Standard

Extra High Voltage System Standard

R586386

Version 1.0 June 2018

Authorisations

Action	Name and title	Date
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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Entire doc	Copied over verbatim from superseded Transend to TasNetworks template.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.
Authorisation	Changed from 5 years to 30 months
1.5	Reference doc updated
3.4 table 1 SR No.9	"Normal frequency variation" changed to "Operational frequency tolerance band"
3.4 table 1 SR No.10	"Frequency variation at times of system disturbance" changed to "extreme frequency excursion tolerance limit"
3.4 table 1 SR No.10	"44.5 to 52.0" changed to "47.0 to 55.0"
3.4 table 1 SR No.11	Changed from 10% to 15% and footnote added

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1 General

1.1 Purpose

To define the requirements for extra high voltage (EHV) systems under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks'). The EHV system includes all primary and secondary systems required to enable connection of a substation to, and transfer of power through, the power transmission network.

1.2 Scope

This standard applies to all EHV systems under the responsibility of TasNetworks.

This standard contains requirements for design, engineering, manufacture, construction, testing at manufacturer's works, secured packaging, supply, transportation, delivery to site, testing and commissioning with complete documentation of EHV systems and is to be applied to new installations as well as redevelopment of part or all of existing installations.

1.3 Objective

TasNetworks requires design, construction, installation and commissioning of equipment and services as covered in this standard to ensure:

(a) relevant Australian legal requirements are met;

(b) requirements of the National Electricity Rules (NER) are met;

(c) personnel and public safety;

(d) safety of TasNetworks' assets;

(e) ease in operation and maintenance;

(f) reliability and continuity of power supply to power transmission network;

(g) minimum disruption to the EHV supply system following a fault;

(h) requirements of TasNetworks' corporate plan are met; and

(i) exposure of TasNetworks' business to risk is minimised.

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 standard.

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 a system, this standard is to be read in conjunction with other standards and documents as applicable. In particular this includes the following, without limitation:

1.1.1 Australian Standards

Voltage transformers for measurement and protection	AS 1243
Conductors - bare overhead, aluminium and aluminium alloy	AS 1531
Substation and high voltage installations exceeding 1 kV a.c.	AS 2067
Common specifications for high-voltage switchgear and controlgear	AS/NZS 62271.1
Wiring rules	AS/NZS 3000
Conductors – bare overhead, aluminium and aluminium alloy – steel reinforced	AS 3607
Insulators ceramic and glass for voltages >1 kV	AS 4398
Instrument transformers – current transformers	AS 60044.1
Instrument transformers – inductive voltage transformers	AS 60044.2
Instrument transformers – Capacitor voltage transformers	AS 60044.5
High voltage switchgear and controlgear – Alternating current disconnectors and earthing switches	AS 62271.102
High voltage switchgear and control gear – Dimensional standardisation of terminals	AS 62271.301

1.1.2 TasNetworks Standards

R522696	Surge Arrester Standard
R586376	EHV Dead Tank and Live Tank Circuit Breakers
R574184	EHV Post Insulators Standard
R527893	Network Transformer Standard
R565986	EHV Cable Systems Standard
R586396	EHV Disconnector and Earth Switch Standard
R565990	EHV Indoor Gas Insulated Switchgear Standard
R565984	AC Distribution System Standard
R522693	DC Distribution System Standard
R586390	Extra High Voltage System Schedule
586389	Extra High Voltage System Deliverables
R590634	Substation Civil Design and Construction Standard
R527890	Supply Transformer Standard
R246439	SCADA Systems Standard

R522687	General Substation Requirements Standard
R579297	Security Fences and Gates Standard
R246497	Testing, Commissioning and Training Standard
R517371	Insulating Oil for Transformer and Switchgear Standard
R590630	HV and LV Cable Systems Standard
R522692	Lightning Protection and Earthing Standard
R586391	EHV Voltage Transformers Standard
R522690	EHV Current Transformer Standard
D04/25966	High Voltage Disc Insulator Standard
D09/84042	Device Setting and Configuration Management Procedure
D11/86620	Metering Specification Standard
R517368	Installation and Repair of Substation Earth Mats Standard
R192942	Environmental Noise
R502077	Transport and Use of Chemicals
R522697	Temporary Earthing of Substation Equipment Standard
D04/20712	Live Line Work Standard
R517372	Substation Signage Standard
R246242	Protection and Control of Network transformer Standard
R246427	Protection of Transmission Lines Standard
D06/6743	Commissioning and Recommissioning of Secondary Protection and Control System Standard
R246414	Protection of EHV Busbar Standard
R793081	Excavation Work Standard
D11/60563	Metering Standard
D06/46987	Protection of EHV Shunt Capacitor Banks Standard
R245707	Protection and Control of Supply Transformers Standard

1.2 Abbreviations

Abbreviations utilised in the standard includes the following, without limitation:

AC (a.c.)	Alternating current
AAC	All aluminium conductor
AIS	Air insulated switchgear
AMIS	Asset management information system
AS	Australian standards
CT	Current transformer
DC (d.c.)	Direct current
DDF	Dielectric dissipation factor

DTCB	Dead Tank Circuit breaker
ECC	Energy control centre
EHV	Extra high voltage
FAT	Factory acceptance testing
GIS	Gas insulated switchgear
HIS	Highly integrated switchgear
IBPCU	Integrated bay protection and control unit
LV	Low voltage
MCB	Miniature circuit breaker
NER	National electricity rules
NOCS	Network operations control system
PD	Partial discharge
SCADA	Supervisory control and data acquisition
SF_6	Sulphur hexafluoride
SOE	Sequence of events
TEC	Tasmanian Electricity Code
VT	Voltage transformer

2 Introduction

The EHV system includes all primary, auxiliary and secondary systems, required to enable connection of a substation to, and transfer of power through, the power transmission network. The EHV system includes, without limitation, the following elements:

(a) **The primary system** elements include, without limitation:

- (i) busbars; line terminals, cables; fittings and joints;
- (ii) bushing, post insulators and support structures;
- (iii) primary protection equipment;
- (iv) switchgear; and
- (v) instrument transformers.

(b) **The auxiliary system** elements include, without limitation:

- (i) AC distribution system;
- (ii) DC distribution system; and
- (iii) associated wiring and terminal requirements.

(c) **The secondary system** elements include, without limitation:

- (i) all elements of protection, control, automation, and monitoring; and
- (ii) integrated bay protection and control units, transmission line protection, metering and other associated ancillaries for the primary purpose of protecting of the EHV primary assets.

3 General

For all EHV systems the general requirements, as stipulated in the following section, must be adhered to, without limitation.

Project specific requirements for the EHV system will be detailed and documented in the relevant project specifications.

3.1 Service conditions

Service conditions must comply with the following requirements:

(a) environmental conditions and any specific design criteria for particular works will be stated in the project specifications; and

(b) all equipment must be capable of operation at its specified rating without assisted means, for example, forced cooling will not be permitted to achieve the rated capacity.

3.1 Civil works

All civil engineering, building works and associated services, including the design, supply of materials, construction, installation and testing associated with the EHV system must be in accordance with document Substation Civil Design and Construction Standard, R590634.

3.2 Primary lightning protection and earthing systems

The primary lightning protection and earthing of all equipment and works associated with the EHV system must be in accordance with document Substation Lightning Protection and Earthing Standard, R522692 and document Surge Arrestor Standard, R522696.

All temporary earthing associated with the EHV system must be in accordance with document Temporary Earthing of Substation Equipment Standard, R522697.

3.3 Performance

The EHV system must, as a minimum, meet or exceed the following performance criteria:

(a) the selection of the equipment must be based on the most severe of:

  (i) the requirements of this standard; or

  (ii) the requirements as stated in the project specifications,

(b) the selection of the equipment constituting the EHV system must be appropriate to satisfy the design and specified performance criteria of this standard;

(c) the design life of the components that constitute an EHV system must be able to attain a minimum of 45 years operational life. Evidence must be supplied by the Supplier supporting its claim that the equipment offered meets this minimum requirement; and

(d) where performance criteria are not stated in TasNetworks' equipment specific standards or project specifications the performance requirements of this standard must be used as the minimum performance standard for EHV equipment as shown in Table 1.

Table 1 EHV System Service conditions for EHV system

Sr. No.	Parameter	Unit	Value

1.	Nominal system voltage (V_n)	kV	110	220
2.	Rated voltage	kV	123	245
3.	Power frequency withstand voltage	kV_{rms}	230	460
4.	Lightning impulse withstand voltage	kV_{peak}	550	1050
5.	Minimum overall height of post insulators	mm	1220	2300
6.	Minimum creepage distance[1]	mm	3075	6125
7.	Normal voltage variation (criteria for equipment design)	$\%V_n$	$^{238}_{93}$10	
8.	Rated frequency	Hz	50	
9.	Operational frequency tolerance band	Hz	$^{238}_{93}$ 2	
10.	extreme frequency excursion tolerance limit	Hz	47.0 to 55.0	
11.	Normal combined voltage and frequency variation (criteria for equipment design)	%	$^{238}_{93}$15[2]	
12.	Minimum symmetric three-phase fault current withstand	kA	25	
13.	Minimum short-circuit withstand time	sec	3	
14.	Neutral earthing		Effectively earthed	
15.	Minimum degree of protection: active equipment	IP	66	
16.	Minimum degree of protection: enclosure	IP	54	
17.	Installation		Outdoor	
18.	Design maximum continuous ambient temperature	°C	45	
19.	Design minimum continuous ambient temperature	°C	-10	
20.	Altitude	m	≤ 1000	
21.	Maximum relative humidity	%	95	
22.	Pollution level		High	

3.1 Rating and duty

The equipment 'Rated Normal Current' offered must be suitable for the actual maximum circuit currents operating continuously for 365 days a year with nil switching operation.

The temperature rise limits for equipment must not be exceeded the limits specified in the applicable Australian Standards.

3.2 Additional requirements

The following additional requirements must be satisfied:

[1] Excludes HV disc insulators. Refer to Section 4.5.3 of this document.

[2] 15% combined V and Hz variation indicates that the output accuracy of a magnetic device, ie CT or VT must remain within tolerance throughout this range. ie. if V at +10% and Hz at +5%.

(a) all equipment must be designed to avoid pockets in which water can collect;

(b) lifting lugs must be provided with each item of equipment and associated components with a mass in excess of 50 kg and which is likely to be handled individually; and

(c) dimensional drawings must be prepared for each item of equipment and its associated accessories showing the mounting structures and all necessary details required to install the equipment in the existing switchyard.

4 Primary system

Unless otherwise stated, the requirements for EHV primary system, as stated in this standard, without limitation, are applicable to:

(a) primary line terminals for the connection to external conductors;

(b) fittings, joints and connections necessary to enable connection between EHV equipment;

(c) bushings and post insulators;

(d) busbars and cables;

(e) support structures;

(f) primary protection systems as applied for the protection of the EHV system including lightning protection, surge protection and earthing;

(g) switchgear including circuit breakers, disconnectors and earthing switches;

(h) instrument transformers, including current transformers, voltage transformers and combined voltage current transformers; and

(i) compensation equipment.

4.1 General

The primary system shall comprise equipment that:

(a) have reliable components and low SF_6 leakage rates;

(b) is complete with independent enclosures, operating mechanisms, local operation, control and marshalling cubicle, electrical and mechanical interlocks and other associated accessories to form a fully functional unit that is fit for the intended application; and

(c) is fully rated to carry the required continuous and fault currents for the specified time in accordance with the applicable standard.

4.1 Primary line terminals

For connection to external conductors, Aluminium, Palm No. 9 primary terminals with horizontal orientation to AS 2395 must be provided.

4.2 Fittings, joints and connections

All fittings, joints and connections must comply with the following requirements:

(a) all fittings shall be located in positions to minimise risk of mechanical damage;

(b) only proprietary brands of bus compression fittings shall be used. All bus fittings must be free from sharp edges and corners to minimise possible corona effects;

(c) all types of clamps must be proven to be suitable for carrying their rated normal and short-time currents by means of type tests in accordance with the relevant standards. The Contractor must provide evidence of such tests to TasNetworks for approval;

(d) connections and joints must be such that hot spots do not form. This must be achieved without the need for regular maintenance, such as periodic tightening due to thermal cyclic effects, short circuit forces or cleaning of chemical by-products;

(e) clamps and conductors must be of the same material, however where this is not the case, the materials used must be suitable for their purpose without giving rise to galvanic corrosion;

(f) adequate means must be adopted to inhibit galvanic corrosion between contact surfaces. A suitable oxide-inhibiting, corrosion-resistant type electrical jointing compound such as Penetrox A, or equivalent, must be used for all current carrying joints and connections;

(g) the contact surfaces of non-plated aluminium and copper must be free from oxide prior to tinning and making connections. Air and moisture must be excluded from the joint through the use of approved grease joint compound;

(h) joints between aluminium-to-aluminium, copper-to-aluminium and copper-to-copper must comply with AS 2067 and AS 62271.301. All copper-to-copper connections must be made with bronze connectors;

(i) each and all welded or bolted type connectors must have a minimum pull-out strength well in excess of the applied load;

(j) for bolted connections between aluminium terminals, galvanised bolts must be used. For connection between copper terminals, 316 grade stainless steel bolts and compatible grade stainless steel nuts, washers and spring washers must be used. Anti-seize compounds must be used on stainless steel bolts.

(k) fastener tension must be maintained by either new helical or Belleville spring washers without the need for periodic re-tightening or maintenance;

(l) where required, fittings must be provided with O-ring seals to prevent water ingress;

(m) connections to equipment must be made using flexible stranded conductors which must be connected to the equipment terminals and the bus using bolted connectors. Compression sleeves shall be used for attaching these connectors to the flexible conductors. Terminals and connections shall be in accordance with AS 62271.301 and AS 2067;

(n) heat must not be applied to stranded conductors to avoid fatigue failure;

(o) fittings used must maximise the contact surface area and provide a firm contact;

(p) bare stranded conductor shall not be connected onto equipment terminal palm without an appropriate fitting to increase the contact surfaces. Where compression type fittings are used for angled connection, provision must be made to prevent water ingress into the sleeves; and

(q) all primary circuit connections must be tested with a micro-Ohmmeter. The results must be recorded and submitted to TasNetworks before energisation.

4.1 Primary bushings and post insulators

All post insulators and bushings must be designed such that:

(a) rod gaps are not required;

(b) sufficient mechanical strength and rigidity for the conditions under which they will be applied is accounted for;

(c) bushings for any particular voltage level must all be identically rated and interchangeable;

(d) post insulators for any particular voltage level must all be identically rated and interchangeable; and

(e) all iron components must be hot-dip galvanized and all joints must be airtight.

4.1.1 Bushings

All bushings must be designed such that:

(a) they be able to satisfactorily withstand the insulation level specified for the rated voltage level;

(b) when operating at normal rated voltage, there must be no electrical discharge between the conductors and bushings that can cause corrosion or damage to conductors, insulators or supports;

(c) the bushing puncture strength of bushings must be greater than dry flashover value;

(d) all gas pressurised bushings must be of composite construction;

(e) uniform compressive pressure on the joints is ensured; and

(f) for condenser type bushings a test tap is provided for Dielectric Dissipation Factor (DDF) and Partial Discharge (PD) tests. The test tap must be brought out as a hermetically sealed test terminal housed in the operating mechanism cubicle and connected to earth through an earth-disconnecting link and so located that testing and maintenance can be conducted without compromising safety.

4.1.1 Transformer bushings

All transformer bushings must be in accordance with documents Network Transformer Standard, R527893, and Supply Transformer Standard, R527890.

4.1.2 Post insulators

All post insulators associated with the EHV system, except for those stipulate in Section 4.4.4, must be in accordance with document EHV Post Insulators Standard, R574184.

4.1.3 Disconnector and Earth Switch post insulators

All post insulator for disconnectors and earth switches must comply with document EHV Disconnector and Earth Switch Standard, R586396.

4.2 Busbars

4.2.1 Design

Busbars must be rated for the highest system load and shall in no circumstances be rated at less than the capacity of the supply system, including allowance for possible increased future capacity. Busbar must be rated for the higher of the:

(a) maximum possible power flow on any circuit connected to the busbar;

(b) nominal rating of the transmission line circuit breaker;

(c) nominal rating of bus coupler circuit breaker;

(d) nominal rating of transformer circuit breaker;

(e) emergency rating of transformer; and

(f) nominal rating of instrument transformer on transmission line circuit breakers.

TasNetworks will furnish the necessary load flow and fault level forecast information with the project specifications to enable the EHV system including the busbar and associated equipment to be appropriately rated.

For outdoor substations, hard drawn tubular busbar or stranded aluminium alloy busbar shall be used. For stranded aluminium alloy busbars "Uranus" type 1350 All Aluminium Conductor (ACC) must be used. All busbars and electrical connections must be in accordance with AS 2067, AS 1531 and AS 3607 in respect of current rating and material analysis.

The busbar must be supplied complete with all supporting insulators and galvanised supporting structure. All necessary terminals and connectors shall be provided for connection to switchyard equipment consistent with the requirements as stipulated in section 4.3.

All busbar and equipment connections must be designed such that:

(g) they are arranged and supported so as to ensure minimum clearances between live metal and earth or earthed metal work, as specified in AS 2067, are maintained in all circumstances;

(h) they are able to be extendable at each end and are able to facilitate connection to the elements of the EHV system by overhead conductors;

(i) the maximum sag to span ratio for stranded aluminium busbar carrying rated continuous current is not more than 1 per cent;

(j) bending of tubular conductors must not result in reduction in tube diameter in excess of 10 per cent;

(k) adequate flexibility is maintained to allow for thermal expansion and contraction. Where required, expansion joints are provided. The interval of the expansion joints must be designed and determined in order to cater for I^2R heating and changes in ambient temperature. An expansion joint made from a welded stack of thin laminations is an acceptable type. In general, the lamination lengths must be not less than four times the amount of expansion to be accommodated;

(l) overhead conductors carried by the substation structures are erected with sags and tensions that when the whole projected area of the conductors, at ambient temperatures are subjected to the transverse wind pressure, the factor of safety must not be less than 2.5; and

(m) the conductors connecting any surge arresters are kept as short as practicable. Where possible surge arresters shall not be a support for busbar conductors.

4.1.1 Conductor stringing

Bus conductor stringing must comply with the following requirements:

(a) the braking device applied to pull out conductors under tension must be a type approved by TasNetworks;

(b) the grooves of the braking device must be profiled to conform to the particular conductor section and the overall design must be such as to avoid sculling of the conductor;

(c) come-along clamps used for tensioning or pulling out the conductors or earthwires must be fitted with liners of soft aluminium or other approved material. They must not pinch nor deform the outer strands of the conductor;

(d) the Contractor shall be responsible for the design of the sag and tension to string the conductor and earthwire;

(e) the designed conductor tension must be accurately applied to the span being strung. The method to be used shall be submitted to TasNetworks for approval. This may be achieved by:

   (i) accurately sighting the sag using an approved reliable quick setting instrument clamped to the structure at the correct optical height, in conjunction with sag boards, or

   (ii) by means of a theodolite set at ground level to set the correct sag; or

(iii) measuring the tension in the conductor,

(f) after suspension clamps are fitted, the suspension insulator strings must be within 20 mm in 1 metre of vertical, and the sags must be within ±1.5 per cent of the required initial sag, under normal tension conditions. For short bus sections where achieving the 1.5 per cent sag is difficult to achieve, an initial sag greater than the diameter of the conductor may be accepted, subject to TasNetworks' approval. Initial sag shall mean the sag, at any given loading condition, which corresponds to the design sag after corrections have been made for bedding down and creep. Design sag shall mean the sag, at any given loading condition, after a 50 year period in service; and

(g) in the application of compression fittings, the manufacturer's instructions must be followed and precautions taken to ensure that the fittings are kept clean for use.

4.1.1 Disc insulators

All disc insulators must comply with document HV Disc Insulator Standard, D04/25966.

4.2 Extra High Voltage and High Voltage cables

Cables must comply with document Extra High Voltage Cable Systems Standard, R565986 and HV Cable Systems Standard, R590630, as applicable.

4.3 Support structures

All equipment support structures must comply with document General Substation Requirements Standard, R522687.

5 Extra High Voltage switchgear

EHV switchgear includes, but is not limited to, circuit breakers, disconnectors, instrument transformers and earthing switches. EHV switchgear can be classified as follows:

(a) **Air Insulated Switchgear (AIS)**: comprising separate physical elements of air insulated disconnectors, air insulated earthing switches, SF6 gas insulated circuit breaker with integrated current transformers, oil insulated capacitor voltage transformers (CVT) and air insulated interconnections between these physical elements;

(b) **Highly Integrated Switchgear (HIS)**: comprising an SF6 gas insulated integration of disconnectors, earthing switches, circuit breaker and current transformers or elements thereof, generally for outdoor application (also known as Compact Switchgear, Mixed Technology Switchgear or Hybrid Switchgear); and

(c) **Gas Insulated Switchgear (GIS)**: comprising of SF6 gas insulated integration of disconnectors, earth switches, circuit breaker, current transformers, voltage transformers and interconnections of these elements, generally for indoor application.

The EHV busbars for both HIS and AIS switchgear shall be air insulated.

The type of switchgear required will be stated in the project specifications.

Where there is a requirement that GIS be installed in an outdoor environment, this will be defined in the project specifications.

5.1 Design requirements for operation of switchgear

In the event of failure of any component, particularly control components, the switchgear must be designed such that it is predisposed not to prevent tripping except where tripping could not be performed satisfactorily.

5.2 Circuit breakers

The following criteria will be applicable for circuit breakers associated with the EHV system:

(a) EHV circuit breakers for AIS and HIS installations must comply with document EHV Dead Tank and Live Tank Circuit Breakers Standard, R586376. The required type of the circuit breaker, either dead tank or live tank, will be nominated in the project specifications; and

(b) EHV circuit breakers for GIS installations must comply with document EHV Indoor Gas Insulated Switchgear Standard, R565990.

5.1 Disconnectors and earthing switches

EHV disconnectors and earth switches must comply with document EHV Disconnectors and Earth Switch Standard, R586396

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All transmission line disconnectors must be equipped with integral earthing switches. Earthing switches are not required on other disconnectors.

5.2 Auxiliary switches

Auxiliary switches fitted to EHV equipment must comply with the requirements as stated in document EHV Dead Tank and Live Tank Circuit Breakers Standard, R586376, EHV Indoor Gas Insulated Switchgear Standard, R565990 and EHV Disconnectors and Earth Switch Standard, R586396.

5.3 Interlocks

5.3.1 General requirements for interlocks

Interlocks must be provided for all EHV switchgear as follows:

(a) as required by AS/NZS 62271.1 and other applicable Australian Standards;

(b) suitable mechanical and electrical interlocks and safety devices must be provided to prevent any inadvertent operation of the switchgear, when any part of the switchgear is connected to EHV network that may be energised;

(c) interlocks must be provided to ensure correct operating sequences are followed to maintain the integrity and security of the electrical system; and

(d) all mechanical interlock devices must be direct acting.

5.1.1 Circuit breaker interlocks

In addition to the interlock requirements stated in document EHV Dead Tank and Live Tank Circuit Breakers Standard, R586376 and EHV Indoor Gas Insulated Switchgear Standard, R565990, interlocks fitted to EHV circuit breakers must comply with the following requirements:

(a) closing of the circuit breaker must be prevented:

(i) if any earthing switch that is directly connected to the electrical circuit to which the concerned circuit breaker is connected, is NOT open;

(ii) where a disconnector is present between a circuit breaker and an earthing switch and the disconnector mechanism cannot be interlocked with the earthing switch, then the circuit breaker must be interlocked with the corresponding earthing switch;

(iii) if the closing spring is not charged;

(iv) if any trip circuit associated with the circuit breaker is faulty;

(v) from being operated locally if the operation of the circuit breaker on the Integrated Bay Protection and Control Unit (IBPCU) is selected to remote;

(vi) from being operated remotely from Supervisory Control and Data Acquisition (SCADA) System or Human Machine Interface (HMI) if the operation of the circuit breaker on the IBPCU is selected to local; and

(vii) from being operated remotely from TasNetworks' Network Operations Control System (NOCS) if the station SCADA is selected to local operation mode,

(b) Castell key interlocks must be provided for interlocks on circuit breakers with remote earthing switches and disconnectors. Provision of Castell keys must conform to the following:

(i) all works associated with installation and commissioning of Castell key locks must be performed;

(ii) Castell key inscriptions must be subject to TasNetworks approval; and

(iii) Castell key exchange box with illustrations to describe the procedures for use must be installed on the keyboard mimic as per document General Substation Requirements Standard R522687.

5.1.1 Disconnector interlocks

In addition to the interlock requirements stated in document EHV Disconnector and Earth Switch standard R586396, disconnectors must be interlocked with associated circuit breakers to prevent the disconnector from making or breaking load.

5.1.2 Earthing switch interlocks

In addition to the requirements stated in document EHV Disconnector and Earth Switch standard, R586396, all earthing switches must be prevented from being closed on to a live circuit. To achieve this:

(a) line-side earthing switches must be prevented from being closed if the circuit breaker and the disconnector directly associated with the earthing switch circuit are NOT open; and

(b) bus earthing switches must be prevented from being closed if any circuit breaker or disconnector unit that can be connected to the busbar is closed.

5.1 Local control and operating panels

In addition to the requirements stated in documents and the respective equipment standards, local control and operating panels must comply with the following requirements:

(a) the location of all manual operating actuators (buttons, switches, terminals) must not exceed a height of 2 metres above finished ground level;

(b) all necessary auxiliary contacts, switches, relays and/or mechanisms must be provided to ensure the proper functioning of the control, indication, interlocking and any other services must be brought to and terminated at a local control panel; and

(c) facilities must be provided at the local control panel for selection of exclusive control at 'LOCAL' and 'REMOTE (STATION)' and for initiating opening and closing of the switchgear. With the selection switch in 'LOCAL', the switchgear must be operable by the controls at the switchgear only and with the selection switch in 'REMOTE (STATION)', no local operation must be possible. Whether the switchgear has been selected for 'LOCAL' or 'REMOTE (STATION)' the operation of protection relays must not be inhibited.

5.1.1 Electrical operation

For electrically operated switchgear, including circuit breakers and motorised disconnectors, operation must be possible from the:

(a) IBPCU;

(b) local station SCADA or substation HMI; and

(c) NOCS.

5.1.1 Mechanical operation

Mechanical (manual) operation of EHV switchgear must be provided and must be possible in the absence of the electrical closing and tripping devices and electrical supply.

5.1.2 Indication

Specific requirements for the various types of equipment are included in the respective TasNetworks equipment standards and document General Substation Requirements Standard, R522687.

All indication must satisfy the following general requirements:

(a) all labels, rating plates, locking, facilities and tools associated with the EHV system must be in accordance with document General Substation Requirements standard, R522687;

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

(c) all electrical indications must be integrated in the IBPCU on the bay protection and control panel; and

(d) electrical indication of any other devices may be required for ease of operation, maintenance and restoration of the system to normal in the event of a fault.

5.1 Cubicles and enclosures for electrical equipment

5.1.1 Construction

Construction of local control, marshalling and termination cubicles and enclosures must comply with document General Substation Requirements Standard, R522687.

Construction requirements for cubicles specific to circuit breakers are documented in document EHV Dead Tank and Live Tank Circuit Breaker Standard, R586376 and EHV Indoor Gas Insulated Switchgear Standard, R565990. In addition to these requirements the following shall apply:

(a) independent operating, control and/or marshalling cubicles must be provided, as applicable, for each:

  (i) live tank circuit breaker with associated current transformers;

(ii) in the case of dead tank circuit breakers for AIS and HIS, the marshalling cubicle for current transformers may be the same as that for the circuit breaker operating mechanism;

(iii) in the case of circuit breakers associated with GIS, the marshalling cubicle for current transformers may be the same as that for the circuit breaker operating mechanism;

(iv) disconnector with associated earthing switch; and

(v) voltage transformer,

(b) where separate air insulated disconnectors are provided, independent operating and control cubicles are required for each such disconnector; and

(c) cabling from the control cubicles to the protection and control panels in the main control room must be direct and must not be via any other termination or marshalling panels.

In addition to the requirements stated in document General Substation Requirements Standard, R522687, cubicles and enclosure for EHV systems must comply with the following requirements:

(d) the cubicles must be of lockable type, constructed with stainless steel sheet metal panels of sufficient thickness and bracing to provide torsional rigidity (for GIS switchgear requirement refer to equipment specific standard);

(e) doors and covers on the cubicle must provide ready access to all operating components for inspections and maintenance and provision must be made for padlocks;

(f) the cubicles must be weather, vermin and dust proof. They must have provisions to avoid formation of water pools. The cubicle must have a degree of protection by enclosure of IP54 (for GIS switchgear requirement refer to equipment specific standard);

(g) the cubicle door must open to an angle of 120◦ and must have stays to prevent free swing in case of winds;

(h) removable gland plate must be provided at the bottom of the cubicle and all cables entry must be through non-ferrous metal glands;

(i) gland plate must be minimum 2mm thick aluminium and must be suitable for drilling on site;

(j) gland plate for entry of cable connections must be separate from that required for cable connections to external equipment on site;

(k) the control cubicle enclosure and similar enclosed compartments must be adequately ventilated by natural means to minimise condensation;

(l) the cubicle must be positioned so as to ensure safe access while the switchgear is in operation;

(m) all cubicles must be provided with cubicle illumination lamps and one (01) off domestic general-purpose outlet with switches and protective covers. A light, which utilises a bayonet type light bulb, must be provided inside the control cubicle and must operate on a dedicated single-phase 230 V AC supply;

(n) the power supply circuits for the illumination lamp in the three operating mechanism's (one per pole of the circuit breaker) and local control cubicle must be possible to be isolated at one common point in the control cubicle; and

(o) the local control and marshalling cubicles must act as a single point interface for remote control and monitoring of the equipment.

5.1.1 Cubicle equipment layout

Equipment in the cubicle must be laid out to facilitate ease in workability without the need to take the equipment out-of-service. In particular:

(a) maintenance, inspection work and connection checks must be able to be carried out without the need to dismantle any apparatus or having to take the equipment out-of-service;

(b) all equipment must be so laid out as to have easy access from the front;

(c) 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;

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

(e) the cubicle must have sufficient free space for future use.

6 EHV instrument transformers

6.1 Current transformers

6.1.1 Design

Current transformers must comply with document Extra High Voltage Current Transformer Standard, R522690.

6.1.2 Application

Current transformers must comply with the following requirements:

(a) separate current transformers must be provided for each:

   (i) transmission line bay;

   (ii) transformer bay; and

   (iii) bus coupler on EHV busbars,

(b) the circuit breakers controlling the primary circuit are capable of making onto a fault and immediately tripping, without any damage (closing onto a fault). The current transformers must be designed with thermal characteristics to satisfy such switching operations;

(c) in case the current transformers have any dependence based on the operation and operation cycle of the circuit breakers associated with the primary circuit then all such factors must be clearly indicated in the Tender;

(d) each single-phase current transformer must be capable of independent function and also render the ability to connect in combination with other current transformers to form two-phase or three-phase combinations as may be demanded by the scheme. These current transformers must be able to function as three-phase combination with other kinds of current transformers in the same switchyard. Each single-phase unit of current transformer must be possible to be combined with other kinds of current transformers (like an oil type current transformer used with an SF6 gas insulated current transformer to form a three-phase combination and vice versa). In case the design of the offered equipment does not allow this, the Supplier must clearly indicate in the tender;

(e) multi-ratios must only be obtained from tappings on the secondary windings and each multi-ratio current transformer must have an output secondary winding tap that is common to all the output secondary connections;

(f) the specified current transformer performance must be obtained without recourse to compensating devices, except as allowed for the use of secondary voltage limiting devices;

(g) a fixed voltage limiting device(s) set to operate at no greater than 10 kV peak must be fitted across the secondary terminals of the protection core(s). The device must be fitted with a protective cover and be mounted in the same terminal box as used for current transformer output terminations. The measurement current transformer core must provide some protection to secondary equipment by saturating under primary system fault conditions;

(h) CT rated burden for each core and winding must be designed to allow for the higher of:

(i) connected secondary circuits plus one additional protection and metering circuit similar to that connected to the respective CT core plus 30 per cent of spare burden; and

(ii) connected secondary circuits plus 50 per cent spare burden at the end of practical completion,

(i) certificates to confirm the connected burden and spare future capacity must be produced for each core and windings at each tap;

(j) the design of the current transformer must be such as to allow the primary winding to carry the rated current whilst the secondary winding is left open circuited. Under such circumstances:

(i) the open circuit voltage must not exceed the withstand capability of any connected equipment including but not limited to terminal blocks, wires, cables, instruments, meters, transducers and relays;

(ii) protection fittings must be positioned at the secondary terminals of the current transformer and must be so positioned such that they can be readily accessed with the busbar in service;

(iii) the operation of these devices must not cause undue tripping of the electrical system and suitable mechanisms must be provided to check the operation of these devices; and

(iv) a report must be provided to TasNetworks highlighting the absence or presence of the secondary voltage limiting devices in instrument transformer secondaries.

6.1.1 Primary circuit

Primary circuits must comply with the following requirements:

(a) multiple primary cores of the CT are permitted for use in the EHV system. High quality assurance procedures must be followed taking into consideration that any failure of single CT would cause the loss of all secondary monitoring and protection devices connected to it. Where multi-core CTs are provided, the design must be such that a burden change on any one core does not affect the performance of the other cores;

(b) the protection and metering cores of the CTs specified in document Extra High Voltage Current Transformer Standard, R522690 must be connected to secondary equipment as shown in the metering protection one line diagram for a specific project, attached with the project specifications;

(c) arrangement and order of the cores must be based on principle of overlapping protection zones;

(d) primary circuit must have polarity marking P1 and P2;

(e) unless otherwise stated in the project specification, the normal direction of current flow for various circuits must be as below:

(i) for transmission line circuits to EHV busbar, current flow into the busbar;

(ii) for transformer bay circuits from EHV busbar, current flow out of the busbar; and

(iii) for bus coupler, current flow towards the bus coupler circuit breaker,

(f) the current transformer must be so arranged so that the ‘normal’ direction of current flow in the current transformer primary is from P1 to P2. In the case of Dead Tank Circuit Breaker (DTCB), where both current transformers are integral to the circuit breaker, this may not be possible. The general rule for DTCB's therefore will be to arrange the circuit breaker for normal direction of current flow from P1 to P2 through the current transformer containing the metering core; and

(g) cores must be numbered serially according to their location relative to primary polarity P1 and P2 with core closest to P1 identified as Core 1.

6.1.1 Secondary circuit

The secondary circuit must comply with the following requirements:

(a) CT taps must be provided to suit the ratio requirements as specified in document Extra High Voltage Current Transformer Standard, R522690;

(b) protection current transformers must be provided with a test tap in accordance with Appendix F of AS 1675. Each test tap must be connected to an individual terminal and physically separate from the output terminals of the secondary winding;

(c) secondary circuit must have polarity markings using xS1, xS2, xS3 and so on. Test taps must have polarity markings xT1, xT2. Here 'x' represents the core number;

(d) 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 CT provided;

(e) all secondary instruments must be connected to the same CT ratios unless otherwise required from protection and metering circuits. Where different ratios are applied for different cores, it needs to be approved by TasNetworks;

(f) CT secondary 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. Common point must normally be decided on the basis of specific application. General guidelines to star point formations are as below:

  (i) for protection schemes the secondary terminal towards the unit to be protected must be star point; and

  (ii) for metering circuits, the secondary terminal away from normal power flow must be the star point,

(g) CT earthing must be as close as possible to the CT. The earth point must be accessible with 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; and

(h) the CT secondary must be possible for reconnection to delta configuration with modifications to wiring at terminal blocks.

6.1.1 Current transformers local marshalling and termination cubicle

In addition to the requirement stated in document General Substation Requirements Standard R522687, current transformers local marshalling and termination cubicles must comply with the following design requirements:

(a) current transformers must be complete with their independent enclosure, marshalling cubicle and other associated accessories to make them a complete functional unit and 'fit for use' for intended application. In case of dead tank circuit breakers and HIS, the marshalling cubicle for the current transformers may be the same as that for the circuit breaker operating mechanism. However, all connections for the current transformer must be separately grouped and covered with a label to indicate their function;

(b) each phase current transformer must have its own independent termination and marshalling panel;

(c) all devices must be wired to the terminal blocks. This must include all connections used in the control schemes or available spares on the equipment;

(d) current transformer secondary wiring must be wired directly to terminal in the marshalling cubicle and must be clearly labelled for identification;

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

(f) current transformer wiring must be brought to separate test terminals. It must be possible to conduct tests on current transformer secondary circuits without disturbing (removing) the primary connections / connections from the primary equipment; and

(g) where a multiple core multiple ratio current transformer is supplied, wiring of each individual core must be separated in bunches and must be suitably labelled to indicate connections at each ratio. Testing facilities in this case must be provided for each core of the current transformer.

6.1.1 Measurement current transformers

In addition to information already specified for current transformers the rated burden, in ohms for each transformation ratio at principal, intermediate and supplementary taps, must be provided for the measurement current transformers.

6.1.2 Protection current transformers

In addition to information already specified for current transformers, the following information must be provided for the protection current transformer:

(a) for Class P and Class PL: the designation in the form as specified by clause 3.4.1 or 3.5.1 of AS 1675 for each rated transformation ratio;

(b) for Class PS and PL the characteristics as required by TasNetworks.

6.1 Voltage transformers

6.1.1 Design

Voltage transformers must comply with document EHV Voltage Transformers Standard, R586391.

6.1.2 Application

Voltage transformers must comply with the following requirements:

(a) separate voltage transformers must be provided for:

  (i) each EHV transmission line bay; and

  (ii) each EHV busbar section,

(b) all voltage transformers must be built up of a combination of three single-phase units;

(c) transmission line circuit voltage transformers must be located so that access for maintenance and repairs does not require a busbar outage;

(d) VT rated burden for each winding must be so designed to allow for the higher of:

  (i) the connected secondary circuits plus one additional protection and metering circuit similar to that connected to the respective voltage transformer winding after any automatic voltage selection scheme transfers all load on one voltage transformer winding plus 30 per cent of spare burden; and

(ii) the connected secondary circuit plus 50 per cent spare burden at the end of practical completion,

Note 1: The calculation of secondary circuit burden must include all possible circuits that are required to be connected to the voltage transformer winding, eg. after operation of voltage transformer selection scheme must be considered.

Note 2: While considering the additional protection and metering circuit, the circuit with maximum burden must be considered:

(e) certificates to confirm the connected burden and spare future capacity must be produced for each core and windings at each tap;

(f) coordination of fuses and MCBs must be by Contractor. Contractor must prepare a detailed report with characteristics of all fuses and MCBs and detail the strategy adopted to select the specific MCB or fuses. The report must also detail the maximum fault level of the secondary circuit, its criteria of calculation and its dependency on any system parameters. This report must be provided to TasNetworks for approval;

(g) any protection circuit fed from MCB must be blocked on tripping of MCB and alarm generated to local SCADA and remote to NOCS;

(i) tripping of the MCBs must not cause any tripping of the primary system;

(ii) auxiliary contacts must be provided for the MCBs to indicate their operation. Blocking signals must be provided for all voltage operated protection on operation of the MCBs unless the connected protection device is configured to detect the loss of VT signal. All such blocking signals must be provided to SCADA and NOCS for alarms;

(iii) a minimum of 50 per cent spare contacts must be provided for future use; and

(iv) a report must be provided to TasNetworks, detailing the selection criteria and the coordination of the MCBs with other protection devices.

6.1 Metering instrument transformers

Metering instrument transformers must comply with the documents Metering Standard, D11/60563.

7 Auxiliary supply system

An auxiliary supply system includes, without limitation, the AC and DC distribution systems and the secondary wiring and terminal requirements necessary to facilitate interconnection between the various elements of the EHV system.

7.1 AC distribution system

The AC distribution system must comply with document AC Distribution System Standard, R565984.

7.1.1 AC distribution system application

AC distribution systems must comply with the following requirements:

(a) single 230V AC supply from the station AC distribution system must terminate in the marshalling cubicles of each item of switchgear that requires an AC supply, and protection and control panels;

(b) each AC distribution circuit must terminate in a miniature circuit breaker and the AC supply bus must be formed with branches to each unit of the cubicle;

(c) each unit must have its own circuit MCB. All AC supplies for that unit must be fed from the MCB circuit; and

(d) each MCB circuit must be independently monitored and alarmed to the SCADA and TasNetworks' Network Operations Control System (NOCS).

7.1.1 Heater circuits

Heater circuits must comply with the following requirements:

(a) heaters with a thermostat must be provided for each compartment independently;

(b) the heaters must be supplied from a 230V AC supply from the AC distribution system;

(c) heater and thermostats must be chosen such that they are capable for continuous service for the entire life of the switchboard;

(d) all heaters and thermostat must be easily accessible and easily replaced; and

(e) settings of the heater and thermostat must be performed and a separate recommended setting sheet must be supplied for each installed heater and thermostat combination.

7.1 DC distribution system

The DC distribution system must comply with document DC Distribution System Standard, R522693.

7.1.1 DC distribution system application

DC distribution systems must comply with the following requirements:

(a) DC supply must be from an unearthed station DC distribution system. Normal rated voltage is 125V DC. Where the station DC distribution system has different rated voltage it will be stated in the scope of works;

(b) DC supplied circuits must be separated and electrically isolated from each other on the following basis:

   (i) close circuit;

   (ii) trip circuit 1;

   (iii) trip circuit 2;

   (iv) interlocking auxiliary circuits. No tripping circuit device may be supplied from this circuit. Where single auxiliary relay exist they must be fed from the trip circuit 1 supply; and

   (v) indications and alarm circuit,

(c) the DC supply circuits must terminate in a miniature circuit breaker (MCB) and DC supply bus must be formed with branches to each unit of the cubicle;

(d) each unit must have its own set of circuit MCBs. All DC supply requirements for that unit must be fed from these MCB circuits;

(e) each MCB circuit must be independently monitored and alarmed to the SCADA and NOCS;

(f) as a minimum five separate DC circuits must be provided for each circuit. The five circuits must be for the following specific functions:

   (i) trip circuit 1;

(ii) trip circuit 2;

(iii) close circuit;

(iv) other supply schemes eg. interlocking auxiliary relays; and

(v) indication and alarm circuits (where indications are built into the IBPCU the indications can be fed from the close circuit),

(g) trip circuit 1 and trip circuit 2 must use independent cables from the DC distribution system;

(h) all circuits must be arranged to facilitate external connections and to provide appropriate isolating points for circuit checking and fault finding. Isolations must be possible in the form of taggable isolating links. Each isolating link must have a specific designation and must be easily identified for the designated purpose. Space must be provided to store such links when removed; and

(i) all devices, connections and small wiring must be brought to a common terminal group in a local control panel. The terminals must be easily and safely accessible from ground or floor level.

7.1 Secondary wiring and terminals

Secondary wiring and terminals must comply with AS/NZS 3000 and the following requirements:

(a) all devices must be wired to terminal blocks. This must include all connections used in the control schemes or available spares on the equipment;

(b) secondary wiring must 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;

(c) the control circuits for the close operation, open operation, primary and secondary trip circuits and spring winding motor must be electrically isolated from each other. Circuits must be separated on a control, trip, indication, alarm, etc. basis as appropriate and must be arranged to facilitate external connections and facilitate appropriate isolating points for circuit checking and fault finding;

(d) all auxiliary contacts, switches, relays and/or mechanisms as required to ensure that the control, indication, interlocking and any other services necessitated by the requirements of this specification must be provided;

(e) internal wiring in cubicles must be carried out in not less than 0.6/1.0 kV grade, oil resistant and weatherproof PVC insulated cables;

(f) all external wiring must be either enclosed in galvanised steel conduit or must be armoured PVC sheathed cable or vulcanised acrylic nitrile rubber base insulated and sheathed cable. Conduits and cables must be adequately supported and must be protected from damage by anyone working on the equipment. Cabling between separate units, eg. between phases, must be screened, with the screen earthed at both ends of each cable;

(g) current transformer and voltage transformer wiring must be brought to separate test terminals. It must be possible to conduct tests on current transformer and voltage transformer secondary circuits without disturbing (removing) the primary connections / connections from the primary equipment;

(h) wiring to anti-condensation heaters (where applicable) must be suitably protected from heat damage or must be heat resistant;

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

(j) wires associated with tripping circuits must be provided with red ferrules marked 'TRIP'. Wires must not be jointed or teed between terminal points and must not be clamped directly under screws;

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

(l) terminals must be consecutively and permanently numbered to AS 2067 and must be grouped according to function as well as providing for neat and economical use of multi-core cables;

(m) AC and DC terminals must be grouped separately;

(n) a separator plate must be provided between the phase and neutral terminals (in case of AC) and positive and negative terminals (in case of DC) on the terminal block;

(o) terminals to which wiring at a voltage greater than 150 V is connected must be shrouded with a transparent cover and must carry a danger notice in red lettering;

(p) all individual CT and VT terminal circuits wherever applicable must be suitably bunched based on the unit connected and are covered using a clip on transparent cover;

(q) a minimum of 50 spare terminals must be provided in each operation and control cubicle and minimum of 25 spare terminals in each marshalling panel, for TasNetworks' use.

8 Secondary protection and control system

The secondary system includes, without limitation all elements of protection, control, automation, and monitoring particular to the EHV primary system, including integrated bay protection and control units, transmission line protection, metering and other associated ancillaries.

This standard does not discuss the requirements for the SCADA system and only discusses the unit level control system on the front of the switchboard. The SCADA system must comply with document SCADA System Standard, R246439.

The control philosophy is detailed in document SCADA System Standard, R246439 and all the requirements of this document must also be complied with.

8.1 Service conditions

The secondary protection and control system must comply with the following service conditions:

(a) the equipment provided must be designed, manufactured and installed to operate satisfactorily under an indoor unconditioned environment pertaining to the site;

(b) as a minimum all protection devices must be able to operate successfully within an ambient temperature of -5◦C to +55◦C and a relative humidity between 10 per cent to 90 per cent;

(c) the Contractor is particularly drawn to the possibility of air borne pollution that may spill into the building; and

(d) even if the Contractor designs and provides air-conditioning for the control/switchgear rooms, this equipment must be able to function properly as designed without limitation in the event of air-conditioning equipment failure.

8.1 Secondary protection and control system application

Secondary protection and control systems must comply with the following requirement:

(a) the new protection and control system as stipulated in this specification must be provided for EHV power supply system;

(b) all equipment must be able to satisfactorily perform its intended functionality and to be able to be used to its full capacity (all available options and functions provided by the unit) in the full range of environmental and system conditions as detailed in the other sections. Where multifunction units are provided detailed logics and all functions must be utilised by effective application of functions possible in the units. Any functionality that is not enabled or configured will need to be specifically approved in writing by TasNetworks. However, the basic functionality as detailed in these specifications must be achieved as a minimum;

(c) all new protection relays and schemes must make use of proven state-of-the-art microprocessor technology with communication features, so as to communicate on software with the SCADA system provided as a part of the project. If any specific scheme proposed does not communicate with the SCADA system, it must be clearly indicated in the Tenders. Sacrifice of protection features to provide integrated communication with the SCADA system is not acceptable;

(d) the relays must have in-built clock and sequence of events (SOE) capability. This requirement is for each bay level control device providing bay level SOE and needs not be applied to each protection relay. It must be possible to connect outputs from the devices without local sequence of event capability to the bay level control devices. The relays must time stamp fault and operational indications with a resolution of 1 ms. The maximum time deviation (internal clock) must not be more than 0.01 per cent (worst case 1 sec/10,000 sec) without time synchronization. All 'loss of time synchronization signals' must be alarmed to the SCADA and NOCS;

(e) the time stamping within the relays must be to the accuracy of better than 1 ms;

(f) the relays must be synchronised by global command from the substation control system on communication bus and must deliver time stamped events to the control system for sequence of events to the substation control system. The details of the synchronization scheme are discussed in a separate section of this specification. In general all relays with built in clock or ability to send time stamped messages must be synchronized by the more accurate of, an IRIG-B input and a digital binary input; and

(g) the protection and control equipment must have self-diagnostic features in the form of 'internal relay failure'. All processes within any protection and control units must be fully supervised and alarms for non-healthiness of the units must be connected to the SCADA and NOCS. On a malfunction of any internal function of the relay, the relay must block itself and no inadvertent tripping must be caused. Self diagnosis outputs must use fail safe contacts to indicate unit failure and problems.

8.1 Fault clearing times and requirements from system reliability

The following requirements must be adhered to:

(a) the 110 kV fault clearance times must be in accordance with the National electricity rules (NER);

(b) the 220 kV and 110 kV bus fault clearance times and the fault clearance times for all unit protection schemes must be better than 100 ms; and

(c) protection equipment must not be used as a substitute to sound design of the primary power system. However, where the power system exists the protection system must be most adequately placed to ensure high utilisation of the primary scheme and higher power system reliability.

8.1 Protection and control panels

Protection and control panels must comply with the following requirements:

(a) new protection and control panels must be provided for protection of extra high equipment. Protection and control panels must be Rittal type with 800 mm width or equivalent;

(b) panels and their accessories must be constructed with best workmanship and material for the specified service life;

(c) the panel construction material and the painting procedures must be described in the tender documentation. Colour of the panels must preferably be RAL7035;

(d) all protection and control apparatus with associated accessories for the protection of the substation EHV system must be located on the new protection and control panels;

(e) separate panels must be provided for protection of each circuit;

(f) panels must be located in one location in the control room, in the main control building. Where a separate room is proposed in the switchyard, the room must be completely enclosed with security system, fire detection system, lighting and a construction subject to approval by TasNetworks. The room must have provisions for a minimum four future protection and control panels. The panels must be located in straight line execution. The panels and their accessories must be constructed with best workmanship and material for the specified service life of 45 years;

(g) the relay and control panel must have transparent glazed perspex sheet cover doors on the front of each cubicle. These doors must be lockable type, to preclude any inadvertent operation or operation by unauthorised personnel. All elements mounted on the front face of the cubicles must be visible from the front through the perplex door;

(h) the Contractor must prepare all general arrangement drawings detailing the layout of apparatus, including arrangement of terminals, on the various panels. The layout of the equipment and the arrangement of terminals will be subject to approval by TasNetworks;

(i) each panel must have a provision for DC supply inputs and AC source inputs from two independent sources. Necessary switches (On/Off) to control the individual circuits must be provided. The two sources must be supervised independently and annunciation must be initiated to the Substation Control System;

(j) all panels must have cable entry from the bottom. All cables must enter through non-ferrous metal glands at the base of the panel;

(k) each of the dual protection systems must be supplied directly from either source separately. The same must apply for dual trip circuits;

(l) all isolation links must be labelled. All labels must be readable with the door closed;

(m) all necessary fuses and connection terminals with associated accessories in accordance with the final wiring scheme;

(n) all calculations and basis for fuse rating selection including fuse coordination study for review by TasNetworks; and

(o) all equipment, cables and wiring must be appropriately and distinctively identified.

8.1 Protection relays and local control

The following protection and local control specific requirements must be complied with:

(a) the maximum reset time of the protection must typically be less than 40 ms;

(b) the relay must operate accurately within the system impedance ratios of 0 to 50;

(c) the accuracy of measurements must conform to the following:

  (i) ± 5 per cent for system impedance ratios up to 30; and

  (ii) ± 10 per cent for system impedance ratios from 30 to 50,

(d) all protection relays must be monitored and operated from the relay front face;

(e) the relays must be capable of operating over the full range of the respective auxiliary power supplies in accordance with the relevant standards, and must not be less than the range of 70 per cent to 110 per cent of the rated voltage substation DC system. Typical auxiliary relays may be approved for voltage range of 80 to 110 per cent of DC supply. However, in no case must this criteria be applied to relays and devices used in trip circuits;

(f) the protective relays must have suitable setting ranges to meet the system requirements. Functional software and settings must be stored in non-volatile memory. Using battery backup to retain software and settings is not acceptable;

(g) provision must be made to maintain the internal clock operation on interruption of the substation auxiliary supplies, including the DC supply system;

(h) programmable controllers must not be offered as an alternative to protection relays;

(i) relay cases must be of robust and dust proof construction. Transparent front covers must be provided that allow visual inspection of the relay settings and indications. Relays must be suitable for flush mounted design;

(j) all protection relay contacts that are to be used for tripping, closing, indication or alarms must be of robust and reliable construction and have appropriate current ratings to match the required duty;

(k) the performance of the relays, including measurement, tripping or blocking, indication, and alarm signalling, must not be affected by the levels of harmonics in the current and voltage waveforms of the system. Nor must the performance of the relays be affected by the quality of the DC supplies ie from the batteries and chargers;

(l) relay burdens must be low and in accordance with modern protection standards. Details of AC voltage, AC current and DC auxiliary burdens under quiescent and operating conditions must be supplied and any short time limitations under operating or test conditions must be stated in the Tender;

(m) auxiliary relays must be provided as required such that sufficient contacts are provided for all purposes with the addition of at least one normally open contact and one normally closed contact as spare after successful completion of the project;

(n) protection-A trip commands must be connected to trip coil A only and Protection-B trip commands must be connected to trip coil B only. Local and remote open commands must be connected to trip coil A only. However, trip command from single protection schemes should be connected to both trip A and trip B coils;

(o) each protection relay must have a unique device number attached to the relay, which identifies it from any other relay at the site. This number will be stated on the setting sheets to facilitate a proper record of the relay settings. Details of equipment numbering system is provided in document General Substation Requirements Standard, R522687;

(p) protection relays and units provided must be directly connected to the station SCADA system using fibre optic cable; and

(q) programming of the unit or downloading of events from the unit must not interfere in the protection function of the units and also must not lead to loss of any events during this time. Any action of downloading or interrogating the protection and control devices for post fault analysis must not be intrusive and must not cause loss of a protection and control device.

8.1 Relay and control equipment electrical and insulation requirements

All relays and control equipment must be selected to conform to the requirements of Table 2 and Table 3.

Table 2 Electrical and insulation requirements

Sr. No.	Characteristics	Specification
1.	Supply interruptions and ripple	All static equipment or static sub assemblies within non-static equipment shall comply with

Sr. No.	Characteristics	Specification
		IEC 255-11 and be unaffected by the following disturbances to the DC auxiliary supply: To IEC 255-11 Interruptions of duration 10 ms To IEC 255-11 AC component of 5% rated value
2.	Insulation (routine test)	To IEC 255 2.0 kV rms, 1 minute OR 2.5 kV rms for 1second.
3	Insulation (type test)	
3.1	Rated insulation	500 V
3.2	Dielectric test voltage series	B
3.3	Dielectric test voltage for open contacts	2.0 kV rms
3.4	Insulation resistance test	1.0 kV rms
3.5	Creepage and clearance distances to tables	IV and V
3.6	Impulse voltage tests	5 kV peak
4.0	Electromagnetic compatibility (type test)	
4.1	1MHZ burst test to IEC 255-22-1	Class III (2.5 kV)
4.2	Electrostatic discharge to IEC 255-22-2 with covers on	Class III (4 kV)
4.3	Electrostatic discharge to IEC 255-22-2 with covers removed to make settings	Manufacturer to state with tender
4.4	Radiated electro-magnetic field to IEC 255-22-3 but with frequency range 20 MHz to 1,000 MHz	Class III (10 V/m)
4.5	Radiated electro-magnetic field to fast transient test to IEC 255-22-4	Class IV (4 kV)
4.6	Data ports for permanent connection	Tenderer to provide information with the tender. The insulation class (2.0 kV rms preferred) and electromagnetic compatibility class of port(s). If there is any galvanic connection from any pin of the port to earth/frame or the station DC supply. Any screen to earth/frame connection shall be declared also due to the need to avoid earth loops. Circumstances in which an external protection/ isolation device is required, and includes the recommended device.

Table 3 Minimum compliance standards for relays in protection circuits

Standard	Title
IEC 68-2-1	Basic environmental testing procedures tests - cold.
IEC 68-2-2	Basic environmental testing procedures tests – dry heat.
IEC 68-2-3	Basic environmental testing procedures tests – damp heat, steady state.
IEC 255-5	Electrical relays - Insulation tests for electrical relays.
IEC 255-11	Electrical relays - Interruptions to and alternating component (ripple) in DC auxiliary energising quantity of measuring relays.
IEC 255-21-1	Vibration, shock, bump and seismic tests on measuring relays and protection equipment. Section One - Vibration Tests (sinusoidal).
IEC 255-21-2	Vibration, shock, bump and seismic tests on measuring relays and protection equipment. Section Two – Shock and Bump Tests
IEC 255-21-3	Vibration, shock, bump and seismic tests on measuring relays and protection equipment. Section Three - Seismic Tests
IEC 255-22-1	Electrical disturbance tests for measuring relays and protection equipment - 1 MHz burst disturbance tests.
IEC 255-22-2	Electrical disturbance tests for measuring relays and protection equipment - Electrostatic discharge tests.
IEC 255-22-3	Electrical disturbance tests for measuring relays and protection equipment - Radiated electromagnetic field disturbance tests.
IEC 255-22-4	Electrical disturbance tests for measuring relays and protection equipment - Fast transient disturbance test.
IEC 529	Classification of degrees of protection provided by enclosures.

8.2 Annunciations and indications

Annunciations and indications must comply with the following requirements:

(a) the existing mimic diagram in the control room must be removed and any associated works performed;

(b) annunciator alarm box, indication lamps wherever provided must be capable of being switched off when the substation is unmanned. Hand switches clearly labelled for their purpose must be provided for this purpose;

(c) hardwired annunciation must be provided as a backup to the SCADA system where full redundancy is not provided for the SCADA system. This new hardwired annunciator must be digital design, long life type with its own sequence of events recording. The hardwired annunciator must be housed on a separate free standing panel that must be provided. The annunciator panel must be installed in the new control room. Where any existing annunciator is still in service, the output of the annunciator must be wired to the new annunciator as a common alarm. Existing audible alarm must be disabled and removed; and

(d) it must be possible to switch off the audible alarms when the substation is unmanned.

8.1 Protection and control of power transformer circuits

Protection and control of power transformer circuits must comply with document Protection of Network Transformers Standard, R246242 and Protection of Supply Transformers Standard, R245707.

8.1.1 Voltage regulation

Voltage regulation of power transformers must comply with document Protection of Network Transformers Standard, R246242 and Protection of Supply Transformers Standard, R245707.

8.2 Protection of transmission line circuits

Protection of transmission lines must comply with the document Protection of Transmission Lines Standard, R246427.

8.3 Protection of EHV busbars

Protection of EHV busbars must comply with the document Protection of EHV Busbar Standard, R246414.

8.4 Protection of EHV shunt capacitor banks

Protection of EHV shunt capacitor banks must comply with the document Protection of EHV Shunt Capacitor Banks Standard, D06/46987.

8.5 Protection settings

TasNetworks' 'StationWare' setting database must be used for all protection settings and TasNetworks' document Device Setting and Configuration Management Procedure, D09/84042 must be followed. In addition to these requirements the following conditions must be adhered to:

(a) the Contractor will be responsible for calculations of all settings for the protection relays and schemes. This will include review of all existing protection relays and schemes at TasNetworks' substation and remote end. A confirmation report must be presented to TasNetworks confirming and detailing all necessary alterations to existing protection schemes;

(b) the Contractor must undertake modifications to wiring and settings of all protection relays at TasNetworks' substations;

(c) the NER must be followed in calculating the settings;

(d) the protection settings must coordinate with the other protection relays and schemes in TasNetworks' substations;

(e) the Contractor must request from TasNetworks any system and relay information, including remote end relay settings required for the protection coordination study. The Contractor must allow 8 working weeks from the date of the request to receipt of the information;

(f) submission of settings must comply with the NER. The Contractor must submit to TasNetworks the information requested not less than 3 months prior to the proposed commencement of commissioning;

(g) Setting sheets must contain the following information:

  (i) relay device number/s;

  (ii) type of relay;

  (iii) description of what equipment is being protected;

  (iv) device number of the relay;

  (v) station name;

  (vi) functions performed by the relay and their respective settings;

(vii) protection function settings to be applied;

(viii) programming logic if applicable; and

(ix) auto-reclose logic for transmission line protection,

(h) settings for each relay must be on separate sets of sheets;

(i) calculation details showing how the setting was derived must be supplied with the setting sheets;

(j) in addition to the setting sheet, any other additional information as requested by TasNetworks or AEMO must be provided to clarify the effect of the changes on the system. This additional information typically may consist of:

(i) a document detailing the type of relay, what causes the relay to operate in primary terms and demonstration of grading being achieved with other equipment; and

(ii) a presentation to AEMO and other effected code participants on the equipment being upgraded and its effect on the system,

(k) an update of final protection settings within two weeks of placing into service at any site must be provided;

(l) where TasNetworks has approved a setting and configuration, it must not be modified without a revised submission and approval of TasNetworks. Revised submission and approval must follow the same process as normal submission; and

(m) if the relays are set using a software program an electronic copy of the setting file and a legal registered copy of the program must be provided for use by TasNetworks to prepare and apply the settings to the relay in future.

8.1 Commissioning and recommissioning of secondary protection and control systems

Commissioning and recommissioning of secondary protection and control systems must conform to the document Commissioning and Recommissioning of Secondary Protection and Control System Standard, D06/6743.

9 Testing, commissioning and training

Testing, commissioning and training of all equipment and works associated with the EHV system must be in accordance with document Testing, Commissioning and Training Standard, R246497.

9.1 Pre-commissioning and commissioning tests

The following pre-commissioning and commissioning tests must be adhered to:

(a) all components of the EHV system must be duly tested in accordance with relevant applicable Australian and International standards. Where tests are optional in the standard, it will be considered that these tests are required by TasNetworks, unless otherwise requested by the Contractor and agreed in writing by TasNetworks before award of the contract;

(b) commissioning tests shall be conducted on the installed system after erection on site and before it is put into service to prove that it has not been damaged during transportation or erection;

(c) the commissioning testing procedures shall be submitted to TasNetworks for approval;

(d) on load checks shall be carried out on all protection and metering circuits and shall include recording of phase angles; and

(e) commissioning test reports shall be submitted to TasNetworks for approval and records.

9.1 Specific electrical tests

In addition to the specific test requirements specified in document Testing, Commissioning and Training Standard, R246497 the following tests must be performed:

(a) phase rotation checks must be carried out for all items of electrical equipment, including the main incoming supplies. Phasing of cables and correct termination of all cables must be as shown on the contractor drawings and the Contractor will be responsible for the correct phasing/connection of cables;

(b) before making equipment alive, a visual inspection must be made. An insulation test must be performed to ensure that no obvious defects in insulation are present;

(c) insulation tests must be taken on all motors and other electrical equipment including switchgear, starters and other circuits to test insulation resistance and absence of earth leakage. TasNetworks must have approved all readings, before circuits are energised. If in the opinion of TasNetworks after these tests, a dryout operation is necessary on any machines or equipment, a dryout operation and subsequent test must be conducted to establish correct and safe operation, to TasNetworks' satisfaction;

(d) where the installation, or any part thereof, includes the installation of earth electrodes the resistance to earth must not exceed that stated in the specified Australian Standards;

(e) all cabling and wiring installed must be continuity and termination tightness tested to verify the correct identification and connection of the individual cores;

(f) full functional testing and operational tests of all electrical equipment must be carried out on all equipment to ensure the correct operation or sequencing of operations. This will include making all necessary adjustments to starters, switches and control devices, and must ensure that overloads, relays, time lags and similar features and devices operate correctly, and that the installation is fit for commercial service. As part of this testing, instruments such as pressure, temperature, flow, and level transmitters are to be powered-up and checked for correct indication.

(g) functional testing must include all interlock logics and detailed schematic testing;

(h) for protection and control apparatus, power switch off and switch on followed by a visual check of all setting and configuration parameters must be done prior to certifying for service;

(i) immediately prior to final closing of covers of the equipment eg. circuit breakers, motor starters, etc. a final check must be made to ensure that all bolts, nuts, screws, fuse holders, etc. are secure and that all internal metal and insulating parts are clean and free from debris; and

(j) voltages of equipment must be checked to ascertain that the equipment is compatible with the supply about to be connected.

9.1.1 Cabling and busbars

The following tests shall be performed on cabling and busbars without limitation:

(a) insulation resistance test using the appropriate test device for LV cables and busbars. Testing must be done upon receipt of cables at site, immediately prior to installation, and after connecting to equipment;

(b) phase check;

(c) DC over potential test (prior to connection to equipment); and

(d) conductor resistance (busbars).

9.1.1 Lighting

The following tests must be performed on the lighting system without limitation:

(a) functional test of all circuits; and

(b) luminosity; and

(c) evidence of functional tests being performed must be submitted to TasNetworks for approval including the recording of luminous power per area in lumen (1 lx = 1 lm/m2 = 1 cd·sr·m−2), where lux = lx.

9.1 Specific instrument tests

The following instrument tests must be performed without limitation:

(a) prior to installation all instruments must be examined to ensure the equipment is in working order;

(b) all instruments must be protected against the ingress of water and dirt during the testing and connection of cables;

(c) the calibration of all switches and transmitters must be checked at 0 per cent, 25 per cent, 50 per cent, 75 per cent and 100 per cent rising and falling input value and corrected if necessary. All readings and settings must be clearly recorded on the calibration sheets; and

(d) all position limit switches must be adjusted after installation to ensure proper functioning.

9.1 Testing to SCADA and NOCS

SCADA and NOCS testing must comply with document SCADA System Standard, R246439. All testing to SCADA and NOCS must be carried out.

9.2 Software and programming tools

The Contractor must provide the following information and tools particular to the works:

(a) all programming and software tools required for parameterisation and configuration of the equipment;

(b) detailed instructions for use at least four months prior to factory acceptance testing. This will enable TasNetworks to familiarise with the software documentation;

(c) all complete and necessary hardware in the form of computers, cables etc. as may be required; and

(d) all necessary data analysis and recording equipment.

9.1 Maintenance and routine test plans

Maintenance and routine test plans must comply with the following requirements:

(a) a routine test plan must be recommended;

(b) blank schedules and forms for maintenance and routine testing, for use by TasNetworks maintenance personnel, must be provided; and

(c) all procedures and task guides for the system supplied must be provided.

9.1 Asset Management Information System

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

The Contractor must provide information required to maintain the currency of AMIS for each asset in standard proformas. TasNetworks will provide the proformas to the Contractor. The proformas are required to be populated for both new and decommissioned assets.

The completed proformas must be submitted to TasNetworks as follows:

(a) design information and maintenance regime information for all assets before commencing installation on site;

(b) information on test results for all assets prior to commissioning; and

(c) information of decommissioned assets on decommissioning.

10 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document R586390.

11 Deliverables

Requirements for project deliverables are outlined in document R586389.