Standard

Extra High Voltage (EHV) Indoor Gas Insulated Switchgear Standard

R565990

Version 1.0, June 2018

Authorisations

Action	Name and title	Date
Prepared by	Michael Verrier, Senior Asset Strategy Engineer	June 2018
Reviewed by	Santosh Dhakal, Asset Engineer	June 2018
Authorised by	Darryl Munro, Asset Strategy Team Leader	June 2018
Review cycle	30 months	

Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Strategy Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

Minimum Requirements

The requirements set out in TasNetworks' documents are minimum requirements that must be complied with by all TasNetworks team members, contractors, and other consultants.

The end user is expected to implement any practices which may not be stated but which can be reasonably regarded as good practices relevant to the objective of this document.

Record of revisions

Section number	Details
Entire doc	Copied over verbatim from superseded Transend to TasNetworks template. Updated Transend to TasNetworks document reference numbers where known including Australian Standards.
14	Hold points added.

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1 General

1.1 Purpose

To define the requirements for extra high voltage (EHV) indoor gas insulated switchgear (GIS) under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks').

1.2 Scope

This standard details TasNetworks' EHV GIS requirements for the:

(a) design, manufacture, construction, and testing at the manufacturer's works;

(b) secure packaging, supply, transportation and delivery from the manufacturer's works to site;

(c) site testing and commissioning; and

(d) documentation to be provided.

1.1 Objective

TasNetworks requires the design and application of EHV GIS substation apparatus as covered in this standard to ensure:

(a) that relevant Australian legal requirements are met;

(b) that the requirements of the Tasmanian Electricity Code and National Electricity Rules are met;

(c) personnel and public safety and environmental hazards are identified, analysed and eliminated or control measures adopted;

(d) ease of operation and maintenance;

(e) reliability and continuity of power supply;

(f) minimum disruption to the electricity transmission system following an asset failure;

(g) risk to TasNetworks' assets is minimised;

(h) compliance with TasNetworks' environmental policy;

(i) that the requirements of TasNetworks' performance objectives are met;

(j) that the exposure of TasNetworks' business to risk is minimised; and

(k) that TasNetworks' responsibilities under connection agreements are met.

1.1 Precedence

Any apparent conflict between the requirements of this standard and the law, mandatory requirements, industry standards, project specifications, non-statutory standards or guidelines, and any other associated documents should be brought to the immediate attention of TasNetworks for resolution and no action must be taken that might result in a breach of law or mandatory requirement.

Where there may be a conflict between the requirements of this standard and any:

(a) law, mandatory requirement or industry standard, then that law or statutory requirements will prevail over this standard;

(b) non-mandatory standard, or guideline, then this standard will prevail over that standard or guideline; and

(c) project specification, then the contract documentation will prevail over this standard.

Approval for a deviation to this standard may only be accorded if it does not reduce the quality of workmanship, pose a safety risk to personnel or equipment and does not deviate from the intent of this standard. Deviations if any must be specifically requested and approved in writing by TasNetworks' Network Performance and Strategies Manager.

1.1 References

As a component of the complete specification for GIS, this standard is to be read in conjunction with other relevant standards as applicable. Unless otherwise specified in the project specifications, the equipment shall be in accordance with the latest edition and amendments of the standards listed below. The following documents, without reservation, contain provisions that, through reference in the text, constitute the requirements of this standard:

1.1.1 TasNetworks standards

R565986	Extra-high-voltage cable system standard
R590634	Substation Civil Design and Construction Standard
R522687	General substation requirement standard
R590630	HV and LV Cable systems standard
R586386	Extra High Voltage System Standard
R522692	Substation Lightning Protection and Earthing Standard
R246497	Testing, Commissioning and Training Standard
R586380	EHV Dead Tank and Live Tank Circuit Breakers Schedule
R586378	EHV Dead Tank and Live Tank Circuit Breakers Deliverables
R586391	EHV voltage transformer standard
R522690	EHV current transformer standard
R522697	Temporary earthing of substation equipment standard
R590629	Extra-high-voltage GIS information to be provided with tender
R590628	Extra-high-voltage GIS deliverables
R246497	Testing, commissioning and training standard

1.1.2 Other standards

Voltage transformers for measurement and protection	AS 1243
Bushings for alternating voltages above 1000 V	AS/NZS 60137
Structural steel welding	AS 1554
Metal finishing and pre-treatment of surfaces	AS 1627
Lightning protection	AS/NZS 1768
Insulation coordination	AS 1824
Switchgear assemblies & ancillary equipment for alternating voltages above 1 kV	AS 2067

Common specifications for high voltage switchgear and controlgear standards	AS/NZS 62271.1
Electrical installations (known as the Australian/New Zealand Wiring Rules)	AS/NZS 3000
Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions	AS 3008.1.1
Pressure equipment - In service inspection	AS/NZS 3788
Steel structures	AS 4100
Pressure equipment - Hazard levels	AS 4343
Pressure equipment - Manufacture	AS 4458
Hot-dip galvanised (zinc) coatings on fabricated ferrous articles	AS 4680
Cast aluminium alloy enclosures for gas-filled high-voltage switchgear and controlgear	AS EN 50052-2008
Wrought aluminium and aluminium alloy enclosures for gas-filled high-voltage switchgear and controlgear	AS EN 50064 2008
Instrument transformers – Part 1: Current transformers	IEC 60044.1
Instrument transformers – Part 2: Inductive voltage transformers	IEC 60044.2
High-voltage test techniques	IEC 60060
Insulation coordination	IEC 60071
Surge arresters	IEC 60099
Insulated bushings for alternating voltages above 1000V	IEC 60137
Electrical relays	IEC 60255
High-voltage test techniques – Partial discharge measurements	IEC 60270
Standards for station grounding	IEC 60364/60479
Specification of technical grade Sulphur hexafluoride (SF_6) for use in electrical equipment	IEC 60376
Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use	IEC 60480
Degrees of protection provided by enclosures (IP Code)	IEC 60529
Guide for the selection of insulators in respect of pollution conditions	IEC 60815
Electromagnetic compatibility (EMC)	IEC 61000
Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above	IEC 61639
Rigid high-voltage, gas-insulated transmission lines for rated voltages of 72.5 kV and above	IEC 61640
Communication networks and systems	IEC 61850
High-voltage switchgear and controlgear – Part 1: Common specifications	IEC 62271.1
High-voltage switchgear and controlgear – Part 3: Digital interfaces based on IEC 61850	IEC 62271.3
High-voltage switchgear and controlgear – Part 100: HV Alternating Current circuit breakers	IEC 62271.100
High-voltage switchgear and controlgear – Part 101: Synthetic testing	IEC 62271.101

High-voltage switchgear and controlgear – Part 102: AC disconnectors and earthing switches	IEC 62271.102
High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	IEC 62271-203
High-voltage switchgear and controlgear – Part 104: Alternating current switches for rated voltages of 52 kV and above	IEC 62271.104
High-voltage switchgear and controlgear – Part 108: High-voltage alternating current disconnecting circuit-breakers for rated voltages of 72.5 kV and above	IEC 62271.108
High-voltage switchgear and controlgear – Part 110: Inductive load switching	IEC 62271.110
High-voltage switchgear and controlgear – Part 203: Gas insulated metal-enclosed switchgear for voltages above 52 kV	IEC 62271.203
High-voltage switchgear and controlgear – Part 207: Seimic qualification for gas insulated switchgear assemblies for rated voltages above 52 kV	IEC 62271.207
High-voltage switchgear and controlgear – Part 209: 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	IEC 62271.209
High-voltage switchgear and controlgear – Part 301: Dimensional standardisation of terminals	IEC 62271.301
High-voltage switchgear and controlgear – P art 308: Guide for asymmetrical short-circuit breaking test duty T100a	IEC 62271.308

2 Design parameters

The EHV GIS switchgear and its components must:

(a) comply with the limits stated in AS/NZS 62271.1, together with the particulars of the system stated in Table 1. Any specific design criteria for particular equipment will be stated in the project specifications;

(b) be capable of operating indoors in a non air-conditioned environment under the environmental conditions and site specific design criteria stated in the project specifications. Where there is a requirement that the EHV GIS be installed in an outdoor environment, as opposed to an indoor environment, this will be defined in the project specification;

(c) be capable of continuous duty at its specified rating under the specified ambient conditions 24 hours a day, 365 days a year without assisted means; ie. forced cooling will not be permitted to achieve the rated capacity; and

(d) be immune to interference from high frequency radio noise emanating from local transmitters such as mobile phones and two-way radios.

Table 1 Service and design parameters for EHV GIS

Sr. No.	Parameter	Unit	Value	
Common Parameters				
1.	Nominal system voltage	kV	110	220
2.	Rated voltage	kV	132	220

Sr. No.	Parameter	Unit	Value	
3.	System highest voltage	kV_{rms}	145	245
4.	Power frequency withstand voltage	kV_{rms}	275	460
5.	Lightning impulse withstand voltage	kV_{peak}	650	1050
6.	Minimum bushing creepage distance	mm/kV	25	25
7.	Minimum symmetrical three-phase, phase-to-phase, and phase-earth fault current withstand of all switching equipment and busbars	kA_{rms}	40	
8.	Minimum short circuit withstand duration	sec	3	
9.	Rated peak withstand current	kA_{peak}	108	
10.	Rated normal current	A_{rms}	3150	
11.	Normal voltage variation (criteria for equipment design)	$\%V_n$	$^{238}_{93}10$	
12.	Number of phases	-	3	
13.	Installation class	-	Indoor	
14.	Rated frequency	Hz	50	
15.	Normal frequency variation	Hz	$^{238}_{93}$ 2	
16.	Frequency variation at times of system disturbance	Hz	48.8-52	
17.	Normal combined voltage and frequency variation (criteria for equipment design)	%	$^{238}_{93}10$	
18.	Neutral earthing	-	Effectively earthed	
19.	Minimum degree of protection by enclosure	IP	51	
20.	Design maximum continuous ambient temperature	°C	40	
21.	Design minimum continuous ambient temperature	°C	-10	
22.	Altitude	m	≤ 1000	
23.	Maximum relative humidity	%	95	
24.	Average lightning ground flash density	flashes/km^2/yr	< 0.5	
25.	Seismic horizontal acceleration	g	0.2	
26.	Seismic vertical acceleration	g	0.2	
27.	Maximum leakage rate of each individual SF_6 gas compartment Each compartment should be designed to have an SF_6 gas leakage rate of not more than 0.1% per year and should be routine tested to demonstrate an achieved leakage of less than 0.5% per year.	% pa	0.1	

Circuit Breakers				
28.	Rated Cable Charging Making/Breaking Current	A	160	250
29.	Transient Recovery Voltage for short circuit breaking current tests to be in accordance with IEC 62271.100 as follows:- • Test Duties T30, T60, T100 • Short Line Faults	- -	Table 14a Table 1b	Table 14a Table 1d
30.	First Pole to Clear Factor for S/C Breaking Tests	-	1.5	1.5
31.	Rated Short Circuit Making Current	kA_{peak}	100	
32.	DC time constant for determination of percentage d.c. component for asymmetrical breaking current. (Test Duty T100a taking minimum relay time as 10 milliseconds).	ms	45	
33.	Rated Operating Sequence		O – 0.3 sec - CO - 3 min - CO	
34.	Minimum number of 40kA Fault Operations before Maintenance is Required.	-	20 (Circuit breakers with a greater number of allowable fault operations are preferred).	
35.	Rated Nominal Auxiliary Supply Voltage **(Note 1)**	V dc	125	
36.	Shunt Trip Release Supply Voltage **(Note 2)**	V dc	125 +25% / -40%	
37.	Maximum Trip Coil Current @ 125V d.c.	A	5	
38.	Shunt Closing Release Supply Voltage (Note 2)	V dc	125 +25% / -20%	
39.	Spring Release Coil Resistance	ohms	Not less than 20 ohms	
40.	Opening Coil Resistance	ohms	Between 20 & 50 ohms @ 20°C	
41.	Number of Trip Coils	-	2	
Power Disconnector Switches				
42.	Rated current	A	3150	
43.	Maximum motor current @125V d.c.	A	4	
Earthing Switches (fast acting)				
44.	Rated Short Circuit Making Current	kA_{peak}	100	
45.	Maximum Spring Charging Motor Current @ 125V d.c.	A	4	

Notes

1. Compliance testing of the circuit breaker must be completed at the range of 70 per cent to 110 per cent of the rated nominal dc supply voltage in accordance with the requirements of the Australian and IEC Standards. In addition to this requirement TasNetworks requires positive operation of the breaker, on no load, at a trip supply voltage of 60 per cent of normal measured at the dc input terminals of the switchgear. Whilst being sensitive to this low value of supply voltage, the mechanism must be stable and not capable of being opened by shocks or jars.
2. The shunt opening and closing release supply voltage must be suitable for operation from a nominal 125 Volt battery with maximum boost setting of plus 10 per cent of nominal voltage. All components in the secondary circuits must accordingly be suitably rated for nominal voltage plus 10 per cent.

3 Service requirements

The following service requirements are applicable to EHV GIS installation:

(a) the design life of the switchboard must be a minimum of 45 years. Evidence must be supplied by the manufacturer supporting its claim that the equipment offered meets this requirement;

(b) the circuit breakers must be housed in separate compartments from the busbars and cable terminating arrangements;

(c) any portion of the switching equipment must be capable of being removed or replaced with minimum disturbance to adjacent components. In particular, it must be possible to remove a complete bay, or a component within a bay, without the need to move or de-energise adjacent bays. Not more than two adjacent circuits connected to the common busbar must be impacted. The Contractor shall describe in the Technical Schedule 'Information to be provide with the Tender', details of any requirements when working adjacent to gas barriers that are at full pressure or reduced pressure. For example, the adjacent compartment/s must be reduced in pressure and the value of this pressure must be given;

(d) the design of the partitions within the equipment must permit the depressurising of any compartment without the need to reduce pressure in adjacent compartments for maintenance and repair purposes. Should the Contractor not be able to conform to this requirement the Contractor shall describe in the Technical Schedule 'Information to be provide with the Tender', details of any requirements when working adjacent to gas barriers that are at full pressure or reduced pressure. For example, the adjacent compartment/s must be reduced in pressure and the value of this pressure;

(e) in case of any internal arc fault in a busbar, busbar disconnector or bus-section circuit breaker, repair works must be possible without shutting down the complete switchgear installation and at least one half of the switchgear must remain in operation. It must be clearly demonstrated that this requirement is met by the equipment offered, ie. the sequence of repair work steps and description of necessary restrictions during these works. Should the proposed configuration of the EHV GIS installation restrict the fulfilment of this requirement the Contractor shall offer an alternative arrangement;

(f) materials selected in the manufacture of the switchgear must be compatible such that corrosion is minimal at the interface of dissimilar materials and the design life is not compromised;

(g) operating mechanisms must be 125 V dc motor-charged spring operated units suitable for operating the three poles of the switching device as a single operating unit or when specified in the project specifications, as single pole operating units capable to be used in conjunction with point-on-wave switching devices;

(h) where other than motor-charged stored energy systems are offered, maintenance and inspection requirements for the system must be included in the whole of life cost of the switchgear. In this regard the recommended maintenance cycles and tasks, estimated time to complete each maintenance task, and cost of recommended replacement components must be submitted to TasNetworks. Alternative systems should only be offered as an option to the preferred requirements;

(i) all components required for normal operation of the switchgear must be located so as to allow easy access. A flat floor or a suitably designed walkway must be provided, with no obstruction above the level of the floor or the walkway that impedes access to these components or creates a potential safety issue; and

(j) the switchgear must be fitted with all necessary isolation and test facilities to enable dielectric and current injection tests to be carried out. Details of the facilities included for these purposes must be supplied to TasNetworks.

4 Installation requirements

This section details the general installation requirements for an EHV GIS installation as follows:

(a) the EHV GIS system will generally be installed in a purposefully constructed indoor switchroom. Allowance must be made to either evacuate the building of any leaked SF_6 gas that has accumulated within the confines of the building before anyone is allowed to enter the building and for the duration that anyone is in the building or make provisions to prevent anyone form gaining access to areas within the building where leaked SF_6 gas may have accumulated. Details of the building construction will be outlined in the project specifications;

(b) the design of the EHV GIS switchgear bays shall be such as to minimise assembly work during installation. The Contractor shall describe in the Technical Schedule 'Information to be provide with the Tender', details, method and indicative duration for the installation of the respective EHV GIS switchgear bays.

(c) the Contractors must submit proposed layout and elevation plans for the switchgear. These shall show recommended clearances required for:

  (i) safe operation, inspection and maintenance of all equipment being supplied as part of the EHV GIS installation;

  (ii) lifting clearances for installation and maintenance; and

  (iii) maximum component weight to be lifted during installation and maintenance.

(d) the availability of an overhead gantry and crane assembly (permanent or temporary), including maximum lifting capacity of the crane will be specified in the project specifications;

(e) all incoming circuits will be either connected by overhead lines or cables and will enter either through the switchroom wall via SF_6 – air bushings or through the floor to the associated switchgear connection enclosure. The specific requirement for the particular project will be defined in the project specification;

(f) the following must be provided with the switchgear:

  (i) skates or other device to move the switchgear transport units in the switchroom: and

  (ii) lifting facilities to off load transport units from the truck to the switchroom.

(g) for the purpose of training of TasNetworks' personnel in the operation of the switchgear some TasNetworks personnel must be involved in the assembly and pre-commissioning of the switchgear;

(h) the installation must be undertaken by suitably skilled persons so that each module, and the assembled switchboard, when installed is:

  (i) level and true in all planes;

  (ii) perpendicular to the building lines of the room;

  (iii) properly secured to the floor so that movement does not occur under any operating fault;

  (iv) without excessive compression, tension or torsional forces that may reduce the life or affect the operation of any part of the equipment; and

(v) fully operational and compliant with this document, relevant standards, and good work practices in all respects.

(i) full details of the proposed installation methods must be submitted to TasNetworks.

5 Switchgear assemblies

5.1 General

The following general requirements are applicable to EHV GIS installation:

(a) The equipment enclosures must comprise aluminium or aluminium alloys exclusively, except for special components such as bellow compensators.

(b) The manufacturer's standard paint colour must be used and shall be a satin matt finish with a high scratch resistance.

(c) Fittings for gas monitoring and gas supply must be made of copper, aluminium, brass or high grade steel.

(d) All gas compartments must be fitted with filter material which absorbs residual moisture inside the high-voltage enclosure as well as any that enters the compartment. Filters in gas compartments with switching devices must also be capable of absorbing the gas decomposition products resulting from the switching arc.

(e) All supporting structures for the switchgear bays and for the related overhead line connection, cable connection and transformer connection enclosure shall be part of the Contractor's supply.

(f) Each switchgear assembly must be prepared and suitable for future extension at either end without the need for any drilling, cutting or welding on the existing equipment or the relocation of existing switchgear bays.

(g) All switchgear components that are at earth potential must be electrically interconnected.

(h) TasNetworks reserves the right to:

(i) call a design review meeting at TasNetworks' premises, before production commences;

(ii) witness type and routine tests; and

(iii) inspect the switchgear before packaging and shipment from the manufacturer's works.

(i) TasNetworks must be advised, no less than 28 days prior to testing and prior to commencement of packaging, of the switchboard modules for shipment.

5.1 Maintainability

The following maintainability requirements are applicable to EHV GIS installation:

(a) The maintenance intervals of the circuit breakers shall not be less than 18 rated short-circuit current interruptions (cumulative), 6000 rated current interruptions (cumulative) or 25 years of operation, whatever is earlier.

(b) Routine maintenance of external parts of the EHV GIS switchgear, including instrument transformers, should not be necessary at intervals of less than 8 years.

(c) Maintenance activities shall comprise only simple inspections and no exchange of parts or complex adjustments should be required during the design life of the installation.

(d) For routine inspections, all elements must be accessible without removal of supporting structure.

(e) Evidence must be provided to TasNetworks regarding the effectiveness of proposed reliability and fault recovery strategies for GIS with respect to impact on the availability of the remaining un-faulted equipment.

(f) The consequences of failures in, for example, bus section circuit breakers affecting the service of adjoining busbars and the possible likelihood of long-term outages whilst replacement parts are sourced and installed are of particular interest. For this reason alternative switchboard arrangements to those proposed, which will increase reliability or reduce switchboard downtime due to repairs, should be submitted for consideration.

(g) Alternatively, information may be submitted that shows how the product is designed and engineered to reduce the impact of mid-life maintenance and failures, eg. gas partition design and locations, removal of complete bays or switching equipment without the need for long-term outages.

5.1 Safety

The following safety requirements are applicable to EHV GIS installation:

(a) TasNetworks must be advised by the manufacturer of any risk of failure of an SF_6 barrier if the barrier is inadvertently struck during dismantling or assembly whilst one side is pressurised; and

(b) the switchgear must provide a maximum degree of safety for the operators and others in the vicinity of the switchgear under all normal operating conditions and under fault conditions (short-circuit). To this end:

  (i) it must be not be possible to touch any live part of the switchgear unintentionally, ie. without the use of tools or brute force;

  (ii) an operator standing in the normal operating position must not be endangered by any moving external part of the switchgear; and

  (iii) interlocks must be provided to prevent any maloperation of the switchgear.

5.1 Arc containment

The following arc containment requirements are applicable to EHV GIS installation:

(a) pressure relief devices must be fitted to each gas compartment in accordance with Section 5.8.

(b) if an arc should occur despite the provision of all reasonable safety measures, the following is required:

  (i) the effects of an internal arcing fault must be limited to the related gas compartment by gas tight barriers;

  (ii) all earthing connections must remain operational; and

  (iii) the enclosure of the switchgear must withstand the thermal effects of an arc at the full rated short-circuit current until the nearest protective relay has tripped.

(c) to limit the effects of an internal arc the switchgear must be suitably subdivided into individual arc and gas-proof compartments, at least for:

  (i) busbar including disconnect/earthing switches;

  (ii) circuit breakers;

  (iii) line disconnectors and cable connections; and

  (iv) voltage transformers.

5.1 Interlocking and safety devices

The following arc interlocking and safety device requirements are applicable to EHV GIS installation:

(a) each unit must be provided with all necessary locking, interlocking and safety devices. All mechanical interlocking devices must be direct acting and be of substantial mechanical construction. All locking facilities should be suitable for a padlock with a 5mm diameter hasp; and

(b) details of interlocking recommended by the manufacturer must be submitted to TasNetworks for approval.

5.1 Gas filled vessels

The following requirements are applicable to gas filled vessels:

(a) the manufacturer must provide a statement as to whether any gas filled vessel offered, and which is operating above atmospheric pressure, is a pressure vessel in accordance with the requirements of AS 1210 and AS 4343;

(b) under Occupational Health & Safety legislation TasNetworks is required to ensure a safe place of work for its employees. Accordingly, where a pressure vessel is offered, the following documentation must be provided:

  (i) the assigned pressure vessel hazard level over the operating life of the switchgear in accordance with AS 4343;

  (ii) the required frequency of any external periodic inspection of the pressure vessel in accordance with AS/NZS 3788; and

  (iii) the volume and gas pressure in each compartment.

(c) the following documentation on the pressure vessels shall be included in the Operating and Maintenance Manual technical documentation:

  (i) the vessel design verification; and

  (ii) The 'Manufacturer's Data Report' as per AS 4458, certified by the manufacturer and the inspection body.

5.1 Requirements from SF_6 gas and associated devices

The following requirements are applicable to SF_6 gas and associated devices:

(a) gas supplied must comply with requirements of IEC 60376;

(b) gas quality must not be inferior to the recommendations of the supplier of SF_6 gas;

(c) gas handling, servicing and monitoring facilities must be provided for all gas insulated equipment suitable for the initial filling and the future servicing of SF_6 filled compartments. Where switchgear has independent poles, each pole must have its own self-contained gas system along with facility for gas handling, servicing and monitoring;

(d) the gas monitoring system and gas filling system must be designed to identify any leakage in the gas from the entire assembly;

(e) joints in chambers containing gas must be arranged so that shrinkage of gaskets and seals with time that could result in leakage can be taken up;

(f) the switchgear must operate satisfactorily with gas having the following properties:

  (i) Dew Point < - 40 °C at 101 kPa;

(ii) Purity > 98 per cent; and

(iii) Contamination < 1 ppm decomposition products.

(g) during transportation from factory to site, EHV GIS must be filled with a slightly positive gas pressure to prevent moisture ingress during shipment. The remaining gas must be supplied in appropriate gas cylinders and filled on site;

(h) gas density monitors are to be provided on each compartment for indicating the compartment pressure, complete with the necessary gas filling attachments. The gas monitoring of each bay must be carried out for all three phases commonly. The function of all monitors must be clearly labelled. All monitors must be visible and of sufficient size to enable an operator standing at floor level to confirm that the gas pressure is satisfactory or unsatisfactory;

(i) TasNetworks requires all switching device compartments to be fitted with duplicate gas density monitors, one analogue and the other digital. Each gas density monitor must have a separate gas interface and a readily visible contact wired to provide a low gas pressure alarm. Digital gas density monitors must be suitable for connection to the SCADA system for the purpose of trend analysis;

(j) all monitors must be calibrated to indicate whether the compartment gas pressure exceeds the minimum required for satisfactorily operating the switchgear. The gas density monitor on switching device compartments must be calibrated to indicate whether the compartment contains sufficient gas pressure to operate the switching device at rated current and to break or make maximum rated fault current;

(k) the gas density monitor shall be backed up by a stop valve to allow replacing of the gauge without de-gassing the compartment;

(l) a gas density switch with two independent setting levels must be provided corresponding to gas density abnormal alarm and gas density abnormal lockout. A minimum of two normally closed contacts (closed when gas is healthy) must be provided for the alarm stage and lockout stage;

(m) the settings for alarm and trip stage must be as per the supplier's recommendation and recorded on formal setting sheets handed over to TasNetworks as a part of the documentation;

(n) the contacts must be potential free silver plated contacts. The contacts must be rated at 5 A, capable of making and breaking dc indication circuits from 87.5 V to 137.5 V dc for remote signalling. Micro switches are not acceptable for pressure monitoring devices;

(o) if the gas density is not below the lockout stage it must be possible to trip the circuit breaker manually. At rated load, the circuit breaker in this state must be capable of clearing a fault and successfully re-closing without any undue damage. Conversely if the gas density is below the lockout stage it must not be possible to trip the circuit breaker;

(p) topping of the SF_6 gas must be possible with the switchgear in service. All hardware, external accessories and procedures necessary for filling gas in the equipment must be supplied. The filling valves supplied must allow connection to either a DN8 or DN20 spring type gas coupling complete with dust cap for use with the service truck manufactured by DILO;

(q) the SF_6 filling valve shall be backed up by a stop valve to allow for replacement of the filling valve without degassing the circuit breaker;

(r) suitable provisions and protection must be provided to ensure that gas topping does not exceed the safe refill level for the equipment;

(s) a gas sampling device must be an integral part of the equipment;

(t) suitable absorbing devices must be provided to remove decomposition products from arcing in the gas; and

(u) where the manufacturer requires additional action in the event of low gas pressure in an equipment compartment, full details of any additional such requirements for each type of compartment must be submitted to TasNetworks for prior approval.

5.1 SF_6 insulated pressure relief

The following requirements are applicable to SF_6 insulated pressure relief:

(a) each gas filled compartment must be fitted with a pressure relief device. The pressure relief device must include a device fitted to the compartment that operates to reduce pressure when internal failure or flashover occurs. It may comprise:

- (i) a rupture disc,
- (ii) expansion bolts, or
- (iii) other approved device.

(b) internal relief devices between adjacent compartments are not acceptable;

(c) the operation of the devices must be coordinated with the bursting pressure of all other components of the compartment to ensure that their operation prevents the fracturing or fragmentation of those components; and

(d) in the event of operation of the pressure relief device, no component is permitted to be expelled from the GIS equipment such that it would create a hazard. The pressure relief device must be equipped with a deflector in order to control the direction of gas or vapour emission such that there is minimal risk to an operator working in places accessible for normal operation. The operation of the pressure relief device should be monitored and its activation shall raise an alarm.

5.1 De-energising device

It is mandatory that all de-energised circuits be proven dead prior to applying any earthing switch. In order to conform to this requirement the following condition must be satisfied:

(a) where the preferred method of proving a circuit is de-energised is a portable voltage detector, which is checked for positive operation before and after testing the circuit is offered, two portable voltage detector devices must be included for each switchboard. The voltage detection equipment supplied must be of a type approved by TasNetworks as specified in R522697, Temporary earthing of substation equipment standard;

(b) systems where earthing bars or connections are to be removed are not acceptable; and

(c) alternative systems for proving the circuit is de-energised may be offered for consideration by TasNetworks. Full details of the proposed method must be provided to TasNetworks prior to the award of the contract.

It is also a preferred practice to confirm isolation of switchgear though visually open-points. To satisfy this requirement the following requirement should be offered:

(d) a suitable positioned viewing window/s be installed to confirm the open status of the EHV GIS switchgear; and

(e) the viewing window must be able to confirm the status of the EHV GIS switchgear from ground level.

5.1 Circuit breakers

This section details requirements for the EHV GIS circuit breakers.

5.1.1 Primary design requirements

All circuit breakers must:

(a) be of a single-break, self-compression type circuit breakers with SF6 gas as arc quenching and insulation medium designed with a minimum maintenance contact system which complies with IEC class M2, this standard and the requirements as detailed in the referenced standards and other applicable Australian Standards for normal service conditions are acceptable;

(b) meet the minimum requirements of current rating and fault current rating as stated in Table 1 without exceeding the temperature rise limits specified in applicable Australian Standards. Where a particular project requires ratings different from those stated in Table 1 it will be stated in the project specifications;

(c) be an SF6 gas insulated design;

(d) be of trip free type and it must not be possible to close the circuit breakers whilst the trip circuits are energised. The trip free mechanism must become ready for operation before the arcing contacts make contact. It must not be possible for a circuit breaker to close, even with the control switch in the 'close' position, once the trip free feature has operated;

(e) be capable of closing onto a fault and immediately tripping without causing any damage to the circuit breaker;

(f) provide re-strike free interruption of capacitive currents and also low over-voltages while switching inductive currents (ie quenching must be at current zero);

(g) require a low operating force and current interrupting contacts should close with minimal impact force;

(h) be free of any contact bounce detrimental to its performance;

(i) have operating mechanism(s) that do not require any critical in-service adjustment;

(j) be strong, rigid, positive and fast in operation. The maximum difference between the instant of contact touching / separating must not exceed ½ cycle between the three poles; and

(k) be designed to minimise both the quantity of SF6 gas required and the annual SF6 gas leakage rate of the circuit breaker.

5.1.1 Operating mechanism

Circuit breakers must be designed to meet the following operation requirements:

(a) the motor, opening and closing spring must be fitted with appropriately set limit switches to prevent over-travel along with the necessary fuse and starter units. A motor protection schematic diagram and details of the motor protection devices must be provided to TasNetworks for prior approval;

(b) in the event of a failure of any component, particularly control components, the circuit breaker must be designed to prevent tripping except where tripping could be performed satisfactorily. The operating mechanism shall be capable of performing a complete O – 0.3 sec – CO – 3 min – CO IEC operating sequence;

(c) in the case of failure of the motor drive or breakdown of the control voltage an O – CO operation must still be possible;

(d) provision for manual emergency operation must be made;

(e) each circuit breaker must be provided with a minimum of two trip coils and one closing coil;

(f) mechanical (manual) operation of the circuit breaker must be provided such that, in the absence of the electrical closing and tripping devices and electrical supply, mechanical operation is possible;

(g) be free of any tendency to operate accidentally when the springs are charged;

(h) spring charged stored energy operating mechanism must be designed and constructed to enable manual spring charging with a removable handle in emergency conditions;

(i) mechanical (manual) charging and electrical charging of the motors must be interlocked to ensure only one mode of operation (mechanical / electrical) is able to control the spring charging at any instant;

(j) one handle must be supplied for each circuit breaker. A suitable attachment must be provided in the control cubicle to securely store the handle when not in use;

(k) the operating mechanism must be such that the circuit breaker cannot be closed unless the circuit breaker opening spring is fully charged and capable of opening the circuit breaker;

(l) the circuit breaker must be provided with an anti-pumping device. The operating mechanism must be arranged such that 'pumping' on to a fault does not occur if the 'close' circuit is energised continuously;

(m) the mechanism must incorporate a non-resettable counter to record the number of operations, readable from floor level with the naked eye;

(n) auxiliary switches must conform with the requirements as stipulated in Section 5.15.4; and

(o) the circuit breaker must allow operation from both local and remote (for example SCADA system or bay protection panel) locations. A Local-Remote-Off control selector switch must be provided in the circuit breaker control and operating cubicle to meet the following functional requirements:

  (i) when switched to remote, all external close and trip circuits must be enabled and all local operation must be disabled;

  (ii) when switched to local, control from the local control switches must be enabled and remote manual close and trip circuits must be disabled, however remote protection trips must be enabled; and

  (iii) when switched to off; all local and remote close and trip circuits must be disabled.

5.1.1 Arc quenching and contact wear monitoring

Circuit breakers must:

(a) have an SF6 gas arc extinction and insulation medium;

(b) be of a single-break, self-compression type circuit breakers ;

(c) have an effective arc quenching mechanism to prevent contact erosion due to switching operations;

(d) be fitted with a mechanism that indicates the extent of contact erosion; and

(e) have filters in gas compartments with switching devices capable of absorbing the gas decomposition products resulting from the current interruption process.

5.1.1 Closing device

The circuit breaker operating mechanism(s) must have the following closing attributes:

(a) the closing operation of each circuit breaker must be by means of energy stored in closing springs;

(b) closing spring charging must be achieved by means of an electric spring winding motor;

(c) spring charging mechanism must be designed such that the spring can be charged irrespective of the status of the circuit breaker (open/closed). The spring charging motor must commence charging as soon as the breaker is closed;

(d) discharge of the closing spring must not be possible while the circuit breaker is closed;

(e) moving contacts must not move without the spring charge being sufficient for satisfactory completion of circuit breaker closing operation. This may be achieved by means of suitable mechanical and electrical interlocks;

(f) damping devices must be provided to absorb excessive energy of the closing mechanism to prevent circuit breaker damage;

(g) a double pole contactor for controlling the supply to the closing device must be supplied with the switchgear and must be must be rated for 125 V dc with an operating range of 70 per cent to 110 per cent of rated nominal dc auxiliary supply voltage;

(h) positive closing operation of the circuit breaker under type test duties must be obtainable between the closing supply voltage range of 80 per cent to 125 per cent of the rated nominal dc auxiliary supply voltage;

(i) in addition to the contacts required for interlocks in closing and tripping circuits, a minimum of two normally closed (NC) spare contacts must be available for status of spring charged for each spring charging mechanism. The contacts must be closed when the spring is charged. These contacts must be potential free clean contacts, suitable for making and breaking indication circuits for remote signalling operating between the range of 70 per cent to 110 per cent of rated nominal dc auxiliary supply voltage;

(j) in the event of a failure of the spring charging motor supply, at least one open-close-open operation must be available;

(k) the spring charging time should be less than 15 seconds and the spring must be fully discharged upon closing the circuit breaker;

(l) spring charging motor must be able to operate within a operating range of 70 per cent to 110 per cent of rated nominal dc auxiliary supply voltage;

(m) the spring winding motor circuit must be provided with an independent motor starter circuit;

(n) a separate control for the spring charging contactor and spring release coil is required;

(o) electric motor protection must be provided and control of starters must be possible using miniature circuit breakers (MCBs) mounted in individual operation mechanisms;

(p) a lever must be supplied with each circuit breaker for manual charging of the spring. Manual operation should require minimal operator effort; and

(q) mechanical (manual) charging and electrical charging of the motors must be interlocked to ensure only one mode of operation (mechanical / electrical) is able to control the spring charging at any instant.

5.1.1 Opening device

The circuit breaker operating mechanism(s) must have the following opening attributes:

(a) the opening spring must be compressed during the closing operation. The operating mechanism must be such that the circuit breaker cannot be closed unless the opening spring is fully charged and capable of opening the circuit breaker;

(b) the opening spring must not require any electrical or mechanical charging from external sources. The charging of the opening spring must be automatic and be designed to be fail proof;

(c) two mechanically independent opening mechanisms that act directly on the circuit breaker mechanism and two magnetically and electrically independent trip coils must be provided for each circuit breaker;

(d) the opening must be through shunt trip release. Positive operation of the circuit breaker on no load must be obtained between the opening supply voltage range of 60 per cent to 125 per cent of the rated nominal dc auxiliary supply voltage, measured at the dc input terminals of the switchgear assuming that the connections to it have a resistance of 1 ohm. Whilst being sensitive to this low value of supply voltage, the mechanism must be stable and not capable of being tripped by shocks or jars;

(e) each circuit breaker pole must have two independent trip coils and must have a provision for two separate auxiliary supplies for the two trip circuits. The circuit breaker opening mechanism must be operated by two independent attachments to the opening or trip latch in the circuit breaker cubicle;

(f) a mechanical actuator must be provided for manual tripping of the circuit breaker in the absence of a trip supply, and must be located within the control cabinet; and

(g) circuit breakers must be capable of single pole high speed auto reclosing.

5.1 Instrument transformers

All instrument transformers must be suitable for continuous operation when installed on the switchgear under the ambient conditions as stated in Table 1 as well as under all rated and short-circuit conditions stated in the relevant Tables 1.

5.1.1 General

The following general requirements are applicable to instrument transformers:

(a) toroidal current transformers of the single or multi-ratio type with grounded cores are preferred;

(b) current transformers (CTs) must have secondary terminals outside the high-voltage enclosure, mounted in suitable, accessible terminal boxes; and

(c) optical instrument transformers and other technology, such as sensors, may be proposed as an alternative only if they have been tested in accordance with Australian Standards and have certification from relevant authorities in Australia for application to revenue metering measurement applications as per the National Electricity Rules. Optical instrument transformers and other technology proposed as an alternative will need to comply with IEC 62271-3.

5.1.1 Current transformers

The required CT parameters and performance must comply with the:

(a) requirements of IEC 60044.1;

(b) service conditions as stated in Table 1;

(c) parameters for CTs for EHV GIS systems as stated in Table 2; and

(d) required performance for individual cores of CTs as stated in Table 3 and Table 4.

Table 2 Design parameters for current transformers for EHV GIS systems

Sr. No.	Parameter	Unit	Value
1.	Rated secondary current	A	1
2.	Number of protection cores per phase	-	Four (4)
3.	Number of metering cores per phase	-	One (1)
4.	Order of cores assembly 1-2-X-3-4-5, where; P= protection, M = metering, X = circuit breaker		P-P-X-M-P-P
5.	Rated transformation ratio for all cores	A	1500/1200/1000/750/(400)-1 (refer note 1)

6.	Rated secondary thermal limit current for each secondary core (at any tapped winding)	A	2.0
7.	Rated short time thermal current (for any tapped winding) (I_{th})	A	As per the continuous rating of the circuit breaker
8.	Rated dynamic withstand current (I_{dyn})	kA_{rms}	As per the circuit breaker rating
9.	Rated short time withstand time	s	As per the circuit breaker rating
10.	Rated continuous thermal current	kA_{rms}	As per the circuit breaker rating

Table 3 Standard performance parameters for CT protection cores

Sr. No.	Parameter	Value
1.	Turns ratio	All principal, intermediate and derived ratios
2.	Performance designation	PX
3.	Max. secondary exciting current (I_e) at rated E_k	0.10 A
4.	Rated knee point voltage, E_k (V) = K x (R_{ct} + R_b) x I_{sn}	100(R_{ct} + 2)

Table 4 Standard performance parameters for CT metering core

Sr. No.	Parameter	Value
1.	Duty	Metering
2.	Performance designation	0.5M @ 750/1 tap (Note 2)
3.	Rated output	50 VA @ 750/1 tap (Note 3)
4.	Instrument security factor (FS)	≤ 10 (Note 4)

Notes:

1. An additional tap at 400/1 may be required and shall be stated in the project specifications
2. Performance designations for principal taps (ie. 1500, 1200, 1000 and 750 (and 400 where required)) and intermediate taps (ie. 800, 600, 500, 300 and 250) must be Class 0.5M. Routine tests for accuracy must be provided for all principal taps. Routine tests for accuracy must be carried out for the intermediate taps for each current transformer. All test results and certificates must be forwarded to TasNetworks for approval.
3. Rated output at other ratios must be proportional.
4. Ratio and Phase angle error must be the same as at 100 per cent primary current.

The following must be provided for CT secondary circuits:

(e) the actual CT ratio for connection must be confirmed with TasNetworks before commissioning. All pre-commissioning and commissioning tests must be based on this selected ratio. Testing on all ratios must be conducted during factory acceptance testing and must be conducted for each current transformer provided;

(f) all secondary instruments must be connected to same CT ratios unless otherwise required from protection and metering circuits. Where it is proposed to apply different ratios for different cores, approval must first be received from TasNetworks;

(g) secondary circuit must have polarity marking xS1, xS2, xS3 and so on. Test taps must have polarity markings xT1, xST2 (where "x" represents the core number);

(h) CT secondary windings for three phase CT combination must be normally connected in star configuration. The common star point must be formed on the terminal blocks in the low voltage compartment of the circuit breaker. The common point must normally be decided on the basis of the specific application. General guidelines to star point formation are as below:

   (i) for normal metering circuits S1 must be the star point; and

   (ii) for protection schemes the secondary terminal towards the equipment to be protected must be the star point.

(i) CT earthing must be applied as close as possible to the CT. The earth point must be accessible with the CT in service and must normally be dependent on the scheme of secondary connection, eg. CTs used in high impedance differential circuits are earthed only at one point;

(j) CT wiring must be brought to separate test terminals. It must be possible to conduct tests on the CT secondary circuits without disturbing (removing) the primary connections;

(k) the wiring must be arranged such that it is possible to reconnect the CT secondary to a delta configuration by altering the connections at the terminal blocks;

(l) the local marshalling and termination cubicle of the GIS bay operating mechanism must be used for CT connections. However, all CT secondary wiring connections must be separately grouped and fitted with an identification label to indicate function;

(m) wherever practical, individual CT terminal circuits must be grouped based on the unit connected and covered with a clip-on transparent cover;

(n) all devices must be wired to the terminal blocks; and

(o) where a multiple-core multiple-ratio CT is supplied, wiring of each individual core must be separated in bundles and must be suitably labelled to indicate connections at each ratio.

4.1.1 Measurement current transformers

The rated burden in ohms for each transformation ratio (at principal and intermediate taps) for measurement CTs must be submitted to TasNetworks.

4.1.2 Protection current transformers

The following must be submitted to TasNetworks for protection CTs:

(a) for class PX:

   (i) the performance specification detailed in Clause 14.1 of AS 60044.1 for each rated transformation ratio; and

   (ii) all other details as listed below.

(b) For class PR:

   (i) characteristics as stated in the project specifications.

4.1.1 Voltage transformers

Voltage transformers supplied must conform with the following:

(a) three phase VTs must comply with AS 1243, whilst single phase VTs must comply with IEC 60044.2;

(b) service conditions as stated in Table 1; and

(c) parameters for VTs for EHV GIS systems as stated in Table 5.

Table 5 Parameters for voltage transformers

Sr. No.	Parameter	Unit	Value	
	Particulars of the System			
1.	Nominal system voltage	kV	110	220
2.	Highest voltage (U_M)	kV	145	245
3.	Power frequency withstand voltage (PFWV)	kV_{rms}	275	460
4.	Lightning impulse withstand voltage (LIWV)	kV_{peak}	650	1050
5.	Normal voltage variation (criteria for equipment design)	$\%V_n$	$^{238}_{93}10$	
6.	Frequency (f_R)	Hz	50	
7.	Normal operating frequency excursion band	Hz	48.8 to 52	
8.	Power system frequency range	Hz	44.8 to 52	
9.	Normal combined voltage and frequency variation (criteria for equipment design)	%	$^{238}_{93}$ 10	
10.	System earthing	-	effectively earthed	
11.	Number of phases	-	3	
	Particulars of Voltage Transformers			
12.	Installation	-	Indoor metal –enclosed, gas insulated (GIS)	
13.	Number of identical windings per phase	-	2	
14.	Insulation medium	-	SF_6	
15.	Rated short-time thermal current	kA	40	
16.	Rated dynamic current	kA	100	
17.	Rated short-time	s	3	
18.	Rated primary voltage (U_{PR})	kV	110 / √ 3	220 / √ 3
19.	Rated transformation ratio (K_R)	-	1000	2000
20.	Rated output, accuracy and accuracy range for each winding	-	refer Table 6	
21.	Rated secondary voltage (U_{SR})	V	110/√3	
22.	Rated voltage factor (F_V)	-	1.5	
22.1	Rated time for F_V	s	30	
23.	Degree of protection by enclosure	IP	51	
24.	Rated supply voltage of heater circuit	V_{ac}	240	

Sr. No.	Parameter	Unit	Value
25.	Rated supply voltage of auxiliary (motor), indication and interlocking circuits	V_{dc}	125
26.	Rated supply voltage range of auxiliary (motor), indication and interlocking circuits	V_{dc}	87.5 – 137.5
27.	Contact rating of auxiliary switches at 125 V_{dc}	A	4

Specific parameters for secondary windings for voltage transformers are listed in Table 6.

Other voltage transformer parameters, such as additional windings, modified connections, ratios or accuracy class will be allowed only if it is requested in the project specifications or it is proven to TasNetworks' satisfaction that the proposed parameters are more onerous than those listed in Table 5 and Table 6.

Table 6 Specific parameters for secondary windings for voltage transformers

Sr. No.	Secondary Winding Parameter	Unit	Winding 1	Winding 2
1.1	Duty	-	Protection & metering	Protection & metering
1.2	Rated output per winding	VA	100	100
1.3	Measuring accuracy class	-	0.5M for Type 2 or 3 Metering Installations, or 0.2M for Type 1 Metering Installations (Specified at time of tender)	0.5M for Type 2 or 3 Metering Installations, or 0.2M for Type 1 Metering Installations (Specified at time of tender)
1.4	Protection accuracy class	-	3P	3P
1.5	Output range	%	5 to 100	5 to 100

The following requirements are applicable to voltage transformers:

(d) the VT is to be housed in a dedicated gas compartment;

(e) VTs that are be able to have their primary connection disconnected to facilitate cable testing without degassing and removing the VT unit are preferred. Should this arrangement be offered a suitable means of isolation of the VT primary circuit for testing purposes must be provided;

(f) VT's shall include suitable means of preventing ferro-resonance;

(g) if offered, three phase VTs must have a 5-limb core with ratios in accordance with the requirements of the project specification and a rated burden of 100VA per winding. Single phase VTs forming a three phase set must have a ratio, rated burden and accuracy in accordance with the project specification;

(h) the VTs must be connected Star-Star . The primary star point must be earthed. The secondary windings must be capable of being connected in a star configuration with an earth neutral point;

(i) all resin encapsulated VTs will be subject to compliance with partial discharge test levels and testing methods in accordance with the relevant IEC standards;

(j) the secondary terminals must be located in accessible, grounded terminal boxes mounted on the VT itself. The secondary connections must be wired to a terminal strip in the local control cabinet;

(k) the insulation of the conductors forming the high voltage windings must be uniform throughout the winding. Grading of the insulation is not permitted; and

(l) low voltage MCBs to adequately protect the VT from damage due to the effects of short circuits or sustained overloads must be provided in a readily accessible position under an easily removable cover, on the outside of the VT compartment and as close as possible to the VT secondary terminals.

4.1 Disconnectors

The following requirements are applicable to disconnectors:

(a) all disconnectors must be of the three-phase gang-operated type. They may be either high-speed power operated or motor controlled and must be suitable for 125V dc operation;

(b) a double pole contactor for controlling the supply to the motor must be supplied with the switchgear and must be operated from the 125V dc supply. The maximum current taken by the contactors coil must not exceed 2 amperes at this voltage. Positive closing operation of the circuit breaker under type test duties specified must be obtainable between the closing supply voltage range of 80 per cent to 125 per cent of the rated nominal dc auxiliary supply voltage;

(c) the disconnector operating mechanism must be designed and constructed to enable manual operation of the disconnector with a removable crank for switching the disconnector to either the closed or open positions. One crank must be supplied for each bay of the EHV GIS equipment. Whenever the crank is inserted in the drive mechanism it must be impossible to operate the device electrically. A suitable attachment must be provided in the control cubicle for securely storing the crank when not in use;

(d) viewing windows must be provided to enable visual confirmation, from floor level, of the correct operation and position of the disconnector whilst the equipment is energised. Where this is not possible camera must be fitted to the EHV GIS to accurately establish the correct position of the disconnector whilst the equipment is in service. The monitor must be located at a location such that. Should camera and monitors be a requirement of the design, details of the camera and monitors installation and design must be submitted to TasNetworks for approval;

(e) the disconnector must be provided with a locking point to lock the switch in either the open or closed position. The locking point must be suitable for installation of TasNetworks' standard 5mm diameter hasp shutter lock, a sample of which can be provided on request. The locking point must be accessible from floor level without the need to climb onto the switchgear;

(f) where combination three-position type disconnector and earthing switches are offered the switch must be designed to stop and lock in each switch position: disconnector closed, disconnector and earthing switch open, earthing switch closed;

(g) manual operation of the operating mechanism by removable handle must be provided. The manual operation must have a definite stop and lock at each switch position to prevent manual operation of the switch from the disconnector closed to earth switch closed position. Locking points must be provided to lock the switch in each of the three positions;

(h) the actual position of each disconnector and earthing switch must be indicated by mechanically coupled auxiliary switches with at least four NO and four NC contacts. Mechanical indicators connected directly and permanently to the drive mechanism shaft are required to display the actual switch position. Contractors shall advise how this is to be achieved in the event of a failure of the drive shaft, or if unable to achieve this directly, how they intend to achieve this;

(i) disconnectors and associated earthing switches must be mechanically interlocked to each other; and

(j) auxiliary switches must conform with the requirements as stipulated in Section 5.15.4.

4.1 Earthing switches

The following requirements are applicable to earthing switches:

(a) motor operated and high speed earthing switches with a fault making capability must be provided on the GIS equipment in accordance with the project specifications;

(b) dedicated motor operated earthing switches may be offered as an alternative to the combination three position type disconnector earthing switches. These must be 125V dc motor drive spring charged stored energy type closing devices. A motor protection schematic diagram and details of motor protection devices must be provided;

(c) a double-pole contactor for controlling the supply to the motor must be supplied with each earthing switch and must be operated from the 125 V dc supply. The maximum current taken by the contactor's coil must not exceed 2 amperes at this voltage. Positive closing operation of the earthing switch under type test duties specified must be obtainable between the closing supply voltage range of 80 per cent to 125 per cent of the rated nominal dc auxiliary supply voltage;

(d) earthing switches on the line side of overhead line feeders must have make-proof contacts and high-speed operating mechanisms so that they are suitable for discharging capacitive and inductive currents as well as for closing on to a fault;

(e) the earthing switch operating mechanism must be designed and constructed to enable manual operation of the earthing switch with a removable crank for switching the earth switch to either the closed or open positions. One (1) crank must be supplied for each bay of the GIS equipment. Whenever the crank is inserted in the drive mechanism it must be impossible to operate the device electrically. A suitable attachment must be provided in the control cubicle for securely storing the crank when not in use;

(f) test points are required on each phase of the earthing switch for single or three phase current injection testing of each protection scheme. The test point is to be located external to the switchgear enclosure with a link, located for easy access and removal by personnel, between the test point and the connection of the earthing switch to the main earthing bar. Test bushings on high speed earthing switches must be suitable for the application of single phase test voltages for cable fault location. The test bushings must be suitable for withstanding a test voltage of 10 kV rms;

(g) all earthing switches must be provided with a locking point to lock the switch in either the open or closed position. The locking point must be suitable for installation of TasNetworks' standard 5 mm diameter hasp shutter lock, a sample of which can be provided on request. The locking point must be accessible from floor level without the need to climb onto the switchgear;

(h) viewing windows must be provided to enable visual confirmation, from floor level, of the correct operation and position of the earth switch whilst the equipment is energised;

(i) the actual position of each earthing switch must be indicated by mechanically coupled auxiliary switches with at least 4 NO and 4 NC contacts;

(j) capacitive type proving dead devices to confirm that circuit connections are de-energised prior to closing earthing switches must be installed at the locations as indicated on the project specification. Full details are to be submitted to TasNetworks for prior approval;

(k) mechanical position indicators must display the actual switch position and be connected directly and permanently to the drive mechanism shaft of the moving contact. The mechanical position indication shall be marked 'ON' (closed) and 'OFF' (open) and must be clearly visible from the switchroom floor. Tenderers shall advise how this is to be achieved in the event of a failure of the drive shaft;

(l) earthing switches and the related disconnector must be mechanically interlocked to each other. All earthing switches shall be interlocked with associated circuit breakers and disconnectors so that it is not possible to close an earthing switch onto a live circuit or to make the circuit live when the earthing switch is closed; and

(m) auxiliary switches must conform with the requirements as stipulated in Section 5.15.4.

4.1 Primary cable and overhead line terminations

4.1.1 Primary cable termination box, terminals and fittings

The following primary cable termination box, terminals and fittings requirements shall be applicable:

(a) the EHV GIS to primary cable interface shall be in accordance with IEC 62271.209 and TNM-DS-806-0260, Extra-high-voltage cable system standard;

(b) the EHV cable comprising three single-core, copper conductor cable, of a rating and voltage will be specified in the project specification;

(c) the Contractor will be required to coordinate the design of the cable sealing endboxe's cable interface;

(d) the design will take account of the movement, vibration and expansion variations. If the earthing system of the EHV GIS and the cables are isolated from each other the open connections shall be protected against over-voltages;

(e) provision shall be made at the cable compartment to allow isolation and earthing (visual) of the cable from the EHV GIS circuit with the minimum dismantling of plant and evacuation of SF_6 gas. This isolation is required for testing the cable or other repair work;

(f) the final connection of the EHV cable circuits in the EHV GIS shall be by means of individual single-phase cables, with one or two cable per phase;

(g) all cable end modules shall be suitable for connecting single core crosslinked polyethylene insulation (XLPE) copper solid dielectric cable;

(h) the switchgear end boxes must be suitable for incorporating Südkabel type EHSVS Compact Sealing Ends. The items to be supplied with the GIS switchgear include the switchgear receptacle (socket) and the cable sealing end. The cable chambers must be entirely suitable for these compact dry plug-in type terminations complying with IEC 60859;

(i) the cable connection compartment must be suitable for termination of the single core XLPE copper cable sizes as required by the project specification;

(j) the cable connection enclosure with receptacle fitted must be entirely suitable for the sealing end to be inserted into the receptacle without the need to reduce gas pressure within the cable end box compartment. Full details of the proposed isolating and test facilities for the primary cables must be submitted to TasNetworks for prior approval;

(k) the cable connection enclosure must be designed such that the screens on each phase of the connected cable are insulated from the switchgear and from each other. The insulation must be capable of withstanding a 50 Hz HV ac test of a minimum of 15 kV rms for 1 minute. A removable shorting link must be provided across the insulation to enable the cables to be operated with the cable screens either connected or disconnected from the switchgear;

(l) each cable connection enclosure must provide a facility for isolating the cable from the switchgear with removable links or approved alternative; and

(m) where bushings for cable testing are required they shall be located at the cable connection enclosure in accordance to the requirements of IEC 62271.203 and IEC 60859.

4.1.1 Overhead line terminals

The following requirements are applicable to overhead line terminals:

(a) where overhead EHV line terminals are to be installed on the outside of the switchroom they must be SF_6-air type of composite construction and must be rated for the actual insulation level of the switchgear; and

(b) where gas-filled bushing insulators are offered the pressure gauge must be located inside the switchroom.

4.1 Secondary design requirements

The following section details the secondary requirements for an EHV GIS installation as follows:

(a) the local control cubicle must form an integral part of the switchgear bay or may be a free standing type, accessible from floor level without the use of any aids. Where local control cubicles form an integral part of the switchgear, CT circuits shall be allowed to be directly connected to the protection panel. For free standing cubicles al secondary leads of all CTs must be wired to shorting-type terminals on the terminal strip in the local control cubicle of each bay;

(b) provide full mimic type position indication and local control of all switching devices;

(c) all local control functions, including the following, must be located in the local control cubicle:

  (i) switchgear interlocking functions;

  (ii) MCB's for low voltage equipment;

  (iii) local operation of the switchgear; and

  (iv) indicating and measuring equipment.

(d) the main contact position of all three poles must be indicated by directly activated auxiliary position switches with a minimum of eight NO and eight NC adjustable spare contacts wired to a plug connector in the local control panel, suitable for dc operation between 87.5 V and 137.5 V; and

(e) each control circuit, except the tripping circuit, must be protected by a miniature circuit-breaker with an auxiliary contact. The auxiliary contacts of all MCBs must be monitored as a common alarm.

4.1.1 Indications

The following indication requirements are applicable:

(a) all indications, operator accessible components, control panels, rating plates must be positioned such that they are visible from floor level with the naked eye with the switchgear in service and without the need to open any cover, barrier or unit door; and

(b) mechanical indications must be independent of electrical indications and not require electrical supply for operation.

4.1.1.1 Mechanical indications

Mechanical indications must be provided, and be visible with the control cabinet door closed, for the following:

(a) open and close state of the circuit breaker. The indicator must be positioned external to the mechanism enclosure and marked ‘I’ (red background) – closed, ‘O’ (green background) – open, and the ‘Earthed’ position marked with a amber background; and

(b) spring charged and discharged states for stored energy spring operated mechanisms closing spring. The indicator must be marked ‘Charged’ and ‘Free’ for each spring operated mechanism.

4.1.1.1 Electrical indications

The circuit breakers must provide facilities to enable electrical indication of the following:

(a) open and closed state of the circuit breaker;

(b) spring charged for closing spring;

(c) gas density alarm and lockout stage;

(d) trip circuit unhealthy;

(e) close circuit unhealthy;

(f) circuit breaker healthy indication;

(g) AC / DC circuit MCB trip; and

(h) any other devices that may be required for easy operation, maintenance and restoration of system to normal in the event of a fault.

4.1.1 Interlocking

The following functions must be provided:

(a) suitable mechanical and electrical interlocks and safety devices must be provided to prevent any inadvertent operation of the circuit breaker when any part of the circuit breaker is connected to an energised EHV network and shall comply with Australian Standard AS/NZS 62271.1;

(b) electrical interlocking facilities must be located in the local control cabinet of each bay. They must provide absolute and reliable protection against any potentially harmful maloperation of the switchgear;

(c) interlocks must ensure a correct operating sequence has to be followed for electrical system security and integrity. The operator must be forced into the only safe and logical sequence to actuate circuit-breakers, switches, disconnectors and earthing switches;

(d) the actual, completely closed or completely opened position of all switching devices must be visually verified before and after each operation;

(e) implementation of logic checks and issuing the resulting signals ENABLE or BLOCKED for the switching device;

(f) manual local operation and automatic remote operation for all essential functions;

(g) local emergency unlocking equipment via an interlock defeat key switch under full responsibility of the operator;

(h) all mechanical interlock devices must be direct acting;

(i) in the event of failure of any component, particularly control components, the circuit breaker must be designed to prevent tripping except where tripping can be performed satisfactorily;

(j) all interlocks required for the closing and tripping of the circuit breaker (from local and remote) based on the status of gas density and spring charging mechanism must be provided; and

(k) the operating mechanism must be such that the circuit breaker cannot be closed unless the circuit breaker opening spring is fully charged and capable of opening the circuit breaker.

4.1.1 Local control and operating cubicles

4.1.1.1 Construction

Local control and operating cubicles must:

(a) be constructed of sheet metal or marine grade aluminium panels of sufficient thickness and bracing to provide torsional rigidity;

(b) provision shall be made for locking each cubicle door in the closed position using a padlock with a 5mm diameter hasp;

(c) have doors and covers providing ready access to all operating components for inspection and maintenance purposes. Door/s must open to an angle of 120◦ and have stays fitted to prevent free swing;

(d) provide a degree of protection to IP 51;

(e) have a removable gland plate at the bottom of the cubicle to allow entry of all cables. The aluminium gland plate must be a minimum of 2 mm thick and suitable for drilling on site;

(f) act as a single point interface for remote control and monitoring system with the equipment;

(g) be positioned to ensure safe access while the switchgear is in operation;

(h) contain and utilise suitably rated MCB to protect spring wound motors, space heaters, internal lighting and associated wiring;

(i) be provided with a single-phase 240 V AC fluorescent light for illumination. The power supply circuits for the light and local control cubicle must be arranged such that it is possible to isolate them at one common point inside the control cubicle; and

(j) have thermostatically controlled anti-condensation heaters with cut-off control switches to prevent moisture condensation must be provided in the control cabinets, in the operating mechanism housings of disconnectors, earthing switches and circuit-breakers. The heaters and thermostats must be:

    (i) suitable for single phase 240 V, 50 Hz AC system operation;

    (ii) capable of continuous service for the entire life of the circuit breaker;

    (iii) easily accessible and easily replaceable; and

    (iv) supplied with appropriate settings and a recommended settings sheet for each installed heater and thermostat combination.

4.1.1.1 Layout of equipment

The following equipment layout requirements are applicable:

(a) the layout of apparatus in the control and operating cubicle must facilitate ease in workability without the need to take the bay out of service;

(b) maintenance and inspection work and connection checks must be possible without the need to dismantle any apparatus or having to take the bay out of service; and

(c) MCBs must be grouped and labelled in accordance with Australian Standard AS 2067. Any other arrangement must be submitted to TasNetworks for prior approval.

4.1.1 Auxiliary switches

Each switching device, including circuit breakers, disconnector and earth switches must be equipped with auxiliary switches. Auxiliary switches must:

(a) be fully type tested in accordance with AS/NZS 62271.1;

(b) be suitable for their intended duty in terms of environmental conditions and the making and breaking capacity for the life of the auxiliary switch;

(c) have a positive wiping action on closing and be capable of making, breaking and continuously carrying currents of 5 A at 125 V DC or 240 V AC, unless otherwise stated in this standard or the project specifications;

(d) be simple and robust, capable of easy adjustment at site, readily accessible, capable of maintaining their adjustment and contain rust-proof springs;

(e) be constructed with a removable cover and installed in such a manner that the contacts can be inspected and maintained without dismounting or dismantling the switch;

(f) be adjustable to either open when the circuit breaker opens or to open when the circuit breaker closes;

(g) be positively driven in both directions when operated in conjunction with the main contacts;

(h) be suitably protected against accidental arcing from the main circuit when installed on the frame of switching devices;

(i) have insulation that is resistant to tracking and moisture absorption. This also applies to auxiliary circuit terminals;

(j) be provided to interrupt the supply of tripping current to operating mechanisms. The number of auxiliary switches used for closing and tripping circuits must be kept to a minimum; and

(k) the auxiliary equipment must be segregated by earthed metallic partitions from the main circuit, unless otherwise specified in relevant Australian Standard.

4.1.1 Secondary wiring and terminals

The EHV GIS system, including all secondary wiring and terminals must comply with AS/NZS 3000.

The following secondary wiring and terminal requirements are applicable:

(a) be carried out in not less than 0.6/1.0 kV grade, oil resistant and weatherproof PVC insulated, copper screened and PVC sheathed cables that comply with AS 3008.1.1;

(b) all devices must be wired to terminal blocks;

(c) unless otherwise approved by TasNetworks in writing, secondary wiring must use the following colour code:

- (i) AC phases – Red, White and Blue;
- (ii) Neutral and unspecified cores – Black;
- (iii) DC – Grey; and
- (iv) Earth – Green/Yellow.

(d) be brought out through a hermetically sealed barrier and terminated in the marshalling/termination cubicles. The control cubicle may act as a marshalling and termination cubicle;

(e) be provided with red ferrules marked 'TRIP' where circuits are associated with a tripping circuit;

(f) not be jointed or teed between terminal points and must not be clamped directly under screws;

(g) be heat resistant where they are connected to, or in close proximity to, space heaters;

(h) terminals must be:

- (i) located to ensure safe access to wiring with the equipment live;
- (ii) segregated, fully shrouded with clear plastic and labelled for voltages above 150 V AC or DC;
- (iii) grouped separately for AC and DC voltages; and
- (iv) consecutively and permanently numbered to AS 2067 and grouped according to function, providing neat and economical use of multi-core cables.

(i) terminal blocks must:

(i) utilise slide-disconnect terminals comprised of 'Klippon' Weidmuller type SAKT1-4379.2, Phoenix type URTK/S-BEN or equivalent;

(ii) have a separator plate between the phase and neutral terminals (in case of AC) and positive and negative terminals (in case of DC); and

(iii) contain a minimum of 50 spare terminals in each control and operating cubicle and minimum 25 spare terminals in each marshalling panel.

(j) the control, indication, interlocking and alarm circuits for the close operation, open operation, primary and secondary trip circuits and spring winding motor must be electrically isolated from each other. Control, indication, interlocking and alarm circuits must be arranged to facilitate external connections and allow appropriate isolating points for circuit checking and fault finding;

(k) all auxiliary contacts, switches, relays and/or mechanisms required to ensure the control, indication, interlocking and any other services must be provided;

(l) the functional identification of all connections in control, indication and alarm circuits must be in accordance with relevant Australian Standards;

(m) all incoming voltage circuits must be fed through and be connected to the upper terminals; and

(n) all individual current transformer terminal circuits, wherever applicable, must be suitably bunched based on the unit connected and be covered using a clip-on transparent cover.

5 Other requirements

5.1 On-line monitoring and diagnostic testing

The following on-line monitoring requirements are applicable:

(a) the provision of on-line monitoring and diagnosing testing, which will generally include SF_6 overpressure monitoring, partial discharge measuring systems, circuit breaker travel transducers, and motor current monitoring, will be defined in the project specification; and

(b) full technical details of the manufacturer's proposed on-line monitoring and partial discharge measuring systems, together with the sensor modules, installation tables, location drawings, sensitivity factors, verification procedures, and commissioning details must be provided to TasNetworks for approval.

5.1 Phasing

The following phasing requirements are applicable:

(a) provision of a device for the electrical phasing of the EHV circuits connected to the switchgear against the main busbar without the need to disconnect the EHV cables. This process is normally carried out during commissioning or following any changes to feeder circuits by an operator prior to closing the feeder circuit breaker; and

(b) whether or not such a device is offered, the recommended method of phasing the EHV circuits connected to the switchgear against the main busbar must be submitted to TasNetworks for approval.

5.1 Surface preparation

The following surface preparation requirements are applicable:

(a) all ferrous metal support structure surfaces must be protected against corrosion by hot dipped galvanising;

(b) both contact surfaces at all terminations and connections in the main circuits shall be hard silver plated. Where other than silver plating is offered, a statement on service history of the offered connection must be submitted to TasNetworks;

(c) all earthing bars must be tin plated; and

(d) the contact material of all switching devices and the surface preparation, including plating, must be submitted to TasNetworks.

5.1 Earthing

While the physical characteristics of an EHV GIS installation is different to that of an Air Insulated Switchgear (AIS) installation and most noticeably the smaller footprint of an EHV GIS installation, the basic earthing requirements of an earthing system are no different to those for an AIS installation. The following earthing requirements are applicable:

(a) earthing of all equipment and works associated with the EHV system must be in accordance with R522692;

(b) frames of all equipment supplied must be provided with reliable earth connections, which are adequate to carry the fault current, and comply with relevant Australian Standards;

(c) all connections to earth must comply with the requirements of AS/NZS 3000 and ensure a reliable connection for the entire life of the equipment;

(d) all connection must be short and as direct as possible to reduce the effects Transient Enclosure Voltage (TEV) in the copper conductors;

(e) a continuous copper main earthing bar of minimum dimensions 40 mm x 6 mm must be provided to run the full length of the switchgear and be connected to the structure earthing point at each switchgear bay. The main earthing bar must be drilled at each end suitable for two M16 stainless steel bolted connections to the substation earth grid;

(f) the earth side of each earth switch must be connected to the switchgear main earth bar by a copper bar rated for the thermal and electrical stress for the fault rating specified in Section 2. Continuity through switchgear enclosures alone is not acceptable;

(g) a tinned copper earth bar, of minimum dimensions 20 mm x 6 mm and equipped with a minimum of 8 off M5 stainless steel bolts, flat and spring washers for the termination of 7/0.67 mm earthing conductors, must be provided in each switching device local control cabinet or where applicable each free standing control panel. The bar must be directly connected to the integral switchgear structure main point. On site drilling of the equipment casing or other installation structure for earth bonding connection will not be permitted;

(h) connection of the earth bar in the control panel to the earthing attachment point by continuity of the cubicle and support structure is not acceptable;

(i) earth connection points on equipment shall be indelibly marked with the symbol for protective earth; and

(j) all accessories required for connection to earth must be provided.

5.1 Special tools

A price and details must be submitted to TasNetworks for a complete unused set of all-special tools or appliances, required for the operation, adjustment and overhaul of the equipment for its entire life. Each set must include:

(a) one complete set of special tools necessary for the adjustment or removal of any part of the switchgear and its component parts; and

(b) one slow closing handle for each type of switching device offered.

5.1 Nameplates and labels

The following nameplate and label requirements are applicable:

(a) nameplates and labels must comply with R522687, General substation requirement standard;

(b) all the necessary number plates and labels required for the operation of the equipment, and in accordance with the relevant standard, must be provided with and fixed to the switchgear. The type, size, information and position of labels must be approved by TasNetworks. The main circuit breaker label must carry the inscription 'TasNetworks Contract No. ####'.

(c) nameplates must be:

    (i) legible and in the English language;

    (ii) permanently and indelibly marked;

    (iii) securely fixed in position to the body of the secondary terminal box of the current transformer (not to be fixed to a removable component, such as a hinged door); and

    (iv) made of brass, stainless steel or material of equal durability.

(d) a blank plate of approved size must be mounted on the fixed portion of the switchgear, for each circuit or incomer, on which the circuit designation is stamped;

(e) current transformers must be fitted with nameplates complying with IEC 60044.1. Duplicate nameplates must be mounted in the circuit breaker control cabinet with details of each current transformer regarding their ratio, class, rated burden, type, function, thermal rating on each tapping and their relative positions on the circuit breaker; and

(f) warning labels fitted within CT secondary terminal boxes must be traffolyte, with black text on a yellow background. The following warning labels must be fitted within the secondary terminal box and clearly state:

ATTENTION: WHEN HIGH VOLTAGE IN SERVICE,
THE DDF TERMINAL MUST BE CONNECTED TO GROUND

ATTENTION: DO NOT OPERATE THE CT WITH ANY CORE
OPEN-CIRCUIT

(g) in addition to the requirements of AS/NZS 62271.1, the following information must be included on the circuit breaker nameplate:

    (i) the name or registered trade name or mark of the manufacturer/supplier;

    (ii) year of manufacture;

    (iii) description: Circuit Breaker;

    (iv) manufacturer's serial number, relating device to the test certificate(s);

    (v) number of phases: single phase or three phase;

    (vi) rated operating sequence;

(vii) first-pole-to-clear-factor;

(viii) rated line charging breaking current;

(ix) rated out of phase breaking current;

(x) rated supply voltage of all auxiliary circuits;

(xi) rated mechanical load of terminals;

(xii) highest voltage for equipment Um;

(xiii) mass of the SF6 gas (in kg);

(xiv) mass of device (in kg);

(xv) purchaser: Tasmanian Networks Pty Ltd; and

(xvi) purchase Order Number: refer to project specifications.

5.1 Spare parts

The following spare parts requirements are applicable:

(a) a comprehensive list of recommended spares is required for the EHV GIS, including a price for each item. The spare parts, if ordered, must be identical in all respects with similar parts incorporated in the EHV GIS and will be submitted to the tests and inspections specified herein wherever applicable. Note that TasNetworks is seeking advice from the manufacturer as to what spare parts should be held;

(b) the spares parts include, but are not limited to:

(i) operating and tripping mechanisms;

(ii) switching equipment components;

(iii) gas barriers and busbar supports;

(iv) gas pressure vessels; and

(v) any other components considered essential for the continued operation of the switchgear.

(c) an assurance that the capability, facilities and any information required to supply and manufacture spare and wear parts will be retained by the manufacturer over the life of the switchgear. This standard requires the design life of the switchboard to be a minimum of 45 years. Manufacturers are required to outline their policy for holding essential spare and wear parts for the life of the switchgear. Information to be supplied includes:

(i) their policy of holding spares and wear parts including details of what spares are held by the manufacturer;

(ii) delivery lead times for spare and wear parts to Tasmania;

(iii) spares and wear parts while series production is operational;

(iv) spare and wear parts at time of phase out and indicative phase out of the switchgear production. Prior to the official phase out of the switchgear production TasNetworks is to be notified in writing; and

(v) spare and wear parts after phase out of the switchgear production including the ability and facilities to manufacture spares for the remaining life of the switchgear;

(d) the information provided in response to the above queries will assist in determining whether or not some essential spare parts will be purchased and stored by TasNetworks;

(e) manufacturers are required to outline their policy for maintaining technical support and servicing capabilities for the life of the switchgear, ie 45 years;

(f) spare parts must be packed in long term sealed plastic bags and delivered to the TasNetworks' store in wooden cases of adequate strength to protect the equipment from damage and the ingress of moisture during transport and handling; and

(g) each case must be suitably marked so the contents can be ascertained without it being necessary to open the case. Case marking must include the purchaser's contract No. and the mass of the crate.

5.1 Documentation requirements

The following documentation must be provided and the requirements observed:

(a) dimensioned drawings must be produced and submitted for the EHV GIS and its associated accessories. The drawings must show the mounting structures and all details required to install the equipment in an existing switchyard environment;

(b) all documents and drawings must be clear, legible and free from errors or omissions;

(c) all documents and drawings must be in the English language ONLY;

(d) only SI system of units can be used. Units must be stated for all values;

(e) scales, wherever used, must be as per the applicable Australian Standards; and

(f) all drawings that are made to scale must include a scale block.

Only information relevant to the particular type of EHV GIS supplied shall be shown in the documentation and drawings.

6 Data for asset management information system

TasNetworks maintains a comprehensive 'Asset Management Information System' (AMIS) that contains all design, test results and the condition of all TasNetworks assets. The AMIS also contains maintenance regimes for all assets.

The supplier must provide information required to maintain the currency of AMIS for each asset in standard proformas. TasNetworks will provide the proformas to the selected supplier. Proformas are required to be filled for new assets and for decommissioned assets. These proformas must be completed and submitted to TasNetworks as below:

(a) information on test results for all assets must be submitted prior to commissioning; and

(b) design information and maintenance regime information for all assets must be submitted to TasNetworks at completion of the project.

7 Maintenance procedures and plans

The supplier must provide:

(a) a detailed maintenance plan, procedures and task guides covering the design life of the equipment;

(b) recommend the frequency for maintenance based on time, operational count, operational events; etc;

(c) a recommended routine test plan; and

(d) blank schedules and forms for maintenance and routine testing, for use by TasNetworks maintenance personnel.

8 Condition based risk management

The Contractor must document all relevant information to support TasNetworks' Condition Based Risk Management (CBRM) process. If the Contractors do not have a CBRM or Failure Mode, Effects and Criticality Analysis (FMECA) process, Table 7 should be completed.

The purpose of the CBRM information is to review and analyse the EHV GIS design to establish:

(a) potential failure modes;

(b) the likelihood of failure;

(c) the significance of failure in terms of safety, operational performance, environmental impact and economic consequence;

(d) the criticality of failure in terms of system operations;

(e) the potential risk the EHV GIS installation subjects TasNetworks to over the life of the asset; and

(f) assist with identifying, development and optimising of maintenance regime and reliability improvement programs over the life of the asset.

Table 7 CBRM requirements

Heading	Requirement
Item/Assemby and Part No/Drg No	Identify the asset, manufacturer's part identification, and drawing details.
Functional description	Provide an overview description of the EHV GIS function including the functions of major component functions.
MTBF (hrs)	Enter the asset/item's Mean Time Between Failure in hours of the major components and complete EHV GIS system.
Gas leakage rate (pa)	Enter the expected maximum gas (SF_6) leakage rate of each individual compartment. Such leakage rate should be supported by real in-service data as it becomes available
Function	Principal functions - which represent the business reason for an assets existence. Enter the item name and, as concisely as possible, the function(s) of the item to meet the design intent. Functions may also be identified in the form of a desired standard of performance with functional failure deemed to have occurred when this level of performance is not available. Include information regarding the environment in which the system operates. (eg, define temperature, voltage etc).
Failure mode	Failure modes are the effects by which failures are observed. It includes the manner by which the failure is observed and is generally described by the way in which the failure occurs and its impact, if any, on the equipment operation

Cause of Failure	Need to state the engineering mechanism of failure that leads to the particular functional or conditional failure. Failure causes are derived from the design. They are associated with the detailed design approach taken, the materials used, the operating environment including such information as physical loads and corrosive materials. Human factor information is also required, to support the allocation of warning notices in manuals or service schedules.
Local effects	Identify that impact a particular failure mode has on the operation, function or status of an item. The description of the failure effect must be adequately detailed to allow classification into one of the criticality categories:- • Hidden/safety/environment. • Evident/safety/environment. • Evident/economic. • Hidden/economic.
Criticality	Identify the criticality a particular failure mode has on the operation, function or status of the equipment item. Multiple criticalities may be entered for a failure mode:- **H** – Hidden – Loss of function is not evident to the operator. **S** – Safety – Loss of function is likely to lead to death or injury. **E** – Environmental – Loss of function results in adverse impact on the environment. **O** – Operational /economic impact only.
Failure Rate, %	Identify the rate at which this type of failure occurs in failure per million hours (FPMH). If data is not available to establish exact rates, enter the indicative percentage in the next column (with % symbol) that this failure mode / cause combination contributes to the total equipment MTBF

9 Testing

The following testing requirements are applicable:

(a) the switchgear must be tested in the manufacturer's works to demonstrate that the switchgear complies with the project specification. The testing must be carried out in accordance with AS 1931, IEC 62271.100, IEC 62271.102 and IEC 62271.203, and other relevant standards as is applicable;

(b) the manufacturer is directly responsible for Type Tests, Routine Factory Tests and Special Tests. In addition the manufacturer is responsible for providing switchgear which is fit for purpose and which complies with the requirements of this standard. Thus the manufacturer is responsible for providing equipment which complies with the requirements for commissioning and maintenance tests;

(c) when the manufacturer is carrying out Routine and Special Tests on the EHV GIS, TasNetworks must be notified at least 28 days prior to the date of the testing. TasNetworks reserves the right to witness these tests; and

(d) where tests are optional in the standards, it will be considered that these tests are required by TasNetworks, unless otherwise requested by manufacturer and agreed in writing by TasNetworks.

9.1 Test reports

A formal test report shall conform to the following requirements:

(a) one copy in Acrobat .PDF format of all Type, Routine and Additional Test reports must be provided to TasNetworks for approval;

(b) all test results must be contained within a formal test report which lists:

- (i) the testing organisation and the testing officer;
- (ii) the testing location and date of the tests;
- (iii) clear identification of the circuit breaker, busbar or item of equipment being tested; and
- (iv) a brief description of the test, any test equipment and, for any electrical test, the test circuit.

(c) the formal test report shall contain a record of;

- (i) all measurements taken during tests;
- (ii) the values of the test measurements and their uncertainties;
- (iii) the formal result of the tests (Satisfactory or Unsatisfactory);
- (iv) the relevant drawings and photographs; and
- (v) any relevant comments.

A summary of final results is not acceptable.

The tests will be considered as completed only after approval of test results by TasNetworks in writing.

9.1 Type tests

The following Type Test requirements are applicable:

(a) the manufacturer must be able to demonstrate by providing the original or certified copies of Type Test Reports performed after 2003, that the major individual items of equipment and the switchgear, as a whole, will perform as specified and complies with the relevant Australian or IEC Standards;

(b) all Type Tests must be carried out prior to despatch. A certified test report, detailing the results of such tests along with the procedures followed, must be provided to TasNetworks. These tests must have been applied to switchgear of identical design with that offered, or on switchgear of a design which does not differ from that offered in any way that might influence the properties to be confirmed by the Type Test. The static terminal load test of IEC 62271.100 must be included for SF_6 to air bushings;

(c) the test report shall include test results for the Special Type Test to verify withstand duration without burn-through, the effects of arcing due to internal faults in accordance with IEC 62271.203. The first stage protection clearing time shall be 0.2 seconds and the second stage fault clearing time shall be 0.5 seconds;

(d) where such tests have already been performed, a copy of Type Test reports must be submitted to TasNetworks for approval; and

(e) where Type Tests differ from the requirements under the relevant Australian Standards, the manufacturer must detail and submit a list of non-conformances to TasNetworks for prior approval.

9.1 Routine tests

The following Routine Test requirements are applicable:

(a) procedures for Routine Tests with supporting documentation must be submitted to TasNetworks for approval. Routine tests must not be conducted unless the routine test procedures have been approved by TasNetworks;

(b) Routine Test results and certificates must be submitted to TasNetworks for approval and acceptance. Such tests will only be considered to be complete after TasNetworks has approved, the test results;

(c) Routine Factory Test results must be approved by TasNetworks prior to dispatch of equipment to site; and

(d) the manufacturer must carry out Routine Tests prior to the dispatch of the switchgear. These tests must include the following as a minimum:

  (i) SF6 gas must be tested in accordance with IEC 60376;

  (ii) bushings must be tested as required in AS/NZS 60137;

  (iii) current transformers must be tested as required in IEC 60044.1 for routine tests;

  (iv) voltage transformers must be tested as required in IEC 60044.2 for routine tests; and

  (v) mandatory tests required by IEC 62271.100 and IEC 62271.203

9.1 Additional tests:

9.1.1 Dielectric dissipation factor

The dielectric dissipation factor must be measured over a range of voltages up to 1.5 UM for bushings and 1.1 UM for other components where UM is the system highest voltage. The maximum dielectric dissipation factor on individual components such as bushings, insulators, operating rods and current transformers, etc. when measured at 0.6 UM phase to earth and UM between phases where applicable, at a temperature of 20◦C must be 0.020 for synthetic materials and 0.01 for paper insulation.

9.1.2 Partial discharge tests

The partial discharge tests must be carried out at Factory Acceptance Tests and on Site Acceptance Tests, after all other dielectric tests are completed in accordance with IEC 60270 and IEC 62271.203.

The maximum permissible partial discharge level shall not exceed 5 pC at the test voltage specified in Table 106 of IEC 62271.203. However, some equipment, such as voltage transformers isolated with liquid, immersed or solid, have an acceptable level of partial discharge in accordance with their relevant standard greater than 5 pC. Accordingly, any sub-assembly containing components with a permitted partial discharge intensity greater than 5 pC shall be considered acceptable if the discharge level does not exceed 10 pC.

9.1.3 Special tests

All tests to be completed as required in IEC 62271.100 and AS 62271.203 for the applicable test type. In addition to the Type and Routine tests, the following Special tests must be completed at the factory:

(a) the Time Travel Curves for each circuit breaker. These curves must show the contact movement from the time of energising the closing or opening device, to the cessation of contact movement. The test method must have sufficient discrimination to enable contact bounce to be detected;

(b) the contact resistance of each switching device must be measured at a minimum of 100 A dc;

(c) the minimum trip voltage of each circuit breaker (both trip coils);

(d) calibration of SF_6 pressure switches; and

(e) test showing that the anti-remanence gaps in the feeder protection current transformers limits the remanence to <10 per cent of the knee point flux density.

9.1.1 Progressive site tests and commissioning tests

9.1.1.1 Pre-commissioning tests

The manufacturer is responsible for pre-commissioning electrical and mechanical testing and operational checks of the switchgear from the local control cubicle on or adjacent to the switchgear.

Following installation of the switchboard at the substation the tests listed below must be carried out to prove that the switchgear conforms to the requirements of this standard. These tests must be completed on the complete busbar and on each item of switching equipment. The tests must include the following:

(a) gas leak tests on all flange joints made on site;

(b) insulation resistance tests using a 5 kV portable insulation tester. Tests shall be performed for a duration of 10 minutes, or until the maximum result is reached on the test equipment. Test results shall be recorded at time durations 0.25, 0.5, 1, 2, 5 and 10 minutes;

(c) measurement of the insulation resistance across the open circuit breaker contacts between each phase using a 5 kV portable insulation tester. Test shall be performed for a duration of 10 minutes, or until the maximum result is reached on the test equipment. Test results shall be recorded at time durations 0.25, 0.5, 1, 2, 5 and 10 minutes;

(d) one minute power frequency voltage withstand test on the complete busbar and each circuit breaker and disconnector;

(e) a partial discharge and dielectric dissipation factor tests must be completed;

(f) insulation resistance of the auxiliary supply and control wiring of the assembled switchboard groups. The insulation resistance must be measured between each conductor to the other conductors and the frame, using a 1000 V portable insulation tester. For testing purposes, the MCB must be closed. The insulation resistance must not be less than 100MΩ;

(g) Continuity Resistance of the main (high voltage) power circuit. The continuity resistance must be measured with the circuit breaker and disconnector closed between each pair of phases in turn using a direct current (dc) of at least 10 A. The test result must not exceed the contact resistance value used in the Temperature Rise Test;

(h) functional tests must be carried out to confirm the operation of the circuit breaker, disconnector and earthing switch operating mechanism, including the various opening and closing command initiators, the various indicators, and the interlock devices;

(i) tests on all current transformers, including ratio and resistance tests, and tests to determine the kneepoint of the saturation curve. All tests will be performed from the terminals in the instrument compartments; and

(j) tests on the voltage transformer, including ratio and resistance tests. All tests will be completed from the terminals in the instrument compartment.

TasNetworks' site Project Manager must be advised 7 days prior to commencement of the site and commissioning testing. All commissioning tests must be in accordance with R246497, Testing Commissioning and Training Standard. TasNetworks may witness all commissioning testing by the manufacturer. Test results must be submitted to TasNetworks for approval prior to commissioning.

Where the supplied equipment fails to meet the specification requirements, the manufacturer must at its cost rectify or replace the defective components and cover costs to retest the switchgear.

Where a significant number of secondary terminations are found loose or poorly crimped, the manufacturer must, at its cost, check all secondary terminations and rectify defective terminations.

9.1.1 Maintenance tests

TasNetworks will carry out various Maintenance Tests during the life of the switchgear. These tests may be part of a routine preventive and condition based maintenance program and hence be carried out repeatedly at nominal intervals, substituted by condition based maintenance or, they may be part of a refurbishment or re-commissioning project after an overhaul or repair. TasNetworks' Maintenance Tests may in general consist of:

(a) repeated operational tests and functional checks on the various protection, operation and control and indication systems as part of a routine maintenance program;

(b) occasional one-minute power frequency voltage withstand test on the complete switchgear following a major refurbishment or overhaul; and

(c) occasional dielectric dissipation factor and partial discharge tests in accordance with the relevant Standards.

The equipment offered must be suitable for the repeated application of the various Maintenance Tests.

9.1.1 Tests on cables connected to the switchgear

After connection of the high voltage cables to the switchgear, the cables will be subjected to voltage withstand tests between core and the sheath. Where it is necessary to apply such tests through portions of the switchgear etc, the insulation of such portions of the switchgear must be capable of withstanding the test voltage between each phase in turn with the remaining phases and cable sheath earthed.

The manufacturer must advise any limitations or special requirements, such as the need to increase gas pressure or the removal of links for testing purposes. Any such links must be provided with the switchgear and located for easy personnel access for their removal.

Full details of special fittings or leads required for high voltage cable testing must be submitted to TasNetworks for approval.

10 Packaging

Adequate packaging must be provided to minimise the risk of damage to equipment during delivery. The packaging must be suited to the particular methods of delivery and provide protection against damage from all foreseen hazards.

Each package must be suitably marked so the contents can be ascertained without it being necessary to open the package. Marking must include TasNetworks' Contract No. and the mass of the crate.

Details of packaging methods must be submitted to TasNetworks for approval.

11 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document R590629.

12 Deliverables

Requirements for the switchgear deliverables are outlined in EHV GIS Switchgear document R590628.

13 Hold points

The requirement of documentation is listed in the deliverable schedule in document R590628.

The hold points for EHV GIS Swicthgear include:

(d) "Analysis and preparatory documentation" must be submitted prior to "detailed design" for TasNetworks' review, comments and approval.

(e) "Detailed design documentation" must be submitted prior to manufacturing or procurement of equipment, for TasNetworks' review, comments and approval.

(f) "Inspection and Test Plan" must be submitted prior to any testing of equipment, for TasNetworks' review, comments and approval.

(g) "Invitation to witness testing" must be submitted prior to any testing of equipment, for TasNetworks' arrangements to witness.

(h) Complete updated design documentation, operations and maintenance manuals must be submitted prior to "Factory Acceptance Testing (FAT)" for TasNetworks' preparation to attend FAT, if required.

(i) Final training manuals must be provided at least two weeks prior to training, for use of training team.

(j) FAT results must be submitted to TasNetworks for approval with any non-conformances identified rectified prior to shipment.

(k) All as-built documentation, operation and maintenance manuals, test results and test certificates must be submitted to TasNetworks and be accepted by TasNetworks prior to acceptance.

(l) Inspection of the equipment on site is required by TasNetworks prior to acceptance.