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Equipment Technical Specification

66kV and 132kV indoor GIS

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Equipment Technical Specification

PRIMARY SYSTEMS

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**(Supersedes Substation Design Instruction
 SDI 502.am1 – High Voltage GIS Switchgear)**

ETS 0012 66KV AND 132KV INDOOR GIS

CONTENTS

1.0	PURPOSE.....	4
2.0	SCOPE	4
3.0	REFERENCES.....	4
4.0	DEFINITIONS AND ABBREVIATIONS.....	5
5.0	ACTIONS.....	6
5.1	General requirements	6
5.1.1	General.....	6
5.1.2	Service conditions.....	7
5.2	Network operating conditions	8
5.3	Health, safety and environmental (HSE) requirements.....	8
5.3.1	Insulating gas management and global warming potential (GWP)	8
5.3.2	Special environmental requirements - toxicology safety.....	8
5.3.3	Noise levels and radio interference voltage (RIV)	8
5.3.4	Fall prevention and safe working at heights	9
5.3.5	Fire and blast hazards	9
5.3.6	Technical / operational safety requirements.....	9
5.4	Technical performance summary	9
5.5	Technical requirements	11
5.5.1	Minimum requirements	11
5.5.2	Details of construction and fittings.....	11
5.5.3	GIS gas system	13
5.5.4	Circuit breaker(s)	14
5.5.5	Combined Disconnecter and earthing switches	17
5.5.6	Details of construction and fittings.....	17
5.5.7	Busbars	19
5.5.8	Current transformers.....	19
5.5.9	132kV current transformer options.....	21

5.5.10	<i>Voltage transformers</i>	22
5.5.11	<i>Surge arrestors</i>	23
5.5.12	<i>HV Cable termination/connection enclosures</i>	23
5.5.13	<i>Bushing terminals</i>	24
5.5.14	<i>Surface finish</i>	24
5.5.15	<i>GIS auxiliary and ancillary equipment</i>	24
5.5.16	<i>Earthing / grounding</i>	28
5.6	Operational Requirements	28
5.6.1	<i>Interlocks</i>	29
5.6.2	<i>Testing and monitoring systems</i>	30
5.7	Maintenance requirements	31
5.7.1	<i>Spare parts and management</i>	31
5.8	Quality assurance	32
5.8.1	<i>Quality assurance plan</i>	32
5.8.2	<i>Operations and maintenance manual</i>	32
5.8.3	<i>Additional information</i>	33
5.9	Testing	33
5.9.1	<i>Circuit breaker</i>	34
5.9.2	<i>Disconnectors and Earth Switches</i>	36
5.9.3	<i>Current transformers</i>	37
5.9.4	<i>Voltage Transformers</i>	40
5.9.5	<i>Additional GIS tests</i>	41
5.9.6	<i>Tests after installation</i>	42
5.10	Tender drawings	43
5.11	Packing	43
5.12	Product approval	44
5.12.1	<i>Product approval and audit forms</i>	44
5.12.2	<i>Product approval process</i>	44
6.0	AUTHORITIES AND RESPONSIBILITIES	44
7.0	DOCUMENT CONTROL	45

1.0 PURPOSE

To set out in detail the minimum technical requirements for 66kV and 132kV gas-insulated metal-enclosed switchgear (GIS) used in transmission and zone substations and switching stations in Endeavour Energy's network.

2.0 SCOPE

This specification covers the design, manufacture, factory testing, delivery, installation and testing at site of 66kV and 132kV GIS which is complete with circuit breakers, disconnectors, earth switches, voltage and current transformers, busbars and external interfaces whose configuration is indicated by the single line diagram (SLD). The requirement is for self-contained, sealed pressure GIS, complete with mechanism boxes for the circuit breakers and disconnectors in addition to the applicable interlocking.

It is not the intention to specify all possible design and construction details of the GIS, however, the equipment supplied shall meet all the requirements specified in the standards referenced and in this document.

The scope includes all accessories and equipment necessary and normally supplied for the safe operation of the equipment, whether specified or not.

All equipment shall be manufactured and tested to the standards with the year of publication listed below. Endeavour Energy will consider equipment manufactured to other recognised international standards provided the standards are at least equivalent to Australian and/or IEC standards. In some circumstances based on local network experience, this specification is more stringent than the Australian and International standards it references, in this circumstance the requirements of this specification shall prevail. Any proposed variations from this specification shall be referred to Network Substations Manager for approval in writing prior to acceptance.

3.0 REFERENCES

Company Policy (Network) 9.6.1 – Network Connection
 Company Policy (Network) 9.2.5 – Network Asset Design
 Company Policy (Network) 9.2.10 – Network Asset Ratings
 Company Policy (Network) 9.7.1 – Network Asset Construction
 Company Policy (Network) 9.9.1 – Network Asset Maintenance
 Branch Procedure (Primary Systems) PAE 1004 – Product Approval Process
 Earthing Design Instruction EDI 516 – Major substation earthing design, construct and commissioning
 Equipment Technical Specification ETS 0011 – 132kV/66kV/33kV surge arresters
 Equipment Technical Specification ETS 0014 – Protection and control panels
 Equipment Technical Specification 0103 – 33kV, 66kV and 132kV transmission cable joints and terminations
 Substation Design Instruction SDI 501 – Network configuration
 Substation Design Instruction SDI 526 – Control cabling, panels and terminations
 Substation Design Instruction SDI 528 – Substation signs and equipment labels
 Substation Design Instruction SDI 535 -- Site testing and pre-commissioning
 Substation Design Instruction SDI 545 – Acceptable purity limits for SF6 gas
 Substation Design Instruction SDI 547 – Alarm and tripping requirements in SF6 and dry air equipment
 Network Management Plan (2013 Review)
 NSW Work Health and Safety Act 2011 (NSW)
 AS ISO 1000:1998 - The international system of units (SI)

AS 1627.4:2005 - Code of practice - abrasive blast cleaning of steel surfaces
AS 1734:1997 - Aluminium and aluminium alloy sheet and plate
AS 1824.2:1985 - Insulation co-ordination (phase-to-earth and phase-to-phase, above 1 kV) - Application guide
AS 1852:1988 - International electro technical vocabulary
AS 1874:2000 - Aluminium ingots and castings
AS 1931.1:1996 – High-voltage testing techniques
AS 2067:2008 - Specification for switchgear assemblies and ancillary equipment
AS/NZS 2344:1997 - Limits of electromagnetic interference from overhead a.c. power lines and high voltage equipment installations
AS 2700:2011 - Colour standards for general purposes
AS 4398.2:2005 - Insulators, station post insulators
AS/NZS 4680:2006 - Galvanised coatings
AS 60044.1:2007 - Current transformers for measurement and protection
AS 60044.2:2007 - Voltage transformers for measurement and protection
AS 60137:2008 – High-voltage bushings
AS 60270:2001 – High-voltage test techniques - Partial discharge measurements
AS/NZS CISPR16.2:2002 - Electromagnetic interference measuring equipment
AS 62271.1:2012 - High voltage switchgear and controlgear
AS 62271.100:2008 – High voltage switchgear and controlgear - High voltage alternating current circuit breakers
AS 62271.203:2012 – High voltage switchgear and controlgear – Part 203: Gas insulated switchgear and controlgear for rated voltages above 52 kV
AS/NZS 62271.102:2005 – High-voltage switchgear and controlgear alternating-current disconnectors and earthing switches
IEC 60376:2005 - Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment-Edition 2
IEC 60529:2013 - Degrees of protection provided by enclosures (IP Code)- Edition 2
IEC 61243.5:1997 – Live working - Voltage detectors - Part 5: Voltage detecting systems (VDS)
IEC 62271:209: – High-voltage switchgear and controlgear Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and extruded insulation cables - Fluid-filled and dry-type cable-terminations
ENA National Electricity Network Safety Code (Doc 01-2008)

4.0 DEFINITIONS AND ABBREVIATIONS

AC

Alternating current

CB

Circuit breaker

CT

Current transformer

DC

Direct current

EMF

Electromotive force

GIS

Gas-insulated metal-enclosed switchgear

GWP

Global warming potential

MSDS

Material safety data sheets

Rated peak withstand current

The peak current associated with the first major loop of the short-time withstand current that a mechanical switching device is designed to carry in the closed position under prescribed conditions of use and behavior

Rated normal current

The rms value of the current that a switching device is designed to carry continuously under specified conditions.

Rated insulation level

The rated insulation level is specified by the lightning impulse withstand voltage phase to earth

Rated short time withstand current

The rms value of current that a switching device is designed to carry in the closed position during a specified short time under prescribed conditions of use.

Rated voltage UM

The highest root mean square (rms) phase to phase voltage of the supply on which the switching device is designed to operate.

RIV

Radio interference voltage

RMS

Root mean square

SF6

Sulphur hexafluoride – a non-inflammable, high dielectric strength, chemically stable, non-toxic, biologically inert, odorless and colorless gas that is five times heavier than air and is not ozone friendly.

SLD

Single line diagram

SCADA

Supervisory Control and Data Acquisition

VT

Voltage transformer

5.0 ACTIONS**5.1 General requirements****5.1.1 General**

66kV and 132kV pressurised GIS will be utilised in indoor substations in Endeavour Energy's network.

The GIS offered and supplied shall be designed and manufactured in conformance with:

- AS 62271.1:2012 as the common specification;
- AS 62271.203: 2012 for the metal enclosed switchgear and requirements for the specified voltage class;
- AS 62271.100:2008 & IEC 62271.100:2012 for circuit breakers;
- AS 62271.102:2005 & IEC 62271.102:2013 for disconnectors and earth switches;
- AS 60044.1:2007 for current transformers;
AS 60044.2:2007 for voltage transformers; and
- other relevant standards referenced except where specifically varied in this document.

The GIS shall be designed so that Endeavour Energy's normal service, inspection and maintenance operations can occur safely. This includes but is not limited to the visual determination of the energised or de-energised state of the main circuit and earth switch position, voltage indication for phasing, earthing of connected cables or other apparatus, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of dangerous electrostatic charges to allow works to be carried out safely.

Pressurised dry air, or any gas other than SF6, insulated switchboards utilising vacuum circuit breakers will be considered, and are preferred, where this technology has been adequately proven.

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

Any future extensions or modifications to the GIS shall be as indicated on the SLD submitted with the tender.

The compartment dimensions shall be designed to limit internal arc faults for reasonable transient events as far as possible and the effect of such a fault would be limited to pressure increase of the gas without any fragmentation of the enclosure and internal parts. The internal arc shall not propagate into adjacent gas compartments.

Each gas-filled compartment shall be equipped with static filters/moisture absorbent of ample capacity to absorb any water vapour penetrating during installation into the switchgear and/or during the operation over the entire design or expected life of the switchgear.

The minimal escape of gas and the time between re-fillings for each compartment shall be stated by the supplier; however the relative leakage rate of each compartment shall not exceed 0.1% per year for the whole of life of the GIS.

Rupture diaphragms shall be provided to prevent the enclosures from uncontrolled bursting and suitable deflectors installed to provide protection for operating and maintenance employees.

5.1.2 Service conditions

The GIS shall be designed, manufactured and tested for indoor service conditions. The GIS shall be suitable for use on the Endeavour Energy's 66kV and 132kV 3-phase 50Hz system having the neutral point of the source effectively earthed. The highest system voltage is 72.5 and 145kV RMS respectively.

Service conditions shall be in accordance with the indoor standard requirements of clause 2 of AS 62271-203.

5.2 Network operating conditions

The configuration of the GIS will vary according to the local network requirement of the substation. For this reason, a single line diagram (SLD) will be provided with each order but will be of the configuration detailed in Substation Design Instruction SDI 501 – Network Configuration.

5.3 Health, safety and environmental (HSE) requirements

5.3.1 *Insulating gas management and global warming potential (GWP)*

Endeavour Energy's preference is for the use of switchgear that does not contain SF₆ gas given its management and global warming potential (GWP) where alternative cost-effective technologies are available. Cost-efficient offers of equipment containing SF₆ will be considered however weighting will be applied in the evaluation process to preference equipment with no or minimal SF₆. SF₆ management, environmental impact and disposal costs will be considered in the evaluation process. A similar evaluation weighting will be applied to all gas insulated switchgear, regardless of gas used (except dry-air) weighted by its GWP.

Pressurised dry air, or any gas other than SF₆, insulated switchboards utilising vacuum circuit breakers will be considered, and are preferred, where this technology has been adequately proven.

The supplier of the SF₆ switchgear shall have a return policy whereby they will accept responsibility for disposal of the SF₆ switchgear and any remaining SF₆ gas or by-products. The supplier shall also accept SF₆ gas that is evacuated during maintenance for the whole life of the switchgear. SF₆ management, environmental and disposal costs will be considered in the evaluation process.

A WorkCover Pressure Vessel Certificate shall be provided with the tender. Failure to provide the certificate may result in disqualification of the offer.

5.3.2 *Special environmental requirements - toxicology safety*

The supplier shall provide with the 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 shall be provided for the safe handling, safe operation and maintenance of products supplied. The means of disposal of the materials shall be clearly stated.

Material safety data sheets (MSDS) shall be provided, with copies available on site, for materials that are supplied and subject to safety considerations in handling and use.

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

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

5.3.3 *Noise levels and radio interference voltage (RIV)*

The equipment may be installed in a residential area in close proximity to family residences. Noise and radio interference voltage shall be kept to levels lesser than or equal to 2500 µV.

The supplier shall indicate in the response to this specification typical noise levels and radio interference voltage levels surrounding the equipment tendered, which shall be tested in accordance with AS 62271-1:2012, clause 6.3.

The guaranteed values of RIV shall be as stated in the product approval and audit form referenced in 5.12.

5.3.4 Fall prevention and safe working at heights

The design of the switchgear shall be in such a manner that all operational and maintenance work can be performed at ground level. Where any works are required to be performed at heights, the safety at heights requirement shall be in accordance with the NSW WorkCover Code of Practice: Managing the risk of falls at workplaces Dec 2011 and subject to approval by the Network Substations Manager as part of the evaluation process.

5.3.5 Fire and blast hazards

The switchgear shall be designed in a manner to eliminate the risk of rupture and explosive failure and subsequent employee and fire risk. Where pressurised gas is used or a rapid pressure increase could cause safety hazards to employees or other equipment, the use of appropriately placed pressure release diaphragms and venting positioning shall be provided. Arc fault energy containment, pressure relief and venting are detailed in section 5.5.

Where SF₆ or other gas which release potentially corrosive and toxic by-products as a result of arcing are used, the supplier shall detail appropriate measures to manage the risk to employees and provide measures to eliminate the likelihood of uncontrolled rupture.

5.3.6 Technical / operational safety requirements

Means of visual isolation and safety requirements for operation are detailed in section 5.6.

5.4 Technical performance summary

Network voltage	66kV	132kV
Common requirements		
Compliance with current Australian Standard	IEC 62271.203-2011	
Class	Indoor	Indoor
Interrupting medium	SF6 or Vacuum	SF6
Insulation medium	Pressurised Gas/SF6	Pressurised gas/SF6
Rated voltage (Ur) (kV)	72.5	145
Rated insulation level – lightning impulse (Up) (kV peak)	325	650
Rated insulation level – one (1) min power frequency (Ud) (kV rms)	140	275
Rated frequency (fr) (Hz)	50	50
Rated minimum feeder current(Ir) (A)	1250	2000
Rated minimum busbar current(Ir) (A)	2000	2500
Rated short time withstand current (Ik) (kA)	Option-1: 24; Option-2: 31.5	Option-1: 31.5; Option-2: 40
Rated peak withstand current (Ip) (kA rms)	60 for option-1; 78.75 for option-2	78.75 for option-1; 100 for option-2
Rated duration of short circuit current (tk)(sec)	1	1
System earthing	Neutral effectively	Neutral effectively

Network voltage	66kV	132kV
	earthed	earthed
Circuit breaker		
Applicable Standards	IEC62271.100:2008	IEC62271.100:2008
Class	Indoor	Indoor
First pole to clear factor	1.5	1.5
Rated operating sequence (t=0.3sec,t'=3min)	O-t-CO-t'-CO	O-t-CO-t'-CO
Total short circuit breaking time	0.04 sec	0.04sec
Rated supply voltage of close, trip/open device and aux. CTs (Ua) (V DC)	120 Nominal	120 Nominal
Number of shunt trip coils	Two (2) independently operated coils	Two (2) independently operated coils
Number of close coils	1	1
Mode of closing	Motor charged spring	Motor charged spring
Feeder conditions	Long lines, moderate to severe lightning	Long lines, moderate to severe lightning
Maximum partial discharge level at $1.2U_m/\sqrt{3}$	5 pC	5 pC
Number of available normally open auxiliary contacts	8 minimum	8 minimum
Number of available normally closed auxiliary contacts	8 minimum	8 minimum
Minimum operations with spring fully charged and circuit breaker fully de-energised	Trip – close – trip	Trip – close – trip
Nominal voltage of auxiliary supplies(DC)	120 V	120V
Combined disconnecter and earth switch		
Applicable standards	AS 62271.102:2005; AS 62271.1:2012 and AS 62271.203:2012	
No. of poles	3	
Primary mode of operation	Motorised	
Mode of operation	Motorised (for disconnecter and earth switch)	
Rated current (only for disconnecter)	2000	2500
Nominal voltage of auxiliary supplies(DC)	120 V	120V
Rated short duration power frequency withstand voltage:		
• Common value	140 kV	275 kV
• Across the isolating distance	160 kV	315 kV
Rated lightning impulse withstand voltage:		
• Common value	325 kV	650 kV
• Across the isolating distance	375 kV	750 kV
Minimum no. of Auxilliary contacts	8	8
Rated value of the bus-transfer voltage at which the disconnecter is capable of switching the rated bus transfer current.	10V rms	
Rated value of the induced current switching capability of earthing switches	50A rms	

5.5 Technical requirements

5.5.1 Minimum requirements

The following minimum requirements shall be satisfied:

- three (3) phase encapsulation of busbars in all compartments;
- visible break in the disconnect/earth switch;
- a minimum of two voltage detection indicators through totally independent sources;
- segregation of insulating gas between all compartments;
- interlocking system to allow safe operating conditions for operators and maintenance employees;
- insulating gas density monitor, compensated for temperature with at least two (2) density level alarms for each compartment;
- ability to fill and extract insulating gas from gas compartments without loss or contamination, or risk to employees or evacuating adjacent gas chambers;
- suitable measures to prevent uncontrolled bursting of enclosures, and for providing protection for operating employees;
- suitable operational procedures for proving de-energised components of the switchgear.
- suitable for reliability centred maintenance processes; and
- lifting points to be supplied for each major component.

Similar components within the GIS shall be capable of being interchanged.

The supplier shall provide all accessories and instructions necessary for the safe operation of the equipment.

All connections shall be terminated using crimp lugs and stainless steel or hot dip galvanised bolts, as appropriate. Clamps or u-bolt connections are not acceptable.

All equipment shall be enclosed in earthed enclosures bonded to the main station earthgrid to the extent that there is no safety hazard to operating employees, to prevent accidental shorts by human error, flying objects or rodents, and to prevent mechanical damage to the GIS. The supplier shall indicate to Endeavour Energy the amount of circulating currents in the enclosures and whether current limiting at the earthing points is essential.

The design and construction shall be in accordance with the technical requirements stated. All materials shall be of the type and quality that will give a normal life expectancy of 50 years or more.

All values submitted shall be guaranteed values and shall be treated as such in the evaluation when assessing whether the delivered equipment meets the specification.

5.5.2 Details of construction and fittings

5.5.2.1 Construction features

The GIS covered by this specification shall include the following construction features:

- indoor compartmentalised GIS complete with external tank and high voltage cable terminations;
- transformer, feeder, bus-section and bus-coupler circuit breaker interrupters within the enclosure complete with external spring charged mechanisms;
- internal disconnectors and earth switches for the busbars and feeders complete with external operating mechanisms;

- internal busbar and feeder current transformers complete with external termination boxes;
- gas insulated voltage transformers mounted on the appropriate compartment;
- gas tight solid insulation that separates the live parts of the GIS from the earthed parts under normal operation;
- a fully integrated steel structure/support of adequate mechanical strength suitable to mount the GIS and accessories; and
- partitioning or barriers made of material having insulating and mechanical properties so as to insure proper operation over the lifetime of the GIS.

The configuration of the above components and their quantities shall be as outlined in the single line diagram supplied with the tender.

Bolts, screws and nuts shall be ISO metric. All bolts shall be no longer than necessary. All bolts, nuts and washers used shall be hot dip galvanised or stainless steel. All nuts used shall be fitted with approved positive locking device.

Sharp edges and corners shall be rounded off to avoid risk of injury and corona.

The general arrangement and configuration of individual components shall allow for easy dismantling and removal without the need to dismantle other components. Welded surfaces shall be free of scale, dirt, grease, paint or heavy rust. The welding sequence adopted should be to reduce distortion as much as possible.

All similar parts shall be accurately machined so that they can be interchangeable. All surfaces that will be connected together, or that have to be accurate for the purposes of sealing, levelling or setting up during erection, shall be accurately machined.

The insulation shall be of a type and quality that will not deteriorate over the life of the switchgear. The manufacturer shall submit details of the type tests, routine and special tests, and the acceptable results of those tests that are applied to the various insulation components during and on completion of manufacture.

5.5.2.2 *Switchgear compartments*

The switchgear assembly enclosure shall be of either aluminium or stainless steel metal, permanently earthed to the station's earthgrid and capable of withstanding the normal and transient pressures to which it is subjected in service. The enclosure shall be able to withstand absolute vacuum.

The assembly shall consist of completely separate pressurised gas tight compartments designed to minimise the risk of damage to switchgear in adjacent compartments, and employees in the event of a failure occurring within the equipment. It shall be possible to remove and replace any section of the switchgear in a compartment with no disturbance of the remaining pressurised switchgear. There shall be no leakage of gas between compartments for the whole of life operation of the switchgear.

The high voltage switchgear shall be capable of withstanding the thermal and mechanical effects of short circuits with fault currents, as may arise from any type of fault. The switchgear shall be designed to maximise the safety of employees working on or near the equipment both during normal and fault situations.

5.5.2.3 Partitioning or barriers

Partitions shall maintain their dielectric withstand strength at service voltage when contaminated by SF₆ by-products generated from normal load switching or short-circuit fault breaking over the lifetime of the GIS. Partitioning shall comply with AS 62271.203:2012.

5.5.2.4 Nameplate details

The GIS and all of its operating devices and main components shall be provided with durable and clearly legible nameplates, which shall contain information outlined in the particular component standard in addition to the following minimum information where applicable:

- manufacturer's name or trademark;
- type designation and serial number
- rated voltage;
- rated normal current for busbars and circuit breakers;
- rated frequency;
- rated short-time withstand current;
- lightning impulse withstand voltage (BIL) at which trip/lockout occurs;
- gas density at which trip/lockout occurs;
- rated pressure for operation;
- minimum gas density for insulation; and
- design pressure for switchgear assembly;
- space for Endeavour Energy asset number to be stamped.

The nameplate details shall be laser etched onto a stainless steel plate attached to the appropriate operating device and components. The nameplate shall be easy to read.

5.5.3 GIS gas system

The GIS system shall comprise of separate, sealed, gas tight, compartments connected together through plug or bolt connected busbars.

A gas compartment schematic diagram that shows the entire arrangement of switchboard shall be permanently fitted to the switchgear, or permanently mounted on a wall adjacent to the switchgear.

Full details shall be provided of charging/discharging and storing of the insulating gas, including equipment needed and any necessary safety measures.

Any exposed gas pipe work shall be mechanically protected against any accidental damage. Density monitors shall be installed in a central and easily accessible location on each compartment of the switchgear bay.

The gas density gauge shall provide a quick and accurate indication of the gas density. The range of acceptable density/pressure shall be indicated on or adjacent to the gauge.

The control system shall provide alarm signals and internal interlocks to inhibit closing of the circuit breaker after the circuit breaker has tripped out due to the SF₆ density within the circuit breaker interrupter compartment dropping below the minimum permissible level.

As outlined in Substation Design Instruction SDI 547 – Alarm and tripping requirements in SF₆ and dry air equipment, all gas-filled chambers shall be fitted with density monitors with a minimum of three (3) electrical contacts. The density monitor electrical contacts (fail-safe) shall operate when the gas density falls below the manufacturer's recommended minimum

operating density to enable the following to be achieved in the part of the switchgear that it monitors:

- stage 1 low gas density alarm. The output contact used for stage 1 low gas density alarm shall be closed at pressures above the manufacturer's recommended alarm gas density, and open when the gas density drops to the alarm density; and
- stage 2 low gas density alarm, concurrent with the CB trip and lockout of the defective part of the switchgear. Two output contacts used for stage 2 low gas density tripping and lockout shall be open at pressures above the manufacturer's recommended minimum functional density, and closed when the gas density drops to the minimum functional density.

Each circuit breaker shall be fitted with a gas density sensing device that can be reconfigured by inserting a link at the local control cubicle terminal strip to either:

- lockout; to prevent the operation of the circuit breaker where the gas density is less than that specified by the manufacturer for correct operation of the circuit breaker; and
- trip and lockout. The self-tripping of the circuit breaker on low gas shall be achieved directly from a voltage free contact of the electromechanical gas density monitor.

An on-site facility shall be provided to override the *trip and lockout* function, for use in exceptional circumstances on critical feeders.

Alarm indication shall be conducted and provided through the SCADA control panel.

The lightning impulse withstand voltage of the GIS at trip and lock out, shall be greater than the rated basic insulation level (BIL) of the equipment.

The gas tightness shall be obtained by elimination of any part likely to wear, age or corrode. The supplier shall provide as a part of the tender submission the weight of the SF6 contained in each compartment.

The acceptable level of purity of new SF6 gas shall be 99.7% by weight and shall be confirmed by the supplier. Endeavour Energy's requirement for gas impurities is detailed in Substation Design Instruction SDI 545 – Acceptable purity limits for SF6 gas.

A WorkCover Pressure Vessel Certificate shall be provided with the tender. Failure to provide the certificate may result in disqualification of the offer.

5.5.4 Circuit breaker(s)

The technical characteristics and operational requirements applicable to the GIS circuit breakers shall be as outlined in section 5.4 above.

Each circuit breaker of similar current rating shall be physically and completely interchangeable.

The circuit breaker shall be arranged horizontally or vertically and the arc chambers and contacts shall be freely accessible.

Means for checking the main contacts wear without the need for emptying the chambers of gas, shall be provided where available.

The circuit breaker shall be designed to minimise switching over voltages by being prestrike and restrike free.

The complete system shall be designed to withstand a minimum of 20 operations at full short - circuit rating without the necessity to open the circuit breaker for service or maintenance. The supplier shall provide a table of values and a graph (as shown in annexure 1) indicating the switchgear's capability for different X/R ratios relevant to different system fault levels.

A highly reliable spring type operating mechanism shall be employed for closing and opening the circuit breaker.

The control system shall provide alarm signals and internal interlocks that inhibit tripping or closing of the circuit breaker when the SF6 density within the circuit breaker has dropped below the minimum permissible level.

The supplier shall provide control schematics of different bays for the protection circuits with the tender submission.

For vacuum circuit breakers, the design of the interrupting mechanism and contacts shall be such that the energy dissipated in the vacuum is low and does not cause appreciable degradation of the contacts.

Means shall be provided to test the units for the existence of a vacuum without needing to remove the vacuum bottle(s). Any special test equipment required for this purpose shall be included as an option as part of the offer. Means for checking the contact wear shall also be provided.

The vacuum bottles shall be approved for use by the Manager Primary Systems through the Product Approval process set out in branch procedure Branch Procedure (Primary Systems) PAE 1004 – Product Approval Process.

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

The secondary insulation gas parameters and insulators supporting the vacuum interrupter shall be categorically stated in the product approval form.

5.5.4.1 Circuit breaker operating mechanism and enclosure

- The circuit breaker operating mechanism shall be an integral part of the circuit breaker.
- The parts of the mechanism that require preventive inspection and maintenance shall not be enclosed in any gas tight compartment.
- The mechanism shall contain stored energy motor spring charging equipment to operate the circuit breaker. Hydraulic or pneumatic systems are not acceptable. It shall be possible to perform all operations of the circuit breaker manually and electrically.
- The circuit breaker in the closed position shall be able to have a TRIP-CLOSE-TRIP operation.
- The mechanism enclosure shall be manufactured from stainless steel of adequate strength and thickness. Other material to be used is subject to the approval of the Network Substations Manager.
- The enclosure shall be vermin proof.

- Where applicable, the enclosure shall be provided with a low surface temperature thermostatically controlled anti-condensation heater, interior cubicle light and associated control switches.
- The terminals of these devices shall be segregated from all other terminals, shrouded against direct contact and provided with a red-white *Traffolyte* live connections warning label.
- All enclosures shall be mounted so that there is clear unimpeded access to the enclosure and all equipment mounted in the enclosure.
- The circuit breaker enclosure must be provided to house terminal strips and control and monitoring equipment.
- Isolating switches shall be provided in the enclosure to enable all control circuits in the cabinet to be isolated during maintenance.
- These switches should be Kraus and Naimer C26 or similar, as approved by the Network Substations Manager.
- All 230/400V terminals shall be shrouded and fitted with a warning label in accordance with Substation Design Instruction SDI 528 – Substation signs and equipment labels.
- The degree of protection of the mechanism box enclosure shall be not less than IP44.

5.5.4.2 *Circuit breaker operation and control*

- The circuit breaker closing mechanism shall be electrically operated trip-free.
- The circuit breaker shall close when the close command is applied. The circuit breaker shall not attempt to make a second attempt to close if it fails to close on the first attempt.
- The circuit breaker shall open on an open command when a trip signal is applied to one (1) or both trip coils.
- The circuit breaker shall be capable of being operated locally at the local control panel, or remotely through a SCADA system. The SCADA system will provide an OPEN or CLOSE command signal of 1.0 Amp DC maximum for a duration of one (1) second.
- A LOCAL- REMOTE-MAINTENANCE changeover switch shall also be provided in the Endeavour Energy protection panel to facilitate the changeover of control.
- Local CLOSE and OPEN switches or push buttons, coloured red and green respectively, shall be provided in the breaker control panel to operate the breaker locally.
- A mechanical push button or similar device shall be provided for tripping the circuit breaker manually.
- Necessary provision shall be made to prevent the spring charging motor from running continuously in the event that the springs have failed to charge.
- The circuit breaker shall trip only once, even if the trip button is continuously depressed, and shall also close only once in the event that the close button is continuously depressed.

- This shall be achieved by using an anti-pumping relay.
- The coils of the control contactors associated with the solenoid operated closing device shall be rated for continuous operation.

5.5.4.3 *Circuit breaker indication*

The following indications shall be provided on the breaker mechanism panel:

- an indicator to show whether the stored energy device is charged or discharged shall be provided; and
- a mechanically operated indicator that shows whether the breaker is open or closed.

The word OPEN or CLOSED shall clearly indicate and be clearly visible in indicating the status of the circuit breaker. This shall be achieved through the use of semaphores as appropriate. The colour red shall indicate the closed position and the colour green shall indicate the open position.

Each circuit breaker shall be equipped with a non-resettable mechanically operated counter for indicating the number of tripping operations. The counter shall be readable from the front of the switchgear, from ground level, or from the maintenance platform without the removal of equipment.

5.5.5 *Combined Disconnecter and earthing switches*

The disconnector /earthing switch shall comply with AS 62271.1-2012 and AS 62271.102:2005 and shall have the characteristics and requirements listed in section 5.4 of this document.

The continuous current rating of all disconnectors shall be equal to or greater than that of the circuit breaker.

5.5.6 *Details of construction and fittings*

The disconnector and earthing switch assemblies covered by this document shall include the following construction:

- disconnectors and earthing switches complete with contacts, insulators and operating links; and
- fully functional motor operating mechanism and enclosure.

All operating linkages carrying mechanical loads shall be designed for negligible deflections and mechanical clearances shall be kept low to avoid excessive backlash during opening and closing.

The switches shall be designed so that the contacts register fully under normal operating and service conditions and so that all possibilities of misalignment or separation of contacts owing to bounce, springing, vibration, and short-circuit forces, whether during operation or in service, are eliminated. There shall be ample overlap provided in the design of operating mechanism of the switches on the making of all contacts over all ranges of operation.

All rotating parts shall be provided with self-lubricating bearings of approved design and backed by service experience.

5.5.6.1 Arrangement of switches

- All circuit connected maintenance earthing switches (ie Transformer feeders, busbar and feeders) shall be insulated to a minimum of 10kV to enable testing including current injection tests.
- The disconnecter / earthing switch shall be DC motor operated (120V), completely suitable for remote operation and shall have a manual emergency drive mechanism.
- High speed, fault make earthing switches shall be provided on all outgoing feeders and on the busbar.
- Common drive mechanisms with mechanical interlocks shall be provided for isolating and earthing of the switchgear. The isolating and earthing functions shall be carried out through a multi-position (closed, isolated, earthed) moving contact. It shall not be possible for the drive mechanism to move from the closed position to the earthed position in one movement.
- Where common motor driven mechanism and common moving contacts are utilised in the combined disconnecter/earthing switch a safe and effective mechanical interlocking shall be provided which inhibits the drive mechanism to move from the closed position to the earthed position in one movement.
- Each motor-drive shall be self-contained and equipped with auxiliary switches in addition to the mechanical indicators. Minimal lubrication of the bearings shall be required during the life of the drive system.
- It shall be possible to determine the operating position of the disconnecter / earthing switch through visual inspection of the disconnecter / earthing switch. For this purpose individual inspection windows shall be provided for each disconnecter / earthing switch.
- The ON and OFF positions (coloured red and green respectively) of the disconnecter / earthing switch, to be indicated by semaphores, shall be clearly visible through inspection holes and labelled. If the disconnecter / earthing switch is within the busbar chamber then the inside of the chamber should be coloured with a light colour paint such as cream or white to reflect light. In this case two inspection holes are to be provided, one for a flashlight and the other as a viewing window.
- It shall not be possible for the disconnecter / earthing switch to open or close inadvertently due to forces which may occur in service, including those due to a short circuit.
- The main earth connection to the substation earth grid shall be via tin plated flexible copper braid, flexible copper rope will not be acceptable.

5.5.6.2 Contacts and main terminal

The contacts shall be self-aligning and self-cleaning type, and designed so that normal contact can be made after prolonged periods of time under the service conditions.

Contacts and springs shall be designed so that reduction in contact pressure is kept to a minimum as a result of wear on the contact surfaces. Adjustment to maintain contact pressure shall not be necessary throughout the life of the switch and each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all times.

Contacts shall be lubricated by an approved lubricant, which shall reduce wear and scuffing of contacts, but shall not provide a means of reducing the effort to operate the switch.

5.5.7 Busbars

All busbars shall be three-phase encapsulation and shall have a rated normal current as indicated in section 5.4 of this document.

The switchgear shall be designed such that for failure of any equipment in the bus coupler section, which includes gas chambers for circuit breaker and a set of disconnectors/earth switches, there shall be no need to isolate more than one busbar at a time to replace the faulty equipment. This may require the installation of an extra gas chamber to provide gas and pressure isolation.

5.5.8 Current transformers

Current transformers shall comply with AS 60044.1-2007. Typical current transformer requirements are itemised in the table below and are indicative only. Project specific current transformer requirements will be indicated in the Single Line Diagram to be supplied with the tender document.

Endeavour Energy requires appropriate transient performance from the 66kV & 132kV current transformers (CT). The PX class current transformers are to be used for the high accuracy and high speed protection scheme, such as distance protection, feeder differential protection, pilot wire protection, busbar and transformer differential protection schemes at the 66kV and 132kV voltage levels. These protection systems are normally required to operate in the first few cycles of the faults. This type of current transformers needs to induce an e.m.f (knee point voltage) in the secondary winding that shall be sufficient to drive the transient secondary fault currents (ac component + dc component) through the total impedance (burden) of the secondary circuit without any distortion (at least first two cycles).

Its capability is expressed in terms of:

- maximum secondary exciting current in amperes at rated knee point voltage;
- secondary current corresponding to maximum steady state rms primary current (ac component of the fault current); and
- over-dimension factor due to dc component of the fault currents. The dc component of the prospective fault currents depend on the primary system X/R ratio behind a fault or saturation factor that is determined by the time taken for the CT to saturate, primary system time constant, secondary system time constant, maximum resistance of the CT secondary winding at 75 deg. C, and rated resistive burden that to be connected to the current transformer.

The current transformers (CT) have been specified in the following tables in terms of protection requirements in Endeavour Energy. Endeavour Energy does not want to constrain the design of the CT unnecessarily. Therefore, it is left to the manufacturer to design and build the iron and copper circuits of the current transformer (CT) based on the information provided in this specification.

Marking of the nameplate shall be done according to AS 60044.1. The following information shall be marked on the nameplate along with other information accordance with AS 60044.1:2007.

- all available ratios;
- rated primary current;
- rated secondary current;
- maximum secondary exciting current in amperes at rated knee point voltage;
- rated knee point voltage;
- rated secondary winding resistance at 75 deg celcius; and
- rated burden.

A laser etched stainless steel rating plate shall be fitted to each current transformer. A second identical plate is to be fixed within the LV compartment in such a position that facilitates ease of access to read the information.

The nominal rating of the primary winding of all current transformers should be 1.5 times or at least equal to the assigned rating of the associated switchgear and circuit breaker. The secondary windings of the current transformers shall be capable of carrying continuously a current not less than 2 times the rated secondary current.

The CT class/designation format as provided in the table is to give the manufacturer some flexibility in how they design and build the CT. Actual values for knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be specified in the tender offer and these need to be maintained consistently throughout the contract term.

Current transformers shall be mounted in such a position so as to reduce the possibility of damage or failure to perform during equipment failures.

Each set of current transformers shall have all secondary leads brought out to an accessible terminal block inside the control box which shall be adequately sized to allow easy termination and removal of cables.

The terminals and leads shall be clearly marked with current transformer secondary terminal markings to AS 60044.1:2007 and show the current transformer group number in which the current transformer is mounted (for example, 3S2 - terminal number S2 of the third group).

Wiring and terminal/links shall be arranged to enable the easy changing of CT ratios.

The order of the current transformers and the position of the primary terminals relative to the circuit breaker are as shown on the single line diagram.

The induced high voltage test on secondary winding insulation as specified in AS 60044.1-2007 is to equally apply to all current transformer secondary wiring and terminals between the current transformer secondary terminals and terminals provided for ratio change.

All current transformers shall be mounted in a manner so that they are accessible from ground level for operation and maintenance. Suitable work platforms shall be provided for maintenance purpose if accessibility from ground level is not practical.

5.5.8.1 66kV current transformer options

Option 1a – 72.5 kV, 2000 A, 325kV BIL, 31.5 kA/1 sec; 5 cores CT Cores: 1 & 2 Protection, 3 Metering, 4 and 5 Protection		
	Ratios	class
Protection Cores	2000/1000/500/250:1	0.05 PX150($R_{ct}+2$) @ 2000:1
Metering Cores	2000/1000/500:1	0.2, Minimum 5VA burden on all ratios
Secondary rated continuous thermal current	2A on all ratios for all cores	–

Option 1b – 72.5 kV, 2000 A, 325 kV BIL, 31.5 kA/1 sec; 6 cores CT Cores: 1 & 2 Protection, 3,4 Metering, 5 and 6 Protection		
	Ratios	class
Protection Cores	2000/1000/500/250:1	0.05 PX200($R_{ct}+2$) @ 2000:1
Metering Cores	2000/1000/500:1	0.2, Minimum 5VA burden on all ratios
Secondary rated continuous thermal current	2A on all ratios for all cores	–

Option 1c – 72.5 kV, 2000 A, 325 kV BIL, 31.5 kA/1 sec; 5 cores Cores: 1 & 2 Protection, 3 Metering, 4 & 5 Protection		
	Ratios	class
Protection Cores	2000/1000/500/250:1	0.05 PX150($R_{ct}+2$) @ 2000:1
Metering Cores	2000/1000/500:1	0.2, Minimum 5VA burden on all ratios
Secondary rated continuous thermal current	2A on all ratios for all cores	–

5.5.9 132kV current transformer options

Option 2a – 145 kV, 2500 A, 650 kV BIL, 40 kA/1 sec; 6 cores CT Cores: 1 & 2 Protection, 3,4 Metering, 5 and 6 Protection		
	Ratios	Accuracy classes
Protection Cores	3000/2000/1000/500/250:1	0.05 PX200($R_{ct}+2$) @ 2000:1
Metering Cores	2000/1000/800/500:1	0.2, Minimum 5VA burden on all ratios
Secondary rated continuous thermal current	2A on all ratios for all cores	–

**Option 2b- 145 kV, 2500 A, 650 kV BIL, 40 kA/1 sec; 6 cores CT
Cores: 1 & 2 Protection, 3,4 Metering, 5 and 6 Protection**

	Ratios	Accuracy classes
Protection Cores	2000/1000/500/300:1	0.05 PX 150($R_{ct}+2$) @ 2000:1
Metering Cores	2000/1000/800/500:1	0.2, Minimum 5VA burden on all ratios
Secondary rated continuous thermal current	2A on all ratios for all cores	—

**Option 2c- 145 kV, 3150 A, 650 kV BIL, 40 kA/1 sec; 6 cores CT
Cores: 1 & 2 Protection, 3 & 4 Metering, 5 & 6 Protection**

	Ratios	Accuracy classes
Protection Cores	3000/2000/500/300:1	0.05 PX 200($R_{ct}+2$) @ 2000:1
Metering Cores	3000/1500/800/500:1	0.2, Minimum 5VA burden on all ratios
Secondary rated continuous thermal current	2A on all ratios for all cores	—

5.5.10 Voltage transformers

Voltage transformers shall comply with AS 60044.2-2007. Voltage transformer information is itemised below. The relative position of voltage transformers shall be as indicated on the single line diagram submitted with the tender enquiry.

Description	66kV	132kV
Australian standard specification	AS60044.2 - 2007	AS60044.2 - 2007
Connections (vector group)	YNynyn	YNynyn
Rated primary volts (phase-neutral)	66 kV/ $\sqrt{3}$	132 kV/ $\sqrt{3}$
Secondary winding rated volts (phase-neutral)	110 V/ $\sqrt{3}$, 110 V/ $\sqrt{3}$	110 V/ $\sqrt{3}$, 110 V/ $\sqrt{3}$
No. of secondary windings	2	2
Secondary winding accuracy class (metering/protection)	0.2/3P	0.2/3P
Secondary winding rated burden (output)	50 VA	50 VA
Highest system voltages	72.5 kV	145kV
Rated short time withstand current (rms)	31.5 kA	40
Rated voltage factor (duration)	1.9 (60 sec)	1.9 (60sec)
Rated frequency	50 Hz	50 Hz

Description	66kV	132kV
Lightning impulse withstand voltage (LIWV)	325 kV	650 kV
Power frequency withstand voltage (PFWV)	140 kV	275 kV

Voltage transformers shall be gas-insulated and it is preferred that they are removable without disturbing the adjacent gas compartment.

All voltage transformers shall be of the single phase type construction. The supplier will provide the details of the form of isolation offered as part of the tender.

All voltage transformers shall be mounted in a manner so that they are accessible from ground level for operation and maintenance. Suitable work platforms shall be provided for maintenance purpose if accessibility from ground level is not practical.

A laser etched stainless steel rating plate shall be fitted to the voltage transformer. A second identical plate is to be fixed within the LV compartment in such a position that facilitates ease of access to read the information.

The secondary of all voltage transformers shall be protected with a miniature circuit breaker (MCB). Where MCBs are used for secondary isolation a link shall be used in series to provide a visible break. The MCB's shall be single pole with a contact for remote indication. It shall be possible to carry out insulation resistance tests of power cables without removing the voltage transformer. To facilitate this, the primary of the voltage transformer shall be isolatable. Suitable primary isolating links/devices shall be provided on the voltage transformer with padlockable facilities. The auxiliary switches (4 Normally Open and 4 Normally Closed) shall be provided on the manual isolating device of the VT for the following: for indicating the position of the VT on the local control mimic panel, indication to SCADA and for connection to Endeavour Energy's protection schemes.

5.5.11 Surge arrestors

The requirement for surge arrestors shall be as indicated on the single line diagram (SLD). The technical requirements for the surge arrestors shall be as outlined in Endeavour Energy's Equipment Technical Specification ETS 0011 – 132kV/66kV/33kV surge arresters. The supplier shall fill in the technical schedules and guarantees as required in section 5.12.

5.5.12 HV Cable termination/connection enclosures

The GIS HV cable termination/connection enclosures shall be provided by the supplier of the switchgear in accordance with IEC 62271.209:2007 and AS 62271.203:2012. The supplier/manufacturer of the termination/connection (plug-in) assemblies shall comply with these standards to suit design, ratings and dimensions of the enclosures for each of the HV cable entries.

The cable termination/connection enclosure shall be dry type, inside cone style and perfectly dimensioned to suit the terminations specified in Equipment Technical Specification ETS 0103 – 33kV, 66kV and 132kV transmission cable joints and terminations. The typical arrangement of the dry type inside cone connection assembly and the assembly dimensions shall be as described in Type-A of Figure 4 and dimensions to suit the appropriate rated voltages given in Figure 5 of IEC 62271.209, respectively.

The supplier shall provide a technical specification of the termination/connection plug-in system, including details of plug access for terminating and testing of cables/circuit breakers. The plug type, size and part number shall be provided on the general arrangement drawing submitted for approval. The drawings and other related documents shall clearly indicate numbers and titles of all the complying international standards used in the manufacturing and construction of terminations/connections.

Facilities shall be provided to safely isolate a feeder cable and to connect a high voltage test cable to the switchgear.

Endeavour Energy will carry out the termination of the cables.

Provision shall be made for supporting cables below the termination, and the installation of the supports shall not require removal of the cable serving. The cable supports shall be adaptable to cables of different overall diameters of the sizes nominated by Endeavour Energy.

Provision shall be made for the earthing of the cable sheathing. The base plate of the cable head chamber shall have at least two earthing terminals per phase available for connecting the cable earth sheaths.

5.5.13 Bushing terminals

Where required and as indicated on the single line diagram, bushing terminals to connect the indoor GIS to the external lines through the switchgear building wall might be required.

The bushings shall be designed in accordance with AS 60137:2008.

The supplier shall make provision for the supply of this bushing and the appropriate adaptor flanges as necessary and fill in the requirements as outlined in section 5.12.

The applicable information related to any bus ducts including inductance, capacitance, surge impedance and resistances shall be provided by the supplier in line with Table E.4 of AS 62271.203:2012.

5.5.14 Surface finish

All internal and external metal surfaces capable of deteriorating due to corrosion shall be appropriately cleaned and/or treated against corrosion with primer/paint and/or non-corroding metallic coating.

Adequate coating shall be supplied to protect surfaces from corrosive atmosphere, and the selected coating shall be in accordance with AS 62271.203: 2012 and IEC 62271.1: 2011 to uphold that such properties can be maintained following reasonable use, transport and storage.

Surface preparation and coating details shall be supplied with the tender. This shall include all material and application details, as well as available colours. The external surface finish shall be a uniform natural or painted finish without casting marks, grinding marks, gouges, blemishes, flow marks and shall be aesthetically pleasing to the eye.

5.5.15 GIS auxiliary and ancillary equipment

5.5.15.1 Local Control Panel

A local control and interlocking panel shall be supplied as a standard for each switchgear bay. The interlock system shall be fail safe to prevent mal-operations. Interlocking and control shall be implemented in the relay logic. Mimic diagrams and position indicators shall

give clear demonstration of the operation to the operating employees. Provisions for remote control shall be supplied in the Endeavour Energy panel.

Each panel shall be designed and constructed of materials capable of withstanding the mechanical, electrical and thermal stresses as well as effects of humidity, which are likely to be encountered in normal service.

Each panel shall be self-supporting and shall not rely upon other panels to remain rigid. Each control panel shall be segregated from adjacent panels to prevent the spread of fire.

Components in the control panel shall be arranged to be easily accessible for future mounting, wiring, maintenance and replacement. Easy access shall be considered without danger of electric shock.

Each panel or group of panels shall be fitted with lifting facilities, designed so that they do not stress or damage the panels. If separate lifting facilities are required, other than the normal slings, ropes and the like, these shall be supplied with the control panels.

Each panel shall be provided with ventilation louvers fitted to the doors to prevent the build-up of heat inside the panel and be supplied with approved filters to prevent dust.

Each panel shall be fitted with internal fluorescent panel lighting. The lighting shall be controlled using automatic door light switch. The internal fluorescent tubes shall be available within Australia.

The degree of protection for control panels shall be not less than IP55. Refer to IEC 60529:2012.

5.5.15.2 Auxiliary supplies

120V dc station battery supplies will be available for closing, tripping and spring charging motors. Battery voltage: maximum 130V dc, minimum 80V dc.

A three phase, four (4) wire 230/400V, 50Hz station supply is available for power outlets and heater supplies.

5.5.15.3 Access to control equipment

All control equipment within the cubicles shall be easily accessible with the labelling visible from ground level to an operator of average height (175cm).

5.5.15.4 Control fuses

All secondary fuse holders, including those used as links, shall be GEC *Safeclip* C32/20 or similar, as approved by the Network Substations Manager.

Fuse holders containing a fuse link shall be coloured black and those containing a solid link shall be coloured white.

All fuses, links and terminals shall be accessible from the front of the control panel.
Auxiliary contactors and relays

All ancillary contactors and relays shall 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, except the trip coils, shall be continuously rated for the supply voltage used.

The supervisory open and close relays to be used in the circuit breaker control scheme shall be as stated above.

All relays with a plug-in type base shall be provided with holding clips such that the relays do not dislodge from the base due to vibration or due to inadvertent contact. The relays shall not have mechanical test push buttons on the relays.

5.5.15.5 GIS auxiliary switches

Each switchgear unit shall be fitted with sufficient auxiliary switches, plus 20% spare, to perform all the functions required by the unit. The spare auxiliary switches shall be mechanically coupled auxiliary switches from the drive mechanism. Auxiliary switches via multiplying relays are not acceptable.

Each contact shall be suitable for making, carrying and breaking five (5) Amps at 120Vdc and three (3) Amps at 250Vac in a typically inductive (magnet coil) circuit.

5.5.15.6 Control cable wiring

Control cable terminating facilities shall be provided on each unit. All external cabling shall be supplied and terminated by Endeavour Energy.

The supplier shall provide all internal wiring including the external interface wiring to be terminated at the terminal blocks ready for external wiring termination.

All wiring shall be carried out in accordance with Equipment Technical Specification ETS 0014 – Protection and control panels section 5.3 and Substation Design Instruction SDI 526 – Control cabling, panels and terminations.

A blank removable gland plate shall be provided so that Endeavour Energy may drill to suit the cables used. The gland plate shall be large enough to accommodate four (4) glands, each with an overall diameter of 60mm.

5.5.15.7 Wire termination

All control cables (internal panel wiring and external control cables) shall be terminated in accordance with section 5.4 of Equipment Technical Specification ETS 0014 – Protection and control panels.

5.5.15.8 Secondary terminal blocks

The terminals shall be Klippon, Entrelec M series, Phoenix UT series or Weidmuller WDU series or equivalent.

Current transformer terminal blocks shall be of the bolt type (min. 5mm) or tunnel connectors. Where tunnel connectors are used, they shall be spring pressure type, for example, WDU SL.

Protection circuit terminal blocks shall be tunnel connectors of the spring pressure type, for example, WDU SL.

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

Suitable plastic shrouds shall be provided for all control wiring terminal blocks, this includes but is not limited to all terminals inside the motor control box of circuit breakers, disconnectors and earth switches and the local control cubicles (LCC,s). Where the terminal blocks are used for 230V AC termination, the warning labels with red letters of **Warning 230V AC** on a white background are required.

5.5.15.9 Control switch

Each circuit breaker control unit shall be fitted with a Kraus and Naimer (or equivalent) C26 (operating handle G1,02) or push button control switch (subject to Network Substations Manager approval), with spring return to the neutral position following the electrical operation of the circuit breaker by an operator standing at the switchgear.

The escutcheon of the switch shall include a function designation of the circuit breaker operation. The rating of the switch contacts shall be such that they are capable of clearing the coil currents in the event of the breaker not functioning correctly.

5.5.15.10 Labels

All ancillary items required by Endeavour Energy shall be labelled in accordance with Endeavour Energy's standard nomenclature; this requirement will in general apply to all relays, fuses, control switches and miniature circuit breakers.

All equipment within the cubicle(s) shall be clearly labelled to show its function. Labels shall be of laminated plastic having black upper case letters on a white background. Lettering and numbering on labels shall be as large as practical and not less than 5mm high.

It is preferred that all labels are of the same size or at least the number of different sizes is kept to a minimum.

Labels within the control cubicle shall be affixed using mechanical means. Labels shall be fixed to one side of the device only ie above the device. For all devices located on the door of the cubicle, descriptive labels shall be provided on the front and back of the device.

External labels shall be affixed using mechanical means. Labels shall not be directly affixed to items that are readily removable or interchangeable. Labels shall contain the device number and description of its function.

Drawings of the labels shall be submitted for approval.

5.5.15.11 Spare Contacts

All spare contacts of all auxiliary devices, such as density monitors, relays, CB auxiliary contact, disconnector/earth switch auxiliary contacts, voltage detection systems etc shall be wired to the local control panel terminal rail. For the arc fault detection system all spare contacts shall be wired to the terminal rail in the arc fault detection cubicle.

5.5.15.12 Anti-condensation heaters

Sealed type 230V ac anti condensation heaters, as approved by the Network Substations Manager shall be fitted on the base of panels and shall be clearly visible to field staff and be fitted with suitable warning labels.

The terminals for these devices shall be segregated from all other terminals, shrouded against direct contact and provided with a red-white engraved laminated polyvinyl chloride (PVC) live connections warning label.

5.5.16 Earthing / grounding

- Reference shall be made to clause 5.3 of AS 62271.203-2012 and Earthing Design Instruction EDI 516 – Major substation earthing design, construct and commissioning for earthing requirements.
- All bare copper earth bars that come into contact with aluminium or galvanising shall be tinned plated to reduce the possibility of corrosion.
- The enclosure shall be capable of being connected to earth through a minimum of two (2) M12 studs. All metal parts intended to be earthed, and which do not belong to a main or an auxiliary circuit, shall be connected to earth. Fastening by bolting or welding is an acceptable method for providing electrical continuity between the interconnection of enclosures and frames.
- Cubicle earth – two M12 studs are to be provided at each end of the earth bar to facilitate the connection of the control panel to the substation earth grid.
- Earthing of main circuits shall be designed such that safety during maintenance work, all parts of the main circuits to which access is required or provided shall be capable of being earthed. In addition, it shall be possible, after the opening of the enclosure, to connect earth electrodes for the duration of the work.
- Earthing of the main circuits shall be performed by earthing switches.
- The earthing circuits shall be capable of withstanding the thermal and electrical stress caused by earth fault currents.
- Each unit shall have provision to accommodate the power cable screens (M14 studs or equivalent).

5.6 Operational Requirements

The minimum operational requirements of the gas-insulated switchgear are:

- facility to prove that high voltage electrical apparatus and cables are de-energised;
- a minimum of two (2) totally independent voltage detection sources shall be supplied;
- it shall be possible to determine the operating position of the earthing switch by an infallible method;
- it shall be possible to determine the operating position of the disconnect/earth switch through visual inspection. Inspection windows of an appropriate size (100mm) shall be provided for all isolating and earthing devices to determine the operating position of the device. The inspection windows shall be provided with a suitable cover and warning label **“Danger – Do not view when the device is operating”**. Where the inspection window of 100mm is not possible the supplier shall provide a complete camera system which will provide a clear picture of the operating position of device. The camera shall be cordless

with an internal light source within the camera head and shall be easy to use. It shall include recharging facilities and a spare battery pack; and

- interlocking facilities to prevent incorrect operation of circuit breakers, disconnectors, earth switches and other equipment shall be provided to allow safe operating conditions for the operators and maintenance staff.

All necessary information on the purpose and function of interlocks shall be provided. Where a particular interlocking arrangement has not been previously endorsed, approval for its use shall be obtained from the Network Substations Manager.

Where the minimum operational requirements of this Specification cannot be achieved, approval to use the switchgear on the network shall be obtained from the Network Substations Manager.

5.6.1 Interlocks

The interlocks shall comply with AS 62271.100, AS 62271.203, AS 2067 and the following: The use of electronic bay controllers to implement bay and inter-bay interlocks is not acceptable.

5.6.1.1 Circuit breaker (CB):

- The remote operation of the CB is always possible when the disconnector is closed or opened.
- Local operation of the CB is always possible when the circuit breaker *supervisory, panel, maintenance*, selector switch is in the (*maintenance*) position.
- The CB operations are possible only if the pole gas density/pressure is higher than the threshold block.

5.6.1.2 Disconnector

- The bus disconnector operation (both motor and manually operated) is possible only when the CB is open. Interlocking devices shall be provided such that disconnectors are not inadvertently operated.
- The feeder disconnector operation (both motor and manually operated) is possible only when the associated CB or bus disconnectors on either side of the feeder disconnector are open.
- Suitable interlocks mechanical/electrical shall be provided for the disconnector such that it is not possible to manually operate the disconnector when the circuit breaker is closed under normal operating conditions.

5.6.1.3 Earthing switch

- The bus earthing switch operation (closing) (both motor or manually operated) is possible only when the associated bus disconnector and CB is open.
- The feeder earthing switch operation (both motor and manually operated) is possible only when the feeder disconnector is open and there is no-volts indication.

- No-volts interlocks from the voltage detection systems utilising the voltage free contacts shall be provided on feeder earthing switches and transformer feeder earthing switches.
- Suitable interlocks mechanical/electrical shall be provided for the earthing switch such that it is not possible to manually operate the earthing switch when the circuit breaker is closed under normal operating conditions.

5.6.1.4 Isolation of Motor Drives

- It shall be possible to electrically isolate all motor drives associated with earthing switches, disconnectors and circuit breakers.
- It shall be possible to mechanically isolate /inhibit all motor drives associated with earthing switches, disconnectors and circuit breakers, and have adequate facilities for the purpose of padlocking the device covers to create a secure isolation.

5.6.2 Testing and monitoring systems

The following monitoring systems shall be provided on the GIS switchboard.

5.6.2.1 Internal arc detection

An electronic light monitoring and information system shall be provided to detect an internal arc fault.

A sensor probe, connected to a suitable monitoring relay, is required in each switchgear bay compartment. Indication of the faulty bay compartment shall be shown on the relay front panel. A diagram of the light monitoring arc detection system shall be fixed to the substation wall to allow easy identification of the faulty compartment.

The relay shall have at least three (3) voltage free contacts available for tripping, local indication and remote indication through SCADA. The relay shall be capable of self-diagnostic monitoring, with alarm contacts to indicate any malfunction of the relay unit. It shall provide complete protection of all gas compartments for all types of arc faults; shall be frequency and intensity dependent; and, shall not operate for events such as torches or camera flashes and lights.

The light monitoring and information system shall be of a type that enables grouping of output terminals from individual compartments and provides interfacing with protection schemes and SCADA.

Suppliers shall submit details of a single line diagram (SLD) of the light monitoring and arc fault detection system with their submission. The SLD shall incorporate a sufficient number of probes to eliminate any blind spots.

5.6.2.2 Voltage detection system

Voltage detection is required, and two (2) totally independent voltage detection systems to IEC 61243-5: 1997 with integrated display shall be provided to determine the status of each phase of the circuit.

The system shall be capable of continuously monitoring the test circuit to provide voltage indication. For each voltage detection system, at least three (3) voltage free contacts shall be available for interlocking with the respective feeder earth switch and for providing indication.

The detection unit shall be capable of self-diagnostic monitoring with alarm contacts to indicate any malfunction of the unit.

The detection system shall be capable of being easily viewed from an accessible floor level position.

The unit shall be maintenance-free, in accordance with the above IEC requirements. The supplier shall submit complete details of the voltage detection system with the tender submission.

5.6.2.3 Gas pressure monitoring system

A suitable system shall be provided for the measurement and signalling of the insulating gas density for the GIS switchgear. The permanent gas density monitoring system shall include the following minimum functions:

- automatic monitoring of the temperature compensated gas density during operations, using local display at the switchgear;
- a minimum of two (2) levels of pressure sensing in accordance with section 5.2.5 of this specification; and
- conditioning monitoring system (optional item).

Any additional condition monitoring system that would enhance the reliability and minimise maintenance of the GIS switchboard will be considered by the Network Substations Manager.

5.7 Maintenance requirements

5.7.1 Spare parts and management

The supplier shall supply a list of recommended spare parts, special tools and appliances required for the *whole of life* operation and maintenance of the GIS. The list, together with prices, shall be indicated in the appropriate schedule. Special tools are to be part of the main contract.

The items nominated must allow most common defects to be repaired and recommended maintenance to be carried out expeditiously over the whole life of the GIS. The supplier shall indicate the mean time between failures (MTBF) of the GIS and its components including the recommended maintenance regime and maintenance tasks and intervals. This regime shall be based on the mean time between failure (MTFB) and the critical failure modes identified by the failure mode, effects and criticality analysis (FMECA) of the equipment. Details substantiating the FMECA analysis shall be included in the offer.

Recommended tests to be carried out throughout the life of the GIS and its components, including the pass/fail criteria for each test shall be included in the offer.

Predicted availability of ex-stock parts over the life of the GIS is to be considered. Lists shall be complete with part numbers and current prices for each item.

Where identical items have been supplied to Endeavour Energy as spares on previous contracts, details of the quantity and type supplied shall be provided.

The final quantities of spares to be supplied will be decided as part of contract negotiations.

5.8 Quality assurance

Quality assurance certification is required such that the manufacturers ability to design and consistently manufacture switchgear to this specification. The supplier and all its contractors shall have a quality system which complies with the requirements of AS/NZS ISO 9001 or other comparable Australian or International equivalent.

All nominated drawings and documents that have to be reviewed by Endeavour Energy are to be submitted as complete packages using document controls systems such that all the relevant information to enable the design to be reviewed are available. Design suitability approval will not relieve the supplier of its responsibilities for the correctness and appropriateness of the design or their responsibility to conform to this specification.

5.8.1 Quality assurance plan

A quality assurance plan is to be provided as part of the tender; it shall be a document subject to approval of Endeavour Energy and shall contain as a minimum the following information:

- a) The suppliers organisational structure for the works;
- b) A planned outline meeting the requirements and all stages of the scope and specification;
- c) An index showing all existing procedures, inspection and test plans and drawings;
- d) AS/NZS ISO 9001 certification for itself and subcontractors; and
- e) A plan detailing the design, ordering of materials, manufacturing and test plans.

5.8.2 Operations and maintenance manual

One (1) hard copy and one (1) electronic copy of the complete installation, operation and maintenance manual shall be provided for the complete switchboard supplied for each order. Each manual shall relate specifically to the equipment supplied and must not contain any material that is not applicable. The manual shall be A4 size and all drawings shall be suitably folded or reduced for filing within the manual. Each manual shall include:

- a hard cover to withstand normal handling;
- a comprehensive index;
- installation instructions;
- operating instructions;
- instructions for the routine maintenance of the equipment and associated auxiliary equipment;
- recommended maintenance schedules;
- tests after maintenance work;
- type test reports;
- a complete list of parts with serial numbers;
- copies of detailed drawings;

- drawings of auxiliary equipment;
- routine factory tests;
- data sheets for each piece of equipment used in the switchboard clearly marking the components used;
- recommended maintenance regime including maintenance tasks and intervals. This regime shall be based on the mean time between failure (MTFB) and the critical failure modes identified by the failure mode, effects and criticality analysis (FMECA) of the equipment. Details substantiating the FMECA analysis shall be included in the manual; and
- recommended tests to be carried out throughout the life of the switchgear and its components, including the frequency and the pass/fail criteria for each test shall be included in the manual.

5.8.3 Additional information

The following information shall also be submitted;

- a list of recommended spares and tools, with prices and availability of each item;
- details of technical back-up facilities available; and
- details of equipment operating history, including how many in service, where, and for what period, plus reference contact names and numbers.

5.9 Testing

The supplier shall establish an Inspection and Test Plan which contains sufficient details of the work flow so that Endeavour Energy can advise inspecting, witness and hold points.

All the components of the GIS shall be tested in accordance with their individual relevant standards where appropriate in line with section 6.0 of AS 62271.203:2012. The GIS shall be assembled in the factory for full testing of the whole unit and all practicable tests shall be carried out to prove total functionality of all components and integrity of the gas system as appropriate.

The supplier shall provide one (1) copy of certified test reports for all type tests required by AS 62271.203:2012, AS 62271.1:2012 and AS 60044.1& 2:2007 with the tender.

The technical Schedules and guarantees (together with a copy of each of the tests) shall be completed and submitted to Endeavour Energy for evaluation.

All type tests shall be carried out by a testing authority holding accreditation:

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

Tests from other testing authorities may be accepted at the discretion of the Substation Manager.

All type test reports shall be accompanied by copies of the accreditation certificate(s) issued to the testing laboratory. The accreditation certificate(s) shall be valid for the relevant test(s) and for the duration of the test(s).

Type tests shall be less than five (5) years old. Type tests beyond this limit may be acceptable at the discretion of Endeavour Energy's Network Substation Manager if sufficient information can be provided to show that the manufacturing process, raw materials, design and quality control processes have not significantly changed since the original test date.

All sample and routine tests may be conducted at the manufacturing facility's test laboratory on the condition that sufficient evidence is provided to Endeavour Energy's Network Substation Manager to demonstrate the testing facility's capability to perform the specified tests. As a minimum, the following information shall be provided:

- qualifications/experience of the testing staff;
- test procedures for all sample/routine tests;
- testing facility quality control procedures; and
- test instrument calibration certificates/procedures.

As part of the product approval process, the Manager Primary Systems will inform in writing if Endeavour Energy accepts sample and routine tests being conducted at the manufacturing facility's test laboratory.

All documentation submitted (including reports, tests, testing procedures/policies, calibration certificates and the like) written in any language other than English shall not be accepted by Endeavour Energy unless the reports are translated into English by a sworn translator.

The cost of all type, routine and site tests including any sample and special tests (where required) shall be borne by the manufacturer and EE will not be reimbursing the cost incurred for the tests.

The supplier shall submit details of type, routine and special tests that are performed, as standard, to the various insulation components during and on completion of manufacture.

Applicable routine tests in accordance with the applicable standards shall be carried out on each component of the switchgear and shall be submitted to Endeavour Energy as part of the Factory acceptance Tests (FAT). All FAT reports shall be approved by Endeavour Energy first before the equipment is delivered to site.

The acceptance value listed in all test requirements standards listed in this section is the requirement and additional details are provided in the tables below.

5.9.1 Circuit breaker

The supplier shall carry out the following pertinent tests, as a minimum, as outlined in AS 62271.203:2012, AS 62771.100:2008 and AS 62271.1:2012 in the order required by these standards.

5.9.1.1 Type tests:

Type tests	Acceptable value	Test method reference
1. Dielectric tests	No disruptive discharge	AS 62271.203:2012 Cl 6.2
2. Radio interference voltage tests	<2500 μ V for 132kV	AS 62271.203:2012 Cl. 6.3
2. Measurement of the resistance of the main circuit	<10 μ Ω for 2500A, <15 μ Ω for 2000A	AS 62271.203:2012 Cl. 6.4

3. Temperature-rise tests	Temperature rise to be less than 65 Kelvin.	AS 62271.203:2012 Cl 6.5
4. Short-time withstand current and peak withstand current tests	Contact resistance not to vary by >1% of original value. No mechanical damage.	AS 62271.203:2012 Cl 6.6
5. Tightness tests: leakage rate at 40 deg C	0.1% per annum	AS 62271.203:2012 Cl 6.8
6. Mechanical operation test at ambient temperature	Operating characteristics the same.	AS 62271.203:2012 Cl.6.102.1
7. Short-circuit current making and breaking tests	No failure to break from 10% to 100% of rated breaking current	AS 62271.203:2012 Cl. 6.101
8. Capacitive current switching tests: cable-charging current breaking tests	Circuit breaker not to re-strike.	AS 62271.203:2012 Cl. 6.101
9. Verification of the degree of protection of enclosure	Meets requirements of IP55	IEC 60529:2013 Cl.11 to 15
10. Low and high temperature tests	No failure during and at completion of tests	AS 62271.203:2012 Cl. 6.102.3
11. Single-phase earth fault tests	No undue failure of breaker	AS 62271.100:2008 Cl. 6.108

5.9.1.2 Routine tests

The following routine tests shall be carried out by the supplier in addition to the type tests.

Routine test	Acceptable value	Test method reference
1. Dielectric test on main circuit	No disruptive discharge	AS 62271.203:2012 Cl. 7.1
2. Dielectric test on auxiliary and control circuits	No disruptive discharge using 1000 Volt AC for 1 second	AS 62271.203:2012 Cl. 7.2
3. Measurement of resistance of main circuit	<10 $\mu\Omega$ for 2500A, <15 $\mu\Omega$ for 2000A	AS 62271.203:2012 Cl. 7.3
4. Mechanical operation test	Complies with standard after five (5) close/open operations	AS 62271.100:2008 Cl. 7.101
5. Design and visual test	Meets specification	IEC 62271.1:2007 Cl. 7.5
6. Tightness test	No gas leaks equivalent to 0.1% a year.	IEC 62271.1:2007 Cl. 7.4
7. Dielectric dissipation factor (bushings)	<5mR	AS62271.100:2008 Cl. 7.200
8. Partial discharge test at 1.2Um/ $\sqrt{3}$	5pC	AS62271.100:2008 Cl. 7.201

9. Pressure test of enclosures	No bursting of enclosure	AS 62271.203:2012 Cl. 7.101
10. Test of interlocks and auxiliary circuits	Satisfies design requirements	AS 62271.203:2012 Cl. 7.103
11. Test on auxiliary and control circuits	No disruptive discharge	AS 62271.203:2012 Cl. 7.2
12. Pressure test on partitions	No bursting of partitions	AS 62271.203:2012 Cl. 7.104

5.9.2 Disconnectors and Earth Switches

5.9.2.1 Type tests

The following type tests shall be conducted on each type of disconnector and earthing switch offered according to the relevant standards:

Type test	Acceptable value	Test method reference
1. Dielectric test (inclusive of short duration power frequency and lightning impulse withstand test)	No disruptive discharge	Clause 6.2.4 of AS 62271.1-2012
2. Measurement of resistance of main and control circuits	Main circuit resistance not >20% from the value measured before the test.	Clause 6.4 of AS 62271.1-2012
3. Temperature rise test	Temperature rise to be less than 65 Kelvin.	Clause 6.5 of AS 62271.1-2012
4. Short time withstand current and peak withstand current tests	No mechanical damage	Clause 6.6 of AS 62271.1-2012
5. Tests to prove the short circuit making performance of earthing switches	No change to the condition of the switch.	Clause 6.101 of AS 62271.102:2005
6. Tests to prove satisfactory operation and mechanical endurance	Main circuit resistance not >20% from the value measured before the test. Mechanical endurance: 2000 operating cycles.	Clause 6.102 of AS 62271.102:2005
Tests to prove satisfactory operation at temperature limits	Complete three (3) operating cycles at minimum and maximum supply energy.	Clause 6.104 of AS 62271.102:2005

5.9.2.2 Routine tests

The following routine tests shall be conducted on each disconnector and earthing switch supplied to Endeavour Energy according to the relevant standards:

Routine test	Acceptable value	Test method reference
1. Dielectric test on the main circuit	No disruptive discharge.	Clause 7.1 of AS 62271.102:2005
2. Dielectric tests on auxiliary and control circuits	No disruptive discharge at 1kV for one (1) second.	Clause 7.2 of AS 62271.1-2012
3. Measurement of the resistance of the main circuit	Main circuit resistance not >20% from value measured before test.	Clause 7.3 of AS 62271.1-2012
4. Design and visual checks	Verification to specification.	Clause 7.5 of AS 62271.1-2012
5. Mechanical operating tests	No damage to parts.	Clause 7.101 of AS 62271.102:2005

5.9.3 Current transformers

For one (1) current transformer of each type, copies of certified test reports, to be included in the tender, will be accepted. All the relevant tests in accordance with AS 60044.1-2007 shall be performed and tests report issued. Type tests for the first of each of the units shall be provided.

5.9.3.1 Type Tests

The type tests to be carried out, as a minimum, are indicated in the table below:

Type test	Acceptable value	Test method reference
1. Short time current test	According to items a to d in clause 7.1 of AS60044.2:2007	AS 60044.1:2007 Cl.7.1.
2. Temperature rise test	<50 K	AS 60044.1:2007 Cl.7.2
3. Lightning impulse test	No disruptive discharge.	AS 60044.1:2007 Cl.7.3.2
4. Wet test (performed with power frequency voltage)	No flashover	AS 60044.1:2007 Cl.7.4
5. Determination of errors	As set out in tables 11 and 14 of AS 60044.1:2007	AS 60044.1:2007 Cl.11.4, 11.6, 12.4 and 12.5
6. Chopped lightning impulse test on primary winding	No flashover	AS 60044.1:2007 Cl.9.1
7. Measurement of capacitance and dielectric dissipation factor (DDF) Test (Before and after the impulse test)	≤ 0.005 {equivalent to 5 mW/Var (mrad)} @ 20 deg C	AS 60044.2:2007 Cl.9.2
8. Mechanical tests	No evidence of damage	AS 60044.2:2007 Cl.9.3

9. Transmitted overvoltage measurement	As set out in table 16 of AS 60044.1:2007	AS 60044.2:2007 Cl.9.4
10. Secondary dielectric tests for each type of class of PX CTs having: - Rated knee point of $E_k \geq 2\text{kV}$ - Power frequency withstand 5kV rms for 60s. - Rated knee point of $E_k < 2\text{kV}$ - Power frequencies withstand 5kV rms for 60s.	No disruptive discharge.	AS 60044.1:2007 Cl.14.2.1
Additional type tests for each type of class PX current transformers		
11. Proof of low reactance type	As set out in AS60044.1:2007 Cl.14.3.1	AS 60044.1:2007 Cl.14.3.1

The temperature rise test, as set out in AS 60044.1:2007, shall demonstrate that the specified temperature rise will not be exceeded under any combination or ratio, primary current and secondary current up to their respective thermal ratings at an ambient temperature of 45 deg. C.

All routine test reports, as set out in AS 60044.1:2007, resistance measurements, accuracy checks and CT saturation curve shall be provided.

5.9.3.2 Routine tests

Routine tests for current transformers, set out below, shall be performed as in AS60044.1:2007

Routine test	Acceptable value	Test method reference
1. Verification of terminal markings	Verified by manufacturer	AS60044.1:2007 Cl.8.1
2. Power frequency withstand tests on secondary and primary windings	No disruptive discharge	AS60044.1:2007 Cl.8.2.1
3. Partial discharge (PD) test measurement PD Test voltage: $1.2 U_m / \sqrt{3}$ (Phase-to-earth)	5pC	AS60044.1:2007 Cl.8.2.2
4. Power frequency withstand tests on secondary windings	No disruptive discharge @ 3kV rms.	AS60044.1:2007 Cl.8.3 or 14.4.4
5. Power frequency withstand tests between sections	No disruptive discharge @ 3kV rms.	AS60044.1:2007 Cl.8.3 or 14.4.4
6. Inter-turn over voltage test	No inter-turn short circuit	AS60044.1:2007 Cl.8.4
7. Determination of errors for measuring current transformer cores	As set out in table 11 of AS 60044.1:2007.	AS60044.1:2007 Cl.11.5
8. Determination of errors for protective current transformers cores	As set out in table 14 for class 10P20 of AS 60044.1:2007	AS60044.1:2007 Cl.12.3, 14.4

9. Dielectric Dissipation Factor (DDF) Test	0.005 {equivalent to 5 mW/Var (mrad)} @ 20 deg C	AS60044.1:2007 Cl.9.2
10. Insulation resistance (primary circuit)	>50 GΩ at test voltage 5kV DC	-
11. Insulation resistance (secondary circuit)	>100 MΩ at test voltage 1000V DC	-
12. Magnetisation (excitation current) test	Knee transition point between normal operation and saturated region must be above CT burden rating	CT excitation test method
13. Polarity test	Serviceable	-
14. Ratio test	Serviceable	-

Additional routine test requirements for each type of class PX current transformers:

Routine test	Acceptable value	Test method reference
1. Rated knee-point e.m.f. (E_k) and maximum exciting current (I_e)	Exciting current (I_e) at the rated knee point e.m.f. and at any rated percentage shall not exceed the rated value.	AS60044.1:2007 Cl.14.4.1
2. Secondary winding resistance (R_{ct})	Corrected to 75 deg C - Not exceeding specified values	AS60044.1:2007 Cl.14.4.2
3. Turns ratio error	As set out in AS60044.1:2007 4.1c	AS60044.1:2007 Cl.14.4.3
4. Secondary insulation resistance for each type of class of PX CTs having: - Rated knee point of $E_k \geq 2\text{kV}$ - Power frequency withstand 5kV rms for 60s. - Rated knee point of $E_k < 2\text{kV}$ - Power frequencies withstand 3kV rms for 60s	AS60044.1:2007 Cl. 14.2.1 - No disruptive discharge	AS60044.1:2007 Cl.14.4.4; Cl 8.3
5. Inter-turn insulation tests	No disruptive discharge	AS60044.1:2007 Cl 14.4.5; Cl.8.4

For metering CTs, where required, accuracy reports shall meet the requirements of the National Electricity Market Code (Chapter 7, Metering), Schedule 7.3, Clause S7.3.1 (b) (or as amended) in respect of measurement of class accuracy within stated uncertainty of measurement limits. All tests shall be carried out by a testing authority holding appropriate accreditation:

- by NATA Australia; or

- by an accreditation authority recognised by NATA Australia.

5.9.4 Voltage Transformers

5.9.4.1 Type tests

Type tests for voltage transformers shall be carried out in accordance with AS60044.2-2007 as set out below:

Type test	Acceptable value	Test method reference
1. Temperature rise test	<50 K	AS 60044.2:2007 Cl.8.1
2. Short-circuit withstand capability test	According to items a to d in clause 8.2 of AS60044.2:2007	AS 60044.2:2007 Cl.8.2.
3. Lightning impulse test	No disruptive discharge.	AS 60044.2:2007 Cl.8.3.2
4. Determination of errors for measuring voltage transformer cores	According to table 11 of AS 60044.2:2007.	AS 60044.2:2007 Cl.12.3
5. Determination of errors for protective voltage transformer cores	According to table 11 of AS 60044.2:2007	AS 60044.2:2007 Cl.13.6
6. Chopped lightning impulse test on primary winding	Indication of internal fault	AS 60044.2:2007 Cl.10.1
7. Measurement of capacitance and dielectric dissipation factor (DDF) Test (Before and after the impulse test)	≤ 0.005 {equivalent to 5 mW/Var (mrad)} @ 20 deg C	AS 60044.2:2007 Cl.10.2, Cl 6.1.2.5
8. Mechanical tests	No evidence of damage	AS 60044.2:2007 Cl.10.3
9. Transmitted overvoltage measurement	Limits presented in table 14 of AS 60044.2:2007	AS 60044.2:2007 Cl.10.4

5.9.4.2 Routine Tests

In addition to the type tests above, routine tests for voltage transformers shall be carried out in accordance with AS60044.2-2007 as per the table below:

Routine test	Acceptable value	Test method reference
1. Verification of terminal markings	Verified by manufacturer	AS 60044.2:2007 Cl.9.1
2. Power frequency withstand tests on secondary on primary windings	No disruptive discharge	AS 60044.2:2007 Cl.9.2
3. Partial discharge test PD Test voltage: 1.2 Um / $\sqrt{3}$ (Phase-to-earth)	5pC	AS 60044.2:2007 Cl.9.2.4
4. Power frequency withstand tests on secondary windings	No disruptive discharge @ 3kV rms.	AS 60044.2:2007 Cl.9.3

5. Power frequency withstand tests between sections	No disruptive discharge @ 3kV rms.	AS 60044.2:2007 Cl.9.3
6. Determination of errors for measuring VT cores	As set out in table 11 of AS 60044.2:2007.	AS 60044.2:2007 Cl.12.4
7. Determination of errors for protective VT cores	As set out in table 12 of AS 60044.2:2007	AS 60044.2:2007 Cl.13.7
8. Dielectric Dissipation Factor (DDF) Test	≤ 0.005 {equivalent to 5 mW/Var (mrad)} @ 20 deg C	AS 60044.2:2007 Cl.6.1.2.5
9. Insulation resistance (primary circuit)	>50 G Ω at test voltage 5kV DC	-
10. Insulation resistance (secondary circuit)	>100 M Ω at test voltage 1000V DC	-
11. Polarity test	Serviceable	-

5.9.5 Additional GIS tests

In addition to the individual tests on individual components of the GIS carried out in line with their own standards as above, the following additional tests shall be carried out in line with IEC62271.203-2011 as applicable to prove that all associated components can operate together without their performance being influenced by their arrangement with respect to one another.

5.9.5.1 Type tests

Type tests shall be carried out on the contract arrangements or on similar equipment that is representative of the contract arrangements as appropriate.

Test	Acceptable value	Test method reference clause of AS 62271.203:2012
1.Mechanical and environmental tests for included switches	No damage to devices. No leakage of gas.	6.102.1
2. Tests to prove strength of enclosure	Enclosure to withstand 2 times the design pressure.	6.103
3.Gas tightness test	No leakage for full thermal cycle in accordance with table 13	6.8
4.Pressure test on partitions	Partition to rupture at pressure > 3 times design pressure	6.104
5.Test to prove satisfactory operation at limit temperatures	No damage to devices and no leakage of gas.	6.102.2

6. Insulator tests	No disruptive discharge and no leakage of gas after tests.	6.106
7. Effects of arcing due to internal fault	No fragmentation in accordance with table 4.	6.105
8. Corrosion test on earthing connections	Resistance after test not to be >20% of value at beginning of test.	6.107

5.9.5.2 Routine tests

In addition to the type tests applicable to the main components of equipment as above, the following additional routine tests shall be carried out:

Test	Acceptable value	Test method reference clause of AS 62271.203:2012
1. Mechanical operational tests for included switches	No damage to devices. No leakage of gas.	7.102
2. Pressure tests on partitions	Enclosure to withstand 2 times the design pressure.	7.104
3. Gas tightness test	No leakage.	7.4
4. Pressure test of enclosures	Partition to withstand pressure > 2 times design pressure	7.101
5. Test on auxiliary circuits, equipment and interlocks in control mechanism	No damage to devices and no leakage of gas.	7.103

5.9.6 Tests after installation

The following site tests by the supplier are required and need to be documented in the proposed test plan as part of the tender:

1. General wiring commissioning (functional checks)
2. Circuit breaker timing tests and timing charts for the following test cases:
 - a. Five (5) closes,
 - b. Five (5) opens on trip coil T1,
 - c. Five (5) opens on trip coil T2,
 - d. Two (2) close opens on trip coil T1
 - e. Two (2) close opens on trip coil T2
 - f. Minimum volts operation for trip coil T1 (in accordance with AS 62271.1-2012: Clause 5.8.2)
 - g. Minimum volts operation for trip coil T2 (in accordance with AS 62271.1-2012: Clause 5.8.2)

- h. Minimum voltage operation for close coil.
- 3. Partial discharge test for the whole GIS switchboard.
- 4. Power frequency withstand test
- 5. Dielectric tests on auxiliary circuits
- 6. Measurement of the resistance of the main circuit
- 7. Gas tightness tests
- 8. Checks and verifications
- 9. Gas quality verifications
- 10. Circuit breaker and busbar partial discharge test,
- 11. Circuit breaker and busbar HV insulation resistance test,
- 12. Current transformer Routine tests, AS 60044.1-2007
- 13. Voltage transformer Routine tests, AS 60044.2-2007.

Should the plant or any portion thereof fail under either the Supplier's or Endeavour Energy's tests then the cost of replacements, repairs and any further tests shall be borne by the Supplier.

5.10 Tender drawings

The following drawings are supplied as part of this tender and shall be requested from Endeavour Energy as appropriate:

- 1. Single line diagram (SLD) of the project.
- 2. General arrangement for the GIS.
- 3. Requirements for service continuity during maintenance, testing or extensions.
- 4. Typical circuit breaker protection and indication circuit typical GIS circuit breaker DS/ES protection, control and indication circuit schematic diagrams and SCADA and spare contacts diagram.

The Table below provides a list of conceptual drawings for reference purpose:

Drawing description	Drawing title	Drawing number
GIS Single Line Diagram	Equipment Technical – ETS 0012 Pressurised gas insulated switchgear Single Line Diagram and legend	384402 - Revision A
GIS Control circuit diagrams	Equipment Technical – ETS 0012 Pressurised gas insulated switchgear Control circuit diagram	384403 - Revision A
	Equipment Technical – ETS 0012 Pressurised gas insulated switchgear Control circuit diagram	384404 - Revision A
GIS SCADA and spare contacts	Equipment Technical – ETS 0012 Pressurised gas insulated switchgear SCADA and spare contacts	384405 - Revision A

5.11 Packing

The supplier shall suitably pack each switchgear unit in a wooden crate complete with all other accessories, such as bolts, nuts, operating shafts, links, and enclosure parts.

All measures shall be taken to establish that damage will be avoided during packing, transporting and dismantling.

The following shall be written in BLACK lettering (75mm high) on each wooden crate:

- Endeavour Energy;
- contract number;
- supplier's name;
- mass; and
- voltage rating (66kV or 132kV).

5.12 Product approval

5.12.1 Product approval and audit forms

Complete information of the equipment shall be provided in technical schedules and guarantees set out in Branch Form FAE 31XX.

5.12.2 Product approval process

The equipment shall be evaluated under the product approval process set out in PAE 1004. Network Substations Manager, Primary Systems will approve the equipment / components for use on the network.

6.0 AUTHORITIES AND RESPONSIBILITIES

Chief Engineer has the authority and responsibility for:

- approving this specification, including any variations;
- nominating Endeavour Energy's representative(s) for either the manufacturing facility inspection and/or witness testing;
- approving dispensation from this specification where the risk is considered high or extreme in accordance with Endeavour Energy's risk management procedures; and
- delegating any of these authorities and responsibilities to the Manager Primary Systems.

Manager Primary Systems has the authority and responsibility for:

- reviewing this specification and making recommendations to the Chief Engineer;
- making recommendations concerning compliance in respect of this specification;
- approving dispensation from this specification where the risk is considered Low or Medium in accordance with Endeavour Energy's risk management procedures; and
- making nominations of Endeavour Energy's representatives.

Manager Project Development has the authority and responsibility for:

- determining the equipment procured complies with the requirements of this specification.
- checking FAT and site test reports and seek dispensation from Primary Systems as necessary for marginal non-compliances.

Network Substations Manager has the authority and responsibility for:

- reviewing all type and routine test reports and alternative proposals submitted for evaluation, and making recommendations to the Manager Primary Systems;

- clarifying all the technical aspects of this specification to the stakeholders; and
- approving the relevant actions required and outlined in 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.

Project managers have the authority and responsibility for reviewing the equipment supplied to confirm it meets requirement of this specification.

Manufacturers/suppliers have the authority and responsibility for:

- adherence and awareness of their responsibilities under this specification;
- providing suitable training of the contractor/s under their control to safely perform works to this specification;
- implementing an effective safety, environmental and quality auditing system is in place; and
- implementing this specification and keeping Endeavour Energy or other responsible equivalent officers informed of any factors that may prevent them from accepting responsibility for its full implementation.

7.0 DOCUMENT CONTROL

Documentation Content Coordinator : Network Substations Manager

Documentation Distribution Coordinator : Branch Process Coordinator