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Volume 1
Electrical Services

OPERATION AND MAINTENANCE MANUAL FOR

UTS Broadway Building

Nilsen NSW

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1 INTRODUCTION

This Operating and Maintenance Manual covers the Electrical Services for the University of Technology Sydney Faculty of Engineering and Information Technology Project (UTS FEIT).

The scope of work under the Electrical Services includes the following principle items:

Volume 1:

- High Voltage on site Substation (works by Wilken)
- Low Voltage Power and Lighting Infrastructure and reticulation
- Consumer mains
- Main Switchboards
- Cable ladder and cable tray
- Wiring, cables, enclosures and supports
- Lighting
- Intelligent lighting control system (by Dynalite)
- External lighting
- Power outlet and connections to equipment
- Submains cabling and terminations onto all switchboards/ control panels/ MSSB's as required for by other trades
- Provisions and interface for building management system (BMS)
- Power Factor Correction
- Distribution Switchboards
- Power reticulation and general purpose power
- UPS (works by Eaton)
- Emergency and exit lighting including computer monitoring system
- Lightning Protection System
- Floor boxes
- Skirting duct (works by Ductal)
- EMI Screening (works by EMI Shielding)
- Solar Power Generator (works by Solgen)
- Solar Collection (works by NEP Solar)
- Wind Generator by (works by WE Power)
- EIF System Interface (works by Zest Energy/ ZBB)
- Fuel Cells (supplied by Ballard/Horizon)

Volume 1.2 Security and Energy Management System

Volume 1.3 Communications Systems

Volume 1.4 Audio Visual and MATV Systems

1.1 Warnings and Precautions

(i) Disclaimer

Whilst all care has been taken in the preparation of this document, the accuracy, completeness or currency of the content is not warranted or guaranteed. The document has been created as a guide only.

(ii) No Liability

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(iii) Electrical Obligations

Installers and/or repairers of electrical equipment or electrical installations have an obligation under electrical safety legislation to ensure that:

1. The way the electrical equipment or electrical installation is installed or repaired is electrically safe, and
2. The process followed for installing or repairing the electrical equipment or electrical installation ensures that, when installed or repaired, it will be electrically safe, and
3. After the electrical equipment or electrical installation has been installed or repaired, the electrical worker tests and examines it to ensure it is electrically safe.

At all times a safe system for performing electrical work should be in place before any electrical work is performed.

An employer and self –employed person has obligation to ensure a safe system of performing electrical work is in place, this includes the testing of electrical installations and electrical equipment. In addition, an employer and self-employed person must ensure that, unless the circumstances required under Part 2 Division 1 Electrical Safety Regulation 2002 for the performance of live electrical work apply, live work must not be performed.

The Code of Practice for electrical work provides advice and recommendations for safe working practices, which comply with electrical safety legislation requirements. All electrical works should be familiar with the relevant codes.

1.1.1 Power Supplies

- Dangerous voltages exist in the cabinet so ensure circuits are isolated prior to commencing any work
- **Some equipment should not be isolated without prior arrangements so always ensure consultation with Nilsen Contracting otherwise Electrical Service Installation will be compromised**

1.1.2 Earthing

- Do not disconnect or remove any earth connections without fully isolating the equipment the earth connection is terminated on.

1.2 Directory

1.2.1 Electrical Contractor

Nilsen Contracting		Contact: Tom Thornton
		Address: unit 26, 38 – 46 South Street, Rydalmere NSW 2116
		+ 61 2 9898 9355
		+ 61 2 9638 0343
		e-mail: tomthornton@nilsen.com.au
		Internet: www.nilsen.com.au

1.2.2 Construction Manager

Lend Lease Project Management and Construction Pty Ltd		Nicholas Carnevale
		30 The Bond, 30 Hickson Road, Millers Point NSW 2000
		+ 61 2 9236 6111
		+ 61 2 9383 8133
		www.lendlease.com

1.2.3 Architect

Denton Corker Marshall		
		49 Exhibition Street, Melbourne VIC 3000
		+ 61 3 9012 3600
		+ 61 3 9012 3601
		www.dentoncorkermarshall.com

1.2.4 Electrical Consultant

Waterman		Richard Nicoliello
		Level 4, 10 Help Street, Chatswood NSW 2067
		+ 61 2 9411 9900
		+61 2 9415 1717
		e-mail: r.nicoliello@wahw.com.au
		Internet: www.watermangroup.com

1.3 Volume Details

Volume 1	Contains all details for the Electrical Services.
Volume 1.2	Contains all details for the Security and Energy Management System.
Volume 1.3	Contains all details for the Communications System
Volume 1.4	Contains all details for the Audio Visual and MATV Systems.

1.4 Abbreviations

Area	A section or a site which is specific to this trade.
UTS	University of Technology Sydney
LL	Lend Lease
WAHW	Waterman Consulting
BCA	Building Code of Australia
AS/NZ	Australian/ New Zealand Standard
UPS	Uninterrupted Power Supply
TSG	Technical Services Group

2 SYSTEM DESCRIPTION

2.1 General Overview

The Electrical Services installed by Nilsen Contracting for UTS Broadway Building includes the following:

2.1.1 High Voltage on site Substation (works by Wilken)

On Jones Street, Level 00 Ground Level in between switchroom 1 and switchroom 2, a high voltage chamber substation has been constructed including 3x 1500kVA TX's oil filled connected to a LV Distribution Board.

2.1.2 Consumer Mains

2x 3000Amp Consumer Mains consisting of 16x 500mm Fire rated flexible cables have been connected from the substation LV Main Board to UTS FEIT Main Board. These supplies are connected by a bus tie at the main switchboard which is interlocked to the service protection device so that the building can be fed with one supply only if necessary.

2.1.3 Main Switchboards

The main switchboard for the project is installed in switchroom 2. Downstream of this main switchboard we have 3 Main Distribution Boards. MSB1 is located in switchroom 1, MDB2 is located in switchroom 2 and MDB3 is located in switchroom 3 on Wattle Street Level B1. All the essential services are supplied by the main switchboard in switchroom 2 on Jones Street, Level 00 (Ground) – Consumers supply number 2

The building has an alternate supply for most of the essential services from UTS Broadway No. 1 number 15 Broadway Ultimo Level 29 Main Switch Room, room number 2913 Zone C MSB – Extension Circuit Breakers, this supply is permanently energised to the load side of the ATS in the main board with automatic change over on loss of supply to the Broadway substation. There is a time delay between loss of supply and change over.

CAUTION: ENSURE THE FRONT DOORS ARE SECURELY CLOSED AND RETAINING SCREWS FIRMLY TIGHTENED BEFORE ATTEMPTING TO CLOSE ANY CIRCUIT BREAKER ONTO A LOAD.

2.1.4 Cable ladder and cable tray

Cable support has been supplied and installed, manufactured by Eztstrut in accordance with AS/NZS 3013: 2005 section 3.2.1 Essential Services Support.

2.1.5 Lighting

(i) General Lighting

Luminaire Depreciation & Maintenance

General

The light output of luminaires decreases progressively with time because of: -

(a) The accumulation of dust or other deposits on the transmitting and reflecting surfaces, and,
(b) Permanent discoloration of the transmitting and reflecting surfaces caused by age, by radiation from the lamps or by corrosion in some atmospheres.

The rate at which dirt and dust is deposited on luminaires depends on their design and the location in which they are used. Special precautions are necessary in building where there is a substantial quantity of dirt and dust present in the atmosphere.

A film of dust deposited on reflecting surfaces can severely modify the light distribution of the luminaires; where this is an important design factor frequent cleaning is essential.

Ventilated type luminaires in which air can flow freely over the reflecting surfaces have been shown to greatly reduce the amount of dirt deposited.

(ii) Site Specific Lighting

Prior to practical completion, an inspection of all luminaires will be conducted to check for faults and malfunctions in the form of a site walk.

(iii) Exit and Emergency Lighting

1. General

The procedures described below shall be carried out at intervals of not greater than specified in those clauses. Groups of self-contained emergency luminaires and exit signs may be tested on a rotational basis, provided that the maintenance intervals for the individual luminaires or exit signs do not exceed those specified.

Any self-contained emergency luminaire or exit sign, which fails to operate satisfactorily, shall be either repaired or replaced. Where battery replacement is necessary, the requirements of Battery Replacement below apply.

2. Six Monthly Procedures

The following procedures shall be carried out at intervals of not more than six months: -

(a) Operate the self-contained emergency luminaires and exit signs from their battery supply by simulation failure of the monitored supply. The luminaires and exit signs shall remain illuminated for not less than 90 minutes or such longer period as may be required by the building regulations.

Notes: It should be noted that for part of the period during the test the building might be without emergency lighting. This risk is considered acceptable, except where the Inspecting Authority deems otherwise. When selecting a time for the discharge test, consideration should be given to the nature of the occupancy of the building in order to minimize the risk, e.g. conducting the test discharge at a time, which will permit recharging of the battery when the building is unoccupied.

Successful completion of the tests specified above constitutes acceptable performance in accordance with this clause. However, because there will be a progressive reduction in battery capacity with time it is appropriate to extend the test duration specified above by up to 10 per cent. Satisfactory completion of such an extended test will provide some assurance of system performance pending the next annual check.

It may be desirable for the long-term health of the battery, especially nickel cadmium alkaline batteries, for the discharge to be continued until operation is terminated by the automatic battery cut-off device.

(b) Replace any defective lamps.

(c) Restore the emergency luminaires and exit signs to normal condition and check that the battery charger operation indicator functions correctly.

(d) For indirect lighting systems, check that the main interior surfaces onto which the light is directed have a reflectance of not less than 50%.

Note: An approximate assessment of compliance with the above requirement may be obtained by the use of the reflectance gauge AS 1680G.

3. Twelve Monthly Procedures

All light emitting and/or reflecting surfaces of self-contained emergency luminaires and exit signs shall be cleaned at intervals of not more than 12 months.

4. Battery Replacement

The replacement of batteries in self-contained emergency luminaires and exit signs shall be carried out in accordance with the following requirements. -

(a) Where more than one battery is utilized, the complete set of batteries shall be replaced, however, this requirement need not be observed for nickel cadmium batteries of the sealed pocket plate type.

(b) Replacement batteries shall be of the same type and ampere-hour capacity at a given duty cycle.

Whenever batteries are replaced for any reason, a discharge test shall be conducted in accordance with Clause 2(a) except that the duration of operation provided shall be not less 120/90 times that specified in clause 2(a).

(Refer to manufacturer's information for further details)

ALL ELECTRICAL WORK INCLUDING (BUT NOT LIMITED TO) ALTERATIONS, ADDITIONS AND/OR REPAIRS MUST BE UNDERTAKEN BY A SUITABLY LICENSED ELECTRICIAN IN ACCORDANCE WITH THE RESPECTIVE WIRING STANDARD

2.1.6 Intelligent lighting control system (by Dynalite)

Dynalite has been engaged as the dimming manufacturer to provide the switching system for circuits as detailed on the drawings. This includes the switching schedule and a schedule of lighting control equipment that has been approved by the designer. These schedules form part of the Dynalite detail attached.

a) Programmable Preset Switch Panels

Programmable light switch panels have been provide as indicated on the work as executed drawings, as detailed within this schedule. Programmable light switch panels have been supplied by Dynalite and contain illuminated pre-set pushbuttons and programming socket. The switch plates have been manufactured of stainless steel and labelled by engraving and filling in a contrasting colour.

b) Infra-Red Sensors

Infra-red sensors are installed, as indicated on the drawings, to activate lights as nominated in the Switching and Dimming Schedule to the clean mode, 100 % lighting, when in the security mode.

c) Site Visits For Programming

Dynalite Manufacturers have visited site to programme the Dynalite Lighting Control equipment dimmers. The General Lighting is controlled based on design layouts provided by the designer and controlled based on the Switching and Dimming Schedule.

2.1.7 Power outlet and connections to equipment

(i) General Power

Standard:
General: To AS/NZS 3112.
Socket outlet switches: Required.

Pin arrangement: Mount outlets with the earth pins at the 6 o'clock position.

Plugs – 230/400 Volt
General: Plugs, where required, have been provided with integral pins of the insulated type to AS/NZS 3112.

Permanently Connected Equipment
General: Final sub-circuit to permanently connected equipment, are as detailed by the drawings.
Isolation: Isolating switches have been provided adjacent to equipment, and have been supplied to comply to AS/NZS 3133.

3-Phase Outlets
Construction: Surface mounted type of high-impact resistant plastic, with flap lid on the outlet.
Pin arrangement: As nominated on drawings with earth pins at the 6 o'clock position, neutral pins in the centre and the red, white and blue phases in a clockwise sequence when viewed from the front of the outlet.

(ii) General Outlets and Permanently Connected Equipment

Fittings and accessories are of approved manufacture and rating and have been selected to meet the requirements of the location and function, and as specified.
Switch plate samples have been provided for approval of type and colour prior to installation.
All socket outlets have the earth pin located at the six o' clock position and when viewed from front, connections to outlets are earth/active/neutral in clockwise direction.
Combination switch/plug outlets, unless otherwise nominated on drawings, have a 10 amp capacity rating.
Outlets are impact resistant plastic moulded, suitably reinforced, of selected colour and finish.
All power outlets provided are from the Clipsal range and weatherproofed outlets are from the Clipsal 'Weatherproof Series".
Each power outlet has been identified with a "Dymo" type label showing distribution board and circuit number. This detail is also provided on the Work as executed drawings.
All outlets have their identification label located behind the outlet clip on cover.

An isolating switch has been provided adjacent to each item of equipment, as indicated on the work as executed drawings.
All isolating switches shave been identified with the circuit number in the same manner as power outlets

(iii) Residual Current Devices (RCD)

Circuit breakers with RCD protection have been provided for final sub-circuits as required by Clause 2.6.3.2 of AS3000- 2007. All existing circuits that have been modified and all new circuits have been provided with RCD type Circuit breaker protection.

RCDS WILL NOT PROTECT PEOPLE & LIVESTOCK AGAINST ACTIVE AND NEUTRAL FAULTS.

2.1.8 Power Factor Correction

2x 500KVAR Power Factor Correction units have been supplied by Electroserv and installed in switchroom 2 on Jones Street Level 00 (Ground) and connected to the main board.

2.1.9 Distribution Switchboards

Switchboards

The switchgear assemblies are to be operated only by fully qualified, authorised personnel having complete knowledge of all statutory regulations, legal requirements and safety rules applicable working with the 415 volt switchgear.

In general, under normal operating duty the Switchboards should be cleaned and inspected as often as possible with a MAXIMUM period of 12 months between routine services.

The maintenance is to be conducted in accordance with the Australian Standard No.AS2467-1981 and the routine services should include a visual inspection of each item of equipment within its compartment. If any sign of overheating is apparent, a complete examination of the switchgear contacts and connections is to be made.

All switchgear, insulating material surfaces and surrounding cubicles are to be thoroughly cleaned. It is important that no moisture, oil, paint, pencil lines or any other foreign material be allowed to remain on insulating surfaces as it may cause low resistance between points of different potential and result in eventual electrical breakdown.

Any switching device that has not been operated during the period between services should be subjected to at least one close-open operation while being observed.

All equipment is to be operated and maintained strictly in accordance with the Maintenance Schedule included in this section and the Manufacturers recommendation, refer to section manufacturer's literature for further details.

Diagnostic testing in the form of infra-red scanning of the bus bars, connections and equipment to detect any excessive temperature rise should be carried out at regular intervals and millivolt drop or resistance testing should be conducted across each pole of each item of self-contained switchgear to measure the contact resistance and enable progressive comparison checks to be made.

The same instrumentation should be used for each successive series of tests and the results of all tests and all inspection reports are to be recorded to enable ready review and provide effective indication, by highlighting changes, of when more frequent detailed examinations are required.

Detailed examination should normally be carried out at five year intervals or earlier if indicated necessary by the results of the routine inspections and tests. Detailed examinations are to verify that no detrimental deterioration of insulation has occurred, connections are properly tightened and all equipment is functioning correctly.

Full overhaul need only be carried out when necessary as indicated by routine inspections and examinations; however, a maximum interval of 15 years may be advisable.
Post fault examinations should be carried out as soon as possible after the fault has occurred.

Before any equipment is returned to service after a detailed examination, overhaul or post fault it should be subjected to insulation resistance tests (1000V DC phase to phase and phase to earth for main circuits and 500V DC for auxiliary circuits). The test equipment and the method used should always be the same and the results recorded to enable future comparison.

CAUTION: ENSURE THAT ALL SOLID STATE CONTROL AND PROTECTION EQUIPMENT IS COMPLETELY ISOLATED FROM THE CIRCUIT BEFORE APPLYING ANY MEGGER OR HIGH VOLTAGE DIELECTRIC TESTING.

SWITCHBOARD MAINTENANCE SCHEDULE

OPERATIONAL PERIOD	MAINTENANCE TASK
6 months or less	• Test all residual current devices for proper operation and replace any defective items.
12 months or less	• Remove any signs of dust or other contamination • Visual inspection of assembly • Check operating mechanisms and interlocks for binding, excessive friction or wear • Remove and replace stale or hardened lubricant • Check wiring and connections • Check insulation materials and gaskets for tracking, blistering or splitting, presence of pencil line, moisture and other foreign material • Check vents and filters for freedom of air movement • Infra-red thermal imaging of all Bus bars, connections and equipment • Millivolt drop or resistance tests across poles of self-contained switchgear • Functional tests of all Protection relays • Insulation Resistance Tests.
5 years	• Detailed examinations of all insulating materials • All main, auxiliary and earth circuit connections to be checked for tightness • Full functional tests of all equipment • Check contactor contacts for wear • Insulation resistance tests • Primary injection tests of all current transformers

15 years	• Full overhaul including all of the above • Replace contactor contact sets, control relays, indication light LED, etc. as necessary • Withdraw demountable modules from switchboard and check plug-in facilities on all fuse switches, dropper-bar insulators and connections to main bus bars
Post Fault	• Full overhaul including all of the above • Thoroughly clean and remove all traces of carbon from the affected equipment and its surrounds • Replace damaged components

2.1.10 UPS

Eaton UPS System have supplied and commissioned the UPS Units for the project. There is 23x 6kVA small TSG room UPS systems, 3x 10kVA 3 phase UPS systems, 1 in Level 4 large TSG room, 1 in Level 5 large TSG room and 1 in Level 2 Data Arena. We have one 30kVA 3 phase UPS system installed on Level 8 in the Remote Lab. Please refer to the UPS section for maintenance requirements and procedures.

2.1.11 Emergency and exit lighting including computer monitoring system

We have installed a Dali addressable Exit and Emergency lighting system with light fittings supplied by Clevertronics. These fittings are tested and commissioned as part of the Dynalite Lighting Control Solution and all 6 month and 12 month testing requirements are conducted on the Lighting Control System. Manual test buttons are installed on all common area boards.

2.1.12 Lightning Protection System

Lighting protection system has been installed conforming to AS1768-2007, comprising of the following:

- Bonding of metalwork at roof
- Down conductors and/or bonding of structural and concrete reinforcement
- Test links;
- Earth terminations.

2.1.13 Floor boxes

Floor boxes have been supplied by CMS Electrcom.

2.1.14 Skirting duct

Skirting duct has been supplied by Ductall.

2.1.15 EMF Screening

We have had EMF screening installed on switchroom 2 walls and on the B1 Computer Room under switchroom 2 as required to achieve 35 milliGause (mG) when measured at one meter above the floor and not less than 300mm from any shielded surface.

2.1.16 Solar Power Generator

72 solar panels are installed on the roof, connected to the ZBB inverter and batteries as part of the renewable energy system for the building. The solar panels were supplied and installed by Solgen.

2.1.17 Solar Collection

4x 1200 long solar collector arrays have been supplied and installed by NEP Solar as part of the renewable energy system for the building.

2.1.18 Wind Generator

1x 10KW wind turbine has been installed on the roof connected to the ZBB inverter and batteries as part of the renewable energy system for the building. The wind turbine was supplied by WE Power.

2.1.19 Inverter and Batteries

An inverter and batteries have been supplied and installed by ZBB as part of the renewable energy system for the building. This collects the inputs from the wind turbine, solar array, fuel cell and provides a common regulated output.

2.1.20 Fuel Cells

A Ballard Hydrogen fuel cell has been installed in the EIF Plant Room Level 13. An Electrolyser and 2 Ovonics 760SL metal Hydride canisters have been installed in Level 13 EIF Plant Room supplied by Horizon. They are connected to the renewable energy system for the building.

2.1.22 Fire Rating

Fire rated building elements:

Penetrations have been sealed with a system conforming to AS 4072.1., as detailed by the attached documentation.

3 EQUIPMENT SCHEDULE

3.1 Scope of Works Items

Board Name	Drawing No.
DB-JS-CA-B1	PJ2120164-01-01
DB-JS-CA-00	PJ2120164-01-01
DB-JS-CA-02	PJ2120164-01-01
DB-JS-CA-03	PJ2120164-01-01
DB-JS-CA-04	PJ2120164-01-01
DB-JS-CA-05	PJ2120164-01-01
DB-JS-CA-06	PJ2120164-01-01
DB-JS-CA-07	PJ2120164-01-01
DB-JS-CA-08	PJ2120164-01-01
DB-JS-CA-09	PJ2120164-01-01
DB-JS-CA-10	PJ2120164-01-01
DB-JS-CA-11	PJ2120164-01-01
DB-JS-CA-12	PJ2120164-01-01
DB-JS-CA-13	PJ2120164-01-01
DB-NO-CA-00	PJ2120164-02-01
DB-NO-CA-01	PJ2120164-02-01
DB-NO-CA-03	PJ2120164-02-01
DB-NO-CA-04	PJ2120164-02-01
DB-NO-CA-05	PJ2120164-02-01
DB-NO-CA-06	PJ2120164-02-01
DB-NO-CA-07	PJ2120164-02-01
DB-NO-CA-08	PJ2120164-02-01
DB-NO-CA-09	PJ2120164-02-01
DB-NO-CA-10	PJ2120164-02-01
DB-NO-CA-11	PJ2120164-02-01
DB-NO-CA-12	PJ2120164-02-01
DB-NO-CA-13	PJ2120164-02-01
DB-NO-CA-B1	PJ2120164-02-01
DB-NO-CA-B2	PJ2120164-02-01
DB-NO-CA-B3	PJ2120164-02-01
DB-NO-CA-B4	PJ2120164-02-01
DB-WS-CA-00	PJ2120164-03-01
DB-WS-CA-01	PJ2120164-03-01
DB-WS-CA-03	PJ2120164-03-01
DB-WS-CA-04	PJ2120164-03-01
DB-WS-CA-05	PJ2120164-03-01
DB-WS-CA-06	PJ2120164-03-01
DB-WS-CA-07	PJ2120164-03-01
DB-WS-CA-08	PJ2120164-03-01
DB-WS-CA-09	PJ2120164-03-01
DB-WS-CA-10	PJ2120164-03-01
DB-WS-CA-11	PJ2120164-03-01
DB-WS-CA-12	PJ2120164-03-01
DB-WS-CA-13	PJ2120164-03-01
DB-WS-CA-B1	PJ2120164-03-01
DB-CP-CA-B2	PJ2120164-04-01
DB-CP-CA-B3	PJ2120164-04-01

Board Name	Drawing No.
DB-CP-CA-B4	PJ2120164-04-01
DB-NO-Lv12 EIF	PJ2120164-05-01
DB-NO-Lv12 EIF	PJ2120164-05-01
DB-NO-Lv12 EIF	PJ2120164-05-01
DB-NO-Lv12 EIF	PJ2120164-05-01
DB-NO-Lv12 EIF	PJ2120164-05-01
DB-HT (Lv 10)	PJ2120164-06-01
DB-AERO	PJ2120164-06-01
DB-CL	PJ2120164-06-01
DB-DYN	PJ2120164-06-01
DB-EM	PJ2120164-07-01
DB-PS	PJ2120164-08-01
DB-EP	PJ2120164-09-01
DB-SL	PJ2120164-09-01
DB-JC	PJ2120164-09-01
DB-FL-06	PJ2120164-10-01
DB-FL-08	PJ2120164-10-01
TEE-OFF Boxes	PJ2120164-11-01
DB-NO-LT1	PJ2120164-12-01
DB-WS-LT2	PJ2120164-12-01
DB-LT-03	PJ2120164-12-01
DB-LT-04	PJ2120164-12-01
DB-CoSH	PJ2120164-13-01
DB-NO-TS-09	PJ2120164-14-01
DB-NO-TS-B4	PJ2120164-14-01
DB-JS-TS-03	PJ2120164-14-01
DB-WS-TS-03	PJ2120164-15-01
DB-WS-TS-06	PJ2120164-15-01
DB-WS-TS-09	PJ2120164-15-01
DB-WS-TS-11	PJ2120164-15-01
DB-WA-OA-06	PJ2120164-16-01
DB-WA-OA-07	PJ2120164-16-01
DB-WA-OA-08	PJ2120164-16-01
DB-WA-OA-09	PJ2120164-16-01
DB-WA-OA-12	PJ2120164-16-01
DB-NO-TS-04	PJ2120164-16-01
DB-NO-TS-05	PJ2120164-16-01
DB-NO-TS-06	PJ2120164-16-01
DB-NO-TS-10	PJ2120164-16-01
DB-JS-TS-00	PJ2120164-16-01
DB-JS-TS-08	PJ2120164-16-01
DB-JS-TS-10	PJ2120164-16-01
DB-WS-TS-01	PJ2120164-17-01
DB-WS-TS-04	PJ2120164-17-01
DB-WS-TS-05	PJ2120164-17-01
DB-WS-TS-08	PJ2120164-17-01
DB-WS-TS-10	PJ2120164-17-01
DB-NO-TS-08	PJ2120164-17-01
DB-NO-TS-11	PJ2120164-17-01
DB-JS-TS-06	PJ2120164-17-01
DB-JS-OA-06	PJ2120164-18-01

Board Name	Drawing No.
DB-JS-OA-08	PJ2120164-18-01
DB-JS-OA-09	PJ2120164-18-01
DB-JS-OA-10	PJ2120164-18-01
DB-JS-OA-07	PJ2120164-19-01
DB-JS-OA-11	PJ2120164-19-01
DB-JS-TS-04	PJ2120164-20-01
DB-JS-OA-12	PJ2120164-20-01
DB-NO-TS12	PJ2120164-21-01
DB-NO-TS-07	PJ2120164-21-01
DB-NO-TS-B1	PJ2120164-21-01
DB-WS-TS-B1	PJ2120164-22-01
DB-WS-TS-07	PJ2120164-22-01
DB-WS-TS-12	PJ2120164-22-01
DB-JS-TS-B1	PJ2120164-22-01
DB-JS-TS-05	PJ2120164-22-01
LECTURE HALL AV DB1	PJ2120164-23-01
LECTURE HALL AV DB1	PJ2120164-23-01
DB-SU (Level 00)	PJ2120164-24-01
DB-IH (Level 2/3)	PJ2120164-24-01
DB-DA	PJ2120164-25-01
DB-CAFÉ	PJ2120164-25-01
DB-RL	PJ2120164-26-01
TSG DB – 25 OFF	PJ2120164-26-01
DB-RL-UPS	PJ2120164-27-01
DB-TSG-UPS – 25 OFF	PJ2120164-27-01
MDB EIF OUTPUT S/B	PJ2120164-28-01

4 SUPPLIERS AND SUBCONTRACTORS

4.1 List of Suppliers

Substation: Wilken 178 Princes Highway Arncliffe NSW 2205	+61 2 8577 3000
	+61 2 9597 7255
	Email: info@wilken.com.au
Customer Support	internet

Switchboard: SMB Harwal Electric Pty Ltd Unit D3, 16 Mars Rd Lane Cove NSW 2066	+61 2 9420 7777
	+61 2 9420 7700
	Email: salesnsw@smbelectric.com
Customer Support	Internet: http://www.smbharwal.com.au

Cable Support: Ezystrut Lot 304 Progress Circuit Prestons NSW 2170	+61 2 8783 7555
	+61 2 8783 7666
	Email: nsw.sales@ezystrut.com.au
Customer Support	Internet: www.ezystrut.com.au

Submains: Triangle Cables Pty Ltd 33 Prohasky Street Port Melbourne VIC 3207	+61 2 9689 3810
	+61 2 99689 3840
	Email: nswsales@tricab.com
Customer Support	Internet: www.tricab.com

Small Cables: NEXANS OLEX 207 Sunshine Road Tottenham VIC 3012	+61 3 9281 4444
	+61 3 9281 4476
	Email: Sandra.stevenson@ nexans.com
Customer Support: 1300 222 537	Internet: www.olex.com.au

PULVIN COMPOSITE	Light Fittings: Pulvin Composite Unit 18/ 43 – 45 College Street Gladesville NSW 2111	+61 2 9879 3699
		+61 2 9879 3688
		Email: sales@pcls.com.au
	Sales Rep – Tony Killick	Internet: www.pulvin.com.au

CLIPSAL by Schneider Electric	GPO's: Clipsal – Schneider Electric 78 Waterloo Road Macquarie Park NSW 2113	+61 2 9125 8000
		+61 2 9888 7593
		Email:
	Customer Support: 1300 202 525	Internet: www.schneider-electric.com

PHILIPS dynalite	Lighting Control and Emergency Lighting: Philips Dynalite 6/691 Gardeners Rd Mascot NSW 2020	+61 2 8338 9977
		+61 2 8338 9333
		Email: rishi.sharma@philips.com
	Customer Support: Project Manager – Rishi Sharma	Internet: www.philips.com/dynalite

electroserv	Power Factor Correction: Electroserv Pty Ltd 1/22 Beaumont Road Mount Kuring-Gai NSW 2080	+61 2 8005 2621
		+61 2 8005 4179
		Email: info@electroserv.com.au
	Customer Support: 0412 166 179	Internet: www.electroserv.com.au

EATON Powering Business Worldwide	UPS Systems: Eaton Corporation 10 Kent Road, Mascot NSW 2020	+61 2 9693 3333
		+61 2 9693 1258
		Email: AustraliaSales@eaton.com
	Customer Support: 1300 3 EATON	Internet: www.eatonelectric.com.au

emi shielding	EMI Shielding: EMI Shielding 10/40 Edina Road, Ferntree Gully P.O. Box 130, Ferntree Gully Vic 3156	+61 3 9758 3949
		+61 3 9753 5552
		Email: office@emishielding.com.au
	Sales Rep: Kerryn Harrington	Internet: www.emishielding.com.au

Communication Services: Star Group (AV) 46 Harley Cres Condell Park NSW 2200			+61 2 9708 7555
			+61 2 9791 9420
			Email: info@starelectrical.com.au
	Customer Support		Internet: www.star-group.com.au

Security Services: Honeywell Level 3, 2 Richardson Place North Ryde NSW 2113			+ 61 2 9353 7329
			+ 61 2 9353 8819
			Email: Chris.Gane@honeywell.com
	Customer Support: Chris Gane		Internet: www.honeywell.com

Skirting Duct: Ductall Systems 444 Punchbowl Road Belfield NSW 2191			+61 2 9759 8200
			+61 2 9759 8144
			Email: sales@ductallsystems.com.au
	Sales Rep: Reece Allen		Internet: www.ductallsystems.com.au

Solar Panels: Solgen Energy Unit 11/ 76 Reserve Road Artarmon NSW 2064			+61 1300 660 704
			+61 1300 660 370
			Email: support@solgen.com.au
	Customer Support: 1300 660 704		Internet: www.solgen.com.au

Solar Trough: Nep Solar Pty Ltd Unit 21, 14 Jubilee Ave Warriewood NSW 2102			+61 2 9998 4700
			+61 2 9999 2077
			Email
	Customer Support		Internet: www.nep-solar.com

Wind Turbine: WE Power SAWT Inc.			+86-21-5724-6161 ext 801
			+86-137-7426-8827
			Email: claude@sawtenergy.com
	Customer Support		Internet: www.sawtenergy.com

EIF Converter: ZBB Energy Corporation N93 W14475 Whittaker way Menomonee Falls, WI 53051		+1 262-253-9800 x0
		+1 262-253-9822
		Email: nathan.coad@zbbenergy.com
Customer Support		Internet: www.zbbenergy.com

Fuel Cell: Horizon Fuel Cell Technologies PO Box 5106 NSW 2065		+61 2 9
		+61 2 8580 4640
		Email: craig@horizonfuelcell.com
Customer Support: sales@horizonfuelcell.com		Internet: www.horizonfuelcell.com

Lightning Protection: RWV Industries 2463 River Road Wisemans Ferry NSW 2775		+61 2 4566 4376
		+61 2 4566 4376
		Email: sales@rwv.com.au
Customer Support: sales@rwv.com.au		Internet: www.rwv.com.au

Fire Rating: Fire Stopping Unit 6, 252 Allambie Road Allambie NSW 2100		+ 61 2 9907 0700
		+ 61 2 9907 0728
		Email: nsw@firestopping.com.au
Customer Support		Internet: www.firestopping.com.au

5 MAINTENANCE PROCEDURES

5.1 General

The Maintenance procedures below are provided to assist competent and authorised personnel to operate and maintain the Electrical Services installed in the building.

Any person operating or maintaining this installation must be authorised to do so and be properly trained and competent. This is to ensure proper operation of the System(s), and the health and safety of the building occupants, maintenance personnel, the general public and the environment.

Operation and maintenance of the installation is to be in accordance with the requirements of the Building Code of Australia., The Public health Act, and the Occupational Health and Safety Act.

It is the responsibility of the Building Owner to ensure the operation and maintenance of the installation meets Code and Regulatory Authorities requirements. The building owner should request that any contractor employed for the operation and maintenance of the installation provide certification that the operation and maintenance is in accordance with Code and Regulatory Authority requirements, and that qualified licensed personnel have carried out the operation and maintenance.

5.2 Subcontractor Maintenance Contacts (During DLP)

Description	Subcontractor/ Supplier	Address	Contact	Phone	Fax
Switchboards	SMBH	Unit D3, 16 Mars Rd, Lane Cove, NSW 2066	Terry Schweickle	9420 7711	9420 7700
Lightning Protection	RWV	2463 River Road Wisemans Ferry NSW 2775	Peter Smart	4566 4376	4566 4376
General Light and Power	Nilsen Engineering	Unit 26, 38 – 46 South Street, Rydalmere NSW 2116	Nathan Clegg	9898 9355	9638 0343
UPS System	Eaton Industries	10 Kent Road, Mascot, NSW 2020	Serene Yip	9693 3333	9693 1258

6 MAINTENANCE SCHEDULES

6.1 Power

i. General Power

Generally the power circuits can be isolated by a circuit breaker at the local switchboard. Each outlet (combination) has its own isolating switch. Permanently connected equipment has their isolators located adjacent to the equipment. All local distribution boards contain circuit legend cards to help identify the final sub circuit and its function.

Any electrical work alterations, additions, or repairs will need to be undertaken by suitably licensed electrical trade people and to the relevant electrical wiring standard.

NOTE: Refer to As Built Drawings for further information.

6 Month inspections of general power items and accessories shall be inspected for damage, corrosion or similar defects.

RCD's shall be tested in accordance with:

- 3003 – 2011 for Medical Purposes
- 3000 for General Purposes.

These standards shall be performed by a suitably qualified person and/ or licensed electrician in accordance with the above standards, local circumstances, procedures and law requirements.

ii. Site Specific Power Accessories

- Manufacturer's specs, maintenance and cleaning & TECH DATA
- Preventative Maintenance
- Troubleshooting, disassembly, repair, re-assembly, cleaning, adjustment & checking procedures.

iii. UPS

See Eaton UPS Manual Section for maintenance requirements.

ALL ELECTRICAL WORK INCLUDING (BUT NOT LIMITED TO) ALTERATIONS AND/OR REPAIRS MUST BE UNDERTAKEN BY A SUITABLY LICNESED ELECTRICAN IN ACCORDANCE WITH THE RESPECTIVE WIRING STANDARD

7 CLEANING

7.1 General

This Section of the manual outlines the cleaning frequency and cleaning methods required for the Electrical Services.

7.2 Cleaning

Please refer to Maintenance Schedules Section 7 for the cleaning frequency. Cleaning methods are outlined below.

7.3 Luminaire Cleaning

Luminaires should be cleaned and serviced at regular intervals, recommended every 6 months. To maintain the overall efficiency of the Luminaire, it is essential that the correct cleaning compound be used for the particular materials of the Luminaire. Table A1 provides some guidance on cleaning materials and their uses.

Cleaning Solutions and Their Uses

Material	Best Cleaning Compound	Alternative Cleaners	Remarks
Aluminium	Soap & Water	Water	Acidic or alkaline cleaners may cause chalking of the oxide surfaces. Aluminium should be rinsed thoroughly after cleansing.
Glass	Detergents & Water	Prop Glazing Cleaners	Polishing pastes and fluids are not recommended as these may leave a film on the glass surface, which affects its characteristics in relation to moisture & dirt adhesion. Kerosene must not be used.

Plastics	Non-ionic Detergent & Water	Ordinary	Dust accumulates from a static charge developing on the plastics. It should not therefore be wiped but allowed to drip dry after cleaning. De – static compounds are commercially available as a polish, spray or solution in the rinse bath.

Luminaire Replacement

The approximate lamp life (as advised by the manufacturers) for the various types of lamps installed is listed below.

Lamp Type	Average Lamp Life (Hours)
P.L.	7,500
Fluorescent (Generally)	5,000

(Refer to manufacturer's information for further details)

8 MANUFACTURERS DATA

8.1 Level 1 Substation: Wilken

See attached folder Section 8

Document Set up Data

Field	Data
Client Name	Lend Lease
Client Address	UTS Broadway Building 81 Broadway Ultimo NSW 2007
Manual Type	Operation and Maintenance Manual
Service	
Volume	Electrical Services
Section	
First Issue Date	
This Issue Date	
Latest Revision	A
Binder Size Used	
Binder Number of Rings	2
Separator Page Colour	Yellow
Divider Type	White Card
Divider Level 1 Colour	Red
Divider Level 2 Colour	Blue
Divider Level 3 Colour	
PDF File password	Red Socks
Notes:	All Modified text should be in black. To update Table of Contents Page - right click, update field, update entire table.
	WILKEN GROUP

Ausgrid Substation

OPERATION AND MAINTENANCE MANUAL
FOR

UTS Broadway Building

Wilken Service Pty Ltd

1 INTRODUCTION

1.1 Ausgrid Chamber Substation Project Number SC01596

1.2 Warnings and Precautions

1.2.1 General

The Chamber Substation S.48445 Installed at C25 Lowy Cancer Research Centre contains specialised equipment and is only worked on and accessed by Ausgrid personal

Directory

1.2.1 Electrical Contractor

Wilken		Matthew Brooking
		178 Princes Hwy Arncliffe
		8577 3000
		9597 7255
		info@wilken.com.au
		www.wilken.com.au

1.2.2 Construction Manager

Lend Lease Project Management and Construction Pty Ltd		Nicholas Carnevale
		30 The Bond, 30 Hickson Road, Millers Point NSW 2000
		+ 61 2 9236 6111
		+ 61 2 9383 8133
		www.lendlease.com

1.2.3 Architect

Denton Corker Marshall		49 Exhibition Street, Melbourne, Victoria
		+ 61 9012 3600
		+ 61 3 9012 3601
		www.dentoncorkermarshall.com

1.2.4 Electrical Consultant

Waterman		Richard Nicoliello
		Level 4, 10 Help Street, Chatswood NSW 2067
		+ 61 2 9411 9900
		+ 61 2 9415 1717
		www.watermangroup.com

1.2.5 Level 3 Designer

Simplex Engineering		Tony Shakour
		Suite 602, 12 Mount Street North Sydney 2060
		9460 3622
		94603077

1.3 Volume Details

Volume 1	Contains introductions, and descriptions, general maintenance, asset register and manufacturers user manuals Intended to provide an overview of the project and how the sites and systems integrate. All Maintenance by AUSGRID
Volume 2	Contains manufacturer's user manuals.
Volume 3	Contains manufacturer's user manuals, data sheets and installation manuals.
Volume 4	Contains manufacturer's installation manuals, commissioning and warranties.
Volume 5	Contains drawings.

1.4 Abbreviations

Area	A section or a site which is specific to this trade.
LL	Lend Lease

2 SYSTEM DESCRIPTION

2.1 2. Ausgrid Owned and Operated Chamber Substation

2.2 General Overview

The Chamber Substation S.48445 installed by Wilken Service Pty Ltd and owned and operated by Ausgrid for UTS Broadway Building includes the following:

- 3 x 1500KVA, 11000/4333 Oil Filled Transformers
- 3 x 11KV Circuit Breaker Ring Lucy Sabre
- 3 x Wall Mounted Protection Relay Panel – EF & OC
- 1 x Wall Mounted Relay Panel – Summated OC
- 9 x 100/5 HV Differential Current Transformer 10P25F20
- 3 x K3M Differential Relays
- 9 x 3.85/2.89:4.0/2 Saturating Interposing Current Transformer
- 6 x Electromagnetic Relay: CDG33
- 1 x 2HS Multi Trip Relay
- 2 x Wall Mounted Protection Relay Panel – Customer- OC
- 1 x Transformer Current 400?5 10P2.5F5
- 1 x Relay Steel Earth Fault Indicator Bracket
- 25m Of 11kv 300CU1 G EPR Cable
- 86m Of 185 CU1 LV Cable
- 1 x LV Link Pillar
- 2 x HV joints

3 EQUIPMENT SCHEDULE

3.1 As Per Page 15 and attached Material Issue Sheet

3.2 Scope of Works Items

Quantity	Item Description	Location
1	Ausgrid Certified Design SC01596	

- Subcontractor may insert own equipment schedules in this section.

3.3 Air Handling Units

3.4 Chillers

4 SUPPLIERS AND SUBCONTRACTORS

Ausgrid
Level 1 ASP- Wilken Services Pty Ltd

4.1 List of Suppliers and Subcontractors

Ausgrid	Ausgrid 570 George St Sydney NSW 2000 NSW579	Phone	13 13 88
		Fax	+61 2 9
		Email	email
	Customer Support	Internet	internet

TRI Underground Australia	Tri Underground 8 Cavasinni Pl Wetherill Park NSW 2164	Phone	(02) 9725 1070
		Fax	+61 2 9
		Email	email
	Customer Support	Internet	internet

Supplier Logo	Malbec Electrics 1/53 Fourth Ave Bankstown NSW 2148	Phone	9671 1008
		Fax	+61 2 9
		Email	email
	Customer Support	Internet	internet

5 MAINTENANCE PROCEDURES

5.1 Ausgrid – Chamber Substation all equipment on manual is maintained by Ausgrid, No Access available to UTS Staff

General

The Maintenance of all assets associated with the certified level 3 design SC01596 are owned and operated and maintained by Ausgrid

Ausgrid Chamber Substation
All maintenance and operations are carried out by Ausgrid

No Access available to UTS Staff

5.2 Subcontractor Maintenance Contacts (During DLP)

AUSGRID CHAMBER SUBSTATION

ALL MAINTENANCE AND OPERATIONS ARE CARRIED OUT BY AUSGRID

5.3 Cameras

ALL MAINTENANCE AND OPERATIONS ARE CARRIED OUT BY AUSGRID

6 MAINTENANCE SCHEDULES

ALL MAINTENANCE AND OPERATIONS ARE CARRIED OUT BY AUSGRID

Device / Maintenance Task	Procedure Reference	Frequency					
		Daily	Weekly	Mthly	3 Mth	6 Mth	Yearly
Ausgrid owned and maintained							
1							

*

7 CLEANING & TROUBLE SHOOTING

ALL MAINTENANCE AND OPERATIONS ARE CARRIED OUT BY AUSGRID

8 GENERAL

ALL MAINTENANCE AND OPERATIONS ARE CARRIED OUT BY AUSGRID

8.1 Cleaning

ALL MAINTENANCE AND OPERATIONS ARE CARRIED OUT BY AUSGRID

9 MANUFACTURERS DATA

9.1 Testing Data

Ausgrid – Chamber

9.2 N/A

9.3 Stainless Steel box Gutters

9.4 Acoustic Insulation

ABB Inc.
Small Power Transformers
2135 Philpott Road
South Boston, VA 24592
Instruction Book

NT-1002
Rev. 10/15/01

Liquid Insulated Network Transformers

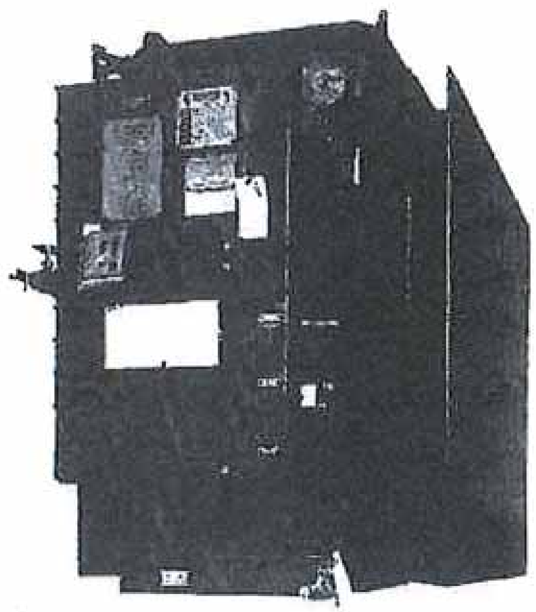


Table of Contents

SECTION II: NETWORK SWITCH

READ THIS INSTRUCTION BOOK CAREFULLY BEFORE ATTEMPTING TO HANDLE, INSTALL, USE OR SERVICE THE TRANSFORMER. FAILURE TO FOLLOW INSTRUCTIONS COULD RESULT IN SEVERE INJURY, DEATH OR PROPERTY DAMAGE.

SAFETY NOTES FOR INSTALLATION AND OPERATION

DO NOT LIFT OR MOVE A TRANSFORMER WITHOUT ADEQUATE EQUIPMENT AND PRECAUTIONS.

TERMINALS ARE FOR ELECTRICAL LOADING ONLY, USE FLEXIBLE CONNECTORS TO AVOID MECHANICAL STRAIN.

DO NOT MAKE ANY CONNECTIONS THAT ARE NOT AUTHORIZED BY THE NAMEPLATE OR CONNECTION DIAGRAM.

DO NOT ENERGIZE TRANSFORMER WITHOUT PROPER GROUND CONNECTIONS.

DO NOT ATTEMPT TO CHANGE THE TAP SETTING WHILE THE TRANSFORMER IS ENERGIZED FROM EITHER H.V. OR L.V. SIDE.

DO NOT TAMPER WITH INTERLOCKS, ALARM AND CONTROL CIRCUIT.

IMPORTANT NOTICE: FAILURE TO OBSERVE THE REQUIREMENTS OF OSHA STANDARD 1910.269 CAN CAUSE DEATH OR SEVERE BURNS AND DISFIGUREMENT. THAT STANDARD SPECIFICALLY PROHIBITS THE WEARING OF POLYESTER, ACETATE, NYLON, OR RAYON CLOTHING BY EMPLOYEES WORKING WITH EXPOSURE TO ELECTRIC ARCS OR FLAMES.

The unit(s) covered by these instructions have been inspected and tested to meet all applicable standards of ANSI, NEMA, and IEEE, to assure you of the highest quality product.

The instructions in this manual should familiarize qualified personnel with the proper procedures to keep all new unit(s) in proper operating condition.

These instructions do not propose to cover all details or variations in equipment, or to provide for every contingency to be met in connection with installation, operation, or maintenance. Should further information be desired, or particular problems arise which are not covered, please contact ABB's South Boston factory.

SECTION I: NETWORK TRANSFORMER

1. INTRODUCTION

These instructions apply to liquid filled network transformers manufactured by the ABB Small Power Transformer Division at South Boston, Virginia.

The equipment covered by these instructions should be operated and serviced only by competent personnel familiar with good safety practices. These instructions are written for such personnel and are not intended as a substitute for adequate training and experience in the use of this equipment.

The transformer outline drawing shows the location of nameplates and warning signs. Read and follow all warning signs and nameplates installed on the transformer.

NOTE: DO NOT REMOVE OR COVER THE WARNING SIGNS AND NAMEPLATES.

Electrical characteristics, winding connections and weights are on the nameplate. Physical details, such as weights and dimensions are shown on the transformer outline drawing. Wiring for the controls, fans and alarms circuits are shown on the wiring diagram. Repair information for all parts is not included because replacement is recommended rather than repair. If information is desired in greater detail, copies of instruction leaflets referred to, but not included with this book can be obtained by contacting the ABB Small Power Transformer Division.

2. RECEIVING

NOTE: Inspection of transformer, packages and parts is required prior to unloading from carrier, in order to establish the condition of the equipment upon delivery.

2.1 Drawing and Documents

Shipping papers, packing list, outline drawings, an instruction book and other pertinent documents furnished with the transformer must be available for use during the inspection.

2.2 External Inspection

All transformers are carefully tested at the factory and are in good condition when shipment is made. If the inspection indicates a shortage, damage or evidence of hidden damage, it must be reported to the carrier's representative and to a representative of the ABB Small Power Transformer Division before unloading the transformer. As a minimum the following inspections should be made.

External Inspection of Transformer Tank and Fittings	
1.	Is there any indication of external damage?
2.	Is the paint finish damaged?
3.	Are the attached fittings loose or damaged?
4.	Is there evidence of fluid leakage on or around the tank coolers?
5.	Are any of the bushings broken or damaged?
6.	Is there any visible damage to the parts or packaging that shipped separately from the transformer?

2.3 Tank Pressure

The tank is pressurized before shipping. However, depending upon liquid temperature, the tank pressure may be positive or negative. In some cases, the vacuum pressure gauge may read zero, which could possibly indicate a tank leak. In such cases, perform a pressure test on the tank according to the instructions in Section 6.4.1. Report tank leaks of new transformers to the ABB Small Power Transformer Division.

2.4 Detail Parts

In making examinations of the parts crates for shipping damage, check carefully for evidence of moisture and for damage to moisture barriers or waterproof wrappings when used.

The detail parts should be stored in a clean, dry area that will minimize exposure to weather and the possibility of damage or loss.

2.5 Internal Inspections

When a new transformer is delivered, an internal inspection is normally not required. Temporary shipping braces are not used inside the transformer. **No internal inspection should be performed unless authorized by ABB Small Power Division.**

3. HANDLING PRIOR TO INSTALLATION

3.1 Tilting

Transformers should be handled in the normal upright position, but in no case tilted more than 15° from vertical, unless instructions have been given to the contrary. Refer to the outline for these instructions.

3.2 Lifting

Lifting hooks or eyes are provided on the transformer tank wall. Only these hooks can be used in lifting the complete transformer. Refer to the outline for the proper lifting hook locations. All four lifting hooks must be used for proper handling.

3.3 Jacking

Refer to the transformer outline drawing for jacking areas on the transformer tank. Only those areas may be used when the transformer is jacked. Note: **When jacking the tank, assure that the jack does not come in contact with the panel radiators.**

4. STORAGE PRIOR TO ENERGIZING

4.1 Storage of Transformer

When storing the transformer, it should be completely assembled and pressure tested in accordance with Section 6.4.1. The gas space above the liquid should be pressurized with dry nitrogen between two to three PSIG. This will aid in preventing moisture from being pulled into the tank during pressure variations caused by temperature changes. Transformers designed for indoor use must be stored indoors.

4.2 Extended Storage Guidelines

If a unit is to be stored more than 60 days before being placed into service, the guidelines listed below should be followed.

1. Store the transformer on a firm level foundation, preferably at its installation site. Perform external inspections listed in Section 2.2 and the tests and inspections listed below.

Additional Test and Inspections

1. Record ambient temperature and barometric pressure for correction of test data.
2. Pressure test to insure the tank and fittings do not have leaks. After test is complete, the pressure should be reduced to two (2) PSIG.
3. Test insulating liquid for dielectric strength and moisture content.
4. Test insulation with a 1000 or 2500 volt megger.
5. Check the insulation power factor using Doble or or similar test equipment. **Note: This test is not possible on a secondary with a solidly grounded neutral.**
6. Test ratio in all tap positions to insure proper tap changer operation.
7. Verify liquid level by gauge reading.

2. The transformer should be completely assembled.

3. If the transformer has externally mounted bushings on the terminal chamber or switch, the bushings should be protected from the environment. A black polyvinyl material placed over bulk bushings and the rubber cap supplied with molded bushing wells, molded inserts and molded single piece bushings will serve as protection. All protective material should be checked during routine inspections to insure that it is not damaged or lost.

4. Parts that are shipped separate from the transformer must be stored in a clean, dry area.

The following inspection must be made while the transformer is in extended storage. Record the results for comparison with previous data to insure that there has been no deterioration in the condition of the transformer.

<u>Quarterly Inspection</u>*

1. Check the black polyvinyl material or rubber caps covering the bushings for damaged. Replace if damaged or lost, if necessary.

2. Record gauge readings, including the ambient temperature and barometric pressure.

a. Take a pressure reading. Compare with previous two (2) psig reading. Variances in barometric pressure must taken into account.

b. If the pressure or liquid level readings indicate a possible leak in the transformer, perform a pressure test according to Section 6.4.1. Any leaks should be repaired immediately.

c. If a leak was found, perform the following;
- Test insulation megger test.
- Insulation power factor.

Refer to Section 6.4.3 for acceptable results.

Perform the first inspection one month after the transformer has been put into storage and quarterly thereafter.

Annual Inspection

1. Check the paint finish and touch up as necessary.

2. Test insulating liquid for dielectric strength and moisture content.

When the transformer is taken out of storage, the pre-energization tests and inspections identified in Section 6.4 must be performed. Review the storage records of the transformer to insure that there has been no deterioration in the condition of the transformer.

5. ACCESSORIES AND COMPONENTS

5.1 Alarm Switch Ratings

Accessories supplied are shown on the outline drawing. When accessories are equipped with alarm contacts, refer to the control wiring diagram referenced, or the outline drawing, for contact type and ratings and terminal points.

5.2 Transformer Nameplate

A nameplate is supplied on each transformer according to ANSI standard C57.12.00. The nameplate provides basic information for use of the transformer.

5.3 Current Transformers

WARNING: CURRENT TRANSFORMER SECONDARIES MUST BE CONNECTED TO A LOAD OR SHORT-CIRCUITED TO AVOID DAMAGING VOLTAGES AT THE TERMINALS. FAILURE TO MAKE THESE CONNECTIONS COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

Current transformers are optional accessories. When supplied, current transformers are mounted inside the transformer tank. Current transformer secondary leads are always wired to non-submersible junction box external to the tank. Refer to the wiring diagram or outline drawing. The current transformer secondary leads are always shorted and grounded to the tank when the transformer is shipped.

5.4 Liquid Level Gauge

The liquid level indicator indicates the liquid level inside the tank. When indicators are installed at the factory, the tank is filled to the level that corresponds to a liquid temperature of 25° C, which is considered the normal level. Should the tank be at some temperature other than 25° C, use Table 1 to determine the variation above or below the normal level before adjusting fluid level. The indicator is shipped mounted on the transformer tank and requires no maintenance other than the periodic inspection recommended in Section 7 of this Instruction Book.

Table 1 - Liquid Level Guage

Average Liquid Temperature (°C)	Correct Level (Percent of Scale Above or Below 25 °C Level)
85 (high)	100
70	75
55	50
40	25
25 (Normal)	0
10	-33
-5	-67
-20 (Low)	-100

Contact factory if liquid level gauge does not agree with Table 1.

5.5 Liquid Temperature Gauge

The temperature gauge is furnished to indicate the top liquid temperature in the tank. The temperature sensitive element is mounted in a dry, leak-proof well, permitting removal of the thermometer without lowering the liquid level. The device is furnished with a red pointer to show the highest temperature attained since last reset. To reset the maximum indicator, rotate the magnet at the center of the dial or, on some models, past the reset button. During normal operations the liquid temperature gauge should read less than the sum on the ambient temperature and the rated temperature rise. For example, 30°C ambient + 55°C rated temperature rise = 85°C top oil temperature.

5.6 Pressure-Vacuum Gauge

WARNING: WHEN THE PRESSURE-VACUUM GAUGE READS ZERO AND DOES NOT CHANGE UNDER ANY TRANSFORMER LOAD, THE TRANSFORMER SHOULD BE CHECKED FOR POSSIBLE LEAKS. A LEAK WILL ALLOW MOISTURE AND AIR TO ENTER THE TRANSFORMER, WHICH COULD DEGRADE THE INSULATION AND FLUID AND POSSIBLY CAUSE A FAILURE.

The pressure-vacuum gauge indicates the tank gas space pressure relative to atmospheric pressure. Maintenance is not required except for the periodic inspection recommended in Section 7 of this instruction book.

5.7 Pressure Relief Mechanism

WARNING: NEVER DISASSEMBLE A PRESSURE RELIEF DEVICE. DISASSEMBLY COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE FROM HAZARDOUS FLYING OBJECTS.

Some transformers are furnished with a pressure relief device others may have relief valves. The pressure relief mechanisms will vent tank gases when excessive tank pressure exists. The relief device consists of a self-resetting, spring-loaded diaphragm and a mechanical operation indicator (Semaphore). The maximum tank pressure at which the pressure relief device will remain sealed is stamped on the relief device nameplate. Should the tank pressure increase above the pressure relief device nameplate rating, the gas pressure will lift the diaphragm, vent the excess pressure, and trip the Semaphore.

Immediately after the pressure returns to normal, the diaphragm will reset and reseal the transformer. This event is not normal. If the semaphore indicator is lifted, the cause of the operation should be investigated. The mechanical operation indicator (semaphore) must be manually reset after each operation. The pressure relief device will withstand full vacuum and need not be removed from the transformer tank during any vacuum. A hood may be bolted over the relief device.

The relief valve is a spring loaded, self-resetting valve stem fitting. As the pressure increases above the valve rating, the stem will move relieving the pressure. The relief valve can also be used to manually relieve the tank pressure.

WARNING: WHEN USING THE RELIEF VALVE TO RELIEVE TANK PRESSURE, A HOT FLUID MAY BE EXPELLED. EYE AND SKIN PROTECTION MUST BE USED TO AVOID PERSONAL INJURY

5.8 De-energized Tapchanger

The de-energized tapchanger is provided as means to adjust the transformer voltage to closely match that of the user system voltage. It is not to be used as a means to regulate the secondary voltage. If the tap changer is used in this manner, it will result in high noise level, higher no-load losses and possible core saturation. Refer to the transformer nameplate for the tap voltages possible for the transformer.

De-energize the transformer before attempting to change tap positions. Usually, the transformer is shipped in the rated voltage position.

WARNING: DO NOT MOVE THE TAPCHANGER POSITION, UNLESS THE TRANSFORMER IS TOTALLY DE-ENERGIZED. FAILURE TO DO SO WILL RESULT IN THE FAILURE OF THE TRANSFORMER AND COULD RESULT IN SEVERE PERSONAL INJURY OR POSSIBLE DEATH.

The de-energized tapchanger is located on the tank cover under a 2-inch pipe cap. A special wrench is inserted with its flat side adjacent to the position indicator. The wrench is then turned one complete revolution for each tap position. The tapchanger must be in a tap position before the wrench can be removed from the operating mechanism. The position indicator always identifies the current tap position. Refer to **Figure 1** below.

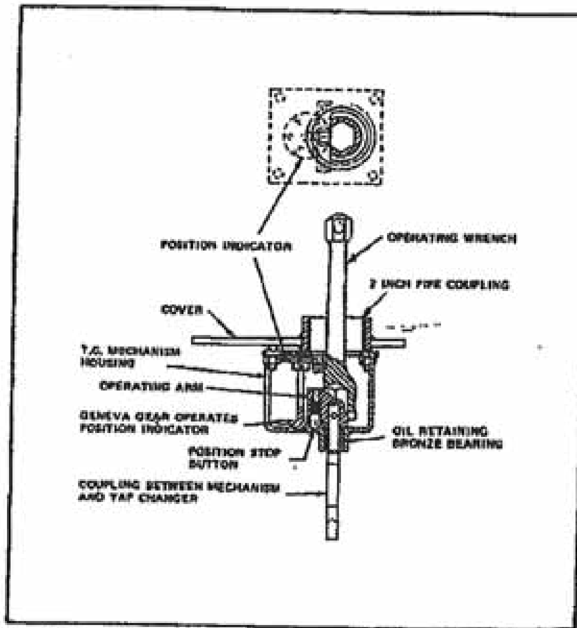


Fig. 1 Tapchanger *Operating Mechanism*

CAUTION: THE TAPCHANGER HAS STOPS AT THE MINIMUM AND MAXIMUM TAP POSITIONS AS INDICATED ON THE NAMEPLATE. DO NOT FORCE THE TAPCHANGER AT THESE POSITIONS. TO DO SO WILL DAMAGE THE TAPCHANGER AND COULD CAUSE A FAILURE.

When the tapchanger is not in use, the wrench must be removed. The 2-inch pipe cap must be in place and sealed. Apply a thread sealant, such as liquid Teflon®, to the threads of the cap coupling and securely tighten.

5.9 Bushings

5.9.1 Primary Bushings

The primary bushings bushing are normally located in the primary network switch. Information regarding these will be will be found in the switch section of the booklet.

5.9.2 Secondary Bushings

Shown in Figure 2 is a cut-away view of the network transformer type RFW low voltage bushing mount in the transformer throat. The type RFW is a rolled flange bushing where the copper bushing cap and flange are attached to the insulator by being rolled into grooves in the insulator over silicone rubber rings. This seal is made at the factory and cannot be repaired in the field. If the intermediate seal is defective, replacement bushings must be obtained from the factory.

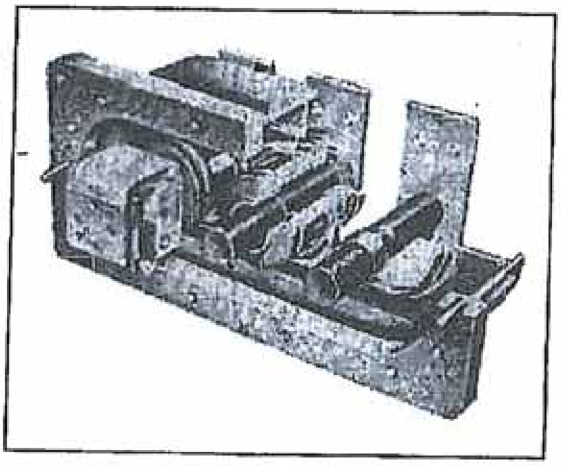


Fig. 2 *Cut-away view of Type "RFW" Bushing*

Inert-arc welding is used to attach the bushing flange to the throat wall, as shown in Figure 3. This method of welding is ideally suited for the mounting of bushings as its high concentration of localized heating gives a quick weld while at the same time it does not cause excessive overheating to adjacent seals. More information on inert-arc welding, removal and replacement of bushing can be obtained through the ABB Small Power Transformer Division.

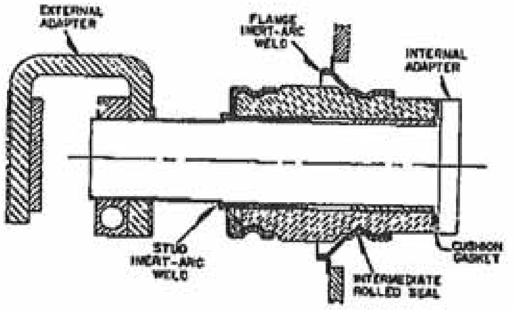


Fig. 3 Bushing Cross Section

6. INSTALLATION

6.1 Location and Mounting

Transformer must be placed on a foundation of sufficient strength to support the weight of the unit. The foundation must be level within one half inch per 100 inch base. If the unit is not level, the liquid may not circulate properly through the panel radiators and cause overheating that will shorten the transformer life. When a transformer is designed for operation while tilted, the degree of maximum tilt will be noted on the transformer nameplate.

6.2 Ventilation for Cooling

Natural ventilation is the basic ventilation system used for Network transformer vaults and is the most dependable. The amount of heat dissipated through the vault walls and the necessary grate openings to remove the heat loss can be calculated by various methods. However, a simplified method for an approximate determination of net grating area is generally accepted. The National Electric Code recommends three square inches of net grating opening for both the air inlet and outlet for each KVA of transformer capacity. The grating is located in the vault roof.

6.3 Opening Transformer Tank

Transformers are generally shipped sealed and need not be opened. An exception to this is when delta-wye and series-multiple connections are made using an internal terminal board. These connections are accessible through a handhole located on the cover. When entry is required read and follow the instructions given below.

Likewise, when access is required for damage inspection or other problems, the following precautions should be followed. **Note: Contact the factory for assistance and directions when damage is suspected or other problems exist. Observe the safety precautions that follow.**

WARNING: RELEASE INTERNAL PRESSURE PRIOR TO REMOVING TANK ACCES-SORIES WITH A PRESSURE SEAL (MANHOLES, RELIEF DEVICE, PLUGS). FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

Internal pressure may be relieved by use of gas sample valves; or by SLOWLY removing the filling cap a thread at a time until the pressure starts to relieve itself.

WARNING: TO AVOID DEATH FROM SUFFOCATION NEVER ALLOW ANYONE TO ENTER THE TRANSFORMER TANK UNLESS AN ANALYSIS OF THE AIR IN THE TANK SHOWS AT LEAST 19.5% OXYGEN. THE GAS SPACE ON AN OPERATING TRANSFORMER CONSISTS OF NITROGEN GAS. WHENEVER ANYONE IS IN THE TANK, A PERSON SHOULD BE STATIONED AT THE MANHOLE OUTSIDE THE TANK TO INSURE SAFETY OF THE PERSON INSIDE.

Safety Precautions for Opening A Tank

When it is necessary to open a transformer, the following procedure should be used. Ventilate the gas space with dry air to purge it of the nitrogen gas that it contains.

Dry air should be used to ventilate the inside of the tank when it is opened for internal fitting. When dry air is used, the following restrictions should be observed:

a. Temperature of dry air entering the transformer shall be at least as high as that of the transformer and at least 10°C higher than the dew point of the outside air.

b. Dry air shall be blown into the transformer so as to create a flow of air through the cover opening. Air hoses may be taken into the transformer if they are clean and made from an oil-proof material.

c. The dew point in the transformer should never be higher than 20°F.

d. Dry Air and Nitrogen. When nitrogen is called for, the nitrogen used should have a dew point not higher than -50°C (-58°F), and total impurities not exceeding 0.1% by volume. Nitrogen can be obtained in high-pressure steel cylinders, or in some locations in insulating low-pressure containers in liquid form. In general, liquid nitrogen that will boil in the container to yield gaseous nitrogen, will have a lower dew point than gas in high-pressure cylinders.

Dry air should also have a dew point of -50°C (-58°F) or lower. It is usually available in cylinders from the nitrogen supplier. Air drying equipment is also available which is capable of producing dry air by passing air through a desiccant bed to remove moisture.

When air or nitrogen is supplied from high-pressure cylinders the proper regulating valve must be used for introducing the gas into the transformer tank. Cylinders should not be completely emptied, but should be returned to the supplier with at least 25 psig residual pressure.

Outside air may be used for ventilating the transformer if dry air is not available. If outside air is to be used for ventilation, open the transformer only if the outside relative humidity is less than 65% and if the temperature of the transformer is at least 10°C higher than the dew point of the outside air.

The maximum total time the transformer should be open is 24 hours. If this time must be exceeded, extend the length of the vacuum prior to filling specified in Table 7 by one hour for each 4 hours that the open time exceeded 24 hours. If work is interrupted, the tank should be closed, evacuated, and refilled with dry air or nitrogen.

Do not open the transformer in an area unprotected from weather during precipitation or in an area where the air may contain dirt or other particles. Either of the above could cause a transformer failure. If the transformer is opened, the openings should be protected from the entry of foreign matter into the transformer tank at all times. It may be necessary to remove some liquid from liquid-filled units for adequate inspection.

While the transformer is open, no one should be permitted on top or inside the transformer until he has emptied all pockets, checked for loose objects elsewhere on his person, such as in pants cuffs, and has removed watches and rings.

Never stand directly on any electrical insulation. Clean drop cloths should be used under working areas in the transformer to prevent objects from dropping into the structure.

All tools must be accounted for. If possible, tools should have lines attached so that they cannot be lost.

One person should be responsible for policing the people and materials into and out of the tank and for making certain that nothing is left in the tank accidentally. This person should also be responsible for limiting the length of time the tank is left open to 24 hours.

After the tank has been opened the following tests should be made.

1. A ratio test should be made on all windings and tap positions. If any measurement is off ratio by more than 0.5%, resistance and temperature measurements should be made of the windings in question and compared with factory test values.

2. Insulation resistance of each winding to all other windings and ground and from all windings to ground should be made with the windings under liquid. Record the temperature of the liquid. These readings should be comparable with measurements made at the factory.

3. When accessible, disconnect the core ground connection on core form transformers and measure the resistance from the core to the tank or end frames, using a 1000-volt megger. The resistance should exceed 100 megohms, if the core is not covered with liquid, or 200 megohms, if the core is under liquid. When the internal inspection is complete, reseal the tank and refill the gas space with dry air or dry nitrogen.

6.4 Preparation for Energization

The following are instructions that must be followed when preparing the transformer for energization. These instructions provide minimum requirements to determine the transformer's readiness for service. Check off each section as it is completed.

6.4.1 ( ) Pressure Test

Prior to energization, check the integrity of the transformer tank by introducing dry air or dry nitrogen through the pressure test fitting (this may be identified as the air test valve or gas sampling valve on the transformer out-line) until a positive internal pressure of 3 to 4 psig is established. Allow the tank to stand for one to two hours, then examine the tank and fittings for leaks.

A leak above the liquid level can be located by applying a soap solution to all joints, pipe fittings and cable connections. When the pressure test is complete, reduce the internal pressure to 1 or 2 psig.

6.4.2 ( ) Insulating Liquid Test

Before energizing the transformer, the liquid must be tested in accordance with Section 8. The dielectric strength of new liquid must be 26 KV or higher.

6.4.3 ( ) Insulation Megger Test

To insure that no grounding of the windings exists, a 1000-volt megger test and a power factor test should be made. Refer to Table 2 and 3 for allowed values of insulation resistance.

Table 2 - Minimum Insulation Resistance in Oil at 20°C

L-L Voltage Class KV	Megohms
1.2	32
2.5	68
5	135
8.66	230
15	410
25	670
34.5	930

Table 3 - Insulation Resistance Transformer Correction

Transformer Temperature °C	Correction Factor	Transformer Temperature °C	Correction Factor
95	89.0	35	2.5
90	66.0	30	1.8
85	49.0	25	1.3
80	36.2	20	1.0
75	26.8	15	0.73
70	20.0	10	0.54
65	14.8	5	0.40
60	11.0	0	0.30
55	8.1	-5	0.22
50	6.0	-10	0.16
45	4.5	-15	0.12

6.4.4 ( ) Ratio Test

A ratio test should be made at all tap positions to insure proper transformer ratios and tapchanger connection.

6.4.5 ( ) Continuity, Resistance Test

There should be a continuity check of all windings. If possible, measure the winding resistance and compare to the factory test values. An increase of more than 10% could indicate loose internal connections.

WARNING: DO NOT CHANGE CONNECTIONS ON A TRANSFORMER THAT IS ENERGIZED NOR MAKE ANY CONNECTIONS EXCEPT AS AUTHORIZED BY THE NAMEPLATE OR CONNECTION DIAGRAM. TO DO SO WILL RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

6.4.6 ( ) Connections

When electrical connections are made:.

( ) a. All mating joints must be clean. All electrical connections must be to the correct terminal and be mechanically secure.

( ) b. Check that the tap changer operating mechanism is in the proper position for the required voltage.

( ) c. If the transformer is equipped with an internal terminal board, read Section 6.3 for instructions and warnings prior to opening tank.

Delta-wye and series-multiple connections are made using an internal terminal board or a de-energized switch. Make the connection according to the chart on the transformer nameplate. Terminal board connections must be mechanically tight to prevent overheating of the joint.

( ) d. The transformer tank must be grounded permanently by connecting a ground cable per the National Electric Code to a ground pad located at the bottom of the tank.

6.4.7 ( ) Liquid Level

Liquid level should be at the correct level according to Table 1.

WARNING: THE TRANSFORMER MUST HAVE THE CORRECT LIQUID LEVEL BEFORE ENERGIZING THE UNIT (REFER TO TABLE 1). FAILURE TO DO SO COULD RESULTING SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.

6.4.8 ( ) Tank Finish

All damaged paint surfaces should be cleaned, primed, and repainted.

6.4.9 ( ) Bolt Check

Tighten all external bolts.

6.4.10 ( ) Tools

All tools or other objects used in installation are accounted for and have been removed from the transformer.

6.4.11 ( ) Liquid Temperature

The liquid temperature must be no lower than -20°C when the unit is energized. The liquid temperature gauge can be used for this determination.

When inspections and tests in Sections 6.4.1 through 6.4.12 are completed and any required repairs have been made, the transformer may be energized.

7. MAINTENANCE

WARNING: ALWAYS DE-ENERGIZE THE TRANSFORMER WHEN WORKING ON THE TRANSFORMER. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH, OR PROPERTY DAMAGE.

7.1 It is the responsibility of the owner to inspect, maintain, and keep the transformer in good repair.

7.2 Report all failures during the warranty period to the ABB Small Power Transformer Division. All warranty repairs must be made or approved by the ABB Small Power Transformer Division.

7.3 The core and coil assembly can be repaired or replaced by authorized ABB personnel. Contact the ABB Small Power Transformer Division.

7.4 Tank leaks must be repaired immediately to prevent serious damage to the transformer and danger to life. Request Instruction Leaflet 48-069-20 for detailed instructions on tank repair.

7.5 The periodic test and inspections listed in Table 4 are recommended as routine maintenance.

Table 4 - Recommended Minimum Maintenance Schedule

Check Period	One Month After Initial Energizing	Once A Year After Energizing
7.5.1 Gauge Readings	X	X
7.5.2 Tank Leaks		X
7.5.3 Paint Finish		X
7.5.4 Liquid Dielectric Test		X

7.5.1 The gauge readings should be recorded as well as the ambient temperature and the KVA load. Any abnormal reading is justification to make other diagnostic test or inspections immediately. Section 5 may be of assistance in determining abnormal readings.

7.5.2 If the pressure or liquid level readings give cause to suspect a leak, make a pressure test in accordance with the instructions and warnings of Sections 6.4.1

7.5.3 Inspect the paint finish for scratches or wear that expose the prime coat or the tank steel itself. Any paint damage must be repaired to prevent base metal corrosion or further deterioration of the paint surface. Contact the factory for repair instructions, if needed.

7.5.4 Liquid Dielectric Test. It is recommended that a liquid sample be taken periodically and tested. The dielectric strength of the liquid should not drop below 26 KV.

7.5.5 If additional instructions are needed, contact the factory.

8. SAMPLING OF INSULATION LIQUID

Care should be taken to procure a sample that fairly represents the liquid in the tank. A quart of liquid should therefore be drawn off before the sample is taken to insure that the sample will not be that which is stored in the sampling pipe. If the sample taken contains free water, it is not suitable for dielectric tests and the sample should be discarded. A second sample should then be taken after at least two quarts of liquid have been withdrawn. If free water still exists, the liquid should be run through a blotter filter press and re-tested for dielectric strength.

The sample of the liquid should be taken when the unit is warmer than the surroundings to avoid condensation and should also be taken only on clear days. When sampling oil from the transformer, the sample must come from the bottom of the tank.

When sampling SILICONE FLUID from the transformer, the sample may come from either the top liquid level or the bottom of the tank.

It is recommended that a 16-ounce amber glass container be used as a sampling receptacle so that any water present may readily be seen. Do not use rubber gaskets or stoppers on SILICONE FLUID sample bottles.

Additional information concerning handling, sampling, filtering, testing and reconditioning can be obtained by ordering Instruction Book 45-063-100 for OIL, and Instruction Book 45-063-102 for SILICONE FLUID through the ABB Small Power Transformer Division.

9. GASKETS

Before replacing a gasket, carefully and thoroughly clean the steel surfaces between which the gaskets are compressed to remove rust, oil grease, paint, and other foreign material. Scraping or wire-brushing the surface with de-natured alcohol is a satisfactory method of cleaning. When applying gaskets, suitable gasket cement must be used. Put the gasket in place and bolt the two surfaces together under uniform pressure. After the unit has been in service for a period of six months, retighten all the bolts.

10. RENEWAL PARTS

Order renewal parts from the ABB Small Power Transformer Division, giving description of parts wanted, as well as the serial number on the transformer nameplate. A renewal parts list can be obtained in the same manner. In order to expedite maintenance, the user should stock the parts listed on the Recommended Parts List.

SECTION II: NETWORK SWITCH

11. INTRODUCTION

The Network disconnect and grounding switch, see Figure 4, is normally welded to one end of the transformer tank. The switch is divided into two parts, a switch chamber and a terminal chamber. In the ground position, the switch will withstand a short circuit current of 15,000 amperes for five seconds without any appreciable movement of the contacts.

11.1 Description

The three-position switch is designed to have the following sequence: "open, "transformer", "ground", while the two-position sequence is "open" and "transformer." The operating mechanism compels a pause in the "transformer" position to allow the electrical interlock to "pick up" or lock the switch in the "transformer" position in case the feeder is energized.

The operating mechanism on both two and three position switches includes a latching device which holds the switch in any normal operating position unless released by the operator and also provides a means by which the customer may padlock the handle.

The Network switches can be designed to interrupt the transformer exciting current (known as a Mag-Break switch) or designed for de-energized operation (known as a Deadbreak switch). The following interlock schematics show the types of operation. Figure 5 shows the operation of the three-position Mag-Break switch.

The three-position, Mag-Break switch has two interlocks. Interlock "A" prevents movement from "closed" to "ground" position while the transformer is energized; Interlock "B" prevents movement from "closed" to "open" position while the LV breaker or network protector is closed.

Interlock "A" is connected directly to the transformer low voltage so that the interlock is engaged whenever the transformer is energized. Its associated cam is slotted so that the interlock does not interfere with movement from "closed" to "open" position but prevents movement from "closed" to "ground" position if the interlock is energized.

Interlock "B" is connected through an auxiliary switch on the Network Protector to the low voltage grid or separates power supply. When the protector is closed, this auxiliary switch is open and interlock coil de-energized. This interlock is arranged to lock when de-energized. Therefore, as long as the protector is closed the switch cannot be operated.

The interlock system requires a source of power independent of the associated transformer and at auxiliary contact on the protector. The schematic diagram shows one lead grounded and the other connected to the low voltage source for each interlock. In some cases both leads from each interlock are carried through and connected to the source.

The two-position Mag-Break switch schematic shown in Figure 6 uses only one interlock.

The interlock prevents movement from "closed" to "open" position while the LV breaker or Network Protector is closed.

This interlock system requires a source of power independent of the associated transformer and an auxiliary contract on the Network Protector.

The interlock is connected through the auxiliary switch on the protector to the low voltage grid or separate power supply. When the protector is closed, this auxiliary switch is open and interlock coil de-energized. This interlock is arranged to lock when de-energized. Therefore, as long as the protector is closed the switch cannot be operated.

The Deadbreak switch interlock schematic is shown in Figure 7.

This interlock system uses one electrical interlock. The interlock prevents movement of the switch from "closed" to "open" and from "closed" to "ground", unless the transformer is de-energized. One side of the interlock is connected to the secondary side of the transformer and the other to ground. The interlock is engaged when the transformer is energized.

Voltage required for the interlock coils will be found on the instruction nameplate furnished with the transformer.

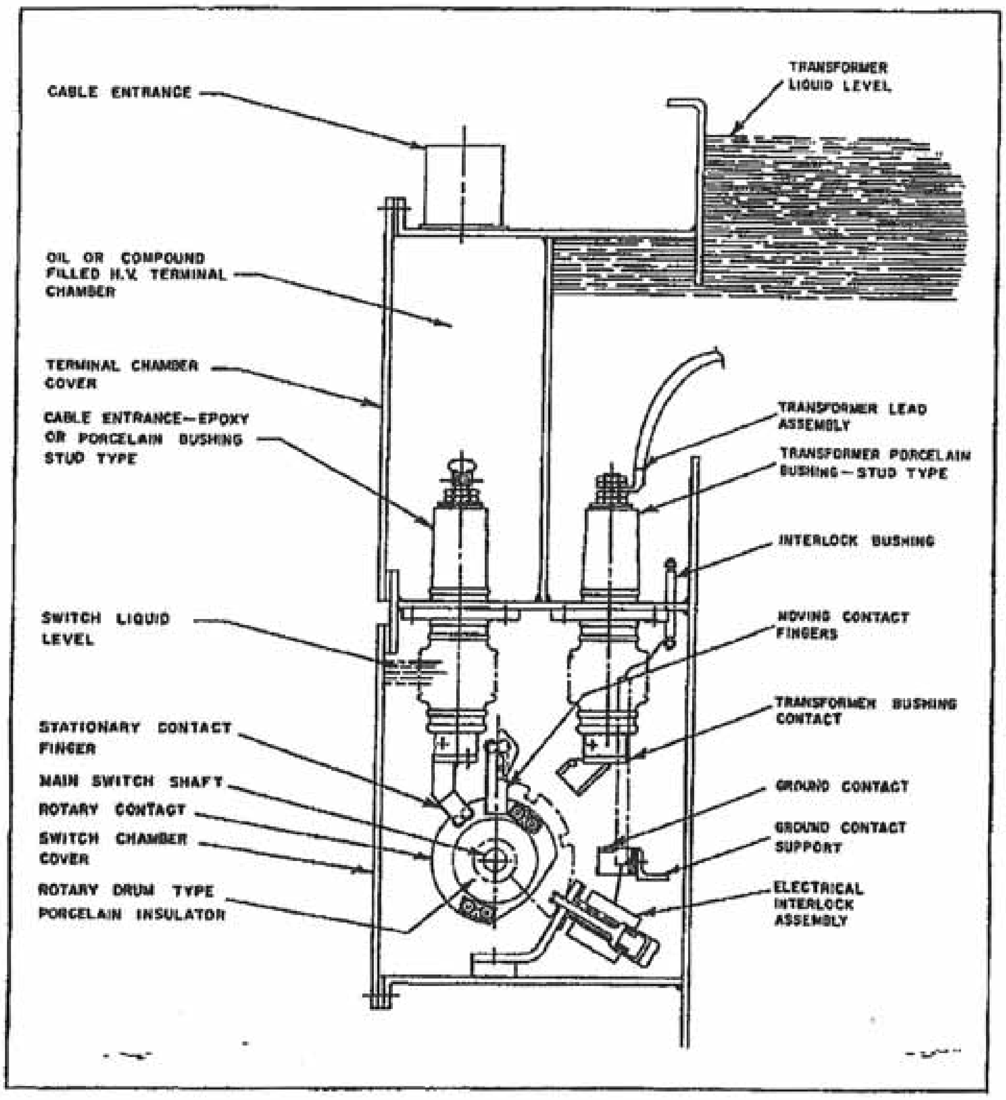


Fig. 4 Network *High Voltage Disconnect and Grounding Switch*

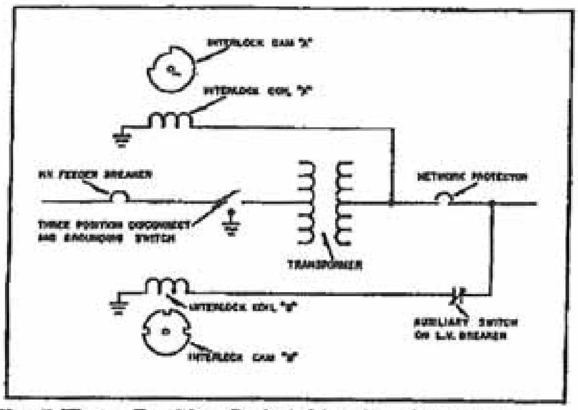


Fig. 5 *Three Position Switch Mag-Break Interlock Schematic*

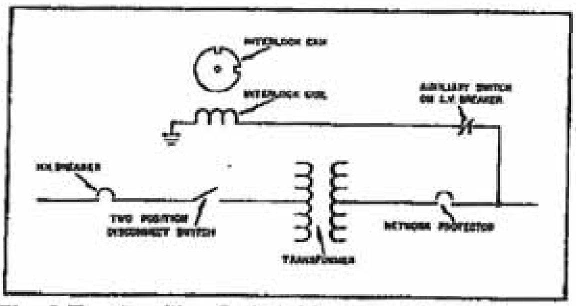


Fig. 6 *Two Position Switch Mag-Break Interlock Schematic*

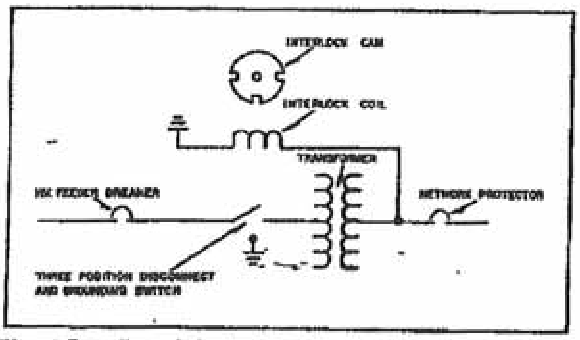


Fig. 7 *Deadbreak Interlock Schematic*

12. INSTALLATION

Before the transformer is installed, carefully examine the switch chamber for leaks. All switch chambers are tested at the factory. It is advisable to make a test at installation to make sure that no joints have opened during shipment. See "Pressure Test" in Part I, Section 6.4.1.

Operate the switch a few times to make sure that all parts move freely. The switch chamber is shipped filled with liquid unless otherwise requested and the cover is sealed in place. It is not necessary to open the switch chamber since all cables are terminated in the terminal chamber.

12.1 Terminal Chamber

The terminal chamber cover gasket is cemented to the chamber side only. Cement is not used on the other side of this gasket to facilitate removal of the cover.

The terminal chamber is usually shipped dry and must be filled with the proper insulating oil or compound (refer to nameplate) after making cable connections and replacing cover.

12.2 Cable Connections

Cable connections are made in the terminal chamber. The cable entrance to the terminal chamber is normally through either:

1) Wiping sleeves

2) Packing glands (stuffing boxes)

3) Potheads or terminators

The type cable used is the key to the kind of connection required. The cable dictates the stress cone used, entrance required and the type compound needed to fill the terminal chamber.

Caution: Refer to the cable manufacturer for stress relief cone requirements. Improper stress cone installation can cause cable failure.

12.3 Insulating Compound or Oil

When specified on the purchase orders, either compounds or oil can be supplied, otherwise the procurement is the user's responsibility. When compound is used, the selection of the proper compound for a particular installation depends on:

1) Cable type and kind of insulation

2) Operating temperatures and voltages

3) Cable system elevation differential (PILC cables only)

Caution: Check specifications on cable to make sure the compound to be used is compatible. Incorrect compound may cause cable failure.

The following instructions apply to preparation and pouring of compounds.

1) Consult compound characteristics for pouring temperature. The compound type or manufacturer's style number is also shown on transformer nameplate, if compound is supplied with transformer.

2) Always use a thermometer to assure proper pouring temperature. Voids may be formed if compound is not heated sufficiently. Compound that is heated too much may damage the insulation on the cable.

Caution: Voids contain trapped air that can lead to partial discharge problems and possible cable failure.

3) Warm the metal parts to at least 70°F (22°C) of the terminal chamber to drive off all moisture and wipe the bushings dry before replacing cover.

4) A filling plug is provided on top of the terminal chamber and a vent plug is located on the cover plate. Remove the filling plug and install a standpipe in its place. Remove the air vent plug.

5) Pour compound through the standpipe into the terminal chamber until it comes out the air vent hole.

6) Disconnect the standpipe and replace the filling and vent plugs.

12.4 Cable Insulation Test

The cable insulation can periodically be tested when connected to the switch bushing. Place the switch in the "open" position and test as follows:

Table 5 - Cable Test Values

Switch Rating	D-C Test Voltage	Time
15KV	45,000	5 min.
25KV	65,000	5 min.
35KV	85,000	5 min.

13. SWITCH ACCESSORIES

Switches, when specified, may be equipped with auxiliary devices that aid in the installation of the transformer and/or provides additional safety.

13.1 Tap Changer Mechanical Key Interlock

This manually operated interlock is designed to prevent operation of the tap changer unless the switch is in "open" or "ground" position.

13.2 Sequential Grounding Provisions

On the three-position disconnect and grounding switch, phasing out contacts may be provided, if specified on the order, so that one phase of the cable can be grounded at a time. Buttons are provided on the operating handle for this operation. Sequence of grounding may be either left to right or right to left.

Move the switch handle from "transformer" toward "ground" with the latch pins on the switch control set for phasing out cable.

Caution: High voltage cable must be de-energized. To ground an energized cable will cause catastrophic failure of the switch that may cause injury or death to those in the immediate area of the switch.

1. When pin marked A on the handle (See Figure 8) stops the movement, the contacts are engaged for phase A. Phases B and C are open-circuited. Check for circuit through phase A with test voltage, then tag.

2. Release pin A on the handle and move the switch handle until pin marked AB stops movement. The contacts are then engaged for phases A and B. Phase C is open-circuited. Check for a circuit through phase B with test voltage, then tag.

3. With the switch in "ground" position, all three contacts are fully engaged.

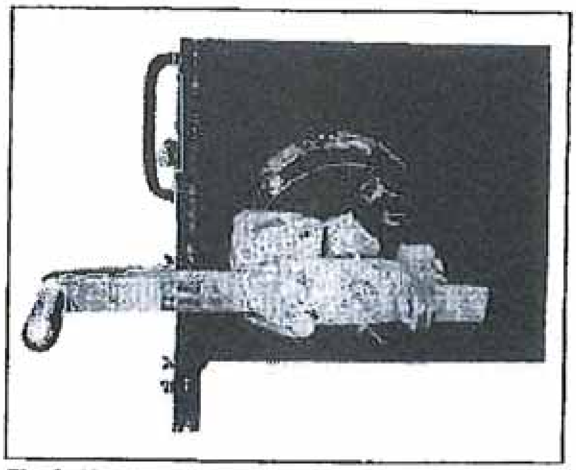


Fig. 8 *Network Switch Operating Handle*

13.3 Phasing Out Tubes

When specified on the order, phasing out tubes will be supplied to provide a means for phasing out the incoming feeder. The tubes are located on the switch cover and are angled such that when phasing probes are inserted through the tubes, the probes will come in contact with the live portion of the switch bushing. The phasing out tubes are sealed with either pipe plugs or pipe caps.

13.4 Primary Bushing

The location of the primary bushings can be seen in Figure 4. There are usually six stud type bushings provided with each network transformer. All six bushings are located in the switch chamber. Three of the bushings terminate in terminal chamber for the cable connections. The other three terminate in the transformer tank opening for the coil connections. These bushings have been carefully aligned at the factory with the switch mechanism to insure proper line connections and grounding of the incoming feeder lines. Generally, additional alignment adjustment of the bushings or contacts is not required. However, alignment inspections are recommended as part of the maintenance schedule. Refer to the maintenance schedule for inspection frequency.

When replacing the bushings is required, it will be necessary to remove the switch contacts located on the end of the bushing stud as well as the cable connected to it. Note the contact location as they are removed.

Remove the nuts from the mounting studs or remove mounting bolts and pull bushing directly down to break the gasket seal. Carefully remove any gasket material remaining on mounting surface.

Important: Replace bushing gasket before installing new bushing. Be sure to use a lock washer and cup washer on each bolt head or nut to insure locking.

When installing the new bushing, tighten all four nuts until the bottom of the flange is 0.13 inchs from the mounting surface. Then tighten one nut 1/2 turn. The opposite nut 1/2 turn and the remaining two nuts 1/2 turn. Repeat this procedure until bushing flange on all sides is .10 ± .01 from the mounting surface.

Caution: Failure to follow the above procedure may result in a broken flange on the cast epoxy resin bushing.

After the bushings are replaced, re-install the switch contacts as previously noted. Carefully aligning the contacts with the switch mechanism before tightening.

13.4.1 Special High Voltage Bushings

Occasionally, instead of the standard HV entrance, separable insulated connectors (Universal Bushing Wells) are mounted on the terminal compartment. In these cases the terminal chamber is filled with insulating liquid at the factory and need not be opened in the field. In making cable connections to these bushings, follow bushing manufacturer's recommendations for installation.

13.5 Quick-Break Mechanism

The quick-break mechanism furnished on Mag-Break switches normally will not require maintenance. The mechanism uses an auxiliary contact arm that maintains the circuit as the switch is moved from "transformer" toward the "open" position. When sufficient clearance between main blade and its contact has been obtained, the auxiliary contact arm opens the circuit by quick-break action regardless of the speed at which the operating handle is moved.

If a bushing of the quick-break arm is replaced, it should be adjusted so that all arms break or snap at the same time. This may be done by filing the end of the arm as necessary.

13.6 Electrical Interlock

The electrical interlock is of the spring-loaded type. The moving latch is equipped with an adjustable tension spring to adjust the pick-up and drop-out voltages of the interlock. This assembly is adjusted at the factory according to the following table:

Table 6 — Interlock Adjustment

Coil Rating	Adjustment: Maximum Pick-up Volts	Adjustment: Minimum Drop-out Volts
125V-60 Hertz	90 V	15V
277V-60 Hertz	200V	33V
460V-60 Hertz	240V	45V
125V-DC	65V	5V
250V-DC	125V	5V

Do not disturb this adjustment unless the interlock is dismantled. The interlock is located in the main switch chamber, to the rear and below the rotary bushing, see Figure 4. The tension spring adjustment can be varied using the screw attached to the spring and locked with two brass nuts.

14. MAINTENANCE

14.1 Maintenance Schedule

Make a periodic examination to keep the switch in good condition and to insure trouble-free operation. Listed below is a recommended maintenance schedule for the Network switch.

Table 7 — Recommended Maintenance Schedule

	Oil Switch		
	6 Mo.	1 Yr.	3 Yr.
Main Contacts and Alignment			X (2)
Auxiliary Contacts Alignment			X (2)
Shaft Packing Gland	X		
Interlock Pickup Voltages and Operation		X	
External Mechanical Interlocks	X		
Switch Operation		X (3)	
Quick-Break Latching Mechanical			X (2)
Case Liquid Leaks	X		
Internal Liquid Leaks		X (1)	X
Condition of Liquid (Color and Dielectric)		X	

(1) Two 1-year intervals followed by 3-year periods.
(2) Or check after every 200 operations.
(3) Operate switch at least once a year.

In addition to the above, all cover bolts should be tightened and the pushbuttons on the operating mechanism should be oiled with a fine grade light machine oil.

15. GASKETS

Refer to PART I Section 9.

16. LIQUID DIELECTRIC TESTS

The dielectric strength of the switch liquid should be checked on a regular basis same as the transformer. See the transformer section of this book for further instructions.

Ausgrid

Authority to Issue Recoverable Material to an ASP 1

Contestable Project Details

IAMS Project No.	SC01596	Region	East
Project Description	Establishment of chamber substation S.48445 'JONES BROADWAY'		
Location	UTS Broadway Building, Broadway, Ultimo		
Accredited Service Provider	Wilken Service		
ASP Contact	Taras Kowal	ASP Phone No.	0408690887

Note: ONLY NEW MATERIAL IS TO BE ISSUED ON CONTESTABLE PROJECTS

Ausgrid Equipment Details

Equipment Name	Equipment Number	Quantity	Description	Stock Code	Reservation No.
JONES BROADWAY	S.48445	3	1500kVA, 11000/4333 oil filled transformer	180359	6712067/1
		3	11kV Circuit Breaker Ring Main Lucy Sabre	178072	6712067/2
	Protection Material				
		3	Wall Mounted Protection Relay Panel - EF & OC	180123	6712067/3
		1	Wall Mounted Protection Relay Panel – Summated OC	70490	6712067/4
		9	100/5 HV Differential Current Transformer 10P25F20	89722	6712067/5
		3	K3M Differential Relay	91058	6712067/6
		9	3.85/2.89:4.0/2.0 Saturating Interposing Current Transf	57554	6712067/7
		4	Electromagnetic Relay: CDG33	62927	6712067/8
		1	2HS Multi Trip Relay	62182	6712067/10
	Customer Protection				
		2	Wall Mounted Protection Relay Panel - Customer -OC	180122	6712067/9
		2	Electromagnetic Relay: CDG33	62927	6712067/8
	EFI Material				
		1	Transformer Current 400/5 10P2.5F5	177474	6712067/11
		1	Relay Electromagnetic EFI3 5amp Earth	61853	6712067/12
		1	RH Steel Earth Fault Indicator Bracket	128025	6712067/13
	Miscellaneous Material				
		6	Saifway Padlock Device – PDO	178338	6712067/14
		3	400amp 92mm centres Bell / MEM "J"	85738	6712067/15
		2	Z3 Abloy Cylinder Lock – Oval – (doors)	To be provided by Project Officer Below	
			Refer to ES10 Appendix H – for reimbursement of LV Panel component(s) procedure		

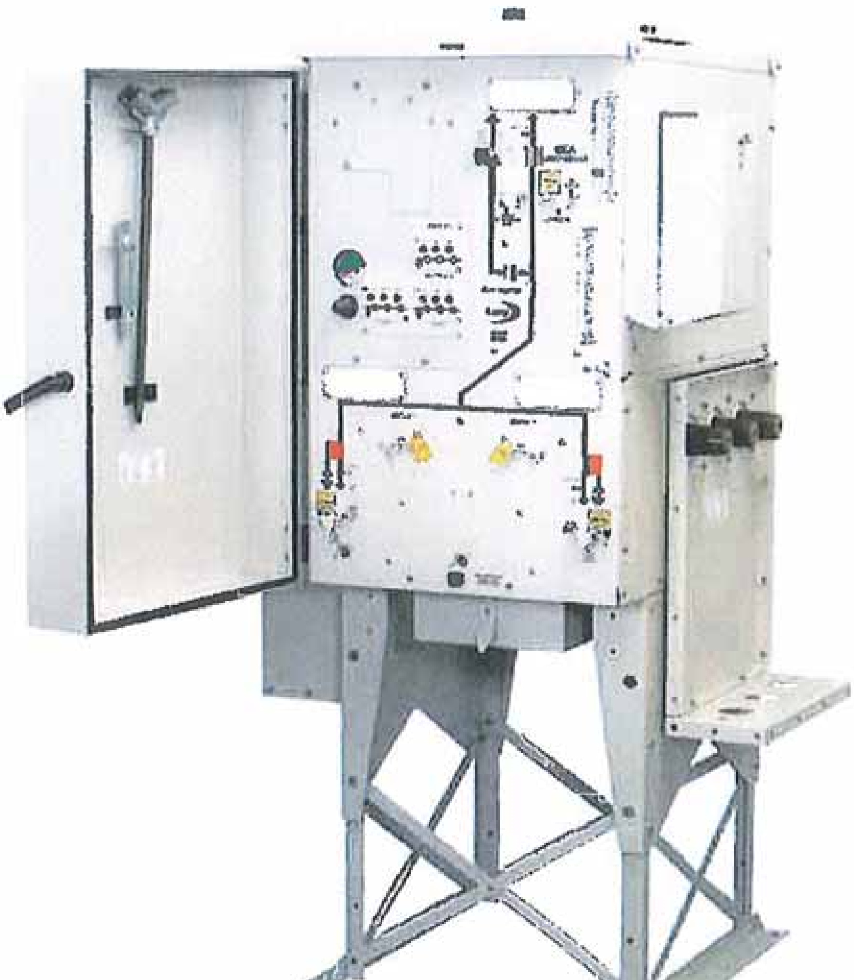
Please contact the Manager – Ausgrid Procurement Customer Service on telephone (02) 9394 6001 to arrange release of this material. This document must be presented as an authority to collect the material.

Office Use Only

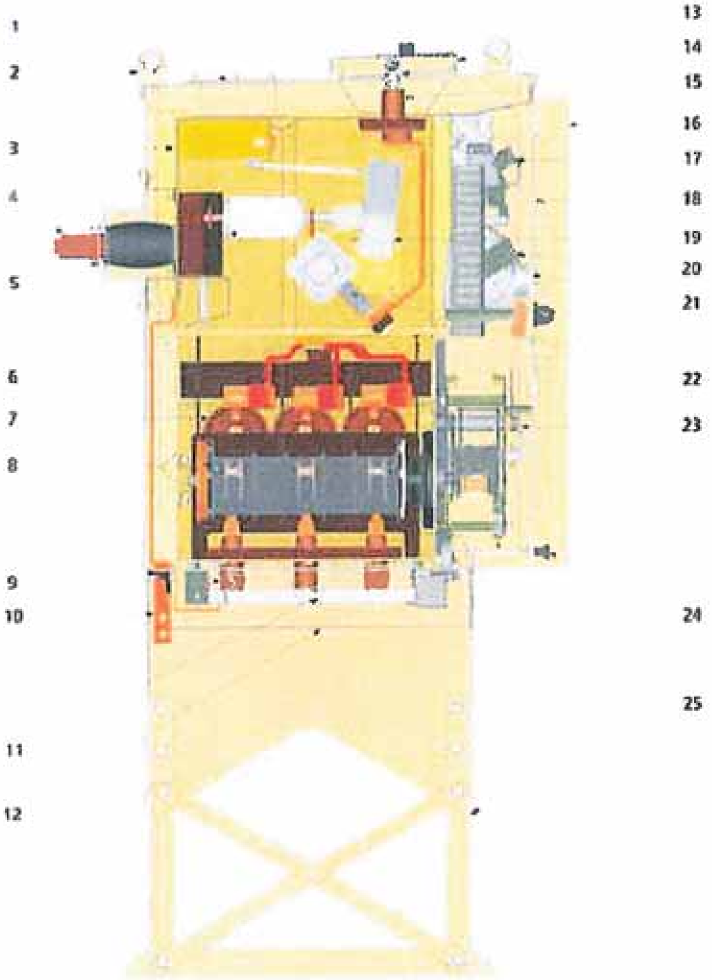
Submitted by	David Tomlin Project Officer	Ph. 02 9585 5823	Fax 02 9585 5797	
Verified by	Ashwin Prasad Manager Contestability - South	Signature		DATE 4.10.2012
Evidence of project expenditure approval may be found on the signed approved *Capital Works Authority* form for this project.				
Send copy of Free Issue Authority Form to :- Scott McKinnon – email smckinnon@ausgrid.com.au Facsimile (02) 93946060 Aaron Forster – email aforster@ausgrid.com.au				

SABRE VRN6a SF6 RMU

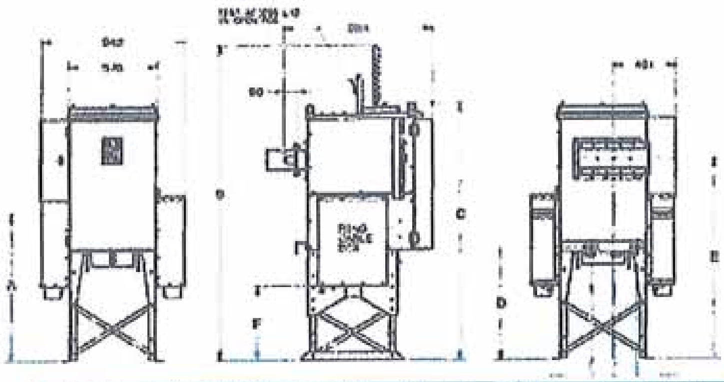
Automated distribution solutions - towards smarter electrical networks



ENGINEERING BRILLIANT SOLUTIONS



1 Internal arc vent
2 Lifting lugs
3 Stainless steel enclosure
4 Tee-off cable terminations
5 Protection CT's
6 Interrupters
7 Ring switch cable termination
8 Three-position ring switch
9 Ring cable test terminals
10 Primary earth point
11 Removable and fully interlocked ring switch star point earth bar
12 Ring switch test access cover
13 Cable test access cover
14 Removable and fully interlocked star point earth
15 Cable test termination
16 Main access door
17 Operation
18 Fascia and mimic
19 Drive beam
20 Disconnector operation
21 Pressure gauge
22 Disconnector
23 Operating mechanism for ring/earth switch
24 Ring switch test access cover release
25 Height adjustable legs - 3 positions



Leg Height	Dim A	Dim B	Dim C	Dim D	Dim E	Dim F (1)	Dim F (2)
Position 1	1052	2163	1773	817	1402	600	480
Position 2	970	2081	1691	715	1320	518	398
Position 3	750	1881	1471	515	1100	298	176

All measurements are in mm

Lucy Switchgear

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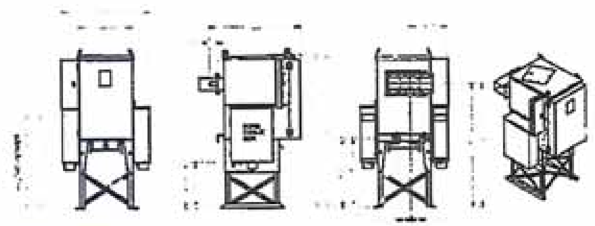
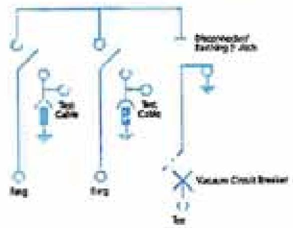
SABRE VRN2a

SABRE VRN2a Dimensions



Bracketed dimensions are alternative lower height
Dimensions in millimetres

SABRE VRN2a Schematic line diagram



Technical data

(ratings in brackets are optional)

[illegible]	[illegible]
[illegible]	12kV (15.5kV)
[illegible]	95kV (95kV)
[illegible]	
Ring Switches	250A
Tee-Off Circuit Breaker	250A
[illegible]	
Ring Switches	[illegible]
Tee-Off Circuit Breaker	[illegible]
[illegible]	
Tee-Off Circuit Breaker	[illegible]
[illegible]	
Ring Switches	[illegible]
Tee-Off Circuit Breaker	[illegible]
[illegible]	
Ring Switches	[illegible]
Tee-Off Circuit Breaker	[illegible]
[illegible]	
Freestanding	[illegible]
Transformer Mounted	[illegible]
[illegible]	
Standard	[illegible]
[illegible]	
Min Operating Pressure	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
BS EN 62271-1	•
BS EN 60129	•
BS EN 60694	•
BS EN 60298	•
IEC 60054	•
ENA TS 41-36	•
IEC 62271-100	•
IEC 62271-100	•
IEC 62271-102	•

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Lucy Asia Pacific Sdn Bhd
[illegible]

Lucy Switchgear Arabia Co. Ltd.
[illegible]

Lucy Electric (Beijing) Co. Ltd.
[illegible]

Lucy Switchgear (South Africa)
[illegible]

Lucy Switchgear

www.lucyswitchgear.com

Design

The Sabre VRN2a is a compact SF6 insulated Vacuum Ring Main Unit (RMU). The unit can be mounted to the smallest distribution transformer or be sited in a free standing format. Designed to be used both indoors and outdoors, the unit has a long service life and requires virtually zero maintenance.

Key features

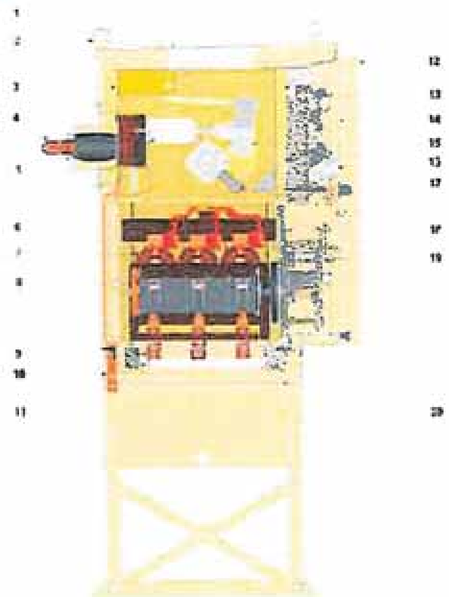
- Compact Design
- 12kV and 13.8kV
- Indoor / Outdoor application
- Mimic Diagram
- Vacuum tee off circuit breaker
- Enhanced duty, in excess of IEC requirements
- Pre-wired for motor actuation
- Fault passage indicators
- Common switching chamber
- Full ratings with zero atmospheric pressure
- Isolation in clean SF6 gas

Options

Protection
All options provide transformer over current protection for phase to phase faults. Earth protection covering phase to earth faults is also available if required.

Cable Boxes
Internal arc test cable boxes are available with IEC and ENA specifications. Interlocked cable boxes are also provided as options.

Automation
The Sabre VRN2a can be pre-wired for automation. Single or double rotary actuators can be easily and rapidly fitted on site whilst the unit is in service – no access is required to the internal workings of the RMU.



1. Internal arc vent
2. Lifting lugs
3. Sealed tank
4. Tee-off cable terminations
5. Protection CTs
6. Circuit breaker vacuum interrupters
7. Ring switch cable termination
8. Three-position ring switch
9. Ring cable test terminals
10. Primary earth point
11. Removable and fully interlocked ring switch point earth
12. Access door
13. Circuit breaker operation
14. Fascia and mimic
15. Vacuum interrupter drive base
16. Two-position disconnector operation
17. Pressure gauge
18. Two-position disconnector
19. Operating mechanism for ring/earth switch
20. Test access cover

DESIGN

The Sabre VRN2a is a non-extensible RMU comprising of a Tee-off vacuum circuit breaker and two fault-make load break ring switches contained within a common SF6 gas insulated stainless steel enclosure. The unit is suitable for both indoor and outdoor applications and can be used either as a freestanding unit or for mounting to a transformer, complying with ENATS 35-1.

Stainless Steel Gas Enclosure
The gas enclosure is manufactured from stainless steel and fabricated utilising automatic "robot welding" techniques to produce consistent leak-free equipment.

Housing
The housing of the Sabre VRN2a is fully treated, using zinc coated steel and electrostatically applied oven cured paint, to resist weather and pollution attacks. All units are provided with a hinged, weatherproof and lockable door. The external support legs can provide a Tee-Off bushing height of 1400mm, 1320mm and 1100mm.

Tee-Off Circuit Breaker
The tee-off circuit breaker comprises of three vacuum interrupters, which have a fault-make, fault-break rating. Opening of the circuit breaker is achieved by manually operating the handle as standard.

Earthing of the outgoing cable, from the Tee-off circuit breaker, is achieved by the use of the circuit breaker and in series with the off-load disconnector/selector switch.

Ring Switches
The two ring switches are of the single break, fault-make / load-break 3 position types, 'ON', 'OFF' and 'EARTH'.

Operation
All operating positions and instructions are indicated on the main panel at the front of the unit. Operation is by means of manually independent mechanisms, which are mounted externally to the gas enclosure.

The Tee-off vacuum circuit breaker has two operating positions, 'ON' or 'OFF', with an off-load, interlocked selector allowing isolation & earthing of the Tee-off circuit.

A single, "T"-bar type operating handle is stored at the front door. Symbols located on the end of the operating handle indicate direction of operation.

Test Facilities
Fully interlocked test facilities are provided in accordance with ENATS 41-36 requirements. Access to the test terminals is obtained by pulling a lever located on the front fascia inside the front door. This will allow the cover underneath the unit to drop down. Where cable test facilities are required on the Tee-off, an alternative interlocked system, using plug-in connectors, is available. The Sabre VRN2a has integral ring switch cable test facilities.

Interlocks
Positive safety interlocks are incorporated on all switch positions to prevent mal-operation.

Padlocks
All switch and selector positions can be padlocked.

Transformer Protection
The circuit breaker enables the VRN2a to protect transformers with ratings well in excess of those with a comparable HV fused unit. Protection is achieved by the use of ring core current transformers in combination with Time Lag Fuse links or a protection relay. The ring core current transformers are mounted around the rear tee-off bushings, external to the SF6 chamber, but within the cladding of the unit. The Time Lag Fuses, or the protection relay, are mounted behind a cover at the front of the unit.

Lucy Switchgear

Sabre Extensibles

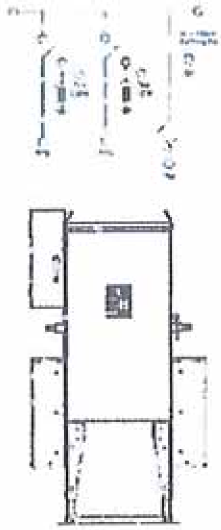
ENGINEERING BRILLIANT SOLUTIONS

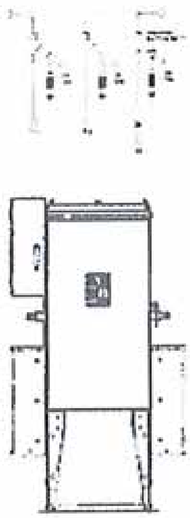
Sabre Range

	VRE2a	VRE6a	VCE2a	VCE6a	SSE6a
Rated Voltage	12kV (15.5kV)	12kV (15.5kV)	12kV (15.5kV)	12kV (15.5kV)	12kV (15.5kV)
Impulse Withstand Voltage (kV Peak)	75kV (95kV)	75kV (95kV)	75kV (95kV)	75kV (95kV)	75kV (95kV)
Normal Current					
Ring Switches	630A	630A	n/a	n/a	630A
Circuit Breaker	250A	630A	250A	630A	n/a
Busbar	630A	630A	630A	630A	630A
Short Circuit Peak Making Current					
Ring Switches	50kA	50kA	n/a	n/a	50kA
Tee-off Circuit Breaker	50kA	50kA	50kA	50kA	n/a
Short Circuit Breaking Current					
Tee-off Circuit Breaker	20kA RMS	20kA RMS	20kA RMS	20kA RMS	n/a
3 Second Short Time Current					
Ring Switches	20kA	20kA	n/a	n/a	20kA
Tee-off Circuit Breaker	20kA	20kA	20kA	20kA	n/a
Earth Switch Peak Making Current					
Ring Switches	50kA	50kA	n/a	n/a	50kA
Tee-off Circuit Breaker	7.9kA	50kA	7.9kA	50kA	n/a
Internal Arc Rating					
Freestanding	20kA 1 sec	20kA 1 sec	20kA 1 sec	20kA 1 sec	20kA 1 sec
Transformer Mounted	n/a	n/a	20kA 1 sec in ENA Housing	n/a	n/a
Gas Pressure					
MOP	zero bar (G)	zero bar (G)	zero bar (G)	zero bar (G)	zero bar (G)
IP Rating					
Up to IP54W	Up to IP54W	Up to IP54W	Up to IP54W	Up to IP54W	Up to IP54W
Dimensions					
Height (mm)	1715	1715	1715	1715	1360
Width (mm)	950	950	565 + busbar	565 + busbar	515 + busbar
Depth (mm)	1080	1080	1080	1080	1065
Weight (kg)	375	385	290	300	230
Weight of SF6 (kg)	1.78	1.91	1.05	1.05	0.76
Protection					
TLF – Time Limit Fuse	•	•	•		
Auxiliary Powered Relay	•	•	•	•	
Self Powered Relay	•	•	•	•	
Testing Standards Applicable					
IEC 62271-103	•	•	•	•	•
IEC 62271-100	•	•	•	•	•
IEC 62271-102	•	•	•	•	•
IEC 60056	•	•	•	•	•
IEC 60265-1	•	•	•	•	•
IEC 60129	•	•	•	•	•
IEC 60694	•	•	•	•	•
IEC 60298	•	•	•	•	•
ENA TS 41-36	•	•	•	•	•
IEC 62271-200	•	•	•	•	•

DSE6a	DSN6a
12kV (15.5kV)	12kV (15.5kV)
75kV (95kV)	75kV (95kV)
630A	630A
n/a	n/a
630A	630A
50kA	50kA
n/a	n/a
n/a	n/a
20kA	20kA
n/a	n/a
50kA	50kA
n/a	n/a
20kA 1 sec	20kA 1 sec
n/a	n/a
zero bar (G)	zero bar (G)
Up to IP54W	Up to IP54W
1260	1260
565 + busbar	565 + busbar
825	825
270	260
0.98	0.98
•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•

Extensible Range


VRE2a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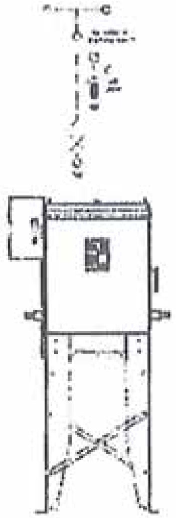
VCE2a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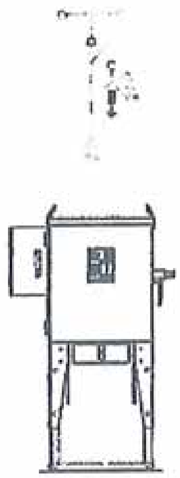
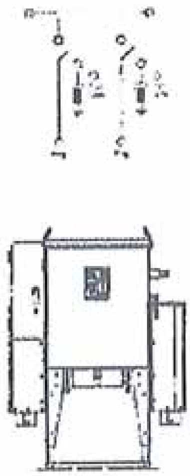
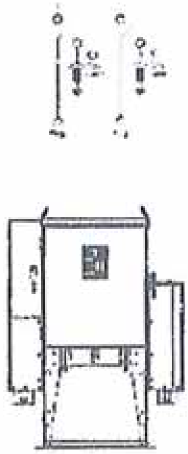
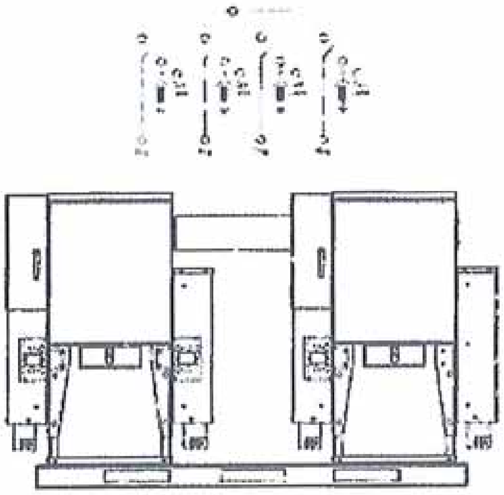
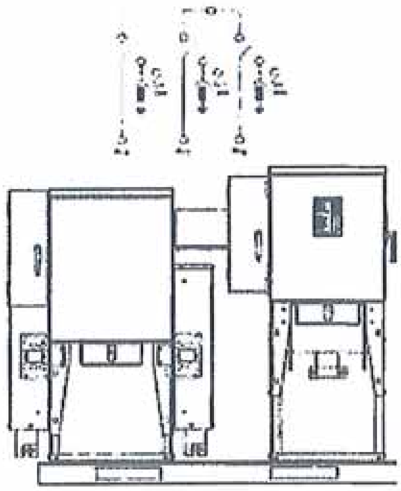

SSE6a


DSE6a

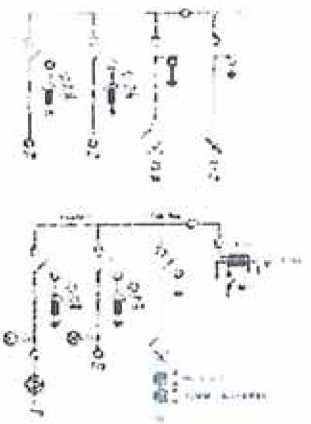

DSN6a

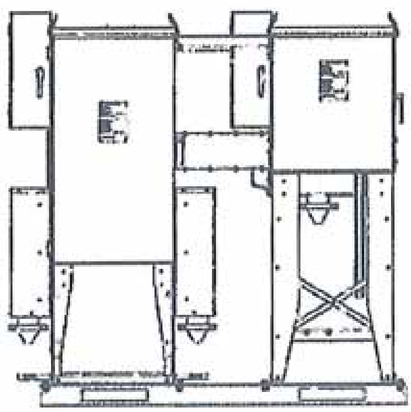


DSEa - DSEa Combo Unit

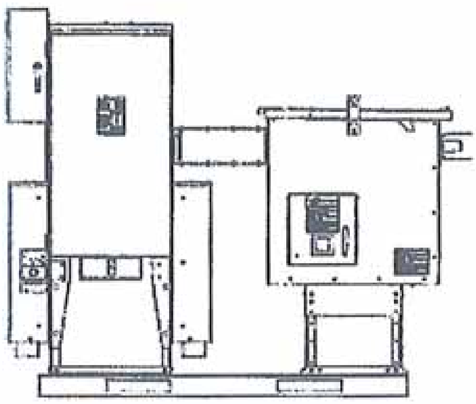


DSEa - SSEa Combo Unit





VREa - VCEa Combo Unit



VRE2a - AMU Combo Unit

Lucy Switchgear

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Ausgrid
Chamber Substation indoor switchgear

installation,operation and maintenance instructions
version 1.6 / February 2009

Schneider Electric

Details of revision

Version	Comment	Date
1.0	First Draft Issue	May 2006
1.1	Includes comments and corrections from customer	July 2006
1.2	Includes additional comments from customer	August 2006
1.3	Information on securing SA Neutral earthing cable added	August 2006
1.4	Design changes incorporated	April 2007
1.5	AG Comments	August 2007
1.6	Details of Busway Chamber added	February 2009

contents

General description

Introduction

These instructions cover all operations concerning handling, installation, operation and maintenance of the Chamber Substation panels for Ausgrid.

The range comprises:-

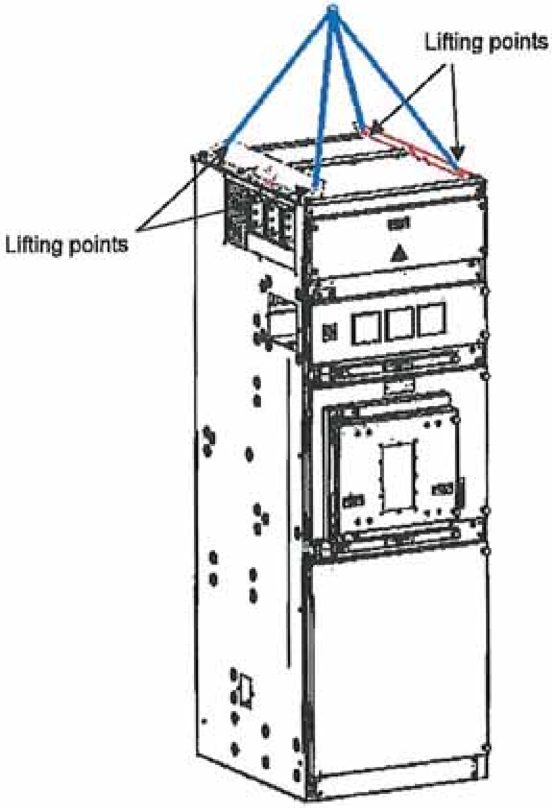
- 3000A Incoming Type 1 & 2
- 2000A Incoming Type 1 & 2
- 3000A Bus-section
- 3000A Customer supply – switch – cable Types 1 & 2
- 3000A Customer supply – circuit breaker – cable Types 1 & 2
- 3000A Customer supply – switch – busbar Types 1 & 2
- 3000A Customer supply – circuit breaker – busbar Types 1 & 2
- 3000A Customer supply – link – busbar
- 1600A distributor panel
- Fused distributor panel

Weights and dimensions

unit(s)	**Standard** W x H x D	**Fused distributor** W x H x D	**Bus-section** W x H x D
average dimensions (mm)	**650 x 1943 x 779**	**650 x 1943 x 779**	**950 x 1943 x 779**
With busbar ventilation chamber fitted	650 x 2243 x 779	650 x 2243 x 779	950 x 2243 x 779
average weight (kg) (packed)	650	430	890
Maximum weight (kg)* (packed)	720	450	910

** Maximum weight includes for a single freestanding unit that includes all available options.*

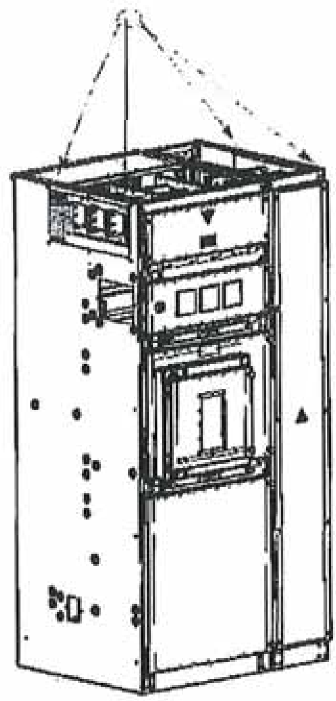
Lifting Instructions



Note: Lifting Chains/ropes should be positioned at 500mm from the lifting points as shown.

Important: during the lifting operation, all four lifting points must be used.

Maximum mass = 720kg



Note: Lifting Chains/ropes should be positioned at 700mm from the lifting points as shown.

Important: during the lifting operation, all four lifting points must be used.

Maximum mass = 910kg

Storage	The equipment is suitable for indoor use only. It is therefore necessary to protect the equipment from the environment before and during erection/commissioning. Should the busbar chamber or cable box become exposed to the elements, they should be thoroughly cleaned prior to energising.
Offloading	All units are offloaded using the lifting lugs that are fitted to the units as standard and should be offloaded using an overhead crane (see diagrams on previous page.).
Storage	These units are designed for indoor use only and must not be left outdoors. They should be stored in a warm, dry switchroom and protected against dust and debris.
Ancillary kits	The ancillary kits (cubicle jointing kit, cubicle end plate kit) are either supplied loose with each unit, fastened to the panel, or secured in the cable box.

Installation

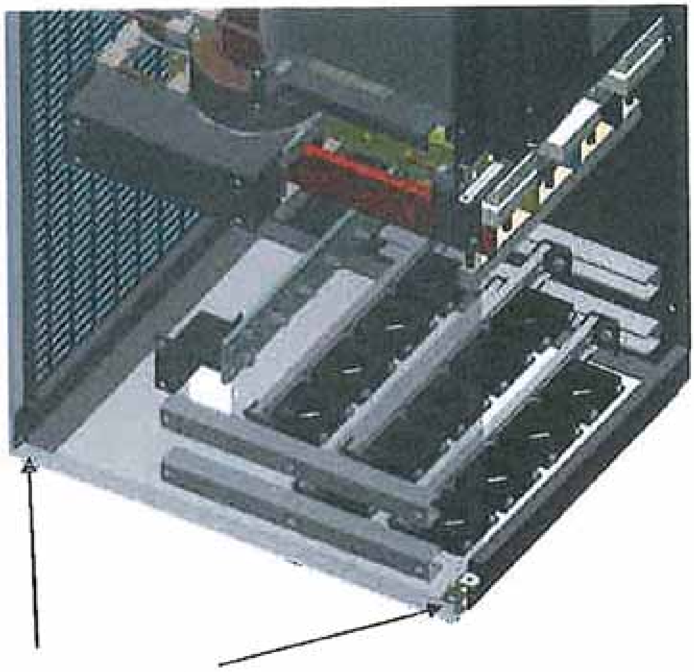
Installation of panels

Panels are to be installed on supporting steel beams over a concrete pit, in accordance with the requirements of Ausgrid Network Standards:
NS 114 for 11kV, or
NS 229 for 33kV.

The supporting beam tolerance is ±1mm over 1 metre.

Line up the first panel in position and attach to supporting beams using M12 bolts, drilling through the supporting beams through the fixing holes at the front and rear of the unit. Finger tighten the bolts (do not over-tighten). Manoeuvre the next panel into position and repeat.

All fixing bolts should be tightened once all panels are in place.



Fixing holes are in each corner of units

Removal of lifting lugs

The lifting lugs are removed by undoing the 4 x M12 bolts in the corners of the unit. The lifting lugs can then be removed

The front top cover should then be removed and saved for later fitting as part of the ventilation chamber.

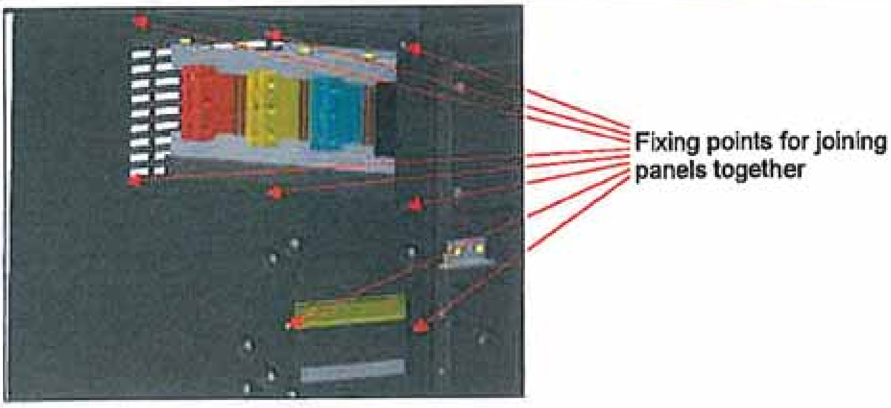
The rear top cover should remain in place. The rear M12 bolts should then be refitted to ensure the internal arc rating is maintained.

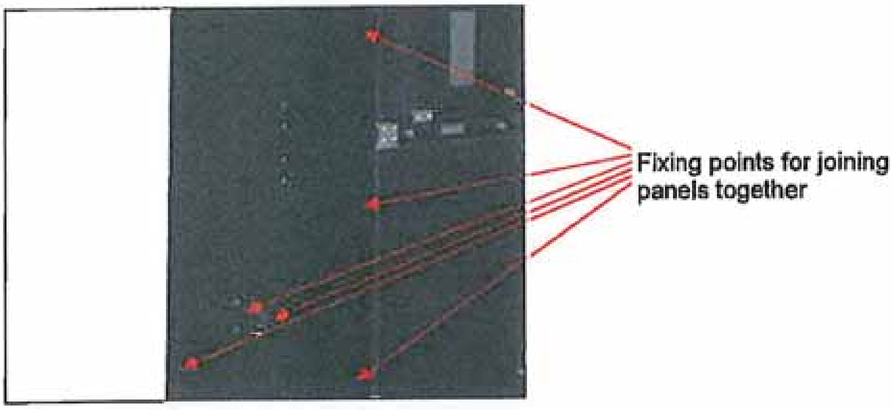
Connection of panels

There are 14 holes designed in to each side panel to join the units together. It is important to maintain the internal arc rating of the equipment that each fixing point is used. Not using a fixing point my result in a failure of the internal arc protection in the event of a failure.

To join panels together a fixing kit EEAJK1 should be used. Each fixing kit provides sufficient loose fixing to join panels together and to interconnect the busbars. When joining panel on to the left-hand side of a bus-section the fixing kit EEAJK1 is not required as each bus-section comes with it own special kit for this joint. However these instructions should still be followed to join the panels together.

The locations of the holes are shown in the following photographs. Access to the fixing holes can be achieved by opening the front doors of the panels.

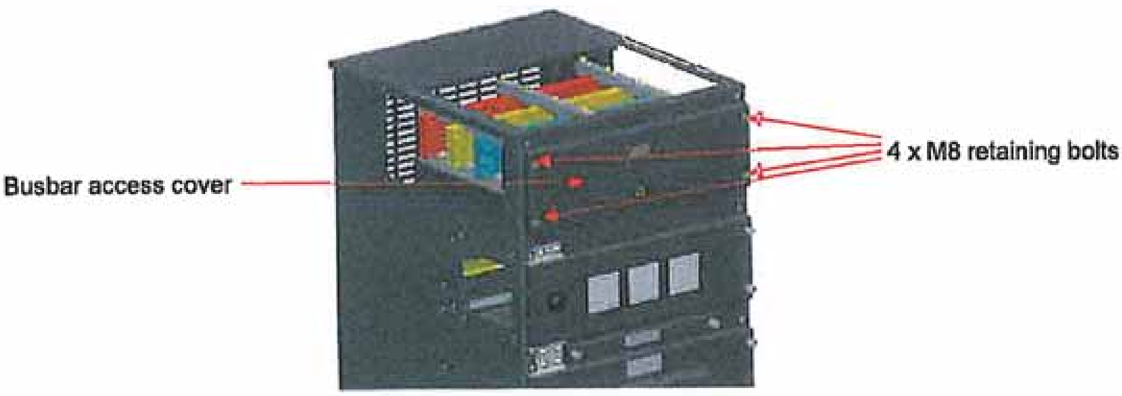




Fitting of main busbars

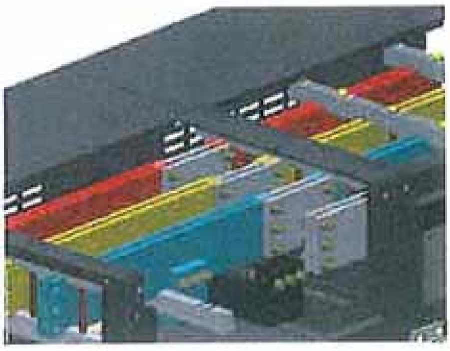
The busbars between panels should be joined together before the ventilation roof is fitted to ease access to the busbars.

The busbar access panel is removed by undoing the 4 x M8 retaining bolts and then removing the cover.

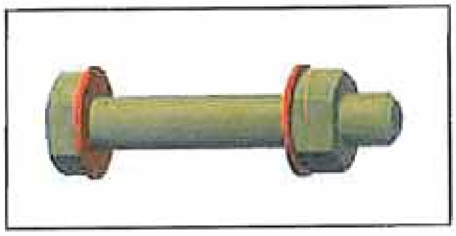


The busbar supports should then be loosen but <u>not</u> removed to ease the fitting of the busbar joints. This is done by loosening the 5 nuts on top of each busbar support.

The busbar links and nuts and bolts required can be found as part of kit EEAJK1



The links should be fitted as shown (towards the front) to each busbar in turn starting with the busbar farthest from the front. The M10 x 60 bolts should be fitted with the head towards the front of the panel. Each bolt head and nut should have a belville washer fitted as shown bellow.



The bolts should be tightened using a torque wrench to 46Nm to ensure a good electrical connection.

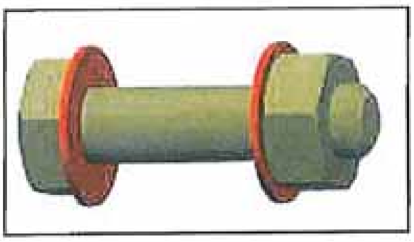
The busbar access panel is re-fitted by reversing the process used to remove it.

Fitting of Earth bar

The earth bar can be fitted by gaining access through the cable termination chamber. The earth link and nuts and bolts required can be found as part of kit EEAJK1.

The earth bar is located at the bottom of each panel. All panels should have the earth bars connected together.

The earth links should be fitted as shown (towards the front) to earth bar. The M10 x 40 bolts should be fitted with the head towards the front of the panel. Each bolt head and nut should have a belville washer fitted as shown bellow.



The bolts should be tightened using a torque wrench to 46Nm to ensure a good electrical connection.

Main cable connection

All units are fitted with dry type cable connections suitable for accepting a cable lug type termination.

The bolt fitting the cable lug to the termination should be tightened using a torque wrench to torque 75Nm

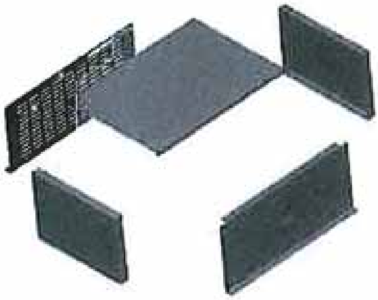
Ensure that the cable clamp supports the cable before tightening the cable lug to the cable termination. This will ensure that not all of the weight of the cable is taken be the circuit breaker chassis.

note:

1. *On incomer panels, Customer Disconnect panels and 1600A fused Distributor panels the Red (L1) phase bushing is on front left of the unit.*
2. *On Fused Distributor panels the phases are arranged Red (L1) left rear, White (L2) right rear and Blue (L3) front middle.*

Fitting of Busbar Ventilation Roof

The Busbar Ventilation top cover is supplied already fitted to the unit, this will have been removed while removing the lifting lugs and should not be used.



The Busbar Ventilation roof is supplied un-assembled. The ventilation roof comprises of two sides, a front panel, a rear-ventilated panel and a roof.

The components, including all the M12 bolts, M8 bolts, earthing washers, c form washers and spring washers, required to assemble the roof are supplied as part of the main panel.

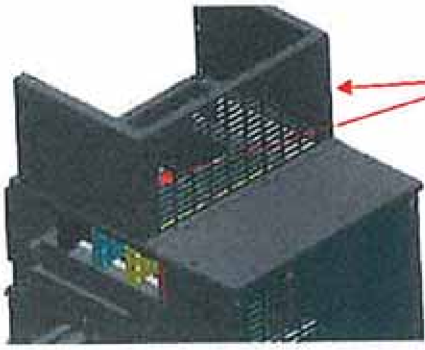
The sides should be fitted first ensuring that the earthing washer is fitted.

Earthing washer should be fitted here

Procedure should be repeated for other side.

The rear-ventilated panel should then be fitted, earthing washers should be used in two locations, one per bolt.

The front cover should also be fitted with earthing washers is a similar location.

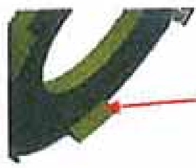


Earthing washers should be fitted here

The roof should then be fitted. Two earthing washers should also be fitted.

Earthing washers should be fitted here

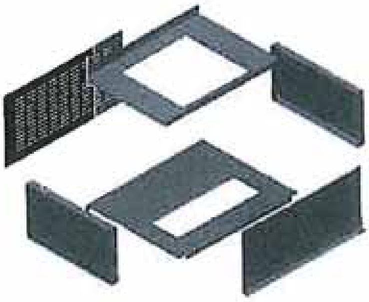
note:
When fitting Earthing Washers they should be fitted with the serrated edge to the panel to ensure they are able to make a good electrical connection.



Serrated edge of Earthing washer

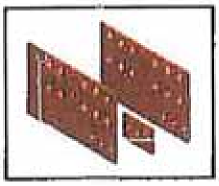
Fitting of Busway Top Chamber

The Outgoing Busway Top Chamber is supplied un-assembled. The Busway Top Chamber comprises of two sides, a front panel, a rear-ventilated panel, a top cover, a bottom plate and the copper connections.

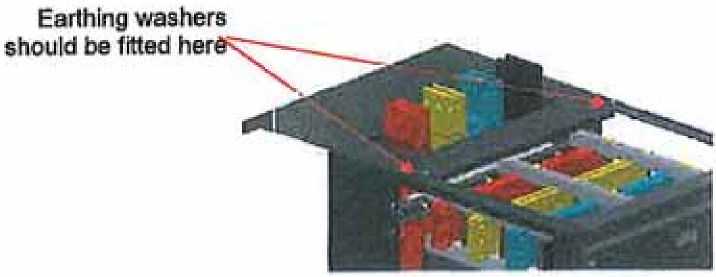


The components, including all the M12 bolts, M8 bolts, earthing washers, c form washers and spring washers, required to assemble the roof are supplied as part of the main panel.

The bottom plate should be fitted first ensuring that the earthing washer is fitted.

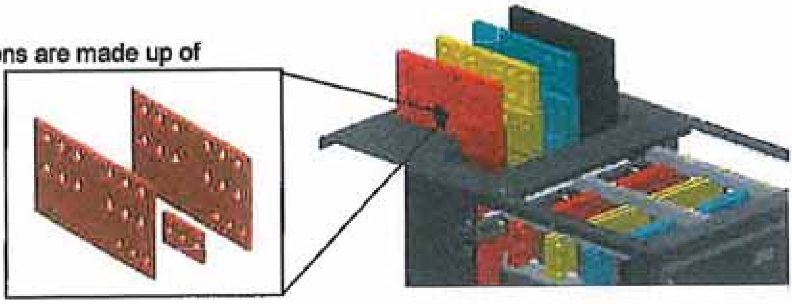


X 4

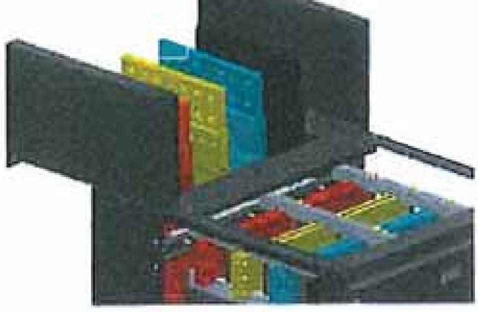


The copper connection should then be fitted before the sides to allow full access to the connections.

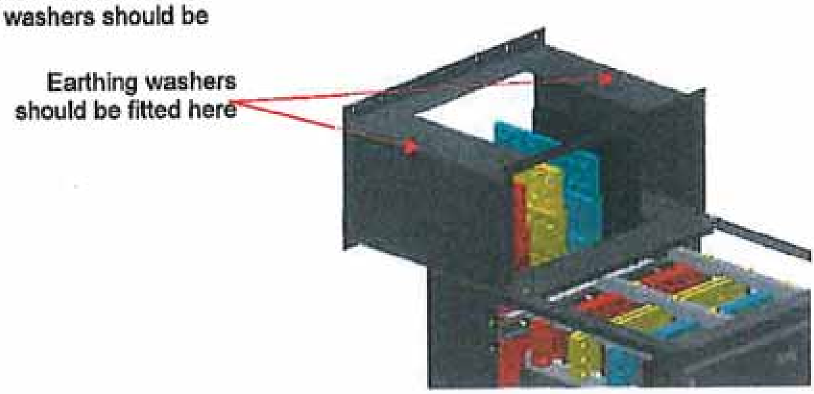
The copper connections are made up of three individual components. All three should be fitted to all phases and neutral.



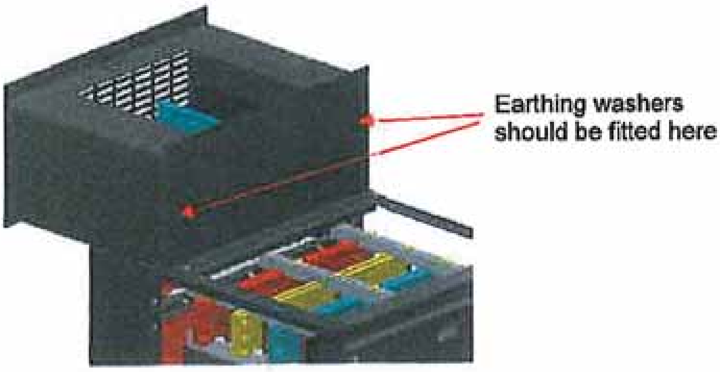
The sides to the chamber should then be fitted ensuring that the earthing washes are fitted.



The top chamber cover should then be fitted. Two earthing washers should be fitted,

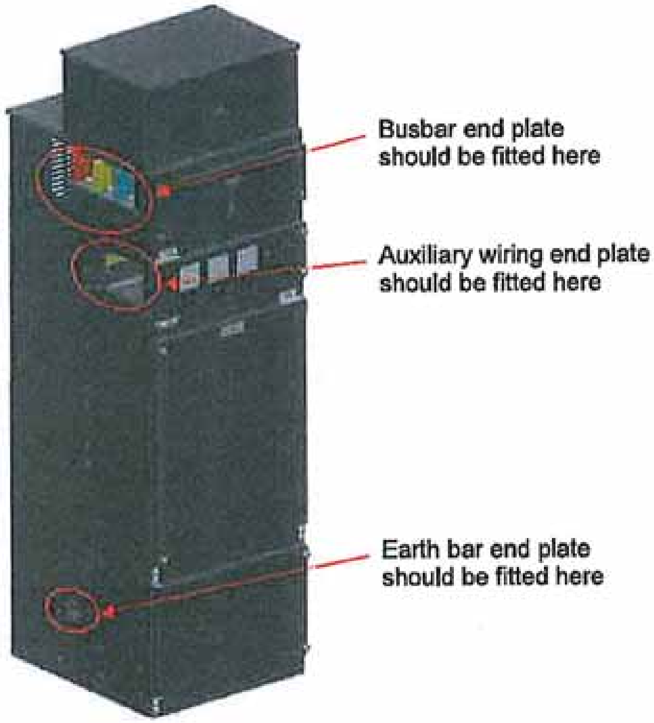


The front and rear-ventilated panel should then be fitted, earthing washers should be used in two locations, one per bolt.



Fitting of End Plates

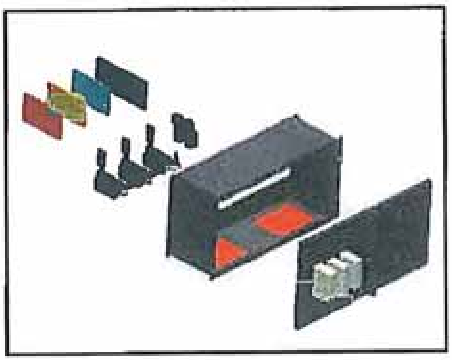
The end plates should be fitted to the panels that are on either end of the substation. There are three end plates to be fitted, one for the busbar aperture, one for the earth bar aperture and one for the auxiliary wiring aperture. The busbar endplate is made up of two parts, the polycarbonate plate should be sandwiched between the panel and the steel plate on the outside. The polycarbonate end plate must be fitted to ensure the internal arc rating of the panel is maintained.



All M8 bolts, washers, spring washers and nuts required are provided as part of the EEAEP1 kit. When fixing the Busbar endplate, the Earth bar endplate and the auxiliary end plate one of the fixing used should be fitted with earthing washers on both the inside of the panel and on the outside of the endplate.

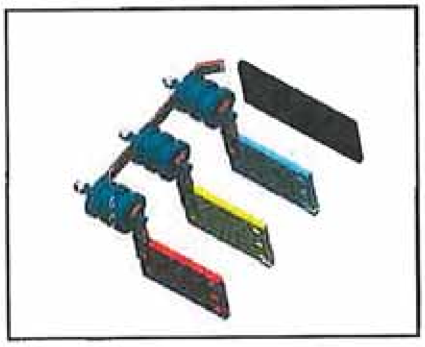
Fitting of Surge arrester end panel

The surge arrester end panel can be fitted to either the left hand or right hand side. The end panel kit (EEAABB) is supplied normal built to be fitted to the right hand side and will need to be re-assembled if it is required to fit the unit to the left hand side. The surge arresters are supplied as a part of the EEAABB kit.



To fit the surge arrester panel the cover first need to be removed. This is done by removing the 10 x M8 bolts. If the surge arrester needs to be fitted to the left hand side then the fuse fittings should be removed and refitted the opposite way up.

The busbar extensions should then be fitted using the M10 x 60mm bolts fitted in the same way as the busbar jointing kit is fitted (see page 8) and tighten using a torque wrench to a torque of 46Nm.

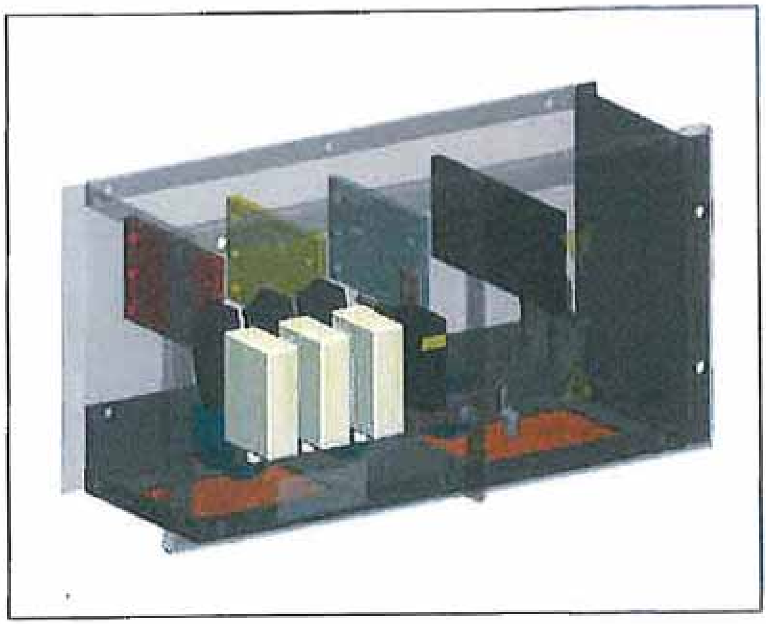


Once main housing for the surge arresters should then be fitted to the panel using the 6 x M8 bolts provided.

The surge arrester should then be fitted as shown in the picture using cable to connect the surge arresters to the relevant busbar extension.

The panel covers then need to be refitted, as the panel with the fuses is fitted the cable from the fuses should also be fitted to the relevent busbar extension so as to give the correct phase indication.

A semitransparent model of the surge arrester panel is shown so as to indicate were to fit the cable lugs to allow for correct operation.



The cable from the neutral to the substation earth should be run down the out side of the panel that the Surge arrester panel has been fitted to. To secure the cable, cleats should be used to fasten the cable to the side of the unit using the fixing points normally used for securing two units next to each other.

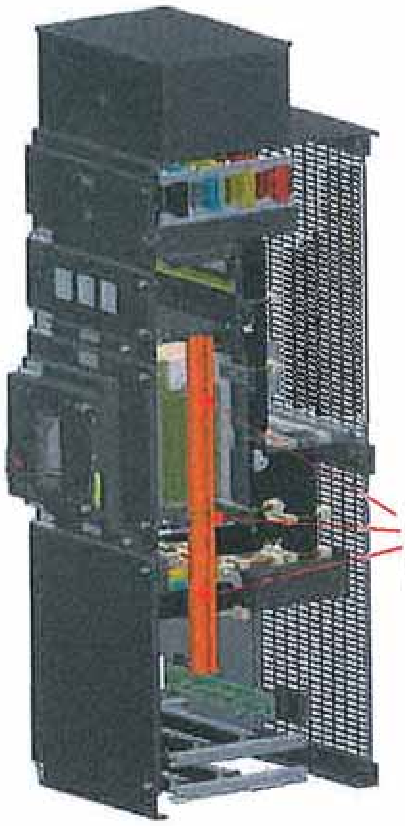
note:
The panel shown is a fused distributor, other panels types have the same fixing points.

Auxiliary wiring ducts

Two cable ducts are provided on all panels except the bus-section panels. There is a cable duct on each side of the panels that allows auxiliary wiring to be routed from the cable box to the auxiliary wiring panel.

Auxiliary wiring for bus-sections should be routed through the panels that are situated on either side of the units and passed through the auxiliary wiring aperture.

The auxiliary wiring should be pulled up to the auxiliary wiring panel from the cable box by using a draw wire.



Auxiliary wiring duct shown on right hand side of panel, left hand side duct similar.

Kit contents
Below is a list of the contents of each optional kit.

Cubicle jointing kit (EEAJK1)
The following is included in this kit :

8 busbar links

1 earth link

24 M10 x 60 Hex HD bolts

4 M10 x 40 Hex HD bolts

56 M10 Belville washers 41260430

28 M10 Full Nuts

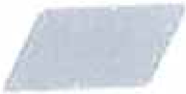
14 M8 x 20 Hex HD bolts

28 M8 B form washers

14 M8 spring washers

14 M8 Full nuts

Cubicle end plate kit (EEAEP1)
The following is included in this kit :



1 polycarbonate busbar end plate

1 steel busbar end plate

1 steel LV auxiliary end plate

1 steel earth end plate

6 M8 x 30 Hex HD bolts

4 M8 x 20 Hex HD bolts

6 M8 earthing washers

8 M8 form B washers

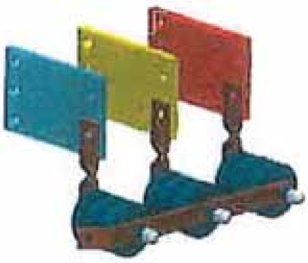
10 M8 spring washers

10 M8 Full nuts 41200080

Surge arrester end panel kit (EEAABB)
The following is included in this kit :

1 off Pre-assembled housing (assembled ready to fit on right hand side)

1 off Neutral busbar



1 off Pre-assembled surge arresters and busbars (assembled ready to fit on right hand side)

4 off fuse (link) stud insulating shroud

Note: *The pre-assembled housing includes the cable to connect fuse links to busbars.*

Operation

Due to the fact that the panels have an internal arc rating the normal operating procedures for the Masterpact NW should not be followed. The following instructions should be used when operating the Masterpact to ensure that the internal arc rating of the switchboard is maintained.

Warning The doors must be closed and the knurled screws fully tightened to maintain the internal arc fault capability.

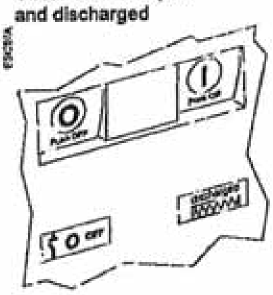
Operation of circuit breaker

The Masterpact indications can be seen through the window on the front of the panel.

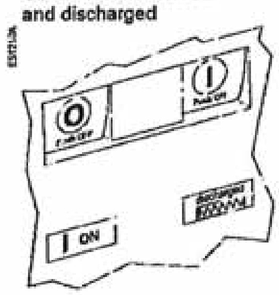
The open and close operations of the circuit breaker are done using the open and close levers on the front panel.

understanding the controls and indications

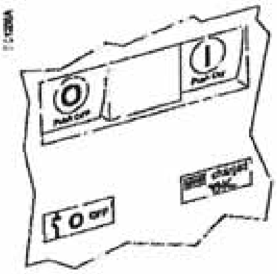
Circuit breaker open and discharged



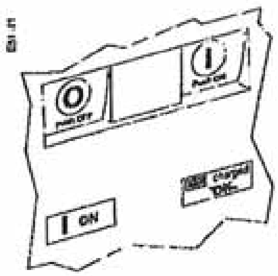
Circuit breaker closed and discharged



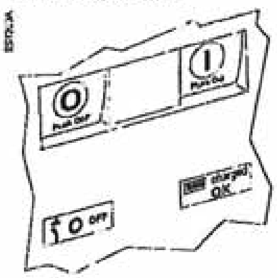
Circuit breaker open, charged and not "ready to close"



Circuit breaker closed, charged and not "ready to close"



Circuit breaker open, charged and "ready to close"



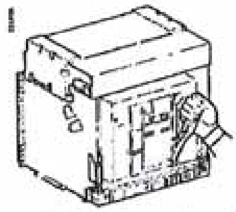
charging the circuit breaker

The springs in the circuit breaker operating mechanism must be charged to store the energy required to close the main contacts. The springs may be charged manually using the charging handle or the optional MCH gear motor.

Manual charging:

To charge the circuit breaker the front access panel must first be opened.

Pull the handle down seven times until you hear a "clack".



Do not close or open the Masterpack with the front access panel open.

Automatic charging:

If the MCH gear motor is installed, the spring is automatically recharged after each closing.

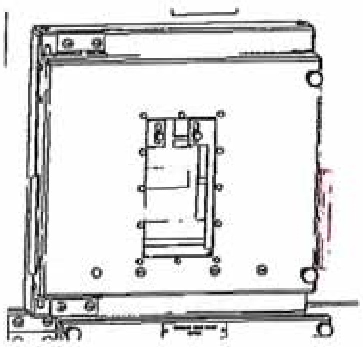
closing the circuit breaker

Closing (i.e. turning the circuit ON) is possible only if the circuit breaker is "ready to close".
The prerequisites are the following:

- device open (OFF)
- springs charged
- no opening order present.

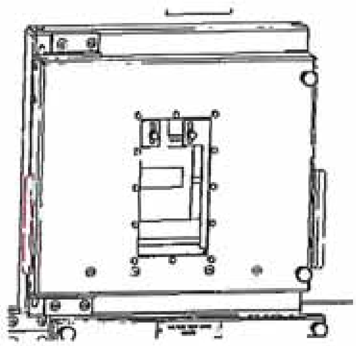
If the circuit breaker is not "ready to close" when the order is given, stop the order and start again when the circuit breaker is "ready to close".

With the front access panel closed push the ON lever (right hand side lever), the circuit breaker should close immediately.



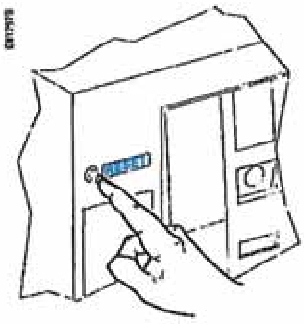
opening the circuit breaker

With the front access panel closed push the OFF lever (Left hand side lever), the circuit breaker should open immediately.



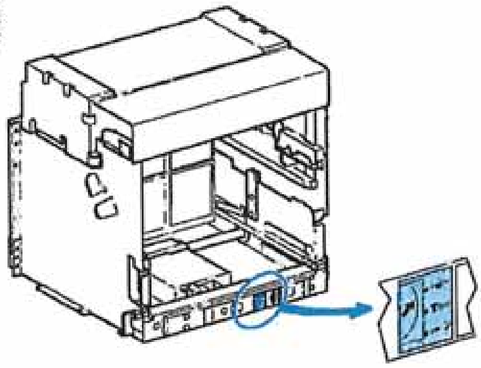
resetting after a fault trip

If the circuit breaker is not equipped with the automatic reset option then the breaker must be reset manually. This is done by opening the front access panel and pressing the reset button, which is located at the top right hand corner of the Masterpact circuit breaker.

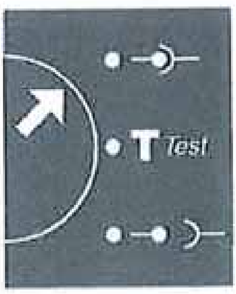


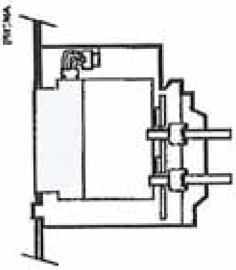
identifying the circuit breaker position in the chassis

The indicator on the front signals the position of the circuit breaker in the chassis.

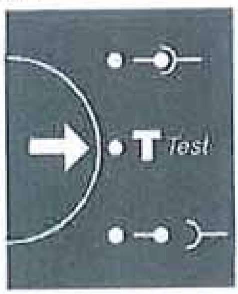


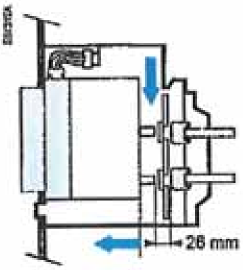
- "connected" position



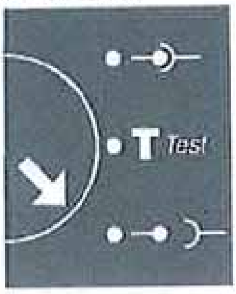


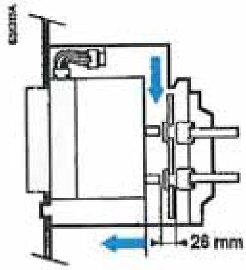
- "test" position





- "disconnected" position





Due to the fact that a plug-in control lead is used the only differnce between the circuit breaker being in the "test" position or the "disconnected" position is that the circuit breaker can be withdrawn when in the "disconnected" position. The plug-in control lead can be removed with the circuit breaker is in the "disconnected" position but it is easier to remove the plug-in control lead when the circuit breaker is in the racked out position (see below on how to rack out the circuit breaker).

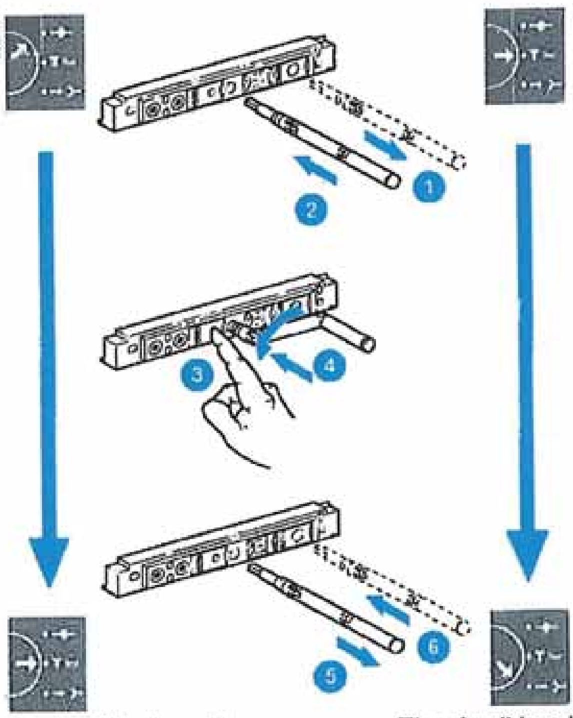
racking

Prerequisites
To connect and disconnect Masterpact, the crank must be used. The locking systems, padlocks and the racking interlock all inhibit use of the crank.

Withdrawing the circuit breaker from the "connected" to "test" position, then to "disconnected" position

The circuit breaker is in "connected" position.

The circuit breaker is in "test" position.

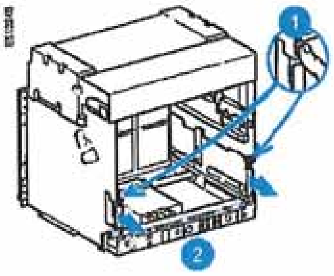


The circuit breaker is in "test" position. Remove the crank or continue to "disconnected" position.

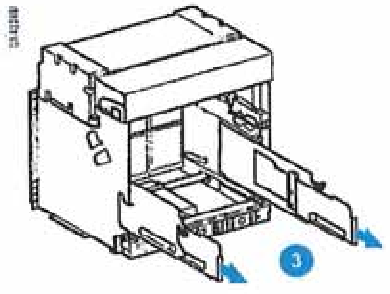
The circuit breaker is in "disconnected" position.

removing the rails

Press the release tabs and pull the rails out.

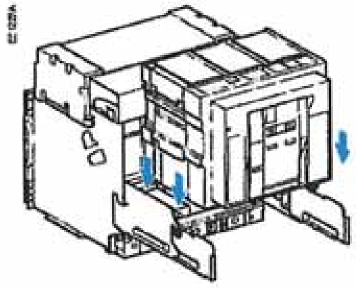


To put the rails back in, press the release tabs and push the rails in.

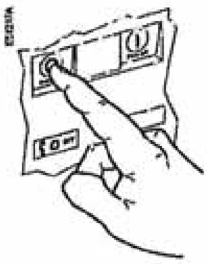


inserting Masterpact

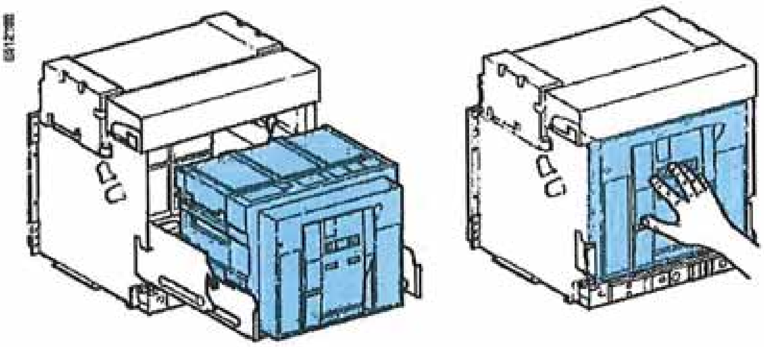
Position the circuit breaker on the rails. Check that it rests on all four supports.



Open the circuit breaker.



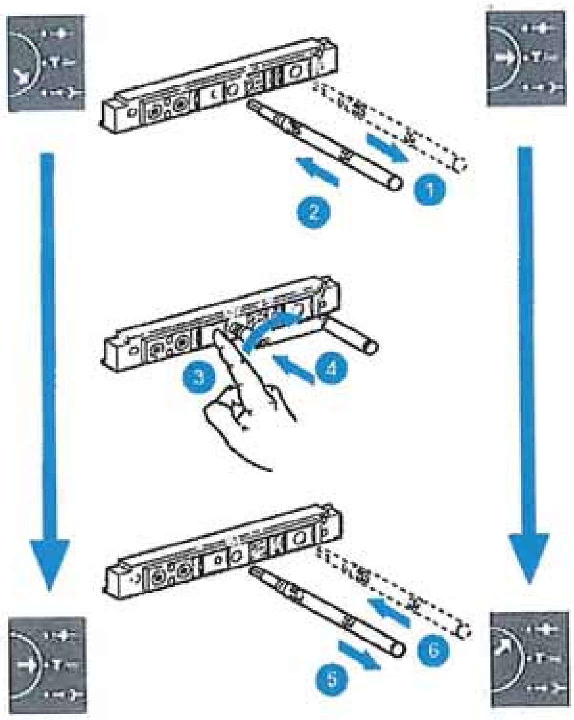
While the circuit breaker is still in the racked out position the plug-in control lead should then be plugged into the circuit breaker. Push the circuit breaker into the chassis, taking care not to push on the control unit.



Racking the circuit breaker from the "disconnected" to "test" position, then to "connected" position

The device is in "disconnected" position

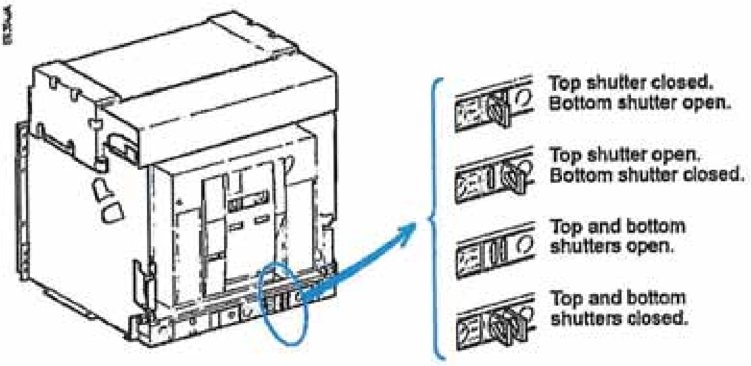
The device is in "test" position.



The device is in "test" position.
Remove the crank or continue to "connected" position.

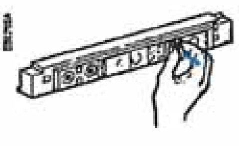
The device is in "connected" position.

Padlocking or position indication on the front



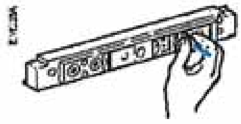
Locking

Pull out the left-hand tab to lock the top shutter.



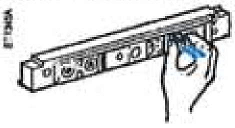
Insert a padlock (shackle 5 to 8 mm).

Pull out the right-hand tab to lock the bottom shutter.



Insert a padlock (shackle 5 to 8 mm).

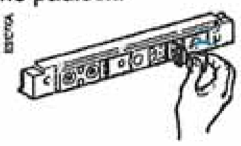
Pull out both tabs to lock both shutters.



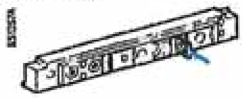
Insert a padlock (shackle 5 to 8 mm).

Unlocking

Remove the padlock.



Release the tab(s).

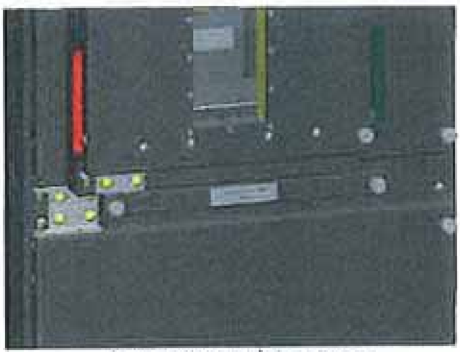


Test point access

On all panels that have circuit breakers or inline switches test points are integrated in to the panel design. An upper test point allows access to the busbar side of the circuit. A lower test point allows access to the cable side of the circuit.

On a bus-section the test access points allow access to the busbars on both sides of the circuit breaker. The upper test point allows access to the left-hand busbar while the lower test access allows access to the right hand busbar.

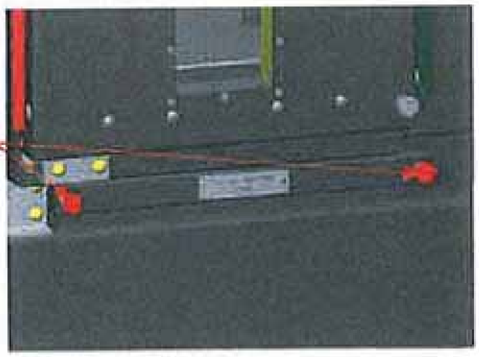
Upper test point access



Lower test point access

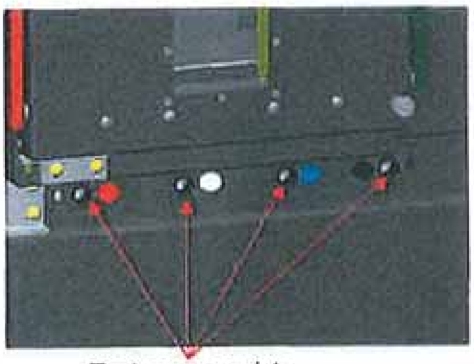
Access to the test points is achieved by loosening both the test points securing fasteners.

Test access fastening points



Once the fasteners have been loosened the test access cover can be removed to reveal the test access points.

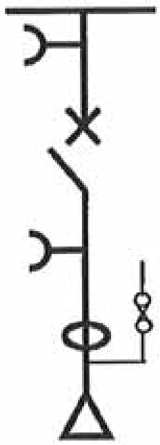
The access points should only be used with the test probes approved by Energy Australia. Use of any other test probe could result in exposure to live parts.



Test access points

The test access cover is fitted by reversing the process to remove the cover.

Architecture
Circuit breaker incoming panels

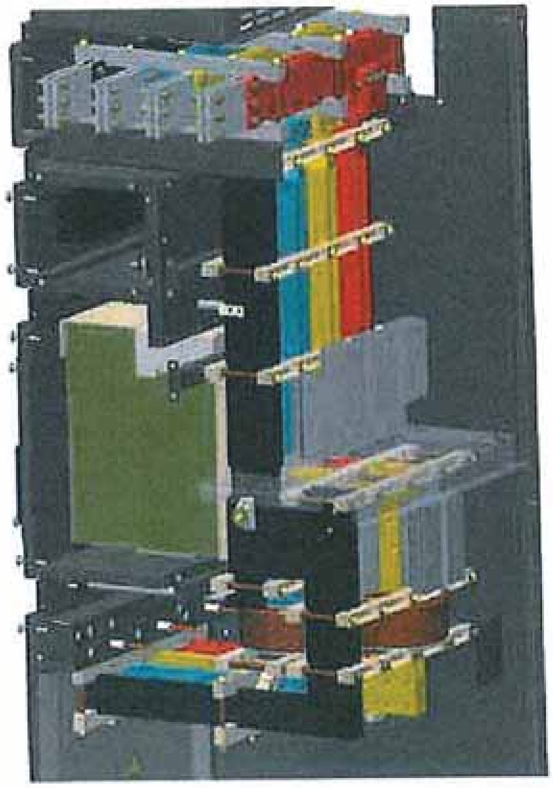


The circuit breaker panels consist of a withdrawable Masterpact circuit breaker and CTs. The panel allows cables to be connected through the circuit breaker to the busbars.

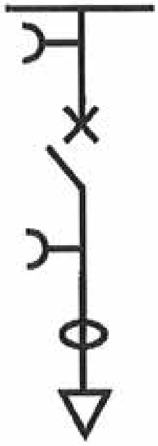
The panels are used as supply to the switchboard.

The panel also provides test point access to both the busbar and cable side of the circuit breaker.

It should be noted that on some incoming panels a 63A "Dead board fuse" supply is included in the design.



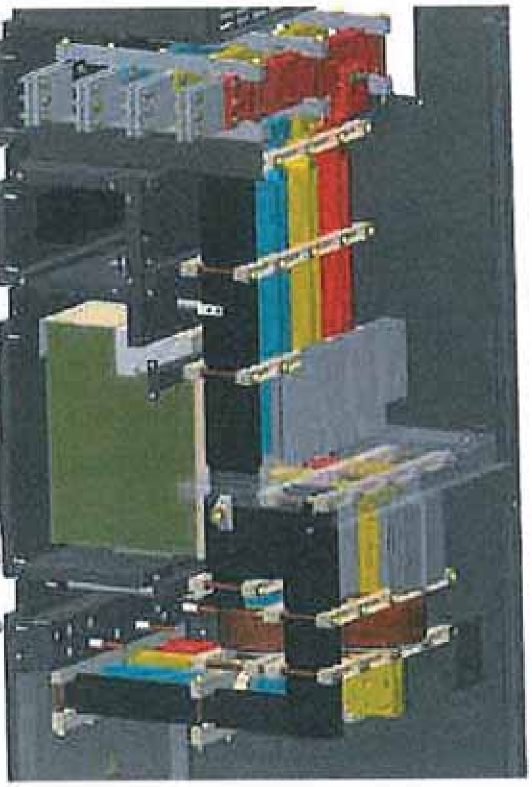
Customer Cable Supply panels



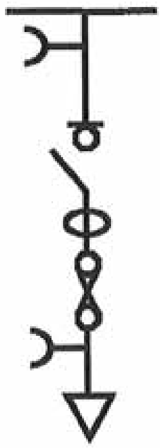
The circuit breaker panels consist of a withdrawable Masterpact circuit breaker and CTs. The panel allows cables to be connected through the circuit breaker to the busbars.

The panel is used for isolating customer supplies.

The panel also provides test point access to both the busbar and cable side of the circuit breaker.



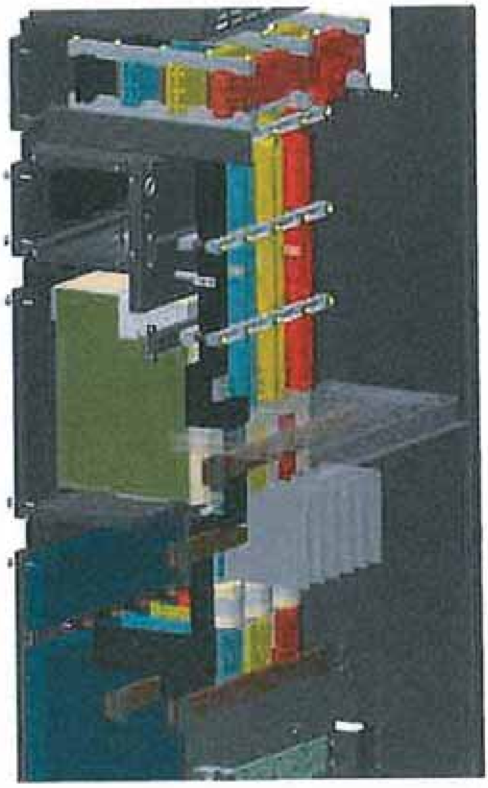
1600A Fused Distributor panel



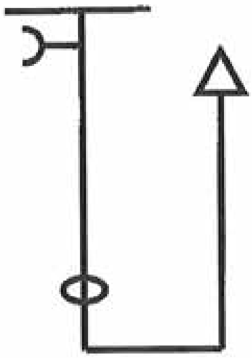
The 1600A Fused Distributor panel consist of a withdrawable Masterpact circuit breaker and large fuses in series. The panel allows outgoing cables to be connected through the circuit breaker and fuses to the busbars.

The panel can be fitted with 1600A, 1200A or 1000A fuses.

The panel also provides test point access to both the busbar and cable side of the fuses.

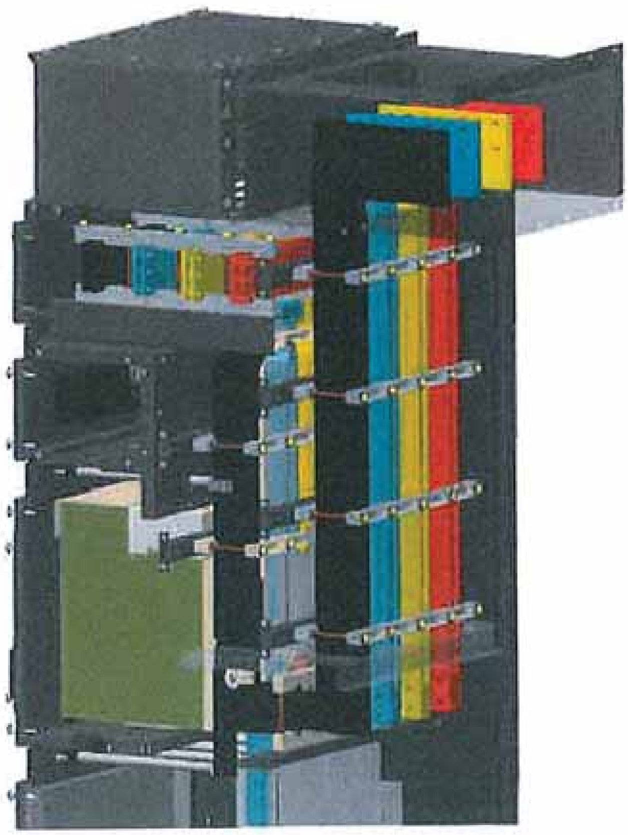


Customer Busbar Supply panels

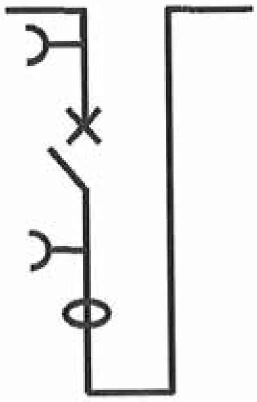


The Busbar Supply panel provides a direct busbar connection to the busbars with out any form overload or short circuit of protection. The panel does provide CT in the out going circuit.

The panel also provides test point access.

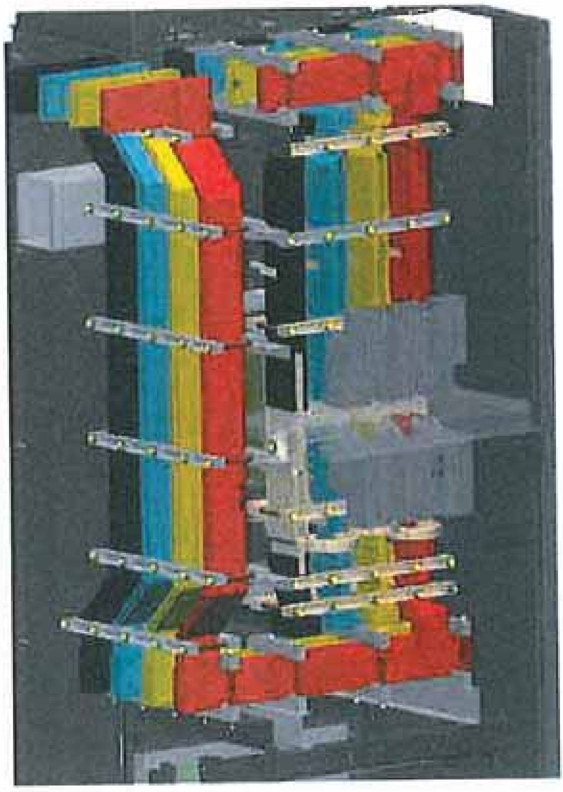


Bus-section panel

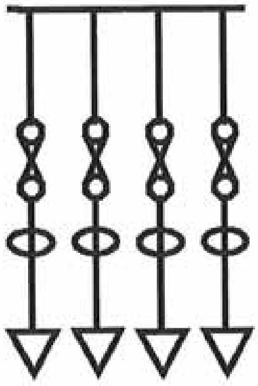


The Bus-section panel consist of a withdrawable Masterpact circuit breaker and indication CT. The panel allows the busbar to be sectioned in to separate isolated parts or to be part of the same circuit.

The panel also provides test point access to both the busbar and cable side of the circuit breaker.



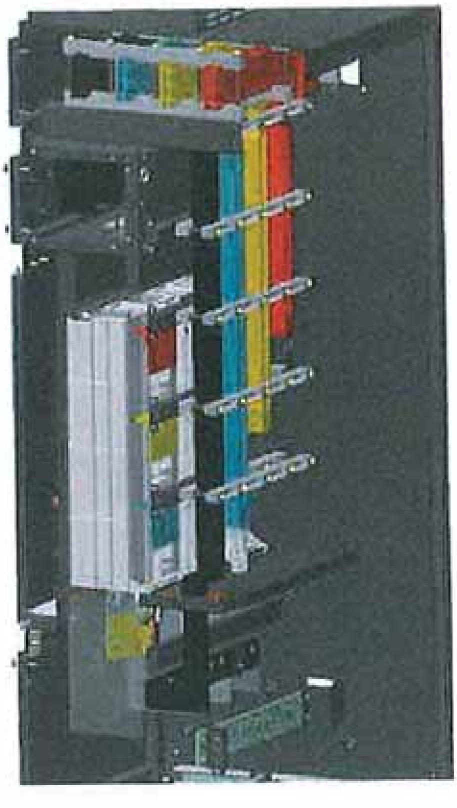
Fused Distributor panel



The Fused Distributor panel consists of a maximum of four SAIF fuseways and indication CTs. The panel allows the outgoing circuits to be connected to the busbars with each fuseway providing individual phase operation for each three-phase fuseway.

The possible combinations of fuseways that can be fitted are:

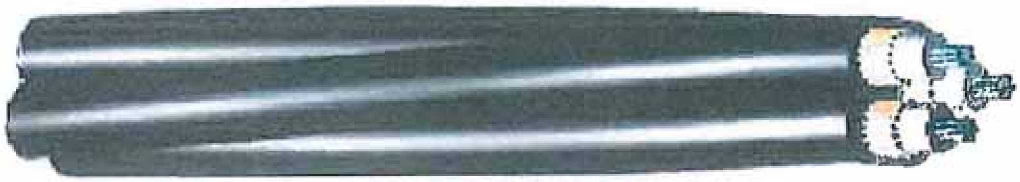
1. Four 400Amp SAIF Fuseways.
2. Two 800Amp SAIF Fuseways.
3. One 800Amp SAIF Fuseway and two 400Amp SAIF Fuseways.



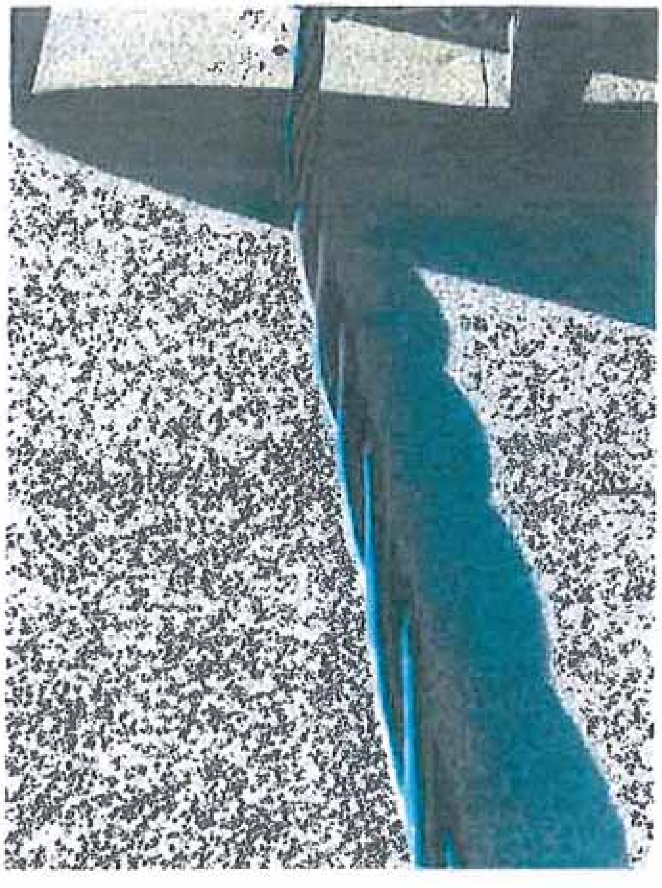
TRIPLEX CABLE INFORMATION

What is a Triplex cable?

A triplex cable is a cable composing of three single core cables laid-up together. A triplex cable is similar to high voltage aerial bundled cable without the catenary wire.



What are the sizes of the triplex cables Ausgrid are currently buying?



Ausgrid are currently buying 185mm^2 and 300mm^2 copper triplex.

Each triplex cable consists of three single core cable. The three single core cables can be either 185mm^2 or 300mm^2 circular stranded compacted copper conductor, Ethylene Propylene Rubber (EPR) or Tree Retardant Cross Linked Polyethylene (TR-XLPE) polymeric insulation, 70mm^2 stranded copper wire concentric screen, composite PVC/HDPE sheath.

What is the cable diameter of the Triplex cable?

There are two diameters to consider, the diameter of the circumscribing circle over the laid-up bundled cable and the diameter of each single core cable.

The diameter of the circumscribing circle over the laid-up bundled cable for the 185mm^2 triplex cable is 76mm and for the 300mm^2 triplex cable is 85 - 89mm (depending on supplier), and the diameter over each single core cable is 35.3mm for the 185mm^2 triplex cable and 39.4 - 41.3mm (depending on supplier) for the 300mm^2 triplex cable.

What is the minimum internal bending radius for triplex cable?

Nominal Minimum Internal Bending Radii for Specified Cables (Guide Only)

Cable type	Minimum Internal Bending Radius		
	During Installation (mm)	After Installation Bundled Cable(mm)	After Installation Phase Cable(mm)
11kV EPR insulated cables:			
185 CU1 EPR 70 CU(WS) Z YQ / TX	1140	760	530
300 CU1 EPR 70 CU(WS) Z YQ / TX	1335	890	620
11kV TRXQ insulated cables:			
300 CU1 TRXQ 70 CU(WS) Z YQ / TX	1300	850	600

Are there any differences with terminating the single core cables associated with the triplex cables as opposed to our current single core cables?

For 300mm^2 triplex cables only, Yes. As detailed in NS177 and in the installation instructions supplied with the cable termination, the outer composite (HDPE) sheath will need to be removed for a distance of 120mm below the gland plate to decrease the cable diameter to ensure the cable gland will fit correctly over the inner composite (PVC) sheath. A 80mm length of rejacketing tube (stockcode 177730) is then shrunk centrally over the outer composite sheath cut.

For both 185mm^2 and 300mm^2 triplex cables, a different screen wire lug (stockcode H95851) and screen wire gland (stockcode 118091) is required to terminate 70mm^2 screens. All new switchgear that come with the gland plates predrilled, have a 26mm diameter hole to suit the screen wire gland (stockcode 118091).

Does Triplex cable have a "memory", making it difficult to set in place when terminating?

No – see photo. The Triplex cable is effectively the same as a single core cable, except the triplex cable has a composite sheath, and uses a 70mm^2 screen instead of a 35mm^2 screen.

Are Triplex cables comparable electrically with single core cables with 35mm^2 screen wires?
Not exactly. They are slightly lower rated, but the difference is negligible. More importantly, they

use 70mm^2 screens per phase, so they are fault rated at 10kA for 1 second, compared to the 5kA that is the maximum the single core cables with 35mm^2 screen wires achieve.

Are there any differences with jointing the single core cables associated with the triplex cables as opposed to single core cables with a 35mm^2 screen?

No. The mechanical screen wire connector currently supplied with Ausgrid's single core polymeric joint kits is suitable for screen wires up to 70mm^2

What is the length of cable on each drum?

For 185mm^2 triplex cable the standard length is 500m, and for 300mm^2 triplex cable the standard length is 320m.

What is the conductor code?

Code	Full Description	Old Description	kV/V	Nickname
000197	11KV 185 CU1 EPR 70 CU(WS) Z YQ / TX / EA1400/10A		11	
000391	11KV 300 CU1 EPR 70 CU(WS) Z YQ / TX / EA1400/10A		11	
000111	11KV 300 CU1 TRXQ 70 CU(WS) Z YQ / TX / EA1400/10B		11	

What are the stockcode numbers?

Full Description	Stockcode number
11KV 185 CU1 EPR 70 CU(WS) Z YQ / TX	181758
11KV 300 CU1 EPR 70 CU(WS) Z YQ / TX	179122

20/

6.35/11kV UNDERGROUND POLYMERIC INSULATED ELECTRIC CABLES
TRIPLEX CABLE CONSTRUCTION

	185 Cu 1 EPR Triplex	300 Cu 1 EPR Triplex	300 Cu 1 TR-XLPE Triplex
5. CONDUCTORS	185 Cu	300 Cu	300 Cu
(b) Shape	Circular	Circular	Circular
(d) Maximum allowable continuous conductor temperature (^{0}C)	90	90	90
(e) Overall dia. (mm)	16.1	20.6	20.7
6. CONDUCTOR SCREEN	Semi-conductive polymer	Semi-conductive polymer	Semi-conductive compound
7. INSULATION			
(a) Type of insulation	EPR	EPR	TR-XLPE
(b) Nominal radial thickness (mm)	3.4	3.4	3.4
(d) Dia. over insulation (mm)	24.1	29.6	28.9
8. NON-METALLIC INSULATION SCREEN			
(c) Dia. over Ins. Screen (mm)	25.8	31.3	30.5
9. METALLIC INSULATION SCREEN			
(a) Number of Wires	40	40	49
(b) Nominal C.S.A of a wire (mm^2)	1.77	1.77	1.43
(d) Details of materials applied over the core screen wires prior to application of the polymeric sheath	Polypropylene Tape	Polypropylene Tape	Polypropylene Tape
10. WATER SWELLABLE TAPE	N/A	N/A	N/A
12. NON-METAL INNER SHEATH			
(a) Material	5V-90 PVC	5V-90 PVC	5V-90 PVC
(c) Dia. over sheath (mm)	31.7	38	35.6
13. POLYMERIC OVERSHEATH			
(a) Material	HDPE	HDPE	HDPE
(c) Dia. over oversheath (mm)	35.3	41.3	39.4
14. COMPLETED CABLE			
(a) Average overall diameter (mm)	76	89	84.9
(b) Min. bending radius (mm) (i) during installation (ii) set of bundled cable (iii) set of phase cable	 1140 760 530	 1335 890 620	 1300 850 600
(c) Mass of cable kg per km	9132	12876	12436
(d) Max. pulling tension, stocking grip (kN): (i) for each core (3 stockings req) (ii) for total cable (1 stocking req)	 13.2 20	 18 20	 16.2 20
(e) Continuous current rating (Amps)*- (i) cable laid direct (70°C) (iii) cable laid in duct (70°C) (iv) cable laid direct (90°C) (vi) cable laid in duct (90°C)	 350 295 410 355	 445 365 525 450	 485 390 535 460

* Based on buried depth of 0.8metres, soil temperature of 25°C and soil resistivity of 1.2°C.m/W.

cables. The reason they are smaller is that the single core cables were purchased for use solely as substation cables – feeder or transformer tails, where the individual screens were connected to the screens over the cores of the three core cables – typically around $35mm^2$ (total $105mm^2$ due to constant contact of screen wires of each phase in three core cable designs). Single core cables should not be used for long lengths without proper consideration of the fault ratings.

Installation constraints

Problems can arise when pulling singles through ducts due to their tendency to bunch up and "jam" when going around conduit bends. When the combined diameters of three cables roughly equal the interior diameter of the conduit (jam ratio ~ 2.5 – 3.3), the cables can line up linearly as they are pulled around the bend. The cables then wedge against the conduit wall as they are forced towards the

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Victoria, 3012, Australia
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Telephone +61 3 9281 4444
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Customer: 3/05/2013
Reference:

DESCRIPTION: One Conductor 185 mm2 Stranded Compacted Plain Annealed Copper, 0.6/1 kV XLPE (X-90) Insulated (1.6 mm min av wall), PVC (5V-90) Sheathed (1.6 mm min av wall), to AS/NZS 5000.1.

Short Description: 1C 185 mm2 PCW 0.6/1 kV XLP PVC

Ident Number: **1404,000185,01,0001** Marketing Code: BDBP25AA001

Colour Code:
- Insulation: Natural
- Sheath: Black, metre marked at 1 metre intervals

Physical Properties:

Cable dimensions :

Overall cable diameter:	22.8 mm nom ± 0.4 mm
Diameter over insulation :	19.4 mm
Conductor Diameter :	16.1 mm
Net mass of cable:	1865 kg/km

Recommended minimum internal bending radius :

Pulling In :	270 mm
Set in Position :	180 mm

Recommended maximum safe pulling/working tension :

Conductors :	7.4 kN

Electrical Properties:

Maximum conductor resistance =	0.0991 ohm/km
Minimum insulation resistance =	240 megohm.km

Despatch Parameters:

Lengths	1 x 100 m
Internal drum size	700 mm x 400 mm B x 350 mm
Overall drum size	700 mm x 480 mm
Gross mass per drum	202 kg
Minimum barrel diameter	400 mm

Cable is metre marked.

Subject to change without notice

Taras Kowal

Subject: FW: Triplex data sheet

Customer: 11/10/2012
Reference:

DESCRIPTION: 3 Conductors 300 mm2 Stranded Compacted Plain Annealed Copper,
Semiconductive Conductor Screen (0.3 mm min wall), 6.35/11 kV TR-XLPE
Insulated (3.4 mm nom wall), Strippolex Insulation Screen (0.6 mm min wall),
Individually Helical Copper Wire Screened (area of each screen 70 mm2 min
suitable for 10.4 kA for 1 sec fault level), PVC (5V-90) Sheathed (1.0 mm
nom wall), HD PE Sheathed (1.8 mm nom wall), Laid up, to AS/NZS 1429.1
(Triplex cable).

Short Description: 3C 300 mm2 PCW 6.35/11 kV TRXLP CWS PVC HDPE Triplex Triplex

Ident Number: **5938,000300,46,1008** Marketing Code: XJNP27TFTR3

Colour Code:
Insulation Natural
Sheath Black, white numbered: 1 one, 2 two and 3 three, no 2 to be metre marked, no 3 marked: 'OLEX 2012 E

Physical Properties:

Cable dimensions :

Overall cable diameter:	83.7 mm nom ± 1.2 mm
Diameter over laying-up :	83.7 mm
Diameter over metal screen :	32.9 mm
Diameter over insulation :	28.6 mm
Conductor Diameter :	20.7 mm
Net mass of cable:	12330 kg/km

Recommended minimum internal bending radius :

Cable :

Pulling In :	1300 mm
Set in Position :	850 mm

Phase Core :

Pulling In :	950 mm
Set in Position :	600 mm

Recommended maximum safe pulling/working tension :

Conductors :	20.0 kN

Electrical Properties:

Maximum conductor resistance =	0.0601 ohm/km
Minimum insulation resistance =	4540 megohm.km
Capacitance of main conductor =	0.478 µF/km

Despatch Parameters:

Lengths	1 x 500 m
Internal drum size	2800 mm x 1500 mm B x 1800 mm
Overall drum size	2800 mm x 2020 mm
Gross mass per drum	7105 kg
Minimum barrel diameter	960 mm

Subject to change without notice

Hi Buddy – please find attached

Regards,

Terrie Anne Hill | Account Manager

Nexans Olex
29 Davis Road, Wetherill Park NSW 2164
P 02 8787 1806 | M 0434 601 768 | F 02 8787 1821
E terrieanne.hill@nexans.com
W http://www.olex.com.au

SAI GLOBAL

LICENCE

for

AS/NZS 2053.2:2001 Conduits and fittings for electrical installations - Rigid plain conduits and fittings of insulating material

Licensee: MR Duane Smyth

Date: Friday, November 19, 2010 12:41 PM

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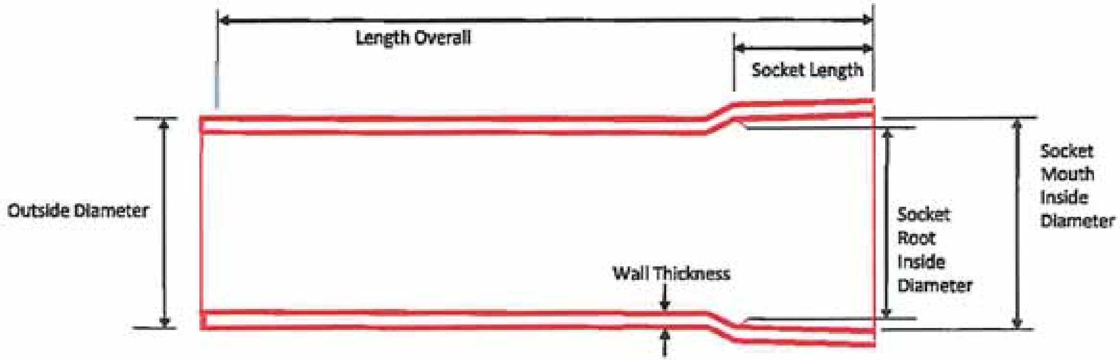
TRI DISTRIBUTORS - CONDUIT SPECIFICATIONS

ELECTRICAL HEAVY DUTY PIPE

TRI Product Code	Pipe Class	Colour	Construction	Length Overall (mm)		Outside Diameter (with Ovality) (mm)		Wall Thickness (mm)		Socket Length (mm)	Socket Mouth Inside Diameter (with Ovality) (mm)		Socket Root Inside Diameter (with Ovality) (mm)		Standard Nominal Weight (kg)
				Min	Max	Min	Max	Min	Max	Min	Min	Max	Min	Max	
CONHD20	Electrical Heavy Duty	Orange	Solid	4016	4036	19.6	20.1	2.3	2.6	16	19.9	20.6	19.2	19.9	0.789
CONHD25	Electrical Heavy Duty	Orange	Solid	4020	4050	24.6	25.1	2.5	2.8	20	24.9	25.6	24.2	24.9	1.098
CONHD32	Electrical Heavy Duty	Orange	Solid	4025	4045	31.6	32.1	2.7	3.0	25	31.9	32.6	31.2	31.9	1.553
CONHD40	Electrical Heavy Duty	Orange	Solid	4032	4062	39.6	40.1	3.1	3.4	32	39.9	40.6	39.2	39.9	2.255
CONHD50	Electrical Heavy Duty	Orange	Solid	4040	4060	49.6	50.1	3.4	3.9	40	49.9	50.6	49.2	49.9	3.303
CONHD63	Electrical Heavy Duty	Orange	Solid	4050	4070	62.5	63.3	3.9	4.5	50	62.9	63.6	62.2	62.9	4.825
CONHD80	Electrical Heavy Duty	Orange	Foam Core	4073	4123	88.4	89.3	4.6	5.3	73	89.0	89.7	88.1	88.8	5.462
CONHD100	Electrical Heavy Duty	Orange	Foam Core	4099	4149	113.7	114.9	5.9	6.7	99	114.6	115.3	113.3	114.0	9.200
CONHD125	Electrical Heavy Duty	Orange	Foam Core	4115	4165	139.5	140.9	7.2	8.1	115	139.5	140.9	139.1	139.9	13.001
CONHD150	Electrical Heavy Duty	Orange	Foam Core	4124	4174	159.5	161.1	8.3	9.3	124	160.5	161.4	159.1	160.0	17.900
CONHD200	Electrical Heavy Duty	Orange	Solid	4147	4197	224.2	226.4	10.5	11.7	147	225.9	226.3	224.3	224.7	46.469



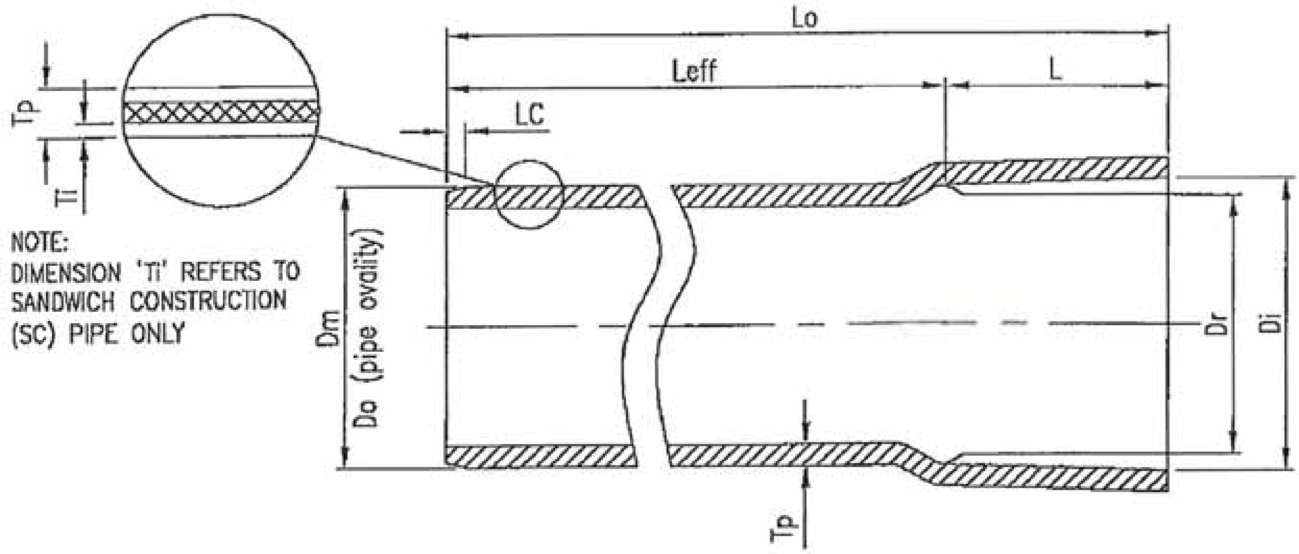
Product Specification 21060

Product Code 21060 | 150 HD VX Elect Cond SC (foam-core) Or | ***Target Weight-kg*** 16.100 - 16.400

Product Brand [9323714005569] 21060 VINIDEX {Factory Free Text} {Long Life Recyclable PVC logo} ELECTRICAL 150 HD SC 0/60 {Ticks/Watermark & License} AS/NZS 2053 {Factory Line} [{Brand Position}] {yymmdd hh:mm} {Factory Extra Brand Text}

Product Specs

Specification Name	*Symbol*	*Spec (Min)*	*Spec (Max)*	*Spec (Other)*	*Unit*
Wall Thickness	Tp	8.3	9.3		mm
Inner Skin Wall Thickness	Ti	0.8			mm
Outer Skin Wall Thickness	To	0.3			mm
Ovality	Do	159.5	161.1		mm
Mean Outside Diameter	Dm	160.0	160.5		mm
Mouth (Inside) Ovality		160.5	161.4		mm
Mean Mouth (Inside) Diameter	Di	160.8	161.1		mm
Root (Inside) Ovality	DrO	159.1	160.0		mm
Mean Root (Inside) Diameter	Dr	159.4	159.7		mm
Overall Length	Lo	4.124	4.174	Metres	m
Effective Length	Leff	4.000		Metres	m
Socket Length	L	124			mm
End Squareness			6.0	mm	mm



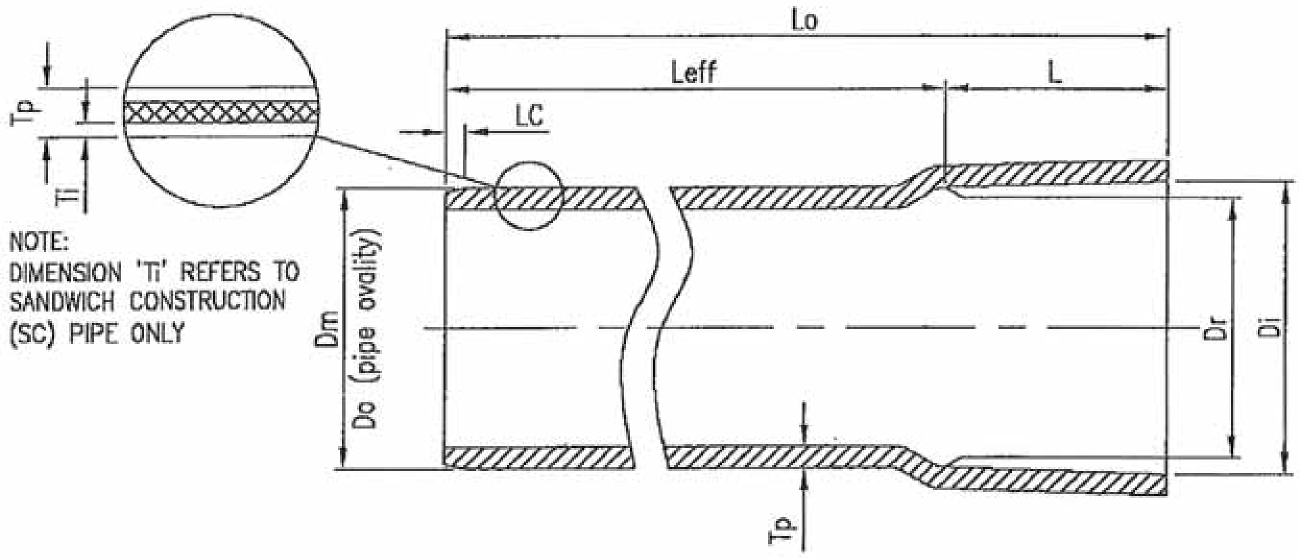
Product Specification 21040

Product Code	21040	100 HD VX Elect Conduit SC (foam-core)	***Target Weight-kg***	7.600 - 8.000

Product Brand [9323714005552] 21040 VINIDEX {Factory Free Text} {Long Life Recyclable PVC logo} ELECTRICAL 100 HD SC 0/60 {Ticks/Watermark & License} AS/NZS 2053 {Factory Line} [{Brand Position}] {yymmdd hh:mm} {Factory Extra Brand Text}

Product Specs

Specification Name	*Symbol*	*Spec (Min)*	*Spec (Max)*	*Spec (Other)*	*Unit*
Wall Thickness	Tp	5.9	6.7		mm
Inner Skin Wall Thickness	Ti	0.8			mm
Outer Skin Wall Thickness	To	0.3			mm
Ovality	Do	113.7	114.9		mm
Mean Outside Diameter	Dm	114.1	114.5		mm
Mouth (Inside) Ovality		114.6	115.3		mm
Mean Mouth (Inside) Diameter	Di	114.8	115.1		mm
Root (Inside) Ovality	DrO	113.3	114.0		mm
Mean Root (Inside) Diameter	Dr	113.5	113.8		mm
Overall Length	Lo	4.099	4.149	Metres	m
Effective Length	Leff	4.000		Metres	m
Socket Length	L	99			mm
End Squareness			4.0	mm	mm



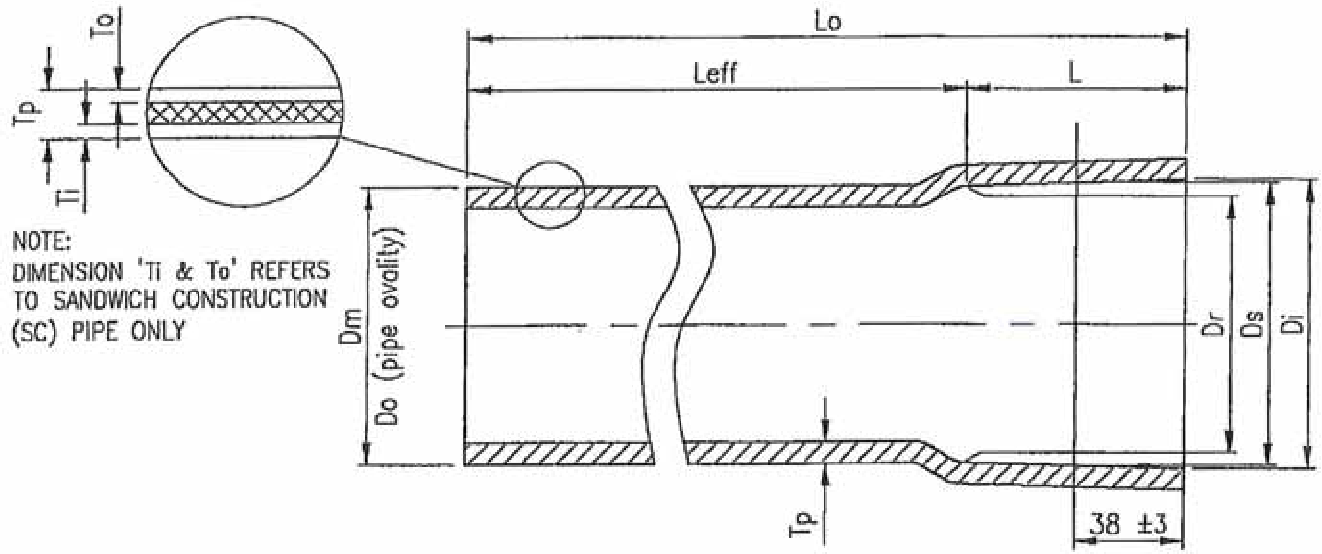
Product Specification **11750F**

Product Code 11750F | 100 Communications Conduit SC (foam-c | ***Target Weight-kg*** 8.800 - 9.500

Product Brand [9323714231777] 11750 VINIDEX {Factory Free Text} {Long Life Recyclable PVC logo} 100 COMMUNICATIONS CONDUIT SC PVCU {Ticks/Watermark & License} {Factory Line} [{Brand Position}] {yymmdd hh:mm} {Factory Extra Brand Text}

Product Specs

Specification Name	*Symbol*	*Spec (Min)*	*Spec (Max)*	*Spec (Other)*	*Unit*
Wall Thickness	Tp	4.3	4.68		mm
Wall Thickness (6-Point Mean)			4.68		mm
Inner Skin Wall Thickness	Ti	0.8		Inner Skin Thickness	mm
Outer Skin Wall Thickness	To	0.3		Outer Skin Thickness	mm
Ovality	Do	113.3	114.55		mm
Mean Outside Diameter	Dm	113.62	114.2	Mean OD	mm
Mid-socket (Inside) Ovality	Tso				mm
Mean Mid-socket (Inside) Diameter	Ts	114.45	114.70		mm
Mouth (Inside) Ovality					mm
Mean Mouth (Inside) Diameter	Di	114.80	115.05		mm
Root (Inside) Ovality	DrO				mm
Mean Root (Inside) Diameter	Dr	112.75	113.00		mm
Overall Length	Lo	6.099	6.149	Metres	m
Effective Length	Leff	6.000		Metres	m
Socket Length	L	99			mm
End Squareness			4.0	mm	mm



9.1 Testing Data

Ausgrid - Chamber Substation

NONE REQUIRED – ALL MAINTENANCE & testing carried BY AUSGRID
Wilken service to Supply Chamber Commissioning paperwork at PC (2 weeks prior to the commissioning)

10 INSPEIINSPECTION TEST PLANS

10.1 N/A Ausgrid owned and operated asset

10.2 Testing Data

Ausgrid – Chamber Substation

None Required – All Maintenance & Testing Carried out by Ausgrid

Wilken service to Supply Chamber Commissioning paperwork at PC (2 weeks prior to the commissioning).

11 COMMISSIONING

AUSGRID – CHAMBER SUBSTATION

Wilken service to Supply Chamber Commissioning paperwork at PC (2 weeks prior to the commissioning)

11.1 Refer to Commissioning Manual/ This Section is Not Applicable

Ausgrid – Chamber substation

No Commissioning Manuals are available as all maintenance & testing is carried out by Ausgrid

12 WARRANTIES AND GUARANTEES

All equipment installed and supplied be the level 1 asp will be warranted by Ausgrid – Wilken Service P/L have a perpetual warranty bond in place with Ausgrid that covers all aspects of the project for a period of 3 years

All equipment installed and supplied be the level 1 asp will be warranted by Ausgrid – Wilken Service P/L have a perpetual warranty bond in place with Ausgrid that covers all aspects of the project for a period of 3 years

12.1 Deed Poll Warranty

ALL EQUIPMENT INSTALLED AND SUPPLIED BE THE LEVEL 1 ASP WILL BE WARRANTED BY AUSGRID – WILKEN SERVICE P/L HAVE A PERPETUAL WARRANTY BOND IN PLACE WITH AUSGRID THAT COVERS ALL ASPECTS OF THE PROJECT FOR A PERIOD OF 3 YEARS

12.2 Suppliers Warranty

All equipment installed and supplied be the level 1 asp will be warranted by Ausgrid – Wilken Service P/L have a perpetual warranty bond in place with Ausgrid that covers all aspects of the project for a period of 3 years

13 DRAWINGS

Ausgrid carry out drawings for external works and will not issue any documentation regarding their network
A red line survey was carried out by LL for the chamber room, Earth Grid and where the conduits enter the room from Jones St

13.1 List of Drawings

Subcontractor to list as built shop drawings in this section.

Red Line Survey carried out be LL for the chamber room, earth grid
Level 3 design SC01596

CABLE TEST RESULTS

Ausgrid

Project Number: | | | | | | | | | SC Number: | | | | | | | Date:

Sub / Asset Address:

Required Cable Test Information

Tests Required

General Tests Required - Insulation Resistance Tests (Phase to Phase & Phase to Earth)
Additional Tests Required - Insulation Resistance Tests for HV cables (Screen to Earth)
Additional Tests Required - Insulation Resistance Tests for LV cables (Phase to Neutral & Neutral to Earth)

Minimum Equipment Required

LV Cable Tests - A 500v Insulation Resistance Tester (Minimum range 200 M Ω)
HV Cable Tests - A 1000v Insulation Resistance Tester (Minimum range 200 M Ω)

Minimum Results Required

LV Cables
New Cables - 200 M Ω
Existing Cables - 20 M Ω

HV Cables
New Cables - 200 M Ω
Existing Cables - 100 M Ω

Existing Cables Advisory - 0.1 M Ω (may be returned to service, but notification must be made to the manager responsible for Maintenance and Replacement Planning)

Insulation Resistance Tests

HV Cables Insulation Resistance

200 M Ω Minimum (New Cables) / 100 M Ω Minimum (Existing Cables)

LV Cables Insulation Resistance

200 M Ω Minimum (New cables) / 20 M Ω (Existing Cables) / Advisory - 0.1 M Ω

Qualified Electrical Supervisor who conducted the tests: Licence Number:

Instument No: Calibration Date: ASP Sign & Submit by Email:

COMMISSIONING PAPERWORK CHECKLIST

Ausgrid

Project Number:		SC Number:		Date:	
Substation / Asset Number:		Sub / Asset Address:			
ASP/1:		Project Manager:		Commissioning Date:	

	Required	Completed	Date Submitted
Inventory Sheet (TEI Sheets)			
Operator Request Form			
Substation Earthing Details Sheet			
Substation Earth Electrode Location Sheet			
Transformer Test Results Sheet			
Cable Test Results Sheet			
Substation (Pole/Kiosk) Checksheet			
ES9 Appendix A			
As Built Field Recordings			
Compaction Certificates			
Data Capture Sheets			
Pole Inspection Checklist (where new pole/s stood)			
Red Line Survey (provided by ASP)			
Written Notification of Practical Completion of Project			
Project Assessment			

Notes -

Project Planning Form - MUST be submitted prior to project commencment
Inventory Sheet (TEI Sheets) - MUST be submitted minimum 5 weeks prior to commissioning
Operator Request Form - MUST be submitted minimum 5 weeks prior to commissioning
Transformer Test Results Sheet - MUST be submitted minimum 5 weeks prior to commissioning
All completed paperwork (except TEI Sheets) - MUST be submitted minimum 2 weeks prior to commissioning
Preliminary As Built Field Recordings - MUST be submitted minimum 2 weeks prior to commissioning
Final As Built Field Recordings - MUST be submitted maximum 2 days after commissioning
Signed and Completed Project Assessment - MUST be submitted maximum 2 days after issue from ASP C/O

Failure to submit the above paperwork as required may result in cancellation of requested commissioning date

ASP Sign & Submit by Email:

EARTH ELECTRODE DETAILS & TEST RESULTS

Ausgrid

Project Number: | | | | | | | | | SC Number: | | | | | | | Date:

Substation / Asset Number: | | | | | | | Sub / Asset Address:

Additional Earth Tests Carried Out -- Earthing Interconnectivity Test: ☐ Loop Impedance Measurement Test: ☐

Earthing Details

Number of Earth Groups: Type of Earthing System: Instrument Calibration Date:

Combined Group Test Results: Soil Resistivity (in Meg Ohms):

Group A

Number of Electrodes:

Depth of Electrodes:

Type of Electrodes:

Installation Meathod:

Earthing Compound Used:

Earth Connection cables:

Cable Connection Meathod:

Installation Date:

Individual Group Test Results:

Group B

Number of Electrodes:

Depth of Electrodes:

Type of Electrodes:

Installation Meathod:

Earthing Compound Used:

Earth Connection cables:

Cable Connection Meathod:

Installation Date:

Individual Group Test Results:

Qualified Electrical Supervisor who conducted the tests: Licence Number:

ASP Sign & Submit by Email:

EARTH ELECTRODE LOCATION SHEET

Ausgrid

Project Number:

SC Number:

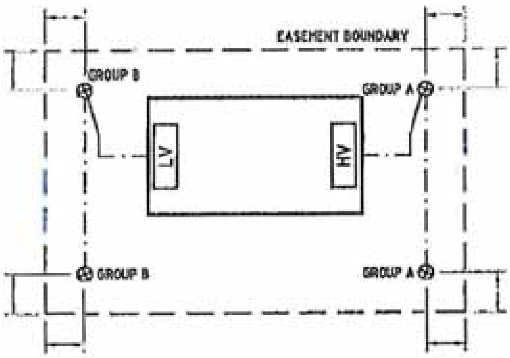
Date:

Earthing Layout Design: Single Kiosk Layout

Substation / Asset Number:

Sub / Asset Address:

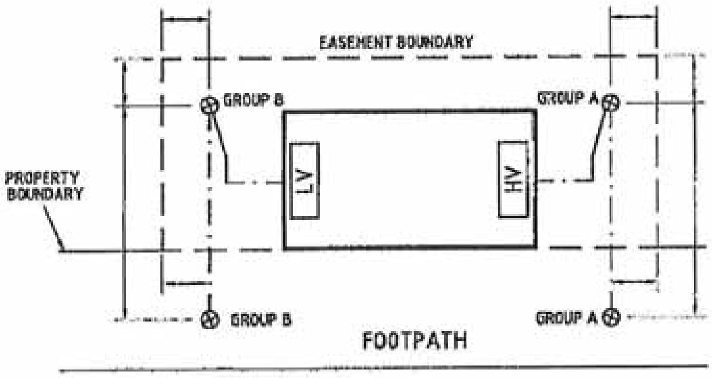
Please Select the Relevent Earthing Layout



TYPICAL LAYOUT 1

Single Substation Layout 1

Click Here for this Layout



TYPICAL LAYOUT 2

Single Substation Layout 2

Click Here for this Layout

Ausgrid

ES9 Appendix A
ASP/1's Certificate

Project Number

SC Number

Pursuant to the ES 9 Agreement between Ausgrid, the Customer and the ASP/1
dated , hereby warrants the following:

1. Accreditation

(a.) The ASP/1 was an ASP/1 at the time it was engaged by the Customer to undertake the Works
(b.) The ASP/1's accreditation remains current at the date of this Certificate.
(c.) The ASP/1 maintains insurances specified by the Code.
(d.) The ASP/1 has employed only fully trained and competent staff relevant to the Works and has ensured that they have been trained and authorised as required by Ausgrid in accordance with Ausgrid's Electrical Safety Rules.

2. Works

(a.) The Works have been completed in accordance with the Agreement and, without limitation, in accordance with:
 i the Applicable Specification;
 ii applicable Laws;
 iii the Design as certified by EnergyAustralia
 iv the Code;
 v Ausgrid's Environmental Requirements; and
 vi Ausgrid's quality and safety requirements
(b.) Only Approved Materials have been used in respect of the Works.
(c.) There are no Major Defects in the Works.
(d.) The Works have been tested in accordance with the Agreement
(e.) The Works are suitable for Electrification
(f.) The Works are in all respects fit for their intended purpose
(g.) Where required under EnergyAustralia's *Electrical Safety Rules*, all relevant workgroups have been notified that the Works have been submitted for Electrification

3. Payment

Subject to satisfactory completion of the Works, arrangements have been made for the following:
(a.) Payment of the ASP/1 by the Customer for undertaking the Works; and
(b.) Payment of any employees, subcontractors, agents or suppliers of the ASP/1 for any work undertaken or for any services performed in relation to the Works.

[Capitalised terms are defined in ES 9.]

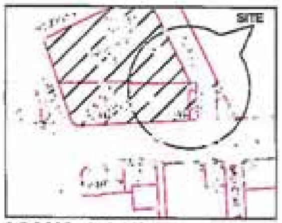
Dated -
Signed -
For and the with authority of **(the ASP/1)**
Witness -

iAMS DATA CAPTURE SHEET

Ausgrid

Project Number:		SC Number:		Date:	

ASP Sign & Submit by Email:



LOCALITY PLAN
SCALE 1:200

ESTABLISH BASEMENT CHAMBER SUBSTATION S.48445 "JONES BROADWAY"

SUBSTATION TYPE:

SUBSTATION PHASING ARRANGEMENT:

SUBSTATION HV CONTROL:

TRANSFORMER LV CONTROL:
3 x 3000A LV DUAL (DC) TRIP-COILS ACBS.

TRANSFORMER SIZES AND TYPE:

TRANSFORMER VOLTAGE RATIO:

TRANSFORMER VECTOR GROUP:

PROTECTION REQUIREMENTS:

PROTECTION BATTERY VOLTAGE:

PROTECTION AND MDI CT SETTINGS (REQUIRED TAP IS UNDERLINED):

LV-BOARD ARRANGEMENT:

LV FUSE ELEMENTS:

LV-CUSTOMER'S CONTROL:

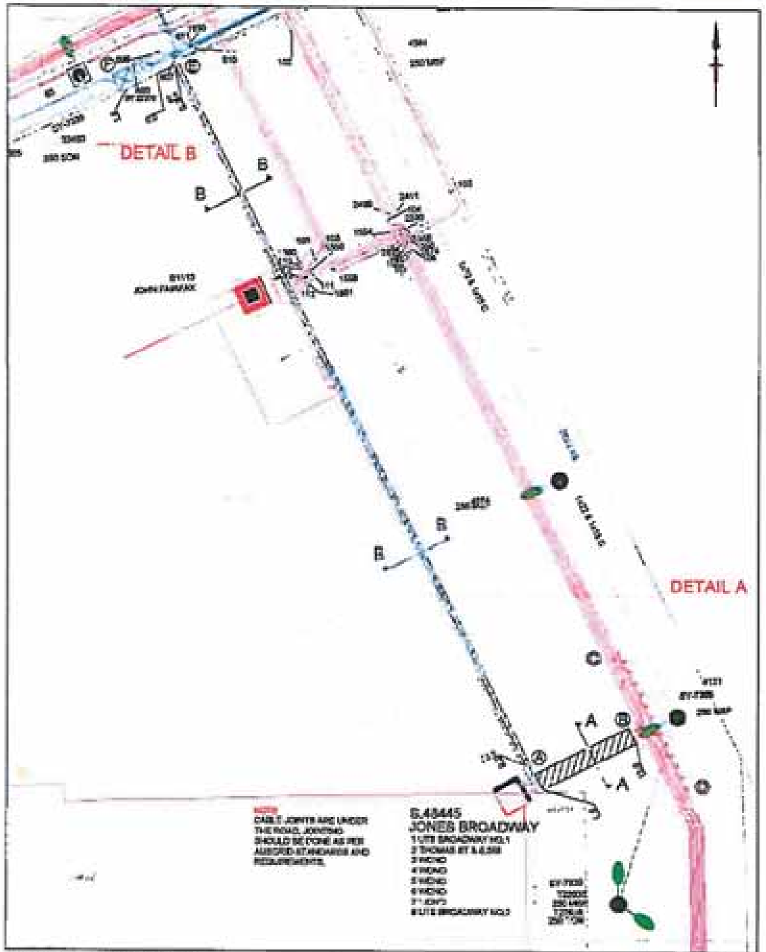
LV-SPARE PANEL OUTLET:

GENERAL NOTES:

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

ATTENTION

NOTE:



CONSTRUCTION PLAN
SCALE 1:200

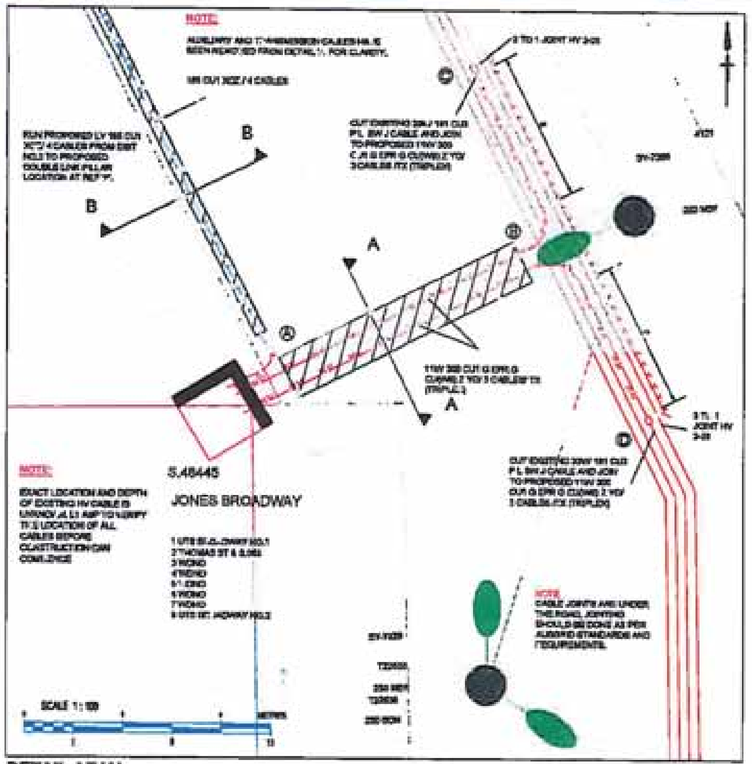
LEGENDS

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

A1 SC01596 1 of 16 0



DETAIL AT 'A'

SCALE 1:100

DETAIL AT 'B'

SCALE 1:200

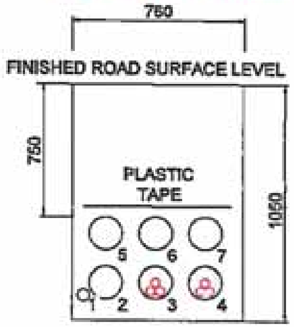
NOTE:

ATTENTION

NOTE:

ALLOW FOR EXCESS CABLE FOR BENDS, JOINTS AND TERMINATIONS INSIDE THE BASEMENT CHAMBER SUBSTATION.

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

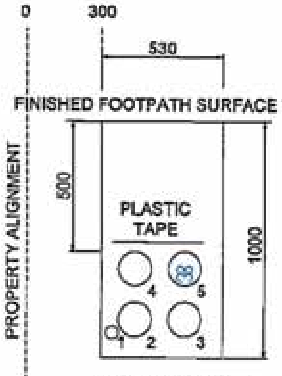


LEGENDS

- CONDUIT
- LV CABLE PROPOSED
- LV CABLE EXISTING
- HV TRIPLEX CABLE EXISTING
- HV TRIPLEX CABLE PROPOSED
- HV CABLE EXISTING
- AUX CABLE EXISTING

SECTION A-A

1 - SPARE 50mm COMMS CONDUIT
2 - SPARE 150mm CONDUIT
3 - 1 SET OF 11kV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX) IN 150MM CONDUIT
4 - 1 SET OF 11KV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX) IN 150MM CONDUIT
5 - SPARE 150MM CONDUIT
6 - SPARE 150MM CONDUIT
7 - SPARE 150MM CONDUIT



SECTION B-B

1 - SPARE 50mm COMMS CONDUIT
2 - SPARE 150mm CONDUIT
3 - SPARE 150MM CONDUIT
4 - SPARE 150mm CONDUIT
5 - 1 x 415V 185 CU1 XQZ / 4 CABLES IN 150mm CONDUIT

UNDERGROUND CONSTRUCTION WORKS SCHEDULE (DUCT PULL VERSION 1.1)

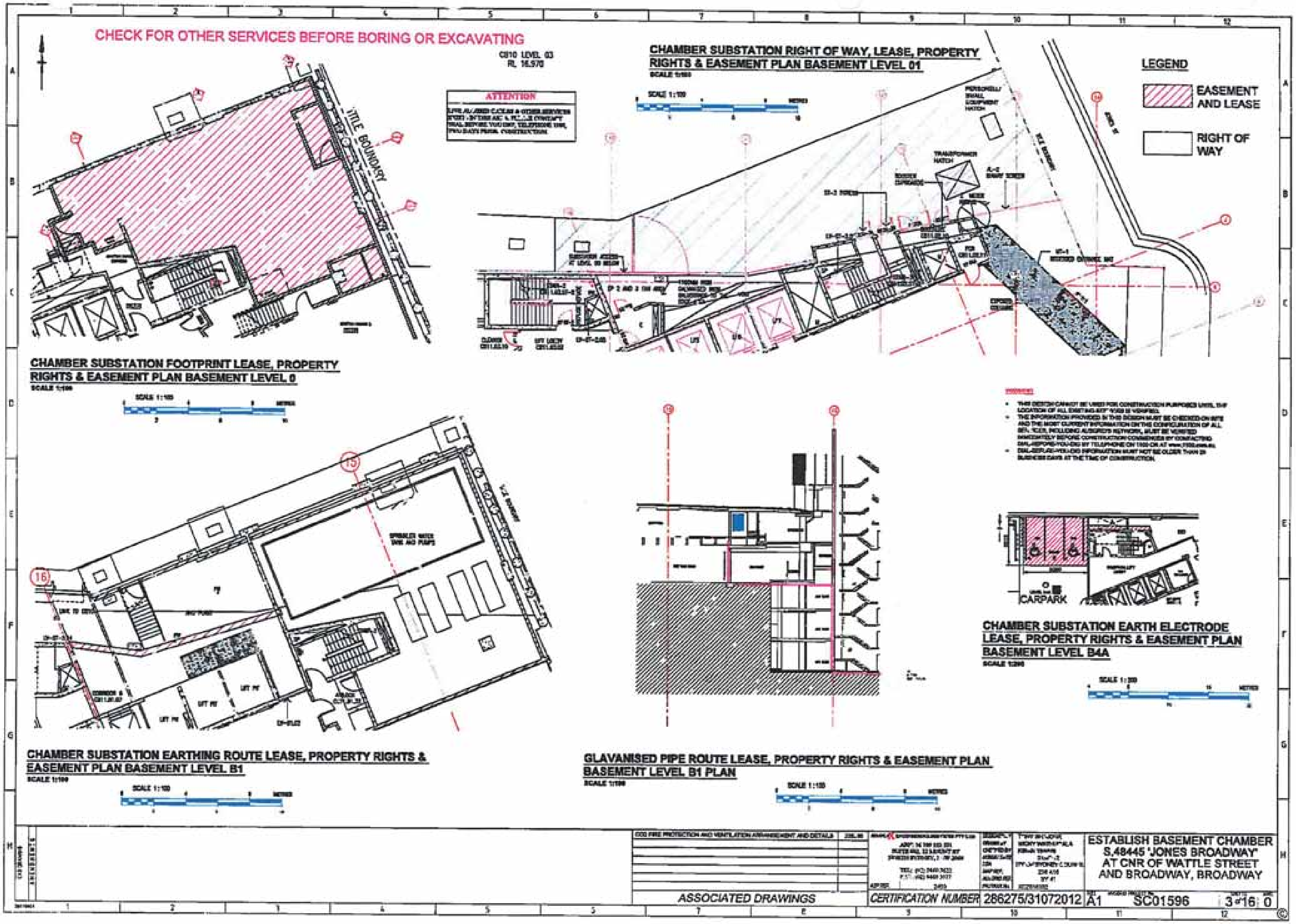
REF. IDENTIFIER	ROUTE DISTANCE (m)	CIRCUIT VOLTAGE	CONDUCTOR OR ASSET DETAIL	CABLE CODE	MIN. INTERNAL BENDING RADIUS (mm) DURING INSTALLATION	MIN. INTERNAL BENDING RADIUS (mm) AFTER INSTALLATION	CALCULATED MAX. PULLING TENSION (kN) DURING INSTALLATION	CONSTRUCTION DETAIL
A	N/A	N/A	BASEMENT CHAMBER SUBSTATION	N/A	N/A	N/A	N/A	- ESTABLISH BASEMENT CHAMBER SUBSTATION AS PER THIS DESIGN.
A TO B	[illegible]	11kV	2 SETS OF 11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/TX (TRIPLEX)	[illegible]	[illegible]	[illegible]	[illegible]	- RUN PROPOSED 11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/TX (TRIPLEX) FROM THE POINT OF ENTRY TO BASEMENT CHAMBER SUBSTATION TO REF 'B' IN PROPOSED CONDUIT. REFER SECTION A-A
	[illegible]	11kV	[illegible]	N/A	N/A	N/A	N/A	- INSTALL CONDUIT BETWEEN REF 'A' AND REF 'B' AS PER SECTION A-A
A TO E	[illegible]	415V	1 x 185 CU1 XQZ / 4 CABLES	[illegible]	[illegible]	[illegible]	[illegible]	- RUN PROPOSED 415V 185 CU1 XQZ / 4 CABLES FROM THE POINT OF ENTRY TO BASEMENT CHAMBER SUBSTATION TO REF 'E' IN PROPOSED CONDUIT. REFER SECTION B-B
	[illegible]		[illegible]	N/A	[illegible]	N/A	N/A	- INSTALL CONDUIT BETWEEN REF 'A' AND REF 'E' AS PER SECTION B-B
B TO C	[illegible]	11kV	11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/ TX (TRIPLEX)	[illegible]	[illegible]	[illegible]	N/A	- DIRECT LAY PROPOSED 11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/TX (TRIPLEX) CABLE FROM END OF CONDUIT TO THE LOCATION OF JOINT.
B TO D	[illegible]	11kV	11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/ TX (TRIPLEX)	[illegible]	[illegible]	[illegible]	N/A	- DIRECT LAY PROPOSED 11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/TX (TRIPLEX) CABLE FROM END OF CONDUIT TO THE LOCATION OF JOINT.
C	N/A	11kV	1 x HV JOINT (HV 3-28)	N/A	N/A	N/A	N/A	- CUT EXISTING HV UG CABLE [illegible] AND JOIN TO PROPOSED 11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/TX (TRIPLEX) USING A HV 3-28 JOINT. - RECOVER REDUNDANT CABLE BETWEEN REF 'C' AND REF 'D'.
D	N/A	11kV	1 x HV JOINT (HV 3-28)	N/A	N/A	N/A	N/A	- CUT EXISTING HV UG CABLE [illegible] AND JOIN TO PROPOSED 11kV 300 CU1 G EPR G CU(WS) Z YQ/3 CABLES/TX (TRIPLEX) USING A HV 3-28 JOINT. - RECOVER REDUNDANT CABLE BETWEEN REF 'D' AND REF 'C'.
E TO F		415V	1 x 185 CU1 XQZ / 4 CABLES	[illegible]	[illegible]	[illegible]	N/A	DIRECT LAY PROPOSED 415V 185 CU1 XQZ / 4 CABLES FROM END OF CONDUIT TO THE LOCATION OF THE PROPOSED DOUBLE LINK PILLAR.
F	N/A	415V	DOUBLE LINK PILLAR (LV 1-40)	N/A	N/A	N/A	N/A	- ESTABLISH PROPOSED DOUBLE LINK PILLAR [illegible] AT PROPERTY BOUNDARY AT LOCATION SHOWN. - CUT EXISTING LV UG CABLE AT JOINT [illegible] - BEND AND TERMINATE AT PROPOSED DOUBLE LINK PILLAR. - RECOVER EXISTING LV UG CABLE FROM JOINT [illegible] TO EXISTING NETWORK-BOX. - RECOVER REDUNDANT JOINTS.
F TO G	[illegible]	415V	1 x 185 CU1 XQZ / 4 CABLES	[illegible]	[illegible]	[illegible]	N/A	DIRECT LAY PROPOSED 415V 185 CU1 XQZ / 4 CABLES FROM PROPOSED DOUBLE LINK PILLAR TO EXISTING NETWORK-BOX AND TERMINATE.

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

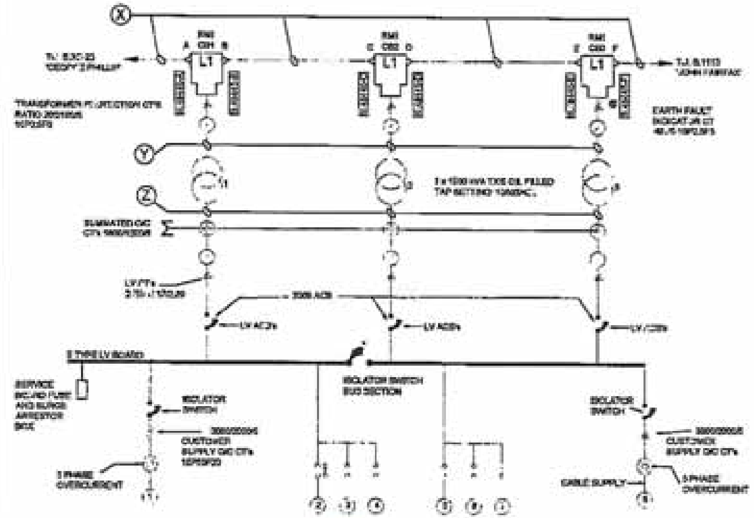
A1 SC01596 2 of 16 0



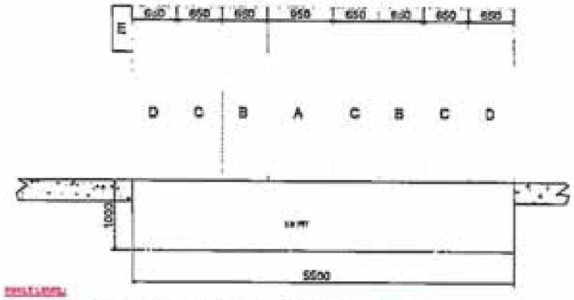
CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING
CHAMBER SUBSTATION RIGHT OF WAY, LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL 01
LEGEND
EASEMENT AND LEASE
RIGHT OF WAY
TITLE BOUNDARY
ATTENTION
CHAMBER SUBSTATION FOOTPRINT LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL 0
CHAMBER SUBSTATION EARTHING ROUTE LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL B1
GLAVANISED PIPE ROUTE LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL B1 PLAN
CHAMBER SUBSTATION EARTH ELECTRODE LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL B4A
CARPARK
SCALE 1:100
ASSOCIATED DRAWINGS
CERTIFICATION NUMBER 286275/31072012
A1
SC01596
3 of 16
0
ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

CHAMBER SUBSTATION SCHEMATIC DIAGRAM

S.48445 'JONES BROADWAY'



E TYPE LV BOARD LAYOUT

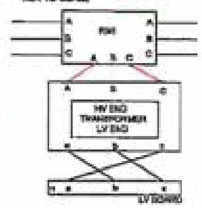


'E' TYPE LOW VOLTAGE BOARD LAYOUT

ID	PANEL ITEM	STOCKCODE NO.
A	1 x 2000 AMP ACB BUS SECTION SWITCH	[illegible]
B	[illegible] FUSE DISTRIBUTOR	[illegible]
C	3 x 2000 ACB INCOMING PANEL [illegible]	[illegible]
D	2 x 2000 AMP ACB CUSTOMER POINT OF SUPPLY	[illegible]
E	1 x SURGE ARRESTOR AND [illegible] AMP AUXILIARY FUSE	[illegible]

PHASING ARRANGEMENT ABC-bca

NOT TO SCALE



NOTE:

- THESE PHASING DETAILS ARE TO BE VERIFIED ON SITE PRIOR TO COMPLETING THE COMMISSIONING JOINTS. [illegible]

FAULT LEVEL:

- THREE PHASE SHORT CIRCUIT CURRENT AT THE TRANSFORMER LOAD TERMINALS = [illegible]
- THE WORST CASE THREE PHASE SHORT CIRCUIT CURRENT AT THE TRANSFORMER LOAD TERMINALS = [illegible]

THE ABOVE FIGURES ARE PROVIDED FOR PROTECTION GRADING PURPOSES. THE NOMINAL PROSPECTIVE SHORT CIRCUIT CURRENT AT THE PROPOSED SUBSTATION LV BOARD IS [illegible]

NOTE:

1. HV TRANSFORMER TAILS ARE TO BE RUN IN TREFOIL.
2. LV TRANSFORMER TAILS TO BE RUN AS SHOWN ON SHEET NO. 4

LV DISTRIBUTOR DETAIL

DIST	DESTINATION
1	UTS BROADWAY NO.1 [illegible]
2	THOMAS ST & [illegible]
3	[illegible]
4	[illegible]
5	[illegible]
6	[illegible]
7	[illegible]
8	UTS BROADWAY NO.2 [illegible]

*NOTE:

LV BUS SECTION C3 MUST BE OPENED PRIOR TO OPENING SWITCHES [illegible] AND MUST BE CLOSED AFTER CLOSING THE HV SWITCHES [illegible]

CAUTION:

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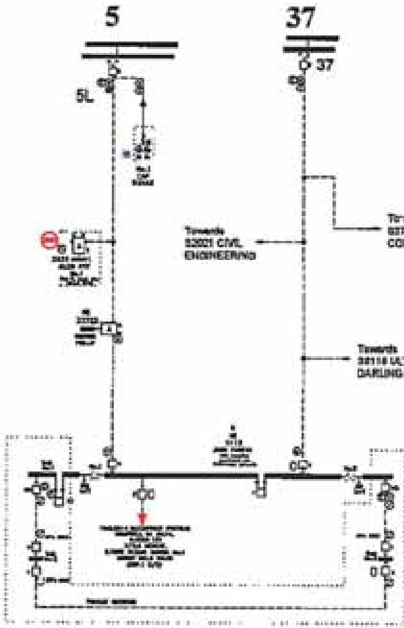
- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN [illegible] DAYS AT THE TIME OF CONSTRUCTION.

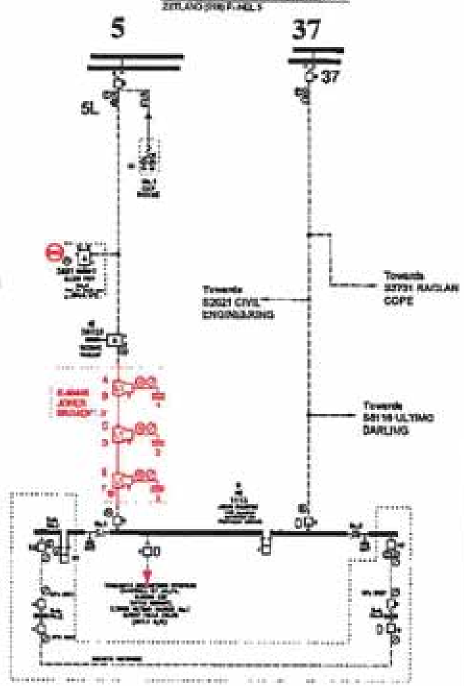
CABLE SCHEDULE

CABLE ID	ORIGIN	DESTINATION	SIZE/DETAIL	CONDUIT SIZE. REFER TO CONDUIT SCHEDULE
Y	RMI1	TX1	3 x 70mm² CU/1 EPR 11kV	100mm HD PVC
Y	RMI2	TX2	3 x 70mm² CU/1 EPR 11kV	100mm HD PVC
Y	RMI3	TX3	3 x 70mm² CU/1 EPR 11kV	100mm HD PVC
Z	TX1	TX1 / [illegible]	[illegible] XLPE/PVC PER PHASE + [illegible] XLPE/PVC PER FOR NEUTRAL	LV CHASE
Z	TX2	TX2 ACB	[illegible] XLPE/PVC PER PHASE + [illegible] XLPE/PVC PER FOR NEUTRAL	LV CHASE
Z	TX3	TX3 ACB	[illegible] XLPE/PVC PER PHASE + [illegible] XLPE/PVC PER FOR NEUTRAL	LV CHASE
X	STREET	RMI1	1 SET OF [illegible] CABLES/TX (TRIPLEX)	125mm HD PVC
X	RMI1	RMI2	1 SET OF [illegible] CABLES/TX (TRIPLEX)	HV SWITCHGEAR PIT
X	RMI2	RMI3	1 SET OF [illegible] CABLES/TX (TRIPLEX)	HV SWITCHGEAR PIT
X	RMI3	STREET	1 SET OF [illegible] CABLES/TX (TRIPLEX)	125mm HD PVC

EXISITNG HV SCHEMATIC



PROPOSED HV SCHEMATIC



CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012

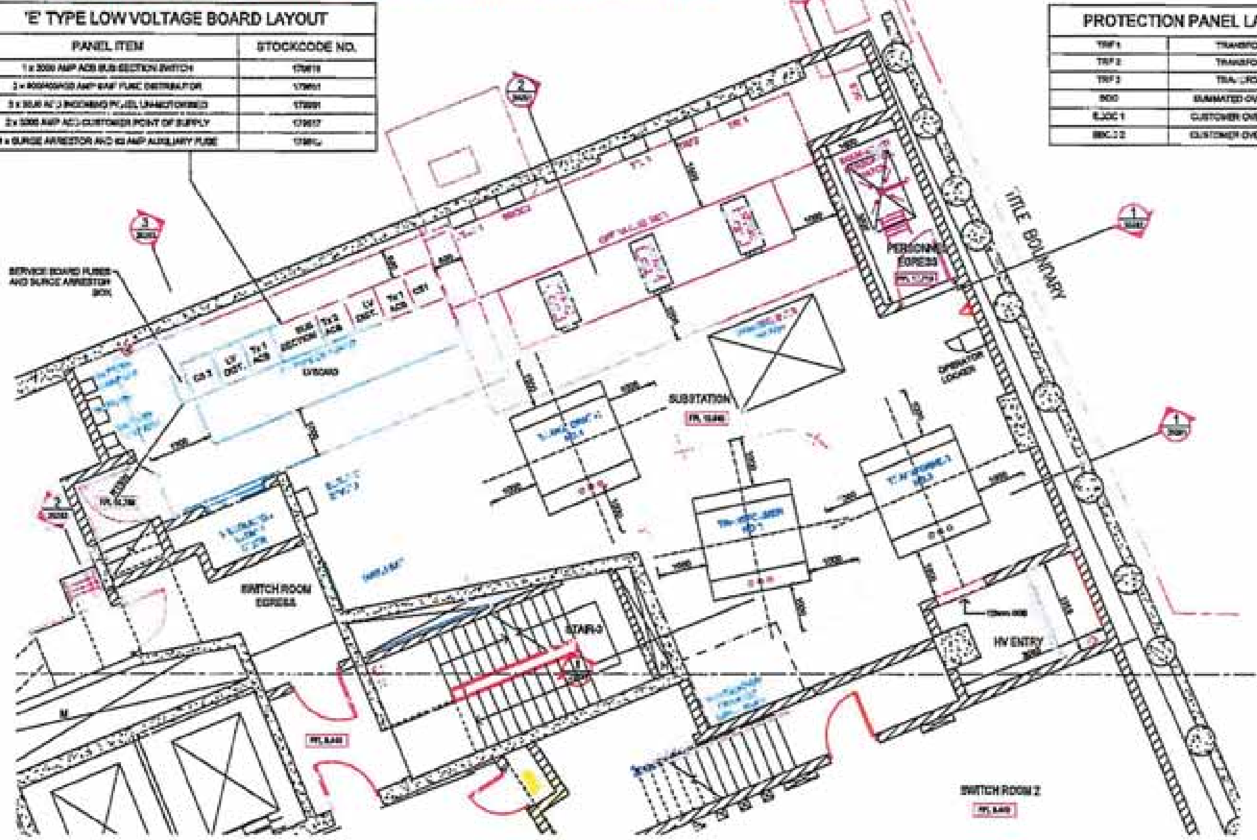
ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

A1 SC01596 4 of 16 0

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

'E' TYPE LOW VOLTAGE BOARD LAYOUT	
PANEL ITEM	STOCKCODE NO.
1 x 3000 AMP ACB BUS SECTION SWITCH	176818
2 x 800/400/400 AMP 6-WAY FUSE DISTRIBUTOR	176801
3 x 3000 AMP INCOMING PANEL (UNMETERED)	[illegible]
2 x 3000 AMP ACB CUSTOMER POINT OF SUPPLY	176817
1 x SURGE ARRESTOR AND 63 AMP AUXILIARY FUSE	[illegible]

PROTECTION PANEL LABELS	
TRF1	TRANSFORMER 1
TRF2	TRANSFORMER 2
TRF3	TRANSFORMER 3
SOO	SUMMATED OVERCURRENT
[illegible]	CUSTOMER OVERCURRENT 1
[illegible]	CUSTOMER OVERCURRENT 2



EQUIPMENT CLEARANCE

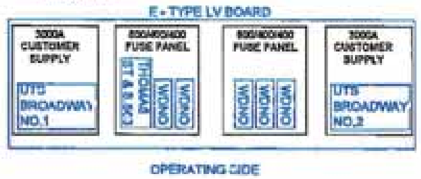
SCALE 1:50

HV SWITCHGEAR LABELS

NOT TO SCALE

LV SWITCHGEAR LABELS

NOT TO SCALE



CHAMBER SUBSTATION REFERENCE DRAWINGS	
A1-4800A	CONSTRUCTION DETAILS - MISCELLANEOUS
A1-40979	PULLING EYES DETAILS TYPE 'S' - 'C'
A1-25131	DETAILS OF EARTH ROD INSTALLATION
176037	'E' TYPE BOARD DIMENSIONS
177208	'E' TYPE LV BOARD CLEARANCES PIT DESIGN & CONSTRUCTION
176209	'E' TYPE LV BOARD STEELWORK GENERAL ARRANGEMENT
176210	'E' TYPE LV BOARD CABLE LADDER INSTALLATION FOR AUXILIARY
176233	RMCB SUBSTATIONS WITH 'E' TYPE LV BOARD AC AND DC SCHEMATICS
176238	'E' TYPE LV BOARD SUMMATED MOI CONNECTIONS DIAGRAM
101843	SUBURBAN TYPE SUBSTATION WITH 1500kVA TRANSFORMER SERVICE BOARD GENERAL ARRANGEMENT AND WIRING DIAGRAM
114901	NUMBERING AND COLOUR CODE OF WIRES FOR CONTROL AND PROTECTION EQUIPMENT
176231	RMS SUBSTATION WITH 'E' TYPE LV BOARD CABLING DIAGRAM AND SCHEDULE
176237	E TYPE LV BOARD MERLIN GERIN MASTERPACT AIR CIRCUIT BREAKERS EXTERNAL CONNECTIONS
181398	SUBSTATION HIGH VOLTAGE SIGN
30212	TRIPPING BATTERY TEST BOX ASSEMBLY AND WIRING DETAILS
113884	EARTH FAULT INDICATOR, TYPE EF13
11367	HV METAL CLAD FUSE SWITCHES & RMU EARTH FAULT INDICATOR TYPE EF13 MOUNTING SUPPORT DETAILS
03474	MOULDED TYPE LINK ASSEMBLIES WIRE TERMINATIONS CODING AND LOCKING STYLE DETAILS
10405	DISTRIBUTION SUBSTATIONS WALL MOUNTED DOUBLE TIER SUPPORTING FRAME FOR TRIPPING BATTERIES
10530	DISTRIBUTION SUBSTATIONS WALL MOUNTED SINGLE TIER SUPPORTING FRAME FOR TRIPPING BATTERIES
20855	SUBSTATION OPERATORS LOCKER DETAILS
180908	INSTALLATION OF LUCY & ORE VENNA RMCB
181073	CITY AND SUBURBAN DISTRIBUTION SUBSTATION PROTECTION PANEL DRILLING DETAILS
110248	DISTRIBUTION SUBSTATION STANDARD AC & DC MOULDED LINKS LABEL NUMBERING AND ENGRAVING
167815	RMS SUBSTATION WALL MOUNTED TRANSFORMER PROTECTION PANEL DRILLING AND WIRING
118534	CITY AND SUBURBAN DISTRIBUTION SUBSTATIONS WALL MOUNTED CUSTOMER SUPPLY & SELECT RENT PROTECTION PANEL DRILLING, WIRING AND CABLING
118579	CITY AND SUBURBAN DISTRIBUTION SUBSTATIONS WALL MOUNTED SUMMATED OVERCURRENT PROTECTION PANEL DRILLING, WIRING AND CABLING

NOTES

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- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 30 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

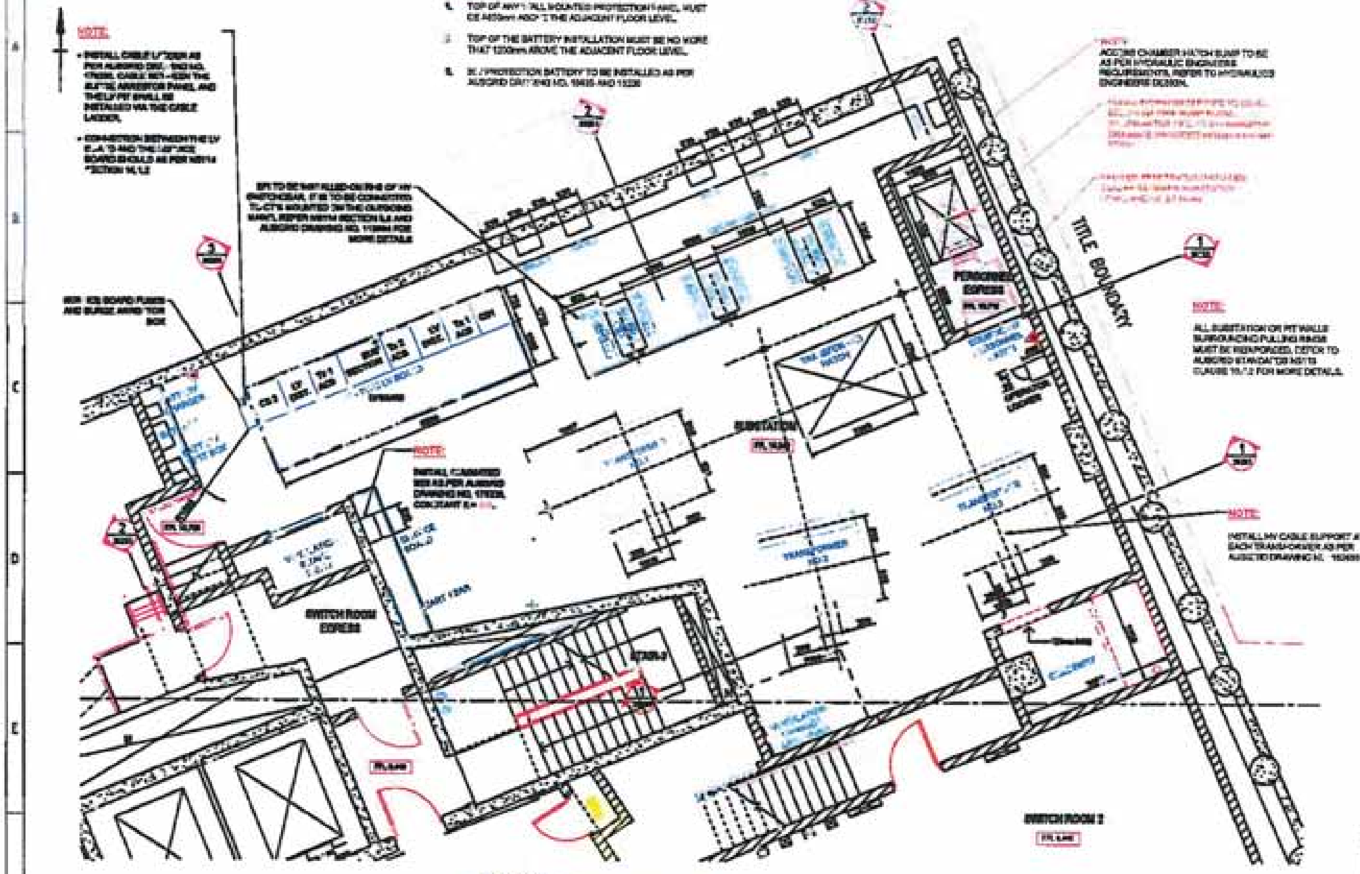
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	235036

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

A1 SC01596 5 of 16 0



EQUIPMENT LAYOUT

SCALE 1:50

SCALE 1:50

CHAMBER SUBSTATION NOTE

1. CONSTRUCTION AND EQUIPPING OF THIS SUBSTATION MUST BE IN ACCORDANCE WITH:
   - NS 0112, 0113, 0114, 0116, 0127, 0128, 0130, 171 AND 177
   - ARCHITECTURAL LOOK-IN DRAWING DETAIL
   - STRUCTURAL LOOK-IN DRAWING DETAIL
2. ALL CONDUITS USED IN CONJUNCTION WITH THE SUBSTATION CHAMBER IS TO CONFORM TO [illegible]
3. WHERE CONDUITS CHANGE DIRECTION, BENDS [illegible]
4. LABELLING AT MAINS AND APPARATUS IS TO BE CARRIED OUT IN ACCORDANCE TO NS [illegible]
5. PROTECTION AND CONTROL CABLE TO BE INSTALLED AS PER NS114 SECTION [illegible]
6. CABLES USED WITHIN THE SUBSTATION CHAMBER SHALL BE MULTI-STRANDED COPPER WITH PVC OR XLPE INSULATION [illegible]

SCHEDULE OF WORKS BY CUSTOMER

AT LOCATION	WORK DESCRIPTION
[illegible]	ESTABLISH THE BASEMENT CHAMBER SUBSTATION [illegible] IN THE LOCATION SHOWN. * PREPARE THE SITE AND CARRY OUT THE CIVIL WORKS. * SUPPLY AND INSTALL CONDUITS, CABLE CHASES AND PITS. * [illegible] * SUPPLY, INSTALL AND CONNECT EARTHING RODS & CABLES. * INSTALL PREWIRED PROTECTION PANELS. SUPPLY AND INSTALL THE FOLLOWING: * SECONDARY PROTECTION WIRING HV AND LV TRANSFORMER TAILS. * BATTERY AND ASSOCIATED COMPONENTS. * SERVICE BOARD. * PULLING RINGS. * LIGHTING. * WATER SUPPLY. * FIRE EXTINGUISHERS. * HV DIFFERENTIAL CTS. * EARTHING CABLE FROM THE SUBSTATION BAR TO [illegible] * [illegible] AND ASSOCIATED COMPONENTS. * [illegible]

AUSGRID FUNDED

UNDERGROUND CONSTRUCTION	LOW VOLTAGE MAINS COMPONENTS WITHIN DEDICATED PUBLIC ROADWAYS AND THE SUBSTATION PROPERTY RIGHTS AREA(S) USED FOR SUPPLYING NETWORK LOADS BEYOND THE DEVELOPMENT PROPERTY AS FOLLOWS: [illegible] THE INSTALLATION OF SPARE CONDUITS [illegible] - THE INSTALLATION OF THE FIBRE OPTIC PILOT CABLE CONDUIT ALONG THE HIGH VOLTAGE CABLE AND/OR CONDUIT ROUTE. TRENCHING FOR THE INSTALLATION OF AUSGRID FUNDED CABLE OR CONDUIT INSTALLATIONS THAT HAVE ONLY AUSGRID FUNDED COMPONENTS INSTALLED.
OVERHEAD CONSTRUCTION	NIL
MISCELLANEOUS	[illegible]
REIMBURSEMENT FOR NON-CONTESTABLE WORKS & INCLUDING GST	[illegible]

MATERIALS FUNDED BY AUSGRID

AT LOCATION	WORK DESCRIPTION
[illegible]	SUPPLY - [illegible] - [illegible] OIL-FILLED TRANSFORMERS - PREWIRED PROTECTION PANELS - PROTECTION RELAYS [illegible] - HV PROTECTION CTS - [illegible]

SCHEDULE OF WORKS BY AUSGRID

AT LOCATION	WORK DESCRIPTION
	[illegible]
[illegible]	[illegible]

GENERAL NOTES:

1. PULLING RINGS TO BE USED FOR PULLING CABLES CAN BE SUBJECTED TO A WORKING LOAD OF [illegible]
2. REINFORCED CONCRETE WITH A CLASS 2 FINISH.
3. AN OPERATORS LOCKER IS TO BE INSTALLED IN THE CHAMBER SUBSTATION. [illegible]
4. SUBSTATION WALLS MUST WITHSTAND [illegible]

LEGEND

[illegible]

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

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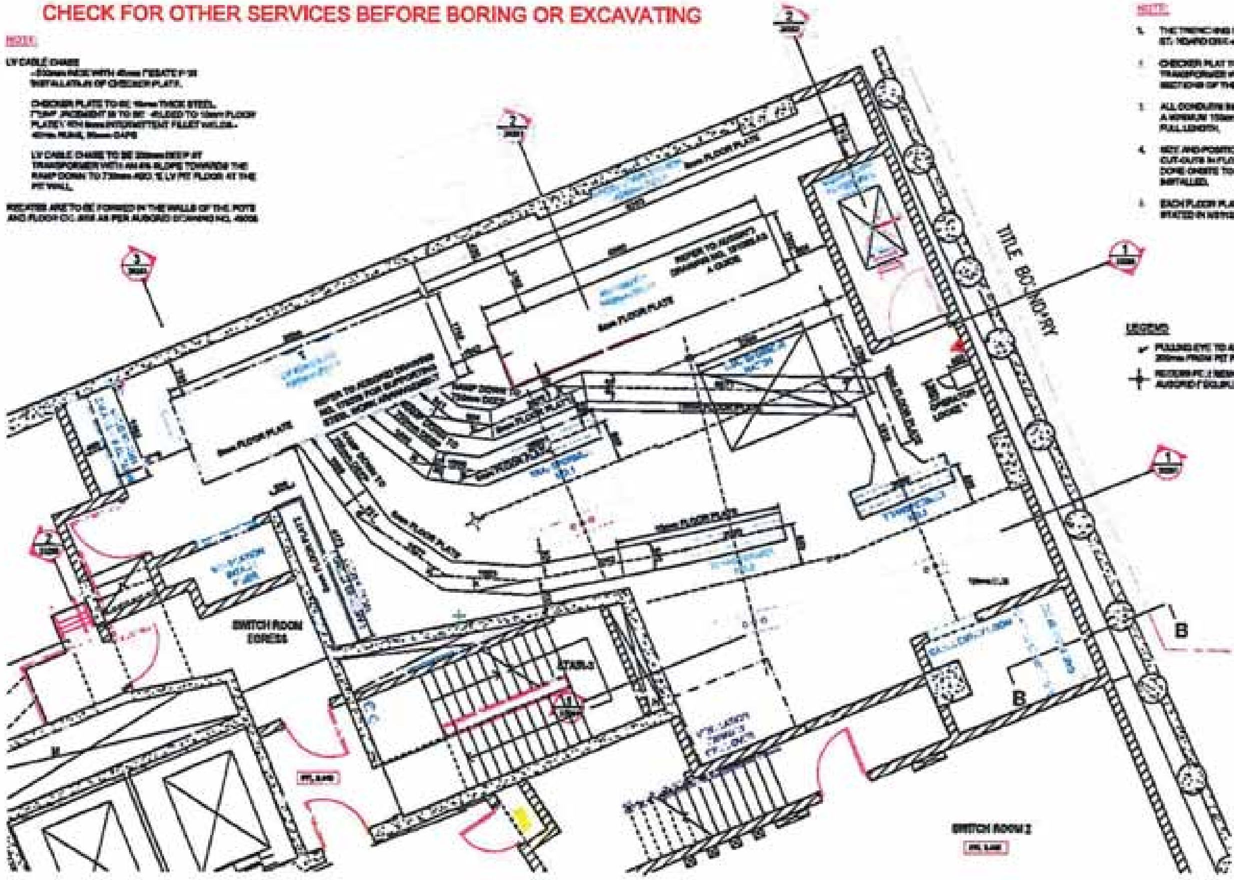
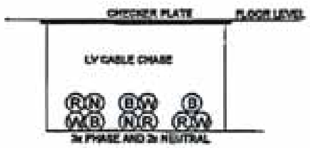
CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING



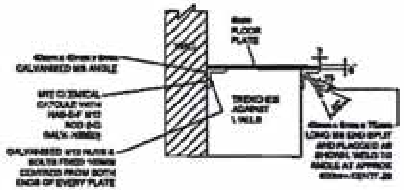
PITS, TRENCHED & CABLE CHASES ARRANGEMENT

SCALE 1:50



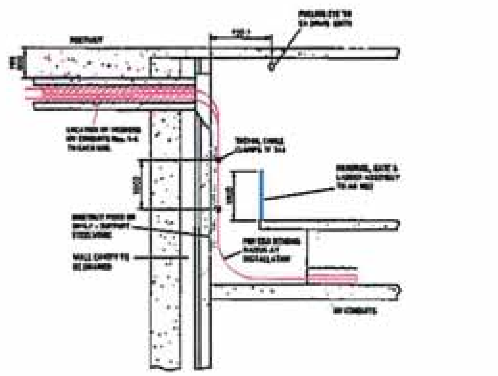
LV TRANSFORMER TAILS ARRANGEMENT IN LV CABLE CHASE

SCALE: NOT TO SCALE



TYPICAL TRENCHED AGAINST WALLS

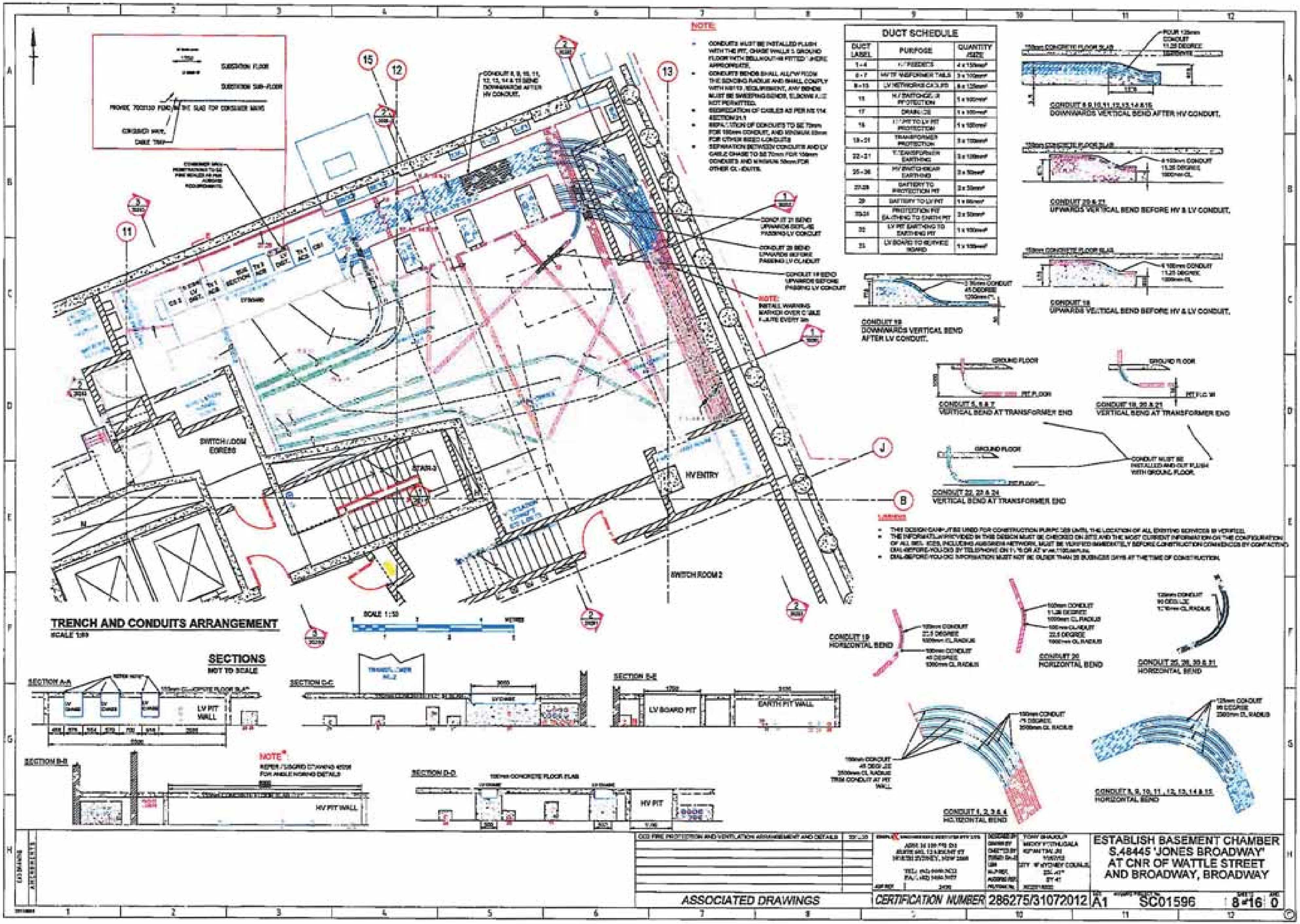
NOT TO SCALE



HV CABLE ENTRY POINT SECTION B-B

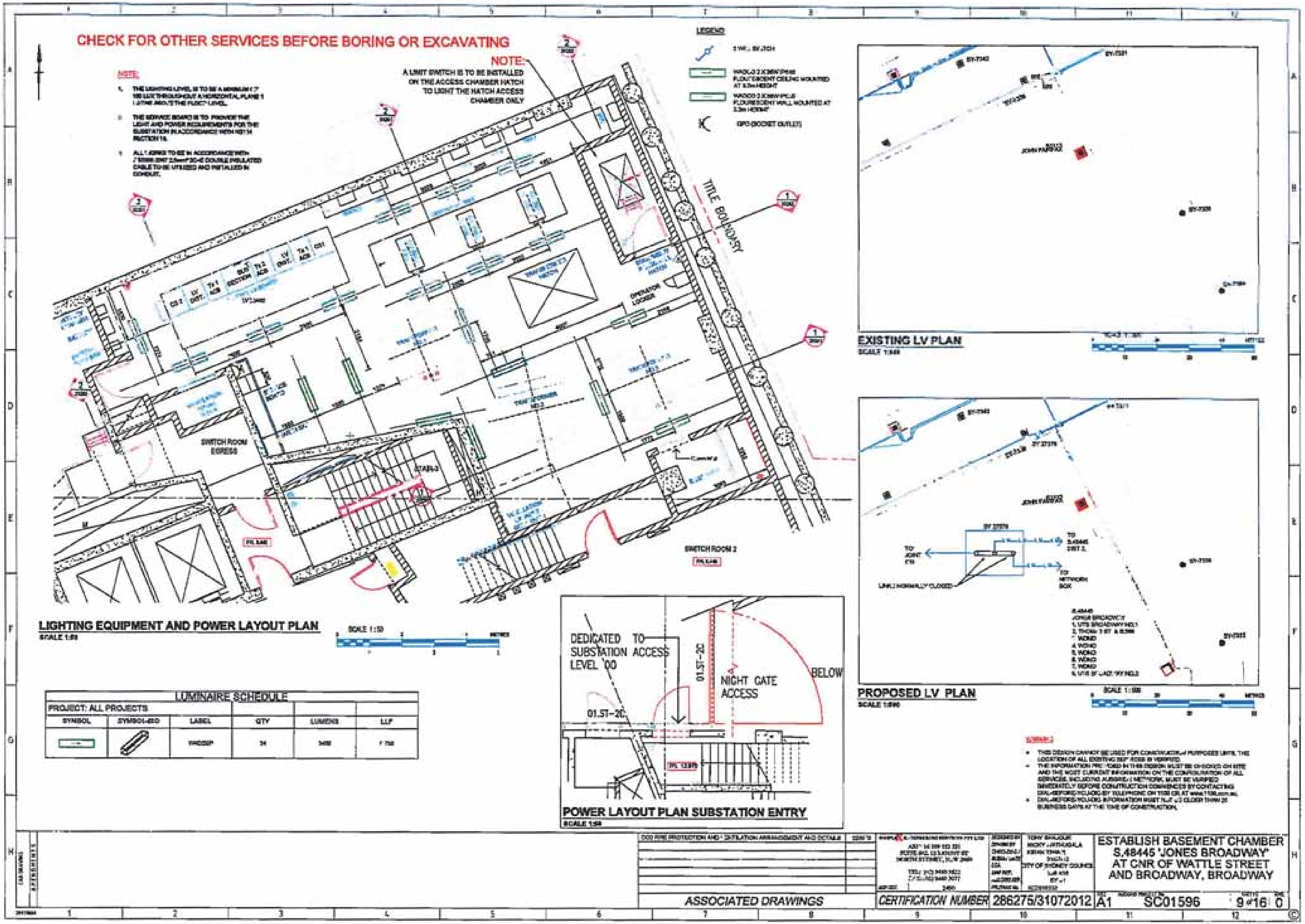
ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY

ASSOCIATED DRAWINGS	CERTIFICATION NUMBER	286275/31072012	A1	SC01596	7 of 16 0



DUCT SCHEDULE

DUCT LABEL	PURPOSE	QUANTITY /SIZE
1-4	HV FEEDERS	4 x 150mm²
5-7	HV TRANSFORMER TAILS	3 x 100mm²
8-15	LV NETWORKS CABLES	8 x 125mm²
16	HV SWITCHGEAR PROTECTION	1 x 100mm²
17	DRAINAGE	1 x 100mm²
18	LV PIT TO LV PIT PROTECTION	1 x 100mm²
19-21	TRANSFORMER PROTECTION	3 x 100mm²
22-24	TRANSFORMER EARTHING	3 x 100mm²
25-26	HV SWITCHGEAR EARTHING	2 x 50mm²
27-28	BATTERY TO PROTECTION PIT	2 x 50mm²
29	BATTERY TO LV PIT	1 x 50mm²
30-31	PROTECTION PIT EARTHING TO EARTH PIT	2 x 50mm²
32	LV PIT EARTHING TO EARTHING PIT	1 x 100mm²
33	LV BOARD TO SERVICE BOARD	1 x 100mm²



CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING
NOTE:
A LIMIT SWITCH IS TO BE INSTALLED ON THE ACCESS CHAMBER HATCH TO LIGHT THE HATCH ACCESS CHAMBER ONLY
LEGEND
TITLE BOUNDARY
SWITCH ROOM EGRESS
SWITCH ROOM 2
STAIR-3
OPERATOR LOCKER
LIGHTING EQUIPMENT AND POWER LAYOUT PLAN
SCALE 1:50
LUMINAIRE SCHEDULE
PROJECT: ALL PROJECTS
SYMBOL
SYMBOL-2D
LABEL
QTY
LUMENS
LLF
DEDICATED TO SUBSTATION ACCESS LEVEL '00
01.ST-2C
NIGHT GATE ACCESS
BELOW
POWER LAYOUT PLAN SUBSTATION ENTRY
EXISTING LV PLAN
PROPOSED LV PLAN
LINK (NORMALLY CLOSED)
ASSOCIATED DRAWINGS
CERTIFICATION NUMBER 286275/31072012
ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY
A1
SC01596
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0

NOTE:

1. BUILDERS MUST PROVIDE HOLES NOT LESS THAN 38mm DIAMETER THROUGH INTERMEDIATE FLOORS TO ALLOW FOR EARTHING CABLES TO PASS THROUGH.

2. PENETRATIONS THOUGH ANY WATERPROOF MEMBRAN SHALL BE APPROPRIATELY SEALED AS PER AUSGRID DRAWING NO. A1-25121.

3. ELECTRODES ARE TO BE INSTALLED TO NATURAL GROUND AT THE BASEMENT LEVEL B4 WITH ALLOCATED EARTHING EASEMENT.

EARTHING TABLE		
CONDUITS	DESCRIPTION	CABLE TYPE
22, 23 & 24	TRANSFORMER EARTH PIT	2 x 70mm² EACH TRANSFORMER
22, 23 & L1	TRANSFORMER TANK EARTH	4 x 70mm² EACH TRANSFORMER
25 & 26 & EARTHING PIT	HIGH VOLTAGE SWITCHGEAR EARTH	2 x 70mm² LOOP AROUND ONE CABLE IN EACH CONDUIT
27 & EARTHING PIT	PROTECTION PANEL EARTHING	2 x 6mm² LOOP AROUND ONE CABLE IN EACH CONDUIT
EARTHING PIT	LV BOARD EARTHING	6 x 70mm²
	WATER SUPPLY EARTHING	1 x 16mm²

LEGEND

PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)

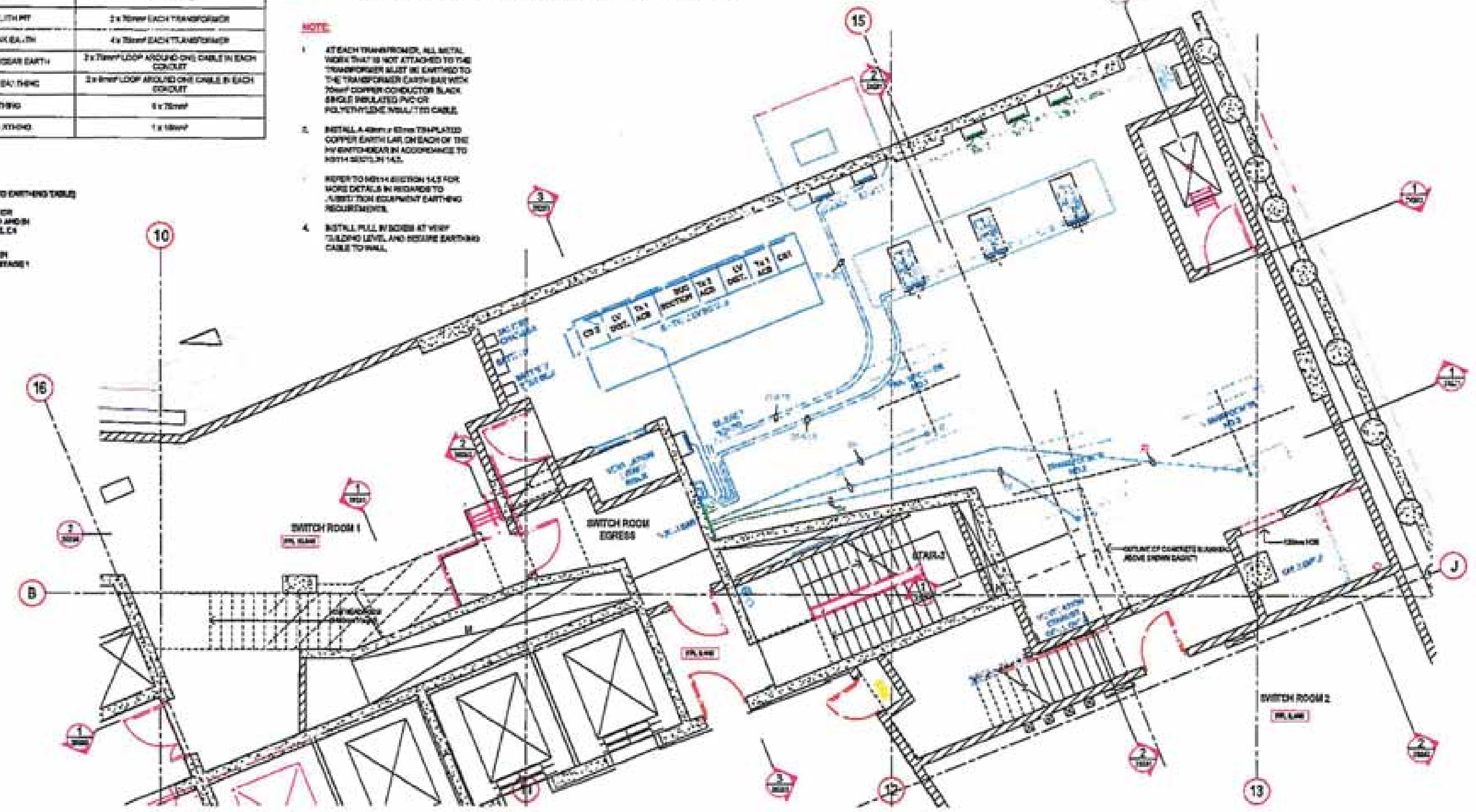
70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4

MINIMUM 6m DEEP EARTH ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF SCOPE

2 x 75mm GALVANISED PIPES

NOTE:

1. AT EACH TRANSFORMER, ALL METAL WORK THAT IS NOT ATTACHED TO THE TRANSFORMER MUST BE EARTHED TO THE TRANSFORMER EARTH BAR WITH 70mm² COPPER CONDUCTOR BLACK SINGLE INSULATED PVC OR POLYETHYLENE INSULATED CABLE.
2. INSTALL A 40mm x 6mm TIN-PLATED COPPER EARTH LAR ON EACH OF THE HV SWITCHGEAR IN ACCORDANCE TO NS114 SECTION 14.2.
3. REFER TO NS114 SECTION 14.5 FOR MORE DETAILS IN REGARDS TO SUBSTATION EQUIPMENT EARTHING REQUIREMENTS.
4. INSTALL PULL IN BOXES AT VERY BUILDING LEVEL AND SECURE EARTHING CABLE TO WALL.



EARTHING PLAN AT LEVEL 00
SCALE 1:50

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

ASSOCIATED DRAWINGS

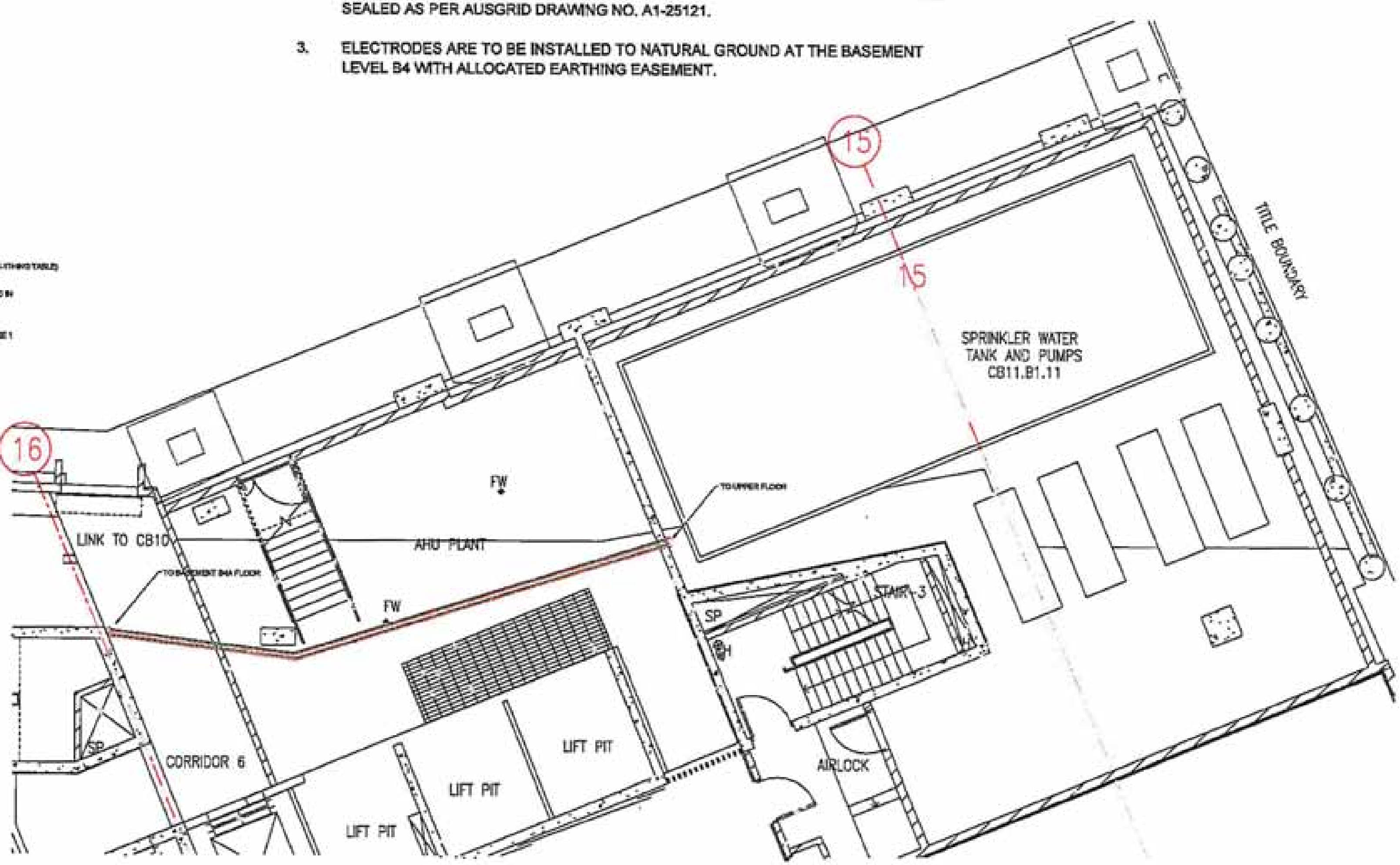
CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

A1 SC01596 10 of 16 0

NOTE:

1. BUILDERS MUST PROVIDE HOLES NOT LESS THAN 38mm DIAMETER THROUGH INTERMEDIATE FLOORS TO ALLOW FOR EARTHING CABLES TO PASS THROUGH.
2. PENETRATIONS THOUGH ANY WATERPROOF MEMBRAN SHALL BE APPROPRIATELY SEALED AS PER AUSGRID DRAWNG NO. A1-25121.
3. ELECTRODES ARE TO BE INSTALLED TO NATURAL GROUND AT THE BASEMENT LEVEL B4 WITH ALLOCATED EARTHING EASEMENT.



EARTHING PLAN AT LEVEL B1

SCALE 1:50

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012 A1

ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY

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CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

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- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 30 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

NOTE:

1. INSTALL PULL IN BOXES AT VERY BUILDING LEVEL AND SECURE EARTHING CABLE TO WALL.

LEGEND

PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)

70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4

MINIMUM 1m DEEP EARTH ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF [illegible]

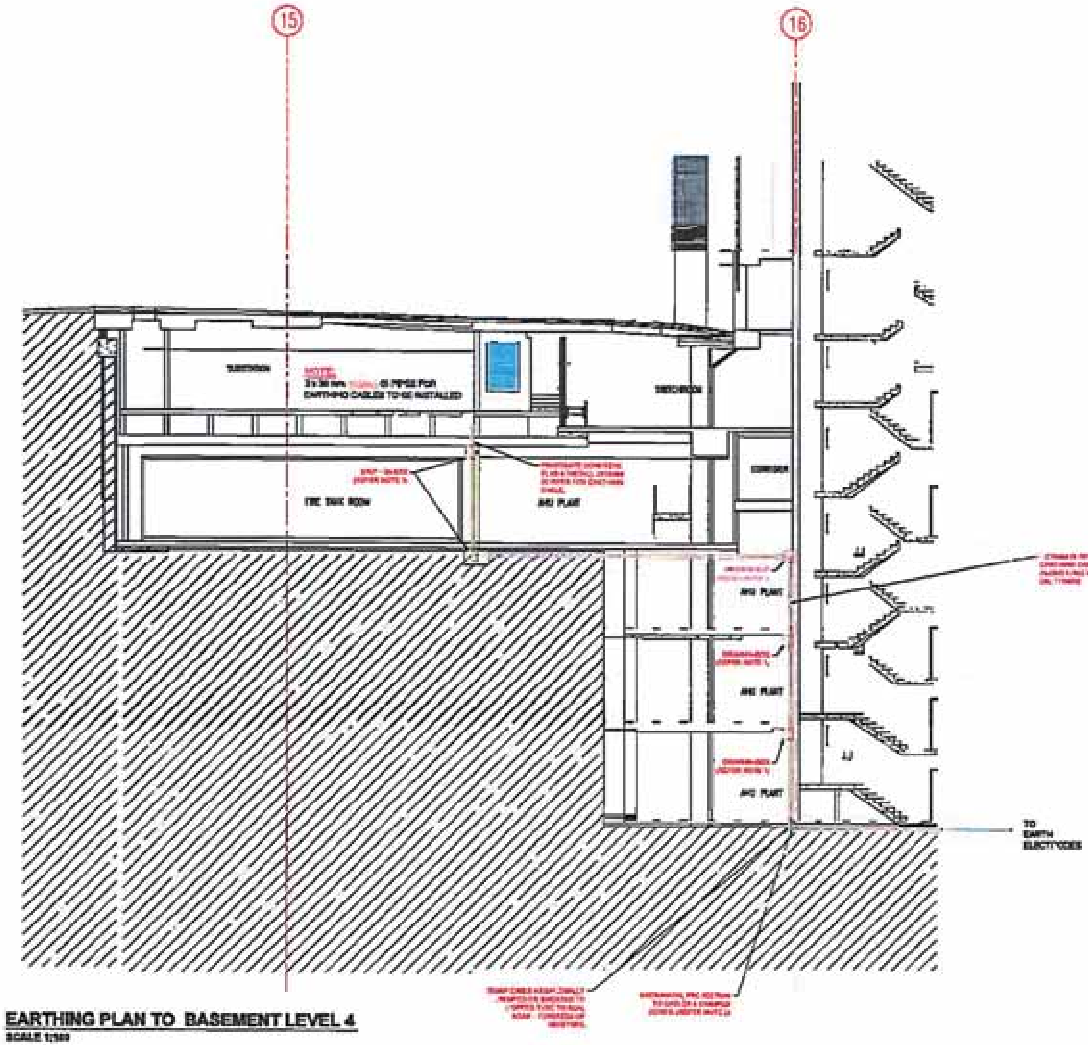
2 x 35mm GALVANISED PIPES

DRAWIN BOX

NOTE:

1. A SUITABLE GALVANISED STEEL DRAWIN BOX IS TO BE INSTALLED AT EACH CHANGE OF DIRECTION. THE BOX IS TO BE MOUNTED SUCH THAT IT IS ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
2. THE MECHANICAL PROTECTION TO CABLES AND CRIMPED JOINTS BETWEEN [illegible] BASEMENT INSTALLATIONS IS TO BE PERFORMED BY A REMOVABLE GALVANISED STEEL COVER. THE COVER IS TO BE ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
3. SUPPLY AND INSTALLATION OF EARTH ELECTRODES, FITTINGS AND CABLES IS TO BE CARRIED OUT BY THE SUBSTATION EQUIPPING CONTRACTOR BEFORE THE INSTALLATION OF ANY WATERPROOF MEMBRANE AND POURING OF THE BASEMENT OR SUBSTATION FLOOR SLAB.
4. EARTH ELECTRODES TO BE INSTALLED AS PER AUSGRID DWG NO. [illegible] FOR TYPICAL INSTALLATION OF EARTH ELECTRODES.

ALL WORKS TO BE CARRIED OUT AS PER AUSGRID DWG NO. [illegible] FOR TYPICAL INSTALLATION OF EARTH ELECTRODES.



EARTHING PLAN TO BASEMENT LEVEL 4

SCALE 1:[illegible]

ASSOCIATED DRAWINGS	CERTIFICATION NUMBER	286275/31072012	A1	SC01596

ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY

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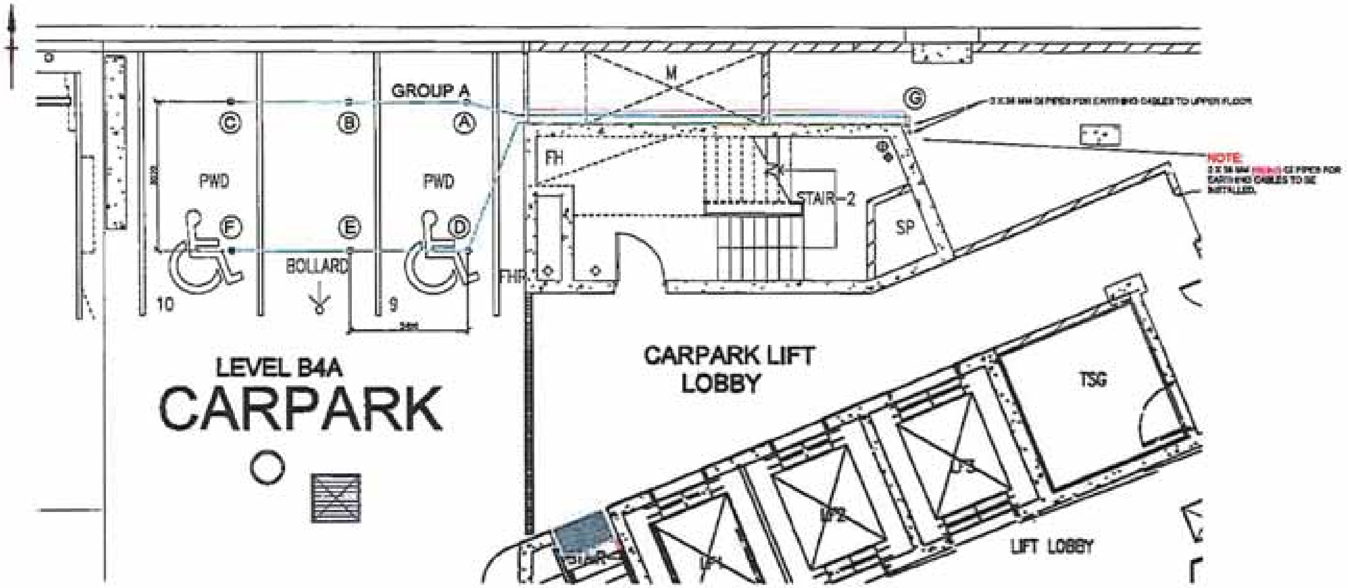


EARTHING PLAN 2 BASEMENT LEVEL B4A

SCALE 1:50

SCALE 1:50 METRES

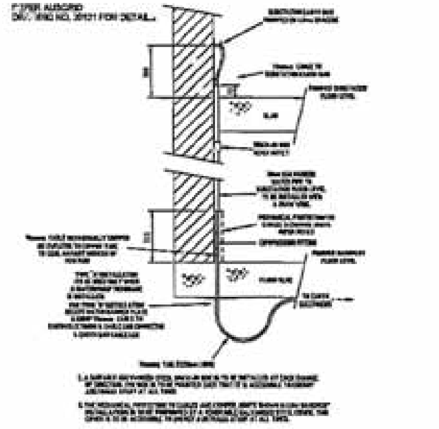
LEGEND

- PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)
- 70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4
- MINIMUM 3m DEEP ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF WORKS (AC2011002)
- 2 x 38mm GALVANISED PIPES

EARTHING SCHEDULE		
LOCATION	CONSTRUCTION DETAIL	PVC INSULATED 70 SQMM STRANDED COPPER CABLE LENGTH (m)
A TO B	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'A' AND REF 'B'	3.4
B TO C	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'B' AND REF 'C'	3.4
D TO E	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'D' AND REF 'E'	3.4
E TO F	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'E' AND REF 'F'	3.4
G TO A	RUN 70mm2 CU CABLE IN 38mm GI PIPE FROM WALL AT REF 'G' TO EARTH ROD AT REF 'A'	10.3
G TO D	RUN 70mm2 CU CABLE IN 38mm GI PIPE FROM WALL AT REF 'G' TO EARTH ROD AT REF 'D'	11.8

NOTES:

1. THIS DRAWING SHOWS TYPICAL INSTALLATION OF EARTH ELECTRODES IN CHAMBER SUBSTATIONS AND INDICATES:
   a. TYPE 'A' INSTALLATION (USED ONLY WHEN A WATERPROOF MEMBRANE IS INSTALLED).
   b. TYPE 'B' INSTALLATION (USED ONLY WHEN A WATERPROOF MEMBRANE IS NOT REQUIRED).
   AND SHOULD BE READ IN CONJUNCTION WITH THE SUBSTATION LAYOUT DRAWINGS AND NETWORK STANDARDS NS 13, NS 114, AND NS 116.
2. SUPPLY AND INSTALLATION OF EARTH ELECTRODES, FITTING AND CABLES IS TO BE CARRIED OUT BY THE SUBSTATION EQUIPPING CONTRACTOR BEFORE THE INSTALLATION OF ANY WATERPROOF MEMBRANE AND POURING OF THE BASEMENT OR SUBSTATION FLOOR SLAB.
3. ALL TERMINATIONS AND JOINTS IN STRANDED EARTH CONDUCTORS ARE TO BE MADE BY APPROVED COMPRESSION TECHNIQUES.
4. WHERE GROUND CONDITIONS PERMIT, ELECTRODES ARE TO BE DRIVEN USING APPROPRIATE ROD DRIVERS AND DRIVING HEADS. WHERE GROUND CONDITIONS REQUIRE DRILLING, A 70mm DIAMETER HOLE FOR ROCK OR A 50mm DIAMETER HOLE FOR CLAY IS TO BE BORED FOR EACH ELECTRODE, AN APPROVED EARTHING COMPOUND IS TO BE PUMPED INTO THE BORE HOLE AFTER ELECTRODE INSTALLATION. ALL ELECTRODE INSTALLATION ARE TO BE TO A MINIMUM DEPTH OF 3 METRES.
5. COPPER EARTHING CONNECTION ARE TO BE KEPT CLEAR OF STEEL REINFORCING OF FLOOR SLAB WHERE POSSIBLE. OTHERWISE PVC INSULATED CABLES ARE TO BE USED AND COMPRESSION FITTINGS ARE TO BE TAPED OVER.
6. A SUITABLE GALVANISED STEEL DRAWN BOX IS TO BE INSTALLED AT EACH CHANGE OF DIRECTION, THE BOX IS TO BE MOUNTED SUCH THAT IT IS ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
7. THE MECHANICAL PROTECTION TO CABLES AND CLAMPED JOINTS SHOWN IN LOW BASEMENT INSTALLATIONS IS TO BE PROVIDED BY A REMOVABLE GALVANISED STEEL COVER. THIS COVER IS TO BE ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
8. THE INSTALLATION AND CONNECTION OF THE EARTH RODS AND CONNECTING CABLES ARE TO BE INSPECTED AND APPROVED BY AUSGRID NOMINATED OFFICER BEFORE THE INSTALLATION OF ANY WATERPROOF MEMBRANE AND POURING OF THE BASEMENT OR SUBSTATION FLOOR SLAB.
9. FULL LENGTH OF EARTH CABLE FROM SUBSTATION TO THE EARTH ROD LOCATION INCLUDING EARTH ROD LOCATION SHALL BE NOMINATED AS AUSGRID EASEMENT WITH 24/7 ACCESS AS PER AUSGRID REQUIREMENTS.



TYPE A INSTALLATIONS WITH EARTH RODS IN THE LOWEST BASEMENT (LEVEL B4)

SCALE: NOT TO SCALE. (REFER AUSGRID DRAWING NO. A1-20121 FOR MORE DETAILS)

WARNING

- THIS DESIGN CANNOT BE USED FOR CONSTRUCTION PURPOSES UNTIL THE LOCATION OF ALL EXISTING SERVICES IS VERIFIED.
- THE INFORMATION PROVIDED IN THIS DESIGN MUST BE CHECKED ON SITE AND THE MOST CURRENT INFORMATION ON THE CONFIGURATION OF ALL SERVICES, INCLUDING AUSGRID NETWORK, MUST BE VERIFIED IMMEDIATELY BEFORE CONSTRUCTION COMMENCES BY CONTACTING DIAL-BEFORE-YOU-DIG BY TELEPHONE ON 1100 OR AT www.1100.com.au. DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

EARTHING REQUIREMENTS

- EARTHING OF SUBSTATION TO BE CARRIED OUT IN ACCORDANCE WITH NS-116, DRAWING NO. 187171 SHEETS 2 & 3, DRAWING NO. 20121 AND THIS DESIGN.
- THE EARTHING SYSTEM MUST BE INSTALLED BEFORE CEILING FLOOR IS CONSTRUCTED.
- THE EARTH GRIDS SHALL CONSIST OF A DEEP ELECTRODE SYSTEM INTERCONNECTED WITH EARTHING CABLE AS SPECIFIED IN NS 116 DESIGN STANDARDS FOR DISTRIBUTION EARTHING.
- THE MINIMUM NUMBER OF ELECTRODES IN EACH GROUP SHALL BE AS SPECIFIED IN NS 116 DESIGN STANDARDS FOR DISTRIBUTION EARTHING.
- MINIMUM SEPARATION BETWEEN ELECTRODES IS 3m.

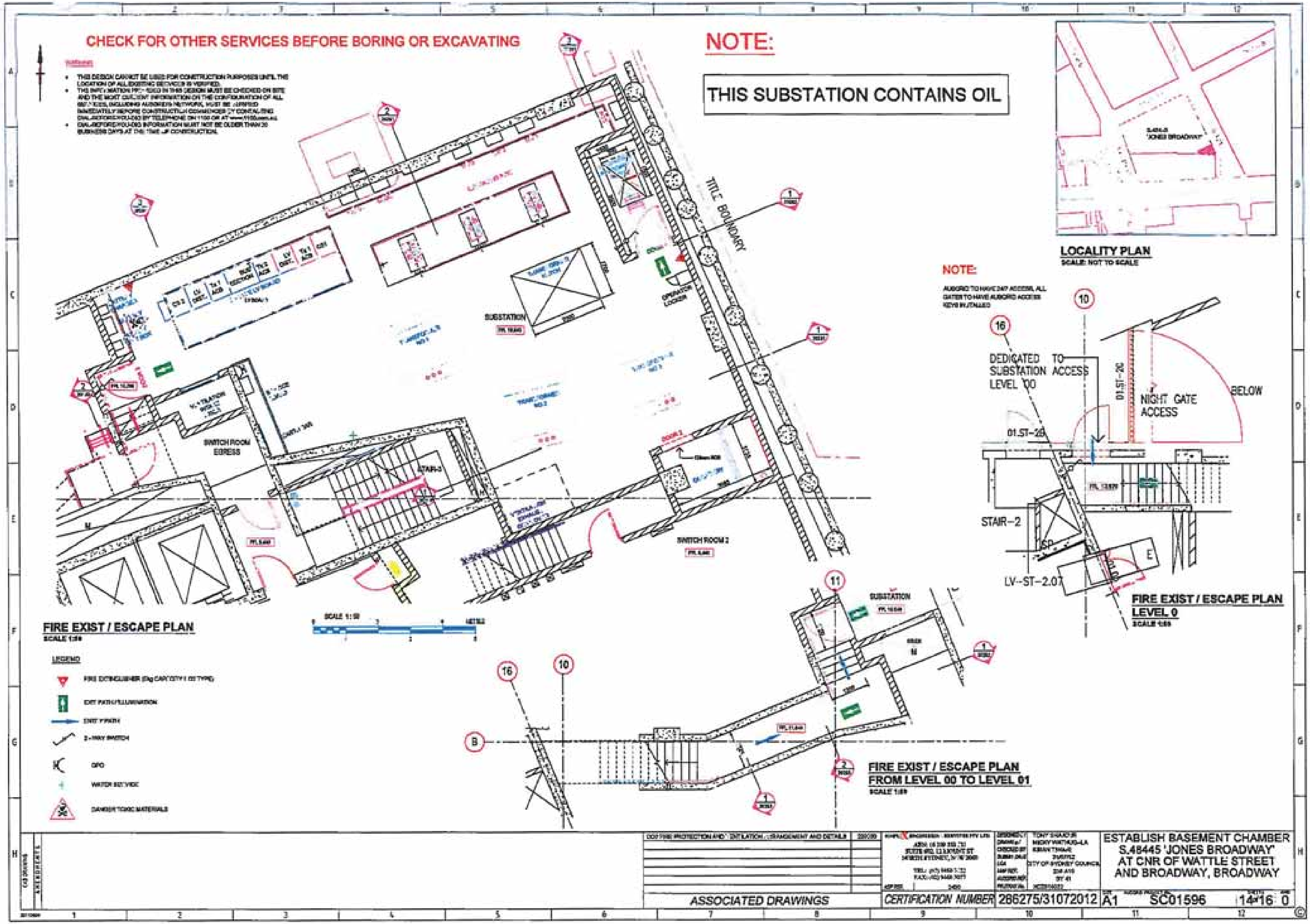
CONSTRUCTION PROCEDURE

- INSTALL THE EARTH ELECTRODES IN PROPOSED LOCATION USING SLEEVE HOLE/COPPER TUBE SYSTEM. THE ELECTRODE MUST BE INSTALLED TO A MIN. DEPTH OF 7.50m BELOW THE NATURAL GROUND LEVEL.
- THE EARTH ELECTRODES MUST BE MIN. 3m APART AND SEPARATION OF EACH GROUP OF ELECTRODE TO BE MIN. 2.5m OR AS PER EARTHING DIAGRAM.
- EARTHING GROUPS A AND B MUST BE CONNECTED TO THE EARTH BAR WITH PVC INSULATED 70 SQMM STRANDED COPPER CABLE.
- THE A AND B EARTH ELECTRODE GROUPS MUST BE INDEPENDENTLY CONNECTED AT THE EARTH BAR IN THE CHAMBER.

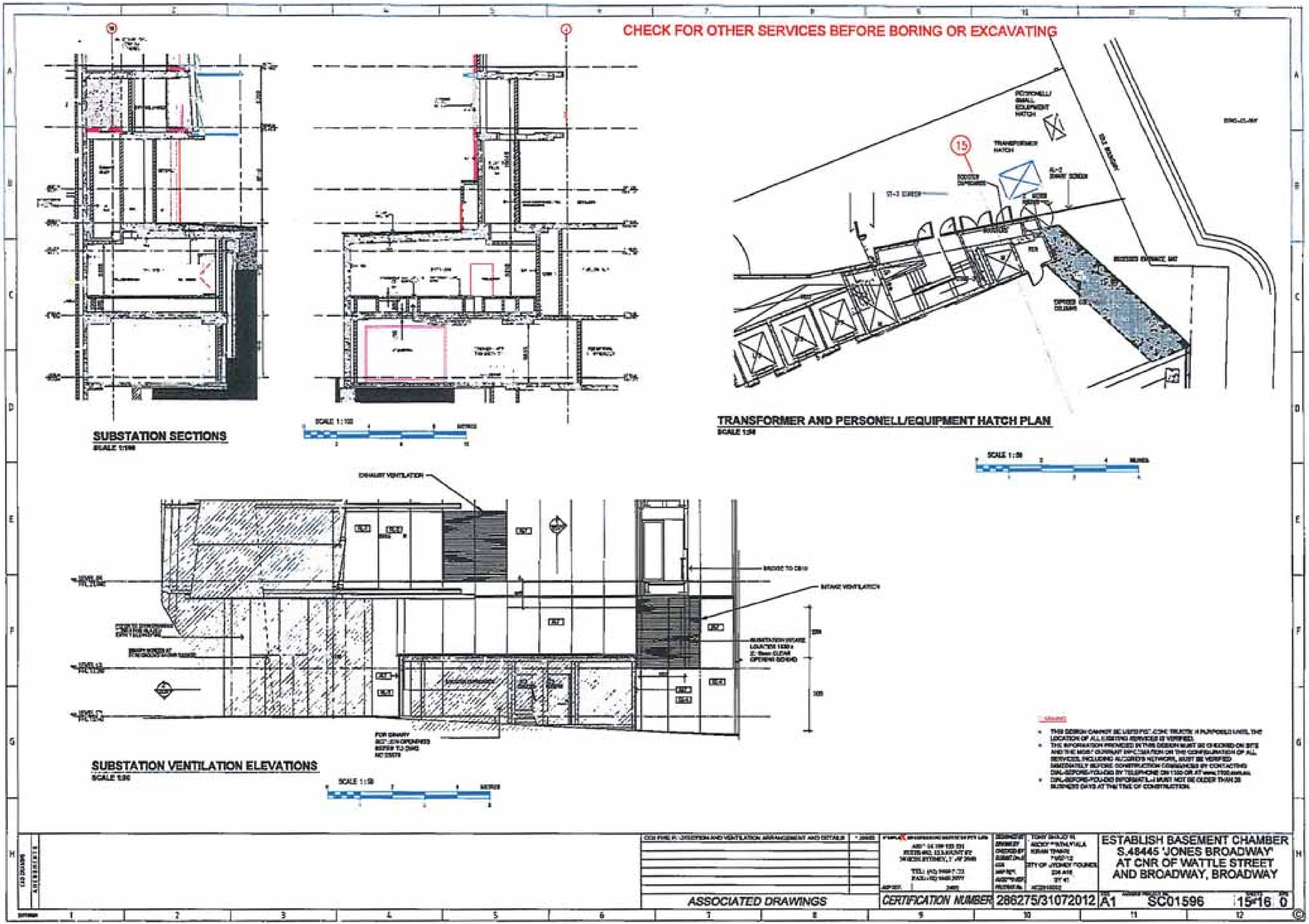
CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

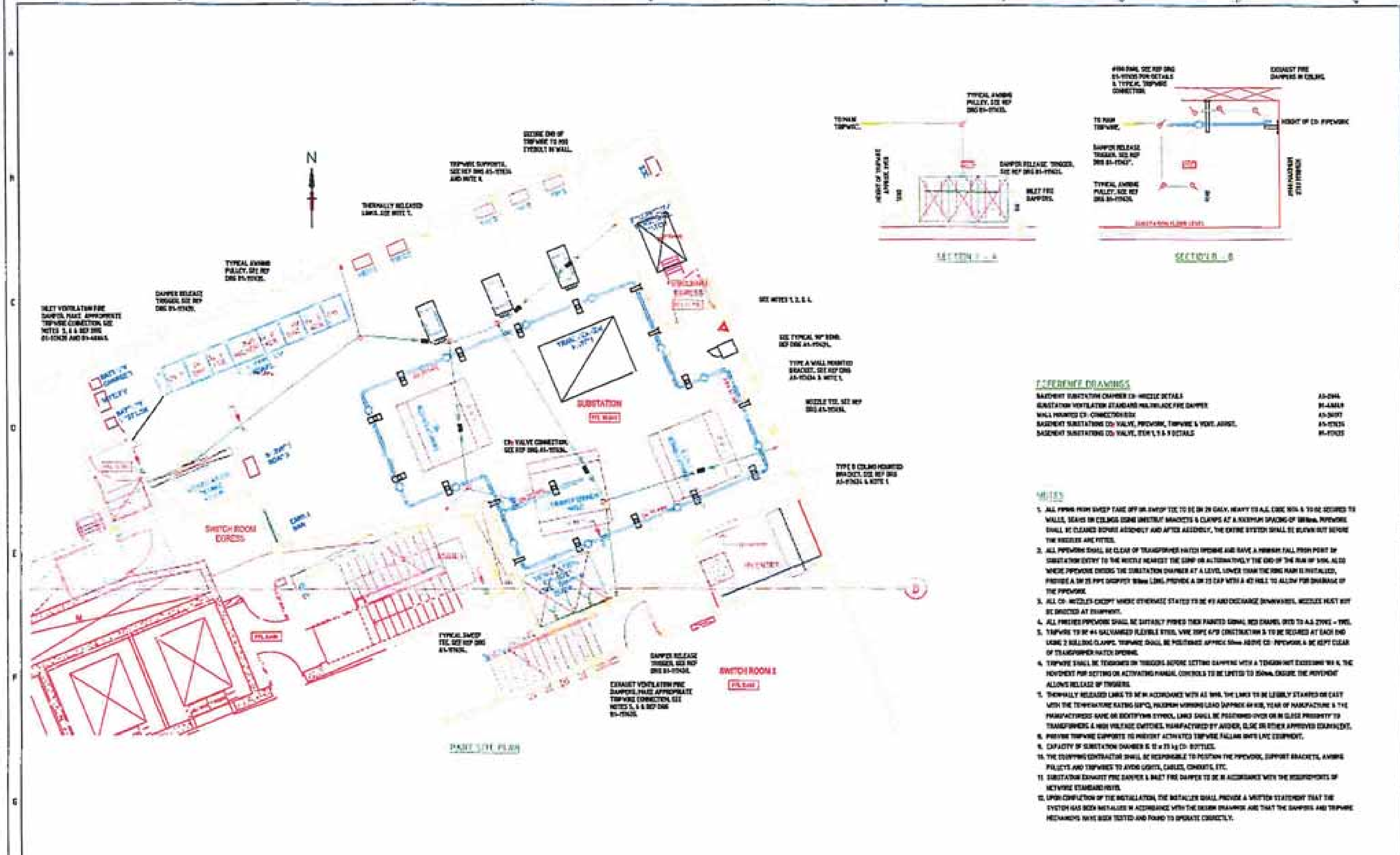
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS			
ASSOCIATED DRAWINGS	CERTIFICATION NUMBER 286275/31072012	A1	SC01596 13 of 16 0

ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY



CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING
NOTE:
THIS SUBSTATION CONTAINS OIL
TITLE BOUNDARY
LOCALITY PLAN
SCALE: NOT TO SCALE
NOTE:
SUBSTATION
SWITCH ROOM EGRESS
SWITCH ROOM 2
STAIR-2
DEDICATED TO SUBSTATION ACCESS LEVEL 00
NIGHT GATE ACCESS
BELOW
01.ST-20
LV-ST-2.07
FIRE EXIST / ESCAPE PLAN
LEVEL 0
FIRE EXIST / ESCAPE PLAN
SCALE 1:50
LEGEND
FIRE EXIST / ESCAPE PLAN
FROM LEVEL 00 TO LEVEL 01
ASSOCIATED DRAWINGS
CERTIFICATION NUMBER 286275/31072012
ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY
A1
SC01596
14/16
0


CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING
SUBSTATION SECTIONS
SCALE 1:100
TRANSFORMER AND PERSONELL/EQUIPMENT HATCH PLAN
SCALE 1:50
TRANSFORMER HATCH
15
EXHAUST VENTILATION
BRIDGE TO CB10
INTAKE VENTILATION
SUBSTATION VENTILATION ELEVATIONS
SCALE 1:50
ESTABLISH BASEMENT CHAMBER
S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY
ASSOCIATED DRAWINGS
CERTIFICATION NUMBER 286275/31072012
A1
SC01596
15 of 16
0



REFERENCE DRAWINGS

BASEMENT SUBSTATION CHAMBER CO2 NOZZLE DETAILS	A3-2944
SUBSTATION VENTILATION STANDARD MULTIBLADE FIRE DAMPER	B1-44849
WALL MOUNTED CO2 CONNECTION BOX	A3-36017
BASEMENT SUBSTATIONS CO2 VALVE, PIPEWORK, TRIPWIRE & VENT. ARRGT.	A1-117634
BASEMENT SUBSTATIONS CO2 VALVE, ITEM 1, 5 & 9 DETAILS	B1-117635

NOTES

1. ALL PIPING FROM SWEEP TAKE OFF OR SWEEP TEE TO BE DN 20 GALV. HEAVY TO A.S. 1074 & TO BE SECURED TO WALLS, BEAMS OR CEILINGS USING UNISTRUT BRACKETS & CLAMPS AT A MAXIMUM SPACING OF 1800mm. PIPEWORK SHALL BE CLEANED BEFORE ASSEMBLY AND AFTER ASSEMBLY, THE ENTIRE SYSTEM SHALL BE BLOWN OUT BEFORE THE NOZZLES ARE FITTED.
2. ALL PIPEWORK SHALL BE CLEAR OF TRANSFORMER HATCH OPENING AND HAVE A MINIMUM FALL FROM POINT OF SUBSTATION ENTRY TO THE NOZZLE NEAREST THE SUMP OR ALTERNATIVELY THE END OF THE RUN OF 1:100. ALSO WHERE PIPEWORK ENTERS THE SUBSTATION CHAMBER AT A LEVEL LOWER THAN THE RING MAIN IS INSTALLED, PROVIDE A DN 25 PIPE DROPPER 150mm LONG. PROVIDE A DN 25 CAP WITH A 4Ø HOLE TO ALLOW FOR DRAINAGE OF THE PIPEWORK.
3. ALL CO2 NOZZLES EXCEPT WHERE OTHERWISE STATED TO BE #3 AND DISCHARGE DOWNWARDS. NOZZLES MUST NOT BE DIRECTED AT EQUIPMENT.
4. ALL FINISHED PIPEWORK SHALL BE SUITABLY PRIMED THEN PAINTED SIGNAL RED ENAMEL (R13) TO A.S. 2700S - 1996.
5. TRIPWIRE TO BE #4 GALVANISED FLEXIBLE STEEL WIRE ROPE 6/19 CONSTRUCTION & TO BE SECURED AT EACH END USING 2 BULLDOG CLAMPS. TRIPWIRE SHALL BE POSITIONED APPROX 50mm ABOVE CO2 PIPEWORK & BE KEPT CLEAR OF TRANSFORMER HATCH OPENING.
6. TRIPWIRE SHALL BE TENSIONED ON TRIGGERS BEFORE SETTING DAMPERS WITH A TENSION NOT EXCEEDING 180 N. THE MOVEMENT FOR SETTING OR ACTIVATING MANUAL CONTROLS TO BE LIMITED TO 350mm. ENSURE THE MOVEMENT ALLOWS RELEASE OF TRIGGERS.
7. THERMALLY RELEASED LINKS TO BE IN ACCORDANCE WITH AS 1890. THE LINKS TO BE LEGIBLY STAMPED OR CAST WITH THE TEMPERATURE RATING (68°C), MAXIMUM WORKING LOAD (APPROX 64 KG), YEAR OF MANUFACTURE & THE MANUFACTURERS NAME OR IDENTIFYING SYMBOL. LINKS SHALL BE POSITIONED OVER OR IN CLOSE PROXIMITY TO TRANSFORMERS & HIGH VOLTAGE SWITCHES. MANUFACTURED BY ARCHER, GLOBE OR OTHER APPROVED EQUIVALENT.
8. PROVIDE TRIPWIRE SUPPORTS TO PREVENT ACTIVATED TRIPWIRE FALLING ONTO LIVE EQUIPMENT.
9. CAPACITY OF SUBSTATION CHAMBER IS 13 x 23 kg CO2 BOTTLES.
10. THE EQUIPPING CONTRACTOR SHALL BE RESPONSIBLE TO POSITION THE PIPEWORK, SUPPORT BRACKETS, AWNING PULLEYS AND TRIPWIRES TO AVOID LIGHTS, CABLES, CONDUITS, ETC.
11. SUBSTATION EXHAUST FIRE DAMPER & INLET FIRE DAMPER TO BE IN ACCORDANCE WITH THE REQUIREMENTS OF NETWORK STANDARD NS115.
12. UPON COMPLETION OF THE INSTALLATION, THE INSTALLER SHALL PROVIDE A WRITTEN STATEMENT THAT THE SYSTEM HAS BEEN INSTALLED IN ACCORDANCE WITH THE DESIGN DRAWINGS AND THAT THE DAMPERS AND TRIPWIRE MECHANISMS HAVE BEEN TESTED AND FOUND TO OPERATE CORRECTLY.

CAD DRAWING
AMENDMENTS

Ausgrid
DESIGN & ENGINEERING BRANCH
570 GEORGE STREET
SYDNEY NSW 2000

SCALE	1 : 50
DESIGNED	COLIN SAWDY
DRAWN	COLIN SAWDY
CHECKED	PETER WRIGHT
APPROVED	PHIL HUDSON
DATE	03.01.2012
PRJ/TRK No.	
PROJECT NUMBER	

S48445 JONES BROADWAY
Cnr JONES STREET AND BROADWAY ULTIMO
CO2 FIRE PROTECTION AND VENTILATION
ARRANGEMENT AND DETAILS

DRAWING No. 229960 SHEET 16 AMD 0 SIZE A1

20110604

8.2 Switchboards: SMBH

SMB UNITED LIMITED

ELECTRICAL SWITCHBOARD MANUAL

SMB Harwal Electric Pty Ltd
a member of the SMB group

SMB Harwal Electric Pty Ltd

Unit D3, Lane Cove Business Park, 16 Mars Road, Lane Cove NSW 2066
PO Box 4078, Lane Cove NSW 1595
Telephone: + 61 (2) 9420 7777
Website: www.smbharwal.com.au

SMB Macquarie Electric Pty Ltd
a member of the SMB Group

SMB Macquarie Electric Pty Ltd

Unit 3, 171 – 175 Newton Road, Wetherill Park NSW 2164
PO Box 6800, Wetherill Park DC NSW 1851
Telephone: + 61 (2) 9733 0600
Website: www.smbmacquarie.com.au

Table of Contents

1. Introduction

SMB Harwal Electric Pty Ltd and SMB Macquarie Electric Pty Ltd are wholly owned subsidiaries of SMB United Limited. With a manufacturing facility based at Lane Cove and Wetherill Park NSW producing high quality Electrical Switchboards.

Electrical Switchboards are manufactured in accordance with the following Australian Standards –
AS/NZS 3439.1 Low-voltage switchgear and control gear assemblies
AS/NZS 3000 Wiring Rules

Switchboards are tested in accordance with these standards and a copy of the relevant Inspection and Test Plans are available on request.

Work Health and Safety (WHS) regulations require the manufacturer of plant to identify risks associated with the use of said plant in this case the Electrical Switchboard. Section 2 will identify hazards associated with the use of the Electrical Switchboard and the control measures taken to reduce the risk associated with the hazard. This will ensure the "Person Conducting a Business or Undertaking" (PCBU as defined in the WHS Regulation) where the switchboard is located can ensure the proper use of the switchboard.

Section 3 identifies the maintenance requirements for the Electrical Switchboard. AS/NZS 3439.1 Low-voltage switchgear and control gear assemblies states:

"It is the responsibility of the owner of the ASSEMBLY to institute a system of maintenance. The manufacturer's recommendations should be addressed, together with the recommendations of AS 2467, in a planned preventative maintenance programme. This will minimize the risk of injury or breakdown and the consequent human suffering and/or loss of supply."

2. Work Health and Safety (WHS) Hazard Identification and Risk Assessment

Hazards associated with the use of the Electrical Switchboard are identified in this section. They are assigned a rating based on the follow risk matrix.

	Very likely Could happen anytime	**Likely** Could happen sometime	**Unlikely** Could happen but very rarely	**Very unlikely** Could happen but probably never will
Kill or cause permanent disability or ill health	1	1	2	3
Long term illness or serious injury	1	2	3	4
Medical attention and several days off work	2	3	4	5
First aid needed	3	4	5	6

Matrix as detailed in Workcover Hazpak – "A Practical Guide to Basic Risk Management"

Risk Matrix

Potential Hazard	Details of Hazard	Likelihood	Consequences	Severity	Risk Rating	Control Measure
Electrocution	Touching live parts whilst working on an isolated circuit	3	Electrocution	1	3	Form of Separation used to prevent contact. If form insufficient isolate entire switchboard prior to work
Arc Flash	Turning on a circuit breaker that has tripped	1	Burns	2	2	Ensure the fault has been cleared and the circuit tested prior to turning on
Arc Flash	Dust build up on live components	3	Burns	1	4	Ensure dust seals are not damaged
Lifting	Racking out and replacing Air Circuit Breakers	2	Back strain	3	5	Ensure appropriate mechanical device is used such as lifting trolley

3. Maintenance

AS/NZS 3439.1 Low-voltage switchgear and control gear assemblies states:

"It is the responsibility of the owner of the ASSEMBLY to institute a system of maintenance. The manufacturer's recommendations should be addressed, together with the recommendations of AS 2467, in a planned preventative maintenance programme. This will minimize the risk of injury or breakdown and the consequent human suffering and/or loss of supply."

The frequency of maintenance to be carried out on an electrical switchboard is subject to the environment in which the switchboard is located and the loading of the switchboard. Typically the following would be required:

Twelve Monthly Intervals (shutdown not required)

- Thermoscan the switchboard under load, provide a detailed report identifying any abnormal hot spots.
- Visual inspection of cable connections, insulation, door gaskets, signs of arc flash and faulty equipment.
- Corrosion or discolouration of paintwork.
- Correct operation of door locks and keys.
- Labelling.
- Energy Authority seals and locks.
- Ingress of vermin.
- Penetrations left unsealed.

Twenty Four Month Intervals (shutdown required)

- Carry out visual inspection as above.
- Torque tension all connections.
- Confirm all insulation barriers are in place.
- Close inspection of busbar supports.
- Thorough internal clean to ensure no build-up of foreign matter.

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form General Inspection & Testing	No. F-PRO- 11 Revision: I · Date: 12/12/08 · Page: 1 of 2

PROJECT:	ITEM:	DRAWING No:
UTS BROADWAY	MSB 1	2120163-01-01
	CHECKED OK	DRAWING REVISION: 02

GENERAL INSPECTION

ITEMS	N/A	YES	COMMENTS
GENERAL			
Paint colour & finish (visual inspection)		✓	
Equipment fitted square & neatly		✓	
Doors open & close satisfactory	✓		COVERS
Door latches close satisfactory i.e. 1/4 turn locks, T Handles & 3 point locking		✓	
Correct rubber fitted to doors/covers		✓	
Line side shrouds fitted			
Earth Contact clip fitted in each cubicle & connected to fitted pan		✓	
Heat Temperature stickers fitted (rear connect Inlelect joints)		✓	
LABELLING			
Wording checked against drawing		✓	
All standard labels fitted e.g. Control fuses behind etc		✓	
Background colour & text colour checked against drawing		✓	
All Warning labels fitted including discrimination label		✓	
Label fixing i.e. screw fix, nylon rivets or double sided tape complete		✓	SCREW FIX
SPD Supply Authority label requirements complete		✓	
All internal labels fitted neatly & straight.		✓	
Labelling complete		✗	'E1' DOOR LABEL T-BA
SWITCHGEAR			
Switchgear Ratings checked & Quantities checked against drawing		✓	
Service Protection Device pad lockable in **ON & OFF** position		✓	
Contactors & overloads ratings checked against drawing		✓	
Mechanical interlocks fitted & operated correctly		✓	
Fuse links continuity check		✓	
Inlelect Module stickers correctly filled out & check signed		✓	
Shorting Link for CT's fitted including bridges		✓	
C/T's correct ratio & polarity checked against drawing		✓	
R Clip fitted correctly holding mounting pan in position		✓	
Power Monitors fitted and set (see inspection form F-PRO-44)		✓	CT RATIO SET ONLY
BUSBARS			
Busbar sizes checked against drawing		✓	
Minimum Clearance (19mm phase to phase 16mm phase to Earth)		✓	
Supports in correct locations			
Three Phase connections tightened and check marked on nuts		✓	
Neutral connections tightened & check marked on nuts		✓	
Earth connections tightened and check marked on nuts		✓	
Inlelect copper spacers fitted		✓	
Hardware 8.8 high tensile bolts used on joints		✓	
Phase colour coding correct and checked against drawing		✓	
Covering - i.e. PVC dipping, PVC sleeving or heat shrink		✓	
Busbar joints wrapped satisfactory		✓	
Busbar joint covers fitted		✓	
Busbar flags for Submains suitable for cables		✓	

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form General Inspection & Testing	No. F-PRO- 11		
		Revision 1	Date 12/12/08	Page 2 of 2

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS
MISCELLANEOUS ITEMS			
Schedule holder fitted (supplied loose or stuck to inside door)	✓		
2 x 1/4 turn Keys provided with switchboard (cable tie to D handle)		✓	
Keys enclosed for ATS Selector switches		✓	
Council sealing on all unmeted doors (front & rear)		✓	
Correct Gland Plate material used as shown on drawing		✓	
Neutral numbered correctly to cell / circuit number		✓	
Neutral circuit connection bolts same as phase connection bolts		✓	
MEN link fitted and accessible		✓	
Timer instructions enclosed with switchboard		X	
CONTROL WIRING / POWER CABLING			
Colour coding on power cable lugs correct phasing		✓	
Correct coloured control cables used i.e. voltage free grey, Phase coloured actives etc		✓	
Terminal Terminations tight and fitted correctly		✓	
Control cable lugs crimped correctly		✓	
Correct duct size used. Check against drawing.		✓	
Cable supports in place		✓	
Correct rated control/power cable size used		✓	

ELECTRICAL TESTING

MEGGER & HI POT TESTING

NOTE: REMOVE ALL CONTROL FUSES & FAULT CURRENT LIMITERS & DISCONNECT NEUTRAL & EARTH AT SURGE DIVERTER

MΩ	SUPPLY 1 MΩ Before Hi Pot	SUPPLY 1 2.5kV 60 sec mA	SUPPLY 1 MΩ After Hi Pot	SUPPLY 2 MΩ Before Hi Pot	SUPPLY 2 2.5kV 60 sec mA	SUPPLY 2 MΩ After Hi Pot	SUPPLY 3 MΩ Before Hi Pot	SUPPLY 3 2.5kV 60 sec mA	SUPPLY 3 MΩ After Hi Pot
RED TO WHITE	∞	1.75mA	∞	∞					
RED TO BLUE	∞	1.75mA	∞	∞					
WHITE - BLUE	∞	1.75mA	∞	∞					
RWB - N									
RWN - NE	∞	4.25mA	∞	∞					

FUNCTIONAL TESTS

CIRCUIT	OPERATION CORRECT	INDICATIONS	AUXILIARY CONTACTS	COMMENTS
ATS Control				
Surge diverters 1,2,3	✓	✓	✓	
PFR 2,3 and 4	✓	✓	✓	
Power Monitors	✓	✓		CT RATIO SET ONLY

SHORTAGES

'E1' DOOR LABEL T.B.A.

Name of Testing Officer COLIN SADLER Signed C Sadler Date 04/12/12

Approved for release by Senior Electrical Supervisor Signed: [signature] Date 10/1/13

SMB Harwal Electric Pty Ltd
a member of the SMB Group

Form **Power Monitor** **General Inspection** **& Testing**	No. F-PRO-44			
	Revision A	Date 23/09/08	Page 1 of 1	

PROJECT: HTS BROADWAY	**ITEM:** MSB 1	**DRAWING NO:** 2120163-01-01
	CHECKED OK	**DRAWING REVISION:** 02

GENERAL INSPECTION

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		B7
CT ratio set up with in power monitor / state ratio		✓	Settings: 600
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 3000/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		F7
CT ratio set up with in power monitor / state ratio		✓	Settings: 600
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 3000/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		H4
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		H6
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		L4
CT ratio set up with in power monitor / state ratio		✓	Settings: 50
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 250/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form Power Monitor General Inspection & Testing	No. F-PRO-44		
		Revision A	Date 23/09/08	Page 1 of 1

PROJECT: LITS BROADWAY	ITEM: MSB 1		DRAWING NO: 2120163-01-01
ITEMS	CHECKED OK		DRAWING REVISION: 02
	NO	YES	COMMENTS

GENERAL INSPECTION

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(L6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(L8)
CT ratio set up with in power monitor / state ratio		✓	Settings: 80
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 400/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(M4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 50
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 250/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(M6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 17
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 60/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(M8)
CT ratio set up with in power monitor / state ratio		✓	Settings: 80
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 400/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

SMB Harwal Electric Pty Ltd	Form ATS Testing	No. F-PRO- 45		
		Revision A	Date 10/08/09	Page 1 of 1

PROJECT: UTS BROADWAY	ITEM: MSB 1	DRAWING No: 2120163-01-01	
		DRAWING REVISION: 02	

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS

GENERAL INSPECTION

ATS SELECTOR SWITCH 1 IN ~~[illegible]~~ OFF POSITION

	N/A	YES	COMMENTS
Both NORMAL & STANDBY breakers will not change over		✓	

ATS SELECTOR SWITCH 1 IN THE MANUAL POSITION & SELECTOR SWITCH 2 IN THE SUPPLY 1 (NORMAL) POSITION

	N/A	YES	COMMENTS
Both supplies are not available and both breakers are in off position		✓	
Normal Supply Available NORMAL breaker closed after time out period		✓	
Lose of Normal supply and Standby supply available no changeover of Breakers		✓	
Lose of both supplies no change in ATS. ATS remains NORMAL breaker closed		✓	
Both Supplies available manually switch STANDBY Breaker to on while NORMAL breaker on		✓	Mechanical interlock should not allow to happen
Both Supplies available manually switch NORMAL Breaker to off		✗	

ATS SELECTOR SWITCH 1 IN THE MANUAL POSITION & SELECTOR SWITCH 2 IN THE OFF POSITION

	N/A	YES	COMMENTS
Both NORMAL & STANDBY breakers are in the off position			
NORMAL breaker remains off when Normal Supply available			
STANDBY breaker remains off when Standby supply available			
Both NORMAL & STANDBY breakers are in the off position when either supply available			

ATS SELECTOR SWITCH 1 IN THE MANUAL POSITION & SELECTOR SWITCH 2 IN THE SUPPLY 2 (STANDBY) POSITION

	N/A	YES	COMMENTS
Both supplies are not available and both breakers are in off position		✓	
Standby supply Available STANDBY breaker closed after time out period		✓	
Lose of Standby supply and Normal supply available no changeover of Breakers		✓	
Lose of both supplies no change in ATS. ATS remains STANDBY breaker closed		✓	
Both Supplies available manually switch NORMAL Breaker to on while STANDBY breaker on		✓	Mechanical interlock should not allow to happen
Both Supplies available manually switch STANDBY Breaker to off		✗	

ATS SELECTOR SWITCH IN AUTO POSITION

	N/A	YES	COMMENTS
Both supplies are not available and both breakers are in off position		✓	
Normal Supply Available NORMAL breaker closed after time out period		✓	
Both supplies available NORMAL breaker remains closed		✓	
Lose of Normal supply and Standby supply available ATS changeover of Breakers to STANDBY breaker after time out period		✓	
Return of Normal supply ATS changes to NORMAL Breaker after time out period		✓	
Lose of both supplies no change in ATS. ATS remains Normal supply breaker closed		✓	

ATS SELECTOR SWITCH IN REMOTE POSITION

	N/A	YES	COMMENTS
Both supplies and remote signal are not available Both breakers are in off position			
Both supplies available and no remote signal Both breakers are in off position			
Remote Normal Close signal available NORMAL breaker closed			
Remote Normal Open signal available NORMAL breaker open			
Remote Standby Close signal available STANDBY breaker closed			
Remote Standby Open signal available STANDBY breaker open			

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form General Inspection & Testing	*No.* F-PRO- 11		
		Revision *1*	*Date* 12/12/08	*Page* *1 of 2*

PROJECT: HTS BROADWAY	ITEM: MSB-1 (TIER 'P')	DRAWING No: 2120163-01-01
ITEMS	CHECKED OK	DRAWING REVISION: 03

GENERAL INSPECTION

ITEMS	N/A	YES	COMMENTS
GENERAL			
Paint colour & finish (visual inspection)		✓	
Equipment fitted square & neatly		✓	
Doors open & close satisfactory		✓	COVERS
Door latches close satisfactory i.e. 1/4 turn locks, T Handles & 3 point locking		✓	
Correct rubber fitted to doors/covers		✓	
Line side shrouds fitted		✓	
Earth Contact clip fitted in each cubicle & connected to fitted pan		✓	
Heat Temperature stickers fitted (rear connect intelect joints)		✓	
LABELLING			
Wording checked against drawing		✓	
All standard labels fitted e.g. Control fuses behind etc		✓	
Background colour & text colour checked against drawing		✓	
All Warning labels fitted including discrimination label	✓	✗	~~[illegible]~~
Label fixing i.e. screw fix, nylon rivets or double sided tape complete		✓	SCREW
SPD Supply Authority label requirements complete	✓		
All internal labels fitted neatly & straight.		✓	
Labelling complete		✓	
SWITCHGEAR			
Switchgear Ratings checked & Quantities checked against drawing		✓	
Service Protection Device pad lockable in **ON & OFF** position	✓		
Contactors & overloads ratings checked against drawing	✓		
Mechanical interlocks fitted & operated correctly	✓		
Fuse links continuity check		✓	
Intelect Module stickers correctly filled out & check signed		✓	
Shorting Link for CT's fitted including bridges		✓	
C/T's correct ratio & polarity checked against drawing		✓	
R Clip fitted correctly holding mounting pan in position		✓	
Power Monitors fitted and set (see inspection form F-PRO-44)		✓	CT RATIO SET ONLY
BUSBARS			
Busbar sizes checked against drawing		✓	
Minimum Clearance (18mm phase to phase 16mm phase to Earth)		✓	
Supports in correct locations	✓		
Three Phase connections tightened and check marked on nuts		✓	
Neutral connections tightened & check marked on nuts		✓	
Earth connections tightened and check marked on nuts		✓	
Intelect copper spacers fitted		✓	
Hardware 8.8 high tensile bolts used on joints		✓	
Phase colour coding correct and checked against drawing		✓	
Covering - i.e. PVC dipping, PVC sleeving or heat shrink		✓	
Busbar joints wrapped satisfactory		✓	
Busbar joint covers fitted		✓	
Busbar flags for Submains suitable for cables		✓	

SMB Harwal Electric Pty Ltd (a member of the SMB Group)	Form General Inspection & Testing	No. F-PRO- 11		
		Revision I	Date 12/12/08	Page 2 of 2

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS
MISCELLANEOUS ITEMS			
Schedule holder fitted (supplied loose or stuck to inside door)	✓		
2 x 1/4 turn Keys provided with switchboard (cable tie to D handle)		✓	
Keys enclosed for ATS Selector switches		✓	
Council sealing on all unmetered doors (front & rear)	✓		
Correct Gland Plate material used as shown on drawing		✓	
Neutral numbered correctly to cell / circuit number		✓	
Neutral circuit connection bolts same as phase connection bolts		✓	
MEN link fitted and accessible	✓		
Timer instructions enclosed with switchboard	✓		
CONTROL WIRING / POWER CABLING			
Colour coding on power cable lugs correct phasing		✓	
Correct coloured control cables used i.e. voltage free grey. Phase coloured actives etc		✓	
Terminal Terminations tight and fitted correctly		✓	
Control cable lugs crimped correctly		✓	
Correct duct size used. Check against drawing.		✓	
Cable supports in place		✓	
Correct rated control/power cable size used		✓	

ELECTRICAL TESTING

NOTE: REMOVE ALL CONTROL FUSES & FAULT CURRENT LIMITERS & DISCONNECT NEUTRAL & EARTH AT SURGE DIVERTER

MEGGER & HI POT TESTING

MΩ	SUPPLY 1 MΩ Before Hi Pot	SUPPLY 1 2.5kV 60 sec mA	SUPPLY 1 MΩ After Hi Pot	SUPPLY 2 MΩ Before Hi Pot	SUPPLY 2 2.5kV 60 sec mA	SUPPLY 2 MΩ After Hi Pot	SUPPLY 3 MΩ Before Hi Pot	SUPPLY 3 2.5kV 60 sec mA	SUPPLY 3 MΩ After Hi Pot
RED TO WHITE	∞	1 mA	∞						
RED TO BLUE	∞	1 mA	∞						
WHITE - BLUE	∞	1 mA	∞						
RWB - N	∞	2 mA	∞						
RWN - NE									

FUNCTIONAL TESTS

CIRCUIT	OPERATION CORRECT	INDICATIONS	AUXILIARY CONTACTS	COMMENTS
POWER MONITORS	✓	✓		CT RATIO SET ONLY

SHORTAGES

Name of Testing Officer COLIN SADLER Signed [signature] Date 19/03/13

Approved for release by Senior Electrical Supervisor Signed: [signature] Date 25/03/1[illegible]

SMB Harwal Electric Pty Ltd	Form Power Monitor General Inspection & Testing	No. F-PRO-44		
		Revision A	Date 23/09/08	Page 1 of 1

PROJECT:	ITEM:	DRAWING NO:
UTS BROADWAY	MSB-1	2120163-01-01
		DRAWING REVISION: 03

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS

GENERAL INSPECTION

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96HD		(P1)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms Interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(P3)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms Interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(P5)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms Interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(P7)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms Interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(P9)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms Interface		✓	

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form General Inspection & Testing	No. F-PRO-11		
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PROJECT: UTS BROADWAY	ITEM: MDB 1	DRAWING No: 2120163-02-01
	CHECKED OK	DRAWING REVISION: 02

GENERAL INSPECTION

ITEMS	N/A	YES	COMMENTS
GENERAL			
Paint colour & finish (visual inspection)		✓	
Equipment fitted square & neatly		✓	
Doors open & close satisfactory		✓	
Door latches close satisfactory i.e. 1/4 turn locks, T Handles & 3 point locking		✓	
Correct rubber fitted to doors/covers		✓	
Line side shrouds fitted		✓	
Earth Contact clip fitted in each cubicle & connected to fitted pan		✓	
Heat Temperature stickers fitted (rear connect intelect joints)		✓	
LABELLING			
Wording checked against drawing		✓	
All standard labels fitted e.g. Control fuses behind etc		✓	
Background colour & text colour checked against drawing		✓	
All Warning labels fitted including discrimination label		✓	
Label fixing i.e. screw fix, nylon rivets or double sided tape complete		✓	
SPD Supply Authority label requirements complete		✓	
All internal labels fitted neatly & straight.		✓	
Labelling complete		✓	
SWITCHGEAR			
Switchgear Ratings checked & Quantities checked against drawing		✓	
Service Protection Device pad lockable in ON & OFF position	✓		
Contactors & overloads ratings checked against drawing	✓	✓	
Mechanical interlocks fitted & operated correctly		✓	
Fuse links continuity check		✓	
Intelect Module stickers correctly filled out & check signed		✓	
Shorting Link for CT's fitted including bridges		✓	
C/T's correct ratio & polarity checked against drawing		✓	
R Clip fitted correctly holding mounting pan in position		✓	
Power Monitors fitted and set (see inspection form F-PRO-44)		✓	CT RATIO SET ONLY
BUSBARS			
Busbar sizes checked against drawing		✓	
Minimum Clearance (10mm phase to phase 16mm phase to Earth)		✓	
Supports in correct locations		✓	
Three Phase connections tightened and check marked on nuts		✓	
Neutral connections tightened & check marked on nuts		✓	
Earth connections tightened and check marked on nuts		✓	
Intelect copper spacers fitted		✓	
Hardware 8.8 high tensile bolts used on joints		✓	
Phase colour coding correct and checked against drawing		✓	
Covering - i.e. PVC dipping, PVC sleeving or heat shrink		✓	
Busbar joints wrapped satisfactory		✓	
Busbar joint covers fitted		✓	
Busbar flags for Submains suitable for cables		✓	

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form General Inspection & Testing	No. F-PRO-11 Revision: / · Date: 12/12/08 · Page: 2 of 2

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS
MISCELLANEOUS ITEMS			
Schedule holder fitted (supplied loose or stuck to inside door)	✓		
2 x 1/4 turn Keys provided with switchboard (cable tie to D handle)		✓	
Keys enclosed for ATS Selector switches	✓		
Council sealing on all unmeted doors (front & rear)	✓		
Correct Gland Plate material used as shown on drawing		✓	
Neutral numbered correctly to cell / circuit number		✓	
Neutral circuit connection bolts same as phase connection bolts		✓	
MEN link fitted and accessible	✓		
Timer instructions enclosed with switchboard	✓		
CONTROL WIRING / POWER CABLING			
Colour coding on power cable lugs correct phasing		✓	
Correct coloured control cables used i.e. voltage free grey. Phase coloured actives etc		✓	
Terminal Terminations tight and fitted correctly		✓	
Control cable lugs crimped correctly		✓	
Correct duct size used. Check against drawing.		✓	
Cable supports in place		✓	
Correct rated control/power cable size used		✓	

ELECTRICAL TESTING

MEGGER & HI POT TESTING

NOTE: REMOVE ALL CONTROL FUSES & FAULT CURRENT LIMITERS & DISCONNECT NEUTRAL & EARTH AT SURGE DIVERTER

	SUPPLY 1			SUPPLY 2			SUPPLY 3		
MΩ	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot
RED TO WHITE	∞	1.75 mA	∞						
RED TO BLUE	∞	1.75 mA	∞						
WHITE - BLUE	∞	1.75 mA	∞						
RWB - N	∞	2.0 mA	∞						
RWN - NE									

FUNCTIONAL TESTS

CIRCUIT	OPERATION CORRECT	INDICATIONS	AUXILIARY CONTACTS	COMMENTS
POWER MONITORS	✓	✓		CT RATIO SET ONLY

SHORTAGES

Name of Testing Officer COLIN SADLER Signed [signature] Date 14/12/12

Approved for release by Senior Electrical Supervisor Signed: [signature] Date 10/01/13

SMB Harwal Electric Pty Ltd	Form Power Monitor General Inspection & Testing	No. F-PRO- 44		
		Revision A	Date 23/09/08	Page 1 of 1

PROJECT: UTS BROADWAY	ITEM: MDB 1		DRAWING NO: 2120168-02-01
ITEMS	CHECKED OK		DRAWING REVISION: 02
	NO	YES	COMMENTS

GENERAL INSPECTION

POWER MONITOR SETUP

Item	NO	YES	Comments
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(A3)
CT ratio set up with in power monitor / state ratio		✓	Settings: 400
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 2000/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Item	NO	YES	Comments
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(A8)
CT ratio set up with in power monitor / state ratio		✓	Settings: 126
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 630/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Item	NO	YES	Comments
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(B4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Item	NO	YES	Comments
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(B6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Item	NO	YES	Comments
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(C2)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

SMB Harwal Electric Pty Ltd	Form Power Monitor General Inspection & Testing	No. F-PRO-44		
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PROJECT:	ITEM:	DRAWING NO:
UTS BROADWAY	MDB1	2120163-02-01
		DRAWING REVISION: 02

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS

GENERAL INSPECTION

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(E4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96HD		(E8)
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96HD		(F4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96HD		(F6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(F8)
CT ratio set up with in power monitor / state ratio		✓	Settings: 12
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 60/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

SMB Harwal Electric Pty Ltd

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Form
Power Monitor General Inspection & Testing

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PROJECT: LITS BROADWAY

ITEM: MDB 1

DRAWING NO: 2120163-02-01

DRAWING REVISION: 02

GENERAL INSPECTION

POWER MONITOR SETUP

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(G1)
CT ratio set up with in power monitor / state ratio		✓	Settings: 12
Correct Ct's fitted in board & ratio checked against Dwg		✓✓	CT Ratio: 60/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS
Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

POWER MONITOR SETUP

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS
Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

POWER MONITOR SETUP

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS
Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

POWER MONITOR SETUP

ITEMS	CHECKED OK NO	CHECKED OK YES	COMMENTS
Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

SMB Harwal Electric Pty Ltd (a member of the SMB Group)	Form General Inspection & Testing	No. F-PRO-11		
		Revision 1	Date 12/12/08	Page 1 of 2

PROJECT: UTS BROADWAY	ITEM: MOB 2	DRAWING No: 2120163-03-01
	CHECKED OK	DRAWING REVISION: 02

GENERAL INSPECTION

ITEMS	N/A	YES	COMMENTS
GENERAL			
Paint colour & finish (visual inspection)		✓	
Equipment fitted square & neatly		✓	
Doors open & close satisfactory	✓		COVERS
Door latches close satisfactory i.e. 1/4 turn locks, T Handles & 3 point locking		✓	
Correct rubber fitted to doors/covers		✓	
Line side shrouds fitted		✓	
Earth Contact clip fitted in each cubicle & connected to fitted pan		✓	
Heat Temperature stickers fitted (rear connect Intelect joints)		✓	
LABELLING			
Wording checked against drawing		✓	
All standard labels fitted e.g. Control fuses behind etc		✓	
Background colour & text colour checked against drawing		✓	
All Warning labels fitted including discrimination label		✓	
Label fixing i.e. screw fix, nylon rivets or double sided tape complete		✓	SCREW FIX
SPD Supply Authority label requirements complete		✓	
All internal labels fitted neatly & straight.		✓	
Labelling complete		✓	
SWITCHGEAR			
Switchgear Ratings checked & Quantities checked against drawing		✓	
Service Protection Device pad lockable in **ON & OFF** position	✓		
Contactors & overloads ratings checked against drawing	✓		
Mechanical interlocks fitted & operated correctly		✓	
Fuse links continuity check		✓	
Intelect Module stickers correctly filled out & check signed		✓	
Shorting Link for CT's fitted including bridges		✓	
C/T's correct ratio & polarity checked against drawing		✓	
R Clip fitted correctly holding mounting pan in position		✓	
Power Monitors fitted and set (see inspection form F-PRO-44)		✓	CT RATIO SET ONLY
BUSBARS			
Busbar sizes checked against drawing		✓	
Minimum Clearance (19mm phase to phase 16mm phase to Earth)		✓	
Supports in correct locations			
Three Phase connections tightened and check marked on nuts		✓	
Neutral connections tightened & check marked on nuts		✓	
Earth connections tightened and check marked on nuts		✓	
Intelect copper spacers fitted		✓	
Hardware 8.8 high tensile bolts used on joints		✓	
Phase colour coding correct and checked against drawing		✓	
Covering - i.e. PVC dipping, PVC sleeving or heat shrink		✓	
Busbar joints wrapped satisfactory		✓	
Busbar joint covers fitted		✓	
Busbar flags for Submains suitable for cables		✓	

SMB Harwal Electric Pty Ltd	Form General Inspection & Testing	No. F-PRO-11		
		Revision I	Date 12/12/08	Page 2 of 2

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS
MISCELLANEOUS ITEMS			
Schedule holder fitted (supplied loose or stuck to inside door)	✓		
2 x 1/4 turn Keys provided with switchboard (cable tie to D handle)			
Keys enclosed for ATS Selector switches	✓		
Council sealing on all unmated doors (front & rear)	✓		
Correct Gland Plate material used as shown on drawing		✓	
Neutral numbered correctly to cell / circuit number		✓	
Neutral circuit connection bolts same as phase connection bolts		✓	
MEN link fitted and accessible	✓		
Timer instructions enclosed with switchboard	✓		
CONTROL WIRING / POWER CABLING			
Colour coding on power cable lugs correct phasing		✓	
Correct coloured control cables used i.e. voltage free grey. Phase coloured actives etc		✓	
Terminal Terminations tight and fitted correctly		✓	
Control cable lugs crimped correctly		✓	
Correct duct size used. Check against drawing.		✓	
Cable supports in place		✓	
Correct rated control/power cable size used		✓	

ELECTRICAL TESTING

MEGGER & HI POT TESTING

NOTE: REMOVE ALL CONTROL FUSES & FAULT CURRENT LIMITERS & DISCONNECT NEUTRAL & EARTH AT SURGE DIVERTER

	SUPPLY 1			SUPPLY 2			SUPPLY 3		
MΩ	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot
RED TO WHITE	∞	1.75mA	∞						
RED TO BLUE	∞	1.75mA	∞						
WHITE - BLUE	∞	1.75mA	∞						
RWB - N	∞	4mA	∞						
RWN - NE									

FUNCTIONAL TESTS

CIRCUIT	OPERATION CORRECT	INDICATIONS	AUXILIARY CONTACTS	COMMENTS
Power Monitors	✓	✓		CT Ratio set only

SHORTAGES

Door Labels, B2 TBA

Name of Testing Officer: Colin Sadler Signed: [signature] Date: 10/12/12

Approved for release by Senior Electrical Supervisor Signed: [signature] Date: 15/01/13

SMB Harwal Electric Pty Ltd a member of the Vlb Group	Form Power Monitor General Inspection & Testing	No. F-PRO-44 Revision A / Date 23/09/08 / Page 1 of 1
PROJECT: LTS BROADWAY / ITEM: MSB 2		DRAWING NO: Z120163-03-01
ITEMS	CHECKED OK	DRAWING REVISION: 02

GENERAL INSPECTION

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (A3)
CT ratio set up with in power monitor / state ratio		✓	Settings: 500
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 2500/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96HD (B2)
CT ratio set up with in power monitor / state ratio		✓	Settings: 16
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 80/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (B4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 50
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 250/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96HD (B6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (C2)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

SMB Harwal Electric Pty Ltd a member of the SMB Group	Form Power Monitor General Inspection & Testing	No. F-PRO- 44		
		Revision A	Date 23/09/08	Page 1 of 1

PROJECT: UTS BROADWAY	ITEM: MSB 2		DRAWING NO: 2120163-03-01
ITEMS	CHECKED OK		DRAWING REVISION: 02
	NO	YES	COMMENTS

GENERAL INSPECTION

POWER MONITOR SETUP

	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(C4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96HD		(C6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓	✓	
Point to Point comms interface		✓	

POWER MONITOR SETUP

	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(D4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		(D6)
CT ratio set up with in power monitor / state ratio			Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

POWER MONITOR SETUP

	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

SMB Harwal Electric Pty Ltd (a member of the SMB Group)	Form General Inspection & Testing	No. F-PRO-11		
		Revision /	Date 12/12/08	Page 1 of 2

PROJECT: UTS BROADWAY
ITEM: MDB 3
DRAWING No: 2120163 - 04.01
DRAWING REVISION: 02

GENERAL INSPECTION

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS
GENERAL			
Paint colour & finish (visual inspection)		✓	
Equipment fitted square & neatly		✓	
Doors open & close satisfactory		✓	
Door latches close satisfactory i.e. 1/4 turn locks, T Handles & 3 point locking		✓	
Correct rubber fitted to doors/covers		✓	
Line side shrouds fitted		✓	
Earth Contact clip fitted in each cubicle & connected to fitted pan		✓	
Heat Temperature stickers fitted (rear connect intelect joints)		✓	
LABELLING			
Wording checked against drawing		✓	
All standard labels fitted e.g. Control fuses behind etc		✓	
Background colour & text colour checked against drawing		✓	
All Warning labels fitted including discrimination label		✓	
Label fixing i.e. screw fix, nylon rivets or double sided tape complete		✓	SCREW FIX
SPD Supply Authority label requirements complete		✓	
All internal labels fitted neatly & straight.		✓	
Labelling complete		✓	
SWITCHGEAR			
Switchgear Ratings checked & Quantities checked against drawing		✓	
Service Protection Device pad lockable in **ON & OFF** position	✓		
Contactors & overloads ratings checked against drawing	✓		
Mechanical interlocks fitted & operated correctly		✓	
Fuse links continuity check		✓	
Intelect Module stickers correctly filled out & check signed		✓	
Shorting Link for CT's fitted including bridges		✓	
C/T's correct ratio & polarity checked against drawing		✓	
R Clip fitted correctly holding mounting pan in position		✓	
Power Monitors fitted and set (see inspection form F-PRO-44)		✓	C.T. RATIO SET ONLY
BUSBARS			
Busbar sizes checked against drawing		✓	
Minimum Clearance (19mm phase to phase 16mm phase to Earth)		✓	
Supports in correct locations		✓	
Three Phase connections tightened and check marked on nuts		✓	
Neutral connections tightened & check marked on nuts		✓	
Earth connections tightened and check marked on nuts		✓	
Intelect copper spacers fitted		✓	
Hardware 8.8 high tensile bolts used on joints		✓	
Phase colour coding correct and checked against drawing		✓	
Covering - i.e. PVC dipping, PVC sleeving or heat shrink		✓	
Busbar joints wrapped satisfactory		✓	
Busbar joint covers fitted		✓	
Busbar flags for Submains suitable for cables		✓	

SMB Harwal Electric Pty Ltd	Form General Inspection & Testing	No. F-PRO-11		
		Revision I	Date 12/12/08	Page 2 of 2

ITEMS	CHECKED OK N/A	CHECKED OK YES	COMMENTS
MISCELLANEOUS ITEMS			
Schedule holder fitted (supplied loose or stuck to inside door)	✓		
2 x 1/4 turn Keys provided with switchboard (cable tie to D handle)		✓	
Keys enclosed for ATS Selector switches	✓		
Council sealing on all unmeted doors (front & rear)	✓		
Correct Gland Plate material used as shown on drawing		✓	
Neutral numbered correctly to cell / circuit number		✓	
Neutral circuit connection bolts same as phase connection bolts		✓	
MEN link fitted and accessible	✓		
Timer instructions enclosed with switchboard	✓		
CONTROL WIRING / POWER CABLING			
Colour coding on power cable lugs correct phasing		✓	
Correct coloured control cables used i.e. voltage free grey. Phase coloured actives etc		✓	
Terminal Terminations tight and fitted correctly		✓	
Control cable lugs crimped correctly		✓	
Correct duct size used. Check against drawing.		✓	
Cable supports in place		✓	
Correct rated control/power cable size used		✓	

ELECTRICAL TESTING

MEGGER & HI POT TESTING

NOTE: REMOVE ALL CONTROL FUSES & FAULT CURRENT LIMITERS & DISCONNECT NEUTRAL & EARTH AT SURGE DIVERTER

	SUPPLY 1			SUPPLY 2			SUPPLY 3		
MΩ	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot	MΩ Before Hi Pot	2.5kV 60 sec mA	MΩ After Hi Pot
RED TO WHITE	∞	1mA	∞						
RED TO BLUE	∞	1mA	∞						
WHITE - BLUE	∞	1mA	∞						
RWB - N	∞	2mA	∞						
RWN - NE									

FUNCTIONAL TESTS

CIRCUIT	OPERATION CORRECT	INDICATIONS	AUXILIARY CONTACTS	COMMENTS
POWER MONITORS	✓	✓		CT RATIO SET ONLY

SHORTAGES

Name of Testing Officer COLIN SADLER Signed [signature] Date 17/12/12

Approved for release by Senior Electrical Supervisor Signed: [signature] Date 10/01/13

SMB Harwal Electric Pty Ltd (a member of the 1st IS Group)	Form Power Monitor General Inspection & Testing	No. F-PRO-44		
		Revision A	Date 23/09/08	Page 1 of 1
PROJECT: UTS BROADWAY	ITEM: MDB 3	DRAWING NO: 2120163-04-01		
ITEMS	CHECKED OK	DRAWING REVISION: 02		

GENERAL INSPECTION

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (A3)
CT ratio set up with in power monitor / state ratio		✓	Settings: 320
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 1600/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (B2)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (B4)
CT ratio set up with in power monitor / state ratio		✓	Settings: 32
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 160/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96 HD (B6)
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface			

POWER MONITOR SETUP

ITEMS	NO	YES	COMMENTS
Type of Power Monitor Fitted and Location within board			NEMO 96HD (D3)
CT ratio set up with in power monitor / state ratio		✓	Settings: 50
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 250/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

SMB Harwal Electric Pty Ltd (a member of the UGL Group)	Form Power Monitor General Inspection & Testing	No. F-PRO- 44		
		Revision A	Date 23/09/08	Page 1 of 1

PROJECT: VTS BROADWAY	ITEM: MDB 3	DRAWING NO: 2120163-06-01

ITEMS	CHECKED OK		DRAWING REVISION:
	NO	YES	COMMENTS

GENERAL INSPECTION

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96HD		D5
CT ratio set up with in power monitor / state ratio		✓	Settings: 20
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 100/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board	NEMO 96HD		D7
CT ratio set up with in power monitor / state ratio		✓	Settings: 40
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 200/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

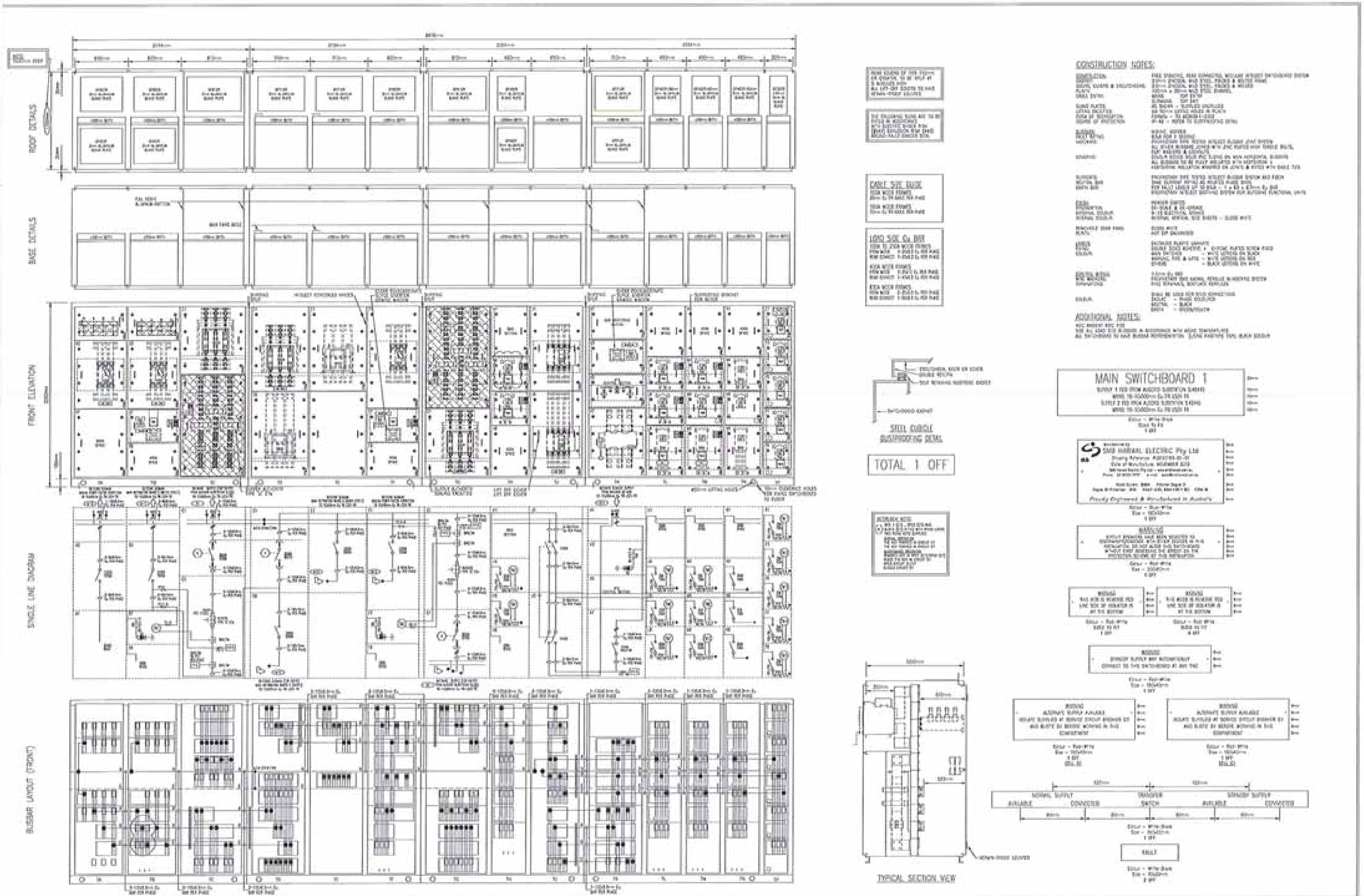
Type of Power Monitor Fitted and Location within board	NEMO 96 HD		D9
CT ratio set up with in power monitor / state ratio		✓	Settings: 12
Correct Ct's fitted in board & ratio checked against Dwg		✓	CT Ratio: 60/5A
CT polarity fitted correctly in board (P1 towards incomming)		✓	
Wiring correct from CT's to shorting links		✓	
Wiring correct from shorting links to power monitors		✓	
CT shorting links bridged	✓		
Point to Point comms interface		✓	

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			

POWER MONITOR SETUP

Type of Power Monitor Fitted and Location within board			
CT ratio set up with in power monitor / state ratio			Settings:
Correct Ct's fitted in board & ratio checked against Dwg			CT Ratio:
CT polarity fitted correctly in board (P1 towards incomming)			
Wiring correct from CT's to shorting links			
Wiring correct from shorting links to power monitors			
CT shorting links bridged			
Point to Point comms interface			



REVISIONS	
REFERENCES	

IT IS THE ELECTRICAL CONTRACTORS RESPONSIBILITY TO VERIFY OVERALL DIMENSIONS, CABLE ENTRIES AND SITE ACCESS FOR POSITIONING OF SWITCHBOARDS

SMB Harwal Electric Pty Ltd
a member of the SMB Group
Unit 03, Lane Cove Business Park, 16 Mars Road, Lane Cove NSW 2066, Email: sales@smbharwal.com.au
Ph: +61 (0)2 9420 7777, Fax: +61 (0)2 9420 7700

CONTROLLED	
DRAWN	
CHECKED	MT
DATE	05.09.12
SCALE	NONE
CLIENT	NILSEN (NSW) PTY LTD
DRAWING TITLE	MAIN SWITCHBOARD 1 GENERAL ARRANGEMENT
PROJECT	UTS BROADWAY
DRAWING NUMBER	PJ2120163-01-01
SHEET SIZE	A1
ISSUE	04
DRAWING STATUS	AS BUILT
FOREIGN NUMBER	CB11EP N1-E-SPD-0050

MAJOR EQUIPMENT SCHEDULE

No.	EQUIPMENT DETAILS	SETTINGS	LABEL DESCRIPTION	LABEL DETAILS	WIRING/DRAWING
A3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A7	[illegible]		[illegible]	[illegible]	
B3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B7	[illegible]		[illegible]	[illegible]	
B9	[illegible]		[illegible]	[illegible]	
C1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C5	[illegible]		[illegible]	[illegible]	
D1	[illegible]		[illegible]	[illegible]	
D6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
F1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
F7	[illegible]		[illegible]	[illegible]	
F9	[illegible]		[illegible]	[illegible]	
G1	[illegible]		[illegible]	[illegible]	
G7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
H8	[illegible]		[illegible]	[illegible]	
J1	[illegible]	[illegible]	[illegible]	[illegible]	
J6	[illegible]	[illegible]	[illegible]	[illegible]	
K3	[illegible]		[illegible]	[illegible]	
K7	[illegible]		[illegible]	[illegible]	[illegible]
L1	[illegible]		[illegible]	[illegible]	
L4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
M1	[illegible]		[illegible]	[illegible]	
M4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
M6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
M8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N1	[illegible]		[illegible]	[illegible]	
N4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MINOR EQUIPMENT SCHEDULE

No.	ITEMS	DESCRIPTION	REFERENCE	PART NO.	QUANTITY TOTAL
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

REVISIONS

ISSUE	DESCRIPTION	DATE	BY	CHKD
A	ISSUED FOR APPROVAL	[illegible]	[illegible]	[illegible]
01	[illegible]	[illegible]	[illegible]	[illegible]
02	[illegible]	[illegible]	[illegible]	[illegible]
03	[illegible]	[illegible]	[illegible]	[illegible]
04	AS BUILT	[illegible]	[illegible]	[illegible]

REFERENCES

DRAWING NO.	TITLE
[illegible]	[illegible]
[illegible]	[illegible]

IT IS THE ELECTRICAL CONTRACTORS RESPONSIBILITY TO VERIFY OVERALL DIMENSIONS, CABLE ENTRIES AND SITE ACCESS FOR POSITIONING OF SWITCHBOARDS

SMB Harwal Electric Pty Ltd

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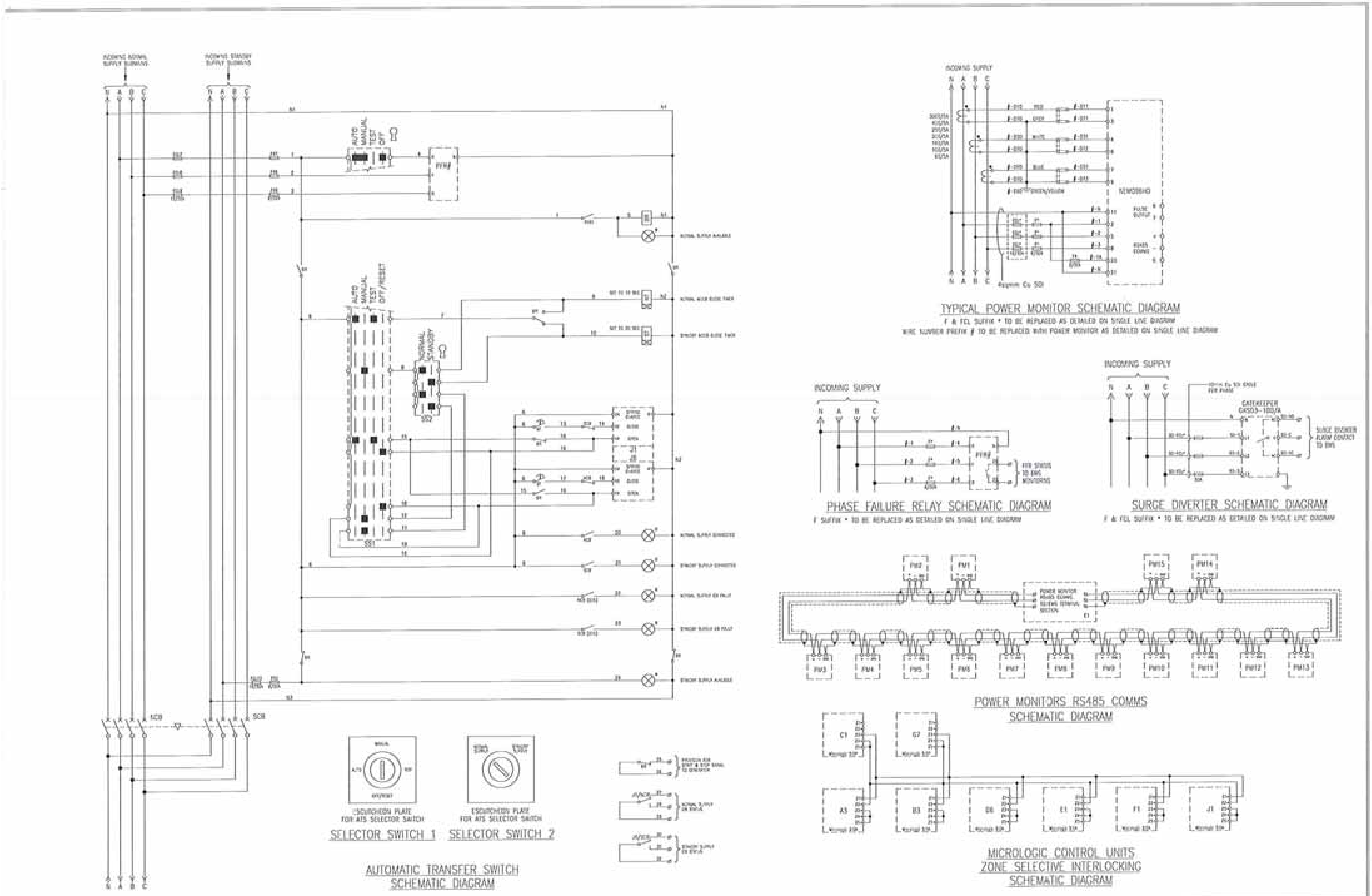
CLIENT	NILSEN (NSW) PTY LTD
DRAWING TITLE	MAIN SWITCHBOARD 1 EQUIPMENT SCHEDULE
PROJECT	UTS BROADWAY
DATE	03.09.12
SCALE	NONE
DRAWING NUMBER	PJ2120163-01-02
SHEET SIZE	A1
ISSUE	04
DRAWING STATUS	AS BUILT
FOREIGN NUMBER	CB11EP NL-E-SPD-D251



REVISIONS

ISSUE	DESCRIPTION	DATE	BY	CHK'D
A	ISSUED FOR APPROVAL	[illegible]	JPS	MT
01	REVISED AS PER COMMENTS	[illegible]	JPS	MT
02	ISSUED FOR CONSTRUCTION	[illegible]	JPS	MT
03	REVISED TO SI2 0817-E3-2002 REV A	[illegible]	JPS	MT
04	AS BUILT	[illegible]	JPS	MT

REFERENCES

DRAWING NO.	TITLE
1XX-01-01	MAIN SWITCHBOARD 1 GENERAL ARRANGEMENT
1XX-01-02	MAIN SWITCHBOARD 1 EQUIPMENT SCHEDULE

IT IS THE ELECTRICAL CONTRACTORS RESPONSIBILITY TO VERIFY OVERALL DIMENSIONS, CABLE ENTRIES AND SITE ACCESS FOR POSITIONING OF SWITCHBOARDS.

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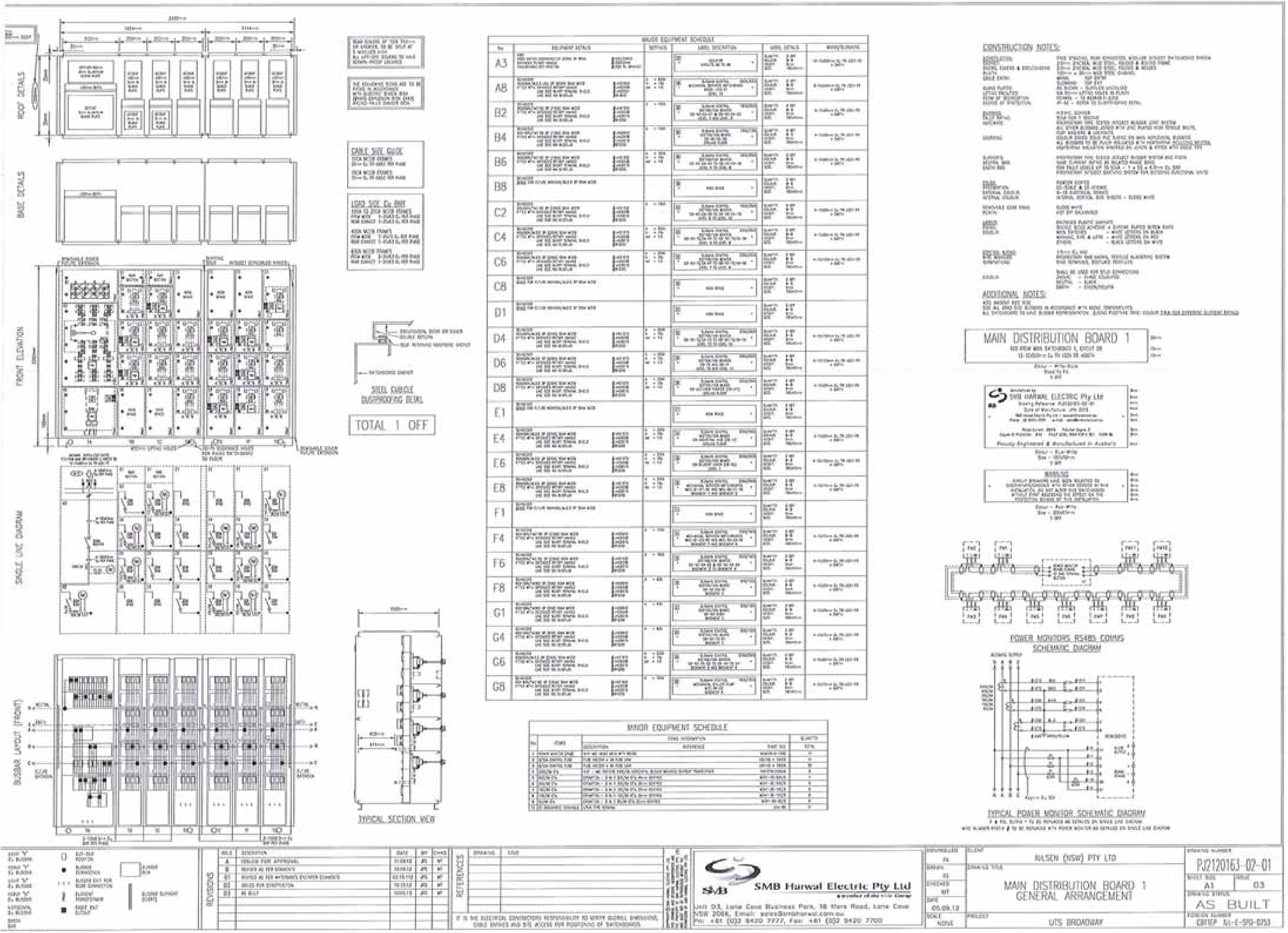
CONTROLLED	JN
DRAWN	JN
CHECKED	MT
DATE	05.09.12
SCALE	NONE
CLIENT	NILSEN (NSW) PTY LTD
DRAWING TITLE	MAIN SWITCHBOARD 1 SCHEMATIC DIAGRAM
PROJECT	UTS BROADWAY
DRAWING NUMBER	PJ2120163-01-03
SHEET SIZE	A1
ISSUE	04
DRAWING STATUS	AS BUILT
FOREIGN NUMBER	CB11EP AL-E-SFD-0752



ROOF DETAILS
BASE DETAILS
FRONT ELEVATION
SINGLE LINE DIAGRAM
BUSBAR LAYOUT (FRONT)
CABLE SIZE GUIDE
LOAD SIDE Cu BAR
STEEL CUBICLE DUSTPROOFING DETAIL
TOTAL 1 OFF
TYPICAL SECTION VIEW
MAJOR EQUIPMENT SCHEDULE
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SMB HARWAL ELECTRIC Pty Ltd
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WARNING
POWER MONITORS RS485 COMMS SCHEMATIC DIAGRAM
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REFERENCES
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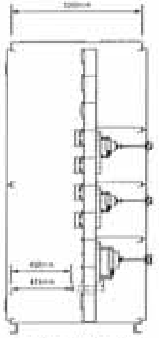
MAIN DISTRIBUTION BOARD 1
GENERAL ARRANGEMENT
UTS BROADWAY
05.09.12
NONE
PJ2120163-02-01
A1
03
AS BUILT

CABLE SIZE GUIDE

LOAD SIZE Cu BAR

STEEL CUBICLE DUSTPROOFING DETAIL

TOTAL 1 OFF



TYPICAL SECTION VIEW

MAJOR EQUIPMENT SCHEDULE

No.	EQUIPMENT DETAILS	SETTINGS	LABEL DESCRIPTION	LABEL DETAILS	WIRING/BUSBARS
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C2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D1	[illegible]		[illegible]	[illegible]	
D4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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MINOR EQUIPMENT SCHEDULE

No.	ITEMS	DESCRIPTION	REFERENCE	PART NO.	QUANTITY TOTAL
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3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CONSTRUCTION NOTES:

ADDITIONAL NOTES:

MAIN DISTRIBUTION BOARD 2

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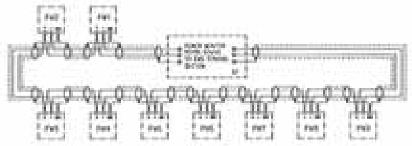
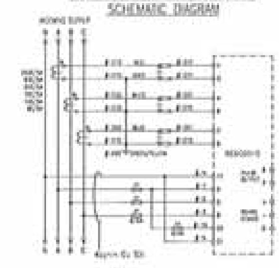


POWER MONITORS RS485 COMMS SCHEMATIC DIAGRAM



TYPICAL POWER MONITOR SCHEMATIC DIAGRAM

REVISIONS

ISSUE	DESCRIPTION	DATE	BY	CHK'D
A	ISSUED FOR APPROVAL	[illegible]	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]	[illegible]
01	[illegible]	[illegible]	[illegible]	[illegible]
02	[illegible]	[illegible]	[illegible]	[illegible]
03	AS BUILT	[illegible]	[illegible]	[illegible]

REFERENCES

DRAWING NO.	TITLE

IT IS THE ELECTRICAL CONTRACTORS RESPONSIBILITY TO VERIFY OVERALL DIMENSIONS, CABLE ENTRIES AND SITE ACCESS FOR POSITIONING OF SWITCHBOARDS

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DRAWN	FS
CHECKED	MT
DATE	05.09.12
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CLIENT: NILSEN (NSW) PTY LTD

DRAWING TITLE: MAIN DISTRIBUTION BOARD 2 GENERAL ARRANGEMENT

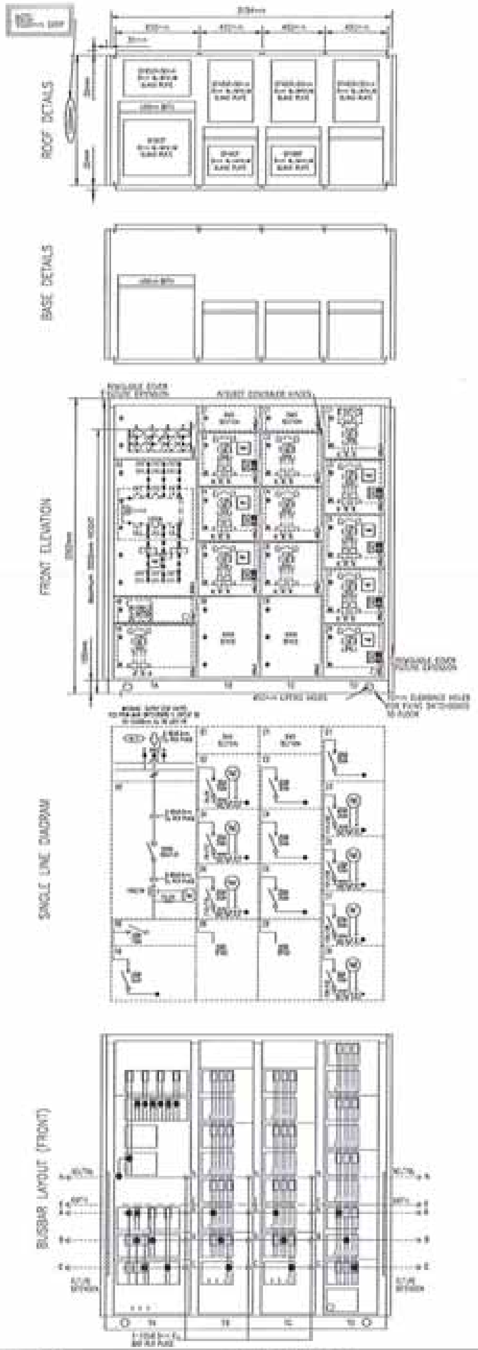
PROJECT: UTS BROADWAY

DRAWING NUMBER: PJ2120163-03-01

SHEET SIZE: A1 ISSUE: 03

DRAWING STATUS: AS BUILT

REFERENCE NUMBER: CB11EP 61-E-SPD-0754

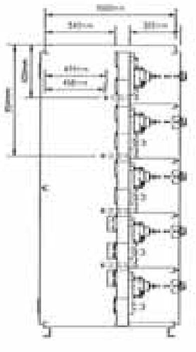


CABLE SIZE GUIDE

LOAD SIDE Cu BAR

STEEL CUBICLE
DUSTPROOFING DETAIL

TOTAL 1 OFF



TYPICAL SECTION VIEW

MAJOR EQUIPMENT SCHEDULE

No.	EQUIPMENT DETAILS	SETTINGS	LABEL DESCRIPTION	LABEL DETAILS	MAINS/SUBMAINS
A3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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B4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B8	[illegible]		[illegible]	[illegible]	
C2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C8	[illegible]		[illegible]	[illegible]	
D1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MINOR EQUIPMENT SCHEDULE

No.	ITEMS	DESCRIPTION	REFERENCE	PART NO.	TOTAL
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CONSTRUCTION NOTES:

ADDITIONAL NOTES:

MAIN DISTRIBUTION BOARD 3

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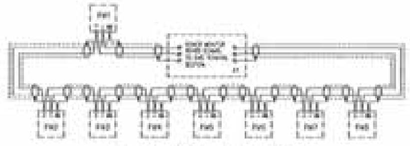
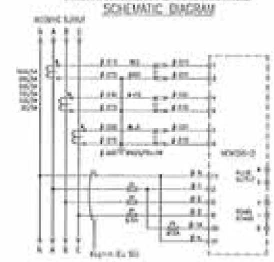


POWER MONITORS RS485 COMMS
SCHEMATIC DIAGRAM



TYPICAL POWER MONITOR SCHEMATIC DIAGRAM

REVISIONS

ISSUE	DESCRIPTION	DATE	BY	CHKD
A	ISSUED FOR APPROVAL	[illegible]	JPS	MT
B	[illegible]	[illegible]	JPS	MT
01	[illegible]	[illegible]	JPS	MT
02	ISSUED FOR CONSTRUCTION	[illegible]	JPS	MT
03	AS BUILT	[illegible]	JPS	MT

REFERENCES

IT IS THE ELECTRICAL CONTRACTORS RESPONSIBILITY TO VERIFY OVERALL DIMENSIONS, CABLE ENTRIES AND SITE ACCESS FOR POSITIONING OF SWITCHBOARD.

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CONTROLLED	IN
DRAWN	TS
CHECKED	MT
DATE	05.09.13
SCALE	NONE

CLIENT: NILSEN (NSW) PTY LTD

DRAWING TITLE: MAIN DISTRIBUTION BOARD 3 GENERAL ARRANGEMENT

PROJECT: UTS BROADWAY

DRAWING NUMBER: PJ2110163-04-01

SHEET SIZE: A1

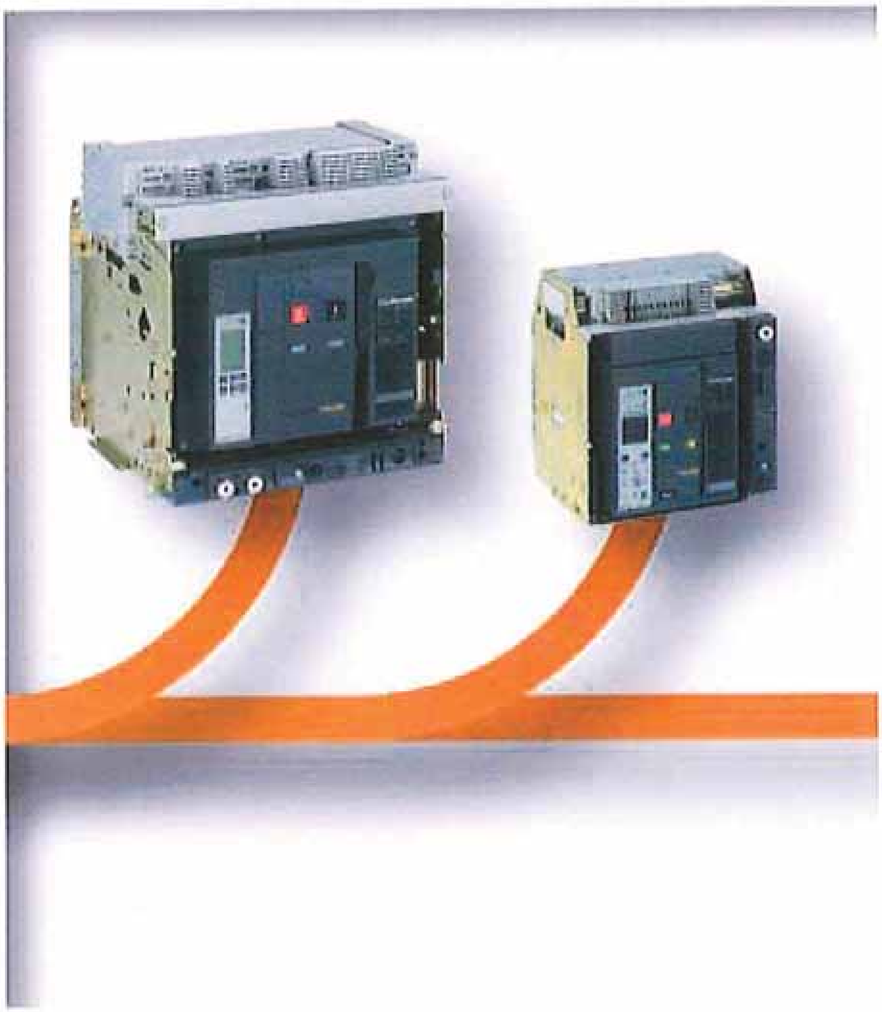
ISSUE: 03

DRAWING STATUS: AS BUILT

DO NOT HAND MODIFY

LV power circuit breakers
and switch-disconnectors
Masterpact NT and NW

Maintenance
guide



a brand of
Schneider
Electric

Merlin Gerin

This guide is intended primarily for qualified personnel in charge of equipment maintenance and for Schneider Electric after-sales support personnel for the information on system diagnostics.

Thank you for purchasing a Merlin Gerin protection device.

To maintain the device's operating and safety characteristics as they are indicated in the catalogue from the beginning to the end of the product's service life, Schneider Electric recommends that systematic checks and periodic maintenance be carried out by qualified personnel, as indicated in this "Masterpact maintenance". Please read this document carefully and keep it at hand, near the device.

It provides detailed information on:

- *the various types of maintenance required, depending on the criticality of the protected circuit.*
- *what must receive maintenance.*
- *the risks involved if the component ceases to operate correctly.*
- *what is understood by the terms normal, improved and severe environment and operating conditions.*
- *the periodic preventive maintenance operations that should be carried out under normal environment and operating conditions as well as the level of competence required for the operations.*
- *the environment and operating conditions that accelerate device ageing.*
- *the limits governing use of mechanical and electric accessories and subassemblies.*
- *finally, all the product guides available in order to maintain the device in proper operating condition.*

The level II and III procedures mentioned in this guide may be obtained on request from the Schneider Electric after-sales support department.

Contents

The different types of maintenance

Corrective maintenance

Corrective maintenance repairs a system in view of fulfilling a required function.

Incidents during system start-up

Many malfunctions result from non-observance of the start-up instructions or lack of knowledge concerning the equipment and/or switchgear procedures.
Schneider Electric operating guides, supplied with products and equipment, contain clear instructions for operators or maintenance personnel on how to correct malfunctions. These instructions are included at the end or this guige.
The list of the available operating guides may be found at the end of this document. The PDF files may de downloaded from the www.merlin-gerin.com site.

Breakdowns during operation

Contact the certified maintenance department.
The Schneider Service Centres may be contacted via the www.schneider-electric.com site.

Preventive maintenance

Preventive maintenance consists in carrying out, at predetermined intervals or according to prescribed criteria, checks intended to reduce the probability of a failure or deterioration in the operation of a system.

There are two types of preventive maintenance:

■ **periodic maintenance**

For each type of product, maintenance recommendations are laid out by the technical department. These verification procedures, intended to maintain systems or their subassemblies in correct operating condition over the targeted service life, must be carried out according to the time intervals stipulated in this document.
Under no circumstances can Schneider Electric be held responsible for any damage caused by the failure of device if the periodic checks were not carried out in accordance with the recommendations in this document.

■ **conditional maintenance**

To a certain extent, conditional-maintenance operations are a means to reduce (but not eliminate) the recommended periodic-maintenance operations (thus limited to the strict minimum) that require an annual shutdown of the installation.
These operations are launched when programmed alarms indicate that a predefined threshold has been reached. To that end, sensors must be installed on the switchgear and in the switchboard. Conditional maintenance is the means to optimise installation maintenance.
For more information on the possibilities offered by conditional maintenance, contact your Schneider after-sales support department.

The different types of maintenance

Predictive maintenance

Predictive maintenance, based on the recording and analysis of system parameters, is the means to detect drift from the initial state and significant trends. Using predictive maintenance, the customer can anticipate on the corrective action required to ensure equipment safety and continuity of service, and plan the action for the most convenient time.
To ensure the highest possible level of installation reliability and optimise the service life of equipment, it is advised to establish a maintenance plan.
The plan indicates for each piece of equipment:
- the most suitable type of maintenance
- the recommended frequency of maintenance.

The plan is based on two criteria:
- the criticality of each device in the installation
- device operating conditions.

Criticality depends on the consequences of device failure in terms of the safety of life and property, production losses, the cost of repair and start-up, etc. An empirical estimate may be sufficient for simple cases, but it is recommended to undertake a reliability analysis of the installation for more complex architectures involving backup sources, transfer mechanisms, etc. Check with your Schneider Service Centre for more information.
The operating conditions reflect the environment in which the device is installed (relative humidity, heat, dust, etc.) and how the device is used (load, frequency of operation, quality of the supply current, etc.). These conditions are discussed in detail in this document, as well as the ensuing maintenance recommendations.
Consequently, for a given device, the recommended maintenance may vary substantially both in terms of the necessary operations and their frequency.

Example of Masterpact predictive maintenance

Monitoring and recording	Goal	Tool	Service offered
Number of operating cycles	Monitor manufacturer limits and determine the probable replacement date	Electronic counter with the communication module + MPS100 server	Remote monitoring by: ■ customer supervisor or ■ Serenity service (1)
Trip and alarm histories	Analyse the distribution-system phenomena that resulted in tripping or alarms caused by transient overloads, setting changes or a modification in the installation	Micrologic P/ H event log + MPS100 server	Remote monitoring by: ■ customer supervisor or ■ Serenity service (1)
Contact wear	Monitor (without dismantling) the arc chutes on the circuit breakers and plan their replacement	Micrologic P/ H event log + MPS100 server	Remote monitoring by: ■ customer supervisor or ■ Serenity service (1)
Percent load	Estimate as precisely as possible the probable service life of the device		Remote monitoring by: ■ customer supervisor or ■ Serenity service (1)
Pole opening and closing speed	Monitor any mechanical drift in devices and evaluate their condition	Prodiag tester	Remote monitoring by: ■ customer supervisor or ■ Serenity service (1)

***(1)** Serenity is a Schneider Electric service providing installation diagnostics and analysis of distribution systems.*

For more information on the possibilities offered by predictive maintenance, contact your Schneider after-sales support department.

Masterpact NT/NW
What must be maintained and why ?

The case

The case is an essential element in the circuit breaker. First of all, it ensures a number of safety functions:

- functional insulation between the phases themselves and between the phases and the exposed conductive parts in order to resist transient overvoltages caused by the distribution system
- a barrier avoiding direct user contact with live parts
- protection against the effects of electrical arcs and overpressures caused by short-circuits.

Secondly, it serves to support the entire pole operating mechanism as well as the mechanical and electrical accessories of the circuit breaker.

On the case, there should be:

- no traces of grime (grease), excessive dust or condensation which all reduce insulation
- no signs of burns or cracks which would reduce the mechanical solidity of the case and thus its capacity to withstand short-circuits.

Preventive maintenance for cases consists of a visual inspection of its condition and cleaning with a dry cloth or a vacuum cleaner. All cleaning products with solvents are strictly forbidden. It is advised to measure the insulation every five years and following trips due to a short-circuit. The case must be replaced if there are signs of burns or cracks.

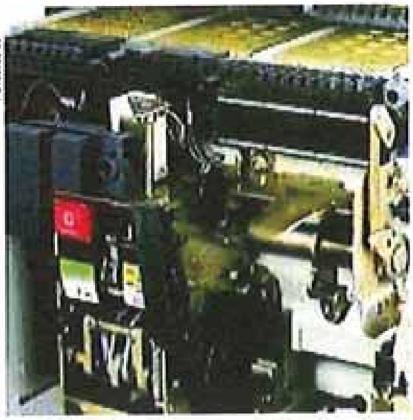
Arc chutes

During a short-circuit, the arc chute serves to extinguish the arc and to absorb the high level of energy along the entire path of the short-circuit. It also contributes to arc extinction under rated current conditions. An arc chute that is not in good condition may not be capable of fully clearing the short-circuit and ultimately result in the destruction of the circuit breaker.
The arc chutes must be regularly checked. The fins of the arc chutes may be blackened (due to the gases produced at In) but must not be significantly damaged. What is more, the filters must not be blocked to avoid internal overpressures. It is advised to use a vacuum cleaner rather than a cloth to remove dust from the outside of the arc chutes.

Main contacts

The contacts make and break the current under normal conditions (rated current for the installation) and under exceptional conditions (overloads and short-circuits). The contacts are eroded by the many opening and closing cycles and can be particularly deteriorated by short-circuit currents.
Worn contacts may result in abnormal temperature rise and accelerate device ageing.
It is imperative to remove the arc chutes and visually check contact wear at least once a year and following each short-circuit.
The contact-wear indicators constitute an absolute minimum value that must not be overrun.
To plan and reduce the number of shutdowns, an electronic wear counter is available with the Micrologic P and H. A visual check is required when the counter reaches 100. When the counter reaches 300, the contacts must be replaced.

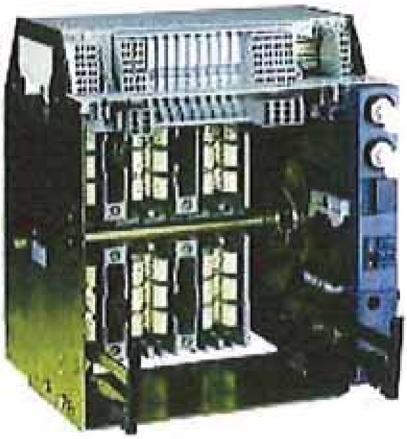
Masterpact NT/NW
What must be maintained and why ?



Device and chassis mechanisms
Mechanical operation of the circuit breaker may be hindered by dust, knocks, aggressive atmospheres, no greasing or excessive greasing. Operating safety is ensured by dusting and general cleaning, proper greasing and regular opening and closing of the circuit breaker.

■ **dusting**
Dusting is best carried out using a vacuum cleaner.

■ **cleaning**
Cleaning should be carried out using a cloth or brush that is perfectly clean and dry, without using any solvents, avoiding greased parts except for grease on electrical contacts.
Application of products under pressure or containing solvents (trichloroethane, trichloroethylene) is strictly forbidden (e.g. WD40).
The main problems of products under pressure are the following:
□ it may be impossible to regrease inaccessible lubrication points (greased for the life of the product)
□ corrosion of points that are not regreased
□ damage caused by the pressure of the product
□ risk of temperature rise due to the presence of an insulating solvent in the contact zones
□ elimination of special protection
□ deterioration of plastic materials.



■ **greasing**
This operation is carried out after cleaning on certain mechanical parts as described in the maintenance procedures, using the various greases recommended by Schneider Electric. Grease must not be over applied because the excess, if mixed with dust, may result in mechanism malfunctions.
Generally speaking, under normal operating conditions, the pole-operating mechanism does not require any regreasing (greased for the life of the product).
□ The clusters and disconnecting-contacts must be greased according to the defined intervals using the greases indicated by Schneider Electric.
□ The main contacts must not be greased.

■ **operating cycles**
The imperative need to ensure continuity of service in an installation generally means that power circuit breakers are rarely operated. If, on the one hand, an excessive number of operating cycles accelerates device ageing, it is also true that a lack of operation over a long period can result in mechanical malfunctions. Regular operation is required to maintain the normal performance level of each part involved in the opening and closing cycles.

In installations where power circuit breakers are used in source changeover systems, it is advised to periodically operate the circuit breaker for the alternate source.

Masterpact NT/NW
What must be maintained and why ?

Auxiliary circuits

■ **control auxiliaries**

MX and XF shunt releases are respectively used to remotely open and close the circuit breaker using an electrical order or by a supervisor via a communication network.
The MN undervoltage release is used to break the power circuit if the distribution-system voltage drops or fails in order to protect life (emergency off) or property.
Communicating MX and XF releases and MN releases are continuously supplied and the internal electronic components may suffer accelerated ageing if there is temperature rise in the circuit breaker.
Preventive maintenance consists in periodically checking operation at minimum values. Depending on the operating and environment conditions, it is advised to estimate their service life using the "service life" software (1) and to replace them if necessary to avoid any risk of non-operation when they are needed.

■ **auxiliary wiring**

Auxiliary wiring is used to transmit orders to the various control devices and to transmit status-condition information. Incorrect connections or damaged insulation may result in either non-operation of the circuit breaker or nuisance tripping.
Auxiliary wiring must be regularly checked and replaced as needed, particularly if there are vibrations, high ambient temperatures or corrosive atmospheres.

■ **indication contacts**

The contacts indicating the status of the circuit-breaker (ON / OFF), of the chassis (CE, CD, CT), a trip due to an electrical fault (SDE) or that the circuit breaker is ready to close (PF) provide the operator with the status information required to react correspondingly. Any incorrect indications may result in erroneous device operation that could endanger life and property. Contact failure (wear, loose connections) may result from vibrations, corrosion or abnormal temperature rise and preventive maintenance must ensure that contacts correctly conduct or isolate according to their positions.

■ **gear motor**

The gear motor (MCH) automatically recharges the operating-mechanism springs as soon as the circuit breaker is closed. The gear motor makes it possible to instantaneously reclose the device following an opening. This function may be indispensable for safety reasons. The charging lever serves simply as a backup means if the auxiliary voltage fails.
Given the mechanical forces exerted to charge the mechanism, the gear motor wears quickly. Periodic checks on gear-motor operation and the charging time are required to ensure the device closing function.

(1) For more information, contact your Schneider after-sales support department.

Masterpact NT/NW
What must be maintained and why ?

Electronic trip unit

If an electric fault occurs in the installation, the electronic trip unit detects the fault and orders the circuit breaker to open and thus protect life and property. Electronic components and circuit boards are sensitive to the environment (ambient temperature, humid and corrosive atmospheres) and to severe operating conditions (magnetic fields, vibrations, etc.). To ensure correct operation, it is necessary to periodically check:

- the chain of action resulting in a trip
- the response time as a function of the level of the fault current.

Depending on the operating and environment conditions, it is advised to estimate their service life using the "service life" software (1) and to replace them if necessary to avoid any risk of non-operation when they are needed.

Communication module and accessories

Via the communication bus, the communication option transmits data to a remote site for use by various departments (maintenance, management, production, etc.). A break in the transmission of data can result in:

- production losses due to unawareness concerning the status of a circuit breaker
- financial losses due to incorrect system management
- diagnostic errors
- etc.

Periodic checks on the orders (read, write, commands) transmitted by the communication bus are required to maintain a high degree of reliability and confidence in the communication system.

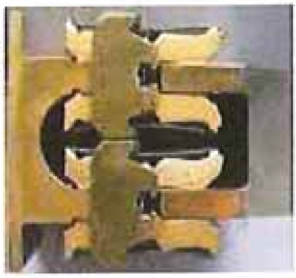
(1) For more information, contact your Schneider after-sales support department.

Masterpact NT/NW
What must be maintained and why ?

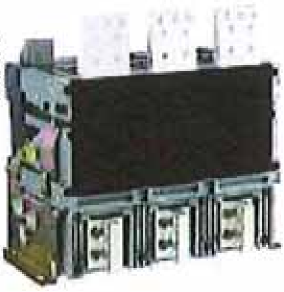
Connections

The connections between the various distribution systems in a switchboard (busbars, cables) and the switchgear are a major source of heat loss. Incorrect tightening may lead to thermal runaway which in turn can provoke damage to the device, the cable insulation and even result in a short-circuit and/or a fire.
This type of malfunction is often due to disregard for installation requirements during switchboard assembly.

***Nota :** connections must never use different materials (copper / aluminium).*



■ sliding connections (chassis)
They are made up of two parts, the clusters and disconnecting contacts. This type of connection is critical and requires periodic cleaning in compliance with the described procedures. The grease facilitates the connection between the clusters and the disconnecting contacts and avoids damaging the silver-coated surface by reducing the racking-in friction.
In sulphurous (corrosive) atmospheres (H_2S / SO_2), it is necessary to implement the cleaning procedure using the Thiourea solution, with mandatory regreasing using the specified fluorinated grease. This type of grease protects the silver and copper-coated contacts against sulphuration. Because silver or copper sulphide being insulating it provokes an increase in the contact resistance and thus greater temperature rise.
The grease breaks down over time and it is therefore necessary to replace it regularly.



■ fixed connections
Connections using lugs or bars.
When made in compliance with Schneider Electric recommendations (tightening torque, 8.8 hardware and contact washer), this type of connection does not require any particular maintenance. Otherwise, regularly check the temperature-rise points (change in colour of copper or tinning), dismantle the connections, clean and scrape the contact surfaces, then reassemble the connections using new hardware.
Check the terminals.

Recommended preventive maintenance and time intervals

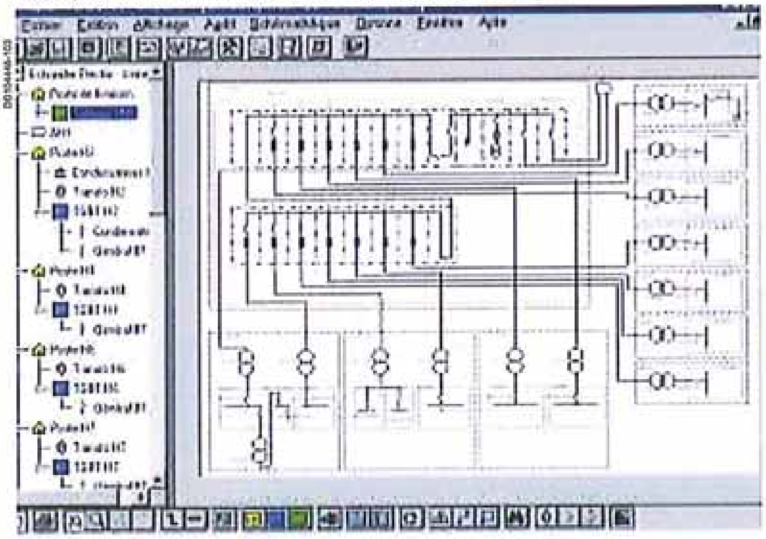
Normal conditions

The maintenance guide (1) that must be carried out every one, two or five years on Masterpact NT/NW subassemblies and the level of competence required on the part of service agents are described in the tables on pages 12, 13 and 14.
At the end of each five year period, the maintenance guide must be systematically repeated.
These maintenance operations apply for normal operating and environment conditions as defined below.

Normal operating and environment conditions	
Temperature	Average annual temperature < 25 °C outside the switchboard (Ta (1))
Percent load	< 80 % of In 24/24 hours
Harmonics	Harmonic current per phase < 30 % of In
Relative humidity	< 70 %
Corrosive atmosphere	Device installed in environment category 3C1 or 3C2 (IEC 60721-3-3)
Salt environment	No salt mist
Dust	Low level Device protected in switchboard equipped with filters or ventilated IP54 enclosure
Vibration	Permanent vibration < 0.2 g

Beyond the above limits, the circuit breakers suffer accelerated ageing that may rapidly result in malfunctions. For this reason, periodic checks must be carried out at shorter time intervals. On the other hand, when special efforts are made to improve the operating and environment conditions, the preventive-maintenance operations can be carried out less often.

(1) The Masterpact maintenance guide is taken into account by the Schneider Electric CamSoft software.
Example of a maintenance plan managed by CamSoft.



Recommended preventive maintenance and time intervals

Favourable conditions or device protected

The time interval between two preventive-maintenance visits can be doubled **if all the conditions** presented below are met.
The only exception is the check-up program recommended for the 5th year.

Favourable operating and environment conditions or device protected	
Temperature	Average annual temperature < 25 °C outside the switchboard (Ta [1]). The device is installed in an air-conditioned room or in a ventilated enclosure
Percent load	< 50 % of In 8/24 hours or 24/24 hours
Relative humidity	< 50 %
Corrosive atmosphere	Device installed in environment category 3C1 or in a protected room (air is conditioned and purified)
Salt environment	None
Dust	Negligible Device protected in switchboard equipped with filters or ventilated IP54 enclosure
Vibration	None

(1) (Ti)–(Ta), see the definition in the Masterpact catalogue.

Example depending on the conditions:
- normal: check on charging time = 2 years
- favourable: check on charging time = 2 x 2 = 4 years

Severe conditions and device not protected

The time interval between two preventive-maintenance visits must be reduced by half **if any of the conditions** presented below are present.

Severe operating and environment conditions	
Temperature (annual average)	Average annual temperature between 35° and 45°C around the switchboard (see definition in EN 60439-1)
Percent load	> 80 % of In 8/24 hours or 24/24 hours
Relative humidity	> 80 %
Corrosive atmosphere	Device installed in environment category 3C3 or 3C4 without any particular protection
Salt environment	Installation < 10 kilometers from seaside and device without any particular protection
Dust	High level Device not protected
Vibration	Continuous vibrations between 0.2 and 0.5 g

Example depending on the conditions:
- normal: check on charging time = 2 years
- severe: check on charging time = 0.5 x 2 = 1 year

Recommended preventive maintenance and time intervals

Device check-up

During the 5th year of operation, it is advised to run a complete check-up on the device to determine its status condition.

This diagnostic must be carried out by Schneider Service or by certified personnel having received Level IV training.

The complete diagnostic must be systematically carried out following:
- tripping due to a short-time or instantaneous short-circuit
- five trips due to overloads.

See the Level IV program, voir page 14.

Check after prolonged storage

Storage conditions

Devices must be stored in a dry, ventilated room, protected from rain, water and chemical agents.
They must be well protected against dust, rubble, paint, etc.

If storage is for an extended period, the relative humidity in the room must be maintained below 70 %.
- storage conditions:
  - devices without their control unit: -40°C +85°C.
  - devices with their control unit: -25°C +85°C.

Devices must be stored in the open (OFF) position with the charging springs discharged.

Check and maintenance

After extended storage and if the conditions above were respected, the checks below must be carried out to ensure correction device operation.

Storage ≤ 2 years

Run the Level II and III 2nd year program on the subassemblies below:
- mechanism
- control unit
- device and chassis locking
- chassis.

Storage > 2 years

Run the Level III and IV 5th year diagnostic program on the subassemblies below:
- mechanism
- control auxiliaries
- control unit
- device and chassis locking
- chassis.

If the devices were stored under severe conditions (high temperature, corrosive atmosphere), it is necessary to:
- check the surface condition of the metal parts (zinc) and the copper parts (silver coatings (Ag) or tinning (Sn))
- check the greasing for the device and chassis
- clean and regrease the clusters and disconnecting-contacts.

Level II preventitive maintenance recommended every year

Level II

Minor preventive-maintenance operations such as greasing and operating checks, as well as repairs by standard exchange of certain assemblies, carried out by a certified customer employee according to the manufacturer maintenance instructions.

Check	Year					Tool	Procedure number
	1	2	3	4	5 (1)		
Device							
Check the general condition of the device (escutcheon, control unit, case, chassis, connections)	■	■	■	■	■	None	device NII_1_1.pdf
Mechanism							
Open/close device manually and electrically	■	■	■	■	■	None	mechanism NII_1_1.pdf
Charge device electrically	■	■	■	■	■	None	mechanism NII_1_2.pdf
Check complete closing of device's poles	■	■	■	■	■	None	mechanism NII_1_3.pdf
Check number of device operating cycles	■	■	■	■	■	Operation counter	mechanism NII_1_4.pdf
Breaking unit (arc chutes + contacts)							
Check the filters cleanlines and the fixing of the arc-chute chambers	■	■	■	■	■	Dynamometric crank	breaking unit NII_1_1.pdf
Control auxiliaries							
Check auxiliary wiring and insulation	■	■	■	■	■	None	auxiliaries NII_1_1.pdf
Control unit							
Trip control unit using test tool and check operation of contacts SDE1 and SDE2	■	■	■	■	■	HHTK or FFTK	control unit NII_1_1.pdf
Check earth-fault protection function (Micrologic 6.0) or earth-leakage protection function (Micrologic 7.0)	■	■	■	■	■	None	control unit NII_1_2.pdf
Device locking							
Open and close keylocks installed on device	■	■	■	■	■	None	device locking NII_1_1.pdf
Open and close padlocking system installed on device	■	■	■	■	■	None	device locking NII_1_2.pdf
Chassis (optional)							
Remove device from chassis and put it back	■	■	■	■	■	None	chassis NII_1_1.pdf
Check operation of position contacts (CE, CT, CD, EF)	■	■	■	■	■	None	chassis NII_1_2.pdf
Check operation of safety shutters	■	■	■	■	■	None	chassis NII_1_3.pdf
Chassis locking							
Open and close keylocks installed on chassis	■	■	■	■	■	None	chassis locking NII_1_1.pdf
Operate padlocking system	■	■	■	■	■	None	chassis locking NII_1_2.pdf

(1) These checks will be carried out by Schneider Services in case of diagnostic the fifth year (see page 14).

Level III preventive maintenance recommended every 2 years

Level III

General preventive-maintenance operations such as general adjustments, trouble-shooting and diagnosis of breakdowns, repairs by exchange of components or functional parts, minor mechanical repairs, carried out by a qualified customer technician using the tools and measurement/setting devices specified in the manufacturer maintenance instructions.

Check	Years 1	2	3	4	5 (2)	Tool	Procedure number
Mechanism							
Check gear-motor charging time at 0,85 Un		■		■	■	Stop-watch + external power supply	mechanism NIII_2_1.pdf
Check general condition of mechanism		■		■	■	Screwdriver	mechanism NIII_2_2.pdf
Breaking unit (arc chutes + contacts)							
Check condition of breaking unit		■		■	■	Screwdriver	breaking unit NIII_2_1.pdf
Control auxiliaries							
Check operation of indication contacts (OF / PF / MCH)		■		■	■	Ωmetre	auxiliaries NIII_2_1.pdf
Check closing operation of control auxiliary XF at 0.85 Un		■		■	■	External power supply	auxiliaries NIII_2_2.pdf
Check opening operation of control auxiliary MX at 0.70 Un		■		■	■	External power supply	auxiliaries NIII_2_3.pdf
Check operation of control auxiliary MN/MNR between 0.35 and 0.7 Un		■		■	■	External power supply	auxiliaries NIII_2_4.pdf
Check delay of MNR devices at 0.35 and 0.7 Un		■		■	■	External power supply	auxiliaries NIII_2_5.pdf
Check MX tripping time		■		■	■	Tester	auxiliaries NIII_2_6.pdf
Control unit							
Check tripping curves using test tool, signalling LED (tripped, overload) Save results on PC		■		■	■	FFTK FFTK report generator software	control unit NIII_2_1.pdf
Chassis (optional)							
Dust and regrease chassis		■		■	■	Mobilith SHC100	chassis NIII_2_1.pdf
Regrease disconnecting-contact clusters(specific case of corrosive athmospheres)		■		■	■	Mobilith SHC100	chassis NIII_2_2.pdf
Power connections							
Check and tighten loose connections	Only after a visual inspection showing overheating marks					Dynamometric crank	power connections NIII_2_1.pdf

(2) These checks and tests will be carried out by Schneider Services in case of diagnostic the fifth year (see page 14).

Level IV manufacturer diagnostic and replacement of components recommended every 5 years

Level IV

All the major preventive and corrective-maintenance work ensured by the Schneider Electric after-sales support department.

Check	Years 5	10	15	20	25	Tool	Procedure number (=S= internal use)
Case							
Measure insulation resistance	■	■	■	■	■	Ohmmeter	device NIV_3_1.pdf
Mechanism							
Check tripping forces (crescent shaped part)	■	■	■	■	■	Tester	mechanism NIV_3_1.pdf
Breaking unit (arc chutes + contacts)							
Measure resistance of input/output contact	■	■	■	■	■	Ohmmeter + injection unit	breaking unit NIV_3_1.pdf
Control auxiliaries							
Check the service life of the auxiliaries XF, MX, MN	■	■	■	■	■	"service life" software	auxiliaries NIV_3_1.pdf
Preventitive replacement of control auxiliaries			■			None	
Micrologic control unit							
Save protection settings, log events (Micrologic P and H), and edit reports.	■	■	■	■	■	Magicbox + SSU software	control unit NIV_3_1.pdf
Check continuity of the tripping chain by primary injection for each phase	■	■	■	■	■	Injection unit	control unit NIV_3_2.pdf
Check DIN/DINF tripping using performer test tool	■	■	■	■	■	Performer test kit	control unit NIV_3_3.pdf
Check operation of thumbwheels	■	■	■	■	■	RSU	control unit NIV_3_4.pdf
Check the service life of control unit	■	■	■	■	■	"service life" software	auxiliaries NIV_3_1.pdf
Preventitive replacement of Micrologic			■			RSU	control unit NIV_3_5.pdf
Chassis (optional)							
Check connection/disconnection torque	■	■	■	■	■	Dynamometric crank	chassis NIV_3_1.pdf
Clean and regrease racking screw (NW only)	■	■	■	■	■	Grease	chassis NIV_3_2.pdf
Communication module and accessories							
Test the device control, the uploading of contact status (OF, SDE, PF, CH) operation of optical link , by using the communication Bus	■	■	■	■	■	Magicbox + RCU software	communication-en NIV_3_1.pdf
Test the uploading of chassis position contacts, the synchronisation of the address between BCM and CCM, the forced replication of the BCM address, by using the communication Bus	■	■	■	■	■	Magicbox + RSU software	communication-en NIV_3_2.pdf
Test the writing of data into Micrologic by using the communication Bus	■	■	■	■	■	Magicbox + RSU software	communication-en NIV_3_3.pdf

Causes of accelerated ageing

A switchboard and the switchgear age, whether they are in operation or not. Ageing is due primarily to the influence of the environment and the operating conditions.

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Influence of the environment

A device placed in a given environment is subjected to its effects.

The main environmental factors that accelerate device ageing are:

- temperature
- percent load
- relative humidity
- salt environment
- current harmonics
- dust
- corrosive atmospheres.

The following tables sum up for each factor:

- why it is harmful : influence
- how to identify it : appearance
- impact on operation : consequences.

Ambient temperature (outside the switchboard)

Influence	Appearance	Consequences
***Nota :** The ambient temperature affects the device temperature, which is itself affected by the percent load. Major variations in temperature (greater than 30°C) cause both mechanical stresses (thermal expansion) and condensation that can accelerate ageing.*		
The mechanical characteristics of plastic parts (insulation, case) are increasingly deteriorated by temperature the higher it rises.	Change in colour.	Breaking of parts leading to failure of functions.
Hardening of grease. Elimination of grease on disconnecting-contact clusters.	Change in colour and viscosity. Caramel colour of clusters.	Device cannot be operated. Increase of racking forces exerted on clusters.
Deterioration of insulating varnishes on coils.	Burning smell.	Failure of coils (CT, MN, MX, XF, MCH, electrical reset).
Hardening of glues.	Visual.	Loss of labels.
Deterioration of electronic components.	Modified display of LCDs.	Loss of display. Nuisance tripping or no tripping.
Deterioration of opto-electronic devices and SCRs.	Not identifiable.	Possible transmission of erroneous orders.
Loss of battery backup power.	Not identifiable.	Fault indications not displayed.
Temperature thresholds in °C.		
< 25°C	**25 - 35°C**	**35 - 45°C**
Optimum operating conditions (1).	A 10°C increase in the ambient temperature is equivalent to a 5 % increase in the percent load.	A 20°C increase in the ambient temperature is equivalent to a 10 % increase in the percent load.
Recommendation		
Preventive maintenance		
Implement the standard program.	Carry out more frequent periodic checks (see page 10).	Carry out more frequent periodic checks (see page 10).
Installation		
No particular precautions required.	No particular precautions required.	Install forced-air ventilation in the switchboard or air-conditioning for the electrical room.

(1) Example. A 100 A device, with an 80 % load, with an annual average ambient temperature of:

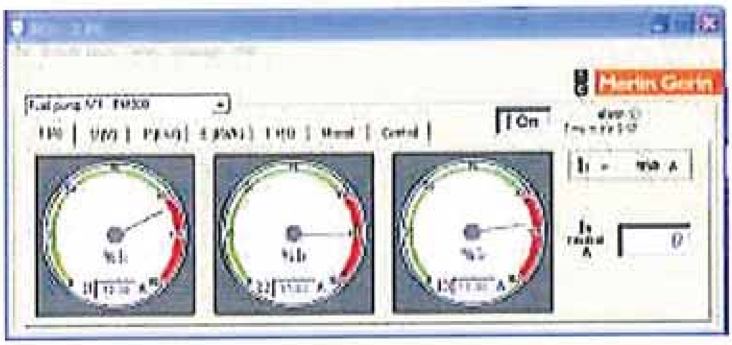
- *25°C will have a service life of approximately 30 years,*
- *35°C will have a service life of approximately 27 years,*
- *45°C will have a service life of approximately 25 years.*

Causes of accelerated ageing

Percent load (I/In)

Influence	Appearance	Consequences
***Nota :** The percent load affects the device temperature, which is itself affected by the ambient temperature.*		
Ageing of plastic insulation.	Change in colour of insulation.	Breaking of parts leading to failure of functions.
Ageing of grease.	Change in colour and viscosity.	Increase in mechanical friction.
Ageing of electronic components.	Modified display of LCDs.	A 10°C increase (i.e. an 85 percent load) cuts the service life of components by approximately half.
Deterioration of characteristics: ■ steel springs (above 100°C), ■ stainless steel springs (above 200°C).	Rupture.	Non operation of mechanisms.

Thresholds				
< 80 %, 24/24 hours	**< 90 %, 8/24 hours**	**< 90 %, 24/24 hours**	**In, 8/24 hours**	**In, 24/24 hours**
Maximum percent load generally taken into account in sizing the installation. At this percent load, temperature rise is reduced approximately 40 % with respect to a 100 percent load.	At this percent load, temperature rise is reduced only 20 %. Heating and cooling cycles impact on the mechanical junctions of the power circuit.	The thermal stress for continuous operation is three times higher than in the previous case, but the absence of thermal cycles slows ageing of the electromechanical components.	Between 90 and 100 %, temperature rise is close to its maximum value. Heating and cooling cycles impact on the mechanical junctions of the power circuit, with major impact on ageing.	Between 90 and 100 %, temperature rise is close to its maximum value. This situation has a major impact on ageing. It is not recommended.
Recommendation				
Preventive maintenance				
Implement the standard program.	Carry out more frequent periodic checks (see page 10).	Preventive maintenance is difficult due to the continuous process.	Carry out more frequent periodic checks (see page 10). Inspect for condensation.	Preventive maintenance is difficult due to the continuous process. Plan more frequent periodic checks.
Installation				
Normal conditions.			Provide ventilation for the switchboard.	Spread the load over other outgoers. Install a device with a higher rating.



Causes of accelerated ageing

Relative humidity

Influence	Appearance	Consequences
Corrosion of metal surfaces that is accelerated when a pollutant is present (corrosive gas, salt, chlorine, etc.).	Appearance of: - red rust on iron, - white rust on zinc, - blue deposit on copper, - black deposit on silver.	Increase in friction. Risk of mechanical rupture resulting in non operation of mechanisms. Increase in contact resistance (clusters and main contacts).
Deterioration of dielectric qualities of plastics.	White traces on case.	Risk of a reduction in insulation.
Deterioration of electronic components, in particular SMCs and silver-coated components. This phenomenon is worsened by the presence of H2S corrosive gas (hydrogen sulphide).	Not visible. Appearance of dentrites on electronic boards.	Short-circuiting of circuits resulting in non operation of control-unit protection, measurement, indication and communication functions.
Deterioration of electronic components, in particular non-varnished copper circuits.	Not visible. Erosion of copper tracks. Oxidation of metal connectors of components and metal cases. Oxidation of connectors of integrated-circuits mounted on supports.	Failure due to short-circuit or open circuit. Rupture of component connectors along case. Poor contact with integrated-circuit supports.
Degradation of opto-electronic components.		Failure of data transmission.
Thresholds in %		
≤ 70 %	**70 to 85 %**	**> 85 %**
Level of relative humidity generally found in continental and temperate zones. The level is generally lower in switchboards due to the internal temperature rise. No significant deterioration is noted at this level.	Level of relative humidity generally found in zones close to water. Possible appearance of condensation on cold parts and accelerated rusting.	Level of relative humidity generally found in tropical zones and certain factories (e.g. paper mills). Increased risk of condensation and rust resulting in difficulties to disconnect devices, risk of non opening or non closing.
Recommendation		
Preventive maintenance		
Implement the standard program.	Carry out more frequent periodic checks (see page 10). Measurement of insulation is advised every 5 years.	Carry out more frequent periodic checks (see page 10). Inspect for rust on metal parts. Measurement of insulation is imperative every 2 years.
Installation		
No particular precautions required.		Install heating resistors in the switchboard.

Causes of accelerated ageing

Salt environment

Influence	Appearance	Consequences
Corrosion of metal parts.	Appearance of: - white rust on zinc coatings, - red rust on steel.	Increase in friction. Freezing of mechanism. Broken springs. Blocking of cores of MX/XF/MN control auxiliaries.
Risk of salt deposits on electronic circuits when thick salt mists occur.	Appearance of salt bridges on electronic boards.	Failure of electronic systems due to short-circuiting of circuits, particularly non-varnished circuits.
Risk of conducting salt deposits on the device when thick salt mists occur.	White deposit.	Deterioration of device dielectric withstand resulting in risk of phase-to-frame short-circuit and a phase-to-phase short-circuit if an overload occurs.
Thresholds		
No salt mist	**Moderate salt mist** ***< 10 km from seaside***	**Significant salt mist** ***< 1 km from seaside***
No influence.	Moderate ageing of switchgear.	Rapid ageing of exposed switchgear. On average, service life is divided by a factor of three for non-protected devices.
Recommendation		
Preventive maintenance		
Implement the standard program.	Carry out more frequent periodic checks (see page 10).	Carry out more frequent periodic checks (see page 10). Test the dielectric withstand every two years.
Installation		
No particular precautions required.	No particular precautions required.	Switchgear must be protected from salt mist. Increase the switchboard IP value (IP54 is advised). Create a protected room.

Causes of accelerated ageing

Harmonics

Influence	Appearance	Consequences
Increase in skin effect, proximity effect, iron losses, Foucault currents.	Change in colour of terminals, insulators and grease. Modified display of LCDs.	Harmonics cause temperature rise greater than that of the fundamental current.
Possible overload of neutral if third-order harmonics and their multiples are present.	Distorted waveform.	Erroneous current value. Nuisance tripping if non-rms trip units.
Thresholds in % of In		
THDI < 30 %	**THDI 30 to 50 %**	**THDI > 50 %**
No notable influence on ageing.	At 40 % THDI, heat loss is approximately 10 % higher, corresponding to 5 % more current.	
Recommendation		
Preventive maintenance		
Implement the standard program.	Carry out more frequent periodic checks (see page 10).	Carry out more frequent periodic checks (see page 10).
Installation		
No particular precautions required.	Standard filtering with an inductor to reduce harmonics.	If necessary, oversize the neutral. Oversize switchgear. Filtering is mandatory.

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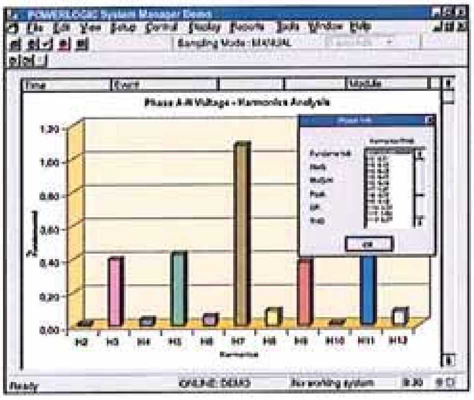

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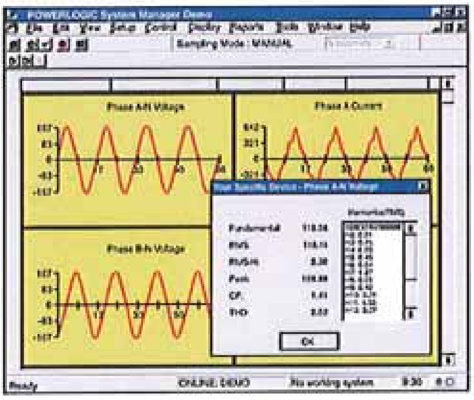

Causes of accelerated ageing

Dust

Influence	Appearance	Consequences
Deposit on grease of mechanisms (device and chassis).	Change in colour and texture of greases.	Premature wear of mechanisms because dust mixed with grease can be abrasive. Increase in mechanical friction and freezing of moving parts. Risk of device not moving on chassis. Risk of device non opening or non closing.
Deposit on grease of clusters.	Change in colour and texture of greases.	Increase in racking forces exerted. Increased contact resistance and temperature rise.
Deposit on displays.		Screen data not legible.
Deposit on insulation.		Reduced insulation resistance (depends on type of dust). This phenomenon is worsened by the presence of humidity.
Deposit on device contacts.		Increased contact resistance and temperature rise.
Deposit on opto-electronic communication system between devices.		Failure of communication-data transmission.
Dust deposit		
Low level	**Moderate**	**High**
Quantity of dust generally deposited on and around devices in commercial buildings and on standard industrial premises.	Quantity of dust found in **protected switchboards** installed in dusty environments such as cement works, grain mills, incineration installations, plastic and steel mills, mines, etc.	Quantity of dust deposited on and around devices inside **non-protected switchboards** installed in dusty environments such as cement works, grain mills, incineration installations, plastic and steel mills, mines, etc.
Recommendation		
Preventive maintenance		
Implement the standard program. It is advised to vacuum cleaner dust deposits.	Carry out more frequent periodic cleaning (see table 10).	Carry out more frequent periodic cleaning (see table 10).
Installation		
Switchboard with standard IP.	Make sure the switchboard remains closed.	Special equipment required to protect the switchgear is mandatory.

Causes of accelerated ageing

Corrosive atmosphere

Corrosive atmosphere	Influence	Appearance	Consequences	Thresholds (ppm [1] in volume) Average value
SO_2 Sulphur dioxide	Corrosion of silver, aluminium and bare copper. Phenomenon accelerated by high temperature and relative humidity.	Blackening of exposed silver surfaces. Appearance of dendrites on electronic and power circuits.	Increased resistance of disconnecting contacts exposed to air. Excessive device temperature rise. Short-circuiting of circuits resulting in non operation of the control unit.	3C1: 0.037 3C2: 0.11 3C3: 1.85 3C4: 4.8
H_2S Hydrogen sulphide	Sulphuration of silver, this phenomenon is accelerated by high temperatures.	Major blackening of exposed silver surfaces. Appearance of dendrites on electronic and power circuits.	Increased resistance of disconnecting contacts exposed to air. Excessive device temperature rise. Short-circuiting of circuits resulting in non operation of the control unit.	3C1: 0.0071 3C2: 0.071 3C3: 2.1 3C4: 9.9
CL_2 Chlorine	Corrosion of metal parts.	Oxidation. Inter-granular corrosion of stainless steel.	Increase in friction. Risk of mechanical rupture. Breaking of stainless-steel springs.	3C1: 0.034 3C2: 0.034 3C3: 0.1 3C4: 0.2
NH_3 Ammoniac	Attacks polycarbonates, corrodes copper.	Cracking of polycarbonates. Blackening of copper.	Risk of rupture. Increased temperature rise.	3C1: 0.42 3C2: 1.4 3C3: 14 3C4: 49
NO_2 Nitrogen oxide	Corrosion of metal parts.	Oxidation.	Increased temperature rise.	3C1: 0.052 3C2: 0.26 3C3: 1.56 3C4: 5.2
Oily atmospheres	Attacks polycarbonates.	Cracking of polycarbonates.	Risk of rupture. Increased temperature rise.	

Environment categories as per standard 721-3-3

Class			
3C1	**3C2**	**3C3**	**3C4**
Rural zones or urban zones with low industrial activity.	Urban zones with scattered industrial activity and heavy traffic.	Immediate vicinity of industrial pollution. Example, paper mills, water treatment, chemicals, synthetic fibres, smelting plants.	Inside polluting industrial premises. Example: paper mills, water treatment, chemicals, synthetic fibres, smelting plants.
Presence of corrosive gases			
Negligible	**Low level**	**Significant level**	**High level**
Impact on switchgear			
No impact on service life because concentrations are very low.	Moderate impact on service life.	Major impact, particularly concerning temperature rise. For electronic systems, no impact on varnished boards and gold-plated contacts.	Significantly reduced service life if no particular precautions are taken. For electronic systems, no impact on varnished boards and gold-plated contacts.
Recommendation			
Preventive maintenance			
Implement the standard program.	Implement the standard program. PYRATEX grease can be used for the disconnecting contacts, but must be changed annually (see the manufacturer procedure).	Carry out more frequent periodic checks (see page 10). Change the grease on the disconnecting contacts.	Carry out more frequent periodic checks (see page 10). Change the grease on the disconnecting contacts.
Installation			
No particular precautions required.	No particular precautions required.	Use fixed rather than drawout devices.	It is advised to install the switchgear in a room protected from the pollution. Use fixed rather than drawout devices, or implement special solutions (gold-plated disconnecting contacts).

(1) Ppm = parts per million.

Causes of accelerated ageing

Operating conditions

Operating conditions directly affect the service life of switchgear due to the limited electrical and mechanical endurance levels of the various subassemblies. Operating conditions include:
- vibrations,
- the number of operating cycles,
- the interrupted currents.

Vibrations

Influence	**Appearance**	**Consequences**	
Premature deterioration of contact surfaces (clusters and main contacts).	Not identifiable.	Increased device temperature rise.	
Untightening of bolted assemblies.	Not identifiable.	Increase in mechanical play.	
Wear of mechanical parts.	Not identifiable.	Broken springs. Increase in mechanical play between parts.	
Appearance of fretting corrosion on auxiliary connections.	Not identifiable.	Erroneous information or loss of continuity in data or supply, excessive temperature rise.	
Breaking of connectors on large electronic components (e.g. large capacitors).	Not identifiable.	Failure of protection function.	
Wear of thumbwheel contacts on the control unit.	Not identifiable.	Nuisance tripping or no tripping.	
Thresholds (g)			
≤ 0.2 g	**0.2 g to 0.5 g**	**0.5 g to 0.7 g**	**> 0.7 g**
Normal condition, no impact on service life.	Reduced service life.	Significant increase in incidents.	Forbidden for standard devices.
Recommendation			
Preventive maintenance			
Implement the standard program.	Carry out more frequent periodic checks (see table).	Carry out more frequent periodic checks (see page 10). Check in particular the tightness of connections.	
Installation			
No particular precautions required.	No particular precautions required.	Install switchgear on a rubber mounting bush.	Use special devices.

Number of operating cycles

Influence	**Appearance**	**Consequences**
The number of operating cycles depends directly on the electrical and mechanical endurance of the device.		Device service life depends on the daily number of operating cycles.
Operating limits		
≤ 30 cycles per month	**≤ 60 cycles per month**	**≤ 120 cycles per month**
Corresponds to one cycle per day. For an endurance of 10 000 cycles and an interrupted current of less than 0.4 In, the service life is 27 years.	Corresponds to two cycles per day. For an endurance of 10 000 cycles and an interrupted current of less than 0.4 In, the service life is 13 years.	Corresponds to four cycles per day. For an endurance of 10 000 cycles and an interrupted current of less than 0.4 In, the service life is 7 years.

Causes of accelerated ageing

Interrupted current

Influence	Appearance	Consequences
Wear of fixed and moving contacts.	Deterioration of contacts.	Beyond the electrical-endurance limit, device temperature rise increases due to the greater contact resistance and a reduction in the pressure of contacts.
Wear of the arc chutes (insulating materials, separators).	Deterioration of insulation.	Beyond the electrical-endurance limit, the insulation (input/output and between phases) is reduced, which results in a reduction of device suitability for isolation. In this case, the safety of persons is no longer guaranteed.
Thresholds		
≤ 0.4 In	≤ 0.8 In	≤ In
This level of interrupted current corresponds to the mechanical durability (see Mechanical endurance).	This level of interrupted current corresponds to approximately 125 % of the electrical durability.	This level of interrupted current corresponds to the electrical durability at the specified voltage (see Electrical endurance).

Operating limits

Maximum number of opening/closing cycles (no load)								
Masterpact NT AC	**(1)**		**Masterpact NW AC**	**(1)**	**(2)**	**Masterpact NW DC**	**(1)**	**(2)**
All ratings	12500		NW08 to NW16 N1, H1, H2, L1	12500	25000	500 V DC / 900 V DC		
and performance levels			NW20 to NW25 H1,H2 H3	10000	20000	NW10 N, H	10000	20000
			NW20 L1	10000	20000	NW20 N, H	10000	20000
			NW32 to NW 40 H1,H2, H3	10000	20000	NW40 N, H	10000	20000
			NW40b to NW63 H1, H2	5000	10000			

(1) Number of device operating cycles without maintenance.
(2) Number of device operating cycles with maintenance. The elements below must be replaced during the device service life to reach the maximum possible number of operating cycles (arc chutes, main contacts, connecting-rod springs, MCH gear motor, interlocks, MX/XF/MH control auxiliaries). In case of contact'swear, all contacts must be changed, the complete breaking block is then replaced.

Masterpact NT AC			**Masterpact NW AC**			**Masterpact NW DC**		
Arc chutes (at In)								
NT08 to10 440 V H1	6000		NW08 to NW16 N1, H1, H2	10000		500 V DC		
NT08 to10 690 V H1	3000		NW08 to NW16 L1	3000		NW10 N, H	8500	
NT12 440 V H1	6000		NW20 to NW25 440 V H1, H2	8000		NW20 N, H	5000	
NT12 690V H1	3000		NW20 to NW25 690 V H1,H2	6000		NW40 N, H	2000	
NT16 440 V H1	3000		NW20 to NW25 H3	2000		900 V DC		
NT16 690 V H1	1000		NW20 to NW25 690 V H1, H2, H3	6000		NW10 N, H	2000	
NT08 to 10 440 V L1	3000		NW20 L1	3000		NW20 N, H	2000	
NT08 to 10 690 V L1	2000		NW32 to NW40 440 V H1, H2	5000		NW40 N, H	1000	
			NW32 to NW40 690 V H1, H2	2500				
			NW32 to NW40 690 V H3	1250				
			NW40b to NW63 H1, H2	1500				
Main contacts (at In)								
NT08 to10 440 V H1	6000		NW08 to NW16 N1, H1, H2	10000		500 V DC		
NT08 to10 690 V H1	3000		NW08 to NW16 L1	10000		NW10 N, H	8500	
NT12 440V H1	6000		NW20 to NW25 440 V H1, H2, H3	8000		NW20 N, H	8500	
NT12 690V H1	3000		NW20 to NW25 690 V H1, H2, H3	6000		NW40 N, H	4000	
NT16 440 V H1	3000		NW20 L1	10000		900 V DC		
NT16 690 V H1	1000		NW32 to NW40 440 V H1, H2, H3	5000		NW10 N, H	2000	
NT08 to 10 440 V L1	3000		NW32 to NW40 690 V H1, H2, H3	2500		NW20 N, H	2000	
NT08 to 10 690 V L1	2000		NW40b to NW63 H1, H2	3000		NW40 N, H	2000	
Connecting-rod springs, gear motor, interlocking mechanisms								
All ratings	12500		NW08 to NW16 N1, H1, H2	12500		500 V DC / 900 V DC		
and performance levels			NW08 to NW16 L1	12500		NW10 N, H	10000	
			NW20 to NW40 H1, H2, H3	10000		NW20 N, H	10000	
			NW20 L1	10000		NW40 N, H	10000	
			NW40b to NW63 H1, H2	5000				
MX/XF/MN control auxiliaries								
All ratings	12500		All ratings and performance levels	12500		500 V DC / 900 V DC		
and performance levels						NW10 N, H	12500	
						NW20 N, H	12500	
						NW40 N, H	12500	

List of available guides

Switchgear guides

	Masterpact NT	Masterpact NW	Micrologic A - P - H
Adaptation and exchange policy (PAR)			
	NT PAR Schneider after-sales support only	NW PAR Schneider after-sales support only	NT PAR & NW PAR Schneider after-sales support only
Catalogues			
	ART56504	ART56504	ART56504
Maintenance procedure			
	Maintenance 15-03 Schneider after-sales support only	Maintenance 15-03 Schneider after-sales support only	Maintenance 15-03 Schneider after-sales support only
Installation manual			
	■ circuit breaker: 51201003AA-A1 ■ circuit breaker accessories: 51201111AA-A0 ■ chassis accessories: 51201112AA-A0	■ circuit breaker: 51156118AA-A0 ■ circuit breaker accessories: 04443717AA-A0 ■ chassis accessories: 04443718AA-A0	
User manual			
	51201115AA-A	AC: 04443719AA-A DC: En: 04444163AA_B1	Micrologic A: 04443723AA-B Micrologic P: 04443725AA-A Micrologic H:
Modbus communication for Micrologic - Installation and user manual			
	En/Fr: 510051284AAA	En/Fr: 510051284AAA	En/Fr: 510051284AAA
List of adaptation sheets			
	FIM NT Schneider after-sales support only	FIM NW Schneider after-sales support only	FIM NT & FIM NW Schneider after-sales support only
List of typical problems			
	See User manual 51201115AA-A	See User manual 04443719AA-A	
Price list for spare parts			
	COMBT15EN	COMBT15EN	COMBT15EN
Portable test-kit user manual			
			48049-183-01

Troubleshooting and solutions

Problem	Probable causes	Solutions
circuit breaker cannot be closed locally or remotely	■ circuit breaker padlocked or keylocked in the "open" position	□ disable the locking fonction
	■ circuit breaker interlocked mechanically in a source changeover system	□ check the position of the other circuit breaker in the changeover system □ modify the situation to release the interlock
	■ circuit breaker not completely connected	□ terminate racking in (connection) of the circuit breaker
	■ the reset button signalling a fault trip has not been reset	□ clear the fault □ push the reset button on the front of the circuit breaker
	■ stored energy mechanism not charged	□ charge the mechanism manually □ if it is equipped with a an MCH gear motor, check the supply of power to the motor. If the problem persists,replace the gear motor (MCH)
	■ MX opening shunt release permanently supplied with power	□ there is an opening order. Determine the origin of the order. The order must be cancelled before the circuit breaker can be closed
	■ MN undervoltage release not supplied with power	□ there is an opening order. Determine the origin of the order. □ check the voltage and the supply circuit (U > 0.85 Un). If the problem persists, replace the release
	■ XF closing release continuously supplied with power, but circuit breaker not "ready to close" (XF not wired in series with PF contact)	□ cut the supply of power to the XF closing release, then send the closing order again via the XF, but only if the circuit breaker is "ready to close"
	■ permanent trip order in the presence of a Micrologic P or H control unit with minimum voltage and minimum frequency protection in Trip mode and the control unit powered	□ disable these protection functions on the Micrologic P or H control unit
circuit breaker cannot be closed remotely but can be opened locally using the closing pushbutton	■ closing order not executed by the XF closing release	□ check the voltage and the supply circuit (0.85 - 1.1 Un). If the problem persists, replace the XF release
unexpected tripping without activation of the reset button signalling a fault trip	■ MN undervoltage release supply voltage too low	□ check the voltage and the supply circuit (U > 0.85 Un)
	■ load-shedding order sent to the MX opening release by another device	□ check the overall load on the distribution system □ if necessary, modify the settings of devices in the installation
	■ unnecessary opening order from the MX opening release	□ determine the origin of the order
unexpected tripping with activation of the reset button signalling a fault trip	a fault is present: ■ overload ■ earth fault ■ short-circuit detected by the control unit	□ determine and clear the causes of the faultthe fault □ check the condition of the circuit breaker before putting it back into service
instantaneous opening after each attempt to close the circuit breaker with activation of the reset button signalling a fault trip	■ thermal memory	□ see the user manual of the control unit □ press the reset button
	■ transient overcurrent when closing	□ modify the distribution system or the control-unit settings □ check the condition of the circuit breaker before putting it back into service □ press the reset button
	■ closing on a short-circuit	□ clear the fault □ check the condition of the circuit breaker before putting it back into service □ press the reset button

Troubleshooting and solutions

Problem	Probable causes	Solutions
circuit breaker cannot be opened remotely, but can be opened locally	■ opening order not executed by the MX opening release	□ check the voltage and the supply circuit (0.7 - 1.1 Un). If the problem persists, replace the MX release
	■ opening order not executed by the MN undervoltage release	□ drop in voltage insufficient or residual voltage (> 0.35 Un) across the terminals of the undervoltage release. If the problem persists, replace the MN release
circuit breaker cannot be opened locally	■ operating mechanism malfunction or welded contacts	□ contact a Schneider service centre
circuit breaker cannot be reset locally but not remotely	■ insufficient supply voltage for the MCH gear motor	□ check the voltage and the supply circuit (0.7 - 1.1 Un). If the problem persists, replace the MCH release
nuisance tripping of the circuit breaker with activation of the reset button signalling a fault trip	■ reset button not pushed-in completely	□ push the reset button in completely
impossible to insert the crank in connected, test or disconnected position	■ a padlock or keylock is present on the chassis or a door interlock is present	□ disable the locking function
iimpossible to turn the crank	■ the reset button has not been pressed	□ press the reset button
circuit breaker cannot be removed from chassis	■ circuit breaker not in disconnected position	□ turn the crank until the circuit breaker is in disconnected position and the reset button out
	■ the rails are not completely out	□ pull the rails all the way out
circuit breaker cannot be connected (racked in)	■ chassis/circuit breaker mismatch protection	□ check that the chassis corresponds with the circuit breaker
	■ the safety shutters are locked	□ remove the lock(s)
	■ the disconnecting-contact clusters are incorrectly positioned	□ reposition the clusters
	■ chassis locked in disconnected position	□ disable the chassis locking function
	■ the reset button has not been pressed, preventing rotation of the crank	□ press the reset button
	■ the circuit breaker has not been sufficiently inserted in the chassis	□ insert the circuit breaker completely so that it is engaged in the racking mechanism
circuit breaker cannot be locked in disconnected position	■ the circuit breaker is not in the right position	□ check the circuit breaker position by making sure the resett button is out
	■ the cranck is still in the chassis	□ remove the crank and store it
circuit breaker cannot be locked in connected, test or disconnected position	■ check that locking in any position is enabled	□ contact a Schneider service centre
	■ the circuit breaker is not in the right position	□ check the circuit breaker position by making sure the rese button is out
	■ the cranck is still in the chassis	□ remove the crank and store it
the crank cannot be inserted to connect or disconnected the circuit breaker	■ the rails are not completely in	□ push the rails all the way in
the right-hand rail (chassis alone) or the circuit breaker cannot be drawn out	■ the crank is still in the chassis	□ remove the crank and store it

Schneider contacts

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F - 92500 Rueil-Malmaison (France)
Tel : +33 (0)1 41 29 85 00

http://www.schneider-electric.com
http://www.merlin-gerin.com

As standards, specifications and designs change from time to time, please ask for confirmation of the information given in this publication.

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MASTERPACT NW08-63 IEC

Low Voltage Products

User manual

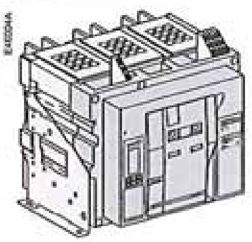
a brand of Schneider Electric

Merlin Gerin

User manual for circuit breakers

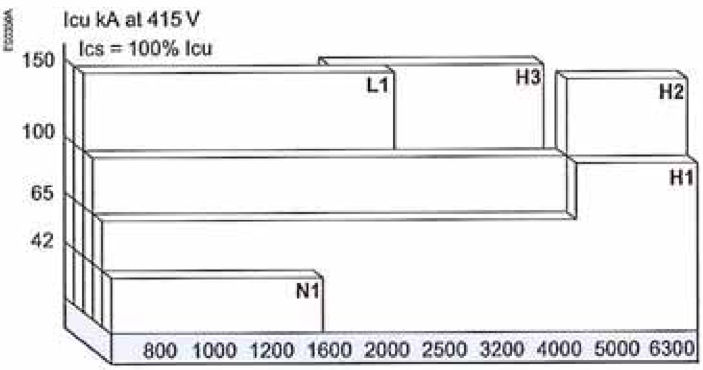
Masterpact NW08-63 IEC

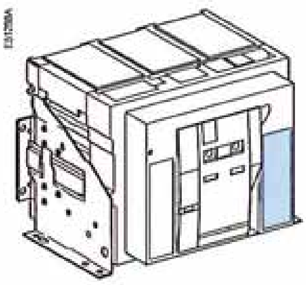
Discovering Masterpact



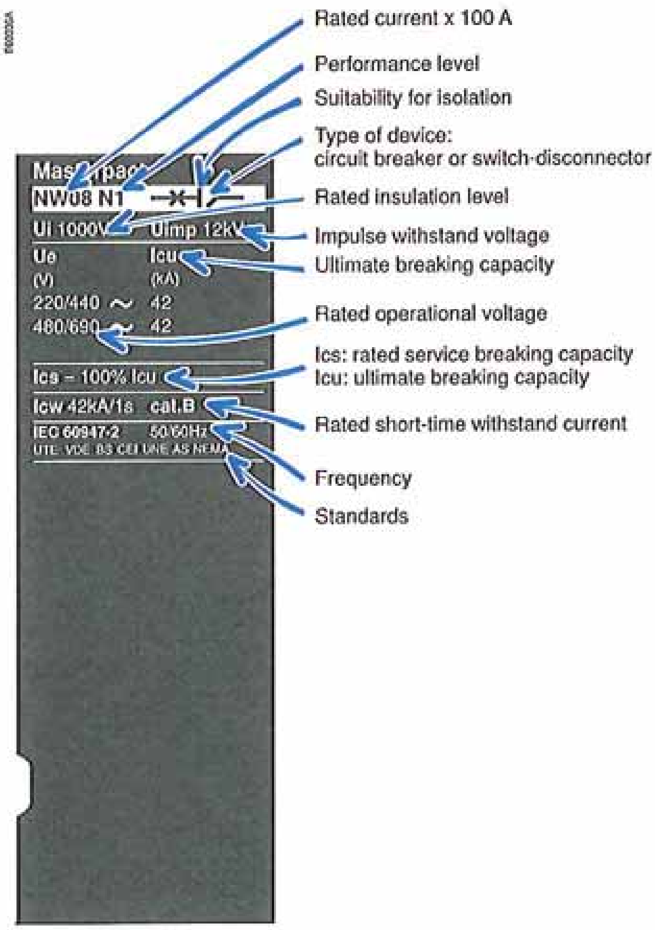
The Masterpact NW range of circuit breakers and switch-disconnectors offer current ratings from 800 A to 6300 A.
Five different performance levels are available:

- N1: standard with total discrimination
- H1: high performance with total discrimination
- H2: a compromise between current limiting and discrimination
- H3: high breaking capacity and discrimination, without current limiting
- L1: high level of current limiting, with some discrimination.



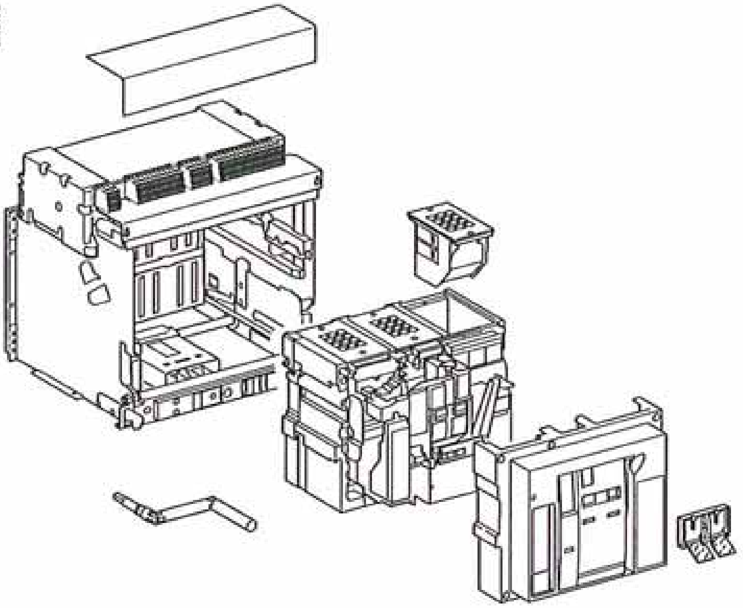


Rating plate

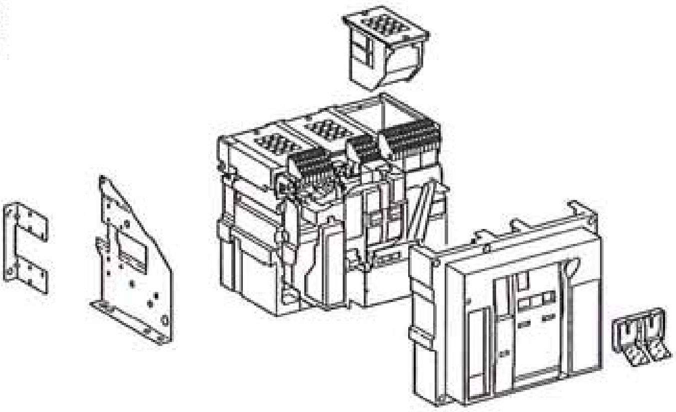


Masterpact circuit breakers are available in drawout and fixed versions.
The drawout version is mounted on a chassis and the fixed version is installed using fixing brackets

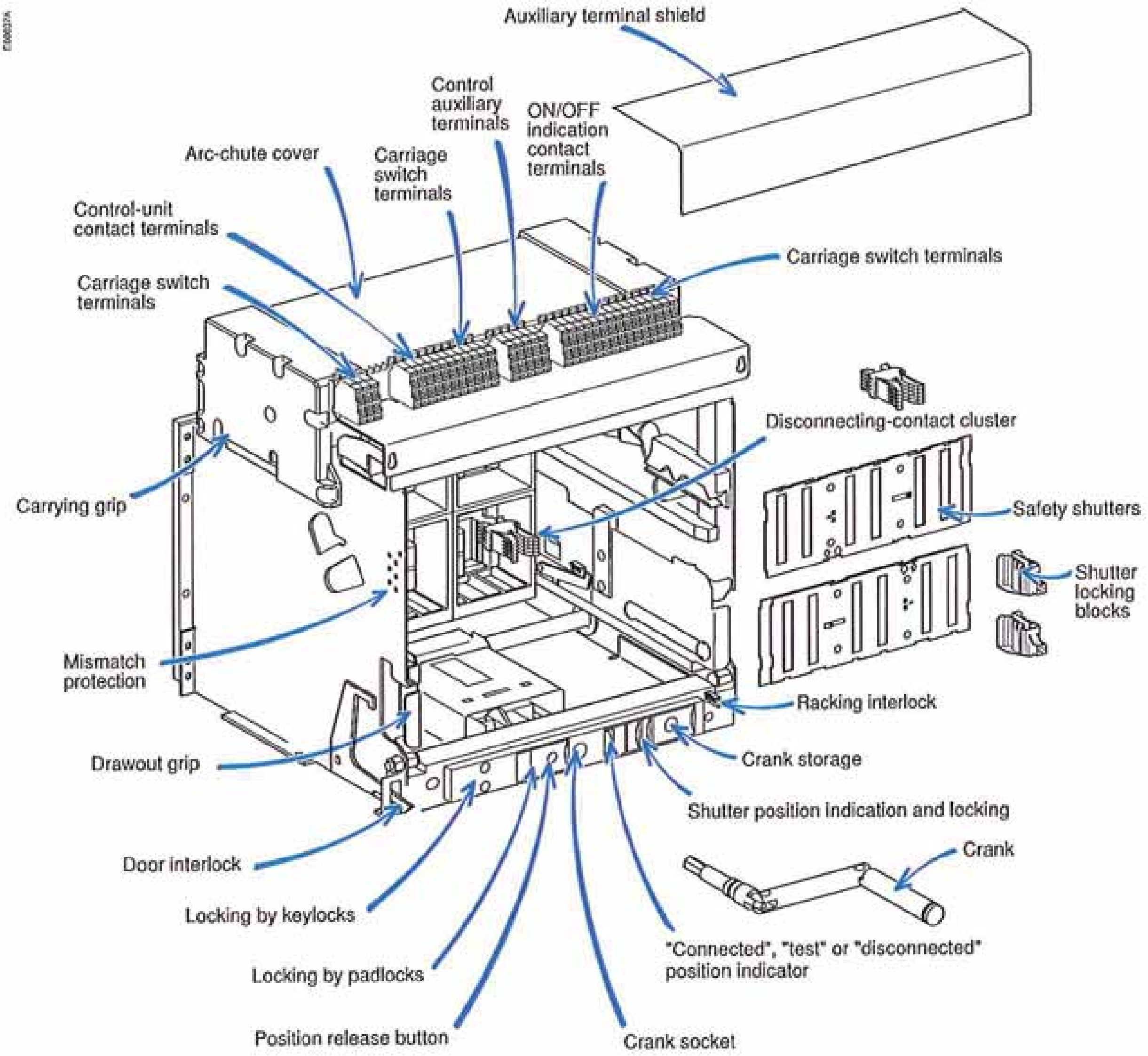
Drawout version



Fixed version

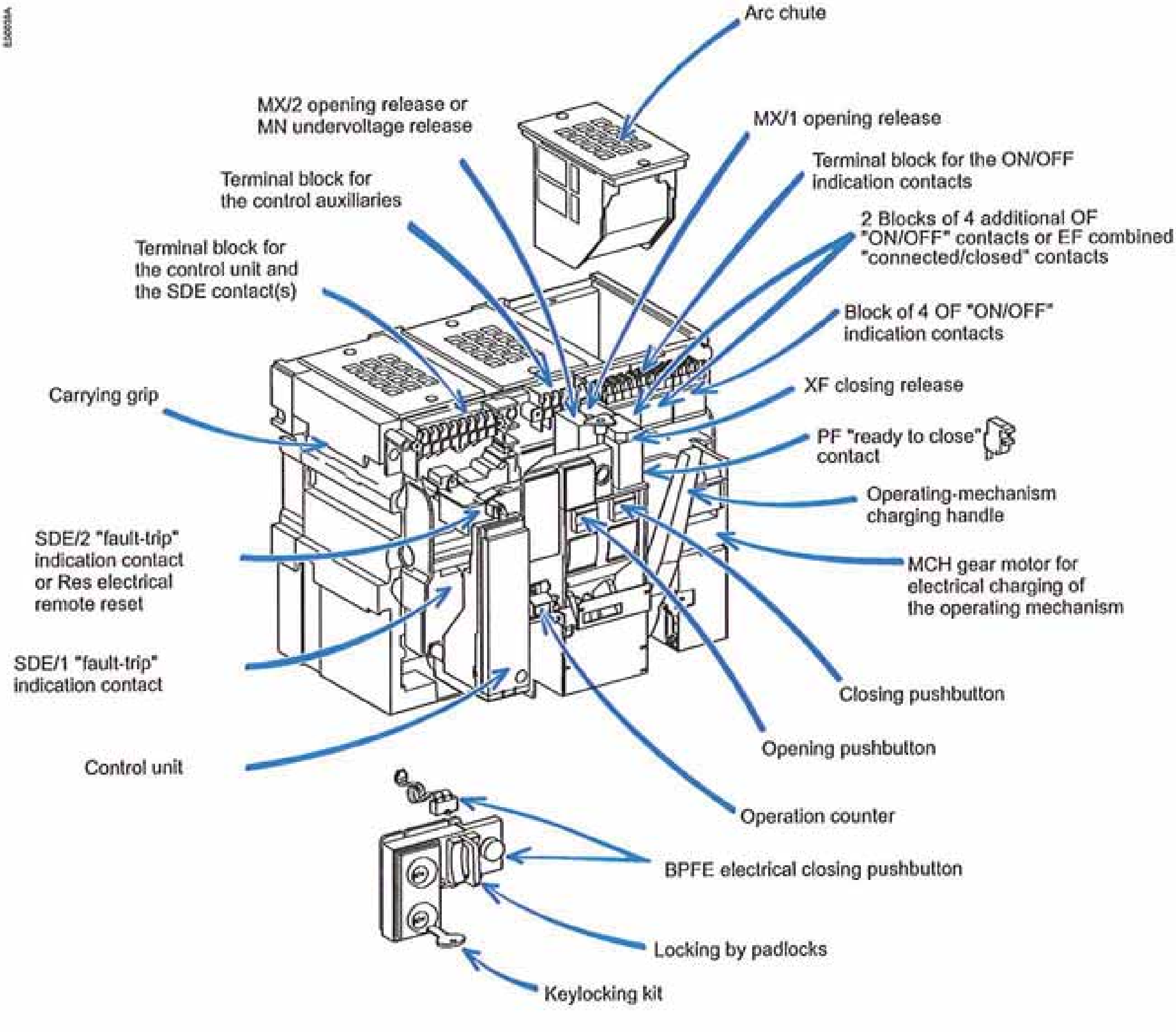


Chassis

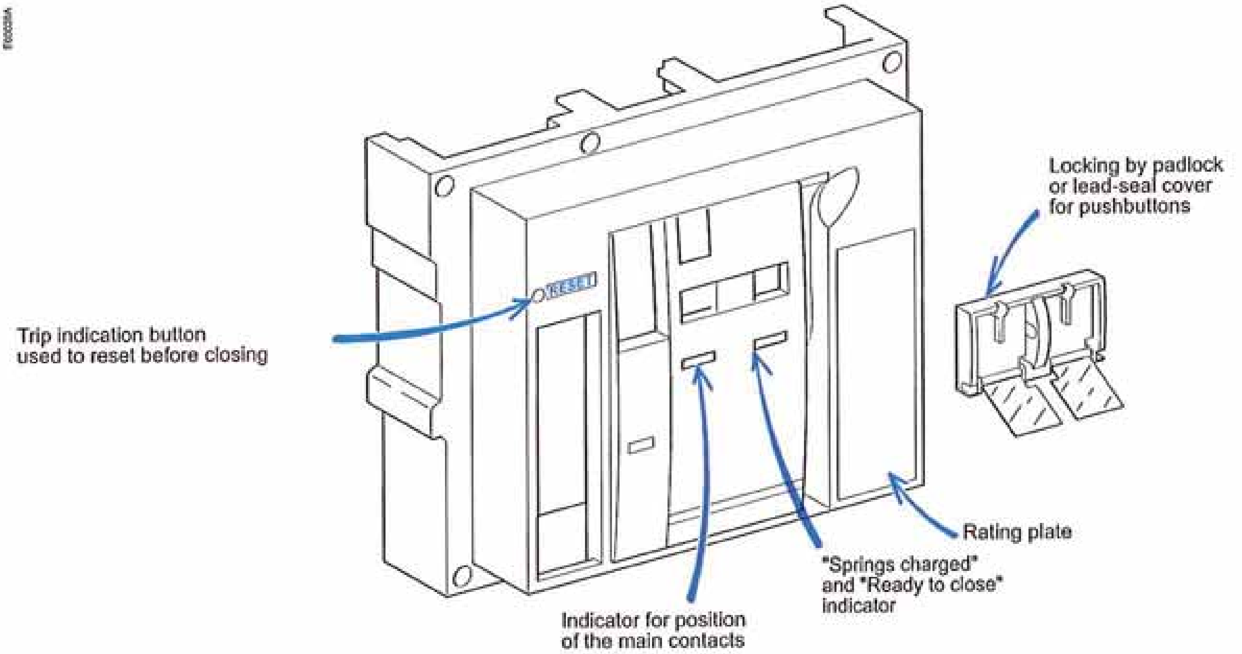


Auxiliary terminal shield
Control auxiliary terminals
ON/OFF indication contact terminals
Arc-chute cover
Carriage switch terminals
Control-unit contact terminals
Carriage switch terminals
Carriage switch terminals
Disconnecting-contact cluster
Carrying grip
Safety shutters
Shutter locking blocks
Mismatch protection
Racking interlock
Drawout grip
Crank storage
Shutter position indication and locking
Crank
Door interlock
Locking by keylocks
"Connected", "test" or "disconnected" position indicator
Locking by padlocks
Position release button
Crank socket

Circuit breaker / switch-disconnector

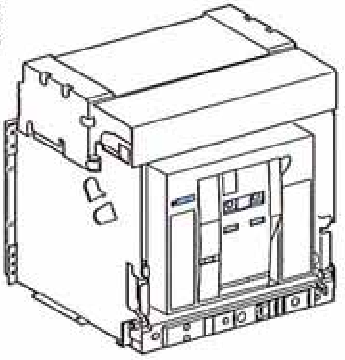


Front

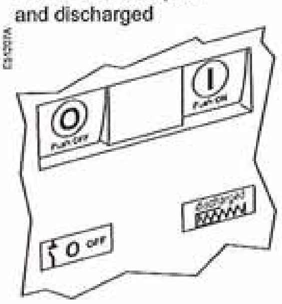


RESET
Trip indication button
used to reset before closing
Locking by padlock
or lead-seal cover
for pushbuttons
Rating plate
"Springs charged"
and "Ready to close"
indicator
Indicator for position
of the main contacts

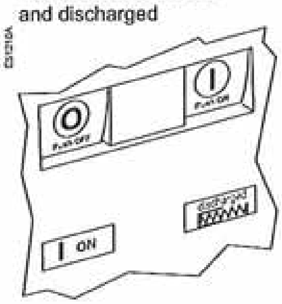
Understanding the controls and indications



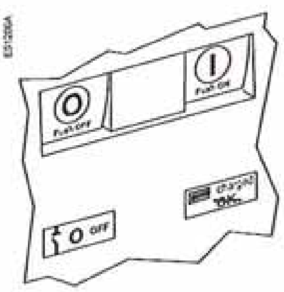
Circuit breaker open and discharged



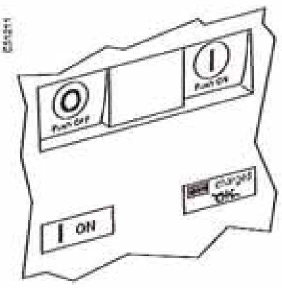
Circuit breaker closed and discharged



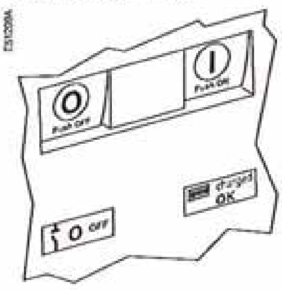
Circuit breaker open, charged and not "ready to close"



Circuit breaker closed, charged and not "ready to close"

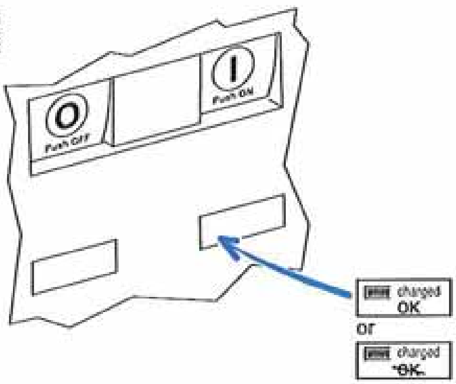


Circuit breaker open, charged and "ready to close"



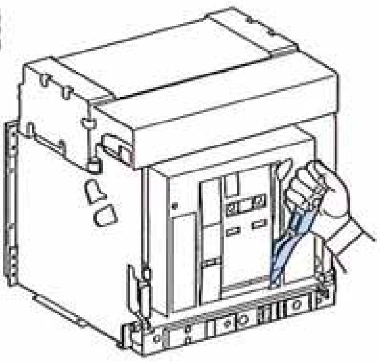
Charging the circuit breaker

The charge status is indicated as follows.

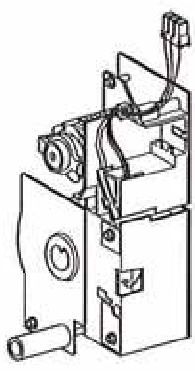


The springs in the circuit breaker operating mechanism must be charged to store the energy required to close the main contacts. The springs may be charged manually using the charging handle or the optional MCH gear motor.

Manual charging:
Pull the handle down seven times until you hear a "clack".

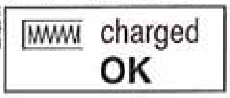


Automatic charging:
If the MCH gear motor is installed, the spring is automatically recharged after each closing.

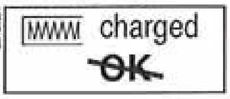


Closing the circuit breaker

Device "ready to close"



Device not "ready to close"



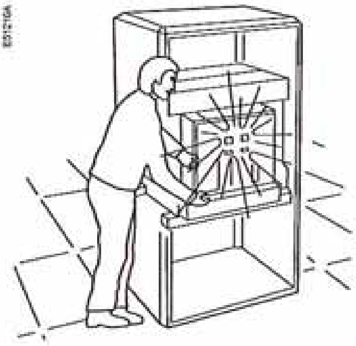
Closing conditions

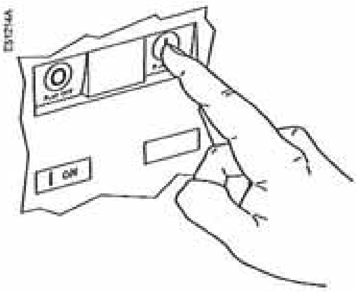
Closing (i.e. turning the circuit ON) is possible only if the circuit breaker is "ready to close".
The prerequisites are the following:
- device open (OFF)
- springs charged
- no opening order present.

If the circuit breaker is not "ready to close" when the order is given, stop the order and start again when the circuit breaker is "ready to close".

Closing the circuit breaker

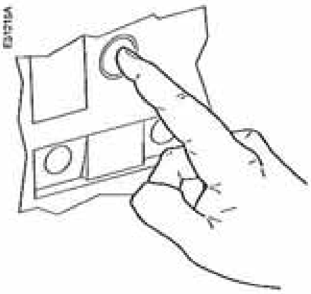
Locally (mechanical)
Press the mechanical ON pushbutton.



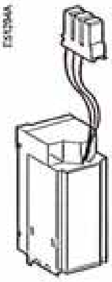


Locally (electrical)

BPFE

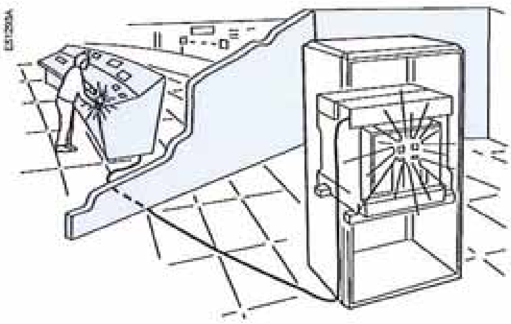


XF

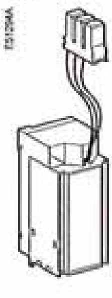


Press the electrical closing pushbutton. By adding an XF closing release, the circuit breaker can be closed remotely.

Remotely



XF

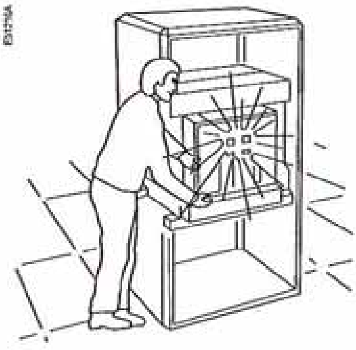


When connected to a remote control panel, the XF closing release (0.85 to 1.1 Un) can be used to close the circuit breaker remotely.

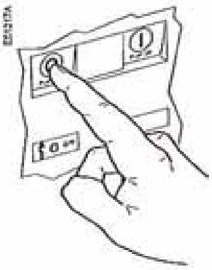
Enabling or disabling the anti-pumping function

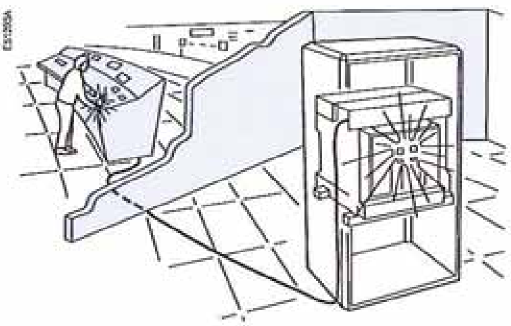
The purpose of the mechanical anti-pumping function is to ensure that a circuit breaker receiving simultaneous opening and closing orders does not open and close indefinitely.
If there is a continuous closing order, after opening the circuit breaker remains open until the closing order is discontinued. A new closing order then closes the circuit breaker. This function can be disabled by wiring the closing release in series with the PF "ready to close" contact.

Opening the circuit breaker



Locally
Press the OFF pushbutton.

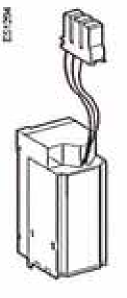




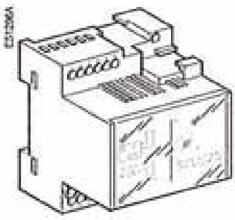
Remotely
Use one of the following solutions:
- one or two MX opening releases (MX1 and MX2, 0.7 to 1.1 Un)
- one MN undervoltage release (0.35 to 0.7 Un)
- one MN undervoltage release (0.35 to 0.7 Un) with a delay unit (R or Rr).

When connected to a remote control panel, these releases can be used to open the circuit breaker remotely.

MX1, MX2, MN



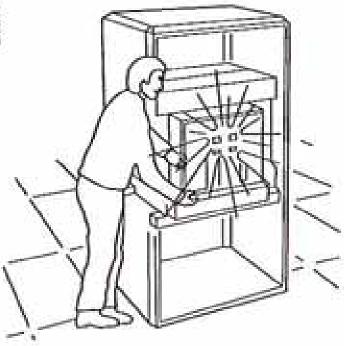
Delay unit

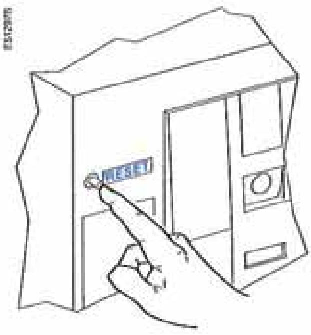


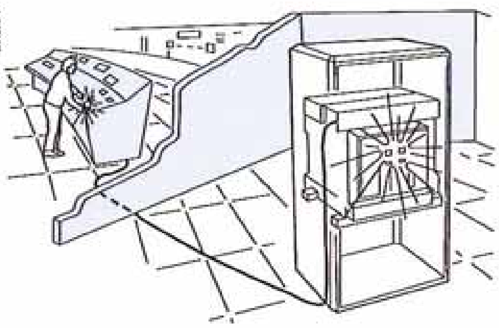
Resetting after a fault trip

The circuit breaker signals a fault by:
- a mechanical indicator on the front panel
- one or two SDE "fault-trip" indication contacts (SDE/2 is optional).

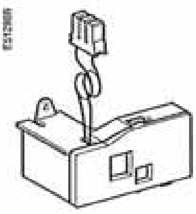
Locally
If the circuit breaker is not equipped with the automatic reset option, reset it manually.



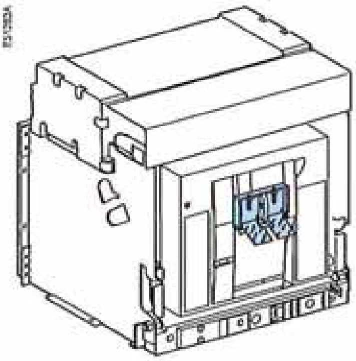




Remotely
Use the Res electrical remote reset option (not compatible with an SDE/2).

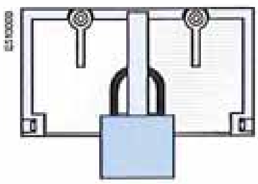


Locking the controls
Disabling circuit-breaker local closing and opening

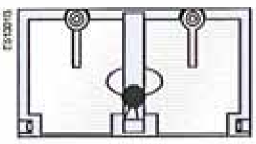


Pushbutton locking using a padlock (shackle diameter 5 to 8 mm), a lead seal or screws.

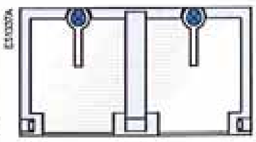
Padlock



Lead seal

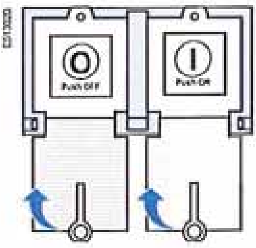


Screws

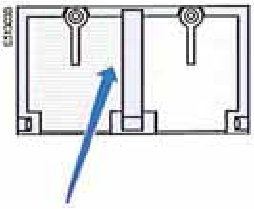


Locking

Close the covers.

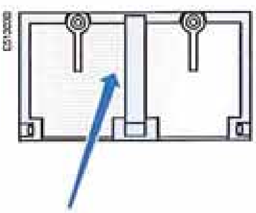


Insert the padlock shackle, lead seal or screws.

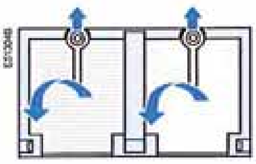


Unlocking

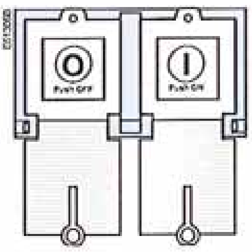
Remove the padlock, lead seal or screws.



Lift the covers and swing them down.



The pushbuttons are no longer locked.



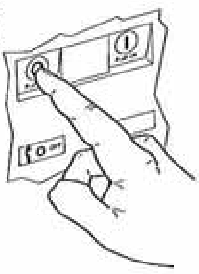
Locking the controls
Disabling local and remote closing

Combination of locking systems
To disable circuit-breaker closing using the pushbuttons or remotely, use as needed:
- a padlock
- one or two keylocks
- a combination of the two locking systems.

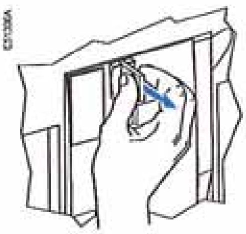
Install a padlock (maximum shackle diameter 5 to 8 mm)

Locking

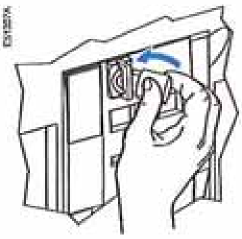
Open the circuit breaker.



Pull out the tab.

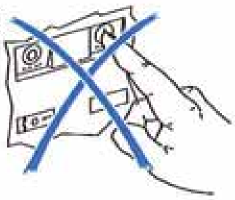


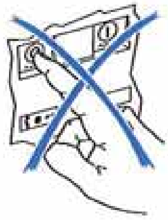
Insert the padlock shackle.



Check

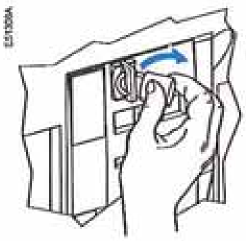
The controls are inoperative.





Unlocking

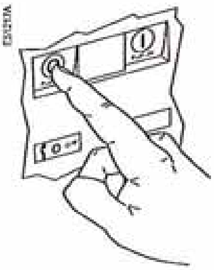
Remove the padlock.



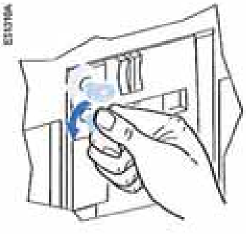
Locking the controls with one or two keylocks

Locking

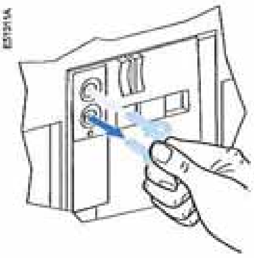
Open the circuit breaker.



Turn the key(s).

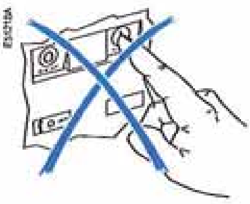


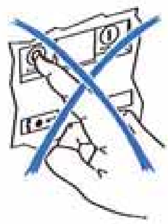
Remove the key(s).



Check

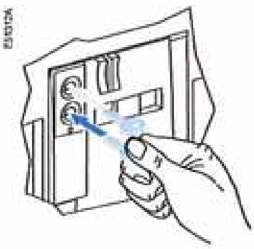
The controls are inoperative.



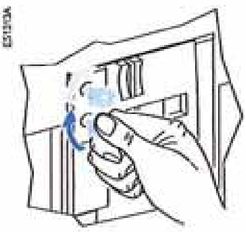


Unlocking

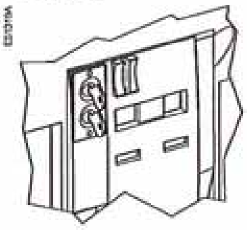
Insert the key(s).



Turn the key(s).

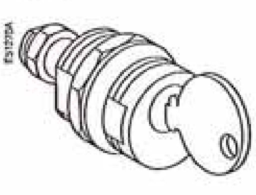


The key(s) cannot be removed.

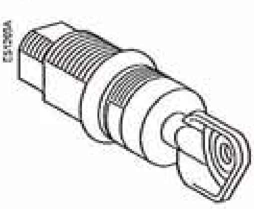


Four types of keylocks are available.

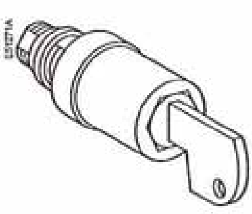
RONIS



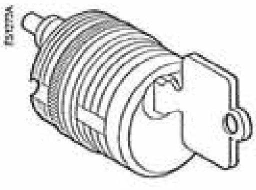
PROFALUX



CASTELL

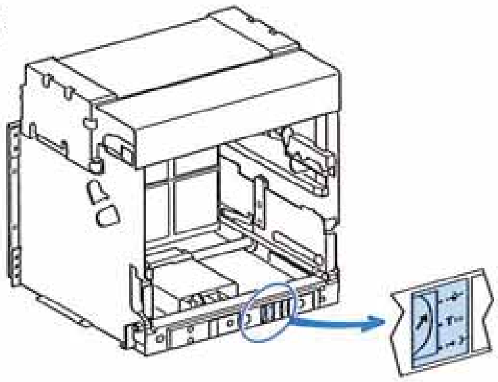


KIRK

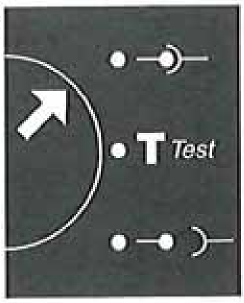


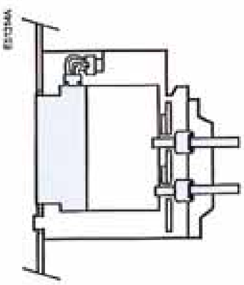
Identifying the circuit breaker positions

The indicator on the front signals the position of the circuit breaker in the chassis.

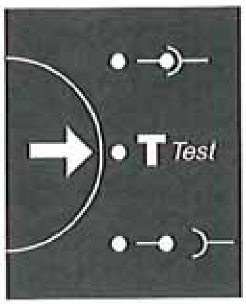


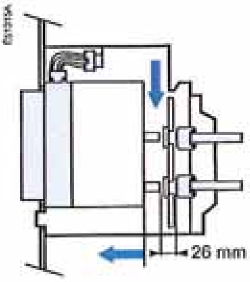
■ "connected" position



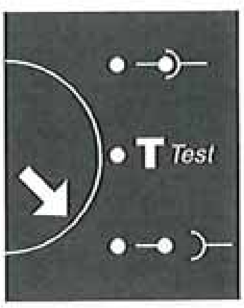


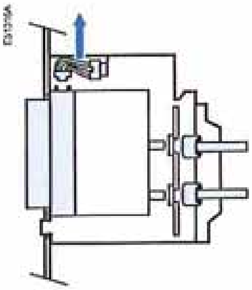
■ "test" position





■ "disconnected" position





Racking

These operations require that all chassis-locking functions be disabled *(see page 21).*

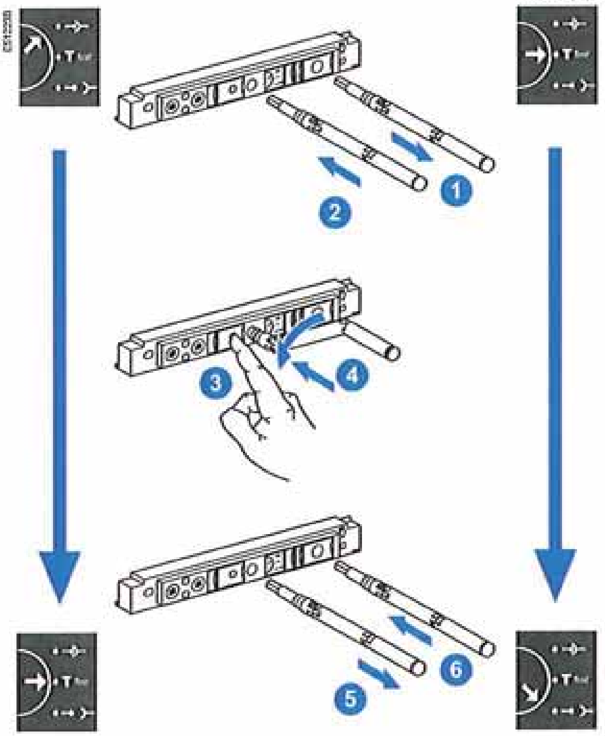
Prerequisites

To connect and disconnect Masterpact, the crank must be used. The locking systems, padlocks and the racking interlock all inhibit use of the crank.

Withdrawing the circuit breaker from the "connected" to "test" position, then to "disconnected" position

The circuit breaker is in "connected" position.

The circuit breaker is in "test" position.



The circuit breaker is in "test" position. Remove the crank or continue to "disconnected" position.

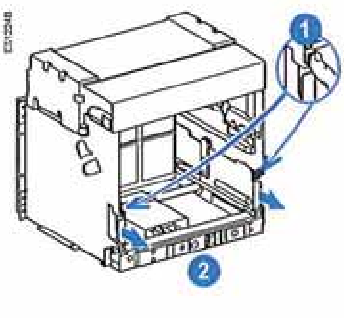
The circuit breaker is in "disconnected" position.

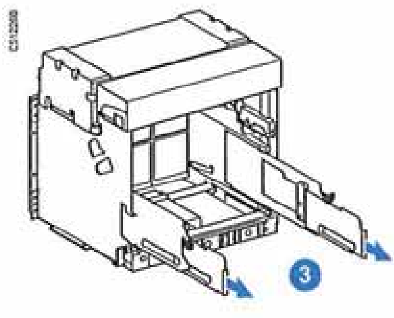
Caution. The right-hand rail cannot be removed if the crank has not been removed or if the circuit breaker is not fully disconnected.

Removing the rails

Press the release tabs and pull the rails out.

To put the rails back in, press the release tabs and push the rails in.





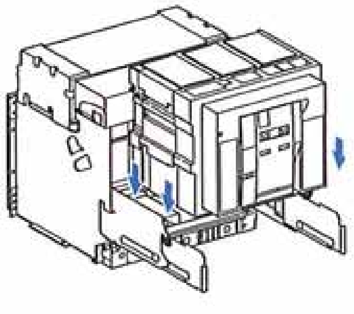
Racking

For complete information on Masterpact handling and mounting, see the installation manual(s).

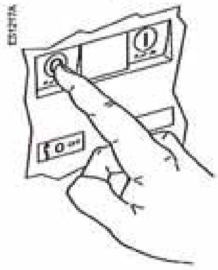
Before mounting the circuit breaker, make sure it matches the chassis.

Inserting Masterpact

Position the circuit breaker on the rails.
Check that it rests on all four supports.

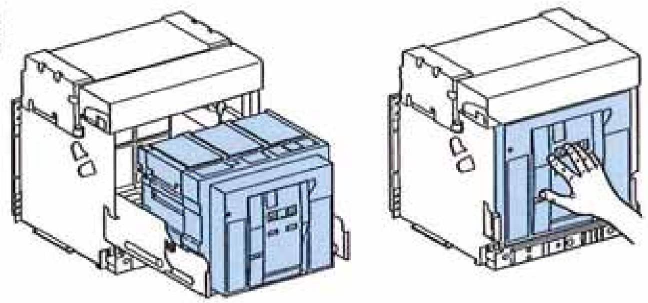


Open the circuit breaker (in any case, it opens automatically during connection).



Push the circuit breaker into the chassis, taking care not to push on the control unit.

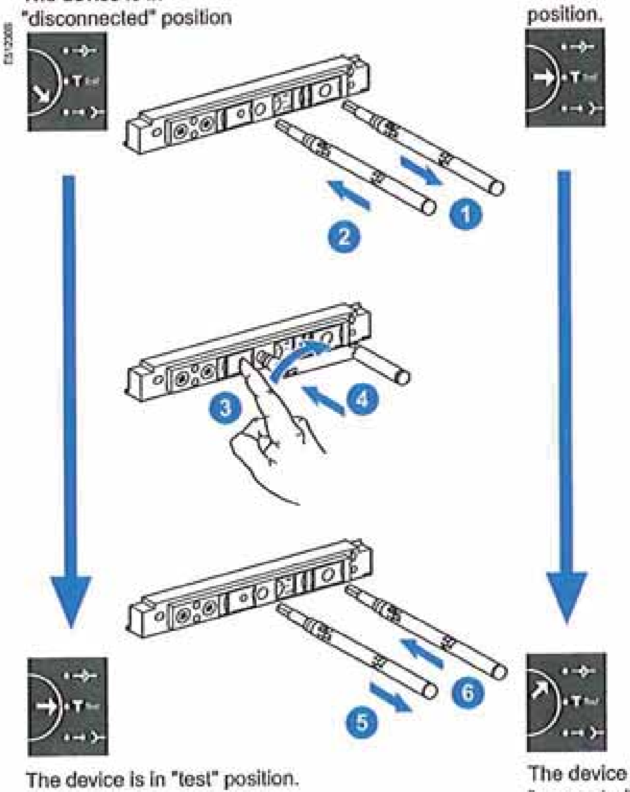
If you cannot insert the circuit breaker in the chassis, check that the mismatch protection on the chassis corresponds to that on the circuit breaker.



Racking the circuit breaker from the "disconnected" to "test" position, then to "connected" position

The device is in "disconnected" position

The device is in "test" position.



The device is in "test" position.
Remove the crank or continue to "connected" position.

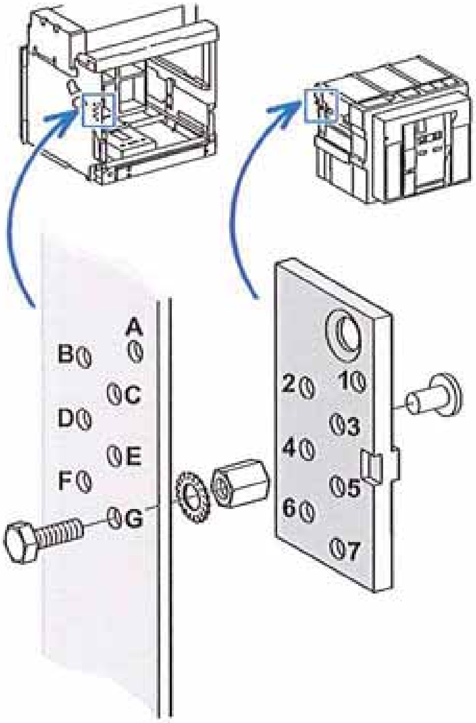
The device is in "connected" position.

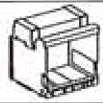
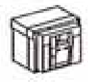
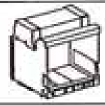
Matching a Masterpact circuit breaker with its chassis

To set up a mismatch-prevention combination for the circuit breaker and the chassis, see the mismatch-prevention installation manual.

The mismatch protection ensures that a circuit breaker is installed only in a chassis with compatible characteristics.

The possible combinations are listed below.

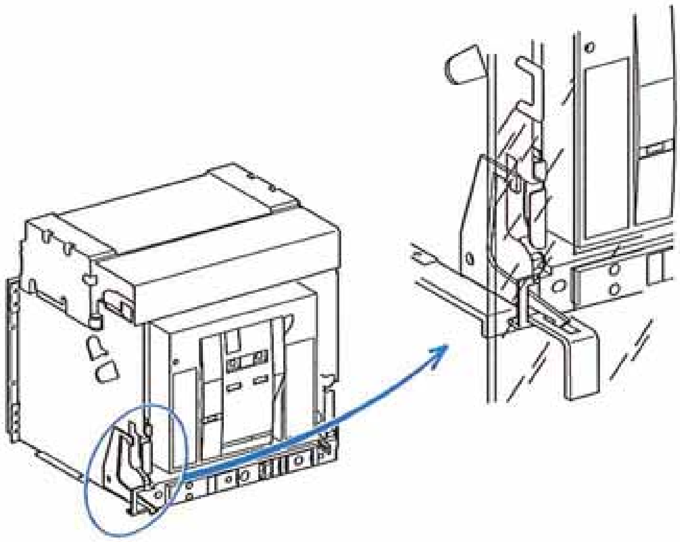


			
A B C D	5 6 7	B C D E	1 6 7
A B C E	4 6 7	B C D F	1 5 7
A B C F	4 5 7	B C D G	1 4 7
A B C G	4 5 6	B C E F	1 4 6
A B D E	3 6 7	B C E G	1 3 7
A B D F	3 5 7	B D E F	1 3 6
A B D G	3 5 6	B D E G	1 3 5
A B E F	3 4 7	B D F G	1 3 4
A B E G	3 4 6	C D E F	1 2 7
A B F G	3 4 5	C D E G	1 2 6
A C D E	2 6 7	C E F G	1 2 4
A C D F	2 5 7	D E F G	1 2 3
A C D G	2 5 6		
A C E F	2 4 7		
A C E G	2 4 6		
A C F G	2 4 5		
A D E F	2 3 7		
A D E G	2 3 6		
A D F G	2 3 5		
A E F G	2 3 4		

Locking the switchboard door

The locking device is installed on the left or right-hand side of the chassis:
■ when the circuit breaker is in "connected" or "test" position, the latch is lowered and the door is locked
■ when the circuit breaker is in "disconnected" position, the latch is raised and the door is unlocked.

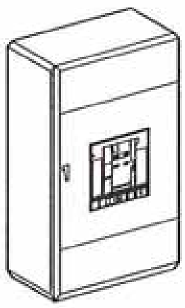
E51215



Disabling door opening

Close the door.

E51232A

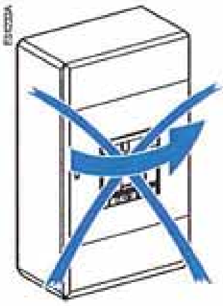


Put the Masterpact in "test" or "connected" position.

E51233A

The door is locked.

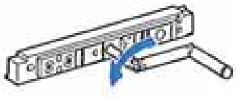
E51235A



Enabling door opening

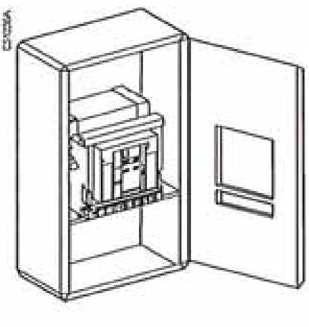
Put the Masterpact in "disconnected" position.

E51234A



The door is unlocked.

E51236A



Locking the circuit breaker in position

Padlocks and keylocks may be used together.

Combination of locking systems

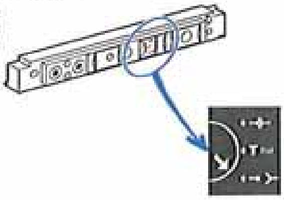
To disable local or remote opening or closing of the circuit breaker, use as needed:

- one to three padlocks
- one or two keylocks
- a combination of the two locking systems.

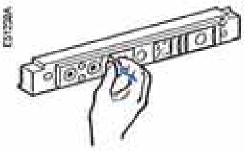
Disabling connection when the circuit breaker is in "disconnected" position, using one to three padlocks (maximum shackle diameter 5 to 8 mm)

Locking

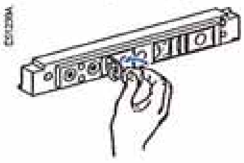
Circuit breaker in "disconnected" position.



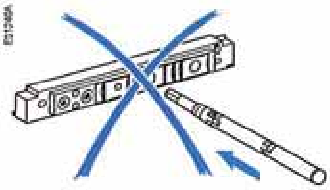
Pull out the tab.



Insert the shackle (max. diameter 5 to 8 mm) of the padlock(s).

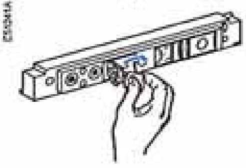


The crank cannot be inserted.

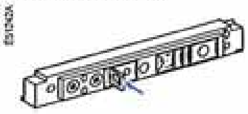


Unlocking.

Remove the padlock(s).



Release the tab.



The crank can be inserted.

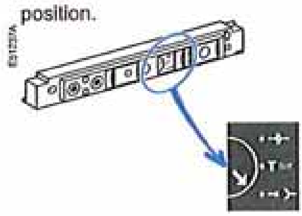
Locking the circuit breaker in position

Padlocks and keylocks may be used together.

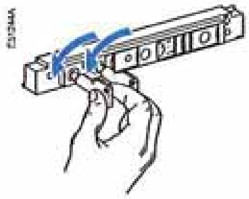
Disabling connection when the circuit breaker is in "disconnected" position, using one or two keylocks.

Locking

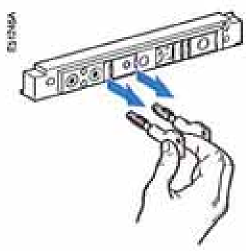
Circuit breaker in "disconnected" position.



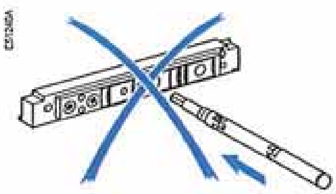
Turn the key(s).



Remove the key(s).

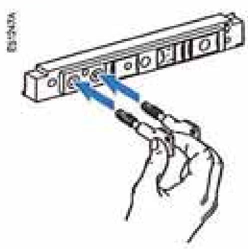


The crank cannot be inserted.

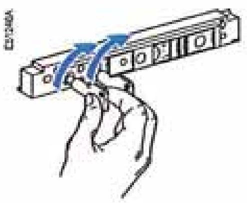


Unlocking

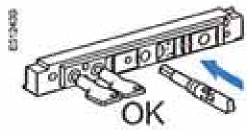
Insert the key(s).



Turn the key(s).

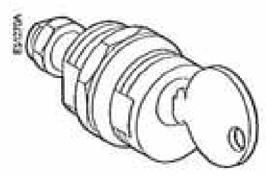


The crank can be inserted.

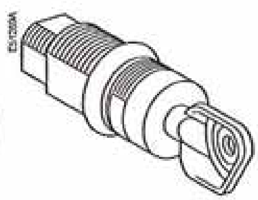


Four types of keylocks are available

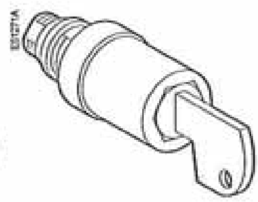
RONIS



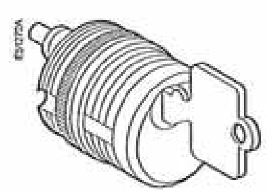
PROFALUX



CASTELL



KIRK

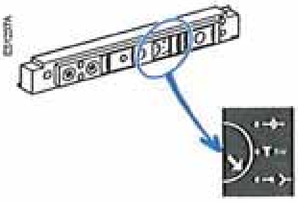


For this operation, the circuit breaker must be removed from the chassis.

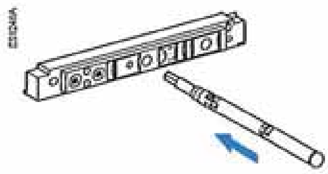
Disabling use of the crank in all positions

It is possible to modify the padlock and keylock locking function. Instead of locking only in "disconnected" position, it is possible to lock the circuit breaker in all positions.

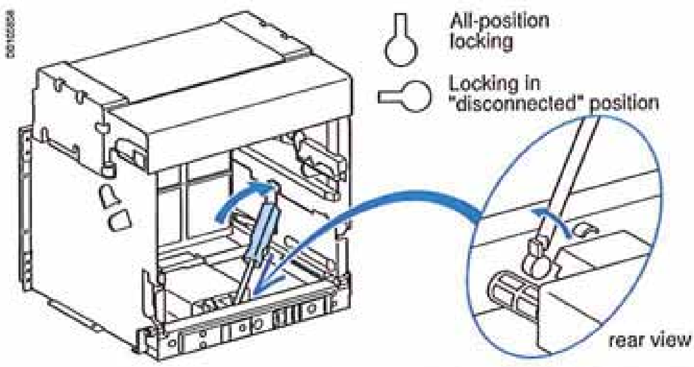
Set the circuit breaker to "disconnected" position. Remove the circuit breaker from the chassis.



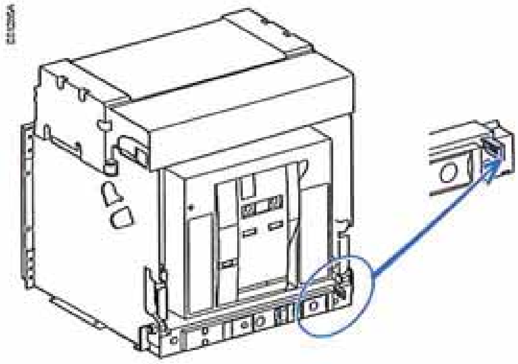
Insert the crank.



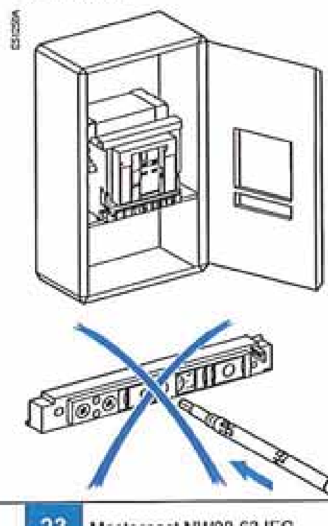
Turn the catch to the right. The circuit breaker can now be locked in all positions.



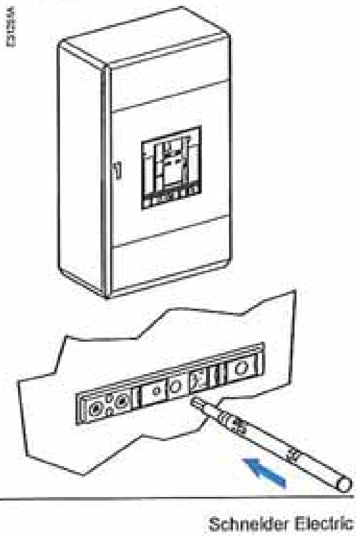
Locking the circuit breaker when the door is open



When the door is open, the crank cannot be inserted.



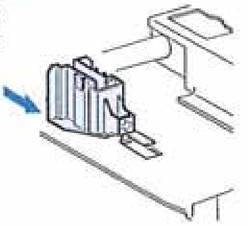
When the door is closed, the crank can be inserted.



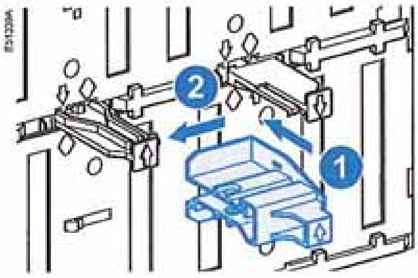
Locking the safety shutters
Padlocking inside the chassis

Using the shutter locking blocks

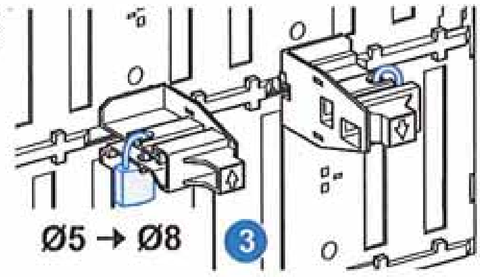
Remove the block(s) from their storage position.



Position the block(s) on the guide(s).

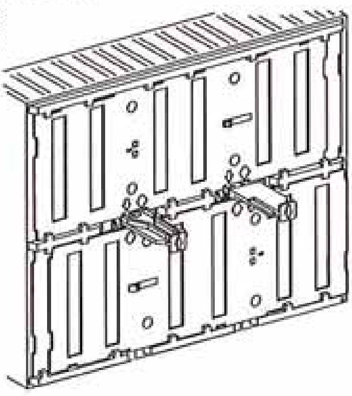


Lock the block(s) using a padlock.

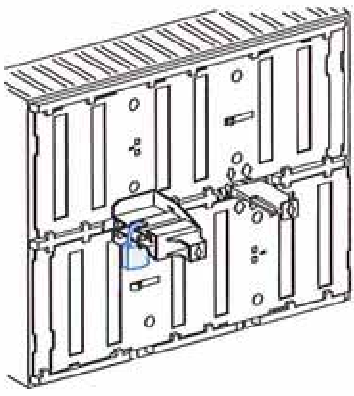


Four locking possibilities

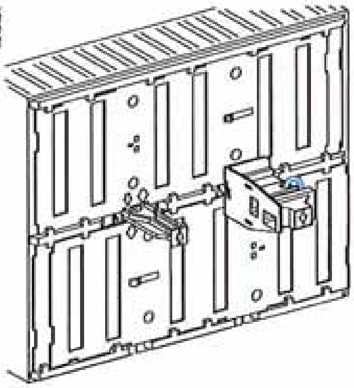
Top and bottom shutters not locked.



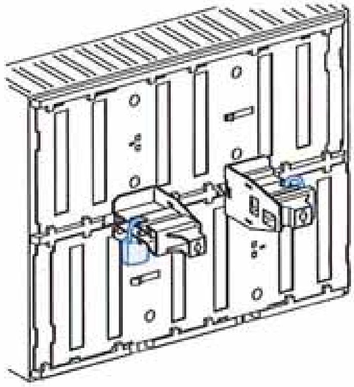
Top shutter locked, Bottom shutter not locked.



Top shutter not locked, Bottom shutter locked.



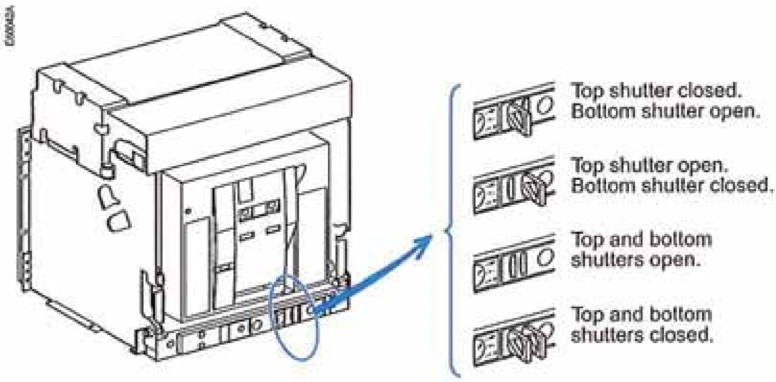
Top and bottom shutters locked.



Padlocking or position indication on the front

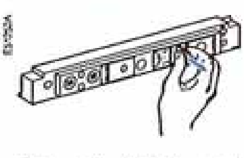
This system offers two functions:

- *padlocking of the top or bottom shutters*
- *indication of the position of each shutter:*
  - *shutter open*
  - *shutter closed.*



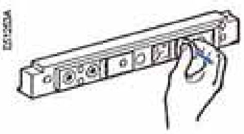
Locking

Pull out the left-hand tab to lock the top shutter.

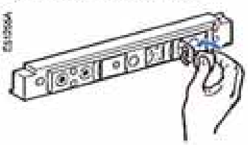


Insert a padlock (shackle 5 to 8 mm).

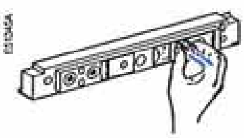
Pull out the right-hand tab to lock the bottom shutter.



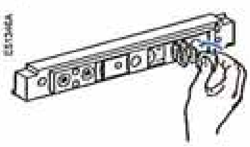
Insert a padlock (shackle 5 to 8 mm).



Pull out both tabs to lock both shutters.

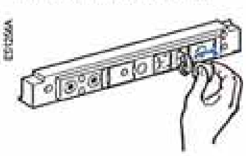


Insert a padlock (shackle 5 to 8 mm).

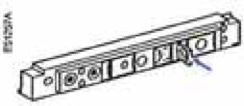


Unlocking

Remove the padlock.



Release the tab(s).



Identification of the connection terminals

Layout of terminal blocks

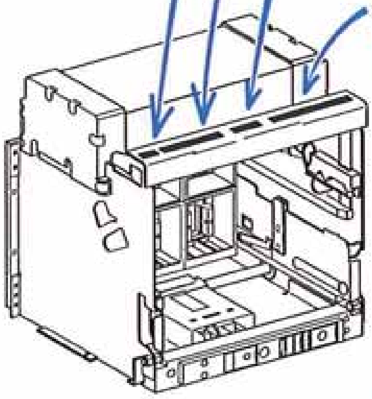
CD3	CD2	CD1
834	824	814
832	822	812
831	821	811

or

CE6	CE5	CE4
364	354	344
362	352	342
361	351	341

Com		UC1		UC2		UC3	UC4	M2C-M6C	SDE2/Res.	SDE1	CE3	CE2	CE1
E5	E6	Z5	M1	M2	M3	F2 +	V3	484/Q3	184/K2	84	334	324	314
E3	E4	Z3	Z4	T3	T4	VN	V2	474/Q2	182	82	332	322	312
E1	E2	Z1	Z2	T1	T2	F1 -	V1	471/Q1	181/K1	81	331	321	311

MN/MX2	MX1	XF	PF	MCH
D2/C12	C2	A2	254	B2
/C13	C3	A3	252	B3
D1/C11	C1	A1	251	B1



OF24	OF23	OF22	OF21	OF14	OF13	OF12	OF11	OF4	OF3	OF2	OF1	CT3	CT2	CT1
244	234	224	214	144	134	124	114	44	34	24	14	934	924	914
242	232	222	212	142	132	122	112	42	32	22	12	932	922	912
241	231	221	211	141	131	121	111	41	31	21	11	931	921	911
or	or	or	or	or	or	or	or						or	

EF24	EF23	EF22	EF21	EF14	EF13	EF12	EF11
248	238	228	218	148	138	128	118
246	236	226	216	146	136	126	116
245	235	225	215	145	135	125	115

CE9	CE8	CE7
394	384	374
392	382	372
391	381	371

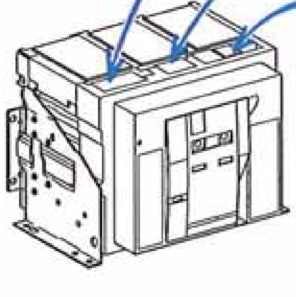
or

CD6	CD5	CD4
864	854	844
862	852	842
861	851	841

Com		UC1		UC2		UC3	UC4	M2C/M6C	SDE2/Res.	SDE1
E5	E6	Z5	M1	M2	M3	F2 +	V3	484/Q3	184/K2	84
E3	E4	Z3	Z4	T3	T4	VN	V2	474/Q2	182	82
E1	E2	Z1	Z2	T1	T2	F1 -	V1	471/Q1	181/K1	81

MN/MX2	MX1	XF	PF	MCH
D2/C12	C2	A2	254	B2
/C13	C3	A3	252	B3
D1/C11	C1	A1	251	B1

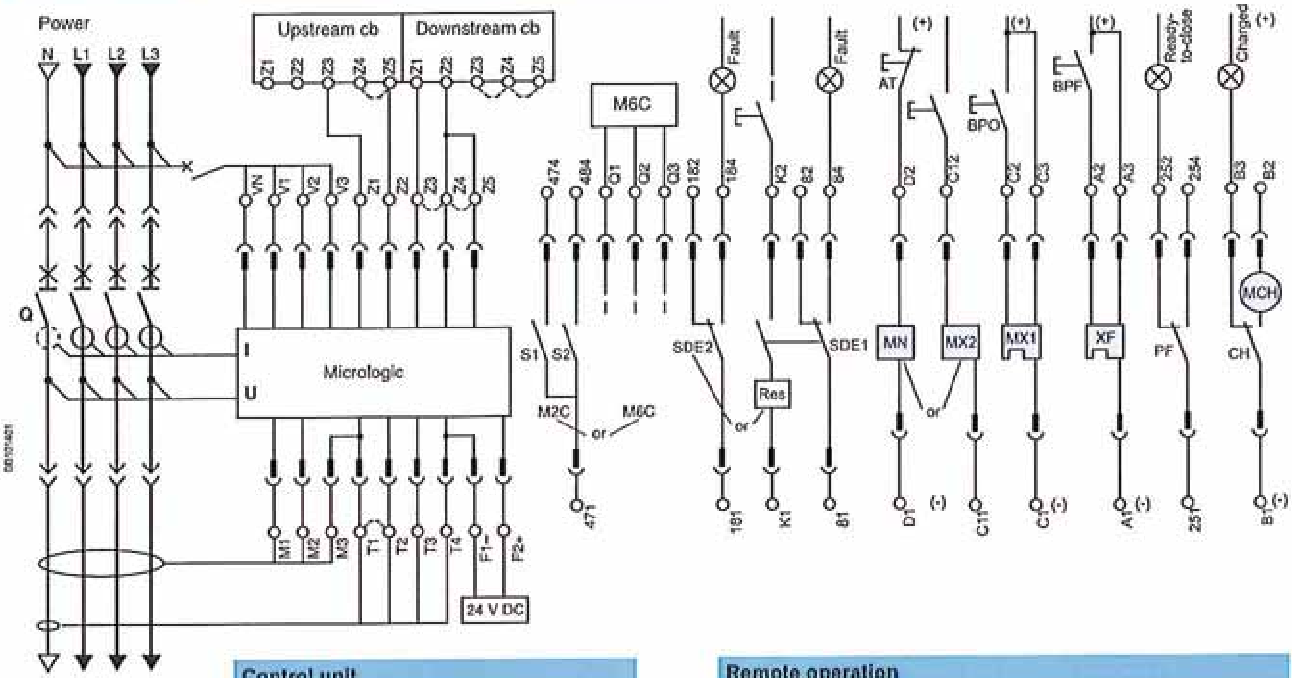
OF24	OF23	OF22	OF21	OF14	OF13	OF12	OF11	OF4	OF3	OF2	OF1
244	234	224	214	144	134	124	114	44	34	24	14
242	232	222	212	142	132	122	112	42	32	22	12
241	231	221	211	141	131	121	111	41	31	21	11



Electrical diagrams
Fixed and drawout devices

The diagram is shown with circuits de-energised, all devices open, connected and charged and relays in normal position.

Power	Control unit	Remote operation



Control unit

Com		UC1		UC2		UC3	UC4	M2C / M6C
E5	E6	Z5	M1	M2	M3	F2+	V3	484 / Q3
E3	E4	Z3	Z4	T3	T4	VN	V2	474 / Q2
E1	E2	Z1	Z2	T1	T2	F1–	V1	471 / Q1

Remote operation

SDE2 / Res	SDE1	MN / MX2	MX1	XF	PF	MCH
184 / K2	84	D2 / C12	C2	A2	254	B2
182	82		C3	A3	252	B3
181 / K1	81	D1 / C11	C1	A1	251	B1

A	P	H	Control unit
■	■	■	**Com:** E1-E6 communication
■	■	■	**UC1:** Z1-Z5 zone selective interlocking; Z1 = ZSI OUT SOURCE Z2 = ZSI OUT; Z3 = ZSI IN SOURCE Z4 = ZSI IN ST (short time) Z5 = ZSI IN GF (earth fault)
■	■	■	M1 = Vigi module input (Micrologic 7)
■	■	■	**UC2:** T1, T2, T3, T4 = external neutral;
■	■	■	M2, M3 = Vigi module input (Micrologic 7)
■	■	■	**UC3:** F2+, F1– external 24 V DC power supply
	■	■	VN external voltage connector
	■	■	**UC4:** V1, V2, V3 optional external voltage protector
	■	■	**M2C:** 2 programmable contacts (internal relay); ext. 24 V DC power supply required
			or
	■	■	**M6C:** 6 programmable contacts (external relay); 24 V DC power supply required

Remote operation

SDE2: Fault-trip indication contact
or
Res: Remote reset

SDE1: Fault-trip indication contact (supplied as standard)

MN: Undervoltage release
or
MX2: Shunt release

MX1: Shunt release (standard or communicating)

XF: Closing release (standard or communicating)

PF: "Ready to close" contact

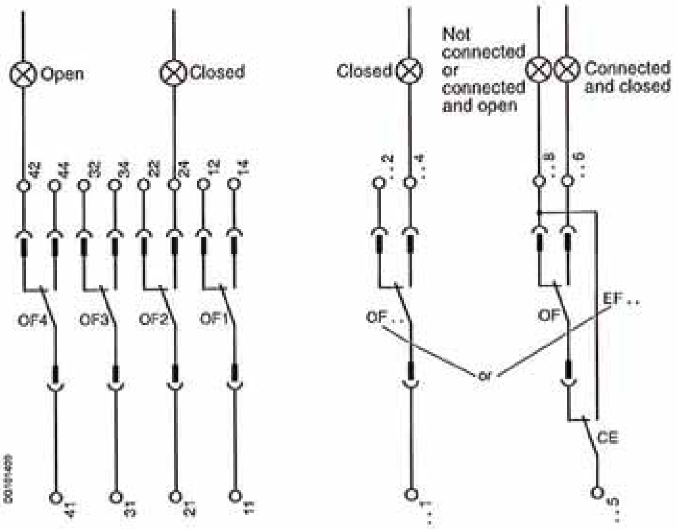
MCH: Gear motor.

Note:
When communicating MX or XF releases are used, the third wire (C3, A3) must be connected even if the communications module is not installed.

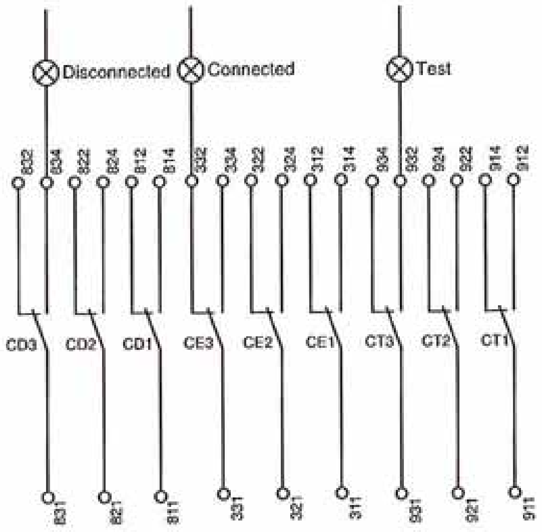
A : Digital ammeter
P : A + power meter + programmable protection
H : P + harmonics

Electrical diagrams

Indication contacts



Chassis contacts



Indication contacts

OF4	OF3	OF2	OF1
44	34	24	14
42	32	22	12
41	31	21	11

OF24	OF23	OF22	OF21	OF14	OF13	OF12	OF11
244	234	224	214	144	134	124	114
242	232	222	212	142	132	122	112
241	231	221	211	141	131	121	111
or	or	or	or	or	or	or	or
EF24	EF23	EF22	EF21	EF14	EF13	EF12	EF11
248	238	228	218	148	138	128	118
246	236	226	216	146	136	126	116
245	235	225	215	145	135	125	115

Chassis contacts

CD3	CD2	CD1	CE3	CE2	CE1	CT3	CT2	CT1
834	824	814	334	324	314	934	924	914
832	822	812	332	322	312	932	922	912
831	821	811	331	321	311	931	921	911

or

CE6	CE5	CE4
364	354	344
362	352	342
361	351	341

or

CE9	CE8	CE7
394	384	374
392	382	372
391	381	371

Indication contacts

OF4: ON/OFF
OF3 indication
OF2 contacts
OF1

OF 24 or EF 24 ON/OFF indication contacts
Combined "connected/closed" indication contacts

OF 23 or EF 23

OF 22 or EF 22

OF 21 or EF 21

OF 14 or EF 14

OF 13 or EF 13

OF12 or EF12

OF11 or EF11

Chassis contacts

CD3: Disconnected
CD2 -position
CD1 contacts

CE3: Connected
CE2 -position
CE1 contacts

CT3: Test-position
CT2 contacts
CT1 contacts

or

CE6: Connected
CE5 position
CE4 contacts

or

CE9: Connected
CE8 position
CE7 contacts

or

CD6: Disconnected
CD5 position
CD4 contacts

Key:

Drawout device only

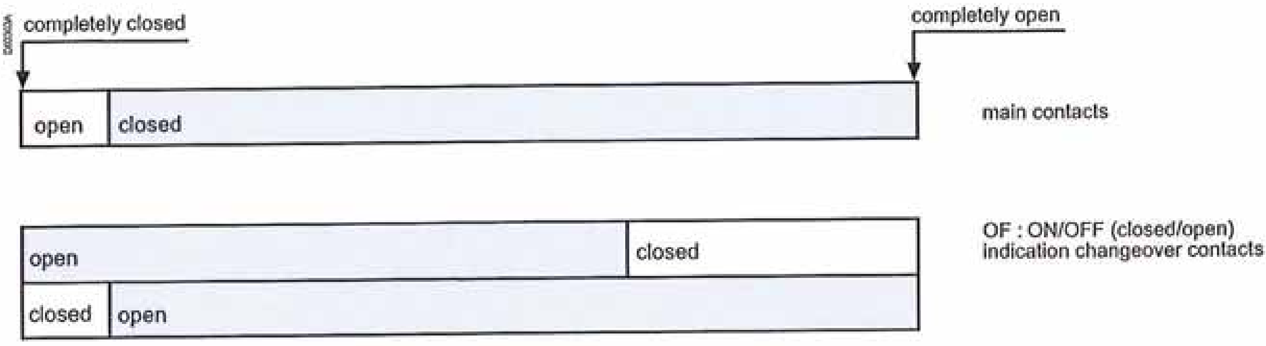
XXX *SDE1, OF1, OF2, OF3, OF4 supplied as standard*

Interconnected connections (only one wire per connection point)

Operation

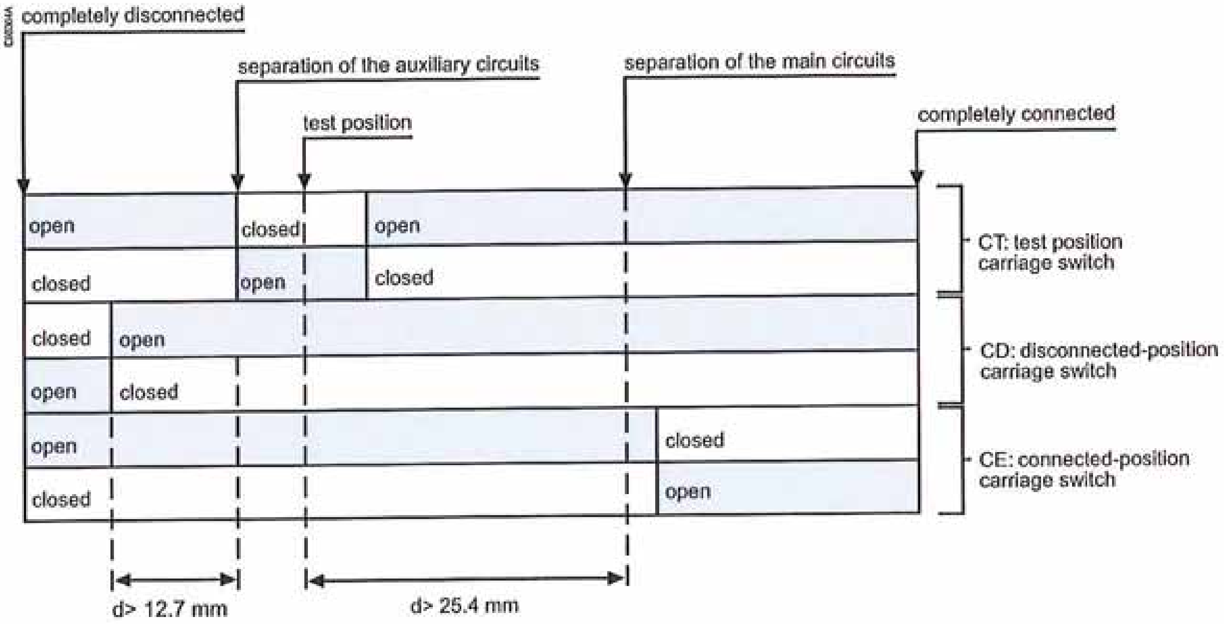
The ON/OFF indication contacts signal the status of the device main contacts.

Circuit breaker



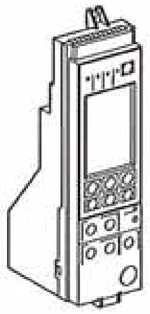
The carriage switches indicate the "connected", "test" and "disconnected" positions.

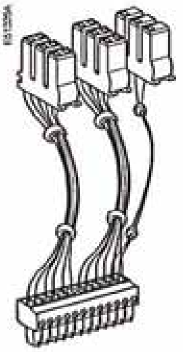
Chassis



Micrologic control units

For more in-depth information, see the control-unit user manual





Micrologic control units

- standard equipment, one per device
- long-time rating plug and connection cables not included, see below:
Micrologic 2.0
Micrologic 5.0
Micrologic 2.0A
Micrologic 5.0A
Micrologic 6.0A
Micrologic 7.0A
Micrologic 5.0P
Micrologic 6.0P
Micrologic 7.0P
Micrologic 5.0P
Micrologic 6.0H
Micrologic 7.0H
- connection cables:
  - for fixed device
  - for drawout device.
- depending on the model, control units offer in addition:
  - fault indications
  - measurement of electrical parameters (current, voltage, power, etc.)
  - harmonic analysis
  - communication.

Long-time rating plugs

- standard equipment, one per control unit.
  - 0.4 to 1 x Ir setting
  - 0.4 to 0.8 x Ir setting
  - 0.8 to 1 x Ir setting
  - Off (no long-time protection).
- the plugs determine the setting range for the Long-time protection.

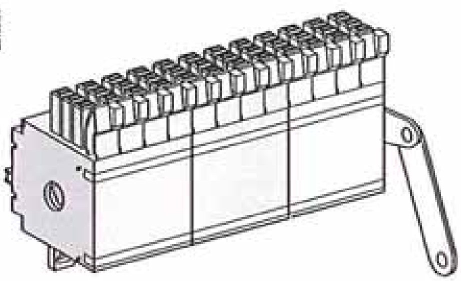
M2C and M6C programmable contacts

- optional equipment, used with Micrologic P and H control units.
- connection cables not included, see below:
  - 2 M2C contacts
  - 6 M6C contacts
- connection cables:
  - for fixed device
  - for drawout device.
- contacts can be programmed using the keypad on the control unit or via the COM option.
- they indicate:
  - the type of fault
  - instantaneous or delayed threshold overruns.
- M2C: 2 contacts (6 A-240 V)
- M6C: 6 contacts (6A-240V).
- permissible load on each of the M6C relay outputs:
  - 240 V AC: 5 A where p.f = 0.7
  - 380 V AC: 3 A where p.f = 0.7
  - 24 V DC: 8 A where L/R = 0
  - 48 V DC: 1.5 A where L/R = 0
  - 125 V DC: 0.4 A where L/R = 0
  - 250 V DC: 0.15 A where L/R = 0
- M6C supply voltage: 24 V DC ± 5%
- M6C maximum consumption: 100 mA

Indication contacts

ON/OFF indication contacts (OF)

- standard equipment: 4 OF per device.
- OF contacts indicate the position of main contacts
- they trip when the minimum isolation distance between the main contacts is reached
- 4 changeover contacts
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 480 V: 10 A (rms)
  - 600 V: 6 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1): 250 V: 3 A.



Additional ON/OFF indication contacts (OF)

- optional equipment, two blocks of 4 OF contacts per device
- connection cables not included, see below: one block of 4 OF contacts
- connection cables:
  - for fixed device
  - for drawout device
- OF contacts indicate the position of the main contacts
- they trip when the minimum isolation distance between the main contacts is reached
- changeover contacts
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 480 V: 10 A (rms)
  - 600 V: 6 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1): 250 V: 3 A.

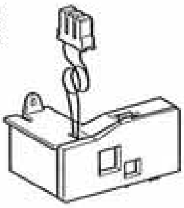
Combined "connected/closed" contacts (EF)

- optional equipment, 8 EF contacts per device
- each contact is mounted in place of the connector of an additional OF contact
- one EF contact
- the contact combines the "device connected" and the "device closed" information to produce the "circuit closed" information
- changeover contacts
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 240 V: 10 A (rms)
  - 380 V: 10 A (rms)
  - 480 V: 10 A (rms)
  - 600 V: 6 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1):
  - 48 V: 2.5 A
  - 130 V: 0.8 A
  - 250 V: 0.3 A.

"Fault-trip" indication contact (SDE/1)

- standard equipment on circuit breakers, one SDE/1 contact per device
- not available for switch-disconnector versions
- the contact provides a remote indication of device opening due to an electrical fault
- changeover contact
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 240 V: 10 A (rms)
  - 380 V: 5 A (rms)
  - 480 V: 5 A (rms)
  - 600 V: 3 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1):
  - 48 V: 3 A
  - 125 V: 0.3 A
  - 250 V: 0.15 A.

Indication contacts

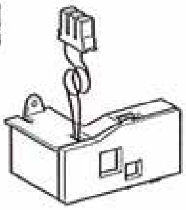


Additional "fault-trip" indication contact (SDE/2)

- optional equipment for circuit breakers, one additional SDE/2 contact per device
- not available for switch-disconnector versions
- not compatible with the Res option
- connection cables not included, see below:
  one SDE/2 contact
- connection cables:
  - for fixed device
  - for drawout device

- the contact remotely indicates device opening due to an electrical fault

- changeover contact
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 240 V: 10 A (rms)
  - 380 V: 5 A (rms)
  - 480 V: 5 A (rms)
  - 600 V: 3 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1):
  - 48 V: 3 A
  - 125 V: 0.3 A
  - 250 V: 0.15 A.



Electrical reset after fault trip (Res)

- optional equipment, one Res per device
- not compatible with the SDE/2 option
- connection cables not included, see below:
  110/130 V AC
  220/240 V AC
- connection cables:
  - for fixed device
  - for drawout device

- the contact remotely resets the device following tripping due to an electrical fault

"Springs charged" limit switch contact (CH)

- standard equipment, one CH contact per device

- the contact indicates the "charged" status of the operating mechanism (springs charged)

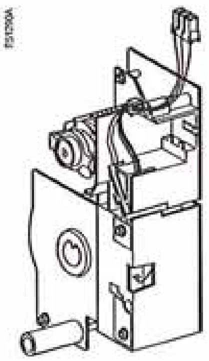
- changeover contact
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 240 V: 10 A (rms)
  - 380 V: 5 A (rms)
  - 480 V: 5 A (rms)
  - 600 V: 3 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1):
  - 48 V: 3 A
  - 125 V: 0.3 A
  - 250 V: 0.25 A.

"Ready to close" contact (PF)

- optional equipment, one PF contact per device
- connection cables not included, see below:
  one PF contact
- connection cables:
  - for fixed device
  - for drawout device

- the contact indicates that the device may be closed because all the following are valid:
  - circuit breaker is open
  - spring mechanism is charged
  - a maintained closing order is not present
  - a maintained opening order is not present

- changeover contact
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  - 240 V: 10 A (rms)
  - 380 V: 5 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1):
  - 48 V: 3 A
  - 125 V: 0.3 A
  - 250 V: 0.15 A.

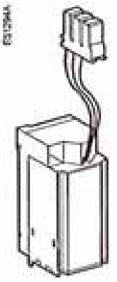


Gear motor (MCH)

■ optional equipment, one MCH gear motor per device
■ connection cables not included, see below:
100/130 V AC
200/240 V AC
277 V AC
380/415 V AC
400/440 V AC
480 V AC
24/30 V DC
48/60 V DC
100/125 V DC
200/250 V DC
■ connection cables:
□ for fixed device
□ for drawout device

■ the gear motor automatically charges and recharges the spring mechanism

■ charging time:
4 seconds max.
■ consumption:
□ 180 VA AC
□ 180 W DC
■ inrush current:
2 to 3 In for 0.1 second
■ operating rate:
maximum 3 cycles per minute.



Opening releases MX/1 and MX/2, closing release XF

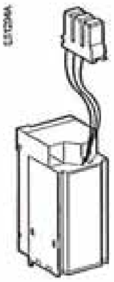
■ optional equipment, 1 or 2 MX releases per device, 1 XF per device
■ the function (MX or XF) is determined by where the coil is installed
■ connection cables not included, see below:
□ standard version:
- 12 V AC 50/60 Hz / DC
- 24/30 V AC 50/60 Hz / DC
- 48/60 V AC 50/60 Hz / DC
- 100/130 V AC 50/60 Hz / DC
- 200/250 V AC 50/60 Hz / DC
- 277 V AC 50/60 Hz / DC
- 380/480 V AC 50/60 Hz / DC.

□ communicating version (with COM option):
- 12 V AC 50/60 Hz / DC
- 24/30 V AC 50/60 Hz / DC
- 48/60 V AC 50/60 Hz / DC
- 100/130 V AC 50/60 Hz / DC
- 200/250 V AC 50/60 Hz / DC
- 240/277 V AC 50/60 Hz / DC
- 380/480 V AC 50/60 Hz / DC

■ connection cables:
□ for fixed device
□ for drawout device
■ the MX release instantaneously opens the circuit breaker when energised
■ the XF release instantaneously closes the circuit breaker when energised, if the device is "ready to close"

■ device response time:
□ MX: 50 ms ± 10
□ XF: 70 ms +10 / -15
> 3200 A: 80 ms ± 10
■ operating threshold:
□ MX: 0.7 to 1.1 x Un
□ XF: 0.85 to 1.1 x Un
■ the supply can be maintained
■ consumption:
□ pick-up (80 ms): 200 VA
□ hold: 4.5 VA.

Auxiliairies for remote operation

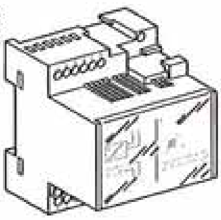


Instantaneous undervoltage releases (MN)

■ optional equipment, 1 MN per device
■ not compatible with the MX/2 opening release
■ connection cables not included, see below:
□ 24/30 V AC 50/60 Hz / DC
□ 48/60 V AC 50/60 Hz / DC
□ 100/130 V AC 50/60 Hz / DC
□ 200/250 V AC 50/60 Hz / DC
□ 380/480 V AC 50/60 Hz / DC
■ connection cables:
□ for fixed device
□ for drawout device

■ the MN release instantaneously opens the circuit breaker when its supply voltage drops

■ device response time: 90 ms ±5
■ operating threshold:
□ opening: 0.35 to 0.7 x Un
□ closing: 0.85 x Un
■ consumption:
□ pick-up (80 ms): 200 VA
□ hold: 4.5 VA

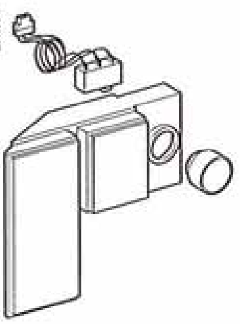


Delay unit for MN releases

■ optional equipment, 1 MN with delay unit per device.
■ delay-unit (must be ordered in addition to the MN):
□ 48/60 V AC 50/60 Hz / DC
□ 100/130 V AC 50/60 Hz / DC
□ 200/250 V AC 50/60 Hz / DC
□ 380/480 V AC 50/60 Hz / DC.

■ the unit delays operation of the MN release to eliminate circuit-breaker nuisance tripping during short voltage dips
■ the unit is wired in series with the MN and must be installed outside the circuit breaker

■ device response time: 0.5, 1, 1.5, 3 seconds
■ operating threshold:
□ opening: 0.35 to 0.7 x Un
□ closing: 0.85 x Un
■ consumption:
□ pick-up (80 ms): 200 VA
□ hold: 4.5 VA

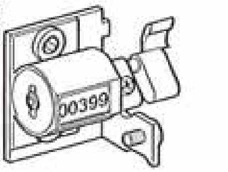


Electrical closing pushbutton (BPFE)

■ optional equipment, 1 BPFE per device
■ connection cables not included, see below:
■ connection cables:
□ for fixed device
□ for drawout device

■ located on the front face of the device, this pushbutton carries out electrical closing of the circuit breaker via the XF release, taking into account all the safety functions that are part of the control/monitoring system of the installation.

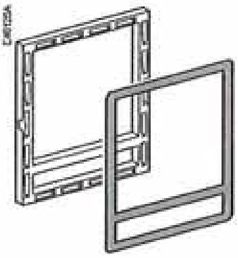
Device mechanical accessories



Operation counter (CDM)

■ optional equipment, one CDM per device

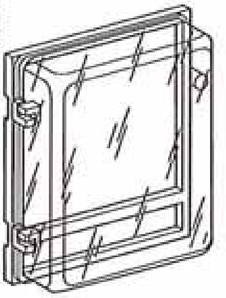
■ the operation counter sums the number of operating cycles.



Escutcheon (CDP)

■ optional equipment, one CDP per device
□ for fixed device
□ for drawout device

■ the CDP increases the degree of protection to IP 40 and IK 07 (fixed and drawout devices).

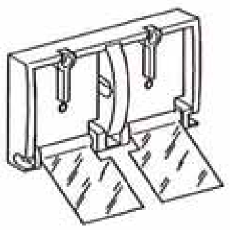


Transparent cover (CCP)

■ optional equipment, one CP per device equipped with a CDP (for fixed and drawout devices)

■ mounted with a CDP, the CP increases the degree of protection to IP 55 and IK 10 (fixed and drawout devices).

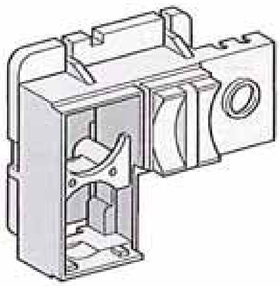
Device mechanical accessories



Transparent cover for pushbutton locking using a padlock, lead seal or screws

■ optional equipment, one locking cover per device

■ the transparent cover blocks access (together or separately) to the pushbuttons used to open and close the device
■ locking requires a padlock, a lead seal or two screws.



Device locking in the OFF position using a padlock

■ optional equipment, one locking system per device

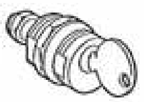
■ the unit inhibits local or remote closing of the device
■ up to three padlocks may be used for locking.

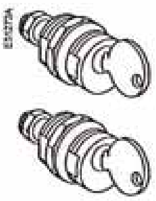
Device OFF position locking kit for keylocks

■ optional equipement, one locking kit per device
■ locks not included:
□ for Profalux or Ronis keylocks
□ for Castell keylocks
□ for Kirk keylocks

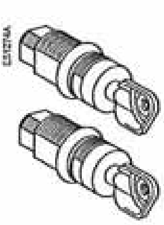
■ the kit inhibits local or remote closing of the device.

Ronis





Profalux

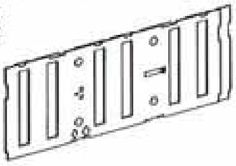


Keylocks required for the device locking kit

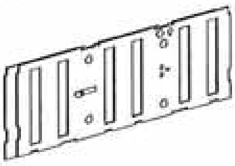
■ one or two keylocks per locking kit
□ Ronis:
1 keylock
2 keylocks.
□ Profalux:
1 keylock
2 keylocks.

Chassis mechanical accessories

Top shutter closed

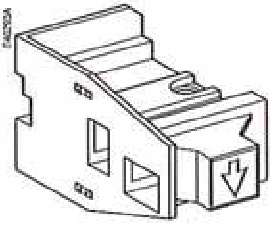


Bottom shutter closed



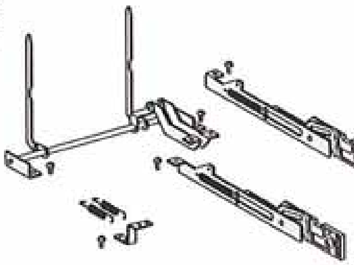
Safety shutters

- optional equipment
- set of shutters for top and bottom:
  - NW08/NW40
    3 poles
    4 poles
  - NW40b/NW63
    3 poles
    4 poles
- mounted on the chassis, the safety shutters automatically block access to the disconnecting contact cluster when the device is in the "disconnected" or "test" positions.
- IP20.



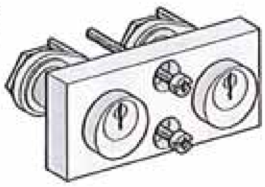
Shutter locking blocks

- optional equipment:
  2 blocks for NW08 to NW40
  4 blocks for NW40b to NW63
- the block may be padlocked. It:
  - prevents connection of the device
  - locks the shutters in the closed position.



Shutter position indication and locking on front face

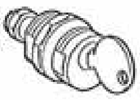
- optional equipment
  - NW08/NW040
    3 and 4 poles
  - NW40b/NW63
    3 poles
    4 poles
- this option located on the front of the chassis:
  - indicates that the shutters are closed
  - can be used to independently or simultaneously padlock the two shutters (top and bottom).

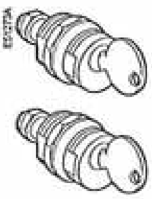


Circuit breaker locking in "disconnected" position

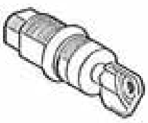
- optional equipment, one locking system per device
  - for Profalux or Ronis keylocks
  - for Castell keylocks
  - for Kirk keylocks
- mounted on the chassis and accessible with the door closed, this system locks the circuit breaker in "disconnected" position using one or two keylocks
- the "disconnected" position locking system may be modified to lock the circuit breaker in all three positions.

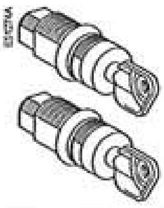
Ronis





Profalux

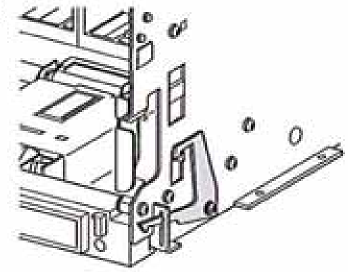




Keylocks required with the "disconnected" position locking system

- one or two keylocks per locking system
  - Ronis:
    1 keylock
    2 keylocks
  - Profalux:
    1 keylock
    2 keylocks.

Chassis mechanical accessories

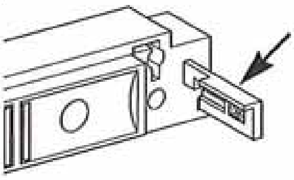


Door interlock

■ optional equipment, one door interlock per chassis

■ this device inhibits opening of the cubicle door when the circuit breaker is in "connected" or "test" position

■ it may be mounted on the left or right-hand side of the chassis.

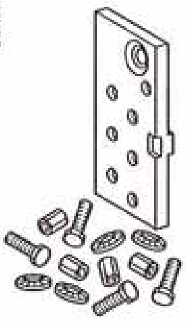


Racking interlock

■ optional equipment, one racking interlock per chassis

■ this device prevents insertion of the racking handle when the cubicle door is open

■ it is mounted on the right-hand side of the chassis



Mismatch protection

■ optional equipment, one mismatch protection device per chassis

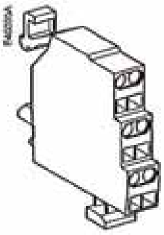
■ mismatch protection offers twenty different combinations that the user may select to ensure that only a compatible circuit breaker is mounted on a given chassis.

Auxiliary terminal shield (CB)

■ optional equipment, one CB shield per chassis

□ NW08/NW040
3 poles
4 poles
□ NW40b/NW63
3 poles
4 poles

■ the shield prevents access to the terminal block of the electrical auxiliaries.



"Connected", "disconnected" and "test" position carriage switches (CE, CD, CT)

- optional equipment, one to nine carriage switches
- standard configuration, 0 to 3 CE, 0 to 3 CD, 0 to 3 CT
- other configurations (by ordering additional actuators):
  0 to 9 CE, 0 CD, 0 CT
  0 to 6 CE, 0 to 3 CD, 0 CT
  0 to 6 CE, 0 CD, 0 to 3 CT
- connection cables not included, see below:
  - 1 carriage switch
  - 1 set of actuators for additional carriage switches
- connection cables (per carriage switch)
- the carriage switches indicate the three positions:
  CE: connected position
  CD: disconnected position (when the minimum isolation distance between the main contacts and the auxiliary contacts is reached)
  CT: test position
- changeover contact
- rated current: 10 A
- breaking capacity 50/60 Hz for AC power (AC12 as per 947-5-1):
  240 V: 10 A (rms)
  380 V: 5 A (rms)
- breaking capacity for DC power (DC12 as per 947-5-1):
  250 V: 0.3 A.

Initial tests
Procedure

These operations must be carried out in particular before using a Masterpact device for the first time.

A general check of the circuit breaker takes only a few minutes and avoids any risk of mistakes due to errors or negligence.
A general check must be carried out:
- prior to initial use
- following an extended period during which the circuit breaker is not used.

A check must be carried out with the entire switchboard de-energised.
In switchboards with compartments, only those compartments that may be accessed by the operators must be de-energised.

Electrical tests

Insulation and dielectric-withstand tests must be carried out immediately after delivery of the switchboard. These tests are precisely defined by international standards and must be directed and carried out by a qualified expert.

Prior to running the tests, it is absolutely necessary to:
- disconnect all the electrical auxiliaries of the circuit breaker (MCH, MX, XF, MN, Res electrical remote reset)
- remove the long-time rating plug on the 7.0 A, 5.0 P, 6.0 P, 7.0 P, 5.0 H, 6.0 H, 7.0 H control units. Removal of the rating plug disconnects the voltage measurement input.

Switchboard inspection

Check that the circuit breakers are installed in a clean environment, free of any installation scrap or items
(tools, electrical wires, broken parts or shreds, metal objects, etc.).

Conformity with the installation diagram

Check that the devices conform with the installation diagram:
- breaking capacities indicated on the rating plates
- identification of the control unit (type, rating)
- presence of any optional functions (remote ON/OFF with motor mechanism, auxiliaries, measurement and indication modules, etc.)
- protection settings (long time, short time, instantaneous, earth fault)
- identification of the protected circuit marked on the front of each circuit breaker.

Condition of connections and auxiliaries

Check device mounting in the switchboard and the tightness of power connections.
Check that all auxiliaries and accessories are correctly installed:
- electrical auxiliaries
- terminal blocks
- connections of auxiliary circuits.

Operation

Check the mechanical operation of the circuit breakers:
- opening of contacts
- closing of contacts.

Check on the control unit

Check the control unit of each circuit breaker using the respective user manuals.

What to do when the circuit breaker trips

Note the fault

Faults are signalled locally and remotely by the indicators and auxiliary contacts installed on circuit breakers (depending on each configuration). See page 12 in this manual and the user manual of the control unit for information on the fault indications available with your circuit breaker.

Identify the cause of tripping

A circuit must never be reclosed (locally or remotely) before the cause of the fault has been identified and cleared.

A fault may have a number of causes.
■ depending on the type of control unit, fault diagnostics are available. See the user manual for the control unit.
■ depending on the type of fault and the criticality of the loads, a number of precautionary measures must be taken, in particular the insulation and dielectric tests on a part of or the entire installation. These checks and test must be directed and carried out by qualified personnel.

Inspect the circuit breaker following a short-circuit

■ check the arc chutes (see page 43).
■ check the contacts (see page 43).
■ check the tightness of connections (see the device installation manual).
■ check the disconnecting-contact clusters (see page 44).

Reset the circuit breaker

The circuit breaker can be reset locally or remotely.
See page 12 in this manual for information on how the circuit breaker can be reset.

Recommended maintenance program

Recommended program for devices used under normal operating conditions: Ambient temperature: -5° C / +60° C Normal atmosphere

Periodic inspections required

Interval	Operations	Procedure
each year	■ open and close the device locally and remotely, successively using the various auxiliaries ■ test the operating sequences ■ test the control unit using the mini test kit	□ see pages 10 and 11 □ see page 8 □ see the user manual of the control unit
every two years or when the control-unit maintenance indicator reaches 100	■ check the arc chutes ■ check the main contacts ■ check the tightness of connections ■ check the disconnecting-contact clusters	□ see page 43 □ see page 43 □ see the device installation manual □ see page 44

Parts requiring replacement, depending on the number of operating cycles

The following parts must be replaced periodically to lengthen the service life of the device (maximum number of operating cycles).

Part	Intervening entity	Description or procedure
arc chutes	■ user	□ see page 43.
main contacts	■ inspection: user ■ replacement: Schneider After Sales Support	□ see page 43.
MCH gear motor	■ user	□ see page 9.
mechanical interlocks	■ user	
connecting-rod springs	■ Schneider After Sales Support	
MX/MN/XF	■ user	□ see pages 10, 11.

Part replacement must be programmed on the basis of the data below, listing the service life of the various parts in numbers of O/C cycles at the rated current.

Number of O/C cycles at the rated current

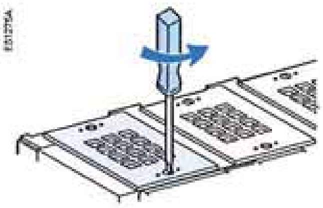
Type of circuit breaker	Maximum service life	Service life of various parts			
		Arc chutes	Main contacts	Connecting-rod springs, MCH	MX/XF releases
NW08 to NW16 types N1/H1/H2	25000	10000	10000	12500	12500
NW08 to NW16 type L1	25000	3000	10000	12500	12500
NW20 types H1/H2	20000	440 V: 8000 690 V: 6000	440 V: 8000 690 V: 6000	10000	12500
NW20 to NW25 type H3	20000	2000	440 V: 8000 690 V: 6000	10000	12500
NW20 type L1	20000	3000	10000	10000	12500
NW25 to NW40 types H1/H2	20000	440 V: 5000 690 V: 2500	440 V: 5000 690 V: 2500	10000	12500
NW32 to NW40 type H3	20000	1250	440 V: 5000 690 V: 2500	10000	12500
NW40b to NW63 types H1/H2	10000	1500	1500	5000	12500

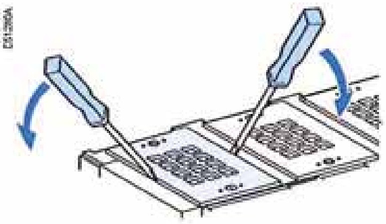
Maintenance operations

Before undertaking any maintenance work, de-energise the installation and fit locks or warnings in compliance with all applicable safety standards.

Arc chutes

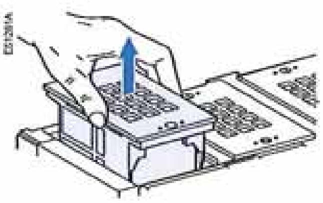
■ remove the fixing screws:
□ types N1, H1 and H2 ≤ NW 40: two screws
□ types H1 and H2 ≥ NW 40b, type H3: three screws
□ type L1: four screws.





■ check the arc chutes:
□ chamber not cracked
□ separators not corroded.

If necessary, replace the arc chutes.



If the control unit has a maintenance indicator, there is no need to systematically check the contacts.

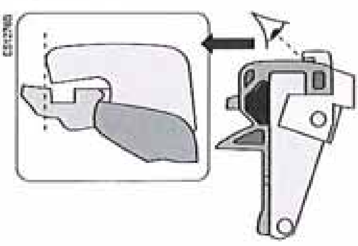
If the contacts are worn, have the concerned poles replaced by the Schneider service centre.

Wear of main contacts

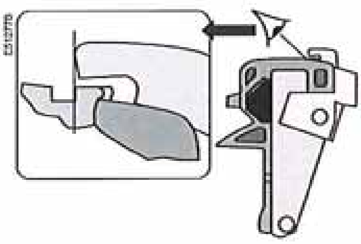
■ remove the arc chutes
■ close the device and check the contacts

Type N1, H1, H2, H3 (≤ 4000 A)

Contacts OK

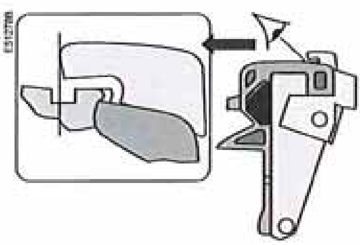


Contacts worn

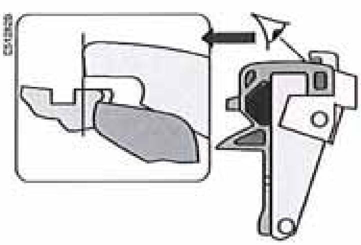


Type H1, H2 (≥ 4000b A), L1

Contacts OK



Contacts worn



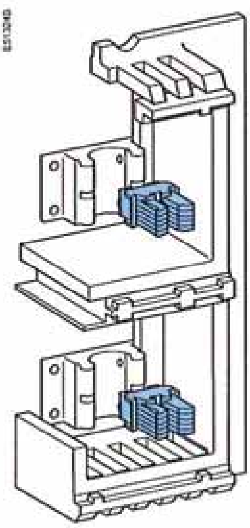
Maintenance operations

Disconnecting-contact clusters

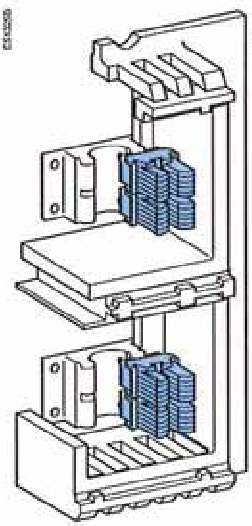
■ grease the contacts using the grease listed on page 45, supplied by Schneider Electric
■ check the contacts as follows:
□ open the circuit breaker
□ de-energise the busbars
□ disconnect the circuit breaker
□ remove the circuit breaker
□ check the contact fingers (no sign of copper should be visible)
Replace any worn clusters.
■ the position of the clusters must correspond to the table below.

Rating / Type	NW08	NW10 NW12	NW16	NW20	NW25	NW32	NW40	NW40b NW50	NW63
N1	layout n° 1 2 clusters/pole								
H1	layout n° 2 4 clusters/pole			layout n° 3 8 clusters/pole		layout n° 4 12 clusters/pole	layout n° 5 14 clusters/pole	layout n° 4 24 clusters/pole	
H2									
H3									
L1	layout n° 3 8 clusters/pole			layout n° 5 14 clusters/pole					
corrosion protection	layout 2' 4 "GOLDEN" clusters/pole		layout 3' 8 "GOLDEN" clusters/pole		layout 5 14 "GOLDEN" clusters/pole			layout 4 24 "GOLDEN" clusters/pole	

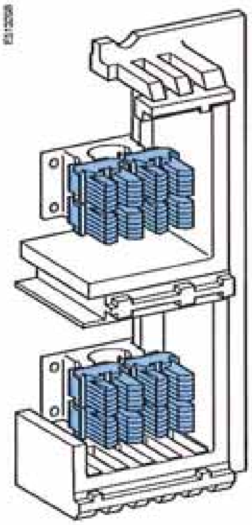
layout n° 1



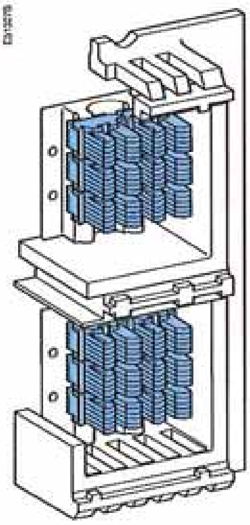
layout n° 2



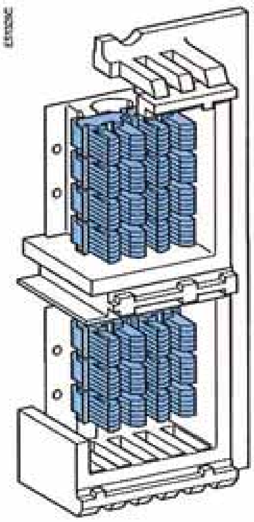
layout n° 3



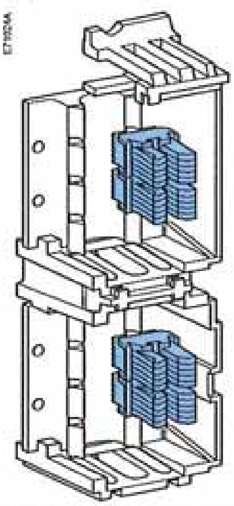
layout n° 4



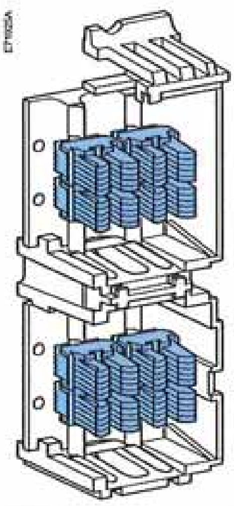
layout n° 5



layout 2'



layout 3'



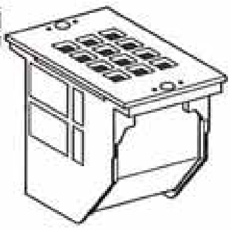
Ordering replacement parts

Electrical accessories

The electrical accessories that may require replacement are the following:

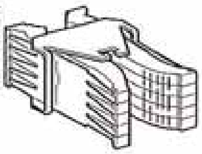
- MCH gear motor
- MX opening release(s)
- XF closing release
- MN undervoltage release.

See pages 33 and 34 in the "Auxiliaries for remote operation" section for their characteristics.



Arc chutes

- 1 arc chute:
  - NW type N1
    NW08 to NW40 types H1 and H2
  - NW40b to NW63 types H1 and H2
    NW type H3
  - NW type L1.
- NW08 to NW40: one chute per pole
  NW40b to NW63: two chutes per pole.

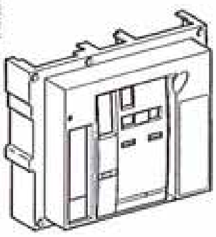


Disconnecting-contact clusters for standard NW

- 1 cluster
- number per circuit breaker, see table page 44.

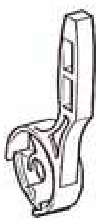
Grease for disconnecting-contact clusters

- 1 can for standard NW.
- 1 can for NW with corrosion protection.



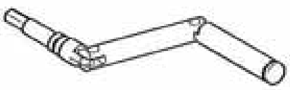
Front

- 1 front for 3- or 4-pole devices.
- 1 per device.



Charging handle

- 1 handle per device.



Crank

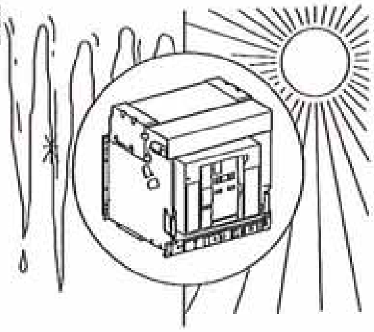
- 1 crank per device.

Troubleshooting and solutions

Problem	Probable causes	Solutions
circuit breaker cannot be closed locally or remotely	■ circuit breaker padlocked or keylocked in the "open" position	□ disable the locking fonction
	■ circuit breaker interlocked mechanically in a source changeover system	□ check the position of the other circuit breaker in the changeover system □ modify the situation to release the interlock
	■ circuit breaker not completely connected	□ terminate racking in (connection) of the circuit breaker
	■ the reset button signalling a fault trip has not been reset	□ clear the fault □ push the reset button on the front of the circuit breaker
	■ stored energy mechanism not charged	□ charge the mechanism manually □ if it is equipped with a an MCH gear motor, check the supply of power to the motor. If the problem persists, replace the gear motor (MCH)
	■ MX opening shunt release permanently supplied with power	□ there is an opening order. Determine the origin of the order. The order must be cancelled before the circuit breaker can be closed
	■ MN undervoltage release not supplied with power	□ there is an opening order. Determine the origin of the order. □ check the voltage and the supply circuit (U > 0.85 Un). If the problem persists, replace the release
	■ XF closing release continuously supplied with power, but circuit breaker not "ready to close" (XF not wired in series with PF contact)	□ cut the supply of power to the XF closing release, then send the closing order again via the XF, but only if the circuit breaker is "ready to close"
	■ permanent trip order in the presence of a Micrologic P or H control unit with minimum voltage and minimum frequency protection in Trip mode and the control unit powered	□ Disable these protection functions on the Micrologic P or H control unit
circuit breaker cannot be closed remotely but can be opened locally using the closing pushbutton	■ closing order not executed by the XF closing release	□ check the voltage and the supply circuit (0.85 - 1.1 Un). If the problem persists, replace the XF release
unexpected tripping without activation of the reset button signalling a fault trip	■ MN undervoltage release supply voltage too low	□ check the voltage and the supply circuit (U > 0.85 Un)
	■ load-shedding order sent to the MX opening release by another device	□ check the overall load on the distribution system □ if necessary, modify the settings of devices in the installation
	■ unnecessary opening order from the MX opening release	□ determine the origin of the order
unexpected tripping with activation of the reset button signalling a fault trip	a fault is present : ■ overload ■ earth fault ■ short-circuit detected by the control unit	□ determine and clear the causes of the fault □ check the condition of the circuit breaker before putting it back into service
instantaneous opening after each attempt to close the circuit breaker with activation of the reset button signalling a fault trip	■ thermal memory	□ see the user manual of the control unit □ press the reset button
	■ transient overcurrent when closing	□ modify the distribution system or the control-unit settings □ check the condition of the circuit breaker before putting it back into service □ press the reset button
	■ closing on a short-circuit	□ clear the fault □ check the condition of the circuit breaker before putting it back into service □ press the reset button

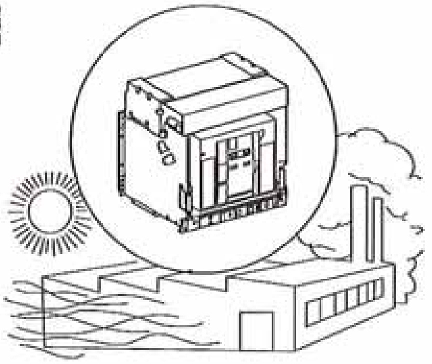
Problem	Probable causes	Solutions
circuit breaker cannot be opened remotely, but can be opened locally	■ opening order not executed by the MX opening release	□ check the voltage and the supply circuit (0.7 - 1.1 Un). If the problem persists, replace the MX release
	■ opening order not executed by the MN undervoltage release	□ drop in voltage insufficient or residual voltage (> 0.35 Un) across the terminals of the undervoltage release. If the problem persists, replace the MN release
circuit breaker cannot be opened locally	■ operating mechanism malfunction or welded contacts	□ contact a Schneider service centre
circuit breaker cannot be reset locally but not remotely	■ insufficient supply voltage for the MCH gear motor	□ check the voltage and the supply circuit (0.7 - 1.1 Un). If the problem persists, replace the MCH release
nuisance tripping of the circuit breaker with activation of the reset button signalling a fault trip	■ reset button not pushed-in completely	□ push the reset button in completely
impossible to insert the crank in connected, test or disconnected position	■ a padlock or keylock is present on the chassis or a door interlock is present	□ disable the locking function
impossible to turn the crank	■ the reset button has not been pressed	□ press the reset button
circuit breaker cannot be removed from chassis	■ circuit breaker not in disconnected position	□ turn the crank until the circuit breaker is in disconnected position and the reset button out
	■ the rails are not completely out	□ pull the rails all the way out
circuit breaker cannot be connected (racked in)	■ chassis/circuit breaker mismatch protection	□ check that the chassis corresponds with the circuit breaker
	■ the safety shutters are locked	□ remove the lock(s)
	■ the disconnecting-contact clusters are incorrectly positioned	□ reposition the clusters
	■ chassis locked in disconnected position	□ disable the chassis locking function
	■ the reset button has not been pressed, preventing rotation of the crank	□ press the reset button
	■ the circuit breaker has not been sufficiently inserted in the chassis	□ insert the circuit breaker completely so that it is engaged in the racking mechanism
circuit breaker cannot be locked in disconnected position	■ the circuit breaker is not in the right position	□ check the circuit breaker position by making sure the resett button is out
	■ the cranck is still in the chassis	□ remove the crank and store it
circuit breaker cannot be locked in connected, test or disconnected position	■ check that locking in any position is enabled	□ contact a Schneider service centre
	■ the circuit breaker is not in the right position	□ check the circuit breaker position by making sure the rese button is out
	■ the cranck is still in the chassis	□ remove the crank and store it
the crank cannot be inserted to connect or disconnected the circuit breaker	■ the rails are not completely in	□ push the rails all the way in
the right-hand rail (chassis alone) or the circuit breaker cannot be drawn out	■ the crank is still in the chassis	□ remove the crank and store it

Checking Masterpact operating conditions



Ambient temperature

Masterpact NW devices can operate under the following temperature conditions:
■ the electrical and mechanical characteristics are stipulated for an ambient temperature of -5° C to +70° C
■ circuit-breaker closing is guaranteed down to -35° C
■ Masterpact NW (without the control unit) can be stored in an ambient temperature of -40° C to +85° C
■ the control unit can be stored in an ambient temperature of -25° C to +85° C.



Extreme atmospheric conditions

Masterpact NW devices have successfully passed the tests defined by the following standards for extreme atmospheric conditions:

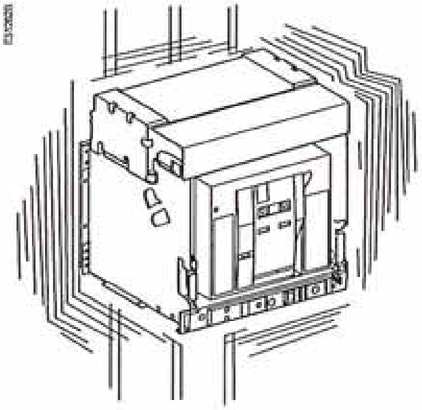
■ IEC 68-2-1: dry cold at -55° C
■ IEC 68-2-2: dry heat at +85° C
■ IEC 68-2-30: damp heat (temperature +55° C, relative humidity 95%)
■ IEC 68-2-52 level 2: salt mist.

Masterpact NW devices can operate in the industrial environments defined by standard IEC 947 (pollution degree up to 4).

It is nonetheless advised to check that the devices are installed in suitably cooled switchboards without excessive dust.

Masterpact NW devices with corrosion protection have successfully passed the tests defined by the following standards for extreme atmospheric conditions:

■ IEC 68-2-42: atmospheres containing sulphur dioxide (SO_2)
■ IEC 68-2-43: atmospheres containing hydrogen sulphide (H_2S).

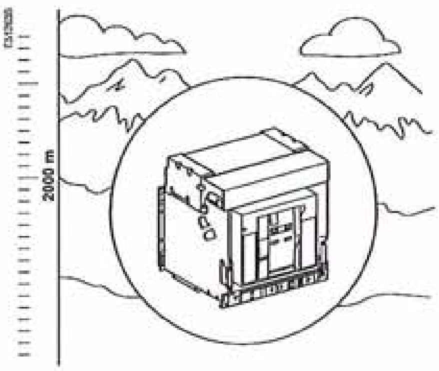


Vibrations

Masterpact NW devices resist electromagnetic or mechanical vibrations.

Tests are carried out in compliance with standard IEC 68-2-6 for the levels required by merchant-marine inspection organisations (Veritas, Lloyd's, etc.):
■ 2 to 13.2 Hz: amplitude ±1 mm
■ 13.2 to 100 Hz: constant acceleration 0.7 g.

Excessive vibration may cause tripping, breaks in connections or damage to mechanical parts.

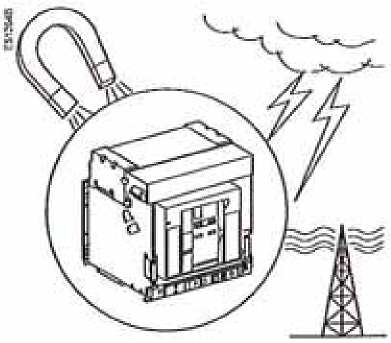


Altitude

Masterpact NW devices are designed for operation at altitudes under 2000 metres.

At altitudes higher than 2000 metres, the modifications in the ambient air (electrical resistance, cooling capacity) lower the following characteristics.

altitude (m)	2000	3000	4000	5000
dielectric resistance voltage (V)	3500	3150	2500	2100
average insulation level (V)	1000	900	700	600
maximum utilisation voltage (V)	690	590	520	460
average thermal current (A) at 40 °C	1 x In	0.99 x In	0.96 x In	0.94 x In



Electromagnetic disturbances

Masterpact NW devices are protected against:
□ overvoltages caused by devices that generate electromagnetic disturbances
□ overvoltages caused by an atmospheric disturbances or by a distribution-system outage (e.g. failure of a lighting system)
□ devices emitting radio waves (radios, walkie-talkies, radar, etc.)
□ electrostatic discharges produced by users.

Masterpact NW devices have successfully passed the electromagnetic-compatibility tests (EMC) defined by the following international standards:
■ IEC 947-2, appendix F
■ IEC 947-2, appendix B (trip units with earth-leakage function).

The above tests guarantee that:
■ no nuisance tripping occurs
■ tripping times are respected.

Cleaning

□ non-metallic parts:
never use solvent, soap or any other cleaning product. Clean with a dry cloth only
□ metal parts:
clean with a dry cloth whenever possible. If solvent, soap or any other cleaning product must be used, make sure that it does not come into contact with non-metallic parts.

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06-05

Remote-operated source-changeover systems

Mechanical interlocking Compact NSX, Compact NS or Masterpact NT/NW

Mechanical interlocking of two or three devices is used to create a remote-operated source-changeover system. A basic mechanical interlocking system enhances the reliability of system operation.

Interlocking of two electrically-operated Compact NSX circuit breakers using a base plate.

Interlocking of two Compact NSX100 to 630 devices using a base plate

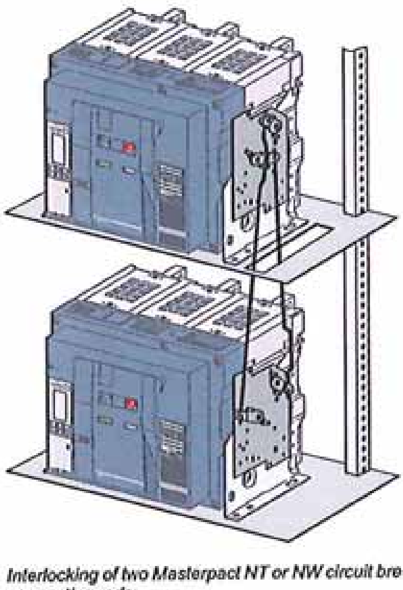
A base plate designed for two Compact circuit breakers can be installed horizontally or vertically on a mounting rail. Interlocking is carried out on the base plate by a mechanism located behind the breakers. Access to the circuit breaker controls and trip units is conserved. Circuit breakers must be fixed or plug-in versions, with or without earth-leakage protection or measurement modules. The base plate and the circuit breakers are supplied separately.

■ **Base plate for Compact NSX100 to 250 devices**
This base plate is intended for two Compact NSX100 to 250 devices.

■ **Base plate for Compact NSX400 to 630 devices**
This base plate is intended for two Compact NSX400 to 630 devices. It may also be used, without any modifications, to interlock a fixed Compact NSX100 to 250 with a Compact NSX400 or 630 device.
An adapter kit is required for plug-in versions of the Compact NSX100 to 250 devices.
Compact NSX100 to 250 devices, in both fixed and plug-in versions, may be equipped with spreaders.

Possible combinations of "Normal" and "Replacement" Compact NSX source circuit breakers

"Normal N"	"Replacement" R				
	NSX100	NSX160	NSX250	NSX400	NSX630
NSX100					
Ratings 12,5... 100 A	■	■	■	■	■
NSX160					
Ratings 12,5...160 A	■	■	■	■	■
NSX250					
Ratings 12,5...250 A	■	■	■	■	■
NSX400					
Ratings 160... 400 A	■	■	■	■	■
NSX630					
Ratings 250... 630 A	■	■	■	■	■



Interlocking of two Masterpact NT or NW circuit breakers using connecting rods.

Interlocking of two Compact NS630b to 1600 or two Masterpact NT and NW devices using connecting rods

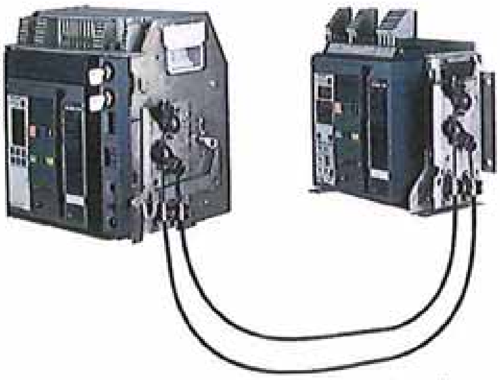
The two devices must be mounted one above the other (either 2 fixed or 2 withdrawable/drawout devices).
Combinations are possible between Compact NS630b to NS1600 devices and between Masterpact NT and Masterpact NW devices.

Installation
This function requires:
■ an adaptation fixture on the right side of each circuit breaker or switch-disconnector
■ a set of connecting rods with no-slip adjustments.
The adaptation fixtures, connecting rods and circuit breakers or switch-disconnectors are supplied separately, ready for assembly by the customer.
The maximum vertical distance between the fixing planes is 900 mm.

Possible combinations of "Normal" and "Replacement" source circuit breakers

"Normal N"	"Replacement" R			
	NS630b to NS1600	NT06 to NT16	NW08 to NW40	NW40b to NW63
NS630b to NS1600				
Ratings 250... 1600 A	■			
NT06 to NT16				
Ratings 250... 1600 A		■	■	■
NW08 to NW40				
Ratings 320... 4000 A		■	■	■
NW40b to NW63				
Ratings 4000... 6300 A		■	■	■

Mechanical interlocking
Compact NS or Masterpact NT/NW



Interlocking of two Masterpact circuit breakers using cables.

Interlocking of two Compact NS630b to 1600 or two Masterpact NT/NW or up to three Masterpact NW devices using cables

For cable interlocking, the circuit breakers may be mounted one above the other or side-by-side.
The interlocked devices may be fixed or drawout, three-pole or four-pole, and have different ratings and sizes.

Interlocking between two devices (Compact NS630b to 1600 or Masterpact NT and NW)

This function requires:
- an adaptation fixture on the right side of each device
- a set of cables with no-slip adjustments.

The maximum distance between the fixing planes (vertical or horizontal) is 2000 mm.

Interlocking between three devices (Masterpact NW only)

This function requires:
- a specific adaptation fixture for each type of interlocking, installed on the right side of each device
- two or three sets of cables with no-slip adjustments.

The maximum distance between the fixing planes (vertical or horizontal) is 1000 mm.

Installation

The adaptation fixtures, sets of cables and circuit breakers or switch-disconnectors are supplied separately, ready for assembly by the customer.

Installation conditions for cable interlocking systems:
- cable length: 2.5 m
- radius of curvature: 100 mm
- maximum number of curves: 3.

Possible combinations of "Normal" and "Replacement" source circuit breakers

"Normal N"	"Replacement" R			
	NS630b to NS1600	NT06 to NT16	NW08 to NW40	NW40b to NW63
NS630b to NS1600				
Ratings 250... 1600 A	■			
NT06 to NT16				
Ratings 250... 1600 A		■	■	■
NW08 to NW40				
Ratings 320... 4000 A		■	■	■
NW40b to NW63				
Ratings 4000... 6300 A		■	■	■

It is not possible to combine Compact NS630b to 1600 and Masterpact NT (or Masterpact NW) devices.
All combinations of two Masterpact NT and Masterpact NW devices are possible, whatever the rating or size of the devices.

Possible combinations of three device

"Normal N"	"Replacement" R			
	NS630b to NS1600	NT06 to NT16	NW08 to NW40	NW40b to NW63
NS630b to NS1600				
Ratings 250... 1600 A				
NT06 to NT16				
Ratings 250... 1600 A				
NW08 to NW40				
Ratings 320... 4000 A			■	■
NW40b to NW63				
Ratings 4000... 6300 A			■	■

Only Masterpact NW may be used for three-device combinations.

Types of mechanical interlocking and combinations

See page A-4 to page A-9.

Remote-operated source-changeover systems
General characteristics
Compact NSX

Range			Compact NSX	
Types of devices			NSX100 to NSX250	NSX400 to NSX630
Types of circuit breakers			N / H / L	N / H / L
Switch-disconnector version			NA	NA
Mixing possibilities			all devices NS100 to NS250 N/H/L/NA fixed or plug-in	all devices NS100 to NS630 N/H/L/NA fixed or plug-in
Electrical characteristics				
Rating			15 to 250 A	15 to 630 A
Insulating voltage Ui (V AC)			750	750
Positive break indication			■	■
Number of poles (N and R devices must have the same number of poles)			3, 4	
Electrical durability			See page A-14	
Operating temperature			-25 °C to +70 °C (50 °C for 440 V - 60 Hz)	
Control characteristics				
Control voltage		AC	48 V - 50 Hz 110/130, 220/240, 380/440 V - 50/60 Hz	48 V - 50 Hz 110/130, 220/240, 380/440 V - 50/60 Hz
		DC	24-250 V	24-250 V
Maximum consumption		AC	500 VA	500 VA
		DC	500 W	500 W
Minimum switching time			800 ms	800 ms
Interlocking				
Mechanical (see page A-10)				
Electrical	by diagram (without IVE)		■	■
	with IVE unit		■	■
	auxiliary contacts used by circuit breaker		1 OF + 1 SDE	1 OF + 1 SDE
Protection and measurement				
Overload protection		long time	■	■
Short-circuit protection		short time	■	■
		instantaneous	■	■
Earth-fault protection				■
Zone selective interlocking (ZSI)				■
Earth-leakage protection	by Vigi module		■	■
	by control unit			
	by add-on Vigirex relay		■	■
Current measurements				
Voltage, frequency, power measurements, etc.				
Indication and control auxiliaries				
Available auxiliary indication contacts			OF + SD (+ SDV)	3 OF + SD (+ SDV)
Voltage releases	MX shunt		■	■
	MN undervoltage		■	■
Voltage presence indicator			■	■
Voltage transformer			■	■
Ammeter module			■	■
Insulation monitoring module			■	■
Source-changeover controller				
With permanent replacement source			■ BA controller	
With standby generator set			■ UA controller	
Remote communication via bus				
Device status indications				
Device remote control				
Transmission of settings			■	■
Indication and identification of protection status and alarms			■	■
Transmission of measurements			■	■
Installation and connection				
Fixed front connected				
Fixed rear connected			■ (long rear connections)	■ (long rear connections)
Withdrawable, plug-in or drawout			■ (plug-in on base)	■ (plug-in on base)
Installation and connection accessories				
Downstream coupling accessory			■	■
Bare-cable connectors			■	■
Terminal extensions			■	■
Terminal shields and inter-phase barriers				■
Locking	by padlock		■	■
	by keylock		■	■
Front panel escutcheons			■	■

	Compact NS	Masterpact	
	NS630b to NS1600	NT06 to 16	NW08 to 63
	N / H / L NA	N1 / H1 / H2 / H3 / L1 NA / HA / HF	N1 / H1 / H2 / H3 / L1 NA / HA / HF
	all devices NS630b to 1600 N/H/L/NA fixed or plug-in	all mixing possibilities (fixed, drawout or fixed + drawout) N1/H1/H2/H3/L1/NA/HA/HF	all mixing possibilities (fixed, drawout or fixed + drawout) N1/H1/H2/H3/L1/NA/HA/HF
	250 to 1600 A	600 to 1600 A	800 to 6300 A
	750	1000	1000
		■	■
		3, 4	
	See page A-14		
		-25 °C to +70 °C (50 °C for 440 V - 60 Hz)	
		48 to 415 V - 50/60 Hz 440 V - 60 Hz	
	24-250 V	24-250 V	24-250 V
	180 VA 180 W	180 VA 180 W	180 VA 180 W
	800 ms	800 ms	800 ms
	■ ■ 1 OF + 1 CE (+ SDE)	■ only with UA or BA 1 OF + 1 CE + 1 PF	■ only with UA or BA 1 OF + 1 CE + 1 PF
	■	■	■
	■	■	■
	■	■	■
	■	■	■
	■	■	■
	■ ■	■ ■	■ ■
	■	■ ■	■ ■
	2 OF + SD	2 OF + SD	2 OF + SD
	■ ■	■ ■	■ ■
		■	■
		■	■
		■	■
		■	■
		■ BA controller	
		■ UA controller	
	■	■	■
	■	■	■
	■	■	■
	■	■	■
	■ (vertical or horizontal) ■ (drawout)	■ (vertical or horizontal) ■ (drawout)	■ (vertical or horizontal) ■ (drawout)
	■		
	■		
	■	■	■
	■	■	■
	■	■	■

Remote-operated source-changeover systems

Mech. and elect. durability Interpact INS, Compact NSX, NS, Masterpact NT/NW

Interpact INS switch-disconnectors

			INS250-100		INS250-160		INS250-200		INS250	
Number of poles			3, 4		3, 4		3, 4		3, 4	
Conventional thermal current (A)	Ith	at 60 °C	100		160		200		250	
Rated operational current (A)	Ie	Electrical AC, 50/60 Hz	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A
		440-480 V	100	100	160	160	200	200	250	250
		660-690 V	100	100	160	160	200	200	250	250
Durability (category A) (O_N-C_R-O_R-C_N cycles)		Mechanical	15000		15000		15000		15000	
		Electrical AC, 50/60 Hz	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A
		440-480 V	1500	1500	1500	1500	1500	1500	1500	1500
		660-690 V	1500	1500	1500	1500	1500	1500	1500	1500

			INS320		INS400		INS500		INS630	
Number of poles			3, 4		3, 4		3, 4		3, 4	
Conventional thermal current (A)	Ith	at 60 °C	320		400		500		630	
Rated operational current (A)	Ie	Electrical AC, 50/60 Hz	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A
		440-480 V	320	320	400	400	500	500	630	630
		660-690 V	320	320	400	400	500	500	630	630
Durability (category A) (O_N-C_R-O_R-C_N cycles)		Mechanical	10000		10000		10000		10000	
		Electrical AC, 50/60 Hz	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A	AC22A	AC23A
		440-480 V	1500	1500	1500	1500	1500	1500	1500	1500
		660-690 V	1500	1500	1500	1500	1500	1500	1500	1500

Compact NSX100-630, Compact NS630b-1600

	NSX100-250	NSX400-630	NS630b-NS1600
Number of poles	3, 4	3, 4	3, 4
Rated current In (A)	100 to 250	400 to 630	630 to 1600
Mechanical durability (O_N-C_R-O_R-C_N cycles)	20000 - 40000 - 50000	15000	8000
Electrical durability at In (O_N-C_R-O_R-C_N cycles) for ≤ 440 V and 480 V NEMA [2]	10000 - 20000 - 30000	4000 - 6000	2000
Electrical durability at In (O_N-C_R-O_R-C_N cycles) for U = 500 V to 690 V [2]	5000 - 7500 - 10000	2000 - 3000	1500

Masterpact NT06-NT16/NW08-NW63 [1]

	NT06-NT10	NT12-NT16	NW08-NW16	NW20	NW25-NW40	NW50-NW63
Number of poles	3, 4	3, 4	3, 4	3, 4	3, 4	3, 4
Rated current In (A)	630 to 1600	1250 to 1600	800 to 1600	2000	2500 to 4000	5000 to 6300
Mechanical durability (O_N-C_R-O_R-C_N cycles)	8000	8000	10000	10000	10000	5000
Electrical durability at In (O_N-C_R-O_R-C_N cycles) for ≤ 440 V and 480 V NEMA [2]	6000	6000 NT16: 3000	10000	8000	5000	1500
Electrical durability at In (O_N-C_R-O_R-C_N cycles) for U = 500 V to 690 V [2]	3000	2000 NT16: 1000	10000	6000	2500	1500

(1) Mechanical and electrical durability not applicable to Masterpact H3 and L versions.
(2) Electrical durability tests carried out with a power factor of 0.8 as per IEC 947-2.

Note:
O_N: opening of Normal source
C_R: closing of Replacement source
O_R: opening of Replacement source
C_N: closing of Normal source

Contactors (22AF)

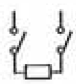
Description

- 3-pole(NO) main contact
- Finger proof design
- DIN rail or screw mountable
- AC or DC control in different physical size
- Front/side mountable accessories available
- Direct mountable overload relay available Rating
- 1NO1NC Auxiliary contact built-in as standard.
- UA-1 is available on only left side

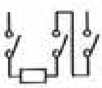
MC-22b

Rating

Contactor type			MC-9b		MC-12b		MC-18b		MC-22b	
			kW	A	kW	A	kW	A	kW	A
AC duty	AC3	200/240V	2.5	11	3.5	13	4.5	18	5.5	22
		380/440V	4	9	5.5	12	7.5	18	11	22
		500/550V	4	7	7.5	12	7.5	13	15	20
		690V	4	5	7.5	9	7.5	9	15	18
	AC4	200/240V	1.5	8	2.2	11	3.7	16	3.7	18
		380/440V	2.2	6	4	9	4	11	5.5	13
	AC1		-	25	-	25	-	32	-	40
DC1 duty (L/R=1ms)	2-pole in series	24V	-	18	-	18	-	18	-	32
		48V	-	17	-	17	-	17	-	30
		110V	-	12	-	12	-	12	-	23
	3-pole in series	24V	-	20	-	20	-	20	-	32
		48V	-	20	-	20	-	20	-	32
		110V	-	15	-	15	-	15	-	27
DC 2,4 duty (L/R=15ms)	2-pole in series	24V	-	15	-	15	-	15	-	25
		48V	-	12	-	12	-	12	-	20
		110V	-	8	-	8	-	8	-	15
	3-pole in series	24V	-	18	-	18	-	18	-	30
		48V	-	15	-	15	-	15	-	30
		110V	-	12	-	12		12	-	20
Directly mountable Overload relay			MT-32							
Conductor size (solid, stranded)		AWG	16~10		16~8		14~8		14~8	
(the max. number of conducts: 2)		mm²	1.5~4		1.5~10		2.5~10		2.5~10	
Conductor type			65/75℃ Cu-wire only							



2pole for DC contact



3pole for DC contact

Coil voltage

AC	50Hz	24, 32, 42, 48, 80, 100, 110, 220, 230, 240, 380, 400, 500, 550V
	60Hz	24, 48, 100, 110, 120, 200, 208, 220, 230, 240, 277, 380, 480, 600V
	50/60Hz	24, 48, 100, 110, 120, 200, 220, 230, 240, 380, 415, 440, 500, 550V
DC	DC	12, 20, 24, 48, 60, 80, 100, 110, 125, 200, 220, 250V

Certification
• CE(IEC) • UL508

circuit protective devices - fuses & circuit breakers

Circuit protective devices

Fuses

A fuse is a thermally-operated device. It operates by fusing one or more of its specially designed and proportioned components, opening the circuit in which it is inserted when the current exceeds a given value for sufficient time. A fuse-link comprises all the parts that form the complete device. The time/current characteristic curve for a fuse is relatively simple to read. See Appendix 2.

Fuse rating	BS 88 Pt 2	BS 1361	single pole switched neutral
2A	L50145 + L171	-	-
4	L50145 + L172	-	-
5	-	L113	-
6	L50145 + L173	-	-
8	L50145 + L174	-	-
10	L50145 + L175	-	L124 + LF138
15	-	L115	-
16	L50145 + L176	-	L125 + LF139
20	L50145 + L177	L116	L126 + LF140
25	L50145 + L178	-	L127 + LF141
30	-	L118	-
32	L50145 + L179	-	L128 + LF142

Note: Bs 88 fuse carriers and links should not be used in domestic consumer units as the physical size of the fuse does not alter with the nominal fuse rating. BS 1361 carriers are designed specifically for use by uninstructed personnel and are therefore suitable for this type of installation.

Circuit breakers

The circuit breaker is a thermomagnetic device capable of making, carrying and interrupting currents under normal conditions, but especially under those considered abnormal. There are many types available, the most common being the 'thermal magnetic circuit breaker'. 'Miniature circuit breakers' or MCBs should comply with BS EN 60898 entitled "Circuit-breakers for Overcurrent Protection for Household and Similar Installations". The scope identifies they are designed for use by uninstructed people. The maximum rated current permitted is 125A.

Circuit breakers for use by instructed persons are called 'Air Circuit Breakers (ACB)' or 'Moulded Case Circuit Breakers (MCCB)'. These devices should comply with BS EN 60947-2 entitled 'Low Voltage Switchgear and Controlgear - Part 2: Circuit Breakers'. The scope identifies that this standard applies to circuit breakers with a rated voltage not exceeding 1000V a.c. or 1500V d.c. and places no restriction on rated current. The minimum size available is 16A.

Both Harmonised British Standards covering low-voltage circuit breakers provide the user with a better assurance of quality and performance by taking into account the actual operating conditions of the breaker. New definitions and symbols have been introduced, some of those most frequently used are:

U_e :	rated operational voltage
U_i :	rated insulation voltage (> Ue)
U_{imp} :	rated impulse withstand voltage
I_{cm} :	rated short circuit making capacity
I_{cn} :	rated short circuit breaking capacity
I_{cs} :	rated service short circuit breaking capacity
I_{cu} :	rated ultimate short circuit breaking capacity
$I\Delta n$:	rated residual operating current (often called residual sensitivity)
I_n:	rated current = maximum value of current used for the temperature rise test
I_r:	thermal trip setting
Δt:	trip delay of residual current devices
I_{cw}:	short time withstand current

IDEC - PUSHBUTTONS & PILOT LIGHTS - YW SERIES

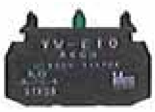
Features:

- Small and light weight construction
- Locking lever removable contact block assembly
- Fingersafe IP20 contacts as standard
- Up to 3 contact blocks possible for non-illuminated pushbuttons

YW1B-M1E10G

YW1L-M2E10Q4A

YW1L-M2E11QS-K



YW-E10

YW SERIES - DIA 22mm IP65 (COMPLETE UNITS)

Type	Operation	Contact	Colour	Part No.
Flush	Momentary	1 NO	Black	YW1B-M1E10B
		1 NO	Green	YW1B-M1E10G
		1 NO	Yellow	YW1B-M1E10Y
		1 NC	Red	YW1B-M1E01R
Mushroom 40mm	Momentary	1 NC	Red	YW1B-M4E01R
Illuminated Pushbuttons (Lamp Included) - 24VAC/DC				
Extended LED	Momentary	1NO	Amber	YW1L-M2E10Q4A
		1NO	Green	YW1L-M2E10Q4G
		1NO	White	YW1L-M2E10Q4W
		1NO	Yellow	YW1L-M2E10Q4Y
		1NC	Red	YW1L-M2E01Q4R
Extended Incandescent	Momentary	1NO	Amber	YW1L-M2E10Q7A
		1NO	Green	YW1L-M2E10Q7G
		1NO	White	YW1L-M2E10Q7W
		1NO	Yellow	YW1L-M2E10Q7Y
		1NC	Red	YW1L-M2E01Q7R
Illuminated Pushbuttons (LED Included) - 240VAC				
Extended LED	Momentary	1NO-1NC	Amber	YW1L-M2E11QA-K
		1NO-1NC	Green	YW1L-M2E11QG-K
		1NO-1NC	Red	YW1L-M2E11QR-K
		1NO-1NC	Blue	YW1L-M2E11QS-K
		1NO-1NC	White	YW1L-M2E11QW-K
		1NO-1NC	Yellow	YW1L-M2E11QY-K
Contact Blocks				
		Contact Block 1NO		YW-E10
		Contact Block 1NC		YW-E01

Features:

- Small and light weight construction
- Fingersafe IP20 contacts as standard
- Super bright LEDs - very low heat and long life
- Incandescent - low cost option with long life

YW1P-2EQ0G

YW1P-2EQ4R

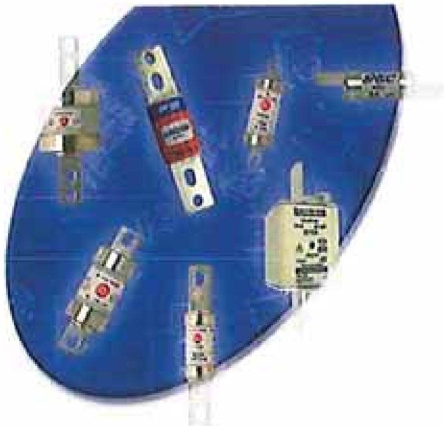
YW1P-2EM42A

YW SERIES - DIA 22mm IP65 (COMPLETE UNITS)

Type	Operating Voltage	Part No.
Full Voltage (Lamp Not Included)		
Without Lamp		YW1P-2EQ0*
Note: Lamps to be ordered separately. See table on next page.		
Full Voltage (24V AC/DC LED Included)		
Amber	24V AC/DC	YW1P-2EQ4A
Green	24V AC/DC	YW1P-2EQ4G
Red	24V AC/DC	YW1P-2EQ4R
Blue	24V AC/DC	YW1P-2EQ4S
Transformer Type (Lamp Included)		
LED	100/110VAC	YW1P-2EH2*
	230/240VAC	YW1P-2EM42*
Note: LED Lamp type LSTD-6 Included (6V)		
Incandescent	100/110VAC	YW1P-2EH5*
	230/240VAC	YW1P-2EM45*

Note: Incandescent Lamp IS-6 Included (6V)

* Colour: A - (Amber), G - (Green), R - (Red), S - (Blue), W - (White), Y - (Yellow)



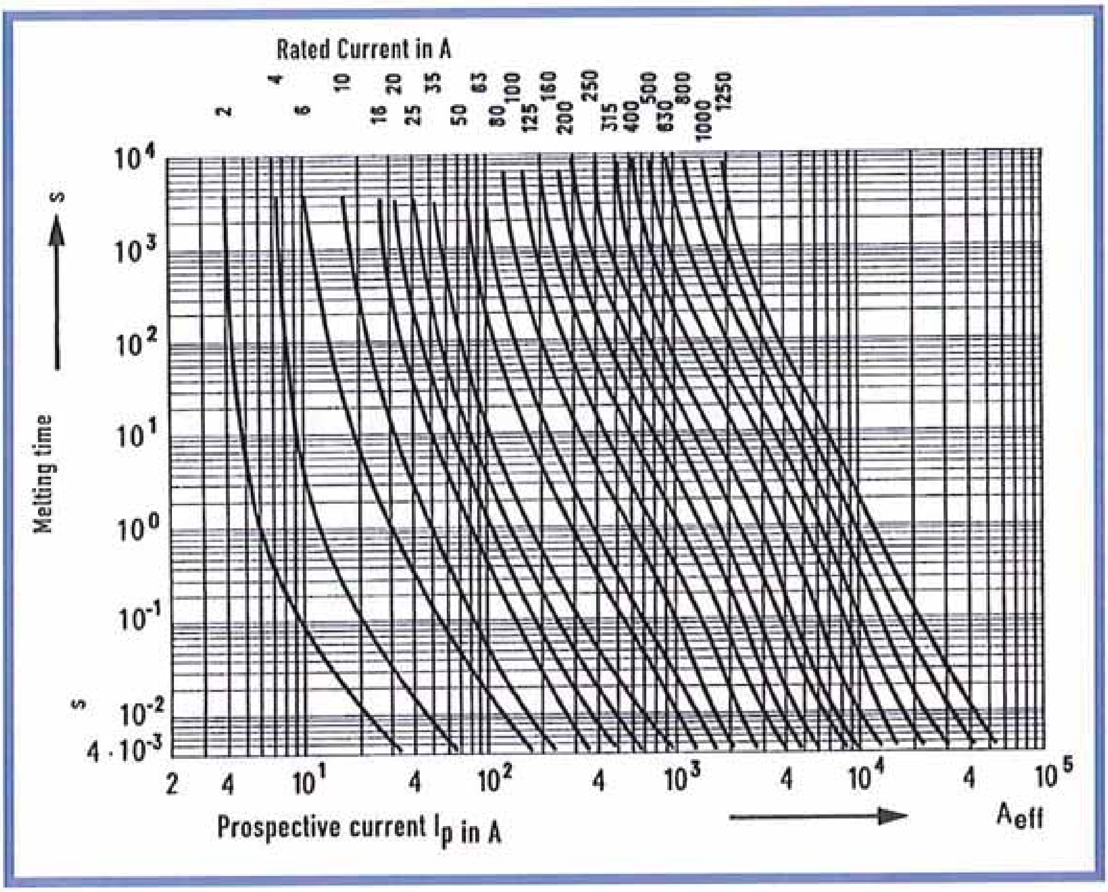
NH FUSES

500V AC gL-gG

Cd/Pb - Free

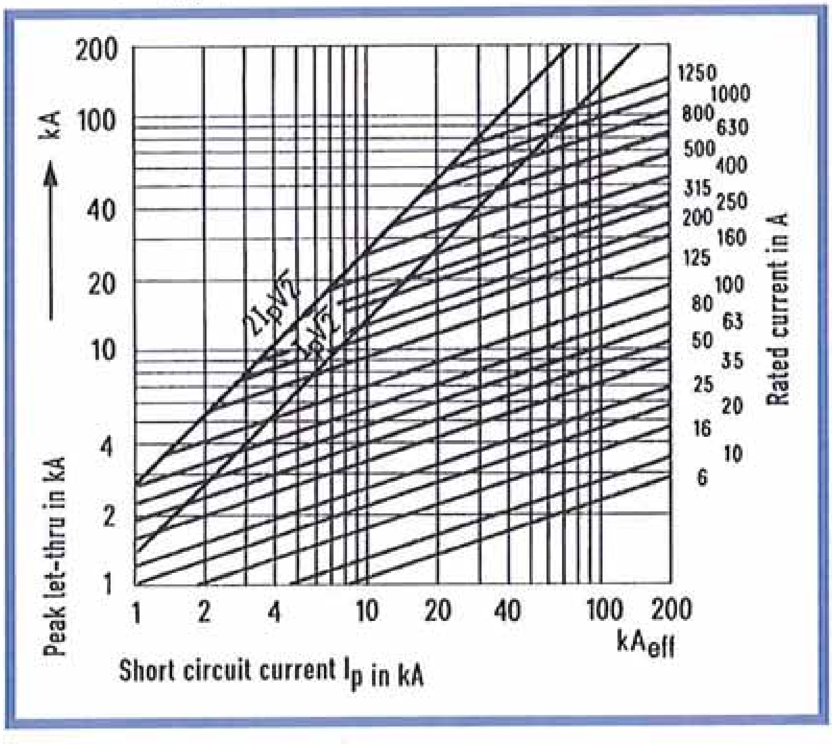
- Short circuit rating 120kA
- Conducting grip lugs
- Complies with IEC 60269-2, DIN 13620 parts 1 to 4, DIN VDE 0636 part 201
- Rated full range, general purpose for cable and line protection
- Size 4 for screw contact type base (NH4BASE)
- Size 4A fuses available for disconnect type mountings
- Other ratings available

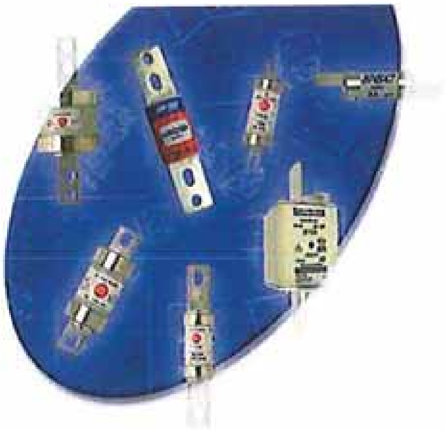
Size	Rated Current (A)	Rated DC voltage (V DC)	Power Losses (W)	Part Number	Reference Number
	6		1.6	**NHG00-006**	D235661
	10		1.1	**NHG00-010**	E235662
	16		1.8	**NHG00-016**	F235663
	20		2.4	**NHG00-020**	G235664
	25		2.4	**NHG00-025**	H235665
000/C00	32	250	2.7	**NHG00-032**	J235666
	35		3.0	**NHG00-035**	K235667
	40		3.4	**NHG00-040**	L235668
	50		3.9	**NHG00-050**	M235669
	63		4.7	**NHG00-063**	N235670
	80		5.7	**NHG00-080**	P235671
	100		6.7	**NHG00-100**	Q235672
00	125	250	8.4	**NHG00-125**	R235673
	160		10.6	**NHG00-160**	S235674
	63		6.2	**NHG1-063**	F235962
	80		7.1	**NHG1-080**	B235682
	100		8.7	**NHG1-100**	C235683
1	125	440	11.0	**NHG1-125**	D235684
	160		11.7	**NHG1-160**	E235685
	200		14.5	**NHG1-200**	F235686
	250		19.7	**NHG1-250**	H235688
	125		10.6	**NHG2-125**	J235689
	160		11.9	**NHG2-160**	K235690
2	200		14.0	**NHG2-200**	L235691
	250	440	19.1	**NHG2-250**	N235693
	315		24.0	**NHG2-315**	Q235695
	355		26.2	**NHG2-355**	R235696
	400		30.2	**NHG2-400**	S235697
	315		22.4	**NHG3-315**	T235698
	355	440	23.5	**NHG3-355**	V235699
3	400		30.1	**NHG3-400**	W235700
	500		44.0	**NHG3-500**	Z235703
	630	250	47.5	**NHG3-630**	A235704
	500		35.0	**NHG4-500**	X216542
	630		44.0	**NHG4-630**	W217576
4	800	440	70.0	**NHG4-800**	E218090
	1000		85.0	**NHG4-1000**	H201694
	1250		93.0	**NHG4-1250**	C213994



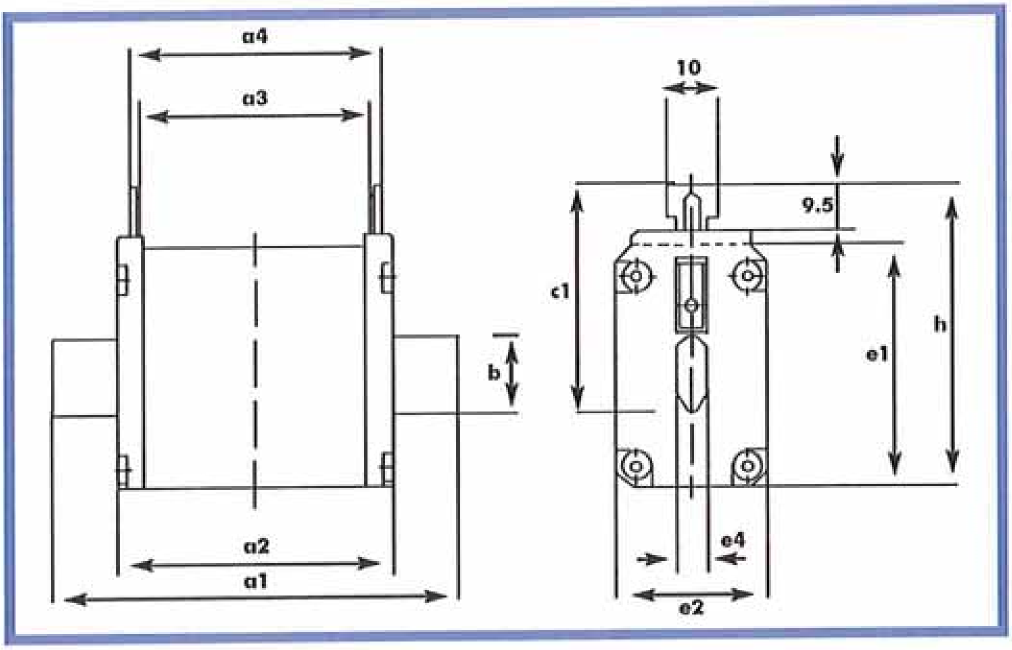
Peak let-thru current data

Size 000 to 4/4a, gl-gG, - 500V





NH FUSE DIMENSIONS



Standard 500 V gL-gG with voltage-conducting lug

	Rated in Current	a1	a2	a3	a4	b	c1	e1	e2	e4	h
SIZE 000	2-100A	79.0	52.0	45.5	49.5	15.0	35.0	40.5	20.8	6.0	52.5
SIZE 00	125/160A	79.0	52.8	45.0	50.0	15.0	35.0	47.5	29.5	6.0	59.5
SIZE 1	63-250A	135.0	70.8	63.0	68.0	20.0	40.0	52.5	39.5	6.0	64.5
SIZE 2	125-400A	150.0	72.3	63.0	68.0	26.0	48.0	60.0	51.0	6.0	72.0
SIZE 3	315-630A	150.0	72.3	63.0	68.0	33.0	60.0	74.0	70.0	6.0	86.0
SIZE 4	400-1250A	200.0	85.0	64.0	68.0	33.0	85.0	104.0	89.0	8.0	97.0
SIZE 4a	500-1600A	200.0	98.0	83.5	89.0	50.0	94.0	118.0	96.0	6.0	121.0

Safeclip Fuse Fittings

20, 32 & 63A
415/550V AC.

Complying fully with
AS2005.29 – 1990,
BS88 : Part 6 : 1988.

Features & Benefits

- NEW easy to remove fuse carrier.
- Self cleaning, self aligning base contacts.
- Fuse carriers moulded from tough flame retardant material.
- No screws or tools required to fit fuse.
- Made from flame retardant thermoplastic or phenolic.
- Integral DIN rail mounting feature.
- Full shrouding and complete compliance with the direct contact electric shock requirements.

Rating Amp	Type of Connection	List Number	Colour	Associated HRC Fuse Links
20	Front	SC20H	Black, White	NS2 – 20 NS20M25 & 32
	Front	SC32H	Black, White	NS2 – 32 NS20M25 & 32
	Back	SC32P	Black, White	
	Busbar/Front	SC32BH	Black	
	Busbar/Front	SC32BHA+	Black	
	Back Wired	SC32BW	Black	
63	Front	SC63H-D	Black, White	NS2 – 32*
	Back	SC63P	Black	ES40, 50 & 63
	Busbar/Front	SC63BH	Black	ES63M80

** SCA63NS carrier required*
Note: All fuse fittings provided with DIN rail facility except: SC32 & 63BH; SC63P
+ Long stud version

Accessories

	Rating	List Number
Adaptor carrier for fitting Type NS fuse links into SC63 fuse holder	32	SCA63NS
Copper links	20/32	SC20/32LINK
	63	ESCLINK

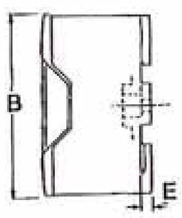
Recommended Maximum Cable Sizes

Rating amp	H and PH types	BW types
20	16mm²	–
32	16mm²	16mm²
63	25mm²	–

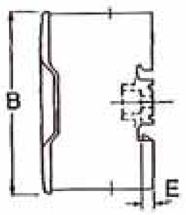
SAFECLIP Fuse Fitting Dimensions

Front Connected

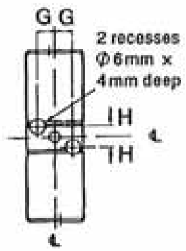
20A & 32A



63A

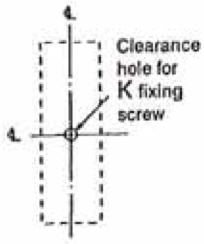


20 to 63A

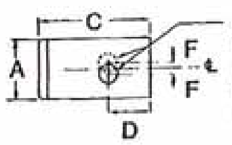


Panel drilling viewed from front of panel

20 to 63A



20 & 32A; 63A

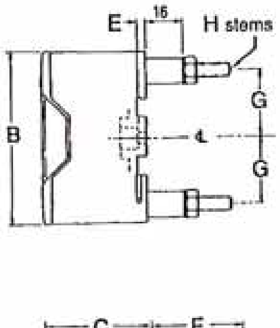


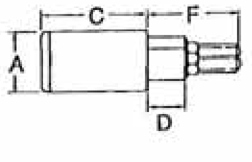
J diameter holes accommodate cables up to:
20 & 32 amp – 16mm²
63 amp – 25mm²

Rating amp	A	B	C	D	E	F	G	H	J	K
20 & 32	26.5	75.5	54	16	4	2	–	–	6	M5
63	30	96	58	24	5	6	8	5	8	M5

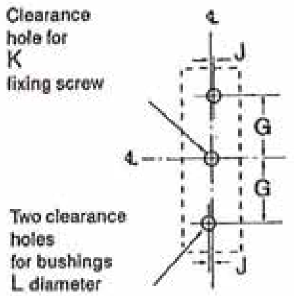
Back Connected

32A

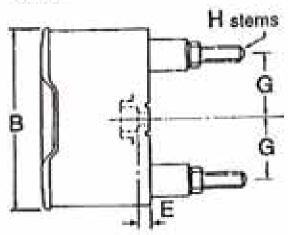




Panel drilling viewed from front of panel



63A

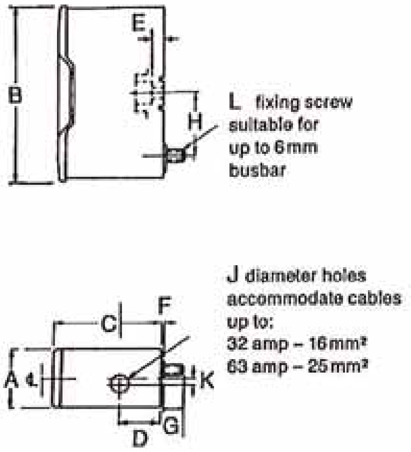


Rating amp	A	B	C	D	E	F	G	H	J	K	L
32	26.5	75.5	54	16	5	40	29	M6	2	M5	14
63	30	96	53	16	5	51	32	M8	5	M5	17

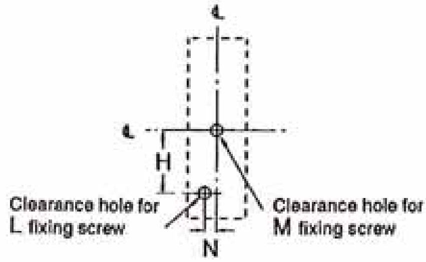
SAFECLIP Fuse Fitting Dimensions

Busbar/Front Connected

32 & 63 amp



Panel drilling viewed from front of panel

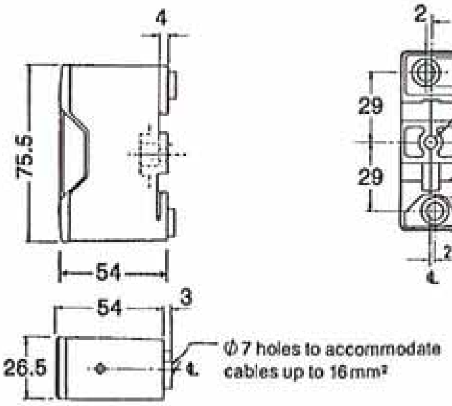


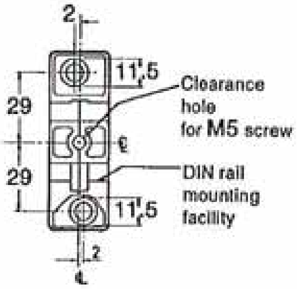
Rating amp	A	B	C	D	E	F	G	H	J	K	L	M	N
32	25	81	47	18	5	1	12	29	6	2	M5	M5	4
32/A*	26.5	75.5	54	16	–	1	40	29	6	2	M6	M5	2
63	30	96	53	20	5	1	12	33	8	6	M6	M5	6

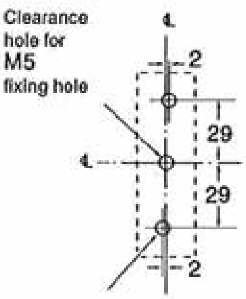
** Long stud version*

Back Wired

32 amp







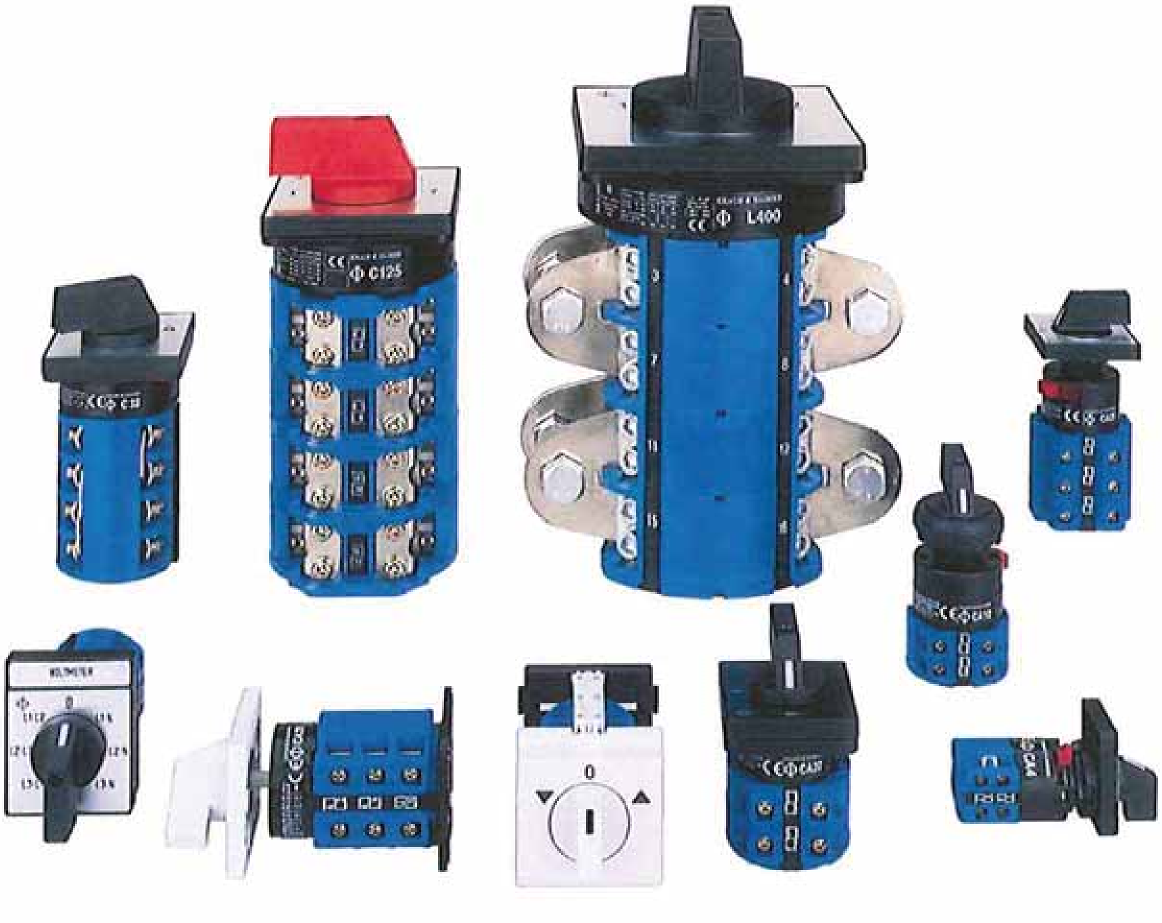
KRAUS & NAIMER
BLUE LINE SWITCHGEAR

www.krausnaimer.com

SINCE 1907

Catalog 100

CL Switches 10 A-20 A
C, CA, CAD Switches 10 A-315 A
L Switches 350 A-2400 A



Construction Data

The load switches of the C, CA, CAD and CL-series offer a solution for most cam switch applications. Different contact designs, contact materials and terminals allow for their use as control switches, instrumentation switches and motor control switches, as well as in electronic circuitry and in aggressive environments according to IEC 60947-3 and VDE 0660 part 107.

The stage is the basis for all switches and can be supplied with a maximum of 2 contacts. The terminals are accessible from the side. CA and CAD switches are supplied with open terminals to facilitate wiring and are protected against accidental finger contact according to EN 50274, VDE 0660 part 514 and BGV A3. Switches up to type CA25B are supplied with captive screws with clamping plates. The switch types CA40-CA63 are supplied with box terminals. Captive plus-minus terminal screws and integrated screwdriver guides facilitate wiring.

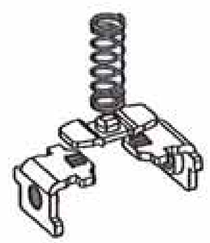
The switches of the new CL-series are supplied with rust-free and acid-resisting IDC terminals (Insulation Displacement Connection) instead of screw type terminals. The stripping or preparation of the insulation is no longer required. Eliminate errors due to i.e., stripped end of the conductor too long or too short, incorrect sleeves used, sleeves crimped incorrectly or wrong crimping tool is used, terminal screws not tightened properly etc. The CL switches reduce installation time by 60 %-70 % compared to the screw type terminals. This translates to significant cost savings. For connecting 2 conductors to a terminal an additional screw terminal with plus-minus screw is available.

If a positive manual operation or a higher DC rating is required, many of these switches can be fitted with a snap action latching mechanism - suffix „S" - to the switch type.

The cam-operated switches of the L-series are continuous current rated for off-load switching. They may be used to switch resistive or low inductive loads.

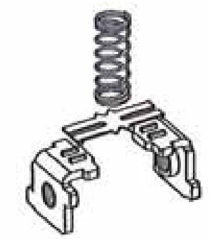
Special Contact Systems

CA4/CA4-1



High contact reliability by multiple cross-point contacts, electronic compatible, CA4 with 1 μ and CA4-1 with 35 μ gold plating.

CAD11/CAD12



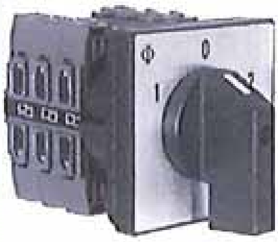
H-bridge with „cross-wire" contact system, high contact reliability also at lower voltages. CAD11 with gold-plated contacts, CAD12 with silver contact.

Type	Size	Possible Switching Angles	Max. No. of Stages
CA4, CA4-1	S00	30°, 45°, 60°, 90°	9
CL4	S00	30°, 45°, 60°, 90°	8
CA10-CA25	S0	30°, 45°, 60°, 90°	12
CA10S-CA25S	S0	60°	on request
CAD11, CAD12	S0	30°, 45°, 60°, 90°	12
CL10	S0	30°, 45°, 60°, 90°	10
CA10B-CA25B	S1	30°, 45°, 60°, 90°	12
CA40, CA50, CA63	S1	30°, 45°, 60°, 90°	12
C80, C125	S2	20°, 30°, 45°, 60°, 90°	12
C315	S3	20°, 30°, 45°, 60°, 90°	12
L350/51, L630/31, L1000/01, L1250/51	S2	30°, 45°, 60°, 90°	12
L400, L600, L800, L1200, L1600, L2000	S3	30°, 45°, 60°, 90°	12

CL Switches

CA and CAD Switches (CA4-CA25B)

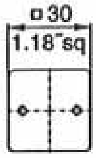
CA Switches (CA40-CA63)

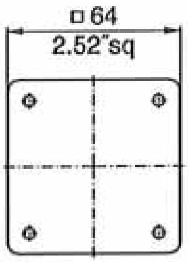


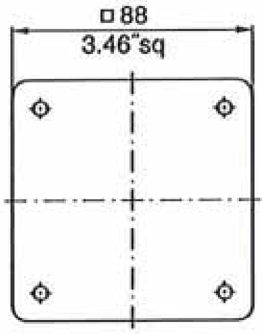
C Switches

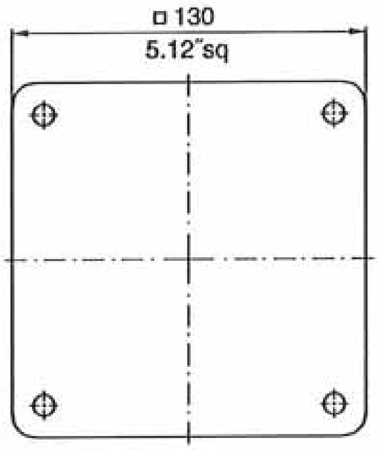
L Switches

Above illustrates the standard terminal positions.









Switch Size	Type	According to IEC 60947-3/VDE 0660 part 107 Insulation Voltage[1] U_i V	Thermal Current I_u/I_{th} A	Motor Rating 3 x 380 V-440 V AC-23 kW	AC-3 kW
S00	CA4	440	10	3	2,2
	CA4-1	440	10	3	2,2
	CL4	440	10	3	2,2
S0	CA10	690	20	7,5	5,5
	CA11	690	20	7,5	5,5
	CA20	690	25	11	7,5
	CA25	690	32	15	11
	CAD11	600	6	-	-
	CAD12	600	6	-	-
	CL10	690	20	7,5	5,5
S1	CA10B	690	20	7,5	5,5
	CA11B	690	20	7,5	5,5
	CA20B	690	25	11	7,5
	CA25B	690	32	15	11
	CA40	690	40	18,5	15
	CA50	690	50	22	18,5
	CA63	690	63	30	18,5
S2	C80	690	115	45	30
	C125	690	150	75	37
	L350	690	350	90	37
	L351	690	350	90	37
	L630	690	630[2]	90	37
	L631	690	630[2]	90	37
	L1000	690	1000[2]	90	37
	L1001	690	1000[2]	90	37
	L1250	690	1250[2]	90	37
	L1251	690	1250[2]	90	37
S3	C315	690	315	132	55
	C316[3]	1000	315	132	55
	L400	690	500	132	55
	L600	690	800[2]	132	55
	L800	690	1100[2]	132	55
	L1200	690	1450[2]	132	55
	L1600	690	1900[2]	132	55
	L2000	690	2400[2]	132	55

For further technical details, refer to pages 40-43.
To furnish with gold contacts and quick connects see page 4.

[1]Valid for lines with grounded common neutral termination, overvoltage category III, pollution degree 3. Values for other supply systems on request. [2]Ambient temperature 35 °C max. [3]Additional switch functions on request.

How to order

Disconnectors and Main Switches according to IEC 60947-3 see Catalog 500

Three types of data (shown below) are required for ordering Blue Line cam-operated switches. Code numbers for ordering are shown in this catalog.

1. Type of Switch

The type of switch required may be easily selected by referring to the table on page 3 which shows the thermal current, power rating and dimensions of each switch. For further technical details, refer to pages 40-43. Variations of contacts and terminals are shown below.

2. Switch Function

The code numbers for standard switches shown on pages 6-28 indicate the switch function, escutcheon plate, handle and any optional extras.

Additional coding to modify type and color of handle and escutcheon plate is explained below.

3. Type of Mounting

Types of mounting are shown on pages 29-35. Catalog **101** describes enclosures and optional extras.

Specify the mounting code to indicate required mounting.

CA10	A202-600	VE

Type of Switch

Extending the switch type coding the following combinations will define:

Amendment	Definition	For switch types
-1	with gold contacts[1]	CA10, CA11, CA10B, CA11B
-4	with quick connects	CA4
B	S0 switches with latching mechanism size S1	CAD11, CAD12
C	S1 switches with latching mechanism size S2	CA40, CA50, CA63
L	with lockout-relay w/o manual release for std. sw.	CA10, CA40[2], CA50[2], CA63[2]
M	with lockout-relay with manual release for std. sw.	CA10, CA40[2], CA50[2], CA63[2]
X	with power failure release	CA10, CA11, CA20, CA25, CAD12, CA40[2], CA50[2], CA63[2]
Y	with power failure release and trip-free release	CA10, CA11, CA20
S	with snap action	CA10, CA11, CA20, CA25, CA40[2], CA50[2], CA63[2] with 60° or 90° switching
R	with spring return latching mechanism	CA10

Example: Coding for switch type **CA10** with gold contacts is **CA10-1.**

Modification of Switches

The part number for switch function and options may be modified in cases where items are required other than standard. The modification may involve the escutcheon plate inscription, color combination of escutcheon plate and handle, type of escutcheon plate and handle or the optional extra.

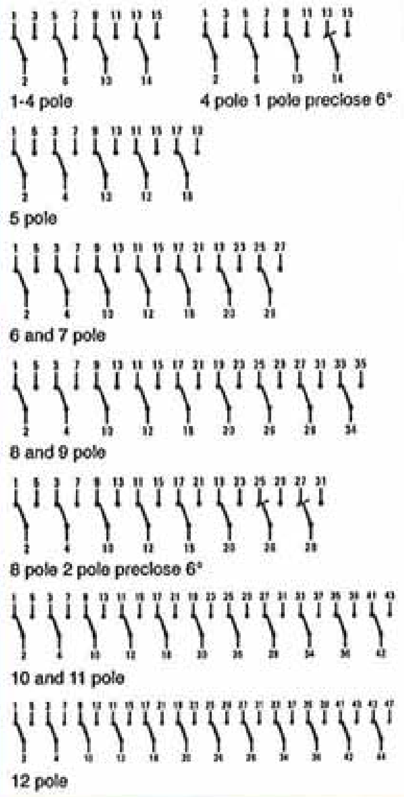
Switch Size	Escutcheon Plate Frame	Handle	Escutcheon Plate Backing	Escutcheon Plate Lettering	Dash Number
S0, S1, S2, S3	electro-gray	electro-gray	brushed alu	black	-100
S0, S1, S2, S3	electro-gray	electro-gray	black	mat silver	-500
S00, S0, S1, S2, S3	black	black	brushed alu	black	-600
S00, S0, S1, S2, S3	black	black	black	mat silver	-700

[1]Technical data on request. [2]In preparation.

Double-throw Switches without „OFF“ 60° Switching

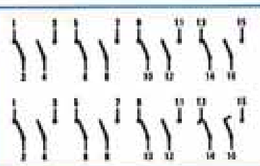
Function	Escutch. Plate	Type/Handle CA4 CA4-1 CL4	CAD.. CA10- CA25 CL10	CA10B- CA25B	CA40 C315	Code	Stages
1 pole						A220-600	1
2 pole						A221-600	2
3 pole						A222-600	3
4 pole						A223-600	4
4 pole 1 pole preclose 6° [3]						A673-600	4
5 pole						A369-600	5
6 pole						A370-600	6
7 pole						A371-600	7
8 pole						A372-600	8
8 pole 2 pole preclose 6° [3]						A972-600	8
9 pole		[2]				A373-600	9
10 pole						A374-600	10
11 pole			[4]			A375-600	11
12 pole			[4]			A376-600	12

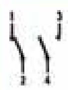
Connection Diagram



Double-throw Switches without „OFF“ with electrically isolated contacts

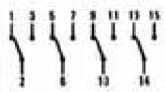
Function	Escutch. Plate	CA4 CA4-1 CL4	CAD.. CA10- CA25 CL10	CA10B- CA25B	CA40 C315	Code	Stages
1 pole						A720-600	1
2 pole						A721-600	2
3 pole						A722-600	3
4 pole						A723-600	4
4 pole 1 pole preclose 6° [3]						A973-600	4
1 pole with spring return						A795-600	1





Double-throw Switches without „OFF“ 30° Switching

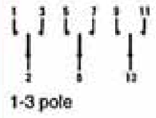
Function	Escutch. Plate	CA4 CA4-1 CL4	CAD.. CA10- CA25 CL10	CA10B- CA25B	CA40 C315	Code	Stages
1 pole						A120-600	1
2 pole						A121-600	2
3 pole						A122-600	3
4 pole						A123-600	4
1 pole with spring return						A295-600	1
2 pole with spring return						A296-600	2
3 pole with spring return			[1]			A297-600	3
1 pole with spring return						A295-620	1
2 pole with spring return						A296-620	2
3 pole with spring return			[1]			A297-620	3

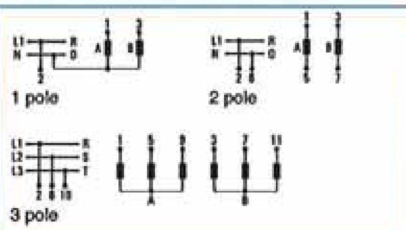
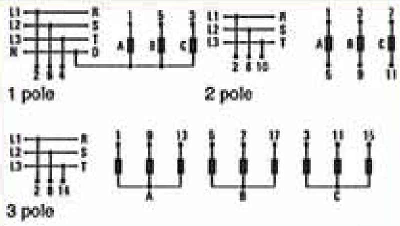
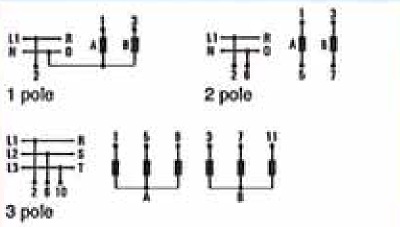


[1] not available for switch type CA25 [2] not available for switch type CL4 [3] for use in a three phase four-wire system with switched neutral
[4] not available for switch type CL10

Function	Escutch. Plate	Type/Handle: CA4 CA4-1 CL4	Type/Handle: CAD.. CA10- CA25 CL10	Type/Handle: CA10B- CA25B	Type/Handle: CA40 C315	Code	Stages	Connection Diagram

Double-throw Switches with Spring Return to Center

Function	Escutch. Plate	CA4 CA4-1 CL4	CAD.. CA10- CA25 CL10	CA10B- CA25B	CA40 C315	Code	Stages	Connection Diagram
1 pole with spring return					[2]	A214-600	1	
2 pole to center					[3]	A215-600	2	
3 pole			[1]		[4]	A216-600	3	
1 pole					[2]	A214-620	1	
2 pole					[3]	A215-620	2	
3 pole			[1]			A216-620	3	
1 pole with spring return						A320-600	1	
2 pole from left to center						A321-600	2	
3 pole			[1]			A322-600	3	
1 pole						A320-621	1	
2 pole						A321-621	2	
3 pole			[1]			A322-621	3	

General Application Switches

Function	Escutch. Plate	CA4 CA4-1 CL4	CAD.. CA10- CA25 CL10	CA10B- CA25B	CA40 C315	Code	Stages	Connection Diagram
1 pole 2 Gang						A310-600	1	
2 pole Switching sequence:						A312-600	2	
3 pole 0, A, A+B						A314-600	3	
1 pole						A310-620	1	
2 pole						A312-620	2	
3 pole						A314-620	3	
1 pole 3 Gang						A311-600	2	
2 pole Switching sequence:						A313-600	3	
3 pole 0, A, A+B, A+B+C						A315-600	5	
1 pole						A311-620	2	
2 pole						A313-620	3	
3 pole						A315-620	5	
1 pole 2 Gang						A330-600	1	
2 pole Series switching						A331-600	2	
3 pole Switching sequence: 0, A, B, A+B						A332-600	3	
1 pole						A330-620	1	
2 pole						A331-620	2	
3 pole						A332-620	3	
2 pole 2 Gang Series-parallel Switching						A339-600	2	
Switching sequence: 0, A+B series, A, A+B parallel						A339-620	2	

[1]not available for switch type CA25 [2]not available for switch type C315 [3]available only up to switch type CA63

Single Hole Mounting		Terminals rotated 90°	Code	CA4 CA4-1 CL4	CAD.. CA10-CA25 CL10
	With locking nut and shaft seal, protection IP 66			mm	mm
	Without escutcheon plate		FS1	16/22	
		●	FS1-V	16/22	
			FT1		22
		●	FT1-V		22
			FT3		22/30
		●	FT3-V		22/30
	With square escutcheon plate		FS2	16/22	
		●	FS2-V	16/22	
			FT2		22
		●	FT2-V		22
			FT4		22/30
		●	FT4-V		22/30
	With size S1 square escutcheon plate and heavy duty latching		FH3		22
		●	FH3-V		22
	With rectangular escutcheon plate		FS4	16/22	
		●	FS4-V	16/22	
			FT6		22
		●	FT6-V		22
	With size S1 rectangular escutcheon plate and heavy duty latching		FH4		22
		●	FH4-V		22
	Mounting key for locking nut		S00 T170 09		

TECHNICAL DATA SHEET
POWER SURGE DIVERTERS

GKSD SURGE DIVERTER

Product Description:

General: The *Gatekeeper* range manufactured by Lighting Down Under Pty Ltd, has been designed to provide high-energy surge protection for single and three phase power circuits. Being full three mode devices, the diverters have been designed for mounting at either main power switchboards, major distribution boards or sub-boards and should be installed in front of any surge filters to maximise the protection offered to the load.

Technology: The *Gatekeepers* are a parallel connected surge diverter consisting of fast response metal oxide varistors connected in series with a high energy fuse which will allow the varistor to reach maximum capacity and fail safe, isolating the damaged varistor. The GKSD is available in an assortment of surge capacities with the GKSD3-320 offering a maximum surge capacity of 320,000 Amps allowing long life protection. Combined with the MOV technology is our surge reduction circuitry, which allows the surge diverter to enjoy a lower let-through voltage and is internally fused for both over-current and thermal stress further enhancing the surge protection.

Warranty: All *Gatekeeper* surge diverters are supplied with our standard 10-year manufacturers warranty, which includes our 2-year replacement guarantee. This means that should the unit need replacing during the first 2 years of its life due to lightning or surges, we will replace or repair the unit at half the cost of a replacement unit.

Features:

- Low Let-through voltage
- High surge current
- Internal fusing
- Status and power indication
- Full multimode protection (multimode)
- Long service life

Electrical Specification:		GKSDX-50	GKSDX-100	GKSDX-150	GKSDX-210	GKSDX-320
Connection Type:		Parallel				
Phases:		Single or Three				
Nominal Input Voltage per Phase:	U_o	230Vac / 50Hz				
Maximum Continuous Voltage per Phase:	U_c	275Vac / 50hZ				
Modes of protection		All Mode (L-N, L-E, N-E)				
Primary Surge Protection (per mode)	I_{MAX}	50KA	100KA	150KA	210KA	320KA
N-E Protection		50KA	50KA	50KA	50KA	50KA
Response time	t_A	<5ns				
Earth leakage current:		<1mA				
Display:		Power/Status - LED				
Internal Current Fusing		YES				
Internal Thermal Fusing		YES				
Alarm Contacts		Optional		Standard		
Mechanical Specifications:						
Connection Type:		Screw terminal				
Power Terminal Capacity:		16mm2				
Alarm Terminal Capacity		2.5mm2				
IP index:		IP 20				
Mounting:		TS35 DIN rail or Wall Mount				
Width (mm) (3 phase units):		75	95	70	70	240
Height:		101	101	185	185	285
Depth (mm):		84	84	80	80	100
Weight (3 phase units):		650g	750g	900g	1kg	3.5 kg
Standards:						
Country of Manufacture:		Australia				
Standard Compliance:		ANSI C62.41 cat, A, B, C, AS1768-2007 cat. A, B, C, BS6651-1999 cat A, B, C, CP33-1999 cat A, B, C, IEC 1000-4-5-1995 UL1449 Second Edition, RMC 5140, CE, AS3260, IEC 61643-1				

Table of specifications

MC type
Magnetic Contactors


Frame size				18AF				22AF			
Type				MC-6a	MC-9a	MC-12a	MC-18a	MC-9b	MC-12b	MC-18b	MC-22b
	screws clamp terminals			●	●	●	●	●	●	●	●
Number of poles				3pole				3pole			
Rated operational voltage, Ue				690V				690V			
Rated insulation voltage, Ui				690V				690V			
Rated frequency				50/60Hz				50/60Hz			
Rated impulse withstand voltage, Uimp				6kV				6kV			
Maximum operating rate in operating cycles per hour(AC3)				1800 operations per hour				1800 operations per hour			
Durability	Mechanical			15 mil. operations				15 mil. operations			
	Electrical			2.5 mil. operations				2.5 mil. operations			
Current and power	AC-1, Thermal current		A	25	25	25	32	25	25	40	40
	AC-3	200/240V	kW	2.2	2.5	3.5	4.5	2.5	3.5	4.5	5.5
			A	9	11	13	18	11	13	18	22
		380/440V	kW	3	4	5.5	7.5	4	5.5	7.5	11
			A	7	9	12	18	9	12	18	22
		500/550V	kW	3	4	7.5	7.5	4	7.5	7.5	15
			A	6	7	12	13	7	12	13	20
		690V	kW	3	4	7.5	7.5	4	7.5	7.5	15
			A	4	5	9	9	6	9	9	18
UL rating (50/60Hz)	Continuous current		A	25	25	25	32	25	25	40	40
	Single phase	110~120V	HP	0.5	0.5	0.75	1	0.5	0.75	1	2
		220~240V	HP	1.5	1.5	2	3	1.5	2	3	3
	Three phase	200~208V	HP	2	2	3	5	2	3	5	7.5
		220~240V	HP	3	3	5	7.5	3	5	7.5	10
		440~480V	HP	5	5	7.5	10	5	7.5	10	15
		550~600V	HP	7.5	7.5	10	15	7.5	10	15	20
	NEMA size			00	00	0	0	00	00	0	1
Size and weight 	AC control	Weight	kg	0.33				0.34			
		Size(W×H×D)	mm	45×73.5×80.4				45×73.5×87.4			
	DC control	Weight	kg	0.4				0.41			
		Size(W×H×D)	mm	45×73.5×96.6				45×73.5×103.6			
Auxiliary(standard)				1NO or 1NC				1NO1NC			
Auxiliary	Side mount			UA-1				UA-1			
	Front mount			UA-2, UA-4				UA-2, UA-4			

Note) Minimum conduct current of Auxiliary contactor is DC 17V 5mA.

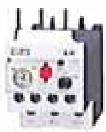
MT type
Thermal Overload Relays


Type				MT-12/□	MT-32/□
	Screws clamp terminals			●	●
Rated operational voltage, Ue				690V	690V
Rated insulation voltage, Ui				690V	690V
Rated impulse withstand voltage, Uimp				6kV	6kV
Trip class				10A, 20	10A, 20
Setting range				0.1~18A	0.1~40A
Size and weight		Weight	kg	0.1	0.17
		Size(W×H×D)	mm	45×73.2×63.7	45×75×90

* The safety cover of magnetic contactor and thermal overload relay is optional.

Metasol

40AF	
MC-32a	MC-40a
●	●
3pole	
690V	
1000V	
50/60Hz	
8kV	
1800 operations per hour	
12 mil. operations	
2 mil. operations	
50	60
7.5	11
32	40
15	18.5
32	40
18.5	22
28	32
18.5	22
20	23
50	60
2	3
5	7.5
7.5	15
10	15
20	30
25	30
1	1
0.4	
45×83×90	
0.6	
45 ×83×117.1	
2NO2NC	
UA-1	
UA-2, UA-4	



MT-32/☐
●
690V
690V
6kV
10A, 20
0.1~40A
0.17
45×75×90

65AF	
MC-50a	MC-65a
●	●
3pole	
690V	
1000V	
50/60Hz	
8kV	
1800 operations per hour	
12 mil. operations	
2 mil. operations	
70	100
15	18.5
55	65
22	30
50	65
30	33
43	60
30	33
28	35
70	100
3	5
10	15
20	25
25	30
40	50
50	60
2	2
0.9	
55×106×119	
1.2	
55×106×146.4	
2NO2NC	
UA-1	
UA-2, UA-4	

MT-63/☐
●
690V
690V
6kV
10A, 20
4~65A
0.31/0.33
55×81×100

100AF		
MC-75a	MC-85a	MC-100a
●	●	●
3pole		
690V		
1000V		
50/60Hz		
8kV		
1800 operations per hour		
12 mil. operations		
2 mil. operations		
110	135	160
22	25	30
75	85	105
37	45	55
75	85	105
37	45	55
64	75	85
37	45	55
42	45	65
110	135	160
5	7.5	10
15	15	20
25	30	30
30	40	40
50	60	75
60	75	75
2	3	3
1.6		
70×140×135.8		
2.6		
70×140×172.3		
2NO2NC		
UA-1		
UA-2, UA-4		

MT-95/☐
●
690V
690V
6kV
10A, 20
7~100A
0.48/0.5
70×97×110

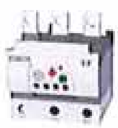
Metasol

Table of specifications

MC type Magnetic Contactors

Frame size				150AF		225AF	
Type				MC-130a	MC-150a	MC-185a	MC-225a
	screws clamp terminals			●	●	●	●
Number of poles				3pole		3pole	
Rated operational voltage, Ue				690V		690V	
Rated insulation voltage, Ui				1000V		1000V	
Rated frequency				50/60Hz		50/60Hz	
Rated impulse withstand voltage, Uimp				8kV		8kV	
Maximum operating rate in operating cycles per hour(AC3)				1200 operations per hour		1200 operations per hour	
Durability	Mechanical			5 mil. operations		5 mil. operations	
	Electrical			1 mil. operations		1 mil. operations	
Current and power	AC-1, Thermal current		A	160	210	230	275
	AC-3	200/240V	kW	37	45	55	75
			A	130	150	185	225
		380/440V	kW	60	75	90	132
			A	130	150	185	225
		500/550V	kW	60	70	110	132
			A	90	100	180	200
		690V	kW	55	55	110	140
			A	60	60	120	150
UL rating (50/60Hz)	Continuous current		A	160	210	230	275
	Single phase	110~120V	HP	10	15	15	15
		220~240V	HP	20	25	30	40
	Three phase	200~208V	HP	40	40	60	60
		220~240V	HP	40	50	60	75
		440~480V	HP	75	100	125	150
		550~600V	HP	75	75	125	150
	NEMA size			3	4	4	4
Size and weight	AC control	Weight	kg	2.4		5.4	
		Size(W×H×D)	mm	95×158×130.3		138×203×185.1	
	DC control	Weight	kg				
		Size(W×H×D)	mm				
Auxiliary(standard)				2NO2NC		2NO2NC	
Auxiliary	Side mount			UA-1		AU-100, AU-100E (Max.4NO4NC)	
	Front mount			UA-2, UA-4		-	

MT type Thermal Overload Relays



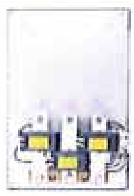
Type			MT-150/□	MT-225/□
	Screws clamp terminals		●	●
Rated operational voltage, Ue			690V	690V
Rated insulation voltage, Ui			690V	690V
Rated impulse withstand voltage, Uimp			6kV	6kV
Trip class			10A, 20	10A, 20
Setting range			34~150A	65~240A
Size and weight	Weight	kg	0.67	2.5
	Size(W×H×D)	mm	95×109×113	147×141×184

* The safety cover of magnetic contactor and thermal overload relay is optional.

400AF		
MC-265a	MC-330a	MC-400a
●	●	●
	3pole	
	690V	
	1000V	
	50/60Hz	
	8kV	
	1200 operations per hour	
5 mil. operations		2.5 mil. operations
1 mil. operations		0.5 mil. operations
300	350	450
80	90	125
265	330	400
147	160	200
265	330	400
147	160	225
225	280	350
160	200	250
185	225	300
300	350	450
-	-	-
-	-	-
75	100	125
100	125	150
200	250	300
200	250	300
5	5	5
	9.2	
	163×243×204.4	
	2NO2NC	
	AU-100, AU-100E (Max.4NO4NC)	
	-	

MT-400/□
●
690V
690V
6kV
10A, 20
85~400A
2.6
151×171×198

800AF		
MC-500a	MC-630a	MC-800a
●	●	●
	3pole	
	690V	
	1000V	
	50/60Hz	
	8kV	
	1200 operations per hour	
	2.5 mil. operations	
	0.5 mil. operations	
580	660	900
147	190	220
500	630	800
265	330	440
500	630	800
265	330	500
400	500	720
300	400	500
380	420	630
580	660	900
-	-	-
-	-	-
150	200	200
200	250	300
400	500	600
400	500	600
6	6	7
	22.4	
	285×312×245.3	
	2NO2NC	
	AU-100, AU-100E (Max.4NO4NC)	
	-	



MT-800/□
●
690V
690V
6kV
10A, 20
200~800A
11.5
360×530×212

Low voltage electrical distribution

Micrologic

Control units
5.0 P, 6.0 P and 7.0 P

User manual
09/2009

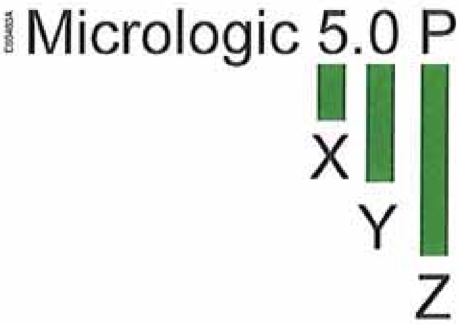
Schneider Electric

Contents

Contents

Identification

All Masterpact NT and NW circuit breakers are equipped with a Micrologic control unit that can be changed on site.
Control units are designed to protect power circuits and connected loads.
They offer current, voltage, frequency, power and energy measurements.
The functions provided by Micrologic 5.0 P, 6.0 P and 7.0 P control units optimise continuity of service and power management in your installation.



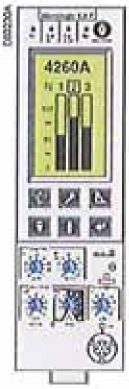
X: type of protection
- 2 for basic protection
- 5 for selective protection
- 6 for selective + ground-fault protection
- 7 for selective + earth-leakage protection

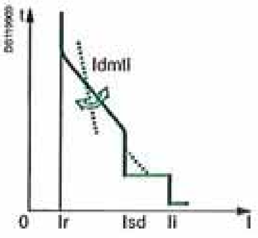
Y: version number
Identification of the control-unit generation:
"0" signifies the first generation.

Z: type of measurement
- A for "ammeter"
- P for "power meter"
- H for "harmonic meter"
- no indication = no measurements

Micrologic 5.0 P

Selective protection + Idmtl,
power measurements and additional protection

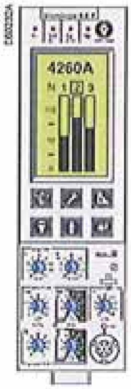


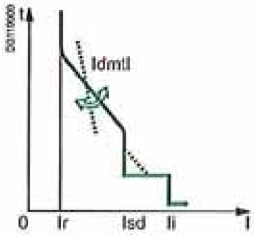


Selective protection + Idmtl

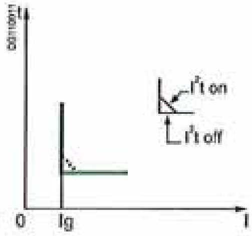
Micrologic 6.0 P

Selective protection + Idmtl + ground-fault protection,
power measurements and additional protection





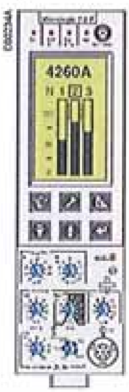
Selective protection
+ Idmtl

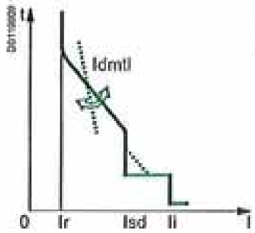


Ground-fault protection

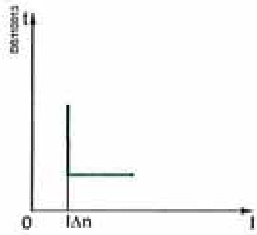
Micrologic 7.0 P

Selective protection + Idmtl + earth-leakage protection,
power measurements and additional protection





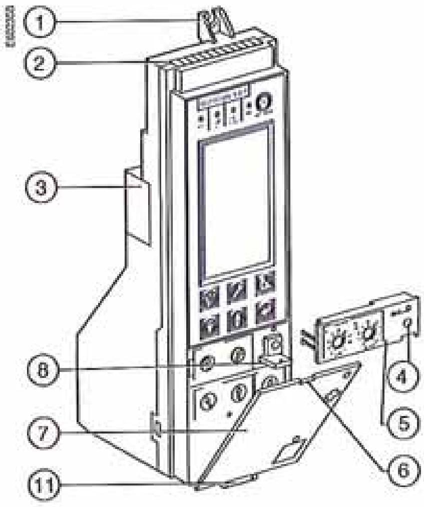
Selective protection
+ Idmtl

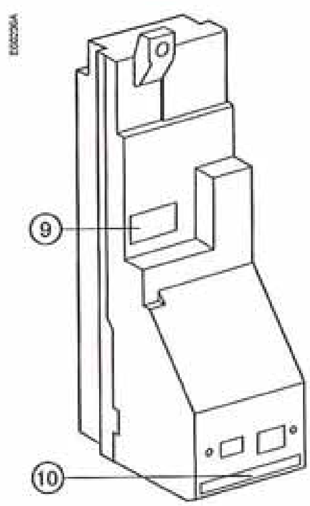


Earth-leakage protection

Presentation

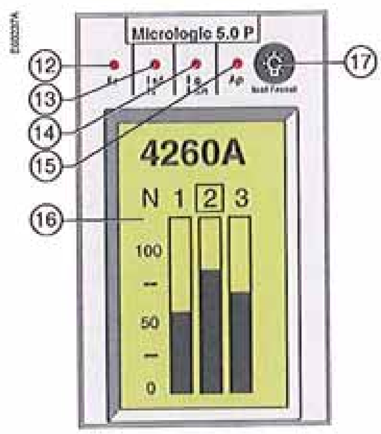
1 top fastener
2 terminal block for external connections
3 housing for battery
4 screw for long-time rating plug
5 long-time rating plug
6 cover opening point
7 protective cover
8 lead-seal fixture for protective cover
9 infrared link with communications interfaces
10 connection with circuit breaker
11 bottom fastener





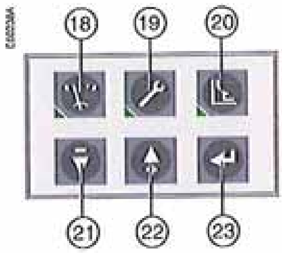
Indications

12 LED indicating long-time tripping
13 LED indicating short-time or instantaneous tripping
14 LED indicating ground-fault or earth-leakage tripping
15 LED indicating additional-protection or auto-protection tripping
16 graphics display
17 button for reset of fault-trip LED reset and battery test



Navigation

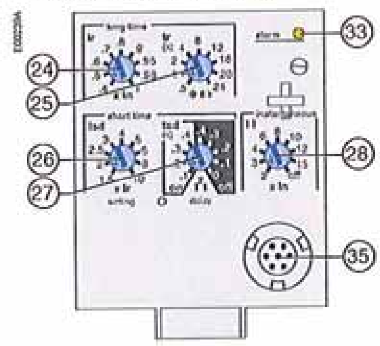
18 access button to the "Metering" menu (1)
19 access button to the "History, maintenance and setup" menu (1)
20 access button to the "Protection" menu (1)
21 button used to scroll down or reduce the displayed value
22 button used to scroll up or increase the displayed value
23 button used to select or confirm a choice



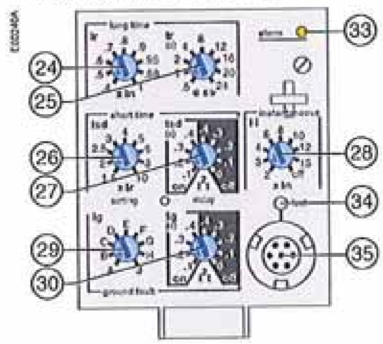
Adjustment dials

24 long-time current setting Ir
25 long-time tripping delay tr
26 short-time pickup Isd
27 short-time tripping delay tsd
28 instantaneous pickup Ii
29 ground-fault pickup Ig
30 ground-fault tripping delay tg
31 earth-leakage pickup IΔn
32 earth-leakage tripping delay Δt
33 LED indicating an overload
34 test button for ground-fault and earth-leakage protection
35 test connector

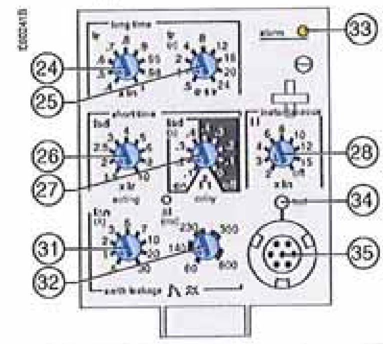
Micrologic 5.0 P control unit



Micrologic 6.0 P control unit



Micrologic 7.0 P control unit



(1) These buttons include a LED indicating the active menu.

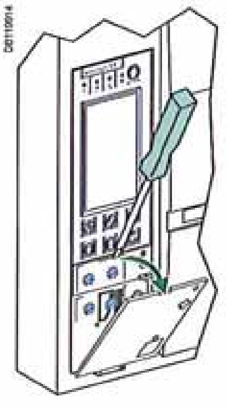
Setting procedure

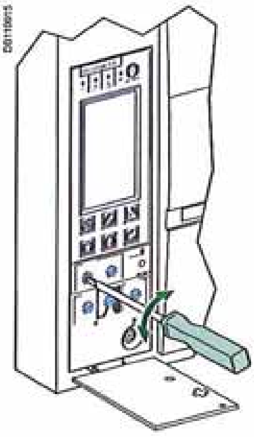
Dials

■ Dials are used to set Micrologic P protection thresholds and tripping delays for overloads, short-circuits, ground faults and earth leakage.

■ If the set thresholds are overrun, these protection functions systematically trip the circuit breaker.

Settings using the dials





■ Open the protective cover.

■ Make the necessary settings using the dials

■ The screen automatically displays the relevant curve

■ Check the set value on the screen, in absolute value in amperes (A) and in seconds (s).

Buttons

■ Buttons on the keypad are used for fine adjustments of the protection thresholds and tripping delays for overloads, short-circuits, ground faults and earth leakage. The value previously set using a dial automatically becomes the maximum value for the keypad settings.

■ They may also be used to activate other factory-disabled protection functions available on Micrologic P. These other protection functions are not accessible via the dials.

With the protective cover open, make all the necessary settings for your control unit.

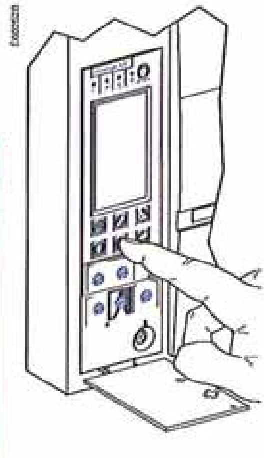
All fine adjustments are permanently stored in memory, unless the setting is modified using the adjustment dial.

For remote settings using the communications option, see the "Remote settings" section in the "Com setup" menu under "History, maintenance and setup".

Settings using the keypad

■ The ▽ and ⇕ buttons under the screen may be used for fine adjustments of the settings made using the dials.

■ All the settings not available via the dials are made in the same manner, using the keypad.



Caution!

A new overload (long-time) or short-circuit (short-time and instantaneous) protection setting made using one of the dials:

■ deletes all the fine adjustments previously made using the keypad for the overload (long-time) and short-circuit (short-time and instantaneous) protection

■ does not affect the fine adjustments made using the keypad for ground-fault and earth-leakage protection

■ does not affect any other settings made using the keypad.

Similarly, a new ground-fault or earth-leakage protection setting made using one of the dials:

■ deletes all the fine adjustments previously made using the keypad for the ground-fault and earth-leakage protection

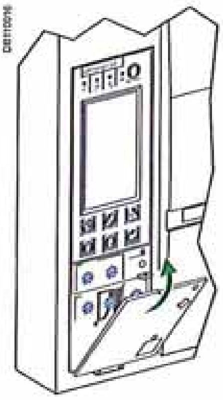
■ does not affect the fine adjustments made using the keypad for the overload (long-time) and short-circuit (short-time and instantaneous) protection

■ does not affect any other settings made using the keypad.

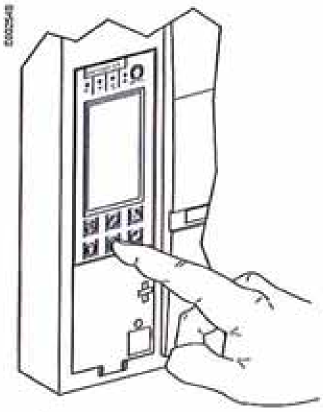
Setting procedure

With the protective cover closed, it is not possible to set the protection functions. However, it is possible to set metering functions and alarms, as well as view all measurements, settings and histories.

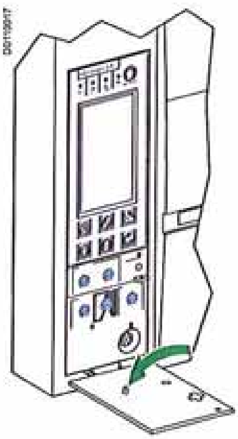
View the settings and measurements



- Close the protective cover for the dials
- Access to the dials is blocked and it is no longer possible to make fine adjustments using the keypad



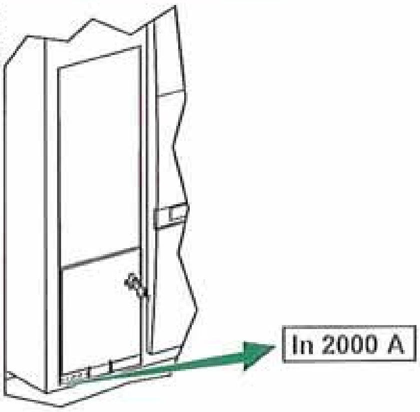
- If necessary, install a lead seal to protect the settings
- Settings may be viewed at any time using the keypad.



Caution!
If you notice that the tab on the back of the protective cover has been broken off, contact the Schneider Electric after-sales support department to replace the cover.

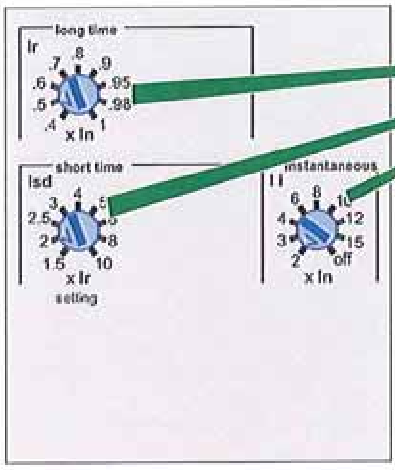
Setting Micrologic 5.0 P using the dials

Consider a 2000 A circuit breaker.



In 2000 A

Set the thresholds



In = 2000 A

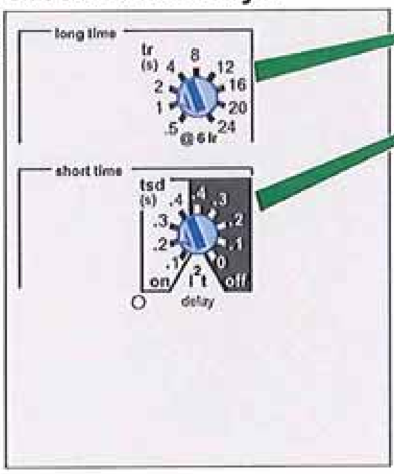
Ir = 0.5 x 2000 = 1000 A

Isd = 2 x 1000 = 2000 A

Ii = 2 x 2000 = 4000 A

See pages 22 and 24 for selection of the setting ranges.

Set the time delays

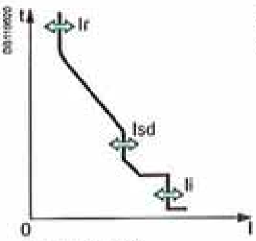


tr = 1 s

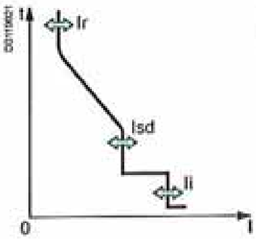
tsd = 0.2 s

Thresholds

I²t ON curve



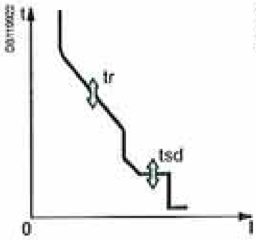
I²t OFF curve



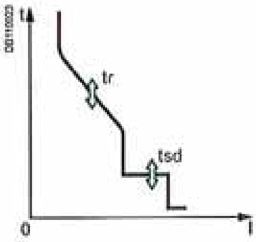
Ir: LT threshold
Isd: ST pickup
Ii: Instantaneous pickup

Time delays

I²t ON curve



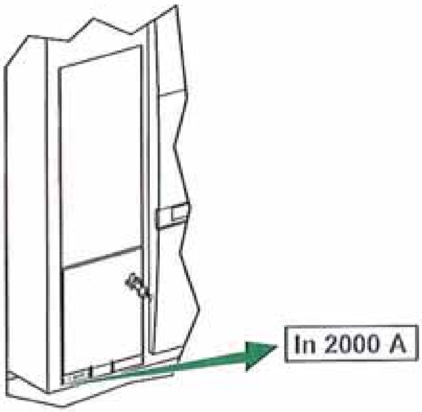
I²t OFF curve



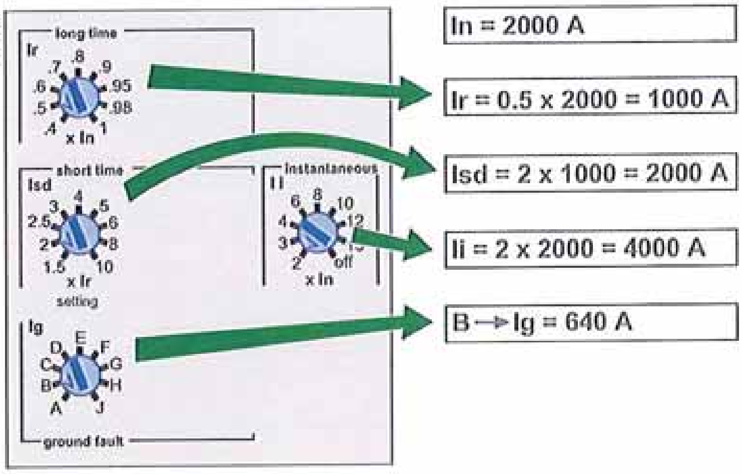
tr: LT tripping delay
tsd: ST tripping delay

Setting Micrologic 6.0 P using the dials

Consider a 2000 A circuit breaker.

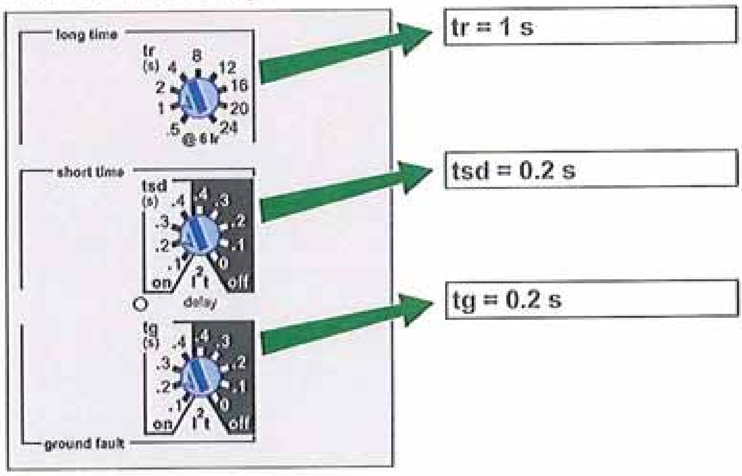


Set the thresholds



See pages 22 to 26 for selection of the setting ranges.

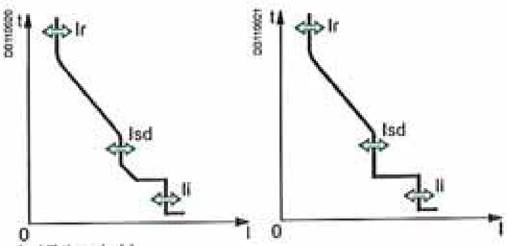
Set the time delays



Thresholds

I^2t ON curve

I^2t OFF curve

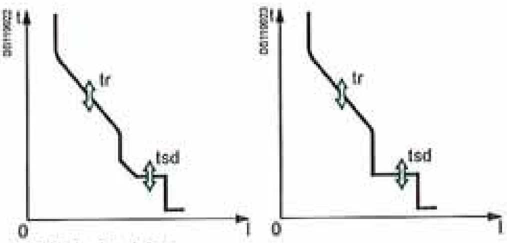


Ir: LT threshold
Isd: ST pickup
Ii: Instantaneous pickup

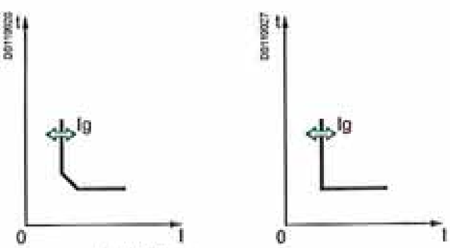
Time delays

I^2t ON curve

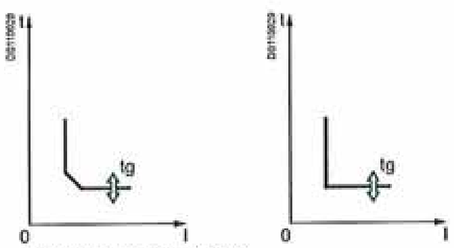
I^2t OFF curve



tr: LT tripping delay
tsd: ST tripping delay



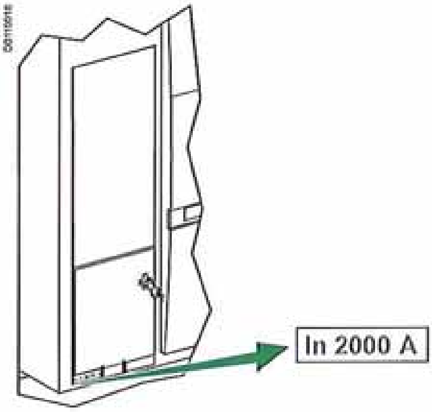
Ig: ground-fault pickup



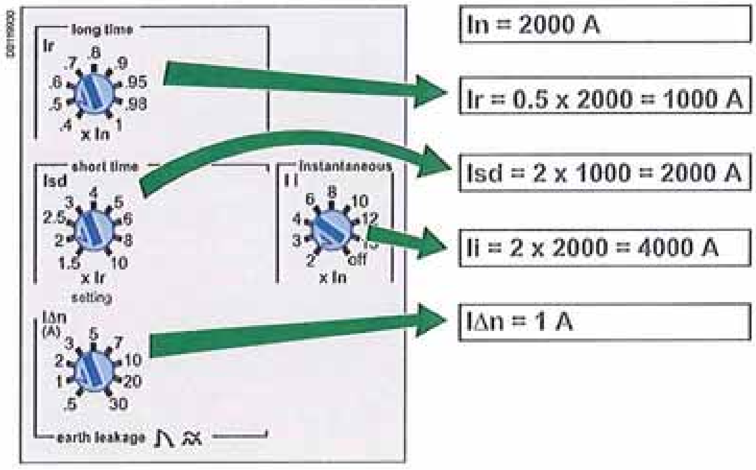
tg: ground-fault tripping delay

Setting Micrologic 7.0 P using the dials

Consider a 2000 A circuit breaker.

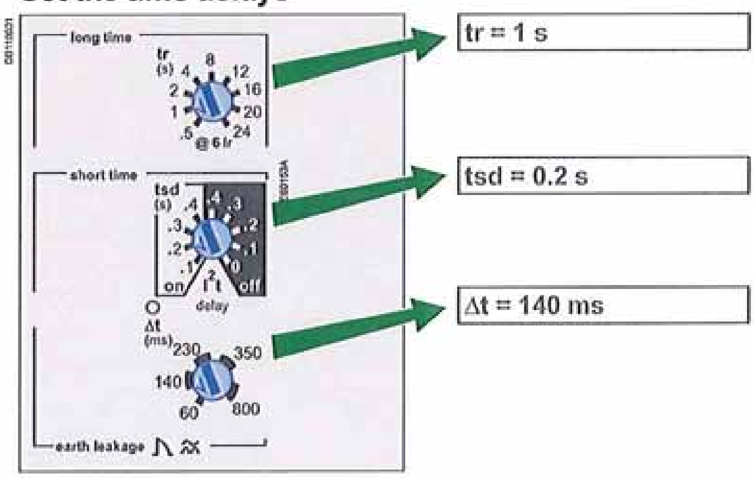


Set the thresholds



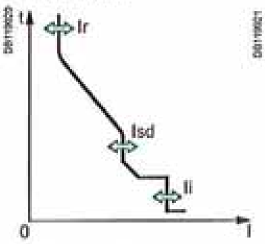
See pages 22 to 26 for selection of the setting ranges.

Set the time delays

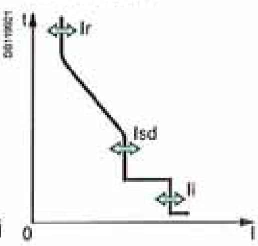


Thresholds

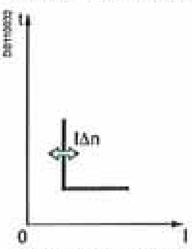
I^2t ON curve



I^2t OFF curve



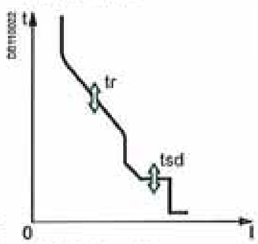
Ir: LT threshold
Isd: ST pickup
Ii: Instantaneous pickup



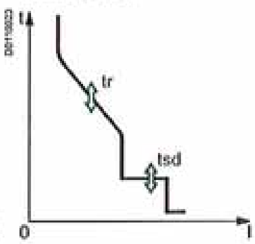
IΔn: earth-leakage pickup

Time delays

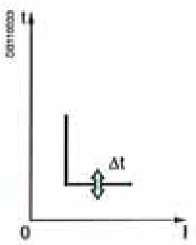
I^2t ON curve



I^2t OFF curve

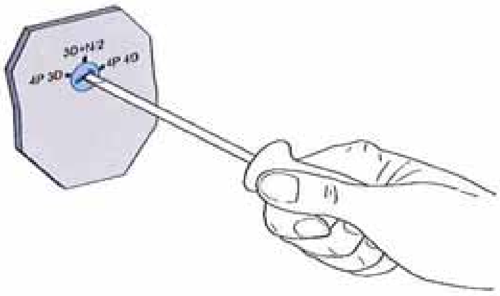


tr: LT tripping delay
tsd: ST tripping delay



Δt: earth-leakage tripping delay

Selecting the type of neutral protection



Caution!
With the 4P 3D setting, the current in the neutral must not exceed the rated current of the circuit breaker.

Selection dial on four-pole circuit breakers

On four-pole circuit breakers, it is possible to select the type of neutral protection for the fourth pole using the three-position dial on the circuit breaker:

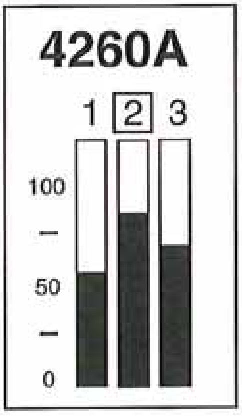
- no neutral protection 4P 3D
- half neutral protection 3D + N/2
- full neutral protection 4P 4D

The factory default setting is 3D + N/ 2.

Main menus

The Micrologic P control unit offers access to the main screen and three menus:
- the main screen displaying the continuous measurement of the phase currents (I1, I2, I3) and the neutral current (IN), if it exists
- the "Metering" menu
- the "History, maintenance and setup" menu
- the "Protection" menu.

Main screen



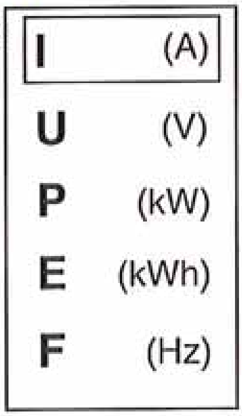
As long as no functions are activated, Micrologic P control units display in real time the current on the most heavily loaded phase.
The number for that phase is presented in a square.

The current in the neutral is displayed if the neutral CT is set as internal or external (see "Ineutral (A)" settings in the "Current protection" menu).

When a menu button is pressed, a presentation screen is displayed and the green LED on the button goes ON.

"Metering", "History, maintenance and setup" and "Protection" menus

- "Metering" menu



- press the or button to return to the main screen
- press the button to return to the previous screen
- whatever the screen displayed, if no further action is taken, the system returns to the main screen after a few minutes
- the LED goes OFF on exiting the menu.

Main menus

■ "History, maintenance and setup" menu

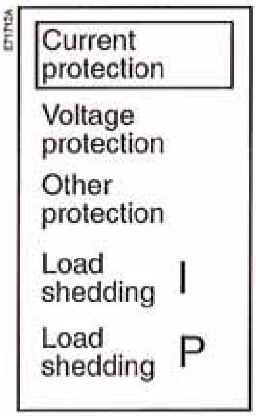
□ press the or button to return to the main screen

□ press the button to return to the previous screen

□ whatever the screen displayed, if no further action is taken, the system returns to the main screen after a few minutes

□ the LED goes OFF on exiting the menu.

■ "Protection" menu



□ press the or button to return to the main screen

□ press the button to return to the previous screen

□ whatever the screen displayed, if no further action is taken, the system returns to the main screen after a few minutes

□ the LED goes OFF on exiting the menu.

■ Saving settings

When a setting is made in any of the three menus, the screen used to save the modification(s) may be accessed by pressing one of the three buttons , or .

□ select yes to save the modifications

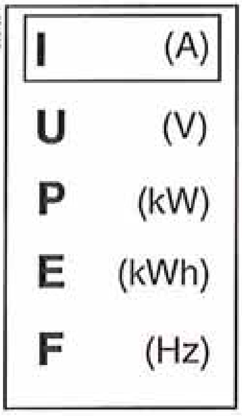
□ select no to cancel and maintain the previous settings

□ this screen remains displayed until yes or no are selected.

Metering

Press the button to select the "Metering" menu.

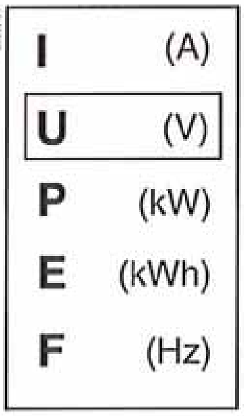
- move the cursor down the screen or decrement a value.
- move the cursor up the screen or increment a value.
- select an option in a list, confirm a selection or the value of a setting.
- indicates that the operator is in the "Metering" menu and returns to the previous screen.
- return to the main screen.



Current measurements

I (A) — access to the following sections:

- Instant.
  - I1, I2, I3, IN — I1, I2, I3, IN currents (depending on the type of system)
  - Max — Storing and reset of the maximum instantaneous currents.
- Demand
  - $\overline{I1}$, $\overline{I2}$, $\overline{I3}$, $\overline{IN}$ — Demand current on the phases $\overline{I1}$, $\overline{I2}$, $\overline{I3}$ and on $\overline{IN}$ (depending on the type of system)
  - Max — Storing and reset of the maximum demand currents.

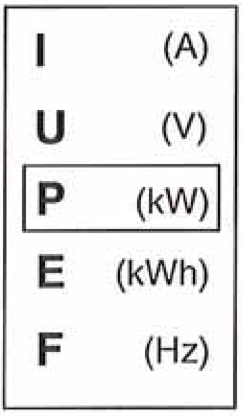


Voltage measurements

U (V) — access to the following sections:

- Instant. — Instantaneous phase-to-phase U12, U23, U31 and phase-to-neutral V1N, V2N, V3N voltages (depending on the type of system)
- Average 3 Φ — Average voltage U average of the phase-to-phase voltages.
- Unbal 3 Φ — Unbalance voltage U unbal. of the phase-to-phase voltages.
- Phase rotation — Phase sequence.

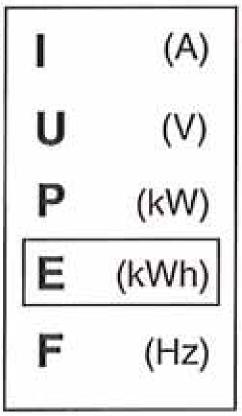
Metering



Power measurements

P (kW) — access to the following sections:

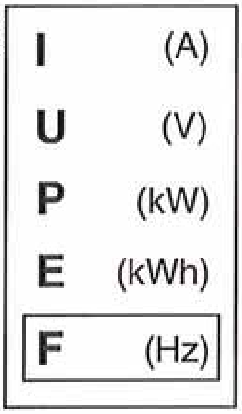
- Instant.
  - P, Q, S, — Total active power P; Total reactive power Q; Total apparent power S
  - Power factor — Power factor PF
- Demand
  - $\overline{P}$, $\overline{Q}$, $\overline{S}$ — Demand values for the:
    - total active power P
    - total reactive power Q
    - total apparent power S
  - Max — Storing and reset of the maximum demand power values



Energy measurements

E (kWh) — access to the following sections:

- E total — Total active energy E.P; Total reactive energy E.Q; Total apparent energy E.S
- E in — Positive component of:
  - the total active energy E.P
  - the total reactive energy E.Q
- E out — Negative component of:
  - the total active energy E.P
  - the total reactive energy E.Q
- Reset Energy — Reset all the energy values to zero



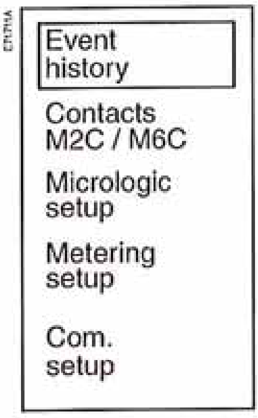
Frequency measurement

F (Hz) — access to the frequency measurement

History, maintenance and setup

Press the button to select the "History, maintenance and setup" menu.

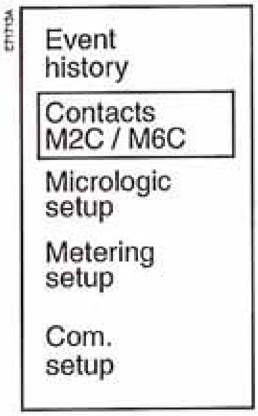
- move the cursor down the screen or decrement a value.
- move the cursor up the screen or increment a value.
- select an option in a list, confirm a selection or the value of a setting.
- indicates that the operator is in the "History, maintenance and setup" menu and returns to the previous screen.
- return to the main screen.



Event history

Event history: access to the following sections:

Trip history	The last ten faults recorded
Alarm history	The last ten alarms recorded
Operation counter	Number of operations (opening or closing)
Contact wear	Wear of the circuit-breaker main contacts



M2C / M6C Contacts

Contacts M2C / M6C: access to the following sections:

Alarm type	Assignment of a protection alarm to an M2C or an M6C contact
Setup	Latching mode for each M2C or M6C contact
Reset	Reset of the M2C or M6C contacts

History, maintenance and setup

Event history
Contacts M2C / M6C
Micrologic setup
Metering setup
Com. setup

Micrologic setup

Micrologic setup ↵	access to the following sections:
Language	Selection of the display language
Date / time	Setting of the date and time
Breaker selection	Indication of the circuit-breaker type
Power sign	Setting the power sign
VT ratio	Select of the primary and secondary voltages on the instrument transformer
System frequency	Indication of the rated system frequency

Event history
Contacts M2C / M6C
Micrologic setup
Metering setup
Com. setup

Metering setup

Metering setup ↵	access to the following sections:
System type	■ 3 phases, 3 wires, 3 CTs: method using two wattmeters ■ 3 phases, 4 wires, 3 CTs: method using three wattmeters ■ 3 phases, 4 wires, 4 CTs: method using three wattmeters with measurement of the neutral current.
Current demand	Selection of the calculation method and setting of the time interval for the calculation
Power demand	Selection of the calculation method and setting of the parameters for the calculation
Sign convention	Setting of the sign convention for the power factor and reactive power, i.e. IEEE, IEEE alternate or IEC (see page 87 to determine the sign convention)

Event history
Contacts M2C / M6C
Micrologic setup
Metering setup
Com. setup

COM communications-option setup

Com. setup ↵	access to the following sections:
Com. parameter	Setting of parameters for the COM communications option (address, baud rate, parity)
Remote settings	Authorisation of access to settings via the COM communications option.
Remote control	Authorisation of access to the circuit-breaker ON and OFF commands via the COM communications option.

Protection

Press the button to select the "Protection" menu.

- move the cursor down the screen or decrement a value
- move the cursor up the screen or increment a value
- select an option in a list, confirm a selection or the value of a setting
- indicates that the operator is in the "Protection" menu and returns to the previous screen
- return to the main screen

Current protection
Voltage protection
Other protection
Load shedding I
Load shedding P

Current protection

Current protection — access to the following sections:

Screen	Function
I (A)	Fine settings of the long-time I^2t, short-time and instantaneous protection functions
Idmtl (A)	Fine settings of the long-time Idmtl, short-time and instantaneous protection functions
I⏚ (A)	Fine settings of the: ■ ground-fault (Micrologic 6.0 P) ■ earth-leakage (Micrologic 7.0 P) protection functions
Ineutral (A)	Selection of the type of neutral sensor and type of neutral protection
I⏚ Alarm	Setting of the I⏚ alarm
Iunbal (%)	Setting of the current-unbalance protection I unbal
$\overline{I1}$ max (A)	Setting of the maximum-current protection $\overline{I1}$ max
$\overline{I2}$ max (A)	Setting of the maximum-current protection $\overline{I2}$ max
$\overline{I3}$ max (A)	Setting of the maximum-current protection $\overline{I3}$ max
$\overline{IN}$ max (A)	Setting of the maximum-current protection $\overline{IN}$ max

Protection

Current protection
Voltage protection
Other protection
Load shedding I
Load shedding P

Voltage protection

Voltage protection — access to the following sections:

- Umin (V) — Setting of the minimum-voltage protection U min.
- Umax (V) — Setting of the maximum-voltage protection U max.
- Uunbal (%) — Setting of the voltage-unbalance protection U unbal.

Current protection
Voltage protection
Other protection
Load shedding I
Load shedding P

Other protection

Other protection — access to the following sections:

- rPmax (W) — Setting of the reverse-power protection rP max
- Fmin (Hz) — Setting of the minimum-frequency protection F min
- Fmax (Hz) — Setting of the maximum-frequency protection F max
- Phase rotation — Setting of the phase-rotation protection

Current protection
Voltage protection
Other protection
Load shedding I
Load shedding P

Load shedding depending on current

Load shedding I — Access to load shedding and reconnection depending on current

Current protection
Voltage protection
Other protection
Load shedding I
Load shedding P

Load shedding depending on power

Load shedding P — Access to load shedding and reconnection depending on power

Current protection

I^2t long-time protection

For the default values, the setting ranges, increment steps and setting accuracies, see the technical appendix.

The long-time protection function protects cables against overloads. This function is based on true rms measurements.
It is possible to select either I^2t long-time protection or Idmtl long-time protection.

I^2t long-time protection

Long-time current setting Ir and standard tripping delay tr

Micrologic control unit	Accuracy		5.0 P, 6.0 P and 7.0 P								
Current setting	Ir = In (*) x ...		0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.98	1
tripping betweeen 1.05 and 1.20 Ir			other ranges or disable by changing rating plug								
Time setting			0.5	1	2	4	8	12	16	20	24
Time delay (s)	tr at 1.5 x Ir	0 to -30%	12.5	25	50	100	200	300	400	500	600
	tr at 6 x Ir	0 to -20%	0.7 (1)	1	2	4	8	12	16	20	24
	tr at 7.2 x Ir	0 to -20%	0.7 (2)	0.69	1.38	2.7	5.5	8.3	11	13.8	16.6

** In: circuit breaker rating*
(1) 0 to -40%
(2) 0 to -60%

■ It is possible to enhance the Ir setting accuracy (reduced range) or disable the long-time protection function by using a different long-time rating plug.
See the technical appendix "Changing the long-time rating plug".

Thermal memory

■ The thermal memory continuously accounts for the amount of heat in the cables, both before and after tripping, whatever the value of the current (presence of an overload or not). The thermal memory optimises the long-time protection function of the circuit breaker by taking into account the temperature rise in the cables.
■ The thermal memory assumes a cable cooling time of approximately 15 minutes.

Current protection

Idmtl long-time protection

Idmtl Protection

Long-time current setting Ir and Idmtl tripping delay tr

Micrologic control unit		Accuracy	5.0 P, 6.0 P and 7.0 P								
Current setting	Ir = In (*) x ...		0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.98	1
tripping between 1.05 and 1.20 Ir			other ranges or disable by changing rating plug								
Time setting			0.5	1	2	4	8	12	16	20	24
DT											
Time delay (s)	tr at 1.5 x Ir	0 to -20%	0.53	1	2	4	8	12	16	20	24
	tr at 6 x Ir	0 to -20%	0.53	1	2	4	8	12	16	20	24
	tr at 7.2 x Ir	0 to -20%	0.53	1	2	4	8	12	16	20	24
	tr at 10 x Ir	0 to -20%	0.53	1	2	4	8	12	16	20	24
SIT											
Time delay (s)	tr at 1.5 x Ir	0 to -30%	1.9	3.8	7.6	15.2	30.4	45.5	60.7	75.8	91
	tr at 6 x Ir	0 to -20%	0.5	1	2	4	8	12	16	20	24
	tr at 7.2 x Ir	0 to -20%	0.7 (1)	0.88	1.77	3.54	7.08	10.6	14.16	17.7	21.2
	tr at 10 x Ir	0 to -20%	0.7 (2)	0.8	1.43	2.86	5.73	8.59	11.46	14.33	17.19
VIT											
Time delay (s)	tr at 1.5 x Ir	0 to -30%	3.6	7.2	14.4	28.8	57.7	86.5	115.4	144.2	173.1
	tr at 6 x Ir	0 to -20%	0.5	1	2	4	8	12	16	20	24
	tr at 7.2 x Ir	0 to -20%	0.7 (1)	0.81	1.63	3.26	6.52	9.8	13.1	16.34	19.61
	tr at 10 x Ir	0 to -20%	0.7 (2)	0.75	1.14	2.28	4.57	6.86	9.13	11.42	13.70
EIT											
Time delay (s)	tr at 1.5 x Ir	0 to -30%	12.5	25	50	100	200	300	400	500	600
	tr at 6 x Ir	0 to -20%	0.7 (1)	1	2	4	8	12	16	20	24
	tr at 7.2 x Ir	0 to -20%	0.7 (2)	0.69	1.38	2.7	5.5	8.3	11	13.8	16.6
	tr at 10 x Ir	0 to -20%	0.7 (2)	0.7 (1)	0.7 (1)	1.41	2.82	4.24	5.45	7.06	8.48
HVF											
Time delay (s)	tr at 1.5 x Ir	0 to -30%	164.5	329	658	1316	2632	3950	5265	6581	7900
	tr at 6 x Ir	0 to -20%	0.7 (1)	1	2	4	8	12	16	20	24
	tr at 7.2 x Ir	0 to -20%	0.7 (2)	0.7 (1)	1.1 (1)	1.42	3.85	5.78	7.71	9.64	11.57
	tr at 10 x Ir	0 to -20%	0.7 (2)	0.7 (2)	0.7 (1)	0.7 (1)	1.02	1.53	2.04	2.56	3.07

** In: circuit breaker rating*
(1) 0 to -40%
(2) 0 to -60%

- These curves with different slopes are used to improve:
  - discrimination with fuses positioned upstream (HV) and/or downstream
  - protection for certain types of loads
- Five types of curves are available:
  - DT: definite time curve
  - SIT: standard inverse time curve ($I^{0.5}t$)
  - VIT: very inverse time curve (It)
  - EIT: extremely inverse time curve (I^2t)
  - HVF: compatible with high-voltage fuses (I^4t).

- **Neutral protection**

Overload protection (long time) for the neutral is disabled if the Idmtl protection function is selected. However, the short-circuit protection (short time and instantaneous) remains operational.

- **Intermittent overloads**

As long as the Micrologic P control unit remains supplied with power, the effects of intermittent overloads on cables are calculated. If power is cut, temperature rise in cables is not calculated.

- **Circuit-breaker thermal limit**

For certain settings, the Idmtl curves may be limited by the I^2t curve when the tripping delay tr is set to 24 seconds or by its thermal memory. The maximum I^2t curve remains active for the phases and the neutral even when the Idmtl curves are activated.

Current protection
Short-time and instantaneous protection

For the default values, the setting ranges, increment steps and setting accuracies, see the technical appendix.

Short-time protection

■ The short-time protection function protects the distribution system against impedant short-circuits
■ The short-time tripping delay and the I^2t ON and I^2t OFF options can be used to ensure discrimination with a downstream circuit breaker
■ This function carries out true rms measurements.

■ Use of I^2t curves with short-time protection:
□ I^2t OFF selected: the protection function implements a constant time curve
□ I^2t ON selected: the protection function implements an I^2t inverse-time curve up to 10 Ir. Above 10 Ir, the time curve is constant.

For the characteristics and external wiring of the zone selective interlocking function, see the technical appendix on "Zone selective interlocking".

■ Zone selective interlocking (ZSI)
The short-time and ground-fault protection functions enable time discrimination by delaying the upstream devices to provide the downstream devices the time required to clear the fault. Zone selective interlocking can be used to obtain total discrimination between circuit breakers using external wiring.

■ Intermittent faults are taken into account by Micrologic P and may lead to shorter tripping times than those set.

Short-time pickup Isd and tripping delay tsd

Micrologic control unit		5.0 P, 6.0 P and 7.0 P								
Pickup	Isd = Ir x ... accuracy ± 10 %	1.5	2	2.5	3	4	5	6	8	10
Time delay (ms) at 10 Ir	setting	I^2t Off	0	0.1	0.2	0.3	0.4			
		I^2t On		0.1	0.2	0.3	0.4			
I^2t On or	tsd (max resettable time)	20	80	140	230	350				
I^2t Off	tsd (max break time)	80	140	200	320	500				

If the "without long-time protection" plug is used and the long-time protection function is disabled, the short-time pickup Isd is automatically multiplied by In instead of Ir as is the standard case.

Instantaneous protection

■ The instantaneous-protection function protects the distribution system against solid short-circuits. Contrary to the short-time protection function, the tripping delay for instantaneous protection is not adjustable. The tripping order is sent to the circuit breaker as soon as current exceeds the set value, with a fixed time delay of 20 milliseconds.
■ This function carries out true rms measurements.

Instantaneous pickup Ii

Micrologic control unit		5.0 P, 6.0 P and 7.0 P								
Pickup	Ii = In (*) x ... accuracy ± 10 %	2	3	4	6	8	10	12	15	OFF

** In: circuit-breaker rating*

■ Circuit breakers have two types of instantaneous protection:
□ adjustable instantaneous protection Ii
□ self-protection.
Depending on the circuit breaker, the OFF position corresponds to the self-protection pickup.

Current protection
Neutral protection

For the default values, the setting ranges, increment steps and setting accuracies, see the technical appendix.

Three-pole circuit breakers
Protection of the neutral is possible on a three-pole circuit breaker by connecting an external sensor.
Settings are made using the [▽] and [△] buttons on the control unit.

Micrologic control unit	5.0 P, 6.0 P and 7.0 P			
Setting	OFF	N/2	N	1.6xN

Type of neutral	Description
No neutral protection	The distribution system does not require protection of the neutral conductor.
Half neutral protection	The cross-sectional area of the neutral conductor is half that of the phase conductors. ■ The long-time current setting Ir for the neutral is equal to half the setting value ■ The short-time pickup Isd for the neutral is equal to half the setting value ■ The instantaneous pickup Ii for the neutral is equal to the setting value ■ For ground-fault protection (Micrologic 6.0 P), pickup Ig for the neutral is equal to the setting value.
Full neutral protection	The cross-sectional area of the neutral conductor is equal to that of the phase conductors. ■ The long-time current setting Ir for the neutral is equal to the setting value ■ The short-time pickup Isd for the neutral is equal to the setting value ■ The instantaneous pickup Ii for the neutral is equal to the setting value ■ For ground-fault protection (Micrologic 6.0 P), pickup Ig for the neutral is equal to the setting value.
Oversized neutral protection	In installations with a high level of third-order harmonic currents (or multiples thereof), the current in the neutral conductor may exceed that of the phase currents under steady-state conditions ■ The long-time current setting Ir for the neutral is 1.6 times that of the setting value ■ The short-time pickup Isd for the neutral is 1.6 times that of the setting value, but may not exceed 10 In to limit transients and self-protect the installation ■ The instantaneous pickup Ii for the neutral is equal to the setting value ■ For ground-fault protection (Micrologic 6.0 P), pickup Ig for the neutral is equal to the setting value.

Four-pole circuit breakers
The initial protection setting is made using the dial on the neutral pole of the circuit breaker.

The [▽] and [△] buttons on the control unit may then be used for a more precise setting. The dial setting constitutes the upper limit for adjustments using the keypad.

Micrologic control unit	5.0 P, 6.0 P and 7.0 P		
Setting	OFF	N/2	N

Type of neutral	Description
No neutral protection	The distribution system does not require protection of the neutral
Half neutral protection	The cross-sectional area of the neutral conductor is half that of the phase conductors. ■ The long-time current setting Ir for the neutral is equal to half the setting value ■ The short-time pickup Isd for the neutral is equal to half the setting value ■ The instantaneous pickup Ii for the neutral is equal to the setting value
Full neutral protection	The cross-sectional area of the neutral conductor is equal to that of the phase conductors. ■ The long-time current setting Ir for the neutral is equal to the setting value ■ The short-time pickup Isd for the neutral is equal to the setting value ■ The instantaneous pickup Ii for the neutral is equal to the setting value.

Current protection

Ground-fault and earth-leakage protection

For the default values, the setting ranges, increment steps and setting accuracies, see the technical appendix.

Ground-fault protection on Micrologic 6.0 P

■ An ground fault in the protection conductors can provoke local temperature rise at the site of the fault or in the conductors. The purpose of the ground-fault protection function is to eliminate this type of fault.
■ There are two types of ground-fault protection.

Type	Description
Residual	■ The function determines the zero-phase sequence current, i. e. the vector sum of the phase and neutral currents (depending on the type of installation)
Source Ground Return	■ Using a special external sensor, this function directly measures the fault current returning to the transformer via the earth cable ■ It detects faults both upstream and downstream of the circuit breaker ■ The maximum distance between the sensor and the circuit breaker is ten metres.

■ Ground-fault and neutral protection are independent and can therefore be combined.

Ground-fault pickup Ig and tripping delay tg
The pickup and tripping-delay values can be set independently and are identical for both the residual and "source ground return" ground-fault protection functions.

Micrologic control unit			6.0 P								
Pickup	Ig = In (*) x ... accuracy ± 10 %		A	B	C	D	E	F	G	H	J
	In ≤ 400 A		0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	400 A < In ≤ 1200 A		0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	In > 1200 A		500 A	640 A	720 A	800 A	880 A	960 A	1040 A	1120 A	1200 A
Time delay (ms)	settings	I^2t Off	I^2t Off	0	0.1	0.2	0.3	0.4			
at In or 1200 A		I^2t On		0.1	0.2	0.3	0.4				
I^2t On or	tg (max resettable time)		20	80	140	230	350				
I^2t Off	tg (max. break time)		80	140	200	320	500				

(*) In: circuit-breaker rating

Earth-leakage protection on sur Micrologic 7.0 P

■ The earth-leakage protection function primarily protects people against indirect contact because an earth-leakage current can provoke an increase in the potential of the exposed conductive parts. The earth-leakage pickup value $I\Delta n$ is displayed directly in amperes and the tripping delay follows a constant-time curve.
■ An external rectangular sensor is required for this function
■ This function is inoperative if the long-time rating plug is not installed
□ Protected against nuisance tripping
□ DC-component withstand class A up to 10 A.
■ If the optional external voltage-measurement input is used, a 24 V DC external power supply must be connected to Micrologic P (terminals F1-, F2+).

Pickup value $I\Delta n$ and tripping delay Δt

Micrologic control unit		7.0 P								
Pickup (A)	$I\Delta n$ accuracy 0 to - 20 %	0.5	1	2	3	5	7	10	20	30
Time delay (ms)										
settings	Δt (max resettable time)	60	140	230	350	800				
	Δt (max. break time)	140	200	320	500	1000				

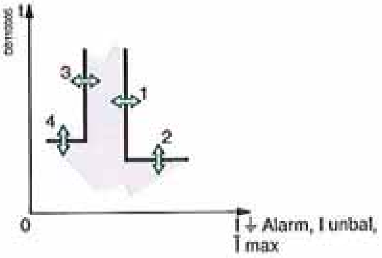
Current protection

I⏚ Alarm, current unbalance, maximum current

For the pickup and dropout thresholds and time delays, see the technical appendix.

Operating principle

Protection tripped by a maximum value



1: pickup threshold
2: pickup time delay
3: dropout threshold
4: dropout time delay

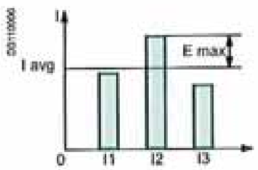
■ For protection tripped by a maximum value, it is possible to set:
□ a pickup threshold (1) that activates an alarm, a contact and/or tripping
□ a pickup time delay (2) that steps in when the pickup threshold (1) is reached
□ a dropout threshold (3) corresponding to deactivation of the alarm and/or contact
□ a dropout time delay (4) that steps in when the dropout threshold (3) is reached
■ The dropout threshold is always less than or equal to the pickup threshold.

I⏚ Alarm

■ The alarm function is tripped by the rms value of an earth-leakage current
■ This alarm signals an earth-leakage current under the pickup value and does not produce circuit-breaker tripping.

Current-unbalance protection I unbal

■ This protection is activated by an adjustable level of unbalance between the RMS values of the three phase currents.



■ From:
□ I avg is the average value of the rms currents of the three phases

$$I\ avg = \frac{I1 + I2 + I3}{3}$$

□ E max is the maximum difference between the current of each phase and I avg
■ Micrologic P uses the two values above to calculate the current unbalance:

$$I\ unbal = \frac{|E\ max|}{I\ avg}$$

Maximum-current protection per phase Īmax

■ Protection values may be set for each of the following currents:
□ Ī1 max: maximum current on phase 1
□ Ī2 max: maximum current on phase 2
□ Ī3 max: maximum current on phase 3
□ ĪN max: maximum current in the neutral
■ This function calculates the rms demand value of the current for the given phase (Ī1, Ī2, Ī3) or the neutral (ĪN), over a sliding time interval.
The time interval is the same as that for the calculation of the demand currents in the "Metering" menu.
Settings are made in the "Metering setup" menu.

Note:
ĪN max protection does not take into account the neutral-protection setting (N, N/2, 1.6xN, OFF).

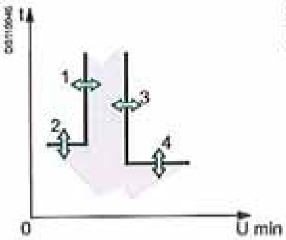
Voltage protection

Minimum voltage, maximum voltage, voltage unbalance

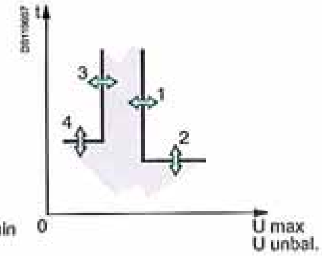
For the pickup and dropout thresholds and time delays, see the technical appendix.

Operating principle

protection tripped by a minimum value



protection tripped by a maximum value



1: pickup threshold
2: pickup time delay
3: dropout threshold
4: dropout time delay

■ For protection tripped by a minimum or maximum value, it is possible to set:
□ a pickup threshold (1) that activates an alarm, a contact and/or tripping
□ a pickup time delay (2) that steps in when the pickup threshold (1) is reached
□ a dropout threshold (3) corresponding to deactivation of the alarm and/or contact
□ a dropout time delay (4) that steps in when the dropout threshold (3) is reached
■ For protection tripped by a minimum value, the dropout threshold is always greater than or equal to the pickup threshold
■ For protection tripped by a maximum value, the dropout threshold is always less than or equal to the pickup threshold
■ If both the minimum and maximum protection functions are activated at the same time, the minimum threshold is automatically limited to the value of the maximum and vice versa.

If the voltage protection functions are activated and the voltage measurement inputs are still energised, it is impossible to reset and close the circuit breaker.

Minimum-voltage protection U min

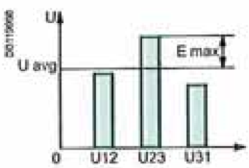
■ This function calculates the minimum rms value of the three phase-to-phase voltages
■ Protection is activated when at least one of the three phase-to-phase voltages (U12, U23, U31) is below the threshold set by the user
■ This protection function does not detect phase failure.

Maximum-voltage protection U max

■ This function calculates the maximum rms value of the three phase-to-phase voltages
■ Protection is activated when the three phase-to-phase voltages (U12, U23, U31) are simultaneously above the threshold set by the user.

Voltage-unbalance protection U unbal

This protection is activated by an adjustable level of unbalance between the rms values of the three phase-to-phase voltages.
This function calculates the rms value of the unbalance between the three phase-to-phase voltages.



■ From:
□ U avg is the average value of the rms voltages of the three phases

$$U\ avg = \frac{U12 + U23 + U31}{3}$$

□ E max: is the maximum difference between the voltage of each phase and U avg
■ Micrologic P uses the two values above to calculate the voltage unbalance:

$$U\ unbal = \left|\frac{E\ max}{U\ avg}\right|$$

Other protection

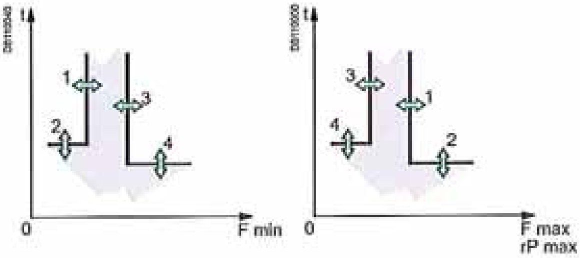
Reverse power, min. frequency, max. frequency, phase rotation

For the pickup and dropout thresholds and time delays, see the technical appendix.

Operating principle

protection tripped by a minimum value

protection tripped by a maximum value



1: pickup threshold
2: pickup time delay
3: dropout threshold
4: dropout time delay

■ For protection tripped by a minimum or maximum value, it is possible to set:
□ a pickup threshold (1) that activates an alarm, a contact and/or tripping
□ a pickup time delay (2) that steps in when the pickup threshold (1) is reached
□ a dropout threshold (3) corresponding to deactivation of the alarm and/or contact
□ a dropout time delay (4) that steps in when the dropout threshold (3) is reached
■ For protection tripped by a minimum value, the dropout threshold is always greater than or equal to the pickup threshold
■ For protection tripped by a maximum value, the dropout threshold is always less than or equal to the pickup threshold
■ If both the minimum and maximum protection functions are activated at the same time, the minimum threshold is automatically limited to the value of the maximum and vice versa.

Reverse-power protection rP max

■ This function calculates the value of the total active power on the three phases
■ The function is activated when the total active power of the three phases flows in the direction opposite that set by the user is greater than the pickup threshold (1) for a time greater than the time delay (2).

Note:
The direction of flow is set by the user in the "Power sign" section of the "Micrologic setup" menu under "History, maintenance and settings".
■ + corresponds to the normal direction of flow, i.e. from the top terminals on the circuit breaker to the bottom terminals
■ - is the opposite.

If the voltage protection functions are activated and the voltage measurement inputs are still energised, it is impossible to reset and close the circuit breaker.

Minimum and maximum-frequency protection F min. and F max

These functions monitor the value of the frequency on the distribution system.

Phase-rotation alarm

This alarm is activated if two of the three phases are inverted.

Note:
The alarm is activated following a fixed 300-millisecond time delay. If one of the phases is absent, the alarm will not operate. If the 400 Hz frequency is set, the alarm cannot be activated.

Load shedding and reconnection

For the pickup and dropout thresholds and time delays, see the technical appendix.

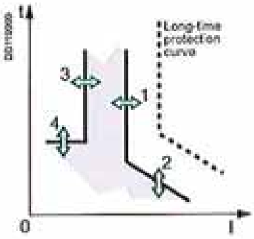
Load shedding and reconnection depending on current

The pickup curve for load shedding and reconnection depending on current is parallel to the LT I^2t and Idmtl curves. If a "without long-time protection" rating plug is installed, the load shedding/reconnection function based on current cannot be activated.

- I^2t protection: the neutral is taken into account
- Idmtl: the neutral is not taken into account.

This function does not trip the circuit breaker, but can be used to set off an alarm linked to an M2C or M6C contact (disconnection and reconnection of non-priority loads).

The load-shedding and reconnection function is determined by thresholds and time delays.



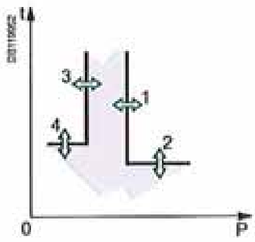
1: pickup threshold
2: pickup time delay
3: dropout threshold
4: dropout time delay

The pickup threshold is always greater than or equal to the dropout threshold.

Load shedding and reconnection depending on power

Load shedding and reconnection depending on power calculates the total active power on the three phases. This function does not trip the circuit breaker, but can be used to set off an alarm linked to an M2C or M6C contact (disconnection and reconnection of non-priority loads).

The load-shedding and reconnection function is determined by thresholds and time delays.



1: pickup threshold
2: pickup time delay
3: dropout threshold
4: dropout time delay

The pickup threshold is always greater than or equal to the dropout threshold.

Measurements

Current and voltage

For the setting ranges and measurement accuracies, see the technical appendix.

Instantaneous current

Micrologic P control units offer two, non-exclusive measurement possibilities.

- On the bargraph display on the main screen

The instantaneous current of the most heavily loaded phase is automatically displayed in amperes for phases 1, 2, 3 and the neutral (depending on the neutral protection settings). The bargraph indicates the percent load of the three phases.

- In the I inst. section of the instantaneous currents
  - display in amperes of the instantaneous currents I (rms) on phases I1, I2 and I3 and the neutral current IN, the ground-fault current Ig (Micrologic 6.0 P), the earth-leakage current IΔn (Micrologic 7.0 P)
  - the maximum instantaneous currents are displayed and stored in memory
  - the stored maximums can be reset at any time.

Demand current

- Display of the demand current on phases $\overline{I1}$, $\overline{I2}$, $\overline{I3}$ and the neutral $\overline{IN}$ (depending on the type of distribution system)
- Selection of the demand calculation method
- Display of the interval over which the value is calculated
- The maximum demand values are displayed and stored in memory
- The stored maximums can be reset at any time.

Note:
The calculation method, the type of calculation window (fixed or sliding) and its duration may be set in the "Metering setup" menu under "History, maintenance and setup".

Phase-to-neutral and phase-to-phase voltages

Micrologic P offers different voltage measurements:

- Phase-to-phase voltages (rms) between phases U12, U23 and U31, displayed in volts
- Phase-to-neutral voltages (rms) between the phases and the neutral V1N, V2N and V3N, displayed in volts.

Average voltage

Average Uavg of the instantaneous voltages between phases U12, U23 and U31.

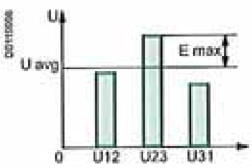
Phase rotation

Displays the phase sequence.

To display the phase-to-neutral voltages, select the "3Φ 4Φ 4CT" option in "System type" in the "Metering setup" menu under "History, maintenance and setup".

Voltage unbalance

Display of the unbalance Uunbal between the three phase-to-phase voltages, displayed as a percentage.



- From:
  - U avg is the average value of the rms voltages of the three phases

$$U\ avg = \frac{U12 + U23 + U31}{3}$$

  - E max is the maximum difference between the voltage of each phase and U avg
- Micrologic P uses the two values above to calculate the voltage unbalance

$$U\ unbal = \left|\frac{E\ max}{U\ avg}\right|$$

Measurements
Power, energy and frequency

For the setting ranges and measurement accuracies, see the technical appendix.

Instantaneous power and power factor
Micrologic P offers a number of different measurements.
■ Total power measurements:
□ instantaneous active power P in kW
□ instantaneous reactive power Q in kvar
□ instantaneous apparent power S in kVA
■ Measurement of the power factor PF.

Demand power
■ Display of the demand values for the active power P, reactive power Q and apparent power S
■ Selection of the demand calculation method
■ Display of the interval over which the value is calculated
■ The maximum demand values are displayed and stored in memory
■ The stored maximums can be reset at at any time.

Note:
■ *the calculation method, the type of calculation window (fixed or sliding) and its duration may be set in the "Metering setup" menu under "History, maintenance and setup".*
■ *the synchronisation function (Synchro.Com) is available only with the COM communication option; with this function, the demand power is determined on the basis of a signal synchronised by the communication module.*
■ *these settings apply to all demand powers (active power P, reactive power Q and apparent power S). If the settings are modified, the demand values are systematically recalculated.*

Energy
Micrologic P offers a number of different measurements:
■ Total energy:
□ total active energy E.P in kWh
□ total reactive energy E.Q in kvarh
□ total apparent energy E.S in kVAh
■ Energy consumed (Energy in), positively incremented:
□ active energy E.P in kWh
□ reactive energy E.Q in kvarh
■ Energy supplied (Energy out), negatively incremented:
□ active energy E.P in kWh
□ reactive energy E.Q in kvarh
■ Energy values can be reset.

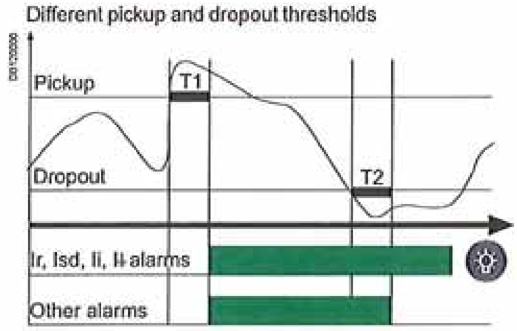
Note:
■ *the Energy in and Energy out values are incremented according to the power sign set in the "Metering setup" menu under "History, maintenance and setup".*
■ *as standard, the total calculated energy values are "absolute total values".*
They represent the sum of the energy in and out values:
□ $EP = \Sigma EPin + \Sigma EPout$
□ $EQ = \Sigma EQin + \Sigma EQout$
■ *as an option (access exclusively via the COM communications option), energy can be calculated algebraically:*
□ $EP = \Sigma EPin - \Sigma EPout$
□ $EQ = \Sigma EQin - \Sigma EQout$
These values are called "signed" energies.

Frequency
The frequency of the distribution system is displayed in Hz.

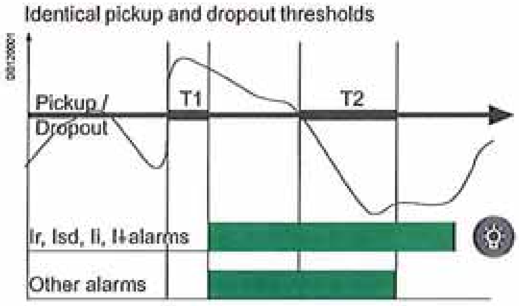
Alarms

For information on the communications option and the portable test kit, see the respective user guides.

Different pickup and dropout thresholds



Identical pickup and dropout thresholds



■ An alarm may be viewed using:
□ the "Alarm history" menu
□ the COM communications option
□ the portable test kit.
■ The commands in the "Protection" menu are used to attribute a specific operating mode to each of the protection functions:
□ OFF: protection disabled
□ Alarm: the function issues an alarm, but does not trip the circuit breaker
□ Trip + Alarm: the function issues an alarm and trips the circuit breaker.
■ The protection functions against overloads (long time), short circuits (short time and instantaneous) and ground faults (ground-fault and earth-leakage currents) automatically result in tripping and cannot be deactivated (Trip mode only).
■ The "I⏚ Alarm" and phase rotation alarms can be set exclusively to OFF or Alarm mode.
■ The other protection functions for current, voltage, power and frequency may be set to any of the three modes, OFF, Alarm or Trip + Alarm.
■ The load shedding and reconnection function may be set to ON or OFF.
■ The resettable alarms linked to device tripping are activated when the Ir, Isd/Ii or I⏚ thresholds are overrun.
The Ir alarm is reset one second after tripping. The Isd/Ii and ⏚ alarms are reset by pressing the (button) button.

Current protection	Off	Alarm	Trip + Alarm
Ir			■
Isd / Ii			■
I⏚			■

■ Delayed alarms are activated when the pickup and dropout thresholds are overrun and the corresponding time delays have expired.

Current protection	Off	Alarm	Trip + Alarm
I⏚ Alarm	■	■	
I unbal	■	■	■
$\bar{I}$1 max	■	■	■
$\bar{I}$2 max	■	■	■
$\bar{I}$3 max	■	■	■
$\bar{I}$N max	■	■	■
Voltage protection	**Off**	**Alarm**	**Trip + Alarm**
U min	■	■	■
U max	■	■	■
U unbal	■	■	■
Other protection	**Off**	**Alarm**	**Trip + Alarm**
rP max	■	■	■
F min	■	■	■
F max	■	■	■
Phase rotation	■	■	
Shedding/reconnection	**Off**	**On**	
current I	■	■	
power P	■	■	

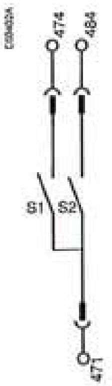
■ History logging
□ Alarm mode: as soon as a given protection threshold is overrun, an alarm is recorded in the "Alarm history"
□ Trip mode: as soon as a given protection threshold is overrun, the circuit breaker trips and the fault is recorded in the "Trip history".
■ The "Protection setup" menu under "History, maintenance and setup" is used to enable or disable the Trip mode that is displayed in the protection-setting screens. On leaving the factory, the protection functions are set to Alarm mode.
■ The "M2C / M6C contacts" menu under "History, maintenance and setup" is used to link an M2C or M6C contact to an alarm. M2C and M6C contacts may not be used together. They require a 24 V external power supply.
■ The COM communications module can be used to transmit alarms to a supervisor.

Optional M2C and M6C contacts

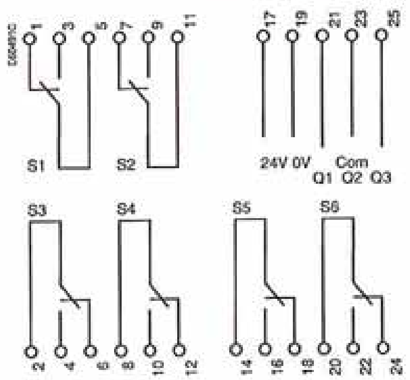
An alarm is issued if the Alarm or the Trip + Alarm mode was set for the given protection function.

Caution!
The M2C and M6C contacts require an auxiliary power supply. See the "Power supply" section in the technical appendix.

Wiring diagram for M2C contacts.



Wiring diagram for M6C contacts



- Available types of contacts:
  - M2C: up to two contacts maximum, S1 and S2
  - M6C: up to six contacts maximum, S1 to S6.

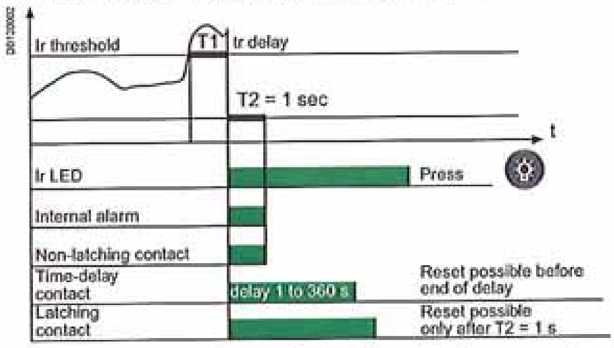
- Current protection:
  - Ir
  - Isd
  - Ii
  - I⏚
  - I⏚ Alarm
  - I unbal
  - $\overline{I1}$ max
  - $\overline{I2}$ max
  - $\overline{I3}$ max
  - $\overline{IN}$ max.

- Voltage protection:
  - U min
  - U max
  - U unbal.

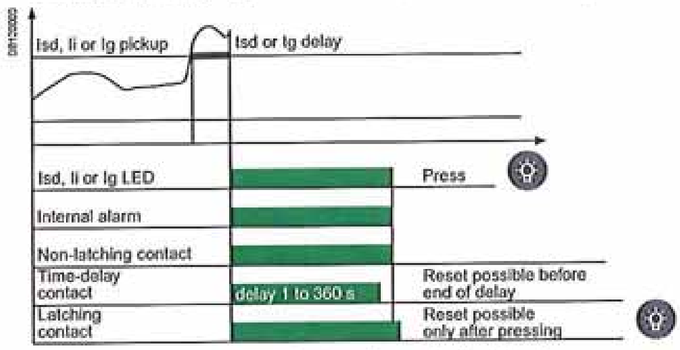
- Other protection:
  - F min
  - F max
  - rP max
  - phase rotation.

- Load shedding and reconnection:
  - current I
  - power P.
- Latching settings:
  - non-latching contact: the contact remains activated as long as the fault that caused the alarm has not been cleared
  - latching contact: the contact remains activated until it is reset ("Reset menu")
  - time-delay contact: the contact remains activated for the duration of an adjustable time delay or until it is reset ("Reset menu").
  - locked to 1: the contact is forced to 1 for an automation test
  - locked to 0: the contact is forced to 0 for an automation test.

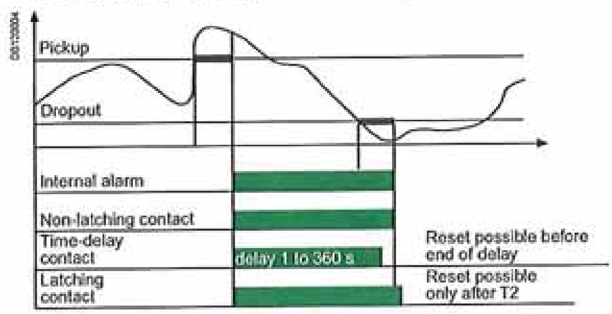
- Contact operating diagram for long-time protection



- Contact operating diagram for short-time, instantaneous and ground-fault protection



- Contact operating diagram for the other protection functions



Event histories

The interrupted currents are indicated in terms of their peak values.

Trip history

■ The trip history is the means to display at any time the parameters measured during the last ten trips.
■ For each trip, the following parameters are recorded:
□ tripping cause
□ trip threshold
□ interrupted currents in amperes (only if an external power supply is present) for Ir, Isd/Ii, Ig or IΔn trips
□ date
□ time (hours, minutes and seconds).

Alarm history

■ The alarm history is the means to display at any time the parameters measured during the last ten alarms.
■ For each alarm, the following parameters are recorded:
□ alarm cause
□ alarm threshold
□ date
□ time (hours, minutes and seconds).

Operation counter

This function is available only via the COM communications option.
■ Micrologic P:
□ stores and displays the total number of operations (incremented each time the circuit breaker opens) since the initial installation of the circuit breaker
□ stores and displays the total number of operations since the last reset.

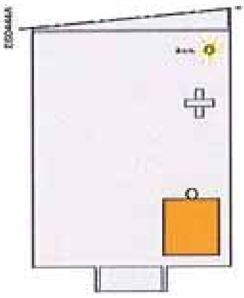
Contact wear indication

This function can be used to:
■ Determine the condition of the most worn contact in the circuit breaker. A counter is displayed on the screen. The contacts must be inspected each time the counter reaches a hundred mark. The message "Not available or circuit breaker type not defined" is displayed if the type of circuit breaker has not been defined. In this case, see "Breaker selection" in the "Micrologic setup" menu under "History, maintenance and setup".
■ Reset the indicator after changing the main contacts. Reset is also carried out via "Breaker selection" in the "Micrologic setup" menu.

Note:
If the control unit is changed, the circuit breaker must be defined again. In this case, see "Breaker selection" in the "Micrologic setup" menu under "History, maintenance and setup".

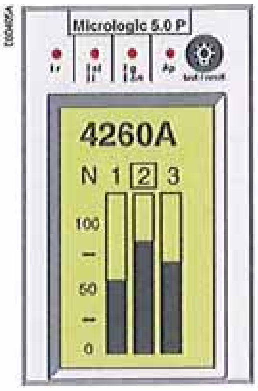
LEDs and display screens

LED indicator



Signals overrun of the long-time current setting (1.125 x Ir).

Overload bargraph on the main screen



Signals the load level on each phase as a percentage of Ir.

The procedure required to reclose the circuit-breaker following a fault trip is presented in the circuit-breaker user guide.

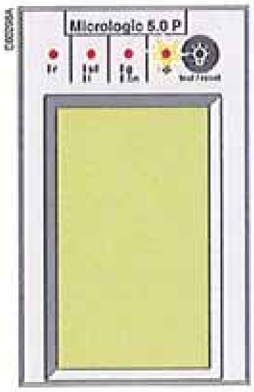
Concerning the presence or absence of an external power supply, see the "Power supply" section in the technical appendix.

Caution!
The battery maintains the trip indications.
If no indications are displayed, check the battery.

Fault-trip indications

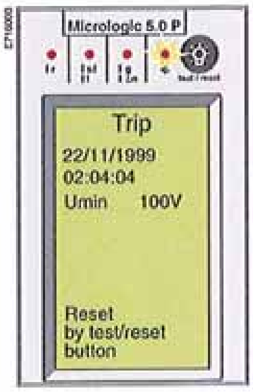
■ Control-unit status
The circuit breaker has tripped.
The control unit may or may not have an external power supply.
The voltage measurement inputs may be connected upstream or downstream.

□ control unit without an external power supply and with voltage measurement input connected downstream



A LED signals the type of fault (Ir, Isd, Ii, Ig, IΔn or Ap).

□ control unit with an external power supply and with voltage measurement input connected upstream



The type of fault is signalled by a LED and on the graphic display.

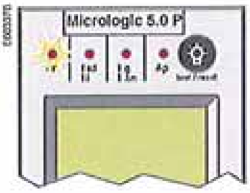
LEDs and display screens

The self-protection function (excessive temperature, fault detected in ASIC power supply or instantaneous self-protection built into the device) trips the circuit breaker and turns the Ap LED on.

A number of simultaneous causes may result in tripping. For example, a short-circuit and a distribution-system voltage under a set value.
The LED signalling the last fault chronologically is the only one to remain ON. E.g., the Ap LED may signal a voltage drop under a set value where the voltage drop was caused by a short-circuit.

- Fault-trip LEDs
- The LEDs indicate the type of fault that tripped the circuit breaker
- The LEDs are located in the upper part of the front panel (red Ir, Isd, Ii, Ig, I^2n and Ap LEDs)
- When activated, a LED remains ON until it is locally reset.

- Ir LED

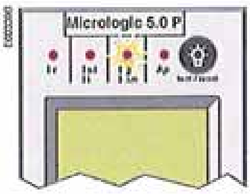


Signals tripping following overrun of the long-time current setting Ir.

- Isd, Ii LED

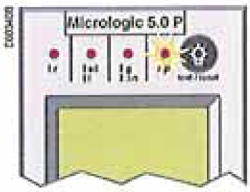
Signals tripping following overrun of the short-time pickup Isd or the instantaneous pickup Ii.

- Ig, $I\Delta n$ LED



Signals tripping following overrun of the ground-fault pickup Ig or the earth-leakage pickup $I\Delta n$.

- Ap LED

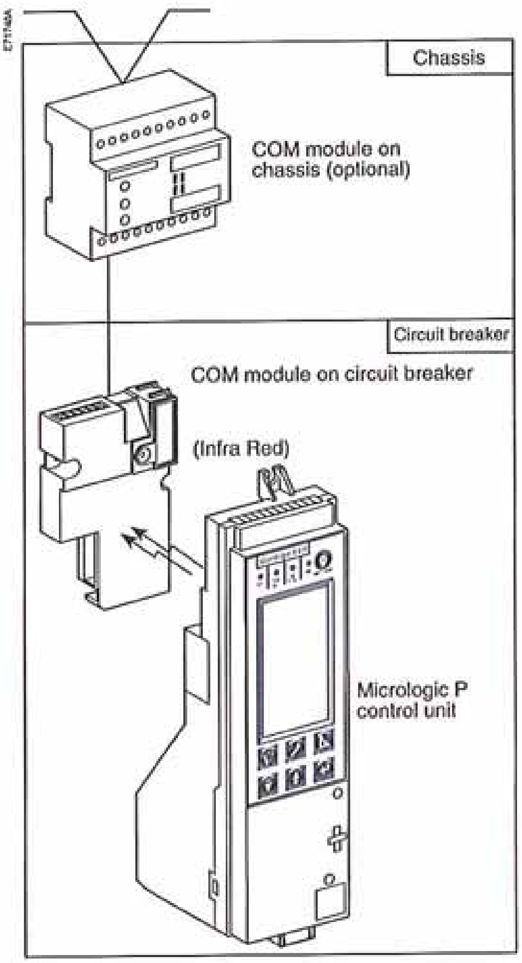


Signals tripping due to:
- Self-protection function:
  - temperature
  - ASIC power supply
  - instantaneous pickup for circuit-breaker self protection
- Protection functions:
  - current unbalance I unbal
  - maximum current $\overline{I1}$ max, $\overline{I2}$ max, $\overline{I3}$ max, $\overline{IN}$ max;
  - voltage unbalance U unbal
  - maximum voltage U max
  - minimum voltage U min
  - reverse power rP max
  - maximum frequency F max
  - minimum frequency F min.

- LEDs on buttons to access the menus

The activated LED indicates the menu for which the screen is displayed:
- "Metering"
- "History, maintenance and setup"
- "Protection".

COM communications option



Communication options

Digipact and ModBus are the indispensable elements when integrating Micrologic P in the Digivision and SMS Powerlogic installation-management systems which communicate via the BatiBus and ModBus protocols.
External gateways are available for communication over other networks, including ProfiBus, Ethernet, etc.

The communications option makes possible the following remote functions:

■ Device identification:
□ address
□ device type
□ control-unit type
□ type of long-time rating plug

■ Settings:
□ reading of the dial settings
□ fine adjustments within the range determined by the dial
□ protection and alarm settings
□ setup of the M2C / M6C contacts.

Operating and maintenance aids

■ Protection and alarm values:
□ standard
□ set.

■ Measurement values:
□ currents
□ voltages, frequencies, power, etc.

■ Fault values:
□ fault type
□ interrupted current.

■ Histories and logs:
□ trip history
□ alarm history
□ event history.

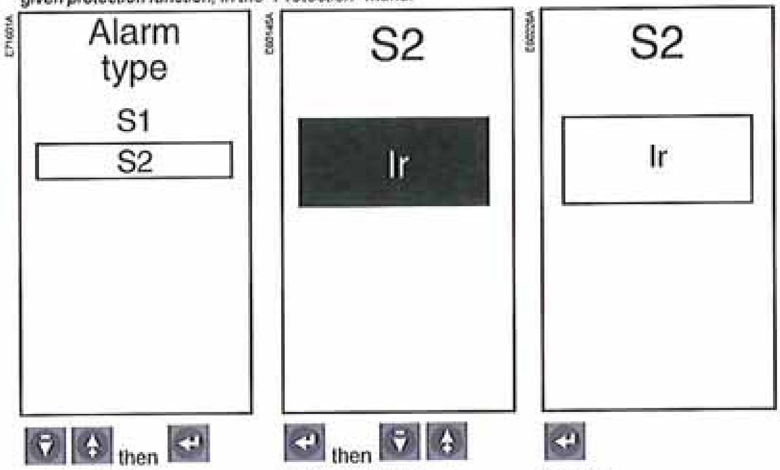
■ Indicators:
□ contact wear, counters, etc.
□ maintenance register.

Setting up the optional M2C / M6C contacts

Select the command

Select an alarm

Note:
An alarm may be selected if the "Alarm" or "Trip + Alarm" mode was selected during setup of the given protection function, in the "Protection" menu.



Select a contact.

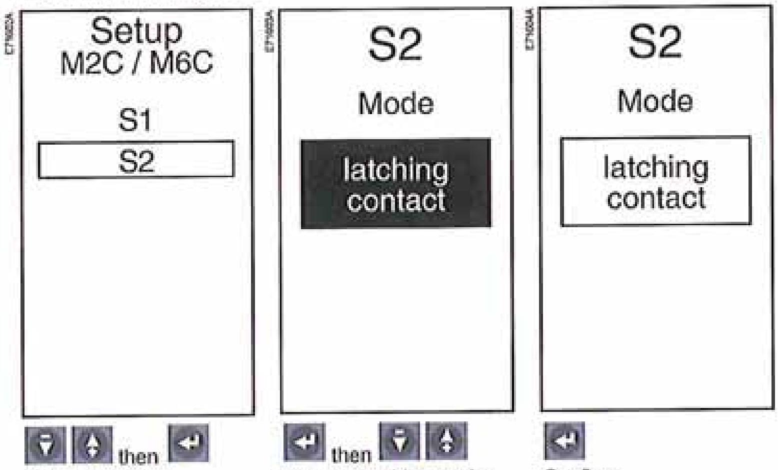
Select an alarm.

Confirm.

Select the command

Set up each contact

■ Select the latching mode



Select a contact.

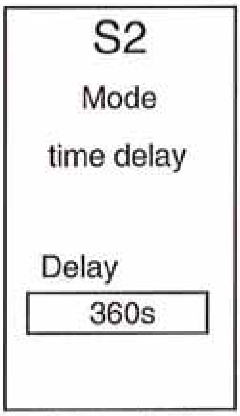
Select a latching mode:
- non-latching
- latching
- time-delay
- locked to 1
- locked to 0.

Confirm.

Setting up the optional M2C / M6C contacts

Select the command

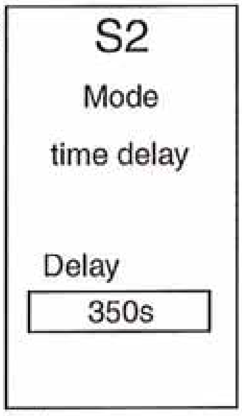
■ Set the time delay for time-delay latching



then

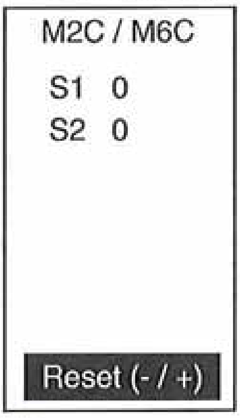
Select the time delay.

Adjust.

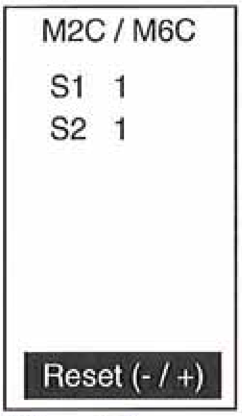


Confirm.

Reset the contacts to 0



Reset the contacts to 0...



then

or cancel the reset, then confirm.

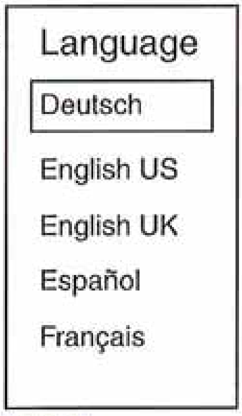
Setting up the Micrologic control unit

Prior to setting up the protection functions or carrying out measurements, the following operations are required:

- selection of the display language
- entry of the date and time
- entry of the circuit-breaker type
- entry the power sign
- selection of the transformation ratio between the primary and secondary windings if an auxiliary voltage transformer is installed
- entry of the rated frequency.

Select the command

Select the display language




Select.


Confirm.

To return to English

1. Return to the main screen by pressing any of the three buttons

or press the button

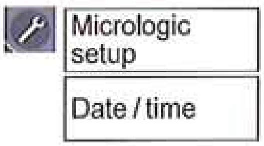
followed by any of the three buttons

2. Select the "History, maintenance and setup" menu by pressing

3. Select the "Micrologic setup" menu by moving the cursor up on the first menu. Move the cursor down on the third menu and confirm by pressing 

4. Select the "Language" menu by moving the cursor up on the first menu.
Confirm by pressing

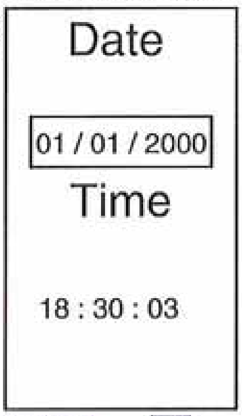
Select the command

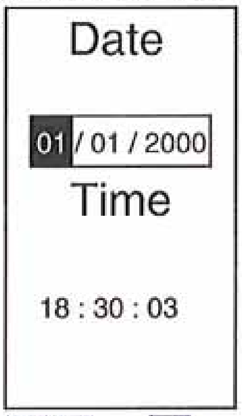


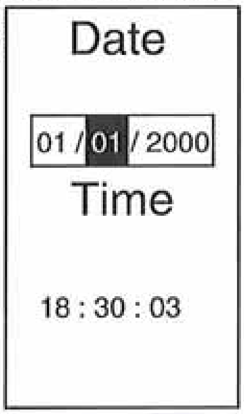
If the time is set via a communications module, any previous manual setting is automatically erased.

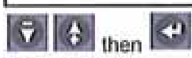
Set the date and time

- Enter the date and time for time-stamping purposes in the trip and alarm histories.









Select the date.

Enter the day.

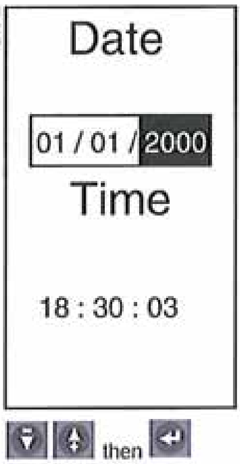
Enter the month.

- The resolution of the time setting is 20 ms.

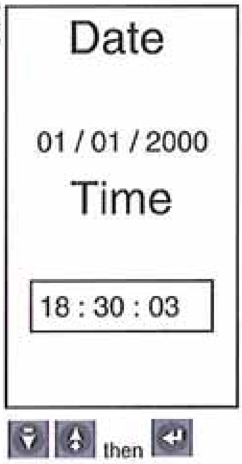
Setting up the Micrologic control unit

Date and time are backed up by battery.

If time is not synchronised by the supervisor via the communication module, a drift of up to one hour per year may be observed.



Enter the year.



Set the time in the same manner.

Circuit-breaker selection

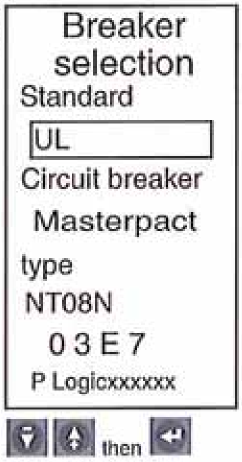
Select the command

The circuit-breaker code is required to identify the device and activate the contact-wear counter.

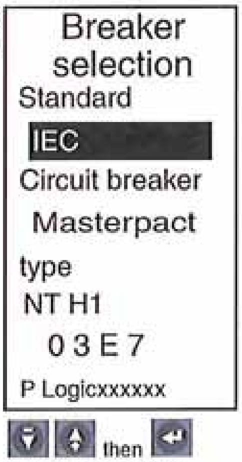
Note this code if the control unit must be changed (example 03E7).

Enter this code when setting up a new control unit on the circuit breaker.
For a new device, the code is set to zero.

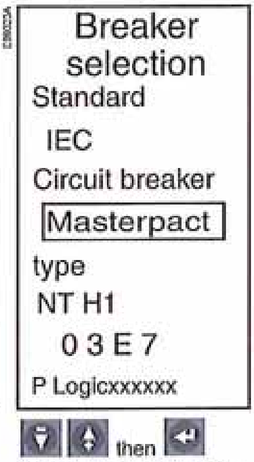
When the main circuit-breaker contacts are replaced, this code must be reset to zero.



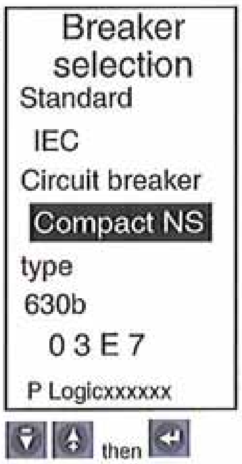
Select the standard.



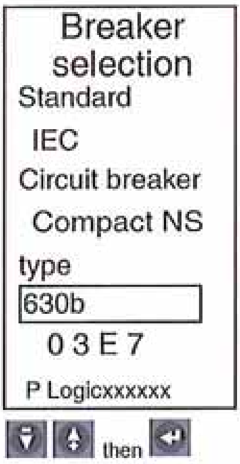
Choose and confirm.



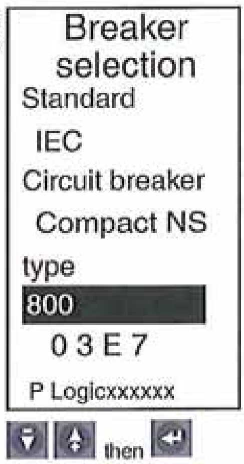
Select the circuit breaker.



Choose and confirm.



Select the type.



Choose and confirm.

Setting up the Micrologic control unit

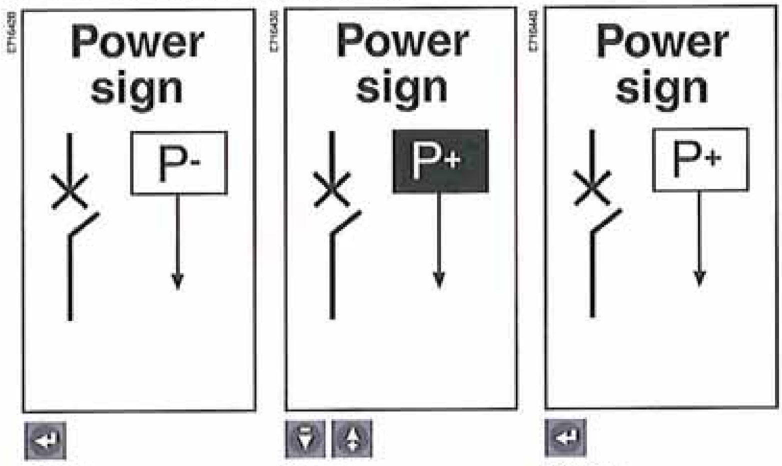
Select the command

Micrologic setup
Power sign

By default, Micrologic P uses P+ for the power flowing from top to bottom terminals. The selected direction of flow is valid for:

- measurement of power and the power factor
- measurement of energy
- load shedding and reconnection depending on power.

Select the sign of the power



Select. Choose. Confirm.

Select the command

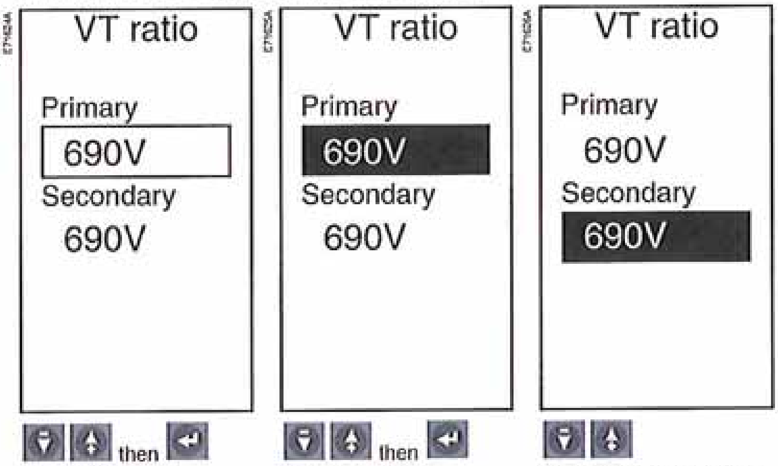
Micrologic setup
VT ratio

If the supply voltage for the control unit exceeds 690 V, an external voltage transformer must be installed.

To display the true voltage values, enter the transformation ratio between the primary and secondary voltages of the transformer.

Note that if Digipact display modules are used, the rated distribution-system voltage must be entered.

Enter the voltage-transformation ratio



Select either the:

- primary voltage
- secondary voltage.

Enter the voltage.

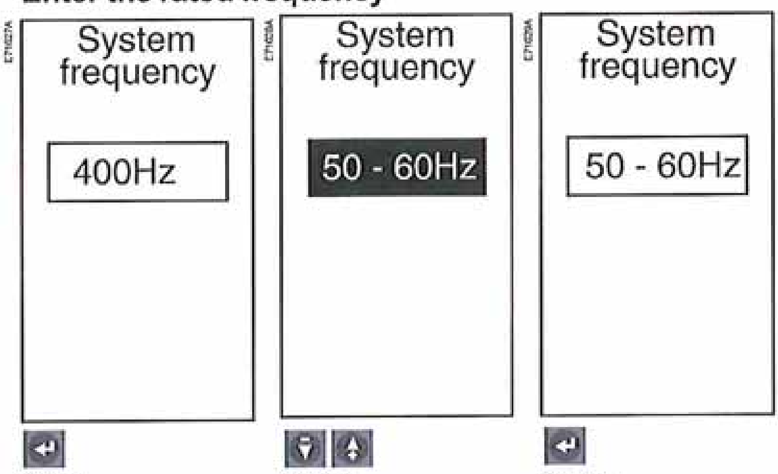
Go on to the next setting.

Select the command

Micrologic setup
System frequency

If the phase-rotation protection function is activated, the 400 Hz frequency may not be selected. If the 400 Hz frequency is selected, the phase-rotation protection function is disabled.

Enter the rated frequency



Select. Choose. Confirm.

Setting up the metering functions

Prior to setting up the protection functions or carrying out measurements, the following operations are required:
- entry of the system type
- selection of the calculation mode for the demand current
- selection of the calculation mode for the demand power
- select the power sign
- select the sign convention for the power factor measurement.

Select the command

Metering setup

System type

Caution!
The neutral current IN cannot be measured with the "3-phase, 3-wire, 3-CT" and "3-phase, 4-wire, 3-CT" types.

For a 3-pole device, the neutral, if distributed, must be connected to terminal VN of the Micrologic P control unit.

See the "Overview of functions" section for information on the available types of measurements.

Select the system type

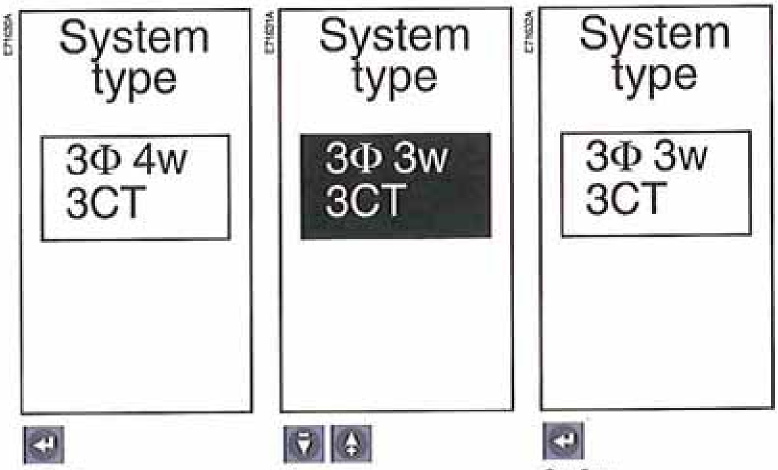
The Micrologic P control unit offers three measurement options:
- 3 phases, 3 wires, 3 CTs (method using two wattmeters)

The currents on phases I1, I2 and I3 are displayed.
The current on the neutral IN is not displayed.
The phase-to-phase voltages U12, U23 and U31 are displayed.
The phase-to-neutral voltages V1N, V2N and V3N are not displayed.
- 3 phases, 4 wires, 3 CTs (method using three wattmeters)

The currents on phases I1, I2 and I3 are displayed.
The current on the neutral IN is not displayed.
The phase-to-phase voltages U12, U23 and U31 are displayed.
The phase-to-neutral voltages V1N, V2N and V3N are displayed.
- 3 phases, 4 wires, 4 CTs (method using three wattmeters)

The currents on phases I1, I2 and I3 are displayed.
The current on the neutral IN is displayed.
The phase-to-phase voltages U12, U23 and U31 are displayed.
The phase-to-neutral voltages V1N, V2N and V3N are displayed.

Note:
It is advised not to use the "3-phase, 4-wire, 4-CT" type of measurement unless the neutral is effectively connected to the control unit (four-pole circuit breaker with an external voltage-measurement input).



Select. Choose. Confirm.

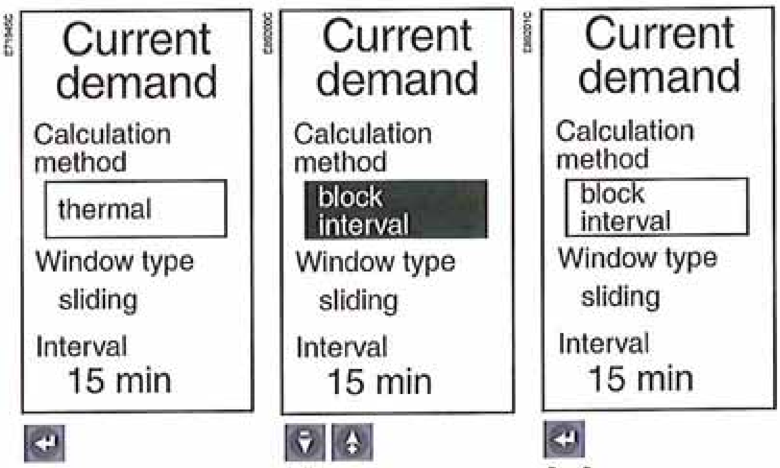
Select the command

Metering setup

Current demand

Thermal method based in I²t calculation.

Select the calculation method for demand current



Select. Adjust. Confirm.

Setting up the metering functions

Current demand
Calculation method
block interval
Window type
sliding
Interval
15 min

Select.

Current demand
Calculation method
block interval
Window type
sliding
Interval
20 min

Adjust.

Current demand
Calculation method
block interval
Window type
sliding
Interval
20 min

Confirm.

Select the command

Metering setup
Power demand

The synchronisation function "Synchro.Com" is available only with the COM communication option. With this function, the demand power is determined on the basis of a signal synchronised by the communication module.

Thermal method based on I^2t calculation.

Sliding window:
power demand is refreshed every 15 secondes.

Fixed window:
power demand is refreshed at the end of the time interval.

Select the calculation method for demand power

Power demand
Calculation method
thermal
Window type
sliding
Interval
15 min

Select.

Power demand
Calculation method
block interval
Window type
sliding
Interval
15 min

Choose between:
- thermal
- block interval
- sync. to comms

Power demand
Calculation method
block interval
Window type
sliding
Interval
15 min

Confirm.

Power demand
Calculation method
block interval
Window type
sliding
Interval
15 min

Select.

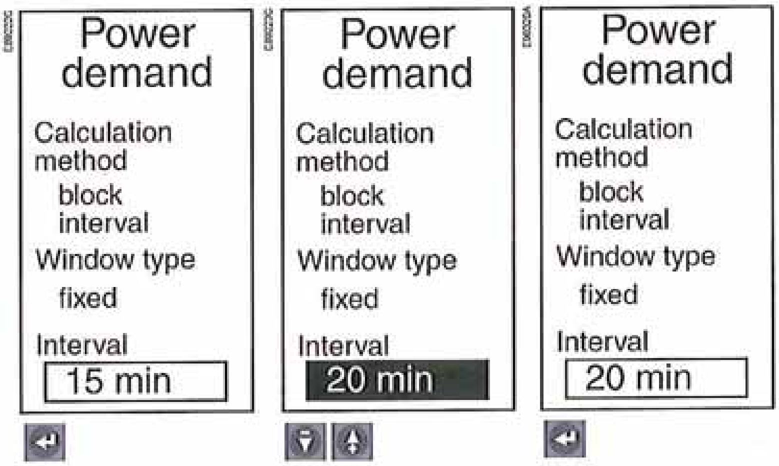
Power demand
Calculation method
block interval
Window type
fixed
Interval
15 min

Choose between fixed or sliding.

Power demand
Calculation method
block interval
Window type
fixed
Interval
15 min

Confirm.

Setting up the metering functions

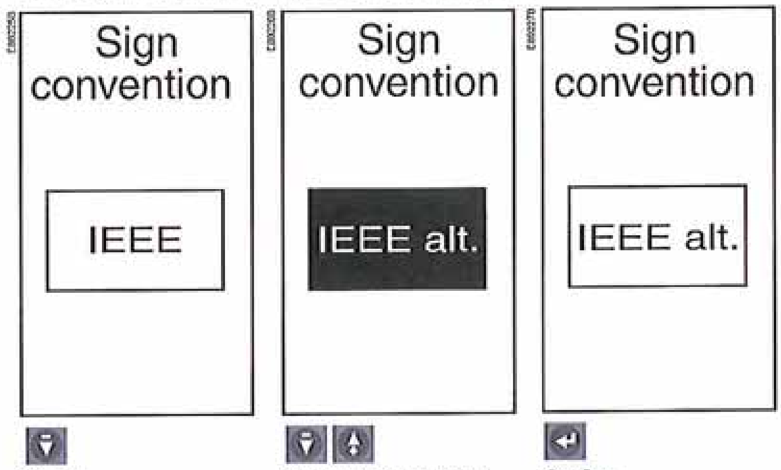


Select. Adjust. Confirm.

Select the command

See page 87 for the description of power factor sign conventions.

Set up the power-factor calculation



Select. Choose between IEEE, IEEE alternate and IEC. Confirm.

Setting up the COM communications option

Select the command

Com. setup

Com. parameter

As soon as the Digipact or ModBus communications option is connected, the control unit recognises it and displays the type of module on the graphic screen. Automatic time updates are possible only with the ModBus system.

When a COM communications option is used, it is necessary to:

- set up the COM communications option
- authorise remote setting of the Micrologic control unit
- authorise remote control of the circuit breaker.

View and set up the communications option

Modbus Com Address 47 Baud-rate 9600 Parity None	Modbus Com Address 45 Baud-rate 9600 Parity None	Modbus Com Address 45 Baud-rate 9600 Parity None
then Select an existing parameter.	Adjust.	Confirm.

Adjust all the other parameters for the communications option in the same manner.

	DIGIPACT (read only)	MODBUS (read and set up)
Address	1 - 255	1 - 47
Baud rate		9 600 bauds 19 200 bauds
Parity		Even None

Select the command

Com. setup

Remote settings

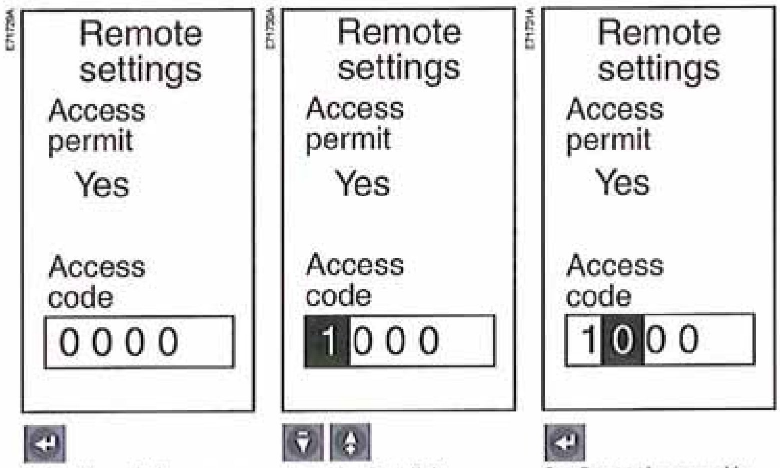
The access code is a password that must be provided by the supervisor prior to accessing the Micrologic settings.

Authorise remote setup of Micrologic

Remote settings Access permit No Access code 0 0 0 0	Remote settings Access permit Yes Access code 0 0 0 0	Remote settings Access permit Yes Access code 0 0 0 0
then Select existing setting.	Choose.	Confirm.

Setting up the COM communications option

If the operator does not enter a specific access code, the default access code is 0000 and is requested by the supervisor.



Select the existing access code setting.

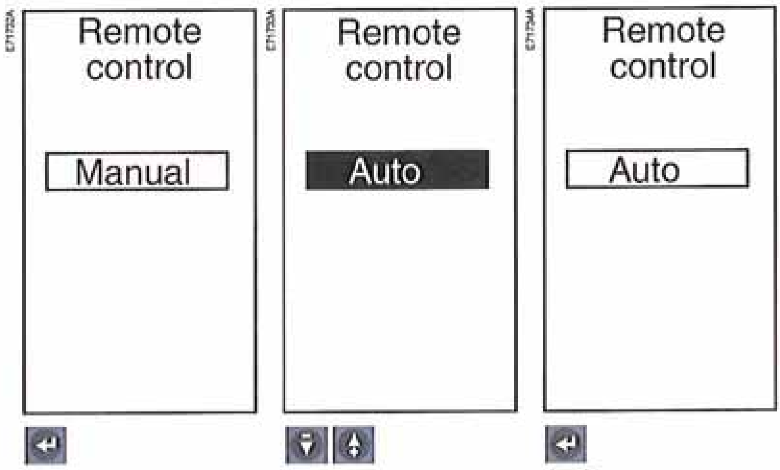
Enter the first digit.

Confirm and proceed in the same manner for the other digits.

Authorise remote control of the circuit breaker

Select the command

It is possible to set circuit-breaker control to local only ("Manual") or to local and remote ("Auto").



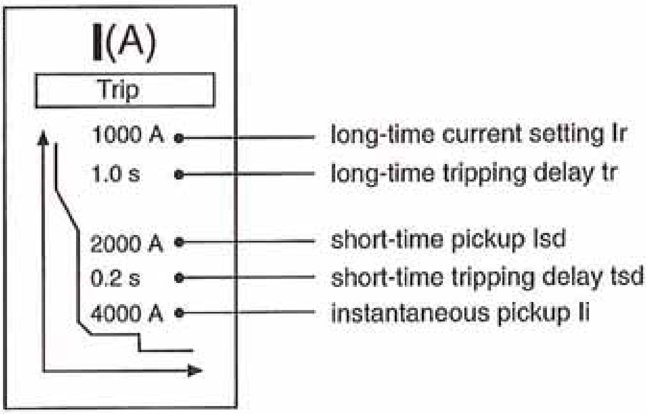
Press enter.

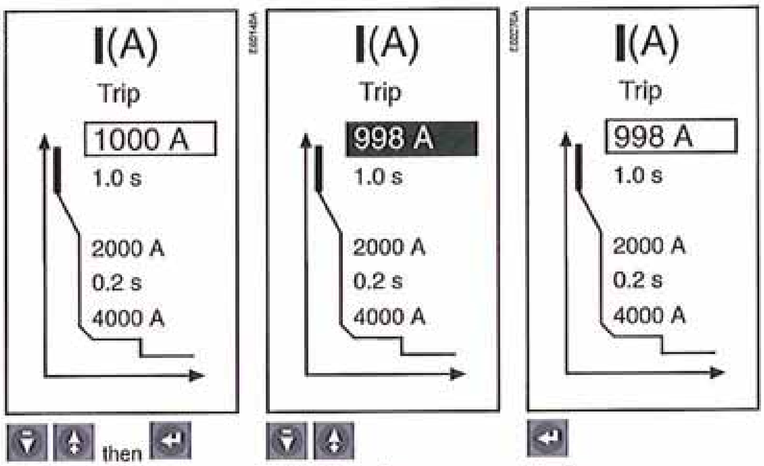
Select Auto or Manual.

Confirm.

Fine adjustment of the long-time I^2t, short-time and Instantaneous settings using the keypad

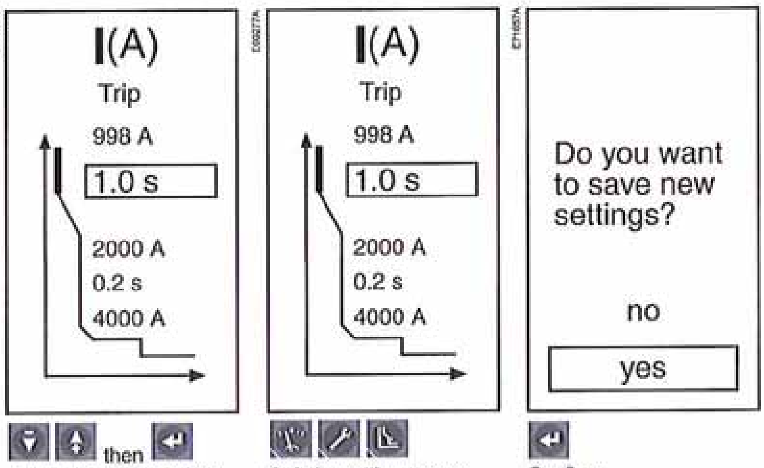
Select the command.





Select a setting. Adjust the value. Confirm.

When all the settings have been adjusted, quit the screen by pressing one of the menu-access buttons. This saves the new values.



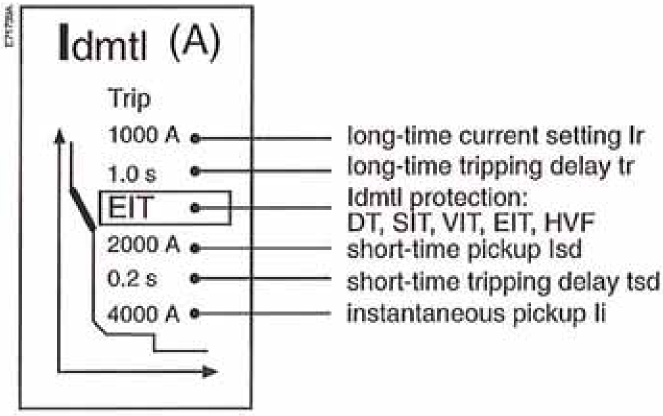
Adjust the other settings and confirm. Quit the setting screen. Confirm.

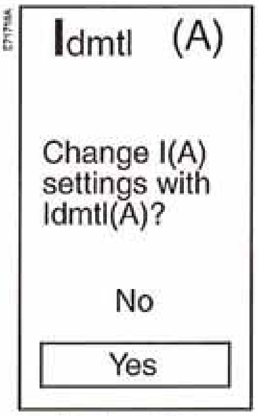
Fine adjustment of the long-time Idmtl, short-time and instantaneous settings using the keypad

Select the command

Current protection

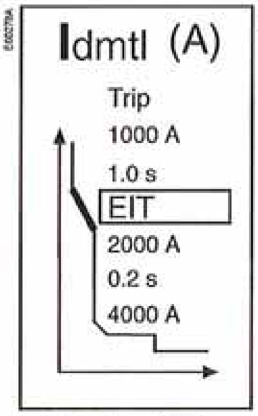
Idmtl (A)





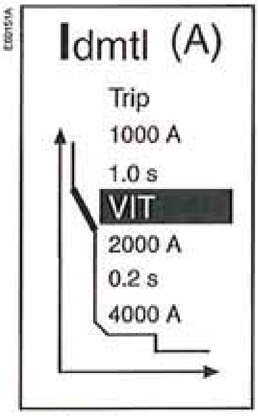
then

Select yes.

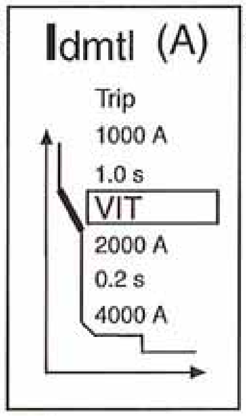


then

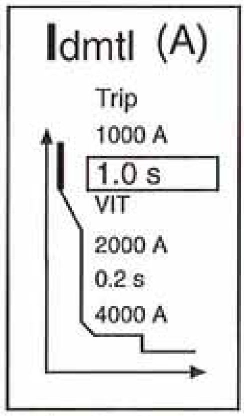
Select a setting.



Change the setting.



Confirm.



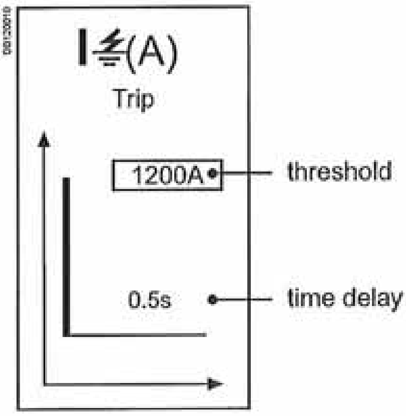
then

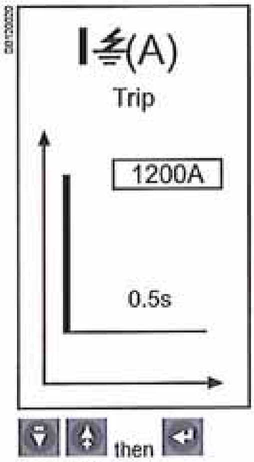
Adjust the other settings.

Confirm.

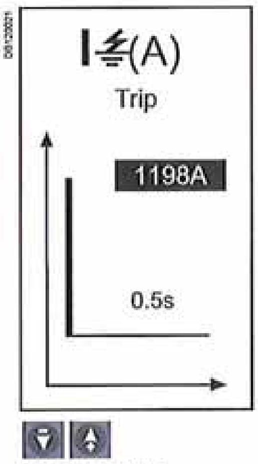
Fine adjustment of the ground-fault and earth-leakage protection setting using the keypad

Select the command

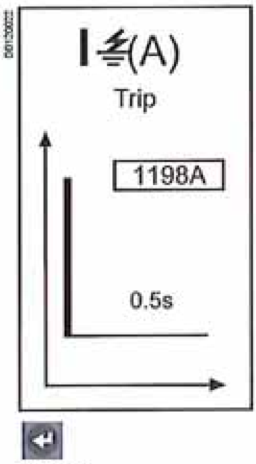




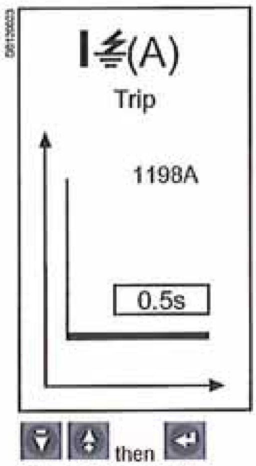
Select a setting.



Adjust the value.

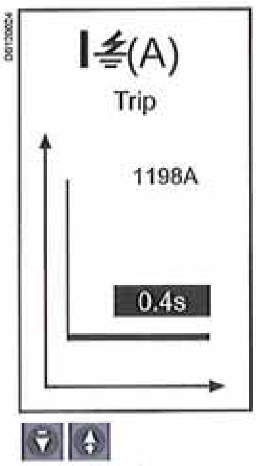


Confirm.

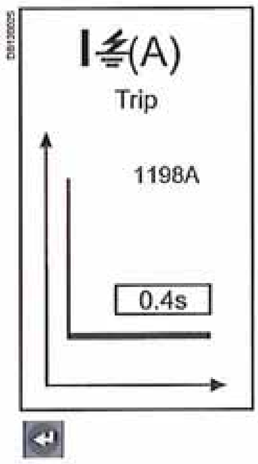


Go to the next setting.

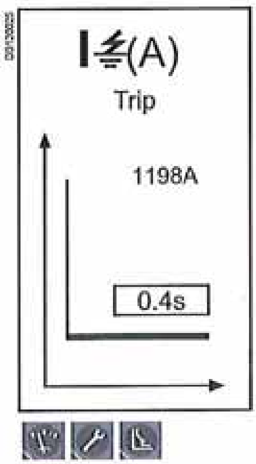
When all the settings have been adjusted, quit the screen by pressing one of the menu-access buttons. This saves the new values.



Adjust the value.



Confirm.



Quit the setting screen.

Setting the neutral protection

Select the command

Current protection

Ineutral (A)

Caution!
Selection of the CT type determines the "Ineutral" protection in the "Protection" menu.
- "none" disables the neutral protection.
- "Internal" for a four-pole circuit breaker provides access to the N/2, N and OFF protection functions.
- "External" for a three-pole circuit breaker provides access to the N/2, N, 1.6xN and OFF protection functions.

Type of circuit breaker	Possibles choices
Four-pole	OFF: no neutral protection N / 2: half neutral protection N: full neutral protection
Three-pole	OFF: no neutral protection N / 2: half neutral protection N: full neutral protection 1.6 x N: oversized neutral protection

Using the keypad on the control unit

Ineutral (A)
Neutral CT
Internal
Protection
OFF

then
Select.

Ineutral (A)
Neutral CT
External
Protection
OFF

Choose between:
- internal
- external
- none.

Ineutral (A)
Neutral CT
External
Protection
OFF

Confirm.

Ineutral (A)
Neutral CT
External
Protection
OFF

then
Select.

Ineutral (A)
Neutral CT
External
Protection
N/2

Choose.

Ineutral (A)
Neutral CT
External
Protection
N/2

Confirm.

Ineutral (A)
Neutral CT
External
Protection
N/2

Quit the setting screen.

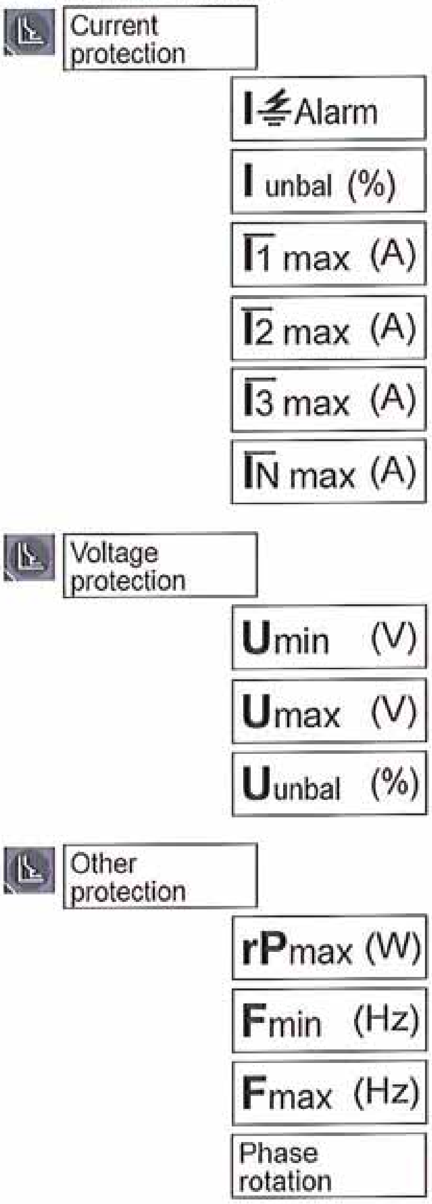
Do you want to save new settings?
no
yes

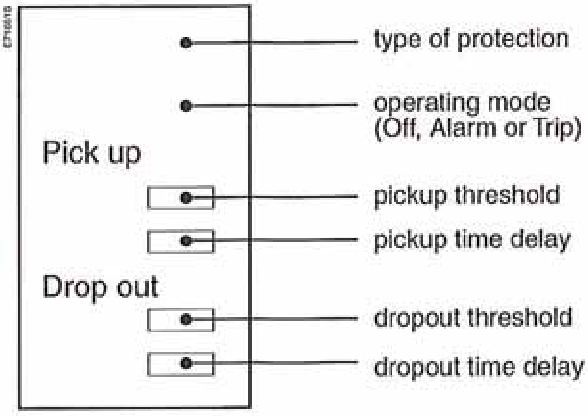
Confirm.

Note:
On four-pole circuit breakers, setting of the neutral using the keypad is limited by the dial setting.

Setting the I⏚, I unbal, Ī max, U min, U max, U unbal, rP max, F min, F max, and phase-rotation protection functions using the keypad

Select the corresponding menu



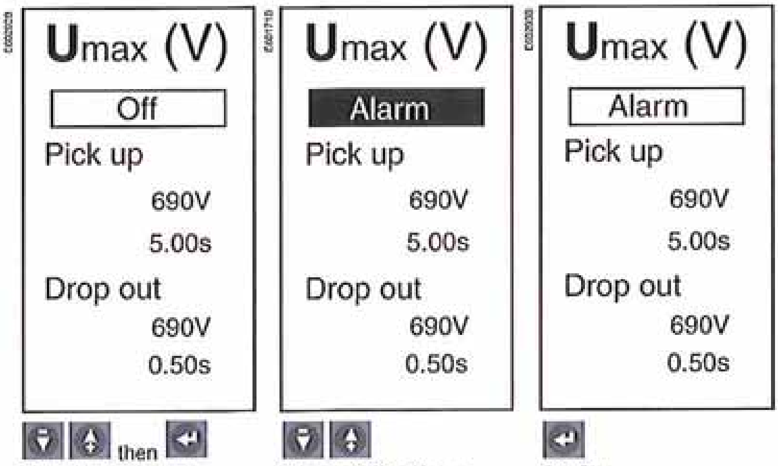


Specific case for I⏚ alarm

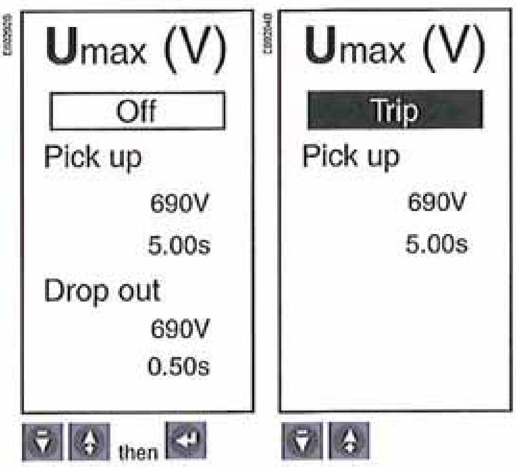
- Only the following choices are available:
  - On: activation of the alarm without fault tripping by the circuit breaker
  - Off: alarm disabled.

Example: Maximum voltage setting (U max)

- Select Alarm mode



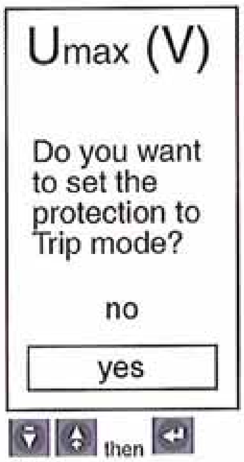
Select the first setting. Choose Off or Alarm. Confirm.



Select the first setting. Choose Trip.

In trip mode, the dropout threshold is equal to the pickup threshold.
The dropout time delay is fixed and equal to 1 second.

Setting the I⏚, I unbal, T max, U min, U max, U unbal, rP max, F min, F max, and phase-rotation protection functions using the keypad



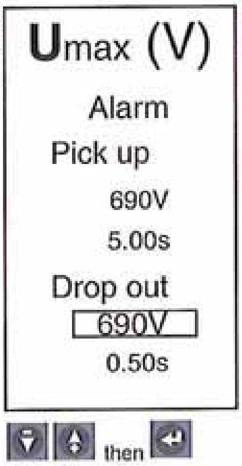
Confirm.

■ Set the pickup and dropout thresholds and time delays

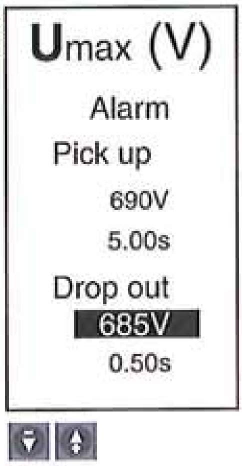
For protection tripped by a maximum value, the dropout threshold is always less than or equal to the pickup threshold.

For protection tripped by a minimum value, the dropout threshold is always greater than or equal to the pickup threshold.

If both the minimum and maximum protection values are activated, the minimum threshold is automatically limited to the value of the maximum and vice versa.



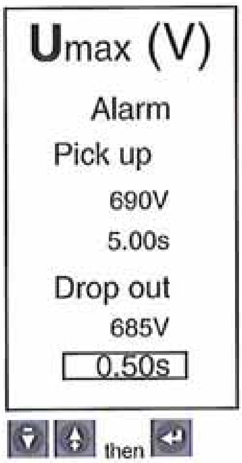
Select the existing dropout threshold setting



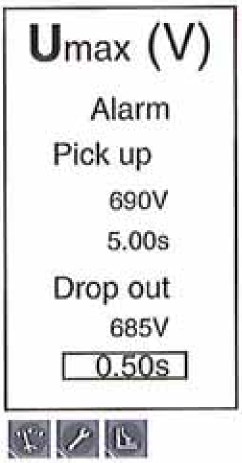
Adjust.

Confirm.

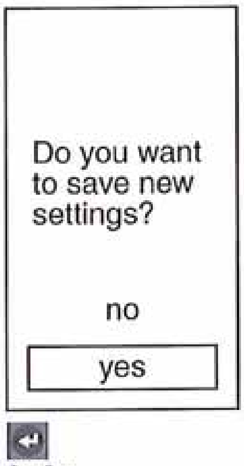
When all the settings have been made, quit the screen by pressing one of the menu-access buttons.
This saves the new values.



Set the other parameters.



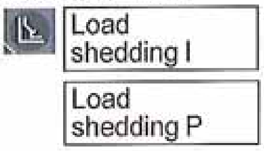
Quit the setting screen.

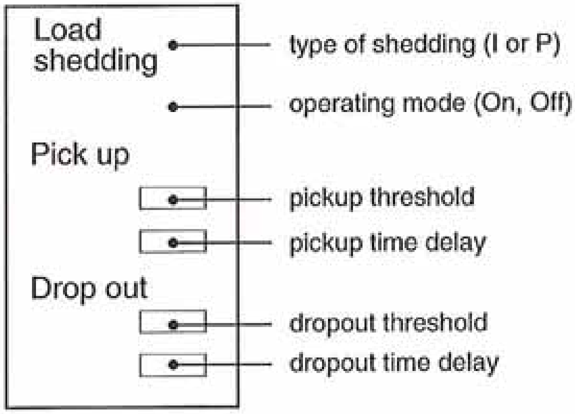


Confirm

Setting load shedding / reconnection

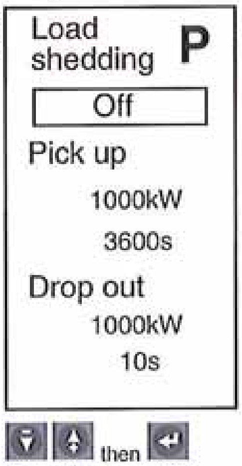
Select the command



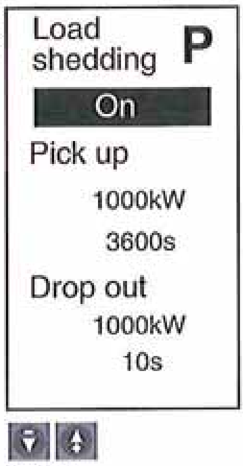


Setting load shedding / reconnection

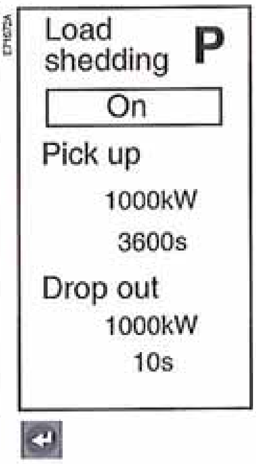
Example: Take load shedding / reconnection depending on power.



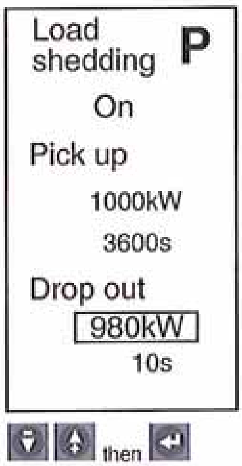
Select the first setting.



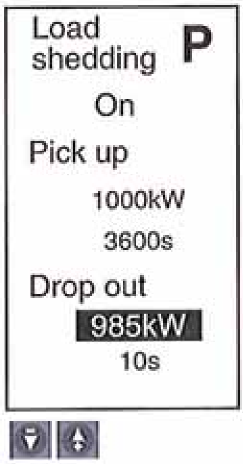
Select:
- Off: load shedding disabled
- On: load shedding enabled.



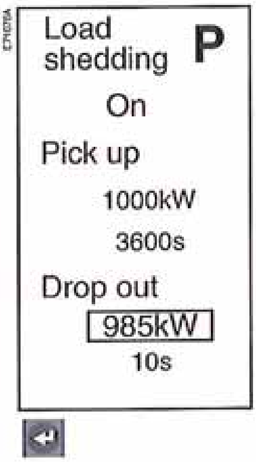
Confirm.



Select the existing dropout threshold.

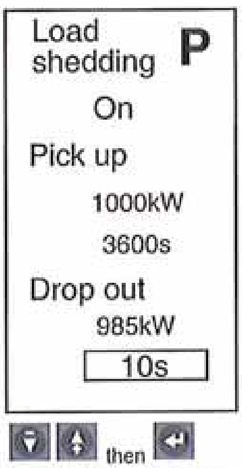


Adjust.

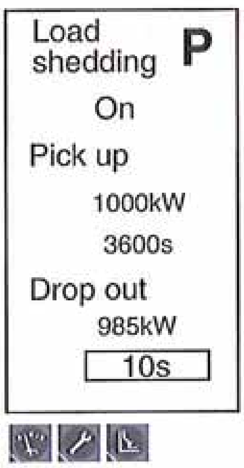


Confirm.

When all the settings have been made, quit the screen by pressing one of the menu-access buttons.
This saves the new values.



Set the other parameters.



Quit the setting screen.

Confirm.

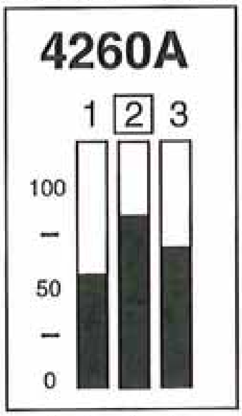
Current measurements

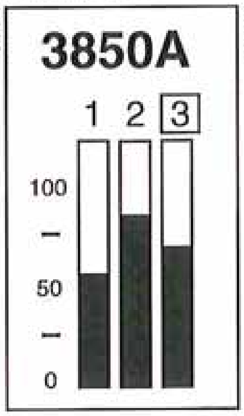
Only the measurements for the phase (1, 2, 3) and neutral currents are displayed on the main screen.

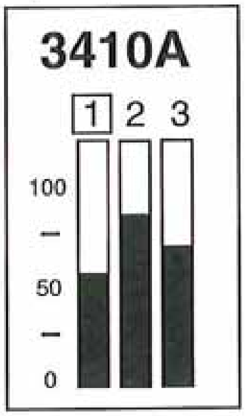
The neutral current is displayed if the neutral CT is set to internal or external (see "Ineutral (A)" settings in the "Current protection" menu).

Continuous current measurement

The bargraph displays the value in amperes of the most heavily loaded phase.

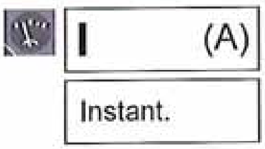






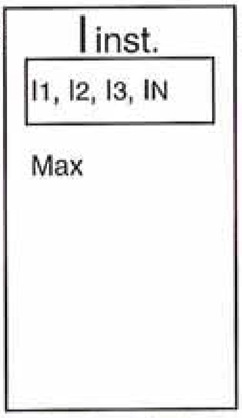
The and buttons may be used to display the currents on the three phases. If the operator no longer uses the buttons for a few seconds, the bargraph returns to the display of the most heavily loaded phase.

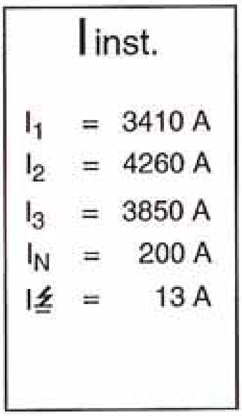
Select the command



Measure an instantaneous-current value

■ Measure the instantaneous currents

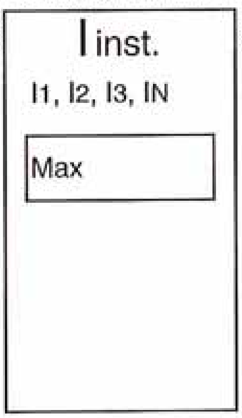


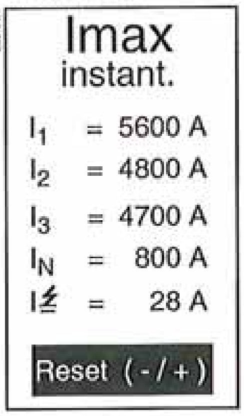


then

Select. View.

■ Check the instantaneous-current maximeter



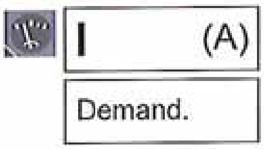


then

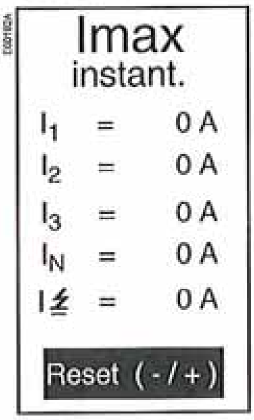
Select. View.

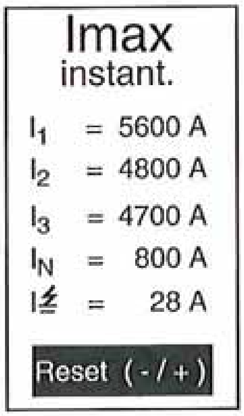
Current measurements

Select the command



■ Reset the maximeter



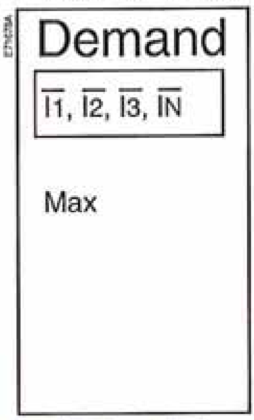


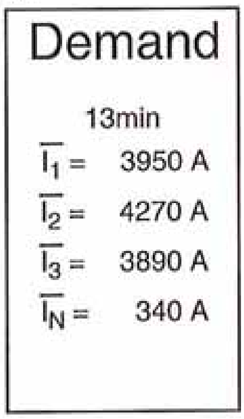
Reset the maximeter or...

cancel the reset.

Measure a demand-current value

■ Measure the demand currents





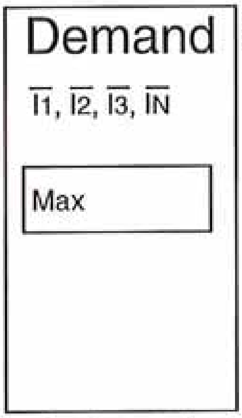
 then 

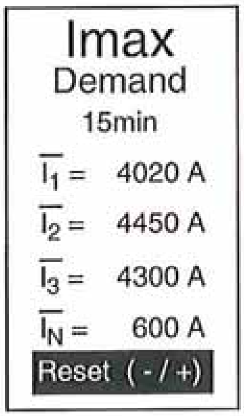
Select.

View.

Current measurements

■ Check the demand-current maximeter



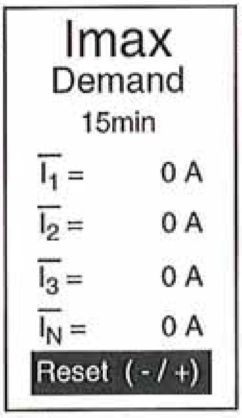


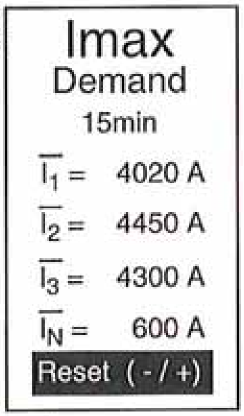
then

Select.

View.

■ Reset the maximeter





Reset the maximeter or...

cancel the reset.

Voltage measurements

Select the command

U (V)

The phase-to-neutral voltages are displayed if the selected system type is 3-phase, 4-wire (see page 43).

Measure an instantaneous-voltage value (U or V)

U (V)	Uinst.
Instant.	U_{12} = 400 V
Average 3Φ	U_{23} = 404 V
Unbal 3Φ	U_{31} = 401 V
Phase rotation	U_{1N} = 230 V
	U_{2N} = 229 V
	U_{3N} = 233 V

then

Select. View.

Measure the average voltage U avg

U (V)	Uavg. 3Φ
Instant.	
Average 3Φ	402 V
Unbal 3Φ	
Phase rotation	

then

Select. View.

Measure the voltage unbalance U unbal

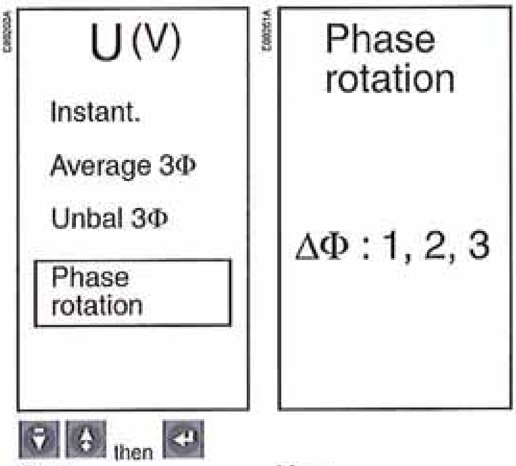
U (V)	Uunbal 3Φ
Instant.	
Average 3Φ	1 %
Unbal 3Φ	
Phase rotation	

then

Select. View.

Voltage measurements

Determine the phase sequence

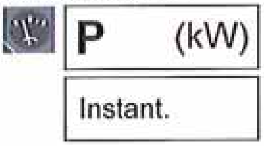


Select.

View.

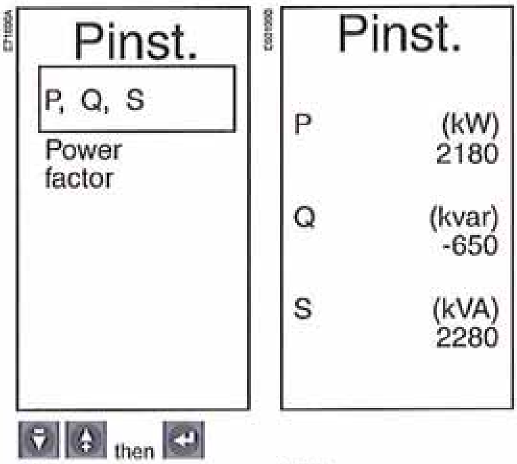
Power measurements

Select the command



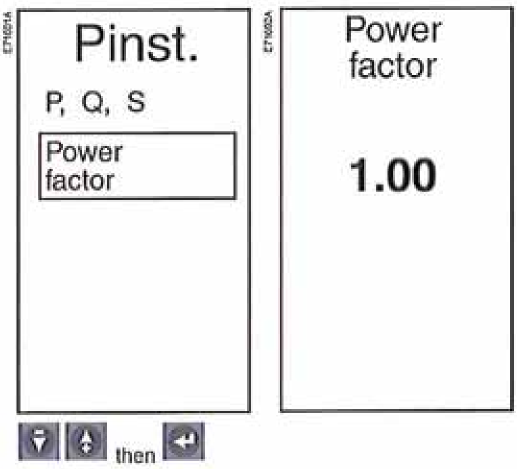
To ensure reliable power and power-factor measurements, the "Power sign" and "Sign convention" parameters must be set.

Measure an instantaneous-power value



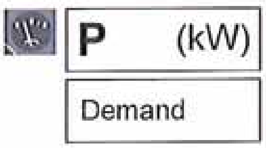
Select. View.

Measure the power factor



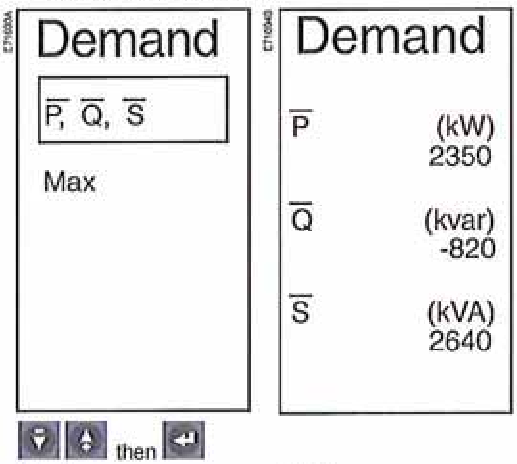
Select. View.

Select the command



Measure a demand-power value

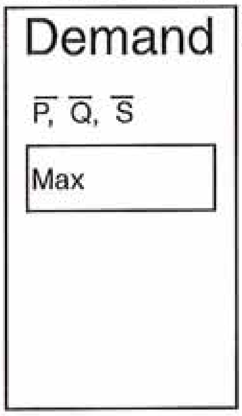
■ Display the demand power

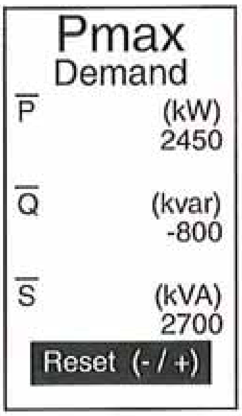


Select. View.

Power measurements

■ Check the demand-power maximeter



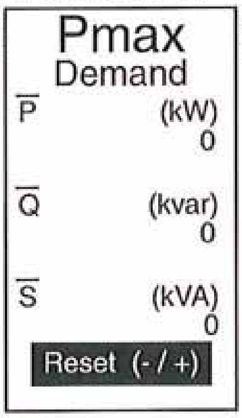


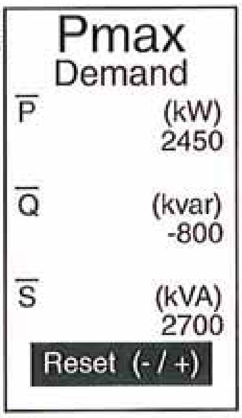
then

Select.

View.

■ Reset the maximeter





Reset the maximeter or...

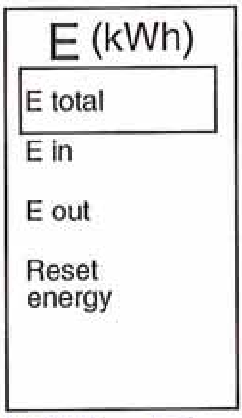
cancel the reset.

Energy measurements

Select the command

To ensure reliable energy measurements, the "Power sign" and "Sign convention" parameters must be set.

Measure the energy values

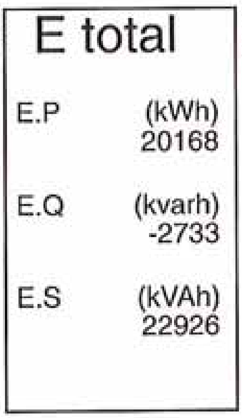


then

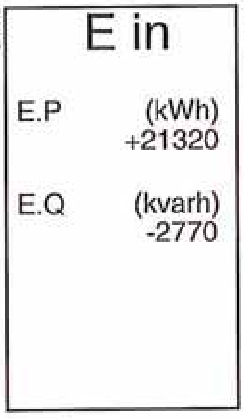
Select.

Select the energy value to be measured:

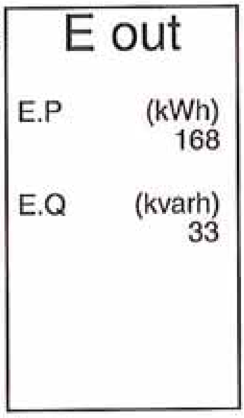
- total energy
- energy in (positive component in the total energy)
- energy out (negative component in the total energy).



View the total energy values.

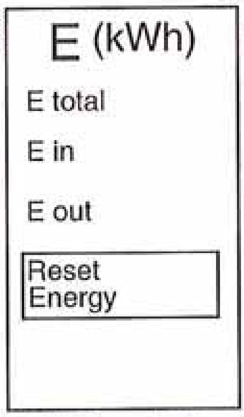


View the energy in values.



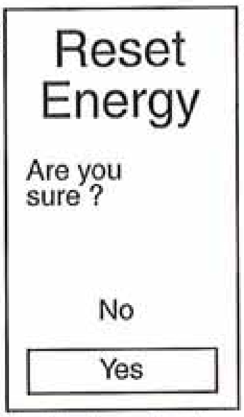
View the energy out values.

Reset the energy values



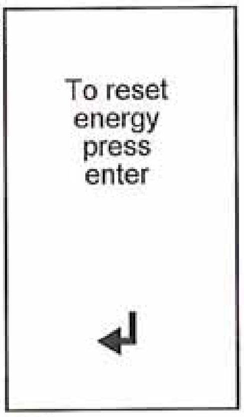
then

Select.



then

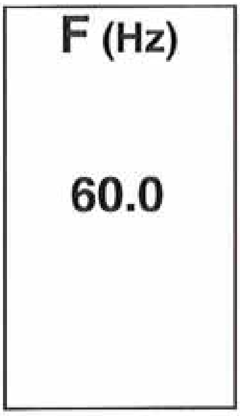
Select yes or no.



If yes, confirm.

Frequency measurements

Select the command

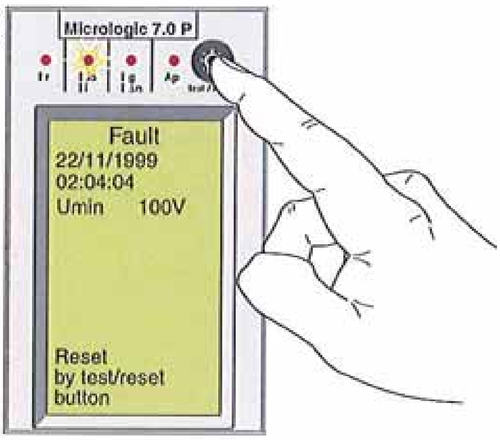


View.

Resetting fault indications

Caution!
If the circuit breaker remains closed and the Ap LED remains ON after the reset, open the circuit breaker and contact the after-sales support department.

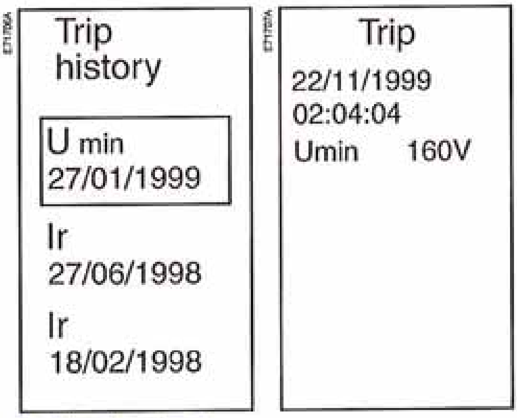
The fault indication is maintained until it is reset on the control panel.
Press the reset button.



Viewing the event histories

Select the command

Trip history

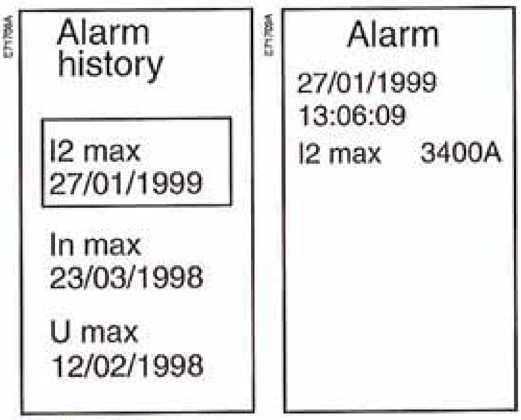


Select a fault.

View.

Select the command

Alarm history



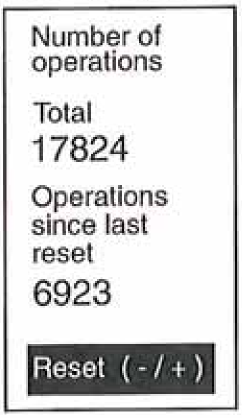
Select an alarm.

View.

Operation counter and contact-wear indicator

Select the command

View and/or reset the operation counter



Reset...

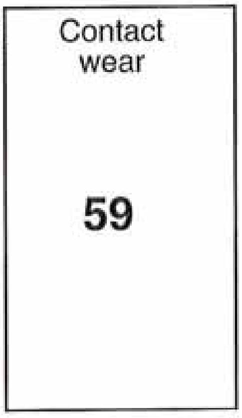
then

... or cancel the reset, then confirm.

Select the command

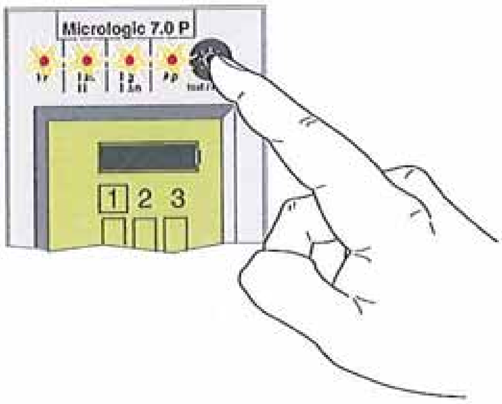
Contact wear is indicated from 0 to 900. The contacts should be inspected every time the counter reaches a multiple of 100.

Check the wear of the contacts

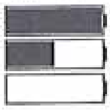


Checking/replacing the battery

Check the control-unit battery



Press and hold down the test button on the control unit to check the LEDs and the battery. The battery information is displayed if the control unit is equipped with an external power supply or if the circuit breaker is ON.



Battery fully charged
Battery half charged
No battery or must be replaced

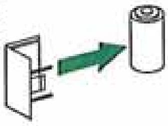
If the battery needs to be changed, order a new battery with the Schneider Electric catalogue number 33593.

- Lithium battery
- 1.2 AA, 3.6 V, 800 mA/h
- Ambient temperature: 130°C.

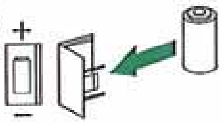
Replacing the control-unit battery

1. remove the battery cover

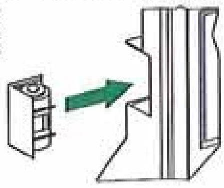
2. remove the battery



3. insert a new battery. Check the polarity.



4. put the cover back in place. Press the battery-test button to check the new battery.

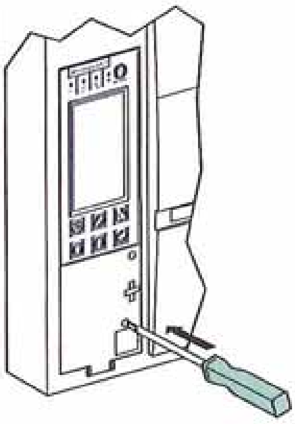


Tests

Test the ground-fault (Micrologic 6.0 P) and earth-leakage (Micrologic 7.0 P) protection functions

The circuit breaker must be supplied with power and closed for the test.

Press the TEST button. The circuit breaker should trip.

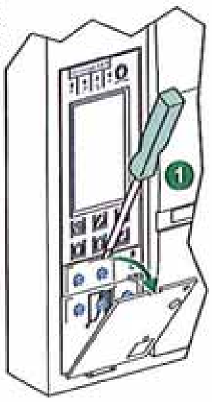


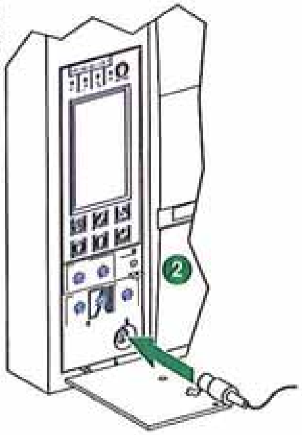
If the circuit breaker does not trip, contact the after-sales support department.

Refer to the manual that comes with the test kits.

Mini test kit and portable test kit

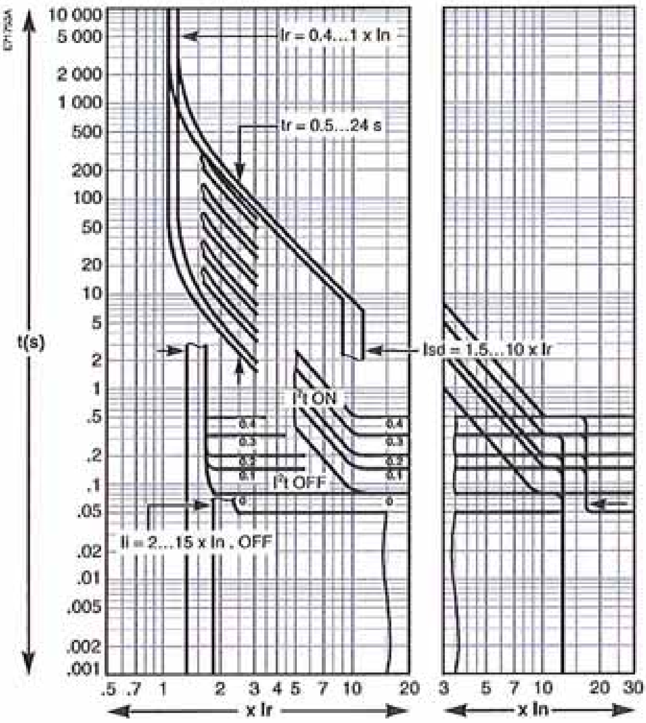
The test connector is used to connect the mini or the portable test kit to check that the control unit is operating correctly.



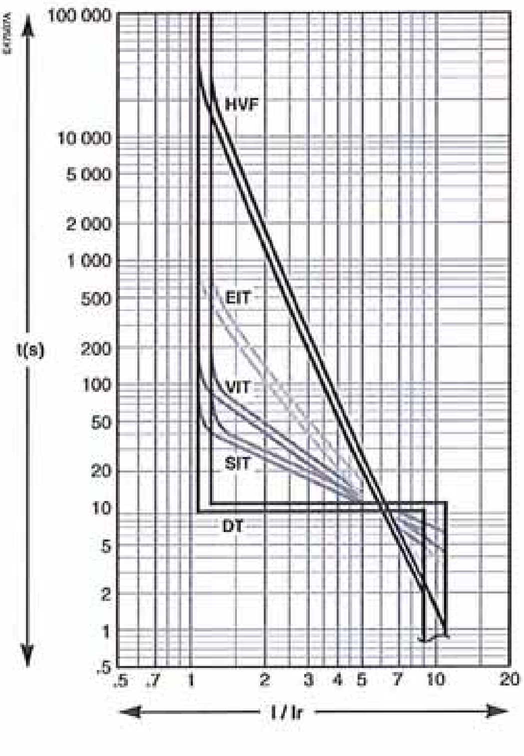


Tripping curves

Long-time I²t, short-time and instantaneous protection Micrologic 5.0 P, 6.0 P, 7.0 P

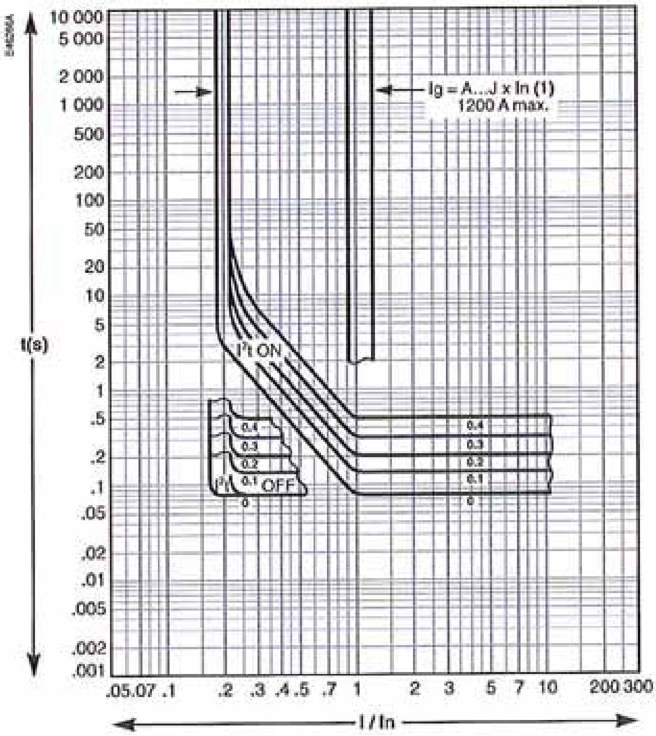


Long-time Idmtl, short-time and instantaneous protection Micrologic 5.0 P, 6.0 P, 7.0 P



Tripping curves

Ground-fault protection - Micrologic 6.0 P



Voltage measurements

Micrologic P is equipped with a three-phase voltage power supply that, with respect to the distribution system, may be considered a delta load. The three-phase power supply reinjects voltage on an open phase.
The voltage-protection functions react as indicated below.

Minimum-voltage protection

This function is based on the measurement of the phase-to-phase voltages.

In diagrams 1, 3 and 4 on the next page, a fuse has blown. The control unit reinjects voltage on the failed phase and measures a phase-to-phase voltage higher than the actual voltage.
The phase-to-neutral voltage should be zero, but the value measured is not zero.

In diagram 2, the phase-to-neutral voltage is effectively zero and the measurement indicates zero as well.

By limiting the pickup threshold of the minimum-voltage protection to the 80% - 100% range of the rated distribution-system voltage, the differences between the real voltages and the measured values are not significant and Micrologic will operate under all circumstances in the expected manner.

Voltage-unbalance protection

This function is based on the measurement of the phase-to-phase voltages.

In diagrams 1, 3 and 4 on the next page, a fuse has blown. The control unit reinjects voltage on the failed phase and measures a phase-to-phase voltage higher than the actual voltage.
The phase-to-neutral voltage should be zero, but the value measured is not zero.

In diagram 2, the phase-to-neutral voltage is effectively zero and the measurement indicates zero as well.

By limiting the pickup threshold of the voltage-unbalance protection to the 0% - 20% range, the differences between the real voltages and the measured values are not significant and Micrologic will operate under all circumstances in the expected manner.

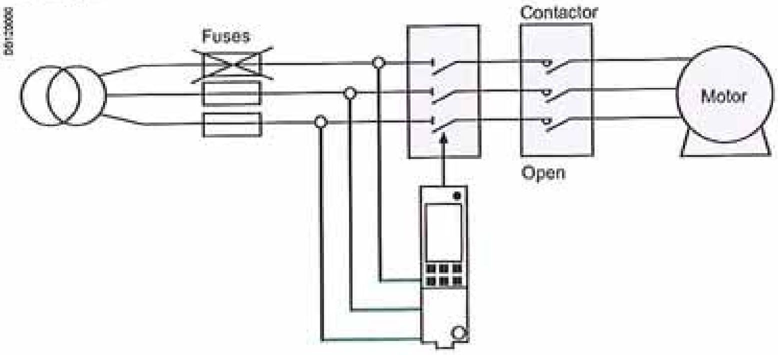
Phase failure

Detection of phase failure is not possible on the basis of the minimum-voltage and voltage-unbalance protection functions.
The Micrologic power supply requires at least two phases (between 100 and 690 V).

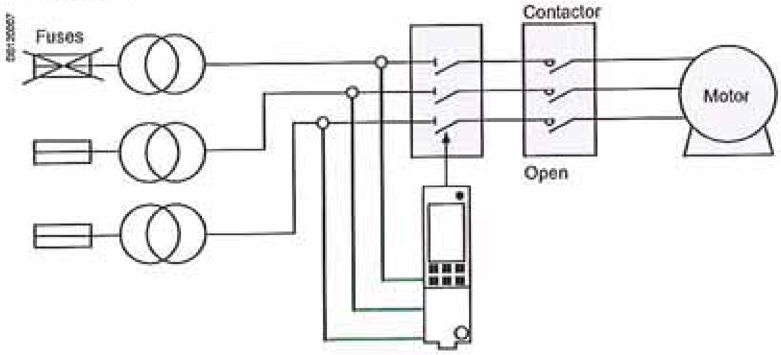
In diagrams 1, 3 and 4, if two phases have failed, Micrologic H measures for the three phases the value of the single voltage present (e.g. U12 = U23 = U31 = 410 V).

Voltage measurements

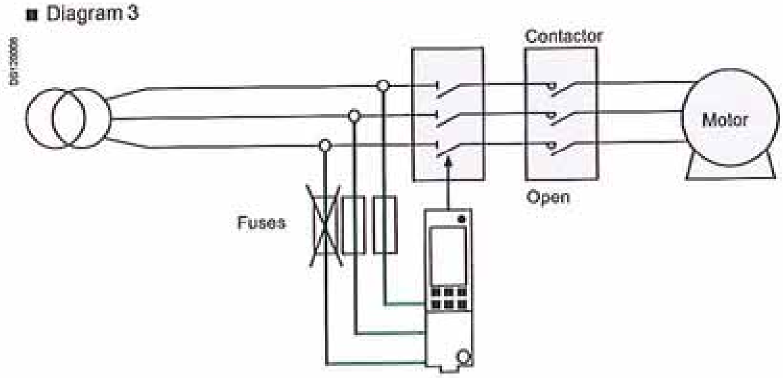
■ Diagram 1



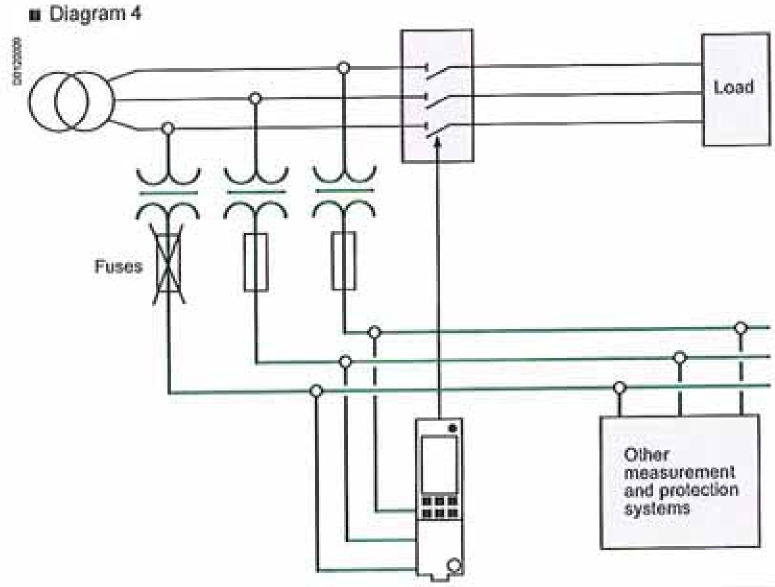
■ Diagram 2



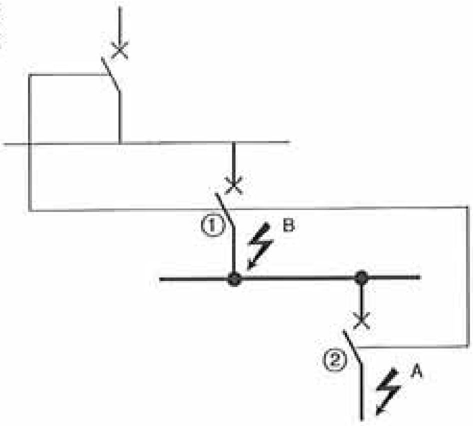
■ Diagram 3



■ Diagram 4



Zone selective interlocking (ZSI)



Operating principle

■ A fault occurs at point A

Downstream device no. 2 clears the fault and sends a signal to upstream device no. 1, which maintains the short-time tripping delay tsd or the ground-fault tripping delay tg to which it is set.

■ A fault occurs at point B

Upstream device no. 1 detects the fault. In the absence of a signal from a downstream device, the set time delay is not taken into account and the device trips according to the zero setting. If it is connected to a device further upstream, it sends a signal to that device, which delays tripping according to its tsd or tg setting.

Note:
On device no. 1, the tsd and tg tripping delays must not be set to zero because this would make discrimination impossible.

Connections between control units

A logic signal (0 or 5 volts) can be used for zone selective interlocking between the upstream and downstream circuit breakers.

■ Micrologic 5.0 A, 6.0 A, 7.0 A
■ Micrologic 5.0 P, 6.0 P, 7.0 P
■ Micrologic 5.0 H, 6.0 H, 7.0 H.

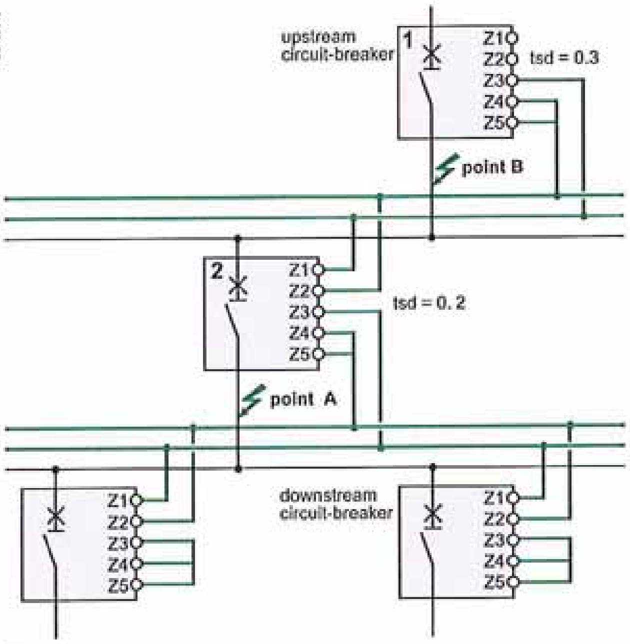
An interface is available for connection to previous generations of trip units.

Caution!
If the protection function is not used on circuit breakers equipped for ZSI protection, a jumper must be installed to short terminals Z3, Z4 and Z5. If the jumper is not installed, the short-time and ground-fault tripping delays are set to zero, whatever the position of the adjustment dial.

Wiring

■ Maximum impedance: 2.7 ý / 300 metres
■ Capacity of connectors: 0.4 to 2.5 mm²
■ Wires: single or multicore
■ Maximum length: 3000 metres
■ Limits to device interconnection:
□ the common ZSI - OUT (Z1) and the output ZSI - OUT (Z2) can be connected to a maximum of ten inputs
□ a maximum of 100 devices may be connected to the common ZSI - IN (Z3) and to an input ZSI - IN CR (Z4) or GF (Z5).

Terminals Z1 to Z5 correspond to the identical indications on the circuit-breaker terminal blocks.



Test

The portable test kit may be used to check the wiring and operation of the zone selective interlocking between a number of circuit breakers.

Power supply

Caution!
It is advised to use the AD power-supply module rather than an off-the-shelf 24 V power supply to ensure Class II insulation on the front panel of the Micrologic P control unit.

The power supply must have the following characteristics:
- output voltage 24 V DC
- DC ripple less than 5%
- power rating 5 W / 5 VA
- Dielectric withstand (input/output): 3 kV rms

AD power-supply module

The AD power-supply module provides auxiliary 24 V DC power for the control-unit functions listed below:
- Graphic display:
  - device OFF or not supplied
  - the long-time, short-time, instantaneous and ground-fault protection functions operate under all circumstances on their own power
- Activation of an M2C programmable contact

The AD power-supply module is required to assign an M2C programmable contact to an alarm.

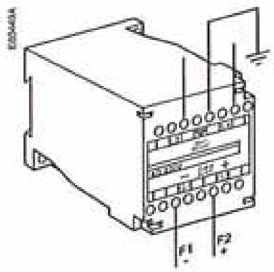
The AD power-supply module can supply the following voltages:
- 110 V AC
- 220 V AC
- 380 V AC
- 24 / 30 V DC
- 48 / 60 V DC
- 125 V DC.

Battery module

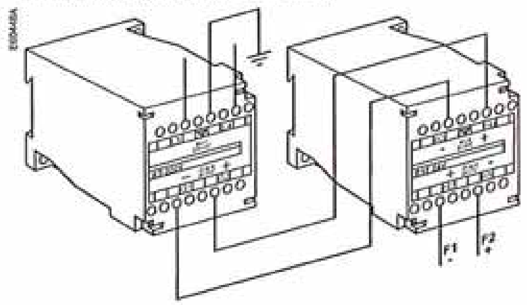
Use of a BAT battery module, mounted in series with the AD power-supply module, ensures a continous supply of 24 V DC power for 12 hours if the AD module fails.

Wiring diagrams

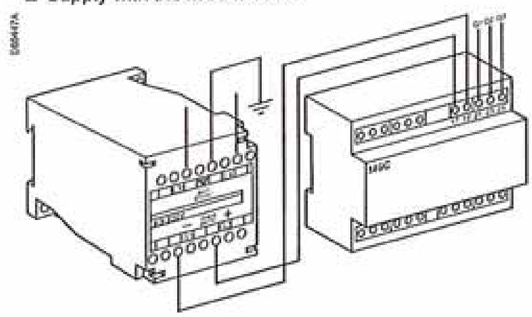
- Reliable or backed-up auxiliary system



- Auxiliary system without back-up



- Supply with the MC6 module



Power supply

Using the AD power-supply module

The 24 V DC external power-supply (AD module) is required for certain operating configurations as indicated in the table below:
- yes means the power supply is required
- no means it is not required.

Circuit breaker	Closed	Open	Open
AC power present for Micrologic P	yes	yes	no
M2C, M6C programmable-contacts option	yes	yes	yes
Display function	no	no	yes
Time-stamping function	no	no	no
Circuit-breaker status indications and control via communications bus	no	no	no
Identification, settings, operation and maintenance aids via communications bus	no	no	yes

- If the 24 V DC external power supply (AD module) is used, the maximum cable length between 24 V DC (G1, G2) and the control unit (F1-, F2+) must not exceed 10 metres.
- The communications bus requires its own 24 V DC power source (E1, E2). This source is not the same as the 24 V DC external power-supply module (F1-, F2+).

Selection of the voltage-measurement inputs

The voltage-measurement inputs are standard equipment on the downstream connectors of the circuit breaker.

It is possible to measure distribution-system voltage externally using the PTE external voltage-measurement input option.

With this option, the internal voltage-measurement inputs are disconnected.
The PTE option is required for voltages greater than 690 V (in which case a voltage transformer is required).

When the PTE option is implemented, the supply circuit of the voltage-measurement input must be protected against short-circuits. Installed as close as possible to the busbars, this protection function is ensured by a P25M circuit breaker (1 A rating) with an auxiliary contact (cat. no. 21104 and 21117).

The supply circuit of the voltage-measurement input is reserved exclusively for the control unit and must never be used to supply other circuits.

Changing the long-time rating plug

Select the long-time rating plug

A number of long-time rating plugs are available for Micrologic P control units.

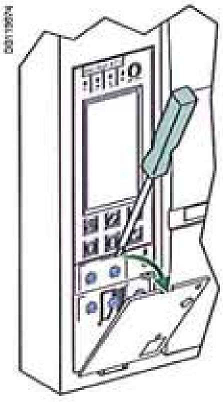
Part number	Setting range for the Ir value	
33542	standard	0.4 to 1 x Ir
33543	low setting	0.4 to 0.8 x Ir
33544	high setting	0.8 to 1 x Ir
33545	without long-time protection ■ Ir = In for the short-time protection setting ■ Frequency protection not available ■ Load shedding / reconnection based on current not available	

Caution!
Following any modifications to the long-time rating plug, all control-unit protection parameters must be checked.

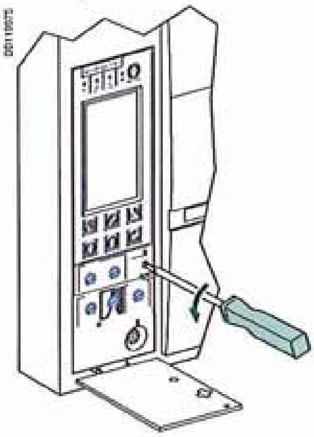
Change the long-time rating plug

Proceed in the following manner.

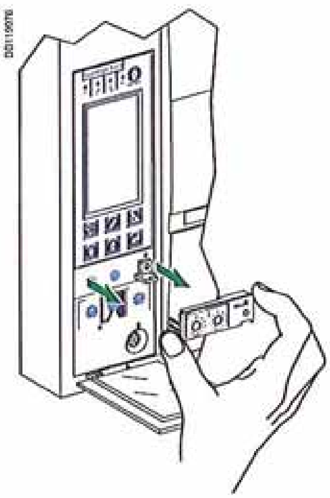
1. open the circuit breaker
2. open the protective cover of the control unit



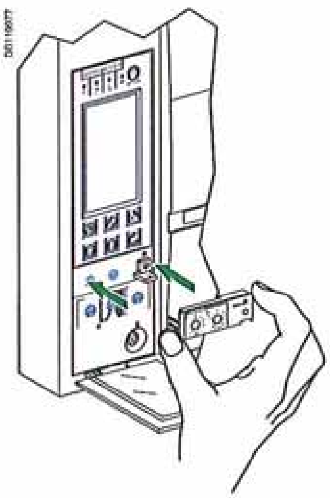
3. completely remove the long-time rating plug screw



4. snap out the rating plug



5. clip in the new rating plug
6. refit the screw for the long-time rating plug
7. check and/or modify the control-unit settings



Caution!
If no long-time rating plug is installed, the control unit continues to operate under the following downgraded conditions:
■ the long-time current setting Ir is 0.4
■ the long-time tripping delay tr corresponds to the value indicated by the adjustment dial
■ the earth-leakage protection function is disabled
■ the voltage-measurement inputs are disconnected.

Thermal memory

Thermal memory

The thermal memory is the means to take into account temperature rise and cooling caused by changes in the flow of current in the conductors.

These changes may be caused by:
- repetitive motor starting
- loads fluctuating near the long-time protection settings
- repeated circuit-breaker closing on a fault.

Control units with a thermal memory record the temperature rise caused by each overload, even very short ones. This information stored in the thermal memory reduces the tripping time.

Micrologic control units and thermal memory

All Micrologic control units are equipped as standard with a thermal memory.

- For all protection functions, prior to tripping, the temperature-rise and cooling time constants are equal and depend depend on the tr tripping delay:
  - if the tripping delay is short, the time constant is low
  - if the tripping delay is long, the time constant is high.

- For long-time protection, following tripping, the cooling curve is simulated by the control unit. Closing of the circuit breaker prior to the end of the time constant (approximately 15 minutes) reduces the tripping time indicated in the tripping curves.

Short-time protection and intermittent faults

For the short-time protection function, intermittent currents that do no provoke tripping are stored in the Micrologic P memory.
This information is equivalent to the long-time thermal memory and reduces the tripping delay for the short-time protection.
Following a trip, the short-time tsd tripping delay is reduced to the value of the minimum setting for 20 seconds.

Ground-fault protection and intermittent faults

The ground-fault protection implements the same function as the short-time protection (see above).

Data available via the COM communications option

The COM communications option can be used to remotely access the Micrologic P measurement, setting, maintenance and protection values.

Measurements

- Currents:
  - □ instantaneous currents
  - □ maximum and minimum instantaneous currents
  - □ average instantaneous currents
  - □ instantaneous-current unbalance per phase
  - □ maximum and minimum instantaneous-current unbalance per phase
- Demand current:
  - □ demand current per phase
  - □ maximum and minimum demand current per phase since last reset
  - □ prediction of demand current per phase
  - □ time-stamping of demand-current maximums and minimums
- Voltages:
  - □ phase-to-neutral and phase-to-phase voltages
  - □ average phase-to-neutral and phase-to-phase voltages
  - □ phase-to-neutral and phase-to-phase voltage unbalance
  - □ maximum and minimum phase-to-neutral and phase-to-phase voltage unbalance
- Active, reactive and apparent power per phase
- Demand power:
  - □ demand power per phase
  - □ maximum and minimum demand power per phase since last reset
  - □ maximum and minimum recommended demand power per phase
  - □ time-stamping of demand-power maximums and minimums
- Energy:
  - □ total active and reactive energy
  - □ positively incremented energy
  - □ negatively incremented energy
- System frequency
- Power factor
- Reset date of demand currents, demand power and energy.

Setup / Maintenance

- Setting of the control-unit date and time
- Password for the measurement module
- Control-unit ID code
- Control-unit ID name
- Selection of the measurement calculation algorithm
- Sign convention for the active power
- Total-energy measurement mode
- Interval for the demand-current calculation window
- Power quality indication
- Demand-power calculation mode
- Interval for the demand-power calculation window
- Battery-charge indication
- Trip and alarm histories
- Operation counter and contact-wear indicator
- Assignment and setup of programmable contacts
- Event log and maintenance register.

Protection

- Circuit-breaker rated current
- Type of neutral protection
- Long-time I^2t protection settings
- Long-time Idmtl protection settings
- Short-time protection settings
- Instantaneous-protection settings
- Ground-fault protection settings
- Earth-leakage protection settings
- Current-unbalance, I⏚ alarm and maximum-current protection settings
- Voltage-protection settings
- Setting for other protection functions.

Threshold and time-delay settings

Long-time I^2t and Idmtl protection

Type	Range	Factory setting	Step	Accuracy
Ir current setting	0.4 to In	maximum	1 A	1.05 to 1.20 Ir
tr tripping delay	0.5 to 24 s	maximum	0.5 s	- 20 %, + 0 %

Short-time protection

Type	Range	Factory setting	Step	Accuracy
Isd pickup	1.5 to 10 Ir	maximum	10 A	± 10 %
tsd tripping delay	0 - 0.1 - 0.2 - 0.3 - 0.4 s	maximum	0.1 s	

Instantaneous protection

Type	Range	Factory setting	Step	Accuracy
Ii pickup	2 to 15 In or off	maximum	10 A	± 10 %

Ground-fault protection on Micrologic 6.0 P

Type	Range	Factory setting	Step	Accuracy
Ig pickup	depends on rating	maximum	1 A	± 10 %
tg tripping delay	0 - 0.1 - 0.2 - 0.3 - 0.4 s	maximum	0.1 s	

Earth-leakage protection on Micrologic 7.0 P

Type	Range	Factory setting	Step	Accuracy
IΔn pickup		maximum	0.1 A	- 20 %, + 0 %
Δt tripping delay	60 - 140 - 230 - 350 - 800 ms	maximum	1 setting	

Neutral protection

Type	Range	Factory setting
Three-pole device	Off, N/2, N, 1.6xN	off
Four-pole device	Off, N/2, N	N/2

Threshold and time-delay settings

Current protection

Type	Range	Factory setting	Step	Accuracy
Current unbalance I unbal				
Pickup threshold	5 % to 60 %	60 %	1 %	-10 %, +0 %
Dropout threshold	5 % of pickup threshold	pickup threshold	1 %	-10 %, +0 %
Pickup time delay	1 s to 40 s	40 s	1 s	-20 %, +0 %
Dropout time delay	10 s to 360 s	10 s	1 s	-20 %, +0 %
Ground-fault I⏚ alarm				
Pickup threshold	20 A to 1200 A	120 A	1 A	+/- 15 %
Dropout threshold	20 A to pickup threshold	pickup threshold	1 A	+/- 15 %
Pickup time delay	1 s to 10 s	10 s	0.1 s	-20 %, +0 %
Dropout time delay	1 s to 10 s	1 s	0.1 s	-20 %, +0 %
Earth-leakage I⏚ alarm				
Pickup threshold	0.5 A to 30 A	30 A	0.1 A	-20 %, +0 %
Dropout threshold	0.5 A to pickup threshold	pickup threshold	0.1 A	-20 %, +0 %
Pickup time delay	1 s to 10 s	10 s	0.1 s	-20 %, +0 %
Dropout time delay	1 s to 10 s	1 s	0.1 s	-20 %, +0 %
Maximum current I_1 max, I_2 max, I_3 max, I_N max				
Pickup threshold	0.2 In to In	In	1 A	± 6.6%
Dropout threshold	0.2 In to pickup threshold	pickup threshold	1 A	± 6.6%
Pickup time delay	15 s to 1500 s	1500 s	1 s	-20 %, +0 %
Dropout time delay	15 s to 3000 s	15 s	1 s	-20 %, +0 %

Voltage protection

Type	Range	Factory setting	Step	Accuracy
Minimum voltage U min				
Pickup threshold	100 V to U max pickup threshold	100 V	5 V	-5 %, +0 %
Dropout threshold	pickup threshold to U max pickup threshold	pickup threshold	5 V	-5 %, +0 %
Pickup time delay	1.2 s to 5 s	5 s	0.1 s	-0 %, +20 %
Dropout time delay	1.2 s to 36 s	1.2 s	0.1 s	-0 %, +20 %
Maximum voltage U max				
Pickup threshold	U min pickup threshold to 1200 V	725 V	5 V	-0 %, +5 %
Dropout threshold	100 V to pickup threshold	pickup threshold	5 V	-0 %, +5 %
Pickup time delay	1.2 s to 5 s	5 s	0.1 s	-0 %, +20 %
Dropout time delay	1.2 s to 36 s	1.2 s	0.1 s	-0 %, +20 %
Voltage unbalance U unbal				
Pickup threshold	2 % to 30 %	30 %	1 %	-20 %, +0 %
Dropout threshold	2 % to pickup threshold	pickup threshold	1 %	-20 %, +0 %
Pickup time delay	1 s to 40 s	40 s	1 s	-20 %, +0 %
Dropout time delay	10 s to 360 s	10 s	1 s	-20 %, +0 %

Threshold and time-delay settings

Other protection

Type	Range	Factory setting	Step	Accuracy
Reverse power rP max				
Pickup threshold	5 to 500 kW	500 kW	5 kW	± 2.5%
Dropout threshold	5 kW to pickup threshold	pickup threshold	5 kW	± 2.5%
Pickup time delay	0.2 s to 20 s	20 s	0.1 s	-0 %, +20 % (1)
Dropout time delay	1 s to 360 s	1 s	0.1 s	-0 %, +20 %
Maximum frequency F max				
Pickup threshold	F min pickup threshold to 440 Hz	65 Hz	0.5 Hz	± 0.5 Hz
Dropout threshold	45 Hz to pickup threshold	pickup threshold	0.5 Hz	± 0.5 Hz
Pickup time delay	1.2 s to 5 s	5 s	0.1 s	-0 %, +20 % (2)
Dropout time delay	1.2 s to 36 s	1.2 s	0.1 s	-0 %, +20 % (2)
Minimum frequency F min				
Pickup threshold	45 Hz to F max pickup threshold	45 Hz	0.5 Hz	± 0.5 Hz
Dropout threshold	pickup threshold to F max pickup threshold	pickup threshold	0.5 Hz	± 0.5 Hz
Pickup time delay	1.2 s to 5 s	5 s	0.1 s	-0 %, +20 % (2)
Dropout time delay	1.2 s to 36 s	1.2 s	0.1 s	-0 %, +20 % (2)
Phase rotation				
Pickup threshold	Ph1, Ph2, Ph3 or Ph1, Ph3, Ph2	Ph1, Ph2, Ph3	none	none
Dropout threshold	pickup threshold	pickup threshold	none	none
Pickup time delay	0.3 s	0.3 s	none	- 0 %, + 50 %
Dropout time delay	0.3 s	0.3 s	none	- 0 %, + 50 %

(1) + 30 % on dial 0.2 s
(2) + 30 % up to 1.5 s

Load shedding and reconnection

Type	Range	Factory setting	Step	Accuracy
Current I				
Pickup threshold	50 % to 100 % Ir	100 % Ir	1 %	± 6 %
Dropout threshold	30 % Ir to shedding threshold	shedding threshold	1 %	± 6 %
Pickup time delay	20 % to 80 % tr	80 % tr	1 %	-20 %, +0 %
Dropout time delay	10 s to 600 s	10 s	1 s	-20 %, +0 %
Power P				
Pickup threshold	200 kW to 10 000 kW	10 000 kW	50 kW	± 2.5 %
Dropout threshold	100 kW to shedding threshold	shedding threshold	50 kW	± 2.5 %
Pickup time delay	10 s to 3600 s	3600 s	10 s	-20 %, +0 %
Dropout time delay	10 s to 3600 s	10 s	10 s	-20 %, +0 %

Other settings

M2C / M6C contacts

Type	Range	Factory setting	Step
Time-delay latching time delay	1 - 360 s	360 s	1 s

Micrologic setup

Type	Range	Factory setting	Step
Language	German English US English UK Italian French Spanish Chinese	English UK	
Date / time			1 s
Circuit-breaker selection		"no def"	
Neutral TC		no TC	
VT ratio			
primary voltage	min. 100 V, max. 1150 V	690 V	1 V
secondary voltage	min. 100 V, max. 690 V	690 V	1 V
System frequency	50/60 Hz or 400 Hz	50/60 Hz	

Measurement setup

Type	Range	Factory setting	Step
System type	3 Φ, 3 w, 3 CT 3 Φ, 4 w, 3 CT 3 Φ, 4 w, 4 CT	3 Φ, 4 w, 4 CT	
Demand-current calculation method	thermal or block interval	block interval	
type of window	fixed or sliding	sliding	
calculation interval	5 to 60 minutes	15 minutes	1 minute
Demand-power calculation method	thermal or block interval or sync. to comms	block interval	
type of window	fixed or sliding	sliding	
calculation interval	5 to 60 minutes	15 minutes	1 minute
Power sign	P+ P-	P+ (flow from top to bottom)	
Sign convention	IEEE IEEE alternate IEC	IEEE	

Communication setup

Type	Range	Factory setting
Com parameter	MODBUS	
adress	1-47	47
baud rate	9600 to 19200 bauds	19200 bauds
parity	even none	even
Remote settings		
access authorisation	yes / no	yes
access code	0000 to 9999	0000
Remote control	manual automatic	automatic

Protection setup

Type	Range	Factory setting
Current protection voltage protection other protection	alarm / trip / OFF	OFF

Measurement setting ranges and accuracy

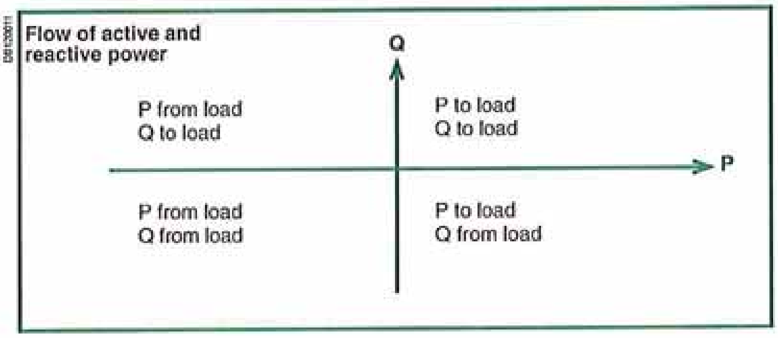
■ The accuracy of the current measurements depends on both the value displayed (or transmitted) and the circuit-breaker rating, where:
Accuracy = 0.5 % In + 1.5 % reading

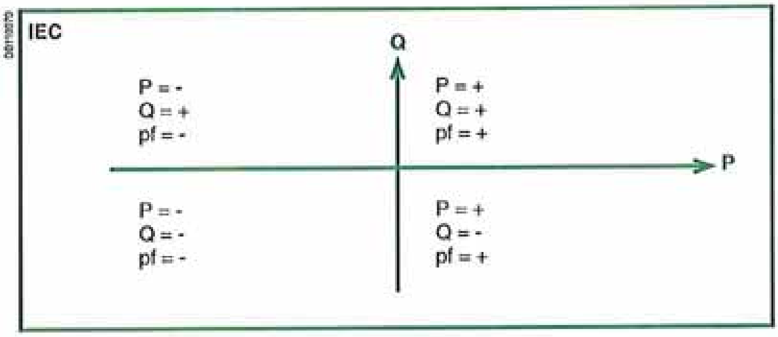
Example:
For a circuit breaker with a 4000 A rating and a current displayed on Micrologic of 49 A, the accuracy is:
0.5 % x 4000 + 1.5 % x 49 = ±21 A

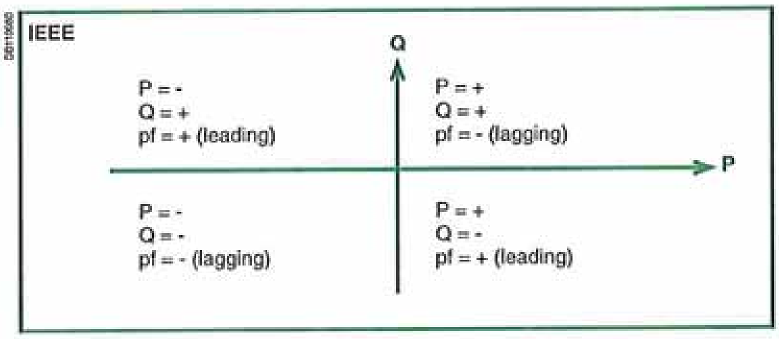
Measurement setting ranges and accuracy

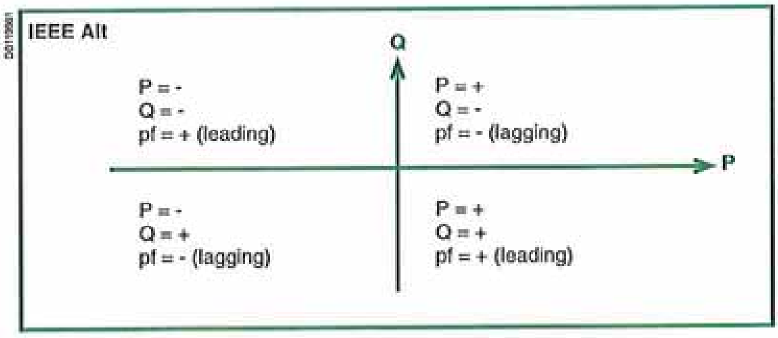
Type	Range	Accuracy at 25 °C
Instantaneous current		
I1, I2, I3	0.05 x In to 20 x In	±1.5 %
IN	0.05 x In to 20 x In	±1.5 %
I⏚ ground	0.05 x In to In	±10 %
I⏚ earth leakage	0 to 30 A	±1.5 %
I1 max, I2 max, I3 max	0.05 x In to 20 x In	±1.5 %
IN max	0.05 x In to 20 x In	±1.5 %
I⏚ max ground	0.05 x In to In	±10 %
I⏚ max earth leakage	0 to 30 A	±1.5 %
Demand current		
$\overline{I1}$, $\overline{I2}$, $\overline{I3}$	0.05 x In to 20 x In	±1.5 %
$\overline{IN}$	0.05 x In to 20 x In	±1.5 %
$\overline{I1}$ max, $\overline{I2}$ max, $\overline{I3}$ max	0.05 x In to 20 x In	±1.5 %
$\overline{IN}$ max	0.05 x In to 20 x In	±1.5 %
Phase-to-phase voltages		
U12	170 to 1150 V	±0.5 %
U23	170 to 1150 V	±0.5 %
U31	170 to 1150 V	±0.5 %
Phase-to-neutral voltages		
V1N	100 to 1150 V	±0.5 %
V2N	100 to 1150 V	±0.5 %
V3N	100 to 1150 V	±0.5 %
Average voltage		
U avg	170 to 1150 V	±0.5 %
Voltage unbalance		
U unbal	0 to 100 %	±0.5 %
Instantaneous power		
P	0.015 to 184 MW	±2 %
Q	0.015 to 184 Mvar	±2 %
S	0.015 to 184 MVA	±2 %
Power factor		
PF	-1 to +1	±2 %
Demand power		
P	0.015 to 184 MW	±2 %
Q	0.015 to 184 Mvar	±2 %
S	0.015 to 184 MVA	±2 %
P max	0.015 to 184 MW	±2 %
Q max	0.015 to 184 Mvar	±2 %
S max	0.015 to 184 MVA	±2 %
Total energy		
E.P	-10^{10} GWh to $+10^{10}$ GWh	±2 %
E.Q	-10^{10} Gvarh to $+10^{10}$ Gvarh	±2 %
E.S	-10^{10} GVAh to $+10^{10}$ GVAh	±2 %
Total energy In		
E.P	-10^{10} GWh to $+10^{10}$ GWh	±2 %
E.Q	-10^{10} Gvarh to $+10^{10}$ Gvarh	±2 %
Total energy out		
E.P	-10^{10} GWh to $+10^{10}$ GWh	±2 %
E.Q	-10^{10} Gvarh to $+10^{10}$ Gvarh	±2 %
Frequency		
F	45 Hz to 440 Hz	±0.1 %

Power factor sign conventions









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Notes

Notes

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Nemo 96HD

Strumento Multifunzione per reti bassa tensione

Linea trifase 80...500V (fase-fase)
Inserzione su TA dedicati
Rapporto TA e TV esterni programmabile

Moduli opzionali
Comunicazione RS485 (NT675)
Comunicazione RS232 (NT676)
Uscita impulsi (NT677)
Uscita analogica (NT678)
Allarmi (NT679)

Low voltage network monitor

Three-phase line 80...500V (phase-phase)
Connection with external dedicated CT
Programmable external CT-VT ratio

Optional modules
RS485 communication (NT675)
RS232 communication (NT676)
Pulse output (NT677)
Analog output (NT678)
Alarms (NT679)

U
Tensioni
Voltages

I
Correnti
Currents

PQS
Potenza attiva,reattiva apparente
Active, reactive apparent power

ET
Energia attiva, reattiva
Active, reactive energy

Fattore di potenza
Power Factor

Frequenza
Frequecy

Contaore
Run Hour

Comunicazione RS485
RS485 communication

Comunicazione RS232
RS232 communication

Uscita impulsi
Pulse output

Uscita analogica
Analog output

Allarmi
Alarms

NT680 09 - 2007 1° Ed. pag.1/5

CODICI DI ORDINAZIONE ORDERING CODE	AL. AUSILIARIA AUX. SUPPLY	INGRESSO INPUT	
MF96001	80...265Vca/ac - 110...300Vcc/dc	80...500V (trifase/three-phase)	1 e / and 5A

VISUALIZZAZIONE

Tipo display: cristallo liquido retroilluminato

Riduzione automatica della retroilluminazione, dopo 20 sec. di inattività della tastiera

Punti di lettura: 10-000 4 cifre (altezza cifre 12 mm)

Conteggio energia: numeratore 8 cifre (altezza cifre 8 mm)

Unità Ingegneristica: visualizzazione automatica in funzione dei rapporti TA e TV impostati

Risoluzione: automatica, con il maggior numero di decimali possibili

Punto decimale: automatico, con la maggior risoluzione possibile

Aggiornamento lettura: 1,1 secondi

Precisione (sulla lettura)

- Tensione: ± 0,5% (80...500V fase - fase)
- Corrente: ± 0,5% (10...120% In)
- Potenze: ± 1,0% (10...120% Pn/Qn/Sn, cosφ 0,5 ind...0,5 cap.)
- Frequenza: ± 0,15 Hz

Conteggio energia (tensione di riferimento 400V)

- Energia attiva: classe 1 (EN62053-21)
- Energia reattiva: classe 2 (EN62053-23)

PAGINE VISUALIZZAZIONE

La visualizzazione è suddivisa in quattro menù, accessibili con i relativi tasti funzione:

DISPLAY

***Type of display:** LCD backlit*

Automatic backlit reduction off after 20 s that keyboard is not used

***N° of reading points:** 10-000 4 digits (high digit 12 mm)*

***Energy count:** 8 digit counter (high digit 8 mm)*

***Engineering units:** automatic display according to the set VT and CT ratios*

***Resolution:** automatic, with the highest possible number of decimals*

***Decimal point:** automatic, with the highest possible resolution*

***Reading update:** 1,1 seconds*

***Accuracy** (of the reading)*

- *Voltage: ± 0,5% (80...500V phase - phase)*
- *Current: ± 0,5% (10...120% In)*
- *Powers: ± 1,0% (10...120% Pn/Qn/Sn cosφ 0,5 ind...0,5 cap.)*
- *Frequency: ± 0,15 Hz*

***Energy count** (reference voltage 400V)*

- *Active energy: class 1(EN62053-21)*
- *Active energy: class 2 (EN62053-23)*

DISPLAY PAGES

Display is divided into four menus which can be reached with the relevant function keys:

U	I	PQS	ET
TENSIONE di fase e concatenata ***VOLTAGE*** *phase and linked*	**CORRENTE** di fase e di neutro ***CURRENT*** *phase and neutral*	**POTENZA TRIFASE** attiva,reattiva, apparente ***POWER THREE-PHASE*** *active, reactive, apparent*	**FATTORE DI POTENZA** di fase e trifase ***POWER FACTOR*** *phase and three-phase*
TENSIONE MINIMA di fase ***MINIMUM VOLTAGE*** *phase*	**CORRENTE MEDIA** di fase ***CURRENT DEMAND*** *phase*	**POTENZA FASE** attiva,reattiva, apparente ***POWER PHASE*** *active, reactive, apparent*	**FREQUENZA** ***FREQUENCY***
TENSIONE MASSIMA di fase ***MAXIMUM VOLTAGE*** *phase*	**PICCO CORRENTE MEDIA** di fase ***MAX. CURRENT DEMAND*** *phase*	**POTENZA MEDIA** attiva,reattiva, apparente ***POWER DEMAND*** *active, reactive, apparent*	**CONTAORE** ***RUN HOUR***
DISTORSIONE ARMONICA TENSIONE di fase ***HARMONIC DISTORTION VOLTAGE*** *phase*	**SOMMA CORRENTI** ***CURRENTS SUM*** $\frac{I1 + I2 + I3}{3}$	**PICCO POTENZA MEDIA** attiva,reattiva, apparente ***MAX. POWER DEMAND*** *active, reactive, apparent*	**ENERGIA ATTIVA POSITIVA** totale e parziale ***POSITIVE ACTIVE ENERGY*** *partial and total*
	DISTORSIONE ARMONICA CORRENTE di fase ***HARMONIC DISTORTION CURRENT*** *phase*		**ENERGIA REATTIVA POSITIVA** totale e parziale ***POSITIVE REACTIVE ENERGY*** *partial and total*
			ENERGIA ATTIVA NEGATIVA ***NEGATIVE ACTIVE ENERGY***
			ENERGIA REATTIVA NEGATIVA ***NEGATIVE REACTIVE ENERGY***

In tutte le pagine di visualizzazione è sempre presente l'energia totale attiva o reattiva (alternate).

The total active or reactive energy (alternatively) is always displayed on all the display pages.

PROGRAMMAZIONE

Programmazione parametri: tastiera frontale, 4 tasti

Accesso alla programmazione: protetto da codice di abilitazione

Conservazione dati e parametri di configurazione: memoria permanente (senza batteria)

PROGRAMMING

***Parameters programming:** front keyboard, 4 keys*

***Programming access:** protected by password*

***Data and configuration parameters retention:** non volatile memory (no battery)*

PARAMETRI PROGRAMMABILI

INGRESSO

Connessione: rete monofase - trifase 3 fili e 4 fili

Corrente nominale: 1 - 5A

Rapporto TV esterno: 1...10 (massima tensione primaria TV 1200V)

Rapporto TA esterno: 1...9999 (massima corrente primaria 50kA/5A - 10kA/1A)

CORRENTE MEDIA - POTENZA MEDIA

Tempo integrazione: 5/8/10/15/20/30/60 min.

DISPLAY

Contrasto: 4 valori selezionabili

Illuminazione: 0 - 30 - 70 - 100%

Pagina personalizzata: grandezze visualizzabili all' accensione.

INGRESSO

Rete monofase, rete trifase 3 e 4 fili

Tensione trifase: 80...500V (fase-fase)

Tensione monfase: 50 - 290V

Inserzione su trasformatori di corrente esterni dedicati

Corrente nominale In: 5A - 1A

Corrente massima Imax: 1,2In

Sovraccarico istantaneo: 20 In/0,5 secondi

Frequenza nominale fn: 50

Variazione ammessa: 47...63Hz

Tipo di misura: vero valore efficace

Contenuto armonico: fino alla 16ª armonica

Tempo di avviamento (conteggio energia): < 5 secondi

Autoconsumo tensione: ≤ 0,5VA (per fase)

Autoconsumo corrente: ≤ 0,5VA (per fase)

ALIMENTAZIONE AUSILIARIA

Valore nominale Uaux ca: 80...265V

Frequenza nominale: 50Hz

Frequenza di funzionamento: 47...63Hz

Autoconsumo: ≤ 4VA (senza moduli)

Valore nominale Uaux cc: 110...300Vcc

Autoconsumo: ≤ 3,5W (senza moduli)

Protezione contro l'inversione di polarità

ISOLAMENTO (EN61010-1)

Categoria di installazione: III

Grado di inquinamento: 2

Tensione di riferimento per l'isolamento: 300V (Fase - neutro)

Prova di tensione a impulso 6kV 1,2/50μs 0,5J

Circuiti considerati: ingresso misura, al.ausiliaria

Prova a tensione alternata 4kV valore efficace 50Hz/1min

Circuiti considerati: tutti i circuiti e massa

PROVE DI COMPATIBILITA' ELETTROMAGNETICA

Prove di emissione e immunità in accordo con EN 62052-11

CONDIZIONI AMBIENTALI

Temperatura di riferimento: 23°C ± 2°C

Campo di funzionamento specificato: -5...55°C

Campo limite per l'immagazzinamento e trasporto: - 25...70°C

Variazione indice di classe: ≤ 0,1% /°C

Adatto all'utilizzo in climi tropicali

Massima potenza dissipata¹: ≤ 5W

¹Per il dimensionamento termico dei quadri

PROGRAMMABLE PARAMETERS

INPUT

Connection: *single-phase and three-phase network, 3 and 4-wire*

Current rating: *1 - 5A*

External VT ratio: *1...10 (max. VT primary 1200V)*

External CT ratio: *1...9999 (max. CT primary 50kA/5A - 10kA/1A)*

CURRENT DEMAND - POWER DEMAND

Average period: *5/8/10/15/20/30/60 min.*

DISPLAY

Contrast: *4 selectables value*

Backlit: *0 - 30 - 70 - 100%*

Customized page: *quantitie which can be displayed when switches on.*

INPUT

Single-phase network, three-phase network 3 and 4-wire

Three-phase voltage: *80...500V (phase-phase)*

Single-phase voltage: *50 - 290V*

Connection with external dedicated current transformers

Current rating In: *5A - 1A*

Max. current Imax: *1,2In*

Instantaneous overload: *20In/0,5 seconds*

Frequency rating fn: *50Hz*

Tolerance: *47...63Hz*

Type of measurement: *true RMS value*

Harmonic content: *up to the 16th harmonic*

Start time *(energy count): < 5 seconds*

Voltage rated burden: *≤ 0,5VA (each phase)*

Current rated burden: *≤ 0,5VA (each phase)*

AUXILIARY SUPPLY

Rated value Uaux ac: *80...265V*

Rated frequency: *50Hz*

Working frequency: *47...63Hz*

Rated burden: *≤ ≤ 4VA (without modules)*

Rated value Uaux dc: *110...300Vdc*

Rated burden: *≤ 3,5W (without modules)*

Protected against incorrect polarity

INSULATION (EN61010-1)

Installation category: *III*

Pollution degree: *2*

Insulation voltage rating: *300V (phase - neutral)*

Impulse voltage test 6kV 1,2/50μs 0,5J

Considered circuits: *measure, aux. supply*

A.C. voltage test 4kV r.m.s. value 50Hz/1min

Considered circuits: *all circuits and earth*

TESTS FOR ELETROMAMAGNETIC COMPATIBILITY

Emission and immunity tests according to EN 62052-11

ENVIRONMENTAL CONDITIONS

Reference temperature: *23°C ± 2°C*

Specified operating range: *-5...55°C*

Limit range for storage and transport: *- 25...70°C*

Variation to the class index: *≤ 0,1% /°C*

Suitable for tropical climates

Max. power dissipation¹: *≤ 5W*

¹For switchboard thermal calculation

CUSTODIA

Custodia: incasso (foratura pannello 92x92mm)

Frontale: 96x96mm

Profondità: 61mm

Profondità massima: 81mm (con moduli opzionali)

Connessioni: morsetti fissaggio a vite (ingressi di corrente) a estrazione (ingressi di tensione)

Portata morsetti voltmetrici: cavo rigido max.4,5 mm^2
cavo flessibile max.2,4 mm^2

Portata morsetti amperometrici: cavo rigido max.6 mm^2
cavo flessibile max.4 mm^2

Materiale custodia: policarbonato autoestinguente

Grado di protezione (EN60529): IP54 frontale, IP20 morsetti

Peso: 285 grammi

MODULI OPZIONALI

Nello strumento possono essere inseriti fino a quattro moduli opzionali.
I moduli comunicazione RS485 e RS232 sono in alternativa tra loro (non possono coesistere).
Per le opzioni uscita impulsi, uscita analogica e allarmi, è possibile inserire uno o due moduli.
Nella tabella vengono riportati i vincoli di composizione dei moduli: numero massimo moduli e posizione di inserimento.

HOUSING

Housing: *flush mounting (panel cutout 92x92mm)*

Front frame: *96x96mm*

Depth: *61mm*

Max. depth: *81mm (with optional modules)*

Connections: *screw terminals (input current) to plug out (input voltage)*

Volmetric terminal range: *rigid cable max.4,5 mm^2*
flexble cable max.2,4 mm^2

Ammetric terminal range: *rigid cable max.6 mm^2*
flexble cable max.4 mm^2

Housing material: *self-extinguishing policarbonate*

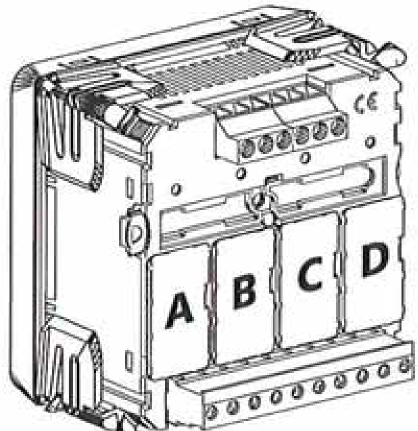
Protection degree (EN60529): *IP54 front frame, IP20 terminals*

Weight: *285 grams*

OPTIONAL MODULES

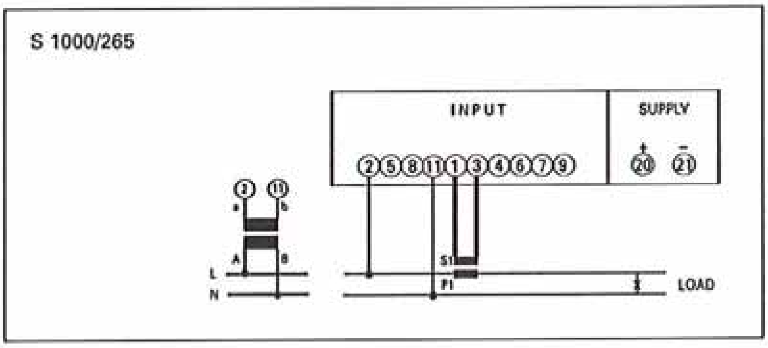
In the meter can be connected up to four optional modules.
RS485 and RS232 communication modules are as an alternative to them (they cannot coexist).
For the options pulse outputs, analog output and alarms, it is possible to connect one or two modules.
In the table are listed module composition constrictions: max. number of modules and connection position.

CODICE CODE	DESCRIZIONE DESCRIPTION	N. MASSIMO N. MAX.	POSIZIONE POSITION			
			A	B	C	D
IF96001	Comunicazione RS485 RS485 communication	1	•			
IF96002	Comunicazione RS232 RS232 communication	1	•			
IF96003	2 uscite impulsi energia 2 energy pulse output	2	•	•	•	•
IF96004	2 uscite analogiche 0/4...20mA 2 analogue outputs 0/4...20mA	2			•	•
IF96005	2 allarmi 2 alarms	2	•	•	•	•

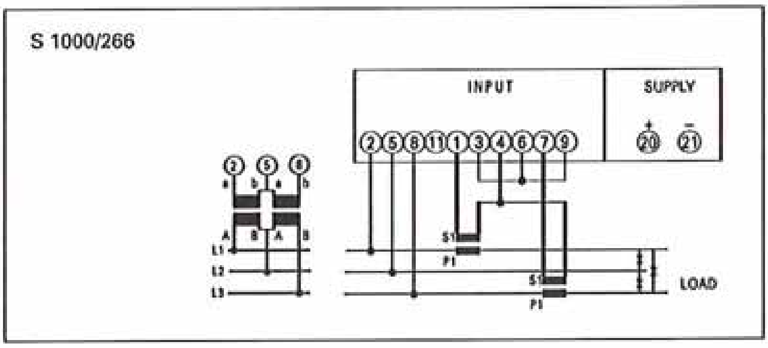


SCHEMI D'INSERZIONE *WIRING DIAGRAMS*

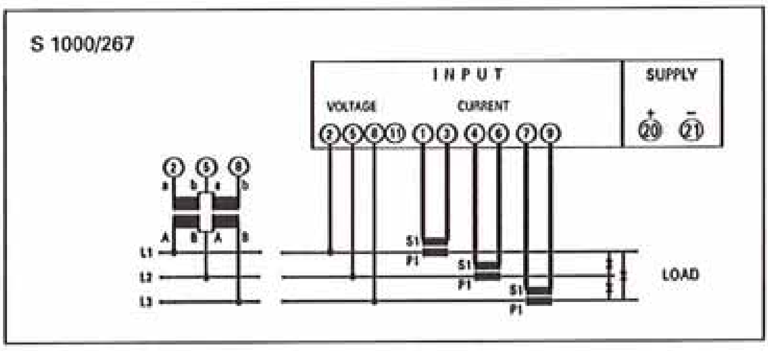
1N1E
Linea monofase
Single phase network



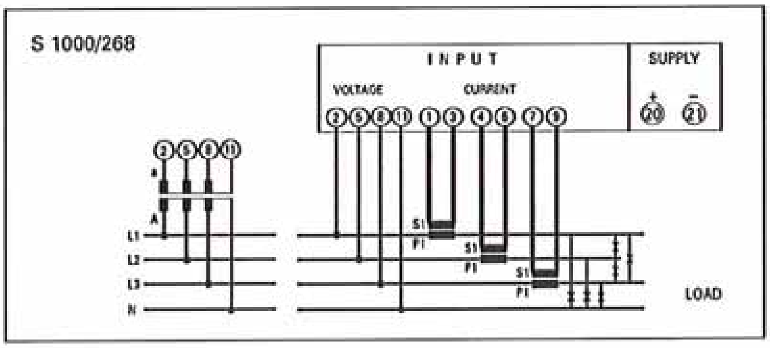
3-2E
Linea trifase 3 fili (Aron)
Three-phase 3-wire network (Aron)



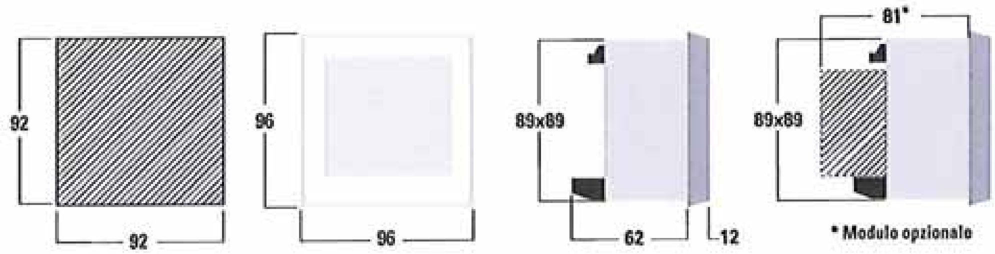
3-3E
Linea trifase 3 fili
Three-phase 3-wire network



3-3E
Linea trifase 4 fili
Three-phase 4-wire network



DIMENSIONI *DIMENSIONS*



IME

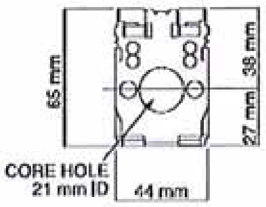
Current transformers

Refer catalogue ITC

- Housing, self-extinguishing thermoplastic
- Highest system voltage, 720 V RMS.
- Test voltage, 3 kV RMS 50 Hz for 1 min.
- Frequency of operation, 40-60 Hz
- Insulation Class, E (120 °C)
- Short circuit thermal current (Ith) 60-100 times rated primary current for 1 sec.
- Rated dynamic current 2.5 times Ith
- Rated continuous thermal current 120 % of rated primary current

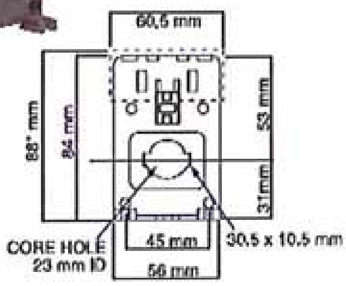
- Compact miniature CT
- DIN rail mountable

TAI BB



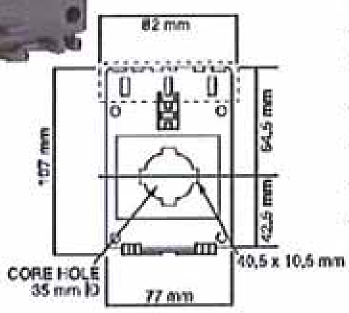
CT Depth 45 mm (overall)

TAI 233



CT Depth 60 mm (overall)

TAI 400



CT Depth 64 mm (overall)

Accuracy class			Ratio:
CL 0.5 VA	CL 1 VA	CL 3 VA	Primary / Secondary current
TAI BB - Cable Ø 21 mm max.			Cat. No ¹)
-	-	1	TAI BB 40 /
-	1.25	1.5	TAI BB 50 /
-	1.25	2	TAI BB 60 /
-	1.5	2.5	TAI BB 75 /
-	1.5	2.5	TAI BB 80 /
2	2.5	3.5	TAI BB 100 /
2.5	3.5	4	TAI BB 120 /
3	4	5	TAI BB 150 /
4	5.5	6	TAI BB 200 /
5	6	7	TAI BB 250 /
6	7.5	8	TAI BB 300 /
TAI 233 - Cable Ø 23 mm, Busbar 30 x 10 mm max.			
-	-	1.5	TAI 233 40 /
-	-	2.5	TAI 233 50 /
-	-	2.5	TAI 233 60 /
-	1.5	3.5	TAI 233 75 /
-	1.5	4	TAI 233 80 /
-	2.5	5	TAI 233 100 /
-	3.5	5.5	TAI 233 120 /
1.5	5.5	6.5	TAI 233 150 /
4	7	8.5	TAI 233 200 /
6	9	11	TAI 233 250 /
7.5	11	13.5	TAI 233 300 /
10.5	15	18	TAI 233 400 /
12	18	22	TAI 233 500 /
14.5	21.5	26	TAI 233 600 /
TAI 400 - Cable Ø 35 mm, Busbar 40 x 10 mm max.			
1	3	6	TAI 400 150 /
1.5	3	6	TAI 400 200 /
2.5	5	8	TAI 400 250 /
4	8	12	TAI 400 300 /
8	12	15	TAI 400 400 /
10	12	15	TAI 400 500 /
12	15	15	TAI 400 600 /
10	12	15	TAI 400 750 /
10	12	15	TAI 400 800 /
10	12	15	TAI 400 1000 /

Note: ¹) Add primary and secondary current + 5 A or 1 A suffix to complete Cat. No.

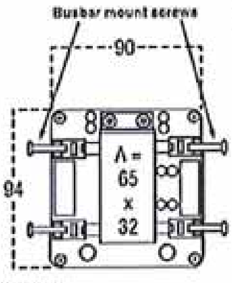
Current transformers

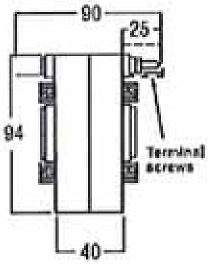
Vertical busbar mount and terminals

TAS105_5A

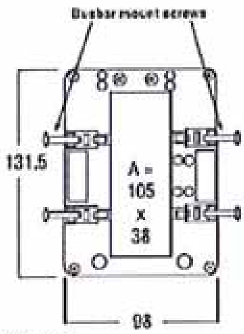
- Compact design busbar CTs
- Reduced overall dimensions and weight
- Mounting parts, terminals and busbar clamps supplied as standard
- Suits popular busbar dimensions

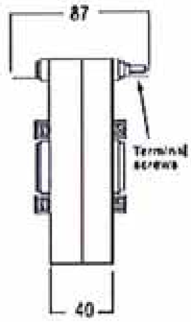
Dimensions in mm:



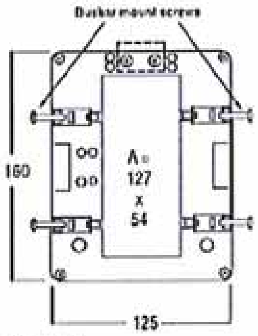


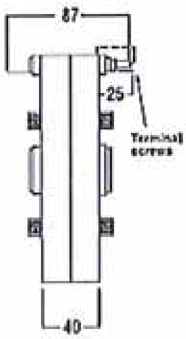
TAS 65



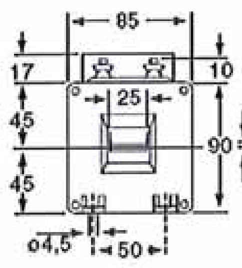


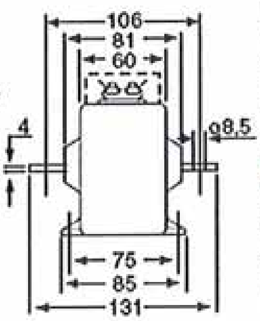
TAS 105





TAS 127B





TAQ 10

Accuracy class

CL 0.5 VA	CL 1 VA	CL 3 VA	Ratio: Primary / Secondary current ¹)
TAS 65	**Busbar 63 x 32 mm (Max.)**		**Cat. No.**
8	10	12	TAS 65 500/5A
8	12	15	TAS 65 600/5A
10	15	15	TAS 65 750/5A
12	15	20	TAS 65 800/5A
15	20	25	TAS 65 1000/5A
15	20	25	TAS 65 1200/5A
20	25	30	TAS 65 1500/5A
TAS 105	**Busbar 100 x 36 mm (Max.)**		**Cat. No.**
10	15	20	TAS 105 1000/5A
12	15	25	TAS 105 1200/5A
15	20	30	TAS 105 1500/5A
20	30	40	TAS 105 2000/5A
25	30	50	TAS 105 2500/5A
25	30	50	TAS 105 3000/5A
TAS 127B	**Busbar 125 x 52 mm (Max.)**		**Cat. No.**
20	30	40	TAS 127B 1500/5A
20	30	40	TAS 127B 1600/5A
25	40	50	TAS 127B 2000/5A
30	50	60	TAS 127B 2500/5A
40	60	60	TAS 127B 3000/5A
50	60	60	TAS 127B 4000/5A
TAQ 10	**Primary wound CT**		**Cat. No.**
10	12	20	TAQ 10 5/5A
10	12	20	TAQ 10 10/5A
10	12	20	TAQ 10 25/5A
10	12	20	TAQ 10 30/5A
10	12	20	TAQ 10 35/5A
10	12	20	TAQ 10 40/5A
10	12	20	TAQ 10 50/5A
10	12	20	TAQ 10 60/5A
10	12	20	TAQ 10 75/5A
10	12	20	TAQ 10 80/5A
10	12	20	TAQ 10 100/5A

Terminal covers (IP 40)	Cat. No.
TAS 65, 105 & 127B	TC-TAS 65 105 127B
TAQ 10	TC-TAQ 10

Note: ¹) Transformers available as 1 amp secondary on an indent basis.

IME

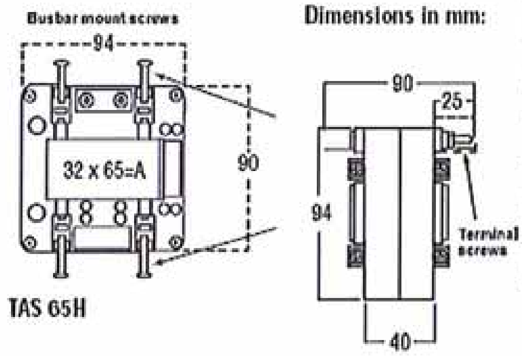
Current transformers

Horizontal busbar mount and terminal

TAS127BH1500/5A

- New compact design busbar CTs
- Reduced overall dimensions and weight
- Mounting parts, terminals and busbar clamps supplied as standard
- Suits popular busbar dimensions

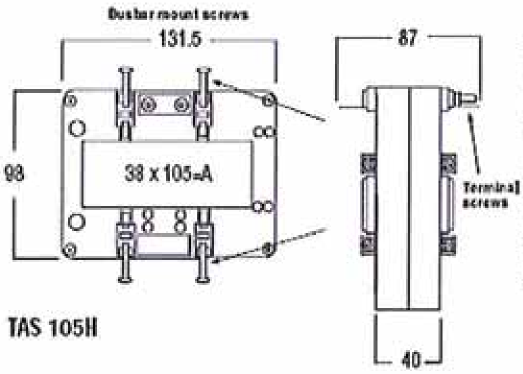
Dimensions in mm:



TAS 65H

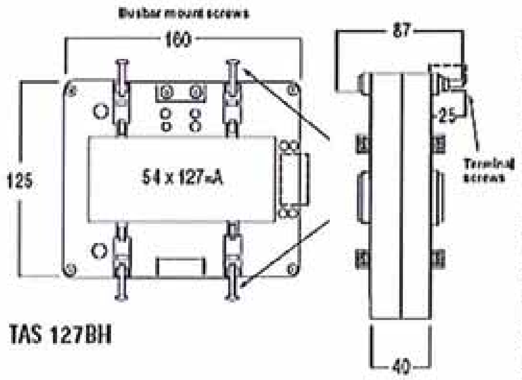
Accuracy class

CL 0.5 VA	CL 1 VA	CL 3 VA	Ratio: Primary / Secondary current [1]
TAS 65	**Busbar 63 x 32 mm (Max.)**		**Cat. No.**
8	10	12	TAS 65H500/5A
8	12	15	TAS 65H600/5A
10	15	15	TAS 65H750/5A
12	15	20	TAS 65H800/5A
15	20	25	TAS 65H1000/5A
15	20	25	TAS 65H1200/5A
20	25	30	TAS 65H1500/5A



TAS 105H

TAS 105	**Busbar 100 x 36 mm (Max.)**		**Cat. No.**
10	15	20	TAS 105H1000/5A
12	15	25	TAS 105H1200/5A
15	20	30	TAS 105H1500/5A
20	30	40	TAS 105H2000/5A
25	30	50	TAS 105H2500/5A
25	30	50	TAS 105H3000/5A



TAS 127BH

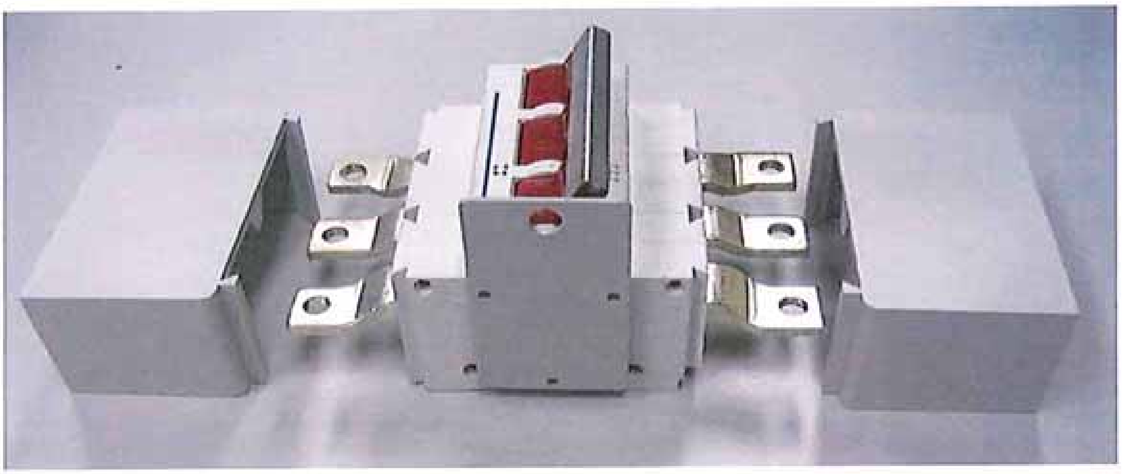
TAS 127B	**Busbar 125 x 52 mm (Max.)**		**Cat. No.**
20	30	40	TAS 127BH1500/5A
20	30	40	TAS 127BH1600/5A
25	40	50	TAS 127BH2000/5A
30	50	60	TAS 127BH2500/5A
40	60	60	TAS 127BH3000/5A
50	60	60	TAS 127BH4000/5A

Terminal covers (IP 40)	Cat. No.
TAS 65, 105 & 127B	TC-TAS 65 105 127B

Note: [1] Transformers available as 1 amp secondary on an indent basis.

BRIDEX | APPLICATION INFORMATION

RUDOLF RI3 250 SWITCH DISCONNECTOR



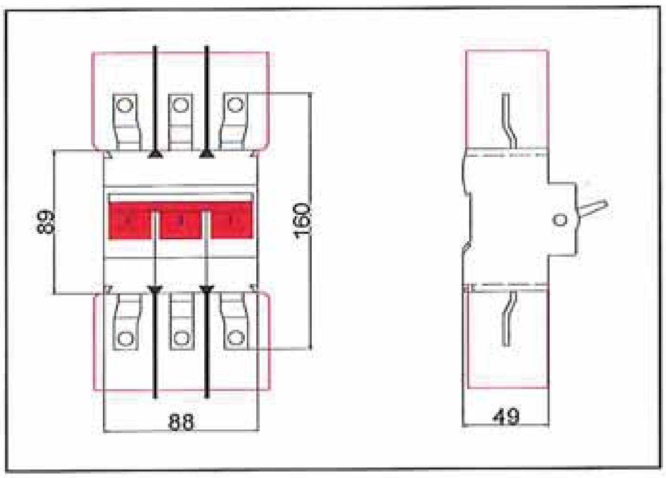
Application

Designed for use as a Switch Disconnector for DIN type Distribution Boards as defined in IEEE Wiring Regulations.

Technical Information

AC 21B	250 Amp	415 VAC
AC 22B	250 Amp	415 VAC
50/60 Hz	Ik	50 kA (with 250A fuses)
Making Capacity	8.5 kA	peak value
Short time rating (1sec)	4.0 kA	rms
Ith 250A		
BSEN/AS/NZ 60947-4	CE	
Electrical endurance	at 0.6 pf	10,000 operations

Dimensions



BRIDEX AUSTRALIA PTY LTD Unit 12 / 20 Narabang Way Belrose NSW 2085 www.bridex.com.au

Publication R 001/05

Rudolf™ 3-Phase MCB Chassis are designed to provide direct and uninterrupted connectivity to most miniature circuit breakers and molded case circuit breakers. Load centers, or circuit breaker boxes are used for the protection and distribution of power in buildings. An installed main circuit breaker plays a dual role of supplying power to the load center and its branch circuits; and also disconnects power from the load center in order to provide overcurrent protection. The unit can serve as a distribution panel where there is a main circuit breaker upstream in the system. Load centers are commonly used as service equipment for buildings where incoming power supply is connected to provide a means to control and cut off the power supply.

FEATURES:

- 250A, 18mm spacing
- Suitable for most 1-pole and 3-pole MCBs
- Incomer suitable for most brands of MCCB up to 250A
- Industrial proven with a solid line-up of chassis ranging from 12 Ways to 96 Ways
- Compliance with ISO / IEC / BS EN 439-1
- Withstand rating of 250A / 25kA for 0.1 sec
- Splayed busbar to connect 160A & 250A switch
- Top and bottom feed at splayed busbars
- All busbars stripped bare, fitted with black caps
- Non-extensible busbars are colour coded to provide ease of identification
- Tee-offs stripped and 100% fitted with black caps
- Top / bottom power feed stripped and 50% capped
- Plastic housing material – hard, rigid, abrasion resistance and thermostability
- Flexible and easy to install

Tested by laboratory accredited by ASTA and NATA to IEC 439-1:

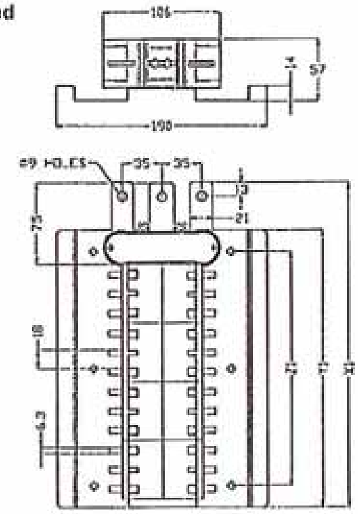
- Temperature-rise Limits
- Conditional Short-circuit current
- Short-time and Peak Withstand Current

Technical Data

Description	Unit	Value
Busbar rating	(Amp)	250
Voltage Rating	(V)	415
Short Circuit Rating	(kA)	25
Short Circuit Time	(sec)	0.1
Peak Short Circuit Rating	(kA)	52.5

Choice of circuit breakers and enclosures available upon customer request

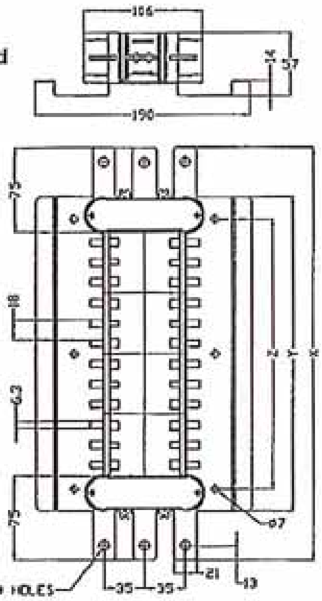
Top Feed



Side View

Top View

Top and Bottom Feed



*Note: Steel pan dimensions may change to suit different makes of MCB

Pole Capacity	Product Code (Top Feed)	Dimensions			Product Code (Top & Bottom Feed)	Dimensions		
		Total Length, X1 (mm)	Plate Length, Y1 (mm)	Length between plate holes, Z1 (mm)		Total Length, X (mm)	Plate Length, Y (mm)	Length between plate holes, Z (mm)
12 Way	LC12W3PSA	191	148	108	LC12W3PDA	258	172	132
18 Way	LC18W3PSA	245	202	162	LC18W3PDA	312	226	186
24 Way	LC24W3PSA	299	256	216	LC24W3PDA	366	280	240
30 Way	LC30W3PSA	353	310	270	LC30W3PDA	420	334	294
36 Way	LC36W3PSA	407	364	324	LC36W3PDA	474	388	348
42 Way	LC42W3PSA	461	418	378	LC42W3PDA	528	442	402
48 Way	LC48W3PSA	515	472	432	LC48W3PDA	582	496	456
54 Way	LC54W3PSA	569	526	486	LC54W3PDA	636	550	510
60 Way	LC60W3PSA	623	581	541	LC60W3PDA	690	605	565
66 Way	LC66W3PSA	677	635	595	LC66W3PDA	744	659	619
72 Way	LC72W3PSA	731	689	649	LC72W3PDA	798	713	673
78 Way	LC78W3PSA	785	744	704	LC78W3PDA	852	768	728
84 Way	LC84W3PSA	839	798	758	LC84W3PDA	906	822	782
90 Way	LC90W3PSA	893	852	812	LC90W3PDA	960	876	836
96 Way	LC96W3PSA	947	906	866	LC96W3PDA	1014	930	890

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Accreditation Bodies:

Testing & Certification Australia

protection

circuit-breakers up to 63 A

C60N circuit-breakers

6kA, C curve
AS/NZS 4898

Approval No: N13634

functions

The circuit-breakers combine the following functions:
- protection of circuits against short-circuit currents,
- protection of circuits against overload currents,
- control,
- isolation,
- protection of persons against indirect contact.

description

technical data common to C60N circuit breakers

■ power circuit
□ voltage rating: 240/415 V AC
- for 2P single phase 240/480V
□ I^2t classification: 3
□ number of cycles (O-C): 20 000
□ foolproof terminal design
- moving barrier prevents incorrect cable insertion
- cable strand centering guides ensure correct cable positions and strand grouping
□ isolation with positive contact indication
□ bistable din clip, simplifies disassembly

■ environment
□ tropicalisation: treatment 2 (relative humidity: 95 % at 55 °C)
□ connection: tunnel terminals for the following cables:
- up to 25A : $16mm^2$ flexible with cable end
: $25mm^2$ stranded
- 32 to 63A : $25mm^2$ flexible with cable end
: $35mm^2$ stranded

C curve

utilisation

cables feeding conventional loads.

technical data

■ power circuit
□ tripping curves: the magnetic trip units operate between 5 and 10 In
□ breaking capacity according to AS/NZS 4898, Icu ultimate breaking capacity (O-CO cycle):

rating (A)	type	voltage (V)	breaking capacity Icu (A)
1...63	1P	240/415	6 000
	2P	415...480	6 000
	3P	415	6 000

catalogue numbers

type	rating (A)	catalogue number
C curve C60N		
1P	1	25797
	2	25798
	4	25800
	6	25801
Width in mod of 9mm - 2	10	25802
	16	25803
	20	25804
	25	25805
	32	25806
	40	25807
	50	25808
	63	25809
2P	1	25811
	2	25812
	4	25814
	6	25815
Width in mod of 9mm - 4	10	25816
	16	25817
	20	25818
	25	25819
	32	25820
	40	25821
	50	25822
	63	25823
3P	1	25825
	2	25826
	4	25828
	6	25829
Width in mod of 9mm - 6	10	25830
	16	25831
	20	25832
	25	25833
	32	25834
	40	25835
	50	25836
	63	25837

25804

25818

25832

protection

circuit-breakers up to 63 A

C60H circuit-breakers

10kA, B, C and D curve
AS/NZS 4898

Approval No: N13634

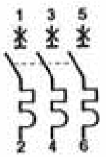
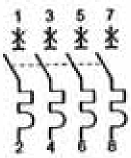
catalogue numbers

25845

25857

25871

25883

type	rating (A)	B Curve	C Curve	D Curve
C60H				
1P 	1	25839	25639	25695
	2	25840	25640	25696
	4	25841	25642	25698
	6	25842	25643	25699
	10	25843	25644	25700
	16	25844	25645	25701
	20	25845	25646	25702
	25	25846	25647	25703
	32	25847	25648	25704
Width in mod of 9mm - 2	40	25848	25649	25705
	50	25849	25651	25707
	63	25850	25652	25708
2P 	1	25852	25653	25709
	2	25853	25654	25710
	4	25854	25656	25712
	6	25855	25656	25713
	10	25856	25658	25714
	16	25857	25659	25715
	20	25858	25660	25716
	25	25859	25661	25717
	32	25860	25662	25718
	40	25861	25663	25719
Width in mod of 9mm - 4	50	25862	25665	25721
	63	25863	25666	25722
3P 	1	25865	25667	25723
	2	25866	25668	25724
	4	25867	25670	25726
	6	25868	25671	25727
	10	25869	25672	25728
	16	25870	25673	25729
	20	25871	25674	25730
	25	25872	25675	25731
	32	25873	25676	25732
	40	25874	25677	25733
Width in mod of 9mm - 6	50	25875	25679	25735
	63	25876	25680	25736
4P 	1	25878	25007	25211
	2	25879	25008	25212
	4	25880	25010	25214
	6	25881	25011	25215
	10	25882	25012	25216
	16	25883	25013	25217
	20	25884	25014	25218
	25	25885	25015	25219
	32	25886	25016	25220
	40	25887	25017	25221
Width in mod of 9mm - 8	50	25888	25018	25222
	63	25889	25019	25223

C60H Single Pole RCBO

Rating	Width in mod. of 9mm	Reference
10A	2	26858
16A	2	26859
20A	2	26860
32A	2	26861

Rated voltage	Width in mod. of 9mm	Reference
	1	26924
	1	26927
240-415V AC 110-130V DC	2	26946
48-130V AC 48VDC	2	26947
220-240V AC	2	26960
48V AC	2	26961
48V DC	2	26962

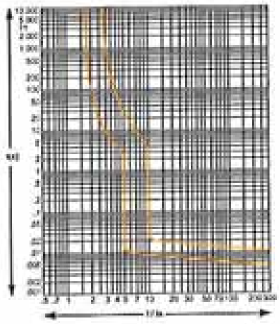
	Reference
elds	26981
	26970

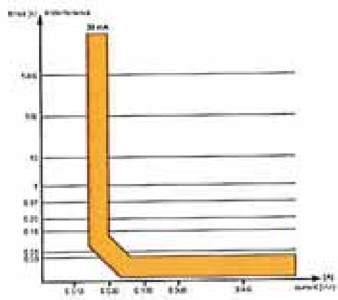
Technical Data

- Voltage rating: 110 - 240V AC
- Breaking capacity I_{cn} - 10kA
- Residual breaking capacity $I_{\Delta m}$ - 6kA
- Current ratings I_n - 10 ...32A
- Electrical endurance (O-C cycles): 20 000
- Tropicalisation: treatment 2 (relative humidity: 95% at 55°C)
- Weight 240g
- Connection:
- L in: tunnel terminals 25mm² cables
  L & N out: tunnel terminals 16mm² cables
- Standards: IEC60898, AS/NZS4898, AS3190 Approval number N13634

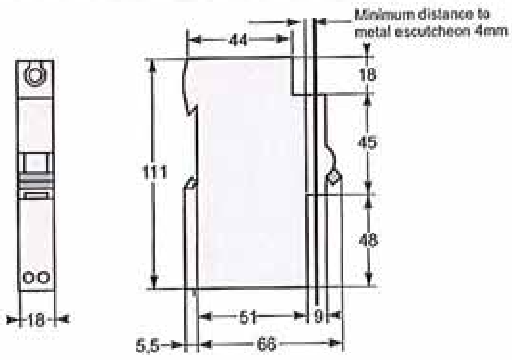
C Curve
tripping curve:
the magnetic trip operates between 5 and 10 In

Tripping Curves



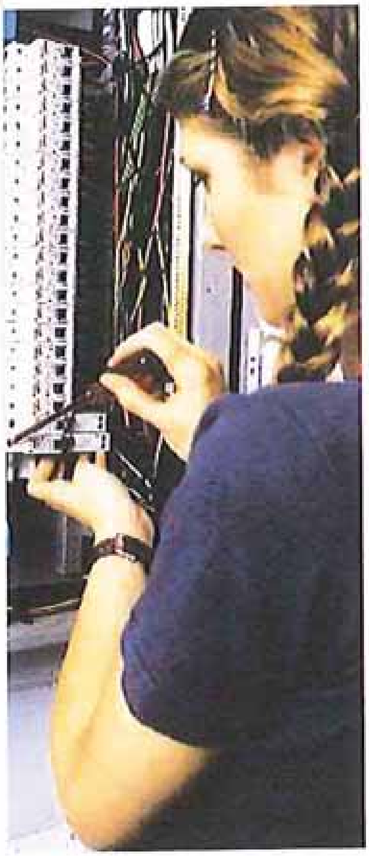


Dimensions



Schneider Electric

ıle Pole RCBO
ıiniature circuit breaker
ıs residual current

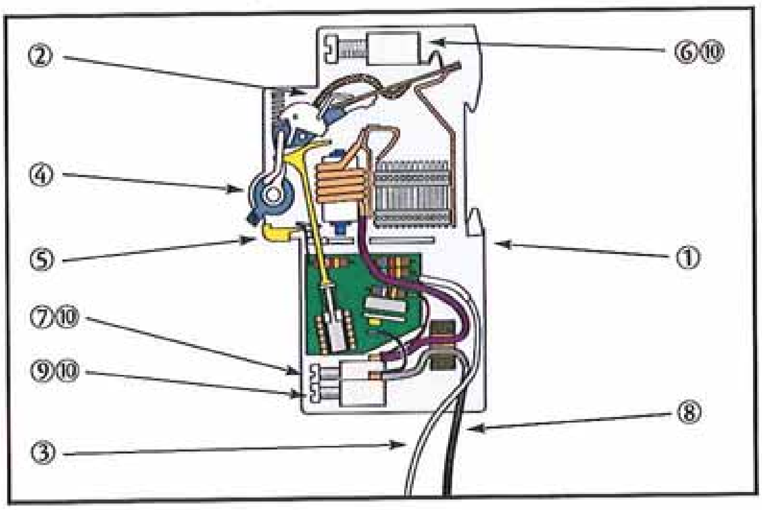


ı single pole width

C60H Single Pole RCBO

Product Design

① Single case construction - ensures product robustness
② Industry proven C60H MCB mechanism
③ Provision of functional earth ensures safe operation even with loss of neutral connection
④ Suitable for isolation - handle position always indicates contact position
⑤ Test trip button - conveniently positioned for periodic testing
⑥ Incoming line connection terminal
⑦ Outgoing line connection terminal
⑧ Incoming neutral connection
⑨ Outgoing neutral connection
⑩ Foolproof terminal design:
- moving barrier prevents incorrect cable insertion
- cable strand centring guides ensure correct cable positions & strand grouping



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Balcatta 6021
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AUS990301

Product data sheet
Characteristics

RE88865115
on-delay timing relay - 1 s..100 h - 24..240 V AC - 1 contact

Main

Range of product	Zelio Time
Product or component type	Industrial timing relay
Contacts type and composition	Timed contact, AgNi (cadmium free)
Component name	RE88865
Time delay type	A At
Time delay range	1 h 1 min 1 s 10 h 10 min 10 s 100 h
[Us] rated supply voltage	24 V DC 24...240 V AC 50/60 Hz

Complementary

Discrete output type	Relay
Width pitch dimension	22.5 mm
Voltage range	0.85...1.1 Us
Connections - terminals	Screw terminals, clamping capacity: 2 x 1.5 mm² with cable end Screw terminals, clamping capacity: 2 x 2.5 mm² without cable end
Housing material	Self-extinguishing
Repeat accuracy	+/- 0.5 % conforming to IEC 61812-1
Temperature drift	+/- 0.05 %/°C
Voltage drift	+/- 0.2 %/V
Setting accuracy of time delay	+/- 10 % of full scale at 25 °C conforming to IEC 61812-1
Minimum pulse duration	100 ms under load 30 ms
Maximum reset time	100 ms on de-energisation
On-load factor	100 %
Maximum power consumption	32 VA 240 V
Maximum power consumption	0.6 W 24 V 1.5 W 240 V
Breaking capacity	2000 VA
Breaking capacity	80 W
Minimum switching current	10 mA
Maximum switching current	8 A
Maximum switching voltage	250 V
Electrical durability	100000 cycles 8 A at 250 V resistive
Mechanical durability	5000000 cycles
[Uimp] rated impulse withstand voltage	5 kV for 1.2...50 µs conforming to IEC 60664-1 5 kV for 1.2...50 µs conforming to IEC 61812-1
Marking	CE
Creepage distance	4 kV/3 conforming to IEC 60664-1
Surge withstand	1 kV (differential mode) conforming to IEC 61000-4-5 level 3 2 kV (common mode) conforming to IEC 61000-4-5 level 3
Mounting support	35 mm symmetrical mounting rail conforming to EN 50022

Local signalling	LED indicator green flashing: timing in progress LED indicator green on steady: relay energised, no timing in progress LED indicator green pulsing: relay energised, no timing in progress
Product weight	0.09 kg

Environment

Immunity to microbreaks	> 10 ms
Dielectric strength	2.5 kV 1 mA/1 minute 50 Hz conforming to IEC 61812-1
Standards	73/23/EEC 89/336/EEC 93/68/EEC EN 50081-1/2 EN 50082-1/2 IEC 60669-2-3 IEC 61812-1
Product certifications	CSA CULus GL
Ambient air temperature for operation	-20...60 °C
Ambient air temperature for storage	-30...60 °C
IP degree of protection	IP20 (terminal block) conforming to IEC 60529 IP40 (housing) conforming to IEC 60529 IP50 (front face) conforming to IEC 60529
Vibration resistance	0.35 mm (f = 10...55 Hz) conforming to IEC 60068-2-6
Relative humidity	93 % without condensation conforming to IEC 60068-2-3
Resistance to electrostatic discharge	6 kV (in contact) conforming to EN/IEC 61000-4-2 level 3 8 kV (in air) conforming to EN/IEC 61000-4-2 level 3
Resistance to electromagnetic fields	10 V/m, 80 MHz to 1 GHz conforming to ENV 50140/204 level 3 10 V/m, 80 MHz to 1 GHz conforming to IEC 61000-4-3 level 3
Resistance to fast transients	1 kV, capacitive connecting clip conforming to IEC 61000-4-4 level 3 2 kV, direct conforming to IEC 61000-4-4 level 3
Immunity to radioelectric fields	10 V (0.15...80 MHz) conforming to ENV 50141 (IEC 61000-4-6)
Immunity to voltage dips	30 %/10 ms conforming to IEC 61000-4-11 60 %/100 ms conforming to IEC 61000-4-11 95 %/5 s conforming to IEC 61000-4-11
Disturbance radiated/conducted	Class B conforming to EN 55022 (EN 55011 group 1)
RoHS EUR status	Compliant
RoHS EUR conformity date	0621

Product data sheet

Technical Description

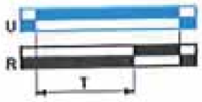
RE88865115

Function A: Delay on Energisation

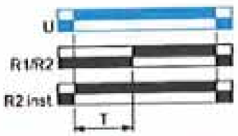
Description

The timing period T begins on energisation. After timing, the output(s) R close(s). The second output can be either timed or instantaneous.

Function: 1 Output



Function: 2 Outputs



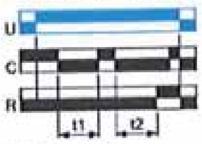
2 timed outputs (R1/R2) or 1 timed output (R1) and 1 instantaneous output (R2 inst.)

Function At: Delay on Energisation with Memory

Description

After power-up, the first opening of control contact C starts the timing. Timing can be interrupted each time control contact closes. When the cumulative total of time periods elapsed reaches the pre-set value T, the output relay closes.

Function: 1 Output



T = t1 + t2 +...

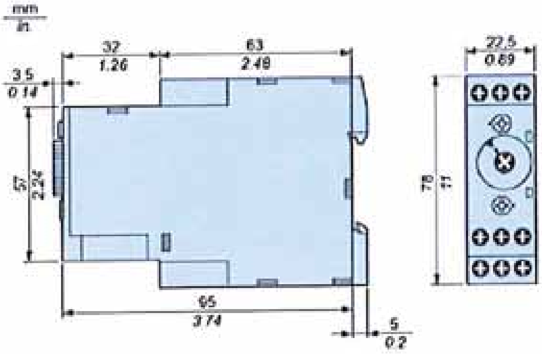
Legend

- Relay de-energised
- Relay energised
- Output open
- Output closed

C	Control contact
G	Gate
R	Relay or solid state output
R1/ R2	2 timed outputs
R2 inst.	The second output is instantaneous if the right position is selected
T	Timing period
Ta	Adjustable On-delay
Tr	Adjustable Off-delay
U	Supply

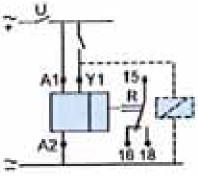
RE88865115

Width 22.5 mm



RE88865115

Wiring Diagram

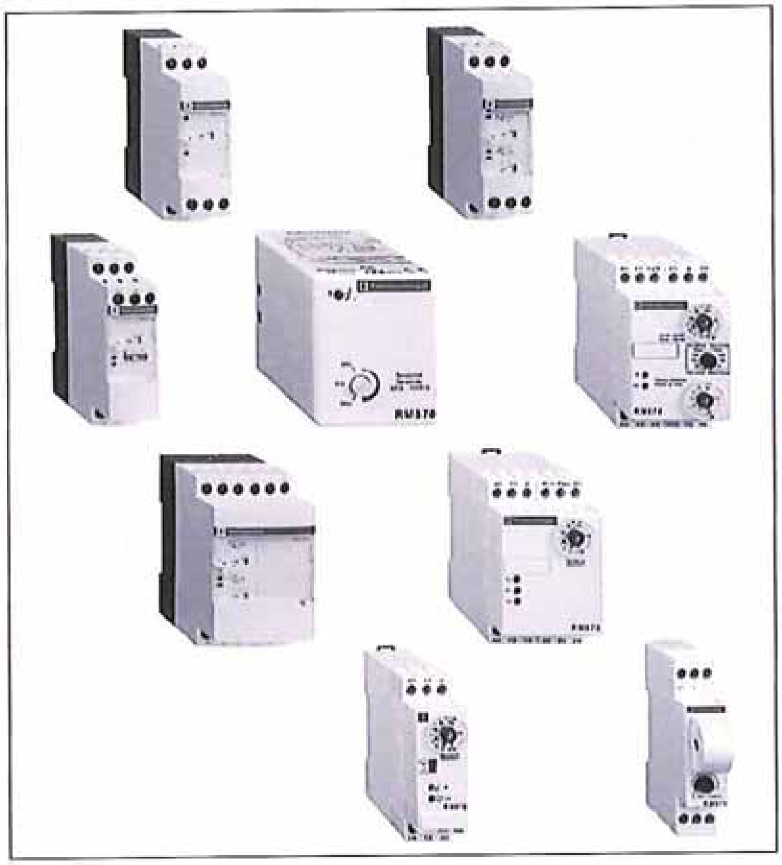


Zelio® Control Measurement Relays RM4 and RM84

File 8430

Catalog
June

05



CONTENTS

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Zelio® Control Measurement Relays
RM4 Application Data

Application Data

Conforming to Standards		IEC 60255-6, EN 60255-6
Product Approvals		File E164353 CNN NKCR; File LR 89150 Guide 3211 07 GL
CE Marking	CE	Zelio-Control measurement relays conform to European regulations relating to CE Marking.
Ambient Air Temperature Around the Device	Storage	-40 to 185 °F (-40 to +85 °C)
	Operation	-4 to 149 °F (-20 to +65 °C)
Permissible Relative Humidity Range	Conforming to IEC 60721-3-3	15 to 85% Environmental class 3K3
Vibration Resistance	Conforming to IEC 60068-2-6, 10 to 55 Hz	a = 0.35 ms
Shock Resistance	Conforming to IEC 60068-2-27	15 gn, 11 ms
Degree of Protection	Housing	IP 50
	Terminals	IP 20
Degree of Pollution	Conforming to IEC 60664-1	3
Overvoltage Category	Conforming to IEC 60664-1	III
Rated Insulation Voltage Between contact circuit and power supply, or between contact circuit and control inputs	Conforming to IEC	500 V
	Conforming to CSA, UL	500 V
Test Voltage for Insulation Tests	Dielectric test	UL Hipot at 2,200 V (IEC 2,500 V)
	Shock wave	4.8 kV
Voltage Limits	Power supply circuit	0.85–1.1 Uc ▲
Disconnection Value	Power supply circuit	> 0.1 Uc
Mounting Position without Derating	In relation to the normal vertical mounting position	Any position
Connection Maximum Cross-Section	Stranded wire without cable end	Two #14 AWG (2.5 mm²)
	Stranded wire with cable end	Two #16 AWG (1.5 mm²)
Tightening Torque		4.5–9.9 lb-in (0.5–1.1 N•m)
Mounting		Can be mounted directly to a panel or on a 1.38 in. (35 mm) wide by 0.29 in. (7.5 mm) or 0.59 in. (15 mm) depth mounting track.

Immunity from Electromagnetic Interference (EMC)
(Application Class 2 Conforming to EN 61812-1)

Electrostatic Discharge	Conforming to IEC 61000-4-2	Level 3 (6 kV contact, 8 kV air)
Electromagnetic Fields	Conforming to IEC 61000-4-3	Level 3 (10 V/m)
Rapid Transients	Conforming to IEC 61000-4-4	Level 3 (2 kV output power, 1 kV control)
Shock Waves	Conforming to IEC 61000-4-5	Level 3 (2 kV common mode, 1 kV differential mode)
Radiated and Conducted Emissions	CISPR11	Group 1 Class A
	CISPR22	Class A

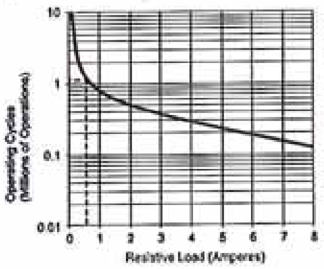
▲ Except RM4T, see page 31.
gn = gravitational unit = 9.8 m/s²

Output Relay Specifications

Mechanical Durability ■	In millions of operating cycles	30 ■		
Current Limit Ith		8 A		
Rated Operational Limits at 158 °F (70 °C)		24 V	115 V	250 V
Conforming to IEC 60947-5-1/1991 and VDE 0660	AC-15	3 A	3 A	3 A
	DC-13	2 A	0.3 A	0.1 A
UL and CSA Current Ratings	Resistive Rating	5 A		
(NEMA/UL B300)	Inductive Rating	3600 VA Make Rating 360 VA Break Rating 5 A Carry		
Minimum Switching Capacity		12 V/10 mA		
Switching Voltage	Rated	250 Vac		
	Max.	440 Vac		
Contact Material		Silver Nickel 90/10		

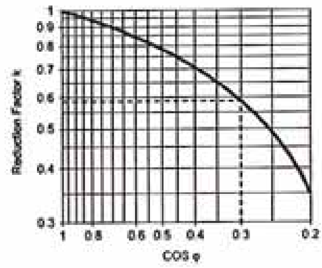
Curve 1
AC Load

Electrical durability of contacts on resistive load in millions of operating cycles ■

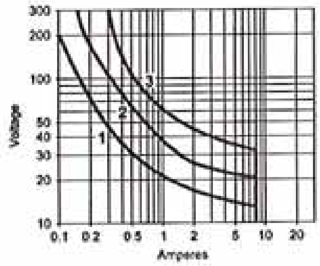


Curve 2
▲

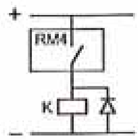
Reduction factor k for inductive loads (applies to values taken from the durability curve opposite) ■



DC Load
Load Limit Curve ■



1 L/R = 20 ms
2 L/R with load protection diode
3 Resistive load



♦

Example:

An LC1F185 contactor supplied with 115 V/50 Hz for a consumption of 55 VA or a current consumption equal to 0.1 A and cos φ = 0.3.

For 0.1 A, Curve 1 indicates a durability of approximately 1.5 million operating cycles.

As the load is inductive, it is necessary to apply a reduction coefficient k to this number of cycles, as indicated by curve 2.

For cos φ = 0.3: k = 0.6

The electrical durability therefore becomes:
1.5×10^6 operating cycles $\times$ 0.6 = 900,000 operating cycles.

■ The product life expressed above is based on average usage and and normal operating conditions. Actual operating life will vary with conditions. The above statements are not intended to nor shall they create any expressed or implied warranties as to product operation or life. For information on the listed warranty offered on this product, refer to the Square D terms and conditions of sale found in the *Digest*.

♦ When used with a DC contactor, it is recommended that a free-wheel diode be connected in parallel on the coil.

▲ Curve 2 based on 35% power factor.

Zelio® Control Measurement Relays
RM4JA Current Measurement Relays

RM4JA01

RM4JA32

FUNCTIONS

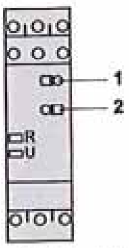
These devices detect when the current level on an AC or DC supply exceeds a pre-set threshold. They have a transparent, hinged cover on the front face to prevent accidental alteration of the settings. This cover can be sealed.

Catalog Number	Overcurrent Control	Overcurrent or Undercurrent Control ■	Measuring Range
RM4JA01	Yes	No	3 mA to 1 A
RM4JA31	Yes	Yes	3 mA to 1 A
RM4JA32	Yes	Yes	0.3 A to 15 A

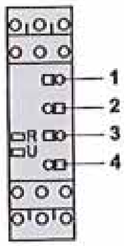
Applications

- Excitation control of DC machines
- Controlling the load state of motors and generators
- Controlling current drawn by a three-phase motor
- Monitoring heating or lighting circuits
- Controlling pump draining (undercurrent)
- Controlling overtorque (crushers)
- Monitoring electromagnetic brakes or clutches

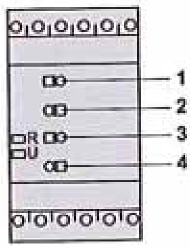
RM4JA01
Width 0.89 in (22.5mm)



RM4JA31
Width 0.89 in (22.5mm)



RM4JA32
Width 1.77 in (45mm)



1 Adjustment of current threshold as a percentage of the setting range maximum value.
2 Hysteresis adjustment from 5 to 30% ▲.
3 Fine adjustment of time delay as a percentage of the setting range maximum value.
4 10-position switch combining
 — selection of the timing range: 1 s, 3 s, 10 s, 30 s, no time delay.
 — selection of overcurrent (>) or undercurrent (<) detection. See table below.
R Yellow LED: indicates relay state (Off for de-energized relay, On for energized).
U Green LED: indicates that supply to the RM4 is present.

Detailed Positions for Switch 4

Switch Position	Function	Time Delay (t)
< 0	Undercurrent detection	No time delay
< 1	Undercurrent detection	0.05 to 1 s
< 3	Undercurrent detection	0.15 to 3 s
< 10	Undercurrent detection	0.5 to 10 s
< 30	Undercurrent detection	1.5 to 30 s
> 0	Overcurrent detection	No time delay
> 1	Overcurrent detection	0.05 to 1 s
> 3	Overcurrent detection	0.15 to 3 s
> 10	Overcurrent detection	0.5 to 10 s
> 30	Overcurrent detection	1.5 to 30 s

■ Selection by switch on front face.
▲ Value of current difference between energization and de-energization of the output relay (% of the current threshold to be measured).

OPERATING PRINCIPLE

The supply voltage is connected to terminals A1–A2. The current to be monitored is connected to terminals B1, B2, or B3 (depending on the current range) and C. See the diagram below.

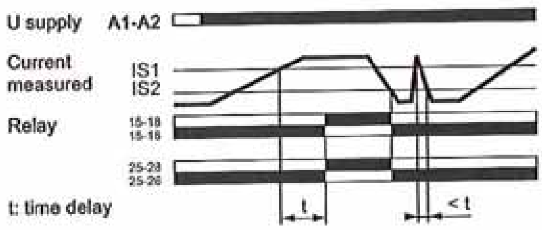
Hysteresis (h) is adjustable between 5 and 30%. For overcurrent, $h = (IS1 - IS2)/IS1$; for undercurrent, $h = (IS2 - IS1)/IS2$. A measuring cycle lasts only 80 ms, allowing rapid detection of changes in current.

Overcurrent detection (RM4JA01 or selector on ">" for model RM4JA3•).
When the current level exceeds the threshold setting (IS1), the output relay is energized (with or without a time delay, depending on the model). When the current returns to a value (IS2) below the threshold, the relay is instantaneously de-energized. The value of IS2 depends on the hysteresis setting.

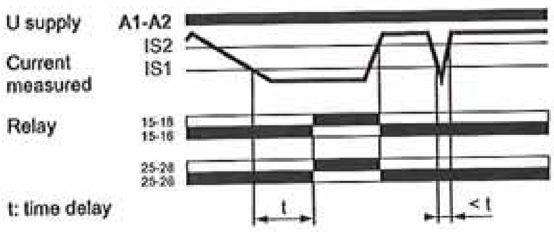
Undercurrent detection (selector on "<" for model RM4JA3• only).
When the current falls below the threshold setting (IS1), the output relay is energized (with or without a time delay, depending on the model). When the current returns to a value (IS2) above the threshold, the relay is instantaneously de-energized. The value of IS2 depends on the hysteresis setting.

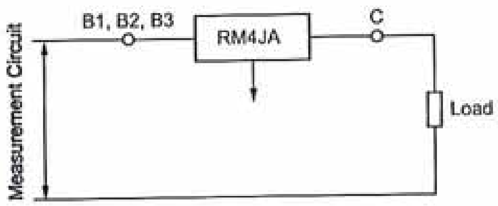
Function Diagrams:

Overcurrent Detection



Undercurrent Detection





NOTE: The measurement ranges can be extended using a current transformer whose secondary is connected to the terminals of the corresponding RM4 relay, or using a resistor connected in parallel with the measuring input (see the example on page 8).

Zelio® Control Measurement Relays
RM4JA Current Measurement Relays

SPECIFICATIONS

Power Supply Circuit Specifications

Type of Relay		RM4JA01			RM4JA31 and RM4JA32			
Rated Supply Voltage (Un)	Vac 50/60 Hz	24	110–130	220–240	24–240	110–130	220–240	380–415
	Vdc	–	–	–	24–240	–	–	–
Average Consumption at Un	VA (Vac)	2	1.9–3.3	2.7–3.5	1.5–3.3	1.9–3.3	2.7–3.4	2.7–3
	W (Vdc)	–	–	–	1.2	–	–	–

Output Relay and Operating Specifications

Type of Relay	RM4JA01	RM4JA31 and RM4JA32
Number of C/O Contacts SPDT	1	2
Output Relay State	Energized when: current measured > threshold setting	Energized when: current measured > threshold setting (">" function) current measured < threshold setting ("<" function)
Switching Threshold Setting Accuracy	As a percentage of the full scale value: ±5%	
Switching Threshold Drift	≤ 0.06% per °C, depending on the permissible ambient temperature	
	≤ 0.5%, within the supply voltage range (0.85–1.1 Un)	
Hysteresis (adjustable)	5–30% of the current threshold setting	
Time Delay Setting Accuracy	As a percentage of the full scale value: ±10%	
Time Delay Drift	–	≤ 0.07% per °C, depending on temperature
		≤ 0.5%, within the supply voltage range (0.85–1.1 Un)
Measuring Cycle	≤ 80 ms	

Measuring Input Specifications

Internal Input Resistance and Permissible Overload Depending on the Current Measurement Ranges

Type of Relay	RM4JA01 and RM4JA31			RM4JA32		
Measurement Range 50–60 Hz Vac/Vdc	3–30 mA	10–100 mA	0.1–1 A	0.3–1.5	1–5 A	3–15 A
Internal Input Resistance Ri	33 Ω	10 Ω	1 Ω	0.06 Ω	0.02 Ω	0.006 Ω
Permissible Continuous Overload	0.05 A	0.15 A	1.5 A	2 A	7 A	20 A
Permissible Non-Repetitive Overload for t ≤ 3 s	0.2 A	0.5 A	5 A	10 A	15 A	100 A


RM4JA01

SELECTION

Current Measurement Relays: Overcurrent Detection

Time Delay	Current to be Measured Depending on Connection Vac or Vdc	Width in. (mm)	Output Relay	Supply Voltage 50/60 Hz	Catalog Number	Weight lb (kg)
None	3–30 mA 10–100 mA 0.1–1 A	0.87 in. (22.5 mm)	1 C/O-SPDT	24 Vac	RM4JA01B	0.38 (0.172)
				110–130 Vac	RM4JA01F	0.38 (0.172)
				220–240 Vac	RM4JA01M	0.38 (0.172)

Current Measurement Relays: Overcurrent or Undercurrent Detection

Adjustable Time Delay	Current to be Measured Depending on Connection Vac or Vdc	Width in (mm)	Output Relay	Supply Voltage 50/60 Hz	Catalog Number	Weight lb (kg)
0.05–30 s	3–30 mA 10–100 mA 0.1–1 A	0.87 in. (22.5 mm)	2 C/O-DPDT	24–240 Vac/Vdc	RM4JA31MW	0.38 (0.172)
				110–130 Vac	RM4JA31F	0.38 (0.172)
				220–240 Vac	RM4JA31M	0.38 (0.172)
				380–415 Vac	RM4JA31Q	0.38 (0.172)
	0.3–1.5 A 1–5 A 3–15 A	1.77 in. (45 mm)	2 C/O-DPDT	24–240 Vac/Vdc	RM4JA32MW	0.45 (0.204)
				110–130 Vac	RM4JA32F	0.45 (0.204)
				220–240 Vac	RM4JA32M	0.45 (0.204)
				380–415 Vac	RM4JA32Q	0.45 (0.204)

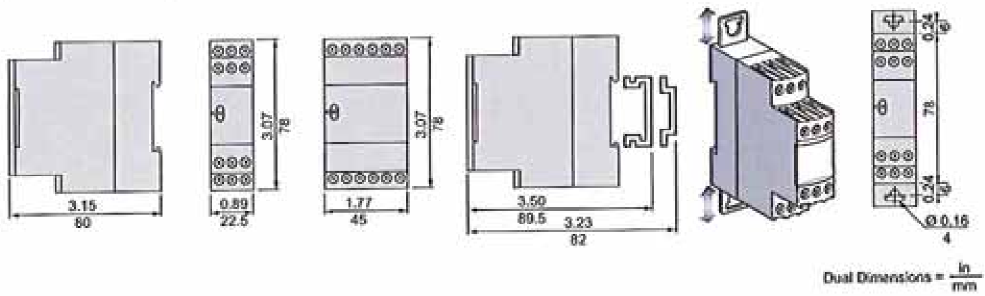

RM4JA32

For additional application data, refer to page 2.

 Telemecanique

DIMENSIONS (approximate)

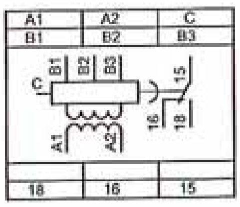
RM4JA (common side view) **RM4JA•1** **RM4JA32** **Rail Mounting** **Direct Mounting**



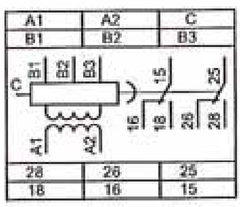
WIRING

Terminal Blocks

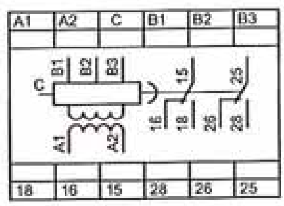
RM4JA01



RM4JA31



RM4JA32

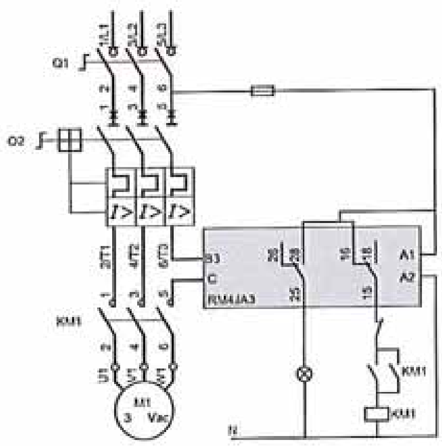


Connection and current values to be measured, depending on type of **RM4JA**					
RM4JA01 and RM4JA31	B1–C	3–30 mA	**RM4JA32**	B1–C	0.3–1.5 A
A1–A2 Supply voltage	B2–C	10–100 mA		B2–C	1–5 A
B1, B2, B3, C Currents to be measured (see table to right)	B3–C	0.1–1 A		B3–C	3–15 A

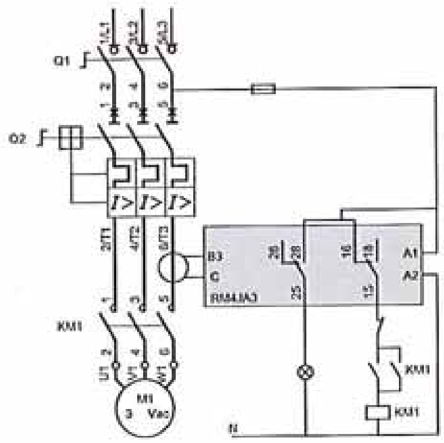
Application Diagrams

Example: Detection of a blockage on a crusher (overcurrent function)

Current measured ≤ 15 A



Current measured > 15 A



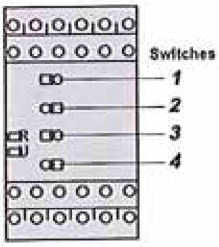
 Telemecanique

Example: Measuring Overcurrent

Overcurrent threshold at: 13 A
Output relay time delay (t): 5 s

Reset current threshold: 11 A
Supply voltage: 120 Vac

- Product selected **RM4JA32MW**
  Connection of current being measured: B3–C (3 to 15 A)



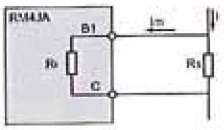
Adjustments

- Function and timing range, Switch 4 (see page 4 for a detailed list of switch positions)
  - Determine whether overcurrent or undercurrent detection is required (in this example, overcurrent).
  - Determine the timing range, and select a time exceeding the time required from page 4 (in this example, 10 s).
  - Set Switch 4 according to the criteria above (in this example, set Switch 4 to **> 10**).
- Time delay, Switch 3
  Depending on the maximum range setting displayed on Switch 4 (in this example, 10 s), use the potentiometer, Switch 3, to set the required time delay as a percentage of the value on Switch 4.
  In this example, the required time (t) = 5 s, therefore:

  $$\frac{t \times 100}{\text{Time range of Switch 4}} = \frac{5 \times 100}{10} = 50\%$$ Set time delay potentiometer, Switch 3, to **50**
- Current-threshold setting potentiometer, Switch 1, set as a percentage of the maximum value of the measuring range selected when wiring
  In this example: Wiring B3–C, the maximum value of the measurement range = 15 A, therefore:

  $$\text{Switch } 1 = \frac{13 \times 100}{15} = 87\%$$ Set the current threshold setting potentiometer, Switch **1**, to **87**.
- Hysteresis, Switch 2, set as a percentage of the threshold value
  In this example:

  $$\text{Switch } 2 = \frac{13 - 11}{13} = 15.4\%$$ Set the hysteresis, Switch 2, to **15**



Extension of the Measurement Range

AC or DC Supply

Connect a resistor, Rs, to terminals B1–C (or B2–C or B3–C) on the measuring input.

The relay energization threshold will be in the center of the setting potentiometer range if the value of Rs is equal to:

$$Rs = \frac{Ri}{(2I/Im) - 1}$$

where:

Ri	Internal resistance of input B1–C.
Im	Maximum value of the threshold setting range.
I	Current threshold to be measured.

Power dissipated by Rs: $P = Rs(I - Im/2)^2$

Application

- Using relay **RM4JA31••** (10–100 mA)
- Connecting B2–C to measure a threshold of 1 A, given that Ri = 10 Ω for this rating and Im = 100 mA

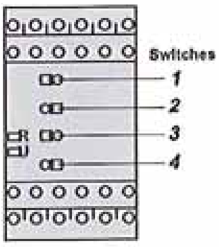
$$Rs = \frac{10}{(2 \times 1 / 0.1) - 1} = 0.526\ \Omega$$ **therefore:** $$P = \left(1 - \frac{0.1}{2}\right)^2 \times 0.526 = 0.47\ W$$

Select a resistor, Rs, capable of dissipating at least twice the calculated value (1 W for this example) to limit temperature rise.
On an AC supply, a current transformer could be used.

Example: Measuring Undercurrent

Undercurrent threshold at: 8 A
Output relay time delay (t): 5 s
Reset current threshold: 9 A
Supply voltage: 120 Vac

- Product selected **RM4JA32MW**
  Connection of current being measured: B3–C (3 to 15 A)



Adjustments

- Function and timing range, Switch 4 (see page 4 for a detailed list of switch positions)
  — Determine whether overcurrent or undercurrent detection is required (in this example, undercurrent).
  — Determine the timing range, and select a time exceeding the time required from page 4 (in this example, 10 s).
  — Set Switch 4 according to the criteria above (in this example, set Switch 4 to **< 10**).
- Time delay, Switch 3
  Depending on the maximum range setting displayed on Switch 4 (in this example, 10 s), use the potentiometer, Switch 3, to set the required time delay as a percentage of the value on Switch 4.
  In this example, the required time (t) = 5 s, therefore:
  $\frac{t \times 100}{\text{Time range of Switch 4}} = \frac{5 \times 100}{10} = 50\%$ Set time delay potentiometer, Switch 3, to **50**
- Current-threshold setting potentiometer, Switch 1, set as a percentage of the maximum value of the measuring range selected when wiring
  In this example: Wiring B3–C, the maximum value of the measurement range = 15 A, therefore:
  $\text{Switch 1} = \frac{8 \times 100}{15} = 53\%$ Set the current threshold setting potentiometer, Switch 1, to **53**.
- Hysteresis, Switch 2, set as a percentage of the threshold value
  In this example:
  $\text{Switch 2} = \frac{9-8}{9} = 11.1\%$ Set the hysteresis, Switch 2, to **11**

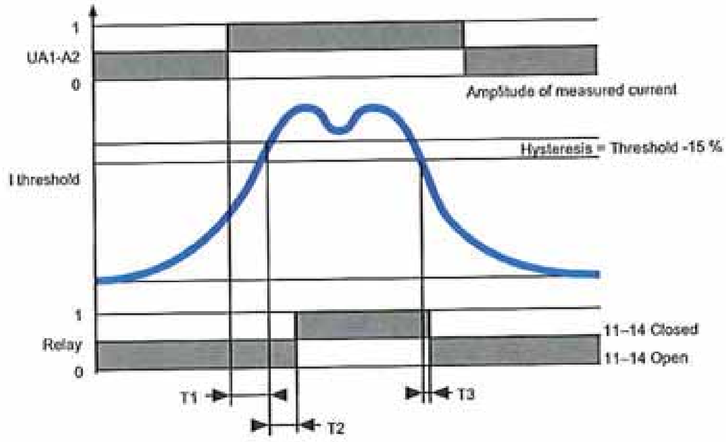
Zelio® Control Measurement Relays
RM84871 Current Measurement Relays

- *Current transformer incorporated by passing a cable through the front panel*
- *AC current threshold adjustable from 1–20 A (30 Hz to 400 Hz) via button on front panel*
- *Relay output 5 A–250 Vac–1 N/O contact*
- *Multivoltage supply:*
  - *— 110–240 Vac, 50/60 Hz,*
  - *— 24 Vac/Vdc*
- *17.5 mm enclosure, clips onto symmetrical 35 mm DIN rail*

OPERATING PRINCIPLE

The relay contact (11 and 14) closes when the current value exceeds the threshold.

The relay contact (11 and 14) opens when the current value falls below 15% (hysteresis) of the threshold.

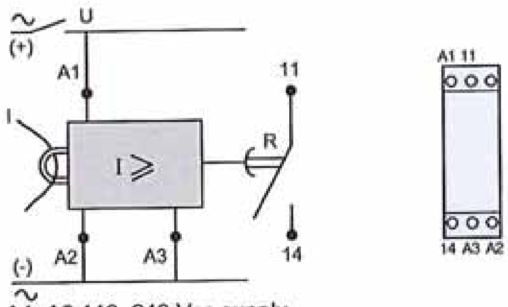


T1: Delay on pick-up 500 ms maximum

T2: Response time to sensing 400 ms ±50%

T3: Response time on de-energization 120 ms ±50%

WIRING



A1–A2 110–240 Vac supply

A1–A3 24 Vac or Vdc supply

RM84871102

SELECTION

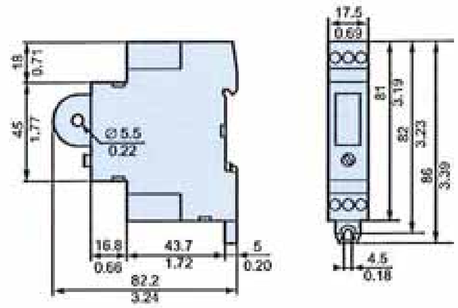
AC current control relays

Voltage	Catalog Number	Weight oz (kg)
24 Vac/Vdc; 110–240 Vac	RM84871102	2.8 (0.080)

NOTE: The graduated set-point scale on the front panel relates to sinusoidal or delta current measurement. The relay can measure non-sinusoidal currents, for example, currents subject to phase control. In this case, an error coefficient may be assigned to the display; this coefficient is a function of the tripping angle of the phase controller (form factor).

Supply characteristics			
Supply voltage Un		V	24Vac/Vdc; 110–240 Vac
Frequency		Hz	50/60
Operating range			±15% for 24 Vac/Vdc; -15 to +10% from 110 to 240 Vac
Maximum consumption	24 Vac	VA	1
	240 Vac	VA	9
	24 Vdc	W	0.6
Temperature drift			0.06% per °C
Repeat accuracy			0.45%
Relative humidity			95%
Input characteristics			
Measured current range		A	1–20 sinusoidal
Frequency range of measured current		Hz	30–400
Setting accuracy		A	±10% of the maximum scale value
Switching hysteresis			15% of the set value
Maximum continuous current		A	40
Accidental overload current		A	100 A for 3 s
Response time to sensing	t2	ms	400 ±50%
	t3	ms	120 ±50%
Delay on pick-up	t1	ms	500 max.
Output circuit characteristics			
Output			1 N/O contact (AgCdO)
Breaking capacity		VA	1250
Maximum breaking current		A	5 (AC or DC)
Minimum breaking current		mA	10 (AC or DC)
Maximum switching voltage		V	250 Vac/Vdc
Mechanical life			30 × 10^5 operating cycles ▲
Electrical life			10^5 operating cycles at 1250 VA resistive ▲
Terminal capacity	With cable end	AWG (mm^2)	Two #16 (1.5)
	Without cable end	AWG (mm^2)	Two #14 (2.5)
Other characteristics			
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60)
	Storage	°F (°C)	-22 to +158 (-30 to +70)
Dielectric strength	Conforming to IEC 255-5	kV	2.5/1 min/1 mA/50 Hz
Approvals	cULus File 173076 CCN NRNT; File 173076 CCN NRNT 7		CSA File 217698 Guide 3211 07; CE

DIMENSIONS (approximate)

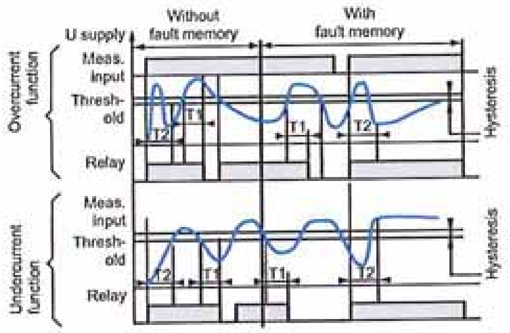


Dimensions: $\frac{mm}{in.}$

▲ The expected life expressed above is based on average usage and normal operating conditions. Actual operating life will vary with conditions. The above statements are not intended to nor shall they create any expressed or implied warranties as to product operation or life. For information on the listed warranty offered on this product, refer to the Square D terms and conditions of sale found in the *Digest*.

Zelio® Control Measurement Relays
RM84871 Current Measurement Relays

- *Space savings, accurate measurement, and optimized functions improve the safety of your electrical installation.*
- *A DIP switch on the underside of the unit allows you to:*
  - *Select Overcurrent or Undercurrent mode.*
  - *Choose whether to activate the fault memory function, and to set the threshold crossing delay T1 and the inhibit time delay T2.*
    AC/DC mode is detected automatically.
- *Accuracy: three products allow you to choose the best product for greater measuring accuracy, provided by a microprocessor.*



OPERATING PRINCIPLE

Control of AC/DC current without memory

When the value of the controlled current (either AC or DC) reaches the threshold displayed on the front panel, the output relay changes state at the end of time delay T1.

It instantly returns to the initial state when the current drops below the hysteresis threshold, or when the power supply is disconnected.

Control of AC/DC current with memory

The output relay changes state at the end of time delay T1 and remains latched in this position. To reset it, the memory function must be reactivated by disconnecting the auxiliary supply.

Overcurrent function

The time delay on energization, T2, prevents current peaks due to motor starting.

The delay on upward crossing of the threshold, T1, provides immunity to transients and other interference, preventing false triggering of the output relay.

Undercurrent function

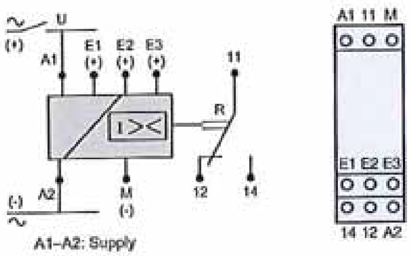
The time delay on energization, T2, prevents the occurrence of current troughs.

The delay on downward crossing of the threshold, T1, provides immunity to random dips, preventing false triggering of the output relay.

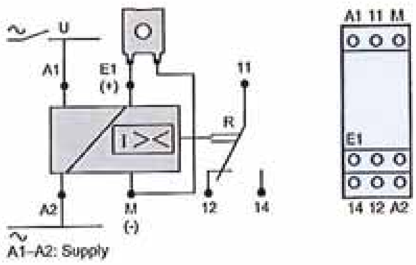
NOTE: In Undercurrent mode, the absolute value of the hysteresis cannot exceed the measurement range maximum.

WIRING

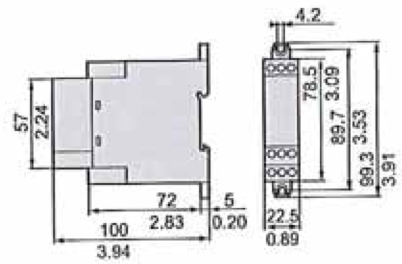
RM8487102p, RM8487103p



RM84871044



DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

Télémecanique

SELECTION

RM848710••

Current control relay

Measurement range	Supply voltage	Catalog Number	Weight, oz (kg)
2–500 mA	24 Vac	RM84871021	5.3 (0.150)
	120 Vac	RM84871023	5.3 (0.150)
	230 Vac	RM84871024	5.3 (0.150)
0.1–10 A	24 Vac	RM84871031	5.3 (0.150)
	120 Vac	RM84871033	5.3 (0.150)
	230 Vac	RM84871034	5.3 (0.150)
10–100 A with current transformer	230 Vac	RM84871044	5.3 (0.150)

Accessories

Description	Catalog Number	Weight, oz (kg)
Current transformer	RM26852304	2.3 (0.065)

Auxiliary supply characteristics

Relay type			RM84871021 RM84871023 RM84871024	RM84871031 RM84871033 RM84871034	RM84871044
Supply voltage Un		V	24, 120, 230 50/60 Hz (galvanic isolation by transformer)		230 50/60 Hz
Operating range			0.8–1.15 Un		
Average consumption		VA	3		

Output characteristics

Output relay			1 cadmium-free C/O contact
Rated current		A	8
Switching voltage		Vac	250
Maximum voltage		Vac	440
Rated breaking capacity		VA	2000
Minimum breaking current		mA	100 at 12 Vdc
Electrical life	AC-12		10^5 operating cycles at 8 A at 250 Vac (see ▲ on page 11)
Mechanical life			2×10^7 operating cycles (see ▲ on page 11)
Time delay	On crossing threshold T1	s	0,1–3 ±10%
	On energization T2	s	1–20 ±10%

Input characteristics

Measurement range		mA	2–500			–			–
		A	–			0.1–10			10–100 with current transformer
Frequency of the measured signal		Hz	40–500						
Adjustable hysteresis			5–50% of the threshold setting						
Threshold value			10–100% of the range						
Threshold setting accuracy			±10%						
Measurement ranges	Inputs		E1-M	E2-M	E3-M	E1-M	E2-M	E3-M	E1-M
	Sensitivity	mA	2–20	10–100	50–500	–	–	–	–
		A	–	–	–	0.1–1	0.5–5	1–10	10–100
	Input resistance	kΩ	5	1	0.2	0.1	0.2	0.01	4

Other characteristics

Temperature		°F (°C)	**Operation:** -4 to +122 (-20 to +50); **Storage:** -40 to +178 (-40 to +70)
Relative humidity	Without condensation		95%
Enclosure material			Self-extinguishing
Degree of protection	Conforming to IEC 60529		Enclosure: IP 40D, terminal block: IP 20
Connection	Stranded wire	AWG (mm²)	**Without cable end:** One #12 (4) or two #14 (2.5); **with cable end:** two #16 (1.5)
Tightening torque		lb-in (N•m)	8.8 (1)
Dielectric strength	Conforming to IEC 60255-5	kV	2.5 for 1 minute at 1 mA, 50 Hz
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Vibration resistance	Conforming to IEC 60068-2-6		a = 0.035 mm (0.0014 in.)
Approvals	cULus File 173076 CCN NRNT File 173076 CCN NRNT 7		CSA File 217698 Guide 3211 07; CE

Immunity to electromagnetic interference (EMC) (application class 2 conforming to EN 61812-1)

Electrostatic discharge	Conforming to IEC/EN 61000-4-2	Level 3 (6 kV contact, 8 kV air)
Electromagnetic fields	Conforming to IEC/EN 61000-4-3	Level 3 (10 V/m)
Fast transients	Conforming to IEC/EN 61000-4-4	Level 3 (2 kV)
Shock waves	Conforming to IEC/EN 61000-4-5	Level 3 (2 kV)
Radio frequencies	Conforming to IEC/EN 61000-4-6	Level 3 (10 V rms)
Voltage dips and breaks	Conforming to IEC/EN 61000-4-11	30% for 10 ms, 60% for 100 ms and 1 s, > 95% for 5 s and 10 ms
Damped oscillatory wave at 1 MHz	Conforming to IEC 61255-22-1	Class III
Radiated and conducted emissions		Class B

Zelio® Control Measurement Relays
RM4UA Voltage Measurement Relays

RM4UA01

FUNCTIONS

These devices detect when voltage exceeds a pre-set threshold on an AC or DC supply. They have a transparent, hinged cover on the front face to prevent accidental alteration of the settings. This cover can be sealed.

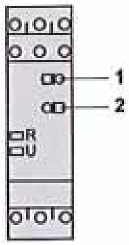
Type of Relay	Overvoltage Control	Overvoltage or Undervoltage Control ■	Measuring Range
RM4UA0•	Yes	No	50 mV to 500 V
RM4UA3•	Yes	Yes	50 mV to 500 V

Applications

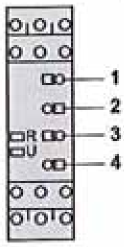
- DC motor overspeed control
- Battery monitoring
- Monitoring of AC or DC supplies
- Speed monitoring (with tacho-generator)

PRESENTATION

RM4UA0•
Width 0.89 in (22.5mm)



RM4UA3•
Width 0.89 in (22.5mm)



1 Adjustment of the voltage threshold as a percentage of the setting range maximum value.
2 Hysteresis adjustment from 5–30%. ▲
3 Adjustment of the time delay as a percentage of the setting range maximum value.
4 Switch combining:
— selection of the timing range: 1s, 3s, 10s, 30s, no time delay
— selection of overvoltage (>) or undervoltage (<) detection. See table below.
R Yellow LED: Indicates relay state (off for de-energized relay, on for energized relay).
U Green LED: Indicates that supply to the RM4 is present.

Details for Switch 4

Switch Position	Function	Time Delay (t)
< 0	Undervoltage detection	No time delay
< 1	Undervoltage detection	0.05 to 1 s
< 3	Undervoltage detection	0.15 to 3 s
< 10	Undervoltage detection	0.5 to 10 s
< 30	Undervoltage detection	1.5 to 30 s
> 0	Overvoltage detection	No time delay
> 1	Overvoltage detection	0.05 to 1 s
> 3	Overvoltage detection	0.15 to 3 s
> 10	Overvoltage detection	0.5 to 10 s
> 30	Overvoltage detection	1.5 to 30 s

■ Selection by the switch on the front face.
▲ Value of the voltage difference between energization and de-energization of the output relay (% of the voltage threshold to be measured).

OPERATING PRINCIPLE

The supply voltage is connected to terminals A1–A2.
The voltage to be monitored is connected to terminal B1, B2, or B3 and terminal C.

Hysteresis (h) is adjustable from 5–30%:
for overvoltage, $h = (US1 - US2) / US1$; for undervoltage, $h = (US2 - US1) / US2$.
A measurement cycle lasts only 80 ms, allowing rapid detection of voltage changes.

Relays set for **overvoltage** detection (RM4UA0• or selector on ">" for model RM4UA3•):

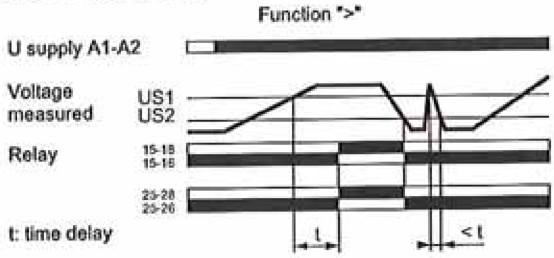
When the voltage exceeds threshold setting US1, the output relay is energized (with or without a time delay). When the voltage returns to value US2 below the threshold, the relay is instantaneously de-energized. The value of US2 depends on the hysteresis setting.

Relays set for **undervoltage** detection (selector on "<", model RM4UA3• only):

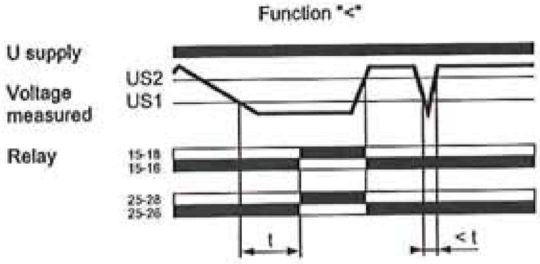
When the voltage falls below threshold setting US1, the output relay is energized (with or without a time delay). When the voltage returns to value US2 above the threshold, the relay is de-energized. The value of US2 depends on the hysteresis setting.

Function Diagrams

Overvoltage Control



Undervoltage Control



NOTE: The measurement ranges can be extended above 500 V by adding a resistor (see page 18). The measurement range on an AC supply can be extended using a voltage transformer whose secondary is connected to the measuring terminals of the corresponding RM4 relay.

Zelio® Control Measurement Relays
RM4UA Voltage Measurement Relays

SPECIFICATIONS

Power Supply Circuit Specifications

Type of Relay		RM4UA0•			RM4UA3•			
Rated Supply Voltage (Un)	Vac 50/60 Hz	24	110–130	220–240	24–240	110–130	220–240 V	380–415
	Vdc	–	–	–	24–240	–	–	–
Average Consumption at Un	VA (Vac)	2	1.9–3.3	2.7–3.5	1.5–3.3	1.9–3.3	2.7–3.4	2.7–3
	W (Vdc)	–	–	–	1.2	–	–	–

Output Relay and Operating Specifications

Type of Relay	RM4UA0•	RM4UA3•
Number of C/O Contacts, SPDT	1	2
Output Relay State	Energized when: voltage measured > threshold setting	Energized when: voltage measured > threshold setting (">" function) voltage measured < threshold setting ("<" function)
Switching Threshold Setting Accuracy	As a percentage of the full scale value: ±5%	
Switching Threshold Drift	≤ 0.06% per °C, depending on the permissible ambient temperature ≤ 0.5%, within the supply voltage range (0.85–1.1 Un)	
Hysteresis (adjustable)	5–30% of the voltage threshold setting	
Time Delay Setting Accuracy	As a percentage of the full scale value: ±10%	
Time Delay Drift	–	≤ 0.5%, within the supply voltage range (0.85–1.1 Un)
Measuring Cycle	≤ 80 ms	≤ 0.07% per °C, depending on the rated operating temperature

Measuring Input Specifications

Internal Input Resistance and Permissible Overload Depending on the Current Measurement Ranges

Type of Relay	RM4UA•1			RM4UA•2			RM4UA•3	
Measurement Range 50–60 Hz Vac and Vdc (V)	0.05–0.5	0.3–3	0.5–5	1–10	5–50	10–100	30–300	50–500
Internal Input Resistance Ri (kΩ)	6.6	43	71	23	112	225	668	1111
Permissible Continuous Overload (V)	20	60	80	90	150	300	400	550
Permissible Non-Repetitive Overload for t ≤ 1 s (V)	25	80	100	100	200	400	500	550

SELECTION

Voltage Measurement Relays: Overvoltage Detection

RM4UA01

Time Delay	Voltage to be Measured Depending on Connection (Vac or Vdc)	Width in. (mm)	Output Relay	Supply Voltage 50/60 Hz	Catalog Number	Weight lb (kg)
None	0.05–0.5 V 0.3–3 V 0.5–5 V	0.87 (22.5)	1 C/O–SPDT	24 Vac	RM4UA01B	0.37 (0.168)
				110–130 Vac	RM4UA01F	0.37 (0.168)
				220–240 Vac	RM4UA01M	0.37 (0.168)
	1–10 V 5–50 V 10–100 V	0.87 (22.5)	1 C/O–SPDT	24 Vac	RM4UA02B	0.37 (0.168)
				110–130 Vac	RM4UA02F	0.37 (0.168)
				220–240 Vac	RM4UA02M	0.37 (0.168)
	30–300 V 50–500 V	0.87 (22.5)	1 C/O–SPDT	24 Vac	RM4UA03B	0.37 (0.168)
				110–130 Vac	RM4UA03F	0.37 (0.168)
				220–240 Vac	RM4UA03M	0.37 (0.168)

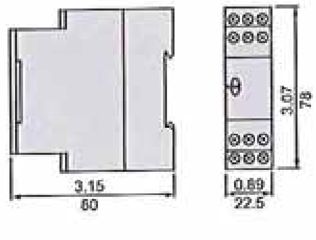
Voltage Measurement Relays: Overvoltage or Undervoltage Detection

Adjustable Time Delay	Voltage to be Measured Depending on Connection (Vac or Vdc)	Width in. (mm)	Output Relay	Supply Voltage 50/60 Hz	Catalog Number	Weight lb (kg)
0.05–30 s	0.05–0.5 V 0.3–3 V 0.5–5 V	0.87 (22.5)	2 C/O–DPDT	24–240 Vac/Vdc	RM4UA31MW	0.37 (0.168)
				110–130 Vac	RM4UA31F	0.37 (0.168)
				220–240 Vac	RM4UA31M	0.37 (0.168)
				380–415 Vac	RM4UA31Q	0.37 (0.168)
	1–10 V 5–50 V 10–100 V	1.77 (45)	2 C/O–DPDT	24–240 Vac/Vdc	RM4UA32MW	0.37 (0.168)
				110–130 Vac	RM4UA32F	0.37 (0.168)
				220–240 Vac	RM4UA32M	0.37 (0.168)
				380–415 Vac	RM4UA32Q	0.37 (0.168)
	30–300 V 50–500 V	1.77 (45)	2 C/O–DPDT	24–240 Vac/Vdc	RM4UA33MW	0.37 (0.168)
				110–130 Vac	RM4UA33F	0.37 (0.168)
				220–240 Vac	RM4UA33M	0.37 (0.168)
				380–415 Vac	RM4UA33Q	0.37 (0.168)

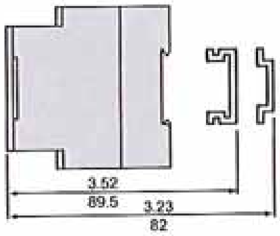
For additional application data, refer to page 2.

DIMENSIONS

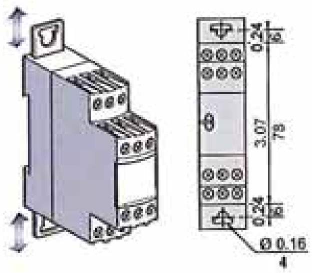
RM4UA
(common side view)



Rail Mounting



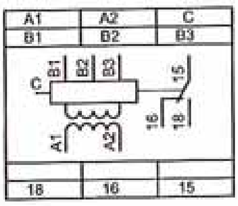
Direct Mounting



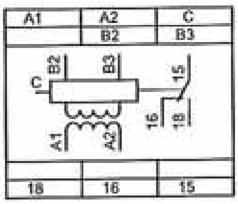
Dual Dimensions = in/mm

WIRING CONNECTIONS

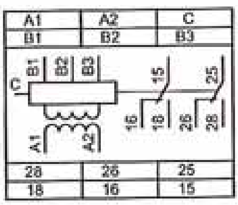
Terminal Blocks
RM4UA01, UA02



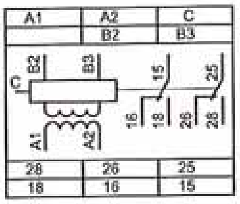
RM4UA03



RM4UA31, UA32



RM4UA33

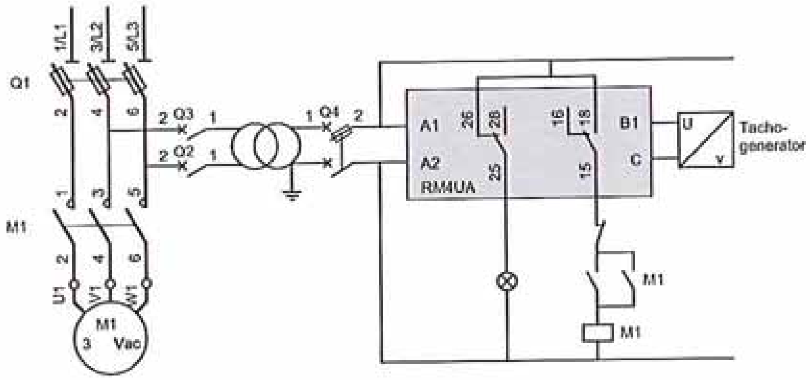


Connection and current values to be measured, depending on type of RM4UA

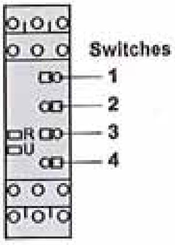
RM4UA•1	B1–C	0.05–0.5 V	**RM4UA•2**	B1–C	1–10 V	**RM4UA•3**	B2–C	30–300 V
A1–A2 supply voltage	B2–C	0.3–3 V		B2–C	5–50 V		B3–C	50–500 V
B1, B2, B3, C Voltages to be measured (see table to right)	B3–C	0.5–5 V		B3–C	10–100 V			

Application Diagrams

Example: Overspeed Monitoring (Undervoltage Function)



Example: Measuring Undervoltage



Product selected: **RM4UA32F**
Connection of voltage to be measured: B2–C (5–50 V)

- Undervoltage threshold: 12 Vdc
- Time delay of the output relay (t): 20 s
- Reset voltage threshold: 13.2 V
- Supply voltage: 120 Vac/60 Hz

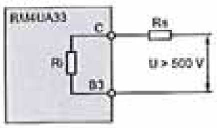
Adjustments:

- Adjustment of function and timing range, Switch 4 (see page 14 for a detailed list of switch positions):
  - — Determine whether overvoltage or undervoltage detection is required; in this example undervoltage.
  - — Determine the timing range and select a time exceeding the time required; in this example, 30 s.
  - — Position Switch 4 according to the criteria above (in this example, set Switch 4 to **< 30**).
- Fine adjustment of time delay:
  Depending on the maximum range setting displayed on Switch 4 (in this example, 30 s), use the potentiometer, Switch 3, to set the required time delay as a percentage of the value on Switch 4.
  In this example, the required time = 20 s. Therefore:
  $$\frac{t \times 100}{\textit{Timing range of Switch 4}} = \frac{20 \times 100}{30} = 66\%$$
  Set the time delay potentiometer, Switch 3, to **66**.
- Set the voltage threshold setting potentiometer, Switch 1, as a percentage of the maximum value of the measuring range selected when wiring.
  In this example: wiring is B2–C; the maximum value of the measuring range = 50 V; and the undervoltage threshold = 12 Vdc. Therefore:
  $$\textit{Setting of Switch 1} = \frac{12 \times 100}{50} = 24\%$$
  Set the voltage threshold setting potentiometer, Switch 1, to **24**.

  Set the hysteresis, Switch 2, as a percentage of the threshold value; in this example:
  $$\textit{Setting of Switch 2} = \frac{13.2 - 12}{13.2} = 9\%$$
  Set the hysteresis, Switch 2, to **9**.

Extension of the Measuring Range

AC or DC Supply



Simply connect a resistor, Rs, in series with the measuring input, B3 or C.

If the value of Rs is equal to:

$$Rs = Ri\left(\frac{U}{Um} - 1\right)$$

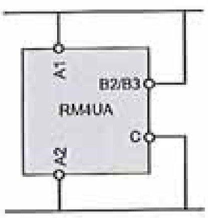
where:

Ri	Internal resistance of input B3–C.
Um	Maximum value of threshold setting range.
U	Voltage threshold to be measured.

The tripping threshold of the relay will be toward the maximum graduation on the threshold setting potentiometer. In general, the power consumed by the resistor does not exceed 0.5 W.

For AC voltages, it is also possible to use a voltage transformer.

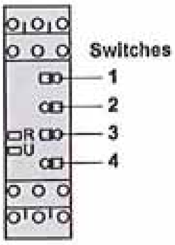
Supply by the Measured Voltage



For monitoring mains and power supplies, the RM4UA can be supplied by the voltage to be controlled, if:

- The measurement threshold is within the operating range of the product's power supply (0.85–1.1 Uc)
- Variations of the voltage to be measured are compatible with the supply and measurement voltage ranges

Example: Measuring Overvoltage



Product selected **RM4UA32F**
Connection of voltage to be measured B2–C (5–50 V)

- Overvoltage threshold: 12 Vdc
- Time delay of the output relay (t): 20 s
- Reset voltage threshold: 11 Vdc
- Supply voltage: 120 Vac/60 Hz

Adjustments:

- Adjustment of function and timing range, Switch 4 (See page 14 for a detailed list of switch positions):
  - — Determine whether overvoltage or undervoltage detection is required; in this example overvoltage.
  - — Determine the timing range and select a time exceeding the time required; in this example, 30 s.
  - — Position Switch 4 according to the criteria above; in this example, Switch 4 on **> 30**.
- Fine adjustment of time delay:

  Depending on the maximum range setting displayed on Switch 4 (in this example, 30 s), use the potentiometer, Switch 3, to set the required time delay as a percentage of the value on Switch 4.

  In this example, the required time = 20 s. Therefore:

  $$\frac{t \times 100}{\textit{Timing range of Switch 4}} = \frac{20 \times 100}{30} = 66\%$$

  Set the time delay potentiometer, Switch 3, to **66**.
- Set the voltage threshold setting potentiometer, Switch **1**, as a percentage of the maximum value of the measuring range selected when wiring.

  In this example: wiring is B2–C; the maximum value of the measuring range = 50 V; and the overvoltage threshold = 12 Vdc. Therefore:

  $$\textit{Setting of Switch 1} = \frac{12 \times 100}{50} = 24\%$$

  Set the voltage threshold setting potentiometer, Switch 1, to **24**.

  Set the hysteresis, Switch 2, as a percentage of the threshold value; in this example:

  $$\textit{Setting of Switch 2} = \frac{12 - 11}{12} = 8.3\%$$

  Set the hysteresis, Switch 2, to **8**.

- *Space savings, accurate measurement, and optimized functions improve the safety of your electrical installation.*
- *Assurance that equipment is working under the correct conditions by checking the supply voltage.*
- *Using a DIP switch:*
  - *— Select Overvoltage or Undervoltage mode.*
  - *— Choose whether to activate the fault memory function and the delay on threshold crossing.*
- *Accuracy: two products for greater measuring accuracy, provided by a microprocessor.*

OPERATING PRINCIPLE

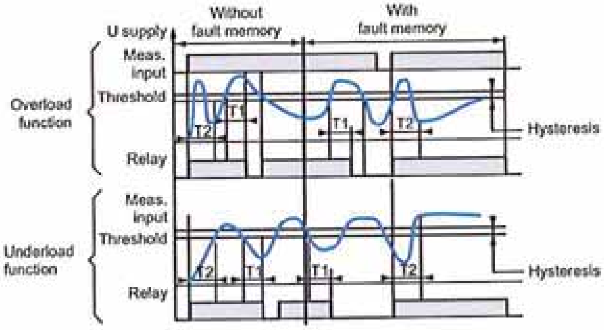
Control of AC/DC voltage without memory

When the value of the controlled voltage (AC or DC) reaches threshold Ue displayed on the front panel, the output relay changes state at the end of time delay T1, which can be set on the front panel to between 0.1 and 3 s.

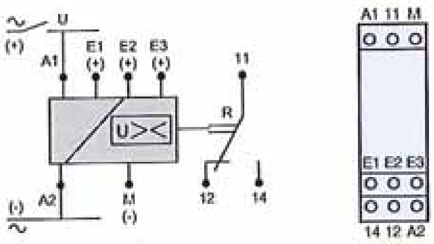
As soon as the voltage drops below 5–50% of the threshold (hysteresis), the output relay instantly changes state again. Changing the hysteresis on the front panel does not modify the value of the pre-set threshold.

Control of AC/DC voltage with memory

When the value of the controlled voltage (AC or DC) reaches threshold Ue displayed on the front panel, the output relay changes state at the end of time delay T1 (which can be set between 0.1 and 3 s on the front panel) and remains latched in this position.

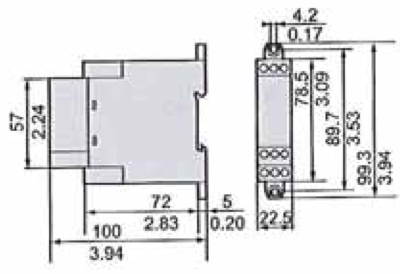


WIRING



A1–A2: Supply

DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

 Telemecanique 6/2005

RM8487203•

SELECTION

Measurement range	Supply voltage	Catalog Number	Weight, oz (kg)
0.2–60 V	24 Vac	RM84872021	4.2 (0.120)
	120 Vac	RM84872023	4.2 (0.120)
	230 Vac	RM84872024	4.2 (0.120)
15–600 V	24 Vac	RM84872031	4.2 (0.120)
	120 Vac	RM84872033	4.2 (0.120)
	230 Vac	RM84872034	4.2 (0.120)

Auxiliary supply characteristics

Relay type			RM8487202p	RM8487203p
Supply voltage, Un		V	24, 120, 230 50/60 Hz (galvanic isolation by transformer)	
Operating range			0.8–1.15 Un	
Average consumption		VA	3	

Output characteristics

Output relay			1 cadmium-free C/O contact
Rated current		A	8
Switching voltage		Vac	250
Maximum voltage		Vac	440
Rated breaking capacity		VA	2000
Minimum breaking current		mA	100 at 12 Vdc
Electrical life	AC-12		10^5 operating cycles at 8 A at 250 Vac (see ▲ on page 11)
Mechanical life			2×10^7 operating cycles (see ▲ on page 11)
Time delay	On crossing threshold T1	s	0.1–3 ±10%
	On crossing threshold T2	s	1–20 ±10%
Delay on pick-up		ms	500

Input characteristics

Measurement range		V	0.2–60			15–600		
Frequency of the measured signal		Hz	40–500					
Adjustable hysteresis			5–50% of the threshold setting					
Threshold value			10–100% of the range					
Threshold setting accuracy			±10%					
Measurement ranges	Inputs		E1-M	E2-M	E3-M	E1-M	E2-M	E3-M
	Sensitivity	V	0.2–2	1–10	6–60	15–150	30–300	60–600
	Input resistance	kΩ	2	10	60	100	300	600

Other characteristics

Temperature		°F (°C)	**Operation:** -4 to +122 (-20 to +50); **Storage:** -40 to +158 (-40 to +70)
Relative humidity	Without condensation		95%
Enclosure material			Self-extinguishing
Degree of protection	Conforming to IEC 60529		Enclosure: IP 40D, terminal block: IP 20
Connection	Without cable end	AWG (mm²)	One #12 (4) or two #14 (2.5)
Flexible cable	With cable end	AWG (mm²)	Two #16 (1.5)
Tightening torque		lb-in (N•m)	8.8 (1)
Dielectric strength	Conforming to IEC 60255-5	kV	2.5 kV for 1 min at 1 mA 50 Hz
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4 kV/3
Vibration resistance	Conforming to IEC 60068-2-6		a = 0.035 mm (0.0014 in.)
Approvals	cULus File 173076 CCN NRNT File 173076 CCN NRNT 7		CSA File 217698 Guide 3211 07	CE

Immunity to electromagnetic interference (EMC) (application class 2 conforming to EN 61812-1)

Electrostatic discharge	Conforming to IEC/EN 61000-4-2	Level 3 (6 kV contact, 8 kV air)
Electromagnetic fields	Conforming to IEC/EN 61000-4-3	Level 3 (10 V/m)
Fast transients	Conforming to IEC/EN 61000-4-4	Level 3 (2 kV)
Shock waves	Conforming to IEC/EN 61000-4-5	Level 3 (2 kV)
Radio frequencies	Conforming to IEC/EN 61000-4-6	Level 3 (10 V rms)
Voltage dips and breaks	Conforming to IEC/EN 61000-4-11	30% for 10 ms, 60% for 100 ms and 1 s, > 95% for 5 s and 10 ms
Damped oscillatory wave at 1 MHz	Conforming to IEC 61255-22-1	Class III
Radiated and conducted emissions		Class B

Zelio® Control Measurement Relays
RM84872 Voltage Measurement Relays

- *Simple to install, these threshold relays check their own supply voltage level.*
- *RM48487204•: Select Overvoltage or Undervoltage mode and the memory function via the DIP switches, then set the delay on crossing threshold T1.*
- *RM48487205•: set the required high and low voltage thresholds and the delay on crossing threshold T1.*

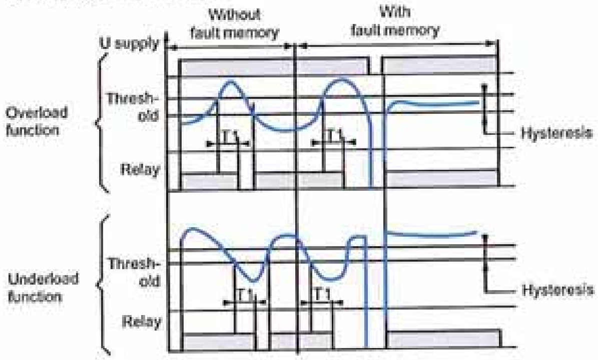
OPERATING PRINCIPLE

Overvoltage–undervoltage control with memory

Two operating modes are available:

- AC/DC voltage control without memory
- AC/DC voltage control with memory

Overvoltage–undervoltage control



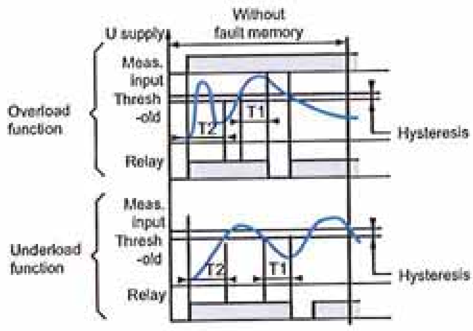
Threshold without memory

The window threshold relay controls an electrical voltage, which also acts as its power supply (for simplified wiring). When the value of the controlled voltage (AC or DC) fluctuates outside the window, the output relay de-energizes at the end of time delay T1, which can be set between 0.1 and 3 s on the front panel.

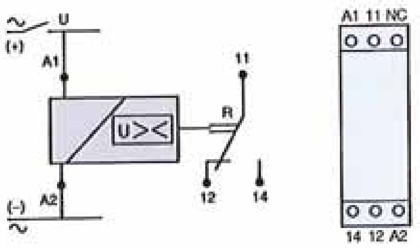
It re-energizes when the voltage returns within the window and stays between the upper and lower thresholds, displayed by two potentiometers on the front panel. A fixed hysteresis ensures bounce-free relay switching around the thresholds.

NOTE: When crossing the upper and lower thresholds, time delay T1 provides immunity to transients to prevent false triggering of the output relay.

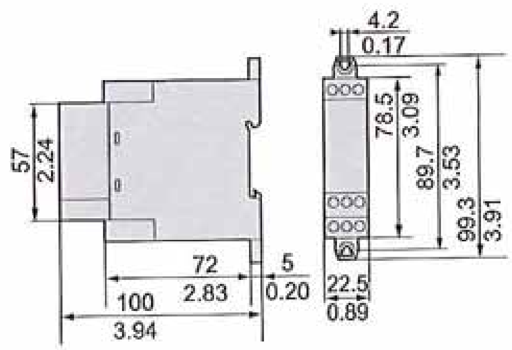
Threshold without memory



WIRING



DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

RM848720pp

SELECTION

Type	Voltage to be measured	Catalog Number	Weight, oz (kg)
With memory	20–80 Vac/Vdc	RM84872046	3.5 (0.100)
	65–260 Vac/Vdc	RM84872047	3.5 (0.100)
Without memory	20–80 Vac/Vdc	RM84872056	3.5 (0.100)
	65–260 Vac/Vdc	RM84872057	3.5 (0.100)

Supply characteristics				
Relay type			RM8487204•	RM8487205•
Supply voltage Un		Vac/Vdc	20–80, 65–260	
Operating range		V	15–150, 50–275	
Maximum consumption	260 Vac	VA	6.7	6
	80 Vac	VA	2	2
	260 Vdc	W	2	2
	80 Vdc	W	0.8	0.8
Output characteristics				
Output relay			1 cadmium-free C/O contact	
Rated current		A	8	
Switching current		Vac	250	
Maximum voltage		Vac	440	
Rated breaking capacity		VA	2000	
Minimum breaking current		mA	100 at 12 Vdc	
Electrical life	AC-12		10^5 operating cycles at 8 A at 250 Vac (see ▲ on page 11)	
Mechanical life			2×10^7 operating cycles (see ▲ on page 11)	
Time delay	On crossing threshold T1	s	0.1–3 ±10%	
Delay on pick-up		ms	500	
Input characteristics				
Relay type			Measures its own supply voltage	
Measurement range		V	20–80 or 65–260 depending on model	
Frequency of the signal measured		Hz	50–60 ±1	
Hysteresis			Adjustable 5–20%	Fixed 5%
Threshold setting accuracy			±10%	
Repeat accuracy	With constant parameters		±0.3%	
Temperature drift			±0.5% per °C	
Other characteristics				
Temperature		°F (°C)	**Operation:** -4 to +122 (-20 to +50); **Storage:** -40 to +158 (-40 to +70)	
Relative humidity	Without condensation		95%	
Enclosure material			Self-extinguishing	
Degree of protection	Conforming to IEC 60529		Enclosure: IP 40D, terminal block: IP 20	
Connection	Without cable end	AWG (mm^2)	One #12 (4) or two #14 (2.5)	
Flexible cable	With cable end	AWG (mm^2)	Two #16 (1.5)	
Tightening torque		lb-in (N•m)	8.8 (1)	
Dielectric strength	Conforming to IEC 60255-5	kV	2.5 kV for 1 min at 1 mA 50 Hz	
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4 kV/3	
Vibration resistance	Conforming to IEC 60068-2-6		a = 0.35 mm (0.014 in.)	

Approvals: cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7; CSA File 217698 Guide 3211 07; CE

Immunity to electromagnetic interference (EMC) (application class 2 conforming to EN 61812-1)		
Electrostatic discharge	Conforming to IEC/EN 61000-4-2	Level 3 (6 kV contact, 8 kV air)
Electromagnetic fields	Conforming to IEC/EN 61000-4-3	Level 3 (10 V/m)
Fast transients	Conforming to IEC/EN 61000-4-4	Level 3 (2 kV)
Shock waves	Conforming to IEC/EN 61000-4-5	Level 3 (2 kV)
Radio frequencies	Conforming to IEC/EN 61000-4-6	Level 3 (10 V rms)
Voltage dips and breaks	Conforming to IEC/EN 61000-4-11	30% for 10 ms, 60% for 100 ms and 1 s, > 95% for 5 s and 10 ms
Damped oscillatory wave at 1 MHz	Conforming to IEC 61255-22-1	Class III
Radiated and conducted emissions		Class B

- *LCD display showing the actual value and the pre-set value*
- *Automatic detection for controlling AC or DC signals*
- *Overload or underload modes selectable*
- *Threshold and hysteresis separately adjustable*
- *Memory function in the event of a fault*
- *Delay on threshold crossing*

OPERATING PRINCIPLE

These devices control an AC or DC electric signal.

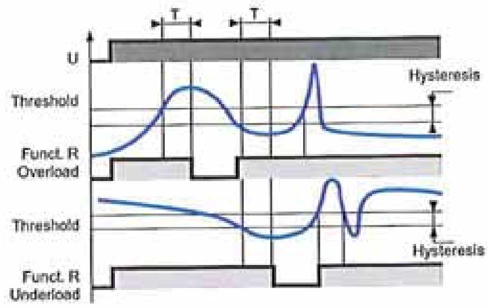
The threshold and hysteresis can be adjusted separately via two potentiometers on the front panel of the device. Before powering up the device, the operating mode must be selected using two DIP switches on the underside of the device (with/without memory, over/under value).

The mode is validated when power is applied to terminals A1–A2.

The signal to be monitored is connected between terminal E1, E2, or E3 (depending on the range) and terminal M.

Voltage or current control, without memory

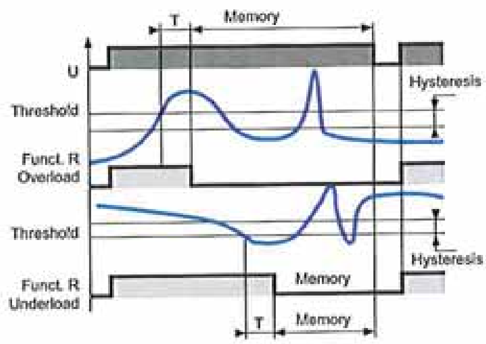
When the value of the controlled signal (AC or DC) reaches the threshold set on the front panel, the output relay opens (fail-safe) at the end of time delay T. It closes immediately when the signal falls below (or rises above, in under-value mode) the threshold minus hysteresis (plus hysteresis, in under-value mode).



Voltage or current control, with memory

When the threshold is reached, the output relay opens at the end of time delay T and remains in that position. The relay is reset by switching off the power supply.

This operating mode enables the detection of over or under values of short duration.



NOTE: The threshold-crossing time delay T, which can be adjusted on the front panel from 0.1 to 3 s, ensures immunity to transients and other interference, to prevent false triggering of the output relay.

In Under Value mode, the absolute value of the hysteresis cannot exceed the maximum of the measurement range.

Programming: display

Normal mode

In this mode, the device displays the value of the measured signal, its form (Vac or Vdc), the mode selected (OVER or UNDER), the memory function (ON or OFF), and the state of the output relay.

The display indicates a measurement overflow with three dashes on the screen and the flashing symbol OVER.

Parameter entry mode

To modify one of the three parameters (Threshold, Hysteresis or Threshold Delay), set the corresponding potentiometer. The value of the modified parameter automatically appears.

After 2 s, the current value of the measured signal reappears in the display (return to Normal mode).

Parameter display mode

To review the parameters, press the push button (VISU) several times in succession to cycle through the settings. Keep the push button depressed to scroll through the values.

Exception

In Under mode (underload), since the hysteresis always exceeds the threshold, it may exceed the maximum measurement range according to the settings *(Threshold + Hysteresis > Max. Threshold)*. To remedy this problem, when the hysteresis or threshold setting proportions exceed the management capacity, the value of the hysteresis is automatically corrected so that it does not exceed the range maximum. In addition, the UNDER symbol flashes.

Zelio® Control Measurement Relays
RM84871 Current Measurement Relays and RM84872 Voltage Measurement Relays

RM84872305

SELECTION

Control relay with LCD display: Voltage-Current

Measurement	Supply voltage	Catalog Number	Weight, oz (kg)
0.2–60 V	230 Vac	RM84872305	5.6 (0.160)
15–600 V	230 Vac	RM84872310	5.6 (0.160)
2–500 mA	230 Vac	RM84871305	5.6 (0.160)
0.1–10 A	230 Vac	RM84871310	5.6 (0.160)

Supply characteristics

Supply voltage		Vac	230 (50/60 Hz)
Operating range			0.85–1.10 × Un
Maximum power consumption		VA	3
Immunity to microbreaks		ms	10
Delay on pick-up		ms	500
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4 kV/3

Output characteristics

Relay type			1 C/O contact, AgCdO, 5 A, 250 V
Minimum current		mA	100
Mechanical life			5 to 10^6 operating cycles (see ▲ on page 11)
Electrical life	AC-12	VA	1250, 10^5 operating cycles (see ▲ on page 11)
	AC-15		Cos φ = 0.3, 6000 operating cycles (see ▲ on page 11)
	DC-13		L/R = 300 ms, 6000 operating cycles (see ▲ on page 11)
Delay on crossing the threshold			0.1–3 s ±10%
LCD display			Relay state. Over or Under mode. Memory function. Type of signal (AC or DC). Measurement overflow.

Other characteristics

Protection class	Conforming to IEC 529		Terminal block: IP 20, front panel: IP 40, enclosure: IP 50
Enclosure			Self-extinguishing
Terminal capacity	With cable end	AWG (mm^2)	Two #16 (1.5)
	Without cable end	AWG (mm^2)	Two #14 (2.5)
Tightening torque		lb-in (N•m)	5.3 (0.6) maximum
Temperature limits		°F (°C)	**Operation:** -4 to +140 (-20 to +60); **Storage:** -22 to +158 (-30 to +70)
Relative humidity			93% without condensation
Dielectric strength	Conforming to IEC 255-5	kV	2.5/1 min/1 mA/50 Hz
Approvals	cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7		CSA File 217698, Guide 3211 07; CE

Voltage control relay input characteristics

			RM84872305			RM84872310		
Relay type			RM84872305			RM84872310		
Input circuits			E1-M	E2-M	E3-M	E1-M	E2-M	E3-M
Measurement ranges		V	0.2–2	1–10	6–60	15–150	30–300	60–600
Input resistance		kΩ	2	10	60	100	300	650
Maximum continuous voltage at 68 °F (20 °C)		V	4	20	120	200	350	650
Peak overload	< 1 ms at 68 °F (20 °C)	V	50	100	300	–	–	–
	< 50 ms at 68 °F (20 °C)	kV	–	–	–	2	2	2

Current control relay input characteristics

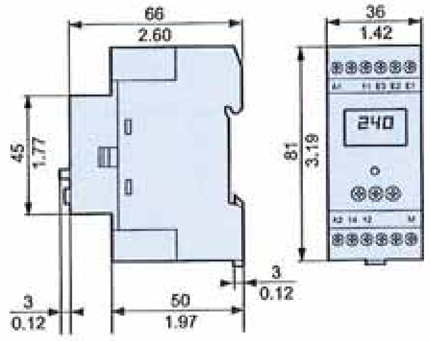
Relay type			RM84871305			RM84871310		
Input circuits			E1-M	E2-M	E3-M	E1-M	E2-M	E3-M
Measurement ranges			2–20 mA	10–100 mA	50–500 mA	0.1–1 A	0.5–5 A	1–10 A
Input resistance		Ω	5	1	0.2	0.1	0.02	0.01
Maximum continuous current at 68 °F (20 °C)			40 mA	200 mA	1 A	2 A	10 A	14 A
Peak overload	< 1 ms at 68 °F (20 °C)	A	1	5	8	17	20	50

General input characteristics

Maximum line voltage		Mains 277 / 480 Vac
Hysteresis		Adjustable from 5 to 50% of threshold
Frequency of AC signal measured	Hz	40–500
Threshold setting accuracy		±10%
Repeat accuracy		±0.1% with constant parameters
Temperature drift		±0.05% per °C
Voltage drift		≤ 0.5%

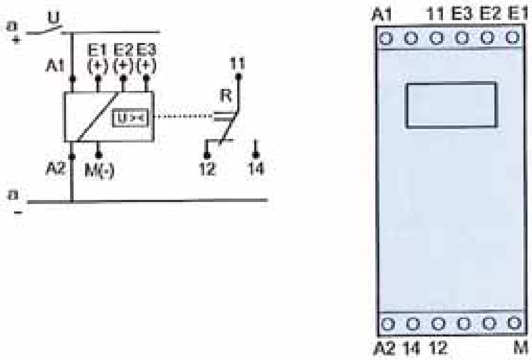
DIMENSIONS (approximate)

RM84871305, RM84871310, RM84872305, RM84872310



Dimensions: $\frac{mm}{in.}$

WIRING



RM84871 Current Measurement Relays

Input current to be measured into proper terminal (E1, E2, or E3)

RM84872 Voltage Measurement Relays

Input voltage to be measured into proper terminal (E1, E2, or E3)

Zelio® Control Measurement Relays
RM4T Three-Phase Monitoring Relays

RM4T

FUNCTIONS

These devices monitor three-phase supplies, and protect motors and other loads against the faults listed in the table below. They have a transparent, hinged cover on their front face to prevent accidental alteration of the settings. This cover can be sealed.

Fault	RM4TG	RM4TU	RM4TR	RM4TA
Phase Reversal	Yes	Yes	Yes	Yes
Phase Loss	Yes	Yes	Yes	Yes
Undervoltage	No	Yes	No	No
Overvoltage and Undervoltage (2 thresholds)	No	No	Yes	No
Phase Imbalance	No	No	No	Yes

Applications

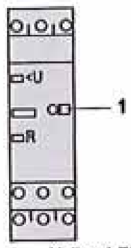
- Control for connection of moving equipment (site equipment, agricultural equipment, refrigerated trucks)
- Control for protection of personnel and equipment against the consequences of reverse running (lifting, handling, elevators, escalators, etc.)
- Control of sensitive three-phase supplies
- Phase loss protection
- Normal/emergency power supply switching

Features

RM4TG

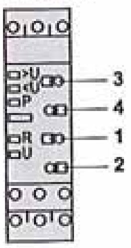
R Yellow LED: Indicates relay output state.

RM4TU

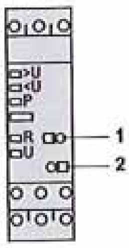


R Yellow LED: Indicates relay output state.
< U Red LED: Undervoltage fault.
1 Undervoltage setting potentiometer.

RM4TR31
RM4TR32

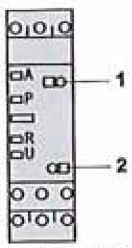


RM4TR33
RM4TR34

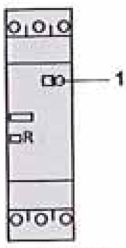


1 Time delay function selector:
⌧ Fault detection delayed (off delay).
■ Fault detection extended (on delay).
2 Potentiometer for setting time delay in s.
3 Potentiometer for setting overvoltage.
4 Potentiometer for setting undervoltage.
R Yellow LED: Indicates the relay state.
U Green LED: Indicates that the relay power supply is on.
> U Red LED: Overvoltage fault.
< U Red LED: Undervoltage fault.
P Red LED: Phase failure or phase reversal.

RM4TA3



RM4TA0



1 Phase imbalance setting potentiometer, from 5–15%
2 Potentiometer for setting time delay, 0.1 to 10 s.
R Yellow LED: Indicates the relay state.
U Green LED: Indicates that the relay power supply is on.
A Red LED: Phase imbalance.
P Red LED: Phase failure or phase reversal.

OPERATING PRINCIPLE

The supply voltage to be monitored is connected to product terminals L1, L2, and L3.
RM4T relays are self-powered by terminals L1, L2, and L3; they require no separate power supply.

- Monitoring rotation direction of phases and detection of complete loss of one or more phases (**RM4T** all models)

  When terminals L1, L2, and L3 are energized, the relay is energized and the yellow LED comes on only if *(a)* the rotation direction of phases is correct, and *(b)* all three phases are present. If one or more phases have failed, or if the rotation direction is incorrect, the relay is not energized at switch-on. In normal operation (no fault), the relay is energized; it de-energizes instantaneously (or after the time delay) if one or more phases fails. To prevent detection of the absence or failure of a single phase, a voltage exceeding the detection threshold (≈130 V on RM4TG, undervoltage threshold setting on RM4TU and RM4TR) can be generated back through the control circuit. For this purpose, we recommend using RM4TA relays. The illumination of LED **P** signals the absence of a phase on RM4TR and RM4TA.

- Overvoltage and undervoltage detection (**RM4TR**):

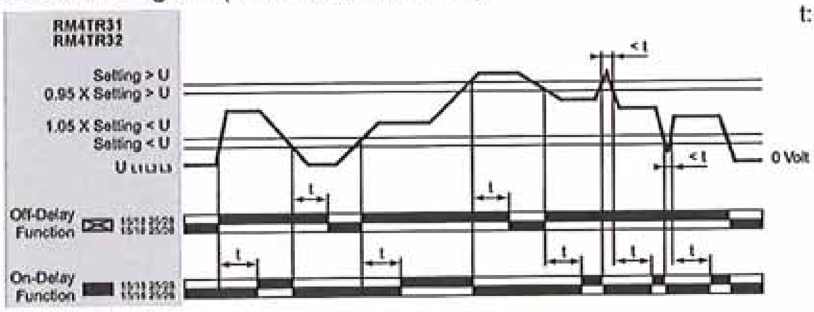
  In normal operation, the relay is energized and LEDs **U** and **R** are lit.
  If the average of the three voltages between phases fluctuates outside the range to be monitored, the output relay is de-energized.

  — Overvoltage: the Red LED "> U" illuminates.

  — Undervoltage: the Red LED "< U" illuminates.

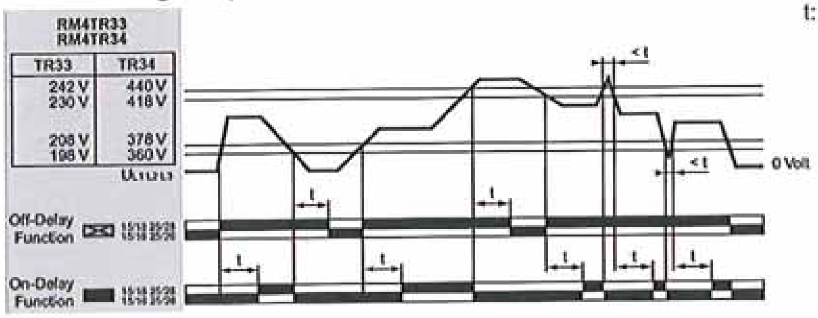
  When the supply returns toward its rated value, the relay is re-energized according to the hysteresis value (5%), and the corresponding red LED goes out. A switch allows selection of a time delay, adjustable from 0.1 s to 10 s. With the off-delay function ▭, over- or undervoltages have no effect. With the on-delay function ▬, over- or undervoltages delay the re-energization of the relay. Regardless of the switch setting, an over- or undervoltage is detected only if its duration exceeds the measuring cycle time (80 ms).

Function Diagram (RM4TR31, RM4TR32)



t: time delay

Function Diagram (RM4TR33, RM4TR34)



t: time delay

OPERATING PRINCIPLE

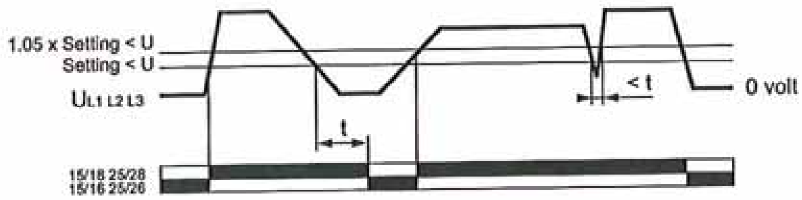
- Undervoltage detection only (**RM4TU**)

  In normal operation, the output relay is energized and the yellow LED is lit.

  When the average of the three voltages between phases falls below the undervoltage threshold setting, the relay is de-energized after 550 ms and the red LED "< U" illuminates.

Function Diagram

t: fixed time delay = 550 ms



- Detection of phase imbalance (**RM4TA**)

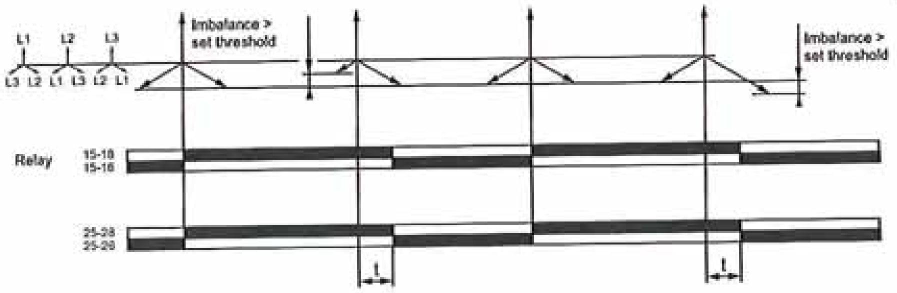
  In normal operation, the output relay is energized and the yellow and green LEDs are lit.

  In the event of an imbalance fault, after a time delay set between 0.1 s and 10 s (on RM4TA3 only), the output relay is de-energized, the yellow LED goes out, and red LED **A** illuminates (RM4TA3• only).

  The relay re-energizes when the measured imbalance value drops below 50% of the imbalance setting (hysteresis).

Function Diagram

t: time delay



Example: Imbalance set at 10%, mains supply voltage 400 V

— Relay de-energization threshold: $400\ V - 10\% = 360\ V$

— Relay re-energization threshold: $400\ V - \frac{10\%}{2} = 380\ V$

NOTE: Distortion in the sine wave of the three-phase supply can cause the RM4T phase supply control relay to malfunction.

Telemecanique

Output relay and operating characteristics

Relay type			RM4 TG	RM4 TU	RM4 TR	RM4 TA
Number of C/O contacts			2 C/O–DPDT	2 C/O–DPDT	2 C/O–DPDT	RM4 TA3• 2 C/O–DPDT RM4 TA0• 1 C/O–SPDT
Output relay state			Energized during fault-free operation. De-energized or unable to energize on detection of rotation direction fault or failure of one or more phases.	Energized during fault-free operation. De-energized on detection of undervoltage or rotation direction fault or failure of one or more phases.	Energized during fault-free operation. De-energized on detection of overvoltage, undervoltage or rotation direction fault or phase failure.	Energized during fault-free operation. De-energized on detection of asymmetry fault, phase failure or rotation direction fault.
Switching threshold setting accuracy	As a percentage of the set value		–	±3%	±3%	±3%
Switching threshold drift	Depending on the permissible ambient temperature		–	≤ 0.06% per °C	≤ 0.06% per °C	≤ 0.06% per °C
	Within the measuring range		–	≤ 0.5%	≤ 0.5%	≤ 0.5%
Time delay setting accuracy	As a percentage of the full-scale value		–	±10%	±10%	±10%
Time delay drift	Within the measuring range		–	≤ 0.5%	≤ 0.5%	≤ 0.5%
	Depending on the rated operational temperature		–	≤ 0.07% per °C	≤ 0.07% per °C	≤ 0.07% per °C
Hysteresis	Fixed		–	About 5% of the de-energization threshold	About 5% of the de-energization threshold	About 50% of the asymmetry percentage
Delay on pick-up		ms	< 650	< 650	< 650	< 650
Measuring cycle		ms	≤ 80	≤ 80	≤ 80	≤ 80

Measuring input characteristics

Relay type		RM4 TG	RM4 T••1 RM4 TR33	RM4 T••2 RM4 TR34
Nominal voltage	V	220–440	**RM4 T••1:** 220–240 **RM4 TR33:** 220	**RM4 T••2:** 380–440 **RM4 TR34:** 400
Maximum operating range	V	198–484	160–300	290–484

(1) Minimum voltage required for operation of indicators and of the time delay.

Zelio® Control Measurement Relays
RM4T Three-Phase Monitoring Relays

SELECTION


RM4TG20

Control Relays: Phase Reversal and Presence of Phases

Time Delay	Rated Mains Supply Voltage ■		Width in (mm)	Output Relay	Catalog Number	Weight lb (kg)
None	220–440 Vac 50/60 Hz		0.89 in (22.5 mm)	2 C/O-DPDT	RM4TG20	0.24 (0.110)

Control Relays: Phase Reversal and Presence of Phases + Undervoltage

Time Delay	Rated Mains Supply Voltage ■	Control Threshold	Width in (mm)	Output Relay	Catalog Number	Weight lb (kg)
None	220–240 V 50/60 Hz	Undervoltage 160–220 V	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TU01	0.24 (0.110)
	380–440 V 50/60 Hz	Undervoltage 300–430 V	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TU02	0.24 (0.110)

Control Relays: Phase Reversal and Presence of Phases + Overvoltage and Undervoltage


RM4TR33

Relays with Fixed Voltage Thresholds

Adjustable Time Delay	Rated Mains Supply Voltage ■	Control Threshold	Width in (mm)	Output Relay	Catalog Number	Weight lb (kg)
0.1–10 s	220 V 50/60 Hz	Undervoltage 198 V Overvoltage 242 V	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TR33	0.24 (0.110)
	400 V 50/60 Hz	Undervoltage 360 V Overvoltage 440 V	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TR34	0.24 (0.110)

Relays with Adjustable Voltage Thresholds

Adjustable Time Delay	Rated Mains Supply Voltage ■	Control Threshold	Width in (mm)	Output Relay	Catalog Number	Weight lb (kg)
0.1–10 s	220–240 V 50/60 Hz	Undervoltage 160–220 V Overvoltage 220–300 V	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TR31	0.24 (0.110)
	380–440V 50/60 Hz	Undervoltage 300–430 V Overvoltage 420–480 V	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TR32	0.24 (0.110)

Control Relays: Phase Reversal and Presence of Phases + Imbalance


RM4TA01

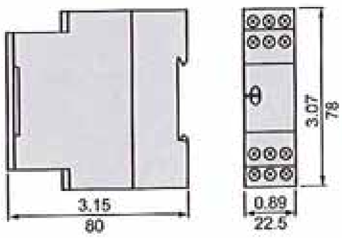
Time Delay on De-Energization	Rated Mains Supply Voltage ■	Control Threshold	Width in (mm)	Output Relay	Catalog Number	Weight lb (kg)
Fixed 0.5 s	220–240 V 50/60 Hz	Imbalance 5–15%	0.89 in (22.5 mm)	1 C/O-SPDT	RM4TA01	0.24 (0.110)
	380–440 V 50/60 Hz	Imbalance 5–15%	0.89 in (22.5 mm)	1 C/O-SPDT	RM4TA02	0.24 (0.110)
Adjustable 0.1–10 s	220–240 V 50/60 Hz	Imbalance 5–15%	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TA31	0.24 (0.110)
	380–440 V 50/60 Hz	Imbalance 5–15%	0.89 in (22.5 mm)	2 C/O-DPDT	RM4TA32	0.24 (0.110)

■ Can be used on other supply voltages if the minimum operational voltages, maximum voltage between phases, and compatibility are within the control threshold ranges shown in the specification table on page 31.

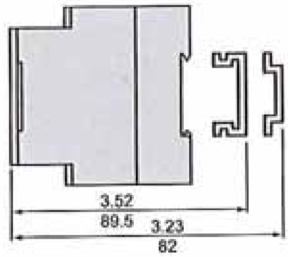
For additional application data, refer to page 2.

DIMENSIONS (approximate)

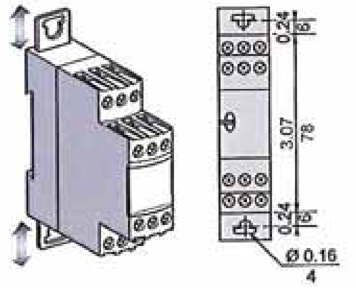
RM4T



Rail Mounting



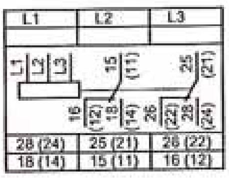
Direct Mounting



Dual Dimensions = in/mm

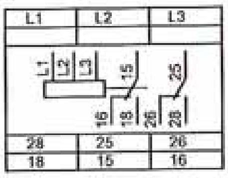
WIRING

Terminal Blocks
RM4TG20, TU0•



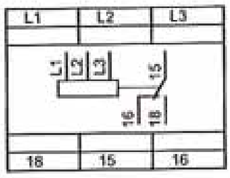
L1, L2, L3	Supply to be monitored
15(11)-18(14)	1st C/O contact
15(11)-16(12)	of the output relay
25(21)-28(24)	2nd C/O contact
25(21)-26(22)	of the output relay

RM4TR3•, TA3•



L1, L2, L3	Supply to be monitored
15–18	1st C/O contact
15–16	of the output relay
25–28	2nd C/O contact
25–26	of the output relay

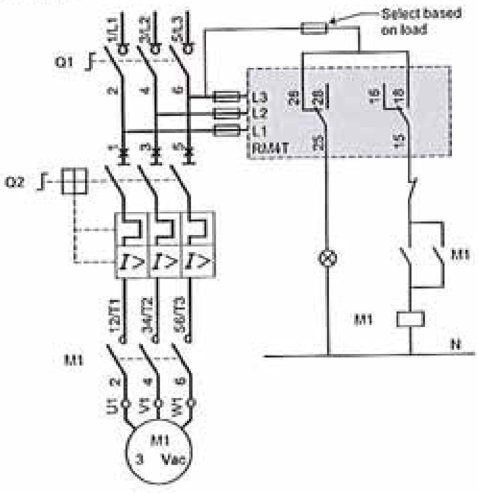
RM4TA0•



L1, L2, L3	Supply to be monitored
15–18	1st C/O contact
15–16	of the output relay

Application Diagram

Example



Suggested Line Fuses for L1, L2, and L3

100 mA, fast blow or standard

Zelio® Control Measurement Relays
RM84873 Three-Phase Monitoring Relays

- *Optimized installation and space savings (22.5 mm)*
- *No adjustment required to monitor phase failure or phase reversal*
- *Versions with one or two C/O output contacts for selecting the safety level of the installation*
- *Self-powered for ease of installation; uses the controlled supply for its power supply*

OPERATING PRINCIPLE

These relays monitor for:

- correct sequencing of phases L1, L2, and L3
- a total loss of one of these phases

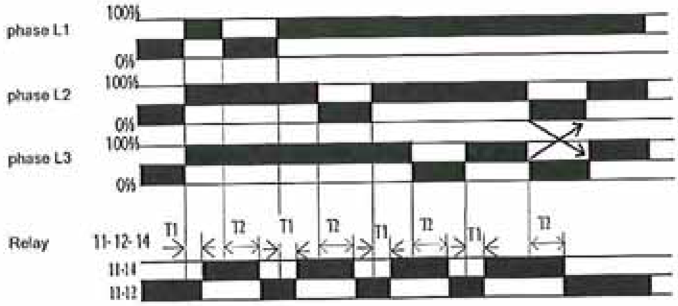
When the phase sequence is correct, the output relay is energized and the yellow LED is lit.

The relay de-energizes and the LED goes out when one of the following faults occurs:

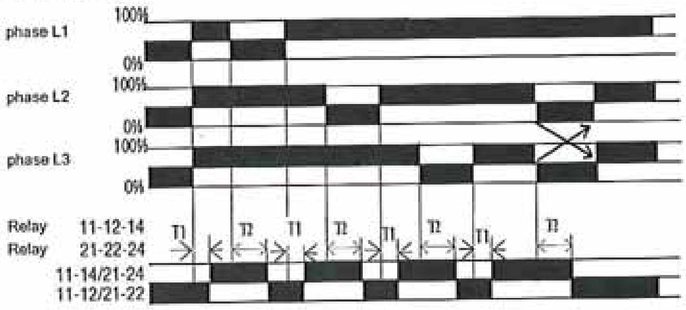
- an incorrect sequence of phases at terminals L1, L2, and L3
- a total loss of one phase or of all three phases (phase failure detection threshold < 50 Vac)

Timing diagrams

RM84873299

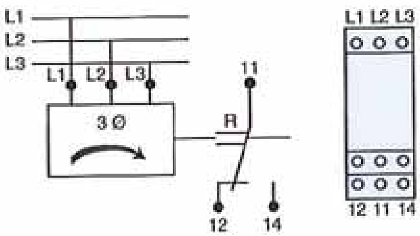


RM84873004

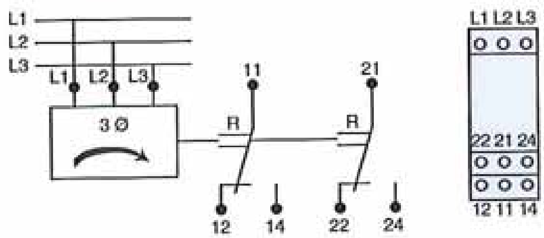


WIRING

RM84873299



RM84873004



RM84873004

SELECTION

Phase control relays

Outputs	Catalog Number	Weight oz (kg)
1 C/O	RM84873299	3.5 (0.100)
2 C/O	RM84873004	3.5 (0.100)

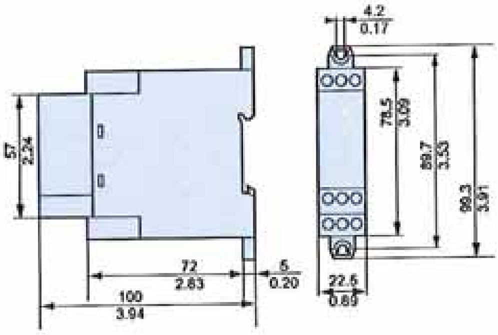
Input characteristics			
Supply voltage		Vac	3 @ 230–400 self-powered
Operating range		V	200–500
Frequency			50/60 Hz ±1 Hz
Maximum consumption		VA	25
Output characteristics			
Output relay			Cadmium-free
Rated current		A	8
Maximum switching voltage		Vac	250 / 440
Rated breaking capacity		VA	2000
Minimum breaking current		mA	10 / 5 V
Electrical life ▲			AC-12: 10^5 operating cycles at 8 A / 250 Vac ▲
Mechanical life ▲			2×10^7 operating cycles ▲
Pick-up delay	t1	ms	< 200
Drop-out delay	t2	ms	< 300 in the event of loss of one phase
Other characteristics			
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Clamping capacity	Without cable end	AWG (mm^2)	Two #14 (2.5)
	With cable end	AWG (mm^2)	One #12 (4) or two #16 (1.5)
Tightening torque		lb-in (N•m)	8.8 (1); M3 screw/IEC 60947-1
Temperature limits	Operation	°F (°C)	-4 to +122 (20 to +50)
	Storage	°F (°C)	-22 to +158 (-30 to +70)
Enclosure material			Self-extinguishing
Protection class	Terminal block		IP 20
	Enclosure		IP 40
Dielectric strength	Conforming to IEC 60255-5		2.5 kV/1 min/1 mA/50 Hz

Approvals

File E173076 CCN NRNT
File E173076 CCN NRNT 7

RM84873299 only
File 217698
Guide 3211 07

DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

▲ The expected life expressed above is based on average usage and normal operating conditions. Actual operating life will vary with conditions. The above statements are not intended to nor shall they create any expressed or implied warranties as to product operation or life. For information on the listed warranty offered on this product, refer to the Square D terms and conditions of sale found in the *Digest*.

- *Control:*
  - — *phase sequence*
  - — *phase failure*
  - — *voltage drop on one or more phases*
- *Regeneration rate: 90% of Un*
- *Power supply: 3 @ 230 Vac and 3 @ 400 Vac*
- *Dual frequency: 50 and 60 Hz*
- *Yellow LED: phase presence and relay state*
- *Relay output: two C/O contacts, 8 A*

OPERATING PRINCIPLE

These relays monitor for:

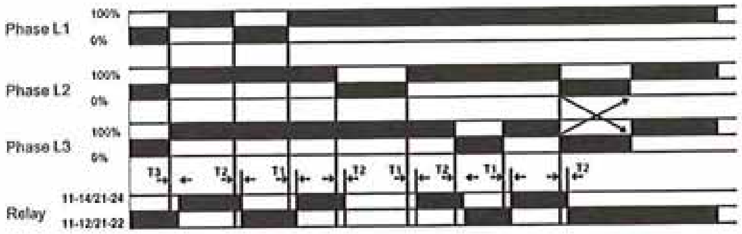
- correct sequencing of phases L1, L2, and L3
- a regeneration rate equal to 90% (-10% of Un)

When the phase sequence is correct, the output relay is energized and the yellow LED is lit.

The relay de-energizes and the LED goes out when one of the following faults occurs:

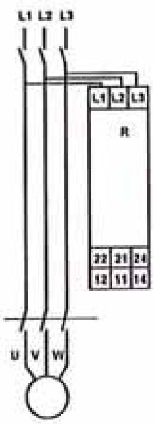
- incorrect sequence of phases at terminals L1, L2, and L3
- voltage drop on one or more phases

Timing diagrams

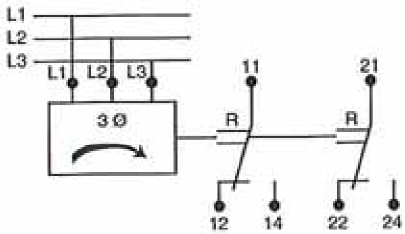


T3 < 200 ms

WIRING



RM84873511
RM84873512



 Telemecanique

RM84873511

SELECTION

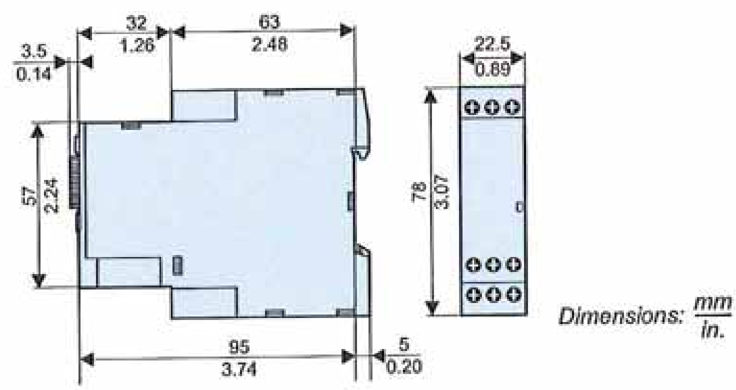
Phase control relays

Voltage	Catalog Number	Weight oz (kg)
230 Vac	RM84873511	4.2 (0.120)
400 Vac	RM84873512	4.2 (0.120)

Input characteristics			
Supply voltage		Vac	3 @ 230 and 3 @ 400 self-powered
Operating range			-20 to +15% Un
Frequency			50–60 Hz ±1 Hz
Maximum consumption at Un		VA	17 at 50 Hz (20 at 60 Hz)
		VA	23 +15% at 50 Hz (27 at 60 Hz)
Output characteristics			
Output type			2 cadmium-free C/O contacts
Rated current		A	8
Maximum switching voltage		Vac	250 / 440
Rated breaking capacity		VA	2000
Minimum breaking current		mA	100 / 12 V
Electrical life ▲			AC-12: 10^5 operating cycles at 8 A/ 250 Vac ▲
Mechanical life ▲			2×10^7 operating cycles ▲
Time to onset of fault t2 (dropout)		ms	< 200
Time to disappearance of fault t1 (pickup)		ms	< 200
Clamping capacity	Without cable end	AWG (mm^2)	One #12 (4) or two #14 (2.5)
	With cable end	AWG (mm^2)	Two #16 (1.5)
Other characteristics			
Tightening torque		lb-in (N•m)	8.8 (1); M3 screw/IEC 60947-1
Temperature limits	Operation	°F (°C)	-4 to +122 (-20 to +50)
	Storage	°F (°C)	-40 to +158 (-40 to +70)
Humidity			95% max. without condensation
Enclosure material			Self-extinguishing
Protection class	Terminal block		IP 20
	Enclosure		IP 40
Dielectric strength	Conforming to IEC 60255-5	kV	2.5/1 min/1 mA/50 Hz
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4 kV/3
Insulation coordination	Conforming to IEC 60664-1		Overvoltage category III; degree of pollution 3; 4 kV/3
Vibration	Amplitude	mm	0.35 peak
Conforming to IEC 60068-2-6	Frequency	Hz	10–55

Approvals: cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7; CSA File 217698 Guide 3211 07; CE

DIMENSIONS (approximate)



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- *Control:*
  - — *phase imbalance (asymmetry)*
  - — *phase sequence*
  - — *phase failure*
  - — *voltage drop on one or more phases*
- *Asymmetry rate adjustable on the front panel: -5% to -15% of Un*
- *Power supply: 3 @ 230 Vac and 3 @ 400 Vac*
- *Dual frequency: 50 and 60 Hz*
- *Yellow LED: phase presence and relay state*
- *Relay output: two C/O contacts, 8 A*

OPERATING PRINCIPLE

These relays monitor for:

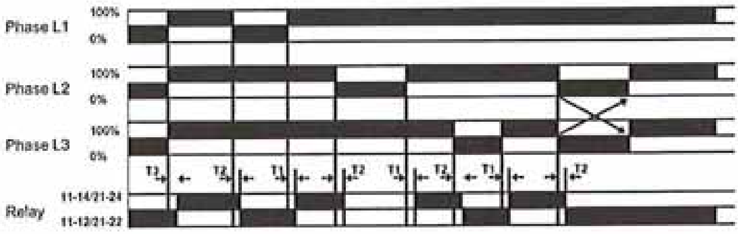
- correct sequencing of phases L1, L2, and L3
- a regeneration rate of -5% to -15% of Un

When the phase sequence is correct, the output relay is energized and the yellow LED is lit.

The relay de-energizes and the LED goes out when one of the following faults occurs:

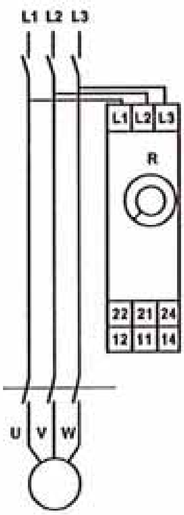
- incorrect sequence of phases at terminals L1, L2, and L3
- voltage drop on one or more phases

Timing diagrams

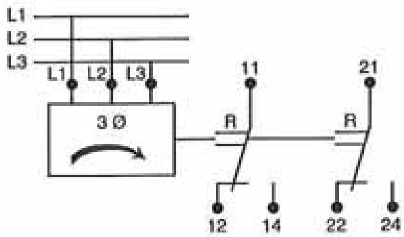


T3 < 200 ms

WIRING



RM84873501
RM84873502



 Telemecanique

RM84873501

SELECTION

Phase asymmetry control relays

Voltage	Catalog Number	Weight, oz (kg)
230 Vac	RM84873501	4.2 (0.120)
400 Vac	RM84873502	4.2 (0.120)

Input characteristics			
Supply voltage		Vac	3 @ 230 and 3 @ 400 self-powered
Operating range			-20 to +15% Un
Frequency			50–60 Hz ±1 Hz
Maximum consumption at Un		VA	17 at 50 Hz (20 at 60 Hz)
		VA	23 +15% at 50 Hz (27 at 60 Hz)
Output characteristics			
Output type			2 cadmium-free C/O contacts
Rated current		A	8
Maximum switching voltage		Vac	250 / 440
Rated breaking capacity		VA	2000
Minimum breaking current		mA	100 / 12 V
Electrical life ▲			AC-12: 10^5 operating cycles at 8 A/ 250 Vac ▲
Mechanical life ▲			2×10^7 operating cycles ▲
Time to onset of fault t2 (dropout)		ms	< 200
Time to disappearance of fault t1 (pickup)		ms	< 200
Clamping capacity	Without cable end	AWG (mm^2)	One #12 (4) or two #14 (2.5)
	With cable end	AWG (mm^2)	Two #16 (1.5)
Other characteristics			
Tightening torque		lb-in (N•m)	8.8 (1); M3 screw/IEC 60947-1
Temperature limits		°F (°C)	**Operation:** -4 to +122 (-20 to +50); **Storage:** -40 to +158 (-40 to +70)
Humidity			95% max. without condensation
Enclosure material			Self-extinguishing
Protection class	Terminal block		IP 20
	Enclosure		IP 40
Dielectric strength	Conforming to IEC 60255-5	kV	2.5/1 min/1 mA/50 Hz
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Vibration	Amplitude	mm	0.35 peak
Conforming to IEC 60068-2-6	Frequency	Hz	10–55
Approvals	cULus File E173076 CCN NRNT File E173076 CCN NRNT 7	CSA File 217698 Guide 3211 07	CE

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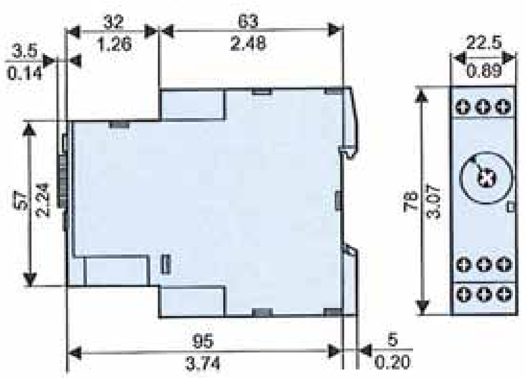
DIMENSIONS (approximate)



Dimensions: mm / in.

Zelio® Control Measurement Relays
RM84873 Three-Phase Monitoring Relays

- *Control:*
  - *— phase sequence*
  - *— loss of one or more phases*
  - *— undervoltage*
- *Senses its own supply voltage*
- *Potentiometer for adjusting mains power*
- *Adjustable time delay in the event of a fault: 0.2–10 s*
- *Relay output: two C/O contacts, 8 A*
- *Two LEDs: power on and relay state*

NOTE: Time delay T is not operational during loss of L1 and L2. It operates during loss of L3, phase inversion, or voltage drop. Its purpose is to avoid false triggering of the output relays during transient states, notably during motor starting.

OPERATING PRINCIPLE

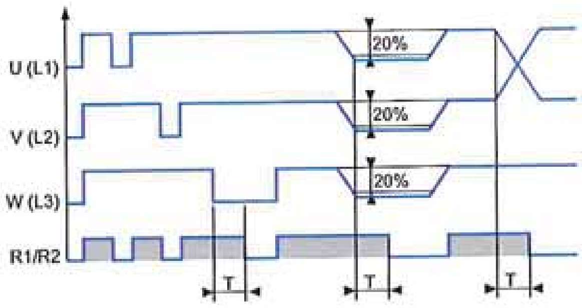
On a three-phase supply, this relay simultaneously monitors:

- phase sequence
- loss of a phase, with a maximum regeneration rate of 70% of the voltage indicated by a potentiometer on the front panel
- symmetrical voltage drop on the three phases of less than 20% of the pre-set value

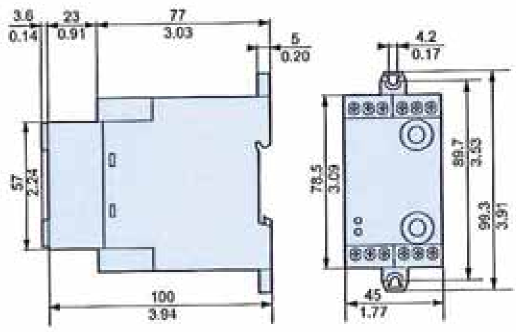
When the three phases are in sequence, the output relay is energized and the yellow LED is lit.

The output relay de-energizes and the LED goes out (after time delay T, adjustable from 0.2–10 s on the front panel) when one of the following faults occurs:

- reversed direction of phase rotation
- absence of one or more phases
- voltage drop



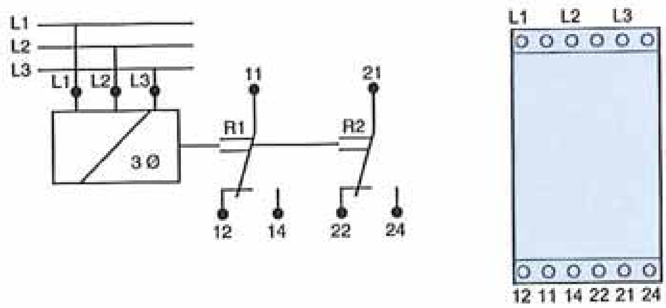
DIMENSIONS (approximate)



RM84873010
RM84873012
RM84873015
RM84873016

Dimensions: $\frac{mm}{in.}$

WIRING



 Telemecanique

RM84873010

SELECTION

Phase sequence and loss of phase control relays

Voltage	Setting range Vac	Catalog Number	Weight oz (kg)
3 @ 230 Vac	180–260	RM84873010	12.3 (0.350)
3 @ 400 Vac	320–460	RM84873012	12.3 (0.350)
3 @ 480 Vac	380–550	RM84873015	12.3 (0.350)
3 @ 575 Vac	460–660	RM84873016	12.3 (0.350)

Technical characteristics			
Supply			Self-powered, terminals L1–L2
Operating range			0.7–1.2 × Un
Frequency		Hz	50/60
Maximum consumption		VA	6
Immunity to microbreaks		ms	10
Delay on pick-up		ms	500
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Input characteristics			
Measurement input resistance		kΩ	1 at Un
Regeneration rate			max. 70% of the threshold setting
Undervoltage detection (symmetrical drop)			≥ 20% of the threshold setting
Threshold setting accuracy			±10%
Output characteristics			
Output type			2 C/O contacts, AgCdO
Breaking capacity			2000 VA (AC), 80 W (DC)
Maximum breaking current	AC/DC	A	8
Minimum breaking current	AC/DC	mA	100
Maximum switching voltage		Vac/Vdc	250
Electrical life ▲	AC-12		2000 VA, 10^5 operating cycles ▲
	AC-15		Cos φ = 0.3, 6000 operating cycles ▲
	DC-13		L/R = 300 ms, 6000 operating cycles ▲
Time delay in the event of a fault		s	0.2–10 Max.: 10–15
Other characteristics			
Indication	Power on		Green LED
	Relay		Yellow LED
Enclosure			Self-extinguishing
Terminals	Without cable end	AWG (mm^2)	Two #14 (2.5)
	With cable end	AWG (mm^2)	Two #16 (1.5)
	Tightening torque	lb-in (N•m)	5.3 (0.6) max.
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60)
	Storage	°F (°C)	-22 to +158 (-30 to +70)
Relative humidity			93% without condensation
Vibration	Amplitude	mm	0.35
	Frequency	Hz	10–55
Insulation resistance	Conforming to IEC 60664-1	MΩ	> 100 at 500 V
Dielectric strength		kV	3 at 1 mA for 1 minute/50 Hz
Approvals	cULus File E173076 CCN NRNT File E173076 CCN NRNT 7		CSA File 217698 Guide 3211 07 — CE

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- *Control:*
  - *phase imbalance (asymmetry)*
  - *phase sequence*
  - *disconnection of one or more phases with regenerated voltage equivalent to 95% of Un*
- *Asymmetry rate adjustable on the front panel: 5–20%*
- *Three-phase power supply: 3 @ 230 Vac and 3 @ 400 Vac*
- *Dual frequency: 50 and 60 Hz*
- *Two LEDs: indicate phase presence and relay state*
- *Adjustable time delay in the event of a fault: 0.5–10 s*
- *Relay output:*
  - *one C/O contact, 8 A*
  - *two C/O contacts, 8 A*

OPERATING PRINCIPLE

The device is self-powered by two phases. A green LED indicates that the power supply is on.

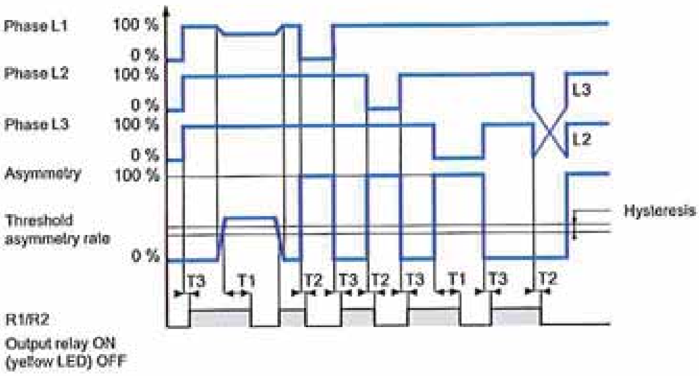
When the phase sequence is correct and the asymmetry rate is lower than the threshold indicated on the front panel, the output relay is energized and the yellow phase presence LED is lit.

The output relay de-energizes after a delay T1 (adjustable on the front panel) when one of the following faults occurs:

- incorrect phase sequence
- absence of L3
- asymmetry rate higher than the threshold setting: an imbalance representing an increase or decrease in the voltage of two phases compared to the voltage of a different phase

The output relay de-energizes instantaneously in the event of a phase loss on L1 or L2. A hysteresis fixed at about 10% ensures bounce-free relay switching around the threshold.

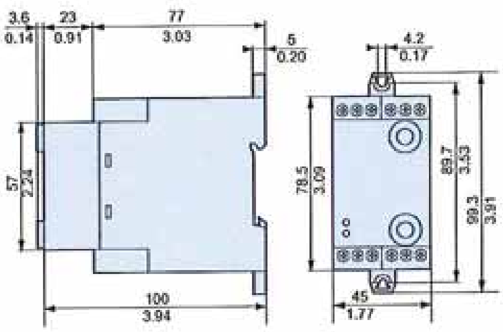
Since differential measurement is used, the relay does not react to symmetrical increases or decreases in the mains supply.



T1: Delay after a fault
T2: Delay on power-down
T3: Delay on power-up.

DIMENSIONS (approximate)

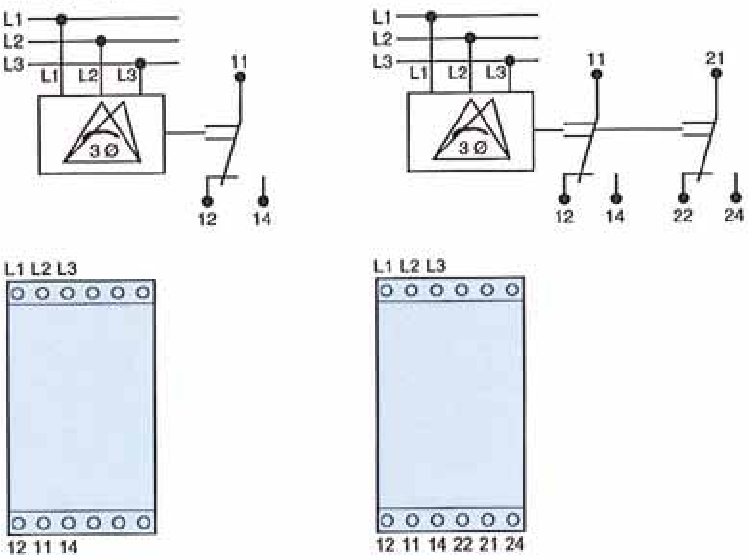
RM84873300, RM84873301, RM84873310, RM84873311



Dimensions: mm / in.

WIRING

RM84873300, RM84873301 **RM84873310, RM84873311**



 Telemecanique


RM84873300

SELECTION

Phase asymmetry control relays, self-powered

Number of output contacts	Supply voltages measured	Catalog Number	Weight oz (kg)
1	3 @ 230 Vac	RM84873300	12.7 (0.360)
	3 @ 400 Vac	RM84873301	12.7 (0.360)
2	3 @ 230 Vac	RM84873310	12.7 (0.360)
	3 @ 400 Vac	RM84873311	12.7 (0.360)

Auxiliary power supply characteristics			
Auxiliary voltage	self-powered from terminals L1-L2	Vac	230, 400
Operating range			0.8–1.2 × Un
Frequency		Hz	50–60
Maximum consumption		VA	4 at Un, 8 at Un +20%
Immunity to microbreaks		ms	10
Delay on power-up	t3	s	1 max.
Delay on power-down	t2		300 max.
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Input characteristics			
3-phase supply	Rated voltage	Vac	3 @ 230, 3 @ 400
	Operating range	Vac	185–275, 320–480
Frequency (can be altered via switch beneath the device)		Hz	50–60
Regeneration rate			max. 95% of Un
Asymmetry rate adjustment			5–20% of Un
Threshold setting accuracy	Conforming to VDE 0435		±20% at full scale
Temperature drift			0.1% per °C
Repeat accuracy			±1% at full scale
Fixed hysteresis			10% of the threshold setting
Output characteristics			
Output type			1 or 2 C/O contact, AgCdO
Breaking capacity			2000 VA (AC), 80 W (DC)
Maximum breaking current	AC/DC	A	8
Minimum breaking current	AC/DC	mA	100
Maximum switching voltage		Vac/Vdc	250
Electrical life	AC-12		2000 VA, 10^5 operating cycles (see ▲ on page 41)
	AC-15		Cos φ = 0.3, 6000 operating cycles (see ▲ on page 41)
	DC-13		L/R = 300 ms, 6000 operating cycles (see ▲ on page 41)
Mechanical life			5×10^6 operating cycles (see ▲ on page 41)
Other characteristics			
Time delay in the event of fault t1		s	0.5–10, Max.: 10–16
Indication	Supply		Green LED
	Relay		Yellow LED
Protection class	Terminal block		IP 20
	Enclosure		IP 30
Enclosure			Self-extinguishing
Terminal block clamping capacity	Without cable end	AWG (mm^2)	Two #14 (2.5)
	With cable end	AWG (mm^2)	Two #16 (1.5)
	Tightening torque	lb-in (N•m)	5.3 (0.6) max. (M3 screw/IEC 60947-1)
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60, conforming to IEC 60068-2-14)
	Storage	°F (°C)	-22 to +158 (-30 to +70, conforming to IEC 60068-2-1/2)
Relative humidity	Conforming to IEC 60068-2-30		93% without condensation
Vibrations	Amplitude	mm	0.35
(conforming to IEC 68-2-6)	Frequency	Hz	10–55
Insulation resistance	Conforming to IEC 60255-5	mΩ	> 100 at 500 Vac
Dielectric strength	Conforming to IEC 60255-5	kV	2.5 / 1 min / 1 mA / 50 Hz
Impulse voltage	Conforming to IEC 60255-5/664-1	kV	5/wave 1.2–50 μs
Approvals	File E173076 CCN NRNT File E173076 CCN NRNT 7		File 217698 Guide 3211 07 — GL•: RM8487330• only

Zelio® Control Measurement Relays
RM84873 Three-Phase Monitoring Relays

- *Controls overvoltage and undervoltage on its own power supply (window type)*
- *RM84873201: phase to phase*
  RM84873211: between phase and neutral
- *Minimum and maximum thresholds separately adjustable*
- *Absence of neutral detected on relay RM84873211*
- *Delay on crossing the upper or lower threshold, adjustable from 0.1–10 s on the front panel of the device*
- *Two yellow LEDs: overvoltage and undervoltage*
- *One green LED: power on*
- *Two output relays: upper and lower threshold*
- *Two separate time delays*

OPERATING PRINCIPLE

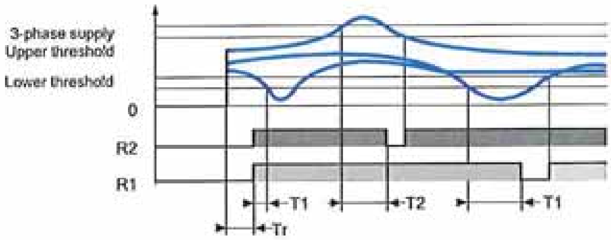
The two output contacts are energized when the measured voltages are between the minimum and maximum thresholds, separately adjustable using two potentiometers on the front panel of the device.

When one or more voltages fluctuates outside the window between the two thresholds, the relay corresponding to the fault de-energizes (following a delay adjustable on the front panel). Each relay can have its own individual time delay (0.1 to 10 s).

A hysteresis fixed at 3% ensures bounce-free relay switching when the voltage levels return to a value between the upper and lower thresholds.

The device is not affected by the phase sequence or harmonic distortion.

A green LED indicates that the power supply is on. Two yellow LEDs indicate when the upper and lower thresholds are exceeded: they are lit when the voltages are within the set window.

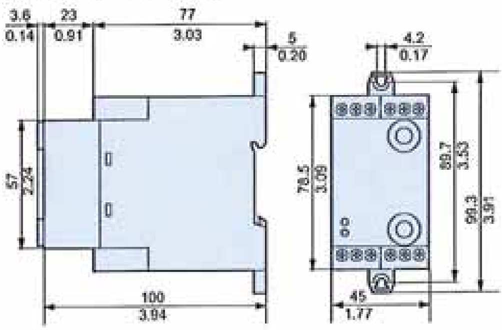


Tr = about 3 s
T1 = adjustable fault delay: 0.1–10 s
T2 = adjustable fault delay: 0.1–10 s

Catalog Number	Lower threshold	Upper threshold
RM84873201	340–392	408–460
RM84873211	195–225	235–264

DIMENSIONS (approximate)

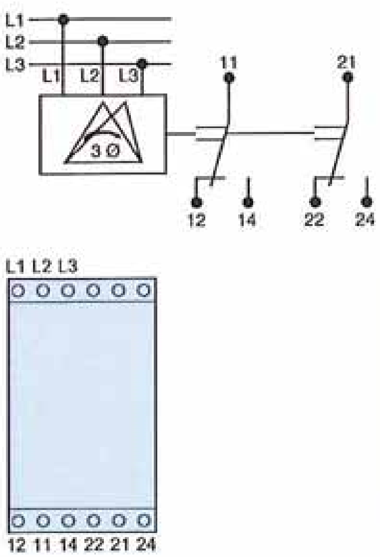
RM84873201, RM84873211



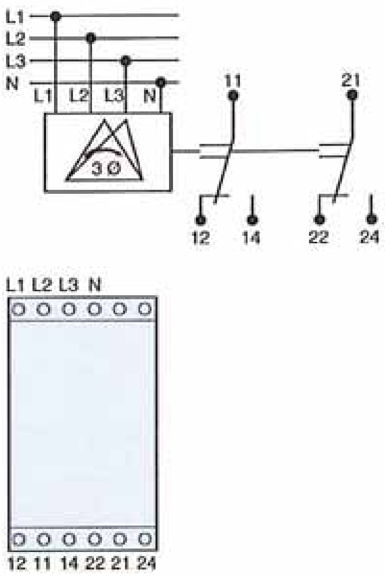
Dimensions: $\frac{mm}{in.}$

WIRING

RM84873201



RM84873211



 Telemecanique


RM84873211

SELECTION

Voltage control relays for 3-phase supply

Power supplies measured	Catalog Number	Weight oz (kg)
3 @ 400 Vac	RM84873201	10.9 (0.310)
3 @ 400 Vac + neutral	RM84873211	10.9 (0.310)

Supply characteristics			
Supply voltage Un on terminals L1-L2		Vac	400 ±30% (50/60 Hz)
Maximum power		VA	4 at Un 8 at Un +20%
Immunity to microbreaks		ms	10
Delay on pick-up		s	About 3
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Control circuit characteristics			
Adjustment of upper threshold			102–115% of Un
Adjustment of lower threshold			85–98% of Un
Fault delay		s	0.1–10 (0 to +50%)
Hysteresis			About 3%
Setting accuracy			±10%
Repeat accuracy	Upper threshold		0.06%
	Lower threshold		0.09%
Temperature drift			±0.05% per °C
Output circuit characteristics			
Output			2 C/O contacts, AgCdO
Breaking capacity			2000 VA (AC), 80 W (DC)
Maximum breaking current	AC/DC	A	8
Minimum breaking current	AC/DC	mA	100
Maximum switching voltage		Vac or Vdc	250
Mechanical life			30 × 10^6 operating cycles (see ▲ on page 41)
Electrical life	AC-12		2000 VA, 10^5 operating cycles (see ▲ on page 41)
	AC-15		Cos φ = 0.3, 6000 operating cycles (see ▲ on page 41)
	DC-13		L/R = 300 ms, 6000 operating cycles (see ▲ on page 41)
Other characteristics			
Delay on crossing the threshold		s	0.1–10 Max.: 10–15)
Indication	Supply		Green LED
	Overvoltage relay		Yellow LED
	Undervoltage relay		Yellow LED
Protection class	Terminal block		IP 20
Conforming to IEC 60529-5	Enclosure		IP 50
Enclosure			Self-extinguishing
Terminal capacity	With cable end	AWG (mm²)	Two #16 (1.5)
	Without cable end	AWG (mm²)	Two #14 (2.5)
Tightening torque	Conforming to IEC 60947-1	lb-in (N•m)	5.3 (0.6) max. (M3 screw)
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60, conforming to IEC 60068-1-14)
	Storage	°F (°C)	-22 to +158 (-30 to +70, conforming to IEC 60068-1-1/2)
Relative humidity	Conforming to IEC 60068-2-30		93% without condensation
Vibrations	Amplitude	mm	0.35
Conforming to IEC 682-6	Frequency	Hz	10–55
Insulation resistance	Conforming to IEC 60255-5	MΩ	> 10 at 500 Vac
Dielectric strength	Conforming to IEC 60255-5	kV	> 2.5/1min/1 mA/50 Hz
Impulse voltage	Conforming to IEC 60255-5/664-1	kV	5, wave 1.2-50 μs
Approvals	c UL us File E173076 CCN NRNT File E173076 CCN NRNT 7		File 217698 Guide 3211 07

Zelio® Control Measurement Relays
RM4UB Single-Phase Monitoring Relays

RM4UB

FUNCTIONS

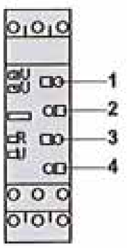
These devices are designed for monitoring single phase mains and power supplies. They have a transparent, hinged cover on their front face to prevent accidental alteration of the settings. This cover can be sealed.

Applications

- Protecting electronic or electromechanical devices against overvoltage and undervoltage
- Normal/emergency power supply switching

Features

RM4UB



1	Overvoltage setting potentiometer
2	Undervoltage setting potentiometer
3	Time delay function selector
	Fault detection delayed (off delay)
	Fault detection extended (on delay)
4	Potentiometer for setting time delay (s)
R	Yellow LED: Indicates relay state
U	Green LED: Indicates that supply to the RM4 is present
>U	Red LED: Overvoltage fault
<U	Red LED: Undervoltage fault

OPERATING PRINCIPLE

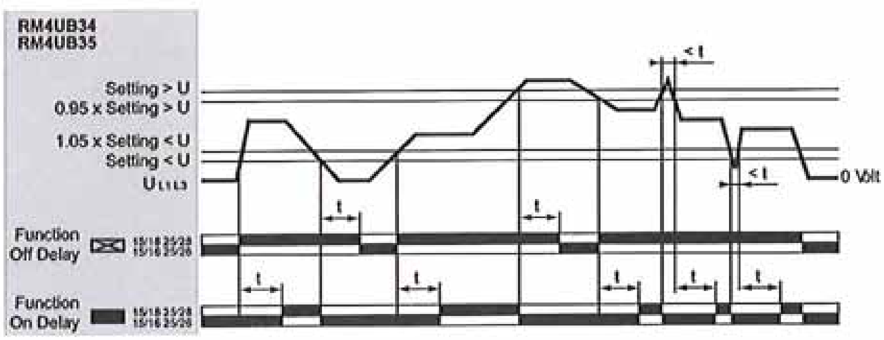
The supply voltage to be monitored is connected to product terminals L1, L3. RM4UB relays are self-powered by terminals L1 and L3; they require no separate power supply.

When the voltage fluctuates outside the range to be monitored, the output relay is de-energized.

- Overvoltage: Red LED "> U" illuminates
- Undervoltage: Red LED "< U" illuminates

When the supply returns toward its rated value, the relay is re-energized according to the hysteresis value (5%), and the corresponding red LED goes out. A switch allows selection of an adjustable time delay from 0.1–10 s. With the off-delay function, over- and undervoltages have no effect. With the on-delay function, over- and undervoltages delay the re-energization of the relay. Regardless of the switch setting, an over- or undervoltage is detected only if its duration exceeds the measuring cycle time (80 ms).

Function Diagram



SPECIFICATIONS

Output Relay and Operational Specifications

Number of C/O (SPDT) Contacts		2 C/O–DPDT
Output Relay State		Energized during fault-free operation. De-energized on detection of an overvoltage or undervoltage fault.
Setting Accuracy of Switching Threshold	As a percentage of the setting value	±3%
Switching Threshold Drift	Depending on the permissible ambient temperature	≤ 0.06% per °C
	Within the measuring range	≤ 0.5%
Accuracy of Time Delay Setting	As a percentage of the full scale value	±10%
Time Delay Drift	Within the measuring range	≤ 0.5%
	Depending on the rated operational temperature	≤ 0.07% per °C
Hysteresis	Fixed	About 5% of the de-energization threshold
Measuring Cycle		≤ 80 ms

Measuring Input Specifications

Minimum Operational Voltage	**RM4UB34:** 60 V **RM4UB35:** 160 V
Maximum Permissible Voltage Between L1 and L3	**RM4UB34:** 300 V **RM4UB35:** 300 V

SELECTION

Relays with Adjustable Thresholds

RM4UB

Adjustable Time Delay	Rated Mains Supply Voltage ■	Control Threshold	Width in (mm)	Output Relay	Catalog Number	Weight lb (kg)
0.1–10 s	100–200 V 50/60 Hz	Undervoltage 80–120 V Overvoltage 160–220 V	0.89 in (22.5 mm)	2 C/O DPDT	RM4UB34	0.24 lb (0.110 kg)
	180–270 V 50/60 Hz	Undervoltage 160–220 V Overvoltage 220–300 V	0.89 in (22.5 mm)	2 C/O DPDT	RM4UB35	0.24 lb (0.110 kg)

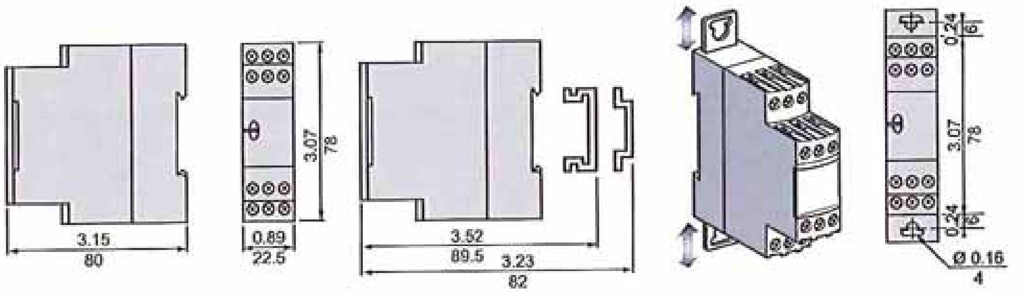
■ Can be used on other supply voltages if the minimum operational voltages, maximum voltage between phases, and compatibility are within the control threshold ranges shown in the table above.

For additional application data, refer to page 2.

Zelio® Control Measurement Relays
RM4UB Single-Phase Monitoring Relays

DIMENSIONS (approximate)

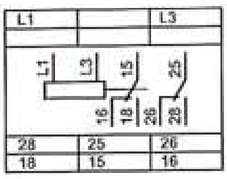
RM4UB | Rail Mounting | Direct Mounting



Dual Dimensions = in/mm

WIRING CONNECTIONS

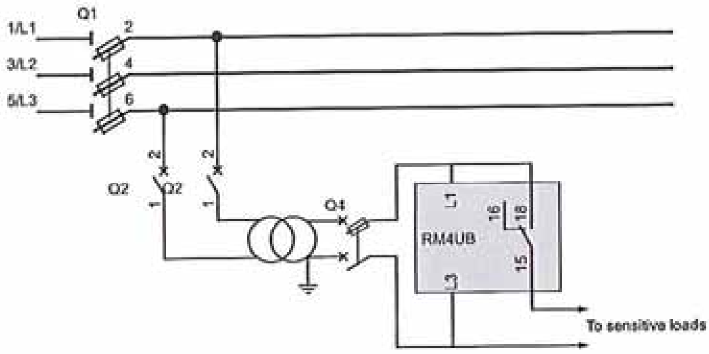
Terminal Blocks
RM4UB



L1, L2, L3	Supply to be monitored
15–18	1st C/O contact
15–16	of the output relay
25–28	2nd C/O contact
25–26	of the output relay

Application Diagram

Example



FUNCTIONS

RM4LG01

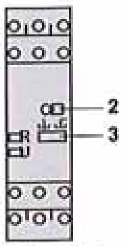
RM4LA32

These devices monitor the levels of conductive liquids. They control the actuation of pumps or valves to regulate levels; they are also suitable for protecting submersible pumps from running empty or tanks from overflowing. They can also control dosing of liquids in mixing processes and protect heating elements in the event of non-immersion. They have a transparent, hinged cover on the front face to prevent accidental alternation of the settings. This cover can be sealed.

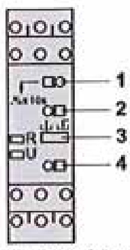
- Compatible liquids include, but are not limited to:
  - Spring, municipal, industrial, and sea water
  - Metallic, acidic, and basic salt solutions
  - Liquid fertilizers
  - Non-concentrated alcohol (< 40%)
  - Liquids in the food processing industry, such as milk, beer, and coffee
- Non-compatible liquids include, but are not limited to:
  - Chemically pure water
  - Fuels and flammable liquid gases
  - Oil and concentrated alcohol (> 40%)
  - Ethylene, glycol, paraffin, varnish, and paint

Features

RM4LG01
Width 0.89 in (22.5 mm)



RM4LA32
Width 0.89 in (22.5 mm)



1 Fine adjustment of the time delay (as a percentage of the maximum value of the setting range)
2 Fine adjustment of the response sensitivity (as a percentage of the maximum value of the setting range)
3 Function selector switch:
empty or fill .
4 Switch combining:
— selection of the response sensitivity range
— selection of time delay on energization ⊠ or de-energization ■ of the relay
R Yellow LED: indicates the relay state (off when de-energized, on when energized)
U Green LED: indicates the presence of the relay supply

Details for Switch 3

Switch Position	Time Delay	Sensitivity
500 ⊠	On delay	High = 500 kΩ range
500 ■	Off delay	High = 500 kΩ range
50 ⊠	On delay	Medium = 50 kΩ range
50 ■	Off delay	Medium = 50 kΩ range
5 ⊠	On delay	Low = 5 kΩ range
5 ■	Off delay	Low = 5 kΩ range

Zelio® Control Measurement Relays
RM4L Liquid Level Relays

OPERATING PRINCIPLE

Operation is based on a change in the resistance measured between immersed or non-immersed electrodes. Low resistance between electrodes means liquid is present. High resistance between electrodes means no liquid is present. The electrodes can be replaced by other sensors or probes that transmit values representing variations in resistance. The AC measuring voltage, which is < 30 V and galvanically insulated from the supply and contact circuits, ensures safe use and the absence of any electrolysis phenomena.

Application

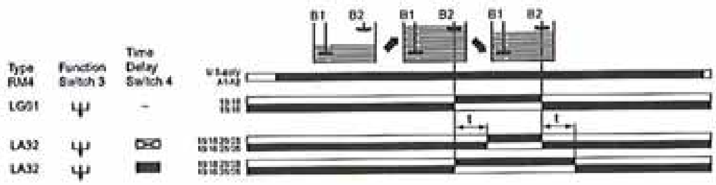
- Detecting a liquid level: operating with 2 electrodes (one reference electrode and one high level electrode) or an LA9RM201 probe (example: preventing tank overflow)
- Regulating a liquid level between a minimum and a maximum level: operating with 3 electrodes or an LA9RM201 probe (example: a water tower)

Configuration

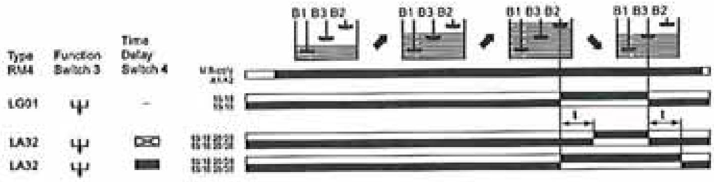
- Empty function : The output relay is energized when high level electrode B2 is immersed, and de-energized when low level electrode B3 is dry. ■
- Fill function : The output relay is energized when the low level electrode is dry, and de-energized when the high level electrode is immersed. ■

On model RM4LA32, a time delay can be set on energization or de-energization of the output relay, to raise the maximum level (function) or to lower the minimum level (function). This function also makes it possible to avoid output relay pulsing (wave effect) when operating with two electrodes.

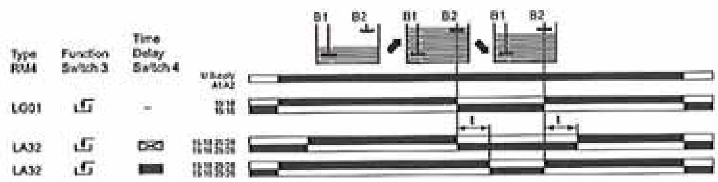
Empty Function, Maximum Level Detection (2 Electrodes or 1 Probe LA9RM201)



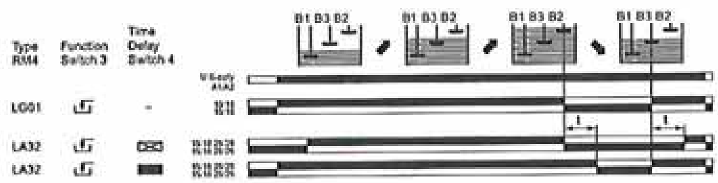
Empty Function, Regulation between a Maximum and a Minimum Level (3 Electrodes or 2 Probes LA9RM201)



Fill Function, Maximum Level Detection (2 Electrodes or 1 Probe LA9RM201)



Empty Function, Regulation between a Maximum and a Minimum Level (3 Electrodes or 2 Probes LA9RM201)



B1: Reference electrode **B2: High level electrode** **B3: Low level electrode**

■ When operating with two electrodes, the high level electrode performs both high and low level functions.

SPECIFICATIONS

Power Supply Circuit Specifications

Type of Relay 50/60 Hz		RM4LG01				RM4LA32				
Rated Supply Voltage (Un)	50/60 Hz Vac	24 Vac	110–130 Vac	220–240 Vac	380–415 Vac	24–240 Vac	24 Vac	110–130 Vac	220–240 Vac	380–415 Vac
	Vdc	–	–	–	–	24–240 Vdc	–	–	–	–
Average Consumption at Un	Vac	1.9 VA	2.6 VA	2.4 VA	2.9 VA	2.7 VA	3.1 VA	2.7 VA	2.6 VA	3.4 VA
	Vdc	–	–	–	–	2.4 W	–	–	–	–

Output Relay and Operating Specifications

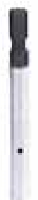
Number of SPDT (C/O) Contacts	1 C/O SPDT	2 C/O DPDT
Output Relay State	Switch configurable: empty or fill	

Electrode Circuit Specifications ■

Sensitivity Scale	5–100 (adjustable) kΩ	0.25–5 kΩ	2.5–50 kΩ	25–500 kΩ
Maximum AC Electrode Voltage (peak to peak)	24 V	24 V	24 V	24 V
Maximum Current in the Electrodes	1 mA	1 mA	1 mA	1 mA
Maximum Cable Capacity	10 nF	200 nF	25 nF	4 nF
Maximum Cable Length	330 ft (100 m)	3300 ft (1000 m)	330 ft (100 m)	66 ft (20 m)


RM4LG01


RM4LA32


LA9RM201

SELECTION

Liquid Level Control Relays

Time Delay	Sensitivity Scale	Width in (mm)	Output Relay	Voltage 50/60 Hz	Catalog Number	Weight lb (kg)
None	5–100 kΩ	0.87 in (22.5 mm)	1 C/O–SPDT	24 Vac	RM4LG01B	0.36 (0.165)
				110–130 Vac	RM4LG01F	0.36 (0.165)
				220–240 Vac	RM4LG01M	0.36 (0.165)
				380–415 Vac	RM4LG01Q	0.36 (0.165)
Adjustable 0.1–10 s	0.25–5 kΩ 2.5–50 kΩ 25–500 kΩ	0.87 in (22.5 mm)	2 C/O–DPDT	24–240 Vac/ Vdc	RM4LA32MW	0.36 (0.165)
				24 Vac	RM4LA32B	0.36 (0.165)
				110–130 Vac	RM4LA32F	0.36 (0.165)
				220–240 Vac	RM4LA32M	0.36 (0.165)
				380–415 Vac	RM4LA32Q	0.36 (0.165)

Liquid Level Control Probe

Type of Installation	Maximum Operating Temperature	Catalog Number	Weight lb (kg)
Suspended by cable	212 °F (100 °C)	LA9RM201	0.22 (0.100)

■ The electrodes may also be incorporated in the probes. The probes are normally designed for mounting to a tank using a bracket with a seal (closed tanks) or suspended by their own electrical connecting cable (boreholes, etc.). See page 53 "Setting-up" Probe LA9RM201.

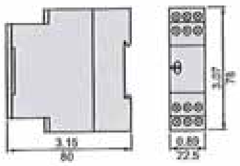
For additional application data, refer to page 2.

For additional probe, refer to page 66.

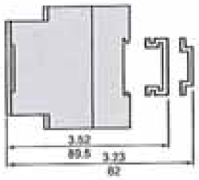
Zelio® Control Measurement Relays
RM4L Liquid Level Relays

DIMENSIONS

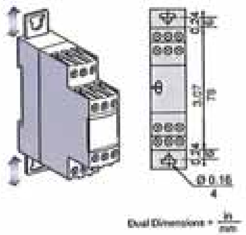
RM4LG01



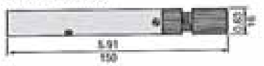
Rail Mounting



Direct Mounting

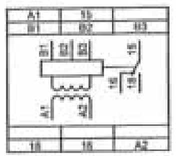


Probe LA9RM201

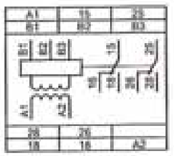


WIRING CONNECTIONS

RM4LG01



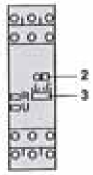
RM4LA32



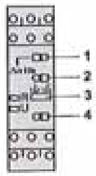
A1–A2	Supply Voltage
B1, B2, B3	Electrodes (see table below)
15–18 **15–16**	1st C/O contact of the output relay
25–28 **25–26**	2nd C/O contact of the output relay

Electrode and Level Controlled

B1	Reference or tank ground electrode
B2	High Level
B3	Low Level



RM4LG01



RM4LA32

Setup

1. Select the empty or fill function as appropriate for the application.
2. If necessary, set potentiometer **1** to minimum (time delay).
3. Set potentiometer **2** to minimum. On RM4LA, select the lowest sensitivity range using potentiometer **4** (5 or 5).
4. With all the electrodes immersed, turn the sensitivity potentiometer toward maximum until the relay is energized (function) or de-energized (function), then exceed the threshold by about 10% to compensate for variation in the supply voltage.
5. If the relay does not energize, do one of the following:
   — Use a higher sensitivity scale (selector **4** on RM4LA32)
   — Replace relay RM4LG with relay RM4LA32 and start the adjustment procedure again
6. Check that the relay de-energizes (function) or energizes (function) as soon as electrodes B3 and B2 are out of the liquid. If the relay does not de-energize, select a lower sensitivity scale.
7. Protect the electrode connection point against corrosion. In areas where thunderstorms are likely, also protect the electrode lines.

NOTE: The high level can be raised from 0.1 –10 s using the adjustable time delay with function .
The low level can be lowered using this same time delay with function .

Probe LA9RM201

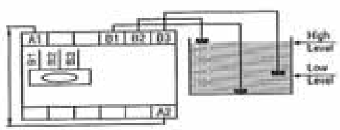
This suspended-type probe is coaxial. In addition to the normal (central) electrode, the stainless steel skirt can also act as the ground (reference) electrode, so no separate reference probe is needed. Controlling one level requires one probe instead of two; controlling two levels requires two probes instead of three. The skirt also acts as a calming chamber to prevent inaccuracy resulting from an agitated surface of the liquid (waves).

Use only a **two-conductor** connecting cable with common cylindrical PVC sheathing and a maximum diameter of 0.25 in. (6.3 mm).

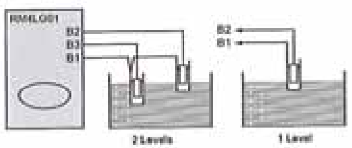
The maximum operating temperature is 212 °F (100 °C).

Probe LA9RM201 can also be mounted to containers such as cisterns or tanks using a bracket or other suitable mounting device.

Connection Examples
Control by Electrodes



Control by Probes



- *Regulation of two levels: minimum and maximum*
- *Function to be monitored (filling/UP or emptying/DOWN) selectable using the switch on the front panel of the device*
- *Probes with AC current flowing through them*
- *Sensitivity adjustment potentiometer on the front panel of the device*
- *Sensitivity adjustable from 5–100 kΩ*

OPERATING PRINCIPLE

These devices control maximum and/or minimum levels of conductive liquids (such as tap water, sea water, waste water, chemical solutions, and coffee).

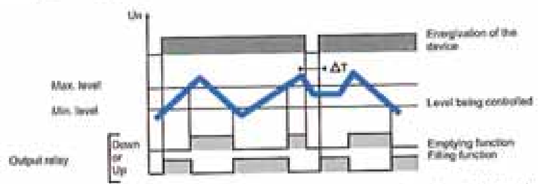
Operation is based on measuring the apparent resistance of the liquid between two submerged probes. When this value falls below the threshold setting on the front panel of the device, the output relay changes state. To avoid electrolytic phenomena, an AC current runs across the probes.

Applications include the food-processing and chemical industries.

Regulation of two levels, minimum/maximum

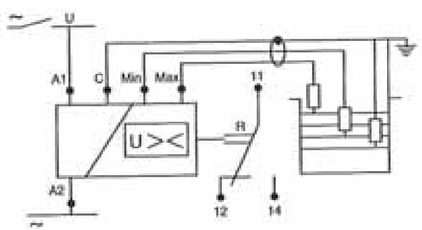
The output relay changes state when the liquid level reaches the maximum level probe, with the minimum level probe submerged. It returns to its initial state when the minimum level probe is no longer in contact with the liquid.

Filling or emptying control



NOTE: If the voltage break ΔT lasts 1 s or more, then the relay is instantly re-energized if in ***Up*** *mode or de-energized if in* ***Down*** *mode.*

WIRING



RM84870001

SELECTION

Filling (Up) and emptying (Down) control relays

Voltage	Catalog Number	Weight oz (kg)
24 Vac	RM84870001	4.9 (0.140)
120 Vac	RM84870003	4.9 (0.140)
230 Vac	RM84870004	4.9 (0.140)

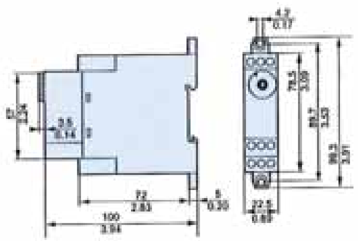
NOTE: The probe cable (maximum length 100 m / 328 ft) need not be shielded, but avoid installing it in parallel with the power supply cables.
When using shielded cable, connect the shielding to the common.

Characteristics

Supply voltage Un		Vac	24, 120, 230 (50/60 Hz)
Operating range			0.85–1.15 × Un
Maximum power consumption		VA	3
Sensitivity adjustment		kΩ	5–100
Measurement accuracy (at maximum sensitivity)			0 to +30%
Electrode voltage (maximum)		Vac	24 (50/60 Hz)
Electrode current (maximum)		mA	1 (50/60 Hz)
Maximum cable capacity		nF	10
Response time	High level	ms	300
	Low level	ms	500
Output relay (to meet AC-1 requirements, resistive load)			1 C/O contact, AgCdO, 8 A (AC) max.
Galvanic isolation via transformer (4 kV, 8 mm creepage distance)			Class II VDE 0551
Isolation of contacts and electrodes from the supply		kVac	2.5
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60)
	Storage	°F (°C)	-22 to +158 (-30 to +70)
Approvals	c UL us File E173076 CCN NRNT, File E173076 CCN NRNT 7		CSA File 217698, Guide 3211 07; CE

For probe, refer to page 66.

DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

- *Regulation of two thresholds: minimum or maximum*
- *Emptying control*
- *Probes with AC current flowing through them*
- *Sensitivity adjustment potentiometer on the front panel of the device*
- *Sensitivity adjustable from:*
  - *250 kΩ to 5 kΩ (low sensitivity)*
  - *50 kΩ to 1 MΩ (high sensitivity)*

OPERATING PRINCIPLE

These devices control maximum and/or minimum levels of conductive liquids (such as tap water, sea water, waste water, chemical solutions, and coffee).

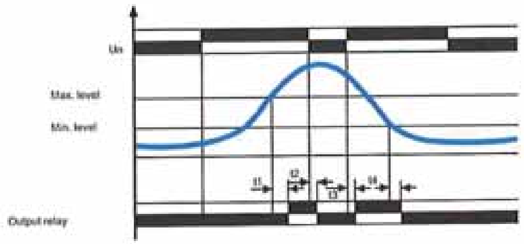
Operation is based on measuring the apparent resistance of the liquid between two submerged probes. When this value falls below the threshold setting on the front panel of the device, the output relay changes state. To avoid electrolytic phenomena, an AC current runs across the probes.

Applications include the food-processing and chemical industries.

Regulation of two levels, minimum/maximum

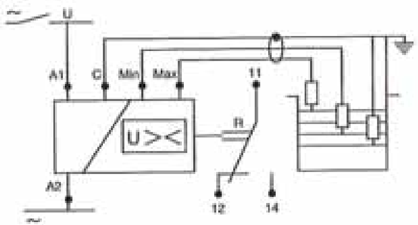
The output relay changes state when the liquid level reaches the maximum level probe, with the minimum level probe submerged. It returns to its initial state when the minimum level probe is no longer in contact with the liquid.

Emptying control



For values of t1, t2, t3, and t4, refer to page 57.

WIRING



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RM84870131

SELECTION

Emptying control relays (low and high sensitivity)

Voltage	Sensitivity	Catalog Number	Weight oz (kg)
24 Vac	250 Ω to 5 kΩ	RM84870121	5.3 (0.150)
	50 kΩ to 1 MΩ	RM84870131	5.3 (0.150)

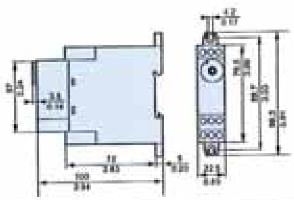
NOTE: The probe cable (maximum length 100 m / 328 ft) need not be shielded, but avoid fitting it in parallel with the power supply cables.
When using shielded cable, do not exceed the capacities indicated.

Characteristics

Relay type			RE84870121	RE84870131
Supply voltage		Vac	24 (50/60 Hz)	
Supply range			±15% of Un -15 to +10% if other products are mounted on the same rail	
Maximum power consumption		VA	3	
Sensitivity adjustment			250 kΩ to 5 kΩ	50 kΩ to 1 MΩ
Measurement accuracy (at maximum sensitivity)			±30%	±30%
Maximum electrode voltage		Vac	24 (50/60 Hz)	24 (50/60 Hz)
Maximum electrode current			3 mA (50/60 Hz)	50 µA (50/60 Hz)
Maximum cable capacity		nF	100	1
Initialization time	t3	ms	650	650
De-energization time	t2	s	1	1
Response time	t1 (high level)	ms	600	600
	t4 (low level)		300 ms	2 s
Output relay (to meet AC-1 requirements, resistive load)			1 C/O contact, cadmium-free, 8 A / 250 Vac	
Galvanic isolation via transformer (4 kV, 8 mm creepage distance)			Class II VDE 0551	
Isolation of contacts and electrodes from the supply 1 min/1 mA/50 Hz (IEC 60 225-5)		kVac	2.5	
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/2	
Ambient air temperature	Operation	°F (°C)	-4 to +140 (-20 to +60)	
	Storage	°F (°C)	-22 to +158 (-30 to +70)	
Degree of protection	Enclosure		IP 50	
	Terminal block		IP 20	
Enclosure material			Self-extinguishing Pc	
Product certifications	c UL us File E173076 CCN NRNT File E173076 CCN NRNT 7		SP File 217608 Guide 3211 07	CE

For probes, refer to page 66.

DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

- *Controlling the levels of conductive liquids*
- *Regulation of two thresholds: minimum and maximum*
- *Emptying function*
- *Plug-in, 8- or 11-pin connector*
- *Sensitivity adjustable from 5–100 kΩ*

OPERATING PRINCIPLE

These devices control maximum and/or minimum levels of conductive liquids, such as tap water, sea water, waste water, chemical solutions, and coffee.

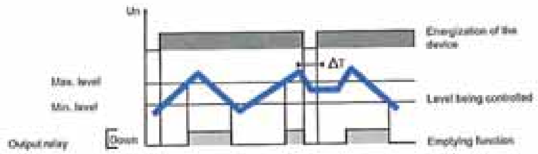
Operation is based on measuring the apparent resistance of the liquid between two submerged probes. When this value falls below the threshold setting on the front panel of the device, the output relay changes state. To avoid electrolytic phenomena, an AC current runs across the probes.

Applications include the food-processing and chemical industries.

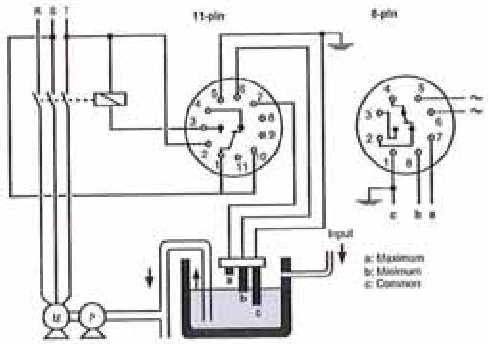
Regulation of two levels, minimum/maximum

The output relay changes state when the liquid level reaches the maximum level probe, with the minimum level probe submerged. It returns to its initial state when the minimum level probe is no longer in contact with the liquid.

Emptying control



WIRING SCHEME



RM84870303

SELECTION

Liquid level control relays

Number of pins	Voltage	Catalog Number	Weight oz (kg)
8-pin	24 Vac	RM84870301	4.9 (0.140)
	120 Vac	RM84870303	4.9 (0.140)
	230 Vac	RM84870304	0.4.9 (0.140)
11-pin	24 Vac	RM84870306	4.9 (0.140)
	120 Vac	RM84870308	4.9 (0.140)
	230 Vac	RM84870309	4.9 (0.140)

NOTE: The probe cable (maximum length 100 m / 328 ft) need not be shielded, but avoid fitting it in parallel with the power supply cables.
When using shielded cable, connect the shielding to the common.

Accessories

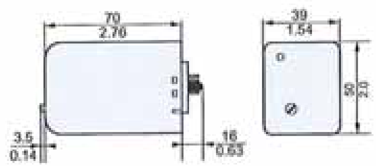
Description		Catalog Number	Weight oz (kg)
8-pin socket	Single tier	8501NR51	1.5 (0.043)
	Double tier	8501NR52	2.1 (0.060)
11-pin socket	Single tier	8501NR61	1.8 (0.050)
	Double tier	8501NR62	2.8 (0.078)

Characteristics

Supply voltage Un		Vac	24, 120, 230 (50/60 Hz)
Operating range			0.85–1.15 × Un
Maximum power consumption		VA	3
Sensitivity adjustment		kΩ	5–100
Measurement accuracy (at maximum sensitivity)			0 to +30%
Maximum electrode voltage		Vac	24 (50/60 Hz)
Maximum electrode current		mA	1 (50/60 Hz)
Maximum cable capacity		nF	10
Response time	High level	ms	300
	Low level	ms	500
Output relay (to meet AC-1 requirements, resistive load)			1 C/O contact, AgCdO ≅ 8 A max.
Galvanic isolation via transformer (4 kV, 8 mm creepage distance)			Class II VDE 0551
Isolation of contacts and electrodes from the supply		kVac	2.5
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60)
	Storage	°F (°C)	-22 to +158 (-30 to +70)
Approvals	cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7		CSA File 217698, Guide 3211 07; CE

For probe, refer to page 66.

DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

Zelio® Control Measurement Relays
RM84870 Liquid Level Relays

- *Controlling the levels of conductive liquids*
- *Combined fill/empty function*
- *Combined regulation of emptying a well and filling a tank*
- *Plug-in, 11-pin connector*
- *LED indicating the output relay state*
- *Sensitivity adjustable from 5–100 kΩ*

OPERATING PRINCIPLE

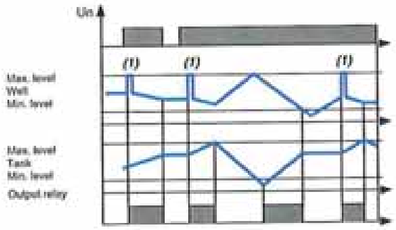
Combined fill/empty function

The output relay changes state when the liquid level in the tank reaches the maximum level probe, with the minimum level probe submerged. It returns to its initial state when the minimum level probe is no longer in contact with the liquid.

When the liquid level in the well reaches the minimum level probe, the pump stops.

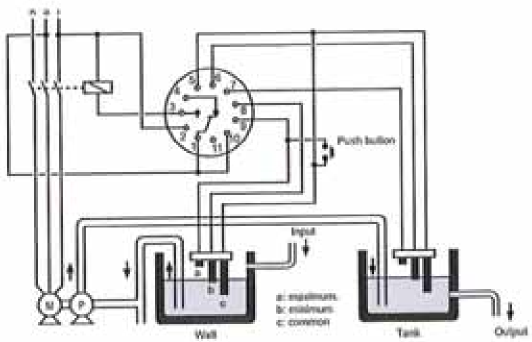
On energization or after a power supply cutoff, if the maximum level probe in the tank is above the liquid level, reset the device by pressing the push button.

Emptying control



(1) Push button

WIRING SCHEME



RM8487040•

SELECTION

Liquid level control relays

Number of pins	Voltage	Catalog Number	Weight oz (kg)
11-pin	24 Vac	RM84870401	4.9 (0.140)
	120 Vac	RM84870403	4.9 (0.140)
	230 Vac	RM84870404	4.9 (0.140)

Accessories

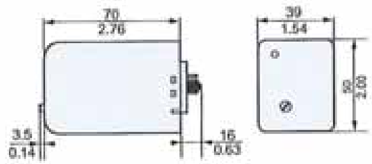
Description		Catalog Number	Weight oz (kg)
11-pin socket	Single tier	8501NR61	1.8 (0.050)
	Double tier	8501NR62	2.8 (0.078)

NOTE: The probe cable (maximum length 100 m / 328 ft) need not be shielded, but avoid fitting it in parallel with the power supply cables.
When using shielded cable, connect the shielding to the common.

Characteristics			
Supply voltage Un		Vac	24, 120, 230 (50/60 Hz)
Operating range			0.85–1.15 × Un
Maximum power consumption		VA	3
Sensitivity adjustment		kΩ	5–100
Measurement accuracy (at maximum sensitivity)			0 to +30%
Maximum electrode voltage		Vac	24 (50/60 Hz)
Maximum electrode current		mA	1 (50/60 Hz)
Maximum cable capacity		nF	10
Response time	High level	ms	300
	Low level	ms	500
Output relay (to meet AC-1 requirements, resistive load)			1 C/O contact, AgCdO 8 A max. (AC)
Galvanic isolation via transformer (4 kV, 8 mm creepage distance)			Class II VDE 0551
Isolation of contacts and electrodes from the supply		kVac	2.5
Ambient air temperature	Operation	°F (°C)	-4 to +140 (-20 to +60)
	Storage	°F (°C)	-22 to +158 (-30 to +70)
Product certifications	cULus File E173076 CCN NRNT2, File E173076 CCN NRNT 8		CSA File 217698, Guide 3211 07; CE

For probe, refer to page 66.

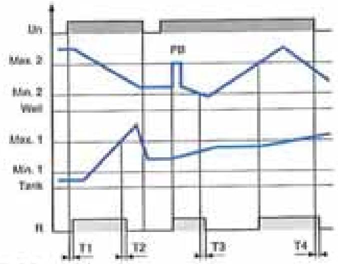
DIMENSIONS (approximate)



Dimensions: mm / in.

Zelio® Control Measurement Relays
RM84870 Liquid Level Relays

- *Control and automatic regulation of liquid levels*
- *Sensitivity adjustable from 5–100 kΩ*
- *Combined regulation of emptying a well and filling a tank*
- *LED indicating power on and output relay state*



T1: Delay on pick-up
T2: Response time on immersion
T3: Response time on emergence
T4: Response time on de-energization

For T values, refer to page 63.

Terminals	
A1–A2	Supply voltage
11–12–14	Output relay (R)
C–Min. 1–Max. 1	Tank probe inputs
C–Min. 2–Max. 2	Well or supply tank probe inputs

OPERATING PRINCIPLE

These devices control tank filling at two levels (min. 1, max. 1), with simultaneous control of well or supply tank emptying at two levels (min. 2, max. 2), to protect a pump against running empty.

Operation is based on measuring the apparent resistance of the liquid between two submerged probes. To avoid electrolytic phenomena, an AC current runs across the probes.

NOTE: In certain applications, fine adjustment of sensitivity leads to the detection of undesirable factors, such as the presence of foam or bubbles on the surface of the liquid, or the appearance of leakage impedance between probes (e.g., extended line capacity or humidity).

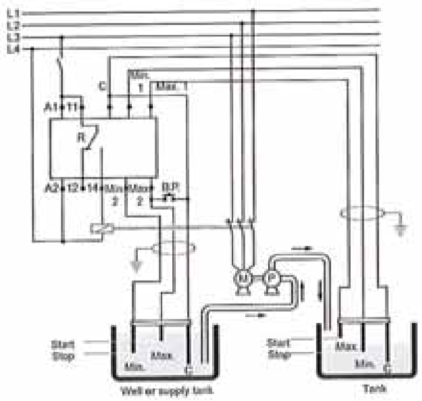
Combined Fill/Empty function

The output relay changes state (de-energizes) when the liquid level in the tank reaches the max. 1 level probe, with the min. 1 level probe submerged. It returns to its initial state (closes) when the min. 1 level probe is no longer in contact with the liquid.

When the liquid level in the well reaches the min. 2 level probe, the pump stops (relay open). This prevents the pump from running empty.

On energization or after a power supply cutoff, if the max. 2 level probe in the tank is above the liquid level, then reset the device by pressing the push button (PB).

WIRING AND APPLICATION SCHEME




RM84870604

SELECTION

Combined fill and empty function

Voltage	Catalog Number	Weight oz (kg)
230 Vac	RM84870604	8.8 (0.250)

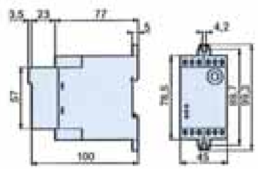
NOTE: The probe cable (maximum length 100 m / 328 ft) need not be shielded, but avoid installing it close to the power supply cables.
To conform to the EMC directive (89/336/EEC), shielded cable must be used, with the shielding connected to the common and to earth.

Supply characteristics				
Supply voltage Un			Vac	230 (50/60 Hz) electrical isolation via transformer
Operating range				0.85–1.15 Un
Power			VA	Rated: 3 max. at Un; Maximum: 4 at Un +15%
Immunity to microbreaks			ms	10
Delay on pick-up		t1	ms	400
Response time on de-energization		t4	ms	500
Creepage distance and clearance	Conforming to IEC 60664-1		kV	4kV/2
Control characteristics				
Sensitivity range				5–100 kΩ
Setting accuracy				±30% at maximum sensitivity
Electrode voltage			Vac	15 (50/60 Hz)
Electrode current			mA	1
Accuracy				±30% at maximum sensitivity
Response time	On immersion	t2	ms	400
	On emergence	t3	ms	700
Output circuit characteristics				
Output type				1 C/O contact, AgCdO
Breaking capacity				2000 VA, 80 W
Maximum breaking current	AC/DC		A	8
Minimum breaking current	AC/DC		mA	100
Maximum switching voltage			Vac/Vdc	250
Mechanical life ▲				5×10^6 operating cycles ▲
Electrical life ▲	AC-12			2000 VA, 10^5 operating cycles ▲
	AC-15			Cos φ = 0.3, 6000 operating cycles ▲
	DC-13			L/R = 300 ms, 6000 operating cycles ▲
Other characteristics				
Enclosure material				Self-extinguishing
Terminal capacity	With cable end		AWG (mm²)	Two #16 (1.5)
	Without cable end		AWG (mm²)	Two #14 (2.5)
Temperature limits	Operation		°F (°C)	-4 to +140 (-20 to +60, conforming to IEC 60068-1-14)
	Storage		°F (°C)	-22 to +158 (-30 to +70, conforming to IEC 60068-1-1/2)
Relative humidity				93% without condensation
Approvals	cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7			CSA File 217698 Guide 3211 07; CE

For probes, refer to page 66.

▲ The expected life expressed above is based on average usage and normal operating conditions. Actual operating life will vary with conditions. The above statements are not intended to nor shall they create any expressed or implied warranties as to product operation or life. For information on the listed warranty offered on this product, refer to the Square D terms and conditions of sale found in the *Digest*.

DIMENSIONS (approximate)



Dimensions: mm / in.

- *Control and automatic regulation of liquid levels*
- *Two sensitivity ranges*
- *Fill or empty function selectable via DIP switch*
- *High or low level alarm selectable via DIP switch*
- *Selectable memory*
- *LEDs indicating power on, output relay state, and alarm relay state*

NOTE: Alarm relay R2 can be programmed to latch in the de-energized state when a fault occurs by setting a switch on the underside of the device (the switch must be operated with the device switched off). To reset alarm relay R2 once the levels have been re-established, the power supply to the device must be switched off.

OPERATING PRINCIPLE

Control of the level of a conductive liquid at specific points (high and low levels) with alarm when the level is abnormally high or abnormally low.

Operation is based on measuring the apparent resistance of the liquid between submerged probes. When this value is below the threshold setting on the front panel of the device, the output relay R1 and/or the alarm relay R2 change state.

To avoid electrolysis phenomena, an AC current runs across the probes.

Sensitivity adjustment

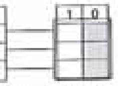
Set the sensitivity so that the relay changes state when the probes are in contact with the liquid, then returns to its initial position as soon as the probes emerge.

NOTE: In certain applications, fine adjustment of sensitivity leads to the detection of undesirable factors, such as the presence of foam or bubbles on the surface of the liquid, or the appearance of leakage impedance between probes (e.g., extended line capacity or humidity).

Programming

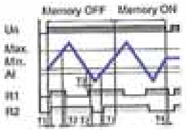
The level controller can be programmed via three switches on the underside of the device:

	1	0
Memory	OFF	ON
Alarm	Low	High
Function	Empty	Fill



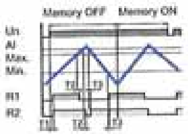
NOTE: The device must be switched off when making Memory, Alarm and Function selections.

Filling control with low level alarm



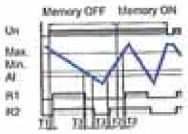
On energization, probe Al is submerged, relays R1 and R2 change to the energized state, and the pump is on. Filling starts, and the LED for relay R1 is lit. When the liquid reaches the max. level probe, relay R1 changes to the de-energized state, and the pump is off. Filling stops, and the LED for relay R1 goes out. Relay R1 re-energizes when the min. level probe emerges. In the event of a fault (continual drop in level), probe Al is emerged, relay R2 changes to the de-energized state, and the alarm is triggered; the LED for relay R2 comes on. This fault can be memorized.

Filling control with high level alarm



On energization, the level in the tank is low, relays R1 and R2 change to the energized state, and the pump is on. Filling starts, and the LED for relay R1 is lit. When the liquid reaches the max. level probe, relay R1 de-energizes, and the pump is off; filling stops and the relay LED goes out. In the event of a fault, if the level continues to rise and reaches probe Al, relay R2 de-energizes and the alarm is triggered; the LED for relay R2 comes on. This fault can be memorized.

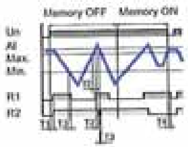
Emptying control with low level alarm



On energization, the min. level, max. level, and Al probes are submerged; relays R1 and R2 change to the energized state; and the pump is on. Emptying starts, and the LED for relay R1 is lit. When the liquid reaches the max. level probe, relay R1 de-energizes and the pump is off; emptying stops, and the LED for relay R1 goes out. In the event of a fault, if the level continues to drop, probe Al emerges, relay R2 de-energizes, and the alarm is triggered; the LED for relay R2 comes on. This fault can be memorized.

Emptying control with high level alarm

T1: Delay on pick-up
T2: Response time on immersion
T3: Response time on emergence
T4: Response time on energization



On energization, the min. level and max. level probes are submerged and probe Al is above the liquid level; relays R1 and R2 change to the energized state; and the pump is on. Emptying starts, and the LED for relay R1 is lit. When the min. level probe emerges, relay R1 de-energizes, and the pump is off. Emptying stops, and the LED for relay R1 goes out. The relay re-energizes when the max. level probe is submerged. In the event of a fault, if the level continues to rise and reaches probe Al, relay R2 de-energizes and the alarm is triggered; the LED for relay R2 comes on. This fault can be memorized.


RM84870504

SELECTION

Liquid level control relays with alarm

Voltage	Catalog Number	Weight oz (kg)
230 Vac	RM84870504	9.9 (0.280)

NOTE: The probe cable need not be shielded, but avoid installing it close to the power supply cables.
To conform to the EMC directive (89/336/EEC), shielded cable must be used, with the shielding connected to the common and to earth.

Supply characteristics

Supply voltage Un		Vac	230 (50/60 Hz) galvanic isolation by transformer
Operating range			0.85–1.15 Un
Maximum power		VA	Rated: 3 at Un; Maximum: 4 at Un +15%
Immunity to microbreaks		ms	10
Delay on pick-up	t1	s	About 2
Response time on de-energization	t4	ms	500
Insulation coordination			Category III, degree of pollution 2 conforming to IEC 60664-1/VDE 0110: 4 kV/2

Control characteristics

Sensitivity range			5–100 kΩ
Setting accuracy			±30% at maximum sensitivity
Electrode voltage		Vac	15 (50/60 Hz)
Electrode current		mA	1
Response time	On immersion t2	ms	400
	On emergence t3	ms	700

Output circuit characteristics

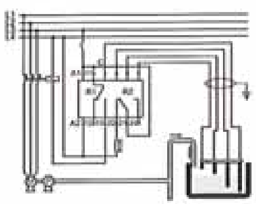
Output type			2 C/O contacts, AgCdO
Breaking capacity			2000 VA, 80 W
Maximum breaking current	AC/DC	A	8
Minimum breaking current	AC/DC	mA	100
Maximum switching voltage		Vac/Vdc	250
Mechanical life			2 x 10^6 operating cycles (see ▲ on page 63)
Electrical life	AC-12		2000 VA, 10^5 operating cycles (see ▲ on page 63)
	AC-15		Cos φ = 0.3, 6000 operating cycles (see ▲ on page 63)
	DC-13		L/R = 300 ms, 6000 operating cycles (see ▲ on page 63)

Other characteristics

Enclosure material			Self-extinguishing
Terminal capacity	With cable end	AWG (mm^2)	Two #16 (1.5)
	Without cable end	AWG (mm^2)	Two #14 (2.5)
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60, conforming to IEC 60068-1-14)
	Storage	°F (°C)	-22 to +158 (-30 to +70, conforming to IEC 60068-1-1/2)
Relative humidity			93% without condensation

Approvals: cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7; CSA File 217698, Guide 3211 07; CE

WIRING

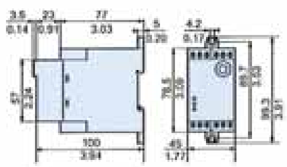


Terminal connections

A1–A2	Supply voltage
11–12–14	Output relay (R1)
21–22–24	Alarm output relay (R2)
C–Min–Max–Al	Probe inputs
Green LED	Power on
Yellow LED	Output relay state
Red LED	Alarm relay state

NOTE: If the reservoir is conductive (metal), it can be used as the reference electrode (C).

DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

SELECTION

Electrode holders

Application	No. of probes	Length in. (mm)	Operating temperature °F (°C)	Maximum pressure kg/cm²	Catalog Number	Weight oz (kg)
Recommended for drink-vending machines and where installation space is limited (Stainless steel)	3	39.4 (1000)	176 (80)	2	RM79696044	28.2 (0.800)
Suitable for boilers, pressure vessels and under high temperature conditions [1] (304 stainless steel)	1	39.4 (1000)	392 (200)	25	RM79696014	12.7 (0.360)

Electrodes

RM79696043

RM79696006

Description	Material	Catalog Number	Weight oz (kg)
Protected electrode for mounting by suspension	Protective shell: PUC (57) Electrode: stainless steel	RM79696043	5.3 (0.150)
Electrode for use up to 662 °F (350 °C) and 15 kg/cm2 [2]	Stainless steel isolated by ceramic	RM79696006	5.3 (0.150)

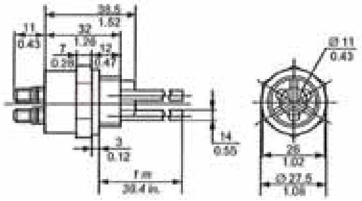
[1] 3/8" BSP mounting thread with hexagonal head. Use a 24 mm wrench for tightening.
[2] 3/8" BSP mounting thread.

Additional probe shown on page 51.

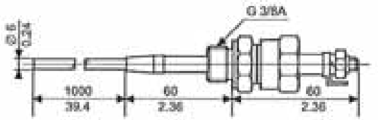
DIMENSIONS (approximate)

Electrode holders

RM79696044

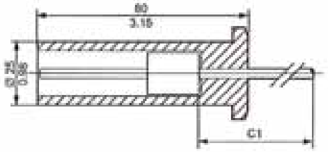


RM79696014

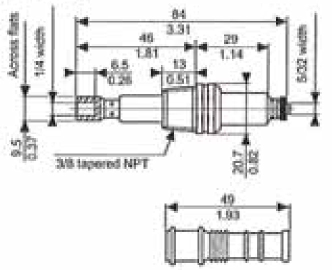


Probes

RM79696043



RM79696006

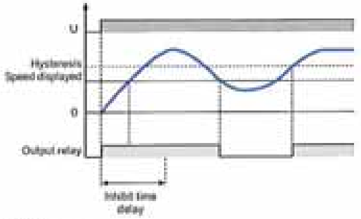


Dimensions: $\frac{mm}{in.}$

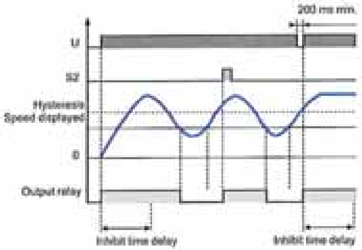
Zelio® Control Measurement Relays
RM84874 Underspeed Relays

- *Detection of motor underspeed, running speed, stopping, or stalling*
- *Information detected by three-wire or NAMUR sensor, or by contact or voltage*
- *Time delay adjustable from 100 ms to 10 min in four sub-ranges*
- *Power-up inhibit time adjustable from 0.3–30 s*
- *Default time delay adjustable from 0.3–3 s*
- *LEDs indicating power on and output relay state*

Without latching



With latching



OPERATING PRINCIPLE

This control relay is used to resolve problems of underspeed on such devices as conveyor belts and conveyors, where crossing a low speed threshold must trigger an alarm.

Speed information is detected via a sensor (such as a three-wire or NAMUR proximity sensor), a volt-free contact, or the voltage.

On power-up, to allow the controlled process to reach its operating speed, control is inhibited for a time between 0.3 and 30 s, adjustable on the front panel of the control relay. When startup requires an inhibition time exceeding 30 s, external contact S2 must be closed during startup (causing the yellow LED to flash), then opened once nominal speed is reached.

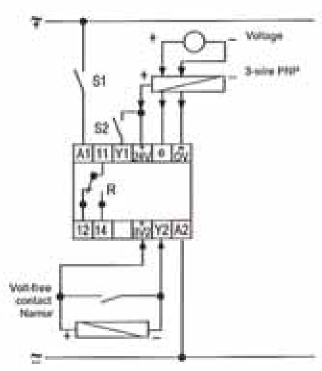
On each cycle of the controlled process, the sensor sends an impulse to the relay. Each of these impulses resets the relay's internal time delay. If the time between two impulses is less than the setting on the relay, then the time delay is reset at each impulse, and the output relay stays closed.

If the speed of the controlled process drops, then the time between two impulses increases. When the time between two impulses exceeds the setting value on the relay, indicating that the controlled process is running at underspeed, the output relay changes state (opens).

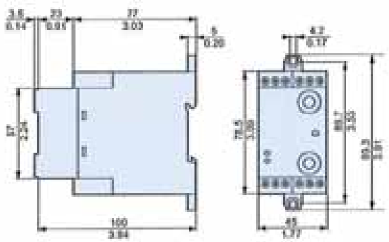
The output relay closes again when the speed of the controlled process exceeds the setting value plus the hysteresis (5% of the setting value).
If Memory mode is selected, then the relay stays open when an underspeed fault is detected. The output relay can only close again after a manual reset is performed by closing external contact S2.

A yellow LED indicates the state of the relay. A green LED indicates that the power supply is on.

WIRING



DIMENSIONS (approximate)



Dimensions: $\frac{mm}{in.}$

Terminals	
Al–A2	Supply voltage
11–12–14	Output relay (R)
+24 V–E–0 V	3-wire PNP sensor
E–0 V	Voltage input
+8 V 2–Y2	Contact/NAMUR sensor input

RM84874304

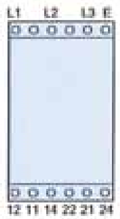
SELECTION

Underspeed control relays

Voltage	Catalog Number	Weight oz (kg)
230 Vac	RM84874304	9.0 (0.255)

Supply characteristics			
Supply voltage Un		Vac	230 (50/60 Hz) galvanic isolation by transformer
Operating range			0.85–1.15 Un
Maximum power consumption		VA	3.5 max. at Un and 5 at Un +15%
Immunity to microbreaks		ms	10
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Input/control circuit characteristics			
Input circuit	3-wire sensor		24 V PNP (50 mA max.)
	NAMUR sensor		8.2 V on 1 kΩ
	Contact		Hard contacts
	Voltage input	V	30 max.
Input resistance		kΩ	16 kΩ except for NAMUR 1
State	High	V	Min. 4.5; max. 30
	Low	V	Min. 0; max. 1
Cut-off frequency		Hz	200
Minimum impulse time		ms	5
Minimum time between impulses		ms	5
Selection of time delay and memory function	Without memory		0.1–1.0 s, 1–10 s, 0.1–1.0 min, 1–10 min — 8-position switch on front panel
	With memory		0.1–1.0 s, 1–10 s, 0.1–1.0 min, 1–10 min
Hysteresis			5% of the threshold setting
Setting accuracy			10% of the full scale value at 77 °F (25 °C)
Repeat accuracy			±0.5% with constant parameters
Temperature drift			±0.05% per °C
Voltage drift			±1% / V
Reset time		ms	200 minimum
Reset time for S2		ms	100 minimum
Inhibit time delay		s	0.3–30 ±10%
Output circuit characteristics			
Output			1 C/O contact, AgCdO
Breaking capacity			2000 VA, 80 W
Maximum breaking current	AC/DC	A	8
Minimum breaking current	AC/DC	mA	100
Maximum switching voltage		Vac/Vdc	100
Mechanical life			5×10^6 operating cycles (see ▲ on page 63)
Electrical life	AC-12		2000 VA, 10^5 operating cycles (see ▲ on page 63)
	AC-15		Cos φ = 0.3, 6000 operating cycles (see ▲ on page 63)
	DC-13		L/R = 300 ms, 6000 operating cycles (see ▲ on page 63)
Other characteristics			
Enclosure material			Self-extinguishing
Terminal capacity	With cable end	AWG (mm^2)	Two #16 (1.5)
	Without cable end	AWG (mm^2)	Two #14 (2.5)
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60, conforming to IEC 60068-1-14)
	Storage	°F (°C)	-22 to +158 (-30 to +70, conforming to IEC 60068-1-1/2)
Relative humidity			93% without condensation
Approvals	cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7		CSA Pending; CE

- *Self-powered*
- *Control of motor overload and underload*
- *Measurement of phase displacement between voltage and current (Cos φ)*
- *Independent adjustment of minimum and maximum thresholds, from 0.1–0.99*
- *Power-up inhibit time adjustable from 0.5–20 s*
- *Default time delay adjustable from 0.3–3 s*
- *Two output relays (one per threshold)*
- *LEDs indicating power on and output relay state*



OPERATING PRINCIPLE

The control relay is used for motor protection. The variation in the power factor (voltage/current phase displacement or Cos φ) is related to the variation in the mechanical load of the motor. The control relay monitors the power factor, and therefore the mechanical load, and checks that it is between two defined and adjustable limits.

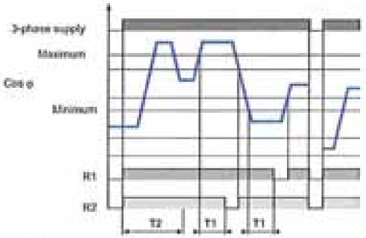
A green LED indicates that the power supply is ON.
Two yellow LEDs indicate the state of the output relays.

On power-up, the two output relays are closed for the duration of the inhibit time (T2 adjustable from 0.5 to 20 s). When the power factor value is between the two threshold settings, both relays are closed.

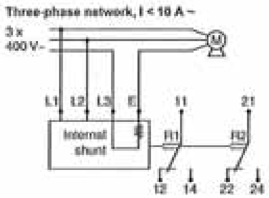
When the power factor exceeds the maximum value set by the user, the high threshold relay is de-energized after a time delay T1 (adjustable from 0.3 to 3 s). During this time delay, the green LED flashes (1 Hz). The relay closes again as soon as the measured value drops below the threshold minus the hysteresis.

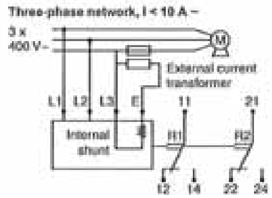
When the power factor drops below the minimum value set by the user, the low threshold relay is de-energized after a time delay T1 (adjustable from 0.3 to 3 s). During this time delay, the green LED flashes. The relay closes again as soon as the measured value rises above the threshold plus the hysteresis.

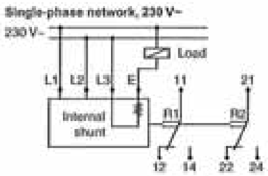
If the high threshold value is set below or equal to the low threshold value, the green LED flashes rapidly (2 Hz).



WIRING







Terminals

L1—L2—L3	Network to be monitored
E	Current read output
11—12—14	Low threshold output relay (R1)
21—22—24	High threshold output relay (R2)

RM84873400

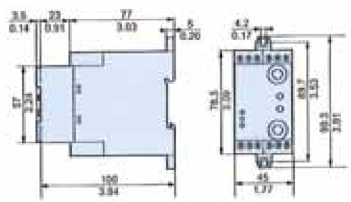
SELECTION

Motor load control relays (Cos φ)

Power supply/control	Catalog Number	Weight oz (kg)
3 @ 230 Vac	RM84873400	12.7 (0.360)
3 @ 400 Vac	RM84873401	12.7 (0.360)

Supply characteristics			
Supply voltage Un		Vac	230, 400, self-powered via L1 and L2
Operating range			0.85–1.15 Un
Power		VA	Rated: 2 at Un; Maximum: 3 at Un +15%
Immunity to microbreaks		ms	10
Creepage distance and clearance	Conforming to IEC 60664-1	kV	4kV/3
Control input circuit characteristics			
Threshold display			0.1–0.99
Voltage circuit input resistance		kΩ	About 2 (Un)
Current measurement			By internal link via 2 terminals
Current range		A	0.5–10
Input resistance		mΩ	20
Maximum continuous current		A	14 at 68 °F (20 °C)
Peak overload		A	50 (< 1 s) at 68 °F (20 °C)
Time delays	On energization (t2)	s	0.5–20 ±20% of the full scale value
	On crossing the threshold (t1)	s	0.3–3 ±20% of the full scale value
Frequency		Hz	50–60
Hysteresis	Cos φ ≥ 0.4		10% fixed
	Cos φ < 0.4		10% <Hysteresis < 30%
Setting accuracy			±10% of the full scale value
Repeat accuracy			±0.08% with constant parameters
Temperature drift			±0.05% per °C
Output circuit characteristics			
Output			2 C/O contacts, AgCdO
Breaking capacity			2000 VA, 80 W
Maximum breaking current	AC/DC	A	8
Minimum breaking current	AC/DC	mA	100
Maximum switching voltage		Vac/Vdc	250
Mechanical life ▲			30 x 10^6 operating cycles ▲
Electrical life ▲	AC-12		2000 VA, 10^5 operating cycles ▲
	AC-15		Cos φ = 0.3, 6000 operating cycles ▲
	DC-13		L/R = 300 ms, 6000 operating cycles ▲
Other characteristics			
Enclosure material			Self-extinguishing
Terminal capacity		AWG (mm²)	With cable end: two #16 (1.5); without cable end: two #14 (2.5)
Temperature limits	Operation	°F (°C)	-4 to +140 (-20 to +60, conforming to IEC 60068-1-14)
	Storage	°F (°C)	-22 to +158 (-30 to +70, conforming to IEC 60068-1-1/2)
Relative humidity			93% without condensation
Approvals	cULus File E173076 CCN NRNT, File E173076 CCN NRNT 7		CSA Pending; CE

DIMENSIONS



Dimensions: mm / in.

▲ The expected life expressed above is based on average usage and normal operating conditions. Actual operating life will vary with conditions. The above statements are not intended to nor shall they create any expressed or implied warranties as to product operation or life. For information on the listed warranty offered on this product, refer to the Square D terms and conditions of sale found in the Digest.

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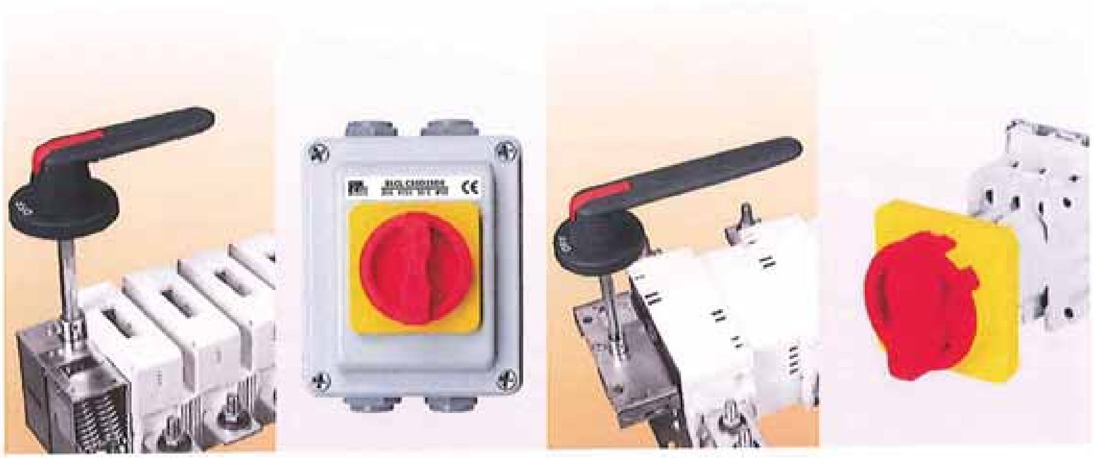

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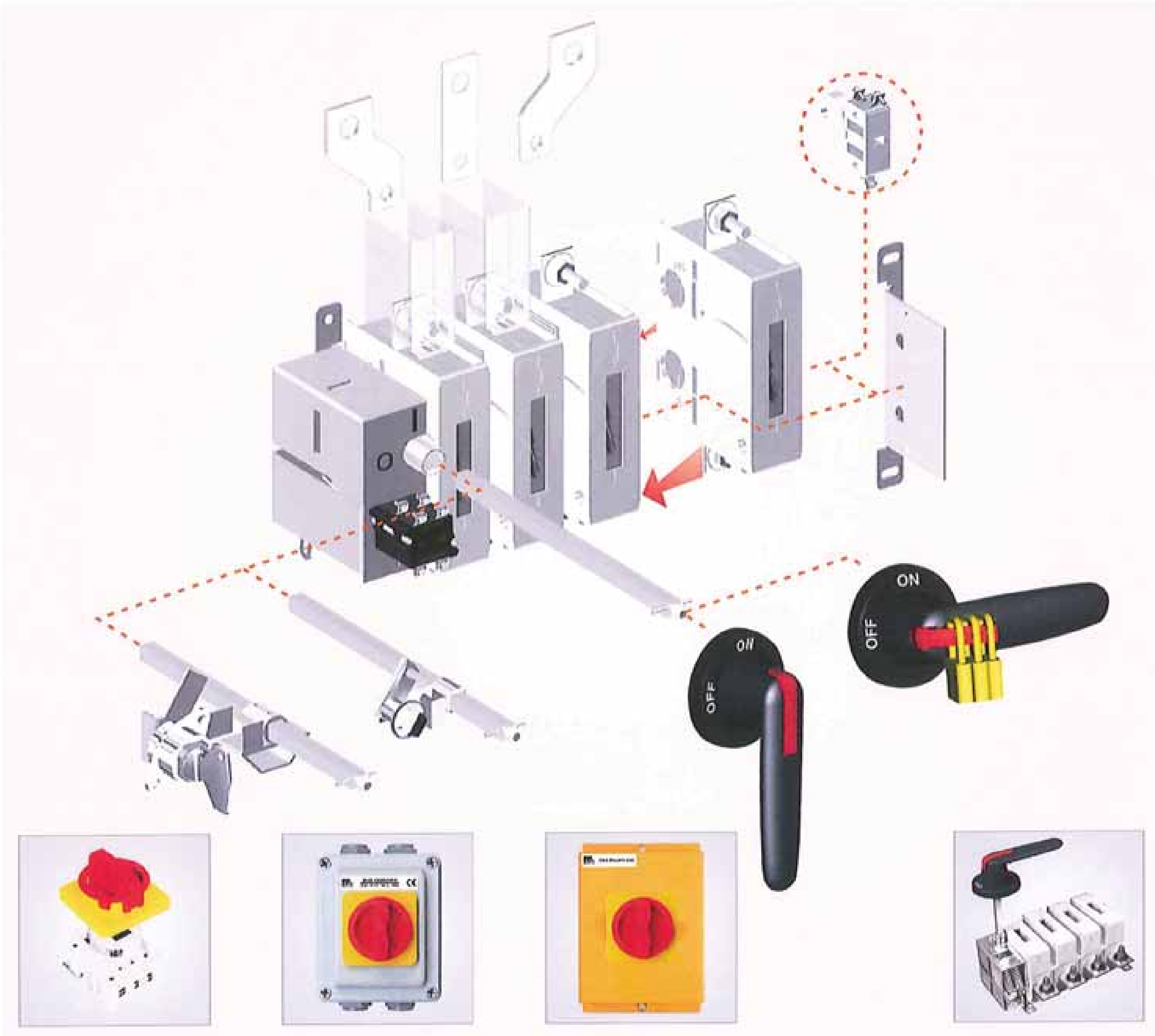
Switchdisconnector 03 2009

We touch your electricity everyday!

Introduction



Rugged construction, Integrating end user convenience with installation flexibility

C&S Electric offers a wide range of Switch Disconnectors (On Load Break Switches) - 25A to 3150A, suitable for operation upto 750/1000V. Available in 3 Pole as well as 4 Pole, interiors as well as in enclosure, they are suitable for AC23 utilization category and confirm to IEC 60947-3 / IS 13947-3.

63A onwards, these switches have individual phase pole construction, enabling any combination from 1 pole to 8 poles. Thus, modular yet rugged construction, with all poles including the neutral having same 100% rating & reliability.

Modular arrangement also eliminates need for matching standard 3 pole switch to specific installation requirement by adding neutral pole in 3 phase 4 wire AC system or looping poles for DC system. Hence these switches are most suitable & economical switch for all applications like:-

- Main Service Entrance Switch from Transformers & Busbars
- AC or DC Power Distribution System
- Switching & Isolating Motors
- Switching & Isolating Capacitors
- Switching & Isolating Industrial Control Equipment
- AC or DC Safety Switch

Their mounting flexibility offers numerous matchless benefits for use in power distribution boards or for standalone mountings. They are compact enough to occupy small panel space yet allowing installation as per convenience and rendering it safe for maintenance.

For machine tool or distribution (scattered) installation in buildings, upto 125A switches are also available in plastic enclosure, which are corrosion proof and add to the aesthetic of the installations.

Multiple accessories to suit application requirements also enhance the flexibility of operation and safety level of installation. They also facilitate these switches to match diverse application requirements.

Manufactured in ISO 9001 certified facilities, rugged design combining ease of operation and maintenance, they have stood the test of adverse environments in all types of climate in various countries, including India for more than in 15 years.

These switches have established their ingenuity in breaking the stalled motor current in the event of emergency, switching highly inductive loads, capacitor banks, DC loads etc.

They have been used successfully in almost every industry, becoming the exclusive choice of every discerning user, be it Power Plants, Building segments, Telecommunication field or industries like Steel, Chemical, Cement, Automobile, Machine Tools etc.

Modular and user friendly

Internationally Endorsed

Tested & Accepted World over

C&S Switch Disconnectors have been tested for their conformity to International as well as Indian Standards at various independent Laboratories like - ASTA for conformity to International Standards – IEC 60947 - 3 and CPRI, ERDA for conformity to Indian Standards IS 13947 - 3. These also conform to the safety regulations adopted in the European Union and carry the CE marking.

OEMs and panel assemblers can be assured that this design is already being used and exported to many countries the world over.

An ISO 9001 certified manufacturing facilities gives the assurance of quality & consistency of these switches

Easy Installation

Convenient, Swift & Economical

The handle in the C&S switch disconnectors has a telescopic shaft. The handle & shaft assembly adjusts to wide depth of the panel so there is no need to place a bracket below the switch while aligning it with enclosure door. It permits installation of the same switch in installations of different depths, without any modification or addition to the enclosures.

Four hole handle fixing on the door permits last minute rotation of the switch inside the panel by 90 degrees on either side as per convenience, again without any modification to the door.

These time saving features increase the ease and flexibility of installation and also reduce installation cost.

Flexible Design

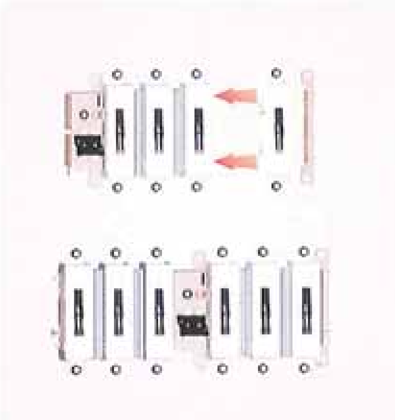
Modular yet reliable construction

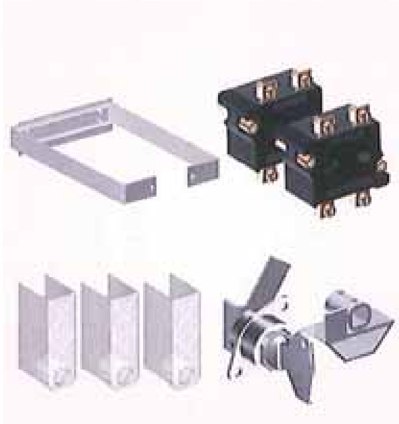
C&S Switch Disconnector have a modular assembly for operating mechanism and pole. Contact system, placed in separate housing for individual phase poles, are joined together to form a switch with any number of poles - from 1 pole, upto 8 poles.

Flexibility of this arrangement also permits to place mechanism in between the poles. 63A-800A, switches with side operated mechanism are also offered.

There is no add-on arrangement, each pole has same 100% rating and operates with same reliability. As each pole is independent of other, its maintenance or replacement is easy & economical in the event of damage.

Switches can hence be ordered as per installation requirement 2 pole for DC; 3 pole for 3 phase, 3 wire system; 4 pole for 3 phase, 4 wire system or 6 pole for Star Delta motors.





Accessories

Flexibility to suit Application

Multiple accessories increase these switches suitability for diverse application, enhance operational flexibility and improve installation safety.

Handle mounting kit lets complete Switch mounted inside enclosure door so that it can be operated only after opening the door. Door mounting kit lets fixing complete switch on to the door, doing away with need for fixing switch on base plate & aligning with door.

Auxiliary contacts permit electrical interlocking, remote indication and Alarm. Key Lock and Castle Lock help interlocking with different category of products.

Extended terminals allow further liberal termination or termination of large number of cables with higher clearances. Shrouds encase the terminals so that no falling hardware may get embedded between the terminals resulting in flashovers.

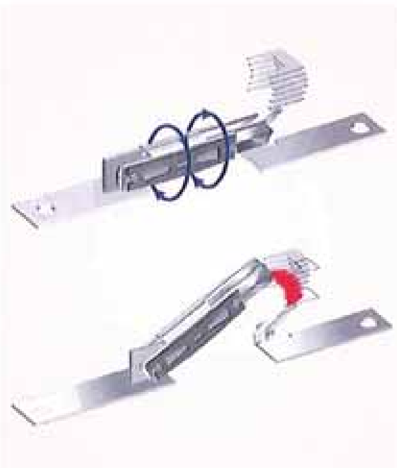
Unique Contact Mechanism

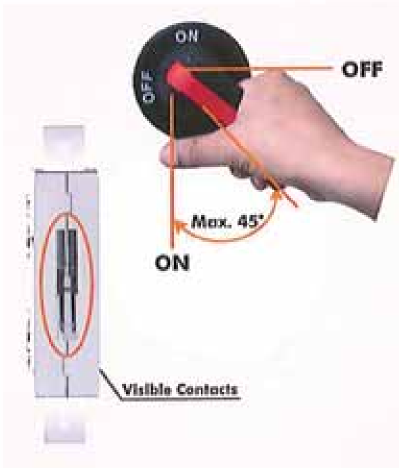
Efficient Switching & Long life

Switch Disconnectors of rating 200A and above employ unique Knife Contact Mechanism, which uses magnetic attraction principle in iron circuit on the moving contacts. As current increases, automatically the contact force too increases, ensuring - good contacts at all times, high making and breaking capacity upto 690V and low temperature rise leading to long electrical life.

The special form of fixed contacts results in separate arcing and current carrying surfaces. It again ensures that current carrying surface remains unaffected by arcing, maintaining same contact pressure and enhancing electrical life. Special shape of fixed contacts also help blow out the Arc into Arc – Chute where it is swiftly extinguished under controlled conditions, safely.

With every switching, the knife contacts clean themselves. This makes them perfectly suited for Indian conditions in general and for high pollution and corrosive conditions as in Chemical Plants, Cement Plants, Steel Plants, etc., including applications like Motors and capacitor switching.





Switch Construction

Safety Built-in

C&Sd esigni ntroducedt hec oncepto fp rotectioni nc aseo f welded contacts by positive break forced opening of contacts. In the event of high current and fuse failing to operate, leading to welding of contacts, the handle will not turn beyond 45° from the ON position, clearly indicating that the contacts are welded.

Convenience of contacts visibility, permits contact position inspection, without removing the switch from installation, thus enhancing reliability and saving time.

Self extinguishing fibre glass re-inforced insulating body of poles has very high tracking index. Large gap between fixed and moving contacts in OFF position, make them suitable for isolation function.

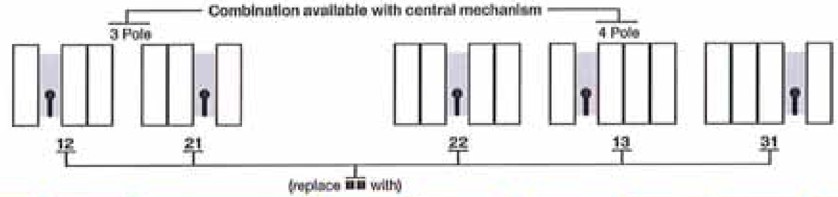
Door interlocking prevents opening in the ON position, guarding the operator against an accidental mishap. As a standard upto 3 padlocks are provided in the OFF position to prevent closing the circuit during maintenance work. They can also be provided for the ON position. Using a suitable gasket alongwith handle enhances ingress protection level to IP 54.

Technical Data

Common Characteristics

Conformity to Standards	-	IEC 60947-3 / IS 13947-3
Rated Operational Voltage (Ue)	V	415
Rated Operational Frequency	Hz	50 / 60
Suitability for Isolation	-	YES
Pollution Degree as per IEC / IS	-	3
Ambient / Cubicle Service Temp.	°C	55
IP Level after mounting	-	IP 54
Number of Poles (4th Pole always 100% rated in 4 Pole switches)	-	3P / 4P 1P to 8P on request



Replace '●' with 3 in case of 3 pole or with 4 in case of 4 pole

Parameters			25A	40A	63A	63A	100A	125A	100A	125A	160A	200A
Type - CSSD with side mechanism			CSSD025D●	CSSD040D●	CSSD63K●	CSSD063D●	CSSD100D●	CSSD125D●	CSSD100DM●	CSSD125DM●	CSSD160DM●	CSSD200DM●
Type - CSSD with central mechanism, 3 pole			-	-	-	-	-	-	-	-	-	CSSD200DM●●
Type - CSSD with central mechanism, 4 pole			-	-	-	-	-	-	-	-	-	CSSD200DM●●
Rated insulation voltage and rated operational voltage AC20 / DC20		V	750	750	750	750	750	750	750	750	750	1000
Dielectric strength	50 Hz 1min.	KV	6	6	6	6	6	6	6	6	6	10
Rated impulse withstand voltage		KV	8	8	8	8	8	8	8	8	12	12
Rated thermal current and rated												
operational current AC20 / DC20 / ambient 40°C	Open Execution	A	32	40	63	63	115	135	115	135	160	250
/ ambient 40°C	Enclosure	A	25	40	63	63	100	125	100	125	160	200
/ ambient 60°C	Enclosure	A	16	25	40	40	63	100	63	100	125	175
With minimum conductor cross section	Cu	mm2	6	10	16	16	35	50	-	-	70	95
Rated operational current, AC-21A	up to 415V	A	25	40	63	80	100	125	100	125	160	200
	440-690V	A	25	40	63	63	100	125	100	125	160	200
	1000V	A	-	-	-	-	-	-	-	-	-	200
Rated operational current, AC-22A	up to 415V	A	25	40	63	63	100	125	100	125	160	200
	440-500V	A	-	-	-	-	-	-	-	125	160	200
	690V	A	-	-	-	-	-	-	100	125	160	200
	1000V	A	-	-	-	-	-	-	-	-	-	200
Rated operational current, AC-23A	up to 415V	A	25	40	63	63	100	125	100	125	160	200
	440V	A	20	25	40	40	50	63	60	70	100	200
	500V	A	20	25	32	32	50	63	60	70	100	200
	690V	A	16	25	32	32	40	50	40	50	63	200
	1000V	A	-	-	-	-	-	-	-	-	63	125
Rated operational current / poles in series, DC-21A	up to 48V	A	16/2	16/2	16/2	16/2	16/2	16/2	100/2	125/2	160/2	200/2
	110V	A	16/3	16/3	16/3	16/3	16/3	16/3	100/3	125/3	160/3	200/2
	220V	A	16/3	16/3	16/3	16/3	16/3	16/3	100/3	125/3	160/3	200/2
	440V	A	16/4	16/4	16/4	16/4	-	-	-	-	-	200/3
	750V	A	-	-	-	-	-	-	-	-	-	200/4
Rated operational current / poles in series, DC-22A	up to 48V	A	16/2	16/2	16/2	16/2	16/2	16/2	100/2	125/2	160/2	200/2
	110V	A	16/3	16/3	16/3	16/3	16/3	16/3	100/3	125/3	160/3	200/2
	220V	A	16/3	16/3	16/3	16/3	16/3	16/3	100/3	125/3	160/3	200/2
	440V	A	16/4	16/4	16/4	16/4	-	-	-	-	-	200/3
	750V	A	-	-	-	-	-	-	-	-	-	200/4
Rated operational current / poles in series, DC-23A	up to 48V	A	16/2	16/2	16/2	16/2	16/2	16/2	100/2	125/2	160/2	200/2
	110V	A	16/3	16/3	16/3	16/3	16/3	16/3	100/3	125/3	160/3	200/2
	220V	A	16/3	16/3	16/3	16/3	16/3	16/3	100/3	125/3	160/3	200/2
	440V	A	16/4	16/4	16/4	16/4	-	-	-	-	-	200/3
	750V	A	16/4	16/4	16/4	16/4	-	-	-	-	-	200/4

Technical Data

Parameters				25A	40A	63A		100A	125A	100A	125A	160A	200A
Rated operational power, AC-23A	The kW-ratings are accurate for	220-240V	kW	4	5.5	11	11	22	22	22	22	22	55
	3 phase 1500 R.P.M. standard	400-415V	kW	9	11	22	22	37	45	37	45	45	110
	asynchronous motors	440V	kW	9	11	22	22	37	45	37	45	45	110
		500V	kW	9	11	22	22	37	45	37	45	45	132
		690V	kW	9	11	15	15	37	45	37	45	45	170
Rated breaking capacity, AC-23A		up to 415V	A	200	320	504	504	800	1000	800	1000	1280	1600
		440V	A	160	200	320	320	400	504	480	560	1280	1600
		500V	A	160	200	256	256	400	504	480	560	1280	1600
		690V	A	128	200	256	256	320	400	320	400	1280	1600
Rated breaking capacity/poles in series, DC-23A		up to 48V	A	100/2	128/2	180/2	180/2	400/2	500/2	400/2	500/2	640/1	800/2
		110V	A	100/2	128/2	180/2	180/2	400/2	500/2	400/2	500/2	640/2	800/2
		220V	A	100/4	128/4	180/4	180/4	252/4	252/4	252/4	252/4	252/4	800/2
		440V	A	40/4	40/4	40/4	40/4	-	-	-	-	-	800/3
		750V	A	64/8	64/8	-	-	-	-	-	-	-	800/4
Rated conditional (fused) short-circuit current r.m.s. and corresponding cut-off current of the fuse in single-phase test according IEC 269	Cut-off /Back up fuse Rating	50kA	kA	6.5	6.5	13	13	16.5	16.5	16.5	16.5	18	36
		415V		40/32	40/32	100/80	100/80	125/125	125/125	125/125	125/125	160/160	400/400
		50kA	kA	6.5	6.5	13	13	16.5	16.5	16.5	16.5	18	36
		500V		40/32	40/32	100/80	100/80	125/125	125/125	125/125	125/125	160/160	400/400
		50kA	kA	4	4	11	11	10	10	10	10	10	48
		690V		25/16	25/16	80/63	80/63	63/63	63/63	63/63	63/63	63/63	400/400
		100kA	kA	-	-	17	17	-	-	-	-	-	48
		500V		-	-	100/80	100/80	-	-	-	-	-	400/400
Rated short-time withstand current	R.M.S. -value Icw	690V,0.2s	kA	1	1	2	2	5	5	5	5	8	17.5
		690V,0.25s	kA	1	1	2	2	5	5	5	5	8	-
		690V,1s	kA	0.5	0.5	1	1	2.5	2.5	2.5	2.5	5	8
Rated short circuit making capacity	Peak value Icm	690V/500V	kA	0.7	0.7	1.4	1.4	3.6	3.6	3.6	3.6	7	35
Rated capacitor power	The capacitor ratings are	400V	kVAR	10	15	25	25	40	50	40	50	60	90
	limited by the fuse link	415V	kVAR	10	15	25	25	40	50	40	50	60	90
Power loss / pole	At rated operational current		w	0.6	1.6	2.8	2.8	4	6.3	4	6.3	9	3.5
Mechanical Endurance	Divide by two for operation cycles		Operations	20000	20000	20000	20000	20000	20000	20000	20000	20000	16 000
Electrical Endurance	At 0.65 pf	415V	Operations	5000	5000	5000	5000	5000	5000	5000	5000	1000	1000
Weight without accessories	With handle and shaft	3-Pole	kg	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	1.8	3
		4-Pole	kg	0.25	0.25	0.4	0.5	0.5	0.5	0.5	0.5	2.25	3.7
Terminal suitable for cable lug size	Cu- wire suitable for terminal clamp		Sq mm	0.75-10	1.5-35	1.5-35	1.5-35	10-70	10-70	10-70	10-70	10-95	8x25
Terminal tightening torque	Counter torque required		Nm	0.8	2	2	5.5	6	8	6	8	8	30...44
Operating torque	3-pole switch-disconnector		Nm	1	1	1.2	1.2	2	2	2	2	2.5	8.2

Catalogue Reference

E□ CSSD 1250 D 3 □

Mounting

EABW	Plastic Enclosure, Gray base & Gray cover (25A-63A)
EACL	Plastic Enclosure, Gray base & Yellow cover (25A-63A)
ELCL / ELBL	Aluminum Enclosure, Gray base & Gray cover (16A-125A) (Refer our Enclosed Switch Catalogue for more info.)
E	In Sheet Steel Enclosure
Blank	Without Enclosure

Rating

40	40A
800	800A
2500	2500A

Switch Type

D	Old Series, 25A, 40A, 63A, 100A & 125A
DM	Compact Series, upto 100 - 315A
K	63A, 400A - 3150A, 3 pole
C	Toggle Type 25A - 125A

No. of Poles

3	3 Pole
4	4 Pole

Combination available with central mechanism

3 Pole 4 Pole

12 21 22 13 31

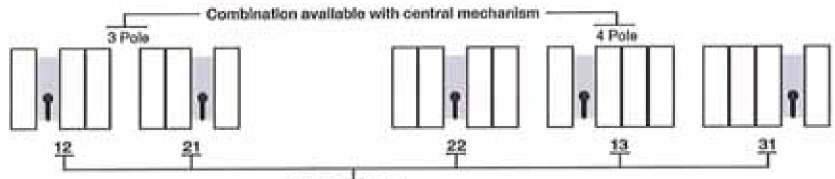
Mechanism Type

Blank	Front Operated
SO	Side Operated, 63 - 800A (not applicable for combinations with central mechanism)

Technical Data

Common Characteristics

Conformity to Standards	-	IEC 60947-3 / IS 13947-3
Rated Operational Voltage (Ue)	V	415
Rated Operational Frequency	Hz	50 / 60
Suitability for Isolation	-	YES
Pollution Degree as per IEC / IS	-	3
Ambient / Cubicle Service Temp.	°C	55
IP Level after mounting	-	IP 54
Number of Poles (4th Pole always 100% rated in 4 Pole switches)	-	3P / 4P 1P to 6P on request



Replace '●' with 3 in case of 3 pole or with 4 in case of 4 pole

Parameters			250A	315A	400A	630A	800A	1000A	1250A	1600A	1800A	2500A	3150A
Type - CSSD with side mechanism			CSSD0250DM●	CSSD0315DM●	CSSD400K●	CSSD630K●	CSSD800K●	CSSD1000K●	CSSD1250K●	CSSD1600K●	CSSD1800K●	CSSD2500K●	CSSD3150K●
Type - CSSD with central mechanism, 3 pole			CSSD0250DM●●	CSSD0315DM●●	CSSD400K●●	CSSD630K●●	CSSD800K●●	CSSD1000K●●	CSSD1250K●●	CSSD1600K●●	CSSD1800K●●	CSSD2500K●●	CSSD3150K●●
Type - CSSD with central mechanism, 4 pole			CSSD0250DM●●	CSSD0315DM●●	CSSD400K●●	CSSD630K●●	CSSD800K●●	CSSD1000K●●	CSSD1250K●●	CSSD1600K●●	CSSD1800K●●	CSSD2500K●●	CSSD3150K●●
Rated insulation and rated operational voltage AC20 / DC20	50 Hz 1min.	V	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Dielectric strength		KV	10	10	10	10	10	8	8	8	8	8	8
Rated impulse withstand voltage		KV	12	12	12	12	12	8	8	8	8	8	8
Rated thermal current and rated operational current AC20/DC20 / ambient 40°C	Open Execution	A	315	350	500	630	800	1000	1250	1600	1800	2500	3150
/ ambient 40°C	Enclosure	A	270	315	500	630	720	1000	1250	1600	1800	2300	2600
/ ambient 60°C	Enclosure	A	220	260	410	500	600	900	1000	1250	1600	1950	2300
with minimum conductor cross section	Cu	mm2	120	185	2x150	2x185	2x240	2x(60x5)	2x(80x5)	2x(100x5)	-	4x(100x5)	3x(100x10)
Rated operational current, AC-21A	up to 415V	A	250	315	400	630	800	1000	1250	1600	1800	2500[2]	3150[2]
	440-690V	A	250	315	400	630	800	1000	1250	1600	1800	2500[2]	3150[2]
	1000V	A	250	315	400	630	630	1000	1000	1000	1000	1000[2]	1000[2]
Rated operational current, AC-22A	up to 415V	A	250	315	400	630	800	1000	1250	1600	1600	1600[2]	1600[2]
	440-500V	A	250	315	400	630	800	1000	1250	1600	1600	1600[2]	1600[2]
	690V	A	250	315	400	630	800	-	-	-	-	-	-
	1000V	A	250	315	400	630	630	-	-	-	-	-	-
Rated operational current, AC-23A	up to 415V	A	250	315	400	630	720	-	-	-	-	-	-
	440V	A	250	315	400	590	670	-	-	-	-	-	-
	500V	A	250	315	400	580	600	-	-	-	-	-	-
	690V	A	250	315	350	350	350	-	-	-	-	-	-
	1000V	A	125	125	125[2]	150[2]	150[2]	-	-	-	-	-	-
Rated operational current / poles in series, DC-21A	up to 48V	A	250/2	315/2	400/2	630/1	800/1	1000/1	1250/1	1600/1	1800/1	-	-
	110V	A	250/2	315/2	400/2	630/2	800/2	1000/2	1250/2	1600/2	1800/2	-	-
	220V	A	250/2	315/2	400/2	630/2	800/2	1000/3	1250/3	1600/3	1800/3	-	-
	440V	A	250/3	315/3	400/3	630/3	800/3	-	-	-	-	-	-
	750V	A	250/4	315/4	-	-	-	-	-	-	-	-	-
Rated operational current / poles in series, DC-22A	up to 48V	A	250/2	315/2	400/1	630/1	800/1	-	-	-	-	-	-
	110V	A	250/2	315/2	400/2	630/2	800/2	-	-	-	-	-	-
	220V	A	250/2	315/2	400/2	630/2	800/2	-	-	-	-	-	-
	440V	A	250/3	315/3	400/3	630/3	800/3	-	-	-	-	-	-
	750V	A	250/4	315/4	-	-	-	-	-	-	-	-	-
Rated operational current / poles in series, DC-23A	up to 48V	A	250/2	315/2	400/1	630/1	800/1	-	-	-	-	-	-
	110V	A	250/2	315/2	400/2	630/2	800/2	-	-	-	-	-	-
	220V	A	250/2	315/2	400/2	630/2	630/2	-	-	-	-	-	-
	440V	A	250/3	315/3	400/3	400/3	400/3	-	-	-	-	-	-
	750V	A	250/4	315/4	-	-	-	-	-	-	-	-	-

2) IEC 947-3, utilization category B, infrequent operation

Technical Data

Parameters				250A	315A	400A	630A	800A	1000A	1250A	1600A	1800A	2500A	3150A
Rated operational power, AC-23A	The kW-ratings are accurate for	220-240V	kW	75	90	132	180	200	250	250	250	250	250	250
	3 phase 1500 R.P.M. standard	400-415V	kW	132	160	200	315	355	400	400	400	400	400	400
	asynchronous motors.	440V	kW	132	160	315	355	355	400	400	400	400	400	400
		500V	kW	160	200	315	355	400	450	450	450	450	450	450
		690V	kW	200	250	315	355	355	-	-	-	-	-	-
Rated breaking capacity, AC-23A		up to 415V	A	2000	2520	4000	5040	5760	-	-	-	-	6400	6400
		440V	A	2000	2520	4000	4720	5360	-	-	-	-	6400	6400
		500V	A	2000	2520	4000	4640	4800	-	-	-	-	6400	6400
		690V	A	2000	2520	2800	2800	2800	2500	2500	2500	-	4800	4800
Rated breaking capacity/poles in series, DC-23A		up to 48V	A	1000/2	1260/2	-	-	-	-	-	-	-	-	-
		110V	A	1000/2	1260/2	-	-	-	-	-	-	-	-	-
		220V	A	1000/2	1260/2	-	-	-	-	-	-	-	-	-
		440V	A	1000/3	1260/3	-	-	-	-	-	-	-	-	-
		750V	A	1000/4	1260/4	-	-	-	-	-	-	-	-	-
Rated conditional(fused) short-circuit current r.m.s.	Cut-off /Back up fuse Rating	50kA	kA	36	36	42	63	63	105	105	105	105	140	140
and corresponding cut-off current of the fuse		415V		400/400	400/400	500/500	630/800	630/800	-	-	-	-	-	-
in single-phase test according IEC 269		50kA	kA	36	36	42	63	63	105	105	105	105	140	140
		500V		400/400	400/400	500/500	500/500	630/800	-	-	-	-	-	-
		50kA	kA	48	48	54	70	70	105	105	105	105	140	140
		690V		400/400	400/400	500/500	630/800	630/800	-	-	-	-	-	-
		100kA	kA	48	48	54	70	70	105	105	105	105	105	105
		500V		400/400	400/400	500/500	630/800	630/800	-	-	-	-	-	-
Rated short-time withstand current	R.M.S. -value Icw	690V,0.2s	kA	17.5	17.5	-	38	38	-	-	-	-	-	-
		690V,0.25s	kA	-	-	31	-	-	56	56	56	56	-	-
		690V,1s	kA	8	8	17	17	17	50	50	50	50	80	80
Rated short circuit making capacity	Peak value Icm	690V/500V	kA	35	35	65	80	80	105	105	105	105	105/140	105/140
Rated capacitor power	The capacitor ratings are	400V	kVAR	110	140	250	300	330	-	-	-	-	-	-
	limited by the fuse link	415V	kVAR	110	140	250	300	330	-	-	-	-	-	-
Power loss / pole	at rated operational current		w	5.5	8.5	13	22	40	27	40	67	-	90	140
Mechanical Endurance	Divide by two for operation cycles		Operations	16 000	16 000	10 000	10 000	10 000	6 000	6 000	6000	6000	1200	1200
Electrical Endurance	At 0.65 pf	415V	Operations	1000	1000	1000	500	500	500	500	500	500	100	100
Weight without accessories	With handle and shaft	3-Pole	kg	3	3	5.2	6.2	6.2	16.3	16.3	17.5	17.5	37	37
		4-Pole	kg	3.7	3.7	6.4	7.6	7.6	20.5	20.5	22.5	22.5	47	47
Terminal suitable for cable lug size	Cu- wire suitable for terminal clamp		Sq mm	10x30	10x30	10x40	12x40	12x40	12x60	12x60	12x60	12x60	12x60	12x60
Terminal tightening torque	Counter torque required		Nm	30...44	30...44	30...44	50...75	50...75	50...75	50...75	50...75	50...75	50...75	50...75
Operating torque	3-pole switch-disconnector		Nm	8.2	8.2	17	21	21	21	21	21	21	50	50

Ratings	25 - 40 Type D	63 Type K/D	100-125 Type D	100 - 160 Type DM	200 - 315 Type DM	400 - 800 Type D/K	1000 - 1800 Type K	2500 - 3150 Type K
Handle	CSSDZX 104	CSSDZX 104	CSSDZX 104	CSWH 80 S6	CSWH 80 S8	CSWH 145 S12	CSWH 220 S12	CSWH 220 S12/CSDA 8[6]
Handle Shaft	CSP5X70	CSP5X70	CSP5X70	CSP6X165	CSP8X240	CSP12X255	CSP12X255	CSP12X325
Handle Mounting Kit	-	-	-	-	HMK-2	HMK-1-1	HMK-3-1	-
Door Mounting Kit, 3P / 4P	DMK1/1A	DMK1/3	DMK2/3	-	-	-	-	-
Changover Mechanism	CSSDZW 6	CSSDZW 6/1	CSSDZW 6/1	CSSDZW 6/1	CSSDZW 6/1	CSSDZW 11	CSSDZW 12	CSSDZW 12
Auxiliary Contact - 1NO + 1NC, 3P-4P	CSSDZX 49/87	CSSDZX 79/55	CSSDZX 52/55	CSSDZX 1	CSSDZX 37	CSSDZX 33	CSSDZX 35	CSSDZX 35
Auxiliary Contact - 2NO + 2NC, 3P-4P	CSSDZX 50/88	CSSDZX 80/56	CSSDZX 53/56	CSSDZX 16	CSSDZX 38	CSSDZX 34	CSSDZX 36	CSSDZX 36
Terminal Shrouds	-	-	SF701	SF702	SF703	SF703(200-400)/SF704(630-800)	-	-
Extended Terminals, 3P/4P	-	-	ET325/ET326	ET327/ET328	ET329/ET330	ET329/ET330(upto 400A)	-	-
Key Interlock	CSSDZW-16	CSSDZW-16	CSSDZW-16	CSSDZW-16	CSSDZW-5	CSSDZW-5	CSSDZW-5	CSSDZW-5
Castle Lock	CSSDZW-15	CSSDZW-15	CSSDZW-15	CSSDZW-15	CSSDZW-4	CSSDZW-4	CSSDZW-4	CSSDZW-4
Neutral Link	-	-	-	-	-	CSSDFZX85	CSSDZX159	CSSDZX159(2Nos.)

3) PF 0.95 4) PF 0.65 5) Max. Distance between busbar support and switch terminal shall be 70 mm 6) Metallic Handle (CSDA 8) for 2500 - 3150A available on request.

Mounting Instruction for Accessories

Auxiliary Contact

For CSSD25-125A

- Unscrew the two grub screw and remove the bush from the switch.
- Fit the auxiliary bracket onto the switch and place the locking bush on it.
- Fit the cam and screw it with the locking bush.
- Fit auxiliary contact at the corner and screw it diagonally.
- Fit the two NO/NC auxiliary at the other corner and screw it properly, if required.

For CSSD63-160A Compact (ZX1, 16)

- Place the auxiliary and name plate at rear end (opposite to mechanism) by ensuring name plate between auxiliary and switch and screw them properly.
- Fit the cam on the main shaft and screw it at the flat surface of the shaft.

For CSSD200-315A Compact (ZX37, 38)

- Fit the auxiliary contact on the top of mechanism and screw it diagonally at the provided holes properly.
- Fitt het woN O/NCa uxiliarya tt het opo ft hea uxiliarya nds crewi t diagonally, if required.

For CSSD 200-800A (ZX33, 34)

- Fit the auxiliary contact on the top of mechanism and screw it diagonally at the provided thread.
- Fitt het woN O/NCa uxiliarya tt het opo ft hea uxiliarya nds crewi t diagonally, if required.

For CSSD1000-3150A (ZX35, 36)

- Fit the cam on the tubular shaft with the square bush.
- Fit the auxiliary contact along with the bracket (Z type) by screwing diagonally, if provided separately.
- Place and screw the auxiliary contact onto the mechanism by matching of bracket hole and tubular shaft.

Auxiliary Contacts ratings

- Thermal Rating 10A
- AC 15 @ 415V - 4A
- DC 13 @ 220V - 1A


Auxiliary Contacts - 200A & above


Auxiliary Contacts - 100A to 160A


Door Mounting Kit
(25A - 125A Type D)

Castle Lock

- Make a hole in panel door for fitment of castle lock as per given drawing.
- Fit the castle lock onto the panel door from front.
- Fit the lever onto the lock shaft in unlock position from back and tighten the lever by providing U clamp and screw.
- Fit the Square pipe assembly with the switch main shaft and adjust the position so as the lever can lock it from behind of this assembly and tighten the screw.

Key Interlock

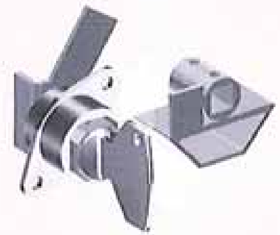
- Make a hole in the panel door for castle lock fitment as per given drawing.
- Fit the key lock onto the panel door from front.
- Fit the lever onto the lock shaft and circlip it in unlock position.
- Fit the square pipe assembly with the switch main shaft and adjust the position so as the lever can lock it in grove provided and tighten the screw.

Door Mounting Kit (25-125A)

- Fit the switch at the rear using din rail mounting channel.
- Mount the channel using hole provided for screwing on the door.

Handle mounting Kit (200A-1800A)

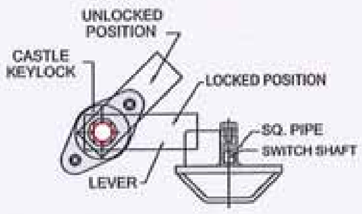
- Unscrew the bolt (provided for earthing on mechanism) and Philips head screw (given below the earth bolt) as shown in model.
- Fit the handle mounting bracket and tighten the bolt and screw.
- Fit the handle assembly on given profile of the mounting kit.


Castle Lock


Key Lock

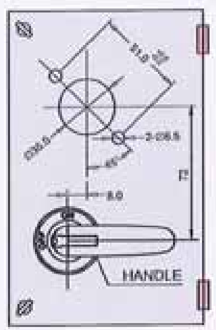

Handle Mounting Kit
(200A - 1800A)

Castle Lock

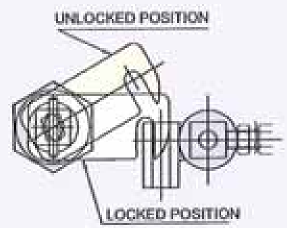


Catalogue No.	Type of Switch
CSSDZW15	CSSD 25-160A
CSSDZW4	CSSD 200-3150A

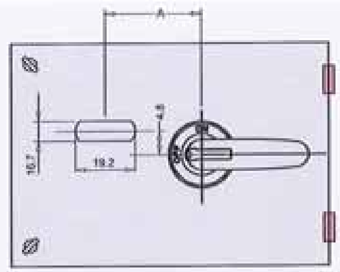
Panel Drilling Plan



Key Interlock



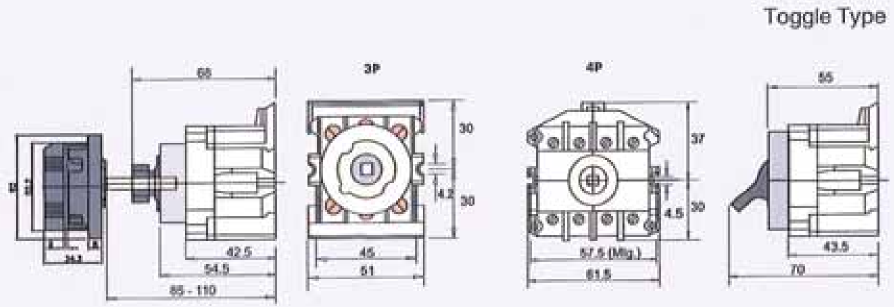
Panel Punching Plan



Catalogue No.	Type of Switch	'A'
CSSDZW16	CSSD 25-160A	47.7 ±0.3
CSSDZW5	CSSD 200-3150A	53.0 ±0.3

Dimensional Details

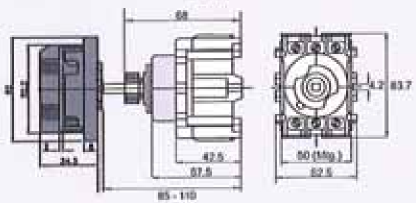
25A & 40A



63A, 100A & 125A (Type D/K)

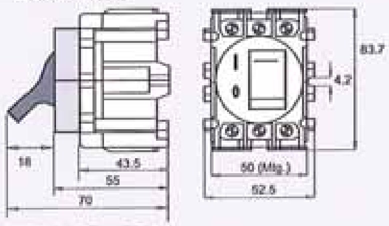
Rotary Type

3 Pole

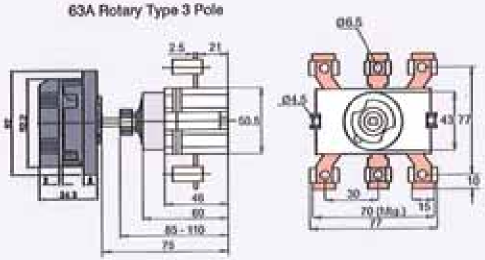


63A Rotary Type 3 Pole

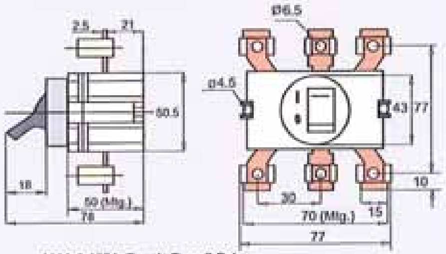
Toggle Type



63A, Toggle Type 3 Pole

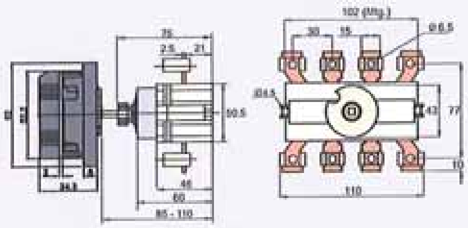


100A & 125A Rotary Type 3 Pole

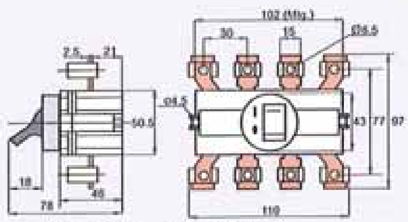


100A & 125A, Toggle Type 3 Pole

4 Pole



63A, 100A & 125A Rotary Type 4 Pole



63A, 100A & 125A, Toggle Type 4 Pole

ILLUSTRATIONS NOT TO SCALE

Enclosures CSSD25A - 125A

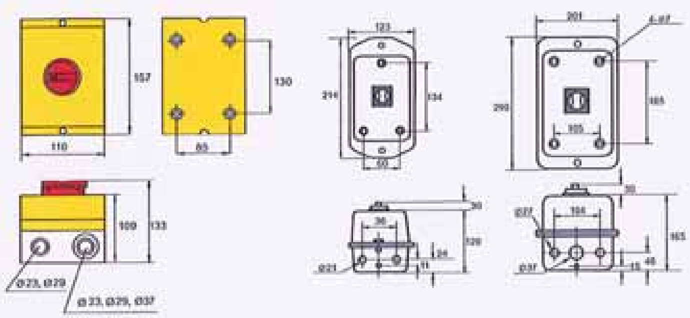
For 25A-40A 3P/4P & 63A 3P

Plastic Enclosures

For 25A-40A 3P/4P & 63A 3P

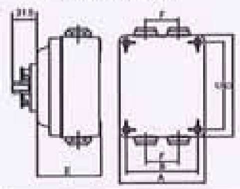
Metallic Enclosures

For 125A 3P/4P & 63A 4P



For 16A - 125A 3P/4P

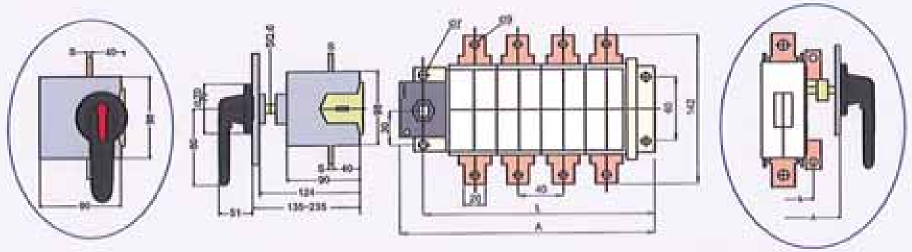
Aluminum Enclosures



	CSSD16D3/D4 CSSD40D3/D4	CSSD63K3/K4 125D3
A	110	147
B	92	123
C	112	179
D	130	203
E	82	94
F	42	42

Dimensions are in mm.

100A - 160A (DM)



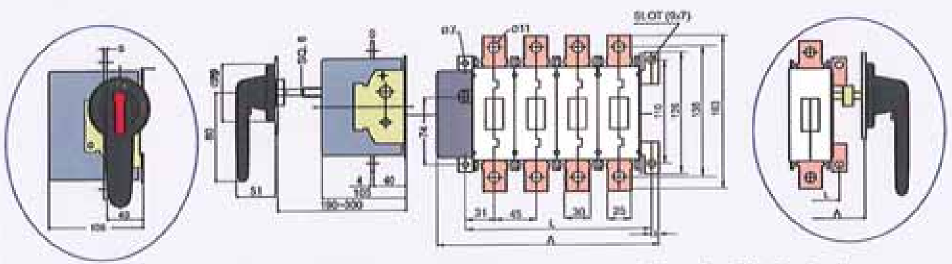
Dimensions Front Operated

Rating	A 3P	A 4P	L 3P	L 4P	S
100A	190	230	160	200	2
125A-160A	190	230	160	200	3

Dimensions Side Operated

Rating	A 3P	A 4P	L 3P	L 4P	S
100A	205	245	158	198	2
125A-160A	205	245	158	198	3

200A - 315A (DM)



Dimensions Front Operated

Rating	A 3P	A 4P	L 3P	L 4P	S
200-315A	195	240	155.5	200.5	4

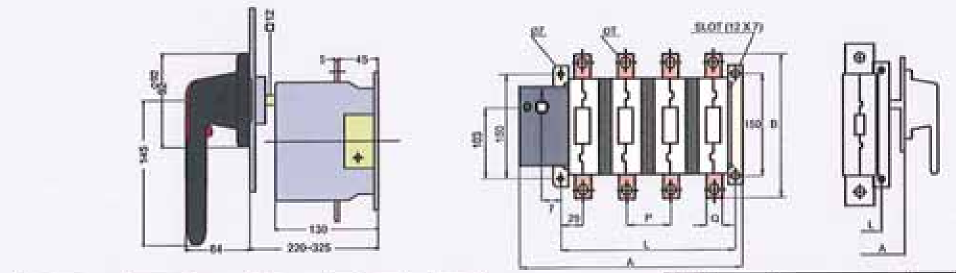
Dimensions Side Operated

Rating	A 3P	A 4P	L 3P	L 4P	S
200-315A	217	262	155.5	200.5	4

ILLUSTRATIONS NOT TO SCALE

Dimensional Details

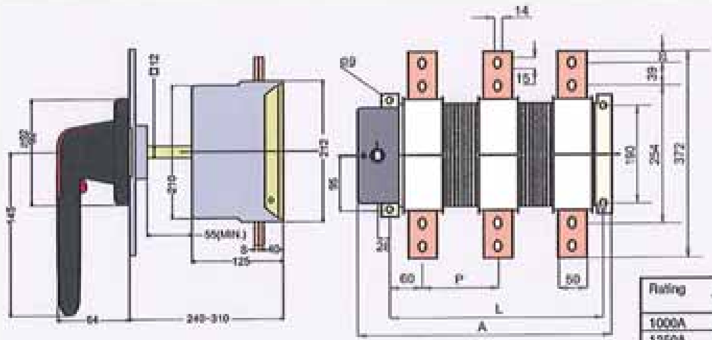
400A - 800A



Rating	A		B	L		P	Q	S	T
	3P	4P		3P	4P				
400A	211	257	205	151	197	46	25	4	11
630A	244	306	223	183	245	62	40	5	13.5
800A	260	330	223	199	269	70	40	5	13.5

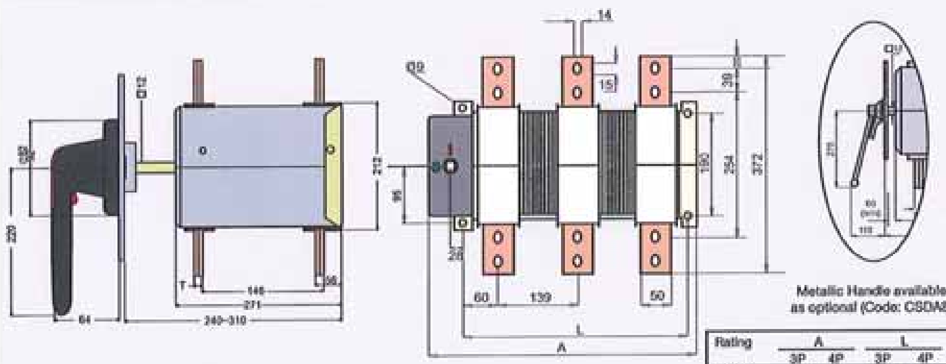
Rating	A		L	
	3P	4P	3P	4P
400A	265	311	151	197
630A	298	360	183	245
800A	314	384	199	269

1000A - 1800A



Rating	A		L		P	S
	3P	4P	3P	4P		
1000A	343	423	278	358	80	12
1250A	343	423	278	358	80	12
1600A	461	600	396	535	139	16
1800A	461	600	396	535	139	16

2500A - 3150A



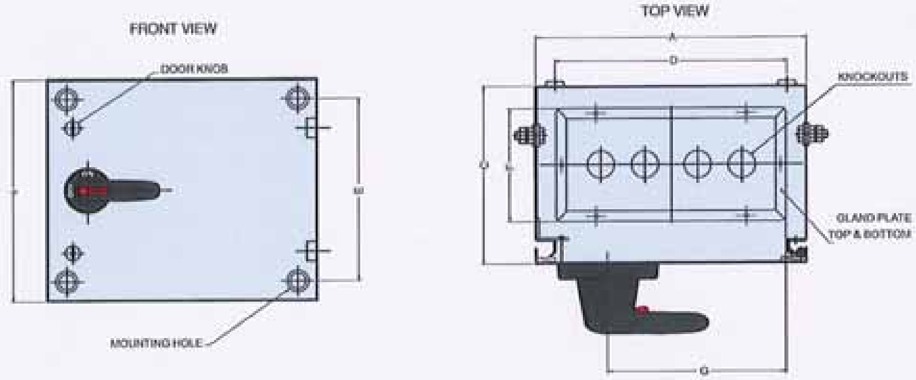
Metallic Handle available as optional (Code: CSDA8)

Rating	A		L		T
	3P	4P	3P	4P	
2500A	468	607	403	542	12
3150A	468	607	403	542	16

LINKS ARE NOT IN STANDARD SCOPE OF SUPPLY.

ILLUSTRATIONS NOT TO SCALE.

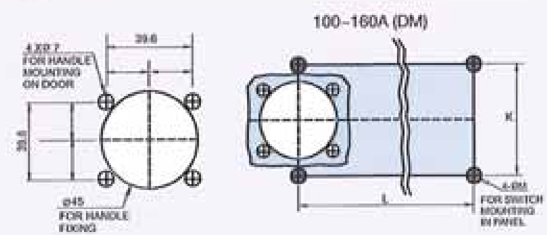
SS Enclosure 63A - 315A (DM) & 200A - 3150A



Rating	A	B	C	D	E	F	G
125 - 160A (DM)	275	275	180	235	235	115	233
200 - 315A (DM) 400A (D3P/4P) 630 - 800A (3P)	325	400	220	285	360	155	283
630 - 800A (4P)	400	400	220	360	360	155	358
1000 - 1800A (3P)	600	500	275	560	460	210	558
1000 - 1250A (4P) & 2500 - 3150A (3P)	600	600	350	560	560	285	483
1600 - 3150A (4P)	700	600	350	660	560	285	658

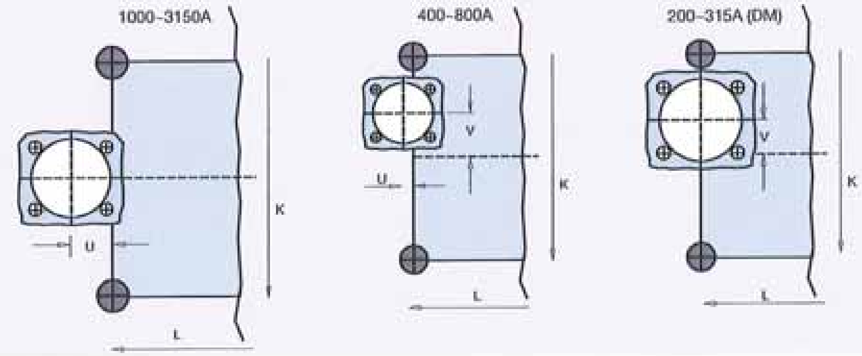
SS Enclosure Details	
Gasket Type	EPDM Sponge Rubber
Cover Sheet Thickness	18 SWG
Gland Sheet Thickness	16 SWG
Enclosure Paint Shade	Basalt Gray RAL 7012
Door Paint Shade	Light Gray RAL 7035
IP Level	IP54
Door Hinge Degree	120°
Earthing Studs	2

Mounting Details, 100A - 315A (DM) & 200A - 3150A



For Mounting Details

Rating	K	L		M	U	V
		TPN	4P			
100A - 160A	60	200	160	7	-	-
400A	150	151	197	7	7	28
630A	150	183	245	7	7	28
800A	150	199	269	7	7	28
1000A - 1250A	190	278	358	9	24.5	-
1600A - 1800A	190	396	535	9	24.5	-
2500A - 3150A	190	403	542	9	24.5	-



ILLUSTRATIONS NOT TO SCALE

SOLAR PV STC ASSIGNMENT FORM

1

OWNER'S DETAILS			
First Name:	Bankstown		
Surname:	Library		
Postal Address:	80 RICKARD RD		
	Bankstown	State: NSW	Postcode: 2200
Telephone:	(w)	(h)	
Fax:	(w)	(h)	
Mobile:			
Email:			

2

Address of installation:	AS ABOVE		
		State:	Postcode:
Is there more than one Solar PV installation at this address?	Yes☐ Yes	☒ No	
If yes to above, please describe where this system is installed in comparison to previous Solar PV systems at the address: e.g 'Upgrade to original installation - New panels lay to the west of original set' or 'On roof of Granny Flat'			

3

Panel Brand	Canadian Solar
Panel Model	CS6P-250P
Inverter Brand	SMA
Inverter Model	SMA STP 17000TL
Installation date	
Number of panels	80
Panel serial number/s (please attach separate sheet if necessary)	SEE ATTACHED
Rated power output (kW)	20
Is the system grid-connected?	☒ Yes☐ No (if no, additional Statements applicable)

4

Have you received or been approved for a rebate or financial assistance for any small generation unit at this address?	☐ Yes☒ No
Have you previously received Solar Credits (multiplied STCs) for small generation unit at this premises/address?	☐ Yes☒ No
Is this an ***ELIGIBLE*** premises for Solar Credits (STC multiplier)?	☒ Yes☐ No
Are you installing a complete unit (additional capacity to an existing system is not considered a complete unit)?	☒ Yes☐ No
Do you meet the transitional requirements for receiving the 2x multiplier?	☐ Yes☒ No
Do you meet the transitional requirements for receiving the 4x multiplier?	☐ Yes☒ No
Do you have all of the required compliance paperwork? (Please view the Agents Guide for more information on the requirements http://ret.cleanenergyregulator.gov.au/ret/for-industry/agents)	☒ Yes☐ No
Have you Collected all Out of Pocket Expenses Documentation? (Please view the SGU STC Out-of-Pocket Expenses Calculations information at http://ret.cleanenergyregulator.gov.au/Certificates/Small-scale-Technology-	☒ Yes☐ No

	CALCULATE OUT OF POCKET EXPENSE	
	Total Costs for Installation (parts and labour):	$ 60500
	Meter Connection Cost: (This charge might come at a later date – if so please estimate)("N/A" for QLD residents)	$ 400
	Any Other Costs (e.g. Tree felling):	$ 0
	Deduct value of STCs, any rebates or benefits:	- 14520
	Please State Total Out of Pocket Expense:	46380
6	For what period will you be assigning your rights to create STCs?:(Note: you may assign STCs annually or in 5 year periods or in a one off 15 year period. For further eligibility requirements for the deeming periods please view the SGU owners guide at http://ret.cleanenergyregulator.gov.au)	☐ One Year ☐ Five Years ☒ Fifteen Years
7	STC Eligibility – Number of STCs this system is entitled to: (Please refer to SGU Owners Guide http://ret.cleanenergyregulator.gov.au) 414	
8	Comments, if the unit has any unusual circumstances not discussed above, please describe them here:	
9	CEC Installer Details	
	First Name:	
	Surname:	
	CEC Accreditation Number & Classification (GC/SPS):	
	Installation Company:	
	Postal Address	
	Telephone:	
	Fax:	
	Mobile:	
	Email:	
10	CEC Designer Details (If different to installer than designer must also sign written statements on next page)	
	First name:	
	Surname:	
	CEC Accreditation Number & Classification (GC/SPS):	
11	Electrical Workers Details	
	First Name:	
	Surname:	
	Licence Number:	
	State of Issue:	

INSTALLER MANDATORY STATEMENTS

- I (name of installer) have public liability insurance of at least $5 million and am bound by the Clean Energy Council's Code of Conduct and have complied with that code of conduct for the installation of the above unit. The Clean Energy Council's Code of Conduct is available at http://www.cleanenergycouncil.org.au

- I verify that all local, Sate or Territory government requirements have been met for the siting of the unit; and if the unit is attached to a building or structure – the attachment of the unit to the building or structure; and if the unit is grid connected – the grid connection of the system for the SGU installation at the installation address stated on page one.

- I confirm that the installation complies with the following Australian Standards:
  AS/NZS 3000, *Wiring Rules;*
  AS/NZS 1768, *Lightning protection;*
  AS 4777, *Grid connection of energy systems via inverters*
  AS/NZS 5033, *Installation of photovoltaic (PV) arrays*
  AS/NZS 1170.2, *Structural design actions, Part 2 Wind actions*

- I confirm that I installed and/or supervised the install of a model of a photovoltaic module listed in AS/NZS 5033 Compliant PV Modules as in force from time to time and available at http://www.cleanenergycouncil.org.au; and (if the system uses an inverter) used a model of grid-connect inverter listed in Tested and Approved Grid Connected Inverters as in force from time to time and available at http://www.cleanenergycouncil.org.au

- If indicated on page one that the system is **not grid connected**. I verify that the SGU unit is not grid-connected; and an electrical worker holding an unrestricted license for electrical work issued by the State or Territory authority for the place where the unit was installed undertook all wiring of the unit that involves alternating current of 50 or more volts or direct current of 120 or more volts for the sgu installation at the address stated on page one.

- If indicated on page one that the system is not grid connected. I verify that the system meets the following Australian Standards as in force at the time of installation:

  AS/NZS 4509.1, Stand-alone power systems, Part 1:Safety and Installation
  AS 4086.2, Secondary batteries for use with stand alone power systems, Part 2: Installation and maintenance.

- I declare that the above statements are true and understand that the provision of false or misleading information contravenes Section 24B of the Renewable Energy (Electricity) Act 2000. Failure to comply with the Act can result in penalties and prosecution where warranted.

- I declare that the details in the form above are correct.

The CEC Installer of SGU	**The CEC Designer of the SGU** (If indicated on page 2 of assignment form as different to installer)	**Witnessed by**
Signed:	Signed:	Signed:
Name:	Name:	Name:
CEC Accreditation Number:	CEC Accreditation Number:	Date
Date:	Date:	

OWNER MANDATORY DECLARATION

I am the owner of the solar (photovoltaic) system mentioned in this STC Assignment form and I agree to assign my right to create STCs to   for a period of 15 year(s) commencing (date)   . I have not previously assigned or created any STCs for this system within this period.

I understand that this system is eligible for 414 STCs and in exchange for assigning my right to create these STCs I have received a point of sale discount from Todae Solar Pty Ltd [*name of retailer*]

I am aware that penalties can be applied for providing misleading information in this form under the Renewable Energy (Electricity) Act 2000.

I confirm that the accredited installer and/or supervisor mentioned above has either physically attended and undertaken the installation themselves OR Physically attended and supervised the installation by others.

The Owner of Installation	**Witnessed by**
Signed:	Signed:
Name:	Name:
Date:	Date:

8.3 Cable Support: Ezystrut

Certificate of Test

No. 2207

This is to certify that the element of construction described below was tested by the CSIRO Division of Material Science and Engineering in accordance with Australian and New Zealand Standard 3013:2005, Electrical installations – Classification of the fire and mechanical performance of wiring systems on behalf of:

Korvest Ltd
580 Prospect Road
Kilburn SA

A full description of the test specimen and the complete test results are detailed in the Division's sponsored investigation report numbered FSH 1384.

Product Name: Cable Support System 2 (trapeze support at 1500-mm centres – ladder incorporating a splice plate – load 50 kg/m)

Description: The 2950-mm long x 600-mm wide cable ladder consisted of 95-mm high C-section side rails joined with 40-mm x 40-mm Ezystrut E1000S channel cross rails at 333-mm centres. The Ezystrut channels were welded to the side rails with the open side of the channel facing down. The cable ladder incorporated a joint in close proximity to one of the two supports. The two side rails were bolted together using a splice plate and two SBH coach bolts with CNH collar nuts.

Each of the two trapeze supports consisted of two 60-mm x 40-mm x 710-mm long Ezystrut E5500 channels stitch welded together, one on top of the other, suspended by M12 rods penetrating each end of the channels and secured with M12 hex nuts and a square 40-mm x 40-mm x 6-mm thick washer.

The cable ladder was secured to the supports channels using N2 hold down units clamping down on the bottom lip of the ladder's side rails. Each end of the cable ladder was restrained using two M22 threaded rods connected to the end of the side rails and fixed through the double brick walls, and retained by a nut and a nominal 250-mm x 250-mm x 16-mm steel plate washer. The cable ladder supports were suspended above Cable Support System 1, approximately 540-mm below the concrete slabs and were spaced at 1500-mm centres.

The cable ladder was loaded with evenly distributed 225 off 2600-mm long x 6-mm diameter steel rods tied into bundles, equalling to 50 kg per lineal metre. The bundles consisted of seven rods each, bound with steel wire ties. The rods were not tied to the cable ladder.

Construction of the cable support system is detailed in drawings numbered N2-E1000 test 2, sheets 1 to 4, all dated 18 August 2009, by Korvest Ltd.

In accordance with Clause C7 AS/NZS 3013:2005 Appendix C, the following support system met all the test criteria.

SPECIMEN	CLASSIFICATION
Cable Support System 2 (trapeze support at 1500-mm centres – ladder incorporating a splice plate – load 50 kg/m)	WS5X

For the purposes of the Building Regulations in Australia the above cable support system met the requirements as stated in section 3.2.1 of AS/NZS 3013:2005.

Testing Officer: Chris Wojcik Date of Test: 11 November 2009.

Issued on the 21st day of January 2010 without alterations or additions.

Garry E Collins

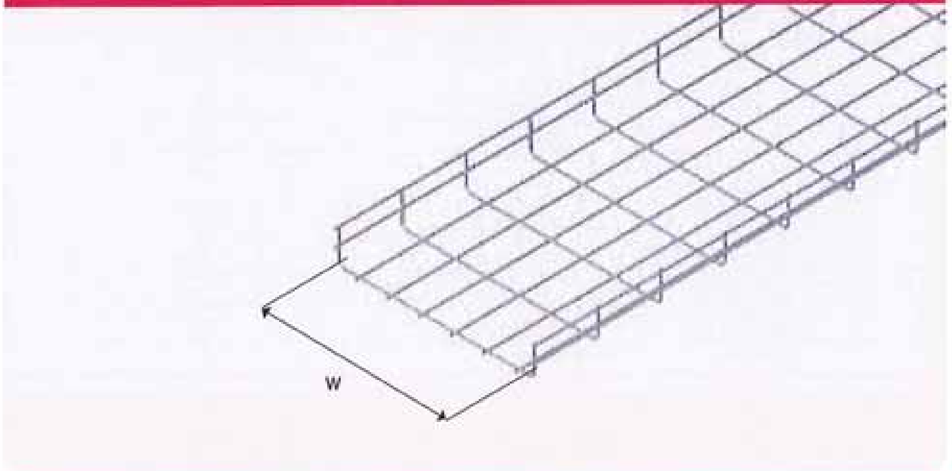
Garry E Collins
Manager, Fire Testing and Assessments

CSIRO Materials Science and Engineering
14 Julius Avenue, Riverside Corporate Park, North Ryde NSW 2113 AUSTRALIA
Telephone: 61 2 9490 5444 Facsimile:61 2 9490 5555

This document is issued in accordance with NATA's accreditation requirements

EZYMESH CABLE MESH

EZYMESH



PRODUCT DETAILS

EzyStrut EzyMesh provides premium performance in commercial and light industrial applications. Strong, versatile and easy to install EzyMesh is complemented with all the accessories you need. Your EzyMesh lengths can be created into bends, tees, risers and crosses to suit the application.

Tested to NEMA Standard VE1-2002.

STANDARD LENGTH

- 3 Metres

ORDERING DETAILS

Supplied per length

AVAILABLE FINISH	ORDERING CODE
Zinc Plated	EM...**Z**
Hot Dip Galvanised	EM...**H**
Stainless Steel	EM...**S**

EzyMesh is available in stainless steel against firm orders only. Minimum production quantities may apply.

Ordering Code	Cable Laying Width - W (mm)	Cable Laying Depth (mm)	Overall Width (mm)	Side Rail Height(mm)
EM150	150	47	170	58
EM300	300	47	320	58
EM450	450	47	470	58
EM500	500	47	520	58
EM600	600	47	620	58

LOAD RATING AND DEFLECTION

EzyMesh Cable Mesh has been tested in accordance with NEMA standards. Loading applies to 600mm wide section and loading may vary for other widths.

A guide to deflection for continuous runs has been included for easy reference, however it should be noted that the positioning of splice joints and loading techniques can significantly impact upon the actual deflection.

EzyStrut EZYMESH CABLE MESH — ACCESSORIES

PRODUCT DETAILS

A full range of EzyMesh accessories is available to complement the system and provide easy on site installation.

EzyMesh accessories are common for all mesh widths and can be used to make tees, bends, risers, and crosses.

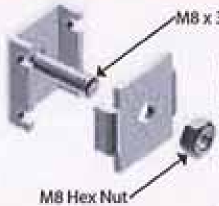
ORDERING DETAILS

Supplied per length/individually

AVAILABLE FINISH	ORDERING CODE
Hot Dip Galvanised	EM...H
Zinc Plated	EM...Z

EMBC
EZYMESH CUTTER

EMSB
EZYMESH BOLT JOINER KIT Wt: 0.10kg

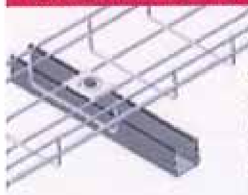


Manufactured from pressed steel, and supplied with Grade 4.6 fasteners for assembly.

Supplied individually

Available Finish: **Z**

EMHD
EZYMESH HOLD DOWN BRACKET Wt: 0.10kg



Manufactured from pressed steel.

Thickness: **2.0mm**
Screw Diameter: **M8**
Working Load: **350kg**
Safety Factor: **3:1**
Slipping Force: **100kg**
Supplied individually

Available Finish: **Z, H**

EMWB
EZYMESH WALL MOUNT Wt: 0.049kg

To be used on mesh up to 150mm in width. Fasteners required: **1 x M8**

Manufactured from pressed steel to AS1594.

Supplied individually

Available Finish: **Z**

EMS
EZYMESH SIDE JOINER Wt: 0.17kg

Manufactured from pressed steel to AS1594.

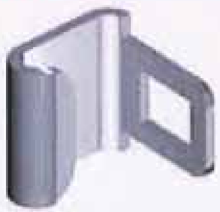
See assembly method, page 6.4 for required quantities to be used with side joiners.

Span (m)	Max. Allowable Load (kg/mtr)
3.0	27
2.5	39
2.0	61
1.5	109

Supplied individually

Available Finish: **Z**

EMSC
EZYMESH BOTTOM JOINER Wt: 0.017kg



Manufactured from pressed steel to AS1594.

See assembly method, page 6.4 for required quantities to be used with side joiners. To be used for straight joints only in conjunction with side joiners.

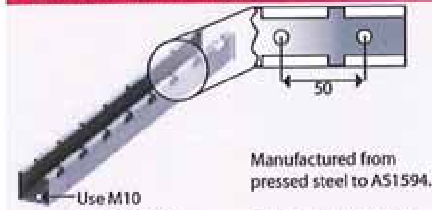
Span (m)	Max. Allowable Load (kg/mtr)
3.0	27
2.5	39
2.0	61
1.5	109

Supplied individually

Available Finish: **Z**

EZYMESH CABLE MESH — ACCESSORIES

EMT
EZYMESH TRAPEZE BRACKET



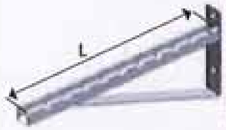
Manufactured from pressed steel to AS1594.

Supplied Individually

Available Finish: **Z**

Ordering Code	Width (mm)	Load Capacity (kg)
EMT150	250	90
EMT300	400	90
EMT450	550	90
EMT500	650	90
EMT600	700	90
EMT3000	3000	90

EMC
EZYMESH CANTILEVER BRACKET



Manufactured from steel to AS1594.

Thickness: **2.0mm**
Hole Diameter: **11mm**
Hole Spacing: **50mm**
Working Load: **350kg**
Safety Factor: **3:1**

Supplied Individually

Available Finish: **Z, H**

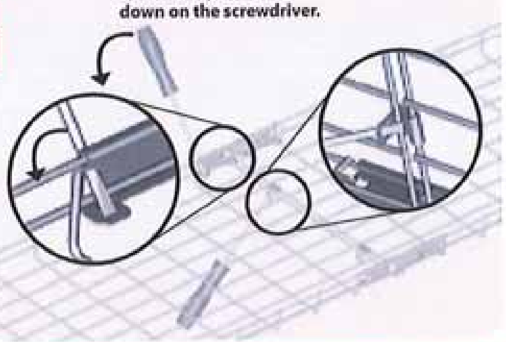
Ordering Code	Length - L (mm)	Weight (kg)
EMC150	200	1.3
EMC300	350	1.8
EMC450	450	2.2
EMC500	550	2.3
EMC600	600	2.4

EzyStrut EZYMESH CABLE MESH — ASSEMBLY METHOD

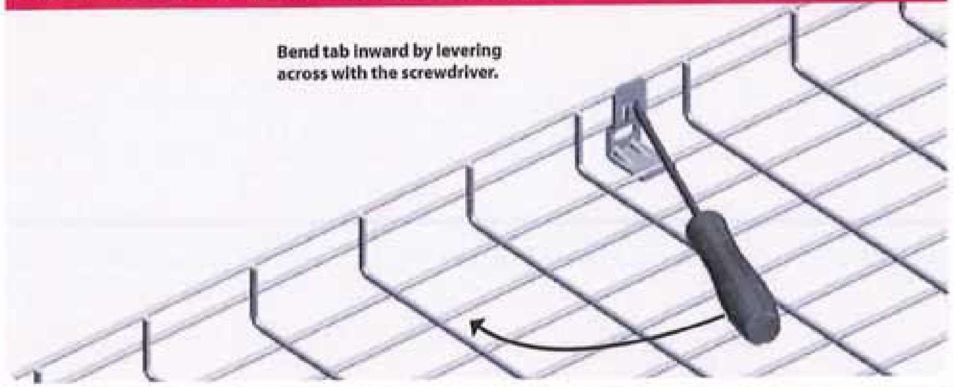
JOINING A STRAIGHT LENGTH

EzyMesh	Number of Side Joiners Required	Number of Bottom Joiners Required
EM150	2 x EMS	1 x EMSC
EM300	2 x EMS	2 x EMSC
EM450	2 x EMS	2 x EMSC
EM500	2 x EMS	2 x EMSC
EM600	2 x EMS	3 x EMSC

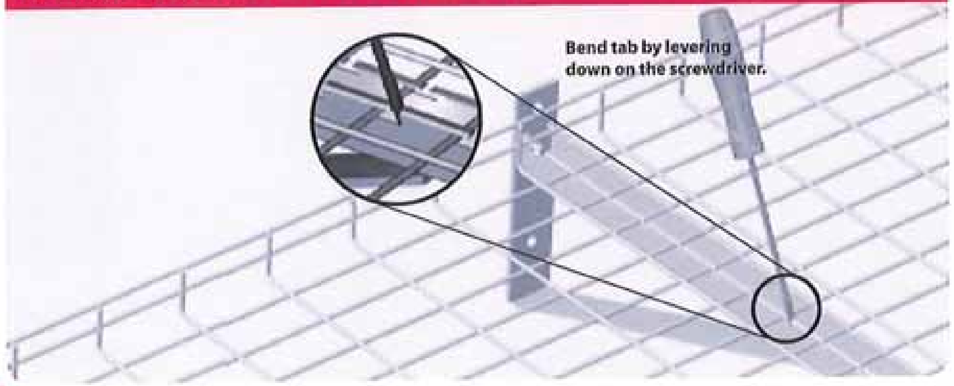
Order Joiners separately for joining Cable Mesh lengths



ASSEMBLING A WALL MOUNT (EM150 ONLY)



ASSEMBLING A TRAPEZE AND CANTILEVER



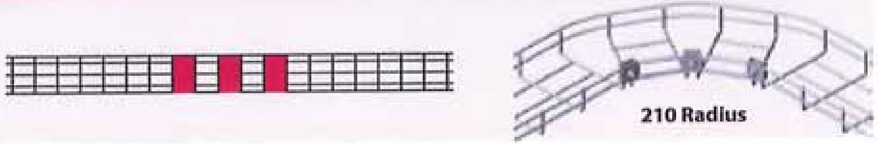
EZYMESH CABLE MESH — ASSEMBLY METHOD

EzyMesh	Number of Cut Outs Required	Number of Bolt Joiner Kits Required
EM150	3	3
EM300	6	6
EM450	4	4
EM500	5	5
EM600	6	6

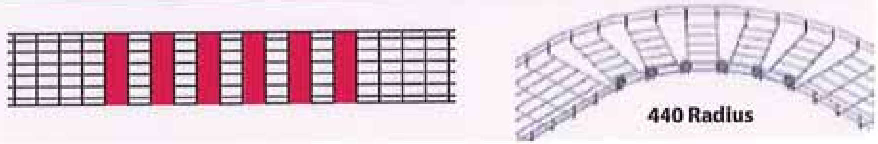
BENDS

1 — Remove Mesh
2 — Bend to Shape
3 — Attach Bolt Joiners

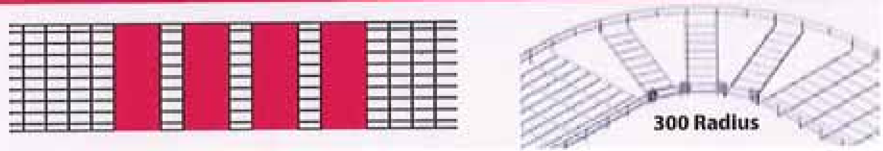
EM150 90° BEND



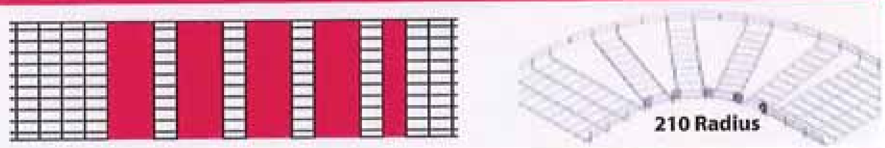
EM300 90° BEND



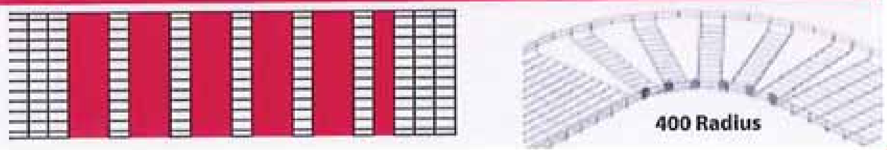
EM450 90° BEND



EM500 90° BEND



EM600 90° BEND



EzyStrut

EZYMESH CABLE MESH — ASSEMBLY METHOD

Radius	Number of Cut Outs Required
150	4
300	6
450	8
600	10

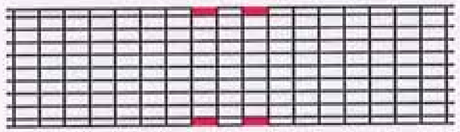
Note: Illustrations below show an EM450 as typical.

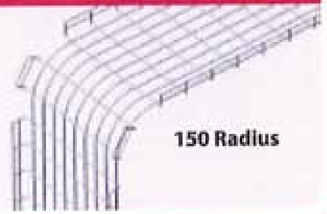
EXT. RISERS

1 — Remove Mesh

2 — Bend to Shape

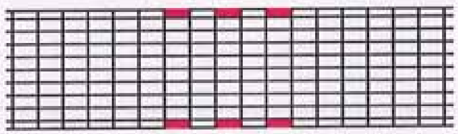
EXTERNAL RISER 150 RADIUS

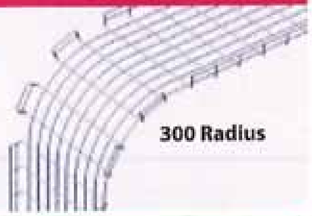




150 Radius

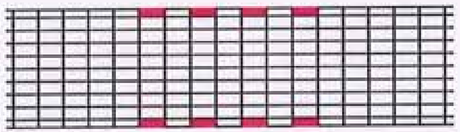
EXTERNAL RISER 300 RADIUS

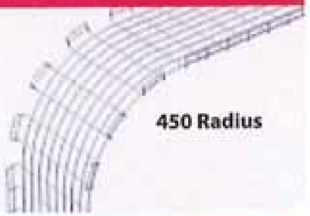




300 Radius

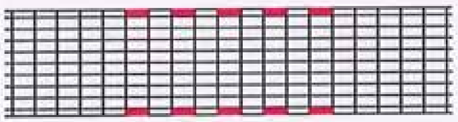
EXTERNAL RISER 450 RADIUS

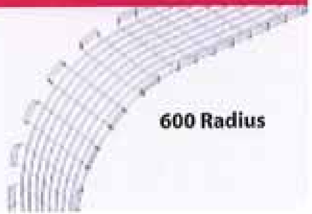




450 Radius

EXTERNAL RISER 600 RADIUS





600 Radius

EZYMESH CABLE MESH — ASSEMBLY METHOD

EzyStrut

Radius	Number of Cut Outs Required
150	4
300	6
450	8
600	10

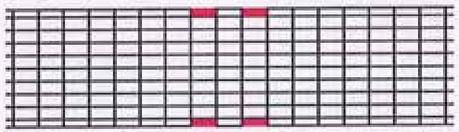
Note: Illustrations below show an EM450 as typical.

INT. RISERS

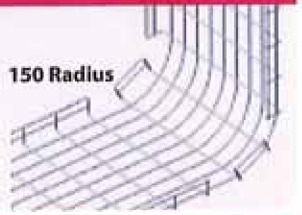
1 — Remove Mesh

2 — Bend to Shape

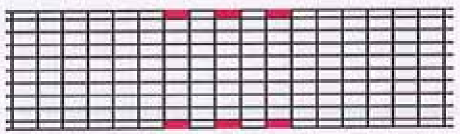
INTERNAL RISER 150 RADIUS



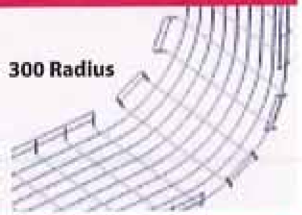
150 Radius



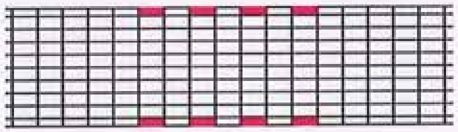
INTERNAL RISER 300 RADIUS



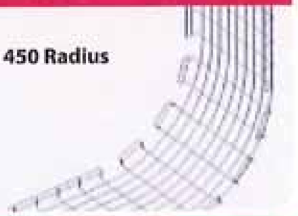
300 Radius



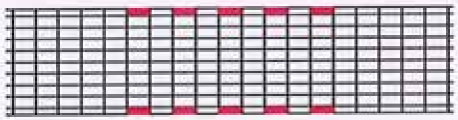
INTERNAL RISER 450 RADIUS



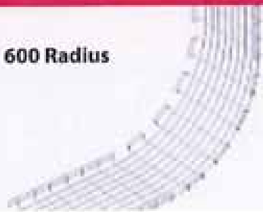
450 Radius



INTERNAL RISER 600 RADIUS



600 Radius



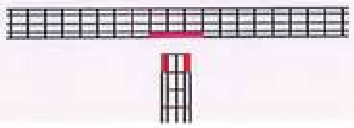
EZYMESH CABLE MESH — ASSEMBLY METHOD

EzyMesh	Number of Bolt Joiner Kits Required
EM150	4
EM300	4
EM450	6
EM500	6
EM600	7

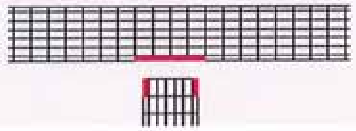
TEES

1 — Remove Mesh
2 — Bend to Shape
3 — Attach Bolt Joiners

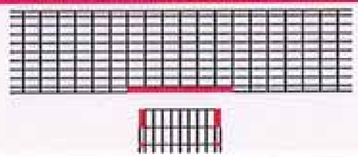
EM150 TEE




EM300 TEE




EM450 TEE




EM500 TEE


EM600 TEE


EZYMESH CABLE MESH — ASSEMBLY METHOD

EzyStrut

EzyMesh	Number of Bolt Joiner Kits Required
EM150	8
EM300	8
EM450	12
EM500	12
EM600	14

CROSSES

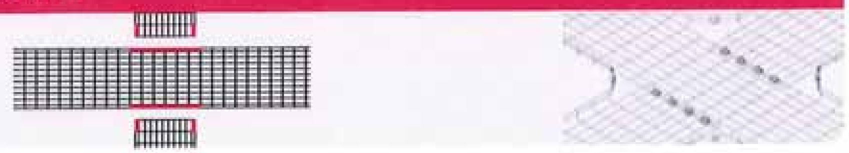
1 — Remove Mesh
2 — Bend to Shape
3 — Attach Bolt Joiners

EM150 CROSS

EM300 CROSS

EM450 CROSS

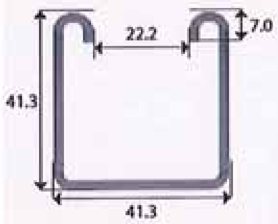
EM500 CROSS

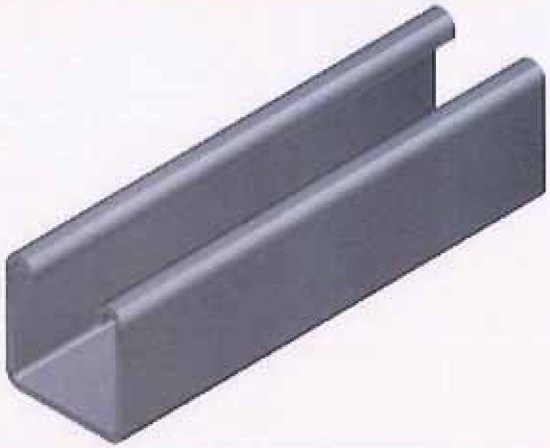


EM600 CROSS

E1000 CHANNEL

Wt: 2.65kg/mtr (Steel)





PRODUCT DETAILS

EzyStrut E1000 Channel section is manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397
- Stainless Steel to AS1449, AS2837

ORDERING DETAILS

Supplied in standard 6m lengths

AVAILABLE FINISH	ORDERING CODE
Mill (Plain)	E1000**M**
Pre-Galvanised	E1000**G**
Hot Dip Galvanised	E1000**H**
Stainless Steel	E1000**S**
Fibre Reinforced Plastic (FRP) (see page 9.1 for details)	E1000**FRP**

MATERIAL SPECIFICATION

Thickness 2.5mm
Length 6m

TECHNICAL DETAILS

The load values shown are in accordance with AS/NZS4600: 1996, using a minimum yield stress for Fy of 210 MPa on plain channels.

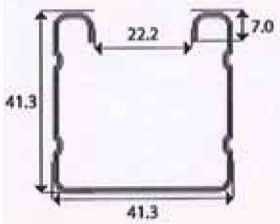
The published results are based on a uniformly loaded, simply supported span.

Deflection has been calculated using standard formulae at the maximum permissible stress.

Span (mm)	Max. Allowable Load (kg)	Deflection at Allowable Load (mm)
250	1308	0.17
500	654	0.68
750	436	1.53
1000	328	2.72
1250	261	4.25
1500	218	6.13
1750	187	8.34
2000	163	10.90
2250	145	13.80
2500	131	17.03
2750	119	20.61
3000	109	24.56

E2000 RIBBED CHANNEL

Wt: 1.78kg/mtr (Steel)
Wt: 0.61kg/mtr (Aluminium)



PRODUCT DETAILS

EzyStrut E2000 Channel section is manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397
- or from extruded aluminium alloy 6005A-T5 to AS1866:1997

ORDERING DETAILS

Supplied in standard 6m lengths

AVAILABLE FINISH	ORDERING CODE
Mill (Plain)	E2000**M**
Pre-Galvanised	E2000**G**
Hot Dip Galvanised	E2000**H**
Aluminium	E2000**A**

MATERIAL SPECIFICATION

Thickness	1.6mm
Length	6m

TECHNICAL DETAILS

The load values shown are in accordance with AS/NZS4600: 1996, using a minimum yield stress for Fy of 210 MPa on plain channels.

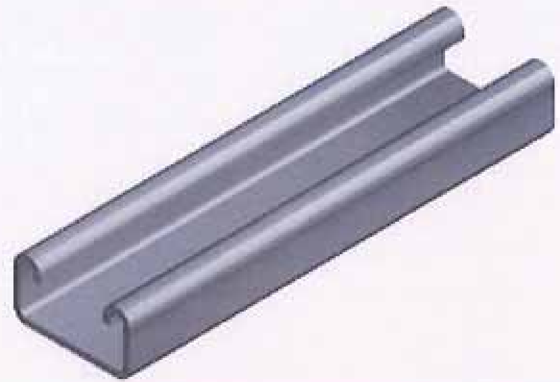
The published results are based on a uniformly loaded, simply supported span.

Deflection has been calculated using standard formulae at the maximum permissible stress.

Span (mm)	Max. Allowable Load (kg)	Deflection at Allowable Load (mm)
250	945	0.16
500	471	0.65
750	314	1.46
1000	236	2.59
1250	189	4.05
1500	157	5.84
1750	135	7.94
2000	117	10.37
2250	105	13.80
2500	94	16.20
2750	85	19.62
3000	78	23.34

E3300 CHANNEL

Wt: 1.88kg/mtr (Steel)



PRODUCT DETAILS

EzyStrut E3300 Channel section is manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397
- Stainless Steel to AS1449, AS2837

ORDERING DETAILS

Supplied in standard 6m lengths

AVAILABLE FINISH	ORDERING CODE
Mill (Plain)	E3300**M**
Pre-Galvanised	E3300**G**
Hot Dip Galvanised	E3300**H**
Stainless Steel	E3300**S**

MATERIAL SPECIFICATION

Thickness	2.5mm
Length	6m

TECHNICAL DETAILS

The load values shown are in accordance with AS/NZS4600: 1996, using a minimum yield stress for Fy of 210 MPa on plain channels.

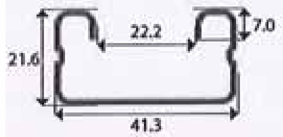
The published results are based on a uniformly loaded, simply supported span.

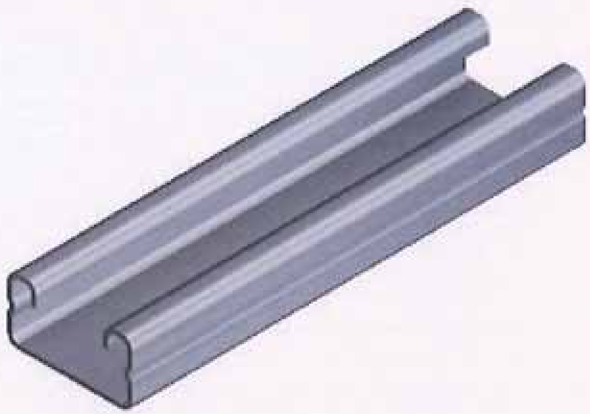
Deflection has been calculated using standard formulae at the maximum permissible stress.

Span (mm)	Max. Allowable Load (kg)	Deflection at Allowable Load (mm)
250	442	0.29
500	221	1.17
750	147	2.64
1000	110	4.69
1250	89	7.34
1500	73	10.57
1750	63	14.39
2000	55	18.79
2250	49	23.78
2500	44	29.35
2750	40	35.52
3000	37	42.27

E4000 RIBBED CHANNEL

Wt: 1.27kg/mtr (Steel)
Wt: 0.43kg/mtr (Aluminium)





PRODUCT DETAILS

EzyStrut E4000 Channel section is manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397
- or from extruded aluminium alloy 6005A-T5 to AS1866:1997

ORDERING DETAILS

Supplied in standard 6m lengths

AVAILABLE FINISH	ORDERING CODE
Mill (Plain)	E4000**M**
Pre-Galvanised	E4000**G**
Hot Dip Galvanised	E4000**H**
Aluminium	E4000**A**

MATERIAL SPECIFICATION

Thickness	1.6mm
Length	6m

TECHNICAL DETAILS

The load values shown are in accordance with AS/NZS4600: 1996, using a minimum yield stress for Fy of 210 MPa on plain channels.

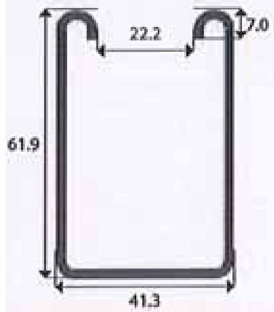
The published results are based on a uniformly loaded, simply supported span.

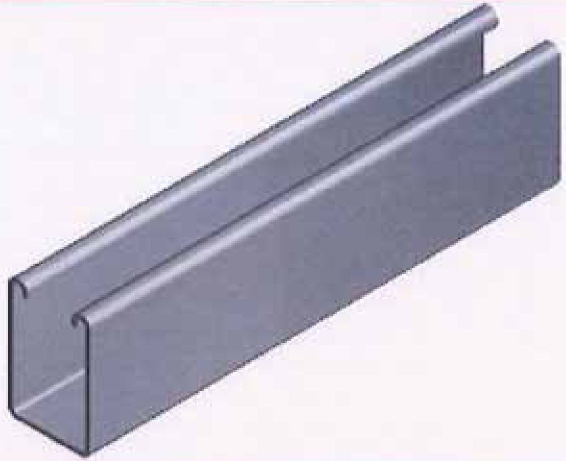
Deflection has been calculated using standard formulae at the maximum permissible stress.

Span (mm)	Max. Allowable Load (kg)	Deflection at Allowable Load (mm)
250	350	0.31
500	175	1.22
750	116	2.76
1000	88	4.89
1250	70	7.65
1500	58	11.02
1750	50	15.00
2000	44	19.59
2250	39	24.82
2500	35	30.61
2750	32	37.04
3000	30	44.15

E5500 CHANNEL

Wt: 3.43kg/mtr (Steel)





PRODUCT DETAILS

EzyStrut E5500 Channel section is manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397

ORDERING DETAILS

Supplied in standard 6m lengths

AVAILABLE FINISH	ORDERING CODE
Mill (Plain)	E5500**M**
Pre-Galvanised	E5500**G**
Hot Dip Galvanised	E5500**H**

MATERIAL SPECIFICATION

Thickness 2.5mm
Length 6m

TECHNICAL DETAILS

The load values shown are in accordance with AS/NZS4600: 1996, using a minimum yield stress for Fy of 210 MPa on plain channels.

The published results are based on a uniformly loaded, simply supported span.

Deflection has been calculated using standard formulae at the maximum permissible stress.

Span (mm)	Max. Allowable Load (kg)	Deflection at Allowable Load (mm)
250	2488	0.11
500	1244	0.45
750	830	1.02
1000	622	1.81
1250	498	2.82
1500	414	4.06
1750	355	5.54
2000	311	7.23
2250	276	9.16
2500	249	11.30
2750	226	13.68
3000	207	16.28

EzyStrut SLOTTED CHANNEL

PRODUCT DETAILS
EzyStrut Slotted Channel sections are manufactured from strip steel to the following standards:
- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397
- Stainless Steel to AS1449, AS2837
- or from extruded aluminium alloy 6005A-T5 to AS1866:1997

SLOTTING DETAILS
25 x 14mm slots are punched continuously at 38mm centres

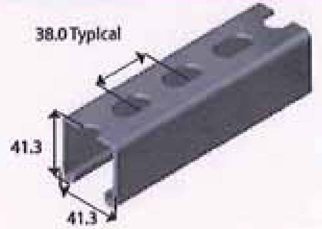
MATERIAL SPECIFICATIONS
Length 6m

ORDERING DETAILS
Supplied in standard 6m lengths

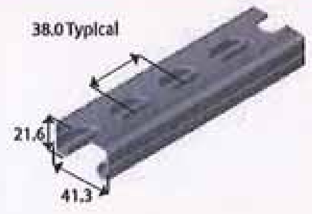
AVAILABLE FINISH	ORDERING CODE
Pre-Galvanised	E...SG
Hot Dip Galvanised	E...SH
Stainless Steel	E...SS (E1000 and E3300 profiles only)
Aluminium	E...SA (E2000 and E4000 profiles only)

Example: To order E1000 Slotted in Hot Dip Galvanised, use product code: E1000SH

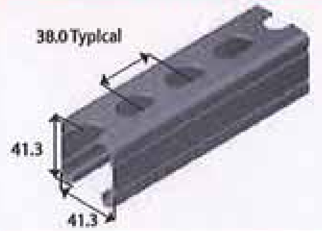
E1000S
Wt: 2.32kg/mtr (Steel)



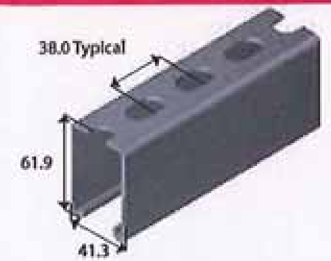
E4000S
Wt: 1.09kg/mtr (Steel)
Wt: 0.39kg/mtr (Aluminium)



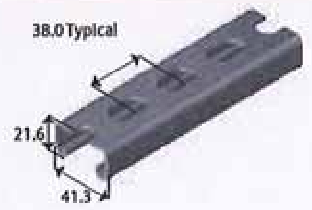
E2000S
Wt: 1.60kg/mtr (Steel)
Wt: 0.21kg/mtr (Aluminium)



E5500S
Wt: 3.10kg/mtr (Steel)



E3300S
Wt: 1.54kg/mtr (Steel)



COMBINATION CHANNEL

EzyStrut

PRODUCT DETAILS

EzyStrut Combination Channel sections are manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Pre-Galvanised to AS1397
- Stainless Steel to AS1449, AS2837
- or from extruded aluminium alloy 6005A-T5 to AS1866:1997

WELDING DETAILS

The channel is continuously spot welded at a maximum of 150 centres

MATERIAL SPECIFICATIONS

Length 6m

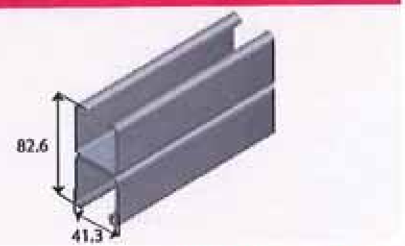
ORDERING DETAILS

Supplied in standard 6m lengths

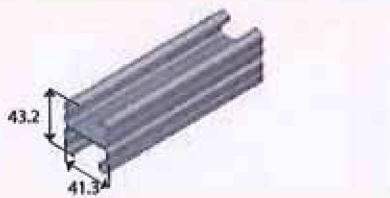
AVAILABLE FINISH	ORDERING CODE
Pre-Galvanised	E...1G
Hot Dip Galvanised	E...1H
Stainless Steel	E...1S (E1000 and E3300 profiles only)
Aluminium	E...1A (E2000 and E4000 profiles only)

All Combination Channel other than E1001H is manufactured against firm orders only.

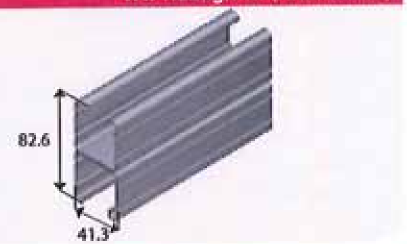
E1001 Wt: 5.30 kg/mtr (Steel)



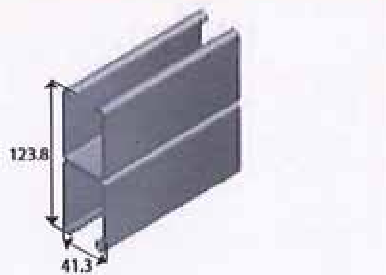
E4001 Wt: 2.54kg/mtr (Steel) Wt: 0.86kg/mtr (Aluminium)



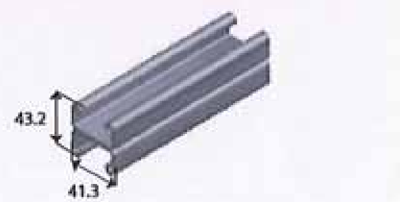
E2001 Wt: 3.56kg/mtr (Steel) Wt: 1.22kg/mtr (Aluminium)



E5501 Wt: 6.86kg/mtr (Steel)



E3301 Wt: 3.76kg/mtr (Steel)



EzyStrut COMBINATION CHANNEL

PRODUCT DETAILS

EzyStrut Combination Channel sections are manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461
- Stainless Steel to AS1449, AS2837

WELDING DETAILS

The channel is continuously spot welded at a maximum of 150 centres

MATERIAL SPECIFICATIONS

Length 6m

ORDERING DETAILS

Supplied in standard 6m lengths

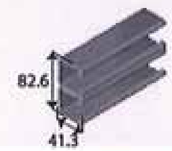
AVAILABLE FINISH	ORDERING CODE
Hot Dip Galvanised	E...1...**H**
Stainless Steel	E...1...**S** (E1000 and E3300 profiles only)

Most channel combinations can also be manufactured from other strut profiles. To order simply change the digits to represent the strut profile.

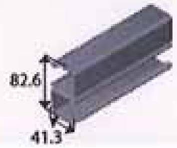
Example: To use E2000 channel, the product code would be E2001-xx

All Combination Channel other than E1001H is manufactured against firm orders only.

E1001-A Wt: 5.30kg/mtr

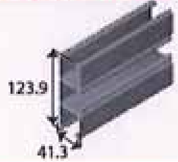


E1001-B Wt: 5.30kg/mtr

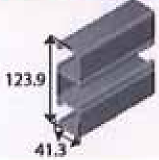


E1001-C Wt: 5.30kg/mtr

E1001-A3 Wt: 7.95kg/mtr



E1001-B3 Wt: 7.95kg/mtr



E1001-3 Wt: 7.95kg/mtr

E1001-C3 Wt: 7.95kg/mtr

E1001-D3 Wt: 7.95kg/mtr

E1001-C41 Wt: 10.60kg/mtr

CONCRETE INSERT CHANNEL

EzyStrut

PRODUCT DETAILS

EzyStrut Concrete Insert Channel is manufactured from strip steel to the following standards:

- Mild steel & Hot Dip Galvanised to AS/NZS1365, AS1594, AS/NZS4680, ISO1461

Lugs are punched continuously along the channel length at 200mm centres.

LOADING DETAILS

E1000CI Testing on 200mm section confirms a maximum pullout load of 1030kg with a safety factor of 3.
E3300CI Testing on 200mm section confirms a maximum pullout load of 600kg with a safety factor of 3.

NOTES

- The tests were carried out in controlled laboratory conditions using a concrete strength of 25MPa (average).
- The rated load performance will change when using other concrete strengths and depending on positioning of the concrete reinforcing mesh.

ORDERING DETAILS

Supplied in standard 6m lengths

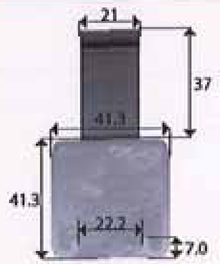
Channel can be supplied pre cut in increments of 200mm (nominal).

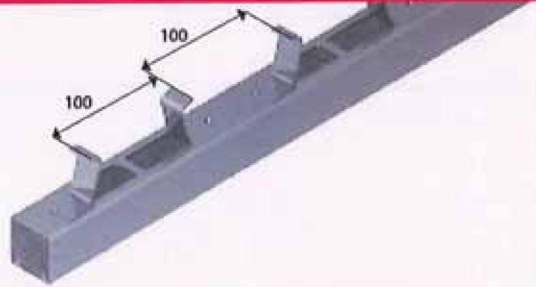
Cutting charges and minimum order quantities may apply.

AVAILABLE FINISH	ORDERING CODE
Hot Dip Galvanised	E...CIH

E1000CI

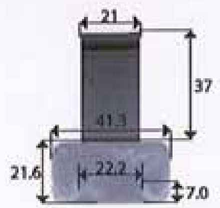
Wt: 2.86kg/mtr

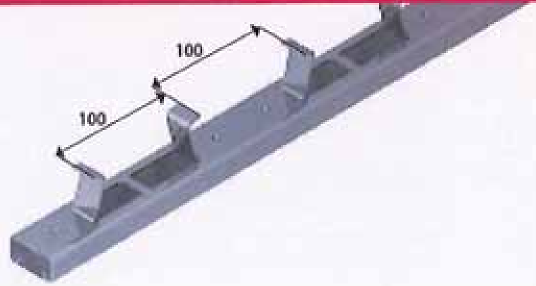




E3300CI

Wt: 2.00kg/mtr





EzyStrut CHANNEL CLOSURES

PRODUCT DETAILS

EzyStrut provides a range of plastic accessories to complement most channel sections.

Commonly used in lighting grid applications, channels are easy transformed into cable conduits using the channel cover strip and range of end caps.

ORDERING DETAILS

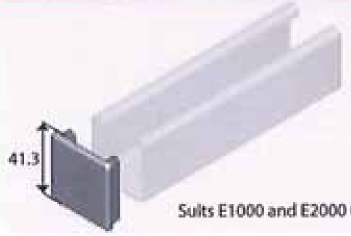
Supplied individually

AVAILABLE FINISH	ORDERING CODE
White/Grey Plastic	E..P
Aluminium	E..A

E1184

Supplied in 3 metre lengths

E1180

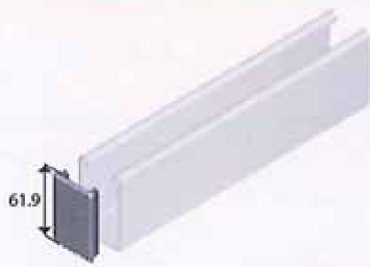


Suits E1000 and E2000 Channels

E3380

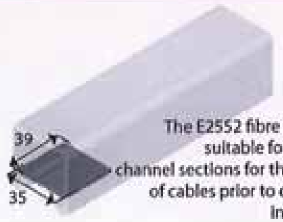
Suits E3300 & E4000 Channel

E5580



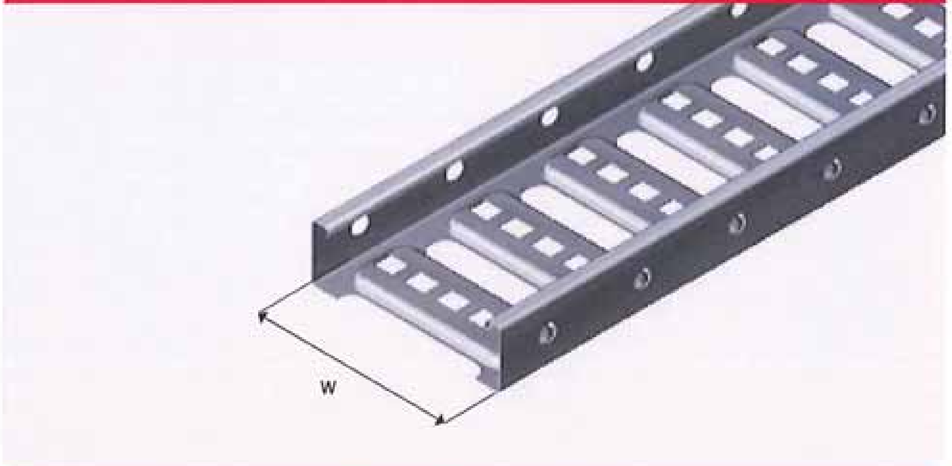
Suits E5500 Channel

E2552



The E2552 fibre retainer is suitable for use in all channel sections for the support of cables prior to cover strip installation.

EZYTRAY



PRODUCT DETAILS
EzyTray is the sensible choice for all general purpose installations, being made from durable steel, and used extensively for office fit outs, shopping centres and light industrial applications. Lightweight and easy to install, and complemented by a full range of accessories to enable fast on site fabrication of tees, risers, bends and crosses.

EzyTray is manufactured to the following standards:
- Pre-Galvanised to AS1397
- Hot Dip Galvanised to AS/NZS4680; ISO1461

STANDARD LENGTH
- 3 Metres

ORDERING DETAILS
Supplied per length

AVAILABLE FINISH	ORDERING CODE
Hot Dip Galvanised	ET...**H**
Pre-Galvanised	ET...**G**

Ordering Code	Cable Laying Width W (mm)	Cable Laying Depth (mm)	Overall Width (mm)	Side Rail Height
ET150	150	38	150	45
ET300	300	38	300	45
ET450	450	38	450	45
ET600	600	38	600	45

LOAD RATING AND DEFLECTION

EzyTray has been tested in accordance with NEMA standards and the load ratings certified by a NATA accredited testing facility.

A guide to deflection for continuous runs has been included for easy reference, however it should be noted that the positioning of splice joints and loading techniques can significantly impact upon the actual deflection. Refer to NEMA VE2 Installation guidelines for further explanation.

EzyStrut

PRODUCT DETAILS
A full range of EzyTray accessories is available to complement the system and provide easy on site installation.

EzyTray accessories are common for all tray widths and can be used to make tees, bends, risers, and crosses.

ORDERING DETAILS
Supplied per length/individually

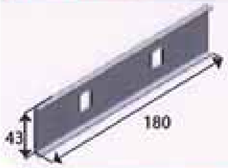
AVAILABLE FINISH	ORDERING CODE
Hot Dip Galvanised	ET...**H**
Pre-Galvanised	ET...**G**

ETDS DIVIDER STRIP Wt: 0.63kg

Standard Length: **2.4m**

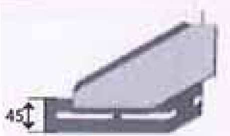
Order fasteners separately for installation:
3 x HS620
3 x E3016

ETS SPLICE Wt: 0.09kg



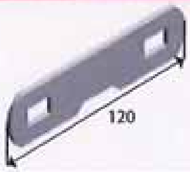
2 Splices required per length of tray. Order fasteners separately for installation:
2 x SBH
2 x CNH

ETTX TEE/CROSS BRKT Wt: 0.43kg



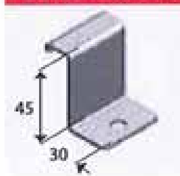
2 TX Brackets required to make a tee; 4 required to make a cross. Order fasteners separately for installation (per TX Bracket):
4 x SBH
4 x CNH

ETRL RISER LINK Wt: 0.05kg



6 Riser Links required to perform a 90° set. Order fasteners separately for installation (per RL):
2 x SBH
2 x CNH

ETHD HOLD DOWN Wt: 0.06kg



Order fasteners separately for installation:
1 x HS825
1 x E3007

SBH & CNH Wt: 0.03kg

ORDERING DETAILS
Both items are ordered separately.

EzyStrut Splice Bolts have a smooth head to eliminate the risk of sheathing the cable during installation.

Purpose made Counterbore Nuts ensure that full tension is achieved during installation.

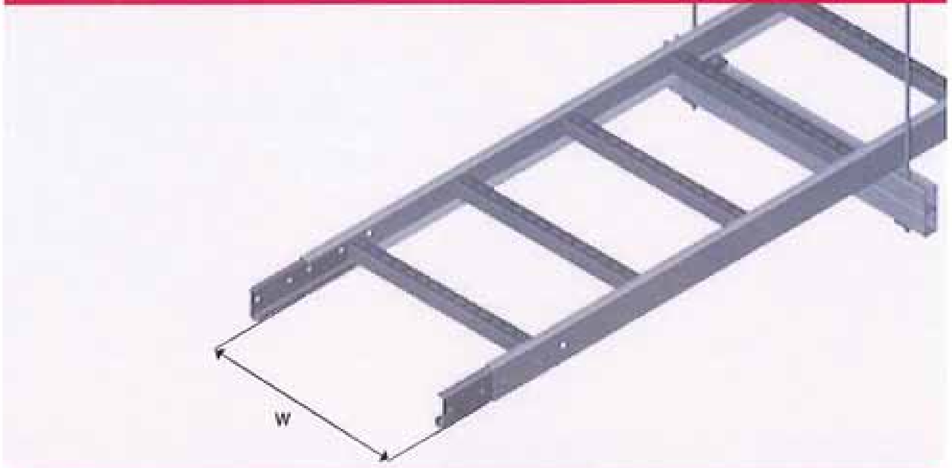
Specify ETFKH when both parts are required. ETFKH supplied in packs of 40. Hot Dip Galvanised.

ETRP RADIUS PLATE Wt: 1.00kg

Standard 2.0m length. Order fasteners separately for installation. **Aproximate length required to make a 150mm radius bend:**

Tray Size	Length Required	Fasteners Required
ET150	0.7m	6
ET300	0.9m	6
ET450	1.2m	6
ET600	1.4m	6

NEMA 2 AS3013:2005 FIRE RATED CABLE LADDER



PRODUCT DETAILS

EzyStrut Nema 2 Fire Rated Steel Cable Ladder is manufactured from strip steel to comply with the AS3013:2005 standard.

- Reverse Rail System complete with Splice Plates.
- Achieves standard 2 hour fire rating at 1050°C.
- Uniform Load Rating of 50kg per metre.
- Max Support Span: 1.5m.
- Hot dip galvanised finish to AS/NZS4680:2005.
- Supplied with Trapeze Support pre drilled for M12 Hot Dip Galvanised threaded rod.
- Custom fittings available upon request.
- Fire rating only applies when used as a complete system.
- End of runs must be tied. Contact your local EzyStrut sales office for more information.
- Australian Innovation Patent 2011100385.

STANDARD LENGTH

- 6 Metre lengths manufactured against firm orders only

ORDERING DETAILS

Supplied per length

AVAILABLE FINISH	ORDERING CODE
Hot Dip Galvanised	N2LFR...**H**

- Supplied with ES5001S Trapeze Support.
- Requires threaded rod TR12H.

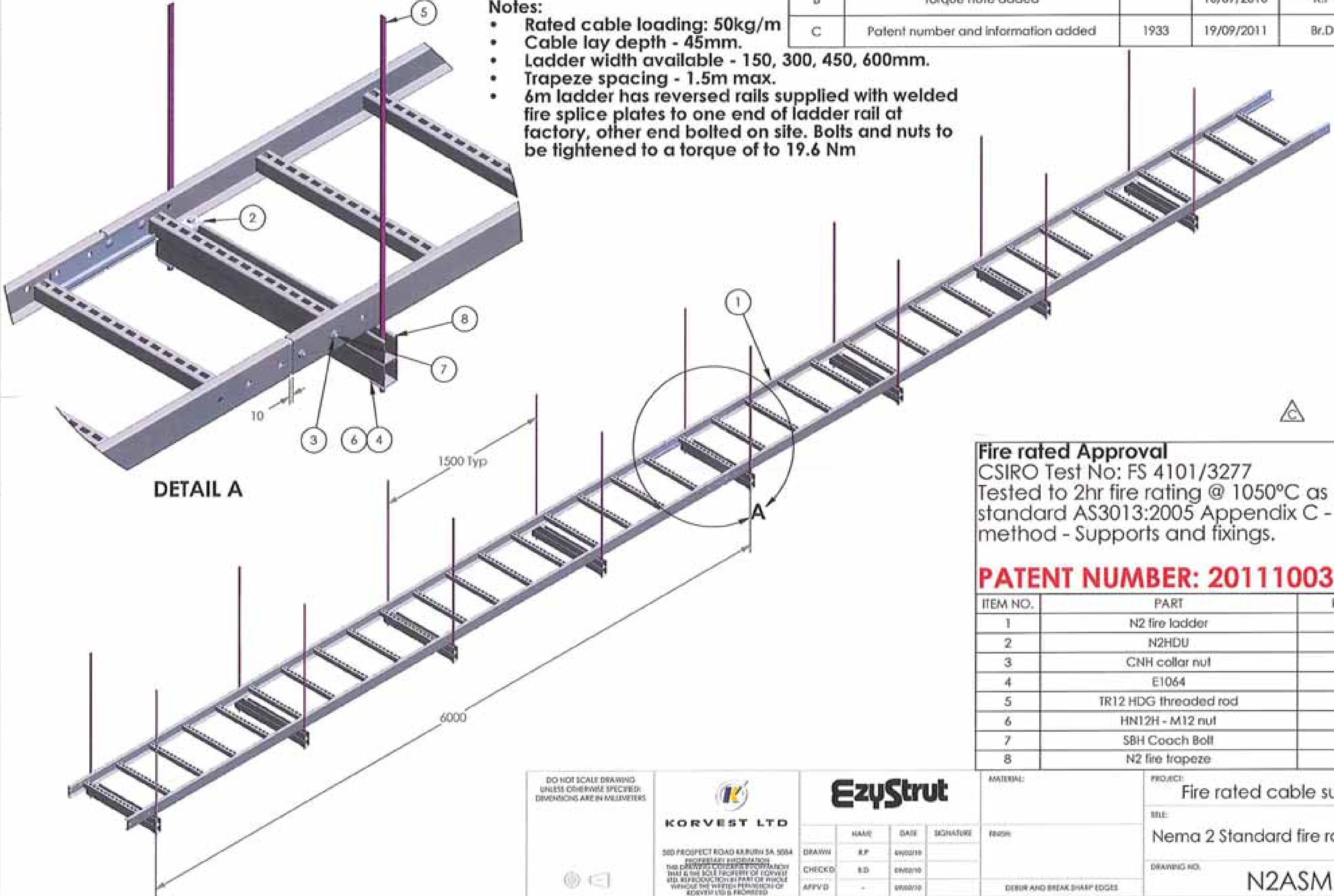
Ordering Code	Cable Laying Width - W (mm)	Cable Laying Depth (mm)	Overall Width (mm)	Side Rail Height (mm)
N2LFR150	150	45	260	93
N2LFR300	300	45	410	93
N2LFR450	450	45	560	93
N2LFR600	600	45	710	93

REVISIONS

REV.	DESCRIPTION	RFC	DATE	AUTHOR	CHECKED BY
A	Drawing project, title and number changed, drawing released for manufacture.	1718	7/07/2010	Br.D	B.D
B	Torque note added		16/09/2010	R.P	J.D
C	Patent number and information added	1933	19/09/2011	Br.D	J.D

Notes:

- **Rated cable loading: 50kg/m**
- **Cable lay depth - 45mm.**
- **Ladder width available - 150, 300, 450, 600mm.**
- **Trapeze spacing - 1.5m max.**
- **6m ladder has reversed rails supplied with welded fire splice plates to one end of ladder rail at factory, other end bolted on site. Bolts and nuts to be tightened to a torque of to 19.6 Nm**



Fire rated Approval
CSIRO Test No: FS 4101/3277
Tested to 2hr fire rating @ 1050°C as per test standard AS3013:2005 Appendix C - Fire test method - Supports and fixings.

PATENT NUMBER: 2011100385

ITEM NO.	PART	DRAWING NO.
1	N2 fire ladder	N2LFR
2	N2HDU	N2HDU
3	CNH collar nut	SNH M10
4	E1064	E1064
5	TR12 HDG threaded rod	-
6	HN12H - M12 nut	-
7	SBH Coach Bolt	SBH M10
8	N2 fire trapeze	N2TBFR

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

KORVEST LTD

580 PROSPECT ROAD KILBURN SA 5084

EzyStrut

	NAME	DATE	SIGNATURE
DRAWN	R.P		
CHECKD	B.D		
APPV'D	-		

MATERIAL:

FINISH:

DEBUR AND BREAK SHARP EDGES

PROJECT: Fire rated cable support — A3

TITLE: Nema 2 Standard fire rated assembly

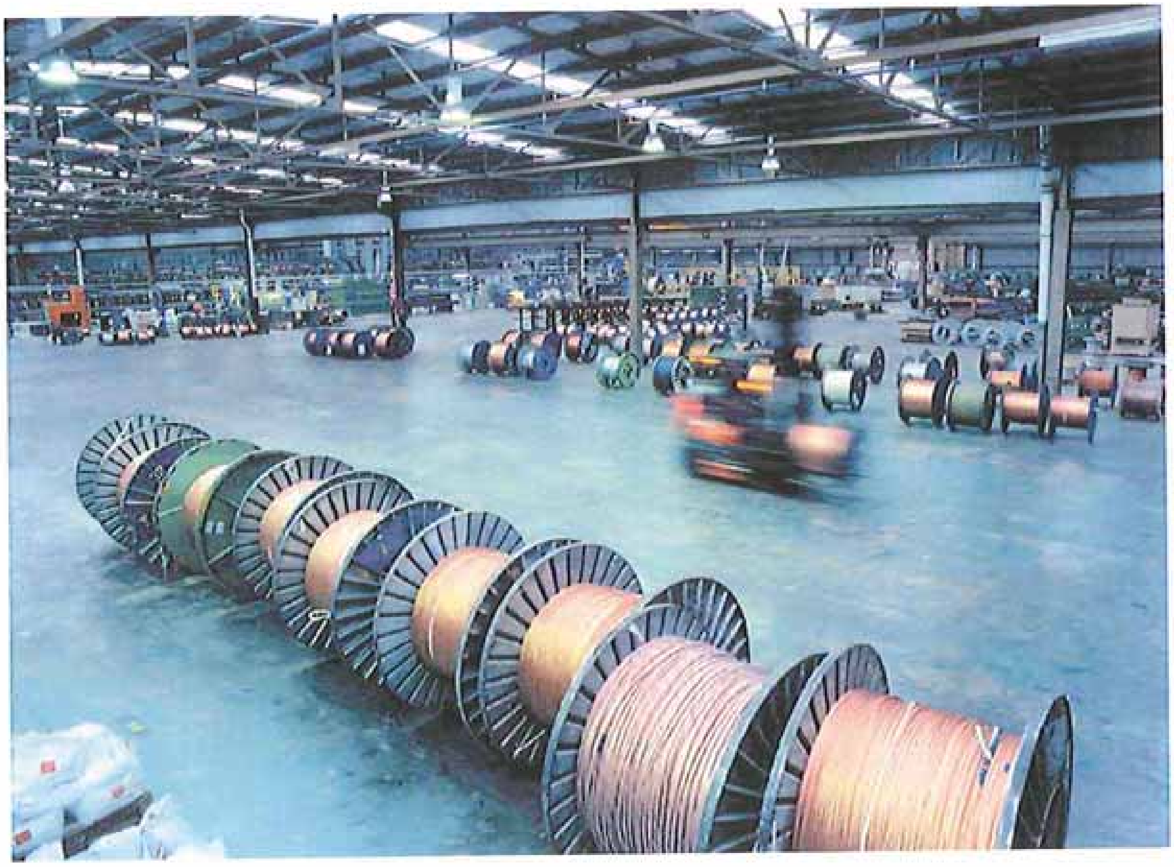
DRAWING NO. N2ASMFR — REV. C

SHEET 1 OF 1

R:\Corporate_Working\Engineering\Products\Drawings\EzyStrut\Cable Supports\A - Ladders & Fittings HDG_SS\N2 Fire rated ladder\

8.4 Submains: Triangle

Contents - Technical Information



Product Coding and Lugging

INDUSTRIAL CABLE - PRODUCT CODES

XL - PA X N / 1 C 240 OR

XL (1) - PA (3) X (4) N (5) / 1 (6) C (7) 240 (8) OR (9)

MARINE CABLE - PRODUCT CODES

DV A - PA T D / 3 C 1.5 BK

DV (1) A (2) - PA (3) T (4) D (5) / 3 (6) C (7) 1.5 (8) BK (9)

1. PRODUCT SERIES

eg: **XL** series, **DV** series

2. SHEATH TYPE *(Marine Cables only)*

A = SHF-1
B = SHF-2
C = NEK606

3. CORE COLOUR CONFIGURATION

eg: **PA** = AS/NZS Fixed Wiring with Earth

RE WH BL BK EA

eg: **PB** = AS/NZS Fixed Wiring without Earth

RE WH BL BK

eg: **PD** = AS/NZS Flexible

BR BK WH BL EA

4. BRAID/ARMOUR *(Not all examples shown)*

T = Tinned Copper Wire Braid
G = Galvanized Steel Wire Braid
L = Tinned Copper Wire Braid + drain wire
S = Steel Wire Armour
A = Aluminium Braid
R = Aluminium Laminate Tape
X = Not Applicable

5. CONDUCTOR

N = Plain Annealed Copper Wire
D = Tinned Annealed Copper Wire

6. NUMBER OF CONDUCTORS/PAIRS/TRIADS

7. CORE TYPE

C = Power/Control
T = Triad
P = Pair
Q = Quad

8. CONDUCTOR CROSS SECTION AREA (MM2)

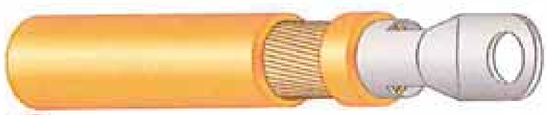
9. SHEATH COLOUR

OR = Orange
WH = White
BR = Brown
BL = Blue
EA = Green/Yellow (Earth)
BK = Black
GY = Grey
RE = Red
GN = Green

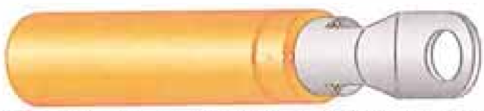
LUGGING RECOMMENDATION

1 Cut at required length and remove.

2 Cut section and slide towards the end of the conductor* (allow 5mm clearance)



3 Place standard lug at the end of conductor.



4 Gently push both lug and section until they meet the sheath. Cut and remove section.

5 Compress lug using hexagonal die and hydraulic crimper.

*Stripping at 25mm maximum lengths is recommended. For longer lengths cutting and stripping in 25mm sections is advised

Installation Recommendation

CORRECTION FACTORS FOR CABLE CURRENT RATING

Ambient Temperature

The maximum current ratings in this catalogue are based on an ambient temperature of 40°C and soil temperature of 25°C. For other ambient temperatures, the correction factors below should be applied:

Maximum Conductor Temperature	Ambient Air Temperature						
°C	25°C	30°C	35°C	40°C	45°C	50°C	55°C
110	1.10	1.07	1.04	1.00	0.96	0.93	0.89
90	1.15	1.10	1.05	1.00	0.94	0.88	0.81

Maximum Conductor Temperature	Ambient Soil Temperature						
°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C
110	1.08	1.06	1.03	1.00	0.97	0.94	0.91
90	1.11	1.07	1.03	1.00	0.97	0.93	0.89

INSTALLATION

Cable runs should be fixed in straight lines as far as practicable. The minimum bending radius for cable should be selected in accordance with the table below.

Cable Construction	Cable OD	Minimum bending radius (times cable OD)
Unbraided	all sizes	4X
Unbraided, fire resistant	all sizes	8X
Braided	all sizes	6X
Braided, fire resistant	all sizes	10X
Nylon protected	all sizes	10X
Steel wire armoured	all sizes	10X

The installation of cables across expansion joints in any structure should be avoided. Where this is not feasible, a loop of cable sufficient to accommodate the expansion of the joint should be provided. The internal radius of the loop is to be at least 12 times the overall diameter of the cable.

Cables should be installed away from heat sources as far as practicable. If this cannot be avoided and there is possibility of damage to the cable, then suitable shields, insulation or other protective measures should be installed.

Cables are not to be coated or painted with materials which may adversely affect their sheath or fire performance.

Cables should be installed away from sources of mechanical damage, as far as is practicable. If this cannot be avoided the cables should be protected with suitable metallic casing.

VOLTAGE DROP

When selecting cable size, consideration must be given to voltage drop. Refer to formula and table below:

$$Vd = \frac{L \times I \text{ mV/Am}}{1000}$$

Where: Vd = voltage drop in volts
L = route length of cable in metres
I = current to be carried in amps
mV/Am = millivolts per ampere metre value

(the drop in voltage shall not exceed 5% of supply voltage)

CONDUCTOR SIZE - SHORT CIRCUIT RATING

The short circuit current ratings in this catalogue are based on a one second duration. To calculate the maximum permissible short circuit ratings, the following formula should be applied.

$$\frac{C \times 143}{\sqrt{t}} \quad 90°C \qquad \frac{C \times 132}{\sqrt{t}} \quad 110°C$$

C = cross section area of conductor in mm2
t = short circuit time in seconds

Cross Sectional Area (mm²)	Short Circuit Current (Amps for 1 second)		Three-Phase Voltage Drop at 50Hz (mV/A.m)*			
			Single Core Trefoil		Multicore	
	90°C	110°C	90°C	110°C	90°C	110°C
0.5	72	66	86.1	91.4	86.1	91.4
0.75	107	99	57.4	61.0	57.4	61.0
1	143	132	43.1	45.7	43.1	45.7
1.5	215	198	29.4	31.2	29.4	31.2
2.5	358	330	17.6	18.7	17.6	18.7
4	572	528	10.9	11.6	10.9	11.6
6	858	792	7.29	7.74	7.29	7.74
10	1430	1320	4.22	4.48	4.22	4.48
16	2288	2112	2.68	2.84	2.68	2.84
25	3575	3300	1.73	1.84	1.73	1.84
35	5005	4620	1.24	1.31	1.23	1.31
50	7150	6600	0.869	0.921	0.866	0.917
70	10010	9240	0.622	0.658	0.618	0.654
95	13585	12540	0.483	0.509	0.477	0.504
120	17160	15840	0.388	0.408	0.383	0.403
150	21450	19800	0.325	0.340	0.318	0.334
185	26455	24420	0.280	0.293	0.273	0.286
240	34320	31680	0.233	0.242	0.225	0.234
300	42900	39600	0.207	0.213	0.198	0.205
400	57200	52800	0.183	0.187	0.174	0.178
500	75100	66000	0.169	0.172	0.160	0.163
630	90090	83160	0.157	0.159	-	-

** AS/NZS3008.1.1:2009, Table 46 and Table 48. To determine the single-phase Voltage drop, multiply the three-phase value by 1.155. All information above is intended as a guide only.*

MAXIMUM INSTALLATION TENSION

To calculate the maximum allowable tension of cables during installation the following formula should be applied:

50 x C x Nc

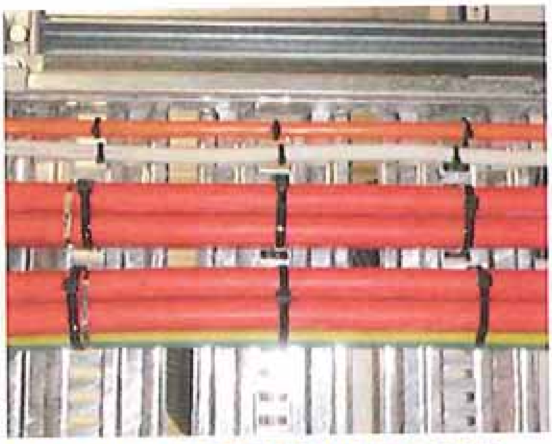
C = cross section area of conductor in mm²

Nc = total number of cores

Maximum tension must not exceed 20,000N (kg = N/9.81)

Installation Recommendation For Fire Resistant Cables

The following installation recommendations are minimum requirements only, and local statutory, building code, and guidelines for the installation of associated products should also be taken into account:



1. INSTALLED ON CABLE TRAY OR LADDER:

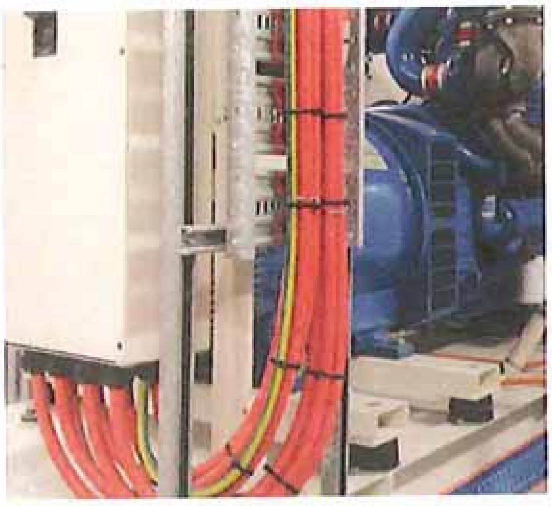
Cables should be secured with metal fixings such as stainless steel cable ties, strapping, or cable clamps, with the following minimum fixing distances:

Horizontal:

Cables should be secured with cable ties every 350mm and with stainless steel cable ties every 1000mm

Vertical, Inclined or Unsupported:

Cables should be secured with cable ties every 300mm and with stainless steel cable ties every 600mm



2. INSTALLED BY DIRECT FIXING TO WALLS, CEILINGS AND IN CONDUIT:

Horizontal:

Cables should be secured with cable ties every 350mm and with stainless steel cable ties every 1000mm

Vertical, Inclined or Unsupported:

- for cables or cable bunches with an overall diameter $\leq$ 25mm fix every 600mm
- for cables or cable bunches with an overall diameter > 25mm fix every 300mm

3. INSTALLED USING UNSUPPORTED SPANS

Unsupported spans over 600mm are not recommended for cable or cable bunches with overall diameters $\leq$ 25mm, and spans over 300mm are not recommended for cable or cable bunches with overall diameters >25mm.

Note: That steel expanding bolts or similar systems should be used to fix trays and ladders to the fire rated elements of the building structure. Refer to the manufacturer's recommendation for fire conditions for the loading of trays and fixing.

4. INSTALLED ON CATENARY WIRE

Cables must be secured to catenary wires using metal fixings such as stainless steel cable ties or strapping with the following recommended fixing distances:

- for cables or cable bunches with an overall diameter $\leq$ 25mm fix every 600mm
- for cables or cable bunches with an overall diameter > 25mm fix every 300mm

Catenary wires should be secured to fire rated elements of the building structure and should only be loaded to 50% of the manufacturers recommended maximum.

INSTALLATION MUST ALSO COMPLY WITH AS/NZS 3000:2007 WIRING RULES:

"Wiring systems shall be installed in accordance with the generally accepted principles of safe and sound practice, using methods that will protect the electrical installation against mechanical or electrical failure under ordinary use, wear and tear, and any abnormal conditions that may reasonably be anticipated".

and

"Wiring systems shall be supported by suitable means, in accordance with Clause 3.3.2.8. Wiring systems shall be fixed in position, in accordance with this Standard, by suitable clips, saddles or clamps or by means that will not damage the wiring system and that will not be affected by the wiring system material or any external influences. For wiring systems installed in building elements, the positioning and size of openings and checks shall not reduce the structural strength of those building elements below the levels required by National Building Codes."

Conductor Data

CONDUCTOR - CONSTRUCTION

Triangle uses very fine 0.3mm copper wires to ensure maximum flexibility and ease of use. The following table from IEC 60228 provides a comparative analysis.

size (mm²)	Triangle	class 2	class 5	class 6
0.5	7 X 0.30	7 X 0.30	16 X 0.20	28 X 0.15
0.75	11 X 0.30	7 X 0.37	24 X 0.20	42 X 0.15
1	14 X 0.30	7 X 0.43	32 X 0.20	56 X 0.15
1.5	21 X 0.30	7 X 0.52	30 X 0.25	84 X 0.15
2.5	35 X 0.30	19 X 0.41	50 X 0.25	140 X 0.15
4	56 X 0.30	19 X 0.52	56 X 0.30	224 X 0.15
6	84 X 0.30	19 X 0.64	84 X 0.30	192 X 0.20
10	144 X 0.30	49 X 0.51	80 X 0.40	320 X 0.20
16	224 X 0.30	49 X 0.65	128 X 0.40	512 X 0.20
25	350 X 0.30	84 X 0.62	200 X 0.40	800 X 0.20
35	490 X 0.30	133 X 0.58	280 X 0.40	1120 X 0.20
50	714 X 0.30	133 X 0.69	400 X 0.40	705 X 0.30
70	980 X 0.30	189 X 0.69	356 X 0.50	999 X 0.30
95	1344 X 0.30	259 X 0.69	485 X 0.50	1340 X 0.30
120	1672 X 0.30	336 X 0.67	614 X 0.50	1699 X 0.30
150	2128 X 0.30	592 X 0.69	765 X 0.50	2123 X 0.40
185	2584 X 0.30	494 X 0.69	994 X 0.50	1470 X 0.40
240	3344 X 0.30	627 X 0.70	1125 X 0.50	1905 X 0.40
300	4256 X 0.30	61 X 2.50	1530 X 0.50	2385 X 0.40
400	5488 X 0.30	61 X 2.89	2035 X 0.50	3200 X 0.40
500	6944 X 0.30	61 X 3.20	1768 X 0.50	4010 X 0.40
630	8736 X 0.30	59 X 3.70	3200 X 0.50	5020 X 0.40

CONDUCTOR - DC RESISTANCE

To calculate the DC Resistance of copper conductors for a given temperature (°C), the resistance at 20°C, as detailed must be multiplied by the appropriate correction factor below.

Nominal Cross-Sectional Area (mm²)	Maximum resistance of conductor at 20°C	
	Plain Copper Ohm/Km	Tinned Copper Ohm/Km
0.5	39.0	40.1
0.75	26.0	26.7
1	19.5	20.0
1.5	13.3	13.7
2.5	7.98	8.21
4	4.95	5.09
6	3.30	3.39
10	1.91	1.95
16	1.21	1.24
25	0.78	0.795
35	0.554	0.565
50	0.386	0.393
70	0.272	0.277
95	0.206	0.210
120	0.161	0.164
150	0.129	0.132
185	0.106	0.108
240	0.0801	0.0817
300	0.0641	0.0654
400	0.0486	0.0495
500	0.0384	0.0391
630	0.0287	0.0292

AMBIENT Temperature (°C)	Correction Factor
20	1.000
25	1.020
30	1.039
35	1.059
40	1.079
45	1.098
50	1.118
55	1.138
60	1.157
65	1.177
70	1.196
75	1.216
80	1.236
85	1.255
90	1.275

All information above is intended as a guide only.

CONVERSION TABLE - CROSS-SECTIONAL AREA AWG/MCM TO MM²

AWG	mm²
20	0.519
18	0.823
16	1.31
14	2.08
12	3.31
10	5.26
8	8.37
6	13.30
4	21.15
2	33.62
1	42.41
1/0	53.49
2/0	67.43
3/0	85.01
4/0	107.2
MCM	**mm²**
250	126.7
300	152.0
350	177.3
400	202.7
450	228.0
500	253.4
550	278.7
600	304.0
650	329.4
700	354.7
750	380.0
800	405.4
850	430.7
900	456.0
950	481.4
1000	506.7
1250	633.4

MINIMUM EARTHING CONDUCTOR SIZE

Nominal Cross Sectional Area of Active Conductor	Nominal Cross Sectional Area of Earthing Conductor
mm²	mm²
0.75	0.75
1	1
1.5	1.5
2.5	2.5
4	2.5
6	2.5
10	4
16	6
25	6
35	10
50	16
70	25
95	25
120	35
150	50
185	70
240	95
300	120
400	≥120
500	≥120
630	≥120

Refer to Section 5 of AS/NZS3000 2007 for other information

Low Smoke Zero Halogen (LSZH) What does it mean?

LSZH

LSZH simply translates to Low Smoke Zero Halogen and refers to the behaviour of chemical compounds when combusted - specifically the quantity of smoke generated and the toxicity of the emissions.

HALOGENS - WHAT ARE THEY?

Halogens are a group of five elements comprising; Fluorine, Chlorine, Bromine, Iodine and Astatine.

Fluorine Chlorine Bromine Iodine Astatine

HALOGENS - AND THE EFFECT OF COMBUSTION

In their basic form, Halogens are very toxic, strong oxidizers and very chemically reactive. In the event of combustion, LSZH and non LSZH cables behave in very different ways, as indicated below.

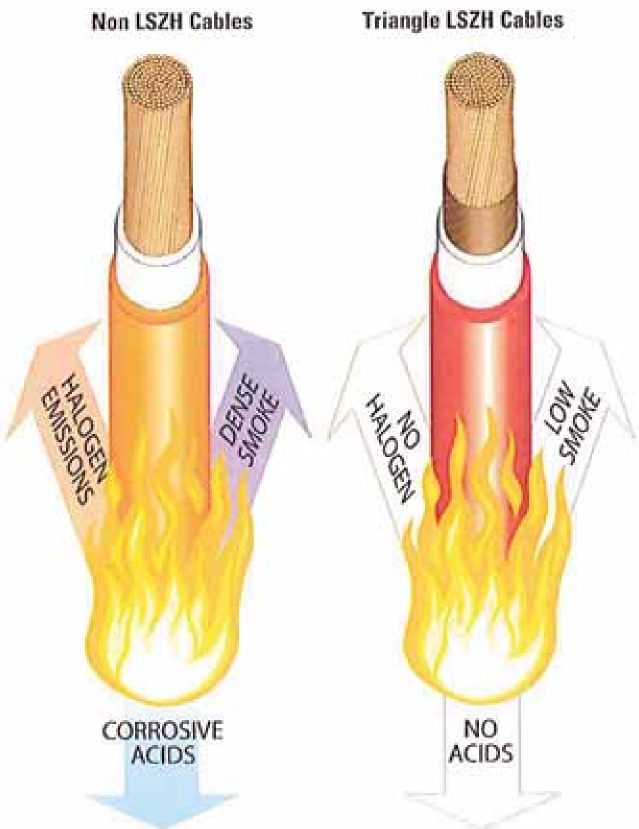
WHAT'S THE DIFFERENCE BETWEEN LSZH AND NON LSZH CABLES?

LSZH cables have a zero Halogen content, emit no toxic fumes, generate very little smoke and produce no corrosive or caustic acids. LSZH cables are therefore ideally suited for all applications where personnel safety and protection of valuable equipment are of paramount importance.

Non LSZH cables, or Halogenated Cables, are typically manufactured from thermoplastic compounds, such as PVC. On combustion, these compounds generate highly toxic fumes that cause severe irritation to the eyes, nose, mouth, throat and lungs. Increased concentrations are considered fatal to humans.

They also generate large volumes of dense black smoke that blocks visibility and severely disrupts evacuation procedures. The smoke and fumes can also lead to suffocation from smoke inhalation. A one metre length of burning cable that contains 0.85Kg of PVC will completely obscure a room of 1000m³ with black toxic smoke in less than five minutes.

When combusted, Halogens combine with moisture to form Hydrochloric Acid. This extremely corrosive acid is potentially deadly to humans and always causes extensive property damage. Acids of this nature aggressively attack electrical switchboards, motors, fixtures, furnishings, floor coverings, paint surfaces etc. In many cases the effects of acid corrosion after a fire are much more severe than the actual fire damage itself.



TRIANGLE LSFLEX® LSZH CABLES

- ✓ are halogen free
- ✓ do not form corrosive acids
- ✓ emit low smoke
- ✓ have an extremely low fuel element

Fire Testing and WS Rating

AS/NZS 3013 - CLASSIFICATION OF THE FIRE AND MECHANICAL PERFORMANCE OF WIRING SYSTEM ELEMENTS

This test is conducted in three parts:

FIRE TEST METHOD

Cable specimens are placed in a furnace which is programmed to follow a standard time-temperature curve, in order to determine the ability of the cable to maintain circuit integrity under fire conditions. The cable is deemed to have passed when the specimen has been exposed to the test for the appropriate minimum time requested by the submitter without a failure.

WATER TEST METHOD

After the cable specimen has passed the fire test, it is removed from the furnace and exposed to a water spray for 3 minutes. The cable is deemed to have achieved the desired degree of protection when it has been exposed to the fire test for the appropriate time and has sustained the effects of the water spray.

MECHANICAL TEST METHOD

Impact Test: The cable specimen is conditioned, placed on the test apparatus anvil, and connected to the circuit integrity monitoring system. The impactor which is set at the prescribed drop height, is dropped 3 times onto the specimen. The cable is deemed to have passed when it has been exposed to the specified level of impact energy without failure.

Cutting Test: A wedge shaped indentor is forced against the cable specimen and loaded until it cuts through the insulation in order to determine the ability of the cable to withstand cutting action. The cable is deemed to have passed when it has been exposed to the specified level of cutting force without failure.

IEC 60332-3, AS/NZS 1660.5.1 FLAME RETARDANT TEST

This test is conducted by placing cables together on a vertical ladder tray and then exposing them to the flames of a ribbon burner for the appropriate time (detailed below).

After removal of the flame, the cables are wiped clean and the charring should not have exceeded 2.5 meters.

Category A: 7 litres of combustible material exposed to flame for 40 minutes

Category B: 3.5 litres of combustible material exposed to flame for 40 minutes

Category C: 1.5 litres of combustible material exposed to flame for 20 minutes

IEC 60331, AS/NZS 1660.5.5 - FIRE TEST

This test is conducted by mounting a 1200mm length of cable over a gas burner and energizing it to its rated voltage. Flames are applied for 90 minutes at a temperature of at least 750°C. After 90 minutes the gas is turned off. After a further 15 minutes the power is disconnected. To pass the requirements of this test, the cable must remain operational both during the 90 minute exposure and the 15 minute cooling period.

IEC 60754-1&2, AS/NZS 1660.5.3 ACID GAS EMISSION TEST

This test determines the amount of acid gas emitted by burning cables. The criteria of this test states that the weighted pH value should not be less than 4.3 when related to 1 litre of water. The weighted value of conductivity should not exceed 10µs/mm.

IEC 61034-1&2, AS/NZS 1660.5.2 SMOKE DENSITY TEST

This test measures the smoke emission from cables during fire. This test is carried out in a 3m cubed enclosure where a cable sample is subjected to fire. The smoke emission and density are measured by alight beam emitted across the inside of the enclosure to a photocell, measuring the amount of luminous transmission received.

WS RATING

All our fire resistant cables are WS rated to AS/NZS 3013. A rating that defines the performance of a Wiring System.

The rating consists of the designation "**WS**" (Wiring System), followed by two numbers and a letter.

WS 5 2 W

First Numeral indicates how long the system maintained circuit integrity under fire conditions.

1	15 minutes
2	30 minutes
3	60 minutes
4	90 minutes
5	**120 minutes**

Second Numeral indicates the level of protection to the system during impact and cutting tests.

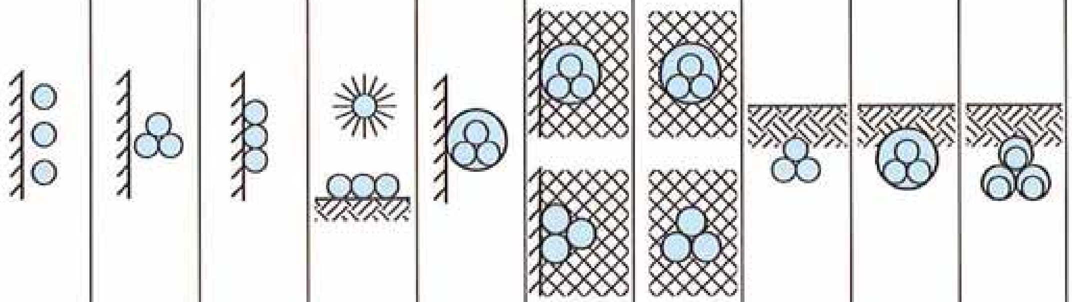
	Impact Test (J)	Cutting Test (kN)	Level of Protection
1	2.5	0.3	Light
2	**15**	**1.0**	**Moderate**
3	50	5.0	Heavy
4	500	5.0	Very Heavy
5	5000	5.0	Extremely Heavy

Supplementary Letter "**W**" means that the cable has passed the fire test and subsequent water spray test.

CURRENT-CARRYING CAPACITIES OF THREE SINGLE-CORE 0.6/1KV 90°C

(LSFLEX® XL-20 Insulation)

Applicable to single core cables in our XL, XN series



Conductor size mm²	Unenclosed				Enclosed	Thermal Insulation		Buried Direct	Underground Wiring Enclosure	
	Spaced	Spaced from Surface	Touching	Exposed to sun	Wiring enclosure in air	Partially surrounded by thermal insulation	Completely surrounded by thermal insulation			
	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper	Copper	Copper	Copper Flexible	Copper
1	20	17	16	13	15	12	8	18	19	22
1.5	25	22	20	16	19	15	10	22	23	27
2.5	33	29	27	21	24	20	14	31	30	38
4	45	38	36	27	31	26	19	40	38	49
6	57	49	46	34	41	34	24	50	49	60
10	80	69	64	48	55	45	32	67	66	79
16	106	91	85	63	73	58	43	117	85	101
25	142	121	114	83	94	77	58	151	109	132
35	177	151	141	103	118	96	72	180	134	158
50	223	191	178	128	144	114	-	214	163	190
70	283	241	225	161	183	146	-	262	203	232
95	341	290	271	192	214	176	-	313	237	276
120	406	346	322	226	256	209	-	356	279	320
150	470	400	372	260	291	236	-	400	316	358
185	540	459	427	296	334	268	-	452	357	413
240	651	553	514	352	391	320	-	523	416	477
300	752	637	591	402	458	375	-	589	479	552
400	909	764	709	477	533	427	-	668	554	626
500	1062	884	821	546	630	506	-	752	642	707
630	1256	1030	956	630	719	571	-	843	729	820

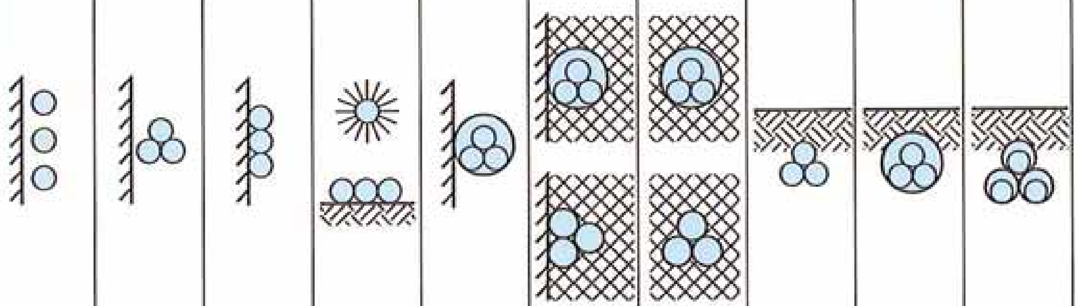
Values are in Amps and based on ambient temperature of 40°C in air, 25°C in ground, maximum conductor temperature of 90°C

Current Ratings Table

CURRENT-CARRYING CAPACITIES OF THREE SINGLE-CORE 0.6/1KV 110°C

(LSFLEX® R-30, LSFLEX® R70, LSFLEX® R-125, LSFLEX® X-125 Insulation)

Applicable to single core cables in our LS, EZ, EH, CC, FR, CN, KK, KF series



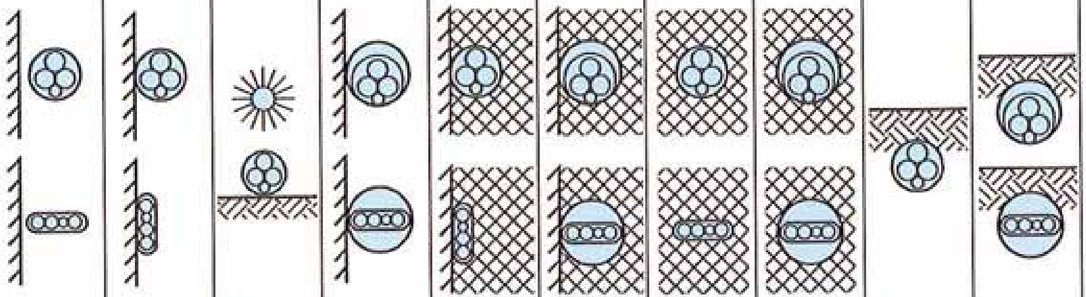
	Unenclosed				Enclosed	Thermal Insulation		Buried Direct	Underground Wiring Enclosure	
	Spaced	Spaced from Surface	Touching	Exposed to sun	Wiring enclosure in air	Partially surrounded by thermal insulation	Completely surrounded by thermal insulation			
Conductor size mm²	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper	Copper	Copper	Copper Flexible	Copper
1	25	22	21	18	18	14	10	20	21	24
1.5	31	27	26	22	23	18	13	25	26	30
2.5	42	36	34	29	31	25	18	36	34	42
4	55	48	45	38	40	33	23	46	44	54
6	70	61	57	48	50	41	30	57	55	67
10	99	85	80	67	70	57	40	77	76	88
16	130	112	105	88	91	74	53	130	97	115
25	173	149	139	116	121	100	72	168	125	148
35	214	184	172	143	148	121	88	201	151	176
50	270	233	217	179	190	146	-	237	188	212
70	340	292	273	224	234	187	-	291	229	259
95	410	353	329	269	277	228	-	348	268	315
120	487	418	390	317	331	269	-	396	316	357
150	562	482	450	365	378	306	-	445	357	400
185	644	553	516	417	438	359	-	503	404	461
240	775	665	620	499	538	439	-	583	481	533
300	895	766	714	572	612	501	-	657	542	617
400	1079	918	855	682	757	575	-	746	648	700
500	1260	1064	990	786	864	692	-	843	729	815
630	1493	1240	1154	913	993	787	-	947	828	920

Values are in Amps and based on ambient temperature of 40°C in air, 25°C in ground, maximum conductor temperature of 110°C.

CURRENT-CARRYING CAPACITIES OF MULTI-CORE 0.6/1KV 90°C

(LSFLEX® XL-20 Insulation)

Applicable to Multi-Core cables in our XL, XN, XU series

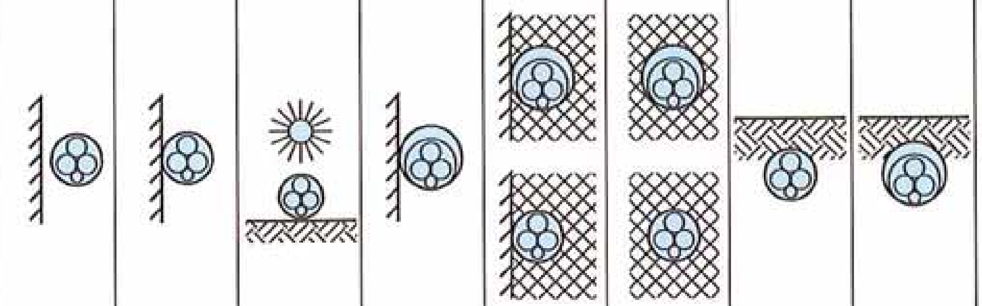


Conductor size mm²	Unenclosed			Enclosed	Thermal Insulation				Buried Direct	Underground Wiring Enclosure
	Spaced	Touching	Exposed to sun	Wiring enclosure in air	Partially surrounded by thermal insulation, unenclosed	Partially surrounded by thermal insulation, in a wiring enclosed	Completely surrounded by thermal insulation, unenclosed	Completely surrounded by thermal insulation, in a wiring enclosed		
	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper	Copper	Copper	Copper Flexible	Copper Flexible
1	16	15	13	14	12	10	7	6	16	17
1.5	20	19	17	17	15	13	9	8	20	21
2.5	27	26	22	23	21	19	13	12	29	28
4	36	34	29	29	28	24	18	15	37	36
6	46	43	37	37	36	30	22	19	46	45
10	66	61	52	52	49	42	31	26	63	62
16	87	81	69	67	66	55	41	34	110	79
25	116	108	92	89	89	73	56	46	143	103
35	144	135	113	111	110	91	69	57	172	127
50	182	170	142	136	134	108	-	-	204	155
70	230	214	177	173	170	138	-	-	251	193
95	275	256	211	202	210	167	-	-	302	226
120	327	303	248	242	245	197	-	-	344	266
150	375	348	283	274	280	222	-	-	385	300
185	428	396	320	314	323	257	-	-	435	339
240	511	472	379	379	383	309	-	-	504	402
300	584	539	430	-	-	-	-	-	567	452
400	692	638	504	-	-	-	-	-	640	537
500	794	730	573	-	-	-	-	-	714	602

Values are in Amps and based on ambient temperature of 40°C in air, 25°C in ground, maximum conductor temperature of 90°C

Current Ratings Table

CURRENT-CARRYING CAPACITIES OF MULTI-CORE 0.6/1KV 110°C
(LSFLEX® R-30, LSFLEX® R70, LSFLEX® R-125, LSFLEX® X-125 Insulation)
Applicable to Multi-Core cables in our EZ, EH, CC, FR, FH, CN, OD, KK, KF, EU series



Conductor size mm²	Unenclosed: Spaced	Unenclosed: Touching	Unenclosed: Exposed to sun	Enclosed: Metallic wiring enclosure in air	Thermal Insulation: Partially surrounded by thermal insulation	Thermal Insulation: Completely surrounded by thermal insulation	Buried Direct	Underground Wiring Enclosure
	Copper Flexible	Copper Flexible	Copper Flexible	Copper Flexible	Copper	Copper	Copper	Copper Flexible
1	21	19	18	17	13	9	19	20
1.5	26	24	22	21	16	12	24	24
2.5	34	32	29	27	23	17	33	31
4	45	42	39	36	30	22	43	41
6	57	54	49	46	38	28	53	51
10	80	75	68	65	51	38	71	71
16	106	99	89	84	68	50	122	91
25	140	131	118	112	93	67	158	118
35	173	162	145	137	112	83	190	143
50	218	204	182	175	139	-	226	178
70	273	255	227	217	173	-	277	217
95	327	306	271	263	216	-	333	259
120	387	360	318	306	249	-	379	298
150	444	413	364	356	288	-	426	341
185	505	470	412	402	329	-	481	381
240	602	559	488	489	398	-	558	453
300	688	638	555	-	-	-	629	509
400	817	756	655	-	-	-	713	606
500	936	865	746	-	-	-	797	680

Values are in Amps and based on ambient temperature of 40°C in air, 25°C in ground, maximum conductor temperature of 110°C

Ripcord Technology

Triangle Cables has been leading the way in cable technology for over 30 years. During this time we have developed a range of superior cable solutions, producing cables that are highly flexible, light weight, flame retardant, LSZH, termite resistant and can operate at temperatures up to 110°C.

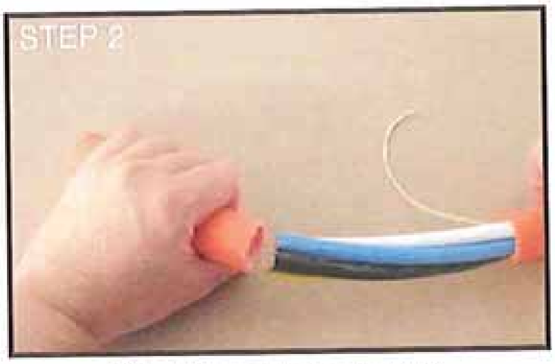
Ripcord Technology is a recent innovation in the manufacture and design of electrical cable. This new feature has been introduced into a selected range of our cables at no extra charge. The ripcord is incorporated during the manufacturing process and is placed just under the outer jacket. It provides the user with a very simple and efficient method of stripping our range of cables.

Our unique Ripcord Technology further enhances the user experience of the Triangle Cables range.

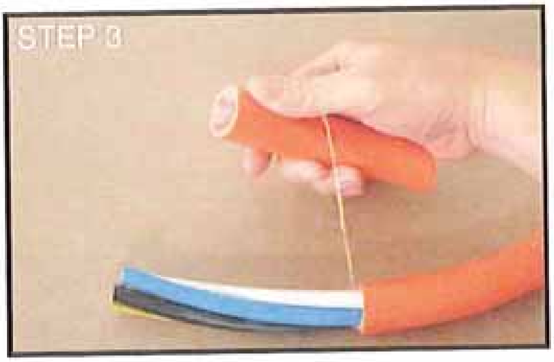
Stripping even the largest of our cables is now easier, faster and safer than ever before.

The steps below show just how easy Ripcord Technology has made stripping our range of cables.

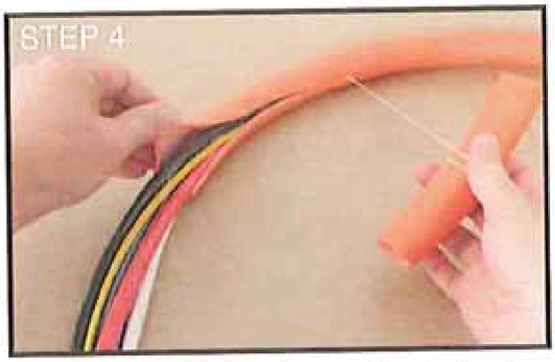
Cut all around and bend the jacket to ensure a complete cut.



Slide off the jacket piece to expose the ripcord and save for next step.

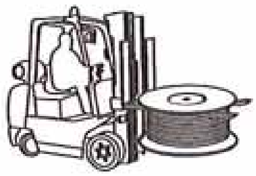


Wrap ripcord several times around removed jacket piece.

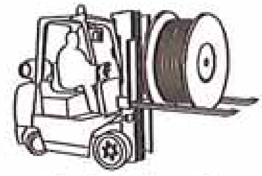


Pull parts in opposite direction to allow the ripcord to slice through the outer jacket, exposing the cores. Strip as much or as little as you require.

Recommended Cable Drum Handling Procedures



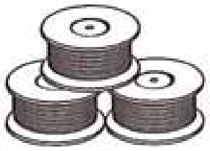
Do not lift by top flange, cable or reel will be damaged.



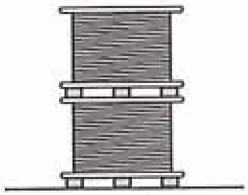
Cradle both reel flanges between forks.

Use a spreader bar to prevent bending the reel flanges and mashing the cable.

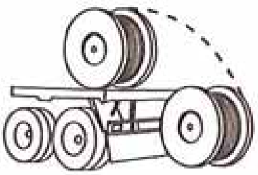
Reels can be hoisted with a shaft extended through both flanges.



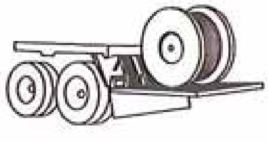
Upended heavy reels will often arrive damaged. Refuse or receive subject to inspection for hidden damage.



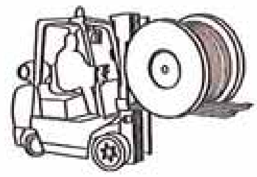
Place spacers under the bottom flange and between reels to create a space to insert the forks.



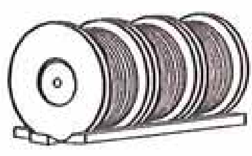
Never drop reels.



Lower reels from truck using hydraulic gate, hoist or fork lift, LOWER CAREFULLY.



Never allow fork tynes to touch cable surface or reel wrap.



Always load with flanges on edge and chock and block securely.

Triangle
CABLES

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e qldsales@tricab.com
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Aitkenvale. Qld 4814

OFFICES ALSO IN:
New Zealand, North America, Asia, Europe and the Middle East

8.5 Subcircuit Cabling: Olex

Olex a Nexans company
ABN 61 087 542 863
55 Main Street, Lilydale
Victoria, 3140, Australia

TELEPHONE *61 03 8739 3333
FACSIMILE *61 03 8739 3339
*61 03 8739 3309
www.olex.com.au

Customer : **NILSEN** 22 May 13
Reference:

DESCRIPTION: Two Cores 1.5 mm2 Uniaxial Plain Annealed Copper, 450/750 V PVC (V-90) Insulated (0.6 mm min av wall), (3V-90) Flat Sheathed (.9 mm min av wall) to AS 5000 Pt.2

Product Code : **CACP05A5002** Ident No. : 7712,002915,02,0001

Colour Code:

Insulation : Red, Black
Sheath : White/metre marked or as ordered

Physical Properties:

Cable dimensions: 7.3 x 4.6 mm nom +/- 0.5 mm
Main Core Dimensions - Conductor : 1.5 mm Insulation : 2.7 mm
Maximum Recommended Safe Pulling Tension : 0.18 kN
Minimum Bending Radius :
Pulling in : 21 mm
Set in Position : 14 mm

Electrical Properties:

Maximum conductor DC resistance = 13.6 ohm/km @ 20°C
Minimum insulation resistance = 14 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Plastic drum
Internal drum size 450 mm x 250 mm B x 300 mm
Overall drum size 450 mm x 300 mm
Net mass of cable: 59 kg/km
Gross mass per drum = 34 kg

All Above Information is Subject to Change Without Notice

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*61 03 8739 3309
www.olex.com.au

Customer : **NILSEN** 22 May 13
Reference:

DESCRIPTION: One Core 2.5 mm2 Uniaxial Plain Annealed Copper, 450/750 V PVC (V-90) Insulated (0.7 mm min av wall), (3V-90) Sheathed (.8 mm min av wall) to AS 5000 Pt.2

Product Code : **AABP07A5001** Ident No. : 7702,002925,01,0001

Colour Code:
Insulation : Red
Sheath : White or as ordered

Physical Properties:
Overall cable diameter: 5.1 mm nom +/- 0.5 mm
Main Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Maximum Recommended Safe Pulling Tension : 0.17 kN
Minimum Bending Radius :
Pulling in : 23 mm
Set in Position : 15 mm

Electrical Properties:
Maximum conductor DC resistance = 7.41 ohm/km @ 20°C
Minimum insulation resistance = 9.2 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Plastic spool
Internal drum size 285 mm x 106 mm B x 251 mm
Overall drum size 285 mm x 251 mm
Net mass of cable: 47 kg/km
Gross mass per drum = 23 kg

All Above Information is Subject to Change Without Notice

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Customer : **NILSEN** 22 May 13
Reference:

DESCRIPTION: 4 Cores 2.5 mm2 Uniaxial Plain Annealed Copper, 450/750 V PVC (V-90) Insulated (0.7 mm min av wall), plus 2.5 mm2 Uniaxial Plain Annealed Copper Earth wire, PVC (V-90) Insulated (0.7 mm min av wall), Laid up, (5V-90) Sheathed (1.3 mm min av wall) to AS 5000 Pt.2

Product Code : **GNHP07AA004** Ident No. : 7742,002925,05,0001

Colour Code:

Insulation : Red, White, Blue, Black, Green/Yellow
Sheath : Orange/metre marked or as ordered

Physical Properties:

Overall cable diameter: 12.1 mm nom +/- 1.2 mm
Diameter over laying-up : 9.1 mm
Main Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Earth Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Maximum Recommended Safe Pulling Tension : 0.84 kN
Minimum Bending Radius :
Pulling in : 72 mm
Set in Position : 48 mm

Electrical Properties:

Maximum conductor DC resistance = 7.41 ohm/km @ 20°C
Maximum earth DC resistance = 7.41 ohm/km @ 20°C
Minimum insulation resistance = 12 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Rebated Flange drum
Internal drum size 700 mm x 400 mm B x 350 mm
Overall drum size 750 mm x 420 mm
Net mass of cable: 255 kg/km
Gross mass per drum = 144 kg

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www.olex.com.au

Customer : **NILSEN** 22 May 13
Reference:

DESCRIPTION: One Core 2.5 mm2 Uniaxial Plain Annealed Copper, 0.6/1 kV PVC Insulated (0.8 mm min av wall), to AS 5000.1

Product Code : **BAAP07A5001** Ident No. : 1002,002925,01,0000

Colour Code:

Insulation : Black

Physical Properties:

Overall cable diameter: 3.6 mm nom +/- 0.4 mm
Main Core Dimensions - Conductor : 2.0 mm Insulation : 3.6 mm
Maximum Recommended Safe Pulling Tension : 0.17 kN
Minimum Bending Radius :
Pulling in : 16 mm
Set in Position : 11 mm

Electrical Properties:

Maximum conductor DC resistance = 7.41 ohm/km @ 20°C
Minimum insulation resistance = 10 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Plastic spool
Internal drum size 285 mm x 106 mm B x 171 mm
Overall drum size 285 mm x 171 mm
Net mass of cable: 32 kg/km
Gross mass per drum = 16 kg

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*61 03 8739 3309
www.olex.com.au

Customer : **NILSEN** 22 May 13
Reference:

DESCRIPTION: Two Cores 2.5 mm2 Uniaxial Plain Annealed Copper, 450/750 V PVC (V-90) Insulated (0.7 mm min av wall), plus 2.5 mm2 Uniaxial Plain Annealed Copper Earth wire, PVC (V-90) Insulated (0.7 mm min av wall), (3V-90) Flat Sheathed (1 mm min av wall) to AS 5000 Pt.2

Product Code : **CNCP07A5002** Ident No. : 7722,002925,03,0001

Colour Code:
Insulation : Red, Black, Green/Yellow
Sheath : White/metre marked or as ordered

Physical Properties:
Cable dimensions: 12.4 x 5.5 mm nom +/- 0.5 mm
Main Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Earth Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Maximum Recommended Safe Pulling Tension : 0.50 kN
Minimum Bending Radius :
Pulling in : 25 mm
Set in Position : 16 mm

Electrical Properties:
Maximum conductor DC resistance = 7.41 ohm/km @ 20°C
Maximum earth DC resistance = 7.41 ohm/km @ 20°C
Minimum insulation resistance = 12 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Plastic drum
Internal drum size 500 mm x 250 mm B x 300 mm
Overall drum size 500 mm x 300 mm
Net mass of cable: 146 kg/km
Gross mass per drum = 78 kg

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www.olex.com.au

Customer : **NILSEN** 22 May 13
Reference:

DESCRIPTION: Two Cores 2.5 mm2 Uniaxial Plain Annealed Copper, 450/750 V PVC (V-90) Insulated (0.7 mm min av wall), (3V-90) Flat Sheathed (1 mm min av wall) to AS 5000 Pt.2

Product Code : **CACP07A5002** Ident No. : 7712,002925,02,0001

Colour Code:
Insulation : Red, White
Sheath : White/metre marked or as ordered

Physical Properties:
Cable dimensions: 8.9 x 5.5 mm nom +/- 0.5 mm
Main Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Maximum Recommended Safe Pulling Tension : 0.33 kN
Minimum Bending Radius :
Pulling in : 25 mm
Set in Position : 16 mm

Electrical Properties:
Maximum conductor DC resistance = 7.41 ohm/km @ 20°C
Minimum insulation resistance = 12 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Plastic drum
Internal drum size 450 mm x 250 mm B x 300 mm
Overall drum size 450 mm x 300 mm
Net mass of cable: 94 kg/km
Gross mass per drum = 51 kg

All Above Information is Subject to Change Without Notice

Nexans Olex

Olex a Nexans company
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55 Main Street, Lilydale
Victoria, 3140, Australia

TELEPHONE *61 03 8739 3333
FACSIMILE *61 03 8739 3339
*61 03 8739 3309
www.olex.com.au

Customer : **NILSEN** 16 May 13
Reference:

DESCRIPTION: Two Cores 2.5 mm2 Uniaxial Plain Annealed Copper, 450/750 V PVC (V-90) Insulated (0.7 mm min av wall), plus 2.5 mm2 Uniaxial Plain Annealed Copper Earth wire, PVC (V-90) Insulated (0.7 mm min av wall), Laid up, (5V-90) Sheathed (1.2 mm min av wall) to AS 5000 Pt.2

Product Code : **CNHP07A5002** Ident No. : 7742,002925,03,0001

Colour Code:

Insulation : Red, Black, Green/Yellow
Sheath : Orange/metre marked or as ordered

Physical Properties:

Overall cable diameter: 10.0 mm nom +/- 1.0 mm
Diameter over laying-up : 7.2 mm
Main Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Earth Core Dimensions - Conductor : 2.0 mm Insulation : 3.4 mm
Maximum Recommended Safe Pulling Tension : 0.51 kN
Minimum Bending Radius :
Pulling in : 60 mm
Set in Position : 40 mm

Electrical Properties:

Maximum conductor DC resistance = 7.41 ohm/km @ 20°C
Maximum earth DC resistance = 7.41 ohm/km @ 20°C
Minimum insulation resistance = 12 megohm.km @ 20°C

Despatch Parameters:

DRUMS QUOTED BELOW ARE TYPICAL ONLY. CUSTOMER REQUIREMENTS WILL TAKE PRECEDENCE.

Lengths: 1 x 500 m

Plastic drum
Internal drum size 580 mm x 250 mm B x 400 mm
Overall drum size 580 mm x 400 mm
Net mass of cable: 173 kg/km
Gross mass per drum = 93 kg

8.6 Light Fittings including Emergency Lights: Pulvin

PROJECT- UTS BROADWAY
TYPE- C/M

Catalogue Number- FBS236-DIF-DB + 3770110
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI

Description- SABRE DIFFUSED BATTEN, 2X36W T8 C/W 1 X DALI BALLAST, 4000K LAMPS & CUSTOM SURFACE MOUNTED ENCLOSURE, PAINTED WHITE WITH 64MM TOP HOLE & 25MM SIDE HOLE TO ALIGN WITH BATTEN AND MOTION SENSOR FITTED. SENSOR SUPPLIED BY OTHERS.

The Sabre Batten Range has been developed for applications such as basement carparks, warehouse, fire stairs, commercial public spaces and industrial sites

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- C

Luminaire Data Sheet

Catalogue Number- FBS236-DIF-DB
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI

Description- SABRE DIFFUSED BATTEN, 2X36W T8 C/W 1 X DALI BALLAST & 4000K LAMPS

The Sabre Batten Range has been developed for applications such as basement carparks, warehouse, fire stairs, commercial public spaces and industrial sites

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PROJECT- UTS BROADWAY
TYPE- CE

Catalogue Number- ZBS236M-DIF-DB-DALI
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI BALLAST & DALI EMERGENCY KIT

Description- SABRE DIFFUSED BATTEN, 2X36W T8 C/W 1 X DALI BALLAST, ZONEWORKS DALI EMERGENCY KIT & 4000K LAMPS

The Sabre Batten Range has been developed for applications such as basement carparks, warehouse, fire stairs, commercial public spaces and industrial sites

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

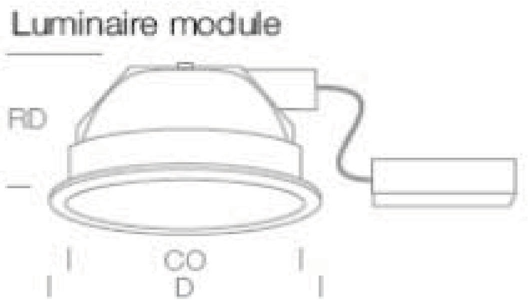
Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PROJECT- UTS BROADWAY
TYPE- D1 A2 BASEMENT

Catalogue Number- T26005-03/DD
Supplier- WILA LIGHTING
Lamp Type - 1X32W 3000K TC-TELI
Control Gear - REMOTE DALI DIMMABLE

Description- 1X32W PLC RECESSED DALI DIMMABLE DOWNLIGHT C/W WHITE TRIM, CONCENTRIC RING LOUVRE & LAMP

CO = 195mm
D = 210mm
RD = 100mm



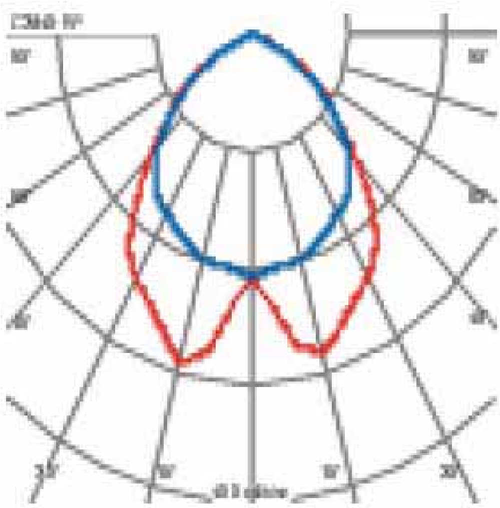
Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- D1C

Catalogue Number- C3840-SP/DALI
Supplier- WILA
Lamp Type - 1X32W TC-TEL 3000K COMPACT FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 1X32W TC-TEL SURFACE MOUNTED DOWNLIGHT C/W CONCENTRIC RING LOUVRE, DALI DIMMABLE BALLAST, 3000K & RAL7030 GREY FINISH
255MM DIAMETER X 140MM HIGH. 1.9KG
TO BE MOUNTED INTO CONCRETE RECESSES.



All Fittings Supplied by Pulvin Composite P/L

Luminaire Data Sheet

Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- EM1

Catalogue Number- ZLIFE-DALI
Supplier- CLEVERTRONICS
Lamp Type - LED
Control Gear - ELECTRONIC

Description- 1x3w LED ROUND, RECESSED EMERGENCY LIGHT, ZONEWORKS DALI C/W F&P.

D32 CLASSIFICATION

NON MAINTAINED

DUAL RATE CHARGE

CEILING CUT OUT DIMENSION: 85MM

CONTROL PACK DIMENSIONS: 232MM X 51MM X 42MM

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

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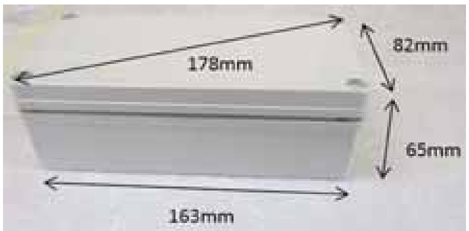
PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- EM2

Catalogue Number- LLIFE-PRO-DALI/SPECIAL
Supplier- CLEVERTRONICS
Lamp Type - LED
Control Gear - ELECTRONIC
Description- 2x3w LED ROUND, RECESSED EMERGENCY LIGHT, ZONEWORKS DALI C/W F&P. PCB HOUSED IN PLASTIC ENCLOSURE. ENCLOSURE TO BE MOUNTED IN CONCRETE RECESS. D50 CLASSIFICATION



Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

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PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- EM3

Catalogue Number- ZLIFE-SMS-DALI
Supplier- CLEVERTRONICS
Lamp Type - LED
Control Gear - ELECTRONIC

Description- 1X3W LED SQUARE SURFACE MOUNTED EMERGENCY LIGHT, ZONEWORKS DALI C/W WHITE FINISH

D32 CLASSIFICATION

NON MAINTAINED

DUAL RATE CHARGE

DIMENSIONS: 232MM X 51MM X 42MM

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- EM4

Luminaire Data Sheet

Catalogue Number- ZLIFE-PRO-DALI
Supplier- CLEVERTRONICS
Lamp Type - LED
Control Gear - ELECTRONIC

Description- 2x3w LED ROUND, RECESSED EMERGENCY LIGHT, ZONEWORKS DALI C/W F&P.

D50 CLASSIFICATION
NON MAINTAINED
DUAL RATE CHARGE
CEILING CUT OUT DIMENSION: 50MM
CONTROL PACK DIMENSIONS: 232MM X 51MM X 42MM

All Fittings Supplied by Pulvin Composite P/L

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PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- EX2

Catalogue Number- LCFPRO-DALI
Supplier- CLEVERTRONICS
Lamp Type - LED
Control Gear - ELECTRONIC, ZONEWORKS DALI

Description- 2 X LED SURFACE MOUNT MAINTAINED CLEVERFIT PRO EXIT SIGN, ZONEWORKS DALI, C/W LITHIUM BATTERIES AND RUNNING MAN DIFFUSERS

24M VIEWING DISTANCE
DIMENSIONS: 367MM X 72MM X 214MM
IP20 RATED

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- F1E/M

Catalogue Number- ZBS236M-DIF-DB-DALI + 3770110
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI BALLAST & ZONEWORKS DALI EMERGENCY PACK

Description- SABRE DIFFUSED EMRGENCY BATTEN, 2X36W T8 C/W 1 X DALI BALLAST, ZONEWORKS DALI EMERGENCY PACK, 4000K LAMPS AND CUSTOM SURFACE MOUNTED ENCLOSURE, PAINTED WHITE WITH 64MM TOP HOLE AND 25MM SIDE HOLE TO ALIGN WITH BATTEN AND MOTION SENSOR FITTED. SENSOR SUPPLIED BY OTHERS.

The Sabre Batten Range has been developed for applications such as basement carparks, warehouse, fire stairs, commercial public spaces and industrial sites

Luminaire Data Sheet

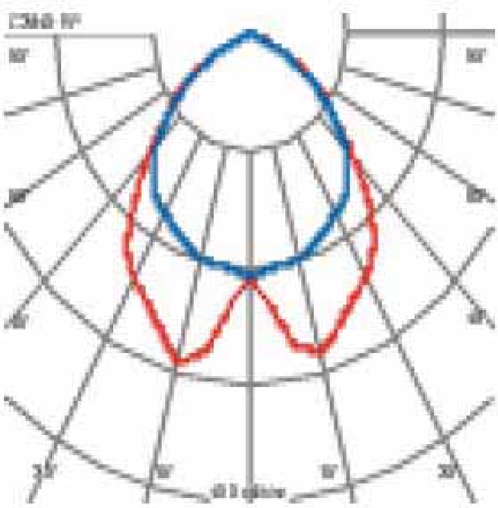
All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- L1.1 - RECESSED

Luminaire Data Sheet

Catalogue Number- C3840-SP/DALI
Supplier- WILA
Lamp Type - 1X32W TC-TEL 3000K COMPACT FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 1X32W TC-TEL SURFACE MOUNTED DOWNLIGHT C/W **CUSTOM PLASTER TRIM ADDER**, CONCENTRIC RING LOUVRE, DALI DIMMABLE BALLAST,
3000K LAMPS & RAL7030 GREY FINISH
255MM DIAMETER X 140MM HIGH. 1.9KG
TO BE MOUNTED INTO CONCRETE RECESSES.

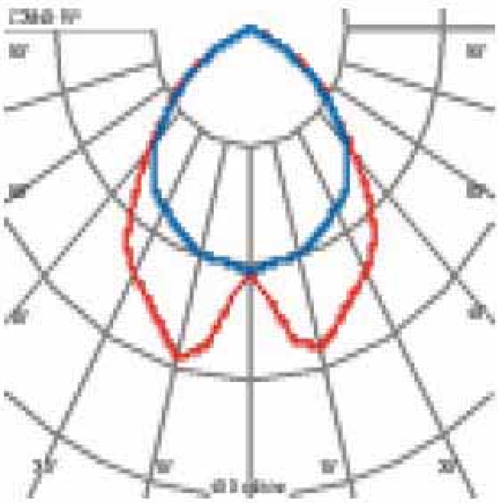


All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- L1.1 - SURFACE MOUNT

Catalogue Number- C3840-SP/DALI
Supplier- WILA
Lamp Type - 1X32W TC-TEL 3000K COMPACT FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 1X32W TC-TEL SURFACE MOUNTED DOWNLIGHT C/W CONCENTRIC RING LOUVRE, DALI DIMMABLE BALLAST, 3000K LAMP & RAL7030 GREY FINISH
255MM DIAMETER X 140MM HIGH. 1.9KG
TO BE MOUNTED INTO CONCRETE RECESSES.



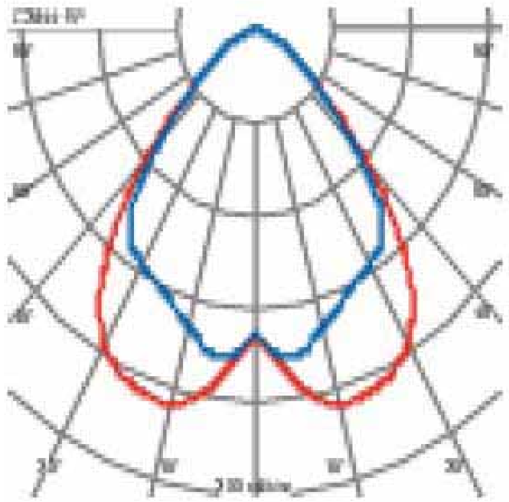
Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- L1.2 - RECESSED

Catalogue Number- C3844-SP/DALI
Supplier- WILA
Lamp Type - 2X32W TC-TEL 3000K COMPACT FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 2X32W TC-TEL SURFACE MOUNTED DOWNLIGHT C/W **CUSTOM PLASTER TRIM ADDER**, CONCENTRIC RING LOUVRE, DALI DIMMABLE BALLAST,
3000K LAMPS & RAL7030 GREY FINISH
255MM DIAMETER X 140MM HIGH. 2.0KG
TO BE MOUNTED INTO CONCRETE RECESSES.



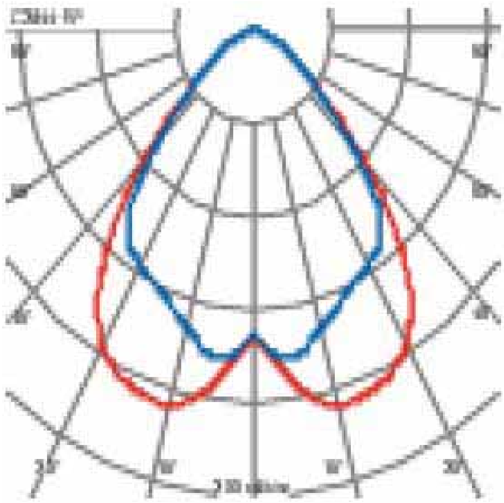
All Fittings Supplied by Pulvin Composite P/L

Luminaire Data Sheet

PROJECT- UTS BROADWAY
TYPE- L1.2 - SURFACE MOUNT

Catalogue Number- C3844-SP/DALI
Supplier- WILA
Lamp Type - 2X32W TC-TEL 3000K COMPACT FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 2X32W TC-TEL SURFACE MOUNTED DOWNLIGHT C/W CONCENTRIC RING LOUVRE, DALI DIMMABLE BALLAST, 3000K LAMP & RAL7030 GREY FINISH
255MM DIAMETER X 140MM HIGH. 2.0KG
TO BE MOUNTED INTO CONCRETE RECESSES.



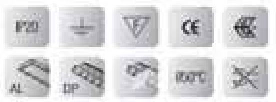
All Fittings Supplied by Pulvin Composite P/L

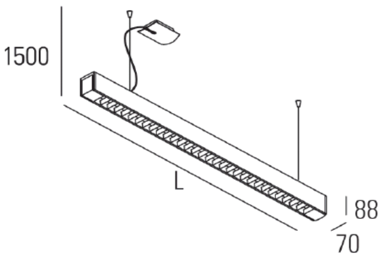
Luminaire Data Sheet

PROJECT- UTS BROADWAY
TYPE- L4.1

Catalogue Number- GYON LINE S
Supplier- TARGETTI
Lamp Type - 28W T5 3000k & LED 3000K
Control Gear - ELECTRONIC DALI DIMMABLE

Description- CONTINUOUS SUSPENDED 28W T5 LIGHTING SYSTEM C/W DALI DIMMABLE BALLAST, UPWARD LED & SATIN LOUVRE. 3000K. ALUMINIUM FINISH





Complete with adjustable suspension kit 1500 mm

Complete with PC ceiling cup and transparent power cable

Luminaire Data Sheet

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PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L7

Catalogue Number- LEDPOD50/MK1
Supplier- KLIK SYSTEMS
Lamp Type - 3000K LED
Control Gear - DALI DIMMABLE LED DRIVER

Description- ASYMMETRIC THROW HANDRAIL LIGHT C/W LED DRIVERS & TRANSFORMERS

features

- Ledpod illuminates in an asymmetric distribution without the need to tilt the handrail, thus eliminating unwanted and disturbing glare.
- Optically designed glass lens.
- Large heat sink with excellent mass and surface areas for efficient heat dissipation.
- The heat sink does not contact the glass lens, thus reducing the temperature at the point of human contact.
- 50,000 hours plus expected from the Cree LED.
- Integrated 500ma driver for each LED. Failure is limited to a single LED in each instance.
- Ease of maintenance with plug and socket and simple but secure snap fix installation.
- IP66.
- No threading of hole required.

Luminaire Data Sheet

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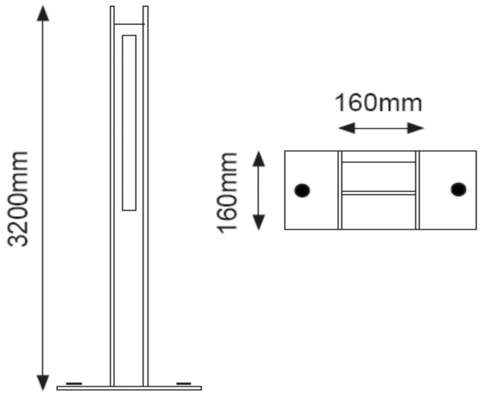
PULVIN COMPOSITE

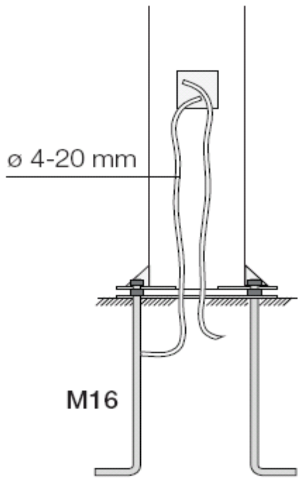
PROJECT- UTS BROADWAY
TYPE- TYPE L8

Catalogue Number- LP-TOTEM
Supplier- LIGHT PROJECT
Lamp Type - 28W T5 3000K G5 LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- CUSTOM MADE 3.2M IP65 XLUX CORTEN TOTEM BOLLARD C/W CORTEN FINISH, OPAL DIFFUSER, 3000K 28W T5 LAMP, DALI DIMMABLE BALLAST DALI DIMMABLE BALLST & RAG BOLT ASSEMBLY

DIMENSIONS 160mm (W) x 160mm (D) x 3200mm (H)





Luminaire Data Sheet

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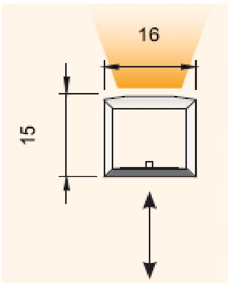
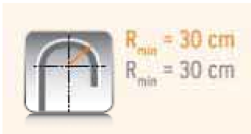
PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L9

Catalogue Number- HBLL-12WR3SXXXXGR
Supplier- HOT BEAM
Lamp Type - 7.7 WATTS PER METRE, IP67 VENUS GREEN LED
Control Gear - ELECTRONIC

Description- 293.225M AQUARIBBON VENUS 3 SIDED GREEN DOT-FREE IP67 LED STRIP C/W DRIVERS, CONNECTING LEADS & MOUNTING CLIPS



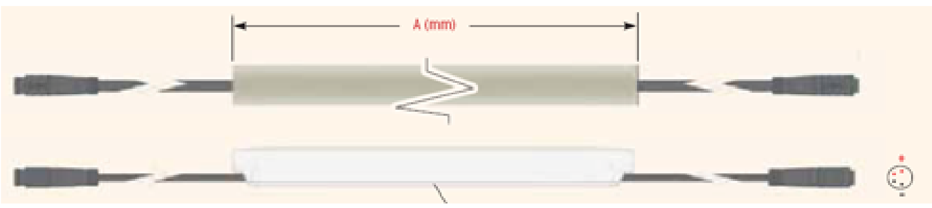


Note: 3 Sided Version Supplied

Biegerichtung Bend direction

Toleranz +/- 5 mm Tolerance +/- 5 mm

VarioLED™ Flex VENUS Color TV IP67	lumen/meter (lm/m)	Color (λ_d)
Green (G)	218	525



Tc-Punkt: Rückseite des Moduls Tc-point: Rear side of module

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- L10

Catalogue Number- 42911696
Supplier- ZUMTOBEL
Lamp Type - 4 X 14W T5 3000K LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 4X14W T5 IP54 SURFACE MOUNTED PERLUCE O WALL LIGHT,
620MM X 620MM X 90MM C/W 3000K LAMPS & DALI DIMMABLE BALLASTS
WHITE FINISH

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

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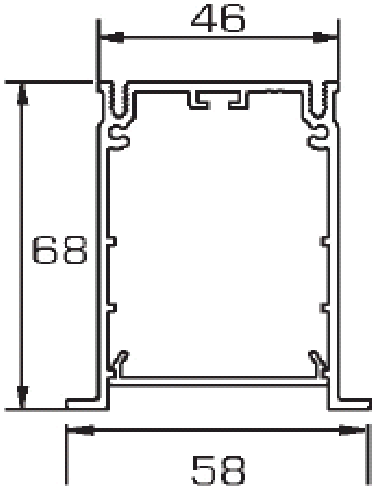
PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L13

Luminaire Data Sheet

Catalogue Number- UTAH.LED / XXXXMM
Supplier- LIGHT PROJECT / PROLICHT
Lamp Type - 3000K 43W/M LED
Control Gear - DALI DIMMABLE LED POWER SUPPLY

Description- PROLICHT UTAH LED RECESSED DALI DIMMABLE LED SYSTEM, 43W/M C/W OPAL DIFFUSER. IP20



All Fittings Supplied by Pulvin Composite P/L

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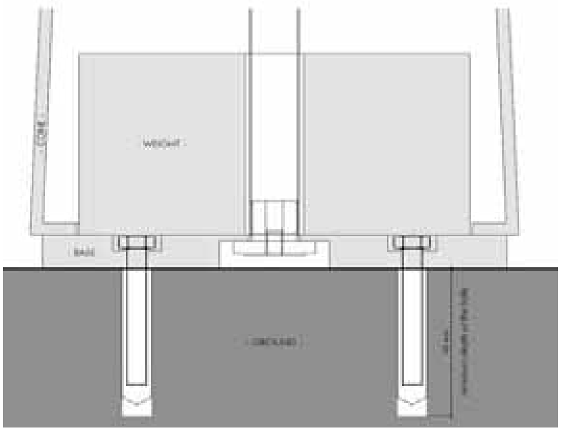
PULVIN
COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L14

Catalogue Number- P1513001013001
Supplier- INLITE
Lamp Type - 1X22W + 1X40W T5 CIRCULAR FLUORESCENT
Control Gear - ELECTRONIC NON-DIIMMABLE

Description- EQUILIBRE OUTDOOR FLOOR LIGHT C/W WHITE FINISH, WEIGHTED BASE, 1X22W + 1X40W T5 3000K CIRCULAR FLUORESCENT LAMPS AND ELECTRONIC NON-DIMMABLE BALLASTS



Luminaire Data Sheet

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PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L18

Catalogue Number- A004850 + A004030
Supplier- ARTEMIDE
Lamp Type - 10W LED 3000K
Control Gear - ELECTRONIC NON-DIMMABLE

Description- 10W 3000K LED TOLOMEO TABLE LAMP C/W ALUMINIUM FINISH AND 230MM ALUMINIUM TABLE BASE

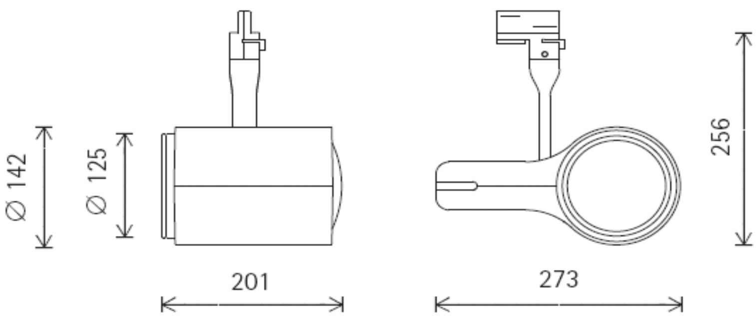
Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- L19

Catalogue Number- 76620
Supplier- ERCO
Lamp Type - 13W LED 3000K
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 13W 3000K LED TRACK MOUNTED EMANON PROJECTOR LIGHT
C/W SPHEROLIT SPOT LENS, POTENTIOMETER & 3 CIRCUIT TRACK ADAPTOR.
WHITE COLOUR



Luminaire Data Sheet

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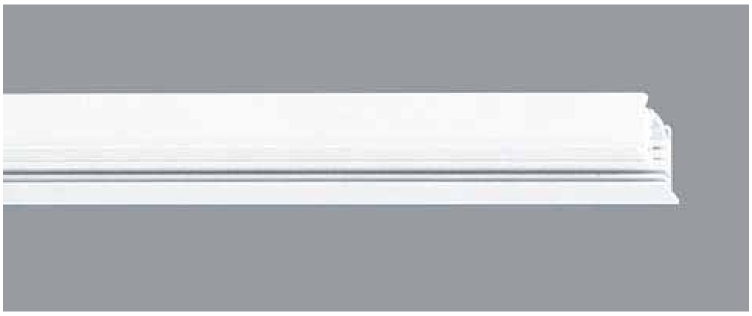
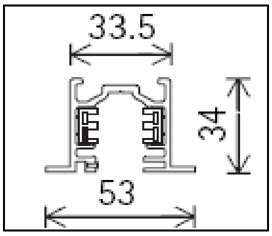
PULVIN
COMPOSITE

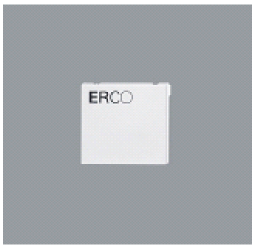
PROJECT- UTS BROADWAY
TYPE- L20

Catalogue Number- 78353 + 79340 + 79315 + 79302
Supplier- ERCO
Lamp Type - N/A
Control Gear - N/A

Description- 3M LENGTH OF 3 CIRCUIT WHITE RECESSED FLANGED LIGHTING TRACK C/W LIVE END, END PLATE & COUPLER







Luminaire Data Sheet

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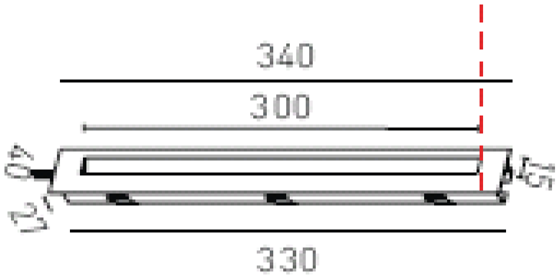
PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L21

Catalogue Number- 22015-03 + LEDPS-25
Supplier- LIGHT PROJECT
Lamp Type - 1X4W LED 3000K
Control Gear - LEDPS-25 ELECTRONIC DALI DIMMABLE

Description- 4W 3000K LED RECESSED STRING ASYMMETRIC 15 STEP LIGHT, WHITE 340MM X 40MM C/W OT DALI 75/220-240/24 LED POWER SUPPLY WITH INTERGRATED DALI DIMMING CONTROL



Luminaire Data Sheet

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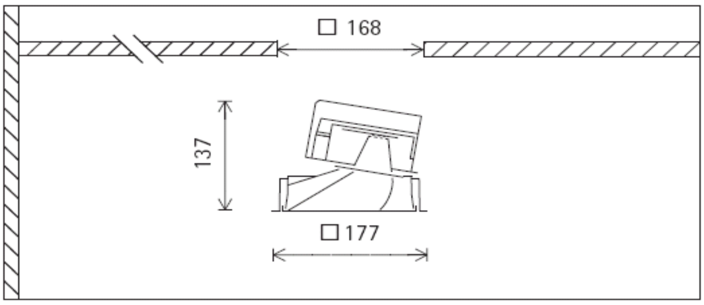
PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L26

Catalogue Number- 36722
Supplier- ERCO
Lamp Type - 27W LED 3000K
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 27W 3000K LED RECESSED WALL WASH DOWNLIGHT C/W WHITE TRIM, AND REMOTE DALI DIMMABLE DRIVER WITH F&P



Luminaire Data Sheet

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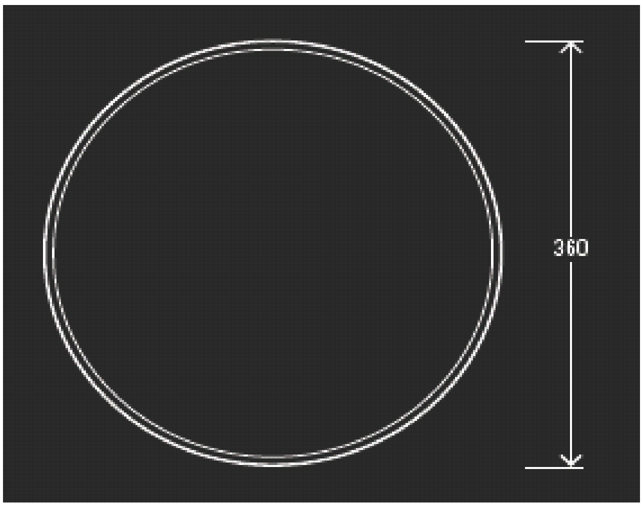
PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- L27

Catalogue Number- WWL-PORT C
Supplier- WORK WITH LIGHT
Lamp Type - 40W T5 CIRCULAR FLUORESCDENT 3000K
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 4-W T5 CIRCULAR SURFACE MOUNT LIGHT C/W SATIN NICKEL FINISH, DALI DIMMABLE BALLAST & 3000K LAMP



All Fittings Supplied by Pulvin Composite P/L

Luminaire Data Sheet

PROJECT- UTS BROADWAY
TYPE- P1

Catalogue Number- FBS236-DIF
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC NON DIMMABLE BALLAST

Description- SABRE DIFFUSED BATTEN, 2X36W T8 C/W 1 X NON-DIIMABLE BALLAST & 4000K LAMPS

The Sabre Batten Range has been developed for applications such as basement carparks, warehouse, fire stairs, commercial public spaces and industrial sites

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- P1E

Catalogue Number- ZBS236M-DIF-A2-DALI
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC NON DIMMABLE BALLAST AND ZONEWORKS DALI EMERGENCY PACK

Description- SABRE DIFFUSED EMERGENCY BATTEN, 2X36W T8 C/W 1 X NON-DIIMABLE BALLAST, ZONEWORKS DALI EMERGENCY PACK & 4000K LAMPS

The Sabre Batten Range has been developed for applications such as basement carparks, warehouse, fire stairs, commercial public spaces and industrial sites

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

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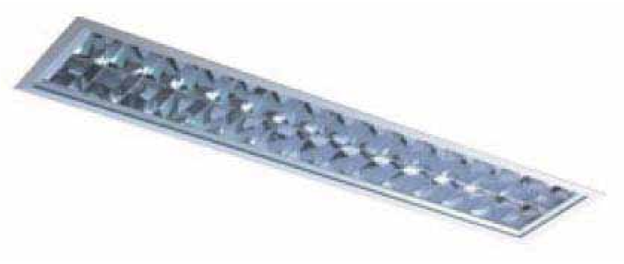
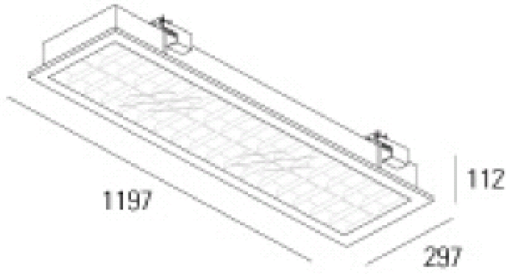
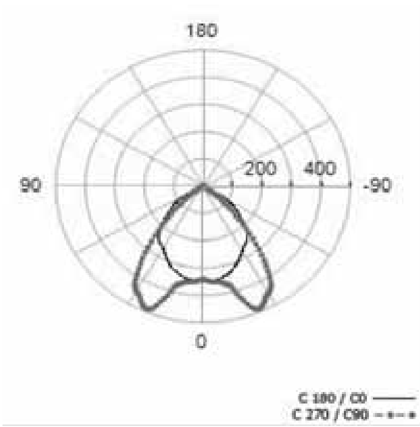
PROJECT- UTS BROADWAY
TYPE- PC

Catalogue Number- 1291121011
Supplier- TARGETTI
Lamp Type - 2X28W T5 4000K LINEAR FLUORESCENT
Control Gear - ELECTRONIC DALI DIMMABLE

Description- 2X28W T5 RECESSED CLEANROOM LIGHT C/W LOUVRE, GLASS IN ALUMINIUM FRAME, ELECTRONIC DALI DIMMABLE BALLAST & 4000K LAMPS







Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY
TYPE- RIU - "ROOM IN USE"

Luminaire Data Sheet

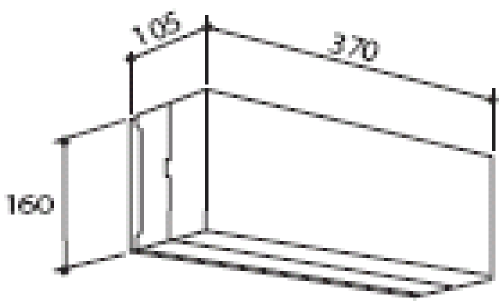
Catalogue Number- EBL10M-WM-SP
Supplier- CLEVERTRONICS
Lamp Type - 10W LINEAR FLUORESCENT
Control Gear - ELECTRONIC

Description- WALL MOUNTED 10W FLUORESCENT BOX LITE C/W WHITE DIFFUSER WITH RED "ROOM IN USE" TEXT AND 4000K LAMP.

NOTE: EXACT TEXT REQUIREMENT TO BE CONFIRMED PRIOR TO ORDERING.

RUNNING MAN DIFFUSER SHOWN FOR EFFECT ONLY.
BOK LIGHT WILL COME WITH ROOM IN USE DIFFER AS PER THE EXAMPLE BELOW.

ROOM IN USE DECAL - RED ON WHITE
IMAGE ABOVE IS FOR ILLUSTRATION PURPOSES ONLY



All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- SAFE LIGHT

Catalogue Number- PTP760
Supplier- PATERSON
Description- GENERAL PURPOSE DARKROOM SAFE LIGHT C/W RED DOME & LAMP

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

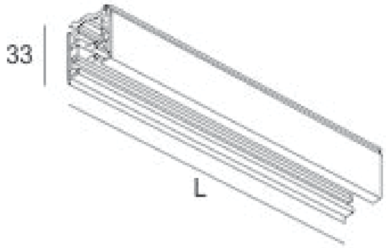
Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PULVIN COMPOSITE

PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- T.11

Catalogue Number- TRACK LIGHTING SYSTEM
Supplier- SPACE LIGHTING
Lamp Type - N/A
Control Gear - N/A

Description- XAL SURFACE MOUNTED 3 CIRCUIT TRACK, 4 X 2000MM LENGTHS, ANODISED ALUMINIUM FINISH C/W MIDDLE POWER FEED, CONNECTORS, END CAPS AND X-CONNECTOR



Luminaire Data Sheet

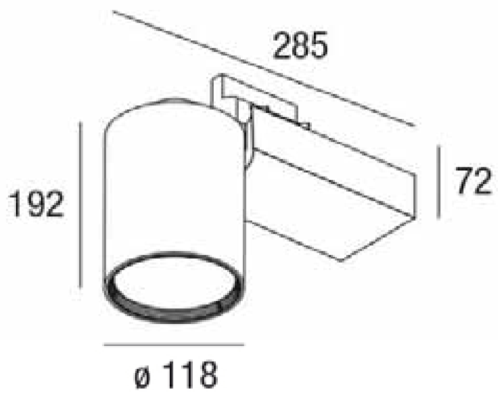
All Fittings Supplied by Pulvin Composite P/L

Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- T.12 / 50W MH

Catalogue Number- 053-1828416W
Supplier- SPACE LIGHTING
Lamp Type - 50W HIT-CE MH 3000K
Control Gear - ELECTRONIC

Description- XAL TIMO FREE 110 WIDE FLOOD 57 DEGREE TRACK MOUNT LIGHT C/W GREY FINISH, 1 X 100W HIT-CE 3000K LAMP



Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

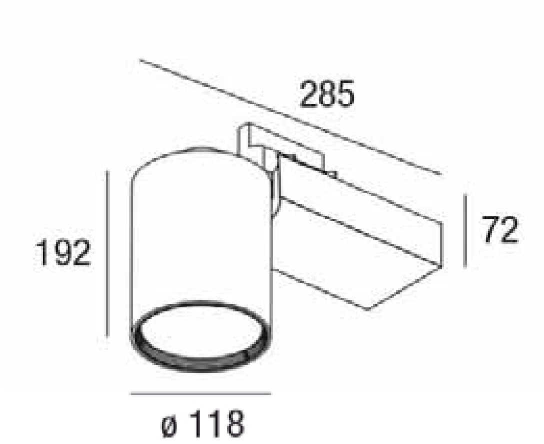
Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PULVIN COMPOSITE

PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- T.12 / 70W MH

Catalogue Number- 053-1828016F
Supplier- SPACE LIGHTING
Lamp Type - 70W HIT-CE MH 3000K
Control Gear - ELECTRONIC

Description- XAL TIMO FREE 110 FLOOD 36 DEGREE TRACK MOUNT LIGHT C/W GREY FINISH,
1 X 100W HIT-CE 3000K LAMP



Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

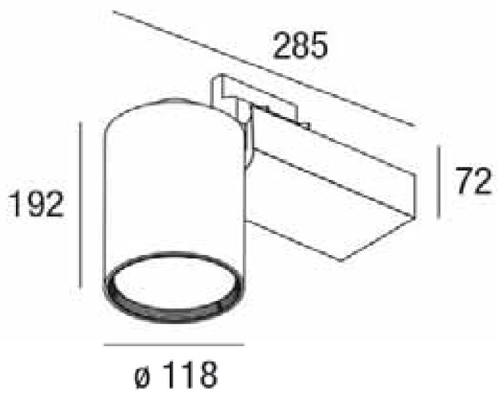
Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PULVIN COMPOSITE

PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- T.12 / 100W MH

Catalogue Number- 053-1828516M
Supplier- SPACE LIGHTING
Lamp Type - 100W HIT-CE MH 3000K
Control Gear - ELECTRONIC

Description- XAL TIMO FREE 110 MEDIUM 25 DEGREE TRACK MOUNT LIGHT C/W GREY FINISH, 1 X 100W HIT-CE 3000K LAMP



Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

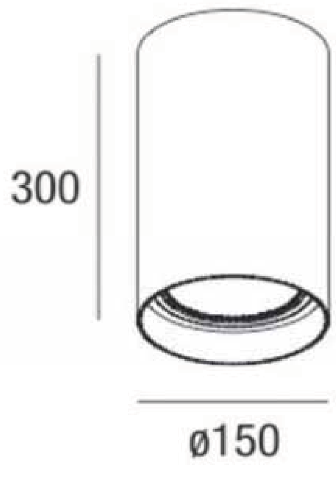
Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PULVIN COMPOSITE

PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- WG.1

Catalogue Number- 058-81305367M
Supplier- SPACE LIGHTING
Lamp Type - 16W 3000K 24 DEGREE LED
Control Gear - DALI DIMMABLE

Description- XAL SASSO UP 150, 16W 24 DEGREE LED SURFACE MOUNTED DOWNLIGHT C/W INTEGRAL DALI DIMMABLE GEAR & GREY POWDERCOAT FINISH

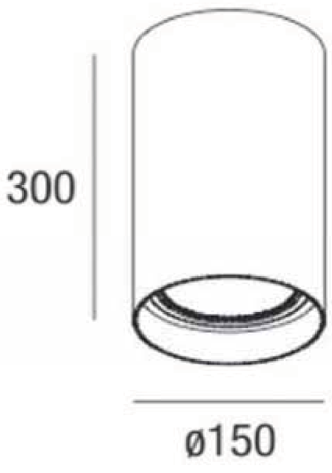


All Fittings Supplied by Pulvin Composite P/L

PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- WG.2

Catalogue Number- 058-8131537F
Supplier- SPACE LIGHTING
Lamp Type - 16W 3000K 40 DEGREE LED
Control Gear - DALI DIMMABLE

Description- XAL SASSO UP 150, 16W 40 DEGREE LED SURFACE MOUNTED DOWNLIGHT C/W INTEGRAL DALI DIMMABLE GEAR & WHITE POWDERCOAT FINISH



Luminaire Data Sheet

Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

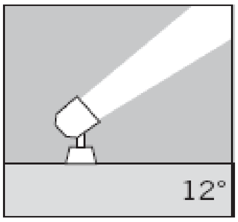
PULVIN COMPOSITE

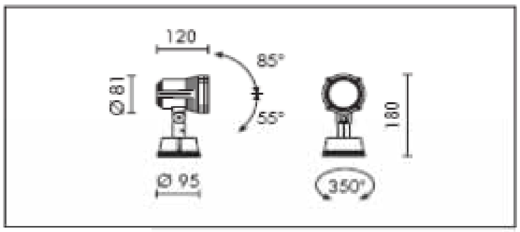
PROJECT- UTS BROADWAY - WINTERGARDEN
TYPE- WG.3

Catalogue Number- S.3595W.14+S.3524.09
Supplier- EAGLE LIGHTING
Lamp Type - 3W 3000K LED
Control Gear - TRIDONIC TALEX CONVERTER 0025 K210 24V ONE4ALL

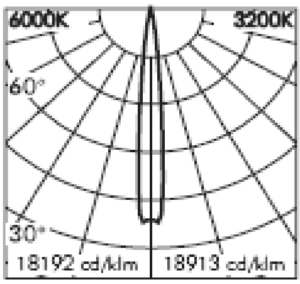
Description- MICROTECHNO, 3W 3000K LED STAKE MOUNTED INGROUND UPLIGHT C/W GREY FINISH, REMOTE 24V DALI DIMMABLE LED DRIVER HOUSED IN IP24 ENCLOSURE (180MM X 120MM X 95MM). ONE DRIVER TO RUN 8 FITTINGS.

Luminaire Data Sheet





S.3595W
With 3 accent leds in warm white 3200K
3W 240V 300lm



h(m)	12° Ø(m)	3200K E(lx)
1	0.21	3991
2	0.41	998
3	0.62	443
4	0.83	249
5	1.03	160

All Fittings Supplied by Pulvin Composite P/L

PULVIN COMPOSITE

PROJECT- UTS BROADWAY
TYPE- X1

Catalogue Number- FWB236-PA2
Supplier- CLEVERTRONICS
Lamp Type - 36W 4000K T8 LINEAR FLUORESCENT
Control Gear - ELECTRONIC A2 NON-DIMMABLE BALLAST

Description- 2X36W WEATHERPROOF IP65 BATTEN C/W 1 X NON-DIMMABLE BALLAST, STAINLESS STEEL CLIPS & 4000K LAMPS

POLYCARBONATE BODY & DIFFUSER

DIMENSIONS: 1270MM X 180MM X 125MM

Luminaire Data Sheet

All Fittings Supplied by Pulvin Composite P/L

Pulvin Composite P/L - Ph 02 9879 3699 Fax 02 9879 3688 Email - sales@pcls.com.au

PULVIN COMPOSITE

8.7 GPO's and Accessories: Clipsal

56C310

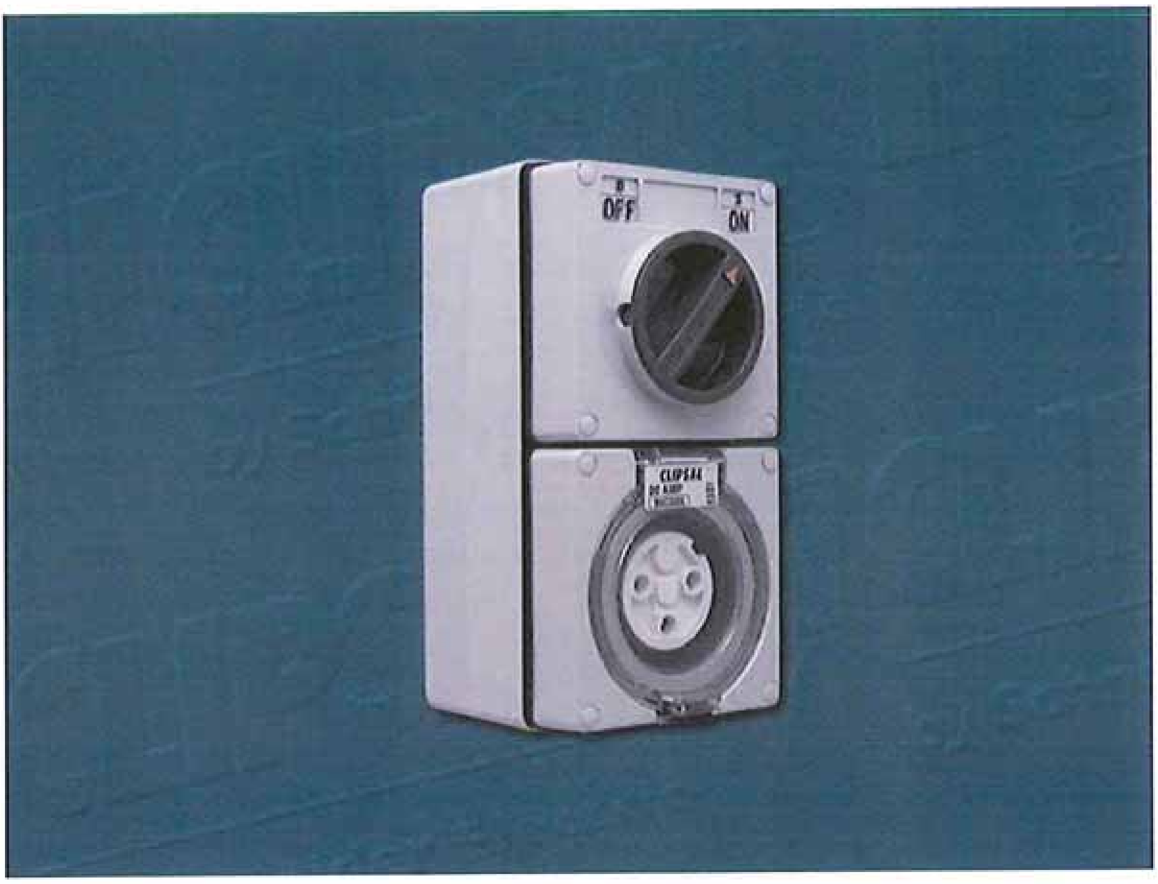
Switched Socket Outlets, Surface Mounting Combinations - IP66, Two Module Models, 250V 10A - 3 Flat pins.

Edition 91 Trade Product Guide Page # 211

56C310RP

Switched Socket Outlets, Surface Mounting Combinations - IP66, Two Module Models, 250V 10A - 3 Round pins.

Edition 91 Trade Product Guide Page # 211



56C320

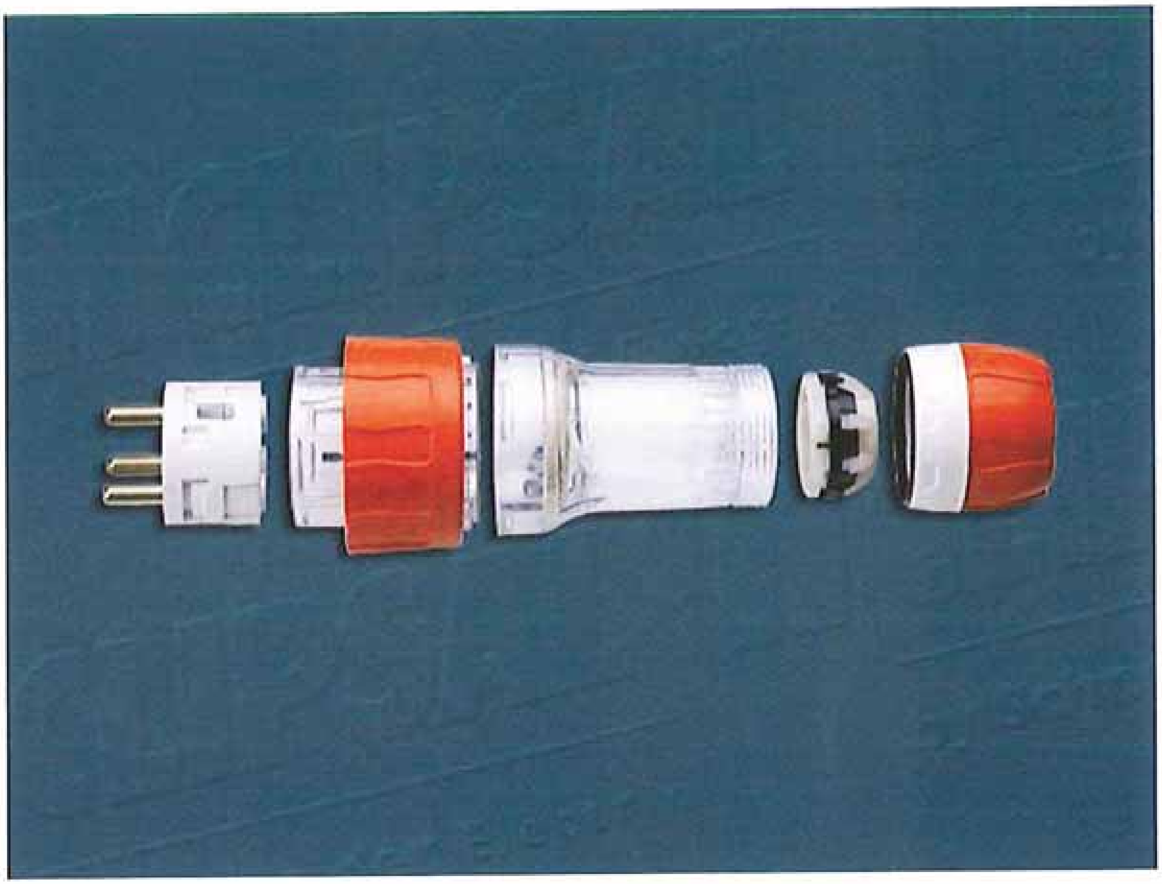
Switched Socket Outlets, Surface Mounting Combinations - IP66, Two Module Models, 250V 20A - 3 Round pins.

Edition 91 Trade Product Guide Page # 211

56C332

Switched Socket Outlets, Surface Mounting Combinations - IP66, Two Module Models, 250V 32A - 3 Round pins.

Edition 91 Trade Product Guide Page # 211

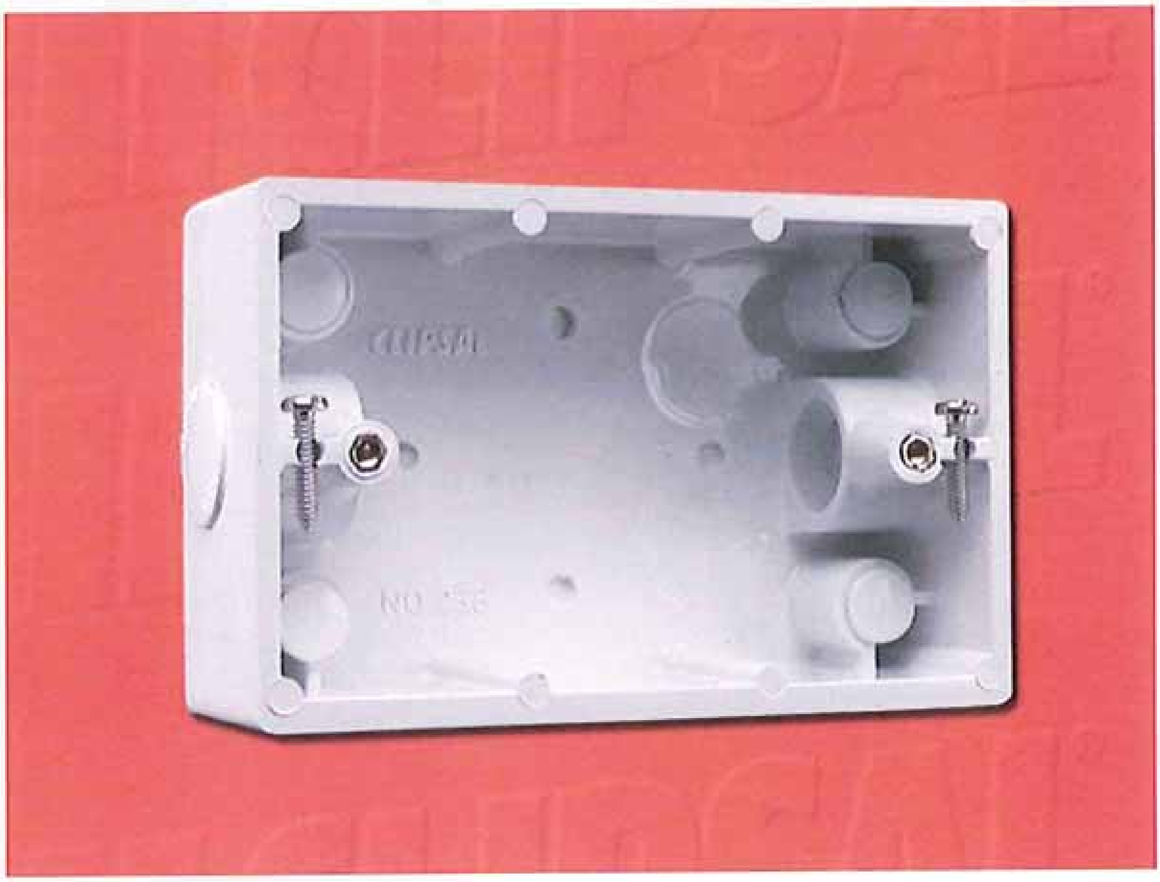


56P332

Plugs and Extension Sockets, Straight Plugs - IP66, 250V 32A - 3 Round pins.

Edition 91 Trade Product Guide Page # 213

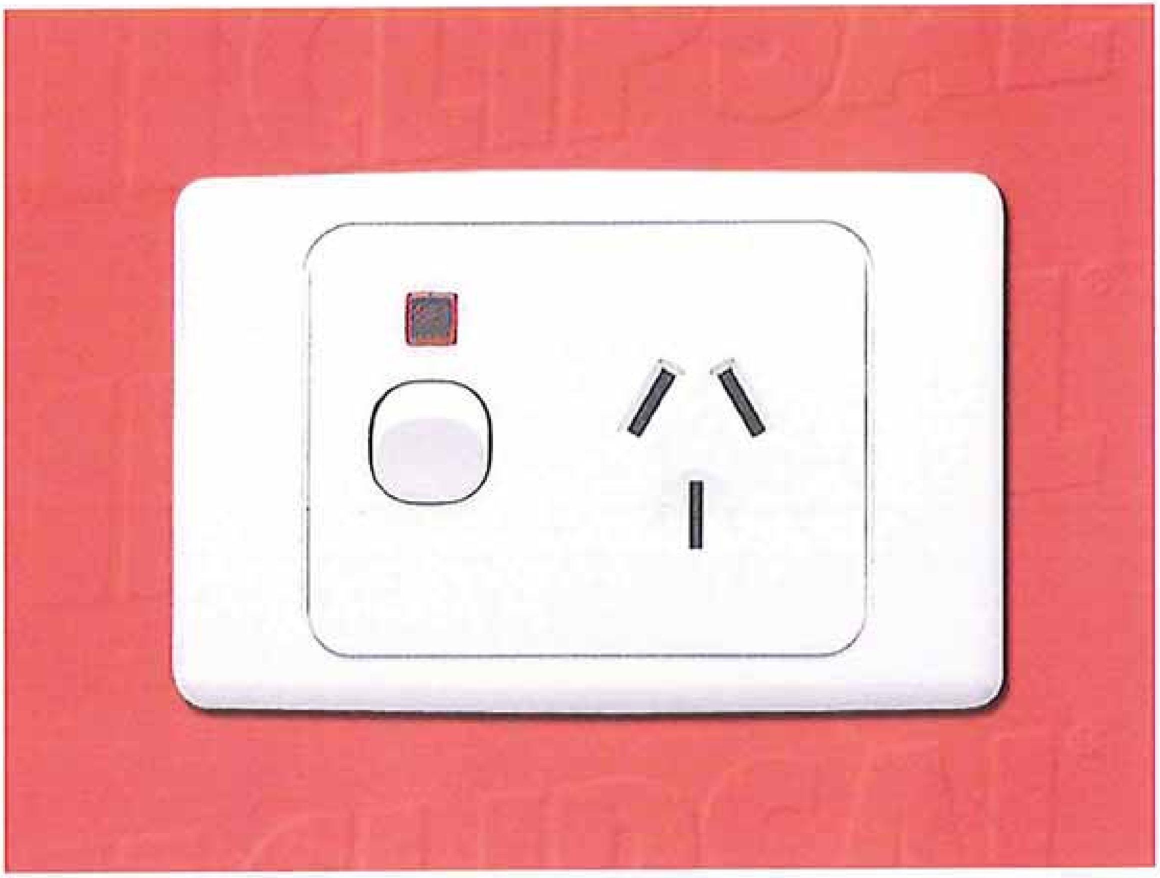
Please refer to the installation instructions for correct assembly and wiring details. Take special note of the alignment markers when inserting the PIN assembly.



238WE

Surface Enclosures, Mounting box with 20 mm end entries.

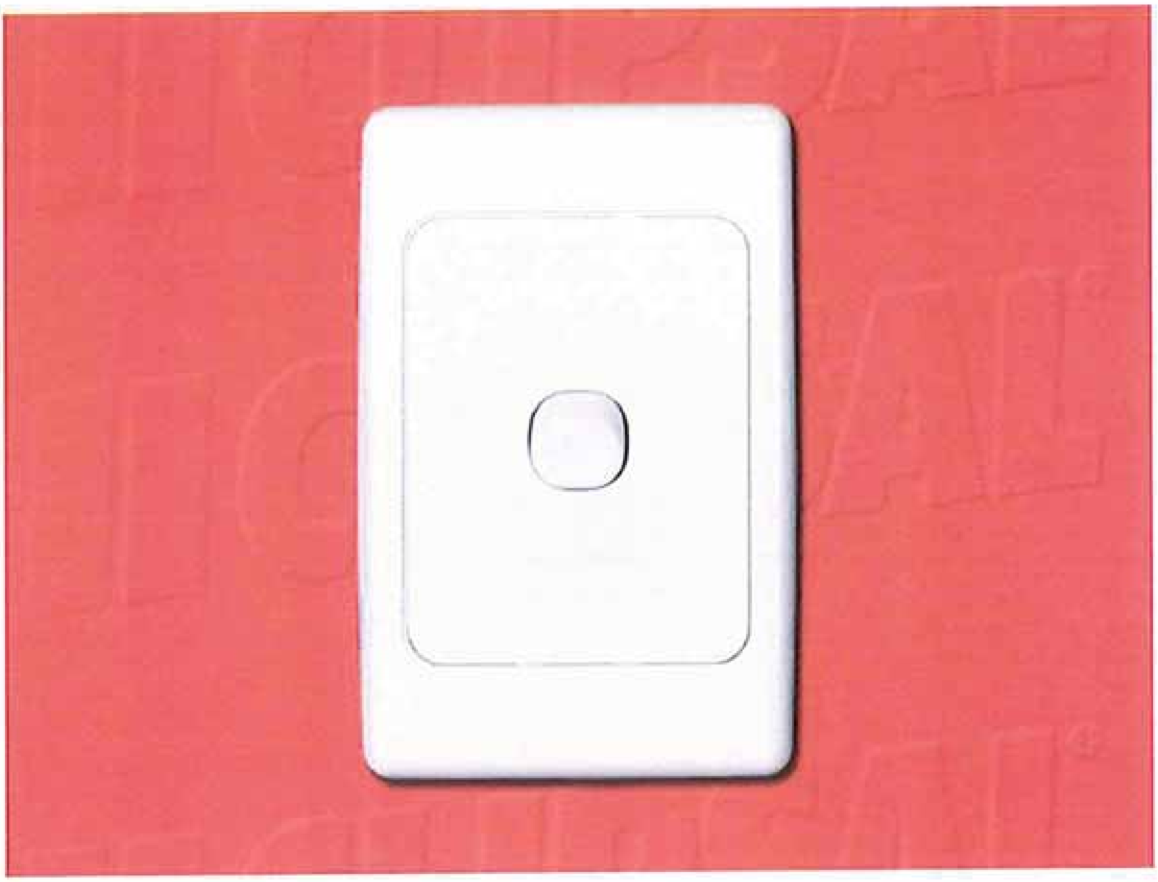
Edition 91 Trade Product Guide Page # 111



2015N20

Socket Outlets, Switched Horizontal 2000 Series, Single - Standard Size - Horizontal Mount, Power Outlet Single 250V 20A - with neon.

Edition 91 Trade Product Guide Page # 67



2031VA-WE

Flush Switches - 2000 Series, Single - Standard Size - Vertical Mount, Switch 1 Gang 250V 10A.

Edition 91 Trade Product Guide Page # 64

30USM-WE

Switch Mechanisms, 30 Series, Universal Switch Mechanism (USM), 250V 20A - 1 way / 2 way, 16AX Rocker.

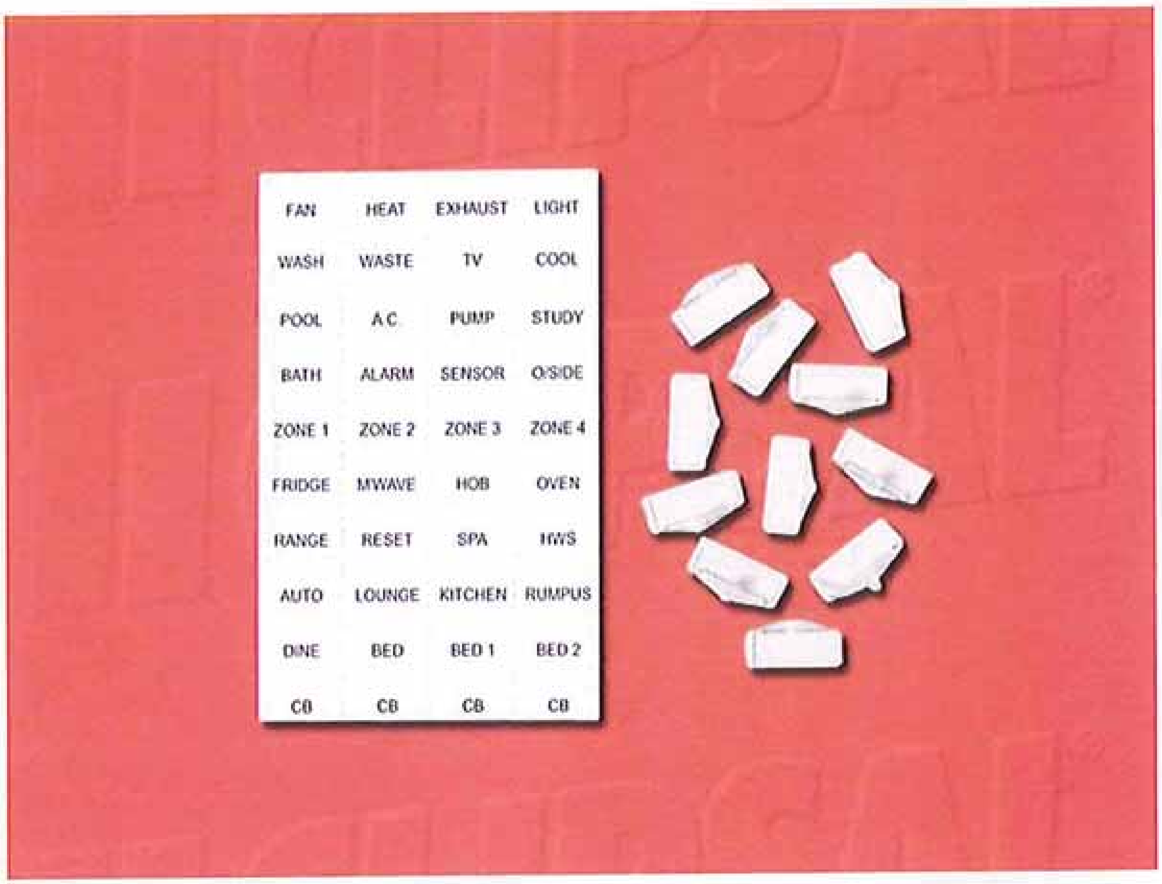
Edition 91 Trade Product Guide Page # 54

30USM,BK replaces 30M16,BK, 30USM-3S replaces 30M20-3S and 30FLM15,3S.

31JSCREW

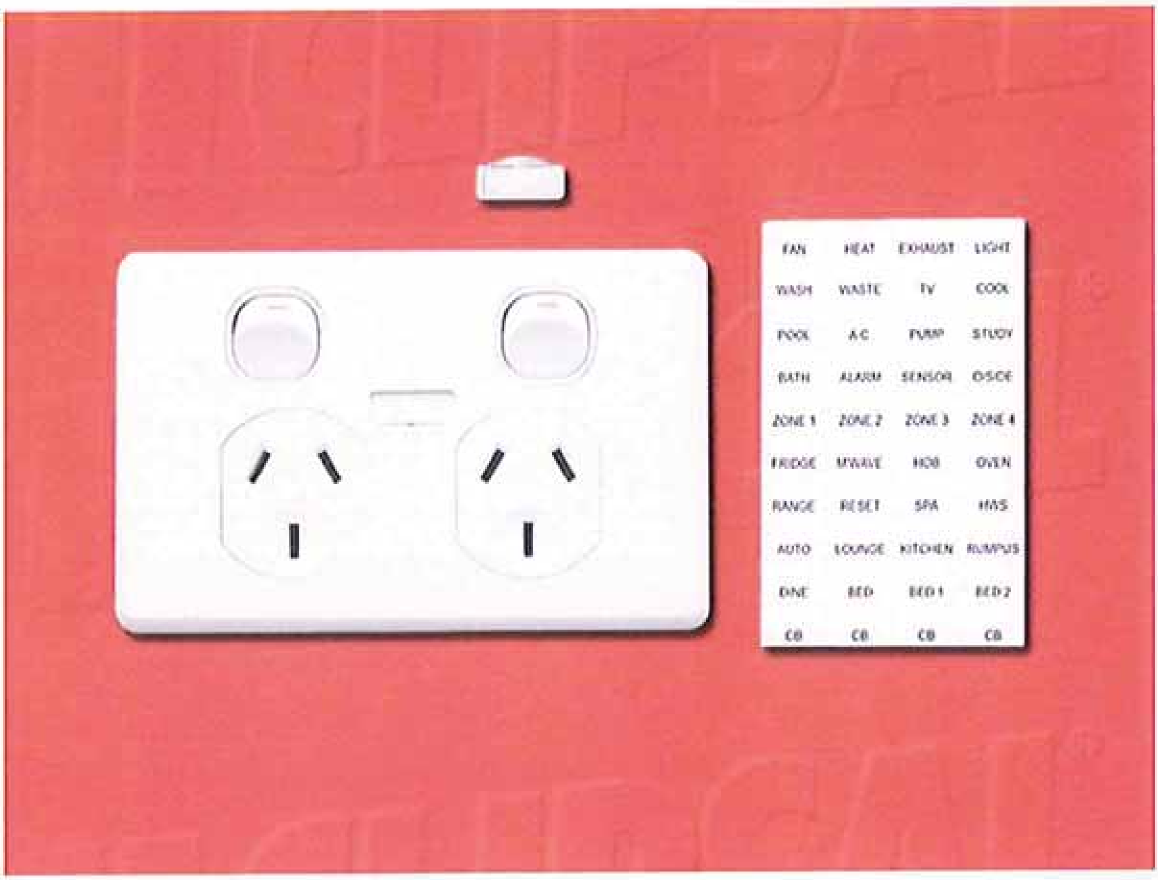
Screws and Nuts, Mechanism holding screw.

Edition 91 Trade Product Guide Page # 120



C2000ID

WINDOW ID SUITS C2000 SERIES



C2025I

Socket Outlets, Switched Horizontal - C2000 Series, Circuit Identification / Label Window Models, Power Outlet Double 250V 10A.

Edition 91 Trade Product Guide Page # 73

WHA120

Surface Switches - Weather Protected, Surface Switches - WHA Series - Weathershield - IP66, Switch 250V 20A - single pole.

Edition 91 Trade Product Guide Page # 99

WSC227/1

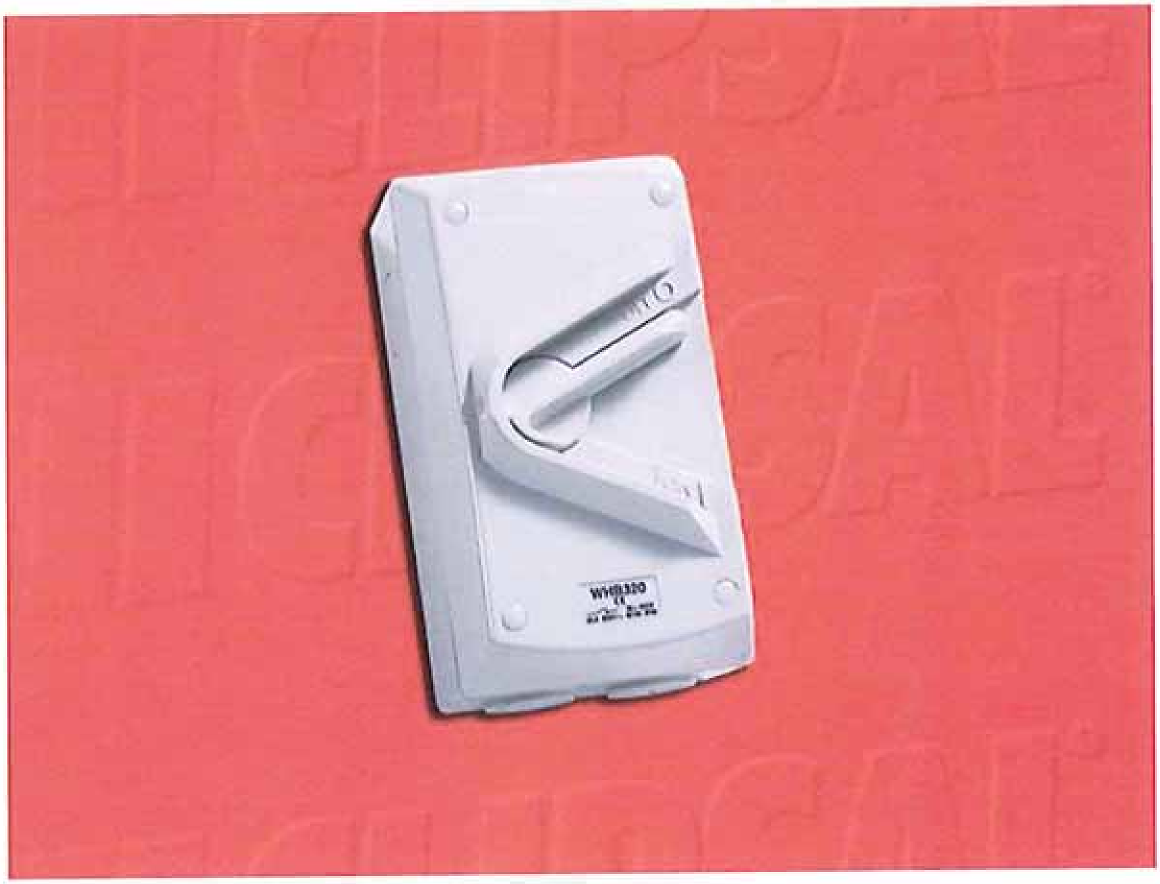
Socket Outlets, Surface Mount - Weather Protected, Surface Mounting - Weathershield - IP53, Power outlet single 250V 10A - standard size.

Edition 91 Trade Product Guide Page # 102

WSC227/2

Socket Outlets, Surface Mount - Weather Protected, Surface Mounting - Weathershield - IP53, Power outlet double 250V 10A - standard size.

Edition 91 Trade Product Guide Page # 102



WHB320

Surface Switches - Weather Protected, Surface Switches - WHB Series - Weathershield - IP66, Switch 500V 20A - triple pole (formerly WHT20).

Edition 91 Trade Product Guide Page # 99

8.8 Lighting Control: Dynalite

Document Set up Data

Field	Data
Client Name	Lend Lease
Client Address	UTS Broadway Building 81 Broadway Ultimo NSW 2008
Manual Type	Operation and Maintenance Manual
Service	Lighting Control
Volume	1.4.1
Section	
First Issue Date	09 May 2013
This Issue Date	28th February 2014
Latest Revision	C
Binder Size Used	
Binder Number of Rings	3
Separator Page Colour	
Divider Type	
Divider Level 1 Colour	
Divider Level 2 Colour	
Divider Level 3 Colour	
Notes:	All Modified text should be in black.
	To update Table of Contents Page - right click, update field, update entire table.

<u>Amendment</u>

Date	Section Updated
28/2/14	2.2.1 DALI Zoned Areas
28/2/14	2.2.2 Corridors
28/2/14	2.2.4 Toilets

UNIVERSITY OF TECHNOLOGY SYDNEY

Lighting Control

OPERATION AND MAINTENANCE MANUAL
FOR

UTS Broadway FEIT Building

Philips Dynalite

1 INTRODUCTION

System Description

The Lighting Control System at the UTS Broadway FEIT Building Sydney was installed by Nilsen Contracting electrical contractors and commissioned by Philips Dynalite. The system controls lighting from the basement levels, B4 to the Plant Room and incorporates a combination of DALI, low voltage and LED luminaires, and employs a number of energy management strategies including timed events, motion sensing and corridor hold functionality.

Each level is divided into three riser distribution boards with separate control equipment for each of the risers. A data cable running through the electrical risers links all the Dynalite equipment of each level to a main trunk located on level 01 & 02. The main trunk is connected to the base build User Head end computer loaded with Mapview, a graphical user interface that provides global control over the lighting control system.

The risers and each level are linked to the main trunk via a Bridge Node device that acts as a filter as well as a translator between the user head end software and the Lighting Control System.

Motion detection sensors deployed throughout the building provide control over each level. The levels are then configured into DALI zones and corridors/common areas.

Third party interfaces will have some control functionality in meeting rooms and a BMS system will monitor lighting status (on/off) within each tenancy.

1.1 Warnings and Precautions

1.1.1 General

- The Philips Dynalite system installed at UTS Broadway contains specialised equipment and should only be worked on by Licensed and Qualified technicians.

1.1.2 Power Supplies

- Dangerous voltages exist in the cabinet so ensure circuits are isolated prior to commencing any work
- **Some equipment should not be isolated without prior arrangements so always ensure consultation with Nilsen Contracting otherwise the lighting control system will be compromised**

1.1.3 Earthing

- Do not disconnect or remove any earth connections without fully isolating the equipment the earth connection is terminated on.

1.2 Volume Details

Contains introductions, and descriptions, general maintenance, contacts, commissioning, warranties and manufacturers data sheets Intended to provide an overview of the project and how the sites and systems integrate.

1.3 Glossary

Corridor Hold	Feature where any occupancy is detected in rooms, this will hold all the corridor lighting to an 'on' state for safe passage
DALI	Digital Addressable Lighting Interface
DALI Zone	The DALI Lighting Universe controlled via a DDBC120-DALI with up to 64 DALI Ballasts
DALI Sensor	The motion sensor used in all Extrusion Lighting that will communicate over the DALI protocol
DyNet	Network Cable
Preset	A pre-programmed light level
Floor Spur	The network cable on each individual level of the building
Main Trunk	The network cable connecting the Head End PC to each network bridge in each riser
Riser Trunk	The network cable in each riser cupboard, Wattle St, North and Jones St
Scene Setting	A pre-determined scene for specific applications – meetings, presentations ect
Switch Panel	Manual control panel located on the wall with set functionality
Ultrasonic Sensor	The motion sensor used in corridors that emits ultrasonic waves allowing increased coverage in larger areas

2 SYSTEM DESCRIPTION

CONTROL SYSTEM

A. The building will be equipped with a state-of-the-art, computer addressable lighting management system providing flexible and efficient monitoring, control and management of lighting. The lighting control system will be a state of the art computer addressable lighting management solution, providing absolute flexibility through independent control of any circuit operated by the system. The system will use a distributed architecture design and advanced windows based graphical programming to enable the lighting operation to be centrally programmed and adapted, but also to ensure full operation of the system should any central communications network fail.

B. The lighting control system configuration will not be locked by the Philips Lighting commissioning engineer so as to prevent potential future programmers from up loading and making changes or maintaining to the lighting control system.

C. All setting and configuration information with in any single device of the lighting control system can be up loaded by the commissioning software. This information can be stored on computer file without encryption or password protection that may prevent future commissioning service teams from gaining access to the systems original setting. Once commissioning is complete a hard copy of the configuration data will be provided to the client for future use.

D. Configuration data relating to individual area names, individual channel names, preset levels, toggle levels and panic level will be stored within the non-volatile memory of each respective controller. The controller will also support device names, area names and channel names each up to 40 characters in length with in its internal memory. The controllers will also be capable of supporting up to 170 presets scenes.

E. It will be possible to upgrade the firmware of all load controllers over the control network without direct access to the individual device.

F. No network device will require direct connection with commissioning computer for configuration or testing. All settings within any network device will be accessible from any point of the lighting control network.

G. All network devices will be able to issue logical instructions direct to other network devices without additional network integration or changing protocol.

H. All network devices are to use the same communication protocol. (DyNet) Network gateways between floors or areas will be provided as per our schematic diagram.

I. The system will comprise Lighting Control Modules, Network Gateways and head-end PC with graphical software. The system will allow for the connection of local devices including switches, time clocks (as described later and detailed on the drawings or schedules) as well as Desktop PC control if this Value engineered proposition is accepted.

J. The system will use advanced graphical software operating under Windows to enable the lighting operation to be centrally programmed and adapted. The system will incorporate virtual wiring software, enabling lighting switching patterns to be set-up and altered from the PC, without the need to access equipment or carry-out wiring alterations in regards to the DALI portion of this project.

K. The system will incorporate distributed intelligence such that every control module contains built-in intelligence to ensure that local operation of a unit can continue in the event of head-end PC failure. To ensure distributed intelligence, each control module will contain non-volatile memory which stores operational parameters for that module. The control system will be of Distributed Control System type, with local control panels and sensors communicating directly with Load Controllers, without requiring the intervention of a central processing unit or network gateway for protocol translation. In the event of a network cable being severed, the system will automatically continue to operate as two independent lighting control networks.

L. All configuration information downloaded from the configuration PC to devices on the bus will be stored in the relevant device, contained within non-volatile EEPROM or FLASH memory. This data will remain secure for an indefinite period, upon loss of supply. When supply is restored, the System will automatically return to the same state as when supply was lost, without requiring any user intervention.

M. For maintenance and future-proofing it will be possible to remotely upgrade on-board software on all system hardware from any point on the network.

2.1 General Overview

The Philips Dynalite Lighting Control System installed by Nilsen Contracting (NSW) for UTS Broadway Building includes the following:

- The system controls lighting from the basement levels, B4 to the Plant Room and incorporates a combination of DALI, low voltage and LED luminaires, and employs a number of energy management strategies including timed events, motion sensing and corridor hold functionality.

- Each level is divided into three riser distribution boards with separate control equipment for each of the risers. A data cable running through the electrical risers links all the Dynalite equipment of each level to a main trunk located on level 01 & 02. The main trunk is connected to the base build User Head end computer loaded with Mapview, a graphical user interface that provides global control over the lighting control system.

- The risers and each level are linked to the main trunk via a Bridge Node device that acts as a filter as well as a translator between the user head end software and the Lighting Control System.

- Motion detection sensors deployed throughout the building provide control over each level. The levels are then configured into DALI zones within the teaching/office spaces and common areas such as corridors, toilets and breakout areas.

- Manual lighting control will be achieved in the nominated teaching spaces, labs, meeting rooms, board rooms and office area's via a switch panel. Preset programming will allow scene setting at a pre-determined lighting level.

- Timed events will be achieved through the BMS system for all out of hours functionality.

- Third party interfaces will have some control functionality in meeting rooms and a BMS system will monitor lighting status (on/off) for each level.

2.2 Functionality

The Lighting Control System will encompass a number of energy efficient functionalities designed to maximise its performance.

2.2.1 DALI Zoned Areas

These areas are typically the classrooms, meeting rooms, offices, boardrooms and labs. Each DALI zone will be connected as a set of individual loops each comprising a maximum of fifty (50) DALI devices initially per loop. Each loop will be expandable to incorporate a total of sixty-four (64) DALI devices if required. The lighting control system will be able to manage one logical control area or lighting group over multiple DALI universe networks and over multiple DALI gateways. Each DALI Zone will be networked with the DALI sensor enabling all devices across all DALI Universes to communicate with each other. This will allow the network to identify occupancy in a DALI Zone and hold the corridor lighting to a preset state, providing a safe egress path. If no motion has been detected for a period of time (sensor performance overview below), the sensor will instruct the area to commence the energy efficiency state and dim the lights to the next level preset. This process repeats until either the area is in an ‘off’ state or motion is detected and the cycle is reset.

1. Detection of movement – all lights to 100%
2. No movement detected after 10 minutes – all lights dimmed to 50% output
3. No movement detected after a further 3 minutes – all lights dimmed to 25% output
4. No movement detected after a further 2 minutes – all lights dimmed to 0% output
5. Upon detection of movement during any stage of the ‘Grace’ period on each level, all lights will go to 100% and the timer will reset the cycle.

2.2.2 Corridors

The corridors are defined throughout the building as the North and South corridors. Each corridor will work independently of each other ensuring lights are not at an ‘on’ state if there is no presence detection in those areas. The corridor sensors will have an ultrasonic feature allowing for a larger detection area. The corridor areas will activate according to motion detection (sensor performance overview below) and will be guided by any detection within enclosed rooms.

1. Detection of movement at any entry point and doors of the corridor – all lights to 100%
2. Detection of movement at all lift lobby points – all lights to 100%

3. Detection of movement in any teaching space – all lights in corridors to 100%
4. No movement detected in teaching spaces or corridors after 10 minutes – all corridor lights to 50%
5. No movement detected in teaching spaces or corridors after a further 3 minutes – all lights to 25%
6. No movement detected in teaching spaces or corridors after a further 2 minutes – all lights to 0%
7. If movement is detected in corridors during dimming cycle or after all lights have been dimmed to 0% - corridor lights to 100% and the timer will reset the cycle
8. All stair lighting between levels will remain on at all times, lighting output will be dimmed via a timer after 12am to 30% to ensure safe passage

2.2.3 Car Parks

The Car Park lighting will be controlled using the DALI System. Motion detection will be used to control these areas and will perform a hold function for a period of time (sensor performance overview below), allowing safe passage to and from the vehicle or car park entry point. After a period of time of no detection, all lights will dim to a pre-determined preset level providing a warning to any occupants in a vehicle that the lights are about to turn off. Once motion is detected the cycle will reset.

1. Detection of movement – all lights to 100%
2. No movement detected after 20 minutes – all lights dimmed to 50% output
3. No movement detected after a further 5 minutes – all lights dimmed to 25% output
4. No movement detected after a further 5 minutes – all lights dimmed to 0% output
5. Upon detection of movement during any stage of the ‘Grace’ period on each level, all lights will go to 100% and the timer will reset the cycle.

2.2.4 Toilets

These areas will be controlled via the ultrasonic sensor providing maximum coverage for all levels of motion detection. Any motion detection in the toilet areas will also utilise the corridor hold function to ensure a safe egress path upon exit. After no motion has been detected for a period of 20 minutes, the sensor will send a command to the network to dim lights to 50%. After a further 10 minutes of no detection, all lights will turn off. Upon detection, cycle will reset. Any motion detected in the corridors will hold 1 light on at the toilet entrance for safe entry passage.

2.2.5 Fire Stairs

The Fire Stairs will be controlled via motion detection sensors. Upon detection at any entry point landing, all lights in the associated stairwell will turn to 100% ‘on’. If there is no detection for a period of 20 minutes, all lights will switch off. The timer will reset upon detection at any landing ensuring a safe exit passage through the stairwell.

2.2.6 Plant Room

The Plant Room will be controlled via both a networked sensor in the corridor and 240V sensors in the individual plant room areas. After a period of time of no detection on the networked sensors, all lights will dim to a pre-determined preset level providing a warning to any occupants that the lights are about to turn off. Once motion is detected the cycle will reset.

2.2.7 Lecture Theatres

To be confirmed in consultation with client.

Touch screens:
Touch screens located in the two lecture theatres will provide the customer with simplified, flexible control of each individual area. Allowance will be made for the use of a customised (UTS logo) screensaver.

On activating the screen by touch, the user will be directed to a security page and a 'Password' will be requested. On successful log in the user will have access to the 'Main Page'. This page will contain individual area buttons to allow the user to navigate to the area control pages. The area control pages will contain the following;

- Top of the page named with the logical area name - Project specific
- Four preset buttons - Allowing the user to recall per-defined lighting levels
- One Custom Preset button - allowing the user to recall a custom preset level
- Lighting level slider - Allowing the user to adjust the lighting level for the area
- Program button - Allowing the adjusted lighting levels to be saved as the custom preset
- A 'Return to Main Page' button

3 INTEGRATION

Interface with other products: We will interconnect dimming system(s) with the following systems after lighting equipment installation work has been completed and is operating properly.

1. Building Management System
   - Integration to the BMS will be provided by the Tridium Jace Box
     - Jace connection to the BMS network to be via Ethernet
     - Jace connection to the DyNet network via serial connection

2. Audio Visual System – Crestron
   - Crestron integration to Philips Dynalite system will be provided by serial connections in TSG rooms

4 SUPPLIERS AND SUBCONTRACTORS

4.1 List of Suppliers

PHILIPS dynalite	Philips Dynalite 6/691 Gardeners Rd Mascot NSW 2020	Phone	+61 2 8338 9977
		Fax	+61 2 8338 9333
		Email	email
	Customer Support	Web	www.philips.com/dynalite

4.2 List of Project Contacts

PHILIPS dynalite	Rishi Sharma NSW Project Manager 6/691 Gardeners Rd, Mascot NSW 2020	Phone	0428 571 970
		Fax	+61 2 8338 9333
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5 MAINTENANCE PROCEDURES

5.1 General

The Maintenance procedures below are provided to assist competent and authorised personnel to operate and maintain the Philips Dynalite Lighting Control System installed in the building.

Any person operating or maintaining this installation must be authorised to do so and be properly trained and certified. This is to ensure proper operation of the System(s), and the health and safety of the building occupants, maintenance personnel, the general public and the environment.

Operation and maintenance of the installation is to be in accordance with the requirements of the Building Code of Australia., The Public health Act, and the Occupational Health and Safety Act.

It is the responsibility of the Building Owner to ensure the operation and maintenance of the installation meets Code and Regulatory Authorities requirements. The building owner should request that any contractor employed for the operation and maintenance of the installation provide certification that the operation and maintenance is in accordance with Code and Regulatory Authority requirements, and that qualified licensed personnel have carried out the operation and maintenance.

MAINTENANCE

Maintenance Service: Prior to Final Completion, submit break-out price and specifics regarding maintenance contract(s) for Dimming Systems equipment, for client's possible acceptance. Offer terms and conditions for furnishing parts and providing continued testing and servicing, including replacement of materials and equipment, for one year period with option for renewal of Agreement by client.

Maintenance Practices: Philips Lighting's recommended maintenance practices describing the materials, devices and procedures to be followed in cleaning and maintaining the work.

Operating Instructions: Philips Lighting's recommended operating instructions describing the procedures to be followed in operating the Work. Include Philips Lighting's brochures and lists describing the actual materials used in the work.

6 MAINTENANCE SCHEDULES

Philips Dynalite systems require a combination of equipment cleaning (user interfaces & electrical controllers), dust removal, program auditing and component recalibration.

User interfaces such as touch screens will require periodic surface cleaning, this can be done by wiping the touch screen surface with a soft cloth soaked in ethyl alcohol. In regard to controller maintenance, system auditing and recalibration we recommend a customised maintenance program.

A typical Philips Dynalite maintenance agreement would include:
Annual NAEBERS Compliance Audit & Report
A Philips Dynalite employed service technician will complete an annual audit of the Lighting control system to ensure operational functionality. From this audit you will be provided with a comprehensive report on the operation of your lighting control system. Subject to the operation of your system you will also be provided with either certification of compliance with original design intent (required under Section I-I2 of the Building Code of Australia and/or recommendations to better utilise the functionality of your lighting control system.
The annual audit will include:
- Removing the covers on each device to determine equipment condition
- Checking the individual devices confirming network voltage across the installed system
- Completing a system audit of all installed devises ensuring they are communicating via the lighting control network.
- Checking & verifying Lux level settings of all Photo Electric sensors
- Confirm firmware versions of all devises
- Auditing the functionality of all control interfaces including touch buttons, multifunction input devices and time clocks

The report will include:
- Test results including:
- Device condition
- Network voltage
- Lux level calibration results,
- Lamp output,
- LCD & Touch panel functionality
- Recommended Firmware upgrades
- Compliance certification of operation
- Recommendations on functional changes (if applicable)

Guaranteed Response Times
Further to the annual audit and report, as part this agreement Philips Dynalite will guarantee response times to service calls to the Philips Dynalite System as well as

provide loan or replacement components as necessary for the operation of the system.

Call outs due to misuse, neglect, failure of electronic power, faulty communications lines, the use of replacement components which are not approved by Philips Dynalite, or to the use of accessories or fittings not detailed in the equipment schedule will be charged at Philips Dynalite call out rates.

7 TROUBLE SHOOTING & FAULT FINDING

7.1 General

This Section of the manual outlines some common problems and trouble shooting techniques. Most other problems will require trained service personnel to identify the problem and carry out the repair, please call for service.

7.2 BMS Fail

Problem	Recommended Action
Lighting System mode not changing between trading and after hours	➢ Check Tridium Jace Box is powered up by LED indicator
	➢ Verify the Dynalite node is connected to the serial port and DyNet network
	➢ Verify trading and after hours triggers have not been changed by BMS programmer

7.3 Crestron Fail

Problem	Recommended Action
No control of Dynalite Lighting system from Crestron	➢ Verify the Dynalite node is connected to the serial port and DyNet network
	➢ Verify local user interfaces are still operational

7.4 Switch Panel Failure

Problem	Recommended Action
Switch panel operation not functional	➢ Cycle panel supply by disconnecting and reconnecting the 12V from the DyNet terminal
	➢ Verify LED indicator status changes on button press
	➢ Check network voltages are within Dynalite tolerances

7.5 Sensor Failure

Problem	Recommended Action
Sensor operation not functional	➢ Cycle panel supply by disconnecting and reconnecting the 12V from the DyNet terminal
	➢ Verify LED indicator status changes on button press
	➢ Check network voltages are within Dynalite tolerances

7.6 Load Controller Failure

Problem	Recommended Action
Physical channels not operational	➢ Check incoming device supply
	➢ Check service LED is flashing
	➢ Reset the device by cycling the power supply
	➢ Check network voltages are within Dynalite tolerances

8 MANUFACTURERS DATA

8.1 Project Data Sheets

DDBC120-DALI
DDBC320-DALI
DDRC1220FR-GL
DDRC420FR
DDNG485
DUS804C-DALI
DUS804C-UP
DUS804C
OCCUSWITCH
DUS704C
DUS704W-MB
DPN914
DPN921
DPN963
DLP910-G
DPN308N
DTK622-RS232
DDNP1501
DTP170
DPMI940

9 INSPECTION TEST PLANS

9.1 Testing Data

Will be provided at completion.

10 COMMISSIONING

10.1 Commissioning

A. Provide complete commissioning and final adjustments of all dimmers and dimming system components.
B. Upon completion of each stage of the installation, the system will be commissioned by a factory-trained engineer. The commissioning will be performed upon notification (allow two weeks from date of notification or as per the forecasted project milestones) by Nilsen Contracting that the system installation is complete and that all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked as per test criteria outlined in the commissioning request form.
C. DALI ballasts are to be commissioned via a common graphical commissioning software interface providing graphical representation of all DALI fixtures & lighting control system devices
D. Initial programming will be via graphical icon positioning and grouping, writing data to products and a single database simultaneously.
E. The end-user software will show the project in a floor plan view, displaying all light fittings, system sensors, control panel and logical groupings.
F. Coordinate a mutually agreeable time with Philips Dynalite for final commissioning.
A project Forecast/Timeline will need to be provided well in advance prior to supply of any equipment. This is a critical requirement in order for Philips Dynalite to ensure the timely delivery and completion of each stage of the commissioning process. Philips Dynalite will NOT be held accountable or responsible for incomplete commissioning if the Forecast/Timeline has NOT been provided.

11 WARRANTIES AND GUARANTEES

11.1 Resellers Warranty

Warranty policy for Philips Dynalite Products
Available only to OEM's, distributors, wholesalers and electrical contractors (i.e. persons who are acquiring the product, or holding themselves out to be acquiring the product, for the purpose of re-supply)

This document sets forth the warranty policy ("Warranty Policy") of Philips Lighting, a division of Philips Electronics Australia Limited ABN 24 008 445 743 of 65 Epping Rd., North Ryde, NSW 2113 Australia ("Philips"). This Warranty Policy is applicable only to Philips Dynalite branded products ("Product") purchased by our OEM's, distributors, wholesalers or electrical contractor customers (i.e. a person acquiring the Product, or holding themselves out to be acquiring the Product, for the purpose of re-supply) ("Purchaser") from 1 August 2012 within Australia or New Zealand. THIS WARRANTY IS NOT AVAILABLE TO CONSUMERS however nothing contained herein is intended to limit or shall affect the rights a consumer may have under the Australian Consumer Law or under the law of New Zealand.

This Warranty Policy is subject to the special conditions set out below and is subject to the terms and conditions attached to this document ("Warranty Terms and Conditions").

This Warranty Policy only applies if it is referred to in a sales agreement between Philips and the Purchaser and replaces the standard warranty clause provided in the Philips general terms and conditions of sale.

Special conditions

• This warranty applies only to Product purchased by the Purchaser from Philips from 1 August 2012 onwards. Product purchased before 1 August 2012 will continue to be covered by the warranty applicable to it at the time it was purchased.
• The warranty period ("Warranty Period") starts on the date the Product is purchased from Philips (date of invoice) and runs for 2 years.
• Proof of purchase for the Product must be made available for inspection by Philips in order for a valid claim to be made under this warranty.
• For Product sold by the Purchaser to a customer within six months of the date the Purchaser purchased the Product from Philips, the Warranty Period is extended by the period of time during which the Product was unsold (i.e. the period of time that elapsed between the date the Purchaser purchased the Product and the date the Purchaser sold the Product, which will not exceed six months) ("Extended Warranty Period"). For example, if the Purchaser sold the Product 4 months after it purchased the Product from Philips, the Warranty Period, including the Extended Warranty Period, would be for 28 months. The maximum possible total Warranty Period, including Extended Warranty Period, is 30 months.
• In order to claim under this warranty during the Extended Warranty Period, the Purchaser must provide to Philips the proof of purchase document which must include the product serial number associated with the Product for which the Purchaser is claiming under the warranty.
• The Product must be used within its specifications (e.g. as regards temperature, water ingress and other extreme conditions, indoor/outdoor usage, etc.) ("Product Specifications") and according to application guidelines.
• This warranty becomes void if the Product is: o used other that in accordance with the Product Specifications and /or application guidelines; or
o not appropriately maintained (e.g. failing to prevent the build-up of dust and dirt, etc.);
o not properly installed;
o not operated in accordance with the manufacturer's instructions and / or guidelines;
o improperly or inappropriately operated, repaired or maintained;
o misused, neglected, damaged, modified or abused;
o connected to any other equipment with which the Product is not compatible; or
o used for purposes other than for which it is designed.

• This warranty is valid only for Product sold in Australia or New Zealand. In other regions, other conditions may apply.
• Adequate records of the history of any maintenance carried out in relation to the Product must be kept by the Purchaser and made available for inspection by Philips in the event that a claim is made in relation to the Product.
• A Philips representative must have access to the defective Product. If Philips suspects that any parts or components of the Product have been tampered with, a Philips representative may invite other manufacturers' representatives to evaluate all parts and components of the Product and any connected systems.
• Labor costs for installation and de-installation of the Product are not covered under this warranty.

12 DRAWINGS

12.1 List of Drawings

DRAWING NO	DRAWING TITLE	REVISION

13 EMERGENCY TEST

13.1 Envision Project Testing Set Up

Enumerate Emergency Ballasts

Emergency Ballast Enumeration

DLight III MapView enables you to enumerate DALI emergency ballasts, schedule and run various tests on these emergency ballasts, and generate reports of test outcome data.

Configuration is performed graphically through MapView. Individual ballasts may be identified and then assigned to collections to facilitate running tests in subsets of the full range of ballasts available.

This feature requires compatible firmware in the DDBC320-DALI devices and DLight III MapView and Server versions 3.4 or later.

Emergency Ballasts are enumerated using the same method as regular DALI ballasts. DALI Emergency luminaires are a variety of load on DALI devices.

1. Right-click on the controller (e.g. type DDBC320-DALI) and select 'Enumerate DALI Ballasts'

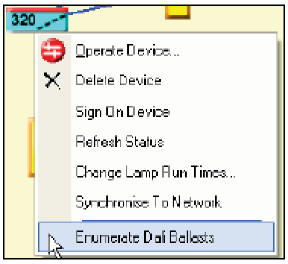


Figure 15-1

MapView will show the DALI Enumeration progress dialog to indicate the status of the enumeration. (Figure 15-2, Figure 15-3, Figure 15-4)

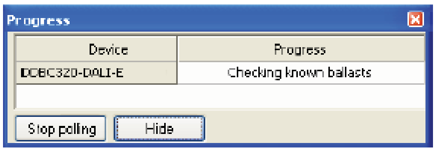


Figure 15-2

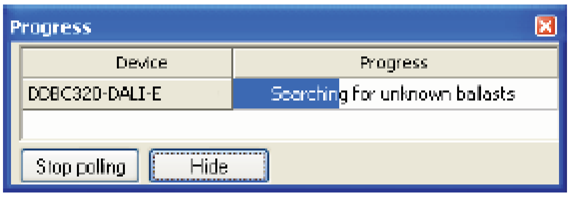


Figure 15-3

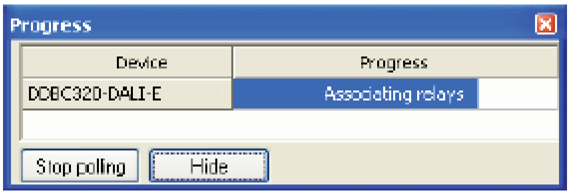


Figure 15-4

2. Once enumeration is complete, double click on the controller and select the DALI tab in the **Device Properties** dialog. (Figure 15-5).

DALI devices signed on in a network cause an extra tab (DALI) to be added. The Emergency Group field under the DALI tab indicates whether the ballast is an emergency ballast.

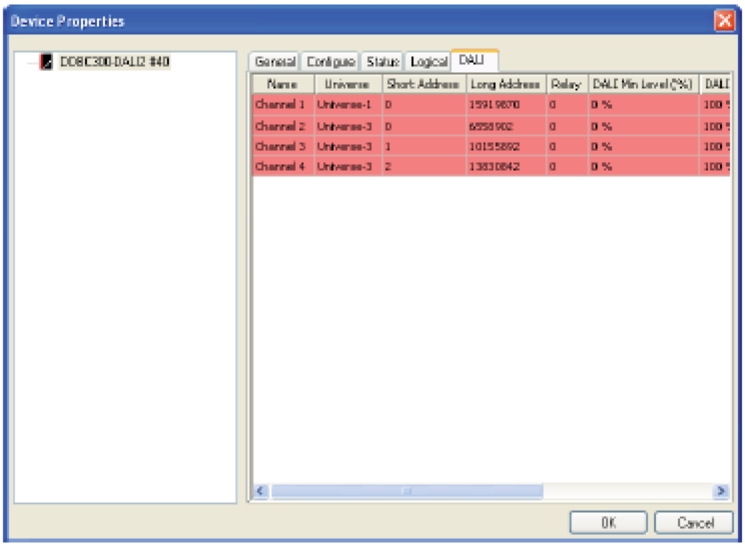


Figure 15-5

3. Add Ballast icons to MapView and the icons linked to the controller.

When a link is being drawn, DLight III will flash the next unassigned ballast to aid in identification.

Note	*Not all emergency ballasts support the methods used to flash them, so visual indication is unreliable for some types of emergency ballasts.*

The reporting function allows you to obtain reports of luminaire function and duration performance at specified intervals. It is possible to set up schedules for testing emergency luminaires in groups. For example, it may be required to schedule testing on a monthly basis.

Emergency Lighting

- To open DALI Emergency Lighting dialog

1. Click on emergency luminaire to select it. (Figure A - 35)

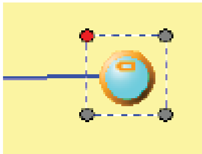


Figure A - 78

2. Right-click on luminaire. (note outline enclosing its icon)

This opens the menu (Figure A - 36):

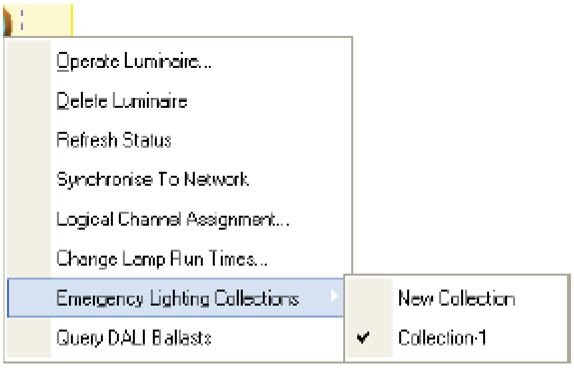


Figure A - 79

If it is a new collection, highlight **New Collection**.

If a collection has been created, called Collection-1, open it.

Ballasts can be added to an Emergency Ballast collection using the **Device Properties** dialog, under the DALI tab. The **Emergency Group** identifies which collection it belongs to. (Figure A - 37)

Any emergency ballasts listed on the DALI tab can be assigned to any collection listed under the Emergency group column.

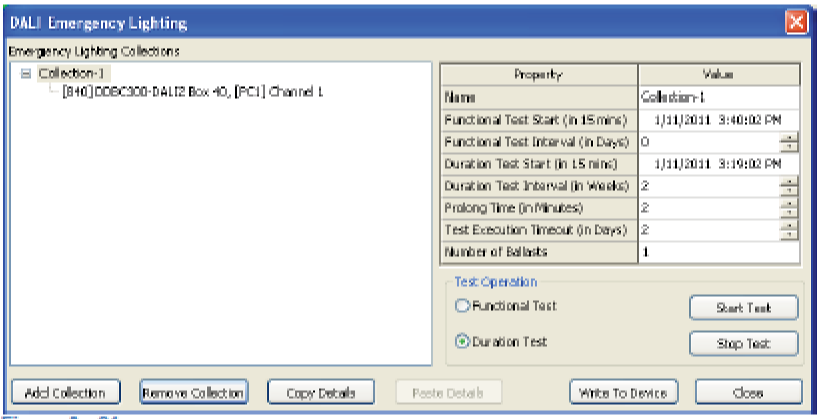


Figure A - 81

Collection-1 is the name of a collection containing one ballast.

Test execution Timeout

The Property lets you select how long a test can stay in pending status. If you do not specify a timeout, the test status reamains indefinitely. Specify a number of days.

To obtain the ballast details, double click on the ballast shown beneath the name of the collection.

This opens a ballast details window (Figure A - 39):

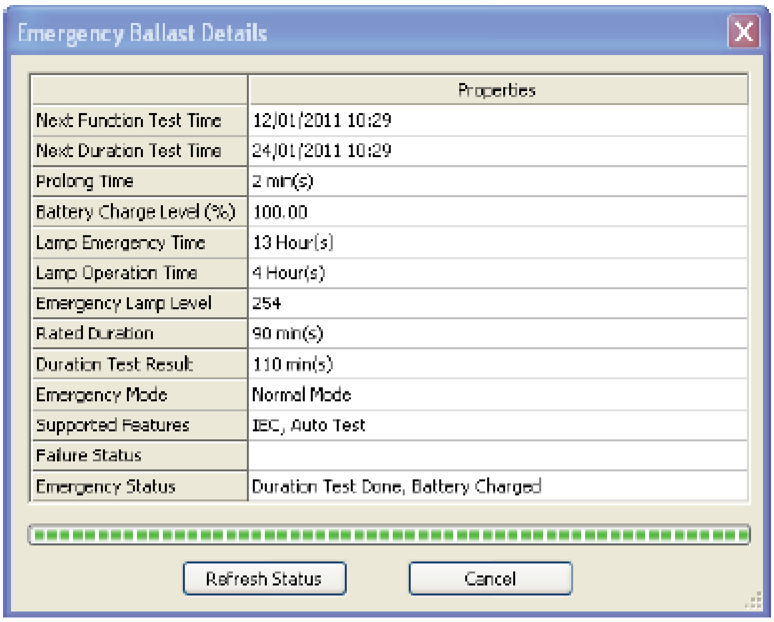


Figure A - 82

Alarm & Activity Viewer shows results of testing. Function Test lasts 10 seconds (standard).

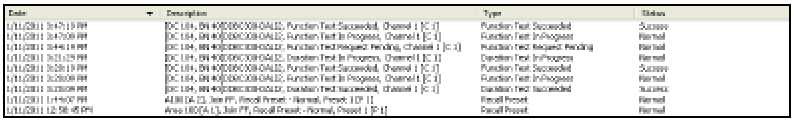


Figure A - 83

The top two lines show a functional test.

- An initiated test is of type request pending: status Normal.
- Its next status is Test In Progress.
- Its final status is Success (in this case).

Note *The Property table in the main window contains schedule properties applying only to emergency ballasts that support in-built scheduled testing. (auto-test ballasts). To schedule tests for ballasts other than auto-testing, use Dlight III schedules with MapView tasks. Refer to setting up Dlight III scheduled tests (page 274)*

Manual testing

The buttons Start Test and Stop Test only apply to manual testing.

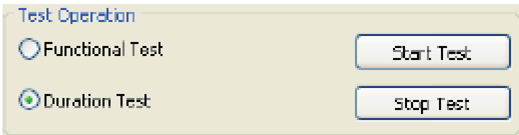
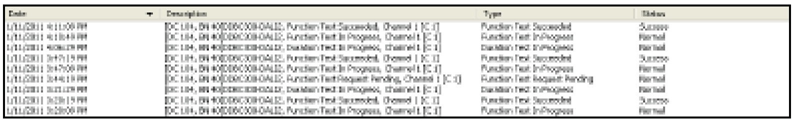


Figure A - 84

- Click Start Test to start selected test.
- Click Stop Test to stop selected test

Alarm & Activity Viewer lower window (Figure A - 42) displays the test description.



Setting up duration tests-Dlight III schedules

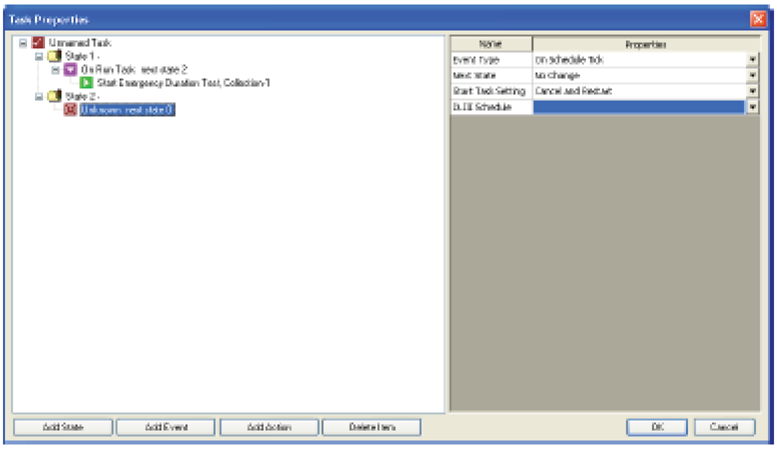


Figure A - 86

A duration test is normally set up in a task, with a pair of actions:

Start Emergency Duration Test, and Stop Emergency Duration Test.

The duration of the test is determined in the test schedule.

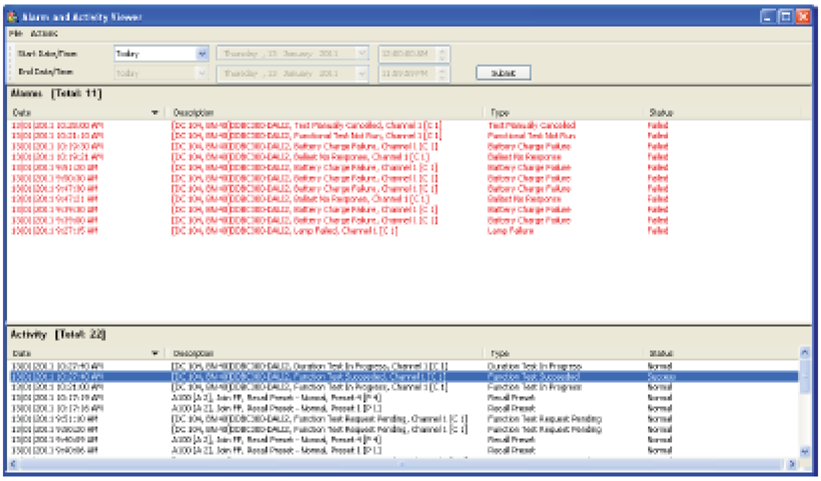
Note Write To Device must succeed in order to perform a schedule test. (auto-test ballasts only)

You can still start and stop a test manually, even if you do not write to device.

Viewing manual duration tests

Alarm and Activity Viewer provides two windows: Alarm (upper) and Activity (lower).

Duration test can be started (displayed in Activity window) and manually stopped (displayed in Alarm window) Manually stopping a test is recorded as an Alarm Event (Test Manually Cancelled).



Managing Emergency Lighting Collections

It may not be convenient to test all of the site's emergency lighting at the same time, considering the emergency lights will be in test mode for a long duration. Therefore, you have the choice to group DALI Emergency Ballasts into collections, and schedule tests on one group of ballasts, while leaving other ballasts in other collections unaffected.

The first step is to build a collection to ensure that adjacent ballasts do not undergo testing procedures simultaneously.

Creating a New Emergency Luminaire Collection

- To create a DALI emergency collection

1. First ensure your DALI controller has Emergency Ballasts connected.
2. Enumerate the DALI device.
3. In the DALI Tab of the Device Properties dialog, select the Ballast Type of some channels , if Emergency type
4. Emergency lamps must be linked to the DALI controller.
5. Right click the lamp names corresponding to the Emergency Ballasts.

   There will be a menu item to add it to an emergency group or create an emergency group.
6. Assign a collection name to each line. If you created a collection in the next dialog, the name of the collection will appear in the DALI collections column of the Device Properties dialog

Add Emergency Lighting Collections to the test group

- Group collections of emergency lights to test

1. select Edit DALI Emergency Lighting from the 'Edit' menu (Figure 15-6)
2. Click [Add Collection] in the window beneath Emergency Lighting Collections for adding an identified collection of ballasts. Or click [Remove Collection] to delete a line from the window.

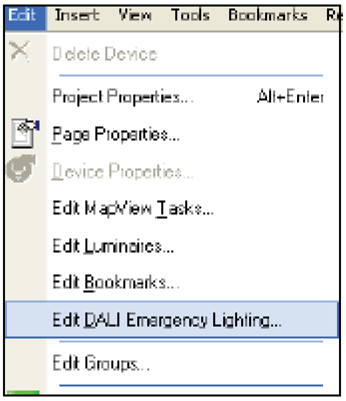
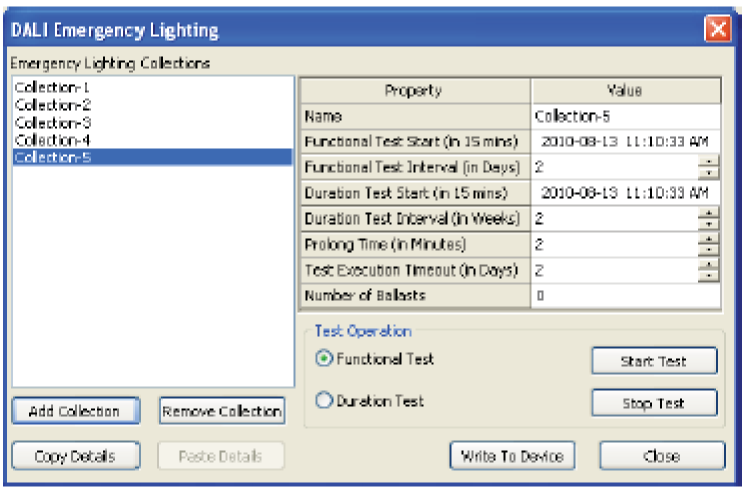


Figure 15-6

The dialog DALI Emergency Lighting (Figure 15-7) shows the collection and test settings associated with it.

If this is your first usage of the **Edit DALI Emergency Lighting** facility, the right hand window will be blanked out. In that case, click Add Collection to obtain the Property list (Figure 15-8).

You can add ballasts to the collection inside the Device Properties dialog.



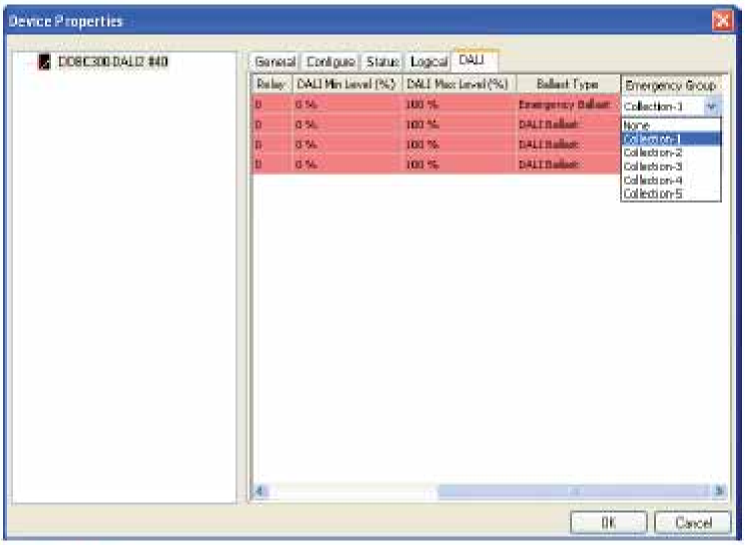


Figure 15-8

DALI Emergency Ballast Testing

automatically run the functional test and the duration test

DLight III MapView provides a facility to run tests on a collection of ballasts. Each test may be triggered manually, or run in a time interval stored in the ballast. This allows tests to occur without intervention, and without the need to have DLight III running or connected.

There are basically two types of test: functional and duration

The test is started only when Start Test is selected.

The dialog may be closed any time after, and the test will proceed.

Select Stop Test to halt testing.

Functional Test

Functional testing is a minimum test, involving switching on and off.

The functional test operates the power loss procedure in each emergency ballast. This test verifies that the ballast correctly switches over to back-up power in the event of a simulated failure, and the ballast recovers properly when power supply is resumed.

Duration Test

Duration testing verifies that lamp circuit continues to run in emergency mode.

The duration test procedure switches the ballast over to backup power, and verifies that the backup power is sufficient to run the ballast for the required interval. It is basically a battery test.

The prolong time is basically a setting to set a time when the emergency lamps continue to operate after power restoration.

- To manually set test times for a collection of ballasts through the DALI

Emergency Lighting dialog.

1. Click the appropriate collection of ballasts,
2. Click the desired test
3. Click Start Test.

The dialog may then be safely closed while the test is performed.

Schedule a time for the test.

4. Click Write To Device

DLight III writes the appropriate time interval and other data to the ballast.

When the scheduled time arrives, the ballasts will execute the test, and results can be read from the ballasts by DLight III after the test completes. The ballasts will then reschedule the next test based on the interval set in the **'DALI Emergency Lighting'** dialog.

- To terminate a test at any time, select Stop Test

Test Results

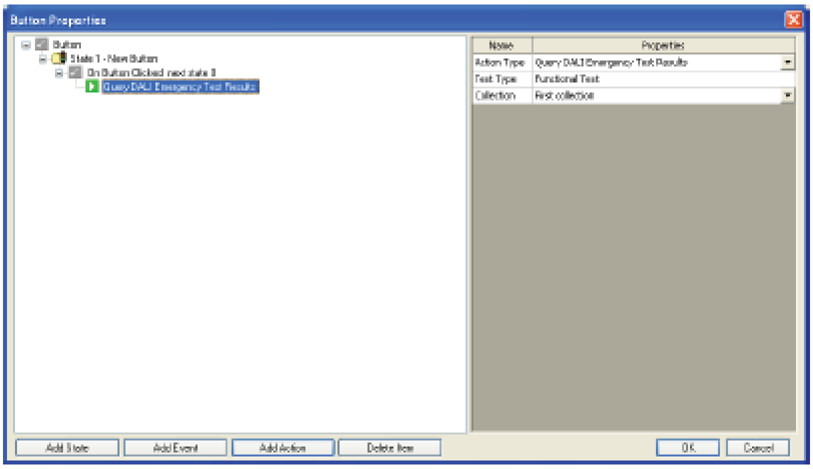
Test results from the ballasts are retrieved by DLight III and added to the standard reporting database. The results are retrieved automatically every 30 minutes after a query is initiated. They may also be retrieved at other desired times.

Scheduling Test Results Query

Test results may be retrieved (queried) using the MapView Schedule function. A schedule may be created, and a task or button action triggered off that schedule.

The task or button action to retrieve a set of test results is **Query DALI Emergency Test Results** (Figure 15-9)

To manually retrieve Test Results, in the same manner as described above, a user button may be created to query the test results. Results are available through the **Alarm and Activity Reports**.



- To retrieve test results by operating a user button

1. Create a button on a MapView page (refer to **Tasking** for explanations)
2. Identify State 1: give it a name identifying the testing
3. Click Add Event
4. Assign next state 0 to the event
5. Click Add Action
6. From Action type, select Query DALI Emergency test Results
7. Select Test (Functional Test; toggle to revert)
8. Select collection from list of existing collections
9. Click OK

   This creates a user button to run a test report.

Alarm and Activity Viewer

As the test proceeds, either automatically of manually, the events will become available through the **Alarm and Activity Viewer**.

(Figure 15-10)

You may open this view from the View menu.

Click **status** in either window to acknowledge a result.

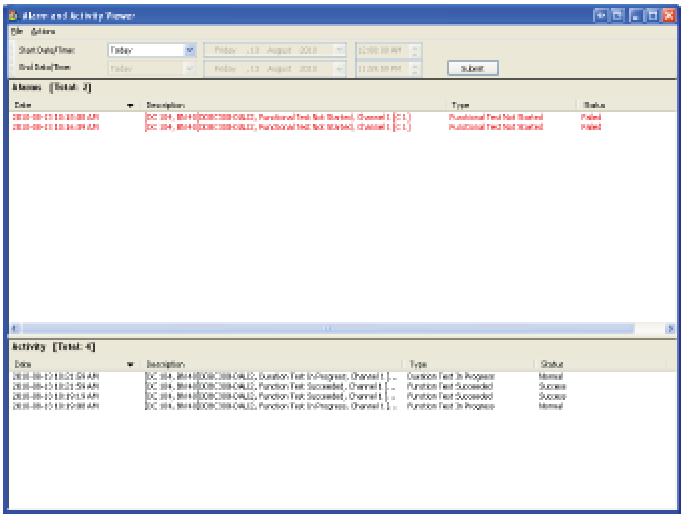


Figure 15-10

DALI Emergency Ballast Test Reports

DLight III MapView provides two reports that may be generated, each containing information about the tests that have been run on the emergency ballast collections. These reports may be printed, or exported in a variety of formats, including .xl and .rpt formats. Each DALI device under test will be listed, together with a status outcome. Refer to Explanations of DALI emergency ballast status terms

DALI Emergency Ballast Status

The DALI Emergency Ballast Status report shows any outstanding test results that have not yet been acknowledged in the Alarm and activity Viewer.

1. Reports > Alarm and Activity Reports
2. Select DALI Emergency Ballast Status
3. Select Run Report to generate Main Report

After the report has been generated, other options become available on the toolbar, including export and print. See Figure 15-11

DALI Emergency Ballast Results

The DALI Emergency Ballast Results report shows any test results read during the requested time period.

1. Reports>Alarm and Activity Reports
2. Select DALI Emergency Ballast Results
3. Select Run Report to generate Main Report

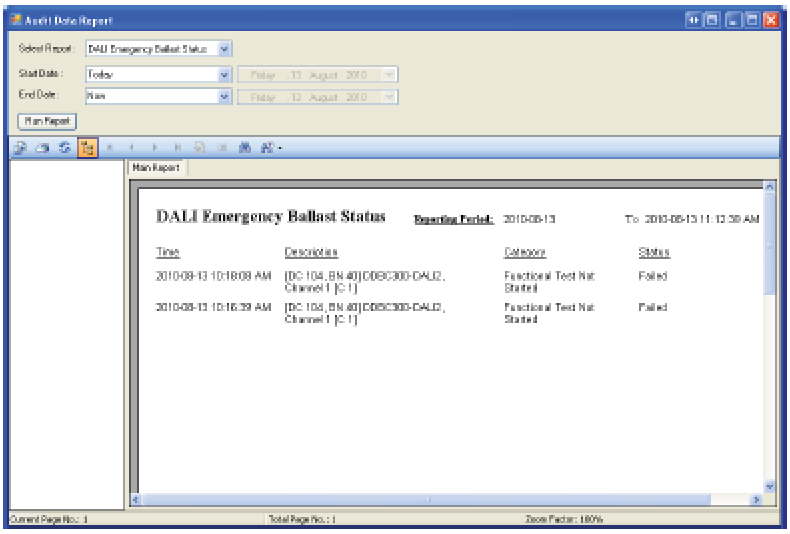


Figure 15-11

After the report has been generated (Figure 15-12), other options become available on the left of the toolbar, including *export* and *print*.

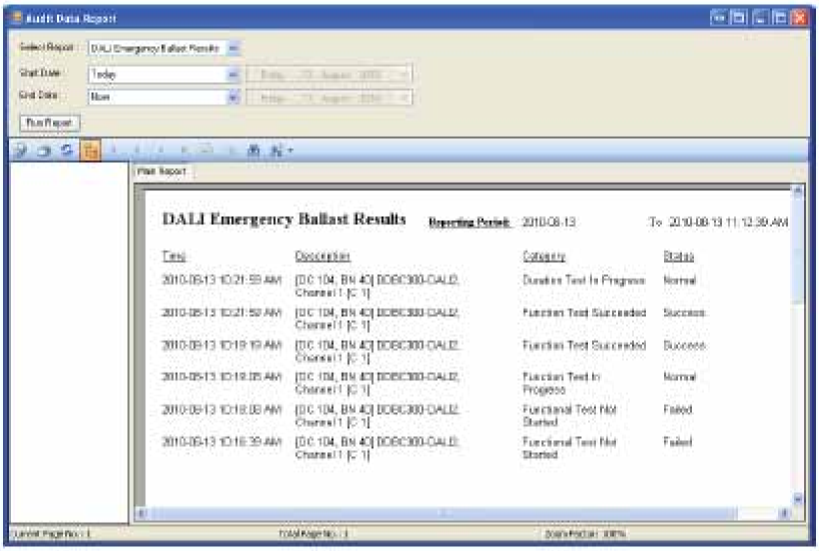


Figure 15-12

You can also run a report on general activity, to obtain other details (Figure 15-13)

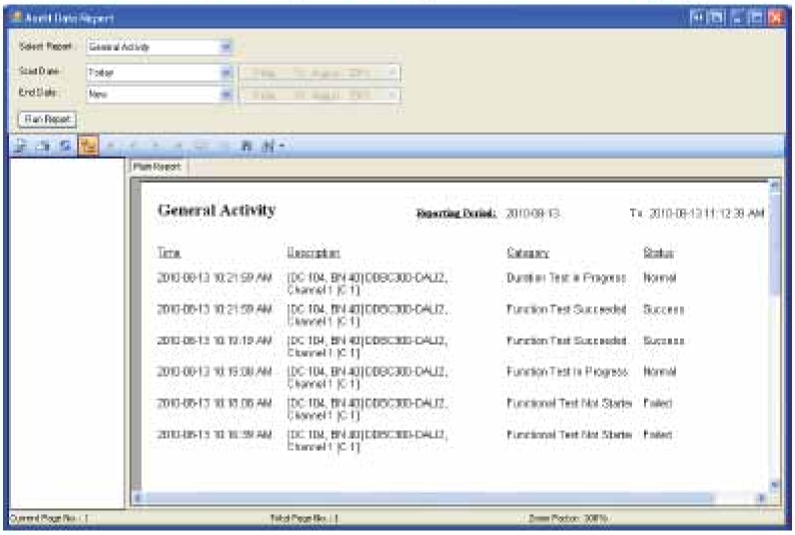


Figure 15-13

Explanations of DALI Emergency Ballast Status terms

Success Outcomes

- There are two successful outcome messages, one from each test type.

Function Test Succeeded

This result indicates simply that the function test performed as expected, and the ballast correctly recovered when power was reapplied.

Duration Test Succeeded

This result confirms that the duration of emergency lighting exceeded the required minimum.

Failure Outcomes

- If a ballast does not pass a test, or if a fault occurs in the ballast outside a test scenario, then the status reported back will reflect the problem.

Circuit Failure

The ballast has identified a fault in the load circuit

Battery Duration Failure

The backup battery capacity was not sufficient for the ballast to complete the test. The actual duration achieved is shown in the event details dialog for the alarm object.

Battery Charge Failure

This indicates that the ballast is reporting that the backup power unit has a charging problem.

Emergency Lamp Failure

If the emergency lamp fails to illuminate, the ballast will report the failure.

Function Test Delay Exceeded

The function test did not complete in the required time interval.

Duration Test Delay Exceeded

The duration test did not complete in the required time interval.

Set up the DLight III DALI Emergency Ballast Report

Two types of test are available: functional and duration. Functional testing indicates whether the luminaire operates at specified levels and at correct times. Duration testing ensures the luminaire operates for sufficient time under emergency conditions.

- To set up report

1. Enter dates and times in the Start rows of Value column.

Optionally, an interval to repeat each test may be set, which will be written to the ballasts in the collection when Write To Device is selected.

The smallest interval is 15 minutes, and the permissible value will differ between ballast manufacturers.

Further to this, many emergency ballasts do not include a real time clock, so the interval is stored in the ballast as an offset, in 15 minute units.

As yet, there are no ballasts in the collection, therefore, if you click Close the action will not write the changes to the device.

1. Add each required DALI ballast to a collection.

   In the dialog (Figure 15-14)

   a. Right-click on the ballast, or selected group of ballasts In the Device Properties window (Figure 15-5),
   b. select Emergency Lighting Collections
   c. select the collection name to which to add the ballast.
   d. Select [Add Collection]

   In the example, ballasts have been added to the group named 'First Collection'

   You can also add Emergency Ballasts to a collection via the DALI tab in a DALI controller's Device Properties.

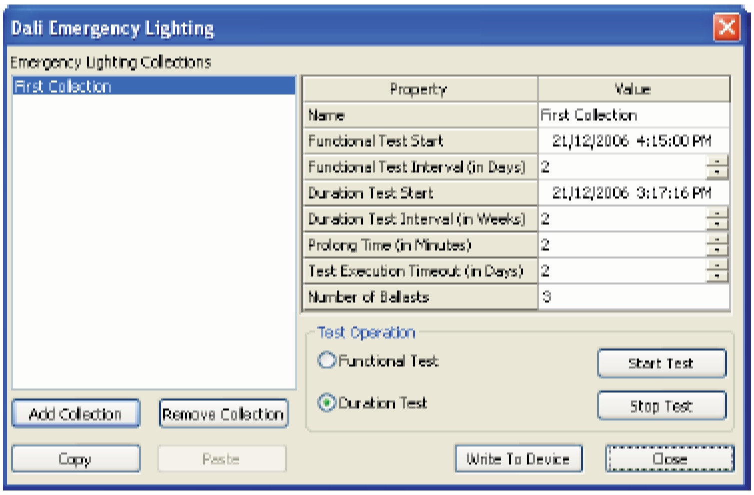


Figure 15-14

1. Click [Write To Device] to write the settings from the Emergency Group Dialog into the ballasts in that group. This will set the prolong time and the schedule for Function and Duration test to the ballast. The prolong time is defined as the time the extended emergency mode will endure before restoration of the mains supply.

To delete a collection

1. select the collection from the DALI Emergency Lighting dialog
2. Click [Remove Collection]

   This removes the collection, but not the emergency lighting included in the database.

   Ballasts in the collection are not actually removed, but the association is broken, so they should be added to a new or existing collection to allow tests to be run on them.

To move a ballast (or selected group of ballasts) to a different existing collection:

- Right click one of the selected ballasts
- select one of the emergency lighting collections
- choose [new collection name], or one of the existing collections

Key Point	*DLight III server does not need to continue running for the duration of the testing, once the test has been set up. MapView may be closed when the testing has been configured. When server is running, retrieve the results.*

13.2 Emergency Lighting Maintenance Procedures and Intervals

General Requirements
Exit and emergency lighting must be tested, inspected and maintained according to the relevant procedures outlined in AS/NZS2293 Part2 1995 (including 1998 amendments). Included below are some extracts from this Standard which detail procedures applicable to a single point emergency lighting system with automatic testing facilities such as the Philips Dynalite Envision Manager system. Please note a full copy of the current Standard is available from www.standards.com.au.
The Philips Dynalite Envision Manager system includes an electronic log book facility which caters for the record keeping requirements of the Standard. Philips Dynalite recommend that an electronic and a hard copy back-up of each final discharge test be kept in addition to the electronic copy located on the site server.
Please note: the Envision Manager User Guide contains specific instructions on how to operate the Philips Dynalite Envision Manager system for both testing and maintenance procedures such as adding or removing luminaires etc.
Required Procedures and Intervals

At a minimum the six and twelve monthly procedures must be carried out in accordance with Part 3 of the Standard:

3.1 REQUIRED PROCEDURES The procedures described in Clauses 3.2 and 3.3 shall be carried out at intervals of not greater than those specified. Groups of self-contained emergency luminaires and exit signs may be tested on a rotational basis, provided that the maintenance intervals for the individual luminaires or exit signs do not exceed those specified.
Any emergency luminaire or exit sign which fails to operate satisfactorily shall be either repaired or replaced. Where battery replacement is necessary, the requirements of Clause

3.4 shall apply. Details of any corrective actions taken shall be recorded in accordance with Clause 1.4.2.

NOTE: With reference to the discharge test of Clause 3.2, it should be noted that for part of the test period the building may be without emergency lighting. This risk is considered acceptable, except where the regulatory authority deems otherwise. When selecting a time for the discharge test, consideration should be given to the nature of the occupancy of the building in order to minimize the risk, e.g. conducting the test discharge at a time that will permit recharging of the battery when the building is unoccupied.

Every 6 months. A 90 minute discharge test must be carried out at least every 6 months. The Envision Manager system can be programmed to automatically perform these tests.

3.2.2.2 Automatic discharge test facilities.
Where the emergency luminaires or exit signs are provided with facilities for automatic discharge testing, a visual check shall be made of the operational status of each unit either by means of the indicator at each unit, where self-contained facilities are provided, or by means of the relevant controller or indicator panel where centralized testing facilities are provided.
Those units which failed the previous discharge test shall be either repaired and restored to normal condition, or replaced.

NOTE: A discharge test may also be carried out at any time using the manual initiation facility, where provided in accordance with Section 4 of AS/NZS 2293.1

3.2.3 Additional check for indirect lighting systems - For indirect lighting systems, carryout the following:

(a) Check that the finish of the major reflecting surfaces (e.g. walls, ceilings) have reflectance's of not less than those on which the design of the system was based.
(b) Check that emergency luminaires of the directional beam type, if used, are aimed in such a manner that the beam will not be directed into the eyes of persons moving through the designated area.

Additionally, every 12 months:

3.3 TWELVE-MONTHLY PROCEDURES
The following procedures shall be carried out at intervals of not more than 12 months:
(a) Carry out all the checks listed in Clause 3.2.
(b) Clean all light-emitting and reflecting surfaces of emergency luminaires and exit signs.
NOTE: Appendix B gives guidance on appropriate cleaning materials and their use.
(c) A visual check shall be made to ensure that the emergency luminaires and exit signs operate in correct relationship to the normal lighting in the designated area (see requirements for the arrangement and control of single-point systems in Section 2 of AS/NZS 2293.1.)

NOTE: This procedure may be carried out in conjunction with the discharge test of Clause 3.2.2.

After changing a battery a 120 minute discharge test is required:

3.4 BATTERY REPLACEMENT
Whenever the batteries of emergency luminaires and exit signs are replaced for any reason, such replacements shall be made in accordance with the following:
(a) Where more than one cell is utilized, the complete battery pack shall be replaced.
(b) Replacement batteries shall be of the same type and ampere-hour capacity.
(c) A discharge test shall

Given the number of Emergency fittings within this project, Philips Dynalite would recommend that the Emergency Lighting Testing be carried out on a floor by floor basis over a week period in times of low occupancy. As outlines above, the tests can be automated via the Envision Manager software or evoked by the end user via the single emergency test button panel in each distribution board if so required.

8.9 Power Factor Correction: Electroserv

electroserv

FORM No. PFC Test Sheet R5
Rev Date Sept 07

POWER FACTOR CORRECTION EQUIPMENT FINAL CHECK & TEST REPORT FORM

CLIENT	NILSEN	**End User**	UTS BROADWAY
Order No.	609330 - 70080	**DATE of Test**	18.2-13
PFC RATING	500kVAr	**Month of Mfg.**	FEBRUARY
Rejection Freq.	189 Hz	**Main Switch ?/ Type**	N/A
Serial No.	C14408 - 12	**Capacitor Type/Batch No**	EPCOS AH-CAP
No. And Size of Steps	10 x 500kVAr	**Controller Type**	EPCOS B26800
		Contactor Part No.	EPCOS B44066
		Reactor Part No.	EPCOS -
		Fuse/Sw. Part No.	SIEMENS

Check List — *sign-off*

1. Clean and Vacuum Internal and External.
2. Check all power and control connections are tight and correct if Necessary.
3. Test Main incoming connections to earth and between phases at Mains Volts or above (≥100MΩ)
4. High Pot check all main power connections to earth and between phases. Record Below (≥1GΩ)*
5. Test, at mains voltage, mains again and capacitor connections to earth at load side of all contactors
6. Check continuity of earth connections. (≤1Ω)
7. Check all fuses are in place and of correct rating.(eg 63A-25kVAr, 125A-50kVAr)
8. Check capacitance meter is within calibration
9. Check Capacitance of all steps and record below. (Range 25kVAr- 200 to 250 µF - 50kVAr- 370-460 µF)
10. Power on test and record results below (range 25kVAr- 32-40ARMS - 50kVAr- 65-78ARMS)
11. Set up controller and fan thermostat Ensure correct operation
12. Clean and pack cubicle and ensure copy (original to file) of this report enclosed

EJS

Step No.	Current- (Amps RMS) Red Phase	Current (Amps RMS) White Phase	Current (Amps RMS) Blue Phase	Capacitance Red-White (µF)	Capacitance Red-Blue (µF)	Capacitance White-Blue (µF)
1	77.9	77.7	78.1	446	447	448
2	78.3	77.8	77.9	447	447	447
3	77.8	77.5	77.8	447	446	448
4	78.0	77.6	78.1	447	448	448
5	78.0	77.9	78.0	445	444	446
6	78.0	77.9	78.2	448	447	448
7	77.7	77.8	77.9	448	447	448
8	78.1	77.9	78.2	449	448	449
9	77.7	77.3	77.4	448	448	449
10	77.6	77.3	77.7	445	446	446
11						
12						

Insulation Level (GΩ@2kV/15Sec.)	Red-White	Red-Blue	White-Blue	Red-Earth	White-Earth	Blue-Earth
	8.67	11.2	8.49	11.7	11.3	11.6

* Download data from Hi-Pot tester if required by Customer

Comments/Special Features:

....

....

Manufactured by : Print Name V.SALMON signed .... Date 18.2.13
Tested by : Print Name V.SALMON signed .... Date 18.2.13
Checked by : Print Name N.SPEARMAN signed .... Date 18.2.13

Ref: C:\Documents and Settings\John Hamilton\My Documents\Letters Services\PFC Test Sheet R5.DOC

ELECTROSERV P/L PO Box 701 Hornsby NSW 1630 Ph 02-8005-2621 Fax 02-8005-4179

electroserv Pty Ltd

MANUFACTURING and INSPECTION PLAN (M . I . P)

\\SERVER1\data\Engineering\Standard Forms\MIP 2000 R1.doc

CUSTOMER	**NILSEN**	**SIZE kVAr**		**500kVAr**	**DATE STARTED**	7/2/13
JOB Title	**UTS BROADWAY**	**kVAr / Steps**		**25kVAr**	**BY**	N.JBRATH
			10	**50kVAr**		
JOB #	**C10108/1**	**Main Switch Size**		**NMS**	**DATE COMPLETED**	18/2/13
ORDER #	**609330/70080**	**Cubicle Size/ Colour**		**2000 / X15**	**Special Requirements**	

Item	Action	Reference Document/s	Completed By	Date	Checked By
1	Read work package for any customer specific requirements, including step sizes, main switch, top/bottom cable entry and delivery date.	Work package and approved customer drawings (if applicable)	NJ	7/2/13	
2	Preparation of Cubicle – - Inspect cubicle for transport damage and paint scratches etc. - drill and tap, if necessary, all required mounting holes - Install wiring duct - Mount pre-wired fans and install vent cover.	Standard Cubicle Drawing No. S0315R2 Fan wiring GA Drawing No. S0605	NJ	12/02/13	[signature]
3a	Pre wire reactors: - Check reactor winding connections - Check lead connection - Check nut & bolt configuration - Sign off on reactor (yourself and checker)		NJ	11/2/13	[signature]
3b	Install reactors into cubicle: - Tie off leads accordingly		NJ	12/2/13	[signature]
4a	Assemble capacitor tray: - Install linking cables/copper - Tighten to appropriate torque		NJ	11/2/13	[signature]
4b	Install capacitor trays: - Connect, starting from lowest level. - Check capacitor connections before installing next level.		NT	11/2/13	[signature]

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MANUFACTURING and INSPECTION PLAN (M . I . P)

Item	Action	Reference Document	Completed By	Date	Checked By
5a	Assemble contactor tray: - Drill & tap appropriate holes if necessary - Screw in earth stud - Mount busbar standoffs - Mount contactors correct orientation		NJ	14/2/13	
5b	Install contactor tray: - Install contactor frames ensure cables from reactors are brought to front and are free to move.		NJ	13/2/13	
6	Assemble and Install Busbar: - Allow for expansion if necessary - Heat shrink busbar where applicable - Install in unit and tighten to appropriate torque		NJ	13/2/13	
7	Install fuse switches: - Tighten to appropriate torque (6Nm) - Install fuse switch linking cables and tighten to appropriate torque (4Nm)		NJ	13/2/13	
8	Prepare Control Panel and Control Rail and install, check mains connections and mark connecting bolts as checked.	Control Rail GA Drawing S0605.	NJ	15/2/13	
9	Install all Control Wiring	Standard Control Circuit Diagram S0316R1	NJ	15/2/13	
10	Wire reactors to contactors: - Tighten to appropriate torque (4Nm)		NJ	15/2/13	
11	Inspection point – 1.Ensure all connections made with correct hardware and tightened to correct torque 2. Check wiring and duct work 3. Ensure all wiring marked and in accordance with wiring diagram 4. Check paint work	Standard Control Circuit Diagram S0316R1	NJ	15/2/13	

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MANUFACTURING and INSPECTION PLAN (M . I . P)

\\SERVER1\data\Engineering\Standard Forms\MIP 2000 R1.doc

Item	Action	Reference Document	Completed By	Date	Checked By
12	1. TESTING -.call Customer 2 days prior to testing, if witness testing specified 2. Megger Check all main power connections to earth (2,000Volt). 3. Megger check between phases on busbars (2,000Volt). 4. Check continuity of earth connections. 5. Check all fuses are in place and of correct rating. 6. Check Capacitance of all steps and record below. Power on test and record results (Note: Follow safety procedure SP1) Set up controller for step No. Ensure correct operation	Safety Test procedure SP1	NS	18-2-13	
13	Clean and pack cubicle and ensure instruction manual completed		NS	18-2-13	

Comments/Special Features:

electroserv

FORM No. PFC Test Sheet R6
Rev Date Sept 07

POWER FACTOR CORRECTION EQUIPMENT FINAL CHECK & TEST REPORT FORM

CLIENT	NIKSEN	**End User**	UTS BROADWAY
Order No.	609530-70080	**DATE of Test**	18-2-13
PFC RATING	500 KVAr	**Month of Mfg.**	FEBRUARY
Rejection Freq.	189 Hz	**Main Switch ?/ Type**	N/A
Serial No.	C10108-2	**Capacitor Type/Batch No**	EPCOS PHI-CAP
No. And Size of Steps	10 x 50 KVAr	**Controller Type**	EPCOS BR6000
		Contactor Part No.	EPCOS - B44066
		Reactor Part No.	EPCOS -
		Fuse/Sw. Part No.	SIEMENS

Check List

1. Clean and Vacuum Internal and External.
2. Check all power and control connections are tight and correct if Necessary.
3. Test Main Incoming connections to earth and between phases at Mains Volts or above (≥100MΩ)
4. High Pot check all main power connections to earth and between phases. Record Below (≥1GΩ)*
5. Test, at mains voltage, mains again and capacitor connections to earth at load side of all contactors
6. Check continuity of earth connections. (≤1Ω)
7. Check all fuses are in place and of correct rating.(eg 63A-25kVAr, 125A-50kVAr)
8. Check capacitance meter is within calibration
9. Check Capacitance of all steps and record below. (Range 25kVAr- 200 to 250 μF - 50kVAr- 370-460 μF)
10. Power on test and record results below (range 25kVAr- 32-40ARMS - 50kVAr- 65-78ARMS)
11. Set up controller and fan thermostat Ensure correct operation
12. Clean and pack cubicle and ensure copy (original to file) of this report enclosed

sign-off

J.S.

Step No.	Current- (Amps RMS) Red Phase	Current (Amps RMS) White Phase	Current (Amps RMS) Blue Phase	Capacitance Red-White (μF)	Capacitance Red-Blue (μF)	Capacitance White-Blue (μF)
1	78·2	77·8	77·6	448	448	448
2	78·2	77·6	77·8	447	448	446
3	77·9	77·6	78·4	447	448	448
4	78·2	77·7	78·1	447	448	447
5	78·0	77·6	77·8	447	448	447
6	78·5	78·0	78·1	448	448	446
7	78·2	77·8	78·2	447	448	448
8	78·3	77·8	78·3	448	448	448
9	78·3	77·7	78·1	448	447	447
10	78·2	77·8	77·8	447	447	446
11						
12						

Insulation Level (GΩ@2kV/15Sec.)	Red-White	Red-Blue	White-Blue	Red-Earth	White-Earth	Blue-Earth
	8·53	11·3	9·02	11·5	11·2	11·6

* Download data from Hi-Pot tester if required by Customer

Comments/Special Features:

Manufactured by : Print Name J. SACHON signed Date 18-2-13
Tested by : Print Name J. SACHON signed Date 18-2-13
Checked by : Print Name N. SERAFIM signed Date 18-2-13

Ref: C:\Documents and Settings\John Hamilton\My Documents\Letters Electroserv\PFC Test Sheet R6.DOC

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MANUFACTURING and INSPECTION PLAN (M . I . P)

\\SERVER1\data\Engineering\Standard Forms\MIP 2000 R1.doc

CUSTOMER	**NILSEN**	**SIZE kVAr**	**500kVAr**	**DATE STARTED**	8-2-13
JOB Title	**UTS BROADWAY**	**kVAr / Steps**	25kVAr 10 50kVAr	**BY**	[signature]
JOB #	**C10108/2**	**Main Switch Size**	**NMS**	**DATE COMPLETED**	18/2/13
ORDER #	**609330/70080**	**Cubicle Size/ Colour**	**2000 / X15**	**Special Requirements**	

Item	Action	Reference Document/s	Completed By	Date	Checked By
1	Read work package for any customer specific requirements, including step sizes, main switch, top/bottom cable entry and delivery date.	Work package and approved customer drawings (if applicable)	[signature]	8.2	
2	Preparation of Cubicle – - Inspect cubicle for transport damage and paint scratches etc. - drill and tap, if necessary, all required mounting holes - Install wiring duct - Mount pre-wired fans and install vent cover.	Standard Cubicle Drawing No. S0315R2 Fan wiring GA Drawing No. S0605	[signature]	8.2	NT
3a	Pre wire reactors: - Check reactor winding connections - Check lead connection - Check nut & bolt configuration - Sign off on reactor (yourself and checker)		NT	11.2	[signature]
3b	Install reactors into cubicle: - Tie off leads accordingly		[signature]	11.2	NT
4a	Assemble capacitor tray: - Install linking cables/copper - Tighten to appropriate torque				[signature]
4b	Install capacitor trays: - Connect, starting from lowest level. - Check capacitor connections before installing next level.		[signature]	11.2	NT

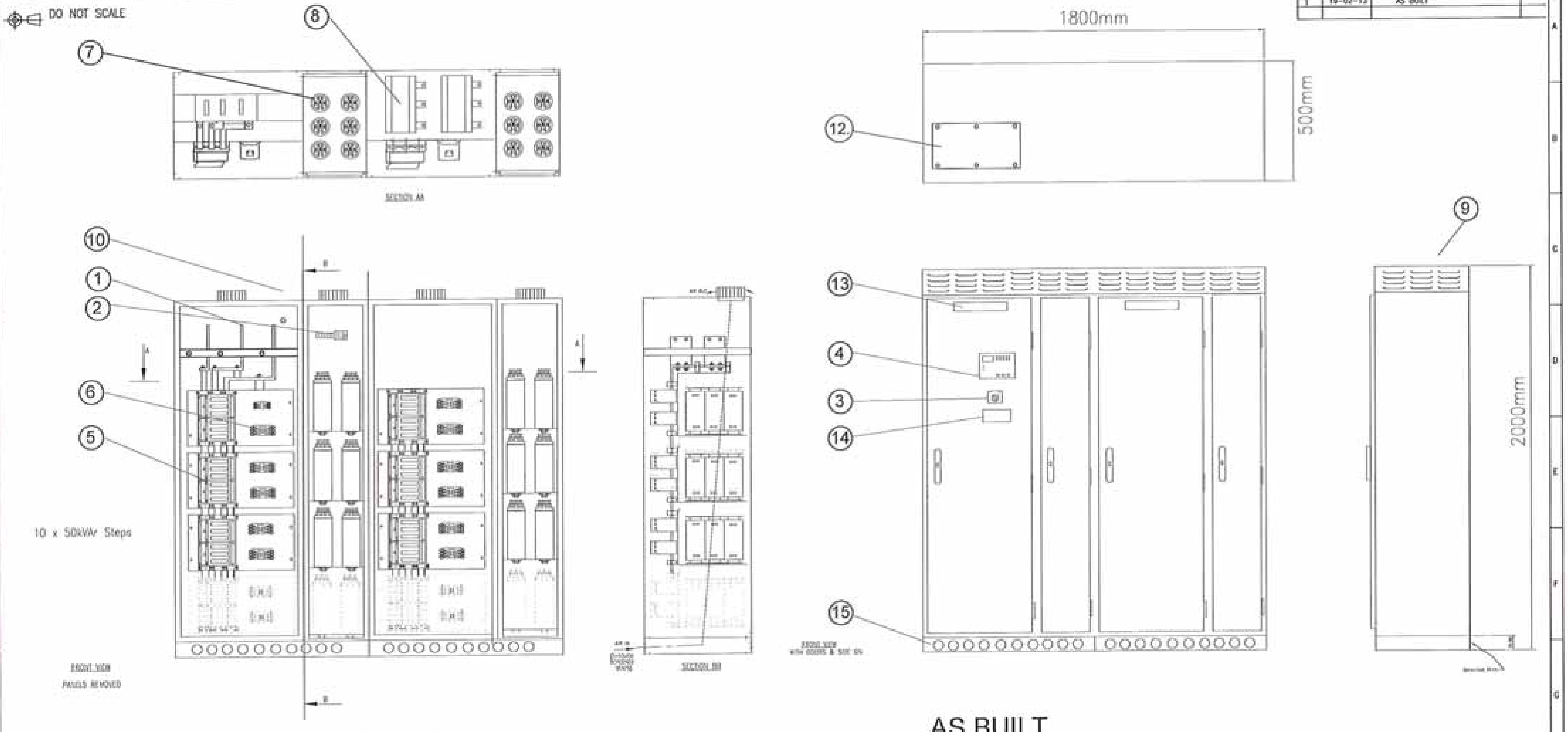
Item	Action	Reference Document	Completed By	Date	Checked By
5a	Assemble contactor tray: - Drill & tap appropriate holes if necessary - Screw in earth stud - Mount busbar standoffs - Mount contactors correct orientation			11. 2	
5b	Install contactor tray: - Install contactor frames ensure cables from reactors are brought to front and are free to move.			11. 2	NJ
6	Assemble and Install Busbar: - Allow for expansion if necessary - Heat shrink busbar where applicable - Install in unit and tighten to appropriate torque			11. 2	NJ
7	Install fuse switches: - Tighten to appropriate torque (6Nm) - Install fuse switch linking cables and tighten to appropriate torque (4Nm)			11. 2	NJ
8	Prepare Control Panel and Control Rail and install, check mains connections and mark connecting bolts as checked.	Control Rail GA Drawing S0605.		12. 2	NJ
9	Install all Control Wiring	Standard Control Circuit Diagram S0316R1		12. 2	NJ
10	Wire reactors to contactors: - Tighten to appropriate torque (4Nm)			13. 2	NJ
11	Inspection point – 1.Ensure all connections made with correct hardware and tightened to correct torque 2. Check wiring and duct work 3. Ensure all wiring marked and in accordance with wiring diagram 4. Check paint work	Standard Control Circuit Diagram S0316R1		13. 2	NJ

e l e c t r o s e r v Pty Ltd

MANUFACTURING and INSPECTION PLAN (M . I . P)

Item	Action	Reference Document	Completed By	Date	Checked By
12	1. TESTING -.call Customer 2 days prior to testing, if witness testing specified 2. Megger Check all main power connections to earth (2,000Volt). 3. Megger check between phases on busbars (2,000Volt). 4. Check continuity of earth connections. 5. Check all fuses are in place and of correct rating. 6. Check Capacitance of all steps and record below. Power on test and record results (Note: Follow safety procedure SP1) Set up controller for step No. Ensure correct operation	Safety Test procedure SP1	NJ	18-2-13	
13	Clean and pack cubicle and ensure instruction manual completed		NJ	18-2-13	

Comments/Special Features:



AS BUILT

Components List

Item No.	Description	Part No.
1	Main Connections	10 x 30mm Tinned Copper
2	Control terminals-C.T.,NEUT,alarm and thermostat	ELE-Cont-01
3	Power Factor Controller - EPCOS 12 STEP	BR6000
4	Control Switch - 2 position - 3 pole	TX-M10HZA3
5	HRC Step fuse switch - 63(25kVAr)/125(50kVAr)	3NP40761CE01
6	Step Contactors-capacitor switching-AC6b-62kVAr	B44066S6210J230
7	Capacitors- 525Volt 65 deg. Self Healing-protected	B32344D5252A020
8	Harmonic Detuning Reactor-189Hz-7%	B44066D7050M441
9	Backward Curve Cooling Fans (4off) (under Vent)	R82C-190/060K010-R2C190
10	Main Earth Connection-Brass Bolt	10mm c/w Nut + Washer
11	Space For Expansion	2x50kVAr Steps
12	Gland Plate	3 mm Aluminium Panel
13	Manfacturers Label - Electroserv Pty Ltd	
14	Warning Label	See Control Switch Detail
15	Plinth	Galvanized 75mm Channel
16	2mm Sheet Steel Doors-lift-off pintel hinges CL001 locks	
17		

NOTES:

FINISH: EXTERNAL – POWDER COAT, COLOUR TO BE ORANGE X15 to AS2700 – (RAL2000)

INTERNAL – ALL MODULES TO BE GLOSS WHITE

ENVIRONMENTAL PROTECTION – IP42 TO AS 60529

THERE ARE TWO(2) IDENTICAL SYSTEMS ON THIS PROJECT

electroserv
Electroserv Pty Ltd
1/22 Beaumont Road
Mt.Kuring-Gai NSW 2080 Australia
Ph: 61-2-9477-7055
Fax: 61-2-9477-5310
email: info@electroserv.com.au

Quality Endorsed Company

CLIENT : NILSEN ELECTRIC PTY LTD

PROJECT : UTS BROADWAY

	NAME	DATE
DRAWN	JR	
CHECKED		
APPROVED		

TITLE: POWER FACTOR CORRECTION

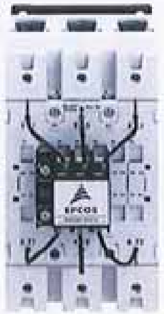
GENERAL ARRANGEMENT 500 kVAr 10x50 kVAr Steps

DRAWING No.

SCALE NTS | DIMENSIONS IN MILLIMETRES | SHEET NO. 1 OF 1 | REV 1 | SHEET SIZE A3

Switching Devices – Capacitor Contactors

General



Applications

-
- reactors

Features

-
-
-
-
-
-
-
-
-
- Voltage range: 400 … 690 V
- Output range: 12.5 … 100 kvar
-
-
- (B44066S****J***)

Approvals

-
- CCC

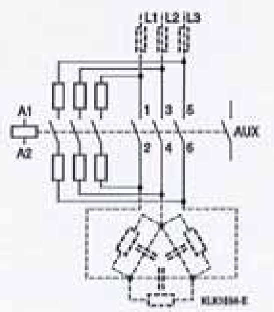
Switching Devices – Capacitor Contactors

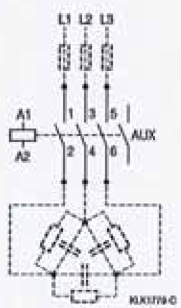
Type Main contacts			B44066*****J230/J110/N230/N110 S1810	S2410	S3210	S5010	S6210	S7410	S9010	S9910
Rated insulation voltage V_i Admissible frequency of operation Contact life	V_{is}	[V AC] 1/h million operations	690[1] 120 0.25	690[1] 120 0.15	690[1] 120 0.15	690[1] 120 0.15	690[1] 120 0.15	690[1] 80 0.12	1,000[1] 80 0.12	1,000[1] 80 0.12
Cable cross section solid or standard		[mm²]	1.5–6	2.5–25	2.5–25	4–50	4–50	4–50	0.5–95/10–120	0.5–95/10–120
flexible		[mm²]	1.5–4	2.5–16	2.5–16	10–35	10–35	10–35	0.5–70/10–95	0.5–70/10–95
flexible with multicore cable end		[mm²]	1.5–4	2.5–16	2.5–16	6–35	6–35	6–35	0.5–70/10–95	0.5–70/10–95
Cables per clamp			2	1	1	1	1	1	2	2
Operating range of magnet coils in multiples of control voltage	V_S		0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1	0.85–1.1
Auxiliary contacts[1] Rated insulation voltage V_i	V_{is}	[V AC]	690[1]	690[1]	690[1]	690[1]	690[1]	690[1]	690[1]	690[1]
Rated current I_{th} at ambient temperature max. 40 °C		I_{oth} [A]	16	10	10	10	10	10	10	10
max. 60 °C		I_{oth} [A]	12	6	6	6	6	6	6	6
Utilization category AC15 220 to 240 V		I_{oth} [A]	12	3	3	3	3	3	3	3
380 to 440 V		I_{oth} [A]	4	2	2	2	2	2	2	2
Short circuit protection Highest fuse rating slow, gL (gG)		I_{oth} [A]	25	20	20	20	20	20	20	20
Auxiliary contacts		NO/NC	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0

Capacitor power at ambient temperature, voltage, 50/60 Hz						Rated current		Weight	Ordering code
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.34	B44066S1810J110
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.60	B44066S2410J110
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.60	B44066S3210J110
20–50	20–50	23–53	23–53	36–82	36–82	72	72	1.10	B44066S6210J110
20–75	20–60	23–75	23–64	36–120	36–100	108	87	1.10	B44066S7410J110
33–80	33–75	36–82	36–77	57–120	57–120	115	108	2.30	B44066S9010J110*
33–100	33–90	36–103	36–93	57–148	57–148	144	130	2.30	B44066S9910J110*
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.34	B44066S1810J230
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.60	B44066S2410J230
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.60	B44066S3210J230
20–33.3	20–33.3	23–36	23–36	36–55	36–55	48	48	1.10	B44066S5010J230
20–50	20–50	23–53	23–53	36–82	36–82	72	72	1.10	B44066S6210J230
20–75	20–60	23–75	23–64	36–120	36–100	108	87	1.10	B44066S7410J230
33–80	33–75	36–82	36–77	57–120	57–120	115	108	2.30	B44066S9010J230*
33–100	33–90	36–103	36–93	57–148	57–148	144	130	2.30	B44066S9910J230*

Switching Devices – Capacitor Contactors

Capacitor power at ambient temperature, voltage, 50/60 Hz						Rated current		Weight	Ordering code
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.23	B44066S1810N110*
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.50	B44066S2410N110*
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.90	B44066S3210N110*
20–50	20–50	23–53	23–53	36–82	36–82	72	72	0.90	B44066S6210N110*
20–75	20–60	23–75	23–64	36–120	36–100	108	87	0.90	B44066S7410N110*
33–80	33–75	36–82	36–77	57–120	57–120	115	108	2.20	B44066S9010N110*
33–100	33–90	36–103	36–93	57–148	57–148	144	130	2.20	B44066S9910N110*
0–12.5	0–12.5	0–13	0–13	0–20	0–20	18	18	0.23	B44066S1810N230*
10–20	10–20	10.5–22	10.5–22	17–33	17–33	28	28	0.50	B44066S2410N230*
10–25	10–25	10.5–27	10.5–27	17–41	17–41	36	36	0.50	B44066S3210N230*
20–33.3	20–33.3	23–36	23–36	36–55	36–55	48	48	0.90	B44066S5010N230*
20–50	20–50	23–53	23–53	36–82	36–82	72	72	0.90	B44066S6210N230*
20–75	20–60	23–75	23–64	36–120	36–100	108	87	0.90	B44066S7410N230*
33–80	33–75	36–82	36–77	57–120	57–120	115	108	2.20	B44066S9010N230*
33–100	33–90	36–103	36–93	57–148	57–148	144	130	2.20	B44066S9910N230*





Reactors – Antiresonance Harmonic Filter

General

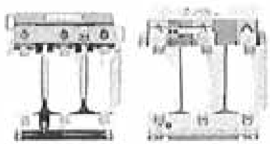
The increasing use of modern power electronic apparatus (drives, uninterruptible power supplies, etc) produces nonlinear current and thus influences and loads the network with harmonics (line pollution).

The power factor correction or capacitance of the power capacitor forms a resonant circuit in conjunction with the feeding transformer. Experience shows that the self-resonant frequency of this circuit is typically between 250 and 500 Hz, i.e. in the region of the 5th and 7th harmonics.

Such a resonance although can lead to the following undesirable effects:

- overloading of capacitors,
- overloading of transformers and transmission equipment,
- interference with metering and control systems, computers and electrical gear,
- resonance elevation, i.e. amplification of harmonics,
- voltage distortion.

These resonance phenomena can be avoided by connecting capacitors in series with filter reactors in the PFC system. These so called "detuned" PFC systems are scaled in a way that the self-resonant frequency is below the lowest line harmonic. The detuned PFC system is purely inductive seen by harmonics above this frequency. For the base line frequency (50 or 60 Hz usually), the detuned system on the other hand acts purely capacitive, thus correcting the reactive power.



Applications

- Avoidance of resonance conditions
- Tuned and detuned harmonic filters
- Reduction of harmonic distortion (network clearing)
- Reduction of power losses

Features

- High harmonic loading capability
- Very low losses
- High linearity to avoid choke tilt
- Low noise
- Convenient mounting
- Long expected life time
- Temperature protection (NC contact)

Technical data and limit values

Filter reactors	
Harmonics*	V_3 = 0.5% V_R (duty cycle = 100%) V_5 = 6.0% V_R (duty cycle = 100%) V_7 = 5.0% V_R (duty cycle = 100%) V_{11} = 3.5% V_R (duty cycle = 100%) V_{13} = 3.0% V_R (duty cycle = 100%)
Effective current	$I_{rms} = \sqrt{(I_1^2 + I_3^2 \ldots I_{13}^2)}$
Fundamental current	$I_1 = 1.05 \cdot I_R$ (50 Hz or 60 Hz current of capacitor)
Temperature protection	microswitch (NC)
Dimensional drawings and terminals	see specific datasheets

Three-phase filter reactors to VDE 0532 / EN 60289

Frequency	50 Hz or 60 Hz
Voltage	400, 440
Output	10 … 100 kvar
Detuning	5.67%, 7%, 14%
Cooling	natural
Ambient temperature	40 °C
Class of protection	I
Enclosure	IP00

* According to DIN ENV V61000-2-2

Reactors – Antiresonance Harmonic Filter

Characteristics

Power	Δ capacitance	Inductance	I_{rms} (I_{eff})	Losses*	Weight	Terminal	Ordering code
kvar	3 · µF	mH	A	W	kg		
Rated voltage V = 440 V, f = 50 Hz, p = 7% (f_r = 189 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.73 · I1							
10	50	4.64	14.9	71	6.5	4 mm² Kl.	B44066D7010S440
12.5	63	3.71	18.7	85	8.5	10 mm² Kl.	B44066D7012S440
25	127	1.87	37.2	170	18	Cu bars Ø 9 mm	B44066D7025M440
* 50	254	0.93	74.3	250	33	Cu bars Ø 9 mm	B44066D7050M440
75	382	0.62	111.4	340	43	Cu bars Ø 9 mm	B44066D7075M440
100	509	0.46	148.7	410	49	Cu bars Ø 9 mm	B44066D7100M440
Rated voltage V = 440 V, f = 50 Hz, p = 14% (f_r = 135 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.37 · I1							
10	47	10.04	14.0	87	10	4 mm² Kl.	B44066D1410S440
12.5	58	8.03	17.5	95	13	10 mm² Kl.	B44066D1412S440
25	117	4.02	35.0	160	27	Cu bars Ø 9 mm	B44066D1425M440
50	235	2.01	70.0	300	40	Cu bars Ø 9 mm	B44066D1450M440
75	353	1.34	105.0	440	53	Cu bars Ø 9 mm	B44066D1475M440
100	471	1.00	140.0	490	65	Cu bars Ø 9 mm	B44066D1499M440
Rated voltage V = 440 V, f = 60 Hz, p = 5.67% (f_r = 252 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 2.00 · I1							
25	107	1.24	42.0	125	18	M5 Al-flat	B44066D5025S441
50	215	0.62	83.8	210	25	M6 Al-flat	B44066D5050S441
75	323	0.41	126.0	300	33	M8 Al-flat	B44066D5075S441
100	431	0.31	167.4	400	47	M8 Al-flat	B44066D5100S441
Rated voltage V = 440 V, f = 60 Hz, p = 7% (f_r = 227 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.73 · I1							
25	106	1.55	37.2	130	18	Cu bars Ø 9 mm	B44066D7025M441
50	212	0.77	74.4	250	27	Cu bars Ø 9 mm	B44066D7050M441
75	318	0.52	111.4	320	39	Cu bars Ø 9 mm	B44066D7075M441
100	424	0.39	148.6	380	44	Cu bars Ø 9 mm	B44066D7100M441
Rated voltage V = 440 V, f = 60 Hz, p = 14% (f_r = 162 Hz) / Linearity: L ≥ 0.95 · L_R for current up to 1.37 · I1							
25	98	3.35	34.8	180	22	Cu bars Ø 9 mm	B44066D1425M441
50	196	1.67	69.5	290	34	Cu bars Ø 9 mm	B44066D1450M441
75	294	1.12	104.3	380	45	Cu bars Ø 9 mm	B44066D1475M441
100	392	0.84	139.1	480	54	Cu bars Ø 9 mm	B44066D1499M441

* Total max. losses, considering max. specified overvoltage and harmonic currents

Other voltages upon request

Power Factor Controller BR6000

Manual
Version 5.0

EPCOS AG
Power Quality Solutions
P.O. Box 80 17 09
D-81617 Munich
St.-Martin-Str. 53
PFC-Hotline
Tel. ++49 89 636 - 25533
Telefax ++49 89 636 - 22748
internet: http://www.epcos.com

CAUTIONS:

1. High voltage !

2. BR6000 may only be used indoor !

3. Make sure that the discharge time set in controller matches capacitor discharge time !

CONTENTS

Section1 General

The power factor controller BR6000 is a modern control device of innovative design with a variety of functions - now in version 5.0
It is designed for a measuring voltage of 30...525V (L-N) or (L-L) and a supply voltage of 110...230VAC.
It features a user interface with a menu-driven display in plain text for maximum ease of operation. Straightforward symbols and alphanumeric displays in the language of the country of use (nine languages) combine maximum ease of handling with convenient presentation of results.
Display of various grid parameters, storage of various values and a test run option make it easy to analyse errors and monitor the system.
An automatic initialization is available which will reduce the commissioning to a minimum.

Main features:

- ☑ Six or 12 switching outputs (depending on the type option for 7 or 13 outputs)
- ☑ Twenty pre-programmed control series with a self-optimized intelligent control response
- ☑ Control-series editor for user-defined control series
- ☑ Complete menu-guided operation and display
- ☑ Illuminated graphic display with 2 x 16 characters
- ☑ Four-quadrant operation
- ☑ Automatic initialization
- ☑ Display of various line parameters (V, I, F, Q, P, S...)
- ☑ Display of voltage and current harmonics
- ☑ Display and monitoring of temperature
- ☑ Monitoring of the individual capacitor power values
- ☑ Storage of maximum line-parameter and switching-operation values as well as of the turn-on times of individual capacitor contactors
- ☑ Manual / automatic operation
- ☑ Programming of fixed stages and the option of skipping individual outputs
- ☑ No-voltage turn-off
- ☑ Error detection for various states and interference-message output
- ☑ Complete 2nd parameter set programmable / switchable
- ☑ Test run of PFC system with error analysis
- ☑ Switchboard-integrated housing 144x144x55 mm

Type series and accessories

BR6000-R6	6 relays outputs, 1 alarm relay
BR6000-R12	12 relay outputs, 1 alarm relay
Option /F	Additional user programmable message relay Input for second parameter set Controller coupling possible (Master-Slave)
Option /S485	Like option /F with additional interface RS485
Accessories	- MMI6000 - MultiMeasuringInterface (for measurement of inherent current of capacitor bank) - Interface converter "RS485 to USB" for PC-connection - Interface converter "RS485 to RS232" for older Pcs

The controller is supplied as standard for an operating voltage of 110...230 VAC (+-15%), a measuring voltage of 30...525 VAC (L-N) or (L-L) and a measuring current of 5A or 1A. A voltage converter is required for different operating voltages.

Caution!
Voltages which exceed the specified voltage range can damage the device!

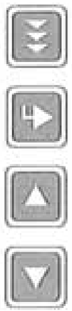
Fig.1 BR6000 front view

Operating mode
- Automatic
- Programming
- Manual operation
- Service
- Expert mode

Enter / OK
Confirm and store values

Increase selected parameter

Reduce selected parameter



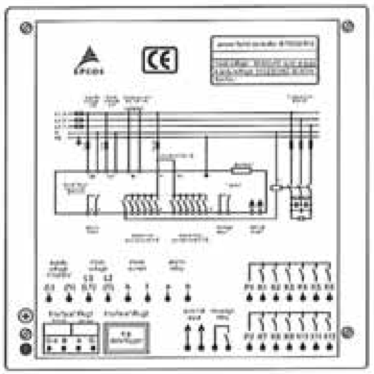


Fig. 2 BR6000 rear view

Section 2 Installation and connection of the controller

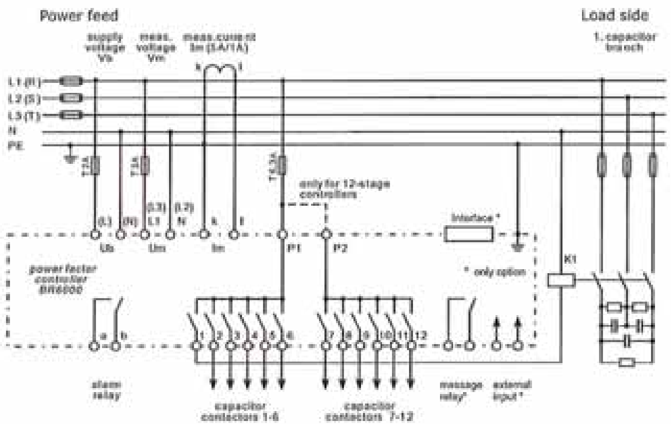
The BR6000 is designed to be incorporated into the front panel of a PFC-cabinet. It requires a switchboard section of 138 x 138 mm to DIN 43700/ IEC 61554. The controller is inserted from the front and is attached by means of the appended clamps. The controller may be inserted only by qualified technicians and must be operated in accordance with the specified safety regulations.
Before the BR6000 is connected up, all leads and cables must be checked to ensure that no current is flowing through them and the current converter must be short-circuited. Care should be taken to ensure that the measuring voltage and current are in the correct phase position. The measuring-current circuit must be wired with copper leads of 2.5mm². The connection should be set up as shown in Fig. 3. The specified safety regulations must be observed.

The measuring voltage may lie in the range from 30 - 525 VAC and can be connected between L - N (default) or between L - L (programming of phase correction needed)

The operating voltage is 110...230 VAC +/- 15% and can be connected between L - N or L -L (depending of the grid).

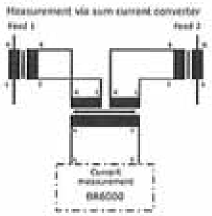
The coil voltage for the capacitor contactors and the measuring voltage must be drawn from the same phase conductor, as only the measuring voltage is monitored. (Protection against direct reconnection of the capacitor contactors in the event of momentary single-phase power failure)

Fig. 3: BR6000 Connection plan



2.1 Current measurement

When installing the current converter, care should be taken to ensure that the load current flows through it. The outputs of the compensation network must be installed behind the current converter (in the direction of current flow). If the BR6000 is connected up via sum-current converters, the overall conversion ratio is entered.
Current converter clamps should be grounded on one side!



Caution !
Current converter clamps should be grounded on one side !

Example:
C.converter 1: 1000/5A
C.converter 2: 1000/5A
Sum-current converter: 5A+5A/5A

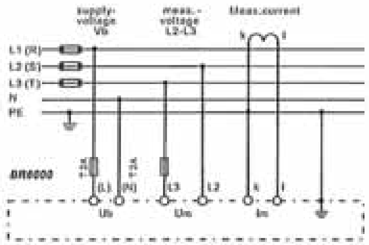
C.converter ratio is: 2000/5A

2.2 Programming of phase-correction - e.g. connection directly L-L (400V)

Adjustment of phase-correction between voltage and current in the meas. system is done in expert mode 1 (page 17)

Example :

Meas.current: L1
Meas. Voltage L3-L2
Phase U/I [90°]



using	meas. current	meas. voltage	phase-angle
Preset:	L1	L1 - N	0°
	L1	L1 - L2	30°
	L1 (k<->l)	L2 - N	60°
	L1	L3 - L2	90°
	L1	L3 - N	120°
	L1	L3 - L1	150°
	L1 (k<->l)	L1 - N	180°
	L1 (k<->l)	L1 - L2	210°
	L1	L2 - N	240°
	L1	L2 - L3	270°
	L1 (k<->l)	L3 - N	300°
	L1 (k<->l)	L3 - L1	330°

2.3 Alarm output / error messages

The alarm contact is closed in normal operation and opens in the event of a fault. The relevant fault is simultaneously shown on the display in plain text (alternating with the standard display in automatic operation). The following fault messages are displayed:

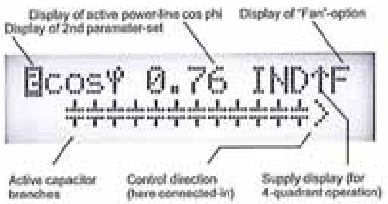
UNDER-COMPENSATED missing reactive power	Display and relay output
OVER-COMPENSATED	Display and relay output
OVERCURRENT	Display and relay output
MEASURING VOLTAGE ?	Display and relay output
OVERTEMPERATURE	Display and relay output
OVERVOLTAGE	Display and relay output
UNDERVOLTAGE	Display and relay output
HARMONICS	Display and relay output

Additionally several messages for different operation states are generated. An individual adjustment resp. suppression of particular messages is possible in expert mode 2. During suppression, the indication of the message in the display, a possible release via alarm-relays and effects on the controlling process will be prevented.

Section 3 Operating modes

When the operating voltage is switched on, the BR6000 briefly displays its designation and software version, then changes to its normal operating status (automatic operation). The active cos-phi value is always displayed in the upper line and the currently connected capacitors are shown as symbols in the lower line (operating display).

Automatic operation



The control direction is symbolized by a closed arrow

▶ Connecting-in

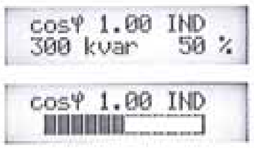
◀ Connecting-out

The connecting-in arrow is always located after the maximum possible number of stages (end stop)

\> An open arrow indicates that the required blocking time (discharge time) is running before an impending switching step

▶▶ A double arrow symbolizes fast switching of several branches

By pressing the cursor buttons, the display of capacitor stages can be changed:

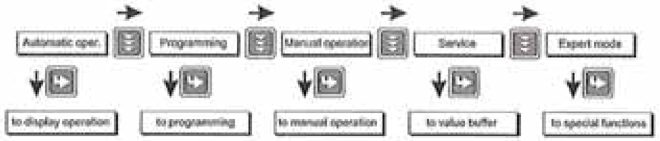


Display of activated stages in kvar and in percent of total output of PFC system

Display of activated stages as bar-graph display in percent of total output of PFC-system

The power values of the individual capacitors are monitored constantly. **If a capacitor is defective or if the deviation from the rated power is excessive, the corresponding capacitor is displayed inversely.**

Repeated pressing of the "Operating Mode" key takes the user to the various menus in sequence: **Auto**matic operation - **Program**ming - **Manual** (manual operation)- **Service**- **Expert** mode and back.



Section 4 Automatic operation - display of network parameter

The BR6000 is set to automatic operation as standard (not AUTO-INIT). Capacitor stages are then automatically connected in or out in order to reach the target power factor. This happens when the required reactive power exceeds the value of the smallest capacitor stage.
In automatic operation, various network parameters can be displayed by repeatedly pressing the "ENTER" key:

Action	Display
ENTER	1 LINE VOLTAGE in V /%
ENTER	2 APPARENT CURRENT in A /%
ENTER	3 REACTIVE POWER in kvar /%
ENTER	4 ACTIVE POWER in kW /%
ENTER	5 APPARENT POWER in kVA /%
ENTER	6 DIFF. kVAR TO TARGET COS
ENTER	7 FREQUENCY in Hz
ENTER	8 TEMPERATURE in °C / °F
ENTER	9 HARMONICS (3.-19) V/%, I/% Selection via arrow-keys
ENTER	10 THD-V, THD-I in %
ENTER	11 Comp. power (only with MMI6000)
ENTER	Software version
ENTER	Return to: 1

The power value specifies the total power (3-phase) assuming symmetrical load. If no key is pressed for 60 seconds, the display automatically returns to the operating status!

Section 5 Programming

Pressing the "Operating mode" key once takes the user from automatic operation to **Programming** mode. Parameter 1 (I-CONVERTER) is reached by pressing "ENTER".
The upper display always shows the parameter and the lower one the set value. The values are changed by pressing the ↑ / ↓ keys. Subsequent pressing of the "ENTER" key stores the value and takes the user to the next parameter.
Description of the parameters: **See the next page**
To quit programming mode in any step, press the "Operating mode" key.

5.1. Automatic initialization

With the automatic initialization the BR6000 will automatically recognize the parameters of the PFC-system. It also serves as plausibility check and storage of these parameters - the user only has to make very little or even no adjustments.
Start of the initialization process is done from the menu point "PROGRAMMING" by pressing the button "↑"
AUTO-INIT [YES] to be confirmed with pressing the ENTER button.

```
AUTO - INIT
[YES]
```

```
1 CURRENT TRANS.
  [UNKNOWN]
```

If the values of the current transformer OR the value of the first stage of the PFC-system are known, they should be entered here. This later enables a display of all values of the net in the correct electrical term. If no value is programmed (selection: unknown), values of current and output can later only be indicated as percent.
After entering of the a.m. values (selection via "↑ / ↓" buttons,confirmation with ENTER) the automatic test-run of the BR6000 is performed.

```
TEST 1   69 kvar
```

```
TEST 3   76 kvar
```

3 test-runs will be performed during which all stages are being switched on and off. All necessary parameters are collected, evaluated and stored. Under certain circumstances 3 additional test-runs may be required for a proper initialization.
After successful finalization of AUTO-INIT the BR6000 will switch to normal operation.

In case of recognition of any discrepancies (plausibility) or of inaccurate connection, the detected error will be displayed in plain text after finalization of AUTO-INIT and can be eliminated. (see possible error messages at the end of the manual). AUTO-INIT may be repeated then.

NOTE: If the BR6000 has been put into operation successfully by AUTO-INIT with all values unknown, some values will be shown as "????" and this can not be changed. If a new programming is required, a reset is needed before: Programming/Basic settings [YES]

5.2. Manual programming (program menu)

LANGUAGE SELECTION: This selects the language of the operating menu
(German, English, Spanish, Portuguese, French, Russian, Cz, NL,PL)

1 I-CONVERTER PRIM: [5...13000]A
This selects the primary current of the current converter. Adjustment is via the ↑ / ↓ keys. Save and continue with ENTER

2 I-CONVERTER SEC: [5 or 1]A
This sets the secondary current of the current converter
Selection via ↑ / ↓. Save and continue with ENTER

3 END STOPP: [6/7 resp. 12/13] switching to 7/13.stage in expert-mode 2
By setting the end stopp, the number of active capacitor branches is matched to the respective capacitor bank. This is done via the ↑ / ↓ keys. The visible symbols of the capacitors correspond to the connected outputs. The maximum possible number of capacitor branches is pre-set at the works (BR6000-R12:12 branches).
Save and continue with ENTER

4 CONTROL SERIES: [1...20 + E]
The ratio of the capacitor branch power determines the control series, the power of the first capacitor always being assigned the value 1. The control series required for the compensation network is again selected via the ↑/↓ keys. If the required control series should exceptionally not be present (Annex 1), the user may define a special one (control series "E").More on this point in the control-series editor in Annex 1.
Save and continue with ENTER

5 CONTROL PRINCIPLE: The control preference may be selected here:

SEQUENTIAL connection
LOOP connection
INTELLIGENT loop connection (default setting)
COMBINED CHOKE
See Section 9 for an explanation of the various control modes.
Selection with ↑ / ↓ keys. Save and continue with ENTER

6 POWER 1. STAGE: [0.01 ... 255.99] kvar
To determine the controller's response sensitivity, the dimensions of the network's smallest capacitor (stage 1) must be known. They are entered in two steps in kvar. The integral kvar values (before the comma) are initially selected via the ↑ / ↓ keys and saved with ENTER. The positions after the comma are then selected, again via the ↑ / ↓ keys. If the response sensitivity of the BR6000 is being undercut, a warning will occur (indication of "I" in the display)
Save and continue with ENTER

7 TARGET COS PHI: [0.3ind ... 0.3cap]
By setting the target cos phi, the power factor to be attained via the PF correction is defined. It is also set via the ↑ / ↓ keys.
Save and continue with ENTER

8 MEASURING VOLTAGE [30 ... 525]V

Programming the measuring voltage of the system.

The values programmed here always refer to the voltage at the clamps of the BR6000 !

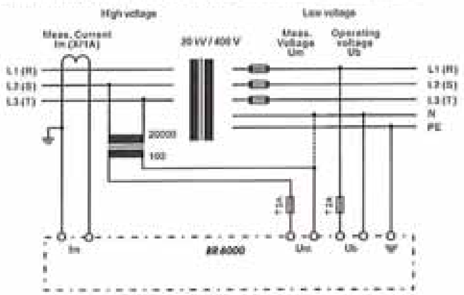
The voltage is selected via the ↑/↓ keys. Save and continue with ENTER.

9 V - CONVERTER RATIO [NO / 1.1 ... 990]

When a measuring-voltage converter (e.g. for HV- measurement) is used, its conversion ratio should be programmed here.

Example: Voltage converter 20000V:100 V => Conversion ratio: 200

Selection via the ↑/↓ keys. Save and continue with ENTER.



10 CONNECTING TIME

This refers to the time between connecting the capacitors to increase the momentary network capacitance. It should be noted that in practical operation the real connection time is affected by the discharge time (locking time).

Setting range: 1 sec. ... 20 min. (long time for HV- networks)

Default setting: 40 sec.

Selection is performed via the ↑/↓ keys. Continue with ENTER

11 DISCONNECTING TIME

This refers to the time between disconnecting the capacitors to reduce the momentary network capacitance.

Setting range: 1 sec. ... 20 min. (long time for HV- networks)

Default setting: 40 sec.

Selection is performed via the ↑/↓ keys. Continue with ENTER

12 DISCHARGE TIME

This is the time for which an individual output is blocked between connecting and disconnecting. This blocking time has priority over connecting and disconnecting times. It depends on the capacitor discharge rating and thus is specified by the compensation network. The discharge time of a conventional network without additional fast-discharge resistors or chokes should be set to no less than 40 seconds. For setting of a second discharge time see 'Expert Mode' point 10

Setting range: 1 sec ...20 min. Default setting: 60 sec.

Selection is performed via the ↑/↓ keys. Continue with ENTER

13 ALARM TEMP [50...85]°C

The alarm temperature programmed here is the temperature at which the capacitor stages are disconnected in steps. The controller's **alarm relay** responds after ten minutes. At the same time the display shows the cause of the alarm (over-temperature). If the temperature drops again, the required branches are automatically re-connected in steps.
The selection is performed with the ↑/↓ keys. Save and continue with ENTER.

14 MESSAGE RELAY (available not in each type)

The message relay can be programmed for one of the following options as required:

"Fan": (Default) Relay switches the external cabinet fan.
The switching threshold can be programmed under point 15.
Display: **"F"**

"Supply": Message when active power is supplied. Display: **"S"**

"Undercurrent": This message appears whenever the measuring current is not reached. Display: **"U"** The signal is generated when the value drops below the response sensitivity of the controller.

"External": The relay switches if an external input signal (230 VAC) is sent to the "external" input. This function may be used to directly compensate a larger load, for example - the required 40-second reconnection delay is already integrated.
Display: Capacitor symbol at the top right of the first line.
When this function is selected, the input cannot be used for the signal '2nd parameter set' and the output cannot be used for the fan.

"Harmonics": This message appears when the limit of the total harmonic distortion THD-V is exceeded. This value can be set under "27 Harmonics" in%

"Remote control R1": Coupling of two controllers via remote control input,
R1= Controller is configured as controller 1 (master)

"Remote control R2": Coupling of two controllers via remote control input,
R2= Controller is configured as controller 2 (slave).
A description for the coupling of two controllers can be found in the annex. When this function is selected, the input cannot be used for the signal '2nd parameter set' and the output cannot be used for the fan.

Selection is via the ↑/↓ keys. Save and continue with ENTER.

15 FAN TEMP* [15...70]°C
Input of the switching threshold for the fan. Only active if option 'Fan' is selected (temperature input as described under point 13)

16 Programming of 2nd parameter set* [NO] (YES / NO)
2 * only applicable for controllers with option /F or /S
* only active if message relay is programmed as "FAN", "SUPPLY" or "UNDERCURRENT"

As a standard, the values of the 2 parameter set are equal to the values of the normal parameters. By changing particular parameters, for example the cos-phi can be switched. Other possible applications may be switching of current transformer or switching of switching times.
By triggering of a 230 V-signal at the external input, the 2nd parameter set will be activated with the following values:

17. I-converter prim, 18. I-converter sec. 19. End stopp, 20. Control series,
21. Control principle, 22. Power 1.stage, 23. Target cos-phi, 24. Switch-on time,
25. Switch-off time, 26. Discharge time

The values of the 2nd parameter set and the indication of activation is marked with the following symbol in the display. 2

27 HARMONICS (harmonic limit) [7]% (0.5 ... 25,5)%
A limit for the total harmonic distortion THD-V (in%) can be entered here. When this threshold is exceeded, a message is given. THD-V is the ratio of the geometric sum of the uneven harmonics to the fundamental. A warning is always shown in the display; an output via message relay only takes place when this was selected under point 14.
Selection is performed via the ↑/↓ keys. Save and continue with ENTER

BASIC SETTING: [NO] (YES / NO)
When the selection is made with YES and confirmed with ENTER, all parameters are reset to the basic setting made by the PFC-system manufacturer.
(Optimal network values when the controller was supplied with a complete PFC-system). If the controller is supplied from the works, this point corresponds to the default setting. **CAUTION: All user settings are lost!**

Programming is now completed. The controller has returned to point 1 of the programming menu.

5.3 Programming lock

The BR6000 is equipped with a programming lock to ensure protection from unauthorized or inadvertent changes to the system parameters. The lock can be activated in expert mode. If the lock is active, all parameters can be checked but not changed.

Section 6 **Manual operation (initial operation, maintenance, service)**
Programming of fixed stages

In manual operation, capacitor branches can be connected/disconnected **in the set control series and switching time** - irrespective of prevailing power-line conditions. The starting condition is STOPP (no stages connected). Connections are made by pressing the ↑ key. Pressing ↓ initially leads back to STOPP mode. Repeated pressing of ↓ leads to the disconnection of stages. The active operating status and active power factor are always shown on the display (self-explanatory).

Manual operation

Pressing ENTER takes the user to the menu point "Programming of fixed stages".
In the normal case, all stages are programmed for automatic operation (default setting).

Setting of fixed stages

In special cases, all controller outputs (C1 - C12) may be permanently defined in succession (continued switching via ENTER) for the following statuses:

AUTO: Automatic (normal) operation
The relevant output is marked by a capacitor symbol.
FIXED: The output is continuously connected, e.g. for fixed PFC. The output is marked by an underlined capacitor symbol.
OFF: The output is continuously disconnected - e.g. for temporarily disconnecting a defective capacitor. The capacitor symbol for this output is faded out. Underlining appears.

The active stage is blinking. The required status is set via ↑ /↓. By pressing ENTER, the user saves this step and moves to the next stage.
The programmed statuses for the outputs also remain visible on the display in automatic operation.
After the required settings have been made, pressing the "Operating Mode" key takes the user to the next menu ("Service") or further to "Automatic Operation".

Section 7 Service menu

The service menu is reached by the operating-mode key.
The stored maximum values of the network parameters can be displayed here as well as the number of switching operations of the individual capacitors and their operating time.
The desired stages [in square brackets] can be selected via the arrow keys.
In addition, a fault memory is available, in which the last 8 fault states of the system are stored with fault code and in plain text. (This allows, for example, capturing short lived events of overtemperature or overvoltage)

Action	Display	
ENTER	1 min/max. VOLTAGE	in V
ENTER	2 max. REACTIVE POWER	in kvar
ENTER	3 max. ACTIVE POWER	in kW
ENTER	4 max. APPARENT POWER	in kVA
ENTER	5 max. TEMPERATURE	in °C / °F
ENTER	6 max. THD - V / THD - I	in %
ENTER	7 RESET the maximum values	
ENTER	8 SWITCHING OPERATIONS	C [1] - ...
+/-	to C [12]	
ENTER	9 OPERATING TIME	C [1] - ... in h
+/-	to C [12]	
ENTER	ERROR MEMORY E [1] -	in plaintext
ENTER	ERROR MEMORY RESET	
ENTER	TEST RUN	
ENTER	C-POWER (only after a test-run or AUTO-INIT)	
ENTER	Back to 1	

TEST-RUN
This menu point allows the user to check the settings of the PFC controller. After activation of the test run, the controller switches each stage on and off successively and calculates the output of the capacitors connected (this procedure is done three times to eliminate possible errors). The values calculated are stored and can be retrieved in the following menu item (C-POWER). At the same time, a plausibility check is conducted with the values programmed.
Any discrepancies found are evaluated and displayed in plain text. The following errors can be displayed:

- No measuring voltage present
- Measuring voltage too high - check programming
- Measuring voltage too low - check programming
- No measuring current? - Short circuit link in current transformer?
- Phase angle current transformer? k/l or phase transposed ?
- Current transformer ratio / 1. Step power wrong ?
- Control series? - check programming
- End stop? - check programming
- Capacitor defect or wrong power input

Note: The results displayed are messages intended to help the user trace the cause of the error. Final evaluation remains the responsibility of the user. Under complicated (high load fluctuations) grid conditions, 100% error recognition cannot be guaranteed.

Section 8 Expert mode 1 and 2

The expert mode is meant for the adjustment of values which normally should not be changed. As a protection against mal-operation this level has an access code branching out in Expert mode 1 or 2.

Password: Expert mode 1: " 6343" Expert mode 2: "2244"

8.1. Expert mode 1

2 BASIC SETTING NEW [NO] (available: NO/YES)
Storage of active programming as a new basic setting (usually performed by the PFC-system manufacturer). Caution: The original values are overwritten in the process!

3 SWITCHING OPERATIONS RESET [NO] (available: NO/YES)
The stored switching operations of all capacitor stages are reset to zero. Caution: No information is then available about the switching frequency of the stages and thus the status of the network. (Reset of individual stages in Expert-mode 2)

4 OPERATING TIME RESET [NO] (available: NO/YES)
The stored operating times of all outputs are set to zero.
(Reset of individual stages in Expert-mode 2)

5 INTEGRATION TIME [1] s (1...255 sec.)
The integration time (the time required to form the mean values of a measurement) can be changed for special applications.

6 SWITCHING POWER max [100] kvar (multiples of the smallest stage)
This factor specifies the maximum power which may be switched in one switching step. It can be used to control the intelligent control system, which switches several stages as a function of the power-factor requirement.

7 SWITCH.TRIGGER [66]% (30...100%)
Threshold for switching on of next stage. It should not be changed in the normal case!

8 OPERATING LOCK [NO] (NO / YES / 24H)
24H means, that it will be locked automatically after 24 hours

9 SWITCHING OPERATIONS WARNING [50]T (1...255)
After an output has performed this number of switching operations (in thousands), a warning message is displayed. (Abrasion of capacitor contactors and capacitors)

10 FAST DISCHARGE [NO] (NO or X for the desired stages)
If only some stages of a network are equipped with fast discharge equipment, those stages can here be indicated with X. In this case, the desired discharge time for these stages can be specified in the next menu point. Otherwise, menu point 11 is omitted.

11 DISCHARGE TIME [1] s (1s ..programmed normal discharge time)
Only available when fast discharge is programmed. The specified discharge time is then also included in the normal display.

12 PHASE I [0°]
[L1] - L1 - N] Adjustment of current phase position

13 PHASE V [0°]
L1 - [L1 - N] Adjustment of voltage phase position

Phase correction between voltage and current in the measuring system.
(See example p.6)

14 C-TEST [YES] (YES / NO)
The power of the particular capacitor stage is calculated during each switching operation and compared with the stage output of the capacitor. If the result varies from the nominal value, an error message is generated. This test can be stopped here.

15 C-FAULT [40] % (10...75 %)
The deviation from the rated value of the capacitor, for which a fault message is generated, can be specified here (see point 14)

16 TEST ATTEMPTS [5] (1...9)
When at least this number of successive measurements has resulted in a fault in the capacitor power, a C-fault message is output.

17 OUTPUT 1. STEP [0...255] (0...2550)
The range for entering the stage output can be increased to [0...2550] here, (e.g. for medium voltage measurement)

18 CONTROL [3] PHASE (3 / 1)
The measuring system of the controller is generally based on single-phase measurement. For all standard settings (three-phase), the measurement is converted and all outputs displayed as three-phase values (symmetry in grid assumed). In the single-phase setting, display and control apply only to the single-phase value measured (application: single-phase correction in asymmetrical grids).

19 PROTOCOL *only with option .../S (interface)

[MODBUS RTU]	MODBUS protocol for individual usage
[MODBUS KTR]	
[MASTER MMI]	when using the MMI6000 for measurement of PFC-current
[ASCII OUT]	output of grid-values as ASCII-file (s.page 20) individual configuration of the protocol possible
[EXTERN]	for usage of an external measuring device (e.g. MMI6000)

Depending on the protocol selection, the appropriate configuration-menu is offered:

20 BAUD RATE	[9600]	(4800...38400)	Transmission rate
21 ADDRESS	[1]	(1 ... 32)	Address
22 Number of MMI	[1]	(1 ... 9)	Nos of connected MMI
23 UPPER VALUE	[130]%	(110 ...200%)	Switch. threshold MMI
24 LOWER VALUE	[60]%	(40 ... 90%)	Switch. threshold MMI
25 ASCII time	[10]sec.	(1...255 sec)	Repetition-time ASCII
26 Type	of the external measuring device		

8.2. Expert mode 2 (Password: 2244)

The additional 2nd expert mode includes all messages for operation, warning and error which are displayed by the BR6000. Here they may be deactivated separately. When deactivated, the indication of the message in the display as well as possible activation of the relay or effects on the control behavior are suppressed (detailed list of all messages s. menu plan last page).
Also, the alarm relay may be programmed here as 7. / 13. stage. Switching operations/operation time of the capacitors can be set back separately.

EXPERT MODE 2 [YES] (YES/NO)

2 ALARM RELAY (ERROR) (Error / 7.or 13. stage / Message relay)
Selection whether the alarm relay should be used for error message or as additional 7th or 13th stage or as message relay for the standard controller of 6 and 12 steps.

Activation of particular operation, warning and error messages (s. above) (23 messages in total)

3 ALARM DELAY TIME [10] min. (1...255min.)
Time after which the alarm relay will respond

4 UNDERVOLTAGE [50] % (20 ...100 %)
meas. voltage below this threshold will switch OFF all stages at the same time

5 OVERVOLTAGE [115] % (105 ...140 %)
meas. voltage above this threshold will switch OFF the stages step by step

If the measure voltage returns to the permissible range, the stages will switch ON again.

6 SWITCH. OPERATIONS C1 RESET [NO] (YES/NO)
to
C12 RESET [NO] (YES/NO)
Reset of switching operations of particular capacitors possible, e.g. after replacement of particular capacitors or contactors

7 OPERATION TIME C1 RESET [NO] (YES/NO)
to
C12 RESET [NO] (YES/NO)
Reset of operation time of particular capacitors possible, e.g. after replacement of particular capacitors

Section 9 Control principle

The control response of the BR6000 can be selected in programming mode. In principle, the controller has four different control modes:

1. Sequential connection
In sequential connection, the required capacitor stages are successively connected and disconnected in stages (last in - first out). The ranking of each step always corresponds to the power of the smallest stage.
Advantage: Exact definition of the next capacitor to be connected in each case
Disadvantage: Long settling time, high switching frequency of the small stages

In order to shorten the settling time, the BR6000 switches several stages simultaneously for a large power-factor requirement. This applies to all control types. The maximum dimensions of the simultaneously switching branches can be changed in expert mode. If the value of the smallest stage is pre-selected, the conventional sequential connection is obtained.

2. Loop connection
In this variant, the controller operates in loop mode (first in - first out) which minimizes the wear on the capacitor bank, i.e. where stages are of equivalent dimensions, the stage which was disconnected for the longest period of time is always connected next.
Advantage: Balanced utilization of equivalent stages and thus an increased operating life of the capacitor bank.
Disadvantage: This mode can only be used in control series with groups of the same stage power and long settling time, as every switching step corresponds to the value of the smallest stage.

3. Intelligent loop connection (default setting)
The intelligent control principle combines the advantages of the network-sparing loop connection (first in - first out) with a much faster settling time, even for large load skips, and reaches this goal with the fewest possible switching operations of the capacitor stages. The optimized time response is achieved by the simultaneous switching of several or larger capacitor groups as a function of the missing power factor in the power line. Both the number of real switching frequencies of the capacitors as well as the turn-on times of the branches are considered.
Advantage: Reaches the target cos phi in a fast-optimized settling time with a low switching frequency of the capacitors.

4. Combined de-tuning (special case for combined de-tuned banks)
Within a combined de-tuned application, 2 adjoining equal steps are switched with just one joint choke. This pairwise de-tuning requires an appropriate closed control series (i.e. 1:1:1:1..., 1:1:2:2..., 1:1:2:2:4:4... or similar)
The condition for the switching behavior is defined in such a way that the number of activated odd steps is always greater than or equal to the number of activated even steps. The controller complies with the requirements of the control regime while largely conforming to the intelligent switching behavior.

Section 10 Interface *(option)

The BR6000 is equipped with an RS 485 interface as an option.
It can be used to implement the following functions:

- ☑ Full parametrization of the controller via a PC
- ☑ Remote read-out of all parameters during operation and displays via a PC
  Display, logging and analysis of all grid parameters
  with software "*BR6000-Soft*" (version 5) for Windows.
  (see separate description of the software)
- ☑ Connection of system accessories
  e.g. remote display or data-logger
- ☑ Selection of MODBUS (see Annex 5) or ASCII (see table below) for permanent display of grid parameters in ASCII format). Any ASCII editor can be used.

  Using with MMI6000 e.g. for measurement of inherent current of capacitor bank or for current measuring at a long distance between CT and BR6000

The following data are permanently displayed and refreshed via ASCII (ASCII Protocol):

Voltage	e.g.	"230 V"	
Current	e.g.	" 85 A"	
Power factor	e.g.	"-0.98"	means: CAP
Reactive power	e.g.	"100 kvar"	
Active power	e.g.	"100 kW"	
Apparent power	e.g.	"100 kVA"	
Outputs	e.g.	"XXX--------"	means: 3 steps active

An individual configuration of the ASCII-protocol is possible in expert-mode 1: points 26 and following.

Section 11 Initial operation

The controller must have been installed before being set up and operated.
All network-specific parameters are fully programmed as described in section 5 (Programming) by being entered in sequence and stored. The controller is then set to automatic operation with the operating mode key. It is now ready for operation.

Section 12 Maintenance and warranty

The BR6000 should need no maintenance if the operating conditions are observed. However, it is recommended that a functional check of the controller be performed in conjunction with the regular checking of the capacitor bank. In the event of any interventions in the controller during the warranty period, all warranty claims lapse.

Section 13 Troubleshooting

Fault	Check / Solution
At target cos phi=1 and inductive load, switch-off or connection of capacitor in the corrected line Supply / Drawing mismatched	Check terminals of the measuring voltage and current (l and k)! Check phase position
Wrong line cos phi is displayed	See above
Display: "UNDER CURRENT"	Current in measuring range? Line interruption? Wrong current-converter factor? Current transformer short-circuited?
Display: "OVERCURRENT" Alarm relay: after 10 min.	Check current-converter ratio Go through measuring current range
Display: "UNDERCOMPENSATED" Alarm relay: after 10 min.	Check connection and phase position! All stages connected - target cos phi not reached: compensation network sufficiently dimensioned?
Display: "OVERCOMPENSATED" Alarm relay: after 10 min.	Check connection and phase position! Capacitive grid, although all stages disconnected
Display: "MEASUREMENT VOLTAGE ???" Alarm relay: after 10 min.	No measurement voltage!
Display: "OVERTEMPERATURE" Alarm relay: after 10 min.	Cabinet temperature too high: Outputs are switched off in stages irrespective of power-line conditions
Stages are disconnected for an inductive line or connected for a capacitive line	If a target cos phi is set which deviates from 1 despite an inductive line load, the display < (disconnect stages) may light up. The arrows indicate the control direction and not the line conditions.
The controller does not connect all stages, or cos phi does not change at the last stages	Check END STOPP !
In automatic operation, individual stages are not connected or disconnected	Check whether individual stages are programmed as fixed stages or OFF in the "Manual operation / Fixed stages" menu!
In strongly asymmetrically loaded lines, differences may occur between control response and power-factor measurement, as the power factor is measured in single phase.	Line measurements allow the most favorable phase for measuring the power factor to be determined. The current converter is set accordingly for the measuring current.
No operating voltage	Note: No display, alarm relay is activated (open)

Section 14 Technical data

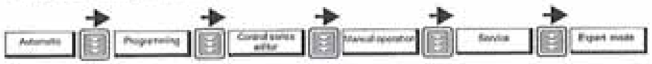
Type series	BR6000....
Outputs	6 or 12 (13)
Languages	D / E / ES / RU / NL / CZ / PL / F / PT
Switching power of relay outputs	250 VAC, 1000 W
Number of active outputs	Programmable
Operation and display	Illuminated graphic display 2 x 16 characters with convenient operating level
Number of control series	20
User-defined control series	1
Control principle	Sequential connection, loop connection or self-optimized switching response Four-quadrant operation
Auto-Init	YES
Operating voltage	110...230 VAC +/-15%, 50 / 60Hz
Measuring voltage	30...525 VAC, 50 / 60Hz
Measuring current	X : 5 / 1A selectable
Power drawn	< 5 VA
Sensitivity	50 mA / 10 mA
Target cos phi	0.3 inductive to 0.3 capacitive adjustable
Connecting time	Selectable from 1 sec ... 20 min.
Disconnecting time	Selectable from 1 sec ... 20 min.
Discharge time	Selectable from 1 sec ... 20 min.
Fixed stages/ skipped stages	Programmable
Alarm relay	Standard
No-voltage triggering	Standard
Display of power-line parameters	Power factor, voltage, apparent current, frequency, reactive-, active-, apparent power, missing kvar, temperature, harmonics
Storage of maximum values	Voltage, reactive power, active power, apparent power, temperature, THD-V, THD-I
Storage of switching number	Yes, each output, individual reset possible
Storage of operating time	Yes, each capacitor, individual reset possible
Temperature measurement range	-30 ... 100°C
Error memory	Last 8 error states are stored
2nd parameter set	Available at version /F and /S
Accuracy	Current, voltage: 1% Reactive-, active-, apparent power: 2%
Housing	Switchboard-integrated housing DIN 43 700, 144 x 144 x 53 mm
Weight	1 kg
Operating ambient temperature	-20 to +60°C
Protection type to DIN 40 050	Front: IP 54, Rear: IP 20
Safety guidelines	IEC 61010-1:2001, EN 61010-1:2001
Sensitivity to interference (industrial areas)	EN 50082-1:1995 IEC 61000-4-2: 8kV IEC 61000-4-4: 4kV
Option /F	Additional external input Additional user programmable message relay
Option /S 485	As option /F with additional interface RS485

Annex 1: Table of control series

No.	Control series	Loop connection
1	1:1:1:1:1:1:1:1:1:1:1:1	Possible
2	1:2:2:2:2:2:2:2:2:2:2:2	Possible
3	1:2:3:3:3:3:3:3:3:3:3:3	Possible
4	1:2:3:4:4:4:4:4:4:4:4:4	Possible
5	1:2:4:4:4:4:4:4:4:4:4:4	Possible
6	1:2:3:6:6:6:6:6:6:6:6:6	Possible
7	1:2:4:8:8:8:8:8:8:8:8:8	Possible
8	1:1:1:1:2:2:2:2:2:2:2:2	Possible
9	1:1:1:1:1:6:6:6:6:6:6:6	Possible
10	1:1:2:2:2:2:2:2:2:2:2:2	Possible
11	1:1:2:2:2:4:4:4:4:4:4:4	Possible
12	1:1:2:2:4:4:4:4:4:4:4:4	Possible
13	1:1:1:2:2:2:2:2:2:2:2:2	Possible
14	1:1:2:3:3:3:3:3:3:3:3:3	Possible
15	1:1:2:4:4:4:4:4:4:4:4:4	Possible
16	1:1:2:4:8:8:8:8:8:8:8:8	Possible
17	1:2:2:3:3:3:3:3:3:3:3:3	Possible
18	1:2:3:4:4:8:8:8:8:8:8:8	Possible
19	1:2:2:4:4:4:4:4:4:4:4:4	Possible
20	1:2:2:2:4:4:4:4:4:4:4:4	Possible
"E"	Control-series editor	Possible

Control-series editor (programming up to a rating of 30)

The control-series editor allows the user to simply define his/her own control series if the required control series is not available for any reason.
The last control series - Control Series E - is selected by pressing the "Programming" key (point 4: Control series) and confirmed with ENTER. This leads to the insertion of an additional menu point in the main menu -> the control-series editor. It may be reached via the "Operating Mode" key.



In the control-series editor, all stages can be set in succession to the desired value with the selection keys ↑ / ↓. The next stage in each case is reached by pressing ENTER.
In the control series editor, the various steps may be programmed up to a rating of 30 (!).
The rating >9 is indicated in the display as follows:
10=A, 11=B, 12=C, 13=D, 14=E, 15=F, 16=G .... 30=U

ALL control series can be generated (even downwards). The customer will decide whether the generated control series is of sense.

The maximum number of stages can be limited by a programmed END STOPP < 12.

Annex 2: Default settings

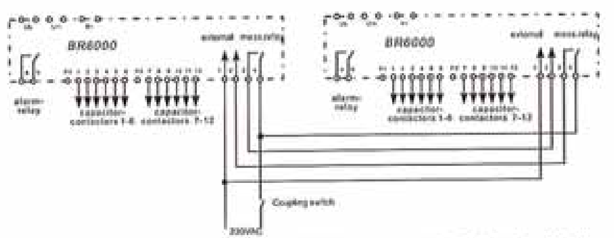
Note: The following values for the default settings apply only if the controller is supplied directly from the manufacturer. Otherwise, these values may have been replaced by settings made by the manufacturer of the compensation network (optimal values for the relevant network).

No.	Parameter (* as option)	Default setting	Programmed values of this system (to be entered by manufacturer or operator)
0	LANGUAGE	ENGLISH	
1	I CONVERTER prim.	1000 A	
2	I CONVERTER sec.	5 A	
3	END STOPP	12 (6)	
4	CONTROL SERIES	1	
5	CONTROL PRINCIPLE	INTELLIGENT	
6	POWER 1. STAGE	25.00 kvar	
7	TARGET COS-PHI	0.98 IND	
8	MEASURING VOLTAGE	230 V L-N	
9	V-CONVERTER RATIO	- NO -	
10	SWITCH- IN TIME	40 sec.	
11	SWITCH- OFF TIME	40 sec.	
12	DISCHARGE TIME	60 sec.	
13	ALARM TEMP.	55 °C	
14	MESSAGE RELAY *	FAN	
15	TEMP. FAN ON	30 °C	
27	HARMONICS THD-V	7.0 %	
	2nd parameter set		Default values are the same as in the 1. parameter set
	Capacitor stages	AUTO	
	Password Expert mode 1	6343	Cannot be changed
	Password Expert mode 2	2244	Cannot be changed
	Integration time	1 sec.	
	Trigger value	66%	
	Max.simult.switch.power	4 x smallest stage	
	Operating lock	- NO -	
	Switch.operations warning	50,000	
	Fast discharge	- NO -	
	Phase shift U/I	0 °	
	C - Test	- YES -	
	C - Fail	40 %	
	Test Attempts	5	
	Power 1. stage	0...255 kvar	
	Control	3 - phase	
	Protocol*	MODBUS-RTU	
	Baudrate*	9600	
	Address*	1	
	Numbers of MMI6000*	1	
	ASCII delivery time*	10 sec.	

Annex 3: Controller coupling (Programming under "14 message relay")

For example, coupling is useful when two separate installations are operating on two transformer supplies and a coupling exists for both systems. When the coupling is closed (because only one supply is working), it is still possible to access the total compensation power of both installations via the coupling of the controllers. The network is then operating in master-slave mode. When all stages of the first controller are connected, the second controller is taking over and switches the remaining stages.
It is therefore also possible to extend networks easily.
When coupling is requested, it is necessary to program "controller1" (as master) and "controller2" (as slave) in this menu point.
For coupling, the controllers of the two installations have to be connected as follows:

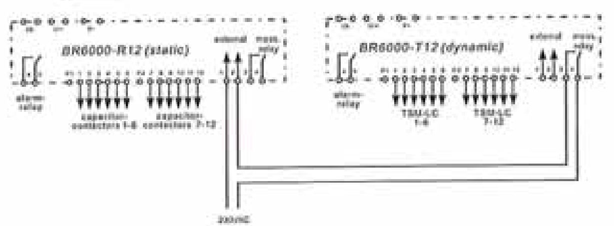
Controller 1 Controller 2



When the coupling switch is open, both installations are operating independently. When the coupling is closed, master-slave operation is initiated automatically.
It is an advantage of this simple solution that an additional serial interface is not required.

NOTE: By coupling a BR6000 with a dynamic controller, a mixed dynamic system can be designed that implements economically the advantages of a dynamic fast network. (Fast changing loads are compensated dynamically and basic loads and slowly changing loads are compensated conventionally):

Controller 1 Controller 2



Annex 4: Capacitor current monitoring using MMI6000

Application

For permanent current monitoring inside the compensation system the MMI6000 is recommended as an accessory for the BR6000. This measuring device is able to determine the sum current of the complete PFC system as well as the current of single capacitor branches.
By monitoring the current of the installed capacitors, extraordinary grid conditions (e.g. harmonic currents which may cause an overload of capacitors) can be identified. In such a case, the power factor controller switches off the relevant compensation stages as long as the extraordinary situation continues. Monitoring of the capacitor current also means monitoring of the capacitor condition (damages, aging ...) and thus gives the opportunity to avoid consequential damages.

The MMI6000 will improve the reliability and safety of a PFC-system.

Method of operation:

The MMI6000 measures the sum current inside the PFC system. For this a current transformer has to be installed at the power input of the compensation system. During each switching operation, the actual current change is measured and compared to the rated current of the switched capacitor(s). In between the switching operations the current of the complete system is monitored.

If the measured current of a step is too low (default 60%), this step is switched off. The relay is deactivated and the BR6000 display shows "E" (error) for this step. The alarm relay is activated. A reactivation of the step is possible in manual mode.
In case the current of a step is too high (default 130%), this step is also switched off. The BR6000 display shows an inverted capacitor symbol. The current is further on checked periodically is the rated current reached again, the step is reactivated.
Is the sum current of the complete PFC system too high (default 130%), stages are switched off one after another and alarm relay is set. Periodical measurements are performed to check whether the current reaches the nominal value again. If so, the step is reactivated.

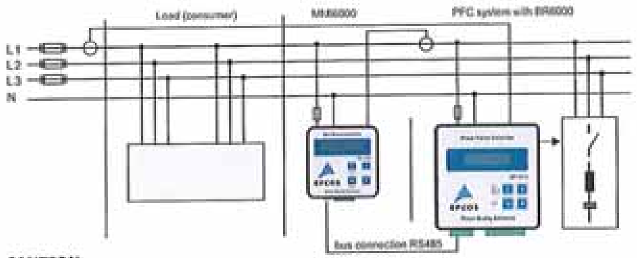
Settings MMI6000:

- Operation mode: Coupling MMI-BR6000
- Grid: 3-phase

Settings BR6000: (ExpertMode)

- Protocol: Master-MMI
- Baud rate
- Number of MMI connected
- Upper limit (%), lower limit (%)
  (limits of the capacitor / system output)

Principle circuit diagram:



CAUTION:

For the bus-connection a shielded cable has to be used!
Bus-connections (in and out) have always to be made directly to the relevant device!
The terminating resistors inside the connected devices have to be activated (DIP-switch ON).

Annex 5: MODBUS-Protocol - Part 1: –only read-register (Functioncode 3)

F	Modbus No	Register / Function	Range	unit / digit	
3	0	Reactive power H-Part	32 Bit Long	1 var	
	1	Reactive power L-Part			
	2	Active power H-Part	32 Bit Long	1 W	
	3	Active power L-Part			
	4	Apparent power H-Part	32 Bit Long	1 VA	
	5	Apparent power L-Part			
	6	Diff. Reactive power H-Part	32 Bit Long	1 var	
	7	Diff. Reactive power L-Part			
	8	Actual system output (in var)	32 Bit Long	1 var	
	9				
	10	Actual system output (in %)	16 Bit	1 %	
	11	Voltage resolution of 0.1V, max. 300V	16 Bit	0.1 V	
	12	Current resolution of 0.1A	32 Bit Long	0.1 A	
	13				
	14	Voltage with resolution of 0.1V	32 Bit Long	0.1 V	
	15	(e.g. 2314 = 231,4V			
	16	Number of actual stages	16 Bit	1 stage	
	19	cos-Phi (100 = 1.00)	16 Bit	0.01 (- = cap)	
	20	Line voltage	16 Bit	1 V	
	21	Apparent current	16 Bit	1 A	
	22	Frequency	16 Bit	1 Hz	
	23	Temperature (cabinet)	16 Bit	1 °C	
	24	Temperature (controller)	16 Bit	1 °C	
	30	Outputs (relays)	16 Bit		
	31 - 39	3. - 19. Harmonics - voltage	16 Bit	0,1 %	
	40	THD - voltage	16 Bit	0,1 %	
	41 - 49	3. - 19. Harmonics - current	16 Bit	0,1 %	
	50	THD - current	16 Bit	0,1 %	
	51	cos-Phi (100 = 1.00)	16 Bit	0.01 (- = cap)	
	60	Failure - register	16 Bit	Bit 0 - 7	
	61	Warnings - register	16 Bit	Bit 0 - 7	
	62	Messages - register	16 Bit	Bit 0 - 7	
	71 - 83	Status outputs 1...12 (13)	16 Bit	0 = OFF 1 = ON	
	85 - 100	Register compressed values	16 Bit		
	101	Language	0 - 7	1 = English	
	102	I - converter prim.	0 - 255	0 = 5A ...	
	103	I - converter sek.	6 - 7	6 = 1A ...	
	104	End slopp	1 - 12		
	105	Control series	1 - 21		
	106	Control mode	12 - 15	12 = Sequ.	
	107	Power 1st stage	0 - 255		
	108	Power 1st stage	0 - 99		
	109	Target cos Phi	80 - 120	80 = 0,8 cap.	
	110	Meas. voltage	29 - 255	Volt	
	111	Voltage converter ratio	1 - 126	Ratio	
	112	Switching - ON time	0 - 138	sec / min	
	113	Switching - OFF time	0 - 138	sec / min	
	114	Discharge time	0 - 138	sec / min	
	115	Alarm temperature	50 - 85	°C	
	116	Message relay	19 - 25	19 = external	
	117	Fan temperature	15 - 70	°C	
	118	2. parameter set 2	0 - 1	NO / YES	
	119	I - converter prim. 2	0 - 255	0 = 5A	
	120	I - converter sek. 2	0 - 1	0 = 1A	
	121	End slopp 2	1 - 12		
	122	Control series 2	1 - 21		
	123	Control mode 2	0 - 4	0 = Sequ.	
	124	Power 1st stage 2	0 - 255		
	125	Power 1st stage 2	0 - 99		
	126	Target cos Phi 2	80 - 120	80 = 0,8 cap.	
	129	Switching - ON time 2	0 - 138	sec / min	
	130	Switching - OFF time 2	0 - 138	sec / min	
	131	Discharge time 2	0 - 138	sec / min	
	132	THD-V threshold	5 - 200	0,5 ... 20%	

Part 2: - only-write -register (Functioncode 6)

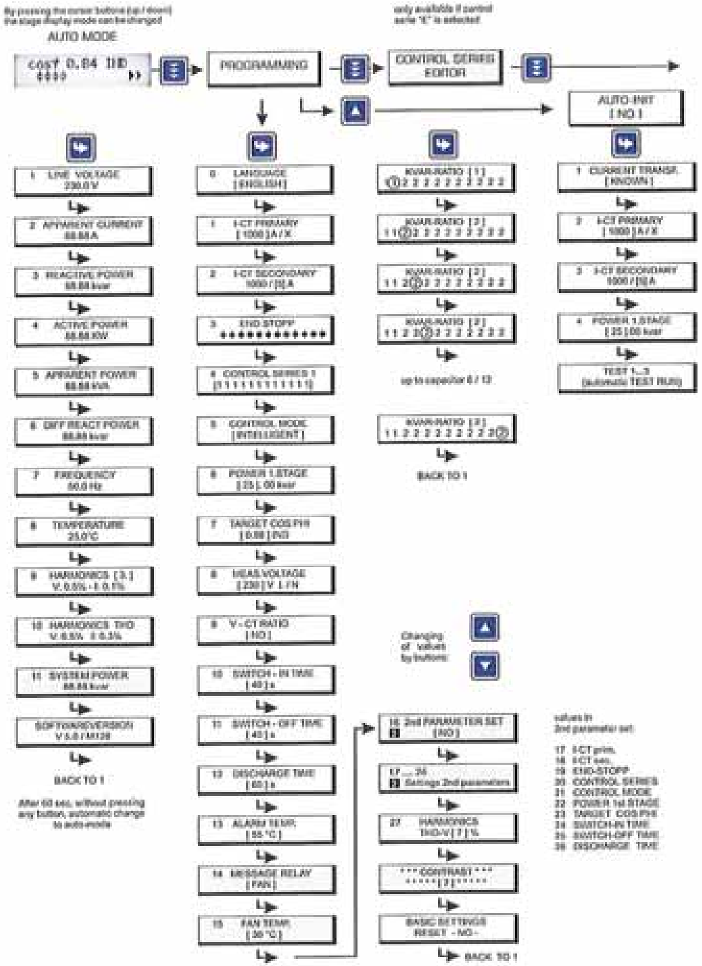
	Modbus No.	Register / Function		Range	unit / digit	
6	1	Language		0 - 7	1 = English	
	2	I - converter prim.		0 - 255	0 = 5A ...	
	3	I - converter sek.		6 - 7	6 = 1A ...	
	4	End stopp		1 - 12		
	5	Control series		1 - 21		
	6	Control mode		12 - 15	12 = Sequ.	
	7	Power 1st stage		0 - 255		
	8	Power 1st stage		0 - 99		
	9	Target cos Phi		80 - 120	80 = 0,8 cap.	
	10	Meas. voltage		29 - 255	Volt	
	11	Voltage converter ratio		1 - 120	Ratio	
	12	Switching - ON time		0 - 138	sec / min	
	13	Switching - OFF time		0 - 138	sec / min	
	14	Discharge time		0 - 138	sec / min	
	15	Alarm temperature		50 - 85	°C	
	16	Message relay		19 - 25	19 = external	
	17	Fan temperature		15 - 70	°C	
	18	2. parameter set	2	0 - 1	NO / YES	
	19	I - converter prim.	2	0 - 255	0 = 5A	
	20	I - converter sek.	2	0 - 1	0 = 1A	
	21	End stopp	2	1 - 12		
	22	Control series	2	1 - 21		
	23	Control mode	2	0 - 4	0 = Sequ.	
	24	Power 1st stage	2	0 - 255		
	25	Power 1st stage	2	0 - 99		
	26	Target cos Phi	2	80 - 120	80 = 0,8 cap.	
	29	Switching - ON time	2	0 - 138	sec / min	
	30	Switching - OFF time	2	0 - 138	sec / min	
	31	Discharge time	2	0 - 138	sec / min	
	32	THD-V threshold		5 - 200	0,5 ... 20%	
	40	Remote control Register value H = Data 1 (switch power max = multiples of the smallest stage)		8 Bit	1 - max	
		Register value L = Data 2 0 - Remote OFF 1 - Switching DOWN, 2 - Stopp 3 - Switching UP		8 Bit	0 - 3	

Part 3 example

MODBUS - Functioncode 3 (only-read-register) example meas. voltage					MODBUS - Functioncode 6 (only-write-register) example remote-control (Remote-ON)		
			answer				answer
Byte 1:	Slave Adresse	1	Sl. Adress	1	Slave Adresse	1	1
Byte 2:	Functioncode	3	Funct. code	3	Functioncode	6	6
Byte 3:	Reg.start adress "H"	0	No of Bytes	2	Registeradr. "H"	0	0
Byte 4:	Reg.start adress "L"	20	Data H	0	Registeradr. "L"	40	40
Byte 5:	Reg. number "H"	0	Data L	233	Reg.value H (Data1)	1*	1
Byte 6:	Reg. number "L"	1	CRC L	121	Reg.value L (Data2)	3*	3
Byte 7:	CRC testcode "L"	196	CRC H	202	CRC testcode "L"	72	72
Byte 8:	CRC testcode "H"	14			CRC testcode "H"	83	83

NOTE:
Due to the priority of the control function of the power factor controller before data exchange, please consider that per command 12 consecutive values maximum (s. table) are transferred blockwise.
Also, parameters should not be retrieved more than 1 x /second.
Settings: 8 data bit, 1 stop bit, no parity

In "Expert Mode" \"17 Protocol" there are 2 types of Modbus-control:
[MODBUS] Modbus without check (default) - there is no warning, if no valid answer from slave is given
[MODBUS KTR] Modbus with check of valid answer from slave - a warning "MODBUS ERROR" will shown on display, if no valid answer from slave is given within 4 minutes.
For MODBUS KTR: no adjustment of program memory (security interlock)



By pressing the cursor buttons (up / down) the stage display mode can be changed
AUTO MODE
PROGRAMMING
only available if control serie "E" is selected
CONTROL SERIES EDITOR
AUTO-INIT [NO]
1 LINE VOLTAGE 230.0 V
2 APPARENT CURRENT 88.88 A
3 REACTIVE POWER 88.88 kvar
4 ACTIVE POWER 88.88 KW
5 APPARENT POWER 88.88 kVA
6 DIFF REACT POWER 88.88 kvar
7 FREQUENCY 50.0 Hz
8 TEMPERATURE 25.0°C
9 HARMONICS [3.]
10 HARMONICS THD
11 SYSTEM POWER 88.88 kvar
SOFTWAREVERSION
BACK TO 1
After 60 sec. without pressing any button, automatic change to auto-mode
0 LANGUAGE [ENGLISH]
1 I-CT PRIMARY [1000] A / X
2 I-CT SECONDARY 1000 / [5] A
3 END STOPP
4 CONTROL SERIES 1
5 CONTROL MODE [INTELLIGENT]
6 POWER 1.STAGE
7 TARGET COS PHI
8 MEAS.VOLTAGE [230] V L / N
9 V - CT RATIO [NO]
10 SWITCH - IN TIME [40] s
11 SWITCH - OFF TIME [40] s
12 DISCHARGE TIME [60] s
13 ALARM TEMP. [55 °C]
14 MESSAGE RELAY [FAN]
15 FAN TEMP. [30 °C]
KVAR-RATIO [1]
KVAR-RATIO [2]
up to capacitor 6 / 12
BACK TO 1
1 CURRENT TRANSF. [KNOWN]
2 I-CT PRIMARY [1000] A / X
3 I-CT SECONDARY 1000 / [5] A
4 POWER 1.STAGE [25] 00 kvar
TEST 1...3 (automatic TEST RUN)
Changing of values by buttons:
16 2nd PARAMETER SET [NO]
17 ... 26 Settings 2nd parameters
27 HARMONICS THD-V [7] %
*** CONTRAST ***
BASIC SETTINGS RESET - NO -
BACK TO 1
values in 2nd parameter set:
17 I-CT prim.
18 I-CT sec.
19 END-STOPP
20 CONTROL SERIES
21 CONTROL MODE
22 POWER 1st STAGE
23 TARGET COS PHI
24 SWITCH-IN TIME
25 SWITCH-OFF TIME
26 DISCHARGE TIME

Operating diagram (Brief programming)
Power Factor Controller BR 6000 (V5.0)

General

Applications

- compensation

Features

- Voltage range 230 ... 525 V
- Output range 0.5 ... 30 kvar

Electrical

R)

- Maintenance-free

Safety

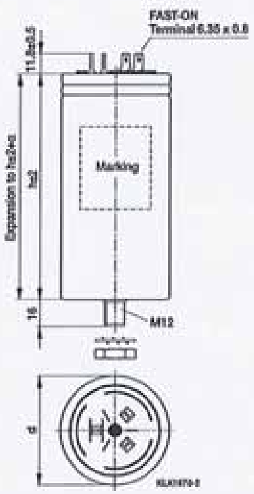
- Self-healing

series

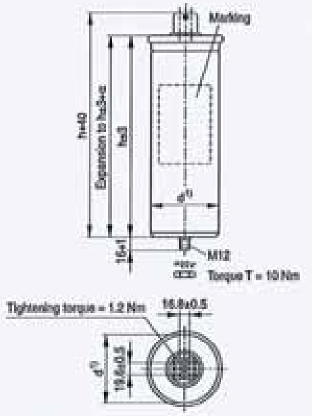
Overvoltage	V_{max}	V_R R V_R R
Overcurrent	I_{max}	up to 1.5 · I_R
	I_S	up to 200 · I_R
Losses:		
	V_{TT}	2.15 · V_R
	V_{TC}	
xpectancy	$t_{LD(Co)}$	
		–40/D)
		–40/D; max. temp. 55 °C; max. mean 24 h = 45 °C; max. mean 1 year = 35 °C; lowest temperature = –40 °C
Cooling		
Humidity	H_{rel}	
Altitude		
		upright
		≤
Safety		
Case		
Enclosure		
Dielectric		
Impregnation		
Terminals		z

Type	50 Hz Output kvar	50 Hz I_R A	60 Hz Output kvar	60 Hz I_R A	C_R µF	d x h mm	Weight kg	Ordering code	Packing unit*
MKP230-D-0.5	0.5	1.3	0.6	1.6	3				
MKP230-D-0.7	0.7	1.9	0.9	2.3	3				
MKP230-D-1.0	1.0	2.5	1.2	3.0	3				
MKP230-D-1.5	1.5	3.8	1.8	4.6	3				
MKP230-D-2.0	2.0	5.0	2.4	6.0	3				
MKP230-D-2.5	2.5	6.3	3.0	7.5	3				
MKP230-D-5.0	5.0	12.6	6.0	15.1	3				
MKP230-D-7.5	7.5	18.8	9.0	22.6	3				
MKP230-D-10.0	10.0	25.1	12.0	30.2	3				
MKP230-D-12.5	12.5	31.4	15.0	37.7	3				
MKP230-D-15.0	15.0	37.7	–	–	3				
MKP400-D-1.0	1.0	1.4	1.2	1.7	3				
MKP400-D-1.5	1.5	2.2	1.8	2.6	3				
MKP400-D-2.0	2.0	2.9	2.4	3.5	3				
MKP400-D-2.5	2.5	3.6	3.0	4.3	3				
MKP400-D-5.0	5.0	7.2	6.0	8.6	3				
MKP400-D-6.3	6.3	9.1	7.5	11.0	3				
MKP400-D-7.5	7.5	10.8	9.0	13.0	3				
MKP400-D-8.3	8.3	12.0	10.0	14.5	3				
MKP400-D-10.0	10.0	14.5	12.0	17.3	3				
MKP400-D-12.5	12.5	18.1	15.0	21.7	3				
MKP400-D-15.0	15.0	21.7	18.0	26.0	3				
MKP400-D-16.7	16.7	24.1	20.0	28.9	3				
MKP400-D-20.0	20.0	28.9	24.0	34.7	3				
MKP400-D-25.0	25.0	36.1	–	–	3				
MKP415-D-1.0	1.0	1.4	1.2	1.6	3				
MKP415-D-1.5	1.5	2.1	1.8	2.4	3				
MKP415-D-2.0	2.0	2.8	2.4	3.4	3				
MKP415-D-2.5	2.5	3.5	3.0	4.2	3				
MKP415-D-5.0	5.0	7.0	6.0	8.4	3				
MKP415-D-6.3	6.3	8.8	7.5	10.6	3				
MKP415-D-7.5	7.5	10.4	9.0	12.5	3				
MKP415-D-10.0	10.0	13.9	12.0	16.7	3				
MKP415-D-12.5	12.5	17.4	15.0	20.9	3				
MKP415-D-15.0	15.0	20.9	18.0	25.1	3				
MKP415-D-20.0	20.0	27.9	24.0	33.4	3				
MKP415-D-25.0	25.0	34.8	–	–	3				
MKP440-D-0.9	0.9	1.2	1.0	1.3	3				
MKP440-D-1.0	1.0	1.3	1.2	1.6	3				
MKP440-D-1.2	1.2	1.6	1.5	2.0	3				

Type	50 Hz		60 Hz		C_R	d x h	Weight	Ordering code	Packing unit*
	Output kvar	I_R A	Output kvar	I_R A	µF	mm	kg		
MKP440-D-1.5	1.5	2.0	1.8	2.3	3				
MKP440-D-2.1	2.1	2.7	2.5	3.3	3				
MKP440-D-2.5	2.5	3.3	3.0	3.9	3				
MKP440-D-4.2	4.2	5.5	5.0	6.6	3				
MKP440-D-5.0	5.0	6.5	6.0	7.8	3				
MKP440-D-6.3	6.3	8.3	7.5	9.9	3				
MKP440-D-7.5	7.5	9.9	9.0	11.8	3				
MKP440-D-8.3	8.3	10.9	10.0	13.1	3				
MKP440-D-10.0	10.0	13.1	12.0	15.8	3				
MKP440-D-10.4	10.4	13.7	12.5	16.4	3				
MKP440-D-12.5	12.5	16.4	15.0	19.7	3				
MKP440-D-15.0	15.0	19.7	18.0	23.6	3				
MKP440-D-16.7	16.7	21.9	20.0	26.3	3				
MKP440-D-20.8	20.8	27.3	25.0	32.8	3				
MKP440-D-25.0	25.0	32.8	30.0	40.0	3				
MKP440-D-28.0	28.0	36.8	–	–	3				
MKP440-D-30.0	30.0	39.0	–	–	3				
MKP480-D-1.5	1.5	1.8	1.8	2.2	3				
MKP480-D-2.0	2.0	2.4	2.4	2.9	3				
MKP480-D-2.5	2.5	3.0	3.0	3.6	3				
MKP480-D-4.2	4.2	5.1	5.0	6.1	3				
MKP480-D-5.0	5.0	6.0	6.0	7.2	3				
MKP480-D-6.3	6.3	7.6	7.6	9.1	3				
MKP480-D-7.5	7.5	9.0	9.0	10.8	3				
MKP480-D-8.3	8.3	10.0	10.0	12.0	3				
MKP480-D-10.4	10.4	12.5	12.5	15.0	3				
MKP480-D-12.5	12.5	15.1	15.0	18.1	3				
MKP480-D-15.0	15.0	18.1	18.0	21.7	3				
MKP480-D-16.7	16.7	20.1	20.0	24.1	3				
MKP480-D-20.8	20.8	25.0	25.0	30.1	3				
MKP480-D-25.0	25.0	30.1	30.0	36.1	3				
MKP480-D-30.0	30.0	36.1	–	–	3				
MKP525-D-1.0	1.0	1.1	1.2	1.3	3				
MKP525-D-1.5	1.5	1.6	1.8	2.0	3				
MKP525-D-2.0	2.0	2.2	2.4	2.6	3				
MKP525-D-2.5	2.5	2.7	2.7	3.0	3				
MKP525-D-5.0	5.0	5.5	6.0	6.6	3				
MKP525-D-6.3	6.3	6.9	7.6	8.3	3				
MKP525-D-8.3	8.3	9.1	10.0	11.0	3				
MKP525-D-10.4	10.4	11.5	12.5	13.7	3				
MKP525-D-12.5	12.5	13.8	15.0	16.5	3				
MKP525-D-16.7	16.7	18.3	20.0	21.9	3				
MKP525-D-20.8	20.8	22.9	25.0	27.5	3				
MKP525-D-25.0	25.0	27.5	30.0	33.0	3				



Creepage distance	10.5 mm (ø 53) 10.0 mm (ø 63.5)
Clearance	13.0 mm (ø 53) 16.5 mm (ø 63.5)
Diameter (ø)	53.0 mm
α	
Mounting	
	(ø 63.5 mm) (ø 53.0 mm)
Torq	



[1] Seaming adds 4 mm in diameter

Diameter d (ø)	75.0 mm / 85.0 mm
α	
Mounting	
	M12
Torq	

electroserv

Certified System
Quality
ISO 9001

ELECTROSERV PTY LTD

Designers and Manufactures of Electrical Equipment

WARRANTY STATEMENT

FOR

AUTOMATIC POWER FACTOR CORRECTION EQUIPMENT

Equipment designed and manufactured by Electroserv Pty Ltd is supplied under a parts and labour warranty for a period of 3 Years from date of commissioning by Electroserv Pty Ltd Staff.

Note: This Warranty is further extended to five(5) years from date of Commissioning if it is serviced annually from the date of Commissioning.

Electroserv Pty Ltd
Unit 1, 22 Beaumont Road Mount Kuring-Gai NSW Australia
Ph: 02-9477-7055 Fax: 02-9477-5310
Email: info@electroserv.com.au Web: www.electroserv.com.au

ENGLISH

9SX 5000
9SX 6000
9PX 5000
9PX 6000
9SX EBM 180V
9PX EBM 180V

Installation and user manual

Service and support:
Call your local service representative

5-6kVA EU_EN

SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS. This manual contains important instructions that should be followed during installation and maintenance of the UPS and batteries.

The 9SX and 9PX models that are covered in this manual are intended for installation in an environment within 0 to 40°C, free of conductive contaminant.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Certification standards

- Safety: IEC/EN 62040-1 / Ed.1: 2008.
  UL 1778 4th edition
- EMC: IEC/EN 62040-2 / Ed.2: 2006.
  FCC part 15 Class A.
- Performance: IEC/EN 62040-3 / Ed.2.0: 2011.
- IEC 61000-4-2 (ESD): level 3.
- IEC 61000-4-3 (Radiated field): level 3.
- IEC 61000-4-4 (EFT): level 4.
- IEC 61000-4-5 (Fast transients): level 4.
- IEC 61000-4-6 (Electromagnetic field): level 3.
- IEC 61000-4-8 (Conducted magnetic field): level 4.

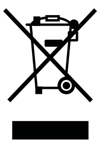
Special symbols

The following are examples of symbols used on the UPS or accessories to alert you to important information:

RISK OF ELECTRIC SHOCK - Observe the warning associated with the risk of electric shock symbol.

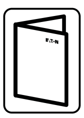
Important instructions that must always be followed.

Do not discard the UPS or the UPS batteries in the trash.
This product contains sealed lead acid batteries and must be disposed as it's explain in this manual.
For more information, contact your local recycling/reuse or hazardous waste center.



This symbol indicates that you should not discard waste electrical or electronic equipment (WEEE) in the trash. For proper disposal, contact your local recycling/reuse or hazardous waste center.

Information, advice, help.



Refer to the user manual of UPS accessories.

SAFETY INSTRUCTIONS

Safety of persons

- The system has its own power source (the battery). Consequently, the power outlets may be energized even if the systems is disconnected from the AC power source. Dangerous voltage levels are present within the system. It should be opened exclusively by qualified service personnel.
- The system must be properly grounded.
- The battery supplied with the system contains small amounts of toxic materials.
  To avoid accidents, the directives listed below must be observed:
  - servicing of batteries should be performed or supervised by personnel knowledgeable about batteries and the required precautions.
  - when replacing batteries, replace with the same type and number of batteries or battery packs.
  - do not dispose of batteries in a fire. The batteries may explode.
  - batteries constitute a danger (electrical shock, burns). The short-circuit current may be very high.

Precautions must be taken for all handling:

- Wear rubber gloves and boots.
- Do not lay tools or metal parts on top of batteries.
- Disconnect charging source prior to connecting or disconnecting battery terminals.
- Determine if battery is inadvertently grounded. If inadvertently grounded, remove source from ground. Contact with any part of a grounded battery can result in electrical shock. The likelihood of such shock can be reduced if such grounds are removed during installation and maintenance (applicable to equipment and remote battery supplies not having a grounded supply circuit).

Product safety

- The UPS connection instructions and operation described in the manual must be followed in the indicated order.
- CAUTION - To reduce the risk of fire, the unit connects only to a circuit provided with branch circuit overcurrent protection for : 30A rating, for 5-6kVA models in accordance with the National Electric Code, ANSI/NFPA 70 (US installations only).
  The upstream circuit breaker must be easily accessible.
  The unit can be disconnected from AC power source by opening this circuit breaker.
- Disconnection and overcurrent protection devices shall be provided by others for permanently connected AC input/output circuits.
- Check that the indications on the rating plate correspond to your AC powered system and to the actual electrical consumption of all the equipment to be connected to the system.
- For PLUGGABLE EQUIPMENT, the socket-outlet shall be installed near the equipment and shall be easily accessible
- Never install the system near liquids or in an excessively damp environment.
- Never let a foreign body penetrate inside the system.
- Never block the ventilation grates of the system.
- Never expose the system to direct sunlight or source of heat.
- If the system must be stored prior to installation, storage must be in a dry place.
- The admissible storage temperature range is -15ºC to +50ºC.
- The system is not for use in a computer room AS DEFINED IN the standard for the Protection of Information Technology Equipment, ANSI/NFPA 75 (US installations only).
  Contact Eaton resellers to order a special battery kit if needed to meet the NE code requirement.

Special precautions

- All handling operations will require at least two people (unpacking, installation in rack system).
- Before and after the installation, if the UPS remains de-energized for a long period, the UPS must be energized for a period of 24 hours, at least once every 6 months (for a normal storage temperature less than 25°C). This charges the battery, thus avoiding possible irreversible damage.
- During the replacement of the Battery Module, it is imperative to use the same type and number of element as the original Battery Module provided with the UPS to maintain an identical level of performance and safety. In case of doubt, don’t hesitate to contact your EATON representative.
- All repairs and service should be performed by AUTHORIZED SERVICE PERSONNEL ONLY.
  There are NO USER SERVICEABLE PARTS inside the UPS.

Contents

1. Introduction

Thank you for selecting an EATON product to protect your electrical equipment.

The 9SX and 9PX range has been designed with the utmost care.
We recommend that you take the time to read this manual to take full advantage of the many features of your UPS (Uninterruptible Power System).

Before installing your 9SX and 9PX, please read the booklet presenting the safety instructions.
Then follow the indications in this manual.

To discover the entire range of EATON products and the options available for the 9SX and 9PX range, we invite you to visit our web site at www.eaton.com/powerquality or contact your EATON representative.

1.1 Environmental protection

EATON has implemented an environmental-protection policy.
Products are developed according to an eco-design approach.

Substances

This product does not contain CFCs, HCFCs or asbestos.

Packing

To improve waste treatment and facilitate recycling, separate the various packing components.

- The cardboard we use comprises over 50% of recycled cardboard.
- Sacks and bags are made of polyethylene.
- Packing materials are recyclable and bear the appropriate identification symbol 01 PET

Materials	Abbreviations	Number in the symbols 01 PET
Polyethylene terephthalat	PET	01
High-density polyethylene	HDPE	02
Polyvinyl chloride	PVC	03
Low-density polyethylene	LDPE	04
Polypropylene	PP	05
Polystyrene	PS	06

Follow all local regulations for the disposal of packing materials.

End of life

EATON will process products at the end of their service life in compliance with local regulations.
EATON works with companies in charge of collecting and eliminating our products at the end of their service life.

Product

The product is made up of recyclable materials.
Dismantling and destruction must take place in compliance with all local regulations concerning waste.
At the end of its service life, the product must be transported to a processing center for electrical and electronic waste.

Battery

The product contains lead-acid batteries that must be processed according to applicable local regulations concerning batteries.
The battery may be removed to comply with regulations and in view of correct disposal.

1. Introduction

The Eaton® 9SX and 9PX uninterruptible power system (UPS) protects your sensitive electronic equipment from the most common power problems, including power failures, power sags, power surges, brownouts, line noise, high voltage spikes, frequency variations, switching transients, and harmonic distortion.

Power outages can occur when you least expect it and power quality can be erratic. These power problems have the potential to corrupt critical data, destroy unsaved work sessions, and damage hardware - causing hours of lost productivity and expensive repairs.

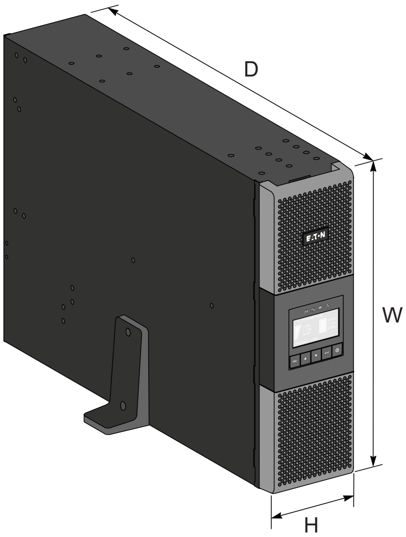
With the Eaton 9SX and 9PX, you can safely eliminate the effects of power disturbances and guard the integrity of your equipment. Providing outstanding performance and reliability, the Eaton 9SX and 9PX's unique benefits include:

- True online double-conversion technology with high power density, utility frequency independence, and generator compatibility.
- ABM® technology that uses advanced battery management to increase battery service life, optimize recharge time, and provide a warning before the end of useful battery life.
- Selectable High Efficiency mode of operation.
- Standard communication options: one RS-232 communication port, one USB communication port, and relay output contacts.
- Optional connectivity cards with enhanced communication capabilities.
- Extended runtime with up to twelve Extended Battery Modules (EBMs) per UPS.
- Firmware that is easily upgradable without a service call.
- Remote On/Off control through Remote On/Off (ROO) and Remote Power Off (RPO) ports.
- Backed by worldwide agency approvals.

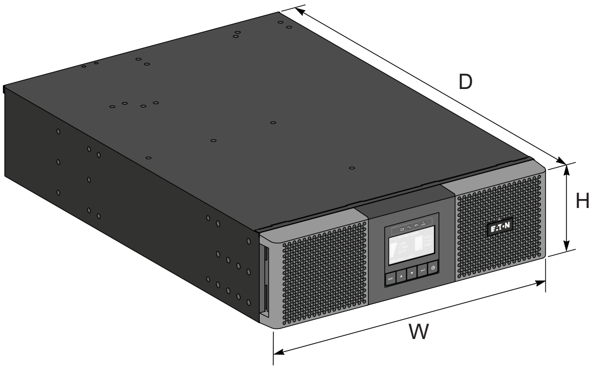
2. Presentation

2.1 Standard installations

Tower installation



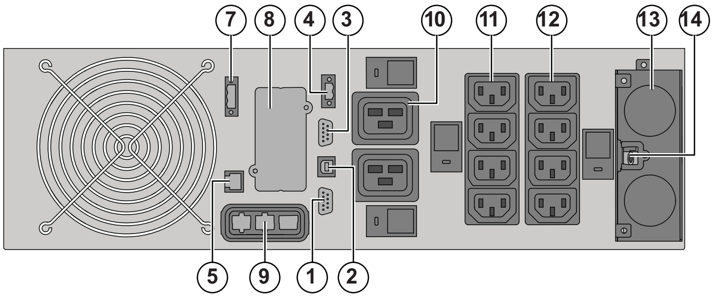
Rack installation



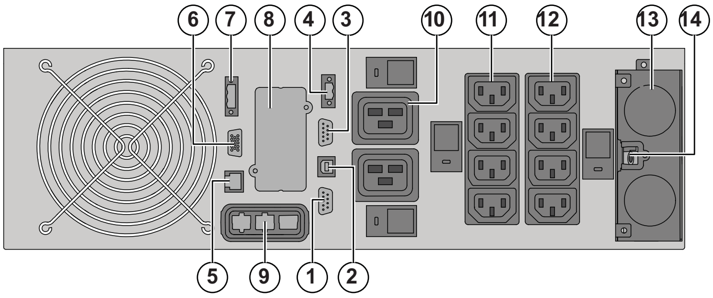
Description	Weights (**lb**/kg)	Dimensions (**inch**/mm) **D x W x H**
9SX 5000	106 / 48	27.0 x 17.3 x 5.1 / 685 x 440 x 130
9SX 6000	106 / 48	27.0 x 17.3 x 5.1 / 685 x 440 x 130
9PX 5000	106 / 48	27.0 x 17.3 x 5.1 / 685 x 440 x 130
9PX 6000	106 / 48	27.0 x 17.3 x 5.1 / 685 x 440 x 130
9SX EBM 180V	150 / 68	25.4 x 17.3 x 5.1 / 645 x 440 x 130
9PX EBM 180V	150 / 68	25.4 x 17.3 x 5.1 / 645 x 440 x 130

2.2 Rear panels

9SX 5000 / 6000

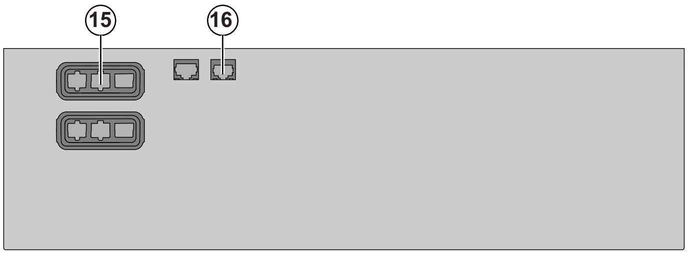


9PX 5000 / 6000



1. RS232 communication port
2. USB communication port
3. Dry (relay) contacts communication port
4. Connector for ROO (Remote On/Off) control
5. Connectors for automatic recognition of an additional battery module
6. Connector for Parallel operation (for 9PX only)
7. Connector for RPO (Remote Power Off) control
8. Slot for optional communication card
9. Connector for additional battery module
10. Primary group: 16A outlets for connection of critical equipment
11. Group 1: (4) 10A programmable outlets for connection of equipment
12. Group 2: (4) 10A programmable outlets for connection of equipment
13. Input/Output terminal blocks
14. Connector for HotSwap MBP detection

9SX/9PX EBM 180V (Extended Battery Module)



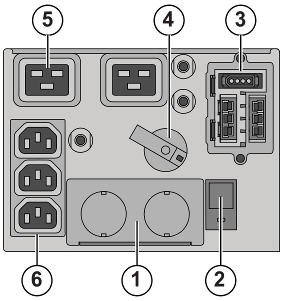
15. Connectors for battery modules (to the UPS or to the other battery modules)
16. Connectors for automatic recognition of battery modules

2. Presentation

2.3 Accessories

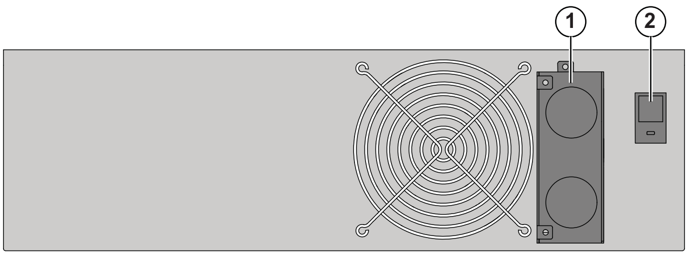
Part number	Description
9SXEBM180RT, 9PXEBM180	Extended battery module
9RK	Rack kit 9PX/9SX
Network-MS	Network card
Modbus-MS	Modbus and network card
Relay-MS	Relay card
MBP6Ki	HotSwap MBP 6000i
TFMR11Ki	Transformer 11000i
BINTSYS	Battery Integration System
EBMCBL180	1.8m cable 180V EBM

MBP6Ki



1. Input/Output terminal blocks
2. Normal AC source switch
3. Input/Output connector to the UPS
4. Manual Bypass switch
5. (2) 16A outlets
6. (3) 10A outlets

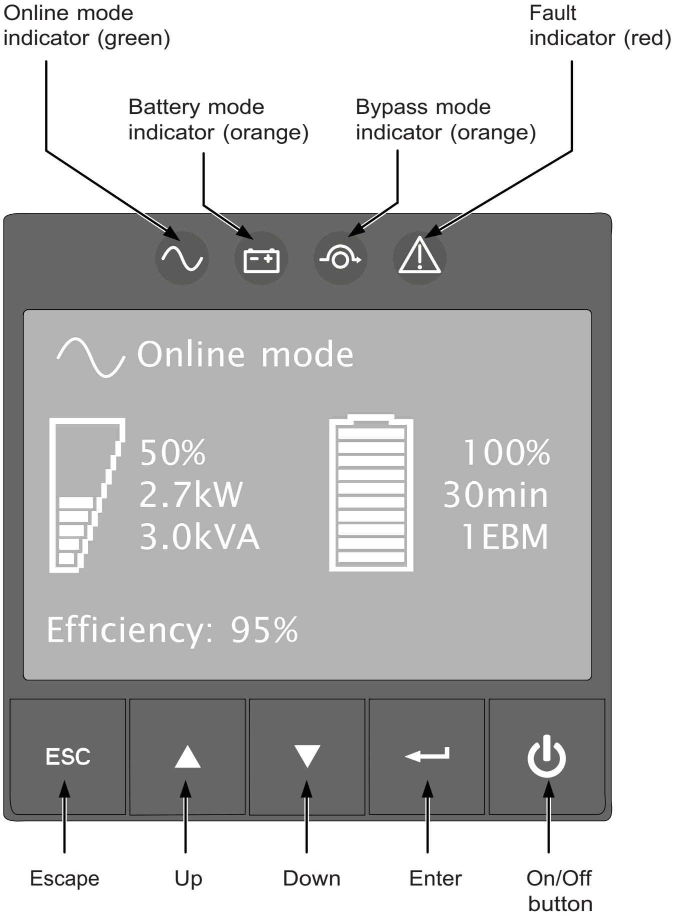
TFMR11Ki



1. Input/Output terminal blocks
2. 50A output circuit breaker

2.4 Control panel

The UPS has a five-button graphical LCD. It provides useful information about the UPS itself, load status, events, measurements and settings.



The following table shows the indicator status and description:

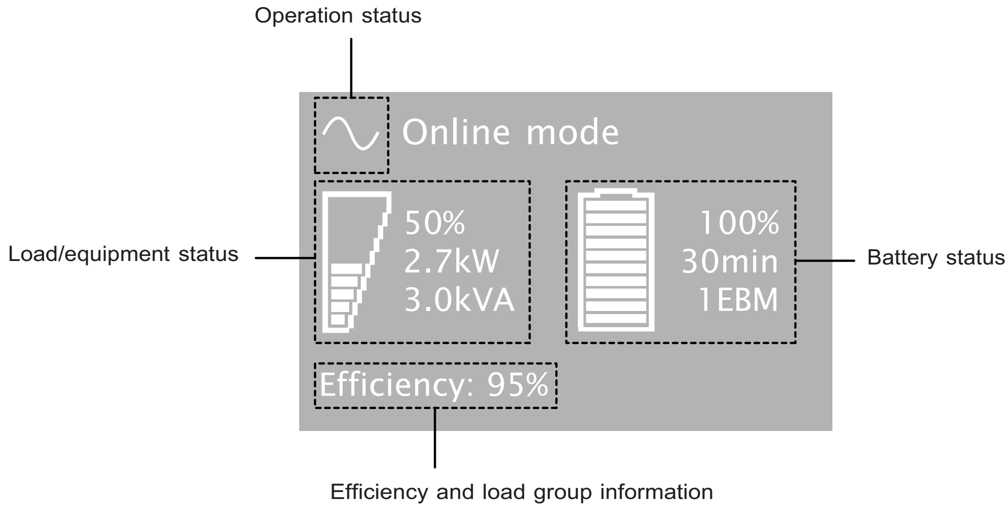
Indicator	Status	Description
Green	On	The UPS is operating normally on Online or on High Efficiency mode.
Orange	On	The UPS is on Battery mode.
Orange	On	The UPS is on Bypass mode.
Red	On	The UPS has an active alarm or fault. See trouble-shooting on page 38 for additional information.

2. Presentation

2.5 LCD description

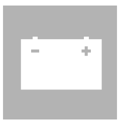
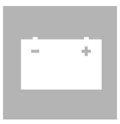
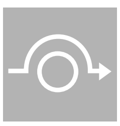
After 5 minutes of inactivity, the LCD displays the screen saver.

The LCD backlight automatically dims after 10 minutes of inactivity. Press any button to restore the screen.



The following table describes the status information provided by the UPS

Note: If other indicator appears, see troubleshooting on page 37 for additional information.

Operation status	Cause	Description
Standby mode 	The UPS is Off.	Equipment is powered but not protected by the UPS.
Online mode 	The UPS is operating normally.	The UPS is powering and protecting the equipment.
Battery mode  1 beep every 10 seconds	A utility failure has occured and the UPS is on Battery mode.	The UPS is powering the equipment with the battery power. Prepare your equipment for shutdown.
End of backup time  1 beep every 3 seconds	The UPS is on Battery mode and the battery is running low.	This warning is approximate, and the actual time to shutdown may vary significantly. Depending on the UPS load and number of Extended Battery Modules (EBMs), the "Battery Low" warning may occur before the battery reaches 20% capacity.
High Efficiency mode 	The UPS is operating on High Efficiency mode.	The UPS is powering and protecting the equipment
Bypass mode 	An overload or a fault has occurred, or a command has been received, and the UPS is in Bypass mode.	Equipment is powered but not protected by the UPS.

2.6 Display functions

Press the Enter (⟵) button to activate the menu options. Use the two middle buttons (▲ and ▼) to scroll through the menu structure. Press the Enter (⟵) button to select an option. Press the ESC button to cancel or return to the previous menu.

Main menu	Submenu	Display information or Menu function
Measurements		[Load] W VA A pf / [Input/Bypass] V Hz / [Output/Efficiency] V Hz % / [Battery] % min V n° / [DCbus] V / [Average power usage] Wh / [Cumulat. power usage] Wh since date
Control	Go to Bypass	Transfers the UPS on Bypass mode
	Load segments On/Off	Commands the load segments
	Start battery test	Starts a manual battery test
	Reset fault state	Clears active fault
	Restore factory set	Returns all settings to original values
	Reset average power	Clears average power usage measurement
	Reset cumul. power	Clears cumulated power usage measurement
	Dry contacts test	Tests dry contact relay outputs
Settings	Local settings	Sets product general parameters
	In/Out settings	Sets Output parameters
	On/Off settings	Sets On/Off conditions
	Battery settings	Sets battery configuration
Event log	Event filter	Selects faults, alarms and/or events to display
	Event list	Displays the events stored
	Reset event list	Clears events
Fault log	Fault list	Displays the faults stored
	Reset fault list	Clears faults
Identification		[Product type/model] / [Part/Serial number] / [UPS/NMC firmware] / [Com card IPv4], [Com card IPv6], [Com card MAC] / [Detected accessories]
Register product		Links to Eaton registration website

2.7 User settings

The following table displays the options that can be changed by the user.

	Submenu	Available settings	Default settings
Local settings	Language	[English] [French] [German] [Spanish] [Russian] [Portuguese] [Italian] Menus, status, notices and alarms, UPS fault, Event Log data and settings are in all supported languages.	[English] User selectable when UPS is powered for the first time.
	Date/ time	Format: [International] [US]	[International]
	LCD	Modify LCD screen brightness and contrast to be adapted to room light conditions.	
	Audible alarm	[Enabled] [Disabled on battery] [Always disabled] Enable or disable the buzzer if an alarm occurs.	[Enabled]
In/Out settings	Output voltage	[200V] [208V] [220V] [230V] [240V]	[230V]
	Output frequency	Frequency converter: [Enabled] [Disabled] Frequency settable in frequency converter mode	Disabled
	Load segments	[Auto start delay] [Auto shutdown delay]	Group1: [3s] Group2: [6s] Group1: [Disabled] Group2: [Disabled]
	Output mode	[Industrial] [Network] Set UPS behavior regarding transfer on Bypass	[Industrial]
	Input volt hysteresis	Sets input voltage hysteresis from 1 to 10V	[10V]
	High Efficiency mode	[Enabled] [Disabled] Power the output from Bypass for high efficiency	[Disabled]
	Bypass transfer	Transfer if BP AC NOK [Enabled] [Disabled] Allow transfer on Bypass out of tolerance	[Enabled]

2. Presentation

	Submenu	Available settings	Default settings
In/Out settings	Interrupt time	If Bypass transfer is enabled, Interrupt time: [10ms] [20ms] Define break duration when transfer on Bypass	[10ms]
	Overload prealarm	[10%] … [102%] Load % when overload alarm occurs	[102%]
	Redundancy mode	[Unitary UPS] [Hot Standby] Force slew rate value to 0.5Hz/s	Unitary UPS
On/Off settings	Cold start	[Enabled] [Disabled] Authorize the product to start on battery power.	[Enabled]
	Forced reboot	[Enabled] [Disabled] If mains recover during a shutdown sequence: If set to Enabled, shutdown sequence will complete and wait 10 seconds prior to restart, If set to Disabled, shutdown sequence will not complete and restart will occur immediately.	[Enabled]
	Auto restart	[Enabled] [Disabled] Authorize the product to restart automatically when mains recovers after a complete battery discharge.	[Enabled]
	Auto start	[Enabled] [Disabled] The UPS automatically starts up as soon as mains power is available (no need topress the ⏻ button).	[Disabled]
	Energy saving	[Disabled] [100W] … [1000W] If Enabled, UPS will shutdown after 5 min. of back-up time, if load is less than threshold.	[Disabled]
	Sleep mode	[Enabled] [Disabled] If Disabled, LCD and communication will turn OFF immediately after UPS is OFF. If Enabled, LCD and communication stays ON 1h30 min after UPS is OFF.	[Enabled]
	Remote command	[Enabled] [Disabled] If Enabled, shutdown or restart commands from software are authorized.	[Enabled]
	Bypass standby	[Enabled] [Disabled] Define if output is powered from Bypass in Standby mode.	[Enabled]
Battery settings	Automatic battery test	In constant charge mode: [No test] [Every day] [Every week] [Every month] In ABM cycling mode : [No test] [Every ABM cycle]	[Every ABM cycle]
	Low battery warning	[0%] ... [100%] The alarm triggers when the set percentage of battery capacity is reached during back-up time.	[20%]
	Restart bat. level	[0%] ... [100%] If set, automatic restart will occur only when percentage of battery charge is reached.	[0%]
	Battery charge mode	[ABM cycling] [Constant charge]	[ABM cycling]
	External battery	[Auto detection] [Manual EBM set.] [Manual battery set.] [No battery]	[Auto detection] Using standard EBM, UPS detects automatically the number of EBM connected
	Deep Disch. protect.	[Yes] [No] If set to Yes, the UPS automatically prevents battery from deep discharge by adapting end of back-up time voltage threshold. Warranty void if set to No.	[Yes]

3. Installation

3.1 Inspecting the equipment

If any equipment has been damaged during shipment, keep the shipping cartons and packing materials for the carrier or place of purchase and file a claim for shipping damage. If you discover damage after acceptance, file a claim for concealed damage.

To file a claim for shipping damage or concealed damage:

1) File with the carrier within 15 days of receipt of the equipment;

2) Send a copy of the damage claim within 15 days to your service representative.

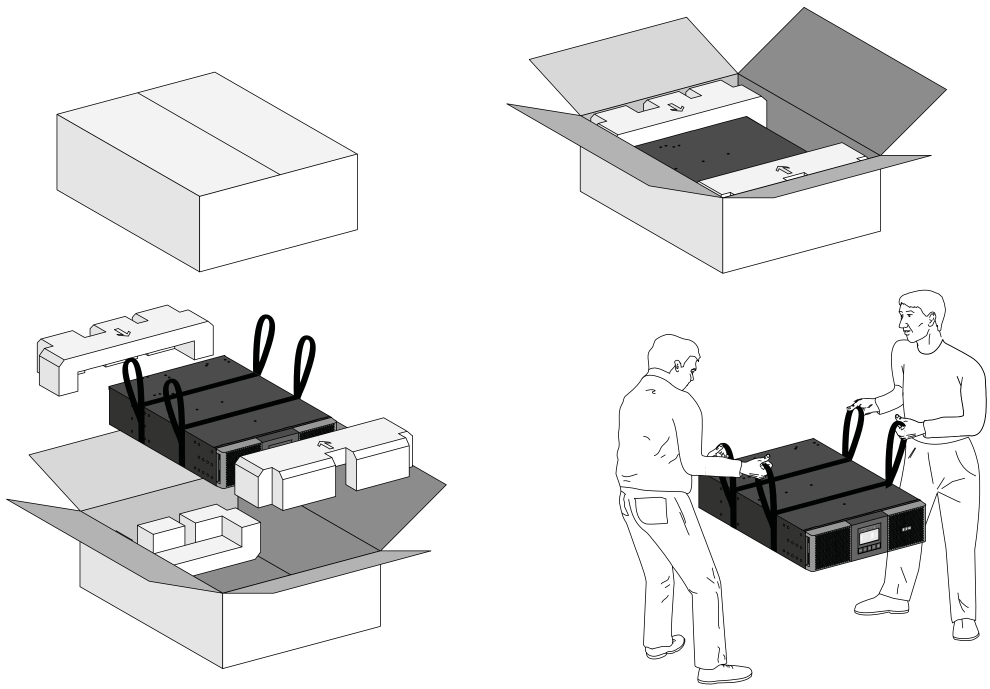
Check the battery recharge date on the shipping carton label. If the date has passed and the batteries were never recharged, do not use the UPS. Contact your service representative.

3.2 Unpacking the cabinet

- Unpacking the cabinet in a low-temperature environment may cause condensation to occur in and on the cabinet. Do not install the cabinet until the inside and outside of the cabinet are absolutely dry (hazard of electric shock).
- The cabinet is heavy (see page 40). Use caution to unpack and move the cabinet.

Unpack the equipment and remove all the packing materials and shipping carton.

Note: Do not lift the UPS or EBM from the front panel.



Unpacking UPS and Extended Battery Module.

Discard or recycle the packaging in a responsible manner, or store it for future use.

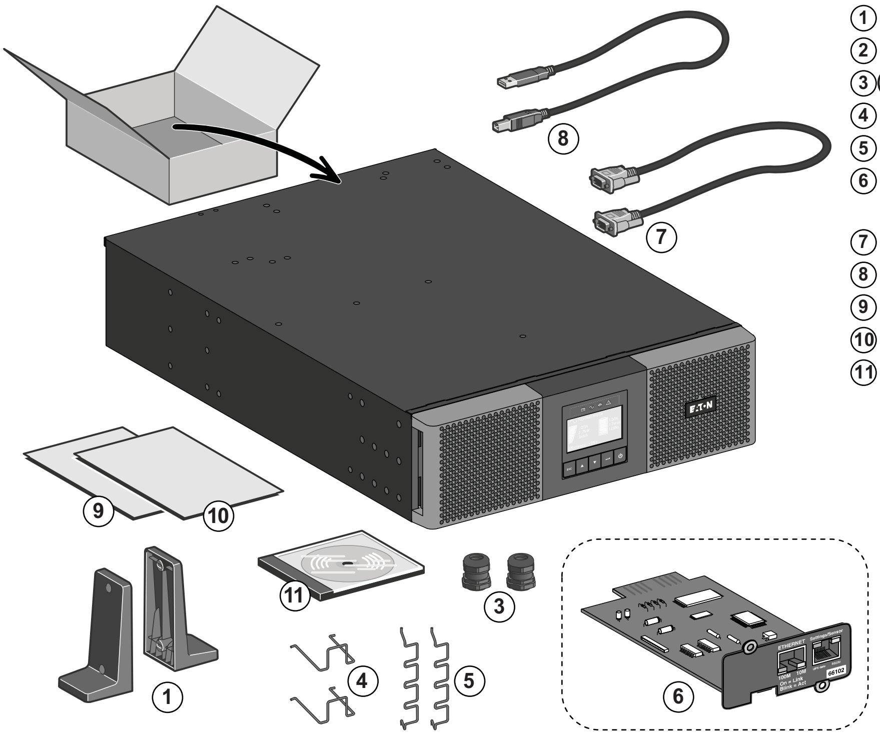
Place the cabinet in a protected area that has adequate airflow and is free of humidity, flammable gas, and corrosion.

Packing materials must be disposed of in compliance with all local regulations concerning waste. Recycling symbols are printed on the packing materials to facilitate sorting.

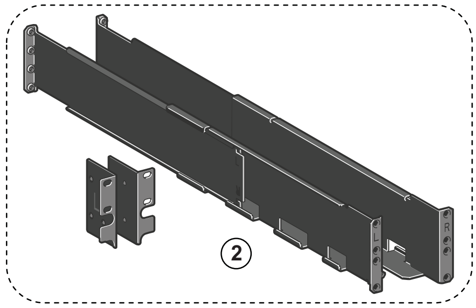
3. Installation

3.3 Checking the accessory kit

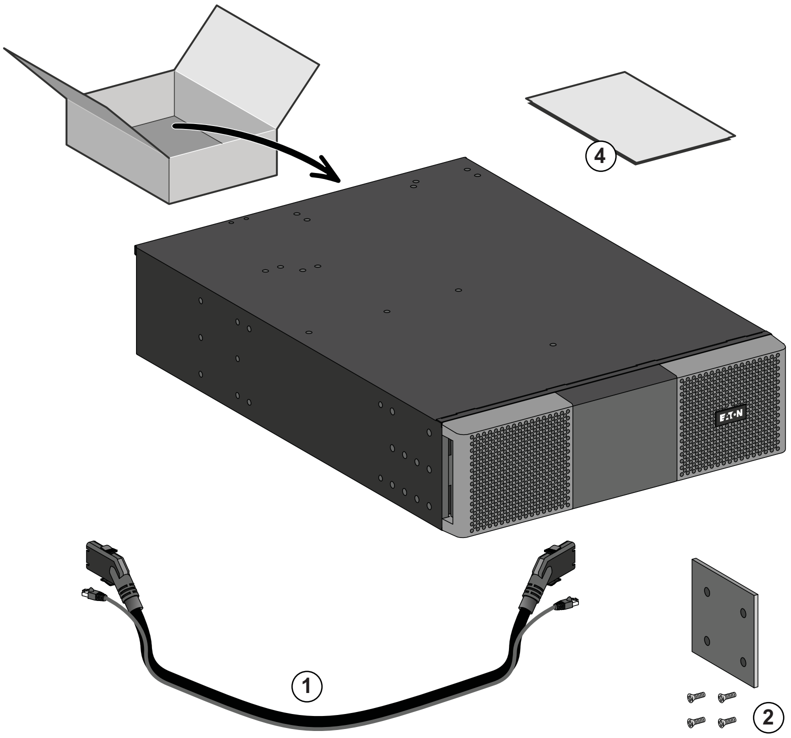
- Verify that the following additional items are included with the UPS:



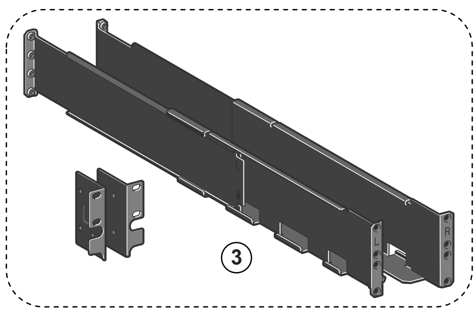
1. (2) Tower stands
2. Rack kit for 19-inch enclosures (optional)
3. (2) cable glands for Input/Output connection
4. (2) cable lockers for 16A outlets
5. (2) cable lockers for 10A outlets
6. Network-MS communication card (optional)
7. RS232 communication cable
8. USB communication cable
9. User manual
10. Safety instructions
11. Software CD-ROM



- If you ordered an optional Extended Battery Module (EBM), verify that the following additional items are included with the EBM:



1. Battery power cable, attached with battery detection cable
2. Stabilizer bracket (4 screws included)
3. Rack kit for 19-inch enclosures (optional)
4. EBM Installation manual.



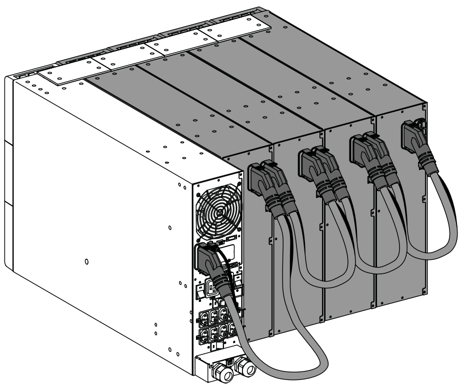
Discard the EBM user’s guide if you are installing the EBM with a new UPS at the same time.
Use the UPS user’s guide to install both the UPS and the EBM.

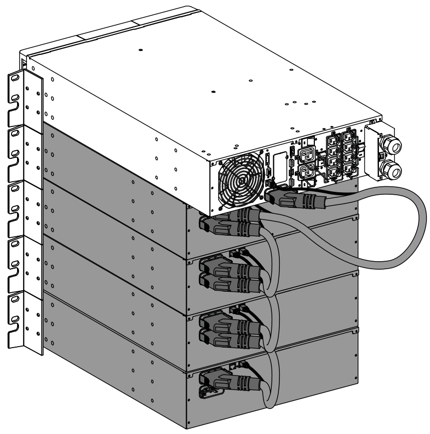
If you ordered other UPS accessories, refer to specific user manuals to check the packing contents.

3.4 Connecting the EBM(s)

A small amount of arcing may occur when connecting an EBM to the UPS. This is normal and will not harm personnel. Insert the EBM cable into the UPS battery connector quickly and firmly.

1. Plug the EBM power cable(s) into the battery connector(s). Up to 12 EBMs may be connected to the UPS.
2. Verify that the EBM connections are tight and that adequate bend radius and strain relief exist for each cable.
3. Connect the battery detection cable(s) to the connector of the UPS and of the EBM(s).





3.5 Connecting other accessories

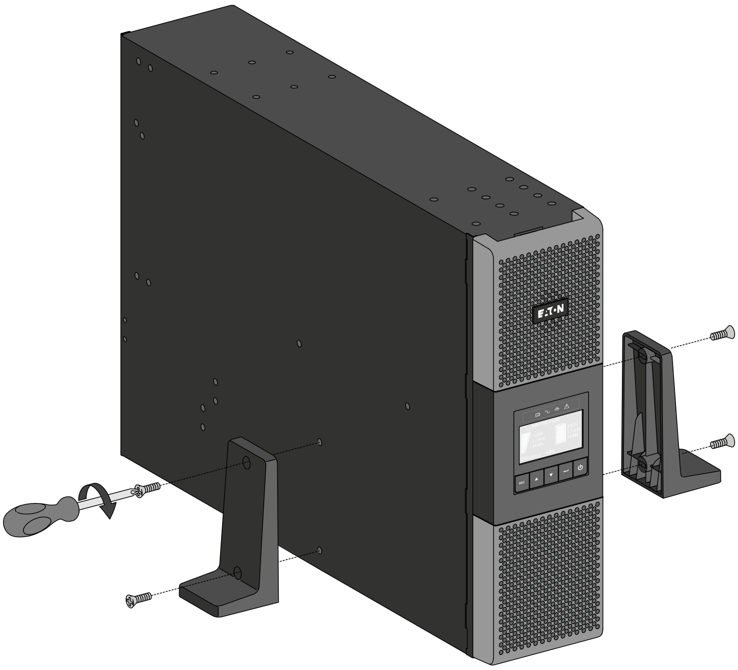
If you ordered other UPS accessories, refer to specific user manuals to check the connection to the UPS.

3.6 Tower installation

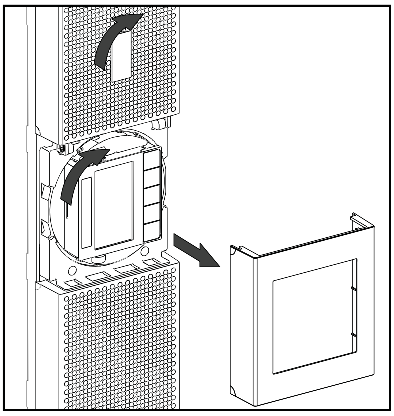
If you ordered other UPS accessories, refer to specific user manuals to check the tower installation with the UPS.

To install the cabinet:

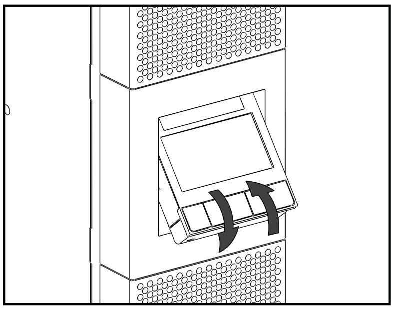
1. Place the UPS on a flat, stable surface in its final location.
2. Always keep 150 mm of free space behind the UPS rear panel.
3. If installing additional cabinets, place them next to the UPS in their final location.



p Adjustment of the orientation of the LCD panel and of the logo.



p Adjustment of the angle of vision of the LCD panel.



3.7 Rack installation

If you ordered other UPS accessories, refer to specific user manuals to check the rack installation with the UPS.

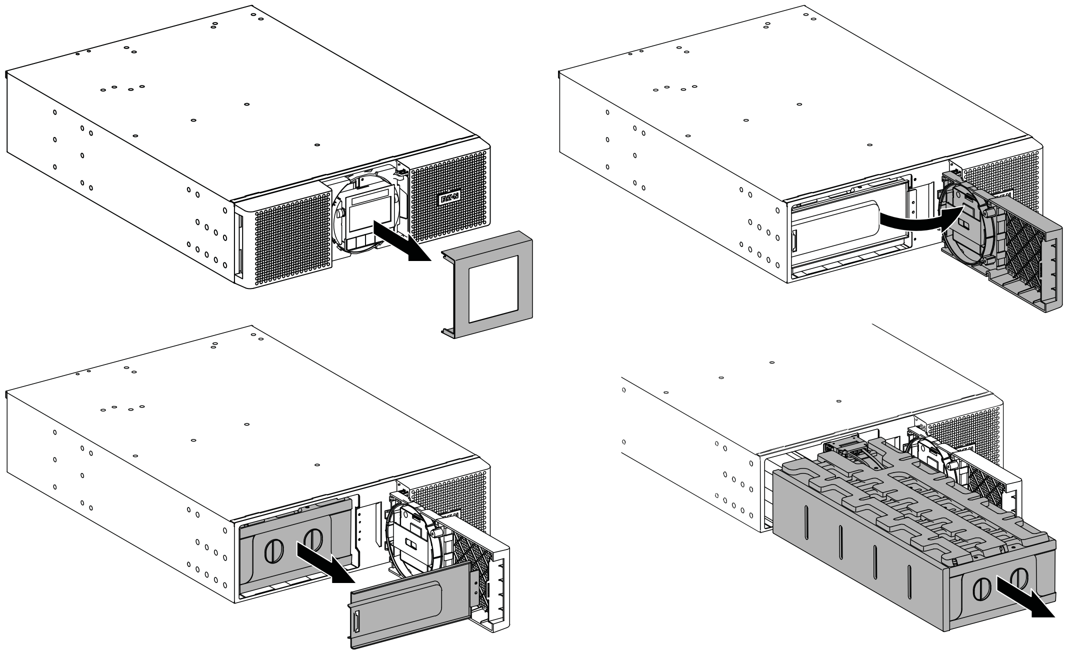
p Prepare UPS for rack mounting.

This step requires two people.

The UPS is heavy. To ease its rack mounting, you can remove the battery pack from the UPS as explained below.

1. Remove the center cover of the front panel
2. Remove the two screws to open the left side of the front panel
3. Remove the two screws to pull out the metal protection cover of the battery

A ribbon cable connects the LCD control panel to the UPS. Do not pull on the cable or disconnect it.

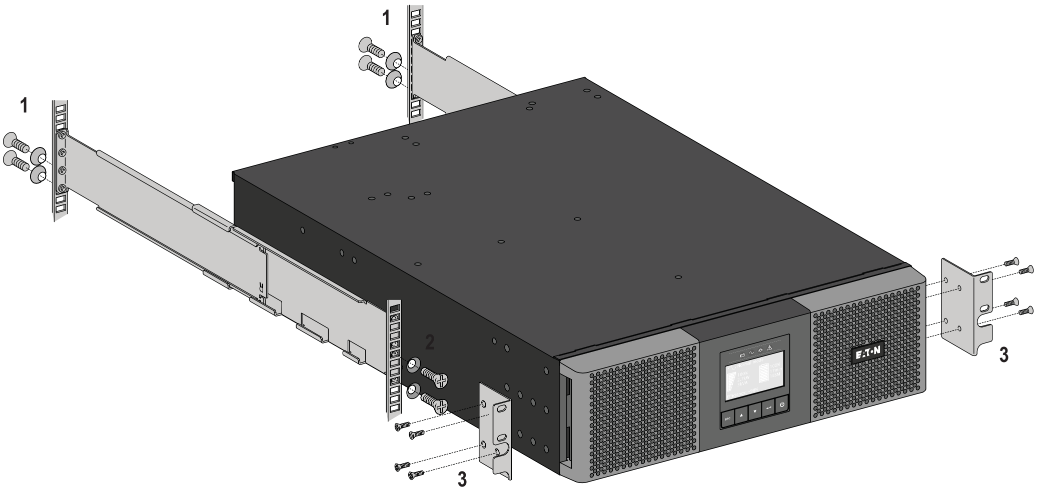


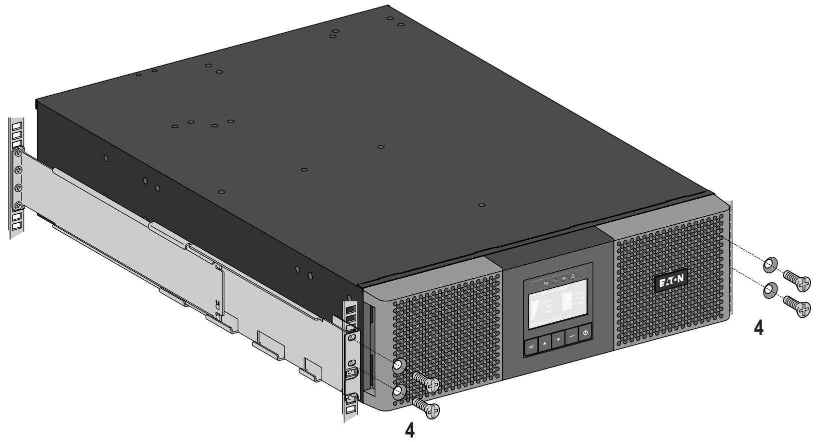
4. Pull out the plastic handle of the battery pack, and slide the pack out slowly on to a flat and stable surface. Use two hands to support the battery pack. Set it aside for reinstalling after that the UPS is rack mounted.
5. Mount the UPS on rack
6. Put back the battery pack, screw back the metal protection cover and the front panel, then clip the center cover.

3. Installation

p Rack mounting of UPS, EBM, and accessory modules.

Follow steps 1 to 4 for module mounting on the rails.





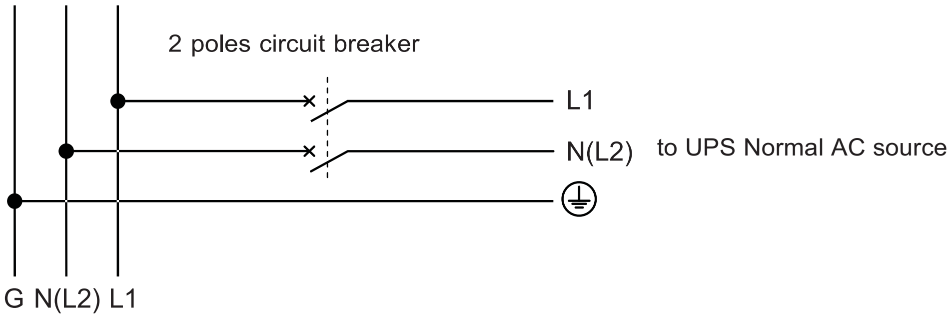
The rails and necessary hardware are supplied by EATON.

3.8 Installation requirements

Recommended protective devices and cable cross-sections

1. Recommended upstream protection

UPS power rating	Upstream circuit breaker
5000VA	D curve – 32A
6000VA	D curve – 32A



2. Recommended cable cross-sections

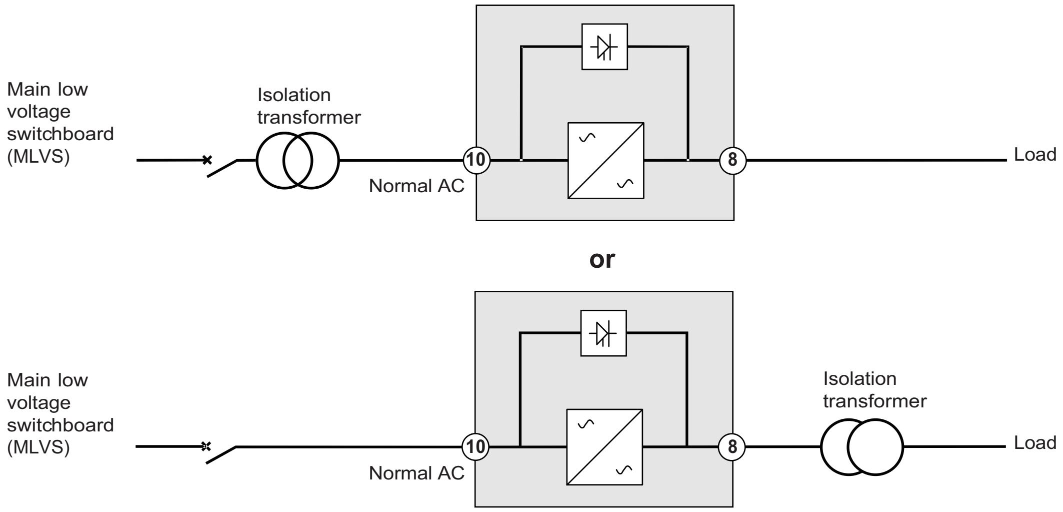
Terminal position	Wire function	Terminal wire size rating	Minimum input wire size	Tightening torque
L1	Phase	4-16 mm^2 (12-6 AWG)	6 mm^2 (10 AWG) 105°C 10 mm^2 (8 AWG) 75°C	10 lb in
N(L2)	Neutral (Phase)			
⏚	Ground			

Copper wire, solid or stranded.

3. Installation

3.9 Installation depending on the system earthing arrangement (SEA)

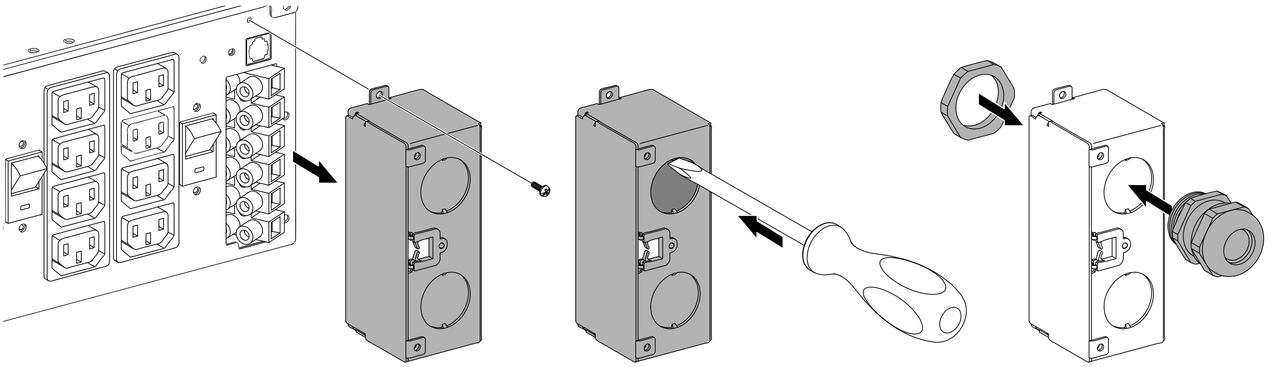
Change in SEA between upstream and downstream or galvanic isolation required



4. Power cables connection

4.1 Access to terminal blocks

1. Remove the terminal blocks cover (one screw)
2. Punch the knockouts and insert the cables/conduits inside

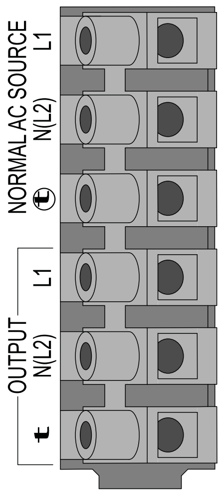


- **High leakage current:**
Earth connection essential before connecting supply.

4.2 Input/Output connection

This type of connection must be carried out by qualified electrical personnel
Before carrying out any connection, check that the upstream protection device (Normal AC source) is open "O" (Off).
Always connect the ground wire first

If you ordered a HotSwap MBP, refer to the specific user manual to check the terminal blocks connection of the UPS with the MBP.



1 - Insert the Normal AC cable through the cable gland.

2 - Connect the three cables to the Normal AC source terminal blocks.

3 - Insert the Output cable through the cable gland.

4 - Connect the three cables to the Output terminal blocks.

5 - Put back and secure the terminal blocks cover with the screw.

6 - Tighten the cable glands.

5. Operation

5.1 UPS startup and shutdown

If you ordered a HotSwap MBP, refer to the specific user manual to check the startup sequence of the UPS with the MBP.

Starting the UPS

Verify that the total equipment ratings do not exceed the UPS capacity to prevent an overload alarm.

To start the UPS:

1. If optional EBMs are installed, verify that the EBM are connected to the UPS.
   See "Connecting the EBM(s)" on page 17.
2. Verify that the UPS terminal blocks are connected to AC source.
3. Set the upstream circuit breaker (not provided) to the "I" position (On) to switch on the utility power.
   The UPS front panel display illuminates and shows EATON logo.
4. Verify that the UPS status screen shows ⏻, press ⏻ to start.
5. Press the ⏻ button on the UPS front panel for at least 3 seconds.
   The UPS front panel display changes status to "UPS starting...".
6. Check the UPS front panel display for active alarms or notices. Resolve any active alarms before continuing. See "Troubleshooting" on page 37.
   If the ⚠ indicator is on, do not proceed until all alarms are clear. Check the UPS status from the front panel to view the active alarms. Correct the alarms and restart if necessary.
7. Verify that the ∿ indicator illuminates solid, indicating that the UPS is operating normally and powering the output.
   The UPS should be in Online mode.

The internal batteries charge to 90% capacity in less than 3 hours. However, Eaton recommends that the batteries charge for 48 hours after installation or long-term storage.

Starting the UPS on Battery

Before using this feature, the UPS must have been powered by utility power with output enabled at least once. Battery start can be disabled. See Coldstart setting in user settings on page 13.

To start the UPS on battery:

1. Press the ⏻ button on the UPS front panel until the UPS front panel display illuminates and shows a status of "UPS starting...".
   The UPS cycles through Standby mode to Battery mode. The 🔋 indicator illuminates solid.
   The UPS supplies power to your equipment.
2. Check the UPS front panel display for active alarms or notices. Resolve any active alarms before continuing. See "Troubleshooting" on page 37.
   Check the UPS status from the front panel to view the active alarms. Correct the alarms and restart if necessary.

UPS shutdown

To shut down the UPS:

1. Press the ⏻ button on the UPS front panel. The UPS transfers to Standby mode.
2. Set the upstream circuit breaker (not provided) to the "O" position (Off) to switch off the utility power.

5.2 Operating modes

The Eaton 9SX and 9PX front panel indicates the UPS status through the UPS indicators, see page 13.

Online mode

During Online mode, the indicator illuminates solid and the UPS is powered from the utility.
The UPS monitors and charges the batteries as needed and provides filtered power protection to your equipment. Optional High Efficiency and Energy Saving settings minimize heat contribution to the rack environment. See user settings on page 13.

Battery mode

When the UPS is operating during a power outage, the alarm beeps once every ten seconds and the indicator illuminates solid. The necessary energy is provided by the battery.

When the utility power returns, the UPS transfers to Online mode operation while the battery recharges.

If battery capacity becomes low while in Battery mode, the audible alarm beeps once every 3 seconds. This warning is approximate, and the actual time to shutdown may vary significantly.

Shutdown all applications on the connected equipment because automatic UPS shutdown is imminent.

When utility power is restored after the UPS shuts down, the UPS automatically restarts.

Bypass mode

In the event of a UPS overload or internal failure, the UPS transfers your equipment to utility power. Battery mode is not available and your equipment is not protected; however, the utility power continues to be passively filtered by the UPS. The indicator illuminates.

Depending on overload conditions, the UPS remains in Bypass mode for at least 5 seconds and will stay in this mode if three transfers to Bypass occur within 20 minutes.

The UPS transfers to Bypass mode when:

- the user activates Bypass mode through the front panel.
- the UPS detects an internal failure.
- the UPS has an overtemperature condition.
- the UPS has an overload condition listed in table 6 on page 41.

The UPS shuts down after a specified delay for overload conditions listed in table 6 on page 41.
The UPS remains on to alarm the fault

Standby mode

When the UPS is turned-off and remains connected to AC source, the UPS is in Standby mode.

Depending if Bypass Standby setting is enabled, the output is powered but not protected.
The battery recharges when necessary and the communication ports are powered.

5.3 Transferring the UPS between modes

From Online (or Battery) to Bypass mode. Press any button to activate the menu options, then select Control and Go to Bypass.

From Bypass to Online (or Battery) mode. Press any button to activate the menu options, then select Control and Go back normal.

5.4 Setting High Efficiency mode

On High Efficiency mode, the UPS operates normally on Bypass, transfers to Online (or Battery) mode in less than 10 ms when utility fails, and transfers back to Bypass in 5 minutes after utility returns.

Eaton recommends to use the HE mode only to protect I/T equipment.

To set the High Efficiency mode:

1. Press any button to activate the menu options, then select Settings, Output settings, and High Efficiency mode.
2. Select Enabled and Enter to confirm.

5.5 Configuring Bypass settings

The following settings are available for configuring Bypass operation.

Bypass transfer out of tolerance

1. Press any button to activate the menu options, then select Settings, Output settings, and Bypass transfer.
2. Select Enabled or Disabled for BP AC NOK, and Enter to confirm.
   If Enabled, the UPS transfers to Bypass even if Bypass AC source is out of tolerance, depending on output mode. If Disabled, the UPS output is shutdown.

Interrupt time

This setting is displayed to define the break duration during transfer to Bypass, only if transfer out of tolerance is enabled. 10 ms or 20 ms can be selected.

5.6 Configuring battery settings

Automatic battery test

Automatic battery tests are done every week in constant charging mode and at each cycle in ABM mode.
The tests frequency can be modified.
During the test, the UPS transfers to Battery mode and discharges the batteries for 25 seconds under load.

Battery mode is not displayed and battery low alarm does not activate during a battery test.

The battery test may be cancelled due to bad conditions, or failed.

Low battery warning

During discharge, the low battery alarm is activated if the battery capacity goes below 20%.
This threshold can be modified.

External battery setting

The number of Extended Battery Module is automatically detected, or can be set manually in number of EBM or in Ah.

Deep discharge protection

This setting is recommended to avoid damaging the battery. Warranty is void if deep discharge protection is disabled.

5.7 Retrieving the Event log

To retrieve the Event log through the display:

1. Press any button to activate the menu options, then select Event log.
2. Scroll through the listed events.

5.8 Retrieving the Fault log

To retrieve the Fault log through the display:

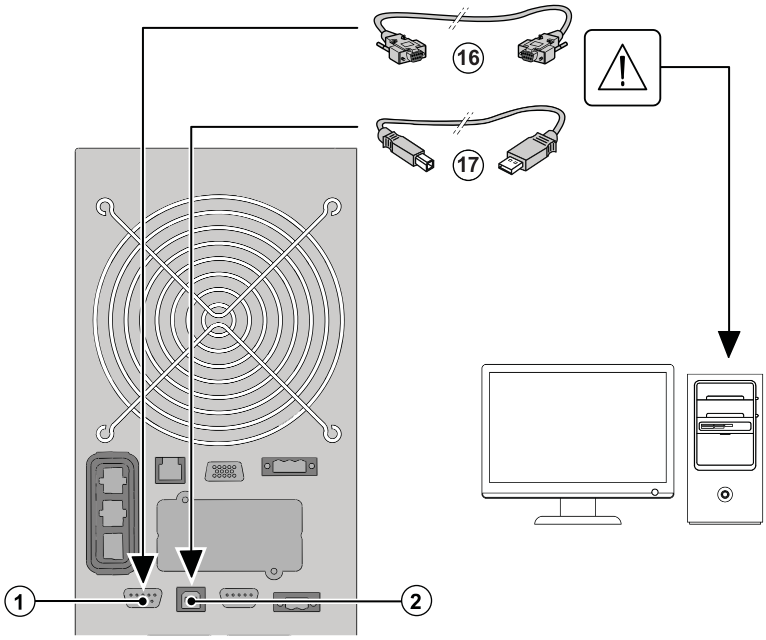
1. Press any button to activate the menu options, then select Fault log.
2. Scroll through the listed faults.

6. Communication

6.1 Communication ports

● RS232 or USB communication ports

The RS232 and USB communication ports cannot operate simultaneously.



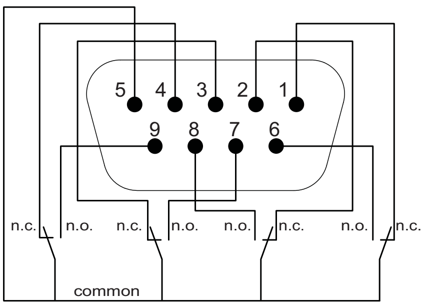
1. Connect the RS232 16 or USB 17 communication cable to the serial or USB port on the computer.

2. Connect the other end of the communication cable 16 or 17 to the RS232 1 or USB 2 communication port on the UPS.

The **UPS** can now communicate with EATON power management software.

● Relay output contacts

The UPS incorporates four programmable relay outputs; each information is available with a close or open contact.

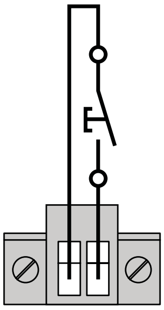


Status active information: (if contact between pin and common is closed)
- Pin 1: not on Bypass
- Pin 2: load not protected
- Pin 3: not low battery
- Pin 4: not on Battery
- Pin 5: user common
- Pin 6: on Bypass
- Pin 7: low battery
- Pin 8: load protected
- Pin 9: on Battery
- n.o.: contact normally open
- n.c.: contact normally closed

The relay output contacts must not be connected to any utility connected circuits.
Reinforced insulation to the utility is required. The relay output contacts have a maximum rating of 250 Vac/5A.

Remote On/Off

Remote On/Off allows remote action of ⏻ button to switch On/Off the UPS.



Normally open

When contact changes from open to closed, the UPS is switched-on (or stays On).
When contact changes from closed to open, the UPS is switched-off (or stays Off).

On/Off control via ⏻ button has priority over the remote control.

Remote Power Off

RPO is used to shutdown the UPS remotely. This feature can be used for shutting down the load and the UPS by thermal relay, for instance in the event of room over temperature. When RPO is activated, the UPS shuts down the output and all its power converters immediately. The UPS remains on to alarm the fault.

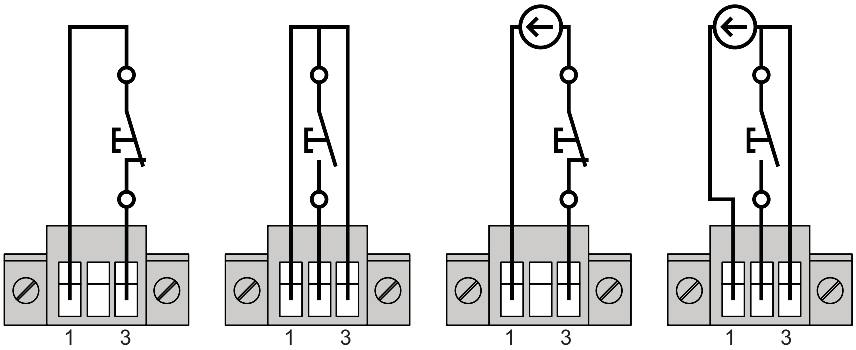
The RPO circuit is an IEC 60950 safety extra low voltage (SELV) circuit. This circuit must be separated from any hazardous voltage circuits by reinforced insulation.

- The RPO must not be connected to any utility connected circuits. Reinforced insulation to the utility is required. The RPO switch must have a minimum rating of 27 Vdc and 20 mA and be a dedicated latching-type switch not tied into any other circuit. The RPO signal must remain active for at least 250 ms for proper operation.
- To ensure the UPS stops supplying power to the load during any mode of operation, the input power must be disconnected from the UPS when the Remote Power Off function is activated.

Leave the RPO connector installed in the RPO port on the UPS even if the RPO function is not needed.

RPO connections:

Internal power supply **External power supply**



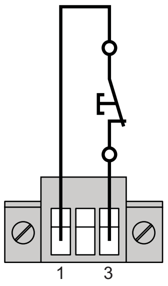
Normally closed Normally open Normally closed Normally open

Terminal wire size rating is 0.32-4 mm^2 (22-12 AWG).
Suggested wire size is 0.82 mm^2 (18 AWG).

6. Communication

Remote control connection and test

1 - Check the UPS is shut down and the electrical supply network disconnected.
2 - Remove RPO connector from the UPS by unfitting the screws.
3 - Connect a normally closed volt-free contact between the two pins of connector.



Normally closed

Contact open: shut down of UPS
To return to normal operation, deactivate the external remote shut down contact and restart the UPS from the front panel.

4 - Plug the RPO connector into the back of the UPS and fix the screws.
5 - Connect and restart the UPS according to the previously described procedures.
6 - Activate the external remote shut down contact to test the function.

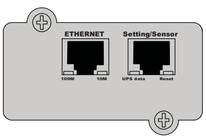
Always test the RPO function before applying your critical load to avoid accidental load loss.

● Connectivity Cards

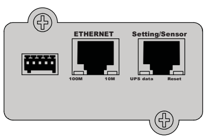
Connectivity cards allow the UPS to communicate in a variety of networking environments and with different types of devices. The 9SX and 9PX models have one available communication bay for the following
connectivity cards:

- **Network-MS card** - has SNMP and HTTP capabilities as well as monitoring through a Web browser interface; connects to Ethernet network. In addition, a Environmental Monitoring Probe can be attached to obtain humidity, temperature, smoke alarm, and security information.
- **Modbus-MS card** - has connection to Modbus protocol in addition to network management.
- **Relay-MS card** - has isolated dry contact (Form-C) relay outputs for UPS status: Utility failure, Battery low, UPS alarm/OK, or on Bypass.

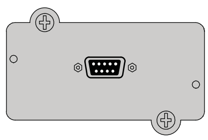
See on page 21 for the location of the communication bay.



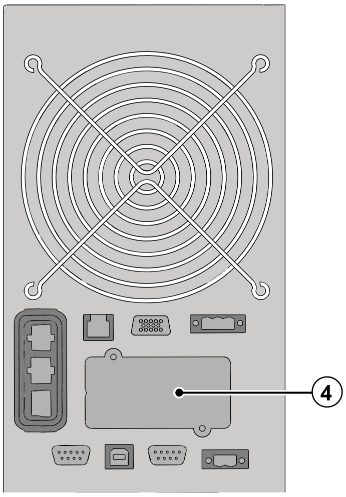
Network-MS card



Modbus-MS card


Relay-MS card

Installation of the communication cards



It is not necessary to shutdown the UPS before installing a communication card.

1. Remove the slot cover ④ secured by screws.
2. Insert the communication card in the slot.
3. Secure the card cover with the 2 screws.

- **Parallel communication port.**

This slot is used for Parallel operation (only on 9PX models).

6.2 Eaton Intelligent Power Software suite

Each 9SX and 9PX UPS ships with Eaton Intelligent Power Software suite. To begin installing, see the instructions accompanying the Software suite CD.

Eaton Software suite provides up-to-date graphics of UPS power and system data and power flow.

It also gives you a complete record of critical power events, and it notifies you of important UPS or power information.

If there is a power outage and the 9SX and 9PX UPS battery power becomes low, Eaton Software suite can automatically shut down your computer system to protect your data before the UPS shutdown occurs.

7. UPS maintenance

7.1 Equipment care

For the best preventive maintenance, keep the area around the equipment clean and dust free.
If the atmosphere is very dusty, clean the outside of the system with a vacuum cleaner.
For full battery life, keep the equipment at an ambient temperature of 25°C (77°F).

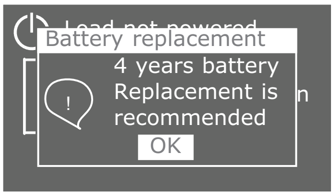
If the UPS requires any type of transportation, verify that the UPS is disconnected and turned off.
The batteries are rated for a 3-5 year service life. The length of service life varies, depending on the frequency of usage and ambient temperature. Batteries used beyond expected service life will often have severely reduced runtimes. Replace batteries at least every 4 years to keep units running at peak efficiency.

7.2 Storing the equipment

If you store the equipment for a long period, recharge the battery every 6 months by connecting the UPS to utility power. The internal batteries charge to 90% capacity in less than 3 hours.
However, Eaton recommends that the batteries charge for 48 hours after long-term storage.
Check the battery recharge date on the shipping carton label.
If the date has passed and the batteries were never recharged, do not use them. Contact your service representative.

7.3 When to replace batteries

When the battery replacement screen is displayed, it is recommended to replace the batteries.
Contact your service representative to order new batteries.



7.4 Replacing batteries

DO NOT DISCONNECT the batteries while the UPS is in Battery mode.

Batteries can be replaced easily without turning off the UPS or disconnecting the load.
If you prefer to remove input power to change the batteries, see "UPS Shutdown" on page 24.

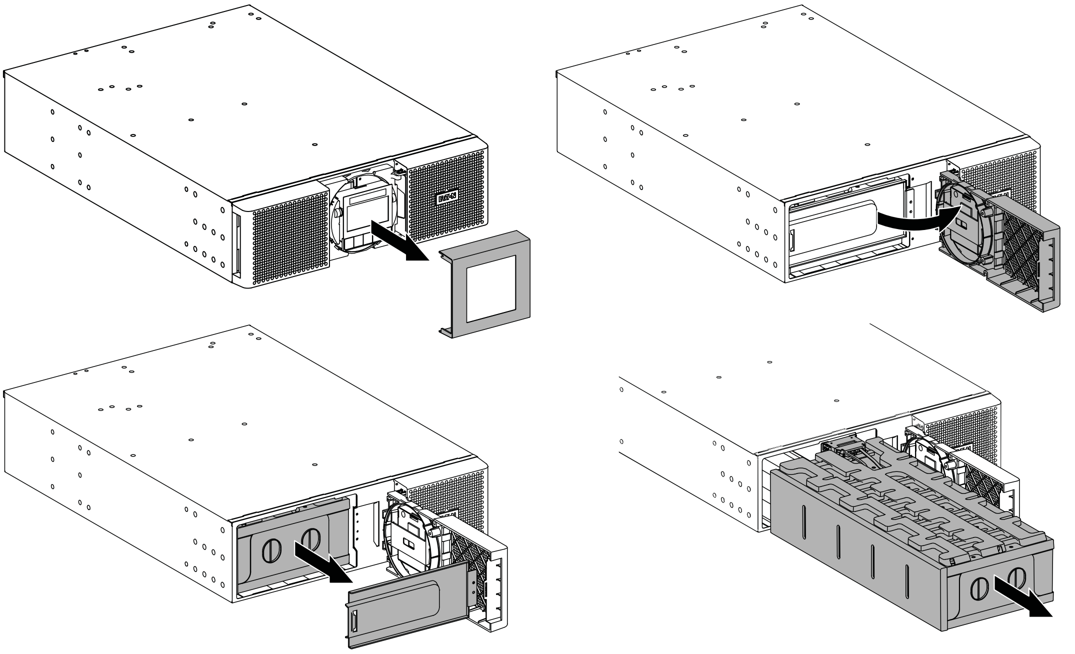
Consider all warnings, cautions, and notes before replacing batteries.

- Servicing should be performed by qualified service personnel knowledgeable of batteries and required precautions. Keep unauthorized personnel away from batteries.
- Batteries can present a risk of electrical shock or burn from high short circuit current. Observe the following precautions:
  1. Remove watches, rings, or other metal objects,
  2. Use tools with insulated handles,
  3. Do not lay tools or metal parts on top of batteries,
  4. Wear rubber gloves and boots.
- When replacing batteries, replace with the same type and number of batteries or battery packs. Contact your service representative to order new batteries.
- Proper disposal of batteries is required. Refer to your local codes for disposal requirements.
- Never dispose of batteries in a fire. Batteries may explode when exposed to flame.
- Do not open or mutilate the battery or batteries. Released electrolyte is harmful to the skin and eyes and may be extremely toxic.
- Determine if the battery is inadvertently grounded. If inadvertently grounded, remove source from ground. Contact with any part of a grounded battery can result in electrical shock. The likelihood of such shock can be reduced if such grounds are removed during installation and maintenance (applicable to equipment and remote battery supplies not having a grounded supply circuit).
- ELECTRIC ENERGY HAZARD. Do not attempt to alter any battery wiring or connectors. Attempting to alter wiring can cause injury.
- Disconnect charging source prior to connecting or disconnecting battery terminals.

7. UPS maintenance

- **Replacing the internal battery**

The internal battery is heavy. Use caution when handling the heavy batteries.



To replace the battery pack:

1. Remove the center cover of the front panel
2. Remove the two screws to open the left side of the front panel
3. Remove the two screws to pull out the metal protection cover of the battery

A ribbon cable connects the LCD control panel to the UPS. Do not pull on the cable or disconnect it.

4. Pull out the plastic handle of the battery pack, and slide the pack out slowly on to a flat and stable surface. Use two hands to support the battery pack. See "Recycling the used equipment" on page 36 for proper disposal.
5. Verify that the replacement batteries have the same rating as the batteries being replaced.
6. Put the new battery pack into the UPS. Push the battery pack firmly to ensure a proper connection.
7. Screw back the metal protection cover and the front panel, then clip the center cover.
8. Continue to “Testing new batteries” on page 35.

Replacing the EBM(s)

⚠ The EBM is heavy. Lifting the cabinet into a rack requires a minimum of two people.

To replace the EBM(s):

1. Unplug the EBM power cable and battery detection cable from the UPS.
   If additional EBM(s) are installed, unplug the EBM power cable and battery detection cable from each EBM.
2. Replace the EBM(s). See "Recycling the used equipment" on page 36 for proper disposal.

i A small amount of arcing may occur when connecting an EBM to the UPS. This is normal and will not harm personnel. Insert the EBM cable into the UPS battery connector quickly and firmly.

3. Plug the EBM cable(s) into the battery connector(s). Up to twelve EBMs may be connected to the UPS.
4. Verify that the EBM connections are tight and that adequate bend radius and strain relief exist for each cable.
5. Connect the battery detection cable(s) to the connector of the UPS and of the EBM(s).

Testing new batteries

To test new batteries:

1. Charge the batteries for 48 hours.
2. Press any button to activate the menu options.
3. Select Control then Start battery test.
   The UPS starts a battery test if the batteries are fully charged, the UPS is in Normal mode with no active alarms, and the bypass voltage is acceptable.
   During the battery test, the UPS transfers to Battery mode and discharges the batteries for 25 seconds. The front panel displays "Battery test in progress" and the percentage of the test completed.

7. UPS maintenance

7.5 Replacing the UPS equipped with a HotSwap MBP

The HotSwap MBP allows to service or replace the UPS without interrupting the connected loads.

Refer to the specific user manual for more information about HotSwap MBP.

To remove the UPS:

1. Press any button to activate the menu options. Select Control then Go to Bypass.
2. Check that the UPS is in Bypass mode (Bypass LED should be On).
3. Turn the HotSwap MBP switch to the Bypass position: the red LED on the HotSwap MBP goes On, indicating that the load is now powered directly from utility power.
4. Set the Normal AC source switch on the HotSwap MBP to the "O" position and wait for 30s.
5. The UPS stops and can now be disconnected.

To reinstall the UPS:

1. Check that the UPS is correctly connected to the HotSwap MBP.
2. Set the Normal AC source switch on the HotSwap MBP to the "I" position.
3. Press the ⏻ button to switch On the UPS.
4. Select Control then Go to Bypass.
5. Turn the HotSwap MBP switch to the Normal position: the red LED on the HotSwap MBP goes Off, indicating that the load is now powered by the UPS (Bypass LED should be On).
6. Select Control then Go back normal.
7. Check that the UPS is in Online mode: the load is now protected by the UPS (Online LED should be On).

7.6 Recycling the used equipment

Contact your local recycling or hazardous waste center for information on proper disposal of the used equipment.

- Do not dispose of the battery or batteries in a fire. Batteries may explode. Proper disposal of batteries is required. Refer to your local codes for disposal requirements.
- Do not open or mutilate the battery or batteries. Released electrolyte is harmful to the skin and eyes. It may be toxic.

Do not discard the UPS or the UPS batteries in the trash. This product contains sealed, lead acid batteries and must be disposed of properly. For more information, contact your local recycling/reuse or hazardous waste center.

Pb

Do not discard waste electrical or electronic equipment (WEEE) in the trash. For proper disposal, contact your local recycling/reuse or hazardous waste center.

8. Troubleshooting

The Eaton 9PX and 9SX are designed for durable, automatic operation and also alert you whenever potential operating problems may occur. Usually the alarms shown by the control panel do not mean that the output power is affected. Instead, they are preventive alarms intended to alert the user.

- Events are silent status information that are recorded into the Event log. Example = "AC freq in range".
- Alarms are recorded into the Event log and displayed on the LCD status screen with the logo blinking. Some alarms may be announced by a beep every 3 seconds. Example = "Battery low".
- Faults are announced by a continuous beep and red LED, recorded into the Fault log and displayed on the LCD with a specific message box. Example = Out. short circuit.

Use the following troubleshooting chart to determine the UPS alarm condition.

8.1 Typical alarms and faults

To check the Event log or Fault log :

1. Press any button on the front panel display to activate the menu options.
2. Press the ↓ button to select Event log or Fault log.
3. Scroll through the listed events or faults.

The following table describes typical conditions.

Conditions	**Possible cause**	**Action**
Battery mode LED is On. 1 beep every 10 seconds.	A utility failure has occurred and the UPS is in Battery mode.	The UPS is powering the equipment with battery power. Prepare your equipment for shutdown.
Battery low LED is On. 1 beep every 3 seconds.	The UPS is in Battery mode and the battery is running low.	This warning is approximate, and the actual time to shutdown may vary significantly. Depending on the UPS load and number of Extended Battery Modules (EBMs), the "Battery Low" warning may occur before the batteries reach 20% capacity.
No battery LED is On. Beep continuous.	The batteries are disconnected.	Verify that all batteries are properly connected. If the condition persists, contact your service representative.
Battery fault LED is On. Beep continuous.	The battery test is failed due to bad or disconnected batteries, or the battery minimum voltage is reached in ABM cycling mode.	Verify that all batteries are properly connected. Start a new battery test: if the condition persists, contact your service representative.
The UPS does not provide the expected backup time.	The batteries need charging or service.	Apply utility power for 48 hours to charge the batteries. If the condition persists, contact your service representative.
Bypass mode LED is on.	An overload or a fault has occurred, or a command has been received and the UPS is in Bypass mode	Equipment is powered but not protected by the UPS. Check for one of the following alarms: overtemperature, overload or UPS failure.

8. Troubleshooting

Power overload LED is On. Beep continuous.	Power requirements exceed the UPS capacity (greater than 100% of nominal; see in table 6 on page 41 for specific output overload ranges).	Remove some of the equipment from the UPS. The UPS continues to operate, but may switch to Bypass mode or shut down if the load increases. The alarm resets when the condition becomes inactive.
UPS overtemperature LED is On. 1 beep every 3 seconds.	The UPS internal temperature is too high or a fan has failed. At the warning level, the UPS generates the alarm but remains in the current operating state. If the temperature rises another 10°C, the UPS transfers to Bypass mode or shuts down if Bypass is unusable.	If the UPS transferred to Bypass mode, the UPS will return to normal operation when the temperature drops 5°C below the warning level. If the condition persists, shut down the UPS. Clear vents and remove any heat sources. Allow the UPS to cool. Ensure the airflow around the UPS is not restricted. Restart the UPS. If the condition continues to persist, contact your service representative.
The UPS does not start.	The input source is not connected correctly.	Check the input connections.
	The Remote Power Off (RPO) switch is active or the RPO connector is missing.	If the UPS Status menu displays the "Remote Power Off" notice, inactivate the RPO input.
Input bad wiring / Output bad wiring Led is On. Beep continuous.	Input/Output cables are not connected to the correct terminal blocks.	Connect correctly the Input/Output cables.
MBP disconnected	The HotSwap MBP is no more connected to the UPS.	If the HotSwap MBP is connected to the UPS, check that the detection connector is correctly plugged.

8.2 Silencing the alarm

Press the ESC (Escape) button on the front panel display to silence the alarm. Check the alarm condition and perform the applicable action to resolve the condition. If the alarm status changes, the alarm beeps again, overriding the previous alarm silencing.

8.3 Service and support

If you have any questions or problems with the UPS, call your **Local Distributor** or your local service representative and ask for a UPS technical representative.

Please have the following information ready when you call for service:

- Model number
- Serial number
- Firmware version number
- Date of failure or problem
- Symptoms of failure or problem
- Customer return address and contact information

If repair is required, you will be given a Returned Material Authorization (RMA) number. This number must appear on the outside of the package and on the Bill Of Lading (if applicable). Use the original packaging or request packaging from the Help Desk or distributor. Units damaged in shipment as a result of improper packaging are not covered under warranty. A replacement or repair unit will be shipped, freight prepaid for all warrantied units.

For critical applications, immediate replacement may be available. Call the **Help Desk** for the dealer or distributor nearest you.

9. Specifications

9.1 Model specifications

Table 1. Power Module model list

Model	Power ratings
9SX5KiRT	5000VA / 4500W
9PX5Ki	5000VA / 4500W
9SX6KiRT	6000VA / 5400W
9PX6Ki	6000VA / 5400W

Table 2. Extended Battery Module model list

Model	Configuration	Battery voltage	For power ratings
9SXEBM180RT	Rack / Tower	180Vdc	5000-6000VA
9PXEBM180	Rack / Tower	180Vdc	5000-6000VA

Table 3. Weights and dimensions

Model (UPS)	Dimensions D x W x H (mm / in)	Weight (lb / kg)
9SX5KiRT	685 x 440 x 130 (27.0 x 17.3 x 5.1)	106 / 48
9PX5Ki	685 x 440 x 130 (27.0 x 17.3 x 5.1)	106 / 48
9SX6KiRT	685 x 440 x 130 (27.0 x 17.3 x 5.1)	106 / 48
9PX6Ki	685 x 440 x 130 (27.0 x 17.3 x 5.1)	106 / 48
Model (EBM)	**Dimensions D x W x H (mm / in)**	**Weight (lb / kg)**
9SXEBM180RT	645 x 440 x 130 (25.4 x 17.3 x 5.1)	150 / 68
9PXEBM180	645 x 440 x 130 (25.4 x 17.3 x 5.1)	150 / 68

Table 4. Electrical input

Nominal frequency	50/60Hz auto-sensing
Frequency range	50Hz : 40-60Hz before transfer to battery 60Hz : 50-70Hz before transfer to battery
Bypass voltage range	-20% / +15% of nominal value (default)
Noise filtering	MOV for normal and common mode noise

Model	Default input (Voltage/Current)	Selectable input Voltage range	Voltages at 100% Load
9SX5KiRT	230V / 21A	200V, 208V, 220V, 230V, 240V	176-276V
9PX5Ki			
9SX6KiRT	230V / 25.2A		
9PX6Ki			

Table 5. Electrical input connections

Model	Input connection	Input cable
9SX5KiRT	Hardwired	Not provided
9PX5Ki		
9SX6KiRT		
9PX6Ki		

Table 6. Electrical output

All models	Normal mode	Battery mode
Voltage regulation	±1%	±1%
Efficiency	> 98% (High Efficiency mode) > 93%	> 91%
Frequency regulation	Sync with line ±5% of nominal line frequency (outside this range: ±0.5% of auto-selected nominal frequency)	±0.5% of auto-selected nominal frequency
Nominal output	200/208/220/230/240V (voltage configurable) 5000/6000VA 4500/5400W	
Frequency	50 or 60Hz, autosensing or configurable as a frequency converter	
Output overload	100-102% : no alarm 102-110% : load transfers to Bypass mode after 2 minutes 110-125% : load transfers to Bypass mode after 1 minute 125-150% : load transfers to Bypass mode after 10s > 150% : load transfers to Bypass mode after 500ms	
Output overload (Bypass mode)	100-125% : no alarm 125-150% : UPS shuts down after 1 minute > 150% : UPS shuts down after 1s	
Voltage waveform	Sinewave	
Harmonic distortion	< 2% THDV on linear load < 5% THDV on non-linear load	
Transfer time	Online mode: 0 ms (no break) High Efficiency mode: 10ms maximum (due to loss of utility)	
Power factor	0.9	
Load crest ratio	3 to 1	

Table 7. Electrical output connections

Model	Output connection	Output cable
9SX5KiRT	Hardwired (2) IEC16A (4) IEC10A group 1 (4) IEC10A group 2	Not provided
9PX5Ki		
9SX6KiRT		
9PX6Ki		

Table 8. Environmental and safety

EMC certifications	IEC/EN 62040-1: 2008 IEC/EN 62040-2: 2006 Cat. C2 IEC/EN 62040-3: 2011 IEC 60950-1 UL 1778 4th CSA 22.2
EMC (Emissions)*	CISPR22 Class A AS/NZS 22 Class A IEC 61000-3-2 (-3-12) IEC 61000-3-3 (-3-11) FCC part 15 Class A
EMC (Immunity)	IEC 61000-2-2 IEC 61000-4-2, Level 3 IEC 61000-4-3, Level 3 IEC 61000-4-4, Level 4 (also on signal ports) IEC 61000-4-5, Level 4, Criteria B IEC 61000-4-6, Level 3 IEC 61000-4-8, Level 4 IEC 61000-4-11

***** for output cable < 10m.

9. Specifications

Agency markings	CE / C-Tick / cULus
Operating temperature	0 to 40°C (32 to 104°F) in Online mode, with linear derating for altitude **Note:** thermal protection switches load to Bypass in case of overheating.
Storage temperature	0 to 40°C (32 to 104°F) with batteries -15 to 60°C (5 to 140°F) without batteries
Transit temperature	-25 to 55°C (-13 to 130°F)
Relative humidity	0 to 95% no condensing
Operating altitude	Up to 3,000 meters (9,843 ft) above sea level with 10% derating per 1000m
Transit altitude	Up to 10,000 meters (32,808 ft) above sea level
Audible noise	< 45 dBA at 1 meter typical

Table 9. Battery

	Internal batteries	**EBM**
Rack / Tower configuration	5000/6000VA: 180Vdc 15 x 12V, 5Ah	9SXEBM180RT, 9PXEBM180: 180Vdc 2 x 15 x 12V, 5Ah
Fuse	63A	63A
Type	Sealed, maintenance-free, valve-regulated, lead-acid, with minimum 3-year float service life at 25°C (77°F)	
Monitoring	Advanced monitoring for earlier failure detection and warning	
Battery port	External three-pole SBS75G Black connector on UPS for connection to EBM	
EBM battery cable length	40cm (15.7in)	

Table 10. Communication options

Communication bay	(1) available independent communication bay for connectivity cards
Compatible connectivity cards	Network-MS Modbus-MS Relay-MS
Communication ports	RS-232 (DB9): 1200-19200 bps USB: 19200 bps Parallel port (DB15): only for 9PX models
Relay output contacts	(4) programmable relay outputs (normally open or normally closed)
Remote On/Off	2 pins jumper (normally open)
Remote Power Off	3 pins jumper (normally open or normally closed)

10. Glossary

Bypass AC source	Source supplying the bypass line. The equipment can be transferred to the bypass line if an overload occurs on the UPS output, for maintenance or in the event of a malfunction.
Frequency converter	Operating mode used to convert the AC-power frequency between the UPS input and output (50Hz -> 60Hz or 60Hz -> 50Hz).
Low-battery warning	This is a battery-voltage level indicating that battery power is low and that the user must take action to prevent the imminent break in the supply of power to the load.
Backup time	Time during which the load can be supplied by the UPS operating on battery power.
Load	Devices or equipment connected to the UPS output.
HE mode	Operating mode by which the load is supplied directly by the AC source if it is within the tolerances defined by the user. This mode reduces the consumption of electrical power
Manual bypass	Rotary switch controlled by the user, used to connect the loads directly to the AC source. Transfer of the load to the manual bypass enables UPS maintenance without interrupting the supply of power to the connected loads.
Normal (double conversion) mode	The normal UPS operating mode in which the AC source supplies the UPS which in turn supplies the connected loads (after electronic double conversion).
Normal AC source	Normal source of power for the UPS.
Relay contacts	Contacts supplying information to the user in the form of signals.
UPS	Uninterruptible Power Supply.

EATON | Powerware

EATON INDUSTRIES Pty Ltd
Ref: QC029 Rev:07 Issued: 21/08/08

TEST REPORT: 9155 UPS 8-30kVA. 9355 UPS 8-40kVA

Rating:……………………………………kVA
Type:………………………………………………
Local Part No:……………………………………
Customer No:……………………………………
Customer:………………………………………
Parallel Unit No:……………of:……………

Job No:……………………………………………
Manufacturer Part No:……………………………
Manufacturer Serial No:…………………………
Sales Order No:…………………………………
Battery Pack Serial No(s):………………………
XCP Test Software Version:………………………

Regrade from kVA to kVA

Magic Number:

Test meters used (Item Nos.) …………… …………… …………… …………… ……………

Firmware. Revision supplied: ………….. Revision installed: ………… To SB9155:4

PCB "all boards" setup done if new rev Langloader installed or UPS rerated Y/N ☐

Settings. User settings. User LCD screen amended to read correct model No. etc Y/N ☐

1	Date set to (mm/dd/yy)	/ /	2	Time set to (Hr/min)	:
3	Contrast required adjustment	Y/N ☐	4	English language selected	Y/N ☐
5	Relay configuration changed	Y/N ☐			
6	Signal Input 1set to Force Bypass	Y/N ☐	6a	Input 2 set to Ext batt breaker	Y/N ☐
7	Serial port config set to 19,200 baud	Y/N ☐	8	Parallel settings adjusted	Y/N ☐
9	Start screen 'Mimic'	Y/N ☐	10	User password disabled	Y/N ☐
11	Audible alarms on normal	Y/N ☐	12	Battery charge ABM cycling	Y/N ☐
13	Number of strings	☐	14	Battery size Watts/cell	WPC
15	Bat low alarm level 1.880 Volts dc	Y/N ☐	16	Maximum charge rate	A
17	Output Voltage set at	V	18	Bypass limits +10% -15%	Y/N ☐
19	Output frequency set to	Hz	20	Synchronisation enabled	Y/N ☐
21	Synchronisation window set+/- 2%	Y/N ☐	22	Unsynch Xfer to Byp allowed	Y/N ☐
23	Output slew rate set to +/- 0.2Hz	Y/N ☐	24	Input current limit (set by lang load)	A
25	Use of bypass enabled	Y/N ☐	26	Power strategy 'standard'	Y/N ☐
27	Prefer battery in input break	Y/N ☐	28	Immediate X'fer on overload	Y/N ☐
29	Automatic start delay zero	Y/N ☐	30	Auto batt shutdown -1 sec	Y/N ☐
31	command from X-slots allowed	Y/N ☐	32	X-slot signal delay 5 secs	Y/N ☐
33	Input signal shutdown 120 sec	Y/N ☐	34	Site wiring fault enabled	Y/N ☐

System Check.

35 Output Voltage display calibrated (no load) ΦA Y/N ☐ ΦB Y/N ☐ ΦC Y/N ☐

36 UPS run at ....kW resistive load for ☐ Hrs Load indicated ☐ %

37 Inverter interlock fitted Y/N ☐ Tested Y/N ☐ 38 EPO tested Y/N ☐

39 Amps indicated ΦA ☐ ΦB ☐ ΦC ☐ Actual ΦA ☐ ΦB ☐ ΦC ☐

Amps adjusted Y/N ☐

40 Parallel system tested at ☐ kW load for ☐ Hrs

Partial discharge.

41 Mains failure with ☐ Ah batteries for ☐ min Batts charged to ☐ V

41 Charge current verified at ☐ A

Battery installation. Battery Part No: ……………………………………. Quantity ☐

Circuit breaker Part No: ……………………………………………….

Battery pack Part No: ………………………………………… Quantity ☐

Settings. Service settings.

EATON INDUSTRIES Pty Ltd
Ref: QC029 Rev:07 Issued: 21/08/08

Parameter settings.

Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr
0			15			31			48	*	
1			16			32			49		
2			17			33			50		
3			18			34			51	**	
4			19			36	*		52		
5			20			37			53		
6			21			38			54		
7			22			39			55		
8			24			40			56		
9			25			41			57	....	
10			26			43			58	*	
11			27			44			59		
12			28			46			60		
14			30			47			61		
									62		

* Parameters 36, 48, 51 & 58 are not loaded in parallel systems ** Parameter 51 is not loaded on 9x55 20-40KVA UPS

EEPS saved in computer No. ______ File No. ______

Manufacturers test sheet supplied	Y/N	Installation checklist supplied	Y/N
Warranty form supplied (9355 only)	Y/N	Rating label attached	Y/N
Data cable & user pack correct	Y/N	Blue Eaton service label attached	Y/N
Eaton-Powerware label attached	Y/N	All screws/brackets replaced	Y/N
Serial number attached	Y/N		

Tested by: ______ Date: ______ Signed: ______

Notes:	Labels:

Eaton E Series DX

30/40kVA B

380/400/415V 50/60Hz

(3-phase input/output)

User Guide

Powering Business Worldwide

User Guide UPS 30/40kVA B, 380/400/415V, 50/60 Hz
(3-phase input/3-phase output)
614-09946-00

1 Safety instructions

This user manual contains important safety instructions and operating instructions. Please read the user manual carefully before operating or working on the UPS and save it for reference in the future.

1.1 Safety caution

The UPS operates with external AC mains, battery cabinet(s) or bypass power. It contains components that carry hazardous voltages and high currents, The properly installed enclosure is earthed and IP20 rated against electrical shock and foreign objects. The user is not permitted to open it. Failure to observe this could result in electric shock risk.
Only qualified personnel is allowed to install and service the UPS.

> Warning!
>
> Operations inside the UPS must be performed by a service engineer from the manufacturer or from an agent authorised by the manufacturer.

Use the optional Maintenance Bypass Switch (MBS) for service inside the UPS when installed to the system. Remember to open battery cabinet(s) breaker. Always ensure by measuring with a multimeter that no dangerous voltages are present. For detailed MBS operation instructions please see 4.5.

1.2 Audience caution

The intended audiences of this manual are people who plan the installation, install, commission, and use or service the UPS. The manual provides guidelines to check delivery, installing and commissioning of the UPS. The reader is expected to know the fundamentals of electricity, wiring, electrical components and electrical schematic symbols. This manual is written for a global reader.

Caution!

Read the manual before operating or working on the UPS.

1.3 CE marking

The product has the CE marking in compliance with the following European directives:
LVD Directive (Safety) 2006/95/EEC
EMC Directive 2004/108/EEC

Note!

This product for commercial and industrial application in the second environment Installation restrictions or additional Measures may be needed to prevent disturbances.

1.4 User precaution

The only user operations permitted are:
Start up and shut down the UPS, excluding the commissioning start-up.Use of the LCD control panel and Emergency Power Off (EPO) switch.Use of optional connectivity modules and their software.The user must follow the precautions and only perform the described operations.Any deviations from the instructions could be dangerous to the user or cause accidental load loss.

Warning!

The user is not permitted to open any screws excluding connectivity plates and the Emergency Power Off (EPO) switch. Failure to recognise the electrical hazards could prove fatal.

1.5 Environment

The UPS must be installed according to the recommendations in this manual.Under no circumstances the UPS should be installed in an airtight room, in the presence of flammable gases, or in an environment exceeding the specification.Excessive amount of dust in the operating environment of UPS may cause damage or lead to malfunction. The UPS should be always protected from the outside weather and sunshine. The recommended operating temperature is from +15 to +20 Celsius degrees.The recommended operating humidity:20% to 90%.

1.6 Inquiries

Address any inquiries about the UPS and battery cabinet(s) to the local office or agent authorized by the manufacturer. Please quote the type code and the serial number of the equipment.

2 Introduction

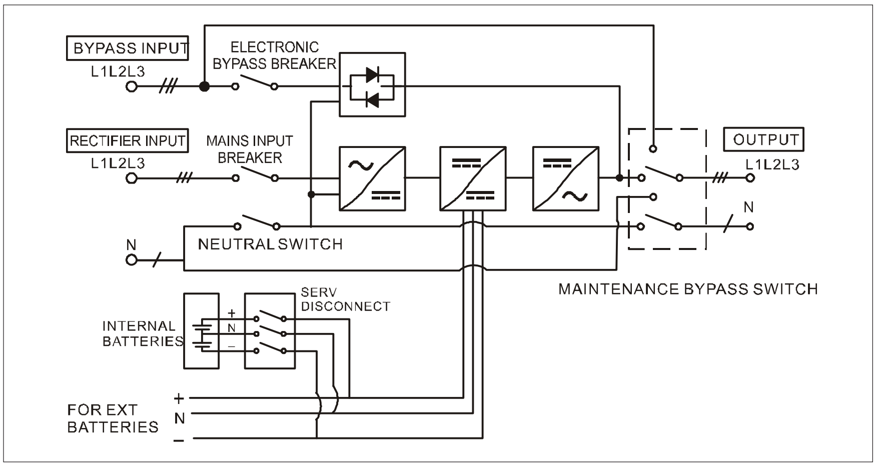
The product described in this manual is an Uninterruptible Power Supply (UPS). It is a true online, continuous duty, double conversion, solid state, three-phase system, providing conditioned and uninterruptible AC power to protect the end-user's load.

2.1 System description

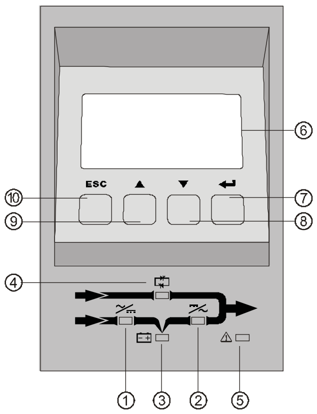
Eaton E Series DX products are high-efficiency and high-performance, double conversion, pure-online and three phase input and three phase output UPS, with unit capacity ranging between 20KVA-40KVA. Categorized by capacity, the products can be further divided into 20KVA, 30KVA and 40KVA. This series not only provides perfect solution for power source protection and successfully solves problems such as blackout, boost, brownouts, sags, decaying, oscillation, high voltage impulse, voltage fluctuations, surges, harmonic distortion, disturbances, frequency fluctuation etc, but also enhances adaptability to complicated working environments so that the application fields is well extended to computer equipments, communication equipments and other controlling equipments with good adaptability to complicated industrial environments as well. Therefore, this series products can be applied in a diversified multi-industries field such as telecommunications, financing, transportation, government, manufacturing and energy sectors.

Eaton E Series DX products are also capable of ECO mode. ECO mode means UPS load is powered by bypass AC supply while in case of abnormal AC supply the load will be supplied by accumulator battery after conversion through inverter. As the energy conversion efficiency reaches as high as 98% and transfer time less than 10ms under ECO mode when there is normal AC supply, the energy saving effect of UPS is remarkable.
Remark: ECO mode is applicable only to single unit.

2.2 Basic system configuration



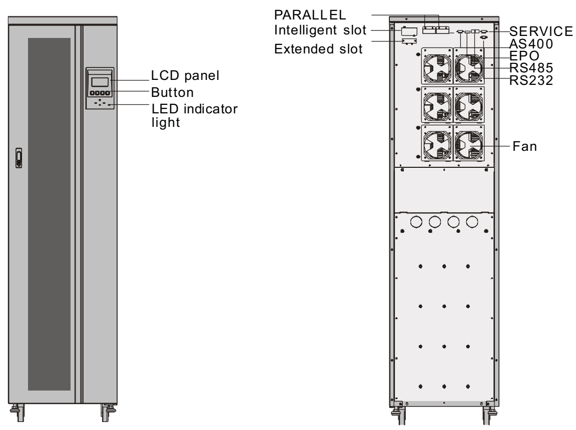
2.3 Panel figure



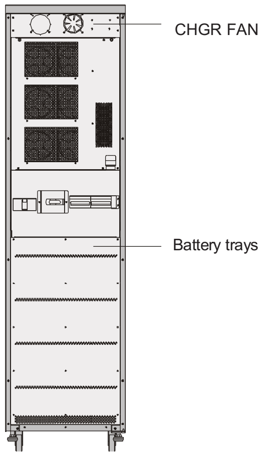
① AC: This light and inverter light will turn "green" when UPS is powered by Rectifier Input;
② Inverter: This light will turn "green" when UPS load is through the inverter;
③ Battery: This light will turn "yellow" when UPS is powered by batteries;
④ Bypass: This light will turn "green" when UPS load is powered by Bypass Input;
⑤ Fault: If the UPS worked under fault condition,this light would turn on and stay “red” with continuous warning tone being given off in case of UPS abnormal function;or flash “red” with intermittent warning tone being given off.
⑥ LCD: Display UPS commands.
⑦ ↵ :Confirm/Enter; press this button to select a menu or confirm an operation.
⑧ ▼ :PageDown; press this button to switch to next screen display under the same menu.
⑨ ▲ :PageUp; press this button to return to next screen display under the same menu.
⑩ Esc: Escape; press this button to return to previous menu or cancel a certain operation.
Remark: Refer to Chapter 12 for detailed information of LED in accordance with UPS condition.

2.4 Exterior view

Exterior figure of Eaton E Series DX 30kVA, 40kVA B UPS



Front view   Rear view



Front view(door open)

3 Technical data

3.1 Standards

UPS	30kVA B	40kVA B
Safety	IEC62040-1:2008,EN62040-1:2003 and EN60950-1:2005	
EMC	IEC62040-2:2006 and EN62040-2:2005	
Product	IEC62040-3:1999 and EN62040-3:2001	

3.2 Environment

UPS	30kVA B	40kVA B
Working Temperature	0 to +40℃	
Storage Temperature	-30℃to +65℃ (without batteries)	
	0℃ to +40℃ (with batteries)	
Relative Humidity	5% to 90%, no condensation allowed	
Altitude derating coefficient	See user operations section for more detail information	
Vibration	IEC68-2-6; max. 0.3mm (2 to 9Hz), max. 1m/s2 (9 to 200Hz) sinusoidal	

3.3 Dimensional drawings

	30kVA B/40kVA B	
W × D × H (mm)	470*700*1752.5	Without package
	974*743*2008	With package
Net Weight (Kg)	195	Without batteries
	515	With batteries
Gross Weight (Kg)	255	Without batteries
	575	With batteries

3.4 Characteristics

	30kVA B	40kVA B
Efficiency-nominal load	Up to 92%	
Noise (ISO 7779)	<57dB at 75% load	

3.5 AC input

	30kVA B	40kVA B
Rectifier input	3 phases + N	
Bypass input	3 phases + N	
Voltage (L-N)	121V-274 Volts without using battery	
Frequency	40-70 Hz	
Power factor	0.99	
Input distortion	< 5% THD(I)	
Rated input voltage	380V/400 V/415V	
Rated input current	43A/41A/40A	57A/54A/52A

3.6 DC circuit

Battery number		2 × 16
Battery nominal voltage	Positive battery	+192V DC
	Negative battery	-192V DC
Cut off voltage		154 ± 2V DC(when load > 2kw)
		176 ± 2V DC(when load ≤ 2kw)
Battery charging current (A)		± 4.5A

3.7 AC output

		30kVA B	40kVA B
Active power		24KW	32KW
Number of phases		3-phases + N	
Frequency		50/60HZ	
Voltage (L-N)		220/230/240 VAC	
Overload capability (Mains available)	110%<Load<=125%	10 minutes minimum, then transfer to bypass and alarm	
	125%<Load<=150%	1 minutes minimum, then transfer to bypass and alarm	
	Load>150%	0.5 seconds minimum, then transfer to bypass and alarm	
Overload capability (battery available)	110%<Load<=125%	10 minutes minimum, then transfer to bypass and alarm	
	125%<Load<=150%	1 minutes minimum, then transfer to bypass and alarm	
	Load>150%	0.5 seconds minimum, then transfer to bypass and alarm	

3.8 Battery and Charger

	30kVA B	40kVA B
Internal battery package	Panasonic LC-RW 1245W / CSB HR 1234WF2	
Dimensions	94*151*64.5/pc(Panasonic)	94*151*65/pc(CSB)
Strings	2 x 16	
Stored energy time	up to 860s At Rated liner Load,25℃	up to 540s At Rated liner Load,25℃
Restored energy time	<8Hours Up to 90% charge	
Charger Input Protection	8 A fuse	
Rated Charge Voltage	± 216V Default for Integrated bettery	
Initial Charging Current	4.5A	
Battery Leakage	< 3.5mA	
Battery protection	30A Fuse*3 For PCBA level	30A Fuse*2*3 For PCBA level
	125A Breaker	
Max discharging current	87A Ubat=308VDC,Full RCD load	116A Ubat=308VDC,Full RCD load

4 Mechanical installation

The UPS and accessories are delivered on a specifically designed pallet that is easy to move with a forklift or a pallet jack. Keep the UPS always in upright position and do not drop the equipment. Do not stack the pallets.

4.1 Delivery check

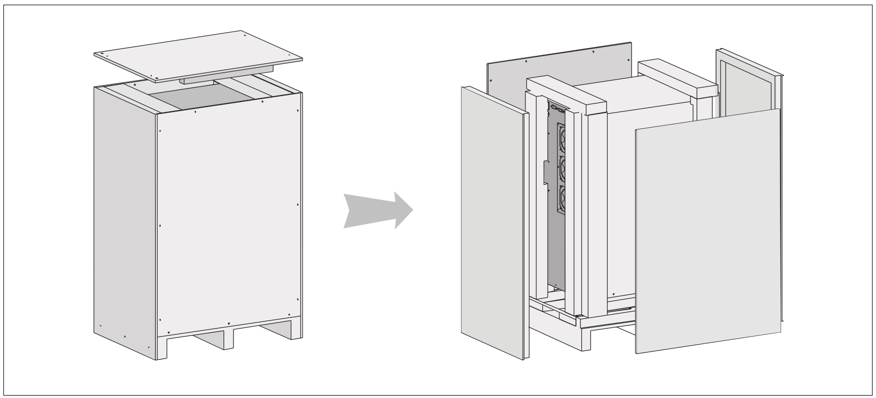
The UPS is delivered with the following items:
1. Winpower disc
2.RS-232 serial cable
3.Delivery documents
4.User Guide
5.Key
6.Battery kit(wires & trays)(Only for model without batteries)

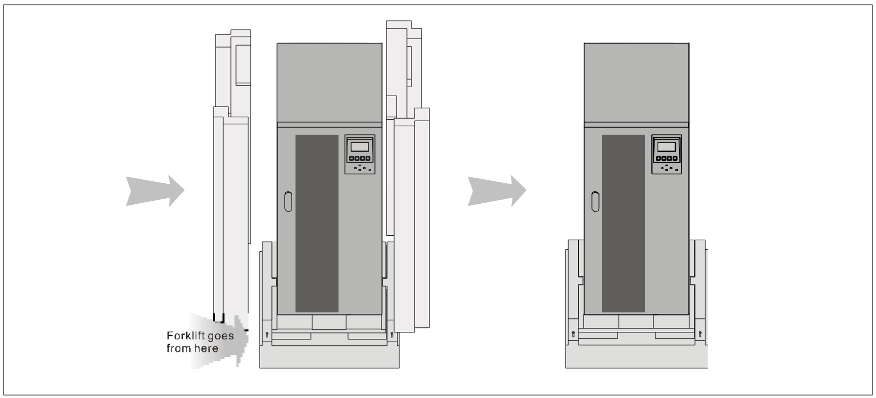
4.2 Unpacking and visual inspection

Check that there are no signs of shipping damages. The equipment should be transported in the upright position.

> ⚠ Note!
>
> A claim for shipping damage must be filed immediately and the carrier must be informed within 7 days of receipt of the equipment. The packing materials should be stored for further investigation.

Unpack the equipment by removing the packing and shipping materials. Make a visual inspection. Remove the equipment from the pallet and make sure that the floor surface is solid and suitable for the wheeling and heavy weight.
Remove cover plate → Remove side plate → Remove stuffing and fix

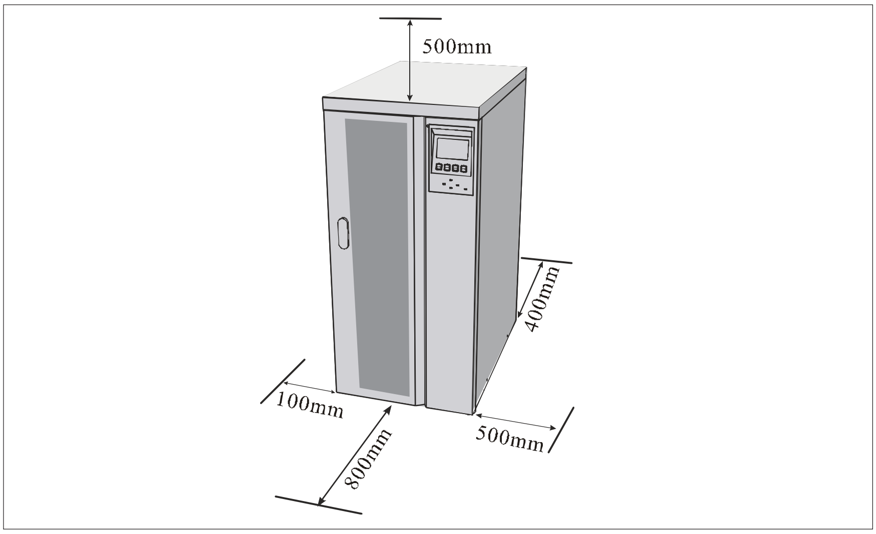




Check the information on the type designation label of the equipment to verify that the unit is of the correct type. The type designation label includes ratings, a CE marking, a type code, a part number and a serial number. The serial number is important when making inquiries. It allows individual recognition of the equipment.

4.3 Planning before installation

The equipment must be installed in upright position. The equipment requires space to front and back to enable cooling airflow. Service and maintenance require more than 500mm clearance on right hand side. All cooling air enters at front and exits at unit rear. The required minimum clearance from unit rear to an obstruction is 400mm. Because the service and user access is in the front there should be reserved enough space (min 800mm).



Preparation for installation.

1. Avoid extremes of ambient temperature; excessive dust, moisture or vibration; flammable gases; and corrosive or explosive atmospheres.

2.Altitude for normal UPS function should not exceed 1000m.

3.The battery cabinet should work within a temperature range from15℃ to 25℃.

4.The maximum ambient temperature for normal UPS performance should not exceed 40℃.

4.4 Cabinet installation

Note!

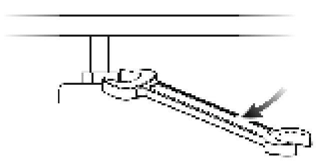
Please use stabilizing devices to fix the UPS prior to the installation.

The required distance for UPS units should allow for service access. The same applies to the battery cabinet(s) that should be installed next to the UPS cabinet(s).

Caution!

UPS cabinet(s) can fall over if the installation brake pads are not used. Both rear and front pads must be used to secure the UPS cabinet to the floor.

Use a 19mm wrench in clockwise direction to screw the brake pad down to the ground, keeping the machine from moving.



4.5 Maintenance Bypass Switch(MBS)

Warning!

All operations inside the unit must be performed only by a service engineer from the manufacturer or from an agent, authorised by the manufacturer.

The operation of the MBS is allowed for a service engineer from the manufacturer or from an agent, authorised by the manufacturer. The full UPS wiring diagram with a MBS switch is presented in the installation part of the manual.

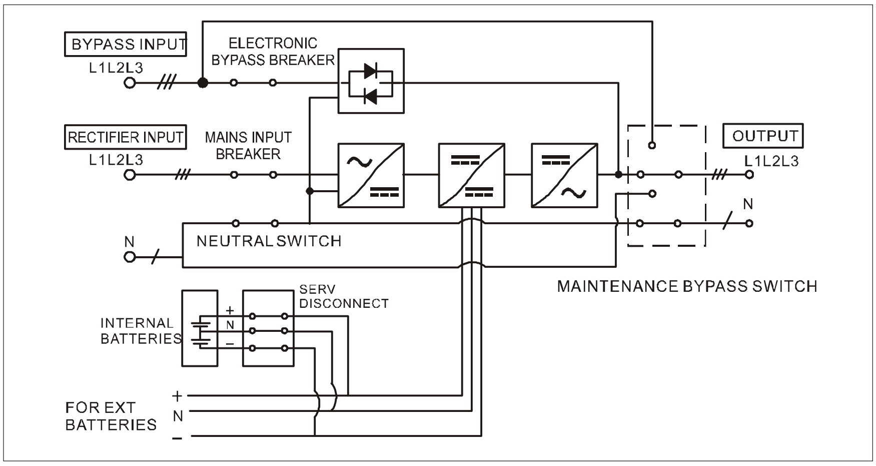
The switching sequence for circuit breaker from normal position to maintenance position:

Maintenance

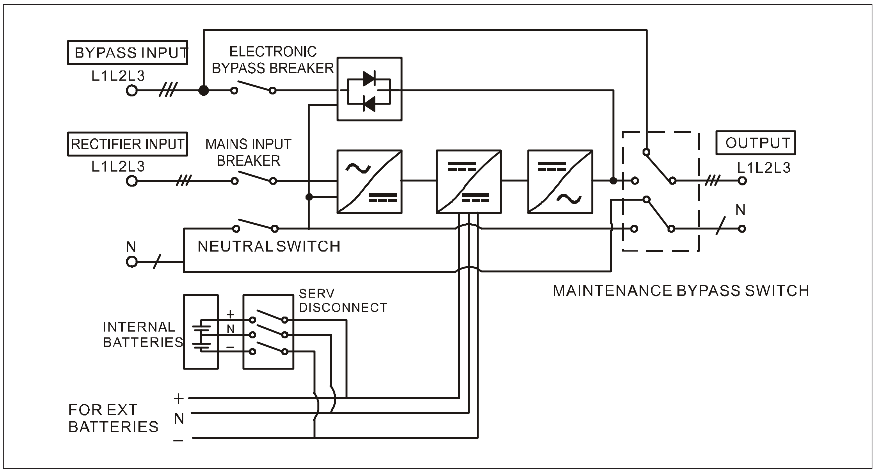
	Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
Normal	OFF	ON	ON	ON	ON
Step1	OFF	OFF	ON	ON	OFF
Step2	ON	OFF	ON	ON	OFF
Maintenance	ON	OFF	OFF	OFF	OFF

Recovery

The normal positions of the MBS switches.



The maintenance positions of the MBS switches



Transfer UPS from normal mode to maintenance bypass mode:

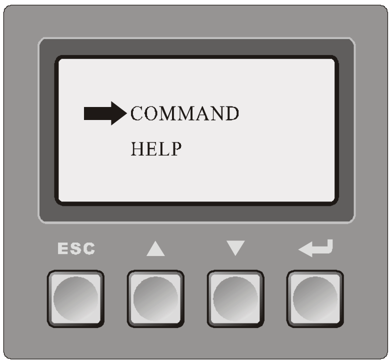
1.The normal start position should be following:

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
OFF	ON	ON	ON	ON

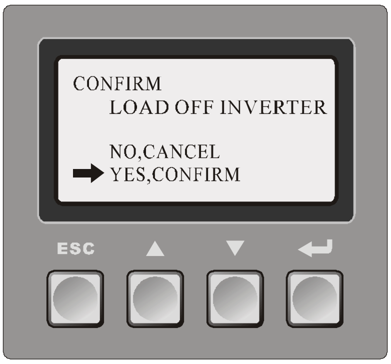
2.Use LCD to turn the UPS from normal mode to bypass mode:

Switch-off action (press ESC to exit above picture)

1)Switch-off picture



2)If it is in single machine mode, the following will appear



Remember to verify the transfer before proceeding the next step.

3.Remove the locking plate of maintenance switch.

4.Turn OFF the Rectifier Input switch and battery breaker.

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
OFF	OFF	ON	ON	OFF

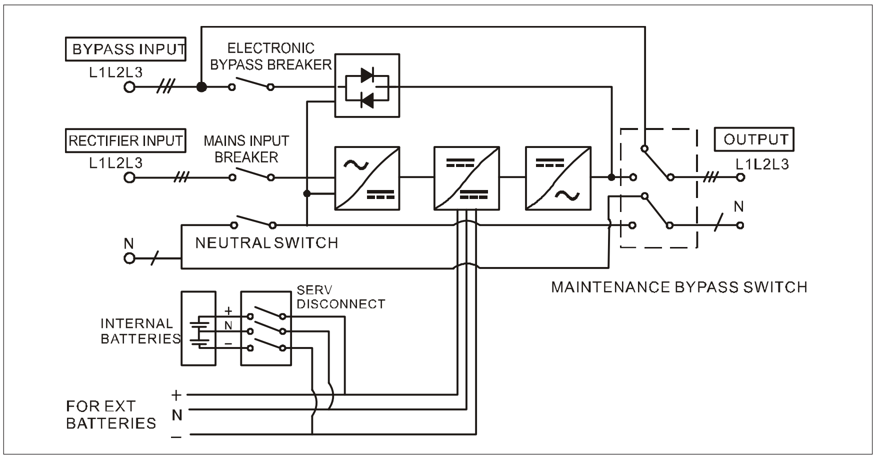
5.Turn the Maintenance switch to “MAINTENANCE” side.

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
ON	OFF	ON	ON	OFF

6.Turn OFF the Bypass Input switch and N switch.

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
ON	OFF	OFF	OFF	OFF

7.UPS is now in the maintenance bypass mode, see below (Note: the Serv disconnect i.e. battery breaker must be turned off):



Transfer UPS from maintenance bypass mode to normal mode:

1.The normal start position should be following:

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
ON	OFF	OFF	OFF	OFF

2.Turn ON the Bypass Input switch and N switch

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
ON	OFF	ON	ON	OFF

When the LED of bypass turns green,the UPS enters into bypass mode.

3.Turn the Maintenance switch to “UPS” side.

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
OFF	OFF	ON	ON	OFF

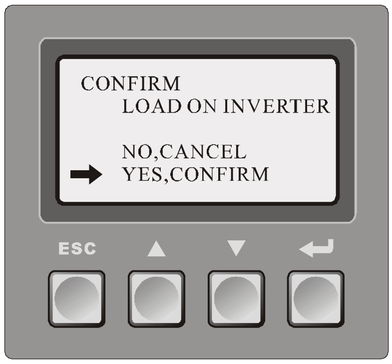
Then the UPS turn to bypass mode.
4.Turn ON the Rectifier Input switch and battery breaker.

Maintenance switch	Rectifier Input	Bypass Input	N	Battery breaker
OFF	ON	ON	ON	ON

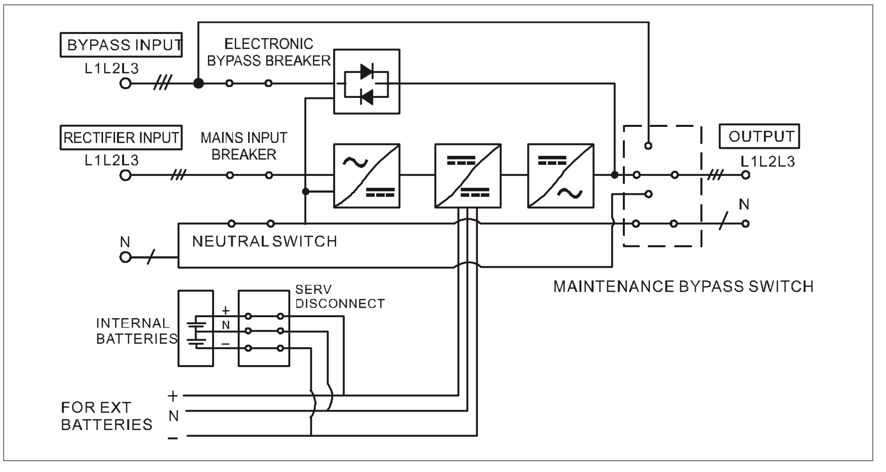
5.Use LCD to turn the UPS from bypass mode to normal mode:
Switch-off action (press ESC to exit above picture)

1)Switch-on picture

2)Press ENTER



6.UPS is now in the normal mode,see below:



7.Remount the locking plate of maintenance switch to the position to prevent the use of it.

5 Electrical installation

5.1 Electrical Preparations

Note!

It must be ensured that no line input source can accidentally be connected to the UPS during installation.

Warning!

Installation may only be carried out by qualified technicians and in conformity with the applicable safety standards.

Warning!

The UPS unit is not applicable to the IT power distribution system.

5.2 Installation and wire connection diagram

The UPS unit has the following power connections:

Three-phase (L1, L2, L3), Neutral (N) and Protective Earth (PE) connection for the rectifier input.

Three-phase (L1, L2, L3), Neutral (N) and Protective Earth (PE) connection for the bypass input (N is INTERNALLY common for rectifier and bypass inputs).

Three-phase (L1, L2, L3), Neutral (N) and Protective Earth (PE) connection for the load output.

Positive pole (+),Negative pole (-), Common midpoint/Neutral pole and Protective Earthing (PE) connection for the external batteries.

56 red wires (B2) with an approximate length of 70mm, 4 red wires (B3) with an approximate length of 770mm and 8 red wires (B4) with an approximate length of 65mm for BAT+;

4 red wires (B9, B10 and B11) for BAT+ connection;

4 blue wires (B5) with an approximate length of 65 mm, 4 blue wires with an approximate length of 770mm (B6) for BATN;

8 blue wires (B14, B15, B16, and B18) for BATN connection;

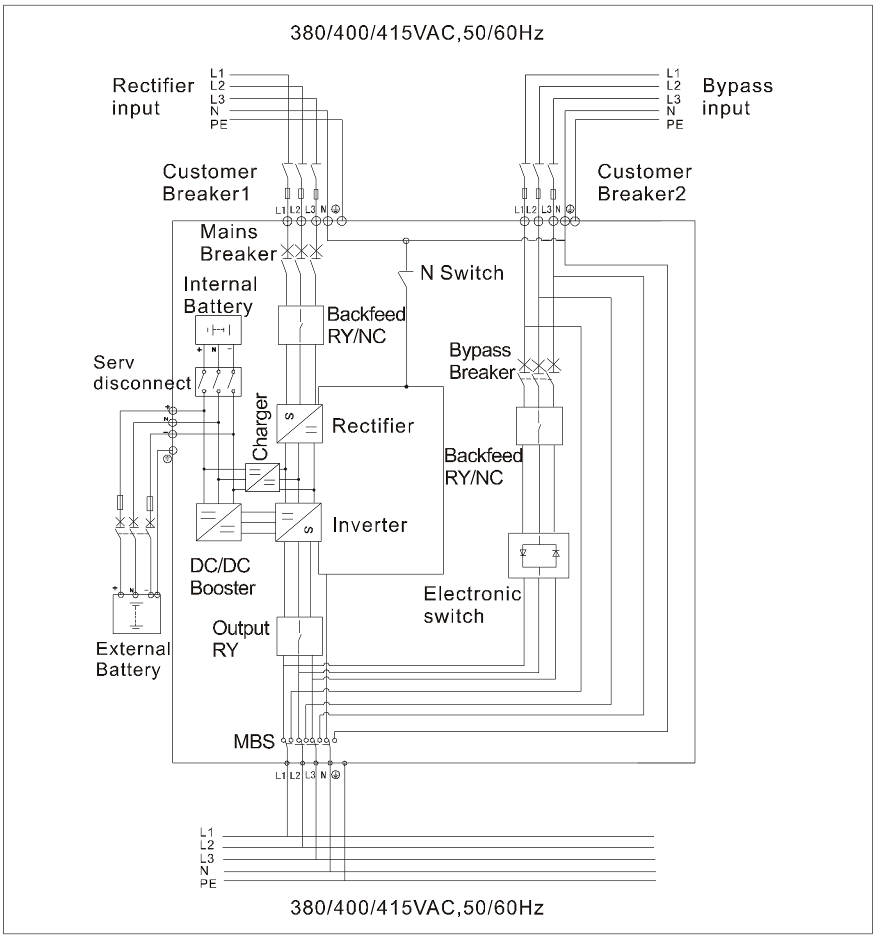
56 black wires (B1) with an approximate length of 70mm, 8 black wires (B7) with an approximate length of 770mm and 4 black wires (B8) with an approximate length of 65mm for BAT-;

4 black wires (B12, B13, and B17) for BAT- connection.

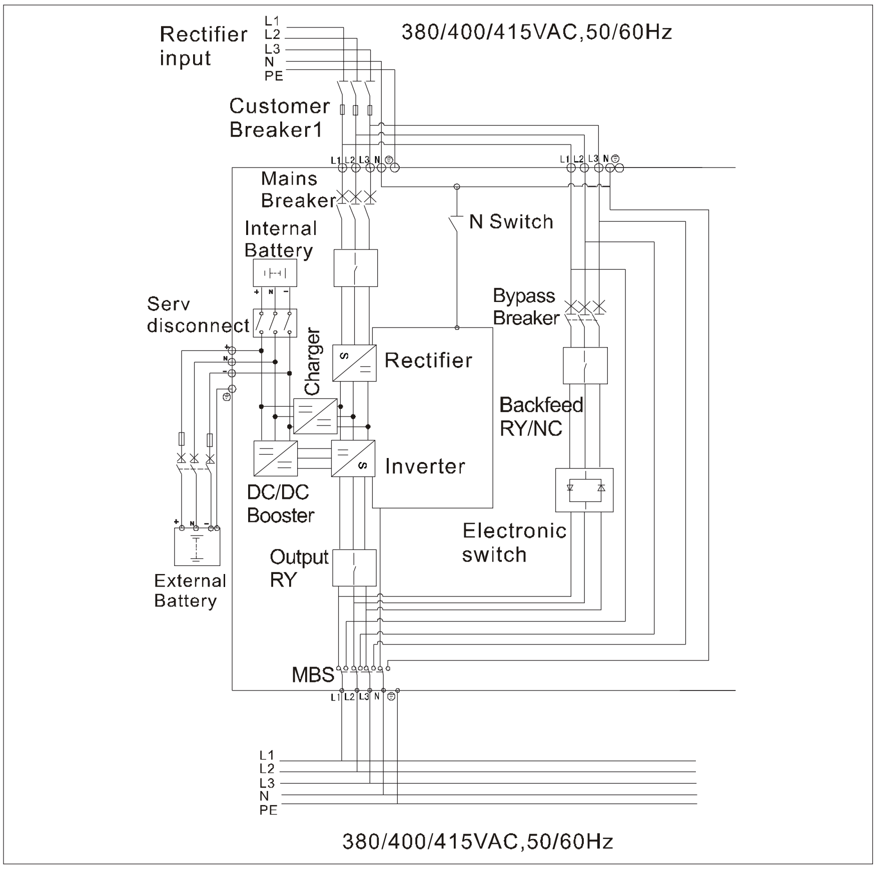
1.If UPS rectifier input and bypass input are supplied from two mains:

Connect the mains 1 supply cables to the UPS rectifier input terminals L1, L2, L3, N and PE.

Connect the mains 2 supply cables to the UPS bypass input terminals L1, L2, L3, N and PE.



2.If UPS rectifier input and bypass input are supplied from one mains only:
Connect the mains supply cables to the UPS rectifier input terminals L1, L2, L3, N and PE .
The following three jumpers must be fixed between the rectifier and bypass input terminals:
L1-L1, L2- L 2, L3- L3.



Terminal block diagram

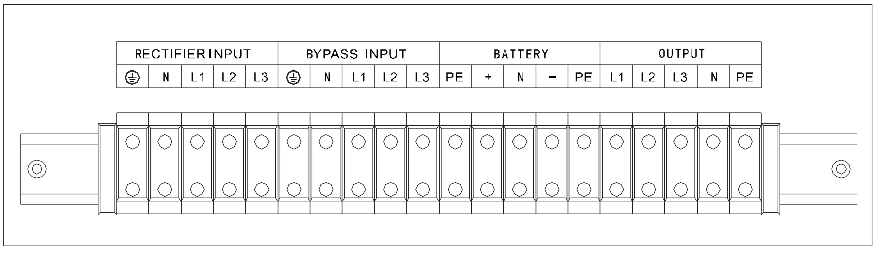
Warning!

High touch current earth connection essential before connecting supply.

In order to gain access to the external electrical connections it is necessary to remove the front terminal protective panel of the UPS. Before the cables are connected they shall be passed through the cable glands to hold them in position and tightened.

Connect the Protective Earthing (PE) cable first.
Connect other cables as shown in the connection terminal representations on the preceding and following pages.

Ensure that the UPS is isolated before removing front terminal protective panel.



5.3 Suggested cable and protective devices

> ⚠ Caution!
> All cables should always use copper cable type.

The conductor cross sections apply for maximum currents:
(1) For PVC-insulated copper cables (at 70℃)
(2) When routed in conduits for electrical installations
(3) When air temperature surrounding the conduits does not exceed 30℃
(4) For cable lengths up to 30 m

> ⚠ Notice!
> Should there be any variation in the conditions it will be necessary to verify whether the cable dimensions satisfy the requirements of IEC-287 and DIN VDE 0298. In cases where the cables are so long that they cause a drop in voltage of >3%, a larger dimension shall be selected.

Routing of communication cables or data lines should be kept separate from the UPS input, output, and external battery cables.

Use cable cross section and protective device specification

Model	30kVA	40kVA
Rectifier Input L1, L2, L3, N, Bypass Input L1, L2, L3, N, min. conductor cross section[mm^2] max. possible cross section[mm^2]	10 35	16 35
Rectifier Input L1, L2, L3, N breaker (A)	80A 230VAC	100A 230VAC
Bypass Input L1, L2, L3, breaker (A)	80A 230VAC	100A 230VAC
Rectifier Input fuse (A)	80A 250VAC	100A 250VAC
Bypass Input fuse	80A 250VAC	100A 250VAC
Internal battery switch	125A 690VAC	
Output L1, L2, L3, N, min. conductor cross section[mm^2] max. possible cross section[mm^2]	10 35	16 35
External Battery Cabinet Positive pole(+),Neutral pole,Negative pole (-), min. conductor cross section[mm^2] max. possible cross section[mm^2]	16 35	25 35
External Battery Cabinet Fuse (A) in Positive pole(+),Neutral pole, Negative pole (-),	120A 250VAC	150A 250VAC
External Battery Cabinet breaker (A) in Positive pole(+),Neutral pole,Negative pole (-),	120A 250VAC	150A 250VAC
Backfeed protection device	60A 250V AC Clearance distances:>=1.4mm Break time<=15s	
Protective Earthing conductor [mm^2]	Max 35	
Torque for fixing above terminals	2.8-3 Nm	

Notice!

The following label must be displayed on all switching devices installed in the same electrical system as the UPS, even when these are located at a distance from the area in which it is located (according to European standard EN 62040-1).

Warning!

ENSURE THAT THE UNINTERRUPTIBLE POWER SYSTEM IS ISOLATED BEFORE WORKING ON THIS CIRCUIT.

5.4 Internal Battery Installation

Please complete the procedure below to install batteries:

1. Make sure that the breaker is in off position (Located in front of the unit).
2. Remove the eighteen screws on the battery cover and take off the battery cover (see Fig. 1).

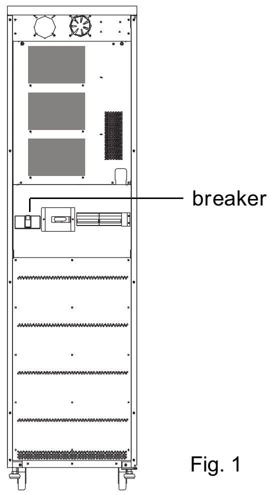


Fig. 1

3. Assemble the battery packs.There are eight batteries in each battery pack, four packs in each shelf and total is four shelves.

Step1: Put batteries into the trays (see Fig. 2).

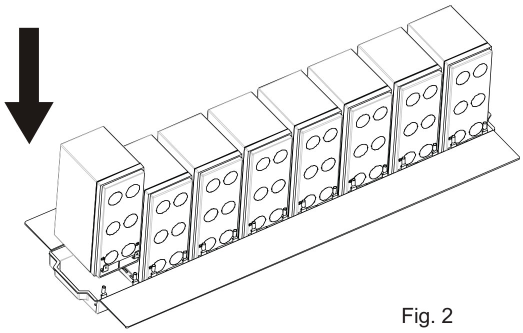
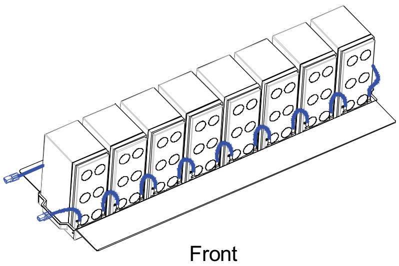
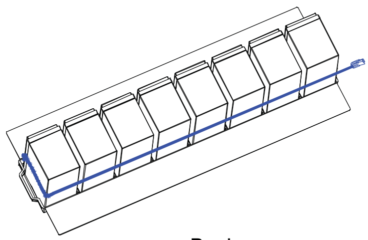


Fig. 2

Step2: connect the wires between the batteries (see Fig. 3).



Front



Back

Fig. 3

Please refer to the following figure(Fig.4) for wire connections of the four battery packs.

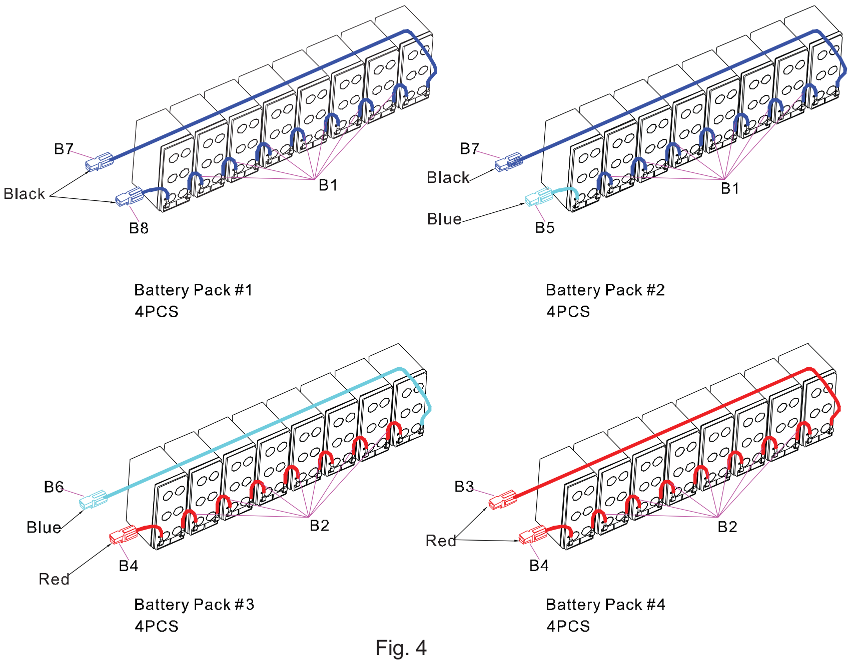


Fig. 4

Step3: Install the top tray downward, and fold both the top and bottom tray flanges (see Fig 5).

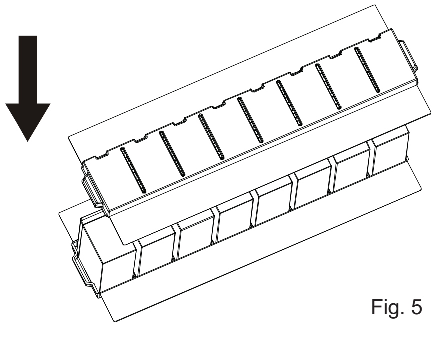
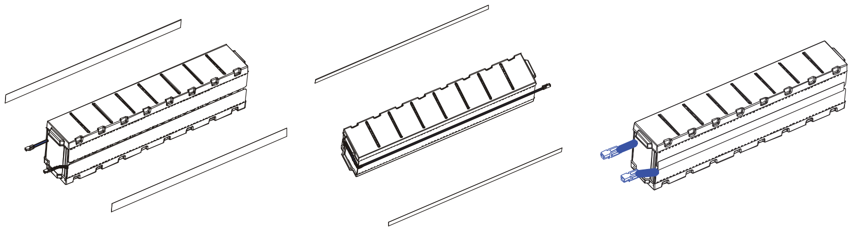


Fig. 5

Step4: Tape two sides (see Fig.6).Make sure the cable is placed between the tray edges during tape mounting.



Front Back Battery Pack Assembly

Fig. 6

Step5: Paste the labels to the battery packs (see Fig. 7).

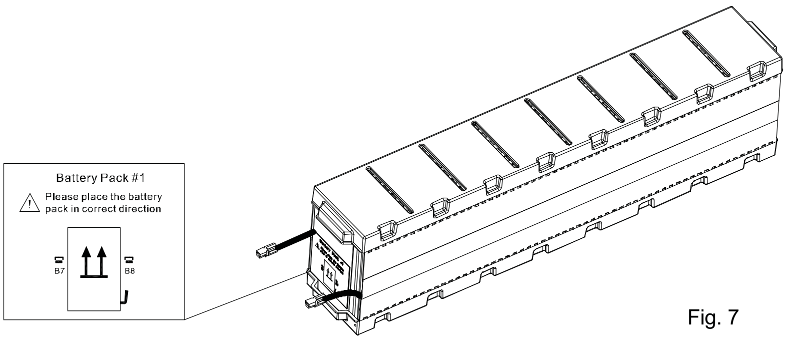


Fig. 7

Make sure to paste the correct label to each battery pack and the battery packs are placed conformably with the labels, i.e. the battery terminals are located on the bottom right corner (see Fig. 8).

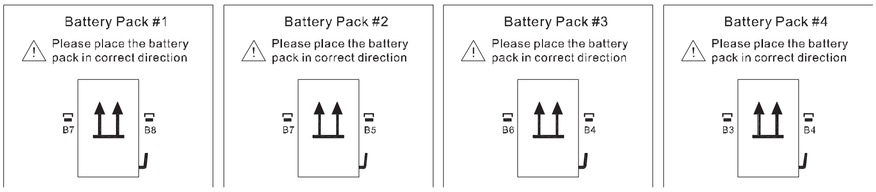


Fig. 8

4. Put the battery packs into the enclosure from left to right and bottom to top and cover each shelf with a fix-plate(see Fig. 9) (please refer to Fig.4 for correspending battery packs).

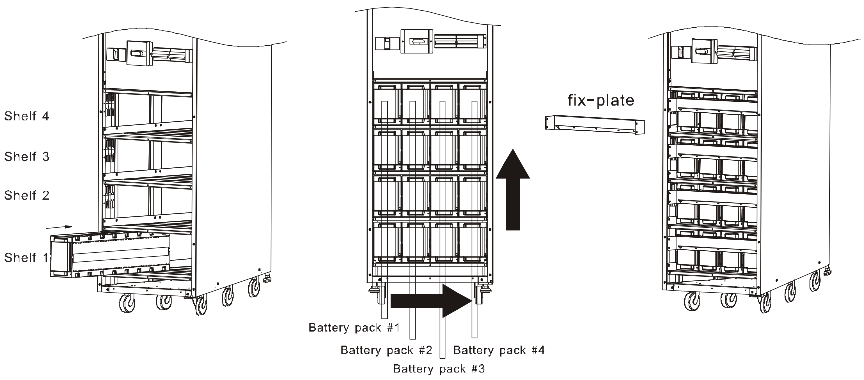


Fig. 9

5. Connect the cables to each shelf respectively (see Fig. 10).

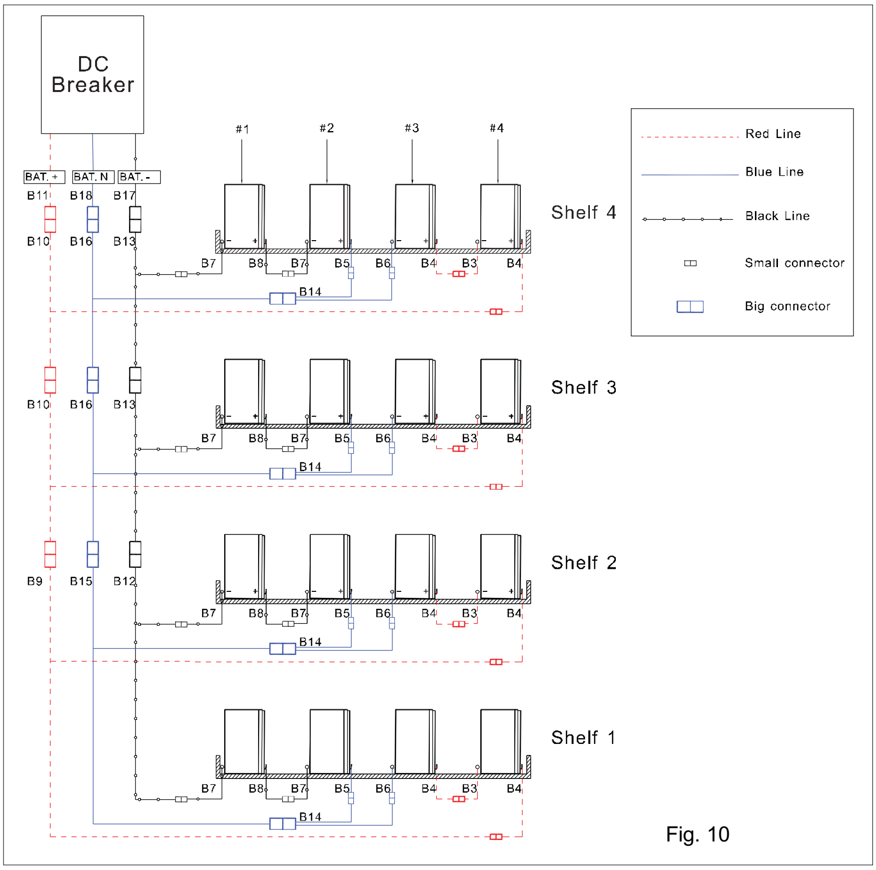


Fig. 10

6. Secure each fix-plate with four screws (see Fig. 11).

Remark: make sure to connect wires with the same color.

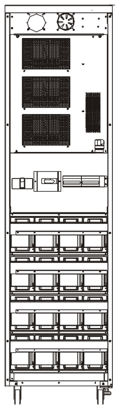


Fig.11

7. Tie up the wires properly(see Fig. 12).

Fig.12

8. Reinstall the battery cover and secure it with the eighteen screws.

Table1:Battery cable list

Lable	B1	B2	B3	B4	B5	B6	B7	B8	B9		B10		B11	B12		B13		B14		B15		B16		B17	B18
Colour	Blk	Red	Red	Red	Blu	Blu	Blk	Blk	Red		Red		Red	Blk		Blk		Blu		Blu		Blu		Blk	Blu
Quantity	56	56	4	8	4	4	8	4	1		2		1	1		2		4		1		2		1	1
Length(mm)	70	70	770	65	65	770	770	65	662	490	152	490	152	262	90	152	90	770	70	462	290	152	290	152	152

Remark:

The following warnings should be observed during the operation:

-The batteries may contain potential electric shock danger because of high voltage.

-Wear safety goggles.

-Make sure to verify battery polarity before connecting.

-Make sure to keep wires away from the adjacent legs and sharp edges of shelves handles.

5.5 Connecting the external battery

Before connecting the external battery, please read the notice and warning label on the UPS.

Warning!

In the event of malfunction, the battery cabinet chassis or battery cabinet frames may become live!

Warning!

Special care should be taken when working with the battery cabinet associated with the Eaton E Series DX 30 - 40 kVA. When the battery cabinet is connected the overall voltage exceeds 400V. It is very important to ensure that the batteries are installed separately, in a dedicated battery cabinet.

Notice!

The most common battery type used in UPS installations is the valve regulated battery. Valve regulated cells are not sealed. The amount of gas given off is less than for flooded cells, but when planning the battery installation, allowance must be made for adequate ventilation and heat dissipation. Valve regulated cells are not completely maintenace- free. They must be kept clean and their connections checked periodically to ensure they are tight, and that there is no evidence of corrosion. It is inevitable that the batteries will lose charge during transportation and storage; before attempting to carry out an autonomy test, ensure that the batteries are fully charged as this may take several hours. Cell performance typically improves after a few discharge/recharge cycles.

> **Notice!**
>
> The requirements of the EC directives are satisfied when battery cabinet are used with original accessories. If alternative batteries are used, you must ensure that the applicable EC directives are met and declare conformity.

Connect the battery cabinet as follows:

Turn off the UPS.

Check the internal battery breaker is off and/or any external battery switchs open.

Connect PE first.

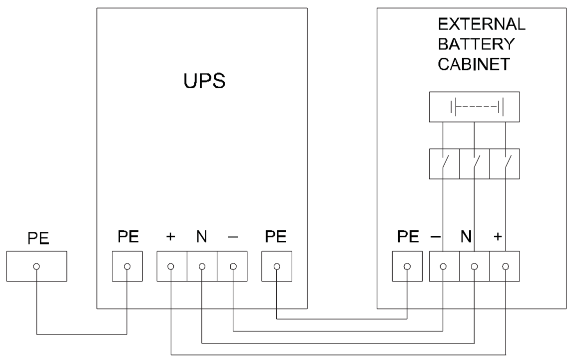
Connect the battery cabinet(s) with cables sized according to cable cross setion and protective device specification to terminals + (positive pole) ,- (negative pole) and Neutral pole.

Refer to instruction provided with the battery cabinet or by vendor.

> **Warning!**
>
> ENSURE CORRECT POLARITY!

5.6 Connections between battery cabinet and UPS

Make sure the Protective Earthing (PE) connected first.



External Battery Cabinet Connections

5.7 Handling the batteries

Warning!

Batteries are a potential source of danger due to their electrical charge and chemical composition. Therefore observe the battery handling instructions of the manufacturer. These usually can be found in the material which accompanies the shipment.

Recharging batteries

Warning!

When recharging, observe the indications on the packaging.

Exchanging batteries

Warning!

Before replacing batteries, make sure that those to be installed are fully charged.

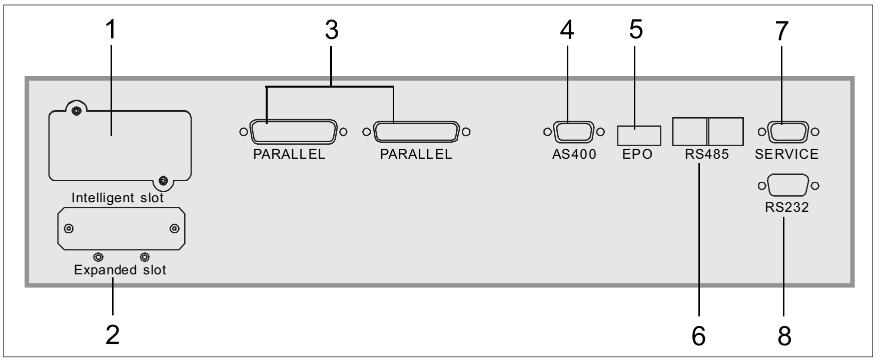
Connecting external battery cabinet

Warning!

If a battery cabinet has been disconnected and is to be reconnected, the battery isolator may only be reconnected after you have made certain that voltage with the correct polarity is present on both sides of isolating device.

6 Software and connectivity

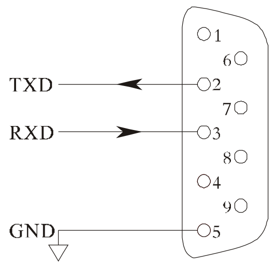
The Series provide Intelligent Slot, Expanded Slot, PARALLEL, AS400, EPO, RS485 and RS232 as well as SERVICE Supervising Communication Interface exclusively available to Eaton technical personnel.



1. Intelligent slot: suitable for WebPower card of remote supervising management,enabling you to realize remote supervising management on UPS through Internet.
2. Expanded slot: Reserved for special applications
3. PARALLEL: communication interface for parallel machine mode.
4. Standard AS400 interface: provides AS400 and users can directly use UPS supervising function offered by AS400 system to realize power source management (See Appendix for AS400 port Pin).
5. EPO: Emergency Power Off, providing the possibility of emergency shut down.Normally closed.
6. Standard RS485 Interface: It can be used to monitor parallel units for completely control of UPS (See Appendix for RS485 port Pin).
7. SERVICE Interface: available only to Eaton technicians
8. Standard RS232 Interface: applicable to WinPower supervising software of graphic management (See Figure for RS232 port Pin)

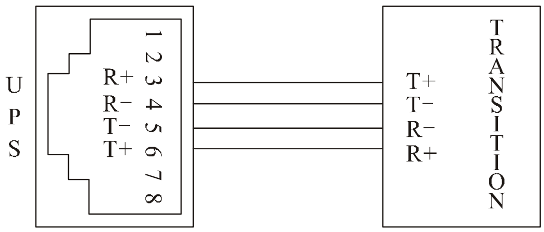
RS232 port

Pin #	Description	I/O
2	TXD	Output
3	RXD	Input
5	GND	common



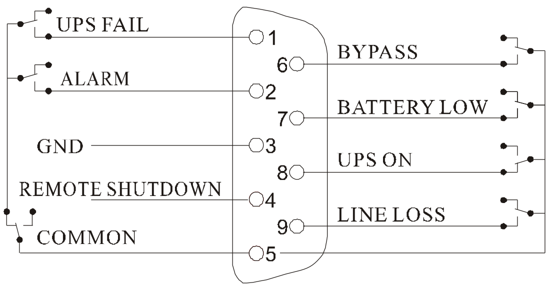
RS485 port

Pin #	Description	I/O
3	RXDA	Input
4	RXDB	Input
5	TXDB	Output
6	TXDA	Output



AS400 port

Pin #	Description	I/O
1	UPS Fail	Output
2	Alarm	Output
3	GND	Common
4	Remote Shutdown	Input
5	Common	Common
6	Bypass	Output
7	Battery Low	Output
8	UPS ON	Output
9	Line Loss	Output



Note!

The UPS have to be manually reset if remote shutdown occurs.

7 User operations

Warning!

High touch current earth connection essential before connecting supply.

The only user operations permitted are:
Start up and shut down the UPS, excluding the commissioning start-up.
Use of the LCD control panel and Emergency Power Off (EPO) switch.
Use of optional connectivity modules and their software.

Warning!

The user must follow the precaution, warnings and only perform the described operation. Any deviations from the user manual could be dangerous to the user or cause accidental load loss.

Should the UPS be intended for application above 1000m, progressive decrease of rated output should be applied as listed in the following chart:

Altitude(M)	1000	1500	2000	2500	3000	3500	4000	4500	5000
Derating coefficient	100%	95%	91%	86%	82%	78%	74%	70%	67%

7.1 Single machine operation

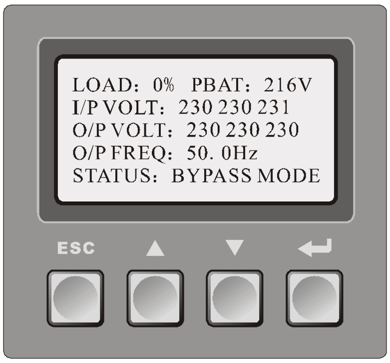
1. Make sure L1, L2 and L3 phase sequences are correctly connected and then supply power to UPS.
2.Close internal battery breaker.
3. Turn on the switch on battery box if the UPS equipped with External battery(make sure that the “+”,“N” and “-” of terminal bay are in accordance with those on the battery box).
4. Switch on “Input Switch” (Rectifier Input Switch,Bypass Input Switch) on UPS and fans start to rotate for UPS self-inspection. Main menu can be accessed within about 4sec and then operations should be carried.

Remark: the following drawing takes Eaton E Series DX 20KVA as an example and statistics are only for reference.

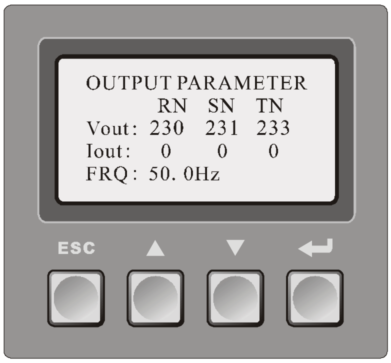
1)Power on

2)Automatic access within about 4s

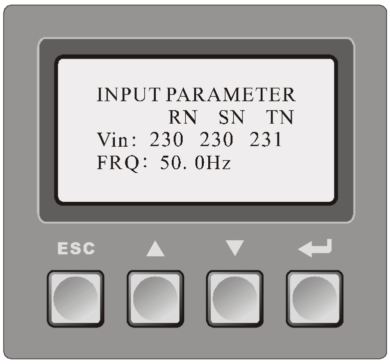
3)Press ESC to access or automatically within 1min with no button being pressed



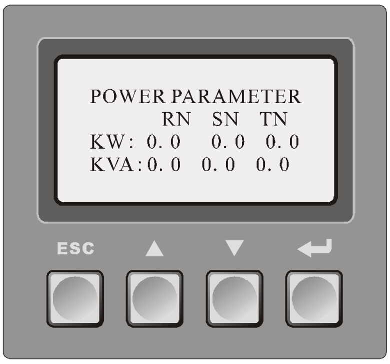
4)Press ▼ to obtain the below information



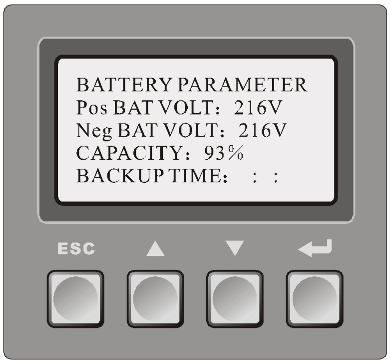
5)Press ▼ again to obtain the below information



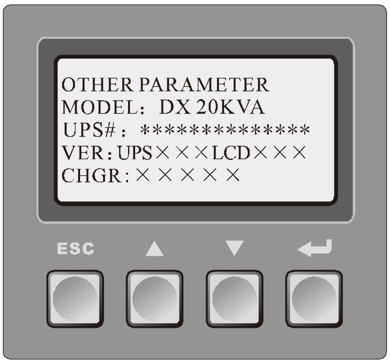
6)Press ▼ again to obtain the below information



7)Press ▼ again to obtain the below information

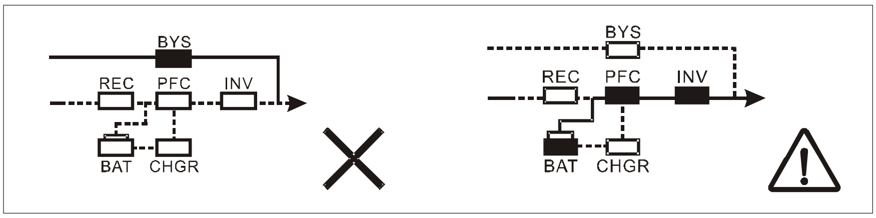


8)Press ▼ again to obtain the below information



Note!

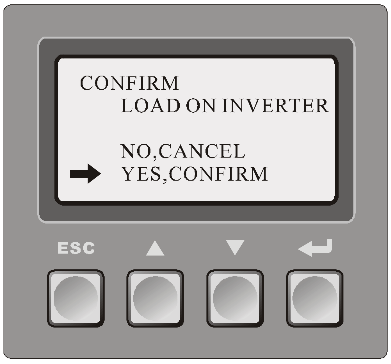
If malfunction occurs, “x” will appear at the lower right corner of the display,while a warning occurs, “ ⚠ ” will appear at the same position (as illustrated in the below picture with battery mode as an example).



4. Start-up action (press ESC to exit the above picture)

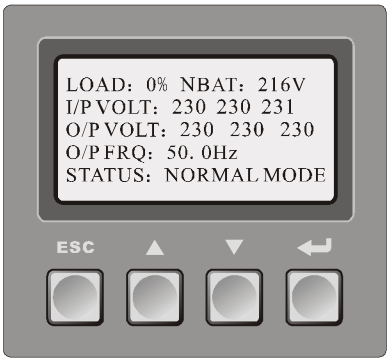
1)Switch-on picture

2)Press ENTER

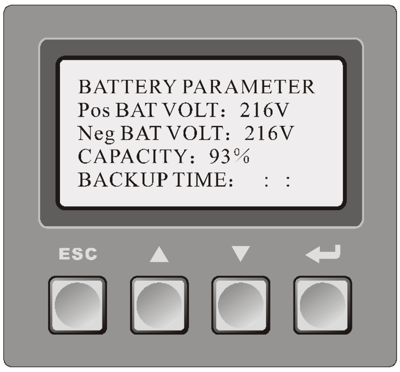


3)Select “Yes, Confirm” to switch on the machine

4)Normal Switch-on

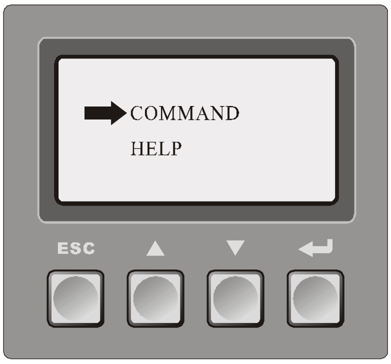


5)Battery power supply (switch off line input switch)

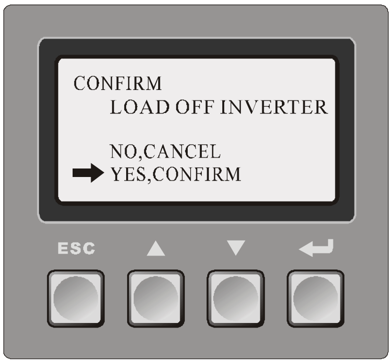


5. Switch-off action (press ESC to exit above picture)

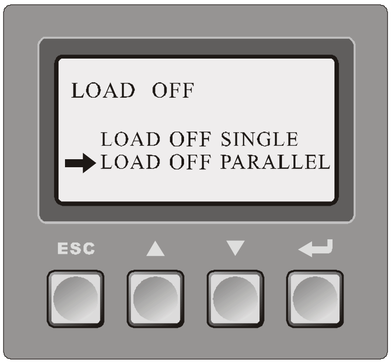
1)Switch-off picture



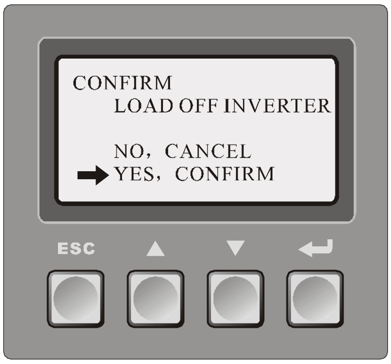
2)If it is in single machine mode, the following will appear



3)If it is in parallel machine mode, the following will appear



4)Press ENTER



5)Select “Yes, Confirm” to switch off the machine

6)Normal Switch-off

Note!

If you intend to switch off only one set of UPS among the parallel machine system, select “single machine switch-off”; if switch-off is intended for the entire parallel machine system, select “parallel machine switch-off”.

6. Help

1)Help picture

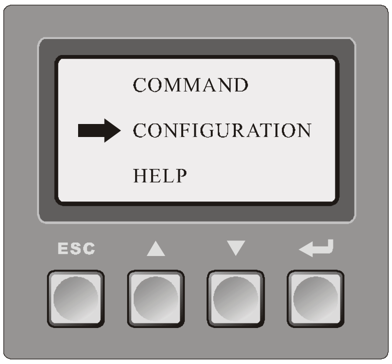
2)Press ENTER on help picture

7. Configuration (press ESC to exit the above picture)

You are able to access Setting picture by using user combination (default: 1234, subject to personal modification) so as to set the following programs.

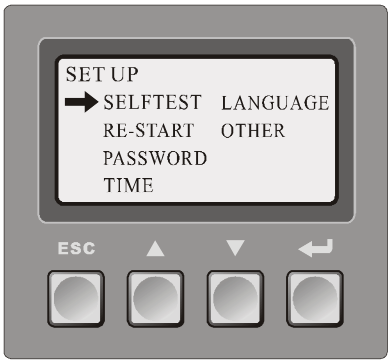
1)Action display (bypass power supply)

2) Press ▼



3)Enter respective password

4)Select action item



8. The Series is capable of DC start-up without AC input, panel display being similar to switch-on picture with AC supply. DC switch-on and off are available by following instructions appearing in the pictures.

9. Procedures of DC switch-on:

- Activate DC switch-on function set under UPS bypass mode
- Make sure that “+”, “-” and “N” wires of batteries are properly connected to UPS
- Switch on batteries
- Lightly touch ENTER
- Manually conduct switch-on order within about 1min after LCD self-inspection

> ⚠ Note!
>
> UPS will be switched off automatically if there is no operation within 1min after LCD self -inspection is completed!

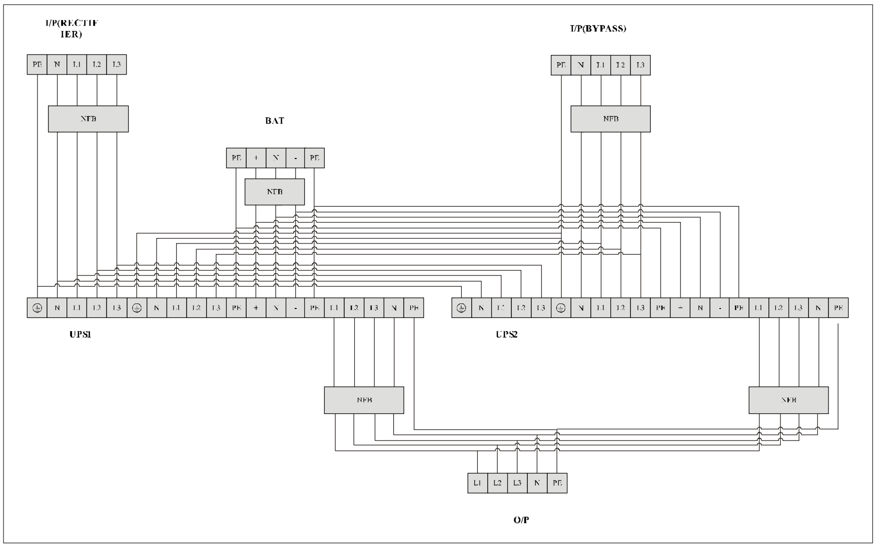
7.2 Parallel machine operation

Redundancy introduction

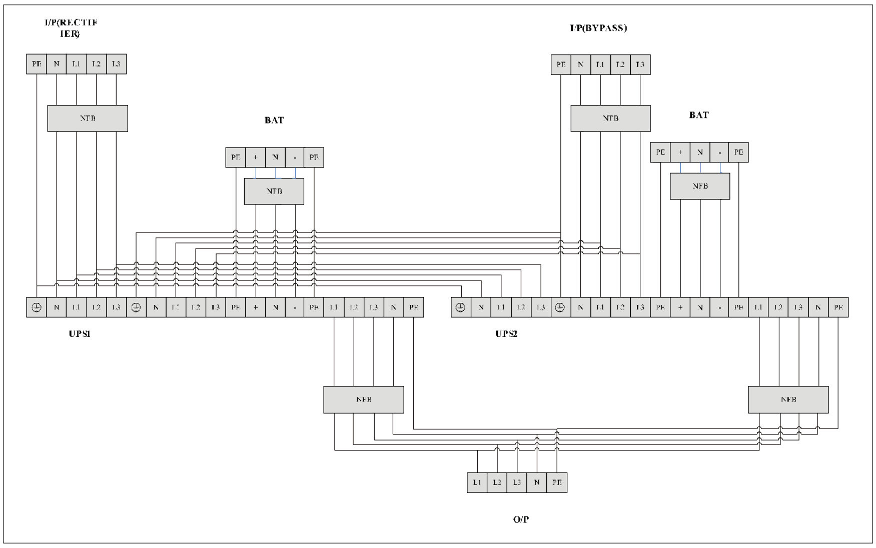
N+X is currently the most reliable power supply structure, in which N indicates the minimum UPS number required for the total load and X is the redundant UPS number, namely, the malfunctioning UPS number that the system can simultaneously bear. The larger X is, the higher reliability of system will be. For instance, if the total load of a customer registers 55kVA, we can use 20KVA for N+X design. With N taking up 3, X can be selected in accordance with reliability degree or cost requirement. Supposing customer selects X=2 and equalized UPS power supply is 11kVA for each unit, when one set of UPS breaks down with malfunction, the remaining four sets will provide power with almost 14kVA equalized current; if two sets of UPS fail, the remaining three sets of UPS are supposed to provide power supply with almost 18kVA equalized current. The maximum allowance of this system is for two sets of UPS going down at the same time, the chances of which are much smaller than those of one UPS malfunction. Therefore, the reliability degree can be largely enhanced, making it an optimal mode for application in locations where high degree of reliability is always a focus.

Eaton E Series DX 30/40 kVA B is capable of direct parallel connection, which only requires the parallel connection wires (optional) for 2 to 8 sets of UPS in parallel connection in order to realize power redundancy (N+X).

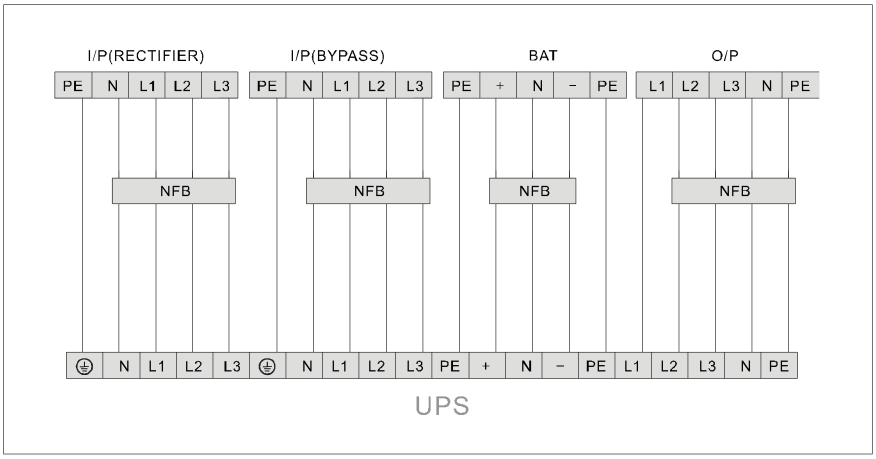
Parallel machine wire connection drawing(one battery supply)



Parallel machine wire connection drawing(separate battery supply)



Single machine wire connection drawing



8 Maintenance

> Warning!
>
> The Maintenance must be performed by a service engineer form the manufacturer or form an agent authorised by the manufacturer.

Eaton DX 30/40 kVA B requires minimum maintenance.
1. If battery is switched off, loaded equipments will not be covered for power-off protection.
2. Make sure UPS vent are properly ventilated and clean side frames and fan vents from dusts every half a year (switch off AC, battery cabinet and internal battery fuse prior to cleaning)

8.1 Battery Maintenance

The battery is key component of the UPS. The battery life depends on the ambient temperature, charge and discharge times. High ambient temperature and deep discharge will shorten the battery life.
1. Sealed maintenance-free lead acid battery be used in the standard. When being connected to the utility power and if the UPS has been turned on, the UPS keeps charging the battery and also offers the protective function of charging and discharging.
2. Keep the ambient temperature between 15℃ and 25℃.
3. If the UPS has not been used for a long period, charging is recommended at the interval of 3 months.
4. Normally, the battery should be charged and discharged every 4 to 6 months. Charging should be started after the UPS shut down automatically in the course of discharging. In the regions of hot climates, the battery should be charged and discharged every 2 months. Moreover, the standard charging time should be no less than 10 hours.
5. It’s not recommended to replace batteries individually. Complete replacement should follow instructions given by battery suppliers.
6. Under normal conditions, the battery life lasts 3 to 5 years. Should batteries be found in poor performance, replacement should be done as soon as possible only by qualified personnel with proper training. Users are not allowed to replace without authorization.

Remark:

A. Prior to battery replacement, switch off UPS and remove it from AC and battery, take off internal battery breaker.

B. Take off metallic articles such as rings and watches.

C. Use screw drivers equipped with insulated handles and do not place tools or other metallic substances on the batteries.

D. Short circuit or reverse connection is forbidden for battery polarity connection.

The troubleshooting procedure gives simple remedial if a malfunction occurs in the UPS. The operator should start the trouble shooting if there is an active alarm indicated on the LCD screen. Service should be contacted if the active alarm is abnormal and displayed as a service code.

Should maintenance prove necessary, the following steps should be followed:

1. Check if UPS input wiring is done properly.
2. Check if all air switches are tripped out.
3. Check if voltage input is within specified range

Please refer to “Light Reference Table” of this User Manual first and then conduct proper treatment. If problems still exist, please record UPS model, serial number as well as purchase date, symptom on fault, light condition, LCD malfunction or warning information.

Table of Malfunctions		
SYMPTOM	LCD DISPLAY OR POSSIBLE CAUSE	SOLUTION
The Fault LED is lit, periodic beeps	Overloaded in bypass or inverter operation mode	Unloaded to the required value
	Mains out of tolerance	Check that the input wiring and input voltage are normal
	Battery disconnected	Check the battery switch and the battery wiring
LCD panel has no display		Switch off and make sure socket is properly connected. Power up again

8.2 Regular service/intervals

The UPS requires very little maintenance if installed in an appropriate environment. In order to ensure maximum availability of the UPS, manufacturer recommends signing a proactive service agreement with a local authorised service provider.

Maintenance	Interval
Batteries change	3-5 years or according to battery suppliers recommendations
Batteries test	18 months
Cooling fan change	5 years

8.3 Cooling fan

The cooling fan lifespan of the UPS unit is about 60 000 operating hours. The actual lifespan depends on the environment and ambient temperature.

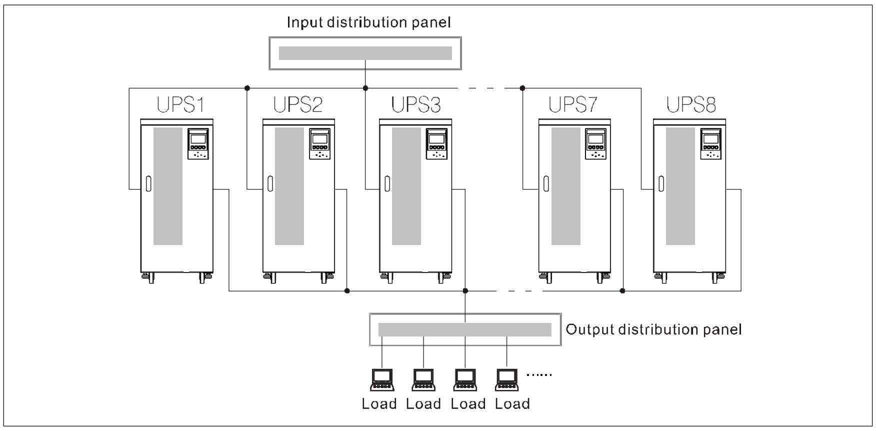
Fan failure can be predicted by increasing noise from the fan bearings. The fan replacement is recommended once this symptom starts appearing.

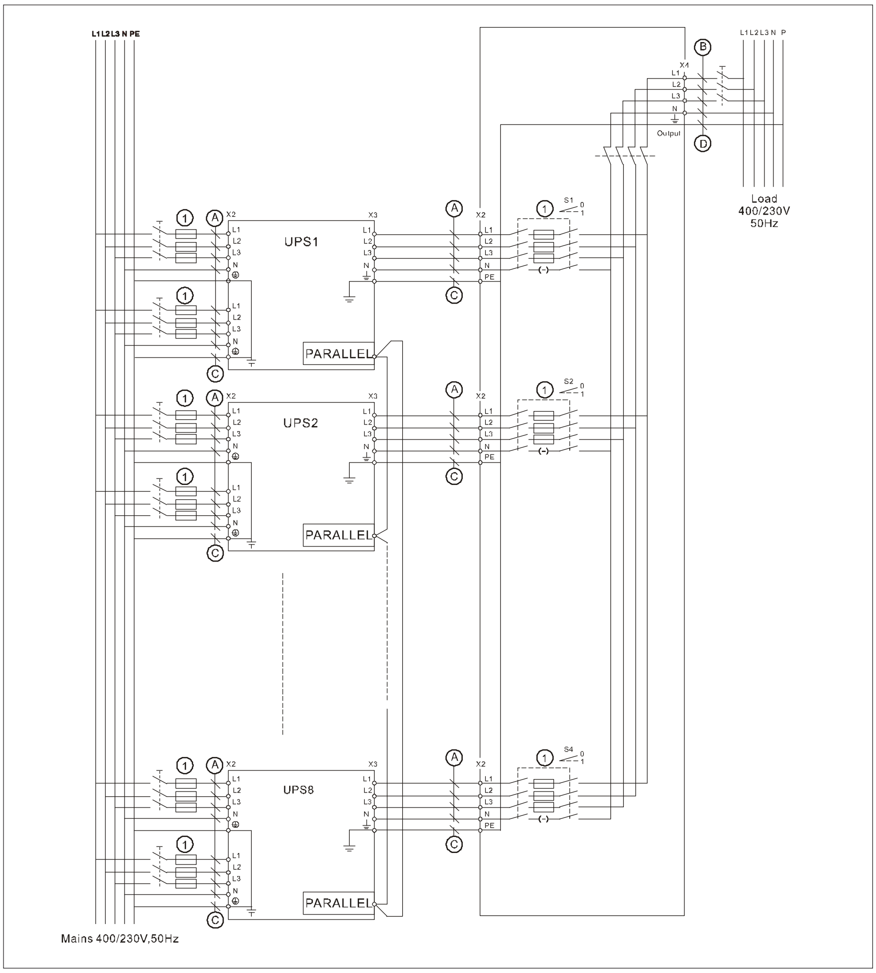
Do not use other than manufacturer’s specified spare parts.

9 Parallel systems

> **Note!**
>
> Parallel is only connected to identical ports for the UPS of same models and kVA rating.

1) Follow installation instructions for general installation requirements.
2)Ventilation spacing between machines should allow for service access.
3) Input wiring for each set of UPS should follow the requirements for that of single unit.Each UPS input should be connected to the same input patch board.
4) Each UPS output wire should be connected to the output patch board, from which wires are distributed for load as illustrated in following figure.
Remark 1: common battery pack is applicable in parallel machine mode;
Remark 2: each battery pack should be of the same model from the same manufacturer;
Remark 3: requirement of output wiring length:
When the lead from the output terminal of each set of UPS to the output patch board is less than 20m, wire difference should be less than 20%;
When the lead from the output terminal of each set of UPS to the output patch board is longer than 20m, wire difference should be less than 10%.





Note!

Parallel signal cable should be connected as a loop.

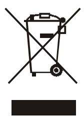
10 Recycling the used UPS or battery

Before scrapping UPS or its battery cabinet, the battery bank must be removed. Local requirements must be followed in battery recycling or discard. The removal of batteries is allowed only by authorised service personnel due to high energy and voltage.
Do not discard waste electrical or electronic equipment in the trash. For proper disposal, contact your local collecting/recycling/reuse or hazardous waste center and follow the local legislation.
These symbols indicate on a product:
You can find out which recycling firm is responsible for your neighbourhood by contacting your local authority.

Batteries must not be put in the domestic refuse either!

All consumers have a statutory duty to take all batteries to a collection point in their municipality/district or to a retail store so that they can be disposed of in an environmentally-friendly way,regardless of whether they contain toxic substances.
All batteries should be fully discharged before they are returned for disposal.

PROTECTION OF THE ENVIRONMENT/DISPOSAL OF THE EQUIPMENT.



Do not on any account put your old equipment out with the domestic refuse.

For the sake of the environment,please use your local authority's collection point set to return and recycle old electric and electronic equipment.

11 Warranty

The product is warranted against defects in design, materials and workmanship for a period of twelve (12) months from its original date of purchase. The local office or distributor may grant a warranty period different to the above and refer to local terms of liability as defined in the supply contract.

The UPS manufacturer is not responsible for
1) Any costs resulting from a failure if the installation, commissioning, repair, alternation,or ambient conditions of the equipment do not fulfil the requirements specified in the documentation delivered with the unit and other relevant documentation.
2) Equipment subjected to misuse, negligence or accident
3) Equipment comprised of materials provided or designs stipulated by the purchaser.

Under no circumstances shall the manufacturer, its suppliers or subcontractors be liable for special, indirect, incidental or consequential damages, losses or penalties.
The technical data, information and specifications are valid at the time of printing. The UPS manufacturer reserves the right to modifications without prior notice.

12 Display reference Table

Serial No.	working condition	Indicator					BUZZER
		Bypass light	Line light	Inverter light	Battery light	Fault light	
1	Standby Mode						
	Normal					one flashing every 8 sec	one beep every 8 sec
	Warning					one flashing every 4 sec	one beep every 4 sec
	Overload					one flashing every 1 sec	one beep every 1 sec
2	Bypass Mode						
	Normal	●				one flashing every 2 min	one beep every 2 min
	Warning	●				one flashing every 4 sec	one beep every 4 sec
	Bypass phase error or bypass loss	●				one flashing every 2 sec	one beep every 2 sec
	Overload	●				one flashing every 1 sec	one beep every 1 sec
3	Line Mode						
	Normal		●	●			None
	Warning		●	●		one flashing every 4 sec	one beep every 4 sec
	Overload		●	●		one flashing every 1 sec	one beep every 1 sec
4	Battery Mode						
	Normal			●	●	one flashing every 4 sec	one beep every 4 sec
	Warning			●	●	one flashing every 4 sec	one beep every 4 sec
	Low battery voltage			●	★	one flashing every 1 sec	one beep every 1 sec
	Overload			●	●	one flashing every 1 sec	one beep every 1 sec
5	Battery Self Diagnosis Mode						
	Normal	★	★	★	★	None	None
	Warning	★	★	★	★	one flashing every 4 sec	one beep every 4 sec
	Low battery voltage			●	★	one flashing every 1 sec	one beep every 1 sec
	Overload			●	●	one flashing every 1 sec	one beep every 1 sec
6	Fault Mode						
	Normal					Long light	Long beep
7	Converter Mode						
	Normal		●	●		None	None
	Warning		●	●		one flashing every 4 sec	one beep every 4 sec
8	ECO Mode						
	Normal	●		one flashing every 1 min		None	one beep every 1 min
	Warning	●				one flashing every 4 sec	one beep every 4 sec

Should any display or warning message excluded in the above table be found,please contact distributor or call EATON Hot line for advice.

● Indicator light is on

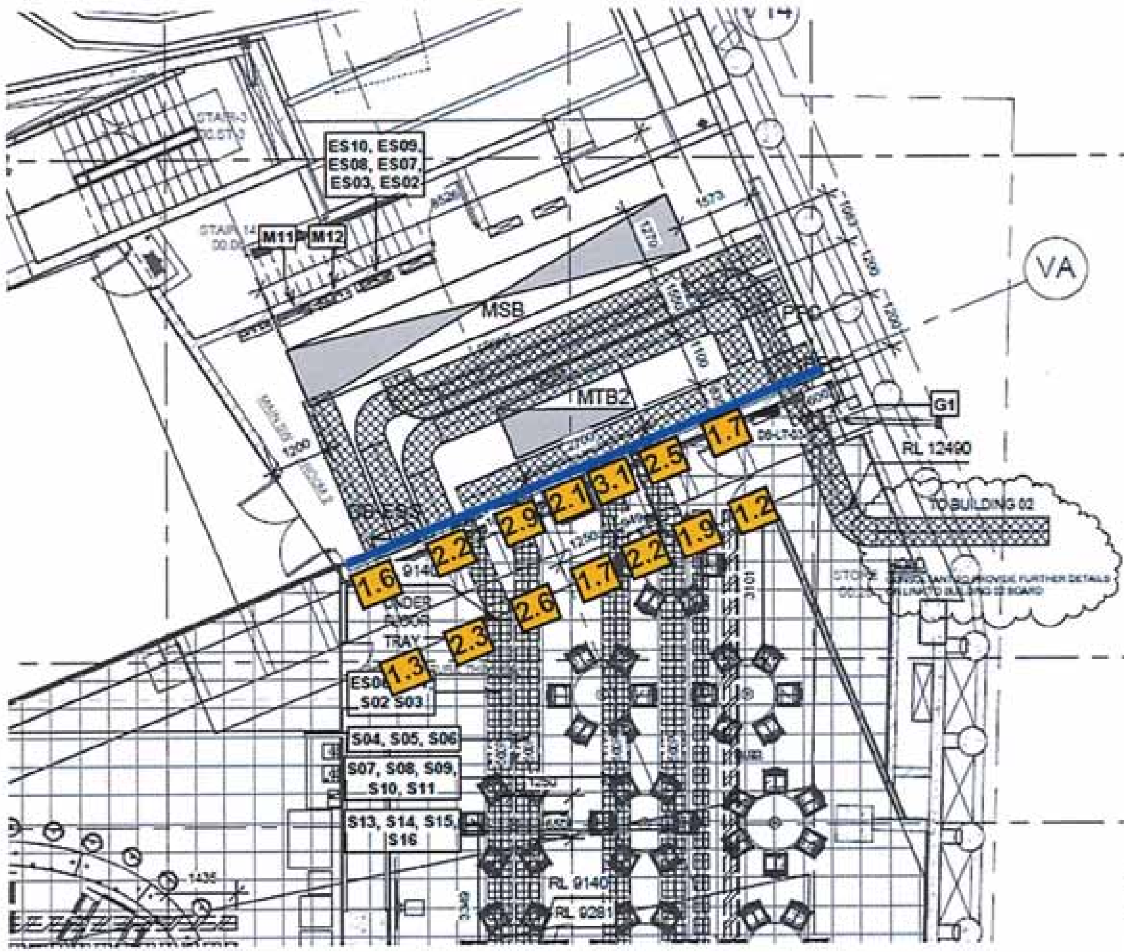
★ Indicator light flashes

Warning include one or more than one of these:

1.EPO active	*11.Charger failure*
2.Line loss	*12.Battery over restrict*
3.Neutral loss	*13.Battery over temperature*
4.Line phase error	*14.Fan over restrict*
5.Bypass loss	*15.BUS capacitor over restrict*
6.Bypass phase error	*16.Fan failure*
7.Battery open	*17.Fan disconnected*
8.Low battery voltage	*18.Low temperature Battery*
9.Over charger	*19.communication disconnected*
10.Battery reverse	*20.Auxiliary charger failure*

8.11 EMI Shielding: EMI Shielding

See attached folder Section 8



0.1 Denotes EMF reading in milliGauss (mG) taken at 1m above floor level

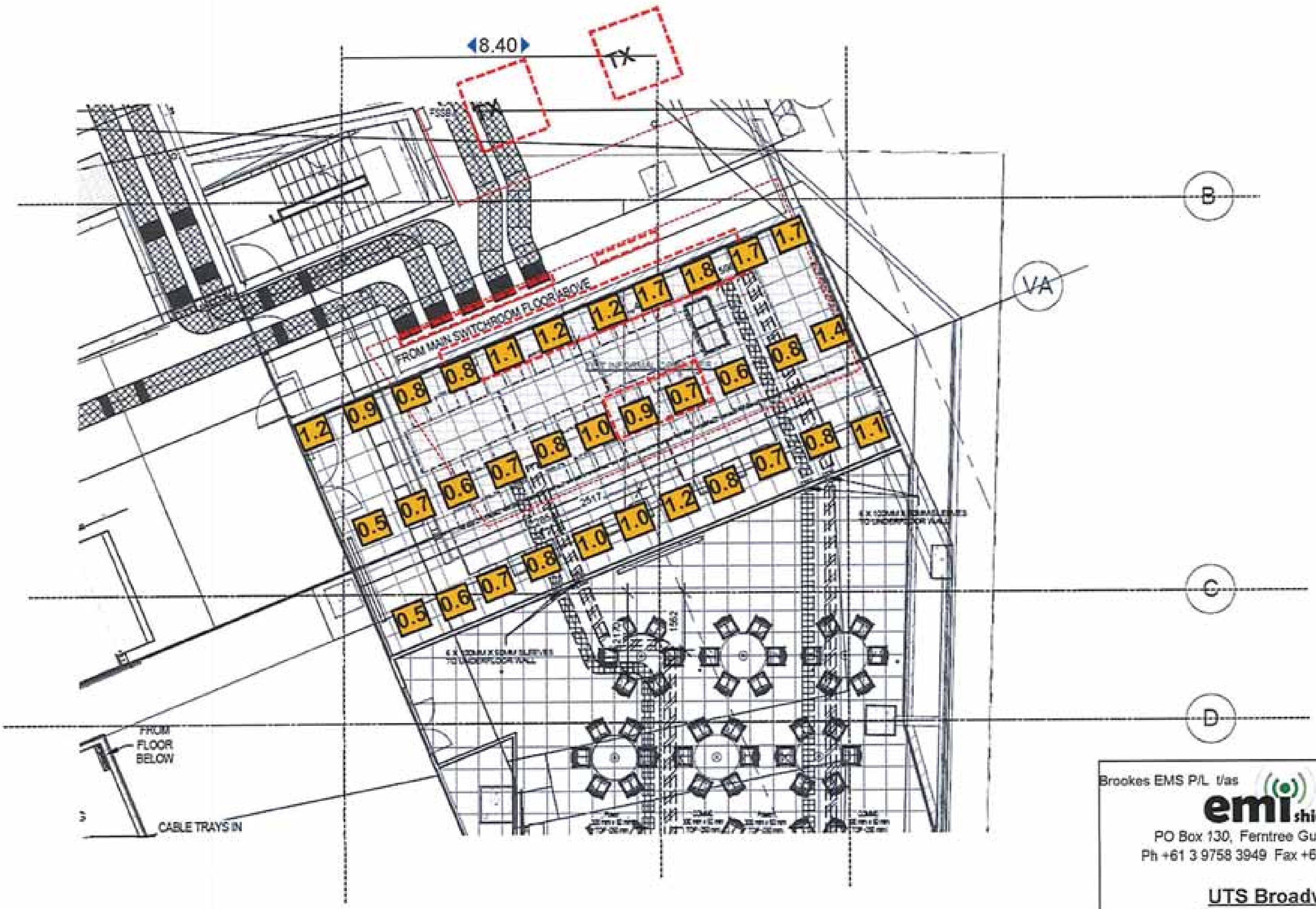
Wall Shielding

NOT TO SCALE

Brookes EMS P/L t/as
emi shielding
PO Box 130, Ferntree Gully VIC 3156
Ph +61 3 9758 3949 Fax +61 3 9753 5552

UTS Broadway
Ground /00 Level

EMF Shielding - Test Reading
13th February , 2014 TR1



0.1 Denotes EMF reading in milliGauss (mG) taken at 1m above floor level

Outline of electrical installation above

NOT TO SCALE

Brookes EMS P/L t/as

emi shielding

PO Box 130, Ferntree Gully VIC 3156

Ph +61 3 9758 3949 Fax +61 3 9753 5552

UTS Broadway

Basement Level 1

EMF Shielding - Test Readings

13th February, 2014

TR2

UTS BROADWAY – BUILDING 11

50Hz EMF SURVEY REPORT (pre-installation draft copy only)

1. Introduction

Electromagnetic shielding has been installed to the South wall of the Main Switchroom No.2 and the soffit and North wall of the Basement Level computer lab below the Main Switchroom in accordance with the design specification. The shielding is designed to limit EMF in the Basement Level computer lab and the Level 00 Lecture Theatre to not more than 35 milliGauss (mG) when measured at one metre above floor level.

EMF testing was conducted Thursday 13th February, between 11:30am and 12:15pm in the presence of a Nilsen representative. Photographs taken during testing are attached for client reference. At the time of testing the building was unoccupied but general light and power was on. The ambient outdoor temperature was approximately 28 degrees Celsius.

Testing was carried out using a TM-192 tri-axial digital gaussmeter calibrated for 50Hertz frequency with Serial No 100401382. The meter has a resolution of 0.01**milliGauss (mG)** and range 0.01 - 2000mG. A NATA calibration certificate is attached.

2. Electrical Information

Load information was obtained from the digital metering on the main switchboard. At the time of testing the phase current was as follows:

MSB-1		**MSB-2**	
Phase A	190 Amps	Phase A	85 Amps
Phase B	156 Amps	Phase A	73 Amps
Phase C	80 Amps	Phase A	100 Amps
Neutral	97 Amps (calculated)	Neutral	23 Amps (calc)

Design load is 80% of rated current. Actual load was less than 10% of design load, therefore factoring of final readings for future increases in load is not relevant.

Ph: +61 3 9758 3949
web: www.emishielding.com.au

PO Box 130
Ferntree Gully, VIC 3156

Fax: +61 3 9753 5552
email: office@emishielding.com.au

2. EMF Readings

Refer to attached TR1 and TR2 for a graphical representation of readings taken.

Summary of EMF readings at 1m AFL:

	Level 1 Lecture Theatre (mG)	Level B1 Computer Lab (mG)
Min	1.2	0.5
Max	3.1	1.8
Average	2.1	0.9

As electrical load was too low to provide accurate factoring for maximum demand conditions, additional readings were taken to demonstrate that the shielding effectiveness of the installed materials was adequate when compared with the designed requirement.

	Reading on floor of main switchroom	Reading at 2m above floor level in computer lab	Shielding Effectiveness
Computer Lab	39.3mG	1.4mG	28dB
Lecture Theatre	**Reading at cable riser in Main Switchroom**	**Readings at same location on opposite side of wall shielding in Lecture Theatre**	**Shielding Effectiveness**
	17.37mG	1.7mG	20dB

Conclusion

The readings taken at the time of testing comply with the performance criteria of not more than 35mG in the Basement Level Computer Lab and the Level 00 Lecture Theatre adjacent to the Main Switchroom.

Fluctuations in load will increase EMF readings, however, the shielding is performing within the design intent and readings are not anticipated to exceed 35mG.

The client may wish to commission additional testing when the building is occupied and operating under typical daily load conditions.

Ph: +61 3 9758 3949
web: www.emishielding.com.au

PO Box 130
Ferntree Gully, VIC 3156

Fax: +61 3 9753 5552
email: office@emishielding.com.au

Reported By:

Kerryn Harrington
Electrical Engineer
20th February, 2014

Checked By:

Ken Brookes
Director
21st February, 2014

Attachments:
TR1_Ground Level Test Readings.pdf
TR2_Computer Lab Test Readings.pdf
Yellow No 2 Calibration Certificates 15112013.pdf
Photo references x 7

Ph: +61 3 9758 3949
web: www.emishielding.com.au
PO Box 130
Ferntree Gully, VIC 3156
Fax: +61 3 9753 5552
email: office@emishielding.com.au

Calibration and Testing Services

SA Power Networks

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements are traceable to Australian/national standards.

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SA Power Networks ABN 13 332 330 749 a partnership of: Spark Infrastructure SA (No.1) Pty Ltd ABN 54 091 142 380, Spark Infrastructure SA (No.2) Pty Ltd ABN 19 091 143 038, Spark Infrastructure SA (No.3) Pty Ltd ABN 50 091 142 362, each incorporated in Australia. CKI Utilities Development Limited ABN 65 090 718 880, PAI Utilities Development Limited ABN 82 090 718 951, each incorporated in The Bahamas.

CALIBRATION REPORT ON

A Magnetic Field Strength Meter

Serial Number: 100401382

Report Number: 179/13/4410N | **Report Date: 15th November 2013**

Calibrated by:
Peter Bagusauskas P.B.
Telephone: 08 8292 0404

Checked by:
Khang Vu
Authorised Signatory

Page: 1 of 3

W/O: 20130895e

Authorised by: K.Vu

Contact Calibration and Testing Services at:
Delivery Address: Gate 7 Grove Avenue Marleston SA 5033
Street Address: 47-61 Barnes Avenue Marleston SA 5033
Postal Address: PO Box 284 Marleston SA 5033
Telephone: (08) 8292 0121 Facsimile: (08) 8292 0105

CLIENT DETAILS

Reference:	-
Name:	Brookes EMS Pty Ltd
Address:	PO Box 130, Ferntree Gully, VIC 3156

ITEM DETAILS

Date Received:	25th October 2013
Manufacturer:	TENMARS
Model:	TM-192D

TEST DETAILS

Work Order:	20130895e	
Date of Test:	15th November 2013	
Test Method:	TM1.34.08-00	
Nature of Test:	Calibration check.	
Test Method:	The DUT was placed in Helmholtz coils and readings recorded and compared to the calculated field.	
Conditions of Test:	20°C ±1°C. 50Hz essentially sinusoidal supply.	
Reference Equipment:	Helmholtz Coils	01355
	DMM	B020188
	1Ω Standard Resistor	21901
	10Ω Standard Resistor	3401/1958
	100Ω Standard Resistor	3402/1958
	1000Ω Standard Resistor	3403/1958
Results of Tests:	See next page	
Uncertainty of Measurement:	For axial components:	± (5% of Reading + 0.7mG)
	For XYZ readings:	± (5% of Reading + 0.7mG)

Uncertainty

The stated uncertainties have been estimated for 95% confidence limits. Unless stated otherwise in the report a coverage factor of k=2 has been used.

The uncertainties apply at the time of measurement and at the stated 'Conditions of Test'. They do not consider drift after the calibration date nor do they take into account the environment and the conditions in which the instrument may be used.

Range (mG)	Input (mG)	% Error of Readings			
		X	Y	Z	XYZ
20	17.5	-0.9	+0.6	-0.9	-2.9
	10	-3.5	-1.0	-2.5	-2.5
200	175	-3.0	-2.0	-3.1	-1.3
	150	-3.0	-1.8	-3.0	-3.0
	125	-2.8	-2.1	-3.1	-3.1
	100	-2.8	-1.8	-2.7	-2.7
	75	-2.5	-1.9	-2.3	-2.3
	50	-2.8	-2.6	-3.2	-3.2
	20	-5.2	-4.5	-4.8	-4.8
2000	1750	-3.1	-1.9	-3.0	-1.7
	200	-3.0	-2.5	-3.0	-3.0

Note: a positive error indicates that the device under test reads higher than the true value and vice versa.

Calibration and Testing Services

SA Power Networks

SA Power Networks ABN 13 332 330 749 a partnership of: Spark Infrastructure SA (No.1) Pty Ltd ABN 54 091 142 380, Spark Infrastructure SA (No.2) Pty Ltd ABN 19 091 143 038, Spark Infrastructure SA (No.3) Pty Ltd ABN 50 091 142 362, each incorporated in Australia. CKI Utilities Development Limited ABN 65 090 718 880, PAI Utilities Development Limited ABN 82 090 718 951, each incorporated in The Bahamas.

NATA

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements are traceable to Australian/national standards.

NATA Accredited Laboratory - Number 179

CALIBRATION REPORT ON

A Magnetic Field Strength Meter

Serial Number: 080912093

Report Number: 179/13/4411N | **Report Date: 15th November 2013**

Calibrated by:
Peter Bagusauskas P.B
Telephone: 08 8292 0404

Checked by:
Khang Vu
Authorised Signatory

W/O: 20130895e

Authorised by: K.Vu

Contact Calibration and Testing Services at:
Delivery Address: Gate 7 Grove Avenue Marleston SA 5033
Street Address: 47-61 Barnes Avenue Marleston SA 5033
Postal Address: PO Box 284 Marleston SA 5033
Telephone: (08) 8292 0121 Facsimile: (08) 8292 0105

www.sapowernetworks.com.au

CLIENT DETAILS

Reference:	-
Name:	Brookes EMS Pty Ltd
Address:	PO Box 130, Ferntree Gully, VIC 3156

ITEM DETAILS

Date Received:	25th October 2013
Manufacturer:	-
Model:	Triaxial ELF

TEST DETAILS

Work Order:	20130895e	
Date of Test:	15th November 2013	
Test Method:	TM1.34.08-00	
Nature of Test:	Calibration check.	
Test Method:	The DUT was placed in Helmholtz coils and readings recorded and compared to the calculated field.	
Conditions of Test:	20°C ±1°C. 50Hz essentially sinusoidal supply.	
Reference Equipment:	Helmholtz Coils	01355
	DMM	B020188
	1Ω Standard Resistor	21901
	10Ω Standard Resistor	3401/1958
	100Ω Standard Resistor	3402/1958
	1000Ω Standard Resistor	3403/1958
Results of Tests:	See next page	
Uncertainty of Measurement:	For axial components:	± (5% of Reading + 0.7mG)
	For XYZ readings:	± (5% of Reading + 0.7mG)

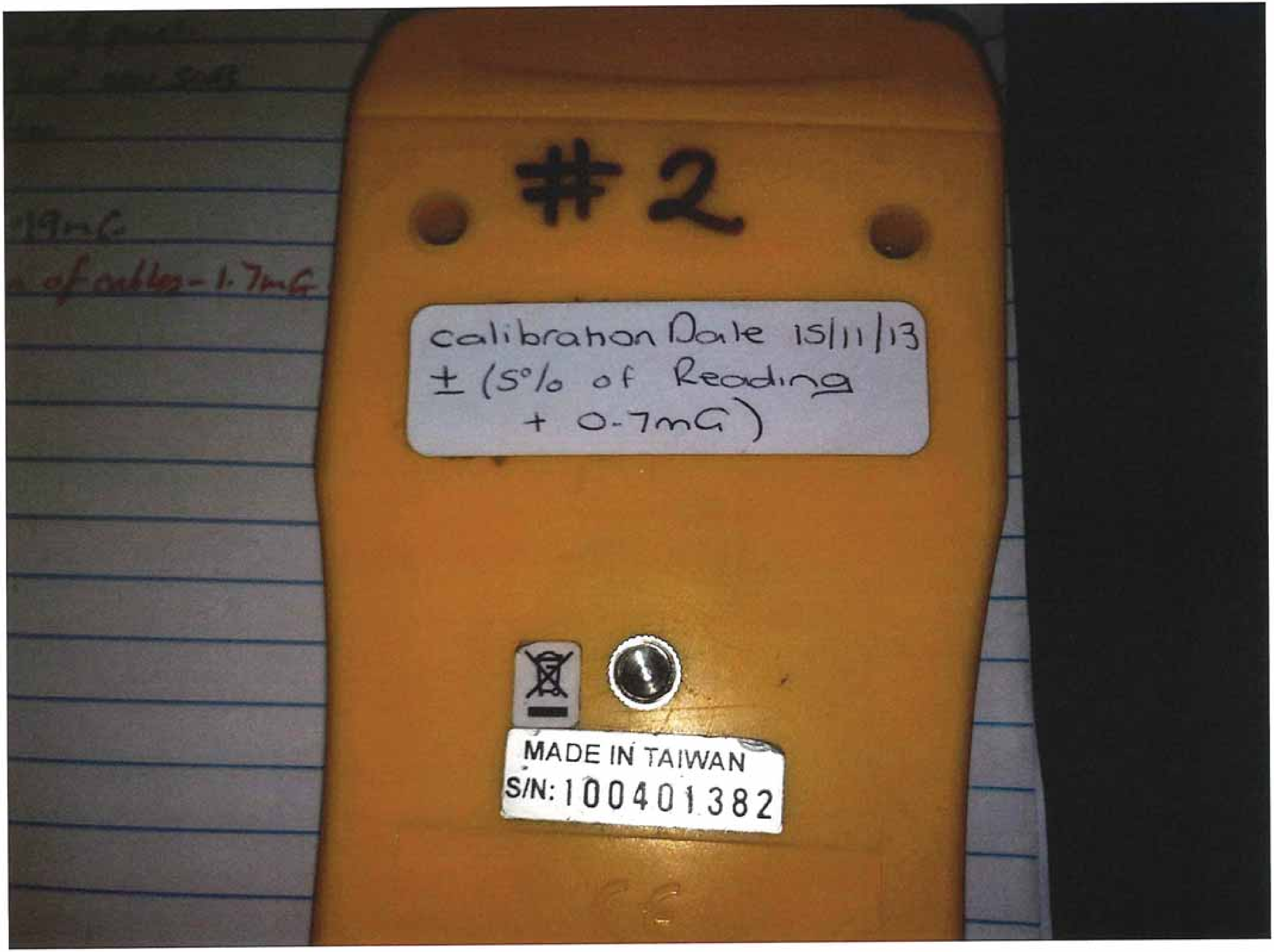
Uncertainty

The stated uncertainties have been estimated for 95% confidence limits. Unless stated otherwise in the report a coverage factor of k=2 has been used.

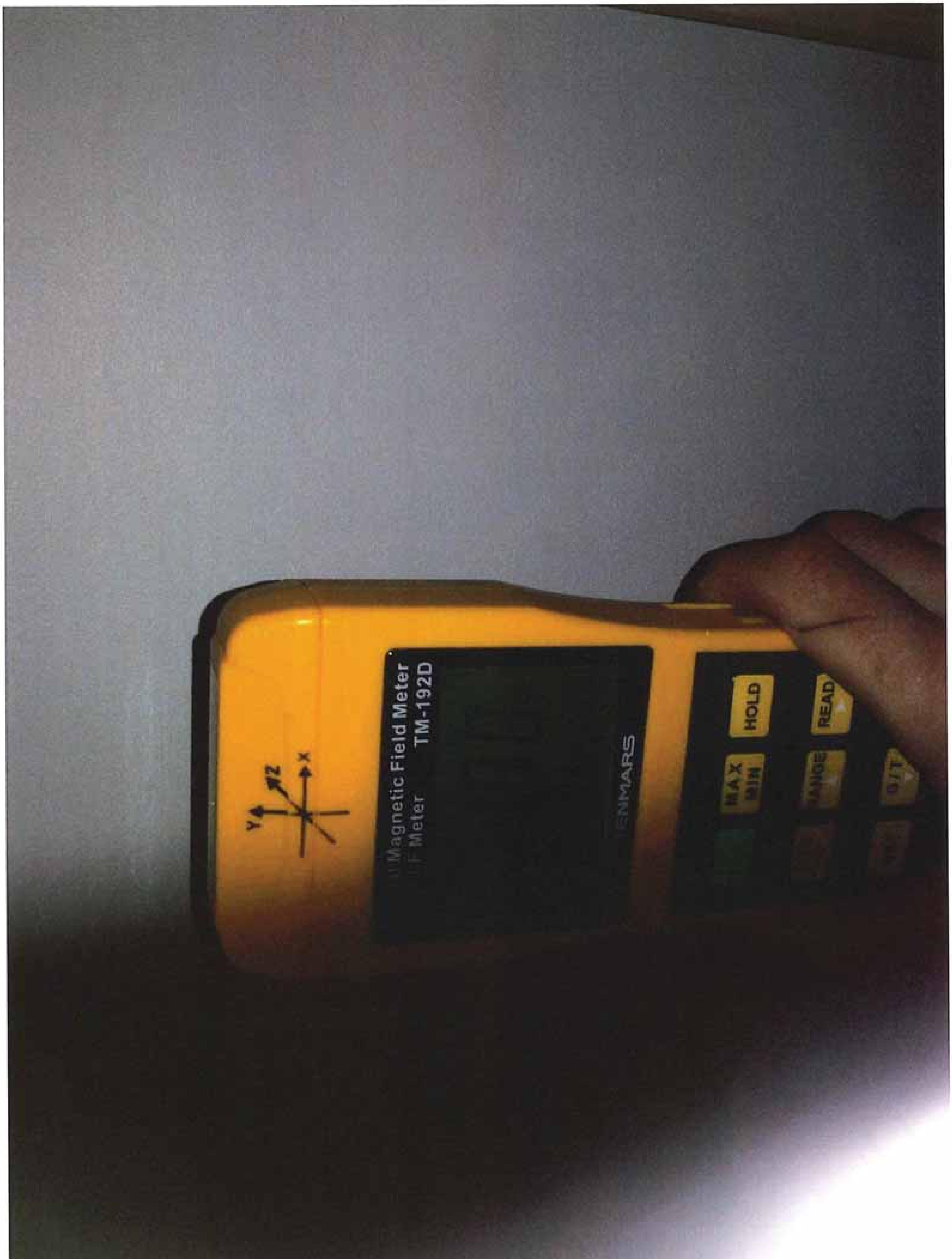
The uncertainties apply at the time of measurement and at the stated 'Conditions of Test'. They do not consider drift after the calibration date nor do they take into account the environment and the conditions in which the instrument may be used.

Range (mG)	Input (mG)	% Error of Readings			
		X	Y	Z	XYZ
20	18	+8.9	-3.3	-10.3	-2.2
	2	-5.0	-17.5	-17.5	-15.0
200	180	+10.0	-3.6	-11.4	-5.2
	160	+9.3	-3.5	-11.9	-5.3
	140	+9.6	-3.8	-11.8	-8.1
	120	+10.0	-3.3	-11.7	-5.4
	100	+10.0	-3.5	-11.9	-8.4
	80	+11.0	-3.6	-12.3	-6.1
	60	+8.8	-3.5	-12.3	-6.8
	40	+9.5	-3.8	-13.0	-8.2
	20	+7.5	-3.0	-10.0	-3.5
2000	1750	+10.8	-3.2	-11.4	-7.8
	200	+8.5	-3.0	-11.0	-4.0

Note: a positive error indicates that the device under test reads higher than the true value and vice versa.


#2
calibration Date 15/11/13
± (5% of Reading
+ 0-7mG)
MADE IN TAIWAN
S/N: 100401382


Triaxial Magnetic Field Meter
EMF/ELF Meter
TM-192D
TENMARS
HOLD
MAX MIN
READ
RANGE
REC
G/T
SET


Magnetic Field Meter
TM-192D
HOLD
READ
MAX
MIN

Triaxial Magnetic Field Meter
EMF/ELF Meter TM-192D
TENMARS
Y
Z
X
HOLD
MAX
MIN
RANGE
REC


Triaxial Magnetic Field Meter
EMF/ELF Meter
TM-192D
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TENMARS
MAX
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RANGE
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SET
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Y
Z
X


Triaxial Magnetic Field Meter
EMF/ELF Meter
TM-192D
TENMARS
MAX MIN
HOLD
REC
RANGE
READ
SET
G/T

8.12 Skirting Duct: Ductall

DUCTALL SYSTEMS PTY LTD

3 Channel Series 'D' Centre Line Extruded Aluminium Skirting Duct

Standard Surface Series

ALL SERVICES ON THE **CENTRE LINE**

CATALOGUE NO: D150.50.3CL

- Extra Data Capacity
- Largest Data/Phone Capacity
- Wiring Installation Costs Slashed
- Easy to Install
- No maintenance – all aluminium body

3 CHANNEL SERIES 'D' CENTRE LINE EXTRUDED ALUMINIUM SKIRTING DUCT
Catalogue No: D150.50.3CL

DUCTALL SYSTEMS PTY LTD

Standard Surface Mounted

MAIN FEATURES

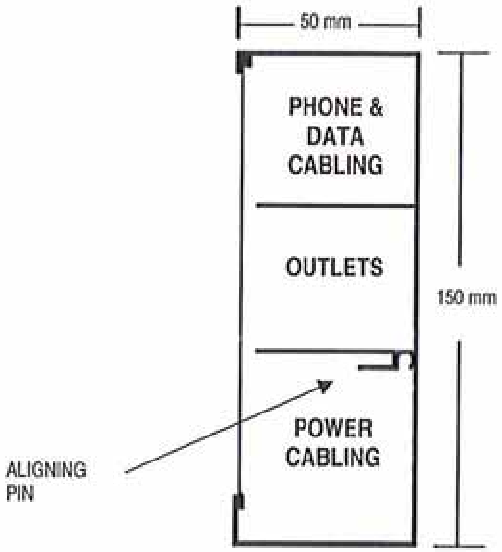
- Extra large data/phone capacity
- All services exit in a straight line
- All aluminium body (will not rust)
- Available with drop-in cover (aluminium or marviplate)

ACCESSORIES

1. Single power outlet mounting kit – D150.50.3CL/SP.
2. Double power outlet mounting kit – D150.50.3CL/DP.
3. Telephone outlet mounting kit – D150.50.3CL/T.
4. Data outlet mounting kit – D150.50.3CL/D.
5. End cover plate with fixing screws – D150.50.3CL/E.
6. Right angle external corner – D150.50.3CL/C.

NOTES

- Recommended fixing centres 800mm max.
- Over 130 special colours available on request (acrylic or powder coated).
- Standard duct in black three (3) metre lengths (P.O.A.).
- Medium voltage cables in duct to be double insulated type to save earth bonding covers and body.



D150.50.3CL Skirting Duct

GENERAL:

The contractor shall supply and install the skirting duct system where shown on the drawings. The ducting system shall be complete with all factory made accessories.

COMPLIANCE:

The Contractor shall ensure that the entire skirting wiring duct installation complies with the requirements of the local supply Authority and Austel. All ducting shall be earthed.

TYPE:

The skirting wiring duct shall:-

* Be of extruded aluminium section.
* Be a minimal size of 150mm x 50mm.
* Have three (3) segregated wiring compartments for phone/data and power cabling with all outlets terminated in the middle channel (third channel).
* Have an extruded continuous threaded screw flute section to enable screw fixing of all duct accessories.
* Be suitable for surface mounting.
* Have a minimum 20mm aluminium carpet strip located at the bottom of the duct to enable carpet to abut to the duct without interfering with the duct cover plates.
* Have recesses for fishplates or dowel to align duct sections at joints.
* Have front cover plates of sheet steel either powdercoated a nominated colour or affixed with a bonded vinyl film of selected colour similar to Marviplate.
* Have exposed duct body finished in baked enamel (powdercoated) of selected colour.
* The duct shall be equal to Ductall Systems D150.50.3CL skirting.

INSTALLATION:

The skirting wiring duct shall be fixed to walls alternatively at the top and bottom of the duct at maximum centres of 1000mm. All joints (butt, corner and angled) shall be neatly made in a tradesman like fashion with no visible gaps.

Supply and install wiring access via conduits within stud walls, etc. and associated draw wires, to all duct sections throughout this installation. Access shall be separate for each duct channel to maintain electrical isolation.

8.13 Solar Panels: Solgen

University of Technology Sydney
Broadway Building Lab

UNIVERSITY OF TECHNOLOGY SYDNEY

PROJECT CHECKLIST

PROJECT DETAILS

Name: **Address:** **System Size:** **Panel:**	**Contact details**

Mounting System:	**NMI:**	**Meter No:**

OH&S

'Pre-Start Risk Assessment Form - Solar' completed ☐

INSTALLATION DETAILS

Location of Solar PV System:	Location of PCU:
Location of Communication Equipment:	Location of PV Array Main Switch:
Location of Solar Supply Main Switch:	Location of Temp Sensor:
Monitoring System Serial Number(s):	**PCU Model:**
Monitoring System IP Address:	**PCU Serial Number:**

PHOTOGRAPH CHECKLIST

Full view of Array	☐	Mounting & External Cabling	☐	PV Array Junction Box	☐
Smart Meter & Display	☐	PV Array Main Switch (DC)	☐	Monitoring System	☐
Inverter & Control System Layout	☐	DB with Solar Supply Main Switch (AC)	☐		

INSTALLER COMPLETION CHECKLIST

Completed Forms Required:		Signatures Required:	
Pre-Start Risk Assessment Form	☐	Installation team	☐
Certificate of Compliance	☐	Installer	☐
Compulsory Written Statement	☐ ☐ ☐ ☐	Installer Designer Owner Witness	☐ ☐ ☐ ☐
System Installation & Pre Commissioning Checklist	☐	Installer	☐
Commissioning Test Sheets	☐	Installer	☐
Operation & Shutdown / On Site Verification	☐	Installer Owner	☐ ☐
Government Installation Report	☐	Installer Owner	☐ ☐

UNIVERSITY OF TECHNOLOGY SYDNEY

PROJECT CHECKLIST

Day 1 Comments – Date:	People on site:
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	
....	
....	
Day 2 Comments – Date:	
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	
....	
Day 3 Comments – Date:	
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	Name ....Hrs Worked.......
....	
....	

Follow up notes:

UNIVERSITY OF TECHNOLOGY SYDNEY

PROJECT CHECKLIST

SECTION ONE – OPERATION & SHUT DOWN PROCESS

System operation and shut down process and procedure shown and explained to:

Client/Designated Person:

Name:____

Signature:________________________ **Date:**_______________

Installation person showing and explaining the operation and shut down procedure.

Name:____

Signature:________________________ **Date:**_______________

SECTION TWO – ON SITE VERIFICATION

I ________________________ am the owner of the solar (photovoltaic) system mentioned in this STC Assignment form and I confirm that the accredited installer and/or supervisor mentioned above has either:

1. Physically attended and undertaken the installation themselves

OR

2. Physically attended and supervised the installation by others.

THE OWNER OF INSTALLATION	WITNESS
Signed:	**Signed:**
Name:	**Name:**
Date:	**Date:**

System Installation and Pre-Commissioning Checklist

UNIVERSITY OF TECHNOLOGY SYDNEY

Customer Name... ....

Customer Address.......................................**Date**......................

PV ARRAY

PV Array Inclination? ☐

PV Array Orientation? ☐

Solar Array is securely fastened? ☐

Details

No dissimilar metals are in contact with the array frames or supports? ☐

PV Wiring losses are less than 3% at the maximum current output of the array? ☐

Weatherproof isolator is mounted immediately adjacent to the array? ☐

Wiring is protected from UV and mechanical damage? ☐

PCU

DC isolator mounted adjacent to the PCU? ☐

(Rating...............V DC ....A)

LOW VOLTAGE CABLING

...Is clearly defined? ☐

...Is in accordance with relevant Standards and guidelines? ☐

System Installation and Pre-Commissioning Checklist

UNIVERSITY OF TECHNOLOGY SYDNEY

Customer Name... ....

Customer Address.......................................Date.......................

SIGNAGE (As per AS/NZS5033:2012)	
Shutdown procedure with PCU location and Array Voc/Isc fixed to the main switch board?	☐
Shutdown procedure fixed to sub-boards and PCU?	☐
"Solar Array On Roof" with array location fixed to the main switch board?	☐
"Warning Dual Supply" with solar supply location fixed to the main switch board?	☐
"Warning Dual Supply" with isolation procedure located at all sub-boards?	☐
"PV Array Isolation Box" located on each array adjacent isolation point?	☐
"Warning do no operate fuse under load" located with system overcurrent protection?	☐
"Solar DC" on DC cable/conduit/cable tray ever 2 metres and at every bend?	☐
"PV Array Main Switch" located at the solar systems point of connection (PCU)?	☐
"PV array DC isolator" located adjacent to the inverter (unless inverter is within 3 metres of array)?	☐
Green reflective "PV" label on main and sub boards?	☐
"Warning Multiple DC sources" located at inverter station IF REQUIRED?	☐
"Warning Hazardous Voltage Authorised Access Only" located at array area entrance IF REQUIRED?	☐
"Warning Hazardous DC Voltage" located at array?	☐

This checklist is based on the Clean Energy Council Design and Installation Guidelines. These guidelines demonstrate the Industry "Best Practise" and are to be read in conjunction with the relevant Australian Standards.

AUTHORISATION: I, ...

CEC accreditation number...

Verify that the following system has been installed to the standard indicated by these guidelines and complies with the relevant standards

Name of the person for whom the system was installed

....

Location of system

....

Signed

.... Date..............................

Commissioning Test Sheets

UNIVERSITY OF TECHNOLOGY SYDNEY

Customer Name... ....

Customer Address.......................................Date......................

PV ARRAY – DC

Continuity between strings and Array Junction Box? ☐

Circuit Checked:

- *Between sub-array and array adjacent islotor*
- *Between array adjacent isolator and DC main switch*
- *Between DC main switch and inverter*
- *Others*______________________________

	Polarity Check	Open Circuit Voltage (VDC)	Short Circuit Current (A)
String 1			
String 2			
String 3			
String 4			
String 5			
String 6			
String 7			
String 8			
String 9			
String 10			
String 11			
String 12			
Array			

WARNING:

- If string is reversed and connected to others, fire may result.
- If polarity is reversed at the inverter, damage may occur to the inverter.
- Continuity of earth between primary and redundant.

Insulation Resistance Measurements (MΩ)
Array positive to earth:
Array negative to earth:

WARNING: restrict access to authorised personnel only during insulation resistance measurements. PV array should be isolated at the array adjacent isolator (follow shutdown procedure)

Irradiance (at time of recordings)...W/m^2

Average module cell temperature..........................°C

Commissioning Test Sheets

UNIVERSITY OF TECHNOLOGY SYDNEY

Customer Name... ....

Customer Address...Date........................

PCU
PCU commissioning to be done according to supplier documentation ☐

START-UP OF SYSTEM
System operates in accordance with PCU supplier documentation? ☐
Continuity of earth between primary and redundant (if required) ☐
Voltage at DC input of inverter..V DC
Voltage within operating limits of inverter? ☐
Input power of the inverter..W
Output power as expected? ☐
System disconnects in accordance with PCU supplier documentation?

Site:			
Project No:			
Name of Person Checking List:			
Installation	Yes	No	Action Required
Array Installed	❑	❑	
DC Junction Box & Cables Installed Correctly	❑	❑	
Roof Labelling Done	❑	❑	
Monitoring System Installed	❑	❑	
Monitoring System reporting as expected	❑	❑	
Labelling Done DB	❑	❑	
Labelling Done MSB	❑	❑	
Photos Taken of Array, Junction Box, etc.	❑	❑	
PCU, Monitoring, DB, Labelling	❑	❑	
System Commissioned	❑	❑	
Install Checklist Completed	❑	❑	
Commissioning Sheets Completed	❑	❑	
CoEC Complete with NMI & Meter No & Signed	❑	❑	
Installation Documents and Photos to be delivered within 2 working days	❑	❑	
Issues to be Addressed:	❑	❑	
Signature :	❑	❑	
Completion Date:	❑	❑	

STP300 - 24/Ve
STP295 - 24/Ve
STP290 - 24/Ve

SUNTECH

300 Watt
POLYCRYSTALLINE SOLAR MODULE

Features

High module conversion efficiency
15.5%
Module efficiency up to 15.2% achieved through advanced cell technology and manufacturing capabilities

Self-cleaning & anti-reflective
Self-clean
Higher module efficiency from anti-reflective, hydrophobic layer with higher light absorption and minimal surface dust

Positive tolerance
0/+5%
Guaranteed positive tolerance of 5% delivers higher outputs reliably

Excellent weak light performance
Weak light
Excellent performance under low light conditions

Extended wind and snow load tests
3800Pa 5400Pa
Module certified to withstand extreme wind (3800 Pascal) and snow loads (5400 Pascal) *

Suntech current sorting process
2%
System output maximized by reducing mismatch losses up to 2% with modules sorted & packaged by amperage

Certifications and standards:
UL1703, IEC 61215, IEC 61730, conformity to CE

IEC CE PV CYCLE ** CSA C US

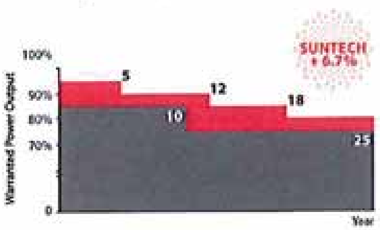
Trust Suntech to Deliver Reliable Performance Over Time

- World's No.1 manufacturer of crystalline silicon photovoltaic modules
- Unrivaled manufacturing capacity and world-class technology
- Rigorous quality control meeting the highest international standards: ISO 9001: 2008, ISO 14001: 2004 and ISO17025: 2005
- Tested for harsh environments (salt mist and ammonia corrosion testing: IEC 61701, DIN 50916:1985 T2)***

Compact and Durable Frame Design

The new compact frame means more modules per package, so it saves your shipping and inventory cost. The rigid and durable hollow chamber guarantee the same long-term and reliable performance.

Industry-leading Warranty based on Pnom



- Based on nominal power (Pnom)
- 25-year transferrable power output warranty: 5 years/95%, 12 years/90%, 18 years/85%, 25 years/80% ****
- Warrants 6.7% more than the market standard over 25 years
- 10-year material and workmanship warranty

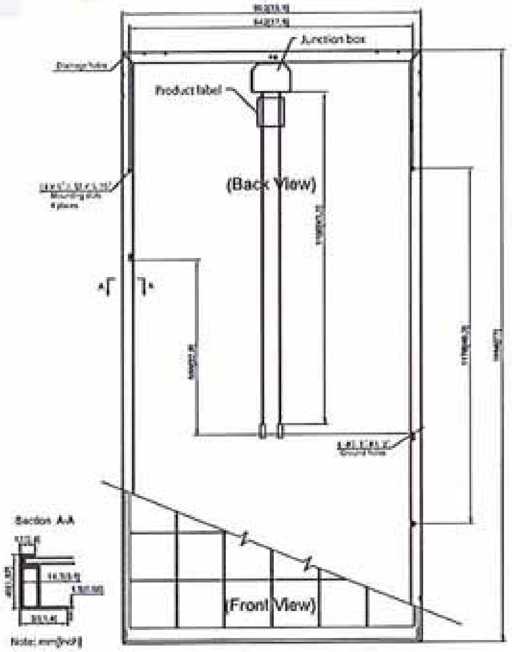
Most modern IP67 Rated Junction Box

Supports installations in multiple orientation. High performance, low resistance connectors ensure maximum ouptput for highest energy production.

* Please refer to Suntech Standard Module Installation Manual for details. **PV Cycle only for EU market.
*** Please refer to Suntech Product Near-coast Installation Manual for details. **** Please refer to Suntech Product Warranty for details.

STP300 - 24/Ve
STP295 - 24/Ve
STP290 - 24/Ve

SUNTECH



Electrical Characteristics

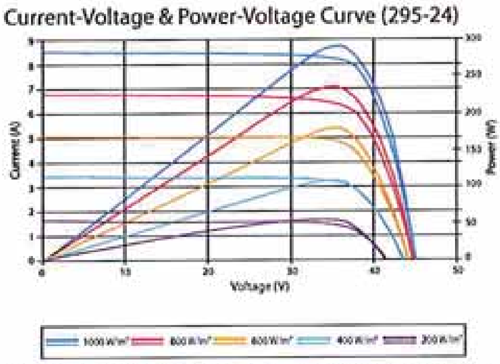
STC	STP300-24/ Ve	STP295-24/ Ve	STP290-24/ Ve
Maximum Power at STC (Pmax)	300 W	295 W	290 W
Optimum Operating Voltage (Vmp)	36.1 V	35.7 V	35.6 V
Optimum Operating Current (Imp)	8.32 A	8.27 A	8.15 A
Open Circuit Voltage (Voc)	45.2 V	45.1 V	45.0 V
Short Circuit Current (Isc)	8.65 A	8.57 A	8.42 A
Module Efficiency	15.5%	15.2%	14.9%
Operating Module Temperature	-40 °C to +85 °C		
Maximum System Voltage	1000 V DC (IEC) / 600 V DC (UL)		
Maximum Series Fuse Rating	20 A		
Power Tolerance	0/+5 %		

STC: Irradiance 1000 W/m², module temperature 25 °C, AM=1.5;
Best in Class AAA solar simulator (IEC 60904-9) used, power measurement uncertainty is within +/- 3%

NOCT	STP300-24/ Ve	STP295-24/ Ve	STP290-24/ Ve
Maximum Power at NOCT (Pmax)	218 W	215 W	211 W
Optimum Operating Voltage (Vmp)	32.5 V	32.3 V	32.2 V
Optimum Operating Current (Imp)	6.71 A	6.66 A	6.56 A
Open Circuit Voltage (Voc)	41.4 V	41.3 V	41.2 V
Short Circuit Current (Isc)	6.97 A	6.90 A	6.80 A

NOCT: Irradiance 800 W/m², ambient temperature 20 °C, AM=1.5, wind speed 1 m/s
Best in Class AAA solar simulator (IEC 60904-9) used, power measurement uncertainty is within +/- 3%

Current-Voltage & Power-Voltage Curve (295-24)



Excellent performance under weak light conditions: at an irradiation intensity of 200 W/m² (AM 1.5, 25 °C), 95.5% or higher of the STC efficiency (1000 W/m²) is achieved

Temperature Characteristics

Nominal Operating Cell Temperature (NOCT)	45±2°C
Temperature Coefficient of Pmax	-0.44 %/°C
Temperature Coefficient of Voc	-0.33 %/°C
Temperature Coefficient of Isc	0.055 %/°C

Mechanical Characteristics

Solar Cell	Polycrystalline silicon 156 × 156 mm (6 inches)
No. of Cells	72 (6 × 12)
Dimensions	1956 × 992 × 40mm (77.0 × 39.1 × 1.6 inches)
Weight	25.8 kgs (56.9 lbs.)
Front Glass	4.0 mm (0.16 inches) tempered glass
Frame	Anodized aluminium alloy
Junction Box	IP67 rated (3 bypass diodes)
Output Cables	TUV (2Pfg1169:2007), UL 4703, UL44 4.0 mm² (0.006 inches²), symmetrical lengths (-) 1100mm (43.3 inches) and (+) 1100 mm (43.3 inches)
Connectors	H4 connectors(MC4 connectable)

Dealer information

Packing Configuration

Container	20'GP	40'GP	40'HC
Pieces per pallet	25	25	25
Pallets per container	5	12	24
Pieces per container	125	300	600

Specifications are subject to change without further notification

1. Maintenance Plan

1.1 Introduction

The following section provides information pertaining to the University of Technology Sydney – Broadway Building Lab photovoltaic system. The plan, along with the associated manuals, will provide the information required to operate and maintain the system. The report includes the following:

- **Main System Components** – outlines the main components of the installed solar PV system
- **System Design** – an overview of the system design and specifications and the relevant standards the system is designed to.
- **Shutdown & Isolation Procedures** – provides details on how to safely shutdown the system.
- **General Maintenance** – provides an overview of maintenance requirements.

1.2 Main System Components

The main components of the installed solar PV system are as follows:

SOLAR MODULES

The function of the solar module is to convert the sunlight into a useful electrical output. On overcast or cloudy days the output of the solar system will be lower than on bright sunny days. No electricity is produced at night after the sun has set where no light is present.

When a number of modules are connected together, the useful potential output of the system is increased. A number of Solar PV modules connected together in series is called a ‘string’. A solar ‘array’ is the complete solar PV system which is made up of a number of strings of modules.

ZBB PCU

The ZBB EnerSystem Power Conditioning Unit (PCU) will control the flow of power from the BB micro-grid to the renewable energy generators. ZBB EnerSystem PCU is to be installed by others. Please refer to supplier documents regarding the PCU.

MODULE ROOF-MOUNTING SYSTEM

The roof-mounting system provides a method for securing the solar modules to the roof. The mounting system is to be constructed by others. Please refer to steel works supplier documents regarding the solar module mounting system.

BOS (BALANCE OF SYSTEM) COMPONENTS (E.G. ELECTRICAL WIRING / PROTECTION SYSTEM)

The Balance of System components make up the remainder of the solar PV system. The largest part of this element is the electrical cabling and associated components.

The electrical cabling connects the modules in their various strings and then connects strings together to form the complete solar array. The ratings of the various protection devices are selected against the expected voltage and current as determined by the solar PV design. When combined, the electrical protection devices provide a comprehensive safety system from the solar module to the point of entry into the existing electrical supply.

All cables, cable sizes, fuses, isolation switches, cable runs, conduit and trunking sizes are selected according to AS3000 (Electrical Wiring Rules) to ensure correct material and size selection as well as lasting system performance. Other items included in the BOS are safety signs and all mechanical fixings and fasteners.

1.3 System Design and Specification

The PV system is designed in accordance with relevant Australian Standards and Industry guidelines. Details of the applicable standards and system specification are detailed below:

APPLICABLE STANDARDS

The system has been designed with all necessary standards and all safety requirements of a stand-alone solar PV systems in Australia. All individual components have been selected to comply with relevant technical specifications and both International and Australian Electrical standards including:

a) AS 5033 Installation of Photovoltaic Arrays
b) AS 3000 Electrical Wiring Rules
c) AS 3008 Electrical Installation - Selection of Cables
d) AS 1768 Lightning Protection
e) AS 1170.2 Wind Loads
f) AS 2053 Conduits and Fittings for Electrical Installations
g) AS 4509 Stand-Alone Power Systems
h) NATSPEC Electrical Services 2008.National Building and Services Reference Specification 2008 Edition
i) New South Wales Service and Installation Rules

1.4 Shutdown and Isolation Information and Procedures

The location and function of all points of isolation (switch on/off) should be understood by all designated persons. There are four points of isolation;

1. PCU

- Solar System Isolation at the PCU to be done by others. Please refer to supplier documents regarding isolation at the PCU.

2. DC MAIN SWITCH TO SIDE OF THE PCU

- DC Main Switch labelled 'PV ARRAY MAIN SWITCH '

AN INDIVIDUAL DC ISOLATOR DISCONNECTS THE PV ARRAY FROM THE DC SIDE OF THE INVERTER. THIS ISOLATOR IS LOAD-BREAK RATED BUT THE PCU SHOULD BE ISOLATED BEFORE ISOLATING THE PV ARRAY IF POSSIBLE.

3. ARRAY ROOF-TOP – PV ARRAY JUNCTION BOX

- DC Main Switch labelled 'PV ARRAY D.C. ISOLATOR'
- DC String Fuses

Array adjacent isolation provides a visible point of isolation whilst performing any maintenance or emergency procedures

ISOLATE THE PCU AND THE 'PV ARRAY MAIN SWITCH' BEFORE OPENING 'PV ARRAY D.C. ISOLATOR'. ONLY WITHDRAW FUSES WHEN THE 'PV ARRAY D.C. ISOLATOR' IS OPENED. DO NOT WITHDRAW FUSES UNDER LOAD.

4. ARRAY ROOF-TOP – PV MODULE CONNECTORS

- Red (positive +) and Blue (negative -) cables run from each module and are connected together in series with other PV modules in the same string.
- Interlocking connectors connect the module cabling. DO NOT OPEN CONNECTORS UNDER LOAD.

ISOLATE THE PCU AND ARRAY BEFORE OPENING STRING CABLE CONNECTORS

FOR ALL SHUTDOWNS - Isolate the PCU BEFORE the 'PV Array Main Switch'

FOR ALL START-UPS - Energise the 'PV Array Main Switch' BEFORE the PCU

EMERGENCY ISOLATION AND SHUTDOWN PROCEDURE

From the PCU:

1. Isolate the PCU from the PV Array. Please refer to PCU supplier documentation for this step.
2. Open the DC Main switch 'PV ARRAY MAIN SWITCH' next to the PCU.
3. Open the DC Main switch ' PV ARRAY D.C. ISOLATOR' adjacent to the array. This is to be done by a service professional.

NOTE: FOR A SAFE START UP CARRY OUT THE ABOVE PROCEDURE IN REVERSE

NOTE: DO NOT BREAK INDIVIDUAL MODULE PLUG CONNECTIONS UNTIL ALL CIRCUITS HAVE BEEN ISOLATED. MODULE PLUGS ARE NOT LOAD BREAK RATED AND WILL BE DAMAGED IF THEIR CONNECTION IS BROKEN UNDER LOAD

NOTE: LOCK OFF ALL ISOLATION WHEN PERFORMING ANY MAINTENANCE TO PREVENT ACCIDENTAL CONTACT CLOSURES AND TO PREVENT THE ACCIDENTAL RE-ENERGISING OF ISOLATED PV SYSTEMS.

NOTE: PLANNED ISOLATION AND SYSTEM RE-STARTS SHOULD ONLY BE CARRIED OUT BY AUTHORISED PERSONNEL.

1.5 General Maintenance

It is essential that electrical maintenance on the equipment should only be performed by competent trade people who are licensed by the relevant authorities to perform electrical work and that items requiring maintenance are isolated from electrical supply prior to commencement of work.

It is recommended to use professional services when working at heights. It is recommended that only qualified personnel who are trained and hold current certification conduct maintenance activities on roofs due to the potential hazards when working at heights.

Settings and/or ratings of protection equipment should be maintained at the correct current level. If and when parts/components are required to be replaced, and when original manufactured spare parts/components cannot be sourced, alternative manufactured parts/components with the identical rating and capacity should only be used.

Exclusion of dust, grease, moisture and grit from electrical components with switching contacts is essential. Should it be necessary to clean accumulated dust from these areas containing switchgear, a vacuum cleaner and soft brush should be used in preference to a blower or compressed air supply. Should compressed air be used, it is essential that it is an oil free air supply when used on electrical switchgear. It is essential that all electrical conductor connections, whether "screwed", "bolted" or "plugged in", are electrically continuous and where vibration occurs, terminals should be checked regularly to ensure connections are tight.

1.6 Safety Considerations

- In case of an emergency, follow the Emergency Shutdown Procedure (in section 1.4 and on the PCU label).
- In case of a ground fault, contact authorized maintenance personnel immediately. Do not attempt to service the system.
- Obey all warning signs.
- Do not attempt to operate or carry out maintenance on any system or part thereof unless qualified and authorized.
- Do not open or touch any electrical switchboard or electrical equipment unless qualified and authorized.
- Do not use wire of any type in place of a HRC fuse. Use only correctly rated fuses.
- Do not leave the plant operating in a dangerous condition without authorization.

1.7 Maintenance Principle

- Log all visits and call-outs providing the nature of the call, and rectification undertaken. The technician must always sign the Log Sheet.
- Turn off electric system only at the power isolating switch (always isolate at the PCU - refer to “Shutdown Procedure” label on or near the PCU).
- Notify the Engineer in charge prior to performing any works.
- Ensure that all isolation points are locked before leaving them.
- Hang a sign on any item of equipment which is out of order, or being serviced and not to be operated. The sign should clearly indicate the following:
    - reason for being off
    - time turned off
    - expected duration of shutdown
    - person responsible for the shutdown
- Immediately replace items that are showing wear sufficiently to cause failure before the next inspection.
- Carry out scheduled maintenance. Note any items that are wearing, but which will last, to be replaced at the next maintenance.
- Obey all signs installed around or on items of equipment.
- Record any abnormal conditions and notify the Engineer in charge immediately.
- Use the correct tools and equipment during service and ensure the correct lubricants are used when oiling or greasing equipment.

1.8 Solar Module Maintenance

In many situations solar systems are maintenance free, however, with occasional maintenance and inspection, the performance of all the solar modules in the array can be assured. The most common maintenance task for solar modules is the cleaning of the glass area of the module to remove excessive dirt. Where modules are mounted at an angle greater than 10º, rainfall should be sufficient to enable the module to self clean. During long dry periods when there is no rainfall, dust and dirt can be removed from the modules by simply washing the panel with water. If the module has thick dirt or grime, which is harder to remove, wash with warm water and a sponge. Detergents should not be used when cleaning the modules.

ANYONE CLEANING SOLAR MODULES MUST USE SUITABLE FALL PROTECTION EQUIPMENT E.G. HARNESS AND/OR ROOF EDGE PROTECTION

Once cleaned, check the modules for defects such as chips and cracks, discolouration and water ingress beneath the top layer of glass. Make a note of any obvious defects so they can be monitored in the future and the deterioration of the array can be tracked.

When inspecting the solar modules, the condition of the array mounting frame should also be noted. Items to observe should include the array mounting bolts (eg. bolts rusting) and checks to ensure that the frame and modules are firmly secured.

In the event that a solar module must be replaced, shut the solar system down in accordance with the shutdown procedure. Clean Energy Council accredited maintenance personnel with the proper safety training shall replace the panel in accordance with the mounting system installation manual. Ensure that when the module is replaced, all clamps are tightened and all cabling is mechanically secured. Ensure that equipotential bonding of the frame is maintained after the replacement panel is installed.

1.9 PCU Maintenance

The photovoltaic system PCU is to be provided by others. Please refer to the appropriate manual for system maintenance.

1.10 Balance of System Maintenance

These items generally require very little maintenance but when maintenance is being performed on other parts of the system then the following should be undertaken:

- Check that all interconnections and cables/conduits are mechanically secure;
- Check for any broken section or deterioration in exposed conduit and wiring
- Check connections for any signs of corrosion or burning
- Check that all switches and circuit breakers are operating correctly;
- Check the integrity of waterproof seals and glands.
- If any damage is noticed, contact the system supplier or installer

1.11 Maintenance Schedule

After installation, very little maintenance of the solar PV system should be required, however it is recognised that system monitoring and some preventative maintenance can maintain optimum system performance. The table below provides a suggested maintenance schedule.

	Activity	Weekly	Monthly	Every 6 Months	Every 3 years	Every 5 years
1.	Check monitoring system for output during sunny weather					
2.	Watch for shading by obstructions					
3.	Inspect the PV array surface for excessive dirt or debris (bird droppings, leaves, etc.)					
4.	Check for visual defects including: a. Fractures b. Browning or discoloration c. Moisture penetration d. Frame corrosion					
5.	Inspect junction boxes for: a. Tightness of connections b. Water accumulation / build up c. Integrity of lid seals d. Integrity of cable entrance, glands and/or conduit sealing e. Integrity of clamping devices f. Verify by-pass diodes					
6.	Verify mechanical integrity of conduits					
7.	Verify insulation integrity of cables installed without conduit					
8.	Check junction boxes for: a. Tightness of connections b. Water accumulation / build up c. Integrity of lid seals d. Integrity of cable entrance, glands and/or conduit sealing e. Integrity of clamping devices					
9.	Verify: a. Surge arresters for degradation (If applicable)					
10.	Check earthing connections (if applicable): a. Tightness of connections b. Corrosion					
11.	Measure open circuit voltages					
12.	Measure short circuit currents					
13.	Measure equipotential bonding and resistance to ground					
14.	Check PV array electrical output is consistent with prevailing weather conditions					
15.	Check PCU operation is correct					
16.	Verify operation of isolation points					
17.	Verify operation of earth fault current protection system (PCU)					
18.	Verify operation of solar array isolation device(s)					
19.	Verify tightness and integrity of bolts and other fastening devices					
20.	Check array mounting security					
21.	Check damage to mechanical cable protection					
22.	Inspect for corrosion					

Maintenance Manual

Concentrating Solar Thermal Collectors

UTS Broadway

NEP Solar

Contents

1. Introduction

NEP Solar Pty Ltd has supplied and installed four Polytrough 1200 Concentrating solar thermal collectors for the roof of the UTS FEIT building.

1.1. Warnings and Precautions

1.1.1. General

- Caution should be exercised around the solar collector field. Concentrated solar radiation can cause burns and damage to eyes. Category 3 Sunglasses should be worn as a minimum precaution.
- The solar collectors can operate at temperatures up to 200oC, care should be taken not to perform any work when the system is operating or has been recently operating.
- The solar collectors will operate and move automatically to provide heat when required. Care should be taken not to place any items in or around the field that could collide with the rotating collector. Any maintenance or cleaning personnel should ensure that the collectors are shutdown prior to carrying out their work.

1.2. Directory

1.2.1. NEP Solar Pty Ltd

NEPSOLAR	NEP Solar Pty Ltd Unit 20, 14 Jubilee Ave Warriewood NSW 2102		+61 2 9998 4700
			Email: johan.dreyer@nep-solar.com
	Customer Support:		Internet: www.nep-solar.com

2. System Description

NEP Solar Pty Ltd has supplied and installed four Polytrough 1200 Concentrating solar thermal collectors for the roof of the UTS FEIT building.

Hot water at up to 180oC from the collectors is delivered to the solar tri-generation plant room for use in the tri generation system.

The operation and control of the solar collectors is handled by the solar tri generation system for more information refer to separate documentation.

3. Maintenance Procedures

3.1. Reflector Panels

3.1.1. Cleaning

The cleaning of the mirror surfaces is an important regular maintenance required for any concentrating solar system. The cleaning interval depends on dust and rain conditions at the project site. Optimum cleaning intervals will vary between sites and due to seasonal conditions that result in higher levels of dust soiling. NEP Solar recommends monthly cleaning for optimum performance.

Procedure: Mirror cleaning is performed manually by using a 1m wide window cleaning “squeegee”, Care should be exercised not to scratch the mirror surface while cleaning, large dust or dirt particles should be rinsed off with water prior to cleaning with “squeegee”.

Manual Method

- Spray mirrors with water to remove large dust and dirt particles.
- Wash mirrors with diluted window cleaning detergent using the sponge side of a large squeegee. It is important that no harsh chemicals are used as this may damage the mirrors surface finish.
- Whilst the mirror is still wet, wipe away the water with the reverse of the squeegee to leave the reflector dry and clean.

Pressure Washer Method

- An industrial pressure washer with a “fan” style nozzle is needed for this cleaning method. (Caution: A point or rotating style nozzle will damage the reflector.)
- Spray the mirror with even strokes to wash away dust and dirt particles.
- For air drying, demineralised water must be used to avoid drying marks.
- For manual drying, wipe away the water with a squeegee or a clean absorbent microfiber cloth.

3.2. Reflector Panel Mounting

Over the lifespan of the system it will be important to ensure that the reflector panels remain securely connected to the mounting structure.

Procedure: Carrying out a simple visual inspection of the connection bolt and nuts every 3 months and a more thorough check (confirming appropriate torque setting for fastening nut) annually.

3.3. Glass Receiver Assembly

3.3.1. Cleaning

Dust is likely to build up on the exterior glass receiver tube reducing the transmission of concentrated sunlight to the receiver tube. Cleaning of the glass tube should be part of the regular cleaning cycle.

Procedure: Wipe the glass tube using a damp microfiber cloth. Be sure to rinse the cloth & change water regularly to prevent the build-up of dirt and dust which will result in uneven cleaning.

3.4. Structural Steel Components

3.4.1. Surface Finish

The structural steel components are hot-dip-galvanised (HDG) to protect against corrosion. Where the structure is unsuitable for HDG it is either zinc plated or fabricated from pre-HDG components and any welds treated with zinc rich paint. These may require touch up painting if patches of rust begin to develop.

Procedure: Visually inspect the system when cleaning of the reflector panels. Clean any rust with a wire brush, wipe clean using a suitable degreaser and apply a coat of protective exterior grade paint or primer. Zinc rich paint (commonly referred to as "Cold-Gal") is best suited for this application. 2 coats of brush on paint is recommended over aerosol spray.

3.4.2. Mounting Stands - Restraint Cables

The restraint cables, along with the drive chain secure the tracking components to the stands. It is important that these cables remain properly adjusted to prevent damage to the structure in case of a storm event.

Procedure: Inspect and adjust the restraint cables annually as required. Gauge the tension of the restraint cable by hand and adjust using the nuts so that there is minimal but NOT zero free play. The cables should be "just tight", over tightening may cause excessive friction and result in improper tracking or damage to the drive system.

3.5. Drive System

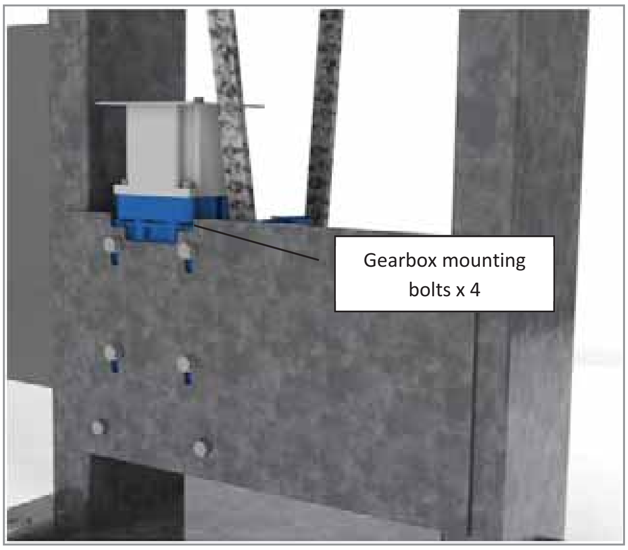
The simple nature of the drive system requires minimal maintenance beyond corrosion protection/lubrication and monitoring of chain tension & gearbox alignment. The gearbox is a sealed unit and maintenance free.

3.5.1. Corrosion protection / Lubrication

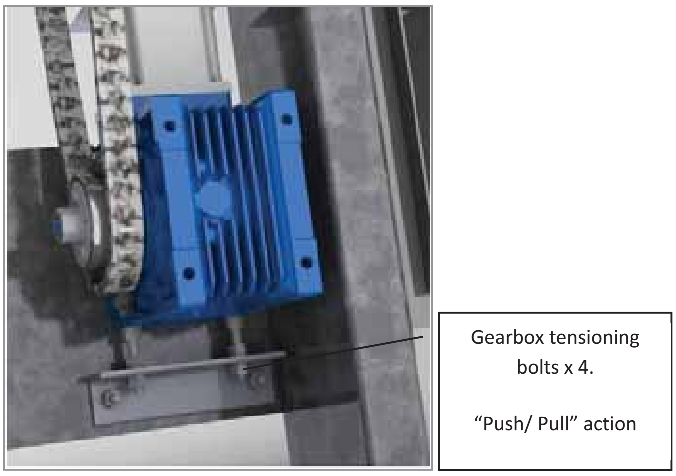
Procedure: The chain should be inspected annually. The removal of the chain cover first requires the removal of the threaded rod that secures the limit brackets together. A dry filming heavy wax type corrosion inhibitor / lubricant is recommended to. Prior to assembly the chains are treated with "CRC Soft Seal". Generously apply the lubricant to all areas of the chain. In addition to this a similar product should be applied to the bare steel parts of the gearbox to prevent corrosion. If corrosion has occurred clean the rust of with a wire brush before relubricating. Wipe away any spills with a clean rag

3.5.2. Chain Tension & Gearbox Alignment

Procedure: To check gearbox alignment visually inspect each drive unit. To check chain tension press on each side of the chain midway along its length, tensioning is required for chain deflections greater than 10 mm under firm pressure. If there is excess movement in the chain then follow the procedure below to align gearbox and tension chain.



1. Place a small spirit level resting on the gearbox case.
2. Loosen the 4 gearbox mounting bolts.
3. Use the 4 gearbox tensioning nuts on the underside of the gearbox to "push" or "pull" the gearbox into a level position.
4. Check the chain tension adding more tension as required by using the 4 gearbox tensioning nuts as mentioned above.
5. Once the chain tension is sufficient and the gearbox is level secure the gearbox in position by tightening the 4 gearbox retaining bolts.



3.5.3. Motor and Electronics

The collector stepper motor is powered by 48v through a motor driver located in the Solar tri-generation plant room. All electrical and signal connections to and from the collector are terminated at the Drive Termination Enclosure (DTE) mounted on the drive stand of each collector.

Each Collector has a highly accurate inclinometer mounted in an enclosure on the drive shaft. Internal inspection of this enclosure is not required unless there is suspicion of a fault arising from the inclinometer.

Each collector has 2 robust proximity switches mounted onto the drive stand of the collector.

Procedure: Visually inspect all components annually.

3.6. Hydraulic Fittings

At the ends of each collector row there is a piping arrangement connecting the collector receiver tube to the supply and return piping for the solar field.

Procedure: Visually inspect annually for damage to cladding and signs of water ingress / egress

3.7. Field Piping

The field piping is fully insulated and clad.

Procedure: Visually inspect annually for damage to cladding and signs of water ingress / egress

3.8. Field Instruments

The field instruments consist of one PT100 Temperature Sensor at the outlet of each collector and one Davis 6140 Wind speed and direction sensor.

For detailed maintenance of these instruments refer to the manuals.

Procedure: Visually inspect all components annually for signs or abnormal wear.

4. Maintenance Schedules

4.1. Monthly Cleaning

Frequency	Component	Action	Completed (✓)											
			J	F	M	A	M	J	J	A	S	O	N	D
Monthly	Reflector Panels	Clean reflector panel as per procedure												
Monthly	Glass Receiver Tube	Clean glass receiver tube as per procedure												

4.2. Annual Inspection

Component	Action	Completed (✓)
Reflector Panels: Mounting	Inspect as per procedure, adjust if required	
Structural Steel: Surface Finish	Inspect and repair as per procedure if required	
Structural Steel: Restraint cable	Inspect as per procedure, adjust if required	
Drive System: Corrosion Protection / Lubrication	Inspect and lubricate chain and gearbox as per procedure	
Drive System: Chain tension	Inspect as per procedure, adjust if required	
Drive System: Motor and Electronics	Inspect as per procedure	
Hydraulic Fittings	Inspect as per procedure	
Field Piping	Inspect as per procedure	
Field Instruments	Inspect as per procedure	

8.15 Wind Turbine: WE Power

See attached folder Section 8

Operation Manual

For installation and maintenance

Model: PK10-AB Vertical Axis Wind Turbine

No. 16393 PuWei Hwy. Shanghai China
www.sawt.us
Tel: 86 21 57246161
Fax: 86 21 57242567
Email: sales@sawtenergy.com; salessawt@gmail.com

Protected by US Patents 7967596; 8272840; 8322035 Korea Patents 10-1039915; 10-1115740

Special Attention:

Please note that below steps are critical to safety and to the performance of the turbine and therefore need to be exactly followed. This page is to remind you that you need to pay extra attention to these steps. Detailed instructions can be found on their respective pages as marked below.

1. Installation of blades:

1.1 Silicone sealant needs to be inserted into the small gap between the blades and short arms. Refer to Figure 2 on Page 7.

1.2 The drainage hole on each blade needs to keep unblocked so condensed water can be released. Refer to Figure 3 on Page 7.

Please be noted if the above steps are not done correctly, the turbine may not function to its specifications and may cause damage to the blades.

Installation instructions start from next page

About the Product

This product can be used by in any areas with good wind resource, such as building roof tops in cities, farms, individual households, schools, hospitals, factories & warehouses, shopping malls, telecommunication towers, oil fields, billboards, remote islands, remote resorts, electric car charging stations, street lights, etc. It can provide stable and reliable electricity for lighting, electrical appliances, water heater, telecommunication equipment, machinery, cars, etc. The turbine is ideal for many environmental friendly applications.

Major Components and Functions

The whole unit consists of a tower, a rotor, a generator, a controller, and an inverter. The rotor spins when wind speed is between 2m/s and 25m/s. When the rotor spins, the generator produces AC power. Then the AC power will be converted into DC power by the controller. And finally, the DC power is converted into standard AC power output through the inverter.

3.2 Assemble the turbine

3.2.1 Prior to assembly of the turbine, verify all the parts as listed below:

SAWT Inc.
SAWT Energy—Power the Future
No. 16393 PuWei Hwy. Shanghai China

http://www.sawtenergy.com
sales@sawtenergy.com
salessawt@gmail.com
+86-21-57246161; 57242197

Part List #1(Steel frame)

Serial #	Item	Quantity	Remark
1	Generator Assembly	1	

Part List #2(Plywood box)

Serial #	Item	Quantity	Specification	Standard	Remark
1	Hexagonal head bolts	12	M24×100	8.8 Dacromet	For generator base & tower up-flange connection
2	Flat washers	24	φ 24	8.8 Dacromet	
3	Locknuts	12	M24	Dacromet	
4	Hexagonal head bolts	20	M20×110	Dacromet	For assembly of long arms & flanges
5	Flat washers	40	φ20	Dacromet	
6	Locknuts	20	M20	Dacromet	
7	Hexagonal head bolts	10	M8×180	Dacromet	For assembly of blades & short arms
8	Hexagonal head bolts	10	M8×100	Dacromet	
9	Extra large flat washers	40	φ8	Dacromet	
10	Locknuts	20	M8	Dacromet	
11	Locknuts	40	M8	Stainless steel	For assembly of blades & flaps
12	Extra large flat washers	40	φ8	Stainless steel	
13	Spring washers	40	φ8	Stainless steel	
14	Slot bolts	10	Customized	Stainless steel	For assembly of short arms & the long arms
15	Flat washers	10	φ12	Dacromet	
16	Split pins	10	3x20	Dacromet	
17	Locknuts	10	M12	Dacromet	
18	Arms-Long	10			
19	Over-speed control Springs	10			
20	Silicone Sealant	5			
21	Thread lock glue	1			
22	Manual	1			
23	Warranty card	1			
24	Spring extension tool	1			For extending the springs
25	Installation Disc	1			Installation reference

Part List #3(Plywood box)

Serial #	Item	Quantity	Remark
1	Arms-Short	10	

Part List #4(Shipping box)

Serial #	Item	Quantity	Remark
1	Controller	1	
2	Manual	1	

Part List #5-9(Paper box)

Serial #	Item	Quantity	Remark
1	Blade	1	
2	Flaps	2	

Part List #11(No packing)(Optional part)

Serial #	Item	Quantity	Remark
1	Tower	1	

3.2.2 Main structure and key parts illustration. Refer to Figure 1. Please watch the installation CD prior to starting of the installation.

1, Blades*5
2, Rain cover*1
3, Generator*1
4, Tower*1
5, Over-speed control spring*10
6, Top flange*1
7, Lower flange*1
8, Flaps*10
9, Long arms*10
10, Short arms*10

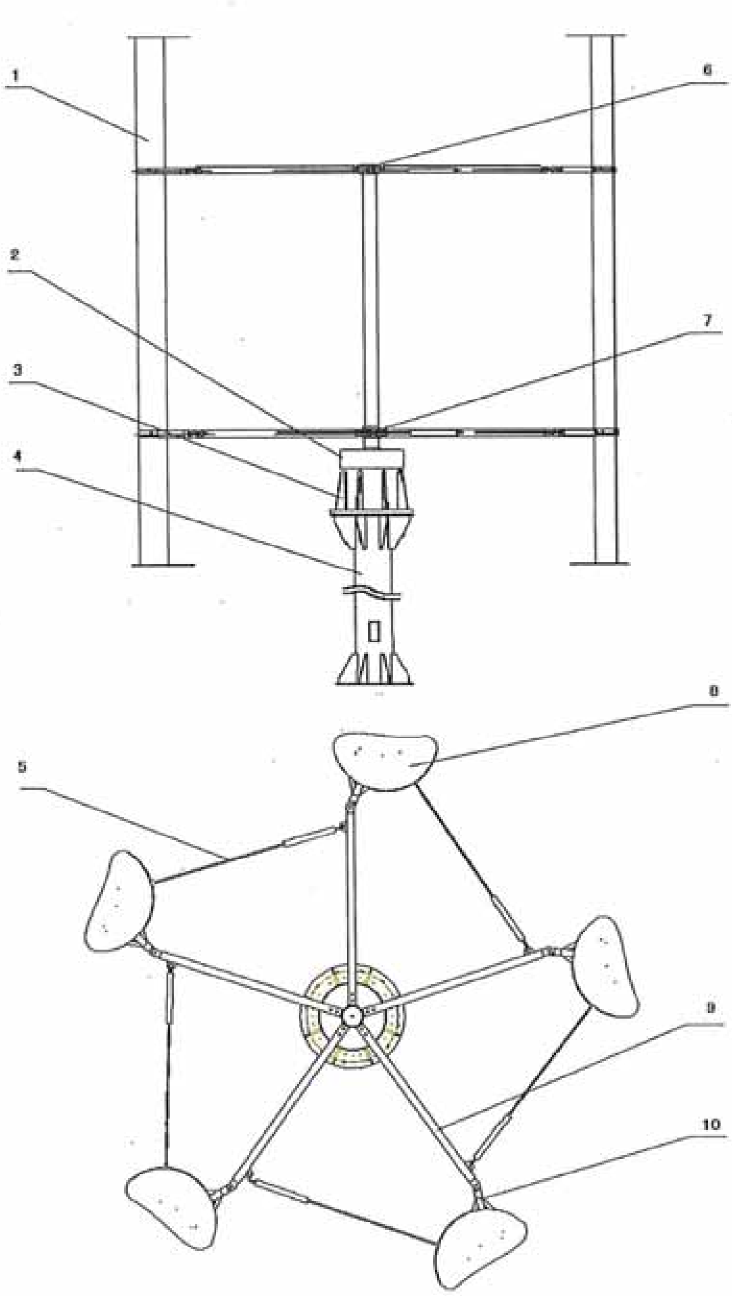


Figure 1

3.2.3 Assemble the short arms onto the blades. Apply silicone sealant between blades and short arms and then tighten with bolts (M8X180), bolts (M8X100), flat washer (Φ8), and locknuts (M8). Wipe the silicone sealant to ensure it covers the gaps between the blades and short arms on both sides. Wipe off the extra sealant. Refer to Figure 2

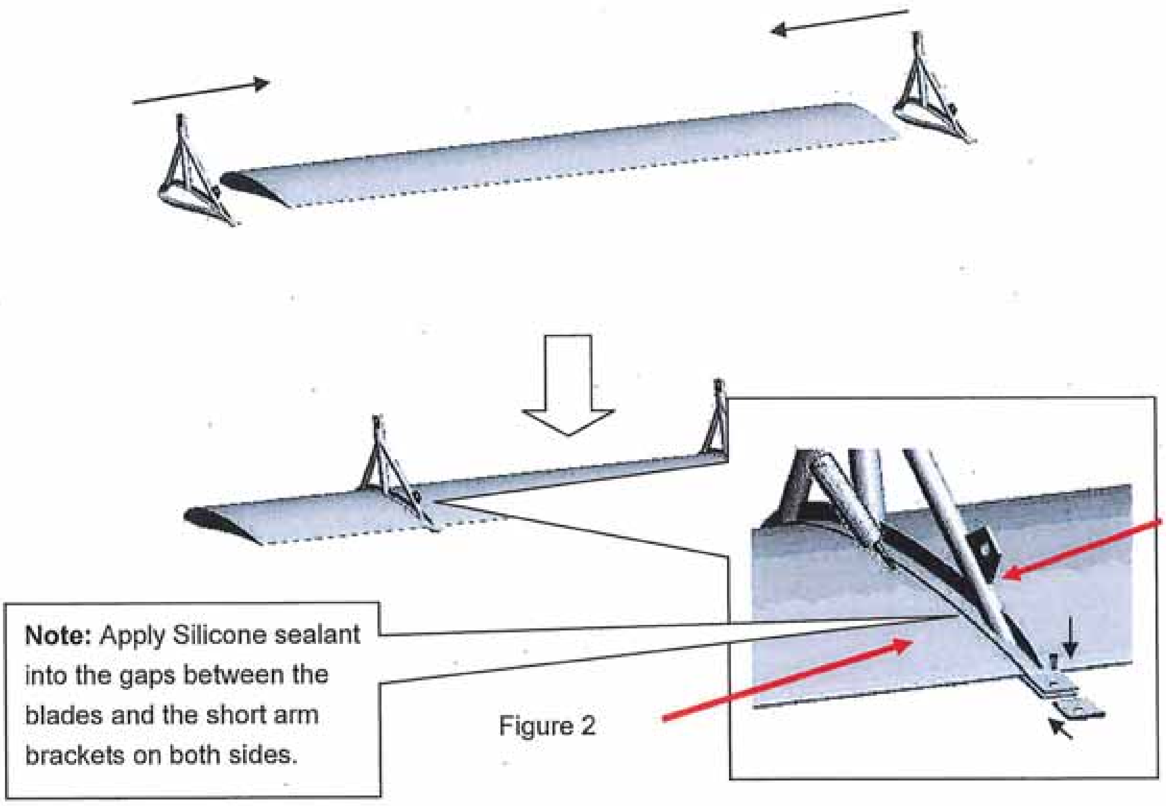


Figure 2

3.2.4 Fix the flaps on both ends of the blades and tighten with locknuts (M8*30), flat washers (Φ8) and spring washer (Φ8) with torch force at 6 NM. Refer to Figure 2 & 3

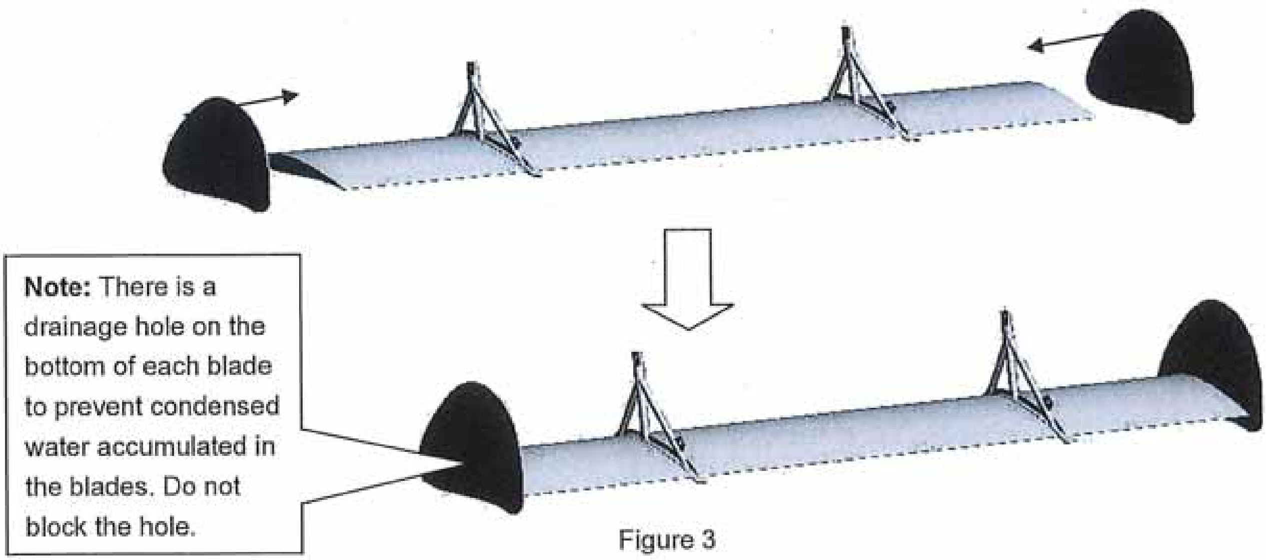
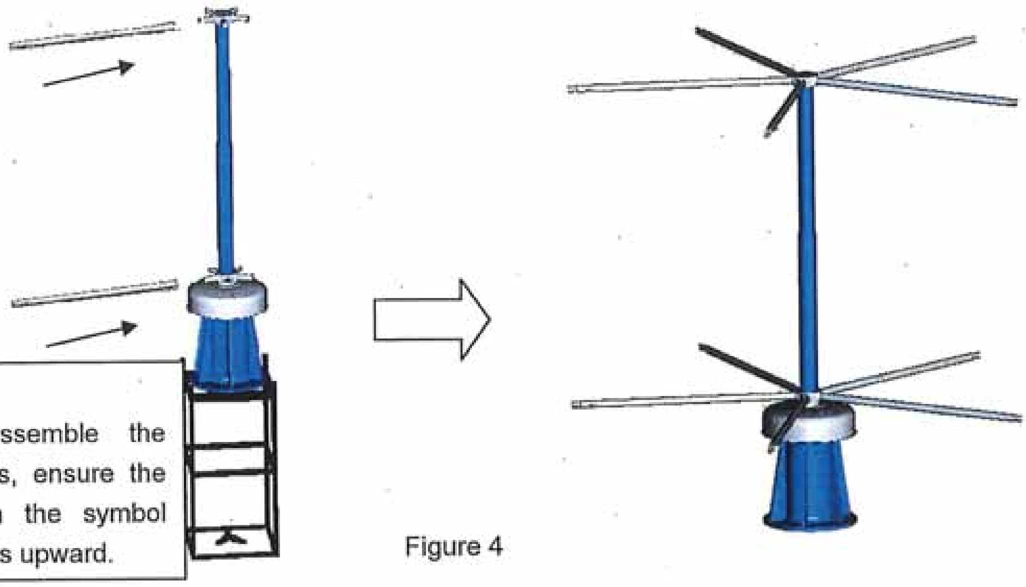


Figure 3

3.2.5 Take the generator assembly out of the transportation steel frame using a crane. Make sure to use all the lifting eyelets mounted on the bottom of the Generator. Flip the steel frame upside down. Place the generator base on to the top of steel frame to use it as an assembly platform.

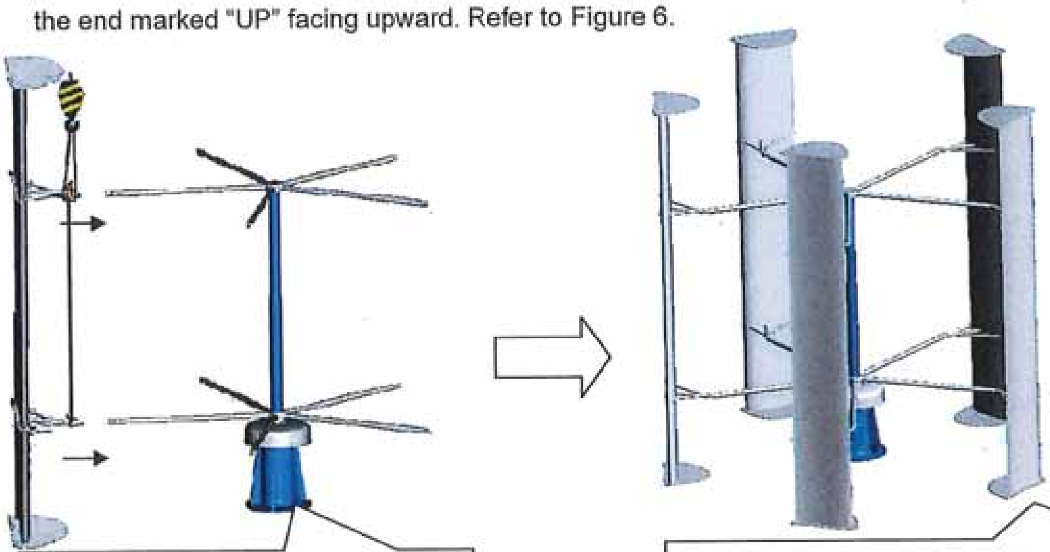
3.2.6 Assemble the 5 long arms in parallel onto the upper and lower flanges located on both ends of the generator shaft, and fix with the bolts (M20X110), flat washers (Φ20), and locknuts (M20), Make sure the symbol "UP" is facing upward. Refer to Figure 4.



Note:
When assemble the long arms, ensure the side with the symbol "UP" faces upward.

Figure 4

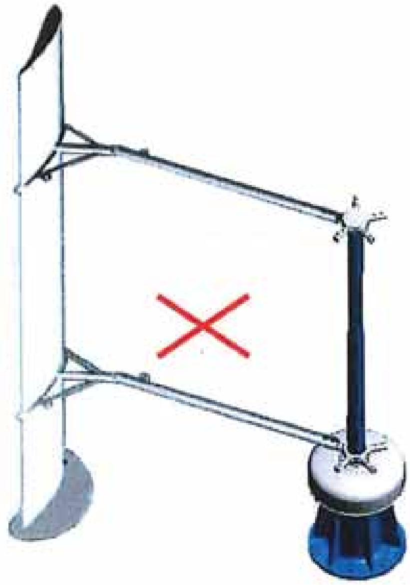
3.2.7 Assemble blades and short arm assembly onto the long arms using customized bolts, and tighten with flat washers (Φ12) and locknuts (M12), then insert the split cotter pins into the customized bolts. Refer to Figure 5. Make sure all the five blades are installed in the correct installation direction with the end marked "UP" facing upward. Refer to Figure 6.



Note: Tear off the cellophane tape on the bottom of the generator.

Note: There is a drainage hole on the bottom of each blade to prevent any condensed water accumulation in the blades. Do not block the hole.

Figure 5



Correct installation direction Figure 6 Wrong installation direction

3.2.8 Insert the two ends of each over-speed control spring into the two holes on the long arms and short arm using the Spring Extension Tool. Refer to Figure 7.

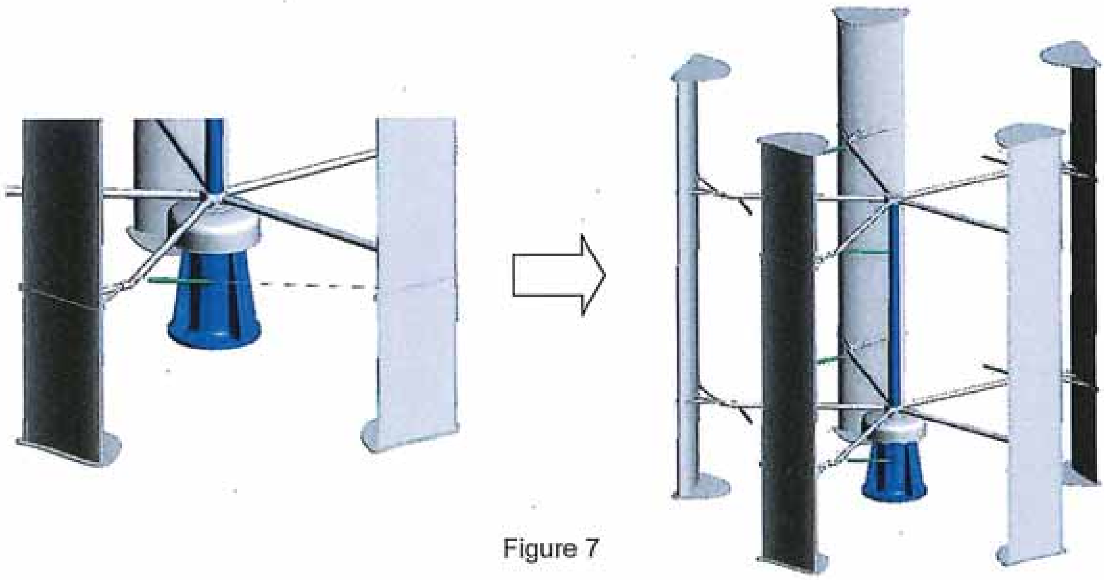


Figure 7

3.2.9 Lift the wind turbine onto the top of the tower using a crane. Make sure to use all the lifting eyelets on the generator base. Use a rope to pull the turbine to prevent it from turning or flipping when lifted up. Fix the generator base with the tower using bolts (M24X100), flat washer (Φ24), and locknuts (M24). Refer to Figure 8.

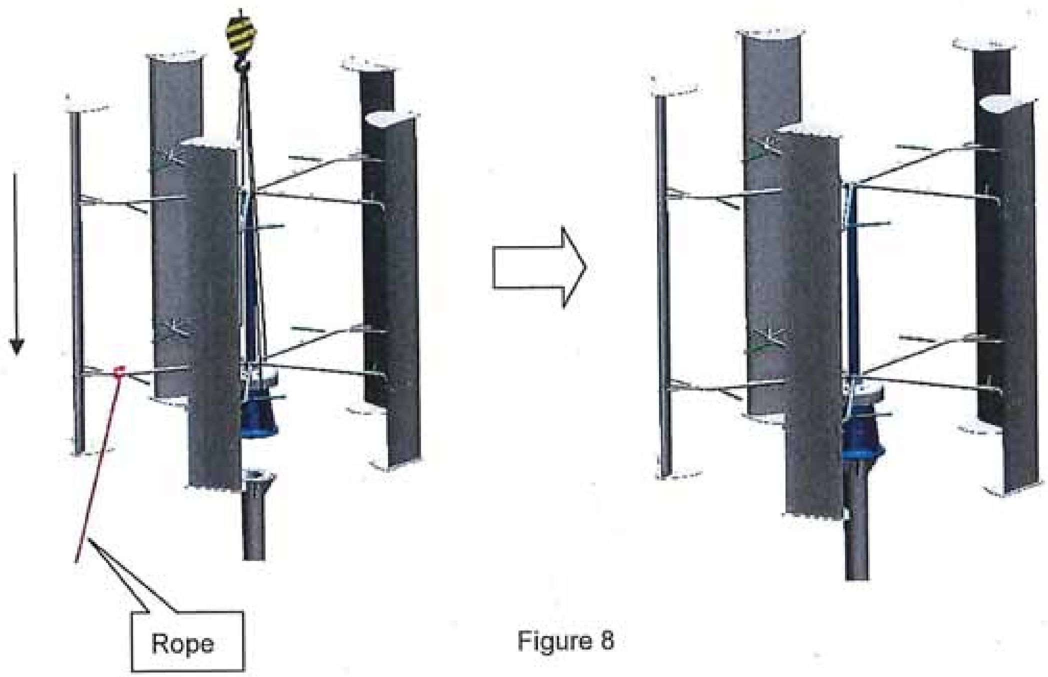


Figure 8

Note: All joint points of the bolts and nuts must be coated with thread locking glue (shipped with the parts in shipping box #2)

4. Connect cables between generator and controller

Note: To avoid danger, injure, and damage, make sure that all parts are disconnected from grid before starting any electrical connection procedure.

4.1 Connection of on-grid system

4.1.1 Main circuit connecting cable diameters and amounts are as follows:

Description	Wireless Diameter	Amount of Cables	
Wind Generator Input AC	6mm^2	Three(3)	U1, V1, W1
DC Output +, -	10mm^2	Two(2)	+,-
Grid Input L, N	1mm^2	Two (2)	L, N by pass
Ground	4mm^2	One(1)	PE
Brake	1.5mm^2	Three(3)	W2, U2, V2

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4.1.2 The procedure of connecting the cables to the controller is as follows, Refer to Figure 9

- Step 1 Connect the **GROUND(PE)**
- Step 2 Connect the **DC OUTPUT**
- Step 3 Connect the **GENERATOR INPUT**
- Step 4 Connect the **BRAKE cable**
- Step 5 Measure the electric resistance of **W2/U2** and **W2/V2** with ohmmeter. The resistance of **W2/U2** should be only a few Ω and the resistance of **W2/V2** should be about 30Ω。
- Step 6 Connect the **GRID AC By pass**

Note: After finishing connecting, do not touch any cables.

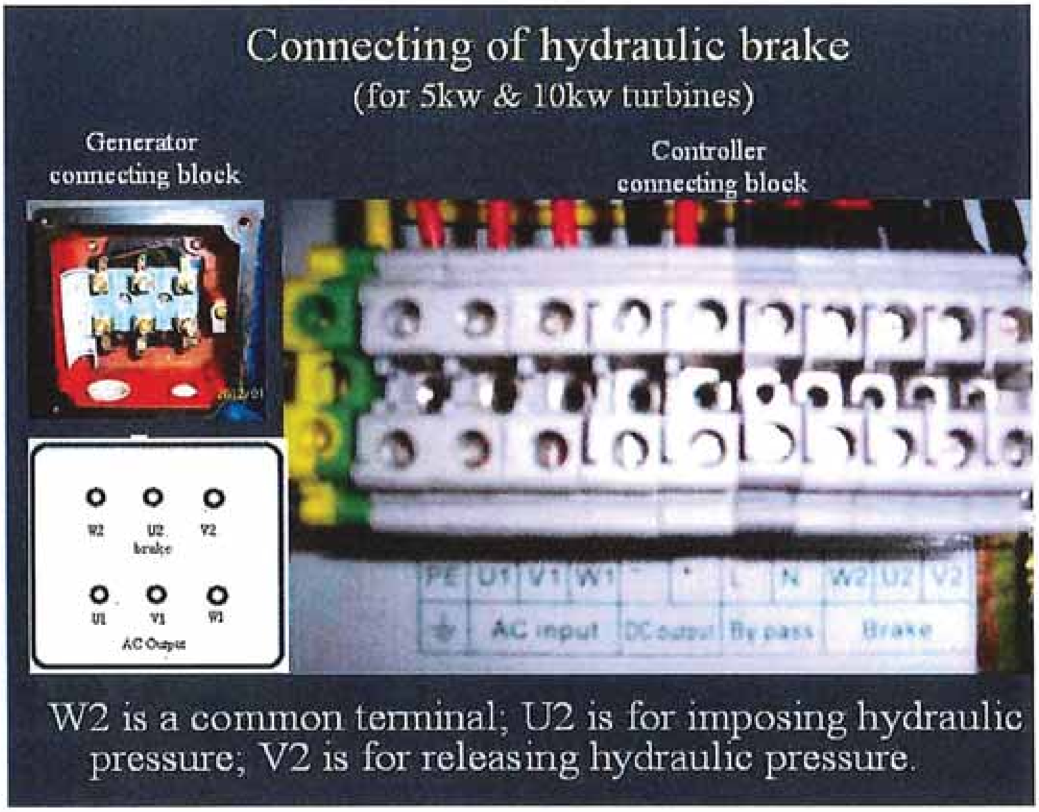

Figure 9

4.1.3 Test of emergency braking system

- ► Press the **Emergency button** for emergency braking, and the manual brake function is activated.
- ► The yellow LED flashes for 20 seconds (which indicates the hydraulic pressure is being applied).
- ► Then the yellow LED turns to stable illumination (which indicates the wind turbine is locked).
- ► Press the **Emergency button** again, and the yellow LED flashes for 30 seconds (which indicates the brake is being released).
- ► Emergency braking will be released when the yellow LED stops flashing and turns off.

Note: While the yellow LED is flashing, pressing the **Emergency button** is invalid.

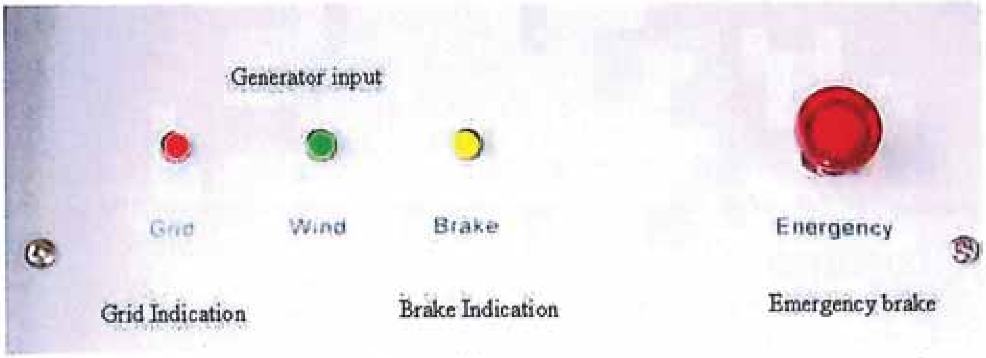

Figure 10

4.2 Connection of off-grid system

4.2.1 Main circuit connecting cable diameters and amounts are as follows:

Description	Wireless Diameter	Amount of Cables	
Wind Generator Input AC	$6mm^2$	Three(3)	U1, V1, W1
Battery +, -	$10mm^2$	Two(2)	+,-
Ground	$4mm^2$	One(1)	PE
Brake	$1.5mm^2$	Three(3)	W2, U2, V2

4.2.2 The procedure of connecting the cables to the controller is as follows, Refer to Figure 11

- Step 1 Connect the **GROUND(PE)**
- Step 2 Connect the **Battery**
- Step 3 Connect the **BRAKE cable**
- Step 4 Connect the **WIND INPUT**
- Step 5 Measure the electric resistance of **W2/U2** and **W2/V2** with ohmmeter. The resistance of **W2/U2** should be only a few Ω and the resistance of **W2/V2** should be about 30Ω。
- Step 6 Switch on the **BREAKER**

Note: After finishing connecting, do not touch any cables.

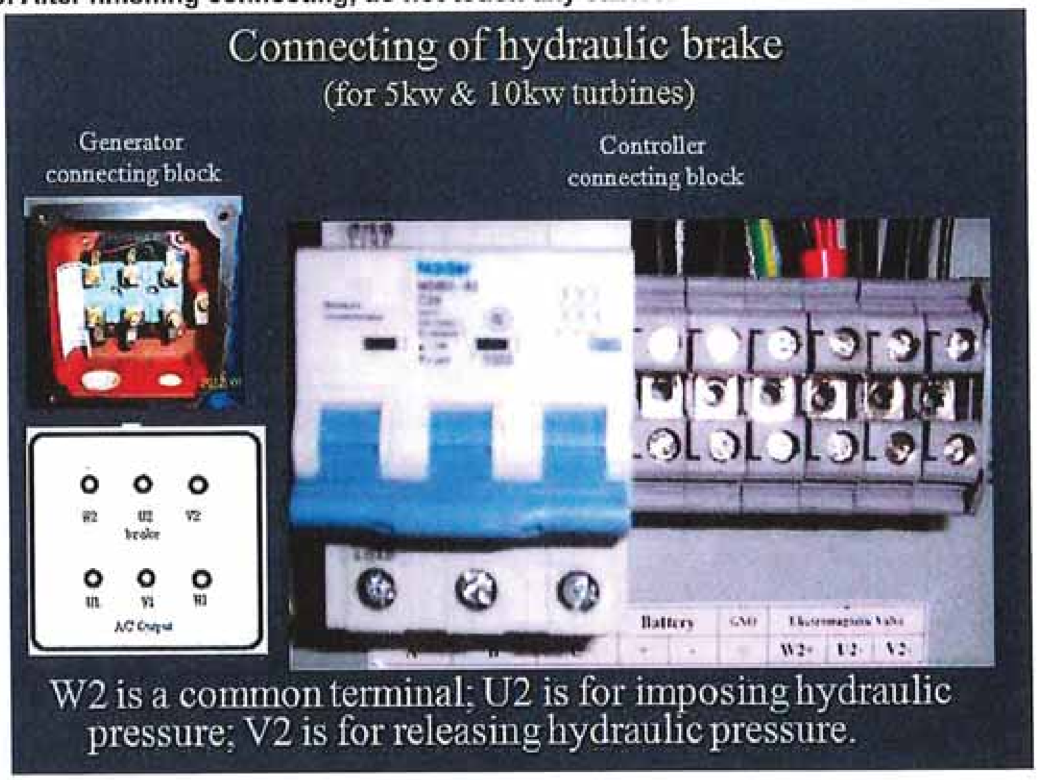

Figure 11

4.2.3 Test of emergency braking system

- ▶ Press the **Emergency button** for emergency braking, and the manual brake function is activated.
- ▶ The yellow LED flashes for 20 seconds (which indicates the hydraulic pressure is being applied).
- ▶ Then the yellow LED turns to stable illumination (which indicates the wind turbine is locked).
- ▶ Press the **Emergency button** again, and the yellow LED flashes for 30 seconds (which indicates the brake is being released).
- ▶ Emergency braking will be released when the yellow LED stops flashing and turns off.

Note: While the yellow LED is flashing, pressing the **Emergency button** is invalid.

4.2.4 Display and Indicators

Push "READ" button to display data of input voltage, charging current and output voltage.

LED indicators:

- INPUT VOLTAGE: the rectified dc voltage from the wind turbine
- CHARGE CURRENT: the charging current to the battery
- OUTPUT VOLTAGE: the output dc voltage

5. Testing

5.1 Check all the bolts before the testing to make sure they are all securely tightened.

5.2 Spin the blades slightly with hands to check if the turbine turns smoothly. Fix it if it does not turn smoothly.

Installation completed, your turbine is ready to generate electricity.

Congratulations!

Maintenance Instructions

Appropriate and timely maintenance of the system is critical to the performance and life cycle of the turbine. Key points are:

6.1 Inspect the bolts and nuts every three years to ensure no loose fasteners.

6.2 Clean the blade surface every three years.

6.3 Clean and paint all the exposed parts and remove all rusts if any every three years.

6.4 Check hydraulic oil level and add oil every three years.

There is 400ml oil in the oil tank when it is shipped. The oil level can go as low as 150ml in the oil tank without need for replenishment. However, if you observe significant oil stain on the outside of the generator, you need to check the oil level and replenish oil as needed.

Please note, if the temperature in your area is lower than $-20C^0$ in winter, you need to use low temperature oil. It could work under $-40C^0$. Otherwise general hydraulic oil would work

Below shows how to check oil level and add oil:

6.5 When inspecting the controller and inverter.

For off-grid system, the DC output should be disconnected first and after inspection, the batteries should be connected before the wind turbine is connected.

For on-grid system, the turbine should be disconnected from grid first and reconnected after inspection.

Storage Requirement

7.1 Inverter/controller should be placed in a dry, ventilated and non-polluted environment.

Read carefully the manual for the controller and the inverter.

7.2 The storage batteries might leak certain amount of caustic gas, so they should be placed in a ventilated area without flames.

7.3 Do not place anything on the terminals of the storage batteries to prevent short circuits.

Troubleshooting

Problems	Causes	Solutions
Emergency brake system not activated	No electricity from the grid Battery dead in controller Loose cable connection	Wait for electricity from grid to come back on Replace battery Check loose cable connection and tighten it
Emergency brake system activated but not braking	Oil leak in the hydraulic system	Check surface of the generator to see if there is oil leak. Add oil to the hydraulic cylinder as needed.
Controller indicates there is DC power but no electricity output from inverter.	The DC voltage from the controller is lower than the minimum working voltage of the inverter Inverter problem	If DC voltage is lower than the inverter working voltage, it is normal, because the inverter is in a waiting mode. If DC voltage is higher than the inverter working voltage, the inverter may have problems, please refer to the inverter manual

Warranty Statement

SAWT standard warranty period is 36 months starting from the shipping date. Serial numbers of the generator and the controller are necessary for warranty services. Fill out the warranty card and send back by fax or E-mail. Failure to do so will disqualify you from warranty coverage. It is also important that you use the recommended inverter and set up the remote monitoring system accordingly, failure to do so will also disqualify you from warranty coverage.

8. In the warranty period, any of the below problems occurred due to manufacturing quality, exchange for new parts and repair is free of charge. Please contact your local distributor for warranty service if needed.

8.1 With normal installation and use of the product according to the Operation Manual, generator is not functioning due to parts malfunction, generator will be replaced.

8.2 With normal installation and use of the product according to the Operation Manual, if the generator cover is broken it may affect the performance of the system. The part will be replaced.

8.3 With normal installation and use of the product according to the Operation Manual, damaged blades will be replaced.

8.4 With normal installation according to Operation Manual, and normal use according to the controller manual, the controller is unable to work or is damaged, it will be replaced or repaired.

9. SAWT charges for repairs and parts when warranty does not cover or any other problems including those that arise as a result of:

9.1 Components dropped or damaged because of external force due to mishandling

9.2 Damages to the blades because of improper stopping of the turbine, I,E., with a wood pole to stop the blades. Or some parts get broken because of improper operating when the system is running at a high speed.

9.3 Damages due to acts or forces of nature, I.E., earthquake, sand storm, strong hail, hurricane and typhoon over product's survival wind speed, lightning strike, grid failure.

9.4 Any other damage due to installation or operation not according to the Operation Manual is not covered in the warranty.

9.5 Disassembly of the generator and the brake hub without SAWT's knowledge will void and nullify the entire turbine from warranty coverage.

9.6 SAWT provides the replacement parts to the nearest port to the distributor (or to the customers). SAWT reserves the rights to select the most appropriate mode of transportation.

Series Number: ______________________________

The date of leave the factory: ______________________________

8.16 EIF Inverter: ZBB

ZBB energy corporation

ZBB ENERSTORE™
50V3.1

PRODUCT TEST PROCEDURE

WARNING –
THIS TEST PROCEDURE IS TO BE USE BY QUALIFIED PERSONNEL ONLY. TO REDUCE THE RISK OF ELECTRIC SHOCK, DO NOT PERFORM ANY TASK OTHER THAN THAT SPECIFIED IN THE TEST PROCEDURE UNLESS YOU ARE QUALIFIED TO DO SO.

30-000244

Table of Contents

I. IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This test procedure contains important instructions for Model **50V3.1** that shall be followed during product test of the ZBB ENERSTORE™ 50V3.1.

• THIS TEST PROCEDURE CONTAINS IMPORTANT INSTRUCTIONS FOR ZBB ENERGY CORPORATION EQUIPMENT THAT SHALL BE FOLLOWED DURING STANDARD FACTORY PRODUCT TESTING.

• FOLLOW ALL APPLICABLE SAFETY INFORMATION DURING INSTALLATION, OPERATION, INSPECTION, TESTING & SERVICE, AND MAINTENANCE OF ZBB ENERGY CORPORATION EQUIPMENT.

INTRODUCTION & CONTACT INFORMATION

ZBB Energy Corporation (hereafter, "ZBB") products meet all applicable industry safety standards. ZBB actively promotes safe practices in the use and service of its equipment through training programs, manuals, and the various proactive efforts of its personnel covering design, engineering, manufacturing, marketing, and service.

This test cannot possibly cover all details or variations in equipment, procedures, or processes described, and cannot provide directions for every possible contingency during operation, inspection, or service. When additional information is needed or desired to meet a situation not covered sufficiently, consult **ZBB Engineering Department**

SAFETY INFORMATION

The following information provides GENERAL safety information, including a brief overview of safety, designation of signal words and symbols, hazard statement definitions, notification of hazards, methods to help avoid hazards, and brief statements of the consequences that can occur when failing to follow the safety information. For safe operation and testing of ZBB equipment, read, understand, and follow all safety information.

Testing
The initial verification of product startup of the equipment, known as *Product Test*, is a very specific and necessary safety procedure. **Equipment and product startup is to be performed only by a ZBB-factory certified technician.**

The information contained in this test procedure does not replace any other safety information, practices, or proper judgment. Government agencies, various corporations and employers have their own laws, regulations, codes, and rules. Before starting to operate or work on the equipment, ask about the safety policy in effect at the equipment location. BEFORE attempting to operate, inspect, service, maintain, or test the equipment, learn the safety requirements that are in effect at each location. Safety depends on properly following all appropriate safety requirements.

Safety is most important. Many factors contribute to safe – or unsafe – conditions, including but not limited to:

- Alcohol and / or Drugs
- Attitude
- Carelessness
- Distractions
- Fatigue
- Inattentive / irresponsible behavior
- Overload
- Unfamiliarity with the equipment

YOU are the most important contributor to your own safety. Equipment can be repaired or replaced – death and many injuries are permanent. For the best results, think and act safely and encourage others to do so as well.

Invest in your safety by reading, understanding, and following the information in this procedure. Obey all applicable laws, regulations, rules, codes, locally-mandated practices and procedures. Before attempting to conduct any operation or operation-service on ZBB and associated equipment, consider all of the circumstances, conditions, and other factors that can have an effect on the safety of personnel and property. Take appropriate action to assure safety at all times.

This procedure is not intended as a substitute for appropriate training and experience covering the safe operation of the equipment. Only ***authorized, qualified personnel*** with the proper background and knowledge are permitted to inspect, install, operate, and service ZBB equipment.

AUTHORIZED, QUALIFIED PERSONNEL

The term "authorized, qualified personnel" is used throughout this procedure and is defined as follows: **Authorized, qualified personnel meet these *minimum* qualifications:**

- *Trained and experienced with safe operating practices, procedures, and accepted high-voltage and low-voltage safety and practical techniques covering electrical power devices and power electronics equipment.*
- *Trained and experienced with the use and care of Personal Protective Equipment (PPE), including but not limited to flash-protective clothing, voltage-insulating rubber gloves, face shield, hard hat, safety glasses, and more.*
- *Trained and authorized to work with the type of equipment that this procedure covers, including but not limited to energizing, de-energizing, grounding, and clearing electrical power equipment.*
- *Trained and authorized to work with applicable tools and instruments,*
- *Trained, authorized, and qualified by ZBB Energy Corporation to inspect, install, operate, and service ZBB products.*
- *Has read, understands and follows this procedure.*

ONLY ***authorized, qualified*** personnel, *as defined*, are permitted to access equipment supplied by ZBB Energy Corporation.

Before attempting to operate or service ZBB equipment, know where to obtain medical assistance, how to contact emergency personnel, and how to use a first aid kit and a fire extinguisher or other type of fire suppression system. *If working alone, routinely check with another person to help assure your safety.*

Keep emergency telephone numbers (fire, police, first responder, etc.) with you:

Fire: ____________________

Police: ____________________

First Responder: ____________________

Other (personal, etc.): ____________________

HAZARD STATEMENT IN THIS PROCEDURE

The exclamation mark within a triangle is the Safety Alert Symbol:

⚠

The Safety Alert Symbol means **ATTENTION!** BE ALERT! SAFETY IS INVOLVED!

The symbol is used to direct your attention to safety hazards involving the equipment or procedures. It is used throughout this procedure.

Whenever you see the Safety Alert Symbol: **PAY ATTENTION!** Read, understand, and follow the information included. Your life, health, and safety depend on your appropriate actions.

The message that follows the Safety Alert Symbol includes important details about safety. To avoid possible death or injury, carefully read, understand, and follow all safety messages. Fully understand the potential causes of death or injury and other hazards and comply with safe methods to avoid death or injury.

Hazard Statement Definitions

FAILURE TO UNDERSTAND AND OBEY THESE HAZARD STATEMENTS AND THE ACCOMPANYING INFORMATION COULD RESULT IN DEATH, SERIOUS INJURY / DISMEMBERMENT, OR DAMAGE TO PROPERTY.

This procedure may contain four basic types of hazard communication statements identified by signal words and the presence, or lack, of the Safety Alert Symbol:

⚠	**DANGER:** Indicates an impending hazardous situation, which, if not avoided, ***WILL*** lead to death or serious injury.

The signal word **DANGER** signifies that an extremely hazardous situation exists and will definitely result in **death or severe injury** if proper precautions are not taken.

⚠	**WARNING:** Indicates a potentially hazardous situation, which, if not avoided, ***could*** lead to death or serious injury.

The signal word **WARNING** signifies that a hazardous situation exists with, or involving, the equipment, which can result in **death or injury** if proper precautions are not taken.

⚠	**CAUTION:** Indicates a potentially hazardous situation, which, if not avoided, ***may*** lead to moderate or minor injury. • May also provide an alert to help avoid unsafe practices.

The signal word **CAUTION** signifies that a potentially hazardous situation exists and may result in **injury** if proper precautions are not taken.

CAUTION: Indicates a potentially hazardous situation, which, if not avoided, may lead to equipment damage.

The absence of the Safety Alert Symbol with the use of the signal word **CAUTION** signifies that a potentially hazardous condition exists that may result in **equipment damage only if** proper precautions are not taken.

Additional Types of Special Messages

This instruction also includes the following types of special information:

IMPORTANT! Indicates important information required for proper installation, maintenance, and / or operation.

NOTE: Provides further information covering procedures, methods, etc.

General Safety – Chemical

None – This test will be ONLY be utilizing Deionized Water (hereafter referred to as DI Water). Safe Handling of DI Water is a requirement & safety concern. Please read, understand and follow the directions.

ESD (Electrostatic discharge)

Electrostatic Discharge protection & procedure is required when handling sensitive component. Refer to common practice in handling sensitive component. When handling component by hand(s), always ground yourself with grounding wristband or by touching a safe grounded surface.

HAZARD STATEMENT ON EQUIPMENT

There are safety symbol(s) and label(s) adhered to the equipment. They are used to direct your attention to safety hazards involving the equipment or procedures.

General Symbol

The electrical shock mark within a triangle is the CAUTION – RISK OF ELECTRICAL SHOCK Symbol:

The CAUTION – RISK OF ELECTRIC SHOCK Symbol means **ATTENTION!** BE ALERT! SAFETY IS INVOLVED!

Whenever you see the CAUTION – RISK OF ELECTRIC SHOCK symbol: **PAY ATTENTION!** Read, understand, and follow the information included. Your life, health, and safety depend on your appropriate actions.

Additional Safety Information (I)

Information following the "CAUTION – RISK OF ELECTRIC SHOCK" symbol will alert and/or advise personnel of potential danger.

LIVE VOLTAGE

EXCLUSIVE OF DEVICE'S OPERATION

Additional Safety Information (II)

Whenever you see the "CAUTION" in bold yellow letters accented by a dark background with additional safety information, **PAY ATTENTION!** Read, understand, and follow the information included. Your life, health, and safety depend on your appropriate actions.

Example of Cautionary Label:

Additional Safety Information (III)

Additional Types of Special Messages

The unit also includes the following types of special information:

IMPORTANT! Indicates important information required for proper installation, maintenance, and / or operation.

NOTE: Provides further information covering procedures, methods, etc.

II. PURPOSE & SCOPE

The purpose of this document is to give the details of necessary activities to issue the test certification named ENERSTORE 50V3.1 Product Test. This document is required during the final phase of the production and details testing to the physical & software layout of the equipment package(s). ENERSTORE 50V3.1 Product Test to be completed prior to system test and/or product shipment.

Read This Procedure First

BEFORE attempting to operate & test this equipment, read, understand, and follow this procedure. Follow all locally approved procedures and safety practices.

> **WARNING:** POTENTIAL FOR DEATH OR SERIOUS INJURY.
>
> • This procedure is intended for use by ***authorized, qualified*** personnel ONLY.
>
> • To help reduce the risk of electric shock, DO NOT attempt to operate or service the unit in any manner other than described in this procedure.

Standards

ZBB Energy Corporation equipment is designed and/or tested in accordance with ANSI standards, IEEE, NEC, NFPA, and UL.

The Quality System at the ZBB Energy Corporation factory is ISO 9001 certified.

Additional Information

These instructions cannot cover all details or variations in the equipment, procedures, or process described, nor to provide directions for meeting every possible contingency during installation, operation, or maintenance. When additional information is desired to satisfy a problem not covered sufficiently for the service purpose, please contact ZBB Energy Corporation Service & Technical Support.

ACCEPTANCE AND INSPECTION

Each module shall be completely assembled and inspected. At the time of receipt, refer to check list document(s) to ensure module has been inspected & signed off.

> **IMPORTANT!** If module arrived without document(s), reject & hold off testing until proper document(s) is/are provided.

The module is assembled as a single structure. The following Mechanical, Electrical & Software checks shall be performed by an ***authorized, qualified*** responsible personnel, as defined in this procedure and in accordance with drawings, instruction, and local laws and standards. Setup and the wiring of the equipment are only to be performed by ZBB-trained personnel.

> **IMPORTANT!** Each Mechanical, Electrical & Software section is followed with a "Performed by" and/or "Checked by" with a signature requirement. Signature(s) is a must prior to moving to the next section. **See F-TE-07 50V3.1 Final Test Check List.**

III. INCOMING INSPECTION

IMPORTANT! Energizing of voltage(s) **is not permitted** in this section. LOCK-OUT/TAG-OUT tags to be deployed on distribution panels. Only when sign-offs are finalized & approval given, these tags can be removed.

ASSEMBLY & TEST DOCUMENT

Materials & Tools:

Assembly & Test documents; specific documents will be listed in F-TE-07 Final Test Checklist.

Upon receiving for testing, product shall include but not limited to the assembly & test documents. If the required documentation are not included with the unit; it shall be rejected, moved aside and appropriate manufacturing personnel shall be notified.

See F-TE-07 Final Test Checklist for check off/signoff

MECHANICAL

Materials & Tools:

Mechanical layout drawing(s) & Supplementary documents, Metric/English tape measure, Digital Multimeter (DMM).

Examination of External/Internal Mechanical components shall compose of but not limited to the dimensions, physical locations and mechanical operation of 'non-energized' parts as per mechanical checklist.

1. Module physical location shall be in a dry, well ventilated & dust free environment.
2. Check the module(s) for damages. Record and describe all physical damage; when possible make a photographic record and notify appropriate department(s) to make necessary repairs & replacement if damaged part(s) is to be energized.
3. Manually exercise non-energized mechanical components such as door(s), operator(s), circuit breaker(s) and switch(s). Components shall be properly aligned & foreign object shall not obscure their operations.
4. Cooling air path(s) shall not be obscured by foreign objects.
5. Dimensions, location & material information shall be reviewed against documents.
6. Physical mating & connections shall be in accordance with electrical/mechanical documents.
7. Panel/Cabinet keys are supplied.
8. Grounding/Bonding test shall involve a DMM using continuity settings.
9. Cables installation should be routed in a safe & mechanically appropriate manner.
10. All cables shall be securely attached with straps or clamps to ensure short circuit bracing & avoid loose routing.
11. Examiner(s) shall red-line differences or alterations to design.

See F-TE-07 Final Test Checklist for check off/signoff

ELECTRICAL

Materials & Tools:

Electrical schematic(s) & Supplementary document(s) & Digital Multimeter (DMM).

The purpose of this section is to verify Electrical Schematic of Module per supplementary documents. It's imperative to check all wiring prior to energizing. **Sign-off required.**

1. Thoroughly check all wiring with Electrical Schematic(s), a DMM or equivalent meter to be used for continuity check.
2. Check wiring for tight connections per torque requirements.
3. Loose wiring or foreign objects at termination points shall be addressed & appropriate actions be taken.
4. Cables shall be appropriate dressed, identified & secured with proper means.

See F-TE-07 Final Test Checklist for check off/signoff

IV. INTERCONNECT & STARTUP

IMPORTANT! Energizing of voltage(s) **is permitted** in this section. Refer to module rating table/label and electrical panel distribution capacity.

WARNING: Hazardous Voltage!
POTENTIAL FOR DEATH OR SERIOUS INJURY.

• These operation instructions are intended for use by ***authorized, qualified*** personnel as defined in the Safety section of these instructions.

• The module must be solidly grounded. Improper grounding can result in contact with high voltage that can cause death or severe personal injury.

• Provide adequate spacing in front of the unit per OSHA regulation.

CABLE CONNECTIONS

Materials & Tools:
Single Line Diagram(s), Electrical schematic(s), Supplementary document(s), Digital Multimeter (DMM) and Hand Tools (.ie wrenches, screw drivers)

If connecting additional equipment to the module or other existing equipment, ensure that incoming power is disconnected before work is begun. Disconnecting means should be locked out and/or tagged out. Where it is not feasible to de-energize the system, only ***authorized, qualified*** personnel may work on the equipment and must use practices (appropriate apparel, equipment and tools) in accordance with NEC safety codes and / or the regulatory requirements of other appropriate governing bodies.

IMPORTANT! Only ***authorized, qualified*** personnel may make cable connections to the unit.

Use only NRTL compliance cable(s) and installation practices as specified in the National Electric Code – Section 310. Interconnecting cable(s) must be rated for terminal temperature at 75°C & have insulation rating no less than 90°C and sized at 120% ampacity for the module's rating.

IMPORTANT! Rating of module is listed in Appendix A.

Connect cables to the module with access panel(s) removed and/or ajar; removed panels to be replaced afterwards. Refer to Single Line Diagram(s) and or Electrical Schematic(s).

- Remove cabinet's panels as required for interconnect wiring.
- Interconnect wiring shall be routed in a safe & efficient matter.
- Clean all electrical connectors before assembly.
- Verify that all screw connections are torque to the proper tightness.

IMPORTANT! Power & Control Cable(s) to be separated per NEC, ANSI / NFPA70 & local governing bodies.

- Attach probe to module's DC bus to monitor DC voltage via multimeter.
- Thoroughly check all wiring with Electrical Schematic(s), a DMM or equivalent meter to be used for continuity check.
- Re-install access panels as required.

IMPORTANT!
• Properly GROUND the module in accordance with all required codes, including but not limited to the National Electrical Code, ANSI / NFPA 70.
• DC negative leg is NOT to be bonded to ground.
• DC bus & battery stack voltages will be floating.

COMMUNICATION CONNECTIONS

System Communication between the module and the user is serially through any standard computer. It will then be able to display various system signals as well as access to controls necessary to run the module. Two wire Fiber optic connections are used for direct connection between the module and serial interface. On the module's APC (Auxiliary Power & Controls) board, these two connectors are blue (Rx) and grey (Tx).

See F-TE-07 Final Test Checklist for check off/signoff

PRE-ENERGIZE CHECKLIST

1. Confirm that all ac and dc power upstream / downstream of the module is locked out and tagged out and that all breakers are OFF.

2. Confirm that all AC and/or DC connections are terminated properly.

3. Conduct a general inspection of the module & interconnect. Verify that there is no visible damage, loose wires, moisture, etc.

4. Close and latch all applicable panels and cabinet doors.

APPLYING POWER

> **WARNING:** POTENTIAL FOR DEATH OR SERIOUS INJURY.
>
> • These operation instructions are intended for use by ***authorized, qualified*** personnel as defined in the Safety section of these instructions.
>
> • Read & understand the instructions prior to energizing the unit.
>
> • At any instance where the module is faulted or there is cause for potential issue(s), shutoff the module immediately.

> **IMPORTANT!** Prior to energizing the unit, familiarize with the **50V3.1 Battery Module OPERATION** in the following section below.

Materials & Tools:

Single Line Diagram(s), Electrical schematic(s), Supplementary document(s), Digital Multimeter (DMM), Current Probe, Thermometer Probe,

1. Complete the **Pre-Energize Checklist** (as stated above).

2. Operate AC and/or DC switch(es) upstream of the module as applicable to the ON position.

3. CONFIRM with DMM that the voltage feeding the module and that it's within the ratings specified in Appendix A (.ie DC Voltage input range = 350V-450V).

4. CONFIRM with DMM that the 48V and 24V power supply voltages are within tolerances. Any voltage that is tapped from power supplies also requires confirmation.

5. **CONFIRM** through interface program that communication has been established.

   a. Module is not in fault state & in disable state. If in fault state, reset to disable state. If unsuccessful, contact appropriate engineer(s).

   b. DC Voltage feedback is in range.

   c. Check software version & parameters.

6. Enable the module & run the pumps

7. Visually inspect pipe fittings, stack connections, reservoir tanks and sump.

See F-TE-07 Final Test Checklist for check off/signoff

V. FUNCTIONAL TESTING

PUMPS

Both the Catholyte & Anolyte pumps will be operated for functionality. If findings are out of tolerance the module or component(s) has failed. Notify appropriate personnel.

- Visually confirm that Catholyte & Anolyte reservoirs water level is sinking.
- Visually confirm with computer interface that pumps are running & RPM feedbacks are within tolerance.
- Listen for audible noise that is out of the ordinary (.ie grinding or screeching noise) throughout the testing.

See F-TE-07 Final Test Checklist for check off/signoff

FANS

DC/DC converter & Heat Exchanger Fans to be operated for functionality. If operation failed and/or fan audible noise is out of tolerance notify appropriate personnel.

- Visually confirm the DC/DC converter fans (right side – as viewed from the front) operate continuously. Confirm fans are orientated properly.
- Visually confirm the Heat Exchanger fan operate coninuously.
- All fans, when operated shall have smooth rotation with no audible noise that is out of the ordinary (.ie grinding or screeching noise) throughout the testing.

See F-TE-07 Final Test Checklist for check off/signoff

Valves (Electrically Operated)

All electrically operated valves to be actuated for functionality; only 4-Way Valve needs to be actuated base on time. Values actuation and position to be confirm through computer interface & visually. All data to be recorded; if findings are out of tolerance the module or component(s) has failed. Notify appropriate personnel.

- Listen for audible noise that is out of the ordinary (.ie grinding or screeching noise) throughout the testing.
- The 4-Way Valve will actuate every 5 minutes during normal operation; it can be manually actuated through computer interface. Verify its operation.
- The 2-Way Valve will be manually actuated through computer interface. Verify its operation.

See F-TE-07 Final Test Checklist for check off/signoff

THERMOCOUPLES & NTC

Ambient thermocouple, anolyte thermocouple & NTC feedbacks to be measured for functionality. Temperature from thermocouples & NTC will dictate pumps and fans operation; additionally will enable & fault module. Temperature feedbacks will be confirmed against ambient temperature through the computer interface. Permissives & faults will be created manually through computer interface. If expected outcome is not seen, notify appropriate personnel.

Ambient Thermocouple (0C to +50C). First confirm that thermocouple feedback display matches thermal gun readings. Adjust & calibrated as needed. Through the computer interface, manually adjust feedback to achieve temperature range. Record ambient thermocouple with thermal gun as well as through computer interface. Expected results are as follows:

- 50C or higher – Module Faulted

Anolyte Thermocouple (0C to +65C). First confirm that thermocouple feedback display matches thermal gun readings. Adjust & calibrated as needed. Through the computer interface, manually adjust feedback to achieve temperature range. Record ambient thermocouple with thermal gun as well as through computer interface. Expected results are as follows:

- 35C to 65C – Heat Exchanger Fan on
- 30C or lower – Heat Exchanger Fan off
- 55C or higher – Module Faulted

- 65C or higher – Module won't start
    - 10C or lower – Module Faulted
    - 0C or lower – Module won't start

IGBT's NTC (-20C to 100C). First confirm that thermocouple feedback display matches thermal gun readings. Through the computer interface, manually adjust feedback to achieve temperature range. Expected results are as follows:

- 65C or higher – DC/DC Fan on
- -20C to 65C – DC/DC Fan off
- 100C or higher – Module Faulted
- -20C or lower – Module Faulted

See F-TE-07 Final Test Checklist for check off/signoff

LEAK SENSORS

Both Low & High Leak sensors to be operated for functionality. Tests consist shorting both sensors probes and recording event. Expected results are as follows:

- Low Leak sensor – An alarm is trigger & viewed through computer interface. No action taken.
- High Leak sensor – A trip is trigger & viewed through computer interface. Pumps & temperature controlled fans stop rotating & module is faulted.

See F-TE-07 Final Test Checklist for check off/signoff

THERMOSNAPS

All three thermosnaps to be operated for functionality. Tests consist of removing thermosnap from the circuit while unit is running, thus will cause actuation of a contactor.

Actuation of contactor will cut power to APC, thus cease pump operation.

See F-TE-07 Final Test Checklist for check off/signoff

VI. SHUTDOWN

NORMAL OPERATION

After product test is finalized, a safe method to power down the module is key for personnel & equipment safety. Module may be shutdown with the following steps.

1. Confirm that all components are in most safe state.
2. All fans & pumps to stop rotating via computer interface.
3. Voltage source(s) feeding DC bus to be removed with no or minimal load via disconnect switch or contactor.
4. Main disconnect switch to be in open position. Lock Out-Tag-Out procedure to be implemented.

When test is completed , final signoff is required on Cover Page.

FAULT CONDITION

In the event of a fault or catastrophic failure, best method is to switch main disconnect into the open position. Notify appropriate personnel immediately.

ADDITIONAL SAFETY INFORMATION

Personal Protective Equipment (PPE)

Wear appropriate PPE – safety glasses or goggles, flame resistant clothing, appropriately rated gloves, and head protection.

For example, certain regulations mandate that all workers wear protective helmets in areas where there is a possible danger of head injury from impact, falling or flying objects, or electrical shock and burns. Each worker is required to comply with both industry and company standards concerning when, where, and how to fit and wear protective helmets (hard hats). At a minimum, hard hats must comply with the ASTM Standard F 2413-05 and must be worn at all times when working on the equipment.

At least annually, review all relevant safety materials and standards as they are subject to change. ZBB Energy Corporation encourages and supports the establishment of and adherence to appropriate safety standards along with the use of personal

Lock Out / Tag Out (LOTO)

Now that the equipment has been powered down and this has been verified, conduct the Lock Out / Tag Out (LOTO) procedure in accordance with appropriate guidelines.

At a minimum, the LOTO procedure should be followed as mandated by the United States Occupational Safety and Health Administration (OSHA) and local regulations, including yet not limited to those fostered by ZBB Energy Corporation.

VII. TROUBLESHOOTING

On the spot troubleshooting is not recommended, best practice is to record results, take pictures and address concerns to appropriate personnel. It will be the responsibility of personnel to take action.

Appendix A

RATINGS AND SPECIFICATIONS (Electrical)

The ZBB V3.1 Enerstore is rated per the specification displayed in Table 1

Table 1

ZBB energy corporation

ZBB ENERSTORE™ 50V3.1 FLOW BATTERY
Model # 11-ENERSTORE-50V3.1

Rating Type	
Maximum Input Voltage (DC)	450V
Range of operating voltage (DC)	350-450V
Maximum Continuous input current (DC)	50A (4 X 12.5ADC)
Maximum Continuous output current (DC)	72 A (4 X 18ADC)
Maximum input short circuit current	18kA
Maximum Continuous Input Power (DC)	17kW (4 x 4.25kW)
Maximum Continuous Output Power (DC)	25kW (4 x 6.25kW)
Maximum Output Fault Current (DC) and Duration	616A Pk 100µS (4 x 154ADC)
Maximum Output Overcurrent Protection (per leg)	4X 30A
Normal Operation Temperature Range	0°C to +50°C
Enclosure Type Rating (designed to)	TYPE 3R

Corporate Headquarters

N93 W14475 Whittaker Way
Menomonee Falls, WI 53051 USA
Tel: +1 (262) 253-9800
Fax: +1 (262) 253-9822

HISTORY

ISSUE	DATE	DRF	CHK	APP	DESCRIPTION OF CHANGES
1.0	12/21/12	DV	PG	KD	ISSUE FOR RELEASE
2.0	03/08/12	DV	PG	KD	SEPERATED CHECKLIST & SIGNOFF FROM PROCEDURE (APPENDIX B), ADDED MFG DOCUMENTS TO INCOMING INSPECTION, INCLUDED COMPUTER INTERFACE FOR TESTING PURPOSE.

Commissioning Procedure/Report

Statement

Equipment and system commissioning is to be performed only by a ZBB factory certified technician. Contact the factory to arrange a time and place to have your equipment or system serviced. Violation of this commissioning statement could result in a voided warranty.

Drawing Reference:

Single Line Diagram:	20-000173 UTS EnerSystem SLD REV01
Interconnect Diagram:	20-000179 UTS INTERCONNECT
System Mechanical Outline:	20-000174 UTS ENERSYSTEM LAYOUT Rev 02
System Memory Map:	30-000248 UTS Australia MEMORY MAP

TABLE OF CONTENTS:

Purpose & Scope

The purpose of this section is to give the details of necessary activities to issue the test certification named *Commissioning Procedure/Report*. This document is required during the first phase of the equipment installation and details the physical & software layout of the equipment package(s).

General Safety Statement

COMMISSIONING and ENERGIZING the equipment is ONLY to be conducted after:

PREREQUISITES CHECKLIST
☐ Completed Installation Sign-Off of EnerSystem's EnerSection™(s), EnerStore™(s) & Accessories per OEM installation procedures & furnished drawings.
☐ Final Approval from team leader.

Each section is composed of required safety steps, checklist, materials & tools and directions. Each section is to be initialed after confirmation of the test result. Appropriate parties shall initial each test section as accepted, comments shall be provided for further clarifications. Sections not accepted shall be noted and detailed in the Commissioning Punch List. All copies of documentations & sign-offs shall be attached to the end of this document/procedure & filed electronically and hardcopies.

Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

____
____
____
____

1. Physical Enclosures

1.1 Mechanical Layout Verification

[Safety Precautions]
Energizing control/LV is not permitted in this section.

Directions:
Examination of External Mechanical components shall compose of but not limited to the dimensions, physical locations and mechanical operation of 'non-energized' parts as per mechanical checklist. Shall be inclusive of materials & tools listed and comply with guidelines of NEC.

i. Enclosure physical location shall be in a dry, well ventilated & dust free environment.
ii. Check the Enclosure(s) for damages & make necessary repairs & replacement of damaged part(s) prior to being energized.
iii. Manually exercise non-energized mechanical components such as door(s), operator(s), circuit breaker(s) and switch(es). Components shall be properly aligned & foreign objects shall not obscure their operations.
iv. Verify Equipment Grounding.
v. Examiner(s) shall document findings and resolution.
vi. Verify Field Wiring and Interconnections according to System Drawings

Materials & Tools:
Mechanical Layout Drawings & supplementary documents, Metric/English tape measure, Digital Multimeter (DMM).

EXTERNAL MECHANICAL CHECKLIST	
☐ *Equipment Layout*	☐ *Operation of non-energized mech. component.*
☐ *Damages & Defects.*	☐ *Packaging Materials.*

Initial: ________ Date: ________
Initial: ________ Date: ________

Additional Comments:
____
____
____

2. EnerStore™ 50V3.1 Battery Pre-Setup

2.1 EnerStore™ 50V3.1 Electrolyte

[Safety Precautions]
Energizing control/LV is not permitted in this section.

> [WARNING]
> Electrolyte is caustic and considered a **toxic chemical**! Wear rubber gloves (nitrile or butyl rubber) when working with it. Use baking soda or a baking soda – water solution

to neutralize any spills. Isopropanol (isopropyl alcohol) can also be used on minor splashes or spills. Electrolyte left on the skin will burn. Electrolyte left on untreated or unpainted metallic surfaces will accelerate corrosion/rust.

Refer to MSDS for specifics on Electrolyte.

Directions:
Please fill electrolyte according to instruction for ZBB EnerStore™ 50V3 battery. During Filling, unauthorized non-ZBB personnel should be cleared 20 feet from the 50V3. Only authorized ZBB personal will be within 20 feet of the 50V3 during this procedure.

i. Inspect for any leaks or leakage of electrolyte.
ii. Run EnerStore™ 50V3's pumps using STARIO by accessing V3's APC directly without powering the system or the battery to check for leaks within the EnerStore™ 50V3 housing and its surroundings.
    a. EnerStore™ 50V3's communication shielded CAT6 cable must be unplugged from EnerSystem™ Communication Module (ECM). Without communication, EnerStore™ 50V3 should not be Charging/Discharging. Also, OPEN all DCBUS Fuses from 50V3 to the DC BUS.

Materials & Tools:
Mechanical Layout Drawings & supplementary documents, Document Package

EnerStore 50V3 CHECKLIST	
☐ *PUMPS*	☐ *LEAKS*
☐ *Damages & Defects.*	☐ *Packaging Materials.*

Initial: ________ Date: ________
Initial: ________ Date: ________

Additional Comments:

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3. Interconnect Wiring Verification

3.1 Power Distribution

[Safety Precautions]
Energizing auxiliary/LV is not permitted in this section. LOCK-OUT/TAG-OUT tags to be deployed on distribution panels. Only when sign-offs are finalized & approval given, these tags can be removed.

Directions:
The purpose of this section is to verify Single Line Diagram of System Level Equipment per supplementary documents.

i. Document customer supplied Cables, circuit breaker(s) & safety disconnect switch (es) below. Use **Table 1 & 2** respectively below to verify that EnerSystem's FLA does not exceed protective equipment.
ii. Visually check all wiring and bus connections that have been terminated in this section. Document as necessary.
iii. Loose wiring or foreign objects at termination points shall be addressed & appropriate actions taken.

IT'S INHERENT & IMPERATIVE TO CHECK ALL SYSTEM POWER CONNECTIONS PRIOR TO ENERGIZING.

Materials & Tools:
Supplementary documents:

i. Document package and Operation & Maintenance Manual
ii. Single Line Diagram of EnerSystem™: Supplied by ZBB.
iii. Interconnect Diagram of EnerSystem™: Supplied by ZBB.

Table 1 EnerSystem Full Load Amperage

FLA (AMPS)	VAC	Phase	Frequency (Hz)
30	415	3	50

Table 2 DC PCU Bucket's Full Load Amperage

FLA (AMPS)	VDC		
150	300		

Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

3.2 Unit Power Up

[Safety Precautions]
Energizing auxiliary/LV is permitted in this section. LOCK-OUT/TAG-OUT tags to be removed by appropriate personnel. Follow section on *General Safety* procedures & OEM's safety and startup recommendations. Be aware of arcing requirement prior to energizing panel disconnect switches.

Directions:

i. Exercise ***General Safety***
ii. Verify all main contacts are closed.
iii. Note appropriate comments.

3.2a Point to Point Voltage Check

[Safety Precaution]
Refer to Section: *General Safety*

Before moving to this section, please make sure all Breakers/Switches are Open.

Directions:

- Check Voltages on each termination of ZBB and customer system. Please refer to Single Line Diagram
  - Close the Customer's Breaker/Switch to Source 415VAC. Check Voltage at customer disconnect or circuit breaker.
  - Check the Voltage at the Input side of the Inverter's AC Disconnect.
  - Confirm all Voltages according to the Single line Diagram.
  - Check VDC polarity on each Bucket's Input from customer before Enabling Buckets.

Materials & Tools:

Supplementary documents, HMI & Laptop, Single Line Diagram.

Initial: ________ Date: ________
Initial: ________ Date: ________

Additional Comments:

4 Control Testing

[Safety Precaution]
Refer to Section: *General Safety*

The purpose of the functional test is to verify system integration.

Directions:

i. Check EnerSection™ AC PCU, DC PCU (Each Buckets when available), EnerStore™ 50V3, EnerSystem™ Communication Module's software version as confirmed by Project's Lead S.E.
ii. Confirm set points & verify per single line diagram.

Materials & Tools:
Supplementary documents, Comm Adapter (Fiber to USB), Staraio, Laptop, DMM & document package.

4.1 EnerStore™ 50V3 and ECM's HMI Test (Input Signals)

Verify communication field wiring by simulating one or more Input Signals and verify at HMI.

Directions:

i. Enable V3 from HMI and observe data feedback on HMI.
ii. Confirm Enable/Disable command by observing V3's Power to APC, DCDCs, and pumps operation.

Initial: __________ Date: __________

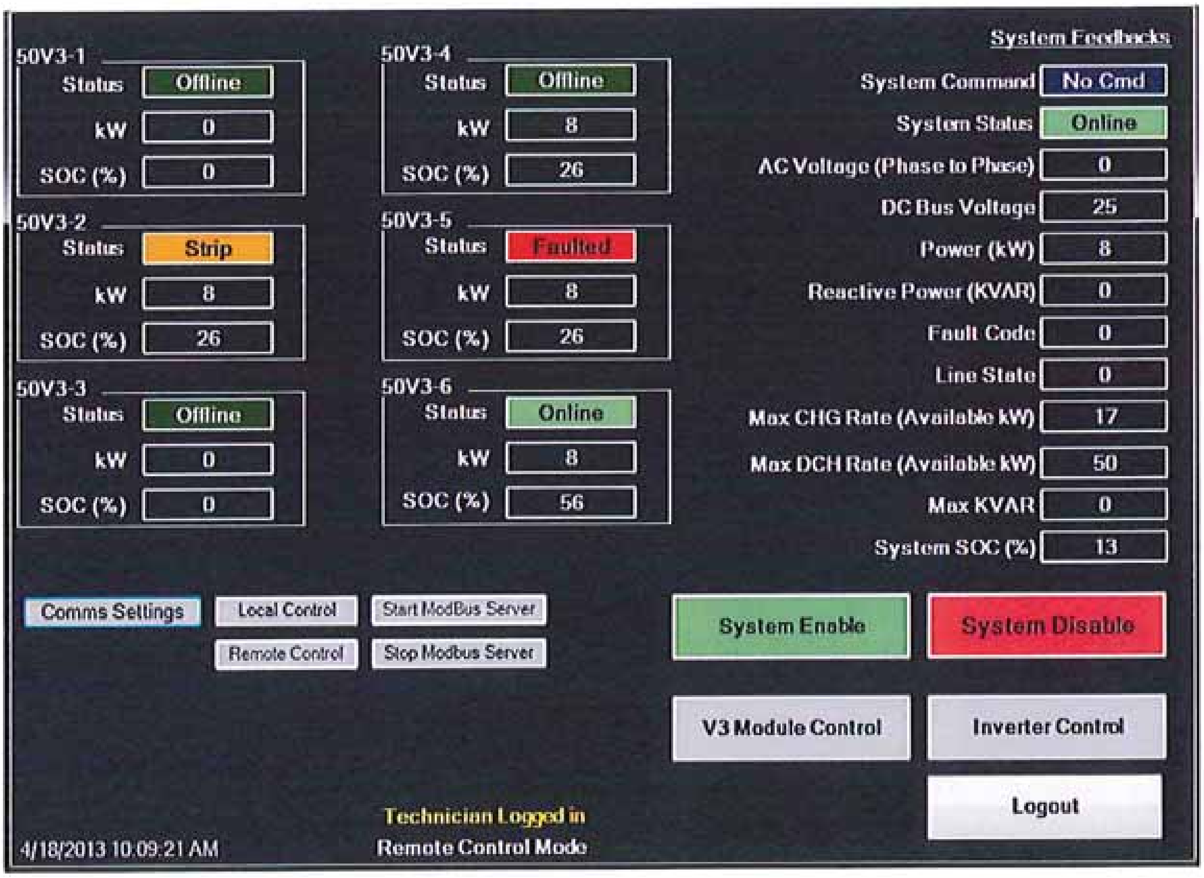
Additional Comments:

4.3 Communication check for each device within the EnerSystem and Customer Controller

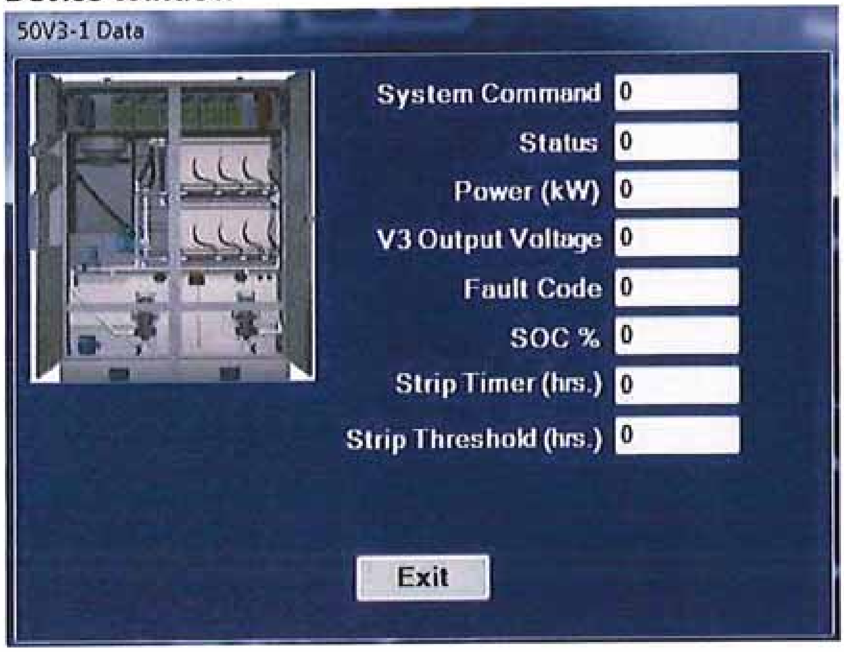
[Safety Precaution]
Refer to Section: *General Safety*

Directions:
Check communication is established on each device (Battery, Buckets, Inverter, ECM, etc.) between customer controller and all devices by looking at the HMI through ECM. From HMI, each device should be visible with their status when enabled. Verify by reading parameters (Power, Voltage, SoC, etc.) from each device on the HMI (example below).

EnerSystem Screen



Device Window



Materials & Tools:
Supplementary documents, Comm Adapter (Fiber to USB), Stario, Laptop, DMM & document package.

Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

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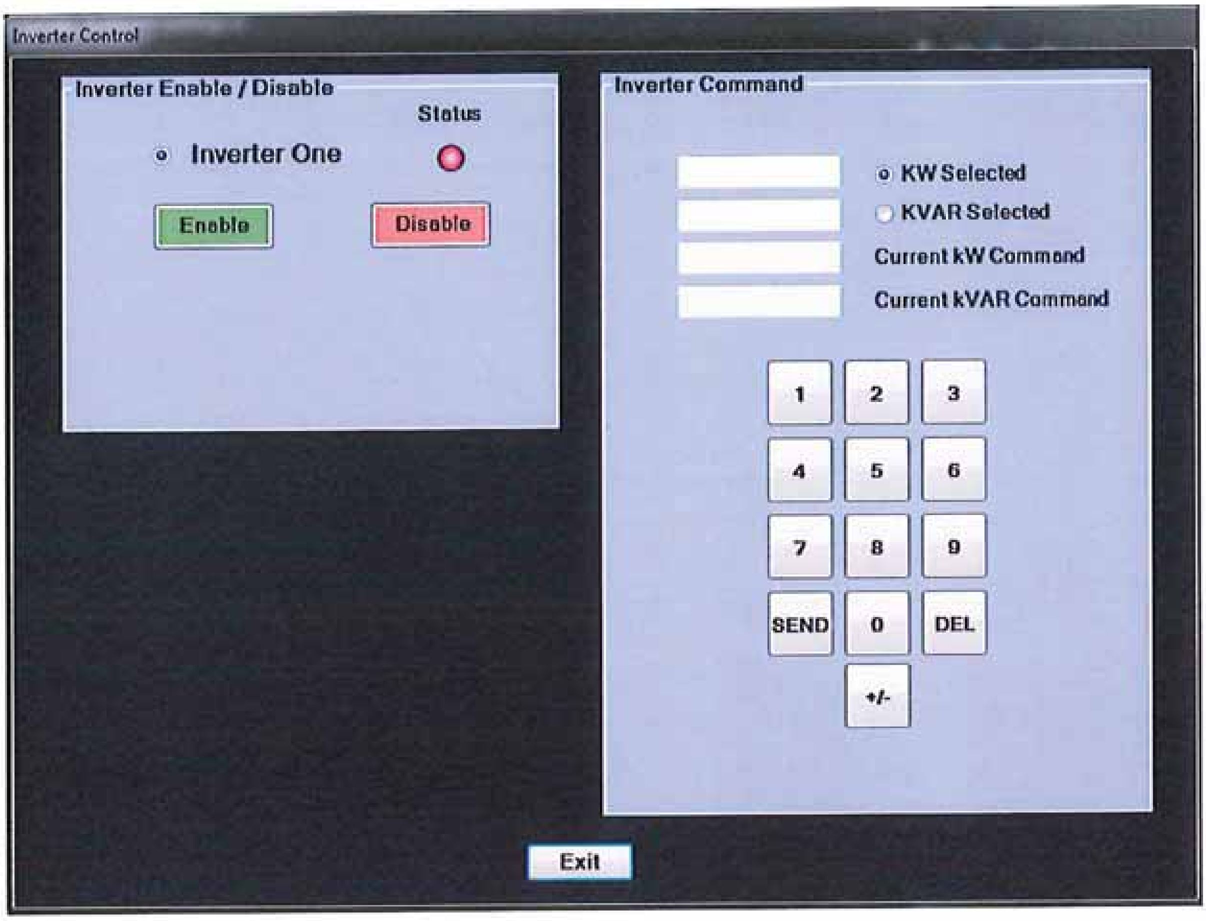
5 Functional & Power Verification

5.1 Main Power Operation

[Safety Precaution]
Refer to Section: *General Safety*

Directions:

- Verify Voltage reading at the HMI and compare it with actual reading from the Inverter's Input using a DMM.
- Verify EnerSystem System readings via HMI (Example below for Inverter)



Materials & Tools:
Supplementary documents, HMI, Laptop, DMM 1000V.

Initial: ________ Date: ________
Initial: ________ Date: ________

Additional Comments:

5.2 EnerStore™ 50V3 Main Power

[Safety Precaution]
Refer to Section: *General Safety*

Directions:

i. Via Customer's Interface based on KW command
   a. Charge Batteries to 50% SoC (State of Charge)
   b. Discharge Batteries to 10% SoC
   c. Verify V3's Power Input and Output for kW command setting for Inverter.

Materials & Tools:
Supplementary documents, HMI & Laptop, Customer Controller.

Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

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5.3 EnerSection™ DC PCU Converter Main Power

[Safety Precaution]
Refer to Section: *General Safety*

Directions:

i. Verify all EnerSection™ DC PCU's buckets (PV, WIND, Fuel Cell, RECT).
ii. Via HMI Interface,
   a. Enable PV and watch PV Bucket power output. Confirm MPPT functional when possible.
   b. Enable WIND and monitor Input and Output Power
   c. Enable Fuel Cell and monitor Input and Output Power
   d. Charge EnerStore using RECT Bucket. Verify RECT bucket's Input AC and Output DC according to Single Line.

Materials & Tools:
Supplementary documents, HMI & Laptop, Customer Controller.

Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

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____

5.4 Cycle Test

[Safety Precaution]
Refer to Section: *General Safety*

Directions:

i. One full charge/discharge cycle via customer KW command or ECM's HMI Command

Materials & Tools:
Supplementary documents, Laptop, Customer Controller.

Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

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5.5 Reactive Power Test (when applicable)

[Safety Precaution]
Refer to Section: *General Safety*

Directions:

i. Via Customer Controller, operate +/- KVAr.
ii. Verify KVAr output based on the command via HMI

Note: Incrementally increase +/- KVAr while monitoring Grid/Utility Voltage.
For +KVAr injection; Limit to $V_{NOMINAL}$ +5%. Record Voltage and KVAr.
For -KVAr injection; Limit to $V_{NOMINAL}$ -5%. Record Voltage and KVAr.

Materials & Tools:
Supplementary documents, Laptop, Customer Controller.
Initial: __________ Date: __________
Initial: __________ Date: __________

Additional Comments:

HISTORY

ISSUE	DATE	ISSUER	DESCRIPTION OF CHANGES
00	04/16/2013	ZMA	ISSUE FOR RELEASE
01			
02			

ZBB ENERSTORE™
50V3.1

50V3.1 FINAL TEST CHECK LIST

NOTE –
THIS TEST/INSPECTION WERE PERFORMED BY ZBB QUALIFIED PERSONNEL ONLY

F-TE-07
REV 02
03/07/2013

Module Serial Number .... Date......................

Assembly and Test Document for V3.1 Module

CHECKED

1. F-MA-05 V3.1 Cabinet Prep Checklist ☐
2. F-MA-06 V3.1 Label Checklist ☐
3. F-MA-07 V3.1 Module Assembly Traveler ☐
4. F-MA-08 V3.1 Wiring Checklist ☐
5. F-EA-12 V3.1 DC/DC Controller Wire Checklist ☐
6. F-EA-13 V3.1 DC Controller Assembly Checklist ☐
7. F-TE-06 V3.1 Module Water/Leak Test Report ☐
8. F-EA-01 DC/DC converter Assembly Check List (4) ☐

- **Performed By:** ______________________
- **Checked By:** ______________________

MECHANICAL

CHECKED

1. Check and confirm that the module(s) has no physical damage. ☐
2. Check and confirm that the cooling air path(s) shall not be obscured by foreign object. ☐
3. Check and confirm that the Panel/Cabinet keys are supplied. ☐

- **Performed By:** ______________________
- **Checked By:** ______________________

ELECTRICAL

CHECKED

1. Check and confirm that all terminals are tightly connected per torque requirements. ☐
2. Check and confirm that all wirings are in conformance with the electrical schematics. ☐
3. Check and confirm that all test equipment used for continuity test are calibrated. ☐

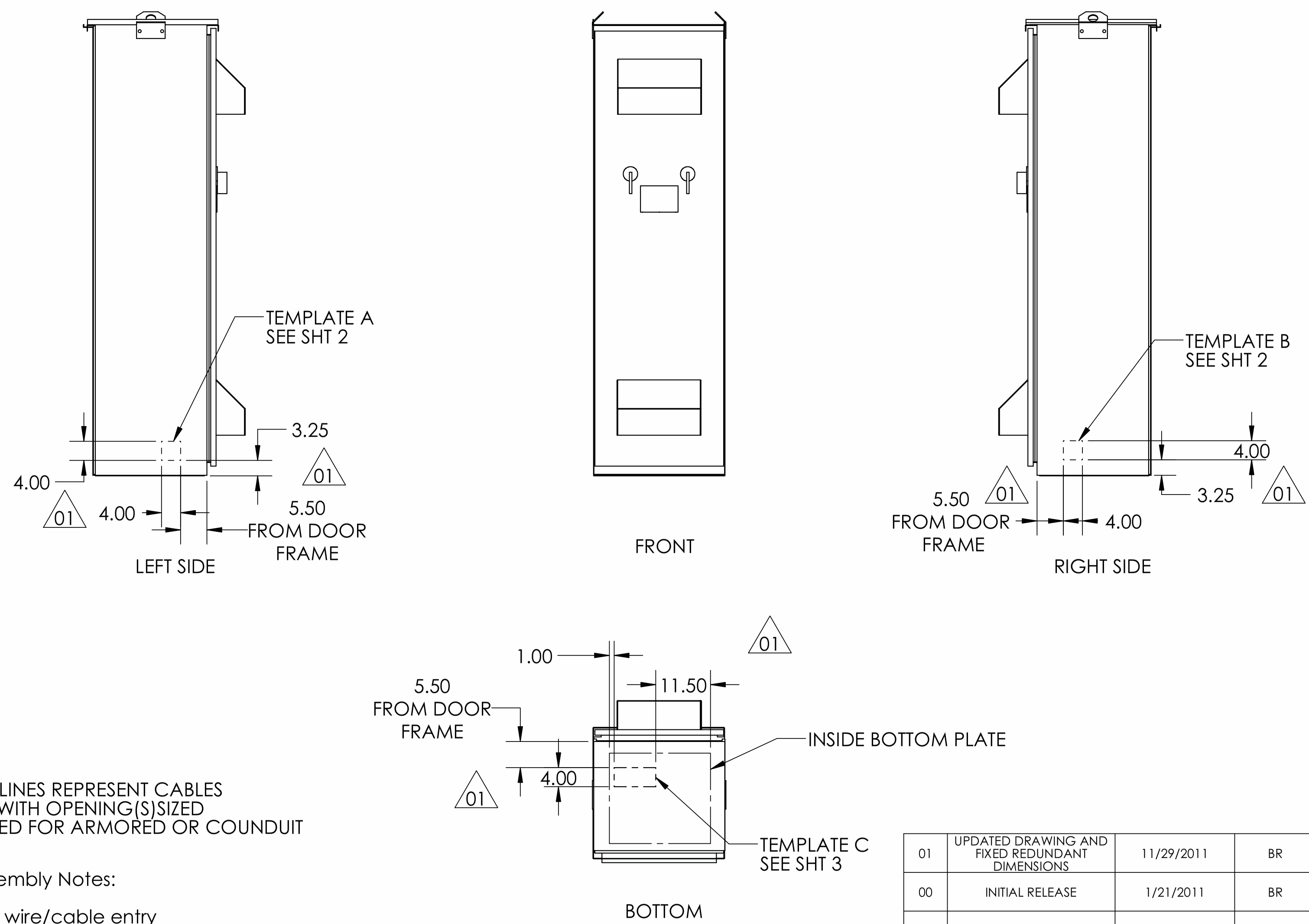
Components	Tight Connection, Wirings and Continuity	CHECKED	FUNCTIONALITY CHECKED
11-DC/DC BATT25-01	Incoming and outgoing terminals	☐	☐
11-DC/DC BATT25-02	Incoming and outgoing terminals	☐	☐
11-DC/DC BATT25-03	Incoming and outgoing terminals	☐	☐
11-DC/DC BATT25-04	Incoming and outgoing terminals	☐	☐

Components	Tight Connection, Wirings and Continuity	CHECKED	FUNCTIONALITY CHECKED
Fuses	Incoming and outgoing terminals	☐	☐
BATT-01 BATT-05	Incoming and outgoing terminals	☐	☐
BATT-02 BATT-06	Incoming and outgoing terminals	☐	☐
BATT-03 BATT-07	Incoming and outgoing terminals	☐	☐
BATT-04 BATT-08	Incoming and outgoing terminals	☐	☐
XC-1 CONTACTOR	Incoming and outgoing terminals	☐	☐
XC-2 CONTACTOR	Incoming and outgoing terminals	☐	☐
XC-3 CONTACTOR	Incoming and outgoing terminals	☐	☐
90-PSU-24-1	Incoming and outgoing terminals	☐	☐
90-PSU-24-2	Incoming and outgoing terminals	☐	☐
90-PSU-24-3	Incoming and outgoing terminals	☐	☐
90-PSU-24-4	Incoming and outgoing terminals	☐	☐
RELAY-1	Incoming and outgoing terminals	☐	☐
RELAY-2	Incoming and outgoing terminals	☐	☐
TB1	Incoming and outgoing terminals	☐	☐
F1-HEAT EXCHANGER FAN	Incoming and outgoing terminals	☐	☐
F2-DC/DC FAN	Incoming and outgoing terminals	☐	☐
F3-DC/DC FAN	Incoming and outgoing terminals	☐	☐
F6-APC FAN	Incoming and outgoing terminals	☐	☐
ENERSYSTEM COMM	Incoming and outgoing terminals	☐	☐
YC-03 (CATHOLYTE MOTOR)	Incoming and outgoing terminals	☐	☐
SE-03 (HALL SENSOR)	Incoming and outgoing terminals	☐	☐

Components	Tight Connection, Wirings and Continuity CHECKED		FUNCTIONALITY CHECKED
YC-04 (ANOLYTE MOTOR)	Incoming and outgoing terminals	☐	☐
SE-04 (HALL SENSOR)	Incoming and outgoing terminals	☐	☐
YC-01 (VALVE1)4WV	Incoming and outgoing terminals	☐	☐
YC-01 (VALVE2)2WV	Incoming and outgoing terminals	☐	☐
LS-01 (LEAK 1)	Incoming and outgoing terminals	☐	☐
LS-02 (LEAK 2)	Incoming and outgoing terminals	☐	☐
TE-01 (THERMOCOUPLE-ELECTROLYTE)	Incoming and outgoing terminals	☐	☐
TE-02 (THERMOCOUPLE-AMBIENT)	Incoming and outgoing terminals	☐	☐
TS1- (THERMOSNAP-CATHOLYTE)	Incoming and outgoing terminals	☐	☐
TS2- (THERMOSNAP-ANOLYTE)	Incoming and outgoing terminals	☐	☐
TS3- (THERMOSNAP-2ND PHASE TANK)	Incoming and outgoing terminals	☐	☐

- **Performed By:** ______________________ **Date** ______________

- **Checked By:** ______________________ **Date** ______________



NOTE:

ALL DOTTED LINES REPRESENT CABLES
TO THE PCU WITH OPENING(S)SIZED
AND INTENDED FOR ARMORED OR COUNDUIT

General Assembly Notes:

1) Fittings for wire/cable entry
shall be liquidtight and /or be
NEMA4 rated w/appropiate temperature
and ratings.

2) Wiring Methods to be Class 1 & Materials per NEC, UL & local
governing bodies.

REV.	ECN #	DATE	BY
01	UPDATED DRAWING AND FIXED REDUNDANT DIMENSIONS	11/29/2011	BR
00	INITIAL RELEASE	1/21/2011	BR

REVISIONS

SIM TO: 700001
Material:
Finish:

UNLESS OTHERWISE NOTED
FINISH PART TOLERANCES-IN INCHES
X.X±.060 ANGULAR
X.XX±.015 ±1
X.XXX±.005 DEGREE

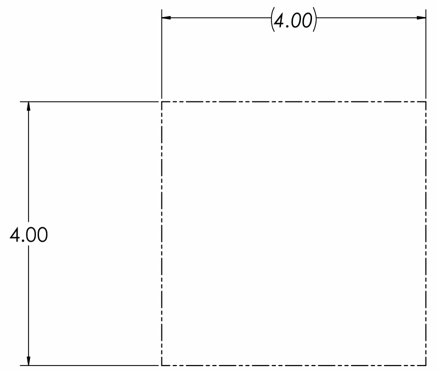
THIS DOCUMENT IS DRAWN AND
MAINTAINED AS A 3D SOLID MODEL

Confidential property of
ZBB TECHNOLOGIES, INC.

DWN.	DATE	APPD.	DATE
BLR	01/21/2011	.	9/20/2011
CKD. .	DATE 9/20/2011	WHERE USED:	

DESCRIPTION
AC-PCU
25kVA UL-1741 INVERTER

SCALE:	PART #	SHEET:	REV:
1:24	10-000075	1 OF 4	01



AC-PCU
25 kVA UL-1741 INVERTER
TEMPLATE A&B QTY 2 REQ.
LEFT & RIGHT LOWER SIDE
WIRE ENTRY TEMPLATE
SCALE-1:1

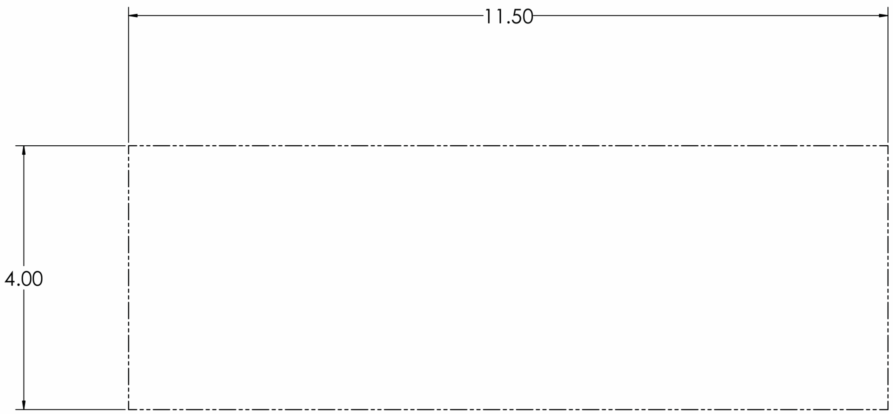
SIM TO:	
MATERIAL:	
FINISH:	

UNLESS OTHERWISE NOTED:
FINISH PART TOLERANCES - IN INCHES
X.X: ±.060
X.XX: ±.015
X.XXX: ±.005
ANGULAR ±1°

DWN: PJB	DATE: 8/9/2011	APPD: BLR	DATE: 5/04/2011
CKD: PJB	DATE: 5/04/2011	WHERE USED:	

DESCRIPTION:
UL-1741 25kVA PCU Inverter
Wire Entry Template

SCALE:	PART #:	SHEET:	REV:
1:1	10-000075	2 OF 4	01



AC-PCU
25kVA UL-1741 INVERTER
TEMPLATE C QTY. 1 REQ.
BOTTOM SIDE LOCATION
WIRE ENTRY TEMPLATE
SCALE-1:1

SIM TO:	
MATERIAL:	
FINISH:	

UNLESS OTHERWISE NOTED:
FINISH PART TOLERANCES - IN INCHES
X.X: ±.060 ANGULAR
X.XX: ±.015 ±1°
X.XXX: ±.005

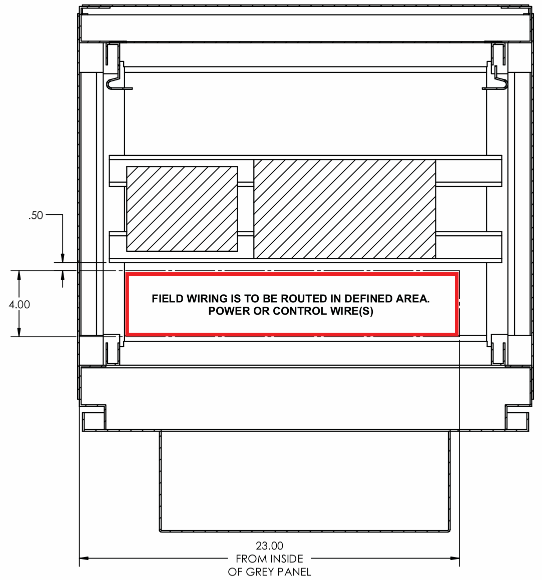
THIS DOCUMENT IS DRAWN AND MAINTAINED AS A 3D SOLID MODEL

CONFIDENTIAL PROPERTY OF
ZBB TECHNOLOGIES, INC.

DWN: PJB	DATE: 8/9/2011	APPD: BLR	DATE: 5/04/2011
CKD: PJB	DATE: 5/04/2011	WHERE USED:	

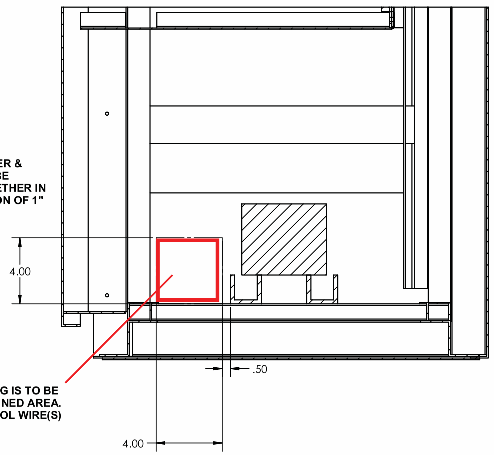
DESCRIPTION:
UL-1741 25 kVA PCU Inverter
Wire Entry Template

SCALE:	PART #:	SHEET:	REV:
1:1	10-000075	3 OF 4	01



NOTE:
IN AREA(S) WHERE POWER & CONTROL WIRE(S) MAY BE ROUTED THROUGH TOGETHER IN PARALLEL, A SEPARATION OF 1" MINIMAL CLEARANCE IS REQUIRED.

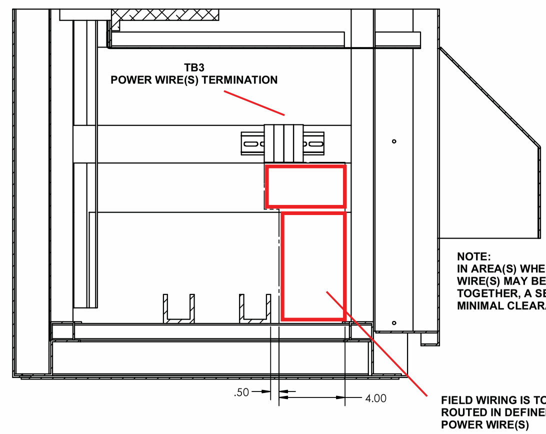
BOTTOM CABLE WIRING AREA
TOP VIEW



FIELD WIRING IS TO BE ROUTED IN DEFINED AREA.
POWER OR CONTROL WIRE(S)

BOTTOM CABLE WIRING AREA
ELEVATION
VIEWED FROM THE RIGHT TOWARD THE LEFT

TB3
POWER WIRE(S) TERMINATION

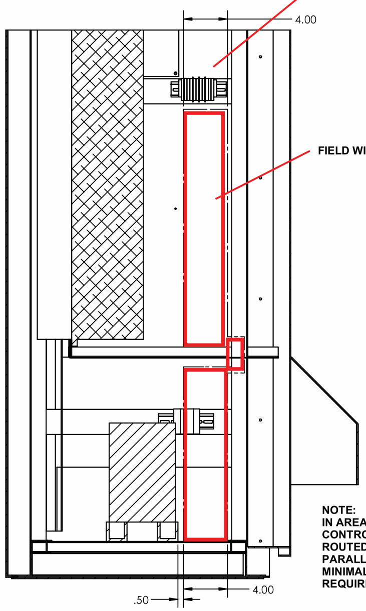


NOTE:
IN AREA(S) WHERE POWER & CONTROL WIRE(S) MAY BE ROUTED THROUGH TOGETHER, A SEPARATION OF 1" MINIMAL CLEARANCE IS REQUIRED.

FIELD WIRING IS TO BE ROUTED IN DEFINED AREA.
POWER WIRE(S)

RIGHT SIDE CABLE WIRING AREA
VIEWED FROM THE LEFT TOWARD THE RIGHT

TB2
CONTROL WIRE(S) TERMINATION



FIELD WIRING IS TO BE ROUTED IN DEFINED AREA.
CONTROL WIRE(S)

NOTE:
IN AREA(S) WHERE POWER & CONTROL WIRE(S) MAY BE ROUTED THROUGH TOGETHER IN PARALLEL, A SEPARATION OF 1" MINIMAL CLEARANCE IS REQUIRED.

CONTROL WIRING AREA
(OPTIONAL)

ZBB energy corporation

THIS DOCUMENT IS DRAWN AND MAINTAINED AS A 3D SOLID MODEL

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ZBB TECHNOLOGIES, INC.

DWN: BLR	DATE: 5/04/2010	APPD: BLR	DATE: 5/04/2011
CKD: PJB	DATE: 5/04/2011	WHERE USED:	

DESCRIPTION: WIRE ROUTING
AC-PCU
25kVA UL-1741 INVERTER

SCALE:	PART #:	SHEET:	REV:
1:1	10-000001	4 OF 4	01

SIM TO: 700001
MATERIAL:
FINISH:

UNLESS OTHERWISE NOTED:
FINISH PART TOLERANCES - IN INCHES
X.X: ±.060 ANGULAR
X.XX: ±.015 ±1°
X.XXX: ±.005

THREE LINE DIAGRAM

UL-1741 25kW PECC-INVERTER

CUSTOMER:	.
PLANT LOCATION:	.
PLANT NAME:	.
ZBB JOB:	PRD1001

REFERENCE	
MECHANICAL LAYOUT	10-000001
EQUIPMENT INDEX	30-000002

TABLE OF CONTENTS

REV#	DESCRIPTION	DATE	BY
REV# 01	UPDATED TO INCLUDE ADDITIONAL FAN & MARKINGS	10/02/11	DV
REV# 00	INITIAL RELEASE	06/11/11	DV

REVISIONS

01 06/11/11 DV KD

ZBB energy corporation

DV 06/11/11 KD 06/11/11

DV 06/11/11 PRD-1001

COVER
UL-1741 25kW PECC INVERTER

SCALE NONE 20-000018 SHEET 1 of 3 REV 00

TABLE OF CONTENT

EQUIPMENT NO. PHILOSOPHY – PREFIX

NO.	DESCRIPTION (IEEE C37.2)
3	CHECKING OR INTERLOCKING RELAY 3Cx = contact
4	MASTER CONTACTOR 4X/xx = auxiliary contact
8	CONTROL POWER DISCONNECTING DEVICE
11	MULTIFUNCTIONAL DEVICE / EQUIPMENT
23	TEMPERATURE CONTROL DEVICE
30	ANNUNCIATOR RELAY
34	MASTER SEQUENCE DEVICE
43	MANUAL TRANSFER OR SELECTOR DEVICE
52	AC CIRCUIT BREAKER
75	POSITION CHANGING MECHANISM
89	LINE SWITCH
90	REGULATING DEVICE

LEGEND

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
XXX YYY/ZZZ	CIRCUIT BREAKER, (600VAC, 250VDC), 3 POLE, THERMAL-MAGNETIC UNLESS NOTED. XXX = IDENTIFIER (IEEE C37.2, ISA 5.1) YYY = FRAME SIZE (A) YYY = INTERRUPTING CURRENT (KA)	XXX – [YYY]	ENCLOSURE OR PANEL XXX = PANEL DESCRIPTION / TAG YYY = LOCATION
XXX/YY ZZ	DISCONNECT SWITCH, OPEN TYPE. XXX = FRAME SIZE (V) YYY = FRAME SIZE (A) ZZ = POSITION AND/OR IDENTIFIER	XXX	INVERTER (208VAC, 3PHASE, 60HZ) UNLESS NOTED. XXX = SIZE (KVA)
XXX/YYY	FUSE, (600VAC, 250VDC) UNLESS NOTED. XXX = FRAME SIZE (A) YYY = INTERRUPTING CURRENT (KA)	XXX YYY ZZZ	CONVERTER XXX = MAX CURRENT CHARGE/DIS-CHARGE YYY = OPERATING VOLTAGE RANGE ZZZ = ADDITIONAL INFORMATION
XXX Y, Z	BRANCH CIRCUIT, 208VAC L-L, 1 WIRE UNLESS NOTED XXX= VOLTAGE LINE Y = PHASE Z = NUMBER OF WIRES	XXX YYY ZZZ	BATTERY XXX = MAX POWER OUT (kW) YYY = MAX VOLTAGE (V) ZZZ = MAX AMPREAGE (A)
XXX Y, Z	BRANCH CIRCUIT, SINGLE PHASE AS DENOTED BY (1) DIAGONAL LINE. XXX = VOLTAGE LINE Y = PHASE Z = NUMBER OF WIRES		FIBER OPTICS.
XXX YYY	DC BRANCH CIRCUIT. XXX = FLA RATING YYY = LOCATION/IDENTIFIER	XXX YYY/ZZZ	REACTOR XXX = IDENTIFIER (IEEE C37.2, ISA 5.1) YYY = VOLTAGE (V) ZZZ = CURRENT (A)
XXX YYY:ZZZ	TRANSFORMER, 3 PHASES & 4 WIRES UNLESS NOTED. WYE & Δ CONNECTIONS ARE INDENTIFIED. XXX = VA RATINGS IN KVA YYY = PRIMARY SIDE VOLTAGE ZZZ = SECONDARY SIDE VOLTAGE	XXX YYY/ZZZ	THERMOSTAT XXX = IDENTIFIER (IEEE C37.2, ISA 5.1) YYY = VOLTAGE (V) ZZZ = CURRENT (A)
XXX YYY	SCOPE OF SUPPLY, GENERALLY DEFINES THE MECHANICAL, ELECTRICAL & SOFTWARE SCOPES OF SYSTEM. XXX = SCOPE INDICATED YYY = SCOPE INDICATED	XXX YYY/ZZZ	TRANSFORMER, 1 PHASE & 2 WIRES XXX = VA RATINGS IN KVA YYY = PRIMARY SIDE VOLTAGE (V) ZZZ = SECONDARY SIDE VOLTAGE (V)
XXX-Y	CIRCUIT BRANCH CONNECTION (ONLY FOR DRAWING PURPOSE), EACH CRKT BRANCH CONNECTION(S) IS DEFINED BY TABLE IN EACH APPLICABLE PAGE(S). XXX = ENCLOSURE IDENTIFIER Y = CONNECTION IDENTIFIER (A~Z)	XXX YYY/ZZZ	4-POLE DC DISCONNECT SWITCH XXX = IDENTIFIER (IEEE C37.2, ISA 5.1) YYY = CURRENT (A) ZZZ = INTERRUPTING CURRENT (kA)
XXX/YYY Z-Z WWW	POTENTIOMETER TRANSMITTER (PT). WWW = SIGNAL DESTINATION XXX = PRIMARY VOLTAGE YYY = SECONDARY VOLTAGE Z-Z = CONNECTION TYPE		

GENERAL NOTES

1. WIRING METHODS & MATERIALS PER NEC, UL & LOCAL GOVERNING BODIES.
2. THREE LINE DRAWING DOES NOT DEPICT THE PHYSICAL LOCATION OF ENCLOSURE & EQUIPMENT.

01	06/11/11	DV	KD

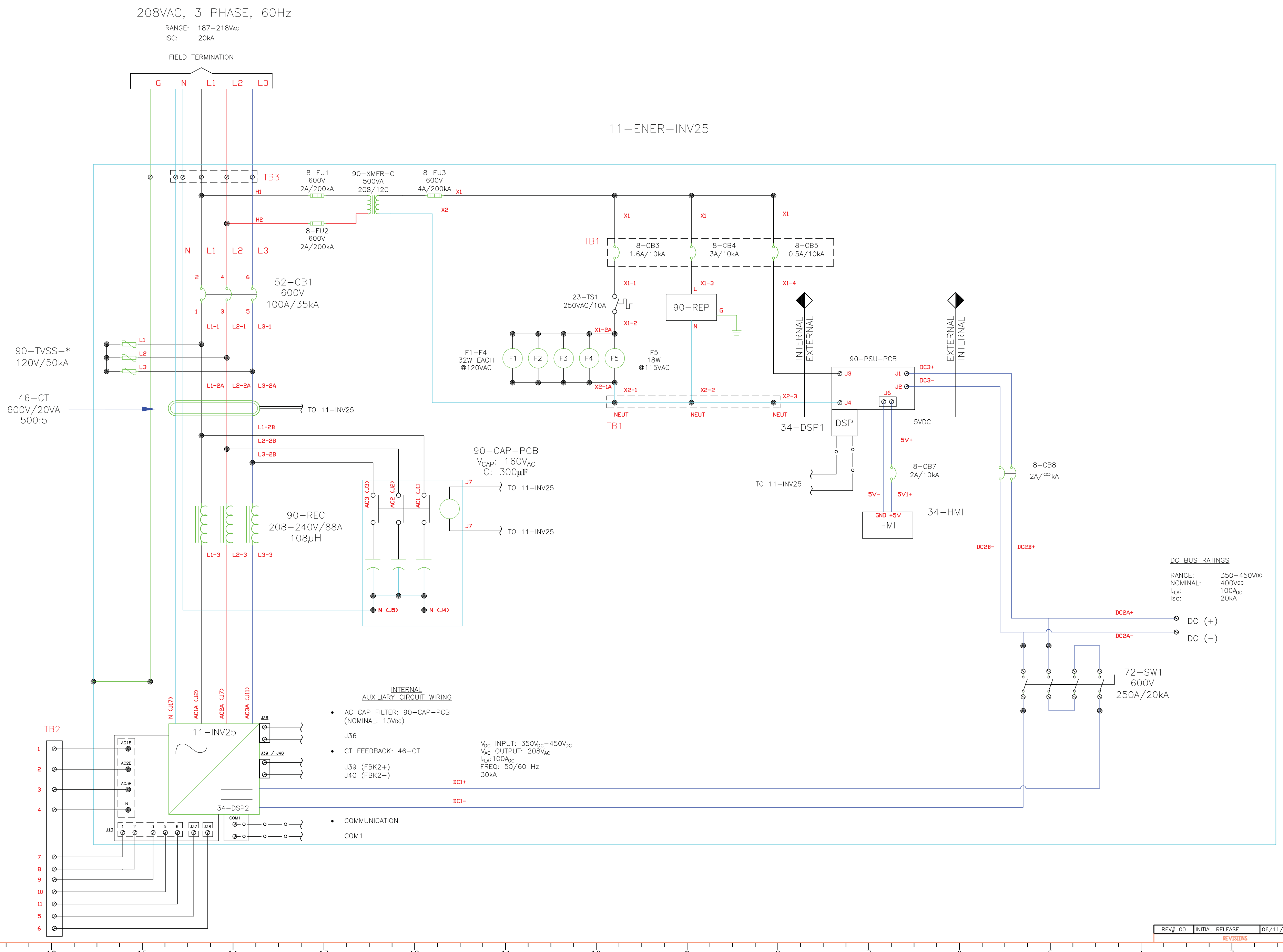
REV# 00	INITIAL RELEASE	06/11/11	DV

REVISIONS

DWN.	DATE	APPD.	DATE
DV	06/11/11	KD	06/11/11
CKD. DV	DATE 06/11/11	WHERE USED: PRD-1001	

DESCRIPTION
T.O.C, LEGEND & GENERAL NOTES
UL-1741 25kW PECC INVERTER

SCALE:	DWG #	SHEET:	REV.
NONE	20-000018	2 of 3	00



EQUIPMENT LIST

EQUIPMENT NO.	DESCRIPTION
11–PECC–INV30	UL–1741 PECC INVERTER
11–INV30	INVERTER (POWER MODULE)
34–DSP1	SYSTEM CONTROLLER
34–DSP2	POWER MODULE CONTROLLER
34–HMI	HUMAN MACHINE INTERFACE
52–CB1	AC CIRCUIT BREAKER (3P)
72–SW1	DC DISCONNECT SWITCH (3P)
90–REC	REACTOR (INDUCTOR)
90–TVSS–L1	TRANSIENT VOLTAGE SURGE SUPRESSOR
90–TVSS–L2	TRANSIENT VOLTAGE SURGE SUPRESSOR
90–TVSS–L3	TRANSIENT VOLTAGE SURGE SUPRESSOR
90–CAP–PCB	CAPACITOR BANK
90–XMFR–C	CONTROL TRANSFORMER
8–FU1	FUSE
8–FU2	FUSE
8–FU3	FUSE
8–CB3	AC CIRCUIT BREAKER (1P)
8–CB4	AC CIRCUIT BREAKER (1P)
8–CB5	AC CIRCUIT BREAKER (1P)
8–CB7	DC CIRCUIT BREAKER (1P)
8–CB8	DC CIRCUIT BREAKER (2P)
23–TS1	THERMOSTAT DISC
90–RECP	OUTLET (GFCI)
46–CT	CURRENT TRANSDUCER

FIELD TERMINATION

TB2 (TERMINAL BLOCK 2)

- GRID VOLTAGE FEEDBACK (RANGE: 200–500Vac)

  –J31, AC1B
  –J30, AC2B
  –J29, AC3B
  –J32, N

- SWITCH CLOSED CONTACT FEEDBACK (NOMINAL: 120Vac)

  –J13, PIN 1
  –J13, PIN 2

- SWITCH SIGNAL COMMAND (NOMINAL: 120Vac)

  –J13, PIN 3
  –J13, PIN 5
  –J13, PIN 6

- SWITCH OPEN CONTACT FEEDBACK (NOMINAL 120VAC)

  –J37
  –J38

TB3 (TERMINAL BLOCK 3)

- AC POINT OF CONNECTION

  L1
  L2
  L3
  N
  G

1. WIRING METHODS & MATERIALS PER NEC, UL & LOCAL GOVERNING BODIES.
2. SINGLE LINE DRAWING DOES NOT DEPICT THE PHYSICAL LOCATION OF ENCLOSURE & EQUIPMENT.

REV# 00	INITIAL RELEASE	06/11/11	DV
REVISIONS			

01	06/11/11	DV	KD

DWN. DV	DATE 06/11/11	APPD. KD	DATE 06/11/11
CKD. DV	DATE 06/11/11	WHERE USED: PRD–1001	

DESCRIPTION
THREE LINE DIAGRAM
UL–1741 25kW PECC INVERTER
PECC INVERTER PCU &
POWER MODULE

SCALE: NONE	DWG # 20–000018	SHEET: 3 of 3	REV. 00

ZBB ENERSECTION™
AC- Power Conversion Unit
25kVA UL-1741 INVERTER

Operation Manual

30-000072

Table of Contents

I. IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This manual contains important instructions for Model **11-ENER-INV25** that shall be followed during installation and maintenance of the ZBB ENERSECTION™ AC-POWER CONVERSION UNIT.

• THIS MANUAL CONTAINS IMPORTANT INSTRUCTIONS FOR ZBB ENERGY CORPORATION EQUIPMENT THAT SHALL BE FOLLOWED DURING INSTALLATION, OPERATION, MAINTENANCE, AND ROUTINE SERVICE.

• FOLLOW ALL APPLICABLE SAFETY INFORMATION DURING INSTALLATION, OPERATION, INSPECTION, SERVICE, AND MAINTENANCE OF ZBB ENERGY CORPORATION EQUIPMENT.

INTRODUCTION & CONTACT INFORMATION

ZBB Energy Corporation (hereafter, "ZBB") products meet all applicable industry safety standards. ZBB actively promotes safe practices in the use and service of its equipment through training programs, manuals, and the various proactive efforts of its personnel covering design, engineering, manufacturing, marketing, and service.

This manual cannot possibly cover all details or variations in equipment, procedures, or processes described, and cannot provide directions for every possible contingency during operation, inspection, or service. When additional information is needed or desired to meet a situation not covered sufficiently, consult

ZBB Service and Technical Support:

ZBB Energy Corporation
N93 W14475 Whittaker Way
Menomonee Falls, WI 53051
(262) 253-9800 • Extension 158

Business Hours

7:00 a.m. to 5:00 p.m.
United States Central Time Zone

ZBB 24 x 7 Service Phone Line:

(262) 442-1216

SAFETY INFORMATION

The following information provides GENERAL safety information, including a brief overview of safety, designation of signal words and symbols, hazard statement definitions, notification of hazards, methods to help avoid hazards, and brief statements of the consequences that can occur when failing to follow the safety information. For safe operation and service of ZBB equipment, read, understand, and follow all safety information.

Initial Start-up / Commissioning
The initial verification of system installation, startup of the equipment and / or system, known as *commissioning*, is a very specific and necessary safety procedure. **Equipment and system commissioning is to be performed only by a ZBB-factory certified technician.** Contact the factory to arrange a time and place to have the equipment or system serviced. Violation of this commissioning statement could result in a voided warranty.

The information contained in this manual does not replace any other safety information, practices, or proper judgment. Government agencies, various corporations and employers have their own laws, regulations, codes, and rules. Before starting to operate or work on the equipment, ask about the safety policy in effect at the equipment location. BEFORE attempting to operate, inspect, service, maintain, or test the equipment, learn the safety requirements that are in effect at each location. Safety depends on properly following all appropriate safety requirements.

Safety is most important. Many factors contribute to safe – or unsafe – conditions, including but not limited to:

- Alcohol and / or Drugs
- Attitude
- Carelessness
- Distractions
- Fatigue
- Inattentive / irresponsible behavior
- Overload
- Unfamiliarity with the equipment

YOU are the most important contributor to your own safety. Equipment can be repaired or replaced – death and many injuries are permanent. For the best results, think and act safely and encourage others to do so as well.

Invest in your safety by reading, understanding, and following the information in this manual. Obey all applicable laws, regulations, rules, codes, locally-mandated practices and procedures. Before attempting to conduct any operation or operation-service on ZBB and associated equipment, consider all of the circumstances, conditions, and other factors that can have an effect on the safety of personnel and property. Take appropriate action to assure safety at all times.

This manual is not intended as a substitute for appropriate training and experience covering the safe operation of the equipment. Only ***authorized, qualified personnel*** with the proper background and knowledge are permitted to inspect, install, operate, and service ZBB equipment.

AUTHORIZED, QUALIFIED PERSONNEL

The term "authorized, qualified personnel" is used throughout this manual and is defined as follows: **Authorized, qualified personnel meet these *minimum* qualifications:**

- *Trained and experienced with safe operating practices, procedures, and accepted high-voltage and low-voltage safety and practical techniques covering electrical power devices and power electronics equipment.*
- *Trained and experienced with the use and care of Personal Protective Equipment (PPE), including but not limited to flash-protective clothing, voltage-insulating rubber gloves, face shield, hard hat, safety glasses, and more.*
- *Trained and authorized to work with the type of equipment that this instruction manual covers, including but not limited to energizing, de-energizing, grounding, and clearing electrical power equipment.*
- *Trained and authorized to work with applicable tools and instruments,*
- *Trained, authorized, and qualified by ZBB Energy Corporation to inspect, install, operate, and service ZBB products.*
- *Has read, understands and follows this manual.*

ONLY ***authorized, qualified*** personnel, *as defined*, are permitted to access equipment supplied by ZBB Energy Corporation.

Before attempting to operate or service ZBB equipment, know where to obtain medical assistance, how to contact emergency personnel, and how to use a first aid kit and a fire extinguisher or other type of fire suppression system. *If working alone, routinely check with another person to help assure your safety*.

Keep emergency telephone numbers (fire, police, first responder, etc.) with you:

Fire: ____________________

Police: ____________________

First Responder: ____________________

Other (personal, etc.): ____________________

HAZARD STATEMENT IN THIS MANUAL

The exclamation mark within a triangle is the Safety Alert Symbol:

⚠

The Safety Alert Symbol means **ATTENTION!** BE ALERT! SAFETY IS INVOLVED!

The symbol is used to direct your attention to safety hazards involving the equipment or procedures. It is used throughout this manual.

Whenever you see the Safety Alert Symbol: **PAY ATTENTION!** Read, understand, and follow the information included. Your life, health, and safety depend on your appropriate actions.

The message that follows the Safety Alert Symbol includes important details about safety. To avoid possible death or injury, carefully read, understand, and follow all safety messages. Fully understand the potential causes of death or injury and other hazards and comply with safe methods to avoid death or injury.

Hazard Statement Definitions

FAILURE TO UNDERSTAND AND OBEY THESE HAZARD STATEMENTS AND THE ACCOMPANYING INFORMATION COULD RESULT IN DEATH, SERIOUS INJURY / DISMEMBERMENT, OR DAMAGE TO PROPERTY. This manual contains four basic types of hazard communication statements identified by signal words and the presence, or lack, of the Safety Alert Symbol:

⚠ **DANGER: Indicates an impending hazardous situation, which, if not avoided, *WILL* lead to death or serious injury.**

The signal word **DANGER** signifies that an extremely hazardous situation exists and will definitely result in **death or severe injury** if proper precautions are not taken.

⚠ **WARNING**: Indicates a potentially hazardous situation, which, if not avoided, ***could*** lead to death or serious injury.

The signal word **WARNING** signifies that a hazardous situation exists with, or involving, the equipment, which can result in **death or injury** if proper precautions are not taken.

⚠ **CAUTION**: Indicates a potentially hazardous situation, which, if not avoided, ***may*** lead to moderate or minor injury. May also provide an alert to help avoid unsafe practices.

The signal word **CAUTION** signifies that a potentially hazardous situation exists and may result in **injury** if proper precautions are not taken.

CAUTION: Indicates a potentially hazardous situation, which, if not avoided, may lead to equipment damage.

The absence of the Safety Alert Symbol with the use of the signal word **CAUTION** signifies that a potentially hazardous condition exists that may result in **equipment damage only** if proper precautions are not taken.

Additional Types of Special Messages

This instruction also includes the following types of special information:

IMPORTANT! Indicates important information required for proper installation, maintenance, and / or operation.

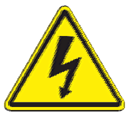
NOTE: Provides further information covering procedures, methods, etc.

HAZARD STATEMENT ON EQUIPMENT

There are safety symbol(s) and label(s) adhered to the equipment. They are used to direct your attention to safety hazards involving the equipment or procedures.

General Symbol

The electrical shock mark within a triangle is the CAUTION – RISK OF ELECTRICAL SHOCK Symbol:



The CAUTION – RISK OF ELECTRIC SHOCK Symbol means **ATTENTION!** BE ALERT! SAFETY IS INVOLVED!

Whenever you see the CAUTION – RISK OF ELECTRIC SHOCK symbol: **PAY ATTENTION!** Read, understand, and follow the information included. Your life, health, and safety depend on your appropriate actions.

Additional Safety Information (I)

Information following the "CAUTION – RISK OF ELECTRIC SHOCK" symbol will alert and/or advise personnel of potential danger.

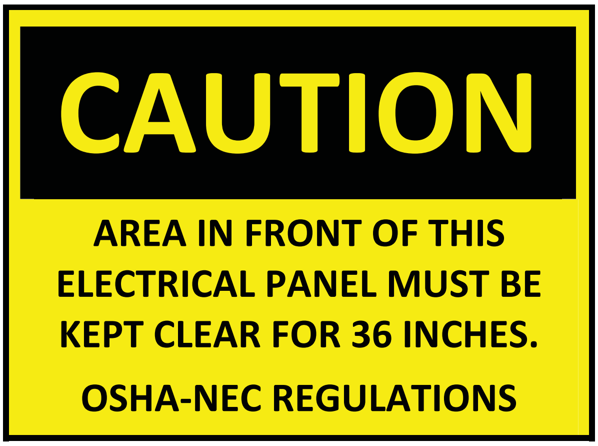
LIVE VOLTAGE

EXCLUSIVE OF DEVICE'S OPERATION

Additional Safety Information (II)

Whenever you see the "CAUTION" in bold yellow letters accented by a dark background with additional safety information, **PAY ATTENTION!** Read, understand, and follow the information included. Your life, health, and safety depend on your appropriate actions.

Example of Cautionary Label:



Additional Safety Information (III)

Additional Types of Special Messages

The unit also includes the following types of special information:

IMPORTANT! Indicates important information required for proper installation, maintenance, and / or operation.

NOTE: Provides further information covering procedures, methods, etc.

II. INTRODUCTION

This manual provides set up and installation instructions, operation information and basic troubleshooting procedures for the ZBB Power Control Unit; hereafter referred to as the PCU Module.

Read This Manual First

BEFORE attempting to operate or to install this equipment, read, understand, and follow this manual. Follow all locally approved procedures and safety practices.

WARNING: POTENTIAL FOR DEATH OR SERIOUS INJURY.

• This manual is intended for use by ***authorized, qualified*** personnel ONLY.

• To help reduce the risk of electric shock, DO NOT attempt to operate or service the unit in any manner other than described in this manual.

Standards

ZBB Energy Corporation equipment is designed and/or tested in accordance with ANSI standards IEEE 1547, NEC, NFPA, and UL 1741.

The Quality System at the ZBB Energy Corporation factory is ISO 9001 certified.

Additional Information

These instructions cannot cover all details or variations in the equipment, procedures, or process described, nor to provide directions for meeting every possible contingency during installation, operation, or maintenance. When additional information is desired to satisfy a problem not covered sufficiently for the user's purpose, please contact ZBB Energy Corporation Service & Technical Support.

ACCEPTANCE AND INSPECTION

Each unit is completely assembled, inspected, tested, adjusted, and properly packed for shipping at the factory. All ZBB equipment is in good condition when accepted by the carrier for shipment with appropriate documentation(s).

At the time of receipt, refer to packaging document(s) & inspect all equipment for physical damage. Conduct the inspection in the presence of your personnel and / or a representative of ZBB Energy Corporation. Refer to appendixes for Incoming Inspection List & Corrective Action Response form.

Upon receipt of ZBB equipment:

1. Inspect the equipment thoroughly for physical damage and loss of parts incurred during shipment. If damage or loss is discovered, file a claim with the carrier immediately.
2. Record and describe all physical damage; when possible make a photographic record and report all negative findings to the shipping company and / or delivery personnel, including submitting a Corrective Action Response to ZBB.
3. With ZBB approve & if applicable, tighten any fasteners that may have loosened during shipment, especially those securing components and wiring connectors to the base of the unit.
4. Examine equipment to ensure that all mechanical components function as designed. Verify that there electrical components have not sustained “breaking force” and that there is no water damage to the unit. Check for signs of obvious trauma, abuse and / or damage.

HANDLING AND STORAGE

Handle and store the equipment in such a way as to help minimize the possibility of any type of damage, particularly to the electronic components.

The ZBB PCU mechanical ratings & dimensions are given in the Appendixes and is packed and shipped in a secure container or crate. Use appropriate lifting methods, preferably with the assistance of a helper and avoid personal injury or equipment damage.

If the equipment is to be stored for an appreciable time before installation, provide a clean, dry, safe INDOOR storage area and keep the equipment in its original shipping carton.

General Description

The ZBB PCU is a component that converts from and to various types of ac and dc power.

The PCU offers a modular, configurable architecture that connects multiple AC and DC power sources directly to energy storage units with variable AC & DC power load outputs. The PCU is designed to operate in grid interactive, grid independent and grid conversion scenarios providing active and reactive power control.

The PCU can function in a wide array of applications and is basically a dc-to-ac converter that is self-supportive and can be positioned on or off the grid.

The PCU is provided with a NEMA 3R enclosure, operating from -30°C to +50°C and grounding is via a grounding bar conveniently positioned at the enclosure's bottom front entrance.

The PCU is fully self-protected from utility disturbances and externally applied short circuits (ac, dc and input power).

When supplied with other ZBB products and systems, such as the ZBB Zinc Energy Storage System (EnerStore) or other bulk energy storage devices, the ZBB PCU helps to comprise a platform that creates an expandable power plant system to independently optimize supply of each generating source.

Each unique platform configuration provides an intelligent energy management system to realize multiple value streams including reducing use of fossil gen sets, firm and shift renewable generation outputs, deliver "supply response" storage dispatch, improve power quality and even be used as an emergency power system independently of the grid during outages.

The ZBB family of modular designs aims to increase or decrease power needed by either adding or subtracting modules in the string. This scalability allows for products suited to almost any power application. Other products do not provide these modular capabilities or transportable designs with their added benefits and flexibility.

III. INSTALLATION

ZBB technical services personnel are available to assist in the physical placement of the system equipment, if necessary.

SET UP

The PCU ships as a single cabinet. Mechanical and electrical connections shall be performed by an ***authorized, qualified*** responsible party. Installation and the wiring of the equipment are only to be performed by ZBB-trained personnel.

Lifting and Handling

Lift the PCU with a fork lift when the PCU is mounted on its pallet of by the lifting lugs.

⚠ **CAUTION**: POTENTIAL FOR PERSONAL INJURY.

• Improper lifting may result in moderate or minor injury.

• Follow all locally approved safety practices when lifting and mounting the equipment.

• Obtain the help of an assistant whenever possible.

• Use the lifting lugs provided.

• Lift the load smoothly.

• DO NOT allow the load to shift.

• Prevent body parts (including hair) and clothing from getting trapped between the unit and its mounting location.

• Provide adequate spacing in front of the unit per OSHA regulation.

CAUTION: POTENTIAL FOR EQUIPMENT DAMAGE.

• Improper lifting can result in equipment damage.

• Follow all locally approved safety practices when lifting and mounting the equipment.

• Use the lifting lugs provided. Lift the load smoothly and do not allow the load to shift.

• Provide adequate spacing in front of the unit to allow ventilation & opening door.

IV. COMMISSIONING

COMMISSIONING

WARNING: POTENTIAL FOR DEATH OR SERIOUS INJURY.

• These operation instructions are intended for use by ***authorized, qualified*** personnel as defined in the Safety section of these instructions.

Commissioning
The power up or re-start after service to the PCU, as with the initial verification of system installation, startup of the equipment and / or system, is a very specific and necessary safety procedure known as commissioning. **Equipment and system commissioning is to be performed only by a ZBB-factory certified technician.** Contact the factory to arrange a time and place to have your equipment or system serviced. Violation of this commissioning statement could result in a voided warranty.

IMPORTANT! This unit or system is provided with fixed trip limits and shall not be aggregated above 30 kW on a single Point of Common Connection.

POWER /CONTROL CABLE CONNECTIONS

IMPORTANT! Only ***authorized, qualified*** personnel may make cable connections to the unit.

Contact ZBB Energy Corporation for technical service.

COMMUNICATIONS CONNECTION

System Communication between the PCU and the user is serially through a PC (remotely) or supplied operator (locally). Any serial communication software may be used as long as it can run the necessary serial protocol described below. Any standard computer will then both be able to display various system signals as well as access to controls necessary to run the PCU. Two wire Fiber optic connections are used for direct connection between the PCU and serial interface.

Serial Communications

Using a fiber optic to DB-9 RS232 Connector, the following two DB-9 pins will be used:

Receive Data: Pin 2
Transmit Data: Pin 3

32 bit Serial (RS232) Communications Protocol

- Asynchronous serial transmission control
- Baud 19200
- 1 stop bit, 1 start bit
- Even Parity Check
- Start character $55 (0x55 in C)

PRE-ENERGIZE CHECKLIST

1. Confirm that all ac and dc power upstream / downstream of the ZBB PCU is locked out and tagged out and that all breakers are OFF.

2. Confirm that the PCU's power switch (es) are in the OFF position.

3. Confirm that all AC & DC connections are terminated properly.

4. Conduct a general inspection of the PCU. Verify that there is no visible damage, loose wires, moisture, etc.

5. Close and latch all panels and cabinet doors.

IMPORTANT! If unit was previously powered, allow 10 minutes for unit to dissipate power prior to touching any circuits.

APPYLING POWER

WARNING: POTENTIAL FOR DEATH OR SERIOUS INJURY.

• These operation instructions are intended for use by ***authorized, qualified*** personnel as defined in the Safety section of these instructions.

• Read & understand the instructions prior to energizing the unit.

• At any instance where the PCU is faulted or there is cause for potential issue(s), record fault code & shutoff the PCU and contact a ZBB representative immediately.

IMPORTANT! Prior to energizing the unit, familiarize with the **PCU OPERATION** in the following section.

1. Complete the **Pre-Energize Checklist**.

2. Operate ac & dc switch (es) upstream of the ZBB PCU as applicable to the on position.

3. **CONFIRM** the voltage feeding the PCU and that they are within the PCU ratings specified in Appendixes.

4. Operate the DC Switch to the ON position.

Note: If there is voltage on the DC bus, follow Steps 4.a-d before proceeding; otherwise skip to next step.

   a. Controller communication established.

   b. PCU is not in fault state & in state 1 (stop). If in fault state, reset to stop state. If unsuccessful, contact ZBB Service & Technical Support.

   c. DC Voltage / Current are typical with startup parameters.

   d. Confirm kW / kVar request & dispatch; typically set to 0.

5. Completing the previous step, operate the AC Switch to the ON position & confirm PCU'S controller is operating & parameters are within specs.

   a. Controller communication established.

   b. PCU is not in fault state & in state 1 (stop). If in fault state, reset to stop state. If unsuccessful, contact ZBB Service & Technical Support.

   c. AC Voltage / Current are typical with startup parameters.

6. Completing Step 5 and enabling the PCU (locally or remotely) through the interface, the PCU will automatically startup per IEEE 1547. During this wait period, the PCU will actively sense & sync to the Grid's Voltage/Frequency.

7. Once IEEE 1547 standard is met, the PCU is readily available to request or dispatch full kW / kVar (limited by Grid and/or renewable(s) power capacity)

8. Fans rotation will begin at any step once power is applied to the PCU's AC connections and is dependent on PCU internal temperature.

V. PCU OPERATIONS

This section provides procedures used to operate the PCU using serial communication controls.

(!	WARNING: POTENTIAL FOR DEATH OR SERIOUS INJURY. • This manual is intended for use by authorized, qualified personnel ONLY. • To help reduce the risk of electric shock, DO NOT attempt to operate or service the unit in any manner other than described in this manual.

Serial Protocol can be divided into two types:

Monitored Signals – Includes all pertinent system monitoring feedback information. (Read-Only)

Controls – Includes controller set points: state control, power request, and user configurable. (Read/Write)

The following table steps through how to operate the PCU when both the serial communications are established and the default parameters settings are valid.

Start Up Configuration	
Request Power(kW) to 0 kW	Write 0
Request Reactive (kVAR) to 0 kVAR	Write 0
Starting Unit	
Request state to Run	Write 3
Changing Power request	
Request Power(kW) to 6 kW	.i.e. Write 6
Request Reactive (kVAR) to 1 kVAR	.i.e. Write 1
Stopping Unit	
Request state to stop	Write 1

Monitoring Unit	
User State	.i.e. State 1
Last Fault (refer to Appendix E for description)	.i.e. 1000 Bus Over Voltage
Voltage AC Output (L-N)	.i.e. 120 Vrms
Current AC Output	.i.e. 68 Arms
Voltage DC	.i.e. 425 Vdc
Real Power (kW)	.i.e. 15kW
Reactive Power (kVAR)	.i.e. 15 kVAR

Power Down Procedure

The following power down procedure is for normal shut down of the ZBB PCU ONLY. Under Emergency situation, devices upstream / downstream of the PCU shall be exercised to isolate the PCU.

1. Confirm PCU is not requesting / dispatching real and/or reactive power & in state 1. Additionally check circuits upstream & downstream affected by procedure.

⚠	**WARNING**: POTENTIAL FOR DEATH OR SERIOUS INJURY. • If switches & overprotection devices are operated during load; run the risk of damaging unit and more importantly injuring or causing death to person(s).

2. Operate the DC Switch to the OFF position.
3. Operate the AC Switch to the OFF position.
4. Operate ac & dc switch (es) upstream of the ZBB PCU to the OFF position.

5. Confirm that all ac and dc power upstream / downstream of the ZBB PCU is locked out and tagged out and that all breakers are OFF.

6. BEFORE attempting to perform any operator-service verify that there is no power to or from any of the ac or dc circuits before proceeding.

7. Allow the system to have ten (10) minutes to completely dissipate its power.

8. After waiting ten (10) minutes, check the system visually.

IMPORTANT! If any lights are lit on the PCU, then it has not been powered down and is NOT safe to touch. Repeat steps 1-8 of this Power Down Procedure again and assure that no lights are lit on the PCU before proceeding.

9. When no lights are lit on the PCU, check the input and output circuits with a multimeter (if applicable) to assure that the PCU has completely discharged. There must be less than 50 volts within ten minutes of power down.

VI. OPERATOR SERVICE

⚠ WARNING: POTENTIAL FOR DEATH OR SERIOUS INJURY.

• These instructions are written for ***authorized, qualified*** personnel as defined in the Safety section of these instructions.

• No user serviceable parts inside.

Only ***authorized, qualified*** service technicians may attempt to service, remove, or replace ZBB Energy Corporation equipment/component.

Beyond the components that needs servicing; please contact ZBB Service & Technical Support.

VII. OPERATOR MAINTENANCE

⚠ WARNING: POTENTIAL FOR DEATH OR SERIOUS INJURY.

• These instructions are written for ***authorized, qualified*** personnel as defined in the Safety section of these instructions.

⚠ CAUTION: POTENTIAL FOR PERSONAL INJURY.

• Routine inspection and maintenance is required to help assure proper operation.
• Improper operation may lead to personal injury.
• Improperly maintained equipment may lead to equipment failure.
• To help prevent personal injury or improper operation, assure that the equipment is appropriately inspected and maintained.

Power electronics equipment manufactured by ZBB Energy Corporation requires routine inspection and maintenance to help assure safety, optimal performance, and proper operation.

When equipment is not properly maintained, operational failure may result. Establish and follow a routine maintenance program to help ensure proper, trouble-free operation.

IMPORTANT! Operator-service maintenance of the ZBB PCU is limited to visual inspection ONLY.

If additional service is needed, contact ZBB Service & Technical Support.

ADDITIONAL SAFETY INFORMATION

Personal Protective Equipment (PPE)

Wear appropriate PPE – safety glasses or goggles, flame resistant clothing, appropriately rated gloves, and head protection.

For example, certain regulations mandate that all workers wear protective helmets in areas where there is a possible danger of head injury from impact, falling or flying objects, or electrical shock and burns. Each worker is required to comply with both industry and company standards concerning when, where, and how to fit and wear protective helmets (hard hats). At a minimum, hard hats must comply with the ASTM Standard F 2413-05 and must be worn at all times when working on the equipment.

At least annually, review all relevant safety materials and standards as they are subject to change. ZBB Energy Corporation encourages and supports the establishment of and adherence to appropriate safety standards along with the use of personal

Lock Out / Tag Out (LOTO)

Now that the equipment has been powered down and this has been verified, conduct the Lock Out / Tag Out (LOTO) procedure in accordance with appropriate guidelines.

At a minimum, the LOTO procedure should be followed as mandated by the United States Occupational Safety and Health Administration (OSHA) and local regulations, including yet not limited to those fostered by ZBB Energy Corporation and its customers.

VIII. TROUBLESHOOTING

The ZBB Energy Corporation PCU is constructed to provide years of trouble-free service. Beyond the recommended maintenance and inspection information and simple fuse replacement, there should be no need for further troubleshooting instructions.

In the event that further information is necessary, consult with ZBB Energy Corporation Service & Technical Support.

IX. Return Goods Authorization

The Return Goods Authorization (RGA) process must be followed whenever a product will be returned to ZBB Energy Corporation.

Consult with your ZBB Energy Corporation project manager to discuss the situation and to determine the appropriate next steps to take regarding whether a return is necessary.

Appendix A

RATINGS AND SPECIFICATIONS (Mechanical)

The ZBB PCU is rated per the specifications displayed in Table 1.a.
The Power Module is rated per the specifications displayed in Table 1.b.

Table 1.a.
PCU Dimensions and Weights

	ENGLISH	METRIC
DEPTH	25.75 inches	64.405 cm
WIDTH	28.85 inches	73.279 cm
HEIGHT	95.25 inches	241.935 cm
WEIGHT	1500 lbs	680.389 kg

Refer to Engineering Document(s) for further details

Table 1.a.
Power Module Dimensions and Weights

	ENGLISH	METRIC
DEPTH	08.375 inches	21.2725 cm
WIDTH	20.000 inches	50.8000 cm
HEIGHT	33.000 inches	83.8200 cm
WEIGHT	165 lbs	74.842741 kg

Appendix A (Continue)

RATINGS AND SPECIFICATIONS (Electrical)

The ZBB PCU is rated per the specifications displayed in Table 2.

Table 2.

ZBB ENERSECTION™ AC-PCU 25kVA UL-1741 INVERTER
Model # 11-ENER-INV25

Rating Type	Utility–Interactive	Stand–Alone
Maximum Input Voltage (DC)	450V	450V
Range of input operating voltage (DC)	350-450V	350-450V
Maximum input current (DC)	160A	160A
Maximum input short circuit current	18kA	18kA
Maximum input source backfeed current to input source (AC)	1A	1A
Output power factor rating	0.6 or Greater 25KVA	0.6 or Greater 25KVA
Operating voltage range (AC)	177.7 - 233.8 V	208V +5%, -5%
Operating frequency range or single frequency	59.53 – 60.42 Hz	45 -65 Hz
Nominal Output Voltage (AC)	208V, 3Ph	208V, 3Ph
Normal Output Frequency	50/60Hz	50/60Hz
Maximum Continuous Output Current (AC)	69A	69A
Maximum Continuous Output Power (AC)	25kW	25kW
Maximum Output Fault Current (AC) and Duration	300A Pk 100µS	300A Pk 100µS
Maximum Output Overcurrent Protection	125 A	125 A
Utility Interconnection Voltage and Frequency Trip Limits and Trip Times	Under 166 ms	Under 166 ms
Synchronization In-Rush Current	35Arms	N/A
Trip Limit and Trip Time Accuracy	300A 100ms +/- 50ms	300A 100ms +/- 50ms
Normal Operation Temperature Range	-30°C to +50°C	-30°C to +50°C
Enclosure Type Rating	TYPE 3R	TYPE 3R

NOTE: Power Module does not have an Enclosure Type Rating.

Appendix B

INCOMMING INSPECTION LIST - Mechanical

Examination of Mechanical component(s) shall compose of but not limited to the dimensions, physical locations and mechanical operation of 'non-energized' parts as per checklist. Shall be inclusive of materials & tools listed and comply with guidelines of Industry Standards, National and/or Local Codes and ruling bodies.

Materials & tools need for inspection shall include but not limited to the following: Engineering Document(s), Metric/English Tape Measure and Digital Multimeter.

Recommended inspection list displayed in Table 3.a. If a discrepancy is found, contact a ZBB representative. A Corrective Action Response section is provided in Appendix F to address concerns.

Table 3.a.

	External Inspection List
i.	Visually inspect packaging for shipping & handling indicators. Also included are packaging documents.
ii.	Proper removal/storage of packaging & loose materials & equipment.
iii.	Check the external panel(s) for physical sign damage(s).
iv.	Manually exercise non-energized mechanical components such as door(s), operator(s), circuit breaker(s) and switch(s). Components shall be properly aligned & foreign object shall not obscure their operations.
v.	Dimensions, location & material information shall be reviewed against engineering document(s).
vi.	Physical mating & connections shall be in accordance to engineering document(s).
vii	Grounding/Bonding test shall involve a DMM using continuity settings.
	Internal Inspection List
viii.	Proper removal/storage of packaging & loose materials & equipment.
ix.	Check the internal panel(s) for physical sign damage(s).
x.	Check the panel(s) for physical sign damage(s). (.ie scratches or dents)
xi.	Manually exercise non-energized mechanical components such as, operator(s), circuit breaker(s) and switch(s). Components shall be properly aligned & foreign object shall not obscure their operations.
xiii.	Physical mating & connections shall be in accordance to engineering document(s).
xiv.	Grounding/Bonding test shall involve a DMM using continuity settings.
xv.	Cables installation should be routed in a safe & mechanically appropriate manner.
xvi.	All cables shall be securely attached with straps or clamps to ensure short circuit bracing & avoid loose routing.

Appendix B (continue)

REFERENCED LABELS

User should keep track of the PCU's Product & Serial Number in the provided Table 3.b. to reference when contacting ZBB Service & Technical Support.

Table 3.b.

i.	Nameplate & Rating per Appendix A
ii.	Model No. adhered on the External of the PCU's door. Record Product No. _____________________________
iii.	Serial No. adhered on the Internal of the PCU's door. Record Serial No. _____________________________

Appendix C

ENGINEERING DOCUMENT LIST

The ZBB PCU is supplied with the following Engineering Document as listed in Table 4.

If Engineering Document(s) is/are needed, please contact a ZBB representative.

Table 4.

	Engineering Document Description	Document Part Number
i.	Power Control Unit Operation Manual	30-000072
ii.	Mechanical Layout	10-000001

Appendix E

Fault Code – Lookup Table

The ZBB PCU generates fault code(s) as defined by Table 6.

Table 6.

Fault Code	Name	What to do
1000	Bus Over Voltage	Contact ZBB
1250	Bus Under Voltage	Contact ZBB
2030	AC load voltage phase A (non grid tie)	Contact ZBB
2040	AC load voltage phase B (non grid tie)	Contact ZBB
2050	AC load voltage phase C (non grid tie)	Contact ZBB
3000	Over Current phase A1	Contact ZBB
3030	Over Current phase A2	Contact ZBB
3010	Over Current phase B1	Contact ZBB
3040	Over Current phase B2	Contact ZBB
3020	Over Current phase C1	Contact ZBB
3050	Over Current phase C2	Contact ZBB
4000	IGBT 1 Temp Over	Contact ZBB
4250	IGBT 1 Temp Under	Contact ZBB
4001	IGBT 2 Temp Over	Contact ZBB

Fault Code	Name	What to do
4251	IGBT 2 Temp Under	Contact ZBB
10	IGBT fault A1	Contact ZBB
20	IGBT fault A2	Contact ZBB
30	IGBT fault B1	Contact ZBB
40	IGBT fault B2	Contact ZBB
50	IGBT fault C1	Contact ZBB
60	IGBT fault C2	Contact ZBB
100	Pre-charge Fault	Contact ZBB
110	External Pre-charge Fault	Contact ZBB
200	Un-decoded Hardware Fault	Contact ZBB
2300	VRMS Under phase A (non grid tied)	Contact ZBB
2310	VRMS Under phase B (non grid tied)	Contact ZBB
2320	VRMS Under phase C (non grid tied)	Contact ZBB
2400	VRMS Over phase A (non grid tie)	Contact ZBB

Fault Code	Name	What to do
2410	VRMS Over phase B (non grid tie)	Contact ZBB
2420	VRMS Over phase C (non grid tie)	Contact ZBB
2600	Voltage Imbalance phases AB	Contact ZBB
2610	Voltage Imbalance phases BC	Contact ZBB
2620	Voltage Imbalance phases CA	Contact ZBB
3500	Current Imbalance phase AB	Contact ZBB
3510	Current Imbalance phase BC	Contact ZBB
3520	Current Imbalance phase CA	Contact ZBB
5000	Overload phase A	Contact ZBB
5010	Overload phase B	Contact ZBB
5020	Overload phase C	Contact ZBB
4010	DSP Temp. Over	Contact ZBB
4260	DSP Temp. Under	Contact ZBB
120	Grid Contactor Fault 1 (dip switch on aepc709 will disable)	Contact ZBB

Fault Code	Name	What to do
121	Grid Contactor Fault 2 (dip switch on aepc709 will disable)	Contact ZBB
510	Digital Ground Fault	Contact ZBB
7000	Ground Fault	Contact ZBB
8000	Line Frequency Over	Contact ZBB
8250	Line Frequency Under	Contact ZBB
2000	Line Transient Voltage Phase A	Contact ZBB
2010	Line Transient Voltage Phase B	Contact ZBB
2020	Line Transient Voltage Phase C	Contact ZBB
2430	Line RMS Over Phase A	Contact ZBB
2440	Line RMS Over Phase B	Contact ZBB
2450	Line RMS Over Phase C	Contact ZBB
2300	Line RMS Under Phase A	Contact ZBB
2340	Line RMS Under Phase B	Contact ZBB
2450	Line RMS Under Phase C	Contact ZBB

Appendix F

CORRECTIVE ACTION RESPONSE

The ZBB PCU is supplied with the following Corrective Action Response form to address open item(s). Print & clearly detail discrepancy with product and/or documentation. Print as needed to capture all correction actions. Following please contact a ZBB representative with a signed copy.

Product Serial No.: ____ Page __________of________

Inspector(s) name [Print, Sign & Date]:

____ ____

Description(s)	Action By Person(s)

Corporate Headquarters

N93 W14475 Whittaker Way
Menomonee Falls, WI 53051 USA
Tel: +1 (262) 253-9800
Fax: +1 (262) 253-9822

HISTORY

ISSUE	DATE	DRF	CHK	APP	DESCRIPTION OF CHANGES
01	12/10/11	DV	KD	KD	ISSUE FOR RELEASE

ZBB EnerStore® 50V3.1(C) Flow Battery Module

30-000361

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Table of Contents

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1.0 Introduction

ZBB Energy Corporation designs and manufactures advanced Electrical Energy Storage Flow Batteries, and Intelligent, modular power conversion electronics equipment to address today's ever growing conventional and renewable energy needs.

The ZBB EnerSystem™, which includes the Patented ZBB EnerSection® and the ZBB EnerStore®, is a modular, expandable, and flexible power electronics architecture that provides the complete integration of various types of renewable energy generating sources, conventional energy generating sources and various types of energy storage; automatically manages the generating assets along with the energy storage assets and provides single or multiple outputs for the required customer application needs. Being completely modular and built on a standard industrial MCC (Motor control Center) platform, the ZBB EnerSection® can easily and readily be expanded upon to accommodate future needs of additional generation and/or additional energy storage with minimal installation and startup effort, referred to as "Plug-n-Play".

Whether it is AC Voltage or DC Voltage, this unique ZBB proprietary topology and control concept eliminates the need for complex software algorithms typically used in hybrid systems with multiple generating sources, including the capability of multiple outputs to customer loads through a single device, and utilization in On-Grid and/or Off-Grid applications. Furthermore, the ZBB EnerSection® can provide the active power (kVa) required for applications, in addition to the reactive power (kVar) for power factor correction, regulation, and voltage stability. When utilizing the ZBB EnerSection® platform, the customer truly has a modular, expandable "plug-n-play" energy and power routing device that optimizes the use of the connected generation resources in an intelligent way.

The ZBB EnerStore® 50V3.1(C) Zinc Bromide Flow Battery technology provides the energy storage needed in many applications; from support to Micro-grids, to smoothing and shifting renewable energy generation, to providing the necessary energy storage for Off-Grid or On-Grid controllable power plants utilizing renewable energy. The ZBB EnerStore® 50V3.1(C) provides a modular approach utilizing the ZnBr chemistry technology that provides redundancy, high availability, 100% depth of discharge capability, high energy density, small foot print and long life; all being performed as a "controllable" battery as it has the ability of being turned on and off at any State of charge while maintaining a true "green" concept thru utilizing recyclable plastics and an environmentally friendly electrolyte.

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The power electronics and energy storage products ZBB produces are targeted at advancing energy efficiency, energy independence and renewable energy, by providing integrated factory tested systems for direct use by customers and system integrators for On- and Off-Grid applications with and without renewable energy generation.

This solution reduces the installed cost when considering the installation, integration, and commissioning of multi-faceted systems and completely manages the various generation sources and loads through the use of the ZBB EnerSystem™, EnerStore®, and EnerSection® products via the customer communications and control through the ZBB ECM.

One single intelligent, modular, expandable and flexible factory integrated solution developed and deployed for any application.

This Operations and Maintenance Manual provides the user with setup, installation, operations and basic trouble shooting guidelines for the ZBB EnerStore® 50V3.1(C) Flow Battery Module as well as Factory assistance contacts and recommendations.

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2.0 EnerStore® 50V3.1(C) Module Drawings

2.1 Mechanical Drawings

Refer to the following **Drawing # 20-000063** for the **Mechanical Details and Layout** for the ZBB EnerStore® 50V3.1(C) Flow Battery Module.

Refer to the following **Drawing # 30-000256** for the **Mounting and Enclosure Details** for the ZBB EnerStore® 50V3.1(C) Flow Battery Module.

Refer to the following **Drawing # 30-000266** for the **Center of Gravity Details** for the ZBB EnerStore® 50V3.1(C) Flow Battery Module.

Torque Settings for the ZBB EnerStore® 50V3.1(C) Flow Battery Bus connections are based on standard industry recommendations for the specified mechanical sizing.

Screw Torque in lb-in			
	Steel	Steel Class 8.8	Stainless
M3	5.0 - 6.6		8.5 - 11.3
M4	11.6 - 15.5		19.7 - 26.4
M5	23.5 - 31.2		40.0 - 53.4
M6	49.9 - 66.6	76.4 - 101.8	68.1 - 90.7
M8	72.9 - 97.2	185.4 - 246.9	165.5 - 220.4
M10	239.9 - 320.1	367.4 - 489.9	327.5 - 436.6
M12	418.6 - 558.5	740.8 - 854.5	571.3 - 761.7
	Steel	Steel Gr5	Stainless
#4	3.7 - 5.0		6.3 - 8.4
#6	6.9 - 9.2		11.8 - 15.7
#8	12.6 - 16.8		21.5 - 28.7
#10	18.3 - 24.4		31.2 - 41.6
1/4	54.7 - 72.9	84.5 - 112.7	74.5 - 99.4
5/16	112.6 - 150.2	174.1 - 232.1	153.6 - 204.8
3/8	199.8 - 266.4	308.8 - 411.7	272.4 - 363.2
1/2	487.8 - 650.4	753.8 - 1005.1	665.2 - 886.9

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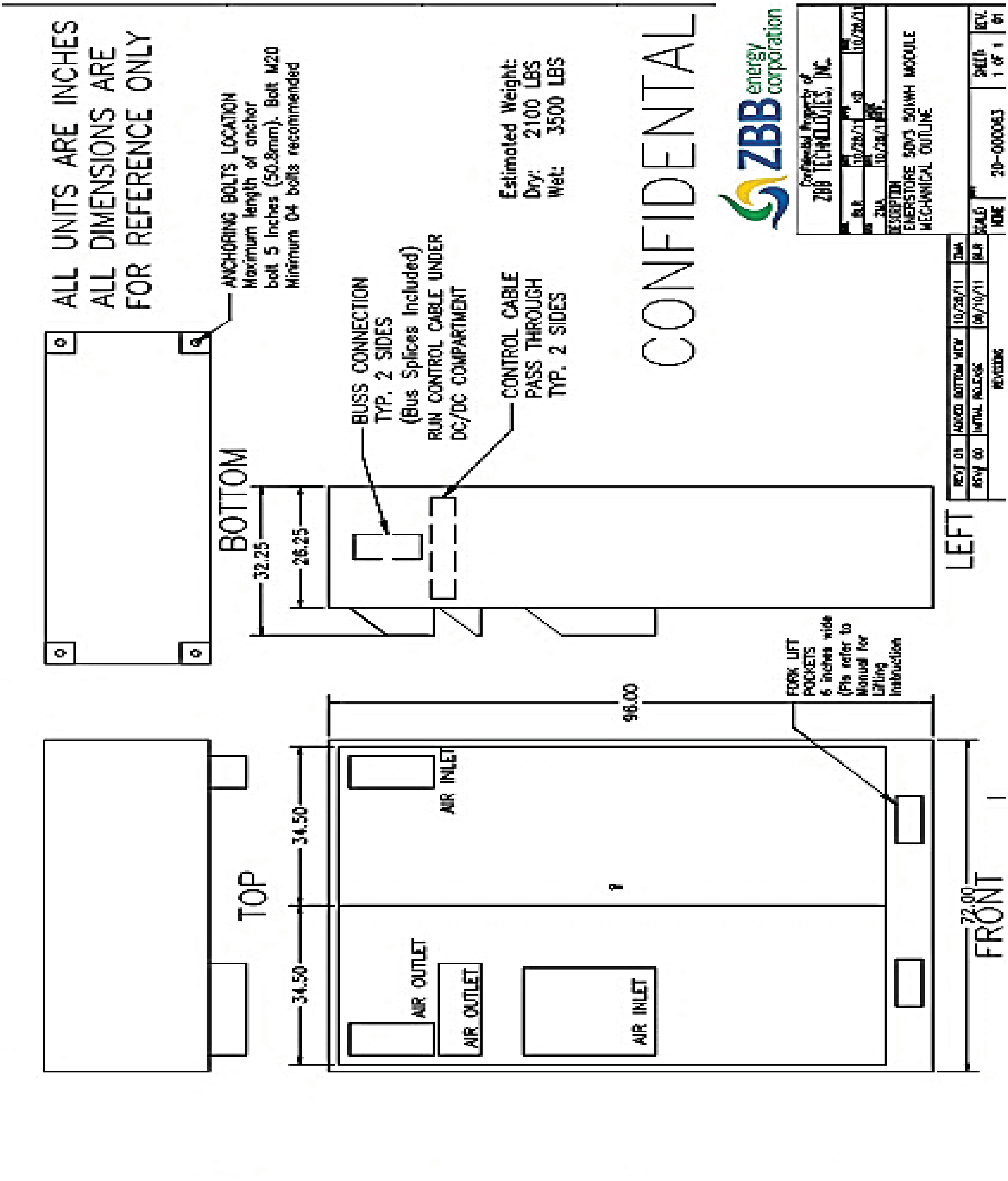

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Drawing # 30-000256

Mounting and Enclosure Details for the ZBB EnerStore® 50V3.1(C) Flow Battery Module.

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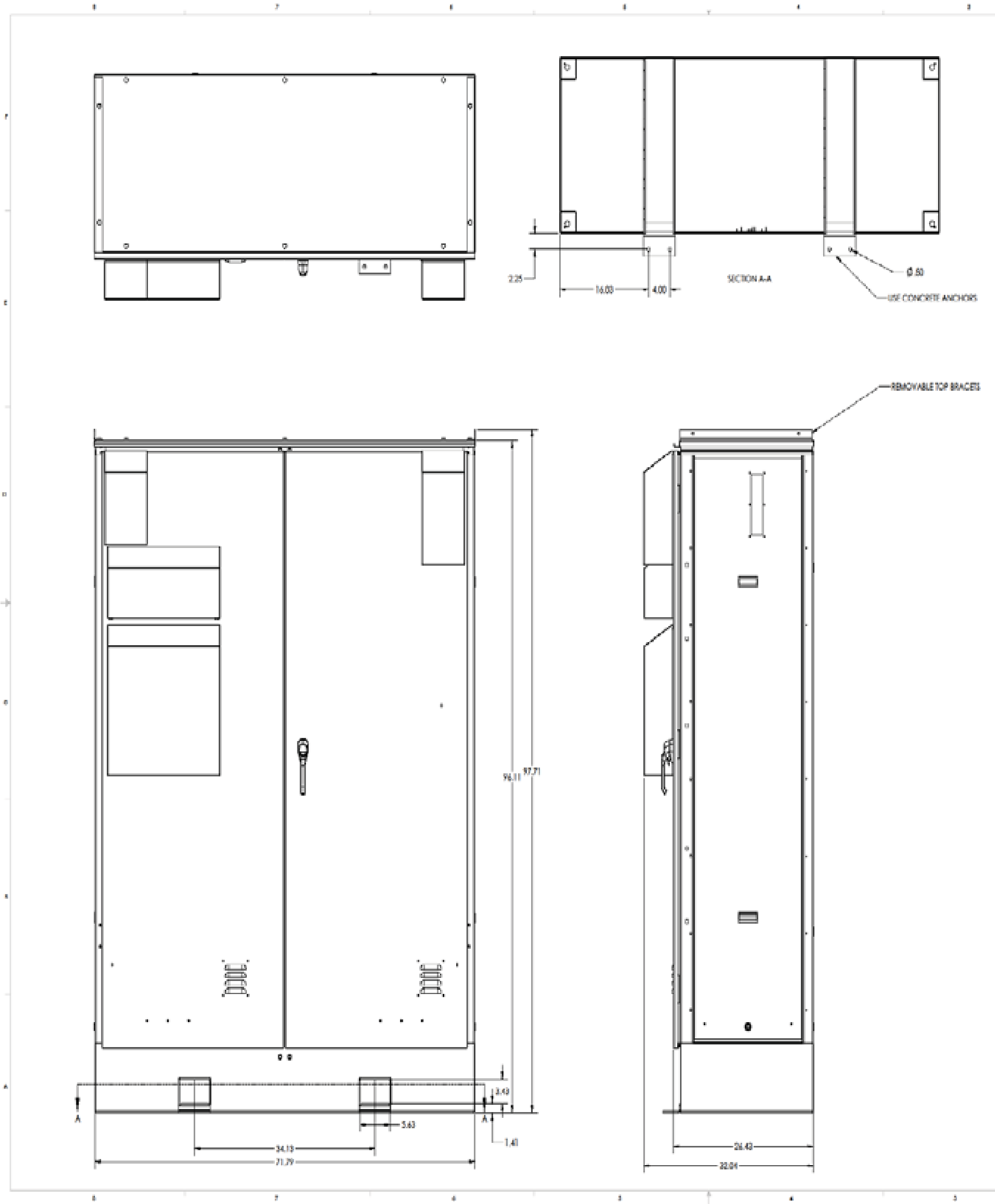

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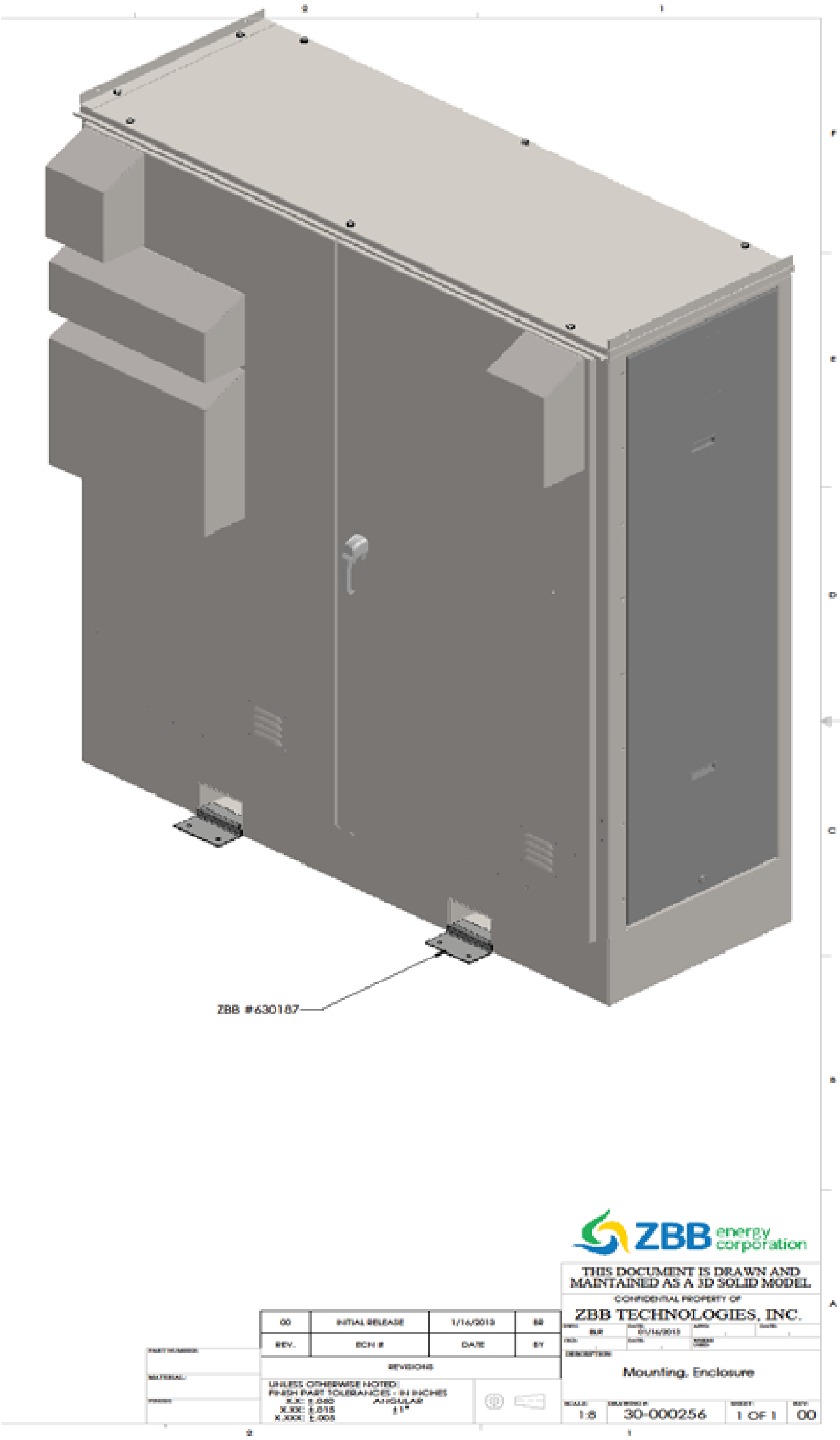

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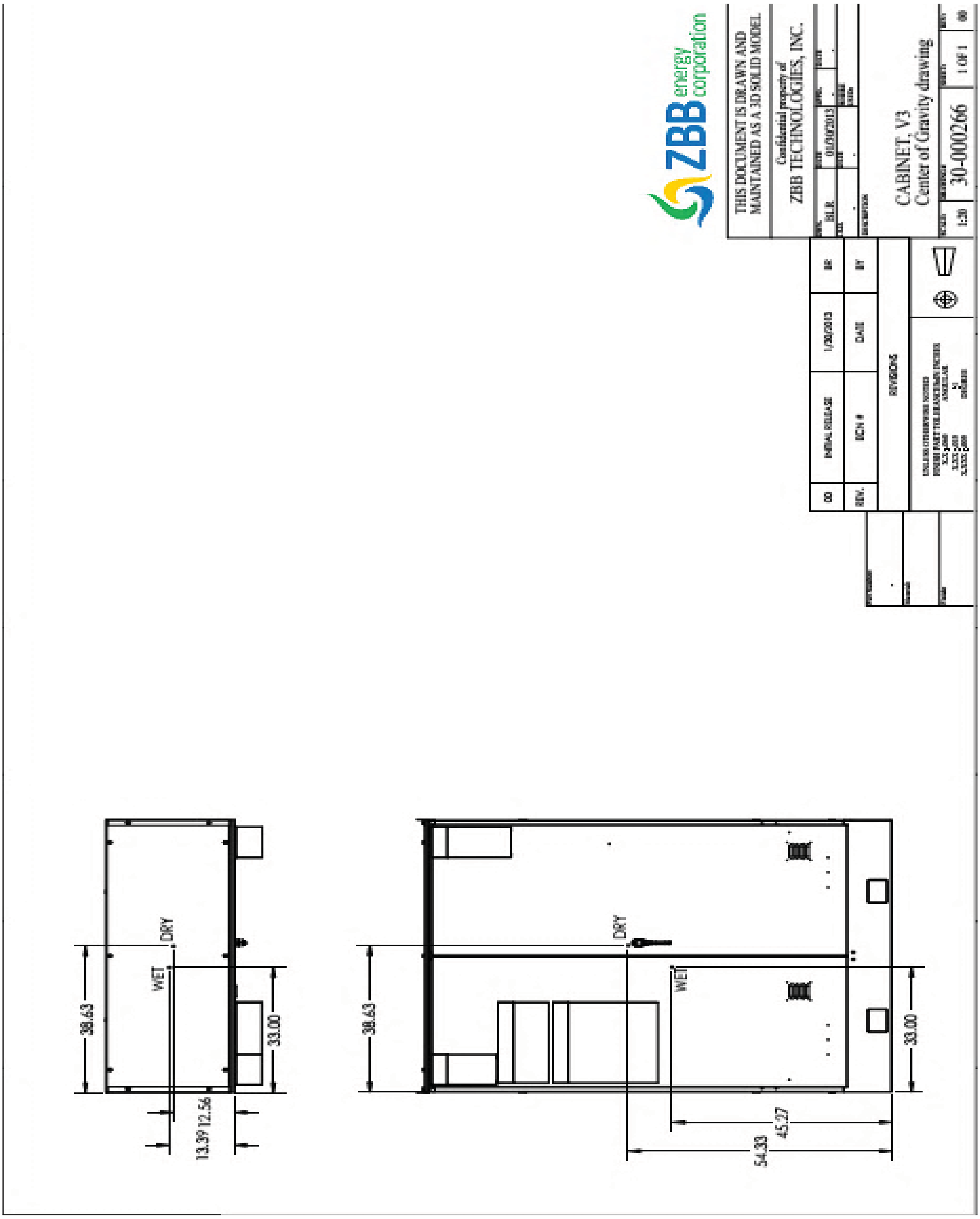

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2.2 Electrical Schematic

Refer to the following **Drawing # 20-000198** for the **Electrical Three Line Diagram** for the ZBB EnerStore® 50V3.1(C) Flow Battery Module.

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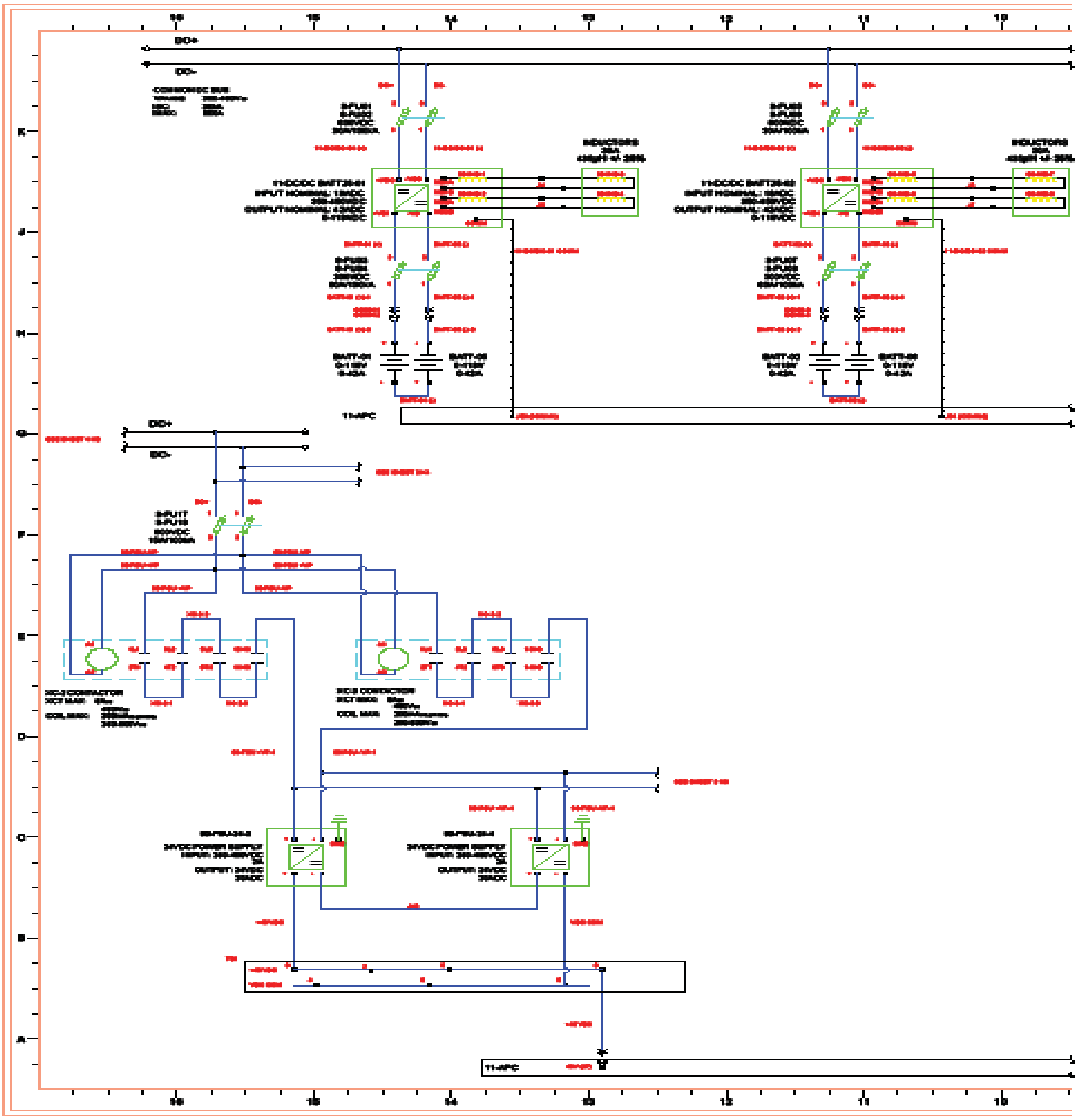

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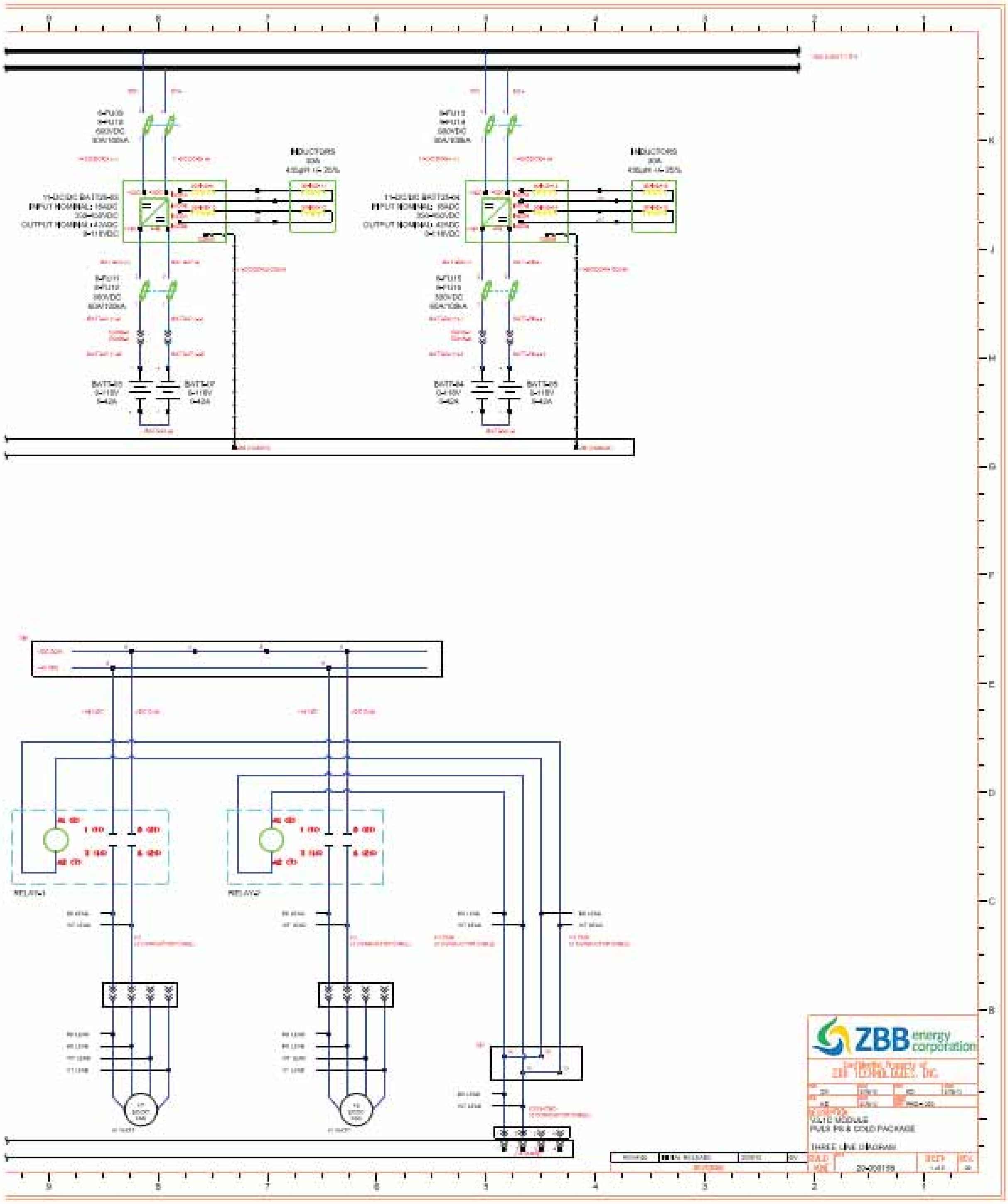

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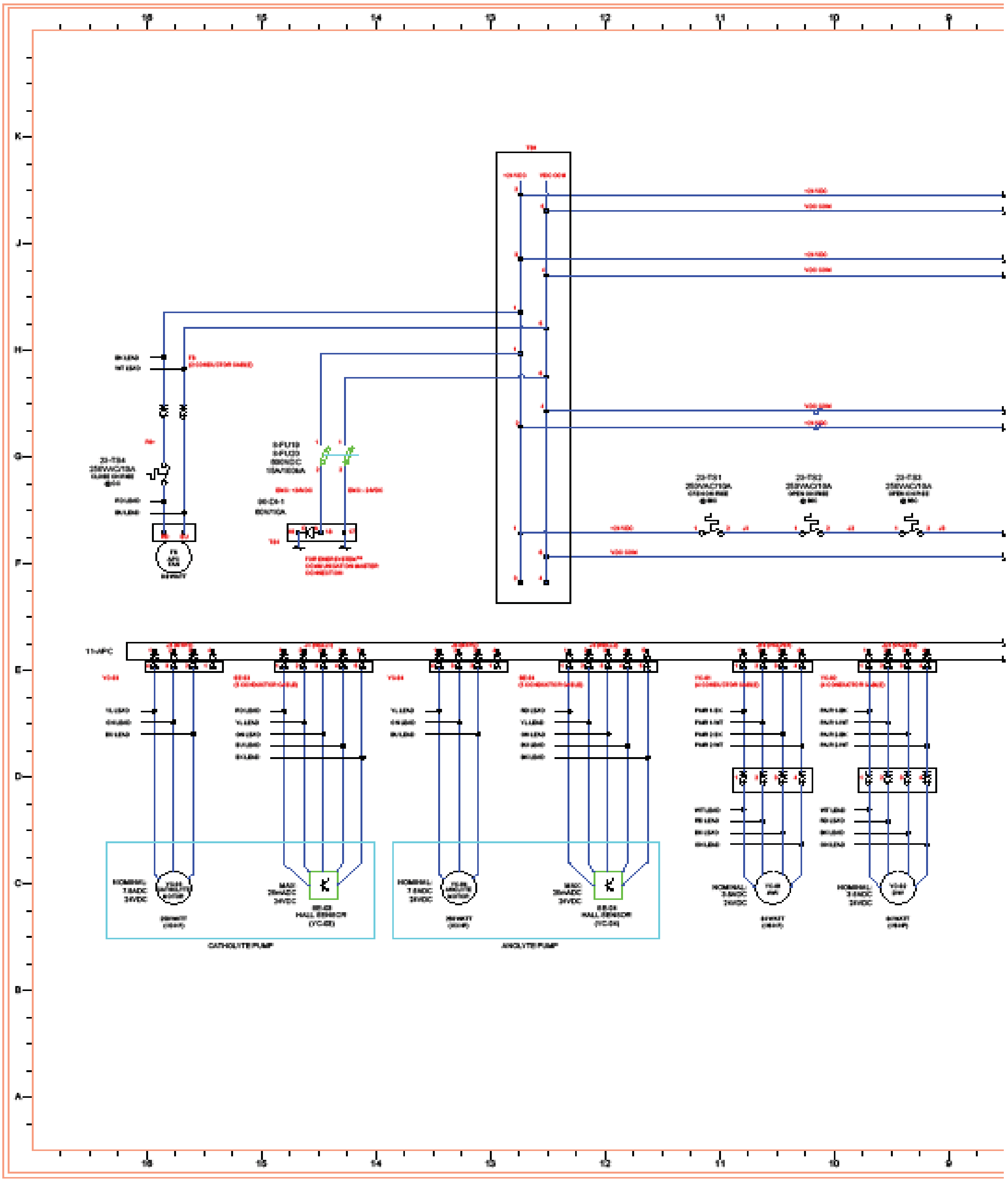
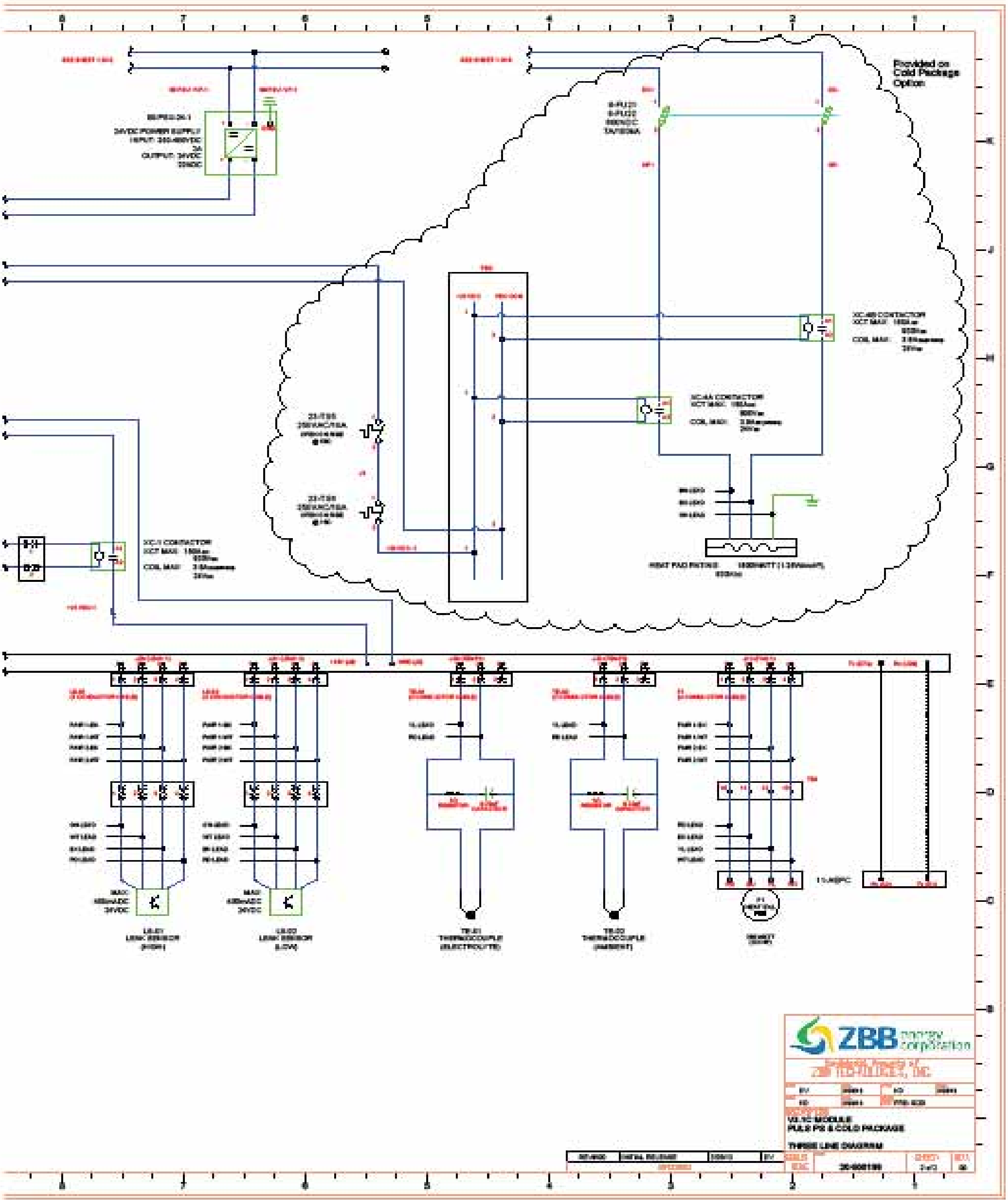

CATHOLYTE PUMP
ANOLYTE PUMP


Provided on Cold Package Option

3.0 General Safety

3.1 General Safety - Electrical

[WARNING]

Energizing control voltages (24VDC or less) & low voltages (600V or less) shall be conducted in a manner that prevents damage to personnel & equipment.

Table 1- ZBB Battery Stack Electrical Ratings

VDC	ADC
120	40

Table 2- ZBB Battery Enclosure Electrical Ratings

VDC	ADC
450	800

[CAUTION]

Work shall only be done by qualified personnel only.

If work is involved in connecting additional equipment to existing equipment, ensure that incoming power is disconnected before work is begun. Disconnecting means should be locked out and/or tagged out. Where it is not feasible to de-energize the system (charged battery) the following precautions should be taken:

i. Person(s) working near exposed parts that are or maybe energized should be instructed and should use practices (appropriate apparel, equipment and tools) in accordance to NEC safety codes or governing bodies.

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ii. Person(s) working on exposed parts that are or may be energized should in addition, be qualified personnel who have been trained to work on energized circuits.

Each section will additionally list appropriate steps & safety precautions when energizing or handling energized equipment. Personnel conducting commissioning SHALL READ THROUGH EACH SECTION PRIOR TO PROCEEDING.

All work should be done in accordance with local safety laws and codes.

3.2 General Safety – Chemical

[WARNING]

Electrolyte is **caustic** and considered a **toxic chemical**! Wear rubber gloves when working with it. Use baking soda or a baking soda – water solution to neutralize any spills. Isopropanol (isopropyl alcohol) can also be used on minor splashes or spills. Electrolyte left on the skin will burn. Electrolyte left on untreated or unpainted metallic surfaces will accelerate corrosion/rust.

Refer to MSDS for specifics on Electrolyte.

4.0 Setup and Installation Guide Lines

4.1 ZBB EnerStore® 50V3.1(C) Setup Procedure

At time of receipt, the EnerStore 50V3 Flow Battery module should be inspected for any physical damage by the customer. All physical damage shall be recorded and described; and if possible, photographs of the damage should be taken and reported to the party responsible for shipping for further coordination with the transport company.

Inspection – A battery system will normally consist of the following major components:

- EnerStore 50V3 Enclosure cabinet
- Qty 8 Battery Stacks
- Qty 4 DC/DC Converters
- Qty 1 Heat Exchanger

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- Qty 2 Pumps for electrolyte
- APC control Board
- Electrolyte Barrels
- Other equipment as ordered per customer request

Examine equipment to ensure all doors open as designed; no electrical component has sustained "breaking force," or water damage. Where possible, check plumbing fixtures – looking for signs of obvious trauma, abuse and / or damage.

Lifting & Handling

- The ZBB EnerStore® 50V3 system cabinet includes the battery module. As shipped, the ZBB EnerStore® 50V3 will weigh approximately 2096 pounds (953 kilograms) with no electrolyte in the module tanks. As designed, the entire cabinet can be lifted with a fork truck having a lift capacity of 5000 pounds (2300 kilograms) or greater.

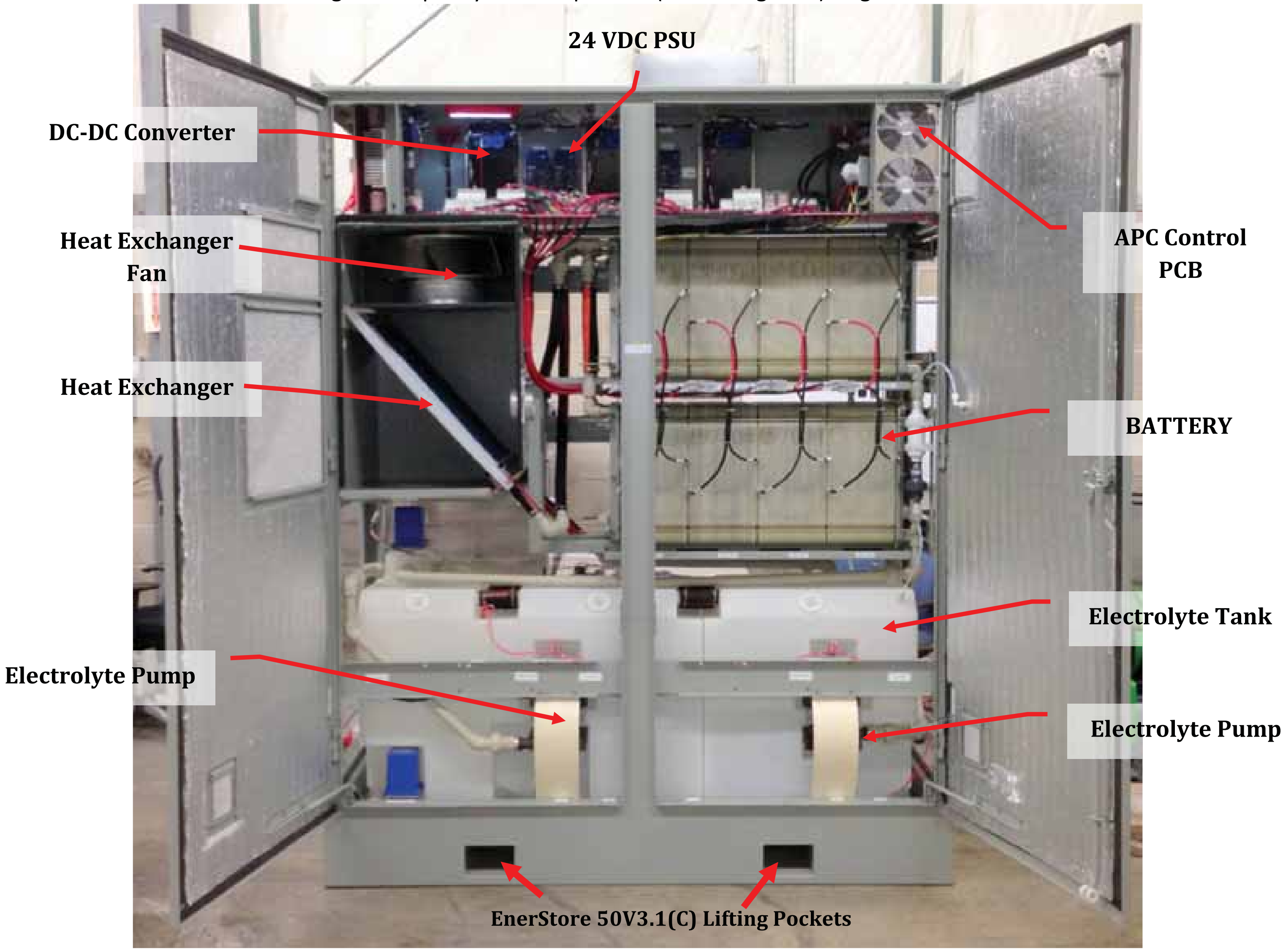

FIGURE: 01

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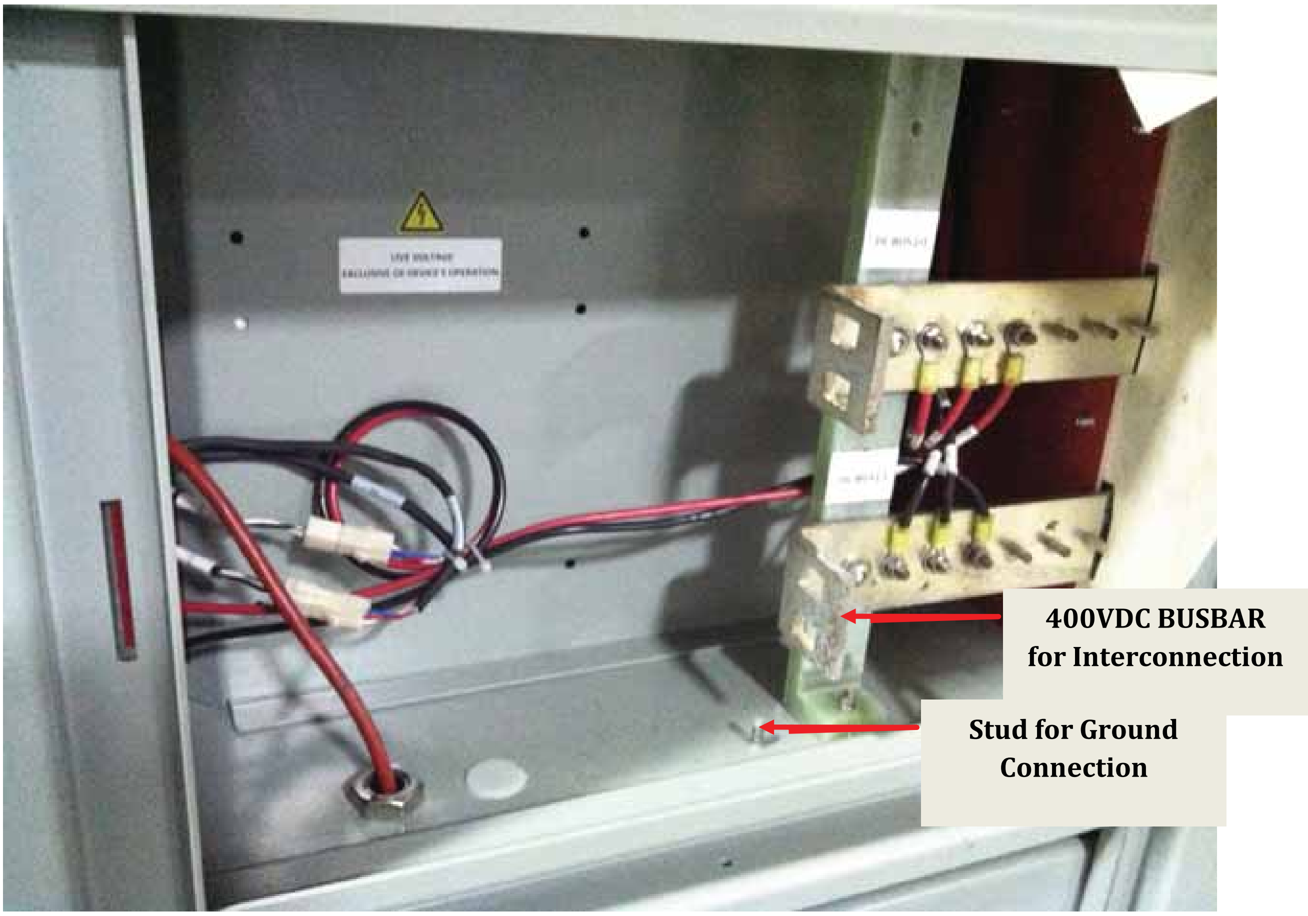
Figure-1 shows the lift points of a 50V3.1(C) cabinet and where the components are physically mounted within the cabinet.

4.2 INSTALLATION

Wire, cable, fiber optic cable, and conduit shall be provided by customer. Bus connections are made using DC BUSBAR interconnect kit provided by ZBB to connect to ZBB EnerSections. Please refer to drawing 20-000063 in Section 2.0 for more details.

System schematics, system interconnection wiring and grounding requirements are provided in section 2.0 of O&M Manual.



Chemical

Only ZBB technical services personnel are to fill the electrolyte and brominated electrolyte before 1st start up.

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Use baking soda or a baking soda – water solution to neutralize any spills. Isopropanol (isopropyl alcohol) can also be used on minor splashes or spills. Electrolyte left on the skin will burn. Electrolyte left on untreated or unpainted metallic surfaces will accelerate corrosion/rust.

4.3 ENERSTORE 50V3.1(C) TYPICAL OPERATION

DISCHARGE:

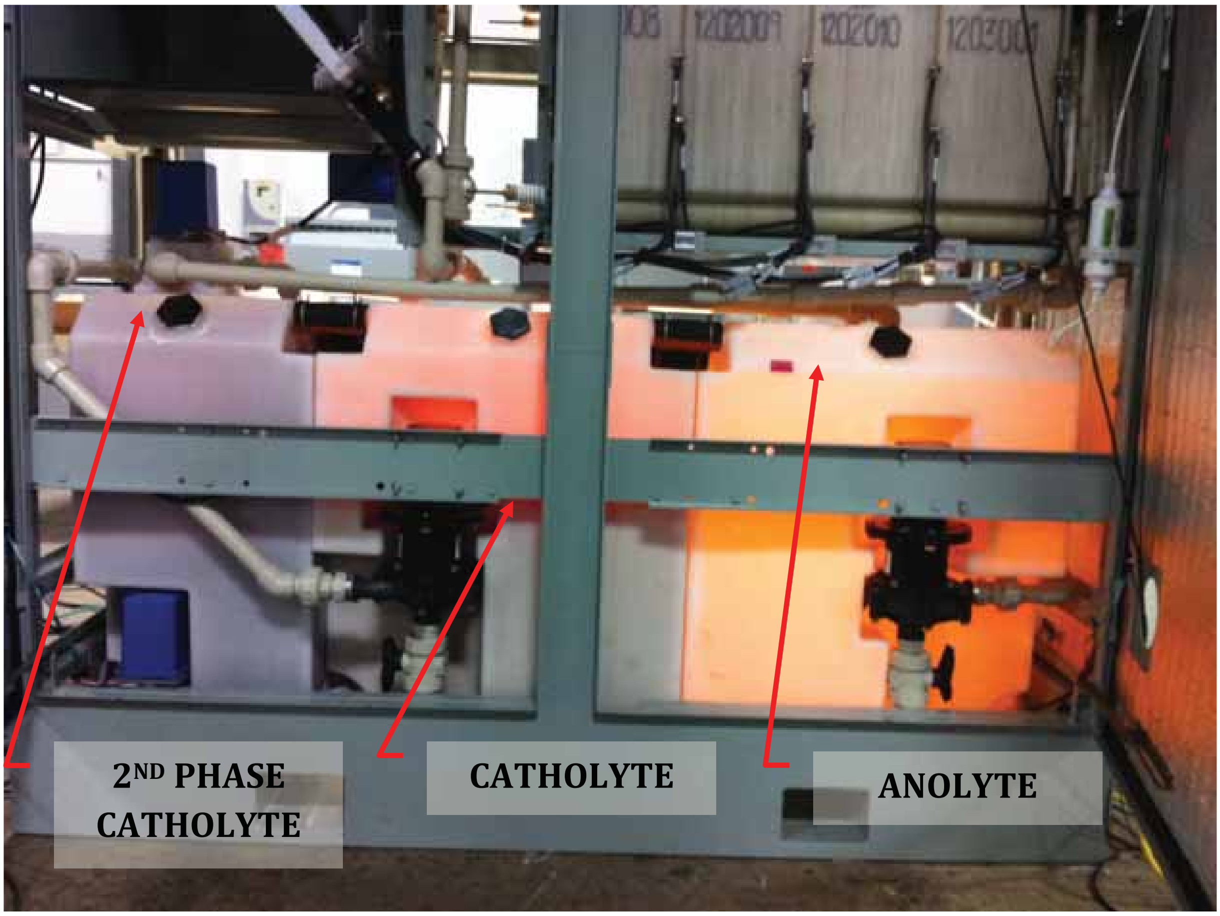
- When the battery is fully discharged, the ANOLYTE and CATHOLYTE tanks should be approximately even

CHARGE

- As the battery is charged, the CATHOLYTE should decrease because of the increased density and viscosity as it charges

PARTIALLY CHARGE

- When partially charged, the ANOLYTE should be slightly above the CATHOLYTE level.



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4.4 ZBB ENERSTORE® 50V3.1(C) ELECTROLYTE: PROCEDURE FOR FILLING AND REMOVAL

CAUTION: Electrolyte is corrosive; and is an inhalation hazardous. Wear rubber gloves, Respirator and safety glasses when working with it. Refer to MSDS sheet.

Electrolyte left on the skin will cause skin irritation. Electrolyte left on untreated or unpainted metallic surfaces will accelerate corrosion/rust.

Use dry Sodium Bicarbonate [baking soda] to neutralize fluid spills. Keep a solution of sodium bicarbonate and water handy for general clean-up. Isopropanol (isopropyl alcohol) can be used on minor splashes or spills.
Oil dry or similar absorbant material can also be used to assist in fluid clean-ups, after neutralization.

Equipment:

1. Drum pump; [e.g. Standard Pump – SP-PVDF-39 or Sethco P-80; Finish Thompson Model S-1]. The pumps are Kynar tubing and piping. Tube length is 39 inches; motor voltage 120VAC or 240VAC [F**igure-1**].
2. Sodium Bicarbonate (baking soda) or Sodium Carbonate (soda ash).
3. Cloth rags or heavy duty paper towels.
4. Squirt bottle of Isopropyl alcohol (Isopropanol).
5. Clean water

   The following hose and fittings are used to make the necessary connections between the pump and tank fittings.

6. 10 feet of 4879 Viton Chemical hose; 1 inch ID diameter.
7. 1 – Kynar Elbow fittings, 1 inch barb to 1 inch male pipe thread; **Ryan Herco Flow Solutions.**
8. 1 - BANJO female coupler –to- female thread (**polypropylene**), 1.25 inch ID.
9. 1 – BANJO 1.5 inch plug for female coupler (**polypropylene**); drum pump hose end.
10. 1 – Kynar 1 inch male pipe thread by 1 inch barb hose adapter.
11. 2 – Oetiker 1 inch step-less, stainless steel, spring clamps.

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NOTE: The fittings and hose type currently used are based on their history of reliability and compatibility with the zinc-bromine electrolyte; the fittings called out are specific to the Sethco pump. No fittings are currently used with the Finish Thompson pump because the hose is much more flexible, therefore easier to maneuver into the tanks and drum.

Figure-1 (**Sethco drum pump**)

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Figure-2 (Finish Thompson drum pump)

Figure-3 (left) shows an example of a drum wrench used to open electrolyte barrels.

Figure-3

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Figure-4

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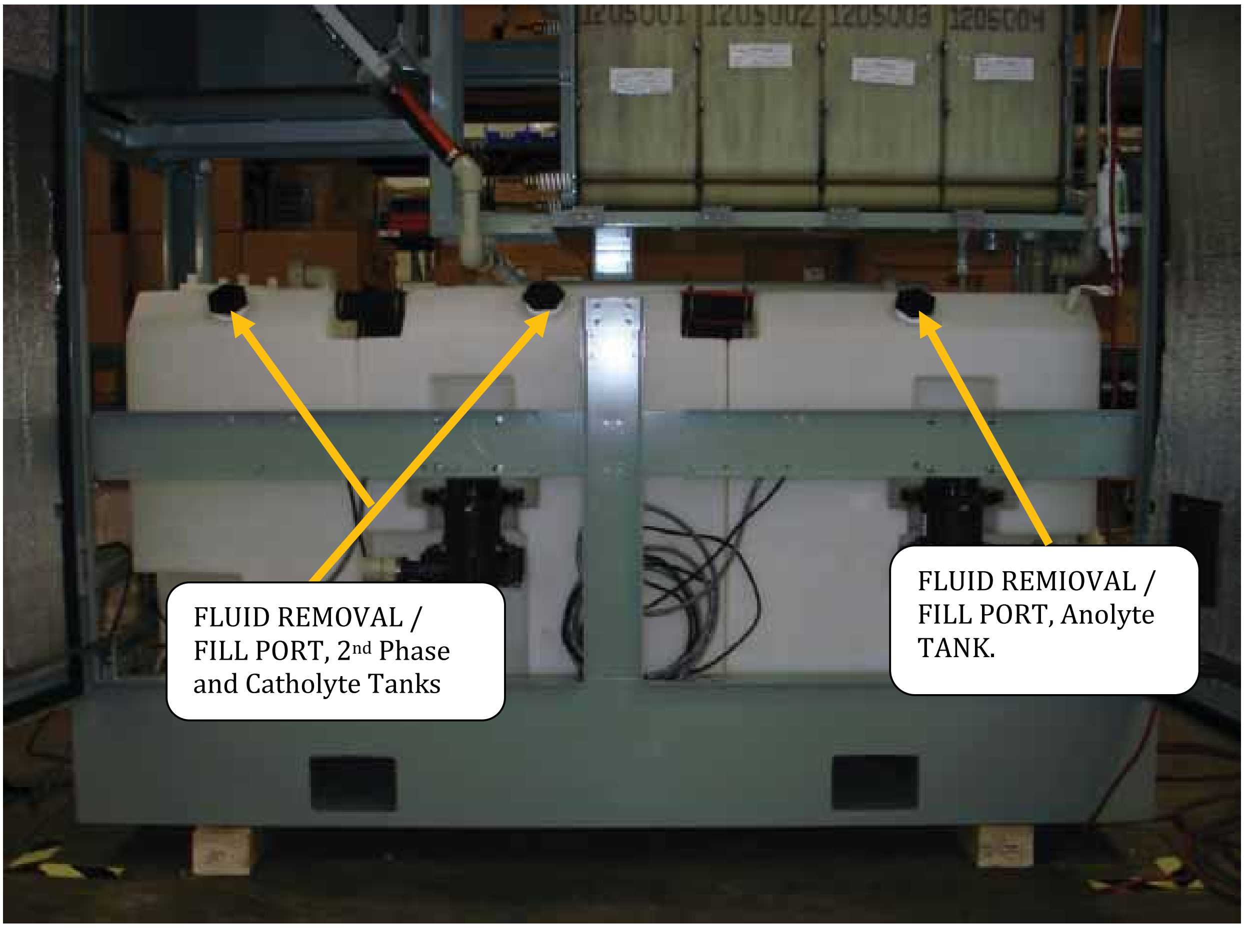

Figure-5

SAFETY

The zinc-bromine electrolyte is corrosive. It will irritate and/or burn bare skin if left untreated. Always wear some type of rubber gloves (e.g. disposable nitrile gloves) when working with electrolyte. Safety glasses are highly recommended as is an apron, smock or coveralls.

It is recommended that when working with electrolyte some sort of respirator designed for chemicals should be worn.

Electrolyte Filling

The V-3 module has a total electrolyte capacity of 130 gallons, distributed across three plastic tanks. From left to right looking at the front of the module: 2nd phase tank, catholyte tank, anolyte tank; Figure-5.

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There is no specified order to which the tanks get filled. The anolyte and catholyte tanks hold approximately 50 gallons apiece, the 2nd phase tank 30 gallons.

Open a barrel of electrolyte and put the Kynar Tube of the drum pump into the barrel; depending on the model of drum pump used – either the hose end or the plastic tube fits into the quick fill port of the tank. Fill each tank to the point where the vertical face of the tank breaks at a 30 degree angle just below the fill port opening.

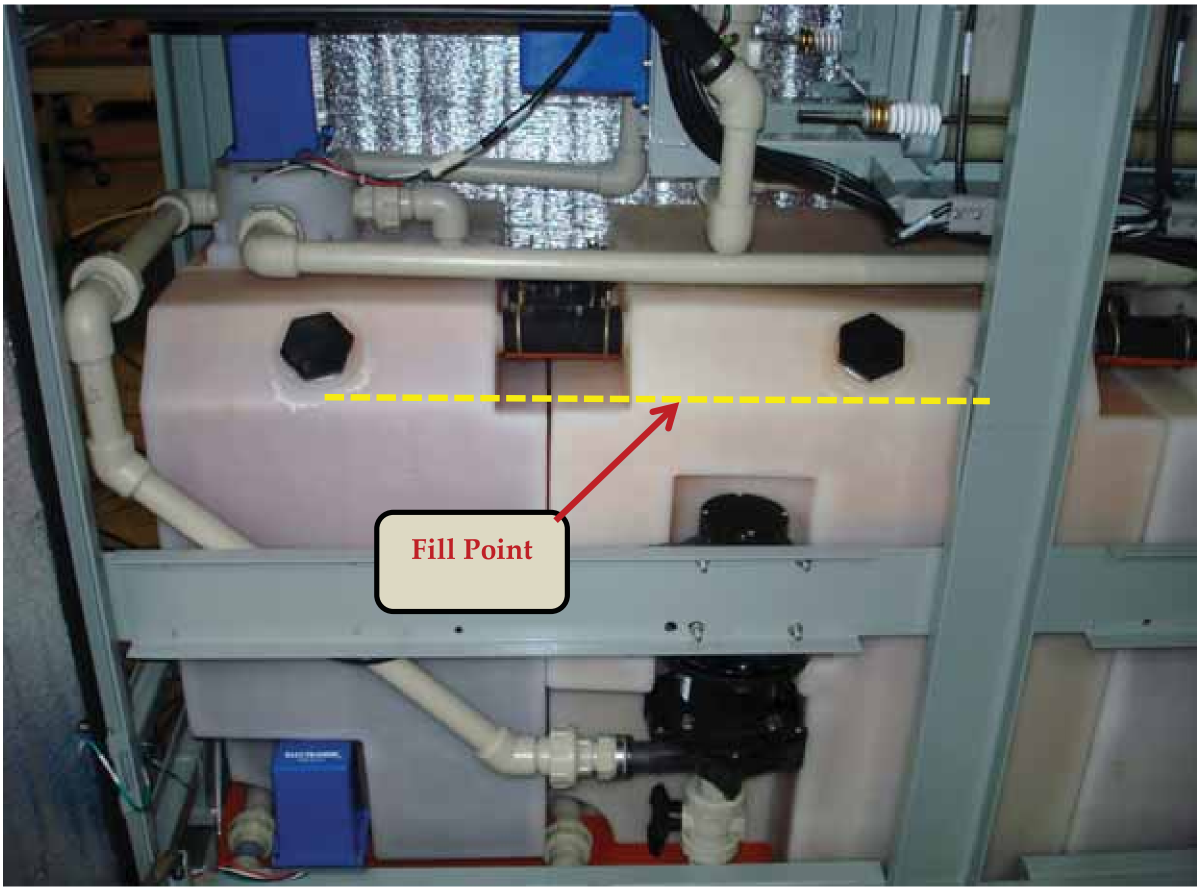

Figure-6

NOTE: With tank filling completed ensure the fill port plugs have 8 to 9 wraps ofTeflon tape on the treads. There is no specific torque spec used for tightening the plugs; turn each one in all the way. Replace and tighten the barrel cap. Clean up any spilled electrolyte with a sodium bicarbonate/water solution.

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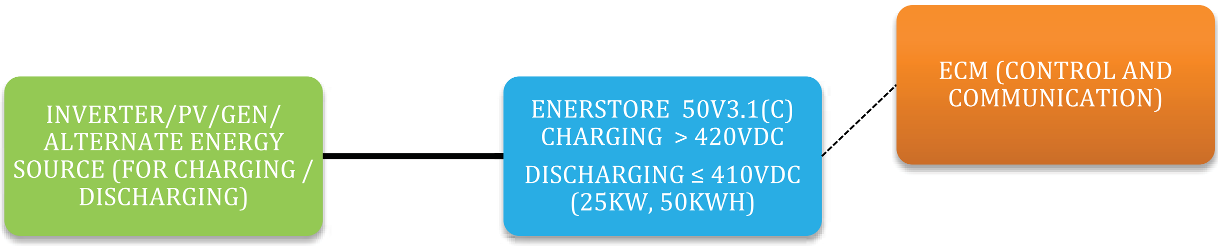
Electrolyte Emptying

Removing electrolyte from the tanks is the reverse of the filling process. The drum pump Kynar tube goes directly into the tank and the Viton hose with fitting(s) goes into the drum. There is one caveat to removing fluid from the electrolyte tank(s): **Ensure the fluid in the tank is not higher than the fill port cap!!!** As can be expected – if that is the case and the cap is opened there will be a sizable electrolyte spill.

5.0 Operations Instructions

Enable/Disable the EnerStore® 50V3.1(C) Flow Battery Module(s) via the ZBB ECM (EnerSystem™ Communications Module). The customer provided communications controller will provide the necessary commands to operate the system based on application specific parameters.

EnerStore 50V3.1(C) operation:



The 50V3.1(C) is Enabled and Disabled locally by the ZBB supplied ECM, and remotely through a ModBus TCP/IP protocol via customer supplied controls. To enable a V3, the DC bus voltage needs to be at 350 VDC or more for the unit to come online. At the ECM, the 50V3.1(C) (V3) is enabled, when the operator selects the V3 they wish to bring online, and presses the “Enable” button on the HMI. When the V3 receives the “Enable” command, the V3 will power up and come online within a variable start time (7secs to 15 min). Start time will depend on what state the V3 module was in before the enable was issued. During the start time, the status of the V3 will show “Wake Up”. Once the enable command is received to a 50V3.1(C) control board (APC), it will perform a hardware check. After the hardware check is completed, the APC will turn on both the Anolyte and Catholyte pumps and start pumping electrolyte throughout the

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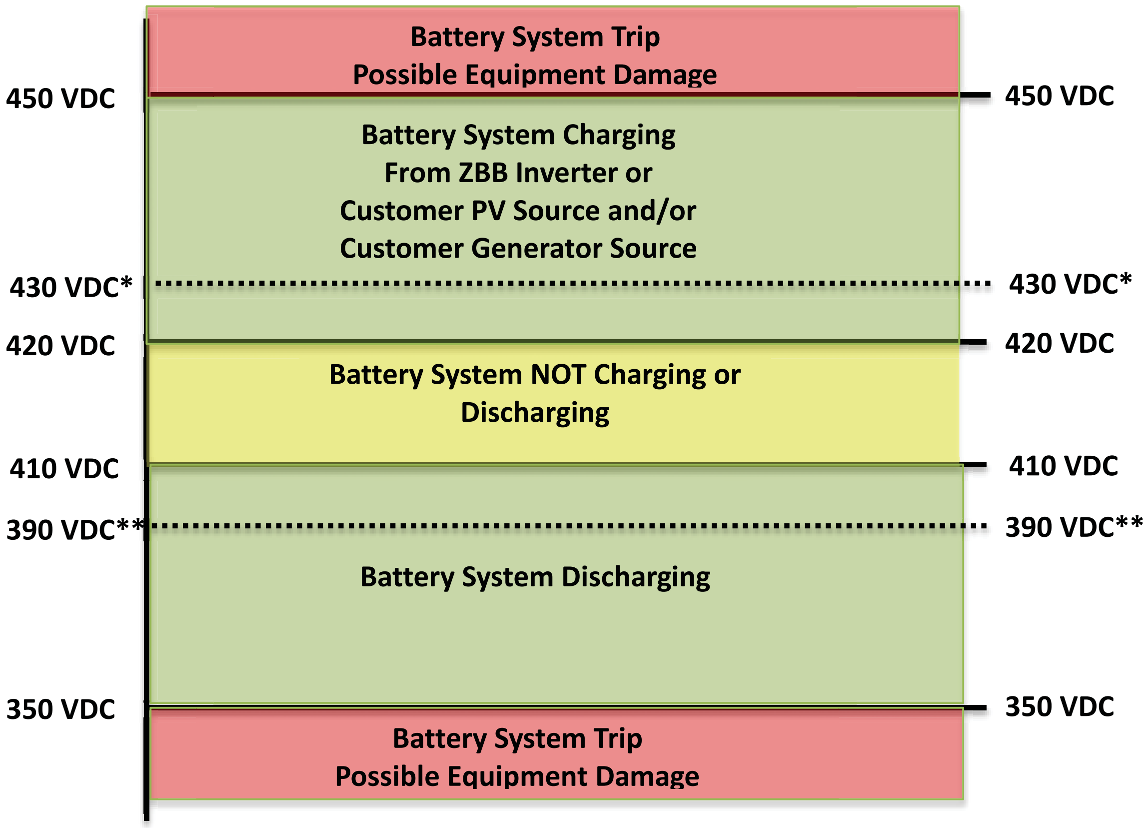
cell stacks. The 50V3.1(C) controller will initialize all valves to confirm their status and report any faults. Then, the 50V3.1(C) controller sends an enable command to all DC - DC Converters. All DC - DC Converters will initialize a start-up, and come online. Once the V3 completes the initialization process and comes online, the V3 status will change to "Online", and depending on its State (STRIP, CHARGE/DISCHARGE, TRIP, ALERT) it will react to the DC BUS voltage to CHARGE or DISCHARGE. If the BUS voltage is over 420VDC, it will start to charge. Once all stacks reach 100% SoC (State of Charge), the DC-DC Converters will stop charging the stacks until SoC < 95%. Once the SoC reaches 95%, the DC-DC converters will start charging the stacks until they reach 100% SoC.



The DC voltage level is controlled by ZBB inverter or customer supplied inverters or Generator under license agreement from ZBB Energy. Voltage levels above are factory default settings.

* Between 420 to 430VDC the battery will allow between 0-100% full amperage of charge, respectively

** Between 410 to 390VDC the battery will allow between 0-100% full amperage of discharge, respectively, provided SOC minimum is not reached.

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When the DC BUS is below or equal to 410VDC, the V3 goes into Discharge mode. The discharge kW amount will depend on the level of kW requested from the system, up to a maximum limit of 25KW per V3. The V3 will discharge until the bus voltage can no longer be maintained, or its SoC is at 0%. Should the DC BUS voltage fall below 350VDC, the V3 will not guaranty export of power.

While the V3 is operational, a Disable command, received from the Client by remote or local control, will initiate a shutdown process and report its status as "Shutdown". The V3, will then disable the DC - DC converters, will cease to import or export power. After a predetermined amount of time, the pumps inside the V3 will also shutdown. Once the shutdown process is complete, the V3 will report its status as "OFFLINE"

After approximately 36 hours of charging and discharging, the V3 module will begin a deep discharge cycle, known as a strip cycle. The V3 will go into a discharge mode, and bring the SoC of its cell stacks to 0%. After the strip process, if the bus voltage is > 350 VDC, the V3 will stay in an idle mode until the bus voltage is raised to 420 VDC. The duration of the Strip cycle varies depending upon; the SoC of the V3 in Strip, the SoC of other V3s if connected, if the system is charging or discharging, and what kW levels the system is charging or discharging. Through local or remote commands, the strip cycle can be expedited by up to 34 hours.

Below is a typical V3's sequence of Operation.

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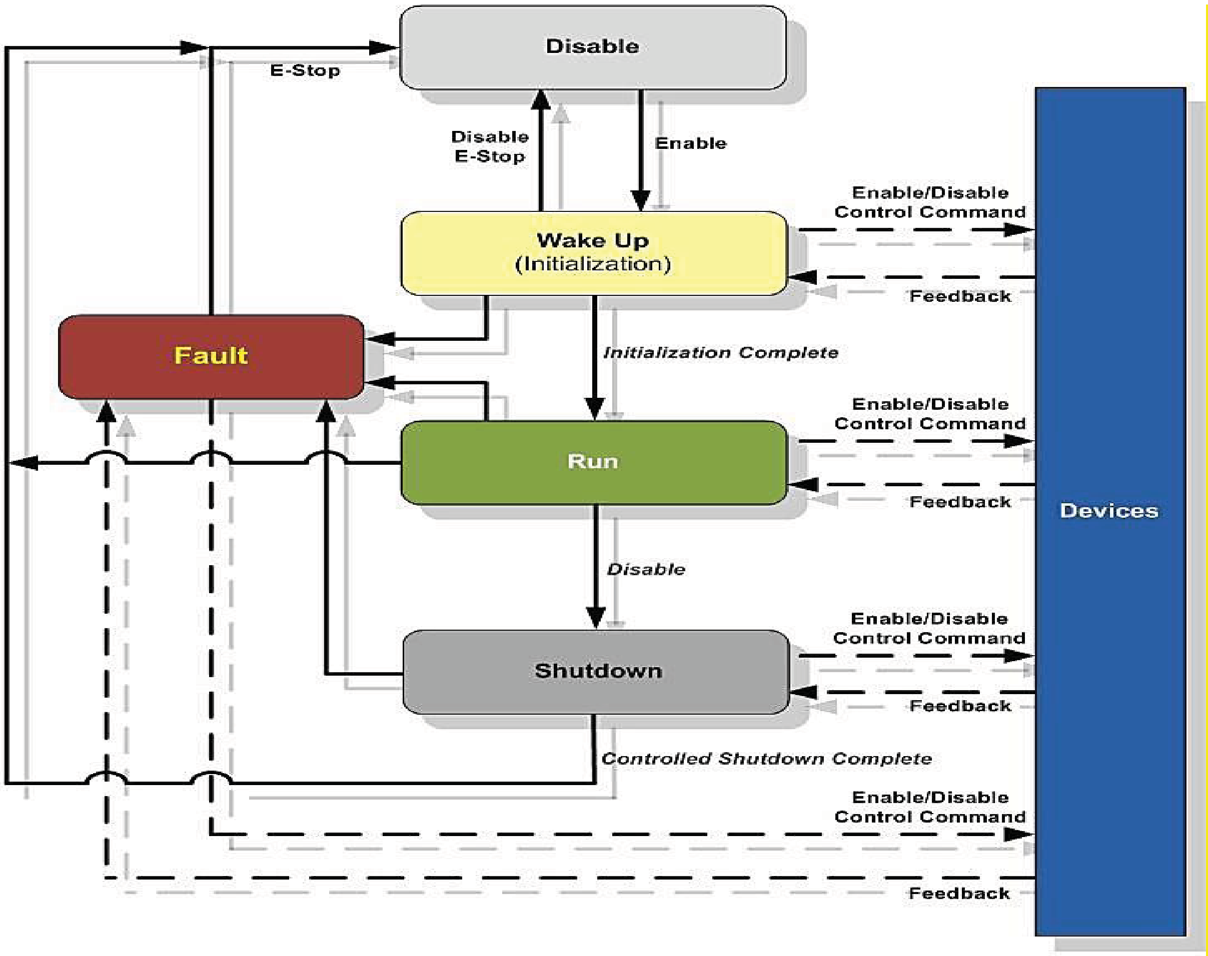

Operator Parameters	
Inputs	**Outputs**
Enable	DC Bus Voltage
Disable	SoC
E-Stop	kW
	Event Code

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6.0 General Maintenance

The ZBB EnerStore® 50V3.1(C) Flow Battery Module should be checked on a regular basis, monthly to twice per year depending upon site conditions. Ensure that there is no debris, no unwanted rodents/insects/etc. nesting inside the unit, and check the air filters on the doors. If the filters on the doors appear to be congested with debris, remove and replace. Contact ZBB if there is a need to purchase more filters.

The electrolyte within the module is reusable between the stack replacements at the set intervals provided it has been operated within its designed specification characteristics.

Maintenance Checklist included in the back of this Manual.

- *Automatic* – A Pre-programmed equalization cycle will occur approximately every 36 hours during operation to reset the EnerStore® battery stacks. This function can be forced, or intentionally reached, upon the full discharge of the module allowing each stack to reach "0" DCV. Depending on the SoC prior to the discharge, it can take from four to six hours for the full cycle.
- *End User* – A Monthly visual check should be performed by the End User to ensure that there is no damage or abnormalities.
- *ZBB Technician* – Monthly Monitoring/Reporting can be performed provided there is customer- established remote internet accessibility. This allows the capability of continuous system recording through analyzed key parameters, updates, and alarm conditions to allow proper operation. **
- *ZBB Technician* – Standard Annual Inspection of the operating system. Address any items regarding maintenance of the system to assure continued operation. Including System connections, electrical inspections and torque settings will be reviewed under this procedure. *(This includes verification of Monthly Maintenance Records, Recording of operation parameters and measurements, and addressing any identified concerns)***
- *ZBB Technician* – 3-year System Operations Inspection and Performance Evaluation. Verification of Annual Maintenance records, operation of full range system cycles and performance measurement, energy storage capacity evaluation. **

** These tasks are optional and inclusive to a customer purchased extended warranty and ZBB maintenance program.

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Frequency	*Description*	*Action By*	*Date*	*Comments*
Alternate Days	Perform Cell Equalization Cycle* ✓ Occurs automatically every 36 hours ✓ Approximately 4 – 12 hours per ZBB EnerStore® Module depending on module SoC	N/A		
Monthly	External Visual Observation for Damage, abnormalities, etc. ✓ Inspection/Operations ✓ Approximately 1 hour per ZBB EnerStore® Module	End User		
Monthly	Remote Monitoring and Reporting Using Customer Supplied Internet Connection ✓ System continuously monitored for operations, key parameters, analyzed data, and alarm conditions ✓ Approximately 2 -4 hours per ZBB EnerStore® Module	ZBB Tech (Remote)		
Annual	System Inspection ✓ Inspection of each module and individual component operations ✓ Mechanical connections, torque settings, standard operations ✓ Electrical connections, standard operations ✓ Internal module cabinet basic cleaning ✓ Verification of monthly maintenance and records ✓ Record operating parameters and internal measurements ✓ Address any noted, or recorded concerns ✓ Approximately 1 – 2 days per Module	ZBB Tech (Onsite)		

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Frequency	Description	Action By	Date	Comments
3-Year	System Inspection and Performance Evaluation ✓ Verify annual maintenance and system operations records ✓ Perform full range of system operations and measure performance factors and standard parameter comparison ✓ Extended Measurements and operations modes to determine state of energy storage capacity of each module ✓ Address any identifiable items or concerns ✓ Approximately 1 -2 days per ZBB EnerStore® Module			

**See Description and details in Section 6 of Manual*

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7.0 Fault Codes / Tech Support

WARNING! Do not attempt any measurement, parts replacement or other service procedure not described in this manual. Such action will void the warranty, may endanger correct operation and increase downtime and expense.

WARNING! All electrical installation and maintenance work described in this chapter should only be undertaken by qualified service personnel. The safety instructions in section *General Safety* must be followed.

EnerStore® 50V3.1(C) Fault Code – Lookup Table

The ZBB EnerStore® 50V3.1(C) generates fault code(s) as defined by the Excel spreadsheet 30-000332 – V3 X sw 3 44 APC EVENT Code – Ring Decoder.xlsx . It is possible to get multiple faults depending on the decimal value. For instance, should you get a decimal value of 3, you will have both a temperature ambient over and a temperature anolyte over fault.

To use the spreadsheet, enter the hexadecimal number for Fault, Fault 2, Alert, or Alert 2 area from the ECM into the Enter Hex number cell. Below the cell, you will get a decimal value. Place that decimal value either into the EVENT Code 1 Parameter for Alert or Fault code, or into EVENT Code 2 Parameter for Alert 2 or Fault 2 code. The spreadsheet will highlight what faults are associated with the value that is entered.

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Step 1. Enter HEX value into the Highlighted Field, result below (Note: for HMI USE ONLY, If not applicable skip to step 2.)

Enter HEX # from 0 to FFFFFFFF >>>	
DEC Result >>>	0

Step 2. Enter DEC value from Step 1 or from interface into Event Code 1 or 2 into the Highlighted Field. The appropiate faults will be highlighted dar

Enter DEC # from 0 to 2^32 >>>>		< Enter EVENT Code 1 Parameter 9000, 900
Enter DEC # from 0 to 2^32 >>>>		< Enter EVENT Code 2 Parameter 9002, 900

				Flag	BIT #
Temperature Ambient Over	0	0	0	0	0
Temperature Anolyte out Over	0	0	0	0	1
Bus Under Voltage	0	0	0	0	2
Batt Over Current	0	0	0	0	3
	0	0	0	0	4
Batt 1 Over Voltage Failure	0	0	0	0	5
Batt 2 Over Voltage Failure	0	0	0	0	6
Batt 3 Over Voltage Failure	0	0	0	0	7
Batt 4 Over Voltage Failure	0	0	0	0	8
Converter 1 No Comm	0	0	0	0	9
Converter 2 No Comm	0	0	0	0	10
Converter 3 No Comm	0	0	0	0	11
Converter 4 No Comm	0	0	0	0	12
Batt 1 Under Voltage Failure	0	0	0	0	13
5 or more of 8 total converters faulted or no comm OR 3 or more of 4 total converters faulted or no comm	0	0	0	0	14
Valve 2W Over Current	0	0	0	0	15
Valve 2W Time Out	0	0	0	0	16
Valve 2W Under Current	0	0	0	0	17
Valve 4W Over Current	0	0	0	0	18
Valve 4W Time Out	0	0	0	0	19
Valve 4W Under Current	0	0	0	0	20
Leak Low	0	0	0	0	21
Leak High Failure	0	0	0	0	22
Batt 2 Under Voltage Failure	0	0	0	0	23
Batt 3 Under Voltage Failure	0	0	0	0	24
Converter 1 Faulted	0	0	0	0	25
Converter 2 Faulted	0	0	0	0	26
Converter 3 Faulted	0	0	0	0	27
Converter 4 Faulted	0	0	0	0	28
Temperature Ambient Under	0	0	0	0	29
Temperature Anolyte Under	0	0	0	0	30
Batt 4 Under Voltage Failure	0	0	0	0	31

				Flag	BIT #
Converter 5 No Comm	0	0	0	0	0
Converter 6 No Comm	0	0	0	0	1
Converter 7 No Comm	0	0	0	0	2
Converter 8 No Comm	0	0	0	0	3
Converter 5 Faulted	0	0	0	0	4
Converter 6 Faulted	0	0	0	0	5
Converter 7 Faulted	0	0	0	0	6
Converter 8 Faulted	0	0	0	0	7
Batt 5 Over Voltage Failure	0	0	0	0	8
Batt 6 Over Voltage Failure	0	0	0	0	9
Batt 7 Over Voltage Failure	0	0	0	0	10
Batt 8 Over Voltage Failure	0	0	0	0	11
Pump Anolyte Over RPM	0	0	0	0	12
Pump Anolyte Under RPM	0	0	0	0	13
Pump Anolyte Over Current	0	0	0	0	14
Pump Anolyte Under Current	0	0	0	0	15
Pump Catholyte Over RPM	0	0	0	0	16
Pump Catholyte Under RPM	0	0	0	0	17
Pump Catholyte Over Current	0	0	0	0	18
Pump Catholyte Under Current	0	0	0	0	19
Batt 5 Under Voltage Failure	0	0	0	0	20
Batt 6 Under Voltage Failure	0	0	0	0	21
Batt 7 Under Voltage Failure	0	0	0	0	22
Batt 8 Under Voltage Failure	0	0	0	0	23
	0	0	0	0	24

HISTORY:

REV	DATE:	ISSUER	DESCRIPTION
0.0	09/05/13	HCB	INITIAL RELEASE
1.0	10/17/13	HCB	ADDED BATT UNDERVOLTAGE & PUMP FAULTS PER EC-0344.

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Table 1 Alarm or Fault

Fault Code (Bit)	Name	Cause	What to do
1 (0)	Temperature Ambient Over	Temperature inside V3.1 is too high	Check ambient temperature inside enclosure by heat exchanger Open doors to allow additional cooling Restart unit once temperature gets below 50 degrees C Contact ZBB should fault continue
2 (1)	Temperature Anolyte Over	Anolyte temperature is too high	Stop charging / discharging Keep unit enabled to allow pumps to run Put unit into strip by adjusting strip cycle counter Contact ZBB should fault continue
4 (2)	Bus Under Voltage	Main DC bus is less than 325 VDC	Verify ZBB EnerSection is enabled If V3.1 is connected to other sources, verify the DC bus is above 325 VDC. Contact ZBB should fault continue
8 (3)	Battery Over Current	Controller instability	Check DC Load Wiring, cycle power Contact ZBB
32 (5)	Battery 1 Over Voltage Failure	Cell stack voltage is over 240 VDC (V3.1), 120 VDC (V3)	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
64 (6)	Battery 2 Over Voltage Failure	Cell stack voltage is over 240 VDC (V3.1), 120 VDC (V3)	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
128 (7)	Battery 3 Over Voltage Failure	Cell stack voltage is over 240 VDC (V3.1), 120 VDC (V3)	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
256 (8)	Battery 4 Over Voltage Failure	Cell stack voltage is over 240 VDC (V3.1), 120 VDC (V3)	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue

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Fault Code	Name	Cause	What to do
512 (9)	Converter 1 No Comm	DC-DC Converter has stopped communicating to the V3.1 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU01, FU02 Contact ZBB
1024 (10)	Converter 2 No Comm	DC-DC Converter has stopped communicating to the V3.1 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU05, FU06 (V3.1), FU03, FU04 (V3) Contact ZBB
2048 (11)	Converter 3 No Comm	DC-DC Converter has stopped communicating to the V3.1 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU09, FU10 (V3.1), FU05, FU06 (V3) Contact ZBB
4096 (12)	Converter 4 No Comm	DC-DC Converter has stopped communicating to the V3.1 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU13, FU14 (V3.1), FU07, FU08 (V3) Contact ZBB
8192 (13)	Battery 1 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Verify fuses are not blown to Cell Stacks FU03, FU04 Put unit into strip cycle by adjusting strip cycle counter Contact ZBB
16384 (14)	5 or more of 8 total converters faulted or no comm OR 3 or more of 4 total converters faulted or no comm	DC-DC Converter has stopped communicating to the V3.1 controller or it has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
32768 (15)	Valve 2W Over Current	Valve is drawing more current than rated, possibly caused by the valve binding in the piping	Disable and enable V3.1 to clear fault Contact ZBB should fault continue
65536 (16)	Valve 2W Time Out	Valve has not opened or closed within the allotted time	Disable and enable V3.1 to clear fault Contact ZBB should fault continue

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Fault Code	Name	Cause	What to do
131072 (17)	Valve 2W Under Current	Valve is drawing less current than rated, possibly caused by actuator decoupling from valve	Disable and enable V3.1 to clear fault Contact ZBB should fault continue
262144 (18)	Valve 4W Over Current	Valve is drawing more current than rated, possibly caused by the valve binding in the piping	Disable and enable V3.1 to clear fault Contact ZBB should fault continue
524288 (19)	Valve 4W Time Out	Valve has not opened or closed within the allotted time	Disable and enable V3.1 to clear fault Contact ZBB should fault continue
1048576 (20)	Valve 4W Under Current	Valve is drawing less current than rated, possibly caused by actuator decoupling from valve	Disable and enable V3.1 to clear fault Contact ZBB should fault continue
2097152 (21)	Leak Low	Fluid has reached the low level sensor in the containment area	Check the V3.1 for leaks Check wiring and contacts of leak sensor LS-2 Contact ZBB
4194304 (22)	Leak High Failure	Fluid has reached the high level sensor in the containment area	Check the V3.1 for leaks Check wiring and contacts of leak sensor LS-1 Contact ZBB
8388608 (23)	Battery 2 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Verify fuses are not blown to Cell Stacks FU03, FU04 Put unit into strip cycle by adjusting strip cycle counter Contact ZBB
16777216 (24)	Battery 3 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Verify fuses are not blown to Cell Stacks FU03, FU04 Put unit into strip cycle by adjusting strip cycle counter Contact ZBB

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Fault Code	Name	Cause	What to do
33554432 (25)	Converter 1 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
67108864 (26)	Converter 2 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
134217728 (27)	Converter 3 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
268435456 (28)	Converter 4 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
536870912 (29)	Temperature Ambient Under	Temperature is not above V3.1 Minimum Operating Point	Verify temperature where the V3.1 is located Increase temperature in area where V3.1 is located Contact ZBB should temperature be above minimum operating point
1073741824 (30)	Temperature Anolyte Under	Electrolyte temperature is not above V3.1 Minimum Operating Point	Verify temperature where the V3.1 is located Increase temperature in area where V3.1 is located For V3.1C, verify heat blanket is operating Contact ZBB should temperature be above minimum operating point
2147483648 (31)	Battery 4 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Verify fuses are not blown to Cell Stacks FU03, FU04 Put unit into strip cycle by adjusting strip cycle counter Contact ZBB

Table 2 Alarm 1 or Fault 1

Fault Code	Name	Cause	What to do

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Fault Code	Name	Cause	What to do
1 (0)	Converter 5 No Comm	DC-DC Converter has stopped communicating to the V3 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU09, FU10 Contact ZBB
2 (1)	Converter 6 No Comm	DC-DC Converter has stopped communicating to the V3 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU11, FU12 Contact ZBB
4 (2)	Converter 7 No Comm	DC-DC Converter has stopped communicating to the V3 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU13, FU14 Contact ZBB
8 (3)	Converter 8 No Comm	DC-DC Converter has stopped communicating to the V3 controller	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter FU15, FU16 Contact ZBB
16 (4)	Converter 5 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
32 (5)	Converter 6 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
64 (6)	Converter 7 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB
128 (7)	Converter 8 Faulted	DC-DC Converter has faulted	Verify lights are on DC-DC converter red/green LEDs Verify fuses are not blown to DC-DC converter Contact ZBB

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Fault Code	Name	Cause	What to do
256 (8)	Battery 5 Over Voltage Failure	Cell stack voltage is over 120 VDC	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
512 (9)	Battery 6 Over Voltage Failure	Cell stack voltage is over 120 VDC	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
1024 (10)	Battery 7 Over Voltage Failure	Cell stack voltage is over 120 VDC	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
2048 (11)	Battery 8 Over Voltage Failure	Cell stack voltage is over 120 VDC	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB should fault continue
4096 (12)	Pump Anolyte Over RPM	Motor has decoupled from the pump	Contact ZBB
8192 (13)	Pump Anolyte Under RPM	Pump or motor has seized or electrolyte liquid is too cold	Verify temperature is above minimum specification for model of V3(.1). Heat area if temperature is too low. Contact ZBB
16384 (14)	Pump Anolyte Over Current	Pump or motor has seized or electrolyte liquid is too cold	Verify temperature is above minimum specification for model of V3(.1). Heat area if temperature is too low. Contact ZBB
32768 (15)	Pump Anolyte Under Current	Motor has decoupled from the pump	Contact ZBB

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Fault Code	Name	Cause	What to do
65536 (16)	Pump Catholyte Over RPM	Motor has decoupled from the pump	Contact ZBB
131072 (17)	Pump Catholyte Under RPM	Pump or motor has seized or electrolyte liquid is too cold	Verify temperature is above minimum specification for model of V3(.1). Heat area if temperature is too low. Contact ZBB
262144 (18)	Pump Catholyte Over Current	Pump or motor has seized or electrolyte liquid is too cold	Verify temperature is above minimum specification for model of V3(.1). Heat area if temperature is too low. Contact ZBB
524288 (19)	Pump Catholyte Under Current	Motor has decoupled from the pump	Contact ZBB
1048576 (20)	Battery 5 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB
2097152 (21)	Battery 6 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB
4194304 (22)	Battery 7 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB
8388608 (23)	Battery 8 Under Voltage Failure	Cell stack has not reached a minimum voltage while charging	Put unit into strip cycle by adjusting strip cycle counter Contact ZBB

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ZBB SERVICE NUMBERS

SERVICE & TECHNICAL SUPPORT

Address:
ZBB Energy Corporation
N93 W14475 Whittaker Way
Menomonee Falls, Wisconsin 53051

Business hours: United States Central Time Zone – 0700 to 1700
Telephone: 1-262-253-9800 ext 135

Emergency Mobile/Cell Number: + 1 262 442 1216

8.0 Recommended Spare Parts

ZBB Energy Corporation 50V3.1C Recommended Spare Parts			
EnerStore™ 50V3.1C Module/s Project Total:			
Item Description	**ZBB Part Number**	**Quantity per Module**	**Recommended No. of Spares**
Valve, Ball 32mm, Soc.,Pump shut-off, 2nd Phase discharge	110041	3	1
Actuator, 24 VDC, 90 degree rotation PLUS 2104750 24VDC	120325	2	1
Valve, 4 way, V3.1	610029	1	1
Heat Exchanger	610008	1	1
Pump, DB6H Anolyte 24VDC,250W, 3.63" Impeller	110175	1	1
Pump, DB6H Catholyte 24VDC,250W, 3.63" Impeller	110176	1	1
Sensor,spill,liquid level,24v	120148	2	2
Heat Pad, 66.5 x 22", 1.25 Watts per/in.,1800 Wats@ 600VDC	120356	1	1
Fan, 404 mm, 48 VDC, 1600 CFM	130123	1	1
Fan, 48V DC, 4A 414W, CFM	130441	2	1
V3 Stack (Complete and Tested)	308001	8	2
DC/DC Converter	327346	4	1
Power Supply, In: DC250-500V, Out: DC 24-48V; 20A, PULS	120855	3	1
Auxiliary Power & Control -APC	620005	1	1
Contactor #EV200HAANA	120120	3	1
Fuse, 10A, fast acting, 600VAC/VDC 100kAIR	120872	2	2
Fuse, 15A Fast Acting, 600V, 100kAIR, Midget	120856	4	2
Fuse, 30A Fast Acting, 600V, 100kAIR, Midget	120857	8	4
Fuse, 60A Fast Acting, 600VAC, 200kAIR/300VDC 100kAIR	120858	8	4
Thermosnap, NC, open on rise 15C, QD Terminal	120789	1	1
Thermosnap, NC, open on rise 60C, QD Terminal	120790	1	1
Thermosnap, NC, open on rise 65C, QD Terminal	120788	1	1
Thermosnap, NC, open on rise 80C, QD Terminal	120787	2	1
Thermosnap , OC NC, Temp Range	120381	1	1
Thermocouple, Omega, Self-Adhesive, K-type	120526	2	1
Fan, Axial, 11.8cfm, 24vdc, 5000rpm,-20-70C	130154	1	1
PCB, RJ-45 to Fiber Optic, Interface w/Sync	327307	1	1
EnerStore™ Special Tools			
Drum pump/fittings kit (fill and empty)	314701	0	1
Peristaltic Pump	155000	0	1

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9.0 Material Safety Data Sheet

MATERIAL SAFETY DATA SHEET

Product Name:	**ZBB ELECTROLYTE**		
Revision Date:	12/05/12	Revision:	6
Supersedes:	07/07/10		

1. Identification Of The Substance And The Company

Chemical name Mixture

Chemical formula Not applicable

Type of product Solution used in batteries

Company ZBB Energy Corp.
N93 W14475 Whittaker Way
Menomonee Falls, WI 53051
(8am-5pm ET) (262) 253-9800

Emergency Contact ZBB Energy Corp. (262) 253-9800
INFOTRAC 1-800-535-5053 (24 hours)

NFPA Profile: **Health = 3 Flammability = 0 Reactivity = 0**
Personal Protection = Oxidizer

2. Composition / Information on Ingredients

Componenets	CAS	Weight %	ACGIH-TLV Data	OSHA (PEL) Data
Zinc Bromide	7699-45-8	30-35	Not determined	Not determined
N-ethyl-N-methylpyrrolidinium Bromide	69227-51-6	7-12	Not determined	Not determined
Zinc Chloride	7646-85-7	3-7	1 mg/m^3 (as fume)	1 mg/m^3 (as fume)
Water	7732-18-5	45-55	Not determined	Not determined
Bromine	7726-95-6	< 1%	0.1 ppm (0.66 mg/m^3) TWA 0.2 ppm (1.3 mg/m^3) STEL	0.1 ppm (0.7 mg/m^3)

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3. Hazards Identification / Health Information

Emergency overview	Corrosive to eyes, skin and mucous membranes. May cause skin sensitization. Bromine vapors are highly irritating and painful to the respiratory tract.
Eye Contact	May cause eye irritation.
Skin Contact	May cause dermatitis.
Inhalation	May cause irritation to the respiratory tract.
Ingestion	May cause severe burns to the mucous membranes of the mouth, esophagus, and stomach, abdominal pain, nausea and vomiting. May cause falling asleep, muscular incoordination and respiratory depression.

4. First Aid Procedures

Eye Contact	Holding the eyelids apart, flush eyes promptly with copious flowing water for at least 20 minutes. Get medical attention immediately.
Skin Contact	Remove contaminated clothing. Wash skin thoroughly with mild soap and plenty of water for 15 minutes. Wash clothes before re-use. Get medical attention immediately.
Inhalation	In case of inhalation, remove person to fresh air. Keep him quiet and warm. Apply artificial respiration if necessary and get medical attention immediately.
Swallowing	If swallowed, wash mouth thoroughly with plenty of water and give water or milk to drink. Get medical attention immediately. ** Note: Never give an unconscious person anything to drink. **
Notes to physician:	Corrosive In case of ingestion DO NOT induce vomiting No specific antidote. Treat symptomatically and supportively.

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5. Fire and explosion hazards

Flash point	None
Auto-ignition Temperature	Not applicable
Flammable limits in air	Not flammable
Extinguishing media	Material is not combustible. Use extinguishing media appropriate to surrounding fire conditions.
Fire fighting procedures	Stay upwind. Avoid any bodily contact. Wear self-contained breathing apparatus in a positive pressure mode and appropriate protective clothing. Use water from side and from safe distance to keep fire exposed containers cool.

Unusual fire & explosion hazards

When heated to decomposition, may release poisonous and corrosive fumes of hydrobromic acid (HBr) and Bromine (Br_2). Although not combustible itself, the fuming liquid will react with combustible materials and may cause them to ignite. Hydrogen, many organic compounds and some metals will burn in a bromine atmosphere.

6. Accidental Release Measures

Personal precautions	Evacuate area. Full protective clothing, including self-contained breathing apparatus or power air purifying respirator, must be used.
Methods for cleaning up	Neutralize, then absorb on sand or vermiculite and place in closed container for disposal. Ventilate area and wash spill site after material pickup is complete. Avoid access to streams, lakes or ponds.

The following neutralizing agents for bromine are listed in order of neutralizing efficiency:

1. 10-50% potassium carbonate solution
2. 10-30% sodium carbonate solution
3. 5-10% sodium bicarbonate solution
4. Sodium thiosulfate solution (prepared by dissolving 4 kg of technical grade sodium thiosulfate in 9 liters of water and adding 100 gr of soda ash). Please note that there is a high heat of reaction released in this procedure.
5. 5% magnesium hydroxide slurry (very slow neutralizing action).
6. 5% slaked lime
7. 5% sodium hydroxide solution

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7. Handling and Storage

Handling Avoid breathing vapors and any other bodily contact. Keep containers tightly closed.

Storage Store in a dry, well-ventilated area away from incompatible materials (see “materials to avoid”).

8. Exposure control / personal protection

PEL/TWA (OSHA Permissible Exposure Limit/Time Weighted Average):
For Bromine: 0.1 ppm, Not established for other components.

TLV/TWA (ACGIH Threshold Limit Value/Time Weighted Average):
For Bromine: 0.1 ppm, Not established for other components.

Ventilation requirements Provide adequate ventilation.
Use local exhaust as necessary, especially under misting conditions.

Personal protective equipment:

- Respiratory protection Respirator with cartridge providing protection against bromine (up to 5 ppm) or self-contained breathing apparatus (above 5 ppm).
For short term exposure to low concentrations, an approved combination acid gas-organic vapor gas mask is suitable.
The wearer should be warned to get out of the area at the first sign of bromine gas odor coming through the mask.
NIOSH recommendation for respirator selection includes any chemical cartridge respirator with a full face piece and cartridge.

- Hand protection Neoprene or rubber gloves, (tucked under sleeves.

- Eye protection Chemical safety goggles or face shield with safety glasses.

- Skin and body protection Protective impervious clothing, hard hat and neoprene or rubber boots.

Hygiene measures Avoid bodily contact.
Safety shower and eye bath should be provided. Do not eat, drink or smoke until after-work showering and changing clothes.

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9. Physical And Chemical Properties

Appearance and Odor:	Yellow to slightly orange liquid with a slightly irritating odor.
Boiling Point/Range:	136°C
Melting Point/Range:	ca. -8°C
Vapor Pressure:	5.2 mm Hg at 25°C
Specific Gravity:	1.4 - 1.6
Vapor Density (Air = 1)	Not available
Evaporation (ether = 1)	Of water
Solubility in Water:	Soluble
Thermal Decomposition	Not available

10. Stability and Reactivity

Stability	Stable under normal conditions
Materials to avoid	Strong oxidants
Conditions to avoid	Not available
Hazardous decomposition products	Hydrogen bromide and bromine
Hazardous polymerization	Will not occur

11. Toxicological Information

Toxicity:

- Rat oral LD50	For zinc bromide 100% (1047 mg/kg)
- Rat inhalation LC50	For bromine 2700 mg/m^3
- Mouse inhalation LC50	for bromine 750 ppm/9 min.

Effects of overexposure

- Ocular	Corrosive Symptoms include redness, pain and blurred vision. Lachrimation occurs at less than 1 ppm.
- Dermal	Corrosive. Mild irritant to intact skin
- Inhalation	Corrosive to mucous membranes and upper respiratory tract. Symptoms include sore throat, dizziness, headache, nosebleed, coughing, abdominal pain, and sometimes rash. Concentrated bromine vapors may cause severe burns that ulcerate and are slow to heal.
- Ingestion	Corrosive by ingestion. Symptoms of inhalation.

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-Chronic toxicity Prolonged exposure may cause chronic bronchitis, contact and allergic dermatitis.
Repeated oral intake of bromides (.9 mg/kg of body weight/day) may affect the central nervous system. Warning symptoms include mental dullness, slurred speech, weakened memory, apathy, anorexia, constipation, drowsiness and loss of sensitivity to touch and pain.

Mutagenicity Not mutagenic by the Ames Test.
MEP is positive in in vivo somatic cell mutagenicity assay, the bone marrow micronucleous test.

Carcinogenicity Not known to be a carcinogen.
Not classified by IARC.
Not included in NPT 10th Annual Report on carcinogens.

12. Ecological Information

Ecological Effects Zinc bromide is classified by IMO as a marine pollutant.
Bromine is not biodegradable.
Because of its high vapor density, bromine id not transferred to the high atmospheric levels.

Note: The following data refer to zinc bromide ($ZnBr_2$)
Aquatic toxicity:
- 96 Hour-LC50, Fish 115.9 mg/l (Juvenile turbot)
- 72 Hour-EC50, Marine alga
6.6 mg/l (Skeletenoma costatum)
- 48 Hour-EC50, Marine invertebrate
2.4 mg/l (Acatia tonsa)
- 48 Hour-EC50, Daphnia magna 8.8 mg/l

13. Disposal Considerations

Waste disposal May be disposed of by absorption on vermiculite or other equivalent absorbent. Dispose of waste in suitable containers covered with sodium carbonate or bicarbonate. Remove to approved incinerator or landfill. Observe all federal, state and local environmental regulations when disposing of this material.

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14. Transportation Information

UN No.	1760
DOT	Proper shipping name: Corrosive Liquid, n.o.s. (contains zinc bromide and bromine) Class: 8 – Corrosives Label: CORROSIVE (8) Marking: MARINE POLLUTANT Packing Group: II
IMO	Proper shipping name: Corrosive Liquid, n.o.s. (contains zinc bromide and bromine) Class: 8 – Corrosives Label: CORROSIVE (8) Marking: MARINE POLLUTANT Packing Group: II
ICAO / IATA	Class: 8 Hazard Label (s): Corrosive Packing Group: II

15. Regulatory Information

USA	Reported in the EPA TSCA Inventory
EPCRA (SARA title III)	Zinc compounds and Bromine (CAS #7726-95-6) are subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40CFR 372. Section 311/312 Categorization (40CFR 370): Zinc bromide & zinc chloride are categorized as an immediate and delayed health hazard. Under the provisions of Section 311 of the Clean Water Act, zinc compounds are designated a hazardous substance if discharged in navigable waters. The Reportable Quantity (RQ) for notification is 1,000 lb/454 kg.
EEC	Not all ingredients in the preparation are reported in EINECS
Japan	Listed in MITI
Australia	Listed in AICS

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16. Other information

The information presented herein is believed to be factual as it has been derived from the works and opinions of persons believed to be qualified experts; however, nothing contained in this information is to be taken as a warranty or representation for which ZBB Technologies, Inc., bears legal responsibility. The user should review any recommendations in the specific context of the intended use to determine whether they are appropriate.

PREPARED BY:	ZBB Energy Corp. N93 W14475 Whittaker Way Menomonee Falls, WI 53051 Ph: (262) 253-9800 www.zbbenergy.com
ISSUE DATE:	December 5, 2012
SUPERSEDES:	(April 2, 2008)

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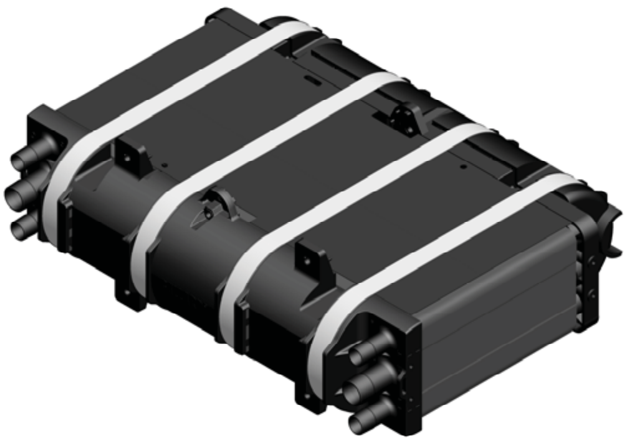
8.17 Fuel Cell

See attached folder Section 8

FCgen®-1310 Fuel Cell Stack

Design Characteristics



Model Name: FCgen®-1310
Part Number: 5119705, 5120575, 5120120, 5120100

Document Number: SPC5103106 rev 0C
Date: October, 2010

FCgen®-1310 Fuel Cell Stack

Design Characteristics

Model Name: FCgen®-1310
Part Number: 5119705, 5120575, 5120120, 5120100
Document Number: SPC5103106 rev 0C
Date: October, 2010

Ballard Power Systems Inc.
9000 Glenlyon Parkway
Burnaby, BC V5J 5J8
Canada
Technical Support: (604) 444-2470

This document is intended for initial evaluations of fuel cell system options and should be used as guidance only.

It may contain estimated values for stack and system attributes, and it may contain errors or omissions.

“TBD” is used where information does not exist or has not been validated

Values are subject to change without notice.

Table of Contents

List of Tables

1.0 GENERAL

1.1. Scope

This document describes the target design characteristics for the FCgen®-1310 Fuel Cell Stack developed by Ballard Power Systems. Unless noted otherwise, all specification values stated are applicable at the beginning of operational lifetime. Some characteristics will change over time as the fuel cell stack is operated.

1.2. Product Configurations

The FCgen®-1310 stack is available in sizes ranging from 27 cells up to 120 cells.

Number of Cells	**Part Number**	**Typical Power Application**
27	5119705	1 - 2 kW
50	5121050	3 kW
75	5120575	5-8 kW
100	5120100	
120	5120120	8 - 10 kW

1.3. Glossary

Term	**Description**
Air bleed	Term used to describe the addition of air to the fuel loop for the purpose of oxidizing Carbon Monoxide (CO)
ATR	Auto Thermal Reformate
BOL	Beginning of Life
CVM	Cell Voltage Monitoring System
MEA	Membrane-Electrode Assembly
sccm	standard cubic centimeter per minute (evaluated at 1 atmosphere and 0°C)
slpm	standard liter per minute (evaluated at 1 atmosphere and 0°C)
stoic	Stoichiometry, used to describe reactant flow rate: Fuel Flow (slpm) = stoic X Load X Number of Cells X 0.00696 [slpm/A/cell] / %H2 Oxidant Flow (slpm) = stoic X Load X Number of Cells X 0.00349 [slpm/A/cell] / %O2
TBD	To be determined

In general, standard SI units and their abbreviations are used in this document, with exceptions noted above. Chemical components are described using standard chemical nomenclature (e.g. H2 for hydrogen gas).

1.4. Reference Documents

- MAN5100304 FCgen®-1310 Product Manual and Integration Guide
- DRW5113912 Interface Control Drawing for 1310 Stacks

2.0 SPECIFICATION

2.1. General Characteristics

The 1310 stack design is built to operate without active cell voltage monitoring provided operating conditions are within the specified regions. The 1310 stack is suitable for operation in an always on steady state power mode or in an on/off cycling power mode.

The 1310 stack may take up to 50 hours of operation in order to be fully conditioned, thus stack performances upon receipt may be lower than stated in this document until this burn in time has been achieved.

2.2. Stack Performance

Stack performances reported in this document are all representative of a steady state stack that has been fully conditioned. Polarisation values are always taken from a higher current to a lower current state. The stack performance shown in Table 1 is based on a typical set of operating conditions utilizing a pure hydrogen system listed in table 3.

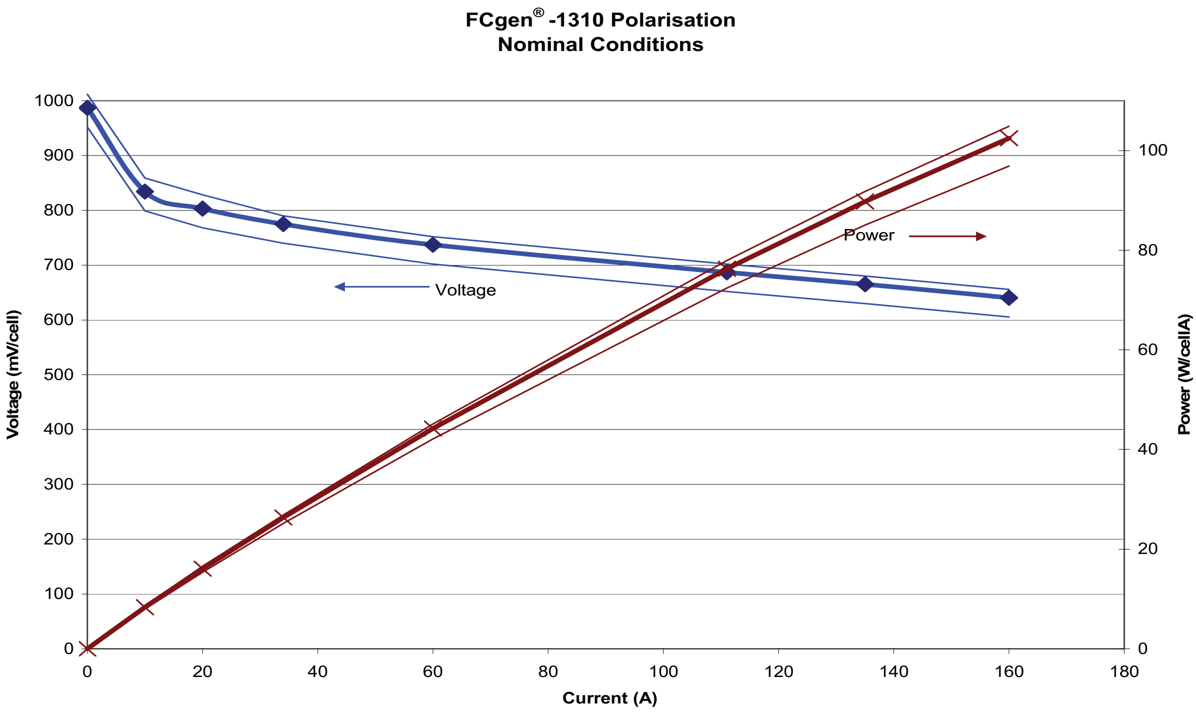
Table 1: Stack Performance at Beginning of Life

Performance Parameter		Stack Current (A)					
		0	34	60	111	135	160[1]
Average Power	W/cell	0	26	44	76	90	102
Average Voltage	mV/cell	987	775	737	687	665	640
Fleet Performance Variability[2]	mV	+25 / -35	+15 / -35	+15 / -35	+15 / -35	+15 / -35	+15 / -35

[1] A nominal operating current of 135A, minimum operating current of 34A, and a maximum operating current of 160A is recommended. See Section 2.3 for details

[2] Performance variability defines the expected variability in performance from stack to stack at Beginning of Life due to manufacturing variability.

Figure 1 = Polarisation (V-I) Curve for range of operation with error bands



2.3. Operating Conditions

Table 2: Specified Operating Condition Ranges

Electrical	
Load	160 A max, 34 A min[3]
Voltage	1.18 V/cell max, 0.50 V/cell min
Current Ramp Rate	1000 A/sec provided conditions for a given load are within specifications.
Fuel	
Composition	H_2/N_2 Blend or Reformate[4], target ≥80%-vol H_2 (dry)
Stoic	≥1.45
Inlet Pressure	< 300 mbar(g)
Pressure Drop	> 50 mbar
Anode-Cathode inlet overpressure	> 0mbar, < 200 mbar, 25 mbar target
Inlet Temperature	Coolant inlet temperature +/- 2 °C
Inlet Humidity	80%-100% RH
Liquid Water Ingestion	Acceptable limits have not been defined for this design
Oxidant	
Composition	Ambient Air
Stoic	>= 1.8
Inlet Pressure	< 300 mbar
Pressure Drop	> 50 mbar
Inlet Temperature	Coolant inlet temperature +/- 2 °C
Inlet Humidity	95% - 100% (non-condensing)
Liquid Water Ingestion	Acceptable limits have not been defined for this design
Coolant	
Composition	De-ionized Water and/or Ethylene Glycol, or Propylene Glycol. < 50% glycol
Conductivity	< 5 µS/cm @ 20 °C
Flow	> 0.1 L/min/cell
Inlet Pressure	> 25 mbar, < 500 mbar
Inlet Temperature	Target: 55 – 60 °C,
Temperature Rise	Target: 0.8 °C per 20 A +2 °C

[3] Recommended minimum and maximum. See Ballard for operation outside these limits.

[4] While this stack can be used with a reformate based fuel system, it requires a fuel purification system between the fuel processor and stack to ensure CO levels are substantially eliminated. Periodic anode recoveries may be required.

Table 3: Nominal Operating Conditions

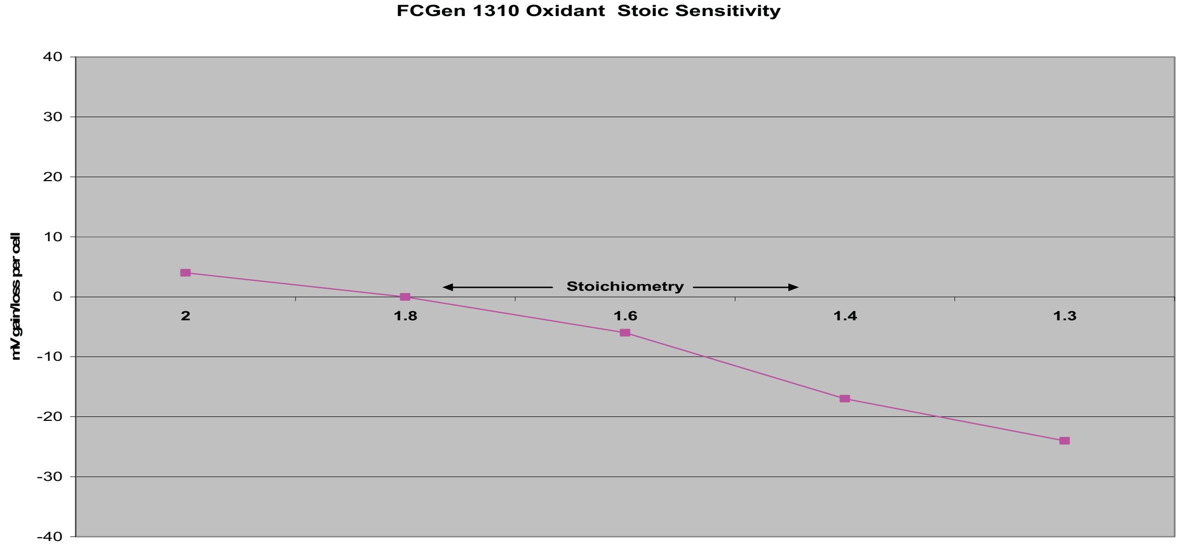
Operating Condition		Stack Current (A)				
		34	60	111	135	160
Fuel						
Composition (H2/N2 Blend)	%H2	90	90	90	90	90
Stoic	-	4.5	2.5	1.45	1.45	1.45
Inlet Pressure	bar(g)	0.130	0.140	0.190	0.220	0.250
Pressure Drop[5]	mbar	50	50	50	56	60
Inlet Temperature	°C	60	60	60	60	60
Inlet Humidity	% RH	57.8	57.8	57.8	57.8	57.8
Oxidant						
Stoic	-	1.8	1.8	1.8	1.8	1.8
Inlet Pressure	bar(g)	0.11	0.12	0.17	0.20	0.23
Pressure Drop[6]	mbar	50	75	130	158	190
Inlet Temperature	°C	58.9	58.9	58.9	58.9	58.9
Inlet Humidity	% RH	95	95	95	95	95
Coolant						
Composition	-	100% De-ionized Water				
Flow	L/min/cell	0.16	0.17	0.18	0.18	
Inlet Temperature	°C	60	60	60	60	60
Temperature Rise	°C	1.9	3.3	5.6	7.5	8.5

[5] Based on 100 cell stack, value will vary due to stack variability.

2.4. Parametric Responses

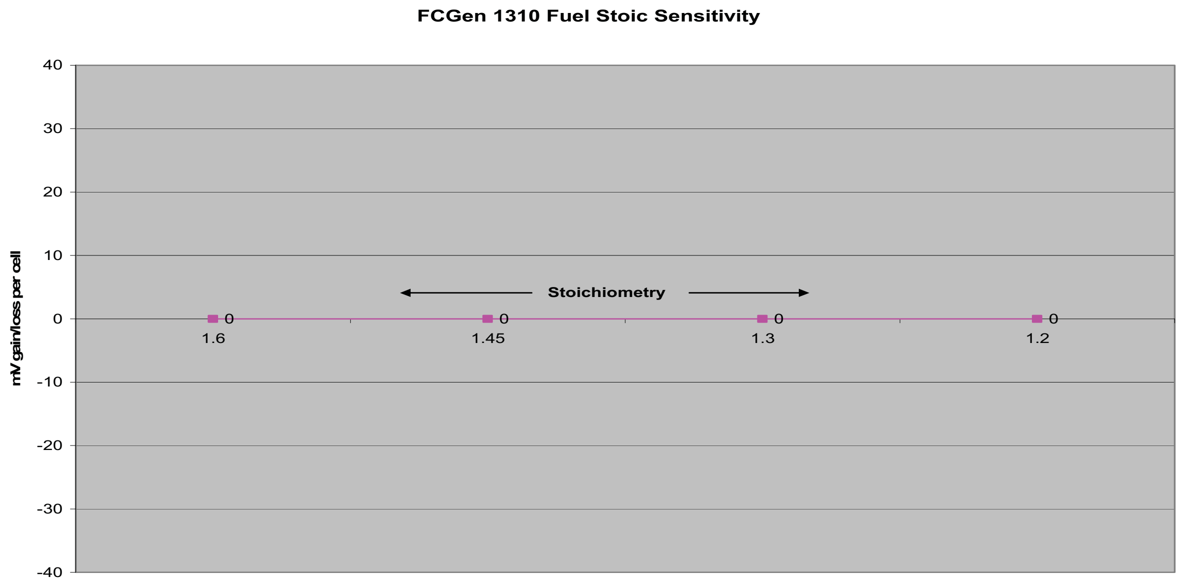
Figures 2 and 3 below show stack response to variables in operating conditions. See 135A point in table 3 for the balance of conditions used.

Figure 2 – Oxidant Stoichiometry Sensitivity at 135A.



Oxidant stoic response is immediately seen on fuel cell stack performance.

Figure 3 – Fuel Stoichiometry Sensitivity at 135A



Fuel stoic does not impact performance as seen in figure 3 above where the performance values are within measurement error of test equipment. However, insufficient fuel stoichiometry can have a serious effect on cell to cell variation within the stack and it is important to stay within the parameters of table 2.

2.5. Ambient Environment Specifications

Table 4: Ambient Environmental Conditions

Ambient Conditions	
Operating Pressure/Altitude	-400m to 4600m
Ambient Temperature, Operation	-20°C to 70°C
Total Allowable Freeze-Thaw Cycles	TBD
Ambient Relative Humidity	TBD
Shock/Vibration	TBD

The ambient conditions refer to environment around the fuel cell stack and not necessarily what the exterior system environment is. For example, the stack will have a nominal ambient temperature of 50 °C when installed in a system enclosure.

2.6. Reactant Specifications

The 1310 stack is designed specifically for use with a purified H_2 fuel stream, with zero CO or CO_2 present (H_2/N_2 blend). The stack is compatible with steam or ATR reformate; however, lower performance and durability should be expected if any CO is present and an air bleed is used, or if a significant amount of CO_2 is present.
Tables 5 and 6 contain maximum levels for common contaminants. A comprehensive list is available in the FCgen®-1310 stack integration guide.

Table 5: Fuel Specification

Description	**Specification**
Inert Diluents	
CH_4	< 4%
N_2	< 25%
Chemical Contaminants	
Carbon Monoxide (CO)	< 0.1 ppm (with air bleed)
Carbon Dioxide (CO_2)	<25%
Air Bleed	< 1%
S	< 1 ppb
NH_3	< 1 ppb

Table 6: Oxidant Specification (Ambient Air)

Description	**Specification**
Chemical Contaminants	
NO_x	< 0.1 ppb

SOx	< 0.1 ppb
Particulate	
Airborne Particles(solid or liquid)	< 20 µg/m^3, < 5 µm diameter
Salt	< 20 µg/m^3, < 5 µm diameter

2.7. Emissions (BOL)

Table 7: Maximum Beginning of Life (BOL) Emissions

Stack Leakage	
External Fuel Leak	1 sccm/cell air @ 0.5 barg
External Coolant Leak	0.1 sccm/cell air @ 0.5 barg
External Oxidant Leak	10 sccm/cell air @ 0.5 barg
Internal Transfer (Fuel To Oxidant)	1 sccm/cell air @ 0.5 barg
Internal Transfer (Fuel to Coolant)	0.1 sccm/cell air @ 0.5 barg
Internal Transfer (Oxidant to Coolant)	0.1 sccm/cell air @ 0.5 barg

2.8. Shipping/Storage Conditions

Table 8: Shipping and Storage Environmental Conditions

Environmental Condition Limits	
Temperature Range	5 °C to +70 °C
Total Allowable Freeze-Thaw Cycles	TBD
Relative Humidity Range	TBD
Shock and Vibration	Designed to withstand normal shipping shock and vibration in standard Ballard packaging.

2.9. Stack Weight and Dimensions

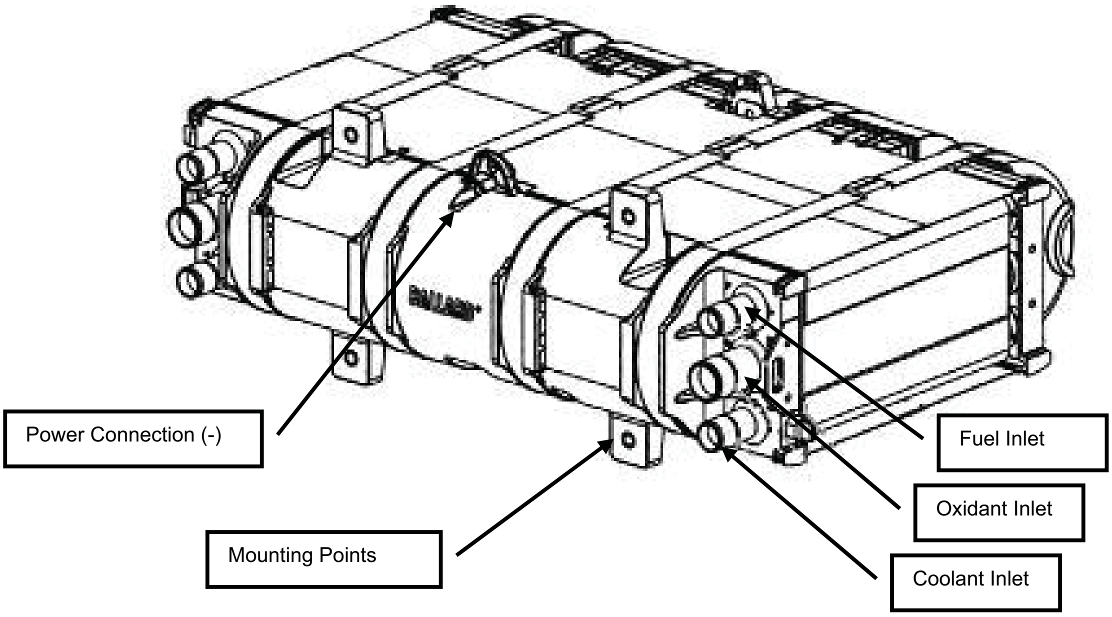
Table 9: Weight and Dimensions

Stack Length	**Height**	**Width**	**Dry Mass**
27 cells: 233 mm 120 cells: 473 mm	180 mm	490 mm	27 cells: 8.3 kg 120 cells: 22.2 kg

All dimensions are nominal. Refer to the corresponding stack interface drawing (DRW5113912) for details.

2.10. Mechanical and Electrical Interfaces

Figure 4 – Physical Interfaces



The fluid inlets and outlets are tube stub with beads designed for rubber tubing with hose clamps. Hose barb outer diameter is ¾" (19.3 mm) for fuel and coolant, and 1" (25.65 mm) for oxidant. The stack is designed for co-flow fluid streams (all fluids flow in the same direction, from inlet side of stack to outlet side).

The power connections require an interfacing lug with two ¼" (6.6 mm) holes spaced ¾" (19.3 mm) apart (for example: Panduit LCD6-14B-L, LCD2-14B-Q, LCD4-14B-L). The hardware is designed for M6 nut and bolt for connection between the buss plate and the interface lug. Cable size should be 6 AWG to 1 AWG dependant on maximum current to be drawn. The connectors should be tin-plated, and copper compression lugs with standard barrel should be used. It is preferred to install the stack as a floating (non-earth bonded) component.

Mounting points are 6.8 mm diameter through-holes and are intended for use with M6 nominal bolt size. Anode side (fluid inlet/outlet side) mounting points are located both on the top and bottom of the stack; cathode side (spring cap side) mounting points are on the bottom of the stack only for use in the flat orientation.

See stack integration guide (MAN5100304) for detailed installation instruction.

2.11. Stack Degradation Rate and Lifetime

There are generally two key life-limiting failure modes that will prevent the stack from performing as required in a given application: voltage loss and fuel leakage. Voltage loss is seen as a steady degradation in maximum power. Fuel leakage will lead to both an increase in fuel consumption, and H2 emissions in the air exhaust stream.

While the definition of specific failure criteria will differ depending on the application, Ballard has used the following End-of-Life (EOL) criteria to measure stack lifetime:

Average cell voltage at 135 A drops to less than 600mV

OR

Anode leakage rate into the Cathode increases to more than 10 cc/min per cell (tested with nitrogen at 0.5 barg).

Lifetime depends primarily on the number of on/off cycles that occur with an air-filled anode. Other factors, such as the number of operating hours, are less significant.

The design target for the lifetime of a FCGen® -1310 stack is 8000 hours and 1250 on/off cycles with air on the anode before reaching End-of-Life (EOL).

For non-cycling applications the stack is expected to meet 20,000 hours of operation provided less than 300 on/off cycles have been performed.

The stack is design to last TBD years calendar time including storage.

If lower voltage or higher leakage are acceptable in the application, of if a more benign duty cycle is used, the FCgen® -1310 stack will be able to be operate beyond these limits.

The stack can be refurbished by replacing MEAs and seals (termed a stack "recore").

2.12. Recoverable Performance Losses

Reversible performance losses over time may occur due to a variety of reasons. Most often these losses are caused by prolonged periods of non-use or contaminants in the air or fuel gas streams. Acceptable recovery methods include operations at reduced air stoics, current pulsing, addition of air bleed on the fuel, air bleed pulsing or air purging of the fuel circuit within the stack.

BALLARD POWER SYSTEMS

CUSTOMER WELCOME GUIDE

BALLARD®

PUTTING FUEL CELLS TO WORK

WWW.BALLARD.COM

Ballard's fuel cell products have put thousands of clean energy solutions to work worldwide...

and our proprietary technology ensures unsurpassed performance in each one of them.

This welcome package has been created for Ballard's customers, including channel distribution partners, fuel cell system integrators, original equipment manufacturers and other direct purchasers of Ballard's fuel cell products

BALLARD®

PUTTING FUEL CELLS TO WORK

BALLARD POWER SYSTEMS

Thank you for your recent purchase from Ballard Power Systems – the global leader in fuel cell products and service. We are pleased to provide you with this information package regarding the support you can expect from our Company.

At Ballard, we have always strived to offer the best, not only in our products, but also in post-sales customer support; anticipating and addressing any potential issues and communicating clearly with customers. We are committed to exceeding your expectations and working with our partners to provide premium support and service to you and your business. This information package was prepared with you in mind, so feel free to let us know if you think anything should be added.

In this package you will find:

- An introduction to the 'Customer Support Portal';
- Overview of Ballard's comprehensive customer support capabilities;
- Overview of Ballard's Applications Engineering and Engineering Service packages;
- Contact details for your Account Manager and the customer support team;
- Answers to frequently asked questions; and
- Customer feedback form.

The most important first step you can take is to register for access to Ballard's Customer Support Portal. This website is your source for product documentation downloads, including the operating manual and integration guide, service bulletins and service request form. To become a member, please visit: **www.ballard.com/members**.

Should you wish to reach a customer support representative, you may contact us by email at **bps.service@ballard.com** or by phone, at the numbers listed on the following page.

We look forward to developing a strong, collaborative relationship and supporting you as you deploy and utilize Ballard's fuel cell products.

Regards,

Larry Stapleton
Vice President, Sales

TECHNICAL SUPPORT

To reach a customer support representative, you may contact us by email at **bps.service@ballard.com**.

Please have your Ballard product serial number ready, or include the serial number in your email message.

Inquiries related to all product lines:

- International calls: +1.604.444.2470
- Toll free within North America: +1.877.909.3889

Inquiries related to ElectraGen™ Telecom Backup Power Systems

AUSTRALIA:	+1.604.444.2470
EUROPE:	+1.604.444.2470
INDONESIA:	+001.803.018.8111
JAPAN:	800.001.31000
MALAYSIA:	800.001.31000
NORTH AMERICA:	+1.877.909.3889
SOUTH AFRICA:	+1.604.444.2470

STAY UP TO DATE

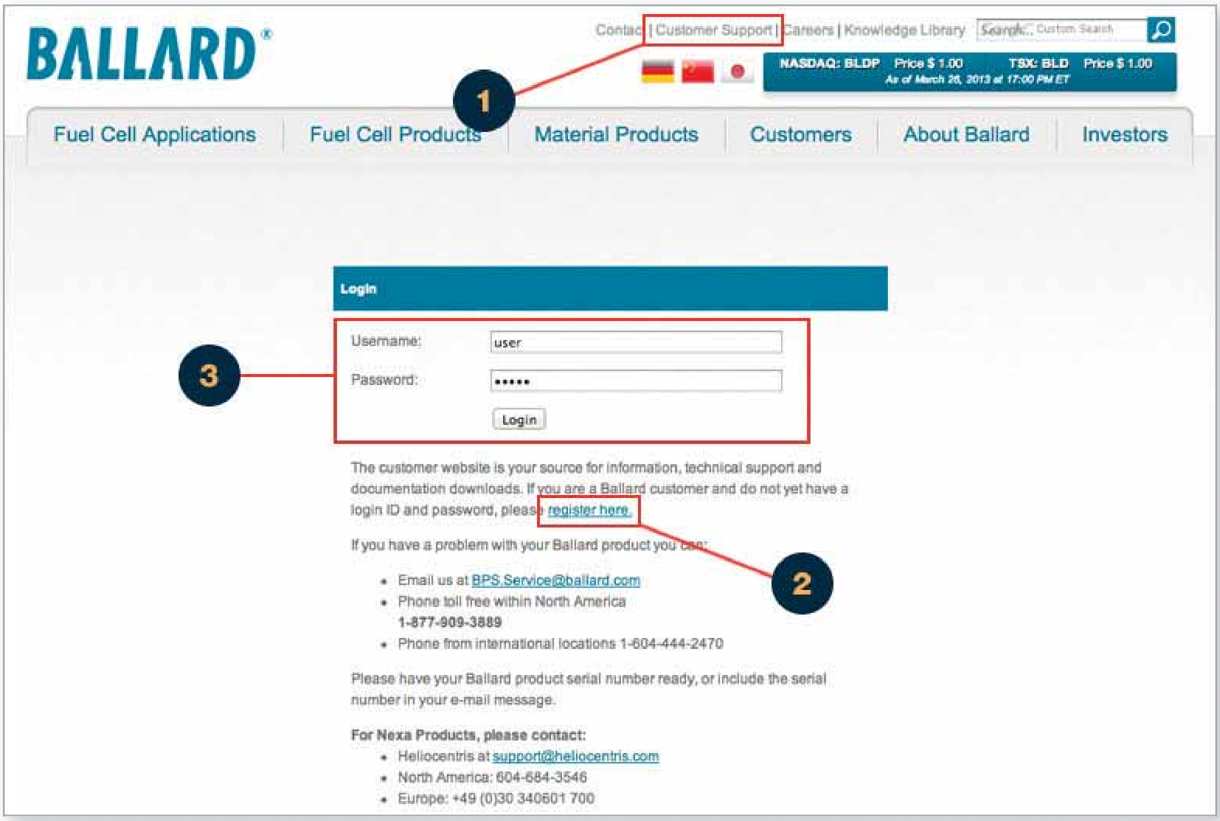
Keep current on all the latest corporate, industry and product news with **The Fuel Cell Advantage**, Ballard's online e-newsletter. **Visit Ballard's website to subscribe.**

The Fuel Cell Advantage

CUSTOMER SUPPORT PORTAL

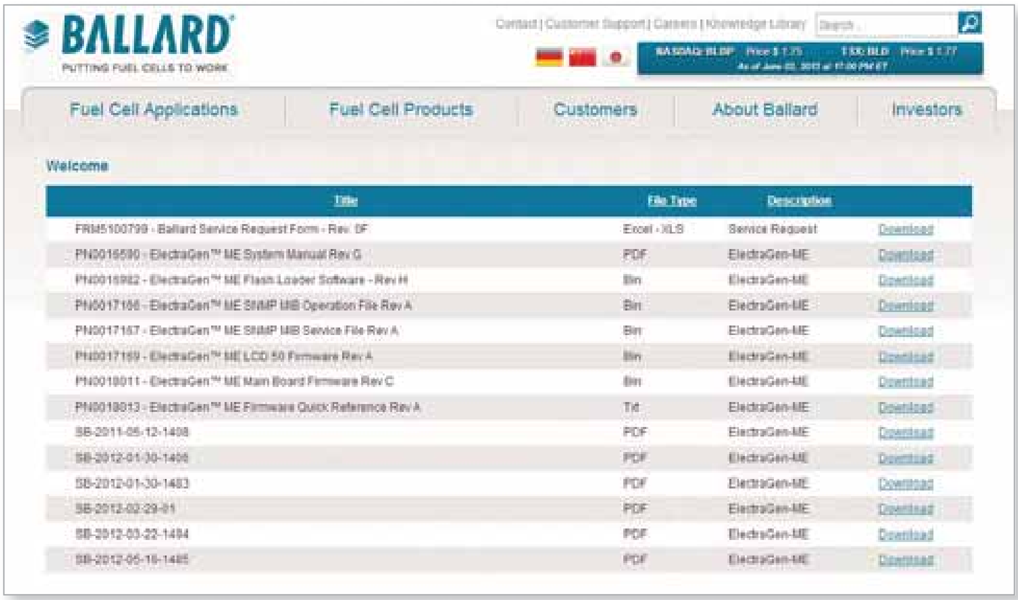
By accessing the Customer Support Portal, customers are ensured of viewing the most up-to-date product documentation.

The portal is accessed through our corporate website at **www.ballard.com**. Click on the 'Customer Support' link at the top of the screen (No. 1 in image below).



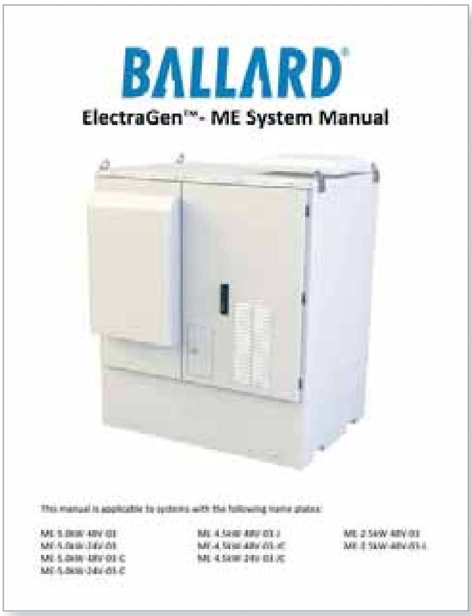
New customers must register for access to the Customer Support Portal. Click on the 'register here' link to submit your information to Ballard's Customer Service Team (No.2 in image above). A representative will respond with your personal login details. Once you have this information, enter your username and password to access documentation related to your specific product (No.3 in image above).

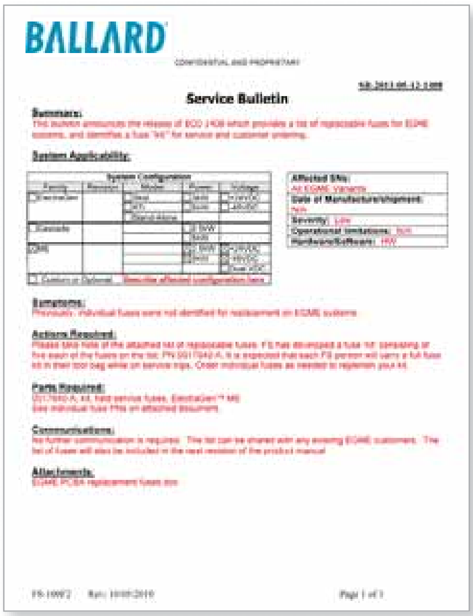
CUSTOMER SUPPORT PORTAL (continued)



Title	File Type	Description	
FRM5100799 - Ballard Service Request Form - Rev. 0F	Excel - XLS	Service Request	Download
PN0016590 - ElectraGen™ ME System Manual Rev G	PDF	ElectraGen-ME	Download
PN0016982 - ElectraGen™ ME Flash Loader Software - Rev H	Bin	ElectraGen-ME	Download
PN0017166 - ElectraGen™ ME SNMP MIB Operation File Rev A	Bin	ElectraGen-ME	Download
PN0017167 - ElectraGen™ ME SNMP MIB Service File Rev A	Bin	ElectraGen-ME	Download
PN0017169 - ElectraGen™ ME LCD 50 Firmware Rev A	Bin	ElectraGen-ME	Download
PN0018011 - ElectraGen™ ME Main Board Firmware Rev C	Bin	ElectraGen-ME	Download
PN0018013 - ElectraGen™ ME Firmware Quick Reference Rev A	Txt	ElectraGen-ME	Download
SB-2011-05-12-1408	PDF	ElectraGen-ME	Download
SB-2012-01-30-1406	PDF	ElectraGen-ME	Download
SB-2012-01-30-1483	PDF	ElectraGen-ME	Download
SB-2012-02-29-01	PDF	ElectraGen-ME	Download
SB-2012-03-22-1484	PDF	ElectraGen-ME	Download
SB-2012-05-16-1485	PDF	ElectraGen-ME	Download

In this example, an ElectraGen™-ME backup power system customer has logged into the Customer Support Portal. Documents available include the service request form, the system manual and a series of service bulletins. Click on the download button on the right-hand side of the screen to open the files. Sample documents are shown below.





SERVICE REQUEST PROCEDURE

If you require technical support for a product, please complete a **Service Request Form**, available for download in the **Customer Support Portal**.

Populate the fields marked with an asterick and forward a completed copy of the form to the Ballard Customer Service team via email to **bps.service@ballard.com**. Upon receipt of the form, the Ballard service representative will review the information with you to determine the appropriate course of action, which could range from technical advice delivered via phone or email, a product returning to Ballard for service, or a Ballard technician traveling to the customer site to provide support, among other options. The Ballard service representative will also issue an RMA number, to be used in reference to your service issue.

Ballard service representatives are committed to working with you to ensure a satisfactory resolution to all technical issues. Please provide as much detail as possible when completing the Service Request Form so we can best assist you.

COMPREHENSIVE CUSTOMER SUPPORT CAPABILITIES

Ballard's team provides world-class technical support and customer service to ensure satisfaction with our products. Relying on many combined years of fuel cell experience, our globally deployed team is available to ensure customer satisfaction through the entire life of the product.

Ballard's comprehensive customer service offerings vary by product line, typically including the following post-sale support:

- **Call Center**
  Ballard's service department provides technical support for customers' mission-critical product applications. Customer service agents provide remote support to solve product issues via phone and email.

- **Product Repair**
  Ballard has a team of product experts and repair technicians ready to solve any issues. Our repair service restores your product to factory standards with quality replacement parts. Depending on the issue, products may be returned to Ballard or repaired on-site.

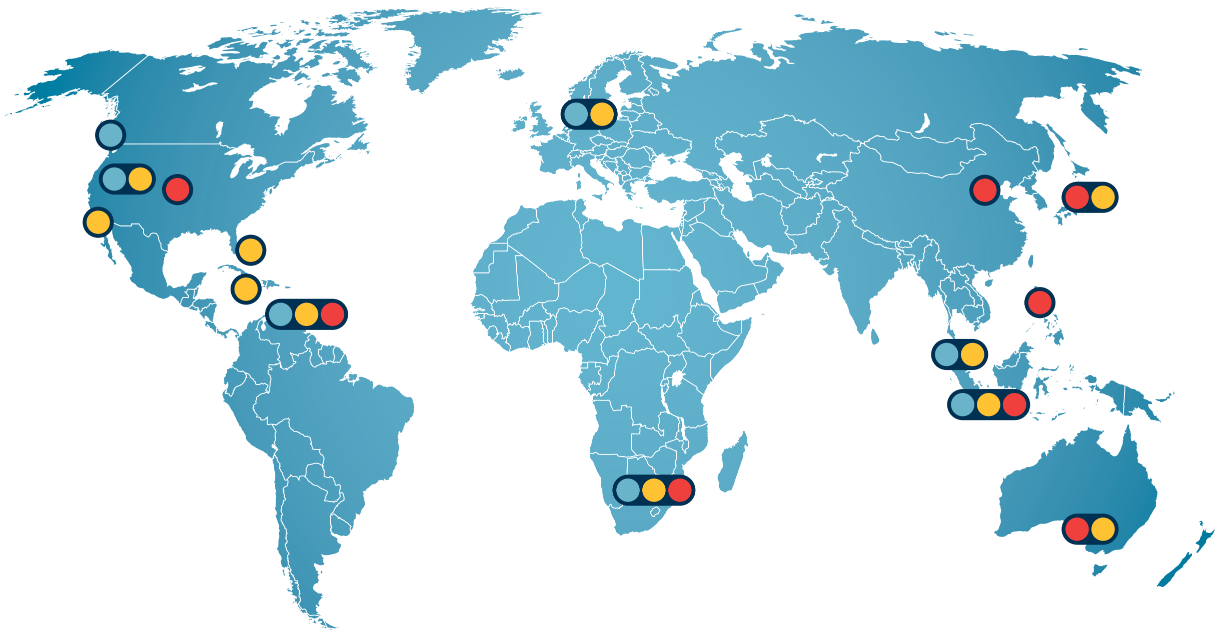
- **Onsite Service**
  Ballard can bring our technicians, specialized equipment and technology to your site to manage your needs at source, whether it be product installation, site commissioning or product performance troubleshooting.

- **Spare Parts Logistics**
  With remote parts warehouses located in key centers around the globe, Ballard's spare parts logistics systems ensure customers receive the parts they require promptly to maintain product functionality.

- **Customer Training**
  Ballard designs and conducts training sessions to transfer fuel cell technology knowledge and product operational understanding to our customers, ensuring successful product deployment. Training sessions are conducted at Ballard premises and at customer sites.

BALLARD GLOBAL SERVICE SUPPORT NETWORK

More than 2,500 ElectraGen™ fuel cell systems for telecom backup power have been shipped to customers around the world. Ballard has developed a global service support network to ensure optimal operation. This network can be put into service to support deployments of other product lines.



Field Service: BALLARD:

- Bend, Oregon, USA
- Hobro, Denmark
- Jakarta, Indonesia
- Johannesburg, South Africa
- Kuala Lumpur, Malaysia
- Port of Spain, Trinidad & Tobago
- Vancouver, BC (World HQ)

Field Service: PARTNERS:

- Beijing, China
- Adelaide, Australia
- Jakarta, Indonesia
- Johannesburg, South Africa
- Kansas, USA
- Manila, Philippines
- Port of Spain, Trinidad & Tobago
- Tokyo, Japan

Spare Parts Stocking Locations:

- Bend, Oregon, USA
- Adelaide, Australia
- Hobro, Denmark
- Jakarta, Indonesia
- Johannesburg, South Africa
- Kingston, Jamaica
- Kuala Lumpur, Malaysia
- Nassau, Bahamas
- Port of Spain, Trinidad & Tobago
- Tijuana, Mexico
- Tokyo, Japan

APPLICATIONS ENGINEERING

With all fuel cell product purchases, Ballard is pleased to offer the following complementary applications engineering support:

- Operating manual and integration guide;
- Initial one-hour teleconference to answer any technical questions regarding the integration guide or fuel cell interface; and
- Access, via email or phone, enabling you to obtain answers to questions regarding the integration guide or fuel cell product specifications.

Following fuel cell stack purchases, customers will also receive:

- A list of commonly used balance of plant components and component suppliers; and
- Analysis of system conformity to Ballard integration guidelines in support of extended commercial warranty terms.

To access these services, please register for Ballard's Customer Support Portal or contact your account manager.

PRODUCT QUALITY

Ballard's fuel cell products are manufactured to the highest quality standards, backed by years of stringent automotive fuel cell development. Ballard maintains a robust quality management system and has been ISO9001 compliant since 1996.

Automated manufacturing techniques replace discrete, labor intensive processes at Ballard's manufacturing facilities

ENGINEERING SERVICES

Customers requiring assistance beyond the standard Applications Engineering support may wish to consider an Engineering Services package.

Leveraging our expertise in proton exchange membrane fuel cell technology, Ballard offers Engineering Services to companies involved at all stages of design, manufacture, use and integration of fuel cell solutions. Clients can leverage a high level of competency in a range of specialized fuel cell activities, including:

- Product development
- Applications engineering
- Reference system design
- Fuel cell testing
- Manufacturing
- Failure analysis
- Simulation and modeling
- Infrastructure improvement

To learn more about these services or receive a quotation, contact your account manager.

FAILURE ANALYSIS

Using a wide array of analysis tools, Ballard determines the cause of any material and product failures and provides an understanding of how components change with use and time, as well as design and operation strategies to avoid future failures and enhance product quality.

Ballard's 60,000 square foot test lab offers integrated data collection & reporting.

FREQUENTLY ASKED QUESTIONS

Q. Who is my first point of contact at Ballard for commercial issues or discussions?
A. Your Ballard Account Manager is:

NAME: Catharine Reid
EMAIL: **catharine.reid@ballard.com**
PHONE: 604-412-3135

Q. I'm experiencing technical difficulty with my product. How do I access support services?
A. Should you need to reach a customer support representative, you may contact us by email at **bps.service@ballard.com** or by phone:

- **Within North America:** 1-877-909-3889 (toll free)
- **International:** 1-604-444-2470

Q. What information do I need to provide to access customer support?
A. Please have your Ballard product serial number ready, or include the serial number in your e-mail message.

Q. How do I get a copy of the operating manual for my product?
A. The most up-to-date product documents, including the operating manual and service bulletins, are available for download at your convenience on the Customer Support Portal. To become a member, visit: **www.ballard.com/members**.

Q. Where do I ship my product for service?
A. Please contact a customer service representative prior to returning a product to Ballard for repair. You will need to complete and submit a service request form, available on the Customer Support Portal, in advance of the shipment.

Q. What warranty coverage is offered by Ballard?
A. Warranty coverage varies by product line. Please refer to your Equipment Sales Agreement or contact your account manager.

Q. Does Ballard offer training sessions?
A. Ballard offers fuel cell training courses to provide you and your team with a detailed introduction to proton exchange membrane fuel cell technology and Ballard's products. Contact your account manager for further details regarding pricing and scheduling.

Tell Us How We're Doing

Ballard welcomes your feedback at all stages of the sales cycle. To let us know how we're doing, please rate our performance using the scale indicated below as a reference, make any comments that you would like to add, and then click on File "Save As" to save the file to your computer. Then, email the file as an attachment to marketing@ballard.com. Thank you for your time and consideration.

CUSTOMER FEEDBACK FORM

RATING SCALE

Far below expectations — Met expectations — Far above expectations

0 1 2 3 4 5 6 7 8 9 10

Ve ry Poor:	0 - 2
Unsatisfactory:	3 - 4
Neutral:	5
Satisfactory:	6 - 7
Good:	8 - 9
Excellent:	10

PRE-SALES

FUNCTION	DIMENSION	RATING										
		0	1	2	3	4	5	6	7	8	9	10
Marketing	Clarity and Scope of Information											
Sales Team	Product Knowledge											
	Focus on Customer Needs											
	Approach to Terms and Conditions											
Administration	Contract Development											
	Invoice Accuracy and Clarity											

IMPLEMENTATION

FUNCTION	DIMENSION	RATING										
		0	1	2	3	4	5	6	7	8	9	10
Engineering Support	Performance (vs Schedule and Budget)											
	Collaboration and Knowledge											
	Quality of Engineering Support											
Manufacture	Product Quality and Consistency											
	On-time Delivery											
	Effective Packaging											
Fuel Cell	Ease of Integration											
	Product Performance											
	Value for Money											

POST-SALES

FUNCTION	DIMENSION	RATING										
		0	1	2	3	4	5	6	7	8	9	10
Account Management	Responsiveness											
	Contact Frequency											
	Quality of Contact											
	Comercial Support (Co-Selling, Co-Marketing, etc.)											
	Technical Support											
Customer Service	Responsiveness											
	Time-to-Repair											
	Cost-to-Repair											
Warranty	Ease of Process											

*** All fields required.**

Name

Company

Date

Comments:

BALLARD FACILITIES & LOCATIONS

Corporate Headquarters
9000 Glenlyon Parkway
Burnaby, BC V5J 5J8
Canada

Production Facility
4343 North Fraser Way
Burnaby, BC V5J 5J9
Canada

Production Facility
Ave. Ferrocarril KM. 14.5
Parque Industrial Los Pinos III
Bodega #57
22680 Tijuana,
Mexico

CONTACT INFORMATION

Investor Relations
Email: investors@ballard.com
Phone: 604-412-3195

Sales & General Inquiries
Email: marketing@ballard.com
Phone: 604-454-0900

Media Relations
Email: media@ballard.com

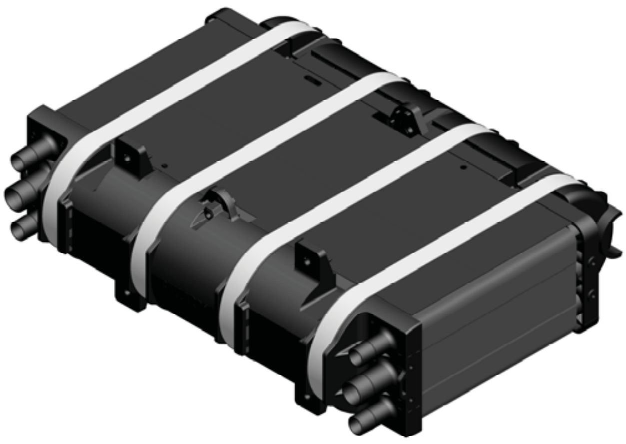
Supply Chain
Email: supplychain@ballard.com

BALLARD®
PUTTING FUEL CELLS TO WORK

WWW.BALLARD.COM

FCgen®-1310 Fuel Cell Stack

Product Manual and Integration Guide



Trademark: FCgen® - 1310,
Part Number: 5119705, 5121050, 5120575, 5120100, 5120120

Document Number: MAN5100304-0B
Date: January 2012

FCgen®-1310 Fuel Cell Stack

Product Manual and Integration Guide

This manual applies to the FCgen® – 1310 fuel cell stack in a pre-production stage of development.

Trademark: FCgen® - 1310,

Part Number: 5119705, 5121050, 5120575, 5120100, 5120120

Document Number: MAN5100304-0B
Date: January 2012
Released under CO20121

Ballard Power Systems Inc.
9000 Glenlyon Parkway
Burnaby, BC V5J 5J8
Canada
Technical Support: (604) 444-2470

NOTE: YOU MUST READ THIS BEFORE ATTEMPTING ANY PROCEDURE DESCRIBED IN THIS MANUAL

There are inherent risks in the operation of a fuel cell stack that could result in death or bodily injury or loss or damage to property. It is therefore necessary for the customer to take all prudent safety precautions in the installation, use, and maintenance of this device. Those who install, operate, and service the device must be technically qualified and experienced in working with electrical equipment, compressed gases, and hydrogen.

This manual includes certain safety guidelines and recommendations; however, this manual is not intended to cover all situations. The customer is responsible for determining the suitability of the customer's particular design or application, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. Ballard Power Systems, Inc. ("Ballard") cannot be responsible for the use of the device in ways, or as part of systems, that deviate from the operating recommendations in the manual. The customer is responsible for being aware of, and complying with, all applicable laws and regulations. Ballard has limited its liability for damages incurred by the customer or its personnel in the contract documents pursuant to which the device is provided to the customer. Please refer to those documents for additional information.

The customer must read this entire manual before attempting any procedure described in any part of the manual. Failure to follow any instruction or recommendation could result in death or bodily injury or loss or damage to property.

Ballard intends for the device to be installed, operated, and serviced only by technically qualified and experienced people who understand the principles of fuel cell technology, are aware of the safe operating limits of fuel cells, and are familiar with the risks posed operating a fuel cell stack. Ballard relies on customers to use their own knowledge and experience when installing, operating, and servicing the device. Ballard also relies on the people using this manual to be familiar with common terms and abbreviations used in the manual.

Table of Contents

(i) Warnings, Cautions and Symbols Used

WARNINGS in this manual indicate actions that may result in an accident, which could cause immediate bodily injury or loss of life or could cause damage to equipment or other property.

CAUTIONS in this manual indicate actions that may result in an accident, which could cause damage to equipment or other property and which could cause bodily injury if not promptly detected and remedied.

ELECTRICAL HAZARDS in this manual indicate actions that pose a risk of high voltage or electrical shock that may result in an accident, which could cause bodily injury or loss of life or could cause damage to equipment or other property.

✸

NOTE: general notes

(ii) Disclaimer

This manual is applicable to the FCgen® -1310 product for stationary applications only. This document does not attempt to address all possible integration options. The customer is responsible for determining the suitability of the various integration options for the customer's particular needs, and for ensuring the safe operation, maintenance, and storage of the device and any systems into which it is integrated. It is the responsibility of the customer to ensure that his or her design is free from claims of patent infringement. Ballard cannot be responsible for any injury or damage caused by the use of its products in ways, or as part of systems, not expressly approved by Ballard.

(iii) Glossary

In general, standard SI units and their abbreviations are used in this document, with the exceptions noted below. Chemical components are described using standard chemical nomenclature (e.g. H2 for Hydrogen gas)

Term	Description
A	Ampere
Air Bleed	Term used to describe the addition of air to the fuel loop for the purpose of oxidizing Carbon Monoxide (CO)
ASL	Above Sea Level
ATR	Auto Thermal Reformate
BOL	Beginning of Life
cc	cubic centimeter
CVM	Cell Voltage Monitoring
EOL	End of Life
EMF	Electromotive force
HRB	Hydrogen Recirculation Blower
ID	Inner Diameter
IEC	International Electrotechnical Commission
MEA	Membrane Electrode Assembly
ms	millisecond
NOPL	Non-Operating Performance Loss
OCV	Open Circuit Voltage
PEM	Proton-Exchange Membrane
PM2.5	Particles up to 2.5 micrometers in diameter
PM10	Particles up to 10 micrometers in diameter
ppm	Parts per million
ppb	Parts per billion
sccm	Standard cubic centimeter per minute, evaluated at 1 atmosphere and 0°C
slpm	standard liter per minute, evaluated at 1 atmosphere and 0°C
stack	Fuel cell stack, generally referring to the FCgen® 1310 fuel cell stack
stoic	Stoichiometry, used to describe reactant flow rate: Fuel Flow(slpm) = stoic X Load X Number of Cells X 0.00696[slpm/A/cell] / %H2 Oxidant Flow(slpm) = stoic X Load X Number of Cells X 0.00349[slpm/A/cell] / %O2
TBD	To Be Determined
V	Volt
WEG	Water Ethylene Glycol

(iv) Scope of Manual

This manual is a guide for the customer to use in integrating the FCgen® -1310 stack into their system and successfully operating it. This document is suitable for **single stack installation**. For multiple stack installations it is strongly recommended to contact Ballard Applications Engineering for support.

Product specifications, expected product performance, required system inputs, electrical interfaces and acceptable operating conditions are included in the manual. This manual will provide guidance for operation within the bounds of the specification. Please contact Ballard Power Systems for questions relating to the operation outside the stated specification.

1.0 Safety

ELECTRICAL HAZARD: Fuel cell stacks generate high voltage. Obey ALL warnings, cautions, and safety instructions. Failure to do so may result in electrical shock leading to personal injury or death.

The installer and operator of the fuel cell stack must be technically qualified and experienced in handling electrical equipment, compressed gases and hydrogen.

1.1. General Safety

- The fuel cell stack may contain residual voltage when not operating.
- Keep all guards, screens, and electrical enclosures in place when the system is operating.
- The fuel cell stack should not be used or stored in wet or damp conditions.
- Remove jewelry, watches, rings, and metal objects on clothing that can cause short circuits when working with the fuel cell stack or system.

1.2. High Temperature and High Pressure Safety

- The fuel cell stack can reach a temperature of 70° C or higher if operated outside the specification. Avoid touching exposed components during or shortly after operation.
- The fuel cell stack and associated system use pressurized gases, which can be hazardous. Use caution and ensure circuits are de-pressurized before opening any lines or fittings.
- The fuel cell stack is assembled under high compression. Do not attempt to disassemble the stack.

1.3. High Voltage Safety

- The fuel cell stack generates up to 142 VDC (open circuit voltage) for a 120-cell stack (maximum ~1.18V/cell). Always ensure that the Stack Power HV+ and HV-terminals are connected to an appropriate load prior to operation.
- Current leakage from the stack will occur through the stack liquid coolant if the conductivity is sufficient to provide a path to ground. It is always recommended to keep stack coolant conductivity within specification, contact Ballard personnel for operations outside specified conductivities.
- Current leakage can also occur if there is inadequate isolation elsewhere in the electrical system and the stack is not fully isolated from that portion of the electrical system. The inadequate isolation could occur elsewhere in the fuel cell module or external to the fuel cell module. This leak path can be minimized by ensuring all electrical equipment and wiring in the fuel cell module is adequately isolated and by ensuring that the fuel cell module electrical buses are isolated from the application electrical system.
- The fuel cell stack has a potential for current leakage across clearances and creepage distances. The fuel cell stack installation should be designed with adequate clearances and creepage distances as listed in applicable standards.
- Stack Power connection cables must be appropriately sized to suit the application for voltage, current and insulation temperature limits. Cables must have suitable voltage rating, current carrying capacity, and insulation temperature rating, depending on the end-users' specific application and operating environment.
- Exercise caution when routing the Stack Power Cables. In particular, ensure that no other electrical cables are routed in between the physical loop formed by the Fuel Cell Stack power terminals, the HV+ and HV- and the load power terminals.
- Contact Ballard for operating multiple stacks in either parallel or series electrical paths as these voltages may exceed design specifications.
- Exercise caution when working with the stack. Residual reactants within the stack can rapidly develop a charge, even when there is no fuel flow and the stack has been short-circuited. A reading of zero volts across the entire stack does not guarantee that all cells are uncharged.
- All metal parts on the stack must be either electrically bonded or considered electrically live. The system integrator must provide a means to: 1) prevent people or objects from touching the live parts, 2) isolate the stack's compression hardware from the integrator's system parts, 3) provide a

label/marking to warn service personnel that the compression hardware may be electrically live.

- Be sure that all electrical connections and connectors are properly installed and connected with proper torque. Do not over-torque, as this can damage the stack.
- Avoid hazardous voltage situations that could result from unsafe conditions such as, but not limited to, the following:
    - Improper grounding
    - Accumulation of foreign material or debris between live stack parts and hardware that could lead to loss of isolation or reduction in creepage/clearance.
    - Handling electrical leads or devices with wet hands or on wet ground
    - Frayed electrical leads
    - Improper connection or re-connection of the terminal leads
    - Short circuits
    - Back-feed from energized normal and emergency power sources.

1.4. Hydrogen Safety

⚠ WARNING

- Hydrogen is a colorless, odorless, highly flammable gas.
- Hydrogen must be sited and handled in accordance with applicable regulations and the gas supplier's recommendations.
- Hydrogen is non-toxic but can cause asphyxiation by displacing the oxygen in the air. There are no warning symptoms before unconsciousness results.

Hydrogen molecules are smaller than any other gas, making hydrogen more difficult to contain. It can diffuse through many materials considered airtight. Fuel lines, non-welded connections, and non-metal seals such as gaskets, O-rings, pipe thread compounds and packings present potential leakage or permeation sites. Furthermore, hydrogen's small molecule size results in high buoyancy and diffusivity, so leaked hydrogen will diffuse and become diluted quickly. Stack hydrogen leak rates will generally increase with stack lifetime.

The responsibility for leak detection and the mitigation of combustible leaks rests with the customer. Hydrogen leaks emanating from the fuel cell stack can be readily detected by means of a hydrogen detector, which can trigger warnings well before the hydrogen/air mixture reaches a flammable concentration.

It is the responsibility of the integrator to follow all local codes and standards for electrical and hydrogen installations.

1.5. Stack Fire Safety

Operation of the fuel cell stack in a manner that is significantly outside specification may result in negative cell voltages in one or more cells, which can lead to open flame at the stack.

Specifically, the following conditions may result in negative cell voltages:

- Fuel Starvation: Operation with insufficient fuel flow, insufficient fuel purge in recirculation mode; or excess liquid water in fuel stream.
- Membrane Dehydration: This can be caused by:
    - Operation above maximum cell temperature rating.
    - Operating without sufficient coolant flow.
    - Operation with one or more severely degraded cells in an otherwise healthy stack.
    - Operating prolonged periods without sufficient reactant humidification.
- External short circuit of some or all cells. Typical cause:
    - Accidental bridging of cells with conductive materials such as tools.

To prevent these conditions, stack operation should be automatically stopped in the event of loss of fuel or coolant flow using either a voltage or stack temperature signal. Furthermore, detection of negative cell voltages, and a system response to prevent stack fire due to negative cell voltages should form an integral part of the system safety strategy. Two methods are recommended:

1) Measure individual cell voltages or voltages of groups of cells. This allows for a direct measurement of the potential hazard; however, it will involve a more complicated interface for measuring cell voltages. A recommended safe shutdown limit if this method is implemented is to shut down instantly (<1sec delay) if any single cell reaches a negative cell voltage of −1V. To avoid stack degradation due to negative cell voltage, a limit of 0V is more suitable.
2) Measure overall stack voltage. A low stack voltage limit can be set based on the value of negative cell voltage to be detected. This method becomes less effective for larger stack sizes. As a starting point, it is recommended that an instant system shutdown (<1sec delay) be implemented if stack voltage drops below Vn-10 V (where Vn = nominal stack voltage at a given current, this number is defined during initial system installation). This should detect a minimum single-cell voltage reversal of about −10V.

Stack operation after a fire poses the potential additional hazard of delayed ignition of the external fuel leak in subsequent restart. This risk can be minimized by prompt detection and immediate shutdown in the event of a stack fire to minimize the resulting fuel leak. Mitigation of this potential hazard may include preventing restart following a stack fire failure or on detection of large fuel leaks, or appropriate enclosure design for overpressure relief.

The cells in the stack contain platinum catalyst, which may react if exposed to certain chemicals. The stack should not be exposed to any chemicals not mentioned in this application guide, and used stacks should be returned to Ballard for proper recycling and/or disposal.

2.0 FCgen® -1310 Stack Physical Characteristics

The FCgen® -1310 is a liquid cooled proton exchange membrane (PEM) fuel cell stack designed to provide stable electrical power while operating on air and either pure hydrogen or reformate mixture over a wide range of operating and environmental conditions. Figures 1 to 3 below show the main physical features of the FCgen® -1310 stack. See section 6.0 for additional information on physical interfaces.

Figure 1 - FCgen® -1310 100 cell Stack

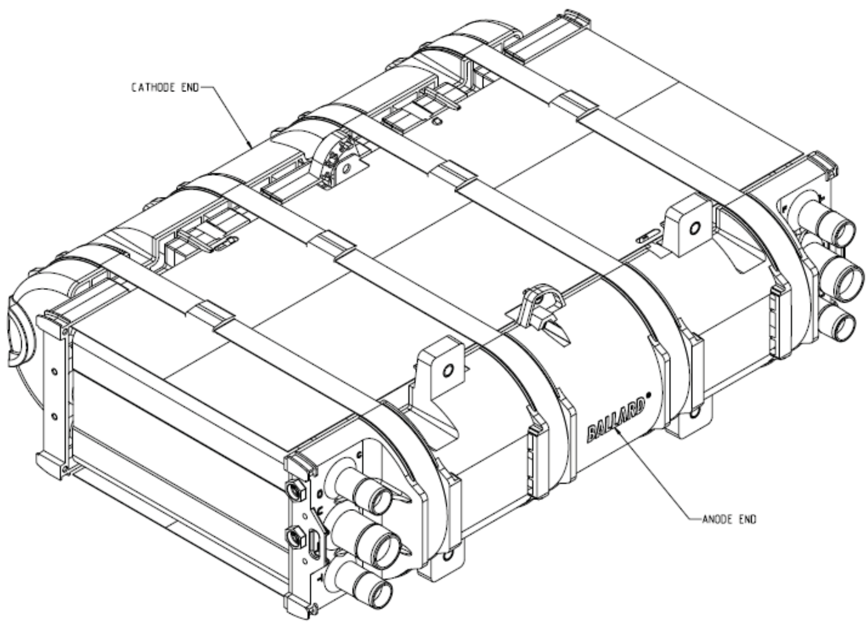


Figure 2 Isometric View from Anode End

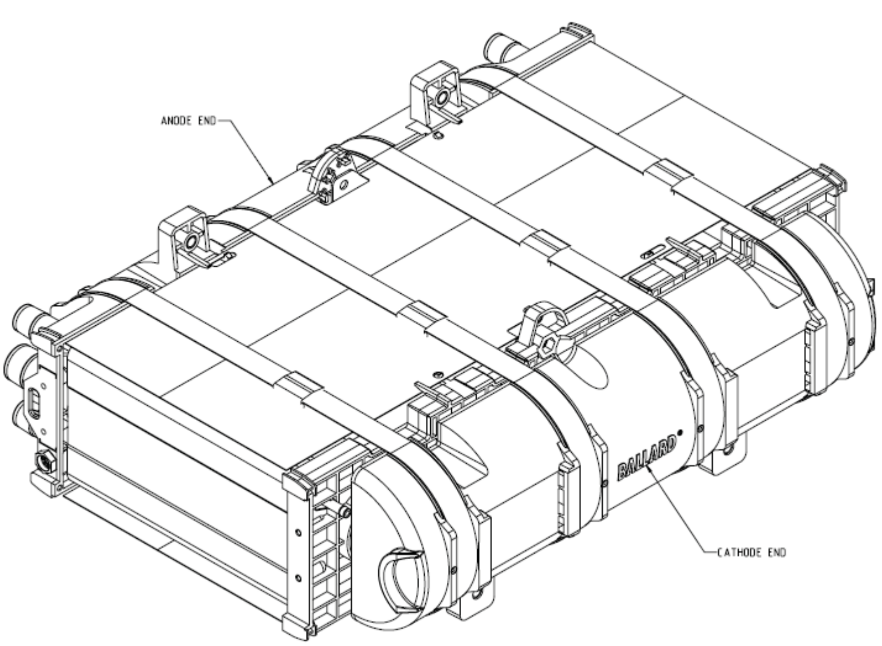


Figure 3 Isometric View from Cathode End

3.0 Stack Specifications

The FCgen® 1310 stack is available in sizes ranging from 27 cells up to 120 cells.

3.1. Stack Performance

Table 1 Stack Performance at Beginning of Life[1]

Performance Parameter		Stack Current (A)					
		0	34	60	111	135	160[2]
Fleet Average Power	W/cell	0	26	44	75	87	98
Fleet Average Voltage[3]	mV/cell	971	766	727	672	647	614
Stack to Stack Performance Variability[4]	mV	+25 / -35	+15 / -35	+15 / -35	+15 / -35	+15 / -35	+15 / -35

[1] Based on operating conditions in table 3. Beginning of life is defined as 50 hours of stack operation under load.

[2] A nominal operating current of 135A, minimum operating current of 34A, and a maximum operating current of 160A is recommended. See Section 4.4 for details

[3] Fleet average is based on 100 stack averages with a +10 /-20 mV range allowable

[4] Performance variability defines the expected variability in performance from stack to stack at Beginning of Life due to manufacturing variability.

3.2. Operating Conditions

Ballard recommends that system integrators design their systems to operate the FCgen® -1310 stack at the optimal conditions listed in table 3 below. Operation at these conditions will maximize stack lifetime while ensuring stable operation.

Table 2 FCgen®-1310 Specified Operating Conditions Range

Electrical	
Load	160A max, 34A min[5]
Voltage	1.18V/cell max, 0.50V/cell min
Current Ramp Rate	1000A/sec provided conditions for a given load are within specifications.
Fuel	
Composition	H_2/N_2 Blend or Reformate[6], target 80%-100% vol H_2 (dry)
Stoic	>=1.45
Inlet Pressure	<300mbar(g)
Pressure Drop	>50mbar
Anode-Cathode inlet overpressure	>0 mbar, <200 mbar, 25 mbar target
Inlet Temperature	Coolant inlet temperature +/- 2°C,
Inlet Humidity	80%-100% RH
Liquid Water Ingestion	Acceptable limits have not been defined for this design
Oxidant	
Composition	Ambient Air
Stoic	>=1.8
Inlet Pressure	<300mbar
Pressure Drop	>50mbar
Inlet Temperature	Coolant inlet temperature +/- 2°C,
Inlet Humidity	95%-100%
Liquid Water Ingestion	Acceptable limits have not been defined for this design
Coolant	
Composition	De-ionized Water and/or Propylene Glycol, or Ethylene Glycol, <50% glycol.
Conductivity	<5 μS/cm @ 20°C
Flow	>0.1 L/min/cell

[5] Recommended minimum and maximum. See Ballard for operation outside these limits.

[6] While this stack can be used with a reformate based fuel system, it requires a fuel purification system between the fuel processor and stack to ensure CO levels are substantially eliminated. Periodic anode recoveries may be required.

Inlet Pressure	>25mbar, <500mbar
Inlet Temperature	Target: 55-60°C,
Temperature Rise	Target: 0.8°C per 20A +2°C

Table 3: FCgen®-1310 Nominal Operating Conditions

Operating Condition		Stack Current (A)				
		34	60	111	135	160
Fuel						
Composition (H2/N2 Blend)	%H2	90	90	90	90	90
Stoic	-	4.5	2.5	1.45	1.45	1.45
Inlet Pressure	bar(g)	0.130	0.140	0.190	0.220	0.250
Pressure Drop[7]	mbar	50	50	50	56	60
Inlet Temperature	°C	60	60	60	60	60
Inlet Humidity	% RH	90	90	90	90	90
Oxidant						
Stoic	-	1.8	1.8	1.8	1.8	1.8
Inlet Pressure	bar(g)	0.11	0.12	0.17	0.20	0.23
Pressure Drop[6]	mbar	50	75	130	158	190
Inlet Temperature	°C	58.9	58.9	58.9	58.9	58.9
Inlet Humidity	% RH	95	95	95	95	95
Coolant						
Composition	-	100% De-ionized Water				
Inlet Temperature	°C	60	60	60	60	60
Temperature Rise	°C	3	5	7	7	8.5

[7] Based on 100 cell stack, value will vary due to stack variability.

3.3. Reactant Specifications

Table 4 Oxidant Specification (Stack Inlet)

Description	**Specification**
Chemical	
SO_x	<0.1 ppb
NO_x	<0.1 ppb
Volatile Organic Compounds (e.g. Benzene C_6H_6, Toluene C_7H_8)	0.008 ppm
Hydrogen Sulfide	0.04 ppm
Ozone	1 ppm
NH_3	<1ppb
Fe	<4 µg/hr
Ni	<3 µg/hr
Cu	<1 µg/hr
Cr	<1 µg/hr
Al	<1 µg/hr
Particulate	
Airborne Particles(solid or liquid)	<20 µg/m3, <5 µm diameter
Salt	<20 µg/m3, <5 µm diameter

Note: See Section 4.8.4 for more detail on oxidant contaminants

Table 5 Fuel Specification

Description	**Specification**
Inert Diluents	
CH_4	<4%
N_2 and/or CH_4	<25%
Chemical Contaminants	
Carbon Monoxide (CO)	<0.1ppm (with air bleed)
Carbon Dioxide	<25% (with air bleed)
Air Bleed	<0.5%
S	<1ppb
NH_3	<1ppb
Fe	<4 µg/hr
Ni	<3 µg/hr
Cu	<1 µg/hr
Cr	<1 µg/hr
Al	<1 µg/hr

3.4. Ambient Environment Specifications

The ambient conditions refer to environment around the fuel cell stack and not necessarily what the exterior system environment is. For example, the stack may have a nominal ambient temperature of 50 °C when installed in a system enclosure.

Table 6 Ambient Environmental Conditions During Operation

Ambient Conditions	
Operating Pressure/Altitude	-400m to 4600m
Ambient Temperature, Operation	-5°C [1]to 70°C
Total Allowable Freeze-Thaw Cycles	Not Defined
Ambient Relative Humidity	Non Condensing
Shock/Vibration	Not Defined

3.5. Emissions (BOL)

Table 7 Beginning of Life (BOL) Emissions

Stack Leakage	
External Fuel Leak	6 sccm + 1 sccm/cell air @ 0.5 barg
External Coolant Leak	6 sccm + 0.05 sccm/cell air @ 0.5 barg
External Oxidant Leak	6 sccm + 60 sccm/cell air @ 0.5 barg
Internal Transfer (Fuel To Oxidant)	1 sccm/cell air @ 0.5 barg
Internal Transfer (Fuel to Coolant)	0.1 sccm/cell air @ 0.5 barg
Internal Transfer (Oxidant to Coolant)	0.1 sccm/cell air @ 0.5 barg

[1] Core temperature must be above 40C for steady state operations.

3.6. Stack Weight and Dimensions

Table 8 Weight and Dimensions

Stack Length	Height	Width	Dry Mass
27 cells: 233mm 120 cells: 473mm	180mm	490mm	27cells: 8.3kg 120cells: 22.2kg

*All dimensions are nominal. Refer to the stack interface drawing (DRW5113912) for details.

3.7. Shipping/Storage Conditions

Table 9 Shipping and Storage Environmental Conditions

Environmental Condition Limits	
Temperature Range	5°C to +40°C nominal, +70°C max for durations less than 500 cumulative hours
Total Allowable Freeze-Thaw Cycles	Not Defined
Relative Humidity Range	Non Condensing
Shock and Vibration	Designed to withstand normal shipping shock and vibration in standard Ballard packaging.

Refer to section 7.0 for additional information on shipping and storage.

4.0 1310 NOMINAL OPERATING CHARACTERISTICS

4.1. Nominal Polarization Characteristics

Figure 4 below shows the polarization curve for a Beginning-of-Life (BOL), fully conditioned FCgen® -1310 stack operating at nominal conditions. Stack to stack manufacturing variability has not been included, however the estimated BOL ranges are shown below. A polarization at nominal operating conditions is as follows:

- Steady-state operation

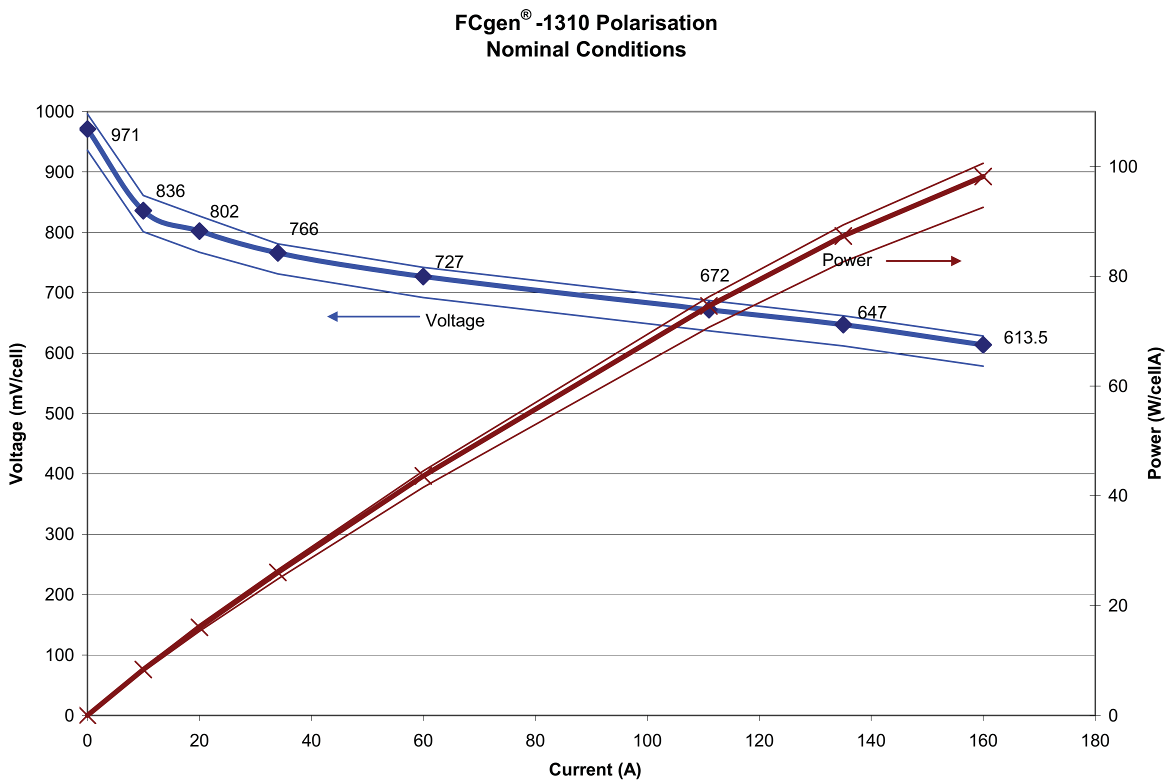


Figure 4 Nominal Polarization

The following equation models the nominal BOL polarization of the FCgen®-1310 fuel cell stack over its working current range of 34A to 160A.

E = -1.173 x Current + 802.41

Where E is cell voltage in mVDC and Current is Amps.

Equation 4.1-1 Estimated Nominal Polarization Characteristic

4.1.1. Polarization Hysteresis

Measured average cell voltage for a given current may be slightly higher than nominal just after a decrease in current. This "boost", or hysteresis, is a characteristic of the 1310 fuel cell stack and is temporary. After a short time the stack will return to steady-state conditions. The amount of the temporary boost varies from about 20 mV at low stack currents to about 40 mV at higher stack currents.

4.2. Cell-to-Cell Voltage Deviation

The usual standard deviation of voltages between the individual cells within a 1310 stack at BOL is approximately 15mV at 135A. A standard deviation up to 20mV is acceptable as long as no individual cell voltage is more than 50mV from the average. A greater standard deviation may indicate a fuel supply problem, or another issue with the stack.

4.3. Stack Degradation Rate and Lifetime

There are generally two key life-limiting failure modes that will prevent the stack from performing as required in a given application: voltage loss and fuel leakage. Voltage loss is seen as a steady degradation in maximum power. Fuel leakage will lead to both an increase in fuel consumption, and H2 emissions in the air exhaust stream.

While the definition of specific failure criteria will differ depending on the application, Ballard has used the following End-of-Life (EOL) criteria to measure stack lifetime:

> Average cell voltage at 135 A drops to less than 600mV
>
> OR
>
> Anode leakage rate into the Cathode increases to more than 10 cc/min per cell (tested with nitrogen at 0.5 barg).

Lifetime depends primarily on the number of on/off cycles that occur with an air-filled anode. Other factors, such as the number of operating hours, are less significant.

The design target for the B50 lifetime of a FCGen® -1310 stack is 8000 hours and 1250 on/off cycles with air on the anode before reaching End-of-Life (EOL).

For non-cycling applications the B50 lifetime of the stack is expected to meet 20,000 hours of operation provided less than 300 on/off cycles have been performed.

The stack is designed to last 10 years calendar time including storage.

If lower voltage or higher leakage rates is acceptable in the application, or if a more benign duty cycle is used, the FCgen® -1310 stack will be able to operate beyond these limits.

In general, to maximize stack life, avoid the following conditions:

- Non-optimal startup procedure (inadequate startup purge or high cell voltage during H2 fill, as described in Section 5.0)
- Fuel starvation (for example, due to inadequate operating purge, or operating for significant periods of time below optimal operating temperature)

- Leakage in the anode loop or fuel system that allows either:
    a) Slow ingress of fuel into an air-filled stack after shutdown
    b) Slow ingress of air into a fuel-filled stack after shutdown
- High operating temperatures (operating for significant periods of time above optimal operating temperature)
- Contaminants in the coolant/oxidant air
- Contaminants in the fuel
- Ripple currents from the Balance-of-Plant (BOP) power conversion subsystem

✸ *NOTE: Stack lifetime is highly dependent on the application. Please contact an Applications Engineer at Ballard for assistance in determining achievable lifetimes in your application.*

4.4. Working Current Range

The working current range for a new, fully conditioned FCgen®-1310 stack is 34A to 135A. A maximum operating current of 160A is recommended. The stack is capable of operating at higher currents for brief amounts of time, contact Ballard Applications Engineering for help with currents below 34A or above 160A.

Furthermore, it is advisable to allow for some buffer between the maximum operating current and the expected peak power point:

- Increasing current when operating near the peak power point results in relatively little gain in available power, while significantly increasing the risk of stack instability.
- The peak power point will shift whenever there is a drop in stack performance from nominal (e.g. due to degradation over lifetime, operation at off spec. conditions, extreme ambient conditions, or extended storage times). The peak power point shifts slightly to the left (lower current) as the stack performance degrades; typically the peak power point occurs at an average cell voltage around 0.5V.

Stack lifetime testing was performed at a maximum operating current of 160A.

4.5. Coolant

The FCgen® -1310 is a liquid cooled stack utilizing either de-ionized water, up to a maximum 50/50 mix of water/ethylene glycol or water/propylene glycol. For applications where a glycol is used there is a risk of exceeding maximum allowable coolant pressure, especially during low temperature operations during startup.

4.5.1. Flow Requirement

The FCgen® -1310 stack must receive enough coolant flow to satisfy both the cooling flow required to maintain the specified temperature difference, as well as overcome any hydraulic requirements to prevent air build-up in the coolant circuit based on stack orientation.

The amount of flow required to cool the FCgen® -1310 stack depends on the number of cells, the operating point (voltage and current), the stack operating temperature, and the type of liquid coolant used. The required flow can be predicted using equation 4.5.1-1 below.

Equation 4.5.1-1 Stack Coolant Flow

$$Q_{stack} = \frac{(\mathrm{n_{cell}} \times q_{cell})}{(\mathrm{T_{Out}} - \mathrm{T_{in}}) \times C} \times 60$$

$$q_{cell} = (E - v_{cell}) \times i_{stack}$$

$$\mathrm{Q_{stack}} = \text{total cooling for stack, lpm}_0$$

$$\mathrm{n_{cell}} = \text{number of cells in stack}$$

$$\mathrm{q_{cell}} = \text{heat produced per cell, W}$$

$$\mathrm{T_{Out}} = \text{stack out temperature, }^{\circ}\mathrm{C}$$

$$\mathrm{T_{in}} = \text{cooling flow inlet temperature, }^{\circ}\mathrm{C}$$

$$\mathrm{E} = \text{maximum EMF of the cell when product water is produced}$$

$$= 1.45\mathrm{V}$$

$$\mathrm{v_{cell}} = \text{cell voltage, V}$$

$$\mathrm{i_{stack}} = \text{stack current, A}$$

$$\mathrm{C} = \text{heat capacity of fluid used J/(kg K). } \mathrm{H_2O} = 4186, 50/50\ \mathrm{WEG} = 3482$$

During start-up or upward transients, the optimal stack operating temperature increases with current and the stack has some thermal capacitance, so the increase in cooling flow will lag the increase in current.

Note: The required coolant flow as predicted by equation 4.5.1-1 is an estimate only, and should be validated for extremely high or low ambient temperature cases. Stack cooling characteristics may change; leading to a requirement for higher flows than predicted under extreme high temperature conditions, and lower flows than predicted under extreme low temperature conditions.

4.5.2. Stack Temperature

In an operating system, the controls should adjust the amount of coolant flow to control the stack temperature difference, measured by the system coolant inlet temperature sensor, to the stack outlet temperature sensor to maintain its optimal temperature (per Section 3).

The FCgen®-1310 stack inlet temperature is the temperature measured by the stack temperature sensor(s) located at the coolant inlet. This temperature is also the reference temperature used for all stack humidity temperatures in the oxidant and fuel inlet streams. The stack outlet temperature is generally governed by the coolant outlet temperature, however the oxidant outlet temperature may also be used for alarm purposes.

The optimal operating temperature for performance and lifetime of the FCgen®- 1310 stack is a 60°C inlet temperature with a stack outlet temperature rise of less than 10°C.

The stack can be operated safely in a range of 40C to 70C however there will be an impact on either performance or lifetime as the limits of this range are approached.

Temperature response data across the full range of 1310 stack operating conditions are not currently available. However, figure 5 below shows the temperature sensitivity of the stack at 135A conditions.

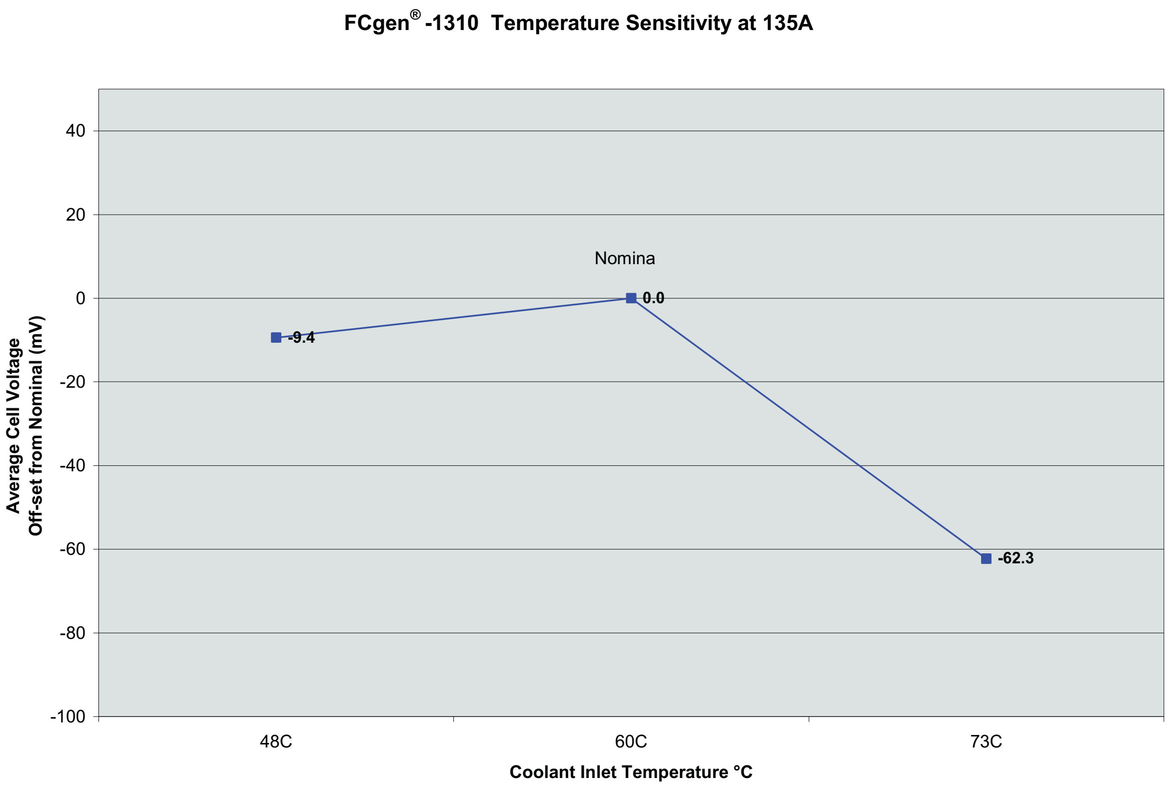


Figure 5 Performance Sensitivity to Operating Temperature

WARNING

- **The fuel cell stack can reach a temperature of 70° C or higher if operated outside the specification. Avoid touching exposed components during or shortly after operation**
- **Operating at temperatures above 80°C or higher may result in stack damage and/or cell reversals due to cell dehydration. Stack current should be reduced before the stack reaches this critical temperature, and operation of the fuel cell stack should be stopped if stack outlet temperature exceeds 80°C.**

As general guidance, the stack should be operated as close to T_{opt} as possible, and no more than 5-10°C above or below T_{opt} for any significant period of time. Operation above 65°C inlet temperature can lead to reduced lifetime of the stack. It is important that the oxidant and coolant relative humidities are maintained within their specifications to prevent condensation or de-hydration of the stacks.

Note that it can take several minutes to reach steady-state performance once the stack temperature is changed. For example, stack voltage is normally lower than expected while the stack is cold during startup. Also, *worse* performance than expected can occur during long runs where:

- Operating above T_{opt} may lead to stack dehydration, causing stack performance to gradually drop over time. This may also reduce stack life, because the higher temperature will accelerate development of leaks.
- Operating below T_{opt} may lead to liquid water accumulation in the gas channels ('flooding'), and resulting cell voltage instability. The flooded cells may also have areas of anode fuel starvation, resulting in cell damage and non-reversible performance loss. Extreme fuel starvation causes cell voltage reversal, which can lead to significant stack damage. During certain operating states such as during cold start-up and following a large load increase, the stack will be operating below optimum temperature.

4.5.3. Coolant Pressure and Pressure Drop

Maximum pressure for the coolant circuit is 500 mbarg. Coolant pressure will be dictated by the amount of coolant flow, pressure drop in system downstream of the stack, and head pressure. When using an ethylene or propylene glycol mix, this maximum pressure will be limiting due to the increased density of the liquid as well as reduced thermal capacity requiring more flow through the stack causing a pressure drop increase of 50% to 60%. When designing a cooling system it is important to ensure air cannot get trapped within the fuel cell stack

4.5.4. Coolant Type and Conductivity

The FCgen® -1310 stack is capable of using three types of fluids, pure de-ionized water, up to a 50/50 mixture of de-ionized water/ethylene glycol or 50/50 mixture of de-ionized water and propylene glycol.

The coolant system should have appropriately sized filters to keep the coolant conductivity within specification per section 6.2 electrical isolation requirements. This requirement will be system specific depending on lengths of non-conductive tubing available, stack size and nominal operating current. For most applications, a coolant conductivity of less than or equal to 5 micro-Siemens per cm (μS/cm) at 20°C is acceptable.

4.6. Oxidant

The oxidant used in the FCgen® -1310 stack is primarily ambient air pressurized to nominal operating pressures. In some circumstances the FCgen® -1310 can be operated in lower oxygen concentrations from 10% to 21% provided the minimum O_2 stoichiometry for that current and minimum oxidant pressure drop is met. Please note that lifetime and stack robustness have not been assessed for concentrations below 21% O_2. Contact Ballard applications engineering for use in these conditions.

4.6.1. Flow Requirement

The FCgen® -1310 stack provides maximum performance with an oxidant stoichiometry between 1.8 and 2.0. There is some performance loss for stoichiometries less than 1.8. The loss becomes more significant if the oxidant stoichiometry is less than 1.5. The stack must have a minimum oxidant stoichiometry of 1.4 to function. The equation below is specific to air containing 21%O_2.

Equation 4.6.1-1 Oxidant Stoichiometry with air

$\lambda = Q_{stack} / (C * I * n_{cell})$
λ = Air Stoichiometry
Q_{stack} = total air for stack, slpm
C = Air Consumption, 0.0167slpm/A/cell
n_{cell} = number of cells in stack
I = Current in amps

Alternatively, the required Oxidant flow can be written

$Q_{stack} = \lambda * C * I * n_{cell}$

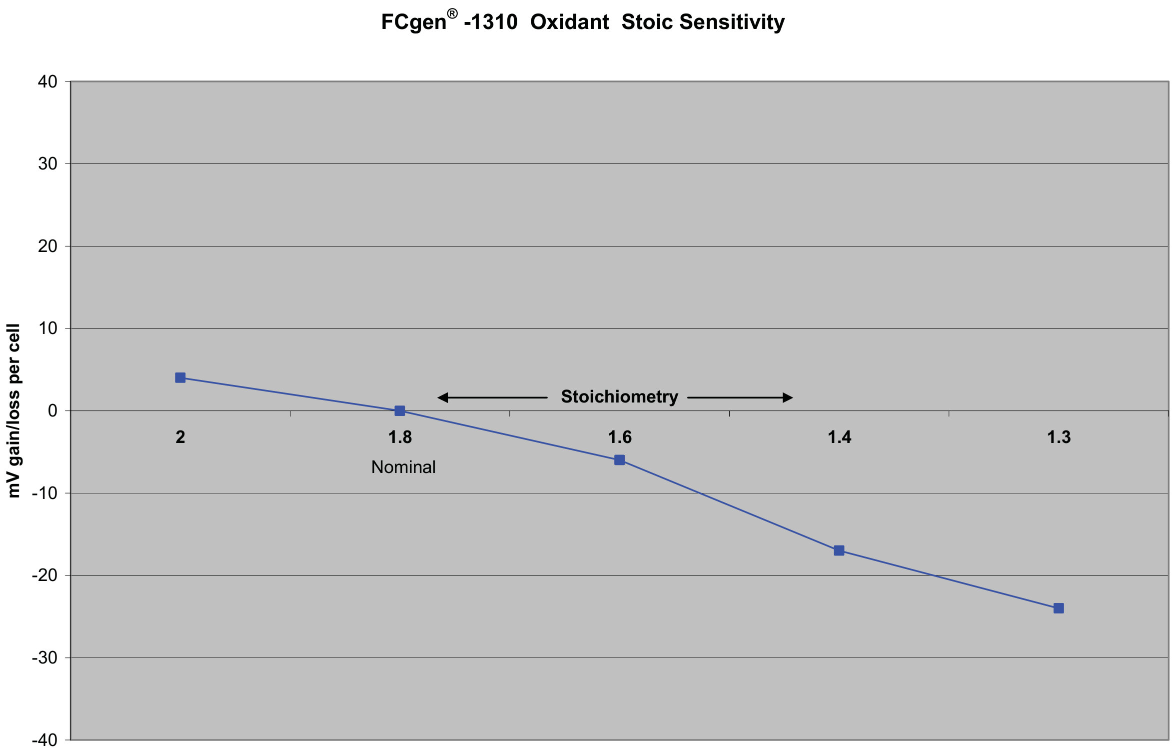


Figure 6 - Effect of Oxidant Stoichiometry on FCgen® -1310 Stack Performance at 135A nominal conditions.

WARNING **The fuel cell stack consumes oxygen, if the stack cathode exhaust is placed in an enclosed area, adequate ventilation must be provided to ensure the oxygen concentration does not drop below 19.5%.**

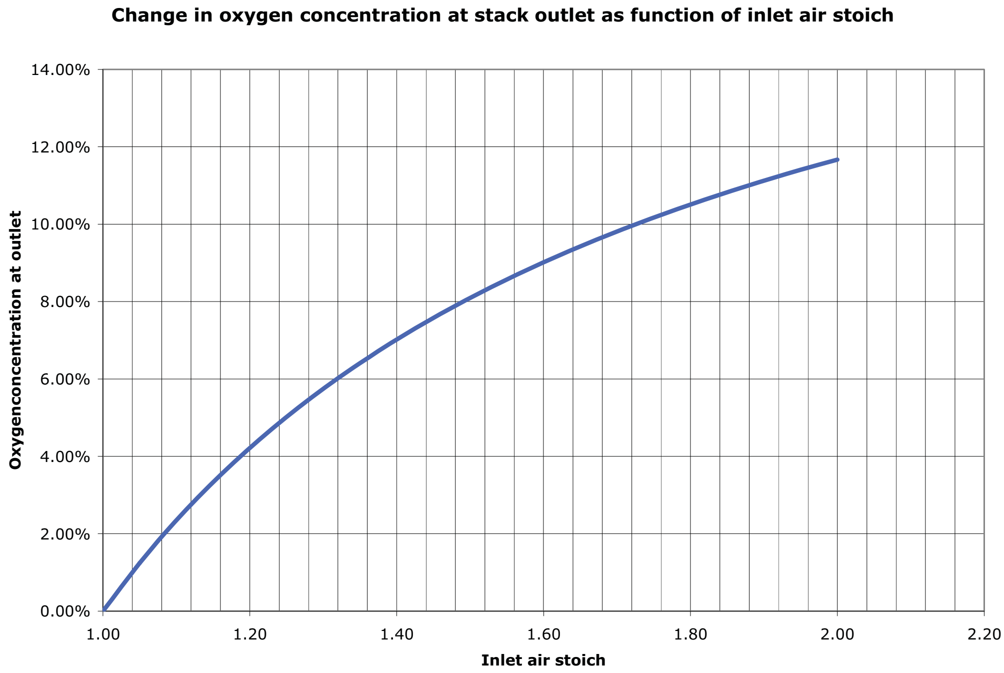


Figure 7- Oxygen concentration at stack outlet as a function of stoichiometry

4.6.1.1 Uniformity of Flow

The air flow into the stack should be in a non-condensing environment and adequate flow to maintain a minimum stack pressure drop of 50 millibar.

Inadequate oxidant flow to the stack will show up as low performance either due to inadequate stoichiometry or due to the build up of liquid water in the channels within the stack.

4.6.2. Oxidant Pressure

The FCgen® -1310 is designed for oxidant inlet pressures of 50 to 300 mbarg operational. Non operational pressures of 500 mbarg are permitted for diagnostic leak tests. Since maximum pressure is stated in mbar gauge, when operating at altitude the absolute operating pressures will be reduced regardless of air supply compression capability. Within this range, inlet pressure has a slight effect on stack performance thus a de-rate is applied when operating in higher altitudes.

Figure 8 illustrates the effect of oxidant air inlet pressure on FCgen® -1310 stack performance when operated at 135A nominal conditions.

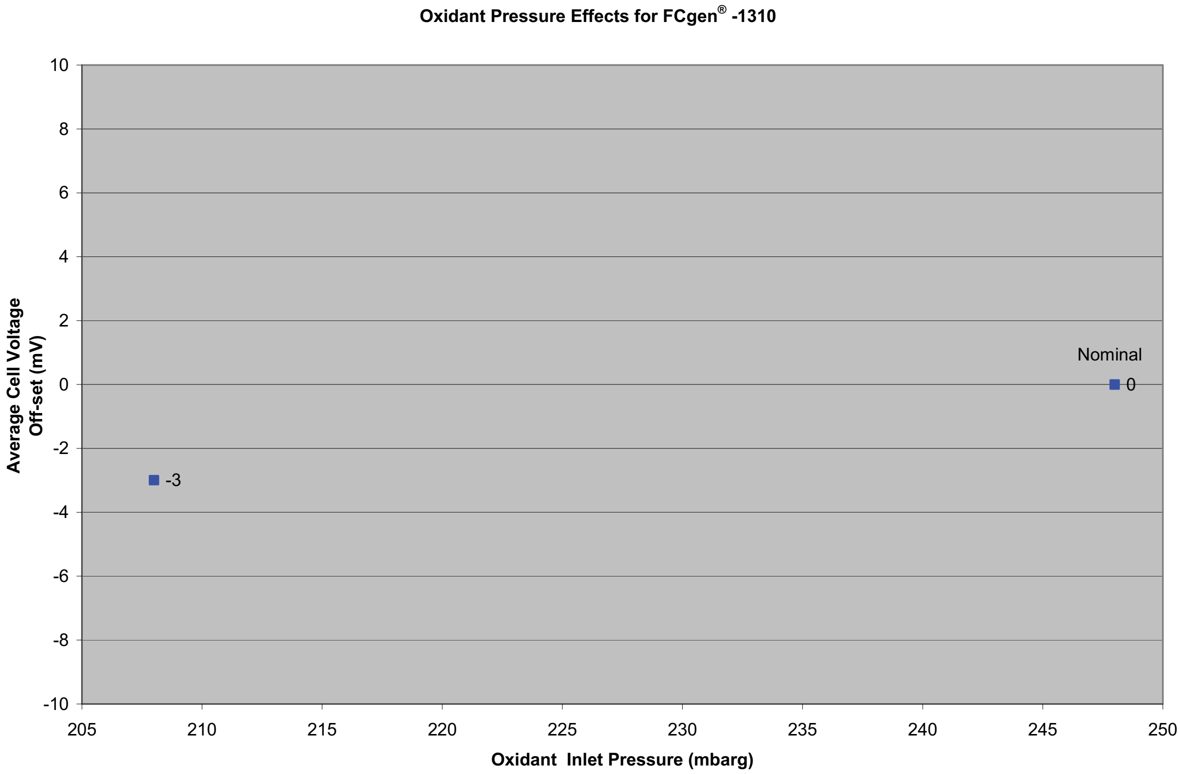


Figure 8 - Effect of Oxidant Inlet Pressures/Altitudes on Stack Performance

4.6.3. *Oxidant Humidity*

The FCgen® -1310 stack provides the best performance and lifetime when the oxidant air inlet humidity is 95% RH or greater with respect to the coolant inlet temperature. Some performance loss is expected if RH is reduced to 90%, if RH is lower than 90%, a reduction in lifetime is expected. Due to current stage of development of the FCgen®-1310, there currently is not a curve available for lifetime vs relative humidity. It should also be noted that the Oxidant and fuel RH are not independent and if both are low the effects are not a simple cumulative performance loss.

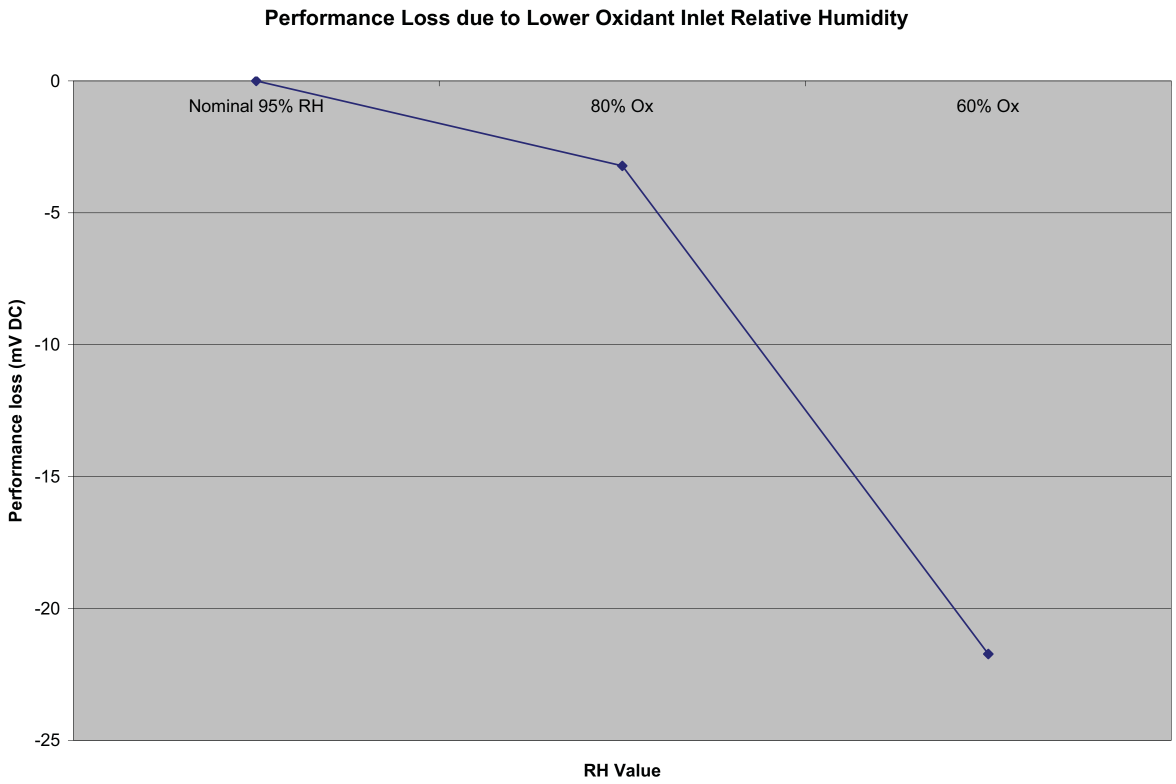


Figure 9 – Ox RH sensitivity when operated at 135A nominal conditions

4.6.4. Oxidant Inlet Temperature

The air temperature into the stack must be such that the gas stream is non-condensing, thus the temperature should not be below the equivalent dew point of the gas stream RH. The gas can be hotter, provided it is not greater than 2°C higher than the coolant inlet temperature, excluding transients (See section 5.1, Transient operations).

4.6.5. Cathode Pressure Drop Characteristic

The FCgen® -1310 nominal pressure drop for a 100 cells stack is shown in figure 10 when using standard conditions from table 2. This should be taken as guidance only. It should be noted that manufacturing variability, stack size and specific operating conditions will all contribute to pressure drop variances.

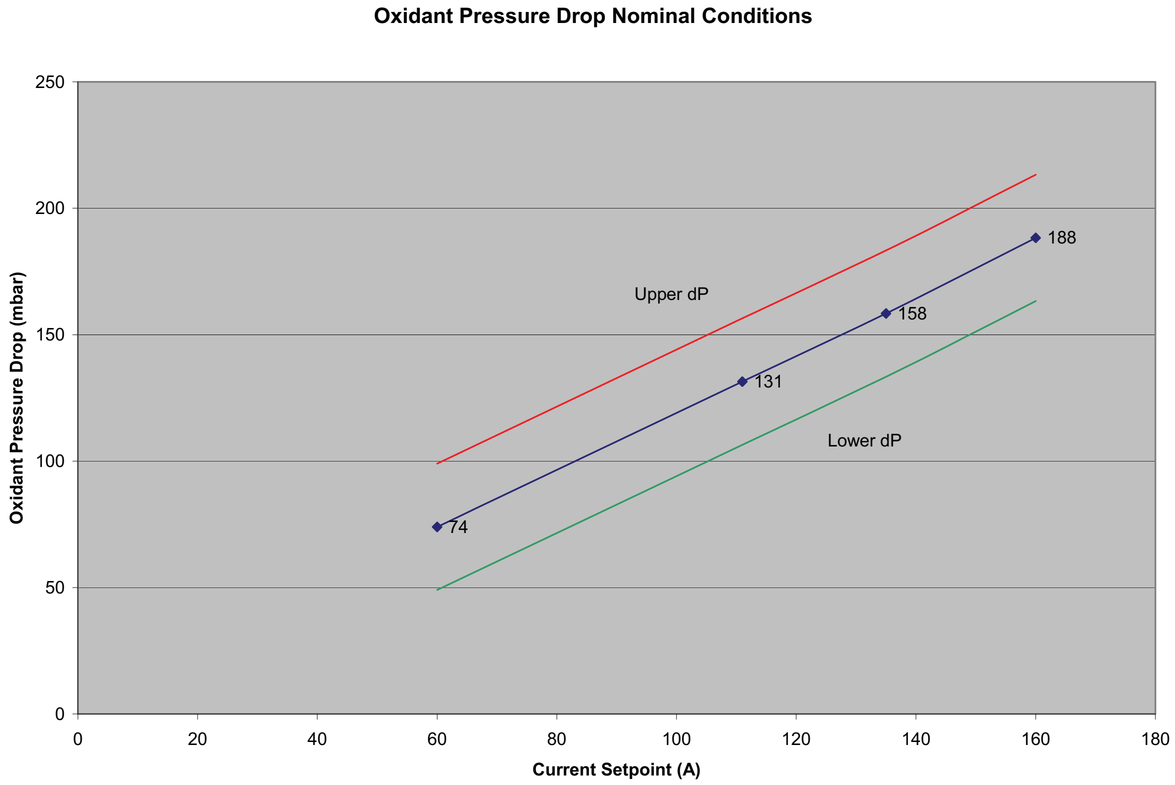


Figure 10 – Cathode pressure drop in a 1310 100 cell stack at1.8 stoichiometry.

4.6.6. Exhaust

The FCgen® -1310 stack oxidant exhaust is a stream of slightly oxygen-depleted, humidified air and liquid water. At beginning of life some carbon particulate wash out from the stack may be present. At current time this has not been quantified.

The liquid water is usually at a pH of 5. This production water should be considered non-potable and be filtered if used in a water recovery system.

The oxidant exhaust air temperature is generally the same as the stack outlet temperature and may be used as an alternate high temperature reference for alarms.

4.7. Fuel

4.7.1. Flow and Purge Requirements

4.7.1.1 Startup Purge

The anode side of FCgen® -1310 stack should be purged with fuel as quickly as possible on each startup to avoid premature performance degradation.

After coolant/oxidant flow is started, an anode flow rate of at least 1.5 slpm per cell should be started to purge the anode. This can also be achieved in an anode recirculation system by ramping the recirculation pump to nominal power conditions and opening the purge valve for at least 1 minute. Note that a higher volume/longer duration purge may be required to ensure that all of the air has been removed from the fuel system (i.e. all associated tubing & components) before drawing load from the stack; the critical requirement to maximize lifetime is to maximize the flowrate during the initial purge.

4.7.1.2 Flow calculations

The FCgen® -1310 stack provides maximum performance with a fuel stoichiometry between 1.45 and 1.6. The minimum allowable fuel inlet stoichiometry is 1.45 hydrogen stoich. There is negligible performance loss for stoichiometries less than 1.45, however internal stack cell stability may decay due to reduced pressure drop at lower flows resulting in unsafe conditions within the stack due to insufficient fuel stoichiometry.

Equation 4.7.1.2-1 Fuel Stoichiometry (hydrogen)

$$\lambda = Q_{stack} / (C * I * n_{cell})$$

λ = Hydrogen Stoichiometry
Q_{stack} = total hydrogen flow for stack, slpm
C = Constant , 0.0069478 slpm/A/cell
n_{cell} = number of cells in stack
I = Current in amps

Alternatively, the required Hydrogen flow can be written

$$Q_{stack} = \lambda * C * I * n_{cell}$$

4.7.1.3 Re-circulation Operation

The FCgen® -1310 stack was designed for a hydrogen recirculation loop operation when operating on pure hydrogen feedstock. This allows the stack to see a localized higher internal stoichiometry while reducing the total system stoichiometry thus improving fuel economy. In theory, there is no anode exhaust and once the recirculation pump has started, the only additional fuel required is what the fuel cell consumes in the reactions, and the system sees a fuel stoichiometry of one. In practice, water vapor, nitrogen, and other inert gases collect in the anode so the anode must be purged periodically. A small percentage of the fuel is exhausted in the purge and as a result the actual stoichiometry is slightly greater than one. See appendix A3 for a process diagram for a typical hydrogen recirculation system.

WARNING

- **Hydrogen is a colorless, odorless, flammable gas. Hydrogen purged from the fuel cell must be managed in a safe manner.**
- **Hydrogen is non-toxic but can cause asphyxiation by displacing the oxygen in the air. There are no warning symptoms before unconsciousness results.**

Although reducing the purge frequency or duration can reduce hydrogen emissions and improve fuel consumption, Ballard strongly recommends that if for maximum stack life, the integrator should design their system to provide frequent and ample anode purges.

WARNING

Failure to provide an adequate purge may lead to fuel starvation, cell reversals, and possibly stack fire.

The FCgen® -1310 stack is designed to have fuel supplied to the anode inlet at constant pressure, usually using a pressure regulator. The anode is purged through an on-off valve at the anode exhaust. The valve is periodically toggled open to exhaust the water vapor and inerts.

Anode purge during operation can be characterized by 3 parameters:

- **Purge Volume**: the total volume of gas removed from anode during each purge event.
- **Purge Duration**: the time over which each purge event occurs (a shorter purge duration for a given volume = higher purge flow rate)
- **Purge Interval**: the time between individual purges

A recommended **purge volume** has not been determined for the FCgen® -1310 and will be influenced by stack size. Smaller purge volumes may not remove all of the inert gases in the anode. For the 25-50 cell stack range, the best sign of an insufficient purge volume is a significant stack voltage drop between purges. With a sufficient purge, stack voltage between purges will remain relatively constant (expect <1-2% change in stack voltage). This may not be seen on larger stacks, and up front stack integration work will need to be done to address cell instability that may occur as a result of insufficient purging. If possible the purge timing and duration should be set to optimize the hydrogen concentration at the stack inlet but still meet the required target efficiency.

A useful method of measuring the purge volume is to collect the anode purge gas over a series of purges and measure the gas volume. This can be performed by purging into an inverted water-filled graduated cylinder, or some other variable-volume container, as shown in figure 11.

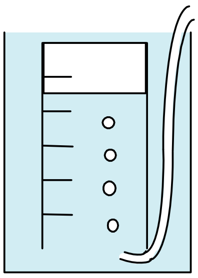


Figure 11 Method of Measuring Anode Exhaust Flow to Develop Purge Duration

4.7.1.4 Flow-through Operation

For some applications flow through operation may be desired where the anode stream is not re-circulated. There are generally fewer concerns with flow through operation provided minimum stoichiometry and fuel pressure drop requirements are met.

For flow through applications, pre-humidification of the gas stream is essential to maintain internal relative humidity in the stack.

4.7.2. Pressure

The nominal fuel inlet pressure for the FCgen® -1310 stack is 75 to 300 mbarg. This limit is applicable to both flow through and re-circulated operations. A maximum non-operating pressure of 500 mbar gauge is permitted for diagnostic testing purposes. Stack damage is expected above this point. The use of a pressure relief device or other fail-safe mechanism to avoid stack overpressure is recommended.

WARNING

- **The fuel cell stack and associated system uses pressurized gases, which can be hazardous. Use caution and ensure circuits are de-pressurized before opening any lines or fittings.**
- **Do not exceed the maximum allowable operating pressure of 300 mbar gauge (30kPa gauge).**

The FCgen® -1310 stack performance sensitivity to variations in fuel pressure within the allowable range is negligible.

4.7.3. *Fuel Humidity*

The FCgen® -1310 stack nominal performance and lifetime are based on a fuel inlet humidity of 90% RH with respect to the coolant inlet temperature. A small performance increase is expected if RH is increased to 95% or greater, if RH is lower than 80%, a reduction in lifetime is expected. Due to current stage of development of the FCgen®-1310, there currently is not a curve available for lifetime vs relative humidity.

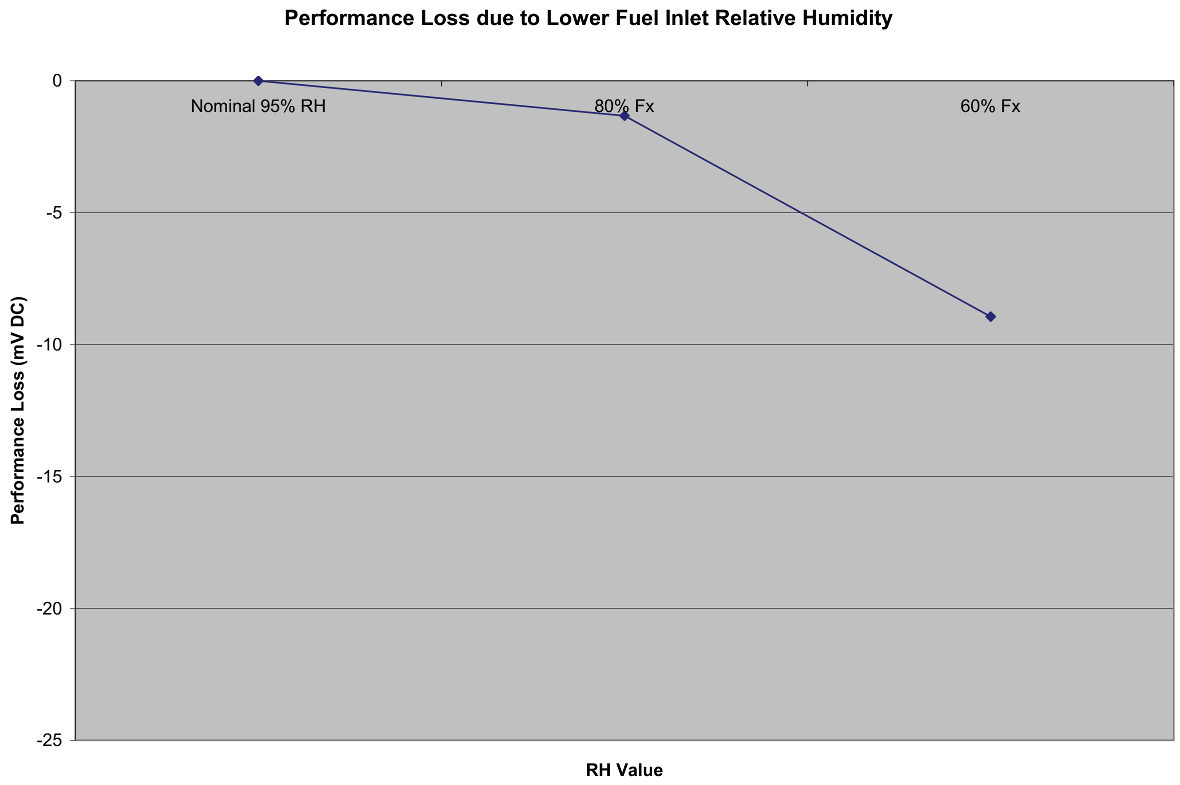


Figure 12 – Fuel RH performance sensitivity

4.7.4. Fuel Inlet Temperature

The fuel temperature into the stack must be such that the gas stream is non-condensing, thus the temperature should not be below the equivalent dew point of the gas stream RH. The gas can be hotter, provided it is not greater than 2°C higher than the coolant inlet temperature, excluding transients (See section 5.1, Transient operations)

4.7.5. Fuel Quality

The FCgen® -1310 stack has been designed for pure hydrogen operations, however some operation with inert gases such as nitrogen or methane is allowable with minimal performance loss.

4.7.5.1 Inerts – Nitrogen, Methane

Some performance loss is expected when the hydrogen is diluted due to nitrogen or other inert gases that may be present on the Anode. A dilution curve is shown below with Nitrogen as the inert gas. Please note that all volumes are calculated on a dry basis.

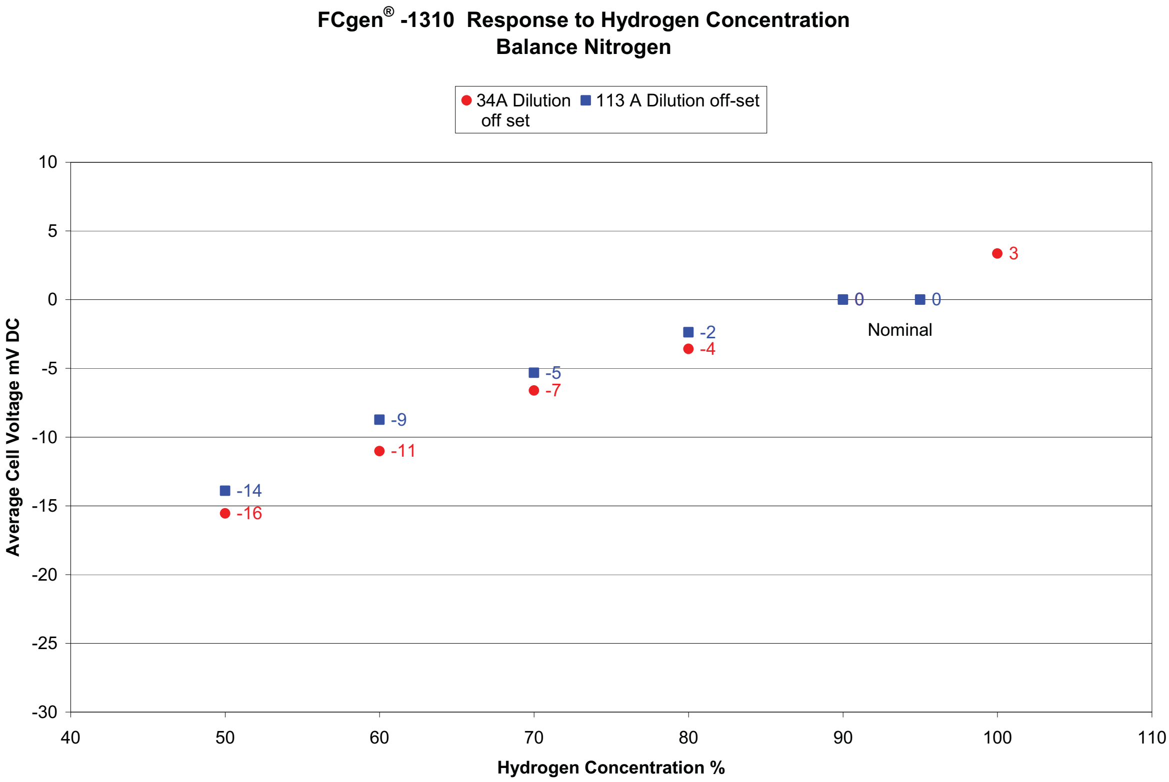


Figure 13 – Hydrogen Dilution Performance Loss at 1.45 stoich

4.7.5.2 Carbon Monoxide and Carbon Dioxide

The stack is particularly intolerant to even small amounts carbon monoxide resulting in a cumulative but recoverable performance loss. Thus, any operations with a reformate system must have a sufficient purification sub system to remove CO to a quantity of <0.1 ppm. It is not recommended to operate a stack in fuel recirculation mode when CO may be present.

For levels of CO less than 1 ppm, a small amount of air introduced to the fuel prior to the stack fuel inlet (called air bleed) will help off-set these effects up to 1 ppm CO. For these levels, a 1% by volume air bleed should be used.

Air Bleed Flow = Total anode inlet Fuel flow (dry basis) x 0.01

The air bleed should be a dry gas meeting the same requirements as the cathode air supply and should be added as close to the stack fuel inlet as possible. System alarm measures should be put into place to ensure this air flow vs fuel flow mix does not enter into a flammable regime ([Air] > 4%). Air bleed flow should never be started prior to fuel flow for this reason.

Figures 14 and 15 below show the performance loss over time with small amounts of CO and the result of adding an air bleed showing no decrease over time. A small performance drop from pure hydrogen operation is expected in applications with CO and air bleed.

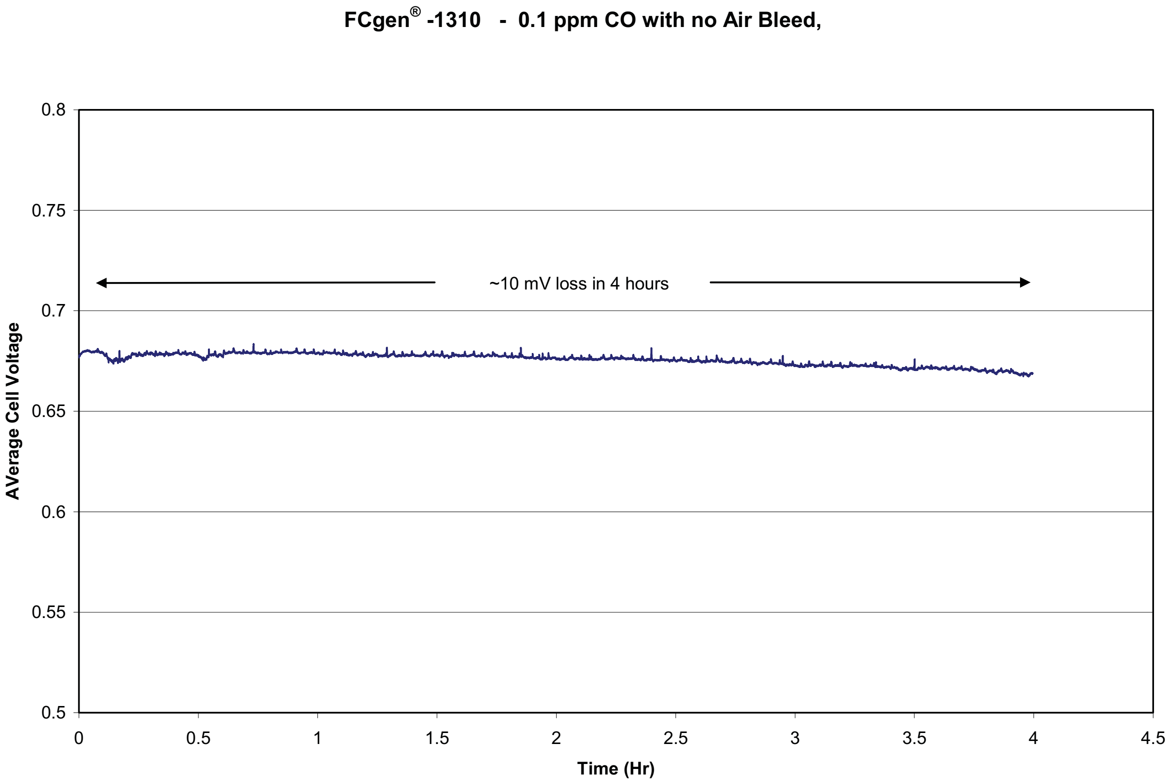


Figure 14 – 0.1 ppm CO introduced to stack fuel inlet at 111A Blended Hydrogen

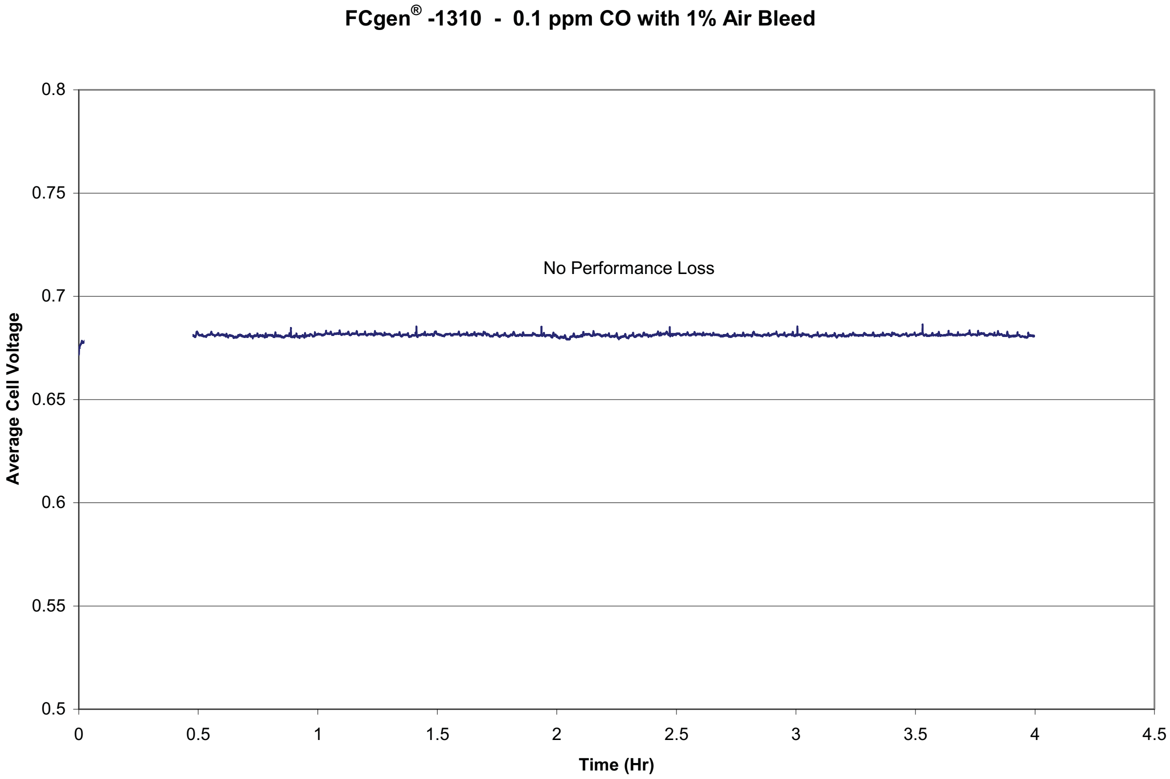


Figure 15 – 0.1 ppm CO with air bleed at 111A Blended Hydrogen

It should be noted that if large amounts of CO_2 are present, in addition to losses due to dilution, an additional performance loss will be seen due to the very small amounts of CO that can be produced within the fuel cell stack. As the root cause of this performance drop is still CO, this can be counteracted by adding a small amount of air bleed with the mix.

Additional contamination information on other compounds is found in section 4.8.4, contaminants.

4.7.6. Anode Pressure Drop Characteristic

The anode side of the FCgen® -1310 has a very low resistance to flow. When the stack is installed in a system, the stack anode pressure drop will probably be small compared with the pressure drop of the fuel piping and valves. This means the stack will need to be operated with sufficient stoichiometry to keep above the minimum operational pressure drop threshold. For the design point of 135A the anode pressure drop will be about 55mbar resulting in a fairly linear curve for currents less than 135A due to the minimum pressure drop requirement of 50mbar. Nitrogen concentration will have a significant effect on this as shown in figure 16 below.

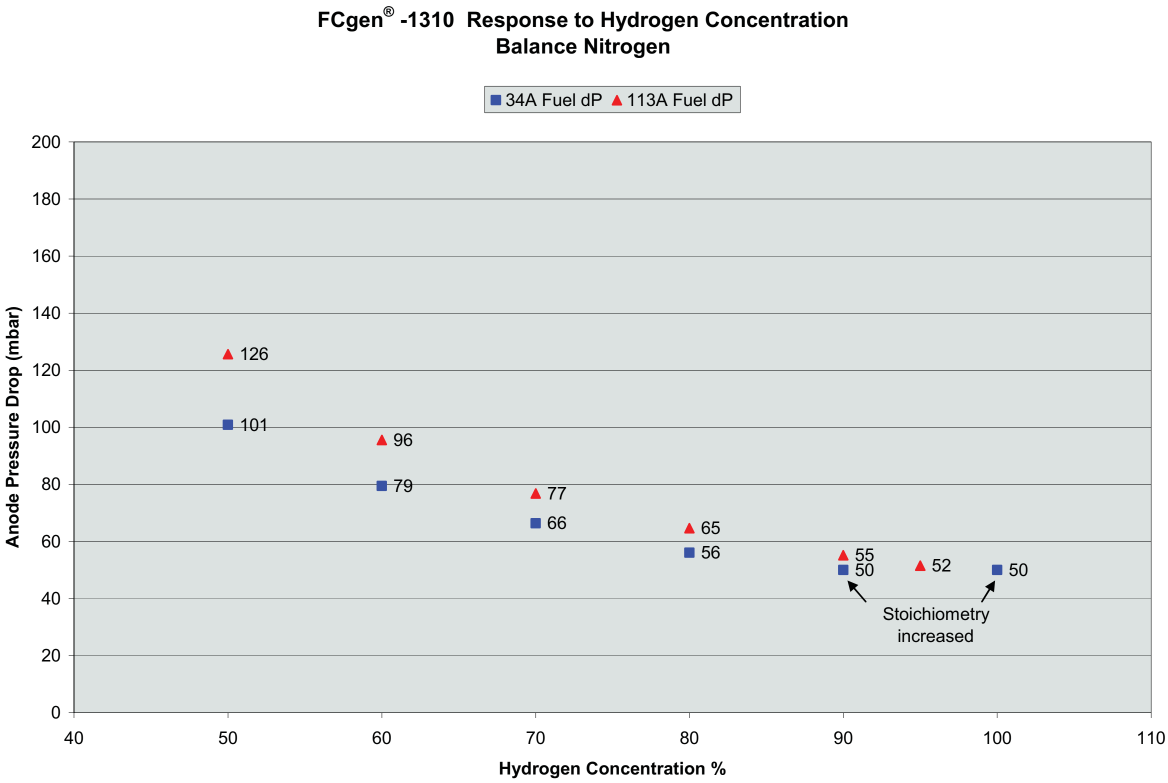


Figure 16 – Effects of Nitrogen concentration on anode pressure drop at 1.45 stoichiometry

4.7.7. Exhaust

When the FCgen® -1310 stack operates in a re-circulation mode using dry hydrogen fuel, the anode purge exhaust consists mainly of water vapor and inert gases, plus a small amount of hydrogen. The anode exhaust does not normally contain liquid water until after the flow stream pressure has dropped (by passing through the purge valve, for instance) or the flow stream has cooled. Liquid water may form in the anode exhaust line after system shutdown as water vapor cools and condenses.

It is important to provide liquid drains to remove excess liquid at the stack inlet to prevent water slugs going into the fuel channels causing localized fuel starvations within the stack.

When the FCgen® 1310 stack operates in a flow-through configuration, the anode exhaust will contain water, inert gases, and hydrogen. The amount of hydrogen will depend on the fuel inlet stoichiometry. If the inlet fuel is dry, the water will mostly be in vapor form. If the inlet fuel contains water vapor, there will likely be liquid water in the exhaust.

4.8. Ambient Environment

The FCgen® -1310 stack is not particularly sensitive to ambient conditions as the three fluid circuits, oxidant, fuel and coolant are pre-conditioned before entering the stack. The reality though is that these ambient effects will affect how the system interacts with the stack and there may be some observable effects on the stack.

4.8.1. Pressure/Altitude

As stated in section 4.6.2, the maximum operating pressure of the oxidant circuit is 300 mbar gauge, thus any increases in altitude will reduce the overall absolute pressure within the stack and some performance de-rate will have to be applied. An estimate for this de-rate can be derived from the pressure sensitivity curves found in the same section.

4.8.2. Startup and Operating Temperatures

The FCgen® -1310 stack is often installed within an enclosure containing the sub-systems required for air, fuel and coolant preparations. As such, the stack was designed to operate in ambient temperatures ranging from -5°C to 70°C. The ambient air outside the enclosure can also indirectly affect stack performance through the effects on air pressurization system and the coolant heat rejection system. Cooler temperatures around the stack should be avoided as there may be inadvertent condensation within the gas streams to the stack causing liquid water which will not only reduce gas humidification but may cause instability within the stack itself.

4.8.3. Humidity

As with temperature, the FCgen® -1310 stack is not affected by ambient humidity but it can be indirectly affected through the effects on air pressurization system and the coolant heat rejection system. The other consideration with ambient humidity is due to the live electrical nature of the stack design, a non-condensing atmosphere is important to prevent electrical current leakage paths through pools or streams of water.

4.8.4. Contaminants

4.8.4.1 Oxidant Contaminants

Operating with contaminant levels below those specified in section 3.3 will guarantee stack performance over the full product lifetime. Exposure to higher contaminant levels is possible, but will generally result in some performance drop; this performance loss may or may not be recoverable.

If the operating environment is expected to be very dusty, filtration of the oxidant air may be required.

For most long life applications, pollution-based lifetime performance degradation may be significant, so chemical filtration should be considered. This is especially true in industrial areas and in countries where rigorous environmental regulations have not been put into effect. In general, the worst case pollutants are Sulphur-containing compounds such as SO_2 or H_2S; these can cause irreversible damage to the cell. NO_x are commonly-occurring pollutants that can also cause significant performance degradation; however, testing has shown that NO_x contamination is reversible.

Figures 17 and 18 show the results of testing at various concentrations of SO_2 and NO_x over a 5-hour, 135A steady state run. In this testing, the voltage loss caused by NO contamination was fully recoverable, while the SO_2 contamination was non-recoverable.

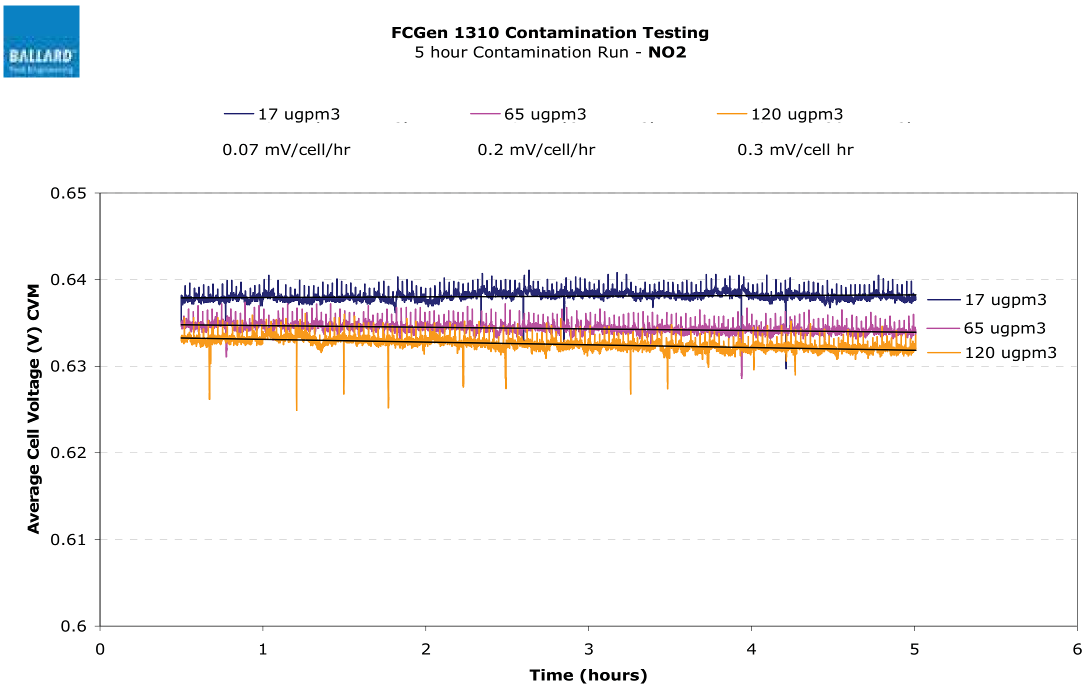


Figure 17 Initial Degradation Rate due to NOx Contamination at 135A Steady State

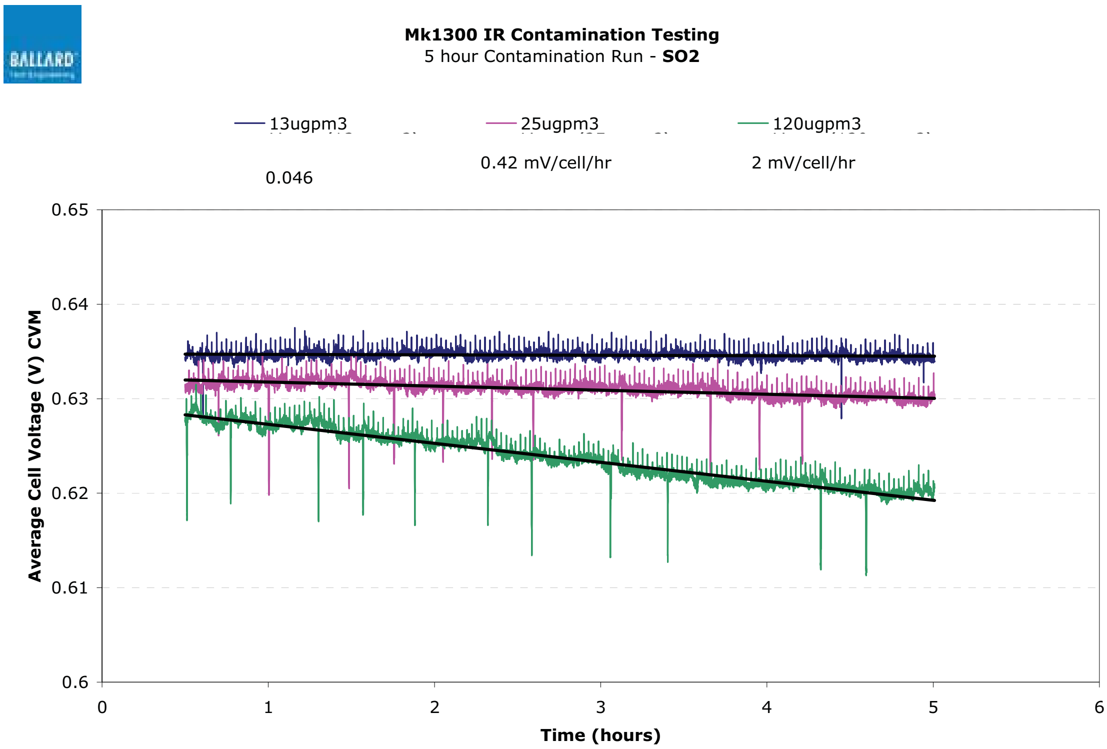


Figure 18 Initial Degradation Rate due to SO_2 Contamination at 135A Steady State

Note that for longer-term exposures to airborne contaminants (>>4 hours), the degradation rate is not expected to be linear. When selecting chemical filters for a given application, the long-term voltage loss over lifetime may be a more critical parameter.

4.8.4.2 Fuel Contaminants

A common anode contaminant will be carbon monoxide and will have a performance impact with any concentrations greater than 0.1 pm. See section 4.7 that shows the effects of carbon monoxide on performance.

Other common fuel contaminants are Sulfur and Ammonia. The FCgen® 1310 has not been specifically tested for other contaminants, however similar fuel cell stacks have shown intolerance to any Sulfur compounds with a non-recoverable performance loss observed in concentrations at the ppb level.

5.0 STACK OPERATION

5.1. Transients

5.1.1. Startup

WARNING

The fuel cell stack may contain residual voltage when not operating. Exercise caution when working with the stack. Residual reactants within the stack can rapidly develop a charge, even when there is no fuel flow and the stack has been short-circuited. A reading of zero volts across the entire stack does not guarantee that all cells are uncharged.

The startup procedure for the FCgen® -1310 stack in a hydrogen recirculation setup as follows.

1. Start coolant flow
2. Complete the startup fuel purge (see Section4.7.1).
3. Start HRB if available
4. Start air compressor and set hydrogen re-circulation to desired set-points.
5. Close electrical contacts
6. Begin normal operation.

Stack startup time to optimum voltage output depends on the temperature, the storage time, the load, and the characteristics of the BOP however power will be immediately available upon sufficient gas flows to the stack.

The time required for the stack to reach steady-state power depends mainly on the time that is required for the stack to reach the optimal operating temperature for the target current. The following can help accelerate the startup:

- If the system coolant stream has other sources of heat, the coolant flow through the stack can be started earlier to pre-heat the stack provided it does not exceed nominal operating temperature.
- This can also be done for the water in humidification loops if a water/gas humidification system is used. This should not be done however if by starting the humidification system, there is a possibility of liquid water build up within the cathode stream that would cause a liquid water slug to go into the stack once cathode air is started.
- Minimize stack voltage as stack is warming up (draw as much load as possible). High current/low voltage operation will produce more heat, accelerating warm-up time.

- Keep coolant flow to a minimum.

Temporarily air-starving the FCgen®-1310 stack on startup may also help to recover Non-Operating Performance Loss (NOPL). See Section 5.3 for a discussion of NOPL mitigation.

5.1.2. Shutdown- Normal conditions

Shutdown of the FCgen® -1310 stack is straightforward.

- Remove load.
- Turn off the oxidant airflow and stop the fuel flow, allowing pressures to drop equally.
- Stop coolant pump

The stack typically cools down to ambient temperatures in about 30 minutes but is highly dependent on the ambient conditions. Cell voltage bleeds down within about 15 minutes as the anode consumes residual hydrogen. Anode pressure typically falls below ambient as the hydrogen is consumed. The anode pressure returns to ambient within about 30 minutes as air diffuses back into the anode.

Ballard does not recommend the use of a bleed resistor to accelerate removal of the voltage from the FCgen® 1310 stack after shutdown. Where many start-ups are required, a bleed resistor may be desirable, contact Ballard applications engineering for support as serious damage may result from improper applications.

Continuing airflow for several minutes after shutdown should not significantly impact performance for the following startup.

5.1.3. Shutdown - Emergency Conditions

An Emergency Shutdown of the FCgen® -1310 stack should comprise of the following:

- Immediate Removal of Load. Open contactor to fuel cell stack.
- Turn off all Oxidant and Fuel flows.
- Immediately de-pressurize the system to remove any potential energy in the system.
- Stop coolant pump

This shutdown procedure will keep electrical potential on the stack for some time after initial shutdown. The live portion of the stack should not be touched unless the voltage has been verified to be below 40 VDC.

The stack integrator must address emergency shutdown procedures to suit each particular application and amend the procedure based on stack installation.

5.1.4. Power transients

The FCgen® -1310 stack responds faster to downward transients than to upward transients. When the load drops the stack responds instantaneously. This is not inherent to the stack response but rather reactant response of the supporting system where the fluid flows need to ramp up to maintain required stoichiometries. For control systems, the flows should always lead on an up transient and lag on a down transient to ensure adequate gas supply.

On down transients the voltage may be slightly higher to start but will stabilize within 30 minutes. On upward transients the voltage will be slightly lower but will increase to its stabilized voltage within 30 minutes. These variances are due to chemical equilibrium reactions inherent with fuel cells.

5.2. Cell Voltage Monitoring

Ballard recommends use of a Cell Voltage Monitoring (CVM) device during system development to ensure the system parameters are set to provide optimal stack operating conditions. It is not necessary to measure each individual cell voltage; the cells can be measured in pairs or larger groups. In a final commercial application, the intent is that measuring only the overall stack voltage (from the stack bus plates) will be adequate to ensure safe stack operation.

Note: Ballard does not provide the CVM or the voltage pickup fingers standard with stack purchase. For lab settings a voltage pickup board is available. Please see appendix A1 for CVM board specifications.

Ballard recommends against using the CVM data as a means of controlling system parameters during operation. Theoretically, reactant flows and hydrogen emissions released in the purge could be minimized by monitoring cell voltages and adjusting system parameters as the cell voltages change. In practice, controlling system parameters to CVM feedback usually results in an unstable system, which can lead to frequent shutdowns and reduced stack life.

5.3. Non-Operating Performance Loss

The FCgen® -1310 stack will experience reversible performance loss during storage. The loss increases with increased storage time and increased storage temperature, but should reach a maximum of no more than 100mV loss per cell at 135A. This will vary depending on desired current and will recover quickly at higher current operation.

The performance loss is due to the growth of a reduction resistant oxidation layer on the cathode catalyst, which impedes performance. The degree of Non-Operating Performance Loss (NOPL) can be limited by minimizing the storage time and avoiding high storage temperatures.

The performance loss is most easily recovered by lowering the cathode potential, causing a reduction reaction on the surface of the cathode catalyst. This serves to remove the catalyst oxide layer and "reactivate" the catalyst. This lowering of the cathode potential can be practically performed in two ways:

1) Operating the fuel cell normally at some high current density. This has been shown to recover NOPL, although typically a significant run time is required (depending on the amount of performance loss). If the FCgen® -1310 stack is exercised regularly, a 15- to 20-minute run is typically enough. If it has reached maximum recoverable performance degradation, from 24 up to 48 hours of operation may be required for full recovery.

2) Briefly starving the cathode of oxygen. This can be done by either removing or reducing air flow while continuing to draw load from the stack (air starvation).

These procedures are recommended if the application includes significant periods of storage/ stand-by, combined with a requirement for full stack performance in the first few minutes of operation.

WARNING

Excess fuel flow must be available during the air starvation procedure. Insufficient fuel flow may result in cell reversals, and possibly stack fire.

Recommended air starvation procedure:

1. Operate the stack for at least 5 minutes at a current of 100A or more to ensure adequate membrane hydration and increase stack temperature.
2. Increase coolant flow by 10% to compensate for the momentary air starvation reaction.
3. Reduce reactant air flow supply to a stoichiometry of 1, continuing to supply fuel and drawing load from the stack.
4. Cell voltage should drop to between 0V and 0.1V per cell. Hold this condition for 5-10 seconds, then restart reactant air flow.
5. This may be repeated up to 10 times.

Note that the interfacing load must be able to draw current at very low or zero stack voltage for this procedure to be effective.

5.4. Dehydration Performance Loss

Initial stack performance during the first few seconds or minutes of startup can also be affected by dehydration of the membrane. Under normal ambient storage conditions, this performance loss typically recovers very quickly (within a few seconds) as the membrane self-hydrates while producing power. This slight difference in performance in the first few seconds of startup between a normally humidified stack and a slightly dehydrated stack is generally not noticeable in terms of bridging energy requirements.

6.0 PHYSICAL INTERFACE CHARACTERISTICS

6.1. Physical Interfaces

6.1.1. Fluid Connections

The FCgen® -1310 stack fluid connections are all located at the anode end of the stack and utilize hose barb connections. The recommended hose sizes are shown in table 10 below.

Table 10 Fluid Interface Connection Specification

Port	Coolant In	Fuel In	Oxidant In	Coolant Out	Fuel Out	Oxidant Out
Recommended Hose Size (ID)	$^3/_4$ inch	$^3/_4$ inch	1 inch	$^3/_4$ inch	$^3/_4$ inch	1 inch

The stack has designated inlets and outlet labeled on the anode end plate. The stack can only be operated in this configuration due to internal routings of the gas streams within the fuel cell stack. Non-conducting hose is recommended for these connections to reduce the potential for leakage current between the live portion of the stack and ground. Side-load or pull forces on the tube stub should not exceed 25N.

There is a single ¼ inch hose connection located at the cathode end of the stack tied into the coolant outlet stream to be used as a de-gassing point when the stack is operated in the vertical orientation. Care should be taken when connecting lines to these two ports as they can be irreparably damaged if the hose is over crimped. Side-load or pull forces on the tube stub should not exceed 10N.

See section 6.3 for suitable materials for supply lines to the stack. Appendix A2 has a recommended hose specification and cleaning procedure for use with the FCgen®-1310 stack.

6.1.2. Stack Mounting

CAUTION

Handling the stack has the potential to damage the bi-polar plate material and sealing of the stack. Care should be taken to avoid contact with the electrically active portion of the stack and only handle the stack end plates.

6.1.2.1 Mounting Orientation

- The 1310 stack can be mounted in three different orientations. Unlike some fuel cell stacks, there are designated inlets and outlets that must be adhered to.

The preferred orientation is the <u>flat orientation</u>, however other acceptable orientations are shown in figure 19 below.

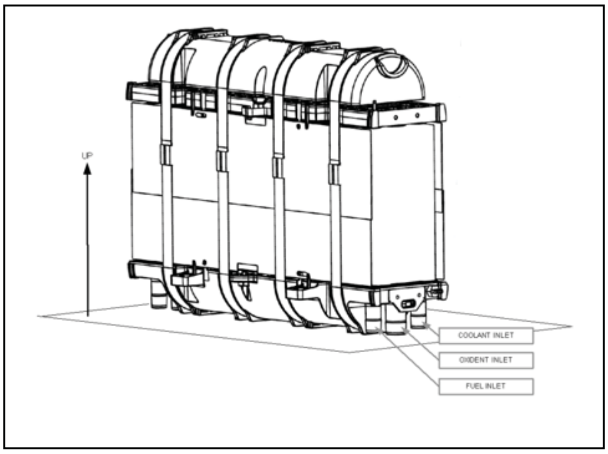
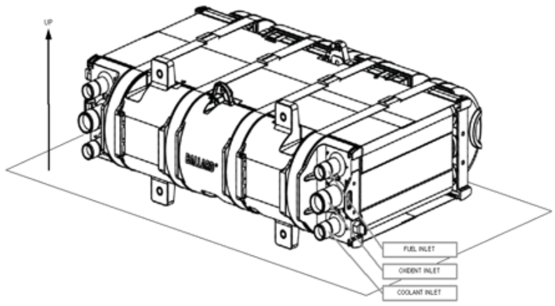
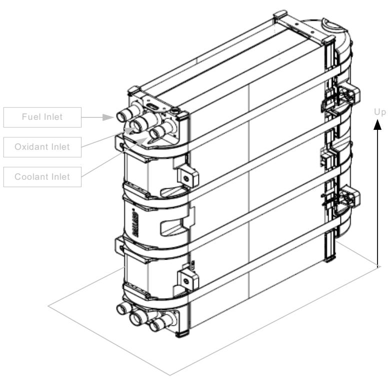
	
Vertical Orientation	Flat Orientation - Recommended
	
Edge Orientation	

Figure 19 – Acceptable Stack Installation Orientations, 120 Cell Stack Shown

Water management is always an issue and the stack integration to the system should be such that:

- Liquid condensate in the oxidant or fuel will never run downhill into the stack for both inlets and outlets.
- In the Flat orientation, the fuel inlet must always be higher than the fuel outlet.
- In the Flat orientation the stack should be level to ensure water does not get trapped in the Cathode end obstructing gas flow throughout the stack.

Coolant will be routed such that air build up within the stack will be prevented, thus the stack should not be the high point in any installation. The one exception is for the vertical orientation where a coolant bleed port is provided on the coolant outlet side of the stack and must be used to ensure no air build up within the stack.

If it is desired to operate the stack in the "Edge" orientation, contact Ballard Applications Engineering for mounting and operational requirements in this orientation.

6.1.2.2 Mounting Points

When mounting the stack in the flat orientation, it is recommended to fix the stack at mounting points 1, 2, 3, and 4 and additionally support the cathode end with pins through mounting points 5 and 6 to allow for stack length variability. It is also acceptable to rest the stack on the four mounting feet (3, 4, 5, and 6) and fix either pair of mounting points (1 and 2 or 3 and 4), as well as constrain the cathode end with pins at mounting points 5 and 6.

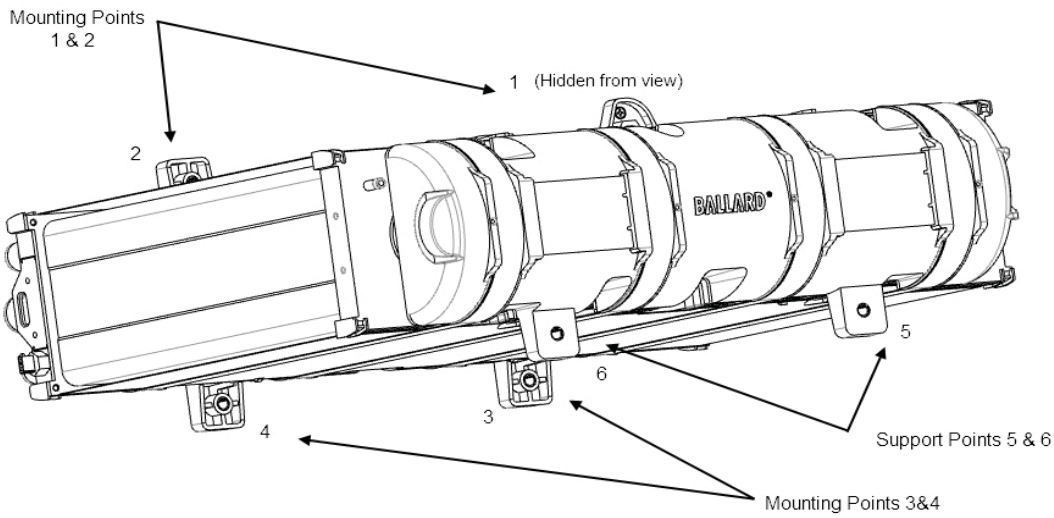


Figure 20 – Stack Mounting in Flat Configuration

The nominal support location for vertical operations is direct support on the flat edge of the stack. When mounting the stack in the vertical orientation, the stack may rest on its end plate the stack should be fastened using either mounting points 1 and 2, or 3 and 4 in figure 21 below.

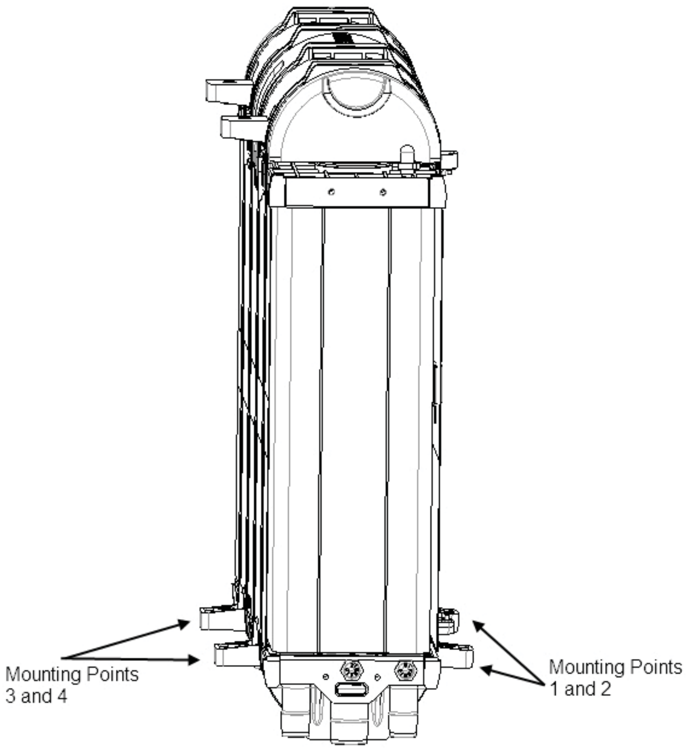


Figure 21 –Stack Mounting in Vertical Configuration

For vertical operations, the stack can be cantilevered from one side by fastening at mounting points 3,4,5 and 6 as shown in diagram below.

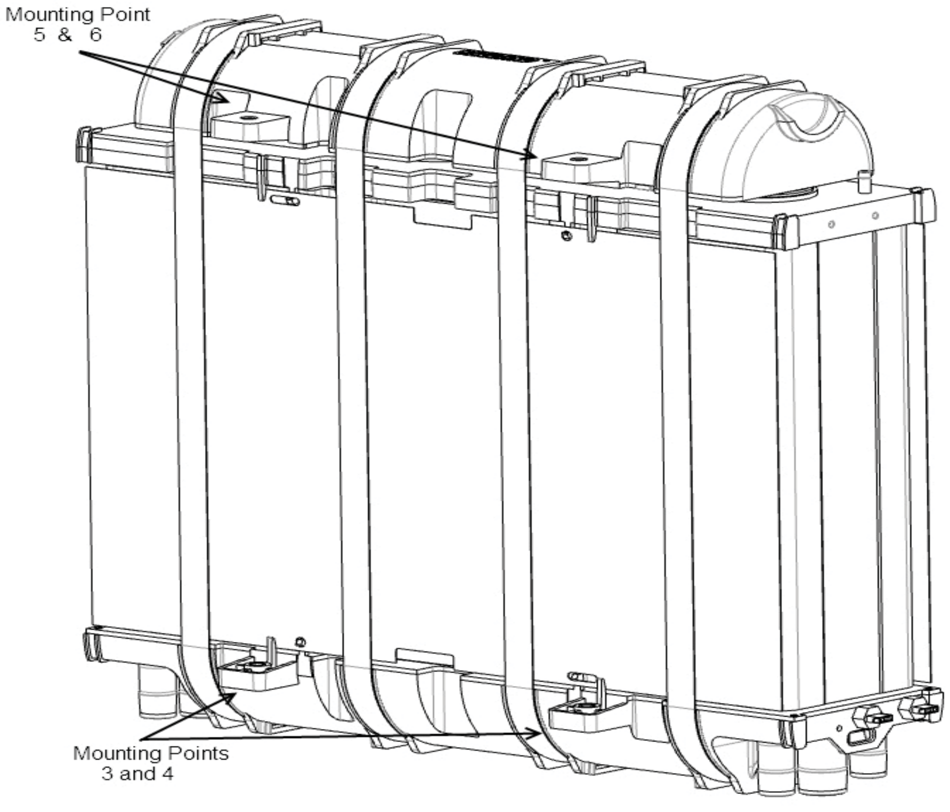


Figure 22 – Alternative Stack Mounting in Vertical Configuration

6.1.2.3 Other Mounting Considerations

FCgen® -1310 stack mounting should compensate for thermal expansion or creep over stack lifetime along the mounting length of the stack therefore no special modifications are needed.

Do not allow the mounting system to put any bending or twisting moments on the FCgen® 1310 stack.

6.1.3. Current Collection

The FCgen® -1310 stack delivers electricity from its bus plates; their locations are shown in figure 23. The bus plate at the anode end of the stack is the negative terminal.

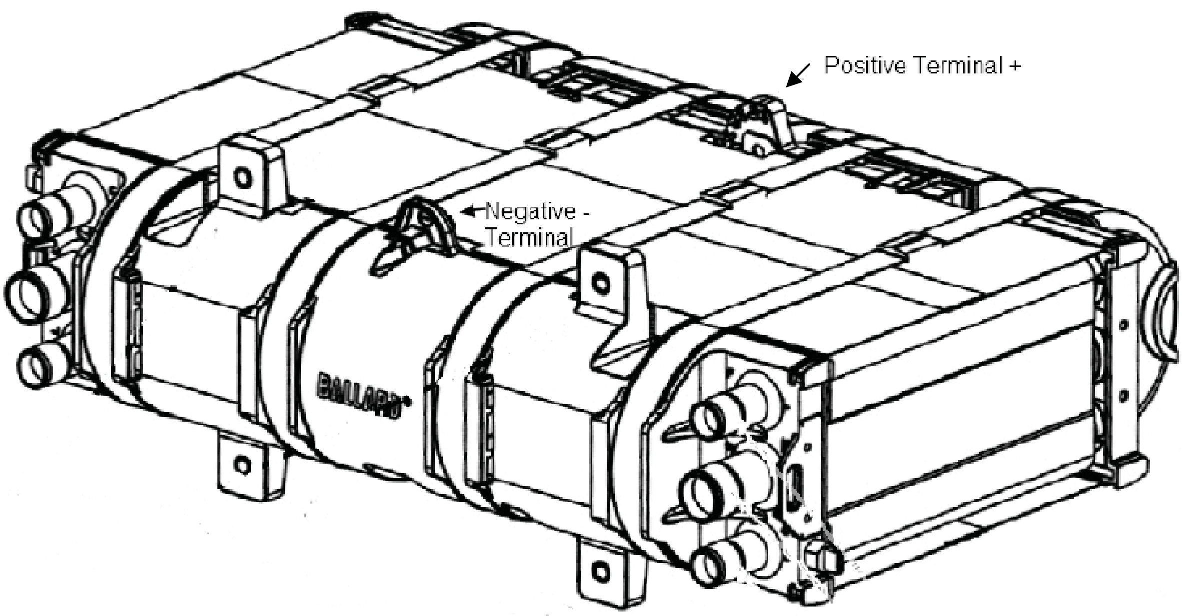


Figure 23- Electrical Terminals

The FCgen® -1310 stack electrical terminal is designed to accept a two-hole standard barrel lug with ¾ inch (19.05 mm) hole spacing and ¼ inch (6.35 mm) stud hole size. Attach suggested lugs, based on current capacity, to the conductive inboard surface of the bus plate using M6 bolt and nut (10 mm across flats) with the recommended torque of 6 N·m. Examples of suggested interface lugs of various conductor sizes include:

Panduit Part Number	Conductor Size
LCD6-14B-L	#6 AWG
LCD4-14B-L	#4 - #3 AWG STR, #2 AWG SOL
LCD2-14B-Q	#2 AWG

The lug can be attached in one of three positions at the stack electrical terminal (see Figure 24), by locating the lug hole closer to the barrel over one of the posts on the end plate electrical tab.

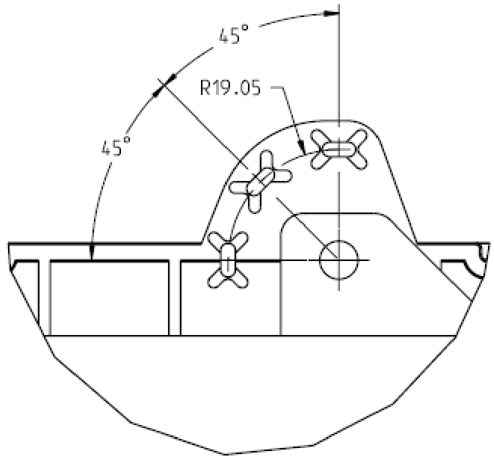


Figure 24. FCgen®-1300 stack electrical terminal.

NOTE: *The customer must choose the appropriate connector for required wire thickness in their application based on applicable codes and standards.*

6.2. Electrical Integration

6.2.1. Electrical Isolation

Ballard recommends installing the FCgen® -1310 stack as a floating electrical system. Under some circumstances it may be acceptable to connect one of the buses to earth. Contact Ballard Applications Engineering for details.

A means must be provided to prevent people or objects from touching the stack or associated electrical connections while the stack is in operation. Ballard recommends Ingress Protection(IP) to a level of at least IP3x (solid protection to prohibit tool entry). Liquid protection to suit application.[1]

The environment around the stack should be such that condensation and dust will not accumulate on the stack thus affecting electrical isolation.

A ground fault detection system is strongly recommended. A ground fault detection system continuously measures the electrical isolation of the stack and stack plus and stack minus electrical terminals with respect to the complete fuel cell system's safety bonding point. Ballard recommends a minimum shutdown threshold for isolation resistance between the

1 See also international standard IEC 60529

fuel cell stack (high voltage) and system ground of 125 ohms per volt[2]. See section 4.1 for maximum stack voltages.

The ground fault detection system should be used in conjunction with a coolant conductivity monitoring program. See Section 4.5 for more information on coolant conductivity.

Typical current leakage paths from the fuel cell stack include the following:

- Leaks from the surface of the stack due to lack of electrical isolation (electrical insulation and/or spacing). These leaks can be prevented by any of the methods typically used to isolate electrical equipment: insulation, physical separation, etc.
- Leaks via the customer DC power system if the customer's system is not adequately isolated. Current leakage through the customer can be prevented by isolating the fuel cell stack from the customer DC power system.
- Leaks through the stack coolant system. Current leakage through the stack coolant is prevented by limiting the maximum conductivity of the coolant or adjusting the coolant piping parameters. The allowable coolant conductivity is dependent on the resistance required to comply with applicable codes and standards as well as the physical shape of the coolant channels that are in close proximity to the stack.

- **The fuel cell stack must be operated in end-user engineered protected enclosure that provides bonding to end-user provided ground in accordance with end-user's applicable electric safety standards**
- **Conductive surfaces on the outside of the stack are not electrically connected together and therefore cannot be intentionally bonded to the end-user's chassis assembly; as such these surfaces may present an electrical touch hazard during stack operation. The end-user must ensure through the design of the enclosure and related safety interlocks that the stack assembly is shielded from intentional or accidental contact with personnel during stack assembly operation (i.e. be "touch-proof").**

The fuel cell stack has a potential for current leakage across clearances and creepage distances. The fuel cell stack installation should be designed with adequate clearances and creepage distances as governed by local applicable standards.[3]

There is a possibility of a carbon track forming at the anode and cathode outlets due to washout from new stacks. The use of longer non-conductive lengths of tubing combined with inspections and/or annual maintenance will reduce this risk.

---

[2] Automotive standard

[3] Ballard commonly uses IEC60664

Care should be taken by the integrator to ensure that no conductive foreign material can enter the stack enclosure area and become trapped between the stack and any grounded components.

6.2.2. Interactions with Balance-of-Plant

The Balance-of-Plant must not draw a ripple current on the FCgen® -1310 stack that is greater than 10% of the average stack current. Ripple currents below about 400 Hz may cause the stack to be starved of reactants at each current peak.[4] Ripple currents above about 100 kHz may cause the stack to radiate EMI.

The Balance-of-Plant must never apply a voltage or impose a reverse polarity on the FCgen® -1310 stack.

6.3. Material Compatibility

6.3.1. Materials for Wet and Dry Gases

The following materials can be used for any process gas lines,

- Teflon, PFA and FEP
- PVDF
- Neoprene
- Glass
- Low sulfur content EPDM [5]
- Viton
- Aluminum, i.e. grade 6061
- Stainless steel[6]

The recommended hose material for connecting directly to the stack is a silicone rubber. This type of material can be made with a variety of processes, please see appendix A2 for hose specification details and cleaning procedure.

6.3.2. Materials for Dry Gases

The following materials may be used for dry gas lines. Do not use these materials for humid gas lines, interface fittings or connections:

---

[4] The value given is for a generic PEM fuel cell stack. A FCgen® -1310 Stack operating in re-circulating mode is probably less susceptible to reactant starvation caused by low frequency ripple currents, because the stack normally operates with sufficient oxidant stoichiometry and with fuel supplied on demand. Lifetime implications of significant ripple currents on the FCgen®-1310 have not been quantified.

[5] This material must be specified or post treated to ensure no volatile organics or sulphur compounds are released.

[6] Stainless steel should not be used in wet hydrogen environments.

- Brass
- Copper
- Stainless steel
- Carbon steel
- Zinc
- Buna N

6.3.3. Materials to Avoid

Do not use the following materials for process gas lines, interface fittings or connections:

- Materials that off-gas (usually indicated by an odor)
- Materials containing Fenton's catalysts
    - Fe, iron
    - Cr, chromium
    - Cu, copper
    - Ti, titanium
    - V, vanadium

Do not use stainless steel near the gas inlets or outlets, where it could become wetted by anode exhaust or by condensed water dripping out of the anode inlet after stack shutdown.

Contact Ballard Power Systems before using materials not specifically mentioned above.

6.4. Other Packaging Considerations

The FCgen® -1310 stack should be protected from contamination from environmental dust, oils, and other pollutants.

It is important to consider fumigation requirements when shipping as chemical fumigants will permanently damage the stacks.

7.0 SHIPPING AND STORAGE

7.1. Preparation For Shipping or Storage

The FCgen® -1310 stack does not require any special operational procedure to prepare it for storage where freezing is not a concern. The stack hose connections should be capped off using the same plastic plugs that it came with to prevent foreign objects from getting inside. Use the standard shipping container to protect it against dust and contaminants.

The stack should be drained of all water and purged with a dry inert gas such as nitrogen to blow out any liquid water in the fuel, oxidant and coolant circuits wherever possible. The total and cross pressure limits apply during this purge and should not be exceeded at any point during the purge. If no external supply of gas is available, the air supply to the stack from the system may be used with the humidification system turned off.

For any shipping, the purge outlined above must be performed prior to shipment.

7.2. Shipping and Storage Ambient Environment

7.2.1. Ambient Temperature and Humidity Range

When shipped in approved packaging, the FCgen® -1310 stack was designed for a shipping and storage temperature range of 5°C to +70°C. Please contact Ballard applications engineering for any special requirements if a stack is to be shipped pre-installed into a system.

The FCgen® -1310 stack has not been tested for the ability to withstand freeze-thaw cycles however if procedure above is followed it is anticipated to only have a slight increase in leak rate and no performance degradation. Multiple freeze-thaw cycles may increase fuel leak rates and may cause performance degradation.

The FCgen® -1310 stack was designed for a shipping and storage ambient humidity range of 0%RH to 100%RH non-condensing.

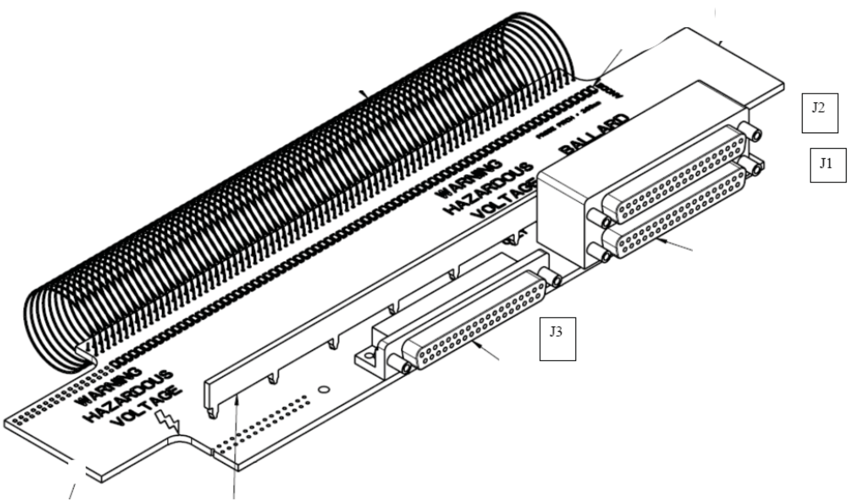
The FCgen® stack was designed for 10 year lifespan thus any storage time is included in this total calendar lifetime.

7.2.2. Shock and Vibration

The FCgen® -1310 has not currently been tested for shock and vibration resistance.

APPENDIX

<table>
<tr><th>A1</th><th>CVM Board Specifications</th></tr>
<tr><td>Picture of 75 cell stack with CVM board mounted</td><td>


The CVM board is <u>always</u> mounted on the fuel outlet side of the stack, using the supplied self tapping screws.
</td></tr>
<tr><td>CVM Board Diagram</td><td>


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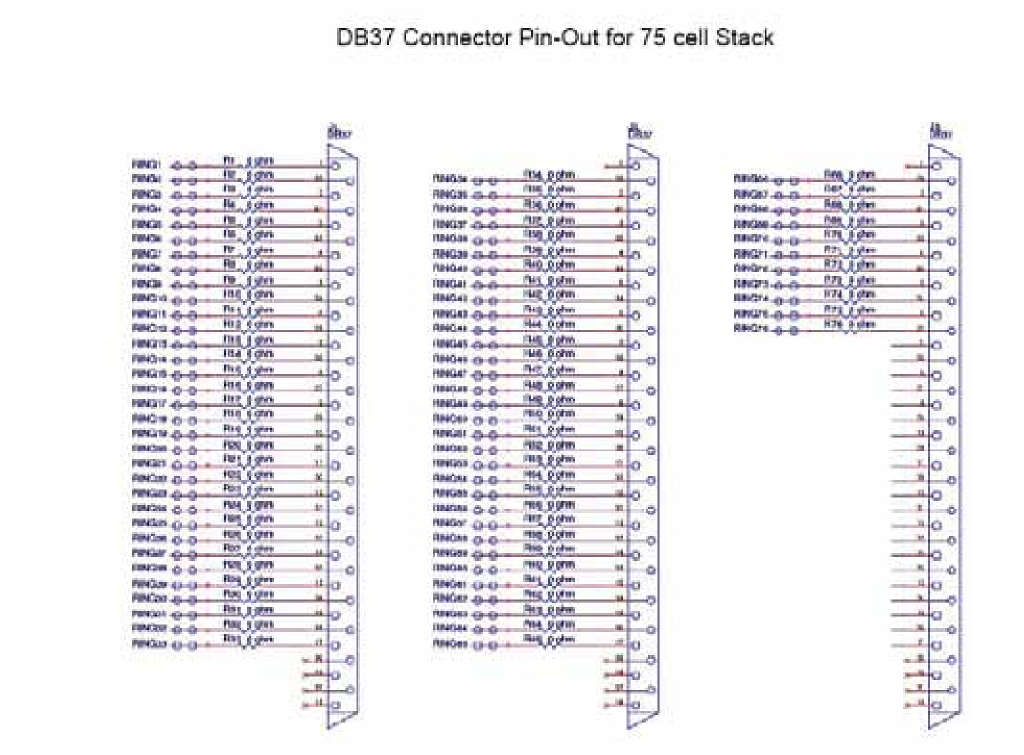
</table>

CVM Board Pin-Out	

A2	Silicone Hose Specification and Cleaning Procedure
Silicone Hose Specification	A2.1 Any purchased hose should have the following information collected Number of materials used in the hose composition (2ply, 3ply, 4ply etc) Type of materials used in the hose composition identified by polymer type (Silicone, Polyester etc.) Material grade identifier. This is not just "silicone" rather an identifier grade number, alpha numeric code or trade mark name. Name of hose supplier Part number of hose with unique identifier Manufacturer(s) of the hose Raw material grades and raw material manufacturer Technical data sheets for the hose Recommendation is to purchase silicone hoses where the wetted surface is a clear platinum cured silicone. Note that the external hose may be a source of contamination if it is exposed to gas inlets or sensors within the system enclosure. Colour additives are another possible source of contamination. A2.2 Purchased parts shall have total extractable compounds ≤5%. The total extractable material is usually not available from a hose distributor/supplier but can be tested. A raw material manufacturer should have this information. Target should be less than 3%. A2.3 Post Baking Purchased silicone hose should be post baked, ideally as a standard part of the production process. If not, exact post bake parameters need to be supplied by the hose supplier to avoid damaging hoses permanently. Post baking parts is necessary to reduce volatile and semi-volatile content with in rubber materials further reducing the risk for contamination. A2.4 Analysis It is recommended prior to purchasing large orders a sample of the hose be tested metals content, anions, volatile, and semi-volatile organics.

<table>
<tr><td></td><td></td></tr>
<tr><td>Silicone Hose Cleaning Procedure</td><td>

Materials and equipment
Cleaning
Source of fresh water, clean bottle brushes
Bake-out:
Oven capable of maintaining 170°C
Materials
Citranox cleaner or equivalent. This is a biodegradable acid cleaner that leaves no residue after rinsing. If Citranox is not available, please contact Ballard with details of substitutes.
Hose washing procedure
• Hoses must be washed in 2% solution of Citranox in warm (~40°C) water.
• Soak hoses in Citranox solution for about 10 minutes.
• Scrub hoses inside and out with brush with special attention to any deposits inside the hose.
• Rinse with warm tap water. The inside of the hoses can be rinsed by filling with water, blocking the ends, shaking well and draining.
• Allow hoses to air dry.
Baking procedure – Ensure hose specified can be baked at this temperature, see point A.2.3 in above section.
• Place hoses in oven.
• Bake at 170°C (or recommended temperature from supplier) for four hours.
• Allow hoses to cool.
Final Rinse
• Rinse with distilled or de-ionized water and allow to air dry.
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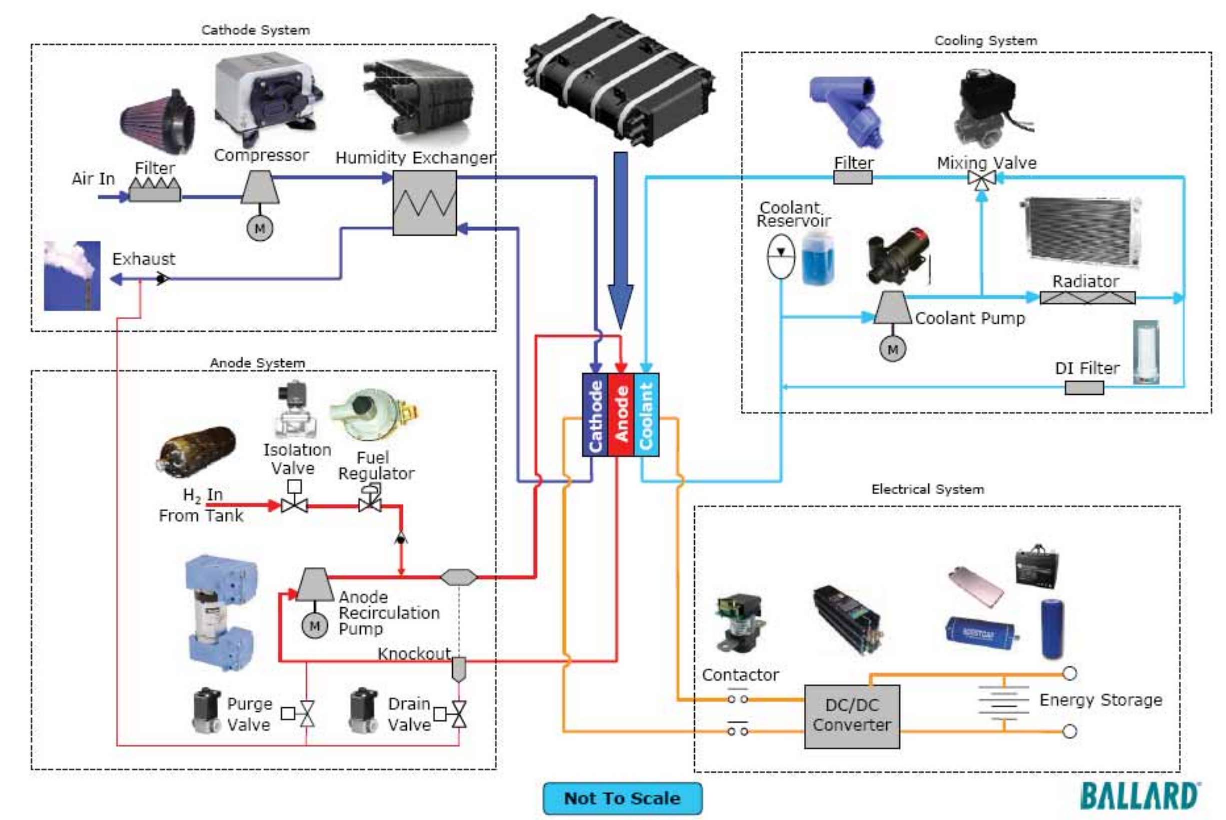
<tr><td></td><td></td></tr>
</table>

A3	Typical Hydrogen System Process Diagram
Process Diagram	

Liquid-Cooled PEM Fuel Cell Systems

Design Guide

Document Number: MAN5100187 Rev.0A
Date: September 22, 2006

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Released under CO10945

Disclaimer

This design guide is provided as a resource to PEM fuel cell system integrators interested in the design of the fuel cell Balance of Plant (BOP) for liquid-cooled fuel cell stacks. It is assumed that the integrators are experienced engineers who have designed other mechanical and electrical systems.

The general information in this design guide is based on Ballard's experience with PEM fuel cell systems and is current at the time of release. The general information in this design guide is not intended to provide, and does not provide, specific technical advice, instruction, or guidance with respect to any actual design, component, or application. This design guide generally describes typical designs that have been shown to work but does not purport to be the final word on all designs for PEM fuel cell Balance of Plant.

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Assembling and operating fuel Cell Systems is potentially dangerous, and serious injuries can result. The fuel cell system designer proceeds at his or her own risk.
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Table of Contents

Table of Figures

(i) Warnings, Cautions and Symbols Used

WARNING & CAUTION symbols in this manual indicate actions that may result in an accident, which could cause bodily injury or loss of life or could cause damage to equipment or other property.

ELECTRICAL HAZARD symbols indicate electrical hazards that may result in an accident, which could cause bodily injury or loss of life or could cause damage to equipment or other property.

✸ *NOTE: General notes and important information*

(ii) Glossary

Abbreviation	Term
A	Ampere
AC	Alternating Current
BOP	Balance of Plant
CVM	Cell Voltage Monitoring
DC	Direct Current
fuel cell stack	Individual fuel cells combined
kW	Kilowatt
MEA	Membrane Electrode Assembly
PEM	Proton Exchange Membrane
SLPM	Standard litre per minute, measured at 1 atm, 0°C
VDC	Voltage, Direct Current

1.0 FUEL CELL MODULE SUBSYSTEMS

1.1. Fuel Cell Stack

The fuel cell stack is usually considered to be the core of the Fuel Cell Module.

A fuel cell stack is composed of multiple fuel cells “stacked” one upon the next. The cells are electrically in series, so although each individual cell is less than one volt, the overall fuel cell stack has a much higher voltage.

A single fuel cell is referred to as a “unit cell”. A conceptual sketch of a unit cell is shown in Figure 1-1.

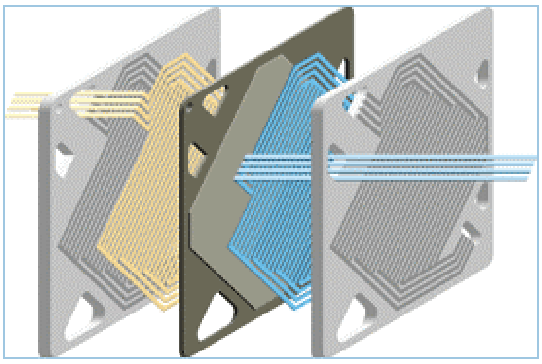


Figure 1-1 Unit Cell

Ballard’s liquid-cooled Proton-Exchange Membrane (PEM) unit cells consist of the following:

1. A bi-polar plate made of a conductive material (usually graphite). The plate is scored with channels for coolant flow on one side of the plate and for reactant flow on the other side of the plate.
2. A Membrane Electrode Assembly (MEA). The MEA is a thin sheet consisting of a cathode layer, an electrolyte layer (a polymer membrane), and an anode layer.
3. A second bi-polar plate.

Manifolds for distributing reactants and coolant to all of the cells in the stack are built into the unit cell in the form of cell-to-cell passageways on the ends of the cell.

Each cell of the fuel cell stack performs the following functions:

a. Consume oxidant
b. Consume fuel
c. Produce electricity
d. Produce heat
e. Produce water
f. Reject waste gases
g. Reject product water

These functions are discussed in detail below.

a. Consume oxidant

A PEM fuel Cell uses oxygen as oxidant. The amount of oxygen used is directly proportional to the amount of electrical current produced. The equation for calculating the amount of oxidant used by the fuel cell stack is given in Section 5.1 of this design guide.

The oxygen can either be supplied in relatively pure form or can be supplied as fresh air. This Design Guide addresses only air-based systems.

PEM fuel cells vary in their ability to tolerate contaminants in the oxidant supply. See the specifications for your fuel cell stack for the required air or oxidant quality.

The oxidant side of the fuel cell is called the cathode side because a reduction reaction occurs there. Electrons flow to the cathode side of the fuel cell from the external circuit; the cathode is positively charged.

b. Consume fuel

A PEM fuel cell uses hydrogen as fuel. The amount of hydrogen used is directly proportional to the amount of electrical current produced. The equation for calculating the amount of hydrogen used by the fuel cell stack is given in Section 5.1 of this design guide.

Hydrogen can either be supplied in relatively pure form or can be supplied in the form of reformate. This Design Guide addresses only pure hydrogen systems.

PEM fuel cells vary in their ability to tolerate impurities in the fuel supply. See the specifications for your stack for the required hydrogen quality.

The fuel side of the fuel cell is called the anode side because an oxidation reaction occurs there. Electrons flow from the anode side of the fuel cell to the external circuit; the anode is negatively charged.

c. Electricity, heat, and water production

A PEM fuel cell combines the fuel and oxidant electrochemically to produce electricity, heat, and water. Under ideal conditions, all the energy of reaction would be converted to electricity and the resulting electromotive force (EMF) would be about 1.18 V. However, in practice the voltage is lower because of various irreversibilities:

- *Activation losses* – losses associated with driving (activating) the chemical reactions
- *Ohmic losses* – electrical resistance losses of the electrodes, membrane and plates
- *Mass transport losses* – losses due to inadequate concentration of reactants at the surface of the electrodes
- *Fuel crossover and internal currents* – losses due to diffusion of fuel molecules across the membrane and current leakages across the membrane

There is also a loss because the maximu
m electrical energy that can be generated by the reaction is less than the heat of combustion of hydrogen.[1] Due to these losses, some of the potential energy of the reaction becomes heat rather than as electricity. This is illustrated in the typical **polarization curve** shown in Figure 1-2 below.

[1] The change in Gibbs energy is less than the change in enthalpy for the reaction.

It should be observed that the higher the current at which the cell is operated, the higher the proportion of energy that is changed to heat rather than electric current. Therefore, the fuel cell is more efficient at lower current densities. The point on the polarization curve at which the fuel cell is operated has a large effect on the efficiency of the overall Fuel Cell Module (FCM); this is further discussed in Section 2.1.1 of this design guide.

Section 5.1 of this Design Guide provides equations for calculating fuel cell stack operating parameters (current, voltage, heat production, and required reactant flows).

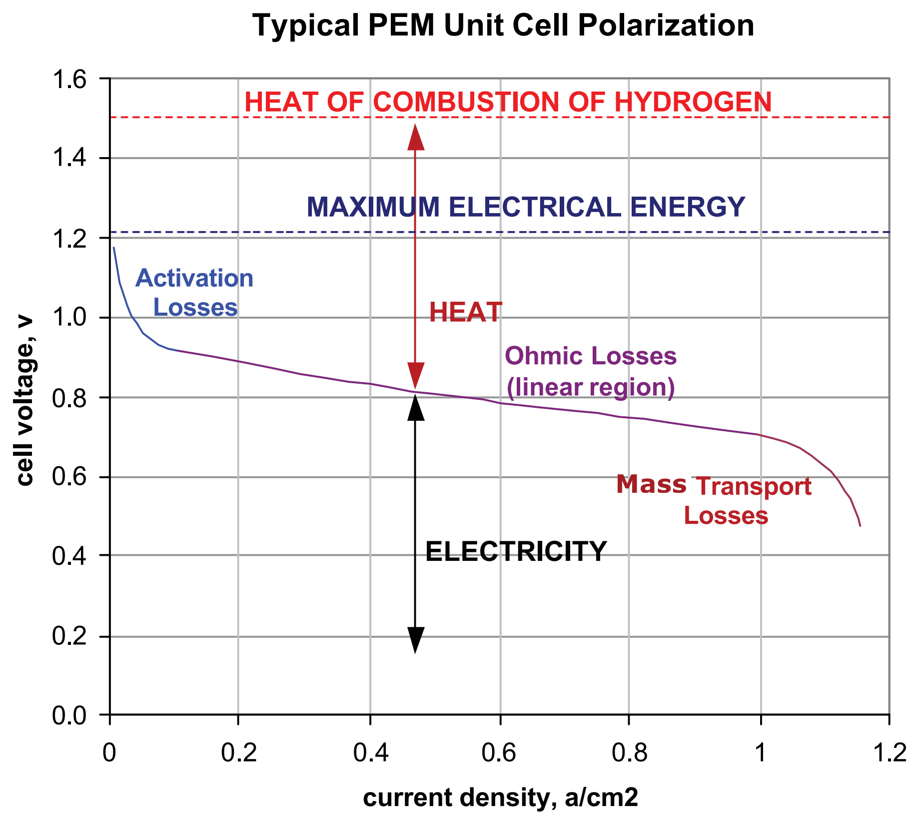


Figure 1-2 Typical polarization curve for a PEM fuel cell

d. Reject waste gases and product water

If air is used as the oxidant, the nitrogen, carbon dioxide, and other unreacted gases must be rejected from the oxidant (cathode) side of fuel cell. There will also be excess, unreacted oxygen in the exhaust stream.

Product water is formed on the oxidant side of a PEM fuel cell. Depending on the operating temperature and pressure, the water may be in the form of liquid, vapor, or a mix of the two. The product water is rejected in the oxidant (cathode) exhaust stream.

The fuel (anode) side of the fuel cell also has waste gases that must be rejected. These waste gases come from two sources: impurities in the fuel feed stock and water and inert gases that diffuse across the membrane from the oxidant (cathode) side of the stack. These waste gases must be purged from the fuel cell because if they build up they will reduce the fuel concentration on the anode. In extreme cases, parts of the cell may be completely fuel starved. Not only does this reduce the cell voltage, it can also cause long-term permanent damage to the cell.

Specific requirements for the fuel cell stack installation and operation are discussed in the sections of this design guide that describe the Balance of Plant subsystems that provide for those requirements (Section 1.2) and in Sections 2.0 and 3.0.

1.2. Balance of Plant

Most of the Balance of Plant (BOP) exists to take care of the fuel cell stack.

The BOP must provide the following services to the fuel cell stack.

- Provide oxidant (air) at the correct temperature, humidity, and flow rate.
- Remove cathode waste gases and water.

  The functions listed above are performed the **Air (Oxidant) Subsystem.**
- Provide fuel (hydrogen) at the correct temperature, humidity, and flow rate.
- Remove anode waste gases and water.

The functions listed above are performed by the **Fuel Subsystem.**

- Remove heat.

  This function is performed by the **Thermal Management Subsystem.**

- Electrically isolate the fuel cell stack from the environment.

  This function is shared among subsystems: the **Enclosure and Support Subsystem**, the **Thermal Management Subsystem**, and the **Electrical (Power Conversion) Subsystem**.

- Provide mechanical protection from the environment

  This function is performed by the **Enclosure and Support Subsystem.**

There are several additional BOP functions that are usually required but which do not directly service the fuel cell stack:

- Regulate output power.

  This function is performed by the **Electrical (Power Conversion) Subsystem**.

- Provide regulated power to BOP equipment.

  This function is performed by the **Power Distribution Subsystem.**

- Control the equipment.
- Provide operator interfaces.

  The functions listed above are performed by the **Controls and Human-Machine Interface (HMI) Subsystem.**

- Prevent build up of combustible gases.

  This function is performed by the **Ventilation Subsystem**.

1.2.1. Air (Oxidant) Subsystem

The Air Subsystem provides the following functions.

a. Provide correct airflow, velocity and pressure to the cathode side of the fuel cell stack.

b. Provide correct amount of oxygen to the cathode side of the fuel cell stack.

c. Ensure that the flow entering the cathode side of the fuel cell stack has the correct relative humidity.

d. Remove impurities from the airflow to the cathode side of the fuel cell stack.

e. Condition the temperature of the air entering the cathode side of the fuel cell stack.

f. Remove of exhaust gases from the cathode side of the fuel cell stack.

g. Remove of exhaust liquid water and water vapor from the cathode side of the fuel cell stack.

h. Contain the cathode inlet and exhaust air and liquid flow streams.

Depending on the system architecture, the Air Subsystem may also be required to perform the following function.

i. Separate liquid water out of the cathode exhaust stream.

These functions are discussed in detail below.

a. Provide correct airflow, velocity and pressure to the cathode side of the fuel cell stack.

b. Provide correct amount of oxygen to the cathode side of the fuel cell stack.

Since fresh air contains 21% oxygen, the amount of airflow into the system and the amount of oxygen flow into the system cannot be controlled independently. Therefore these functions are generally controlled together.

Airflow, velocity, and pressure are required to ensure that product water is removed from the stack. Product water is formed on the cathode side of a PEM fuel cell stack. If the amount of water formed is more than can be evaporated at the operating pressure and temperature, some of the product water will be in liquid form. Ballard's liquid-cooled fuel cell stacks use dynamic water removal to remove the product water droplets. The cathode channel is designed so that the pressure drop of the flow stream will be greater than the surface tension holding the water droplets to the plate, so the droplets will be blown out of the channel. In order to achieve this adequate airflow must be supplied at adequate inlet pressure.

See the specifications for your fuel cell stack for the minimum flow rate to ensure water removal for each power setting.

It may be desired to operate the fuel cell stack at higher-than-ambient pressure. Higher pressure raises the polarization curve; that is, raises the stack voltage at a given current. It also makes it easier to maintain humidification. See the specifications for your fuel cell stack for the effect of increased pressure on performance and for the maximum allowable operating pressure.

The amount of oxygen that the fuel cell stack uses is directly proportional to the output current (see Section 5.1 of this Design Guide for the method of calculation). However, most fuel cells require that excess oxygen be provided. This ensures that oxygen molecules are always present at all reaction sites. The required amount of excess oxygen may be expressed in either of two ways:

$$\textbf{air stoichiometric ratio} = \frac{\textbf{amount of oxygen provided}}{\textbf{amount of oxygen used}}$$

$$\textbf{air utilization} = \frac{\textbf{amount of oxygen used}}{\textbf{amount of oxygen provided}}$$

Air utilization is the inverse of air stoichiometric ratio.

See the specifications for your fuel cell stack for the minimum air stoichiometric ratio for each power setting.

If the minimum flow rate to ensure water removal is different from the minimum flow rate to provide adequate stoichiometric ratio, the higher flow rate should be used.

Air flow rates much higher than those given in the fuel cell stack specifications should be used with caution; if the flow rate is too high, too much moisture can be removed from the cathode. Continued operation with a too-dry cathode causes poor performance and may cause long-term stack damage.

The air flow is usually supplied by a blower or a compressor. If a variable-speed device is chosen, the speed is adjusted to provide the correct flow at each operating point. If a single-speed device is chosen a valve or damper can be used to adjust the flow.

In some applications the cathode flow could be provided from a compressed air source. In this case a flow/pressure control valve can be used to adjust the flow rate.

Unless there is a known, invariable relationship between the compressor speed and the molar flow rate[2] or unless the fuel cell stack can tolerate a wide range of airflow rates at each operating point[3], flow measurement will be needed. The flow feedback signal is used to adjust the compressor / blower speed or valve / damper position to get the correct flow.

The best location for the flow measurement device depends on the flow measurement technology used. At the compressor / blower inlet the density is relatively constant and the temperature is relatively low. At the compressor / blower or valve / damper outlet the density will increase with flow rate; this may give a higher turndown for a DP-type device, but additional instrumentation will be needed to measure the inlet pressure and temperature. Also, the higher temperature may limit the choice of materials.

The blower, compressor, or pressurized air source must be able to provide enough pressure to overcome all the pressure drops in the Air Subsystem plus the pressure drop of the cathode side of the fuel cell stack. The pressure drop characteristics of the fuel cell stack should be given in the fuel cell stack specifications. If the fuel cell stack is to be operated at higher than ambient pressure the blower, compressor, or pressurized air source must provide this additional pressure boost.

[2] This is rarely the case. For positive-displacement devices, speed can be mapped to volumetric flow. But the relationship between inlet volumetric flow and inlet mass/molar flow depends on density. The inlet air density changes with inlet temperature. The compressor / blower inlet pressure can also change if the inlet is blocked, for instance by a dirty filter. It might be possible to measure inlet pressure and temperature and calculate a density correction factor, but this is unlikely to be the most practical approach.

[3] Even if the stack can tolerate an “inaccurate” air flow rate, it may be worthwhile to measure air flow to ensure that power is not being wasted in compressing more air than is needed. This tradeoff depends on the relative importance of Fuel Cell Module efficiency vs. cost and complexity.

Usually the air stream makes a single pass through the fuel cell stack and the exhaust gases and water are vented to atmosphere. This is acceptable because there is nothing hazardous in the exhaust stream.

If the fuel cell stack is to be operated at higher than ambient pressure, some restriction is needed in the cathode exhaust line to maintain the pressure in the stack. This could be a fixed restriction, such as an orifice, a passive device such as a backpressure regulator, or an active device such as a control valve controlling to stack outlet pressure. Note that if a fixed restriction is used, the pressure at the stack outlet will vary directly with flow rate and power setting. A backpressure regulator will result in a constant stack outlet pressure. If a control valve with an upstream pressure sensor is used, the stack outlet pressure can be programmed for each operating condition.

Any of these approaches will result in lower system efficiency because the additional energy that was used to pressurize the air at the cathode inlet is not recovered; instead, the pressure energy is wasted. The performance improvement gained by running the fuel cell stack at higher pressure is rarely enough to make up for the additional energy used in the compressor.

Despite this, it may be necessary to run the system pressurized to achieve the required cathode inlet humidity. This is explained in the next paragraph, which covers humidification.

The cathode exhaust gas can be run through a turbine to recover some of the pressure energy. The amount of energy extracted in the turbine is adjusted to control the stack cathode pressure.

When a turbine is used, it is usually put on a single shaft with the compressor. Unfortunately the second law of thermodynamics prohibits extracting enough energy from the turbine to power the compressor. An electric motor can be added to the shaft to provide the additional power, or a burner can be added upstream of the turbine to add additional thermal energy to the stream. The amount of energy extracted by the turbine is controlled by adjusting the motor power or burner firing rate.

In liquid-cooled fuel cells, the cathode exhaust is usually greater than 100% relative humidity. More water will condense when the flow stream is expanded in the turbine. Since it is not generally desirable to have liquid water in a turbine, provisions must be made to remove most of the water (liquid and vapor) before the turbine.

Using a turbine to extract the pressure energy complicates the system design and increases the initial cost. For this reason, this approach is usually not worthwhile on smaller systems. On larger systems, the additional performance gained by running the fuel cell stack pressurized may make it worthwhile to "turbo charge" the system.

c. Ensure that the flow entering the cathode side of the fuel cell stack has the correct relative humidity.

Many PEM fuel cells require the air entering the cathode to be pre-humidified. The humidity specification is usually given in terms of Relative Humidity (RH) of the cathode inlet stream. The RH should be evaluated at the cathode inlet because it is when the gas stream passes over the MEA that its relative humidity is important.

In most designs, the temperature of the stack at the cathode inlet is the coolant inlet temperature. In most PEM fuel cells the cathode flow and coolant flow are in the same direction (see Section 2.1.3). Because the coolant has much more heat capacity than the cathode or anode flow, the coolant temperature determines the nearby stack temperature. The cathode stream will be heated or cooled to the stack temperature upon entering the stack. Depending on the stack design, the cathode flow may equalize to nearby stack temperature while still in the stack manifold.

If the cathode gas stream is heated upon entering the stack, its RH will drop. If the cathode gas stream is cooled upon entering the stack, its RH will increase. This can be better understood by examining at the Psychometric Chart, Figure 1-3.

Relative Humidity is the ratio of the actual amount of water vapor in the gas stream to the maximum amount of water vapor that the gas stream can hold at that pressure and temperature (the "saturated" value). Figure 1-3 shows the saturated mole fraction of water at various pressures and temperatures in a typical PEM fuel cell operating range. It can be observed that for a given pressure, the saturated mole fraction of water is higher at higher temperature. That is, the hotter the gas, the more water it can hold. This increases the denominator of the ratio so the RH is lower. If the cathode gas entering the fuel cell stack is cooler than the stack inlet, the relative humidity when the flow reaches the MEA may be below specifications even if the cathode gas was at 100%. This condition is to be avoided.

If the cathode gas entering the fuel cell stack is hotter than the stack inlet and the cathode gas was at 100% RH when at the stack inlet, droplets of liquid water will form.

It is generally undesirable to put droplets of liquid water into the stack reactant inlet passages of Ballard fuel cell stacks. If the droplets are too large they can block the gas channel to the whole cell or to part of the cell (depending on the channel design). A cell or portion of a cell that is getting insufficient oxidant or fuel is referred to as "starved". Starvation will result in low cell voltage and cell damage.

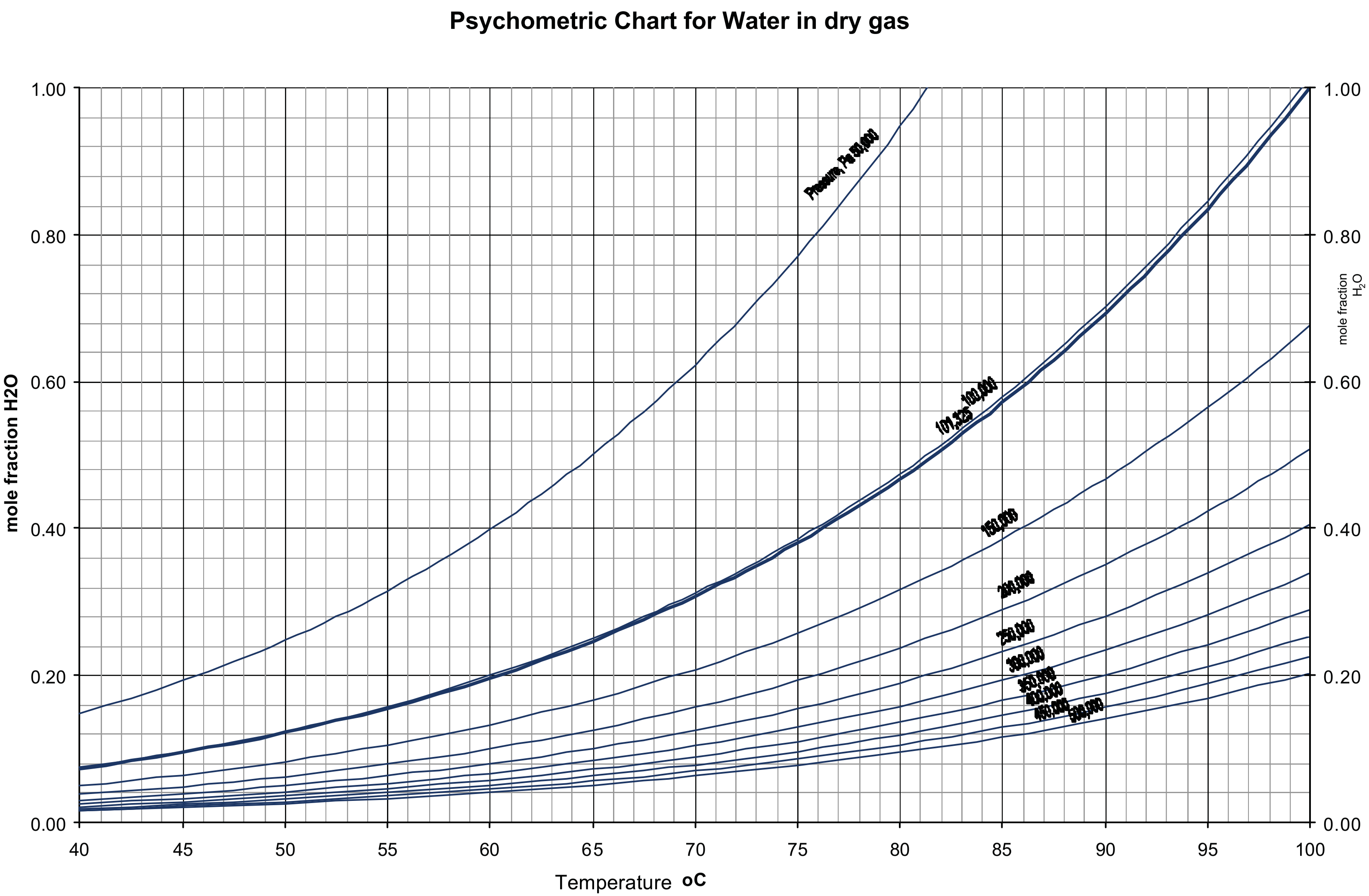


Figure 1-3 Psychometric chart

Section 5.2 of this Design Guide provides equations for calculating relative humidity as a function of temperature, pressure, and mole fraction.

See the specifications for your fuel cell stack for the allowable range of cathode inlet gas relative humidity.

In many cases some of the product water is recycled to humidify the incoming cathode gas. The most direct way is by using a gas-to-gas humidifier. Most gas-to-gas humidifiers are similar to a heat exchanger except that instead of a heat transfer surface they have a water vapor transfer surface, often a membrane. The wet cathode exhaust gases are passed through one side of the humidifier and the dry incoming air is passed through the other side. If the humidifier is sized properly, enough water vapor will be transferred from the exhaust gases to the inlet gases to achieve the desired relative humidity.

If the membrane develops a hole some of the incoming cathode gas will short-circuit directly to the exhaust. If a large hole suddenly develops, the stack will not receive enough cathode flow and the voltage will drop quickly.

The strength of the membrane limits the cross-pressure that a gas-to-gas humidifier can withstand. Since the humidifier is crossing the stack inlet and outlet streams, the cross-pressure is essentially the stack cathode pressure drop. It may not be possible to use a membrane gas-to-gas humidifier with a high-pressure-drop fuel cell stack. See the specifications for your fuel cell stack to determine the cathode pressure drop at maximum airflow.

Another type of gas-to-gas humidifier consists of a rotating wheel with passageways through its thickness. The wet exhaust gas is passed through the wheel on one side and the dry gas on the other side. The molecules of water vapor from the wet gas are adsorbed onto the wheel, are carried around, and are released into the dry gas stream. This device is powered by a small electric motor. The rotational speed may need to be controlled as a function of gas flow rate. The device must have internal seals to prevent too much incoming gas from short-circuiting directly to the exhaust. The seals must be robust enough to last for the planned maintenance interval.

Gas-to-gas humidifiers may warm the cathode inlet flow stream. When water vapor is transferred from the cathode exhaust stream to the cathode inlet stream, some heat is usually transferred as well because the cathode exhaust stream is normally warmer than the cathode inlet stream.

The incoming cathode gas can also be humidified using condensed liquid water from the cathode exhaust. If liquid humidification is used, the liquid water in the cathode exhaust stream must be separated from the gas stream and collected into a reservoir. There may be transients during which the amount of water going into and out of the reservoir does not balance, but over the duty cycle there must be, at least as much product water put into the reservoir as is taken out for humidification. If the operating temperature of the fuel cell stack is high and the operating pressure is low, it may be necessary to cool the cathode exhaust gases to collect enough liquid water.[4] The reservoir must be large enough to store enough water to get through those parts of the operating cycle when less product water is available (for instance, start up). A pump is needed to move the water from the reservoir to the humidification system.

Since there are many applications other than fuel cell systems in which a dry gas stream needs to be humidified using liquid water, there are many methods of doing this. Liquid-to-gas membrane humidifiers and water spray have been used successfully in fuel cell systems.

A liquid-to-gas membrane humidifier is similar to a gas-to-gas membrane humidifier except that it can transfer liquid water. The membrane humidifier may act as its own water reservoir, in which case the additional reservoir is not needed. If the device can withstand enough cross pressure and the water can be made to drain into the humidifier (by system layout and gravity) the pump may not be needed. Some membrane humidifiers transfer both liquid and vapor. Such a humidifier would be crossed between the cathode inlet and exhaust streams, in the same manner as a gas-to-gas humidifier.

[4] The amount of liquid water present at the cathode outlet depends on the cathode outlet temperature and pressure and on the amount of gas flow relative to the current setting (stoichiometric ratio). Calculations are given in Section 4.2.2.

A water spray system consists of a nozzle that sprays water into the flow stream. In this way, some of the water is evaporated and the rest is drained from the bottom of the pipe or vessel and returned to the reservoir. If the nozzle clogs the humidification will stop, so with this type of device it is a good idea to filter the water. If the effectiveness of the device depends on the water being atomized, the nozzle must be robust to erosion.

There is less fuel cell system experience with other liquid humidification technologies. The following should be considered when evaluating other technologies:

1. Is the technology able to achieve the level of humidification required by the fuel cell stack?
2. Is the technology compact enough to allow the fuel cell system to meet its packaging requirements?
3. Does the technology require input power?
4. Does the technology have moving parts that may wear out or fail prematurely?

All liquid water humidification systems require that the liquid water be evaporated into the dry stream. Evaporating the water takes energy. The energy must come from the air, the water, or both. If the compressor pressure ratio is greater than about two or three[5] the air will have enough heat energy to evaporate the required amount of water and the mixture will still require cooling to stack temperature. If the compressor pressure ratio is less than about two or three the air will not have enough heat energy to evaporate the required amount of water and supplemental heating will be required.

Spray humidifiers in fuel cell systems usually get supplemental heating and cooling from coolant routed from the stack outlet or outlet (the choice is discussed in the temperature control section below). The flow comes out of the humidifier at close to coolant temperature.

Since liquid-to-gas humidification subsystems generally require more equipment and more space than gas-to-gas humidification subsystems, so gas-to-gas humidification is preferred for small fuel cell systems.

[5] The exact pressure ratio depends on the airflow rate, the required humidity, and the compressor efficiency.

Both gas and liquid humidification systems are usually installed downstream of the compressor or blower to avoid the additional power load of compressing the water vapor.

An infrequently used option for cathode humidification is cathode recirculation. In this design some of the wet cathode exhaust gas is recirculated back to the cathode inlet. Since the cathode inlet is at higher pressure than the cathode exhaust, the pressure of the recirculated stream must be raised using a compressor or blower.[6] The power required for this can be considerable since the cathode flow is typically fairly high. Also, this increases the total flow through the cathode side of the stack, increasing the stack cathode pressure drop. To overcome the higher-pressure drop, the cathode inlet pressure must be higher.

Cathode recirculation is not usually a good option because of the high power input to the compressor(s). However, it should be evaluated in the following cases:

1. The total amount of gas flow, through the cathode, required for water removal is much higher than the amount of oxidant flow required to provide adequate stoichiometry. This could occur if the cathode stream were an enriched oxygen system or a pure oxygen system.
2. The system is operating at very high pressures. The reduction in oxygen concentration in the cathode (the supply flow is diluted with the "depleted" recirculation flow) is offset by an increase in oxygen concentration due to pressurization. In effect, the same number of oxygen molecules is present in the cathode. Also, the higher the operating pressure the lower the cathode pressure drop, therefore, the power required to re-pressurize the recirculation flow is not as high as it would be for low pressure operation.

Recirculation is a good humidification option for the fuel Supply Subsystem and is further discussed in Section 1.2.2.

[6] If the cathode exhaust pressure is higher than the pressure at the inlet of the main compressor, the flow can be recirculated to the inlet of that compressor. While this eliminates one compressor, but the load on the remaining compressor becomes very large.

With any method of humidification, there may be some droplets of condensed water in the cathode inlet flow stream. Liquid water may have entered the stream and not been fully evaporated or water may have condensed due to piping heat loss. A water knockout at the cathode inlet is recommended as a precaution against blowing water droplets into the fuel cell stack. This may be a water separator or may be as simple as a section of expanded piping where the flow slows down, causing any entrained droplets to fall out. The water knockout should drain to the water reservoir or to the system exhaust. The drain line should be sized to minimize the amount of cathode inlet gas flow that is lost.

Before concluding the discussion of cathode humidification, it should be mentioned that the higher the stack operating pressure, the easier it is to achieve high relative humidity. It can be observed on the Psychometric Chart, Figure 1-3 that for a given temperature the saturated mole fraction decreases with increasing pressure. That is, the higher the pressure, the less water vapor needs to be present to achieve 100% RH.

If the stack is to be operated at a higher temperature, the increase in saturated mole fraction due to the increased temperature can be offset by the decrease in saturated mole fraction due to the increased pressure. So if the stack needs to be run hot the operating pressure may need to be increased in order to get the required cathode inlet RH.

d. Remove impurities from the airflow to the cathode side of the fuel cell stack.

PEM fuel cell stacks, like people, would prefer not to breathe dust and polluted air. Hydrocarbons, carbon monoxide, sulfur compounds, and salts can be a problem; see the specification for your fuel cell stack for the air quality limits for your stack.

It is usually advisable to include a dust filter in the inlet air supply. If the system must operate in a polluted environment a chemical filter may be indicated. The filter is usually put at the entrance to the system so the other Air Subsystem components can benefit from it. Filters are available that also act as noise mufflers.

e. Condition the temperature of the air entering the cathode side of the fuel cell stack.

The temperature of the air entering the cathode side of the fuel cell stack may need to be controlled. At higher compressor / blower compressor ratios the air may be too hot; the high temperature may damage the fuel cell stack. At lower compression ratios and/or on cold days the air may be too cold. If the air is too cold it will be difficult to achieve the required inlet RH (evaluated at the stack temperature at the cathode inlet). See the specification for your fuel cell stack for its cathode air temperature limits.

It is easiest to control the RH and puts least stress on the stack if the cathode flow is conditioned to the same temperature as the coolant flow entering the stack (assuming the cathode and coolant are co-flow).

The humidifier / humidification process may provide adequate heating or cooling of the cathode air. If not, an additional heat exchanger can be added. The heat exchanger may be heated and cooled by system coolant. A water spray humidifier with a coolant stream for supplemental heating and cooling is effectively a humidifier with a built-in heat exchanger.

There are several choices of coolant stream for a heat exchanger or for a water spray humidifier.

1. The coolant can pass through the cathode gas heat exchanger just before it enters the cathode inlet. The advantage of this approach is that the cathode inlet temperature will be very close to the coolant inlet temperature. The disadvantage is that the cathode gas will add some heat to the coolant. The actual coolant temperature change will probably be very small, as the heat capacity of the cathode air is small compared to the heat rejected by the stack. The coolant must be supplied slightly cooler from the radiator in order to provide the desired coolant stack inlet temperature. This can be a problem if the radiator is size is limited. Also, the coolant loop pressure drop will be increased.
2. The coolant can be taken from a path parallel to that going through the stack. In this case the cathode inlet temperature can be very close to the coolant inlet temperature; how close depends on how much coolant flow is supplied to the heat exchanger. The disadvantages of

this approach are that additional piping is required, the flow split to the heat exchanger must be set, and that the total amount of coolant flow is increased. Increasing the total amount of coolant flow may increase the required size of the coolant pump and radiator.

3. The coolant can pass through the cathode gas heat exchanger after it exits the stack. In this case the cathode gas will be hotter than the coolant at the stack inlet. This may be acceptable if the cathode inlet humidity is properly controlled. The coolant loop pressure drop will be increased because the coolant flow passes through an additional component in series with the stack.

If the cathode gas always requires cooling, an air-cooled heat exchanger can be used. A fan can be used to drive cooling air across the heat exchanger or air from the Ventilation Subsystem can be used. Some provision must be made to control the amount of cooling and control the cathode gas temperature: if a fan is used, it can be variable speed with temperature feedback.

An air-cooled heat exchanger will likely be larger than a liquid-cooled heat exchanger with the same heat transfer capacity.

The heat exchanger is usually upstream of a gas-to-gas humidifier. It is easier to control the water vapor transfer in the humidifier if the stream temperature is controlled. The temperature at the compressor / blower outlet varies with ambient temperature and power setting (pressure ratio), while the temperature downstream of the heat exchanger is always close to stack temperature. Also, some membrane humidifiers are not able to withstand the high temperatures that come out of a compressor operating at higher-pressure ratio.

f. Remove exhaust gases from the cathode side of the fuel cell stack.

g. Remove exhaust liquid water and water vapor from the cathode side of the fuel cell stack.

h. Contain the cathode inlet and exhaust gas and liquid flow streams.

These functions are all basically provided by the piping system. It is preferable to have a relatively well-sealed piping system on the cathode inlet side to avoid wasting compressed air. The outlet stream does not need to be particularly well sealed, but there must be adequate flow through the membrane humidifier (if used). Also, it is usually not desirable to have product water dripping out of the system at random locations. The cathode product water and cathode exhaust gases should be routed to fixed locations for venting. They may be kept mixed together or separated, depending on the system needs.

i. Separate liquid water out of the cathode exhaust stream.

If a liquid-to-gas or spray humidifier is used for either the cathode or anode stream, the product water needs to be separated out of the cathode exhaust stream and routed to a reservoir. Liquid water may also be required for purposes outside of the system.

If the humidification involves crossing stack inlet and outlet flow streams, the water separation should be downstream of the wet side of the humidifier.

While devices specially designed for water separation are available, it may be adequate to just expand the piping (to slow the flow) and collect the liquid water from the bottom of the pipe.

The amount of water that is present in the exhaust stream in liquid form depends on the stoichiometry (amount of excess cathode flow) and on the stream temperature. (Equations for calculating the amount of liquid water are given in Section 5.2 of this design guide.) If there is not enough liquid water to provide for the system needs, it may be necessary to cool the exhaust. A gas-to-air heat exchanger would be one possibility. Cooling may be able to be provided by the Ventilation Subsystem.

In some applications it is not acceptable to exhaust liquid product water. Usually enough heat is available from the system to evaporate the product water; some design work will be needed to determine the best way to accomplish this.

1.2.2. Fuel Subsystem

The Fuel Subsystem provides the following functions.

a. Store fuel

b. Provide the correct anode flow, velocity and pressure to the anode side of the fuel cell stack.

c. Provide the correct amount of fuel to the anode side of the fuel cell stack.

d. Remove the exhaust water and gases from the anode side of the fuel cell stack.

e. Ensure that the flow entering the anode side of the fuel cell stack has the correct relative humidity.

f. Condition the temperature of the gas stream entering the anode side of the fuel cell stack.

g. Contain the anode inlet and exhaust gas and liquid flow streams.

These functions are discussed in detail below.
This discussion will is limited to hydrogen fuel systems.

a. Store fuel

The fuel is stored in a Hydrogen Storage Subsystem. A number of methods of storing hydrogen fuel have been proposed; these include high-pressure tanks, nanofibers, metal hydrides, and other chemical compounds. A full discussion of the advantages and disadvantages of various hydrogen storage schemes is beyond the scope of this Design Guide; we will look only at the functions that the Hydrogen Storage Subsystem should provide.

1. If the hydrogen is storage involves pressurization, the Hydrogen Storage Subsystem must have some protection against overpressure. Since the hydrogen is provided in gaseous form, protection against over temperature is also wise. Overpressure and/or over temperature valves are often used to provide this protection.
2. The Hydrogen Storage Subsystem must be able to be filled or charged, vented or emptied, and purged.

3. The Hydrogen Storage Subsystem must be able to be isolated. Usually a hand valve and/or a powered shut-off valve are used. Some safety standards require the use of two automatic shut-off valves. For a fail-safe design the shut-off valves are generally powered open; when power is removed the valves automatically shut.

4. It is usually desirable to include some sort of fuel gauging in the Hydrogen Storage Subsystem. For pressurized hydrogen storage systems, hydrogen pressure is usually considered an adequate gage.

Sometimes the temperature is also measured and the fuel quantity is calculated using the Ideal Gas Law. This works if the hydrogen in the tank is allowed to come to steady state. For instance, the amount of hydrogen in the tank could be estimated before and after the fuel cell operation to find the total fuel consumption. However, this approach does not give good results if the temperature measurement is taken while the hydrogen is flowing. Because the hydrogen expands as it leaves the tank, the tank temperature becomes highly non-uniform. The measured temperature is unlikely to be an "average" so the calculated mass of hydrogen remaining in the tank will be incorrect.

Some vendors provide Hydrogen Storage Subsystems as complete assemblies.

b. Provide the correct anode flow, velocity and pressure to the anode side of the fuel cell stack.

c. Provide the correct amount of fuel to the anode side of the fuel cell stack.

d. Remove the exhaust water and gases from the anode side of the fuel cell stack.

Whether the correct amount of anode flow and the correct amount of fuel flow are the same depends on the particular fuel cell.

The amount of fuel that the fuel cell stack uses is directly proportional to the output current (see Section 5.1 of this design guide for the method of calculation). Some fuel cells require that excess fuel be provided to ensure that hydrogen molecules are always present at all reaction sites.

The required amount of excess hydrogen may be expressed in either of two ways:

$$\textbf{fuel stoichiometric ratio} = \frac{\textbf{amount of fuel provided}}{\textbf{amount of fuel used}}$$

$$\textbf{fuel utilization} = \frac{\textbf{amount of fuel used}}{\textbf{amount of fuel provided}}$$

Fuel utilization is the inverse of fuel stoichiometric ratio. Some fuel cells are able to run with their anode "dead-ended". That means that fuel is supplied in to the anode and it is all used; there is no exhaust gas. For a dead-ended stack the fuel stoichiometric ratio is one and the correct amount of flow is the same as the correct amount of fuel.

A flow control valve and flow sensor can be used to meter the correct amount of fuel flow to the anode, but a simpler approach works just as well. If hydrogen is supplied to the stack anode inlet at a controlled pressure, the correct amount of hydrogen will automatically be supplied. Each time a hydrogen molecule is used in the stack anode a new one will flow in to replace it. The pressure of the hydrogen at the anode inlet needs to be controlled to ensure that the gas pressure in the anode is within the pressure rating for the fuel cell stack. A pressure regulator valve can do this. Sometimes the pressure limit is the differential pressure between the anode and cathode;[7] a high cross-pressure can stress the MEA. In this case a differential pressure regulator with pressure sense points at the anode inlet and cathode inlets can be used.

In practice some anode gas must be vented out of the anode. The fuel contains trace amounts of inerts. Inerts (mainly nitrogen) and water also cross over from the cathode side of the fuel cell. The water and inerts must be removed.

[7] Usually it is preferred to have the anode pressure higher than the cathode pressure. Over time the MEA will develop some leaks; it is considered safer to have a small amount of hydrogen leaking into the air than to have a small amount of air leaking into the hydrogen.

The water and inerts can be removed by allowing the anode side of the fuel cell to be slightly leaky to ambient, by continuously venting a small amount of anode exhaust through a restriction, or by periodically cycling an exhaust valve open to purge the stack. Some of the water to be removed may be in liquid form; the restriction or valve should be sized adequately to expel water droplets.

The amount of gas that needs to be purged or vented can be calculated by calculating the inerts and water crossover rates; see Section 4.2.3 of this design guide. Your fuel cell stack specification may also give guidelines for the amount of anode gas to be purged or vented.

Some fuel cells require that there be excess fuel in the anode; that is, an anode stoichiometric ratio greater than one. Some fuel cells require additional flow in the anode for water removal. Usually if a fuel cell requires excess fuel it also requires additional flow for water removal.

A simple solution would be to design the fuel Supply Subsystem like the Air Subsystem. The fuel comes from a pressurized source and a flow control valve and a flow sensor are used to regulate the amount of fuel flow to the anode side of the stack. The unreacted fuel (the amount of fuel in excess of stoichiometric ratio 1) plus any inerts and water that have crossed over from the cathode are vented to atmosphere.

If the fuel cell stack is to be operated at higher than ambient pressure, some restriction is needed in the anode exhaust line to maintain the pressure in the stack. This can be done the same way on the fuel Subsystem as was described for the Air Subsystem: a fixed restriction, a passive device, or an active device.

This flow-through-and vent approach is not used very often because it vents too much hydrogen. This wastes fuel and also can create a flammable mixture at the anode vent.

A better solution is to recirculate anode exhaust gases back to the anode inlet. This increases both the reactant flow and the total flow through the anode side of the fuel cell stack. The unreacted hydrogen at the anode exhaust is routed back to the anode inlet, where it is added to the fresh fuel supply to raise the anode stoichiometric ratio. Since the anode exhaust gases also have water vapor that has crossed over from the cathode side of the stack, anode recirculation also raises the anode inlet humidity.

The amount of anode exhaust gas to be recirculated is the amount that results in the correct total anode supply flow rate. The required total anode supply flow rate is the greater of either the minimum flow rate to ensure anode water removal or the minimum flow rate to provide adequate anode stoichiometric ratio. Too-high anode recirculation flow rates should be avoided. Anode supply flow rates much higher than those given in the fuel cell stack specifications may cause too much moisture to be removed from the anode. Continued operation with a too-dry anode causes poor performance and may cause long-term stack damage.

Since the anode inlet is at higher pressure than the anode exhaust, the pressure of the recirculated stream must be raised back up to inlet pressure. This can be done using either an ejector or a compressor.

If an ejector is chosen, the pressurized fresh fuel supply is usually used for the motive stream. This way the energy to pump up the recirculated flow is free.

However, it may be difficult to size the ejector properly to get the correct amount of recirculation flow at all operating conditions. Sometimes a series of different-sized ejectors is used, each one sized for a different operating range. The ejectors are manifolded together and each is provided with a powered isolation valve. The correct ejector for the current system operating range is selected by opening the appropriate valve.

The other option is a compressor. A variable-speed device is preferred; the speed can be adjusted to give the correct anode recirculation flow for each operating condition. Ideally the designer could use a flow meter in the anode recirculation stream or anode supply stream to provide feedback to control the compressor speed. In practice, it is difficult to measure the amount of anode recirculation flow correctly because it is a mixture of gases – hydrogen, inerts (mostly N_2), and water vapor – and its composition usually changes with operating condition. Using the compressor speed/flow/pressure characteristic, the designer can analytically determine the correct speed to give the correct flow at each operating condition. The system controller can then be programmed with the recirculation compressor speed vs. operating condition characteristic.

Since the compressor speed must be independently controlled, the compressor will most likely be powered by an electric motor. The system power output will be reduced by the amount of power taken by the compressor motor. If space is a concern, the anode recirc compressor/motor combination will probably be bulkier than the ejector. Also, it may be difficult to find a compressor suitable for wet hydrogen.

Not all of the flow can be recirculated; built-up inerts and water must be vented out of the anode, the same as for a dead-ended anode design. The water and inerts can be removed by the same methods described for a dead-ended system: by allowing the anode side of the fuel cell to be slightly leaky to ambient, by continuously venting a small amount of anode exhaust, or by periodically cycling an exhaust valve open to purge the stack.

Anode exhaust water in liquid form should be separated out and removed in the purge. This prevents too much water from building up in the anode loop. Also, droplets of liquid water may interfere with the ejector operation or damage the compressor.

The amount of purge is usually set to control the maximum buildup of water and inerts in the anode loop. The higher the purge rate, the lower the steady-state concentration of inerts. If your fuel cell stack requires excess fuel, its specification should also list the maximum allowable concentration of inerts at the stack anode inlet. The concentration is usually given on a dry basis, that is, moles of inerts divided by moles of dry gas (hydrogen plus inerts).

Section 4.2.3 of this design guide describes how to calculate the amount of anode exhaust flow that must be purged or vented.

With either recirculation option, the amount of fresh fuel supplied is controlled the same way as for the dead-ended stack. A flow control valve with flow measurement feedback may be used but a pressure regulator valve set to maintain the correct anode inlet pressure or a differential pressure regulator is less costly and works just as well.

e. Ensure that the flow entering the anode side of the fuel cell stack has the correct relative humidity.

Your fuel cell stack may require that the gas entering the anode be pre-humidified; check the specification. The humidity specification is usually given in terms of Relative Humidity (RH) of the anode inlet stream The RH should be evaluated at the temperature of the stack at the anode inlet because it is the relative humidity of the gas stream when it passes over the MEA that is important.

The anode flow and coolant flow may be in same direction (co flow) or they may be in opposite directions (counter flow): seeing Section 2.1.3 for a discussion of the difference. The temperature of the stack at the anode inlet can be taken as being the same as at the coolant inlet or outlet, whichever is on the same side of the stack as the anode inlet. The coolant has much more heat capacity than the cathode or anode flow, so the coolant temperature determines the nearby stack temperature. The anode stream will be heated or cooled to the stack temperature very shortly upon entering the stack, probably while still in the stack manifold.

The adjustment of anode relative humidity supply temperature for stack temperature is the same as for the cathode stream. If the anode gas stream is heated upon entering the stack, its RH will drop. If the anode gas stream is cooled upon entering the stack, its RH will increase.

If the anode gas coming into the fuel cell stack is cooler than the stack inlet, the relative humidity may be below specifications when the flow reaches the MEA (even if the anode gas was at 100% RH entering the stack). This condition is to be avoided.

If the anode gas coming into the fuel cell stack is hotter than the stack inlet, droplets of liquid water will form (even if the anode gas was at 100% RH entering the stack). This condition is also to be avoided.

It is undesirable to blow droplets of liquid water into the stack reactant inlet passages of fuel cell stacks. If the droplets are too large they can block the gas channel to the whole cell or to part of the cell (depending of the channel design). A cell or portion of a cell that is getting insufficient oxidant or fuel is referred to as "starved". Starvation will result in low cell voltage and cell damage.

Equations for calculating relative humidity as a function of temperature, pressure, and mole fraction are given in Section 5.2 of this design guide.

There are several options for humidifying the anode supply gas stream.

Anode recirculation was described above as a method of increasing the anode stoichiometric ratio and the amount of gas passing through the anode for water removal. Anode recirculation also humidifies the anode inlet stream.

Some water crosses from the cathode side of the stack into the anode side of the stack and passes out of the stack with the anode exhaust gases. The anode recirculation loop returns part of the anode exhaust water vapor to the anode inlet. Depending on the recirculation rate, this may be enough water vapor to satisfy the anode inlet humidity requirement. If not, supplemental humidification may be required.

The anode inlet stream can also be humidified using a gas-to-gas humidifier or a liquid-to-gas humidifier; these devices are discussed in the description of the Air Subsystem, Section 1.2.1. If a gas-to-gas humidifier is used, cathode exhaust gases should be used for the wet side. If a liquid-to-gas humidifier is used, the water will come from the water reservoir, which is fed from the cathode exhaust water separator.

With any method of humidification, there may be some droplets of condensed water in the anode inlet flow stream. Liquid water may have entered the stream and not been fully evaporated or water may have condensed due to piping heat loss. As for the cathode inlet, a water knockout at the anode inlet is recommended as a precaution against blowing water droplets into the fuel cell stack. This may be a water separator or may be as simple as a section of expanded piping where the flow slows down, causing any entrained droplets to fall out. The drain line should be sized to minimize the amount of anode inlet gas flow that is lost. The drain can be discharged to the system exhaust or it can be routed to a water reservoir. If the drain is routed to a water reservoir that also receives water and gases from the Air Subsystem, the design must include provisions to prevent the build-up of a combustible mixture in the reservoir.

f. Condition the temperature of the gas stream entering the anode side of the fuel cell stack.

The temperature of the anode supply stream entering the fuel cell stack may need to be controlled. The reasons why a too-hot or too-cold inlet stream may be a problem and the architectural options for controlling the stream temperature are basically the same as for the Air Subsystem. See the discussion for the Air Subsystem in the previous section. The specification for your fuel cell stack should give the anode supply temperature limits.

It may be necessary to condition the temperature of the fresh fuel stream if anode recirculation is used. If there is a possibility of the fresh fuel supply becoming very cold, liquid water or snow may form when the cold fresh fuel stream mixes with the wet recirculated stream. Either the fresh fuel supply should be warmed before mixing or the mixing point should be carefully designed to avoid liquid water and ice formation. The fresh fuel supply can be warmed by exchanging heat with the coolant. On small systems, it may be simpler to use a thermostatically controlled electric heater.

g. Contain the anode inlet and exhaust gas and liquid flow streams.

These functions are all basically provided by the piping system. All fuel piping, including the recirculation loop, if present, and the exhaust piping, should be well sealed to prevent any leaks of flammable gas.

For safety reasons, it may be required to design the Fuel Cell Module such that there is not a flammable concentration of gases even if the fuel line completely fails. In this case it may be helpful to put a flow-limiting device on the fresh fuel supply. The flow-limiting device must be sized so that it does not interfere with regulator operation but limits the maximum fuel discharge to a level that can be made safe. The flow-limiting device could be a flow limiting valve or an orifice or venturi.

1.2.3. Thermal Management Subsystem

The Thermal Management Subsystem for a liquid-cooled fuel cell stack provides the following functions.

a. Add and remove heat from the fuel cell stack:

- Provide coolant at the correct inlet temperature to the stack.
- Maintain the correct coolant temperature rise across the stack.
- Maintain a relatively uniform temperature in the stack.

b. Ensure that the coolant does not provide a path for electrical leakage from or within the fuel cell stack.

Depending on the system design, the Thermal Management Subsystem may also be required to

c. Add and remove heat from other subsystems.

a. Add and Remove heat from the fuel cell Stack

- Providing coolant at the correct inlet temperature to the stack.
- Maintaining the correct coolant temperature rise across the stack.

- Maintaining a relatively uniform temperature in the stack.

Refer to the specification for your fuel cell stack to find the minimum and maximum coolant inlet and outlet temperatures. Some specifications may give the temperature at either the fuel cell stack inlet or outlet and the allowable stack coolant temperature rise.

Some fuel cell stacks are able to operate over a range of temperatures, allowing the designer some discretion in choosing the operating temperatures for the particular application. The following should be considered when choosing stack-operating temperatures:

- Higher operating temperatures usually increase the fuel cell voltage at a given operating current density because higher the operating temperature the more active the reactants.
- The higher the operating temperature, the smaller the heat exchanger needed to reject the waste heat from the coolant.
- The higher the operating temperature the more water vapor must be present in the reactant stream to maintain a given relative humidity (see the Psychometric Chart, Figure 1-3). This makes it more difficult to maintain a relative humidity at or near 100%.

The amount of water vapor needed to maintain a given relative humidity can be reduced by increasing the operating pressure, so sometimes increased temperature is offset by increasing the operating pressure. However, increased operating pressure can bring its own set of problems; see the discussion in the Air Subsystem, Section 1.2.1 above.

- Lower stack operating temperatures may result in longer stack life. This is mainly due to better humidification.
- Operation at lower stack temperatures may result in water management problems. Reducing the amount of water vapor required to achieve 100% RH is a mixed blessing; if the RH exceeds 100% (due to water formation in the cathode or water crossover in the anode, for instance), water droplets will form. If too much liquid water is present it can block the cell channels and result in cell starvation.

Blocked channels due to too much liquid water are most likely to occur if there are cold spots in the stack, for instance on the end cells.

- The greater the stack temperature rise, the greater the ratio of water vapor pressures from the inlet and outlet. This may increase the amount of water vapor that can be transferred to the cathode inlet in a gas-to-gas humidifier.

  The required RH of the cathode inlet stream is evaluated at the cathode inlet temperature, which is the same as the coolant inlet temperature. So the cathode inlet water vapor pressure depends on the coolant inlet temperature.

  The cathode outlet stream is at coolant outlet temperature. The higher the temperature, the greater the amount of water that can be held in vapor form at saturation. In most cases, there is plenty of water at the cathode outlet and the exhaust gas is saturated. So the higher the temperature, the more the water present in vapor form.

  If the gas-to-gas humidifier transfers only water vapor, it seems reasonable that the more water vapor on the wet side the more water vapor is transferred.
- The higher the stack outlet temperature, the more water is evaporated in the stack. This reduces the heating load on the coolant system. As mentioned above, the higher the temperature the more water can be evaporated. Heat is absorbed in evaporating the water; all the heat used in evaporation is heat that would otherwise have to be rejected by the coolant system.
- The higher the stack outlet temperature, the less liquid water is available to be separated out and used for other purposes. If the water is needed, it may be necessary to cool the cathode exhaust to condense the water. The condenser can be cooled with ambient air.

To fully evaluate the effects of stack inlet and outlet temperature and choose the best temperatures for the application, the designer is advised to build a system model and perform the necessary trade studies.

The fuel cell stack may need to be heated. If the fuel cell stack is not able to tolerate storage in subfreezing conditions or if the stack needs to start in subfreezing conditions but is not designed for "freeze start", the stack may need to be kept warm. One way to do this is to circulate heated coolant through the stack.

The equipment needed to remove stack heat is fairly straightforward: a pump to move the coolant and a heat exchanger to reject the heat. If the heat is to be rejected to the ambient air the heat exchanger will take the form of a radiator. A radiator fan may be needed to provide flow over the radiator. The fan may also provide ventilation; a discussion of the requirements and design options for the Ventilation Subsystem follows.

For stationary applications, it may be possible to use an external coolant loop as a heat sink. When external coolant is available, the Fuel Cell Module will usually still have its own dedicated coolant loop. The external coolant is usually not suitable for use as stack coolant because most liquid-cooled fuel cell stacks have very specific requirements for coolant conductivity and for compatibility of the coolant with the stack materials. These are further discussed below.
In some applications it is desired to recover the coolant heat for another purpose such as heating water. Production of hot water will not be discussed in depth in this design guide but it is essentially the same as with a solar water heating system. The fuel cell system uses a heat exchanger in place of the solar panels. There are some considerations that are unique to use of a fuel cell.

- If the water is for domestic use, codes and standards may require that precautions be taken to prevent possible leakage of coolant into the potable water supply. Use of a double-walled heat exchanger usually satisfies this requirement. Another option is to ensure the potable water is at higher pressure than the coolant. However, leakage of tap water into the coolant loop is also not desirable because it may result in increased coolant conductivity.
- Unless the fuel cell system is operated primarily to provide hot water and the electricity is a by-product, there may be times when the Fuel Cell Module needs to operate to provide electricity but there is not enough hot water demand to take all the waste heat. Provisions must be made for an alternative heat sink.

The stack coolant inlet temperature is controlled by controlling the amount of cooling in the radiator or heat exchanger. The amount of cooling in the radiator can be controlled by modulating the fan speed or by allowing some of the coolant flow to bypass the radiator. If a liquid-to-liquid heat exchanger is used, stack coolant inlet temperature can be controlled by modulating the amount of external coolant to the heat exchanger or by modulating the amount of Fuel Cell Module coolant that bypasses the heat exchanger.

The stack temperature rise (or stack outlet temperature) is controlled by controlling the amount of coolant flow that passes through the stack. Usually this is done by adjusting the coolant pump speed. Another option would be to have a stack coolant bypass line and control the amount of coolant that bypasses the stack.

The design of the stack coolant loop should include provisions for draining the coolant (prior to maintenance work, for instance) and for degassing the coolant. Degassing may be required on initial fill and also during operation. Some reactant gases may find their way into the coolant loop. Putting the coolant pump as physically low in the system as possible will help reduce cavitation at the pump inlet.

The coolant itself must be compatible with the fuel cell stack. See your fuel cell stack specification for acceptable coolants.

If heat needs to be added to the stack, the coolant is usually heated using an electric heater. Direct heat using a burner would be more efficient but for smaller systems the increase in efficiency by using a heater that is only occasionally used is not worth the additional cost and complexity.

Most PEM fuel cell stacks need to be kept at a relatively uniform temperature when they are operating. Water will condense in cold spots and may block the flow of reactants. This results in low cell voltage and can result in long-term stack damage. The humidity will get too low in hot spots and the stack may be damaged. The fuel cell stack supplier will have designed the stack coolant distribution system to ensure that all parts of all cells receive an adequate flow of coolant; however, the sides and ends of the fuel cell stack may lose additional heat to the surroundings. It is good practice to insulate the fuel cell stack to prevent cold sides and ends, especially if the Fuel Cell Module will operate in cold ambient conditions.

b. Ensure that the coolant does not provide a path for electrical leakage from or within the fuel cell stack.

The fuel cell stacks should be kept electrically isolated for safety and to prevent the stack from corroding (see Section 2.2). One potential current leakage path is through the stack coolant and the coolant piping or equipment to earth or chassis. Current leakage through the coolant from cell to cell within the stack or between stacks that are electrically in series must also be prevented. Current leakage through the stack coolant is prevented by a limit in the maximum conductivity of the coolant. Sometimes the requirement is expressed as a minimum coolant resistivity. Conductivity is the inverse of resistivity.

Your fuel cell stack may have specific requirements for maximum coolant conductivity; see your stack specification. Usually, however, the allowable coolant conductivity depends on the application: the required stack life, applicable codes and standards, and the operating current density. Equations and method for calculating the allowable coolant conductivity are given in Section 5.3 of this design guide.

The requirement for low coolant conductivity limits the choice of coolants. Very pure coolant is typically required; coolants with corrosion inhibitors or other additives are usually not acceptable.

The coolant can pick up ions from the fuel cell system, for instance, carbon or metal ions from the plates and metal ions from the pump. Dissolved gases from the air can ionize in the coolant. To maintain the low coolant conductivity, these ions must be removed. Usually an in-line deionizing filter is provided in the coolant system. It can be in the stack coolant supply line, so all the stack coolant flow goes through it, or it may be sufficient to put the filter on a parallel loop so only a portion of the flow is filtered on each pass through the system.

c. Add and remove heat from other subsystems.

The Thermal Management Subsystem may be required to add or remove heat from other subsystems:

- The air and fuel supply streams to the stack may need to be temperature conditioned; this was discussed in the Air Supply Subsystem and Fuel Supply Subsystem sections of this guide.
- Spray humidifiers may need a source of heat.
- The fresh fuel supply stream may need to be heated if an anode recirculation system is used and the fuel is stored at very cold temperatures. This is to prevent condensation and ice formation when the fresh fuel mixes with wet recirculated anode gases.
- Equipment in the Electrical (Power Conversion) and Power Distribution Subsystems may require cooling.
- Motors may need cooling.

A wide variety of cooling architectures is possible. Equipment may be heated or cooled by heat transfer with the stack coolant loop, upstream of the stack, downstream of the stack, or in a loop parallel to the stack. Heat can be dissipated to ambient air through radiators or even heat pipes. Cool air may be blown directly over the equipment to cool it. Any cooling design that includes blowing ambient air should be integrated with the Ventilation Subsystem.

If desired the designer can fully optimize all the heat transfer paths by performing a heat exchanger network pinch analysis. In practice, for PEM fuel cell systems cost and packaging constraints are likely to have a bigger impact on the heat transfer network design than thermal optimization, especially for smaller systems.

1.2.4. Ventilation Subsystem

Elements of the Ventilation Subsystem may be shared with the Thermal Management Subsystem. While the functions are described separately in this design guide, the two may be implemented as a single subsystem.

The Ventilation Subsystem performs the following functions.

a. Dilute any discharged combustible gases.

Depending on the system design, the Ventilation Subsystem may also be required to

b. Provide air-cooling to Thermal Management Subsystem.

c. Maintain positive pressure of fresh air in electrical compartments.

d. Maintain negative pressure in fuel compartments.

For safety it is desirable to dilute any discharged combustible gases, both normal releases and abnormal releases. Examples of normal releases include small, unavoidable leaks in the Fuel Supply Subsystem or fuel cell stack and the anode exhaust purge. Examples of abnormal releases would be a sudden failure of the Fuel Supply Subsystem piping or valves or a mechanical failure in the fuel cell stack. The amount of design effort that needs to be put into ensuring dilution of any normal or abnormal discharge depends on the product application and on the applicable codes and standards.

Hydrogen's flammability range in air is 4% (Lower Flammability Limit) to 75% (Upper Flammability Limit). That means that if discharged hydrogen is to be made safe by dilution, there must be enough dilution air to bring the hydrogen concentration to below 4%. However, fuel cell codes and standards require a factor of safety on the dilution. The factor of safety depends on the applicable standard. Usually the required factor of safety for dilution of normal releases is higher than the required factor of safety for dilution of abnormal releases. Some standards allow the dilution to be calculated as an overall average within the zone; other standards require that the extent of the dilution boundary be determined.

Fuel cell codes and standards differ in their definition of the Fuel Cell Module boundary within which combustible mixtures must be prevented from occurring. For some applications it is acceptable to vent purge hydrogen outside the module; for other applications the vented gas mixture must also be made non-combustible.

Fans are the most common way of providing ventilation air. This ventilation air may also serve as cooling air for the Thermal Management Subsystem.

The minimum fan flow should be set to provide adequate dilution for both normal and abnormal discharges. The normal and abnormal conditions must be calculated separately; the condition that requires the most dilution flow sets the minimum fan speed. If the minimum fan speed turns out to be higher than desired (for instance, it may provide too much cooling), the maximum abnormal release rate can be limited by installing a flow restriction or other flow limiting device in the inlet of the fuel Supply Subsystem.

A conservative design will include provisions to verify that the ventilation fan is actually flowing the required flow. Some certification agencies may require this. Sometimes a tachometer is installed on the fan motor or a low current switch is installed on the supply to the fan motor. These devices are hard-wired shutdowns such that if the device trips the system is automatically shut down. However, while the tachometer and the current sensor verify that the fan motor is turning, they don't verify that there is flow. The fan inlet may be blocked or the fan blades may have fallen off. A low flow switch gives a more reliable verification of flow.

Hydrogen sensors can also be used to directly verify that there is no buildup of combustible gases. This solution appears simple but the system designer may have some difficulty sourcing a hydrogen sensor that has adequate stability and reliability for a reasonable price.

Some installations are subject to codes and standards that require that if there is a "fuel compartment", it must be kept at negative pressure relative to the rest of the Fuel Cell Module. Usually the module is designed such that the fuel compartment does not have any sparking equipment or other sources of ignition. The intent of the requirement is to ensure that any leaked fuel vapors remain isolated from

ignition sources. With the fuel compartment at negative pressure, air can leak in but fuel vapors cannot leak out. The negative pressure is usually provided by a fan pulling from the fuel compartment to outside ambient. (Pulling ambient gas from the fuel compartment into adjacent compartments where sparking equipment is present would not satisfy the intent of the requirement.)
Some standards permit sparking equipment in the fuel compartment as long as any leaked hydrogen is adequately diluted.

In these installations, compartments with any sparking equipment that are adjacent to the fuel compartment must be kept at positive pressure relative to the fuel compartment. Again, the intent is to keep fuel vapors out of areas with sparking equipment. The positive pressure can be provided by a fan bringing ambient air into the compartment.

Smaller fuel cell systems rarely have a separate, defined fuel compartment. For smaller systems the entire module is usually treated as a fuel compartment. Electrical equipment may be isolated in a separate enclosure that is kept positively pressurized.

Pressure switches are used to verify the required negative and positive pressures. These devices are also frequently installed as hard-wired shutdowns.

1.2.5. Enclosure and Support Subsystem

The Enclosure and Support Subsystem performs the following functions.

a. Support the fuel cell stack and Balance of Plant elements.

b. Facilitate the handling of the Fuel Cell Module.

c. Protects the Fuel Cell Module or elements of the Fuel Cell Module from the environment.

d. Protect the users from the Fuel Cell Module or elements of the Fuel Cell Module.

These functions are discussed in detail below.

a. Support the fuel cell stack and Balance of Plant elements.

b. Facilitate the handling of the Fuel Cell Module.

The fuel cell stack and Balance of Plant elements need to be held in some fixed orientation to each other. Some sort of framing and brackets may be required. The module elements may be able to be supported off of each other if they are strong enough.

Depending on the size of the Fuel Cell Module and the application, handles or lifting brackets may be required.

c. Protect the Fuel Cell Module or elements of the Fuel Cell Module from the environment.

If the Fuel Cell Module is to be used outdoors, the fuel cell stack likely needs some protection from environmental conditions such as freezing rain, salt spray, mud splash, and gunshots. The fuel cell stack may also need protection against an indoor environment. See the specification for your fuel cell stack for specific environmental exposure requirements.

Your fuel cell stack may also have limits on its ability to withstand shock and vibration; see your stack specification. If the fuel cell stack is to be operated in severe environments some sort of shock mounting may be required for the stack or for the entire module.

Your fuel cell stack may also have specific limits on the amount of bending or twisting that may be imposed on it from its support. Bend or twist could be imposed by a support that was initially not straight, or the support could bend or twist due to thermal loads or due to the weight of other equipment that is installed after the stack. Care should be taken in the design of the Enclosure and Support Subsystem to ensure that the stack is not subjected to excessive bending or twisting.

d. Protect users from the Fuel Cell Module or elements of the Fuel Cell Module

Parts of the Fuel Cell Module may have hot surfaces. Rotating machinery may be present. The fuel cell stack and the Electrical and Power Distribution Subsystems may be at high voltage. The Fuel Cell Module user needs to be protected from any parts of the Fuel Cell Module that could be hazardous to touch. Provisions should also be made to ensure that the Fuel Cell Module can be repaired safely.

Applicable codes and standards may have specific requirements for accessibility of panels, latches, and cutout sizes.

Usually it is also required that the fuel cell stack be electrically isolated from the Support Subsystem for safety (see Section 2.2). Stack isolation can be accomplished by any of the methods typically used to isolate electrical equipment: insulation, physical separation, etc.

It is good practice to electrically bond the Support Subsystem to earth or chassis.

Some designs include ground fault detection for the fuel cell stack. This would normally be set up to detect a fault between the stack and chassis or earth. (If the Support Subsystem has been adequately bonded, detecting a fault to the support would be equivalent.) There are a number of possible electrical architectures to detect a ground fault.

1.2.6. Electrical Subsystem

The Electrical Subsystem is also sometimes called the Power Conversion Subsystem. It performs the following functions.

a. If DC output is required, convert DC current at the stack voltage to DC current at the desired output voltage.

b. If AC output is required, convert DC current at the stack voltage to AC current at the desired output voltage and frequency.

Depending on the application, the Electrical Subsystem may also be required to

c. Electrically isolate the fuel cell stack from the customer bus.

If multiple fuel cell stacks are arranged electrically in parallel the Electrical Subsystem has an additional function.

d. Control the current sharing between parallel fuel cell stacks.

These functions are discussed in detail below.

Matching the Electrical Subsystem design with number of cells in the stack, the required output power, and the required output voltage is fundamental to an optimized fuel cell system design. This tradeoff should be the first step in the system design and will be further discussed in Section 2.1.1.

The specific power conversion device selected for the Electrical Subsystem must be compatible with fuel cell stacks. The device must be able to operate with the range input voltages that will be supplied by the stack, up open circuit voltage. Also, the fuel cell stack can have a complex electrical characteristic with capacitive, resistive, and inductive elements as shown in Figure 1-4 below.

The specific electrical characteristic depends on the particular stack design; see the specification for your fuel cell stack.

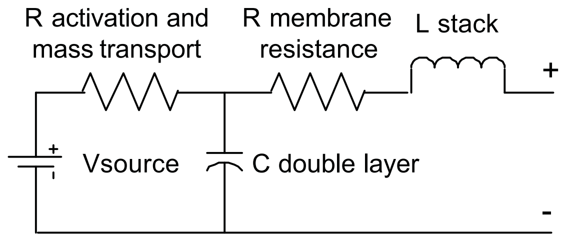


Figure 1-4 Electrical Equivalent of the fuel cell stack

The capacity of the Electrical Subsystem and the Fuel Cell Module must account for overload operating conditions and fault clearing requirements.

a. Convert DC current at the stack voltage to DC current at the desired output voltage.

If the fuel cell stack voltage is higher than the desired output voltage throughout the stack operating range, the voltage will need to be reduced. The usual way to do this is with a DC-DC converter. This device is also known as a switching regulator because it converts the voltage by switching the current on and off. The output power is the same as the input power less efficiency losses, so if the voltage is reduced the current is increased. A DC-DC converter that reduces the voltage is called a "step-down" converter or a "buck" converter.

If the fuel cell stack voltage is lower than the desired output voltage throughout the stack operating range, a DC-DC converter can be used to raise the output voltage. A DC-DC converter that raises the output voltage is called a "step-up" or "boost" converter. A boost converter is also a switching regulator. Since the voltage is being increased the output current will be less than the input current. Usually the efficiency of a boost converter is not quite as high as the efficiency of a buck converter.

Both of these devices convert voltage only one way, up or down. To get the desired output voltage, the stack voltage must always be either higher or lower than the desired output voltage. If the input voltage of a buck converter goes lower than the programmed output voltage the device will either fault and not output any current or will output a voltage that is slightly lower than the input voltage. (There will be some voltage drop due to internal losses.) Similarly, if the input voltage of a boost converter goes higher than its programmed output voltage the device will either fault and not output any current or output a voltage that is slightly lower than the input voltage.

It is also possible to get a "buck-boost" converter; this device can either raise or lower the output voltage. In practice, a buck-boost converter is more complicated and likely to be more expensive than a straight buck or straight boost converter. Its efficiency may also be low.

A linear regulator may also be a good option if the fuel cell stack voltage is always very close to, but higher than, the desired output voltage. A linear regulator works like a pressure regulator valve for electric flow; the current out is the same as the current in but the voltage is reduced. The excess voltage is converted to waste heat. The linear regulator is best used when the stack voltage is very close to the desired output voltage: if the voltage difference is large, a lot of heat is produced and the power conversion efficiency is low.

If the linear regulator input voltage is lower than the desired output voltage, the linear regulator will act like a full-open valve; the current out will be the same as the current in and the output voltage will be the input voltage less about 0.7 V lost in the diodes. A Fuel Cell Module could be designed with a linear regulator occasionally operating in this region if it is acceptable for the output voltage to drop at higher currents.

Both DC-DC converters and linear regulators can be designed to have a fixed output voltage or a variable output voltage set by a controller. A variable output voltage is useful, for instance, if the Fuel Cell Module is used as a battery charger and must follow a particular battery charging algorithm or is used in a hybrid and must load-share with batteries.

b. Convert DC current at the stack voltage to AC current at the desired output voltage and frequency.

An inverter is used when AC output is required. Single-phase inverters are typically used for smaller systems such as domestic generators. Three-phase inverters are typically used for larger systems such as industrial sites or for grid-connected generators.

An inverter, like a DC-DC converter, is a switching device. As for a DC-DC converter it is preferable that the input stack voltage be either always higher than or always lower than the output voltage.

Ideally the inverter output is a pure sine wave. In practice inverters vary in their output waveform depending on how frequent the switching is and how much the output is filtered. The measured difference between a pure sine wave and the actual inverter output is called harmonic distortion. Less expensive inverters typically have more harmonic distortion. Some very inexpensive inverters put out a square wave. While a square wave is adequate for some equipment, other equipment such as electronics, are sensitive to deviations from a pure sine wave. The inverter chosen for the Fuel Cell Module should provide adequate power quality for the intended loads.

If the Fuel Cell Module is operating as a stand-alone generator, the output waveform can be affected by the loads - particularly if they have non-resistive elements. If the inverter is unable to tolerate these deviations it may fault and shut down.

If the Fuel Cell Module output is to be connected to the power grid an inverter specifically designed for grid-connected operation must be used. The inverter must have a way of synchronizing its output with correctly operating grid before connecting. Also, local utilities will require conformance with appropriate standards before permitting connection. The standards vary by region and by utility; the Fuel Cell Module designer must find out and design for the requirements of the target location.

If the Fuel Cell Module will be required to load share with batteries or other power supplies on the customer bus side of the power-conditioning device, a device that is specifically designed for load sharing should be selected. (Load sharing would be needed, for instance, if batteries were used to cushion transients. See Section 1.2.7.)

Any type of switching power conditioning can send ripple currents back to the power source. Ballard fuel cell stacks can tolerate some ripple current with the following limitations:

- A ripple current of up to $\pm$ 10% of the average current is usually acceptable.
- The ripple current must not reverse polarity; that is, it must not force current back into the fuel cell stack.

The fuel cell stack should be sized for the steady-state (average) current, not the peak of the ripple current. The stack reactant flows must be adequate for the amount of current that will be pulled during the peak of the ripple; otherwise the cells can be starved at each peak. This is not usually a problem if the stoichiometric ratios are not set to the absolute minimum. Also, most fuel cell stacks have some capacitance, so if the frequency of the ripple is high enough relative to the stack capacitance, there will probably not be any ripple in the rate of reactant consumption. See the specification for your fuel cell stack for the allowable ripple current.

Switching power conditioning may also generate conducted and radiated EMI. While the fuel cell stack is not affected by EMI, other equipment in the Fuel Cell Module may be. Radiated EMI may affect equipment in the area of the Fuel Cell Module and conducted EMI may affect equipment being powered by the Fuel Cell Module. Most applications will be subject to standards that limit the amount of conducted and radiated EMI the Fuel Cell Module can generate. The power-conditioning device should be selected with these limits in mind. EMI from the Electrical Subsystem load cables should be minimized by using shielded wires. The positive and negative wires should follow the same routing, preferably not near instrumentation wiring.

The Electrical Subsystem may also be susceptible to EMI from outside sources. The power-conditioning device should be able to handle the amount of EMI that is expected in the application. Additional filtering may be required on the load cables.

Cooling for the power-conditioning device is provided by the Thermal Management Subsystem, discussed in Section 1.2.3 above. Air-cooled power conditioning can be easier to integrate and is most often used for smaller systems where the amount of heat that needs to be removed is small. Liquid cooling requires more integration but liquid-cooled power conditioning devices are often more compact as more heat can be rejected with a smaller cooling surface area.

c. Electrically isolate the fuel cell stack from the customer bus.

Fuel cell stacks should not be subjected to a voltage applied from an external source. When the fuel cell is not operating the power conversion device should open at least one of the buses (positive or both positive and negative) to prevent voltage from being applied to the stack from the customer bus.

It may be prudent to provide additional contactors on the power output buses. Contactors may be required on both positive and negative buses, or a single contactor on the positive bus may be adequate, it depends on whether the electrical system is floating and on how high the voltages are. The contactor or contactors would be opened manually or electrically to disconnect the Fuel Cell Module from the customer bus if an unsafe condition is detected (as part of a safety shutdown) or prior to maintenance work. The contactors are usually put on the outputs of the Fuel Cell Module.

The power conversion device also electrically isolates fuel cell stack from the customer bus when the fuel cell stack is operating and the system is exporting power. A basic DC-DC converter or linear regulator isolates the input and output on only one polarity, usually the positive bus. The input and output share a common negative bus. In some applications it may be desirable to isolate both the positive and negative buses. This might be required for safety reasons, for instance if the voltages are very high. If there is some doubt about how well the customer bus is isolated from earth, use of a fully isolated converter will ensure that the fuel cell stack cannot leak current to earth through the negative bus. (Stack isolation requirements are discussed in Section 2.2.) A fully isolated converter will also protect the fuel cell stack from any electrical noise on the customer bus. This may improve stack life and makes it easier to monitor the stack health. However, a fully isolated converter is likely to be more costly than a converter with a common negative bus.

Inverters are usually isolated on both the positive and the negative buses. A grid-connected inverter may be required to have galvanic isolation, which is usually accomplished using transformers.

d. Controlling the current sharing between parallel fuel cell stacks

Sometimes multiple identical fuel cell stacks are installed electrically in parallel. This arrangement provides increased current without increasing the voltage (see Section 2.1.2).

Ideally all the fuel cell stacks that are operating should provide the same output current[8] and should receive the same amount of air and fuel. This ensures that each stack receives the correct amount of reactants for its current output. Since stacks in parallel must all be at the same voltage, their polarization curves will force them to operate at more or less the same current. If one stack were to produce less current its voltage would increase. If its voltage were higher than that of the other stacks, it would supply more current. However, if one of the fuel cell stacks has a performance loss its polarization curve will be lower; it will produce less current at the same overall voltage. The other stacks will provide more than their share of current and will be operating at lower-than-desired stoichiometric ratios. It may be advisable to monitor stack currents to detect and alarm this condition.

If one of the stacks develops a dead short (positive to negative or two shorts to chassis) it will short circuit the other stacks. Their output current will suddenly increase to a level far in excess of the level that can be supported by the reactant flows. This situation usually doesn't last very long because the stacks that are supplying current will fail almost immediately. This situation can be avoided by putting diodes between the stack power buses.

[8] Designs have been proposed in which fuel cell stacks arranged electrically in parallel can be turned on and off to increase and decrease the output current. This requires that provisions be made to isolate the stacks that are turned off: open their power circuits and turn off their reactant flows.

1.2.7. Power Distribution Subsystem

The primary function of the Power Distribution Subsystem is to

a. Provide current at the correct voltage to Balance of Plant (BOP) components.

Depending on the Fuel Cell Module requirements, the Power Distribution Subsystem may need to provide some or all of the following functions.

b. Store and provide power for Fuel Cell Module start up.

c. Store and provide power to reduce the severity of load transients.

d. Remove voltage from the fuel cell stack on shut down.

e. Provide a pulsing load current to the fuel cell stack.

f. Provide safety interlocks if an unsafe condition is detected.

These functions are discussed in detail below.

a. Provide current at the correct voltage to Balance of Plant (BOP) components.

Balance of Plant components such as motors, valves, instrumentation, and controller require electric power. This power can be supplied from the stack output bus on the fuel cell stack side of the Electrical Subsystem or from the Fuel Cell Module output bus on the customer side of the Electrical Subsystem.

Supplying the electrically powered BOP components directly from the stack output bus has several advantages.

+ The amount of current that must be converted by the Electrical Subsystem is reduced. This allows use of a smaller and less expensive power conversion device.
+ Since the BOP electrical loads are not burdened with the efficiency losses of power conversion, this design gives a higher overall system efficiency.

+ The Fuel Cell Module design can be modified to provide different output voltages simply by changing the power conversion device. No changes are required to the rest of the BOP. This makes it easier to provide output voltage options on the Fuel Cell Module.

However, there are several disadvantages to this design:

– There is no power to start the system up. The BOP components need power to be able to provide reactants to the stack; the stack cannot provide any power until it has reactants. This problem is not insurmountable; startup options are discussed in the next section.

– The BOP components must be able to be powered from the range of voltages that will be provided by the stack, from open circuit voltage to the minimum stack voltage at maximum current.

– This architecture can make it more difficult to produce a "family" of Fuel Cell Modules with different output capacities based on a single fuel cell stack design with different numbers of cells. Each stack size will have a different output voltage and the BOP components will need to be re-specified for the new voltage.

Supplying the electrically powered BOP components from the customer bus side of the Electrical Subsystem reverses the advantages and disadvantages discussed above.

+ If there is power on the customer bus it is available to start up the Module.

+ It may be easier to source the electrically powered BOP components as their supply voltage is better regulated.

+ The number of cells in the stack does not directly affect the choice of electrically powered BOP components[9] so it is easier to produce a family of Modules.

– The Electrical Subsystem must convert all the current for the BOP loads. This increases the required capacity of the power conversion device.

– The net BOP loads will be higher because of power lost to the inefficiency of the power conversion device.

[9] Some of the BOP components will need to change to accommodate different reactant flow rates for the different-sized Fuel Cell Modules.

– The BOP electrical components will need to be re-specified if the design is modified to change the output bus voltage.

If the Power Distribution Subsystem is supplied from the customer side of the bus, it is usually on the Fuel Cell Module side of the contactors discussed in Section 1.2.6. This allows the Power Distribution Subsystem to be isolated from the customer bus.

In some applications it makes sense to split the BOP power sources between the two sides of the Electrical Subsystem.

Ideally all the electrically powered BOP components would operate at the supply voltage. In practice more than one voltage is likely to be needed. Large motors are best provided with the highest voltage that is available while instrumentation usually takes lower voltages. Each voltage that is required, other than the source voltage, will require a separate power supply and a separate bus. To minimize cost and complexity, effort should be made to minimize the number of different BOP supply voltages.

If commonality for a family of Fuel Cell Modules is required, a separate, regulated BOP bus can be established. This bus would have its own power conversion supplied from the stack side of the Electrical Subsystem. This bus is at the highest BOP voltage. Power supplies for other BOP buses at lower voltages are stepped down from this main BOP bus. If the Fuel Cell Module needs to be adapted for either a different power output or different voltage output only the main BOP bus converter needs to be changed. This approach is slightly less efficient as some of the power is converted twice. However, if the lower-voltage BOP electric loads are typically not very high, the actual number of watts lost by converting their power twice will be small.

b. Store and provide power for Fuel Cell Module start up.

c. Store and provide power to reduce the severity of load transients.

The fuel cell stack needs reactants before it can start providing current. The electrically powered BOP components need power to provide reactants to the stack. The start-up power, then, must come from another source.

In some applications the start-up power can come from the customer bus side of the Electrical Subsystem, either from other generators or batteries or capacitors on the customer bus or from batteries or capacitors on the customer bus side of the Fuel Cell Module. If batteries or capacitors in the Fuel Cell Module are used, they are recharged when the module is running. A battery charging circuit should be used to regulate the voltage and current supplied to the batteries.

If the Power Distribution Subsystem takes its power from the customer bus side of the Electrical Subsystem there is no startup problem; current from the customer bus, batteries, or can flow to the Power Distribution Subsystem for startup.

If the Power Distribution Subsystem takes its power from the fuel cell stack side of the Electrical Subsystem, there must be a way for the start-up power to go backwards across the power conversion device to the Power Distribution Subsystem.

A bi-directional power conversion device can be used but this added capability can be expected to increase the device's size and cost. Another option is to have two buses supplying the Power Distribution Subsystem, one from the stack side and one from the customer bus side. The Power Distribution Subsystem must take power from only one of these sources at a time, from the customer bus during startup and from the stack during system operation. The bus not being used should be isolated. During module operation, stack current must not be permitted to bypass the power conversion device and go directly to the customer bus. During standby and startup, start-up power must not go to the fuel cell stack; applying voltage or reverse current to a fuel cell stack can damage it.

A three-way switch or diodes can be used to select the desired current source and isolate the other source. If diodes are used, they must not allow current to leak backward and build up a charge on the non-operating stack.

Power for start-up can also be supplied from batteries or capacitors on the fuel Cell side of the Electrical Subsystem. The batteries or capacitors are recharged when the system is running and the stack voltage is higher than the battery or capacitor voltage. A battery charging circuit should be provided to regulate the voltage and current supplied to the batteries. Provisions should be made to isolate the fuel cell stack from the start-up power when it is not operating.

If the Power Distribution Subsystem takes its power from the fuel cell stack side of the Electrical Subsystem, start-up power can be provided directly to the Power Distribution Subsystem.

If the Power Distribution Subsystem takes its power from the customer bus side of the Electrical Subsystem, the first step of the startup will be to enable the Electrical Subsystem so it can convert the startup power at stack bus voltage to customer bus voltage.

If the Fuel Cell Module will be required to load follow, it may be desirable to store enough energy in the module to cushion extreme transients. This allows the reactant supply and fuel cell stack to respond more slowly to increases and decreases in load. When the load increases, power is taken from the batteries or capacitors until the reactant supply "catches up" to the new output setting. When the load decreases, excess power is dumped to the batteries or capacitors until the reactant supply has reduced to match the new load. The more energy that can be stored and released the slower the reactant supplies and fuel cell stack needs to respond. In the extreme case, there is enough stored energy to follow all transients and the stack power output is constant. Transients are further discussed in Section 3.3.

The stored energy can be on either the customer bus side or the fuel cell stack side of the Electrical Subsystem. If the stored energy is on the fuel cell stack side the Fuel Cell Module is essentially a hybrid.

It is convenient to combine the stored energy for start up with the stored energy for transients.

The amount of energy that needs to be stored depends on how many start attempts the Fuel Cell Module needs to be able to do before the energy storage is recharged. The designer should consider whether the Fuel Cell Module might be shut off before the batteries or capacitor have had a chance to fully charge. If energy storage will also be used to cushion transients the designer must consider the magnitude of the maximum transient and the amount of time between the increase in load and the increase in the fuel cell stack current output.

d. Remove voltage from the fuel cell stack on shut down.

It may be desirable to remove voltage from the fuel cell stack upon shut down. This is further discussed in Section 3.2, System Shutdowns.

The fuel cell stack voltage can be bled off by engaging a resistor (usually called a "bleed resistor") upon shutdown. The bleed resistor is installed across the stack output buses in parallel with the stack. For Ballard fuel cell stacks, the bleed resistor should normally be sized to draw about 1% to 2% of the maximum stack current. The bleed current can be up to 5% of the maximum stack current if an anode recirculation system is in use during the bleed down.

The amount of heat generated by the bleed resistor is directly proportional to the amount of energy to be bled off the stack. In larger systems there may need to be special provisions to reject the heat.

e. Provide a pulsing load current to the fuel cell stack.

For some applications and operating conditions it can be useful to draw very brief pulses of high current from the fuel cell stack. The applications of current pulsing are discussed in Section 3.5.

A current pulsing circuit consists of a circuit that shorts the stack. A switch on the circuit opens and closes rapidly to pulse the short-circuit open and closed. Current pulsing circuits usually use a solid-state switch. The current pulsing is controlled by the System Controller.

f. Provide safety interlocks if an unsafe condition is detected.

The Fuel Cell Module needs to be shut down if an unsafe condition is detected[10]. In this context, "unsafe condition" means a condition in which something or someone other

[10] In most applications the Fuel Cell Module should also be shut down if the Fuel Cell Module will be damaged by continued operation. See Section 1.2.8 for a discussion of software shutdowns.

than the Fuel Cell Module could be damaged if the condition is allowed to persist. The system designer will need to perform a safety analysis to determine what unsafe conditions may occur in the particular design under consideration, but typical safety shutdowns include:

- fuel leak / presence of flammable mixture
- fire or explosion
- short-circuit in high voltage circuit
- ground fault in high voltage circuit

Safety shutdowns are usually implemented as hardware interlocks rather than as Fuel Cell Module Controller alarms. Many of the certification agencies consider hardware interlocks to be more reliable and mistake-proof than software alarms, so implementing safety shutdowns as hardware interlocks may make certification easier.

The electrically powered BOP components should be designed such that if power is removed the component defaults to a safe condition. Fuel valves, for instance, should close if power is removed. In some designs, vent valves open if power is removed. Electrical contactors open if power is removed. The designer will need to review the Fuel Cell System design to determine the fail-safe state of each electrical component.

Safety-related instrumentation should be designed such that if the signal is lost, the alarm is triggered. If the safety shutdown is to be implemented entirely in hardware, a switch should be used to trigger it rather than an analog instrument[11].

Upon low signal or loss of signal from the safety switch, the hardware interlock circuit removes power from the safety-related BOP components.

It can be useful to have the safety-related instrumentation or the interlock circuit send a parallel signal to be logged on the System Controller. This makes it easier to troubleshoot the shutdown.

[11] If an analog instrument is used its output must be monitored by the System Controller to determine whether the value is out of the safe range. If the System Controller initiates the shutdown it becomes a software shutdown, not a hardware shutdown.

1.2.8. Control / Human-Machine Interface (HMI) Subsystem

The Control / HMI Subsystem performs the following functions.

a. Provide control signals to Fuel Cell Module equipment.

b. Monitor the system performance and generate alarms if required.

c. Accept input signals from the operator.

d. Provide status signals to the operator.

Depending on the application, the Control / HMI Subsystem may also be required to

e. Log operational data for later retrieval.

a. Provide control signals to Fuel Cell Module equipment.

One of the primary functions of the Control / HMI Subsystem is to control the operation of the BOP equipment. The specific parameters to be controlled will depend on the system architecture but the following are typical.

Air Subsystem

- Control supply air flow rate by modulating air compressor speed, air flow control valve position, or motor boost to a turbo compressor.
- Control humidification by modulating rotating humidifier speed or spray humidifier heating.

Fuel Subsystem

- Control availability of fuel by powering or de-powering fuel shutoff valves.
- Control the rate of fresh fuel supply by modulating fuel flow control valve position.
- Control the flow through the anode side of the fuel cell stack by modulating the anode recirculation compressor speed.

- Control the humidity of the anode inlet by modulating the anode recirculation compressor speed.
- Control the amount of inerts in the anode loop by modulating or toggling the anode exhaust purge valve.

Thermal Management Subsystem

- Control the fuel cell stack inlet temperature by controlling the amount of cooling in the radiator or heat sink heat exchanger. Control the amount of cooling in the radiator or heat sink heat exchanger by modulating the coolant bypass valve or modulating the radiator fan speed.
- Control the fuel cell stack temperature rise by modulating the coolant pump speed.
- Control the amount of cooling to other BOP elements by modulating cooling fan speeds or by toggling fans on and off.
- Control the amount of heat that is supplied to the fuel cell stack by modulating the coolant heater or turning the heater on and off.

Ventilation Subsystem

- Control the amount of ventilation by modulating ventilation fan speeds or by toggling fans on and off.

Electrical Subsystem

- Control the amount of power exported from the Fuel Cell Module by enabling and disabling the power conversion device and by modulating the power conversion device voltage or current set points.
- Control the Fuel Cell Module isolation from the customer bus by opening and closing contactors.

Power Distribution Subsystem

- Control the source of power to the BOP electrical loads by opening and closing contactors or moving a three-way switch.
- Control the fuel cell stack isolation from the rest of the Fuel Cell Module by opening and closing contactors.

- Control the charging of start batteries by modulating the voltage and current supplied to them.
- Control the bleed-down of the fuel cell stack at shutdown by opening and closing the contactor to the bleed resistor.
- Control stack current pulsing by enabling and disabling the current pulsing circuit.

The Control / HMI Subsystem must control the BOP equipment for startup, steady-state operation, and shutdown. It may also need to be able to control the BOP equipment for load-following operation. Because the equipment must be operated differently in different phases of operation, state logic can be useful for controlling more complex systems.

b. Monitor the system performance and generating alarms if required.

The Control / HMI Subsystem should monitor the performance of the fuel cell stack and BOP equipment and should detect whether any abnormal conditions exist. If the controller detects a condition which, if allowed to persist, could result in damage to the Fuel Cell Module, the Control / HMI Subsystem should normally generate a shutdown alarm and begin a system shut down sequence. An exception to this would be if the Fuel Cell Module is powering a load that is so critical that it is preferable to damage the Fuel Cell Module rather than drop the load; for instance, if the Fuel Cell Module were powering a baby incubator.

If a condition is detected which, if allowed to persist, could result in damage to someone or something other than the Fuel Cell Module, it is normally preferred to shut down the system using a hardware interlock rather than a shutdown alarm. See Section 1.2.6. The instrumentation that generates the fault or the circuit that generates the hardware interlock may also send a fault signal to the controller. The controller may just log the signal or it may generate a shutdown alarm. (The shutdown sequence would not be completed because the interlock would shut the system down immediately.)

It may be desirable for the controller to generate a warning alarm prior to shutting the system down. A warning alarm may be useful if the Fuel Cell Module will be attended while operating and if there is anything the operator can do to ameliorate the condition (reducing the load, for example). The warning alarm can precede the shutdown alarm either in terms of:

- **Time** – The detected condition generates a warning alarm. If the condition is not corrected within a certain period of time a shutdown alarm is generated.
- **Condition** – The warning alarm is generated when a parameter reaches a certain value. A shutdown alarm is generated when the parameter exceeds the warning level by a set amount.

There should be some dead band between the parameter value that generates the warning alarm and the value that resets the alarm to prevent the alarm from cycling on and off.

c. Accept input signals from the operator.

d. Provide status signals to the operator.

The amount of interaction between the Fuel Cell Module and the operator depends on the application. In an engineering development unit the operator should be able to override the controller and control almost all parameters. Large stationary generators typically provide the operator with considerable data on system operating conditions and with ability to change parameters. Systems for consumer use typically provide the operator with very little information: on-off status, fuel remaining, alarm condition and any fault code, and perhaps power setting.

The operator interface depends on who is expected to operate the system. How much training will the operator have? Will the operator have the knowledge to be able to safely change system parameters? If the operator is presented with a warning alarm message, will there be anything he or she can do to correct the condition? Does the Fuel Cell Module start automatically in response to some external stimulus or is it started manually?

e. Log operational data for later retrieval

Depending on the Fuel Cell Module application, it may be useful for the Control / HMI Subsystem to log data for later review. The data may be used for performance monitoring or to assist in troubleshooting any failures.

Typically all input parameters, warning alarms, and shutdown alarms are logged. Often controller output commands and some internally used controller parameters are also logged.

2.0 OTHER SYSTEM DESIGN CONSIDERATIONS

2.1. Fuel Cell Stack Choices

2.1.1. Stack Sizing

Choosing the appropriate fuel cell stack size is critical to optimizing the design of the Fuel Cell Module. The fuel cell stack size should be selected to optimize the cost and efficiency of the overall system.

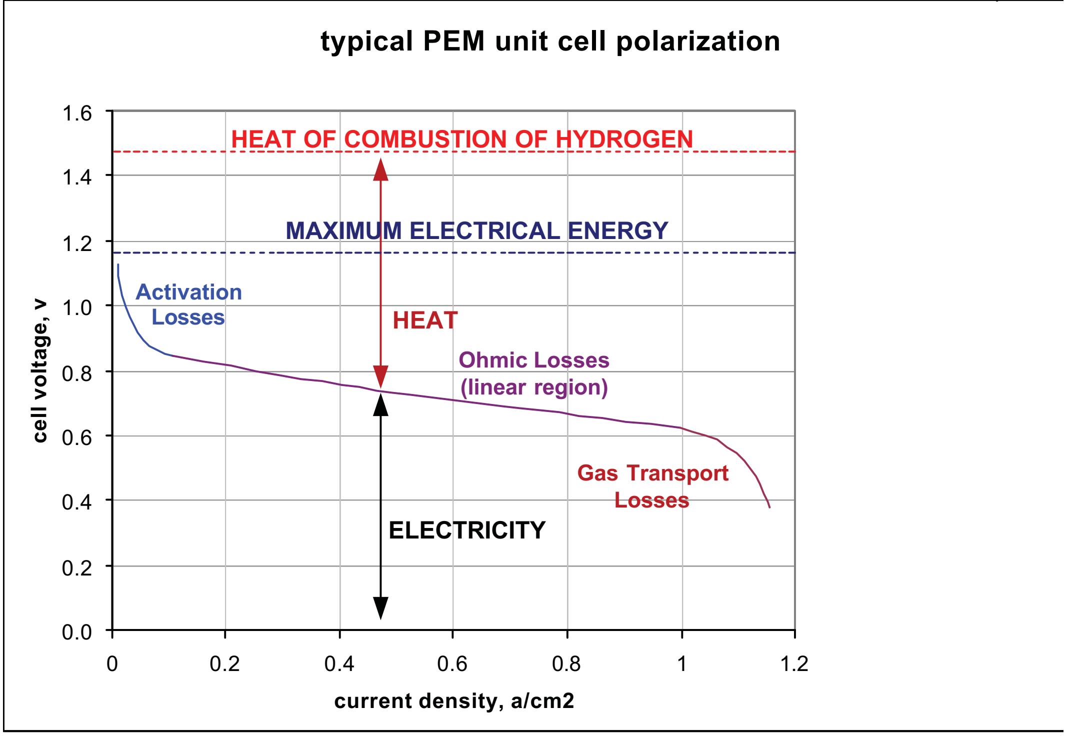


Figure 2-1 Typical polarization and power curves.

In order to use the least costly stack, it is common for a system designer to choose a fuel cell stack with the fewest possible cells that can provide the required power. This requires that the stack be operating at its highest possible power output. Also, fuel cell stack specification sheets typically give the stack power rating at the stack's maximum power point. As shown in Figure 2-1 above, the maximum power point occurs at a relatively high current.

However, the rate of reactant use is proportional to current. The shorter stack may actually use more fuel to produce the same output power than a taller stack operating at lower current density. In choosing the optimum stack size, the efficiency of the Fuel Cell Module needs to be traded off against the initial cost of the fuel cell stack.

When the whole Fuel Cell Module is considered, the use of a shorter fuel cell stack does not necessarily result in the lowest cost or smallest package. A fuel cell stack running at higher current will require higher-capacity BOP subsystems for air, fuel, and coolant. A higher-flow, higher-pressure rise air compressor will be needed to provide the additional air flow. If an anode recirculation compressor is used, it will also have to provide more flow at higher pressure rise. Humidification equipment will need to be able to handle higher flows. Since a greater proportion of the energy in the fuel is converted to heat in the stack, the Coolant Subsystem will need to be able to reject more heat. Since the system runs less efficiently, a larger fuel Storage Subsystem will be required to store enough fuel to provide the same run time. All of these larger components can be expected to cost more and need more volume.

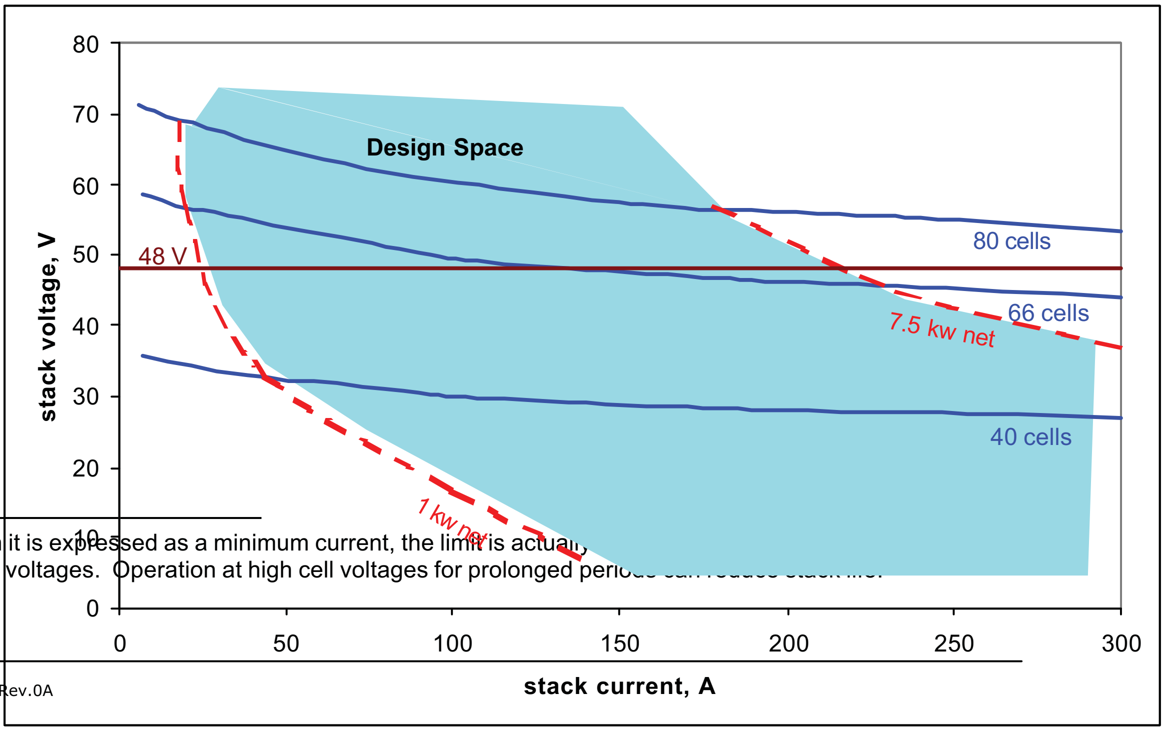
The effect of the number of cells in the fuel cell stack on the Electrical Subsystem cost is more complex. The number of cells should be matched with the desired power output range and with the desired output voltage.

As an example, Figure 2-2 shows polarization curves for stacks with 300-cm2 active area and 40 cells, 66 cells, and 80 cells. The system is required to provide 1 to 7.5 kW net at 48 VDC. If the 66-cell stack is chosen, the Electrical Subsystem will be required to decrease (buck) the voltage at lower currents and increase (boost) the voltage at higher currents. This is not ideal, as a buck-boost DC-DC converter is likely to cost more and have a lower efficiency than a buck-only or boost-only converter. A boost-only converter could be used with the 40-cell stack, but the 40 cells are not able to provide enough power to reach 7.5 kW net output. The 80-cell stack has adequate power and allows use of a buck-only converter.

At the 7.5 kW net power point, the 66-cell stack uses 0.161 g/s of hydrogen to provide 233 A. The 80-cell stack uses 0.149 g/s of hydrogen to provide 178 A for 7.5 kW net power. Over 2000 hours of operation, the difference amounts to 86 kg of hydrogen.

However, the 80-cell stack needs to operate at relatively low current for the 1-kW net case. Some PEM fuel cell stacks have a minimum recommended operating current[12]. If the 1-kW net case requires a current below the minimum recommended, the 80-cell stack would not be an ideal choice either.

Check the specification for your fuel cell stack to see if there is a minimum recommended operating current.



[12] Although it is expressed as a minimum current, the limit is actually … at high cell voltages. Operation at high cell voltages for prolonged periods can reduce stack life.

Figure 2-2 Sizing a fuel cell stack for 1 to 7.5 kW net at 48 VDC

2.1.2. Multiple Fuel Cell Stacks

Sometimes the fuel cell stack that is available does not provide enough current or does not provide enough voltage. It is possible to arrange multiple fuel cell stacks electrically in parallel or electrically in series. If the stacks are in parallel the currents are summed to get the overall current and the voltage is the same for each stack. If the stacks are in series the voltages are summed to get the overall voltage and the current is the same for each stack.

When stacks are arranged electrically in series, their electrical isolation requirements increase because the maximum voltage is increased relative to earth or chassis. Check your fuel cell stack specification to determine the maximum design voltage for the stack internal electrical isolation.

For either electrical arrangement, the reactant flows to the stacks are normally arranged in parallel to ensure equal flow distribution to all cells in all stacks. Some fuel cell stacks may be designed to operate cascaded; the exhaust flows of one fuel cell stack are routed to the inlet of the next fuel cell stack. Check your fuel cell stack specification to determine whether your fuel cell stack is designed for cascaded operation.

Coolant flows are also normally arranged in parallel to ensure that all the stacks are operating at the same temperature. If the fuel cell stacks are electrically in series, the stack coolant inlets will be at different voltages. The possibility of current leakage from stack to stack must be considered when determining the maximum allowable coolant conductivity. This is further discussed in Section 5.3.

If the fuel cell stacks are arranged electrically in parallel, provision needs to be made to ensure that a short in one stack does not damage other stacks.

Some fuel cell stacks may actually be composed of multiple cell rows arranged electrically in series or electrically in parallel. In this case the manufacturer should have designed for the actual maximum voltage or included provisions to minimize damage if one cell row becomes shorted. It is recommended that the designer verify this, however.

2.1.3. Flow Direction – Co flow vs. Counter flow

A **co flow** fuel cell stack is one in which both reactant streams and the coolant stream flow in the same direction across the cell. A **counter flow** fuel cell stack is one in which the cathode stream and the coolant stream flow in one direction across the cell and the anode stream flows the opposite direction across the cell[13].

Most PEM fuel cell stacks are specifically designed to operate in only one of these two configurations. Some fuel cell stacks, though, can operate either way. See the specification for your fuel cell stack to determine the flow direction for your stack.

If your fuel cell stack can operate in either direction, the choice depends on how good the BOP is at managing the humidity's of the reactant streams.

[13] In PEM fuel cell stacks, cathode flow and coolant flow usually go in the same direction across the cell for water management reasons. The coolant will have some temperature rise from one side of the cell to the other. When the cathode gas flows the same direction as the coolant, the cathode inlet is cooler and the cathode exhaust is warmer. As the cathode gas flows across the cell some of the water created in the fuel Cell reaction is evaporated. This makes it easier to remove the product water, as it is easier to water in vapor form than in liquid form. The evaporation also takes heat from the cooling system, reducing the cooling load.

If the cathode gas were to flow counter to the coolant, the cathode inlet would be hotter and the cathode exhaust would be cooler. That means a higher water content would be required at the cathode inlet to get the desired inlet RH. As the cathode gas flowed across the cell it would cool off. The liquid water content would increase from both condensation and from the fuel Cell reaction. It would be more difficult to remove all the liquid water from the cathode channels.

Counter flow may be preferred if the humidification of the cathode inlet stream is marginal as this design tends to recycle humidity in the cathode. If the anode flow is counter to the coolant, the inlet side of the anode stream will be hotter than the exhaust side. Water will cross from the wet cathode outlet end of the cell to the dry anode inlet end of the cell. The anode gas will cool as it crosses the cell and water from the anode outlet end of the cell will cross back to the cathode inlet end of the cell.
The downside of the counter flow arrangement is that there can be build-up of liquid water at the anode exit. This can block anode flow channels and cause starvation. A higher purge rate will be required to eliminate the liquid water. In addition, this arrangement can result in high differential pressures between the anode side of the cell and the cathode side of the cell; one side of the MEA sees the maximum (inlet) pressure of one reactant stream and the other side of the MEA sees the minimum (outlet) pressure of the other reactant stream.

Co flow is preferred if the cathode humidification is adequate. The co flow arrangement results in better humidification of the anode inlet end (because it’s cooler) and less condensed water at the anode outlet. This reduces the need for purge to remove liquid water. The co flow arrangement minimizes the differential pressure between the anode side of the cell and the cathode side of the cell.

2.2. Fuel Cell Stack Isolation

In most applications the fuel cell stack, like other electrical equipment, needs to be electrically isolated for safety. The amount of isolation that is required depends on the particular application and will be listed in the design standard for the application. The required isolation is usually given as a function of maximum voltage. Also, it is recommended that Ballard fuel cell stacks be electrically isolated to prevent stack corrosion.

Typical current leakage paths from the fuel cell stack include the following:

- Leaks from the surface of the stack due to lack of electrical isolation (electrical insulation and/or spacing). These leaks can be prevented by any of the methods typically used to isolate electrical equipment: insulation, physical separation, etc. See Section 1.2.5.

- Leaks through the stack coolant system. Current leakage through the stack coolant is prevented by limiting the maximum conductivity of the coolant. See Section 1.2.3. The method of calculating the maximum allowable coolant conductivity is given in Section 5.3.
- Leaks via the customer bus if the customer bus is not adequately isolated. Current leakage through the customer bus can be prevented by isolating the fuel cell stack from the customer bus. Refer to Section 5.3. Another option is to work with the customer to ensure that the customer bus is adequately isolated.

2.3. Use of Cell Voltage Monitoring (CVM)

In some Fuel Cell Module designs the voltage of each individual cell of the fuel cell stack is measured and monitored. Such a system is called Cell Voltage Monitoring (CVM). CVM is used to ensure that all the cells of the fuel cell stack are operating properly; if a cell is not receiving reactant flows or is damaged its voltage will drop relative to other healthy cells in the fuel cell stack.

The CVM usually has wires or “fingers” that are in contact with each individual cell. There is no current through the fingers, so each finger is at the same voltage as its cell. The other end of the finger goes to an instrument that measures and compares each of the finger voltages.

Sometimes instead of measuring each individual cell, the CVM measures the cell voltages in small groups. If a cell in the group is performing poorly the voltage of that group will be low. Further investigation will be required to find out which cell in the group is low.

Early detection of low cells is important because if the fuel cell stack is allowed to continue operating with low cells, adjacent cells may be damaged. If a cell is low because water has blocked its reactant channels or because of a build-up of inert gases in the anode, the situation may be able to be corrected by performing a resuscitation (see Section 3.4). If the situation cannot be corrected the system may need to be shut down. CVM is a useful tool to detect low cells so corrective action can be taken before any permanent damage is done.

The specification for your fuel cell stack should list the cell voltage at which corrective action should be taken and the cell voltage at which the fuel cell stack should be shut down. There may also be a maximum cell-to-cell or cell-to-average deviation at which corrective action or shutdown should occur.

However, CVM adds cost and complication. CVM finger designs can be relatively fragile so the CVM may be a failure point. The CVM also takes some effort to install. For these reasons, some fuel Cell System designers have eliminated the need for a CVM.

2.4. Materials Selection

The MEA's of most PEM fuel Cells are somewhat susceptible to poisoning from impurities in the reactant streams. Humidified reactant streams can pick up undesirable ions from the piping or components they pass through. It is recommended that the Air and Fuel Subsystem materials be selected according to the following guidelines.

Permissible Wet and Dry Fluid/Gas Components – The following materials can be used for any process fluid or gas lines, interface fittings or connections: Teflon, PVDF, Neoprene, Glass, EPDM, Viton, and Aluminum.

Permissible Dry Gas Components – The following materials may be used for dry gas lines and external (non-process) fluid circuits. These materials must not be used for process fluids in contact with the fuel cell stack or for humid gas lines, interface fittings or connections: Brass, Copper, Carbon Steel, Zinc, Buna N.

There are fewer restrictions for materials for the Coolant Subsystem because the coolant should not be in contact with the MEA. Corrosion-resistant materials are recommended because deionized coolant is extremely corrosive. Besides damaging the coolant loop piping and equipment, corrosion will result in corrosion products in the coolant stream. The more corrosion products the deionizing filter must remove, the shorter its life can be expected to be.

3.0 CONSIDERATIONS FOR FUEL CELL OPERATION

3.1. Startup

The startup sequence for a PEM Fuel Cell Module is typically:

- Start the coolant system.
- Start the anode recirculation system, if used.
- Open the purge and fuel supply valves to start fuel flow.
- Start air flow.
- When adequate stack voltage is detected, apply load and go to operating controls.

Cell damage may occur if, while oxygen is present on the cathode, a front of hydrogen is permitted to sweep across the anode displacing oxygen or air. A voltage is created on the part of the cell that has hydrogen on the anode and oxygen on the cathode. The part of the cell that has oxygen on the anode will be forced to the same voltage. If the voltage is high enough this will cause undesirable degradation in the part of the cell oxygen is present on the anode.

Several design solutions have been shown to mitigate this problem.

- Do not allow oxygen into the anode while the Fuel Cell Module is shut down. As this is affected by careful shutdown procedure, it is discussed in Section 3.2 below.
- Mix up the anode gas before startup to avoid having a defined fuel-oxygen front in the anode. This can be done by starting the anode recirculation system before starting the airflow.
- Use a large purge valve and a high inlet fuel flow rate at startup to replace any air in the anode with fuel as quickly as possible. While the hydrogen-air front will still exist, this minimizes the amount of time it exists in the cell and minimizes the amount of time that the cell is being damaged.

- Apply a load during startup. This reduces the voltage that is developed in the cell while the hydrogen-air front is present. If the voltage is reduced low enough, there may not be enough potential to drive the undesirable degradation.

Even if there is no hydrogen-oxygen front, the load should be applied as soon as practical during the startup. Operation at high voltage for long periods of time can reduce the life of some PEM fuel Cells; see your fuel cell stack specification for guidance. Also, if there is no current, no water is being produced in the stack. Running dry reactant flows through the cells will eventually dry the MEA. This does not inherently cause damage but it may take minutes or hours of operation with load to restore the cell hydration to its normal level and recover normal cell performance.

The fuel cell stack will dry out to some degree between operations. The rate at which the stack dries out depends on the stack design. Ballard's liquid-cooled fuel cell stacks can go for several weeks between operations without substantial drying of the MEA affecting performance.

Some PEM fuel cell stacks need to have the reactant gases pre-humidified at startup. If humidity exchange or recycle is used, startup humidification must be supplied from an external source. Ballard's fuel cell stacks are able to start up without an external source of humidification. It is preferred to pull current as soon as possible to produce water in the reactant exhaust streams that can be recycled back to the reactant inlet streams. If the cells have become dry between startups, it is recommended to pull a substantial load as soon as practical on startup to re-hydrate them. The load should be pulled before the stack gets warm; when the MEA is dry its resistance is high and it produces more heat when operated. If the MEA is allowed to get too hot it will be damaged.

It is more common to have condensed water in the fuel Cells at startup than it is to have dry MEA's. Water that was in vapor form when the fuel cell stack was warm will condense to liquid water when the stack has cooled down to ambient temperature. Droplets of condensed water blocking flow channels usually result in low cells at the next startup. It can be helpful to run higher-than-normal cathode and anode gas flow rates during the initial startup to blow out any condensed water.

3.2. Shutdown

The shutdown sequence for a PEM Fuel Cell Module is typically:

- Remove the load
- Stop air flow
- Open the purge valve
- Apply the bleed resistor, if used (see Section 1.2.7)
- Close the purge valve, close the fuel valve, turn off anode recirculation if used (see Section 1.2.2)
- Remove the bleed resistor
- Turn off coolant flow

A bleed resistor is a resistor that is put across the fuel cell stack to remove stack voltage at shutdown. The stack voltage will naturally decay after shutdown, but use of a bleed resistor is recommended for stacks that take a long time to lose their voltage and could be damaged by sitting at open circuit voltage. See the specification for your fuel cell stack for recommendations.

If a bleed resistor is used, it should be removed when the voltage has been reduced to about ½ to 1/3 open circuit voltage. The cells may not bleed down evenly if the remaining reactants are not equally distributed; the bleed resistor should be removed before voltages of those cells with less reactant go negative.

If the fuel cell stack operates at high voltage it may be desirable, for safety, to connect the bleed resistor or a special shorting jumper across the stack before Fuel Cell Module Maintenance work is done.

Implementation of the bleed resistor is discussed in Section 1.2.7 above.

As mentioned in the startup discussion above, it is desirable to prevent oxygen from entering the anode between operations to avoid having a hydrogen-air front pass through the anode on the next startup.

Air enters the anode between operations to replace hydrogen that has diffused out. After shutdown, hydrogen continues to diffuse across the MEA from the anode side to the cathode side, where it reacts with oxygen[14]. As the hydrogen is used up, the anode pressure drops. Oxygen and nitrogen diffuse across the MEA from the cathode side to the anode side and leak into the anode side through the stack seals to replace the hydrogen.

In order to prevent the oxygen from entering the anode, the system should be designed such that the cathode runs out of oxygen before the anode runs out of hydrogen. There are a number of ways to do this. One is to design the volumes of the Air Subsystem and the Fuel Subsystem such that there is more than twice the number of hydrogen molecules as there are oxygen molecules. Another approach is to allow additional hydrogen to enter the anode as the hydrogen inside the anode is used up, even after shutdown.

In some applications there are concerns about allowing flammable gas to remain in the Fuel Subsystem between operations. The designer should calculate the amount of energy that would be released if the hydrogen were to combust and make provisions to ensure the amount of energy released would not cause damage.

Increasing the reactant flows for a brief period before shutdown helps to remove any condensed water from the cell channels. This may make the subsequent startup easier.

3.3. Transients

Many applications have varying loads. The Fuel Cell Module power output can follow the load either by including hybrid elements (having energy storage that charges and discharges to follow transients - see Section 1.2.7) – or by increasing and decreasing the fuel cell stack output current to follow the load. A combination of these two approaches is very common.

[14] Diffusion of hydrogen molecules from the anode to the cathode also occurs while the fuel Cell is operating. However, when the fuel Cell is operating the amount of hydrogen that diffuses across the MEA is small compared to the amount that is transported across the MEA as protons.

When the load increases, unless there is enough stored energy to provide the additional power, more current must be pulled from the fuel cell stack. The fuel cell stack will try to provide whatever current is asked of it. If the reactant flows are not high enough to provide the recommended excess flow for the new current, the stack voltage will drop more than would be predicted by the polarization curve.[15]

It is preferred not to operate the stack with lower-than-recommended reactant flows for long periods of time as this may cause cell damage. The reactant flows must be increased if the fuel cell stack current is to be increased. If the fuel cell stack is being operated with the minimum allowable reactant flow rates or the reactant flow ramp rates are slow, the ramp rate of the stack current should be limited to the ramp rate of the reactant supply. This can be done by programming maximum allowable current as a function of cathode inlet flow rate and anode inlet flow rate. If the fuel cell stack is being operated with generous reactant flow rates and the reactant flow ramp rates are fast, it may be acceptable to allow the new stack current and let the reactant flows catch up.

Decreases in load (down transients) are not usually an issue for hydrogen-fueled systems. For a system in which the cathode gas makes a single pass through the stack and the anode gas is recirculated, the stack current can be reduced and the reactant flows can follow. The reactant flows should drop relatively quickly as too-high flows can dry the MEA. If the anode is operating dead-ended and a differential pressure regulator is used to control the fresh fuel supply, it may be necessary to open the anode purge valve on a down transient. As the cathode flow drops its stack inlet pressure drops. This reduces the target pressure for the fuel differential pressure regulator. The differential pressure regulator will close and not allow any fresh fuel until the downstream pressure drops. If there is a substantial buildup of inert gases in the anode, the pressure won't drop until the inert gases are vented. In the meantime, the cell may be starved of hydrogen.

[15] In the extreme case, if there are not enough reactants for the desired current the stack voltage will drop quickly and dramatically. The voltage will probably not instantly drop to zero, though, as there is some volume of reactants within the reactant channels of the stack. These reactants must be used up before the voltage goes to zero.

3.4. Resuscitation

Low cell voltage or low stack voltage often indicate a lack of reactant. The first corrective step should be to verify that adequate air and fuel are being supplied.

If adequate reactants are available and only a few cells are low, those cells may be low because of a buildup of inert gases or because water is blocking the reactant flow channels. If this is the case, resuscitation may recover the performance of the low cell or cells.

Resuscitation is basically a system "cough". On the anode side, the purge valve opens and the anode flow is increased. If an anode recirculation compressor is used, it is spooled up. The increased flow through the anode blows out any liquid water. The cathode side can also be resuscitated if need be; this would consist of temporarily increasing the cathode flow rate to blow out any liquid water.

The resuscitation should not last more than a few seconds. If the low cell or cells do not recover, the resuscitation should be discontinued. Depending on the application it may be appropriate to trigger a shutdown alarm.
Another option is to fix the duration of the resuscitation and repeat the resuscitations until the low cells recover. If the cells do not recover after a few resuscitation attempts, the system should be alarmed.

The CVM (Section 2.2) is used to detect low cells.

3.5. Current Pulsing

Current pulsing is the drawing of very brief pulses of high current from the fuel cell stack. Current pulsing can be helpful in a couple of different situations.

1. When the stack needs to be warmed up quickly, for instance on a cold start. Current pulsing to warm up a fuel cell stack is essentially the same as current pulsing to warm up a battery. The high currents generate heat in the stack.
2. When the cell performance is low due to catalyst oxidation. Even though they are noble metals, the

catalysts on the cathode side of the MEA can oxidize[16] in an oxygen environment. When the catalyst is oxidized it is no longer active, so this reduces the number of active sites on the MEA where the fuel cell reaction can take place.

The oxidation can occur while the fuel cell is operating or while it is in storage or standby. Typically the oxidation occurs on all the cells of the stack, so all the cell voltages degrade more or less equally.
The cell performance can be recovered by de-oxidizing the catalyst. Current pulsing has been shown as an effective way to do this.

Section 1.2.7 discusses current pulsing implementation.

3.6. Air Starve

Another way of removing the catalyst oxidation described in Section 3.5 above is to perform an air starve. An air starve consists of reducing the cathode inlet flow for a short period of time while there is a load on the stack. The intent is that if there is not enough free oxygen available for the fuel cell reaction, oxygen that had bonded with the catalyst will be used.

[16] The catalysts on the anode side of the MEA can also oxidize if oxygen is present in the anode between operations. This is not usually a problem because when the anode is flooded with hydrogen at the next startup, the strong reducing environment strips any oxygen off of the catalyst.

4.0 MODELING FUEL CELL SYSTEM PERFORMANCE

It is suggested that a system model be created early in the design process. The model will facilitate trade-off studies to optimize the system design. It will also provide component-operating conditions so the design team can select properly sized components.

This section steps through the order of calculations for a typical steady-state system model. Other methods and orders of calculation may give equally valid results. This discussion assumes that the model is being written in computer code or as a spreadsheet. Creating the model will be simpler if a process modeling software package is used, as the software should have many of the required calculations built in.

4.1. Preparation For Building a Model

Before starting to put a model together, the designer needs to have the following:

- A basic set of requirements

  The designer must know what he or she is trying to achieve. How much output power is required? At what voltage? AC or DC? At what ambient conditions?
- A basic system schematic

  The system to be modeled needs to be defined. If the modeling shows that that planned architecture is not satisfactory, the schematic and model can be changed. (This is a lot easier than changing hardware after the fact!)
- Characteristics of the fuel cell stack to be used

  The designer should have the polarization curve at the planned operating conditions, the number of cells, and the pressure drop characteristics of the anode, cathode, and coolant. It is helpful to have the polarization curve in the form of an equation where $V = f(i)$. The designer should also have stack coolant inlet and outlet temperatures in mind. These can be changed as part of the trade studies. Note that the actual polarization curve will change with stack temperature and operating pressure; this effect should be included in the polarization curve model.

- Predicted characteristics for mechanical equipment such as compressors, pumps, fans, heat exchangers, and humidifiers

  In order to get started, the designer must have an estimate of the efficiencies of the rotating equipment. Once equipment selection starts the estimates can be refined. Pressure drop allocations should be made for heat exchangers, humidifiers, filters, and any significant piping pressure drops. The designer should have some idea of what performance can be expected from the heat exchangers; since the performance depends on the temperature differential between the hot and cold sides ("pinch"), estimated effectiveness is useful. Similarly, it is helpful to have an estimated effectiveness for the humidifier.
- Coolant composition

  The designer will need the coolant heat capacity and density. These depend on the composition.
- Electrical architecture concept

  Will the power for the internal loads be taken on the stack side or on the customer side of the Electrical Subsystem? What type of power conversion will be used? What is its expected efficiency?

It is assumed that the designer is familiar with calculations that are common in engineering analysis:

- heat exchangers: heat transfer, flow stream outlet temperatures
- compressors: pressure rise, temperature rise, power used
- pumps: pressure rise, power used
- pressure drops in piping and components (compressible and incompressible)
- mixing flow streams of different composition, finding mixture composition and temperature
- heat of evaporation of water

Equations that are specific to fuel cells and equations for calculating saturated water pressure and relative humidity are given in Section 5.0 below.

4.2. Outline of Steady-state System Model

Since a typical fuel cell system has a number of feedbacks and interactions between streams, the model requires some iterations. Some of the iterations noted in the outline below may be able to be eliminated by rearranging the calculations. Some of the iterations can be skipped if only a rough calculation is required.

It is strongly recommended that all calculations be done on a molar basis rather than a mass basis. Final results can be converted to mass flows or to standard liters per minute.

This outline is given as a written description of the calculations to be done for a typical system design. Typical schematics are given, but will be helpful for the reader to trace through his or her own system schematic as he or she goes through the description. It may also be helpful to write out the calculations as you go. Since heat exchangers may or may not be present in the design and may be in different locations in the coolant loop, it is up to the reader to ensure the correct heat exchanger calculations are selected.

Some of the calculations given are not precise, however, the result will be close enough for most practical purposes.

The calculations for the Air Supply Subsystem, the fuel Supply Subsystem and the Coolant Subsystem are done by stepping through the stream and then, calculating the flows and properties at each point. The following flow rates may need to be calculated for points in the Air and Fuel Subsystems:

- Inerts (N2) flow rate
- Oxygen flow rate or hydrogen flow rate
- Dry flow rate
- Water vapor flow rate
- Liquid water flow rate
- Water flow rate
- Gas flow rate
- Total flow rate

Dry flow rate is the sum of the inerts (N2) flow rate plus either the oxygen flow rate (Air Subsystem) or the hydrogen flow rate (Fuel Subsystem).

Water flow rate is the sum of the water vapor flow rate plus the liquid water flow rate.

Gas flow rate is the sum of the inerts (N2) flow rate plus either the oxygen flow rate (air subsystem) or the hydrogen flow rate (fuel subsystem) plus the water vapor flow rate.

Total flow rate is the sum of the dry flow rate plus the water flow rate.

The inerts (N2) flow rate, oxygen or hydrogen flow rate, and water flow rate at a particular point are the same as at the previous point unless a calculation for a new value is described.

The water vapor flow rate and liquid water flow rate will change after any change in stream temperature or pressure or change in stream water flow rate. They can be recalculated when needed as follows:

Find the **saturated flow rate of water** from the stream pressure, the saturated vapor pressure, and the dry flow rate using Equation 5-11 with RH set equal to 100%. Compare this to the water flow rate. If the saturated flow rate is less, the difference is the liquid water flow rate. If the saturated flow rate is more, the **liquid water flow rate** is 0. The **water vapor flow rate** is the lesser of the saturated flow rate and the water flow rate.

The following properties may be needed for points in the Air and fuel Subsystems.

- Pressure
- Temperature
- Saturated Vapor Pressure
- Relative Humidity (RH)
- Specific Heat

In the model description below, pressure and temperature at a particular point are the same as at the previous point unless a calculation for a new value is described.

Changes in **pressure** are usually calculated using pressure drop characteristics that give pressure drop as a function of gas flow rate and inlet density. Density depends on pressure, temperature, and gas composition. The gas composition can be calculated from the inerts (N2) flow rate, the oxygen or hydrogen flow rate, and the water vapor flow rate.
Changes in **temperature** are usually calculated based on an amount of heat, the total flow rate, and the specific heat. The **specific heat** can be calculated based on the total flow composition: inerts (N2) flow rate, oxygen or hydrogen flow rate, and water flow rate.

The saturated vapor pressure, Relative Humidity, and specific heat must be calculated for any point where their values are needed.

The **saturated vapor pressure** can be calculated as a function of temperature using Equation 5-9.

The **Relative Humidity** is calculated from the stream pressure, the saturated vapor pressure, and the mole fraction of water (the water flow rate divided by the total flow rate) using Equation 5-10.

4.2.1. Stack Operating Conditions

Start with a selected **current density**. Find the **cell voltage** from the polarization curve.

Using Equation 5-1, find the **stack voltage**

Using Equation 5-2, find the **stack current**.

Using Equation 5-3, find the **gross stack power**

Using Equation 5-4, find the **gross stack heat**.

Using Equation 5-6, find the **rate of oxygen use** and the **rate of hydrogen use**.

Also, find the **heat gained or lost by the stack to ambient** based on the average of the stack coolant inlet and stack coolant outlet temperatures, the surrounding temperature, and the stack external heat loss characteristic (If the amount of heat gained or lost by your fuel cell stack to ambient is significant, this characteristic should be given in its specification).

4.2.2. Air Subsystem

Schematics of the Air Subsystem options that will be described are given in Figure 4-1 and Figure 4-2.

a. Air Inlet

It is assumed in this analysis that the air supplied to the system is no more than 100% RH. It is further assumed in this analysis that all fresh air is supplied to the cathode and that pressure is supplied by a blower or compressor. It is assumed that if there is a cathode heat exchanger or cathode water spray humidifier, it is on the same coolant loop as the fuel cell stack.

4.2.2.a.1 Supply Air

Multiply the rate of oxygen use by the cathode stoichiometric ratio to find the **supply air oxygen flow rate**. Divide by the percentage of oxygen in the air supply (usually 21%) to find the **supply air-dry flow rate**. The **supply air inerts (N_2) flow rate** is the supply air-dry flow rate less the supply air oxygen flow rate.

The supply air is normally at ambient conditions, that is, the **supply air pressure**, **supply air temperature**, and **supply air relative humidity (RH)** are the same as ambient.

Find the **supply air vapor pressure** using the supply air temperature and Equation 5-9. Find the **supply air water flow rate** using the supply air pressure, the supply air vapor pressure, the supply air RH, the supply air-dry flow rate and Equation 5-9.

4.2.2a.2 Air Inlet Filter

Using the total flow rate, calculate any pressure drop through the air inlet filter to find the **air inlet filter outlet pressure**.

4.2.2.a.3 Air Compressor

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the air inlet filter outlet to the air compressor inlet to find the **air compressor inlet pressure** and **air compressor inlet temperature**.

In order to continue, the modeler must make an estimate of the **<u>air compressor outlet pressure</u>**.

Calculate the **air compressor outlet temperature** and the **air compressor work** using the predicted compressor efficiency, the total flow rate, and the compressor inlet pressure and temperature. Use the air compressor work and the predicted air compressor motor efficiency to find the **air compressor electric load**.

4.2.2.a.4 Stack Coolant Loop Flow Estimate

If there are any cathode or anode supply heat exchangers or water spray humidifiers, modeler may need to estimate the **stack coolant flow rate**. A good estimate can be made by dividing a percentage of the gross stack heat by the specific heat of the coolant.

Air Subsystem Option 1: Heat Exchanger and Gas-to-gas Humidifier

The Air Subsystem described by this portion of the model is shown schematically in the figure below:

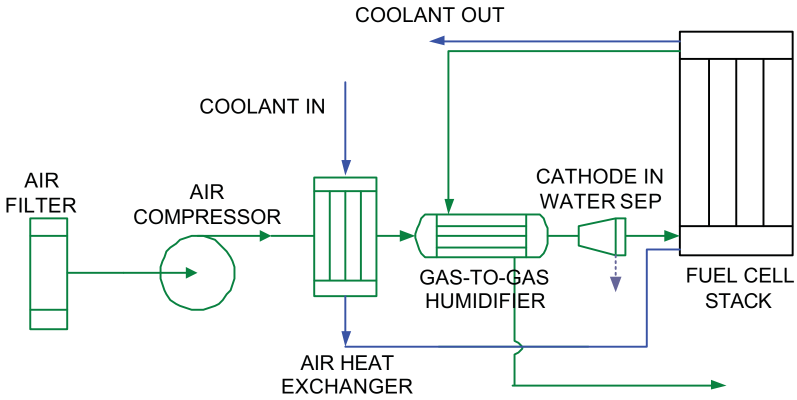


Figure 4-1 Air Supply Subsystem with heat exchanger and gas-to-gas humidifier.

4.2.2.b.1 Air Heat Exchanger

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the air compressor outlet to the air heat exchanger inlet to find the **air heat exchanger inlet pressure** and **air heat exchanger inlet temperature.**

Using the total flow rate, calculate the air heat exchanger air-side pressure drop to find the **air heat exchanger outlet pressure.**

Use the air heat exchanger air side total flow rate and the stack coolant flow rate to find the predicted **air heat exchanger effectiveness**. Calculate the **air heat exchanger outlet** temperature based on the air heat exchanger effectiveness, the air heat exchanger inlet temperature, and the air heat exchanger coolant inlet temperature. (For a first guess, the **air heat exchanger coolant inlet temperature** is the design stack coolant inlet temperature or stack coolant outlet temperature, depending on where in the stack coolant loop the air heat exchanger is.)

Find the **amount of heat transferred from the air heat exchanger air side to the coolant** using the air heat exchanger air side total flow rate, the air mixture specific heat, and the difference between the air heat exchanger inlet and outlet temperatures.

If the air heat exchanger uses coolant before the stack inlet, estimate the **air heat exchanger coolant temperature rise** using the amount of heat transferred, the stack coolant flow rate, and the coolant specific heat. Adjust the air heat exchanger coolant inlet temperature and repeat the calculation above if needed. If the air heat exchanger uses coolant after the stack outlet, no adjustment is necessary.

4.2.2.b.2 Gas-to-Gas Cathode Humidifier Dry Side Part 1

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the air heat exchanger outlet to the cathode humidifier dry side inlet to find the **cathode humidifier dry side inlet pressure** and **cathode humidifier dry side inlet temperature.**

Calculate the **cathode humidifier dry side inlet vapor pressure**, **cathode humidifier dry side inlet water vapor flow rate** and the **cathode humidifier dry side inlet liquid water flow rate**. Depending on the way your humidifier performance data is given, you may also need the **cathode humidifier dry side inlet mole fraction of water.**

Using the total flow rate, calculate the cathode humidifier dry side pressure drop to find the **cathode humidifier dry side outlet pressure**.

The **cathode humidifier dry side outlet dry flow rate** is the same as the inlet dry flow rate.

4.2.2.b.3 Cathode Inlet to Outlet

Before we can calculate the cathode humidifier water transfer, we need to know the cathode outlet stream conditions.

At this point the **<u>cathode inlet water flow rate</u>** must be assumed.

The **temperature inside the cathode inlet** is the design stack coolant inlet temperature and the **pressure inside the cathode inlet** is the humidifier dry side outlet pressure less any piping and water separator pressure drop. Find **water vapor flow rate inside the cathode inlet, liquid water flow rate inside the cathode inlet**, and **RH inside the cathode inlet**.

Using the total flow or dry flow, whichever the characteristic is based on, calculate the cathode pressure drop and find the **cathode outlet pressure**. The **cathode outlet temperature** can be taken as the same as the design stack coolant outlet temperature.

Find the **heat used to raise the temperature of the cathode gas mixture** from stack inlet (coolant inlet temperature) to stack outlet (coolant outlet temperature) temperature based on the total flow rate and the specific heat of the mixture.

The **cathode outlet inerts (N2) flow rate** is the same as the cathode inlet inerts (N2) flow rate[17]. The **cathode outlet oxygen flow rate** is the cathode inlet oxygen flow rate less the rate of oxygen use.

Two water molecules are made for each oxygen molecule used, so the **cathode water production rate** is equal to twice the rate of oxygen use. The **cathode outlet water flow rate** is the cathode inlet water flow rate plus the cathode water production rate.

Find the **cathode outlet water vapor flow**, the **cathode outlet liquid water flow rate**, and the **cathode outlet RH**. The **amount of water evaporated in the cathode** is the difference between the cathode outlet water vapor flow rate and the water vapor flow rate inside the cathode inlet. Find the **heat used to evaporate the cathode water** by multiplying the amount of water vaporized by the heat of evaporation of water at the stack outlet temperature.

4.2.2.b.4 Gas-to-Gas Cathode Humidifier Wet Side Part 1

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the cathode outlet to the cathode humidifier wet side inlet to find the

[17] Some inerts (N2) cross over to the anode side. The amount is very small compared to the amount of nitrogen flowing through the cathode and it can be neglected.

cathode humidifier wet side inlet pressure and **cathode humidifier wet side inlet temperature**.

If there are pressure or temperature changes, calculate the **cathode humidifier wet side inlet vapor pressure, cathode humidifier wet side inlet water vapor flow rate** and the cathode humidifier wet side inlet liquid water flow rate. Depending on the way your humidifier performance data is given, you may also need the **cathode humidifier wet side inlet mole fraction of water**.

4.2.2.b.5 Gas-to-Gas Cathode Humidifier Dry Side Part 2

Now there is enough information to complete the cathode humidifier water transfer calculations. The specific calculations will depend on the type of humidifier, but generally involve the comparing the wet and dry side total flow rates and either the mole fractions of water or the water vapor pressures.

Determine the **cathode humidifier dry side out water flow rate**. The **cathode humidifier water crossover rate** is the cathode humidifier dry side out water flow rate less the cathode humidifier dry side in water flow rate. The **cathode humidifier dry side outlet temperature** should be determined according to the characteristics given for your humidifier. The humidifier dry side out pressure was calculated above.

4.2.2.b.6 Cathode Inlet Separator

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the cathode humidifier dry side out to the cathode inlet separator to find the **cathode inlet separator inlet pressure** and **cathode inlet separator inlet temperature**.

Find **cathode inlet separator water vapor flow rate** and **the cathode inlet separator liquid water flow rate**.

Since the liquid water is drained off at the cathode inlet separator, only the cathode inlet separator water vapor continues to the cathode. That is, the **calculated cathode inlet flow rate** is equal to the cathode inlet separator water vapor flow rate.

Compare the calculated cathode inlet separator water vapor flow rate with the cathode inlet water flow rate estimated in paragraph 4.2.2.b.3 on page 85 above. Adjust the estimated cathode inlet water flow rate and repeat the calculation if necessary.

If the cathode inlet water separator drains to a water reservoir, the cathode inlet separator liquid water flow rate should be added to the reservoir supply flow.

4.2.2.b.7 Cathode Inlet

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the cathode inlet separator to the cathode inlet to find the **pressure inside the cathode inlet** and the **cathode inlet temperature**. If the pressure inside the cathode inlet is substantially different from the one calculated in paragraph 4.2.2.b.3 on page 85, repeat the calculation. Otherwise, use this result to adjust the calculation on the next iteration. Find **cathode inlet water vapor flow rate** and **the cathode inlet liquid water flow rate**.

The cathode mixture will gain or lose heat to the coolant as it goes from the temperature outside the cathode inlet to the temperature inside the cathode inlet. The **water evaporated or condensed in the cathode inlet** is the water vapor flow rate inside the cathode inlet less the cathode inlet water vapor flow rate.

The **heat gained or lost by the cathode mixture as it enters the stack** is the sum of

+ the heat gained lost by the cathode inlet mixture as it goes from cathode inlet temperature to the temperature inside the cathode inlet (calculated with no phase change) plus

+ the heat of evaporation or condensation for the water evaporated or condensed in the cathode inlet (calculated at the temperature inside the cathode inlet).

4.2.2.b.8 Gas-to-Gas Cathode Humidifier Wet Side Part 2

Using the total flow rate at the cathode humidifier wet side inlet, calculate the cathode humidifier wet side pressure drop and find the **cathode humidifier wet side outlet pressure.**

4.2.2.b.8.1 Fixed Cathode Humidifier Wet Side Outlet Pressure

If the cathode humidifier wet side outlet is essentially the system exhaust or if the cathode humidifier wet side outlet goes directly into a back pressure regulator, we can stop here. Compare the calculated cathode humidifier wet side outlet pressure with either ambient pressure or the back pressure regulator set pressure, as appropriate. If they don't match, adjust the compressor outlet pressure estimated in section 4.2.2.a.3 on page 82 and repeat the calculation.

4.2.2.b.8.2 Cathode Humidifier Wet Side Outlet Pressure Varies With Flow

If there are more pressure drops (piping or a restriction orifice) we must find the rest of the humidifier wet side outlet conditions. Some of the cathode humidifier wet side liquid water will be evaporated to make up for the vapor that crossed over. This will drop the temperature of the remaining mixture.

We will model this in two steps: first we will calculate the conditions that would exist at the cathode humidifier wet side outlet if there were no evaporation. We will call these the "intermediate" conditions. Then we will calculate the new equilibrium conditions after the evaporation is taken into account.

Assuming that only water in vapor form is transferred in the humidifier, the **cathode humidifier wet side intermediate water vapor flow rate** is the inlet water vapor flow rate less the cathode humidifier water crossover rate.

Find the **amount of heat that was transferred in the cathode humidifier** by subtracting the cathode humidifier dry side inlet and outlet temperatures and using the cathode humidifier dry side inlet flow rate and specific heat. Find the **cathode humidifier wet side intermediate temperature** from the cathode humidifier wet side inlet temperature, the amount of heat transferred in the cathode humidifier, the cathode humidifier wet side intermediate flow rate and the specific heat of the intermediate mixture.

Estimate the **cathode humidifier wet side outlet temperature** and find the **cathode humidifier wet side outlet water vapor flow rate** and **cathode humidifier wet side outlet liquid water flow rate** based on the estimated temperature.

The **amount of water evaporated in the wet side of the cathode humidifier** is difference between the cathode humidifier wet side outlet water vapor flow rate and the cathode humidifier wet side intermediate water vapor flow rate.

The heat given up by the cathode humidifier wet side mixture as the temperature drops from intermediate to outlet must be equal to the heat gained by the water that evaporates.

Find the sum of

+ the heat gained or lost by the cathode humidifier wet side intermediate mixture as it goes from intermediate temperature to outlet temperature (calculated with no phase change) plus

? the heat of evaporation for the water evaporated in the wet side of the cathode humidifier (evaluated at the outlet temperature).

The sum of these two should be zero; if it is not, adjust the estimated cathode humidifier wet side outlet temperature and repeat the calculation.

Calculate the pressure drops and temperature changes through the remaining elements (piping, restriction orifice, etc.). Compare the calculated **air subsystem outlet pressure** with ambient pressure. If they don't match, adjust the air compressor outlet pressure estimated in paragraph 4.2.2.a.3 on page 82 and repeat the calculation.

Air Subsystem Option 2: Spray Humidifier

The Air Subsystem described by this portion of the model is shown schematically below:

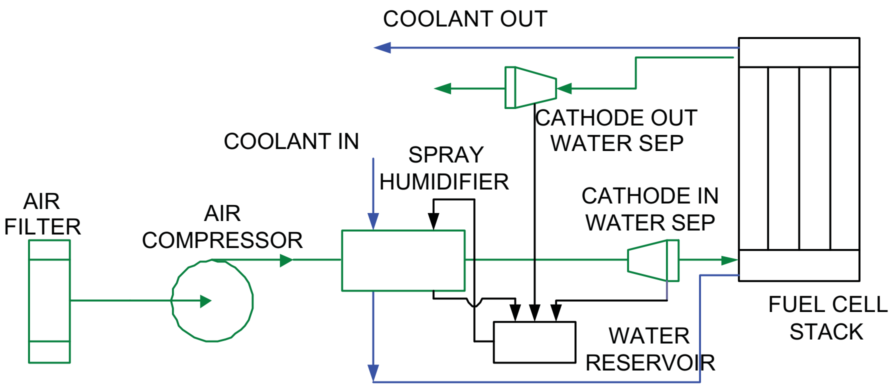


Figure 4-2 Air Supply Subsystem with spray humidifier.

4.2.2.c.1 Cathode Spray Humidifier Part 1

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the air compressor outlet to the cathode humidifier inlet to find the **cathode humidifier inlet pressure** and **cathode humidifier inlet temperature.**
Calculate the cathode humidifier inlet water vapor flow rate and the cathode humidifier liquid water flow rate. Using the total flow rate, calculate the cathode humidifier pressure drop to find the cathode humidifier outlet pressure.

The cathode humidifier outlet dry flow rate is the same as the inlet dry flow rate.

4.2.2.c.2 Cathode Inlet to Outlet

Before we can calculate the cathode humidifier water transfer, we need to know the cathode outlet stream conditions. These are calculated exactly the same way as was described in Option 1c4.2.2.b.3 Cathode Inlet to Outlet paragraph 4.2.2.b.3 on page 85 above.

4.2.2.c.3 Cathode Outlet Water Separator

The calculations for the cathode outlet water separator are essentially the same as for the cathode inlet separator, found in paragraph 4.2.2.b.6 on page 87 above.

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the cathode outlet to the cathode outlet water separator inlet to find the **cathode water separator inlet pressure** and **cathode water separator inlet temperature.**

Find **cathode outlet separator water vapor flow rate** and **the cathode outlet separator liquid water flow rate**.

Since the liquid water is drained off at the cathode outlet separator, only the cathode outlet separator water vapor continues. That is, the **cathode outlet separator outlet water flow rate** is equal to the cathode outlet separator water vapor flow rate.
If the cathode inlet water separator drains to a water reservoir, the cathode outlet separator liquid water flow rate should be added to the reservoir supply flow.

4.2.2.e.1 Cathode Outlet Piping

If the water separator exhausts to ambient, compare the cathode outlet water separator pressure with ambient pressure. If the cathode pressure is maintained by a back pressure regulator, compare the cathode outlet water separator pressure to the regulator set pressure. If the pressures don't match, adjust the air compressor outlet pressure estimated in paragraph 4.2.2.c.2 on page 91 and repeat the calculation.

If there are any additional pressure drop elements, calculate any pressure drops and temperature changes to find the **air subsystem outlet pressure** and compare to ambient pressure. If the pressures don't match, adjust the air compressor outlet pressure estimated in paragraph 4.2.2.c.2 and repeat the calculation.

4.2.2.e.2 Cathode Spray Humidifier Part 2

We now have enough information to complete the cathode spray humidifier calculations. The **cathode humidifier outlet water flow rate** will be the minimum of:

[a] the cathode humidifier outlet saturated water flow rate

[b] the cathode humidifier inlet water vapor flow rate plus the amount of water that can be evaporated with the available heat

[c] the cathode humidifier inlet water flow rate plus the amount of water available to the humidifier

The method of calculating of each of these is explained below.

[a] Use the cathode humidifier inlet flow rate and the stack coolant flow rate to find the predicted **cathode humidifier heat exchange effectiveness**. Calculate the **cathode humidifier outlet temperature** based on the cathode humidifier heat exchange effectiveness, the cathode humidifier inlet temperature, and the cathode humidifier coolant inlet temperature. (For a first guess, the **cathode humidifier coolant inlet temperature** is the design stack coolant inlet temperature or stack coolant outlet temperature, depending on where in the stack coolant loop the cathode humidifier is.)

Find the **cathode humidifier outlet saturated flow rate** based on the calculated outlet temperature.

The cathode humidifier outlet water flow rate for this calculation is the cathode humidifier outlet saturated flow rate.

[b] Using the predicted heat exchange characteristic of the humidifier, the cathode humidifier coolant inlet temperature, and the estimated stack coolant flow rate, calculate the **maximum amount of heat transferred from the coolant in the cathode humidifier**.

Estimate the **<u>cathode humidifier outlet temperature</u>** to find the **cathode humidifier outlet water vapor flow rate** based on the estimated temperature.

The **rate of water evaporation in the cathode humidifier** is difference between the cathode humidifier outlet water vapor flow rate and the cathode humidifier inlet water vapor flow rate.

The heat taken by the cathode mixture as temperature rises from inlet to outlet plus the heat gained by the water that evaporates must be equal to the amount of heat available to be transferred from the coolant.

Find the sum of

+ the heat gained by the cathode humidifier inlet mixture as it goes from inlet to outlet temperature (calculated with no phase change) plus
+ the heat of evaporation for the water evaporated in the cathode humidifier (evaluated at the outlet temperature).

The sum of these two should be the maximum amount of heat transferred from the coolant in the cathode humidifier; if it is not, adjust the estimated cathode humidifier outlet temperature and repeat the calculation.

The cathode humidifier outlet water flow rate for this calculation is the cathode humidifier outlet water vapor flow rate.

[c] The **rate of water available to the cathode humidifier** is a percentage of the water supplied to the water reservoir. The percentage depends on whether some of the water must be supplied elsewhere.

The **rate of water supplied to the reservoir** may need to be estimated on the first pass. Most of the water comes from the cathode outlet separator, so the cathode outlet separator liquid water flow rate is a good first guess.

The cathode humidifier outlet water flow rate for this calculation is the rate of water available to the cathode humidifier plus the cathode humidifier inlet water flow rate.

Calculate the **cathode humidifier water pump electric load** based on the rate of water supplied to the humidifier.

Determine the cathode humidifier outlet water flow rate by comparing the results of the three calculations and choosing the minimum.

a. If the cathode humidifier outlet saturated water flow rate is the limiting factor, the **rate of water added in the cathode humidifier** is the cathode humidifier outlet water flow rate minus the cathode humidifier inlet water flow rate. The **rate of water evaporation in the cathode humidifier** is the cathode humidifier outlet water vapor flow rate minus the cathode humidifier inlet water vapor flow rate.

   The **heat transferred from the coolant in the cathode humidifier** is the sum of

   + the heat gained by the cathode humidifier inlet mixture as it goes from inlet to outlet temperature (calculated with no phase change) plus
   + the heat of evaporation for the water evaporated in the cathode humidifier (evaluated at the outlet temperature).

   The cathode humidifier water pump electric load is the same as was calculated in [c].

b. If the amount of heat available is the limiting factor, the **rate of water added in the cathode humidifier** is the cathode humidifier outlet water flow rate minus the cathode humidifier inlet water flow rate. The **heat transferred from the coolant in the cathode humidifier** is the maximum amount of heat transferred from calculation [b]. The **cathode humidifier outlet temperature** was also calculated in [b]. The cathode humidifier water pump electric load is the same as was calculated in [c].

c. If the amount of water available is the limiting factor, **cathode humidifier outlet temperature** is the same as calculated in [a]. The **rate of water added in the cathode humidifier** is the water available to the cathode humidifier from calculation [c]. The **rate of water evaporation in the cathode humidifier** is the cathode humidifier outlet water vapor flow rate minus the cathode humidifier inlet water vapor flow rate.

The **heat transferred from the coolant in the cathode humidifier** is the sum of

+ the heat gained by the cathode humidifier inlet mixture as it goes from inlet to outlet temperature (calculated with no phase change) plus
+ the heat of evaporation for the water evaporated in the cathode humidifier (evaluated at the outlet temperature).

If the cathode humidifier uses coolant before the stack inlet, estimate the **cathode humidifier coolant temperature rise** using the amount of heat transferred, the stack coolant flow rate, and the coolant specific heat. Adjust the cathode humidifier coolant inlet temperature and repeat the calculation above if needed. If the cathode humidifier uses coolant after the stack outlet, no adjustment is necessary.

4.2.2.e.3 Cathode Inlet Separator

The cathode inlet separator calculations are exactly the same as described in paragraph 4.2.2.b.6 Cathode Inlet Separator above, except that the cathode inlet water flow was estimated in paragraph 4.2.2.c.2 on page 91.

4.2.2.e.4 Cathode Inlet

The cathode inlet calculations are exactly the same as described in paragraph 4.2.2.b.7 on page 88.

4.2.3. Fuel Subsystem

It is assumed in this analysis that the anode inlet pressure is either controlled to a fixed pressure by a pressure regulator or controlled to a relative to the cathode inlet by a differential pressure regulator. The fuel supply temperature and quality are input. The fuel supply is assumed to be dry. It is assumed that if there is an anode heat exchanger or anode water spray humidifier, it is on the same coolant loop as the fuel cell:

Refer to schematics of the Fuel Subsystem options, in Figure 4-3, Figure 4-4, and Figure 4-5.

a. Fuel Subsystem Option 1: Dead-ended Anode with No Anode Humidification

The Fuel Supply Subsystem described by this portion of the model is shown schematically below:

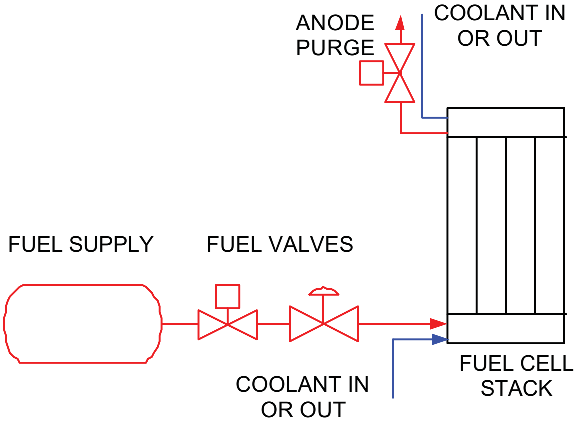


Figure 4-3 Dead-ended Fuel Supply Subsystem with no humidification.

4.2.3.a.1 Fuel Flow Rates

The **hydrogen supply flow rate** is the rate of hydrogen use plus the amount that will be purged. This is usually about 3%; see the specification for your fuel cell stack for manufacturer's recommendations). Divide the hydrogen supply flow by the hydrogen quality (e.g. 99.95%) to find the **fuel supply flow rate**. The **fuel supply inerts (N2) flow rate** is the fuel supply flow rate minus the hydrogen supply flow rate.

4.2.3.a.2 Anode Heat Gains or Losses

The **anode inlet temperature** is same as the fuel supply temperature plus or minus any piping heat gains or losses. Calculate the **heat gained or lost by the anode inlet flow as it enters the stack** based on the fuel supply flow rate, the fuel mixture specific heat, the anode inlet temperature and the stack coolant inlet or outlet temperature (whichever is on the same side of the stack as the fuel inlet).

For a precise calculation it may be necessary to find the **heat used to change the temperature of the anode mixture** as it goes from anode inlet temperature to anode outlet temperature in the stack.

- If the stack is *co-flow*, calculate the heat based on the anode inlet mixture flow rate and specific heat; the anode inlet temperature is stack coolant inlet temperature and the anode outlet temperature is stack coolant outlet temperature.

- If the stack is *counter flow*, calculate the heat based on the anode outlet mixture flow rate and specific heat; the anode inlet temperature is stack coolant outlet temperature and the anode outlet temperature is stack coolant inlet temperature.

b. Fuel Subsystem Option 2: Dead-ended Anode with Water Spray Humidification

The Fuel Supply Subsystem described by this portion of the model is shown schematically in below:

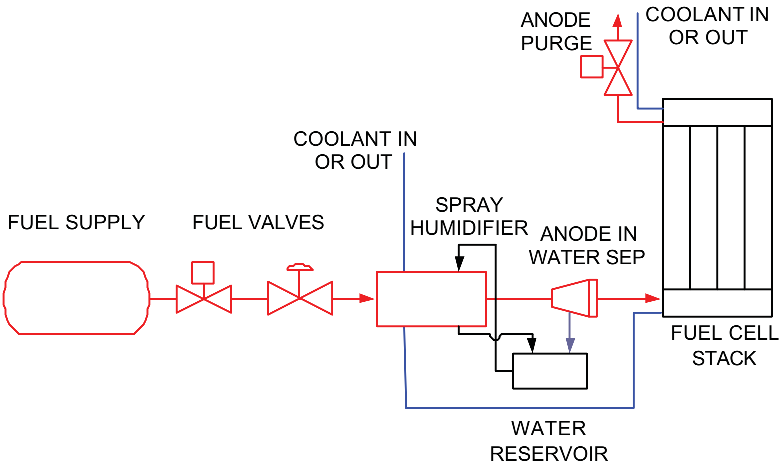


Figure 4-4 Dead-ended fuel Supply Subsystem with water spray humidification.

4.2.3.b.1 Fuel Flow Rates

The fuel flow rates are calculated exactly the same way as for the system with no anode humidification, as explained in paragraph 4.2.3.a.1 on page 97.

4.2.3.b.2 Anode Inlet Spray Humidifier

Estimate the **anode humidifier inlet pressure**. Calculate any piping temperature changes from the fuel supply to the anode humidifier inlet to find the **anode humidifier inlet temperature**. Using the total flow rate, calculate the anode humidifier pressure drop to find the **anode humidifier outlet pressure**.

The **anode humidifier outlet dry flow rate** is the same as the inlet dry flow rate.

The rest of the water spray humidifier analysis is the same as for Cathode Water Spray Humidification, paragraph 4.2.2.c.1 on page 91.

4.2.3.b.3 Anode Inlet Separator

The analysis of the anode inlet separator is the same as for the Cathode Inlet Separator, paragraph 4.2.2.b.6 except that there is no estimated anode inlet water flow rate.

If all the supplies to the water reservoir have now been calculated, compare the **calculated supply to the water reservoir** with the value estimated earlier in the Cathode Spray Humidifier calculation paragraph 4.2.2.c.1 and/or the Anode Spray Humidifier calculation, paragraph 4.2.3.b.2 Adjust the estimate and repeat the calculation if necessary.

4.2.3.b.4 Anode Inlet

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the anode inlet separator to the anode inlet to find the **anode inlet pressure** and the **anode inlet temperature**.

If the anode inlet pressure is controlled by a regulator, the **design anode inlet pressure** is the regulator setting. If the anode inlet pressure is controlled relative to cathode inlet pressure, calculate the **design anode inlet pressure** by adding the pressure offset to the cathode inlet pressure calculated in the previous section. Compare the design anode inlet pressure to the calculated anode inlet pressure. If they do not agree, adjust the estimated anode humidifier inlet pressure and repeat the calculation.

Find **anode inlet water vapor flow rate** and **the anode inlet liquid water flow rate**.

4.2.3.b.5 Anode Inlet to Outlet

The **temperature inside the anode inlet** is the stack coolant inlet or outlet temperature (whichever is on the same side of the stack as the fuel inlet.) The **pressure inside the anode inlet** is the same as the anode inlet pressure.

Find the **water vapor flow rate inside the anode inlet,** the **liquid water flow rate inside the anode inlet**, and **RH inside the anode inlet**.

The anode mixture will gain or lose heat to the coolant as it goes from the temperature outside the anode inlet to the temperature inside the anode inlet. The **water evaporated or condensed in the anode inlet** is the water vapor flow rate inside the anode inlet less the anode inlet water vapor flow rate.

The **heat gained or lost by the anode mixture as it enters the stack** is the sum of

+ the heat gained or lost by the anode inlet mixture as it goes from anode inlet temperature to the temperature inside the anode inlet (calculated with no phase change) plus
+ the heat of evaporation or condensation for the water evaporated or condensed in the anode inlet (calculated at the temperature inside the anode inlet).

For a precise calculation it may be necessary to find the heat gains or losses of the anode mixture in the stack. **The heat used to change the temperature of the anode mixture** (with no phase change) as it goes from anode inlet temperature to anode outlet temperature in the stack is calculated as follows.

- If the stack is *co flow*, calculate the heat based on the anode inlet mixture flow rate and specific heat; the anode inlet temperature is stack coolant inlet temperature and the anode outlet temperature is stack coolant outlet temperature.
- If the stack is *counter flow*, calculate the heat based on the anode outlet mixture flow rate and specific heat; the anode inlet temperature is stack coolant outlet temperature and the anode outlet temperature is stack coolant inlet temperature.

There may also be heat flow due to condensation or evaporation of water in the anode. Find the **anode outlet water vapor flow** and the **anode outlet liquid water flow rate** based on the anode outlet temperature. The **amount of water condensed or evaporated in the anode** is the difference between the anode outlet water vapor flow rate and the water vapor flow rate inside the anode inlet. Find the **heat used to evaporate the anode water** by multiplying the amount of water vaporized by the heat of evaporation of water at the stack outlet temperature.

Fuel Subsystem Option 3: Anode Recirculation System

Modeling an anode recirculation subsystem is more complex than modeling the other anode options, so the method will be described in greater detail.

The fuel Supply Subsystem described by this portion of the model is shown schematically below:

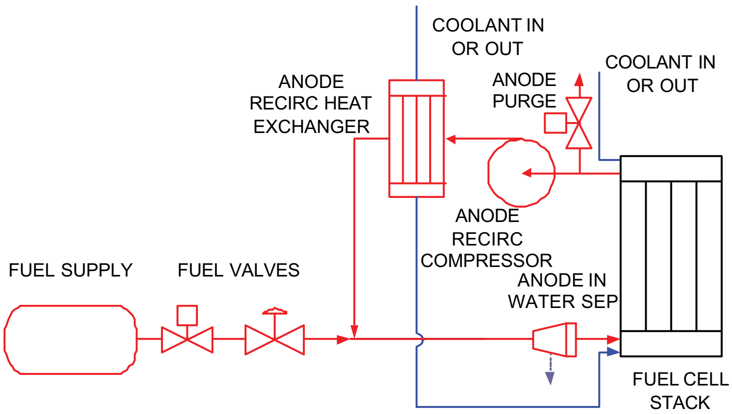


Figure 4-5 Fuel Supply Subsystem with anode recirculation.

4.2.3.c.1 Dry fuel Flow Rates

In order to do this calculation, we must set the design **percentage of inerts (N_2) at the anode inlet**. This percentage should be based only on dry gases (e.g. hydrogen and inerts). Calculate the **percentage of inerts (N_2) at the anode outlet** using Equation 5-8, the percentage of inerts at the inlet, and the anode stoichiometric ratio.

Find the **rate of inerts (N_2) crossing into the anode** using Equation 5-7. See the specification for your fuel cell stack for the permeability, thickness, and cell area.

The rate of hydrogen use has already been calculated in paragraph 4.2.1.

If we draw a control volume around the entire anode system as shown in Figure 4-6 we get the gas balance as shown.

We know that:

hydrogen supply = a% (dry fuel supply) = a% (inerts supply + hydrogen supply)

inerts purged = b% (dry exhaust purged) = b% (inerts purged + hydrogen purged)

where *a* is the hydrogen quality, in percent (e.g. 99.95%) and *b* is the percent inerts at the anode exhaust, dry basis.

From the diagram, we can see that

hydrogen purged = hydrogen supply – hydrogen used in anode

inerts purged = inerts supply + inerts crossing into anode

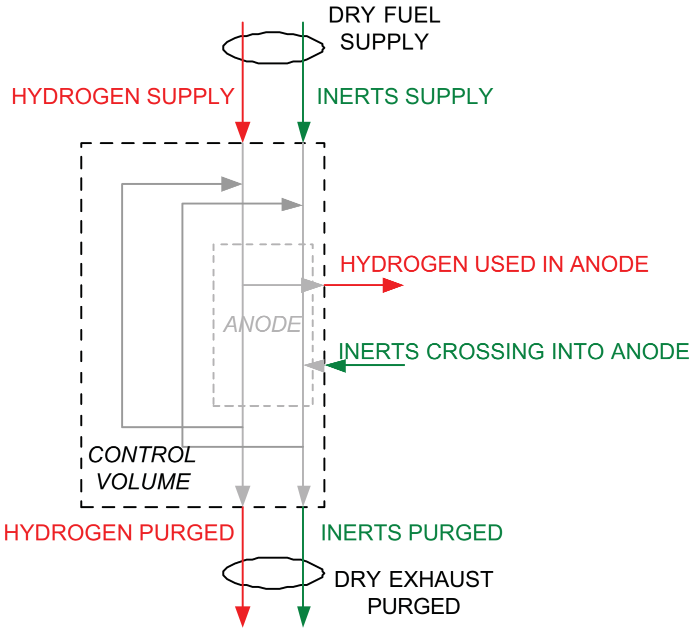


Figure 4-6 Anode Subsystem inlet and outlet dry flows.

We have four equations with eight variables. Four are known:

- rate of hydrogen use in the anode
- rate of inerts crossing into the anode
- ***a*** (hydrogen quality)
- ***b*** (percent inerts in the anode exhaust)

We can solve for the four unknowns:

- hydrogen supply flow rate
- inerts (N_2) supply flow rate
- hydrogen purge rate
- inerts (N_2) purge rate

Now we can draw a diagram of the flow in the anode recirculation loop as shown in Figure 4-7 and find the rest of the dry flows.

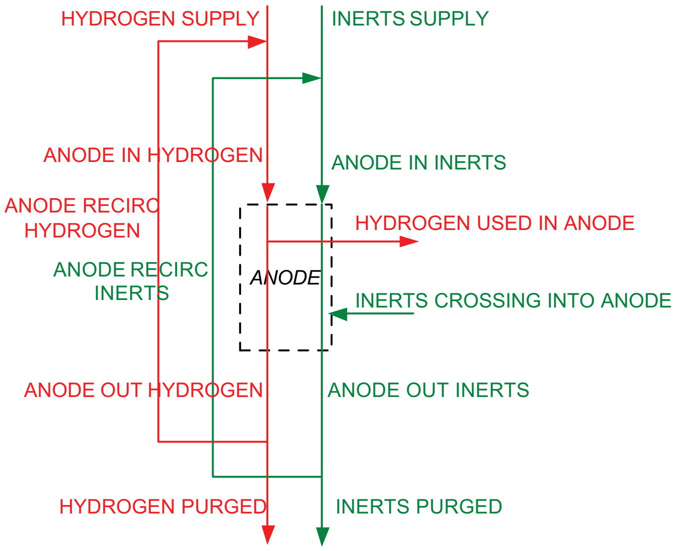


Figure 4-7 Anode Subsystem dry flows.

The **anode inlet hydrogen flow rate** is the rate of hydrogen use in the anode multiplied by the anode stoichiometric ratio.

The **anode outlet hydrogen flow rate** is the anode in hydrogen flow rate less the rate of hydrogen use in the anode.

The **anode recirc hydrogen flow rate** is the anode outlet hydrogen flow rate minus the hydrogen purge rate.

The ratio of the **anode outlet inerts (N2) flow rate** to the anode outlet hydrogen flow rate is the same as the ratio of the inerts purge rate is to the hydrogen purge rate.

The ratio of the **anode recirc inerts (N2) flow rate** to the anode recirc hydrogen flow rate is the same as the ratio of the inerts purge rate is to the hydrogen purge rate.

The **anode inlet inerts (N2) flow rate** is the inerts supply flow rate plus the recirc inerts flow rate.

The dry flow rate at each location is the hydrogen flow rate plus the inerts flow rate.

4.2.3.c.2 Anode Loop Water Flow Rates

Now that we know the dry flows, we can calculate the anode outlet humidity's.

Anode outlet conditions and water flow rate

Estimate the **anode outlet pressure**. The **anode outlet temperature** is the same as the stack coolant inlet temperature or stack coolant outlet temperature, whichever is on the same side as the anode outlet. Unless other information is available, assume that the anode outlet humidity is 100% RH. Calculate the **anode outlet water vapor flow rate**. If the humidity is greater than 100%, calculate the **anode outlet liquid water flow rate**. Otherwise the anode outlet liquid water flow rate is zero.

Purge conditions and water flow rate

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the anode outlet to the anode purge to find the **anode purge pressure** and **anode purge temperature**. Calculate the **water vapor flow rate before the anode purge** and the **liquid water flow rate before the anode purge**.

Since all the liquid water is drained off at the purge, only the water vapor flow rate before the purge should be split between the purge and the anode recirc.
Find the **ratio of water vapor flow rate before the purge to anode outlet dry gas flow rate**. The ratio of **purge water vapor flow rate** to purge dry gas flow rate is the same ratio. The ratio of **anode recirc water vapor flow rate** to the anode recirc dry flow rate is also the same ratio.

Anode inlet water flow rate

The **anode inlet water flow rate** is the same as the anode recirc water flow rate.

4.2.3.c.3 Anode Loop Pressures and Temperatures

Anode Recirc Compressor

Now we can calculate pressures and temperatures around the rest of the anode recirc loop.

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the purge location to the anode recirc compressor inlet to find the **anode recirc compressor inlet pressure** and **anode recirc compressor inlet temperature**.

Estimate the **anode recirc compressor outlet pressure**. The rest of the anode recirc compressor calculations are the same as for the Air Compressor in paragraph 4.2.2.a.3.

Anode Recirc Heat Exchanger

If there is a heat exchanger downstream of the anode recirc compressor, use the total flow rate to calculate any pressure drops and temperature changes through the piping from the anode recirc compressor outlet to the anode recirc heat exchanger inlet to find the **anode recirc heat exchanger inlet pressure** and **anode recirc heat exchanger inlet temperature**.

The anode recirc heat exchanger calculations are the same as for the Air Heat Exchanger in paragraph 4.2.2.b.1. The specific heat of the anode recirc mixture will have to be calculated based on the composition of the anode recirc mixture.

Anode Fresh-Recirc Mix Point

Using the total flow rate, calculate any pressure drops and temperature changes through the piping from the anode recirc heat exchanger outlet to the anode recirc mix point to find the **anode recirc mix point pressure** and **anode recirc mix point temperature**.

Calculate any piping heat gains or losses between the fuel supply and the anode mix point and determine the **fuel supply mix point temperature**.

Mix the fuel supply and anode recirc streams at their respective mix point temperatures to find the **anode supply mix point temperature**. Note that the two streams being mixed have different specific heats. The **anode supply mix point pressure** is the same as the anode recirc mix point pressure. The mix flow rates should be the same as the anode inlet flow rates, which have already been calculated.

Anode Heat Exchanger

If there is a heat exchanger between the mix point and the anode separator, use the total flow rate to calculate any pressure drops and temperature changes through the piping from the anode supply mix point and the anode inlet heat exchanger inlet to find the **anode inlet heat exchanger inlet pressure** and **anode inlet heat exchanger inlet temperature**.

The anode inlet heat exchanger calculations are the same as for the Air Heat Exchanger, paragraph 4.2.2.b.1 on page 84. The specific heat of the anode inlet mixture will have to be calculated based on the composition of the anode inlet mixture.

Anode Inlet Separator

The calculation for piping pressure drops and temperature changes from the heat exchanger to the anode inlet separator and the calculations for the anode inlet separator are the same as those described for the Cathode Inlet Separator, paragraph 4.2.2.b.6 (page 87) except that there is no estimated anode inlet water flow rate.

If all the supplies to the water reservoir have now been calculated, compare the **calculated supply to the water reservoir** with the value estimated earlier in the Cathode Spray Humidifier calculation paragraph 4.2.2.c.1 (page 91) and/or the Anode Spray Humidifier calculation, paragraph 4.2.3.b.2 (page 98). Adjust the estimate and repeat the calculation if necessary.

Anode Inlet

The calculation for piping pressure drops and temperature changes and the calculations of conditions outside the anode inlet are the same as those described for the Anode Inlet for the Dead-ended Anode with Water Spray, paragraph 4.2.3.b.4 (page 99), except that if the calculated anode inlet pressure does not match the design anode inlet pressure, the estimated anode recirc compressor outlet pressure should be adjusted.

Anode Inlet to Outlet

The **temperature inside the anode inlet** is the stack coolant inlet or outlet temperature (whichever is on the same side of the stack as the fuel inlet). The **pressure inside the anode inlet** is the same as the anode inlet pressure.

Using the total flow rate, calculate the stack anode pressure drop to find the calculated **anode outlet pressure**. Compare the calculated anode outlet pressure with the estimated anode outlet pressure. If they do not match, adjust the estimated anode outlet pressure and repeat the calculation.

The rest of the anode inlet-to-outlet calculations are the same as the Anode Inlet-to-Outlet calculations for the Dead-ended Anode with Water Spray paragraph 4.2.3.b.5 (page 99). Anode outlet temperature, anode outlet water vapor flow rate, and anode outlet liquid water flow rate have already been calculated in the Anode outlet conditions and water flow rate paragraph 4.2.3.c.2 (page 104).

4.2.4. Net Output Power

a. System Internal Loads

Make an estimate of the **coolant pump electric load** and of the **radiator fan electric load**.
If all the BOP electrical equipment is provided with the same voltage, add up all the system internal electrical loads:

- Air compressor electric load
- Cathode humidifier water pump electric load
- Anode recirc compressor electric load
- Anode humidifier water pump electric load
- Coolant pump electric load
- Radiator fan electric load
- Electrical allocation for other fans, valves, controller, and miscellaneous electric equipment

The result is the **gross system internal load**.

If there are groups of equipment that operate at other voltages but they are all ultimately supplied from the same bus, find the total load at each voltage. For each total load at a voltage other than the main bus voltage, divide by the efficiency of the power supply providing that voltage. Add the totals to get the gross system internal loads

b. Net Stack Power

4.2.4.b.1 Option 1: Internal Loads from Stack Side of Electrical Subsystem

If the system internal loads are provided from the stack side of the Electrical Subsystem, divide the gross system internal load by the stack voltage to find the **gross system internal loads current**. Subtract the gross system internal loads current from the stack current to find the **net stack current.**

The **net stack power** is the net stack current multiplied by the stack voltage.

4.2.4.b.2 Option 2: Internal Loads from Customer Bus Side of Electrical Subsystem

If the system internal loads are provided from the customer bus side of the Electrical Subsystem, the **net stack current** is the same as the stack current.

The **net stack power** is the net stack current multiplied by the stack voltage.

c. Power Conversion

4.2.4.c.1 Option 1: Linear Regulator

A linear regulator "trims off" any voltage above the selected output voltage but does not change the current. The **linear regulator output current** is the same as the net stack current. The **linear regulator output voltage** is the lesser of the selected output voltage or the stack voltage minus the minimum linear regulator voltage loss.

The **linear regulator output power** is the linear regulator output current multiplied by the linear regulator output voltage. The **linear regulator power loss** is the difference between the linear regulator input power (net stack power) and the linear regulator output power. The **linear regulator heat load** is the same as the linear regulator power loss.

4.2.4.c.2 Option 2: DC-DC Converter

A DC-DC converter changes both the voltage and the current The **DC-DC converter output power** is the input power (net stack power) multiplied by the efficiency. The **DC-DC converter power loss** is the difference between the net stack power and the DC-DC converter output power. The **DC-DC converter heat load** is the same as the DC-DC converter power loss.

The **DC-DC converter output voltage** is normally the selected output voltage. If the DC-DC converter is a buck converter and the stack voltage is less than the selected output voltage, the DC-DC converter output voltage will be the stack voltage minus some minimum DC-DC converter voltage loss. If the DC-DC converter is a boost converter and the stack voltage is higher than the selected output voltage, the DC-DC converter output voltage will be the stack voltage minus some minimum DC-DC converter voltage loss.

The **DC-DC converter output current** is the DC-DC converter output power divided by the DC-DC converter output voltage.

4.2.4.c.3 Option 3: Inverter

An inverter changes both the voltage and the current. The **inverter output power** is the input power (net stack power) multiplied by the efficiency. The **inverter power loss** is the difference between the input power and the inverter output power. The **inverter heat load** is the same as the inverter power loss.

The **inverter output voltage** is the selected output voltage. The **inverter output current** is the output power divided by the output voltage.

d. Net System Output Power

4.2.4.d.1 Option 1: Internal Loads from Stack Side of Electrical Subsystem

If the system internal loads are provided from the stack side of the Electrical Subsystem, the **net system output power** is the same as the power conversion device output power. The **net system output current** is the net system output power divided by the output voltage.

4.2.4.d.2 Option 2: Internal Loads from Customer Bus Side of Electrical Subsystem

If the system internal loads are provided from the customer bus side of the Electrical Subsystem, the **net system output power** is the power conversion device output power less the gross system internal load.

The **net system output current** is the net system output power divided by the output voltage.

4.2.5. Coolant Loop

In this analysis it is assumed that cathode and anode heat exchangers and/or spray humidifiers are on the same coolant loop as the fuel cell stack. If coolant is provided to the electronics, this is a separate loop.

It is further assumed that the stack coolant rejects it heat through a radiator. Radiator outlet temperature is controlled by controlling the amount of coolant that bypasses the radiator.

A schematic of the Coolant Subsystem that will be described is given in Figure 4-8.

Stack Coolant flow

Add up all the stack heat loads:

\+ Gross stack heat load

\+ Heat gained or lost by the cathode inlet mixture as it enters the stack

\+ Heat used to evaporate cathode water

\+ Heat used to raise the temperature of the cathode mixture

\+ Heat gained or lost by the anode inlet mixture as it enters the stack

\+ Heat used to evaporate anode water (if calculated)

\+ Heat used to raise the temperature of the anode gas mixture (if calculated)

\+ Heat gained or lost by the stack to ambient

The result is the **net stack heat load**.

Divide the net stack heat load by the allowable stack coolant temperature rise and the specific heat of the coolant to find the calculated **stack coolant flow rate**. If this does not match the stack coolant flow rate estimated earlier, adjust the estimate and repeat the calculation.

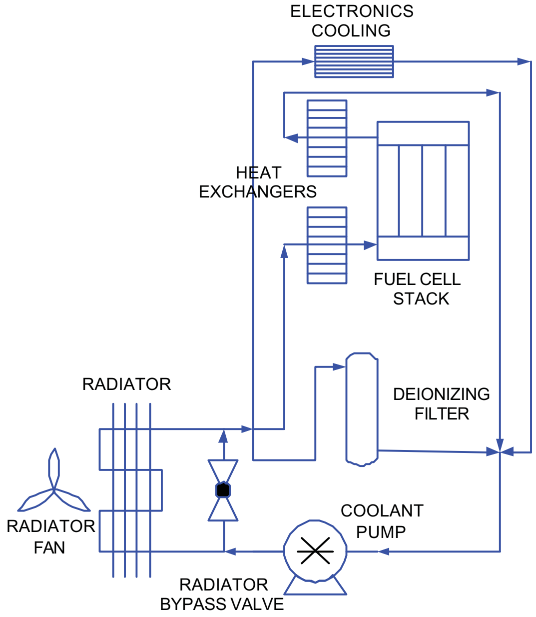


Figure 4-8 Typical coolant loop.

Coolant Loop Pressure Drop Analysis – Part 1

To start the analysis, estimate the **coolant tee pressure** (pressure at the tee where the coolant flow splits to the stack cooling loop, the electronics cooling loop, and the deionizing filter loop).

Using the calculated stack coolant flow rate, calculate the pressure drops through the piping, heat exchangers, spray humidifiers, and fuel cell stack, and due to head changes, for the stack coolant loop from the coolant tee to the coolant mix point to find the **coolant mix point pressure**.

The pressure drops for the electronics coolant loop and for the deionizing filter loop will be the same as for the stack coolant loop[18]; that is, the coolant tee pressure minus the coolant mix point pressure. Based on the available pressure drops (including head changes), calculate the **electronics coolant flow rate** and the **deionizing filter coolant flow rate**.

The **total coolant flow rate** is the sum of the three coolant loop flow rates: the stack coolant loop flow rate, the electronics coolant flow rate, and the deionizing filter flow rate.

Using the total coolant flow rate, calculate the pressure drop due to piping and any head changes to find the **coolant pump inlet pressure.**

If there is a point between the coolant mix point and the coolant pump inlet where the coolant pressure is known (for instance, an open accumulator), compare the calculated pressure for that point to the known pressure. If they are not the same, adjust the estimated coolant tee pressure and repeat the calculation.

Coolant Loop Thermal Analysis

4.2.5.c.1 Coolant Loop Temperatures

The stack coolant inlet temperature is known because this is a design parameter. From the stack coolant inlet, calculate the stack coolant loop temperatures backward to find the **coolant tee temperature**. Include the heat load of all heat exchangers and/or spray humidifiers and any heat gained or lost in the piping.

The stack coolant outlet temperature is also known. From the stack coolant outlet, calculate the stack coolant loop temperatures forward to find the **stack coolant loop mix point temperature**. Include the heat load of all heat exchangers and/or spray humidifiers and any heat gained or lost in the piping.

[18] The pressure drops through the electronics coolant loop and the deionizing filter loop should have been adjusted to give the correct flow at the design point. The design point is usually the maximum power / maximum flow case. For a rough calculation, set fixed flow splits instead of calculating pressure drops.

The coolant tee temperature is the supply temperature to the electronics coolant loop. Calculate the electronics coolant loop temperatures forward from the stack coolant tee to find the **electronics coolant loop mix point temperature**. Include the heat load of all liquid-cooled electronics and any heat gained or lost in the piping.

The coolant tee temperature is the supply temperature to the deionizing filter coolant loop. Calculate the deionizing filter coolant loop temperatures forward from the stack coolant tee to find the **deionizing filter coolant loop mix point temperature**. The heat load will primarily be heat gained or lost in the piping.

Mix the three flow streams to find the **coolant mix point outlet temperature**. Calculate any heat gains or losses through the piping to find the **coolant pump inlet temperature**.

4.2.5.c.2 Radiator bypass flow

Using the total coolant flow rate, calculate any heat gains or losses backward through the piping to find the **radiator mix point coolant outlet temperature**.

For a first analysis, assume that the **radiator inlet temperature** is the same as the coolant pump inlet temperature and find the coolant flow split between the radiator and the radiator bypass. This will give the **radiator coolant flow** and the **radiator bypass coolant flow**.

Also calculate the **radiator fan flow** and the **radiator fan electric load**. If the calculated radiator fan electric load is not the same as the load estimated in paragraph 4.2.4, adjust the estimate and repeat the calculation.

Coolant Loop Pressure Drop Analysis – Part 2

Calculate the pressure drop due to piping and any head change backwards through the radiator and any inlet piping to find the **radiator inlet tee pressure**. Calculate the pressure drops backward through the piping and due to any head changes to find the **coolant pump outlet pressure.**

Now that the coolant pump inlet and outlet pressures are known, calculate the **coolant pump electric load**. If this is not the same as the load estimated in paragraph 4.2.4.a, adjust the estimate and repeat the calculation.

Any temperature change in the coolant pump will probably turn out to be very small and will not affect the overall calculation much. But if a precise calculation is required, calculate the **coolant pump outlet temperature** and calculate any heat gains and losses through the piping to calculate the **radiator inlet temperature**. Compare this to the temperature estimated above; if it is different, adjust the estimate and repeat the calculation.

5.0 ENGINEERING CALCULATIONS FOR FUEL CELL SYSTEM DESIGN

5.1. Fuel Cell calculations

The following equations are used in calculating fuel cell performance.

a. Stack voltage

Equation 5-1

$$V_{stack} = V_{cell} \times N_{cells}$$

V_{stack} = *stack voltage, V*
V_{cell} = *cell voltage, V/cell*
N_{cells} = *number of cells in stack*

b. Stack current

Equation 5-2

$$I_{stack} = cd \times A$$

I_{stack} = *stack current, A*
cd = *current density, A/cm2*
A = *active area, cm2*

c. Stack power

Equation 5-3

$$P_{stack} = V_{stack} \times I_{stack}$$

P_{stack} = *stack power, W*

d. **Gross stack heat**

Equation 5-4

$$Q_{stack} = (E_{HHV} - V_{cell}) \times I_{stack} \times N_{cells}$$

Q_{stack} = *heat produced by stack (higher heating value), W*
E_{HHV} = *EMF based on fuel higher heating value*

E_{HHV} varies depending on the operating temperature, but is usually about 1.47 for hydrogen fuel and a stack temperature about 70°C. If desired, a more precise value of E_{HHV} can be calculated from the change in enthalpy. Use the enthalpy of formation for the higher heating value of water (product water is in liquid form) at your stack operating temperature.

Equation 5-5

$$E_{HHV} = \frac{-Q}{N_{e^-/molecule} \times F}$$

$$Q = \textit{heat of combustion}$$
$$... = \sum N_p \times h_p - \sum N_r \times h_r$$

$$N_p = \textit{number of moles of product}$$
$$h_p = \textit{enthalpy of formation of product}$$
$$N_r = \textit{number of moles of reactant}$$
$$hr = \textit{enthalpy of formation of reactant}$$
$$F = \textit{Faraday's constant, 96,485.3 coulomb/gmol}$$
$$N_{e^-/molecule} = \textit{number of electrons transferred per molecule of product}$$
$$\ldots\ldots\ldots\ldots = 2 \textit{ for } H_2 + \tfrac{1}{2} O_2 \rightarrow H_2O$$

e. Reactant flows

Equation 5-6

$$\dot{N} = \frac{I_{stack} \times N_{cell}}{F \times N_{e^-/molecule}}$$

$$\dot{N} = \textit{reactant flow rate, gmol/s}$$
$$F = \textit{Faraday's constant, 96,485.3 coulomb/gmol}$$
$$N_{e^-/molecule} = \textit{number of electrons transferred per molecule}$$
$$\ldots\ldots\ldots\ldots = 4 \textit{ for } O_2$$
$$\ldots\ldots\ldots\ldots = 2 \textit{ for } H_2$$

f. Inerts crossover

Equation 5-7

$$J_{cell} = A \times p \times \frac{\Delta P}{\Delta x}$$

$$J = J_{cell} \times N_{cell}$$

$J_{cell} = \textit{molar flux per cell (gmol/s} \cdot \textit{cell)}$

$J = \textit{total molar flux (gmol/s)}$

$A = \textit{membrane area, cm}^2$

$p = \textit{membrane permeability, gmol/(cm} \cdot s \cdot \textit{Pa)}$

$?P = \textit{difference in inerts partial pressures across membrane, Pa}$

$\Delta x = \textit{membrane thickness,cm}$

g. Inerts concentration at anode inlet and outlet

If the stack operates with a fuel stoichiometric ratio greater than 1, the inerts mole fraction (dry basis) increases as the fuel stream passes through the anode and some of the hydrogen is used.

Equation 5-8

$$FS = \frac{\dfrac{mf_{inertsout}}{1 - mf_{inertsout}}}{\dfrac{mf_{inertsout}}{1 - mf_{inertsout}} - \dfrac{mf_{inert\,sin}}{1 - mf_{inert\,sin}}}$$

$FS = \textit{fuel stoichiometric ratio}$

$mf_{inertsout} = \textit{dry mole fraction inerts at the anode outlet}$

$mf_{inert\,sin} = \textit{dry mole fraction inerts at the anode inlet}$

5.2. Humidity Calculations

While the following equations are not unique to fuel cell system calculations, they may not be as familiar to the designer as other equations for process flows so they are included here for reference.

Humidity can be expressed in several ways:

- Relative Humidity (mass of water vapor in the air compared to the mass of water vapor that would saturate the air at the same temperature)
- Specific Humidity (mass of water per unit mass of dry gas)
- Absolute Humidity (mass of water per unit volume of mixed gas)
- Mole Fraction (moles of water per mole mixed gas)

Relative humidity and mole fraction are the most convenient measurements to use in fuel cell system calculations.

a. Saturated vapor pressure of water

There are a number of published equations to calculate the saturated vapor pressure of water as a function of temperature. The designer is free to choose his preferred equation. The Magnus Teten[19] equation gives adequate results and is given here for reference.

Equation 5-9

$$\log_{10}(P_{sat}) = \frac{7.5T}{(T + 237.3)} + 0.7858$$

P_{sat} = *saturated vapor pressure of water, hPa*

T = *temperature, ^{o}C*

[19] Murray, 1967

b. Relative humidity equations

The following equations only apply if $P_{sat} < P_{tot}$; that is, if the water has not boiled.

Equation 5-10

$$RH = \frac{N_{H2O}}{\sum N} \times \frac{P_{tot}}{P_{sat}}$$

$RH = \textit{relative humidity}$

$N = \textit{number of moles}$

$N_{H2O} = \textit{number of moles of water}$

$\sum N = \textit{total number of moles of all constituents of mixture}$

$P_{tot} = \textit{total pressure of mixture}$

$P_{sat} = \textit{saturated pressure of water}$

Usually we are looking for the mole fraction of water. Rearranging Equation 5-10,

Equation 5-11

$$N_{H2O} = \frac{P_{sat} \times RH \times \sum N_{dry}}{P_{tot} - P_{sat} \times RH}$$

$\sum Ndry = \textit{total moles of all constituents of mixture other than water}$

5.3. Fuel Cell Stack Coolant Conductivity Calculations

As discussed in Sections 1.2.3 and 2.2, the fuel cell stack should be kept electrically isolated for safety and to prevent the stack from corroding. One potential current leakage path is through the stack coolant. It is assumed that the piping and equipment in the coolant loop is bonded to earth or chassis. Current leakage through the coolant from cell to cell within the stack or between stacks that are electrically in series must also be prevented.

All of these paths should be calculated to determine which one will limit the allowable coolant conductivity. There may also be an absolute maximum coolant conductivity given in your fuel cell stack specification. If so, the maximum allowable conductivity will be the minimum of either the lowest calculated value or the specified value.
The following equations are used for the coolant conductivity calculations that follow.

a. Coolant resistivity

Equation 5-12

$$? = \frac{R \times A}{L}$$

$$? = \text{coolant resistivity, } \Omega \bullet \text{cm}$$

$$A = \text{coolant path cross-sectional area, cm}^2$$

$$L = \text{length of coolant path, cm}$$

b. Coolant conductivity

Equation 5-13

$$s = \frac{1}{?}$$

$$s = \text{conductivity, siemens/cm}$$

5.3.1. Stack-To-Earth Isolation

Determine the resistance for the stack-to-earth or stack-to-chassis leakage path required by the applicable standard. Divide by the maximum stack voltage (usually open circuit voltage) to determine the allowable overall current leakage from stack to earth or stack to chassis.

This leakage current must be allocated among the various leakage paths (stack electrical isolation, electrical isolation of the bus, etc.). Decide what part of the overall leakage current will be allocated to leakage through the coolant. Ten percent can be used as a starting point.

Divide this current by the maximum stack voltage to determine what the resistance of the coolant must be.

Find the allowable coolant resistivity using Equation 5-12 and the allowable coolant conductivity using Equation 5-13.

For this calculation, the coolant cross-sectional area **A** should be the largest cross-sectional area in the part of the coolant circuit under consideration. This may occur in the fuel cell stack manifold or in the Thermal Management Subsystem piping. The cross-sectional area of the coolant channel in the stack manifold should be given in the specification for your fuel cell stack.

The length of coolant path **L** is the distance a slug of coolant would have to travel to go from a live surface in the fuel cell stack to some spot in the coolant piping that is bonded to earth or chassis. There may be a section of isolated coolant path built into the stack coolant manifold; consult the specification for your fuel cell stack. This can be supplemented by isolating an additional length of the coolant piping.

If the fuel cell stack coolant inlet and outlet geometries are different, this calculation should be done for both inlet and outlet.

5.3.2. Cell-to-Cell Isolation

One of the sources of fuel cell stack inefficiency is current leakage from cell to cell within the stack. One of the cell-to-cell leakage paths is through the coolant.

Determine how much stack current will be allocated to internal leakage. This will depend on the required stack life, but 0.1% of the maximum stack current is a good starting place. A lower value should be used if a very long stack life is required.

Of the overall internal leakage current, determine how much will be allocated to the coolant path. Again, 10% is a good starting place.

Multiply the maximum stack current by these two percentages to find the allowable internal leakage current through the coolant path. Divide this current by the maximum stack voltage to determine what the resistance of the coolant must be.

Find the allowable coolant conductivity using Equation 5-12 and Equation 5-13.

For this calculation the length of coolant path **L** is the cell pitch (thickness of one unit cell) and the coolant cross-sectional area **A** is the area of the channel that distributes coolant from cell to cell. If the inlet and outlet channel geometries are different, use the one with the larger cross sectional area. The length of the coolant path and the cross-sectional area should be given in the specification for your fuel cell stack.

5.3.3. Isolation Between Stacks In Series

This calculation only applies if the Fuel Cell Module uses multiple fuel cell stacks arranged electrically in series. It also applies if the fuel cell stack consists of multiple cell rows arranged electrically in series.

Fuel cell stacks that are arranged electrically in series usually receive their reactants and coolant in parallel. That means there is a path through the coolant for leakage between the cells on the same end of the stacks or cell rows. These cells will be at substantially different voltages.

The first step in the calculation is to determine the voltage differential. The maximum will be between end cells that receive coolant in parallel. The voltage depends on the number of stacks and the electrical arrangement. The electric current may zigzag through the stacks or cell rows, as shown in sketch A of Figure 5-1, or may flow in the same direction through all the stacks or cell rows, as shown in sketch B of Figure 5-1.

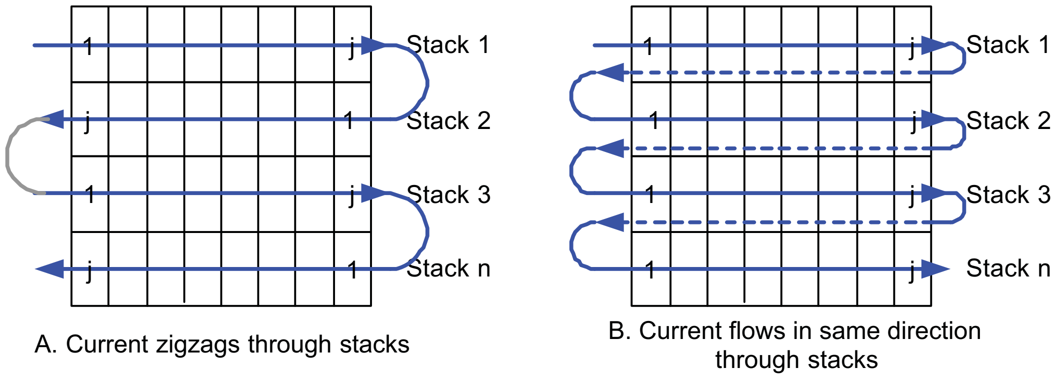


Figure 5-1 Current flow through stacks electrically in series

If the stacks are arranged so the current zigzags and there are an even number of stacks, the maximum voltage will occur between cell 1 of stack 1 and cell *j* of stack *n*. The maximum voltage will be the stack open circuit voltage multiplied by the number of stacks.

If the stacks are arranged so the current zigzags and there are an odd number of stacks, the maximum voltage will occur between cell 1 of stack 1 and cell 1 of stack *n*. The maximum cell voltage will be the stack open circuit voltage multiplied by the number of stacks minus 1.

If the stacks are arranged so the current flows through all the stacks in the same direction, the maximum voltage will occur between cell 1 of stack 1 and cell 1 of stack *n*. The maximum cell voltage will be the stack open circuit voltage multiplied by the number of stacks minus 1.

For this calculation we can use the same internal stack current that we allocated in the cell-to-cell current leakage calculation in paragraph 5.3.2 above. Use Equation 5-12 and Equation 5-13 to find the allowable conductivity. For this calculation the length of coolant path **L** is the coolant path distance between the two cells of interest and cross-sectional area **A** is the maximum cross-sectional area of this channel. If your stack is composed of multiple cell rows arranged electrically in series, the coolant channel should be part of the stack manifold and the length and area should be given in your stack specification.

Operation Guide

Ovonic™ Solid Hydrogen Storage Canisters

60 / 250 / 760 standard liters

Heliocentris

Operating Instructions for *Ovonic™ Solid Hydrogen Storage Canisters*

3rd Edition, November 2007

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GENERAL NOTES FOR THE USER

***Heliocentris Energiesysteme GmbH* provides this documentation to facilitate the safe and correct use of *Ovonic^{TM} Solid Hydrogen Storage Canisters*. All statements, technical information and recommendations in this documentation and accompanying documents are believed reliable, but the accuracy and completeness thereof are not guaranteed or warranted. They are not intended to be, nor should they be understood to be, representations or warranties concerning the products described.**

Ovonic^{TM} Solid Hydrogen Storage Canisters have been developed and manufactured according to recognized technical regulations and have been tested for function and safety before delivery.

Ovonic^{TM} Solid Hydrogen Storage Canisters have been sold subject to the limited warranties set forth in the warranty statement. Further, Heliocentris reserves the right to make changes in the specifications of the products described in this manual at any time without notice and without obligation to notify any person of such changes.

Ovonic^{TM} Solid Hydrogen Storage Canisters are intended for operation only by trained personnel familiar with the use of similar equipment and with safety requirements for the use of Hydrogen. Before operating a storage canister, make sure to read and understand the information provided herein. If you have questions, please contact *Heliocentris Energiesysteme GmbH* or your supplier.

SYMBOLS USED IN THIS GUIDE

The following symbols are used in the Operation Guide to indicate warnings and specific dangers:

	**Warning**	Indicates a potentially dangerous situation. Serious injuries can occur if this reference is ignored.
	**Warning**	Indicates danger of explosion.
	**Prohibition**	**No open fire!**
	**Prohibition**	**Smoking prohibited!**
	**Prohibition**	**Do not attempt to extinguish with water!**
	**Reference**	Draws attention to application tips and other useful information. This is not a reference to dangerous situations.
	**Indicates highly flammable material.**	

TABLE OF CONTENTS

1. Warnings and Safety Instructions

***Ovonic^{TM} Solid Hydrogen Storage Canisters* are laboratory equipment designed for operation by trained personnel for development and demonstration purposes in education and research.**

***Ovonic^{TM} Solid Hydrogen Storage Canisters* are not "consumer-oriented" products, which appropriate operation are generally known and which are protected against operation errors or inappropriate use. Improper operation or abuse can lead to dangers to the health of the operator, the storage canisters themselves and other property items.**

***Ovonic^{TM} Solid Hydrogen Storage Canisters* must only be used by qualified personnel who have received appropriate training, who are familiar with these operating instructions and who understand the procedures of dealing with Hydrogen gas.**

***Ovonic^{TM} Solid Hydrogen Storage Canisters* are equipped with temperature and pressure-sensitive relief valves. These valves provide pressure release of the canisters in case of unexpected extreme operation or storage conditions e.g. open fire. The release conditions of the valves are specified under *Technical Data*.**

The operating and maintenance conditions laid down in these Operating Instructions must be observed. If *Ovonic^{TM} Solid Hydrogen Storage Canisters* are passed on to a third party, the Operating Instructions must also be passed on.

The connections of the storage canisters as well as the whole Hydrogen system must be regularly examined for tightness. The storage canisters must be checked regularly for damage, deformation, etc. If irregularities are found, immediately stop using the system and inform Heliocentris.

Note for use in Member States of the European Union:
This metal hydride storage canister complies with the provisions of article 3, paragraph 3 of Pressure Equipment Directive. The requirement of sound engineering practice of a Member State of the European Union has been met. The canister does not need to be “CE” certified. Once delivered and filled with Hydrogen, the canister is only allowed to be used “in place”, meaning that transportation of the metal hydride storage canister is prohibited. Especially the transport when filled with Hydrogen is prohibited under ADR/RID, GGVS/GGVE, IMDG/GGVSee, ICAO-TI and IATA-DGR.

1.1 Restricted Use

The *Ovonic^{TM} Solid Hydrogen Storage Canisters* are used to store pure gaseous Hydrogen in a solid form and under a low pressure level. The stored Hydrogen can be provided to a fuel cell system or other Hydrogen consuming systems.

The *Ovonic^{TM} Solid Hydrogen Storage Canisters* may only be used for experimentation, demonstration or research purposes. All other uses are not intended and therefore prohibited.

For safety reasons, unauthorized modifications or changes to the canisters are prohibited, since this can cause Hydrogen leakage. The canisters may not be disassembled.

To refill the canisters from a standard compressed Hydrogen cylinder, use the supplied refilling kit only.

1.2 Authorized Operators

Anyone setting-up, operating or maintaining *Ovonic™ Solid Hydrogen Storage Canisters* must be aware of applicable local industrial health and safety regulations. Unsafe conditions may result if the canisters are operated by untrained personnel or by personnel unfamiliar with Hydrogen safety.

Therefore the only personnel allowed to use the canisters are those:

- **who are familiar with Hydrogen safety standards,**
- **whose training give them the necessary knowledge and skills needed to safely operate a Hydrogen containing system,**
- **who have been instructed on proper handling and informed about the potential dangers involved with *Ovonic™ Solid Hydrogen Storage Canisters* ,**
- **who are familiar with this Operation Guide.**

Measures must be taken to prevent unauthorized persons installing, operating or maintaining the storage canisters

In education, the *Ovonic™ Solid Hydrogen Storage Canisters* may only be used by students under the supervision of teaching staff. As the teacher you must ensure proper handling of the storage canisters. You have an obligation to draw attention to potential dangers. Installation, start-up, shut-down and maintenance of the storage canisters may be done only through the teaching staff.

1.3 Workplace

The *Ovonic™ Solid Hydrogen Storage Canisters* are intended for installation and operation in a suitable laboratory area.

- **In particular, the room must be equipped with an effective air-evacuation system that prevents the formation of explosive Hydrogen-air mixtures in the event of any uncontrolled escape of Hydrogen.**
- **Measures must be taken to avoid electrostatic discharge.**
- **Local safety regulations that apply at the installation site must be observed.**
  This applies in particular to the use and storage of Hydrogen compressed gas cylinders that are not part of the supplied system.
- **The storage canisters must be installed and stored in a position such that no danger results from a possible opening of the relief valve.**
- **Do not block the relief valve.**
- **Measures must also be taken to prevent the canisters from toppling or falling down.**
- **The permissible working temperature is according to the Technical Data.**

1.4 Sources of Danger

Source of danger	Possible consequences	Preventive measures
Storage canister contains **Hydrogen**	  **Hydrogen is a highly flammable gas.** ⇓ **Danger of fire and ignition when opening the canister**	  • No open fire! No smoking! • Keep away from sources of ignition • Take precautions against electrostatic charge. • Do not open the canister. Do not remove the valve • Store and operate the canister in a well-ventilated place • Do not allow that Hydrogen can be collected in an enclosed or unventilated area. • Regular examination of the Hydrogen piping and connections for leaks.
	Hydrogen can displace oxygen in enclosed or unventilated areas. ⇓ **Risk of asphyxiation.**	
Storage canister contains **pyrophoric / self heating metal powder**	 **Danger of fire when opening the canister**	 • **In case of fire use class D powder extinguisher.** • **Do not use carbon dioxide extinguisher or water.** • Do not open the canister. Do not remove the valve
Canister is under **pressure**. Pressure rises with increasing temperature.	Unauthorized excess pressure	• Do not expose to sunlight; protect the canister from temperatures above 50 °C • Do not heat a filled storage canister without releasing Hydrogen at the same time • The maximum working pressure of the canister must not be exceeded at any time (see technical data)

1.5 Special Safety Considerations for Handling Compressed Hydrogen Cylinders

You must be aware of and follow local safety regulations for handling compressed gas cylinders and Hydrogen.

In a full compressed Hydrogen cylinder, the pressure is approximately **200 bar**.

Compressed Hydrogen cylinders may not be stored in closed areas without appropriate installations. For indoor storage, special gas cylinder cabinets with a permanent explosion-proof exhaust are required. If this is not possible, cylinders must be stored outdoors.

When using the cylinders in a laboratory area, the following precautions are recommended:

- Provide good ventilation of the area.
- Smoking and open flame are forbidden.
- Avoid sources of heat near the compressed Hydrogen cylinder and Hydrogen piping.
- Take measures to prevent electrostatic charges.
- Use equipment provided by your Hydrogen supplier to prevent the cylinder from falling over.
- The cylinders must not be left unsupervised in the area.

If no Hydrogen is being used, always close the main valve on the compressed Hydrogen cylinder.

1.6 Safety Precautions in an Emergency

Significant Hydrogen escape:

- **Do not operate electrical devices, light switches, etc. as an explosive gas mixture could be present in the area.**
- **Immediately shut off the Hydrogen source.**
- **Provide adequate ventilation to clear the affected area.**

In case of leakage or canister damage, Hydrogen may be released. Due to the nature of metal hydrides, only a small portion of the stored Hydrogen will be released spontaneously. The canister temperature will decrease and further Hydrogen release will occur at a fairly low rate. Therefore it is recommended to put the leaking canister in a well ventilated place (if possible outside of the building) until the canister is completely empty. During this time the canister should be on a fire-proof base away from any sources of ignition. The area should be marked in a suitable way.
Only the manufacturer can repair a damaged storage canister.

Fire or explosion: **Immediately inform the fire department**

Hydrogen burning: **Note: Hydrogen flames are not visible!**

- Evacuate and secure the area and building
- Leave escaping Hydrogen gas to "burn down".

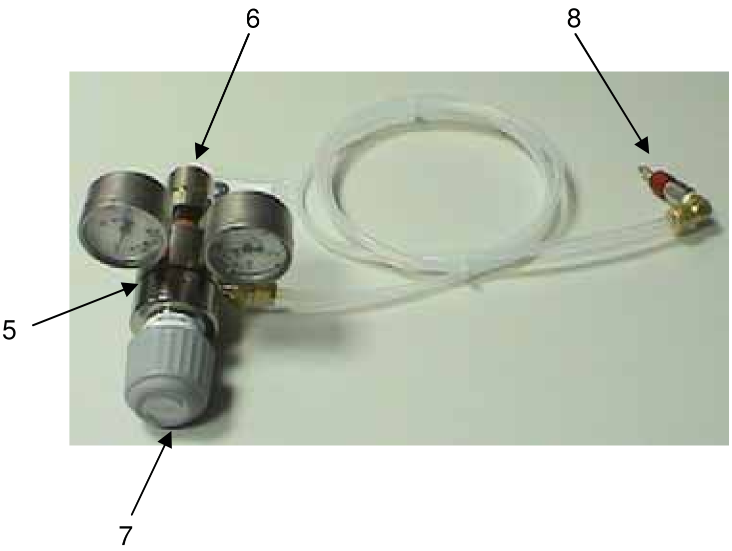
Metal hydride powder burning:

- Evacuate and secure the area and building
- Suffocate fires with class D fire extinguisher or dry sand
- **Do not use water or CO_2 extinguishers**
- If smoldering metal hydride powder cannot ignite adjacent materials, it may be best to leave the hydride burning.

2. Product Overview

2.1 Parts List

Refilling Kit (Optional item)



1	Quick coupler (female)
2	Relief valve
3	Shut-off valve
4	Storage canister
5	Single-stage regulator with pressure gauges for cylinder and delivery pressure
6	Standard connection for compressed Hydrogen cylinders
7	Knob for adjustment of the delivery pressure
8	Connecting line 1/4" with coupling plug for metal hydride storage canister

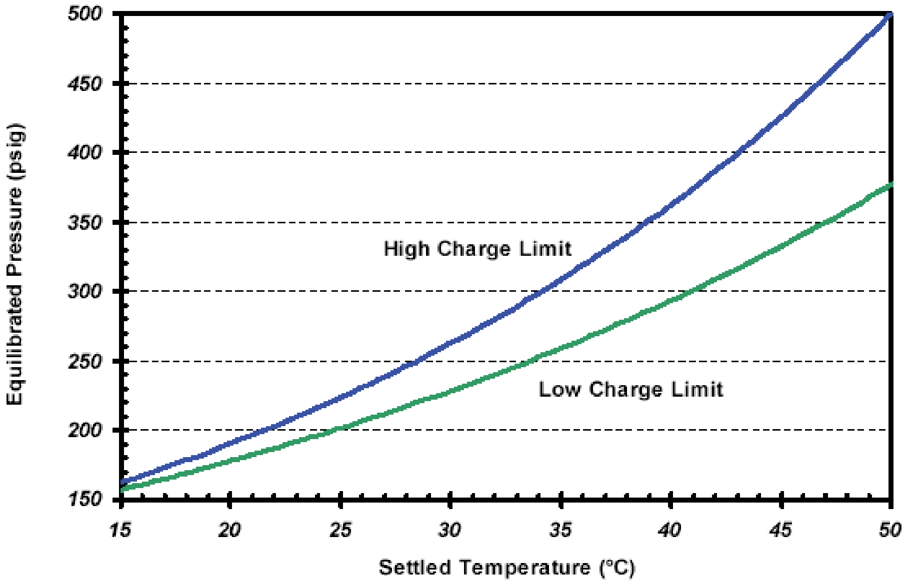
2.2 Basic Function

The storage canister (4) is filled with a special metal hydride alloy. It has a shut-off valve (3) and a gas outlet with quick-coupler (1). Using the Refilling Kit, metal hydride storage canisters can be re-filled from commercial compressed Hydrogen cylinders.

Metal hydride storage is based on the chemical reaction of Hydrogen with certain metal alloys which are able to chemically bind Hydrogen in a reversible reaction. The absorption of Hydrogen is an exothermic process; the Hydrogen delivery is an endothermic process. Both procedures are influenced by the thermodynamic properties of the chemical reactions between Hydrogen and the respective metal alloys. The Hydrogen pressure in the storage canister mainly depends on the temperature of the metal alloy.

2.3 Pressure Temperature Characteristic

Gas pressure in the storage canister rises with increasing canister temperature. Depending upon filling level, various pressures can be achieved. The following graphic shows approximate values for a typical pressure-temperature behavior of the used storage alloy. To avoid a sudden increase in pressure, a fully filled canister should never be heated without simultaneously releasing Hydrogen.



In case of leakage or canister damage, Hydrogen may be released. Due to the nature of metal hydrides, only a small portion of the stored Hydrogen will be released spontaneously. The canister temperature will decrease and further Hydrogen release will occur at a fairly low rate.

2.4 Technical Data

	Canister Type		
	70	220	900
Storage capacity: • Max. • if charging @ 10 bar gauge	60 sl ≈ 45 sl	250 sl ≈ 160 sl	760 sl ≈ 500 sl
Intended gas specification	Dry Hydrogen, purity 5.0 or higher		
Gas connection	Quick-coupler Parker, type Q4CY		
Discharge operation: • Discharging pressure • Max. canister temperature	Approx. 8 bar gauge @ 20 °C (initially higher) +50 °C		
Charge operation: • Recommended charging pressure • Max. charging pressure • Allowed canister temperature	10 bar gauge @ +20 °C 17 bar gauge +15 ... +30 °C		
Max. storage temperature	+50 °C		
Opening conditions of relief valve	P ≈ 82 bar / T ≈ +88 °C		
Dimensions (∅ x length)	51 x 205 mm	64 x 305 mm	90 x 425 mm
Weight	0.8 kg	2.2 kg	7 kg

	Refilling Kit (optional item)
Pressure regulator	Single stage, Hydrogen gas
Input connection	Hydrogen cylinder connection for appropriate national standard
Cylinder pressure	200 bar gauge
Delivery pressure	max. 17 bar gauge
Hydrogen connecting tube	PFA, external diameter 1/4"
Connection to storage canister	Parker quick-coupler, type Q4VY
Recommended operating temperature	+ 5 … +35 °C
Dimensions (l x w x h)	190 mm x 115 mm x 110 mm
Weight	1.6 kg

3. Installation and Use

3.1 Shipping State, Installation and First Use of the Metal Hydride Canister

Usually the metal hydride canisters will be shipped separately from other components. The shipping state of the canisters depends on the region where the customer is located. These different shipping states cause different initial handlings of the canisters.

Customers in Europe:

In Europe the storage canisters are delivered with activated metal alloy, however **without Hydrogen**. Instead they are filled with Helium gas under low pressure. Helium has no effect on fuel cells. However, Helium in the storage canisters will dilute the Hydrogen, and less power could be available from the fuel cell system until the Helium has been purged. To prepare a storage canister for use:

- Follow the two procedures in **3.2 Refilling …**, paying attention to the note in step 7 which suggests only partially filling the canister.
- Then use the Hydrogen in the normal way in the fuel cell system. Power output from the system will not be optimal.
- When the canister becomes depleted, fill it again in the regular way to obtain full capacity of Hydrogen storage.

Customers in the US and Canada:

Customers in the USA and Canada will receive **fully activated and Hydrogen filled** canisters. They can directly start operation according the procedure in **3.3**.

3.2 Refilling a Metal Hydride Storage Canister with Hydrogen

If the pressure in the storage canister is less than 1 bar gauge when the canister is at ambient temperature, the canister must be refilled.

For refilling the storage canister we recommend Hydrogen of purity 5.0 (99.999%). The canister can also be refilled with Hydrogen of purity 3.0, but Hydrogen quality lower than 5.0 leads to a progressive decrease in capacity because the surface of the metal alloy is sensitive to impurities.

Do not allow water, oil, air, or any substances other than pure Hydrogen (or Helium or Argon) to enter the metal hydride storage canister.

Procedure for refilling from a compressed Hydrogen cylinder:

Prevent electrostatic charges, and ensure good ventilation. No smoking or open flame!

1. Place the compressed Hydrogen cylinder on the floor and use the supplied cylinder support or appropriate equipment provided by your Hydrogen supplier to prevent the cylinder from falling over.
2. Before attaching the regulator, in order to clear out impurities, carefully open the main valve of the Hydrogen cylinder for one second.

Note: The cylinder is at high pressure. Do not direct escaping gas toward personnel.

3. Remove the protective cap from the inlet connection (6) on the refilling kit regulator (5). Screw the regulator onto the compressed Hydrogen cylinder and tighten it by hand. **The regulator and cylinder have left-hand threads.**
4. Carefully open the Hydrogen cylinder main valve. Set a delivery pressure of 1 bar gauge with knob (7) at the refilling kit regulator.
5. **Flush the refilling kit**: With your thumb, press the valve of the quick-coupler at the end of the Hydrogen connecting tube (8) for approximately 2 seconds, so that the connecting tube is flushed completely with Hydrogen gas. This ensures that only Hydrogen, not air, will enter the storage canister.
6. **Refill the storage canister:** To fill the storage canister (4) with Hydrogen, attach the connection tube of the refilling kit to the canister's quick-coupler (1). Open the shut-off valve (3) of the storage canister. Then adjust knob (7) of the regulator at the Hydrogen cylinder, increasing the filling pressure to **10 bar**.

   Filling the storage canister must be done in the horizontal position. Do not exceed 15 bar pressure when filling. Unless Hydrogen is being used, never warm a fully filled canister or excessive pressure can occur.

   Note: If the canister warms noticeably, this is an indication that Hydrogen is being absorbed. Filling should begin at a canister temperature of 15 °C. Usually the temperature does not rise beyond 50 °C, because at a certain temperature the hydride formation stops and no further heat is generated. Cooling the tank during charging is not required, but cooling by air ventilation will reduce the charging time.
7. Wait until the tank temperature has returned to the starting temperature. This indicates the charging operation is complete. The refilling can also be terminated earlier. In this case the storage canister is only partially filled with Hydrogen.

   Note: If this is the initial charging of the canister, it is not necessary to completely fill the cylinder, but wait only 10 minutes to absorb enough Hydrogen to effectively dilute the pre-charge of Helium gas.
8. Close the main valve of the compressed Hydrogen cylinder.
9. Close the shut-off valve (3) of the storage canister (4).
10. Disconnect the connection tube of the refilling kit from the quick-coupler of the storage canister (1).
11. Use a small hard object to momentarily depress the valve of the refilling kit quick-coupler, releasing all pressure in the filling mechanism, so that the gauge returns to zero.

    The regulator must be pressure-free before unscrewing it; otherwise the gasket at the cylinder connection can be destroyed.

13. Unscrew the regulator from the cylinder. **Left-hand threads!**

3.3 Using Hydrogen from the Metal Hydride Storage Canister

After successful installation and having made all connections the shut-off valve (3) of the storage canister needs to be opened. When the fuel cell system is in operation, Hydrogen flows from the storage canister into the fuel cell system.

While the storage canister is delivering Hydrogen (discharging), the canister temperature decreases and the pressure in the canister decreases correspondingly. To keep the Hydrogen pressure constant, the storage canister needs to absorb heat from the environment. Normal air circulation is generally enough. Take care that while operating the fuel cell system, the storage canister pressure does not decrease below 1 bar gauge. If it does, reduce the load on the fuel cell system until the storage canister again warms to room temperature and shows higher pressure.

If the pressure within the storage canister falls below 1.0 bar gauge while the canister is at room temperature, the **storage canister needs to be refilled.**

You should keep some pressure in the storage canister at all times. If the canister has little or no pressure at a particular temperature, and the canister becomes further cooled, a negative pressure can develop, sucking air into the canister through the open valve.

3.4 Pausing and Shutting Down

When you are not using Hydrogen from the canister you have to close the shut-off valve (3) of the metal hydride storage canister.

4. Maintenance and Repair

To preserve the storage capacity over a long lifetime, Hydrogen of 5.0 purity (99.999%) should be used.

To further preserve the storage capacity avoid completely emptying the canister and/or refilling it without allowing the canister to cool down. Alternatively the empty canister can be filled with Helium.

To assure functioning of valves, quick couplers, release valves etc. over a long time, protect these components from dust and particles.

All connections at and to the tank must be regularly checked for leakage.

5. Warranty and Complaints

The warranty period for *Ovonic™ Solid Hydrogen Storage Canisters* is 6 months. The warranty period begins on the day of delivery and only covers damage that occurs in the context of proper use through no fault of the operator.

A warranty for specific features (including lifetime and performance over time) is not given.

Warranty claims to Heliocentris shall be deemed invalid if:

- The customer caused the damage by incorrect operation.
- The equipment has been arbitrarily repaired or altered.
- The customer has neglected his/her duty of supervision, and damage has been caused by third parties.

The supplier is liable for damage caused during delivery to the customer and will ensure replacement in the event of any damage.

The customer bears the risk in the event of complaint and the return of the product or components thereof for repair, and must ensure proper and safe packaging.

In case of any questions or problems with the product, please contact your distributor or Heliocentris directly.

6. End of Live Instruction

The product disposal has to be done according the statutory provisions of the respective region of use.

PROTON
THE LEADER IN ON SITE GAS GENERATION.

PD-0100-0001
REVISION M

HOGEN® S SERIES 2
HYDROGEN GENERATOR

Installation & Operation Instructions

Model Numbers:
54-0101-0000: HOGEN Hydrogen Generator
54-0101-0001: HOGEN 40 Load Following Hydrogen Generator
54-0101-0002: HOGEN 40 Tank Filling Hydrogen Generator
54-0101-0005: HOGEN 20 Load Following Hydrogen Generator
54-0101-0006: HOGEN 20 Tank Filling Hydrogen Generator
54-0101-0013: HOGEN 20 Tank Filling Hydrogen Generator

Serial Number ____________________

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SIC 3569-901	Gas Generating Equipment
NAICS 333-999-8556	Gas Generating Equipment

HOGEN S Series 2 Hydrogen Generator

INSTALLATION/OPERATION INSTRUCTIONS

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1 INTRODUCTION

The HOGEN S Series 2 hydrogen generator is a fully automated Proton Exchange Membrane (PEM) based water electrolysis system. Depending on the mode, the HOGEN generator is designed to output up to 40 standard cubic feet per hour (SCFH) of 99.999 percent pure hydrogen. Hydrogen is delivered at a maximum of 200 psig (13.8 barg). The HOGEN generator's operation is continuous when supplied with power and deionized water. It is designed for indoor operation only.

Proton Energy Systems, Inc. (PROTON) has provided these instructions to guide the installation and operation of a HOGEN S Series 2 hydrogen generator. It provides technical product information. Installation requirements are also provided, along with detailed mechanical and electrical interface specifications. Important safety information is also included in this guide. Please take time to familiarize yourself with the system and the manual.

DO NOT USE THE HOGEN S SERIES 2 HYDROGEN GENERATOR IN A MANNER NOT SPECIFIED BY THE MANUFACTURER.

IT IS THE CUSTOMER RESPONSIBILITY TO CONSULT WITH THE LOCAL BUILDING INSPECTOR AND/OR FIRE MARSHALL REGARDING LOCAL CODE REQUIREMENTS FOR INSTALLATION AND OPERATION OF THIS EQUIPMENT.

Figure 1 HOGEN S Series 2 Hydrogen Generator

This manual attempts to answer most of the frequently asked questions with regards to installation and operation of the unit. However, should you have any questions, the PROTON technical staff stands ready to answer them and support the successful deployment of this equipment. Please call **(203) 949-8697** and ask for field service technical support or email customerservice@protonenergy.com. Please have the part number and serial number of your unit available.

1.1 General Description

The HOGEN S Series 2 hydrogen generator is a fully integrated system that produces hydrogen from water and electricity. The system includes an electrolyzer cell stack, as well as all the auxiliary equipment necessary for regulating electrolyzing operations and pressurizing hydrogen. The auxiliary equipment is used to aid in the functions of the system: circulating water, drying hydrogen, pressurizing hydrogen, and shutting down the system. The unit contains sensors and a control board to aid in monitoring system performance and to automate operation.

Figure 2 shows the HOGEN S Series 2 hydrogen generator schematic. The design also shows the system's boundaries and important interface connections. Water is introduced into the system. Hydrogen, water, and oxygen are emitted.

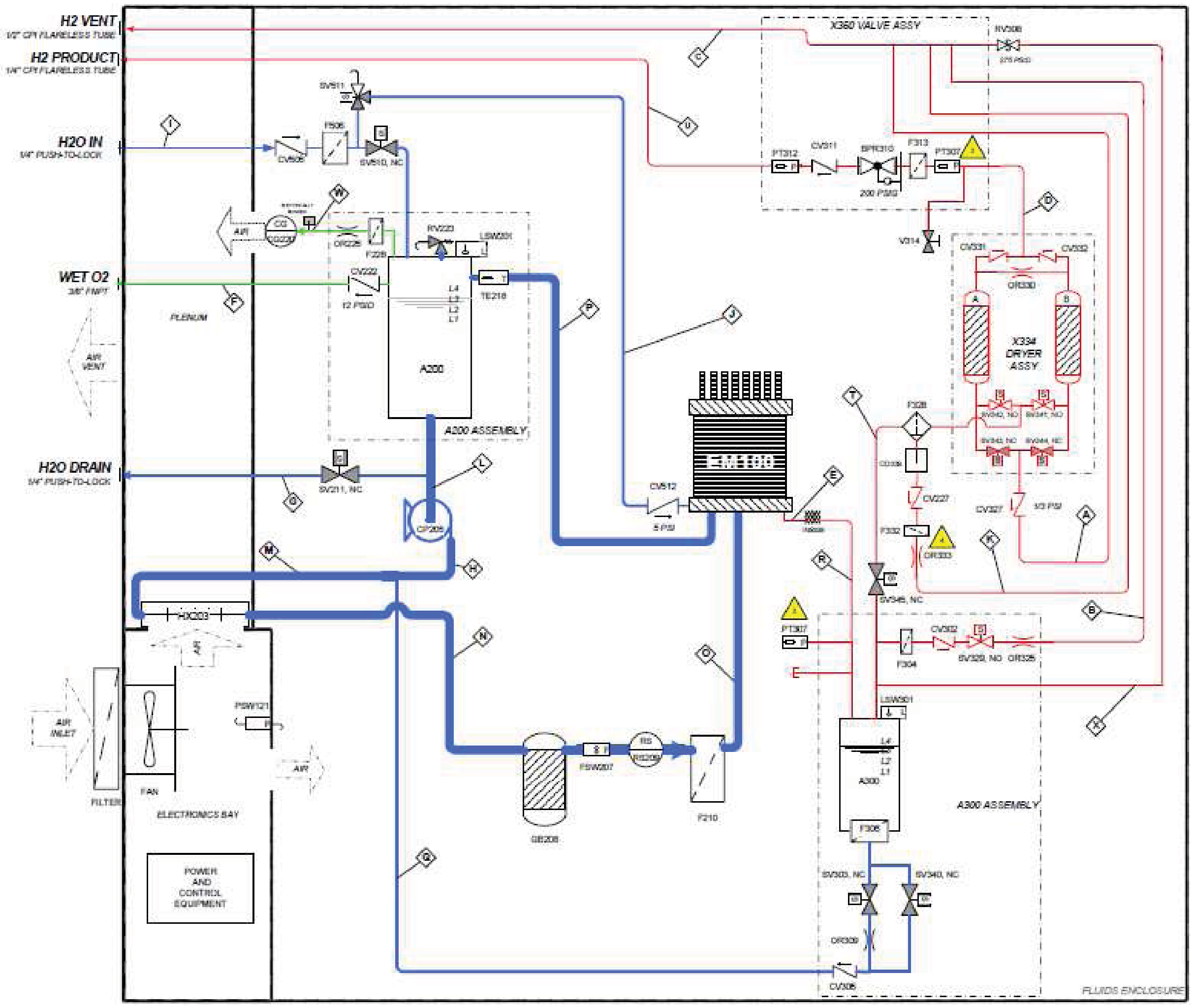


Figure 2 HOGEN S Series 2 Hydrogen Generator Schematic

1.2 Product Specification

Description			
On-site hydrogen generator in integrated, automated, site-ready enclosure. Load following operation automatically adjusts output to match demand.			
Electrolyte			
Proton Exchange Membrane (PEM) – Caustic-Free			
Hydrogen Production			
Requirement	**S10**	**S20**	**S40**
Net Production Rate	10 SCFH (0.26 Nm^3/h) 4.7 SLPM 0.56 kg/24hr	20 SCFH (0.53 Nm^3/h) 9.4 SLPM 1.14 kg/24hr	40 SCFH (1.05 Nm^3/h) 18.8 SLPM 2.27 kg/24hr
Delivery Pressure – Nominal	200 PSIG (13.8 barg)		
Power Consumed/Volume of Hydrogen Gas Produced (Est at EOL)	9.4 kWh/Nm^3 24.6 kWh/100 ft^3	9.0 kWh/Nm^3 23.7 kWh/100 ft^3	8.3 kWh/Nm^3 21.9 kWh/100 ft^3
Purity (Concentration of Impurities)	99.9995% Water Vapor < 5 PPM Water (-65°C/-85°F Dewpoint) N_2 < 2 PPM, O_2 < 1 PPM, All Others Undetectable		
Turndown Range	0 to 100% Net Product Delivery		
Upgradeability	N/A		
DI Water Requirement			
Requirement	**S10**	**S20**	**S40**
Rate at Max Consumption Rate	0.08gal/hr (0.26 L/hr)	0.13 gal/hr (0.47 L/hr)	0.25 gal/hr (0.94 L/hr)
Temperature	41° F to 95° F (5° C to 35° C)		
Pressure	21.8 to 58 PSIG (1.5 to 4 barg)		
Input Water Quality	ASTM Type II Deionized Water Required (< 1 micro Siemen/cm, > 1 megOhm-cm), ASTM Type I Deionized Water Preferred (< 0.1 micro Siemen/cm, >10 megOhm-cm)		
Heat Load and Coolant Requirement			
Requirement	**S10**	**S20**	**S40**
Cooling	Air-Cooled		
Heat Load from System	1.3 kW Max	2.2 kW Max	4.3 kW Max
Coolant	Ambient Air 41° F to 104° F (5° C to 40° C)		
Electrical Specifications			
Requirement	**S10**	**S20**	**S40**
Recommended Breaker Rating (Base Configuration)	6 kVA	8 kVA	12 kVA
Electrical Specification	205-240 VAC, Single Phase, 50 or 60 Hz		
Interface Connections			
Requirement	**S10**	**S20**	**S40**
H_2 Product Port	¼" CPI Compression Tube Fitting, SS		
H_2/H_2O Vent Port	½" CPI Compression Tube Fitting, SS		
DI Water Port	¼" Tube, Push-to-Lock, Polypropylene		
Drain Port	¼" Tube, Push-to-Lock, Polypropylene		

Interface Connections			
Requirement	**S10**	**S20**	**S40**
Electrical	Connect to On-Board Circuit Breaker		
Communications	RS 232, Ethernet		
Control Systems			
Requirement	**S10**	**S20**	**S40**
Standard Features	Fully Automated, Push Button Start/Stop. E-Stop. On-board H2 detection. Automatic fault detection and system depressurization.		
Remote Alarm	Form C Relay (2A/30VDC rated switching)		
Remote Shutdown	Circuit Breaker Shunt Trip		
Enclosure Characteristics			
Requirement	**S10**	**S20**	**S40**
Dimensions (L x D x H)	31" x 38" x 42" (97 cm x 79 cm x 106 cm)		
Weight	475 lbs (215 kg)		
Rating	IP22		
Environmental Considerations			
Requirement	**S10**	**S20**	**S40**
Standard Siting Location	Indoor, Level ± 1°, 0 to 90% RH Non-condensing, Non-hazardous, Non-classified Environment		
Storage/Transport Temperature	41°F to 140°F (5°C to 60°C)		
Ambient Temperature Range	41°F to 104°F (5°C to 40°C)		
Altitude Range – Sea Level to:	5000 ft (Sea Level to 1520 m)		
Ventilation	Proper ventilation must be provided from non-hazardous area at a rate in accordance with IEC60079-10, Zone 2 NE		
Safety and Regulatory Conformity			
Requirement	**S10**	**S20**	**S40**
Cabinet Ventilation with Environment	NFPA 69 and EN 1127-1, Clause 6.2		
	Vent Fan Draws Fresh Air Up to 28 m^3/min 1000 ft^3/min		
Noise (dB(A) at 1 Meter)	< 70 dBa		
Approvals	cTUVus (UL and CSA equivalent), CE (PED, ATEX, LVD, Mach. Dir., EMC); NYFD Approval Received		

Table 1 HOGEN S Series 2 Hydrogen Generator Specifications

2 SAFETY

The safety guidelines below may not cover all situations. If there are concerns or questions, please call PROTON or check with local authorities.

2.1 General Information

This system produces hydrogen. It is important for users to be aware, understand, and comply with all local safety requirements related to the handling of hydrogen and compressed gases.

2.2 Using Hydrogen Gas

Hydrogen is odorless, tasteless, colorless, and highly flammable. It is highly combustible in the presence of oxygen and burns with a colorless flame.

Leaking gas may be hot and pose a burn danger. If you are not in danger, stop the flow of gas and use water to cool the area. The lower explosive limit of hydrogen is 4 percent by volume. If fire occurs, do not attempt to extinguish flames, allow the fire to burn out.

Prevent overexposure to hydrogen. Hydrogen is non-toxic but can act as a simple asphyxiant by displacing the oxygen in air. Effects of oxygen deficiency resulting from simple asphyxiants include: rapid breathing, diminished mental alertness, impaired muscular coordination, faulty judgment, depression off all sensations, emotional instability, and fatigue. As asphyxiation progresses, nausea, vomiting, prostration, and loss of consciousness may result.

FIRE OR EXPLOSION - KEEP ALL SOURCES OF IGNITION AWAY FROM HYDROGEN.

BYPASSING ANY OF THE HYDROGEN GENERATOR SHUTDOWN CIRCUITS IS NOT ADVISEABLE. OPERATION OF THE GENERATOR WITH BYPASSES INSTALLED COULD RESULT IN SERIOUS INJURY AND/OR DAMAGE TO THE GENERATOR.

3 INSTALLATION

The HOGEN S Series 2 hydrogen generator is a fully integrated system. To install the HOGEN generator, mechanical, electrical, communication, and packaging interface requirements must be met. This section describes the interface and installation requirements.
Figure 2 introduces the mechanical system boundaries and principle interfaces for integration. Figure 3 illustrates the hardware, mounting points and connections for system integration and packaging.

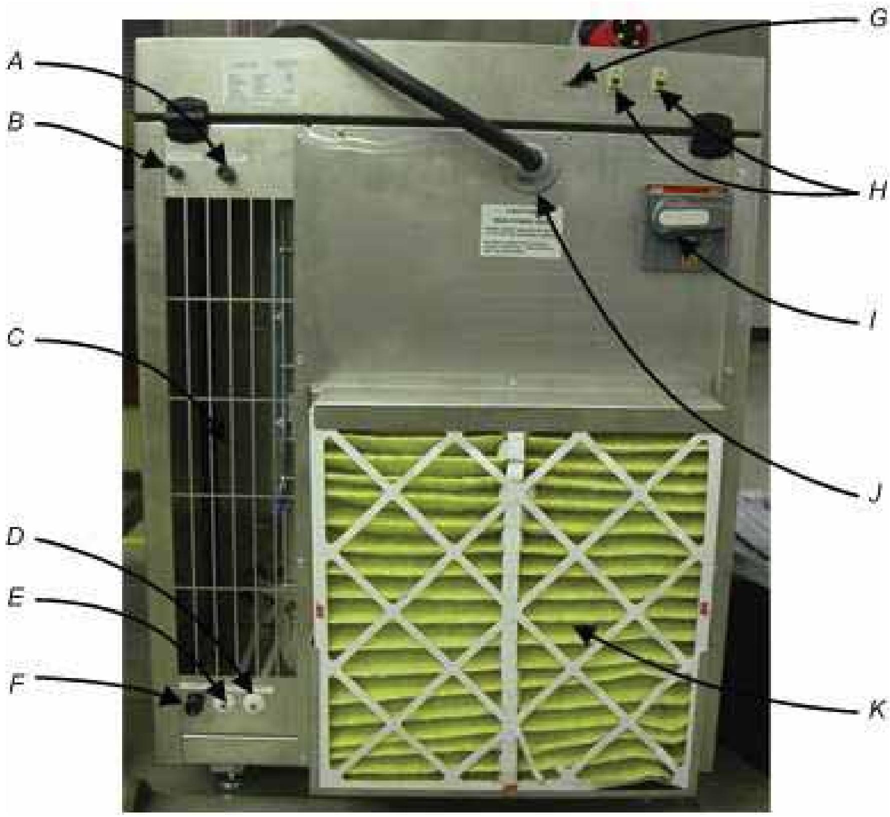


Figure 3 HOGEN S Series 2 Hydrogen Generator Interface Connections

Reference	Interface Connection	Reference	Interface Connection
A	H_2/H_2O Vent Port	G	Remote Shutdown Serial Port
B	Product Hydrogen Port	H	Modem/Ethernet Connections
C	Purge Air Exhaust	I	Main Power Disconnect Switch
D	Water Inlet Port	J	AC Power Feed
E	Water Drain Port	K	Purge Air Inlet
F	Oxygen Vent Port		

Table 2 HOGEN S Series 2 Hydrogen Generator Interface Connections

The top-level steps of installation are as follows:

1. Installing proper ventilating schemes within the area the HOGEN generator is to occupy.
2. Verifying the proper environmental conditions the HOGEN generator is to be exposed to.
3. Siting the unit.
4. Connecting electrical interfaces.
5. Connecting mechanical interfaces.
6. Calibrating the combustible gas detector.
7. Installing the cell stack.
8. Hydrating the cell stack.

Each of these steps is described in further detail in their sub-sections within this section.

3.1 Shipping Crate Removal Instructions

1. Using a Phillips screwdriver, remove 14 Phillips screws from the top cover of the crate.
2. Remove the top cover from the crate. (Refer to Figure 4.)

Figure 4 Removing Top Cover

3. Using a Phillips screwdriver, remove a total of 11 Phillips screws (five {5} on the right panel, five {5} on the left panel, and one {1} on the bottom of the front panel) to loosen the front panel of the crate. (Refer to Figure 5.)

NOTE

The front panel of the crate is marked with the words "Removable Panel."

NOTE

The screws that need to be removed from the crate are marked with red for recognition purposes.

Figure 5 Removing the Front Panel Marked "Removable Panel"

4. Remove the front panel.

Ensure that trained personnel use the forklift to avoid serious injury and potential damage to the unit.

5. Using a forklift, slide the left fork underneath the left side of the unit and the right fork underneath the right side of the unit.
6. Using a forklift, lift the unit up 6 inches before backing the unit out of the crate. (Refer to Figure 6.)

Figure 6 Removing Unit from Crate with Forklift

Do not slide or push unit on its leveling feet. The leveling feet will break off. Leveling feet must be fully retracted and the unit must be lifted to be moved.

3.2 Facility Air Ventilation Requirements

The HOGEN generator design implements ventilation in accordance with EN60079-10, Zone 2, NE. In reference to NFPA 496, a Type Z pressurized ventilation scheme is implemented. A blower at the fresh air inlet forces an excess of 750 cubic feet per minute (CFM) of fresh purge air through the electrical compartment, through the HOGEN generator compartment, and then through the exhaust. The blower is of sufficient power to maintain an internal positive static air pressure in excess of 0.2 in. (50 mm) of water column. A pressure switch within the HOGEN generator cabinet detects any loss of ventilation pressure and will produce an automatic shutdown of the generator upon loss of pressure. Further, the air purge rate is such that it dilutes any internal hydrogen leakage to a concentration below the lower flammable limit (LFL) of hydrogen in air (4 percent). A combustible gas sensor is located at the exit of the air purge stream to detect the presence of hydrogen. This sensor will cause an alarm and an automatic shut down of the HOGEN generator when it detects the concentration of hydrogen within the purge air stream is in excess of 1.2 percent.

PROTON recommends an area air change rate of several hundred times the maximum generation rate of the HOGEN generator to preclude any possible build up of hydrogen concentration in the facility. In the event of internal equipment failure such that a brief hydrogen leak occurs, the HOGEN generator is equipped with an internal hydrogen detector safety circuit that will stop any further generation of hydrogen by automatically shutting down the HOGEN generator. Additionally, the system can be tied into facility fire detection systems, combustible gas sensors or other external facility alarms as required by the facility manager or local code compliance officials.

THE HOGEN S SERIES 2 HYDROGEN GENERATORS ARE DESIGNED TO OPERATE IN NON-EXPLOSIVE ENVIRONMENTS. IT UTILIZES A FRESH AIR PURGE OF THE SEALED EQUIPMENT CABINET TO ESTABLISH A SAFE, NON-EXPLOSIVE INTERNAL OPERATING ENVIRONMENT (US PATENT 5980726).

Always refer to local code requirements to determine minimum facility ventilation requirements. A worksheet for estimating minimum ventilation at your facility is given below.

How to calculate the ventilation requirements for your site:

1. **Record net hydrogen generation rate (*P*) for your selected generator:**

***P* = ________ Nm^3/h (SCFH)**

NOTE

If there is a plan to have multiple hydrogen generators in the room, *P* must be the sum of all generators.

2. **Calculate the gross hydrogen generation rate (*G*). (Add 10 percent):**

$$G = P \times 1.1 = \_\_\_\_\_\_\_\_ \; Nm^3/h \; (SCFH)$$

3. **Calculate recommended ventilation rate (*F*). (Several hundred times gross generation rate):**

$$F \geq 100 \times G/60 = \_\_\_\_\_\_\_\_ \; Nm^3/min \; (SCFM)$$

4. **Confirm if actual room ventilation (F_A) is adequate, F_A =_______________:**
   a. **Is actual room ventilation (F_A) greater than or equal to *F*? YES/NO**

If you answered YES for 4a, then you may install the unit(s) in the room. If you answered NO for 4a, then you may not site the unit in the room until improvements are made to the ventilation system.

Example Calculation:

1. **Record net hydrogen generation rate (*P*) for your selected generator:**

$$P = 40 \; (SCFH)$$

2. **Calculate the gross hydrogen generation rate (*G*). (Add 10 percent):**

$$G = 1.1 \times P = 44 \; (SCFH)$$

3. **Calculate recommended ventilation rate (*F*). (Several hundred times gross generation rate):**

$$F \geq 100 \times G/60 = 4400 \; (SCFH) / 60 = 73.3 \; SCFM$$

4. **Confirm if actual room ventilation (F_A) is adequate, F_A = 950 SCFM**
   a. **Is actual room ventilation (F_A) greater than or equal to *F*? YES**

3.3 Operating Environment

The HOGEN S Series 2 hydrogen generator has been designed for indoor use only. The HOGEN generator shall be situated on a grade of no more than ± 3 degrees. The area in which the system occupies shall have ventilation schemes described in Section 3.2.

The HOGEN generator is rated for ambient temperatures ranging from 41°F to 104°F (5°C to 40°C). The HOGEN generator is not designed for freezing conditions. If the system is introduced to freezing conditions, damage to the system may occur.

IF FREEZING CONDITIONS EXIST AT YOUR SITE, PRECAUTIONS MUST BE TAKEN TO PREVENT THE UNIT FROM FREEZING.

The HOGEN generator contains a thermistor probe that measures the system water temperature. The maximum rated operating temperature for the HOGEN generator is 140°F (60°C). The system will shutdown automatically when the system temperature is over this rating. Temperatures above the maximum rating will damage the cell stack.

The HOGEN generator can be stored and transported in environments that range from 41°F to 140°F (5°C to 60°C) and 0 percent to 95 percent relative humidity, non-condensing. In the event that the unit is to be transported in a freezing environment, water must be drained from the system and the cell stack is to be taken out of the system and transported separately. Instructions for the decommissioning of the system are detailed in the Service Manual, PD-0300-0001.

If freezing conditions exist at your site, you must take measures to prevent condensation from freezing and obstructing the H_2 vent line and freezing the water supply and drain lines.

3.4 Site Preparation

The HOGEN S Series 2 hydrogen generator is designed for indoor installation on a level concrete pad. AC power and deionized water are the key utilities required. Ensure the generator is located so that it is safe from vehicle traffic and is in compliance with local safety regulations.

The HOGEN generator sits on four leveling feet and weighs about 500 lbs. (227 kg). To move the generator, use a fork truck to lift it from under its frame. Alternatively, straps can be used around the bottom and sides as a lift method. A level floor, ± 3 degrees, capable of supporting the generator is required. The minimum clearance requirements of the area around the generator are shown in Figure 7. It is the customers' responsibility to verify the local code requirements for this type of equipment are met when installing this equipment.

Not using a fork truck or pallet lift to move the HOGEN hydrogen generator may cause harm to the stabilizing structure of the unit.

THE GENERATOR IS TYPICALLY SHIPPED WITH THE CELL STACK ALREADY INSTALLED. FOR THIS REASON, DO NOT EXPOSE THE STACK TO FREEZING CONDITIONS WHEN THE UNIT IS NOT RUNNING. PLEASE CONSULT THE FACTORY FOR SPECIAL STORAGE AND HANDLING INSTRUCTIONS IF THE UNIT WILL BE EXPOSED TO FREEZING CONDITIONS PRIOR TO INITIAL START UP.

All gas, water, electrical and communications connections are made from the rear of the system. Access to the rear panel is also required for routine air filter maintenance. Leave sufficient clearance to permit adequate air movement in and out of the generator at the rear of the unit.
The generator is controlled from the front control panel, which has start and stop switches, process status LED indicators, and a RS232 Service access port. Opening the two front doors will permit access for water filter replacement and routine maintenance.

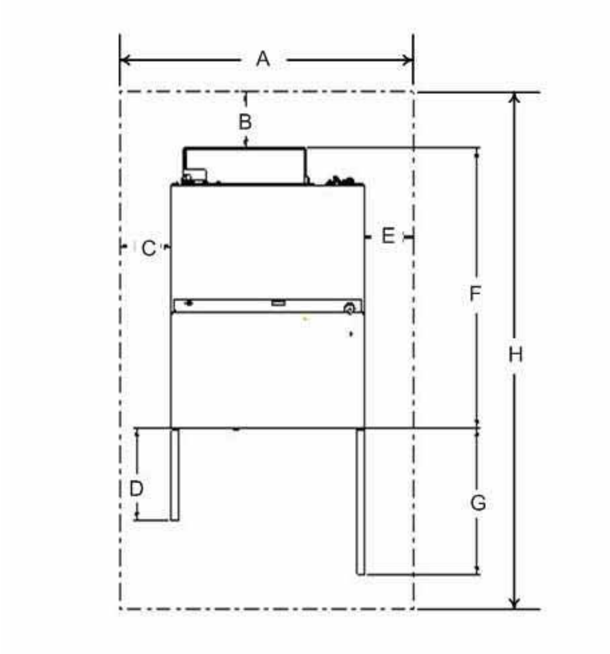


Figure 7 HOGEN S Series 2 Hydrogen Generator Plan View for Installation

Reference Dimension	Units		Reference Dimension	Units	
	Inches	cm		Inches	cm
A	54.9	139.5	E	12.0	30.5
B	12.0	30.5	F	38.25	97.2
C	12.0	30.5	G	20.0	50.8
D	13.0	33.0	H	76.25	193.7

Table 3 Plan View Dimensions

3.5 Electrical Interfaces

Electrical interface connections are made prior to mechanical connections. Once the HOGEN S Series 2 Hydrogen Generator has been properly located, electrical connections can be made. All user supplied I/O cables which interface with this system must not exceed 30 meters (98.4 feet) in length.

3.5.1 Surge Protection

The HOGEN hydrogen generator is designed, tested and certified to meet the electrical surge immunity standards as stated in IEC 61000-4-5.

Supply voltages higher than specified may result in system damage. Voltage surges higher than 2 Kv may result in system damage. It is recommended that the customer provide adequate surge protection in the plant power distribution so as to minimize any potential damage to the HOGEN system.

NOTE

PROTON offers a Surge and Under/Over Voltage Relay Module (KT-1000-0032) to minimize the effects of out of specification line voltage conditions, such as low voltage or large voltage transients.

To ensure proper operation, the user of this system is responsible for providing adequate surge protection for power being supplied to the system. Otherwise, in the event of an AC main high voltage surge, the system may shut down in the following manner:

- Product hydrogen flow and pressure will be lost
- System pressure will begin to bleed down until the C-03 “Low System Pressure” warning is reached. The system may then shutdown on E-02 “Low Cell Stack Voltage”
- Upon shutdown, the system power will need to be shutdown for a minimum of 5 seconds. The circulation pump must be allowed to perform its normal 60-second water circulation
- This shutdown allows the power supplies to clear a latched fault
- After the minimum 5-second shutdown, the system may be restarted and brought to normal operation

3.5.2 Cabling Procedure

The power connections made must be weather-tight, airtight, and compliant with electrical codes. A minimum #6 AWG wire is recommended.

The power connection must be sealed to prevent air pressure leakage. The internal cabinet must be pressurized during operation – Air pressure must be maintained.

OR

Figure 8 Electrical Interfaces on the Rear Panel

Proton requires the use of ferrules to connect power cables to the circuit breaker terminal lug.

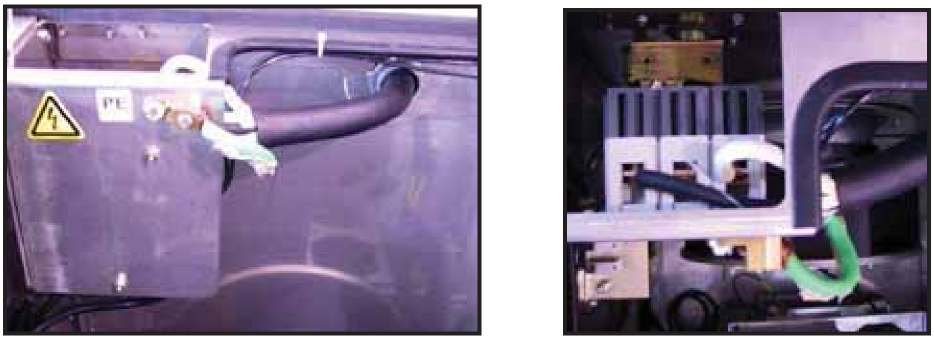


Figure 9 Terminal Connections of Main Power Feed

1. Remove the rear panel from the unit.
2. Feed the power and ground cables through the AC Power Feed (Refer to Figure 8).
3. Connect the power cables to the terminal lugs inside the unit (Refer to Figure 9).

NOTE

Terminals 1 and 3 are used for single-phase hookup.

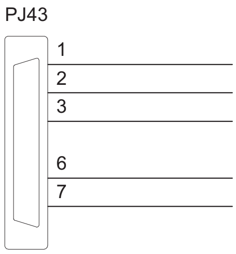
4. Connect the ground cable to the power supply frame ground point.
5. Bring the protective earth ground conductor (#6 AWG) into the unit along with power to the conductors.
6. Terminate the conductors on the chassis ground point on the circuit breaker bracket (Refer to Figure 9).

3.5.3 Remote Alarm Contact and Shutdown Connections

An external alarm to the HOGEN generator may be connected to confirm system status. Both Normally Closed (NC) and Normally Open (NO) contacts are available on the 9-pin serial connector located on the rear panel of the generator, as shown in Figure 9. The form C alarm relay contacts are rated for 2 Amps. **DO NOT** exceed this rating. An external switch can shut down the system. Multiple switches can be wired in parallel. An external dry contact closure across pins 6 and 7 will trip the input power breaker and safely shut down the HOGEN generator (Refer to Figure 10).

NOTE

24 VDC is present on pin 6.



Pin Number	Connections
1	Relay Com
2	Relay NC
3	Relay NO
6	Remote E-Stop
7	Remote E-Stop

Figure 10 Alarm Contact Connections
Table 4 Alarm Contact Connections

3.6 Mechanical Interfaces

This section provides a detailed description of the mechanical interface requirements. The physical layout and dimensions of the HOGEN S Series 2 hydrogen generator are shown. Detailed interface connections for the hydrogen outlet and water supply are supplied also.

3.6.1 Physical Layout, Connections and Dimensions

The physical layout of the HOGEN S Series 2 hydrogen generator is shown in the following figures.

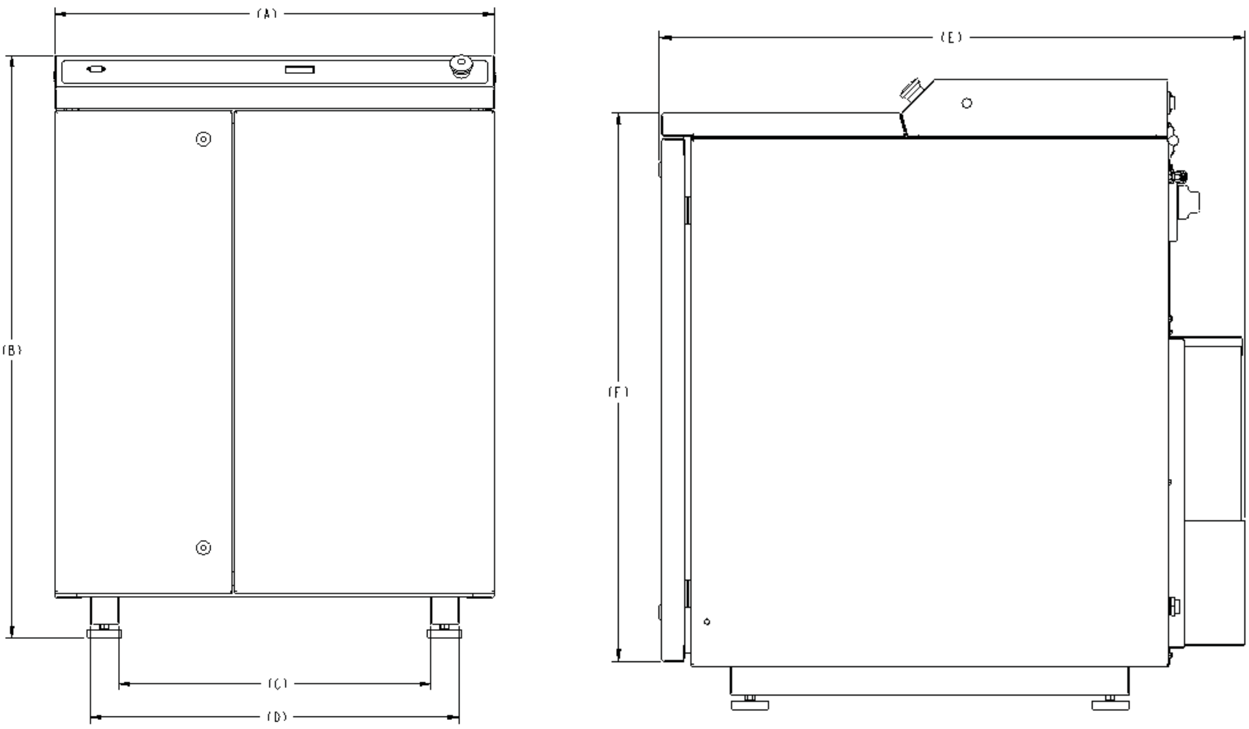


Figure 11 Front and Right Side Views

Reference Dimension	Units		Reference Dimension	Units	
	Inches	cm		Inches	cm
A	30.9	78.5	K	34.6	87.9
B	40.9	103.9	L	25.1	63.8
C	21.9	55.6	M	8.2	20.8
D	25.9	65.8	N	6.7	17.0
E	38.2	97.0	O	3.9	9.9
F	35.6	90.4	P	5.5	14.0
G	4.5	11.4	Q	2.8	7.1
H	2.1	5.3	R	32.9	83.6
I	11.5	29.2	S	35.3	89.7
J	4.6	11.7			

Table 5 Dimensions for Front, Right Side, and Rear Views

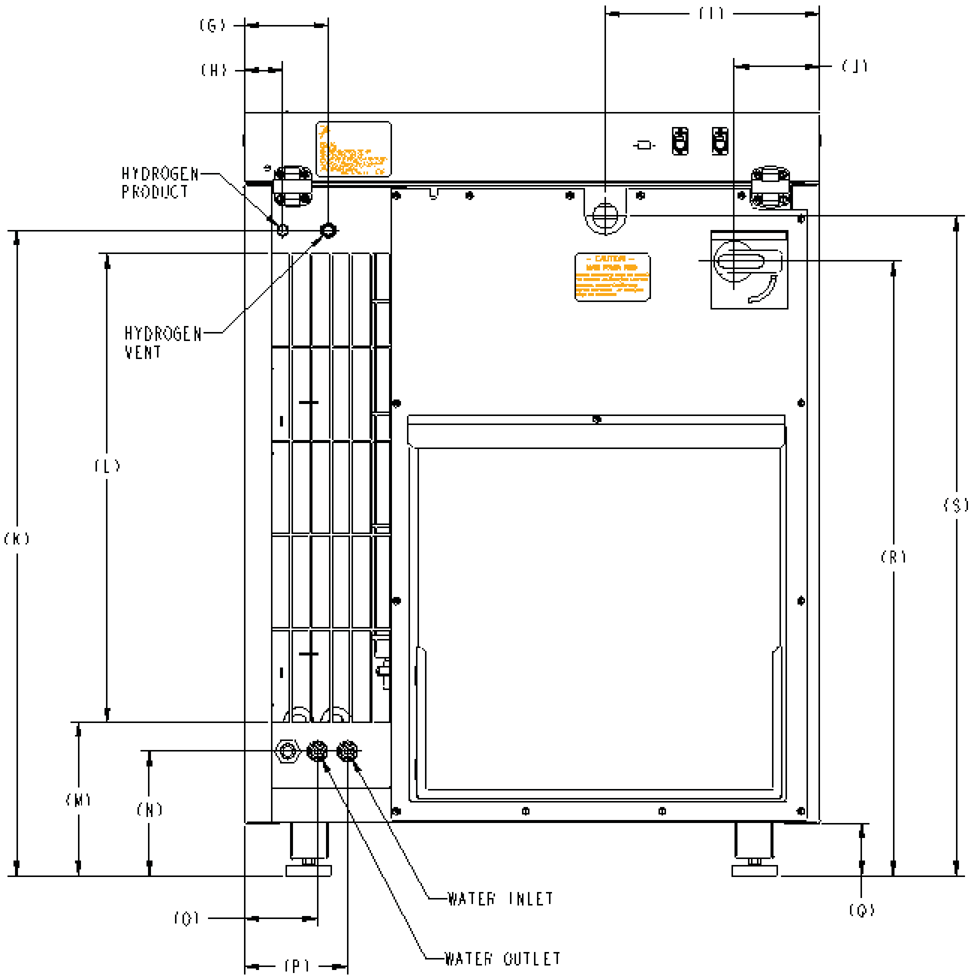


Figure 12 Rear View

3.6.2 Product Hydrogen Interface

The HOGEN S Series 2 hydrogen generator is designed to produce hydrogen that contains no more than 5 PPM of water and 1 PPM of other containments. Hydrogen can be delivered at pressures ranging from 0 to 200 psig and up to the unit's rated flow rate.

For conditions that do not require hydrogen product in the customer process, such as initial equipment commissioning, maintenance and repair conditions, PROTON suggests plumbing in the product bypass line at the time of hydrogen generator installation. (Refer to Figure 13 for suggested plumbing orientation.)

The product hydrogen port uses a Parker CPI compression tube fitting for ¼" OD tubing. Figure 3 shows the connection location.

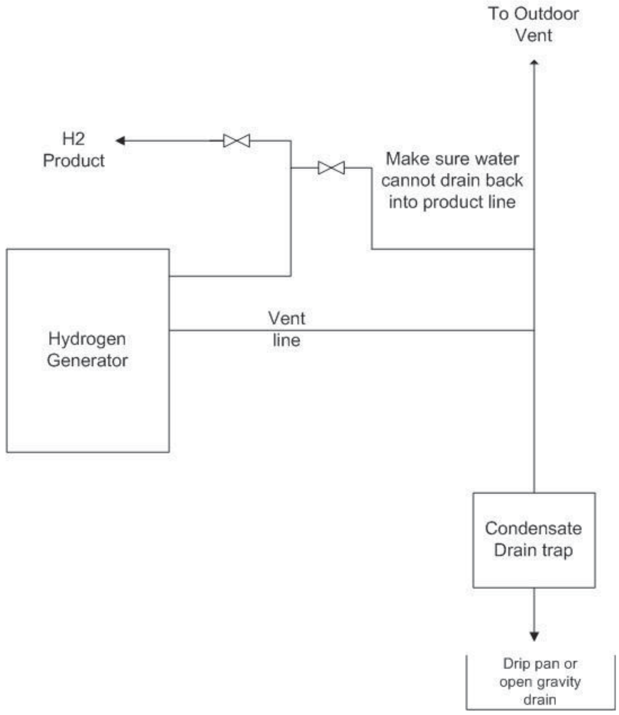


Figure 13 Suggested Plumbing Orientation

3.6.3 Hydrogen Vent Interface

The HOGEN S Series 2 Hydrogen Generator vents hydrogen during startup, system depressurization, dryer purging cycles, and overpressure relief. During startup of the HOGEN generator, the full production rate of hydrogen is vented while the unit is in the GENERATE-VENT state. Once the system switches states, the vent valve (P&ID Tag SV329) closes and the system begins to pressurize. During system shutdown, the entire on-board inventory of hydrogen (approximately 0.5 SCF/0.01 Nm^3) is vented. Depressurization occurs when the vent valve (P&ID Tag SV329) is opened, allowing hydrogen to flow out of the H_2/H_2O vent.
The internal dryer of the HOGEN generator is a pressure-swing dryer. In order to function properly, each bed operates alternately in two half-cycles of equal duration: pressurization followed by adsorption and depressurization followed by a purge. It is during this purge that hydrogen is blown out of the non-operating bed and directed out the H_2/H_2O vent. During these purge cycles, approximately 10 percent of the production rate of hydrogen will exit the H_2/H_2O vent port with residual moisture.

If a vent bypass valve is implemented, reference Figure 13 for a suggested plumbing orientation. This suggested orientation prevents any water build up in the vent line from entering the hydrogen product line when the vent bypass valve is opened.

The HOGEN generator is equipped with a pressure relief valve. If the system experiences an over-pressure condition, the relief valve cracks open and allows the system to depressurize by allowing hydrogen to flow out the H_2/H_2O vent.

The pressure relief valve (RV308) is factory set at 265 psi and should not be adjusted.

The H_2/H_2O vent port uses a Parker CPI compression tube fitting for ½" OD tubing. Figure 3 shows the connection location. The vent line to be attached to the port should be installed per NFPA 50A. The hydrogen should be vented separately into an approved hydrogen vent stack. Due to the residual moisture that exits through the H_2/H_2O vent port, it is recommended that a trap is employed to properly handle the accumulation of condensate.

DO NOT ALLOW HYDROGEN TO VENT INDOORS, NEAR VENTILATION INTAKES, WORK AREAS, OR ANY SOURCE OF IGNITION.

THE HYDROGEN VENT LINE MUST REMAIN FREE FROM OBSTRUCTIONS AND KEPT FROM FREEZING.

3.6.4 Oxygen Interface

The HOGEN generator produces oxygen in its electrolysis process. This oxygen gas and small amounts of water condensate are vented out of the system via the oxygen vent port. The oxygen gas production rate is approximately 50% of the hydrogen production rate and exits at ambient pressure from the Oxygen/Water Phase Separator (P&ID Tag A200).

Adequate ventilation must be provided to assure that oxygen concentration does not build to unsafe levels.

THE OXYGEN VENT LINE MUST REMAIN FREE FROM OBSTRUCTIONS AND KEPT FROM FREEZING.

3.6.5 Water Interfaces

The water ports are ¼" diameter polypropylene plastic tube fittings. Figure 3 shows the connection locations of these two ports. Polypropylene plastic tubing is highly recommended for the water feed line. FEP and PFA plastics are also highly recommended for protecting the cell stack. The only recommended metal line is clean, passivated 316SS. The drain line should be appropriately plumbed based on your specific facility requirements. Post-deionization water tanks should be constructed from polypropylene only as stainless steel tanks will leach out impurities that will damage the system.

The HOGEN generator uses deionized water to produce hydrogen and to actively cool the cell stack. The HOGEN generator requires a minimum of ASTM Type II deionized water. ASTM Type II deionized water calls for a resistivity of at least 1.0 MΩ-cm and a maximum 50-µg total organic carbon per L of water. Other qualities of the water can be found in ASTM designation D1193-99: Standard Specification for Reagent Water. Although ASTM Type II water is required, ASTM Type I deionized water is recommended. By using the highest quality water recommended, the life of the guard bed cartridge and the cell stack will be extended. The water quality sensor will trigger a failure if water quality drops below 1 MΩ-cm. Therefore, it is highly recommended that ASTM Type I deionized water be used to prevent this failure.

Water levels are controlled within the HOGEN generator control logic system. When the water level drops below a set point in the Oxygen/Water Phase Separator, the Water Feed Valve (P&ID Tag SV510) is opened to allow water into the system through the water inlet. Water is drained from the system during startup and when water quality is not maintained. During initial startup, approximately 2 gallons (8 liters) of deionized water may automatically be drained out of the system. When water quality is below 1 MΩ-cm the system flushes out by opening the Drain Valve (P&ID Tag SV211) and water feed valve (P&ID Tag SV510). This allows water to be drained, while adding fresh deionized water to the system. An internal water quality sensor controls this process. This feature ensures that the water quality meets the minimum requirements before electrolysis begins.

An obstructed drain line could prevent the HOGEN generator from draining properly and may result in permanent damage.

DO NOT USE: copper, aluminum, iron or other metal for deionized water inlet tubing as this will result in significant contamination and performance loss over time. *PVC plastics are not acceptable, as they will damage the cell stack.*

3.7 Combustible Gas Sensor Calibration (P&ID Tag CG220)

The HOGEN S Series 2 hydrogen generator contains an e2v Technologies VQ603/2 combustible gas sensor that monitors both the purge air and the oxygen stream from the oxygen/water phase separator (A200) for hydrogen gas. The detection of 50 percent of the lower flammability limit (LFL) of hydrogen within air triggers a safe shutdown of the system. The combustible gas sensor needs to be calibrated prior to the initial startup of the HOGEN generator.

THE COMBUSTIBLE GAS DETECTOR NEEDS TO BE CALIBRATED EVERY 3 MONTHS FOR PROPER OPERATION OF GAS DETECTING EQUIPMENT WITHIN THE HOGEN GENERATOR.

The following items are needed to perform the calibration:

- Combustible Gas Sensor Calibration Kit OR:
    - 2 Percent Hydrogen in Air Calibration Gas
    - Calibrated Air Flow Meter capable of reading 0.5 to 1 liter/minute (Included in the Cal Kit with the regulator and the valve.)
- Gas Sensor Calibration Hood
- Portable Gas Detector and Charger for 115V or 220V applications
- 8 mm hex Wrench
- 5/16" Wrench

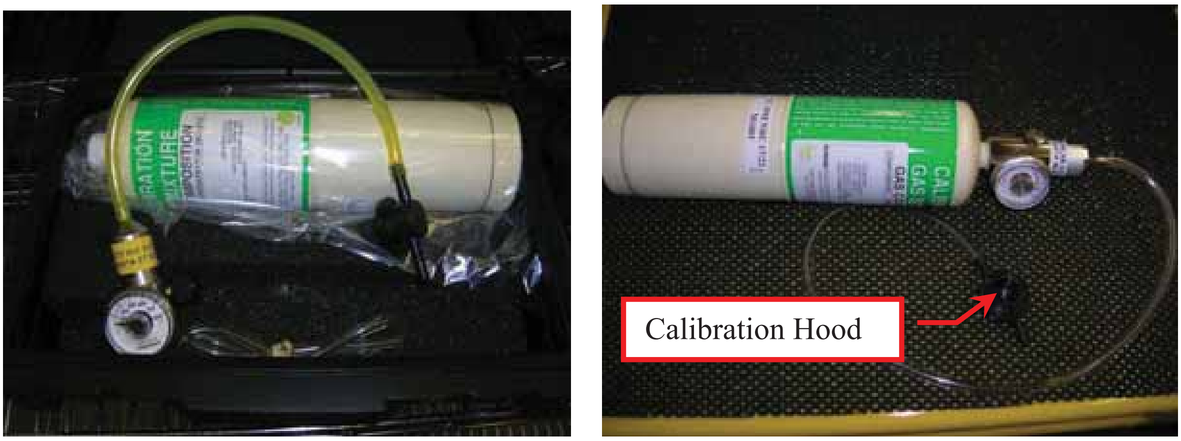


Figure 14 Combustible Gas Sensor Calibration Kit with Calibration Hood

Use the following procedure to calibrate the combustible gas sensor:

1. Shutdown the system and remove power using the main power disconnect switch on the rear panel of the unit.
2. Gain access to the fluids bay and remove the combustible gas sensor head by removing the two (2) screws that hold the sensor head mounting plate to the sensor shield. See Figure 15.

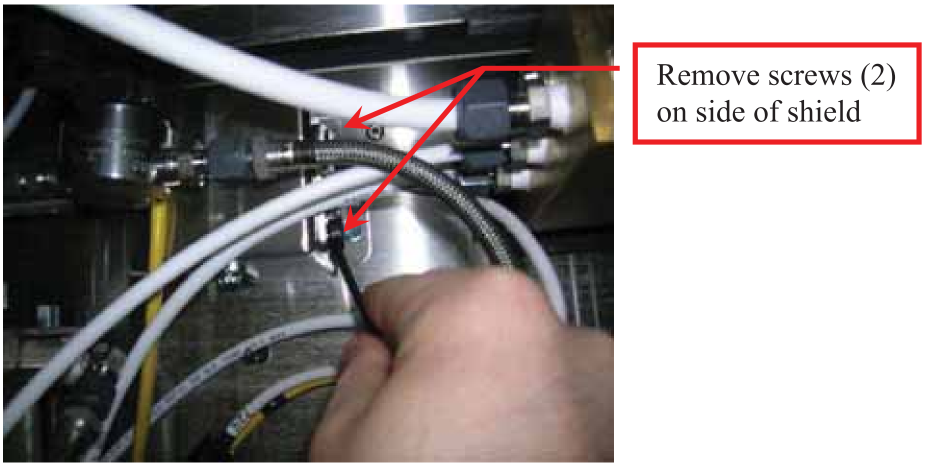


Figure 15 Combustible Gas Sensor Removal

3. Pull the sensor head and plate from the assembly. See Figure 16. Do not disconnect the wiring harness as the sensor needs to be powered to complete the calibration.

Figure 16 Combustible Gas Sensor Removed

4. Power up the system while depressing the "SELECT" and "SYSTEM PRESSURE" buttons. This enters the system into the combustible gas sensor calibration state.
5. After powering up the system in the calibration state, the symbol "6CAL" displays for 10 seconds to signify gas calibration.
6. After the "6CAL" symbol is removed, the symbol "00PC" is displayed to signify 0 percent LFL.
7. Depress the "START" button to begin a 30 second timer to allow the gas sensor to stabilize to 0 percent LFL. Once the "START" button is depressed, the display counts down from 30 to 0.
8. Upon completion of the countdown, "donE" is displayed. Then select the "START" button to continue. No further action is accepted until "donE" appears.
9. Once the "START" button is selected, the symbol "50PC" is displayed.
10. Select the "UP" display scroll button to increase or the "DOWN" display scroll button to decrease the display reading to match the percentage level of calibration gas being used. The acceptable range of calibration gas is 30 percent to 50 percent LFL. The first two digits of the display changes to reflect the selection. Values increase by 1 percent LFL.

% LFL	% Hydrogen in Air	% LFL	% Hydrogen in Air
50	2	39	1.56
49	1.96	38	1.52
48	1.92	37	1.48
47	1.88	36	1.44
46	1.84	35	1.4
45	1.8	34	1.36
44	1.76	33	1.32
43	1.72	32	1.28
42	1.68	31	1.24
41	1.64	30	1.2
40	1.6		

Table 6 Percent LFL to Hydrogen in Air Conversions

11. Install the calibration hood onto the combustible gas sensor head. When installing the calibration hood onto the combustible gas sensor, attach one of the tube ends on the hood to a ¼" flex hose, which is connected to the calibration gas supply. The other tube end remains open to the atmosphere.

Figure 17 Calibration Hood installed on Combustible Gas Sensor

12. Open the calibration gas supply and allow 0.5 to 1 liter/minute of calibration gas to flow to the combustible gas sensor. (Fully open the calibration gas supply when using the Cal Kit. An orifice located within the valve assembly sets the correct flow rate.)
13. Once there is flow to the combustible gas sensor head then select the "START" button to begin a 60 second timer to allow the gas sensor to stabilize to the user-selected percentage of LFL. Once the "START" button is depressed, the display counts down from 60 to 0.
14. Upon completion of the countdown, "donE" is displayed. The "START" button must be depressed to continue. Do not turn off Cal gas until you depress the "START" button. No further action is accepted until "donE" appears.

When not using the calibration gas, the supply should be shut off.

15. Once the "START" button is selected, the message "OFF" is displayed.
16. Ensure the Cal gas bottle is turned Off.
17. Cycle the power to the unit by shutting off the power to the unit through the main power disconnect switch on the rear panel.
18. At any point during the calibration procedure (except during timer countdown), if an error has occurred or if the user must repeat the previous step, the "STOP/RESET" button may be depressed. Depressing the "STOP/RESET" button cancels all actions of the current step and brings the user back to the previous step. A calibration error is signified by displaying "ERR ".
19. To verify calibration, power up the system while depressing the "SELECT" and "PRODUCT PRESSURE" buttons. This allows the system to enter the combustible gas sensor verification state.

20. After powering up the system in the verification state, the symbol “6C PC” displays for 10 seconds to signify gas verification.
21. After the “ 6C PC” symbol is removed, the symbol “00PC” is displayed to signify 0 percent LFL (assuming the sensor is reading 0 percent LFL).
22. Apply the calibration gas to the sensor head by turning on the calibration gas supply. The first two digits of the symbol “00PC” change based on the sensed value of combustible gas. If the “0” and cal gas percent readings are not within +/- 2 percent LFL as determined by the user, the calibration procedure is to be repeated. If the verification readings are acceptable, shut down the system using the main power disconnect switch.
23. Reinstall the combustible gas sensor removed in Step 2 using the two (2) retention screws.
24. Restart the unit in normal operating mode.

3.8 Installing the Cell Stack

The cell stack is typically installed in the system prior to shipment. However, if freezing conditions were anticipated, the cell stack may have been shipped separately. In that event, separate installation instructions will be provided with the cell stack.

Store the cell stack in a non-freezing area. The installed stack is full of water and has all input and output ports capped. Connections to the stack should be the last step in the installation process and should not be done until all previous steps are completed.

NEVER ATTEMPT TO DISASSEMBLE THE CELL STACK, AS THERE ARE NO SERVICEABLE PARTS INSIDE. AVOID CONTACT WITH THE POSITIVE BUSS PLATE AS A CAPACITIVE CHARGE IS RETAINED AND A SEVERE ELECTRICAL SHOCK MAY RESULT. IF YOU SUSPECT A PROBLEM WITH THE CELL STACK, PLEASE CALL PROTON'S SERVICE DEPARTMENT IMMEDIATELY.

Never leave the input and output ports uncapped. Irreversible damage to the stack results if it is allowed to dehydrate.

3.9 Hydrating the Cell Stack

In the event the HOGEN S Series 2 hydrogen generator is not placed in service upon receipt, the cell stack must be properly hydrated.

Check for DI water content in the hoses every 30 days. If DI water is not present in the hoses, rehydrate the hoses as needed. A hydration kit is available through PROTON (KT-1000-0022).

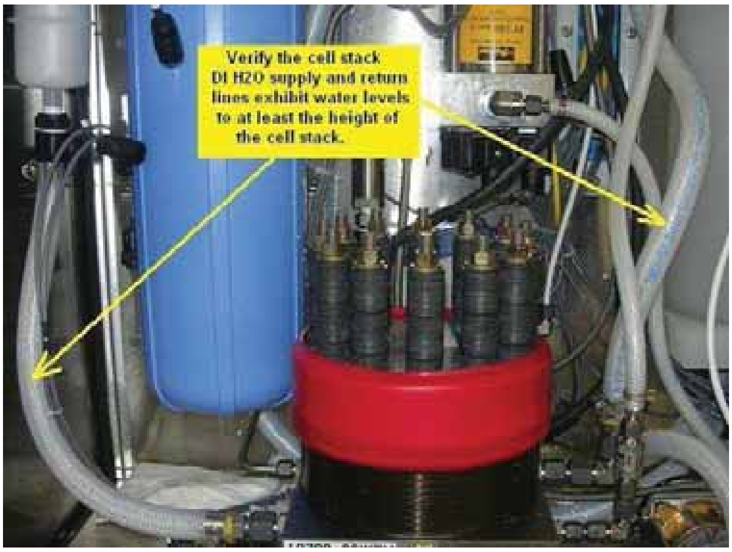


Figure 18 Cell Stack and Hydration Hoses

Perform the following procedure to hydrate the cell stack:

1. Apply power to the generator, by turning the breaker to the "ON" position.
2. Wait for the green "START" button/LED to begin flashing.

NOTE

It may take approximately 20 minutes for the light to begin flashing after power is applied to the unit. If the feed water pressure is low, it may take over an hour for the internal water vessels to fill. If this occurs, Error Code 15 is triggered and the system needs to be reset.

3. Once the light is flashing, depress the "START" button.
4. After 20 seconds, depress the red "STOP" button. DO NOT use the "EMERGENCY STOP" button to shut the system down.

NOTE

The yellow "GENERATE" light illuminates after 120 seconds, indicating hydrogen generation. If you do not wish to generate hydrogen, it is important to press the red "STOP" button before the 120-second time period to stop the system.

5. The system circulates water through the cell stack for 60 seconds after the "STOP" button is depressed.

4 OPERATION

The HOGEN S Series 2 hydrogen generator is a fully automated system. Upon depressing the green "START" key, the system starts a control sequence that leads to the generation of hydrogen gas. Error codes are embedded in the control scheme of the HOGEN generator. The error codes spawn from the monitoring of system parameters.

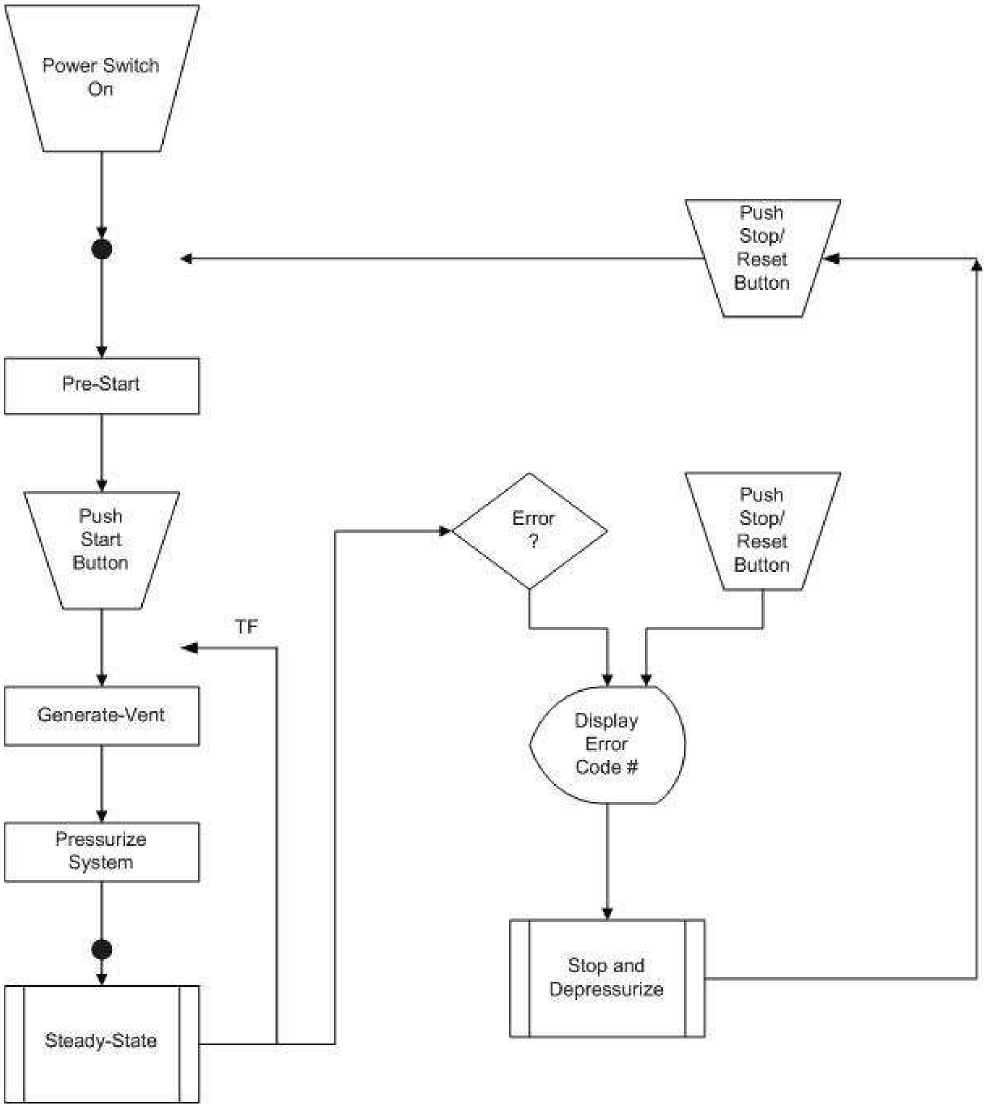


Figure 19 Basic Control Sequence

4.1 Control Panel

The HOGEN S Series 2 hydrogen generator's control panel contains all the buttons to operate the unit. Figure 20 shows the layout of each interface point.

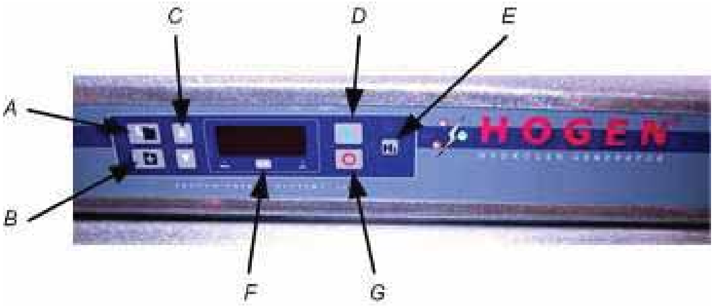


Figure 20 Control Panel Details

Reference	Detail	Reference	Detail
A	Product Pressure	E	Hydrogen Generation Indicator
B	System Pressure	F	Units Toggle (Select)
C	Display Scroll Keys	G	Stop/Reset Button
D	Start Button		

Table 7 Control Panel Details

4.2 Turning ON the Main Power

Turning on the main power to the cabinet initiates the on-board air purge blower. The blower pressurizes and cools the cabinet. The cabinet doors must remain closed and secured in place, as the cabinet must maintain a minimum of 0.2" water column (25 Pa) pressure in order for the system to operate.

1. Verify the cabinet doors are closed and secured.
2. Verify the air inlet and exhaust openings (refer to Figure 3) are not blocked.
3. Switch the Main Power Disconnect Switch (refer to Figure 3) from the OFF (**O** position) to the ON position (**I** position).

POWER IS STILL PRESENT AT THE CIRCUIT BREAKER (Electrical Schematic Tag CB101) IN THE GENERATOR UNTIL THE MAIN POWER DISCONNECT SWITCH IS DEPRESSED TO THE OFF POSITION.

ONLY USE THE E-STOP IN EMERGENCY SITUATIONS. TO REMOVE POWER TO THE SYSTEM, USE THE STOP BUTTON ON THE KEYPAD DISPLAY AND WAIT FOR THE SYSTEM TO COMPLETE A NORMAL STOP (RED LED ON STOP BUTTON WILL BE FLASHING).

4.3 PRE-START Operation

PRE-START operation begins automatically when the main power disconnect switch is turned ON. During this operation the following occurs:

1. The system flushes itself out if water quality is below the required resistivity.
2. Water levels in the oxygen/water phase separator (P&ID Tag A200) and hydrogen/water phase separator (P&ID Tag A300) are adjusted if they are low.
3. During the PRE-START process, a dashed line moves across the center of the display.

Once the PRE-START operation is complete, the green "START" key light flashes indicating the completion of the PRE-START state. The operator can either allow the HOGEN generator to maintain an idle state or enter the GENERATE-VENT state by pushing the green "START" key.

4.4 GENERATE-VENT Operation

The GENERATE-VENT state is initiated after all of the PRE-START conditions are met and the operator presses the green "START" button. Pressing the button at this time activates the following sequence:

1. The circulation pump (P&ID Tag CP205) is turned on.
2. The water flow rate is verified.
3. The quality of the water is verified.
4. During the circulation tests, a dashed line moves in a "racetrack" pattern around the perimeter of the display.
5. Full current is applied to the system after approximately 120 seconds. Once current is applied to the cell stack, a yellow H_2 indicator light illuminates, signaling that hydrogen is being generated.
6. The system verifies hydrogen/water phase separator (P&ID Tag A300) level controls.
7. The system verifies the voltage conditions within the cell stack.
8. The system verifies the rectifier operation.

During the sequence, the system vents oxygen and hydrogen at full production. Once the system goes through the sequence above and the unit passes all the checkpoints (approximately 60 seconds), the unit closes the vent valve (P&ID Tag SV329) and the system begins pressurization.

4.5 PRESSURIZE STORAGE Operation

This operation starts when the HOGEN generator's vent valve (P&ID Tag SV329) closes after the GENERATE-VENT state. During this state, the system pressurizes its hydrogen lines up to the back pressure regulator set point. The system pressure is set through the backpressure regulator (P&ID Tag BPR310).

4.6 STEADY-STATE Operation

During STEADY-STATE operation, the system outputs hydrogen through its product hydrogen port. There are two modes the system can run in during STEADY-STATE operation: load following mode or tank filling mode.

4.6.1 Load Following Mode

This mode maintains pressure at the set point (225 psig for current production units and 200 psig for early production units) as long as the demand for hydrogen does not exceed the rated capacity of the product.

4.6.2 Tank Filling Mode

In tank filling mode, the product pressure transducer (P&ID Tag PT312) controls the gas generation cycle of the HOGEN generator. At pressures below the product pressure set point, full rated flow of hydrogen is delivered. When product pressure reaches the product pressure set point, the power used to generate hydrogen is automatically switched off and the unit goes into an idle state. The HOGEN generator maintains the idle state until the product pressure drops below the product refill pressure set point. When this does occur, the HOGEN generator again delivers full gas production until the product pressure reaches the product pressure set point.

4.7 Monitoring Operation

The HOGEN S Series 2 hydrogen generator is equipped with on-board sensors to monitor system conditions within the unit. The digital display is a 4-digit/ 7-segment display with the ability to display five different parameters during normal operation:

- **Pressure Set Point**: The output of the pressure set point circuit is scaled for 0 to 225 psig (0 to 1,551 kPa) (200 psig for units before serial number 342) and is accessed by pressing either display scroll key for 5 seconds. There are two pressure set points that can be set, Product Pressure and System Pressure. The Product Pressure Key and the System Pressure Key gives the operator the ability to toggle between the two values.
- **Operating Parameters**: Basic system operating parameters can be accessed once the system has reached pressure and is delivering gas. The parameters can be displayed by adjusting the up/down arrow keys while the generator is in this mode of operation. The display of a particular parameter is preceded by a 2-letter symbol identifying the parameter on display. The following is a list of parameters and the associated symbol identifier:

Parameter	Units		Symbol
	English	SI	
System Pressure (default)	PSI	kPa	SP
Product Pressure	PSI	kPa	PP
Hydrogen Flow Rate	SCFH	LPM	HF
System Temperature	℉	℃	SE
Cell Stack Voltage	VDC	VDC	SU
Cell Stack Current	Amps	Amps	SC

* If kPa is selected for pressure display then LPM and °C will be displayed

Table 8 Operating Parameters

The display area has an indication of the measurement units in use, English or SI. Underneath the 4-digit/ 7-segment display is a button to toggle between the two unit measurements.

- **Elapsed Timer**: The amount of time that has elapsed in 10-hour counts of system generation time (current >1 amp) can be accessed through the display panel. Pressing both the product and system pressure keys simultaneously for 5 seconds accesses this option.
- **Error Code**: The output from the shutdown circuit is displayed as a numerical code 0-43.
- **System Idle Condition**: When the water levels are being adjusted, the display segments flash in a sequential pattern.

4.8 Automatic Warnings

The HOGEN S Series 2 hydrogen generator provides an automatic warning when the combustible gas sensor (P&ID Tag CG220) has not been calibrated within 14 days of its three (3) month calibration interval. If the sensor has not been calibrated, the LED display flashes “C-00” for one (1) second, and then returns to normal display for five (5) seconds before flashing the warning again. The combustible gas sensor must be calibrated and the power to the unit must be cycled for the warning to be cleared. Once the calibration interval is beyond the three (3) month interval, the warning results in an automatic shutdown with error code E-25 shown on the LED display.

The HOGEN S Series 2 hydrogen generator is equipped with software that monitors the health of the combustible gas sensor. It detects a blocked or a removed gas sampling line from the oxygen/water phase separator to the combustible gas sensor and provides combustible gas sensor health check monitoring based on hydrogen/water phase separator cycles. The software provides an automatic warning if it detects the combustible gas sensor is not sensing an adequate flow of hydrogen. The automatic warning flashes “C-01” if a too low level of combustible gas is detected. The automatic warning flashes “C-02” if an expected cyclical pattern of combustible gas is not detected.

To clear the warning, the system must be stopped and the combustible gas sensor must be calibrated. While calibrating the combustible gas sensor, it is recommended that the sample stream to the combustible gas sensor (from the oxygen/water phase separator) be checked for loose connections or signs of blockage. Once the sample line is verified to be functioning properly, restart the system and verify the warning has cleared and does not reappear. Continued warnings could signify problems with the combustible gas sensor.

The HOGEN S Series 2 hydrogen generator is also equipped with software that monitors the system temperature. In the event the system temperature falls below a specified limit, “C-30” flashes as a warning providing 48 hours of operation prior to an “E-30” shutdown. (See Table 9 for other warnings.)

4.9 Manual Shutdown

Manual shutdowns of the HOGEN S Series 2 hydrogen generator occur in three ways: by pressing the red “STOP/RESET” button, engaging the E-Stop, or switching the main power disconnect switch to the OFF position.

Do not use the E-Stop or main power disconnect switch to stop gas generation except in the event of emergency. To properly stop the process or reset the control processor, press the red “STOP/RESET” button.

By pressing the red "STOP/RESET" button, the following sequence occurs:

1. The system de-energizes all outputs, except the circulation pump.
2. Water is circulated for 60 seconds after the button is pressed.
3. The power supplies are disabled.
4. The system displays an error code.
5. The system waits for the red "STOP/RESET" button to be pressed again, which resets the controller.

NOTE

The operator is not allowed to reset the unit until the 60-second circulation of water is complete.

By switching the main power disconnect switch OFF, all power for the system is disconnected simultaneously and the HOGEN generator is depressurized.

NOTE

The E-stop is a NORMALLY CLOSED circuit. *Engaging the E-Stop trips the contactor but leaves the breaker and line filter energized.* The generator safely depressurizes when the E-Stop is engaged.

Repeated manual stops while the system is operating in its generate-vent state may cause an A300 flooded condition. To avoid potential A300 flooded conditions and possible water in the plumbing lines downstream of the A300, PROTON highly recommends that, if possible, the operator wait until a generate-vent state is completed (after the initial 60 seconds of hydrogen generation) prior to manually shutting the system down.

4.10 Automatic Shutdowns

The HOGEN S Series 2 hydrogen generator provides automatic shutdowns through continuous monitoring of critical operating parameters. If a parameter is not within its specified limits, the controller takes the appropriate action to the HOGEN generator gas generation process. Upon shutdown of the unit, the controller shows the error code for the type of shutdown on the 4-digit/ 7-segment display.

Code	Description	Default Limit	Sensor (P&ID Tag #)	Time Activated
C-00	Calibration Gas Warning	> 3 Months	N/A	On Power Up
C-01	Calibration Gas Drift Warning	< 2 % LFL	CG220	On Start Switch
C-02	Calibration Gas Peak Warning	< 1 % LFL	CG220	On Start Switch
C-03	System Pressure Low Warning	< 180 psig	PT307	On Pressurize + 60/120 Sec (S40/S20 & S10 Dependent)
C-04	VCC Low Warning	VCC < 4.75	N/A	On Power Up
C-05	VCC High Warning	VCC > 5.25	N/A	On Power Up
C-06	VEE Low Warning	VEE < -5.25	N/A	On Power Up
C-07	VEE High Warning	VEE > -4.75	N/A	On Power Up
C-08	3VDC Low Warning	< 3.135	N/A	On Power Up
C-09	3VDC High Warning	> 3.465	N/A	On Power Up
C-10	24VDC Low Warning	< 22.8	N/A	On Power Up
C-11	VREF Low Warning	< 22.8	N/A	On Power Up
C-12	VREF High Warning	> 25.2	N/A	On Power Up
C-13	High Product Pressure	> 250 (220*) psig	PT312	On Power Up
C-30	System Temperature Low Warning	< 5C	TS218	On Circ. Test + 10 Sec
E-00	Manual Shutdown	Switch Closure	Stop Switch	On Power Up
E-01	Cell Voltage High	> (# Cells x 2.6)	N/A	On Generate + 5s
E-02	Cell Voltage Low	< (# Cells x 0.5)	N/A	On Generate + 5s
E-03	A200 Empty	< Empty Level	LS201-1	On Start Switch
E-04	A200 Flooded	> Flooded Level	LS201-4	On Drain + 30s
E-05	A300 Empty	< Empty Level	LS301-1	On Generate
E-06	A300 Flooded	> Flooded Level	LS301-4	On Generate + 15/30s (S40/S20 & S10 Dependent)
E-07	Poor Water Quality	< 1 MΩ-cm	RS209	On Circ Test + 20s
E-08	Failed Water Quality Sensor	> 18 MΩ-cm	RS209	On Circ Test + 20s
E-09	Low Recirculation Flow	< 3.79 LPM (1GPM)	WS207	On Circ Test + 10s
E-10	System Pressure High	> Pressure Set Point + 25 (50*) psig	PT307	On Power Up
E-11	System Pressure Low	< 180 psig	PT307	C-03 + 180 sec
E-12	Product Pressure High	> Product Pressure Set Point + 25 (20*) psig	PT312	On Power Up
E-13	Hydrogen Leak Detected	> 50% LFL	CG220	On Power Up
E-14	System Temperature High	> 60°C	TS218	On Circ Test + 10s
E-15	A200 Pre-Start Timeout	> 2 Hours	LS201	On Power Up + 2 hrs

Code	Description	Default Limit	Sensor (P&ID Tag #)	Time Activated
E-16	A300 Pre-Start Timeout	> 2 Hours	LS301	On Power Up + 2 hrs
E-17	Rectifier #3 Fault	Fault Signal High	PWR102-3	On Generate + 5s
E-18	Cabinet Purge Pressure Low	< 0.2” Water Column	PS121	On Power Up + 10s
E-19	Rectifier #1 Fault	Fault Signal High	PWR102-1	On Generate + 5s
E-20	Rectifier #2 Fault	Fault Signal High	PWR102-2	On Generate + 5s
E-21	Processor Fault	Internal Watchdog Failure	N/A	On Power Up
E-22	FPGA Fault	Control Board		All States
E-23	High Current	> 150 Amps	PWR102-1	On Generate
E-24	A300 Flooded Restarts	1 Restart Max	N/A	After 1 E-06
E-25	CG Sensor Out of Calibration	Calibration Past Due	N/A	On Circ Test + 45s
E-26	E-Stop Circuit Fail	E-Stop (Open)	M101	On Power Up
E-27	CG Drift Error	< 2% LFL	N/A	On Generate
E-28	CG Peak Error	< 1% LFL Range on A300 Cycle	N/A	On Generate
E-29	CG Full Production Peak Error	< 1% LFL Range on A300 Cycle	N/A	On Generate
E-30	System Temperature Low	< 5°C	TS218	On Circ Test + 10s
E-31	State Machine Fault	Control Board		All States
E-32	Flow Switch	Closed on Power Up	WS207	Active at Power Up
E-34	A200 Invalid State		LS201	Active at Power Up
E-35	A300 Invalid State		LS301	Active at Power Up
E-36	System Pressure Transducer	Input is Below 0.25V	PT307	Active at Power Up
E-37	System Pressure Transducer	Input is Above 4.75V	PT307	Active at Power Up
E-38	Product Pressure Transducer	Input is Below 0.25V	PT312	Active at Power Up
E-39	Product Pressure Transducer	Input is Above 4.75V	PT312	Active at Power Up
E-40	System Temperature Sensor	Input is Shortened	TS218	Active at Power Up
E-41	System Temperature Sensor	Input is Open	TS218	Active at Power Up
* = value for units before serial number 342 or Tank Filling Units				

Table 9 Warning and Error Codes for HOGEN S Series 2 Hydrogen Generator

Table 9 lists the possible warning and error code displays, their cause, and the system response as warning or controlled shut down and depressurization. Consult the maintenance manual or PROTON field service for corrective action.

Code	Description	Comment	Sensor	Activated
S 0	Corrupt FPGA Load	Call Factory	N/A	On Power Up
S 1	Corrupt FPGA Scratch	Call Factory	N/A	On Power Up
S 2	Corrupt Dataflash Init	Call Factory	N/A	On Power Up
S 3	Corrupt Calibration Load	Load Calibration File	N/A	On Power Up
S 4	Corrupt PID Load	Load Configuration File	N/A	On Power Up
S 5	Corrupt Parameter Load	Load Configuration File	N/A	On Power Up
S 6	Corrupt GasCal Load	Calibrate CG sensor	N/A	On Power Up
S 7	Corrupt RTC Set	Set Time and Date	N/A	On Power Up
S 8	Corrupt RTC OSC	Call Factory	N/A	On Power Up
S 9	Corrupt Name & Password	Reset default passwords	N/A	On Power Up
S 10	Corrupt Generation Hours	Reset Elapsed Timer	N/A	On Power Up
S 11	Corrupt System Information	Load System Info File	N/A	On Power Up
S 12	Corrupt CG Test Load	Call Factory	N/A	On Power Up
S 13	Corrupt CG Drift Recal	Call Factory	N/A	On Power Up
S 14	Corrupt CG Peak Recal	Call Factory	N/A	On Power Up
S 15	Corrupt CG Full Prod Recal	Call Factory	N/A	On Power Up
S 16	Watchdog Test Failure	Call Factory	N/A	On Power Up
S 17	Post Remote Info Load	Load System Info File	N/A	On Power Up
S 18	Post Remote Email Load	Load System Info File	N/A	On Power Up

Table 10 Post Error Codes

4.11 Routine Maintenance and Extended Shut-down

Routine maintenance schedules are defined in the Maintenance Manual, PD-0200-0001. Operators should regularly inspect the incoming air filter to establish the change frequency required under local or seasonal conditions.

Extended shut down of the HOGEN S Series 2 hydrogen generator is considered to be one month or longer without operation. The HOGEN generator must be kept hydrated or damage to the PEM cell stack may occur. PROTON recommends a schedule of monthly operation of the generator to maintain good water hydration of the cell stack.

If you need to shut down the HOGEN S Series 2 hydrogen generator for a period of longer than 1 month, then make provisions to keep the cell stack hydrated.

Contact PROTON field service for advice on your application.

APPENDIX A: INSTALLATION CHECKLIST

Installation Checklist

This checklist is intended to guide installation personnel during the initial installation of a HOGEN hydrogen generator at a customer site. This form should be completely filled out and faxed back to Proton personnel arriving on-site for the installation verification and initial start-up phase.

1. Power

1.1 Provide the plated electrical service including Protective Earth ground to the hydrogen generator following local wiring codes for industrial equipment installation.

(Refer to Section 3.5)

Initial	Date

1.2 Verify proper electrical service is provided for the installation

Unit	Volts	Phase	Amps	Hz	kVa
S10	205-240	1	30	50/60	5.8
S20	205-240	1	30	50/60	7.2
S40	205-240	1	50	50/60	12.0
Actual:					

Initial	Date

2. Fluids Hookup

2.1 General guidelines

All water, drain and vent lines should be heat traced and insulated if freezing temperatures may be experienced.

All plumbing materials should conform to the guidelines outlined in Section 3.6. Listed below are the fluid connections that need to be connected prior to system operation.

- Feed water in accordance with ASTM TYPE II minimum required ASTM TYPE I recommended

  (>1 MΩ-cm)

Initial	Date

- DI water drain connected and free from obstruction and freezing

Initial	Date

- Verify the oxygen vent is free from obstruction and freezing

Initial	Date

- Hydrogen vent installed in accordance with local codes and free from obstruction and freezing

Initial	Date

- Hydrogen product connected to process in accordance with local codes

Initial	Date

NOTE

Pressure must be reduced prior to the process connection if less than 200 psig is required.

3. Site Information

Generator Model:	Serial Number:
Customer Name:	
Customer Site:	
Site Contact:	
Site Phone #:	
Signature:	Date:

Please fax Installation Checklist to:

ATTN: Customer Service at **203-949-8016**

APPENDIX B: OPTIONS DIAGRAM

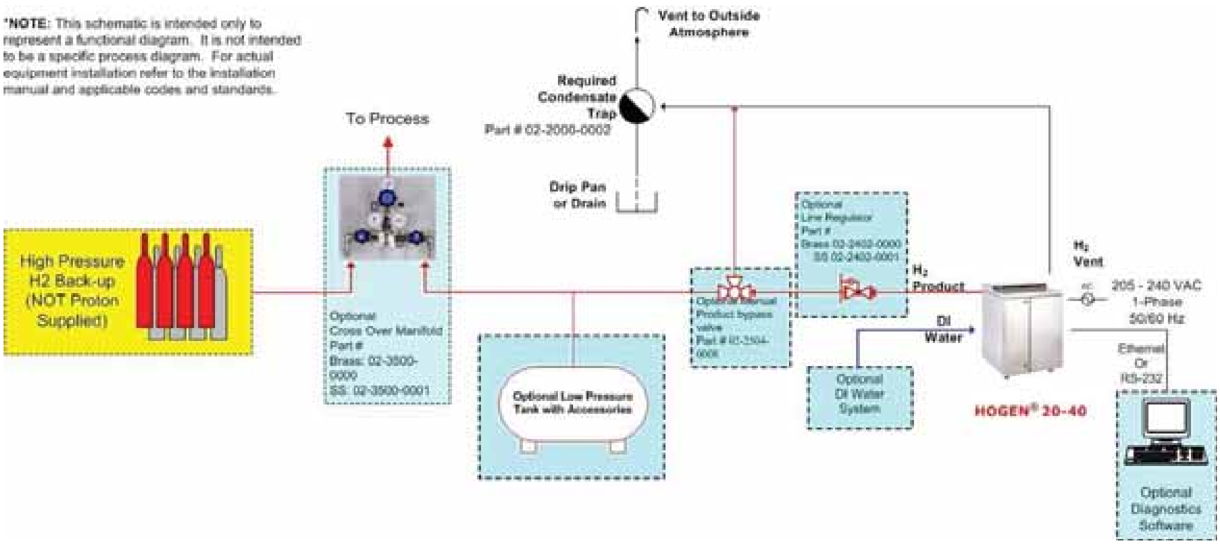


Figure 21 Options Diagram

APPENDIX C: CROSSOVER MANIFOLD OPTION

The crossover manifold option is available for use when high-pressure, backup storage is desired.

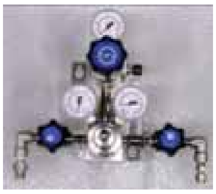


Figure 22 Crossover Manifold

The crossover manifold is available from PROTON using the following part numbers:

- Part # 02-3500-0001 for SS
- Part # 02-3500-0000 for Brass

NOTE There is a 50 psi pressure drop with this component.

To install the crossover manifold, use the following instructions:

1. The cross over manifold assembly is wall mountable.
    a. Hole Pattern: 3 13/16" X 5 ¼" on center. Hole Size: 5/16"

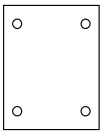


Figure 23 Wall Mountable Crossover Manifold Diagram

2. The left side of the manifold is for high-pressure feed and is labeled H.P. IN with a 4,000 psi pressure gauge. This side is connected to a storage tank or a high-pressure back up.
    a. Plumbing connection is: CGA or ¼" FNPT
3. The right side of the manifold is for low-pressure feed [hydrogen generator connection] and is labeled L.P. IN with a 250 psi pressure gauge.
    a. Plumbing connection is ¼" CPI or ¼" FNPT
4. The hydrogen supply exit is located at the top right.
    a. Plumbing connection is ¼" CPI or ¼" FNPT

NOTE This option may not be compatible with the StableFlow® Hydrogen Control System as part of the total integrated solution. Consult with the Proton Energy Systems Applications or Service Departments for further information.

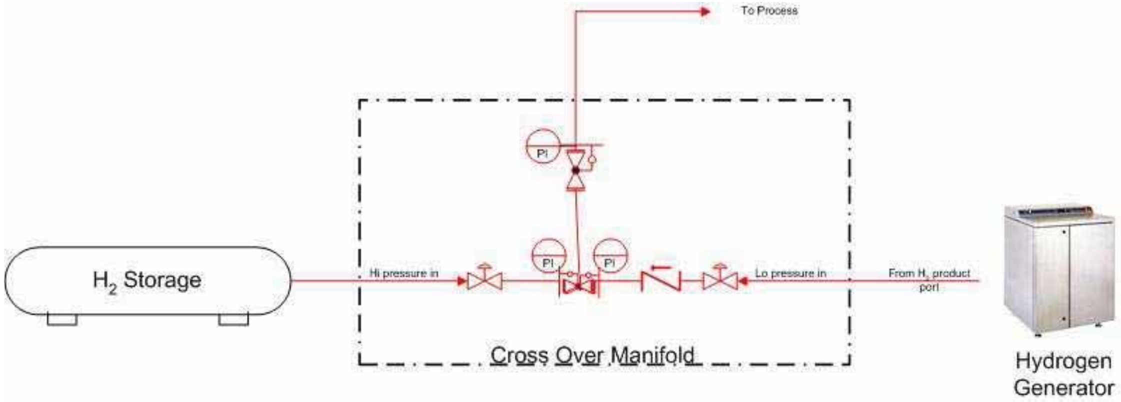


Figure 24 Crossover Manifold Diagram

APPENDIX D: PRESSURE REDUCING REGULATOR OPTION

The HOGEN S Series 2 is capable of supplying product hydrogen up to 200 psig. The hydrogen product line pressure can be reduced from 200 psig down to ambient using a pressure reducing regulator. The pressure reducing regulator may be installed anywhere between the product outlet on the HOGEN S Series 2 system and the point of use.

Selection of a regulator must be rated for hydrogen service.

NOTE

The reducing regulator should be sized for the desired pressure drop and maximum flow rate.

NOTE

The unit can only produce its rated output of flow. If flow requirements exceed the unit's rated output flow, it cannot maintain the desired delivery pressure.

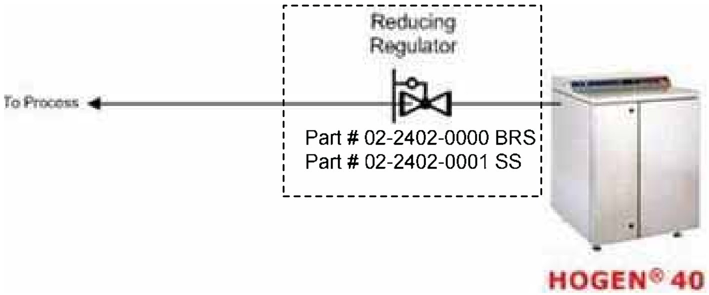


Figure 25 Pressure Reducing Regulator Schematic

APPENDIX E: DI WATER OPTION

Aqua Solutions® Deionized (DI) water treatment system is designed to support the S Series 2 HOGEN hydrogen generator. The system is designed to provide Type 2 or better DI water to one or more HOGEN S Series hydrogen generators. The system requires tap water, a drain and a grounded 100-240 VAC, 50-60 Hz electrical outlet in order to operate properly. The system can be bench, wall or shelf-mounted up to 10 feet from the hydrogen generator.

Figure 26 Aqua Solutions DI Water Option

Refer to the Aqua Solutions Model H-40-C Operating Manual, Revision 3.02 – 10/04 or later, for information regarding your DI water system.

APPENDIX F: WINDOWS DIAGNOSTIC SOFTWARE OPERATION

Windows-based Diagnostic Software is available as an option for the HOGEN S Series 2 hydrogen generator and can be purchased through Proton. The software enables users to monitor data, data log, modify configuration settings, and download software to the system control board. Instructions on how to operate these functions are detailed below.

System Information

To obtain miscellaneous system information use one of the two following procedure (screens cannot be used at the same time):

1. System Monitoring

   Monitoring I/O

   To monitor any analog or digital signal available from the system use the following procedure:

   1. Select VIEW > SYSTEM MONITORING from the toolbar.
   2. Select “Start Monitoring” button to start monitoring data
   3. Select “Stop Monitoring” button to stop monitoring data

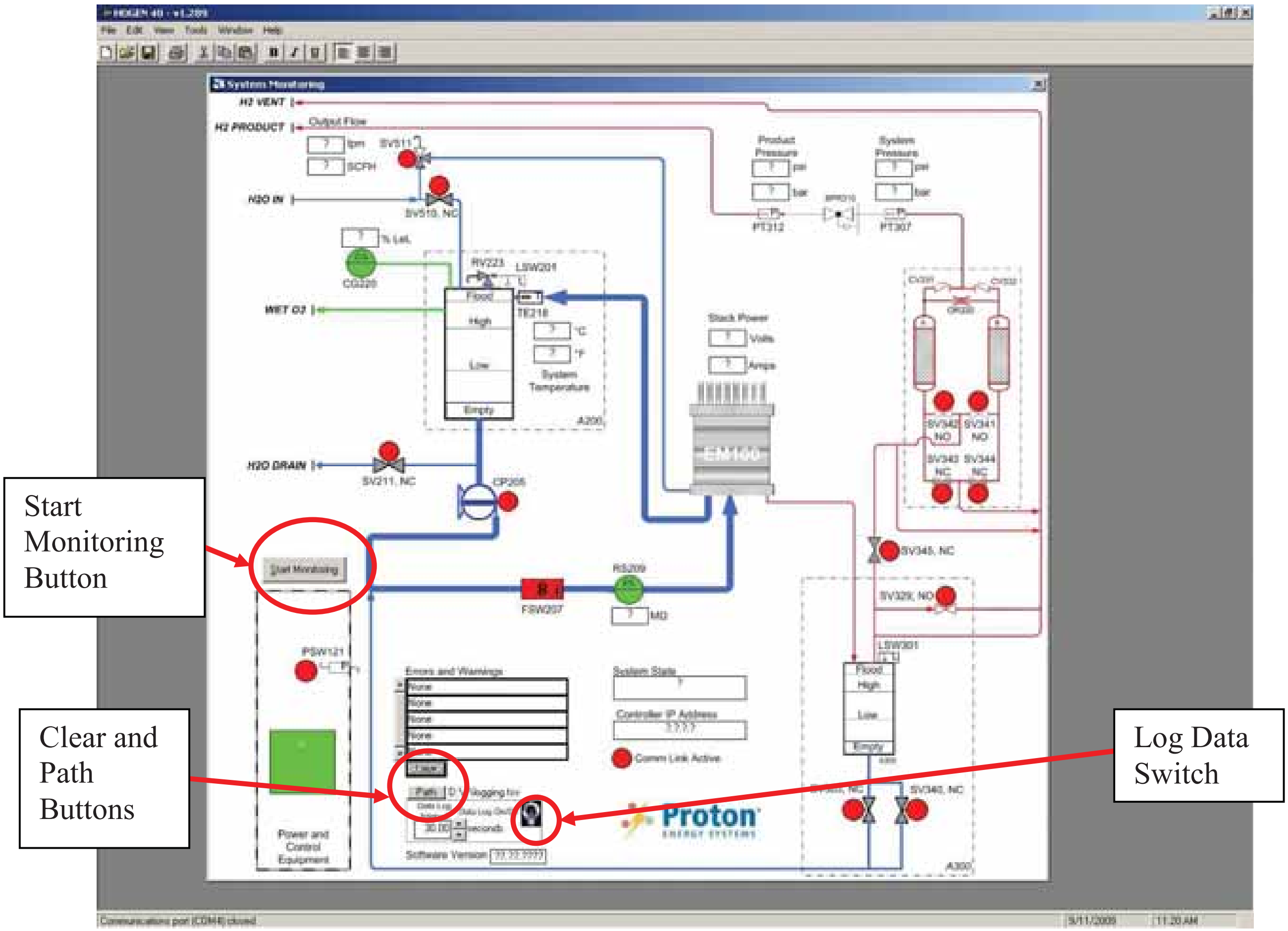


Figure 27 System Monitoring Screen

Logging Data

1. Select "Path" and choose a file name and location to log the data to.
2. Select a sampling Interval (minimum 3 seconds, maximum 60 seconds)
3. Click on the Log Data Switch

Errors and Warnings

Errors and Warnings are displayed live while the software is monitoring. To clear Errors and Warnings from the screen press the "Clear" button.

NOTE The System Monitoring screen must be stopped (press the "Stop Monitoring" button) to perform other functions (use Diagnostics screen, get/set configuration or calibration files, etc.)

2. Diagnostics
   1. Select VIEW > DIAGNOSTICS from the toolbar.

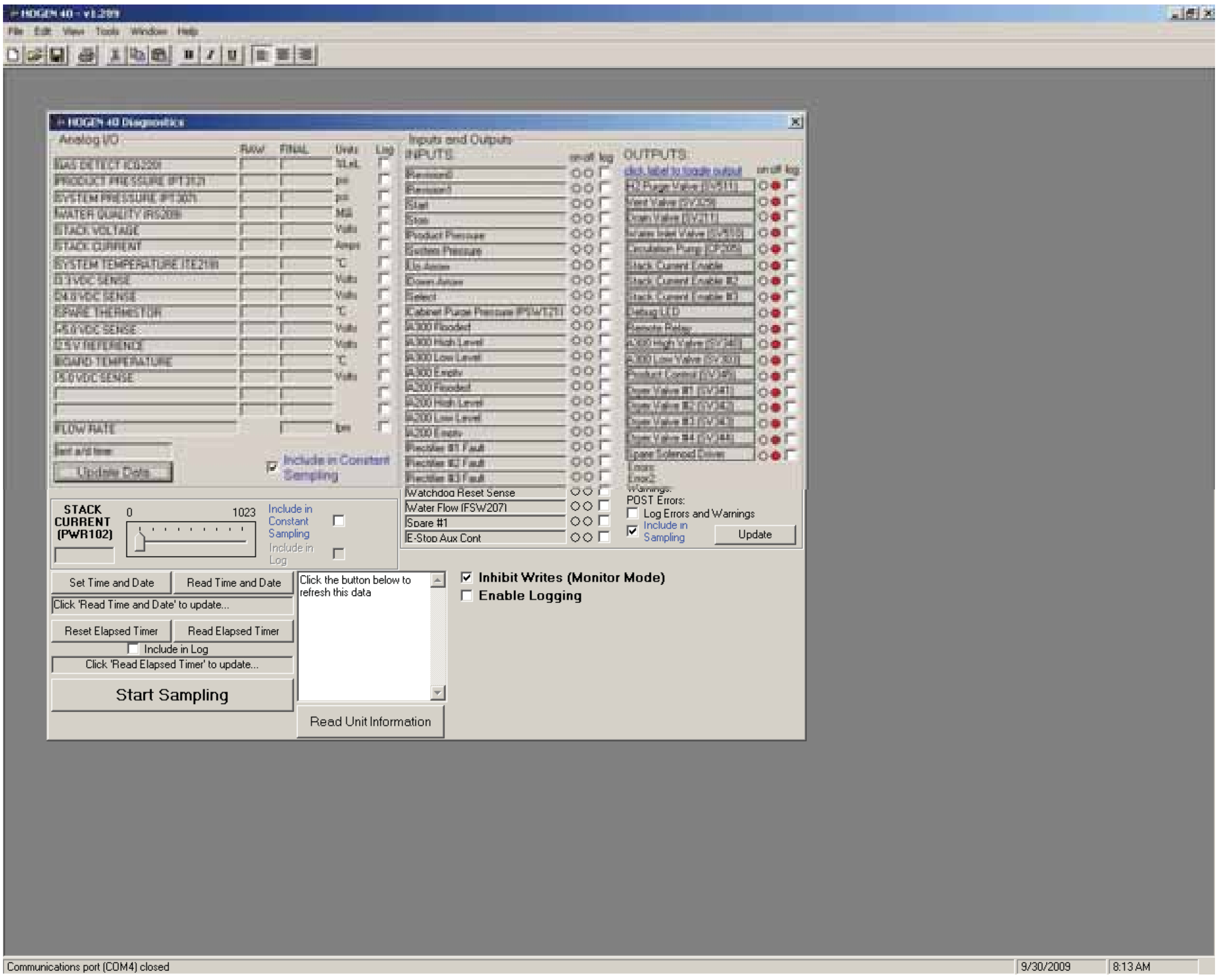


Figure 28 Diagnostics Window

2. Select the "Read Unit Information" button to obtain the FPGA version and the Board Hardware version.

3. To set or read the system time and date, select the appropriately labeled button. To set the system time and date requires technician level or higher security access.

4. To reset or read the system Elapsed Run Timer in hours, select the appropriately labeled button. To reset the system Elapsed Run Timer requires technician level or higher security access.

Monitoring I/O

To monitor any analog or digital signal available from the system use the following procedure:

1. Select VIEW > DIAGNOSTICS from the toolbar.
2. Once in the Diagnostics screen, ensure the "Inhibits Writes" box is checked.

3. Check the appropriate boxes for all signals desired for monitoring; i.e., Analog Inputs, Digital Inputs, Digital Outputs and Stack Current.
4. Select the “Start Sampling” button to begin data monitoring.
5. Select the “Stop Sampling” button to end data monitoring.
6. To perform updates for particular sets of I/O, select the “Update Data” button.

NOTE: For Digital Inputs and Outputs: Green implies “ON”, or that a state has been met. Red implies “OFF”, or that a state has not been met.

Logging I/O

To data log any analog or digital signal available from the system use the following procedure:

1. Select VIEW > DIAGNOSTICS from the toolbar.
2. Once in the Diagnostics screen, ensure the “Inhibits Writes” box is checked.
3. Ensure the “Enable Logging” box is checked.
4. Check all Log boxes for signals desired for logging. Use “All” and “None” buttons as required.
5. Select a desired sample rate from the pull down menu.
6. Use the “Change Path” button to select the file where the data is to be logged to.

Configuration and Calibration Parameters

To retrieve or send configuration or calibration parameters (Technician level or higher security required for sending) use the following procedure:

1. Select VIEW > CONFIGURATION or CALIBRATION OPTIONS as required from the toolbar.
2. Select the “Get From Device” button to upload parameters from the system. (Note: Configuration parameters P-00 through P-11 will appear in the shaded boxes.)
3. Select the “Get From File” button to obtain a specific file (installed on host computer or via a network connection.)

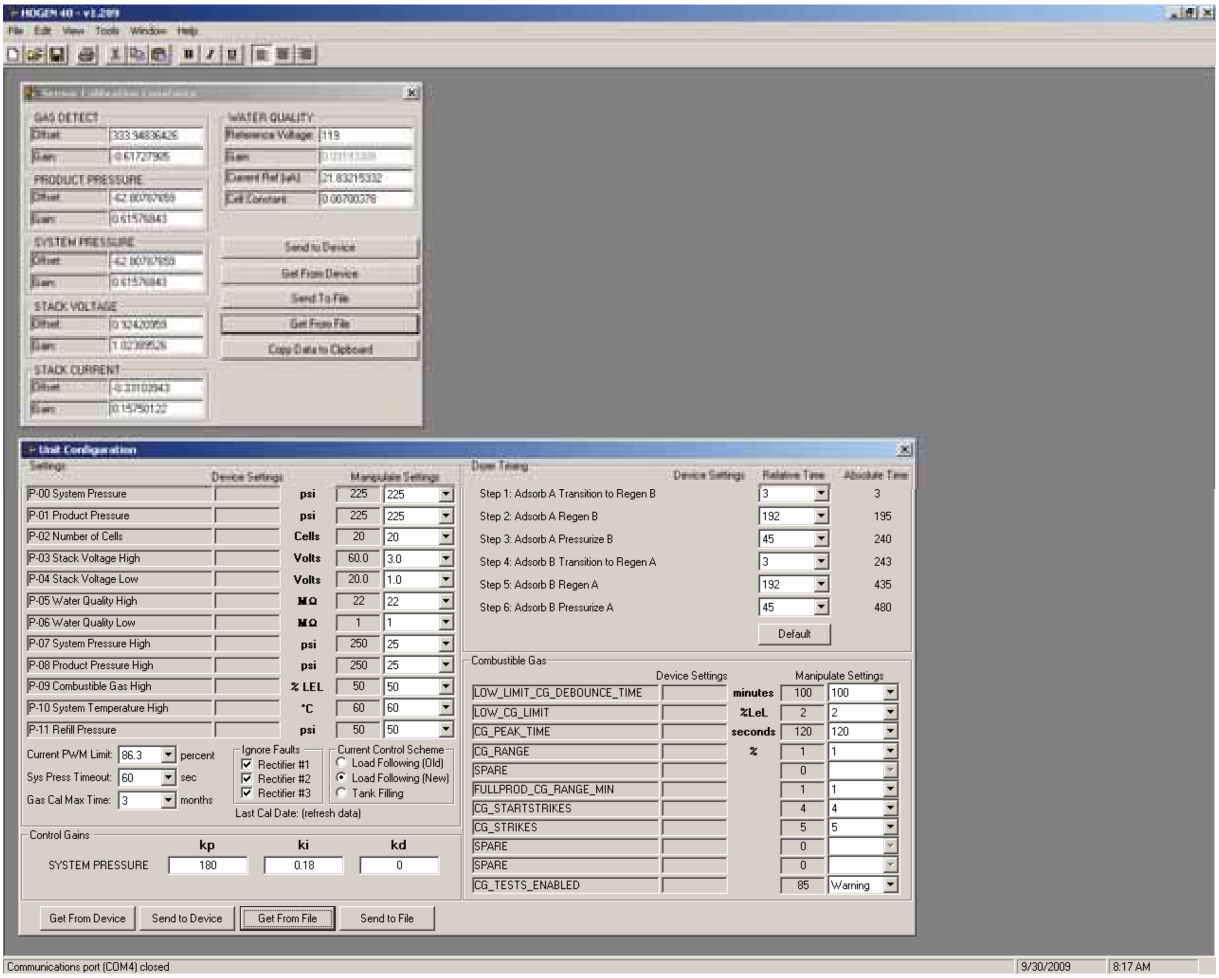


Figure 29 Configuration and Calibration Windows

4. Select the "Send to Device" button to send a particular set of parameters to the system.
5. Select the "Send to File" button to save a particular set of parameters to a file.
6. FOR CALIBRATION FILES ONLY: To copy the calibration constant values to a clipboard, select the "Copy Data to Clipboard" button.

Application and FPGA Downloads

To download application and FPGA codes to the system (Service Level or higher security required) use the following procedure:

1. Power off the unit.
2. Press and hold the stop and select button on the keypad display.
3. While holding the stop and select button power on the unit.

4. Continue to hold the stop and select button until the word IDLE is displayed on the screen. The unit is now in IDLE mode and it is safe to load the software.
5. Select VIEW > APPLICATION or FPGA OPTIONS as required from the toolbar.
6. To select a file to download, select the "Change Path" button (file installed on host computer or via a network connection.).
7. To download a listed file to the system, select the "Send to Device" button.

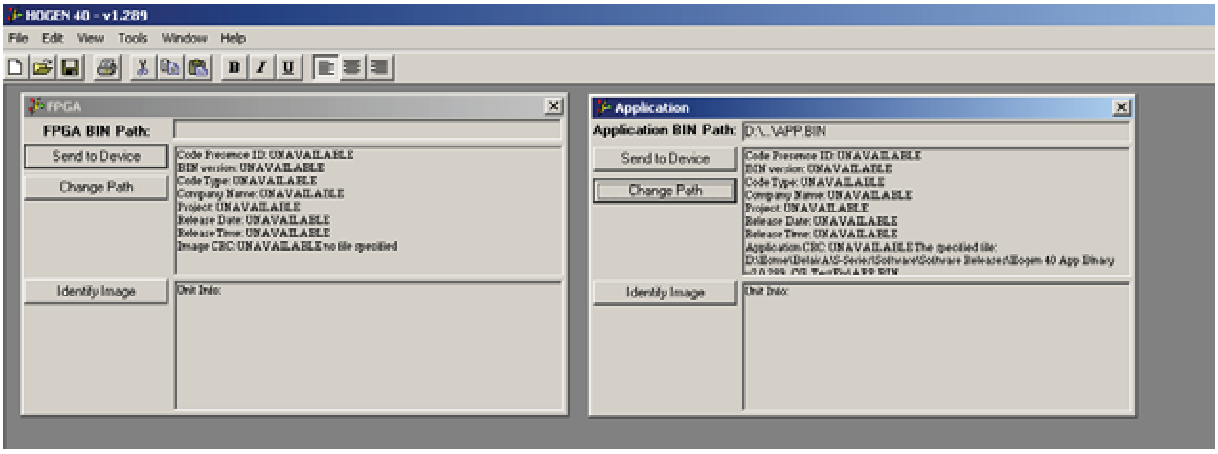


Figure 30 FPGA and Application Windows

8. Cycle power to the system after the device is sent.
9. FOR APPLICATION FILES ONLY: To retrieve the version of Application Code presently loaded into the system, select the "Get From Device" button. No security required for version retrieval.

Real Time Data Collection

To perform real time data collection use the following procedure:

1. Select VIEW > REAL TIME DATA and select the "Configuration" button.

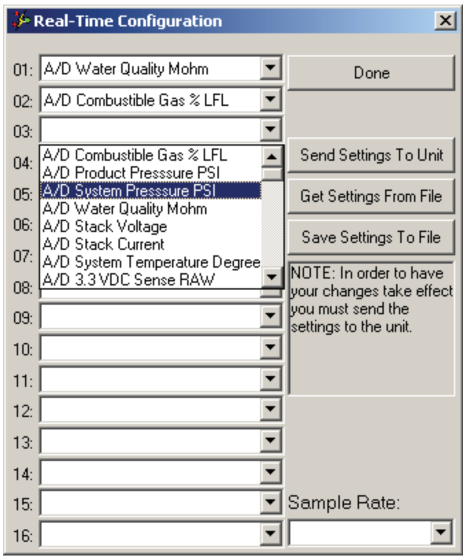


Figure 31 Real Time Data Configuration Window

a. To obtain a file of parameters/signals to collect, select the "Get Settings From File" button.

b. To save a particular set of data collection parameters to a file, select the "Save Settings To File" button.

c. To send a selected set of signals for data collection to the system along with a sample rate, use pull down menus as necessary to make selections. Upon completion of the selections select the "Send Settings To Unit" Button.

d. Upon completing the configuration setup for the Real Time Data Collection, select the "Done" button.

2. To monitor a pre-selected set of parameters (see Step 1), select the "Start Monitoring" button. To end the monitoring session, select the "Stop Monitoring" button.

3. To begin streaming data collection of a pre-selected set of parameters, select the "Start Streaming" button and verify the "Direct to File" box is checked.

   a. Select the file name and path to stream to, then select "Save".

   b. To end the Real Time Streaming session, select the "Stop Streaming" button.

4. If communication to the system is lost while in the middle of real time streaming, select the "Reset Unit" button to stop the streaming process and allow for proper disconnection from the system.

Options

To set or adjust file paths and communication options use the following procedure:

1. Select TOOLS > OPTIONS from the toolbar.
2. To select the Communications Port and other settings, select the “Communications” tab and select the appropriate Com port for the local computer.
3. If communicating via a Communications Module over Ethernet, select the TCP/IP connection box and enter the IP address assigned to the Communications Module.
4. To select default file paths for configuration, calibration, Application and FPGA files, select the “Directories” Tab.

Usernames and Passwords

To log into the system use the following procedure:

1. Select TOOLS > LOG IN from the toolbar and enter a valid username and password (service level or higher security required).
2. To log out of the system, select TOOLS > LOG OUT from the toolbar.
3. To update usernames or passwords, select TOOLS > USERNAMES/PASSWORDS from the tool bar and enter a valid username and password.
    a. To obtain existing usernames and passwords from the system, select the “GET” button.
    b. To modify a username or password, make changes to the appropriate boxes. Selecting from the pull down menus can modify user levels.
    c. To send a set of usernames and passwords to the system, select the “SEND” button.

NOTE

A service/administrator must always be sent to the system or the username and password feature will no longer be fully operational to the customer once the service/administrator logs out of the system. Also, sending a list of new usernames and passwords without the default usernames and passwords will result in deleting the defaults from the control board.

4. Reference the attached Table for a list of username and password permissions.

Function Performed	Minimum Security Level
Set Time and Date	Technician
Reset Elapsed Timer	Technician
Calibration File Load	Technician
Configuration File Load	Technician
Application Load	Service

FPGA Load	Service
User Name and Password Change	Service
Real Time Data	N/A
Diagnostics Logging	N/A
Read Time and Date	N/A
Read Elapsed Timer	N/A
Read Calibration File	N/A
Read Configuration File	N/A
Read Application Version	N/A

Table 11 Function Needs for Usernames and Passwords

5. The Default password for the control board is (case sensitive):

   Username: Technician **Password:** PRTNTECH (Technician)

6. In the event they have been corrupted or eliminated, performing a specific power up sequence will retrieve default usernames and passwords. Power down the system. Power the system back up while depressing keypad buttons Start, Stop, Select, and the Up arrow simultaneously. Upon power up the control board will "chirp." Once the "chirping" has stopped the default passwords will have been reset.

Errors/Warnings

To view a list of runtime error codes use the following procedure:

1. Select HELP > ERROR CODES from the toolbar.
2. To view a list of start up / power up error codes, select HELP > POST ERROR CODES from the toolbar.
3. To view a list of warning codes, select HELP > WARNING CODES from the toolbar.
4. To view a list of shutdown error codes, select HELP > ERROR CODES from the toolbar.
5. To view a list of Post (Power Up) error codes, select HELP > POST ERROR CODES from the toolbar.

Emulated Console

To view the Emulated Console, use the following procedure:

1. Select VIEW > CONSOLE from the toolbar.
2. The Emulated Console is a virtual representation of the front keypad display on the system. In order for the Emulated Console to be active, the Diagnostics screen must be Sampling Data.
3. To stop the generator remotely, select the STOP button 0 . Service level security required.
4. To reset or reboot the control board, select the RESET button. Service level security required. A RESET is required after any write command performed on the control board.

Pop Up Errors

To view the Pop Up Errors, use the following procedure:

1. Select VIEW > ERRORS from the toolbar.
2. The Pop Up Error box displays all current Warning and Shutdown Error Codes associated with the system.
3. In order for the Pop Up Error box to automatically display on a Warning or Shutdown condition, the Diagnostics screen must be Sampling Data.

NOTE

Errors and Warnings can also be seen in the System Monitoring screen while monitoring the unit.

Communications over Ethernet (TCP/IP 10/100 Base-T)

Requirements:
- Host Computer with Windows 2000 or Windows XP Professional
- Ethernet Card and Associated Cable. Maximum Cable Length of 100 Meters between Transmitter and Receiver

System Information

To set or adjust Ethernet communication options for IP and Email addresses, use the following procedure:

1. Select VIEW > SYSTEMS INFORMATION from the toolbar.
2. Entries are required for the following sections and must be obtained from a Network Administrator: IP Address, Subnet Mask, Gateway, DNS Server, To Email Address, SMTP Server, and SMTP Domain.
3. The remaining sections can be entered in based on the user's specific descriptions. For example, the Model Number, Serial Number and Build Date are specific to the HOGEN generator. The Subject is the message appearing in the header each time an email is sent. To activate email notification in the event of a warning, shutdown or other system status change, ensure the Enable Remote Email Notify button is checked.
4. System information must initially be sent to the control board via RS232. The Communication Module leaves the factory with default settings.
5. A system power cycle or a control board reset is required for the parameter change to be accepted.
6. Select the "From Device" button to upload parameters from the system.
7. Select the "From File" button to obtain a specific file (installed on host computer or via a network connection).
8. Select the "To Device" button to send a particular set of parameters to the system.
9. Select the "To File" button to save a particular set of parameters to a file.

10. The “Send Test Email” button is for a feature to be activated in future releases (V287 and higher).

Communication Module Website

As a troubleshooting aid, the Communication Module hosts a simple website. This website consists of the PROTON logo along with a computer that is updated every five (5) seconds. In the event the user is unable to communicate to the Communication Module with Windows Diagnostics software, enter the IP address assigned to the Communication Module into the Address section of Windows Explorer (ex: http://192.168.10.99) and select ENTER. If the website can be accessed, then a connection to the Communication Module exists and the user must verify the System Information and Options sections of the Windows Diagnostic software.

NOTE

If while performing a Read or Write operation and communication is lost, a Socket Error message may appear at the bottom of the Windows Diagnostics page. If communication does not re-establish automatically, try on the following:

- Close and then Re-Open the Windows Diagnostics Software
- Reboot the Control Board

NOTE

To prevent a potential communication loss, perform only one action a time. For example, stop sampling or logging data prior to performing a “write” operation, such as logging into the system as a Technician. Also, once communication is re-established after a loss (such as reconnecting a cable), it may take up to 60 seconds before full communication to the control board can be restored.

APPENDIX G: COMMUNICATIONS MODULE SOFTWARE OPERATION

Communication over Ethernet

Requirements:

- Host Computer with Windows 2000 or Windows XP Professional.
- Ethernet Card and associated cable. Maximum cable length of 100 meters between transmitter and receiver.

Adjusting Ethernet Communication Options for IP and Email Addresses

To set or adjust Ethernet communication options for IP and Email addresses, use the following procedure:

1. Select VIEW > SYSTEM INFORMATION from the toolbar.
2. Entries are required for the following sections and must be obtained from a Network Administrator: IP Address, Subnet Mask, Gateway, DNS Server, To Email address, SMTP Server, SMTP Domain.
3. The remaining sections can entered in based on the user's specific descriptions. For example, the Model Number, Serial Number and Build Date are specific to the HOGEN Generator. The Subject is the message appearing in the header each time an email is sent. To activate email notification in the event of a warning, shutdown, or other system status change, ensure the Enable Remote Email Notify button is checked.
4. System information must initially be sent to the control board via RS232. The Communication Module leaves the factory with default settings.
5. A system power cycle or a control board reset is required for the parameter change to be accepted.
6. Select the "From Device" button to upload parameters from the system.
7. Select the "From File" button to obtain a specific file. (Installed on host computer or via a network connection.)
8. Select the "To Device" button to send a particular set of parameters to the system.
9. Select the "To File" button to save a particular set of parameters to a file.
10. The "Send Test Email" button is for a feature to be activated in future releases (V286 and higher).

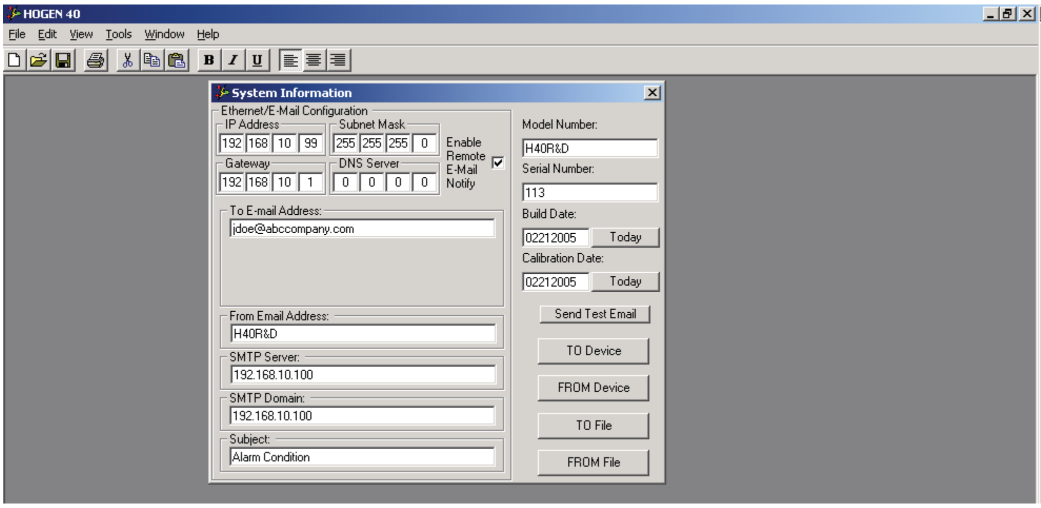


Figure 32 Ethernet System Information Window

Communications Module Application

To download the Communication Module application (Service Level or higher security required) use the following procedure:

1. Select VIEW > COMM MODULE OPTIONS as required from the toolbar.
2. To select a file to download, select the "Change Path" button. (The file installed on host computer or via a network connection.)
3. To download a listed file to the system, select the "Send to Device" button.
4. A system power cycle or a control board reset is required for the parameter change to be accepted.

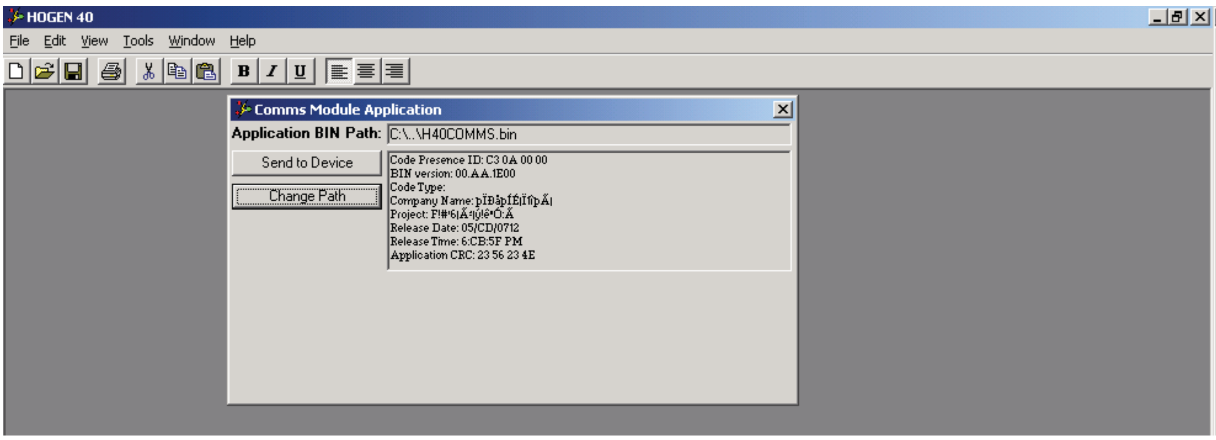


Figure 33 Communications Module Application Window

Communications Module Website

As a troubleshooting aid, the communications module hosts a simple website. This website consists of the Proton logo along with a counter that is updated every five (5) seconds. In the event the user is unable to communicate to the communications module with Windows Diagnostic software, use the following instructions:

1. Enter the IP address assigned to the communications module into the Address section of Windows Explorer (example: http://192.168.10.99) and select ENTER.
2. If the website can be accessed, then a connection to the communications module exists. Verify the System Information and Options sections of the Windows Diagnostics software.

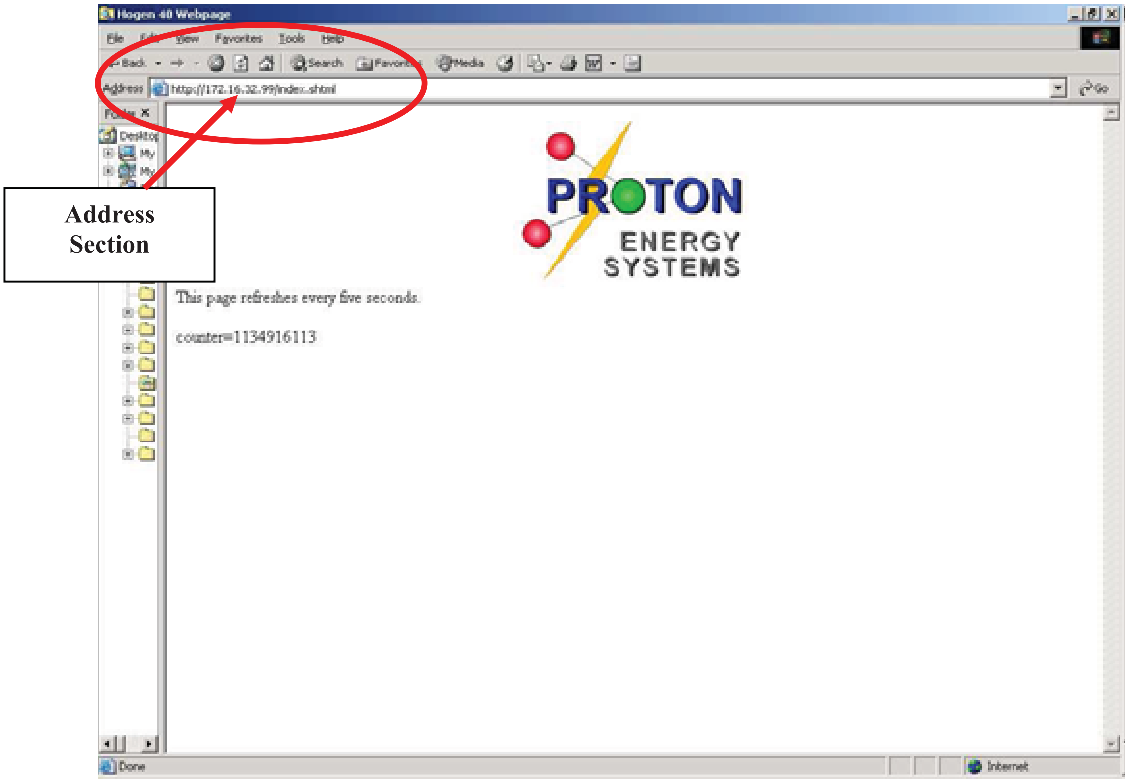


Figure 34 Communications Module Hosted Website

NOTE

If while performing a Read or Write operation and communication is lost, a Socket Error message may appear at the bottom of the Windows Diagnostics page. If communication does not re-establish automatically, try one of the following:

1. Close and then re-open the Windows Diagnostic software.
2. Reboot the control board.

CAUTION

To prevent a potential communication loss, perform only one action at a time. For example, stop sampling or logging data prior to performing a Write operation, such as logging into the system as Technician or Service.

NOTE

Once communication is re-established after a loss (such as reconnecting a cable), it may take up to 60 seconds before full communication to the control board can be restored.

8.18 Lightning Protection: RWV

Certification & Maintenance Manual

of the

LIGHTNING PROTECTION SYSTEM

at

UTS Broadway Building, Sydney, NSW.

Installation, testing and certification carried out by;

RWV Industries.
2463 River Road,
Wisemans Ferry, NSW, 2775.
Ph/Fax 02 4566 4376
sales@rwv.com.au

INDEX;

Description of building;

The building is of steel and concrete construction. It is a city campus building for the University of Technology Sydney. The roof has a wind turbine on it and the building has Binary Screen.

Description of lightning protection system;

Aerial termination;

The air termination on the roof of the building consists of three 5 meter lightning spires, one 15 meter spire, and the perimeter metal screen. The spires and the screen are bonded into the steel structure of the building.

Down conductors;

The steel within the concrete columns and steel frame of the structure is utilised as the down conductor.

Earth termination;

The footings of the building are utilised as the earth termination, see earth test ET30712N-1.

2463 River Rd
Wisemans Ferry, NSW, 2775.
Ph/Fax; 02 4566 4376
sales@rwv.com.au
Report No.; 30712N
Date; 26/04/13

RWV Industries.

Protecting Your Investment

Earth Test Report

General:

Building:	**UTS Broadway Building**	Report No;	**ET30712N -1**
Location:	**Cnr Wattle and Broadway St, Broadway.**	Test Conducted:	**1/9/2012**
Testing;	**Installation of Lightning protection system**		

Instrument Details:

Test Instrument:	**Megger Earth Tester DET4TD2**	Certificate No:	**T2421**
Calibrated by:	**Megger Instruments Limited**	Calibrated on:	**20/10/2011**

Test Details:

	Test Point Location	Meter reading
Test Point 1	**Test Point – Basement**	**0.56Ω**
Test Point 2	**Test Point – Basement**	**0.56Ω**
Test Point 3	**Test Point – Basement**	**0.54Ω**
Test Point 4	**Test Point – Basement**	**0.52Ω**
Test Point 5	**Test Point – Basement**	**0.47Ω**

Ground Density:	Soft	Pegs push in by hand. i.e. landscaping	Soil Moisture:	Low	Dry, no visible signs of moisture.
	Medium	Pegs hammered in. i.e. clay		Medium	Area moist, no water lying around.
	Hard	Pegs need holes drilled. i.e. rock		High	Raining, water lying around.

Test Method used:	"3 Pin Fall of Potential"	**"Dead Earth"**

NOTES; In accordance with the recommendations of AS1768-2007, the maximum earth resistance of an individual earth termination is 10Ω. The earth resistance is well under the recommendations of AS1768

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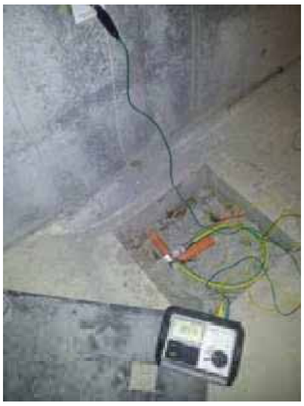
sales@rwv.com.au



If you have any questions regarding this report, please do not hesitate in contacting the undersigned.

Regards,

Peter Smart

0418 223 143

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Wisemans Ferry, NSW, 2775.
Ph/Fax; 02 4566 4376
sales@rwv.com.au
Report No.; 30712N
Date; 26/04/13

RWV Industries.

Protecting Your Investment

Certificate of Calibration

Megger.

Issued by: Megger Instruments Limited
Archcliffe Road
Dover
Kent CT17 9EN
www.megger.com

Instrument Details

Model: DET4TD2
Description: Megger Earth Tester
Serial Number: 1000347101097031

Environment Details

Temperature	Relative Humidity	Mains Frequency	Mains Voltage	Date Tested	20-Oct-2011
20°C ± 3°C	50% ± 20%	50Hz ± 0.5Hz	230V -2% + 10%	Date Commissioned	

Traceability Information

Serial No	Test Equipment Description	Procedure Version
T2421	Universal Earth Tester	V7.1

Test Title	Applied Value	Reading Value	Tolerance	Uncertainties	Pass/Fail
Voltage Ranges					
100 Vac	100 V	100 V	4 V	±1% ±1d	Pass
Resistance Ranges					
0 Ω	0.027 Ω	0.03 Ω	0.04 Ω	±0.5% ±1d	Pass
10 Ω	10 Ω	10.03 Ω	0.23 Ω	±0.5% ±1d	Pass
25 Ω	25 Ω	25 Ω	0.8 Ω	±0.5% ±1d	Pass
180 Ω	180 Ω	179.9 Ω	3.9 Ω	±0.5% ±1d	Pass
1.8 KΩ	1.8 KΩ	1.799 KΩ	39 Ω	±0.5% ±1d	Pass
18 KΩ	18 KΩ	18 KΩ	390 Ω	±0.5% ±1d	Pass

This certificate provides traceability of measurement to certified National Standards, and to the units of measurement realised at the National Physical Laboratory or other recognised National Standards Laboratories.

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Report No.; 30712N
Date; 26/04/13

RWV Industries.

Protecting Your Investment

SYSTEM CERTIFICATION

DIRECT STRIKE LIGHTNING PROTECTION SYSTEM

Certificate Date; 10/5/2013 Certificate Number; SC30712N

Structure Details;

Building; **UTS Broadway Building**
Location; **Broadway St, Broadway**
Usage; **University Building** Construction; **Concrete and Steel**

System Details;

Installing company; **RWV Industries Pty Ltd**
Installation date; **May 2013**
Type; **AS1768 - 2007**
Strike count; **N/A**
Aerial termination; **Screen & spires**
Down conductors; **Steel in Concrete**
Earth termination; **Structure footings**

Earth test Detail;

Report number; **ET30712N-1**
Test result **0.53Ω** Maximum allowed; **10.00 Ω**

Inspection Detail;

Inspecting company; **RWV Industries. 2463 River Rd, Wisemans Ferry, NSW 2775.**
Inspected by; **Peter Smart**
Date of Inspection; **25/03/2014**

Important Notice:
AS1768 in clause 8.2 states a routine inspection should be made of the lightning protection system. For this certificate to remain in force, the installed system must be annually inspected.

Next Inspection Due: 25/03/2015

This certificate is to certify that the design, installation and materials of the direct strike lightning protection system are in accordance with the manufacturers design recommendations.

Compliance Certified: Date 25/03/14

✓

Peter Smart

Service and Maintenance:

Inspection:

All mechanical bonds and fixings on the system should be physically examined for loose mechanical pressure and corrosion every 12 months as in accordance with AS1768.

Testing of the Lightning Protection System Earth:

Testing of the earth system should be conducted in accordance with AS1768, which states, "the resistance to earth of the whole installation and of each earth termination should be measured, and the electrical continuity of all conductors, bonds and joints and their mechanical condition verified. The testing should be carried out in accordance with Appendix B.

If the resistance to earth of the lightning protection system, when so determined, exceeds the specified value for the particular applications, the value should be reduced to be in accordance with the recommendations of this standard. If the resistance is less than the recommended value but significantly higher than the previous reading, the cause should be investigated in accordance with Appendix B."

AS1768 does not state specific testing periods, however it is the industry standard and good practice to test the earth system every 12 months and at the same time the general maintenance inspection is conducted.

Any repairs or earth test reading should be carried out by the installer to their satisfaction and to the satisfaction of the building supervisor.

Maintenance:

The periodic inspections and tests will indicate what maintenance should be undertaken. Particular attention should be paid to earthing, to any evidence of corrosion and to any alterations to the structure, which may affect the lightning protection system.

System Warranty:

This Lightning Protection System produced and installed or repaired by RWV Industries Pty Ltd is guaranteed to be free from defects in material for a period of one (1) year from the date of acceptance by the customer. This guarantee or any other implied warranty or condition whatsoever incorporated doesn't and shall not cover;

1. The repair of any fault in the product or the replacement of any part thereof where such repair or replacement has resulted from negligence or malpractice of the customer, its servants, agents, employees or any other third parties or persons.

2. Any consequential loss or damage suffered by the customer arising from any defect in design, materials or workmanship of the product, including any damage or cost due to loss of operation or lost profit or any other direct or indirect cost or damages.

3. The repair or replacement of any product where the product has been altered or modified by the purchaser, or where the Customer has not installed the product, in strict accordance with the initial specifications upon which the Company's quotation for the product was based.

The above guarantee is additional to rights which arise for the sale of industrial and technical products and services to knowledgeable buyers under the Australian Trade Practices Act 1974 as amended. However, to the extent that the Trade Practices Act permits a company to limit its liability to a breach of a condition or warranty implied by the said Act, the company's liability for such breach of a condition or warranty shall be limited to:

- The replacement of the product.
- The repair of the product.
- The payment of the cost of having the product repaired.

In the case of a service:

- The supply of the service again.
- The payment of having the service repeated.

The purchaser agrees that since atmospheric lightning discharge is a natural and unpredictable process and subject to the laws of nature, under these conditions a guarantee cannot be given with respect to the operation of our equipment. Total protection is not offered i.e. 100% protection cannot be guaranteed.

Photos of construction

8.19 Fire Rating: Fire Stopping

See attached folder Section 8

FIRE STOPPING
PASSIVE FIRE PROTECTION
ABN 47 064 568 770

NSW Office
PO Box 737
Balgowlah, NSW 2093

Unit 6, 252 Allambie Road,
Allambie Heights, NSW 2100

Phone: (02) 9907 0700
Fax: (02) 9907 0728

QLD Office
PO Box 562
Virginia BC, QLD 4014

Unit 7, 53 Northlink Place
Virginia, QLD 4014

Phone: (07) 3265 7781
Fax: (07) 3265 5976

Installation Certification

ADDRESS:	83 – 117 Broadway, Ultimo
PROJECT:	UTS BROADWAY PROJECT – BUILDING 11

I, Andrew St John of Fire Stopping Pty Ltd

(Name) (Firm)

Unit 6 / 252 Allambie Road, Allambie Heights, NSW 2100

(Address)

Qualifications and Experience:	**Accredited Passive Fire Products Installer**
	9 Years Experience

Phone Numbers:	Bus:	9907 0700	Fax:	9907 0728	Mob:	

Hereby certify:

That the Fire seals protecting electrical cable penetrations

have been installed and commissioned / tested to comply with:

a. The relevant clauses of the Building Codes of Australia, as follows:

BCA Clause C3.15

b. The relevant Australian Standards listed in the Building Code of Australia (Specification A1.3) as follows:

AS1530.4 – 2005

AS4072.1 - 2005

c. The following additional Australian Standards (if applicable):

N/A

d. Other practices, standards, reports or relevant Development Consent Conditions relied upon for this certification:

N/A

e. Exclusions: YES / NO

No

Signature: A. [signature] **Date:** 27/2/2014

Materials Science and Engineering
14 Julius Avenue, Riverside Corporate Park
North Ryde NSW 2113
PO Box 310, North Ryde NSW 2113, Australia
Telephone: (02) 9490 5444 • Facsimile: (02) 9490 5555 • ABN 41 687 119 230

CSIRO

Our ref: FCO-1579/3671

Trafalgar Building Products
Level 4
10-14 Waterloo Street
SURRY HILLS NSW 2010

Attention: Mr Cho Nguyen

FYREFLEX SEALANT MANUAL PAS 5.01
Assessment No. FCO-1579

We have re-examined the supplied document numbered PAS 5.01 (previously known as DW 4.02 entitled "Fyreflex, Fire Rated Sealant") with reference to the constructional specifications of various penetration and control joint systems as they relate to likely fire performance. We have retained a copy of this document. Other information assessed included:-

- Australian Standard 1530, Methods for fire tests on building materials, components and structures, Part 4-1997, Fire-resistance tests of elements of building construction;
- Australian Standard 4072 Components for the protection of openings in fire-resistant separating elements, Part 1-1992, Service penetrations and control joints; and
- test reports listed in the publication.

Based on this information it is the assessment of the Division that from a fire engineering perspective the document represents systems consistent with our analysis as capable of achieving the designated fire-resistance levels if they were tested in accordance with AS 1530.4-1997.

It should be noted that the metal pipes penetrations, the damper installation and the bus bar system will not satisfy the insulation criterion of Section 2 of AS 1530.4-1997. Dampers are not required by the test standard to satisfy this criterion.

TERM OF VALIDITY

This assessment report will lapse on 31 March 2014. Should you wish us to re-examine this assessment with a view to the possible extension of its term of validity, would you please contact us three to four months before the date of expiry. This Division reserves the right at any time to amend or withdraw this report in the light of new knowledge.

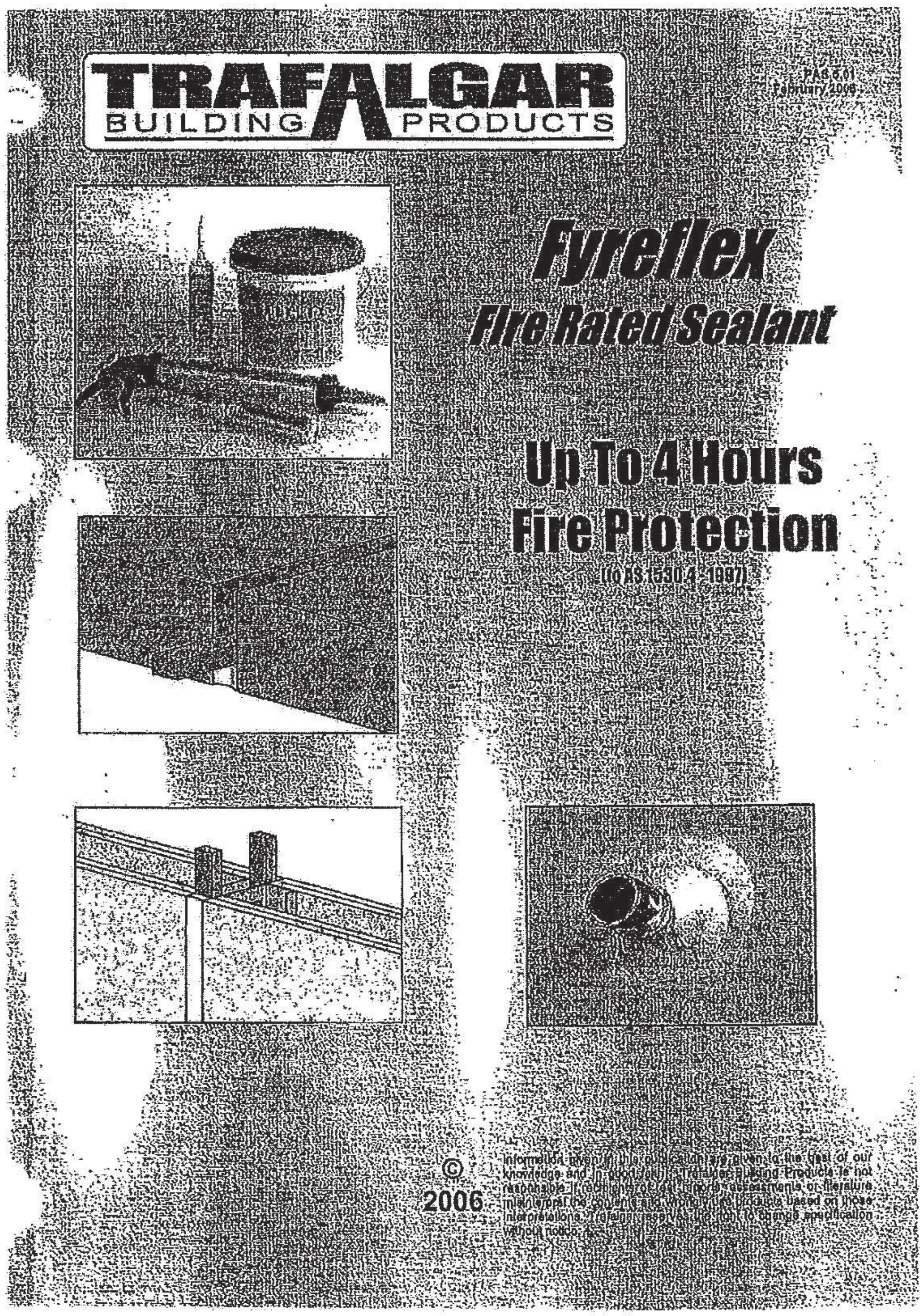
Yours faithfully,

Garry E Collins

Garry E Collins
Manager, Fire Testing and Assessments

31 March 2009

THIS ASSESSMENT SUPERSEDES FCO-1579 ISSUED ON 25 NOVEMBER 2003


TRAFALGAR
BUILDING PRODUCTS
Fyreflex
Fire Rated Sealant
Up To 4 Hours
Fire Protection
(to AS 1530.4 - 1997)
© 2006

Fyreflex Sealant

Description

Fyreflex is an acrylic (water based) gun grade mastic with limited (±5%) joint movement capability. Supplied in 10 litre buckets, 600ml sausage style sachets and 300ml cartridges with nozzle.

Fyreflex is available in off-white to suit plasterboard and grey to suit masonry applications.

Applications

Fyreflex is designed for sealing internal joints and wall penetrations subject to low movement and requiring up to 4 hours fire rating compliance.

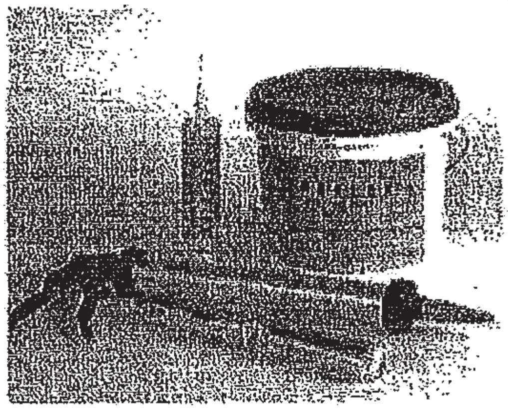
- Insitu internal jointing of concrete, precast panels, block and brick work and drywall systems.
- Sealing of electrical cables and pipe penetrations.
- Acoustic gap filling combined with fire rating requirement.
- May be used in conjunction with other systems such as fire collars, pillows, board systems and fire rated mortar.

Advantages

- Water based (easy clean up)
- Smooth gunnability and tool off finish
- Excellent adhesion to metal, wood, plasterboard and all masonry
- Paintable
- Water resistant once cured
- Excellent acoustic properties with ratings up to 45 STC in joints

Method of Application

Install back-up material or joint filler as specified. Apply Fyreflex sealant in a continuous operation using a positive pressure adequate to properly fill and seal the joint or penetration. Tool Fyreflex with sufficient pressure to spread the sealant against the back-up material and onto the joint surfaces. A tool with a concave profile is recommended to achieve the correct shape.



Joint And Penetration Design

Fyreflex is gunned into and around the service penetrations and into any clearance holes through the fire separating element. Depth fill into cavities is controlled by pre-packing with foamed plastic backing rod.

Application Limitations

a) Fyreflex is not recommended for water immersion, exposed external joint sealing or areas subject to heavy traffic.
b) Fyreflex has a ±5% joint movement capability.
c) Fyreflex should not be applied with wet tooling techniques - using solvents, water or detergent/ soap solution is not recommended.
d) Fyreflex should not be applied to surfaces with special protective or cosmetic coatings without prior consultation with the manufacturer. Such surfaces include, but are not limited to, mirrors, reflective glass, or surfaces coated with Teflon, polyethylene or polypropylene.
e) Fyreflex can be affected by water before or during cure. The sealant should not be stored, applied or cured in areas where unusually high humidity or free water are pressent during the application or intial cure.
f) Fyreflex should be allowed to cure for 7 days prior to subjecting to any intermittent water exposure.
g) Temperature range during application +5°C to +35°C

TRAFALGAR BUILDING PRODUCTS

SALES OFFICE:

NSW:	Ph:	(02) 9938 5499	Fax:	(02) 9905 7019
QLD:	Ph:	(07) 3267 8444	Fax:	(07) 3267 8018
VIC:	Ph:	(03) 9720 2141	Fax:	(03) 9729 0715

31/3114

Fyreflex Sealant

Specification And Standards

Testing
Fire tests have been conducted to AS 1530.4, in accordance with AS4072.1, on concrete floors, brick, masonry, tilt-up panels, block, and plasterboard walls.

Construction and Expansion Joints:
Construction and expansion joints to be fire stopped to maintain the required FRL of the wall or floor element by treatment with Fyreflex fire resistant sealant in accordance with Trafalgar Building Products instructions.

Service Penetrations:
Service penetrations to be fire stopped to maintain the required FRL of the penetrated wall or floor element by treatment with Fyreflex fire resistant sealant in accordance with Trafalgar Building Products instructions.

NOT TO BE TAKEN
KEEP OUT OF REACH OF CHILDREN

Avoid contact with skin and eyes and avoid breathing vapours. If poisoning occurs contact a doctor or poisons information centre. If skin contact occurs remove contaminated clothing and wash skin thoroughly. Refer to Material Safety Data Sheet for further information.

Storage & Handling

All materials shall be stored under cover in a manner that will prevent damage preferably on pallets and protected from moisture.

Do not freeze. Store in temperatures 5°C - 30°C.

Warranty

Limited Warranty:

Your purchase and use of this product is subject to Trafalgar's standard terms and conditions of sale. Trafalgar's sole liability in the event of a product defect is, at our option, to replace this product or return its purchase price.

All other warranties whether express or implied, including without limitations, any warranty of merchantability or fitness of purpose are expressly disclaimed unless prohibited by law or given in writing by Trafalgar for a specific project.

Disclaimer:

Information given in this publication is given to the best of our knowledge and in good faith. Trafalgar Building Products is not responsible if recipients of test reports, assessments or literature misinterpret the contents and wrongly use products based on those interpretations. No liability is accepted for error or omissions in this document. Trafalgar Building Products reserves the right to change the specification without notice.

Fyreflex Usage Rate (ml/m)

DEPTH OF JOINT (mm)	WIDTH OF JOINT(mm)						
	10	15	20	25	30	40	50
10	100	150	200	250	300	400	500
12	120	180	240	300	360	480	600
15	150	225	300	375	450	600	750
20	200	300	400	500	600	800	1000

PAS 5.01
February 2006

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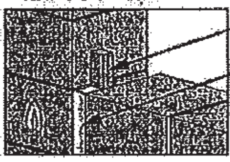
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0716

Fyreflex Grey

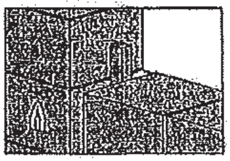
Masonry Construction and Expansion Joints

Concrete, Brick and Block Walls

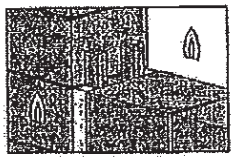
A) JOINT PROTECTED FROM EXPOSED SIDE



B) JOINT PROTECTED FROM UNEXPOSED SIDE



C) JOINT PROTECTED FROM BOTH SIDES

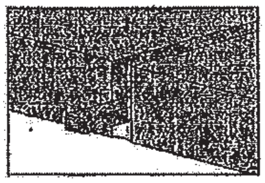


Fill Depths of Fyreflex (mm)

JOINT WIDTH (mm)	10			20			25		30		40		50	
JOINT FILL TYPE	A	B	C	A	B	C	A	C	A	C	A	C	A	C
RATING (hrs)														
-/120/120	10	15	10	10	30	10	12	12	15	15	20	20	25	20
-/180/180	10	15	10	10	30	10	12	12	15	15	20	20	25	20
-/240/240	15	15	10	30	35	15	30	20	30	20	40	20	40	20

NOTE: Joint may be filled on one side if direction of fire is known. If direction of fire is not known, sealant must be applied from both sides.

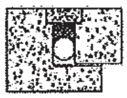
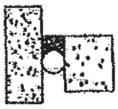
Internal Concrete and Pre-Cast Slabs



Fill Depths of Fyreflex (mm)

	JOINT WIDTH (mm)					
RATING (hrs)	10	20	25	30	40	50
-/120/120	10	10	12	15	20	25
-/180/180	10	10	12	15	20	25
-/240/240	15	30	30	30	40	40

Special Applications

System Description	System Diagram	System Description	System Diagram
• External applications • Up to 4 hours • With non-rated external grade sealant		• Steel decking • Upto 4 hours	
• Slab-on-slab • Up to 4 hours • With non-rated external or internal grade sealant		• Joint between wall and floor slab • Upto 4 hours	

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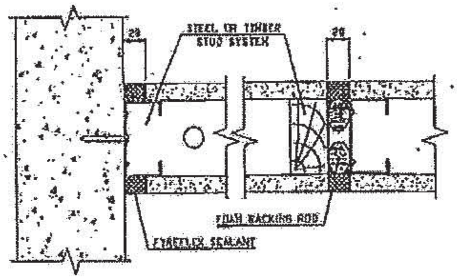
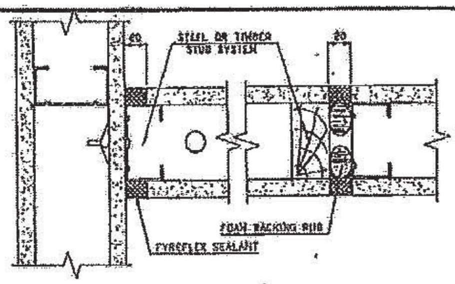
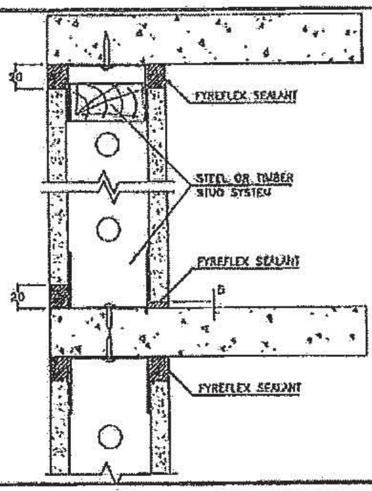
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0715

Fyreflex White

Drywall Construction and Expansion Joints

1 Hour Plasterboard Systems

SYSTEM	SYSTEM DIAGRAM
• T-Junction between concrete wall and plasterboard wall • Typical control joint in plasterboard wall	
• T-junction between two plasterboard walls • Typical control joint in plasterboard wall	
• Deflection head and base between concrete slabs and plasterboard wall *NOTE:* • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*	

PAS 6.01
February 2006

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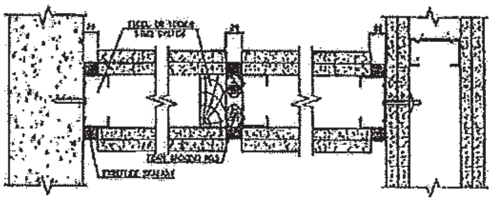
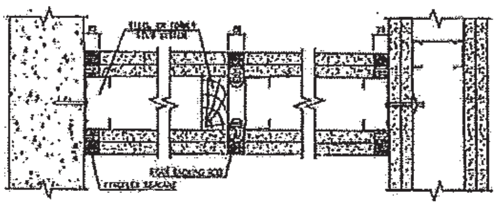
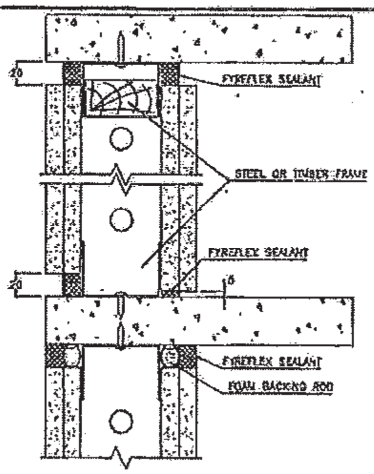
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0715

Fyreflex White

Drywall Construction and Expansion Joints

2 Hour Plasterboard Systems

SYSTEM	SYSTEM DIAGRAM
• T-Junction between concrete wall and plasterboard wall • Typical control joint in plasterboard wall • T-junction between two plasterboard walls	
• T-Junction between concrete wall and plasterboard wall • Typical control joint in plasterboard wall • T-junction between two plasterboard walls	
• Deflection head and base between concrete slabs and plasterboard wall ***NOTE:*** • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*	

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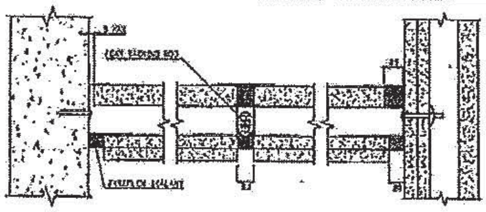
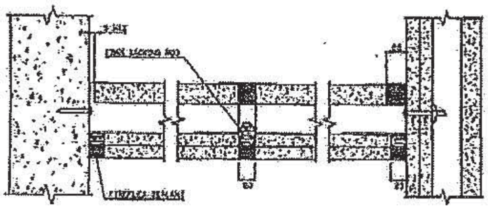
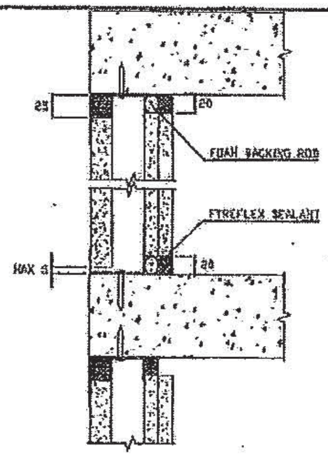
QLD: Ph: (07) 3267 6444 Fax: (07) 3267 6018
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0716

THIS ASSESSMENT SUPERSEDES FCO-1579 ISSUED ON 25 NOVEMBER 2003

Fyreflex White

Drywall Construction and Expansion Joints

2 Hour Shaft Wall Systems

SYSTEM	SYSTEM DIAGRAM
• T-Junction between concrete wall and shaft wall • Typical control joint in shaft wall • T-junction between two shaft walls	
• T-Junction between concrete wall and shaft wall • Typical control joint in shaft wall • T-junction between two shaft walls	
• Deflection head and base between concrete slabs and plasterboard wall ***NOTE:*** • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*	

PAS 5.01
February 2008

TRAFALGAR BUILDING PRODUCTS

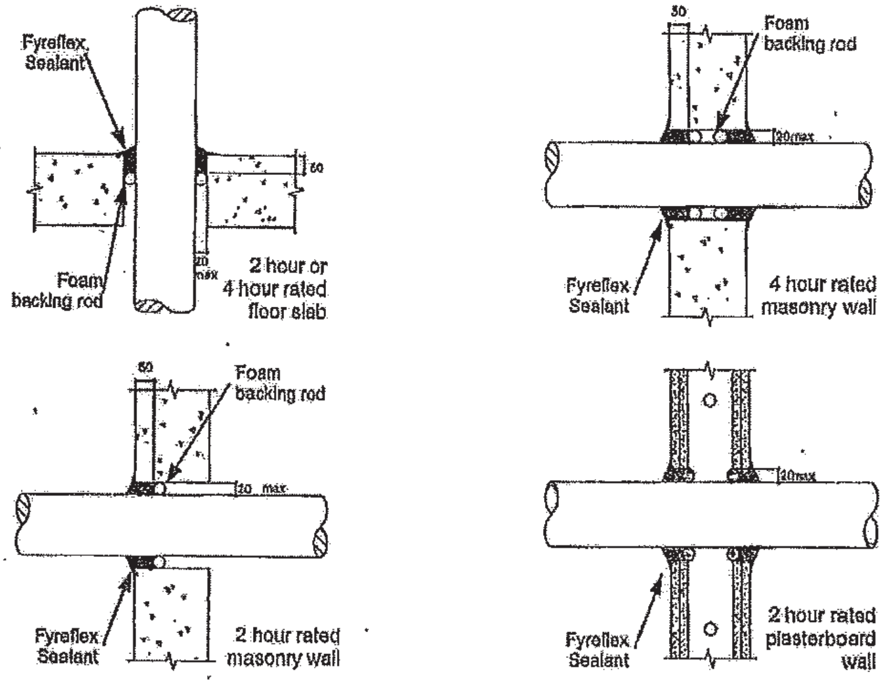
SALES OFFICE:
NSW: Ph: (02) 9938 5499 Fax: (02) 9905 7019
QLD: Ph: (07) 3267 8444 Fax: (07) 3267 5018
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0715

Fyreflex Sealant

Page 8

Miscellaneous Penetrations

Pipe Penetrations



PIPE TYPE	WALL OR FLOOR	PIPE SIZES	FRL
STEEL			
⇒ Non Insulated	Walls and floors	Up to 225mm diam.	240/240/-
⇒ With 25mm rockwool insulation	Floors only	Up to 200mm diam.	180/180/-
CAST IRON			
⇒ Non Insulated	Walls and floors	Up to 225mm diam.	240/240/-
⇒ With 25mm rockwool insulation	Floors only	Up to 200mm diam.	180/180/-
BRASS			
⇒ Non Insulated	Walls and floors	Up to 102mm diam.	240/240/-
COPPER			
⇒ Non Insulated	Walls and floors	Up to 225mm diam.	240/240/-
⇒ With 25mm rockwool insulation	Floors only	Up to 19mm diam.	120/120/-
FIBRE RE-INFORCED CEMENT PIPES AND COLUMNS	Walls and floors	Up to 225mm diam.	120/120/120

PAS 6.01
February 2005

TRAFALGAR BUILDING PRODUCTS

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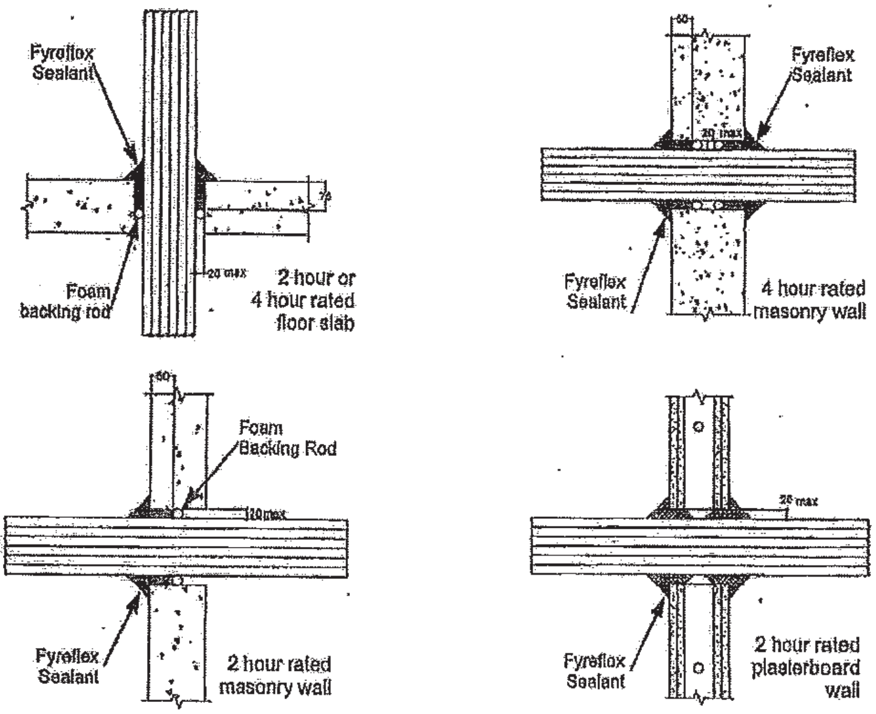
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0715

Fyreflex Sealant

Miscellaneous Penetrations

Electrical Cable Penetrations



PENETRATION TYPE	WALL OR FLOOR	PENETRATION SIZES	FRL
SINGLE CABLE	Walls and floors	Up to 54mm diam.	240/240/110
CABLE BUNDLE	Walls and floors	Bundle of up to 24 cables.	240/240/95
STEEL CABLE TRAY	Walls and floors	Up to 380mm wide with assorted cables	240/240/110
BUS BARS	Walls and floors	50 x 10mm copper bus bars	120/120/-

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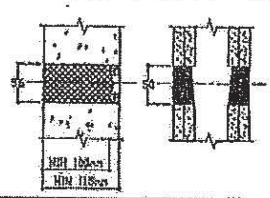
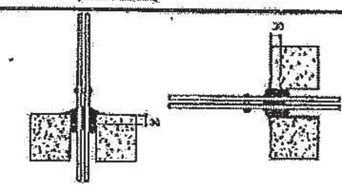
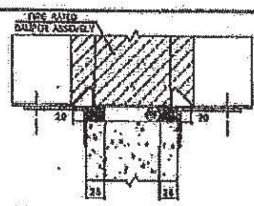
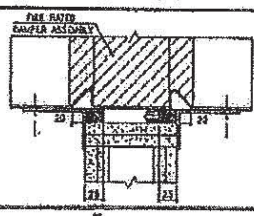
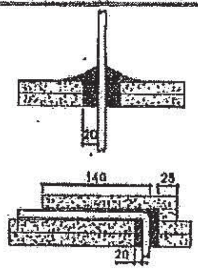
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0715

THIS ASSESSMENT SUPERSEDES FCO-1579 ISSUED ON 25 NOVEMBER 2003

Fyreflex Sealant

Miscellaneous Penetrations

Special Applications

SYSTEM	SYSTEM DIAGRAM	FIRE RESISTANCE
• Blank penetration, walls and floors. Max 56mm diameter.		120/120/120
• Copper and aluminium bus bars. Walls and floors. Max size 10 x 200mm.		120/120/-
• Perimeter seal for steel duct and damper used in masonry walls and floors.		120/120/-
• Perimeter seal for steel duct and damper used in drywalls.		120/120/-
• Cable penetrations through plasterboard ceiling		60/60/- *NOTE:* • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*

TRAFALGAR BUILDING PRODUCTS

SALES OFFICE:
NSW: Ph: (02) 9938 5499 Fax: (02) 9905 7019
QLD: Ph: (07) 3287 8444 Fax: (07) 3287 5018
VIC: Ph: (03) 9729 2141 Fax: (03) 9729 0716

THIS ASSESSMENT SUPERSEDES FCO-1579 ISSUED ON 25 NOVEMBER 2003

Fire Pillows
Technical Data Sheet

FIRE STOPPING
PASSIVE FIRE PROTECTION
ABN 47 064 568 770

Photo shows Thermachek Fire Pillows during 3 hour fire test on a Masonry Wall

Product description

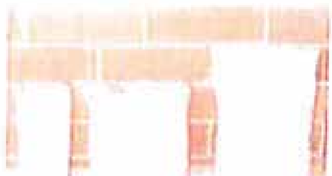
Fire Rated Pillows for floor & wall penetrations

The Thermachek™ fire pillow is suited to fire wall and floor penetrations. The pillows are manufactured with a fire rated material, sewn into a high quality cloth envelope. The pillows can be used in environments where pipes, telecommunications cables, cable trays and service shafts penetrate a fire wall or floor. When used with a fire-rated sealant, the fire pillows will maintain the integrity of a fire wall or floor.

Thermachek™ fire pillows have been tested and certified for up to 3 hours of fire protection. They comply with fire resistance measures found with AS1530.4-1997 and AS4072-1992 as engaged by Warrington Test Report No. F.91876 dated 12 June 2001, Warrington Test Report No.F.91879 dated 12 June 2001 & CSIRO AssessmentNo. FCO.2263 dated 21st August 2003.

Size & Quantity

Large	300 x 200 x 40mm (box of 30)
Medium	200 x 200 x 40mm (box of 50)
Small	200 x 100 x 40mm (box of 125)



Advantages.

- Reusable - allows for opening & reopening of penetrations
- Non-toxic
- Convenient sizes
- Easy to carry, transport and store
- Low-cost solution to maintaining fire wall integrity
- Complies with all relevant standards
- Tested for up to three hours fire protection

www.firestopping.com.au
E: admin@firestopping.com.au

Warrington Fire Research test reports. Test duration 3 hours.

Test No. F91876 (dated 12 June 2001)
Test for Fire Pillows protecting openings in masonry walls when tested in accordance with AS1530.4-1997 sections 2, 4 & 10 and AS4072.1-1992 as appropriate.
Test No. F91879 (dated 12 June 2001)
Test for Fire Pillows protecting openings in concrete floors when tested in accordance with AS1530.4-1997 sections 2, 4 & 10 and AS4072.1-1992 as appropriate.

Performance summary

In accordance with AS1530.4-1997 sections 2, 4 & 10 and AS4072.1-1992 as appropriate.

Separating Element	Fire Resistance Level (FRL) in minutes		
Minimum Thickness	Unpenetrated Openings	Cables / Cable Trays supporting telecommunications & electrical cables as recommended by AS4072.1-1992	Copper, Brass, Steel, & Cast Iron Pipes
140mm Concrete or Masonry wall	N/A/180/180	N/A/180/180	N/A/180/180
150mm Concrete floor	N/A/180/180	N/A/180/180	N/A/180/180

Installation

The pillows can be used to seal an opening in a floor or wall to a maximum width or height of 400 mm by any practical length.
The sealing between the pillows is achieved by 'pillow pressure' and the use of fire rated sealant to fill in voids around the various pipes, cables and penetrations.
The pillows should be stacked tightly in the direction of the least span (up to 400mm) and restrained on the sides by wall section or pillows. Working from one side of the opening additional pillows should be stacked in the same direction and packed in tightly against the sides of the pillows already installed (see figure 1).
The appropriate size pillows should be packed around the various pipes, cables and penetrating elements and fire rated sealant used to a depth of 25mm to seal any gaps or voids around the pillows or penetrating elements.
The method of stacking the pillows used by the installer will vary depending on the shape and dimensions of the various apertures and penetrating elements (see figure 2).

Figure 1

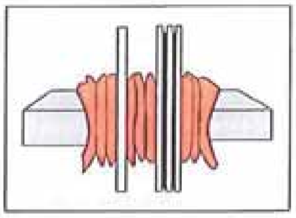
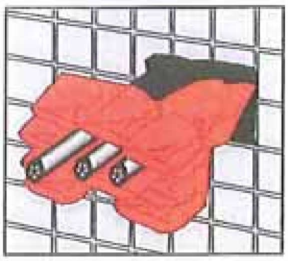


Figure 2



+61 03 95740522

Materials Science and Engineering
Riverside Corporate Park, 14 Julius Avenue,
North Ryde NSW 2113
PO Box 310, North Ryde NSW 2113, Australia
Telephone: (02) 9490 5444 • Facsimile: (02) 9490 5555 • ABN 41 687 119 230

CSIRO

Our Ref: 2263/CO3681

Melbourne Fire Doors Pty Ltd
58 Renver Road
North Clayton Vic 3168

Attention: Mr Bill Diggins

APERTURE SIZE FOR THERMACHEK FIRE PILLOWS
Assessment Number FCO-2263
Your email of 19 August.

INTRODUCTION

You have requested us to re-examine an increase in the aperture size for Thermachek fire pillows. The provided information included:-

- Report numbered WFRA No. F91876 issued on 12 June 2001 by Warrington Fire Research (Aust) Pty Ltd; and
- Report numbered WFRA No. F91879 issued on 12 June 2001 by Warrington Fire Research (Aust) Pty Ltd.

We have retained these documents.

ANALYSIS

On 24 April 2001, Warrington Fire Research (Aust) Pty Ltd conducted a fire-resistance test in accordance with AS1530.4-1997 and AS4072-1992 on a number of penetrations through an aperture nominally 600-mm wide x 400-mm high in a concrete block wall. A variety of sizes of Thermachek fire pillows were packed around the penetrations filling in the remainder of the aperture. Along the perimeter between the wall and pillows Tyco FS33 fire rated sealant was applied to a depth of nominally 25 mm. Any gaps were also filled with the fire rated sealant. The pillows and penetrations achieved an FRL of -/180/180.

A full description of the test specimen and the test results are detailed in Warrington Fire Research (Aust) Pty Ltd report numbered WFRA No. F91876.

THIS ASSESSMENT SUPERSEDES FCO-2263 DATED 21 AUGUST 2003.

On the 25 May 2001, Warrington Fire Research (Aust) Pty Ltd conducted a fire-resistance test in accordance with AS1530.4-1997 and AS4072-1992 on a number of penetrations through an aperture nominally 600-mm wide x 400-mm high in a concrete floor slab. A variety of sizes of Thermachek fire pillows were packed around the penetrations filling in the remainder of the aperture. Along the perimeter between the wall and pillows Tyco FS33 fire rated sealant was applied to a depth of nominally 25 mm. Any gaps were also filled with the fire rated sealant. The pillows and penetrations achieved an FRL of -/180/180.

A full description of the test specimen and the test results are detailed in Warrington Fire Research (Aust) Pty Ltd report numbered WFRA No. F91879.

Based on the above results it is considered that if the width of the aperture was extended sideways to any practical length it would not prejudice the fire performance of the fire pillow system on the condition that they are installed as tested and described in Warrington Fire Research (Aust) Pty Ltd reports numbered WFRA No. F91876 and WFRA No. F91879. The pillows must be laid horizontally across the width of the aperture and fully restrained on all sides.

Tyco FS33 fire rated sealant was used to fill any openings and along the perimeter between the element and pillows in the systems tested and described in Warrington Fire Research (Aust) Pty Ltd reports numbered WFRA No. F91876 and WFRA No. F91879. It is considered that any fire rated mastic which has been tested in a similar situation would be suitable to replace the Tyco FS33 sealant.

CONCLUSION/ASSESSMENT

Based on the factors detailed above it is the assessment of the Division that the Thermachek fire pillows installed in aperture of any practical width would achieved an FRL of at least -/180/180 if tested in accordance with AS1530.4-1997 and constructed as tested and described in Warrington Fire Research (Aust) Pty Ltd reports numbered F91876 and F91879. The pillows must be laid horizontally across the width of the aperture and fully restrained on all sides.

TERM OF VALIDITY

This assessment report will lapse on 30 September 2013. Should you wish us to re-examine this assessment with a view to the possible extension of its term of validity, would you please apply to us three to four months before the date of expiry. This Division reserves the right at any time to amend or withdraw this report in the light of new knowledge.

Yours faithfully,

Garry E Collins

Garry E Collins
Manager, Fire Testing and Assessment

18 September 2008

THIS ASSESSMENT SUPERSEDES FCO-2263 DATED 21 AUGUST 2003.

+61 03 95740522

Materials Science and Engineering
14 Julius Avenue, Riverside Corporate Park
North Ryde NSW 2113
PO Box 310, North Ryde NSW 2113, Australia
Telephone: (02) 9490 5444 • Facsimile: (02) 9490 5555 • ABN 41 687 119 230

CSIRO

Our ref: FCO-2721/3694

Melbourne Fire Doors Pty Ltd
58 Renver Road
NORTH CLAYTON VIC 3168

Attention: Mr Bill Diggins

THERMACHEK FIRE PILLOWS INSTALLED IN A FRAMED WALL SYSTEM
Assessment Number FCO-2721
Your e-mail of 19 August 2008

INTRODUCTION

You have requested an assessment as to the likely effect of installing your Thermachek fire pillows into a plasterboard-lined framed wall system. The provided information included

- Warrington Test Report No. F.91876 for a fire-resistance test of penetrations systems conducted on 24 April 2001;
- Warrington Test Report No. F.91879 for a fire-resistance test of penetrations systems conducted on 25 May 2001;
- CSIRO assessment report numbered FCO-2409 regarding the change of encapsulating material; and
- CSIRO assessment report numbered FCO-2263 regarding the permissible width of the protected penetration.

We have retained these documents.

ANALYSIS

Report No. F91876 by Warrington Fire Research conducted a fire-resistance test in accordance with AS1530.4-1997 and AS4072-1992 on the 24 April 2001 on a number of penetrations through an aperture nominally 600-mm wide x 400-mm high in a concrete block wall. A variety of sizes of Thermachek fire pillows were packed around the penetrations filling in the remainder of the aperture. Along the perimeter between the wall and pillows Tyco FS33 fire rated sealant was applied to a depth of nominally 25 mm. Any gaps were also filled with the fire rated sealant. The pillows and penetrations achieved an FRL of -/180/180.

Report No. F91879 by Warrington Fire Research conducted a fire-resistance test in accordance with AS1530.4-1997 and AS4072-1992 on the 25 May 2001 on a number of penetrations through an aperture nominally 600-mm wide x 400-mm high in a concrete floor slab. A variety of sizes of Thermachek fire pillows were packed around the

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penetrations filling in the remainder of the aperture. Along the perimeter between the wall and pillows Tyco FS33 fire rated sealant was applied to a depth of nominally 25 mm. Any gaps were also filled with the fire rated sealant. The pillows and penetrations achieved an FRL of -/180/180.

The proposal is to use the Thermachek pillows to protect penetrations in plasterboard-lined framed wall systems as an alternative to the tested systems in concrete and masonry.

The tests referenced above have demonstrated the stability of the pillows and their ability to maintain integrity and insulation up to 180 minutes. Framed wall systems, particularly those incorporating steel studs will exhibit greater deflection than the tested concrete and masonry elements but in the relatively small area of the proposed penetration systems this additional deflection would small. Provided that the same compression and the same infill material is used then the installation into the framed wall would have little affect on the overall fire performance of the penetration system.

CONCLUSION/ASSESSMENT

Based on the factors detailed above it is the assessment of the Division that the Thermachek fire pillow penetration systems, constructed as tested in Warrington test reports F91876 and F91879, would achieved fire-resistance levels (FRL) of at least -/120/120 if tested in accordance with AS1530.4-1997 when installed into a plasterboard-lined framed wall system provided that

(i) the maximum width is 600-mm or the distance between adjoining studs, whichever is the lesser;
(ii) the penetration is framed with noggins above and below the opening;
(iii) the pillows are compressed to the same level as the tested systems;
(iv) the wall system has an established FRL of 120/120/120 or -/120/120.

Similarly for plasterboard-lined framed wall systems of lesser FRL the installation of Thermachek pillows in the manner detailed above would not detrimentally affect the established FRLs of the wall system

TERM OF VALIDITY

This assessment report will lapse on 30 April 2014. Should you wish us to re-examine this assessment with a view to the possible extension of its term of validity, would you please apply to us three to four months before the date of expiry. This Division reserves the right at any time to amend or withdraw this report in the light of new knowledge.

Yours faithfully,

Garry E Collins

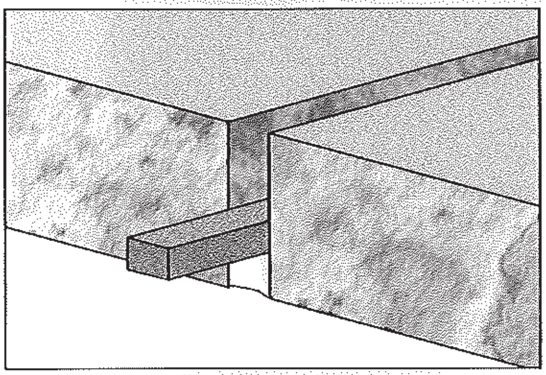
Garry E Collins
Manager, Fire Testing and Assessments.

9 April 2009

TRAFALGAR

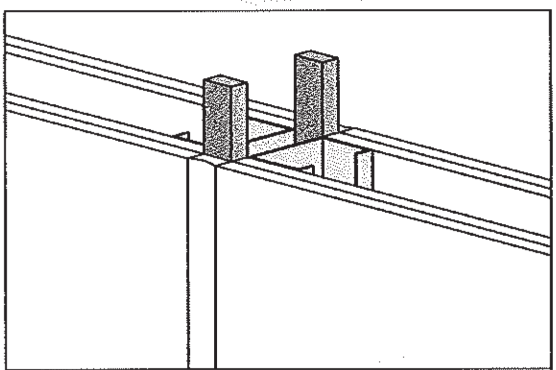
PAS 5.01
April 2009

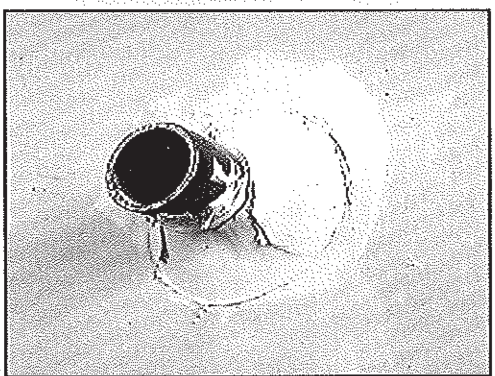
Fyreflex
Fire Rated Sealant



Up To 4 Hours Fire Protection

(to AS 1530.4 - 1997)





Fyreflex Sealant

Description

Fyreflex is an acrylic (water based) gun grade mastic with limited (±5%) joint movement capability. Supplied in 10 litre buckets, 600ml sausage style sachets and 300ml cartridges with nozzle.

Fyreflex is available in off-white to suit plasterboard and grey to suit masonry applications.

Applications

Fyreflex is designed for sealing internal joints and wall penetrations subject to low movement and requiring up to 4 hours fire rating compliance.

- Insitu internal jointing of concrete, precast panels, block and brick work and drywall systems.
- Sealing of electrical cables and pipe penetrations.
- Acoustic gap filling combined with fire rating requirement.
- May be used in conjunction with other systems such as fire collars, pillows, board systems and fire rated mortar.

Advantages

- Water based (easy clean up)
- Smooth gunnability and tool off finish
- Excellent adhesion to metal, wood, plasterboard and all masonry
- Paintable
- Water resistant once cured
- Excellent acoustic properties with ratings up to 45 STC in joints

Method of Application

Install back-up material or joint filler as specified. Apply Fyreflex sealant in a continuous operation using a positive pressure adequate to properly fill and seal the joint or penetration. Tool Fyreflex with sufficient pressure to spread the sealant against the back-up material and onto the joint surfaces. A tool with a concave profile is recommended to achieve the correct shape.

Joint And Penetration Design

Fyreflex is gunned into and around the service penetrations and into any clearance holes through the fire separating element. Depth fill into cavities is controlled by pre-packing with foamed plastic backing rod.

Application Limitations

a) Fyreflex is not recommended for water immersion, exposed external joint sealing or areas subject to heavy traffic.
b) Fyreflex has a ±5% joint movement capability.
c) Fyreflex should not be applied with wet tooling techniques - using solvents, water or detergent/ soap solution is not recommended.
d) Fyreflex should not be applied to surfaces with special protective or cosmetic coatings without prior consultation with the manufacturer. Such surfaces include, but are not limited to, mirrors, reflective glass, or surfaces coated with Teflon, polyethylene or polypropylene.
e) Fyreflex can be affected by water before or during cure. The sealant should not be stored, applied or cured in areas where unusually high humidity or free water are pressent during the application or intial cure.
f) Fyreflex should be allowed to cure for 7 days prior to subjecting to any intermittent water exposure.
g) Temperature range during application +5°C to +35°C

Fyreflex Sealant

Specification And Standards

Testing
Fire tests have been conducted to AS 1530.4, in accordance with AS4072.1, on concrete floors, brick, masonry, tilt-up panels, block, and plasterboard walls.

Construction and Expansion Joints:
Construction and expansion joints to be fire stopped to maintain the required FRL of the wall or floor element by treatment with Fyreflex fire resistant sealant in accordance with Trafalgar Building Products instructions.

Service Penetrations:
Service penetrations to be fire stopped to maintain the required FRL of the penetrated wall or floor element by treatment with Fyreflex fire resistant sealant in accordance with Trafalgar Building Products instructions.

NOT TO BE TAKEN
KEEP OUT OF REACH OF CHILDREN

Avoid contact with skin and eyes and avoid breathing vapours. If poisoning occurs contact a doctor or poisons information centre. If skin contact occurs remove contaminated clothing and wash skin thoroughly. Refer to Material Safety Data Sheet for further information.

Storage & Handling

All materials shall be stored under cover in a manner that will prevent damage preferably on pallets and protected from moisture.

Do not freeze. Store in temperatures 5°C - 30°C.

Warranty

Limited Warranty:

Your purchase and use of this product is subject to Trafalgar's standard terms and conditions of sale. Trafalgar's sole liability in the event of a product defect is, at our option, to replace this product or return its purchase price.

All other warranties whether express or implied, including without limitations, any warranty of merchantability or fitness of purpose are expressly disclaimed unless prohibited by law or given in writing by Trafalgar for a specific project.

Disclaimer:

Information given in this publication is given to the best of our knowledge and in good faith. Trafalgar Building Products is not responsible if recipients of test reports, assessments or literature misinterpret the contents and wrongly use products based on those interpretations. No liability is accepted for error or omissions in this document. Trafalgar Building Products reserves the right to change the specification without notice.

Fyreflex Usage Rate (ml/m)

DEPTH OF JOINT (mm)	WIDTH OF JOINT(mm)						
	10	15	20	25	30	40	50
10	100	150	200	250	300	400	500
12	120	180	240	300	360	480	600
15	150	225	300	375	450	600	750
20	200	300	400	500	600	800	1000

TRAFALGAR

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National: 1800 888 714

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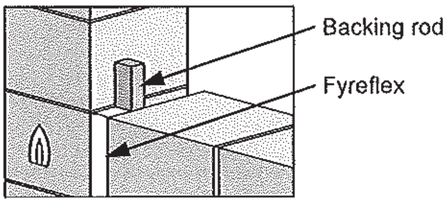
Fyreflex Grey

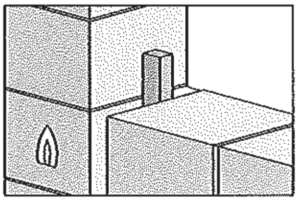
Masonry Construction and Expansion Joints

Concrete, Brick and Block Walls

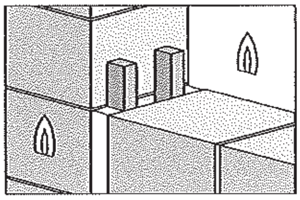
A) JOINT PROTECTED FROM EXPOSED SIDE



B) JOINT PROTECTED FROM UNEXPOSED SIDE



C) JOINT PROTECTED FROM BOTH SIDES

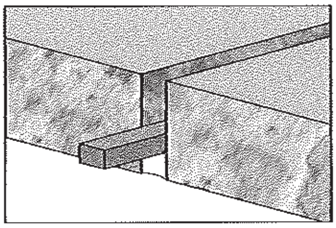


Fill Depths of Fyreflex (mm)

JOINT WIDTH (mm)	10			20			25		30		40		50	
JOINT FILL TYPE	A	B	C	A	B	C	A	C	A	C	A	C	A	C
RATING (hrs)														
-/120/120	10	15	10	10	30	10	12	12	15	15	20	20	25	20
-/180/180	10	15	10	10	30	10	12	12	15	15	20	20	25	20
-/240/240	15	15	10	30	35	15	30	20	30	20	40	20	40	20

NOTE: Joint may be filled on one side if direction of fire is known. If direction of fire is not known, sealant must be applied from both sides.

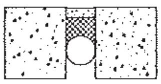
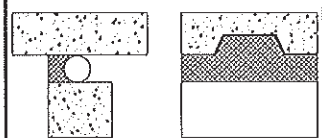
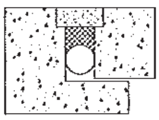
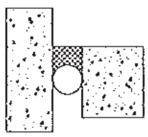
Internal Concrete and Pre-Cast Slabs



Fill Depths of Fyreflex (mm)

	JOINT WIDTH (mm)					
RATING (hrs)	10	20	25	30	40	50
-/120/120	10	10	12	15	20	25
-/180/180	10	10	12	15	20	25
-/240/240	15	30	30	30	40	40

Special Applications

System Description	System Diagram	System Description	System Diagram
• External applications • Up to 4 hours • With non-rated external grade sealant		• Steel decking • Upto 4 hours	
• Slab-on-slab • Up to 4 hours • With non-rated external or internal grade sealant		• Joint between wall and floor slab • Upto 4 hours	

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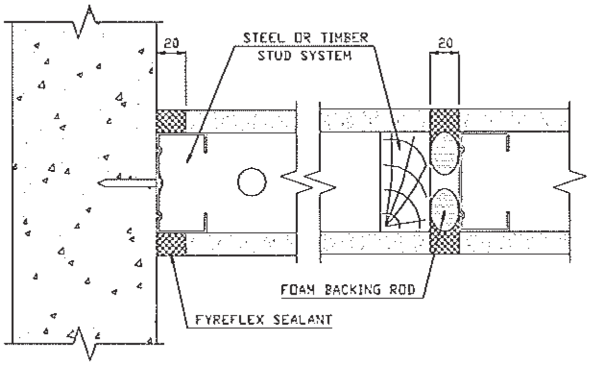
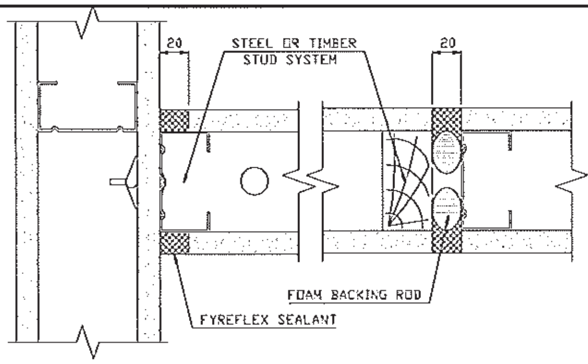
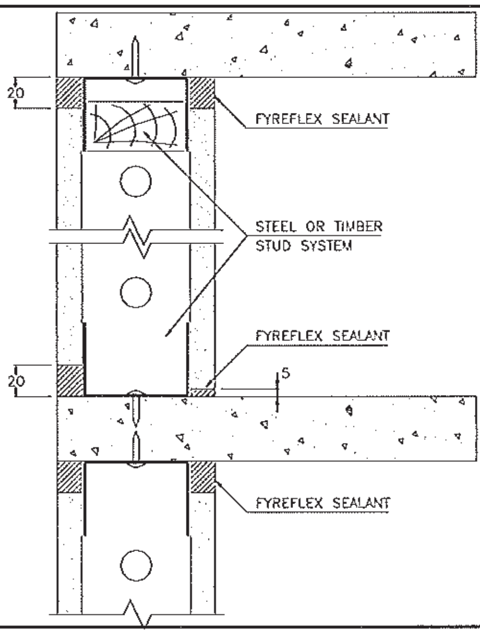
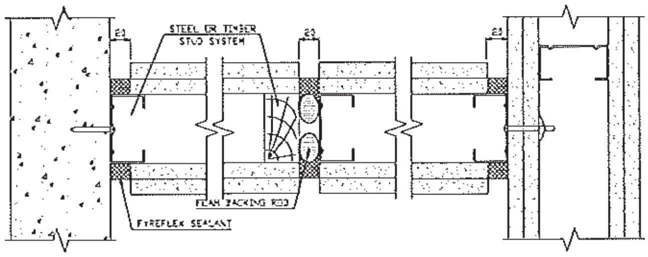
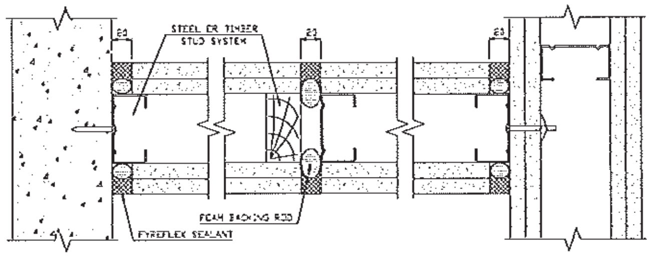
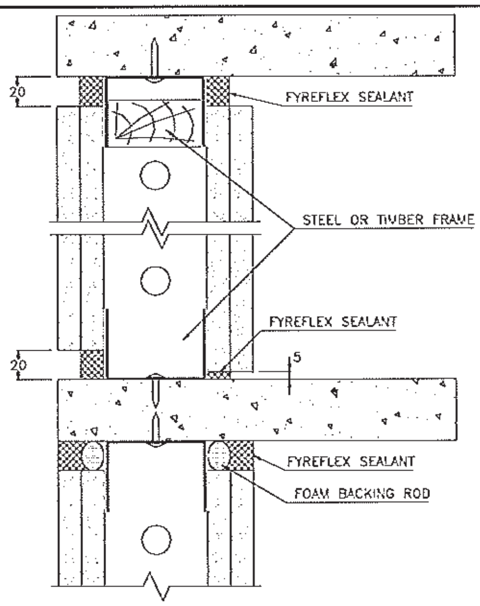
Drywall Construction and Expansion Joints

1 Hour Plasterboard Systems

SYSTEM	SYSTEM DIAGRAM
• T-Junction between concrete wall and plasterboard wall • Typical control joint in plasterboard wall	
• T-junction between two plasterboard walls • Typical control joint in plasterboard wall	
• Deflection head and base between concrete slabs and plasterboard wall ***NOTE:*** • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*	

Drywall Construction and Expansion Joints

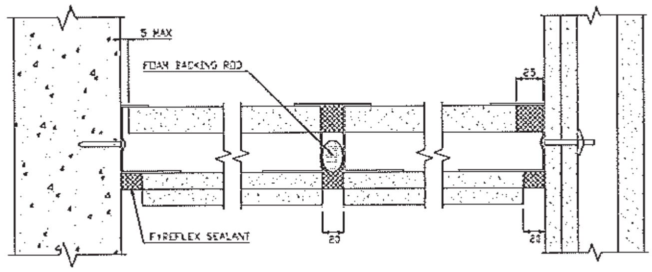
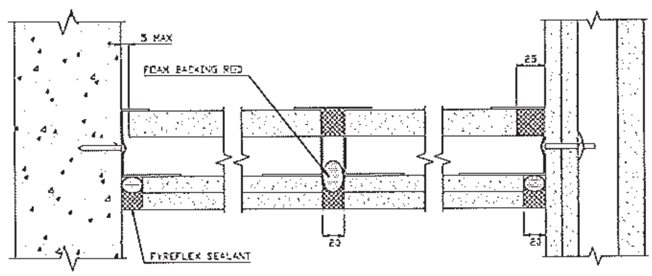
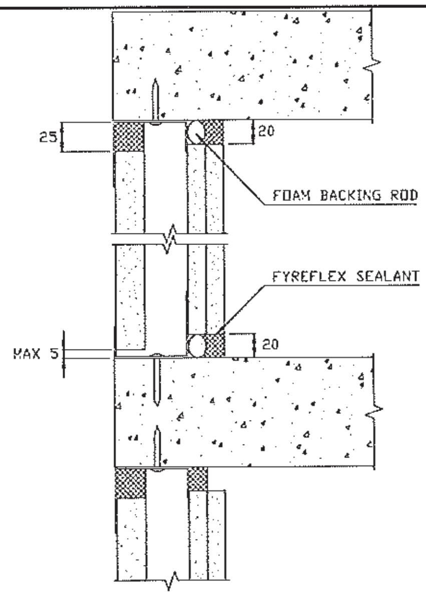
2 Hour Plasterboard Systems

SYSTEM	SYSTEM DIAGRAM
• T-Junction between concrete wall and plasterboard wall • Typical control joint in plasterboard wall • T-junction between two plasterboard walls	
• T-Junction between concrete wall and plasterboard wall • Typical control joint in plasterboard wall • T-junction between two plasterboard walls	
• Deflection head and base between concrete slabs and plasterboard wall ***NOTE:*** • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*	

Fyreflex White

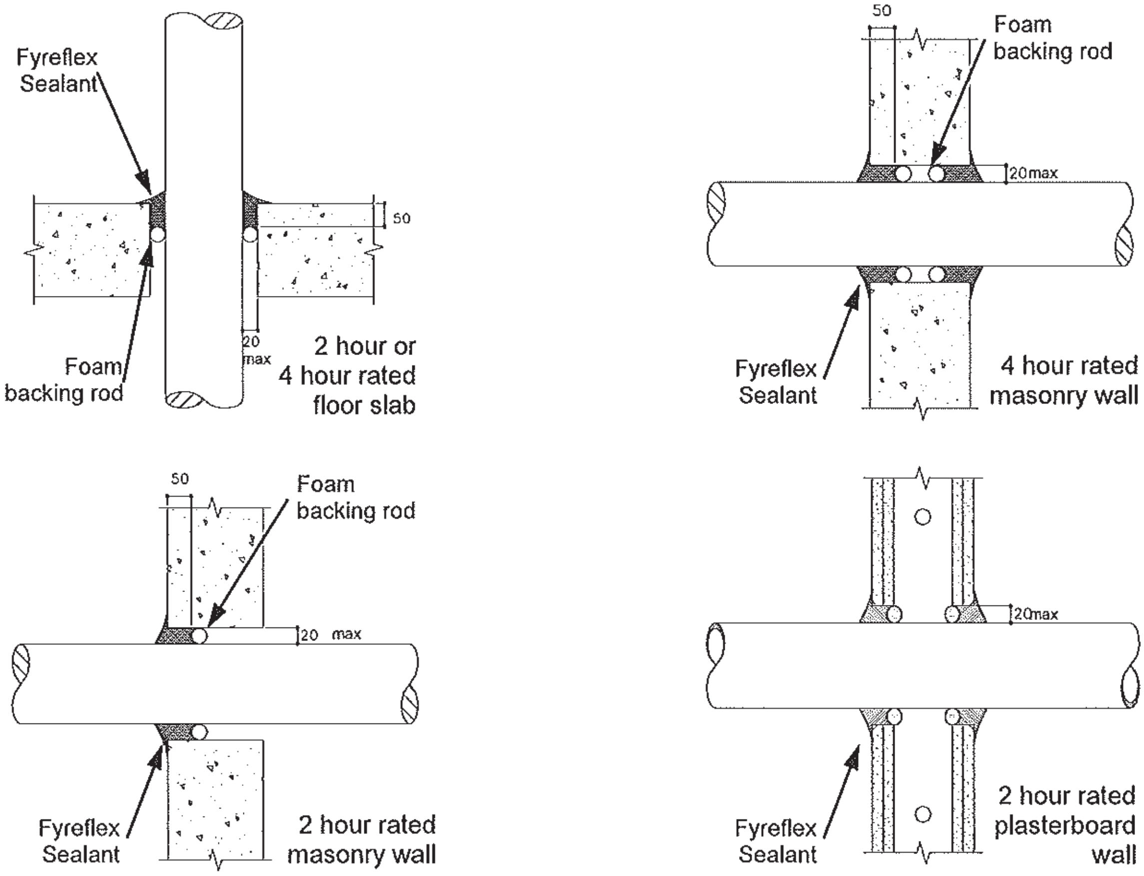
Drywall Construction and Expansion Joints

2 Hour Shaft Wall Systems

SYSTEM	SYSTEM DIAGRAM
• T-Junction between concrete wall and shaft wall • Typical control joint in shaft wall • T-junction between two shaft walls	
• T-Junction between concrete wall and shaft wall • Typical control joint in shaft wall • T-junction between two shaft walls	
• Deflection head and base between concrete slabs and plasterboard wall ***NOTE:*** • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*	

Miscellaneous Penetrations

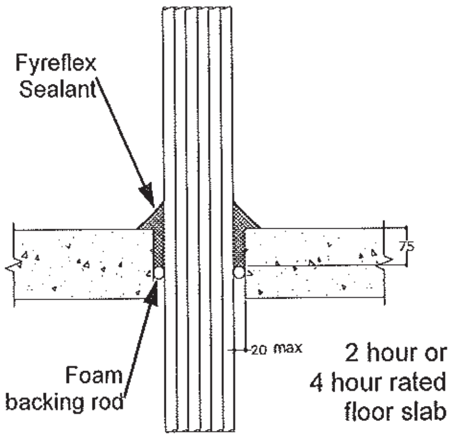
Pipe Penetrations

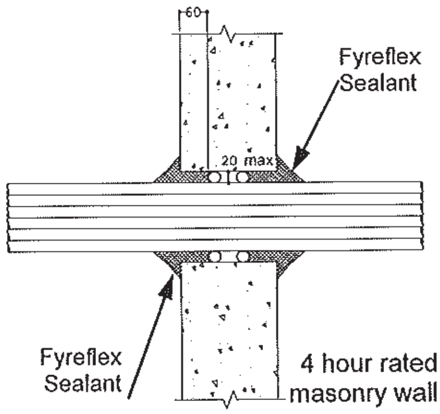


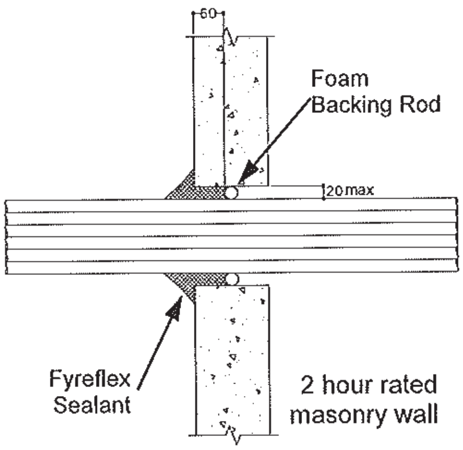
PIPE TYPE	WALL OR FLOOR	PIPE SIZES	FRL
STEEL ⇒ Non insulated ⇒ With 25mm rockwool insulation	Walls and floors Floors only	Up to 225mm diam. Up to 200mm diam.	240/240/- 180/180/-
CAST IRON ⇒ Non insulated ⇒ With 25mm rockwool insulation	Walls and floors Floors only	Up to 225mm diam. Up to 200mm diam.	240/240/- 180/180/-
BRASS ⇒ Non insulated	Walls and floors	Up to 102mm diam.	240/240/-
COPPER ⇒ Non insulated ⇒ With 25mm rockwool insulation	Walls and floors Floors only	Up to 225mm diam. Up to 19mm diam.	240/240/- 120/120/-
FIBRE RE-INFORCED CEMENT PIPES AND COLUMNS	Walls and floors	Up to 225mm diam.	120/120/120

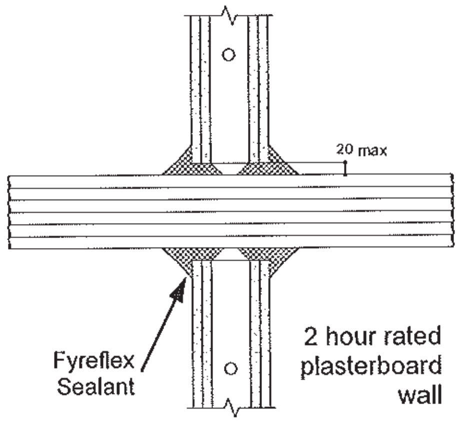
Miscellaneous Penetrations

Electrical Cable Penetrations





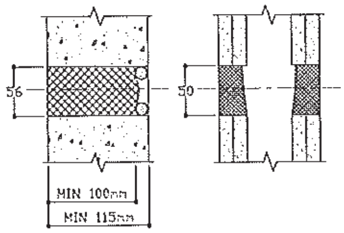
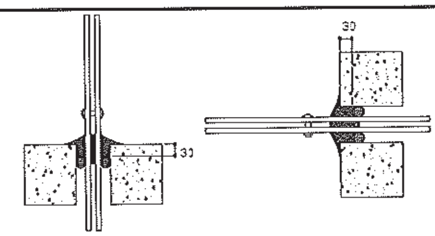
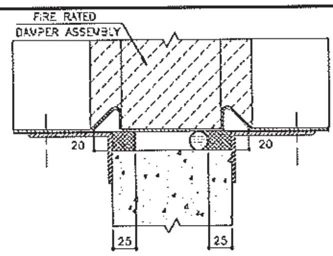
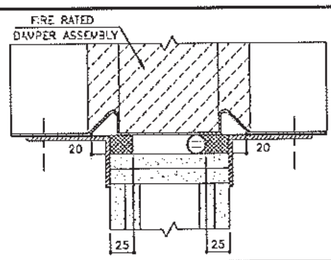
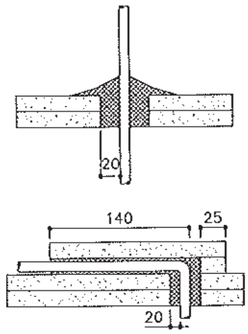




PENETRATION TYPE	WALL OR FLOOR	PENETRATION SIZES	FRL
SINGLE CABLE	Walls and floors	Up to 54mm diam.	240/240/110
CABLE BUNDLE	Walls and floors	Bundle of up to 24 cables.	240/240/95
STEEL CABLE TRAY	Walls and floors	Up to 380mm wide with assorted cables	240/240/110
BUS BARS	Walls and floors	50 x 10mm copper bus bars	120/120/-

Miscellaneous Penetrations

Special Applications

SYSTEM	SYSTEM DIAGRAM	FIRE RESISTANCE
• Blank penetration. walls and floors. Max 56mm diameter.		120/120/120
• Copper and aluminium bus bars. Walls and floors. Max size 10 x 200mm.		120/120/-
• Perimeter seal for steel duct and damper used in masonry walls and floors.		120/120/-
• Perimeter seal for steel duct and damper used in drywalls.		120/120/-
• Cable penetrations through plasterboard ceiling		60/60/- ***NOTE:*** • *Fire Rated Plasterboard Systems must be installed according to manufacturers instructions.* • *Fyreflex is filled to depth of plasterboard sheet.*

Fyreflex Sealant

Joint Sealant Quantity Estimation Table

Note: All quantities estimated for 100 lineal metre requirement

Joint Size WIDTH	DEPTH	LITRES	300 ml Cartridge	600 ml SAUSAGES	10 LITRE PAIL
5	10	5	17	9	-
6	10	6	20	10	-
8	10	8	27	14	-
10	10	10	34	17	1
15	10	15	50	25	2
15	15	22.5	75	38	3
20	10	20	67	34	2
20	15	30	100	50	3
20	20	40	134	67	4
25	15	37.5	125	63	4
25	20	50	167	84	5
30	15	45	150	75	5
30	20	60	200	100	6
40	20	80	266	134	8
50	20	100	334	167	10
60	20	120	400	200	12

FORMULA FOR ESTIMATING QUANTITY OF JOINT SEALANT REQUIREMENTS
(Use whole numbers for millimetres and for metres)

L = Length of joint in metres	D = Depth of joint in millimetres
W = Width of joint in millimetres	Q = Quantity in Litres required
$Q = \frac{L \times W \times D}{1000}$	eg $Q = \frac{100m \times 15mm \times 10mm}{1000}$ = 15 litres required

Notes:
1. Sealant depth in joints between 10mm & 40mm wide should never be less than half the width
2. It is not recommended for any sealant depth to be less than 10mm or greater than 20mm
3. To estimate the quantity of a triangular fillet, the amount of sealant required would be half that required for a rectangular joint of the same dimensions

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FyreSET™

FIRE RATED MORTAR

Trafalgar Fyreset mortar is a special cement based mixture formulated specifically for fire rating applications, in particular openings in fire barriers that include complicated or mixed service penetration types.

Fyreset is easily mixed on site with water to a required consistency for either pouring or towelling into wall or floor slabs.

Fyreset has been fire tested in numerous configurations and with a multitude of service penetration types as required by the Building Code of Australia.

Fyreset mortar has over 25 years of proven performance in Australia's harshest building site conditions.

Warning - Fyreset mortar is non-load bearing.

APPLICATION

Fyreset Mortar is used for fire stopping of service penetrations in wall and floor openings where a specific FRL has to be maintained.

- Sealing of cables and pipe penetrations.
- Ideal where difficult penetrations require complex cutting and shaping of preformed materials.
- Suitable for use in walls and floors

KEY FEATURES AND BENEFITS

- Known and trusted brand - Benchmark Quality
- Australian made using Australian raw materials
- Lightweight
- Up to 4 hours fire ratings with most service penetration types
- Does not shrink in fire conditions
- Tested with most service penetration types
- Readily cut, drilled and shaped with ordinary wood working tools
- Flush mounted and surface mounted testing

The information contained in this brochure was correct at the time of printing. E&OE

FIRE RATED MORTAR

FYRESET

Trafalgar is the well respected brand, synonymous with the supply of engineered solutions for the containment of fire, smoke and sound. As the foremost Australian owned supplier of passive fire protection systems, Trafalgar's products have been specified and installed into Australian buildings for over 60 years.

Trafalgar Since 1945
CONTAINMENT & ACCESS SOLUTIONS
WHOLLY AUSTRALIAN OWNED

FYREFLEX FIRE RATED MORTAR

Maximum Size Opening	Fire Resistance Level	Mortar Thickness
Floor Slabs		
600mm x 600mm	-/180/180	80mm
1000mm x 1000mm	-/240/240	125mm
Walls		
600mm x 600mm	-/120/120	90mm
1120mm x 1000mm	-/240/180	140mm
600mm x 200mm	-/240/240	150mm

PRODUCT DESCRIPTION

COLOUR - Neutral grey.

MIXING – Each bag mixes with water to form approximately 36 litres of mixture. Mix Fyreset with between 12 and 16 litres of water depending on the required stiffness of the mix.

DRYING TIME – Fyreset is cement based and has a good pot life making it ideal for contractors who want to minimise waste.

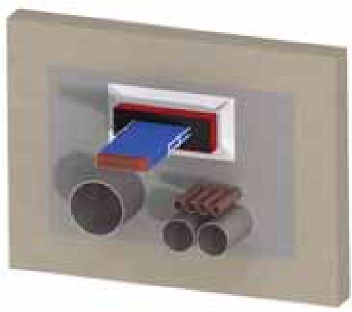
STORAGE & HANDLING – All materials shall be stored under cover, in a manner that will prevent damage (preferably on pallets). Fyreset mortar must be kept dry at all times.

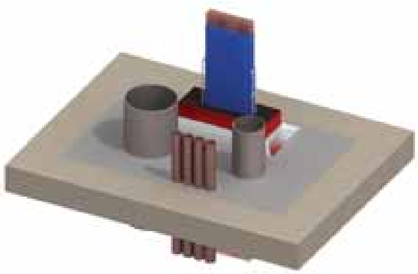
TESTING - Tested to AS1530.4 and AS4072.1 standards

ENVIRONMENT - Easy clean-up, low Volatile Organic Compounds (VOC) and Ozone Depleting Potential (ODP) formula.

SAFETY - Please refer to product MSDS for full safety information. Fyreset mortar is non load bearing.

ALSO AVAILABLE – Trafalgar offers a complete range of other fire stopping and fireproofing products.



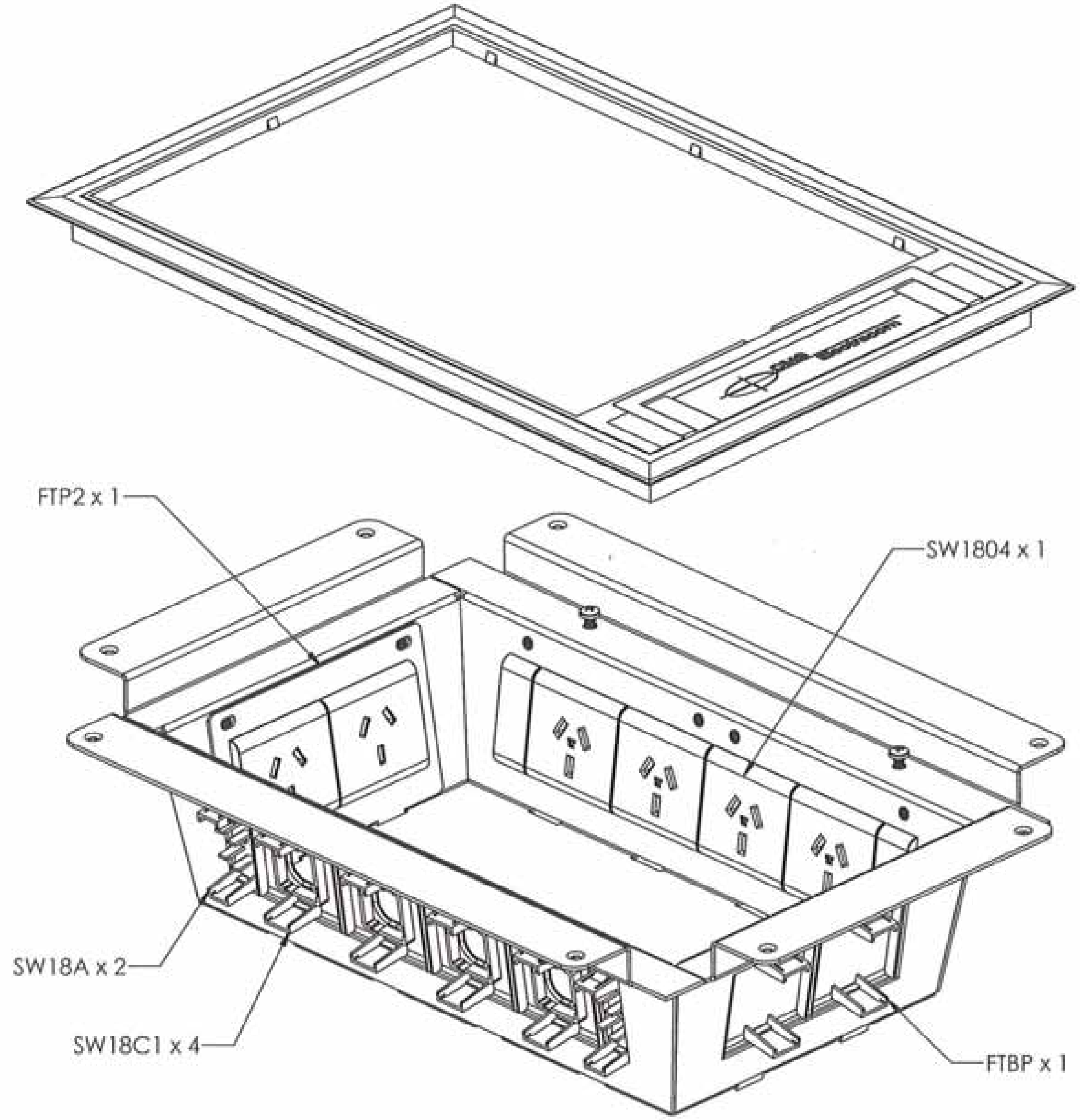


SPECIFICATION

All openings are to be sealed, so as to maintain the FRL of the element (floor or wall) in accordance with AS1530.4 using Trafalgar Fyreset mortar systems as detailed in Trafalgar's printed installation instructions.

Trafalgar reserves the right to change specifications without notice.
Please check with your supplier at the time of order.

8.20 Floor Boxes: CMS



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TITLE: Titan floor box FTA4 F64

DWG NO. LU-3718

PART NO. TBC

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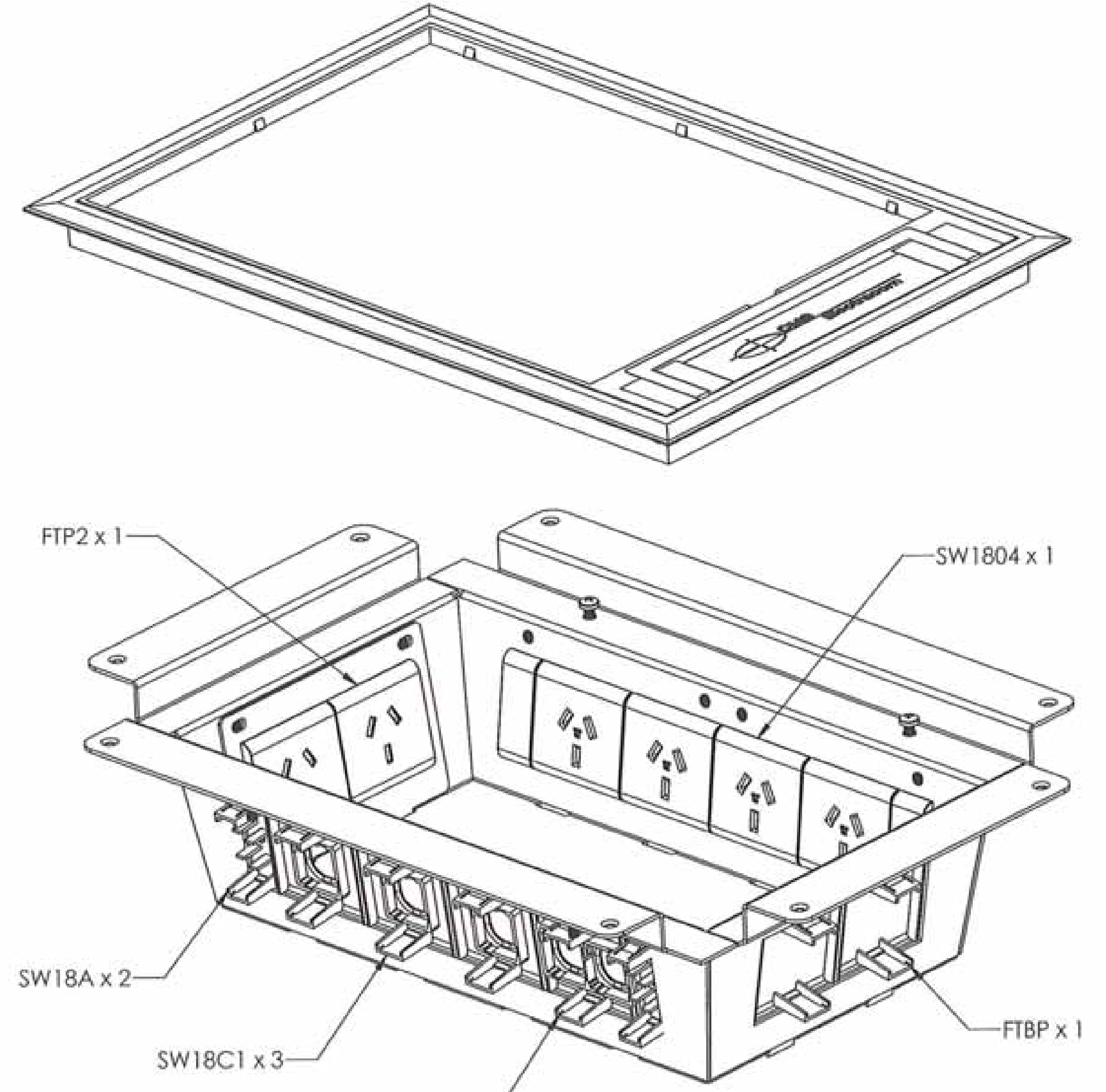
A3



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PART NO. TBC
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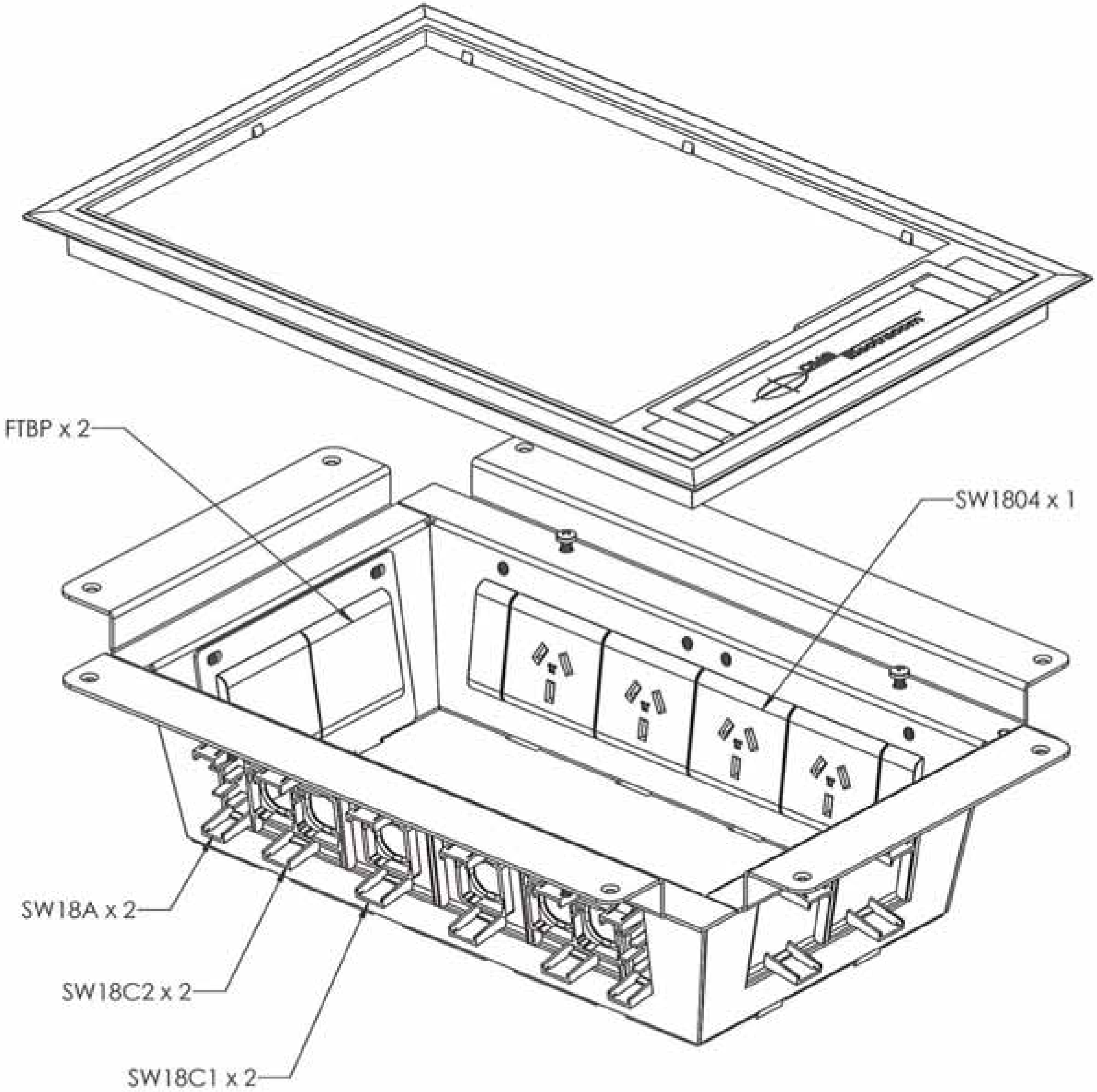

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TITLE: Titan floor box FTA4 F36

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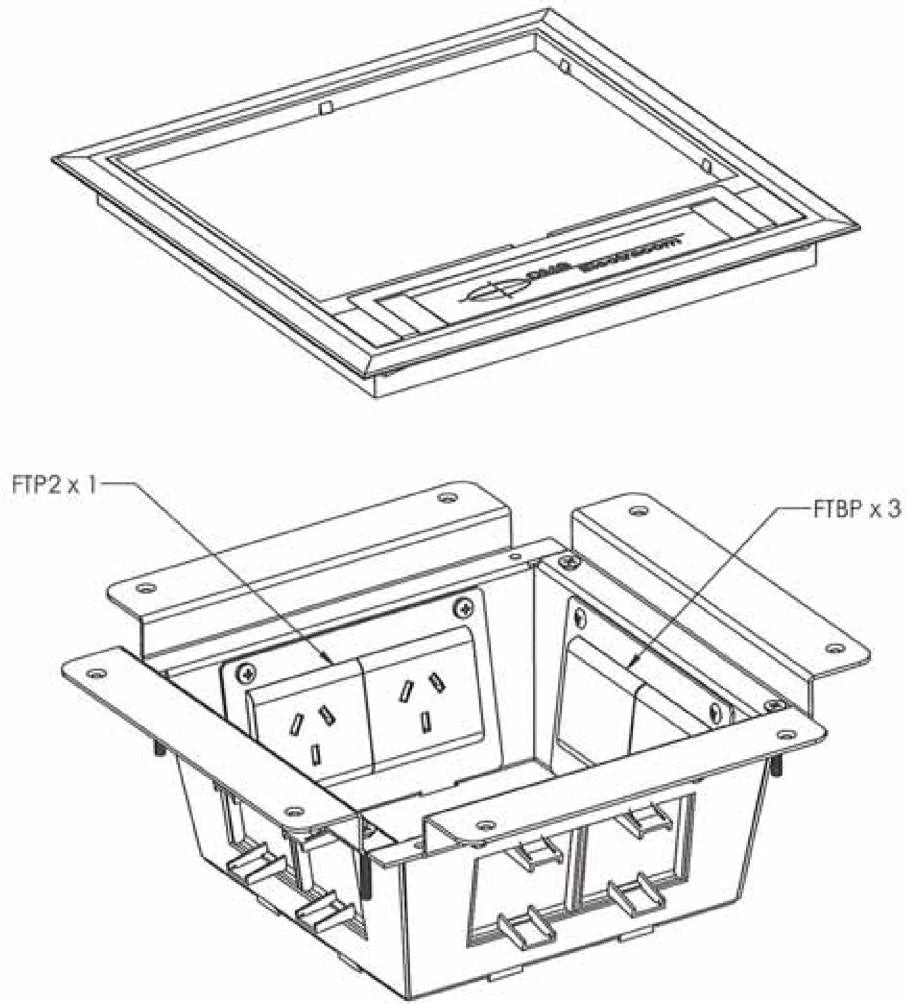

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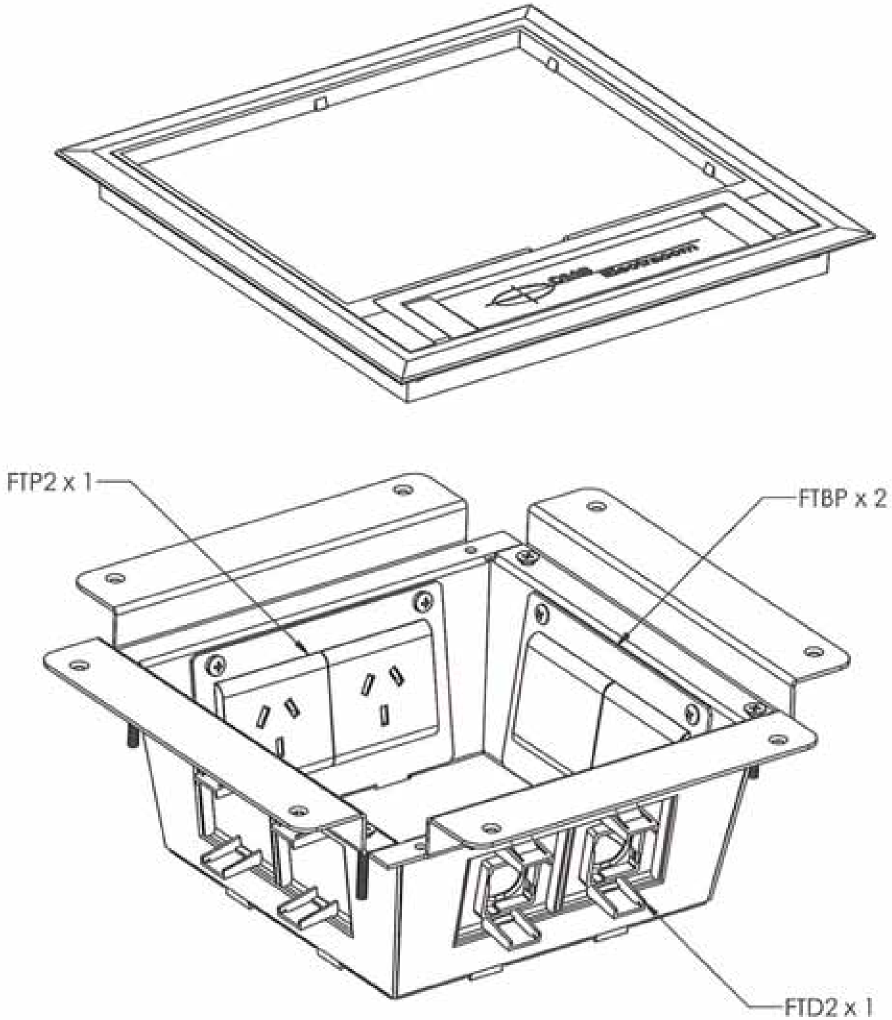

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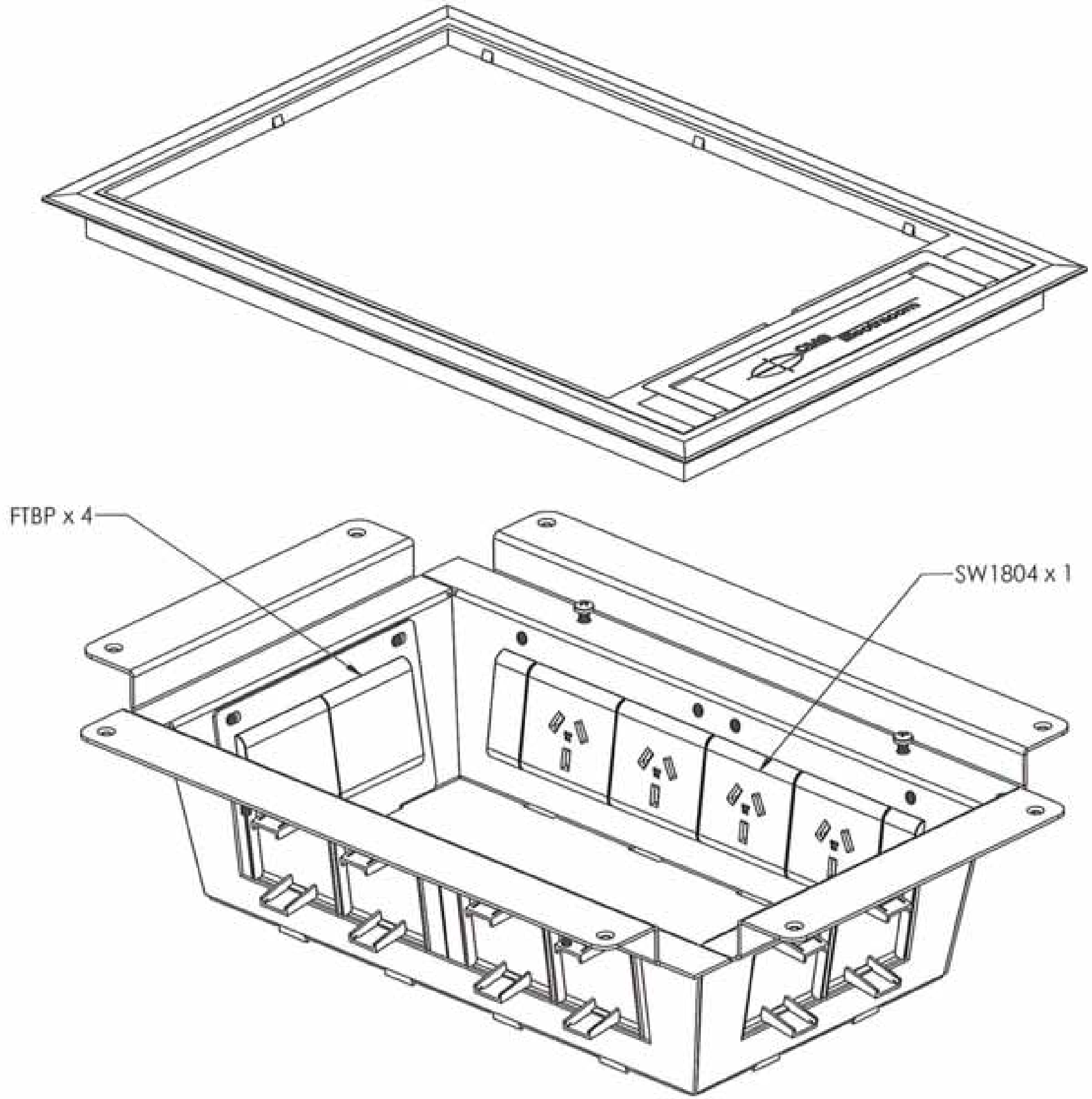

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DWG NO. LU-3710
PART NO. TBC
SCALE N/A
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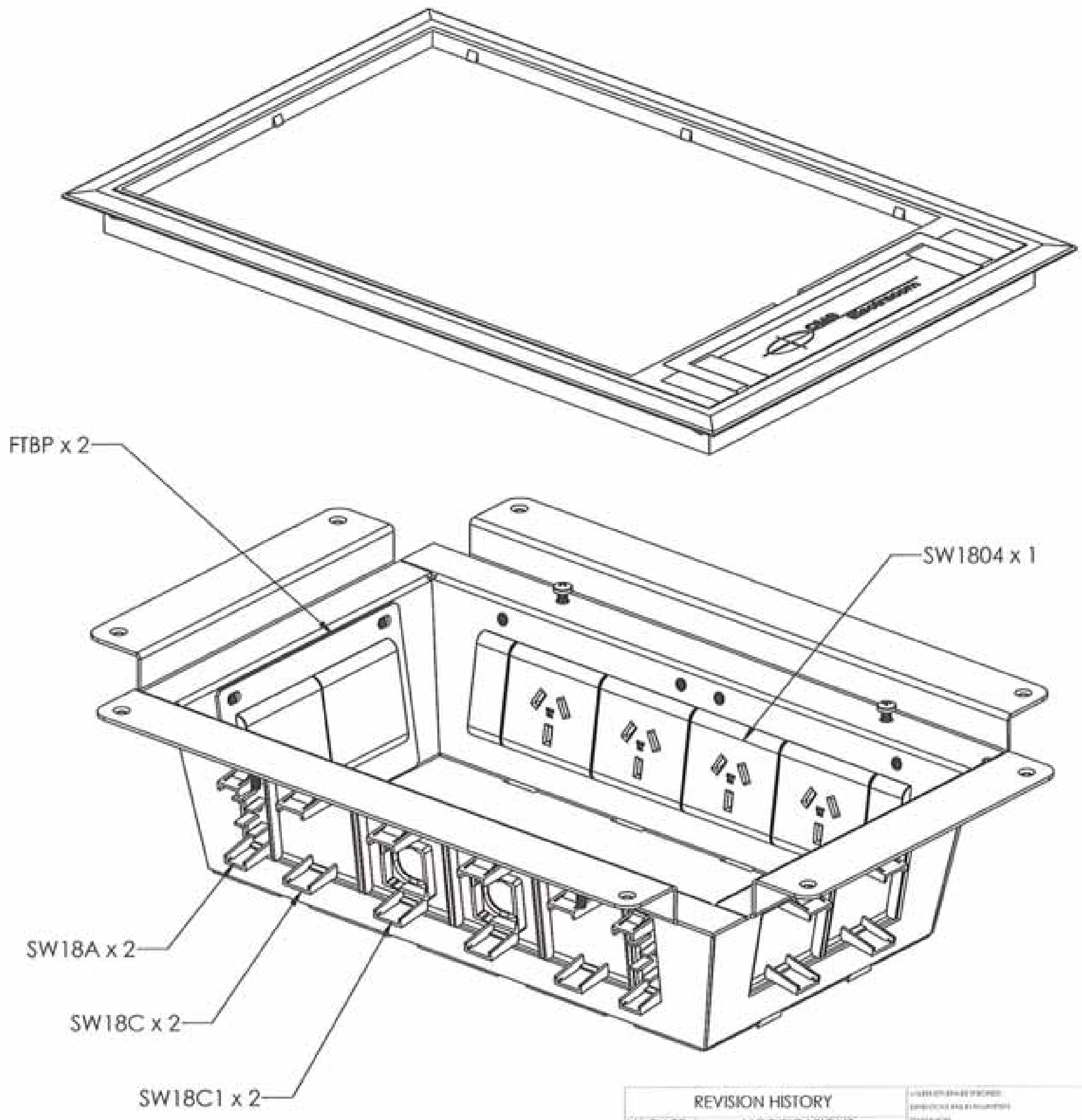

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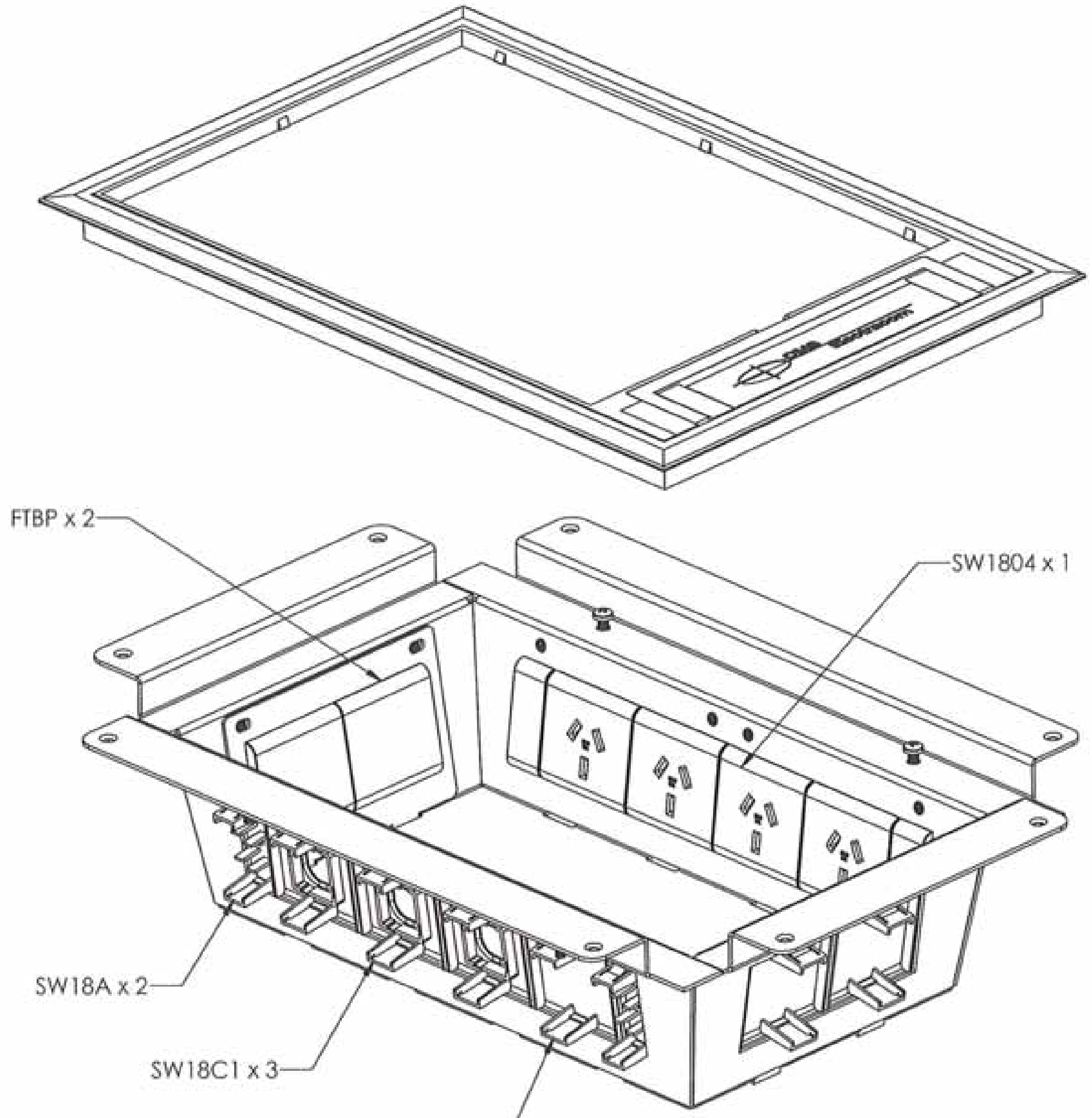

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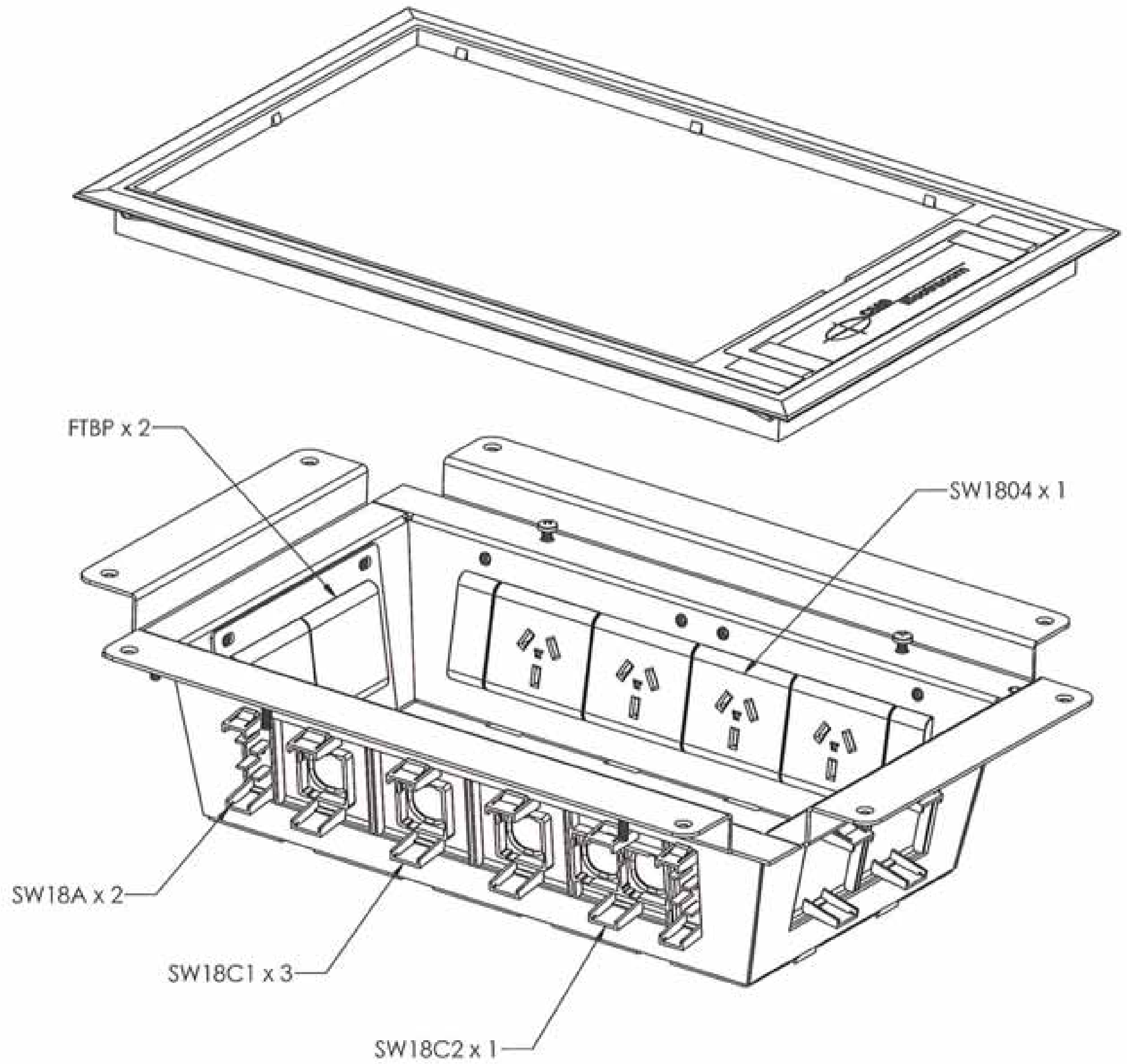

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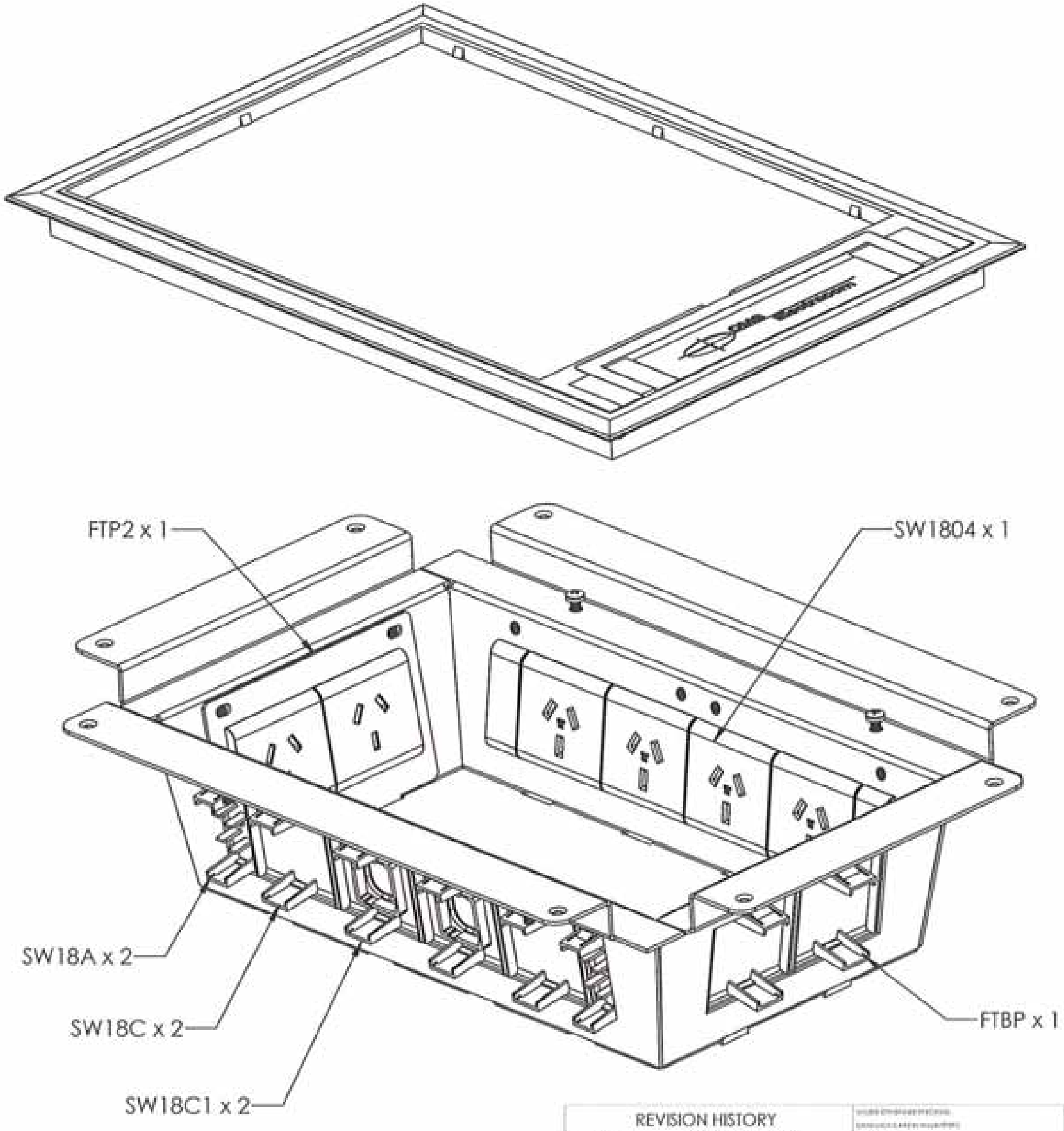
Titan floor box FTA4
F45

DWG NO.	LU-3713	A3
PART NO.	TBC	
SCALE	N/A	SHEET 1 OF 1



REVISION HISTORY		
N.	DATE	MODIFICATIONS
1	26/06/12	ISSUED FOR EVALUATION
2		
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NAME	DATE
LUCKY	26/06/12

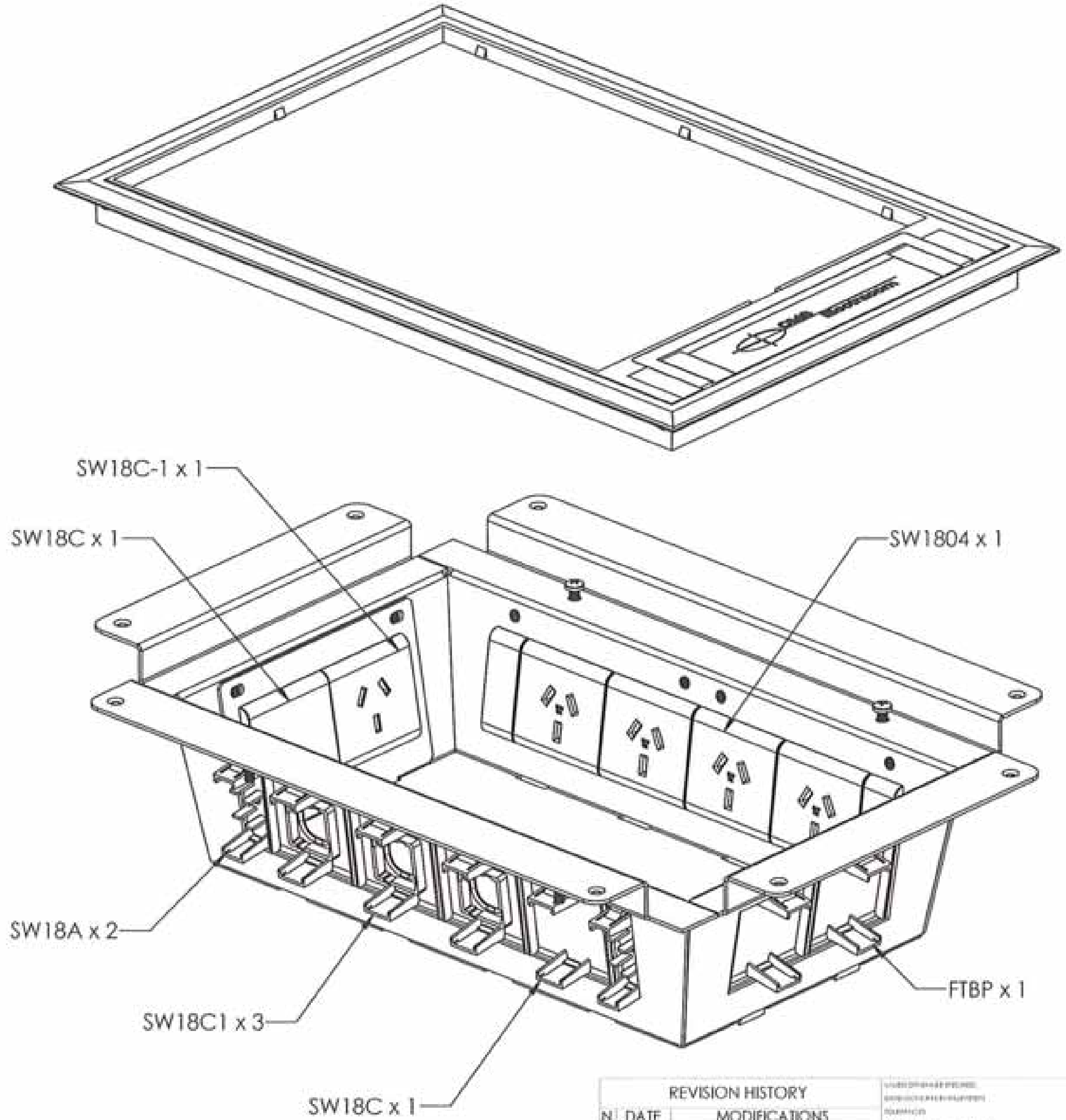
MATERIAL: X
FINISH: X
FILE ON SHARED\CAD:

DO NOT SCALE DRAWING — REVISION 1

CMS Electracom

TITLE: Titan floor box FTA4 F62

DWG NO. LU-3717
PART NO. TBC
SCALE N/A — SHEET 1 OF 1 — A3



REVISION HISTORY		
N.	DATE	MODIFICATIONS
1	26/06/12	ISSUED FOR EVALUATION
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NAME	DATE
LUCKY	26/06/12

MATERIAL: X
FINISH: X
FILE ON SHARED\CAD:
FILE ON NAS:

DO NOT SCALE DRAWING — REVISION 1

CMS Electracom

TITLE: Titan floor box FTA4 F53

DWG NO. LU-3716
PART NO. TBC
SCALE N/A — SHEET 1 OF 1
A3

9 INSPECTION TEST PLANS

9.1 Testing Data

See attached folder 9

Title: Standard UPS Commissioning Notes/Instructions			
Document No.	ES-W013	Revision Index	A
First Issue (date)	6/03/2012	Revision date	6/03/2012

1 PURPOSE:

To document the Standard commissioning scope offered with our hardwired UPS equipment when purchased by customers.

2 SCOPE:

All hardwired Eaton supplied UPS units.

3 REFERENCES:

3.1 Eaton Serrvice Report - Commissioning

4 ABBREVIATIONS/DEFINITIONS:

UPS – Uninterruptable Power System.

5 STANDARD UPS COMMISSIONING INSTRUCTIONS:

SITE CONDITIONS

Room temp

Measure room temperature using an electronic thermometer. Room temperature shall normally be between +15...+25 degrees C, If temperature is significantly outside normal values customer actions shall be proposed.

Humidity

Check that site location is dry and non-condensing and give status in report. If acceptable or wet customer actions shall be proposed.

Cleanliness

Check that site location is clean and free from dust and dirt and give status in report. If acceptable or dirty customer actions shall be proposed.

EQUIPMENT INSPECTION

Shipping damages

Check unit and options for shipping damages both externally and internally. If any shipping damages are found check with customer that proper measures have been taken with the transportation company and that the responsibility of the insurance company is clear and settled, otherwise consult with the customer responsible to make it clear.

Installation damages

Check unit and options for installation damages both externally and internally. If any installation damages are found check with customer that proper measures have been taken with the installation company and that the responsibility is clear and settled, if not, consult with the responsible customer person to make it clear.

If repairs have to be made service engineer must get commitment from installation company or from the customer to take responsibility for costs. If in doubt consult with service manager.

INSTALLED OPTIONS

Follow up what options the customer have bought with the system and make notes in report: **product type, data and serial number** for standard options.

CONTROL OF INSTALLATION

Common items

Check and tighten all external connections to UPS, battery and load.
Check phase order of AC and polarity of DC connections.
Check also all protective earth connections for proper installation and cable area.
Check installation of service switch if fitted.

Rectifier/converter, Bypass line, Load

Check that cable area and fuses are correct according to installation manual.
Check that distribution fuses and cable area for distribution cables are correct according to connected loads.

Computer interface/options

Check that installation and connections of all options are made according to installation manual and customer's requirements.

POWER ON

The following activities will mainly be performed with voltage on. Make sure to take care of safety aspects properly.

Line voltage rect/conv

Connect line voltage to UPS Rect/Conv line and measure voltage.

Line voltage By-Pass

Connect line voltage UPS By-Pass line and measure voltage.

Unit started

Perform normal unit start up and check that unit is operating normally.

Output voltage/frequency

Measure output voltage and check output voltage waveform and frequency.

SYSTEM TEST

The following activities will mainly be performed with voltage on. Make sure to take care of safety aspects properly.

Front panel display and switches

Check that all leds light:
- UPS ON: start UPS and look at the led.
- LINE FAILURE: Make the line break in by-pass line.
- UPS BY-PASSED: Change the load to the line with the internal by-pass switch.
- OVERLOAD: Add load over the nominal load, if possible.
- UPS ALARM: Make failure, example turn the rectifier circuit breaker to off-position.
- Check the MECHANICAL BY-PASS switch. Transfer the load from the inverter via the static switch to the mechanical by-pass switch. Check with test equipment the UPS output voltage and check that the switch doesn't not make break.

Line failure/Synchronization test

- Look at the inverter output voltage and line voltage with test equipment. Make the line break in the by-pass line and connect the line voltage back. Check that the inverter synchronizes with the line after 10 sec. and the phase angle is zero degrees.

Starting up and shutting down

Make starting up and shutting down procedures as described in the User's manual.

Function of installed options

Test the function of each of the options installed.
See preventive maintenance instruction for the UPS series concerned for detailed information.

UPS failure test

Check that UPS changes the load to the by-pass line if applicable, when simulating trip of internal UPS fault.

BASIC OPERATOR TRAINING

During the Operator Training session make sure that the operators are acquainted with the user's manual and use it as the training material.

Operating principles

Explain the operating principles of the UPS in common and for the actual system in specific. Explain also the function of installed options.

-Normal operation
-Mains failure
-Overload
-By-Pass switch, -static, -internal, -service

Safety information

Review safety information according to the user's manual and make sure that the message is understood.

Indications and alarms

Review functions and meanings of all indications and alarms.
Review function of computer interface and actions that shall be taken in the event of a mains failure.

Start and stop procedure

Review and let operators perform starting up and shutting down procedures for the UPS according to the instructions in the user's manual.

Fault tracing

Review the fault tracing activities based on the fault indications from the front panel as described in the user's manual.

6 FORMS/TEMPLATES:

n/a

7 MANAGER(S) RESPONSIBLE:

Technical Services Manager

8 REVIEW CYCLE

Annually.

9 APPROVAL:

Conrad Gall
GM Services

10 REVISION AND DOCUMENT CHANGES:

Rev. Index	Revision Date	Description of changes
A	6/03/2012	Original Issue

UTS FEIT

BROADWAY

DATE: 5/8/2013

COMMISSIONING PLAN

ELECTRICAL SERVICES INSTALLATION

NILSEN

NILSEN (NSW) PTY LTD
UNIT 26 / 38 SOUTH STREET,
RYDALMERE NSW 2116
TELEPHONE: (02) 9898 9355
FACSIMILE: (02) 9638 0343

COMMISSIONING PLAN

UTS FEIT BROADWAY

Builder:- Lend Lease

Telephone: (02) 8218 1914
Facsimile: (02) 9211 7592

Architects:- Denton Corker Marshall

Telephone: (03) 9012 3600
Facsimile: (03) 9012 3601

Electrical Contractor:- NILSEN (NSW) PTY LTD

UNIT 26 / 38 SOUTH STREET,
RYDALMERE NSW 2116
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FACSIMILE: (02) 9638 0343

24 Hour Emergency Contact No:

(02) 9898 9355

SECTION 1 INDEX

Purpose

The purpose of the commissioning plan is to:

Provide the appropriate direction, management and training to fulfil the requirements necessary for the successful commissioning and handover of electrical services and apparatus associated within the project.

In addition to the procedures outlined in this document, further, vendor specific commissioning and testing procedures may be implemented to ensure that the validity of warranties is maintained.

A summary of training requirements is listed for each section outlined within the plan. The summaries of each section will form the basis of a final training plan to be developed and implemented by Nilsen (NSW)

The commissioning plan takes into account all the relevant requirements outlined within the project documents and all relevant AS standards. The referenced documents and AS standards include, but not limited to;

AS 3017:2007 Electrical Testing Guidelines
AS 3000:2008 Wiring Rules
AS 2293.1 & AS 2293.2 Emergency and Evacuation Lighting
AS 1768:2007 Lightning Protection
AS 1931.1 HV Testing Procedures
AS 3080 Telecommunications Installations

3.1 Earth / Main Earth Continuity and Resistance

Objective

Earth continuity and Resistance Tests are necessary to ensure that the Earthing System has been installed in an appropriate manner and that the resistance of the protective earthing conductor is low enough to permit the passage of sufficient current to cause circuit protective devices to operate if there is a fault between live parts and exposed conductive parts.

Desired Results

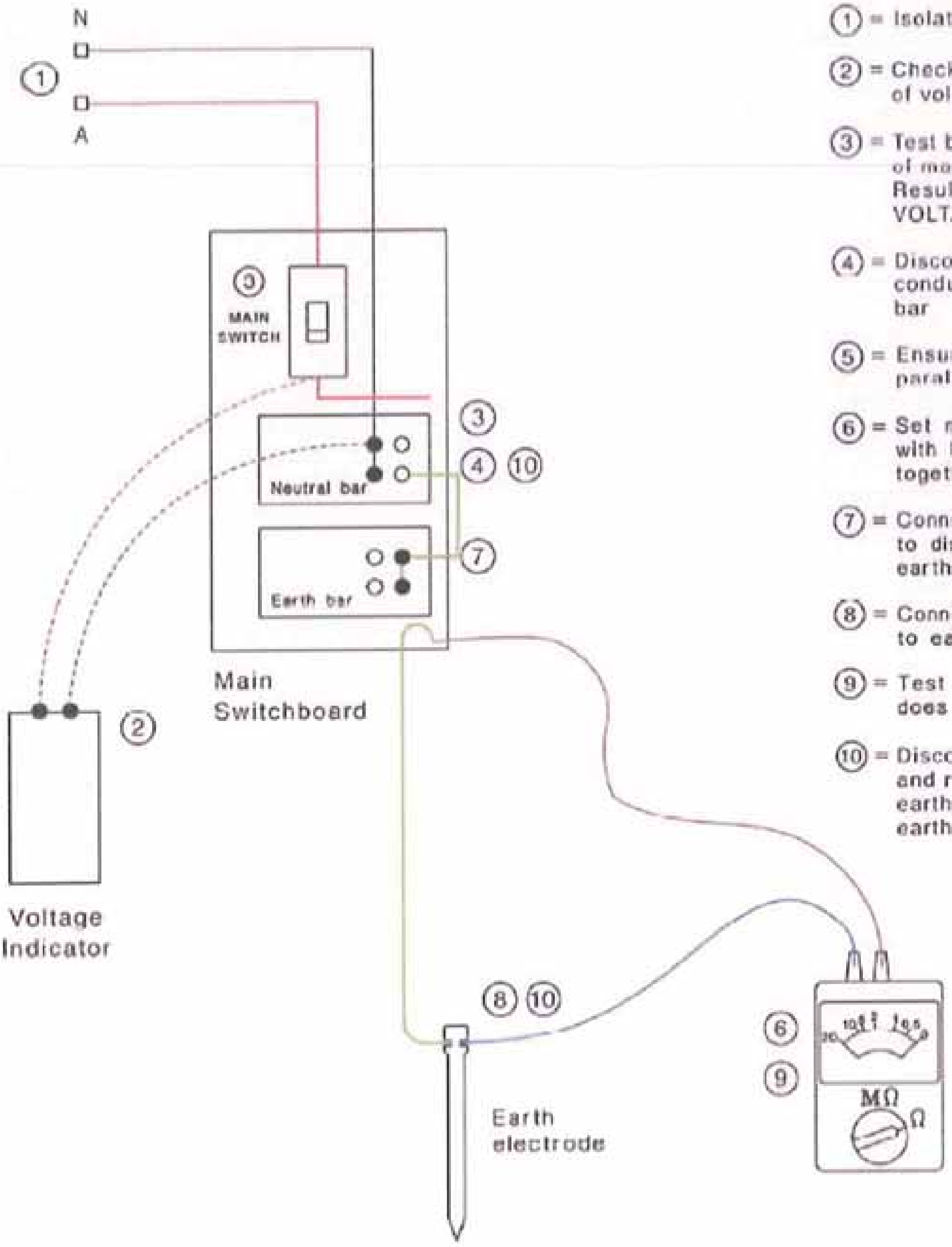
The resistance of the main earthing conductor and any equipotential bonding conductor shall not be greater than 0.5 ohms.

Test Procedure

The test proceedures below show methods of testing the continuity and resistance of earthing and bonding conductors. This procedure is an extract from AS 3017:2007 and the most recent release of this document should be referenced when carrying out these tests.

The following sequence should be followed when testing in accordance with the considerations shown in AS/NZS 3017:2007

Test Procedure Continued – Main Earth Continuity and Resistance



TEST SEQUENCE:

(1) = Isolate supply

(2) = Check operation of voltage indicator

(3) = Test between load side of main switch and neutral. Result should indicate NO VOLTAGE is present

(4) = Disconnect main earthing conductor from the earth bar

(5) = Ensure there are no parallel earth paths

(6) = Set meter to zero Ω with leads connected together

(7) = Connect one test lead to disconnected main earthing conductor

(8) = Connect other test lead to earth, electrode

(9) = Test that resistance does not exceed 0.5 Ω

(10) = Disconnect test leads and reconnect the main earthing conductor at the earth bar

NOTE — Numbers indicate test sequence.

3.2 Insulation Resistance

Objective

Insulation resistance tests are necessary to ensure that the insulation resistance between all live conductors and earth or, as the case may be, all live parts and earth is adequate to ensure the integrity of the insulation. This is to prevent:

(a) Electric shock hazards from inadvertent contact
(b) Fire hazards from short circuits
(c) Equipment damage

In addition, insulation resistance tests between all conductors are necessary for consumers mains and submains to minimise the potential for insulation breakdown, injury or property damage due to failure of such conductors.

Desired Results

The insulation resistance between:

(a) The conductors of consumers mains and submains; and
(b) Live and earthed parts of an electrical installation, or parts thereof, including consumers mains and submains

Shall not be less than 1M Ohm.

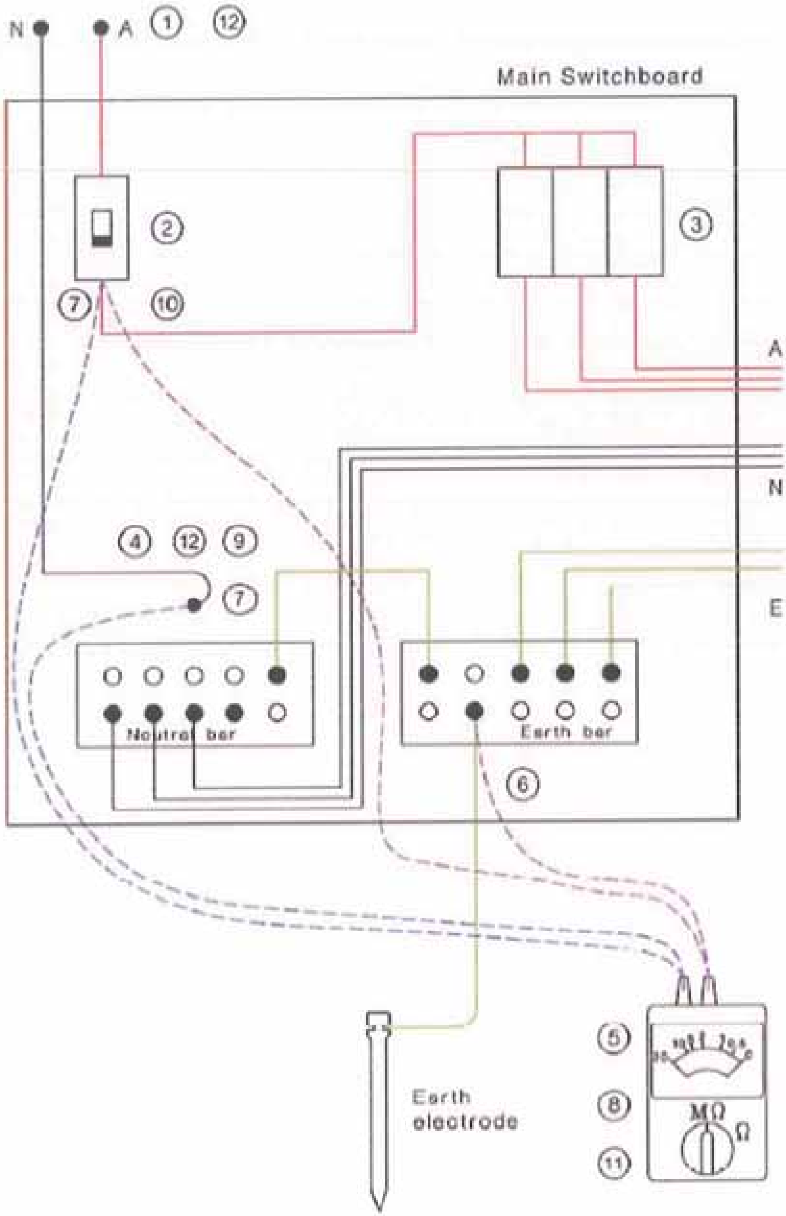
RCD's with a functional earth connection and some other electrical equipment may cause test results lower than desired. These should be disconnected from the circuit prior to testing.

Test Procedure

The procedure for testing the mains and submains connected to each switchboard is as per the following diagram.

This procedure is an extract from AS 3017:2007 and the most recent release of this document should be referenced when carrying out these tests.

Test Procedure Continued – Insulation Resistance(supply not connected)



TEST SEQUENCE:

① = Ensure all live conductors are disconnected from the supply

② = Turn main or isolating switch(es) ON

③ = Ensure all circuit fuses are OUT and circuit-breakers are OFF

④ = Disconnect the supply neutral from the neutral bar

⑤ = Set meter to read MΩ

⑥ = Connect one test lead to the main earthing conductor at the earth bar

⑦ = Connect other test lead to each live conductor in turn

⑧ = Test that resistance complies with 3.2.2

⑨ = Connect one test lead to the disconnected supply neutral

⑩ = Connect other test lead to each active conductor in turn

⑪ = Test that resistance complies with 3.2.2

⑫ = Disconnect test leads, reconnect supply neutral, consumers mains or submains conductors

NOTE —

(1) Test can be carried out on each conductor separately.

(2) For multiphase consumers mains also test between phase conductors

(3) Numbers indicate test sequence.

3.3 Polarity

Objective

Polarity testing is necessary to ensure that no shock hazard results from the incorrect connection of active, neutral and earthing conductors. This testing is to ensure:

(a) Active and Neutral conductors of the consumers mains or submains are not transposed resulting in the electrical installation earthing system becoming energised;

(b) There are no combinations of incorrect active, neutral and earthing conductor connections resulting in exposed conductive parts of the electrical installation becoming energised; and

(c) Switches do not operate in neutral conductors, resulting in parts of appliances, such as heating elements and lampholders, remaining energised when isolation devices have been operated.

Desired Results

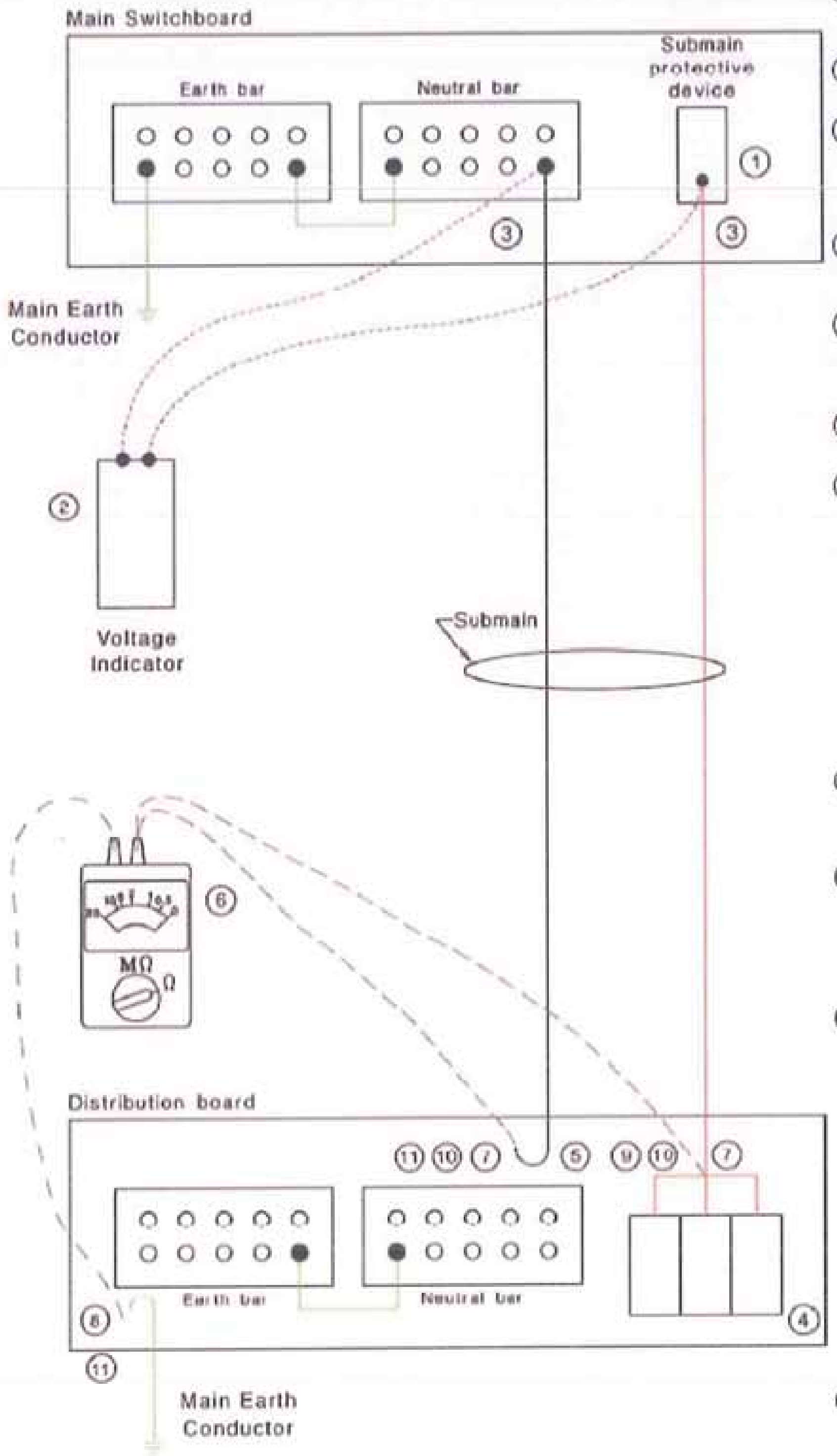
The desired results for this test are as shown within the test procedure description.

Test Procedure

The following test procedure shows two methods for testing polarity of the electrical installation. The first method shows the test procedure with no supply, the second with supply available. Both are acceptable methods, however depending on the stage of construction on the project the site staff will decide which test is more suitable for them to carry out.

This procedure is an extract from AS 3017:2007 and the most recent release of this document should be referenced when carrying out these tests.

Test Procedure Continued – Polarity(supply not connected)



TEST SEQUENCE:

1 = Remove fuse or turn OFF circuit-breaker protecting submain at switchboard

2 = Check operation of voltage indicator

3 = Test between submain protective device and neutral bar at switchboard. Result should indicate NO VOLTAGE is present

4 = Remove all fuses and turn OFF all circuit-breakers at the distribution board

5 = Disconnect submain neutral conductor and the main earth conductor at the distribution board

6 = Set meter to zero Ω with leads connected together

7 = Bridge active and neutral conductors at the main switchboard. Measure the resistance between the active and neutral conductors at the distribution board. Result should indicate SHORT CIRCUIT. Remove bridge at main switchboard and measure resistance between active and neutral conductors at distribution board. Result should indicate OPEN CIRCUIT

8 = Connect one test lead to the disconnected earth conductor at the distribution board

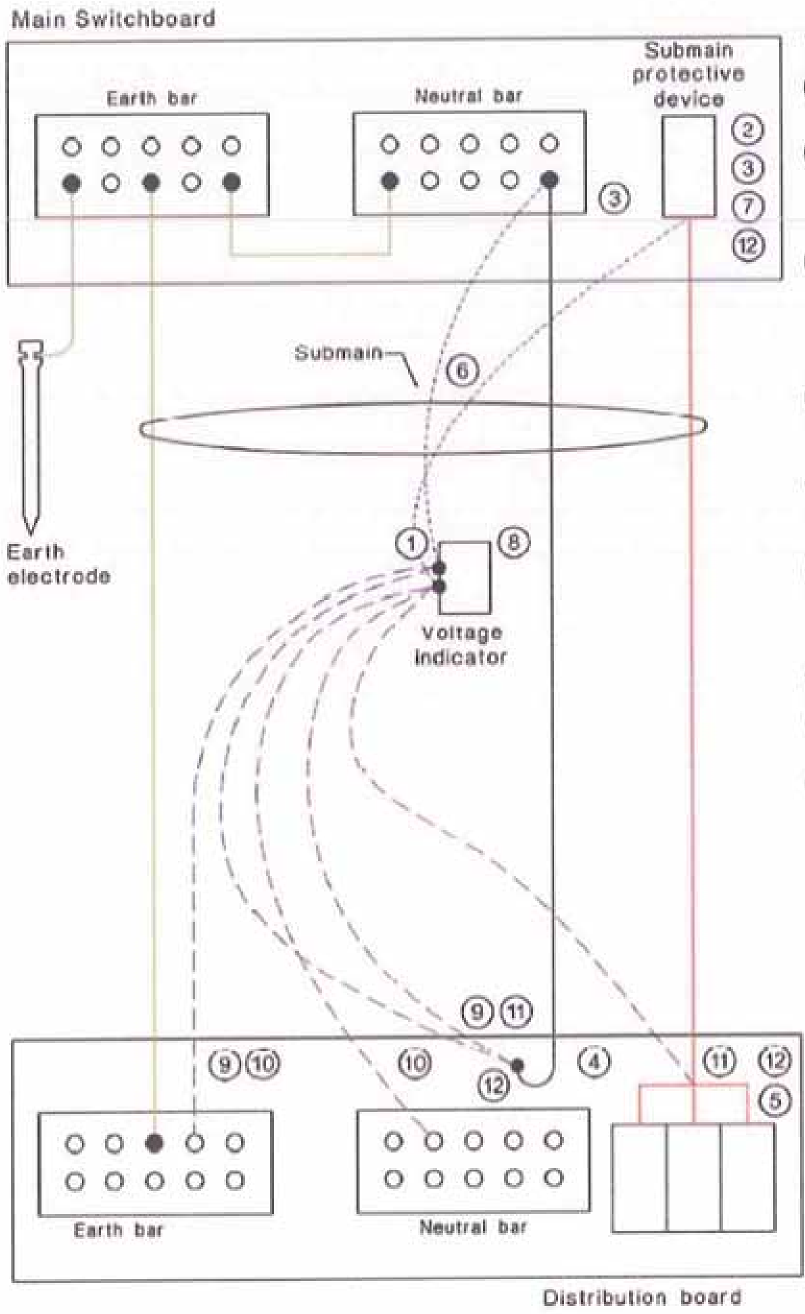
9 = Connect other test lead to active conductor at line side of protective devices on distribution board. Result should indicate OPEN CIRCUIT

10 = Disconnect test lead from active conductor and connect to disconnected submain neutral conductor. Result should indicate SHORT CIRCUIT

Note: Continuity depends upon the earth resistance back to the main switchboard and it may be necessary to select a higher ohm range or use the 500 V range of an insulation tester to verify the connection between the neutral conductor and the earthing system

11 = Disconnect test leads and reconnect submain neutral conductor and main earth conductor at distribution board

Test Procedure Continued – Polarity(supply connected)



TEST SEQUENCE:

(1) = Check operation of voltage indicator

(2) = Remove fuse or turn OFF circuit-breaker protecting submain at main switchboard

(3) = Test between actives and neutral at main switchboard and at distribution board. Results should indicate NO VOLTAGE is present

(4) = Disconnect submain neutral conductor at the distribution board

(5) = Isolate outgoing circuits at the outbuilding switchboard protective devices

(6) = Ensure insulation resistance of submain neutral is satisfactory (see figure 3.4)

(7) = Energize submain

(8) = Check operation of voltage indicator

(9) = Test between disconnected neutral submain conductor and earth bar at distribution board. Result should indicate NO VOLTAGE present

(10) = Test between neutral bar and earth bar at distribution board. Result should indicate NO VOLTAGE present

(11) = Test between active submain conductors and disconnected neutral of submain at outbuilding switchboard. Result should indicate SUPPLY VOLTAGE present

(12) = Isolate supply to submain and reconnect neutral submain conductor at outbuilding switchboard

NOTE — Numbers indicate test sequence.

3.4 Correct Circuit Connections

Objective

Tests for correct circuit connections are necessary to ensure the following:

(a) Protective earthing conductors do not carry current in non-fault conditions; and
(b) No short circuit exists, because current flowing between live conductors and through part of the earthing system can cause considerable fire damage or personal injury, particularly in high current situations.

Desired Results

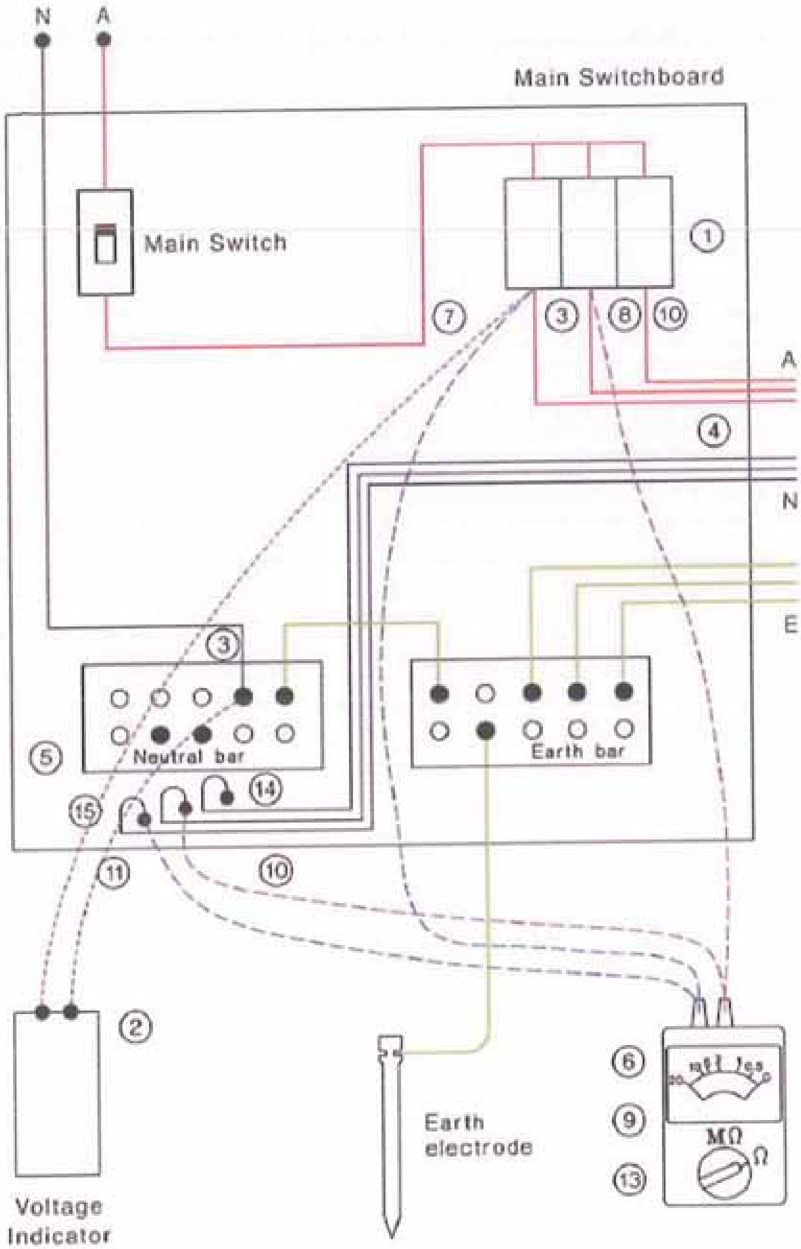
The active, neutral and earthing conductors of each circuit shall be correctly connected so that there is no interconnection of conductors between different circuits.

Test Procedure

Testing should confirm that any resistance between the Active and Neutral conductors of a circuit is consistent with the load. For example a socket outlet with no connected equipment should measure a high resistance(approx infinity); whereas on a 230V, 4.8kW water heater a resistance of about 11 ohms should be expected.

This procedure is an extract from AS 3017:2007 and the most recent release of this document should be referenced when carrying out these tests.

Test Procedure Continued – Correct Circuit Connections(supply not connected)



TEST SEQUENCE:

(1) = Remove fuses or turn OFF circuit-breakers protecting all circuits under test

(2) = Check operation of voltage indicator

(3) = Test between active and neutral conductor at switchboard. Result should indicate NO VOLTAGE is present

(4) = Ensure all circuit switches are ON

(5) = Disconnect all neutral conductors of circuits under test from neutral bar

(6) = Set meter to zero Ω with leads connected together

(7) = Connect one test lead to one active conductor

(8) = Connect other test lead to all other active conductors in turn

(9) = Test results should indicate approximately infinity

(10) = Repeat steps 7 to 9 for all other active conductors

(11) = Connect one test lead to one neutral conductor

(12) = Connect other test lead to all other neutral conductors in turn

(13) = Test results should indicate approximately infinity

(14) = Repeat steps 11 to 13 for all other neutral conductors

(15) = Remove test equipment and reconnect neutral conductors

NOTE — Numbers indicate test sequence.

3.5 Phase Sequence

Objective

Phase sequence testing is necessary to ensure that multi-phase equipment such as multi-phase motors and equipment operate in a predictable manner.

Desired Results

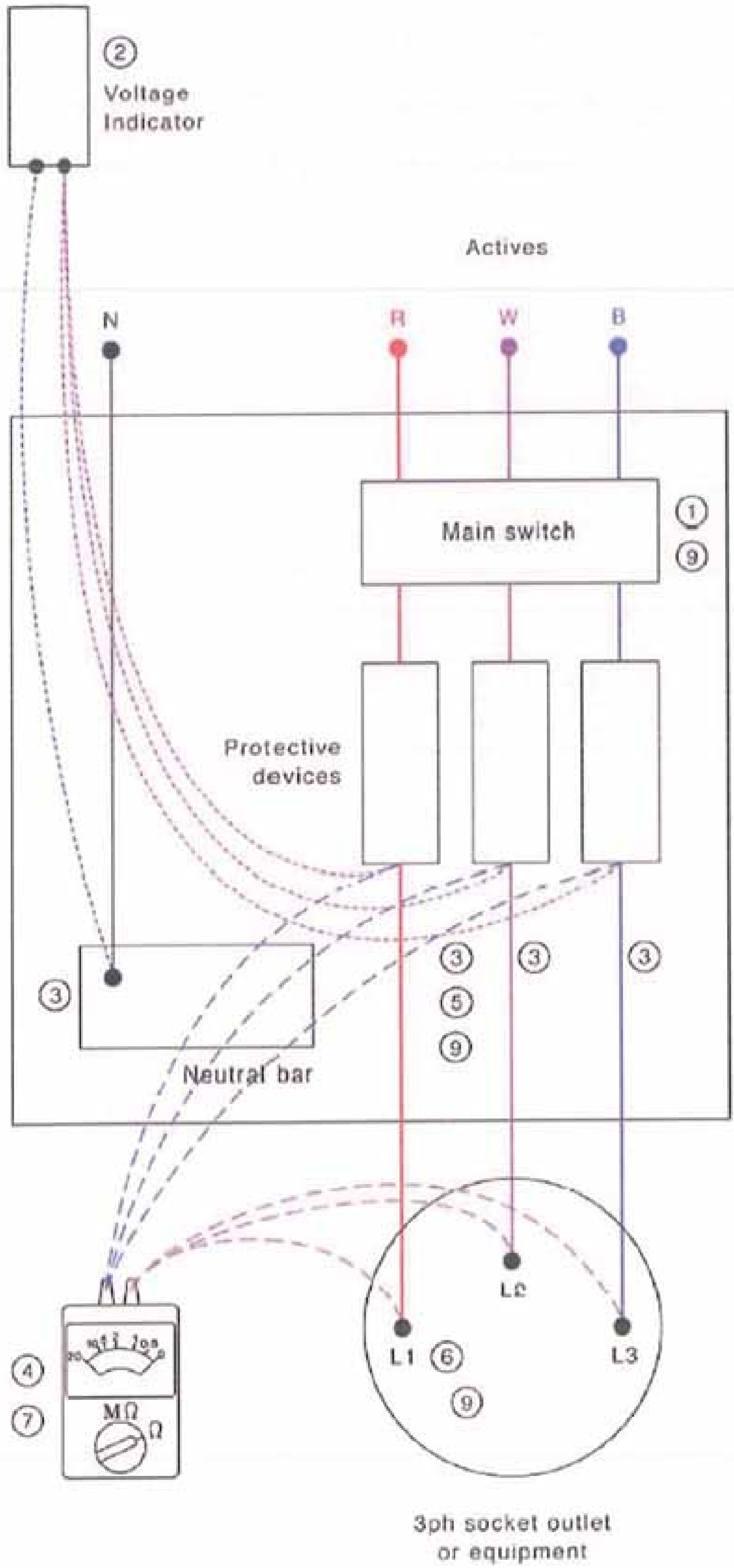
Phase sequence should be maintained throughout the electrical installation.

Test Procedure

If there is supply available use a phase sequence tester in accordance with the manufacturers instructions. If supply is not available test as per the following procedure.

This procedure is an extract from AS 3017:2007 and the most recent release of this document should be referenced when carrying out these tests.

Test Procedure Continued – Phase Sequence(supply not connected)



TEST SEQUENCE:

① = Turn main switch OFF

② = Check operation of voltage indicator

③ = Test between actives and neutral. Result should indicate NO VOLTAGE is present

④ = Set meter to zero Ω with leads connected together

⑤ = Connect test lead to load side of red phase protective device

⑥ = Connect other test lead to L1 contact on 3ph socket outlet on equipment

⑦ = Result should indicate short circuit

⑧ = Repeat 5 - 7 for white and blue phases to L2 and L3 respectively

⑨ = Disconnect test leads and turn main switch ON

3.6 VISUAL INSPECTION OF ALL CONNECTIONS

Objective

A visual inspection of all connections should be carried out to ensure that any potential oversights in procedure are captured prior to energisation.

The visual inspection should confirm that all bolts have been tightened, phases are correctly sequenced, the switchboard is clear of debris/filings etc, all cables are terminated or sleeved, cable markings are complete and that all earth conductors are connected.

Desired Results

- All conductive bolts should be check-marked by the installing technician to indicate they have been correctly torqued
- Phase sequence should be continuously identified at all connections with the respective coloured heat shrink, unless this sequence is required by specific equipment to be altered
- Cable markings should identify the circuit designation as per the requirements of the electrical specification
- There should be no loose debris/filings on top of breakers or bars and the bottom of each cubicle should be clear. No surplus conductive bolts should be left laying in the bottom of switchboards.
- All protective earth conductors for completed circuits should be connected to the earth bar
- Neutral conductors should be terminated under the bolt/screw with the number corresponding to the circuit breaker number
- Cable glands should be tightened around conductors
- There should be no open penetrations on the external switchboard to prevent the ingress of any dust, moisture or vermin.

Test Procedure – Visual Inspection(Supply not Connected)

NB. Should be carried out with 3.3.11(vacuuming and debris removal)

1. Ensure supply is isolated and confirm DEAD
2. Remove any covers/escutcheons that obscure view of components to be inspected
3. Visually inspect components as required, paying close attention to the items noted above
4. Any items of concern should be rectified IMMEDIATELY
5. Replace covers ensuring that they are securely fitted upon completion

3.7 TORQUE / TENSION ALL CONDUCTIVE BOLTS

Objective

Ensuring that all conductive bolts are correctly tightened to the correct torque is essential to ensure there are no loose connections that could cause hot joints.

Desired Results

Torque for bolted connections of Phase Busbars, Neutral and Earth

Type of Connection	Bolt Size	Nm
Bolted	M6	8
	M8	20
	M10	40
	M12	70
	M16	140

Test Procedure

Conductive bolts should be tightened to the correct torque and check-marked by the installer to confirm this has been completed.

Carry out a visual inspection to ensure conductive bolts have been check-marked..

Should no check-marks be found on bolts then ensure the switchboard has been de-energised and confirm tension with a suitable torque wrench. DO NOT commence checks or repairs if the board is energised.

3.8 VACUUMING AND DEBRIS REMOVAL

Objective

The interior of switchboards must be kept clear of debris to ensure the possibility of any arching faults is minimised, as these could result in catastrophic failure of the board and its internal components.

Desired Results

Upon completion the switchboard should be clear of any dust, filings, cable off-cuts and the like. This includes the base of all switchboard cubicles and any flat surfaces including switchboard components where dust and debris may settle.

Test Procedure

NB. Should be carried out with 3.3.9(visual inspection of all connections)

Vacuuming and debris removal MUST be completed PRIOR to energisation of any switchboard to ensure there is no possibility of harm to persons or equipment as a result of debris in any given switchboard.

All covers should be removed, and should be given a wipe down with a soft cloth and a mild cleaning agent.

Use vacuum cleaner to remove any debris or filings. Checks should include but not be limited to the following...

1. Circuit breaker housings
2. Busbars
3. Busbar cleats
4. Switches or control equipment
5. Contactors etc
6. Base of all cubicles

All cubicles of the switchboard should be photographed, and a switchboard drawing marked up with photograph numbers so the images can be easily referenced in the future.

Covers should be replaced ensuring that all fixing screws are securely tightened.

3.9 ESCUTCHEON LABELLING

Objective

To ensure compliance with local supply authority rules and the requirements of AS/NZS 3000:2007.

Desired Results

The following items should be clearly indicated on all Main Switchboards / Distribution Boards.

1. Switchboard name
2. Circuit designations
3. Origin of supply
4. Labelling of safety services
5. Location of Main Earth
6. Location of MEN point
7. Circuit breaker ratings
8. Neutral number
9. Cable size for mains cables

Test Procedure

Carry out a visual inspection of the labels fitted to the board, noting any missing or unclear labelling. Note on ITP any required labels.

Refer missing label issues to switchboard manufacturer for rectification.

SECTION 4 MAIN SWITCHBOARDS AND DISTRIBUTION BOARDS

4.1 General

The installation of new LV Main Switchboards and distribution boards will be carried out as per the project documents and as per the relevant Australian Standards.

Nilsen will implement project specific ITP's during the installation and commissioning phases of the switchboards

In addition to project specific requirements, switch boards will undergo testing and commissioning as per manufactures specifications and recommendations

Both the House Main Switchboard and the Tenants Main Switchboard on this project shall have the following test and commissioning procedures carried out as per section 3 of this commissioning plan.

1. Main Earth Continuity and Resistance
2. Insulation Resistance
3. Polarity
4. Correct circuit connections
5. Phase Sequence
6. Visual inspection
7. Torque/Tension of all conductive bolts
8. Vacuuming and Debris Removal
9. Labelling of Escutcheon
10. Thermal Imaging Report

The installation of new LV Main Switchboards and distribution boards will be carried out as per the project documents and as per the relevant Australian Standards.

Nilsen will implement project specific ITP's during the installation and commissioning phases of the switchboards

In addition to project specific requirements, switch boards will undergo testing and commissioning as per manufactures specifications and recommendations.

A summary of the testing and commissioning procedures for LV Distribution boards is listed below;

1. Earth Continuity and Resistance
2. Insulation Resistance
3. Polarity Testing
4. Correct Circuit Connections
5. Phase Sequence
6. RCD testing
7. Dynalite function test (Where installed)
8. Visual Inspection of all connections

9. Torque/Tension of all conductive bolts
10. Vacuuming and removal of any debris from within cubicle
11. Labelling of escutcheon and cable numbering
12. Thermal imaging report

4.2 Training

On completion of the testing and commissioning phase of installation, Nilsen will provide training to personnel for the ongoing maintenance of LV distribution boards

A summary of the training procedures is listed below;

1. RCD testing procedures
2. Familiarisation of switch board and switching equipment
3. Thermal imaging requirements
4. Location of downstream devices
5. Understanding of labelling methodologies

5.1 General

The installation of a lightning protection system will be carried out as per the project documents, the relevant Australian Standards and as per an independent design completed by RWV Lighting protection

Nilsen and RWV will implement project specific ITP's during the installation and commissioning phases of the lightning protection system. Appropriately trained technicians in the field of lightning protection will carry out insulation resistance testing and continuity testing on down conductors of the LPS

In addition to project specific requirements, the LPS will undergo testing and commissioning as per manufactures specifications and recommendations

5.2 Test Procedure

A summary of the testing and commissioning procedures is listed below;

1. Identification of soil resistivity to determine speed of corrosive deterioration of copper conductors associated with the LPS
2. Continuity of down conductors
3. Impedance testing of LPS conductors
4. Resistance testing of LPS conductors
5. Inspection of earth electrodes

The results of these tests will be provided to Nilsen on the subcontractors site specific commissioning checklist.

5.3 Training

On completion of the testing and commissioning phase of installation, Nilsen and LDU will provide training to personnel for the ongoing maintenance of the LPS

It should be noted that limited maintenance is required on LPS after installation

A summary of the training procedures is listed below;

1. Visual identification of conductors which have been subject to transient voltages or direct lightning strike
2. Visual inspection of copper conductors to check condition and joints

SECTION 6 EMERGENCY EVACUATION LIGHTING

6.1 General

The installation of a monitored emergency/evacuation lighting system will be carried out as per the project documents and as per the relevant Australian Standards

Nilsen will implement project specific ITP's during the installation and commissioning phases of emergency and evacuation lighting

In addition to project specific requirements, the emergency and evacuation lighting will undergo testing and commissioning as per manufactures specifications and recommendations

6.2 Test Procedure

A summary of the testing and commissioning procedures is listed below;

1. Programming of fixtures onto software database
2. Site numbering and adhesive fitting specific bar codes
3. Router radio frequency testing, ensure communications link is complete
4. Initial discharge test for AS compliance
5. Record of initial discharge tests onto data base
6. Setup of 6 monthly and 12 monthly discharge tests

The results of the general installation aspects of the Emergency and Evacuation lighting commissioning will be captured by the Dynalight ITP sheets.

Commissioning results of the overall system are a proprietary based report generated by a pc connected to the emergency and exit lighting system. A copy of this report must be submitted as part of this commissioning plan.

6.3 Training

On completion of the testing and commissioning phase of installation, Nilsen will provide training to personnel for the ongoing maintenance of emergency and evacuation lighting

A summary of the training procedures is listed below;

1. Familiarisation of network hardware locations
2. Software training
3. Understanding diagnostic fault reports
4. Programming of zoned discharge tests
5. Data compilation and recording for BCA requirements

SECTION 7 GENERAL POWER CABLING AND OUTLETS

7.1 General

The installation of general power cabling and outlets will be carried out as per the project documents and as per the relevant Australian Standards

Nilsen will implement project specific ITP's during the installation and commissioning phases of final sub circuit cabling and outlets

In addition to project specific requirements, outlets and cabling, were applicable, will undergo testing and commissioning as per manufactures specifications and recommendations

7.2 Training

On completion of the testing and commissioning phase of installation, Nilsen will provide training to personnel to enable ease of ongoing cable installations and identify cable pathways

A summary of the training procedures is listed below;

1. Familiarisation of cable path ways
2. Identifying locations of provisioned cable pathways, cable trays and conduits for new cabling installations
3. Access panel locations
4. Familiarisation of origin of final sub circuit cabling
5. Isolation procedures and lock off points

SECTION 8 GENERAL LIGHTING CABLING AND FIXTURES

8.1 General

The installation of general lighting cabling and fixtures will be carried out as per the project documents and as per the relevant Australian Standards

Nilsen will implement project specific ITP's during the installation and commissioning phases of lighting cabling and fixtures

In addition to project specific requirements, lighting fixtures and cabling, were applicable, will undergo testing and commissioning as per manufactures specifications and recommendations

8.2 Test Procedure

A summary of the testing and commissioning procedures is listed below;

1. Insulation resistance testing
2. Earthing resistance and continuity
3. Polarity testing
4. Fault loop impedance testing
5. Visual inspection of cabling terminations
6. Check off sheet to ensure correct lamps and hardware are installed

8.3 Training

On completion of the testing and commissioning phase of installation, Nilsen will provide training to personnel to enable ease of ongoing cable installations and identify cable pathways

A summary of the training procedures is listed below;

1. Familiarisation of cable path ways
2. Identifying locations of provisioned cable pathways, cable trays and conduits for new cabling installations
3. Access panel locations
4. Familiarisation of origin of final sub circuit cabling
5. Lamp replacement techniques
6. Familiarisation of O & M manuals
7. Isolation procedures and lock off points

SECTION 9 SECURITY

9.1 General

The installation of a fully monitored security system inclusive of cabling, hardware and head end equipment will be carried out as per the project documents and as per the relevant Australian Standards

Nilsen and Longhurst & Andrews security subcontractor will implement project specific ITP's during the installation and commissioning phases of security related equipment

In addition to project specific requirements security equipment will undergo testing and commissioning as per manufactures specifications and recommendations

A summary of the testing and commissioning procedures is listed below;

1. Check operation of card and credential readers

2. Check door status operation
3. Fire trip simulation test, ensure door release
4. Check operation of intruder devices
5. Check zoning allocations
6. System keypad checks on siren

9.2 Training

On completion of the testing and commissioning phase of installation, Nilsen and its subcontractor will provide training to personnel for the ongoing maintenance of the security system

A summary of the training procedures is listed below;

1. Comprehensive training in the security management system
2. Staff station monitoring procedures
3. Field equipment operation
4. Understanding alarm status and system reports
5. Familiarisation of head end equipment location

SECTION 10 DATA & COMMUNICATIONS SYSTEMS

10.1 General

The installation of a data and telecommunications system will be carried out as per the project documents and as per the relevant Australian Standards

Nilsen will implement project specific ITP's during the installation and commissioning phases of UTP, copper cabling

In addition to project specific requirements the data and communications cabling and hardware will undergo testing and commissioning as per manufactures specifications and recommendations

10.2 Test Procedure

A summary of the testing and commissioning procedures is listed below;

1. Collating cabling test results for submission
2. Impedance and capacitance testing of UTP cabling
3. Insertion loss margin results
4. Cable polarity testing
5. Labelling methodology
6. Distance testing and cabling bending radius are within parameters

10.3 Training

On completion of the testing and commissioning phase of installation, Nilsen will provide training to personnel to enable ease of ongoing cable installations and identify cable pathways

A summary of the training procedures is listed below;

1. Understanding labelling methodology
2. Identifying future cable path way provisions
3. Familiarisation of specific field equipment locations
4. Fault identification and rectification principals
5. Identifying potential dangers associated with laser radiation
6. Understanding site layouts and computer room layouts
7. Patching procedures of field cabling and devices

SECTION 11 NILSEN ITP's

Attached are samples of Nilsen and subcontractors project specific ITPs

Nilsen (NSW) Pty Ltd
Unit 26 / 38 South Street
Rydalmere NSW 2116
PO Box 368, Rydalmere NSW 1701
Ph: (02) 9898 9355
Fax: (02) 9638 0343

Nilsen (NSW) Pty Ltd
Quality Plan

SUMMARY SHEET

Client:		Specification Ref:	
Project:			
Job No:			

	Test Sheet Name	Reference
1	Transformer - Installation & Construction Verification.	FIC-01
2	High Voltage cable - Termination, Test & Pre-commission Verification.	FIC-02
3	High Voltage equipment - Test & Pre-commission Verification.	FIC-03
4	Switchboard / Control Panel - Installation & Construction Verification.	FIC-04
5	Switchboard / Control Panel - Test & Pre-commission Verification.	FIC-05
6	Low Voltage Circuit Breaker - Test & Pre-commission Verification.	FIC-06
7	Power Factor Correction - Installation & Construction Verification.	FIC-07
8	Power Factor Correction - Test & Pre-commission Verification.	FIC-08
9	UPS / Power Supply - Installation & Construction Verification.	FIC-09
10	UPS / Power Supply - Test & Pre-commission Verification.	FIC-10
11	Motor Drive - Construction Verification.	FIC-11
12	Motor Outlet - Installation & Construction Verification.	FIC-12
13	Motor & Drive - Test & Pre-commission Verification.	FIC-13
14	Cable ladder - Installation & Construction Verification.	FIC-14
15	Cable - Installation & Construction Verification.	FIC-15
16	Power cable - Termination & Testing.	FIC-16
17	Control / Instrument cable - Termination & Testing.	FIC-17
18	Data cable - Termination & Testing.	FIC-18
19	Earth cable - Termination & Testing.	FIC-19
20	Earth Grid - Installation, Test & Construction Verification.	FIC-20
21	Lightning Protection - Installation, Test & Construction Verification.	FIC-21
22	Instrument marshalling Box - Installation & Construction Verification.	FIC-22
23	Instrument - Installation & Construction Verification.	FIC-23
24	Instrument - Power up Verification.	FIC-24
25	Light & Power - Installation & Construction Verification.	FIC-25
26	Light & Power - Termination, Test & Pre-commission Verification.	FIC-26
27	High Voltage Conduit Installation - Termination, Test & Pre-Commissioning	FIC-27
28	Flow Switch Installation & Operation Verification	FIC-28
29	Installation of Underground Conduits	FIC-29
30	Conduit (PVC/metal) - Installation & Construction Verification.	FIC-30
31	Permanently Connected Equipment - Installation & Construction Verification.	FIC-31
32		Apartments

OTHERS
Individual Circuit Test Sheet
Apartment Quality Inspection Sheet

SECTION 4: LV MAIN SWITCH BOARD

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Resistance and Continuity of main earth conductor			
2. Insulation Resistance			
3. Polarity Testing			
4. Correct circuit connections			
5. Phase Sequence			
6. Visual inspection of all connections			
7. Torque/Tension of all conductive bolts			
8. Vacuuming and removal of any debris from within cubicle			
9. Labelling of escutcheon			
10. Thermal imaging report			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Familiarisation of switch board and switching equipment			
2. Thermal imaging requirements			
3. Location of downstream devices			
4. Understanding of labelling methodologies			

SECTION 4: LV DISTRIBUTION BOARDS

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Earth Resistance and Continuity			
2. Insulation Resistance			
3. Polarity Testing			
4. Correct circuit connections			
5. Phase Sequence			
6. Operation of RCD's			
7. Dynalite operation			
8.Visual inspection of all connections			
9. Torque/Tension of all conductive bolts			
10. Vacuuming and removal of any debris from within cubicle			
11. Labelling of escutcheon			
12.Thermal imaging report			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. RCD testing procedures			
2. Familiarisation of switch board and switching equipment			
3. Thermal imaging requirements			
4. Location of downstream devices			
5. Understanding of labelling methodologies			

SECTION 5: LIGHTING PROTECTION

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Identification of soil resistivity to determine speed of corrosive deterioration of copper conductors associated with the LPS			
2. Continuity of down conductors			
3. Impedance testing of LPS conductors			
4. Resistance testing of LPS conductors			
5. Inspection of earth electrodes			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Visual identification of conductors which have been subject to transient voltages or direct lightning strike			
2. Visual inspection of copper conductors to check condition and joints			

SECTION 6: EMERGENCY EVACUATION LIGHTING

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Programming of fixtures onto software database			
2. Site numbering and adhesive fitting specific bar codes			
3. Initial discharge test for AS compliance			
4. Record of initial discharge tests onto data base			
5. Setup of 6 monthly and 12 monthly discharge tests			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Familiarisation of network hardware locations			
2. Dali Emergency software training			
3. Understanding diagnostic fault reports			
4. Programming of zoned discharge tests			
5. Data compilation and recording for BCA requirements			

SECTION 7: GENERAL POWER CABLING AND OUTLETS

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Insulation resistance testing			
2. Earthing resistance and continuity			
3. Polarity testing			
4. Visual inspection of cabling terminations			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Familiarisation of cable path ways			
2. Identifying locations of provisioned cable pathways, cable trays and conduits for new cabling installations			
3. Access panel locations			
4. Familiarisation of origin of final sub circuit cabling			
5. Isolation procedures and lock off points			

SECTION 8: GENERAL LIGHTING CABLING AND FIXTURES

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Insulation resistance testing			
2. Earthing resistance and continuity			
3. Polarity testing			
4. Visual inspection of cabling terminations			
5. Check off sheet to ensure correct lamps and hardware are installed			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Familiarisation of cable path ways			
2. Identifying locations of provisioned cable pathways, cable trays and conduits for new cabling installations			
3. Access panel locations			
4. Familiarisation of origin of final sub circuit cabling			
5. Lamp replacement techniques			
6. Familiarisation of O & M manuals			
7. Isolation procedures and lock off points			

SECTION 9: SECURITY

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Check operation of card and credential readers			
2. Check door status operation			
3. Fire trip simulation test, ensure door release			
4. Check operation of intruder devices			
5. Check zoning allocations			
6. System keypad checks on siren			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Comprehensive training in the security management system			
2. Staff station monitoring procedures			
3. Field equipment operation			
4. Understanding alarm status and system reports			
5. Familiarisation of head end equipment location			

SECTION 10: DATA & COMMUNICATIONS SYSTEMS

TESTING	ACCEPTED		
	Lend Lease	WAHW	Nilsen
1. Collating cabling test results for submission			
2. Impedance and capacitance testing of UTP cabling			
3. Insertion loss margin results			
4. Cable polarity testing			
5. Light meter testing of fibre optic cabling			
6. Labelling methodology			
7. Distance testing and cabling bending radius are within parameters			
TRAINING	**ACCEPTED**		
	Lend Lease	**WAHW**	**Nilsen**
1. Understanding labelling methodology			
2. Identifying future cable path way provisions			
3. Familiarisation of specific field equipment locations			
4. Fault identification and rectification principals			
5. Identifying potential dangers associated with laser radiation			
6. Understanding site layouts and computer room layouts			
7. Patching procedures of field cabling and devices			

10 COMMISSIONING

10.1 Refer to Commissioning Manual

See attached folder 10

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1,2,3	**Location/Area:**	B1 - WATTLE S.C
Power Cable/Circuit No.	19,21,22,23,24		
SWBD Origin	DB-WS-CA-B1		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	☑	☐	☐
2	Ensure correct cable size & type	☑	☐	☐
3	Cable spacing / segregation maintained	☑	☐	☐
4	Cable bending radius maintained	☑	☐	☐
5	Cable tied / fastened as required	☑	☐	☐
6	Correct cable length at ends for termination	☑	☐	☐
7	Damage	☐	☑	☐
8	Cable Termination completion	☑	☐	☐
9	Cleanliness	☑	☐	☐
10	Physical DB check all circuits terminated	☑	☐	☐
11	Physical Circuit check all light circuits complete	☑	☐	☐
12	Physical Circuit check all Power circuits complete	☑	☐	☐
13	Circuit Tested	☑	☐	☐

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): FINTAN KENNY Signature: Licence No. 186489C Date: 14-02-14	**Approved By (Name):** Terry [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1,2,3	Location/Area:	B1-WATTLE S.C
Power Cable/Circuit No.	19,21,22,23,24		
SWBD Origin	DB-WS-CA-B1		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): FINTAN KENNY
Signature: [signature] Date: 14-02-2014
Licence No. Nilsen Licence number 186489 C

Approved By (Name): [signature]
Sign: [signature] Date: 25/2/2014

Distribution: Customer: Yes ☑ No ☐
Others:

NCR No. (if any):

Nilsen (NSW) Pty Ltd	Issue No:	Revision 1
	Issue Date:	3/02/2014
	Authorised:	T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 - 8	**Location/Area:**	B1 - WATTLE St
Power Cable/Circuit No.	41 - 84		
SWBD Origin	DB - WS - TS - B1		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage		✓	
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): FINTAN KENNY Signature: [signature] Licence No. 186489C Date: 14-02-14	**Approved By (Name):** [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1-8	**Location/Area:**	B1-WATTLE St
Power Cable/Circuit No.	41 - 84		
SWBD Origin	DB-WS-TS-B1		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [x] No [ ]

Comments/Remarks:

Checked By (Name): FINTAN KENNY
Signature: [signature] Date: 14-02-14
Licence No. Nilsen Licence number 186489 C

Approved By (Name): Tony [signature]
Sign: [signature] Date: 24/2/2014

Distribution: Customer: Yes [x] No [ ]
Others:

NCR No. (if any):

Nilsen (NSW) Pty Ltd	Issue No:	Revision 1
	Issue Date:	3/02/2014
	Authorised:	T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1,2,3,4	**Location/Area:**	B1- NORTH RISER
Power Cable/Circuit No.	43-72		
SWBD Origin	DB-NO-TS-B1		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage		✓	
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): FINTAN KENNY
Signature: [signature] Date: 20-02-14
Licence No.

Approved By (Name): Terry [signature]
Sign: [signature] Date: 25/2/2014

Distribution: Customer: Yes ☑ No ☐
Others:

NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1,2,3,4	**Location/Area:**	B1 - NORTH RISER
Power Cable/Circuit No.	43 - 72		
SWBD Origin	DB-NO-TS-B1		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks:

Checked By (Name): FINTAN KENNY		**Approved By (Name):**	
Signature:	Date: 20-02-2014	Sign:	Date: 25/2/2014
Licence No.	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes [✓] No [ ] Others:	**NCR No.** (if any):	

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 12	**Location/Area:**	LEVEL 4
Power Cable/Circuit No.	CB-25 TO 48		
SWBD Origin	DB-JS-CA-04		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	☑	☐	☐
2	Ensure correct cable size & type	☑	☐	☐
3	Cable spacing / segregation maintained	☑	☐	☐
4	Cable bending radius maintained	☑	☐	☐
5	Cable tied / fastened as required	☑	☐	☐
6	Correct cable length at ends for termination	☑	☐	☐
7	Damage	☑	☐	☐
8	Cable Termination completion	☑	☐	☐
9	Cleanliness	☑	☐	☐
10	Physical DB check all circuits terminated	☑	☐	☐
11	Physical Circuit check all light circuits complete	☑	☐	☐
12	Physical Circuit check all Power circuits complete	☑	☐	☐
13	Circuit Tested	☑	☐	☐

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): Signature: Licence No. 100266C Date: 29-1-14	**Approved By (Name):** Terry Hill Sign: Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd Quality Plan		Check List No: FIC-15 Circuit Test results item 13 Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 12	Location/Area:	LEVEL 4
Power Cable/Circuit No.	CB-25 TO 48		
SWBD Origin	DB-55-CA-04		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name):		**Approved By (Name):**	Terry Kuitert
Signature: [signature]	Date: 29-1-14	Sign: [signature]	Date: 25/2/2014
Licence No:	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):	

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	DB-1 TO 14	**Location/Area:**	LEVEL 4
Power Cable/Circuit No.	CB-69 TO 96		
SWBD Origin	DB-JS-TS-04		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks: 76, 92, 94 SPARE CB.

Checked By (Name): T. STONE
Signature: [signature]
Licence No. 100266C
Date: 3-2-14

Approved By (Name): [signature]
Sign: [signature]
Date: 25/2/2014

Distribution: Customer: Yes ☑ No ☐
Others:

NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	DB-1 TO 14	**Location/Area:**	LEVEL 4
Power Cable/Circuit No.	CB-69 TO 96		
SWBD Origin	DB-JS-TS-24		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:
76, 92, 94 SPARE CB

Checked By (Name): T. Siona		**Approved By (Name):**	Terry Kt
Signature:	Date: 3-2-14	Sign:	Date: 25/2/2014
Licence No:	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):	

Nilsen (NSW) Pty Ltd		Issue No:	Revision 1
		Issue Date:	3/02/2014
		Authorised:	T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB - 1 TO 12	**Location/Area:**	LEVEL 5
Power Cable/Circuit No.	CB 31 TO 48		
SWBD Origin	DB - 5S - CA - 05		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks: SPARE CBs - 1, 33, 39. & 40

Checked By (Name): T. STONE Signature: [signature] Date: 6-2-14 Licence No: 100266C	**Approved By (Name):** Terry W[illegible] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-2-TO 12	**Location/Area:**	LEVEL 5
Power Cable/Circuit No.	CB-31 TO 48		
SWBD Origin	DB-5S-CA-05		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks: 1, 33, 39 $ 40 SPARE CB's

Checked By (Name): T. STONE		**Approved By (Name):** Tony Kuitert	
Signature: [signature]	Date: 6·2·14	Sign: [signature]	Date: 25/2/2014
Licence No.	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes [✓] No [ ] Others:	**NCR No.** (if any):	

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd Quality Plan		Check List No: FIC-15 Page: 1 of 1	
CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION			
Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB.1 TO 13	**Location/Area:**	LEVEL 5
Power Cable/Circuit No.	CB.57 TO 84		
SWBD Origin	DB-55-TS-05		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks: SPARE CB. 11, 72, 81, 82

Checked By (Name): T. STONE Signature: [signature] Licence No. 100266C Date: 7-2-14	**Approved By (Name):** Terry Kutel Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 13	Location/Area:	LEVEL 5
Power Cable/Circuit No.	CB-57 TO 84		
SWBD Origin	DB-5S-TS-05		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks: SPARE CB - 11, 72, 81 & 82

Checked By (Name):		Approved By (Name):	Terry Kuitert.
Signature: [signature]	Date: 7-2-14	Sign: [signature]	Date: 25/2/2014
Licence No.	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes [✓] No [ ] Others:	NCR No. (if any):	

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 9	**Location/Area:**	LEVEL 6
Power Cable/Circuit No.	CB-32 TO 48		
SWBD Origin	DB-J5-CA-06		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks: SPARE 1

Checked By (Name): T. STONE Signature: [signature] Licence No. 100261C Date: 11-2-14	**Approved By (Name):** Terry Kutet Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB - 1 TO 9	**Location/Area:**	LEVEL 6
Power Cable/Circuit No.	CB - 32 TO 48		
SWBD Origin	DB - JS - CA - 06		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks: SPARE - CB-2.

Checked By (Name):	**Approved By (Name):** Terry Kultd
Signature: [signature] Date: 11-2-14	Sign: [signature] Date: 25/2/2014
Licence No: Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 12	**Location/Area:**	LEVEL 6
Power Cable/Circuit No.	CB-57 TO 72		
SWBD Origin	DB-5S-0A-06		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): Signature: [signature] Licence No. 100266C Date: 14-2-14	**Approved By (Name):** Terry [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 12	**Location/Area:**	LEVEL 6
Power Cable/Circuit No.	CB-57 TO 72		
SWBD Origin	DB-55-OA-06		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): T. STONE		**Approved By (Name):** Terry Kuitert	
Signature: [signature]	Date: 14-2-14	Sign: [signature]	Date: 25/2/2014
Licence No:	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):	

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO CB-6	**Location/Area:**	LEVEL-6
Power Cable/Circuit No.	CB-35 TO 60		
SWBD Origin	DB-55-TS-06		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): T.STONE
Signature: [signature] Date: 15/2-14
Licence No: 102266C

Approved By (Name): Terry Kitt
Sign: [signature] Date: 25/2/2014

Distribution: Customer: Yes ☑ No ☐
Others:

NCR No. (if any):

Nilsen (NSW) Pty Ltd	Issue No:	Revision 1
	Issue Date:	
	Authorised:	

Nilsen (NSW) Pty Ltd Quality Plan	Check List No: FIC-15 Circuit Test results item 13 Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO CB-6	Location/Area:	LEVEL 6
Power Cable/Circuit No.	CB-35 TO CB-60		
SWBD Origin	DB-J5-TS-06		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks:

Checked By (Name): T. Sidhu Signature: [signature] Date: 15-2-14 Licence No. Nilsen Licence number 186489 C	Approved By (Name): Tony [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes [✓] No [ ] Others:	NCR No. (if any):

Nilsen (NSW) Pty Ltd	Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB - 1 TO 6	**Location/Area:**	LEVEL 7
Power Cable/Circuit No.	CB - 35 TO 48		
SWBD Origin	DB - 55 - CA - 07		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): T. STONE Signature: [signature] Licence No: 100266C Date: 18-2-14	**Approved By (Name):** Tony Kitt Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB - 1 TO 6	**Location/Area:**	LEVEL 7
Power Cable/Circuit No.	CB - 35 TO 48		
SWBD Origin	DB - 5S - CA - 07		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): T. SIONE	**Approved By (Name):** Tony Kt
Signature: [signature] Date: 18.2.14	Sign: [signature] Date: 25/2/2014
Licence No. Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No:	Revision 1
		Issue Date:	3/02/2014
		Authorised:	T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	CB-1 TO 1D	**Location/Area:**	LEVEL 7
Power Cable/Circuit No.	CB-49 TO 84		
SWBD Origin	DB-55-0A-07		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name):	**Approved By (Name):** Tony [signature]
Signature: [signature] Date: 19-2-14	Sign: [signature] Date: 25/2/2014
Licence No. 100266C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	KB - 1 TO 19	**Location/Area:**	LEVEL 7
Power Cable/Circuit No.	OB - 49 TO 84		
SWBD Origin	DB - JJ - OA - 07		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks:

Checked By (Name): T. STONE		**Approved By (Name):** Terry Kuitert	
Signature:	Date: 20.2.14	Sign:	Date: 25/2/2014
Licence No	Nilsen Licence number 186489 C		
Distribution:	Customer: Yes [✓] No [ ] Others:	**NCR No.** (if any):	

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1704.	**Location/Area:**	LEVEL 7 NORTH
Power Cable/Circuit No.	37 TO 12.		
SWBD Origin	DB -NO-TS-07 TEACHING SPACE		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MASCHER
Signature:
Licence No. 186482C
Date: 21/2/14

Approved By (Name): Tony
Sign:
Date: 25/2/2014

Distribution: Customer: Yes ☑ No ☐
Others:

NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 4	**Location/Area:**	LEVEL 7 NORTH
Power Cable/Circuit No.	37 TO 72		
SWBD Origin	DB-NO-TS-07 TEACHING SPACE		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MASCHER	**Approved By (Name):** Terry Kuit
Signature: Date: 21/2/14	Sign: Date: 25/2/2014
Licence No. 57925 S Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 7	**Location/Area:**	LEVEL 7 NORTH
Power Cable/Circuit No.	24 TO 36.		
SWBD Origin	DB-NO-CA-07 COMMON AREA.		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): Signature: Licence No. 186484C Date: 15/2/14	**Approved By (Name):** Terry Kutt Sign: Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 7	Location/Area:	LEVEL 7 NORTH
Power Cable/Circuit No.	24 TO 36		
SWBD Origin	DB-NO-CA-07 COMMON AERA.		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks:

Checked By (Name):	Approved By (Name):
Signature: A. MASCHIKE Date: 15/2/14.	Sign: Date: 25/2/2014
Licence No: [illegible] Nilsen Licence number 186489 C	
Distribution: Customer: Yes [✓] No [ ] Others:	NCR No. (if any):

Nilsen (NSW) Pty Ltd
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 6	**Location/Area:**	LEVEL 6 NORTH.
Power Cable/Circuit No.	29 TO 36		
SWBD Origin	DB-TEACHING-TS-06		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A MASCHER	**Approved By (Name):** Terry Kuitert
Signature: [signature] Date: 11/2/14	Sign: [signature] Date: 25/2/2014
Licence No. [illegible] Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 6	**Location/Area:**	LEVEL 6 NORTH
Power Cable/Circuit No.	29 TO 36.		
SWBD Origin	DB-NO-TS-06 TEACHING SPACE.		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A MASCHER Signature: [signature] Date: 11/2/14 Licence No. 186484C	**Approved By (Name):** Tony [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 7	**Location/Area:**	LEVEL 6 NORTH
Power Cable/Circuit No.	25 TO 36		
SWBD Origin	DB - NO - CA-06 COMMON AREA.		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A.MASCHER	**Approved By (Name):** Tony [signature]
Signature: [signature] Date: 7/2/14	Sign: [signature] Date: 25/2/2014
Licence No. 186484C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 7	Location/Area:	LEVEL 6 NORTH
Power Cable/Circuit No.	25 TO 36		
SWBD Origin	DB-NO-CA-06 COMMON AREA.		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MASCHEE	Approved By (Name): Tom K
Signature: Date: 7/2/14	Sign: Date: 25/2/2014
Licence No: Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 8	**Location/Area:**	LEVEL 5 NORTH
Power Cable/Circuit No.	20 - 35		
SWBD Origin	DB-NO-CA-05 COMMON AREA.		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MATSCHER Signature: [signature] Date: 5/2/14 Licence No. 186989C	**Approved By (Name):** Terry [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 8	Location/Area:	LEVEL 5 NORTH.
Power Cable/Circuit No.	20 TO 35		
SWBD Origin	DB-NO-CA-05. COMMON AREA.		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MASCHER	Approved By (Name): Terry Kuitert.
Signature: [signature] Date: 5/2/14.	Sign: [signature] Date: 25/2/2014
Licence No: 7125C Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1,2,3,5.	**Location/Area:**	LEVEL 5 NORTH.
Power Cable/Circuit No.	32, 34.		
SWBD Origin	DB-NO-B-05 TEACHING SPACE		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
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4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
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6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MATSCHER	**Approved By (Name):** Terry K
Signature: [signature] Date: 3/1/14.	Sign: [signature] Date: 25/2/2014
Licence No. 5 MLS C Nilsen Licence number 186489 C	
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No:	Revision 1
		Issue Date:	3/02/2014
		Authorised:	T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1, 2, 3, 5.	**Location/Area:**	LEVEL 5 NORTH.
Power Cable/Circuit No.	32, 34.		
SWBD Origin	DB-N0-T5-05. TEACHING SPACE.		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓	☐	☐
2	Ensure correct cable size & type	✓	☐	☐
3	Cable spacing / segregation maintained	✓	☐	☐
4	Cable bending radius maintained	✓	☐	☐
5	Cable tied / fastened as required	✓	☐	☐
6	Correct cable length at ends for termination	✓	☐	☐
7	Damage	✓	☐	☐
8	Cable Termination completion	✓	☐	☐
9	Cleanliness	✓	☐	☐
10	Physical DB check all circuits terminated	✓	☐	☐
11	Physical Circuit check all light circuits complete	✓	☐	☐
12	Physical Circuit check all Power circuits complete	✓	☐	☐
13	Circuit Tested	✓	☐	☐

All applicable items checked and satisfactory. Yes ✓ No ☐

Comments/Remarks:

Checked By (Name): A MASCHER Signature: [signature] Licence No. 186489C Date: 31/1/14	**Approved By (Name):** Terry [signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ✓ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1, TO 8	**Location/Area:**	NORTH LEVEL 4.
Power Cable/Circuit No.	24 TO 30; 32 TO 36.		
SWBD Origin	NO-CA-04. (COMMON AREA)		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	☑	☐	☐
2	Ensure correct cable size & type	☑	☐	☐
3	Cable spacing / segregation maintained	☑	☐	☐
4	Cable bending radius maintained	☑	☐	☐
5	Cable tied / fastened as required	☑	☐	☐
6	Correct cable length at ends for termination	☑	☐	☐
7	Damage	☑	☐	☐
8	Cable Termination completion	☑	☐	☐
9	Cleanliness	☑	☐	☐
10	Physical DB check all circuits terminated	☑	☐	☐
11	Physical Circuit check all light circuits complete	☑	☐	☐
12	Physical Circuit check all Power circuits complete	☑	☐	☐
13	Circuit Tested	☑	☐	☐

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MASCHER Signature: [signature] Licence No. 186984C Date: 24/1/14	**Approved By (Name):** Terry K[signature] Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Revision 1 Issue Date: Authorised:

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1 TO 8	Location/Area:	LEVEL 4 NORTH.
Power Cable/Circuit No.	24 TO 30 ; 32 TO 36		
SWBD Origin	NO - CA - 04 COMMON AREA		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes ☑ No ☐

Comments/Remarks:

Checked By (Name): A. MATCHKE Signature: [signature] Date: 24/1/14. Licence No. 5M25C Nilsen Licence number 186489 C	Approved By (Name): Tony Kuitert Sign: [signature] Date: 25/2/2014
Distribution: Customer: Yes ☑ No ☐ Others:	NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15
Page: 1 of 1

CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	**Lend Lease**		
Project:	**UTS Broadway FEIT**		
Job No:	70080	**Specification Ref:**	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1, 2, 3	**Location/Area:**	LEVEL 4 NORTH
Power Cable/Circuit No.	35, 36		
SWBD Origin	DB-NO-TS-04. (TEACHING SPACE.		

Item	Activity Description	Yes	No	N/A
1	Check approved cable schedule is available	✓		
2	Ensure correct cable size & type	✓		
3	Cable spacing / segregation maintained	✓		
4	Cable bending radius maintained	✓		
5	Cable tied / fastened as required	✓		
6	Correct cable length at ends for termination	✓		
7	Damage	✓		
8	Cable Termination completion	✓		
9	Cleanliness	✓		
10	Physical DB check all circuits terminated	✓		
11	Physical Circuit check all light circuits complete	✓		
12	Physical Circuit check all Power circuits complete	✓		
13	Circuit Tested	✓		

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks:

Checked By (Name): A MASCHER Signature: [signature] Date: 21/1/14 Licence No. 186489C	**Approved By (Name):** Tony W[signature] Sign: [signature] Date: 25/2/2014.
Distribution: Customer: Yes [✓] No [ ] Others:	**NCR No.** (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1

Nilsen (NSW) Pty Ltd
Quality Plan

Check List No: FIC-15 Circuit Test results item 13
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CABLE - INSTALLATION CHECK & CONSTRUCTION VERIFICATION

Client:	Lend Lease		
Project:	UTS Broadway FEIT		
Job No:	70080	Specification Ref:	WAHW Spec: 23193 UTS Broadway Building
Lighting Cable/Circuit Nos.	1, 2, 3	Location/Area:	LEVEL 4 NORTH
Power Cable/Circuit No.	35, 36		
SWBD Origin	DB-NO-TS-04.		

Item	Activity Description
1	Physical Inspection of de energised DB to ensure all cabling has been run into the DB and terminated in its correct location in accordance with Nilsen for Construction Lighting and power plans
2	Test Chassis Busbar prior to energisation with a continuity tester to ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
3	Energise DB by turning on Tee Off Box Circuit breaker and Main switch in sequence. Check with Test Lamps or Multimeter for 3 Phases to be present. A) Check each Phase to Neutral B) Check each phase to earth C) Check A to B , B to C & C to A to check 415V Present. A pass for checks A & B is 240V present , a pass for Test C is 415V present
4	Physical Inspection of de energised Lighting and power circuits to ensure all circuits are fitted off and complete and correct in accordance with Nilsen for Construction Lighting and power plans
5	Test all Lighting CBs prior to energisation with a continuity tester ensure no dead shorts between phases to Neutral and Phases to Earth A) Each phase active to Neutral Bar B) Each Phase Active to Earth Bar C) Neutral bar to Earth bar to see connection of MEN. A pass reading Active to Neutral is greater than > 2M ohms , A pass reading Each phase to Earth is open Circuit greater than > 2M ohms , A pass reading Neutral to Earth is dead short less than 0.2 ohms due to the MEN connection. Note All CBs to be in off position.
6	Energise Lighting Circuits individually , conduct a visual check that lights illuminate as per the for construction plans, remove switched active from the circuit breaker to see switched lights turn off and emergency lights remain illuminated. Remove unswitched active from circuit breaker to see operation of emergency lights and 24hr lights turn off.
7	Perform an RCD test on the lighting circuit breaker at the Distribution board by installing a flex from the CB incl connection an earth cable into the earth bar , flex has plug for connection RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
8	Test all Power CBs prior to energisation with Meger set to 500V to ensure no dead shorts A) Active to Neutral B) Active to Earth Bar . A pass reading Active to Neutral is Greater than < 2 meg ohms open circuit without connected appliances , A pass reading Active to Earth is Greater than < 2 meg ohms open Circuit. Note All CBs to be in off position.
9	Energise Power Circuits individually , conduct a polarity check with a plugin LED check device on each connected GPO as per the construction drawings , use a flex lead with plug base to check 20amp Starter Sockets. Check GPO switch operation.
10	Perform an RCD test on the Power circuit breaker at the final circuit point by plugging in RCD tester , a pass result is a trip between 25 to 40 milliseconds at 30millamps
11	Perform an earth Continuity Test from the earth bar to the underfloor cable basket and a screw adjacent to the DB on the access floor to ensure both are earthed. A pass is a result achieved 2 ohms or less.

All applicable items checked and satisfactory. Yes [✓] No [ ]

Comments/Remarks:

Checked By (Name): A-MARGHR Signature: Date: 21/1/14. Licence No. 19255 Nilsen Licence number 186489 C	Approved By (Name): Tony Kuit Sign: Date: 25/2/2014
Distribution: Customer: Yes [✓] No [ ] Others:	NCR No. (if any):

Nilsen (NSW) Pty Ltd		Issue No: Issue Date: Authorised:	Revision 1 3/02/2014 T Kuitert

V.Jun2012

Ausgrid

Cable Test Results Sheet

SC & Prj Trk Number	SC01596 / XCZ016032					
Location	JONES STREET BROADWAY					
Date	1/08/2013					
Time	2PM					
Reference Temperature	18 DEGREES					
Procedure & Minimum Equipment Required						
LV Cables	A 500v Megger (Min range 200 megohms)					
HV Cables	A 1000v Megger (Min range 200 megohms)					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth)					
Minmimum Results Required (as per NS161- Clause 8.2)						
LV Cables	New cables - 200 megohms Old Cables (1yr on) - 20 megohms					
HV Cables	New cables - 400 megohms Old Cables (1yr on) - 100 megohms					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth) & (Phase to Neutral)					
HV Cable	Type -	300mm Triplex epr	Location -	S.48445/D TO S.48445/E		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
HV Cable	Type -	70mm XLPE 11KV	Location -	RMI CB 1 TO TX 1		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
LV Cable	Type -	500mm XLPE	Location -	TX1 TO E-TYPE TX1		
	A-B	>200 meg ohms	A-Earth	>200 meg ohms	Pass/Fail	PASS
	A-C	>200 meg ohms	B-Earth	>200 meg ohms	Pass/Fail	PASS
	B-C	>200 meg ohms	C-Earth	>200 meg ohms	Pass/Fail	PASS
	Phase - N	>200 meg ohms	N-Earth	>200 meg ohms	Pass/Fail	PASS
LV Cable	Type -	500mm XLPE	Location -	TX2 TO E-TYPE TX2		
	A-B	>200 meg ohms	A-Earth	>200 meg ohms	Pass/Fail	PASS
	A-C	>200 meg ohms	B-Earth	>200 meg ohms	Pass/Fail	PASS
	B-C	>200 meg ohms	C-Earth	>200 meg ohms	Pass/Fail	PASS
	Phase - N	>200 meg ohms	N-Earth	>200 meg ohms	Pass/Fail	PASS
LV Cable	Type -	500mm XLPE	Location -	TX3 TO E-TYPE TX3		
	A-B	>200 meg ohms	A-Earth	>200 meg ohms	Pass/Fail	PASS
	A-C	>200 meg ohms	B-Earth	>200 meg ohms	Pass/Fail	PASS
	B-C	>200 meg ohms	C-Earth	>200 meg ohms	Pass/Fail	PASS
	Phase - N	>200 meg ohms	N-Earth	>200 meg ohms	Pass/Fail	PASS
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	

ASP/1 -	WILKEN 12
Name -	KARL ANDERSON
Qualification (note) -	ELECTRICIAN
Signed -	K. Anderson
Date -	19-8-13
Test Instrument Details -	KYORITSU 3132A
Instrument No. -	5176482
Calibration Date -	6/02/2013
Testing Organisation -	TRVMS
NATA Registration Number -	116/109

The person must have equivalent qualifications to an electrical fitter mechanic

V.Jun2012

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Cable Test Results Sheet

SC & Prj Trk Number	SC01596 / XCZ016032					
Location	JONES STREET BROADWAY					
Date	14/08/2013					
Time	10.30PM					
Reference Temperature	114 DEGREES					
Procedure & Minimum Equipment Required						
LV Cables	A 500v Megger (Min range 200 megohms)					
HV Cables	A 1000v Megger (Min range 200 megohms)					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth)					
Minmimum Results Required (as per NS161- Clause 8.2)						
LV Cables	New cables - 200 megohms Old Cables (1yr on) - 20 megohms					
HV Cables	New cables - 400 megohms Old Cables (1yr on) - 100 megohms					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth) & (Phase to Neutral)					
HV Cable	Type -	300mm Triplex epr	Location -	S.48445/ATO STJ		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
HV Cable	Type -	300mm Triplex epr	Location -	S.48445/F TO STJ		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	

ASP/1 -	WILKEN 12
Name -	KARL ANDERSON
Qualification (note) -	ELECTRICIAN
Signed -	KAnd
Date -	19-8-13
Test Instrument Details -	KYORITSU 3132A
Instrument No. -	5176482
Calibration Date -	6/02/2013
Testing Organisation -	TRVMS
NATA Registration Number -	116/109

The person must have equivalent qualifications to an electrical fitter mechanic

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Cable Test Results Sheet

SC & Prj Trk Number	SC01596 / XCZ016032					
Location	JONES STREET BROADWAY					
Date	1/08/2013					
Time	2PM					
Reference Temperature	18 DEGREES					
Procedure & Minimum Equipment Required						
LV Cables	A 500v Megger (Min range 200 megohms)					
HV Cables	A 1000v Megger (Min range 200 megohms)					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth)					
Minmimum Results Required (as per NS161- Clause 8.2)						
LV Cables	New cables - 200 megohms Old Cables (1yr on) - 20 megohms					
HV Cables	New cables - 400 megohms Old Cables (1yr on) - 100 megohms					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth) & (Phase to Neutral)					
HV Cable	Type -	70mm XLPE 11KV	Location -	RMI CB 2 TO TX 2		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
HV Cable	Type -	70mm XLPE 11KV	Location -	RMI CB 3 TO TX 3		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	

ASP/1 -	WILKEN 12
Name -	KARL ANDERSON
Qualification (note) -	ELECTRICIAN
Signed -	K And
Date -	19-8-13
Test Instrument Details -	KYORITSU 3132A
Instrument No. -	5176482
Calibration Date -	6/02/2013
Testing Organisation -	TRVMS
NATA Registration Number -	116/109

The person must have equivalent qualifications to an electrical fitter mechanic

Ausgrid

Cable Test Results Sheet

SC & Prj Trk Number	SC01596 / XCZ016032					
Location	JONES STREET BROADWAY					
Date	15/08/2013					
Time	11.30PM					
Reference Temperature	13 DEGREES					
Procedure & Minimum Equipment Required						
LV Cables	A 500v Megger (Min range 200 megohms)					
HV Cables	A 1000v Megger (Min range 200 megohms)					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth)					
Minmimum Results Required (as per NS161- Clause 8.2)						
LV Cables	New cables - 200 megohms Old Cables (1yr on) - 20 megohms					
HV Cables	New cables - 400 megohms Old Cables (1yr on) - 100 megohms					
Tests Required	Insulation Resistance - (Phase to Phase) & (Phase to Earth) & (Phase to Neutral)					
HV Cable	Type -	300mm Triplex epr	Location -	S.48445/B to S.48445/C		
	A-B	400 MEG OHM	A-Earth	400 MEG OHM	Pass/Fail	PASS
	A-C	400 MEG OHM	B-Earth	400 MEG OHM	Pass/Fail	PASS
	B-C	400 MEG OHM	C-Earth	400 MEG OHM	Pass/Fail	PASS
HV screen to earth	screen - earth	400 MEG OHM			Pass/Fail	PASS
HV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
HV screen to earth	screen - earth				Pass/Fail	
LV Cable	Type -	185mm XLPE	Location -	Pillar to S.48445/D2		
	A-B	200 MEG OHM	A-Earth	200 MEG OHM	Pass/Fail	PASS
	A-C	200 MEG OHM	B-Earth	200 MEG OHM	Pass/Fail	PASS
	B-C	200 MEG OHM	C-Earth	200 MEG OHM	Pass/Fail	PASS
	Phase - N	200 MEG OHM	N-Earth	200 MEG OHM	Pass/Fail	PASS
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
LV Cable	Type -		Location -			
	A-B		A-Earth		Pass/Fail	
	A-C		B-Earth		Pass/Fail	
	B-C		C-Earth		Pass/Fail	
	Phase - N		N-Earth		Pass/Fail	
ASP/1 -	WILKEN 12					
Name -	KARL ANDERSON					
Qualification (note) -	ELECTRICIAN					
Signed -	K. Anderson					
Date -	19-8-13					
Test Instrument Details -	KYORITSU 3132A					
Instrument No. -	5176482					
Calibration Date -	6/02/2013					
Testing Organisation -	TRVMS					
NATA Registration Number -	116/109					
The person must have equivalent qualifications to an electrical fitter mechanic						

COMMISSIONING PAPERWORK CHECKLIST

Ausgrid

Project Number:	X C Z 0 1 6 0 3 2	SC Number:	S C 0 1 5 9 6	Date:	12 September 2013
Substation / Asset Number:	S 4 8 4 4 5	Sub / Asset Address:	JONES ST BROADWAY		
ASP/1:	WILKEN SERVICE	Project Manager:	MATT BROOKING	Commissioning Date:	19 September 2013

	Required	Completed	Date Submitted
Inventory Sheet (TEI Sheets)	Yes	Yes	29 July 2013
Operator Request Form	Yes	Yes	29 July 2013
Substation Earthing Details Sheet	Yes	Yes	29 July 2013
Substation Earth Electrode Location Sheet	Yes	Yes	29 July 2013
Transformer Test Results Sheet	Yes	Yes	29 July 2013
Cable Test Results Sheet	Yes	Yes	12 September 2013
Substation (Pole/Kiosk) Checksheet	Yes	Yes	12 September 2013
ES9 Appendix A	Yes	Yes	12 September 2013
As Built Field Recordings	Yes	Yes	
Compaction Certificates	Yes	Yes	12 September 2013
Data Capture Sheets	Yes	No	19 September 2013
Pole Inspection Checklist (where new pole/s stood)	N/A	N/A	N/A
Red Line Survey (provided by ASP)	Yes	Yes	12 September 2013
Written Notification of Practical Completion of Project	Yes		
Project Assessment			

Notes -

Project Planning Form - MUST be submitted prior to project commencment
Inventory Sheet (TEI Sheets) - MUST be submitted minimum 5 weeks prior to commissioning
Operator Request Form - MUST be submitted minimum 5 weeks prior to commissioning
Transformer Test Results Sheet - MUST be submitted minimum 5 weeks prior to commissioning
All completed paperwork (except TEI Sheets) - MUST be submitted minimum 2 weeks prior to commissioning
Preliminary As Built Field Recordings - MUST be submitted minimum 2 weeks prior to commissioning
Final As Built Field Recordings - MUST be submitted maximum 2 days after commissioning
Signed and Completed Project Assessment - MUST be submitted maximum 2 days after issue from ASP C/O

Failure to submit the above paperwork as required may result in cancellation of requested commissioning date

ASP Sign & Submit by Email:

V.Jun2012

Ausgrid

Substation Earthing Details Sheet

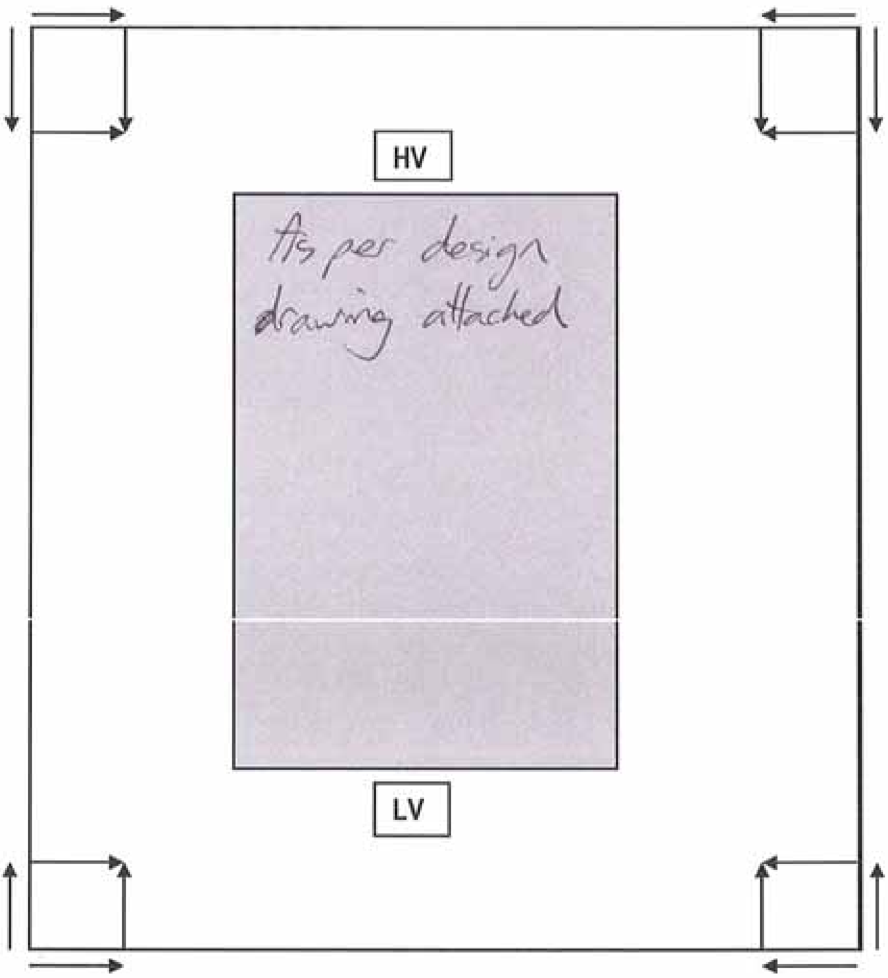
SC & Prj Trk Number	SC01596
Substation Number	S.48445
Substation Name	Jones Broadway

	Group A	Group B
Soil Type	Rock	Rock
Electrode Type	Deep drilled	Deep Drilled
Earthing Compound Used (Y or N)	Y	Y
Quantity of Electrodes Per Group	3	3
Material of Electrode	70mm Bare copper	70mm Bare copper
Diameter of Electrode(mm)	15	15
Depth of Electrodes(m)	7.5m	7.5m
Electrode Installation Method	Deep drilled	Deep Drilled
Electrode Installation Date	10/05/2013	10/05/2013
Cable Type / Size	70mm PVC	70mm PVC
Cable/Rod Connection Method	Compression crimp	Compression crimp
Individual Test Readings (in Ω)	12.36	9.89
Combined Test Readings (in Ω)	6.89	6.89
Soil Resistivity (in ΩM)	250	250

ASP/1 -	Wilken Service
Name -	Malcolm Brierley
Qualification (note) -	Elec Cont. 108424C
Signed -	MBrierley
Date -	10/05/2013

The person must have equivalent qualifications to an electrical fitter mechanic

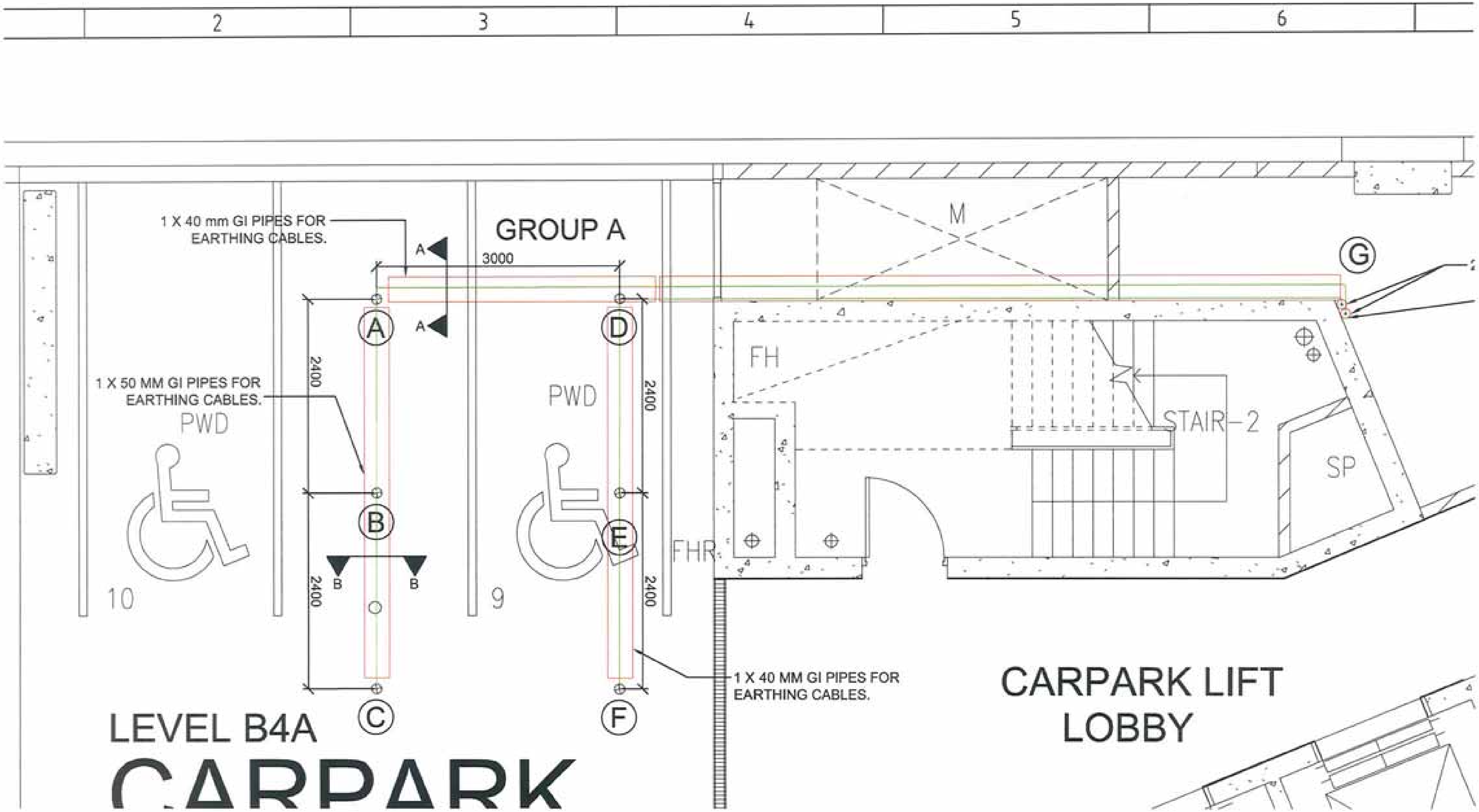
Substation Kiosk Earthing Electrode Location Sheet



Note: This arrangement may change dependant on site condition & be approved via Compliance Officer

Substation Number -	S.48445
Substation Name -	Jones Broadway
ASP/1 -	Wilken Service
Qualification (note) -	Elec Cont. 108424C
Signed -	[signature]
Date -	10/05/2013

The person must have equivalent qualifications to an electrical fitter mechanic


2
3
4
5
6
GROUP A
1 X 40 mm GI PIPES FOR EARTHING CABLES.
3000
1 X 50 MM GI PIPES FOR EARTHING CABLES.
PWD
PWD
2400
2400
2400
2400
A
B
C
D
E
F
G
10
9
M
FH
STAIR-2
SP
FHR
1 X 40 MM GI PIPES FOR EARTHING CABLES.
CARPARK LIFT LOBBY
LEVEL B4A
CARPARK

Ausgrid

ES9 Appendix A
ASP/1's Certificate

Project Number | X | C | Z | 0 | 1 | 6 | 0 | 3 | 2 |

SC Number | S | C | 0 | 1 | 5 | 9 | 6 |

Pursuant to the ES 9 Agreement between Ausgrid, the Customer and the ASP/1
dated 12 March 2012 , WILKEN SERVICE hereby warrants the following:

1. Accreditation

(a.) The ASP/1 was an ASP/1 at the time it was engaged by the Customer to undertake the Works
(b.) The ASP/1's accreditation remains current at the date of this Certificate.
(c.) The ASP/1 maintains insurances specified by the Code.
(d.) The ASP/1 has employed only fully trained and competent staff relevant to the Works and has ensured that they have been trained and authorised as required by Ausgrid in accordance with Ausgrid's Electrical Safety Rules.

2. Works

(a.) The Works have been completed in accordance with the Agreement and, without limitation, in accordance with:
- i the Applicable Specification;
- ii applicable Laws;
- iii the Design as certified by EnergyAustralia
- iv the Code;
- v Ausgrid's Environmental Requirements; and
- vi Ausgrid's quality and safety requirements

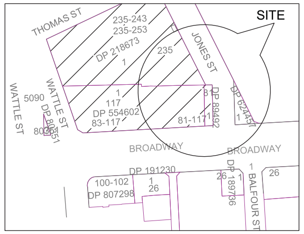
(b.) Only Approved Materials have been used in respect of the Works.
(c.) There are no Major Defects in the Works.
(d.) The Works have been tested in accordance with the Agreement
(e.) The Works are suitable for Electrification
(f.) The Works are in all respects fit for their intended purpose
(g.) Where required under EnergyAustralia's *Electrical Safety Rules*, all relevant workgroups have been notified that the Works have been submitted for Electrification

3. Payment

Subject to satisfactory completion of the Works, arrangements have been made for the following:
(a.) Payment of the ASP/1 by the Customer for undertaking the Works; and
(b.) Payment of any employees, subcontractors, agents or suppliers of the ASP/1 for any work undertaken or for any services performed in relation to the Works.

[Capitalised terms are defined in ES 9.]

Dated - 10/9/13
Signed - M Breel
For and the with authority of **WILKEN SERVICE** **(the ASP/1)**
Witness -



LOCALITY PLAN
SCALE 1:250

ESTABLISH BASEMENT CHAMBER SUBSTATION S.48445
'JONES BROADWAY'

SUBSTATION TYPE:
- 11kV/433 BASEMENT ENCLOSURE WITH EQUIPMENT INDOOR. SUBURBAN (NON-CBD) CHAMBER SUBSTATION

SUBSTATION PHASING ARRANGEMENT:
SEE PHASING DIAGRAM FOR DETAILS (REFER SHEET 4)

SUBSTATION HV CONTROL:
3 x RMI CB'S. FIXED FRONT TYPE (NON-RACKING).
SUBSTATION TO RING MAIN INTO EXISTING 11kV FEEDER.

TRANSFORMER LV CONTROL:
3 x 3000A LV DUAL (DC) TRIP-COILS ACBS.

TRANSFORMER SIZES AND TYPE:
3 x 1500kVA OIL FILLED TRANSFORMERS.

TRANSFORMER VOLTAGE RATIO:
10505/433V.

TRANSFORMER VECTOR GROUP:
DYN1.

PROTECTION REQUIREMENTS:
NETWORK STANDARD PROTECTION SCHEMES IN ACCORDANCE WITH AUSGRID DRAWING 178232.

PROTECTION BATTERY VOLTAGE:
30V DC

PROTECTION AND MDI CT SETTINGS (REQUIRED TAP IS UNDERLINED):
- HV TX DIFFERENTIAL CTS - 200 / 100 : 5
- LV TX DIFFERENTIAL AND OVERCURRENT CTS - 2450 / 1837 : 2.89
- SUMMATED OVERCURRENT INTERPOSING CTS -
- CUSTOMER SUPPLY OVERCURRENT CTS - 3000 / 2000 : 6
- MDI AND SUMMATED MDI CTS - 1600 / 1200 : 5

LV-BOARD ARRANGEMENT:
- 2 x 3000A CUSTOMER POINT OF SUPPLY (CABLE)
- 3 x 2000A ACBS FOR TRANSFORMER PROTECTION
- 1 x SURGE ARRESTOR AND 62A AUXILIARY FUSE PANEL
- 2 x SAIF FUSEWAY PANEL WITH 2 x400A AND 1 x 800A FUSE STRIPS
- 1 x 3000A LV BUS SECTION

LV FUSE ELEMENTS:
400 amp 92mm CENTRES BELL / MEM "J"

LV-CUSTOMER'S CONTROL:
- RELAY PROTECTION SUPPLIES. THE OVERCURRENT PROTECTION ON EACH SUPPLY WILL HAVE A 3600A PRIMARY PICK-UP, A 0.1 TIME MULTIPLIER, AND A VERY INVERSE CHARACTERISTIC.
- DISTRIBUTORS TO BE LABELED:
DIST 1: UTS BROADWAY NO.1
DIST 2: THOMAS ST & S.568
DIST 8: UTS BROADWAY NO.2

LV-SPARE PANEL OUTLET:
FIVE UNUSED FUSE STRIPS ARE TO BE LABELLED "WDNO".

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

GENERAL NOTES:

1. THIS DESIGN IS TO BE READ IN CONJUNCTION WITH, BUT NOT RESTRICTED TO NETWORK STANDARDS:
   - NS.100, 0112, 0113, 0114, 0116, 0127, 0129, 0130, 0143, 0149, 0156, 0158, 0161, 0165, 0171, 0177, NUS 174 & NUS 211.
   - REFERENCED AUSGRID DRAWINGS
   - ARCHITECTURAL GENERAL ARRANGEMENTS.
2. HIGH VOLTAGE MAINS TO HAVE: 600mm COVER IN FOOTWAY,750mm IN ROADWAY. LOW VOLTAGE MAINS TO HAVE: 500mm COVER IN FOOTWAY, 750mm IN ROADWAY.
3. ALL CONDUITS USED TO UNPLASTICIZED POLYVINYL CHLORIDE (UPVC) ORANGE CONDUITS FOR UNDERGROUND CABLING AS A MINIMUM REQUIREMENT IN ACCORDANCE WITH NS 130.
4. ALL TRENCHING, PITS, CABLES & CONDUITS ARE TO BE SURVEYED, MARKED, & PHOTOGRAPHED (INSPECTED BY THE COMPLIANCE OFFICER PRIOR TO BACKFILLING). REFER TO CLAUSE 12 OF ES10 FOR TESTING & INSPECTION REQUIREMENT.
5. CONSTRUCTOR TO ENSURE THAT ALL CABLES AND CONDUITS ARE INSTALLED RELATIVE TO FINAL LEVELS.
6. DO NOT PLACE ANY RELIANCE ON ANY QUANTITIES OR DIMENSIONS GIVEN IN THIS DRAWING. QUANTITIES AND DIMENSIONS GIVEN IN THIS DRAWING ARE BASED ON THE DESIGN INFORMATION AND SITE CONDITIONS AT THE TIME OF THE DESIGN. AS QUANTITIES AND DIMENSIONS ARE SUBJECT TO CHANGE, THE BUILDER OF THIS PROJECT MUST CHECK ALL QUANTITIES AND DIMENSIONS ON THE PRIOR TO TENDERING AND PRIOR TO CONSTRUCTION.
7.
8. THE PREPARATION OF THIS DESING HAS BEEN UNDERTAKEN GIVING DUE CONSIDERATION TO THE EXISTING SERVIXES. THE PROJECT CONSTRUCTOR IS HOWEVER, WHOLLY RESPONSIBLE FOR VERIFYING THE EXACT LOCATION F EXISTING SERVICES AND PERMANENT SURVEY MARKS BEFORE CONSTRUCTION COMMENCES, AND NO RESPONSIBILITY NOR LIABILITY WILL BE ACCEPTED BY THE DESIGNER OF THIS PROJECT FOR DAMAGE TO EXISTING SERVICES AS A RESULT.
9. SUBSTATION SITE AREA TO BE CLEAR OF ALL OBSTRUCTIONS AND SERVICES.
10. ACCREDITED DESIGNER IS TO BE CONTACTED REGARDING ISSUES RAISED WITH THIS DESIGN.
11. AUSGRID TO IDENTIFY CORRECT FEEDER AND CONDUCT HV PHASING.
12. ASP /1 TO CONDUCT LV NETWORK PHASING.
13. HAND EXCAVATION IS TO BE USED IN THE VICINITY OF EXISTING UNDERGROUND SERVICES.
14. CUSTOMER IS TO PREPARE A REGISTERED SURVEY OF THE SUBSTATION AREA FOR EASEMENT ESTABLISHMENT PURPOSES. FOR THE PURPOSES OF THE SURVEY PLAN, THE CABLE TRENCH MUST BE SURVEYED BY A REGISTERED SURVEYOR, WHILST IT IS OPEN.
15. ALL CONSUMERS MAINS LENGTHS ARE TO BE INSTALLED AS PER THE REQUIREMENTS OF AS / NZS 3000:2007, THE NSW SERVICE & INSTALLATION RULES (OCT 2006, 'AMENDMENT 3' JAN 2010) AND EA'S ES1 DOCUMENT. CUSTOMERS INSTALLATION TO COMPLY WITH NS 114 (APPENDIX D).
16. THE COMBINED SYSTEM OF EARTHING IS TO BE INSTALLED. L1 ASP IS TO ENSURE THAT EARTH RESISTANCE READINGS OF MAX 1 OHM SERVICE AND 15 OHMS PER GROUP ARE OBTAINED. EARTH RODS ARE TO BE INSTALLED AS PER NS116 AND DRAWING NO.167433.
17. THE WORKS WILL NOT BE COMMISSIONED UNLESS THE DEED OF AGREEMENT IS SIGNED BY ALL RELEVANT PARTIES & AN EASEMENT IS REGISTERED IN NSW DEPARTMENT OF LAND. THE EASEMENT BOUNDARIES MUST BE PEGGED OUT (BASED ON THIS DESIGN PLAN) PRIOR TO EXCAVATION AVOID DELAYS IN COMMISSIONING THE WORKS, IT IS RECOMMENDED THAT A SURVEYOR PREPARES PLAN AND SUBMITS IT TO AUSGRID. ONCE AUSGRID APPROVES THE SURVEY PLAN, THE EASEMENT AND RIGHT- OF-WAY MAY BE FINALISED WITH THE LAND TITTLES OFFICE. EASEMENT TERMS MAY BE FOUND UNDER APPENDIX G OF AUSGRID'S ES10 DOCUMENT.
18. ALL THE CABLE LAYING TO BE RECORDED INCOMPLIANCE WITH NUS 100.
19. HV JOINTS SHOULD NOT BE UNDER THE DRIVEWAY/ROADWAY, L1 ASP SHOULD VERIFY THE LOCATION OF HV JOINTS BEFORE CONSTRUCTION.
20. ALL DUCTS WHETHER USED OR NOT USED SHALL BE SEALED TO PREVENT WATER INGRESS TO THE SUBSTATION AND OIL FROM THE SUBSTATION.
21. RADIUS OF BEND OF CABLE TO COMPLY WITH AUSGRID STANDARD NS130.
22. CLAIMS FOR VARIATIONS TO THE COST OF NON-CONTESTABLE WORKS, INCLUDING ROCK EXCAVATION, WILL NOT BE ACCEPTED UNLESS VERIFIED ON SITE BY AUSGRID WHILE THE WORKS ARE IN PROGRESS.
23. THE ASP1 IS RESPONSIBLE FOR UNDERTAKING SATISFACTORY CONSULTATION WITH ALL LOCAL CUSTOMERS WHO MAY POTENTIALLY BE AFFECTED BY THE CONSTRUCTION WORKS INCLUDING ALL ALTERATIONS TO SERVICE MAINS.
24. THE ASP/1 MUST MINIMISE THE IMPACT OF THE WORKS ON THE ELECTRICITY SUPPLY TO CUSTOMERS AND INTERRUPTIONS TO SUPPLY MUST BE AVOIDED, WHERE POSSIBLE. UNLESS THE ASP/1 CAN PROVIDE AUSGRID WITH WRITTEN AGREEMENT FROM THE AFFECTED CUSTOMER(S), THEN AUSGRID MAY REQUIRE THE ASP/1 TO PROVIDE A GENERATOR(S) IN ORDER TO MAINTAIN SUPPLY TO CUSTOMERS BEING INTERRUPTED. WHERE INTERRUPTIONS ARE PERMITTED, AT LEAST TWO (2) WORKING DAYS NOTICE MUST BE PROVIDED TO ALL AFFECTED CUSTOMERS PRIOR TO ANY PLANNED INTERRUPTIONS TO THE ELECTRICITY SUPPLY.NOTICE MUST BE IN WRITING IN ACCORDANCE WITH CLAUSE 12 OF EA'S STANDARD FORM CUSTOMER CONNECTION CONTRACT.
25. SPECIFIC PRIOR APPROVAL MUST BE SOUGHT FROM AUSGRID FOR ANY PLANNED ELECTRICITY SUPPLY INTERRUPTIONS WHERE THE PLANNED INTERRUPTION WILL EXCEED ONE (1) HOUR IN DURATION OR THE DURATION WILL BE LESS THAN ONE HOUR, BUT A SUITABLE TIME FOR THE INTERRUPTION CANNOT BE MUTUALLY AGREED TO WITH THE AFFECTED CUSTOMER(S).
26. THE ASP/1 IS TO MAINTAIN ADEQUATE PUBLIC LIGHTING LEVELS FOR THE DURATION OF THE WORKS. IF NECESSARY, THE ASP/1 IS TO ARRANGE FOR SUITABLE TEMPORARY STREET LIGHTING TO BE PROVIDED UNTIL PERMANENT LIGHTING IS RE-ESTABLISHED.
27. ARRANGE PHASING OF 11kV AND LOW VOLTAGE TRANSFORMER TERMINATIONS TO ACHIEVE DYN 11 INTERCONNECTION CAPABILITIES.
28. ALL SURFACES TO BE REINSTATED TO ORIGINAL STATE UPON COMPLETION OF ANY EXCAVATION OR UNDERBORING WORKS

WARNING

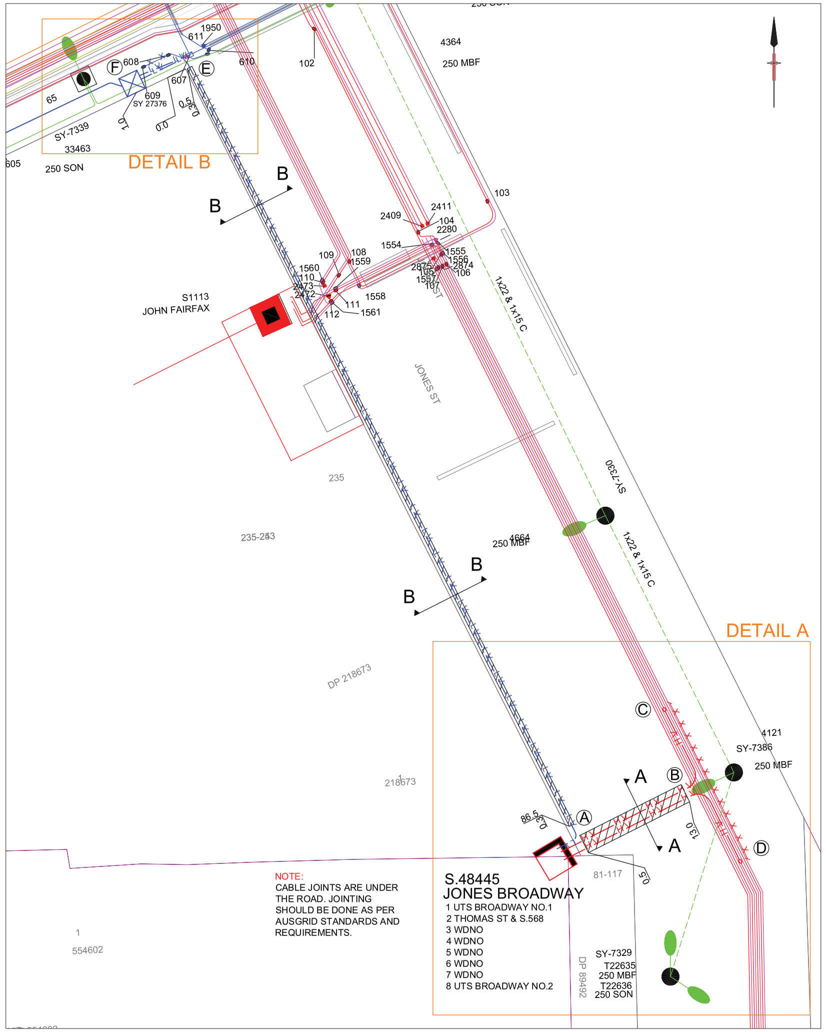
- THIS DESIGN CANNOT BE USED FOR CONSTRUCTION PURPOSES UNTIL THE LOCATION OF ALL EXISTING SERVICES IS VERIFIED.
- THE INFORMATION PROVIDED IN THIS DESIGN MUST BE CHECKED ON SITE AND THE MOST CURRENT INFORMATION ON THE CONFIGURATION OF ALL SERVICES, INCLUDING AUSGRID'S NETWORK, MUST BE VERIFIED IMMEDIATELY BEFORE CONSTRUCTION COMMENCES BY CONTACTING DIAL-BEFORE-YOU-DIG BY TELEPHONE ON 1100 OR AT www.1100.com.au.
- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

ATTENTION

LIVE AUSGRID CABLES & OTHER SERVICES EXISTS IN THIS AREA. PLEASE CONTACT 'DIAL BEFORE YOU DIG', TELEPHONE 1100, TWO DAYS PRIOR CONSTRUCTION.

NOTE:

THIS WORKS WILL NOT BE COMMISSIONED UNLESS A LEASE, EASEMENT AND RIGH-OF-WAY IS REGISTERED ON THE LAND TITLE, OR OTHER ARRANGEMENTS ARE MADE TO THE SATISFACTION OF AUSGRID.



CONSTRUCTION PLAN
SCALE 1:250

SCALE 1 : 250
0 5 10 15 20 METRES 25

LEGENDS

	PROPOSED	EXISTING
Pole		
SL Standard		
Pillar Standard		
LV Pillar		
LV Link Pillar		
Streetlight		
Streetlight-PEC		
Streetlight-replacement		
Streetlight-removal		
Pole-to be removed		
USL		
ABS		
IDT		
Kiosk Sub		
Chamber Sub		
Pole Sub		
Two Pole Sub		

PROPOSED: UGOH Pot End; Joint Sealed End; Conduit; OH Lines; UG Cables; -HV- -LV- -SL- -SV-

EXISTING: UGOH Pot End; Joint Sealed End; OH Lines; UG Cables

REMOVE: UG Cables HV LV SL; OH Cables HV LV SL; Joints HV LV SL

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960	SIMPLEX ENGINEERING SERVICES PTY LTD ABN: 16 109 553 531 SUITE 602, 12 MOUNT ST NORTH SYDNEY, NSW 2060 TEL: (02) 9460 3622 FAX: (02) 9460 3077	DESIGNED BY	TONY SHAJOUR
			DRAWN BY	MICKY WATHUGALA
			CHECKED BY	KIRAN TIWARI
			SUBMIT DATE	31/07/12
			LGA	CITY OF SYDNEY COUNCIL
			MAP REF.	236 A16
			AUSGRID REF.	SY 41
		ASP REF. 2490	PRJTRAK No.	XCZ016032

ASSOCIATED DRAWINGS

CERTIFICATION NUMBER 286275/31072012

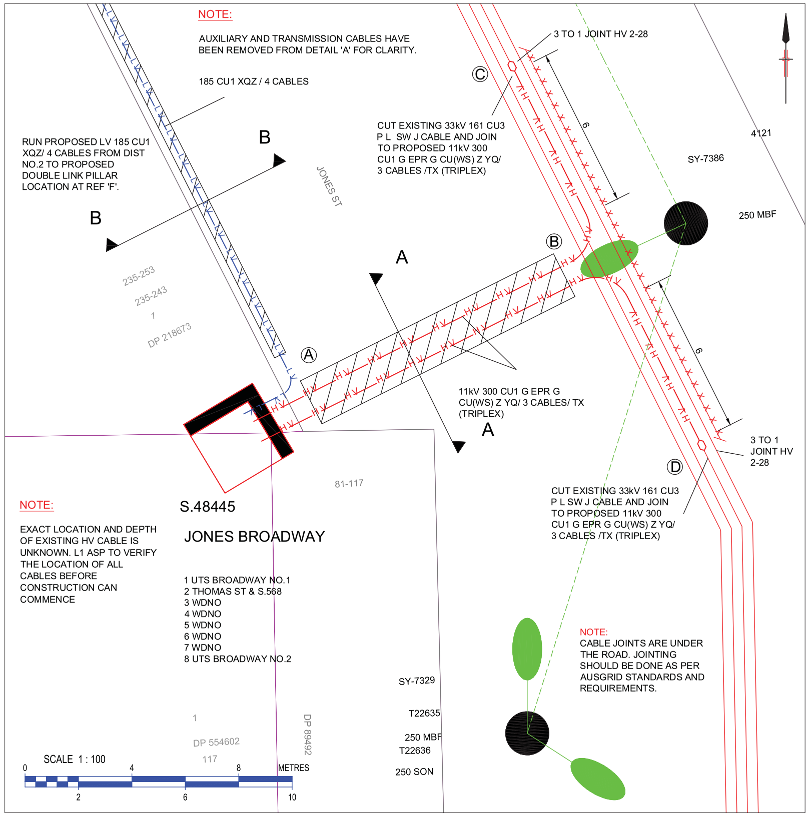
ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 1 of 16 | AMD. 0

CAD DRAWING | AMENDMENTS

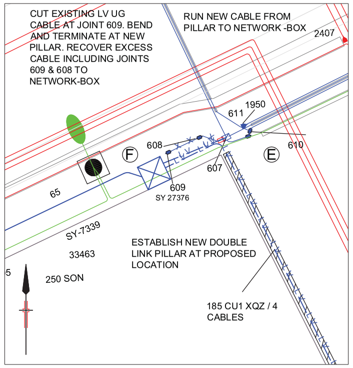
20110604

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING



DETAIL AT 'A'

SCALE 1:100



DETAIL AT 'B'

SCALE 1:200

NOTE:

AUXILIARY AND TRANSMISSION CABLES HAVE BEEN REMOVED FROM DETAIL 'B' FOR CLARITY.

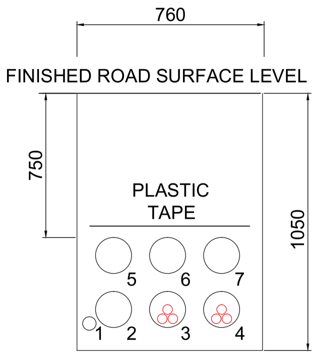
SCALE 1 : 200 METRES

ATTENTION

LIVE AUSGRID CABLES & OTHER SERVICES EXISTS IN THIS AREA. PLEASE CONTACT 'DIAL BEFORE YOU DIG', TELEPHONE 1100, TWO DAYS PRIOR CONSTRUCTION.

WARNING

- THIS DESIGN CANNOT BE USED FOR CONSTRUCTION PURPOSES UNTIL THE LOCATION OF ALL EXISTING SERVICES IS VERIFIED.
- THE INFORMATION PROVIDED IN THIS DESIGN MUST BE CHECKED ON SITE AND THE MOST CURRENT INFORMATION ON THE CONFIGURATION OF ALL SERVICES, INCLUDING AUSGRID'S NETWORK, MUST BE VERIFIED IMMEDIATELY BEFORE CONSTRUCTION COMMENCES BY CONTACTING DIAL-BEFORE-YOU-DIG BY TELEPHONE ON 1100 OR AT www.1100.com.au.
- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.



SECTION A-A

1 - SPARE 50mm COMMS CONDUIT
2 - SPARE 150mm CONDUIT
3 - 1 SET OF 11kV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX) IN 150MM CONDUIT
4 - 1 SET OF 11KV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX) IN 150MM CONDUIT
5 - SPARE 150MM CONDUIT
6 - SPARE 150MM CONDUIT
7 - SPARE 150MM CONDUIT

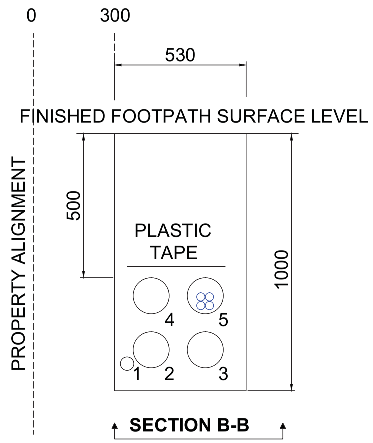
LEGENDS

- CONDUIT
- LV CABLE PROPOSED
- LV CABLE EXISTING
- HV TRIPLEX CABLE EXISTING
- HV TRIPLEX CABLE PROPOSED
- HV CABLE EXITISNG
- AUX CABLE EXISTING

EXISTING AUSGRID HV AND LV UG CABLE IN VICINITY. LEVEL 1 ASP NEED TO LOCATE THE CABLE BEFORE CONSTRUCTION.

NOTE:

ALLOW FOR EXCESS CABLE FOR BENDS, JOINTS AND TERMINATIONS INSIDE THE BASEMENT CHAMBER SUBSTATION.



SECTION B-B

1 - SPARE 50mm COMMS CONDUIT
2 - SPARE 150mm CONDUIT
3 - SPARE 150MM CONDUIT
4 - SPARE 150mm CONDUIT
5 - 1 x 415V 185 CU1 XQZ / 4 CABLES IN 150mm CONDUIT

UNDERGROUND CONSTRUCTION WORKS SCHEDULE *(DUCT PULL VERSION 1.1)*

REF. IDENTIFIER	ROUTE DISTANCE (m)	CIRCUIT VOLTAGE	CONDUCTOR OR ASSET DETAIL	CABLE CODE	MIN. INTERNAL BENDING RADIUS (mm) DURING INSTALLATION	MIN. INTERNAL BENDING RADIUS (mm) AFTER INSTALLATION	CALCULATED MAX. PULLING TENSION (kN) DURING INSTALLATION	CONSTRUCTION DETAIL
A	N/A	N/A	BASEMENT CHAMBER SUBSTATION	N/A	N/A	N/A	N/A	- ESTABLISH BASEMENT CHAMBER SUBSTATION AS PER THIS DESIGN.
A TO B	12.5	11kV	2 SETS OF 11kV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX)	391	1335	890	0.87	- RUN PROPOSED 11kV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES /TX (TRIPLEX) FROM THE POINT OF ENTRY TO BASEMENT CHAMBER SUBSTATION TO REF 'B' IN PROPOSED CONDUIT. REFER SECTION A-A
	10	11kV	6 x 150mm CONDUIT (4 SPARE) + 50mm CONDUIT (1 SPARE)	N/A	N/A	N/A	N/A	- INSTALL CONDUIT BETWEEN REF 'A' AND REF 'B' AS PER SECTION A-A
A TO E	86	415V	1 x 185 CU1 XQZ / 4 CABLES	2257	600	390	1.64	- RUN PROPOSED 415V 185 CU1 XQZ / 4 CABLES FROM THE POINT OF ENTRY TO BASEMENT CHAMBER SUBSTATIO TO REF 'D' IN PROPOSED CONDUIT. REFER SECTION B-B
	84		4 x 150mm CONDUIT (3 SPARE) + 50mm CONDUIT (1 SPARE)	N/A	N/A	N/A	N/A	- INSTALL CONDUIT BETWEEN REF 'A' AND REF 'E' AS PER SECTION B-B
B TO C	6	11kV	11kV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX)	391	1335	890	N/A	- DIRECT LAY PROPOSED 11KV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES /TX (TRIPLEX) CABLE FROM END OF CONDUIT TO THE LOCATION OF JOINT.
B TO D	6	11kV	11kV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/ TX (TRIPLEX)	391	1335	890	N/A	- DIRECT LAY PROPOSED 11KV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES /TX (TRIPLEX) CABLE FROM END OF CONDUIT TO THE LOCATION OF JOINT.
C	N/A	11kV	1 x HV JOINT (HV 2-28)	N/A	N/A	N/A	N/A	- CUT EXISTING HV UG CABLE 33kV 161 CU3 P L SW J AND JOIN TO PROPOSED 11KV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES /TX (TRIPLEX) USING A HV 2-28 JOINT. - RECOVER REDUNTANT CABLE BETWEEN REF 'C' AND REF 'D'.
D	N/A	11kV	1 x HV JOINT (HV 2-28)	N/A	N/A	N/A	N/A	- CUT EXISTING HV UG CABLE 33KV 161 CU3 P L SW J AND JOIN TO PROPOSED 11KV 300 CU1 G EPR G CU(WS) Z YQ/ 3 CABLES /TX (TRIPLEX) USING A HV 2-28 JOINT. - RECOVER REDUNTANT CABLE BETWEEN REF 'D' AND REF 'C'.
E TO F		415V	1 x 185 CU1 XQZ / 4 CABLES	2257	600	390	N/A	DIRECT LAY PROPOSED 415V 185 CU1 XQZ / 4 CABLES FROM END OF CONDUIT TO THE LOCATION OF THE PROPOSED DOUBLE LINK PILLAR.
F	N/A	415V	DOUBLE LINK PILLAR (LV 1 - 60)	N/A	N/A	N/A	N/A	- ESTABLISH PROPOSED DOUBLE LINK PILLAR SY 27376 AT PROPERTY BOUNDARY AT LOCATION SHOWN. - CUT EXISTING LV UG CABLE AT JOINT 609 - BEND AND TERMINATE AT PROPOSED DOUBLE LINK PILLAR - RECOVER EXISTING LV UG CABLE FROM JOINT 609 TO EXISTING NETWORK-BOX - RECOVER REDUNDANT JOINTS.
F TO E	6	415V	1 x 185 CU1 XQZ / 4 CABLES	2257	600	390	N/A	DIRECT LAY PROPOSED 415V 185 CU1 XQZ / 4 CABLES FROM PROPOSED DOUBLE LINK PILLAR TO EXISTING NETWORK-BOX AND TERMINATE.

CAD DRAWING

AMENDMENTS

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS 229960

ASSOCIATED DRAWINGS

SIMPLEX ENGINEERING SERVICES PTY LTD
ABN: 16 109 553 531
SUITE 602, 12 MOUNT ST
NORTH SYDNEY, NSW 2060
TEL: (02) 9460 3622
FAX: (02) 9460 3077
ASP REF. 2490

CERTIFICATION NUMBER 286275/31072012

DESIGNED BY	TONY SHAJOUR
DRAWN BY	MICKY WATHUGALA
CHECKED BY	KIRAN TIWARI
SUBMIT DATE	31/07/12
LGA	CITY OF SYDNEY COUNCIL
MAP REF.	236 A16
AUSGRID REF.	SY 41
PRJTRAK No.	XCZ016032

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 AUSGRID PROJECT No. SC01596 SHEETS 2 of 16 AMD. 0

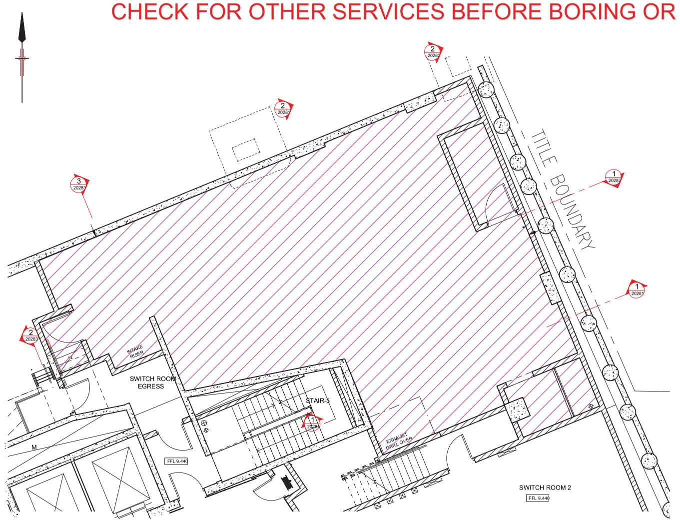
20110604

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

CB10 LEVEL 03
RL 16.970

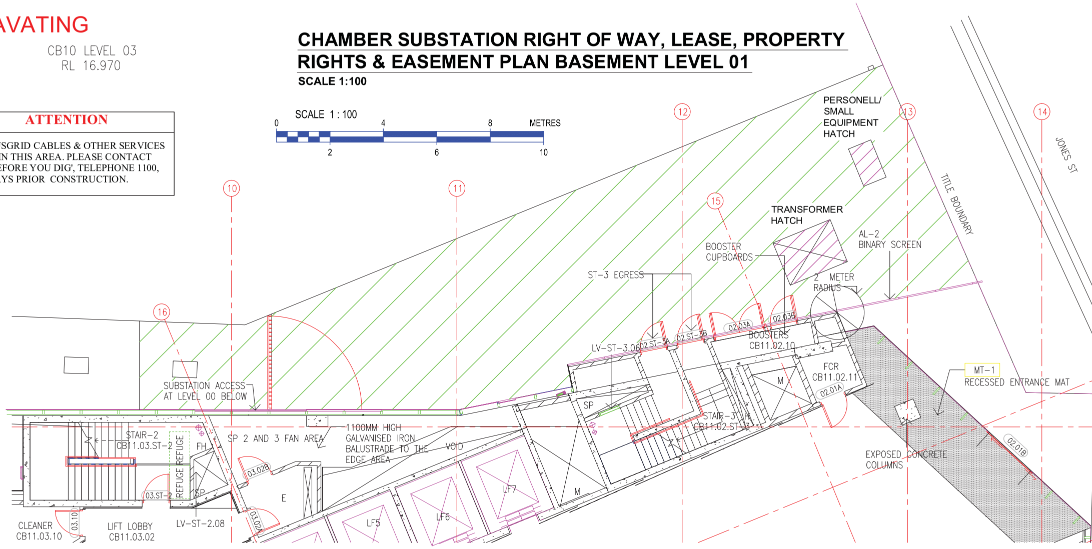
ATTENTION

LIVE AUSGRID CABLES & OTHER SERVICES EXISTS IN THIS AREA. PLEASE CONTACT 'DIAL BEFORE YOU DIG', TELEPHONE 1100, TWO DAYS PRIOR CONSTRUCTION.



CHAMBER SUBSTATION FOOTPRINT LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL 0

SCALE 1:100



CHAMBER SUBSTATION RIGHT OF WAY, LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL 01

SCALE 1:100

LEGEND

EASEMENT AND LEASE

RIGHT OF WAY

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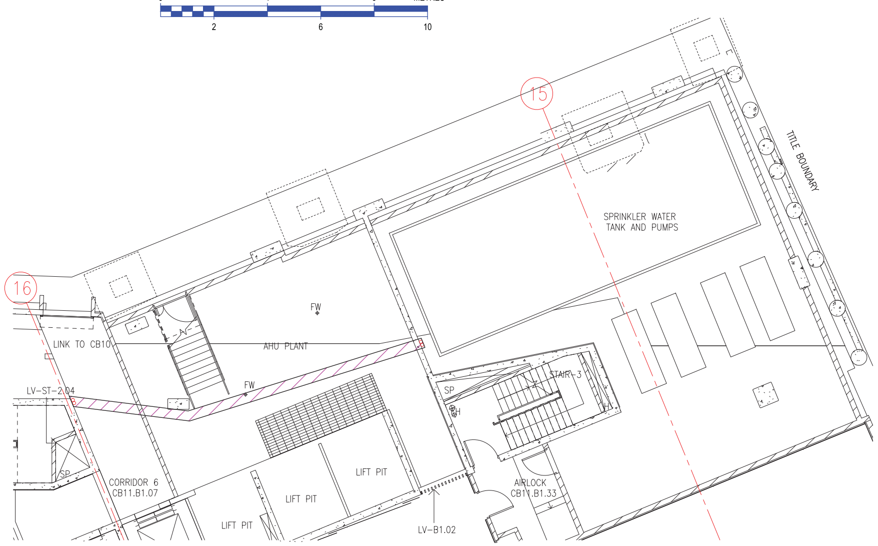
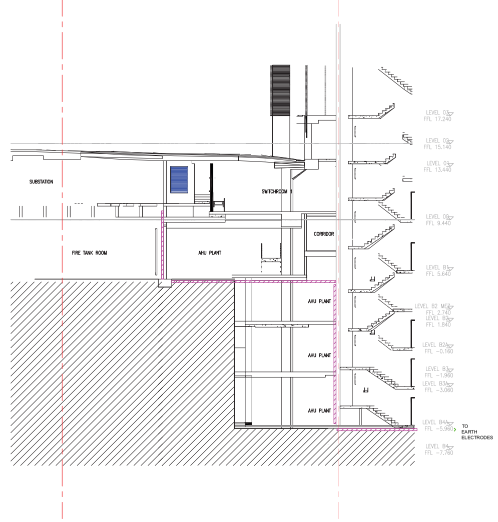


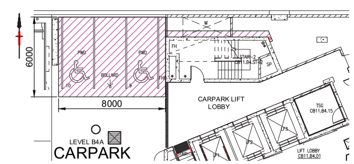
CHAMBER SUBSTATION EARTHING ROUTE LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL B1

SCALE 1:100



GLAVANISED PIPE ROUTE LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL B1 PLAN

SCALE 1:100



CHAMBER SUBSTATION EARTH ELECTRODE LEASE, PROPERTY RIGHTS & EASEMENT PLAN BASEMENT LEVEL B4A

SCALE 1:200

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960	
ASSOCIATED DRAWINGS		

SIMPLEX ENGINEERING SERVICES PTY LTD
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ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

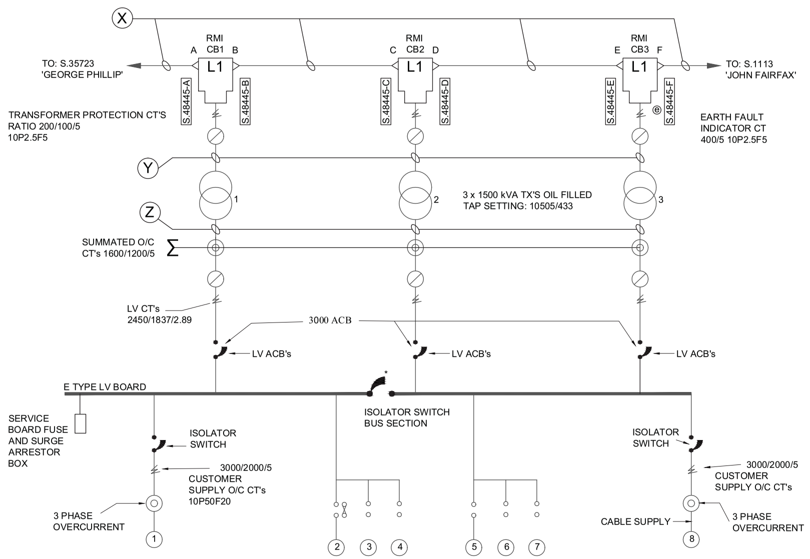
SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 3 of 16 | AMD. 0

CAD DRAWING
AMENDMENTS

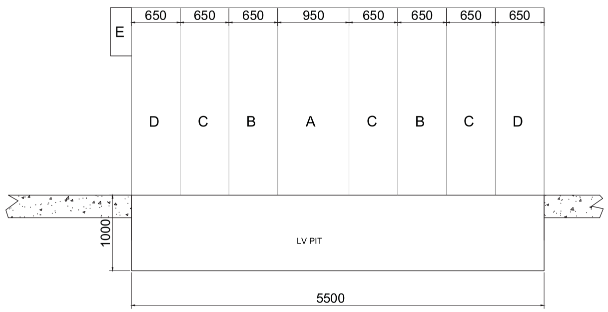
20110604

CHAMBER SUBSTATION SCHEMATIC DIAGRAM

S.48445 'JONES BROADWAY'



E TYPE LV BOARD LAYOUT



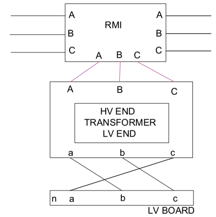
'E' TYPE LOW VOLTAGE BOARD LAYOUT

ID	PANEL ITEM	STOCKCODE NO.
A	1 x 3000 AMP ACB BUS SECTION SWITCH	179616
B	2 x 800/400/400 AMP SAIF FUSE DISTRIBUTOR	179651
C	3 x 3000 ACB INCOMING PANEL UN-MOTORISED	179615
D	2 x 3000 AMP ACB CUSTOMER POINT OF SUPPLY	179617
E	1 x SURGE ARRESTOR AND 62 AMP AUXILIARY FUSE	179619

PHASING ARRANGEMENT ABC-bca

NOT TO SCALE

NOTE:
- THESE PHASING DETAILS ARE TO BE VERIFIED ON SITE PRIOR TO COMPLETING THE COMMISSIONING JOINTS.
- SUGGESTED PHASING ASSUMING THE INSTALLED 'L-TYPE' KIOSK SUBSTATION WILL CONTAIN A DYN1 CONNECTED TRANSFORMER HV - ABC / LV - bca. HOWEVER, IT IS ESSENTIAL TO PHASE OUT WHEN COMMISSIONING AND RECONNECT AS REQUIRED.
- ENERGY AUSTRALIA IDENTIFY, STAB & PHASE AS MONOPOLY FUNCTION.



FAULT LEVEL:

- THREE PHASE SHORT CIRCUIT CURRENT AT THE TRANSFORMER LOAD TERMINALS - 50kA.
- THE WORST CASE THREE PHASE SHORT CIRCUIT CURRENT AT THE TRANSFORMER LOAD TERMINALS - 63kA.

THE ABOVE FIGURES ARE PROVIDED FOR PROTECTION GRADING PURPOSES. THE NOMINAL PROSPECTIVE SHORT CIRCUIT CURRENT AT THE PROPOSED SUBSTATION LV BOARD IS 63kA

NOTE:

1. HV TRANSFORMER TAILS ARE TO BE RUN IN TREFOIL.
2. LV TRANSFORMER TAILS TO BE RUN AS SHOWN ON SHEET NO. 4

LV DISTRIBUTOR DETAIL

DIST	DESTINATION
1	UTS BROADWAY NO.1 (3000/3000)
2	THOMAS ST & S.568 (0/400)
3	WDNO (0/400)
4	WDNO (0/800)
5	WDNO (0/400)
6	WDNO (0/400)
7	WDNO (0/800)
8	UTS BROADWAY NO.2 (3000/3000)

*NOTE:

LV BUS SECTION CB MUST BE OPENED PRIOR TO OPENING SWITCHES B AND C, AND MUST BE CLOSED AFTER CLOSING THE HV SWITCHES B AND C.

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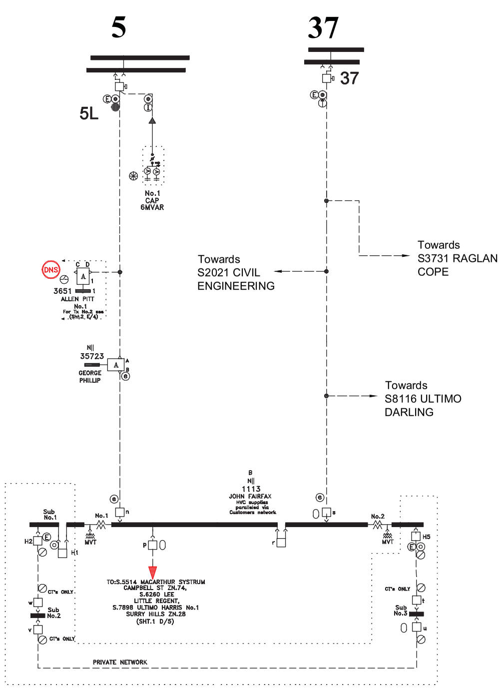
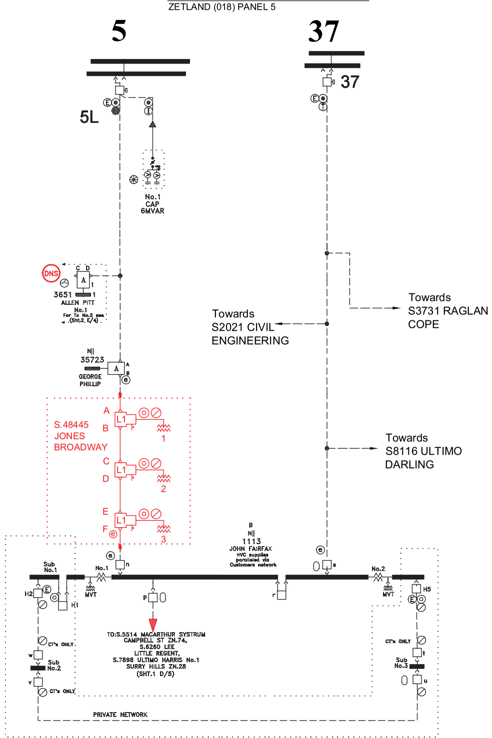
EXISITNG HV SCHEMATIC

ZETLAND (018) PANEL 5



PROPOSED HV SCHEMATIC

ZETLAND (018) PANEL 5



CABLE SCHEDULE

CABLE ID	ORIGIN	DESTINATION	SIZE/DETAIL	CONDUIT SIZE. REFER TO CONDUIT SCHDULE
Y	RMI1	TX1	3 x 70mm² CU1 EPR 11kV	100mm HD PVC
Y	RMI2	TX2	3 x 70mm² CU1 EPR 11kV	100mm HD PVC
Y	RMI3	TX3	3 x 70mm² CU1 EPR 11kV	100mm HD PVC
Z	TX1	TX1 ACB	3 x 500mm² CU1 XLPE/PVC PER PHASE + 2 x 500mm² XLPE/PVC PER FOR NEUTRAL	LV CHASE
Z	TX2	TX2 ACB	3 x 500mm² CU1 XLPE/PVC PER PHASE + 2 x 500mm² XLPE/PVC PER FOR NEUTRAL	LV CHASE
Z	TX3	TX3 ACB	3 x 500mm² CU1 XLPE/PVC PER PHASE + 2 x 500mm² XLPE/PVC PER FOR NEUTRAL	LV CHASE
X	STREET	RMI1	1 SET OF 300mm² CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/TX (TRIPLEX)	125mm HD PVC
X	RMI1	RM2	1 SET OF 300mm² CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/TX (TRIPLEX)	HV SWITCHGEAR PIT
X	RMI2	RMI3	1 SET OF 300mm² CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/TX (TRIPLEX)	HV SWITCHGEAR PIT
X	RMI3	STREET	1 SET OF 300mm² CU1 G EPR G CU(WS) Z YQ/ 3 CABLES/TX (TRIPLEX)	125mm HD PVC

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

ASSOCIATED DRAWINGS

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ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 4 of 16 | AMD. 0

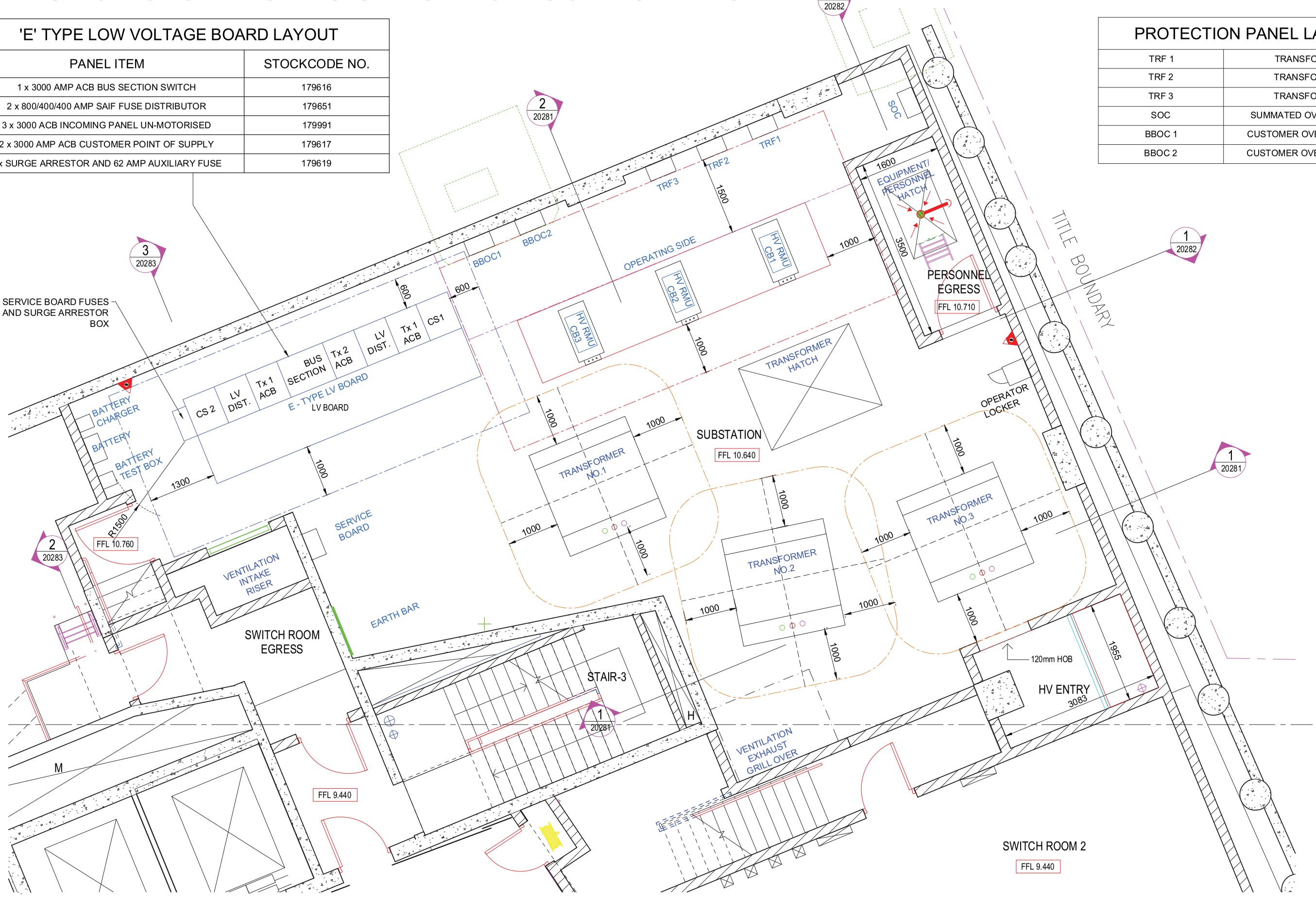
CAD DRAWING AMENDMENTS

20110604

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

'E' TYPE LOW VOLTAGE BOARD LAYOUT

PANEL ITEM	STOCKCODE NO.
1 x 3000 AMP ACB BUS SECTION SWITCH	179616
2 x 800/400/400 AMP SAIF FUSE DISTRIBUTOR	179651
3 x 3000 ACB INCOMING PANEL UN-MOTORISED	179991
2 x 3000 AMP ACB CUSTOMER POINT OF SUPPLY	179617
1 x SURGE ARRESTOR AND 62 AMP AUXILIARY FUSE	179619



EQUIPMENT CLEARANCE

SCALE 1:50

PROTECTION PANEL LABELS

TRF 1	TRANSFORMER 1
TRF 2	TRANSFORMER 2
TRF 3	TRANSFORMER 3
SOC	SUMMATED OVERCURRENT
BBOC 1	CUSTOMER OVERCURRENT 1
BBOC 2	CUSTOMER OVERCURRENT 2

HV SWITCHGEAR LABELS

NOT TO SCALE

OPERATING SIDE

S.48445 - F | HV RMU CB3 | S.48445 - E
S.48445 - D | HV RMU CB2 | S.48445 - C
S.48445 - B | HV RMU CB1 | S.48445 - A

LV SWITCHGEAR LABELS

NOT TO SCALE

E - TYPE LV BOARD

3000A CUSTOMER SUPPLY	800/400/400 FUSE PANEL	800/400/400 FUSE PANEL	3000A CUSTOMER SUPPLY
UTS BROADWAY NO.1	THOMAS ST & S.568 / WDNO / WDNO	WDNO / WDNO / WDNO	UTS BROADWAY NO.2

OPERATING SIDE

CHAMBER SUBSTATION REFERENCE DRAWINGS

A1-48008	CONSTRUCTION DETAILS - MISCELLANEOUS
A1-63678	PULLING EYES DETAILS TYPE 'B' - 'C'
A1-25121	DETAILS OF EARTH ROD INSTALLATION
178227	'E' TYPE BOARD COMINSATIONS
178228	'E' TYPE LV BOARD CLEARANCES PIT DESIGN & CONSTRUCTION
178229	'E' TYPE LV BOARD STEELWORK GENERAL ARRANGEMENT
178230	'E' TYPE LV BOARD CABLE LADDER INSTALLATION FOR AUXILIRAY
178232	RMICB SUBSTATIONS WITH 'E' TYPE LV BOARD AC AND DC SCHEMATICS
178238	'E' TYPE LV BOARD SUMMATED MDI CONNECTIONS DIAGRAM
121949	SUBURBAN TYPE SUBSTATION WITH 1500kVA TRANSFORMER SERVICE BOARD GENERAL ARRANGEMENT AND WIRING DIAGRAM
114601	NUMBERING AND COLOUR CODE OF WIRING FOR CONTROL AND PROTECTION EQUIPMENT
178231	RMIB SUBSTATION WITH 'E' TYPE LV BOARD CABLING DIAGRAM AND SCHEDULE
178237	E TYPE LV BOARD MERLIN GERIN MASTERPCT AIR CIRCUIT BREAKERS EXTERNAL CONNECTIONS
153366	SUBSTATION HIGH VOLTAGE SIGN
22212	TRIPPING BATTERY TEST BOX ASSEMBLY AND WIRING DETAILS
113884	EARTH FAULT INDICATOR, TYPE EFI 3
53567	HV METAL CLAD FUSE SWITCHED & RMIS EARTH FAULT INDICATOR TYPE EFI 3 MOUNTING SUPPORT DETAILS
52474	MOULDED TYPE LINK ASSEMBLIES WIRE TERMINATIONS CODING AND LOOMING STYLE DETAILS
10635	DISTRIBUTION SUBSTATIONS WALL MOUNTED DOUBLE TIER SUPPORTING FRAME FOR TRIPPING BATTERIES
15230	DISTRIBUTION SUBSTATIONS WALL MOUNTED SINGLE TIER SUPPORTING FRAME FOR TRIPPING BATTERIES
31858	SUBSTATION OPERATORS LOCKER DETAILS
192908	INSTALLATION OF LUCY SABRE VRN6A RMICB
191086	CITY AND SUBURBAN DISTRIBUTION SUBSTATION PROTECTION RELAYS DRILLING DETAILS
115248	DISTRIBUTION SUBSTATION STANDARD AC & DC MOULDED LINKS LABEL NUMBERING AND ENGRAVING
187815	RMIB SUBSTATION WALL MOUNTED TRANSFORMER PROTECTION PANEL DRILLING AND WIRING
118558	CITY AND SUBURBAN DISTRIBUTION SUBSTATIONS WALL MOUNTED CUSTOMER SUPPLY OVERCURRENT PROTECTION PANEL DRILLING, WIRING AND CABLING
118559	CITY AND SUBURBAN DISTRIBUTION SUBSTATIONS WALL MOUNTED SUMMATED OVERCURRENT PROTECTION PANEL DRILLING, WIRING AND CABLING

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ASSOCIATED DRAWINGS	
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

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SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 5 of 16 | AMD. 0

CAD DRAWING AMENDMENTS

20110604

NOTE:
- INSTALL CABLE LADDER AS PER AUSGRID DRAWING NO. 178230. CABLE BETWEEN THE SURGE ARRESTOR PANEL AND THE LV PIT SHALL BE INSTALLED VIA THE CABLE LADDER.
- CONNECTION BETWEEN THE LV BOARD AND THE SERVICE BOARD SHOULD AS PER NS114 SECTION 16.1.2

EFI TO BE INSTALLED ON RHS OF HV SWITCHGEAR. IT IS TO BE CONNECTED TO CT'S MOUNTED ON THE OUTGOING MAINS. REFER NS114 SECTION 8.8 AND AUSGRID DRAWING NO. 113884 FOR MORE DETAILS

SERVICE BOARD FUSES AND SURGE ARRESTOR BOX

NOTE:
1. TOP OF ANY WALL MOUNTED PROTECTION PANEL MUST BE A850mm ABOVE THE ADJACENT FLOOR LEVEL.
2. TOP OF THE BATTERY INSTALLATION MUST BE NO MORE THAT 1200mm ABOVE THE ADJACENT FLOOR LEVEL.
3. 30V PROTECTION BATTERY TO BE INSTALLED AS PER AUSGRID DRAWING NO. 10635 AND 15230

NOTE:
ACCESS CHAMBER HATCH SUMP TO BE AS PER HYDRAULIC ENGINEERS REQUIREMENTS. REFER TO HYDRAULICS ENGINEERS DESIGN.

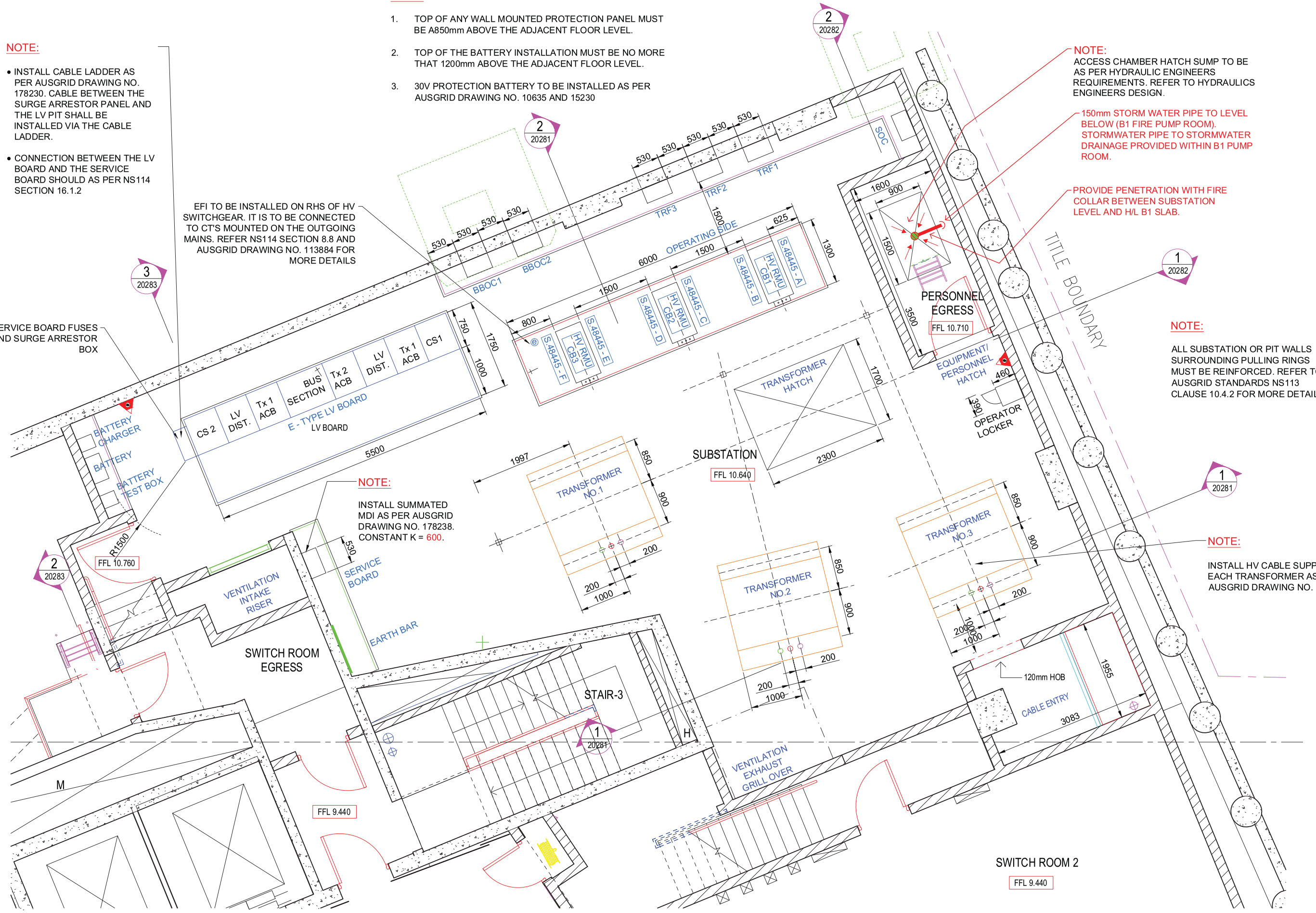
150mm STORM WATER PIPE TO LEVEL BELOW (B1 FIRE PUMP ROOM). STORMWATER PIPE TO STORMWATER DRAINAGE PROVIDED WITHIN B1 PUMP ROOM.

PROVIDE PENETRATION WITH FIRE COLLAR BETWEEN SUBSTATION LEVEL AND H/L B1 SLAB.

NOTE:
INSTALL SUMMATED MDI AS PER AUSGRID DRAWING NO. 178238. CONSTANT K = 600.

NOTE:
ALL SUBSTATION OR PIT WALLS SURROUNDING PULLING RINGS MUST BE REINFORCED. REFER TO AUSGRID STANDARDS NS113 CLAUSE 10.4.2 FOR MORE DETAILS.

NOTE:
INSTALL HV CABLE SUPPORT AT EACH TRANSFORMER AS PER AUSGRID DRAWING NO. 162655



EQUIPMENT LAYOUT
SCALE 1:50

SCALE 1 : 50 — 0 1 2 3 4 5 METRES

GENERAL NOTES:
1. PULLING RINGS TO BE USED FOR PULLING CABLES CAN BE SUBJECTED TO A WORKING LOAD OF 50kN. WHILST THE WORKING LOAD OF 5kN CAN BE EXERTED ON PULLING RINGS USED FOR TRANSFORMER MANEUVERING. PULLING RINGS SHOULD BE AS PER AUSGRID REQUIREMENTS.
2. REINFORCED CONCRETE WITH A CLASS 2 FINISH.
3. AN OPERATOR'S LOCKER IS TO BE INSTALLED IN THE CHAMBER SUBSTATION. (STOCKCODE: 123067).
4. SUBSTATION WALLS MUST WITHSTAND A LIVE LOADING FROM SUBSTATION SIDE OF NOT LESS THAN 2kPA UNIFORMLY DISTRIBUTED.

LEGEND
- FIRE EXTINGUISHER (5kg CAPACITY CO2 TYPE)
- PULLING EYE TO AUSGRID DRAWING NO. 63678 200mm FROM PIT FLOOR
- RECESS FOR REMOVABLE PULLING RING TO AUSGRID DRAWING NO. 48008

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MATERIALS FUNDED BY AUSGRID

AT LOCATION	WORK DESCRIPTION
S.48445	SUPPLY - 3 x HV RMI CBS - 3 x 1500kVA OIL-FILLED TRANSFORMERS - PRE-WIRED PROTECTION PANELS - PROTECTION RELAYS (BUSBAR OC, SUMMATED OC, DIFFERENTIAL ETC.) - HV PROTECTION CTS - MDI PANEL & CT - EFI & CT

NOTE:
"E - TYPE" SWITCHBOARD COMPONENTS SHALL COMPLY WITH AUSGRID CURRENT SPECIFICATION, AND SHALL BE ASSEMBLED AND INSTALLED IN ACCORDANCE WITH NS114, AND APPENDICES - MERLIN GERING AUSGRID CHAMBER SUBSTATION INDOOR SWITCHGEAR INSTALLATION, OPERATION AND MAINTENANCE, WHICH IS EXTERNAL TO NS114. STEEL TO SUPPORT THE SWITCHGEAR ABOVE THE LV PIT SHALL BE INSTALLED IN ACCORDANCE WITH THE DETAILS SHOWN ON AUSGRID DRAWING NO. 178229

NOTE:
- THE HV SWITCHGEAR SHALL BE ANCHORED TO THE FLOOR USING M12 BOLTS WHEN MOUNTED ON A STEEL CHANNEL. REFER AUSGRID DRAWING NO. 191085, 161431 IN CONJUNCTION WITH DIMENSIONS AND LAYOUT SHOWN ON THIS SHEET FOR LAYOUT OF HV SWITCHES, PIT AND SUPPORT CHANNELS.
- HV CT'S AND FOUR WAY OBA MARSHALLING TERMINAL BLOCK TO BE INSTALLED AS PER NS114 SECTION 15. FINAL DETAILS TO BE CONFIRMED ON SITE TO AUSGRID APPROVAL.
- ALL ITEMS OF THE HV SWITCHGEAR SHALL BED LABELED IN ACCORDANCE WITH NS158.

CHAMBER SUBSTATION NOTE
1. CONSTRUCTION AND EQUIPPING OF THIS SUBSTATION MUST BE IN ACCORDANCE WITH:
   - NS 0112, 0113, 0114, 0116, 0127, 0129, 0130, 171 AND 177
   - THIS DRAWING
   - BUILDING SCHEDULE SPECIFICATION
   - REFERENCE DRAWINGS AS INDICATED
   - ELECTRICAL DESIGN DRAWING (SHEETS 1 TO 16)
   - ARCHITECTURAL LOCK-IN DRAWING DETAIL
   - STRUCTURAL LOCK-IN DRAWING DETAIL
2. ALL CONDUITS USED IN CONJUNCTION WITH THE SUBSTATION CHAMBER IS TO CONFORM TO AS/NZS2053:2:1995.
3. WHERE CONDUITS CHANGE DIRECTION, BENDS, COMPLYING WITH APPENDICES OF NS130 MUST BE USED. ELBOWS MUST NOT BE USED AND UNDER NO CIRCUMSTANCES ARE CONDUITS TO BE BENT TO ACHIEVE THE BENDING RADII.
4. LABELING AT MAINS AND APPARATUS IS TO BE CARRIED OUT IN ACCORDANCE TO NS158. ALL COMPONENTS IN CHAMBER SUBSTATION ARE TO BE LABELED IN ACCORDANCE TO NS158.
5. PROTECTION AND CONTROL CABLE TO BE INSTALLED AS PER NS114 SECTION 15.7.
6. CABLES USED WITHIN THE SUBSTATION CHAMBER SHALL BE MULTI-STRANDED COPPER WITH PVC OR XLPE INSULATION. THIS EXCLUDE THE ALLUMINIUM LV STREET FEEDER CABLE. CABLES SHALL BE RUN IN A TREFOIL CONFIGURATION TO REDUCE EMF.

SCHEDULE OF WORKS BY CUSTOMER

AT LOCATION	WORK DESCRIPTION
S.48445	ESTABLISH THE BASEMENT CHAMBER SUBSTATION S.48445 IN THE LOCATION SHOWN. * PREPARE THE SITE AND CARRY OUT THE CIVIL WORKS. * SUPPLY AND INSTALL CONDUITS, CABLE CHASES AND PITS. * SITE & INSTALL 3 x 1500kVA OIL-FILLED TRANSFORMERS. * SUPPLY AND INSTALL 1 x 'E' - TYPE LV BOARD. * SUPPLY, INSTALL AND CONNECT EARTHING RODS & CABLES. * INSTALL 3 x RMI CB'S. * TERMINATE 2 SETS OF 300CU1 TRIPLEX HV CABLES. * INSTALL PRE-WIRED PROTECTION PANELS. SUPPLY AND INSTALL THE FOLLOWING: * SECONDARY PROTECTION WIRING HV AND LV TRANSFORMER TAILS. * BATTERY AND ASSOCIATED COMPONENTS. * SERVICE BOARD. * PULLING RINGS. * LIGHTING. * WATER SUPPLY. * FIRE EXTINGUISHERS. * HV DIFFERENTIAL CTS. * EARTHING CABLE FROM THE SUBSTATION BAR TO DRAW-IN-BOX AT THE LOWEST BASEMENT LEVEL VIA DRAW-IN-BOXES ON ALL LEVELS. * EFI AND ASSOCIATED COMPONENTS. * AT S.48445, TERMINATE THE LV CABLE INTO THE LV BOARD VIA A 400AMP FUSE.

AUSGRID FUNDED

UNDERGROUND CONSTRUCTION	2 x 800/400/400AMP SAIF FUSED DISTRIBUTOR PANEL (SC:179651). LOW VOLTAGE MAINS COMPONENTS WITHIN DEDICATED PUBLIC ROADWAYS AND THE SUBSTATION PROPERTY RIGHTS AREA(S) USED FOR SUPPLYING NETWORK LOADS BEYOND THE DEVELOPMENT PROPERTY AS FOLLOWS. ~ LOW VOLTAGE INTERCONNECTION FROM PROPOSED SUBSTATION TO S.568 DISTRIBUTOR 4 (THOMAS ST & OH). THE INSTALLATION OF SPARE CONDUITS (EXCLUDING TRENCHING AND UNDER BORES) AS FOLLOWS. ~ THE INSTALLATION OF THE FIBRE OPTIC PILOT CABLE CONDUIT ALONG THE HIGH VOLTAGE CABLE AND /OR CONDUIT ROUTE. TRENCHING FOR THE INSTALLATION OF AUSGRID FUNDED CABLE OR CONDUIT INSTALLATIONS THAT HAVE ONLY AUSGRID FUNDED COMPONENTS INSTALLED.
OVERHEAD CONSTRUCTION	NIL
MISCELLANEOUS	NIL
REIMBURSMENT FOR NON-CONTESTABLE WORKS $ INCLUDING GST	$60,109.00

SCHEDULE OF WORKS BY AUSGRID

AT LOCATION	WORK DESCRIPTION
	ID AND SPIKE EXISTING HV CABLES
S.48445	AUSGRID SHALL ONLY CARRY OUT THOSE MONOPOLY SERVICES DETAILED IN SECTION 9.6 OF THE ES10

NOTE:
ASP/1 IS TO LABEL ALL ELECTRICAL EQUIPMENT IN THE SUBSTATION IN ACCORDANCE TO NS158

ASSOCIATED DRAWINGS	
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

SIMPLEX ENGINEERING SERVICES PTY LTD
ABN: 16 109 553 531
SUITE 602, 12 MOUNT ST
NORTH SYDNEY, NSW 2060
TEL: (02) 9460 3622
FAX: (02) 9460 3077

ASP REF.	2490
DESIGNED BY	TONY SHAJOUR
DRAWN BY	MICKY WATHUGALA
CHECKED BY	KIRAN TIWARI
SUBMIT DATE	31/07/12
LGA	CITY OF SYDNEY COUNCIL
MAP REF.	236 A16
AUSGRID REF.	SY 41
PRJTRAK No.	XCZ016032

CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 6 of 16 | AMD. 0

CAD DRAWING — AMENDMENTS

20110604

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

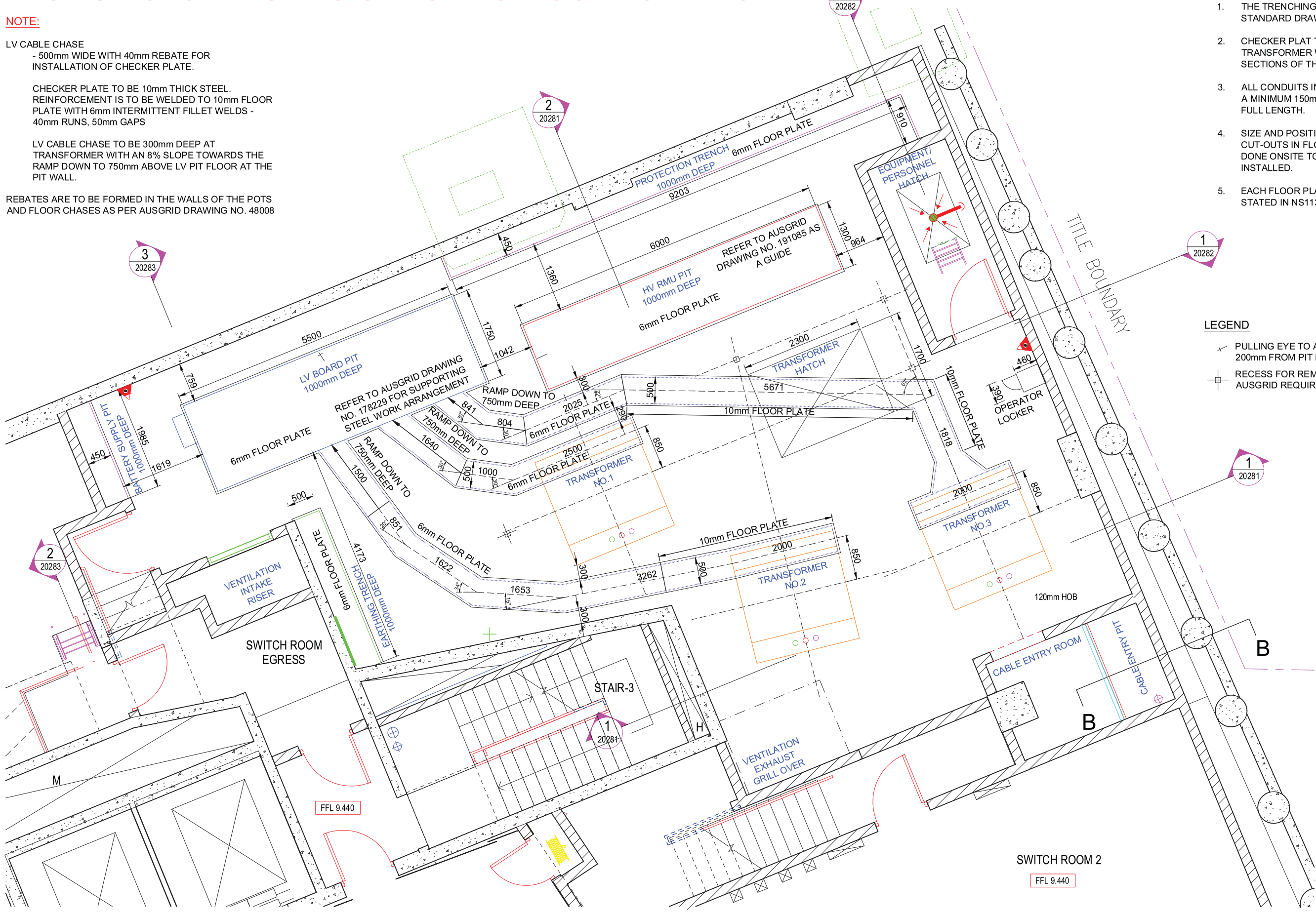
NOTE:

LV CABLE CHASE
- 500mm WIDE WITH 40mm REBATE FOR INSTALLATION OF CHECKER PLATE.

CHECKER PLATE TO BE 10mm THICK STEEL. REINFORCEMENT IS TO BE WELDED TO 10mm FLOOR PLATE WITH 6mm INTERMITTENT FILLET WELDS - 40mm RUNS, 50mm GAPS

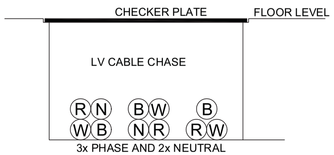
LV CABLE CHASE TO BE 300mm DEEP AT TRANSFORMER WITH AN 8% SLOPE TOWARDS THE RAMP DOWN TO 750mm ABOVE LV PIT FLOOR AT THE PIT WALL.

REBATES ARE TO BE FORMED IN THE WALLS OF THE POTS AND FLOOR CHASES AS PER AUSGRID DRAWING NO. 48008



PITS, TRENCHED & CABLE CHASES ARRANGEMENT

SCALE 1:50



LV TRANSFORMER TAILS ARRANGEMENT IN LV CABLE CHASE

SCALE: NOT TO SCALE

WARNING

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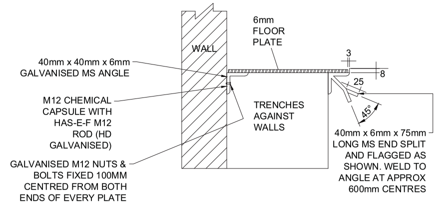
- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

NOTE:

1. THE TRENCHING REBATE TO BE 40mm WIDE. REFER TO AUSGRID STANDARD DRAWING NO. 48008.
2. CHECKER PLAT TO BE 10mm THICK FOR CABLE CHASE WHERE TRANSFORMER WILL TRAVEL OVER AND 6mm FOR THE REMAINING SECTIONS OF THE CABLE CHASE AND PITS.
3. ALL CONDUITS INSTALLED WITHIN THE SUBSTATION ARE TO HAVE A MINIMUM 150mm COVER CONCRETE ENCASEMENT FOR THEIR FULL LENGTH.
4. SIZE AND POSITION OF CABLE PENETRATIONS INDICATIVE ONLY. CUT-OUTS IN FLOOR PLATES FOR ABLE PENETRATIONS TO BE DONE ONSITE TO AUSGRID APPROVAL AFTER CABLE ARE INSTALLED.
5. EACH FLOOR PLATE MUST HAVE WEIGHT OF LESS THAN 20kg AS STATED IN NS113. REFER AUSGRID DRAWING No.48008

LEGEND

- PULLING EYE TO AUSGRID DRAWING NO. 63678 200mm FROM PIT FLOOR
- RECESS FOR REMOVABLE PULLING RING TO AUSGRID REQUIREMENTS.

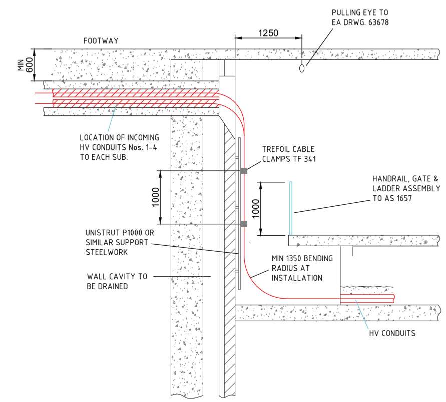


TYPICAL TRENCHED AGAINST WALLS

NOT TO SCALE

GENERAL NOTES:

1. PULLING RINGS TO BE USED FOR PULLING CABLES CAN BE SUBJECTED TO A WORKING LOAD OF 50kN. WHILST THE WORKING LOAD OF 5kN CAN BE EXERTED ON PULLING RINGS USED FOR TRANSFORMER MANEUVERING. PULLING RINGS SHOULD BE AS PER AUSGRID REQUIREMENTS.
2. REINFORCED CONCRETE WITH A CLASS 2 FINISH.
3. AN OPERATOR'S LOCKER IS TO BE INSTALLED IN THE CHAMBER SUBSTATION. (STOCKCODE: 123067).
4. SUBSTATION WALLS MUST WITHSTAND A LIVE LOADING FROM SUBSTATION SIDE OF NOT LESS THAN 2kPA UNIFORMLY DISTRIBUTED.



HV CABLE ENTRY POINT SECTION B-B

SCALE 1:50

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS 229960

ASSOCIATED DRAWINGS

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NORTH SYDNEY, NSW 2060
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FAX: (02) 9460 3077

ASP REF. 2490

CERTIFICATION NUMBER 286275/31072012

DESIGNED BY	TONY SHAJOUR
DRAWN BY	MICKY WATHUGALA
CHECKED BY	KIRAN TIWARI
SUBMIT DATE	31/07/12
LGA	CITY OF SYDNEY COUNCIL
MAP REF.	236 A16
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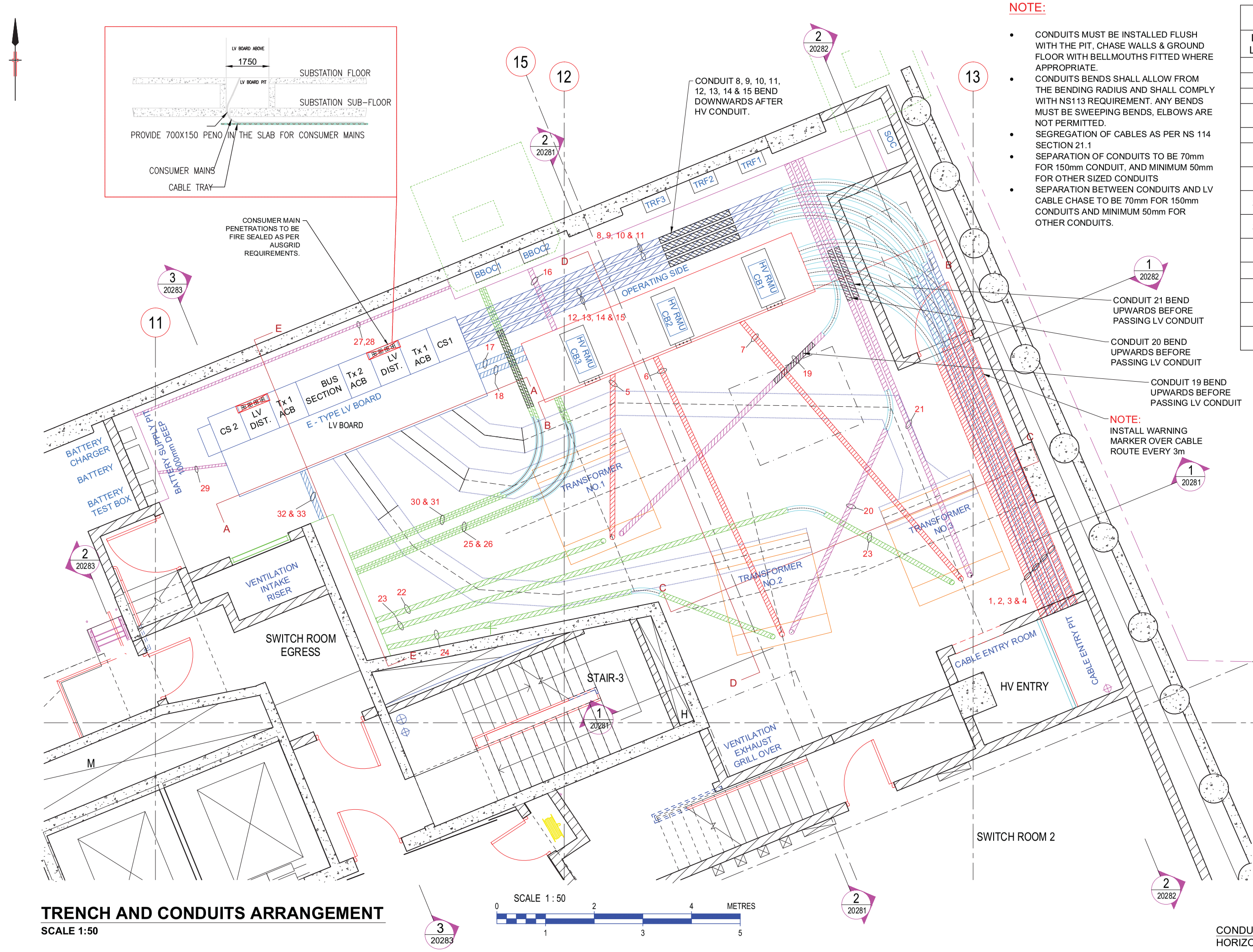
SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 7 of 16 | AMD. 0

CAD DRAWING 20110604 | AMENDMENTS

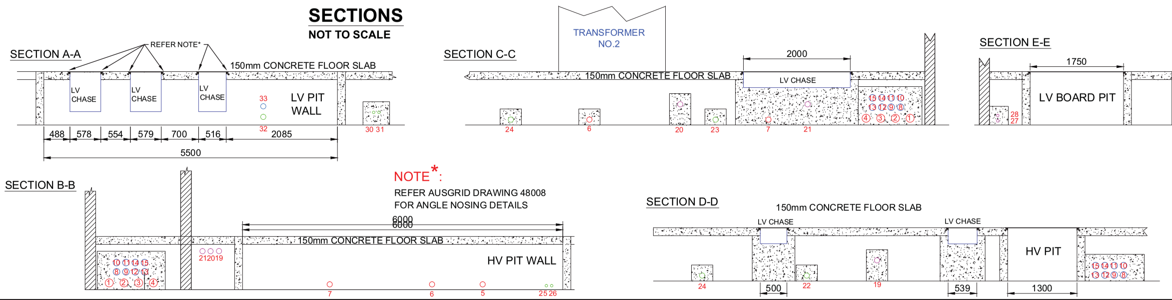


TRENCH AND CONDUITS ARRANGEMENT

SCALE 1:50

SECTIONS

NOT TO SCALE



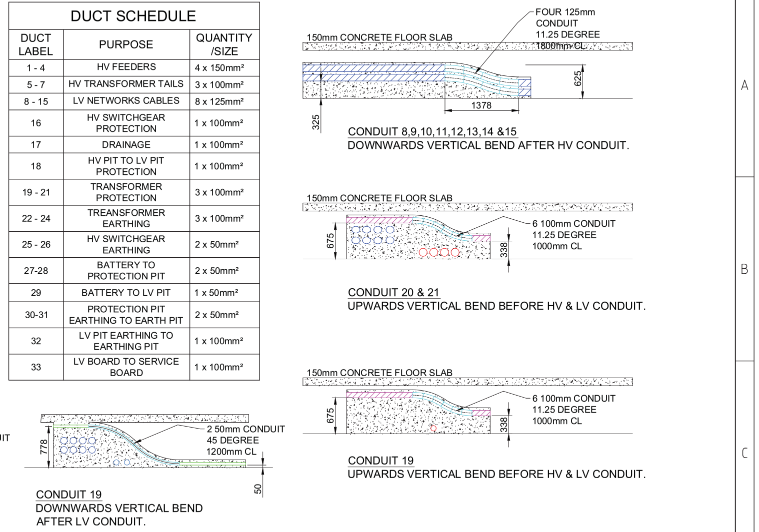
NOTE*:
REFER AUSGRID DRAWING 48008 FOR ANGLE NOSING DETAILS

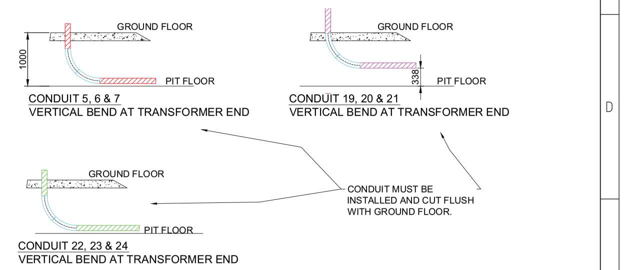
NOTE:

- CONDUITS MUST BE INSTALLED FLUSH WITH THE PIT, CHASE WALLS & GROUND FLOOR WITH BELLMOUTHS FITTED WHERE APPROPRIATE.
- CONDUITS BENDS SHALL ALLOW FROM THE BENDING RADIUS AND SHALL COMPLY WITH NS113 REQUIREMENT. ANY BENDS MUST BE SWEEPING BENDS, ELBOWS ARE NOT PERMITTED.
- SEGREGATION OF CABLES AS PER NS 114 SECTION 21.1
- SEPARATION OF CONDUITS TO BE 70mm FOR 150mm CONDUIT, AND MINIMUM 50mm FOR OTHER SIZED CONDUITS
- SEPARATION BETWEEN CONDUITS AND LV CABLE CHASE TO BE 70mm FOR 150mm CONDUITS AND MINIMUM 50mm FOR OTHER CONDUITS.

DUCT SCHEDULE

DUCT LABEL	PURPOSE	QUANTITY /SIZE
1 - 4	HV FEEDERS	4 x 150mm²
5 - 7	HV TRANSFORMER TAILS	3 x 100mm²
8 - 15	LV NETWORKS CABLES	8 x 125mm²
16	HV SWITCHGEAR PROTECTION	1 x 100mm²
17	DRAINAGE	1 x 100mm²
18	HV PIT TO LV PIT PROTECTION	1 x 100mm²
19 - 21	TRANSFORMER PROTECTION	3 x 100mm²
22 - 24	TREANSFORMER EARTHING	3 x 100mm²
25 - 26	HV SWITCHGEAR EARTHING	2 x 50mm²
27-28	BATTERY TO PROTECTION PIT	2 x 50mm²
29	BATTERY TO LV PIT	1 x 50mm²
30-31	PROTECTION PIT EARTHING TO EARTH PIT	2 x 50mm²
32	LV PIT EARTHING TO EARTHING PIT	1 x 100mm²
33	LV BOARD TO SERVICE BOARD	1 x 100mm²





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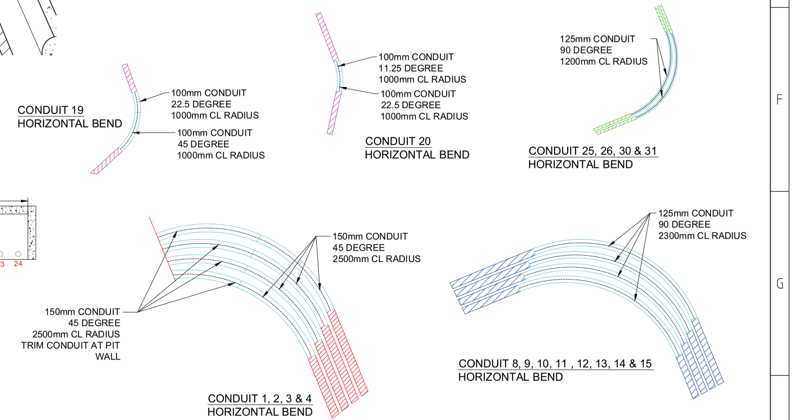

CAD DRAWING	AMENDMENTS
20110604	

ASSOCIATED DRAWINGS	
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

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DRAWN BY	MICKY WATHUGALA
CHECKED BY	KIRAN TIWARI
SUBMIT DATE	31/07/12
LGA	CITY OF SYDNEY COUNCIL
MAP REF.	236 A16
AUSGRID REF	SY 41
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ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 8 of 16 | AMD. 0

©

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

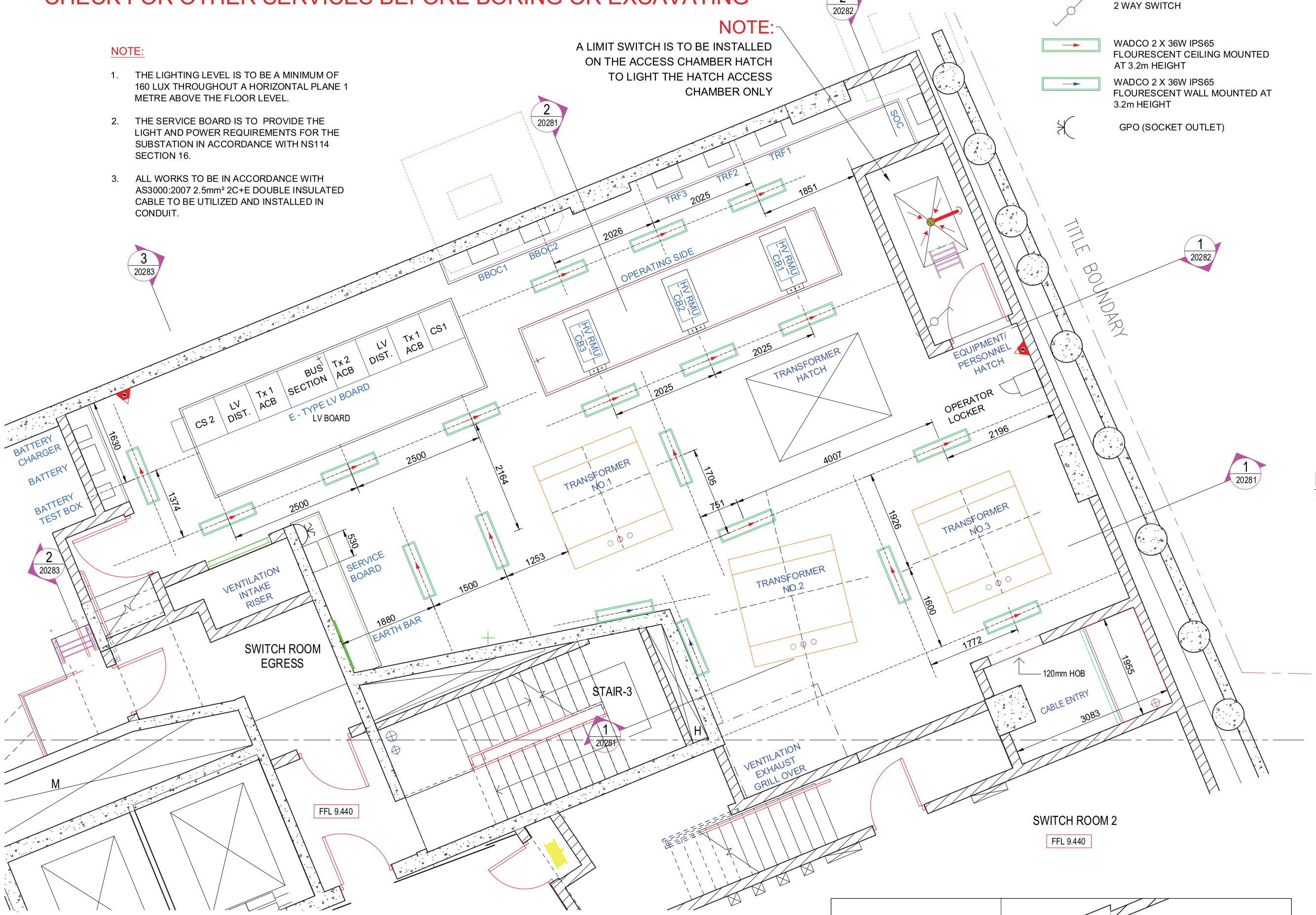
NOTE:

1. THE LIGHTING LEVEL IS TO BE A MINIMUM OF 160 LUX THROUGHOUT A HORIZONTAL PLANE 1 METRE ABOVE THE FLOOR LEVEL.
2. THE SERVICE BOARD IS TO PROVIDE THE LIGHT AND POWER REQUIREMENTS FOR THE SUBSTATION IN ACCORDANCE WITH NS114 SECTION 16.
3. ALL WORKS TO BE IN ACCORDANCE WITH AS3000:2007 2.5mm² 2C+E DOUBLE INSULATED CABLE TO BE UTILIZED AND INSTALLED IN CONDUIT.

NOTE:
A LIMIT SWITCH IS TO BE INSTALLED ON THE ACCESS CHAMBER HATCH TO LIGHT THE HATCH ACCESS CHAMBER ONLY

LEGEND

	2 WAY SWITCH
	WADCO 2 X 36W IPS65 FLOURESCENT CEILING MOUNTED AT 3.2m HEIGHT
	WADCO 2 X 36W IPS65 FLOURESCENT WALL MOUNTED AT 3.2m HEIGHT
	GPO (SOCKET OUTLET)



LIGHTING EQUIPMENT AND POWER LAYOUT PLAN

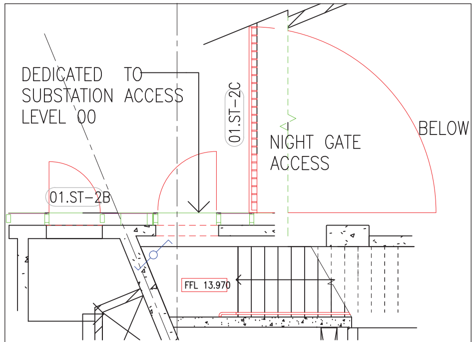
SCALE 1:50

SCALE 1 : 50 — METRES

LUMINAIRE SCHEDULE

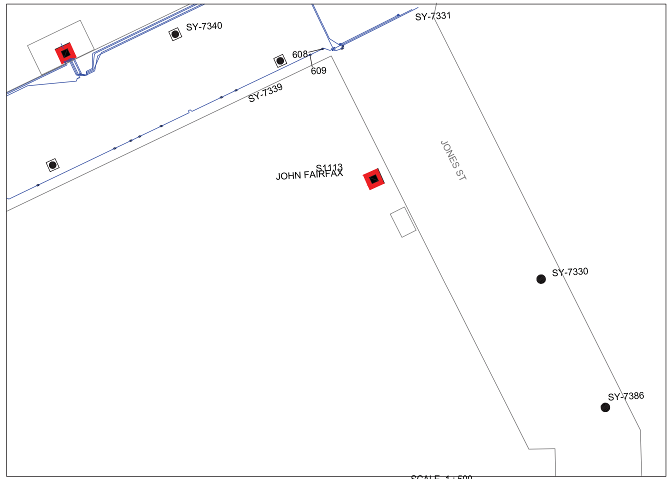
PROJECT: ALL PROJECTS

SYMBOL	SYMBOL-ISO	LABEL	QTY	LUMENS	LLF
		WAD23IP	24	3450	0.750



POWER LAYOUT PLAN SUBSTATION ENTRY

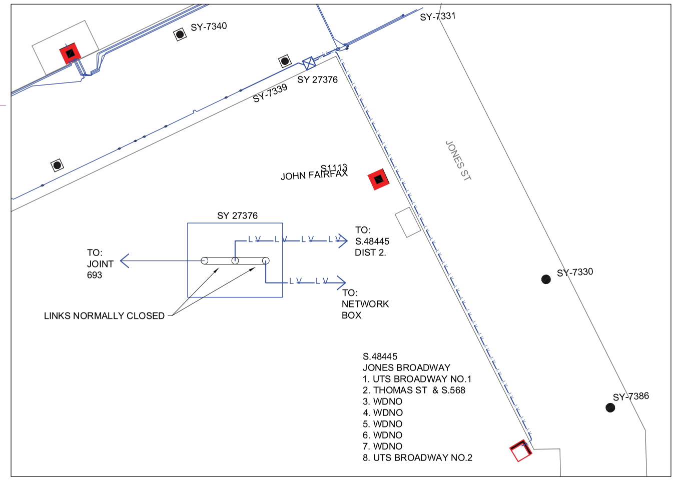
SCALE 1:50



EXISTING LV PLAN

SCALE 1:500

SCALE 1 : 500 — METRES



PROPOSED LV PLAN

SCALE 1:500

SCALE 1 : 500 — METRES

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ASSOCIATED DRAWINGS	
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

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ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE	AUSGRID PROJECT No.	SHEETS	AMD.
A1	SC01596	9 of 16	0

CAD DRAWING

AMENDMENTS

20110604

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NOTE:

1. BUILDERS MUST PROVIDE HOLES NOT LESS THAN 38mm DIAMETER THROUGH INTERMEDIATE FLOORS TO ALLOW FOR EARTHING CABLES TO PASS THROUGH.
2. PENETRATIONS THOUGH ANY WATERPROOF MEMBRAN SHALL BE APPROPRIATELY SEALED AS PER AUSGRID DRAWING NO. A1-25121.
3. ELECTRODES ARE TO BE INSTALLED TO NATURAL GROUND AT THE BASEMENT LEVEL B4 WITH ALLOCATED EARTHING EASEMENT.

EARTHING TABLE

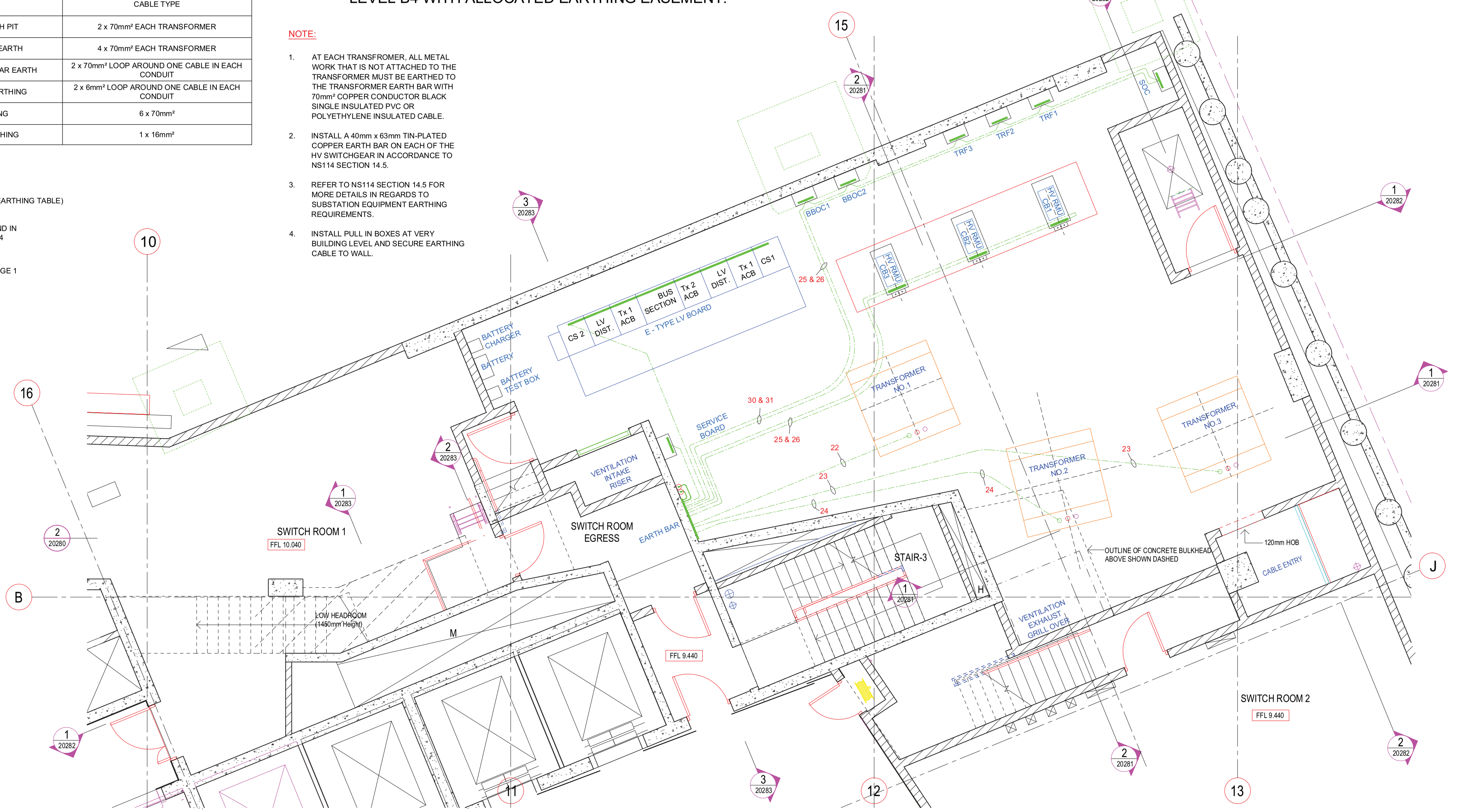
CONDUITS	DESCRIPTION	CABLE TYPE
22, 23 & 24	TRANSFORMER EARTH PIT	2 x 70mm² EACH TRANSFORMER
22, 23 & 24	TRANSFORMER TANK EARTH	4 x 70mm² EACH TRANSFORMER
25 & 26 & EARTHING PIT	HIGH VOLTAGE SWITCHGEAR EARTH	2 x 70mm² LOOP AROUND ONE CABLE IN EACH CONDUIT
27 & EARTHING PIT	PROTECTION PANEL EARTHING	2 x 6mm² LOOP AROUND ONE CABLE IN EACH CONDUIT
EARTHING PIT	LV BOARD EARTHING	6 x 70mm²
	WATER SUPPLY EARTHING	1 x 16mm²

NOTE:

1. AT EACH TRANSFROMER, ALL METAL WORK THAT IS NOT ATTACHED TO THE TRANSFORMER MUST BE EARTHED TO THE TRANSFORMER EARTH BAR WITH 70mm² COPPER CONDUCTOR BLACK SINGLE INSULATED PVC OR POLYETHYLENE INSULATED CABLE.
2. INSTALL A 40mm x 63mm TIN-PLATED COPPER EARTH BAR ON EACH OF THE HV SWITCHGEAR IN ACCORDANCE TO NS114 SECTION 14.5.
3. REFER TO NS114 SECTION 14.5 FOR MORE DETAILS IN REGARDS TO SUBSTATION EQUIPMENT EARTHING REQUIREMENTS.
4. INSTALL PULL IN BOXES AT VERY BUILDING LEVEL AND SECURE EARTHING CABLE TO WALL.

LEGEND

- PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)
- 70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4
- MINIMUM 5m DEEP EARTH ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF SC0159 (XCZ016032)
- 2 x 38mm GLAVANISED PIPES



EARTHING PLAN AT LEVEL 00

SCALE 1:50

SCALE 1 : 50 0 1 2 3 4 5 METRES

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

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CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

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SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 10 of 16 | AMD. 0

CAD DRAWING
AMENDMENTS
20110604

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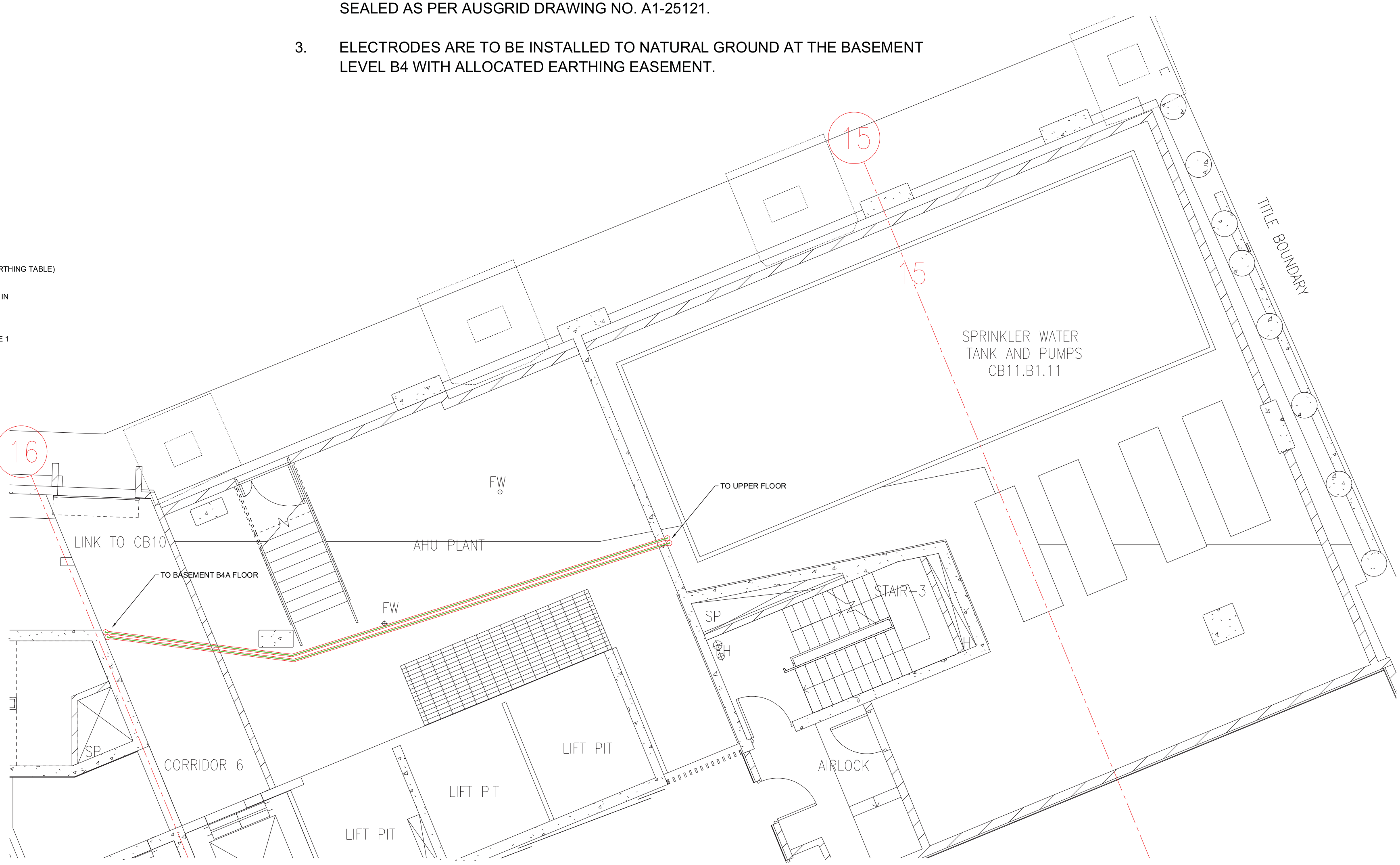
LEGEND

- PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)
- 70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4
- MINIMUM 5m DEEP EARTH ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF SC0159 (XCZ016032)
- 2 x 38mm GLAVANISED PIPES



EARTHING PLAN AT LEVEL B1

SCALE 1:50

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960
ASSOCIATED DRAWINGS	

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S.48445 'JONES BROADWAY'
AT CNR OF WATTLE STREET
AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 11 of 16 | AMD. 0

CAD DRAWING | AMENDMENTS

20110604

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- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

NOTE:

1. INSTALL PULL IN BOXES AT VERY BUILDING LEVEL AND SECURE EARTHING CABLE TO WALL.

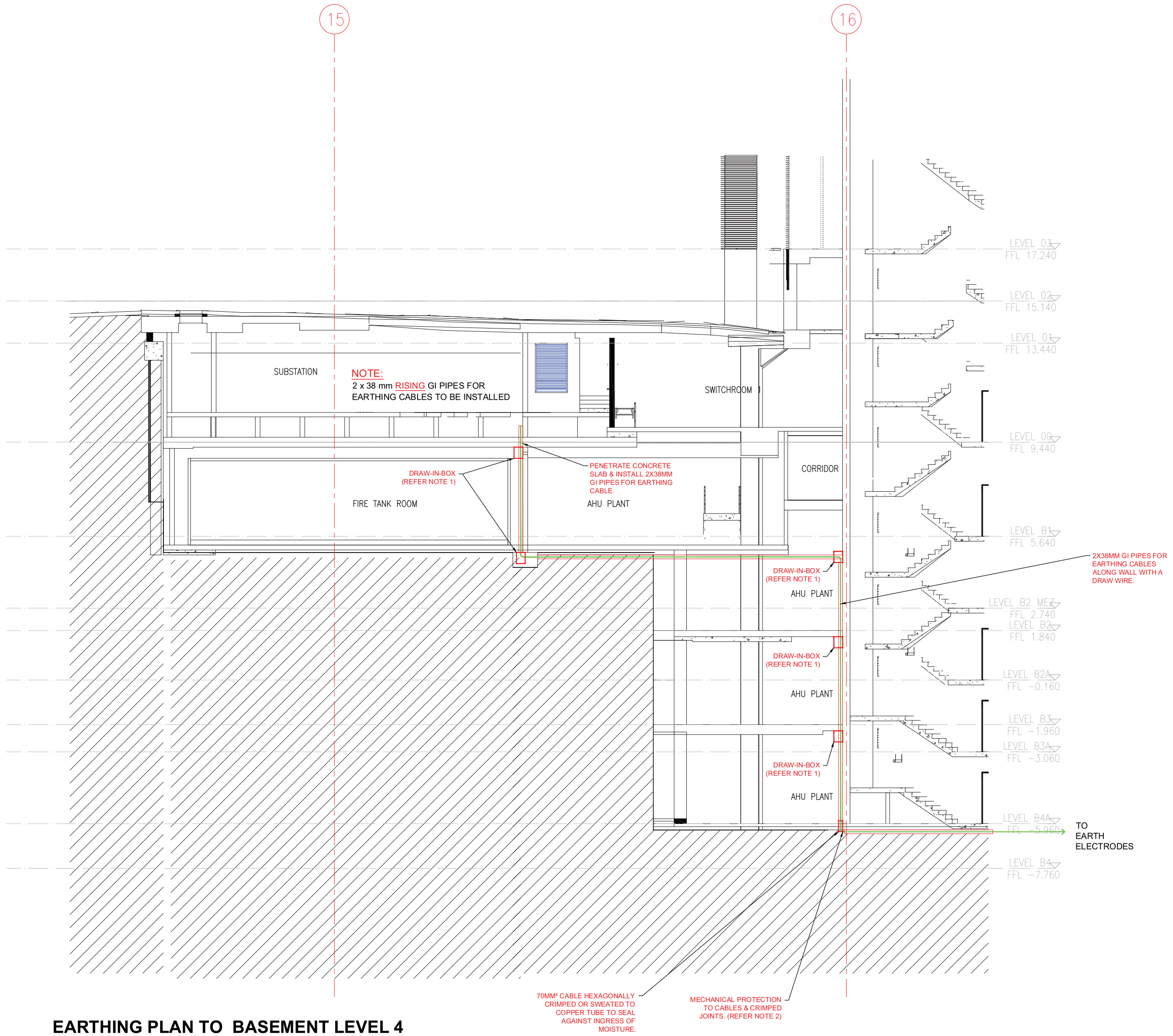
CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

LEGEND

	PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)
	70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4
⊕	MINIMUM 5m DEEP EARTH ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF SC0159 (XCZ016032)
	2 x 38mm GLAVANISED PIPES
	DRAW-IN BOX

NOTE:
1. A SUITABLE GALVANISED STEEL DRAW-IN BOX IS TO BE INSTALLED AT EACH CHANGE OF DIRECTION.THE BOX IS TO BE MOUNTED SUCH THAT IT IS ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
2. THE MECHANICAL PROTECTION TO CABLES AND CRIMPED JOINTS SHOWN IN LOW BASEMENT INSTALLATIONS IS TO BE PERFORMED BY A REMOVABLE GALVANISED STEEL COVER.THIS COVER IS TO BE ACCESSIBLE TO AUSGROD STAFF AT ALL TIMES.
3. SUPPLY AND INSTALLATION OF EARTH ELECTRODES,FITTINGS AND CABLES IS TO BE CARRIES OUT BY THE SUBSTATION EQUIPPING CONTRACTOR BEFORE THE INSTALLATION OF ANY WATERPROOF MEMBRANE AND POURING OF THE BASEMENT OR SUBSTATION FLOOR SLAB.
4. EARTH ELECTRODES TO BE INSTALLED AS PER AUSGRID DWG NO.25121 FOR TYPICAL INSTALLATION OF EARTH ELECTRODES.

ALL WORKS TO BE CARRIED OUT AS PER AUSGRID DWG NO.25121 FOR TYPICAL INSTALLATION OF EARTH ELECTRODES.



EARTHING PLAN TO BASEMENT LEVEL 4

SCALE 1:100

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960
ASSOCIATED DRAWINGS	

SIMPLEX ENGINEERING SERVICES PTY LTD
ABN: 16 109 553 531
SUITE 602, 12 MOUNT ST
NORTH SYDNEY, NSW 2060
TEL: (02) 9460 3622
FAX: (02) 9460 3077

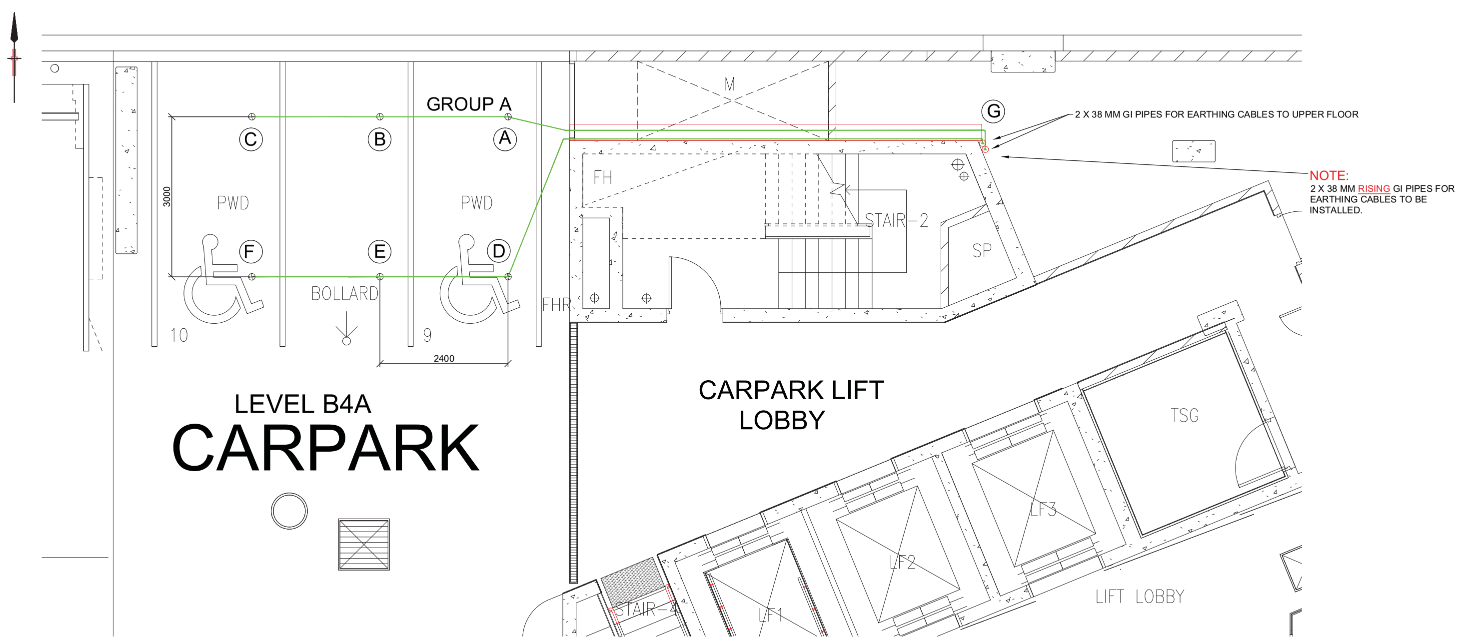
ASP REF.	2490
DESIGNED BY	TONY SHAJOUR
DRAWN BY	MICKY WATHUGALA
CHECKED BY	KIRAN TIWARI
SUBMIT DATE	31/07/12
LGA	CITY OF SYDNEY COUNCIL
MAP REF.	236 A16
AUSGRID REF.	SY 41
PRJTRAK No.	XCZ016032

CERTIFICATION NUMBER 286275/31072012

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE	AUSGRID PROJECT No.	SHEETS	AMD.
A1	SC01596	12 of 16	0

CAD DRAWING
AMENDMENTS
20110604



EARTHING PLAN 2 BASEMENT LEVEL B4A

SCALE 1:50

SCALE 1 : 50 — 0 1 2 3 4 5 METRES

LEGEND

- PROPOSED EARTHING CABLE (REFER TO EARTHING TABLE)
- 70mm² STRANDED COPPER BLACK PVC OR POLYETHYLENE INSULATED CABLES TO AND IN NATURAL GROUND AT BASEMENT LEVEL B4
- MINIMUM 5m DEEP EARTH ELECTRODE IN NATURAL GROUND INSTALLED UNDER STAGE 1 OF SC0159 (XCZ016032)
- 2 x 38mm GLAVANISED PIPES

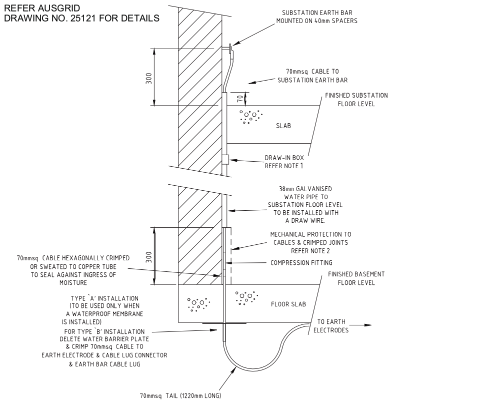
EARTHING SCHEDULE

LOCATION	CONSTRUCTION DETAIL	PVC INSULATED 70 SQMM STRANDED COPPER CABLE LENGTH (m)
A TO B	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'A' AND REF 'B'	2.4
B TO C	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'B' AND REF 'C'	2.4
D TO E	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'D' AND REF 'E'	2.4
E TO F	RUN 70mm2 CU CABLE BETWEEN THE EARTH RODS AT REF 'F' AND REF 'G'	2.4
G TO A	RUN 70mm2 CU CABLE IN 38mm GI PIPE FROM WALL AT REF 'H' TO EARTH ROD AT REF 'A'	10.0
G TO D	RUN 70mm2 CU CABLE IN 38mm GI PIPE FROM WALL AT REF 'H' TO EARTH ROD AT REF 'D'	11.0

NOTES:

1. THIS DRAWING SHOWS TYPICAL INSTALLATION OF EARTH ELECTRODES IN CHAMBER SUBSTATIONS AND INDICATES:
   a. TYPE 'A' INSTALLATION (USED ONLY WHEN A WATERPROOF MEMBRANE IS INSTALLED)
   b. TYPE 'B' INSTALLATION (USED ONLY WHEN A WATERPROOF MEMBRANE IS NOT REQUIRED).
   AND SHOULD BE READ IN CONJUNCTION WITH THE SUBSTATION LAYOUT DRAWINGS AND NETWORK STANDARDS NS 13, NS 114, AND NS 116.
2. SUPPLY AND INSTALLATION OF EARTH ELECTRODES, FITTING AND CABLES IS TO BE CARRIED OUT BY THE SUBSTATION EQUIPPING CONTRACTOR BEFORE THE INSTALLATION OF ANY WATERPROOF MEMBRANE AND POURING OF THE BASEMENT OR SUBSTATION FLOOR SLAB.
3. ALL TERMINATIONS AND JOINTS IN STRANDED EARTH CONDUCTORS ARE TO BE MADE BY APPROVED COMPRESSION TECHNIQUES.
4. WHERE GROUND CONDITIONS PERMIT, ELECTRODES ARE TO BE DRIVEN USING APPROPRIATE ROD DRIVERS AND DRIVING HEADS. WHERE GROUND CONDITIONS REQUIRE DRILLING, A 35mm DIAMETER HOLE FOR ROCK OR A 50<+mm DIAMETER HOLE FOR CLAY IS TO BE BORED FOR EACH ELECTRODE. AN APPROVED EARTHING COMPOUND IS TO BE PUMPED INTO THE BORE HOLE AFTER ELECTRODE INSTALLATION. ALL ELECTRODE INSTALLATIONS ARE TO BE TO A MINIMUM DEPTH OF 5 METRES.
5. COPPER EARTHING CONNECTION ARE TO BE KEPT CLEAR OF STEEL REINFORCING OF FLOOR SLAB WHERE POSSIBLE. OTHERWISE PVC INSULATED CABLES ARE TO BE USED AND COMPRESSION FITTINGS ARE TO BE TAPED OVER.
6. A SUITABLE GALVANISED STEEL DRAW-IN BOX IS TO BE INSTALLED AT EACH CHANGE OF DIRECTION. THE BOX IS TO BE MOUNTED SUCH THAT IT IS ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
7. THE MECHANICAL PROTECTION TO CABLES AND CRIMPED JOINTS SHOWN IN LOW BASEMENT INSTALLATIONS IS TO BE PREFORMED BY A REMOVABLE GLAVANISED STEEL COVER. THIS COVER IS TO BE ACCESSIBLE TO AUSGRID STAFF AT ALL TIMES.
8. THE INSTALLATION AND CONNECTION OF THE EARTH RODS AND CONNECTING CABLES ARE TO BE INSPECTED AND APPROVED BY AUSGRID NOMINATED OFFICER BEFORE THE INSTALLATION OF ANY WATERPROOF MEMBRANE AND POURING OF THE BASEMENT OR SUBSTATION FLOOR SLAB.
9. FULL LENGTH OF EARTH CABLE FROM SUBSTATION TO THE EARTH ROD LOCATION INCLUDING EARTH ROD LOCATION SHALL BE NOMINATED AS AUSGRID EASEMENT WITH 24/7 ACCESS AS PER AUSGRID REQUIREMENTS.

REFER AUSGRID DRAWING NO. 25121 FOR DETAILS



1. A SUITABLE GALVANISED STEEL DRAW-IN BOX IS TO BE INSTALLED AT EACH CHANGE OF DIRECTION. THE BOX IS TO BE MOUNTED SUCH THAT IT IS ACCESSIBLE TO ENERGY AUSTRALIA STAFF AT ALL TIMES.
2. THE MECHANICAL PROTECTION TO CABLES AND CRIMPED JOINTS SHOWN IN LOW BASEMENT INSTALLATIONS IS TO BE PERFORMED BY A REMOVABLE GALVANISED STEEL COVER. THIS COVER IS TO BE ACCESSIBLE TO ENERGY AUSTRALIA STAFF AT ALL TIMES.

TYPE A INSTALLATIONS WITH EARTH RODS IN THE LOWEST BASEMENT (LEVEL B4)

SCALE: NOT TO SCALE. (REFER AUSGRID DRAWING NO. A1-25121 FOR MORE DETAILS)

WARNING

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- THE INFORMATION PROVIDED IN THIS DESIGN MUST BE CHECKED ON SITE AND THE MOST CURRENT INFORMATION ON THE CONFIGURATION OF ALL SERVICES, INCLUDING AUSGRID'S NETWORK, MUST BE VERIFIED IMMEDIATELY BEFORE CONSTRUCTION COMMENCES BY CONTACTING DIAL-BEFORE-YOU-DIG BY TELEPHONE ON 1100 OR AT www.1100.com.au.
- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

EARTHING REQUIREMENTS:

- EARTHING OF SUBSTATION TO BE CARRIED OUT IN ACCORDANCE WITH NS-116,DRAWING NO.167433 SHEETS 2 & 3, DRAWING NO.25121 AND THIS DESIGN.
- THE EARTHING SYSTEM MUST BE INSTALLED BEFORE COVERING FLOOR IS CONSTRUCTED.
- THE EARTH GRIDS SHALL CONSIST OF A DEEP ELECTRODE SYSTEM INTERCONNECTED WITH EARTHING CABLE AS SPECIFIED IN NS 116 DESIGN STANDARDS FOR DISTRIBUTION EARTHING.
- THE MINIMUM NUMBER OF ELECTRODES IN EACH GROUP SHALL BE AS SPECIFIED IN NS 116 DESIGN STANDARDS FOR DISTRIBUTION EARTHING.
- MINIMUM SEPARATION BETWEEN ELECTRODES IS 3m.

CONSTRUCTION PROCEDURE:

- INSTALL THE EARTH ELECTRODES N PROPOSED LOCATION USING BORE HOLE/COPPER TUBE SYSTEM. THE ELECTRODE MUST BE INSTALLED TO A MIN. DEPTH OF 7.55m BELOW THE NATURAL GROUND LEVEL.
- THE EARTH ELECTRODES MUST BE MIN. 3m APART AND SEPARATION OF EACH GROUP OF ELECTRODE TO BE MIN. 2.8m OR AS PER EARTHING DIAGRAM.
- EARTHING GROUPS A AND B MUST BE CONNECTED TO THE EARTH BAR WITH PVC INSULATED 70 SQMM STRANDED COPPER CABLE.
- THE A AND B EARTH ELECTRODE GROUPS MUST BE INDEPENDENTLY CONNECTED AT THE EARTH BAR IN THE CHAMBER.

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

ASSOCIATED DRAWINGS	
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960

SIMPLEX ENGINEERING SERVICES PTY LTD
ABN: 16 109 553 531
SUITE 602, 12 MOUNT ST
NORTH SYDNEY, NSW 2060
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FAX: (02) 9460 3077

ASP REF. 2490

CERTIFICATION NUMBER 286275/31072012

DESIGNED BY	TONY SHAJOUR
DRAWN BY	MICKY WATHUGALA
CHECKED BY	KIRAN TIWARI
SUBMIT DATE	31/07/12
LGA	CITY OF SYDNEY COUNCIL
MAP REF.	236 A16
AUSGRID REF.	SY 41
PRJTRAK No.	XCZ016032

ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 13 of 16 | AMD. 0

CAD DRAWING AMENDMENTS

20110604

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING

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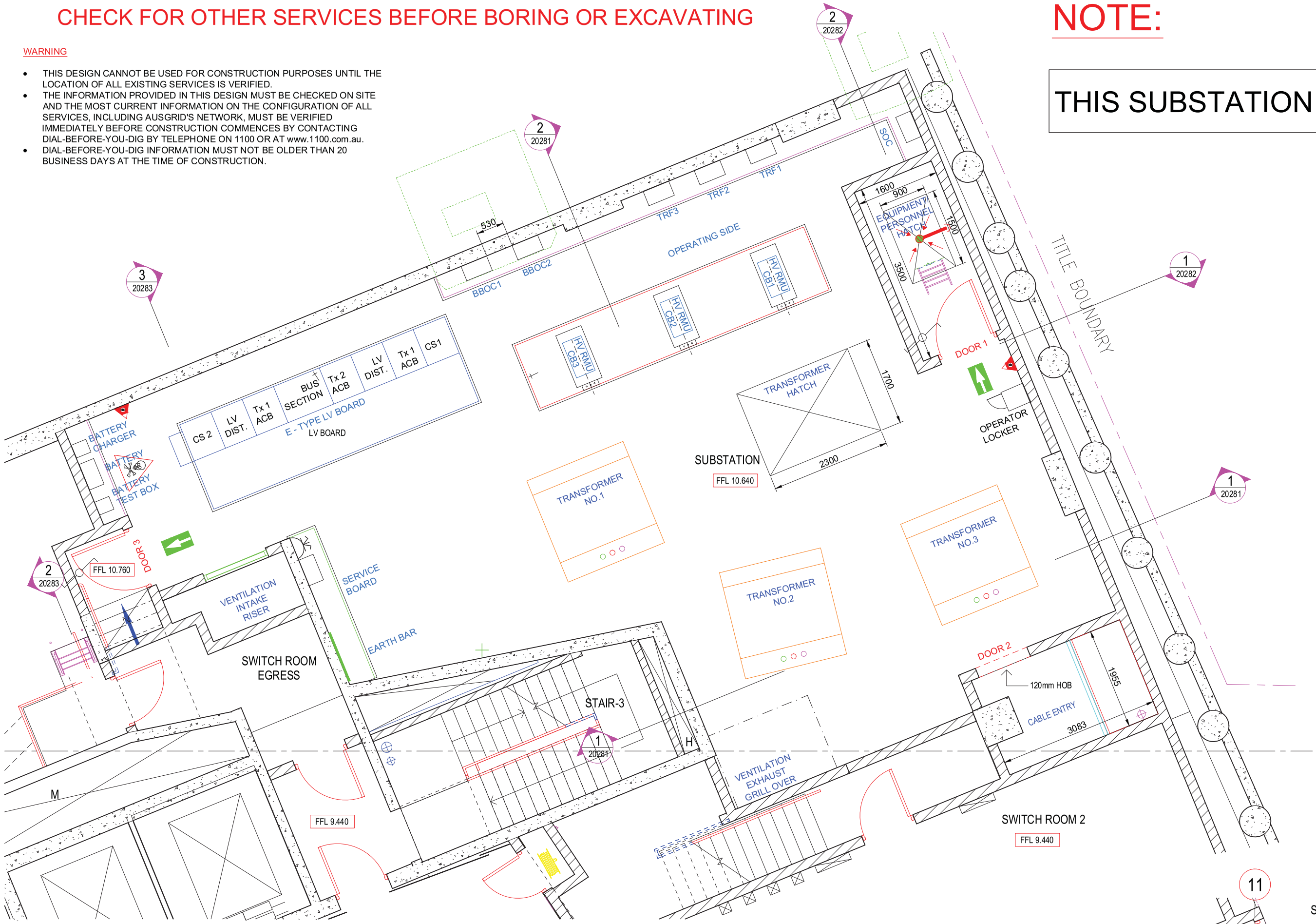
- DIAL-BEFORE-YOU-DIG INFORMATION MUST NOT BE OLDER THAN 20 BUSINESS DAYS AT THE TIME OF CONSTRUCTION.

NOTE:

THIS SUBSTATION CONTAINS OIL



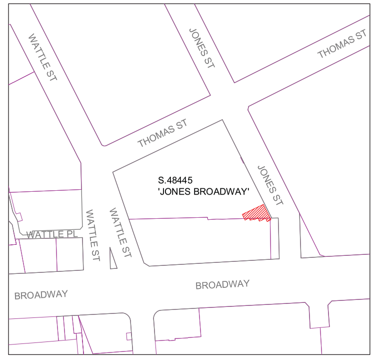
FIRE EXIST / ESCAPE PLAN

SCALE 1:50

SCALE 1 : 50 — 0 1 2 3 4 5 METRES

LEGEND

- FIRE EXTINGUISHER (5kg CAPACITY CO2 TYPE)
- EXIT PATH / ILLUMINATION
- ENTRY PATH
- 2 - WAY SWITCH
- GPO
- WATER SERVICE
- DANGER TOXIC MATERIALS

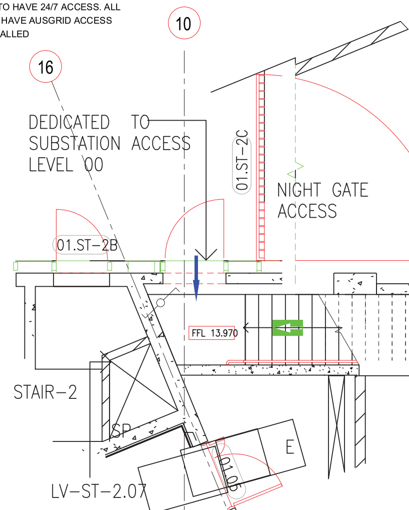


LOCALITY PLAN

SCALE: NOT TO SCALE

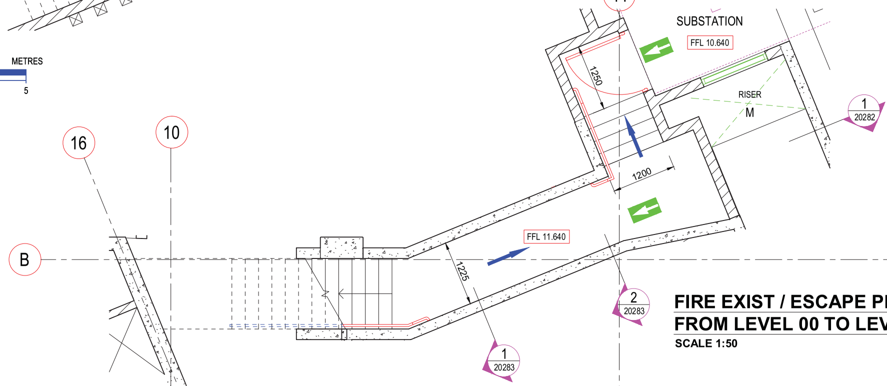
NOTE:

AUSGRID TO HAVE 24/7 ACCESS. ALL GATES TO HAVE AUSGRID ACCESS KEYS INSTALLED



FIRE EXIST / ESCAPE PLAN LEVEL 0

SCALE 1:50



FIRE EXIST / ESCAPE PLAN FROM LEVEL 00 TO LEVEL 01

SCALE 1:50

CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960	
ASSOCIATED DRAWINGS		

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LGA	CITY OF SYDNEY COUNCIL
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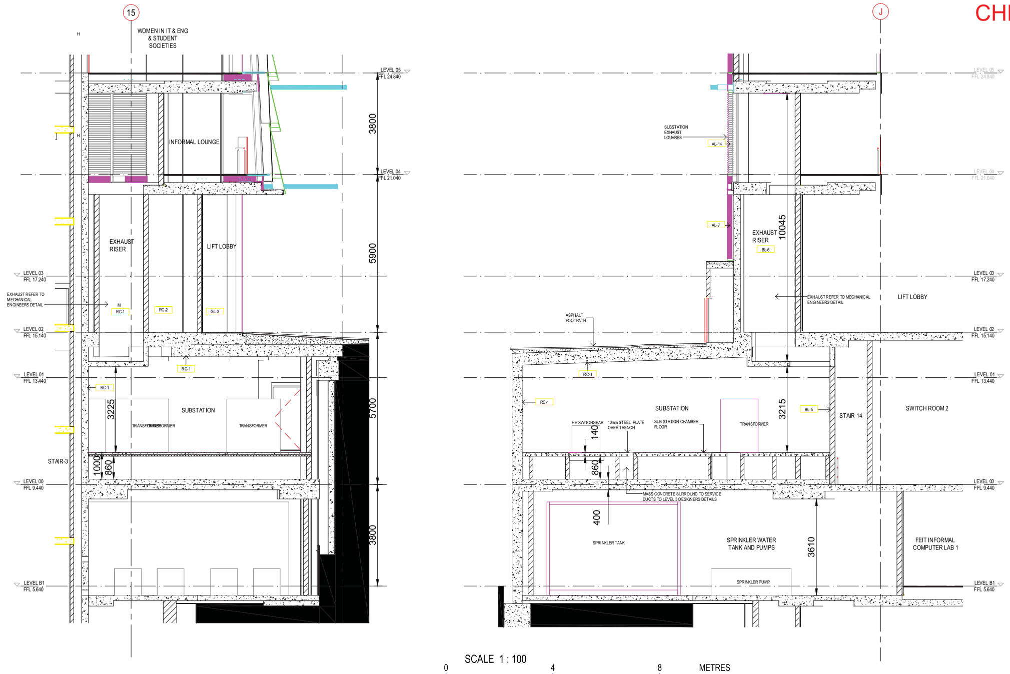
ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 14 of 16 | AMD. 0

CAD DRAWING — AMENDMENTS

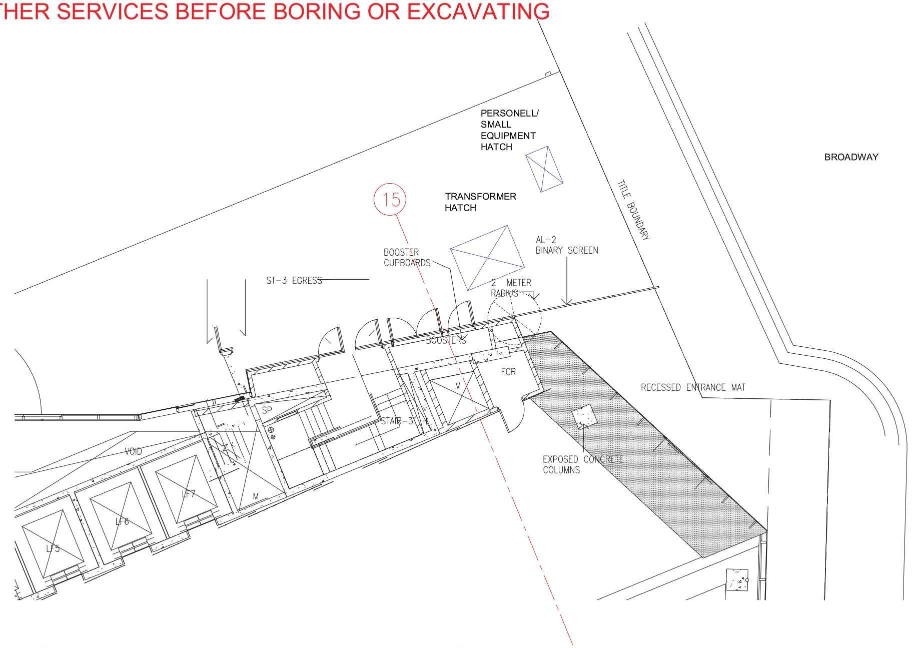
20110604

CHECK FOR OTHER SERVICES BEFORE BORING OR EXCAVATING



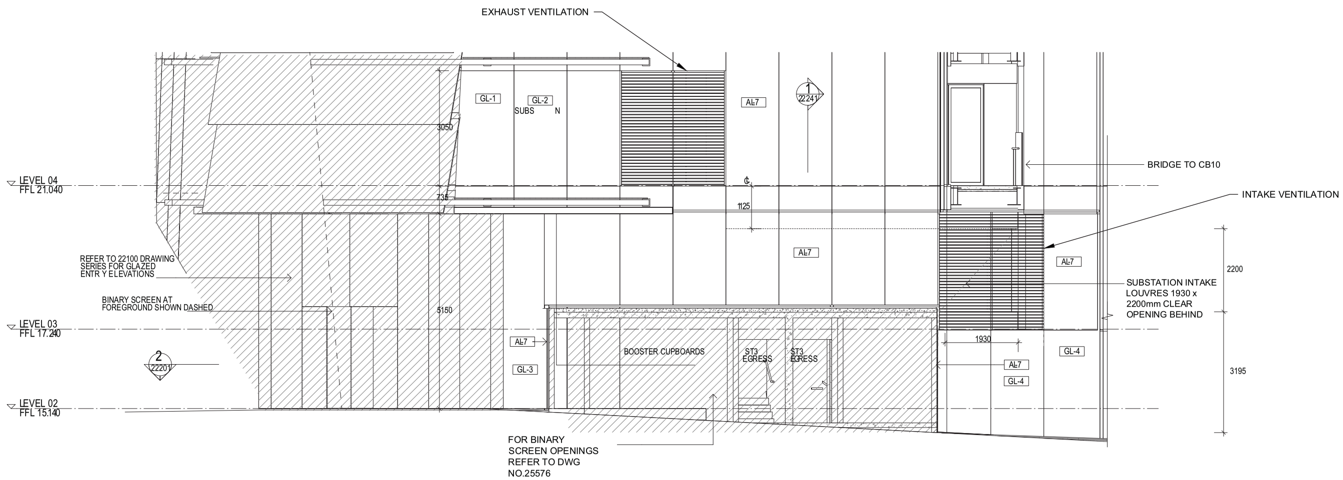
SUBSTATION SECTIONS

SCALE 1:100



TRANSFORMER AND PERSONELL/EQUIPMENT HATCH PLAN

SCALE 1:50



SUBSTATION VENTILATION ELEVATIONS

SCALE 1:50

WARNING

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CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS	229960
ASSOCIATED DRAWINGS	

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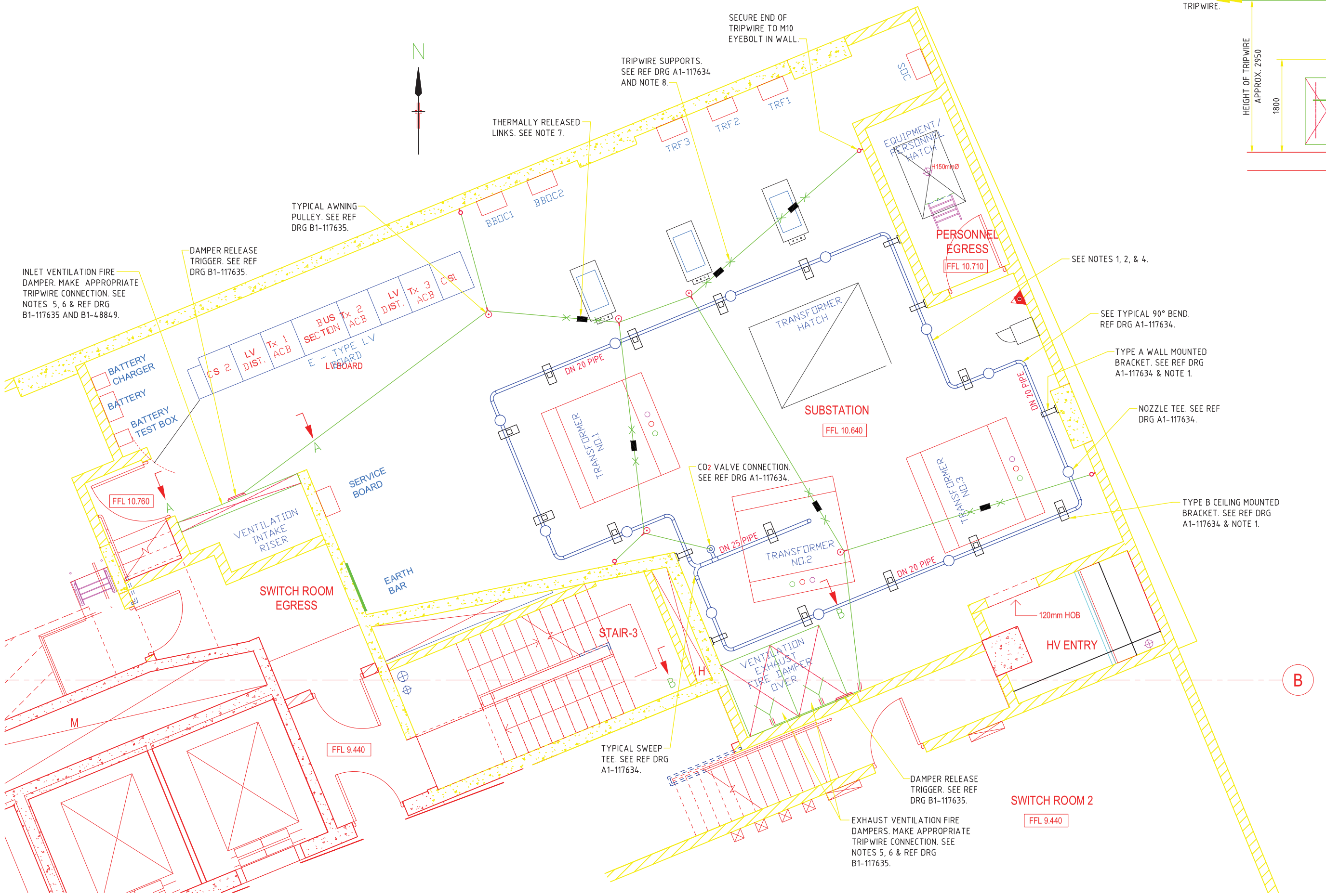
ESTABLISH BASEMENT CHAMBER S.48445 'JONES BROADWAY' AT CNR OF WATTLE STREET AND BROADWAY, BROADWAY

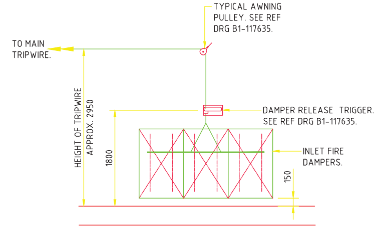
SIZE A1 | AUSGRID PROJECT No. SC01596 | SHEETS 15 of 16 | AMD. 0

CAD DRAWING AMENDMENTS

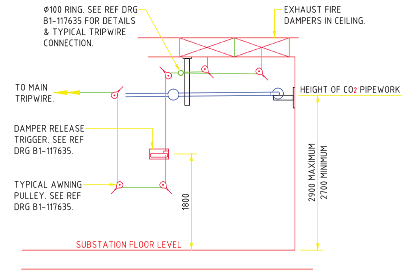
20110604



PART SITE PLAN



SECTION A - A



SECTION B - B

REFERENCE DRAWINGS

BASEMENT SUBSTATION CHAMBER CO_2 NOZZLE DETAILS	A1-2064
SUBSTATION VENTILATION STANDARD MULTIBLADE FIRE DAMPER	B1-48849
WALL MOUNTED CO_2 CONNECTION BOX	A1-56197
BASEMENT SUBSTATIONS CO_2 VALVE, PIPEWORK, TRIPWIRE & VENT. ARRGT.	A1-117634
BASEMENT SUBSTATIONS CO_2 VALVE, ITEM 1, 3 & 9 DETAILS	B1-117635

NOTES

1. ALL PIPING FROM SWEEP TAKE OFF OR SWEEP TEE TO BE DN 20 GALV. HEAVY TO A.S. CODE 1074 & TO BE SECURED TO WALLS, BEAMS OR CEILINGS USING UNISTRUT BRACKETS & CLAMPS AT A MAXIMUM SPACING OF 1800mm. PIPEWORK SHALL BE CLEANED BEFORE ASSEMBLY AND AFTER ASSEMBLY, THE ENTIRE SYSTEM SHALL BE BLOWN OUT BEFORE THE NOZZLES ARE FITTED.
2. ALL PIPEWORK SHALL BE CLEAR OF TRANSFORMER HATCH OPENING AND HAVE A MINIMUM FALL FROM POINT OF SUBSTATION ENTRY TO THE NOZZLE NEAREST THE SUMP OR ALTERNATIVELY THE END OF THE RUN OF 1:100. ALSO WHERE PIPEWORK ENTERS THE SUBSTATION CHAMBER AT A LEVEL LOWER THAN THE RING MAIN IS INSTALLED, PROVIDE A DN 25 PIPE DROPPER 100mm LONG. PROVIDE A DN 25 CAP WITH A Ø3 HOLE TO ALLOW FOR DRAINAGE OF THE PIPEWORK.
3. ALL CO_2 NOZZLES EXCEPT WHERE OTHERWISE STATED TO BE Ø3 AND DISCHARGE DOWNWARDS. NOZZLES MUST NOT BE DIRECTED AT EQUIPMENT.
4. ALL FINISHED PIPEWORK SHALL BE SUITABLY PRIMED THEN PAINTED SIGNAL RED ENAMEL (R13) TO A.S 2700S - 1985.
5. TRIPWIRE TO BE Ø4 GALVANISED FLEXIBLE STEEL WIRE ROPE 6/19 CONSTRUCTION & TO BE SECURED AT EACH END USING 2 BULLDOG CLAMPS. TRIPWIRE SHALL BE POSITIONED APPROX 50mm ABOVE CO_2 PIPEWORK & BE KEPT CLEAR OF TRANSFORMER HATCH OPENING.
6. TRIPWIRE SHALL BE TENSIONED ON TRIGGERS BEFORE SETTING DAMPERS WITH A TENSION NOT EXCEEDING 180 N. THE MOVEMENT FOR SETTING OR ACTIVATING MANUAL CONTROLS TO BE LIMITED TO 350mm. ENSURE THE MOVEMENT ALLOWS RELEASE OF TRIGGERS.
7. THERMALLY RELEASED LINKS TO BE IN ACCORDANCE WITH AS 1890. THE LINKS TO BE LEGIBLY STAMPED OR CAST WITH THE TEMPERATURE RATING (68°C), MAXIMUM WORKING LOAD (APPROX 60 KG), YEAR OF MANUFACTURE & THE MANUFACTURERS NAME OR IDENTIFYING SYMBOL. LINKS SHALL BE POSITIONED OVER OR IN CLOSE PROXIMITY TO TRANSFORMERS & HIGH VOLTAGE SWITCHES. MANUFACTURED BY ARCHER, ELSIE OR OTHER APPROVED EQUIVALENT.
8. PROVIDE TRIPWIRE SUPPORTS TO PREVENT ACTIVATED TRIPWIRE FALLING ONTO LIVE EQUIPMENT.
9. CAPACITY OF SUBSTATION CHAMBER IS 12 x 23 kg CO_2 BOTTLES.
10. THE EQUIPPING CONTRACTOR SHALL BE RESPONSIBLE TO POSITION THE PIPEWORK, SUPPORT BRACKETS, AWNING PULLEYS AND TRIPWIRES TO AVOID LIGHTS, CABLES, CONDUITS, ETC.
11. SUBSTATION EXHAUST FIRE DAMPER & INLET FIRE DAMPER TO BE IN ACCORDANCE WITH THE REQUIREMENTS OF NETWORK STANDARD NS113.
12. UPON COMPLETION OF THE INSTALLATION, THE INSTALLER SHALL PROVIDE A WRITTEN STATEMENT THAT THE SYSTEM HAS BEEN INSTALLED IN ACCORDANCE WITH THE DESIGN DRAWINGS AND THAT THE DAMPERS AND TRIPWIRE MECHANISMS HAVE BEEN TESTED AND FOUND TO OPERATE CORRECTLY.

0 1 2 3 4 5 m
METRES ON ORIGINAL DRAWING AT SCALE 1:50

CAD DRAWING
DO NOT MANUALLY AMEND
AMENDMENTS

Ausgrid
DESIGN & ENGINEERING BRANCH
570 GEORGE STREET
SYDNEY NSW 2000

SCALE	1 : 50
DESIGNED	COLIN SAWDY
DRAWN	COLIN SAWDY
CHECKED	PETER WRIGHT
APPROVED	PHIL HUDSON
DATE	03.07.2012
PRJTRK No.	
PROJECT NUMBER	

S48445 JONES BROADWAY
Cnr JONES STREET AND BROADWAY ULTIMO
CO2 FIRE PROTECTION AND VENTILATION ARRANGEMENT AND DETAILS

DRAWING No 229960 SHEET 16 AMD 0 SIZE A1

20110604 ©

Schneider Electric

SAP Order No

TRANSFORMER TEST CERTIFICATE

Tank No. 770
Transformer Serial No : AC131240121
SO No : 20201806028

TRANSFORMER RATING DETAILS

1500 kVA
3 Phase
50 Hz.

Volts H.V. 11000 Amps H.V. 78.73
Volts L.V. 433 Amps L.V. 2000

Tapping : +3 x 1.5%, 0, -5 x 1.5% (9 Taps)

Date of Test : 18/06/2013 Vector Group Connection : Dyn1

Routine Tests to AS 60076 - 2005 Cl 10.1.1 (IEC 60076)

VOLTAGE RATIO TEST			PASS
Taps :	"A" phase	"B" phase	"C" phase
1	46.011	46.011	46.014
2	45.307	45.306	45.306
3	44.650	44.649	44.653
4	44.006	44.007	44.006
5	43.362	43.360	43.365
6	42.720	42.724	42.720
7	42.015	42.007	42.005
8	41.367	41.369	41.369
9	40.719	40.712	40.728
Vector Group :	Dyn1	PASS	

INDUCED OVERVOLTAGE TEST (Duration 1 Min)		
Voltage:	866 V	PASS
Frequency :	100 Hz	

APPLIED VOLTAGE TEST (Duration 1 min)	
HV to LV & E Required	28 kV
HV to LV & E Actual	28.0 kV PASS
LV to HV & E Required	15 kV
LV to HV & E Actual	15.0 kV PASS

RESISTANCE TEST @		16.3 °C	
HV Terminals	Ohms	LV Terminals	Ohms
AB	0.5323	ab	0.000718
AC	0.5339	ac	0.000729
BC	0.5327	bc	0.000717

INSULATION RESISTANCE TEST @ 2.5 kV d.c.		
	M Ohms	
HV to LV & E	9600	PASS
LV to HV & E	7640	PASS

No Load Loss							
Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss
50 Hz	433.0 V	3.230 A	1.820 A	2.920 A	2.657 A	0.13%	1169 W
							PASS

Full Load Losses at		16.3 °C		(Tested on Tap # 4)		Results at 75°C	
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss	Full Load Loss	Impedance
846.0 V	68.52 A	68.85 A	68.17 A	68.51 A	9310 W	13963 W	8.85%
						PASS	*PASS*

Calculated Minimum Energy Performance (Efficiency @ L=0.5, cosφ =1.0 to AS 2374.1.2 Cl 1.5.1)	
99.38%	PASS

Guaranteed Performance			
No Load Loss	Full Load Loss	Impedance at 75 oC	MEPS Requirement
1115 Watts	13690 Watts	8.50%	99.35%

Remarks : This transformer complies with AS 2374.1.2 - 2003
EA serial Number 85112
EA Contract Number (CONTRACT 7878P/05)
EA Item Number (ITEM 12)

Certified : Kay Mathieson Date : 18/06/2013

Customer Witness : None

Schneider Electric (Australia) Pty Limited ABN 42 004 969 304
88 Sydney Road , PO Box 122, Benalla Vic 3672
Tel (03) 5762 3411, Fax (03) 5762 8062

Schneider Electric

TRANSFORMER TEST CERTIFICATE

Tank No. 685
Transformer Serial No : AC131240117
SO No : 20201806015

TRANSFORMER RATING DETAILS

1500 kVA	Volts H.V. 11000	Amps H.V. 78.73	
3 Phase	Volts L.V. 433	Amps L.V. 2000	
50 Hz.			

Tapping : +3 x 1.5%, 0, -5 x 1.5% (9 Taps)

Date of Test : 3/05/2013 Vector Group Connection : Dyn1

Routine Tests to AS 60076 - 2005 Cl 10.1.1 (IEC 60076)

VOLTAGE RATIO TEST			PASS
Taps :	"A" phase	"B" phase	"C" phase
1	46.018	46.001	45.985
2	45.303	45.306	45.303
3	44.662	44.656	44.655
4	44.010	44.014	44.011
5	43.378	43.354	43.366
6	42.712	42.715	42.711
7	42.012	42.012	42.009
8	41.380	41.368	41.355
9	40.714	40.716	40.706
Vector Group :	Dyn1	PASS	

INDUCED OVERVOLTAGE TEST (Duration 1 Min)		
Voltage:	866 V	PASS
Frequency :	100 Hz	

APPLIED VOLTAGE TEST (Duration 1 min)	
HV to LV & E Required	28 kV
HV to LV & E Actual	28.0 kV PASS
LV to HV & E Required	15 kV
LV to HV & E Actual	15.0 kV PASS

RESISTANCE TEST @	14.8 °C		
HV Terminals	Ohms	LV Terminals	Ohms
AB	0.5320	ab	0.000724
AC	0.5327	ac	0.000731
BC	0.5342	bc	0.000718

INSULATION RESISTANCE TEST @ 2.5 kV d.c. M Ohms		
HV to LV & E	16500	PASS
LV to HV & E	13300	PASS

No Load Loss							
Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss
50 Hz	433.0 V	2.520 A	1.760 A	2.350 A	2.210 A	0.11%	1149 W
							PASS

Full Load Losses at		14.8 °C		(Tested on Tap # 4)		Results at 75°C	
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss	Full Load Loss	Impedance
845.2 V	69.69 A	69.56 A	68.91 A	69.39 A	9532 W	14012 W	8.73%
						PASS	*PASS*

Calculated Minimum Energy Performance (Efficiency @ L=0.5, cosφ =1.0 to AS 2374.1.2 Cl 1.5.1)	
99.38%	PASS

Guaranteed Performance			
No Load Loss	Full Load Loss	Impedance at 75 oC	MEPS Requirement
1115 Watts	13690 Watts	8.50%	99.35%

Remarks : This transformer complies with AS 2374.1.2 - 2003
EA serial Number 84861
EA Contract Number (CONTRACT 7878P/05)
EA Item Number (ITEM 12)

Certified : [signature]

Date : 3/05/2013

Customer Witness : None

Schneider Electric

SAP Order No

TRANSFORMER TEST CERTIFICATE

Tank No. 786
Transformer Serial No : AC131240119
SO No : 20201806021

TRANSFORMER RATING DETAILS

1500 kVA
3 Phase
50 Hz.

Volts H.V. 11000 Amps H.V. 78.73
Volts L.V. 433 Amps L.V. 2000

Tapping : +3 x 1.5%, 0, -5 x 1.5% (9 Taps)

Date of Test : 4/06/2013 Vector Group Connection : Dyn1

Routine Tests to AS 60076 - 2005 Cl 10.1.1 (IEC 60076)

VOLTAGE RATIO TEST			PASS
Taps :	"A" phase	"B" phase	"C" phase
1	46.007	46.005	46.009
2	45.306	45.304	45.302
3	44.660	44.657	44.662
4	44.001	44.012	44.011
5	43.356	43.358	43.354
6	42.712	42.714	42.713
7	42.014	42.014	42.017
8	41.365	41.361	41.367
9	40.718	40.721	40.727
Vector Group :	Dyn1	PASS	

INDUCED OVERVOLTAGE TEST (Duration 1 Min)		
Voltage:	866 V	PASS
Frequency :	100 Hz	

APPLIED VOLTAGE TEST (Duration 1 min)	
HV to LV & E Required	28 kV
HV to LV & E Actual	28.0 kV PASS
LV to HV & E Required	15 kV
LV to HV & E Actual	15.0 kV PASS

RESISTANCE TEST @		15.9 °C	
HV Terminals	Ohms	LV Terminals	Ohms
AB	0.5280	ab	0.000716
AC	0.5292	ac	0.000722
BC	0.5291	bc	0.000713

INSULATION RESISTANCE TEST @ 2.5 kV d.c. M Ohms		
HV to LV & E	9990	PASS
LV to HV & E	8410	PASS

No Load Loss							
Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss
50 Hz	433.0 V	2.750 A	1.750 A	2.480 A	2.327 A	0.12%	1105 W
							PASS

Full Load Losses at		15.9 °C		(Tested on Tap # 4)		Results at 75°C	
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss	Full Load Loss	Impedance
867.1 V	71.19 A	71.35 A	70.47 A	71.00 A	9927 W	13881 W	8.75%
						PASS	PASS

Calculated Minimum Energy Performance (Efficiency @ L=0.5, cosφ =1.0 to AS 2374.1.2 Cl 1.5.1)	
99.39%	PASS

Guaranteed Performance			
No Load Loss	Full Load Loss	Impedance at 75 oC	MEPS Requirement
1115 Watts	13690 Watts	8.50%	99.35%

Remarks : This transformer complies with AS 2374.1.2 - 2003
EA serial Number 85109
EA Contract Number (CONTRACT 7878P/05)
EA Item Number (ITEM 12)

Certified : [signature] Kay Mathieson

Date : 4/06/2013

Customer Witness : None

V.Jun2012

Ausgrid

Substation Kiosk
Pre Commissioning Check Sheet

SC & Prj Trk Number	SC01596 / XCZ016032
Substation Number	S.48445
Substation Name	JONES BROADWAY

	Checked (Y)
Substation Housing	
The kiosk has been sited in accordance with NS 141 has been completed to the standards.	Y
Check substation number is fitted	Y
Check DANGER Signs in place	Y
Check operations of all locks and doors	Y
Check integrity of all paint/panels	Y
Check that HV & LV cable penetrations have been sealed	Y
Substation Equipment - HV	
Check all RMI operations and interlocks are operational	Y
If HV RMCB, check that PE have succcssfully completed their checks	Y
Check HV fuse size and type is correct as per SAO	N/A
Check HV fuses are installed with correct orientation of fuse striker pins (as indicated on the switch)	N/A
Check EFI (if required) fitted on correct HV cable	Y
Check RMI & TX oil level.	Y
Check transformer details and that nominated tap ratio is selected	Y
Transformer testing has been conducted as per NS117	Y
Check correct HV phasing (transformer leads)	Y
All HV cables have been installed and terminated as per Network Standards	Y
Substation Equipment - LV	
Check operations of the LV board & check correct LV phasing	Y
Check LV distributor cables / numbering are correct as per SAO	Y
Check LV fuse size and type to SAO	Y
Check MDI shorting link open and all CTs fitted	Y
All LV cables have been installed and terminated as per Network Standards	Y
Substation Equipment - Earthing	
Check earthing groups have been correctly terminated, labelled and that satisfactory readings were achieved	Y
Labelling	
Check all HV & LV labelling complies with NS 158 and all labelling is correct as per SAO	Y
Paperwork & Reports	
Completed TEI sheet have been submitted	Y
All equipment and cables have been tested as per Network Standards, and test reports submitted	Y
General	
All connections (electrical and fixing) have been checked	Y
Only approved materials have been used	Y
All excavations have been backfilled or made safe as per NS130	Y
Substation is complete to the relevant drawings and is ready to commission	Y
Equipping Permit	
Completed Equipping Permit (to be signed off at commissioning)	Y

ASP/1 -	WILKEN 2439/12
Name -	KARL ANDERSON
Qualification -	ELECTRICIAN
Signed -	K. And
Date -	11/09/2013

The person must have equivalent qualifications to an electrical fitter mechanic

Schneider Electric

SAP Order No

TRANSFORMER TEST CERTIFICATE

Tank No. 770
Transformer Serial No : AC131240121
SO No : 20201806028

TRANSFORMER RATING DETAILS

1500 kVA — Volts H.V. 11000 — Amps H.V. 78.73
3 Phase — Volts L.V. 433 — Amps L.V. 2000
50 Hz.

Tapping : +3 x 1.5%, 0, -5 x 1.5% (9 Taps)

Date of Test : 18/06/2013 Vector Group Connection : Dyn1

Routine Tests to AS 60076 - 2005 Cl 10.1.1 (IEC 60076)

VOLTAGE RATIO TEST			PASS
Taps :	"A" phase	"B" phase	"C" phase
1	46.011	46.011	46.014
2	45.307	45.306	45.306
3	44.650	44.649	44.653
4	44.006	44.007	44.006
5	43.362	43.360	43.365
6	42.720	42.724	42.720
7	42.015	42.007	42.005
8	41.367	41.369	41.369
9	40.719	40.712	40.728
Vector Group :	Dyn1	PASS	

INDUCED OVERVOLTAGE TEST (Duration 1 Min)		
Voltage:	866 V	PASS
Frequency :	100 Hz	

APPLIED VOLTAGE TEST (Duration 1 min)	
HV to LV & E Required	28 kV
HV to LV & E Actual	28.0 kV PASS
LV to HV & E Required	15 kV
LV to HV & E Actual	15.0 kV PASS

RESISTANCE TEST @	16.3 °C		
HV Terminals	Ohms	LV Terminals	Ohms
AB	0.5323	ab	0.000718
AC	0.5339	ac	0.000729
BC	0.5327	bc	0.000717

INSULATION RESISTANCE TEST @ 2.5 kV d.c.		
	M Ohms	
HV to LV & E	9600	PASS
LV to HV & E	7640	PASS

No Load Loss							
Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss
50 Hz	433.0 V	3.230 A	1.820 A	2.920 A	2.657 A	0.13%	1169 W
							PASS

Full Load Losses at		16.3 °C		(Tested on Tap # 4)		Results at 75°C	
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss	Full Load Loss	Impedance
846.0 V	68.52 A	68.85 A	68.17 A	68.51 A	9310 W	13963 W	8.85%
						PASS	*PASS*

Calculated Minimum Energy Performance (Efficiency @ L=0.5, cosφ =1.0 to AS 2374.1.2 Cl 1.5.1)	
99.38%	PASS

Guaranteed Performance			
No Load Loss	Full Load Loss	Impedance at 75 oC	MEPS Requirement
1115 Watts	13690 Watts	8.50%	99.35%

Remarks : This transformer complies with AS 2374.1.2 - 2003
EA serial Number 85112
EA Contract Number (CONTRACT 7878P/05)
EA Item Number (ITEM 12)

Certified : Kay Mutmoon Date : 18/06/2013

Customer Witness : None

Schneider Electric

TRANSFORMER TEST CERTIFICATE

Tank No. 685
Transformer Serial No : AC131240117
SO No : 20201806015

TRANSFORMER RATING DETAILS

1500 kVA — Volts H.V. 11000 — Amps H.V. 78.73
3 Phase — Volts L.V. 433 — Amps L.V. 2000
50 Hz.

Tapping : +3 x 1.5%, 0, -5 x 1.5% (9 Taps)

Date of Test : 3/05/2013 Vector Group Connection : Dyn1

Routine Tests to AS 60076 - 2005 Cl 10.1.1 (IEC 60076)

VOLTAGE RATIO TEST			PASS
Taps :	"A" phase	"B" phase	"C" phase
1	46.018	46.001	45.985
2	45.303	45.306	45.303
3	44.662	44.656	44.655
4	44.010	44.014	44.011
5	43.378	43.354	43.366
6	42.712	42.715	42.711
7	42.012	42.012	42.009
8	41.380	41.368	41.355
9	40.714	40.716	40.706
Vector Group :	Dyn1	PASS	

INDUCED OVERVOLTAGE TEST (Duration 1 Min)		
Voltage:	866 V	PASS
Frequency :	100 Hz	

APPLIED VOLTAGE TEST (Duration 1 min)	
HV to LV & E Required	28 kV
HV to LV & E Actual	28.0 kV PASS
LV to HV & E Required	15 kV
LV to HV & E Actual	15.0 kV PASS

RESISTANCE TEST @	14.8 °C		
HV Terminals	Ohms	LV Terminals	Ohms
AB	0.5320	ab	0.000724
AC	0.5327	ac	0.000731
BC	0.5342	bc	0.000718

INSULATION RESISTANCE TEST @ 2.5 kV d.c. M Ohms		
HV to LV & E	16500	PASS
LV to HV & E	13300	PASS

No Load Loss							
Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss
50 Hz	433.0 V	2.520 A	1.760 A	2.350 A	2.210 A	0.11%	1149 W
							PASS

Full Load Losses at		14.8 °C		(Tested on Tap # 4)		Results at 75°C	
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss	Full Load Loss	Impedance
845.2 V	69.69 A	69.56 A	68.91 A	69.39 A	9532 W	14012 W	8.73%
						PASS	PASS

Calculated Minimum Energy Performance (Efficiency @ L=0.5, cosφ =1.0 to AS 2374.1.2 Cl 1.5.1)	
99.38%	PASS

Guaranteed Performance			
No Load Loss	Full Load Loss	Impedance at 75 oC	MEPS Requirement
1115 Watts	13690 Watts	8.50%	99.35%

Remarks : This transformer complies with AS 2374.1.2 - 2003
EA serial Number 84861
EA Contract Number (CONTRACT 7878P/05)
EA Item Number (ITEM 12)

Certified : [signature] Date : 3/05/2013

Customer Witness : None

Schneider Electric (Australia) Pty Limited ABN 42 004 969 304
88 Sydney Road , PO Box 122, Benalla Vic 3672
Tel (03) 5762 3411, Fax (03) 5762 8062

Schneider Electric

SAP Order No

TRANSFORMER TEST CERTIFICATE

Tank No. 786
Transformer Serial No : AC131240119
SO No : 20201806021

TRANSFORMER RATING DETAILS

1500 kVA
3 Phase
50 Hz.

Volts H.V. 11000 Amps H.V. 78.73
Volts L.V. 433 Amps L.V. 2000

Tapping : +3 x 1.5%, 0, -5 x 1.5% (9 Taps)

Date of Test : 4/06/2013 Vector Group Connection : Dyn1

Routine Tests to AS 60076 - 2005 Cl 10.1.1 (IEC 60076)

VOLTAGE RATIO TEST			PASS
Taps :	"A" phase	"B" phase	"C" phase
1	46.007	46.005	46.009
2	45.306	45.304	45.302
3	44.660	44.657	44.662
4	44.001	44.012	44.011
5	43.356	43.358	43.354
6	42.712	42.714	42.713
7	42.014	42.014	42.017
8	41.365	41.361	41.367
9	40.718	40.721	40.727
Vector Group :	Dyn1	PASS	

INDUCED OVERVOLTAGE TEST (Duration 1 Min)		
Voltage:	866 V	PASS
Frequency :	100 Hz	

APPLIED VOLTAGE TEST (Duration 1 min)	
HV to LV & E Required	28 kV
HV to LV & E Actual	28.0 kV PASS
LV to HV & E Required	15 kV
LV to HV & E Actual	15.0 kV PASS

RESISTANCE TEST @		15.9 °C	
HV Terminals	Ohms	LV Terminals	Ohms
AB	0.5280	ab	0.000716
AC	0.5292	ac	0.000722
BC	0.5291	bc	0.000713

INSULATION RESISTANCE TEST @ 2.5 kV d.c. M Ohms		
HV to LV & E	9990	PASS
LV to HV & E	8410	PASS

No Load Loss							
Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss
50 Hz	433.0 V	2.750 A	1.750 A	2.480 A	2.327 A	0.12%	1105 W
							PASS

Full Load Losses at		15.9 °C		(Tested on Tap # 4)		Results at 75°C	
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss	Full Load Loss	Impedance
867.1 V	71.19 A	71.35 A	70.47 A	71.00 A	9927 W	13881 W	8.75%
						PASS	PASS

Calculated Minimum Energy Performance (Efficiency @ L=0.5, cosφ =1.0 to AS 2374.1.2 Cl 1.5.1)	
99.39%	PASS

Guaranteed Performance			
No Load Loss	Full Load Loss	Impedance at 75 oC	MEPS Requirement
1115 Watts	13690 Watts	8.50%	99.35%

Remarks : This transformer complies with AS 2374.1.2 - 2003
EA serial Number 85109
EA Contract Number (CONTRACT 7878P/05)
EA Item Number (ITEM 12)

Certified : [signature] Kay Matheson

Date : 4/06/2013

Customer Witness : None

Schneider Electric (Australia) Pty Limited ABN 42 004 969 304
88 Sydney Road , PO Box 122, Benalla Vic 3672
Tel (03) 5762 3411, Fax (03) 5762 8062

Chamber Substation
TEI Sheet

Details Recorded by (ASP/1)	WILKEN 12	Date	25/07/2013
Details Checked by (ASP Compliance)		Date	

Substation Details	
SC & Prj Trk Number	SC01596 XCZ016032
Substation Number	S.48445
Substation Name	JONES BROADWAY
Address	CNR OF WATTLE STREET AND BROADWAY
Suburb	BROADWAY
Substation Type	BASEMENT CHAMBER
Substation Phasing (Confirmed by Ausgrid)	ABC - cab?????
Non Firm Rating (Supplied by Ausgrid)	
Load Cycle (Supplied by Ausgrid)	

Chamber Building Construction			
Roof Manufacturer	LEND LEASE	Type	RE-INFORCED CONCRETE
Wall Manufacturer	LEND LEASE	Type	RE-INFORCED CONCRETE &
Floor Manufacturer	LEND LEASE	Type	CONCRETE
Perimeter Manufacturer		Type	

Earthing Details		
Combined or Segregated		
	Group A	Group B
Quantity of Electrodes	3	3
Depth of Electrodes(m)	7.2m	7.2m
Type of Electrode	COPPER CLAD STEEL	COPPER CLAD STEEL
Earthing Compound used (Y or N)	YES	YES
Material of Electrode	COPPER CLAD STEEL	COPPER CLAD STEEL
Diam of Electrode(mm)	15	15
Installed Method	DRILLED	DRILLED
Installed Date	10/05/2013	10/05/2013
Earth Cable (Cable Type / Size)	70mm PVC	70mm PVC
Cable Connection Type	COMPRESSION CRIMP	COMPRESSION CRIMP
Test Results (Individual) - (Ω)	12.36 OHMS	9.89 OHMS
Test Results (Combined) - (Ω)	6.89 OHMS	6.89 OHMS

No.1 Transformer / RMCB / LV CB Details

No.1 RMI / RMCB Details	
Manufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Contract No.	EA8448/06
Serial No.	SF00058097
Nameplate Voltage	12
Current rating	630A
HV fuse type and rating (if applicable)	

No.1 RMI / RMCB Endbox Details	
Position	RIGHT
Name	S.48445/A
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Interlock Fitted (Y /N)	YES

No. 1 RMI / RMCB Endbox Details	
Position	CENTRE
Name	TRANSFORMER 1
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	YES

No. 1 RMI / RMCB Endbox Details	
Position	LEFT
Name	S.48445/B
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	YES

No.1 Transformer Details	
Manufacturer	SCHNEIDER ELECTRIC
Year of Manufactuer	2013
Vector Group	Dyn1
Ausgrid Contract (Spec) Number	7578P/05
Serial Number (T / AC)	AC131240121
Serial Number (Ausgrid)	EA85112
KVA	15000KVA
Volts(Primary / Secondary)	11000/433
Impedance %	8.85%
Set Tap Position	7
Ratio of Set Tap Position	10505/433
Set Tap Voltage % (Supplied by Ausgrid)	-4.5%
Date Tap Set	25/07/2013
HV TX Tails (Cable Type / Size)	3x70mm CU1 XLPE 11KV

No.1 Transformer Cabling Details			
	HV Cables	**LV Cables**	**Neutral**
Type	CU1 XLPE 11KV	CU1 XLPE/PVC	CU1 XLPE/PVC
Size	70mm	500mm	500mm
Installation	CONDUIT	CABLE TRENCH	CABLE TRENCH
Qty per Phase	1	3	2

No.1 Transformer LV Circuit Breaker Details	
On LV Busbar No.	1
Manufacturer	SCHNEIDER ELECTRIC
Type	BNW40HFD3XXVV01
Contract No.	8P/05
Serial No.	N/A
Nameplate Voltage	690V
Current rating	3000A

No.1 Transformer MDI Details		No.1 Transformer CT Details	
On Phase	ABC	On Phase	ABC
Manufacturer	HOBUT	Maunfacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS3938
Scale	0-3600A	Voltage Rating	415V
K-Factor	1	Ratio	3000-5A

No.2 Transformer / RMCB / LV CB Details

No.2 RMI / RMCB Details	
Manufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Contract No.	EA8448/06
Serial No.	SF00058101
Nameplate Voltage	12KV
Current rating	630A
HV fuse type and rating (if applicable)	

No.2 RMI / RMCB Endbox Details	
Position	RIGHT
Name	S.48445/C
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	YES

No. 2 RMI / RMCB Endbox Details	
Position	CENTRE
Name	TRANSFORMER 2
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	Y

No. 2 RMI / RMCB Endbox Details	
Position	LEFT
Name	S.48445/D
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	Y

No.2 Transformer Details	
Manufacturer	SCHNEIDER ELECTRIC
Year of Manufactuer	2013
Vector Group	Dyn1
Ausgrid Contract (Spec) Number	7578P/05
Serial Number (T / AC)	AC131240117
Serial Number (Ausgrid)	EA 84861
KVA	1500KVA
Volts(Primary / Secondary)	11000/433
Impedance %	8.73%
Set Tap Position	7
Ratio of Set Tap Position	10505/433
Set Tap Voltage % (Supplied by EA)	-5%
Date Tap Set	25/07/2013
HV TX Tails (Cable Type / Size)	XLPE 11KV CU1 70mm

No.2 Transformer Cabling Details			
	HV Cables	**LV Cables**	**Neutral**
Type	XLPE 11KV CU1	XLPE/PVC CU1	XLPE/PVC CU1
Size	70mm	500mm	500mm
Installation	CONDUIT	CABLE TRENCH	CABLE TRENCH
Qty per Phase	1	3	2

No.2 Transformer LV Circuit Breaker Details	
On LV Busbar No.	1 LEFT
Manufacturer	SCHNEIDER ELECTRIC
Type	BNW40HFD3XXVV01
Contract No.	8P/05
Serial No.	N/A
Nameplate Voltage	690V
Current rating	3000A

No.2 Transformer MDI Details		No.2 Transformer CT Details	
On Phase	ABC	On Phase	ABC
Manufacturer	HOBUT	Maunfacturer	SCHNEIDER
Type	ANALOGUE	Type	BS3938
Scale	0-3600A	Voltage Rating	415V
K-Factor	1	Ratio	3000/5A

No.3 Transformer / RMCB / LV CB Details

No.3 RMI / RMCB Details	
Manufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Contract No.	EA 8448/06
Serial No.	SF00058106
Nameplate Voltage	12KV
Current rating	630A

No.3 RMI / RMCB Endbox Details	
Position	RIGHT
Name	S.48445/E
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	Y
HV fuse type and rating (if applicable)	

No. 3 RMI / RMCB Endbox Details	
Position	CENTRE
Name	TRANSFORMER 3
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	Y

No. 3 RMI / RMCB Endbox Details	
Position	LEFT
Name	S.48445/F
Maufacturer	ADAPT AUSTRALIA
Type	LUCY VRN6A
Current Rating	630A
Interlock Fitted (Y /N)	Y

No.3 Transformer Details	
Manufacturer	SCHNEIDER ELECTRIC
Year of Manufactuer	2013
Vector Group	DYN1
Ausgrid Contract (Spec) Number	7578P/05
Serial Number (T / AC)	AC131240119
Serial Number (Ausgrid)	EA 85109
KVA	1500KVA
Volts(Primary / Secondary)	11000/433
Impedance %	8.75%
Set Tap Position	7
Ratio of Set Tap Position	10505/433
Set Tap Voltage % (Supplied by Ausgrid)	-4.50%
Date Tap Set	25-Jul
HV TX Tails (Cable Type / Size)	XLPE 11KV CU1 70mm

No.3 Transformer Cabling Details			
	HV Cables	**LV Cables**	**Neutral**
Type	XLPE	XLPE	XLPE
Size	70mm	500mm	500mm
Installation	CONDUIT	CABLE TRENCH	CABLE TRENCH
Qty per Phase	1	3	2

No.3 Transformer LV Circuit Breaker Details	
On LV Busbar No.	2 RIGHT
Manufacturer	SCHNEIDER ELECTRIC
Type	BNW40HFD3XXVV01
Contract No.	8P/05
Serial No.	NW051028
Nameplate Voltage	690V
Current rating	3000A

No.3 Transformer MDI Details		No.3 Transformer CT Details	
On Phase	ABC	On Phase	ABC
Manufacturer	HOBUT	Maunfacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS3938
Scale	0-3600A	Voltage Rating	415V
K-Factor	1	Ratio	3000/5A

Common LV Board Details

LV Board Details	
Manufacturer	SCHNEIDER ELECTRIC
Type	LV BOARD
Nameplate (A)	
No. of Busbars	2
No. of Circuits	8

LV Bus Section Details	
Between LV Busbars	1&2
Manufacturer	SCHNEIDER ELECTRIC
Type	BNW40
Model	BNW40HFD3XXVV02
Operating Voltage	690V
Nameplate (A)	3000A

Summated MDI Details		Summated CT Details	
On Phase	ABC	On Phase	ABC
Manufacturer	ENERGY CONTROLS	Maunfacturer	SCHNEIDER ELECTRIC
Type	70D	Type	BS7626
Scale	0-12A	Voltage Rating	415V
K-Factor	K=600	Ratio	2450/5A

LV Surge Arrestors Details	
Manufacturer	AK POWER SOLUTIONS
Type	LN51AA
Quantity	3
Volts	510V

LV Distibutor Panel Details

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 1. UTS BROADWAY N0.1		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Busbar	1	Type	CIRCUIT BREAKER
Panel Rating	3000A	Size	3000A
Type	E-TYPE	Quantity	1
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse /CB Details	
Distributor No. / Name	DIST 2. THOMAS ST & S.568		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	EATON
Busbar	1	Type	J-TAG
Panel Rating	400A	Size	400A
Type	SAIFWAY	Quantity	3
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 3. WDNO		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	
Busbar	1	Type	
Panel Rating	400A	Size	
Type	SAIFWAY	Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 4. WNDO		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	
Busbar	1	Type	
Panel Rating	800A	Size	
Type	SAIFWAY	Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 5. WDNO		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	
Busbar	2	Type	
Panel Rating	400A	Size	
Type	SAIFWAY	Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 6. WDNO		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	
Busbar	2	Type	
Panel Rating	400A	Size	
Type	SAIFWAY	Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 7. WDNO		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	
Busbar	2	Type	
Panel Rating	800A	Size	
Type	SAIFWAY	Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name	DIST 8. UTS BROADWAY NO.2		
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Busbar	2	Type	CIRCUIT BREAKER
Panel Rating	3000A	Size	3000A
Type	E TYPE	Quantity	1
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name			
Manufacturer		Manufacturer	
Busbar		Type	
Panel Rating		Size	
Type		Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distributor Panel		LV Fuse / CB Details	
Distributor No. / Name			
Manufacturer		Manufacturer	
Busbar		Type	
Panel Rating		Size	
Type		Quantity	
Is relabelling required in a remote sub?:	If yes, new name:		
Remote sub name		Existing name	

LV Distibutor MDI / CT Details

MDI		CT	
Distributor Panel No.	DIST 1. UTS BROADWAY NO.1		
Phase	ABC	Phase	ABC
Manufacturer	HOBUT	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS3938
Scale	0-3600A	Volatge Rating	415V
K factor	1	Ratio	3000/5A

MDI		CT	
Distributor Panel No.	DIST 2. THOMAS ST & S.568		
Phase	A or B or C	Phase	ABC
Manufacturer	HOBUT	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS3938
Scale	0-480A	Volatge Rating	415V
K factor	1	Ratio	400/5A

MDI		CT	
Distributor Panel No.	DIST 3. WDNO		
Phase	A or B or C	Phase	ABC
Manufacturer	HOBUT	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS 3938
Scale	0-480A	Volatge Rating	415V
K factor	1	Ratio	400/5A

MDI		CT	
Distributor Panel No.	DIST 4. WDNO		
Phase	A or B or C	Phase	ABC
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS 3938
Scale	0-960A	Volatge Rating	415V
K factor	1	Ratio	800/5A

MDI		CT	
Distributor Panel No.	DIST 5. WDNO		
Phase	A or B or C	Phase	ABC
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS 3938
Scale	0-480A	Volatge Rating	415V
K factor	1	Ratio	400/5A

MDI		CT	
Distributor Panel No.	DIST 6. WDNO		
Phase	A or B or C	Phase	ABC
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS 3938
Scale	0-480A	Volatge Rating	415V
K factor	1	Ratio	400/5A

MDI		CT	
Distributor Panel No.	DIST 7. WDNO		
Phase	A or B or C	Phase	ABC
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS 3938
Scale	0-960A	Volatge Rating	415V
K factor	1	Ratio	800/5A

MDI		CT	
Distributor Panel No.	DIST 8. UTS BROADWAY NO.2		
Phase	ABC	Phase	ABC
Manufacturer	SCHNEIDER ELECTRIC	Manufacturer	SCHNEIDER ELECTRIC
Type	ANALOGUE	Type	BS 3938
Scale	0-3600A	Volatge Rating	415V
K factor	1	Ratio	3000/5A

MDI		CT	
Distributor Panel No.			
Phase		Phase	
Manufacturer		Manufacturer	
Type		Type	
Scale		Volatge Rating	
K factor		Ratio	

MDI		CT	
Distributor Panel No.			
Phase		Phase	
Manufacturer		Manufacturer	
Type		Type	
Scale		Volatge Rating	
K factor		Ratio	

Protection Details

LV Distributor Over Current Ct's			
Panel No.	DIST 1.	Quantity	3
Manufacturer	SCHNEIDER ELECTRIC	Voltage	415V
Type	BS7626	Ratio	3000/5A

LV Distributor Over Current Ct's			
Panel No.	DIST 8.	Quantity	3
Manufacturer	SCHNEIDER ELECTRIC	Voltage	415V
Type	BS7626	Ratio	3000/5A

LV Distributor Over Current Ct's			
Panel No.		Quantity	
Manufacturer		Voltage	
Type		Ratio	

LV Distributor Over Current Ct's			
Panel No.		Quantity	
Manufacturer		Voltage	
Type		Ratio	

EFI Details			
Manufacturer	SCHNEIDER ELECTRIC	Quantity	1
Type	CAFR11XX0001A	Voltage	11KV

EFI CT Details			
Location	S.48445/F	Quantity	1
Manufacturer	STEMAR ELECTRICAL	Voltage	1.1/2.5 KV
Type	EA 177474	Ratio	400/5A

No.1 Transformer HV Differential CT's			
Location	RMICB 1	Quantity	3
Manufacturer	TWS	Voltage	1.1/2.5KV
Type	SAS 83	Ratio	100/5A

No.1 Transformer VV Differential CT's			
Location	TX1	Quantity	3
Manufacturer	SCHNEIDER ELECTRIC	Voltage	415V
Type	BS3938	Ratio	2450/5A

No.2 Transformer HV Differential CT's			
Location	RMICB 2	Quantity	3
Manufacturer	TWS	Voltage	1.1/2.5KV
Type	SAS 83	Ratio	100/5A

No.2 Transformer LV Differential CT's			
Location	TX2	Quantity	3
Manufacturer	SCHNEIDER ELECTRIC	Voltage	415V
Type	BS3938	Ratio	2450/5A

No.3 Transformer HV Differential CT's			
Location	RMICB 3	Quantity	3
Manufacturer	TWS	Voltage	1.1/2.5KV
Type	SAS 83	Ratio	100/5A

No.3 Transformer LV Differential CT's			
Location	TX3	Quantity	3
Manufacturer	SCHNEIDER ELECTRIC	Voltage	415V
Type	BS3938	Ratio	2450/5A

Summated Over Current CT's			
Location	LV BOARD	Quantity	9
Manufacturer	SCHNEIDER ELECTRIC	Voltage	415V
Type	BS3938	Ratio	2000/5A

Relay Protection Panel Details

Panel 1			
Purpose	CUSTOMER 1		
Manufacturer	AUSGRID WORKSHOP		
Relay 1			
Purpose	OVERCURRENT	Serial No.	31992720
Manufacturer	SCHNEIDER ELECTRIC	Model No.	CDG33ER9003A5C
Relay 2			
Purpose		Serial No.	
Manufacturer		Model No.	
Relay 3			
Purpose		Serial No.	
Manufacturer		Model No.	

Panel 2			
Purpose	CUSTOMER 2		
Manufacturer	AUSGRID WORKSHOP		
Relay 1			
Purpose	OVERCURRENT	Serial No.	32156644
Manufacturer	SCHNEIDER ELECTRIC	Model No.	CDG33ER9003A5C
Relay 2			
Purpose		Serial No.	
Manufacturer		Model No.	
Relay 3			
Purpose		Serial No.	
Manufacturer		Model No.	

Panel 3			
Purpose	TRANSFORMER 3		
Manufacturer	AUSGRID WORKSHOP		
Relay 1			
Purpose	OVERCURRENT	Serial No.	32156645
Manufacturer	SCHNEIDER ELECTRIC	Model No.	CDG33ER9003A5C
Relay 2			
Purpose	DIFFERENTIAL	Serial No.	
Manufacturer	ELECTRIC SYSTEMS	Model No.	K3M
Relay 3			
Purpose		Serial No.	
Manufacturer		Model No.	

Panel 4			
Purpose	TRANSFORMER 2		
Manufacturer	AUSGRID WORKSHOP		
Relay 1			
Purpose	OVERCURRENT	Serial No.	32218447
Manufacturer	SCHNEIDER ELECTRIC	Model No.	CDG33ER9003A5C
Relay 2			
Purpose	DIFFERENTIAL	Serial No.	
Manufacturer	ELECTRIC SYSTEMS	Model No.	K3M
Relay 3			
Purpose		Serial No.	
Manufacturer		Model No.	

Panel 5			
Purpose	TRANSFORMER 1		
Manufacturer	AUSGRID WORKSHOP		
Relay 1			
Purpose	OVERCURRENT	Serial No.	32218449
Manufacturer	SCHNEIDER ELECTRIC	Model No.	CDG33ER9003A5C
Relay 2			
Purpose	DIFFERENTIAL	Serial No.	
Manufacturer	ELECTRIC SYSTEMS	Model No.	K3M
Relay 3			
Purpose		Serial No.	
Manufacturer		Model No.	

Panel 6			
Purpose	SUMMATED OVERCURRENT		
Manufacturer	AUSGRID WORKSHOP		
Relay 1			
Purpose	OVERCURRENT	Serial No.	32218454
Manufacturer	SCHNEIDER ELECTRIC	Model No.	CDG33ER9003A5C
Relay 2			
Purpose		Serial No.	
Manufacturer		Model No.	
Relay 3			
Purpose		Serial No.	
Manufacturer		Model No.	

Substation Battery Details			
Manufacturer	SAFT	Battery Voltage	10V
Type	SBH 12-2	Total Voltage	30V
No.	3	Amp Hours	10

V.Jun2012

Ausgrid

Transformer Test Results Sheet

Substation Number	S.48445	Make	SCHNEIDER ELECTRIC
Substation Name	JONES BROADWAY	KVA	1500 KVA
Transformer No. (Ausgrid)	85109	Ratio	11000/433
Serial No.	AC 132140119	Set Tap Position	10505/433 (7)
Make	SCHNEIDER ELECTRIC	Vector	DYN1
SC & Prj Trk Number	SC0 1596 XCZ 16032		

Insulation Resistance	100+ megohms is acceptable if the highest reading on scale				
HV - Earth (200 megohms min)	400MEG Ω	Result	Ω	Pass/Fail	PASS
LV Earth (100 megohms min)	220MEG Ω	Result	Ω	Pass/Fail	PASS
HV - LV (200 megohms min)	400 MEG Ω	Result	Ω	Pass/Fail	PASS

HV Continuity	all results per tap should be similar, generally between 0.5 & 1.0 ohm							
Tap Position 1.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 2.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 3.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 4.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 5.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 6.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 7.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS
Tap Position 8.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS
Tap Position 9.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS

LV Continuity	all results should be close to 0.0 ohms							
	A-N	0Ω	B-N	0Ω	C-N	0Ω	Pass/Fail	PASS

HV Earth Continuity	must be less than 0.5 ohms	Result	0Ω
		Pass/Fail	PASS
LV Earth Continuity	must be less than 0.5 ohms	Result	0Ω
		Pass/Fail	PASS
Substation HV & LV Earth Insulation (only for segregated earthing systems)	completed with the bond disconnected at the test point & the HV & LV earth group tails disconnected (minimum 1.0 megohm)	Result	Ω
		Pass/Fail	N/A

ASP/1 -	WILKEN
Name -	GLENN HUDSON
Qualification (note) -	ELECTRICIAN
Signed -	
Date -	30/07/2013
Test Instrument Details -	KYORITSU 3132A
Instrument No. -	5176495
Calibration Date -	8/05/2013
Testing Organisation -	TRVMS
NATA Registration Number -	116/109

The person must have equivalent qualifications to an electrical fitter mechanic

V.Jun2012

Ausgrid

Transformer Test Results Sheet

Substation Number	S.48445	Make	SCHNEIDER ELECTRIC
Substation Name	JONES BROADWAY	KVA	1500 KVA
Transformer No. (Ausgrid)	84861	Ratio	11000/433
Serial No.	AC 132140117	Set Tap Position	10505/433 (7)
Make	SCHNEIDER ELECTRIC	Vector	DYN1
SC & Prj Trk Number	SC0 1596 XCZ 16032		

Insulation Resistance	100+ megohms is acceptable if the highest reading on scale				
HV - Earth (200 megohms min)	400MEG Ω	Result	Ω	Pass/Fail	PASS
LV Earth (100 megohms min)	220MEG Ω	Result	Ω	Pass/Fail	PASS
HV - LV (200 megohms min)	400 MEG Ω	Result	Ω	Pass/Fail	PASS

HV Continuity	all results per tap should be similar, generally between 0.5 & 1.0 ohm							
Tap Position 1.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 2.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 3.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 4.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 5.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 6.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 7.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS
Tap Position 8.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS
Tap Position 9.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS

LV Continuity	all results should be close to 0.0 ohms							
	A-N	0Ω	B-N	0Ω	C-N	0Ω	Pass/Fail	PASS

HV Earth Continuity	must be less than 0.5 ohms	Result	0Ω
		Pass/Fail	PASS
LV Earth Continuity	must be less than 0.5 ohms	Result	0Ω
		Pass/Fail	PASS
Substation HV & LV Earth Insulation (only for segregated earthing systems)	completed with the bond disconnected at the test point & the HV & LV earth group tails disconnected (minimum 1.0 megohm)	Result	Ω
		Pass/Fail	N/A

ASP/1 -	WILKEN
Name -	GLENN HUDSON
Qualification (note) -	ELECTRICIAN
Signed -	
Date -	30/07/2013
Test Instrument Details -	KYORITSU 3132A
Instrument No. -	5176495
Calibration Date -	8/05/2013
Testing Organisation -	TRVMS
NATA Registration Number -	116/109

The person must have equivalent qualifications to an electrical fitter mechanic

V.Jun2012

Ausgrid

Transformer Test Results Sheet

Substation Number	S.48445	Make	SCHNEIDER ELECTRIC
Substation Name	JONES BROADWAY	KVA	1500 KVA
Transformer No. (Ausgrid)	85112	Ratio	11000/433
Serial No.	AC 132130007	Set Tap Position	10505/433 (7)
Make	SCHNEIDER ELECTRIC	Vector	DYN1
SC & Prj Trk Number	SC0 1596 XCZ 16032		

Insulation Resistance	100+ megohms is acceptable if the highest reading on scale				
HV - Earth (200 megohms min)	400MEG Ω	Result	Ω	Pass/Fail	PASS
LV Earth (100 megohms min)	220MEG Ω	Result	Ω	Pass/Fail	PASS
HV - LV (200 megohms min)	400 MEG Ω	Result	Ω	Pass/Fail	PASS

HV Continuity	all results per tap should be similar, generally between 0.5 & 1.0 ohm							
Tap Position 1.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 2.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 3.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 4.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 5.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 6.	A-B	0.55Ω	A-C	0.55Ω	B-C	0.55Ω	Pass/Fail	PASS
Tap Position 7.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS
Tap Position 8.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS
Tap Position 9.	A-B	0.50Ω	A-C	0.50Ω	B-C	0.50Ω	Pass/Fail	PASS

LV Continuity	all results should be close to 0.0 ohms							
	A-N	0Ω	B-N	0Ω	C-N	0Ω	Pass/Fail	PASS

HV Earth Continuity	must be less than 0.5 ohms	Result	0Ω
		Pass/Fail	PASS
LV Earth Continuity	must be less than 0.5 ohms	Result	0Ω
		Pass/Fail	PASS
Substation HV & LV Earth Insulation (only for segregated earthing systems)	completed with the bond disconnected at the test point & the HV & LV earth group tails disconnected (minimum 1.0 megohm)	Result	Ω
		Pass/Fail	N/A

ASP/1 -	WILKEN
Name -	GLENN HUDSON
Qualification (note) -	ELECTRICIAN
Signed -	
Date -	30/07/2013
Test Instrument Details -	KYORITSU 3132A
Instrument No. -	5176495
Calibration Date -	8/05/2013
Testing Organisation -	TRVMS
NATA Registration Number -	116/109

The person must have equivalent qualifications to an electrical fitter mechanic

10 Kent Road
Mascot, NSW 2020

www.powerware.com

Powering Business Worldwide

UPS MAINTENANCE REPORT

For

UTS

CNR BROADWAY & WATTLE STREET
ULTIMO, NSW 02007

Attention: **TERRY KUITERT**
Phone: **0419 492 982 x02 9212 1433**
Email: terrykuitert@nilsen.com.au

Inspection Date: 1/09/2014

Service Performed By: ***Dave Ng***

Service Request:	**Serial Number:**
2649406	2F281JBA06

CSE Signature ______________________ Date 9/01/2014
Dave Ng

Customer Signature ______________________ Date 9/01/2014
TERRY KUITERT

EATON
Powering Business Worldwide

Date 09/01/14
SR # 2649406
Party # 965636
Contract ANZWARR_1
Expiration (27-Nov-2014)

UPS Field Activity Report

Site Information

Name UTS
Address
CNR BROADWAY & WATTLE STREET
City ULTIMO ST NSW Zip 02007

Equipment Information

Unit / Model PW9355-10-NL-25-64X9AH KVA 10 KW 9
Serial # 2F281JBA06
CTO or PN# 935510NL25
Location

QOS Information

POC TERRY KUITERT
Company NILSEN (NSW) PTY LTD
Address PO BOX 368

City RYDALMERE ST NSW Zip 01701
TEL 0419 492 982 EXT 02 9212 1433 FAX
Email: terrykuitert@nilsen.com.au

Battery Information

Manufacture EATON
Battery Model PWHR1234W2FR
# of Strings 2 Jars/Str 32 Cells/Jar 6
Date Code Age 0
Battery Type Sealed Battery Cabinet Type Cab - No Tray

Service Information

☐ Emergency Maintenance ☐ Preventive Maintenance ☐ Customer Visit ☐ Stand-By Service ☐ Modification ☒ Start-Up
☐ Battery Maintenance ☐ Quarterly ☐ Semi-Annual ☐ Monthly ☐ Annual ☐ Load Test ☐ Battery Update
☐ Contract ☐ Warranty ☐ No Charge ☐ Billable ☒ Quoted ☐ Performance Check ☐ Major PM ☐ Other:

Part Usage

Part Number	Description	Qty	CSE or Customer

☐ Counter to Counter ☐ Overnight Other Cost $

Notes:

UPS room has got no air-con during commissioning. Advised customer to turn on air-con as soon as possible as UPS was left online before left site.

Advised customer main breaker to UPS is under-rated for10KVA UPS under full load.

Bypass signal cables were connected and tested OK.

Performed mains failure for battery discharge test OK. Load transferred from 'Normal' to 'Bypass' OK.

Operational Inspection - OK
Environmental Evaluation - No room ventilation at this point of time
Battery Discharge - OK
Visual Inspection - OK
Mechanical Inspection - OK
Electrical Inspection - OK

Powering Business Worldwide

Date	09/01/14
SR #	2649406
Party #	965636
Contract	ANZWARR_1
Expiration	(27-Nov-2014)

UPS Field Activity Report

Site Information

Name **UTS**
Address
CNR BROADWAY & WATTLE STREET
City **ULTIMO** ST **NSW** Zip **02007**

Equipment Information

Unit / Model **PW9355-10-NL-25-64X9AH** KVA **10** KW **9**
Serial # **2F281JBA06**
CTO or PN# **935510NL25**
Location

QOS Information

POC **TERRY KUITERT**
Company **NILSEN (NSW) PTY LTD**
Address **PO BOX 368**
City **RYDALMERE** ST **NSW** Zip **01701**
TEL **0419 492 982** EXT **02 9212 1433** FAX
Email: **terrykuitert@nilsen.com.au**

Battery Information

Manufacture **EATON**
Battery Model **PWHR1234W2FR**
# of Strings **2** Jars/Str **32** Cells/Jar **6**
Date Code Age **0**
Battery Type **Sealed** Battery Cabinet Type **Cab - No Tray**

Input Readings

Nominal	239.6
A-B VAC	428
B-C VAC	428.4
C-A VAC	428.7
A-N VAC	245.9
B-N VAC	245.6
C-N VAC	249
A-I	3
B-I	3
C-I	3
Frequency	50

Bypass Readings

Nominal	239.6
A-B VAC	428
B-C VAC	428.4
C-A VAC	428.7
A-N VAC	245.9
B-N VAC	245.6
C-N VAC	249

Output Readings

(MOB Closed)

Nominal	239.6
A-B VAC	417.3
B-C VAC	417.1
C-A VAC	416.9
A-N VAC	241.1
B-N VAC	240.8
C-N VAC	240.9
A-I	0
B-I	0
C-I	0
Frequency	50
Percent Load	0%

Other Readings

Battery Volts **435**

UPS Visual Inspection	Good	Remote Monitor Panel Operation	N/A	Battery Visual Inspection	Good
UPS Fans	Good	Monitor Panel Function	N/A		
UPS Metering	Good	Communication Function	Good	UPS Room Temperature	See Note
		Mimic Screen	Good	UPS Room Ventilation	See Note
Ctrl & Pwr Wire Heating	Good	Cellwatch / Battery Monitor	N/A	UPS Room Cleanliness	Good
AC/DC Caps	Good	Time and Date Set Correctly	Good	UPS Room Floor Type	Good
Static Switch Fuses	Good	Download/Check Event Log	Good	UPS Air Filters	N/A
Output Fuses	Good	Download EEPS	Good	Battery Room Temperature	N/A
Connector (Crimp&Bolt)	Good	Download Configuration Report	N/A	Battery Room Ventilation	N/A
Waveform Distortion	N/A	Download Unit Stats	N/A	Battery Room Cleanliness	N/A
System Transfers	Good	FSB's checked	Good	Battery Room Floor Type	N/A

Powering Business Worldwide

Date	09/01/14
SR #	2649406
Party #	965636
Contract	ANZWARR_1
Expiration	(27-Nov-2014)

UPS Field Activity Report

Site Information

Name **UTS**

Address

CNR BROADWAY & WATTLE STREET

City **ULTIMO** ST **NSW** Zip **02007**

Equipment Information

Unit / Model **PW9355-10-NL-25-64X9AH** KVA **10** KW **9**

Serial # **2F281JBA06**

CTO or PN# **935510NL25**

Location

Notes:

Maintenance Bypass Switch

Part no: MBS33NSB40BW
Serial no: 03098112

PQO-A UPS and Battery Field Service Daily Safety

Customer:	NILSEN (NSW) PTY LTD	Date:	9/01/2014
Customer Location:	ULTIMO, NSW	Eaton Area Manager:	Robert King
Customer Contact:	Terry Kuitert	Eaton Job Number:	2649406

Job Site (Customer) Requirements :

	Yes	No		Yes	No
Hardhat	X		Ladders		X
Safety Shoes	X		LOTO Procedure		X
Safety Glasses		X	Safety Grounds		X
Hearing Protection		X	Fire Extinguisher		X
Gloves		X	Quick Review Checklists Reviewed		X
Fall Protection		X	ARC Flash Hazard/ Risk Category:		X
Flame Retardant Clothing		X	Requires higher than level 2 PPE		X
GFCI use required		X	Energized Work Permit Required		X
First Aid		X	Other:____________________		X
Hazcom/WHMIS (MSDS)		X	Other:____________________		X

Environmental Check: LOOK AROUND

	Yes	No		Yes	No
Live work / Adjacent Circuits	X		Backfeed/Electrical Shock	X	
Stored Energy	X		Eye Hazard		X
Capacitors	X		Lifting Hazard		X
Overhead Work		X	Hearing Hazard		X
Hazardous Atmosphere		X	Other:________________		X
Confined Space		X	Other:________________		X
Rotating Machinery		X	Other:________________		X
Tripping		X			
Fire Hazard		X			
Hazardous Materials		X			

REQUIRED!

DOES EVERYONE ON THE CREW THOROUGHLY UNDERSTAND:

	Yes	No
THE JOB?	X	
THEIR ROLE IN THE JOB?	X	
ALL SAFETY REQUIREMENTS?	X	

Crew Members:

Name	Date	LOTO On	LOTO Off
Dave Ng	1/10/2014	X	

PRE-ENERGIZED CHECKLIST

	Yes	No
Customer Notified & Authorized	X	
All Crew MembersNotified	X	
All Grounds Removed	X	
All LOTO's Removed	X	

Switching Authorized by

Customer:

Being an authorized representative of the above, I hereby authorize Eaton Electrical Services & Systems to perform the switching of the designated device(s) below on behalf of customer. Customer will be responsible for, and will waive and release Eaton Electrical from, any claims, loss or damage to, or arising from, customer's equipment, operations, processes or services which may result from switching these device(s).

Device Designation(s):

Name / Date / Time:

Signature: ____________________

10 Kent Road
Mascot, NSW 2020

www.powerware.com

UPS MAINTENANCE REPORT

For
UTS

CNR BROADWAY & WATTLE STREET
ULTIMO, NSW 02007

Attention: **TERRY KUITERT**
Phone: **0419 492 982 x02 9212 1433**
Email: terrykuitert@nilsen.com.au

Inspection Date: 9/01/2014

Service Performed By: ***Dave Ng***

Service Request:	**Serial Number:**
2649424	2F281JBA07

CSE Signature ______________________ Date 9/01/2014
Dave Ng

Customer Signature ______________________ Date 9/01/2014
TERRY KUITERT

EATON

Powering Business Worldwide

Date	09/01/14
SR #	2649424
Party #	965636
Contract	ANZWARR_1
Expiration	(27-Nov-2014)

UPS Field Activity Report

Site Information

Name **UTS**

Address

CNR BROADWAY & WATTLE STREET

City **ULTIMO** ST **NSW** Zip **02007**

Equipment Information

Unit / Model **PW9355-10-NL-25-64X9AH** KVA **10** KW **9**

Serial # **2F281JBA07**

CTO or PN# **935510NL25**

Location

QOS Information

POC **TERRY KUITERT**

Company **NILSEN (NSW) PTY LTD**

Address **PO BOX 368**

City **RYDALMERE** ST **NSW** Zip **01701**

TEL **0419 492 982** EXT **02 9212 1433** FAX

Email: **terrykuitert@nilsen.com.au**

Battery Information

Manufacture **EATON**

Battery Model **PWHR1234W2FR**

# of Strings **2** Jars/Str **32** Cells/Jar **6**

Date Code Age **0**

Battery Type **Sealed** Battery Cabinet Type **Cab - No Tray**

Service Information

☐ Emergency Maintenance ☐ Preventive Maintenance ☐ Customer Visit ☐ Stand-By Service ☐ Modification ☒ Start-Up

☐ Battery Maintenance ☐ Quarterly ☐ Semi-Annual ☐ Monthly ☐ Annual ☐ Load Test ☐ Battery Update

☐ Contract ☐ Warranty ☐ No Charge ☐ Billable ☒ Quoted ☐ Performance Check ☐ Major PM ☐ Other:

Part Usage

Part Number	Description	Qty	CSE or Customer

☐ Counter to Counter ☐ Overnight Other Cost $

Notes:

UPS room has got no air-con during commissioning. Advised customer to turn on air-con as soon as possible as UPS was left online before left site.

Advised customer main breaker to UPS is under-rated for10KVA UPS under full load.

Bypass signal cables were connected and tested OK.

Performed mains failure for battery discharge test OK. Load transferred from 'Normal' to 'Bypass' OK.

Operational Inspection - OK
Environmental Evaluation - No room ventilation at this point of time
Battery Discharge - OK
Visual Inspection - OK
Mechanical Inspection - OK
Electrical Inspection - OK

EATON
Powering Business Worldwide

Date	09/01/14
SR #	2649424
Party #	965636
Contract	ANZWARR_1
Expiration	(27-Nov-2014)

UPS Field Activity Report

Site Information

Name	UTS
Address	
	CNR BROADWAY & WATTLE STREET
City	ULTIMO
ST	NSW
Zip	02007

Equipment Information

Unit / Model	PW9355-10-NL-25-64X9AH
KVA	10
KW	9
Serial #	2F281JBA07
CTO or PN#	935510NL25
Location	

QOS Information

POC	TERRY KUITERT
Company	NILSEN (NSW) PTY LTD
Address	PO BOX 368
City	RYDALMERE
ST	NSW
Zip	01701
TEL	0419 492 982
EXT	02 9212 1433
FAX	
Email:	terrykuitert@nilsen.com.au

Battery Information

Manufacture	EATON
Battery Model	PWHR1234W2FR
# of Strings	2
Jars/Str	32
Cells/Jar	6
Date Code	
Age	0
Battery Type	Sealed
Battery Cabinet Type	Cab - No Tray

Input Readings

Nominal	239.6
A-B VAC	430.3
B-C VAC	429.9
C-A VAC	432.6
A-N VAC	249.3
B-N VAC	248.6
C-N VAC	250.4
A-I	3
B-I	3
C-I	3
Frequency	50

Bypass Readings

Nominal	239.6
A-B VAC	430.3
B-C VAC	429.9
C-A VAC	432.6
A-N VAC	249.3
B-N VAC	248.6
C-N VAC	250.4

Output Readings
(MOB Closed)

Nominal	239.6
A-B VAC	417.2
B-C VAC	417.1
C-A VAC	416.8
A-N VAC	240.8
B-N VAC	241.2
C-N VAC	240.8
A-I	0
B-I	0
C-I	0
Frequency	50
Percent Load	0%

Other Readings

Battery Volts	434

UPS Visual Inspection	Good
UPS Fans	Good
UPS Metering	Good
Ctrl & Pwr Wire Heating	Good
AC/DC Caps	Good
Static Switch Fuses	Good
Output Fuses	Good
Connector (Crimp&Bolt)	Good
Waveform Distortion	N/A
System Transfers	Good

Remote Monitor Panel Operation	N/A
Monitor Panel Function	N/A
Communication Function	Good
Mimic Screen	Good
Cellwatch / Battery Monitor	N/A
Time and Date Set Correctly	Good
Download/Check Event Log	Good
Download EEPS	Good
Download Configuration Report	N/A
Download Unit Stats	N/A
FSB's checked	Good

Battery Visual Inspection	Good
UPS Room Temperature	See Note
UPS Room Ventilation	See Note
UPS Room Cleanliness	Good
UPS Room Floor Type	Good
UPS Air Filters	N/A
Battery Room Temperature	N/A
Battery Room Ventilation	N/A
Battery Room Cleanliness	N/A
Battery Room Floor Type	N/A

Powering Business Worldwide

Date	09/01/14
SR #	2649424
Party #	965636
Contract	ANZWARR_1
Expiration	(27-Nov-2014)

UPS Field Activity Report

Site Information

Name **UTS**

Address

CNR BROADWAY & WATTLE STREET

City **ULTIMO** ST **NSW** Zip **02007**

Equipment Information

Unit / Model **PW9355-10-NL-25-64X9AH** KVA **10** KW **9**

Serial # **2F281JBA07**

CTO or PN# **935510NL25**

Location

Notes:

Maintenance Bypass Switch

Part No: MBS33NSB40BW
Serial no: 03098117

PQO-A UPS and Battery Field Service Daily Safety

Customer:	NILSEN (NSW) PTY LTD	Date:	9/01/2014
Customer Location:	ULTIMO, NSW	Eaton Area Manager:	Robert King
Customer Contact:	Terry Kuitert	Eaton Job Number:	2649424

Job Site (Customer) Requirements :

	Yes	No		Yes	No
Hardhat	X		Ladders		X
Safety Shoes	X		LOTO Procedure		X
Safety Glasses		X	Safety Grounds		X
Hearing Protection		X	Fire Extinguisher		X
Gloves		X	Quick Review Checklists Reviewed		X
Fall Protection		X	ARC Flash Hazard/ Risk Category:		X
Flame Retardant Clothing		X	Requires higher than level 2 PPE		X
GFCI use required		X	Energized Work Permit Required		X
First Aid		X	Other:____________________		X
Hazcom/WHMIS (MSDS)		X	Other:____________________		X

Environmental Check: LOOK AROUND

	Yes	No		Yes	No
Live work / Adjacent Circuits	X		Backfeed/Electrical Shock	X	
Stored Energy	X		Eye Hazard		X
Capacitors	X		Lifting Hazard		X
Overhead Work		X	Hearing Hazard		X
Hazardous Atmosphere		X	Other:________________		X
Confined Space		X	Other:________________		X
Rotating Machinery		X	Other:________________		X
Tripping		X			
Fire Hazard		X			
Hazardous Materials		X			

REQUIRED!

DOES EVERYONE ON THE CREW THOROUGHLY UNDERSTAND:

	Yes	No
THE JOB?	X	
THEIR ROLE IN THE JOB?	X	
ALL SAFETY REQUIREMENTS?	X	

Crew Members:

Name	Date	LOTO On	LOTO Off
Dave Ng	9/01/2014	X	

PRE-ENERGIZED CHECKLIST

	Yes	No
Customer Notified & Authorized	X	
All Crew MembersNotified	X	
All Grounds Removed	X	
All LOTO's Removed	X	

Switching Authorized by

Customer:

Being an authorized representative of the above, I hereby authorize Eaton Electrical Services & Systems to perform the switching of the designated device(s) below on behalf of customer. Customer will be responsible for, and will waive and release Eaton Electrical from, any claims, loss or damage to, or arising from, customer's equipment, operations, processes or services which may result from switching these device(s).

Device Designation(s):

Name / Date / Time:

Signature: ____________________

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number 116.
Site Number 109

TEST REPORT

Instrument Details: | **Report Number NC 13.30989**

Description:	Clamp Meter
Brand:	Fluke
Model:	337
Serial No:	593290372
Asset No:	T093
CALID No:	1027295

Customer Details:
Eaton Industries Pty Ltd - Power Quality - NSW
10 Kent Road
Mascot NSW 2020

Reference:
539620
Test Location:
Prestons

Test Details:

Calibration Date:	12, March 2013
Client Specified Due Date:	12, March 2015
Issue Date:	12, March 2013
Environment:	23.0°C

Traceability
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/National Standards.

Procedure/Specification Reference
CP980771/Manufacturer's Specifications

Test Results:
As Found Condition: All measurements fall within the tolerance limits specified in the above Specification Reference.

As Left Condition: All measurements fall within the tolerance limits specified in the above Specification Reference.

Testing Officer: Desmond Ha **Approved Signatory:** Paul Jensen

Attachment A: **Test Results** (3 pages)

Checked:

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number 116.
Site Number 109

TEST REPORT

Report Number NC 13.30990

Instrument Details:

Description:	Multimeter
Brand:	Fluke
Model:	289
Serial No:	96620002
Asset No:	
CALID No:	1023642

Customer Details:
Eaton Industries Pty Ltd - Power Quality - NSW
10 Kent Road
Mascot NSW 2020

Reference:
539620
Test Location:
Prestons

Test Details:

Calibration Date:	14, March 2013
Client Specified Due Date:	14, March 2015
Issue Date:	14, March 2013
Environment:	23.0°C

Traceability
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/National Standards.

Procedure/Specification Reference
CP980719/Manufacturer's Specifications

Test Results:
As Found Condition: All measurements fall within the tolerance limits specified in the above Specification Reference.

As Left Condition: All measurements fall within the tolerance limits specified in the above Specification Reference.

Testing Officer: Desmond Ha

Approved Signatory: Mario Cafarelli

Attachment A: **Test Results** (4 pages)

Checked:

EATON | **Powerware**

EATON INDUSTRIES Pty Ltd
Ref: Rev:01 Issued: 22/08/2011

TEST REPORT: EDX 20 - 40kVA.

Rating: 30 kVA
Job No: 1050700
Type: EDX30K4AU
Manufacturer Part No: EDX30K4AU
Local Part No:
Manufacturer Serial No: 1003256889 0002
Customer No:
Sales Order No: 9193535
Customer: NILSEN (NSW)
Battery Pack Serial No(s):
Parallel Unit No: of:
Test meters used (Item Nos.) T092 T093

Firmware. Revision supplied:
UPS: 0.8 LCD: 0.5
Static Bypass Board Modified Y/N N

Revision Upgraded: Y/N N
UPS: LCD:
Setup S/N:
Setup Model:

Settings. *User settings.* User LCD screen to read correct model / SN No. etc Y/N Y

1 Restart when Mains restore enable Y/N Y
2 Date set to (mm/dd/yy) 02/25/13
3 Time set to (Hr/min) 10 : 00
4 English language selected Y/N Y

Service settings.

5 Bypass Voltage max. (+10%) 264 V
5a Bypass Voltage min. (-15%) 204 V
6 Output Voltage set at 240 V
7 Line Voltage max. 274V Y/N Y
7a Line Voltage min. 161V Y/N Y
8 Line Freq. max. 70Hz Y/N Y
8a Line Freq. max. 40Hz Y/N Y
9 Phase Lock set at 1.0Hz/s Y/N Y
10 Bypass Freq. Offset max. +4.0% Y/N Y
10a Bypass Freq. Offset min. -4.0% Y/N Y
11 Charge Type set to Type 1
12 Charge Current set to 4.5A
13 Battery Capacity set to 38 AH
14 Volt 1/2 13.5 V / 13.5 V
15 Battery number set to 32
16 Battery Low Voltage Alarm 11.0V Y/N Y
17 EPO active Y/N Y

System Check.

35 Output Voltage displayed: ΦA 238 V ΦB 238 V ΦC 239 V
Output Voltage measured: ΦA 239 V ΦB 239 V ΦC 239 V
36 UPS run at 18 kW resistive load for 1 Hrs Load indicated 74%
38 EPO tested Y/N Y Run time indicated 50 min
39 Amps indicated ΦA 24 ΦB 24 ΦC 23 Actual ΦA 24 ΦB 25 ΦC 24
40 Parallel system tested at - kW load for - Hrs

Partial discharge.

41 Mains failure with 40 Ah batteries for 5 min with load 18 kW
42 Charge current verified at +4.5A -4.5A Batts charged to +/- 208/207V

Battery installation. Battery Part No: Quantity
Battery pack Part No: Quantity

Final Assembly Check

Data cable & user pack correct Y/N Y
Blue Eaton service label attached Y/N Y
All screws/brackets replaced Y/N Y

Tested by: TONG LUU **Date:** 25/2/13 **Signed:** Tony

EATON
Powering Business Worldwide

EATON INDUSTRIES Pty Ltd
Ref: PR-F027 Rev: A Issued: 01/11/201

TEST REPORT: 9155 UPS 8-30kVA. 9355 UPS 8-40kVA

Rating: 10 kVA
Type: 935510NL25
Local Part No: 1023414
Customer No:
Customer: NILSEN (NSW)
Parallel Unit No: of

Job No: 1050699
Manufacturer Part No: 1023440
Manufacturer Serial No: 2F281JBA05
Sales Order No: 9193535
Battery Pack Serial No(s):
XCP Test Software Version: 3.26.01

Regrade from kVA to kVA

Magic Number:

Test meters used (Item ID) T092, T093

Firmware. Revision supplied C2(2.52.5)/1 Revision installed C2(2.52.5)/5 To: SB9155;4
PCB "all boards" setup done if new rev Langloader installed or UPS rerated Y/N Y

Settings. User settings. User LCD screen amended to read correct model No. etc Y/N Y

1	Date set to (dd/mm/yy)	22/2/2013	2	Time set to (Hr/min)	7 : 10
3	Contrast required adjustment	Y/N N	4	English language selected	Y/N Y
5	Relay configuration changed	Y/N N			
6	Signal Input 1 set to Force Bypass	Y/N Y	6a	Input 2 set to Ext batt breaker	Y/N N
7	Serial port config set to 19,200 baud	Y/N Y	8	Parallel settings adjusted	Y/N N
9	Start screen Mimic	Y/N Y	10	User password disabled	Y/N Y
11	Audible alarms on normal	Y/N Y	12	Battery charge ABM cycling	Y/N Y
13	Number of strings	2	14	Battery size Watts/cell	34 WPC
15	Bat low alarm level 1.880 Volts dc	Y/N Y	16	Maximum charge rate	1.8 A
17	Output Voltage set at	240 V	18	Bypass limits +10% -15%	Y/N Y
19	Output frequency set to	50 Hz	20	Synchronisation enabled	Y/N Y
21	Synchronisation window set+/- 2Hz	Y/N Y	22	Unsynch Xfer to Byp allowed	Y/N Y
23	Output slew rate set to +/- 0.2Hz/s	Y/N Y	24	Input current limit (set by lang load)	29 A
25	Use of bypass enabled	Y/N Y	26	Power strategy 'standard'	Y/N Y
27	Prefer battery in input break	Y/N Y	28	Immediate X'fer on overload	Y/N Y
29	Automatic start delay zero	Y/N Y	30	Auto batt shutdown -1 sec	Y/N Y
31	command from X-slots allowed	Y/N Y	32	X-slot signal delay 5 secs	Y/N Y
33	Input signal shutdown 120 sec	Y/N Y	34	Site wiring fault enabled	Y/N Y

System Check.

1 Output Voltage calibrated Indicated ΦA 239V ΦB 239V ΦC 238V
@ no load Actual ΦA 238V ΦB 238V ΦC 238V

2 UPS run at 6 kW resistive load for 1 Hrs Load test passed Y/N Y
Load indicated 63% Run time indicated 33 Min

3 Amps indicated ΦA 8.2A ΦB 8.2A ΦC 7.9A Actual ΦA 8.0A ΦB 8.1A ΦC 7.9A

4 Bypass operation (front panel) tested Y/N Y

5 Inverter interlock fitted Y/N N Tested Y/N Y 6 EPO tested Y/N Y

7 Parallel system tested at kW load for Hrs

Partial discharge.

1 Mains failure with 2X9 Ah batteries for 5 Min with load 6 kW

2 Charge current verified at 1.7 A (measured) Batts charged to 443 V

Battery installation. Battery Part No: Quantity
Circuit breaker Part No:
Battery pack Part No: Quantity

Settings. Service settings. **EATON INDUSTRIES Pty Ltd**

Ref: PR-F027 Rev: A Issued: 01/11/2011

Parameter settings.

Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr
0	1	210	16	0	410	33	1	3234	51	0	206
1	0	211	17	5	232	34	50	237	52	1	112
2	2	212	18	0	230	36	*0.2	240	53	3600	314
3	1	229	19	-1	231	37	29	250	54	0	311
4	0	238	20	120	228	38	0	0	55	0	112
5	0	238	21	5	213	39	0	0	56	5	288
6	0	238	22	2	313	40	0	0	57	....	289
7	0	112	24	34	351	41	0	238	58	*60	277
8	0	238	25	1.88	338	43	0	102	59	0	290
9	0	238	26	2.27	325	44	1	103	60	0	291
10	0	238	27	1.8	3307	46	0	112	61	0	238
11	0	239	28	240	233	47	0	0	62	1	206
12	0	239	30	10	234	48	0	206	63	0	206
14	0	320	31	-15	235	49	0	0	64	0	206
15	0	320	32	2	3233	50	0	0			

* Parameters 36, 48, 51 & 58 are not loaded in parallel systems ** Parameter 51 is not loaded on 9x55 20-40KVA UPS

EEPS saved in network folder File No. 9155sn2F281JBA05.dat

Manufacturers test sheet supplied	Y/N Y	Sheet completed correctly	Y/N Y
Data cable & user pack correct	Y/N Y	Unit secured to pallet	Y/N Y
Panels free from scratches/dents	Y/N Y	Rating label attached	Y/N Y
Installation checklist supplied	Y/N Y	Eaton Service label attached	Y/N Y
Warranty registration form supplied	Y/N Y	Panels, brackets & screws refitted	Y/N Y

Tested by: Tong Luu Date 22/2/2013 Signed: Tong

Notes:

Labels:

EATON | Powerware N869

TYPE: 9355-10-NL-25

PART No.: 1023414 REV: C

SERIAL No.: 2F281JBA05 MFG:200213

INPUT:	3/N/PE	415V	50Hz	15A
BY-PASS INPUT:	3/N/PE	415V	50Hz	15A
BATTERY:	DC	384V	64x9 Ah	30A
OUTPUT:	3/N/PE	415V	50Hz	15A
		10kVA	9kW	CE

Made in TAIWAN CAA: KA1012223000001

9355 Test Report

EATON
Powering Business Worldwide

Unit Information	P/N	Rev	S/N	Manuf
9355-10-N-0-64x0Ah	1023440	C	2F281JBA05	A02

CAA: KA1012220000001
NOMINAL POWER: 10kVA 9.0kW

Firmware Information	P/N	Rev	S/N	PRDA	Manuf
PCBAS K15 I/O 3PH II	1022770	A1			
DISPLAY fw	1023709	C			
MAIN CONTROL DSP fw	1023711	P2			
MAIN CONTROL BOOTLDR fw	1023720	C4			
MAIN CONTROL PLD fw	1023721	C			

Subassembly Information	P/N	Rev	S/N	PRDA	Manuf
DISPLAY PCBAS	1021647	D	000386	1226	A03
POWER PCBAS	1022655	E	000099	1227	A03
CAPACITOR PCBAS	1023215	C	000086	1226	A03
PCBAS K15 I/O 3PH II	1023728	C1	000069	1227	A03
CONTROL BOARD II PCBAS	1024460	B	000616	1226	A03

Test Information

This UPS unit is tested with tests based on the standard IEC 62040-3.
Test procedure(s) used is:

9355 Final Test	1028876	E

Output Voltage L1 / L2 / L3 : 230,5 / 230,5 / 230,5 VAC

Configuration and Calibration	PASS
Functional tests	PASS
Safety tests	PASS
Burn in	PASS

Test Report printed and verified 29.6.2012

6/9

EATON Powering Business Worldwide

EATON INDUSTRIES Pty Ltd
Ref: PR-F027 Rev: A Issued: 01/11/201

TEST REPORT: 9155 UPS 8-30kVA. 9355 UPS 8-40kVA

Rating: 10 kVA	Job No: 1050699
Type: 935510NL25	Manufacturer Part No: 1023440
Local Part No: 1023414	Manufacturer Serial No: 2F281JBA06
Customer No:	Sales Order No: 9193535
Customer: NILSEN (NSW)	Battery Pack Serial No(s):
Parallel Unit No: of	XCP Test Software Version: 3.26.01
Regrade from kVA to kVA	**Magic Number:**

Test meters used (Item ID) T092, T093

Firmware. Revision suppliec C2(2.52.5)/1 Revision installed C2(2.52.5)/5 To: SB9155;4

PCB "all boards" setup done if new rev Langloader installed or UPS rerated Y/N Y

Settings. User settings. User LCD screen amended to read correct model No. etc Y/N Y

1	Date set to (dd/mm/yy)	25/2/2013	2	Time set to (Hr/min)	7 : 10
3	Contrast required adjustment	Y/N N	4	English language selected	Y/N Y
5	Relay configuration changed	Y/N N			
6	Signal Input 1 set to Force Bypass	Y/N Y	6a	Input 2 set to Ext batt breaker	Y/N N
7	Serial port config set to 19,200 baud	Y/N Y	8	Parallel settings adjusted	Y/N N
9	Start screen 'Mimic'	Y/N Y	10	User password disabled	Y/N Y
11	Audible alarms on normal	Y/N Y	12	Battery charge ABM cycling	Y/N Y
13	Number of strings	2	14	Battery size Watts/cell	34 WPC
15	Bat low alarm level 1.880 Volts dc	Y/N Y	16	Maximum charge rate	1.8 A
17	Output Voltage set at	240 V	18	Bypass limits +10% -15%	Y/N Y
19	Output frequency set to	50 Hz	20	Synchronisation enabled	Y/N Y
21	Synchronisation window set+/- 2Hz	Y/N Y	22	Unsynch Xfer to Byp allowed	Y/N Y
23	Output slew rate set to +/- 0.2Hz/s	Y/N Y	24	Input current limit (set by lang load)	29 A
25	Use of bypass enabled	Y/N Y	26	Power strategy 'standard'	Y/N Y
27	Prefer battery in input break	Y/N Y	28	Immediate X'fer on overload	Y/N Y
29	Automatic start delay zero	Y/N Y	30	Auto batt shutdown -1 sec	Y/N Y
31	command from X-slots allowed	Y/N Y	32	X-slot signal delay 5 secs	Y/N Y
33	Input signal shutdown 120 sec	Y/N Y	34	Site wiring fault enabled	Y/N Y

System Check.

1 Output Voltage calibrated Indicated ΦA 239V ΦB 239V ΦC 238V
@ no load Actual ΦA 238V ΦB 238V ΦC 238V

2 UPS run at 6 kW resistive load for 1 Hrs Load test passed Y/N Y
Load indicated 63% Run time indicated 33 Min

3 Amps indicated ΦA 8.3A ΦB 8.3A ΦC 8.1A Actual ΦA 8.1A ΦB 8.1A ΦC 7.9A

4 Bypass operation (front panel) tested Y/N Y

5 Inverter interlock fitted Y/N N Tested Y/N Y 6 EPO tested Y/N Y

7 Parallel system tested at kW load for Hrs

Partial discharge.

1 Mains failure with 2X9 Ah batteries for 5 Min with load 6 kW

2 Charge current verified at 1.7 A (measured) Batts charged to 443 V

Battery installation. Battery Part No: Quantity

Circuit breaker Part No:

Battery pack Part No: Quantity

Settings. Service settings.

EATON INDUSTRIES Pty Ltd
Ref: PR-F027 Rev: A Issued: 01/11/2011

Parameter settings.

Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr
0	1	210	16	0	410	33	1	3234	51	0	206
1	0	211	17	5	232	34	50	237	52	1	112
2	2	212	18	0	230	36	*0.2	240	53	3600	314
3	1	229	19	-1	231	37	29	250	54	0	311
4	0	238	20	120	228	38	0	0	55	0	112
5	0	238	21	5	213	39	0	0	56	5	288
6	0	238	22	2	313	40	0	0	57	....	289
7	0	112	24	34	351	41	0	238	58	*60	277
8	0	238	25	1.88	338	43	0	102	59	0	290
9	0	238	26	2.27	325	44	1	103	60	0	291
10	0	238	27	1.8	3307	46	0	112	61	0	238
11	0	239	28	240	233	47	0	0	62	1	206
12	0	239	30	10	234	48	0	206	63	0	206
14	0	320	31	-15	235	49	0	0	64	0	206
15	0	320	32	2	3233	50	0	0			

* Parameters 36, 48, 51 & 58 are not loaded in parallel systems ** Parameter 51 is not loaded on 9x55 20-40KVA UPS

EEPS saved in network folder File No. 9355sn2F281JBA06.dat

Manufacturers test sheet supplied	Y/N Y	Sheet completed correctly	Y/N Y
Data cable & user pack correct	Y/N Y	Unit secured to pallet	Y/N Y
Panels free from scratches/dents	Y/N Y	Rating label attached	Y/N Y
Installation checklist supplied	Y/N Y	Eaton Service label attached	Y/N Y
Warranty registration form supplied	Y/N Y	Panels, brackets & screws refitted	Y/N Y

Tested by: Tong Luu Date 25/2/2013 Signed: Tong

Notes:

Labels:

EATON | Powerware

N869

TYPE:	9355-10-NL-25			
PART No.:	1023414		REV:	C
SERIAL No.:	2F281JBA06			MFG:200213
INPUT:	3/N/PE	415V	50Hz	15A
BY-PASS INPUT:	3/N/PE	415V	50Hz	15A
BATTERY:	DC	384V	64x9 Ah	30A
OUTPUT:	3/N/PE	415V	50Hz	15A
		10kVA	9kW	CE

Made in TAIWAN CAA: KA1012223000001

9355 Test Report

EATON
Powering Business Worldwide

Unit Information	P/N	Rev	S/N	Manuf
9355-10-N-0-64x0Ah	1023440	C	2F281JBA06	A02

CAA: KA1012220000001

NOMINAL POWER: 10kVA 9.0kW

Firmware Information	P/N	Rev	S/N	PRDA	Manuf
PCBAS K15 I/O 3PH II	1022770	A1			
DISPLAY fw	1023709	C			
MAIN CONTROL DSP fw	1023711	P2			
MAIN CONTROL BOOTLDR fw	1023720	C4			
MAIN CONTROL PLD fw	1023721	C			

Subassembly Information	P/N	Rev	S/N	PRDA	Manuf
DISPLAY PCBAS	1021647	D	000388	1226	A03
POWER PCBAS	1022655	E	000095	1227	A03
CAPACITOR PCBAS	1023215	C	000065	1226	A03
PCBAS K15 I/O 3PH II	1023728	C1	000053	1227	A03
CONTROL BOARD II PCBAS	1024460	B	000609	1226	A03

Test Information

This UPS unit is tested with tests based on the standard IEC 62040-3.
Test procedure(s) used is:

9355 Final Test	1028876	E
Output Voltage L1 / L2 / L3 :	230,5 / 230,5 / 230,5	VAC
Configuration and Calibration	PASS	
Functional tests	PASS	
Safety tests	PASS	
Burn in	PASS	

Test Report printed and verified 29.6.2012

程 6/9

EATON
Powering Business Worldwide

EATON INDUSTRIES Pty Ltd
Ref: PR-F027 Rev: A Issued: 01/11/201

TEST REPORT: 9155 UPS 8-30kVA. 9355 UPS 8-40kVA

Rating: 10 kVA
Type: 935510NL25
Local Part No: 1023414
Customer No:
Customer: NILSEN (NSW)
Parallel Unit No: of

Job No: 1050699
Manufacturer Part No: 1023440
Manufacturer Serial No: 2F281JBA07
Sales Order No: 9193535
Battery Pack Serial No(s):
XCP Test Software Version: 3.26.01

Regrade from kVA to kVA

Magic Number:

Test meters used (Item ID) T092, T093

Firmware. Revision supplied C2(2.52.5)/1 Revision installed C2(2.52.5)/5 To: SB9155;4

PCB "all boards" setup done if new rev Langloader installed or UPS rerated Y/N Y

Settings. User settings. User LCD screen amended to read correct model No. etc Y/N Y

1	Date set to (dd/mm/yy)	22/2/2013	2	Time set to (Hr/min)	9 : 10
3	Contrast required adjustment	Y/N N	4	English language selected	Y/N Y
5	Relay configuration changed	Y/N N			
6	Signal Input 1 set to Force Bypass	Y/N Y	6a	Input 2 set to Ext batt breaker	Y/N N
7	Serial port config set to 19,200 baud	Y/N Y	8	Parallel settings adjusted	Y/N N
9	Start screen 'Mimic'	Y/N Y	10	User password disabled	Y/N Y
11	Audible alarms on normal	Y/N Y	12	Battery charge ABM cycling	Y/N Y
13	Number of strings	2	14	Battery size Watts/cell	34 WPC
15	Bat low alarm level 1.880 Volts dc	Y/N Y	16	Maximum charge rate	1.8 A
17	Output Voltage set at	240 V	18	Bypass limits +10% -15%	Y/N Y
19	Output frequency set to	50 Hz	20	Synchronisation enabled	Y/N Y
21	Synchronisation window set+/- 2Hz	Y/N Y	22	Unsynch Xfer to Byp allowed	Y/N Y
23	Output slew rate set to +/- 0.2Hz/s	Y/N Y	24	Input current limit (set by lang load)	29 A
25	Use of bypass enabled	Y/N Y	26	Power strategy 'standard'	Y/N Y
27	Prefer battery in input break	Y/N Y	28	Immediate X'fer on overload	Y/N Y
29	Automatic start delay zero	Y/N Y	30	Auto batt shutdown -1 sec	Y/N Y
31	command from X-slots allowed	Y/N Y	32	X-slot signal delay 5 secs	Y/N Y
33	Input signal shutdown 120 sec	Y/N Y	34	Site wiring fault enabled	Y/N Y

System Check.

1 Output Voltage calibrated @ no load — Indicated ΦA 239V ΦB 239V ΦC 238V; Actual ΦA 238V ΦB 238V ΦC 238V

2 UPS run at 6 kW resistive load for 1 Hrs Load test passed Y/N Y
Load indicated 63% Run time indicated 33 Min

3 Amps indicated ΦA 8.3A ΦB 8.3A ΦC 8.0A Actual ΦA 8.1A ΦB 8.1A ΦC 7.9A

4 Bypass operation (front panel) tested Y/N Y

5 Inverter interlock fitted Y/N N Tested Y/N Y 6 EPO tested Y/N Y

7 Parallel system tested at kW load for Hrs

Partial discharge.

1 Mains failure with 2X9 Ah batteries for 5 Min with load 6 kW

2 Charge current verified at 1.7 A (measured) Batts charged to 443 V

Battery installation. Battery Part No: Quantity

Circuit breaker Part No:

Battery pack Part No: Quantity

Settings. Service settings.

EATON INDUSTRIES Pty Ltd
Ref: PR-F027 Rev: A Issued: 01/11/2011

Parameter settings.

Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr	Nº	Value	Addr
0	1	210	16	0	410	33	1	3234	51	0	206
1	0	211	17	5	232	34	50	237	52	1	112
2	2	212	18	0	230	36	*0.2	240	53	3600	314
3	1	229	19	-1	231	37	29	250	54	0	311
4	0	238	20	120	228	38	0	0	55	0	112
5	0	238	21	5	213	39	0	0	56	5	288
6	0	238	22	2	313	40	0	0	57	....	289
7	0	112	24	34	351	41	0	238	58	*60	277
8	0	238	25	1.88	338	43	0	102	59	0	290
9	0	238	26	2.27	325	44	1	103	60	0	291
10	0	238	27	1.8	3307	46	0	112	61	0	238
11	0	239	28	240	233	47	0	0	62	1	206
12	0	239	30	10	234	48	0	206	63	0	206
14	0	320	31	-15	235	49	0	0	64	0	206
15	0	320	32	2	3233	50	0	0			

* Parameters 36, 48, 51 & 58 are not loaded in parallel systems ** Parameter 51 is not loaded on 9x55 20-40KVA UPS

EEPS saved in network folder File No. 9155sn2F281JBA07.dat

Manufacturers test sheet supplied	Y/N Y	Sheet completed correctly	Y/N Y
Data cable & user pack correct	Y/N Y	Unit secured to pallet	Y/N Y
Panels free from scratches/dents	Y/N Y	Rating label attached	Y/N Y
Installation checklist supplied	Y/N Y	Eaton Service label attached	Y/N Y
Warranty registration form supplied	Y/N Y	Panels, brackets & screws refitted	Y/N Y

Tested by: Tong Luu Date 22/2/2013 Signed: Tong

Notes:

Labels:

EATON | Powerware

N869

TYPE:	9355-10-NL-25			
PART No.:	1023414		**REV:**	C
SERIAL No.:	2F281JBA07			MFG:200213
INPUT:	3/N/PE	415V	50Hz	15A
BY-PASS INPUT:	3/N/PE	415V	50Hz	15A
BATTERY:	DC	384V	64x9 Ah	30A
OUTPUT:	3/N/PE	415V	50Hz	15A
		10kVA	9kW	CE

Made in TAIWAN CAA: KA1012223000001

9355 Test Report

EATON
Powering Business Worldwide

Unit Information	P/N	Rev	S/N	Manuf
9355-10-N-0-64x0Ah	1023440	C	2F281JBA07	A02

CAA: KA1012220000001

NOMINAL POWER: 10kVA 9.0kW

Firmware Information	P/N	Rev	S/N	PRDA	Manuf
PCBAS K15 I/O 3PH II	1022770	A1			
DISPLAY fw	1023709	C			
MAIN CONTROL DSP fw	1023711	P2			
MAIN CONTROL BOOTLDR fw	1023720	C4			
MAIN CONTROL PLD fw	1023721	C			

Subassembly Information	P/N	Rev	S/N	PRDA	Manuf
DISPLAY PCBAS	1021647	D	000384	1226	A03
POWER PCBAS	1022655	E	000103	1227	A03
CAPACITOR PCBAS	1023215	C	000061	1226	A03
PCBAS K15 I/O 3PH II	1023728	C1	000056	1227	A03
CONTROL BOARD II PCBAS	1024460	B	000607	1226	A03

Test Information

This UPS unit is tested with tests based on the standard IEC 62040-3.
Test procedure(s) used is:

9355 Final Test	1028876	E
Output Voltage L1 / L2 / L3 :	230,5 / 230,5 / 230,5	VAC
Configuration and Calibration	PASS	
Functional tests	PASS	
Safety tests	PASS	
Burn in	PASS	

Test Report printed and verified 29.6.2012

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INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**			
Location: L3 North		Identify Role Of Each As Necessary	

No	Inspection And Test Point	Comments		
Electrical Services				
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		
5	Ceiling services installed	Done	Star to room is	install AV once locked
6	Ceiling services commissioned	Done.	Light hangers not cut due to incomplete accoustic panels.	

REFERENCE DOCUMENTATION: ***ACTION POINTS:*** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 6/2/14 SWillo **CHECKED BY:** TCH **DATE:** 6/2/2014 **APPROVED BY:** TCH **DATE:** 6/2/2014	**DOCUMENT NO:** **SECTION NO:** **ISSUE:** 1 **REV:** A **DATE:** 6/2/2014 **PAGE:** 1

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INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080			
Location: L3 West		Identify Role Of Each As Necessary	

No	Inspection And Test Point	Comments		
Electrical Services				
1	Underfloor services installed	Finished		
2	Underfloor services commissioned	Finished		
3	Wall services complete	Finished		
4	Wall services commissioned	Finished		
5	Ceiling services installed	Finished	Star to install AV gear once room locked.	
6	Ceiling services commissioned	Finished		

REFERENCE DOCUMENTATION:	PREPARED BY: Scott Willoughby DATE: 6/2/14	DOCUMENT NO: SECTION NO:
***ACTION POINTS*:** **H-HOLD** **I- INSPECT** **W- WITNESS** **R-RANDOM** **S- SUBMIT** **V-VERIFY** **N-NOTIFICATION POINT** **C-COMMENT**	CHECKED BY: DATE: 6/2/2014 APPROVED BY: DATE: 6/2/2014	ISSUE: 1 REV: A DATE: 6/2/2014 PAGE: 2

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INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**			
Location: L3 South		Identify Role Of Each As Necessary	

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		
5	Ceiling services installed	Done	AV to be installed once rooms locked	
6	Ceiling services commissioned	Done	Light hangers not cut due to incomplete accoustic panels.	

REFERENCE DOCUMENTATION: ***ACTION POINTS* :** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 6/2/14 SWillo **CHECKED BY:** RH **DATE:** 6/2/2014 **APPROVED BY:** RH **DATE:** 6/2/2014	**DOCUMENT NO:** **SECTION NO:** **ISSUE:** 1 **REV:** A **DATE:** 6/2/2014 **PAGE:** 3

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INSPECTION AND TEST PLAN *REGISTER*			REFERENCE:	
PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**				
Location: L4 West			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		
5	Ceiling services installed	Done	AV to be installed once rooms locked	
6	Ceiling services commissioned	Done		

REFERENCE DOCUMENTATION: ***ACTION POINTS:*** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 6/2/14 SWillo	**DOCUMENT NO:** **SECTION NO:**
	CHECKED BY: RH	**ISSUE:** 1
	DATE: 6/2/2014	**REV:** A
	APPROVED BY: RH	**DATE:** 6/2/2014
	DATE: 6/2/2014	**PAGE:** 4

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INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**			
Location: L4 North		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		
5	Ceiling services installed	Done	AV to be installed once room is locked.	
6	Ceiling services commissioned	Done		

REFERENCE DOCUMENTATION: ***ACTION POINTS*:** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 6/2/14 [signature]	**DOCUMENT NO:** **SECTION NO:**
	CHECKED BY: [signature]	**ISSUE:** 1
	DATE: 6/2/2014	**REV:** A
	APPROVED BY: [signature]	**DATE:** 6/2/2014
	DATE: 6/2/2014	**PAGE:** 5

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INSPECTION AND TEST PLAN *REGISTER*			REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080				
Location: L4 South			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		
5	Ceiling services installed	Done	AV to be rooms	installed once locked.
6	Ceiling services commissioned	Done		

REFERENCE DOCUMENTATION: ***ACTION POINTS :*** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 6/2/14 [signature]	**DOCUMENT NO:** **SECTION NO:**
	CHECKED BY: [signature]	**ISSUE:** 1
	DATE: 6/2/2014	**REV:** A
	APPROVED BY: [signature]	**DATE:** 6/2/2014
	DATE: 6/2/2014	**PAGE:** 6

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INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080			
Location: L4 East		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		
5	Ceiling services installed	Done	AV to be installed once rooms locked.	
6	Ceiling services commissioned	Done		

REFERENCE DOCUMENTATION: ***ACTION POINTS*:** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 6/2/14 [signature]	**DOCUMENT NO:** **SECTION NO:**
	CHECKED BY: [signature]	**ISSUE:** 1
	DATE: 6/2/2014	**REV:** A
	APPROVED BY: [signature]	**DATE:** 6/2/2014
	DATE: 6/2/2014	**PAGE:** 7

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INSPECTION AND TEST PLAN *REGISTER*		**REFERENCE:**	
PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**			
Location: L5 West		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Finished		
2	Underfloor services commissioned	Done		
3	Wall services complete	Finished		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned	Yes		

REFERENCE DOCUMENTATION: ***ACTION POINTS :*** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 10/2/14	**DOCUMENT NO:** **SECTION NO:**
	CHECKED BY:	**ISSUE:** 1
	DATE: 10/2/2014	**REV:** A
	APPROVED BY:	**DATE:** 10/2/2014
	DATE: 10/2/2014	**PAGE:** 1

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INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080			
Location: L5 North		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Yes		
2	Underfloor services commissioned	Yes		
3	Wall services complete	Yes		
4	Wall services commissioned	Yes		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned	Yes		

REFERENCE DOCUMENTATION: ***ACTION POINTS*:** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 10/2/14	**DOCUMENT NO:** **SECTION NO:**
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E-mail: @nilsen.com.au

INSPECTION AND TEST PLAN *REGISTER*		REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080			
Location: LS East		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Yes		
2	Underfloor services commissioned	Yes		
3	Wall services complete	Yes		
4	Wall services commissioned	Yes		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned	Yes		

REFERENCE DOCUMENTATION:	PREPARED BY: Scott Willoughby DATE: 10/2/14 Scott	DOCUMENT NO: SECTION NO:
ACTION POINTS*:** ***H-HOLD ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	CHECKED BY: TH DATE: 10/2/2014 APPROVED BY: TH DATE: 10/2/2014	ISSUE: 1 REV: A DATE: 10/2/2014 PAGE: 3

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<tr><td colspan="3">PROJECT NAME: FEIT UTS Broadway
PROJECT NO: 70080</td><td colspan="2"></td></tr>
<tr><td colspan="2">Location: LS South</td><td></td><td colspan="2">Identify Role Of Each As Necessary</td></tr>
<tr><td>No</td><td>Inspection And Test Point</td><td>Comments</td><td></td><td></td></tr>
<tr><td colspan="5">Electrical Services</td></tr>
<tr><td>1</td><td>Underfloor services installed</td><td>Yes</td><td></td><td></td></tr>
<tr><td>2</td><td>Underfloor services commissioned</td><td>Yes</td><td></td><td></td></tr>
<tr><td>3</td><td>Wall services complete</td><td>Yes</td><td></td><td></td></tr>
<tr><td>4</td><td>Wall services commissioned</td><td>Yes</td><td></td><td>AV to be installed</td></tr>
<tr><td>5</td><td>Ceiling services installed</td><td>Yes</td><td></td><td>once room is locked.</td></tr>
<tr><td>6</td><td>Ceiling services commissioned</td><td>Yes</td><td></td><td></td></tr>
</table>

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S- SUBMIT
V-VERIFY
N-NOTIFICATION POINT
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INSPECTION AND TEST PLAN *REGISTER*			**REFERENCE:**	
PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**				
Location: L6 West			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		
Electrical Services				
1	Underfloor services installed	Yes		
2	Underfloor services commissioned	Yes		
3	Wall services complete	Yes		
4	Wall services commissioned	Yes		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned	Yes		

REFERENCE DOCUMENTATION: ***ACTION POINTS*:** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	**PREPARED BY:** Scott Willoughby **DATE:** 10/2/14 SWilloughby	**DOCUMENT NO:** **SECTION NO:**
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INSPECTION AND TEST PLAN *REGISTER* | **REFERENCE:**

PROJECT NAME: FEIT UTS Broadway
PROJECT NO: 70080

Location: L6 North.

Identify Role Of Each As Necessary

No	Inspection And Test Point	Comments		
Electrical Services				
1	Underfloor services installed	Yes		
2	Underfloor services commissioned	Yes		
3	Wall services complete	Yes		
4	Wall services commissioned	Yes		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned	Yes		

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INSPECTION AND TEST PLAN *REGISTER*			REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080				
Location: L6 East			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Yes		
2	Underfloor services commissioned	Yes		
3	Wall services complete	Yes		
4	Wall services commissioned	Yes		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned			

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INSPECTION AND TEST PLAN *REGISTER* | **REFERENCE:**

PROJECT NAME: FEIT UTS Broadway
PROJECT NO: 70080

Location: L6 South

Identify Role Of Each As Necessary

No	Inspection And Test Point	Comments		
Electrical Services				
1	Underfloor services installed	Yes		
2	Underfloor services commissioned	Yes		
3	Wall services complete	Yes		
4	Wall services commissioned	Yes		AV to be installed
5	Ceiling services installed	Yes		once room is locked.
6	Ceiling services commissioned	Yes		

REFERENCE DOCUMENTATION:

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I- INSPECT
W- WITNESS
R-RANDOM
S- SUBMIT
V-VERIFY
N-NOTIFICATION POINT
C-COMMENT

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DATE: 10/2/14
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INSPECTION AND TEST PLAN *REGISTER*			REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080				
Location: L7 West			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

REFERENCE DOCUMENTATION:	**PREPARED BY:** Scott Willoughby **DATE:** [signature] 14/2/14	**DOCUMENT NO:** **SECTION NO:**
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INSPECTION AND TEST PLAN *REGISTER*			REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080				
Location: L7 North			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

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PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080			
Location: L7 East		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

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PROJECT NAME: FEIT UTS Broadway **PROJECT NO: 70080**			
Location: L7 South		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

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INSPECTION AND TEST PLAN *REGISTER*			REFERENCE:	
PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080				
Location: L8 West			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

REFERENCE DOCUMENTATION: ***ACTION POINTS:*** ***H-HOLD*** ***I- INSPECT*** ***W- WITNESS*** ***R-RANDOM*** ***S- SUBMIT*** ***V-VERIFY*** ***N-NOTIFICATION POINT*** ***C-COMMENT***	PREPARED BY: Scott Willoughby DATE: S Willoughby 14/2/14	DOCUMENT NO: SECTION NO:
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PROJECT NAME: FEIT UTS Broadway PROJECT NO: 70080			
Location: L8 North		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

No	Inspection And Test Point	Comments		
1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

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Location: L8 East		Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

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Location: L8 South			Identify Role Of Each As Necessary	
No	Inspection And Test Point	Comments		

Electrical Services

1	Underfloor services installed	Done		
2	Underfloor services commissioned	Done		
3	Wall services complete	Done		
4	Wall services commissioned	Done		AV to be installed
5	Ceiling services installed	Done		once room is locked.
6	Ceiling services commissioned	Done		

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11 WARRANTIES AND GUARANTEES

11.1 Warranties & Guarantees

In addition to the warranties required under the Defects Liability Period Nilsen provide warranties on relevant services and equipment, including warranties within the As-Installed Documentation.

The Warranty Period commences from the date of Practical Completion and will run for a period of twelve (12) months, from that date.

All items of equipment installed are covered by Warranty for the whole of the period mentioned above.

Detailed Supplier Warranties, as per attached;

11.2 Deed Poll Warranty

11.3 Suppliers Warranty

See attached folder Section 11

Melbourne
46-48 Rathdowne St
Carlton Vic 3053
P: 03 9349 3310
F: 03 9349 3320
www.artemide.com

Artemide Warranty - International Wording

We thank you for having chosen our product.

Artemide, producer of innovative and original design illumination devices has always pledged to improve the quality and reliability of its products. The consumer is granted some rights in accordance with national regulations in the country of purchase (The Australian Trade Practices Act) left unprejudiced by the present guarantee. They are also safe of other binding rules of law.

Conventional Guarantee of the producer (1 year)

Artemide guarantees that the product is lacking any fault of manufacture.

In case of any fault of manufacture you may ask for the guarantee enforcement on the product or on one of its components **within one year** from the starting date of the guarantee.

The lack of conformity of the product must be announced within two months of the discovery. The lack of conformity must be recognised by Artemide, a retailer, or from an authorised assistance centre.

What to do in case of faulty item

Contact the Artemide branch from which the product was purchased. Supply to the above said operators a descriptive note of the fault. Do not forget to produce a proof of purchase and delivery date, either the invoice or a signed delivery note. This will be necessary to validate that the claim is falling within the two year warrantee period.

Send or personally bring the defective product to the Artemide branch, possibly using the original packaging, and however using a suitable package.

Artemide reserves the right not to operate the guarantee in absence of the proof of purchase and in case insufficient information is supplied, or they are not compatible with the product.

The Guarantee will not be valid in case of:

- Installation and/or assembly not in conformity to regulations as well as to technical prescriptions on installation, use and the maintenance of the product
- Utilisation of materials or spares not original or otherwise adequate
- Faults caused by non-authorised technical personnel
- Electrical system not complying to the in force local regulations
- Improper or negligent use
- Damages given by accidental events or cause of greater force such as lightning bolts, floods, fire, or coming from environmental conditions, climatic or of whatever else nature ..not compatible with the product.
- Damages caused by post-delivery transportation and/or handling
- Wear and tear caused by day-to-day use, and not affecting the operating of the product, for the example of scuff marks or scratches.

Artemide or the retailer reserve themselves the rights to replace or repair the defective component/s of the product at their sole discretion
Artemide shall not be responsible for damages that can be directly or indirectly attributed to persons, animals or things as a result of the missed observance of instructions, and of the applicable rules for installation, use and maintenance of the products.

Excluded from the guarantee are the materials of consumption or as subject to the normal usage, by way of example, non-integral light-sources, batteries.

When your warrantee claim is not valid

If your claim does not conform with the conditions of warrantee listed herein, or if you experience difficulty outside of the one year period, Artemide will instead provide you with the contact details of an approved local repairer to quote upon your requirements. If you use our approved repairers within the original warrantee period, the warrantee will remain valid for the remainder of the one year period. If you elect to source other repairers, the warrantee will be henceforth invalidated.

Clevertronics®
Emergency lighting innovation

9 Distribution Place
Seven Hills NSW 2147
Phone: (02) 8805 6400
Fax: (02) 8805 6444

CLEVERTRONICS PRODUCT WARRANTIES
Effective 1st October 2013

Standard Product Warranty:

- All products in the Standard or Economy Range have a 12 month back to base replacement
- warranty, excluding lamps.

Clevertronics Premium Warranty:

- All products in Premium, Clever-test and Automatic testing ranges (including Zoneworks and Dali products) have a 2 year back to base replacement warranty, including for LED and Cold Cathode lamps, but excluding other lamps.
- The Lifelight and Lifelight Pro range (non-maintained) include a lifetime lamp warranty.

Clevertronics L10:

- All products in the L10 Range have a 4 year back to base replacement warranty, including for LED and Cold Cathode lamps, but excluding other lamps.
- The L10 Lifelight and Lifelight Pro range (non-maintained) include a lifetime lamp warranty.

Zoneworks DLP On-Site Warranty:

- Zoneworks computerized emergency lights that have been commissioned by Clevertronics have an on-site warranty through to the end of the Defects Liability Period, up to a maximum of 2 years from invoice date.

Zoneworks L10 DLP On-Site Warranty:

- Zoneworks computerized L10 emergency lights that have been commissioned by Clevertronics have an on-site warranty through to the end of the Defects Liability Period, up to a maximum of 3 years from invoice date.

Please note:

- All warranties are from date of invoice.
- Where the manufacturer of components used within Clevertronics products provide an extended warranty it is passed on to the client. (e.g. some long life fluorescent lamps when specified).
- These warranties are effective from 1 October 2013.

Zoneworks DLP On-Site Warranty Terms and Conditions:

- The Zoneworks On-Site DLP Warranty applies onto sites within 100km of the GPO of the following cities: Sydney, Melbourne, Brisbane, Perth, Hobart, Darwin, Canberra and Adelaide. Please contact your Clevertronics Representative to confirm your warranty terms if your site lay outside these areas.
- The Installing Contractor must supply a representative to assist with the on-site warranty process and must be available at all times. This person shall have intimate knowledge of the site.
- Special lifting equipment to access high level emergency luminaires (not accessible with a 2m step ladder) shall be supplied by the Installing Contractor. The high level emergency luminaires under warranty shall be removed by the installing contractor for repair/replacement by Clevertronics on-site personnel.
- Work hours for on-site warranty work shall be between 6am and 6pm Monday-Friday. Work outside these hours will be charged at the difference between the standard 6am-6pm hourly rate*1 and the applicable after-hours rate*2 (the after-hours rate varies depending on the specific work time).
- Free, uninhibited access must be provided to the Clevertronics on-site personnel. Failure to provide this access will result in charges relating to the time incurred waiting for access at the appropriate hourly rate.
- Delays incurred by Clevertronics personnel associated with incorrect labelling, incorrect positions on drawings or changes/alterations (including wiring and other general luminaires that affect communications or performance) shall be charged at the appropriate hourly rate.
- The on-site warranty does not cover the following:
  - Any software (other than Zoneworks), loss of data or computer viruses.
  - Damage to the ZSERV or Emergency Luminaires due to or power surge.
  - Damage caused by flood, fire, lightning or corrosion.
  - Damage caused by operator error, equipment misuse, negligence or an unsuitable environment.

*1Please confirm the normal 6am-6pm hourly rate with your Clevertronics representative.

*2Please confirm the after-hours rate with your Clevertronics representative.

WORK WITH LIGHT

Darkon Architectural Lighting PTY LTD

Product Warranty

All products designed, built and supplied by Darkon Architectural Lighting Pty Ltd. are produced in accordance with Australian standards AS/NZS 60598.1.

OUR WARRANTY

Darkon Architectural Lighting Pty Ltd. warrants this Product to be free from defects in design, material and workmanship at the time of its original purchase by a consumer, and for a subsequent period of (1) year.

WHAT WE WILL DO

If, during the warranty period, this Product fails to operate under normal use and service, due to defects in design, materials or workmanship, Darkon Architectural Lighting Pty Ltd., authorised distributors or service partners, in the country/region where you purchased the Product, will at their option, either repair or replace the Product in accordance with the terms and conditions stipulated herein.

Darkon Architectural Lighting Pty Ltd. and its service partners reserve the right to charge a handling fee if a returned Product is found not to be under warranty according to the conditions below.

CONDITIONS

1. The warranty is valid for a period of (1) year from the date of purchase.

2. If Darkon Architectural Lighting Pty Ltd. repairs or replaces the Product, the repaired or replaced product shall be warranted for the remaining time of the original warranty period or for ninety (90) days from the date of repair, whichever is longer. Replaced parts or components will become the property of Darkon Architectural Lighting Pty Ltd

3. The warranty does not cover any failure of the Product due to normal wear and tear, or due to misuse, including but not limited to use in other than the normal and customary manner, in accordance with the Darkon Architectural Lighting Pty Ltd instructions for use and maintenance of the product. Nor does this warranty cover any failure of the Product due to accident, hardware modification or adjustment, acts of God or damage resulting from liquid.

4. The warranty does not cover Product failures caused by installations, modifications, or repair or opening of the Product performed by a non- Darkon Architectural Lighting Pty Ltd authorised person.

5. The warranty does not cover Product failures which have been caused by use of accessories or other peripheral devices which are not Darkon Architectural Lighting Pty Ltd approved accessories intended for use with the Product.

6. THERE ARE NO EXPRESS WARRANTIES, WHETHER WRITTEN OR ORAL, OTHER THAN THIS PRINTED LIMITED WARRANTY. ALL IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THIS LIMITED WARRANTY. IN NO EVENT SHALL DARKON ARCHITECTURAL LIGHTING PTY LTD OR ITS LICENSORS BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY NATURE WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOST PROFITS OR COMMERCIAL LOSS; TO THE FULL EXTENT THOSE DAMAGES CAN BE DISCLAIMED BY LAW.

Some countries/states do not allow the exclusion or limitation of incidental or consequential damages, or limitation of the duration of implied warranties, so the preceding limitations or exclusions may not apply to you.

The warranty provided does not affect the consumer’s statutory rights under applicable legislation in force, nor the consumer’s rights against the dealer arising from their sales / purchase contract.

ERCO

Terms and Conditions of Sale for Australia

Valid as of: 1. 1. 2007

1. General
All quotations are made and orders accepted subject to the following Conditions of Sale. ERCO Lighting Pte. Ltd., Singapore, (The Company) will not accept any other terms and conditions other than those specified nor any other addition or variation thereto.

2. Guarantee
The Company's products are manufactured in accordance with the latest international Test House approval specification. Components which develop faults not caused by clients negligence within the 24 month guarantee perriod will be repaired or replaced at our discretion. Under no circumstances can the Company accept liability for labour charges, out of pocket expenses or damage incurred by defects however caused.

3. Prices
All prices quoted are exclusive of GST or WST and exclusive of lamps. Whilst every endeavour will be made to invoice goods at the prices quoted and/or acknowledged that the Company reserves the right to invoice at prices ruling at time of despatch.

4. Specification/Quantities
The Company endeavours to quote the correct quantities specified. It is the responsibility of the client or contractor to verify quantities against drawings and final specification.

5. Terms
Settlement of approved Distributor accounts is required before the end of the month following month of invoice date. Goods remain the property of the Company until payment has been made, the risk of goods remains that of the client after goods have been despatched. The Company shall have the right to stop at any time delivery and the discretion to determine any contract if the cllient defaults on payment of any order after it has become due for payment.

6. Despatch
Any times quoted for despatch are given and intended as estimates only and the Company shall not be liable for any loss for failure to deliver or despatch within these times.

The customer shall undertake to ensure the disposal of the products supplied. In case of a resale, the customer shall pass this obligation on to its buyer.

7. Carriage
Carriage is free to the ERCO Distributor's adress in Australia. If direct flight or any other urgent delivery is requested by the Distributor the cost will be charged in full.

8. Loss or Damage in Transit
Unless goods have been checked on receipt they should be signed for "Unexamined". Claims for shortage or damage in transit must be notified in writing to the carrier and ourselves within three days of receipt and in case of non-delivery within 10 days of date of advice.

9. Cancellations and Returns
The written consent of the Company must be obtained before cancellation of any order is accepted. The Company reserves the right to charge for costs involved in accepting the cancellation. Goods may not be returned without the Company's written consent and without the Company's return form. Where permission for the return of goods is given a handling charge plus any carriage charge involved will be made. Goods should be returned carriage paid to our warehouse in good resaleable condition with its original packing. Special fittings manufactured to a special non standard design cannot be cancelled when production has started and cannot be returned.

10. Export
Goods purchased for the Australian market must not be offered for export without the Company's previous written consent.

11. Trade Description
All reasonable precautions have been taken to ensure that the descriptions, illustrations and technical data in the Company's catalogues are correct at the time of printing. As the Company's products are subject to improvements and modification all information is intended as guidance only. Colour finishes will be maintained as accurately as possible.

12. Copyright
All trade works drawings, descriptions and other information issued by the Company remain the property of the Company together with the copyright and patents therein.

13. Warranty
The ERCO warranty claim expires for ERCO products that have been changed, modified or amended etc. by third parties (outsiders), i.e. if they are no longer in the original condition they were in when they passed the ERCO final inspection and left the factory.

For product information and technical support:

ERCO Lighting Pte. Ltd.
Representative Office
349 Pacific Highway
North Sydney NSW 2060
Australia

Tel.: +61 2 9004 8801
Fax: +61 2 9004 8805
info.au@erco.com

ERCO Lighting Pte.Ltd.
93 Havelock Road
#03-532
Singapore 160093

Tel.: +65 6227 3768
Fax: +65 6227 8768
info.ap@erco.com
www.erco.com

For our up-to-date address list, please visit www.erco.com

Facsimile Message

INTERNATIONAL LIGHTING

Date: 20/02/2014

Company : PULVIN

Attention : Tony Killick

From: Arsen Agaciyan

Subject: UTS Broadway
Warranty Terms and Conditions

Pages: 1 of 1

Dear Tony,

Thank you for your enquiry regarding warranty applicable for the ERCO light fittings required for the above project.
We offer and are bound by Warranty/Guarantee conditions that form part of the :

"TERMS AND CONDITIONS OF SALE FOR ERCO PRODUCTS IN AUSTRALIA"
(Copy Attached)

The Guarantee of 24months (see paragraph 2) commences from the date fittings are supplied to the customer or received by an agent or freight company appointed by the customer.

This guarantee does not apply to lamps or other manufacturers remote control gear supplied as part of the order. The guarantee for those products would be as available from the individual manufacturers.

In general there is no warranty on lamps, but we do appreciate that on occasion lamps may fail after a very short time, or well before their recommended life. We are not inflexible and will do our best to replace those lamps being aware that any free issue lamps will be at the discretion of the manufacturer.

We believe this covers your request but if you require clarification or need further information please do not hesitate to call the undersigned.

Thank You & Kind Regards,

Arsen Agaciyan
02 9816 4155
Arsen.Agaciyan@intlighting.com.au

TERMS AND CONDITIONS

INLITE

1. GENERAL
(a) These terms and conditions constitute the entire agreement between the seller and the buyer relating to the goods purchased by the buyer and there are no agreements understanding warranties or representations between the parties other than those contained herein. The buyer expressly agrees that his/her offer to purchase the goods contains these terms and no other.
(b) This agreement shall be completed by the signature of the seller or his representative of this agreement.
(c) It is the buyer's responsibility to obtain any licences or permits necessary for the performance of this agreement.
(d) All descriptions specifications performance figures drawings data dimensions and weights furnished by the seller and/or contained catalogues price lists or advertisements are by way of general description only of the goods and do not constitute warranties.
(e) The buyer acknowledges and warrants that it has information necessary to enable performance of this agreement prior to the acceptance of the offer by the seller and agrees to bear any losses costs and to compensate the seller for any losses costs or expenses incurred by it arising directly or indirectly from any error or omissions in that information.

2. LEASING
If the buyer intends to lease all or any of the goods covered by the agreement, he must, at the time of entering into the agreement notify the seller of the name of the leasing company and the name of its executives who is handling the leasing arrangements. The seller is not obligated to deliver any goods intended to be leased until the leasing formalities have been completed and the seller has been duty authorised by the leasing company to deliver the goods.

3. PRICE
(a) Prices are quoted based on the full quantity specified.
(b) Price quoted are exclusive of GST which, when applicable will be charged to the purchaser at the rate applicable on the data of the invoice.
(c) Prices quoted include the cost of standard packaging and any special packaging specifically requested by the buyer in writing shall be charged extra unless specifically included in the quoted price.
(d) Price quoted are subject to delivery taking place within not more than 60 days from the placement of an order. If delivery takes more than 60 days from the placement of an order then the prices quoted are subject to adjustment to allow for any increase in the seller's current ruling price for goods of the relevant kind as between the date of placing the order and the date upon which delivery is to take place, such adjustment not being limited to only increases in taxes duties or exchange rates.

4. TERMS OF PAYMENT
(a) Prices quoted are strictly net and unless credit arrangements satisfactory to seller previously have been made by the buyer with the seller, payment shall be made in full on demand and failing the making of any demand within 30 days of the date of invoice.
(b) If the buyer fails to make any payments in accordance with the terms and conditions hereof, or shall fail to comply with any such demand by the seller, the seller may at its option, and without any liability on its part :-
(1) treat such failure or refusal as a repudiation of that portion of the contract and of any other existing contracts which is with the buyer or
(2) resell the goods at any one or more public or private sales at wholesale or otherwise and recover from the buyer the amount by which the price of the good under this contract exceeds the amount so received together with all costs and losses occasioned by default of the buyer, or
(3) stop production and deferred deliveries of any goods purchased hereunder or under any other contract with the buyer except upon receipt of satisfactory security to it of cash before delivery.
(c) At the discretion of the seller, interest shall be paid by the buyer on overdue accounts calculated on the daily balances from the day following the date upon which payments should have been made, at the rate of 20% per annum and without any demand being necessary. payments made by the buyer shall be allocated first to the interest and then to the unpaid invoices in the order in which those invoices were issued to the buyer.

5. DELIVERY, RISK AND PROPERTY
(a) All prices are ex-factory and all carriage of the goods shall be the onus of the buyer, and the buyer shall pay all carriage and carriage insurance and the buyer or risk associated with the carriage of the goods.
(b) Seller may at its discretion agree to act as agent for the buyer for delivery of the goods.
(c) Property in the goods hereby sold and/or supplied shall not pass to the buyer or a third party but shall remain with the seller until the seller has received full payment of the contract / invoice price. If the seller has not received payment in accordance with the terms hereof or upon the seller being entitled to terminate this agreement, it shall be lawful for the seller immediately, without notice to the buyer or third party and without prejudice to any other rights the seller may have, to retake possession of the goods hereby sold, and the seller for that purpose of retaking possession as foresaid or in search of the goods for that purpose, is hereby authorised to enter into any premises of or in the occupation of or controlled by the buyer and as the act of the buyer may enter the premises of any other person. The buyer shall indemnify the seller against liability for anything lawfully done in purported performance of the provisions the provisions of this clause.
(d) The seller may at its discretion make and invoice partial deliveries against an order and each such delivery shall be a separate sale under the terms and conditions of this contract.
(e) If after seven days from the date of which the goods are ready for dispatch, delivery is delayed for any reason beyond sellers reasonable control. Seller may store the goods at its premises or elsewhere and the cost of storage handling and insurance shall be payable by the buyer on demand by the seller and notwithstanding the seller may at its discretion at the expiration of the said seven days resell the goods.
(f) No delivery shall be deferred except with consent of the seller.
(g) Seller will use its best endeavours to complete this contract by any delivery date quoted but such time shall be a bona fide estimate only and shall not constitute a term of this agreement.

6. CANCELLATION OF ORDERS
In the absence of any agreement to the contrary and without prejudice to any other rights of the seller, inthe event that the seller accepts the repudiation of this agreement in whole or in part by the buyer, the buyer shall forthwidth return to the seller at his place of business all the goods, the subject of the said repudiation and the buyer shall pay to the seller 25% of the whole of the price agreed to be paid hereunder together with the invoice value of any goods not so returned.

7. INSPECTION AND ACCEPTANCE
Upon delivery of goods the buyer shall inspect goods and all costs associated with such inspection by the buyer personally, his servant or agent or by any third party shall be at the expense of buyer, whether such inspection includes installation or testing and the buyer shall give written notice to the seller within seven days of delivery of any non-conformity to description or the terms and conditions of this contract and failure to give such notice shall constitute an irrevocable acceptance of the goods by the buyer.

8. FORCE MAJEURE
Seller shall not be liable for any failure or delay to supply the goods due in any substantial part to any cause beyond control such as, but not limited to, any act or neglect of any carrier, sub-contractor, importer, distribution, manufacturer, supplier, or seller, acts of god, strikes, lock-outs, bans or other industrial disturbances, fire, flood, explosion, civil riot or commotion, governemnt intervention request or laws, regulations or orders of any government or competent statutory authority. No such failure or delay shall entitle buyer to terminate this contract and sellers obligaiton to buyer shall be suspended without liability on the part of seller while such course exist.

9. DEFAULT
Upon the happening of any of the following events:
(a) Under the commission by buyer of any act of bankruptcy or buyer going into liquidation or a petition being presented for the sequestration of buyers estate or for winding up of buyer, or
(b) Buyer assigning its property for the benefit of creditors or having a receiver or official manager appointed; or
(c) Buyer failing to make any payment to seller on the due date; or
(d) Buyer being in breach of any othese terms and condition then in such event seller shall without prejudice to
(e) any other remedies have the right to;
(i) cease supply of goods, and/or
(ii) decline to deliver the goods or any balances of the goods still due under this contract; and/or
(iii) stop any goods in transit; and/or
(iv) otherwise cease to perform any of its obligations to the buyer; and/or
(v) terminate the contract without incurring any laibility at law or in equity and without prejudice to its rights to recover amounts owing to it by buyer and/or damages; and/or
(vi) Enter into any premises of buyer and reposesses any goods already delivered to the buyer where property in such goods has not passd to buyer (in respect of which entry buyer shall indemnify and keep indemnified seller for all damages for which seller may be responsible; and/or
(vii) Recover from buyer the contract price of all goods delivered and for freight storage handling and all other expenses incurred by seller; and/or
(viii) To sell elsewhere and recover from buyer the amount of any resultant loss.

10. WARRANT AND LIABILITY OF SUPPLIER
(a) Seller’s usual written warranty shall apply in respect of the goods.
(b) If the goods are not a kind ordinarily acquired for personal domestic or household use the liability of seller for breach of any condition or warranty implied by the trade practices act 1974 (other than by section 69) shall be limited to one of the folloing at sellers option:-
(i) the replacement of the goods of the supply of equivalent goods; or
(ii) the repair of the goods; or
(iii) the payment of the cost of replacing the goods or the acquiring equivalent goods; or
(iv) the payment of the cost of having goods repaired.
(c) To the full extent permitted by law or other warranties or liabilities imposed or implied whether by law or by statute are expressly negatived.
(d) Buyer shall assume all risk and liability resulting from the use of the goods either alone or in conjunction with other goods or materials even if seller had or should have had prior knowledge of the use to which the goods would be put.
(e) Seller warrants that goods or parts of goods manufactured by it are free from defects in design, materials and workmanship. Seller’s liability under this warranty shall be limited to repair or replace free of charge at one of its warehouses selected by it of the defective part within seven days of the delivery provided notification of such defect is given to seller immediately upon the same becoming apparent and on seller’s request the goods are promptly returned to seller, carriage paid. Seller shall not be liable for any defect which is due to accident, fair wear and tear, negligent use, tampering, improper handling, improper operation or improper storage or any other default on the part of any person other than the seller.
(f) The seller’s designs and drawings may not be reproduced or disclosed to any third party without the seller’s written consent. The buyer may not without the seller’s previous consent copy or enable others to copy any goods or part thereof by seller.

11. MISCELLANEOUS
(a) The buyer agrees that he is liable for the principle of the performance of all obligations cast upon the buyer pursuant to this agreement.
(b) In the event that the buyer is a company, and in the absence of a guarantee for the due performace of this agreement by the buyer being executed by one or more directors of the buyer company in a form satisfactoy to the seller, the person signing this agreement for and on behalf of the buyer in consideration of the entry by the seller into this agreement, hereby guarantees to the seller the payment of all monies which may become due under this agreement and hereby indemnifies the seller against any loss or damage howsoever arising out of this agreement.
(c) If the person signing this agreement is not the buyer, the person signing this agreement hereby warrants that he is duty authorised by the buyer to enter into this agreement as agent or director for the buyer.
(d) All notices to be served upon buer shall be seemed to be duty served if left at or sent by ordinary prepaid post to the last known address of the buyer. Buyer shall be deemed to have received any notice two days after posting.
(e) This contract shall be governed by and construed inaccordance with the laws of Victoria and the courts of Victoria shall have exclusive jurisdiction in all matters arising herefrom.
(f) No waiver by seller of any default on the part of the buyer in the performance of any part of this agreement shall constitute a waiver of that or any other obligation or condition of this agreement.
(g) The singular shall include the plural and vice versa words imparting any gender shall include any other gender and where there is more than one buyer shall be bound to seller jointly and severally.

Consumer product guarantee

Consumer Guarantee Conditions

The benefits under this guarantee are in addition to other rights and remedies you have under a law in relation to the Products and any limitations on our liability outlined below only apply to the full extent permitted by law.

KLIKsystemsaustralia Pty Ltd (KLIK) offers a 5 year guarantee on all devices with a rated life of at least 50,000 hours of operation. A guarantee of 3 years is offered on devices with a rated life of less than 50,000 hours of operation. Lamps other than LEDs and batteries are excluded from this guarantee.

1. Products

This guarantee applies to all product and electronic control gear supplied by KLIK (electronic ballasts for fluorescent lamps, electronic ballasts for HID lamps, electronic transformers, ignitors, emergency units, converters for LED light sources, control units, magnetic ballasts for fluorescent and HID lamps) as well as LED light sources.

2. Duration of the guarantee

The guarantee period for KLIK products is 3 or 5 years, as set out below.

Basic guarantee

For products with a physical rated life of greater than or equal to 50,000 hours of operation or more, KLIK offers a guarantee for a period of 5 years.

Limited guarantee

For products with a physical rated life of less than 50,000 hours of operation, KLIK offers a guarantee for a period of 3 years.

3. Guarantee conditions

The guarantee offered by KLIK is valid under the following conditions:

The products from KLIK must be used in accordance with the relevant product and application specifications. Limit values for temperatures and voltages must not be exceeded and the product not exposed to any mechanical stresses.

The guarantee for electronic operating devices applies only if the product is installed with lamps that comply with the relevant IEC specifications.

The guarantee covers solely product failures caused by material, design or production faults and failure rates that exceed the rated failure rate. The rated life and rated failure rate of a device are considered to be the values defined in the technical documentation.

4. Execution of the guarantee

For the purpose of the guarantee, the term "nominal failure rate" is a failure rate of 0.2% per 1000 burning hours.

In the event of failures exceeding the nominal failure rate (0.2% per 1000 burning hours), KLIK in its sole discretion might decide to repair defective components or products, supply adequate products as replacement or reimburse the cost of the products to the original customer. The customers or end customers bear the costs for demounting and remounting as well as for sending in and returning products. Any other costs, e.g. replacement costs upon installation, costs caused from failures of the installation or other damage and/or consequential damage are not covered by this guarantee.

The indicated lifetime is achieved by operating lighting components according to the conditions specified by the manufacturers, to the relevant international standards and in accordance with local regulations. All electronic products having an expected failure rate require continuous monitoring, which must be documented in writing.

In view of the statistical failure rate of electronic products, installations with electronic operating devices and LED light sources require regular maintenance. The products must therefore be easy to access at all times. When installing the products, the requirements of easy maintenance must therefore be taken into consideration to keep maintenance costs down. If simple replacement is not carried out in good time, the end customer must be informed of the additional costs that may arise in connection with standard maintenance. In designing and installing luminaries, it should be remembered that the controller, ballast and/or LED light source may have to be replaced before the luminaire comes to the end of its life.

Additional Information for LED modules

The guarantee conditions relate exclusively to mortality beyond the nominal failure rate. In view of technical advances and the changes in the luminous flux of products depending on their usage there may be differences in the photometric properties between replacement or additional LED modules and the original products.

5. Utilisation of the Guarantee

To make a claim under this guarantee, you will need to contact KLIK on +61 2 9851 3300 or KLIK's authorised distributor for the territory in which you purchased the goods, and register your claim and provide details to let KLIK assess the claim. You will also need to return the defective product to KLIK or to KLIK's authorised distributor and KLIK will provide details of the authorised distributor to you. If it is not practical for you to return the goods or the service of the goods is on-site or in-home pick up, KLIK or its authorised distributor will contact you to make the necessary arrangements.

Please note, proof of purchase will be required before we can process a claim under this guarantee.

KLIK will either repair or replace the goods depending upon the nature and extent of the problem and this will be at KLIK's election.

KLIK and its authorised distributor may ask for reimbursement of any costs incurred in transporting the goods or inspecting them if the goods are found to be in good working order.

6. Limitation of guarantee

To the full extent permitted by law, KLIK is not liable:

(a) if the goods have not been installed, operated, maintained or used in accordance with KLIK's instructions or specification provided for the goods;

(b) for damage or failure caused by events outside of KLIK's control e.g. alterations or abuse of the goods, fire, liquid spillage, power surges and dips, acts of God etc.; or

(c) if the goods are sold by KLIK within Australia, for service of any products whilst it is outside Australia.

7. Applicable Law

This guarantee is subject to the laws of New South Wales, Australia.

PROJECT – UTS Broadway : Suppliers Warranty

We confirm Light Project Pty Ltd has supplied various products as listed in the following Invoices:

- Invoice # 99873, dated 10/12/2012
- Invoice # 10393, dated 14/05/2013
- Invoice # 10610, dated 10/7/2013
- Invoice # 10923, dated 26/9/2013
- Invoice # 10935, dated 30/9/2013
- Invoice # 11030, dated 21/10/2013
- Invoice # 11062 & # 11063, dated 28/10/2013
- Invoice # 11078, dated 29/10/2013
- Invoice # 11182, dated 22/11/2013
- Invoice # 11242, dated 4/12/2013

Light Project Pty Ltd confirm that the standard Manufacturers Warranty applies for the products supplied by us for this project, as listed in the Invoices shown above, as follows:

- Lumino products – 5 years subject to the conditions as listed on http://www.lumino.co.uk/uploads/5_YEAR_LIMITED_WARRANTY.pdf
- Prolicht products – 2 years subject to the manufacturers specific warranty
- BLux products - 2 years subject to the manufacturers specific warranty

Please note these Warranties <u>do not</u> apply in the case of:

1. Installation and/or assembly did not conform to manufacturer's specification.
2. The products are not used in accordance with their intended use.
3. Voltage, temperature and all other specified operating conditions were not adhered to.
4. Any other condition or application which would alter the standard operating process of the fittings in accordance with the manufacturers specification.

Signed By

Director

20.02.2014.

Date

Light Project Sydney Office
Suite 303, 55 Miller Street Pyrmont NSW 2009
P 1300 473 100
F +61 3 8415 1973

Light Project Melbourne Office
30-32 Easey Street Collingwood 3066
P +61 3 8415 1970
F +61 3 8415 1973

General Enquiries
W www.lightproject.com.au
E info@lightproject.com.au

SILL LIGHTING
AUSTRALASIA PTY LTD
ABN 67 109 075 023

Unit 18A 380 Eastern Valley Way
Chatswood 2067
Phone: 61-2-9882 6122
Fax: 61-2-9882 6444
Email: sillaust@bigpond.com.au

Our reference:
03502

Thursday, February 20, 2014

Pulvin Lighting
unit 18
Gladesville NSW 2111

Manufacturers warranty - UTS Broadway Project

Tony

I can confirm that the standard Manufacturers Warranty offered by Wila Germany GMBH and as stipulated in their warranty terms and conditions, which applies to the the product supplied on Order no. 155075, 155683.1255823, 158205 is Two (2) years .

Your sincerely

Dave Russell
Sill Lighting Australasia

Corte Franca, 13.02.2013

TO WHOM IT MAY CONCERN

Subject: Simes Warranty Declaration

Dear Sirs,

we declare that the SIMES luminaries purchased through the official SIMES sales channels are under a warranty for a period of 24 months from the date of invoice.

The standard conditions of warranty cover all the items supplied as integral to the system (Excluding lamps) against manufacturing defects & faulty workmanship.

This warranty becomes void if the system is not operated under our specified conditions of voltage, ingress, temperature & humidity and/or faulty installation and storage at site. All the luminaries must be installed as per SIMES official installation instructions and/or maintenance schedule.

The warranty does not cover damage to the finishes and any cost such as (Freight cost, custom clearance and installation costs) relative to the items supplied.

Any type of modification or alterations done locally (by yourself or any third part) without the specific authorization from the manufacturer SIMES S.p.A. voids the warranty.

We stay at your disposal for any further information.

With best regards

SIMES S.p.A.
EXPORT SALES DEPARTMENT

TARGETTI
POULSEN

WARRANTY

All Targetti products sold by Targetti Australia carry their full warranty that they are free of defect.

Warranty is twelve (12) months on parts and components.

Should defect occur, Targetti Australia will replace that part or whole at no charge, excluding outside influence, third party interference or negligence, following investigation and consideration of all relevant information.

The distributors und authorised sales partners of XAL GmbH with registered offices at Auer-Welsbachgasse 36, A-8055 Graz, are authorised to grant the following

5-year guarantee on XAL products:
We guarantee that any products sold under the brand name “XAL” are free of production and / or material defects under normal conditions of use for a guarantee period of five years starting from the invoice date.

§ 1 Scope of guarantee

(1) This guarantee shall only apply to products
 (a) which are used in accordance with the product and application specifications indicated on the data sheet;
 (b) which were installed and put into operation by an authorised electrical contractor in accordance with the installation instructions;
 (c) the maintenance requirements of which are met in a professional manner;
 (d) the threshold values of which are not exceeded for external influencing factors such as temperatures and voltages;
 (e) which are not exposed to improper mechanical stresses or loads;
 (f) which are only fitted with lamps that comply with existing IEC specifications;
 (g) which have not been modified or repaired in any way without our express permission in writing.

(2) This guarantee does not refer to
 (a) normal wear and tear and worn items or software defects, viruses and similar;
 (b) deliberate or grossly negligent damage;
 (c) construction faults;
 (d) special production orders when we work to plans, drawings and specifications submitted by the customer;
 (e) settings or parameter adjustments to equipment which has changed due to wear, fatigue or dirt;
 (f) deviations of the product from illustrations or data in our catalogues or other sales documents;
 (g) articles of merchandise and products of other manufacturers which we sell.

(3) This guarantee applies to permanent malfunctions of products due to significant produc tion and/or material defects whenever the former exceed the nominal failure rate. Unless otherwise stipulated in the product and application specifications, the nominal failure rate for electronic operating devices and components such as LEDs shall be set at 0.2% per 1,000 operating hours, unless expressly indicated otherwise. Furthermore, a decrease in luminous flux of up to 1.0% per 1,000 operating hours and a colour point shift over the service life of LED modules shall be considered normal and shall not be covered by this guarantee. In the event that LED modules are replaced, lighting properties may vary from the original product due to technical progress and changes in luminous flux as a result of usage.

§ 2 Conditions for establishing claims

(1) This guarantee is only issued on condition that the customer completes an online registration at www.xal.com (in the case of companies/corporate customers) or www.xal-living.com (in the case of consumers/private customers) within 10 weeks of the XAL invoice date. At the time of registration, the customer shall confirm whether he is a corporate or private customer; incorrect or misleading information in this regard may lead to the guarantee being declared invalid In the case of corporate customers the minimum information required for registration must include the warranty number and the place where the products are installed in addition to the contact details of the customer. In the case of private customers the minimum information required for registration must include information on the purchased products in addition to the contact details of the customer. Furthermore, the private customer must submit the original purchase receipt in the event of making a warranty claim. We reserve the right to ask corporate and private customers for further information where necessary.

(2) In order to make a guarantee claim, the customer must inform us in writing within two weeks of establishing that some or all of the products registered for the guarantee exhibit production and/or material defects. We reserve the right to be allowed a reasonable period of time to check the products. The customer shall bear the costs in the event that the products must be sent back to us for checking purposes. In the events that doubts emerge that the alleged defect actually exists or is due to a production and/or material defect covered by this guarantee, the customer shall assume the burden of proof to demonstrate the existence of the defect and/or the causality of a production and/or material defect covered by this guarantee; the customer shall furnish appropriate evidence of the same.

§ 3 Fulfilment of warranty obligations

(1) In the event that a product registered for guarantee claim turns out, upon examination, to exhibit the alleged defect or shortcomings and that the latter are covered by the guarantee statement we may either rectify the defect or replace the product as we choose in the form of an equal or equivalent or product, or refund the purchase price.

(2) The customer shall bear all additional costs incurred from the fulfilment of this guarantee. These include in particular, but not exclusively, costs of assembly and disassembly, of transport or dispatch of the defective and of the repaired product or of the replacement product, of disposal, of journey and travel times, of lifting equipment and scaffolding. The customer shall also bear the costs of any new system start-ups, software reinstallations or software updates required under this warranty.

(3) The functionality of our replacement products or parts shall correspond to that of the product or part which is to be replaced. The replacement products or parts can contain new or re-used materials that may have already been used, re-fitted or overhauled, but which are equivalent to new products or parts with regard to their performance and reliability; however, replacement products or parts may vary slightly in regard to their dimensions and design.

(4) Fulfilment of any part of this warranty shall not lead to an extension of the warranty period. However, replacement products or parts shall be covered by the warranty to the extent that we vouch that they are free of any production and/or material defects over the remaining applicable warranty period for the product which is being replaced, or into which the replacement products or parts are installed.

§ 4 Final provisions

(1) This guarantee shall only apply to products delivered on or after 03.10.2011.

(2) We shall not assume any liability extending beyond this warranty. In particular, under this warranty, we shall not assume liability for any indirect, special or consequential damage, or for any financial loss including the loss of actual or expected profits, interest, earnings, expected savings or expected business, damage to goodwill, or damage of any kind incurred by third parties. Our implied warranty shall remain unchanged, however, and shall apply in addition this warranty.

(3) Liability from this guarantee shall be restricted to the purchase price of the products affected. It is subsidiary to a liability arising from other legal reasons. An entitlement to additional services or payments, or any services and payments exceeding the actual value of the damage, may not be derived from this warranty.

(4) The customer may not transfer the guarantee or his rights arising thereunder without our express permission in writing. Third parties shall not be entitled to enforce any provision contained in this guarantee.

(5) Austrian law applies. The provisions of the UN Convention on Contracts for the International Sale of Goods shall not apply.

(6) The place of jurisdiction for any disputes arising from this warranty statement shall be Graz.

(7) If part or all of a provision of this guarantee statement is or becomes invalid or unenforceable, this shall not affect the validity of any other provision. The partially or completely invalid or unenforceable provision shall be replaced by a valid provision that comes closest to the purpose intended by the parties.

Zumtobel Lighting (Australia) Pty Ltd, ABN: 35 002 281 601 of 333 Pacific Highway, North Sydney NSW 2060, provides the following:

5-year manufacturer's guarantee on Zumtobel products:

We guarantee that, if used in accordance with their intended purpose, the products marketed under the trade mark "Zumtobel" (unless they are excepted as set forth in Item 3) are free from manufacturing defects and/or defective material for the guarantee period of five years from the invoice date. This guarantee shall apply only to products delivered on or after April 1, 2010.

The guarantee provided shall apply exclusively on the condition that the products are used in accordance with the given product and application specifications (data sheets) and that they have been installed and put into service in a workmanlike manner (according to the installation instructions enclosed with the product). The guarantee applies to all products sold by Zumtobel Lighting (Australia) Pty Ltd, including those branded Zumtobel, Bega, Glashutte Limburg or Boom. Temperature and voltage limits must not be exceeded, the product must not be exposed to any mechanical stresses and strains that are not in accordance with its intended purpose. The guarantee for electronic control gear shall apply only if the product is installed with lamps that meet the relevant I EC specifications. The guarantee exclusively covers product failures that were caused by proven defects in material, design or production as well as failure rates exceeding the nominal failure rate. In case of electronic control gear and/or components such as LEDs, the nominal failure rate is 0.2%/1000 burning hours, unless the nominal service life and nominal failure rate of a gear or of a component are defined otherwise in the product and application specifications (data sheet). The guarantee is provided only on the condition that the customer registers the respective installation (building) online (www.zumtobel.com.au/guarantee/registration) within 12 months of the invoice date.

1. If a claim is made under this guarantee and this guarantee applies we shall be at liberty to either repair the product or to replace it. Should an examination of the product reveal that the product has defects which are covered by this guarantee, we shall be at liberty, within the scope of what is reasonable, to either provide a replacement in the form of an identical or equivalent product chosen by us or refund the purchase price instead of providing a replacement.

2. This manufacturer's guarantee is a replacement products guarantee or replacement parts guarantee, as the case may be. Any and all replacement products or replacement parts may contain new or recycled materials which are equivalent to new products or parts in respect of performance and reliability. The dimensions and the design of the replacement product may deviate to a minor (justifiable) extent from those of the original product. "Recycled materials" are parts or products that have been used or overhauled and are not new. Although such parts or products are not new, they are in "like new" condition as regards performance and reliability after having been overhauled or repaired. The functionality of any and all replacement products or replacement parts is equivalent to that of the product or part to be replaced. We guarantee that replacement products or replacement parts will not have any defects in material or manufacturing defects for the remaining duration of the applicable guarantee period for the product that is replaced or into which they are incorporated.

3. The guarantee does not apply to

   a) any ancillary costs incurred in connection with remedying the defects (such as, for instance, the costs of installation and dismantling, transport of the defective and of the repaired and/or new product, disposal, mileage, travel time, hoisting engines, scaffolding); such costs shall be borne by the customer;

   b) parts subject to wear, such as, for instance, all standard lamps, batteries and starters for luminaires with magnetic ballasts and hard drives; computers and servers containing either hard discs or mechanical parts subject to wear; likewise, software defects, bugs or viruses;

   c) 3rd party components or products which Zumtobel sells separately (for instance, OEM lamps, ballasts or other componentry that are not fixed to or installed in the luminaire)

   d) settings and/or parameterizations on facilities that vary on account of wear, fatigue, or dirt; and

   e) products that have been shipped to and installed in a country other than Australia or New Zealand.

4. The guarantee shall expire immediately if any changes to or any repair work on the product is performed without written consent or if the product is installed inappropriately or by non-qualified staff.

5. Additional information concerning LED products: The guarantee conditions apply exclusively to the mortality exceeding the nominal failure rate (0.2% per 1000 burning hours). With LED modules, a reduction in luminous flux is normal as long as the relevant value does not fall below 0.6%/1000h burning hours and is thus not covered by the guarantee. Due to technical progress and to the change in the luminous flux of products that is caused by their use, subsequent deliveries of LED light sources may have light properties deviating from those of the original products.

6. We do not assume any liability in excess of this manufacturer's guarantee other than to the extent required by law. Our warranty, however, shall remain in effect without change and shall continue to be in place beside this manufacturer's guarantee.

7. The customer bears all expenses incurred in making a claim under this guarantee.

8. Within 14 days of becoming aware of an alleged fault, the customer must

   a) notify us in writing that a defect has arisen and that the customer wishes to claim the warranty. The notice must be, accompanied by the purchase contract or a corresponding invoice; and

   b) return the relevant goods to the local office at 333 Pacific Highway, North Sydney NSW 2060.

9. In the case of any dispute under this guarantee, we reserve the right to obtain the opinion of a suitably qualified independent expert whose opinion as to any question of fact under this guarantee is binding on the parties.

10. Applicable law

   a) The benefits of the guarantee are in addition to other rights and remedies under any applicable law.

   b) Our goods come with guarantees that cannot be excluded under the Australian Consumer Law. You are entitled to a replacement or refund for a major failure and compensation for any other reasonably foreseeable loss or damage. You are also entitled to have the goods repaired or replaced if the goods fail to be of acceptable quality and the failure does not amount to a major failure.

   c) Reference is made to the Terms of Sale attached to the invoice and/or to the General Conditions of Business.

11. Zumtobel's liability to the customer for:

(a) any breach of any conditions or guarantees which may apply to the contract by virtue of the provisions of Part 3-2 of the Australian Consumer Law (at Schedule 2 of the Australian Competition and Consumer Act 2010) ("**Australian Consumer Law"**) (other than sections 51, 52 or 53 of the Australian Consumer Law) or which may otherwise be included in the contract by operation of law; or

(b) any breach of contract or tort (including negligence), in connection with the sale of the goods by Zumtobel, or the giving of any information or advice by Zumtobel in relation to the goods

is limited to

(i) in the case of goods, any one or more of the following (as Zumtobel may decide):

(1) the replacement of the goods or the supply of equivalent goods;

(2) the repair of the goods;

(3) the payment of the cost of replacing the goods or of acquiring equivalent goods; or

(4) the payment of the cost of having the goods repaired.

(j) in the case of any services Zumtobel provides, either of the following (as Zumtobel may decide):

(1) the supplying of the services again; or

(2) the payment of the cost of having he services supplied again.

AGL ELECTROSERV PTY LTD

Designers and Manufactures of Electrical Equipment

WARRANTY STATEMENT

FOR

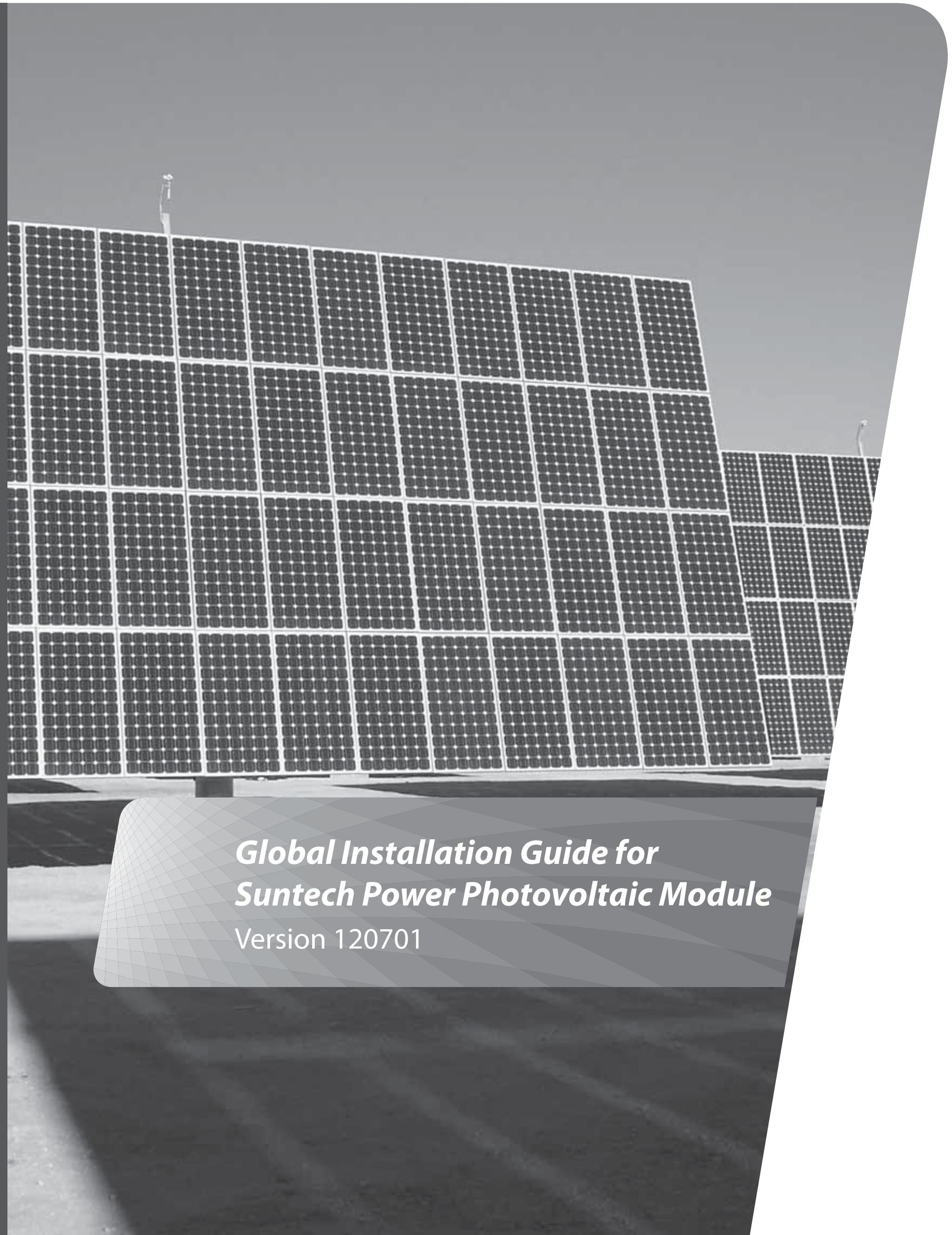
AUTOMATIC POWER FACTOR CORRECTION EQUIPMENT

Equipment designed and manufactured by Electroserv Pty Ltd is supplied under a parts and labour warranty for a period of 3 Years from date of commissioning by AGL Electroserv Pty Ltd Staff.

Note: This Warranty is further extended to five(5) years from date of Commissioning if it is serviced annually from the date of Commissioning.

AGL Electroserv Pty Ltd
Unit 1, 22 Beaumont Road Mount Kuring-Gai NSW Australia
Ph: 02-9477-7055 Fax: 02-9477-5310
Email: info@electroserv.com.au Web: www.electroserv.com.au

www.suntech-power.com



Global Installation Guide for Suntech Power Photovoltaic Module

Version 120701

Wuxi Suntech Power Co., Ltd.
Address: Changjiang South Road, New District Wuxi, China 214028
Customer Service Hot Line: +86 400 8888 009 Fax: +86 510 8534 3321
E-mail: services@suntech-power.com
Or please contact our local representatives, details at www.suntech-power.com

Table of Contents

- This guide contains information regarding the installation and safe handling of Suntech Power Co., Ltd photovoltaic module (hereafter referred to as "module"). Suntech Power Co., Ltd referred to as "Suntech".
- Installers must read and understand this guide prior to installation. For any questions, please contact Suntech's Global Quality & Customer Support department or our local representatives for more detailed information. Installers must follow all safety precautions as described in this guide as well as local requirement and regulations by law or authorised organisations.
- Before installing a solar photovoltaic system, installers should familiarize themselves with its mechanical and electrical requirements. Keep this guide in a safe place for future reference (care and maintenance) and in case of sale or disposal of the modules.
- Suntech modules are tested and certified for installation worldwide. Different regions may have different regulations for solar PV installations. In this guide, hereafter "IEC Only" is used to refer to regions where IEC standard applies, e.g. Europe, Middle East, most of Asia Pacific countries; " UL Only " is used to refer to regions where UL standard applies, e.g. United States, Canada; all other references are global.

General safety

- Modules that fall under this application class may be used in system operation at more than 50V DC or 240W, where general contact access is anticipated. Modules qualified for safety under IEC 61730-2 and within this application class are considered to meet the requirements for Safety Class II. (IEC Only)
- Installing solar photovoltaic systems requires specialized skills and knowledge. Installation must only be performed by qualified personnel.
- Installers should assume all risks of injury that might occur during installation, including, but not limited to, the risk of electric shock.
- One single module may generate more than 30V DC when exposed to direct sunlight. Contact with a DC voltage of 30V or more is potentially hazardous.
- Do not disconnect under load.
- Photovoltaic solar modules convert light energy to direct current electrical energy. They are designed for outdoor use. Modules can be ground mounted, mounted on rooftops, vehicles or boats. The proper design of support structures lies within the responsibility of the system designers and installers.
- When installing the system, abide to all local, regional and national statutory regulations. Obtain a building permit if necessary.
- The electrical characteristics are within ±10 percent of the indicated values of Isc, Voc and Pmax under standard test conditions (irradiance of 1000 W/m^2, AM 1.5 spectrum, and a cell temperature of 25°C (77°F)).
- Only use equipment, connectors, wiring and support frames suitable for solar electric systems.

- Do not use mirrors or other magnifiers to concentrate sunlight onto the modules.
- Always use fall protection equipment when working from heights of 6 feet (183cm) or above. Follow Occupational Safety and Health Act (OSHA) or local governing safety regulations regarding Fall Protection. (UL Only)

Handling safety

- Do not lift the module by grasping the module's junction box or electrical leads.
- Do not sit, stand, step or walk on any side of the module.
- Do not drop the module or allow objects to fall on the module.
- Do not place any heavy objects on the module.
- Be cautious when placing the module down onto a surface, particularly when placing it in a corner.
- Inappropriate transport and installation may break the module and void the warranty.
- Do not attempt to disassemble the modules, and do not remove any attached nameplates or components from the modules.
- Do not apply paint or adhesive to the module top surface or backsheet.
- To avoid damage to the backsheet, do not scratch, dent or hit the backsheet.
- Do not drill holes in the frame. This may compromise the frame strength, cause corrosion of the frame and void the warranty.
- Do not scratch the anodized coating of the frame (except for grounding connections at the grounding connection point on the back side of the module). It may cause corrosion of the frame or compromise the frame strength.
- A panel with broken glass or torn backsheet cannot be repaired and must not be used since contact with any panel surface or the frame can cause an electric shock.
- Work only under dry conditions, and use only dry tools. Do not handle panels under wet conditions unless wearing appropriate protective equipment.
- When storing uninstalled panels outdoors for any period of time, always cover the panels and ensure that the glass faces down on a soft flat surface to prevent water from collecting inside the panel and causing damage to exposed connectors.

Installation safety

- Never open electrical connections or unplug connectors while the circuit is under load.
- Contact with electrically charged parts of the panels, such as terminals, can result in burns, sparks and lethal shock whether or not the panel is connected.
- Do not touch the PV module unnecessarily during installation. The glass surface and the frame may be hot; there is a risk of burns and electric shock.
- Do not work in the rain, snow or in windy conditions.
- Avoid exposing cables to direct sunlight in order to prevent insulation degradation.
- Use only insulated tools that are approved for working on electrical installations.

Purpose of this guide

- Keep children well away from the system while transporting and installing mechanical and electrical components.
- Completely cover the module with an opaque material during installation to prevent electricity from being generated.
- Do not wear metallic rings, watchbands, earrings, nose rings, lip rings or other metallic objects while installing or troubleshooting photovoltaic systems.
- Follow the safety regulations(eg. safety rules for working on electrical power plant stations) for all other system components, including wires and cables, connectors, charging regulators, inverters, storage batteries, rechargeable batteries, etc.
- Under normal conditions, a photovoltaic module is likely to experience conditions that produce more current and/or voltage than reported at standard test conditions. Accordingly, the values of Isc and Voc marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor current ratings, minimum factor of fuse sizes, and size of controls connected to the PV output.
- Only use same or connectable connectors to connect modules to form a string, or connect to another device. Removing the connectors will void the warranty.

Fire Safety

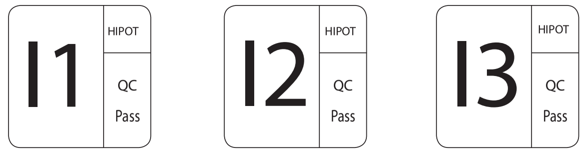
- Consult your local authority for guidelines and requirements for building or structural fire safety.
- Roof constructions and installations may affect the fire safety of a building; improper installation may create hazards in the event of a fire.
- Use components such as ground fault circuit breakers and fuses as required by local authority.
- Do not use panels near equipment or in places where flammable gases may be generated.
- The modules have been rated Fire Class C, and are suitable for mounting on to a Class A roof.

Product identification

Each module has three labels providing the following information:

1. Nameplate: describes the product type; rated power, rated current, rated voltage, open circuit voltage, short circuit current, all as measured under standard test conditions; weight, dimensions etc.; the maximum system voltage is 600 volts DC for UL standard and 1000 volts DC for IEC standard.

2. Current Sorting and Quality label: three different marks are shown on this sticker. "QC Pass" assures that the module has passed the quality control examination. "HIPOT" means that it has passed the insulation test. Finally modules are sorted out according to their output current, referred as a corresponding symbol "Ix" attached, in which x takes the value 1, 2 or 3(I3 marks physically the highest current). To get optimal performance out of a string of modules it is recommended to connect only modules of the same "Ix" class (for example only I2 modules) in one given string.



Current Sorting and Quality label

3. Barcode: each individual module has a unique serial number. The serial number has 18 digits. The 15th and the 16th digits are the week code, and the 17th and the 18th digits are the year code. For example, STP xxxxxxxxxxxxx4411 means the module was assembled and tested in the 44th week of 2011. Each module has only one bar code. It is permanently attached to the interior of the module and is visible from the top front of the module. This bar code is inserted prior to laminating.

STP 041913243082834411

Typical serial number barcode label

Do not remove any labels. Removing a label will make the Suntech warranty void.

Mechanical Installation

Selecting the location

- Select a suitable location for installing the modules.
- The modules should face south in northern latitudes and north in southern latitudes.
- For detailed information on the best installation angle, refer to standard solar photovoltaic installation guides or consult a reputable solar installer or systems integrator.
- Modules should not be shaded at any time. If a module is shaded or even partially shaded, it will fail to perform at ideal conditions and result in lower power output. A permanent shade on the module may void the warranty.

- This installation manual is applicable for all pv system of 500 m or more away from the coastline. If your system gets closer please contact Suntech's Global Quality & Customer Support department or our regional representatives and/or refer to the Near-coast Installation Guide for Suntech Power Photovoltaic Module.
- Do not use modules near equipment or in locations where flammable gases may be generated or collected.

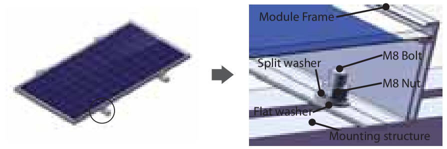
General Installation

- The module mounting structure must be made of durable, corrosion-resistant and UV-resistant material.
- In regions with heavy snowfall in winter, select the height of the mounting system so that the lowest edge of the module is not covered by snow for any length of time. In addition, ensure that the lowest portion of the module is placed high enough so that it is not shaded by plants, trees or damaged by ground soil moved by or through the air.
- For ground mounting systems, the minimum distance Suntech recommend from the ground to the bottom of the module is at least 24 inches (60cm).
- Modules must be securely attached to the mounting structure. For Clamping System installation methods, the recommended maximum compression for each clamp is 2900 PSI (20 Mpa) in order to avoid potential damages to module frames.
- Provide adequate ventilation under the modules in conformity to your local regulations. A minimum distance of 10 cm between the roof plane and the frame of the module is generally recommended.
- Always observe the instructions and safety precautions included with the module support frames.
- Before installing modules on a roof, always ensure the roof construction is suitable. In addition, any roof penetration required to mount the module must be properly sealed to prevent leaks.
- Dust building up on the surface of the module can impair with the module performance. Suntech recommends installing the modules with a tilt angle of at least 10 degrees, making it easier for dust to be removed by rain.
- Observe the linear thermal expansion of the module frames (the recommended minimum distance between two modules is 2 cm).
- Always keep the backsheet of the panel free from foreign objects, plants and vegetation, structural elements, which could come into contact with the panel, especially when the panel is under mechanical load.
- When installing a module on a pole, select a pole and module mounting structure that will withstand the anticipated winds for the area.
- Ensure panels are not subject to wind or snow loads exceeding the maximum permissible loads, and are not subject to excessive forces due to the thermal expansion of the support structures: Refer to the following installation methods for more detailed information.

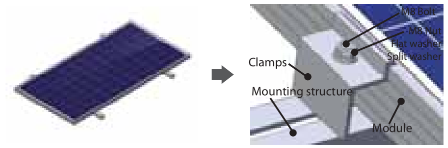
Installation methods

- Modules can be installed on the frame using mounting holes, clamps* or an insertion system. Modules must be installed according to the following examples. Not mounting the modules according to these instructions may void the warranty.

Module installed with mounting holes



Module installed with clamps



** The minimum recommended length for each clamp is 50 mm.*

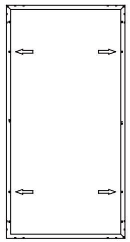
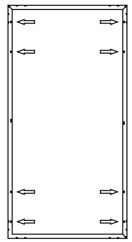
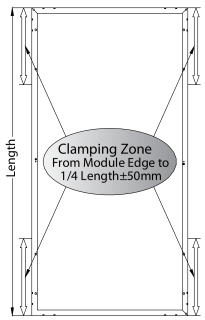
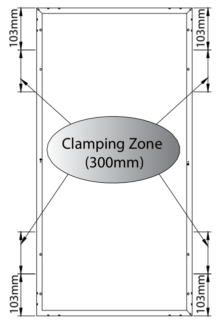
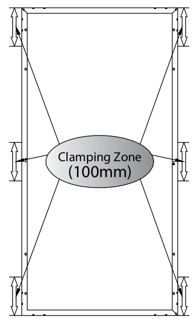
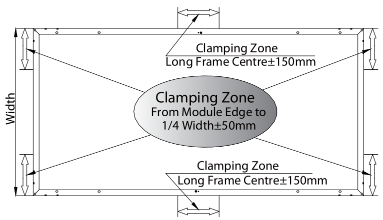
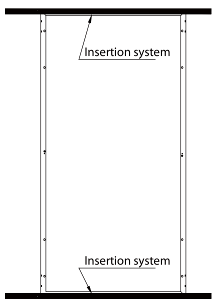
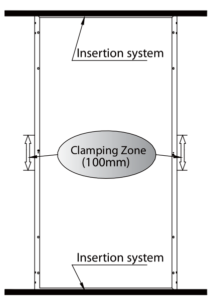
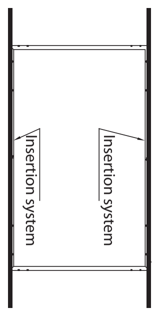
- Module can be installed in both landscape and portrait modes.
- The modules must be properly secured to their support so that they can withstand live load conditions, including wind uplift, to the pressure they have been certified for. It is the installer's responsibility to ensure that the clamps used to secure the modules are strong enough.

Attachment guidelines

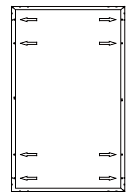
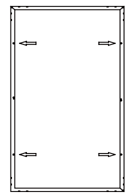
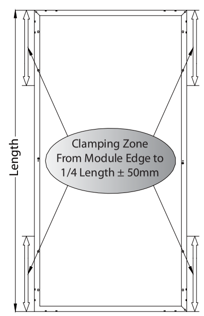
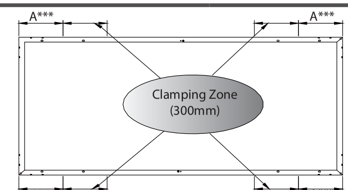
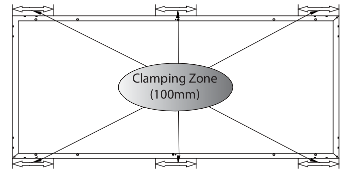
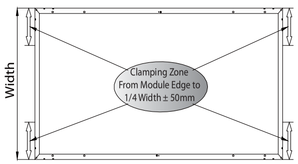
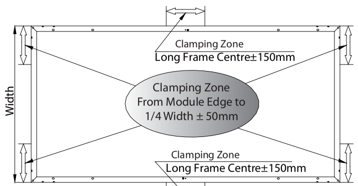
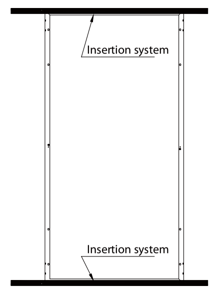
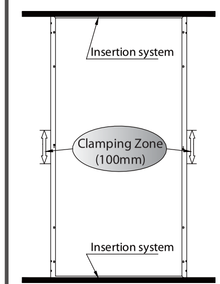
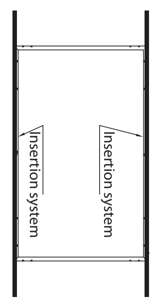
- Select the proper installation method depending on the load(See below for more detailed information).
- With different installation methods, the modules have been tested to withstand the loads of 2400 Pa, 3800 Pa and 5400 Pa according to IEC 61215 standard, equivalent of 1600 Pa, 2500 Pa and 3600 Pa respectively under UL 1703 standard.
- The diagrams in the tables below are designed for illustration purpose. For each installation, modules can be installed either in portrait or landscape mode.

Suntech Module Type	Module Dimension Length×Width×Thickness
A Series	1580 mm×808 mm×35 mm
W Series	1640 mm×992 mm×35 mm
W Series	1640 mm×992 mm×50 mm
Wdl (Made in Korea)	1675 mm×1001 mm×34 mm
V Series	1956 mm×992 mm×50 mm
Ve	1956 mm×992 mm×40 mm
Vdx (V landscape series)	1930 mm×998 mm×50 mm

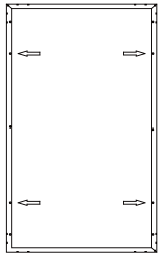
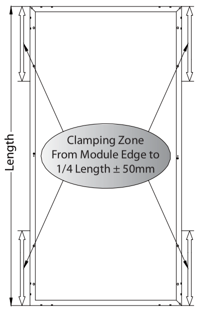
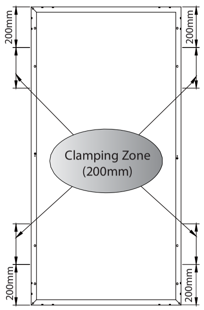
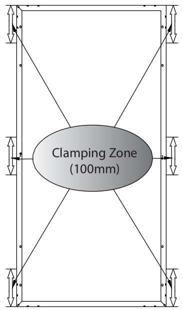
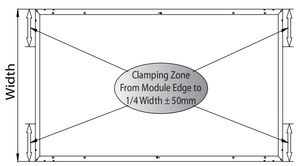
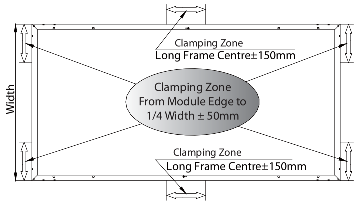
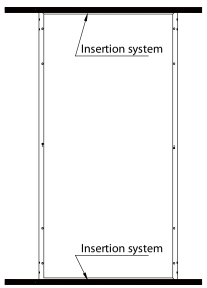
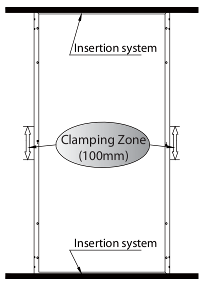
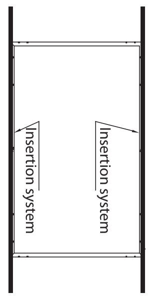
Suntech A series module

	2400 Pa Load * *2400 Pa Wind Load* *2400 Pa Snow Load*	**3800 Pa Load *** *3800 Pa Wind Load* *3800 Pa Snow Load*	**5400 Pa Load *** *5400 Pa Snow Load* *3800 Pa Wind Load*
Mounting system		 Use four mounting holes	 Use eight mounting holes
Clamping system ** Attachment to the long frame	 Use four clamps		 Use four clamps  Use six clamps
Clamping system ** Attachment to the short frame			 Use four clamps on the short frame and two clamps at the center of each long frame
Insertion System	 Use insertion system on short frame		 Use insertion system on a short frame and two clamps at the center of each long frame  Use an insertion system on a long frame

Suntech W series, V series, Vdx (V landscape series) module

	2400 Pa Load * *2400 Pa Wind Load* *2400 Pa Snow Load*	**3800 Pa Load *** *3800 Pa Wind Load* *3800 Pa Snow Load*	**5400 Pa Load *** *5400 Pa Snow Load* *3800 Pa Wind Load*
Mounting system			 Use eight mounting holes (Exclude Ve)  Use four mounting holes
Clamping system ** Attachment to the long frame	 Use four clamps		 Use four clamps  Use six clamps
Clamping system ** Attachment to the short frame	 Use four clamps on short frame		 Use four clamps on the short frame and two clamps at the center of each long frame
Insertion System	 Use insertion system on short frame		 Use insertion system on a short frame and two clamps at the center of each long frame  Use an insertion system on a long frame

Suntech Wdl (Made in Korea) module

	2400 Pa Load * *2400 Pa Wind Load* *2400 Pa Snow Load*	**5400 Pa Load *** *5400 Pa Snow Load* *2400 Pa Wind Load*	**5400 Pa Load *** *5400 Pa Snow Load* *3800 Pa Wind Load*
Mounting system		 Use four mounting holes	
Clamping system ** Attachment to the long frame	 Use four clamps	 Use four clamps	 Use six clamps
Clamping system ** Attachment to the short frame	 Use four clamps on short frame		 Use four clamps on the short frame and two clamps at the center of each long frame
Insertion System	 Use insertion system on short frame		 Use insertion system on a short frame and two clamps at the center of each long frame  Use an insertion system on a long frame

**	The loads of 2400 Pa, 3800 Pa and 5400 Pa are under IEC standard. The installation methods applicable for 5400 Pa are also relevant for 3800 Pa and 2400 Pa. The installation methods applicable for 3800 Pa are also relevant for 2400 Pa.*

***	The module clamps must not come into contact with the front glass or deform the frame in any way. Avoid shading effects from the module clamps and insertion systems. Drainage holes in the module frame must not be closed or obscured by the clamps.*

****	Measurement A stands for the distance from the module edge to the clamping zone. Measurement A is 108 mm for W series 50mm thickness, 180mm for W series 35mm thickness, 127 mm for V series 50mm thickness (including Vdx) and 280mm for V series 40mm thickness. The clamping zone defines the range for the middle point of the clamp.*

Electrical Installation

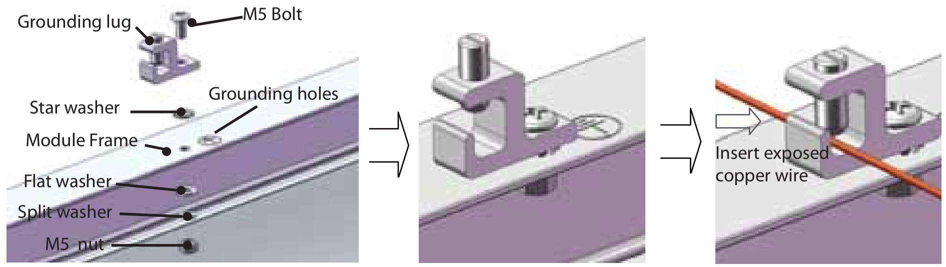
General installation

- Any hardware used must be compatible with the mounting structure material to avoid galvanic corrosion.
- It is not recommended to use modules with different configurations (grounding, wiring) in the same system.
- Excessive cables must be organized or fixed in an adequate way, e.g. attached to the mounting structure by using non-metallic cable ties. Solar connectors should not be exposed to water exposure and water submersion.
- For applications requiring high operating voltage several modules can be connected in series to form a string of modules; the system voltage is then equal to the sum of the voltage of each module.
- For applications requiring high operating currents several strings of modules can be connected in parallel; the system current is then equal to the sum of the current of each string of modules.
- The maximum system voltage is 600 volts DC according to UL standards. However products are rated for use up to 1000V where UL standards do not apply. (UL Only)
- The maximum number of series connected modules depends on system design, the type of inverter used and environmental conditions.
- Based on the maximum series fuse rating of module and local electrical installation code, always make sure Suntech PV modules with more than three strings in parallel for connection need to be assembled with the appropriate string fuse for circuit protection.
- There is no limitation on the number of modules that can be connected in parallel, the number of modules is determined by system design parameters such as current or power output.
- To prevent the cables and the connectors from overheating, the cross section of the cables and the capacity of the connectors must be selected to suit the maximum system short circuit current. The recommended cable is PV wire with a cross section of at least $4mm^2$.

- Please refer to local regulations to determine the system wires size, type and temperature.
- Suntech modules are supplied with connectors used for system electrical connections. The recommended connectors are H&S Radox™ connectors, Amphenol H4, Multi Contact MC4 or equivalent, of which Amphenol H4 and Multi Contact MC4 are connectable.
- To ensure reliable electric connection and to prevent possible intrusion of humidity, H&S Radox™ integrated twist locking connectors have to be fully mated together and then manually twisted clockwise (a turn of around 90° shall be performed until the gap between the 2 connectors is closed), while Amphenol H4 and Multi Contact MC4 connectors must be mated and locked together until a click can be heard.
- Long-term exposure to wet environments may cause connectors' poor connectivity, resulting in current leakage and poor conductivity. Suntech recommends proper connector/cable/wire management to prevent moisture intrusion. Depending on the amount of humidity, Suntech recommends periodic inspections of the installation system to maintain optimal module performance.
- The DC current generated by photovoltaic systems can be converted into AC and fed into a public Grid. As local utilities' policies on connecting renewable energy systems to the Grids vary from region to region. Always seek the advice from a qualified system designer or integrator. Building permits, inspections and approvals by the local utility are generally required.

Grounding

- For grounding and bonding requirements, please refer to regional and national safety and electricity standards. If grounding is required, use a recommended connector type for the grounding wire.
- For grounding, this guide refers to module frame grounding. If grounding is required, make sure module frames (metal exposed to touch) are always grounded.
- System grounding is not mandatory for Suntech modules, however negative system grounding may be required by local authorities and can therefore be recommended. In practice, Suntech has observed certain installations with a positive impact on system performance due to implementation of negative system grounding.
- If grounding is required, the grounding wire must be properly fastened to the module frame to assure adequate electrical connection.
- Suntech recommends the lay-in lug (Cat. No. GBL-4DBT (Supplier: ILSCO)) when grounding, which is applicable for A, W (Wdl excluded), V series. Please refer to appropriate connector specifications for instructions.
- When using the GBL-4DBT grounding lug, assemble the grounding lug to the aluminum frame using stainless steel M5 screw and hardware as shown below. The star washer is fitted directly under the grounding lug and makes electrical contact by penetrating the anodized coating of the aluminum frame; the screw assembly is further fitted with a flat washer, then a split lock washer and finally a nut to secure the entire assembly (see the pictures below). Recommended M5 screw assembly torque is 1.5 N•m. Next, insert the ground wire (10-12AWG exposed copper wire is recommended) to the feet of the lug, and screw down the slotted screw. Be careful not to damage the wire core.



Maintenance

To ensure optimum module performance, Suntech recommends the following maintenance measures:

- Clean the glass surface of the module when required. Always use clean water and a soft non-abrasive sponge or cloth for cleaning. A mild, non-abrasive cleaning agent may be used to remove stubborn dirt.
- Check the electrical, grounding and mechanical connections every six months to verify that they are clean, secure,undamaged and free of corrosion.
- If any problem arises, consult a professional solar service providers for suggestions.
- Caution: observe solar manufacturers' maintenance instructions for all components used in the system, such as support frames, charging regulators, inverters, batteries etc.

A series - 1580 mm×808 mm×35 mm

Module	Optimum Operating Voltage (Vmp) at STC, (V dc)	Optimum Operating Current (Imp) at STC, (A dc)	Open Circuit Voltage (Voc) at STC, (V dc)	Short Circuit Current (Isc) at STC, (A dc)	Maximum Power (Pmax) at STC, (Watts)	Maximum System Voltage (IEC/UL)	Maximum Series Fuse Rating
STP200S-24/Ad+	36.7	5.45	45.5	5.81	200	1000/600	15
STP195S-24/Ad+	36.6	5.33	45.4	5.69	195	1000/600	15
STP190S-24/Ad+	36.6	5.20	45.2	5.62	190	1000/600	15
STP185S-24/Ad+	36.4	5.09	45.0	5.43	185	1000/600	15
STP180S-24/Ad+	36.0	5.00	44.8	5.29	180	1000/600	15
STP175S-24/Ad+	35.8	4.90	44.7	5.23	175	1000/600	15
STP190S-24/Adb+	36.6	5.20	45.2	5.62	190	1000/600	15
STP185S-24/Adb+	36.4	5.09	45.0	5.43	185	1000/600	15
STP180S-24/Adb+	36.0	5.00	44.8	5.29	180	1000/600	15
PLUTO200-Ade	36.6	5.48	45.4	5.80	200	1000/600	15
PLUTO195-Ade	36.4	5.36	45.3	5.67	195	1000/600	15
PLUTO190-Ade	36.3	5.24	45.1	5.55	190	1000/600	15
PLUTO180-Ade	35.9	5.02	44.7	5.30	180	1000/600	15

Wdl - 1675 mm×1001 mm×34 mm

Module	Optimum Operating Voltage (Vmp) at STC, (V dc)	Optimum Operating Current (Imp) at STC, (A dc)	Open Circuit Voltage (Voc) at STC, (V dc)	Short Circuit Current (Isc) at STC, (A dc)	Maximum Power (Pmax) at STC, (Watts)	Maximum System Voltage (IEC/UL)	Maximum Series Fuse Rating
STP245-20/Wdl	30.4	8.06	37.4	8.54	245	1000/600	15
STP240-20/Wdl	30.3	7.93	37.2	8.44	240	1000/600	15
STP235-20/Wdl	30.1	7.84	37.0	8.35	235	1000/600	15

W series - 1640 mm×992 mm×50 mm/1640 mm×992 mm×35 mm

Module	Optimum Operating Voltage (Vmp) at STC, (V dc)	Optimum Operating Current (Imp) at STC, (A dc)	Open Circuit Voltage (Voc) at STC, (V dc)	Short Circuit Current (Isc) at STC, (A dc)	Maximum Power (Pmax) at STC, (Watts)	Maximum System Voltage (IEC/UL)	Maximum Series Fuse Rating
STP260-20/Wd	30.9	8.42	37.7	8.89	260	1000/600	20
STP255-20/Wd	30.8	8.28	37.6	8.76	255	1000/600	20
STP250-20/Wd	30.7	8.15	37.4	8.63	250	1000/600	20
STP245-20/Wd	30.5	8.04	37.3	8.52	245	1000/600	20
STP240-20/Wd	30.2	7.95	37.2	8.43	240	1000/600	20
STP235-20/Wd	30.2	7.79	37.0	8.35	235	1000/600	20
STP230-20/Wd	29.8	7.72	36.8	8.25	230	1000/600	20
STP225-20/Wd	29.6	7.61	36.7	8.15	225	1000/600	20
STP220-20/Wd	29.5	7.46	36.6	8.05	220	1000/600	20
STP215-20/Wd	29.2	7.37	36.5	7.95	215	1000/600	20
STP210-20/Wd	29.0	7.25	36.4	7.86	210	1000/600	20
STP265S-20/Wd	31.0	8.55	37.8	9.01	265	1000/600	20
STP260S-20/Wd	30.9	8.42	37.7	8.89	260	1000/600	20
STP255S-20/Wd	30.8	8.28	37.6	8.76	255	1000/600	20
STP250S-20/Wd	30.7	8.15	37.4	8.63	250	1000/600	20
STP245S-20/Wd	30.5	8.04	37.3	8.52	245	1000/600	20
STP240S-20/Wd	30.2	7.95	37.2	8.43	240	1000/600	20
STP265S-20/Wdb	31.0	8.55	37.8	9.01	265	1000/600	20
STP260S-20/Wdb	30.9	8.42	37.7	8.89	260	1000/600	20
STP255S-20/Wdb	30.8	8.28	37.6	8.76	255	1000/600	20
STP250S-20/Wdb	30.7	8.15	37.4	8.63	250	1000/600	20
STP245S-20/Wdb	30.5	8.04	37.3	8.52	245	1000/600	20
STP240S-20/Wdb	30.2	7.95	37.2	8.43	240	1000/600	20
STP235S-20/Wdb	30.2	7.79	37.0	8.35	235	1000/600	20
PLUTO260-Wdm	30.4	8.56	37.9	8.84	260	1000/600	20
PLUTO255-Wdm	30.2	8.45	37.7	8.72	255	1000/600	20
PLUTO250-Wdm	30.0	8.34	37.4	8.63	250	1000/600	20
PLUTO245-Wdm	29.8	8.23	37.2	8.55	245	1000/600	20
PLUTO240-Wdm	29.6	8.11	36.9	8.46	240	1000/600	20
PLUTO235-Wdm	29.4	8.00	36.4	8.42	235	1000/600	20
PLUTO230-Wdm	29.2	7.88	36.2	8.27	230	1000/600	20
PLTUO245-Wde	29.8	8.23	37.2	8.55	245	1000/600	20
PLUTO240-Wde	29.6	8.00	36.9	8.46	240	1000/600	20
PLUTO235-Wde	29.4	8.00	36.4	8.42	235	1000/600	20
PLUTO230-Wde	29.2	7.88	36.2	8.27	230	1000/600	20

W series - 1640 mm×992 mm×35 mm

Module	Optimum Operating Voltage (Vmp) at STC, (V dc)	Optimum Operating Current (Imp) at STC, (A dc)	Open Circuit Voltage (Voc) at STC, (V dc)	Short Circuit Current (Isc) at STC, (A dc)	Maximum Power (Pmax) at STC, (Watts)	Maximum System Voltage (IEC/UL)	Maximum Series Fuse Rating
STP260-20/Wde	30.9	8.42	37.7	8.89	260	1000/600	20
STP255-20/Wde	30.8	8.28	37.6	8.76	255	1000/600	20
STP250-20/Wde	30.7	8.15	37.4	8.63	250	1000/600	20
STP245-20/Wde	30.5	8.04	37.3	8.52	245	1000/600	20
STP240-20/Wde	30.2	7.95	37.2	8.43	240	1000/600	20
STP235-20/Wde	30.2	7.79	37.0	8.35	235	1000/600	20
STP230-20/Wde	29.8	7.72	36.8	8.25	230	1000/600	20
STP225-20/Wde	29.6	7.61	36.7	8.15	225	1000/600	20
STP220-20/Wde	29.5	7.46	36.6	8.05	220	1000/600	20
STP215-20/Wde	29.2	7.37	36.5	7.95	215	1000/600	20
STP210-20/Wde	29.0	7.25	36.4	7.86	210	1000/600	20

V series - 1956 mm×992 mm×40 mm

Module	Optimum Operating Voltage (Vmp) at STC, (V dc)	Optimum Operating Current (Imp) at STC, (A dc)	Open Circuit Voltage (Voc) at STC, (V dc)	Short Circuit Current (Isc) at STC, (A dc)	Maximum Power (Pmax) at STC, (Watts)	Maximum System Voltage (IEC/UL)	Maximum Series Fuse Rating
Superpoly STP310-24/Ve	36.5	8.50	45.4	8.85	310	1000/600	20
Superpoly STP305-24/Ve	36.3	8.41	45.3	8.74	305	1000/600	20
Superpoly STP300-24/Ve	36.1	8.32	45.2	8.65	300	1000/600	20
Superpoly STP295-24/Ve	35.7	8.27	45.1	8.57	295	1000/600	20
Superpoly STP290-24/Ve	35.6	8.15	45.0	8.42	290	1000/600	20
Superpoly STP285-24/Ve	35.4	8.06	44.9	8.37	285	1000/600	20
Superpoly STP280-24/Ve	35.2	7.95	44.8	8.33	280	1000/600	20
STP310-24/Ve	36.5	8.50	45.4	8.85	310	1000/600	20
STP305-24/Ve	36.3	8.41	45.3	8.74	305	1000/600	20
STP300-24/Ve	36.1	8.32	45.2	8.65	300	1000/600	20
STP295-24/Ve	35.7	8.27	45.1	8.57	295	1000/600	20
STP290-24/Ve	35.6	8.15	45.0	8.42	290	1000/600	20
STP285-24/Ve	35.4	8.06	44.9	8.37	285	1000/600	20
STP280-24/Ve	35.2	7.95	44.8	8.33	280	1000/600	20
STP275-24/Ve	35.1	7.84	44.7	8.26	275	1000/600	20
STP270-24/Ve	35.0	7.71	44.5	8.20	270	1000/600	20
STP260-24/Ve	34.8	7.47	44.0	8.09	260	1000/600	20

V series (Vdx) - 1956 mm×992 mm×50 mm (1930 mm×998mm×50 mm)

Module	Optimum Operating Voltage (Vmp) at STC, (V dc)	Optimum Operating Current (Imp) at STC, (A dc)	Open Circuit Voltage (Voc) at STC, (V dc)	Short Circuit Current (Isc) at STC, (A dc)	Maximum Power (Pmax) at STC, (Watts)	Maximum System Voltage (IEC/UL)	Maximum Series Fuse Rating
Superpoly STP310-24/Vd	36.5	8.50	45.4	8.85	310	1000/600	20
Superpoly STP305-24/Vd	36.3	8.41	45.3	8.74	305	1000/600	20
Superpoly STP300-24/Vd	36.1	8.32	45.2	8.65	300	1000/600	20
Superpoly STP295-24/Vd	35.7	8.27	45.1	8.57	295	1000/600	20
Superpoly STP290-24/Vd	35.6	8.15	45.0	8.42	290	1000/600	20
Superpoly STP285-24/Vd	35.4	8.06	44.9	8.37	285	1000/600	20
Superpoly STP280-24/Vd	35.2	7.95	44.8	8.33	280	1000/600	20
STP310-24/Vd	36.5	8.50	45.4	8.85	310	1000/600	20
STP305-24/Vd	36.3	8.41	45.3	8.74	305	1000/600	20
STP300-24/Vd	36.1	8.32	45.2	8.65	300	1000/600	20
STP295-24/Vd	35.7	8.27	45.1	8.57	295	1000/600	20
STP290-24/Vd	35.6	8.15	45.0	8.42	290	1000/600	20
STP285-24/Vd	35.4	8.06	44.9	8.37	285	1000/600	20
STP280-24/Vd	35.2	7.95	44.8	8.33	280	1000/600	20
STP275-24/Vd	35.1	7.84	44.7	8.26	275	1000/600	20
STP270-24/Vd	35.0	7.71	44.5	8.20	270	1000/600	20
STP260-24/Vd	34.8	7.47	44.0	8.09	260	1000/600	20
STP290-24/Vdx	35.6	8.15	45.0	8.42	290	1000/600	20
STP280-24/Vdx	35.2	7.95	44.8	8.33	280	1000/600	20
STP275-24/Vdx	35.1	7.84	44.7	8.26	275	1000/600	20
STP270-24/Vdx	35.0	7.71	44.5	8.20	270	1000/600	20
STP260-24/Vdx	34.8	7.47	44.0	8.09	260	1000/600	20
PLUTO295-Vdx	36.5	8.09	45.3	8.57	295	1000/600	20
PLUTO290-Vdx	36.3	7.99	45.1	8.52	290	1000/600	20
PLUTO285-Vdx	36.1	7.90	44.9	8.46	285	1000/600	20
PLUTO280-Vdx	35.5	7.89	44.4	8.41	280	1000/600	20
PLUTO310-Vdm	36.8	8.43	45.6	8.84	310	1000/600	20
PLUTO305-Vdm	36.7	8.32	45.5	8.72	305	1000/600	20
PLUTO300-Vdm	36.6	8.20	45.4	8.62	300	1000/600	20
PLUTO295-Vdm	36.5	8.09	45.3	8.57	295	1000/600	20
PLUTO290-Vdm	36.3	7.99	45.1	8.52	290	1000/600	20
PLUTO285-Vdm	36.1	7.90	44.9	8.46	285	1000/600	20
PLUTO280-Vdm	35.5	7.89	44.4	8.41	280	1000/600	20

SUNTECH POWER
LIMITED WARRANTY FOR PV MODULES

Effective from January 1, 2012

You have made the right choice by purchasing SUNTECH products with a long life time. Suntech photovoltaic modules are covered by warranty as described in detail below.-

Suntech Standard PV Module Products covered under this warranty are:
STPXXX(S)-YY/Zd(b)(+) (XXX = 170-320 / YY = 18, 20, 24, / Z = A, U, V, W)
PlutoXXX-Zd(a, e, m, x) (XXX = 170-320 / Z=A, U, V, W)
MSZXXX-J-C (XXX = 170-200)
MSZXXX-J-D (XXX = 170-200)
XXX is a module power rating. S/Z/d/+/b/e/m/x/J/C/D defines module variants as described in corresponding product data sheet.

For the standard solar module types listed above, Wuxi Suntech Power Co., Ltd. (SUNTECH POWER) shall WARRANT its Photovoltaic Solar Modules' (MODULES) performance (i) starting from the date of sale (SALES DATE) to the first customer installing (for their own use) the MODULES (CUSTOMER) or (ii) starting at the latest 12 months after MODULES dispatch from the SUNTECH POWER factory, whichever occurs earlier (the WARRANTY START DATE).

1. Limited Product Warranty – Ten Years Repair, Replacement or Refund Remedy

SUNTECH POWER warrants its MODULES, including factory-assembled DC connectors and cables, if any, to be free from defect in materials and workmanship under normal application, installation, use and service conditions. If MODULES fail to conform to this warranty, during the period of One Hundred Twenty (120) months from the WARRANTY START DATE, SUNTECH POWER will, at its option, either repair or replace the product, or refund the current list price of comparable SUNTECH POWER MODULES. The repair or replacement or refund remedy shall be the sole and exclusive remedy provided under the "Limited Product Warranty" and shall not extend beyond the period set forth herein. This "Limited Product Warranty" does not warrant a specific power output, which shall be exclusively covered under clause 2 hereinafter ("Limited Peak Power Warranty").

2. Limited Peak Power Warranty - Limited Remedy

Warranted Percentages of Nominal Power Output

- 5 Year Limited Warranty of 95% of the Nominal Power Output
- 12 Year Limited Warranty of 90% of the Nominal Power Output
- 18 Year Limited Warranty of 85% of the Nominal Power Output
- 25 Year Limited Warranty of 80% of the Nominal Power Output

SUNTECH POWER warrants each Module against defects in materials and workmanship that result in the failure of the MODULES to produce the warranted percentage specified above of the nominal power output for the Module set forth in SUNTECH POWER's product datasheet. If SUNTECH POWER determines in its discretion that any Module is not providing the warranted percentage of the nominal power output because of defects in materials and workmanship, SUNTECH POWER will at its option either (1) replace such loss in power by either, (a) providing additional MODULES to the CONSUMERto make up for such loss in power or (b) replacing the defective Module(s) or part by a functional equivalent or (2) refund the percentage of the cost of the Module(s) representing the percentage of the power that is less than the warranted percentage of the nominal power.

The remedies set forth in this clause 2 shall be the sole and exclusive remedies provided under the "Limited Peak Power Warranty".

Nominal Power Output in product datasheet is the power in Watt peak that a Photovoltaic Solar Modules generates in its Maximum Power Point under Standard Testing Conditions (STC). STC are as follows: (a) light spectrum of AM 1.5, (b) an irradiation of 1000 W per and (c) a cell temperature of 25 degrees centigrade at right angle irradiation. The measurements are carried out in accordance with IEC 61215 as tested at the connectors or junction box terminals – as applicable – per calibration and testing standards of SUNTECH POWER valid at the date of manufacture of the PV-modules.

3. Exclusions and Limitations

To the extent permitted by law:

(1) In any event, all warranty claims must be received within the applicable warranty period for this warranty to be effective.
(2) The "Limited Product Warranty" and the "Limited Peak Power Warranty" do not apply to any MODULES which have been subjected to:

- Misuse, abuse, neglect or accident;
- Alteration, improper installation or application;
- Non-observance of SUNTECH POWER' s installation manual or maintenance instructions;
- Repair or modifications by someone other than an approved service technician of SUNTECH POWER;
- Power failure surges, lightning, flood, fire, accidental breakage or other events outside SUNTECH POWER's control.

(3) Both "Limited Product Warranty" and "Limited Peak Power Warranty" do not cover any costs associated with installation, removal or re-installation of the MODULES (subject to last sentence of Clause 5) and customs clearance or any other costs for return of the MODULES.
(4) Warranty claims will not be honored if the type or serial number of the MODULES have been altered, removed or made illegible.
(5) Both "Limited Product Warranty" and "Limited Peak Power Warranty" does not apply to MODULES marked as "Grade A-1" or "Grade B". SUNTECH POWER explicitly refers to their "Limited Warranty for PV Modules marked Grade A-1", their "Special Limited Warranty for PV Modules marked Grade B" reflecting these categorized modules.

4. Limitation of Warranty Scope

THIS "LIMITED WARRANTY FOR PV MODULES" AS SET FORTH HEREIN IS EXPRESSLY IN LIEU OF AND EXCLUDE ALL OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR PARTICULAR PURPOSE, USE, OR APPLICATION, AND ALL OTHER OBLIGATIONS OR LIABILITIES ON THE PART OF SUNTECH POWER, UNLESS SUCH OTHER OBLIGATIONS OR LIABILITIES ARE EXPRESSLY AGREED TO IN WRITING SIGNED AND APPROVED BY SUNTECH POWER. SUNTECH POWER SHALL HAVE NO RESPONSIBILITY OR LIABILITY WHATSOEVER FOR DAMAGE OR INJURY TO PERSONS OR PROPERTY, OR FOR OTHER LOSS OR INJURY RESULTING FROM ANY CAUSE WHATSOEVER ARISING OUT OF OR RELATED TO THE MODULES, INCLUDING, WITHOUT LIMITATION, ANY DEFECTS IN THE MODULES, OR FROM USE OR INSTALLATION. UNDER NO CIRCUMSTANCES SHALL SUNTECH POWER BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES, HOWSOEVER CAUSED. LOSS OF USE, LOSS OF PROFITS, LOSS OF PRODUCTION, AND LOSS OF REVENUES ARE SPECIFICALLY AND WITHOUT LIMITATION EXCLUDED. SUNTECH POWER´S AGGREGATE LIABILITY, IF ANY, IN DAMAGES OR OTHERWISE, SHALL NOT EXCEED THE INVOICE VALUE AS PAID BY THE CONSUMER, FOR THE SINGLE UNIT OF MODULE.

THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE. THIS LIMITED WARRANTY DOES NOT AFFECT ANY ADDITIONAL RIGHTS YOU HAVE UNDER LAWS IN YOUR JURISDICTION GOVERNING THE SALE OF CONSUMER GOODS, INCLUDING, WITHOUT LIMITATION, NATIONAL LAWS IMPLEMENTING EC DIRECTIVE 99/44. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE LIMITATIONS OR EXCLUSIONS IN THIS LIMITED WARRANTY STATEMENT MAY NOT APPLY TO YOU.

5. Obtaining Warranty Performance/Claim Procedure

If the CUSTOMER wishes to bring a claim under this "Limited Warranty for PV Modules", an immediate notification shall be filed by the CUSTOMER directly to either:
(a) the installer company; or
(b) SUNTECH POWER's authorized distribution partner, who supplied affected modules; or
(c) SUNTECH POWER office in your region. Regional contact details of SUNTECH POWER offices are listed under clause 12.
by letter, facsimile or email, and the notification should specify name and address of CUSTOMER, name and address of installer and authorized SUNTECH POWER distribution partner, the evidence of the claim with the affected Module type, affected quantity and corresponding serial numbers together with the date on which the MODULES have been

purchased. The notification shall enclose copy of a related invoice document with stamp or signature of SUNTECH POWER or its authorized distributor as part of the evidence.

The CUSTOMER shall bring a claim under this limited warranty immediately after discovery of breach of warranty and within the warranty period.

The return of any MODULES will not be accepted unless prior written authorization has been given by SUNTECH POWER. –
To the extent permitted by law and subject to the last sentence in this clause, SUNTECH POWER will, in its sole discretion, either refund CUSTOMER (based on purchase price and taking into account of depreciation) for the defective MODULES, or repair or replace the defective MOUDLES. In connection with both the "Limited Product Warranty" and "Limited Peak Power Warranty", SUNTECH POWER shall reimburse CUSTOMER for reasonable, customary and documented transportation charges by sea freight for both authorised return of defective MODULES and reshipment of any repaired or replaced MODULES, only if this cost is authorized by SUNTECH POWER.

THE FOLLOWING STATEMENT APPLIES TO CUSTOMERS THAT ARE 'CONSUMERS' WITHIN THE MEANING OF THE AUSTRALIAN CONSUMER LAW: *The benefits given to the consumers in this warranty are in addition to other rights and remedies of the consumer under a law in relation to the goods or services to which the warranty relates. Our goods come with guarantees that cannot be excluded under the Australian Consumer Law. You are entitled to a replacement or refund for a major failure and for compensation for any other reasonably foreseeable loss or damage. You are also entitled to have the goods repaired or replaced if the goods fail to be of acceptable quality and the failure does not amount to a major failure.*

6. Severability

If a part, provision or clause of this "Limited Warranty for PV Modules", or the application thereof to any person or circumstance, is held invalid, void or unenforceable, such holding shall not affect and shall leave all other parts, provisions, clauses or applications of this "Limited Warranty for PV Modules", and to this end such other parts, provisions, clauses or applications of this "Limited Warranty for PV Modules" shall be treated as severable.

7. Disputes

In case of any discrepancy in a warranty-claim, a first-class international test-institute such as Fraunhofer ISE in Freiburg/ Germany, TÜV Rheinland in Cologne/ Germany or ASU Arizona State University shall be involved to judge the claim finally. All fees and expenses shall be born by the losing party, unless otherwise awarded.

8. Various

The repair or replacement of the MODULES or the supply of additional MODULES, does not cause the beginning of new warranty terms, nor shall the original terms of this "Limited Warranty for PV Modules" be extended. Any replaced MODULES shall become the property of SUNTECH POWER made for their disposal. SUNTECH POWER has the right to deliver another type (different in size, color, shape and/or power) in case SUNTECH POWER has discontinued producing the replaced MODULES at the time of the claim.

9. Warranty Transfer

This "Limited Warranty for PV Modules" is transferable when the product remains installed in its original installation location.

10. Force Majeure

SUNTECH POWER shall not be responsible or liable in any way to the consumer or any third-party arising from any non-performance or delay in performance of any terms and conditions of sale, including this "Limited Warranty for PV Modules", due to acts God, war, riots, strikes, warlike conditions, plague or other epidemics, fire, flood, or any other similar cause or circumstance beyond the reasonable control of SUNTECH POWER. In such cases, performance by SUNTECH POWER of this Limited Warranty shall be suspended without liability for the period of delay reasonably attributable to such causes.

11. Validity

This "Limited Warranty for PV Modules" is valid for all MODULES dispatched from SUNTECH POWER's factories between 1st January 2012 and 31st December 2012.

THIS "LIMITED WARRANTY FOR PV MODULES" WILL BECOME NULL AND VOID IF THE MODULE IS TRANSFERRED FROM THE ORIGINAL CONTINENT OF DESTINATION (E.G. NORTH AMERICA, EUROPE, ASIA, AUSTRALIA, AFRICA OR SOUTH AMERICA) WITHOUT WRITTEN PERMISSION FROM SUNTECH POWER. ALL CUSTOMERS, DIRECT AND INDIRECT, ARE HEREBY NOTIFIED OF SUCH POTENTIAL NULLIFICATION.

12. Contact

In case of questions regarding our products, quality and performance contact the regional headquarters or your nearest SUNTECH POWER office which can be found at www.suntech-power.com

North & South America
Suntech America, INC.
Add: 71 Stevenson Street 10th floor, San Francisco CA 94105, USA
Tel: +1 415 8829922
Fax: +1 415 8829923
Email: services@suntech-power.com

ASIA
Wuxi Suntech Power Co., Ltd.
Add: 9 Xinhua Road, Wuxi New District, China 214028
Tel: +86 400 8888 009（CustomerService Hot Line）
Fax: +86 510 8534 3321
Email: services@suntech-power.com

Suntech Power Japan Co.
Add: 6F, Nishishinjuku KS Building,3-6-11, Tokyo 160-0023 Japan
Tel: +81 3 33423838
Fax: +81 3 33426534
Email: services@suntech-power.com

Suntech Power Australia Pty Ltd
Add: Suite 1101, level 11, 201 Miller Street, North Sydney NSW 2060, Australia
Tel: +61 81882450
Fax: +61 81882440
Email: services@suntech-power.com.au

Europe
Suntech Germany
Add: Bayerstr. 71-73, 80335 Muenchen, Germany
Tel: +49 89 544599-900
Fax: +49 89 544599-969
Email: services@suntech-power.com

Suntech France
Add: 55 Rue Blais Pacal, 38330 Montbonnot, France
Tel: +33 476 446275
Fax: +33 438 240495
Email: services@suntech-power.com

Suntech Italy
Add: Viale Colleoni 25, Palazzo Pegaso, Agrate Brianza 20041, Italy
Tel: +39 039 9633000
Fax: +39 039 9633024
Email: services@suntech-power.com

Suntech Spain
Add: Edifizio Cuzco IV, Paseo de la Castellana 141, 28046 Madrid, Spain
Tel: +34 91 7498065
Fax: +34 91 7498070
Email: services@suntech-power.com

Suntech Power International Ltd.
Add: Muehlentalstr. 36, CH-8200 Schaffhausen, Switzerland
Tel: +41 52 6331200
Fax: +41 52 6331299
Email: services@suntech-power.com

System Owner's Manual

Tigo Energy® Maximizer™ System

Applies to the following:
Tigo Energy® Module Maximizer™ (MM-ES)
Tigo Energy® Dual Maximizer™ (MM-2ES)
Tigo Energy® Maximizer™ Management Unit (MMU)
Model numbers: All MM-ES and MMU

IMPORTANT SAFETY INSTRUCTIONS
SAVE THESE INSTRUCTIONS

This System Owner's Manual contains important instructions for the use and maintenance of the Tigo Energy product models MM-ES, MMU, and related Tigo Energy software applications. The Tigo Energy® Maximizer™ System must be installed and serviced by a trained solar installation professional.

System Owner's Manual V.2
Please visit tigoenergy.com to download the latest version of System Owner's manual.

User Name: ____________________________

Password: ____________________________

(Provided by your installer)

Table of Contents

1. Tigo Energy® Maximizer™ System

The Tigo Energy System (Fig.1) is a perfect enhancement to a well-designed solar array. The Tigo Energy Maximizer System improves energy harvest by maximizing each module independently, provides module-level operation and maintenance (O&M), and enables the PV-Safe feature to disconnect the array at the module level.

The Tigo Energy Maximizer System includes a Module Maximizer installed on the back of every solar module or Dual Maximizer installed on the back of every other solar module.

It also includes a Maximizer Management Unit (MMU) which is typically wall-mounted near the inverter. The MMU features an LCD display showing the system status, and also has a button to activate PV-Safe. Finally, the system includes the MaxiManager Software to view the array's performance from anywhere.

This owner's manual will help you get the most out of your Tigo Energy System, explaining key features of the software, as well as how to activate and test the safety features.

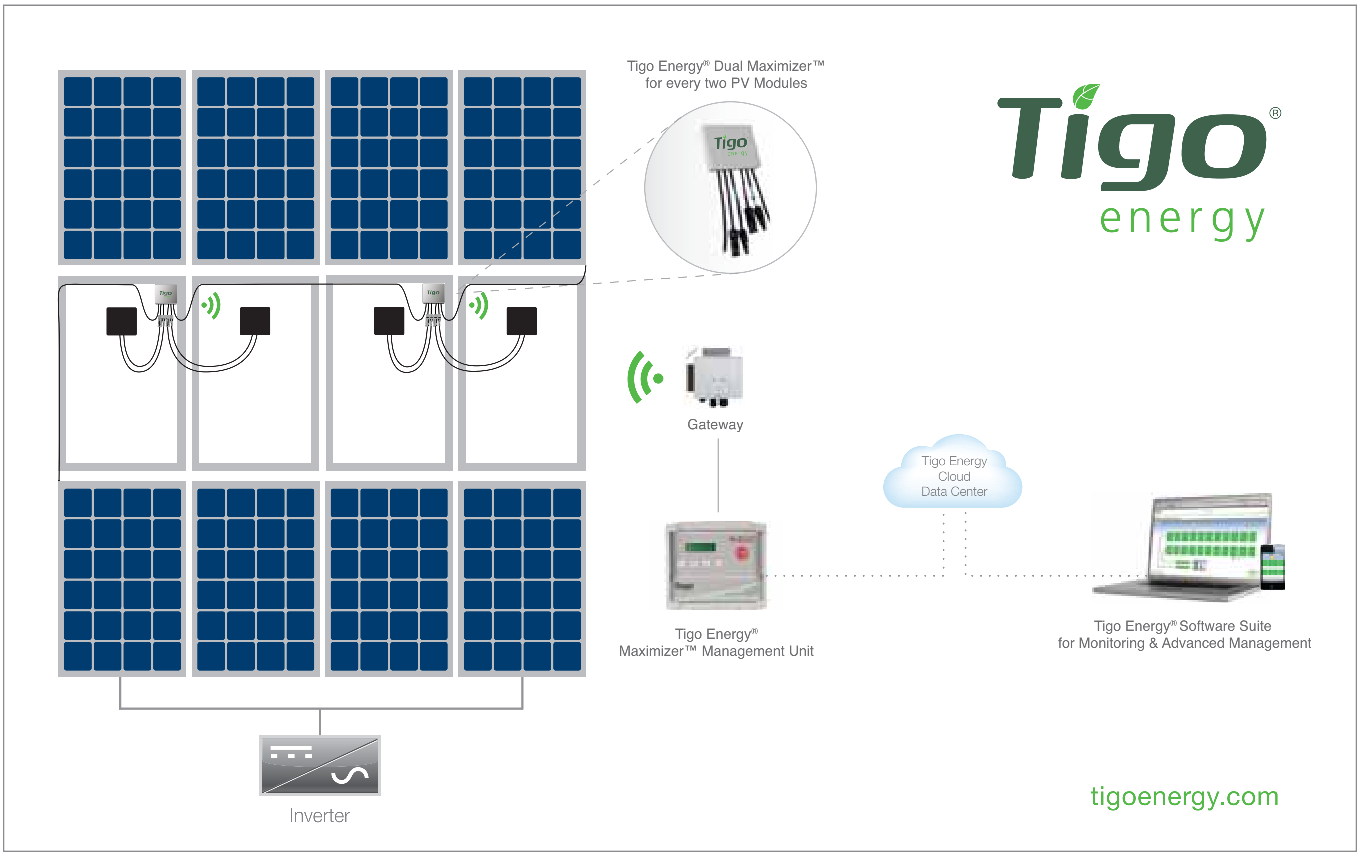


Fig. 1 -- The Tigo Energy Maximizer System

2. Tigo Energy® PV-Safe™ Feature

Fig. 2 -- Tigo Energy Maximizer Management Unit (MMU)

When inspecting your installation, check the front panel of the Tigo Energy® Maximizer™ Management Unit (MMU) for the Tigo Energy PV-Safe button. This is an indication that the system is equipped with the advanced safety feature.

The Tigo Energy PV-Safe feature provides the ability to de-energize your solar array at the module, so there are no high-voltage wires running down from the array. This should be used in emergency and maintenance situations. By pressing the PV-Safe button on the Management Unit, the Tigo Energy® Module Maximizers™ will attempt to stop voltage from passing to the PV wiring between the Module Maximizer and the inverter.

If the Maximizer Management Unit does not have access to AC power or is otherwise impaired, the PV-Safe function will not be able to be initiated from the PV-Safe button on the MMU. However, a system configured with the Tigo Energy Maximizer solution will attempt to enter the PV-Safe mode automatically when the AC is disconnected at the building main breaker.

Once PV-Safe is activated, confirm that the modules are disabled on the Management Unit display, on the Summary page of the web-based software tool, or by testing the DC lines with a voltmeter.

When the PV-Safe button is activated, the MMU will display "PV-SAFE PRESSED" and "Requesting ..." to indicate the command has been sent to the Maximizers. As the Maximizers are responding, the MMU display will indicate how many have successfully disconnected (example: "Resp: 15/48"). Once the system successfully receives acknowledgement from all of the Module Maximizers in the array, the MMU will display "RESPONDING".

Should the MMU not receive proper response from one or more of the Module Maximizers or communication has been lost, the display will read "NOT RESPONDING". If the "NOT RESPONDING" message is present, the system owner must assume that the system is still active and voltage is present as in a standard PV array.

Always inspect the system prior to re-energizing the modules. Returning the modules to the "ON" state may only be done from the MMU console. Ensure the MMU is properly powered and the inverter is in the "ON" position. Lift the protective cover on the MMU and press the "MENU" button, then press "ENTER". Use the down arrow to select "2. CONTROL", then press "ENTER". Scroll down to "2.1. PANELS ON", then press "ENTER". Press "ENTER" again to confirm. Ensure the inverter is receiving DC voltage.

While PV-Safe is meant to enhance system safety, care should always be exercised to avoid high voltage DC wiring regardless of whether the PV-Safe function is enabled. Tigo Energy cannot guarantee complete deactivation of the array when the PV-Safe button is pressed. Tigo Energy PV-Safe must be tested as part of the installation process, and should be routinely tested on an annual basis.

3. Tigo Energy® MaxiManager™ Software

The Tigo Energy MaxiManager software manages arrays of all sizes to give system owners unprecedented visibility of every module. System owners are alerted to actionable information so that they can manage their system based on pre-set parameters.

System analytics track performance relative to expectations and proactively suggest maintenance actions to keep the system operating at maximum production and uptime.

3.1. Log In

To manage and view your system, please open your web browser and navigate to: **www.tigoenergy.com**
In the upper right hand corner of the home page, click the Login link to go to the Login screen.

Please enter the login and password that was provided to you by your installer.

Fig. 3 -- Login Page

Login information provided by your installer

3.2 My Installations Page

The "My Installations" page provides a set of summary tools to monitor the performance of your array(s). The fields include Dashboard, System Map, and Kiosk view. There is also a System List which you can use to navigate to a system-specific view.

Dashboard

The Dashboard view provides summary statistics such as total energy production, carbon offset, aggregated peak power, or number of installations. You can also see these statistics on any time frame including lifetime, year-to-date or a specific date (Fig. 4).

System Map

The System Map shows the physical location of each site. The satellite view of the installation can help you better understand orientation, shade and system lay-out with Google Map integration (Fig. 4).

System List

From here, select the installation that you would like to access by clicking the project name of the system (Fig. 4).

Kiosk View

Looking for a way to show off your system on a TV screen or lobby? The Tigo Energy Kiosk View enables an easy-to-understand slideshow with a variety of images & graphs that showcase your system's performance. Simply check the charts you would like to see, and hit "Start". The Kiosk mode will then cycle automatically between the charts (Fig. 5).

Dashboard collapse option

Dashboard

Map

Systems List

Page Setup (lets you customize My Installations page)

Kiosk Setup

Filter Systems (for accounts with multiple installations)

Click on the Site Name to view the installation Summary page

Fig. 4 -- My Installations Page

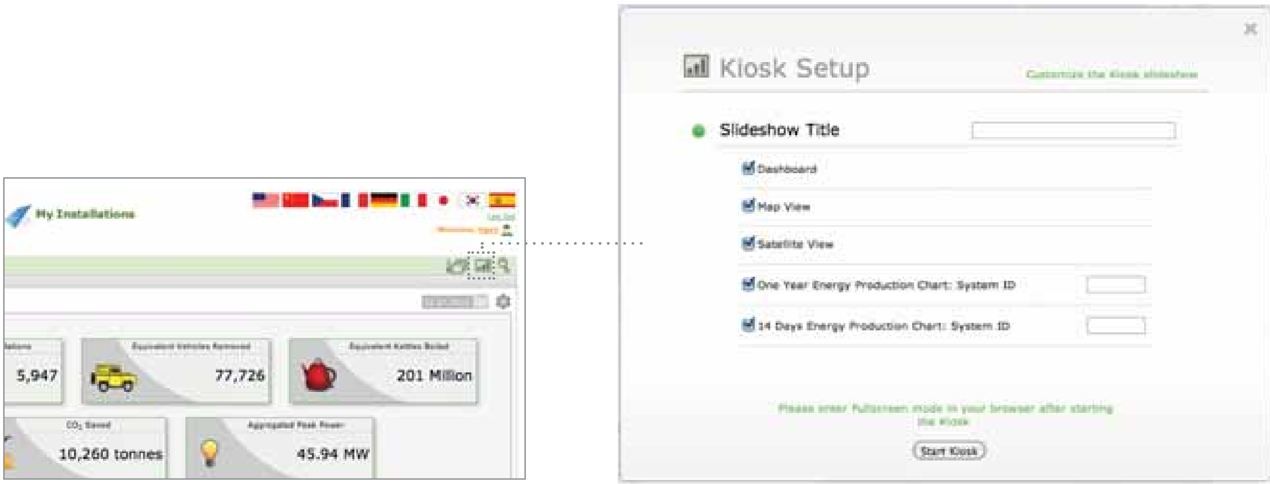


Fig.5 -- Kiosk Setup window

3.3 Summary Page

Once you've clicked the system that you would like to access, you will be taken to the Summary page. This screen shows real-time and historic power production from each module of your array.

The color of each PV module indicates a comparative measurement of power generated among modules (brightest indicates most power production). This is particularly useful for finding anomalies such as shading.

The number displayed inside each module is the instantaneous power measured at the time indicated in the Data Navigator (lower left corner of the Summary page). These numbers are also meaningfully colored. The text on a panel will be yellow if the module's power is less than 90% of the expected production. It's red if the power is less than 75%.

When placing the cursor over a module, the program automatically highlights all modules on the same string, along with its corresponding inverter. When the cursor is over the inverter, all strings attached to that inverter are highlighted.

Note: If different module types are used in the solar array, their max voltage will be displayed on the bottom right corner of each individual module.

3.3.1 Large System

For arrays with 300 or more modules, the view is displayed at a string level first. The same color scheme and definitions described above apply to the string shapes. The border of the string is colored to indicate if there are any underperforming modules in that string. The presence of one panel operating under 90% of the maximum will result in a yellow border; less than 75% results in a red border.To view the panel level detail of the array, simply zoom in on the system map via the Zoom Control or using the mouse wheel. You may also double click directly on the area you'd like to see.

If the system includes an optional light sensor, the sun intensity (irradiance, measured in Watts per square meter - W/m^2) is indicated in the upper right hand corner above the modules. Similarly, if the system is equipped with temperature sensors, the ambient or module temperature (depending on the placement of the sensor) will be displayed next to the small thermometer icon.

The Summary view goes into auto-updating mode after 30 minutes of inactivity. Until the system is interrupted, the view will refresh itself every 10 minutes thereafter.

Note: If the module placement does not represent the physical layout of your array, see section 3.6.2. This section will provide instructions on how to move the modules and inverters on the Summary Page to more accurately reflect the actual layout of the PV array.

Fig. 6 -- Summary Page

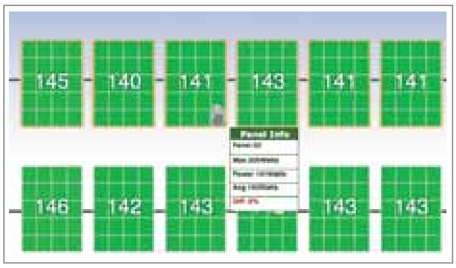


Fig. 7 -- Summary Page: placing the cursor over a module.

Fig. 8 -- Summary Page for large system (zoomed out).

Zoom

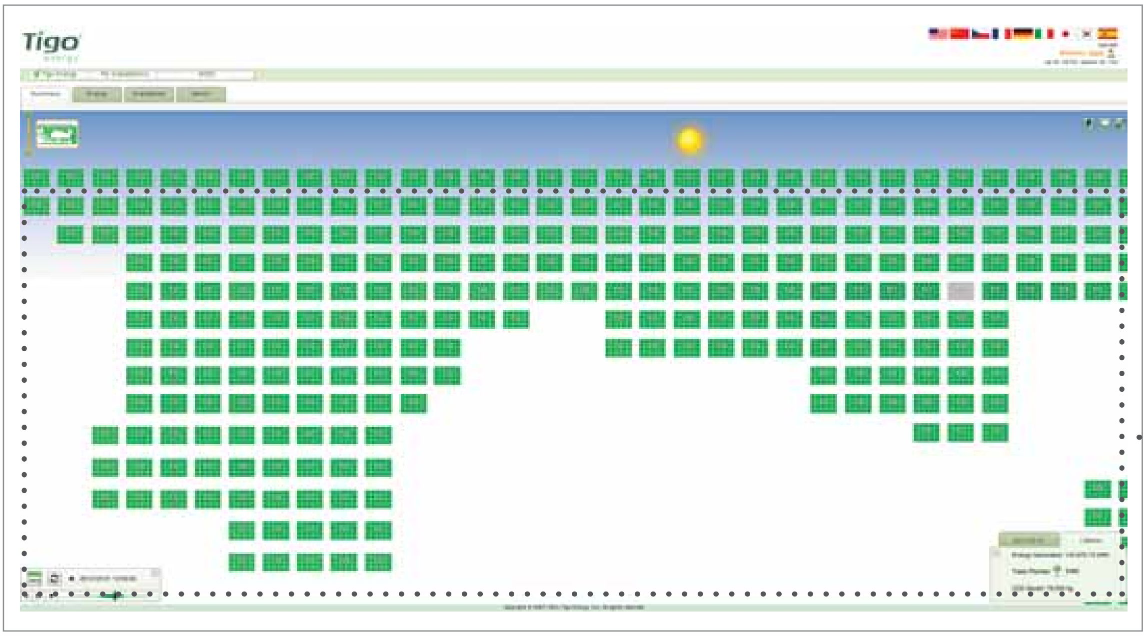


Fig. 9 -- Summary Page for large system (zoomed in).

Data Navigator

In the bottom left corner is the "Data Navigator", a tool bar that can be used to view data at different time intervals. Drag the slider left or right to see power production throughout the day. Alternately, drag the sun back and forth to achieve the same effect or use the play button to see a continuous timelapse of the day. You can also click directly on the slider bar to jump to a desired time. The time will change in one minute intervals.

Clicking on the calendar icon enables the selection of a particular day so that its summary data may be viewed. To more quickly change to the next and previous days, there are corresponding buttons surrounding the date label.

Also in the Data Navigator is a Refresh button that refreshes the data to the most recent data available.

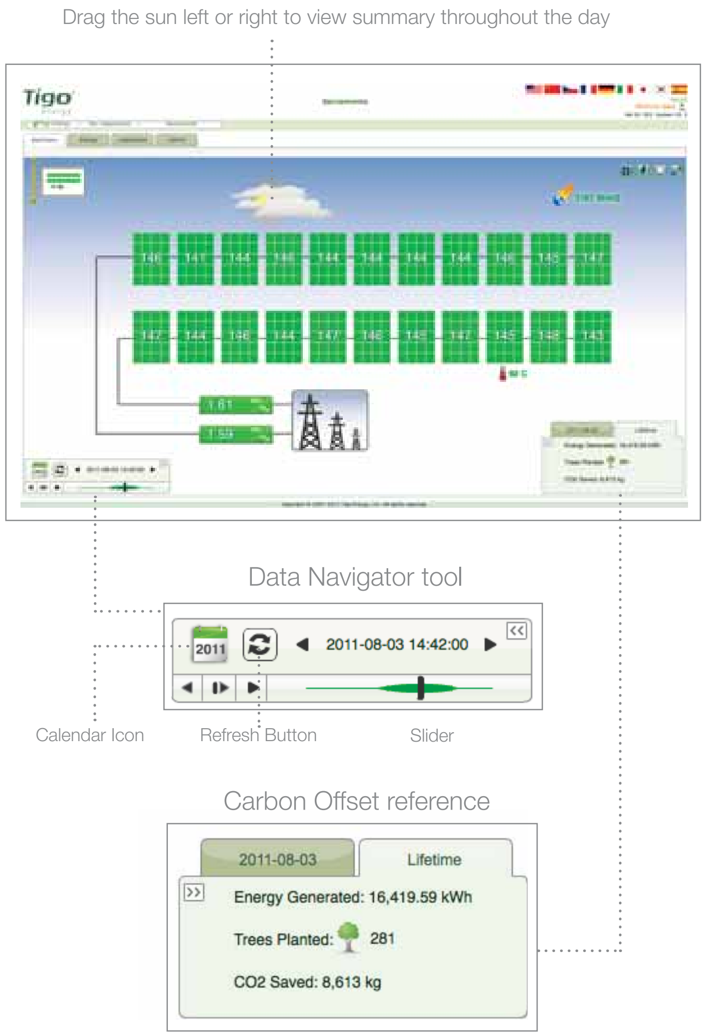


Fig. 10 -- Summary Page: Data Navigator and Carbon Offset tools

Carbon Offset

In the lower right hand corner of the summary view there is a box that displays the total energy generated for the day and the lifetime energy generated for the system. One can toggle between these two views by clicking on the appropriate tab.

This box also shows the amount of carbon dioxide (CO_2) in kilograms (kg) the system has saved for a specified date and over its lifetime. In addition, it will display the equivalent trees planted or kettles boiled based on the CO_2 offset from the system.

This display box, as well as the toolbox aforementioned, can be minimized by clicking the arrow button in the upper right and upper left hand corners of the boxes respectively.

Zoom Control

In the upper left-hand corner of the Summary page is a "Zoom Control" that may be used to zoom in or out of the array.

This tool is particularly useful for large systems with hundreds or thousands of modules. Once zoomed in at any level, drag the viewing area within the mini map to focus on a particular portion of the array. Alternately, the main view of the summary may be dragged around the screen.

The visibility of the Zoom Control window may be toggled by mousing over it and clicking on the top right arrow that appears. It will slide in/out much like the lower display boxes.

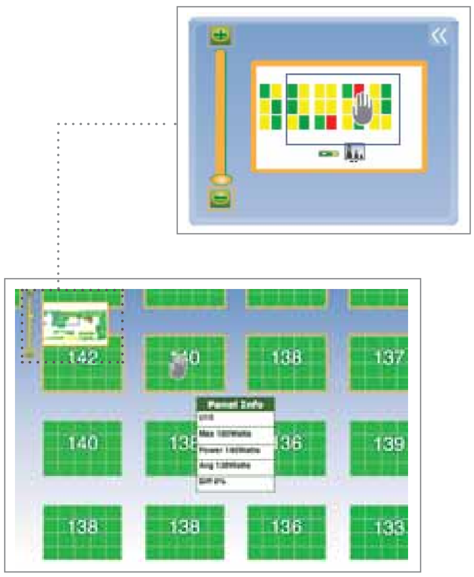


Fig. 11 -- Summary Page: Zoom Control tools

Options Toolbar

In the upper right corner of the Summary page you can find the Options Toolbar. Toggle button allows you to toggle between the electrical and physical layout of your system. If a system's physical view matches its electrical layout, this button will not be visible.

Click on the Background button to change the background on the Summary page. From the dropdown menu you can select Tigo Energy background, no background, or select to view one of the custom images if any were uploaded via the upload tool discussed in section 3.6.2

Full Screen button allows you to toggle into and out of full screen mode.

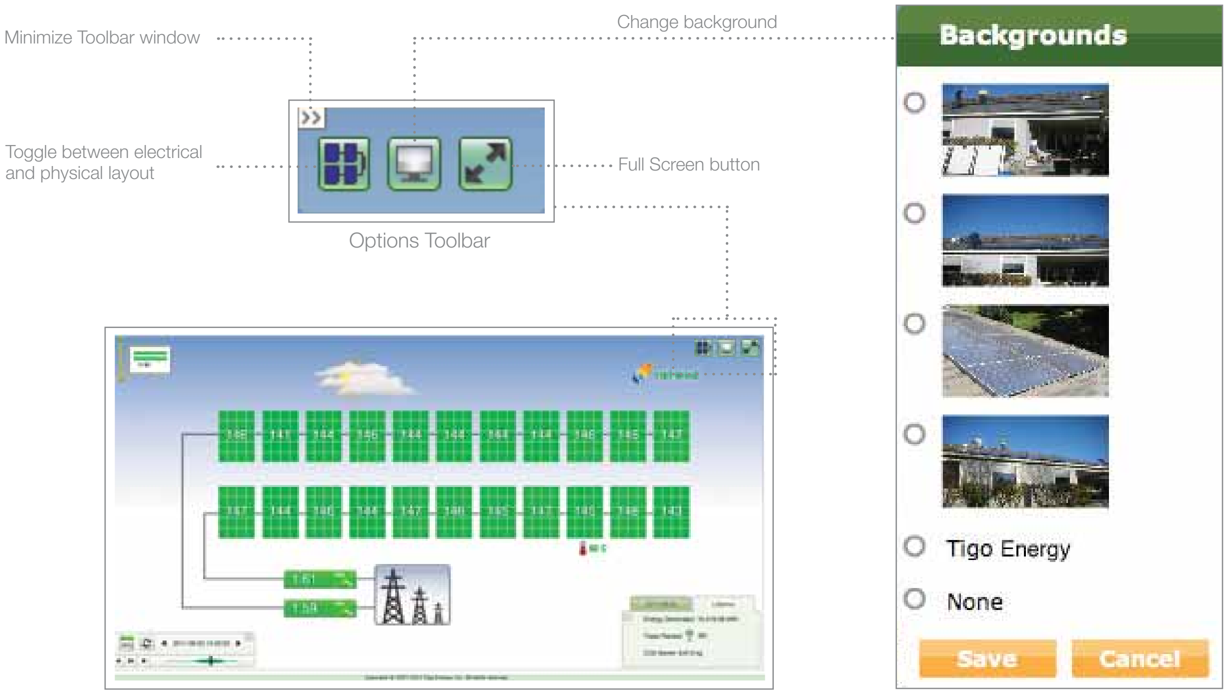


Fig. 12 -- Summary Page: Options Toolbar

3.4 Energy Page

Click on the Energy tab in the menu bar to see information about the energy output of the array over a given period of time. This page will default to the Performance sub-tab view and show the energy your array produced today by hour. Select data from each inverter, string, or even module by clicking on the System icons on the left. Press shift and click on multiple icons to compare different objects.

To change the timescale select the desired time interval located at the bottom of the Performance tab. The date selection may also be made from the calendar icon in the bottom right corner.

By clicking on the Advanced sub-tab, choose to compare objects by power, temperature, voltage and a number of other variables. In the bottom right corner, click the Download button to export the raw data to a .CSV file format, or choose Open Graph button to view the data in a Java-based graphing tool.

Summary for the dates selected on the Performance and Advanced pages will also be displayed on the Summary page.

Fig. 13 -- Energy Page: Performance and Advanced sub-tabs

3.5 Installation Page

The Installation tab shows non-editable information about your site. From this page, you may add comments about your installation by clicking on the "Add a Comment" button. You may also view pictures in the album by clicking on them. (To add a picture to the album, see section 3.6.2.)

Fig. 14 -- Installation Page

3.6 Admin Page

The Admin section consists of additional sub-tabs that allow you to view, add or modify site related information, such as site name, company, contact details, images of the installation and more.

3.6.1 Settings Sub-tab

When the Admin tab is selected, the “Settings” sub-tab is selected by default. Modify site information, account information, or create a shareable guest link from this page. The sharable link allows your guests to have a limited access to view your Summary and Energy pages. Simply copy the link and share it with friends.

3.6.2 Appearance Sub-tab

Navigating to the “Appearance” sub-tab allows you to add or change the display of the system. Add an image by clicking the “Add New Picture” button. From the pop-up, upload a picture, add comments about this picture, and choose to set the picture to be displayed in the Installation page.

Fig. 15 -- Admin Page, Settings sub-tab

Fig. 16 -- Admin Page, Appearance sub-tab

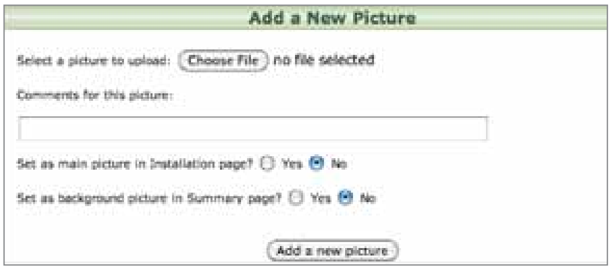


Fig. 16 (a) -- Add a New Picture pop-up window

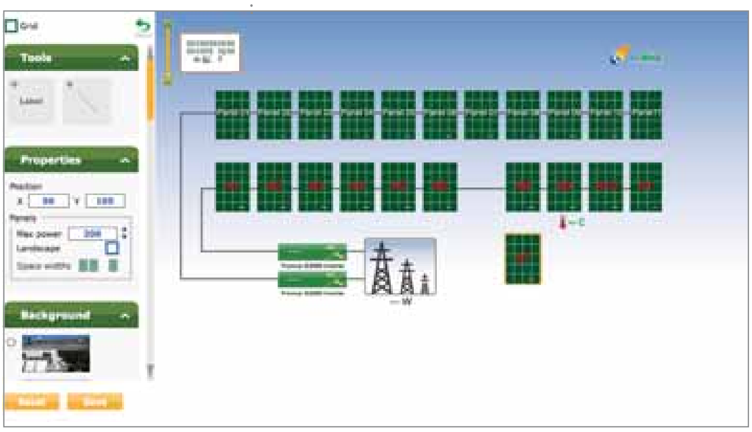


Fig. 16 (b) -- Edit System Map pop-up window

Edit System Map:

Click on the "Edit System Map" button for the pop-up window to appear, which enables the system owner to modify the appearance and placement of modules displayed on the Summary page. Modify the layout of the array by clicking and dragging modules with the cursor. To snap the modules to a grid, click the "Grid" check box in the upper left.

Add Lines and Labels:

Lines and labels can be added to the system map under the tools category. Clicking on anything in the picture will pull up the properties menu. In this menu modules can be moved and arranged in landscape orientation.

Select a Background Picture:

A picture can be uploaded to the background of the site if desired. This can be done under the background menu on the bottom left of the "Edit System Map" pop-up window.

When a system looks correct and the desired modifications are complete, hit the "Save" button and the changes will reflect in the Summary page. The System Editor auto-saves every 10 minutes.

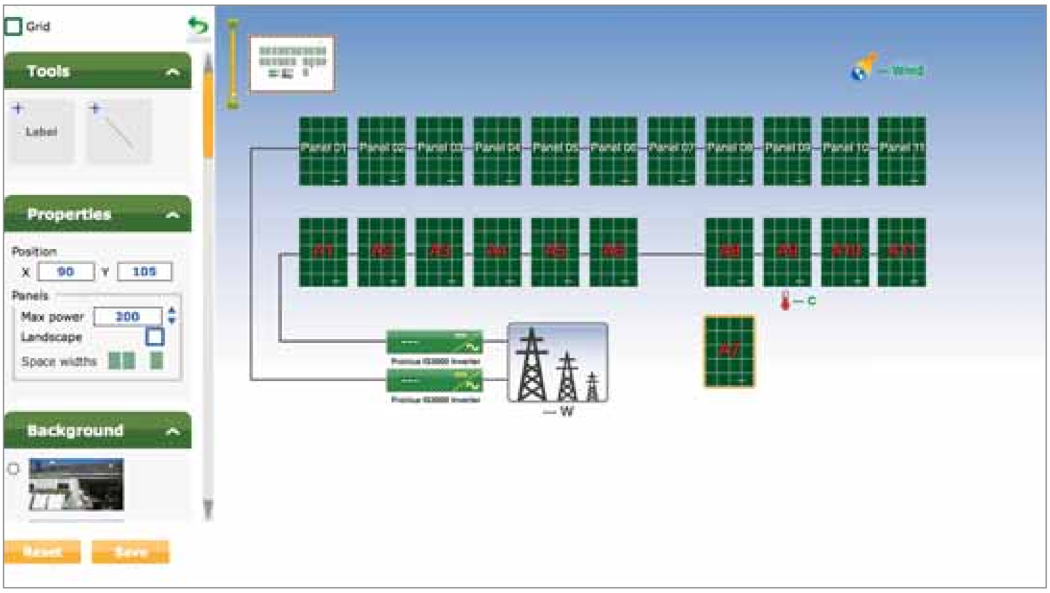


Fig. 16 -- Admin Page, Edit System Map view

3.6.3 Site Details Sub-tab

You can view your installation details such as information of your Installer, PV Modules, and Inverters by selecting the "Site Details" sub-tab.

Fig. 17 -- Admin Page, Site Details sub-tab

3.7 Account Information Page

To view or update your account information, click on your name displayed in the top right corner. This will take you to the “Account Information” page. Here you can view or edit your account information, including selecting your language preference from a language drop-down menu, or changing your password. Click on the “Update Account” button to save changes.

Fig. 18 -- Account Information Page

Customer Support Line (toll-free in US):
1-888-609-TIGO (8446)

Customer Support Fax (toll-free in US):
1-888-681-TIGO (8446)

support@tigoenergy.com
Skype: support.tigoenergy
www.tigoenergy.com

Tigo Energy, Inc.
420 Blossom Hill Road
Los Gatos, CA 95032
United States

office: +1(408) 402 0802
fax: +1(408) 358 6279

04.17.12.ENGL

PN 002-00002-00

Tigo Energy Limited Warranty

Tigo Energy, Inc. ("Tigo Energy") has developed a Management Unit and communication Gateway ("Equipment"). This Tigo Energy limited warranty ("Limited Warranty") covers defects in workmanship and materials of the Equipment for a period of five (5) years ("Warranty Period") from the earlier of: (i) 4 months for the date the Equipment is shipped from Tigo Energy; and (ii) the installation date of the Equipment at customer site. Notwithstanding the foregoing, with respect to smart junction box equipment ("Module Embedded Equipment") the foregoing Warranty Period shall not exceed the warranty period provided by the applicable module manufacturer.

During the Warranty Period, if Tigo Energy determines (in its sole and absolute discretion), through inspection, the existence of a defect that is solely due to defects in Equipment material or workmanship, the Equipment will be considered defective and will be subject to remedy under the terms of this Limited Warranty.

If a remedy is allowed for defective Equipment under the terms of this Limited Warranty, Tigo Energy will, at its option, either pay to the customer the appropriate residual market value of the Equipment, or repair or replace the defective Equipment free of charge. Tigo Energy will, at its option, use new and/or reconditioned parts in repairing or replacing the defective Equipment. Tigo Energy reserves the right in connection with in repairing or replacing the defective Equipment to use parts or products of original or improved design in such repair or replacement. If Tigo Energy repairs or replaces defective Equipment, this Limited Warranty will continue for the repaired or replacement Equipment for the remainder of the original warranty period or ninety (90) days from the date of Tigo Energy's return shipment of the repaired or replaced Equipment, whichever is later. This Limited Warranty does not include labor costs related to un-installing the defective Equipment or re-installing the repaired or replacement Equipment. This Limited Warranty covers the costs of shipping repaired or replacement Equipment from Tigo Energy to customer, via a non-expedited freight carrier selected by Tigo Energy, but does not cover the shipping cost of returning defective Equipment to Tigo Energy. The Limited Warranty does not cover, and Tigo Energy will not be responsible for, shipping damage or damage caused by mishandling by the freight carrier and any such damage is the responsibility of the freight carrier.

The Equipment is designed to withstand normal operating conditions and typical wear and tear when used for its original intent and in compliance with the installation and operating instructions supplied with the original Equipment. The Limited Warranty does not apply to, and Tigo Energy will not be responsible for, any defect in or damage to any Equipment that: (1) has been misused, neglected, tampered with, altered, or otherwise damaged, either internally or externally; (2) has been improperly installed, operated, handled or used, including use under conditions for which the Equipment was not designed, use in an unsuitable environment, or use in a manner contrary to the Tigo Energy User Manual or applicable laws or regulations; (3) has been subjected to fire, excessive water exposure, generalized corrosion, biological infestations, acts of God, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the Equipment specifications, including high input voltage from generators or lightning strikes; (4) has been subjected to incidental or consequential damage caused by defects of other components of the system into which the Equipment is integrated; or (5) has had the original identification markings (including trademark or serial number) of the Equipment defaced, altered, or removed. The Limited Warranty does not cover cosmetic, technical or design defects or shortcomings, which do not materially influence or affect the energy production or degrade form, fit or function of the Equipment. Tigo Energy's maximum obligation under this Limited Warranty for each piece of Equipment is limited to the original cost of such Equipment.

To obtain repair or replacement service, or a credit or refund (as applicable), under this Limited Warranty, the customer must comply with the following policies and procedures:

- All defective Equipment must be returned to Tigo Energy with a Return Merchandise Authorization (RMA) number, which the customer must obtain from Tigo Energy. Before obtaining an RMA number, however, the customer must contact a Tigo Energy technical support representative to evaluate and troubleshoot the problem while the Equipment is in the field, since many problems can be solved in the field.

- If in-field troubleshooting does not solve the problem, the customer may request an RMA number, which request must include the following information:

    - Proof-of-purchase of the defective Equipment in the form of: (i) the dated purchase receipt from the original purchase of the Equipment at point of sale to the end user, (ii) the dated dealer invoice or purchase receipt showing original equipment manufacturer (OEM) status, or (iii) the dated invoice or purchase receipt showing the Equipment exchanged under warranty.
    - Model number of the defective Equipment.
    - Serial number of the defective Equipment.
    - Detailed description of the defect.
    - Shipping address for return of the repaired or replacement Equipment (as applicable).

- All defective Equipment authorized for return must be returned in the original shipping container or other packaging that is equally protective of the Equipment.

- The returned defective Equipment must not have been disassembled or modified without the prior written authorization of Tigo Energy.

TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, TIGO ENERGY HEREBY DISCLAIMS, AND SHALL HAVE NO RESPONSIBILITY OR LIABILITY WHATSOEVER FOR, DAMAGE OR INJURY TO PERSONS OR PROPERTY OR FOR OTHER LOSS OR INJURY RESULTING FROM ANY CAUSE WHATSOEVER ARISING OUT OF OR RELATED TO ANY OF ITS EQUIPMENT OR ITS USE. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, UNDER NO CIRCUMSTANCES SHALL TIGO ENERGY BE LIABLE TO THE CUSTOMER, OR TO ANY THIRD PARTY CLAIMING THROUGH OR UNDER THE CUSTOMER, FOR ANY LOST PROFITS, LOSS OF USE, OR EQUIPMENT DOWNTIME, OR FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES OF ANY KIND, HOWSOEVER ARISING, RELATED TO THE EQUIPMENT, EVEN IF TIGO ENERGY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, TIGO ENERGY'S AGGREGATE LIABILITY, IF ANY, IN DAMAGES OR OTHERWISE, SHALL NOT EXCEED THE PURCHASE PRICE PAID TO TIGO ENERGY BY THE CUSTOMER FOR THE EQUIPMENT IN THE CASE OF A WARRANTY CLAIM.

THE LIMITED WARRANTIES SET FORTH HEREIN ARE IN LIEU OF AND EXCLUDE ALL OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE OR APPLICATION, AND ALL OTHER OBLIGATIONS ON THE PART OF TIGO ENERGY UNLESS SUCH OTHER WARRANTIES AND OBLIGATIONS ARE AGREED TO IN WRITING BY TIGO ENERGY. SOME JURISDICTIONS LIMIT OR DO NOT PERMIT DISCLAIMERS OF WARRANTY, SO THIS PROVISION MAY NOT APPLY TO THE CUSTOMER.

THE CUSTOMER ACKNOWLEDGES THAT THE FOREGOING LIMITATIONS ON LIABILITY ARE AN ESSENTIAL ELEMENT OF THE AGREEMENT BETWEEN THE PARTIES AND THAT IN THE ABSENCE OF SUCH LIMITATIONS THE PURCHASE PRICE OF THE EQUIPMENT WOULD BE SUBSTANTIALLY DIFFERENT. SOME JURISDICTIONS LIMIT OR DO NOT PERMIT DISCLAIMERS OF LIABILITY, SO THIS PROVISION MAY NOT APPLY TO THE CUSTOMER. SOME JURISDICTIONS DO NOT ALLOW LIMITATIONS ON

THE EXCLUSION OF DAMAGES SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO THE CUSTOMER.

YOU MAY HAVE SPECIFIC LEGAL RIGHTS OUTSIDE THIS WARRANTY, AND YOU MAY ALSO HAVE OTHER RIGHTS THAT VARY FROM STATE TO STATE OR COUNTRY TO COUNTRY. THIS LIMITED WARRANTY DOES NOT AFFECT ANY ADDITIONAL RIGHTS YOU HAVE UNDER LAWS IN YOUR JURISDICTION GOVERNING THE SALE OF CONSUMER GOODS. SOME STATES OR COUNTRIES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTIAL OR CONSEQUENTIAL DAMAGES, SO THE LIMITATIONS OR EXCLUSIONS IN THIS LIMITED WARRANTY STATEMENT MAY NOT APPLY.

Tigo Energy Limited Warranty

Tigo Energy, Inc. ("Tigo Energy") has developed Power Optimizers ("Equipment"). This Tigo Energy limited warranty ("Limited Warranty") covers defects in workmanship and materials of the Equipment for a period of ten (10) years ("Warranty Period") from the installation date of the Equipment ("Warranty Start Date").
Registration with Tigo Energy Monitoring must be completed in 90 days from installation date for Limited Warranty to be valid.

In addition, Tigo Energy warrants that for a period of twenty five (25) years from the Warranty Start Date that the Equipment power output will be no less than 80% of the Minimum Peak Power as specified at the date of delivery by the module vendor's datasheet.

Notwithstanding the foregoing, with respect to smart junction box equipment ("Module Embedded Equipment") the foregoing Warranty Period and the foregoing twenty five (25) year warranty shall not exceed the warranty period provided by the applicable module manufacturer.

During the Warranty Period, if Tigo Energy determines, in its sole and absolute discretion, through inspection, the existence of a defect that is solely due to defects in Equipment material or workmanship, the Equipment will be considered defective and will be subject to remedy under the terms of this Limited Warranty.

If a remedy is allowed for defective Equipment under the terms of this Limited Warranty, Tigo Energy will, at its option, either pay to the customer the appropriate residual market value of the Equipment, or repair or replace the defective Equipment. Tigo Energy will, at its option, use new and/or reconditioned parts in repairing or replacing the defective Equipment. Tigo Energy reserves the right in connection with in repairing or replacing the defective Equipment to use parts or products of original or improved design in such repair or replacement. If Tigo Energy repairs or replaces defective Equipment, this Limited Warranty will continue for the repaired or replacement Equipment for the remainder of the original warranty period or ninety (90) days from the date of Tigo Energy's return shipment of the repaired or replaced Equipment, whichever is later. This Limited Warranty does not include labor costs related to un-installing the defective Equipment or re-installing the repaired or replacement Equipment. This Limited Warranty covers the costs of shipping repaired or replacement Equipment from Tigo Energy to customer, via a non-expedited freight carrier selected by Tigo Energy, but does not cover the shipping cost of returning defective Equipment to Tigo Energy. The Limited Warranty does not cover, and Tigo Energy will not be responsible for, shipping damage or damage caused by mishandling by the freight carrier, and any such damage is the responsibility of the freight carrier.

The Equipment is designed to withstand normal operating conditions and typical wear and tear when used for its original intent and in compliance with the installation and operating instructions supplied with the original Equipment. The Limited Warranty does not apply to, and Tigo Energy will not be responsible for, any defect in or damage to any Equipment that: (1) has been misused, neglected, tampered with, altered, or otherwise damaged, either internally or externally; (2) has been improperly installed, operated, handled or used, including use under conditions for which the Equipment was not designed, use in an unsuitable environment, or use in a manner contrary to the Tigo Energy User Manual or applicable laws or regulations; (3) has been subjected to fire, excessive water exposure, generalized corrosion, biological infestations, acts of God, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the Equipment specifications, including high input voltage from generators or lightning strikes; (4) has been subjected to incidental or consequential damage caused by defects of other components of the system into which the Equipment is integrated; or (5) had the original identification markings (including trademark or serial number) of the Equipment have been defaced, altered, or removed. The Limited Warranty does not cover cosmetic, technical or design defects, or shortcomings, which do not materially influence or affect the energy production or degrade form, fit or function of the Equipment. Tigo Energy's maximum obligation under this Limited Warranty for each piece of Equipment is limited to the original cost of such Equipment.

The Tigo Energy Limited Warranty requires Premium Monitoring to be valid. Premium Monitoring is not included in the purchase price of the equipment. Tigo Energy may, at its discretion, offer a free evaluation period of Premium Monitoring to new systems. Tigo Energy's policy offers free Limited Warranty for a defined time,

To obtain repair or replacement service, or a credit or refund (as applicable), under this Limited Warranty, the customer must comply with the following policies and procedures:

- All defective Equipment must be returned to Tigo Energy with a Return Merchandise Authorization (RMA) number that the customer must obtain from Tigo Energy. Before obtaining the RMA, however, the customer must contact a Tigo Energy technical support representative to evaluate and troubleshoot the problem while the Equipment is in the field, since many problems can be solved in the field.

- If in-field troubleshooting does not solve the problem, the customer may request an RMA number, which request must include the following information:

    - Proof-of-purchase of the defective Equipment in the form of: (i) the dated purchase receipt from the original purchase of the Equipment at point of sale to the end user, (ii) the dated dealer invoice or purchase receipt showing original equipment manufacturer (OEM) status, or (iii) the dated invoice or purchase receipt showing the product exchanged under warranty.
    - Model number of the defective Equipment.
    - Serial number of the defective Equipment.
    - Detailed description of the defect.
    - Shipping address for return of the repaired or replacement Equipment (as applicable).

- All defective Equipment authorized for return must be returned in the original shipping container or other packaging that is equally protective of the Equipment.

- The returned defective Equipment must not have been disassembled or modified without the prior written authorization of Tigo Energy.

TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, TIGO ENERGY HEREBY DISCLAIMS, AND SHALL HAVE NO RESPONSIBILITY OR LIABILITY WHATSOEVER FOR, DAMAGE OR INJURY TO PERSONS OR PROPERTY OR FOR OTHER LOSS OR INJURY RESULTING FROM ANY CAUSE WHATSOEVER ARISING OUT OF OR RELATED TO ANY OF ITS EQUIPMENT OR ITS USE. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, UNDER NO CIRCUMSTANCES SHALL TIGO ENERGY BE LIABLE TO THE CUSTOMER, OR TO ANY THIRD PARTY CLAIMING THROUGH OR UNDER THE CUSTOMER, FOR ANY LOST PROFITS, LOSS OF USE, OR EQUIPMENT DOWNTIME, OR FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES OF ANY KIND, HOWSOEVER ARISING, RELATED TO THE EQUIPMENT, EVEN IF TIGO ENERGY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, TIGO ENERGY'S AGGREGATE LIABILITY, IF ANY, IN DAMAGES OR OTHERWISE, SHALL NOT EXCEED THE PURCHASE PRICE PAID TO TIGO ENERGY BY THE CUSTOMER FOR THE EQUIPMENT IN THE CASE OF A WARRANTY CLAIM.

THE LIMITED WARRANTIES SET FORTH HEREIN ARE IN LIEU OF AND EXCLUDE ALL OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE

OR APPLICATION, AND ALL OTHER OBLIGATIONS ON THE PART OF TIGO ENERGY UNLESS SUCH OTHER WARRANTIES AND OBLIGATIONS ARE AGREED TO IN WRITING BY TIGO ENERGY. SOME JURISDICTIONS LIMIT OR DO NOT PERMIT DISCLAIMERS OF WARRANTY, SO THIS PROVISION MAY NOT APPLY TO THE CUSTOMER.

THE CUSTOMER ACKNOWLEDGES THAT THE FOREGOING LIMITATIONS ON LIABILITY ARE AN ESSENTIAL ELEMENT OF THE AGREEMENT BETWEEN THE PARTIES AND THAT IN THE ABSENCE OF SUCH LIMITATIONS THE PURCHASE PRICE OF THE EQUIPMENT WOULD BE SUBSTANTIALLY DIFFERENT. SOME JURISDICTIONS LIMIT OR DO NOT PERMIT DISCLAIMERS OF LIABILITY, SO THIS PROVISION MAY NOT APPLY TO THE CUSTOMER. SOME JURISDICTIONS DO NOT ALLOW LIMITATIONS ON THE EXCLUSION OF DAMAGES SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO THE CUSTOMER.

YOU MAY HAVE SPECIFIC LEGAL RIGHTS OUTSIDE THIS WARRANTY, AND YOU MAY ALSO HAVE OTHER RIGHTS THAT VARY FROM STATE TO STATE OR COUNTRY TO COUNTRY. THIS LIMITED WARRANTY DOES NOT AFFECT ANY ADDITIONAL RIGHTS YOU HAVE UNDER LAWS IN YOUR JURISDICTION GOVERNING THE SALE OF CONSUMER GOODS. SOME STATES OR COUNTRIES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTIAL OR CONSEQUENTIAL DAMAGES, SO THE LIMITATIONS OR EXCLUSIONS IN THIS LIMITED WARRANTY STATEMENT MAY NOT APPLY.

UTS Broadway. Solar Collectors

Warranty Conditions

rev	author	date	Remarks
A	JD	19/02/14	Released

Contents

1. Introduction

NEP Solar has been commissioned to supply and install a solar thermal tri-generation system at the UTS Broadway project as part of the "EIF" equipment. The supply comprises:

- 4 PolyTrough 1200 solar collectors delivering hot water (supply by Nilsen)
- One Eneftech ENEFCOGEN GREEN ORC turbine (supplied by UTS).
- One Pink PC19 absorption chiller (supplied by UTS)
- A "heat dump" heat exchanger
- A "domestic hot water (DHW)" heat exchanger
- A "chilled water (CHW)" heat exchanger.
- A hot water buffer tank.
- A pressurisation and expansion tank system.
- Pumps
- Bypass valves
- Instrumentation
- PLC based control system
- SCADA system and HMI PC to operate system.

2. Request for Warranty per equipment

NEP Solar proposed that Warranty on the equipment will be as obtained directly from the equipment manufacturers.

Lend Lease has previously requested NEP Solar to provide the warranty conditions of the equipment. This is contained in NEPDOC0031_0012_A_UTS_Warranty

Nilsen has requested a Warranty Statement for the Solar Collectors as ordered per Nilsen Order 610718/ 70080

3. Warranty Period

Component	Qty	Model	Warranty Period
Solar Field	4	NEP Solar PolyTrough 1200	24 months from delivery

4. Warranty conditions

As per our Terms and Conditions of Sale:

"10. WARRANTIES

10.1. The only conditions and warranties which are binding on the Seller in respect of the state, quality or condition of any Goods and/or Services supplied by it to the Buyer are those imposed and required to be binding by stature (including the Trade Practices Act 1974) and to the extent permitted thereby. The liability, if any, of the Seller arising from the breach of such conditions or warranties shall at the Seller's option be limited to and completely discharged by either the replacement or the repair by the Seller of the Goods and/or resupply of Services supplied to the Buyer and otherwise all other conditions and warranties whether express or implied by law in respect of the state, quality or condition of the said Goods which may apart from this clause be binding on the Seller are hereby expressly excluded and negatived.

10.2. Except to the extent provided immediately above, the Seller shall have no liability (including liability in negligence) to any person for any loss or damage consequential or otherwise howsoever suffered or incurred by any such person in relation to any Goods and/or Services without limiting the generality thereof in particular any loss or damage consequential or otherwise howsoever suffered or incurred by any such person caused by or resulting directly or indirectly from any failure, breakdown defect or deficiency of whatsoever nature or kind of or in the Goods and/or Services."

As per our Warranty Statement:

Nr	Collector component	Guarantee Coverage	Exclusions
1	Aluminium reflector elements	Major defects from manufacturing, material properties per supplier specifications	Degradation due to normal wear and tear. Aging within specified limits. Defects and degradations due to improper operating and maintenance or external influence (weather storms, fire, and accidental damage).
2	Absorber tubes with selective coating	Major defects from manufacturing, material properties per supplier specifications	Degradation due to normal wear and tear. Aging within specified limits. Defects and degradations due to improper operating and maintenance or external influence (weather storms, fire, and accidental damage).
3	Receiver glass tubes	Breakage caused by material properties	Glass breakage during operations due to improper operating and maintenance or external influence (projectiles, weather storms, fire, and accidental damage).
4	Tracking drive system and electronic control system	Major defects from manufacturing, and malfunction of electronic components	Degradation due to normal wear and tear. Defects and degradations due to improper operating and maintenance or external influence (weather storms, direct lightning strikes, fire, accidental damage, severe electromagnetic interference).
5	Steel mounts	Major defects due to poor material or workmanship.	Degradation due to normal wear and tear. Defects and degradations due to improper operating and maintenance or external influence (weather storms, fire and accidental damage).
6	Flexible hoses, hydraulic fittings and valves	Major defects due to poor material or workmanship.	Degradation due to normal wear and tear. Defects and degradations due to improper operating and maintenance or external influence (weather storms, fire and accidental damage).

N93 W14475 Whittaker Way
Menomonee Falls, WI 53051 USA
+1 262.253.9800

Customer Warranty/Certification

February 19, 2014

Terry Kuitert
Nilsen (NSW) Pty Ltd
unit 26, 38-46 South Street
Rydalmere NSW 2116

Dear Terry,

This letter is to inform you that your product has shipped and is ready for installation. The end date of your warranty is February 6th, 2015. Should any warranty issues arise, please contact the service group at 262-442-1216.

Terms of the Warranty are as follows:

Warranties and Remedies.

(a) Products and Services Warranty. ZBB warrants that Products (excluding Software, which is warranted as specified in paragraph (d) below) shall be delivered free of defects in material and workmanship and that Services shall be free of defects in workmanship. The warranty remedy period for Products (excluding Software, spare parts and refurbished or repaired parts) shall end twelve (12) months after installation or eighteen (18) months after date of shipment, whichever first occurs. The warranty remedy period for new spare parts shall end twelve (12) months after the date of shipment. The warranty remedy period for refurbished or repaired parts shall end ninety (90) days after the date of shipment. The warranty remedy period for Services shall end ninety (90) days after the date of completion of Services. Each of the above warranty remedy periods shall be hereinafter referred to as a "Warranty Remedy Period."

(b) Products and Services Remedy. If a nonconformity to the foregoing warranty is discovered in the Products or Services during the applicable Warranty Remedy Period, as specified above, under normal and proper use and provided the Product has been properly stored, installed, operated and maintained and written notice of such nonconformity is provided to ZBB promptly after such discovery and within the applicable Warranty Remedy Period, ZBB shall, at its option, either (i) repair or replace the nonconforming portion of the Products or re-perform the nonconforming Services or (ii) refund the portion of the price applicable to the nonconforming portion of Products or Services. If any portion of the Products or Services so repaired, replaced or re-performed fails to conform to the foregoing warranty, and written notice of such nonconformity is provided to ZBB promptly after discovery and within the original Warranty Remedy Period applicable to such Products or Services or thirty (30) days from completion of such repair, replacement or re-performance, whichever is later, ZBB will repair or replace such nonconforming Products or re-perform the nonconforming Services. The original Warranty Remedy Period shall not otherwise be extended.

(c) Exceptions. ZBB shall not be responsible for providing working access to any of the nonconforming Products, including disassembly and re-assembly of non-ZBB supplied equipment, or for providing transportation to or from any repair facility, all of which shall be at Purchaser's risk and expense. ZBB shall have no obligation hereunder with respect to any Product which (i) has been improperly repaired or altered; (ii) has been subjected to misuse, negligence or accident; (iii) has been used in a manner contrary to ZBB's instructions; (iv) is comprised of materials provided by or a design specified by Purchaser; or (v) has failed as a result of ordinary wear and tear. Products supplied by ZBB but manufactured by others are warranted only to the extent of the manufacturer's warranty, and only the remedies, if any, provided by the manufacturer will be allowed.

(d) Software Warranty and Remedies. ZBB warrants that, except as specified below, the Software will, when properly installed, execute in accordance with ZBB's published specification. If a nonconformity to the foregoing warranty is discovered during the period ending one (1) year after the date of shipment and written notice of such nonconformity is provided to ZBB promptly after such discovery and within that period, including a description of the nonconformity and complete information about the manner of its discovery, ZBB shall correct the nonconformity by, at its option, either (i) modifying or making available to the Purchaser instructions for modifying the Software; or (ii) making available at ZBB's facility necessary corrected or replacement programs. ZBB shall have no obligation with respect to any nonconformities resulting from (1) unauthorized modification of the Software or (2) Purchaser-supplied software or interfacing. ZBB does not warrant that the functions contained in the software will operate in combinations which may be selected for use by the Purchaser, or that the software products are free from errors in the nature of what is commonly categorized by the computer industry as "bugs."

(e) THE FOREGOING WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES OF QUALITY AND PERFORMANCE, WHETHER WRITTEN, ORAL OR IMPLIED, AND ALL OTHER WARRANTIES INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USAGE OF TRADE ARE HEREBY DISCLAIMED. THE REMEDIES STATED HEREIN CONSTITUTE PURCHASER'S EXCLUSIVE REMEDIES AND ZBB'S ENTIRE LIABILITY FOR ANY BREACH OF WARRANTY.

Regards,

Philip Gull, PE
Project Manager
ZBB Energy Corporation
www.zbbenergy.com

N93W14475 Whittaker Way
Menomonee Falls, WI 53051
TEL: 262.253.9800 ext. 114
Cell Phone: 262.327.8009

PROTON
THE LEADER IN ON SITE GAS GENERATION
10 Technology Drive, Wallingford, Connecticut 06492 USA
T: 203.678.2000 F: 203.949-8016 www.Protononsite.com

LIMITED WARRANTY

GENERATOR SYSTEMS

LIMITED WARRANTY: PROTON ENERGY SYSTEMS INC. (“**PROTON”**) warrants that the ITEMS LISTED BELOW shall be free from defects in material and workmanship for the period of time stated below.

Generator System: Twelve (12) months from shipment

Repair or replacement parts for Generator System: Ninety (90) days from shipment

EXCLUDED FROM THIS LIMITED WARRANTY: The following shall be excluded from the Limited Warranty:

• Parts and items considered consumable in normal operations, including those parts and items supplied with the Generator System (“System”) for maintenance.

• Any Generator and its parts that are not installed, operated, and maintained in accordance with the unit’s operation and maintenance manuals supplied with the System.

• Damages due to accident, abuse, acts of God, acts of terrorism, misuse or negligence, or which result, in whole or in part, from improper or unauthorized use or repair of the System, or use of the System in a manner for which it was not designed, or by causes external to the System such as, but not limited to, power or air conditioning failure or voltage irregularities.

REMEDY: BUYER’S sole and exclusive remedy in the event of defect, and the liability of PROTON hereunder is limited to the adjustment, repair, or replacement of the defective item or part with a similar item or part free of defect.
Such adjustments, repairs, or replacements will be made at PROTON’S Wallingford, Connecticut, plant or, for Generators only, at the site of the Generator, if BUYER so elects. All costs for shipping equipment or parts shall be on the account of the BUYER whether to or from the point of manufacture. Labor costs associated with travel, expenses, and subsistence costs for field services shall be on the account of the BUYER.

VOIDING OF THE LIMITED WARRANTY: This Limited Warranty is immediately void upon:

• THE DISASSEMBLY OF THE ELECTROLYSIS CELL STACK, OR
•THE SALE, ASSIGNMENT OR ANY OTHER TRANSFER OF TITLE BY BUYER OF THE ITEMS OR PARTS OTHERWISE COVERED UNDER THIS LIMITED WARRANTY

WAIVER OF ALL OTHER WARRANTIES: THE LIMITED WARRANTY PROVIDED HEREUNDER AND THE RIGHTS AND REMEDIES OF THE BUYER HEREUNDER ARE IN LIEU OF, AND BUYER EXPRESSLY WAIVES, ALL OTHER WARRANTIES, GUARANTEES, OBLIGATIONS, LIABILITIES, OR REMEDIES, EXPRESSED OR IMPLIED, ARISING BY LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY AND NON-INFRINGEMENT, IMPLIED WARRANTIES ARISING FROM THE COURSE OF DEALING OR USAGE OF TRADE AND IMPLIED WARRANTIES OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

LIMITATION OF LIABILITY: THE REMEDIES PROVIDED IN THIS LIMITED WARRANTY ARE EXCLUSIVE AND PROTON SHALL IN NO WAY BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND WHATSOEVER INCLUDING WITHOUT LIMITATION LOSS OF USE, REVENUE OR PROFIT.

LIMITED WARRANTY FOR NEW OVONIC SOLID HYDROGEN CANISTERS

THIS LIMITED WARRANTY IS EXPRESSLY LIMITED TO THE ORIGINAL RETAIL BUYER OF AN OVONIC SOLID HYDROGEN STORAGE CANISTER ("CANISTER"). THIS WARRANTY IS NOT ASSIGNABLE OR TRANSFERABLE. OVONIC HYDROGEN SYSTEMS LLC ("OHS") MAKES NO WARRANTY TO ANYONE ELSE, INCLUDING OTHER PURCHASERS AND/OR USERS, AND NONE WILL BE IMPLIED. NO ONE IS AUTHORIZED TO MAKE ANY STATEMENT OR REPRESENTATION ALTERING THE TERMS OF THIS WARRANTY.

General Terms

A Canister is warranted against defects in material and workmanship for 90 days from the date the Canister is delivered to the first retail purchaser or put in use prior to sale at retail, whichever date occurs first (the "Warranty Period").

Exclusive Remedy

The sole and exclusive remedy for any Canister found to be defective is repair or replacement, at OHS' option. The existence of a defect will be determined by OHS in accordance with procedures established by OHS.

Exclusions

This limited warranty does not cover repairs required due to accident, abuse, misuse, misapplication, failure to repair or maintain, storage damage, negligence or modification.

OHS is not responsible for labor costs for Canister removal and reinstallation.

Other Limitations

THIS LIMITED WARRANTY IS THE ONLY WARRANTY APPLICABLE TO THE CANISTER. OHS MAKES NO OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT WILL OHS BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES (INCLUDING LOST PROFIT, DOWNTIME OR INCONVENIENCE) WHETHER BASED ON WARRANTY, CONTRACT, TORT OR ANY OTHER LEGAL THEORY.

If the exclusive remedy set forth in this limited warranty is deemed to have failed of its essential purpose, OHS' liability will not exceed the purchase price of the Canister.

To Obtain Warranty Service

If you believe a Canister has a defect, please immediately discontinue using the Canister and contact OHS for instructions. Should your Canister require repair service under this limited warranty, you may be asked to provide proof of purchase. You may be required to reimburse OHS for certain costs, including testing and transportation costs, if a returned Canister is determined to be out of warranty.

Additional Information

Instructions regarding the appropriate use, maintenance, storage and handling of Canisters is available upon request from OHS or from OHS' website.

Ovonic Hydrogen Systems LLC
2983 Waterview Drive, Rochester Hills, MI 48309
Tel: (248) 293-8772 Fax: (248) 299-4520
www.ovonic-hydrogen.com

Rev. September 2006

FIRE STOPPING
PASSIVE FIRE PROTECTION
ABN 47 064 568 770

NSW Office
PO Box 737
Balgowlah, NSW 2093

Unit 6, 252 Allambie Road,
Allambie Heights, NSW 2100

Phone: (02) 9907 0700
Fax: (02) 9907 0728

QLD Office
PO Box 562
Virginia BC, QLD 4014

Unit 7, 53 Northlink Place
Virginia, QLD 4014

Phone: (07) 3265 7781
Fax: (07) 3265 5976

27 February 2014
Our ref: AJ14-6149
ASJ

Mr. Terry Kuitert
Nilsen (NSW) Pty Ltd
PO Box 368
RYDALMERE NSW 1701

Dear Terry,

STATEMENT OF INSTALLATION COMPLIANCE
RE: UTS BROADWAY PROJECT – BUILDING 11

This is to verify that the Fire Stopping Materials listed below have been installed to the manufacturer's design & details and tested in accordance with AS1530.4-2005 Fire Resistance Test of Elements of Building Construction, AS4072.1-2005 and BCA Clause C3.15.

AREAS OF INSTALLATION:

LEVEL/AREA	METHOD USED	FRL	TEST REF.
BASEMENT LEVEL 4			
Central Riser			
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
BASEMENT LEVEL 3			
Wattle Street Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)

LEVEL/AREA	METHOD USED	FRL	TEST REF.
Central Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
BASEMENT LEVEL 2			
Wattle Street Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Central Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)

LEVEL/AREA	METHOD USED	FRL	TEST REF.
BASEMENT LEVEL 1			
Wattle Street Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Central Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Jones Street Riser			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
LEVEL 00			
Wattle Street Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)

LEVEL/AREA	METHOD USED	FRL	TEST REF.
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Central Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
Jones Street Riser			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
Main Switch Room			
To fire seal nominated floor penetrations	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
LEVEL 1			
Wattle Street Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)

LEVEL/AREA	METHOD USED	FRL	TEST REF.
Central Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Jones Street Riser			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
LEVEL 2			
Wattle Street Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetration	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Central Riser / Core			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)

LEVEL/AREA	METHOD USED	FRL	TEST REF.
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
Jones Street Riser			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
To fire seal nominated wall penetrations	Thermachek Fire pillows Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-3031 CSIRO FCO-1579 (Revision)
WATTLE STREET RISER, LEVEL 3 TO LEVEL 13 INCLUSIVE			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
CENTRE RISER, LEVEL 3 TO LEVEL 13 INCLUSIVE			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
JONES STREET RISER, LEVEL 3 TO LEVEL 13 INCLUSIVE			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)

LEVEL/AREA	METHOD USED	FRL	TEST REF.
EAST TSG ROOM RISER, BASEMENT LEVEL 3 TO LEVEL 12 INCLUSIVE			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)
WEST TSG ROOM RISER, BASEMENT LEVEL 3 TO LEVEL 12 INCLUSIVE			
To fire seal nominated floor penetration	Trafalgar Fyreset Mortar Floor Slab Trafalgar Fyreflex Fire Rated Sealant	-/120/120 -/120/120	CSIRO FCO-2480 & BRANZ Report FAR1892 CSIRO FCO-1579 (Revision)

An inspection of the above works was carried out on Thursday the 27th of February 2014. No responsibility will be taken for alterations, additions and/or damage caused by other persons since the date of inspection.

The information contained in this document is, to the best of my knowledge and belief, true and accurate.

For and on behalf of Fire Stopping Pty Ltd

Andrew St John
SUPERVISOR

12 DRAWINGS

12.1 As Built Drawings - Preface

In order to achieve accurate drawings, all relevant information relating to the Contract works has been entered onto the work as executed, as built, drawings.
Each Electrical Distribution Board or Distribution Board cupboard contains a plastic laminated “As-Installed" drawings for each Distribution Board and Lighting Control panel.
The Main Switchboard "As-Installed" drawings have also been placed within the Main Switch Room, in laminated A2 format and have been permanently fixed to the wall adjacent to the Main Switchboard.
All "As-Installed" drawings have also been provided within Section 6 of the operating and maintenance instruction manual.
"As-Installed" drawings have also been provided within the operating and maintenance instruction manual on a Compact disc.

The "As-Installed" drawings have been prepared based on the existing Project Managers drawings and contain the standard project specific title block.

At the completion of the work Nilsen has provided the builder with a detailed set of drawings marked up in red showing all amendments and “as-installed” details.
Drawings generally include:

- Dimensions, types and location of the services in relation to permanent site features and other underground services.
- Include all changes made during commissioning and the maintenance period.
- Include all documented shop drawings for new electrical distribution switchboards and Main Switchboard modifications.

Where a drawing shows extensions and/or alterations to existing installations, we have included details on existing installation to make the drawing comprehensible without referencing drawings of the original installation, where required.

12.2 AS BUILT DOCUMENTATION - Shop Drawings

Shop drawings were provided and included plans, elevations, sections, details and schematic wiring diagrams to show makeup of the Main Switchboard. Shop drawings were submitted to and approved by the Electricity Distributor prior to approval by the project Manager and prior to construction.

12.3 DB Schedule

See attached folder Section 12.3

12.4 List of Drawings

Electrical Services Title	Dwg No.	Comments	Scale
Level B4 Lighting Layout Sheet 1	NIL-E-SPD-0003	Construction	1:100 @ A1
Level B4 Lighting Layout Sheet 2	NIL-E-SPD-0004	Construction	1:100 @ A1
Level B4 Power Layout Sheet 1	NIL-E-SPD-0005	Construction	1:100 @ A1
Level B4 Power Layout Sheet 2	NIL-E-SPD-0006	Construction	1:100 @ A1
Level B4 Cable Tray Layout Sheet 1	NIL-E-SPD-0007	Construction	1:100 @ A1
Level B3 Lighting Layout Sheet 1	NIL-E-SPD-0008	Construction	1:100 @ A1
Level B3 Lighting Layout Sheet 2	NIL-E-SPD-0009	Construction	1:100 @ A1
Level B3 Power Layout Sheet 1	NIL-E-SPD-0010	Construction	1:100 @ A1
Level B3 Power Layout Sheet 2	NIL-E-SPD-0011	Construction	1:100 @ A1
Level B3 Cable Tray Layout Sheet 1	NIL-E-SPD-0012	Construction	1:100 @ A1
Level B3 Cable Tray Layout Sheet 2	NIL-E-SPD-0013	Construction	1:100 @ A1
Level B2 Lighting Layout Sheet 1	NIL-E-SPD-0014	Construction	1:100 @ A1
Level B2 Lighting Layout Sheet 2	NIL-E-SPD-0015	Construction	1:100 @ A1
Level B2 Power Layout Sheet 1	NIL-E-SPD-0016	Construction	1:100 @ A1
Level B2 Power Layout Sheet 2	NIL-E-SPD-0017	Construction	1:100 @ A1
Level B2 Cable Tray Layout Sheet 1	NIL-E-SPD-0018	Construction	1:100 @ A1
Level B2 Cable Tray Layout Sheet 2	NIL-E-SPD-0019	Construction	1:100 @ A1
Level B1 Lighting Layout Sheet 1	NIL-E-SPD-0020	Construction	1:100 @ A1
Level B1 Lighting Layout Sheet 2	NIL-E-SPD-0021	Construction	1:100 @ A1
Level B1 Power Layout Sheet 1	NIL-E-SPD-0022	Construction	1:100 @ A1
Level B1 Power Layout Sheet 2	NIL-E-SPD-0023	Construction	1:100 @ A1
Level B1 Cable Tray Layout Sheet 1	NIL-E-SPD-0024	Construction	1:100 @ A1
Level B1 Cable Tray Layout Sheet 2	NIL-E-SPD-0025	Construction	1:100 @ A1
Level 00 Lighting Layout Sheet 1	NIL-E-SPD-0026	Construction	1:100 @ A1
Level 00 Lighting Layout Sheet 2	NIL-E-SPD-0027	Construction	1:100 @ A1
Level 00 Power Layout Sheet 1	NIL-E-SPD-0028	Construction	1:100 @ A1
Level 00 Power Layout Sheet 2	NIL-E-SPD-0029	Construction	1:100 @ A1
Level 00 Cable Tray Layout Sheet 1	NIL-E-SPD-0030	Construction	1:100 @ A1
Level 00 Cable Tray Layout Sheet 2	NIL-E-SPD-0031	Construction	1:100 @ A1
Level 1 Lighting Layout Sheet 1	NIL-E-SPD-0032	Construction	1:100 @ A1
Level 1 Lighting Layout Sheet 2	NIL-E-SPD-0033	Construction	1:100 @ A1
Level 1 Power Layout Sheet 1	NIL-E-SPD-0034	Construction	1:100 @ A1
Level 1 Power Layout Sheet 2	NIL-E-SPD-0035	Construction	1:100 @ A1
Level 1 Cable Tray Layout Sheet 1	NIL-E-SPD-0036	Construction	1:100 @ A1
Level 1 Cable Tray Layout Sheet 2	NIL-E-SPD-0037	Construction	1:100 @ A1
Level 2/3 Lighting Layout Sheet 1	NIL-E-SPD-0038	Construction	1:100 @ A1
Level 2/3 Lighting Layout Sheet 2	NIL-E-SPD-0039	Construction	1:100 @ A1
Level 2/3 Power Layout Sheet 1	NIL-E-SPD-0040	Construction	1:100 @ A1

Level 2/3 Power Layout Sheet 2	NIL-E-SPD-0041	Construction	1:100 @ A1
Level 2/3 Cable Tray Layout Sheet 1	NIL-E-SPD-0042	Construction	1:100 @ A1
Level 2/3 Cable Tray Layout Sheet 2	NIL-E-SPD-0043	Construction	1:100 @ A1
Level 4 Lighting Layout Sheet 1	NIL-E-SPD-0044	Construction	1:100 @ A1
Level 4 Lighting Layout Sheet 2	NIL-E-SPD-0045	Construction	1:100 @ A1
Level 4 Power Layout Sheet 1	NIL-E-SPD-0046	Construction	1:100 @ A1
Level 4 Power Layout Sheet 2	NIL-E-SPD-0047	Construction	1:100 @ A1
Level 4 Cable Tray Layout Sheet 1	NIL-E-SPD-0048	Construction	1:100 @ A1
Level 4 Cable Tray Layout Sheet 2	NIL-E-SPD-0049	Construction	1:100 @ A1
Level 5 Lighting Layout Sheet 1	NIL-E-SPD-0050	Construction	1:100@A1
Level 5 Lighting Layout Sheet 2	NIL-E-SPD-0051	Construction	1:100@A1
Level 5 Power Layout Sheet 1	NIL-E-SPD-0052	Construction	1:100@A1
Level 5 Power Layout Sheet 2	NIL-E-SPD-0053	Construction	1:100@A1
Level 5 Cable Tray Layout Sheet 1	NIL-E-SPD-0054	Construction	1:100@A1
Level 5 Cable Tray Layout Sheet 2	NIL-E-SPD-0055	Construction	1:100@A1
Level 6 Lighting Layout Sheet 1	NIL-E-SPD-0056	Construction	1:100@A1
Level 6 Lighting Layout Sheet 2	NIL-E-SPD-0057	Construction	1:100@A1
Level 6 Power Layout Sheet 1	NIL-E-SPD-0058	Construction	1:100@A1
Level 6 Power Layout Sheet 2	NIL-E-SPD-0059	Construction	1:100@A1
Level 6 Cable Tray Layout Sheet 1	NIL-E-SPD-0060	Review	1:100@A1
Level 6 Cable Tray Layout Sheet 2	NIL-E-SPD-0061	Review	1:100@A1
Level 7 Lighting Layout Sheet 1	NIL-E-SPD-0062	Review	1:100@A1
Level 7 Lighting Layout Sheet 2	NIL-E-SPD-0063	Review	1:100@A1
Level 7 Power Layout Sheet 1	NIL-E-SPD-0064	Review	1:100@A1
Level 7 Power Layout Sheet 2	NIL-E-SPD-0065	Review	1:100@A1
Level 7 Cable Tray Layout Sheet 1	NIL-E-SPD-0066	Review	1:100@A1
Level 7 Cable Tray Layout Sheet 2	NIL-E-SPD-0067	Review	1:100@A1
Level 8 Lighting Layout Sheet 1	NIL-E-SPD-0068	Review	1:100@A1
Level 8 Lighting Layout Sheet 2	NIL-E-SPD-0069	Review	1:100@A1
Level 8 Power Layout Sheet 1	NIL-E-SPD-0070	Review	1:100@A1
Level 8 Power Layout Sheet 2	NIL-E-SPD-0071	Review	1:100@A1
Level 8 Cable Tray Layout Sheet 1	NIL-E-SPD-0072	Review	1:100@A1
Level 8 Cable Tray Layout Sheet 2	NIL-E-SPD-0073	Review	1:100@A1
Level 9 Lighting Layout Sheet 1	NIL-E-SPD-0074	Review	1:100@A1
Level 9 Lighting Layout Sheet 2	NIL-E-SPD-0075	Review	1:100@A1

Level 9 Power Layout Sheet 1	NIL-E-SPD-0076	Review	1:100@A1
Level 9 Power Layout Sheet 2	NIL-E-SPD-0077	Review	1:100@A1
Level 9 Cable Tray Layout Sheet 1	NIL-E-SPD-0078	Review	1:100@A1
Level 9 Cable Tray Layout Sheet 2	NIL-E-SPD-0079	Review	1:100@A1
Level 10 Lighting Layout Sheet 1	NIL-E-SPD-0080	Review	1:100@A1
Level 10 Lighting Layout Sheet 2	NIL-E-SPD-0081	Review	1:100@A1
Level 10 Power Layout Sheet 1	NIL-E-SPD-0082	Review	1:100@A1
Level 10 Power Layout Sheet 2	NIL-E-SPD-0083	Review	1:100@A1
Level 10 Cable Tray Layout Sheet 1	NIL-E-SPD-0084	Review	1:100@A1
Level 10 Cable Tray Layout Sheet 2	NIL-E-SPD-0085	Review	1:100@A1
Level 11 Lighting Layout Sheet 1	NIL-E-SPD-0086	Review	1:100@A1
Level 11 Lighting Layout Sheet 2	NIL-E-SPD-0087	Review	1:100@A1
Level 11 Power Layout Sheet 1	NIL-E-SPD-0088	Review	1:100@A1
Level 11 Power Layout Sheet 2	NIL-E-SPD-0089	Review	1:100@A1
Level 11 Cable Tray Layout Sheet 1	NIL-E-SPD-0090	Review	1:100@A1
Level 11 Cable Tray Layout Sheet 2	NIL-E-SPD-0091	Review	1:100@A1
Level 12 Lighting Layout Sheet 1	NIL-E-SPD-0092	Review	1:100@A1
Level 12 Lighting Layout Sheet 2	NIL-E-SPD-0093	Review	1:100@A1
Level 12 Power Layout Sheet 1	NIL-E-SPD-0094	Review	1:100@A1
Level 12 Power Layout Sheet 2	NIL-E-SPD-0095	Review	1:100@A1
Level 12 Cable Tray Layout Sheet 1	NIL-E-SPD-0096	Review	1:100@A1
Level 12 Cable Tray Layout Sheet 2	NIL-E-SPD-0097	Review	1:100@A1
Level 13 Lighting Layout Sheet 1	NIL-E-SPD-0098		
Level 13 Lighting Layout Sheet 2	NIL-E-SPD-0099		
Level 13 Power Layout Sheet 1	NIL-E-SPD-0100		
Level 13 Power Layout Sheet 2	NIL-E-SPD-0101		
Level 13 Cable Tray Layout Sheet 1	NIL-E-SPD-0102		
Level 13 Cable Tray Layout Sheet 2	NIL-E-SPD-0103		
AV	NIL-E-SPD-0200		
AV	NIL-E-SPD-0201		
AV	NIL-E-SPD-0202		
AV	NIL-E-SPD-0203		
AV	NIL-E-SPD-0204		
AV	NIL-E-SPD-0205		
AV	NIL-E-SPD-0206		
AV	NIL-E-SPD-0207		
AV	NIL-E-SPD-0208		
AV	NIL-E-SPD-0209		
AV	NIL-E-SPD-0210		
AV	NIL-E-SPD-0211		
AV	NIL-E-SPD-0212		

AV	NIL-E-SPD-0213		
AV	NIL-E-SPD-0214		
AV	NIL-E-SPD-0215		
AV	NIL-E-SPD-0216		
AV	NIL-E-SPD-0217		
AV	NIL-E-SPD-0218		
AV	NIL-E-SPD-0219		
AV	NIL-E-SPD-0220		
AV	NIL-E-SPD-0221		
AV	NIL-E-SPD-0222		
AV	NIL-E-SPD-0223		
AV	NIL-E-SPD-0224		
AV	NIL-E-SPD-0225		
AV	NIL-E-SPD-0226		
AV	NIL-E-SPD-0227		
AV	NIL-E-SPD-0228		
AV	NIL-E-SPD-0229		
AV	NIL-E-SPD-0230		
AV	NIL-E-SPD-0231		
AV	NIL-E-SPD-0232		
AV	NIL-E-SPD-0233		
AV	NIL-E-SPD-0234		
AV	NIL-E-SPD-0235		
AV	NIL-E-SPD-0236		
AV	NIL-E-SPD-0237		
AV	NIL-E-SPD-0238		
AV	NIL-E-SPD-0239		
AV	NIL-E-SPD-0240		
Data	NIL-E-SPD-0241		
Data	NIL-E-SPD-0242		
Data	NIL-E-SPD-0243		
Data	NIL-E-SPD-0244		
Data	NIL-E-SPD-0245		
Data	NIL-E-SPD-0246		
Data	NIL-E-SPD-0247		
Data	NIL-E-SPD-0248		
Data	NIL-E-SPD-0249		
Data	NIL-E-SPD-0250		
Lighting Control SLD	NIL-E-SPD-501	Review	NTS
Lighting Control SLD	NIL-E-SPD-502	Review	NTS
Lighting Control SLD	NIL-E-SPD-503	Review	NTS
Lighting Control SLD	NIL-E-SPD-504	Review	NTS
Lighting Control SLD	NIL-E-SPD-505	Review	NTS
Lighting Control SLD	NIL-E-SPD-506	Review	NTS
Lighting Control SLD	NIL-E-SPD-507	Review	NTS
Lighting Control SLD	NIL-E-SPD-508	Review	NTS

Lighting Control SLD	NIL-E-SPD-509	Review	NTS
Lighting Control SLD	NIL-E-SPD-510	Review	NTS
Lighting Control SLD	NIL-E-SPD-511	Review	NTS
Lighting Control SLD	NIL-E-SPD-512	Review	NTS
Lighting Control SLD	NIL-E-SPD-513	Review	NTS
Lighting Control SLD	NIL-E-SPD-514	Review	NTS
Lighting Control SLD	NIL-E-SPD-515	Review	NTS
Lighting Control SLD	NIL-E-SPD-516	Review	NTS
Lighting Control SLD	NIL-E-SPD-517	Review	NTS
Lighting Control SLD	NIL-E-SPD-518	Review	NTS
Lighting Control SLD	NIL-E-SPD-519	Review	NTS
Lighting Control SLD	NIL-E-SPD-520	Review	NTS
Lighting Control SLD	NIL-E-SPD-521	Review	NTS
Lighting Control SLD	NIL-E-SPD-522	Review	NTS
Lighting Control SLD	NIL-E-SPD-523	Review	NTS
Lighting Control SLD	NIL-E-SPD-524	Review	NTS
Lighting Control SLD	NIL-E-SPD-525	Review	NTS
Lighting Control SLD	NIL-E-SPD-526	Review	NTS
Lighting Control SLD	NIL-E-SPD-527	Review	NTS
Lighting Control SLD	NIL-E-SPD-528	Review	NTS
Lighting Control SLD	NIL-E-SPD-529	Review	NTS
Lighting Control SLD	NIL-E-SPD-530	Review	NTS
Lighting Control SLD	NIL-E-SPD-531	Review	NTS
Lighting Control SLD	NIL-E-SPD-532	Review	NTS
Lighting Control SLD	NIL-E-SPD-533	Review	NTS
Lighting Control SLD	NIL-E-SPD-534	Review	NTS
Lighting Control SLD	NIL-E-SPD-535	Review	NTS
Lighting Control SLD	NIL-E-SPD-536	Review	NTS
Lighting Control SLD	NIL-E-SPD-537	Review	NTS
Lighting Control SLD	NIL-E-SPD-538	Review	NTS
Lighting Control SLD	NIL-E-SPD-539	Review	NTS
Lighting Control SLD	NIL-E-SPD-540	Review	NTS
Lighting Control SLD	NIL-E-SPD-541	Review	NTS
Lighting Control SLD	NIL-E-SPD-542	Review	NTS
Lighting Control SLD	NIL-E-SPD-543	Review	NTS
Lighting Control SLD	NIL-E-SPD-544	Review	NTS
Lighting Control SLD	NIL-E-SPD-545	Review	NTS
Lighting Control SLD	NIL-E-SPD-546	Review	NTS
Lighting Control SLD	NIL-E-SPD-547	Review	NTS
Lighting Control SLD	NIL-E-SPD-548	Review	NTS
Lighting Control SLD	NIL-E-SPD-549	Review	NTS
Lighting Control SLD	NIL-E-SPD-550	Review	NTS
Lighting Control SLD	NIL-E-SPD-551	Review	NTS
Lighting Control SLD	NIL-E-SPD-552	Review	NTS
Lighting Control SLD	NIL-E-SPD-553	Review	NTS
Lighting Control SLD	NIL-E-SPD-554	Review	NTS
Lighting Control SLD	NIL-E-SPD-555	Review	NTS

Lighting Control SLD	NIL-E-SPD-556	Review	NTS
Lighting Control SLD	NIL-E-SPD-557	Review	NTS
Lighting Control SLD	NIL-E-SPD-558	Review	NTS
Lighting Control SLD	NIL-E-SPD-559	Review	NTS
Lighting Control SLD	NIL-E-SPD-560	Review	NTS
Lighting Control SLD	NIL-E-SPD-561	Review	NTS
Lighting Control SLD	NIL-E-SPD-562	Review	NTS
Lighting Control SLD	NIL-E-SPD-563	Review	NTS
Lighting Control SLD	NIL-E-SPD-564	Review	NTS
Lighting Control SLD	NIL-E-SPD-565	Review	NTS
Lighting Control SLD	NIL-E-SPD-566	Review	NTS
Lighting Control SLD	NIL-E-SPD-567	Review	NTS
Lighting Control SLD	NIL-E-SPD-568	Review	NTS
Lighting Control SLD	NIL-E-SPD-569	Review	NTS
Lighting Control SLD	NIL-E-SPD-570	Review	NTS
Lighting Control SLD	NIL-E-SPD-571	Review	NTS
Lighting Control SLD	NIL-E-SPD-572	Review	NTS
Lighting Control SLD	NIL-E-SPD-573	Review	NTS
Lighting Control SLD	NIL-E-SPD-574	Review	NTS
Lighting Control SLD	NIL-E-SPD-575	Review	NTS
Lighting Control SLD	NIL-E-SPD-576	Review	NTS
Lighting Control SLD	NIL-E-SPD-577	Review	NTS
Lighting Control SLD	NIL-E-SPD-578	Review	NTS
Lighting Control SLD	NIL-E-SPD-579	Review	NTS
Lighting Control SLD	NIL-E-SPD-580	Review	NTS
Lighting Control SLD	NIL-E-SPD-581	Review	NTS
Lighting Control SLD	NIL-E-SPD-582	Review	NTS
Lighting Control SLD	NIL-E-SPD-583	Review	NTS
Lighting Control SLD	NIL-E-SPD-584	Review	NTS
Lighting Control SLD	NIL-E-SPD-585	Review	NTS
Lighting Control SLD	NIL-E-SPD-586	Review	NTS
Lighting Control SLD	NIL-E-SPD-587	Review	NTS
Lighting Control SLD	NIL-E-SPD-588	Review	NTS
Lighting Control SLD	NIL-E-SPD-589	Review	NTS
Lighting Control SLD	NIL-E-SPD-590	Review	NTS
Lighting Control SLD	NIL-E-SPD-591	Review	NTS
Lighting Control SLD	NIL-E-SPD-592	Review	NTS
Lighting Control SLD	NIL-E-SPD-593	Review	NTS
Lighting Control SLD	NIL-E-SPD-594	Review	NTS
Lighting Control SLD	NIL-E-SPD-595	Review	NTS
Lighting Control SLD	NIL-E-SPD-596	Review	NTS
Electrical Overview Single Line Diagram	NIL-E-SPD-0700	Construction	NTS
Main Switchroom 1 Located on Level 00 Single Line Diagram	NIL-E-SPD-0701	Construction	NTS
Main Switchroom 2 Located on Level 00 Single Line Diagram	NIL-E-SPD-0702	Review	NTS

Main Switchroom 3 Located on Level 00 Single Line Diagram	NIL-E-SPD-0703	Review	NTS
Lighting Control Schematics Sheet 1 of 2	NIL-E-SPD-0706	Review	NTS
Lighting Control Schematics Sheet 2 of 2	NIL-E-SPD-0707	Review	NTS
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	NIL-E-SPD-0756		
	NIL-E-SPD-0757		
	NIL-E-SPD-0758		
	NIL-E-SPD-0759		
	NIL-E-SPD-0760		
	NIL-E-SPD-0761		
	NIL-E-SPD-0762		
	NIL-E-SPD-0763		
	NIL-E-SPD-0764		
	NIL-E-SPD-0765		
	NIL-E-SPD-0766		
	NIL-E-SPD-0767		
	NIL-E-SPD-0768		
	NIL-E-SPD-0769		
	NIL-E-SPD-0770		
	NIL-E-SPD-0771		
	NIL-E-SPD-0772		
	NIL-E-SPD-0773		
	NIL-E-SPD-0774		
	NIL-E-SPD-0775		