# AMS Series

## 12 / 24kV Air-Insulated Metal-Clad Switchgear

## Operation and Maintenance Manual


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# 1 Technical Description

## 1. General

The “ AMS” series of switchgear is an air insulated, factory -assembled and type tested medium voltage switchgear for indoor installations. The switchgear is an air insulated metal enclosed fully withdrawable switchgear design, fitted with Vacuum Circuit Breakers.

The AMS switchgear is fitted with VEP Embedded Pole Vacuum withdrawable circuit breakers. The switchgear is of a front access design that allows efficient space utilisation within the switchroom. The switchgear is designed for maximum safety, with all operations performed behind closed doors for optimum safety, this includes isolation withdrawal and application of earths via integral fault making earthing switches to power circuits. The door to the circuit breaker compartment is interlocked such that the door cannot be opened unless the circuit breaker is withdrawn to the isolated position, behind the closed door. The circuit breaker status of open/closed/ racked in /racked out can be inspected through the viewing window on the circuit compartment door.

In addition to VEP Embedded Pole Vacuum withdrawable circuit breakers, the switchgear can also be equipped with vacuum contactor, and a voltage transformer truck. The switchgear is designed to meet various system configurations as per individual project requirement.

The switchgear features partitioning between the busbars, the circuit breaker, the low voltage compartment and the cable compartment. The generously dimensioned low voltage compartment is designed to both modern and conventional control and protection systems. The AMS control panels can be combined

The functional units of the switchgear are guaranteed arc proof in accordance with the AS and IEC Standards. All the start -up, maintenance and service operations can be carried out from the front.

The switchgear is designed in accordance with the Australian and IEC Switchgear Standards. The switchgear is fully type tested and compliant with AS 62271.200:2005 and IEC 62271-200, Ed1.0 (2003). And the vacuum circuit breaker is fully type tested and compliant with AS 62271.100:2005 and IEC
62271-100, Ed 1.2 (2006). In addition to AS and IEC standards the switchgear also meets the requirements of DIN and VDE (German) Standards.

- The main characteristics of the switchgear are as follows:
- Metal-clad, air-insulated switchgear.
- Suitable for medium voltage distribution.
- Guaranteed arc-proof units.
- Factory-tested for indoor installations.
- Tested in accordance with AS and IEC Standards.
- Wide range of functional units available for all installation solutions.
- Compartments segregated by metallic partitions.
- Modular structure, easily built -up.
- 
- Highly effective use of space.
- Start-up, maintenance and service operations can be carried out from the front.
- Apparatus handling with the door closed.
- Units can be installed against the wall.
- Limited and simple maintenance activities.
- Complete with mechanical safety interlocks.
- Earthing switch with full making capacity.
- Designed to guarantee maximum service continuity.
- Conventional or integrated protection and measurement systems.

## 2. Applications

The switchgear has been designed and installed in the following type of applications:

Utilities and Power Plants
- Distribution and zone substations
- Power generation stations
- Transformer stations
- Main and auxiliary switchgear.
- Nuclear power stations

Industry
- Mining
- Pulp and Paper
- Cement
- Textiles
- Chemicals
- Food
- Automotive
- Petrochemical
- Quarrying
- Oil and gas pipelines
- Metallurgy
- Rolling mills
- Water and sewage works

Transport
- Airports
- Ports
- Railways
- Underground transport.

Services
- Supermarkets
- Shopping malls
- Hospitals
- Large infrastructures and civil works.

## 3. Electrical Characteristics

| No. | Description | Unit | AMS 12 | AMS 24 |
|---|---|---|---|---|
| 1 | Rated service voltage | kV rms | 11 | 22 |
| 2 | System highest voltage | kV rms | 12 | 24 |
| 3 | Rated frequency | Hz | 50 | |
| 4 | Rated current of main bus bar | A rms | 1250, 2000, 2500, 3150, 4000* | |
| 5 | Rated current of branch bus bar | A rms | 630, 1250, 2000, 2500, 3150, 4000* | |
| | * - Forced cooling ventilation is required | | | |
| 6 | Power frequency voltage that the completely assembled group of panels comprising a main bus will withstand for 60 seconds | | | |
| 6.1 | At factory | kV rms | 28 | 50 |
| 6.2 | At site | kV rms | 22.4 | 40 |
| 7 | Lightning impulse withstand voltage (peak value) | kV rms | 95 | 125 |
| 8 | Rated short time withstand current (3 sec) | kA | 20, 25, 31.5, 40, 50 | |
| 9 | Rated peak withstand current (peak value) | kA | 50, 63, 80, 125, 130 | |
| 10 | Resistance of main circuit | μΩ | ≤150+CT* (≤630A) | |
| | | | ≤100+CT* (≤1250A) | |
| | | | ≤70+CT* (≤2000A) | |
| | | | ≤50+CT* (≥2500A) | |

| No. | Description | Unit | AMS12 | AMS 24 |
|---|---|---|---|---|
| 11 | Ingress Protection | | | |
| 11.1 | • High voltage parts | | IP4X | |
| 11.2 | • Open Enclosures | | IP2X | |
| 11.3 | • Low voltage compartment | | IP2X | |
| 12 | Maximum temperature rise at rated normal current (CB in unit) | ºC | 40 | 40 |
| 13 | Resistance voltage drop across contacts at rated normal current | mV | 250 | 250 |
| 14.1 | Secondary control voltage (DC) | Vdc | 48, 110, 220 | |
| 14.2 | Secondary control voltage (AC) | Vac | 110, 220 | |
| 14.3 | Rated voltage 50Hz for auxiliary devices (lighting, heaters, spring charge motor, etc) | Vac | 240 | |
| 15 | Minimum trip and close coil current | A | 1A @ 220Vdc | |
| 16 | Minimum permissible interval („dead time") between break & high speed make at 100% rated breaking and making capacity | s | 180 | |
| 17 | Minimum dc trip voltage at control cabinet terminals at which total short circuit break time (Item 12 above) is valid (% of nominal dc supply voltage) | % | 70 | |
| 18 | Opening time | | | |
| 18.1 | • Under no-load conditions | ms | 25 – 35 | |
| 18.2 | • At rated breaking capacity | ms | 25 – 35 | |
| 19 | Maximum arcing time at the following breaking capacities | | | |
| 19.1 | • 100% rated asymmetrical | ms | 15ms @ 51% | |
| 19.2 | • 100% rated symmetrical | ms | 15 | |
| 19.3 | • 60% rated symmetrical | ms | 15 | |
| 19.4 | • 30% rated symmetrical | ms | 15 | |
| 19.5 | • 10% rated symmetrical | ms | 15 | |
| 19.6 | • 5% rated symmetrical | ms | 15 | |
| 20 | Maximum impulse wave for which the circuit breaker insulation will be coordinated (with cables connected) | | | |
| 20.1 | • Prospective peak | kVp | 95 | 125 |
| 20.2 | • Wave shape | µs | 1.2/50 | 1.2/50 |
| 21 | Maximum internal partial discharge at 120% rated phase-to-earth voltage when tested in accordance with AS62271.200 | pC | <20 | <20 |
| 22 | Number of opening operations permissible before inspection and maintenance of contacts and other essential parts | | | |
| 22.1 | • At rated normal current | No. | 10000 | 10000 |
| 22.2 | • At rated breaking capacity | No. | 50 | 50 |
| | For Vacuum interrupters | | | |
| 23 | • Method of testing the integrity of vacuum interrupters | | Dielectric test | Dielectric test |

| No. | Description | Unit | AMS12 | AMS 24 |
|---|---|---|---|---|
| 24 | Minimum time interval between inspections for lubrication and maintenance of moving parts | | | |
| 24.1 | • Mechanism and drive system | Years | 20 | 20 |
| 24.2 | • Interrupters | Years | 20 | 20 |
| 24.3 | • Isolating contacts – CB | Years | 20 | 20 |
| 24.4 | • Isolating contacts – Fixed | Years | 20 | 20 |
| 25 | Busbar material | | Copper | |
| 26 | Busbar method of clamping/fixing to busbars | | Bolt | |
| 27 | Busbar insulation | | Raychem | |
| 28 | Material used for busbar insulation | | Epoxy Resin | |
| 29 | Maximum allowable continuous operating temperature of the insulation material | ºC | 115 | |
| 30 | Metal Enclosure | | | |
| 30.1 | • Class | | Indoor | |
| 30.2 | • Type | | Withdrawable | |
| 30.3 | • Service continuity classification | | LSC2B | |
| 30.4 | • Partition class | | PM | |
| 31 | Protection of equipment against mechanical impact | | 2J | |
| 32 | Insulating medium for all compartments | | Air | |
| 33 | Number of compartments in panel | | 4 | |
| 34 | Internal arcing fault (IAC) withstand – AS 62271-200 Appendix A | | | |
| 34.1 | IAC to AS 62271-200 Appendix A | | Yes | |
| 34.2 | • Accessibility type | | A, FLR | |
| 35 | Finishing coating – interior & exterior | | | |
| 35.1 | • Atmospheric corrosive category (AS2312) | | B | |
| 35.2 | • Thickness | µm | 75 | |
| 36 | Creepage distance | mm/kV | 20 | |
| 37 | Cross section area of earth bar | mm2 | 30 x 8mm | |
| 38 | Details of protection of secondary wiring in main HV compartments | | Metallic duct & sock | |
| 39 | Busbar and cable shutters operate and lock independently | | Yes | |
| 40 | Shutter bonded to panel earthing system via adequate flexible earth braids | | Yes | |
| 41 | Rated power frequency withstand voltage | | | |
| 41.1 | • Conductor to earth | kV | 42 | 50 |
| 41.2 | • Across isolation distance | kV | 48 | 60 |

| No. | Description | Unit | AMS 12 | AMS 24 |
|---|---|---|---|---|
| 42 | Rated lightning impulse withstand voltage | | | |
| 42.1 | • Conductor to earth | kV | 75 | 125 |
| 42.2 | • Across isolation distance | kV | 85 | 145 |
| 43 | Maximum number of cables per phase | | | |
| 43.1 | • 630A | | 4 cable sizes | 3 cable sizes |
| 43.2 | • 1250A | | 4 cable sizes | 3 cable sizes |
| 43.3 | • 1600A | | 6 cable sizes | 6 cable sizes |
| 43.4 | • 2000A | | 6 cable sizes | 6 cable sizes |
| 43.5 | • 2500A | | 6 cable sizes | 6 cable sizes |

Table 1 – Switchgear Electrical Characteristics

## 1.4 Terms and definitions

### 1.4.1 Switchgear and controlgear

General term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

### 1.4.2 Metal enclosed switchgear and controlgear

Switchgear and controlgear assemblies with an external metal enclosure intended to be earthed and completely assembled, except for external connections

### 1.4.3 Functional unit (of an assembly)

Part of metal-enclosed switchgear and controlgear comprising all the components of the main circuits and auxiliary circuits that contribute to the fulfilment of a single function

NOTE Functional units may be distinguished according to the function for which they are intended, for ex ample, incoming unit, outgoing unit, etc

### 1.4.4 Multitier

Two or more functional units arranged vertically within a single enclosure

### 1.4.5 Transport unit

Part of metal-enclosed switchgear and controlgear suitable for shipment without being dismantled

### 1.4.6 Enclosure

Part of metal-enclosed switchgear and controlgear providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

### 1.4.7 Compartment

Part of metal-enclosed switchgear and controlgear enclosed except for openings necessary for interconnection, control or ventilation

Four types of compartments are distinguished, three that can be opened, called accessible and one that cannot be opened, called non -accessible.

NOTE Compartments are identified according to the main component(s) contained therein.

**1.4.7.1 Interlock-controlled accessible compartment**
Compartment containing high-voltage parts, intended to be opened for normal operation and/or normal maintenance as stated by the manufacturer, in which access is controlled by integral design of the switchgear and controlgear

NOTE Installation, extension, repairing, etc. are not considered as normal maintenance.

**1.4.7.2 Procedure-based accessible compartment**
Compartment containing high-voltage parts, intended to be opened for normal operation and/or normal maintenance as stated by the manufacturer, in which access is controlled by a suitable procedure combined with locking

NOTE Installation, extension, repairing, etc. are not considered as normal maintenance.

**1.4.7.3 Tool-based accessible compartment**
Compartment containing high-voltage parts, that may be opened, but not for normal operation and maintenance. Special procedures are required. Tools are necessary for opening

**1.4.7.4 Non-accessible compartment**
Compartment containing high -voltage p a r t s t h a t m u s t n o t b e o p e n e d . Opening mayde story the integrity of the compartment. Clear indication not to open is provide d on/by the compartment

**1.4.8 Partition**
Part of metal-enclosed switchgear and controlgear separating one compartment from other compartments

**1.4.9 Partition class**
Class defining whether metallic or non -metallic material for separation to live parts is used

**1.4.9.1 Partition class PM**
Metal-enclosed switchgear and controlgear providing continuous metallic partitions and/or shutters (if applicable), intended to be earthed, between opened accessible compartments and live parts of the main circuit

**1.4.9.2 Partition class PI**
Metal-enclosed switchgear and controlgear having one or more non -metallic partitions or shutters between opened accessible compartments and live parts of the main circuit

**1.4.7.10 Shutter**
Part of metal-enclosed switchgear and controlgear that can be moved from a position where it permits contacts of a removable part, or moving contact of a disconnector, to engage fixed contacts, to a position where it becomes a part of the enclosure or partition shielding the fixed contact

**1.4.7.11 Segregation (of conductors)**
Arrangement of conductors with earthed metal interposed between them in such a manner that disruptive discharges can only occur to earth

NOTE A segregation may be established b e t w e e n the conductors as well as between the open contacts of a switching d e v i c e or disconnector.

**1.4.7.12 Bushing**
Structure carrying one or more conductors through an enclosure or partition and insulating it therefrom, including the means of attachment

**1.4.13 Component**
Essential part of the main or earthing circuits of metal -enclosed switchgear and controlgear which serves a specific function (for example, circuit -breaker, disconnector, switch, fuse, instrument transformer, bushing, busbar

**1.4.14 Main circuit (of an assembly)**
All the conductive parts of metal -enclosed switchgear and controlgear included in a circuit which is intended to transmit electrical energy.

**1.4.15 Earthing circuit**
Connection of each earthing device, or points provided for earthing purposes, to the terminal intended to be connected to the earthing system of the installation

**1.4.16 Auxiliary circuit**
All the conductive parts of metal -enclosed switchgear and controlgear included in a circuit (other than the main circuit) intended to control, measure, signal and regulate

NOTE The auxiliary circuits of metal -enclosed switchgear and controlgear include the control and auxiliary circuits of the s witching devices.

**1.4.17 Pressure relief device**
Device intended to limit the pressure in a compartment

**1.4.18 Relative pressure**
Pressure, referred to the standard atmospheric pressure of 101.3 kPa

**1.4.19 Ambient air temperature (of metal -enclosed switchgear and controlgear)**
Temperature, determined under prescribed conditions, of the air surrounding the enclosure of metal -enclosed switchgear and controlgear

**1.4.20 Removable part**
Part of metal-enclosed switchgear and controlgear connected to the main circuit and that may be removed entirely from the metal -enclosed switchgear and controlgear and replaced, even though the main circuit of the functional unit is live

**1.4.21 Withdrawable part**
Removable part of metal -enclosed switchgear and controlgear that can be moved to positions in which an isolating distance or segregation between open contacts is established, while the part remains mechanically attached to the enclosure

**1.4.22 Service position (connected position)**
Position of a removable part in which it is fully connected for its intended function

**1.4.23 Test position (of a withdrawable part)**
Position of a withdrawable part in which an isolating distance or segregation is established in the main circuit and in which the auxiliary circuits are connected

**1.4.24 Disconnected position (of a withdrawable part)**
Position of a withdrawable part in which an isolating distance or segregation is established in the circuits of the withdrawable part, that part remaining mechanically attached to the enclosure

NOTE In high- voltage metal-enclosed switchgear and controlgear, the auxiliary circuits may not be disconnected.

**1.4.25 Removed position (of a removable part)**
Position of a removable part when it is outside and mechanically and electrically separated from the enclosure

**1.4.26 Loss of service continuity category (LSC)**
Category defining the possibility to keep other compartments and/or functional units energised when opening a main circuit compartment

NOTE 1 The LSC category describes the extent to which the switchgear and controlgear are intended to remain operational in case access to a main -circuit compartment is necessary. The extent to which it is considered necessary to open main -circuit compartments with a liv e installation might be dependent on several aspects.

NOTE 2 The LSC category does not describe ranks of reliability of switchgear and controlgear.

**1.4.26.1 Category LSC2 switchgear and controlgear**
Switchgear and controlgear having accessible compartments other than the busbar compartment of a single busbar switchgear and controlgear

For metal-enclosed switchgear and controlgear, when any accessible compartment in a functional unit is open, all other functional units are intended to remain energised and operated normally. An exception applies in the case of the busbar compartment of single -busbar switchgear and controlgear which, when opened, prevents service continuity.
Two subdivisions are recognized:
LSC2B: switchgear and controlgear of category LSC2 where the cable compartment is also intended to remain energised when any other accessible compartment of the corresponding functional unit is open.

LSC2A: LSC2 switchgear and controlgear, other than LSC2B

**1.4.26.2 Category LSC1 switchgear and controlgear**
Metal-enclosed switchgear and controlgear other than category LSC2

**1.4.27 Internal arc classified switchgear and controlgear (IAC)**
Metal-enclosed switchgear and controlgear for which prescribed criteria for protection of persons are met in the event of internal arc as demonstrated by the appropriate tests.
Types of accessibility
A distinction is made between two types of accessibility to the metal-enclosed switchgear and controlgear which are possible in the site of installation:

• Accessibility Type A: restricted to authorized personnel only.
• Accessibility Type B: unrestricted accessibility, including that of the general public.
The metal-enclosed switchgear and controlgear may have different types of accessibility on the various sides of its enclosure.
For identification purposes of the different sides of the enclosure the following code shall be used:
F for Front side
L for Lateral side
R for Rear side

**1.4.28 Degree of protection**
Extent of protection provided by an enclosure, partition or shutter if applicable, against access to hazardous parts, against ingress of solid foreign objects and/or ingress of water and verified by standardized test methods (see 3.3 of IEC 60529)

### 1.4.29 Rated Value

Quantity value assigned, generally by a manufacturer, for a specified operating condition of a component device or equipment

### 1.4.30 Disruptive discharge

Phenomena associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero

NOTE 1 The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

NOTE 2 A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be only temporary (self -restoring insulation).

NOTE 3 The term "spark over" is used when a disruptive discharge occurs in a gaseous or liquid dielectric. The t e r m "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in gaseous or liquid medium. The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

## 1.5 Operating Conditions

The AMS switchgear has been designed for normal operating conditions for in indoor installations, in compliance with AS 2650:2005 and IEC 62271 -1 Ed 1.0 (2007).

a) The maximum ambient air temperature is 40 °C and its average value, measured over a period of 24 h does not exceed 35 °C.
The minimum ambient air temperature is -5 °C for class "minus 5 indoor".

b) The influence of solar radiation is neglected.

c) The installation altitude does not exceed 1 000 m above sea level.

d) The ambient air is not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapours or salt.

e) The average value of the relative humidity, measured over a 24h period, does not exceed 95% Depending on additional ambient conditions (e.g. container installation), it may be necessary to install a heater.

f) Vibration due to causes external to the switchgear and controlgear or earth tremors are negligible.

g) Induced electromagnetic disturbances at interfaces of the secondary system, as a result of switching in the high-voltage system, do not exceed 1 .6 kV common mode for normal EMC severity class, and 0.8 kV common mode for reduced EMC severity class .

### 1.5.1 Altitude

If the switchgear is to be installed at altitudes higher than 1000 m above sea level, the reduced dielectric strength of air must be taken into consideration.
Example:

Rated voltage of a power network at 3000 m = 12 kV Rated Voltage $_{3000\ m} = \frac{12kV}{0.8} = 15\,kV$

The Altitude factor as per IEC and AS Standards: 0.8 at 3000 m above sea level

Thus, the 12kV switchgear installed at altitudes of 3000 m above sea level must be designed to withstand 17.5 kV.

## 1.6 Degrees of protection

The degrees of protection of the switchboards conform to Australian and International Standards, AS 60529 and IEC 60529 Standards. The AMS switchboard is normally supplied with the following standard degrees of protection:

- IP4X on the external housing.
- IP2X inside the units.

## 1.7 Colour of external surface

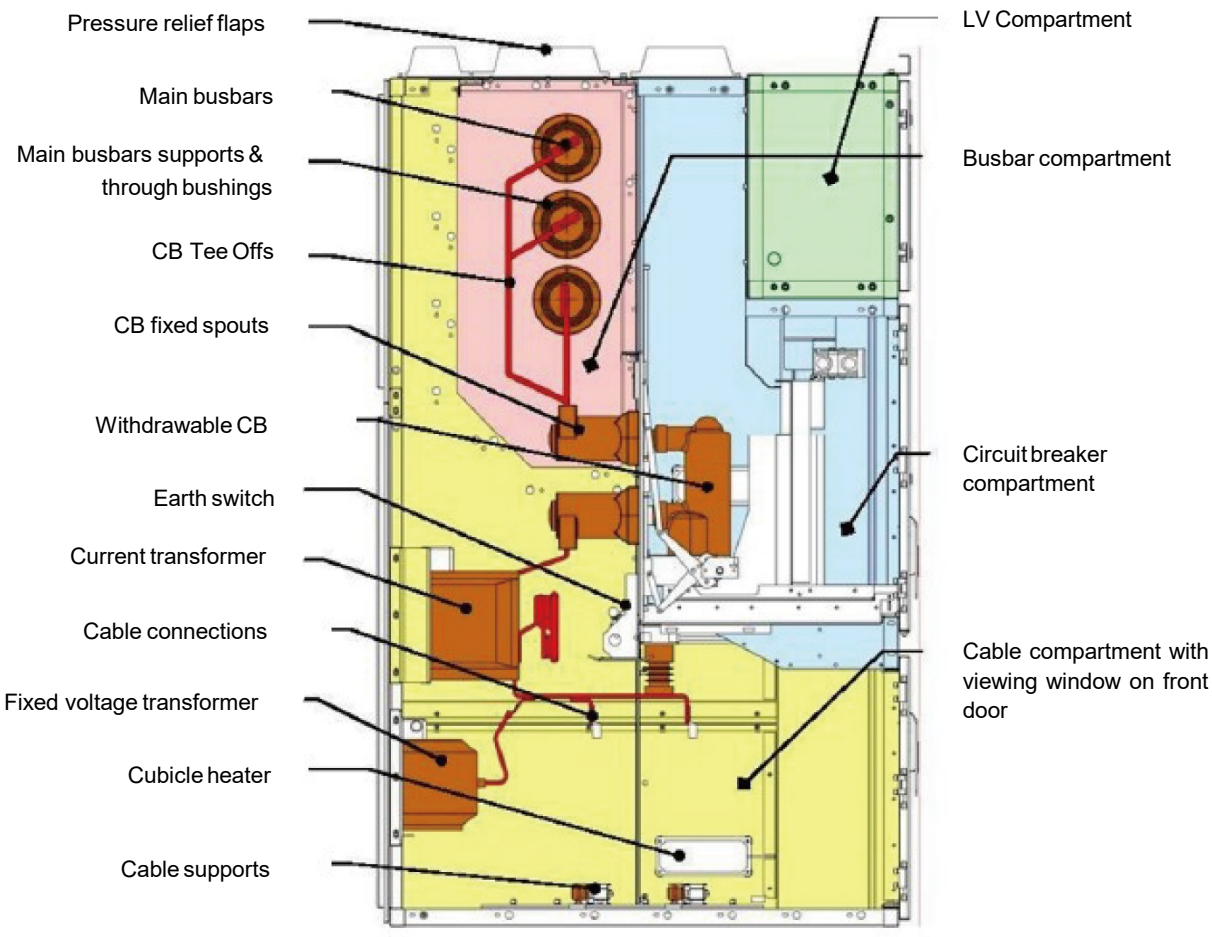
The AMS switchgear is normally supplied with our standard colour finish which is RAL 7035 for the VCB door, cable compartment door, LV compartment door, rear covers and each end panel of the switchboard while the rest of the switchboard is natural galvabond. On request, a different external colour finish from the RAL standard can be provided.

## 1.8 Functional areas and compartments

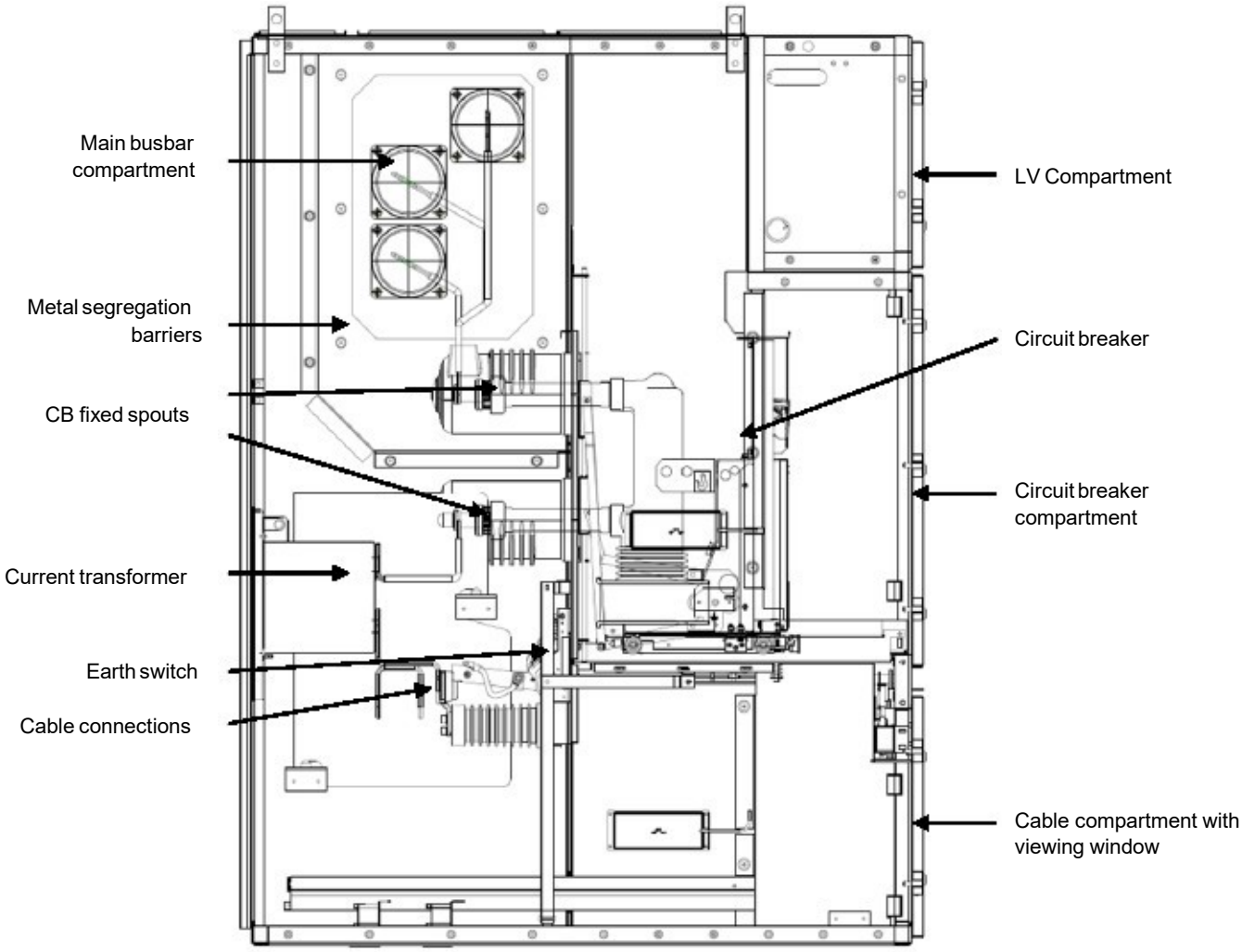
The AMS switchgear panel is subdivided into four functional areas:

- Bus-bar compartment
- Circuit breaker compartment
- Cable compartment
- Low-voltage compartment

The AMS switchgear is a full metal enclosed construction with segregation of all major compartments to enhance the safety and reliability for personnel, equipment and the operating plant. All the compartments are segregated from each other to IP2X, this is achieved with metal segregation barriers within the switchgear and is to prevent the transfer of faults to other areas of the switchgear under an internal arc fault.




Functional areas and main components (12kV)




Functional areas and main components (24kV)

## 1.9 Loss of service continuity

With IEC 62271-200, new aspects relative to new definitions and classifications of MV switchgear have been introduced. One of the most significant changes introduced in this release is that classification of switchgear into metal-clad, compartmented and cubicle types has been completely abandoned. Revision of switchgear classification rules has been based on the user's point of view, in particular on aspects like service and maintenance of the switchgear, according to the requirements and expectations for good substation management, from installation to dismantling. In this context, Loss of Service Continuity has been chosen as a fundamental parameter for the user.

According to the updated rules, the AMS switchgear can be defined as follows:

### 1.9.1 Interlock controlled accessible compartment

Compartment containing high-voltage parts, intended to be opened for normal operation and/or normal maintenance, in which access is controlled by integral design of the switchgear and controlgear, such as the circuit breaker compartment and the cable compartment.

### 1.9.2 Tool based accessible compartment

Compartment containing high -voltage parts, that may be opened, but not for normal operation and maintenance. Special procedures are required. Tools are necessary for opening, such as the busbar compartment

#### 1.9.3 LSC2B
Busbar, Cable and LV compartments are physically and electrically segregated. This is the category that defines the possibility of keeping other compartments and/or functional units energised when opening a main circuit compartment.

#### 1.9.4 Partition Class-PM
Metal-enclosed switchgear and controlgear providing continuous metallic partitions and/or shutters, intended to be earthed, between opened accessible compartments and live parts of the main circuit. Metallic partitions and shutters or metallic parts of them shall be connected to the earthing point of the functional unit.

## 1.10 Compartments
Each unit consists of three power compartments: circuit breaker compartment, busbars compartment and cable compartment.

Each unit is fitted with the LV compartment, where all the instruments and low voltage cabling are housed. The compartments are segregated from each other by metallic partitions.

Arc-proof switchgear is normally provided with an arc-tunnel for evacuation of the gases produced by an internal arc, if the internal height of the switchroom is less than 4.9m.

All the units are accessible from the front and the maintenance and service operations can therefore also be carried out with the switchgear installed a p p r o xi m a t e l y 100mm from the wall . However we do recommend that for ease of on -going maintenance a 600mm space is maintained at the rear for easy access.

#### 1.10.1 Main busbars
The busbar compartment contains the main busbar system connected to the fixed upper isolating contacts of the circuit breaker by means of branch connections.
The busbars are covered with an insulating material. There is a single busbar compartment along the whole length of the switchgear and this is fitted with segregations for dividing each unit into compartments.

#### 1.10.2 Earthing switch
Each cable compartment can be fitted with an earthing switch for cable earthing.

The same device can also be used to earth the busbar system (ESW panel and bus -tie/riser panel). The earthing switch is rated at the short-circuit making capacity of the switchboard.

Control of the earthing switch is from the front of the switchgear with manual operation via the earth switch handle. The position of the earthing switch can be seen from the front of the switchgear by means of an indicator mounted directly onto the operating shaft of the earth switch.

#### 1.10.3 Insulating bushings and shutters
The insulating bushings c ontained in the circuit breaker compartment contain the fixed contacts for connection of the circuit breaker with the busbar compartment and cable compartment respectively.

They are single-pole type and are made of epoxy resin. The shutters are metallic and are activated automatically during movement of the circuit breaker from the racked- out/disconnected position to the service position and vice versa.

### 1.10.4 Arc-tunnel (optional)

The arc tunnel is positioned above the switchgear and runs along its entire length. Each power compartment is fitted with a pressure relief flap positioned on the top of it. The pressure generated by the fault makes it open, allowing the gas to pass into the arc tunnel.

Evacuation from the room of the hot gases and incandescent particles produced by the internal arc must normally be carried out. The ECO BLOCK switchgear is fitted with a complete range of solutions to deal with all requirements, either in the case where evacuation is possible directly at the end of the switchgear, or when solutions from the front or rear are requested.

## 1.11 Interlocks

### 1.11.1 Mechanical Interlocks

The AMS switchgear is normally supplied with the following standard mechanical interlocking features:

Circuit Breaker door Interlocks

- The circuit breaker compartment door cannot be opened unless circuit breaker is fully racked out to its disconnected position.
- The circuit breaker cannot be racked in unless the circuit breaker compartment door is closed and secure d.
- The circuit breaker compartment door cannot be closed unless the auxiliary plug is connected.

**Circuit breaker Interlocks**

- The circuit breaker cannot be racked in/out if the circuit breaker is closed
- The circuit breaker cannot be closed if it is not in the service or disconnected position.
- The circuit breaker cannot be racked in if the auxiliary plug is unplugged.
- The auxiliary plug cannot be unplugged unless the circuit breaker is fully racked out to its disconnected position.
- The circuit breaker cannot be racked in if the earth switch is closed.

**Cable compartment door and Earth switch Interlocks**

- The earth switch cannot be closed unless the circuit breaker is fully racked out to its disconnected position.
- The cable compartment door cannot be opened unless the earth switch is closed.
- The earth switch cannot be opened unless the cable compartment door is closed.

### 1.11.2 Key Interlocks

The AMS switchgear can also be supplied with the following optional key interlock features to be integrated into equipment isolation and access systems:

- The circuit breaker can be locked in the disconnected position
- The earth switch can be locked in the open position
- The earth switch can be locked in the closed position

### 1.11.3 Blocking magnets

In addition to standard mechanical and optional key interlocks, blocking magnets can also be used to provide additional automatic electro/ mechanical interlock logic without human intervention.

The circuit breaker racking, circuit breaker closing and earth switch operations can be prevented via these blocking magnets. The magnets operate with active logic (failsafe) and therefore the loss of auxiliary voltage blocks the applicable operations.

## 1.12 Arc proof

When developing modern medium voltage switchgear, personnel safety must necessarily take first place and this is why the AMS switchgear has been designed and tested to withstand an internal arc due to a short-circuit current of the same level as the maximum short -time withstand level. Tests undertaken prove that the metal housing of the AMS switchgear is able to protect personnel operating near the switchgear in the case of a fault which evolves as far as striking an internal arc.

An internal arc is among the most unlikely of faults, and can be caused by various factors, such as:

- Insulation defects due to quality deterioration of the components.
- Over voltages of atmospheric origin or generated by operation of a component.
- Incorrect operations.
- Breakage or tampering of the safety interlocks.
- Overheating of the contact area, due to the presence of corrosive agents or when the connections are not sufficiently tightened.
- Entry of rodents or reptiles into the switchgear.
- Material left behind inside the switchgear during maintenance operations.

The design characteristics of the AMS switchgear notably reduce the incidence of these causes in generation of faults, but some of them cannot be completely eliminated.

The energy produced by the internal arc causes the following phenomena:

- Increase in the internal pressure.
- Increase in temperature.
- Visual and acoustic effects.
- Mechanical stresses on the switchgear structure.
- Melting, decomposition and evaporation of materials including copper and metal.

Unless suitably controlled, these releases of energy can have very serious consequences for the operators, such as wounds (due to the shock wave, flying parts and the doors opening) and burns (due to emission of hot gases).

Internal arc fault tests ensure that compartment doors remain closed and that no components, flame or gases are ejected from the switchgear in a manner that would poses a threat to the safety of personnel working near the switchgear.

In addition, the tests verify that no holes are produced in the external frame o f freely accessible parts of the housing and finally, that all the connections to the earthing circuit remain effective, guaranteeing the safety of personnel who may access to the switchgear after the fault.

Standards AS 62271.200 and IEC 62271-200 describe the methods to be used for carrying out the tests and the criteria which the switchgear must conform to. The AMS switchgear fully conforms to all the criteria indicated:

- The doors of the switchgear must remain closed and no opening of the cover panels must occur.
- Any part of the switchgear which may be hazardous for personnel must not be ejected.
- No holes must appear in the external housing of the switchgear in any parts accessible to personnel.
- The vertically and horizontally arranged fabric indicators placed outside the switchgear must not get burnt.
- All the switchgear earthing connections must remain effective.

In the case where IAC classification is proven by the tests, the metal enclosed switchgear will be designated as follows:

- General: classification IAC (stands for Internal Arc Classified)
- Accessibility: A, B or C (switchgear accessible to authorized personnel only (A), to all (B), not accessible due to installation (C))
- Test values: test current in kilo amperes (kA), and duration in seconds (s).

AMS switchgear is classified IAC AFLR. When installing the switchgear, some fundamental points must be taken into consideration:

- Level of the fault current
- Duration of the fault

- Escape routes for the hot and toxic gases given off by combustion of materials
- Dimensions of the room, with special attention to the height

## 1.13 Type Tests

The AMS switchgear is designed in accordance with the Australian and IEC Switchgear Standards. The switchgear is fully type tested and compliant with AS 62271.200:2005 and IEC 62271-200, Ed1.0 (2003). The vacuum circuit breaker is fully type tested and compliant with AS 62271.100:2005 and IEC 62271-100, Ed 1.2 (2006). In addition to AS and IEC standards the switchgear also meets the requirements of DIN and VDE (German) Standards. These include:

- Dielectric Test
- Lightning Impulse voltage test
- Power Frequency voltage test
- Measurement of resistance of the main circuit
- Temperature rise test and main circuit impedance measurements
- Short time withstand current and peak withstand current test
- Verification of making and breaking capacities (CB and Earth Switch)
- Mechanical operations test
- Verification of IP coding
- Internal Arc test

Brief descriptions of the Type tests are as follows:

• Dielectric

These tests check that the switchgear has sufficient capability to withstand the lightning impulse and the power frequency voltage. The power frequency withstand voltage test is carried out as a type test, but is also routine on every switchgear unit manufactured.

- Measurement of resistance of the main circuit

The resistance test is carried out for two purposes:

1.Initial verification of the effectiveness of bolted connections to pass current continuously without exceeding guaranteed operating temperature limits. These tests are conducted by passing a known DC current through bolted busbar joints and connections and measuring the voltage drop between these 2 points. The joint resistance, typically recorded in micro-ohms(μΩ), is determined using Ohm's law, V=IR.

2.Joint condition monitoring. Joint resistance measurements taken during regular maintenance can be compared against initial measurements to identify any increase in joint resistance which may be an early indication of potential joint failure.

• Temperature Rise

The temperature rise test is carried out at the rated current value of the switchgear unit and shows that the temperature does not become excessive inside of it. During the test, both the switchgear and the apparatus it may be fitted with are checked (circuit -breakers, contactors etc).

Apparatus subject to testing in free air is able to withstand higher rated currents than that inserted in a switchgear unit; therefore the rated current of the apparatus depends on the characteristics of the switchgear.

• Short time & peak withstand current

The test shows that the main power and the earthing circuits resist the stresses caused by the passage of the short-circuit current without any damage. I t should also be noted that both the earthing system of the withdrawable apparatus and the earthing busbar of the switchgear are subjected to the test. The mechanical and electrical properties of the main busbar system and of the top and bottom branch connections remain unchanged even in case of a short-circuit fault.

• Apparatus making & breaking capacity

All the apparatus (circuit -breakers, contactors and switch -disconnectors) are subjected to the rated current and short -circuit current breaking tests. Furthermore, they are also subjected to the opening and closing of capacitive and inductive loads, capacitor banks and cable lines.

• Earth switch making capacity

The earthing switch of the switchgear can be closed under short -circuit. In actual fact, the earthing switch is normally interlocked to avoid being operated on circuits which are still live. However, should this happen for any one of several reasons, safety of the personnel operating the installation would be fully safeguarded.

• Mechanical operations

The mechanical life tests of all the operating parts highlight the reliability of the apparatus (CB). General experience in the electro -technical sector shows that mechanical faults are one of the most common causes of a fault in an installation. The switchgear and apparatus it contains are tested by carrying out a high number of operation - higher than those which are normally carried out in installations in service. Moreover, the switchgear components are part of a quality program system and are regularly taken up from the production lines and subjected to mechanical life tests to verify that the quality is identical to that of the components subjected to the type tests.

• Internal arc test

When developing modern medium voltage switchgear, personnel safety must necessarily take first place and this is why the AMS switchgear has been designed and tested to withstand an internal arc due to a short -circuit current of the same level as the maximum short -time withstand level. The tests show that the metal housing of the switchgear is able to protect personnel working near the switchgear in the case of a fault which evolves as far as striking an internal arc. The test is performed in every HV –compartment of a typical unit.

In accordance with the requirements of these standards, the tests were carried out on the switchgear units considered most susceptible to the effects of the tests and therefore the results are applicable to the whole range. Apart from the type tests, each switchgear unit is subjected to routine tests in the factory before its delivery. These tests are aimed at a functional check of the switchgear based on the specific characteristics of each installation. These include:

- Visual inspection and check
- Mechanical sequence operations
- Cabling check
- Electrical sequence operations
- Insulation test (power frequency)
- Measurement of the resistance of the main circuits
- Current transformer primary injection & polarity checks

Note – Additional routine tests for example partial discharge and CT secondary injection tests can be completed upon request

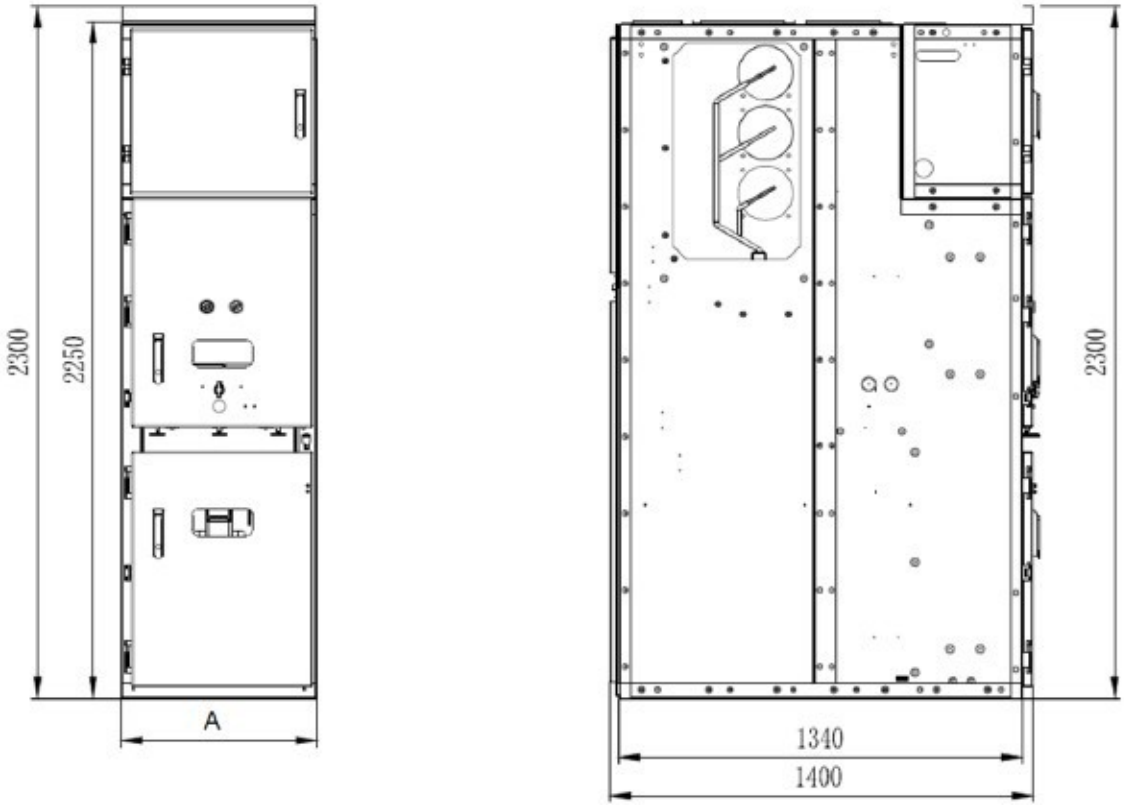
## 1.14 Mechanical Configurations

### 1.14.1 Busbar Ratings and Typical Switchgear Dimensions

| Rated Current | | (A) | 630 | 1250 | 1600 | 2000 | 2500 |
|---|---|---|---|---|---|---|---|
| Main Busbar, up to 1250A | | (mm) | 1 x 80 x 10 | | - | | |
| Main Busbar, up to 2000A | | (mm) | 2 x 80 x 10 | | | | |
| Main Busbar, up to 2500A | | (mm) | 2 x 100 x 10 | | | | |
| Main Busbar, up to 3150A | | (mm) | 2 x 120 x 10 | | | | |
| Main Busbar, up to 4000A | | (mm) | 3 x 120 x 10 | | | | |
| Pole Spacing | 12kV | (mm) | 150 | | 210 | | 275 |
| | 24kV | (mm) | 210 | | 275 | | |
| Panel Width | 12kV | (mm) | 650 | | 800 | | 1000 |
| | 24kV | (mm) | 800 | | 1000 | | |
| Panel Height | 12kV | (mm) | 2250 (allow additional 570 for arc tunnel) | | | | |
| | 24kV | (mm) | | | | | |
| Panel Depth | 12kV | (mm) | 1400 | | | | |
| | 24kV | (mm) | 1680 | | | | |

Table 2 – Busbar Ratings and Switchgear Dimensions

NOTE – Panel depth is subject to the number of current transformers installed.
NOTE – The Busbar ratings of the AMS switchgear are normally rated up to 2500A, however higher ranges are available on request up to 4000A.

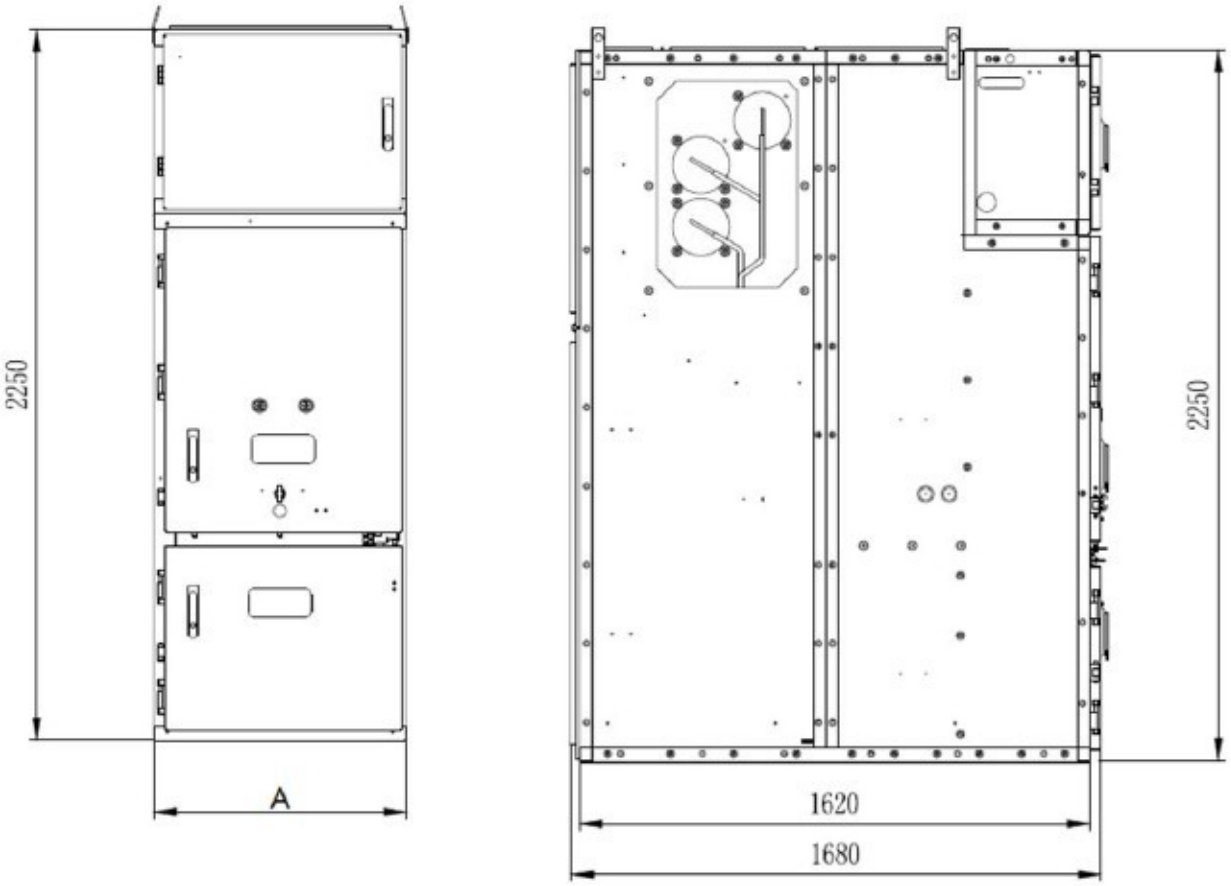



Front View

Side View

NOTE The Standard panel h eight is 2250 mm, however if panel identification plate is fitted on top of LV compartment, the height increases to 2300 mm.

Typical Switchgear Dimensions (12kV)



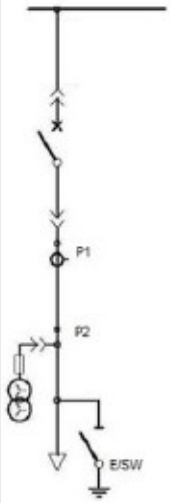
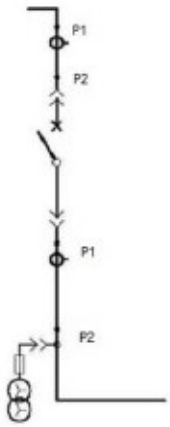

Front View

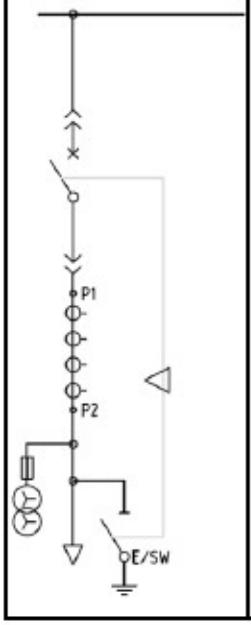
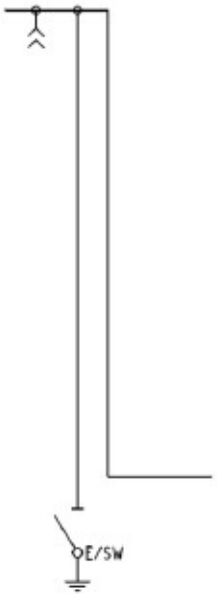
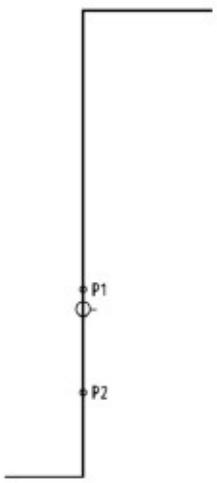
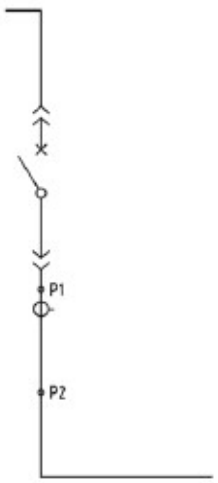
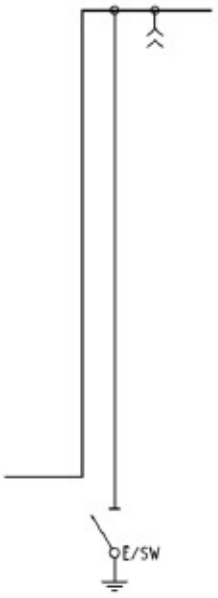
Side View

NOTE The Standard panel height is 2250 mm, however if panel identification plate is fitted on top of the LV compartment, the height increases to 2300 mm.

Typical Switchgear Dimensions (24kV)

### 1.14.2 Typical switchgear variants

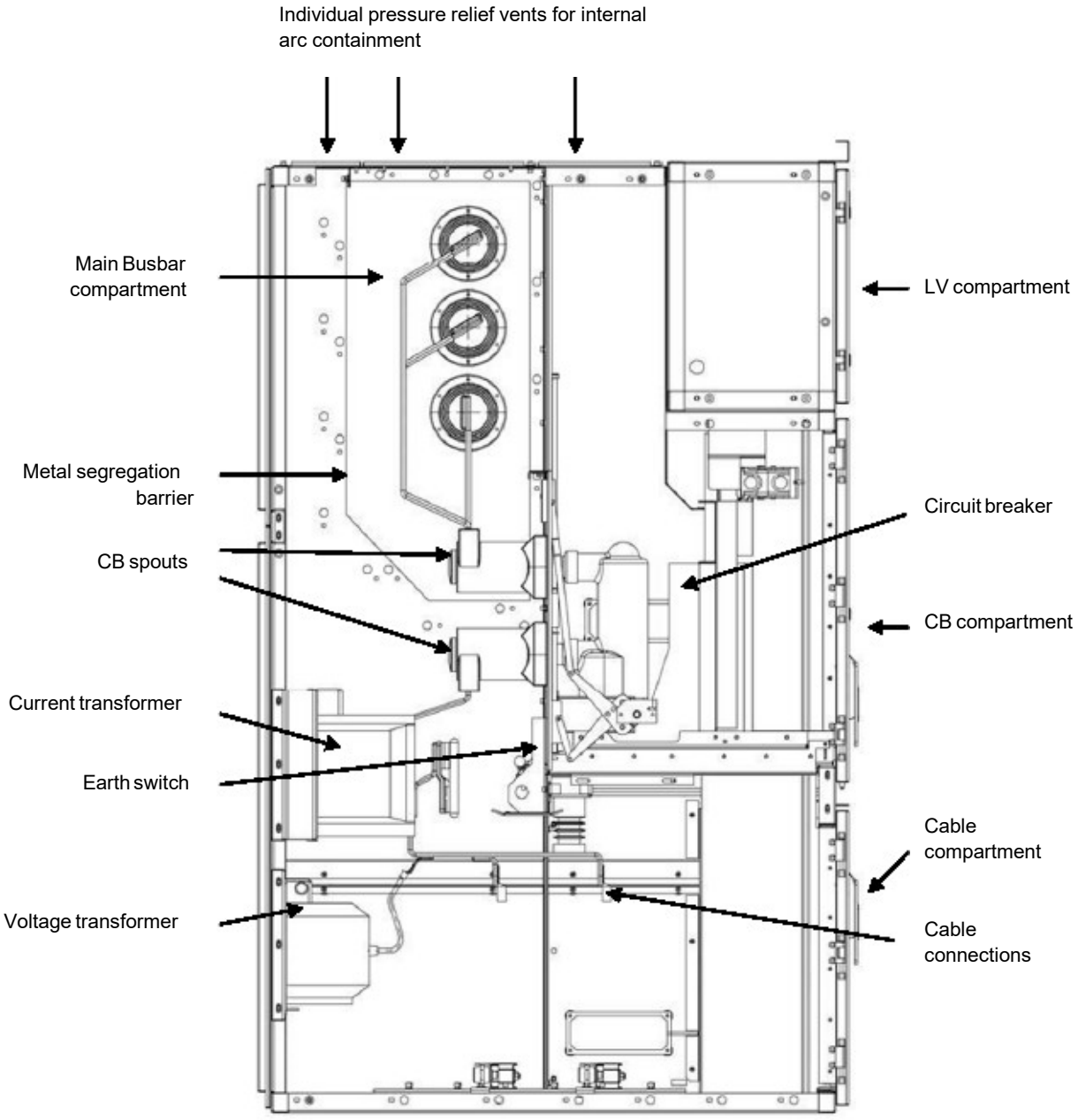
| Incoming / Outgoing Feeder (with optional CT's and VT's) | Bus-Tie (with optional CT's and VT's) | Bus-Riser (with optional Earth switch and VT's | |
|---|---|---|---|
|  |  |  |  |

| Incoming / Outgoing Feeder (with optional CT's and VT's | Bus Riser (with optional earth switch) | Bus Riser (with bus CT's) | Bus Tie (with optional CT's) | Bus Riser (with optional earth switch) |
|---|---|---|---|---|
|  |  |  |  |  |

Single line diagram of main typical units

### 1.14.3 Variants of type AMS 12 kV, 630A Switchgear

A typical configuration of an incomer/feeder panel with circuit breaker, cable connector, current and voltage transformers.

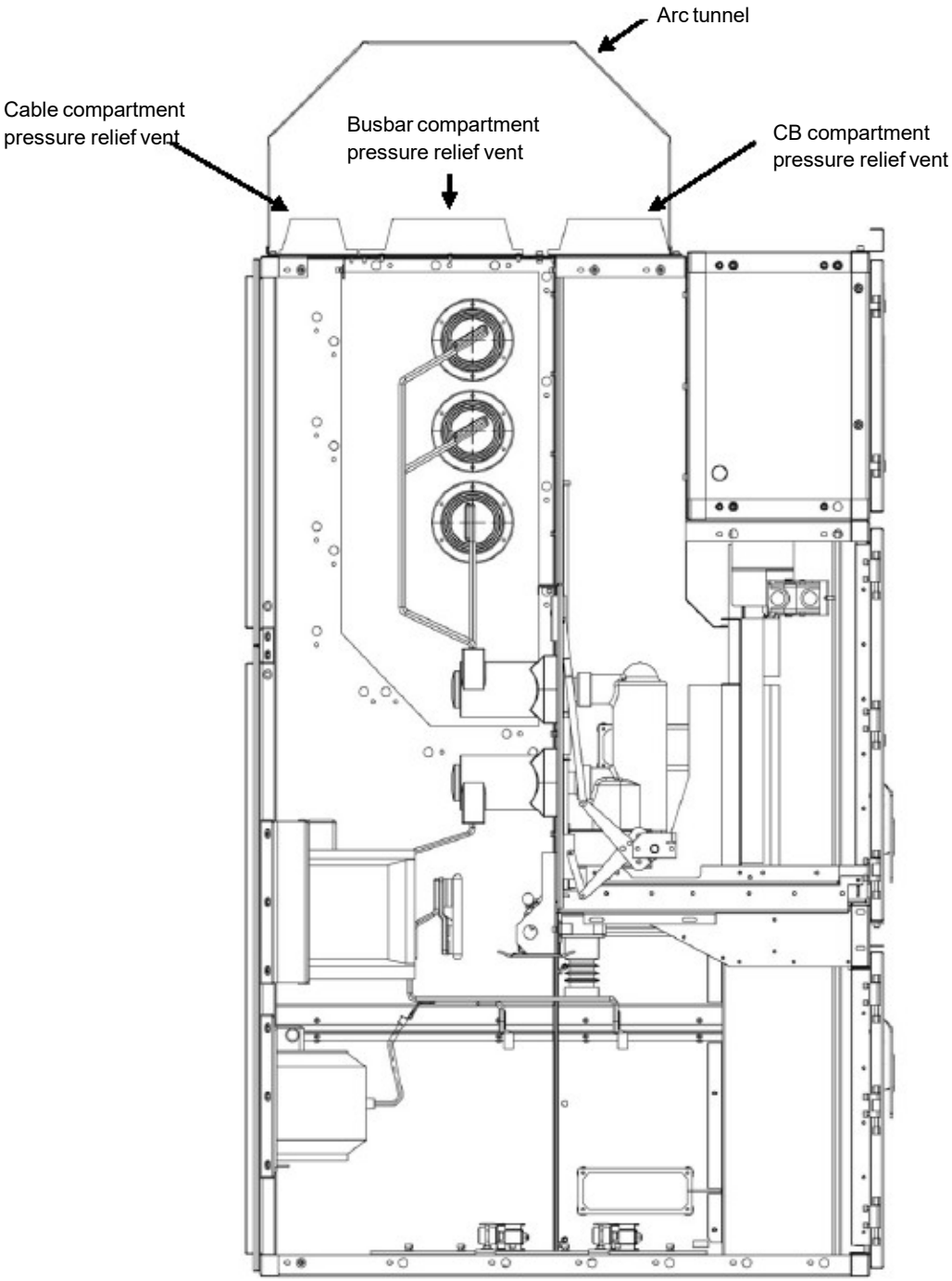



Configuration of a typical Incomer/Feeder CB panel (12kV)

### 1.14.4 Variants of type 12 kV,1250A Switchgear

A typical configuration of a panel with circuit breaker, cable connector, current and voltage transformers and an arc tunnel to vent out hot ionised gases under an internal arc fault.

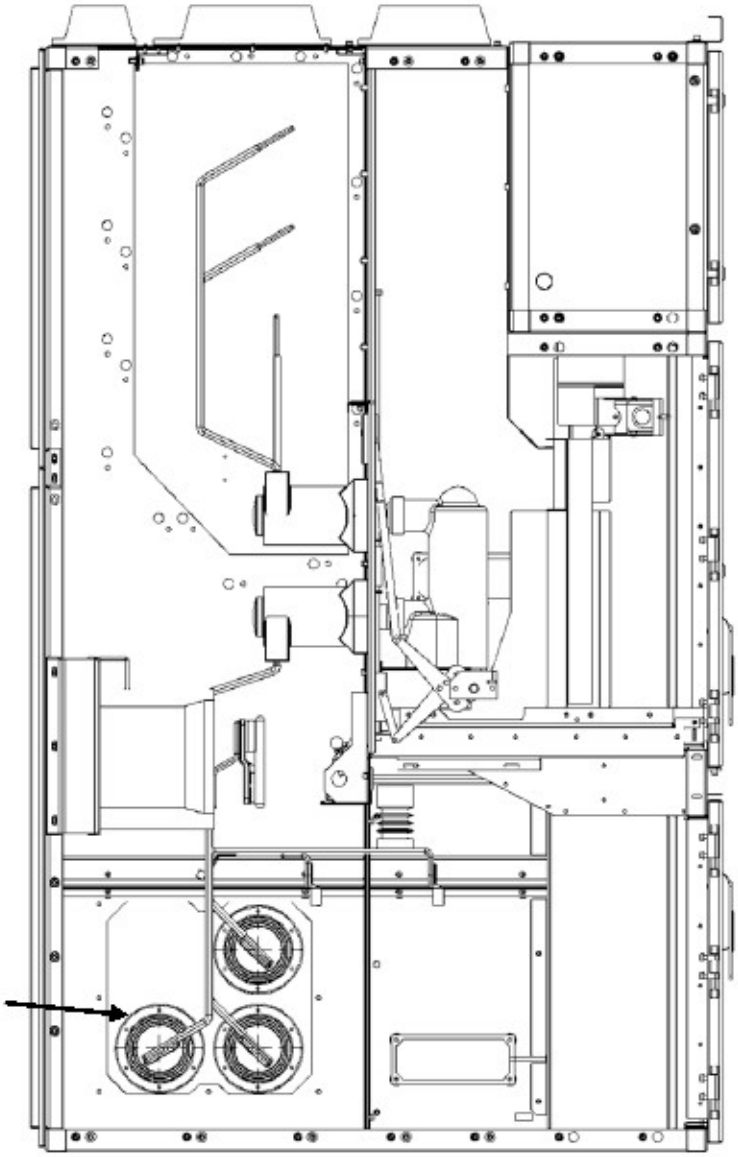
The arc tunnel is utilised when the floor to ceiling height of 4.9m is not available or the design require s venting of hot ionised gases outside the switchroom.




Configuration of a panel with an arc tunnel (12kV)

### 1.14.5 Variants of type AMS 12 kV,1250ASwitchgear

A typical configuration of a Bus-Tie panel with circuit breaker, current transformers, earth switch and a coupling section to connect the bus-section to the bus riser panel.

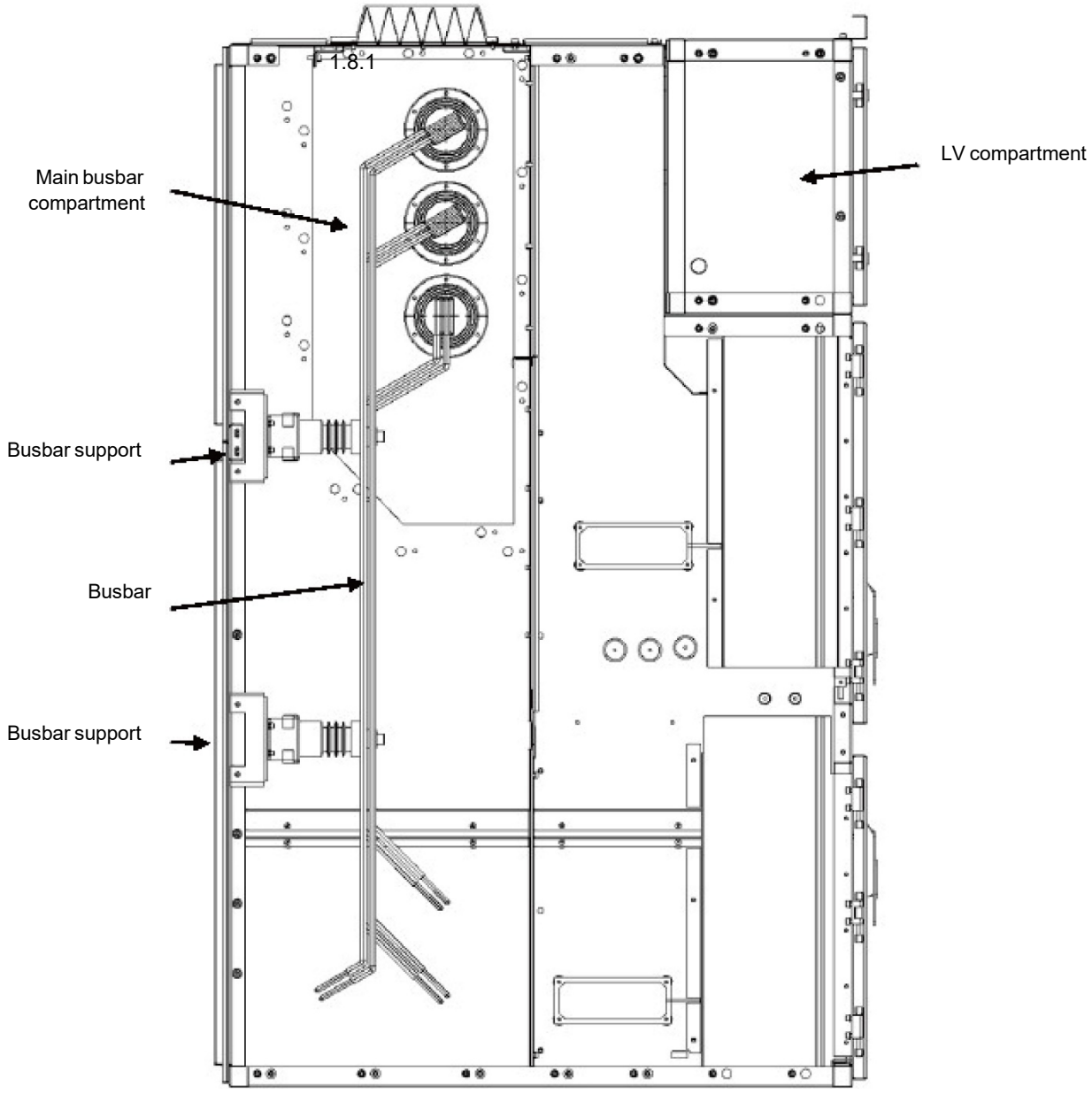



A typical configuration of Bus-Tie panel (12kV)

### 1.14.6 Variants of type AMS 12 kV,1600A/2000/2500A Switchgear

A typical configuration of a Busbar Riser panel.

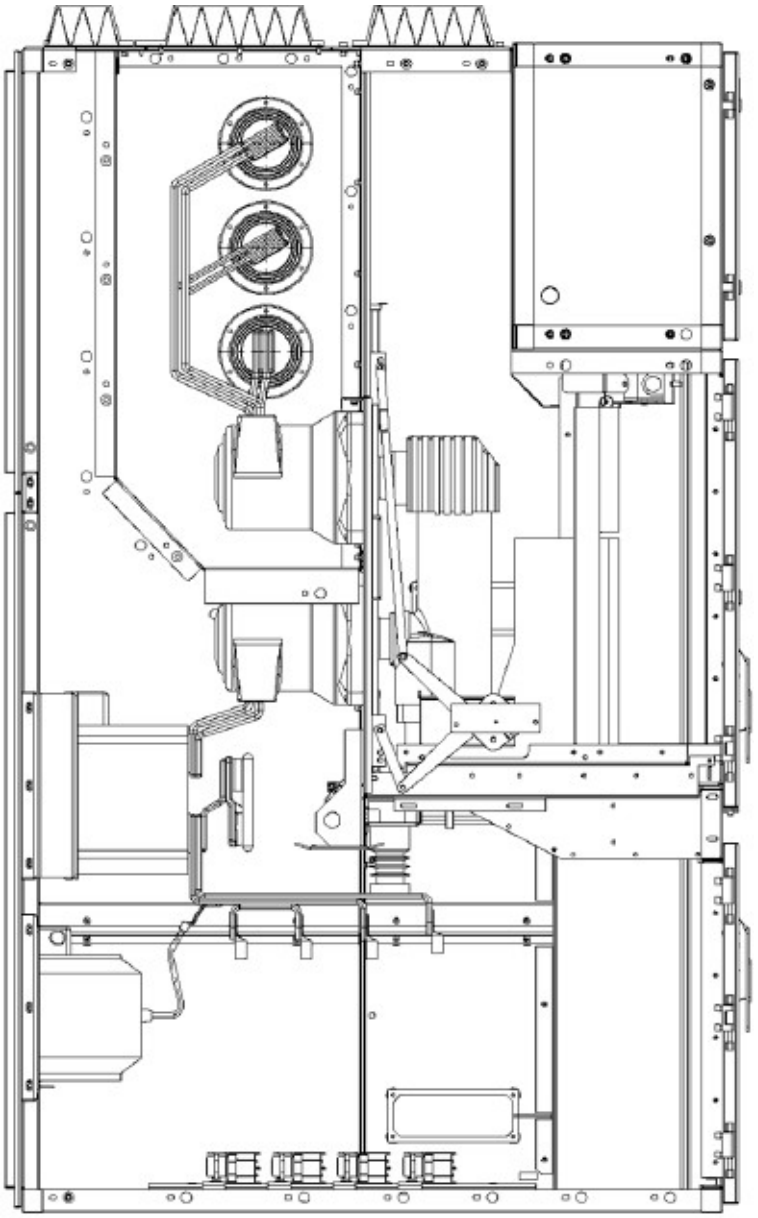
A bus riser panel is required in conjunction with a Bus tie panel (see fig 1.6).The Bus -riser panel can also be fitted with an earth switch, to be used to earth a section of the main busbar.




A typical configuration of a Bus-riser panel (12kV)

### 1.14.7 Variants of type AMS 12 kV, 2000/2500A Switchgear

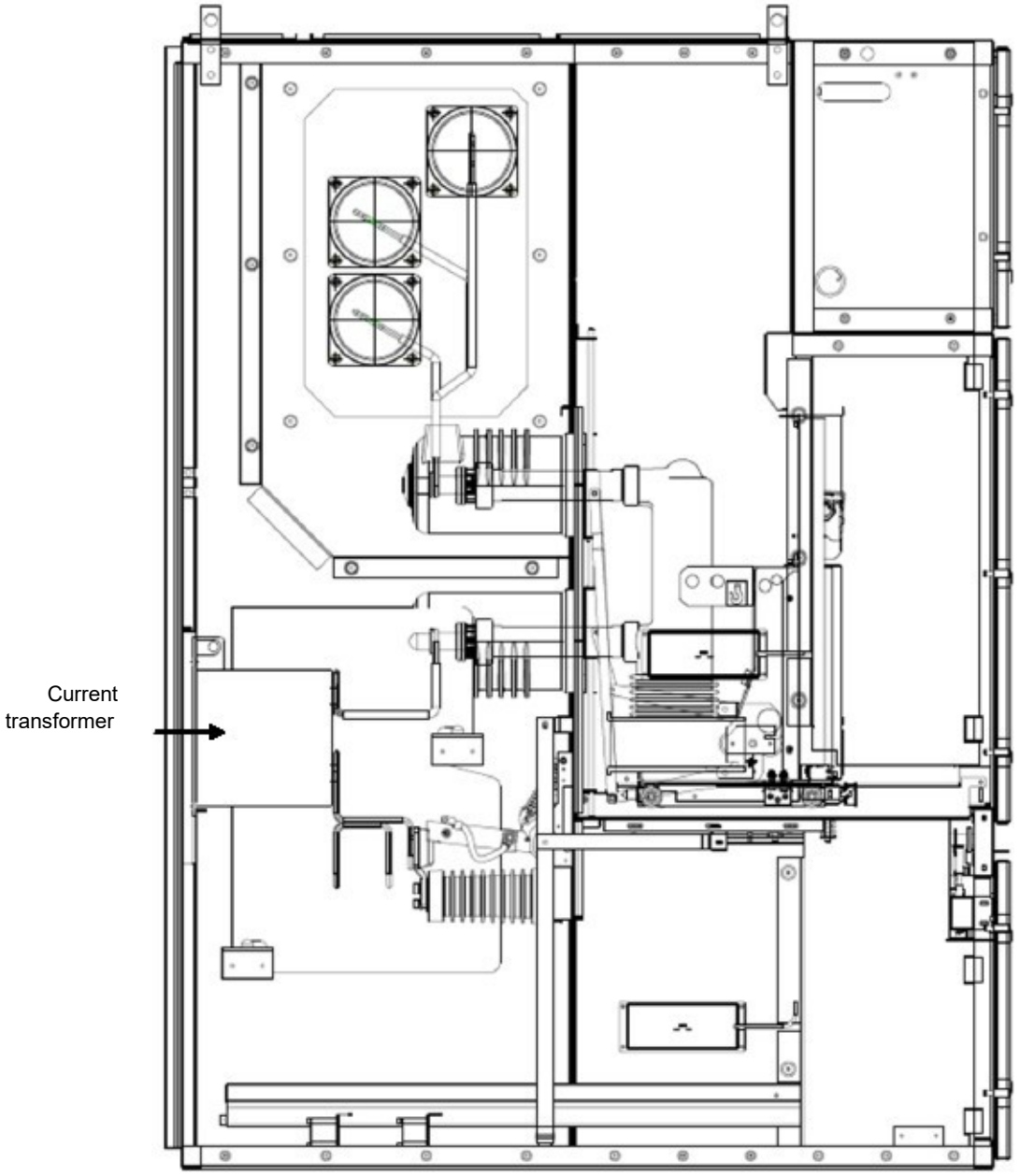
A typical configuration of an Incomer/Feeder circuit breaker panel with cable connector, current and voltage transformers.



Typical configuration of an Incomer/Feeder 2000/2500A CB panel (12kV)

### 1.14.8 Variants of type AMS 24 kV, 630/1250A Switchgear

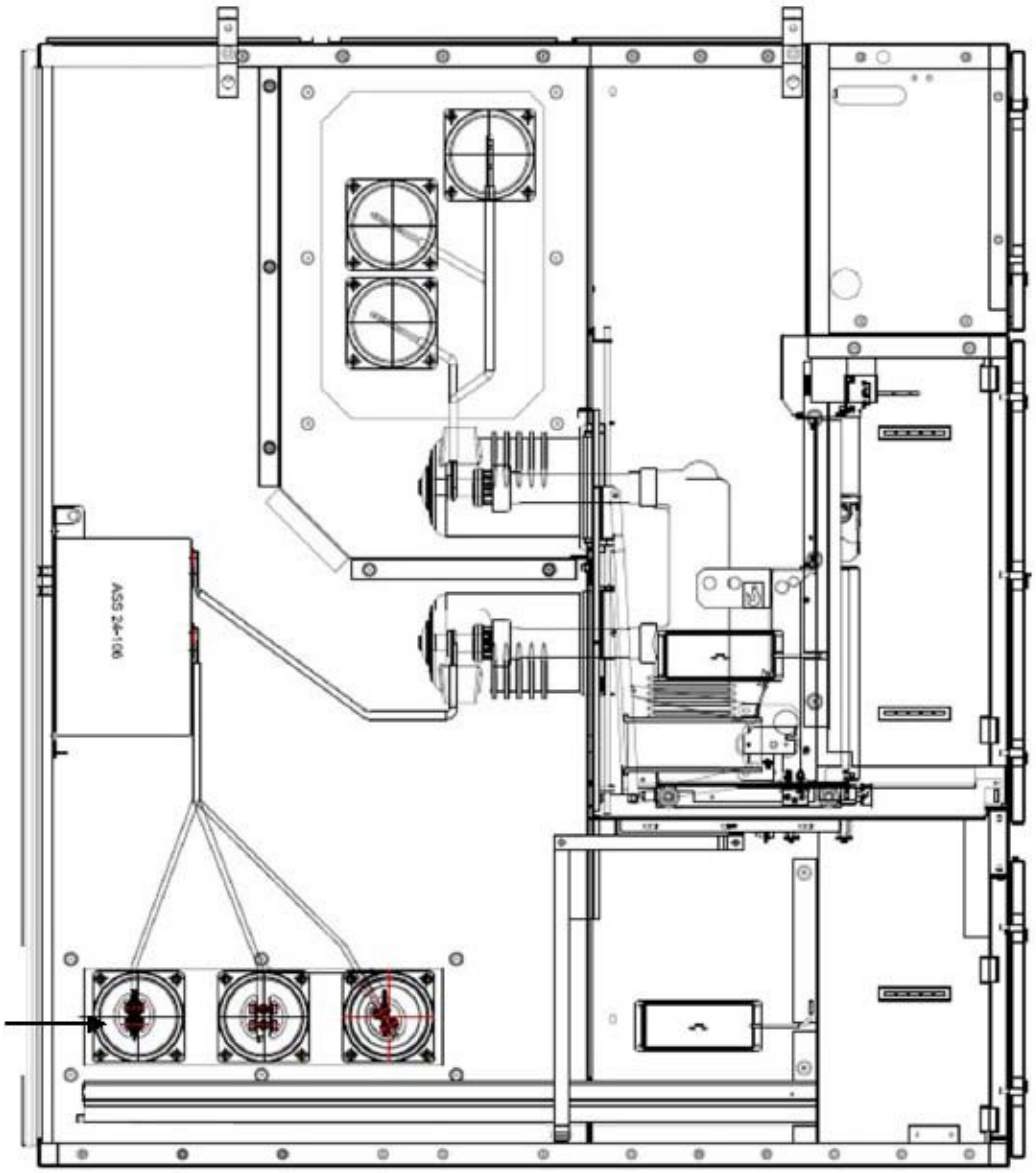
A typical configuration of a feeder panel with circuit breaker, cable connector, current transformer.




Configuration of a typical Feeder CB panel (24kV)

### 1.14.9 Variants of type AMS 24 kV, 1250A Switchgear

A typical configuration of a Bus-Tie panel with circuit breaker, current transformer and a coupling section to connect the bus-section to the bus riser panel.

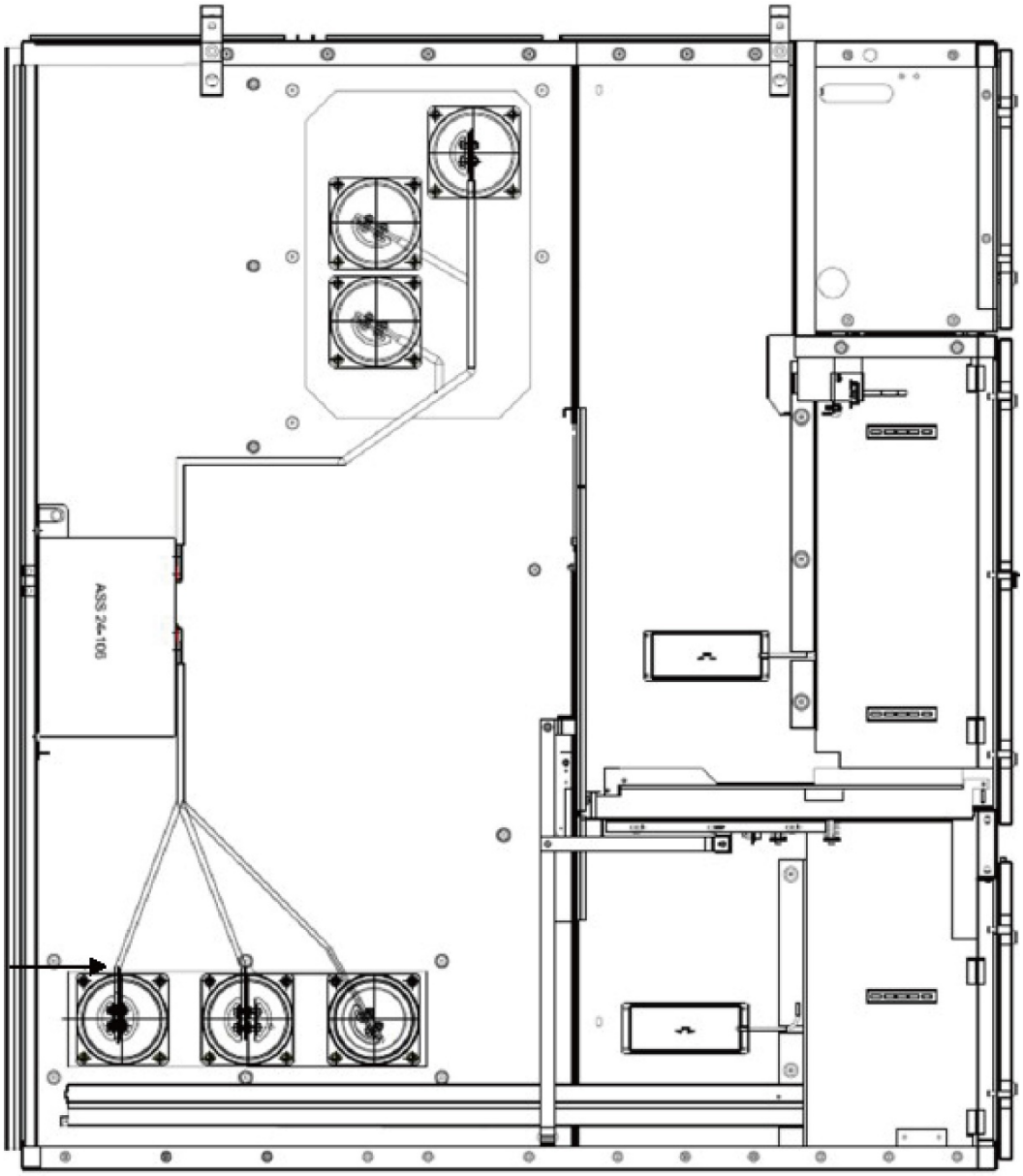



A typical configuration of Bus -Tie panel (24kV)

### 1.14.10 Variants of type AMS 24 kV, 1250A Switchgear

A typical configuration of a Bus-Riser with bus CT.

A bus riser panel is required in conjunction with a Bus tie panel (see fig 1.11).

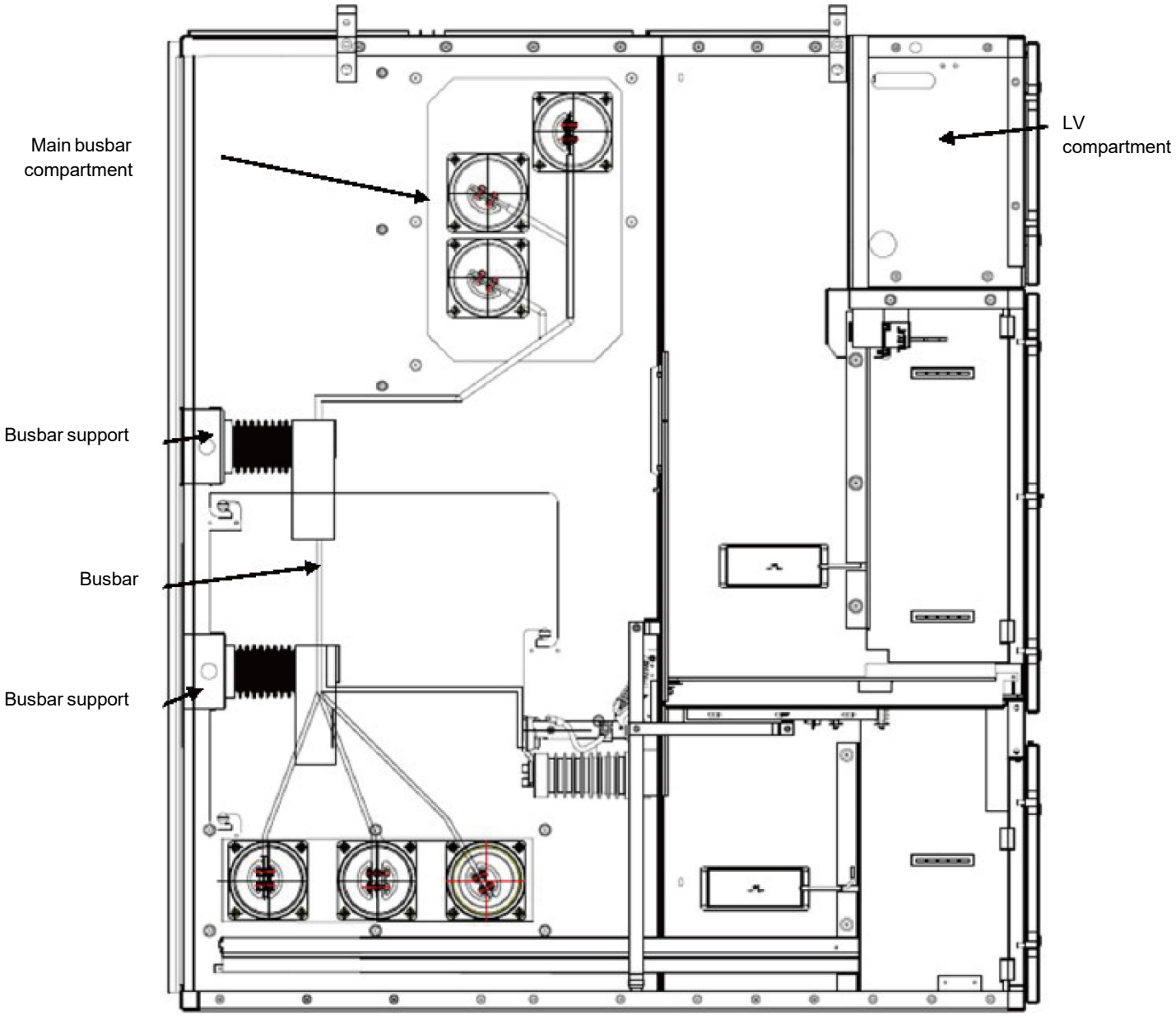



A typical configuration of Bus -Riser with Bustie CT panel (24kV)

### 1.14.11 Variants of type AMS 24 kV, 1250A Switchgear

A typical configuration of a Busbar Riser panel.

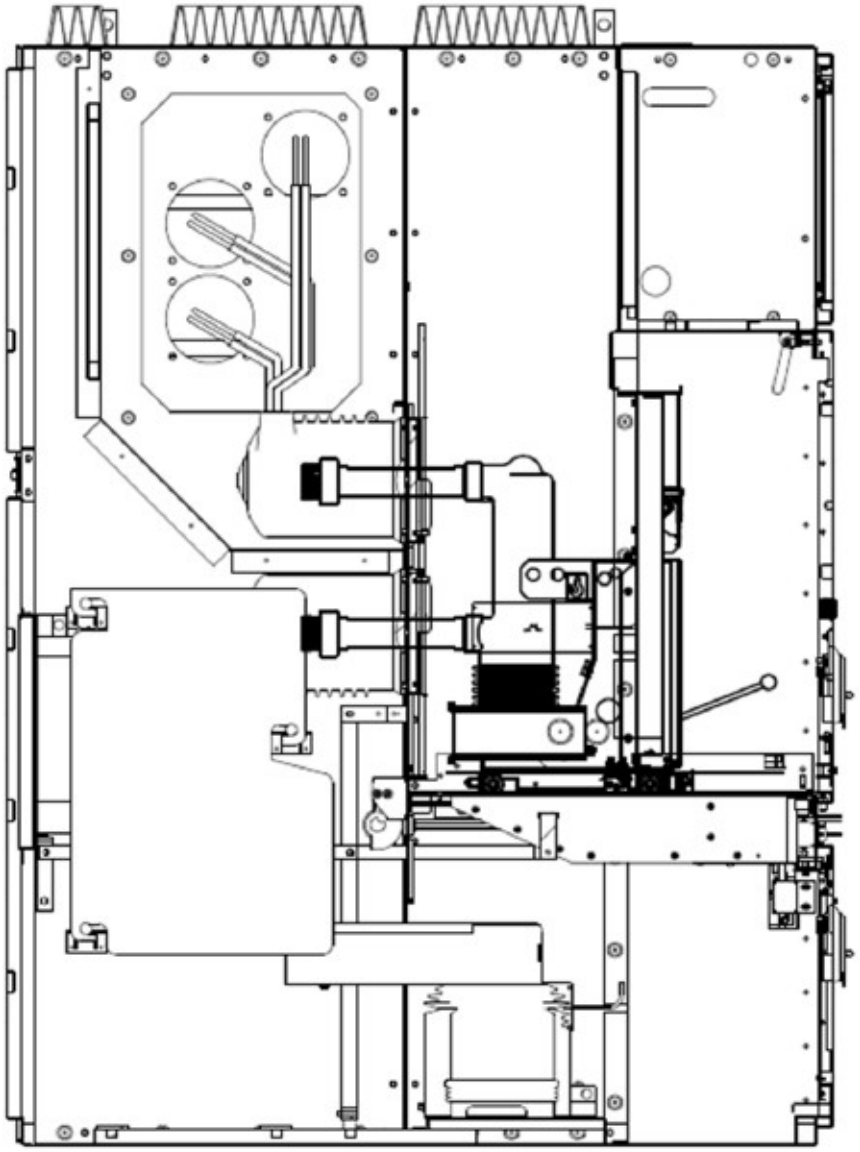
A bus riser panel is required in conjunction with a Bus tie panel (see fig 1.11).The Bus-riser panel can also be fitted with a earth switch, to be used to earth a section of the main busbar.




A typical configuration of a Bus -riser panel (24kV)

### 1.14.12 Variants of type AMS 24 kV, 1600A/2000A Switchgear

A typical configuration of a feeder/incomer panel with circuit breaker, voltage transformer and current transformer.



Configuration of a Feeder/Incomer panel with VT and CT (24kV)

# 2 Operation

## 2.1 General

The relative work and operating procedures must be carried out carefully by trained specialists familiar with the installation, taking into account all the relative safety regulations according to the AS, IEC and other relevant professional standard bodies, as well as any Australian and site work regulations and instructions. All switching operations must be performed by skilled electrical technicians with the door closed.

The operating tools necessary for the safe operation of the switchgear are shown below.

Manual Racking Handle

Manual Spring Charge Handle

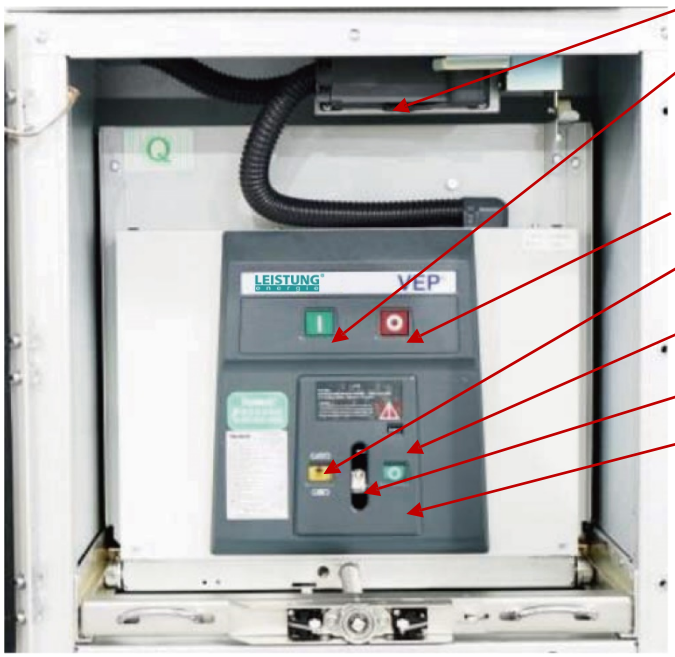
Earth Switch Operating Handle

Emergency Tripping Bar

## 2.2 Circuit Breaker Identification

### 2.2.1 Front indication and controls

The mechanical status indicators can be viewed on the front of the CB. All CB status can be confirmed with the CB inserted into its compartment and the compartment door closed via a viewing window.




Low Voltage plug connector

CB close mechanical pushbutton. Note – This button will only be operational if blocking and/or optional undervoltage magnets are energised and in their healthy states.

CB open mechanical pushbutton

CB closing spring charged/discharged status

Mechanical operations counter

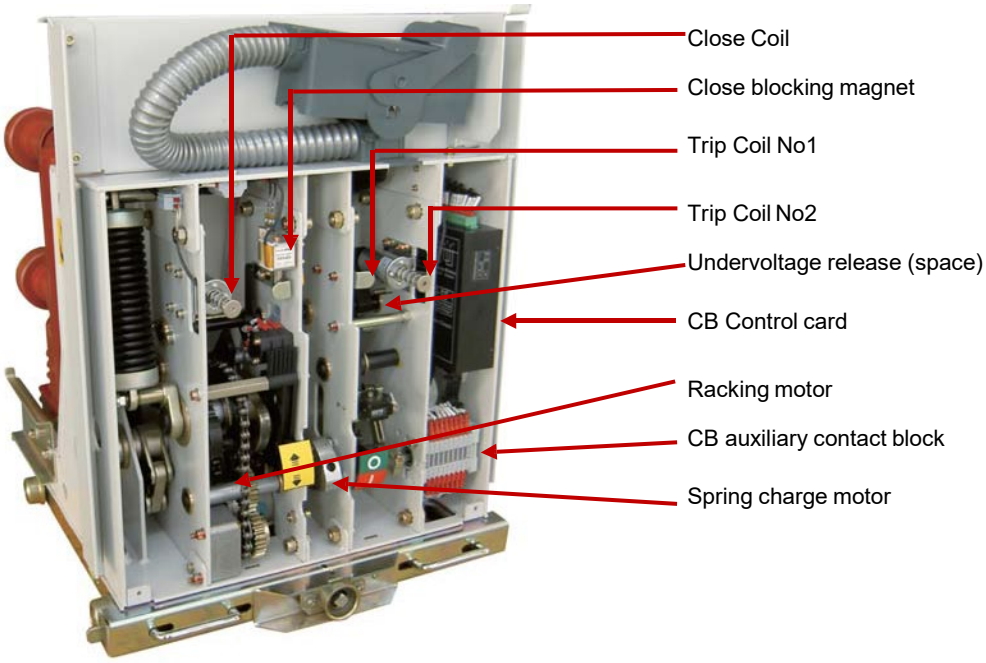
Manual spring charge mechanism

CB open/closed status

To manually charge the closing spring, insert the manual spring charge handle into the manual spring charge mechanism and move the handle in an up/down manner until the closing spring status indicates the spring is fully charged. The change in indication from discharged to charged coincides with a loss of resistive pressure to the charging handle operation.

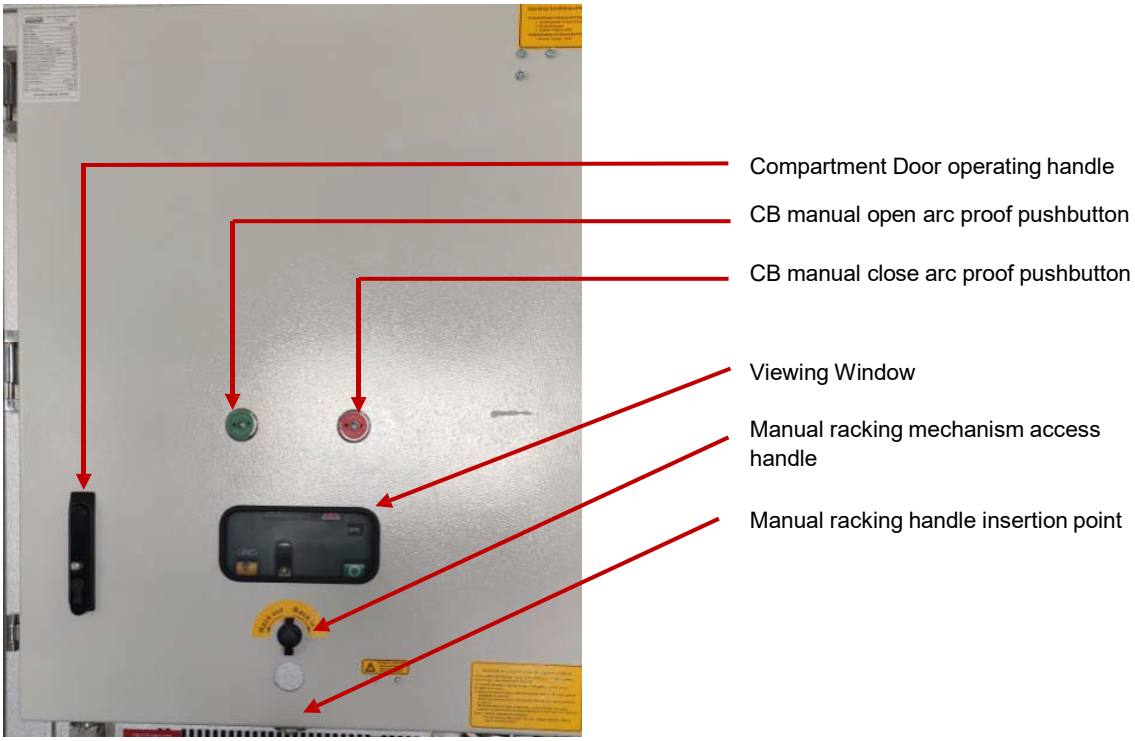
### 2.2.2 Internal identification

The main internal electrical and mechanical operating components of the CB are




### 2.2.3 CB Compartment door identification

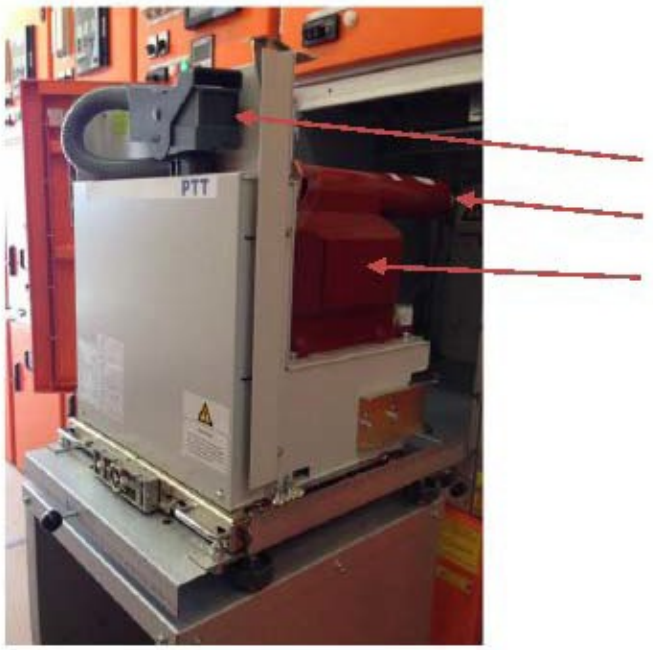
The main mechanical components fitted to the CB compartment door are



## 2.3 Withdrawable Voltage Transformers

There are 2 available options with respect to installing Withdrawable Voltage Transformer truck into a panel. A withdrawable VT truck can replace a CB in a panel and derive its supply from the main busbars of the switchboard (BUS VT) or it can be located in the cable compartment of a standard panel and derive its supply from the cable side supply (CABLE VT).

Insertion of a Bus VT basically follows the same procedure as that to insert and connect a CB as detailed in section 2.5 below. Insertion of a Cable VT used a separately supplied ramp to insert and connect the low voltage connections.




BUS VT Arrangement

Low Voltage plug connector

Voltage transformer primary connection

Voltage transformer block


CABLE VT Arrangement

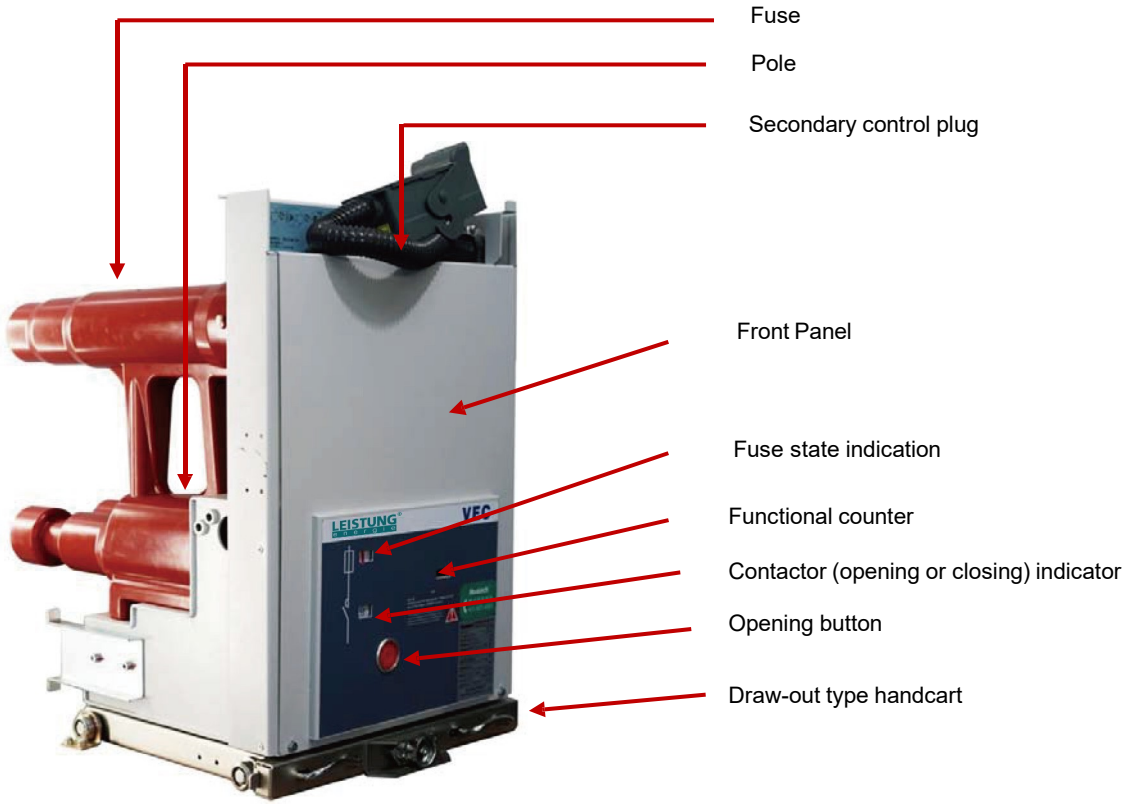
Connected position latches

Low Voltage plug connector (see inset below for connected arrangement)

Removable floor mounted insertion ramp

## 2.4 Vacuum Contactor

The contactor is a three-phase integrated device， and mainly used for motor starting/braking and opening and closing of capacitor bank. The main parts and components of the VEC vacuum contactor are




the VEC vacuum contactors enhance compatibility with other related products and can be directly splice with AMS switchgear. Insertion of a contactor basically follows the same procedure as that to insert and connect a CB as detailed in section 2.5 below.

## 2.5 CircuitBreaker Racking

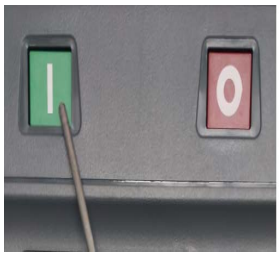
The following sections detail the procedure to take a circuit breaker, insert it into a panel and then rack it into the service position.

Note: this procedure also applies to a Bus VT panel where the CB is replaced with a withdrawable VT arrangement.

### 2.5.1 Insertion of CB into compartment

1. Ensure that the CB is in the open position and if necessary mechanically trip the CB using the emergency tripping bar.
2. Lift the CB onto the CB trolley. Retract the CB truck locking pins by moving the two handles on the truck horizontally towards each other. Lock the CB in position at the front of the trolley by releasing the two handles allowing the locking pins to lock the CB in place on the trolley.
3. Open the CB compartment door by rotating the compartment door operating handle in an anti-clockwise direction. This will lift the entire door on its hinges and clear of its locking mechanisms and allow the door to swing open.
4. Ensure the LV plug interlock mechanism is in the latched position (see section 2.6.1)
5. Position the CB trolley (with CB) in front of the compartment and lock in place. To lock the trolley in place the 2 locating pins at the front of the trolley must engage with the corresponding holes in the front of the switchgear panel, the spring loaded catch at the front of the trolley must engage and lock onto the latch mounted on the front of the switchgear panel.
6. Unlock the CB from the trolley and while holding the two handle in, push the CB back into the CB compartment and release the locking pins. The handles will engage into the locating slots in the compartment housing.
7. THE CB IS NOW LOCATED IN THE TEST (OR ISOLATED) POSITION.
8. Release the trolley spring loaded catch and move away from the front of the panel.

CB in Open Position




Tripping CB via mechanical trip pushbutton

CB Truck LH locking pin retracted

CB truck RH locking pin retracted

CB Truck LH locking pin in position on CB trolley

CB Truck RH locking pin in position on CB trolley

CB Truck RH locking pin in position on CB trolley

CB Truck locked on CB trolley

CB Compartment door rotated to open

CB Compartment door opened

LV Plug Interlock mechanism in latched position

CB Trolley position in front of compartment

CB Trolley locked in position

CB being inserted into compartment

CB inserted and locked in Test Position

CB Trolley catch handle

CB Trolley catch released

CB Trolley released

### 2.5.2 LV Plug connection

1. To allow the CB to be racked in, the LV plug must be connected which engages the LV plug interlock mechanism. This mechanism is detailed in section 2.7.1 below and prevents the CB compartment door from closing unless the LV plug is properly connected.

LV Plug in foreground with socket behind

LV Plug engaged with socket

### 2.5.3 CB Compartment Door Close

1. With the CB locked in the isolated position and the LV plug connected, the CB compartment door can be closed engaging all locking and interlocking mechanisms around the door perimeter.
2. The CB compartment utilises a lever mechanism to lift the door and disengage the locking mechanisms around its perimeter. To close the door and engage the perimeter locks, first ensure the door is hinged shut then rotate the handle 90 degrees in a clockwise direction. The door will drop down approximately 10mm engaging the perimeter locks allowing the handle to be inserted into its housing.

CB Compartment door open

CB Compartment door closed ready to engage perimeter locks

CB Compartment door with perimeter locks engaged

### 2.5.4 CB Lock

1. Before racking can occur, ensure the CB Lock is released and in its reset position as detailed in section 2.7.5 below.

CB Lock reset

### 2.5.5 Earth Switch Interlock

1. Before racking can occur, the panel earth switch must be open as detailed in section 0 below. This ensures that the mechanical interlock between CB and earth switch is in the correct position to allow CB racking.

Earth switch operating mechanism open indication

Earth switch open mechanical indicator visible through cable compartment door viewing window (arrow points to indicator)

### 2.5.6 CB Racking Blocking Magnet (optional)

1. Before racking can occur, the CB racking blocking magnet (when fitted), must be energised and in its healthy state. Refer to panel electrical schematics to verify whether one is fitted.

### 2.5.7 CB Manual racking operation (refer to section 2.4.8 for CB electrical racking operation)

1. Rotate the manual racking access handle to reveal racking handle insertion point.
2. When this handle is rotated, a limit switch is activated disabling motorised racking operations when fitted.
3. Insert the manual racking handle and turn clockwise (approximately 20 turns) until the CB hits the stops at the rear of the CB compartment. The manual racking access handle can also be released upon insertion of the racking handle.
4. Remove the racking handle allowing the access handle to reset.
5. THE CB IS NOW IN THE SERVICE POSITION.

Manual racking access handle operated

Limit switch operated to disable motorised racking (looking from inside of door)

Manual racking handle inserted for operation

Manual racking access handle released

**2.5.8 CB Electrical racking operation (refer to section 2.4.7 for CB manual racking operation)**

1. Referring to the electrical control circuits for the panel, initiate the electrical racking in of the CB either by pushbutton activation, PLC/SCADA control or via the 'Rack In' pushbutton on the front of the racking controller (where enabled)
2. THE CB IS NOW IN THE SERVICE POSITION.

THE RACKING OF THE CB FROM SERVICE POSITION TO TEST POSITION TO TROLLEY IS THE REVERSE OF THIS PROCESS.

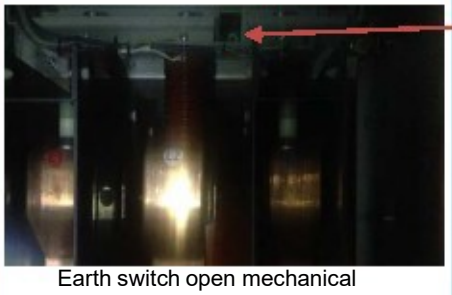
## 2.6 Earth Switch Operation

**2.6.1 Earth switch closing**

The panel earth switch has a snap action mechanism which acts independently of the rotation of the drive shaft. Before attempting to close the earth switch the following steps must be completed in order:

1. Verify that the earth switch is in the open position by visually checking the status indication at the earth switch operating mechanism and via the mechanical indicator visible through the cable compartment door viewing window.
2. Ensure that the panel CB is in the TEST or ISOLATED position as detailed in section 2.4 above. This ensures that the mechanical interlock between CB and earth switch is in the correct position to allow earth switch closing. Ensure the earth switch mechanical interlocks are released and in their reset positions as detailed in section 2.7.5 below.
3. Ensure the earth switch blocking magnet is energised and in its healthy state. Refer to panel electrical schematics to verify whether one is fitted.
4. With all earth switch interlocks in reset position, push the earth switch access gate down and insert the earth switch operating handle. Rotate the handle in a clockwise direction until the switch operates and then remove the operating handle.
5. Verify that the earth switch is in the closed position by visually checking the status indication at the earth switch operating mechanism and via the mechanical indication visible through the cable compartment door viewing window.
6. With the earth switch closed, the cable compartment door can be opened dis-engaging all locking and interlocking mechanisms around the door perimeter. Operation of the cable compartment door is similar to the CB compartment door detailed in section 2.4.3 above.

Earth switch operating mechanism open indication



Earth switch open mechanical indicator visible through cable compartment door viewing window (arrow points to indicator)

Earth Switch interlocks in reset position

Earth switch access gate operated

Earth switch handle inserted for operation

Earth switch operating mechanism closed indication

Earth switch closed mechanical indicator visible through cable compartment door viewing window (arrow points to indicator)

Cable compartment door open

**2.6.2 Earth switch opening**

The panel earth switch has a snap action mechanism which acts independently of the rotation of the drive shaft. Opening the earth switch is essentially the reverse of the closing sequence detailed in section 2.5.1 above. Before attempting to open the earth switch the following steps must be completed in order:

1. Cable compartment door must be closed engaging all locking and interlocking mechanisms around the door perimeter.
2. Ensure the earth switch blocking magnet is energised and in its healthy state. Refer to panel electrical schematics to verify whether one is fitted.
3. Ensure the earth switch mechanical interlocks are released and in their reset positions as detailed in section 2.7.5 below.
4. With all earth switch interlocks in reset position, insert the earth switch operating handle. Rotate the handle in an anti-clockwise direction until the switch operates and then remove the operating handle. The earth switch access gate should reset to its original position.
5. Verify that the earth switch is in the open position by visually checking the status indication at the earth switch operating mechanism and via the mechanical indication visible through the cable compartment door viewing window.

**2.6.3 Earth switch viewing camera (optional**

If fitted the panel will include a closed circuit television (CCTV) camera is focused on the earth switch fixed contacts. The camera is connected via an RJ45 outlet on the panel control door and is power by the hand held monitor. To operate the camera to confirm the closed status of the panel earth switch the following steps must be completed:

1. Connect the hand held monitor to the panel via a CAT5e patch cord and video balun fitted to the “VIDEO IN” BNC connection.
2. Switch the hand held monitor on via the switch on the side of the unit.
3. When the menu screen appears press the number “2” button.
4. Vision of the panel earth switch fixed contacts will appear.

## 2.7 Electrical Interlocks

Electrical interlocks have been incorporated in to the design to ensure correct and safe operation of the switchgear and prevent unauthorised movements or operation of switchgear.

### 2.7.1 CB Compartment door limits

In conjunction with the CB compartment door interlock detailed in section 2.7.2 below, the CB compartment door has 2 independent limit switches activated by opening the door. They are incorporated in the electrical interlock sequence associated with electrical racking of the CB. The compartment door limits are located behind the 2 plungers shown in the photo below. When the compartment door is closed, the plungers are depressed operating the limits and allowing electrical racking. When open When the CB compartment door is open, the plungers are released, releasing the limits and preventing electrical racking.


CB Compartment door limit switches are located behind the 2 plungers shown.

### 2.7.2 CB Lock limit

In conjunction with the CB Lock detailed in section 2.7.5 below, the CB Lock limit is incorporated in the electrical interlock sequence associated with electrical racking of the CB. When the CB mechanical interlock is engaged, the limit is activated preventing electrical racking. When the CB mechanical interlock is reset, the limit is released permitting electrical racking to occur.

CB Lock (view from front of panel)

CB Lock mechanism (internal view with limit switch behind)

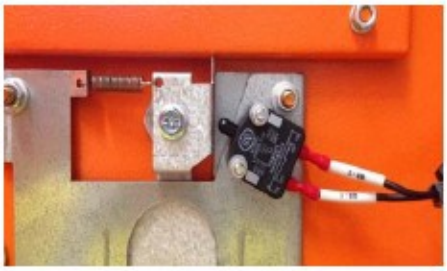
### 2.7.3 Manual Racking access handle limit

The manual racking access handle limit is incorporated in the electrical interlock sequence associated with electrical racking of the CB. When the access handle is operated to allow insertion of the manual racking handle, the limit is activated preventing electrical racking. When the access cover is returned to its closed position, the limit is released permitting electrical racking to occur.

Manual racking access handle operated

Limit switch operated disabling motorised racking (looking from inside of door)

Manual raching access handle released



Limit switch released enabling motorised racking (looking from inside of door)

### 2.7.4 Earth Switch position limit

There are 2 separate banks of Earth Switch position limits, one for the open position and one for the closed. An earth switch open position limit is incorporated in the electrical interlock sequence associated with electrical racking of the CB. When the panel earth switch is closed, the limit is activated preventing electrical racking. When the earth switch has been opened, the limit is released permitting electrical racking to occur. These limit switches are located with the earth switch operating mechanism located in the right hand side of the panel.

### 2.7.5 Blocking magnets (optional)

There are three blocking magnets that can be fitted each preventing an operation unless specific conditions are met. These are the CB close blocking magnet, CB racking motor blocking magnet and earth switch operation blocking magnet. In some circumstances, process controls require these operations to be interlocked with remote equipment with can be simply achieved using these blocking magnets.

## 2.8 Mechanical Interlocks & Locks

Mechanical interlocks have been incorporated in to the design to ensure correct and safe operation of the switchgear and prevent unauthorised movements or operation of switchgear.

### 2.8.1 LV Plug Interlock

The LV plug interlock prevents the CB from being either mechanically or electrically racked into the service position unless the LV plug is correctly fitted. When the LV plug is fitted, a sliding gate allows a door operated plunger to pass through a keyhole in the gate, allowing the compartment door to be closed and racking operations to proceed.

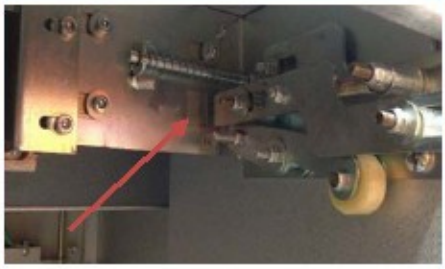
When the LV plug is removed, the sliding gate retracts preventing i) the door operated plunger operation, ii) closing of the compartment door, and iii) any racking operation.

Sliding Gate

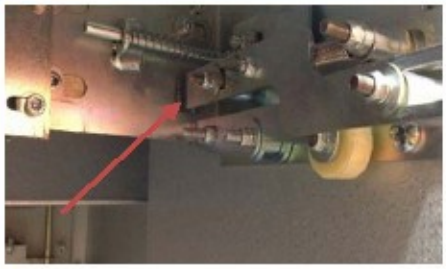
LV Plug Interlock with sliding gate retracted

LV Plug connected with sliding gate operated

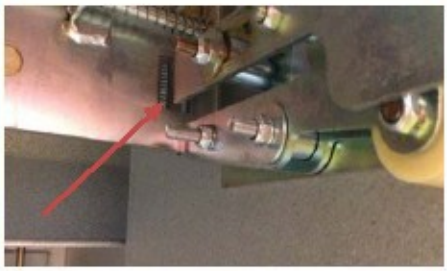
When the CB is removed from the housing, the LV plug interlock must be placed into the latched position to enable the compartment door to be closed without the CB inserted. When the CB is re-inserted into the compartment, the latch is reset via a roller incorporated into the mechanism to ensure racking is again prevented without the LV plug being correctly fitted to the CB.



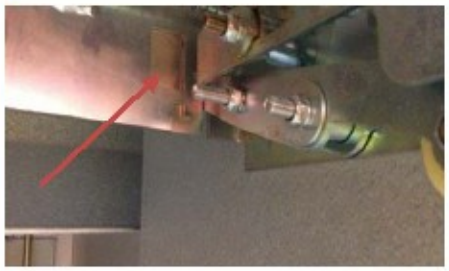
LV plug interlock with sliding gate retracted and keyhole closed (arrow points to keyhole)



Sliding gate operated and latched via roller arm (arrow points to keyhole)



Keyhole open allowing plunger operation (arrow points to keyhole)



Sliding gate reset (arrow points to keyhole)

### 2.8.2 CB Compartment Door Interlock

In conjunction with the CB compartment door limits detailed in section 2.6.1 above, the racking mechanism on the CB is fitted with 2 roller actuators that are operated by closing the CB compartment door. If these actuators are not operated (i.e. if the compartment door is not closed), the manual racking handle cannot be inserted thus preventing racking.

In addition to the racking interlock on the CB compartment door, another interlock mechanism prevents the compartment door from being opened once racking has commenced. A mechanical hook latches onto a bracket fitted to the compartment door preventing opening until the CB is returned to the TEST position.

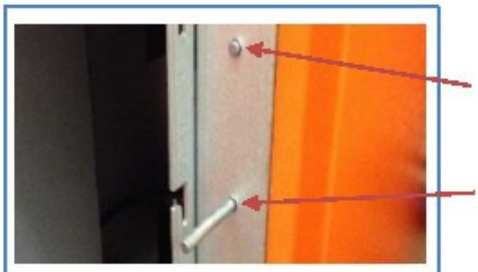
CB mounted roller actuator

CB mounted mechanical hook

CB compartment door hook bracket

### 2.8.3 Cable Compartment Door Interlock

The cable compartment door is interlocked with the panel earth switch to prevent the door opening until the earth switch is closed. A separate mechanism also prevents the earth switch from being opened until the compartment door is closed.




Cable compartment door open

### 2.8.4 CB – Earth Switch Interlock

The CB – Earth Switch interlock prevents the earth switch closing unless the CB is in the test position or has been removed from the panel. The opposite is also true that the CB cannot be racked in from test to service positions if the earth switch is closed.

When the CB is in the service position (or any position between service and test), the CB truck prevents the extension of the interlock arm, preventing operation of the earth switch access gate and insertion of the earth switch operating handle. Only when the CB is in the service position can the interlock be operated, allowing the access gate to open and closing of the earth switch. With the earth switch closed, the access gate remains extended providing a mechanical stop behind the CB truck preventing racking.

Earth Switch access gate

CB - Earth Switch interlock arm reset

CB - Earth Switch interlock arm operated

### 2.8.5 CB Lock

In conjunction with the CB Lock limit detailed in section 2.6.2 above, the CB Lock prevents the CB from being manually racked into the service position via a mechanical stop that extends behind the CB truck. When the CB Lock is engaged and pulled forward, the mechanical stop extends preventing the CB truck from being racked in. The lock slide plate can be locked in this position using a standard 6mm padlock or with an optionally fitted key interlock. With the interlock slide plate reset, the mechanical stop is retracted allowing racking operations.

CB Lock & mechanical stop location (identified by arrow)

CB truck stop extended

CB truck stop reset

CB Lock operated and locked with key interlock

CB Lock operated and locked with personal padlock

### 2.8.6 Earth Switch Lock

There are 2 Earth Switch Lock mechanisms; the first one locking the earth switch open and the second locks the earth switch closed. Each lock mechanism is fitted with a slide plate identical to the CB lock which can be locked in position using a standard 6mm padlock or with an optionally fitted key interlock. With the slide plate extended, the earth switch is locked in position and with the slide plate reset, the earth switch is free to operate.

Earth Switch open and locked with key interlock


Earth Switch open and locked with personal padlock

Earth Switch closed and locked with key interlock


Earth Switch closed and locked with personal padlock

### 2.8.7 CB Shutter Lock

To improve safety during routine maintenance, the Busbar and Cable shutter mechanisms can be individually padlocked in the closed position to prevent accidental operation and exposure to live conductors. The operating mechanism of each shutter has the provision for padlocking on both sides of the enclosure.


CB Enclosure with Busbar and Cable shutters in rear

Shutter mechanism identifying padlock positions for both busbar & cable shutters

## 2.9 Troubleshooting

Some of the common operational issues faced, possible causes and solutions are listed below.

| Problem | Possible Cause | Solution |
|---|---|---|
| Circuit breaker cannot be racked in from TEST position to SERVICE position | 1. Circuit breaker is closed<br>2. Earth switch is closed<br>3. Racking blocking magnet is not energised<br>4. Electrical racking controller has tripped<br>5. CB lock engaged | 1. Trip circuit breaker<br>2. Open earth switch<br>3. Check supply to blocking magnet<br>4. Reset racking controller by pressing reset button on front of controller<br>5. Reset CB lock |
| Circuit breaker cannot be racked out from SERVICE position to TEST position | 1. Circuit breaker is closed<br>2. Racking blocking magnet is not energised<br>3. Electrical racking controller has tripped | 1. Trip circuit breaker<br>2. Check supply to blocking magnet<br>3. Reset racking controller by pressing reset button on front of controller |
| Earth switch cannot be closed | 1. Circuit breaker is in SERVICE position<br>2. Operation blocking magnet is not energised<br>3. Earth switch lock engaged | 1. Trip circuit breaker and rack out to TEST position<br>2. Check supply to blocking magnet<br>3. Reset earth switch lock |
| Earth switch access gate does not reset | Drive shaft of earth switch is not in correct position | Ensure off position indicator “O” is visible and in the centre of the indication cutout. Re-insert operating handle and manoeuvre if necessary and remove handle |
| CB Compartment door cannot be closed | LV plug interlock not engaged | Fit LV plug to socket |
| Cable compartment door cannot be opened | Earth switch is open | Close earth switch |
| Circuit breaker cannot be electrically operated | 1. Auxiliary supply not available<br>2. LV plug not connected<br>3. CB not racked into SERVICE or TEST position | 1. Check supply to operation circuits<br>2. Remove control plug, re-insert and lock into position<br>3. Rack CB into SERVICE or TEST position |

# 3 Installation of Switchgear

## 3.1 General Requirements

The installation of the switchgear must be carried out carefully by trained specialists familiar with the installation, taking into account all the relative safety regulations according to the AS, IEC and other relevant professional standard bodies, as well as any Australian and site work regulations and instructions. Common panel details are listed below:

| Rated Voltage | 12kV | | | 24kV | |
|---|---|---|---|---|---|
| Control panel width | 650mm | 800mm | 1000mm | 800mm | 1000mm |
| Aisle width | 1350mm | 1650mm | 2050mm | 1650mm | 2050mm |
| Door width | 650mm | 800mm | 1000mm | 800mm | 1000mm |
| Approximate weight | 850kg | 1000kg | 1200kg to 1400kg | 1000kg to 1200kg | 1200kg to 1400kg |

For switchroom internal ceilings lower than 4900mm or when additional safety measures are required to expel hot ionised gases from the switchgear, a type tested arc tunnel should be fitted. The tunnel extends the entire length of the switchgear arrangement covering the switching, busbar and cable compartments pressure relief vents in the top of the switchgear.

Where required, to expel the hot ionised gases outside the switchroom, the arc tunnel can be vented through the switchroom wall via a weatherproof, hinged relief vent arrangement.

The switchgear is designed for front access to all components and can therefore be installed against a wall. It is however preferable where possible to maintain a minimum clearance of 600mm from the rear of the panel.

## 3.2 Installation of panels

Panels can be installed in place using a combination of factory fitted top lifting lugs and customer supplied steel pipe rollers. Rollers should be positioned between the sides of the panel and never from the front of the panel to the rear. When mechanical or hydraulic jacks are used for final positioning, care should be taken to ensure a uniform distribution of force over the side under pressure by the use of blocks or beams.

To avoid misalignment of panel to panel joining holes and in extreme cases binding of mechanisms, the switchroom floor must be level both longitudinally and transversally. Typically a tolerance of ±1mm over 1m in either direction is suitable and will ensure no issues joining panels together and during operation.

Where the floor level does not meet these requirements, the use of recessed levelling rails should be considered.

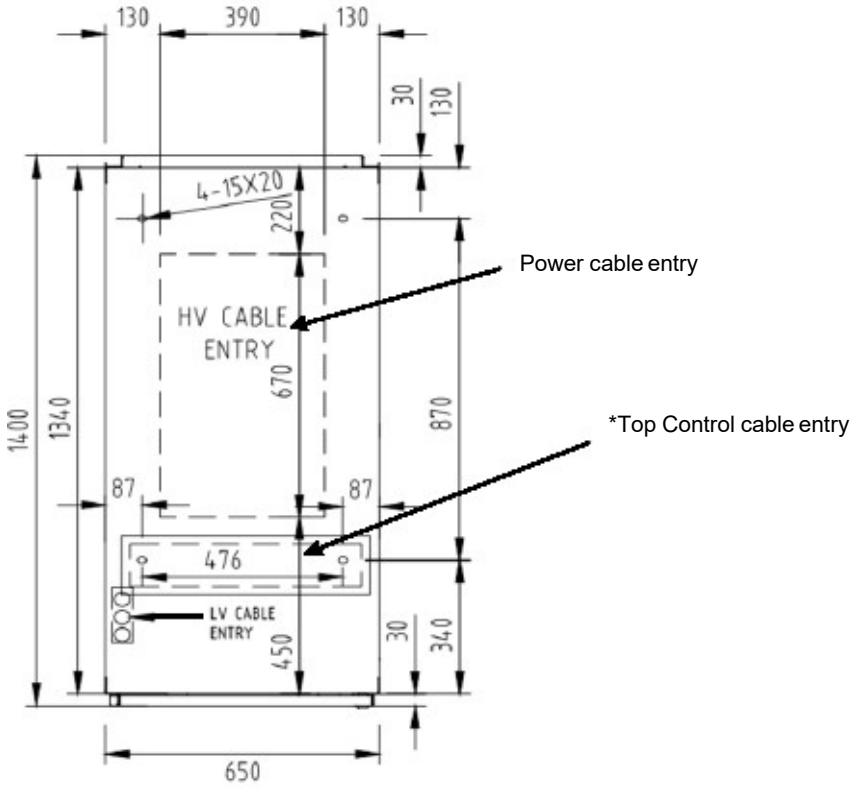
When securing panels to the switchroom floor, it is advisable to first install all inter-panel bolts which avoids any misalignment of floor mounting holes as panels are bolted together. Where 10 or more panels are installed as a single suite, consideration should be given to installing the middle panels first and extending in both directions.

For arrangements of 3 or more panels, it is not necessary to install all 4 hold downs bolts in every panel and consideration can be given to installing hold down bolts only in every second or third panel.

## 3.3 Floor Penetrations

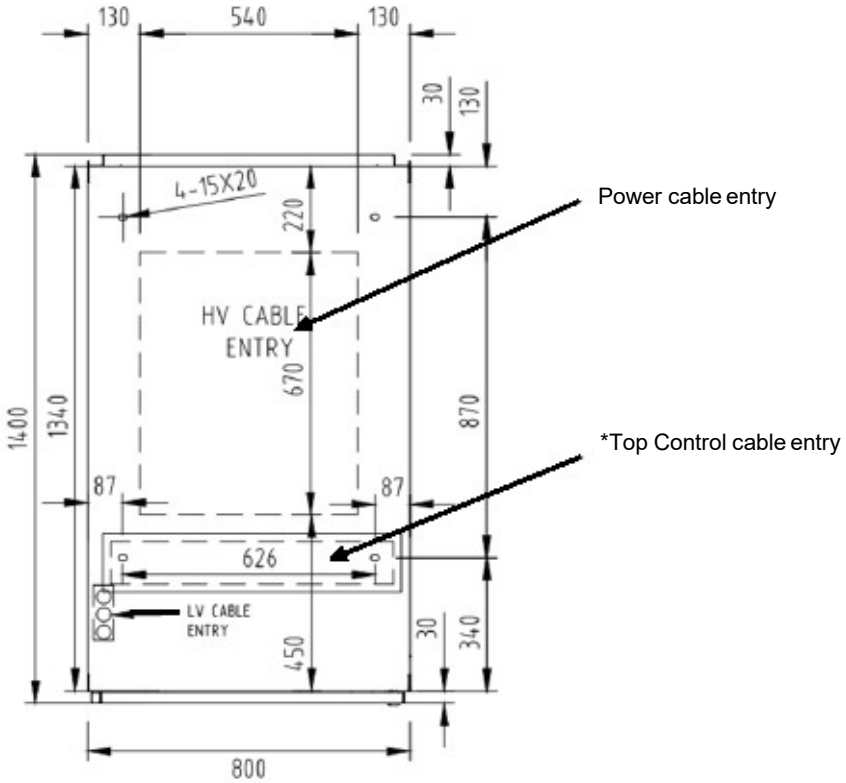
The floor penetrations for power cables and control cables need to be allowed for in the switchroom design and civil works. The diagrams below detail panel mounting and cable penetration details for different width panels. Cabling to the low voltage instrument chambers can also enter the panel via top mounted gland plates as shown.

### 3.3.1 650mm Wide Panel (12kV)



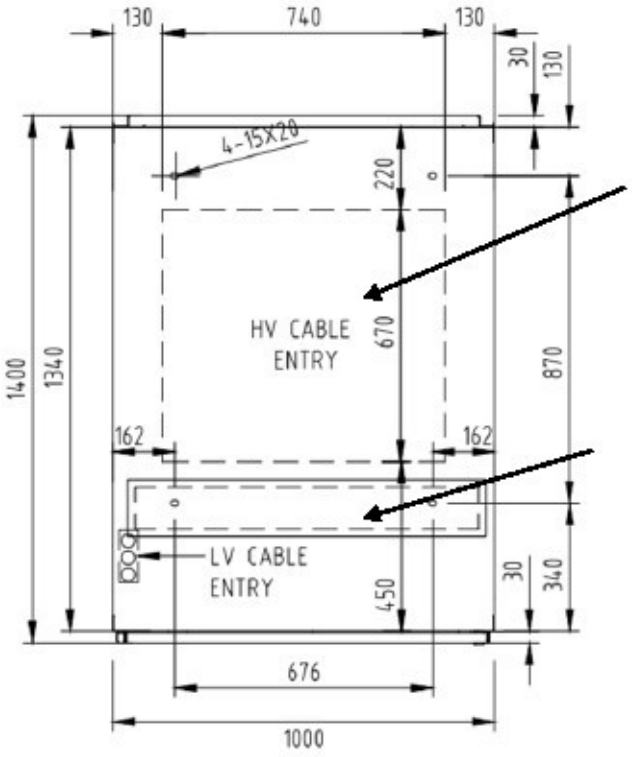

* Control cable entry from TOP is through the gland plate of the LV compartment.

### 3.3.2 800mm wide panel (12kV)



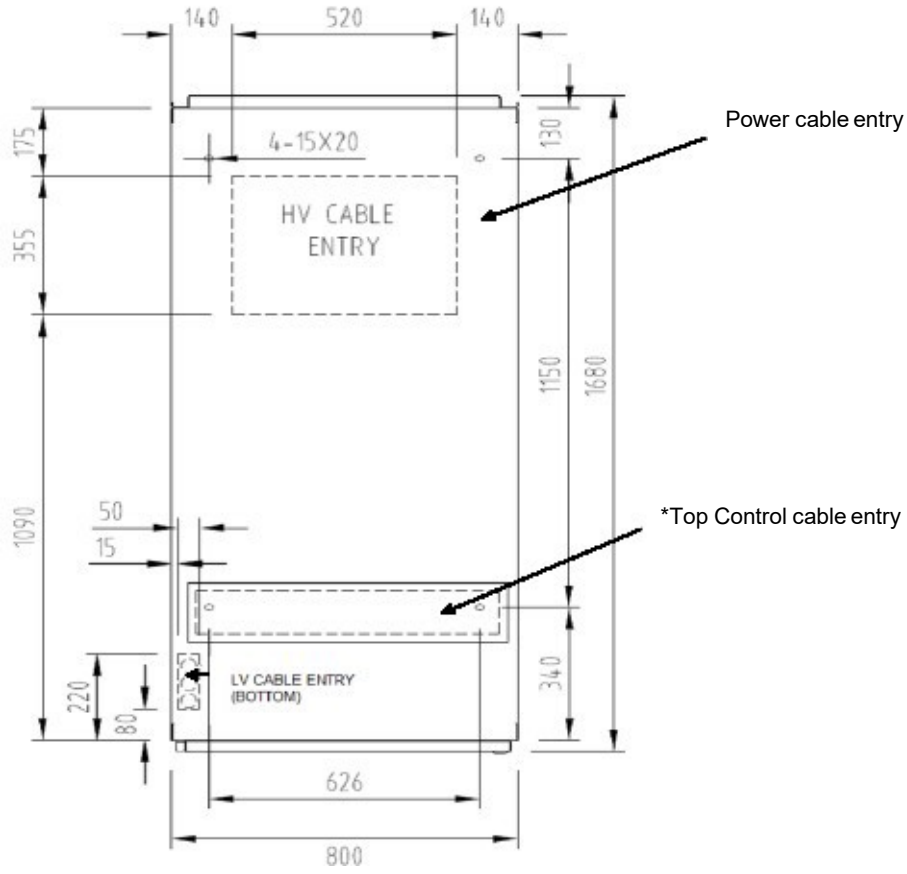

* Control cable entry from TOP is through the gland plate of the LV compartment.

### 3.3.3 1000mm Wide panel (12kV)



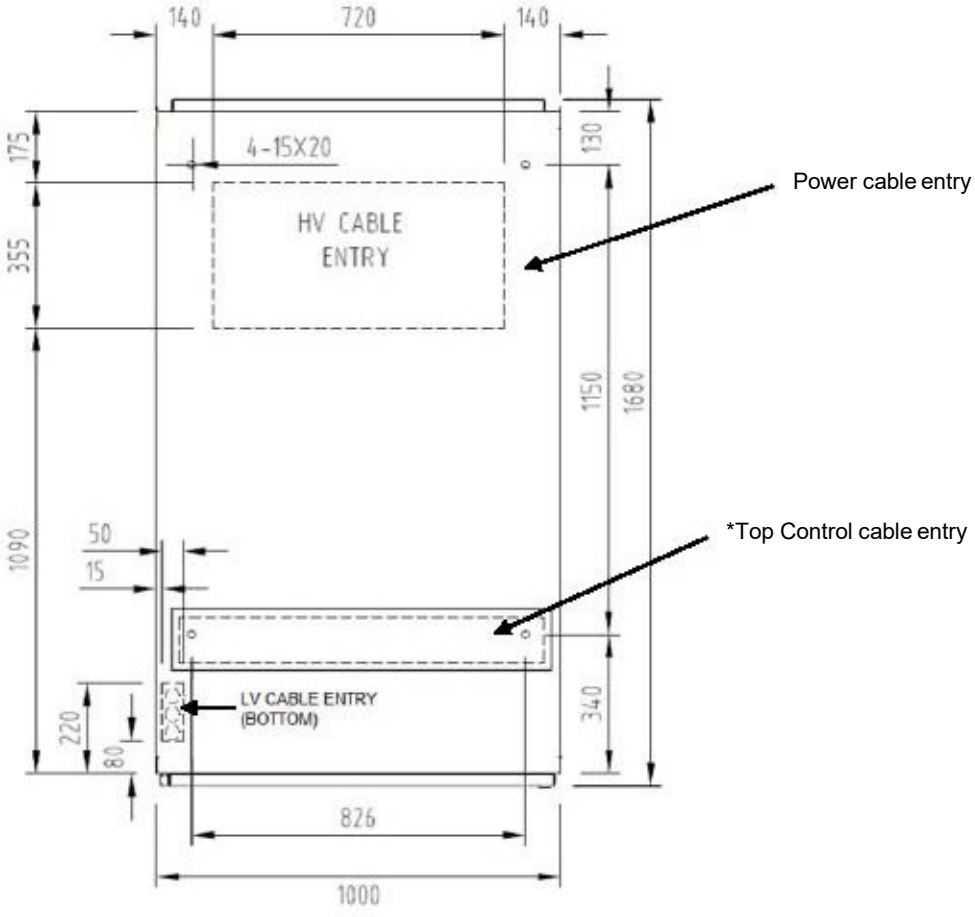

* Control cable entry from TOP is through the gland plate of the LV compartment.

### 3.3.4 800mm Wide panel (24kV)




* Control cable entry from TOP is through the gland plate of the LV compartment.

### 3.3.5 1000mm Wide Panel (24kV)




* Control cable entry from TOP is through the gland plate of the LV compartment.

## 3.4 Main Busbar Installation

The torque settings listed below are to be followed for installation of the main busbar system. Failure to follow these recommendations may result in component failure under situations of extreme stress.

| Spouts/Bushings | |
|---|---|
| M10 | 20 Nm |
| M12 | 40 Nm |
| M16 | 80 Nm |

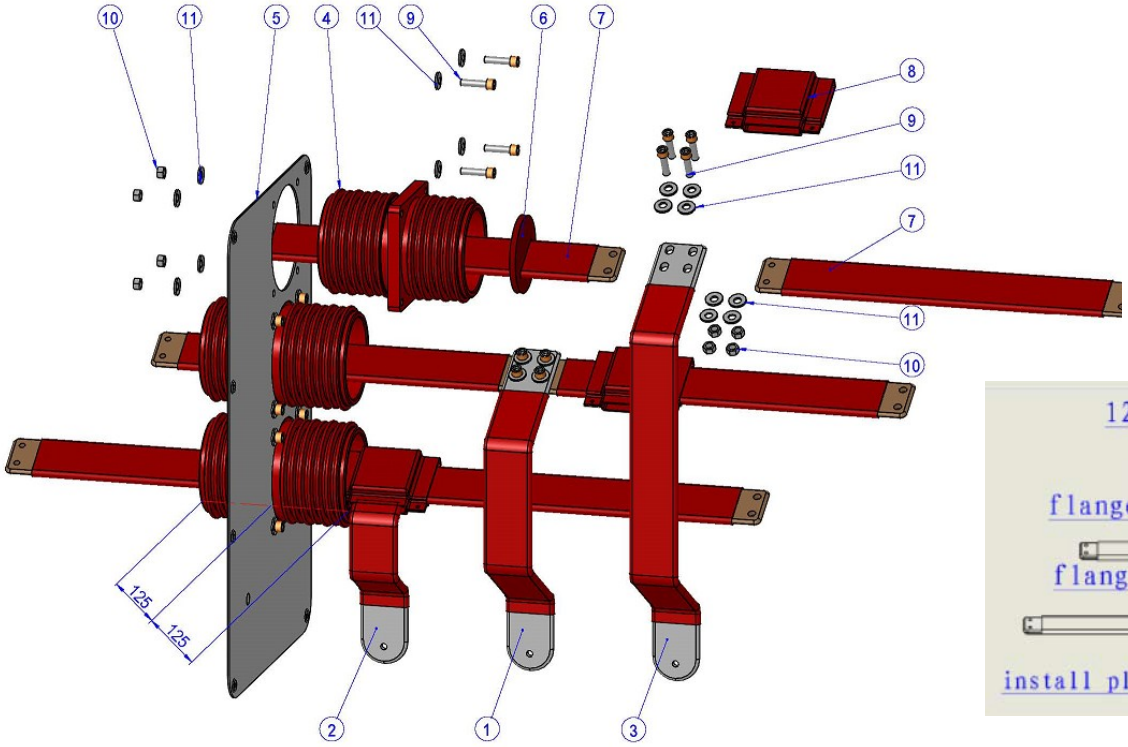
| Panel Bolting | |
|---|---|
| M10 | 47 Nm |
| M20 | 160 Nm |
| | |

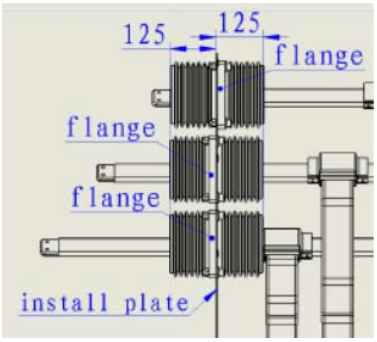
| Post Insulators | |
|---|---|
| M10 | 32 Nm |
| M16 | 110 Nm |
| M20 | 220 Nm |
| | |

| Busbar Connections | |
|---|---|
| M8 | 23 Nm |
| M10 | 47 Nm |
| M12 | 80 Nm |
| M16 | 196 Nm |

The main busbar arrangement is a modular arrangement consisting of individual main busbar sections between each panel joined at the panel branch/dropper bars. All main and dropper busbars are insulated and bolted joints are fitted with insulation shields to reduce the probability of internal arc faults occurring. Insulated through bushings fitted with rubber supporting pads allow busbars to pass between panels. There are four different configurations of the panel busbar depending upon current ratings.

### 3.4.1 Busbar Connection




| No. | Description | Qty |
|---|---|---|
| 1~3 | Panel branch/dropper busbar | 3 |
| 4 | Through bushing | 7 |
| 5 | Busbar Chamber | 1 |
| 6 | Rubber support pad | 3 |
| 7 | Main busbar | 6 |
| 8 | Insulation shield | 3 |
| 9 | Hex bolt M12x45 DIN 912 | 32 |
| 10 | Hex nut, M12 DIN 934 | 32 |
| 11 | Contact washer, top & bottom, Size 12 DIN 6796 | 64 |

### 3.4.2 Main busbar dimensions for on-site connections

When the AMS switchgear arrives on site, the main busbars for connection of each panel, phase to phase, will be supplied in a separate crate. To facilitate ease of connection, the following table shows the different combinations and dimensions of the required busbars.

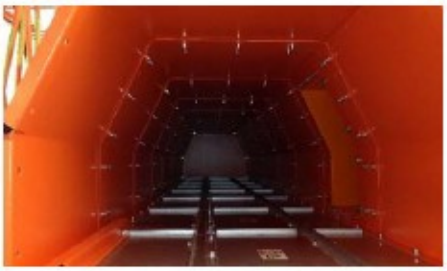
| From Panel | To Panel | Dimensions (mm) | | |
|---|---|---|---|---|
| | | A-A | B-B | C-C |
| 650 Panel | 650 Panel | 645 | 645 | 645 |
| 650 Panel | 800 Panel | 660 | 720 | 780 |
| 650 Panel | 1000 Panel | 695 | 820 | 945 |
| 650 Panel | 650 End Panel | 687 | 687 | 687 |
| 650 Panel | 800 End Panel | 702 | 762 | 822 |
| 650 Panel | 1000 End Panel | *(747) 737 | *(872) 862 | *(997) 987 |
| 650 Panel | 650 Bus-Tie Panel | 687 | 687 | 687 |
| 650 Panel | 800 Bus-Tie Panel | 702 | 762 | 822 |
| 650 Panel | 1000 Bus-Tie Panel | *(747) 737 | *(872) 862 | *(997) 987 |
| 650 End Panel | 650 Panel | 687 | 687 | 687 |
| 650 End Panel | 800 Panel | 702 | 762 | 822 |
| 650 End Panel | 1000 Panel | 737 | 862 | 987 |
| 650 Bus-Tie Panel | 650 Riser Panel | 729 | 729 | 729 |
| 650 Riser Panel | 650 Panel | 687 | 687 | 687 |
| 650 Riser Panel | 800 Panel | 702 | 762 | 822 |
| 650 Riser Panel | 1000 Panel | 737 | 862 | 987 |
| 800 Panel | 650 Panel | 780 | 720 | 660 |
| 800 Panel | 800 Panel | 795 | 795 | 795 |
| 800 Panel | 1000 Panel | 830 | 895 | 960 |
| 800 Panel | 650 End Panel | 822 | 762 | 702 |
| 800 Panel | 800 End Panel | 837 | 837 | 837 |
| 800 Panel | 1000 End Panel | 872 | 937 | 1002 |
| 800 Panel | 650 Bus-Tie Panel | 702 | 762 | 822 |
| 800 Panel | 800 Bus-Tie Panel | 837 | 837 | 837 |
| 800 Panel | 1000 Bus-Tie Panel | *(882) 872 | *(947) 937 | *(1012) 1002 |
| 800 End Panel | 650 Panel | 702 | 762 | 822 |
| 800 End Panel | 800 Panel | 837 | 837 | 837 |
| 800 End Panel | 1000 Panel | 872 | 937 | 1002 |
| 800 Bus-Tie Panel | 800 Riser Panel | 879 | 879 | 879 |
| 800 Riser Panel | 650 Panel | 702 | 762 | 822 |
| 800 Riser Panel | 800 Panel | 837 | 837 | 837 |
| 800 Riser Panel | 1000 Panel | 872 | 937 | 1002 |
| 1000 Panel | 650 Panel | 945 | 820 | 695 |
| 1000 Panel | 800 Panel | 830 | 895 | 960 |
| 1000 Panel | 1000 Panel | 995 | 995 | 995 |
| 1000 Panel | 650 End Panel | 737 | 862 | 987 |
| 1000 Panel | 800 End Panel | 872 | 937 | 1002 |
| 1000 Panel | 1000 End Panel | 1037 | 1037 | 1037 |
| 1000 Panel | 650 Bus-Tie Panel | 737 | 862 | 987 |
| 1000 Panel | 800 Bus-Tie Panel | 872 | 937 | 1002 |
| 1000 Panel | 1000 Bus-Tie Panel | 1037 | 1037 | 1037 |
| 1000 End Panel | 650 Panel | *(997) 987 | *(872) 862 | *(747) 737 |
| 1000 End Panel | 800 Panel | *(1012) 1002 | *(947) 937 | *(882) 872 |
| 1000 End Panel | 1000 Panel | 1037 | 1037 | 1037 |
| 1000 Bus-Tie Panel | 1000 Riser Panel | *(1099) 1121 | *(1099) 1121 | *(1099) 1121 |
| 1000 Riser Panel | 650 Panel | *(997) 987 | *(872) 862 | *(747) 737 |
| 1000 Riser Panel | 800 Panel | 872 | 937 | 1002 |
| 1000 Riser Panel | 1000 Panel | *(1047) 1037 | *(1047) 1037 | *(1047) 1037 |

Note: * Dimension for Current ratings over 1250A

## 3.5 Arc Tunnel

For switchroom internal ceilings lower than 4900mm or when additional safety measures are required to expel hot ionised gases from the switchgear, a type tested arc tunnel should be fitted. The tunnel extends the entire length of the switchgear arrangement covering the switching, busbar and cable compartments pressure relief vents in the top of the switchgear.

Where required, to expel the hot ionised gases outside the switchroom, the arc tunnel can be vented through the switchroom wall via a weatherproof, hinged relief vent arrangement.



Arc Tunnel fitted to top of switchgear with vent through switchroom wall on right hand side in foreground

Complete assembled arc tunnel fitted with vent through switchroom wall on left hand side in background

Arc vent through switchroom wall

Finished switchroom wall with arc vent fitted.

In the event of an internal arc fault, all components must be inspected and replaced if damaged.

## 3.6 HV Power Cable Installation

The cable compartment has enough room for connecting a m a x i m u m o f 4 cables of up to 500mm² per phase in 650mm wide panels and up to 6 cables per phase in 800mm and 1000mm wide panels, dependent on the type of cable installed.

Generous gland plate sizing provides sufficient area for the glanding of multiple single core conductors with adequate spacing between gland plate and phase connections for single phase or three phase HV termination kits.

The switchboard earth bar is located in front of the incoming cable gland plate allowing easy connection of cable screens.

Where additional termination distance or provision for ground fault current transformers are required, under panel drop down boxes can be supplied. Termination distance can be typically increased by up to 400-500mm.

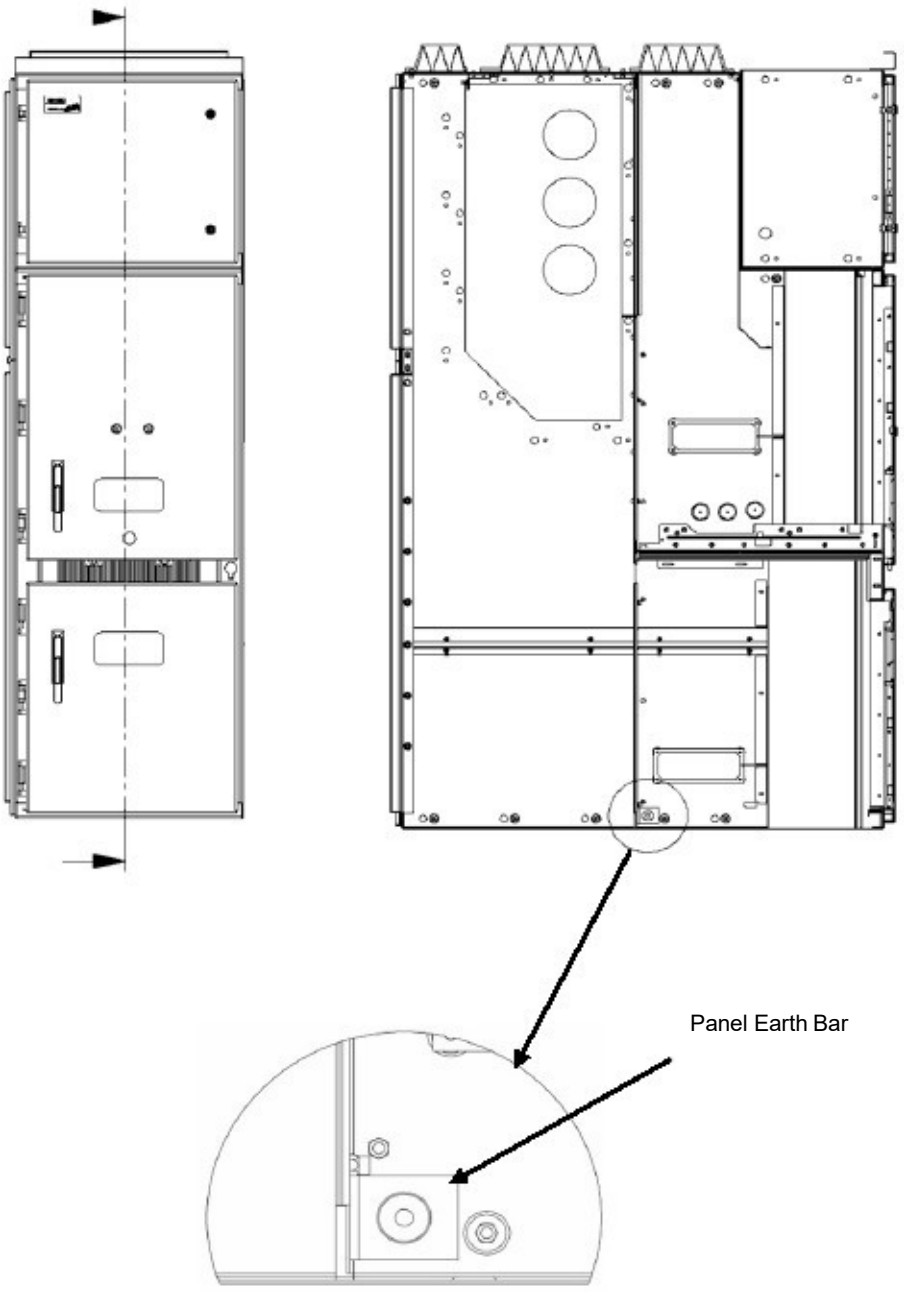
## 3.7 LV Cable Installation

As previously identified, LV control cables can enter the panel either through the floor or preferably through the gland plate located in the top of the LV compartment. If entering through the floor, the control cables pass into the covered cable duct on the left side of the panel, fastened using cable ties and enter into the low voltage compartment. The left hand side is preferred as it contains no mechanical parts and is larger than the cable duct on the right hand side of the panel.

## 3.8 Earthing

It is recommended that the AMS switchgear have at least two separate connections to the installation main earth bar.

The main earth bar runs horizontally through each panel in front of the incoming HV cable gland plate. Fishplates are provided to connect adjacent panel earth bars together to form a continuous earth through the entire arrangement. All internal equipment earthing points including circuit breaker housing and earth switch are connected to this earth bar.




## 3.9 Final Assembly Checks

After all installation and assembly steps are completed, the following should be verified as a minimum:

- Check the system for signs of damage and repair any paint damage if necessary.
- Check all of the bolted joints for tightness and torque verification marks on busbar connections.
- Remove all transport lugs.
- Insert the circuit breaker modules and connect control voltage plugs.
- Close the panel doors and fit all covers to prevent any dust and/or vermin entering the panels.

# 4 Commissioning

Only skilled technicians should commission this switchgear. All switching operations must be performed with all doors closed and bolted covers fitted with all fixing hardware.

In preparation for commissioning, the following work should be completed as a minimum prior to connection of high voltage power:

- Check the general condition of the switchgear for any damage or defects.
- Visually inspect the switching devices, withdrawable parts, isolating contacts, insulating parts, etc. for signs of damage.
- Check connection of the main earthing bar to the installation earthing conductor (following the appropriate safety regulations). Carry out earth continuity checks with appropriate instrument.
- Conduct micro-ohm measurements of busbar joints (main bus and earth bar) and compare with factory results.
- Check the paintwork for damage and, where necessary, touch up as required.
- Remove any material residues, foreign bodies and tools from the switchgear.
- Clean the switchgear, rubbing down insulating parts with a soft, dry, clean, non -fraying cloth.
- Refit all bolted covers etc. removed during assembly and testing procedures.
- Transport caps on vacuum circuit-breakers - if still fitted - must be removed.
- Perform AC voltage testing of the main circuits according to AS 62271.200 and IEC 62271-200 where necessary. Pay special attention to voltage transformers, surge arrestors and cables, etc.
- Perform insulation resistance checks on all 3 phases to earth and between phases.
- Switch the auxiliary and control voltage on.
- Carry out testing operations on switching devices manually and electrically, and simultaneously observe the relative position indicators.
- Check mechanical and electrical interlocks for effectiveness, without using force.
- Set the protective devices in the switchgear to the required values and check their function with test equipment.
- Instruct local operators regarding the basic details of regular handling of the switchgear.
- Check readiness for operation and switching status of electrical systems upstream and downstream of the switchgear.

Depending on the site, it may also be necessary to check the following equipment in areas adjacent to the switchgear:

- Cables (power and auxiliary)
- Auxiliary power source
- Remote control system
- Complete earthing system
- Switchroom equipment and conditions

# 5 Transportation

## 5.1 General

The AMS switchgear is separated into transport units prior to shipping. The transport units consist generally of separate panels each fitted with four (4) transport lugs for tie down and lifting.

Prior to shipping, the plug -in modules are set in the service position and “open”, the doors are closed and all mechanical and electrical connectors between the transport units are removed and supplied as loose parts.

Depending on the type of transportation and destination, the panels are either wrapped in film and placed on wooden pallets or placed in suitable timber boxes. When shipped by land, the units must be transported in vehicles that are closed or covered using tarpaulins. The transport units must be fastened and secured on the transport vehicle. The panels must always be loaded and transported in their upright position.

All painted surfaces with direct contact to wooden boards and similar must be protected using foam inserts.

The top of the panels contain pressure relief vents. Cares should be taken to avoid walking on the top of the panels.

## 5.2 Dimensions and Weights

The table below lists typical panel dimensions and weights for design purposes. Depending upon the required packing medium used, transport dimensions and weights can vary significantly and may add as much as 200mm to each dimension listed below and approximately 120kg to overall weight.

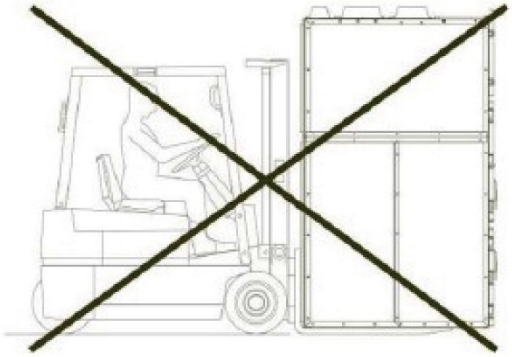
| Rated voltage | | 12 kV | | | 24kV | |
|---|---|---|---|---|---|---|
| Rated current | | ≤ 1250 A | ≤ 2000 A | ≤ 2500 A | ≤ 1250 A | ≤ 2500 A |
| Dimensions | Width | 650 mm | 800 mm | 1000 mm | 800 mm | 1000 mm |
| | Depth | 1400 mm | 1400 mm | 1400 mm | 1680 mm | 1680 mm |
| | Height | 2250 mm | 2250 mm | 2250 mm | 2250 mm | 2250 mm |
| Weight | Panel w/o plug-in module | 680 kg | 1020 kg | 1020 kg | 860 kg | 970 kg |
| | Plug-in module | 120 kg | 180 kg | 180 kg | 140 kg | 230 kg |
| | Complete panel | 800 kg | 1200 kg | 1200 kg - 1400kg | 1000 kg – 1200 kg | 1200-1400 kg |

## 5.3 Loading, Transporting & Positioning Panels

Panels can be either lifted from above or below.

Crane hooks can be attached to the four (4) lifting lugs bolted to the top of each panel. When lifting from the top, care must be taken to ensure that the lifting chains or slings maintain a minimum angle of at least 60° relative to the horizontal plane.

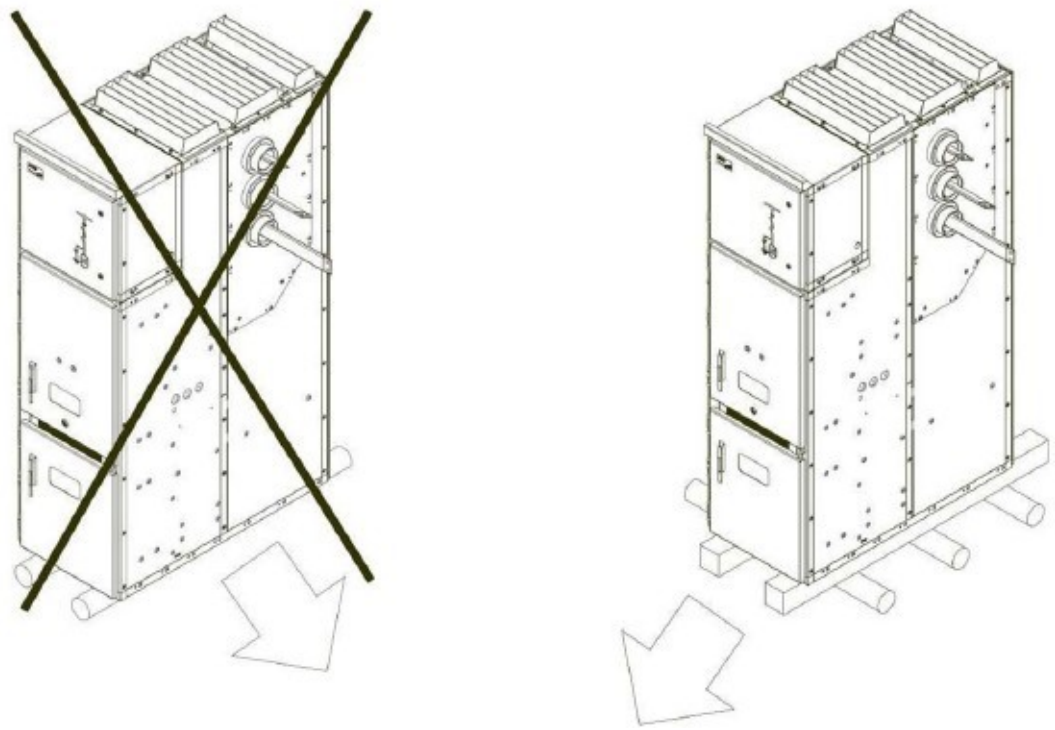
When lifting from below with a forklift, ensure that forks are inserted along the long side of the panel and never from the front or rear.



## 5.4 Transporting with Rollers

Do not remove panels from their transport bases until they are about to be positioned in their final locations. When using rollers to position panels, care must be taken to ensure that rollers span

the full width of the panel to provide maximum support. Rollers should never be inserted from the front of the panel to the rear of the panel.



# 6 Storage

The AMS panels are delivered as fully assembled units ready to be installed into their final operating positions.

If the panels have to be stored for a period of not more than three months, the following minimum conditions are required to prevent any deterioration in quality to the panel s and accessories:

- Storage area to be dry and well-ventilated
- Ambient room temperature not below –5 °C
- No detrimental effects from surroundings ( eg dust, water, salt)
- Control panels stored in upright position
- Control panels are not stacked
- Open packaging partially
- Check for condensed water formation on a regular basis

If the maximum permissible storage duration of 3 months is exceeded, the following must be undertaken:

- Packaging can no longer be guaranteed to protect the system and must be fully inspected and where necessary replaced
- Drying agents (silica gel bags) must be replaced for further storage

# 7 Switchgear Maintenance

## 7.1 General

Maintenance serves to e n s u r e trouble -free operation and achieve the longest possible working life of the switchgear. It comprises the following closely related activities:

- Inspection: Determination of the actual condition
- Maintenance: Measures to preserve the specified condition
- Repair: Measures to restore the specified condition

In accordance with AS 62271.200 and IEC 62271 -200, electrical installations must be checked on a regular basis and maintained in good condition.

Inspections serve to uncover defects at an early phase and to ensure that the system remains safe to operate.

The AMS medium voltage switchgear from is a low-maintenance system, however the system nonetheless has to be inspected and serviced on a regular basis.

Only skilled technicians familiar with medium voltage switchgear should perform inspections.

The AMS switchgear must be serviced every year as a minimum. This interval is determined by the prescribed maintenance intervals from the various equipment manufacturers, the circuit breakers and findings following previous inspections.

If defects are found during an inspection, these must be rectified prior to placing the panels back into service.

### 7.1.1 Log

All inspections and work performed on the panels should be recorded in a log that resides in the same switchroom as the panels. This allows all operators and maintenance personnel to see a complete history during the service life of the panels.

The log should contain the following information:

Date of inspection/maintenance/repair
Name of person performing work
Nature of the work
Copies of all recorded test readings (eg micro ohm readings of busbar joints) for future reference and comparison

## 7.2 Inspecting the Switchgear

The inspection is a visual check that may be carried out while the system is operating. The inspection serves to determine whether the switchgear requires maintenance.

### 7.2.1 Switchgear Room

The switchgear room must be inspected for signs of change that may indicate how the switchgear is operating.

Are there any visible signs of water intrusion or excessive heat?

- Traces of water on the ceiling and walls may indicate that water has entered the switchgear. Water can transport dirt into the system.

Are rodent droppings apparent in the room?

- Rodents can damage insulation on active components.

Are there visible signs of spiders, caterpillars or termites?

- Species such as spiders and caterpillars can damage insulating sections of active system components with their webs and cocoons. Invading termites can also decrease the insulating capability.

Are there visible signs of general soiling in the switchgear room?

Any dirt in the switchgear room can detrimentally affect the system's operation and must be removed immediately.

If, during the inspection, you discover any other potentially negative changes to the system beyond those described above, you must eliminate these by implementing appropriate measures.

#### 7.2.2 Switchgear System

Switchgear doors have special mechanical locks. During operation, mechanical locks secure the doors against opening. Systems with active door locks must be inspected after shutting down the system. The system can be visually inspected at any time.

**CAUTION ** - Under no circumstances should an operator forcibly open locked doors!

- Can all of the LV control panel doors be easily opened and closed?
- Is the paint free of damage?
- Are the areas around bolted fasteners on active components discoloured?
- Are there visible changes at the cable end fittings?
- Are there signs of soiling or other changes in the accessible compartments?
- Is all equipment uniquely designated?
- Is the control panel lighting (optional) functioning?
- Are all of the LV control plugs properly connected and secured?
- Are all control circuit breakers turned on?

## 7.3 Maintenance of the Switchgear

The required maintenance depends on the results of the inspections and the given operating conditions as well as the locally applicable regulations.

Before performing maintenance work, the system must be isolated and earthed.

#### 7.3.1 Cleaning

A key aspect of maintenance is cleaning the system. All moving parts in the system must be

inspected and readjusted whenever necessary.

Only use water-based or hydrocarbon-based cleaning agents for cleaning.

Apply cleaning agents using cloths and also remove any soiling using cloths. Use a vacuum cleaner to eliminate loose dirt. The vacuum cleaner being used must be equipped with an intact air cleaning system.

Before using cleaning agents, use brushes and bro oms together with lint -free cotton cloths to clean the system. Use chemical cleaning agents sparingly. Immediately remove any cleaning agent residue.

Caution: Alkaline-based cleaning agents can damage the zinc plating on the panels and

are therefore inappropriate. Before using any such cleaning agent, make sure that it is compatible with the system and be sure to read the manufacturer's instructions.

After cleaning, dry the system carefully using dry lint-free cotton cloths.

#### 7.3.2 Switchgear Components

Check that the doors close properly and that the lever mechanism functions smoothly. Re-adjust

these when required.

The lever mechanism must have a maximum play of 15° from the door handle to the lever. If the amount of play is too large, replace lever mechanism.

The fit of the moveable hinges has a large amount of play. The hinge shaft must be clean and move without need for oil. No lubricants are required here.

It should be easy to move the doors downwards into the locking position.

Mechanical modifications to the oblong slots in the chassis should not be made as this may affect the performance of the switchgear under fault conditions.

If the doors do not close properly, the only way to adjust them is by loosening the fastening screws on the inside, realigning the doors and tightening the screws again.

### 7.3.3 Busbar Connections

The busbar connections are installed once panels are in place and secured using contact washers. All bolted joints completed during installation must be checked and retightened using the torque values specified in section 3.4.

Bolted joints that are checked during maintenance must be directly marked. This can be done using a permanent felt marker.

Micro-ohm readings should be taken for future reference including details of where the test probes were positioned and value of current injected through joint.

### 7.3.4 Mechanical Interlocks

Regular inspections of mechanical interlocks is important to ensure that no damage has been sustained to mechanisms due to improper operation. Minor damage may in due course result in the interlock malfunctioning and not operating as designed. This may present a dangerous situation during switching operations resulting in an internal fault.

Never forcibly override the locks. If the mechanical locks are engaged, check the current switching status.

### 7.3.5 Racking & Shutter Mechanisms

Verify that the racking and shutter mechanisms move freely through the entire travel and do not bind in any position.

Verification of correct operation of position limits should also be verified.

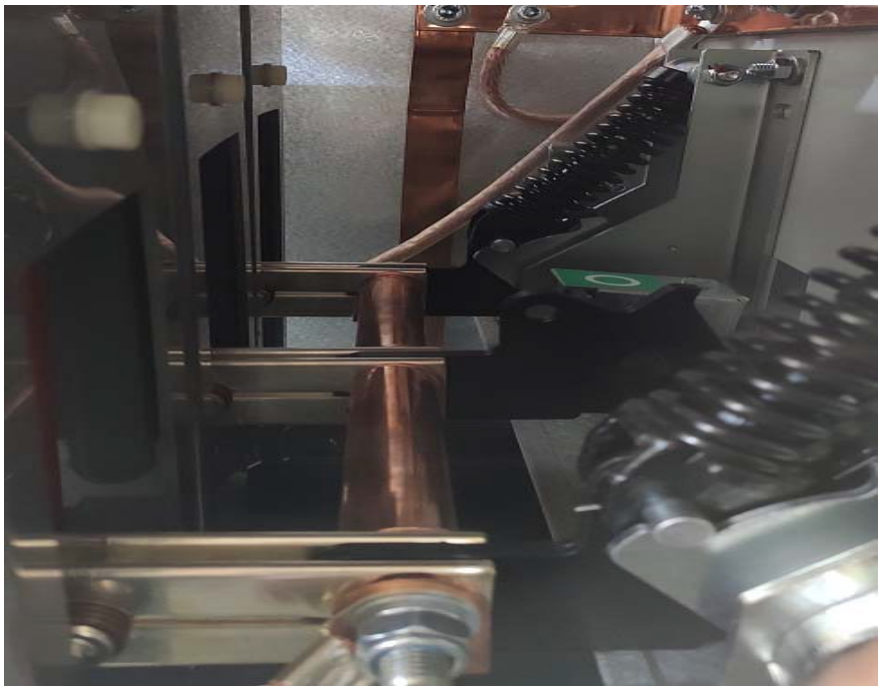
To clean the busbar and cable shutters, withdraw the module from the housing as detailed in section 2.4.

After cleaning, re-install the module and verify correct shutter operation. The shutters should open uniformly and without jamming as soon as the module reaches the entry position. When racking the module, the shutters must reliably operate. The shutter guide rails are oil-free and should never be lubricated.

### 7.3.6 Checking the earthing switch

With the earth switch closed, all 3 switch blades should engage their respective fixed contacts firmly and evenly. Check the earthing switch using a mirror. If it has visibly changed, remove the cables and inspect the switch in detail.

An earth switch position camera is available as an option.



Inspect the switch blades and fixed contacts for evidence of corrosion, partial discharge or discolouration due to excessive heating.

### 7.3.7 Circuit Breaker tulip and fixed contacts

Inspect the CB tulips and fixed contacts for evidence of corrosion, partial discharge or discolouration due to excessive heating.

Verify all tension springs are installed and properly seated

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