Standard

Extra High Voltage (EHV) Dead Tank and Live Tank Circuit Breakers Standard

R586376

Version 1.0, June 2018

Authorisations

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

Responsibilities

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

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

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

Minimum Requirements

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

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

Record of revisions

Section number	Details
Entire doc	Copied over verbatim from superseded Transend to TasNetworks template. Updated Transend to TasNetworks document reference numbers where known including Australian Standards.
3.1.2 (b)	deleted
3.1.9	point (j) added
3.1.9	Point (h) revised
4.2.(a)	Point (ii) updated.
4.2. (a)	Point (v) added.
4.2 (d)	Added "1.5 times the highest knee point in the highest tap whichever is greater"
4.2.1	Table 2 SR N0. 3 and 4. Second metering CT core added.
4.1 (b)	Point (ii) added
4.1 (c)	Updated with details of single pole operated dead tank circuit breakers.
6.3.3 (b)	Point (xvi) added, CT details.

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1 General

1.1 Purpose

To define requirements for extra high voltage dead tank and live tank circuit breakers (hereafter referred to as "circuit breakers") under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as "TasNetworks").

1.2 Scope

This standard details TasNetworks' requirements for the design, construction, testing at manufacturer's works, secured packaging, supply, transportation, delivery to site, testing and commissioning of circuit breakers.

1.3 Objective

TasNetworks requires as covered in this standard to:

(a) ensure relevant Australian legal requirements are met;

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

(c) ensure personnel and public safety;

(d) ensure ease in operation and maintenance;

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

(f) support the implementation of TasNetworks' strategic performance objectives.

1.1 Certificate of conformance

(a) Before any new and/or modified circuit breaker is put into service in TasNetworks' system a certificate of conformance with 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 TasNetworks has approved deviation to specific requirements of this standard, all such approvals must be included with the certificate of conformance.

(b) TasNetworks will supply a blank proforma for certificate of conformance, to be completed by the Contractor.

(c) The circuit breaker will be accepted only after TasNetworks has accepted the certificate of conformance.

1.1 Precedence

Any conflict between the requirements of the codes, specifications, drawings, rules, regulations and statutory requirements or various sections of this standard and other associated documents must be brought to the attention of TasNetworks for resolution.

1.2 Deviation

Special approval for a deviation to this standard may only be accorded if it does not reduce the quality of workmanship, does not deviate from the objective of this document or from the intent of the standard. A request for a deviation must follow a designated procedure that involves approval from TasNetworks. Deviations, if any, must be specifically requested and requires approval in writing by TasNetworks prior to award of Contract.

1.3 References

As a component of the complete specification for a system, this standard is to be read in conjunction with other standards and documents as applicable. In particular this includes the project specifications and the following:

1.3.1 TasNetworks standards

R586386	Extra High Voltage System Standard
R246497	Testing, Commissioning and Training Standard
R586380	EHV Dead Tank and Live Tank Circuit Breakers Schedule
R586378	EHV Dead Tank and Live Tank Circuit Breakers Deliverables

1.3.2 Other standards

Insulated bushings for alternating voltages above 1000 V	AS/NZS 60137
Structural steel welding	AS 1554
Metal finishing and pre-treatment of surfaces	AS 1627
Insulating Oil for transformers and switchgear	AS 1767
Degrees of protection provided by enclosures (IP code)	AS 60529
Substations and high voltage installations exceeding 1 kV a.c.	AS 2067
Common specifications for high-voltage switchgear and controlgear	AS/NZS 62271.1
Electrical installations (known as the Australian/New Zealand Wiring Rules)	AS/NZS 3000
Steel structures	AS 4100
Instrument Transformers – Part 1: Current transformers	AS 60044.1
High-voltage switchgear and control gear Part 100: High-voltage alternating current circuit breakers	AS 62271.100
High Voltage switchgear and controlgear part 301: Dimensional standardisation of terminals	AS/NZS 62271.301
Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or specialised process	AS/NZS 4792
Specification of technical grade sulphur hexafluoride (SF_6) for use in electrical equipment	IEC 60376

2 Service conditions

(a) Any specific design criteria for particular equipment will be stated in the project specifications. Minimum service conditions for circuit breakers are shown in Table 1.

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

Table 1 Service conditions for circuit breakers

Sr. No.	Parameter	Unit	Value	
1.	Nominal system voltage (V_n)	kV	110	220
2.	Rated voltage	kV	123	245
3.	Power frequency withstand voltage	kV_{rms}	230	460
4.	Lightning impulse withstand voltage	kV_{peak}	550	1050
5.	Minimum creepage distance of bushings	mm	3075	6125
6.	Normal voltage variation (criteria for equipment design)	$\%V_n$	$^{238}_{93}$ 10	
7.	Rated frequency	Hz	50	
8.	Normal frequency variation	Hz	$^{238}_{93}$ 2	
9.	Frequency variation at times of system disturbance	Hz	44.5 – 52.0	
10.	Normal combined voltage and frequency variation (criteria for equipment design)	%	$^{238}_{93}$ 10	
11.	Minimum symmetric three phase fault current withstand	kA	25	
12.	Minimum short circuit withstand time	sec	3	
13.	Rated peak withstand current	kA_{peak}	108	
14.	Rated normal current	A_{rms}	2500	
15.	Neutral earthing	-	Effectively earthed	
16.	Minimum degree of protection by enclosure (control cabinet)	IP	55	
17.	Installation	-	Outdoor	
18.	Design maximum continuous ambient temperature	°C	40	
19.	Design minimum continuous ambient temperature	°C	- 10	
20.	Altitude	m	$\leq$ 1000	
21.	Maximum relative humidity	%	95	

3 General circuit breaker design requirements

The required design of the circuit breaker, either dead tank or live tank, will be stated in the project specifications. This section details common primary and secondary requirements for circuit breakers of dead tank or live tank design.

3.1 Primary design requirements

All circuit breakers must:

(a) comply with this standard and requirements detailed in the referenced standards (section 1.7) and other applicable Australian Standards for normal service conditions;

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

(c) be an SF_6 gas insulated design;

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

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

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

(g) have hermetically sealed poles;

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

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

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

(k) be designed to minimise both the quantity of SF_6 gas required and the annual SF_6 gas leakage rate of the circuit breaker. The gas leakage rate from the circuit breaker must be less than 0.5 per cent per annum.

3.1.1 Circuit breaker bushings

Circuit breaker bushings must:

(a) be of composite construction and grey in colour;

(b) satisfactorily withstand the insulation level specified for the rated voltage level, as specified in Table 1;

(c) display no electrical discharge between the conductor and the bushing when operated at normal rated voltage;

(d) have a puncture strength greater than the dry flashover value;

(e) be designed such that uniform compressive pressure is ensured at all joints;

(f) be designed to have ample mechanical strength and rigidity for the specified environmental and service conditions;

(g) have, for the specified voltage level, identical ratings and provide interchange ability;

(h) be rated at least equal to the circuit breaker rating; and

(i) have airtight joints.

All ferrous components must be hot-dip galvanised.

3.1.1 Primary terminals

Circuit breakers must be fitted with;

(a) aluminium primary terminals to AS 62271.301, palm No 9.

3.1.1 Operating mechanism

The circuit breaker operating mechanism must:

(a) be spring operated;

(b) be complete with motor, opening and closing spring with appropriately set limit switches to prevent over-travel along with the necessary fuse and starter units, housed in a weather-proof enclosure;

(c) incorporate a non-resettable counter to record the number of operations, readable from ground level with the naked eye (with the local control and operating door closed);

(d) be free of any tendency to operate accidentally when the spring is charged;

(e) auxiliary equipment and safety devices, such as electrical and mechanical interlocking, auxiliary switches, position indicators, signalling contactors and terminals, must be provided to ensure the safe operation of the circuit breaker; and

(f) a partial slow manual closing and opening arrangement, complete with any necessary operating accessories, must be provided for maintenance purposes. This must essentially allow external non-intrusive contact wear measurement. The manual operating device must be located inside the operating mechanism cubicle.

3.1.1 Circuit breaker closing

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

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

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

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

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

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

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

(g) in addition to the contacts required for interlocks in closing and tripping circuits, a minimum of two normally closed (NC) spare contacts must be available for status of spring charged for each spring charging mechanism. The contacts must be closed when the spring is charged. These contacts must be potential free clean contacts, suitable for making and breaking 87.5 V to 137.5 V DC indication circuits for remote signalling;

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

(i) closing spring charging must not take more than 15 seconds;

(j) spring charging motor must be rated for 125 V DC with an operating range of 87.5 V to 137.5 V DC;

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

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

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

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

3.1.1 Circuit breaker opening

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

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

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

(c) the opening must be through shunt trip release. The release must operate with a supply voltage between 87.5 V and 137.5 V DC;

(d) each circuit breaker pole must have two independent trip coils and must have a provision for two separate auxiliary supplies for the two trip circuits. Rated voltage for the trip coils must be 125 V DC with an operating range of 87.5 V to 137.5 V DC; and

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

3.1.1 Contacts

The contacts must be adjustable and replaceable. Main contacts must have ample surface area and contact pressure for carrying rated current and the short time rated current of the circuit breaker without excessive temperature rise.

3.1.2 Arc quenching and monitoring

Circuit breakers must:

(f) have an SF_6 gas arc extinction medium;

(g) use a puffer type mechanism or equivalent for arc quenching;

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

(i) be fitted with a mechanism indicating contact erosion; and

(j) have suitable absorbing devices that remove decomposition products from the current interruption process.

3.1.1 Circuit breaker operation

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

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

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

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

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

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

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

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

(e) allowance for connection of external closing in the local closing circuit must be provided. Such provisions will be limited to providing connections on the terminal block;

(f) two spare NC contacts each for both local, remote and off status must be provided for remote annunciation and signalling of the status of the local-remote-off selector switch;

(g) at least two spare contacts must be provided for each switch, relay and contactor;

(h) be provided with at least 6 normally open (NO) and 6 NC auxiliary contacts to indicate circuit breaker status for TasNetworks' use; and

(i) be provided with an anti-pumping device.

3.1.1 Requirements from SF_6 gas and associated devices

The following requirements apply to SF_6 gas and associated devices:

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

(b) gas quality must not be inferior to the recommendations of the Supplier of SF6 gas;

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

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

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

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

  (i) Dew Point < - 40 ◦C at 101 kPa

  (ii) Purity > 98 per cent

  (iii) Contamination < 1 ppm decomposition products

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

(h) duplicate gas density monitors, one analogue and the other digital must be fitted, complete with the necessary gas filling attachments. The gas density meter (monitoring instrument) must be placed in the local operation and control panel supplied with the equipment;

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

(j) Each gas density monitor must have a separate gas interface and a readily visible contact wired to provide a low gas pressure alarm. Digital gas density monitors must be suitable for connection to the SCADA system (4-20mA output transducer) for the purpose of trend analysis;

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

(l) the contacts must be potential free clean contacts, capable of making and breaking DC indication circuits from 87.5 V to 137.5 V DC for remote signalling;

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

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

(o) topping of the SF_6 gas must be possible with the circuit breaker in service. All hardware, external accessories and procedures necessary for filling gas in the equipment must be supplied. The filling valves supplied must allow connection to either a DN8 or DN20 fitting manufactured by DILO;

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

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

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

(s) be suitable absorbing devices must be provided to remove decomposition products from arcing in the gas.

3.1 Secondary design requirements

3.1.1 Indications

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

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

3.1.1.1 Mechanical indications

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

(a) open and close state of the circuit breaker. The indicator must be positioned external to the mechanism enclosure and marked "I" (red background) - closed; "O" (green background) – open;

(b) spring charged and discharged state for closing spring. The indicator must be marked "Charged" and "Free" for each spring charging mechanism; and

(c) gas density via a monitor located inside the control and operating cubicle.

3.1.1.1 Electrical indications

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

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

(b) spring charged for closing spring;

(c) gas density alarm and lockout stage;

(d) trip circuit unhealthy;

(e) close circuit unhealthy;

(f) AC/DC circuit MCB trip; and

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

3.1.1 Interlocking

The circuit breaker shall have:

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

(b) interlocks must ensure a correct operating sequence has to be followed for electrical system security and integrity.

(c) all mechanical interlock devices must be direct acting; and

(d) the circuit breaker must be prevented from closing if the opening spring is not charged.

3.1.1 Local control and operating cubicles

3.1.1.1 Construction

(a) Local control and operating cubicles must:

(b) be of a lockable type, constructed from high quality stainless steel (minimum grade 304) sheet metal panels of sufficient thickness and bracing to provide torsional rigidity;

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

(d) be weather, vermin and dust proof. They must have provisions to avoid formation of water pools;

(e) have a degree of protection to IP 55;

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

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

(h) be positioned to ensure safe access while the circuit breaker is in operation;

(i) contain and utilise suitably rated miniature circuit breakers (MCBs) to protect spring wound motors, space heaters, internal lighting and associated wiring.

(j) have a minimum of eight normally open (NO) and eight normally closed (NC) adjustable spare contacts for circuit breaker status, suitable for DC operation between 87.5 V and 137.5 V;

(k) have illumination lamps, specifically a single-phase 230 V AC florescent or LED light must be provided. The power supply circuits for the illumination lamp in the three operating mechanism's (one per pole of a live tank circuit breaker) and local control cubicle must be arranged such that it is possible to isolate them at one common point in the control cubicle;

(l) a 10 A single-phase 230 V AC outlet with switches and protective covers on the outside of the cabinet.

(m) have thermostatically controlled space heaters with cut-off control switches to prevent moisture condensation. The heaters and thermostats must be:

  (i) suitable for single phase 230 V, 50 Hz AC system operation;
  (ii) rated to withstand temperatures of 100 °C;
  (iii) capable of continuous service for the entire life of the circuit breaker;
  (iv) easily accessible and easily replaceable; and
  (v) supplied with appropriate settings and a recommended settings sheet for each installed heater and thermostat combination.

3.1.1.1 Layout of equipment

The layout of apparatus in the control and operating cubicle must facilitate ease in workability without the need to take the circuit breaker out of service. Specifically:

(a) Maintenance and inspection work and connection checks must be possible without the need to dismantle any apparatus or having to take the circuit breaker out of service; and

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

3.1.1.1 Auxiliary switches

Auxiliary switches must:

(a) have a positive wiping action on closing and be capable of making, breaking and continuously carrying currents of 5 A at 125 V DC or 240 V AC;

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

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

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

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

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

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

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

3.1.1.1 Secondary wiring and terminals

(a) All devices must be wired to terminal blocks.

(b) Unless otherwise approved by TasNetworks in writing, secondary wiring must:

- (i) use the following colour code:
  - (ii) AC phases – Red, White and Blue;
  - (iii) Neutral and unspecified cores – Black;
  - (iv) DC – Grey; and
  - (v) Earth – Green/Yellow.
  - (vi) be brought out through a hermetically sealed barrier and terminated in the marshalling/termination cubicles. The control cubicle may act as a marshalling and termination cubicle;
  - (vii) be carried out in not less than 0.6/1.0 kV grade, oil resistant and weatherproof PVC insulated cables;
  - (viii) be provided with red ferrules marked "TRIP" where circuits are associated with a tripping circuit;
  - (ix) not be jointed or teed between terminal points and must not be clamped directly under screws; and
  - (x) be heat resistant where they are connected to, or in close proximity to, space heaters.

(c) Terminals must be:

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

(d) Terminal blocks must:

- (i) utilise slide-disconnect terminals comprised of 'Klippon' Weidmuller type SAKT1-4379.2, Phoenix type URTK/S-BEN or equivalent;
  - (ii) have a separator plate between the phase and neutral terminals (in case of AC) and positive and negative terminals (in case of DC);
  - (iii) contain a minimum of 50 spare terminals in the control and operating cubicle and minimum 25 spare terminals in each marshalling panel.

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

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

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

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

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

4 Dead tank circuit breaker design requirements

This section details specific requirements for dead tank circuit breakers.

4.1 Primary design requirements

Dead tank circuit breakers (DTCBs) must:

(a) be provided with integral current transformers; and

(b) be formed, essentially as detailed in project specification, by

  i a set of three independent poles operated on a common gang; or

  ii a set of three independent poles operated individually.

(c) If comprise a set of three independent poles operated individually must:

  i be suitable for high speed, single phase, multiple shot auto-reclose operation;

  ii have separate operating mechanisms including independent spring charging motors and associated secondary circuits;

  iii have the ability to support controlled (point-on-wave) switching, if stated as a requirement in the project specifications;

  iv have a common mechanical gas density monitor that covers all poles; and

  v have a closing mechanism that:

    (i) has one DC closing coil per pole with a rated normal voltage of 125 V DC. The closing release must be a shunt operated type with an operating range of 87.5 V to 137.5 V; and

    (ii) has separate starting circuits (and all other elements including the spring charging motor) for each of the three poles of the circuit breaker.

4.1 Integrated current transformers

(a) integrated current transformers must:

  (i) be identical for each phase;

  (ii) be located externally on the circuit breaker bushing turrets and arranged with one metering core and two protection cores on each side of the circuit breaker interrupting unit.

  (iii) be rated at the maximum permissible continuous current through the circuit breaker and the short-time current and short-time withstand capability of the circuit breaker; and

  (iv) have secondary wiring that is wired directly to terminals in the control panel cubicle and clearly labelled for identification.

  (v) be able to be removed for maintenance/replacement etc., without removing the bushings.

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

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

(d) Fixed voltage limiting device(s) set to operate at no greater than 4.5 kV peak or 1.5 times the highest knee point in the highest tap whichever is greater must be fitted across the secondary terminals of the protection core(s). The device must be fitted with a protective cover and be mounted in the same terminal box as used for current transformer output terminations. The measurement current transformer core must provide some protection to secondary equipment by saturating under primary system fault conditions.

(e) Markings on the current transformers must be in accordance with AS 60044.1

(f) The current transformer primary terminal marking shall be shown on the physical outline or layout drawings as well as on schematics and wiring diagrams, and be marked in accordance with AS 60044.1

(g) The current transformer must be designed to allow the primary winding to carry the rated current whilst the secondary winding is open circuited. Where fixed voltage limiting devices are required to facilitate this, they must be positioned at the secondary terminals of the current transformer and allow access with the primary connections energised. A report must be provided to TasNetworks highlighting the absence or presence of the secondary voltage limiting devices in the current transformer secondaries.

4.1.1 Current transformer performance requirements

The required current transformer parameters and performance are detailed below:

(a) service conditions for current transformers are as specified in Table 1.

(b) required parameters for current transformers for dead tank circuit breakers (DTCBs) are mentioned in Table 2.

(c) required performance for individual cores of current transformers are specified in Table 3 and Table 4.

Table 2 Specific parameters for current transformers in DTCBs

Sr. No.	Parameter	Unit	Value
1.	Rated secondary current	A	1
2.	Number of protection cores per phase	-	Four (4)
3.	Number of metering cores per phase	-	Two (2) (Note 4)
4.	Order of cores assembly 1-2-3-X-4-5-6, where; P= protection, M = metering, X = circuit breaker		P-P-M-X-M-P-P
5.	Rated transformation ratio for all cores	A	1500/1200/1000/750/(400)-1
6.	Rated secondary thermal limit current for each secondary core (at any tapped winding)	A	2.0
7.	Rated short times thermal current (for any tapped winding) (I_{th})	A	As per the continuous rating of the circuit breaker
8.	Rated dynamic withstand current (I_{dyn})	kA_{rms}	As per the circuit breaker rating
9.	Rated short time withstand time	s	As per the circuit breaker rating
10.	Rated continuous thermal current	kA_{rms}	As per the circuit breaker rating

Table 3 Standard performance parameters for CT protection cores

Sr. No.	Parameter	Value

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

Table 4 Standard performance parameters for CT metering core

Sr. No.	Parameter	Value
1.	Duty	Metering
2.	Performance designation	0.5M @ 750/1 tap (Note 1)
3.	Rated output	25 VA (750/1 tap @ 110 kV and 400/1 tap @ 220 kV) (Note 2)
4.	Instrument security factor (FS)	≤10 (Note 3)

Notes:

1. Performance designations for principal taps (ie. 1500, 1200, 1000 and 750) must be Class 0.5M. Routine tests for accuracy must be provided for all principal taps. Routine tests for accuracy must be carried out for the intermediate taps for each current transformer. All test results and certificates must be forwarded to TasNetworks for approval.
2. Rated output at other ratios must be proportional.
3. Ratio and Phase angle error must be the same as at 100% primary current.
4. Second metering core added for revenue metering purpose, eg. Renewable generation to prevent need for separate free standing CVCT unit.

4.1.1 Current transformer secondary circuit requirements

(a) The nominal secondary rating of all current transformers shall be 1 A.

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

(c) All secondary instruments must be connected to the same current transformer ratios unless otherwise required from protection and metering circuits. Where it is proposed to apply different ratios for different cores, approval must be obtained from TasNetworks.

(d) Secondary circuit must have polarity marking xS1, xS2, xS3 and so on. Test taps must have polarity markings xST1, xST2 (where “x” represents the core number).

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

    (i) For normal protection schemes S1 must be the star point;

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

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

(g) Current transformer wiring must be brought to separate test terminals. It must be possible to conduct tests on the current transformer secondary circuits without disturbing (removing) the primary connections.

(h) The wiring must be arranged such that it is possible to reconnect the current transformer secondary to a delta configuration by altering the connections at the terminal blocks.

(i) The local marshalling and termination cubicle of the DTCBs operating mechanism must be used for current transformer connections. However, all current transformer secondary wiring connections must be separately grouped and fitted with an identification label to indicate function.

(j) Wherever practical, individual current transformer terminal circuits must be grouped based on the unit connected and covered with a clip-on transparent cover.

(k) All devices must be wired to the terminal blocks.

(l) Where a multiple-core multiple-ratio current transformer is supplied, wiring of each individual core must be separated in bundles and must be suitably labelled to indicate connections at each ratio.

4.1.1 Measurement current transformers

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

4.1.2 Protection current transformers

The following must be submitted to TasNetworks for protection current transformers:

(a) for class PX:

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

(ii) all other details as listed below.

(b) For class PR:

(i) Characteristics as stated in the project specifications.

5 Live tank circuit breaker design requirements

This section details specific design requirements for live tank circuit breakers.

5.1 Primary design requirements

Live tank circuit breakers must:

(a) comprise a set of three independent poles;

(b) be suitable for high speed, single phase, multiple shot auto-reclose operation;

(c) have separate operating mechanisms including independent spring charging motors and associated secondary circuits;

(d) have the ability to support controlled (point-on-wave) switching, if stated as a requirement in the project specifications;

(e) have a mechanical gas density monitor for each of the three poles; and

(f) have a closing mechanism that:

  (ii) has one DC closing coil per pole with a rated normal voltage of 125 V DC. The closing release must be a shunt operated type with an operating range of 87.5 V to 137.5 V; and

  (iii) has separate starting circuits (and all other elements including the spring charging motor) for each of the three poles of the circuit breaker.

6 Other requirements

6.1 General construction

All equipment associated with the circuit breaker assembly must be designed to avoid pockets in which water can collect.

Lifting lugs must be provided for each circuit breaker and any of its components having a mass in excess of 50 kg that are likely to be handled separately.

6.2 Support structures

Support structures provided for the circuit breaker must:

(a) be galvanized steel;

(b) conform to relevant Australian Standards for steel structures and welding; and

(c) be supplied with design information for on-site civil requirements to facilitate the installation of the circuit breaker and its associated accessories.

6.1 Earthing

Earthing for all equipment and supports must comply with the following:

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

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

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

(d) dedicated earthing flags, earthing plates or similar prefabricated earthing points must be provided and be suitable for connecting 40mm x 3mm copper earthing strip using, as a minimum, 2 x 13 mm stainless steel bolts. The earth connection points must be made of brass, galvanised steel, or stainless steel welded to the structure. On site drilling of the equipment casing or other installation structure for earth bonding connection will not be permitted;

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

(f) two earth connection points must be provided at diagonally opposite points of its support structure.

6.1.1 Special tools

The following special tools must be provided:

(a) one operating handle for the hand charging the spring operated mechanism; and

(b) one set of special tools to enable slow manual closing or opening.

6.1.1 Documentation requirements

The following documentation must be provided and the requirements observed:

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

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

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

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

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

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

(g) only information relevant to the particular type of circuit breaker supplied shall be shown in the documentation and drawings.

6.1.1 Nameplates

(a) The circuit breaker(s) and operating mechanism(s) must be provided with nameplates, which are:

  (i) in the English language;

  (ii) permanently and indelibly marked;

  (iii) securely fixed in position;

  (iv) weather proof and corrosion-proof; and

  (v) made of brass, stainless steel or material of equal durability to ensure a service life of a minimum of 50 years.

(b) In addition to the requirements of Clause 5.10 of AS/NZS 62271.1, the following information must be included on the circuit breaker nameplate:

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

  (ii) description: Circuit Breaker;

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

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

  (v) rated operating sequence;

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

  (vii) rated line charging breaking current;

  (viii) rated out of phase breaking current;

  (ix) rated supply voltage of all auxiliary circuits;

  (x) rated mechanical load of terminals;

  (xi) highest voltage for equipment Um;

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

(xiii) mass of device (in kg);

(xiv) purchaser: Tasmanian Networks Pty Ltd;

(xv) purchase Order Number: refer to project specifications; and

(xvi) Current transformer details.

7 Data for Asset Management Information System

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

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

(a) Design information and maintenance regime 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.

8 Maintenance and routine test plans

The supplier must provide:

(a) a detailed maintenance plan, procedures and task guides covering the entire life of the circuit breaker;

(b) a recommended routine test plan; and

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

9 Packaging

The supplier is responsible for ensuring that adequate packaging is provided to minimize the risk of damage to equipment during delivery. The packaging must be suited to the particular methods of delivery and provide protection against damage from all foreseen hazards.

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

10 Testing

All components of the circuit breaker 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.

All test reports must be forwarded to TasNetworks for approval and acceptance. The tests will be considered as completed only after approval and acceptance of test results by TasNetworks in writing. A list of the tests to be conducted on circuit breakers is given below.

10.1 Type tests

Type tests are intended to prove the soundness of design of the circuit breaker(s) and their suitability for operation under the conditions detailed in the specifications. Type tests must be carried out before the delivery. A certified test report, detailing the results of such tests along with the procedures followed, must be provided to TasNetworks. These tests must have been applied to a circuit breaker of identical design with that offered, or on a circuit breaker of a design which does not differ from that offered in any way which might influence the properties to be confirmed by the type test.

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.

Type tests must be performed to relevant Australian Standards. Where type tests differ from the requirements under the relevant Australian Standards, the Contractor/Supplier must detail and submit a list of non-conformances to TasNetworks for consideration.

10.2 Routine tests

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.

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.

Routine test results and certificates must be submitted to TasNetworks for approval and acceptance. Routine tests will be considered as completed only after TasNetworks approves and accepts the test results.

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

11 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document R586380.

12 Deliverables

Requirements for circuit breaker deliverables are outlined in document R586378.

13 Hold points

The requirement of documentation is listed in the deliverable schedule in document R586378.

The hold points for circuit breakers include:

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

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

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

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

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

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

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

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

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