

Document No: ETS 0068

Amendment No: 3
(Supersedes ETS 0068.am2 and replaces ETS 0013.am1)

Equipment Technical Specification

Distribution indoor and padmount substation 12-24kV switchgear

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Substation Design Instruction

ASSET STANDARDS & DESIGN

Document No : ETS 0068
 Amendment No : 3
 Approved By : GMAM
 Approval Date : 17/11/2016
 Review Date : 17/11/2021

(Supersedes ETS 0068.am2 and replaces ETS 0013.am1)

ETS 0068 Distribution indoor and padmount substation 12-24kV switchgear

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1.0 PURPOSE

To define the technical requirements for selection and application of 12kV and 24kV switchgear for indoor and padmount substations in the distribution network and for auxiliary switchgear in zone substations.

2.0 SCOPE

This Specification covers the design, engineering, manufacture, testing, supply and delivery of 12kV and 24kV indoor, padmount and zone substation auxiliary switchgear. It is not the intention to specify all design, manufacturing and constructional details of the switchgear. However, the equipment supplied must meet the highest standards of design, engineering and manufacturing practices.

All supplied switchgear and associated equipment must be manufactured and tested to the standards with the year of publication listed in section 3.0 below. In some circumstances based on local network conditions and experience, this specification is more stringent or is inclusive of requirement not covered in Australian and International Standards; in this circumstance the requirements of this specification must take precedence.

On site and constructional requirements, such as installation and easement requirements are covered in MCI 0006 - Underground construction standards manual.

Tenderers must state any non-compliance with the specification in any tender submission and any alternative offers must be submitted in full and separately from any main offer. Any proposed variations from this specification must be referred to Substation Assets Manager for approval prior to acceptance.

3.0 REFERENCES

Internal

Company Policy (Network) 9.2.2 – Network Protection

Company Policy (Network) 9.2.5 – Network Asset Design

Company Policy (Network) 9.7.1 – Network Asset Construction

Company Policy (Network) 9.8.3 – Network Operations

Company Policy (Network) 9.9.1 – Network Asset Maintenance

Branch Form FAE 3013 – Distribution Indoor and Padmount Substation Medium Voltage (11kV and 22kV) Switchgear Product Approval and Audit Form

Earthing Design Instruction EDI100 - Distribution earthing design, construction and test

Equipment Technical Specification ETS 0070 – 11kV and 22kV padmount and indoor distribution transformers

Earthing Design Specification ETS 0071 - Distribution fuses

Earthing Design Specification ETS 0072 – Padmount substation plinth and culvert

Earthing Design Specification ETS 0077 – Padmount substation cubicles

Mains Construction Instruction MCI 0006 – Underground distribution: Construction standards manual

Mains Design Instruction MDI 0028 – Underground distribution design manual

Protection Design Instruction PDI 4002 – Current transformers for protection

Company Network Management Plan December - 2013 Review

External

Work Health and Safety Act 2011 (NSW)

Work Health and Safety Regulation 2011

ENA National Electricity Network Safety Code (Doc. 01-2008)

National Construction Code (NCC)

Australian Standards AS ISO 1000:1998 - The international system of units (SI) and its application

AS1824.1:1995 - Insulation coordination - Definitions, principles and rules

AS 1931.1:1996 - High voltage testing techniques - General definitions and test requirements

AS 2067:2016 - Substations and high voltage installations exceeding 1kV ac

AS 2344:1997 - Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installations in the frequency range 0.15 to 1000 MHz

AS 2629:2008 Separable insulated connectors for power distribution systems above 1kV

AS 2981:2008 High voltage a.c. switchgear and controlgear-Vacuum interrupters-High voltage testing-Protection of personnel from x-ray emission

AS/NZS 3000:2007 Electrical Installations

AS 4026:2008 Electric cables - For underground residential distribution systems

AS 4680:2006 Hot dip galvanised (zinc) coatings on fabricated ferrous articles.

AS 60044.1:2007 - Instrument transformers Part 1: Current transformers

AS/NZS 60265.1:2001 High voltage switches – switches for rated voltages above 1 kV and less than 52kV

AS 60270:2001 - High voltage test techniques - Partial discharge measurements

AS 62271.1:2012 - High voltage switchgear and control gear – common requirements

AS 62271.100:2008 High voltage alternating current – Circuit breakers

AS 62271.102:2005 High voltage alternating current – Disconnectors and earthing switches

AS IEC 62271.105:2015 High voltage alternating current switch fuse combinations

AS 62271.200:2005 High voltage alternating current – AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to 52 kV

AS 62271.201:2008 High voltage alternating current – AC insulation - enclosed switchgear and control gear for rated voltages above 1kV and up to and including 52kV

AS 62271.301:2005 HV switchgear and controlgear. Part 301: Dimensional standardization of terminals

IEC 60255-1:2009 - Measuring relays and protection equipment Part 1: Common requirements

IEC 60255-151:2009 - Measuring relays and protection equipment - Part 151: Functional requirements for over/under current protection

IEC 60282-1:2009 - High Voltage Fuses; Part 1 Current limiting fuses

IEC 61243-5:1997 - Live working – Voltage detectors

IEC 62271-103:2011- High-voltage switchgear and controlgear - Part 103: Switches for rated voltages above 1 kV up to and including 52 kV

NSW Environment Protection Authority (EPA), Industrial noise policy

4.0 DEFINITIONS AND ABBREVIATIONS

AC	alternating current
AFIC	audio frequency injection cell
CB	Circuit breaker
company	Endeavour Energy
CT	Current transformer
DC	direct current
E2	General purpose switch designed so as not to require inspection or maintenance of the interrupting parts of the main circuit and only minimal maintenance of its other parts during its expected operating life
HV	High voltage (within this standard means 11kV and 22kV distribution network)
Indoor substation	An electrical substation housed in a building designed in accordance with the National Construction Code and AS2067. They are generally of brick and concrete construction with gutters and drainage or are a room that is part of a larger

	building.
LV	Low voltage
MCI	Mains Construction Instruction
MMI	Mains Maintenance Instruction
NATA	National Association of Testing Authorities
Padmount substation	An electrical substation housed in an outdoor enclosure that is designed to prevent the ingress of moisture from rain and storms but is subject to water rise at ground level and high levels of humidity. The enclosure can be made from fibreglass, stainless steel or aluminium.
pC	picocoulomb
RMS	Root mean square
RMU	Ring main unit
SCADA	Supervisory Control And Data Acquisition
SDI	Substation Design Instruction
SMI	Substation Maintenance Instruction
SF6	Sulphur hexafluoride gas
Um	Maximum permissible voltage
VT	Voltage transformer
XLPE	Cross linked polyethylene
zone substation	A substation with a primary voltage of 132kV, 66kV or 33kV and a secondary voltage of 22kV or 11kV which is part of the Company's sub-transmission network.

5.0 ACTIONS

5.1 General requirements and service conditions

5.1.1 General

Distribution padmount and indoor 12kV and 22kV (HV) switchgear is used throughout the company's network to provide the protection and switching flexibility to reliably supply the HV network.

The HV switchgear supplied must conform to all the current requirements of the relevant Australian and IEC Standards and this specification.

The equipment supplied must meet the highest standards of engineering, design and manufacturing practices.

The supplier must provide everything necessary, including any special tools, usually supplied for the safe operation of the equipment, whether directly specified or not.

The manufacturer must provide details of the recommended maintenance procedures for the equipment.

Note: All values submitted to tender and in Product Approval Forms must be guaranteed values and will be treated as such in the evaluation, and when assessing whether the delivered equipment meets the specification.

5.1.2 Service conditions

The highest system voltages for the switchgear is 12kV and 24kV RMS for 11kV and 22kV networks respectively. In some 11kV and 22kV areas in the company's system, the neutral point is non-effectively earthed. The insulation system must be suitable for non-effectively earthed systems.

The equipment must be designed for operation in the ambient temperature range of –10 deg. C to 45 deg. C. The air temperature inside the HV end of the cubicle may reach 60 deg C due to transformer losses, the effects of solar radiation and additional heat from the switchgear. The padmount substation can be located in potentially dusty, moist and coastal environments. All ratings and equipment must be suitable for this environment.

Table 1 - Service conditions

Description	Criteria
Normal service condition	Outdoor to AS62271.1
Altitude	<1000m *
Maximum ambient temperature	Refer above
Minimum ambient temperature	-10 deg. C
Average index of mean relative humidity: 9:00am	95%
Seismic acceleration coefficient (maximum)	0.09
Pollution level	Level IV in accordance with AS4436

Note * - Max altitude is 1200m in a small portion of the network which will be evaluated in accordance with the conditions in AS62271.1

5.1.3 Material environment

All ferrous parts of the switchgear must be treated to provide acceptable surface finish and protection. The manufacturer must provide full details of the surface finish provided on the switchgear parts. Where required, equipment may need to be raised or have extra treatment to minimise corrosion on all metal components, particularly those in contact with the plinth.

All external connections must be terminated using crimp lugs and stainless steel or hot dip galvanised bolts or plug in type connectors. Clamps or u-bolt type connections must not be used unless approved otherwise.

All materials must be of a type and quality that will give a normal life expectancy of 45 years without deterioration. All equipment must be enclosed to the extent that there is no safety hazard to operating workers. The equipment must be fully shrouded to prevent accidental shorts by human error, flying objects or by rodents.

5.2 Health, safety and environment (HSE) requirements

5.2.1 Special environmental requirements - toxicology safety

The supplier must provide with any offer, full details, including composition and toxicological information, regarding the health and safety aspects of all the materials offered in their offer or supplied equipment regardless of content.

Recommended procedures must be provided for the safe handling, safe operation and maintenance of products supplied. The means of disposal of the materials must be clearly stated. Material safety data sheets (MSDS) must be provided for materials that are supplied and subject to safety considerations in handling and use.

All equipment, packaging and all other accessories provided must be asbestos free.

The above information is required as part of the offer and will be reviewed as part of any tender process.

5.2.2 Noise levels and radio interference voltage (RIV)

The HV switchgear may be installed in a residential area in close proximity to residences. Therefore, it is necessary that noise levels comply with AS1055.2 Level R1 and the radio interference is less than 2500µV, as specified in AS 62271.1.

5.2.3 Fire and blast hazards

The HV switchgear and its components must be designed in a manner to reduce the risk of rupture and explosive failure and subsequent fire risk. Accordingly the internal arc classification will be proven and meet the requirements of this specification.

5.2.4 SF6 gas

Refer to clause 5.4.1.1 regarding details when SF6 gas is used as part of the insulation or arc quenching material.

5.3 Technical requirements

Table 2 - Technical requirements

Description	12kV	24kV
Common requirements to all switchgear		
Applicable standards	AS 62271.1, AS62271.200 & AS62271.201	AS 62271.1, AS62271.200 & AS62271.201
Rated voltage	12kV	24kV
Highest system voltage	12kV	24kV
Rated busbar current	630 A	630 A
Rated frequency	50 Hz	50 Hz
System earthing	Effective/non-effective earth	Effective/non-effective earth
No. of poles/phases	3	3
Switch operation	3 phase	3 phase
Rated short circuit withstand current	16kA min (20kA preferred)	16kA min (20kA preferred)
Rated duration of short circuit	1 sec	1 sec
Rated peak withstand current	40kA min (50kA preferred)	40kA min (50kA preferred)
Cable test voltage withstand	25kV DC	50kV DC

Description	12kV	24kV
Insulation level - Power frequency withstand: - Common values (Ph-ph, Ph-E) - Across the Open Sw or isolating distance	28 kV for 1 min 32 kV for 1 min	50 kV for 1 min 60 kV for 1 min
Insulation level – Lightning impulse withstand: - Common values (Ph-ph, Ph-E) - Across the Open Sw or isolating distance	95 kV 110 kV	125 kV 145 kV
Interrupting medium	Manuf. To provide	Manuf. To provide
Insulation medium	Air / epoxy / SF6	Air / epoxy / SF6
Internal arc classification (IAC)	AFL (AFLR preferred)	AFL (AFLR preferred)
Arc test current-tank (kA)/ time (sec)	16kA/1sec (20kA/1s preferred)	16kA/1sec (20kA/1s preferred)
Arc test current-cable box (kA)/ time (sec)	16kA/1sec (20kA/1s preferred)	16kA/1sec (20kA/1s preferred)
Loss of service continuity category	LSC2B (LSC2A preferred)	LSC2B (LSC2A preferred)
Maximum partial discharge level at 1.1Um/ $\sqrt{3}$	20 pC	20 pC
Altitude	< 1000 m	<1000 m
Relative humidity max	90%	90%
Temperature rise - Meets cl 4.4.2 of AS 62271.1	Required	Required
Max dimensions inside size 14 cubicle (refer cl 5.4) - Width – complete unit (mm) - Depth (mm) - Height (mm) - Mass (kg)	1240 850 1360 Manuf. To provide	1240 850 1360 Manuf. To provide
Method of operation	Manual with handle	Manual with handle
If SF6 used:		
Leak rate	< 0.1%/yr	< 0.1%/yr
Purity of SF6 gas (by weight)	Manuf. To provide	Manuf. To provide
SF6 rated pressure	Lowest preferred	Lowest preferred
SF6 quantity (by weight)	Lowest preferred	Lowest preferred
SF6 low alarm pressure (motorised unit)	Manuf. To provide	Manuf. To provide
SF6 trip and lockout pressure	Manuf. To provide	Manuf. To provide
Proposed use	Padmount and indoor substations	
Mounting type	Free standing on floor	
Tank material	Stainless steel	
Degree of protection, tank	IP 67	
Degree of protection enclosure	IP3X	
Degree of protection operating mechanism	IP2X	
Earthing device is integrated and interlocked	Required on all functional unit	

Description	12kV	24kV
Temperature compensated pressure gauge	Required	
Pressure relief (pressured gas insulated systems)	Manuf. To provide	
Addition common items for all motorised units		
Mode of operation	Spring charge	Spring charge
Rated supply voltage of closing and opening devices and auxiliary circuits	120V DC (230V AC option)	120V DC (230V AC option)
Local – remote changeover switch per unit	Yes	Yes
Local – remote switch spare contacts (SCADA)	1 NO + 1 NC	1 NO + 1 NC
Trip / close coil quantity	1 (2 preferred) / 1	1 (2 preferred) / 1
Auxiliary switches rating – making, carrying and breaking in a typical inductive circuit	5 A at 120V DC 3 A at 250V AC	5 A at 120V DC 3 A at 250V AC
Aux. switches for switch-disconnector or CB Closed and Open (min)	4 NO + 4 NC or 1 NO + 1 NC + 2 changeover	4 NO + 4 NC or 1 NO + 1 NC + 2 changeover
Aux. switches for earth switch Closed and Open (min)	4 NO + 4 NC or 1 NO + 1 NC + 2 changeover	4 NO + 4 NC or 1 NO + 1 NC + 2 changeover
Aux. switches for gas monitoring (min)	1 NO + 1 NC	1 NO + 1 NC
Network switch disconnector unit (SU)		
Applicable standards for this functional unit	AS 62271.102, IEC 62271.103	AS 62271.102, IEC 62271.103
All above common requirements complied with	Yes	Yes
General purpose switch class	E3 – No maint.	E3 – No maint.
Mechanical endurance offload on/off operations	M1 – 1000 ops	M1 – 1000 ops
Suitable to fit integrated motorising facility for on/off	Preferred	Preferred
Rated current	630 A	630 A
Rated mainly active load breaking current	630 A at 0.7 pf	630 A at 0.7 pf
Rated closed loop breaking current	630 A at 0.3 pf	630 A at 0.3 pf
Rated no load transformer breaking current	6.3A	6.3A
Rated cable charging breaking current	10 A	16A
Rated line charging breaking current	1 A	1.5A
Rated making current of switch	40kA (50kA preferred)	40kA (50kA preferred)
Main circuit resistance AØ/BØ/CØ (µΩ)	Manuf. To provide	Manuf. To provide
Bushings for cable connection, type	C – Bolted M16	C – Bolted M16
Phase centres of cable termination bushings (mm)	Manuf. To provide	Manuf. To provide
Recommended maintenance period (years)	Manuf. To provide	Manuf. To provide
Recommended maintenance	Manuf. To provide	Manuf. To provide
Disconnecter and earth switch - in all units		
Applicable standards for this functional unit	AS 62271.102	AS 62271.102

Description	12kV	24kV
All above common requirements complied with	Yes	Yes
Rated current (only for disconnectors)	630 A	630 A
Rated making current of switch	40kA (50kA preferred)	40kA (50kA preferred)
General purpose switch class	E2 – S/C make	E2 – S/C make
Mechanical endurance offload on/off operations	M0 – 1000 ops	M0 – 1000 ops
Transformer switch-fuse combination unit (SFU)		
Applicable standards for this functional unit	AS 62271.105	AS 62271.105
All requirements of above switch (SU) complied with	Yes	Yes
Rated current (Fuse component)	200 A	200 A
Off load transformer breaking capacity	2A	2A
Peak withstand current at output terminal (kA)	Manuf. To provide	Manuf. To provide
Rated maximum power dissipation withstand (W)	Manuf. To provide	Manuf. To provide
Accommodates fuse-link to specification	See CI 5.7.1	See CI 5.7.1
Type of main insulation	Manuf. To provide	Manuf. To provide
Earth is applied to both sides of fuse carrier	Yes	Yes
Phase centres of cable termination bushings (mm)	Manuf. To provide	Manuf. To provide
Bushings for cable connection, type	A – Plug-in 200A	A – Plug-in 200A
Cable rating and flexibility meet CI 5.11.4	Essential	Essential
Aux. switches for switch Closed and Open (min)	1 NO + 1 NC	1 NO + 1 NC
Transformer circuit breaker unit (CBU)		
Applicable standards for this functional unit	AS 62271.100	AS 62271.100
All above common requirements complied with	Yes	Yes
General purpose CB class	E2 – No maint.	E2 – No maint.
Mechanical endurance offload on/off operations	M1 – 2000 ops	M1 – 2000 ops
Mode of operation	Manual using an operating handle	
Suitable to fit integrated motorising facility for on/off	Preferred	Preferred
Rated current (In)	200A (630A preferred)	200A (630A preferred)
Rated mainly active load breaking current	In at 0.7 pf	In at 0.7 pf
Rated closed loop breaking current	In at 0.3 pf	In at 0.3 pf
Rated no load transformer breaking current	6.3A	6.3A
Rated cable charging breaking current	25 A	31.5A
Rated line charging breaking current	10 A	10A
Rated making current of switch	40kA (50kA preferred)	40kA (50kA preferred)
First pole to clear factor	1.5	1.5
Main circuit resistance AØ/BØ/CØ (µΩ)	Manuf. To provide	Manuf. To provide
Interrupting medium (preferred)	Vacuum	Vacuum
Insulation medium	Air / epoxy / SF6	Air / epoxy / SF6

Description	12kV	24kV
Phase centres of cable termination bushings (mm)	Manuf. To provide	Manuf. To provide
Bushings for cable connection, type	C – Bolted M16	C – Bolted M16
Protection relay and CT details:		
• Applicable standards	IEC 60255-1, IEC 60255-151	IEC 60255-1, IEC 60255-151
• Meets all requirements of Cl. 5.8	Yes	Yes
• Prot. relay (self-powered 3ph O/C+E/F)	Yes	Yes
• Prot. relay (make/type/Specs)	Manuf. To provide	Manuf. To provide
• Prot. CT/current sensors (ratio, output, class)	Manuf. To provide	Manuf. To provide
• Open circuit of CT secondary / current sensor creates a hazardous condition	Manuf. To provide	Manuf. To provide
• Relay to be wired according to Cl 5.7.	Manuf. To provide	Manuf. To provide
• Recommended maintenance period (years)	Manuf. To provide	Manuf. To provide
• Recommended maintenance for CB	Manuf. To provide	Manuf. To provide
• Recommended maintenance for Prot. relay	Manuf. To provide	Manuf. To provide
Aux. switches for CB/switch Closed and Open (min)	2 NO + 2 NC	2 NO + 2 NC
Aux. switches for CB/cable earthed (min)	1 NO + 1 NC	1 NO + 1 NC
Other associated equipment		
Cables and cable terminations	Refer clause 5.11	Refer clause 5.11
Fault current indicators	Refer clause 5.9	Refer clause 5.9
Voltage detecting systems	Refer clause 5.10	Refer clause 5.10

5.4 Construction requirements and test fitting

All high voltage switchboards manufactured and supplied against this specification must be suitable for use in the company's new and old substations, as specified. The sizes nominated in the specific requirements are based on the new design and are approximate only. Due to the minimal dimensional allowance of the padmount cubicles and the various physical layouts of switchgear, the suitability of switchgear to fit inside the various padmount sizes and allow correct construction and operation will need to be confirmed with a test fitting. All switchboards must be designed for free standing on the floor. All switchgear must be designed to fit into a standard size 14 padmount HV cubicle.

The switchgear must face the short end of the cubicle and it must be possible to operate all equipment and replace all fuses with the equipment installed in the cubicle. All operational functions are carried out from the end door only. The manufacturer must provide details of the recommended maintenance procedures for the switchgear.

Due to the wet environment of a padmount installation, where sheet metal enclosures are supplied as part of the switchgear, there must be some additional form of protection provided to prevent rusting of the switchgear enclosure at the base where it secures to the concrete plinth. This additional protection must be included on all offers and will be evaluated as part of the switchgear. Hot dipped galvanising will generally be regarded as the minimum.

Some 24kV switchgear with four (4) functions may not fit the standard cubicle due to excessive width; these units may be accepted for indoor substations in any evaluation.

High voltage distribution boards must be designed and constructed to fully enclose and insulate all live components to prevent contact while operating the equipment, or inadvertent contact while installing feeder cables from below the switchgear. Sharp edges and corners must be rounded off to avoid risk of injury.

Use of both 12kV and 24kV distribution voltages is common in the company's network. Therefore, where a 24kV rated switchgear is offered for use on 12kV network, the supplier must include all accessories such as fuse adaptors, voltage indicator variation techniques and the like.

Detailed instructions must be provided to convert a 24kV switchgear unit for use on 12kV network application and convert it back to 24kV, if required.

When the switchgear is installed in a padmount substation it is mounted in its high voltage compartment, adjacent and very close to the transformer. The switchgear will therefore experience higher cubicle temperatures due to transformer losses. All switchgear must be suitable for this environment.

The switchgear must consist of a fabricated stainless steel sheet tank/enclosure of adequate thickness suitable to provide required rigidity and strength.

It must be possible to work on any unit/panel or cable compartment with the remainder of the switchgear energised. There must be metal partitions between adjacent units/panels to prevent accidental approach to live parts of one panel when working on an adjacent panel.

A pressure relief device must be provided at the rear of the tank/enclosure to discharge any high pressure build-up in the event of an internal arc fault within the tank/enclosure. Hot gas generated due to internal arcing must be released at the rear of the tank in a controlled direction to provide a safe environment for employees and to avoid damage to other equipment in the vicinity.

The parts of the mechanism that require preventive inspection and maintenance must not be enclosed in any gas tight compartment.

Where a motor charging and remote operation system is installed a LOCAL- REMOTE changeover switch must also be provided in the enclosure to facilitate the changeover of control for maintenance.

Where applicable, necessary provisions must be made to prevent the spring charging motor from running continuously in the event that the springs have failed to charge.

5.4.1 Insulation

The insulation must be of a type and quality that will guarantee that it is capable of performing its intended duty without deterioration for its intended life of up to 45 years, taking into account the ambient temperatures, service conditions, loading of the switchgear, and the environment.

Switchgear based on oil as the arc interruption or insulating medium is not acceptable.

5.4.1.1 SF6 requirement

The company's preference is for the use of equipment that does not contain SF6 gas where alternative proven technologies are available. Cost efficient offers of equipment containing SF6 will be considered however preference will be given to equipment containing a minimum amount of

SF6. SF6 management, environmental and disposal costs will be considered in the evaluation process.

Design pressure of all gas filled compartments is limited to a maximum of 300 kPa (relative pressure).

Where SF6 switchgear is offered, the following must apply:

- The acceptable level of purity of new SF6 gas from bottles must be 99.7% by weight and must be confirmed by the supplier's process to conform to IEC 60376:2005.
- The tank must be filled with SF6 gas as required for electrical insulation and/or arc interruption. The tank will preferably be filled under vacuum to remove any air.
- Tanks with SF6 gas must be sealed for life. The gas leakage rate must be guaranteed to be less than 0.1% a year for the lifetime of the equipment. Suitable static filters must be provided within the tank to absorb decomposed products due to arcing.
- The SF6 gas tank/chamber must be suitable for removal of all SF6 gas without tank/chamber crushing.
- The supplier must provide full details of charging (topping up)/discharging (removal) and storing of the gas without loss of gas, including equipment needed and any safety measures necessary where applicable.
- A temperature compensation gas density gauge must be provided to indicate gas operating density within the tank and safe operating levels.
- The gauges must be mounted on the front of each functional unit and it must provide the range of acceptable density using colour coded scales (Red - low, Green - normal).
- On motorised units, and when requested, a density switch must be provided with a set of clean contacts for alarm / indication. The contact must operate when the gas density falls below the manufacturer's recommended minimum.
- The supplier of the SF6 switchgear must have a return policy whereby they will accept responsibility for disposal of the SF6 and any remaining SF6 gas or by-products. Refer to the contract commercial conditions for more details.
- All exposed gas pipe work must be mechanically protected against any accidental damage.
- SF6 volume/weight of each separate switchgear unit must be provided and included in nameplate data.

5.4.1.2 Vacuum interrupter (where applicable)

The design of the interrupting mechanism and contacts must guarantee that the energy dissipated in the vacuum is low and does not cause appreciable degradation of the contacts.

Where possible, means will be provided for the testing and indication of the units for the existence of a vacuum without the necessity for the removal of the vacuum bottle(s). Any special test equipment required for this purpose must be offered as an option in the tender submission.

The contacts of the interrupter must be held open by a positive fail-safe device that is independent of the interrupter vacuum. The closing arrangement must be designed so as to give a positive closing action whilst overcoming the contact hold open device.

The supplier must outline the relevant precautions to be taken by the company when testing the vacuum interrupter in line with the requirements of AS 2981.

X-radiation emission level of vacuum interrupter must meet the requirements of clause 6.11.1 of IEC 62271.1.

5.4.2 Anti-condensation heaters

The electrical performance parameters of switchgear must be guaranteed without the use of anti-condensation heaters.

5.4.3 Auxiliary and ancillary equipment (when motorised)

5.4.3.1 Auxiliary contacts and relays

All ancillary contactors and relays must be of a type proven to be capable of handling the current and voltages involved in the normal operation of the switchgear. All operating coils must be continuously rated for the supply voltage used. The supervisory open and close relays to be used in the circuit breaker control scheme must be as stated above.

5.4.3.2 Switchgear auxiliary switches

Each unit must be fitted with sufficient auxiliary switches to perform all the functions required by the switchgear units as required with the additional switches listed in the technical requirements table.

Each additional contact must be suitable for making, carrying and breaking current as indicated in the technical requirements table.

5.4.3.3 Secondary terminal blocks

The terminals must be Klippon, Entrelec M series, Phoenix UT series or Weidmuller WDU series or equivalent as approved by the Substation Assets Manager.

Tenderers will state if an open circuit on the secondary of the current sensors will create a hazardous condition during normal load or fault conditions. If there is a risk of a hazardous condition, the terminal design will be such that a loose screw/fastener does not result in unintentional withdrawal of the wire. Suitable methods include ring lugs with a stud or screw terminal or, a lip blade lug and spring-loaded terminal combination.

Control wiring terminal blocks must be suitable for the size of conductor being used and the type of terminal strip employed.

Suitable plastic shrouds must be provided for all control wiring terminal blocks. Where the terminal blocks are used for 230V AC termination, warning labels, with red letters of Warning 230V AC on a white background, are required

5.4.3.4 Interface terminal block

All external cabling will be supplied and terminated by the company.

The supplier must provide all internal wiring including the interface terminal blocks ready for external wiring termination. The interface terminal facilities must be provided on each unit.

5.5 Switchgear modules and functional unit description

12kV and 24kV switchgear used by the company in its distribution network can be classified under two (2) broad categories, non-extensible and extensible.

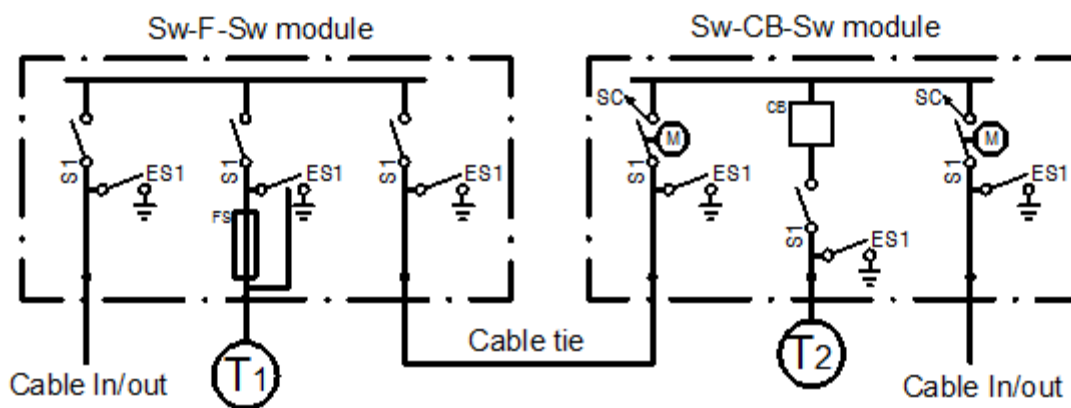
Non-extensible switchgear is the standard for both indoor and padmount substations, extensible switchgear is primarily for maintenance of existing units.

Where extensible switchgear is offered for any new projects, it is required to be assembled in modules in the same configurations to non-extensible switchgear.

When multiple transformers or additional switches are required in indoor substation situations, fully rated network cables will be used to join between separate module groups to form the longer switchboards.

The configuration of modules is as indicated in clause 5.5.3.

Figure 1 – Example two (2) transformer arrangement



5.5.1 Non-extensible switchgear

Non-extensible switchgear usually comprises of multiple function units/components integrated in one (1) module in the same tank/enclosure. This type of switchgear is also commonly known as a ring main unit (RMU).

5.5.2 Extensible switchgear

Where extensible switchgear is approved it must only be used when assembled into modules as indicated for non-extensible switchgear.

The switchgear must be factory tested after assembly into modules as per the specified configurations.

The switchgear must have insulated busbars and the switchgear must be compartmentalised, with separate compartments for switching functions, busbars, operating mechanism and low voltage control equipment (if required).

5.5.3 Switchgear modules and functional unit descriptions

The functional units used by the company in both non-extensible and extensible switchgear are:

Table 3 - Functional unit description

Functional unit description	Abbreviation
Network switch disconnecter unit	SU
Transformer fuse-switch combination unit	FSU
Transformer circuit breaker unit	CBU

Commonly used module configurations in the company's network are:

Table 4 - Module configuration

Item no.	Commonly used configurations
N1	SU – FSU
N2	SU – FSU – SU
N3	SU – FSU – SU – SU
N4	SU – SU – SU
N5	SU – SU – SU – SU
N6	SU – CBU
N7	SU– CBU – SU
N8	SU– CBU – SU –SU

5.5.4 Functional unit - Busbars

The busbars must comprise three (3) single phase copper busbars with connections to the specified functional units. The busbar must be of adequate cross section and adequately supported to withstand all thermal and dynamic forces without damage or deterioration.

5.5.5 Functional unit - Network switch unit (SU)

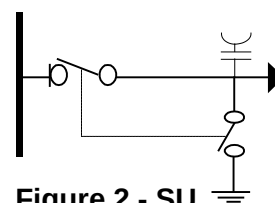
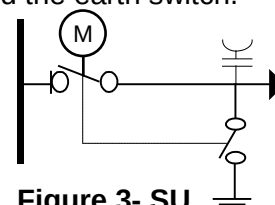
The general configuration must be as set out in the following single line diagram:

The network switch unit (SU) must provide integration between components so as to provide a positive interlock between the switch disconnecter and the earth switch.

The mechanism must provide independent manual operation of the switch and the earth switch.

Mechanical semaphore indicators must be mounted directly on the shaft to provide fail-safe direct indication of open - close - earth positions of the switch.

When motorising is required, the unit will meet all the additional requirements of clause 5.3 including auxiliary contacts and power supplies.

**Figure 2 - SU****Figure 3- SU motorised**

5.5.6 *Functional unit - Transformer fuse-switch combination unit (FSU)*

The general configuration **must** be as set out in the following single line diagram:

The transformer fuse-switch combination unit (FSU) **must** provide integration between components so as to provide a positive interlock between the switch disconnecter and both earth switch.

The mechanism **must** provide independent manual operation of the switch and earth switches. Both earth switches **must** operate simultaneously through the common operating shaft.

Mechanical semaphore indicators **must** be mounted directly on the shaft to provide fail-safe direct indication of open - close - earth positions of the switch.

The transformer fuse-switch combination unit (FSU) **must** provide for use of both 12kV and 24kV HRC fuses. Earth switches **must** be located on both sides of the HV fuse, as shown in the single line diagram.

Access to HV fuses **must** be possible only when the main switch disconnecter is open and fuses are earthed on both sides.

High voltage fuses with a striker pin will be used. Arrangements **must** be made to simultaneously open all the three phases of the switch disconnecter if the striker pin in any phase operates on fuse blow out.

Refer to clause 5.7 for full fuse protection requirements.

5.5.7 *Functional unit - Transformer circuit breaker unit (CBU)*

The general configuration **must** be as set out in the following single line diagram:

The transformer circuit breaker unit (CBU) **must** incorporate a disconnecter and an earth switch as shown. In addition, the unit **must** provide a circuit breaker for protection of the transformer.

The CB unit **will** mainly be used to protect 1500kVA transformers **but can** also be used to protect HV frequency injection equipment, all other lower KVA rated transformers **will** be protected by HV fuses.

Mechanical interlocks **must** be provided to prevent the operation of both the disconnecter and the circuit breaker if the earth switch is closed.

An arrangement where the functions of the circuit breaker and earth switch are integrated in a common unit is acceptable to **the company** provided the unit is easy to operate and is electrically and mechanically safe.

The circuit breaker **must** be manually operated with a self-powered protection relay to trip automatically if the protection relay operated on a faulty condition. The protection relay CTs **must** be an integral part of the switchgear so that there is no fitting or support bracket adjustments required for the units during HV cable installation.

Refer to clause 5.8 for full protection requirements.

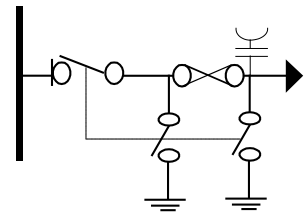


Figure 4 - SFU

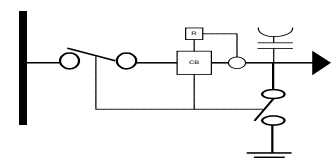


Figure 5 - CBU

5.6 Operational requirements

5.6.1 Operational interlocks

The following operational interlocks must be provided for safe operation of the switchgear. The interlocks must be fail-safe mechanical type:

- It must not be possible to operate a switch-disconnector, disconnector, fuse switch combination or a circuit breaker whilst the corresponding earth switch is in the closed position.
- It must not be possible to gain access to a cable box unless the circuit is isolated and corresponding earth switch is closed.
- It must not be possible to gain access to HV fuses or fuse canisters unless the circuit is isolated and earth switches on both sides of the fuse are closed.
- It must not be possible to prime or charge the closing mechanism when a trip impulse is activated.

5.6.2 Electrical interlocks

In addition to the requirements above (5.6.1), the following electrical interlocks must be provided for safe operation of the motorised switchgear. The interlocks must be of a fail-safe design:

- The local remote switch, when in the local position, must isolate all remote signals for trip or close operation.

5.6.3 Switchgear operation

The switchgear will be front operated. All operations must be manual. It is preferred that one (1) handle is provided to operate all functional units and their earth switches, otherwise one (1) operating handle of each type required for safe operation of switchgear must be provided. The handle must be securely attached to the switchgear at an appropriate location. It is preferable to be able to convert any switch for remote operation by addition of a motor mechanism. Necessary provision must also be made to easily enable such a conversion.

Means must be provided to padlock any disconnector, switch-disconnector, switch-fuse combination, circuit breaker or earth switch in open or closed position.

5.6.4 Circuit identification

Each switch-disconnector, disconnector, fuse switch combination, circuit breaker and earth switch must be labelled by the company with a unique identification number. A clean surface must be provided on the main body of the equipment (not on any removable covers) for this label.

The label must be manufactured from a durable material, such as trafolite. The label must have black writing on a white background. Minimum size of characters is 4mm high. The label must be 15mm x 50mm and must be held in position with screws so that it can be readily changed.

Coloured phase discs must be supplied and installed in accordance with AS 2067.

Earth circuits must be identified by predominantly green or green/yellow colouring and the main circuits are to be a distinctly different colour to the earth circuit.

5.7 Fuses requirements

5.7.1 Fuse carriers

The fuse elements used in the switchgear must comply with AS1033.2 fuse type I, as in App. D.

The maximum power dissipation of the fuse used by the company may be as high as 140 watts for each phase. The manufacturer of the switchgear must calculate temperature rise within the fuse carrier/canister with rated load current flowing through the fuse and the effect of temperature rise on fuse performance. The fuse link intended to be used in the fuse enclosure may require derating. The manufacturer must provide derating characteristic if derating is required.

These calculations and derating factors must be submitted to Substation Assets Manager for approval. Fuse holders/carriers must be suitable for withstanding high temperatures due to fuse losses. The fuse carriers must accept both 12kV and 24kV fuses. Tulip type fuse extensions or adaptors must be provided for all units as most switchgear will be used on the 12kV network.

High voltage fuse holders, used to insert or remove a fuse element from its canister, must be fully insulated, or must provide for earthing the fuse element whilst the operation is being carried out.

Typical current limiting fuse link dimensions used by the company

	12kV	24kV
Barrel length	292mm	442mm
Overall length	360 +2mm to - 3mm	510 +2mm to - 3mm
Overall diameter	88mm max.	88mm max.
Contact ferrule diameter	45 ±1mm	45 ±1mm
Contact ferrule length	34 ±1mm	34 ±1mm

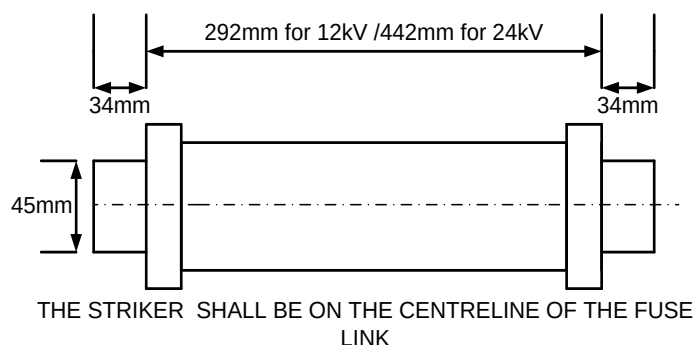


Figure 6 - Fuse link detail

All fuse switch-disconnector and fuse switch combinations must incorporate three-phase switching. Operation of the striking pin in any one fuse must open all three phases simultaneously.

5.8 Protection relay requirements

5.8.1 General requirements

The protection relay which is associated with each circuit breaker:

- must incorporate three-phase overcurrent and residual overcurrent (earthfault) functions which comply with IEC 60255-151 (Functional requirements for over/under current protection)
- must comply with IEC 60255-1 (Protection equipment, common requirements)

- must meet any applicable environmental conditions given in section 5.1.2 of this Standard, where these service conditions exceed the normal environmental conditions given in table 1 of IEC 60255-1
- must be self-powered (requiring no external auxiliary source of supply for operation including tripping)
- must provide a visual indication of an overcurrent or earthfault trip operation
- Must be of a vermin proof design, especially ants.

5.8.2 Overcurrent requirements

The overcurrent function must include at least one dependant time (inverse) characteristic, as well as at least one independent time (definite time) characteristic which is suitable for high speed clearance of high level faults. A third characteristic or overload function which allows for greater sensitivity at low fault levels and overload levels is preferred.

The overcurrent characteristics and their available setting ranges and intervals must be appropriate to achieve the following performance characteristics:

- High sensitivity to low level faults which are greater than normal load currents
- Coordination with downstream and upstream devices including fuses and circuit breakers without excessive compromise
- Coordination with transformer inrush currents (harmonic restraint is preferred)
- A high speed or instantaneous operation at high fault levels.

The overcurrent function must have available either a definite time or dependant time resetting characteristic which is sufficient to allow for the eventual clearance of intermittent faults which are above the overcurrent pickup level and for which the dead time does not exceed 3 seconds. Definite time resetting is preferred.

5.8.3 Earthfault requirements

The earthfault function must include at least one dependant time (inverse) characteristic which allows for enhanced sensitivity for earth faults.

The energising quantities used for the earthfault function must be achieved by way of direct measurement (residual connection of phase CT's or core balance CT), or vector summation of the three phase currents. Alternative options may be considered at the discretion of the Protection Manager.

5.8.4 Other relay requirements

It is preferred that relay setting selection can be done with an interface that allows them to be set, viewed and understood without the need to refer to a manual or setting chart.

It is preferred that the relay be capable of storing event records and/or fault oscillography.

It must be possible to perform relay interaction and event record/oscillography retrieval without the need to take the relay out of service, and all protection functions must remain fully operable.

5.8.5 Relay life and maintenance

The protection relay must have a design life in the relevant application of at least 10 years. Preference will be given to relays with a higher design life, particularly if the stated design life is

backed up by documented reliability analysis, accelerated life testing or a proven track record with similar products made by the relevant manufacturer.

It is preferred that the supplier provide recommended maintenance and testing methods and intervals.

The relay must be able to be tested by way of secondary injection, and all relay functions must be able to be safely and comprehensively tested without exceeding a test current of 90A or a test voltage of 300V.

5.8.6 CT or current sensor requirements

Primary current measurement must be achieved with either current sensors or traditional magnetic core current transformers. The measuring devices must be adequate to achieve the required relay performance between the lowest foreseeable protection pickup level and the maximum fault level, and must also be adequate to power the relay and operate the circuit breaker as required.

If current sensors are used, the required accuracy must meet that of a 10P class current transformer, that is, no greater than 3% magnitude error at the pickup level, and no greater than 10% magnitude error at the maximum fault level. Exceptions to this requirement may be approved by the Protection Manager if analysis indicates that performance will be adequate.

If conventional current transformers are provided, they must comply with AS 60044.1 (Instrument transformers: Part 1: Current transformers), and the Company's Standard PDI 4002 (Current transformers for protection). Exceptions to compliance with PDI 4002 are allowed with the approval of the Protection Manager.

The CT's star point must be located towards the protected zone.

5.8.6.1 Isolation and test link requirements

Test links must be supplied to provide isolation and test point. Test links must be easily accessible from the front of the panel, and be able to accept shrouded M4 test plugs.

Where an open circuit of the current sensor circuit can create a hazardous situation, the test links must comply with the requirements of clause 5.4.3.3

The following diagram is of a typical test link circuit.

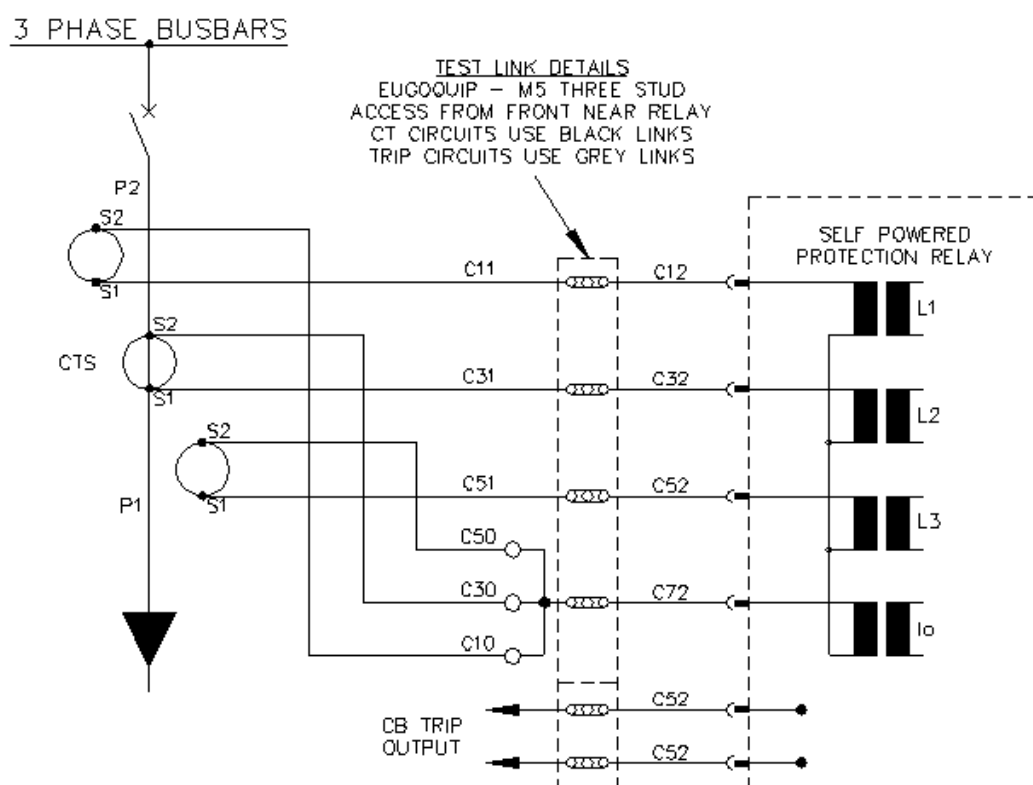


Figure 7 - Test link circuit

5.9 Fault indicators

Short circuit and earth fault current indication **must** be supplied on all switchgear functional units, as shown below. The number of indicators **will** be one less than the number of switch-disconnector and circuit breakers used in a switchgear configuration.

The indicators **must** be provided on switch units (SU) consecutively starting from the left most unit/panel when viewed from the switchboard front, as marked with an asterisk (*) in the table below. Provision **must** be made, to retrofit fault indicators on all panels, if required. The number of fault indicators required on a typical switchgear configuration **must** be as given in Table 5 below.

Table 5 - Fault indicator quantity

Item no.	Switchgear configuration	No. of fault indicators
N1	SU – FSU	-
N2	SU* – FSU – SU	1
N3	SU* – FSU – SU* – SU	2
N4	SU* – SU* – SU	2
N5	SU* – SU* – SU* – SU	3
N6	SU – CBU	-
N7	SU* – CBU – SU	1
N8	SU* – CBU – SU* – SU	2

The fault indicators must be complete with indicating units and a set of at least three current transformers. The indicator must show faults in individual phases if the fault current exceeds the set current.

The set current must be selectable at 400A, 600A, 800A and 1000A for overcurrent and a range of values from 20-160A for earth faults. The indicator must be self-reset type with a time delay of four (4) hours, with a provision to prematurely reset manually through a push button. The indicator must be self-powered, requiring no external auxiliary power.

The preferred overcurrent and earth fault indicator is the Horstman Sigma F&E 3 but others will be considered during the approval process. The unit must be of a vermin proof design, especially ants.

The required settings for the indicators are:

1. Short-circuit trip currents or auto setting = Auto setting [$I > 400-2,000 \text{ A}$]
2. Short-circuit response delay setting = 40ms (minimum)
3. Automatic time reset = 4Hrs
4. Current reset = ON (Resets when the operating current ($I > 5-10 \text{ A}$) is detected for $\geq 1 \text{ s}$ at the end of a time window $> 60 \text{ s}$ after excitation of the instrument)
5. Earth fault trip currents setting = 40A
6. Earth fault response delay setting = 60ms (minimum)
7. Remote signal relay contact, selection of NC or NO = NO
8. Remote signal relay contact, selection of permanent or momentary contact = momentary contact
9. Relay function for selection of phase or group = Group-selective ($I >>$, $IE >$, signal lamp)
10. Inrush current suppression = ON (only if an operating current is detected for at least 5 seconds prior to an overcurrent or earth fault)
11. AR (automatic reclosure) blockade time = AR blockade time 0,1 s
12. Additional switch-off detection criter = Special function: Additional switch-off detection criterion OFF

The CTs for the fault current indicators must be an integral part of the switchgear (bushing mounted design is preferred) so that there is no fitting or support bracket adjustments required for the units during HV cable installation. The fault indicator and associated wiring must be easily replaceable if it malfunctions.

If a battery is required to reset the unit then the battery will be able to be easily replaced by the company without an outage.

5.10 Voltage detecting system (VDS)

The company relies on this device in their switching process to confirm the presence of any voltage on the incoming cables and therefore it is mandatory that the unit is of a fail-safe design. The unit must be able to be tested while in service, or out of service, to confirm that all of its components are functioning correctly including the wiring and connections to the capacitive coupling.

The device must comply with IEC 61243-5 and must be provided on all functional units to test the presence or absence of voltage in the cables. The device must be provided on the front of the switchgear. VDS must provide plug-in points to enable use of an external test device, such as a voltmeter or an indication lamp to check voltage presence or absence.

Plug in points must be suitable to receive a standard 4mm banana plug for test purposes.

The VDS is required to be an integrated system with built in LCD/LEDs. The unit shall be suitable to be used on 11kV or 22kV systems without replacing the unit (WEGA 1.2C Vario is preferred as a minimum).

Provision must be made, to easily replace the VDS display separately from the associated wiring on all panels, if required. Instructions for safe replacement will be provided. The associated wiring should also be suitable for replacement if necessary in the field without dismantling major components.

5.11 Cable connections

5.11.1 Cable compartment (cable box)

A separate cable compartment (cable box) must be provided for each functional unit. The compartment must be fabricated from galvanised steel sheets and must allow easy cable connection to the functional unit. The cable boxes must be air insulated, suitable for connection of dry cable terminations as specified.

Each compartment must be segregated from other compartments by means of steel partition walls. Each compartment must also be fitted with floor plates suitable to prevent vermin entering. Floor plates must not be too restrictive on cable installation and will be fitted with glands to prevent damage to cables from the floor plate. The gland plate must be of non-magnetic material, split to allow cable access, and separate from the sides.

Access to the cable compartment must be from the front by a removable steel cable cover. The front cover must be interlocked with the corresponding functional units in a manner that prevents access to the cable box unless the switch-disconnector or circuit breaker is closed and corresponding earth switch is closed.

The minimum height between the cable lug and cable clamp, near the base of the equipment, will be 550mm. The equipment must be suitable for the termination of cables when the switchboard is fully assembled. A Unistrut type rail (or similar) must be provided in each unit as a fixing/clamping point for all incoming cables.

Plastic cable clamps with rubber/neoprene inserts will be provided for each core of each cable.

5.11.2 Earthing

Each compartment must be fitted with an electro tinned copper earth bar, minimum size = 25 x 3 mm or similar, suitable to carry the full switchgear fault rating. A minimum of four (4) holes, preferably six (6), must be provided on the earth bar/system in each functional unit for connection of cable and termination of earth sheaths plus at least two (2) external earths for connection of portable earths and substation earth grid using M10 bolts.

When multiple functional units are installed to form a module, earth bars/systems must be joined together. The earth bar/system must be laid in such a way that it does not obstruct high voltage cables while connecting and disconnecting from the switchgear, including laying cables in and out through the front access cover. The switchgear frame must be connected to the earth bar/system. The earth bar/system must be brought outside of the switchboard at two points to allow connections to the substation earth grid.

5.11.3 Network cables

The company usually uses the following types of high voltage cables in its underground network. Where a network cable is to be terminated, each functional unit must be suitable for connection of the following cable types.

It is preferred if the switchgear can be suitable for connection of two (2) cables per phase without modification of the main unit or the need to use special cable compartment covers.

Table 6 - Network cable description

Item	Description
Number of cables	1 x 3 phase or 3 x 1 phase
Type of cable	
• Insulation	XLPE, EPR, Paper, PVC etc.
• Screen	Heavy duty
• Sheathed	HDPE, PVC or others
Cable voltage rating	6.35/11 (12) kV for 12kV and 12.7/22 (24) kV for 24kV
Cable conductor	Copper or aluminium
Conductor CSA	Min = 150mm ² max = 300 mm ²

5.11.4 Transformer cables

Cables must be supplied for connection of the transformer circuit breaker unit (CBU), and transformer fuse-switch combination unit (FSU), to the respective transformer. The phase connections between the switchgear and the transformer must be by multiple flexible multi-stranded cables, as detailed below. If this cable is insufficient to meet requirements for bending radius between switchgear and transformer, then a more suitable cable to the same minimum specification must be supplied that does meet the company's requirements.

The supply must include suitable cable terminations and clamps to hold the cable in position and must be sufficiently strong to withstand any short circuit forces that will be inflicted upon it due to a fault.

The minimum specifications of cables are:

Table 7 - Transformer cable description

Purpose	FSU	CBU
Applicable standards	AS/NZS 4026 or equivalent	AS/NZS 4026 or equivalent
Flexibility to suit installation	Must be able to fit in padmount situation	
Voltage rating	12.7/22 (24) kV	12.7/22 (24) kV
Conductor	Copper/Aluminium	Copper
Minimum cross sectional area	25Cu/35Al mm ²	70 mm ²
• Insulation	XPPE or EPR	XPPE or EPR
• Screen	3 kA/1sec	10 kA/1sec
• Outer sheath	PVC, EPR or equal	PVC, EPR or equal
Required cable length	(subject to confirmation for each order)	
• in padmounts	2300 mm	2300 mm
• in indoor substations	8000 mm	8000 mm
Cable end fittings		

• Switchgear end	Screened elbow	Screened elbow
• Transformer end	Screened elbow	Screened elbow
• Rating (min)	200 A	200 A

For padmount substations where switchgear is mounted very close to the transformer, the cable is required to have a very small bending radius. It must be confirmed that the type of cable offered is fit for the intended use and must be flexible enough to prevent undue stress or pressure on the cable and has ease of fitting.

For padmounts, the transformer cables are generally required to exit the switchgear to the rear as there is limited access through the base of the plinth. Switchgear must be suitable to allow cable access to the rear with the cable terminations fitted.

5.11.5 Terminations

Cable termination arrangements will be made as described below using only approved terminations to the following detail.

Table 8 - Cable termination type for each functional unit

Functional unit ->	SU	FSU	CBU
Terminations switchgear end of cables			
Size / type	Type C-400 series	Type A-200 series	Type C-400 series
Standards	AS 2629	AS 2629	AS 2629
Type	Screened elbow	Screened elbow	Screened elbow
Secured with	M16 Bolt	Plug-in + bail clamp	M16 Bolt
Current rating (min)	630 A	200 A	200 A
Terminations transformer end of cables			
Size	-	Type A-200 series	Type A-200 series
Standards	-	AS 2629	AS 2629
Type	-	Screened elbow	Screened elbow
Secured with	-	Plug-in + bail clamp	Plug-in + bail clamp
Current rating (min)	-	200 A	200 A

The company prefers the use of screened elbow connectors as described above. However, after evaluation the Manager Asset Standards & Design may accept switchgear with flat termination palms suitable for a 12mm bolt, for which full details of the cable termination arrangements will be submitted.

Where switchgear bushings require the use of an unscreened cable termination, the termination must be placed behind an earthed metallic or a fully insulated barrier with a removable cover. Necessary interlocks must be provided to prevent access to the termination if the corresponding earth switch is in open position. Warning labels must be provided wherever necessary.

Any arrangement must be subject to Manager Asset Standards & Design's prior approval. Tests must be conducted on cable boxes with unscreened terminations to prove conformance to specifications.

Arrangements **must** be made to enable testing of each phase of each cable terminated to the switchboard.

5.12 Accessories

When required by the company as spares, the following optional accessories **must** be provided. The accessories **must** be suitable for use on the switchgear and **must** provide an easy and safe operation:

- Operating handle for SU.
- Operating handle for FSU.
- Operating handle for CBU.
- Operating handle for earth switch.
- A phase concordance unit
- A voltage indication lamp to check voltage presence a unit.
- A device, such as a dummy fuse, that can be used to directly earth the cable connection to the transformer without having to rely on the continuity of the fuse.
- Special tool for fuse replacement, if required.

5.13 Installation footing/plinth

The switchgear is generally used in a padmount substation but will also be installed over a trench or penetrations for indoor substations.

The offered switchgear **must** be suitable for mounting over both of the company's standard plinth or trench, without modification. If necessary, an adaptor plate or a frame **must** be provided to make it suitable for these locations. Refer also to clause 5.4 and the drawings in clause 5.16.

The manufacturer will need to provide drawings showing the method of installation of this equipment.

5.14 Tests

5.14.1 General

The following clauses detail the testing requirements for the switchgear. The tests **must** confirm the ability of the switchgear to meet the technical requirements as laid down in clause 5.3.

The manufacturer **must** provide two copies of certified test reports for type, routine and special tests.

At any time during the supply of the equipment, the Manager Asset Standards & Design may consider it necessary to confirm performance of the switchgear by conducting any tests.

These tests **will** initially be carried out at the company's expense, however, where it can be demonstrated that the equipment does not meet with the approved test results, the tests **must** be repeated, by the manufacturer, in the presence of an the company representative.

This and subsequent tests will be at the manufacturer's expense.

Depending on the extent of these non-conformances, the company may remove or rectify equipment already in service. Refer to the contract commercial conditions for more details.

5.14.2 Accreditation and acceptability of testing authorities

All tests **must** be carried out by a testing authority holding appropriate accreditation:

- by NATA Australia; or,
- by an accreditation authority recognised by NATA Australia.

Tests from other testing authorities, such as KEMA, may be accepted at the discretion of Manager Asset Standards & Design.

However, routine tests carried out at the manufacturer's testing facilities may be accepted provided the facilities are pre-qualified by the Manager Asset Standards & Design to perform the tests.

The Manager Asset Standards & Design may accept test results of previously conducted type tests, provided the offered switchgear is exactly the same as the type tested switchgear, and type tested switchgear is in accordance with this specification.

Where the offered switchgear has not been successfully type tested, or the test results do not meet the technical requirements of this specification, fresh type tests **must** be conducted at the manufacturer's expense.

Two (2) copies of type test reports **must** be submitted for the Manager Asset Standards & Design's approval.

Test reports **must** not be more than five (5) years old from the closing date of the tender.

Test records (on identical equipment) in the form of validated copies of test certificates **must** be submitted for approval/information.

Copies of the test reports **must** be provided to the company. Reports written in any language other than English **must** not be accepted by the company unless such reports are translated into the English language by a sworn translator.

The company reserves the right to witness type tests for which a minimum of four (4) weeks notice **must** be given.

5.14.3 Type tests

The HV switchgear **must** be of a type-tested design in accordance with the requirements of AS62271 and as listed below.

The following type tests from AS 62271.1 are required on the complete assembled unit/ring main:

Table 9 - Type tests – all equipment

Type test	Test method	Acceptance criteria
Grouping of tests	All of Cl. 6.1.1	No failures
Dielectric tests on main, auxiliary and control circuits - Including partial discharge test – Cl. 5.14.5 below	All of Cl. 6.2	No disruptive discharge
Radio interference voltage (RIV) test	All of Cl. 6.9.1.1	2500µV
Measurement of resistance of main	All of Cl. 6.4	Resistance < 20% of value before

Type test	Test method	Acceptance criteria
current path		temperature rise test
Temperature rise tests	All of Cl. 6.5	Temperature rise to be < 65 Kelvin
Short-time withstand current and peak withstand current tests	All of Cl. 6.6	Contact resistance not to vary by > 1% of original value. No mechanical damage.
Making and breaking tests	See individual tests below	Contact resistance not to vary by > 1% of original value. No mechanical damage
Short-circuit current making and breaking tests		
Capacitive current switching tests: line charging		
Capacitive current switching tests: cable charging		
Tests to verify degrees of protection of enclosures	All of Cl. 6.7	As detailed in clause 5.3 - Technical requirements
Tightness tests	All of Cl. 6.8	< 0.1% a year
Mechanical and environmental tests	See individual tests below	Operating characteristics before test same as after test
Misc. provisions for mechanical and environmental tests		
Mechanical operation test at ambient temperature		
Electrical endurance tests		
Low and high temperature tests		
Humidity test		
Dielectric test on auxiliary and control circuits	All of Cl 6.10.6	Auxiliary and control circuits not damaged
EMC test	All of Cl 6.9.2	Must withstand each of the tests specified without permanent damage. After the tests it must still be fully operative

The following additional type tests from AS 62271.100 are required on all circuit breakers:

Table 10 - Additional type tests - circuit breakers

Type test	Test method	Acceptance criteria
All tests indicated in Table 9		
Making and breaking tests		Its mechanical parts and insulators must be in essentially the same condition as before the test-duty. Condition checking test is mandatory
Short-circuit current making and breaking tests	Cl. 6.102 to 6.106	
Capacitive current switching tests: line charging	Cl. 6.111.5.1	
Capacitive current switching	Cl. 6.111.5.2	

tests: cable charging		
Mechanical and environmental tests		Operating characteristics before test same as after test
Misc. provisions for mechanical and environmental tests	Cl. 6.101.1	
Mechanical operation test at ambient temperature	Cl. 6.101.2	
Electrical endurance tests	Cl. 6.112	
Low and high temperature tests	Cl. 6.101.3	
Humidity test	Cl. 6.101.4	

The following additional type tests from IEC 62271.103 are required on individual switches:

Table 11 - Additional type tests - individual switches

Type test	Test method	Acceptance criteria
All tests indicated in Table 9		
Making and breaking tests	All of Cl. 6.101	The mechanical function and the insulators of the switch must be in practically the same condition as before the tests. The switch must be capable of carrying its rated normal current without its Temp. rise exceeding the values specified
Mechanical operation tests	All of Cl. 6.102	The switch must be in such a condition that it is capable of operating normally, making, carrying and breaking its rated normal current

The following additional type tests from AS/IEC 62271.105 are required on individual fuse-switch components:

Table 12 - Additional type tests - fuse-switches

Type test	Test method	Acceptance criteria
All tests indicated in Table 9		
Measurement of resistance of main current path	Cl. 6.4	Resistance < 20% of value before temperature rise test
Temperature rise tests	Cl 6.5	Temperature rise to be < 65 Kelvin
Making and breaking tests	All of Cl. 6.101	Its mechanical parts and insulators must be in essentially the same condition as before the test-duty. Condition checking test is mandatory
Mechanical operation tests	Cl. 6.102	After performing this test-duty, the mechanical functioning of the trip linkages must be practically the same as before the tests
Mechanical shock test on fuses	Cl. 6.103	The fuses must show neither signs of mechanical damage nor significant

		change in resistance. They must not have become displaced in their contacts
Thermal test with long pre-arcing time of fuse	Cl. 6.104	The striker and the switch have operated correctly. There is no damage on the fuse

The following additional type tests from AS 62271.102 are required on individual disconnectors and earthing switches:

Table 13 - Additional type tests - disconnectors and earth switches

Type test	Test method	Acceptance criteria
All tests indicated in Table 9		
Short-time withstand current and peak withstand current tests	All of Cl. 6.6	Condition check for- Dielectric strength and current Carrying capability
Short-circuit current making performance of earth switch	All of Cl. 6.101	The mechanical function and the insulators of the switch must be in practically the same condition as before the test
Mechanical and environmental tests		
Operating and mechanical endurance tests	All of Cl. 6.102	Operating characteristics before test same as after test
Tests to verify the proper functioning of the position indicating device	Cl. 6.105	The position indicating device indicates correctly the position of the moving contact

5.14.4 Routine tests

The routine test must be conducted on each unit prior to delivery in accordance with the requirements of AS 62271-1.

Table 14 - Routine tests – all equipment

Routine test	Test method	Acceptance criteria
Dielectric tests on main circuits	All of Cl. 7.1	No disruptive discharge
Tests on auxiliary and control circuits	All of Cl. 7.2	No malfunction of circuits
Measurement of resistance of the main circuit and earth switch	All of Cl. 7.3	Main circuit resistance increase < 20% of resistance at temperature rise test results
Tightness test	All of Cl. 7.4	< 0.1% a year
Design and visual checks	All of Cl. 7.5	Compliance to this specifications
VDS functional test after installation	IEC 61243-5	Functions correctly

The following additional routine tests from AS 62271.100 are required on individual circuit breakers:

Table 15 - Additional routine tests - circuit breakers

Routine test	Test method	Acceptance criteria
All tests indicated in Table 14		
Mechanical operation test	Cl. 7.101	Operating characteristics before test same as after test

The following additional routine tests from IEC 62271.103 are required on individual switches:

Table 16 - Additional routine tests - individual switches

Routine test	Test method	Acceptance criteria
All tests indicated in Table 14		
Mechanical operating tests	Cl. 7.101	Operating characteristics before test same as after test

The following additional routine tests from AS/IEC 62271.105 are required on individual fuse-switch components:

Table 17 - Additional routine tests - fuse-switches

Routine test	Test method	Acceptance criteria
All tests indicated in Table 14		
Mechanical operating tests	Cl. 7.101	Operating characteristics before test same as after test

The following additional routine tests from AS 62271.102 are required on individual disconnectors and earthing switches:

Table 18 - Additional routine tests - disconnectors and earth switches

Routine test	Test method	Acceptance criteria
All tests indicated in Table 14		
Dielectric tests on main circuit	Cl. 7.1	No disruptive discharge
Mechanical operation test	Cl. 7.101	Operating characteristics before test same as after test

5.14.5 Partial discharge tests

A partial discharge test **must** be carried out on the switches, earth switches, fuse-switch combinations and circuit breakers in accordance with clause 6.2.9 of AS 62271.1, AS 62271.200 and AS62271.201.

The maximum permissible partial discharge at 1.1U and 1.1U/1.73 (depending on test circuit) **is** 20pC. Three-phase partial discharge testing is required on all switches and all fuse-carriers, checking partial discharge on each phase to phase and phase to earth.

5.14.6 Tests after installation

The company may elect to test cables connected to the equipment by applying 25kV DC (12kV) and 50kV DC (24kV) for 15 minutes between phases and between phases and earth on the cable side of the switches, and they must be capable of withstanding this test.

The company will periodically millivolt drop or resistance check the assemblies to verify production units comply with temperature rise type test requirements.

Duplicate copies of routine test certificates must be supplied with each piece of equipment. The company reserves the right to witness routine testing, for which at least two (2) weeks' notice must be given.

5.15 Product approval

5.15.1 Product approval and audit forms

Complete information of the HV switchgear must be provided on Branch Form FAE 3013.

5.15.2 Product approval process

The company will approve the equipment/components for use on the network. The HV switchgear must be evaluated under the product approval process set out in PAE 1004.

Approval will only be given after a successful installation in a padmount cubicle with a suitable standard company transformer fitted.

5.16 Drawings

The following drawings form part of this instruction:

Table 19 - Drawings

Drawing no.	Amend no.	Title
Current design		
245886	C	Size 14 and 16 padmount sub precast concrete plinth construction details
245887	G	Size 14 and 16 padmount and indoor transformer typical details
264786	B	Size 14 and 16 padmount substation exploded view
264887	B	Size 14 and 16 padmount substation fibreglass cubicle details
264892	A	Size 14 and 16 padmount substation steel plinth construction details
297555	C	Indoor distribution substation switchgear trench cover plate.
297556	C	Indoor distribution substation HV switchgear - trench and mounting support bracket details.
297557	B	Indoor substation – cable trench details
Old design		
061776	D	11kV padmount substation precast plinth construction detail (old style)
077312	C	22kV padmount substation precast plinth construction detail (old style)

6.0 AUTHORITIES AND RESPONSIBILITIES

General Manager Asset Management has the authority and responsibility for:

- approving this specification, including any variations;
- making all decisions concerning compliance in respect to this specification;
- nominating the company's representative(s) for either the manufacturing facility inspection and/or witness testing; and
- delegating any of these authorities and responsibilities to the Manager Asset Standards & Design.

Manager Asset Standards & Design has the authority and responsibility for:

- reviewing this specification and making recommendations to the General Manager Asset Management; and
- making recommendations concerning compliance in respect of this specification; and
- making nominations of the company's representatives.

Substation Assets Manager has authority and responsibility for:

- reviewing all type and routine test reports and alternative proposals submitted for evaluation, and making recommendations to the Manager Asset Standards & Design;
- clarifying all the technical aspects of this specification to the stakeholders; and
- approving the relevant actions required and outlined in this specification.

Protection Manager will be responsible for updating the relevant sections related to protection and control.

SCADA and Program Manager will be responsible for updating the relevant sections related to SCADA and communications.

Contractor Operations Manager has the authority and responsibility for confirming all equipment installed by Level 1 Accredited Service Providers comply with the requirements of this specification.

Commercial Manager has the authority and responsibility to certify that the equipment purchased through the tender process complies with the requirements of this specification.

Manufacturers/suppliers have the authority and responsibility for:

- establishing awareness of their responsibilities under this specification;
- determining the contractor/s under their control have provided suitable training for their employees;
- implementing an effective safety, environmental and quality auditing system is in place; and
- Implementing this specification and keeping the company or other responsible equivalent officers informed of any factors that will prevent them from accepting responsibility for its full implementation.

7.0 DOCUMENT CONTROL

Documentation content coordinator	:	Substation Assets Manager
Documentation process coordinator	:	Branch Process Coordinator