

Assets Planning and Delivery Group

Engineering

DESIGN STANDARD DS 26-09

Type Specifications – Electrical

**Type Specification for Low Voltage Switchboards – General Requirements**

VERSION 3

REVISION 3

SEPTEMBER 2024

**FOREWORD**

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

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[Overview of Western Australia’s Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)](https://www.dmirs.wa.gov.au/sites/default/files/atoms/files/overview_general_regulations.pdf)

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**Head of Engineering**

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**REVISION STATUS**

**The revision status of this standard is shown section by section below:**

| **REVISION STATUS** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SECT.** | **VER/REV.** | **DATE** | | **PAGES REVISED** | **REVISION DESCRIPTION**  **(Section, Clause, Sub-Clause)** | | **RVWD.** | | **APPRV.** |
| **1** | | **0/0** | **01.0801** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **1** | | **1/0** | **27.02.04** | **All** | | | **Sections split, 1.1.8, 1.3.1 general revision** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **7** | | | **1.2.1 includes para 2&3** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **8** | | | **1.2.5 (b)&(c) updated, (f) included** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **9** | | | **1.2.7 clause reference updated** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **10-11** | | | **1.3.6, 1.3.7 new tables** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **11** | | | **1.3.8 ‘intrinsically safe earth’ included** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **12** | | | **1.3.11 new first paragraph** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **12** | | | **1.3.13 1st & 2nd para updated** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **13** | | | **1.3.14 (a) updated** | **NHJ** | **AAK** | |
| **1** | | **1/1** | **30.06.04** | **15** | | | **1.3.20, 1.3.21 new clause** | **NHJ** | **AAK** | |
| **1** | | **1/ 2** | **30.09.04** | **7** | | | **1.2.1 revised** | **NHJ** | **AAK** | |
| **1** | | **1/ 2** | **30.09.04** | **8** | | | **1.2.6-1.2.8 revised** | **NHJ** | **AAK** | |
| **1** | | **1/ 2** | **30.09.04** | **13** | | | **1.3.17 revised** | **NHJ** | **AAK** | |
| **1** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
| **1** | | **2/1** | **30.09.05** | **1** | | | **1.2 & TTRS revised, 1.4 added** | **NHJ** | **AAK** | |
| **1** | | **2/3** | **02.06.09** | **7** | | | **1.2 revised** | **NHJ** | **AAK** | |
| **1** | | **2/4** | **30.08.11** | **8** | | | **1.2 revised** | **NHJ** | **AAK** | |
| **1** | | **3/2** | **30.06.22** | **9** | | | **1.2 revised** | **SWG** | **EDG** | |
| **1** | | **3/3** | **06.09.24** | **9-10** | | | **1.2 revised** | **EdG** | **EdG** | |
|  | |  |  |  | | |  |  |  | |
| **2** | | **0/0** | **01.8.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **2** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
| **2** | | **3/0** | **21.09.16** | **10** | | | **2.3 revised** | **NHJ** | **MSP** | |
|  | |  |  |  | | |  |  |  | |
| **3** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **3** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
| **3** | | **2/2** | **30.06.06** | **8** | | | **3.1.4, 3.3 revised** | **NHJ** | **AAK** | |
| **3** | | **2/2** | **30.06.06** | **9** | | | **3.4 revised** | **NHJ** | **AAK** | |
| **3** | | **2/4** | **30.08.11** | **11** | | | **3.5 revised** | **NHJ** | **AAK** | |
| **3** | | **3/0** | **21.09.16** | **11-12** | | | **3.1.4 and 3.5 revised** | **NHJ** | **MSP** | |
| **3** | | **3/2** | **30.06.22** | **10** | | | **3.1.4 revised** | **SWG** | **EDG** | |
|  | |  |  |  | | |  |  |  | |
| **4** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **4** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
| **4** | | **2/2** | **30.06.06** | **10** | | | **4.3, 5.1, 5.2 revised** | **NHJ** | **AAK** | |
|  | |  |  |  | | |  |  |  | |
| **5** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **5** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
|  | |  |  |  | | |  |  |  | |
| **6** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **6** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
| **6** | | **2/2** | **30.06.06** | **11** | | | **6.2, 6.4 revised** | **NHJ** | **AAK** | |
| **6** | | **2/2** | **30.06.06** | **12** | | | **6.5 revised** | **NHJ** | **AAK** | |
| **6** | | **3/0** | **21.09.16** | **16** | | | **6.1, 6.2 and 6.3 revised** | **NHJ** | **MSP** | |
|  | |  |  |  | | |  |  |  | |
| **7** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **7** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
|  | |  |  |  | | |  |  |  | |
| **8** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **8** | | **2/0** | **23.05.05** | **All** | | | **Entire document revised** | **NHJ** | **AAK** | |
| **8** | | **2/3** | **02.06.09** | **12** | | | **8.1 revised** | **NHJ** | **AAK** | |
| **8** | | **2/3** | **02.06.09** | **13** | | | **8.3 revised** | **NHJ** | **AAK** | |
| **8** | | **2/2** | **30.06.06** | **13** | | | **8.2 revised** | **NHJ** | **AAK** | |
| **8** | | **2/4** | **30.08.11** | **19** | | | **8.3 revised** | **NHJ** | **AAK** | |
| **8** | | **3/0** | **21.09.16** | **19-20** | | | **8.1, 8.2 and 8.3 revised** | **NHJ** | **MSP** | |
| **8** | | **3/2** | **30.06.22** | **15-16** | | | **8.1 and 8.3 revised** | **SWG** | **EDG** | |
|  | |  |  |  | | |  |  |  | |
| **9** | | **0/0** | **01.08.01** | **All** | | | **New Edition** | **NHJ** | **AAK** | |
| **9** | **2/0** | **23.05.05** | | **All** | **Entire document revised** | | **NHJ** | **AAK** | |
| **9** | **0/1** | **18.09.01** | | **1** | **9.1.2 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/1** | **18.09.01** | | **4** | **9.2.6(d) labelled** | | **NHJ** | | **AAK** |
| **9** | **0/1** | **18.09.01** | | **7** | **9.3.8 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/1** | **18.09.01** | | **8** | **9.3.14,9.3.16 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/1** | **18.09.01** | | **9** | **9.3.16 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/2** | **12.03.02** | | **7** | **9.3.8 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/3** | **30.10.02** | | **1** | **9.1.2 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/3** | **18.09.01** | | **7** | **9.3.8 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/4** | **01.09.03** | | **3** | **9.2.6 general revision** | | **NHJ** | | **AAK** |
| **9** | **0/4** | **01.09.03** | | **4** | **9.3.1(a), (c) general revision** | | **NHJ** | | **AAK** |
| **9** | **0/4** | **01.09.03** | | **9** | **9.3.21 general revision** | | **NHJ** | | **AAK** |
| **9** | **3/0** | **21.09.16** | | **21** | **9.1 and 9.2 revised** | | **NHJ** | | **MSP** |
| **9** | **3/2** | **30.06.22** | | **17-18** | **9.8 revised** | | **SWG** | | **EDG** |
|  |  |  | |  |  | |  | |  |
| **10** | **0/0** | **01.08.01** | | **All** | **New Edition** | | **NHJ** | | **AAK** |
| **10** | **2/0** | **23.05.05** | | **All** | **Entire document revised** | | **NHJ** | | **AAK** |
| **10** | **2/2** | **30.06.06** | | **16** | **10.3 revised** | | **NHJ** | | **AAK** |
| **10** | **3/0** | **21.09.16** | | **24-25** | **10.3 and 10.4 revised** | | **NHJ** | | **MSP** |
| **10** | **3/1** | **09.03.17** | |  | **10.3 and 10.4 revised** | | **NHJ** | | **MSP** |
| **10** | **3/2** | **30.06.22** | | **19-22** | **10.3 and 10.4.4 revised** | | **SWG** | | **EDG** |
|  |  |  | |  |  | |  | |  |
| **11** | **0/0** | **01.08.01** | | **All** | **New Edition** | | **NHJ** | | **AAK** |
| **11** | **2/0** | **23.05.05** | | **All** | **Entire document revised** | | **NHJ** | | **AAK** |
| **11** | **2/3** | **02.06.09** | | **17** | **11.1, 11.2 revised** | | **NHJ** | | **AAK** |
| **11** | **3/0** | **21.09.16** | | **26** | **11.1 and 11.2 revised** | | **NHJ** | | **MSP** |
|  |  |  | |  |  | |  | |  |
| **12** | **0/0** | **01.08.01** | | **All** | **New Edition** | | **NHJ** | | **AAK** |
| **12** | **2/0** | **23.05.05** | | **All** | **Entire document revised** | | **NHJ** | | **AAK** |
| **12** | **2/2** | **30.06.06** | | **17** | **12 revised** | | **NHJ** | | **AAK** |
| **12** | **2/4** | **30.08.11** | | **26** | **12 revised** | | **NHJ** | | **AAK** |
| **12** | **3/0** | **21.09.16** | | **27** | **12 revised** | | **NHJ** | | **MSP** |
| **12** | **3/2** | **30.06.22** | | **23** | **12 revised** | | **SWG** | | **EDG** |
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DESIGN STANDARD DS 26-09

**Type Specifications – Electrical**

**Type Specification for Low Voltage Switchboards – General Requirements**

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# GENERAL

## Scope

This Specification covers the general requirements for the construction of Low Voltage electrical switchboards and similar cubicle type enclosures containing electrical power equipment.

## Standards

The workmanship, equipment and materials provided in accordance with this Specification shall comply in design, construction, rating, and performance with the current relevant Australian Standards Codes. In their absence compliance shall be with the relevant British Standards together with the requirements of competent Authorities having jurisdiction over all or any part of the design, manufacture, installation, and operation of the equipment.

All equipment shall comply with the relevant requirements of the following Australian Standards and British Standards unless specified otherwise herein. The latest published revision of each standard shall apply.

|  |  |
| --- | --- |
| 1. AS 1192 | Chromate Conversion Coating – Zinc and Cadmium |
| 1. AS 1627.5 | Metal Finishing – Preparation and Pre-treatment of Metal Surfaces |
| 1. AS 1789 | Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process) |
| 1. AS 1897 | Electroplated Coating on Threaded Components |
| 1. AS 2312.1 | Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings |
| 1. AS 2700 | Colour Standard for General Purposes |
| 1. AS/NZS 3000 | Electrical Installations (Wiring Rules) |
| 1. AS/NZS 4506 | Metal Finishing – Thermoset Powder Coatings |
| 1. ISO 9223 | Corrosion of metals and alloys Corrosivity of atmospheres Classification, determination, and estimation |

## 

## Safety Requirements

All electrical work shall be performed by appropriately qualified and experienced personnel who shall hold a current electrical worker’s license to perform such work.

# CONFORMANCE TO DRAWINGS

## Tolerances

Tolerances on lineal dimensions are generally shown on the Drawings. Where not shown on the Drawings, tolerances on lineal dimensions shall be + 1 mm.

## Equipment Setting

Equipment settings shall be as shown on the Drawings.

## Labelling

Equipment including terminals shall be labelled clearly as shown on the Drawings. Labels shall not be fitted to removable covers or to the removable portion of plug-in equipment but shall be fitted to the area immediately below the equipment to be identified unless otherwise specified. Labels shall be secured with either electro-plated self-tapping screws, or with Scotch Mount 4032 Double Coated Foam Tape, as appropriate.

# DETAIL DESIGN

## Arrangement

### Access for Maintenance

Where the Drawings do not precisely define the arrangement of equipment and/or the positioning of cabling, such arrangement and positioning shall be made so as to permit ready access to equipment during maintenance.

### Access for Cable Terminations

The switchboard arrangement shall be such that access to terminations of external cables is via the same access opening as provides access to external cable entries into the switchboard.

### Location of Surge Diverters

Surge diverters shall be installed so that the total conductor length from the associated phase connection to the associated protective earth connection is less than 1.0 metres.

### Surge Diverters

Surge diverters shall conform to Water Corporation Type Specification DS26.32. Surge diverters shall be protected as per MN and LX series of Drawings.

## Location of Controls

All operator control devices including operating handles, control switches, indicators and meters shall be located no more than 1.8 metres and not less than 0.3 metres above floor level. The location of meters, secondary indicators, fault relays, etc. in a panel separate from the associated main switchboard panel shall be permitted provided that control switches and on-off indicators are mounted on the main switchboard panel with which these are associated.

## Keys

Switchboards of a type tested design, shall be fitted with door locks of the same make and model as those which were fitted to the type tested sample switchboard.

Access to live parts via switchboard doors shall be controlled by the Water Corporation Standard EL2 or equivalent key as per LX series of drawings.

Such access shall be controlled either by the switchboard doors being fitted with locks matched to the above Water Corporation key, or by providing a key interchange box between the above Water Corporation key and the switchboard door key.

## Thermal Derating of Equipment

1. Under maximum ambient and operating conditions, the air temperature rise within switchboard compartments due to equipment losses shall not be such that the maximum ambient temperature rating of any equipment within any particular compartment is exceeded.
2. The maximum ambient air temperature outside switchboards installed in the South West Region of Western Australia shall be taken to be 45 deg. Cwhether the switchboard is to be installed indoors or outdoors.
3. The maximum ambient air temperature outside switchboards installed in the regions of Western Australia other than the South-West Region shall be taken to be 50 deg Cwhether the switchboard is to be installed indoors or outdoors.
4. For outdoor switchboards an additional air temperature rise of 5 deg Cshall be allowed for solar heating.
5. Preferably electromechanical switchgear shall be derated in accordance with the manufacturer’s derating formulae. In the absence of such formulae, electromechanical switchgear shall be derated to 88% of its 35 deg. C rating for an equipment operating ambient temperature of 50 deg. C and to 79% of its 35 deg. Crating for an equipment operating ambient temperature of 60 deg. C.
6. Preferably solid-state power equipment shall be derated in accordance with the manufacturer’s derating formulae. In the absence of such formulae, solid state power equipment shall be derated to 77% of its 35 deg Crating for an equipment operating ambient temperature of 50 deg Cand to 63% of its 35 deg Crating for an equipment operating ambient temperature of 60 deg C.

## Equipment Short Circuit Protection Co-ordination

Equipment selection shall be such that short circuit protection coordination shall be provided between all contactors and overload relays and their associated short circuit protection devices. Such coordination shall be in accordance with the requirements of AS/NZS IEC 60947.4.1 for Type 2 Coordination.

## Short Circuit Protection of Cable Droppers

Cables connecting busbars to circuit fuses or circuit breakers shall be provided with short circuit protection by fault Current limiters on or near the busbars. Such cables shall have a continuous Current rating not less than the continuous Current rating of the circuit protective devices in accordance with the requirements of AS/NZS 3000.

Current limiting fuses shall be sized to grade with the associated circuit protective device and with the main circuit breaker. In any case Current limiter fuse sizes shall not be greater than the values shown hereunder.

Cable tails connecting busbars to the line side of Current limiters shall be double insulated, not more than 500 mm long and have a conductor cross-sectional area not less than 4 mm2.

|  |  |
| --- | --- |
| **Cable Size**  **mm²** | **Maximum Current Limiter**  **Rated Amp** |
| 1.5 | 40 |
| 2.5 | 63 |
| 4 | 100 |
| 6 | 160 |
| 10 | 250 |
| 16 | 400 |

# GENERAL CONSTRUCTION

## Fixings and Supports

All fixings and support necessary to support or hold equipment in place shall be supplied and installed by the Contractor.

## Miscellaneous Fittings

All threaded components, including metal threads, screws and bolts used throughout the electrical equipment cubicle shall be stainless steel; or non-ferrous metal; or nickel chromium electroplated steel to AS 1192; or zinc electroplated steel to AS 1897 and AS 1789, colour yellow iridescent, chromate conversion coating type C.

All saddles, clamps and miscellaneous fastenings shall be non-ferrous metal, stainless steel, zinc plated steel, nylon or P.V.C. Except where specified otherwise, adhesive fixings shall not be used.

## Silicone Based Components

Unless specified otherwise on the Drawings, greases, jellies and/or sealing compounds which include silicone-based compounds shall not be used inside switchboard enclosures.

# METALWORK CONSTRUCTION

## Cubicle Metals

All steel, stainless steel and aluminium sheet used in the construction of switchboard cubicles and panels shall be clean furniture grade.

Aluminium sheet thickness shall be not less than 3mm.

Steel and stainless-steel sheet thickness shall be not less than 2 mm for doors, hinged panels and equipment mounting panels, and shall not be less than 1.2 mm elsewhere.

## Adjacent Dissimilar Metals

Where dissimilar metals are positioned adjacent to one another, bimetallic corrosion shall be prevented by the use of metallic plating or by other approved methods.

Screws and bolts penetrating external aluminium surfaces shall be stainless steel, as shall be any associated nuts and any associated external or internal washers.

Screws, bolts, and washers in contact with internal aluminium surfaces shall be stainless steel or shall be nickel, chromium, or passivated zinc plated steel.

## Additional Supports

Sufficient bracing shall be provided to doors and panels to ensure that the equipment mounted thereon is supported properly.

Where doors and panels are weakened by drilling or cutting during construction of the switchboard, such sections shall be reinforced by additional bracing.

## Welding

All butt joints shall be fully seal welded and all such welds shall be ground flush and smoothed.

# PROTECTIVE COATINGS

## Paint Coatings for Steel

The paint system to be used for steel shall be as hereunder.

1. All surface visible rust, scale and other foreign matter shall be removed completely in accordance with AS 1627.5 so that the surface is suitable for the application of a gloss finish. All cleaning solutions shall be removed completely by thorough rinsing.
2. Immediately prior to priming, all surfaces shall be solvent wiped to remove any handling grime.
3. A gloss paint system providing medium term protection in accordance with AS 2312.1 to ISO 9223 Cat. 3 (industrial and marine) environments shall be applied.

All paint used in the paint system shall be from the same manufacturer who shall certify their compatibility

## Powder Coatings for Steel

Powder coatings shall not be used on bare steel. Powder coatings shall not be used on zinc (or zinc alloy) coated steel on which the coating has been damaged by welding or any other means. Powder coatings shall be applied to zinc (or zinc alloy) coated steel and shall be gloss thermoset powder coating in accordance with AS/NZS 4506 Cat 5 employing a chromate or zinc phosphate pre-treatment and resulting in a powder coating DFT of not less than 60 μm.

## Protective Coatings for Aluminium

The protective coating system to be used for aluminium shall be a paint system as described in clause 6.1 (b) to 6.1 (c) or shall be gloss thermoset powder coating in accordance with AS/NZS 4506 Cat. 5 employing a chromate or chrome phosphate pre-treatment and resulting in a powder coating DFT of not less than 60 μm.

## Protective Coating Colours

1. In order to minimize heating of the enclosed electrical equipment due to solar radiation, cubicles to be installed outdoors shall be painted or powder coated gloss white externally.
2. On steel cubicles which are to be installed indoors, external panels and doors shall be painted, or powder coated a light blue grey gloss colour both inside and out. The preferred colour shall be Storm Grey (N42) to AS 2700. Except as specified hereunder, other internal surfaces of steel cubicles shall be painted gloss white.
3. Galvanized steel panels inside cubicles may remain unpainted.
4. Stainless steel panels inside cubicles shall remain unpainted.
5. Aluminium cubicles are to remain unpainted internally except that anodizing shall be permitted.

## External Fittings

On switchboards which are to be installed outdoors, the mating surfaces between the external protective coating and fittings such as hinge blocks, locks, bolt heads, washers, etc shall be separated by suitable non-metallic gaskets.

Switchboards which are to be installed outdoors shall be designed and constructed so as to minimise the number of penetrations of the external surfaces.

# CONDUCTOR MATERIAL

Busbar and cable conductors used for interconnections within switchboards shall be copper. If a switchboard is to be located in a corrosive environment, such as a sewerage pump station or a sewerage treatment plant, busbars shall be tin plated.

# CABLES

## Cable Colour Coding

As required by AS/NZS 61439.1 all conductors shall be identified by either colour coding or symbols.

If identification of conductors is to be by colour coding, the colour coding system used throughout the whole switchboard shall be in accordance with the following colour coding system:

Red Phase Red

White Phase White

Blue Phase Blue (Bright Blue to AS 2700)

A.C. Neutral Black

Earth Green/Yellow

Instrumentation Analogue Current Signals Orange

Instrumentation Analogue Voltage Signals Orange

DC positive (not earthed) Red

DC zero rail (i.e. the earthed rail) Black

DC negative (not earthed) Blue (Bright Blue to AS 2700)

AC Control Switchwires Brown

DC Control Switchwires Red/White Stripe

Miscellaneous Brown

Where a special proprietary cable having a non-conforming colour coding system is required to be used, cable terminations shall be fitted with coloured sleeving in accordance with the above colour coding system.

## Power Interconnecting Cables

Power cables and flexible insulated busbars interconnecting switchgear mounted within switchboards shall be insulated single core copper conductor type with thermoplastic, elastomer, or XLPE insulation having a Voltage rating of not less than 0.6/1 kV.

All such cables and flexible insulated busbars shall have a site Current rating not less than the onsite Current rating of the equipment to which these cables are connected.

At the site rated Current, the temperature of the above conductors and the associated switchgear terminals shall not exceed the normal use operating temperature of the associated insulation, or the permissible maximum operating temperature of the associated switchgear terminals, whichever is the least.

The permissible maximum operating temperature of such switchgear terminals shall be taken to be:

(a) 105 deg. Cfor silver or nickel plated copper or brass terminals

(b) 100 deg. Cfor tin plated copper or brass terminals

(c) 100 deg. Cfor bare brass terminals

(d) 95 deg. C bare copper terminals

Regardless of length, all such power cables shall have short circuit ratings not less than the energy let through (I2t) of the line side short circuit protective device.

## Light Current Cables

Control and instrumentation cables, interconnecting equipment mounted within the switchboard shall be as tabulated hereunder:

|  |  |
| --- | --- |
| **Application** | **Cable Type** |
| Supply Authority CT secondary cable, CT to test links | 7/0.85 (4 mm2) 1 core PVC 0.6/1.0kV |
| Other CT secondary cable | 50/0.25 (2.5 mm2) 1 core PVC 0.6/1.0kV |
| Supply Authority metering potential circuits | 7/0.67 (2.5 mm2) 1 core PVC 0.6/1.0kV |
| Other metering potential circuits, within cubicles | 30/0.25 (1.5 mm2) 1 core PVC 0.6/1.0kV |
| Cubicle control wiring with 6A fuse max. | 24/0.2 (0.75 mm2) 1 core PVC 0.6/1.0kV |
| Cubicle control wiring with 16A fuse max. | 30/0.25 (1.5 mm2) 1 core PVC 0.6/1.0kV |
| PLC/RTU digital I/O circuits at 24 VDC 3 A fuse max. | 16/0.2 (0.5 mm2) 1 core PVC 110 V/110 V |
| PLC/RTU digital I/O circuits at 24 VDC with 1 A fuse max. | 7/0.2 (0.2 mm2) 1 core PVC 110 V /110 V |
| 4/20 mA Signal Cable | 16/0.2 (0.5 mm 2) 1 core PVC 110 V/110 V |
| Instrumentation Signal Cable – screened (including circuits to CMOS based electronic equipment which does not have I/O isolation) | Olex Dekoron Instrumentation Cable  7/0.50 (1.5 mm2) single pair/triad, overall screened. 7/0.32 (0.5 mm2) multiple pairs, element ad overall screened, 110 V AC/150 V DC. |
| Ribbon cables for data highways etc | In accordance with PLC manufacturer’s recommendations. |

Conductors in control and instrumentation cables not greater than 1.5 mm2 shall be tinned, if possible.

## Earthing Cables

Earthing cables within switchboards shall be PVC insulated single core cables sized to suit application.

# CABLE INSTALLATION

## Cable Terminations

Except for signal cables having special screening requirements all incoming signal cables and Intrinsically Safe system cables shall be terminated in rail mounted terminals. Sufficient rail space shall be provided for 20% spare terminals so as to provide facilities for terminating incoming cable spare cores.

All conductors shall be terminated in a manner appropriate to the type of terminal to which the conductor is to be connected.

Cables terminating at stud or screw type terminals shall be fitted with crimp type ring type terminations.

Flexible conductors shall be terminated with crimp type appropriate to the terminals on which the conductor is to be terminated.

No more than two conductors shall be terminated into the same side of a rail mounted terminal. If two conductors are to be terminated into one side of a rail mounted terminal each conductor shall be terminated with a crimp type flat blade termination. Alternatively, the use of double conductor crimp type terminations shall be permitted for flexible conductors ≥ 1.5 mm2 where such bridging is necessary.

## Gland Plates for External Cables

Removable nonferrous gland plates shall be provided for all incoming cables.

## Fuse Wiring

Upper terminals of conventional fuses shall be wired to the line side of the respective circuit. Similarly, the central contact terminal of co-axial fuses shall be wired to the line side of the respective circuit.

## Cable Markers

Control wires shall be fitted with Grafoplast or Critchley type cable markers at each end. Cable marker numbers shall correspond with those numbers as shown on the Drawings.

## Protection of Cable Insulation

Further to the requirements of AS/NZS 3000, wherever practical, appropriate grommets or glands shall be used to protect cable insulation where such cables pass through holes in panels or cubicles. Such devices shall be selected so as not to reduce the required IP rating of the cubicle.

## Cable Joints

Mid-run cable connections or straight-through cable joints shall not be used.

## Support of Electrical Equipment Cubicle Wiring

Electrical equipment cubicle wiring shall be neatly grouped and harnessed or, where practical enclosed in PVC trunking. Unless otherwise specified, such trunking shall be of the slotted duct type. Any Intrinsically Safe system wiring shall be run in separate blue coloured trunking. Blue coloured trunking shall not be used for any other purpose.

Wiring shall be straight and run parallel when in cable trunking. A minimum clearance of 50 mm shall be maintained between terminals and associated cable trunking. When not run in cable trunking, spiral band lacing and/or cable ties shall be used to form the looms. Looms shall be installed square with the cubicle and frequently supported.

Wiring, wiring looms and cable trunking shall be arranged so that, as far as is practical, equipment labels and/or terminal markings are not obscured.

Cable looms connecting hinged panels shall be supported either side of the hinge, and the loom arranged between such supports in a generous loop so as to prevent cable strain when the hinged panel is moved.

## Cable Screening and Segregation

1. Intrinsically Safe system wiring shall be loomed separately from other signal wiring and from power wiring with the Intrinsically Safe looms positioned as far away from the other looms as is practical. Similarly, field wiring connection terminals for Intrinsically Safe wiring shall be grouped separately from other wiring connection terminals.
2. To the extent that is practical, signal cables including electronic instrumentation analogue signal cables and telemetry PLC/RTU Extra Low Voltage digital I/O cables, shall be loomed and terminated separately from mains Voltage cables.
3. Provided that the cable terminations available include facilities for earthing cable screens, all serial communication links shall be run in screened cable with the screen earthed at each termination, so as to minimise the rise of fast transient/burst interference caused by switching of inductive loads within the switchboard.

If the cable termination at the communications port of a particular piece of equipment is unsuitable for earthing screened cable, sufficient ferrite cores shall be fitted on the communications cable immediately adjacent to the communications port such that the communications input port effective transient/burst immunity level is not less than Level 3 to AS/NZS IEC 61000-4-4.

1. All H.F. communication circuits shall be run in screened cable with the screen earthed at each termination.
2. To the extent that it is practical, 4/20 mA analogue signal cables shall be kept 150 mm clear of 70 Amp conductors, 300 mm clear of 150 Amp conductors, and 600 mm clear of 300 Amp conductors.
3. Except where shown otherwise on the Drawings, low impedance signal cables (e.g. 4/20 mA circuits and RTD circuits) shall be unscreened within the switchboard.
4. High impedance analogue signals shall be run in screened cable with the screen earthed at each termination.

## Cable Crimping

Wherever crimping is necessary, compression tools recommended by the manufacturer of the crimp type terminals shall be used. Where hand operated, the tools shall be of the type which will not release until full compression is applied. Hexagonal crimping dies shall be used on conductors of 70 mm2 cross section and above.

# BUSBARS

## Arrangement of Cable Main Connections to Equipment

Unless otherwise shown on the Drawings, equipment cable main connections which are substantially in one plane, shall be arranged in the order Red-White-Blue as follows:

1. When the run of terminals is vertical, Red shall be top.
2. When the run of terminals is horizontal, Red shall be left or farthest away as viewed from the front of the particular item of equipment to which connection is being made.

## Arrangement of Busbars

Unless otherwise shown on the Drawings, busbars which are substantially in one plane shall be arranged in the order Red-White-Blue as follows:

1. When the run of busbars is horizontal, Red shall be top, or to the left, or farthest away as viewed from the front of the electrical equipment cubicle.
2. When the run of busbars is vertical, the Red shall be left or farthest away as viewed from the front of the switchboard cubicle.
3. When the neutral busbar is in the same plane as the phase busbars, the neutral shall occupy an outer position, and shall be readily distinguishable from phase busbars.

## Continuous Current Rating of Busbars

1. Busbars shall be sized such that the busbar on site maximum operating temperature does not exceed whichever is the least of the following:

(i) 90 deg. C for bare copper conductors

(ii) 105 deg. C for tin or silver plated copper conductors

(iii) The maximum temperature rating of the cables or equipment connected to the busbars

1. With an ambient temperature of 35 deg C full load temperature rise adjacent to Current transformers mounted in the busbar chamber shall not be more than 60 deg C, or the Current transformer maximum ambient temperature rating, whichever is the least.
2. The continuous rating of the main busbars shall be not less than the maximum continuous rating of the incoming circuit breaker(s) or main fuses.
3. All busbar droppers shall be rated to withstand without damage the short time withstand Current specified for the whole switchboard.
4. Busbar droppers to major outgoing circuits shall have a rating not less than 120 % rating of the outgoing circuit.
5. In the case of motor control centre type switchboards, the busbar droppers to equipment stacks shall have a rating not less than 120 % of the rating of the stack when fully equipped.
6. Generally major switchboards will be specified to require busbar ratings to be verified by comparison with a tested reference design in accordance with AS/NZS 61439.1. In such cases original manufacturer certified test certificates shall be provided specifying the following in respect to all sub-assemblies tested:

(i) Test Current

(ii) Ambient temperature external to the switchboard

(iii) Busbar maximum temperature overall

(iv) Busbar maximum temperature at directly connected switchgear terminals

1. If the busbar system design is to be verified by testing, such testing shall be carried out on the busbar system to be supplied under the Contract or on a busbar system of a suitable reference design so as to allow verification of temperature rise by the verification comparison method in accordance with AS/NZS 61439.1.

Where busbar temperature rise tests have been carried out on non-ventilated switchboards with a final test busbar temperature different from the specified final busbar temperature, the busbar Current rating at the specified final busbar temperature shall be determined on the following basis:

Tbras = Tbs - Tas

Tbrat = Tbt - Tat

Is = It \* [Tbras 0.62 \* (1+0.004 \* Tbrat)0.5] / [Tbrat 0.62 \* (1+0.004 \* Tbras)0.5]

Where:

Is = busbar Current rating at specified temperature rise, Amp

It = test busbar Current at test temperature rise, Amp

Tbras = busbar temperature rise above external ambient under specified conditions, deg C

Tbrat = busbar temperature rise above external ambient under test conditions, deg C

Tbs = specified busbar final temperature, deg C

Tas = specified ambient temperature outside the switchboard, deg C

Tat = test ambient temperature outside switchboard, deg C

Tbt = test busbar hot stop final temperature, deg C

For ventilated switchboards, the 0.62 exponent in the above formula shall be replaced with 0.64.

1. In instances where only independently verified summary test certificates are available (i.e. independently verified documented temperature test results are not available), it shall be assumed that the test temperature rises were the maximum allowed under standard AS/NZS 61439.1 as applicable.
2. In cases where the verification of busbar Current ratings by calculation is permitted, the busbar continuous Current ratings shall be determined in accordance with Tables N.1 and N.2 of AS/NZS 61439.1 on the basis of an ambient temperature in the busbar chamber of 60 deg C and a maximum conductor temperature of 90 deg C.

Since values shown in Table N1 of AS/NZS 61439.1 are for busbars mounted on edge, busbars mounted with the largest face horizontal shall be de-rated to 9 % below the values determined from Tables N.1 and N.2 of AS/NZS 61439.1.

## Busbar Joints

### General

1. The design of busbar joints that are to be verified by testing or by comparison with a tested design shall be the prerogative of the Contractor provided that joint efficiencies of 100 % are achieved.
2. If Belleville washers are to be used in design and verification of busbar joints to be verified by testing, the design of the busbar joints shall comply with the requirements of clauses 10.4.2 and 10.4.3 hereunder.
3. Busbar joints the design of which is to be verified by calculation shall employ Belleville washers and shall comply with the requirements of clauses 10.4.2 and 10.4.4 hereunder.

### Belleville Washers

1. Busbar joints shall be made with metric fine or U.N.F. high tensile steel bolts fitted with a Belleville washer under each associated nut.
2. Belleville washers shall be of a type intended specifically for use in copper busbar joints.
3. For busbar joints < 40 mm thick the Belleville washer rated deflection shall be > 0.3 mm and for busbar joints > 40 mm < 80 mm thick the Belleville washer rated deflection shall be > 0.4 mm.
4. For busbar joints > 80 mm < 160 mm thick a Belleville washer with a rated deflection of > 0.4 mm shall be fitted under both the bolt head and the bolt nut in series mode.
5. Belleville washers shall be installed so that the convex side of each Belleville washer is furthest from the busbar surface.
6. A flat steel washer shall be installed on each busbar joint bolt on either side of the busbar. These washers shall be installed immediately adjacent to the busbar surface (i.e. Belleville washers shall not be installed in direct contact with the busbar).

The outside diameter and thickness of such flat washers shall not be less than the outside diameter and thickness of the associated Belleville washer(s).

1. Busbar joint bolts shall be tightened during switchboard manufacture until each associated Belleville washer is only just flat and shall be left at these torque settings.

The point at which the Belleville washer is just flat shall be detected by an abrupt increase in spanner torque, or by the measured tightening torque reaching the Belleville washer rated torque, whichever occurs first.

1. The rated load to flat force of each Belleville washer shall be such as to provide the required joint contact pressure or 6.9 MPa (1000 Psi), whichever is the greater. [The joint contact pressure need not be more than 17.2 MPa (2500 Psi)].

### Verification by Testing

The temperature of joints in busbars the Current rating of which is to be verified by testing shall be monitored during such tests so as to verify that the temperature of all busbar joints at rated full load Current remains not more than the specified maximum allowable busbar temperature.

### Verification by Calculation

1. Edge to flat busbar joints shall not be permitted in the design of a busbar system which is to be verified by calculation.
2. Joints in busbars not less than 38 mm wide, the Current rating of which is to be verified by calculation, shall have a joint efficiency of not less than 100 % as defined by the Copper for Busbars handbook published by the Copper Development Association and as described further hereunder.
3. The busbar joint efficiency depends on contact pressure, busbar thickness and joint overlap. Hence, for flat to flat contact over the full width of the busbar, values of contact pressure and overlap length selected from the following table will satisfy the requirements of sub-clause 10.4.2 (a) above.

|  |  |  |
| --- | --- | --- |
| **Busbar thickness (mm)** | **Contact pressure (MPa)** | **Minimum overlap (mm)** |
| 6 or 6.35 | > 17.2 | 38 |
| 6 or 6.35 | < 17.2, > 13.8 | 50 |
| 6 or 6.35 | < 13.8, > 6.9 | 64 |
| 9.5 or 10 | > 17.2 | 50 |
| 9.5 or 10 | < 17.2, > 13.8 | 64 |
| 9.5 or 10 | < 13.8, > 6.9 | 75 |

1. The contact pressure shall be calculated as follows:

Pc = 0.95 \* Nb \* Fw / Aj

Where:

Pc = contact pressure

Nb = number of bolts in the joint

Fw = Belleville washer load to flat

Aj = contact area of the joint

### Access to Busbar Joints

1. Switchboards shall not require substantial dismantling in order to gain access to busbar joints. The level of access to be provided to busbar joints shall be one of the following as shown on the Drawings.

(i) Grade 1 accessible by opening access doors or removing cover plates

only

(ii) Grade 2 accessible by removing cover plates and a limited amount of

external cabling

(iii) Grade 3 accessible by removing cover plates and a limited amount of

switchboard equipment

(iv) Grade 4 accessible only by first moving the switchboard and then

removing cover plates

1. If the level of busbar access required is not specified on the Drawings, the switchboard shall be such that Grade 1 access shall be provided.

# EARTHING

## Earth Bars

Unless shown otherwise on the Principal’s Drawings, a common earth bar shall be used for protective and instrumentation earth conductors.

If Intrinsically Safe circuits are involved, a separate earth bar shall be provided and used for all Intrinsically Safe circuit earths. The Intrinsically Safe earth bar shall be labelled as such as shall be marked at 200 mm intervals with blue PVC tape.

Each earth bar shall be provided with facilities to allow connection to the site main earth bar. In the case of the intrinsically safe earth bar, provision shall be made for two such connections.

## Metalwork Earth Bonding

All mounting panels within cubicles, including cubicle doors shall be bonded electrically to the cubicle frames and hence to the cubicle protective earth bar. Within cubicles containing electronic signaling or measuring equipment, such bonding shall be achieved by:

1. Welded connections
2. Bare aluminium to bare aluminium bolted connections
3. Bare zinc plated steel to bare zinc plated steel bolted connection
4. Bare stainless steel to bare stainless steel bolted connections
5. Braided conductor bonded connections

The resistance between the cubicle frame or any mounting panel and the cubicle protective earth bar shall be not more than 0.2 Ohm.

# Nameplates

An engraved nameplate shall be fitted to the switchboard in the vicinity of the incoming feeder main switch. The nameplate shall include the following information:

1. Manufacturer
2. Date of manufacture
3. Design verified to standard (e.g. AS/NZS 61439.1/2 or IEC TR 61641)
4. Maximum operational Voltage
5. Rated Current
6. Maximum let through short circuit I²t
7. Ambient air temperature – upper limit
8. Ambient air temperature – daily average maximum
9. Earthing system
10. Drawing number

If the switchboard is of a type tested design, a separate prominent label shall be fitted in the same vicinity engraved as follows:

**Warning – Type Tested Switchboard Design**

**Not to be Modified without Maker’s Approval**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Specification for LV Switchboard – General Requirements Tender Technical Response Schedule** | | | | | |
| **DS26.9** | **Subject** | **Noted** | **Compliance** | | **Comments** |
| **Clause No.** |  |  | **Yes** | **No** |  |
| **1.** | **General** |  |  |  |  |
| 1.1 | Scope |  |  |  |  |
| 1.2 | Standards |  |  |  |  |
| 1.3 | Safety Requirements |  |  |  |  |
| **2.** | **Conformance to Drawings** |  |  |  |  |
| 2.1 | Tolerances |  |  |  |  |
| 2.2 | Equipment Settings |  |  |  |  |
| 2.3 | Labelling |  |  |  |  |
| **3.** | **Detail Design** |  |  |  |  |
| 3.1 | Arrangement |  |  |  |  |
| 3.1.1 | Access for Maintenance |  |  |  |  |
| 3.1.2 | Access for Cable Terminations |  |  |  |  |
| 3.1.3 | Location of Surge Diverters |  |  |  |  |
| 3.2 | Location of Controls |  |  |  |  |
| 3.3 | Keys |  |  |  |  |
| 3.4 | Thermal Derating of Elect. Equipment |  |  |  | Switchgear rated deg. C = |
|  |  |  |  |  | Switchgear derating % = |
|  |  |  |  |  | Electronic equipment rated deg. C = |
|  |  |  |  |  | Electronic equipment derating % = |
| 3.5 | Short Circuit Protection Coordination |  |  |  |  |
| 3.6 | Protection of Cable Droppers |  |  |  |  |
| **4.** | **General Construction** |  |  |  |  |
| 4.1 | Fixings and Supports |  |  |  |  |
| 4.2 | Miscellaneous Fittings |  |  |  |  |
| 4.3 | Silicone Based Components |  |  |  |  |
| **5.** | **Metalwork Construction** |  |  |  |  |
| 5.1 | Cubicle Metals |  |  |  | Metal type = |
|  |  |  |  |  | Door panel thickness. mm = |
|  |  |  |  |  | Mounting panel thickness, mm = |
|  |  |  |  |  | Thickness of other panels, mm = |
| 5.2 | Adjacent Dissimilar Metals |  |  |  |  |
| 5.3 | Additional Supports |  |  |  |  |
| 5.4 | Welding |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Specification for LV Switchboard – General Requirements Tender Technical Response Schedule** | | | | | |
| **DS26.9** | **Subject** | **Noted** | **Compliance** | | **Comments** |
| **Clause No.** |  |  | **Yes** | **No** |  |
| **6.** | **Protecting Coatings** |  |  |  | Type of protective coating = |
| 6.1 | Paint Coatings for Steel |  |  |  |  |
| 6.2 | Powder Coatings for Steel |  |  |  |  |
| 6.3 | Protective Coatings for Aluminium |  |  |  |  |
| 6.4 | Protective Coating Colours |  |  |  | External colour = |
|  |  |  |  |  | Internal colour = |
| **7.** | **Conductor Material** |  |  |  | Cable conductor material = |
|  |  |  |  |  | Busbar material = |
| **8.** | **Cables** |  |  |  |  |
| 8.1 | Cable Colour Coding |  |  |  |  |
| 8.2 | Power Interconnecting Cables |  |  |  |  |
| 8.3 | Light Current Cables |  |  |  |  |
| 8.4 | Earthing Cables |  |  |  |  |
| **9.** | **Cable Installation** |  |  |  |  |
| 9.1 | Cable Terminations |  |  |  |  |
| 9.2 | Gland Plates for External Cables |  |  |  | Gland plate material = |
| 9.3 | Fuse Wiring |  |  |  |  |
| 9.4 | Cable Markers |  |  |  |  |
| 9.5 | Protection of Cable Insulation |  |  |  |  |
| 9.6 | Cable Joints |  |  |  |  |
| 9.7 | Support of Electrical Equipment Wiring |  |  |  |  |
| 9.8 | Cable Screening and Segregation |  |  |  |  |
| 9.9 | Cable Crimping |  |  |  |  |
| **10.** | **Busbars** |  |  |  |  |
| 10.1 | Arrangement of Cable Main Connections |  |  |  |  |
| 10.2 | Arrangement of Busbars |  |  |  |  |
| 10.3 | Continuous Rating of Busbars |  |  |  | Main busbars rated Amp = |
|  |  |  |  |  | Dropper busbars rated Amp = |
| 10.4 | Busbar Joints |  |  |  | Busbar joints access grade = |
| **11.** | **Earthing** |  |  |  |  |
| 11.1 | Earth Bars |  |  |  |  |
| 11.2 | Metalwork Earth Bonding |  |  |  |  |
| **12** | **Nameplates** |  |  |  |  |

**END OF DOCUMENT**