Standard

Network Transformer Standard

R527893

Version 1.0, June 2018

Authorisations

Action	Name and title	Date
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Review cycle	30 months	

Responsibilities

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

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

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

Minimum Requirements

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

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

Record of revisions

Section number	Details
Entire doc	Copied over verbatim from superseded Transend D03/12415 to TasNetworks template. Updated Transend to TasNetworks document reference numbers where known including Australia Standards.
Authorisations	Review cycle changed from 24 months to 30 months.
5.2.1	Added hand rails.
9.4 (f) (iv)	Added 4-20 mA output
12.1.1 12.1.2	Removed reference to DRMCC device. Added detail for clarity of requirements
12.1.3.a(iv)	Added 4-20 mA output.
13.1 (h)	Added option of use of LED light
13.1	In final sentence added (if fitted) to need for glass in doors.
17.2	Routine test sequence altered.

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1 General

1.1 Purpose

The purpose of this standard is to define the requirements for network transformers under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks').

1.2 Scope

This standard applies to all network transformers 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 network transformers 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 Code are met;

(c) personnel and public safety;

(d) ease in operation and maintenance;

(e) reliability and continuity of electricity supply;

(f) that the requirements of TasNetworks' business plan are met;

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

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

1.1 Certificate of conformance

(a) Before any new and/or modified network transformer 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 form for certificate of conformance, to be completed by the Contractor.

(c) The network transformer will be put in service 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 and does not deviate 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 approved 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

Surge Arrester Standard	R522696
Extra High Voltage System Standard	R565983
Network Transformers information to be provided with Tender	R527895
Network Transformers Deliverables	R527894
General Substation Requirements Standard	R522687
Testing, Commissioning and Training Standard	R246497
Insulating Oil for Transformers and Switchgear Standard	R517371
HV and LV Cable Systems Standard	R590630
High Voltage System Standard	R565983
Substation Lightning Protection and Earthing Standard	R522692
Asset Nomenclature Standard	R684808

1.3.2 Other Standards

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
Industrial fall-arrest systems and devices, Part 4: Selection, use and maintenance	AS 1891.4
Degrees of protection provided by enclosures for electrical equipment (IP code)	AS 60529
Switchgear assemblies & ancillary equipment for alternating voltages above 1 kV	AS 2067
On-Load Tap Changers – Part 1 and 2	AS 60214
Power transformers	AS/NZS 60076

High voltage switchgear and control gear, Part 301: Dimensional standardization of terminals	AS 62271.301
Hot-dip galvanised (zinc) coatings on fabricated ferrous articles	AS 4680
Instrument transformers – Part 1: Current transformers	AS 60044.1

2 Network transformer design

2.1 General design requirements

Materials and components must be selected to ensure safe and reliable operation for at least 50 years, with minimum inspection and maintenance.

The transformers must be designed to:

(a) withstand the forces and stresses associated with lifting, jacking, transport and erection so that there must be no cracks in the welds, leakage from or permanent deformation to any part of the transformer due to such forces and stresses;

(b) have adequate over-fluxing (V/f) capabilities to withstand both continuous and temporary over-voltages and under-frequency as per Table 1 Sr. No. 1.3 and 1.6;

(c) enable a sustained emergency loading as per Table 1 under a Weighted Ambient Temperature of 20◦C without exceeding both a winding hot spot temperature of 120◦C and a top oil temperature of 105◦C;

(d) be limited only by the overload capability of the windings and not the capability of any other component, such as bushing, internal cable or tap changer rating;

(e) work in parallel with one or more existing transformers, so that the transformer will not cause circulating currents where this is designed in the PPR;

(f) have sound power levels for the network transformer, complete with coolers and fans, on all ratings below the specified requirement in this standard. Consideration must be given to limiting the extent of on-site noise mitigation measures. Low noise level alternatives may be offered where they are economically available;

(g) demonstrate the incorporation of modern design, insulation processing, and control/monitoring technology;

(h) have the star point of the common windings brought out of the tank through a bushing for direct connection to earth;

(i) have the stabilising winding brought out of the tank through two separate bushings (open-delta configuration) located at one end of the tank for linking and direct connection to earth; and

(j) the rating of the transformer must be achievable with the unit enclosed by four full height walls with a minimum of 1 metre clearance between the transformer and the walls.

2.1 Specific design requirements

Network transformers comprise the auto-transformers within TasNetworks' transmission network, primarily located at the interface points between the 220 kV and 110 kV networks. Their function is to transform and regulate the voltage within the transmission network.

Specific performance requirements are stated in Table 1 of this standard and any additional criteria specific to a project will be stated in the project specifications.

Table 1 Parameters for network transformers

Sr. No.	Parameter	Unit	Network Transformer Type	
			One	Two
	Particular of the System			
1.1	Number of phases	-	3	
1.2	Frequency	Hz	50	
1.3	Normal operating frequency excursion band	Hz	48.8 to 52	
1.4	Power system frequency range	Hz	44.8 to 52	
1.5	Nominal voltage			
1.5a	– series (HV)	kV	220	
1.5b	– common (LV)	kV	110	
1.5c	– tertiary (TV) (stabilising)	kV	11 (or 22 refer note 1)	
1.6	Highest voltage			
1.6a	– series	kV	245	
1.6b	– common	kV	123	
1.6c	– tertiary	kV	12 (24 refer note 1)	
1.7	Lightning Impulse Withstand Voltage			
1.7a	– series	kVp	1050	
1.7b	– common	kVp	550	
1.7c	– neutral	kVp	150	
1.8	Power Frequency Withstand Voltage			
1.8a	– series	kV_{rms}	460	
1.8b	– common	kV_{rms}	230	
1.8c	– tertiary	kV_{rms}	50	
1.8d	– neutral	kV_{rms}	50	
	Particulars of Transformer			
1.9	Number of phases	-	3	
1.10	Type of transformer	-	Auto-connected	
1.11	Type of magnetic circuit	-	Three (3) limb, core form	
1.12	Method of cooling	-	Air cooled radiator	
1.13	Minimum ONAN rating (main windings)	MVA	150	
1.14	Maximum ONAF continuous rating (main windings)	MVA	200	240
1.15	Sustained emergency loading, as a percentage of the maximum continuous rating (ONAF)	p.u.	1.3	1.25
1.16	Minimum duration of the peak load (for sustained emergency loading)	hours	12	12
1.17	Winding connection - vector group symbol	-	YNa0(d11)	
1.18	System earthing – common winding	-	Solidly Earthed	

Sr. No.	Parameter	Unit	Network Transformer Type	
1.19	System earthing – tertiary winding	-	Solidly Earthed	
1.20	Type of insulation – series	-	Graded	
1.21	Type of insulation – common	-	Graded	
1.22	Type of insulation – tertiary	-	Fully Insulated	
1.23	Minimum short circuit withstand			
1.23a	Rated short-time current, 220 kV	kA	40	
1.23b	Rated short-time, 220 kV	s	2	
1.23c	Rated short-time current, 110 kV	kA	40	
1.23d	Rated short-time, 110 kV	S	2	
	Tappings			
1.24	Tapped winding	-	HV winding, at LV line-side terminal	
1.25	Category of voltage variation	-	CFVV	
1.26	Continuous over-voltage on any tapping at maximum continuous rating	%	10	
1.27	Mode of tap change	-	On load	
1.28	Number of tap positions	-	25	
1.29	Step value	V	2490	
1.30	Tapping range	%	+ 9.1, - 18.1	
1.31	Number of positive taps	-	8	
1.32	Number of negative taps	-	16	
1.33	Principal tap number	-	9	
	Impedance voltage HV/LV (base MVA)	MVA	200	240
1.34	Maximum ratio tap (tap 1)	%	16.6	19.9
1.34a	Principal tap (tap 9)	%	16.9	20.3
1.34b	Mid position (tap 13)	%	17.3	20.8
1.34c	Minimum ratio tap (tap 25)	%	18.5	22.2
1.35	Minimum Impedance at ONAF rating, HV/TV - (tap 9)	%	60	
1.36	Minimum Impedance at ONAF rating, LV/TV	%	36	
1.37	HV/LV Impedance voltage tolerance on principal tap	%	+/- 5	
1.38	HV/LV Impedance voltage tolerance, other tap positions	%	+/- 10	
1.39	HV/TV and LV/TV Impedance voltage tolerance	%	+/- 10	
	Bushings			
1.40	HV and LV bushing arrangement	-	A – B – C from left to right, viewed from HV side	

Sr. No.	Parameter	Unit	Network Transformer Type
1.41	HV bushing type	-	ABB bushing type GSB 245
1.41a	Current rating, including conductor & palm terminal	A	1600, continuous
1.42	LV bushing type	-	ABB bushing type GSA 123
1.42a	Current rating, including conductor & palm terminal	A	1600, continuous
1.43	Neutral bushing type	-	Webster-Wilkinson type B4964-122M
1.44	Preferred TV bushing type	-	Identical to Neutral bushing
1.45	TV and neutral bushing arrangement	-	At left hand end of LV side, viewed from HV side
1.46	Palm terminal, TV and neutral bushing	-	Type 8, AS 62271.301
1.47	Pollution class	-	Heavily polluted atmosphere
1.48	Creepage distance	mm/kV	25
1.49	Bushing colour	-	Silver Grey
	Surge Arresters		
1.5	HV arrester type	-	ABB PEXLIM Q192-XH245
1.51	LV arrester type	-	ABB PEXLIM R096-XH123
1.52	Bushing colour	-	Silver Grey
	Cooling Equipment Location		
1.53	Radiators Note: Refer to project specifications for radiator bank location, dependent on site physical constraints and transformer cooling requirements. If specified, radiators may also be separate, free standing, at left hand end only, viewed from HV side.	-	Separate, free standing, at both ends.
1.54	Fans Note: Refer to project specifications for fan location.	-	LV side only, or HV side only, of radiator bank
1.55	Main Conservator	-	Above radiator bank, at left hand end only, viewed from HV side
	Sound Level		
1.56	Method of measurement	-	In accordance with AS 60076
1.57	Maximum permissible value for transformer, complete with coolers and fans on all ratings	dBA	In accordance with the reduced limit of Figure AA1 of AS 60076.6
	Current Transformers		
1.58	HV side, metering & protection	-	Not required
1.59	LV side, metering & protection	-	Not required

Sr. No.	Parameter	Unit	Network Transformer Type
1.60	CT1 on series winding, winding temperature, internal		To be specified by manufacturer
1.61	CT2 on common winding, winding temperature, internal	-	To be specified by manufacturer
1.62	CT3, 4 & 5 (3 toroids) – neutral end of each phase common winding, differential protection, internal (i) ratio (ii) performance designation (where Rs = secondary winding resistance in ohms at the maximum service temperature)		1500/1200/1000/750/1 I_e PX 100 E_k R R_{ct} @1500/1 where I_e = 0.1 and $E_k = (R_{ct} + 2)$
1.63	CT6 – neutral, earth fault protection, external	-	As per CT3
1.64	CT7 – tertiary, earth fault protection, external	-	As per CT3
1.65	Rated secondary thermal limit current for each core	A	2.0
	Cost of losses for the purpose of tender evaluation		
1.66	No-load losses at 100% excitation	$/kW	23,500
1.67	Load losses on principal tap position and at continuous maximum rating	$/kW	2,200
1.68	Cooler losses	$/kW	2,200

Note 1: When a loaded tertiary winding is specified in the Principals Project Requirements (PPR), the system voltage shall be 24 kV. If the tertiary is to be left unloaded and earthed at a single corner, the system voltage shall be 12 kV.

3 Current transformers

Where current transformers are specified they shall meet the following requirements:

(a) internally mounted current transformers must be removable without disturbing the main tank cover or lowering the oil in the main tank below the top of the windings;

(b) externally mounted neutral and tertiary current transformers will be cast-resin toroidal type, with a minimum of 100 mm inner diameter. Brackets suitable for mounting the neutral and tertiary current transformer shall be provided, welded on the left-hand end of LV side, viewed from HV side of the transformer tank. These brackets shall be free from obstruction to allow the CT's to be easily accessible for inspection and maintenance;

(c) current transformers must conform to AS 60044.1;

(d) the short circuit rating of the current transformers must be as a minimum, the same as that for the high voltage system;

(e) the specified performance of the current transformer shall be obtained without recourse to compensating devices;

(f) a fixed voltage-limiting device set to operate at no greater than 4.5 kV shall be fitted across the secondary terminals of protection class current transformers. This device shall be fitted with a protective cover and be mounted on a terminal strip within the transformer marshalling cubicle;

(g) bushing, toroidal or bar type current transformers shall be indelibly marked with the serial number and shall be marked to clearly indicate the polarity of the virtual primary terminals;

(h) primary terminal P1 shall be located adjacent to the neutral bushing for internal neutral current transformers. Primary terminal P1 shall be located remote from the transformer bushing for externally mounted neutral and tertiary current transformers;

(i) each tapping shall be connected to an individual terminal within the transformer marshalling cubicle. Multiple ratio current transformers shall be obtained only from tappings on the secondary winding; and

(j) duplicate rating plates for externally mounted neutral and tertiary current transformers shall be mounted adjacent to the main rating plate.

4 Core and windings

All materials used within the network transformer tank must be suitable for use in the specified service conditions.

4.1 Core and coils assembly requirements

Core form transformers are required and must meet the following criteria:

(a) under normal operation, the temperature of any part of the core, coils or their support structure in contact with oil must not exceed 105°C and under the most extreme operating conditions the temperature of these parts must not exceed 120°C;

(b) the core and insulation structure and earthing systems must be designed to avoid thermal deterioration and breakdown of insulated parts due to temperatures and voltages caused by circulating eddy currents and stray-flux heating;

(c) to reduce no-load loss, current and noise level, cores must have 45◦ mitred corners and must not have bolts passing through the legs or yokes. The steel used in the core must be grain-oriented cold-rolled silicon steel, preferably domain-refined. Cores must be adequately clamped to withstand forces during lifting, transport and short circuits. The core and winding support structure must be of solid steel construction. Wood sections for the frame are not acceptable;

(d) internal earthing connections from the core laminations and core frame must be brought out to separate bushings suitable for insulation test with 2.5 kV dc. The bushings must be suitably rated to carry the prospective fault current and be housed in a secured air insulated weatherproof terminal box mounted on the tank surface. Each bushing must be earthed via a removable link and arranged such that this point is the only connection for earthing the core and frame; and

(e) the transformer (at any tapping position) must be capable of withstanding, without deformation or damage, the thermal and mechanical effects of external short circuits with fault currents that may arise from any type of fault and with full voltage maintained on all windings (zero source impedance). Calculation of short circuit currents and current densities, and finite element calculation of short circuit forces and stresses in windings and end supports, for all fault types, and for principal and extreme tapping positions, must be carried out and be made available at the time specified within the Deliverables document.

4.1 Windings

Windings shall be made of high grade electrolytic copper only and insulated with thermally upgraded paper, where paper insulation is required. The windings shall meet the following requirements:

(a) windings and their connections must be of robust, self-supporting design and construction, sufficient to withstand forces occurring during normal manufacture, transport, installation and service, and also to withstand internal and external short circuits. This includes tertiary winding faults. Reactors must not be used in the tertiary winding circuit for the purposes of short circuit withstand without the prior approval of TasNetworks;

(b) directed oil flow through the windings must be achieved by use of baffles, oil ducts and washers;

(c) where continuously transposed cable (CTC), multi-strand cables or enamel coated strands are used, their individual strands must not make inadvertent electrical contact. This condition must be verified before completing the winding ends and with the windings under pressure by the application of 500V DC between each and every strand in a common covering. Evidence of this test shall be included in the transformer test report;

(d) soft soldering must not be used for joining or connecting leads. Joints may be silver soldered, brazed or welded. Bolted joints carrying current must use 'Belleville' or similar washers to maintain contact pressure. The use of crimped joints is subject to the approval of TasNetworks. The manufacturer should ensure that all joints are performed correctly and reinsulated in such a way as to avoid the entrapment of air which may lead to the evolution of partial discharge. The Manufacturer must record the details of each jointing operation. The Tenderer must specify the type of joints to be used;

(e) the final compression and inspection of windings must be carried out after oil impregnation; and

(f) laminated wood sections shall not be used either within the windings or as a part of the winding support structures.

4.1.1 Requirements for loaded tertiary windings

TasNetworks does not normally require that the tertiary winding is brought out through bushings for the purposes of carrying load. Where the ability to load the tertiary winding is required this shall be stated in the PPR. When required the following points refer specifically to the tertiary winding:

(a) the current carrying capacity of the winding shall be no less than one-third the equivalent two winding rating of the transformer (the nameplate rating of the transformer shall be stated in the PPR);

(b) the winding shall be nominally rated at 22 kV, with an impulse withstand level of 150 kVp and an AC insulation level not less than 50 kV;

(c) the winding shall be self-supporting under all short circuit conditions without the use of current limiting devices, such as reactors, to achieve the required short circuit withstand; and

(d) the windings shall be brought out through bushings, rated at not less than 36 kV and 2500A, at one end of the main tank and the bushings and connections shall be arranged such that the bushings can be mounted either on the transformer lid or on the end wall in an air insulated cable box. Refer to TasNetworks' Supply Transformer Standard, R527890 for specific requirements relating to cable boxes.

4.1.1 Paper samples for use of life monitoring

The Manufacturer must provide three sets of paper samples for 'use of life' monitoring, degree of polymerisation (DP) testing. Each sample must be made up of a strip of transformer board covered by five layers of paper tape. The transformer board strip must be approximately 250 mm long and of the same make and type as used on spacer strips within the windings. The paper must be recovered from surplus conductors of the type used in the winding, re-taped onto the transformer board strip.

The paper samples must accompany the winding coils during the coil pre-dry out (sizing/stabilisation) and be fitted on the transformer prior to the dry out procedure. On final tanking they must be mounted near the top of the tank, accessible from a suitably located access cover. The access cover must be indicated on the outline drawing and have a suitable label attached to it.

The location of the board shall be such that the lid of the transformer shall not need to be disturbed or the oil lowered below the top of the windings in order to remove a paper sample.

Before the transformer is disassembled for transportation and immediately after the completion of factory acceptance testing, one paper sample must be taken for DP testing. The DP value after drying should not normally be less than 1000. Measurement significantly below this figure (>10%) shall be brought to the attention of TasNetworks and require explanation.

5 Tank requirements

5.1 Tank design requirements

The tank must be designed to minimise the heating caused by circulating eddy currents. The tank design must prevent onerous temperatures arising at any part of the tank surface and at flanges between parts of the tank and its components especially at gasket-sealed joints. High temperature gaskets must be used where required for reliable service or where specifically requested by TasNetworks.

5.2 Tank construction requirements

5.2.1 General

The tank must be constructed of welded steel plate and conform to relevant Australian Standards for steel structures and welding. The tank must be suitably reinforced to withstand transport, handling or the excess pressure during fault conditions, without distortion. The tank, conservator and large oil pipes must be fully welded internally and externally. The main flange must be fully welded. Bell type tanks are not permissible.

The network transformer tank must be free of burrs, sharp edges and weld slag. All bolt holes must align without inducing strain due to lack of fit or display any evidence of the need to enlarge holes to fit. Bolted joints shall be match-marked at the factory.

The network transformer tank must be free of external pockets to prevent collection of water.

The tank cover must be designed with sufficient slope to properly shed water. It must also be designed and provided with a non-slip surface to facilitate personnel working on top of the unit.

Attachment points must be provided on the tank to position and tie off a ladder (x two2) and to attach personal fall arrest devices (x three) to facilitate personnel working on top of the tank. Attachment points for ladders must be located at each end of the transformer. One attachment point for a personal fall arrest device must be located at the centre top of the cover and the other attachment points for personal fall arrest devices must be located adjacent to each ladder attachment point. The attachment points for personal fall arrest devices must comprise eye-bolts or rings of minimum internal diameter 50 mm and 16.5 mm cross section, with a minimum load capability of 21 kN, and be designed for use with snap hooks associated with inertia-reel fall arrest devices. Labels are to be securely fixed adjacent to the relevant attachment points, engraved as follows ‘LADDER ATTACHMENT POINT’ and ‘PERSONNEL ATTACHMENT POINT’, together with additional information as detailed within AS 1891.4.

Have hand rails of 1.5m high around the transformer top installed with 0.6m hinged lockable gate (opening inside) located next to the ladder attachment point. The hand rails shall be fabricated with galvanised mild steel pipes and plate. The hand rails shall be removable type to aid in transportation. The hand rails and hinged gate shall be effectively bonded to the tank.

The design and placement of lifting points, stiffeners and under-bases must prevent distortion of the core under lifting stresses, and should be free from obstruction.

"Embelton Shearflex" anti-vibration pads must be provided at the base of the tank, or equivalent pads made from oil resistant synthetic rubber that achieve a minimum of 32 dBA vibration attenuation.

The design of the magnetic circuit and tank and their individual members must be such that their natural frequencies of vibration do not coincide with, or approximate to, the frequency of the magnetic forces or their harmonics.

All studs for mounting tank fittings on the network transformer tank must be stainless steel.

Construction features must be provided where necessary to enhance safe access to the Buchholz relay, bushings, conservators and on-load tap changer (OLTC) for maintenance purposes.

Bolts, screws and nuts must be ISO metric. All bolts, nuts and washers used inside and outside the tank must be stainless steel. All bolts within the tank must be fitted with approved double nuts. Spring washers and star washers must not be used.

5.2.2 Handling facilities

Adequate handling facilities must be provided to permit movement, assembly and dismantling of the complete oil filled network transformer.

Four adequately positioned jacking pads designed to take the weight of the network transformer, complete with oil, must be provided on the tank. The jacking pads must provide clear access for the jacks and must not be blocked by any accessories or control cabling.

Each network transformer must be provided with bollard type lifting lugs suitable for lifting the network transformer completely filled with oil. The lifting lugs and attachments must be designed to allow for possible unequal lifting forces, with an adequate allowance for a safety factor. The lifting lugs should be positioned to avoid the need to remove the bushings in order to lift the transformer.

Lifting eyes must be provided for the cover of the network transformers main tank, conservator tanks, on load tap-changer, radiators and all other parts that require lifting for erection, inspection or repair.

The network transformer base must be suitably reinforced to permit lifting by crane, allow skidding of the network transformer in any direction and for hauling on skates. Easily accessible hauling eyes must be provided on all sides of the tank to allow for unobstructed skidding without the need for any haulage ropes to bend around the transformer tank or base.

5.2.3 Oil-tight joints

Only joints of proven design capable of preventing deterioration of any seal or gasket materials must be applied. Joints must operate satisfactorily under static oil-head or forced oil conditions at ambient temperature or at maximum operating temperatures.

All bolted joints at the main flange, man-holes, hand-holes and bushing openings must be provided with suitable gaskets made from oil resistant non-perishable material. The thermal performance of the material must exceed the maximum temperature attained by the metal parts in contact with the gaskets under all conditions. Screwed joints must not be used where oil tightness is required.

Where cantilever forces exist, gasket stops must be provided to prevent over-compression of gaskets.

5.2.4 Valves

Except where specifically stated, all valves must be metallic seating gate type or approved equivalent. Butterfly type valves are acceptable provided that they have been tested to withstand the head of oil pressure presented by a full conservator. Globe valves are not acceptable unless specifically called for. All valves, which would require lowering of oil in the main tank for replacement, must be of the type that permits changing the valve spindle with the valve gate in the closed position.

Valves must be positioned so that the clearance between the operating handle and adjacent fixtures is

adequate for operation and maintenance of the valve. All drain, filtering and filling valves must be of the female type, fitted with sealed flange plugs. Tapered screwed plugs are not acceptable.

All valves must be equipped with provision for locking in both the fully open and closed position.

When stripped for transport, all flanged valves must be provided with cover plates to prevent oil seepage and ingress of dirt. All transport cover plates must be retained after transformer assembly, becoming the property of TasNetworks, and be included within the transformer spare parts inventory.

Main tank filling valves must have internal oil deflectors to ensure that oil is not sprayed directly on the windings.

The main feed pipe valves for the free-standing cooler may be of an approved butterfly type except for the lower feed pipe isolating valve adjacent to the main tank which must be a metallic seating gate type. The lower feed pipe must also have a valve at the cooler end. Bore drain valves and vent plugs of 25 mm diameter must be provided on all headers and connecting pipes to permit individual draining of sections between valves where this is possible. The lower feed pipe is to be arranged to allow the retro-fit of two cooling pumps supplied as spare parts by the transformer manufacturer. All pipes must be sloped downward to drain valves to allow for complete drainage.

The transformers must be equipped with the following valves:

(a) butterfly valve for the main isolating valves for each individual detachable cooler element; and

(b) valves made of bronze or a non-ferrous equivalent to cater for the following functions:

(i) 50 mm fullway filter and drain valves at the top and bottom of the cooler bank;

(ii) 50 mm fullway filter valve at the top of the main tank;

(iii) 50 mm fullway drain valve at the lowest part of the main tank;

(iv) 25 mm fullway filter valve at the top part of the On Load Tap Changer (OLTC) tank or compartment;

(v) 50 mm fullway filter valve at the top of the main conservator;

(vi) 50 mm fullway drain valve at the bottom of the main conservator;

(vii) 50 mm fullway filter valve at the top of the OLTC conservator;

(viii) 25 mm fullway drain valve at the bottom of the OLTC conservator;

(ix) 25 mm fullway sampling valve on the main tank at the level of the bottom of windings;

(x) 12 mm BSP three way valve attached to the main drain to permit oil sampling;

(xi) 25 mm fullway drain/sampling valve at the bottom of the OLTC tank or compartment; and

(xii) 80 mm nominal bore isolating valve on each side of the Buchholz relay to allow maintenance on the relay without disturbing the transformer oil system.

(c) Valve locations, functional names and normal status must be provided on an engraved valve plate, which must be located adjacent to the network transformer rating plate. The valve plate must be non-corrodible.

5.1.1 Access openings

Network transformers must have at least two access openings on the tank cover for access to the interior without lowering the oil below the top of the core. If a separate tap-changer oil compartment is used, it must also be provided with at least one manhole on the cover.

Access openings must be provided (on the tank cover and the tank walls) to permit access for:

(a) inspection and removal of current transformers, bushing connections, tap-changer connections;

(b) manipulation of bolted links for change of connection arrangements on reconfigurable windings; and

(c) visual check of alignment or engagement of locating pins, oil ducts, internal clearances, electrical connections during detanking and tanking operations.

Each access opening must be a minimum dimension of 660 mm diameter or 660 mm x 660 mm to allow free entry. Access openings shall be fitted with a label, as follows 'ACCESS OPENING'.

All access openings must be kerbed, flanged and raised at least 40 mm above the tank surface to ensure a quality gasket area and to prevent water from entering the openings when individual covers are removed.

All covers must be designed to avoid entrapping gases generated within the transformer and be equipped with lifting lugs and prising-off bolts.

5.1 Surface preparation and coating

Metallic inside and outside surfaces, excluding radiators and fans, must be painted in accordance with the painting requirements detailed within R522687.

The surface preparation must include grit blasting to a Class 2.5 finish to AS 1627.4

The primer must comprise one coat ethyl silicate inorganic primer (Dulux zinc galv. 16 or similar) to a minimum thickness of 75 micrometers and maximum thickness of 100 micrometers.

The paint finish must comprise at least two coats Dulux exterior gloss acrylic, colour Silver Grey N24, or similar, to AS 2700

Metallic surfaces in contact with insulating oil or compound shall be prepared as above and given at least two coats of non-chipping oil resistant paint.

All internal surfaces shall be painted white in colour.

Alternative paint systems may be submitted to TasNetworks for approval. Alternative paint systems must offer a superior paint or application method.

6 Earthing

Stainless steel, grade 316 or better, earth connection points, 50 mm long x 100 mm high x 6 mm, complete with 2 x 13 mm holes at 44 mm centres, suitable for connecting copper earthing strip, size 40 mm x 6 mm, must be provided at ground level at the following locations:

(a) two corners at each end of the transformer on the HV side; and

(b) two corners of each cooler bank support structure on the HV side.

(c) Stainless steel, grade 316, earth connection points, 50 mm long x 100 mm high x 6 mm gauge, complete with 2 x 13 mm holes at 44 mm centres, suitable for connecting insulated copper cable, must be provided at ground level at the following locations:

(d) below the neutral current transformer;

(e) below the tertiary current transformer; and

(f) below each of the two surge counters.

Additional stainless steel, grade 316 or better, connection bar, 300 mm long x 50 mm high x 6 mm gauge, complete with stand-off insulators and 4 x 13 mm holes, suitable for connecting insulated copper cable from each surge arrestor to the surge counter, must be provided immediately above each surge counter.

The main tank cover, bushing turrets and any other components of the network transformer containing items connected to the power system must be effectively bonded to the tank:

(a) all metal work internal and external to the tank must be effectively earthed;

(b) circulating current loops within the earth systems are not permitted so as to avoid localised heating of the tank;

(c) an insulated 120 mm^2 copper cable shall be bolted to the neutral bushing and tertiary bushing and passed through each respective toroidal current transformer for connection to the earth connection point on the transformer base, below each current transformer. The cable shall be fitted with a high compression crimp lug at both ends, attached to stand-off insulators at 600 mm intervals and arranged with a minimum of bends and deviations;

(d) an insulated 120 mm^2 copper cable shall be bolted to each surge arrestor and connected to a termination bar immediately above each surge counter. An insulated 120^2 mm copper cable shall be bolted to each surge counter for connection to the earth connection point on the transformer base, below each surge counter. All cables shall be fitted with a high compression crimp lug at both ends, attached to stand-off insulators at 600 mm intervals and arranged with a minimum of bends and deviations; and

(e) crimp lugs used on insulated copper cable must be rated for the maximum fault current and duration.

7 Bushings

The 220 kV and 110 kV bushings must be of the outdoor oil filled condenser type as per TasNetworks' EHV System standard R565983, and be provided with a tapping for the measurement of the power factor/dielectric loss angle of its insulation. An oil level indication glass positioned for viewing from ground level must be provided on all sealed type oil filled bushings. The bushings must be capable of withstanding the maximum cantilever load stated in AS/NZS 60137. The bushings including conductor must have a current rating at least 50 per cent higher than the maximum current on any tap-position.

Where the bushings are mounted on turrets, the turrets must be fixed by nuts and bolts into a bushing opening in the tank cover. The bushing opening must be kerbed, flanged and raised at least 40 mm above the tank cover. Studs and blind holes for the bushing flange must not be used.

Two tertiary bushings and one neutral bushing must be provided, with a minimum rating of 36 kV, 2500 A. The bushings must be of the cemented flange type, not requiring toe-clamps or rings to fasten them onto the tank. The TV bushings and the neutral bushing must have the same current rating, and be from the same manufacturer and of the same type. The current rating must be no less than that of the LV bushing.

Phase and neutral bushings must have tinned copper palms and be subject to approval by TasNetworks.

A solid conductor bolted link must be provided between the two tertiary bushings. A warning label is to be fitted adjacent to the tertiary bushings, as follows 'WARNING – DO NOT ENERGISE WITHOUT THE EARTHING LINK BEING CONNECTED'.

The minimum electrical clearance, phase-to-phase, between primary and secondary terminals, phase to neutral and to earth of all terminals in air must exceed that required by AS 60076.3.1 for equipment with insulation levels as specified in Table 1.

8 Surge arresters

The transformers must be supplied with 220 kV and 110 kV surge arresters mounted on brackets directly attached to the transformer tank. Surge arresters must be of a type specified in Table 1. In addition, surge arresters must comply with requirements as in TasNetworks' Surge Arrestor standard R522696. Insulating bases must be provided and fitted. One surge counter must be provided for each set of three phase surge arresters. The surge counter must be clearly readable from ground level, at no greater than 1.1 m from the transformer base.

9 Cooling and insulation system

9.1 General requirements

Any degree of oil circulation must not create a static electrification hazard in any part of the network transformer or trip the network transformer.

Oil pipelines and flexible couplings are to be adequately secured to prevent excessive vibration.

9.2 Insulating oil

Insulating oil must comply with the requirements of TasNetworks' Insulating Oil for Transformers and Switchgear standard R517371 and must be supplied to fill the transformer to the correct oil level.

9.3 Pressure and vacuum requirements

The oil containment and circulation system, consisting of main tanks, cooling banks, conservators, valves, vital pipe-work parts and all other associated fittings and components, must be capable of withstanding, without distortion, an internal pressure of 50 kPa in excess of that required to operate the pressure relief valve.

The oil containment and circulation system must be capable of withstanding a vacuum test with a leak rate less than 10 Torr-litres per second. A vacuum of 1 Torr must be maintained for 48 hours duration without any resultant permanent deflection.

9.4 Conservator requirements

Oil expansion in any oil-filled chamber in the network transformer tank (eg. main tank, OLTC compartment) must be accommodated by the use of conservators. Conservators must conform to the requirements stated below:

(a) a separate conservator for the OLTC with both oil and air side separated from the main conservator of the network transformer must be provided;

(b) each conservator must have sufficient capacity to accommodate the change in oil volume expected in the corresponding network transformer chambers that will occur for extremes of loading conditions (range of service to the most severe overload condition specified in AS 60076.7) within the specified ambient temperature range;

(c) the volume of each conservator compartment must in no case be less than 10 per cent of the total oil volume of the corresponding tank chamber;

(d) the conservator should be filled such that under the minimum temperature conditions there is at least a 20 mm depth of oil in the conservator;

(e) each conservator must be fitted with its own oil level indicator, breather, filter/filling and drain/sampling valves, and removable end plates for inspection and maintenance. The valves must be brought down to permit safe connection of filling and sampling devices while standing at ground level with the network transformer energised; and

(f) the oil level indicator must:

  (i) be unaffected by the condition of oil within the conservators;

  (ii) have a sensing mechanism that is electrically and mechanically isolated from the indicating device; magnetic type oil level devices are acceptable;

(iii) have a set of normally open contacts for low oil level alarm;

(iv) include 4-20 mA analogue output connected to separate terminals within the power transformer control cubicle and to the current loop input of the power transformer monitoring and control unit for remote level indication;

(v) be mounted on the conservator tank at a position easily readable with the naked eye from ground level;

(vi) have a visible range of oil levels for oil temperatures from 5°C to 105°C, with calibration from 15°C to 90°C in steps of 15°C. The calibration of the scale and the operation of the contacts must be proven during the temperature rise test and calibrated to the minimum temperature attainable; and

(vii) have a minimum diameter of 250 mm and be mounted at an angle of approximately 20 degrees to the vertical.

9.1.1 Oil–Air exchange

The transformer must be provided with a conservator and air cell. These must meet the following requirements:

(a) the main oil conservator must be fitted with an air cell to prevent direct contact of the oil with the air and labelled accordingly. It must have a sump and the sump protected to cause no damage to the air cell. A relay must be fitted to detect any leakage of the cell, and initiation of the relay must raise an alarm. The alarm must be capable of being connected to the substation SCADA system;

(b) access to the conservator air cell for inspection must be made via a removable end and inspection opening cover situated at the ends of the conservator;

(c) air exchange for each conservator must be via silica gel or other equivalent breathers, sized to contain at least 1 kg desiccant per 3000 litres of oil, unless the manufacturer of the silica gel recommends a ratio lower than this. The breathers must be mounted such that the breather can be easily maintained or inspected while standing in a safe position at ground level;

(d) all silica gel breathers must be fitted with oil cup seals and the airflow directed by baffles or other means to ensure that 'channels' will not form;

(e) blue silica gel has been identified as an occupational health and safety hazard and must not be utilised. All silica gel provided must be orange or other suitable silica gel with properties similar to blue silica gel. Blue coloured silica gel of any type is not permitted; and

(f) all silica gel within any breather should be identical. Mixing of two different types of silica gel is not acceptable.

9.1 Cooling equipment

The radiators must be of robust, compact, maintenance-free design. They must be demountable with machined flanges and arranged as stated in Table 1. If panel radiators are offered they must be hot-dip galvanised with an average coating mass of at least 350 g/m^2, in accordance with AS 4680, and do not require paint.

The transformer must also be provided with a bank of cooling fans arranged as stated in Table 1 and directed such that air flow is in the horizontal direction. Arrangements with the fans blowing air in the vertical direction are not acceptable. The bank of cooling fans must be suitably sized to permit one fan to be out-of-service without any reduction in the continuous ONAF rating. The fan motors must be of the industrial weatherproof and maintenance free type with sealed long-life bearings. Fan blades must be enclosed with a guard to prevent inadvertent contact with the fan blades. The guard must provide a

minimum degree of protection to AS 60529 of IP20. The entire fan assemblies must be resistant to corrosion either by the material used or by the protective covering.

If specified, pumps must be of the axial flow type and fitted with bearing wear monitors. Pumps must not be of the centrifugal type. Pumps must have the direction of flow clearly marked on the external surface of the pump, and each pump should be matched with its own non-return valve.

10 On load tap changer and control

10.1 On load tap changer design

TasNetworks accepts tapchangers manufactured by ABB or Reinhausen only. Any tapchanger offered shall meet the following requirements:

(a) the tap changer must be an oil-immersed, in-tank, and high-speed resistor type and conform to AS 60214;

(b) the nominal current rating of the on load tap changer must exceed the sustained overload rating of the network transformer;

(c) the rating of the on load tap changer must match the short circuit capabilities of the network transformer;

(d) all switches that make, break, or divert current must be contained in a separate compartment that will permanently withstand a difference in pressure of 30 kPa to the main tank. This is so that the oil is completely isolated from that in the main network transformer tank and that any decomposition products from these switching operations must not contaminate the insulating oil of the network transformer windings. The switches must be so mounted that they can be inspected, maintained and, if necessary, removed without disturbing the main tank oil;

(e) the diverter switch compartment must be provided with separate oil drainage, filling and filtering valves, together with drainage suction tube and flanged pipe connection to enable pressure equalisation with the main tank if required during vacuuming;

(f) the design of the tapping winding and the selection of the tap-changer must be such that non-linear devices are not necessary;

(g) the variation of voltage between taps must be smooth and without disturbance of line conditions. The equipment must not cause radio interference in any position of the tap-changer, whether stationary or in motion. Operation of the selector switch(es) in the main tank space must not contribute to the generation of combustible gases in the main tank oil;

(h) the OLTC must be controllable locally and remotely. When the LOCAL/REMOTE switch at the network transformer is selected to the LOCAL mode the tap position can only be controlled locally at the tap changer control panel of the network transformer. With the REMOTE mode selected, the tap position may be controlled remotely by the substation SCADA system or by the voltage regulating relay (voltage regulating relay requirements listed in R565983). The tap changer must be designed to accept a dry clean contact output from the SCADA and voltage regulation relay. There must be an additional set of contract provided for the purpose of local/remote indication;

(i) the OLTC system must include a dc operated tap position transducer with 4-20 mA analogue output connected to separate terminals within the network transformer control cubicle and to the current loop input of the network transformer monitoring and control unit for remote tap position indication. The transducer must function properly and indicate correctly the tap position even under substation blackout conditions;

(j) tap changer control scheme must use 240 V ac power supply, with a 110 V ac operating voltage with centre tap earthed to provide 2 x 55 V with respect to earth;

(k) the tap-changer motor and brake must be rated for a 3 phase 415 V ac, 50 Hz supply.

(l) a tap-changer surge relay or over-pressure switch (if that is the tap-changer manufacturer's standard form of protection) must be provided for every tap-changer diverter compartment in accordance with the tap-changer manufacturer's recommendations. The device must be fitted with two sets of normally open, voltage free (trip) contacts; and

(m) consideration must be given towards limiting maintenance and alternatives may be offered where they are economically available, such as vacuum contacts for diverter switch, or online oil filters.

10.1 On load tap changer control cubicle

A local tap change control cubicle must be provided on the network transformer and house, as a minimum, the equipment listed below:

(a) a counter, visible at ground level without opening the cubicle door, to register the number of tap changes made;

(b) tap position indicator, visible at ground level without opening the cubicle door;

(c) position range indicators on the local tap position indicator to show the maximum and minimum positions reached during operation, with reset facility;

(d) a detachable, manual handle for operation of the tap changer. While manual tap change is being undertaken it must disable electrical operation;

(e) raise and lower push buttons for manual electrical operation, which, once being pressed, must seal in the motor supply until one step is completed;

(f) limit switches and mechanical stop or other approved device to prevent over-running of the tap change mechanism;

(g) an over-current lockout device to block tap-changer operation when the current through the tap-changer is greater than 1.2 * OLTC nominal current;

(h) remote/local control changeover switch;

(i) terminal blocks and other associated accessories to facilitate full testing and monitoring facilities. A minimum of 10 per cent spare terminals must be provided above that normally required for external wiring;

(j) consideration must be given towards limiting maintenance and alternatives may be offered where they are economically available, such as, motor drive monitoring devices; and

(k) have a minimum degree of protection equivalent to IP55.

11 Network transformer mechanical protection devices

Network transformers must be fitted with Buchholz relays and pressure release valves.

11.1 Buchholz relay requirements

A Buchholz relay is required on the main tank and should meet the following requirements:

(a) a Buchholz relay must be provided between the main tank and its conservator compartment. There shall be isolating valves located between the relay and the main tank and between the relay and the conservator to allow the relay to be removed without the need to drain any oil;

(b) Buchholz and surge relays must not operate inadvertently under any combination of pump start-up and run or in the event of loss or restoration of the auxiliary supply;

(c) the transformer must be supplied with a tested relay that is preset at an oil flow setting not less than 25 per cent higher than that which successfully passes the Buchholz stability test.

(d) One set of normally open contacts must be provided for the gas actuated element for alarm, and two sets of normally open contacts for the surge actuated element for indication and tripping of extra high voltage circuit breakers;

(e) any bushing turrets or pockets where gas may collect must have bleed pipework to ensure all gas reports to the Buchholz relay. Such pipework must rise all the way to the relay with a minimum slope of 2 degrees. Horizontal or downward slope will not be acceptable. The strength of the pipework must be such that a point load of 1000 N may be supported without permanent deformation;

(f) a pipe must be brought down from the Buchholz relay to a gas receiver chamber accessible at ground level and fitted with an inspection window and gas sampling cock. An isolating valve must be fitted immediately above the receiver for isolation; and

(g) a mechanical testing facility must be incorporated. Air injection facility will not be acceptable for the Buchholz relay, as a gas detection relay is fitted to the conservator.

11.1 Pressure relief requirements

A pressure relief valve must be provided and meet the following requirements:

(a) at least two approved, spring operated self resetting pressure relief valves must be located on the network transformer tank main compartment at diagonally opposite sides of the tank. The operating pressure must suit the designed pressure withstand requirements;

(b) the devices must be fitted on the tank wall complete with a baffle to deflect the oil downward within the bunded area and away from the locations where the operator will normally approach for inspection;

(c) a pin or flag indicator must be provided at each device clearly visible at ground level to indicate operation of each device; and

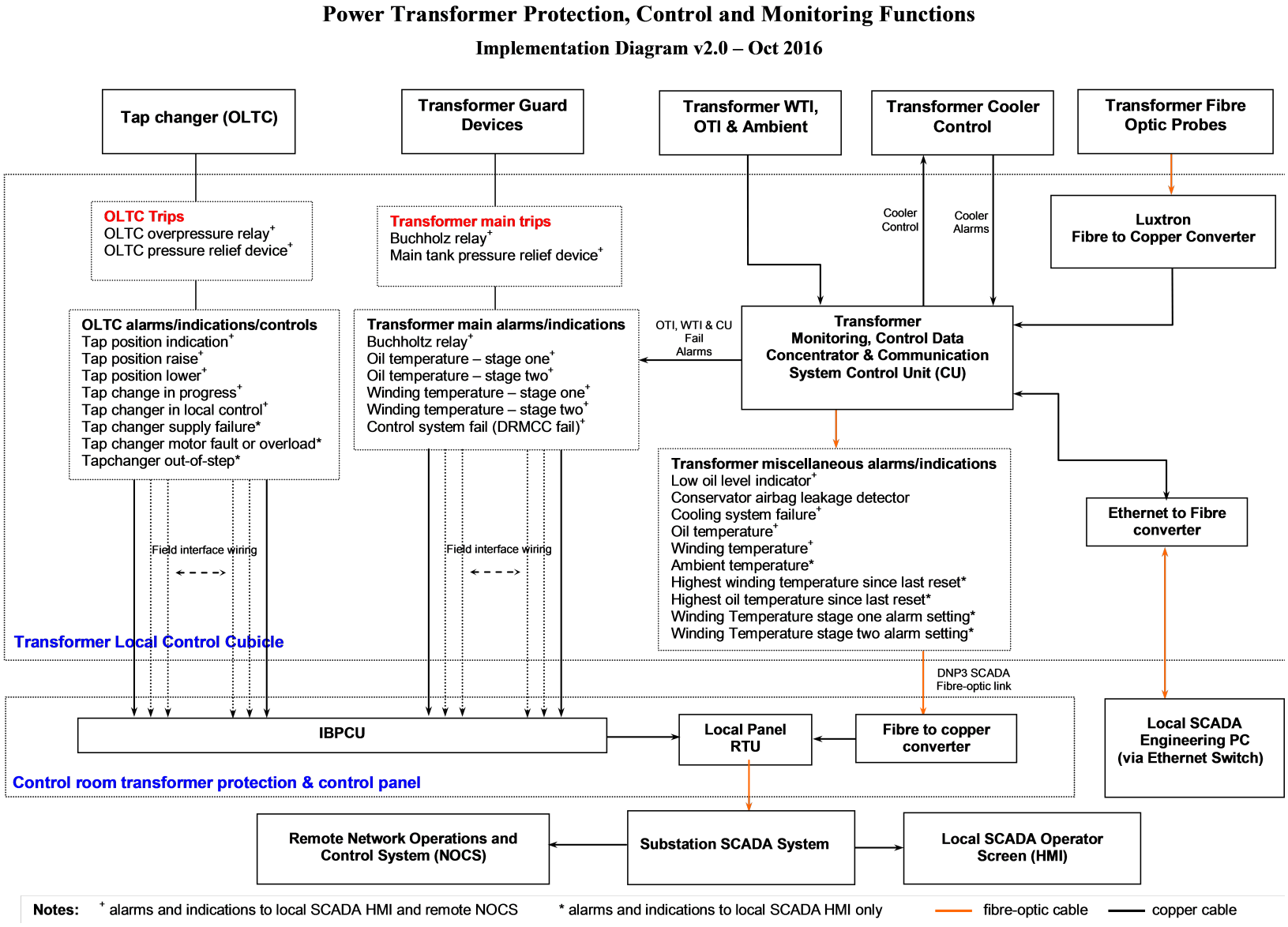
(d) two sets of normally open contacts must be provided for trip indication and trip commands to extra high voltage circuit breakers. The trips from these devices may be paralleled.

12 Control, monitoring and alarms

12.1 Control and monitoring requirements

The complete monitoring and control scheme shall generally be as shown in the "Power Transformer Protection, Control and Monitoring Functions – Implementation diagram v2.0"

Figure 1 Power Transformer Protection, Control and Monitoring Functions – Implementation diagram v2.0



12.1.1 Optical fibre probes

TasNetworks require fibre optic probes to be inserted into the transformer during manufacturing, in order to accurately monitor the internal transformer temperatures. The probes shall be either Luxtron or an equivalent type.

There shall be eight probes inserted into each transformer supplied. One probe shall be inserted into the series and common windings of each phase. The remaining two probes shall usually be inserted into the regulating windings of two phases. These locations will be discussed as part of the design review which may result in a change of location. The oil-to-air interface of the probes shall be above the level of the windings.

The tank penetration for the fibre optic probes shall be above the level of the top of the windings such that any maintenance on this penetration can be conducted without the need to lower the oil below the level of the windings. The penetration shall be protected by weatherproof cabinet.

The instrument end of the fibre optic external extension leads must be terminated within the auxiliary marshalling cubicle at a fixed terminal strip made up of chassis mounted splice adaptors. The end of the unused fibre optic probes must be fitted with sealing caps.

The probes must be used for hot-spot temperature measurement during transformer testing and evaluated in the test report. The results must be used to calibrate the current transformer based winding temperature indicators.

For the purpose of measuring the hot-spot during test, a fibre optic thermometer must be mounted behind a clear Perspex or glass cover within the auxiliary marshalling box. The thermometer must have at least two permanent channels for simultaneous reading of probes inserted into the common and series windings. The thermometer must be operational and used to log, through the transformer monitoring system, a temperature rise record during the temperature rise test. Upon completion of all testing the two hottest probes must be permanently connected to the thermometer.

The optical fibre probes must be terminated in the power transformer marshalling cabinet for future connection to a local and/or remote temperature indicator. A four channel fibre optic transducer, Luxtron type M600 series, shall be provided and interfaced with the transformer monitoring system. The four hottest probes, as identified during the temperature rise test, shall be connected to this device.

The fibre optic probes shall be tested for calibration prior to insertion in the windings. A calibration report shall be available at the time of the factory acceptance testing and shall be included in the transformers operation and maintenance manual.

12.1.2 Intelligent control and monitoring system

A condition monitoring and control data concentrator unit approved by TasNetworks, shall be provided with each power transformer. The Tenderer is invited to offer additional condition monitoring units such as on-line Dissolved Gas Analysis, moisture in oil condition monitor, and on-line tap changer monitor as optional extras. Such options will be evaluated on their merits.

The data concentrator unit must be capable of being connected to the substation SCADA system communications bus over Ethernet for alarms and monitoring.

(a) The monitoring and control unit provided must include the following as a minimum:

- (i) transformer oil temperature monitoring and control;
- (ii) transformer series winding temperature monitoring, with fan and pump control;
- (iii) transformer common winding temperature monitoring, with fan and pump control;
- (iv) ambient temperature;
- (v) tap position indicator;
- (vi) cooler monitoring(fan and pump fail alarm);

(vii) Hot spot measurement (fibre optic based);

(viii) Oil level indication

(ix) Winding and oil temperature alarms in stages;

(x) Cooling fan operation;

(xi) Online dissolved gas analysis (if fitted);

(xii) Online bushing monitoring (if fitted), and

(xiii) alarms (monitoring and control device fail) to substation SCADA system.

(b) The monitoring unit must be capable of being connected to substation SCADA system on both a communication bus for alarms and monitoring or 4-20 mA loops and relay outputs for alarm and monitoring. All oil and winding temperature parameters, related trends, alarms for network transformer and condition of the cooling system must be able to be displayed on the substation SCADA HMI and remotely on the Network Operations Control System (NOCS).

If the data concentrator unit has a user interface panel it shall be mounted inside the transformer control cubicle and shall be visible without needing to open the cabinet door. The data concentrator must be capable of potential future connection of on-line condition monitoring device/s for example, dynamic ratings, bushing monitoring and insulating oil DGA.

12.1.1 Oil and winding temperature indicators and cooler control

(a) Two winding hotspot electro-mechanical gauges (WTI) and one top oil temperature electro-mechanical gauge (OTI) are required. Each oil and winding hot spot temperature indicators must:

(i) be fitted to provide direct reading for local indication of the actual and maximum temperature over a range of 0°C-150°C;

(ii) have temperature indicator needles and markings that are clearly and safely visible without opening the door of the cabinet; and

(iii) be provided with a minimum of two sets of normally open contacts available for both alarm and circuit breaker trip circuits. The contacts must be independently adjustable for closure between 50°C and 120°C, with a close/open differential to prevent hunting under any continuous operation condition.

(iv) include 4-20 mA analogue output connected to separate terminals within the power transformer control cubicle and to the current loop input of the power transformer monitoring and control unit for remote temperature indication

(b) The winding temperature controller must control fans and pumps, if fitted, with inputs from both the series and common winding temperatures.

(c) The fans and pumps must be controlled locally with a separate AUTO/OFF/MANUAL ON control switch within the transformer control cubicle for each fan bank or pump. Each fan bank or pump may be controlled by the winding temperature controller or by the substation SCADA system by selecting the AUTO mode. Each fan bank or pump control may be isolated with the OFF mode selected. Each fan bank or pump may be operated independently of the winding temperature controller by selecting the MANUAL ON mode. The fan bank or pump control must be designed to be capable of accepting a dry clean contact output from the SCADA and winding temperature controller.

(d) Failure of any or all fans and pumps must initiate an alarm.

(e) To accommodate overload requirements, the cooling equipment control system must incorporate means to initiate fans and pumps immediately upon sudden increases of load (current sensing required) or when the winding temperature rises above the set point.

(f) Transformer monitoring and control equipment, including cooling fan and pump control equipment must be housed in the main control cubicle or an adjacent cubicle.

12.1.1 Thermometer pockets

Thermometer pockets must be provided in the network transformer tank and oil circuit to permit measurement of oil temperatures during temperature rise tests and for installation of oil and winding temperature indicators. Thermometer pockets must fulfil the following requirements:

(a) temperature bulbs must be removable without having to drain oil from the tank;

(b) pockets must include screwed plugs to prevent accumulation of moisture within the pockets; and

(c) pockets and plugs must be manufactured from non-corrosive metal.

12.1.1 Alarm requirements

The alarms, as listed in Table 2 and Table 3, must be available to report back to the substation SCADA system and to NOCS.

Auxiliary contacts for TasNetworks' use must be rated at least 0.5 A inductive and 125 V dc.

12.1.2 On load tap changer

Table 2 Alarm indications required from on load tap changer

Sr. No.	Alarm Description
1	Tap change in progress
2	Tap changer on local/remote control
3	Tap changer drive supply failure
4	Tap changer control supply failure
5	Tap changer motor fault or overloaded
6	Tap changer out-of –step
7	OLTC overpressure or surge relay operated

12.1.3 Other alarm requirements

Table 3 Alarm indication requirements

Sr. No.	Alarm Description
1	Oil level indicator (high & low)
2	Air detection relay
3	Pressure relief valve operated
4	Buchholz relay (alarm & trip stage)
5	Oil temperature high (alarm 1 & alarm 2)
6	Series winding temperature high (alarm 1 & alarm 2)
7	Common winding temperature high (alarm 1 & alarm 2)

8	Monitoring & control device fail
9	Fan or pump failure

12.1.4 Other fittings and monitoring provisions

Provision must be included for retrofitting on-line condition monitoring equipment, such as 50 NB valve, on the bottom oil line (between main tank and radiator bank) to permit transducers to sample the oil.

13 Other requirements

Equipment such as instruments, cabinets, terminal boxes that are mounted on the main tank must be attached by means of anti-vibration mountings to prevent the effects of vibration during normal operation.

13.1 Control cubicle/s

Control cubicles/s must be provided for housing the tap changer control, transformer monitoring and control, and main control devices, such as relays, transducers, temperature indicators, cooler supply control contactors, tap changer auxiliary supply transformer, miniature circuit breakers (mcb's), small wiring and accessories. The equipment is to be supplied and arranged as per General Substation Requirements Standard R522687.

The cabinets must be:

(a) stainless steel, minimum grade 316 and 1.6 mm thick, weather-proof with a degree of protection of not less than IP55;

(b) equipped with door stays that lock doors into open position at 120 degrees;

(c) fitted with lockable doors no wider than 750 mm;

(d) fitted with identification labels mounted externally on doors;

(e) arranged for terminal strips to be no less than 200 mm above the gland plate to provide adequate access for TasNetworks' cable terminations below the terminal strips;

(f) fitted with terminals installed on 32 mm DIN 'C' rail, including 25 per cent spare terminals;

(g) mounted on the HV side of the transformer such that the bottom gland plate is 600 mm above the tank base; and

(h) equipped with a thermostatically controlled heater, a door-operated fluorescent or LED cubicle light and a general purpose outlet (GPO). The GPO is to be situated outside the control cubicle. 240/415 V auxiliary supply and connections must be shrouded against accidental contact using clear polycarbonate and fitted with a danger notice. The GPO shall be protected by a mcb located inside the cubical.

In order to minimise the number of cabinets, cabinets with double doors are generally acceptable.

The doors of cabinets must have glass windows to enable an observer to clearly view the temperature indicators and intelligent control systems (if fitted) without the need to open the cubical door.

13.1 Terminals

Terminals must be:

(a) comprised of "Klippon" Weidmuller type SAKT1-4379.2, Phoenix type URTK/S-BEN 10 or equivalent slide-disconnect type terminals for all protection, control, alarm, indication and dc supply circuits;

(b) comprised of feed-through type terminals for 110/240/415 V ac supply circuits;

(c) fully shrouded;

(d) arranged to not clamp wiring ferrules directly under screws;

(e) consecutively and permanently labelled to indicate the applicable core and tap of the current transformer to AS 60044.1;

(f) grouped according to function, providing for neat use of an external PVC insulated, copper screened, multi-core cable for each separate function eg ac supply, dc supply, current transformer core, control wiring, indication, alarm, protection trip circuits;

(g) arranged with a separator plate to segregate each set of terminals for each current transformer core, ac, dc, earth or test terminals; and

(h) arranged to allow for connection of external cables and wires to the bottom of each terminal.

13.1 Labels

All equipment and devices within the control cubicles must be labelled. Equipment and device labels must be traffolyte, with black text on white background. Internal warning labels must be traffolyte, with black text on yellow background. Internal danger labels must be traffolyte, with black text on red background. Traffolyte labels may be fixed with double-sided adhesive tape.

All other identification labels affixed externally to the transformer such as control cubicle, warning, valve, inspection, access, jacking, attachment point labels etc. must be stainless steel, have all lettering engraved and be affixed by means of stainless steel screws.

13.2 Documentation requirements

A general arrangement drawing must be provided and submitted for approval by TasNetworks. The drawing must show plan and section views of the transformer and include information detailed in TasNetworks' Network Transformer Deliverables document R527894. The general arrangement drawing should:

(a) indicate the location of all accessories specified within this document;

(b) each identifiable accessory should be called out and described;

(c) drawings should be single view to an A4 page; and

(d) include isometric and foundation drawings.

Separate rating and nameplate drawings must be produced and submitted for approval by TasNetworks.

Separate schematic and wiring diagrams, current transformer tapping schedule and label details must be produced and submitted for approval by TasNetworks.

A material safety data sheet (MSDS) for the insulating material must be provided.

Details on packaging and handling the equipment during transport and erection, including the recommended maximum duration that the transformer may remain unfilled, must be provided and submitted for approval by TasNetworks.

Operation and maintenance manual must be provided and submitted for approval by TasNetworks. The manual must include, but not be limited to, information detailed in TasNetworks' Network Transformer Deliverables document R527894.

Separate construction drawings must show all detail required to install the equipment, including minimum clearances in air (between poles and to earth), rated static and dynamic mechanical terminal loads.

All documents and drawings must conform to the size, format, and title block requirements listed within TasNetworks' General Substation Requirements standard R522687

All documents and drawings must be clear, legible and free from errors or omissions.

All documents and drawings must be in the English language ONLY.

Only SI system of units can be used. Units must be stated for all values.

Scales, wherever used, must be as per the applicable Australian Standards.

All drawings that are made to scale must include a scale block.

Electronic copies of drawings must be supplied on CD-ROM in the AutoCad Release 14 format.

Only information relevant to the supplied network transformer must be shown in the documentation and drawings.

13.1 Special tools

Any special tools required for the operation and maintenance of the network transformer must be provided. Tools and equipment for obtaining oil samples for Dissolved Gas Analysis (DGA) must be provided.

13.2 Network transformer rating plate information

A non-corrodible name and rating plate must be affixed in a suitable position and bear on it the particulars of the network transformer as required by AS 60076.1, Clause 7 plus those items listed in Table 4, as a minimum.

The layout of the plate must be in accordance with the relevant applicable Australian Standard.

The information must be indelibly and legibly marked on one or more plates securely attached to the transformer and should be located so that it is clearly and safely visible with the transformer in service and without any obstructions.

A non-corrodible name and rating plate must be affixed in a suitable position and bear on it the particulars of:

(a) the tap changer;

(b) the motor drive mechanism;

(c) each bushing; and

(d) each current transformer.

Table 4 Details of the network transformer rating plate information

Sr. No.	Description
1	The name or registered trade name or mark of the manufacturer
2	Manufacturer's general arrangement drawing number
3	Description: (Type of Transformer)
4	Number of the Applicable Standard(s)
5	Manufacturer's serial number, relating the Network Transformer to the test certificate(s)
6	Manufacturer's drawing number
7	Year of Manufacture
8	Number of phases
9	Rated power in MVA

Sr. No.	Description
10	Rated frequency (in Hz)
11	Rated primary voltage in kV
12	Rated secondary voltage in kV
13	Connection symbol (Vector group)
14	Tapping Range and steps
15	Tapping voltage and current at all taps
16	Principal tap
17	Rated Primary Current in A
18	Rated Secondary Current in A
19	Short circuit impedance value (measured in percentage) at all tap positions
20	Zero sequence impedance value at the principal tap (expressed in ohms/phase, referred to the LV winding with the HV winding open circuited)
21	X/R ratio of transformer
22	Type of cooling methods
23	Power values at different cooling methods in MVA
24	Top oil temperature rise
25	Average winding temperature rise
26	Current Transformer designations and details (as per AS 60044.1)
27	Total Mass
28	Transportation Mass (without oil)
29	Mass of Core and Windings
30	Mass of Oil (Volume of Oil)
31	Oil quantity in OLTC (if not shown on OLTC name plate)
32	Oil quantity to cover core and windings
33	Oil quantity in one radiator
34	Oil Flow
35	Vacuum withstand capability of the transformer and the conservator
36	Number of Fans
37	Air Flow and power consumption of fans
38	Contract Number
39	Plant number
40	Owner (marked as 'Property of Tasmanian Networks Pty Ltd')

14 Cable systems

All internal cubicle wiring, cables and cable systems associated with network transformers must be in

accordance with document R590630 HV and LV Cable Systems Standard. Transformer internal cabling, eg for CT's and fibre optic probes, should be fully compatible with hot transformer oil and preferably be Teflon coated.

14.1 Interconnection cables

In addition to other requirements for cable screening, all externally mounted interconnecting cables must be PVC insulated with PVC over sheath, mechanically protected and fixed at intervals to the transformer tank. All cable sheathing shall be resistant to high levels of UV radiation.

15 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 Contractor must provide information required to maintain the currency of AMIS for each asset in standard forms. TasNetworks will provide the forms to the selected Contractor. Forms are required to be completed for new assets and for decommissioned assets.

The completed forms must be 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; and

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

16 Assessment of damages for performance parameters

Power transformer parameters must meet the tolerances specified in AS 60076.1, unless otherwise stated in TasNetworks specifications.

The following loss information must be specified by the supplier for evaluation and subsequent selection of equipment:

(a) no-load losses at 100%, 105% and 110% of rated voltage;

(b) load losses at 75◦C for principal, extreme plus and minus tap positions, and for maximum loss tapping in case it is not one of these tappings, with rated current flowing in each winding; and

(c) cooling equipment losses in kW with all cooling equipment in operation.

The no load loss at 100 per cent and 110 per cent rated voltage and the load losses at principal tapping, extreme plus and minus tapping, and at the maximum loss tapping if different to any of these tappings, must be have zero positive tolerance.

The impedances and the tolerances stated in Table 1 must be met. The transformer will be rejected if any other stated parameters without specified tolerances exceed the tolerances as permitted by AS 60076.1.

Where a measured loss exceeds the value stated at the time of selection it is a minor defect, provided that the losses are still within the tolerances allowed by AS 60076. Where the measured losses are within this range, damages shall be assessed according to the following formula:

Cost Reduction = (ΔNLL*NLLe) + (ΔLL*LLe) + (ΔCL*CLe)

Where;

ΔNLL = the difference between the measured no-load losses and the stated losses, where the no-load losses exceed the stated figure

NLLe = the value of no-load losses as given in Table 1

ΔLL = the difference between the measured load losses and the stated figure, where the measured losses exceed the guaranteed

LLe = the value of load losses as given in Table 1

ΔCL = the difference between the power requirement of the cooling equipment given in the Tender schedules and the measured power consumption

CLe = the evaluated value of the cooling losses as given in Table 1.

This evaluation shall be applied to any and all transformers of an order which fail to meet the stated losses. Where the measured losses exceed the stated figure by an amount greater than that allowed by the Australian standard this shall be considered a test failure and the transformer shall be rejected.

In cases where the measured losses are lower than the stated figure, credit towards a reduction of any damages will not be granted under any conditions. Likewise, requests for an increase in purchase price should the measured losses be below the stated figures will not be considered.

In the event of a failure of one or more of the fibre optic probes inserted in the transformer this shall also be considered a minor defect. In this case the damages assessed shall be at least the purchase price of the failed probe or probes.

Prior to the award of any contract the zero sequence impedances, the testing configuration and the testing currents under which the impedances are obtained must be defined by the Supplier and agreed to by TasNetworks.

Transformers must have a defects liability period after delivery and assembly of not less than 5 years.

All costs incurred by TasNetworks, in witnessing the retesting of a failed transformer, or a failed component, shall be at the cost of the Supplier. Costs may include the labour and expenses of TasNetworks in the provision of up to 2 staff to the manufacturer's works or site for the duration of any retesting. A full detailed report on the likely cause of failure and actions contemplated must be prepared and provided to TasNetworks before oil is drained below the top of the windings or other significant corrective action undertaken, and before any request to attend further testing. Any failure under test must constitute an additional Hold Point in terms of Clause 22.

17 Inspection and testing

Testing, installation and commissioning must comply with the requirements of the document R246497.

To prove compliance with the specification and the performance specified in the tender documents, type and routine tests must be carried out on the transformers as listed in AS 60076.1, except for the additions and amendments listed below.

All components of network transformers must be duly tested in accordance with relevant applicable Australian and International standards. Where tests are optional in the standards, it must be taken that TasNetworks requires these tests, unless otherwise requested by the Supplier and agreed in writing by TasNetworks at tender stage.

Specifically, a type test certificate must be provided for each type of tap changer supplied and a routine test certificate must be provided for each tap changer supplied. Test certificates shall include all tests specified within AS 60214.1.

The transformer must be fully assembled for testing. This requirement includes the cooling equipment. All auxiliary items such as the transformer monitoring and control unit, main control cubicle, current transformers, conservator, fans, fibre-optic equipment, interconnecting and earthing cable, oil gauges, valves, pipes, pumps, Buchholz and surge relays etc. must be fitted and functional for both the type, routine

and site tests. TasNetworks reserves the right to defer the commencement of any specified tests if this requirement is not met.

The Contractor must prepare a detailed test program not less than three months prior to the start of tests, listing all routine and type tests in the chronological order to be carried out.

On each transformer, oil samples must be obtained before the start of each dielectric test, before the start of each stage of the heat run tests (on the type-tested unit), and after all tests are completed. If Dissolved Gas Analysis (DGA) of the final sample indicates the presence of a fault, then DGA must be performed on each interim sample as an aid to diagnosis of the fault.

Oil used for testing must be compatible with the oil supplied on-site. Furthermore, where oil is offered that has not previously been accepted by TasNetworks, the Tenderer must provide full test documentation to AS 1767.2 plus test results that prove continued performance in service. In addition, at TasNetworks' option, a 2-litre sample of the oil must be provided.

The strand to strand test described in Section 5.2(c) shall be included in the test report.

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 network transformers is given below.

17.1 Type tests

Type tests are intended to prove the soundness of design of the equipment and their suitability for operation under the conditions detailed in the specifications. Type tests must be carried out before the delivery of the equipment. 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 equipment of identical design with that offered, or on equipment of a design, which does not differ from that offered in a way that might influence the properties to be checked by the type test.

Where such tests have already been performed, copies of type test reports that qualify for the exemption from conducting these tests must be provided with the tender.

17.1.1 Type test details

The tests listed below must be performed on the first network transformer of each design being supplied. These tests are in addition to those tests which are specified in AS 60076.

Temperature rise test performed on the maximum loss tapping at the corresponding tapping current in all implemented cooling conditions, unless agreed otherwise at the design review, with the tests to include direct measurement of hot-spot temperatures with optical fibre temperature probes. Winding temperatures and gradients must be recorded for all three phases. This test must be performed using the transformers' own conservator.

Additional temperature rise test on all three phases concurrently, at maximum sustained emergency rating, with thermography (infrared camera) to be performed concurrently. The test must be performed for the minimum duration of the peak load specified in Table 1. During the test careful and constant attention must be paid to the temperatures, in particular the fibre-optic sensors, to ensure that no undue loss of life occurs. In certain cases the ambient temperature may dictate that the full overload cannot be achieved for the entire duration of the overload. In this case it may be acceptable to reduce the test current, but not the test time, such that the transformer is exposed to the full duty of the overload. This may only be allowed if it can be proved to the satisfaction of TasNetworks that under the conditions of the overload the transformer would not normally exceed the temperature limits.

Sound pressure levels using sound intensity measurements as per AS 60076, as well as during temperature rise test with maximum tapping current. Background noise must be measured during the test. Background noise correction factors must not be used.

17.2 Routine tests

The routine tests must be conducted on the completely assembled transformer to prove quality of manufacture and conformance with the relevant performance requirements.

The splitting of routine tests into separate phases for individual components is not normally 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 must 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 must 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.

As a minimum, the test and measurements stated below must be performed, generally in the order listed:

(a) vacuum withstand and over-pressure withstand and oil leakage test (using chalk or whitewash to check) on the completed assembly or sub-assembly as appropriate;

(b) oil dielectric strength and diagnostic gas analysis (DGA);

(c) measurement of winding resistance on all taps;

(d) measurement of ratio and vector relationship;

(e) measurement of insulation resistances: windings to earth, between windings, core to earth, core to frame and frame to earth, at 1 minute and 10 minutes after application of the dc voltage;

(f) 2.5 kV applied voltage test to the core, the frame and the tank, in each case with the other components earthed;

(g) measurement of dissipation factor (loss tangent) and capacitance of the windings to earth and between windings. The dielectric loss angle must not exceed 0.005 in any configuration;

(h) measurement of dissipation factor (loss tangent) and the capacitance of HV, LV, TV and neutral condenser bushings;

(i) functional, calibration and performance tests on all accessories and cooling equipment including without limitation:

  (v) Buchholz relay, including Buchholz stability on pump start-up must be proven (if pump fitted)

  (vi) pressure relief device,

  (vii) Oil level indicators,

  (viii) temperature indicators

  (ix) control and monitoring equipment, etc;

(j) pressure test of pressure relief device to prove its operating pressure and reseal / reseat properly after operation;

(k) tests on instrument transformers including knee point voltage determination;

(l) measurement of power and current taken by the fans;

(m) applied high voltage test;

(n) impulse withstand tests, including chopped wave tests, on all line terminals with full wave tests only on the neutral terminal. During these tests one corner of the tertiary winding must be earthed as in service. Further, the tests are to be performed on maximum, minimum and mid-tap positions for each

phase – this is only required for the HV impulse test, with the LV applications to be made with the tapchanger in moving from the maximum to nominal to minimum tap position as each phase is tested. The HV impulse test order required a single FW impulse and a single CW impulse on each tap position with associated reduced level shots as required. This is a total of six 100 per cent impulses per phase;

(o) separate source withstand (ac insulation withstand): each winding to earth with other windings earthed;

(p) induced voltage test;

(q) partial discharge measurement, to be less than 50 pC at 1.2Um. (see Note 2);

(r) measurement of impedance voltages and load losses at >75% load currents on all tappings, except that guaranteed tap positions must be tested at >95% load current (winding temperature, determined by DC resistance, to be measured at the start and end of this test series AND after each guaranteed tap position is tested);

(s) heat run test to confirm the correct operation of fibre optic probes. The test must consist of a minimum 1.3 p.u overload for a minimum of three hours;

(t) measurement of no-load losses and no-load currents at 90%, 100%, 110% and 120% of rated voltage (flux density);

(u) harmonic content and oscillograph of no-load current wave form at 100 per cent and 110 per cent of rated voltage;

(v) measurements of zero phase sequence impedances at maximum and minimum tap in four winding configurations at a high current subject to the limits defined by AS 60076;

(w) on load tap changer operation for each tap-changer, as per AS 60076.1, when un-energized for eight cycles, at 85 per cent auxiliary voltage for one cycle, at full voltage and no-load for one cycle and separately, full current for one cycle;

(x) measurement of insulation resistance of auxiliary wiring and interconnecting cables;

(y) current transformer ratios, magnetisation characteristics on all taps, and DC resistance and polarity check;

(z) operation of pumps, if fitted, to verify satisfactory oil circulation;

(aa) pressure and vacuum tests to prove compliance with this specification;

(bb) frequency response analysis (FRA) for each phase of each winding, and with the HV winding tested on principle, minimum and maximum taps for signatures to be obtained showing the effect of each major tapping section being both in and out of circuit;

Note 2: On condenser-type bushings, the only permissible measure to reduce airborne corona discharge on bushings during partial discharge tests must be electrode spheres on the HV and LV terminals. These spheres should not normally be needed, but should be considered an aid to reduce the effect of airborne discharge. Temporary modifications to the bushing mounting flanges or any other part of the transformer are not acceptable.

Should the transformer fail any one of these tests, either type or routine, then the full suite of tests, both type and routine, shall be repeated following rectification work on the failed transformer. In this case, the tests described in the preceding passage as type tests shall become routine tests for all transformers of that design.

17.1 Site tests on network transformers

Site installation and 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 site test procedures must be submitted to TasNetworks for approval.

Site test reports must be approved and accepted by TasNetworks prior to placing equipment in service.

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

17.1.1 Pre-commissioning tests

After the assembly of the transformer at site the following tests, measurements and inspections must be performed, generally in the order listed, to verify the unit has not been damaged during transport and that it has been erected correctly:

(a) oil tests;

(b) oil level check;

(c) dielectric breakdown strength test on each drum before filling and from the transformer tank after filling;

(d) oil samples for DGA;

(e) protective earthing connections resistance check;

(f) bushing and bushing turrets damage inspection;

(g) on-load tap changer and motor drive mechanical damage inspection;

(h) control cubicles water and dust proof inspection;

(i) control cabling wire terminal tightness check;

(j) auxiliary power cabling – connections check;

(k) current transformer ratios, magnetisation characteristics, DC resistances and polarity;

(l) calibration and function of all control and protection equipment, instruments, gauges, temperature and oil level indicators;

(m) operation of supervisory equipment;

(n) operation of cooling equipment;

(o) operation of on-load tap-changer;

(p) pressure test to confirm oil tightness;

(q) function of fibre-optic thermometer and probes;

(r) voltage ratio on all tappings;

(s) vector group phase displacement;

(t) measurement of power factor and capacitance between all windings and between all windings to earth;

(u) measurement of winding resistance on all tappings;

(v) insulation resistance measurement (the type of instrument and measurement voltage must be recorded) for:

  (i) all windings to earth;

  (ii) between windings;

  (iii) between core to frame;

  (iv) between core to earth;

  (v) between frame to earth;

  (vi) current transformer windings to earth;

(vii) between current transformer windings;

(viii) control cabling;

(ix) auxiliary power cabling;

(x) fan motors;

(xi) tap changer motor;

(xii) Frequency Response Analysis (FRA); and

(xiii) Recovery Voltage Measurement (RVM) (to be performed three (3) months following commissioning).

The Contractor must compare the results of the above to the FAT and advise of any abnormality.

17.1.1 Commissioning tests

The following tests and inspections must be made before commissioning a transformer:

(a) visual inspection;

(b) verify and adjust, if required:

(i) conservator oil level;

(ii) air drier;

(iii) valves;

(iv) cubicles and their cleanliness;

(v) touch up painting;

(vi) cubicle heaters;

(vii) de-aeration of the Buchholz relay and gas detection relay;

(viii) oil leaks;

(ix) tank protective earthing;

(x) neutral earthing;

(xi) tertiary link and earthing;

(xii) line and bus connections;

(xiii) surge arrestor connections; and

(xiv) air clearances.

17.1.1 Energisation

The transformers must be left unloaded for a minimum of 24 hours after energisation.

The transformer must be carefully inspected, especially Buchholz relays for accumulation of gas, temperature indicators and monitoring equipment, and any sign of oil leaks.

Any sign of abnormality must be reported to and witnessed by TasNetworks.

18 Delivery and installation requirements

18.1 Transport

All necessary measures must be taken to comply with the relevant legislation in relation to transport of the transformer and the oil, including preparation of a comprehensive emergency plan to deal with an oil spill.

18.1.1 Transportation of transformers

Network transformers shall be delivered without oil.

During delivery provisions must be made to prevent the ingress of moisture and to maintain the internal insulation in a dry, contaminant-free condition. As the transformer is drained of oil at the factory, the transformer must be filled with an inert dry gas such as nitrogen. Transportation with dry air is unacceptable. Dew-point measurement must be taken before the transformer is dispatched from the factory. This will confirm the insulation moisture level from processing and provides a reference in the event that gas leakage occurs during transportation to evaluate the dryness upon arrival at site.

During transport, the gas must be maintained at a continuous positive pressure. The gas pressure must be monitored and logged continuously throughout the period immediately after the oil is removed until the transformer is refilled with oil at site. The ability to immediately alarm and restore any loss of gas pressure must be maintained at all times.

Integrity of the dryness of the cellulose insulation whilst under gas pressure must be checked by a dewpoint test of the gas after offloading at site. The test results must be submitted to TasNetworks for acceptance and must be below the specified limit.

All tubing, valves, cable connections and fittings attached to the payload are to be adequately protected to minimise the risk of damage during transport, loading and unloading.

18.1.2 Loose equipment

Where other parts such as bushings, cooling equipment, power/control and regulation cabinets, need to be shipped in a disassembled state and where the surfaces of which will be in contact with the transformer oil, they must be properly sealed by gas tight covers to prevent ingress of moisture.

Parts that are vulnerable to damage during transit must be attached by means of anti-vibration mountings or must be otherwise appropriately protected.

18.1.3 Inventory

Each individual component or part is to be properly prepared for dispatch, itemised and labelled. Each item must be named, coded and identified by make or manufacture, size, type, drawing number or part number and recorded in a transport inventory that must form part of the contract documentation.

18.1.4 Impact recorder

To provide a partial record of transport conditions, each transformer must be fitted with a three axis impact recorder on its main tank prior to dispatch from the factory. The impact record must be active for the entire duration of the transport, including loading of the transformer onto the prime mover at the factory.

After the transformers are off-loaded onto the final positions, the Supplier must inspect the impact recorder to determine whether or not the transformers have received rough handling during transport that may lead to internal damage.

TasNetworks must witness the inspection of the impact recorder. The Supplier must notify TasNetworks a

minimum of seven days prior to the arrival of the transformer on site to arrange inspection. The Supplier must supply an interpreted copy of the recordings.

18.1.5 Handling and markings

To facilitate handling and accurate positioning of the transformers onto the foundation pads, the longitudinal and transverse axes and centre of gravity of the main indivisible unit and any other parts as may be required to conform to regulations, must be clearly and indelibly marked. Specifically the transformer base must be marked permanently on the four sides with the longitudinal axes defined by the centre line of the core and winding, and the transverse axes by the position of the HV B-phase bushing. The centre of gravity of the transformer in the transport condition and, if substantially different, that of the transformer is in-service, must be marked at least on one side and one end.

The oil level to just cover the top of the windings must be marked and labelled on the outside of the tank.

All items arranged for transport must have their lifting, jacking and haulage points and safe working load (SWL) clearly marked at all stages of the delivery and the erection period. The markings must be permanent.

All disassembled items must be marked for identification and matching to correct location for assembly.

The general arrangement drawing must also note, and dimension, the above markings.

18.2 Erection

The transformer must be filled on site with degassed oil, conforming to TasNetworks' Insulating oil for Transformers and Switchgear standard R517371 under vacuum condition in order to minimise the oxygen content of the insulation system. The integrity of the dryness of the cellulose insulation whilst under gas pressure must be checked by a dewpoint test of the gas prior to re-filling with oil. The test results must be submitted to TasNetworks for acceptance and must be below the acceptable specified limit. If the dewpoint is above the specified limit then the Contractor must perform all necessary work to reduce the moisture content to below the specified limit prior to proceeding with pre-commissioning tests.

19 Information to be provided with the tender

Requirements for information to be submitted as part of the tender are outlined in document R527895.

20 Deliverables

Requirements for project deliverables are outlined in document R527894.

21 Hold points

The requirement of documentation is listed in the deliverable schedule in document R527894. The hold points for each network transformer are:

(a) 'Critical design information documentation' must be submitted four weeks after letter of acceptance for TasNetworks' review, comments and approval prior to procurement of equipment;

(b) 'Detailed design documentation' must be submitted prior to manufacturing of equipment, for TasNetworks' review, comments and approval. This shall include the completed schedule R527895. A face-to-face design review(s) shall be held no later than 12 weeks after acceptance of the order. This design review shall cover the complete electrical and mechanical design of the transformer, including the construction and capabilities of the transformer, with the primary purpose being to confirm

compliance with TasNetworks' requirements. As a minimum, all information relevant to this review should be provided to TasNetworks a minimum of two weeks prior to this date, and this shall comprise any amendments to the schedule of information, the short circuit information required in the 'Information to be provided with Tender, Table 2' schedule and the draft outline drawing. Drawings showing the internal design of the transformer, including lead routines should be available at this time;

(c) 'Inspection and Test Plan' must be submitted three months prior to 'Factory Acceptance Testing (FAT)', for TasNetworks' review, comments and approval;

(d) during the manufacturing process, prior to the drying of the active part, TasNetworks will perform an inspection of the completed active part. Notice should be given to TasNetworks at least one week prior to this date to allow TasNetworks personnel to attend this inspection;

(e) draft 'Operations and Maintenance manuals (O&M manuals)' must be provided at least three months prior to FAT, for TasNetworks' review, comments and approval;

(f) 'Invitation to witness testing' must be submitted prior to any equipment testing, for TasNetworks' arrangements to witness. A minimum of two weeks notice must be given;

(g) complete updated O&M manuals must be submitted one week prior to FAT for TasNetworks' preparation to attend FAT;

(h) final training manuals must be provided at least two weeks prior to training, for use of training team;

(i) 'FAT' must have been witnessed by TasNetworks and FAT results approved by TasNetworks, prior to dispatch of the transformer from the factory;

(j) all non-conformances as identified during FAT or other inspections must have been completed prior to dispatch of the transformer from the factory;

(k) information required for AMIS pertaining to design information and maintenance regimes must be submitted to TasNetworks prior to commencing installation;

(l) 'pre-commissioning tests' must have been witnessed by TasNetworks and test results approved by TasNetworks, prior to 'commissioning tests';

(m) all non-conformances as identified during pre-commissioning tests must have been completed before commencing any commissioning tests;

(n) results of commissioning tests must have been approved by the 'System Controller', other Code participants and relevant testing authorities as per the requirements of the Code, prior to commissioning;

(o) 'commissioning tests' must have been witnessed by TasNetworks and test results approved by TasNetworks, prior to 'energisation';

(p) all non-conformances as identified during commissioning tests must be completed before commencing any energisation;

(q) 'training' must have been completed prior to energisation;

(r) information for AMIS pertaining to test results must have been submitted to TasNetworks prior to energisation;

(s) certificates of conformance with contract specifications, standard specifications, codes and standards with associated documents, drawings, test results, test reports, test certificates, completed check lists and other documents must be submitted and must have been accepted and approved by TasNetworks prior to energisation;

(t) TasNetworks must have completed the inspection of each asset prior to its energisation; and

(u) all as-built documentation, software licences, O&M manuals, test results and test certificates must be submitted to TasNetworks and be accepted by TasNetworks prior to practical completion.