# Standard

High Voltage System Standard

R565983

Version 1.0, June 2018

Tasmanian Networks Pty Ltd (ABN 24 167 357 299)

# 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| Entire doc | Copied over verbatim from superseded Transend to TasNetworks template.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. |
| 8.5.2 (c) (iv) | 2nd dot point, footnote added. |

# Table of contents

# List of tables

# 1 General

## 1.1 Purpose

To define the requirements from high voltage (HV) systems under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks').

## 1.2 Scope

This standard applies to all HV 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 the HV system 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) that relevant Australian legal requirements are met;

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

(c) personnel and public safety;

(d) risk to TasNetworks' assets is minimised;

(e) ease of operation and maintenance;

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

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

(h) that the implementation of TasNetworks' performance objectives are supported;

(i) that the exposure of TasNetworks' business to loss is minimised; and

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

## 1.1 Certificate of conformance

Before any new and/or modified HV system is put into service in TasNetworks' system, a certificate of conformance to this standard must be submitted to TasNetworks. The certificate of conformance must be duly supported with documents, drawings, test results, test reports, test certificates, completed check lists and other documents as applicable. Where deviations from specific requirements of this standard have been approved by TasNetworks, all such approvals must be included with the certificate of conformance.

TasNetworks will supply a blank form for certificate of conformance, to be completed by the Contractor.

The HV system will be put in service only after TasNetworks has accepted the certificate of conformance.

## 1.2 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.

Except that, the selection of equipment, design and all works associated with substation lightning protection and earthing systems must conform to the requirements as specified in document R522687, General substation requirements 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' Manager, Network Performance and Strategies.

## 1.1 Abbreviations

| | |
|---|---|
| AC (ac) | Alternating Current |
| CB | Circuit Breaker |
| CT | Current Transformer |
| DC (dc) | Direct Current |
| EHV | Extra High Voltage |
| HMI | Human Machine Interface (workstation) |
| HV | High Voltage |
| IBPCU | Integrated Bay Protection and Control Unit |
| LV | Low Voltage |
| MCB | Miniature Circuit Breaker |
| NER | National Electricity Rules |
| NOCS | TasNetworks' Network Operations Control System |
| SCADA | Supervisory Control and Data Acquisition |
| UFLS | Under Frequency Load Shedding |
| VT | Voltage Transformer |

## 1.2 References

As a component of the complete specification for HV systems, this standard is to read in conjunction with other relevant standards as applicable. Unless otherwise specified in the project specification, 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:

## 1.2.1 TasNetworks standards

| | |
|---|---|
| D11/86620 | Metering Standard |
| R246508 | Under Frequency Load Shedding Scheme Standard |
| R522695 | High Voltage Shunt Capacitor Bank Standard |
| R522695 | Protection and Control of HV Shunt Capacitor Banks Standard |
| R245707 | Protection and Control of Supply Transformer Standard |
| R246419 | Protection of HV Busbars and Feeders Standard |
| R565984 | AC Distribution System Standard |
| R522693 | DC Distribution System Standard |
| R246439 | SCADA Systems Standard |
| R522687 | General Substation Requirements Standard |
| R246497 | Testing, Commissioning and Training Standard |
| R570630 | HV and LV Cable Systems Standard |
| R586383 | High Voltage System Schedule |
| R586382 | High Voltage System Deliverables |
| R522692 | Lightning Protection and Earthing Standard |
| D09/84042 | Device Setting and Configuration Management Procedure |

## 1.2.2 International standards

| | |
|---|---|
| Power installations exceeding 1 kV a.c. | AS 2067 |
| Standard voltages | AS 60038 |
| Instrument transformers – Current transformers | AS 60044.1 |
| Instrument transformers – Inductive voltage transformers | AS 60044.2 |
| High-voltage switchgear and control gear – Part 100 Alternating current circuit-breakers | AS 62271.100 |
| High-voltage switchgear and control gear – Part 102 Alternating current disconnectors and earth switches | AS 62271.102 |
| High-voltage switchgear and control gear – Part 200:A.C. | AS 62271.200 |
| metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 52kV | |
| High-voltage switchgear and control gear – Part 300:A.C. | IEC 62271.300 |
| Seismic qualification of alternating current circuit-breakers | |
| High-voltage switchgear and control gear – Part 301: Dimensional standardisation of high-voltage terminals | AS 62271.301 |
| High-voltage switchgear and control gear – Part 303: Use and handling of Sulphur Hexafluoride ($SF_6$) | IEC/TR 62271.303 |

# 2 Introduction

The HV system includes all primary and secondary systems, as required for electrical power transfer to the electricity distribution network including, without limitation:

(a) HV switchgear, including circuit breakers (CB), disconnectors and earth switches.

(b) HV supply system, including busbars, branches, cables and other associated connections.

(c) HV instrument transformers, including current transformers (CTs) and voltage transformers (VTs) and capacitive voltage indicators.

(d) HV shunt capacitor banks.

(e) primary protection systems applied to protection of HV system including lightning protection, surge protection and earthing.

(f) AC distribution system, within the switchboards.

(g) Secondary systems applied for protection, control, metering, and monitoring of HV primary system including integrated bay protection and control units (IBPCU), power transformer protection, HV busbar protection, and HV feeder protection, under frequency load shedding (UFLS), revenue metering and other associated ancillaries.

(h) DC distribution system, within the switchboards.

# 3 General

Project specific requirements for the HV system will be listed in the project specifications.

## 3.1 Software and programming tools

The following condition shall apply for all programming tools and software tools:

(a) All parameterisation, configuration and programming requirements for the equipment must be provided.

(b) Detailed instructions for use must be provided at least four months prior to factory acceptance testing (FAT). This will enable TasNetworks to familiarise with the software documentation.

(c) All programming tools and software must be complete with necessary hardware in the form of computers, cables or other accessories, as required.

(d) All programming and software tools necessary for data analysis and recording must also be provided with such equipment.

## 3.1 Maintenance and routine test plans

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

(a) A detailed maintenance plan for the entire life of the substation design must be provided.

(b) A routine test plan must be recommended.

(c) Blank schedules and forms for maintenance and routine testing, for use by TasNetworks maintenance personnel, must be provided.

(d) Relevant task guides and procedures for testing must support the maintenance and routine testing forms and schedules.

(e) All procedures and task guides for the system supplied must be provided.

## 3.1 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 complete proformas must be submitted to TasNetworks as follows:

(a) Design information and maintenance regimes information for all assets must be submitted to TasNetworks before commencing installation on site.

(b) Information on test results for all assets must be submitted prior to commissioning.

(c) Information of decommissioned assets must be submitted prior to decommissioning.

## 3.1 Service conditions

Service conditions must comply with the following requirements:

(a) Environmental conditions and any specific design, installation, operation or maintenance criteria for particular works will be stated in the project specifications.

(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 Cable Systems

All cables and cable systems associated with the HV system must be in compliance with document Cable System Standard R570630.

## 3.2 Earthing

Earthing of all equipment and works associated with HV system must be in compliance with document Lightning Protection and Earthing Standard R522692.

## 3.3 Labels, rating plates, locking facilities, handling facilities, spare parts, tools and maintenance

All labels, rating plates, locking facilities and tools associated with the HV system must be in compliance with document General Substation Requirements Standard R522687.

## 3.4 Performance

The following performance criteria must be complied with:

(a) the HV system, including its components, must provide reliable performance;

(b) the performance of the HV system must meet all specified electrical, mechanical and environmental criteria under both normal and abnormal system conditions;

(c) the selection of equipment, design and all works associated with the HV system must conform to the requirements as specified in document General Substation Requirements Standard R522687and meet or exceed the specified design criteria and performance stated within this standard; and

(d) where conditions are not stated in the project specifications the performance requirements of this standard must be used as a minimum performance standard for HV equipment as shown in Table 1.

## Table 1 HV System service conditions for HV systems

| Sr. No. | Parameter | Unit | Value | | | |
|---|---|---|---|---|---|---|
| 1. | Nominal system voltage ($V_n$) | kV | 6.6 | 11 | 22 | 33 |
| 2. | Rated voltage | kV | 7.2 | 12 [1] | 24 | 36 |
| 3. | Power frequency withstand voltage | $kV_{rms}$ | 20 | 28 [1] | 50 | 70 |
| 4. | Lightning impulse withstand voltage | $kV_{peak}$ | 60 | 75 [1] | 125 | 170 |
| 5. | Normal voltage variation (criteria for equipment design) | $\%V_n$ | ± 10 | | | |
| 6. | Rated frequency | Hz | 50 | | | |
| 7. | Normal operating frequency excursion band | Hz | 48.8 – 52 | | | |
| 8. | Power system frequency range | Hz | 44.8 – 52 | | | |
| 9. | Rated current @ 40ºC, incoming CB | A | 2000 [2] | | | |
| 10. | Rated current @ 40ºC, bus-coupler CB | A | 2000 [2] | | | |
| 11. | Rated current @ 40ºC, outgoing feeder CB | A | 630 [2] | | | |
| 12. | Normal combined voltage and frequency variation (criteria for equipment design) | % | ± 10 | | | |
| 13. | Minimum symmetric three phase fault current withstand | kA | 25 [3] | | | |
| 14. | Minimum short circuit withstand time | sec | 1 [3] | | | |
| 15. | Neutral earthing | | Solidly earthed at supply transformer neutral | | | |
| 16. | Minimum degree of protection by enclosure | IP | 51 | | | |
| 17. | Installation : Indoor / Outdoor | | Indoor | | | |
| 18. | Design maximum continuous ambient temperature | °C | 40 | | | |
| 19. | Design minimum continuous ambient temperature | °C | -5 | | | |
| 20. | Altitude | m | ≤ 1000 | | | |
| 21. | Maximum relative humidity | % | 95 | | | |

Note 1: To achieve standardisation of equipment and reduction of spare parts holding, HV switchboards, CBs and power cables for 11 kV are to be rated at 24 kV, with the exclusion of associated VTs, unless specified differently within the project specifications.

Note 2: Unless specified differently within the project specifications (note: feeder CT ratios would be different).

Note 3: Specifies rated short-circuit withstand for HV switchboards and short-circuit breaking current for HV CBs.

# 2 High voltage installation

Each HV system must essentially include a switchboard. Switchboard must house all elements constituting the HV system. Certain elements of the HV system, eg primary protection, HV cables, core-balance CT, CT in power transformer neutral connection, transformer protection, capacitor bank protection, or under-frequency load shedding scheme may be housed separately.

## 2.1 Design

The design of the switchboard must comply with the following requirements:

(a) Individual units must be fully sectionalised to prevent spread of fault to adjacent units.

(b) Spare bay provisions must be as required in the project specifications. Spare bay provisions must be limited to space only unless otherwise stated in the project specifications.

(c) All drawings and details, including dimensional details and sectional details, as required for this work must be provided with the Contract documentation.

(d) the switchboard must:

  (i) be air-insulated;

  (ii) consist of a series of metal-clad units (panels and/or cubicles) of the same depth and height;

  (iii) be of modular design;

  (iv) have all functional elements that are guaranteed to be internally arc proof;

  (v) have full arc containment; and

  (vi) be extendable at both ends.

### 2.1.1 Arrangement of switchboard units

The arrangement of the switchboard units must comply with the following requirements:

(a) Each unit must be dedicated to one particular feeder (incoming, outgoing or bus-coupler). Panels may be used for other functions as required, eg bus-riser or bus-earthing.

(b) Each unit must be compartmentalised based on function of the equipment housed in the particular compartment. Typical compartments include:

  (i) busbar compartment;

  (ii) LV compartment;

  (iii) CB compartment;

  (iv) cable compartment; and

  (v) VT compartment,

(c) An LV compartment must be provided in the front for each unit to house all protection, control, metering and monitoring equipment related to the function of the particular unit. It must be possible to do operations and maintenance work on the LV compartment without any risk to personnel safety in the event of an electrical fault at the time the work is undertaken.

(d) Each functional device within a unit, for example, a CB, CT and VT, must be independent of each other. Withdrawal of a CB must not result in withdrawal of the VT or withdrawal of CT and vice versa.

(e) The switchgear elements must be physically arranged within the switchboard such that the operation of any item is performed with compartment doors closed.

## 2.1 Access arrangements

Access arrangements must satisfy the following criteria:

(a) Entry for power cables to each unit must be from underneath the HV switchboard.

(b) Entry for control and instrumentation cables to each LV compartment must be possible via segregated and fully enclosed cable ducts from underneath each separate unit. To minimise the effects of electro-magnetic interference, adequate clearance must be maintained between:

(i) power cables and control cables;

(ii) power cables and control cable trays; and

(iii) control cables and communications cables,

(c) Each compartment of a unit must be fully sectionalised and have independent access. It must be possible to access any particular compartment without risk of accidental contact with live parts in other compartments.

(d) Switchboards must be constructed so that individual compartments of one particular unit can be accessed safely for working without requiring a busbar outage, or outages of adjacent units.

(e) Access to the cable compartment of each unit must be independent.

(f) it must not be possible to access any live parts of the system at any time. This clause applies to all conditions of power supply. It must not be possible to bypass interlocks that prevent access to live parts. Any features that allow bypassing of the interlocks will be subject to approval in writing of TasNetworks. Where TasNetworks does not approve a particular feature the feature must be permanently disabled.

# 3 Auxiliary systems

All LV wiring and circuits must terminate in the LV compartment of the switchboard.

## 3.1 AC supply circuit

The ac distribution system must be in compliance with document AC Distribution System Standard R565984.

The ac distribution system supply circuitry must comply with the following requirements:

(a) The HV switchboard's 230 V ac supply requirements are to be marshalled to within either the bus-riser panel, or the feeder panel at the end of the HV switchboard, for connection to a single cable from the station 400 V ac V ac distribution switchboard.

(b) Each ac distribution circuit must terminate in an appropriately rated miniature circuit breaker (MCB) and a 230 V ac supply bus must be formed, with branches to each unit of the switchboard.

(c) Each unit must have its own MCB. All ac supply circuits for that unit must be fed from the MCB.

(d) Each MCB must be lockable and independently monitored and alarmed to the station's Supervisory Control and Data Acquisition (SCADA) system and TasNetworks' Network Operations Control System (NOCS).

## 3.1.1 Heater circuits

Heater circuits must comply with the following requirements:

(a) A heater must be provided for each compartment.

(b) A separate circuit and separate terminals must be provided for each heater, to permit testing of each inaccessible heater.

(c) A heater with a thermostat must be provided for each LV compartment.

(d) The heaters must be supplied from a 230 V ac supply from the ac distribution system.

(e) Heaters and thermostats must be chosen such that they are capable for continuous service for the entire life of the switchboard.

(f) All heaters and thermostats must be easily replaced.

(g) Settings of the thermostat must be performed and recorded.

## 3.1.1 DC supply circuit

The dc distribution system must be in compliance with document DC Distribution System Standard R522693.

The dc distribution system circuitry must comply with the following requirements:

(a) The dc supply must be from an unearthed station dc distribution system. Normal rated voltage is 125 V dc.

(b) dc supplied equipment must have a continuous withstand capability for possible variation from 70 per cent to 115 per cent of the nominal dc voltage.

(c) Closing circuits must be operational from 85 per cent to 115 per cent of rated dc supply.

(d) All elements of the trip circuit must be rated for duty from 70 per cent to 115 per cent of rated dc voltage.

(e) dc supply circuits within each unit 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 and/or auxiliary circuits. No tripping circuit device may be supplied from this circuit. Where a single auxiliary relay exists it must be fed from the trip circuit 1 supply; and

 (v) indication and alarm circuit,

(f) The HV switchboard's 125 V dc requirements are to be marshalled to either the bus-riser panel, or the feeder panel at the end of the HV switchboard, for connection to two separate cables from the station 125 V dc distribution switchboards.

(g) The dc supply circuits must terminate in an MCB and dc supply buses must be formed with supplies to each unit (panel or cubicle) of the switchboard.

(h) Each unit must have its own set of dc MCB's. All dc supply requirements for that unit must be fed from these MCBs.

(i) Each MCB must be independently monitored and alarmed to the station's SCADA system and NOCS.

(j) As a minimum, five separate 125 V dc supply circuits must be provided within the HV switchboard.

(k) The five separate 125 V dc busbars must be applied to the following specific functions:

 (i) trip circuit 1;

(ii) trip circuit 2;

(iii) close circuit;

(iv) other supply schemes, eg interlocking and/or auxiliary relays; and

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

(l) Trip circuit 1 and trip circuit 2 must use independent cables from the 125 V dc distribution system.

(m) Each 125 V dc supply circuit must be arranged so that it is always monitored for healthy voltage. All alarms must be provided to the station SCADA system and to NOCS.

(n) 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 slide-disconnect link terminals. Each slide-disconnect link terminal must have a specific designation and must be easily identified for the designated purpose.

(o) All 125 V dc supplies must be brought to a common terminal group in each local control panel. The terminals must be easily and safely accessible from floor level.

# 4 High voltage switchgear

HV switchgear must include all devices including, but not limited to, CBs, disconnectors and earth switches.

HV switchgear installations must be compliant with this standard and the relevant Australian standards, in particular the AS 62271 series - high-voltage switchgear and control gear standards.

Metal enclosed switchgear and control gear must be designed with an internal arc classification (IAC) type A accessibility for front, lateral and rear (FLR) as per the AS62271.200. The test report of the offered model must be submitted at the time of tender to verify it.

The internal arc classification designation shall be included in the name plate.

## 4.1 General requirements

HV switchgear must comply with the following requirements:

(a) All HV switchgear must be housed within a HV switchboard.

(b) Each switchgear compartment must be provided with a means for extracting arc products and eliminating moisture pockets.

(c) Infrared (IR) inspection windows must be fitted to each switchgear compartment. The location and number of inspection viewing windows must be such that the internal electrical components, including the busbar, are able to be inspected from these IR inspection windows.

## 4.1 Operation of switchgear

The operation of switchgear must comply with the following:

(a) Operation of the switchgear from any operation system and in any power system state must be possible without compromising the safety of personnel.

(b) The mechanical operating mechanism must have free release and allow for automatic re-charging of stored energy, independent of operator action.

(c) The operating mechanism must be designed to ensure long mechanical life.

(d) The operational and arc-extinguishing mechanism must be designed to ensure a long electrical life, with limited dielectric and thermal stresses on the installation.

### 4.1.1 Local control and operating panels

Local control and operating panels must comply with the following requirements:

(a) 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.

(b) All necessary auxiliary contacts, switches and relays and/or mechanisms must be brought to and terminated at the local control panel.

(c) The local control panel must be sited so as to ensure safe and easy access while the HV system is in service.

(d) Facilities must be provided at the local control panel for selection of exclusive control at 'LOCAL' and 'REMOTE' and for initiating opening or closing of the switchgear. With the selection switch in 'LOCAL', the switchgear must be operable by the local control switches or CBs tripped only by associated protection relays. With the selection switch in 'REMOTE', no local operation can be possible, however operation of protection relays must not be inhibited.

(e) Operator accessible components, such as any MCB, switch, contactor or handle, located in the local control panel must not exceed 1800 mm from floor level.

(f) At least two spare contacts must be provided for each switch, relay, contactor and alike at the end of practical completion.

### 4.1.1 Electrical operation

Operation of electrically operated switchgear must be possible by the following means and locations:

(a) Local from the IBPCU installed on the LV compartment of the switchgear.

(b) Remote from the station's SCADA.

(c) Remote from the NOCS.

### 4.1.1 Mechanical operation

Mechanical operation must comply with the following requirements:

(a) Mechanical (manual) operation of all switchgear must be provided from the front of the switchboard.

(b) Mechanical operation must be possible in the absence of the electrical closing and tripping devices.

(c) Mechanical operation must be interlocked from any system state that can prove to be hazardous to operator safety.

(d) For CBs, mechanical opening must only be possible when in the racked-in (service) position.

## 4.1 Indications

### 4.1.1 Mechanical indications

Mechanical indicators must comply with the following requirements:

(a) Mechanical indications must be provided for the following as a minimum:

  (i) open and close state for CBs;

(ii) open and close state for disconnectors; or alternatively, for withdrawable CBs, service, test and isolated positions;

(iii) open and close state for earth switches; and

(iv) spring charged and discharged state for closing spring,

(b) Mechanical indications must be independent of electrical indications and must not need any electrical supply for their operation.

(c) Mechanical indications must be so positioned such that they are visible and legible from floor level whilst the equipment is in-service and without a need to open any cover, barrier, and enclosure or unit door.

### 4.1.1 Electrical indications

Electrical indications must comply with the following requirements:

(a) Electrical indications must be provided for the following, as a minimum:

(i) open and close state for CBs;

(ii) open and close state for disconnectors, or alternatively, for withdrawable CBs, service, test and isolated position indication;

(iii) open and close state for earth switches;

(iv) spring charged for closing spring;

(v) gas density alarm and lockout stage, where applicable;

(vi) trip circuit unhealthy;

(vii) close circuit unhealthy (where provided);

(viii) ac or dc MCB trip;

(ix) local / remote control selection switch position; and

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

(b) Capacitive voltage indicators with neon bulbs must be provided for each phase of incoming and outgoing feeders and busbars, to indicate live equipment. The neon bulbs must be interchangeable and removable for test purposes.

(c) All electrical indications, except capacitive voltage indicators, must be integrated with the associated IBPCU on the LV compartment.

(d) Electrical indications must be so positioned such that they are visible from floor level whilst the equipment is in service and without a need to opening any cover, barrier, and enclosure or unit door.

## 4.1 Requirements for circuit breakers

### 4.1.1 General requirements

Circuit Breakers must comply with the following general requirements:

(a) CBs must:

(i) use vacuum interrupters. SF6 interrupters will be considered within an alternative offer only;

(ii) be a withdrawable type, to facilitate a disconnector function;

(iii) be mounted in the CB compartment to allow racking in and out;

(iv) be mounted such that they can be racked in or out only with the CB compartment door closed; and

(v) be capable of three-phase auto-reclose duty,

(b) Withdrawable CBs must have a minimum of three positions, namely; service, test and isolated. The purpose of the three positions and the functionality allowed must be as follows:

(i) **Service position:** CB is racked-in with connections to both power cable and HV busbar. In this position, the CB must be fully functional for its intended duty;

(ii) **Test position:** CB is racked-out with its primary circuit isolated. The CB's secondary circuits must remain connected and fully functional, allowing testing of the closing and tripping circuits; and

(iii) **Isolated position:** CB is ready to be removed from the CB compartment. In this position, the CB's primary and secondary circuits are isolated. Manual removal of the secondary circuit connection socket is allowed to bring the CB to the isolated position from the test position,

(c) The design and construction of the CB finger contacts must ensure that, when the CB truck is in the 'service' position, the contact grip is secured properly in position.

(d) A non-resettable mechanical operation counter must be provided with each CB. The counter must be visible from floor level.

### 4.1.1 Circuit breaker operating mechanism

The CB mechanism must comply with the following requirements:

(a) Operating mechanism of the CB must:

(i) be spring operated;

(ii) be stable in the quiescent state; and

(iii) respond correctly, positively and promptly to the appropriate operation commands,

(b) Electrical operation for each CB must be provided with:

(i) a single electrical closing coil; and

(ii) dual electrical trip coils. The two trip coils must have separate magnetic circuits and completely independent electrical circuits,

(c) Manual operation for each CB must comply with the following requirements:

(i) manual operation must be possible from the front of the CB in the event of a failure of electrical auxiliary system;

(ii) manual charging of the closing spring must be possible with the CB in service; and

(iii) manual charging must not compromise operator safety,

(d) Anti-pumping feature must be provided for electrical and manual operation of the CB.

(e) Manual and electrical spring charging must be interlocked such that at any one time only one mode of spring charging is operational.

## 4.1 Requirements for disconnectors

The following specific requirements are applicable for disconnectors:

(a) Disconnectors must be included in the power circuit to provide visible and effective electrical isolation for equipment under maintenance. For HV systems, the racking in and out of the CB may be considered as an effective disconnector function. Where separate disconnectors are provided, they must conform to the requirements of this standard.

(b) The closing and opening of the disconnector must be possible manually from the front of switchgear.

(c) The manual static effort to operate the disconnector must not exceed 150 N.

(d) The manual operating mechanism must not be located higher than 1200 mm above ground level.

## 4.1 Requirements for earthing switches

The following specific requirements shall be applicable for earthing switches:

(a) Lockable integral earth switches must be provided for each HV feeder circuit (incoming and outgoing). The earth switch must be placed to connect cable circuits to earth.

(b) Earth-switches within all incoming and outgoing feeders must be arranged on the power cable side of any CT utilised for high-impedance bus-zone protection.

(c) Separate lockable bus earth switches must be provided for each bus section.

(d) All earth switches provided for the HV system must:

   (i) have a rated short-circuit making current equal to the rated peak withstand current;

   (ii) be designed and so placed that the operation of earth switches does not pose any risk to operator safety;

   (iii) be mechanically or electrically interlocked to prevent risk to operator when operating and also conform to the requirements of this standard;

   (iv) be of identical performance and characteristics;

   (v) have closing and opening from the front of the switchboard; and

   (vi) where possible, be provided with an inspection window to check the position of the earth switch,

(e) Manual operation of the earth switch must be provided.

(f) Where electric operation of the earth switch is also provided, the operation of the earth switch must be possible from the front of the switchgear and station SCADA system.

(g) The earthing blade must be directly connected to the substation earthing grid by means of a dedicated, fully rated earth connection. The earth switch must connect the earthed equipment to this earth blade.

(h) The manual static effort to operate the earth switch must not exceed 150 N.

(i) The manual operating mechanism must not be located higher than 1200 mm above ground level.

(j) The earth switch mechanisms must be designed so that, in the event of failure of the operating mechanism, the earth arms must not swing into the closed position under the action of counterweights or springs and similarly if the device is closed it must not swing into the open position.

## 4.1 Requirements for double busbar arrangement

The following requirements shall be applicable for double busbar arrangements:

(a) Where two CBs are connected to the same feeder circuit:

   (i) it must be possible for only one of the two CBs to be in the racked-in (service) position at any one time; and

(ii) it must be possible for CBs to be in the racked-out (test) position or be isolated regardless of the other CB for the same feeder circuit,

(b) It must be possible for CBs to be operated in the racked-in or racked-out positions independent of the other CB.

(c) Only one IBPCU must be provided for each feeder circuit. This IBPCU must provide all requirements for the particular feeder circuit.

(d) CB operations must be possible from IBPCU, local SCADA and NOCS. Where the IBPCU is mounted on the LV compartment other than the tested CB, push buttons and position indication for control and status of the CB must be provided on the front of the CB.

(e) Operation of the CBs in the 'service' position must be only from IBPCU, SCADA or NOCS.

(f) Only one earth switch per feeder circuit may be provided.

# 4.1 Interlocks

## 4.1.1 General interlocks requirements

The following general requirements are applicable to interlocks:

(a) 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 HV network that may be energised.

(b) Interlocks as required by applicable Australian Standards must be provided.

(c) Interlocks must be provided to ensure correct operation sequence for electrical system security and integrity.

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

(e) The requirement of the interlocks depends on the proposed power supply system and must be reviewed based on the proposed power supply system.

## 4.1.1 Circuit breaker interlocks

CB interlocks must comply with the following requirements:

(a) Closing of a CB must be prevented:

(i) if any earth switch is not open, where the earth switch is directly associated with the CB to be operated;

(ii) where a disconnector is present between a CB and an earth switch and the disconnector mechanism cannot be interlocked with the earth switch, then, the CB must be interlocked with the associated earth switch;

(iii) if the closing spring is not charged;

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

(v) locally if the operation of the CB on the IBPCU is selected to remote;

(vi) remotely (from SCADA or NOCS) if the operation of the switchgear on the IBPCU is selected to local;

(vii) remotely from NOCS if the station SCADA is selected to local operation mode; and

(viii) for a low gas lockout condition, where applicable.

(b) Closing of a feeder or bus-coupler CB in the racked-in (service) position must be prevented if the bus earth switch is not open, where the respective CB can be directly connected to the earthed bus.

(c) Operation of the CB must be prevented if the CB truck is not in the racked-in or racked-out position.

(d) A CB must be prevented from being racked-in or racked-out if the CB is not open.

(e) Racking-in of the CB must be prevented if:

(i) the earth switch, for the feeder circuit, is not open; and

(ii) the bus earth switch is not open, where the respective CB can be directly connected to the earthed bus.

## 4.1.1 Disconnector interlocks

Disconnector interlocks must comply with the following requirements:

(a) The disconnector mechanism must be mechanically interlocked with its integral earth switch.

(b) Castell key or solenoid interlocks must be provided for interlocks on disconnectors with remote earth switches, eg Extra High Voltage (EHV) disconnector for power transformer and HV earth switch for power transformers. The disconnector must be prevented from being operated if the remote earth switch is NOT open. Provision of Castell key must conform to the following:

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

(ii) the 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.

## 4.1.1 Earth switch interlocks

Earth switch interlocks must comply with the following requirements:

(a) Earth switch must be prevented from being closed onto a live bus.

(b) Feeder earth switch must be prevented from being closed if:

(i) the CB or disconnector directly associated with the feeder circuit where the earth switch is located is NOT open; and

(ii) the CB or disconnector directly associated with the feeder circuit where the earth switch is located is NOT in the ‘test’ or ‘isolated’ position.

(c) Castell key or solenoid interlocks must be provided for interlocks on the earth switches on incomer feeder circuits with remote disconnectors. The earth switch must be prevented from being closed if the remote disconnector is NOT open, eg HV earth switch and EHV disconnector for power transformers. Provision of Castell key must conform to the following:

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

(ii) the 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,

(d) Bus earth switch must be prevented from being closed if:

(i) any CB or disconnector unit that can be connected to the busbar is in service position; and

(ii) where any switchgear that can be connected to the busbar has only one position (only 'service' position) then the bus earth switch must not be possible to be closed if the switchgear is closed.

(e) Feeder earth switch must be prevented from being opened if the feeder CB compartment door is open.

### 4.1.1 Other interlocks

Interlocks, where applicable, must comply with the following requirements:

(a) CB compartment door must be prevented from being opened if the CB is NOT in the 'isolated' position. Where there is no 'isolated' position, the compartment door must not be possible to be opened if the CB is NOT in the 'test' position.

(b) If fitted, the cable compartment door must be prevented from being opened unless the earth switch is closed.

(c) Interlocks for access doors to capacitor compartments or access gates to capacitor enclosures must comply with the requirements as specified in document High Voltage Shunt Capacitor Banks Standard R522695.

# 5 High voltage busbars

HV busbars and cables cover all busbars and cable systems, including the associated connections, fittings and joints, as applied for HV systems.

## 5.1 General

The following general requirements shall be applicable for busbars and connections:

(a) Busbars and connections must be so arranged and supported so that under no circumstances, including short-circuit conditions can the clearance between live metal and earth or earthed metal work, or between the live conductors of different phases be less than the minimum clearances specified in relevant applicable Australian and International Standards.

(b) The busbars and connections to equipment must maintain adequate flexibility to allow for thermal expansion and contraction.

## 5.1 Busbars

Busbars must comply with the following requirements:

(a) Busbars must be air insulated and enclosed. $SF_6$ gas-insulated HV busbar systems will not be accepted.

(b) All sections of each busbar must be of an equivalent rating.

(c) Busbars must be electrolytic or superior grade copper of adequate cross section.

(d) Busbars must be extendable at each end of the switchboard;

(e) Busbars must be connected to the elements of the HV system by means of branches.

(f) Busbars must be provided with phase colour coding at all connections and ends to identify the phase. Phase identification must be using non-flammable material.

(g) All busbar contacts and connections must be silver plated.

(h) Busbars must be rated for the higher of:

(i) maximum possible power flow on any feeder connected to busbar;

(ii) nominal rating of incomer CB;

(iii) nominal rating of bus coupler CB;

(iv) nominal rating of feeder CB;

(v) emergency rating of transformer; or

(vi) nominal rating of instrument transformer on the feeder.

## 5.1 Branches and feeder connections

Branch bars and feeder connections must comply with the following requirements:

(a) Branch bars must be electrolytic or superior grade copper of adequate cross section.

(b) Feeder connections must be provided with phase colour coding at all connections and ends to identify the phase. Phase identification must be using non-flammable material.

(c) All feeder connections must be rated for the higher of:

(i) maximum possible power flow on the feeder;

(ii) nominal rating of CB;

(iii) nominal rating of cable; or

(iv) nominal rating of instrument transformer on the feeder.

## 5.1 Earthing busbar

Earthing busbars must comply with the following requirements:

(a) The earthing busbar must be made of electrolytic or superior grade copper with adequate cross section uncovered.

(b) The earthing busbar must run along the whole length of the switchboard longitudinally and must allow for future switchboard extension.

(c) The earthing busbar must be connected to the station earth at least at two independent points.

(d) A report detailing the criteria used for selection of the size of the earthing busbar and the verification of the size must be presented to TasNetworks for approval.

(e) The earthing busbar must be rated for the higher of:

(i) 25 mm x 6 mm

(ii) the size adequate to carry maximum earth fault current that the switchgear and busbar is rated to withstand; or

(iii) the size required to conduct any injection tests on the HV system.

## 5.1 Fittings and joints

All fittings and joints must comply with the following requirements:

(a) Only proprietary brands of bus fittings may be used.

(b) 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. Evidence of such tests must be presented to TasNetworks for approval.

(d) No hot spot should be formed at the connections and joints. This must be achieved without the need for regular maintenance, such as periodic tightening due to thermal cyclic effect or short circuit forces, or cleaning of chemical by-products.

(e) All primary circuit connections must be tested with a micro-ohmmeter. The results must be recorded and provided to TasNetworks before energisation.

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

(g) 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 corrosion.

(h) 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.

(i) All copper-to-copper connections must be made with bronze connectors.

(j) Only 316 grade stainless steel bolts and compatible grade stainless steel nuts, washers and spring washers must be used for bolted connections. Fastener tension must be maintained by either wave or Belleville spring washers without the need for periodic re-tightening or maintenance.

(k) All lugs are to be of the sealed type.

# 6 Instrument transformers

## 6.1 Application

Instrument transformers, namely CT and VT are required for both protection schemes and revenue energy measurement within the HV electrical power network and, dependent on application must comply with the following requirements:

(a) Instrument transformers provided must be suitable for their application in an electricity utility environment. The instrument transformers are to conform to the current applicable Australian Standards:

  (i) AS 60044.1 Instrument transformers - Current transformers; and

  (ii) AS 60044.2 Instrument transformers – Inductive voltage transformers,

(b) Instrument transformers utilised in revenue metering applications must be in accordance with document Metering Specification TNM-GS-809-0024.

## 6.1 Insulation

The insulation of instrument transformers must comply with the following requirements:

(a) Instrument transformers must have necessary insulation as per the above Australian Standards and in no case less than the highest voltages expected in the specific application.

(b) Instrument transformers must be cast resin insulated, completely sealed, solid insulated type.

(c) Oil insulated instrument transformers will not be accepted.

## 6.1 Principle of operation of instrument transformers

Instrument transformers must comply with the following service conditions:

(a) Instrument transformers other than those working on inductive technology may be used only if they are proven to be more reliable and have less operation, maintenance and whole of life costs.

(b) Optical instrument transformers and other technology like sensors may be provided for instrument transformers only if they have been tested in accordance with Australian Standards and have a certification from relevant authorities in Australia for application to revenue measurement applications as per the Tasmanian Electricity Code and National Electricity Rules.

(c) Any such technology proposed must have been in 'commercial service' for at least three years in an electricity utility industry in Australia. Where a technology has not been in commercial service for three years, it must be clearly stated in the Tender.

(d) It will be at TasNetworks' discretion to accept any technology that has not been proven for more than three years.

(e) Any offers must be supported with relevant references, details of installation and all necessary test reports and performance certificates.

## 6.1 General requirements

Instrument transformers must comply with the following general requirements:

(a) The number of primary and secondary windings and cores in the instrument transformers must be decided based on their specific application.

(b) Multiple ratios must be achieved by reconnection of secondary windings taps only. Ratio changes must not be achieved by reconnection of primary windings.

(c) Where multiple ratio, multi tap, multi core instrument transformers are provided, all testing associated with the instrument transformers must be undertaken for each core, winding and tap. A special requirement is the provision of test reports for the accuracy and performance parameters of each ratio, tap and winding for revenue metering instrument transformers in accordance with document Metering Specification TNM-GS-809-0024.

(d) The instrument transformers must be provided with necessary number of cores and windings with performances and classes of precision suited to the functional requirements of the devices connected to them.

(e) The specified performance of the instrument transformers must be obtained without recourse to compensation devices or ancillaries for calibration.

(f) The instrument transformers must have same short circuit withstand capability as that of any other HV elements at the point of connection of the instrument transformer.

(g) Polarity markings must be provided on primary and secondary terminals of all instrument transformers and fixed on the instrument transformers so that it may be easily read without requiring disconnection of the instrument transformer.

(h) Secondary terminal markings must be provided for each tap and each secondary winding. Each secondary tap including any test taps must have their own individual terminal marking.

(i) All secondary terminations including connections from all taps, cores and test taps must be brought out in the corresponding switchgear LV compartment. The termination of the instrument transformers must, as a minimum, be in the LV compartment where the secondary devices are located and must be arranged to be easily accessible from floor level.

(j) All secondary connections must use slide-disconnect link test terminals to enable testing of protection and metering devices without removing any wires from terminals. The CT links should be arranged to fall to closed and the VT links should be arranged to fall to open.

(k) All HV instrument transformers, applied to a HV switchboard, must be of identical technology in terms of insulation and principle of operation.

(l) All instrument transformers must be arranged so that it is possible to conduct primary injection of the instrument transformers without requiring removal of the transformers. Connections for conducting primary injection testing must be suitable for testing of instrument transformers to their full rating as required by the National Electricity Rules for instrument transformers used in revenue metering installation. All such provisions must be clearly identified and instructions for testing must be provided with the Contract.

## 6.1 Requirements for current transformers

### 6.1.1 General requirements

CTs must comply with the following general requirements:

(a) Three separate single-phase CTs must be provided for:

 (i) each incoming feeder to a HV busbar;

 (ii) each side of a bus-coupler on HV busbars; and

 (iii) each outgoing feeder from a HV busbar,

(b) A core-balance CT must be provided for each outgoing feeder cable from a HV busbar.

(c) An externally mounted, cast-resin toroidal CT must be provided for each transformer neutral, with a minimum of 100 mm internal diameter.

(d) CTs for feeders must be located on the cable side of the associated CBs and on the CB side of the associated earth-switch. CTs for bus-coupler must be located on the busbars on both sides of the bus coupler;

(e) CTs on incoming or outgoing feeders must be arranged to allow access for maintenance and repairs without requiring a busbar outage;

(f) CTs for bus-couplers must be arranged to allow access to CTs on one side of the bus coupler without requiring a dual busbar outage;

(g) Minimum rated burden must be 15 VA at any tap, for each CT core and windings. Rated burden of 5 VA must be allowed for CTs with ratios at and below 100/1 Amps, subject to fulfilling the criteria as stated below.

(h) Minimum rated burden for each CT core and winding must allow for the burden of connected secondary circuits and devices, plus an additional device, with similar burden.

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

(j) Secondary voltage limiting devices may be provided to protect the CT and secondary circuits, with the following requirements:

 (i) where voltage limiting devices are provided, they must be positioned such that they must be readily accessed with the busbar in service; and

 (ii) drawings must highlight the absence or presence of secondary voltage limiting devices in CT secondary circuits.

## 6.1.1 Primary circuit requirements

CT primary circuits must comply with the following requirements:

(a) The continuous thermal rating of the primary of the CT must be greater than 120 per cent of the primary current at highest ratio connection of the CT.

(b) Multiple-core CTs will be permitted for use in the HV system. Where multi-core CTs are provided, the design must be such that a burden change on any one core does not effect the performance of the other cores.

(c) Each CT must have the necessary number of cores as required from the intended applications. As a minimum, the number of cores must comply with the following requirements:

(i) a CT for each incoming feeder to a HV busbar must have a minimum of four separate cores applied for the following functions:

- one protection class core for differential protection of the associated power transformer, with a minimum classification PX and ratio 2000/1000/600/1;
- one protection class core for incomer feeder protection and restricted earth fault protection of the secondary winding of the power transformer, with a minimum classification PX and ratio 2000/1000/600/1;
- one protection class core for differential protection of the associated HV busbar, with a minimum classification PX and ratio 2000/1; and
- one metering class core for revenue energy metering, with a minimum accuracy class of 0.5M and ratio 2000/1000/600/1 (note: this core may be a toroidal CT installed on each phase of the power cable and must be provided even if not initially used);

(ii) a CT for one side of a bus-coupler must have a minimum of one protection class core applied for differential protection of the adjacent HV busbar, with a minimum classification PX and ratio 2000/1;

(iii) a CT for the opposite side of a bus-coupler must have a minimum of three separate cores applied for the following functions:

- one protection class core for differential protection of the adjacent HV busbar, with a minimum classification PX and ratio 2000/1;
- one protection class core as spare, with a minimum classification of PX and ratio 2000/1000/600/1; and
- one protection class core for bus-coupler protection, with a minimum classification PX and ratio 2000/1000/600/1,

(iv) a CT for each outgoing feeder from a HV busbar must have a minimum of three separate cores applied for the following functions:

- one protection core for outgoing feeder protection, with minimum classification 5P20 and ratio 600/400/1;
- one metering core for revenue energy measurement with minimum accuracy class of 0.5M and ratio 600/400/1 (note: this core must be provided even if not initially used)[1]; and

[1] In situations where transformer or cable diff protection may be required on feeder cable, this metering core point can be replaced with "one protection core for differential protection of the associated downstream transformer and cable with a minimum classification PX and ratio 600-400/1". This assumes metering of feeder if required can be obtained through IBPCU;

- one protection class core for differential protection of the associated HV busbar with a minimum classification PX and ratio 2000/1;

(v) a core balance CT for each outgoing feeder must have a minimum of one protection class core applied for sensitive earth fault protection of the outgoing feeder, with minimum classification of 5P20 and ratio 100/1;

(vi) a cast resin, toroidal CT for each transformer neutral must have a minimum of three separate cores applied for the following functions:

- one protection class core for restricted earth fault protection of the associated power transformer, with a minimum classification PX and ratio 2000/1000/600/1;
- one protection class core for stand-by earth fault protection of the associated HV feeders, with a minimum classification PX and ratio 2000/1000/600/1; and
- one protection class core for sensitive earth fault check of the associated HV feeders, with a minimum classification 5P20 and ratio 100/1,

(vii) for all CT cores applied to HV busbar protection, the specifications and ratios of CT cores in incomer feeder, outgoing feeder and bus-coupler must be identical;

(d) Arrangement and order of the cores must be based on the principle of overlapping protection zones.

(e) Primary terminals must have polarity markings P1 and P2.

(f) The polarity markings for various circuits must be arranged as below:

(i) for incoming feeder to a HV busbar, P1 located adjacent the HV CB;

(ii) for outgoing feeder from a HV busbar, P1 located adjacent the HV CB;

(iii) for bus-coupler, P1 terminal located adjacent the HV busbar, with P2 terminal located adjacent the bus-coupler CB; and

(iv) for transformer neutral, P1 terminal located remote from the transformer bushing for externally mounted neutral CTs,

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

### 6.1.1 Secondary circuit requirements

CT secondary circuits must comply with the following requirements:

(a) CT ratios are to be based on the primary rating of power transformers, CBs and the feeders supplied from TasNetworks' HV busbars. Where these ratios are not applicable the selection of the applicable secondary tap is to be guided by the actual load requirements for a particular feeder and the applicable CT ratios stated in project specifications.

(b) The nominal secondary rating of all CTs must be 1 Amp.

(c) The thermal rating current of the secondary circuit of the CT must be 2 Amps in any connection configuration.

(d) The secondary short-time withstand capability must be at least equivalent to that of the primary.

(e) Test taps are not required on protection cores, including single or multi-ratio cores.

(f) 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 actual and derived ratios and must be performed during factory acceptance testing and must be performed for each CT provided.

(g) All secondary devices applied to a similar metering or protection application, even if on separate primary circuits, must be connected to the same CT ratio. Where different ratios are applied to CT cores connected to similar devices, they must be subjected to approval from TasNetworks in writing.

(h) Secondary circuit must have polarity marking and must use xS1, xS2, xS3 and xS4. Where utilised, test taps must have polarity markings xT1, xT2. 'x' represents the core number.

(i) CT secondary circuits for each three phase CT combination must be normally connected in a star configuration. The common star point must be formed on terminal blocks in each LV compartment. For the protection CTs, the secondary terminals that are towards the device to be protected must be connected as the star point. For the metering CTs, the S1 terminals must be connected as the star point.

(j) Each CT secondary circuit must be earthed at only one point in each associated LV compartment. Where multiple CTs are connected in parallel in a protection scheme, the secondary circuit will be earthed at only one point adjacent the protection device.

## 6.1 Requirements from voltage transformers

### 6.1.1 General requirements

VTs must comply with the following general requirements:

(a) Three separate single-phase VTs must be provided for:

- (i) each incoming feeder to a HV busbar, located on the cable side; and
- (ii) each HV busbar.

(b) To minimise spares requirements, all VTs provided for one switchboard must be identical.

(c) Each busbar VTs must be provided with HV protection fuses. If possible, incomer feeder VTs are to be provided with HV protection fuses. All VTs must be provided with LV MCBs.

(d) VT fuses and MCBs must be designed to meet the requirements listed below:

- (i) replacement of the fuses must be possible with the busbar in-service;
- (ii) operation of a fuse or MCB must not cause any device to mal-operate or result in primary CB tripping;
- (iii) auxiliary contacts must be provided for the MCBs and fuses to indicate their operation;
- (iv) blocking signals must be provided for all voltage-operated protection on operation of the fuses or MCBs. All such blocking signals must be provided to SCADA and NOCS for alarms; and
- (v) fuses and MCBs must be graded to provide discrimination with all downstream protection devices and allow for a supply of secondary burdens to the limit of VT rated burden,

(e) Withdrawal of a VT must disconnect the VT from primary and secondary circuits and VTs must be designed and arranged to meet the following requirements:

- (i) withdrawal of the busbar VTs for maintenance and repairs must be possible with the associated busbar in-service;
- (ii) VTs on incoming feeders must be arranged to allow safe access for maintenance and repairs, without requiring an associated busbar outage; and
- (iii) withdrawal of a VT must not cause any device to mal-operate or result in primary CB tripping.

(f) VTs are to be equipped with dual secondary windings.

(g) The minimum rated burden must be 50 VA for each VT secondary winding, subject to meeting the criteria listed below.

(h) The minimum rated burden for each VT secondary winding must allow for the sum of:

(i) burden of connected secondary circuits and devices. While calculating the secondary circuit burden all possible circuits that are required to be connected to the VT winding must be considered, eg after operation of VT selection scheme;

(ii) the additional burden due to protection and metering devices associated with any spare feeders. While considering the additional protection and metering circuit, the circuit with maximum burden must be considered; and

(iii) the additional burden due to revenue metering devices that may be installed on outgoing feeders.

(i) Test reports to confirm the connected burden and rated burden must be produced for each VT secondary winding.

## 6.1.1 Primary circuit requirements

VT primary circuits must comply with the following requirements:

(a) The continuous voltage withstand capability of the VT must be at least 120 per cent of the primary circuit's nominal voltage.

(b) VT windings must be such that a change in burden of one winding does not affect the accuracy and performance of the other winding.

(c) Primary circuit must have polarity markings A1 and N.

(d) The neutral terminal of the primary winding must be insulated for at least 2 kV for 1 minute. The neutral end of the primary winding is to be directly connected to earth adjacent to the VT.

## 6.1.1 Secondary circuit requirements

VT secondary circuits must comply with the following requirements:

(a) The nominal phase-phase secondary rating of all VTs must be 110 V ac.

(b) Secondary circuits of the VTs must normally be connected in star configuration. The star point must be formed on terminal blocks in the associated LV compartment It must be possible to wire the secondary of the VT to open delta configuration by changes in wiring on the terminal blocks in the associated LV compartment, without the addition of any new terminals.

(c) Voltage connections (phase-phase or phase-earth) to the protection relays and metering circuits must allow all functionality of the protection and metering equipment to be used without any limitation. Use of any specific function, eg directional power within the protection relay, must not require changes to wiring and connections to the protection. Before practical completion, all such modifications must be performed. After practical completion, all such modifications on wiring to attain full functionality of protection device will be undertaken by TasNetworks at Contractors cost.

(d) Each VT incoming circuit must be protected using three-phase lockable MCBs. Separate locks with minimum two keys must be provided with each of these MCBs.

(e) All secondary circuits must be protected by their own independent MCB. Where the same VT winding is used for more than one secondary circuit, a VT bus must be formed within the switchboard and each individual secondary circuit must be fed from this bus. A fault in any one secondary circuit must not cause tripping of the complete VT supply.

(f) Coordination of fuses and MCBs must be performed. 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 endorsement.

(g) Any voltage-operated protection device fed from a MCB must be blocked on tripping of the MCB and alarm generated to the local SCADA and remote to the NOCS.

(h) The use of a single pole MCB as an alternative instead of a three-pole MCB must be investigated to prevent any protection mal-operation due to the tripping of a three-pole MCB. Protection must not malfunction for the operation of a MCB.

(i) The secondary short time withstand capability must be at least equivalent to that of the primary.

(j) Each VT must have dual secondary windings. High quality assurance procedures should be followed taking into consideration that any failure of one single VT winding does not cause the loss of metering and protection devices connected to the other winding. Where dual secondary winding VTs are provided, the design must ensure that burden changes on either winding will not affect the performance of the other winding.

(k) As a minimum the number of secondary windings must comply with the following requirements:

  (i) the VT for each incoming feeder to the HV busbar must provide a minimum of two separate secondary windings available for the following functions:

  - one core for operational metering and voltage regulation circuits with a minimum classification 0.5M / 3P; and
  - one core for revenue energy metering of the incoming feeder from the power transformer, with a minimum accuracy class of 0.5M / 3P,

  (ii) the VT for each HV busbar must have minimum two separate secondary windings available for the following functions:

  - one core for protection and operational metering circuits with a minimum classification 0.5M / 3P; and
  - one core for revenue energy metering of the outgoing feeders on the HV busbar, with a minimum accuracy class of 0.5M / 3P.

# 7 Primary protection equipment

The primary protection for HV systems shall comprise lightning arrestors, surge diverters, earthing and the like and must be provided in accordance with requirements of document Lightning Protection and Earthing Standard R522692.

# 8 Secondary protection and control system

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 is discussed in document SCADA System Standard R246439. The control philosophy as listed in document SCADA System Standard R246439 and any requirements within this document must also be complied with.

## 8.1 Service conditions

The following service conditions must be adhered to:

(a) the equipment provided must be designed, manufactured and installed to operate satisfactorily within an indoor, non air-conditioned environment;

(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 and 90 per cent;

(c) particular attention must be paid to the possibility of air borne pollution that may drift into the building; and

(d) even if climate control for the control room and/or switchgear room is provided, the equipment must be able to function properly as designed without limitation in the event of an air-conditioning failure.

# 8.1 Application

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

(a) New protection and control system, as per this specification, must be provided for and application to, but not be limited to:

  (i) protection and control of the HV power supply system; and

  (ii) protection and control of the associated power transformers.

(b) All devices must be fit-for-purpose and be able to be used to its full functionality (all available options and functions provided by the unit) in the range of environmental and system conditions listed in Table 1 Where a multi-function IBPCU is provided, internal logic and operating characteristics must be effectively applied to ensure maximum utilisation of the multi-function device. Any functionality that is not enabled or configured will need to be specifically agreed to in writing by TasNetworks. However, the basic functionality as detailed in these specifications must be achieved as a minimum.

(c) All new protection and control devices or schemes must make use of proven microprocessor technology with communication features, to communicate serially with the station SCADA system. If any protection device or scheme proposed does not communicate serially with the station SCADA system, it must be clearly indicated within the Tender, and alternative means of continuous monitoring and sequence-of-event recording proposed.

(d) A protection and control device within each bay must have an in-built clock and sequence of events (SOE) recording capability. Digital outputs from any devices without SOE recording capability must be hard-wired to an IBPCU with SOE recording capability. The IBPCU must be capable of time-stamping fault and operational indications with a resolution of 1 ms. All 'loss of time synchronization signals' must be alarmed to the SCADA and NOCS.

(e) The time stamping within the IBPCU must be to the accuracy of better than 1 ms.

(f) The details of the synchronization scheme are discussed in document R246439 SCADA System Standard. Any IBPCU with an internal clock and ability to send time stamped messages must be synchronized by an IRIG-B input, or equivalent A Global Positioning System (GPS) device must be provided for this purpose.

(g) The protection and control devices must have self-diagnostic features in the form of 'internal relay failure' All processes within any protection and control devices must be continuously supervised and alarms for non-healthiness of the units must be connected to the station SCADA and NOCS. On the detection of an internal malfunction within a device, the device must block itself to prevent mal-operation and a CB trip. Self-diagnostic outputs must use hard-wired fail safe contacts to indicate unit failure and problems.

# 8.1 Installation of protection and control equipment, protection panels and protection relays

## 8.1.1 Protection and control equipment

The installation of protection and control equipment must comply with the following requirements:

(a) All protection and control devices for the HV network must be flush-mounted on the LV compartment of the HV switchboard, where possible.

(b) Associated accessories and auxiliary relays must be mounted within the LV compartment of the switchboard.

(c) The terminals of all devices mounted on and within the LV compartment must be easily accessible.

(d) All protection and control equipment, including IBPCU, for bus-couplers, incoming and outgoing feeders must be mounted on the respective panels to which the protection devices are applied.

(e) Bus-zone protection must be mounted on the bus riser panel adjacent the bus coupler pane.

(f) All protection and control equipment for EHV transmission lines, power transformers, capacitor banks and system protection, such as under-frequency load shedding (UFLS) schemes must be mounted on separate, discrete panels. Associated accessories must be mounted within the same panels.

(g) Any additional feeder protection, in addition to those listed in this specification, that is required by the Distribution Network Service Provider (DNSP) or major industrial (MI) customer will be owned by the respective DNSP or MI, eg unit protection or direct inter-trip schemes on feeders and must comply with the following requirements:

  (i) will be installed on separate panels in a room dedicated for the DNSP's access and use. The space for the location of panels will be provided by the Contractor, however the panels and associated protection and control equipment will be designed, procured, installed and commissioned by the DNSP or MI;

  (ii) terminal blocks of these protection panels will form an asset boundary between TasNetworks and the DNSP, or MI. The terminal blocks will be provided by the DNSP or MI;

  (iii) all works associated with these panels will be by the DNSP or MI;

  (iv) all works associated with connection of the TasNetworks HV system to the terminal blocks will be by the Contractor; and

  (v) the Contractor must prepare common terminal block drawings showing the interfaces between the DNSP's or MI's panels and TasNetworks switchboard.

## 8.1.1 Control panels

The installation of protection and control panels must comply with the following requirements:

(a) New panels must be provided for mounting of protection and control equipment, where required. Protection and control panels must be Rittal, with 483 mm W swing-frame racks, 180º swing-frame hinges and 230 V ac internal lighting, with door-switch. Equipment must be arranged to allow opening of swing-frames to their full extent for safe access to terminals.

(b) The panels must have common dimensions of 800 W x 600 D x 2200 H, with an additional 100 mm plinth.

(c) Colour of the panels must be RAL7035.

(d) Panels must have a transparent glazed, lockable front door, be water-proof and dustproof.

(e) Panels must be located within the control room of a building and segregated from the switchgear room. The control room must be completely enclosed with security system, fire detection system, heating, lighting and power and a construction subject to approval by TasNetworks. The control room must have provisions for a minimum of four future protection and control panels.

(f) Access for cables must be from covered floor ducts, with full glanding of control cables, to ensure rodent-proof conditions. The panels must be located in a straight line, with a minimum of 2000 mm walkway available directly in front of each panel.

(g) Layout drawings must be prepared detailing the location of devices and terminal arrangement for each panel, including material list. Protection relays must be flush-mounted on the swing frame. Associated accessories must be mounted within the panel. The layout of the devices and the arrangement of terminals will be subject to approval by TasNetworks.

(h) Each panel must have a provision for dc supply inputs from two independent sources. MCBs to protect and isolate the individual control and auxiliary circuits must be provided. The two sources must be supervised independently and any operation of the MCBs must be annunciated to the Substation Control System.

(i) Duplicated protection systems must be supplied from separate, independent dc supply sources. The same must apply for duplicated trip circuits.

(j) The Contractor must provide all necessary MCBs and slide-disconnect link terminals with associated accessories in accordance with the final wiring scheme.

(k) All devices, terminals, cables and wiring must be distinctively identified.

### 8.1.1 Protection relays

The installation of protection and control relays must comply with the following requirements:

(a) All protection relays must be fitted with front-mounted setting switches, together with LEDs for alarm and self-reset trip indication.

(b) Protection 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.

(c) Provision must be made to maintain the internal clock operation on interruption of the substation auxiliary supplies, including the dc supply system.

(d) Programmable Logic Controllers (PLCs) will not be accepted as an alternative to protection relays or control equipment.

(e) Relay cases must be of robust construction, with minimum degree of protection by enclosure to IP54. Front covers, where provided, must be transparent to allow visual inspection of the relay settings and indications.

(f) All relay contacts that are to be used for trip, close, indication or alarm must be of robust and reliable construction and have appropriate current ratings to match the required duty of the associated switchgear.

(g) The performance of relays, including measurement, start, trip, block, indication, and alarm, must not be affected by the levels of harmonics in the current and voltage waveforms of the power system. Nor should the performance of the relays be affected by the quality of the dc supplies from the batteries and battery chargers.

(h) All relays must be set to operate on the fundamental frequency component of the current or voltage. Type testing by the manufacturer must confirm this feature.

(i) 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 provided in the tender, including any limitations.

(j) Multiple or single auxiliary relays must be provided, as required, so that sufficient contacts are provided for all purposes, with the addition of at least one spare normally-open contact and one spare normally-closed contact.

(k) All protection trips must initiate both CB trip circuits to prevent the loss of any element of protection system for a failure of a single trip coil, or trip circuit;

(l) Each protection relay must have a unique device number attached to the relay, which distinguishes it from any other relay at the site. This device number will be stated on each relay setting sheet. TasNetworks' equipment numbering system is detailed within document R522687.

(m) Protection and control devices must use optical-fibre patch-cords or cable, within flexible conduit, for any inter-panel connection to the station SCADA system.

(n) Protection relay cases must have shorting contacts across CT inputs to prevent open-circuit of CT secondary circuits, if the relay modules are withdrawable from the relay case.

(o) Programming of a device, or down-loading of events from a device, must not remove the device from effective service and also must not cause loss of any event recording during this time. Down-loading or interrogating a protection and control device for post-fault analysis must not be intrusive and must not remove the device from effective service.

## 8.1 Relay and control equipment electrical and insulation requirements

All relays and control equipment must be selected to conform to requirements as stipulated in Table 2 and Table 3.

Table 2 Electrical and insulation specifications

| Sr. No. | Characteristics | Specification |
|---|---|---|
| 1. | Supply interruptions and ripple | All static equipment or static sub-assemblies within non-static equipment shall comply with IEC 60255-11 and be unaffected by the following disturbances to the dc auxiliary supply:<br>To IEC 60255-11 Interruptions of duration 10 ms<br>To IEC 60255-11 ac component of 5% rated value |
| 2. | Insulation (routine test) | (routine test) to IEC 60255<br>2.0 kV rms, 1 minute, OR 2.5 kV rms, for 1 s. |
| 3. | Insulation (type test) | (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 | Table IV and V |
| 3.6 | Impulse voltage tests | 5 kV peak |
| 4.0 | Electromagnetic compatibility | (type test) |
| 4.1 | 1 MHz burst test to IEC 60255-22-1 | Class III (2.5 kV) |
| 4.2 | Electrostatic discharge to IEC 60255-22-2 with covers on | Class III (4 kV) |
| 4.3 | Electrostatic discharge to IEC 60255-22-2 with covers removed | Manufacturer to state with tender. |
| 4.4 | Radiated electro-magnetic field to IEC 60255-22-3 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 60255-22-4 | Class IV (4 kV) |
| 4.6 | Data ports for permanent connection | Tenderer to provide information with the tender:<br>The insulation class (2.0 kV rms preferred) and electromagnetic compatibility class of port(s).<br>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 the need to avoid earth loops.<br>If an external protection/isolation device is required, and the recommended device. |

Table 3 Minimum standards for compliance of relays used in protection circuits

| Standard | Title |
|---|---|

| | |
|---|---|
| IEC 60255-5 | Electrical relays – Insulation coordination for measuring relays and protection equipment – requirements and tests. |
| IEC 60255-11 | Electrical relays - Interruptions to and alternating component (ripple) in dc auxiliary energising quantity of measuring relays. |
| IEC 60255-21-1 | Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section One: Vibration Tests (sinusoidal). |
| IEC 60255-21-2 | Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section Two: Shock and 3 |
| IEC 60255-21-3 | Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section Three: Seismic Tests |
| IEC 60255-22-1 | Electrical disturbance tests for measuring relays and protection equipment – 1 MHz burst disturbance tests. |
| IEC 60255-22-2 | Electrical disturbance tests for measuring relays and protection equipment – Electrostatic discharge tests. |
| IEC 60255-22-3 | Electrical disturbance tests for measuring relays and protection equipment – Radiated electromagnetic field disturbance tests. |
| IEC 60255-22-4 | Electrical disturbance tests for measuring relays and protection equipment – Electrical fast transient/burst immunity test. |
| IEC 60529 | Classification of degrees of protection provided by enclosures. |
| IEC 60068-2-1 | Environmental testing – Tests – Test A – cold. |
| IEC 60068-2-2 | Environmental testing – Tests – Test B – dry heat. |
| IEC 60068-2-78 | Environmental testing – Tests – Test C – damp heat, steady state. |

## 8.2 Annunciation and indication

Annunciation and indication must comply with the following requirements:

(a) In substations where human machine interface (HMI) work-station and associated SCADA system are existing the HMI and SCADA system is to be modified to include position indication, control, operational metering, alarms and sequence-of-event recording for any new HV system equipment.

(b) Where a HMI is not available, a new HMI and associated SCADA system is to be provided to include position indication, control, operational metering, annunciation and sequence-of-event recording for any new HV system equipment, unless specified differently within the project specifications.

(c) Where requested within the project specifications, the existing mimic and annunciator is to be updated with sequence-of-event information wired directly to the existing RTU.

(d) In all cases, a mimic for position indication and 'local' control of the associated switchgear must be included within any associated new protection and control panels and LV compartments of switchboards. 'Local' alarm and operational metering must be provided on associated IBPCU's LCD display. If sufficient functionality and space is available on the IBPCU's LCD display then a mimic may also be provided, if approved by TasNetworks.

(e) The existing mimic diagram and annunciator within the existing control room must be modified to remove reference to any replaced or redundant equipment.

(f) Where a HMI is not available and a new HMI has been specifically excluded from the project requirements, the existing hard-wired mimic diagram and annunciator in the existing control room must be modified to remove reference to any replaced or redundant equipment and include alarms from any new HV system equipment. Where an existing annunciator is not equipped with enough spare points, then a new hardwired annunciator must be provided. The hardwired annunciator must be housed on a separate free standing panel that must be provided. In addition, any sequence-of-event recording must be either hard-wired, or connected via serial communication directly from new equipment, to the existing SCADA remote terminal unit.

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

## 8.1 Supply transformer protection

The protection of supply transformers must be in compliance with document Protection of Supply Transformers Standard R245707.

## 8.2 Voltage regulation for supply transformers

The principle of operation of the voltage regulator must be detailed in the Tender.

Voltage regulation for supply transformers must comply with the following requirements:

(a) A transformer voltage regulation scheme must be provided for each transformer to regulate the voltage on the HV busbar to within limits.

(b) Potential-free contacts must be provided for tap-changer raise and lower to interface with control relays for each transformer's on-load tap-changer.

(c) The voltage regulator must be mounted with the associated transformer's protection within a free-standing panel.

(d) The scheme must be complete with necessary control switches, indication lamps and voltage regulator devices.

(e) If required, the scheme for voltage regulation must provide effective voltage regulation for three winding power transformers.

(f) The scheme must be arranged keeping in mind that the different transformer secondary windings are connected to different buses and the buses may not be connected together.

(g) The voltage regulation must comply with the requirements of the design criteria and also the criteria as required by the Tasmanian Electricity Code for voltage regulation within the specified limits following a credible contingency event of one winding of the transformer being off loaded.

(h) It should be noted that one winding of the transformer can be connected on load without the second winding being connected to the system. The voltage regulation scheme must give an effective voltage regulation for the load connected winding.

(i) Control of mode of voltage regulator and feedback on the status, mode of operation and other states (alarm / trip) must be connected to the substation control system.

(j) Feedback on the tap position and control of the tap position must also be achieved from the station SCADA system.

(k) The voltage regulator must have the following features, but not be limited to:

   (i) automatic and manual voltage controls of the transformers by using raise or lower signals;

   (ii) Over-current blocking;

   (iii) Under-voltage blocking;

(iv) Over-voltage blocking;

(v) Line drop compensation, to be programmed subject to approval by TasNetworks;

(vi) capable of being configured for parallel operation of all transformers of differing impedances, feeding the same busbar, in minimising circulating current or negative reactance configuration;

(vii) tap-changer position remote indication on transformer control panel, SCADA and NOCS;

(viii) numerical display of setting values, measured values, and system operational status;

(ix) serial communication to the SCADA and NOCS;

(x) the voltage regulator must have an inherent high level security utilising the self-diagnostic features, to ensure a high level of reliability and availability;

(xi) it must be possible for the voltage regulator units of different transformers to communicate at the bay level to ensure a well coordinated operation. Selection of the mode of operation of the transformer voltage regulator must be by either manual control or from SCADA and NOCS. Neither local manual, nor remote control, must preclude selection of control mode either locally or remotely;

(xii) all the settings and configuration for input and output must be possible at site;

(xiii) the device must have a facility to connect an external blocking signal to block the tap-change operation in case of HV system abnormalities, such as capacitor bank switching, that are to be monitored by other protection devices;

(xiv) the voltage regulator must have a provision to connect current and phase-to-phase voltage signals;

(xv) it should detect possible under-voltage, over-voltage and over-current situations and include suitable algorithms to enable settings, such as, to avoid operation of voltage regulator when the system and equipment security is at risk;

(xvi) it must be possible to select an alternative set voltage from an external digital input signal;

(xvii) the line drop compensation feature of the voltage regulator must compensate the resistive and reactive voltage drop of the system supplied by the transformer to maintain the setting voltage at the line end;

(xviii) the resistive line drop compensating factor and the reactive line drop compensation factor must be capable of being set in terms of percentage of the rated voltage value; and

(xix) it must be possible to read the line voltage, current and the phase angle of the network from the front face of the regulator.

## 8.1 Busbar and feeder protection

Busbars and feeders protection settings must be in compliance with document Protection of HV Busbars and Feeder Standard R246419.

# 9 Testing

Testing, installation and commissioning must be in compliance with document Testing, Commissioning and Training Standard R246497.

## 9.1 General

Testing, installation and commissioning must comply with the following general requirements:

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

(b) All test reports must be forwarded to TasNetworks for approval and acceptance. The tests will be considered as completed, only after, an approval and acceptance of test results by TasNetworks in writing. A list of the tests to be conducted on the HV system is given below.

## 9.1 Type tests

Type tests are intended to prove the soundness of design of the systems and their suitability for operation under the conditions detailed in the specifications. Type tests must comply with the following requirements:

(a) Type tests must be carried out before the delivery of the system. 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 made applied to a system of identical design with that offered, or on a system of a design which does not differ from that offered in any way which might influence the properties to be checked by the type test.

(b) Where such tests have already been performed, a copy of type test reports that qualifies for the exemption from conducting these tests must be provided with the tender.

## 9.1 Routine tests

Routine testing must comply with the following requirements:

(a) The routine tests must be conducted on the complete system to prove quality of manufacture and conformance with the relevant performance requirements of the applicable standards. Splitting of routine tests into separate phases for individual components of the system is not acceptable. Routine testing must be performed at the manufacturer's works prior to delivery.

(b) Procedures for routine tests with supporting documentation must be submitted to TasNetworks for approval and acceptance. Routine tests will not be conducted unless the routine test procedures have been accepted and approved by TasNetworks.

(c) Routine test results and certificates must be submitted to TasNetworks for approval and acceptance. Routine tests will not be considered as completed only after TasNetworks approves and accepts the test results.

(d) Routine factory test results must be approved and accepted by TasNetworks prior to dispatch of equipment to site.

(e) As a minimum, the tests stated below must be conducted.

## 9.1 Pre-commissioning and commissioning tests

Pre-commissioning and commissioning testing must comply with the following requirements:

(a) Commissioning tests must 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. The commissioning testing procedure must be submitted to TasNetworks for approval.

(b) On load checks must be carried out on all protection and metering circuits and must also include recording of phase angles.

(c) Commissioning test reports must be submitted to TasNetworks for approval and records.

## 9.1 Metal-enclosed switchgear

The following minimum tests must be conducted:

(a) Routine tests as per AS 62271-200 must be carried out at the manufacturer's works. TasNetworks may depute a representative to witness these routine tests.

(b) Power- frequency voltage tests on the main circuit must be performed at the works at an AC test voltage as specified in Table 1, Column 6 of IEC 694 (Table 1, Column 4 of AS 2650). The same test must be repeated with an AC test voltage on site after erection per Annex DD of AS 2086. DC test voltage will not be acceptable.

(c) Measurement of the resistance of the main circuit must be repeated on site after erection of the complete switchgear assembly ready to be put into service. The measurement must include the contact resistance between the fixed spouts and the withdrawable circuit breaker fingers with the circuit breaker closed in the 'service' position. The measurement results must be compared with the routine test results performed at the manufacturer's works.

(d) The metalclad switchgear must have passed the test on arcing due to internal fault to satisfy the entire criterion, that No 1 to No 6, as stipulated in AS 2086 Clause AA6 of Appendix AA.

(e) Partial discharge (PD) measurements must be taken for individual components at the manufacturer's works as per AS 62271-200, Table B.1, Procedure A. Individual component PD results must be within the limits as stated for the individual components in the relevant AS and TasNetworks standards.

(f) Site PD measurements must be conducted on the entire board as installed at the designated site for commissioning. The PD measurement for the entire installation must not exceed 50 pC.

## 9.1 Specific electrical tests

Specific electrical testing must comply with the following requirements:

(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 energising equipment, a visual inspection must be made. An insulation resistance test must be performed to ensure that no obvious defects in insulation are present.

(c) Insulation resistance 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 dry out operation is necessary on any machines or equipment, a dry out operation and subsequent test must be conducted 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 point-to-point 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, any instruments such as pressure, temperature, flow, and level transmitters are to be powered-up and checked for correct indication.

(g) Timing tests for all HV CBs must occur, recording CB main contact open and close time, CB auxiliary switch operation, trip and close coil currents and auxiliary dc voltages.

(h) Functional testing must include all interlock logic and a detailed schematic testing.

(i) 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.

(j) Immediately prior to final closing of covers of the equipment, eg CBs or motor starters, a final check must be made to ensure that all bolts, nuts, screws or fuse holders are secure and that all internal metal and insulating parts are clean and free from debris.

(k) 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 must be performed on the cabling and busbars without limitation:

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

(b) Phase check.

(c) Ac over-potential test on power cables (prior to connection to equipment).

(d) Conductor resistance (cable terminations and busbar connections performed on site).

### 9.1.1 Earthing

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

(a) Earth continuity check.

(b) Earth resistance of every electrode.

### 9.1.1 Lighting

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

(a) Functional test of all circuits.

(b) Luminosity.

## 9.1 Test instruments

Test instruments used for testing purposes must comply with the following requirements:

(a) Prior to testing, all instruments must be examined to ensure the equipment is in working order and safe.

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

(c) The make, type and serial numbers of all test equipment must be recorded during testing.

(d) All test equipment must have been calibrated within the last 12 months and calibration records provided, attached to the test reports.

## 9.1 Testing to SCADA and NOCS

All testing to SCADA and NOCS must be carried out. Tests must be conducted as per the requirements in document SCADA System Standard R246439.

# 10 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document R586383.

# 11 Deliverables

Requirements for project deliverables are outlined in document R586382.

# 12 Hold points

Hold points will listed in the project specifications.