

# Main Switchboard Design

## **Q: What is the Australian standard for main switchboards?**

Current Australian standard is AS/NZS 3439.1: 2002 originating from IEC 60439. The new series of standard AS/NZS 61439 will supersede the current standard in 2020 if the new standard gets published in 2015.

## **Q: What is meant by TTA?**

Type tested assembly (TTA) is a low voltage switchgear and controlgear assembly that is verified for its performance as per AS/NZS 3439.1

## **Q: What are the type tests that need to be carried out to verify compliance?**

- verification of temperature-rise limits
- verification of the dielectric properties
- verification of the short-circuit withstand strength
- verification of the effectiveness of the protective circuit
- verification of clearances and creepage distances
- verification of mechanical operation
- verification of the degree of protection and internal separation

## **Q: Can you claim type tested assembly if the switchboard construction is different to the tested arrangement or made modifications to suite different applications?**

No. If modifications are made to the components of the switchboard, new type tests have to be carried out only in so far as such modifications are likely to adversely affect the results of the 7 type tests listed above.

## **Q: What is meant by PTTA?**

Partially type tested assembly (PTTA) is a low voltage switchgear and controlgear assembly, containing both type tested and non-type tested arrangements. In this construction, non-type tested arrangements need to be derived (e.g. by calculation etc.) from type tested arrangement. This switchboards construction is mostly used as it is not possible to cover all the possible configurations in your type tested arrangements and therefore customised switchboard arrangements derived from type tested arrangements is more practical in real world applications.

## **Q: Do you need to perform any other tests even if you have type test certificates?**

Yes. Every switchboard need to be routine tested (4 tests) by the manufacturer. Routine tests are intended to detect faults in materials and workmanship and as follows:

- Inspection of the switchboard including inspection of wiring and, if necessary, electrical operation test
  - The effectiveness of mechanical actuating elements, interlocks, locks, etc., shall be checked
  - The conductors and cables shall be checked for proper laying and the devices for proper mounting
  - A visual inspection is also necessary to ensure that the prescribed degree of protection, creepage distances and clearances are maintained
  - The connections, especially screwed and bolted connections, shall be checked for adequate contact, possibly by random tests

- The conformity of the switchboard to the circuit and wiring diagrams, technical data etc.
- Depending on the complexity of the switchboard, it may be necessary to inspect the wiring and to carry out an electrical functioning test.
- Dielectric test.
  - All electrical equipment of the switchboard shall be connected for the test, except current-consuming apparatus like windings, measuring instruments etc. that will be disconnected during the test. Test voltage is selected as per table 10 of AS/NZS 3439.1:2002. (e.g. For 690V applications the test voltage will be 2.5kV)
  - For the test either all circuits should be closed or the test voltage shall be applied for all parts successively.
  - The test voltage shall be applied between the live parts and the conductive structural parts of the ASSEMBLY.
  - The test is considered to have been passed if there is no puncture or flashover
  - Checking of protective measures and of the electrical continuity of the protective circuits
  - The protective measures with regard to protection against direct and indirect contact shall be checked.
  - Screwed and bolted connections shall be checked for adequate contact, possibly by random tests.
- Verification of insulation resistance
  - Insulation measurement using an insulation measuring device at a voltage of at least 500 V shall be carried out
  - In this case, the test is deemed satisfactory if the insulation resistance between circuits and exposed conductive parts is at least 1000  $\Omega/V$  per circuit referred to the nominal voltage to earth of these circuits.
  - By exception, items which, according to their specific requirements, are current-consuming apparatus (e.g. windings, measuring instruments) at the application of the test voltage or are not designed for the full test voltage shall be disconnected as appropriate.

**Q: How do you calculate the distribution busbar size of 10 circuits in the absence of actual currents of those circuits?**

In the absence of actual currents, rated diversity factor is used to calculate the minimum busbar sizing. Below conventional values are used as per table 1 of AS/NZS 3439.1:2002

Number of main circuits Rated diversity factor (RDF)

2 and 3	0.9
4 and 5	0.8
6 and 9 inclusive	0.7
10 (and above)	0.6

(e.g. If 10 x 100A MCCB's are fitted in a distribution chassis the diversity factor is 0.6 allowing a minimum busbar size of 600A)

**Q: Is it mandatory to have a name plate on main switchboards?**

Yes. Each assembly should have one or more name plates with typically below information:

- manufacturer's name or trade mark (mandatory)
- serial number/drawing number (mandatory)
- date of manufacture (mandatory)
- relevant standard (eg. AS/NZS 3439.1:2002)

- type of current (and frequency, in the case of a.c.)
- rated operational voltages
- rated insulation voltages
- short-circuit withstand strength
- degree of protection
- type of earthing system
- weight
- form of internal separation

**Q: What is the minimum clearance distance in a low voltage installation?**

Table 14 of AS/NZS 3439.1:2002 is referred in obtaining this information and if you consider a maximum of 12kV rated impulse withstand voltage with pollution degree of 4 (worst case) the clearance distance should be more than 14mm between phases and between phases and neutral/earth.

**Q: What is the creepage distance in a low voltage installation?**

If pollution degree is 1 or 2 (normally non-conductive pollution occurs, occasionally however, a temporary conductivity based on condensation may occur) the creepage distance should not be less than the associated clearance distance. This leaves the creepage distance also at 14mm.

**Q: What is the minimum IP rating allowed for indoor switchboards?**

IP2X. This is considering there is no need for protection against ingress of water.

**Q: What is the minimum IP rating allowed for outdoor switchboards?**

IP23. Assemblies for outdoor use having no supplementary protection (protective roofing of the like) the second characteristic numeral shall be at least 3.

**Q: Is higher IP rating (e.g. IP66) enclosures better for switchboards?**

This is not necessarily true unless the switchboard is installed in a location where there could be more damage to it by constant spray of water, presence of dust and gases that could increase the pollution degree inside a switchboard.

Switchboards need to be properly ventilated to enable the switchgear to operate within its tested conditions (normally 35-40 deg C maximum temperature) and the heat generated during the operation (through watt loss of conductors and switchgear) should have passage to escape. If the switchboards are constructed with higher IP rating, the switchgear will need to be derated and the conductors need to be upsized to make the switchboard run cooler. Also, you also need to consider pressure release valves to enable the release of pressure build up during an arc. Due to these reasons switchboards are best performed when enclosed in properly ventilated enclosures dropping the IP rating to the minimum suitable level depending on the location and application.

**Q: Apart from properly enclosed switchboard what is another important environment factor to consider for outdoor switchboards?**

Where the switchboards are intended to be installed in a location with high humidity and temperature varying within wider limits, suitable arrangements (ventilation and/or internal heating, drain holes, etc.) shall be made to prevent harmful condensation within the switchboards.

**Q: What are the temperature rise limits for components inside a switchboard?**

Temperature rise limits given in this standard or calculated apply for mean ambient air temperature less than or equal to 35deg C (Therefore, this does not apply for outdoor switchboards where the ambient temperature reach above 35deg C and the effect of solar irradiation on the switchboard operating temperature is unknown)

- Switchgear and controlgear:
- Temperature rise should be as per the manufacturer recommendations.
- Normally switchgear is calibrated at 35-40 deg C operating temperature and higher operating temperature would mean derating the circuit breakers as per the manufacturer data, Also you may need to consider the maximum operating conditions in order to limit the temperature rise within the assembly
- Terminals for external conductors
- 70k rise is based on conventional tests
- Busbars and conductors
- Generally to be considered to be complied with if the temperature rises do not exceed 70k for H.C copper busbars and 55k for H.C aluminium busbars. This is based on 105deg C and 90deg C maximum temperature within an assembly.

**Q: What are the methods used in switchboards to protect the operator against electric shock?**

- Protection by safety extra low voltage (SELV)
- Protection against direct contact

One or more protective measures may be selected to satisfy this requirement:

- Protection by insulation of live parts (e.g. PVC cable, Polythene pinhole free coating with minimum thickness 0.8mm, solid extruded PVD tubing of 1mm thickness, heat shrink sleeve with wall thickness of 0.45mm after shrinking, polycarbonate sheet of minimum 1.6mm thickness and non-conductive powder coating of minimum 0.3mm thickness)
- Protection by barriers or enclosures
- All external surfaces of a switchboard shall be minimum IP2X rated
- All barriers firmly fitted
- Barriers to be fitted with means that requires a key or tool for removal
- Protection against indirect contact
- Using protective circuits (separate earth conductor and conductive structural parts where the continuity is ensured by effective interconnections)

**Q: What is the maximum length of unprotected cable that can be installed in a switchboard where a circuit breaker is fitted at the end of it?**

3 meters. There are conditions that need to be met with this and is available in table 5 of AS/NZS 3439.1:2002 (eg. Single insulated cables with operating temperature above 90deg C where no applied external pressure on them or sheathed, double insulation cable)

**Q: What is the recommended minimum height from ground/platform for the terminals of circuit breaker?**

200mm as per section 7.6 of AS/NZS 3439.1

**Q: What is the maximum height for the operating devices such as handles, push buttons etc from ground/floor?**

For floor-mounted switchboards, indicating instruments which need to be read by the operator should not be located higher than 2 m above the base of the switchboards. Applicable for operating devices, such as handles, push buttons, etc.

**Q: Is there a recommended distance from ground to actuators of emergency stop?**

Yes. The emergency stop buttons to be located in between 0.8m to 1.6m.

**Q: Why internal separation of assemblies used?**

Forms of internal separation are aimed at providing a base to:

- Protect operator against contact with live parts belonging to adjacent functional units, busbars and terminals
- Limit the probability of initiating an arc fault
- Protect passage of solid foreign objects from one unit of assembly to another (achieved by using IP2x separation between each unit)

**Q: Will internal separation guarantee the integrity of the assembly (switchboard) in the event of an arcing fault?**

No. this will only limit the probability of an arcing fault and extra measure to be taken as per section 2.5.5 of AS/NZS 3000:2007 and Annex ZC of AS/NZS 3439.1

**Q: How is internal separation achieved?**

There are two methods of achieving this:

- Standard construction
- By barriers or partitions (these can be metallic or non-metallic)
- Form 1, 2a, 2b, 3a, 3b, 4a, 4b
- By using integral housing (IP2x) of functional unit denoted by 'h'. Applicable forms are 3ah,3bh, 4ah and 4bh
- Insulation of busbars or shrouds denoted by 'i'. Applicable forms are 2bi, 3bi & 4bi
- The combination of housing (h) and insulation (i). Applicable form are 3bih, 4aih and 4bih
- Alternative construction

**Q: Why there are different methods of internal separation of switchboards, who decides which one to use?**

Internal separation is agreed upon the manufacturer and user as per section 7.7 of AS/NZS 3439.1

Following points are considered in deciding on the appropriate internal separation by the user, or in absence of specification by the switchboard manufacturer?

- Is the rated current of the switchboard less than 800A? If YES, you are free to select any form of separation (e.g. Form 1, 2a, 2b, 3a, 3b, 4a, 4b etc.)
- Is the rated current of the switchboard more than 800A? If YES, you are restricted to use one of the prescribed forms of separations as per section 2.5.5.2 of AS3000:2007 to reduce the probability of initiating an arcing fault. (e.g. Form 3b, 3bi, 3bih, 4a, 4ah, 4aih, 4b, 4bi, 4bh and 4bih)
- Can the assembly be isolated elsewhere before removing covers etc.? (If the answer is YES, you may decide to go with the lowest form of separation [form 1] without adding pressure on the switchboard price)

- Do you require additional integrity by having separation between functional units and busbars where the access of busbars in live conditions result in risk of contact with live busbars? (If the answer is YES, you will need to go with minimum form 2 construction)
- Do you require access to functional units (e.g. Circuit breakers) for limited maintenance (eg. Changing the settings) with adjacent circuits live? (If the answer is YES, you will need to go with minimum form 3 construction providing also separation between functional units)
- Do you require access to cable terminals (e.g. Connecting cables to a spare circuit breaker in future while the switchboard is live) of a functional unit with adjacent functional units live? (If the answer is YES, you will need to go with the maximum form of separation-form 4)

**Q: What are the measures to be taken in increasing security against the occurrence or the effect of internal arcing faults?**

- By insulation of all live conductors
- By the arrangement of busbars and functional units in a switchboard where there are vented compartments designed to promote rapid extinction of the arc and to prevent the arc or arc products affecting other parts of the switchboard
- By the use of devices (e.g. fuses or circuit-breakers), designed to limit the magnitude and duration of the arcing current by interruption of the fault
- Combinations of above items, or other methods designed to either prevent the initiation of an arc, or to reduce the damage or risk of injury resulting from an arc, by sensing of the fault followed by interruption

**Q: Can a successful internal arcing fault test guarantee to withstand all arcing faults that may occur in service?**

No. It is not possible to simulate all the conditions that can produce arcing faults in service and that the arc does not always behave in a repeatable manner.

Annex ZD of AS/NZS 3439.1:2002 covers the special tests to verify the increased security against the effects of internal arcing which may occur in service with all doors closed and all covers and internal barriers in place.

*Reference: AS/NZS 3439.1:2002 and AS/NZS 3000:2007*