

Main Roads Technical Standard

MRTS228

Provision of Electrical Switchboards

October 10

 **Queensland** Government

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Provision of Electric Switchboards

1 INTRODUCTION

This standard defines the design, supply, installation, testing and commissioning, performance, documentation, training and maintenance requirements for electric switchboards for applications other than street lighting and traffic signal controllers.

Switchboards, cabling, wiring and terminals for street lighting and traffic signal controllers shall be provided in accordance with MRTS93, MRTS94 and MRTS95.

Where switchboards for street lighting (and/or traffic signal controllers) are required at the same location as an additional application, its switchboard shall be supplied from the street lighting and/or traffic signal controller switchboard.

This Technical Standard shall be read in conjunction with MRTS01 *Introduction to Technical Standards*, MRTS50 *Specific Quality System Requirements* and other Technical Standards as appropriate.

This Technical Standard forms part of the Main Roads Specifications and Technical Standards Manual.

2 DEFINITION OF TERMS

The terms defined in Clause 2 of MRTS01 *Introduction to Technical Standards* and MRTS201 apply to this standard. Additional definitions for equipment provided under this standard are defined in Table 2.

Table 2 – Definitions

Term	Definition
CSA	Cross-Sectional Area
DB	Distribution Board
Essential Circuit	A circuit nominated as “Essential” on the drawings AND/OR a circuit connected to a battery-backed power supply (such as a UPS)
LV	Low-voltage as defined in AS/NZS 3000
MCB	Miniature circuit breaker
MCCB	Moulded case circuit breaker
MEN	Multiple-Earthed Neutral
MSB	Main Switchboard
UPS	Uninterruptible Power Supply

3 REFERENCE DOCUMENTS

The requirements of all referenced documents listed in Table 3 of MRTS201 and Table 3 below apply to this standard. Where there are inconsistencies between this standard and the referenced (including those referenced in MRTS201), the requirements specified in this standard shall take precedence.

Table 3 – Referenced Documents

Document/Source	Description
MRTS201	General Equipment Requirements
AS 1170	SAA Loading Code
AS 2184	Low voltage switchgear and control gear – Moulded-case circuit-breakers for rated voltages up to and including 600 V a.c. and 250 V d.c
AS 3000	SAA Wiring Rules

Document/Source	Description
AS 3013	Electrical installations – Classification of the fire and mechanical performance of wiring systems
AS 3100	Approval and test specification – general requirements for electrical equipment
AS 3111	Approval and test specification – miniature over-current circuit-breakers
AS 3190	Approval and test specification – residual current devices (current-operated earth-leakage devices)
AS 3439	Low voltage switchgear and control gear assemblies
AS 4070	Recommended practices for the protection of low voltage electrical installations and equipment in MEN systems from transient over-voltages
AS/NZS 5000	Electric cables – Polymeric insulated
AS 60269	Low voltage fuses
AS 60529	Degrees of protection provided by enclosures (IP code)
AS 60947.5.1	Low-voltage switchgear and control gear – Control circuit devices and switching elements – Electromechanical control circuit devices

4 QUALITY SYSTEM REQUIREMENTS

The quality system requirements defined in MRTS201 apply to this standard. Additional quality system requirements relevant to this standard are defined in Table 4.

Table 4 – Witness Point

Clause	Witness Point
11.2	1. Relevant documentation to be provided and type tests shall be in compliance with AS 3439.

5 GENERAL

5.1 Design

The switchboard shall be contained within a dedicated, sealed enclosure that prevents contact with any live LV surface. The switchboard enclosure shall comply with the requirements of MRTS201.

Where an item of equipment is required more than once throughout the Works, the same make and model of that equipment shall be used in each instance. Wherever possible, equipment of different size, capacity, function shall be of the same make and model series as similar types of equipment used throughout the Works.

5.2 Operational Requirements

The operational requirements defined in MRTS201 apply to this standard. Additional operational requirements for equipment provided under this standard are detailed in this standard.

5.3 Electrical Requirements

All electrical design, wiring and associated equipment shall comply with the requirements of the Wiring Rules.

All electrical components shall be suitable for operation on a mains 230 volt (and 240 volt) +5% / -10%, 50 Hz ± 0.1 Hz system (and/or three-phase equivalent as appropriate) and rated for the respective calculated, prospective fault current.

Unless otherwise noted, switchboard electrics / equipment shall be mounted on DIN rail complying with DIN 46277. DIN rail shall be TH35 7.5, minimum 400 mm length and fixed securely by screws to prevent movement.

5.4 Identification and Labelling

5.4.1 General

Identification labels shall be in accordance with AS 3000 and AS 3439. Labels shall be provided for switchboards and their contents, including: instruments, controls, circuit designations and ratings, circuit protection devices, discrete devices, cabling, warning notices, and the like.

5.4.2 Electrical Insulation

Electrical insulation colours for wiring cores and busbars shall be as shown in Table 5.4.2.

Table 5.4.2 – Insulation Colours

Core	Multiphase Installations (Colour)	Single Phase Installations (Colour)
Active	Red, white or blue	Red
Neutral	Black	Black
Earth	Green and yellow	Green and yellow
LV Control	White with numbered ferrules	White with numbered ferrules
ELV Control	Purple with numbered ferrules	Purple with numbered ferrules

5.4.3 Electrical Safety Warning / Isolation

A clear cover (Perspex or equivalent) shall isolate live surfaces that could otherwise be touched by a standard test finger (as defined in AS 60529) immediately after opening the switchboard. A danger sign that complies with the relevant requirements of AS 1319 shall be fixed on such covers, and also to the inside of the switchboard access door.

5.4.4 Labelling Requirements

Labels shall be fixed by screws adjacent to the respective equipment. Screws in areas accessible to the public shall be of vandal-resistant design. The label shall be located such that it cannot be mistaken as referring to another device. Unless otherwise specified, labels shall not be fixed ON the equipment.

Labels shall be laminated plastic or brushed aluminium, and coloured as follows:

- a) warning notices: White letters on red background;
- b) essential circuits: Red lettering on white background; and
- c) other labels: Black on white background.

Lettering height shall comply with that shown in Table 5.4.4.

Table 5.4.4 – Label Lettering Height

Label	Lettering Height
“Main Switchboard”	25 mm
Name of other switchboards	15 mm
“Main Switch”	15 mm
DB feeder control switches	10 mm
Name of switchboard panel	6 mm
Equipment labels	4 mm
Warning notices	4 mm

5.4.5 Labelling of Circuit Protection Devices

Devices that protect switchboard and/or DB feeders shall be labelled in a manner similar to the following examples:

- a) number of circuit protection device: Qxx [or] Fxx;
- b) name of connected sub-board: DB 1 – General Light and Power;
- c) setting / Rating of circuit protection device: 315A / 400A; and
- d) connected cable size and type: 4 x 1C 300 mm² Cu/PVC/PVC

Devices that protect other circuits shall be labelled in a manner similar to the following examples:

- a) number of circuit protection device: Qxx [or] Fxx; and
- b) name of final sub-circuit: L1 – S/L North 1.

5.4.6 Schedule Cards

Circuit schedule cards shall be provided to describe final sub-circuits. Cards shall be at least 200 mm x 150 mm in size and contain computer-printed text showing:

- a) number of circuit protection device; and
- b) sub-main or sub-circuit name; destination area (where applicable); cable rating, type and length.

Each card shall be mounted in a purpose-built holder fixed inside the door of the enclosure housing the protection devices. The card shall be protected by a transparent plastic cover.

5.5 Neutral and Earth

Unless otherwise specified, all new cabinets and switchboards shall be bonded to earth by suitable cabling and earth conductor network as a MEN system in accordance with AS/NZS 3000.

Clearly numbered terminals shall be provided for all neutral and earth conductors, including the MEN link. Spare terminals shall be provided for future circuits in each of the neutral and earth bars. The number of spare terminals shall be the greater of: 10% of initial connected terminals, or 6 terminals.

Cables with CSA of 16 mm² or larger shall be provided with stud connections.

5.6 Switchboard Wiring

Wiring within the switchboard shall:

- a) have a minimum CSA of 2.5 mm² (7/0.67) for power supply wiring;
- b) have a minimum CSA of 1.0 mm² (32/0.2) for control and indication wiring;
- c) comply with AS 5000;
- d) be sized to suit the rated current of the particular circuit; and
- e) be de-rated in accordance with AS 3008 Part 1.

Only one wire shall be connected to each terminal. Proprietary bridging links shall be used for parallel connections between adjacent terminals.

Unless otherwise specified, all wiring shall use 0.6/1 kV V-75 Cu/PVC cables that comply with AS 5000. Essential circuits shall utilise a wiring system that complies with WS52 to AS 3013.

Wiring shall be provided within PVC wiring ducts in accordance with MRTS201. Where use of such wiring ducts is impractical, it shall be bundled and supported with PVC ties or strips so as to remain neat, functional, prevent excessive sagging, and avoid interference with maintenance activities within the enclosure.

Protective insulated flashing shall be provided where wiring or cables pass through cut-outs or other sharp edges.

5.7 Terminations

5.7.1 Terminals

Each wiring terminal shall be clearly and indelibly identified. The terminal assembly shall be arranged so that:

- a) the connecting cables can be formed in a neat manner; and

b) all conductors can be connected or disconnected without disturbing other connections

Stud-type terminals (minimum 5 mm diameter) shall be used with wiring connections for CSA greater than 25 mm². Only 1 lug may be installed per mounting stud.

Tunnel-type terminals blocks shall be DIN-rail mounted as follows:

- i. wire CSA 10 mm² to 25 mm² (inclusive): compression screws; and
- ii. wire CSA up to 10 mm² (exclusive): compression screws or spring-type

Tunnel type terminals shall only have one conductor connected to each end of the tunnel.

5.7.2 Lugs

Wiring shall be terminated using compression type lugs / pins that are compatible with the terminals. Lugs / pins shall be crimped in accordance with the manufacturer's instructions.

5.7.3 Arrangement

All internal wiring shall be terminated on one side of the terminal block; wiring that exits the switchboard enclosure shall be terminated on the other side.

Control terminals shall be grouped for each circuit with each group physically segregated.

DIN rails shall provide 25% spare capacity for future circuits.

6 CIRCUIT PROTECTION DEVICES

6.1 General

Mains switching, outgoing circuit switching, motor controls and starters, protection and auxiliary equipment shall be provided as shown on the design documentation.

Circuit protection devices shall be rated for:

- a) full current of connected load – continuous duty; and
- b) starting currents of connected load – a duty equal to the load's rated number of starts per hour.

The protection device's make and break capacity shall be equal to at least the calculated prospective short-circuit fault current of the installation. The minimum utilisation category shall be AC-23 for circuits with motor or other highly inductive loads, and AC-22 for all other loads.

6.2 Switch-Isolator and Fuse-Switch Units

Switch-isolator and fuse-switch units shall comply with AS 3947.

Switch-isolator and fuse-switch units shall allow manual operation with an integral ON-OFF indicator, and a facility to lock the device in the OFF position.

The units shall be totally enclosed and incorporate arc-control devices, and shrouded stationary contacts.

6.3 Fuses

Fuses shall be enclosed, High Rupturing Capacity (HRC) type.

Fuses shall be installed in fuse-holders that allow a blown fuse to be identified while the fuse is installed in the service position. The fuse-holder shall insulate all live parts when the fuse is withdrawn.

A fuse insertion / extraction device shall be provided to safely remove and insert fuses. The extraction device shall be mounted on retention clips within the enclosure.

Each switchboard shall be provided with three (3) spare fuses for each size of fuse used in the switchboard. The spare fuses shall be mounted in holders within the enclosure adjacent the fuse extraction device.

6.4 Moulded Case and Miniature Circuit Breakers

MCCB's and MCB's with fault capacities of 10 kA or more shall be in accordance with AS 2184. MCB's with fault capacities less than 10 kA and a current rating up to 100 A shall be in accordance with AS 3111.

All circuit breakers shall be able to be locked in the "Off" position.

MCCB's need not be mounted on DIN rail.

6.5 Residual Current Devices

Residual Current Devices (RCD) shall be in accordance with AS 3190 and AS 3111.

Where RCD protection is provided on a circuit protected by a MCB, the RCD shall be integral with the MCB.

Unless otherwise specified, the tripping current for all RCD's shall be 30 mA.

7 SWITCHBOARD ELECTRICS / EQUIPMENT

7.1 Protection Against Electrical Transients and Over-Voltage

7.1.1 General

The installation shall incorporate protection against electrical transients and over-voltage. Unless otherwise specified, the installation shall follow the recommended practices for the MEN system, specified in AS 4070 for protection of low-voltage electrical installations and equipment from transient over-voltages.

The installation shall follow the general guidelines for the protection of persons and property from hazards arising from exposure to lightning in accordance with AS 1768.

The switchboard shall also include the necessary devices to protect all equipment being housed in the enclosure from electrical transients and over-voltage.

7.1.2 Surge Diverter

Surge diverters shall be supplied and installed in the switchboard to provide protection against multiple impulses caused by lightning or other transient disturbances. Surge diverters shall be connected on the load side of the installation's main switch between the following terminals:

- a) phase and neutral;
- b) phase and earth; and
- c) phase to phase (at multi-phase installations).

Surge diverters shall:

- i. be in accordance with Australian standard AS 4070;
- ii. have a minimum phase-to-neutral single shot 8/20 μ s rating of 80 kA and be suitably rated to withstand multiple impulses as defined by location category C in AS 1768;
- iii. be based on Metal Oxide Varistor (MOV) technology, with each MOV rated at no less than 40kA for an 8/20 μ s pulse. MOVs shall be internally fused such that they are disconnected if the unit experiences a surge that exceeds its rating;
- iv. have visual indication of MOV fuse operation, loss of power, and thermal overload. In the event of a thermal overload, the protection shall remain in circuit;
- v. have voltage free changeover contact (Alarm output). This shall activate upon any MOV failure, power failure or thermal overload condition. The contact shall be isolated to 4 kV to all active circuitry;
- vi. be rated for a nominal operating phase voltage of 230 V / 240 V, and a maximum operating voltage of at least 275 V rms; and
- vii. have a let through voltage (Residual Voltage) for a 6 kV 1.2/50 μ s, 3 kA 8/20 μ s impulse of less than 900 V when measured at the surge diverter terminals.

7.1.3 Surge Filters

A surge filter shall be supplied and installed on the load side of the surge diverter, and on the line side of sub-circuits supplying electronic equipment and the earth leakage protective devices of switched outlet sub-circuits. Surge filters shall provide finer protection against multiple impulses caused by lightning and other transient disturbances and interferences. The surge filter shall be connected between phase and neutral in accordance with AS 4070.

Surge filters shall:

- a) have a minimum load current rating of 10 A per phase;
- b) have a single shot 8/20 μ s rating of 16 kA per mode and shall be suitably rated to withstand multiple impulses as defined by location category B in AS 1768;
- c) be based upon MOV technology. The line side MOVs shall be internally fused such that they are disconnected if the unit experiences a surge that exceeds its rating;
- d) have visual tags and LED indicating, "power" and "status" for each phase. The power LED shall extinguish when power to the unit is lost. The status visual tags and LEDs shall extinguish when the MOV fuse operates; when power to the unit is lost; or when the unit experiences a thermal overload. In the event of a thermal overload the protection shall remain in circuit;
- e) have a voltage free changeover contact (Alarm output). This shall activate upon any MOV failure, power failure or temperature overload condition. The contact shall be isolated to 4kV to all active circuitry;
- f) be rated for a nominal operating phase voltage of 230 V / 240 V and a maximum operating voltage of at least 275V rms; and
- g) have a let through voltage (Residual Voltage) for a 6kV 1.2/50 μ s, 3 kA 8/20 μ s impulse of less than 600 V when measured at the surge filter terminals.

7.2 Switches and Push Buttons

Control and test switches and push buttons shall comply with AS 60947.5.1.

Switches and push buttons shall have a minimum rating of 6A at 240 Va.c. at utilisation category AC-22 in compliance with AS 3947 Part 1.

Control and test switches shall meet IP56.

Push buttons shall be colour coded according to the following functions:

- a) Start / On / Close: Green;
- b) Stop / Off / Open: Red; and
- c) Reset / Acknowledge: Black.

7.3 Control Relays

Control relays shall be suitable for continuous operation for the application and comply with AS 60947.1. Only one voltage shall be used on the contacts of each relay.

Control relays shall be plug-in type, and be held in the socket base by a captive clip that can be operated without the use of tools.

Contacts shall have a minimum rating of 5A at 240 Va.c. Contacts shall be electrically isolated, double break, silver alloy, non-welding contacts with a duty level of IIIA as specified in AS 2481.

Control relay assemblies shall be provided with a minimum of four contacts, and allow expansion to eight contacts in the same assembly. Contact blocks shall be readily convertible in the field to either normally open or normally closed contacts.

7.4 Time Delay Relays

Time delay relays shall be adjustable over the full timing range and be accurate within 12.5% of the nominal setting.

7.5 Phase Failure Relays

Phase failure relays shall be solid-state with field adjustable trigger level. The sensing circuit shall reject frequencies other than 50 Hz, and be provided with surge filters.

7.6 Power Socket Outlet Panels

A minimum of two (2) proprietary, power socket outlet panels shall be provided in each switchboard enclosure to supply low voltage mains power to equipment that is mounted within the enclosure but not hard-wired. One completely spare socket outlet panel shall be provided. Each power socket outlet panel shall:

- a) be wired to an individual sub-circuit;
- b) provide a minimum of two (2) independently switched socket outlets, arranged so as to allow plug-pack type transformers to be installed in all outlets concurrently;
- c) be mounted so that installed plug-pack type transformers do not interfere with equipment and cabling management system;
- d) be easily accessible from the front of the enclosure (and/or rear of the enclosure where rear access is provided);
- e) be rigidly fixed to prevent it moving when inserting or withdrawing plugs; and
- f) allow any equipment installed within the enclosure to be connected via a power cord with maximum of 1200 mm length.

Double adaptors and power boards without switched socket outlets shall not be used.

8 MINOR SWITCHBOARDS

All parts of the switchboard shall be above the level of the access panel opening, and in any case, shall be at least 300 mm above ground level. Switchboards shall be limited to 5 Rack Units (RU) (approximately 220 mm) in height.

Unless otherwise specified, the switchboard shall incorporate the following:

- a) 1 x Single pole, DIN rail mount, miniature 250 V, 32 A, fused mains isolating switch;
- b) 1 x Single pole, DIN rail mount, 250 V, suitably sized, miniature circuit breaker for the surge diverter;
- c) Surge diverter and surge filter as per Clauses 7.1.2 and 7.1.3;
- d) 1 x 250 V, 10 A feeding remainder of the switchboard;
- e) 2 x 250 V, 6 A miniature ELCB protection for separate cabinet lighting and fan circuits;
- f) 2 x 250 V, 6 A miniature ELCB protection for the socket outlet panels described in Clause 7.6;
- g) Neutral bar and cover (with a capacity suitable for the circuit requirements of the cabinet);
- h) Earth bar (with a capacity suitable for the circuit requirements of the cabinet); and
- i) Earth – Neutral link

Where the switchboard enclosure is contained within a larger, shared enclosure, it shall be mounted in the highest quarter of the enclosure. In such a case it shall have a depth not greater than half that of the larger enclosure, and occupy less than 20% of the larger enclosure.

9 DESIGN AND CONSTRUCTION

9.1 General Design

Switchboards and control panels less than 100 A per phase with the prospective fault current being less than 5kA shall be designed and constructed to the requirements of AS 3000.

Other manufactured switchgear assemblies shall be in compliance with AS 3439.

Unless otherwise specified, the switchboard shall be of type Form 2B as specified in AS 3439.

9.2 External Design

Switchboard enclosures, panels, doors and the like shall be designed and constructed in accordance with AS 3439 to provide the specified segregation and degree of protection.

The specified degree of protection shall be in accordance with AS 60529.

The enclosure shall meet the requirements of MRTS201.

9.2.1 Supporting Structure

Supporting frames shall be fabricated from rolled, cold formed or extruded metal sections with joints fully welded and ground smooth. Concealed fixings or brackets shall be located to allow the assembly to be mounted and fixed in the specified location without the removal of equipment.

9.2.2 Panels

Sheet metal angles, corners and edges shall be machine folded with a minimum return of 25 mm around the edges of front and rear panels, and 13 mm minimum return edge around doors.

Where necessary, panels and doors shall be provided with stiffening to prevent distortion or drumming.

9.2.3 Equipment Fixing

DIN rails and other equipment shall be mounted on equipment mounting panel(s) that are fixed to threaded metal inserts located towards the rear of the enclosure.

9.2.4 Escutcheon Plates

Removable, hinged escutcheon plates with neat cut-outs for circuit breaker handles and the like, shall be provided. The escutcheon plate shall be fitted with lifting handles and captive fixings that can be operated without the use of tools. Sufficient clearance shall be provided around equipment to allow for easy removal of escutcheon plates. Unless otherwise specified, the escutcheon plate shall be transparent.

A continuous support frame shall be provided for the fixing of each escutcheon plate and to prevent panel distortion.

10 INSTALLATION

The installation requirements of MRTS201 apply to this standard.

10.1 Switchboard Enclosure

Switchboards shall be installed in accordance with AS 3000, and be fixed to comply with AS 1170. Switchboards shall be plumb, level and fixed rigidly into position by at least four (4) fixing screws. Masonry anchors shall be used as appropriate.

Floor mounted switchboards shall be mounted on galvanised channel plinths, and fixed to a concrete floor by means of fixing screws at the front and rear, at both ends and at intervals not exceeding 2 m along the length of the enclosure. After levelling, any space under the plinths shall be neatly packed with sand-cement grout.

10.2 Electrics

Fuse-holders shall be arranged such that the fuse may be extracted directly towards maintenance personnel and not towards live parts.

Circuit breakers shall be arranged so that the breaker operation status and current rating indications are clearly visible while the switchboard panel cover or escutcheon is in position.

Where a preformed switchboard enclosure is used, it shall be capable of housing single, double, or triple width MCB's and their related preformed busbars. Proprietary pole fillers shall be provided in all unused portions of the clip tray switchboard enclosure.

11 TESTING AND COMMISSIONING

11.1 General

The testing and commissioning requirements defined in MRTS201 apply to this standard. The minimum additional testing and commissioning requirements for equipment provided under this standard are described below.

11.2 Type Tests

Type tests shall be in compliance with AS 3439. A summarised version of a "Certificate of Verifications and Tests" that complies with AS 3439 shall be provided that states: **Witness Point**

- a) testing authority;

- b) manufacturer;
- c) details of test parameters; and
- d) test results for each test.

Documentation shall be provided to verify that the tests were carried out on a switchboard of essentially identical design to that provided. The manufacturer shall hold available certificates of type tests that evidence of compliance with AS 3439 Part 1, together with detailed particulars of the equipment as tested and a record of any alterations that have been made to the equipment subsequent to the type test.

11.3 Type Acceptance Test

If certificates of type tests are not available for a switchboard of identical design to that specified, available certificates and other evidence to AS 3000 guidelines, in support of the design and acceptance of untested assemblies shall be provided.

11.4 Routine Tests

Routine tests specified in AS 3439 shall be performed as part of the FAT and CAT. The “electrical function” test shall utilise simulated circuits and equipment at the Factory, and be repeated after connection of permanent wiring and equipment on Site.

12 DOCUMENTATION

The documentation requirements defined in MRTS201 apply to this standard.

13 MAINTENANCE

The maintenance requirements defined in MRTS201 apply to this standard.

14 TRAINING

The training requirements defined in MRTS201 apply to this standard.

15 HANDOVER

The Handover requirements defined in MRTS201 apply to this standard.

In addition, as a minimum, the text for circuit schedule cards shall be provided electronically to allow the Principal to further update the schedules as circuits change after the end of the maintenance period.