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Standard governance

Owner: Lead Electrical Engineer, Asset Standards Authority
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Approver: Executive Director, Asset Standards Authority on behalf of the ASA Configuration Control Board

Document history

<table>
<thead>
<tr>
<th>Version</th>
<th>Summary of Changes</th>
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<tbody>
<tr>
<td>1.0</td>
<td>First issue</td>
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</table>

For queries regarding this document, please email the ASA at standards@transport.nsw.gov.au or visit www.asa.transport.nsw.gov.au

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Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance based to create opportunities for innovation and improve access to a broader competitive supply chain.

This standard has been developed to enable the procurement of 66/11 kV transformers suitable for use in the RailCorp electrical network and the content is based on Australian and International standards. This standard also incorporates requirements to ensure compatibility with the existing systems that interface with the transformer.

The standard has been developed through consultation with stakeholders across TfNSW and manufacturers.

This is the first issue of this standard.
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1. Introduction

This document details the whole-of-life performance requirements for the purchase of outdoor two winding, 66/11 kV transformers suitable for use in the RailCorp electrical network.

The transformer is used to convert the 66 kV ac supply voltage to 11 kV ac for distribution to loads located at and between substations. The transformer shall be equipped with a 66 kV automatic on load tap changer (OLTC).

2. Purpose

The purpose of this document is to specify the requirements for 66/11 kV transformers to enable suitable equipment to be procured for use in the RailCorp electrical network.

2.1. Scope

This document provides specifications for outdoor type 66/11 kV transformers that are type and routine tested and fitted with all auxiliary equipment for use in the RailCorp electrical network.

This document provides the specification for the following two configurations of transformers:

- 66 kV connected via cable with separable connectors
- 66 kV connected via busbar with bushings

All information required to ensure that the transformers are electrically suitable for use within the RailCorp high voltage network is contained in this document or referenced by this document.

2.2. Application

This specification is intended to be used by competent personnel engaged in the provision of services relating to railway infrastructure. Compliance with the requirements in this specification will not, by itself, be sufficient to ensure that satisfactory outcomes will be produced. Personnel providing services based on the specification need to bring appropriate expertise to the matters under consideration. In addition to the requirements of this specification, asset decisions shall take into account the life cycle cost considerations specified in T MU AM 01001 ST Life Cycle Costing. TfNSW is concerned to keep lifetime costs, rather than purchase price, to a minimum and features are specified that aim to achieve this. In that regard equipment that requires the minimum possible maintenance over its life time is preferred.

If, when using the standard, it is considered that the intent of stated requirements is not clear, a clarification should be sought from the Lead Electrical Engineer, ASA.

The requirements of this document apply to the purchase of all new 66/11 kV transformers for use in the RailCorp electrical network. These requirements are applicable from the date of issue of this specification.
The requirements of this document are not applicable to existing 66/11 kV transformers currently in service in the RailCorp electrical network.

3. **Reference documents**

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

**International standards**

- IEC 60296 Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear
- IEC 60840 Power cables with extruded insulation and their accessories for rated voltages above 30 kV ($U_m = 36$ kV) up to 150 kV ($U_m = 170$ kV) – Test methods and requirements
- IEC 62535 Insulating liquids – Test method for detection of potentially corrosive sulphur in used and unused insulating oil
- I.S. EN 50180 Bushings above 1 kV up to 52 kV and from 250 A to 31.5 kA for liquid filled transformers

**Australian standards**

- AS 1627.4 Metal finishing – Preparation and pretreatment of surfaces Part 4: Abrasive blast cleaning of steel
- AS/NZS 1891.4 Industrial fall-arrest systems and devices, Part 4: Selection, use and maintenance
- AS 60044.1 Instrument transformers, Part 1: Current transformers
- AS/NZS 60137: Insulated bushings for alternating voltages above 1000 V
- AS/NZS 60076.1 Power transformers: Part 1: General
- AS/NZS 60076.3: Power transformers: Part 3 Insulation levels, dielectric tests and external clearances in air
- AS/NZS 60076.5: Power transformers: Part 5: Ability to withstand short circuit
- AS/NZS 60076.7: Power transformers: Part 7: Loading guide for oil-immersed transformers
- AS/NZS 60076.10: Power transformers: Part 10: Determination of sound levels
- AS/NZS 60076.10.1: Power transformers: Part 10.1: Determination of sound levels – Application guide
- AS 60214.1 Tap-changers, Part 1: Performance requirements and test methods
AS 2067 Substations and high voltage installations exceeding 1 kV a.c.
AS 2629 Separable insulated connectors for power distribution systems above 1 kV
AS 2700 Colour standards for general purposes
AS/NZS 3000 Electrical installations
AS/NZS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles

**Transport for NSW standards**

TMD 0001 CAD and Drafting Manual – Electrical Design – Section 4
T MU AM 01001 ST Life Cycle Costing
T MU AM 01002 MA Maintenance Requirements Analysis Manual
T MU HF 00001 ST Human factors Integration – General requirements
T HR EL 00002 PR Electrical Power Equipment – Integrated Support Requirements
T HR EL 20001 ST High Voltage AC and 1500 V DC Traction Power Supply Cable Requirements
TN 050: 2014 Electrical Type Approvals – Interim process
EP 00 00 00 13 SP Electrical Power Equipment – Design Ranges of Ambient Conditions
EP 00 00 00 15 SP Common Requirements for Electric Power Equipment
EP 02 00 00 01 SP Transformer Loss Evaluation
EP 19 00 00 02 SP Protection System Requirements for the High Voltage Network

4. **Terms and definitions**

The following terms and definitions apply in this document:

ASA Asset Standards Authority
CT current transformer
HV winding the winding having the highest rated voltage
IP ingress protection
ISO International Organization for Standardization
LV low voltage: exceeding 50 V ac or 120 V ripple-free dc but not exceeding 1000 V ac or 1500 V dc
LV winding the winding having the lowest rated voltage
NATA National Association of Testing Authorities, Australia
OLTC on load tap changer
ONAN oil natural air natural
PCB polychlorinated biphenyl
RCD residual current device
RFT request for tender
RTU remote terminal unit
SCADA supervisory control and data acquisition
TfNSW Transport for New South Wales
VT voltage transformer
XLPE Cu cross-linked polyethylene copper

5. **ASA type approval**

Transformers procured to this specification require type approval by ASA prior to being connected to the RailCorp electrical network.

The current ASA process for type approval at the time of publication of this document is TN 050: 2014 *Electrical Type Approvals – Interim process*.

6. **Functional requirements of transformer**

The transformers shall provide for the following:

- transformation of nominal system voltage of 66 kV to 11 kV
- automatic on load voltage adjustment
- connection of 66 kV and 11 kV cables to the associated high voltage switchgear or connection of 66 kV to busbar and 11 kV cables to high voltage switchgear
- monitoring of the transformer temperature oil, winding and hot spot
- provision of oil surge and gas detection
- connection of supervisory controlled and data acquisition system (SCADA), protection and auxiliary cabling
- suitable for operation in an environment with conditions as prescribed in this specification
7. Transformer configurations

This specification provides detail on two transformer configurations as summarised in Table 1.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Type of 66 kV connection</th>
<th>Type of 11 kV connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bushing</td>
<td>Separable connector</td>
</tr>
<tr>
<td>2</td>
<td>Separable connector</td>
<td>Separable connector</td>
</tr>
</tbody>
</table>

The 11 kV is connected to indoor switchgear via cable with separable connectors for both configurations. The exact configuration will be specified at the time of order.

The transformer shall be designed for one configuration or the other, not for both.

8. Performance characteristics

Where not specifically detailed in this document, the performance characteristics of the transformer shall be in accordance with the following standards:

- AS/NZS 60076 *Power Transformers* (all parts)
- AS 60214.1 *Tap-changers, Part 1: Performance requirements and test methods*

Table 2 provides details of general requirements of the transformer.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>• outdoor</td>
</tr>
<tr>
<td></td>
<td>• separate winding</td>
</tr>
<tr>
<td></td>
<td>• three phase unit</td>
</tr>
<tr>
<td>Type of cooling</td>
<td>ONAN</td>
</tr>
<tr>
<td>Type of liquid</td>
<td>Liquid immersed (mineral oil)</td>
</tr>
</tbody>
</table>

Table 3 provides details on the technical ratings of the transformer.

<table>
<thead>
<tr>
<th>Technical parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage:</td>
<td></td>
</tr>
<tr>
<td>• HV</td>
<td>66 kV (rms)</td>
</tr>
<tr>
<td>• LV</td>
<td>11 kV (rms)</td>
</tr>
<tr>
<td>System highest voltage:</td>
<td></td>
</tr>
<tr>
<td>• HV</td>
<td>72.5 kV (rms)</td>
</tr>
<tr>
<td>• LV</td>
<td>12 kV (rms)</td>
</tr>
<tr>
<td>Connection symbol</td>
<td>Dyn1</td>
</tr>
</tbody>
</table>
**Technical parameter** | **Rating**
--- | ---
Rated insulation level:  
• HV – lightning impulse  
• HV – power frequency  
• LV – lightning impulse  
• LV – power frequency |  
• 325 kV (peak)  
• 140 kV (rms)  
• 95 kV (peak)  
• 28 kV (rms)
Rated frequency ($f_r$) | 50 Hz
Rated power | 2 MVA
Method of neutral earthing of the system | Both effectively earthed and non-effectively earthed
Impedance at 2 MVA | 6%
Fault level (maximum):  
• HV  
• LV |  
• 1500 MVA for 3 phase symmetrical fault  
• limited by transformer impedance
Sound power level | Refer to AS 60076.10 Power transformers, Part 10: Determination of sound levels
Overload requirements | Refer to AS 60076.7 Power transformers, Part 10: Loading Guide for oil immersed power transformers
Type of 66 kV termination (Refer to note) |  
Configuration 1: bushing  
Configuration 2: separable connector
Type of 11 kV termination | Separable connector
Ambient temperature range | EP 00 00 00 13 SP Electrical Power Equipment – Design Ranges of Ambient Conditions

**Note:** The type of connection will be nominated in the RFT.

Table 4 provides details on the general requirements of the OLTC.

**Table 4 – OLTC requirements**

| Technical parameter | Rating |
--- | ---|
High voltage winding tapping range | +5% to -15% of nominal voltage in increments of 1.25% |
Type of tap changer | On load |
Tap changer control voltage | 125 V dc |
Tap changer motor drive voltage (Refer to note) |  
• Option 1 – 220 V ac  
• Option 2 – 415 V ac

**Note:** The substation auxiliary ac voltage will be nominated at time of order of the transformer. The 220 V supply is an unearthed supply.
9. **Technical characteristics**

The ratings of bushings, tap changers, connecting leads shall be of sufficient capacity such that the transformer can be loaded in accordance with AS 60076.7.

All equipment supplied shall withstand normal handling during transportation and installation, continuous operation under the conditions specified in this specification, and is suitable for the required duty.

Bolts, screws and nuts shall be ISO metric. All bolts, nuts and washers used outside the tank shall be hot dip galvanised or stainless steel. All nuts within the tank shall be fitted with locking devices.

All valves, flanges and other equipment shall be easily accessible with the transformer installed on a flat concrete slab. The transformers shall be transported complete and be simple to install to minimise construction time.

9.1. **Transformer winding requirements**

Windings and their connections shall be of robust design and construction, sufficient to withstand forces occurring during normal manufacture, transportation, installation and service, and shall also withstand external short circuits.

Independent of the tapping in use, the transformer shall be capable of withstanding, without deformation or injury, the thermal and mechanical effects of fault currents arising from any type of external short circuit with full voltage being maintained on the winding.

The following calculations shall be completed for three phase faults and earth faults including extreme tapping positions:

- short circuit current and current densities
- short circuit forces and stresses in windings
- end supports using finite element analysis

9.2. **Transformer core requirements**

The core shall be designed and constructed to withstand, without deterioration, the stresses imposed by service conditions, lifting, transportation, handling, and earthquakes in the RailCorp geographical area.

There shall be one connection only between the core and the tank (earth). The core earth connection shall be inserted in the core lamination to such a depth that the core clamp brings sufficient pressure to bear upon it.
9.3. **Transformer main tank**

The following sections provide detail on specific requirements to the transformer main tank.

9.3.1. **Limiting dimensions**

The 66 kV tank, radiators and associated equipment arrangement shall satisfy the limiting dimensions supplied in the request for tender (RFT).

9.3.2. **Welds**

All permanent joints shall be welded and all external welds shall be continuous. Welds on external surfaces shall be smoothed out, rough edges rounded and weld spatter removed.

9.3.3. **Accumulation of gas**

The main transformer tank and on load tap changer shall have separate oil systems. The internal surfaces of the tanks shall be such as to prevent the accumulation of gas. All gas generated within the tank shall find an easy route to the Buchholz relay.

9.3.4. **Access to 66 kV bushing and OLTC**

Hand-holes complete with covers shall be provided to enable removal, fitting of bushings and current transformers and inspection of the on load tap changer (OLTC) selector switch without removing the main lid.

Inspection covers shall be permanently labelled with details of the equipment that is accessible under the cover.

9.3.5. **Tank earth**

Two earthing tabs (stainless steel 316) with 2 x 14 mm diameter holes suitable for connection of 2 x M12 bolt shall be located externally at opposite ends of the tank, near the bottom of the tank for connection to the substation earth grid.

9.3.6. ** Provision for temperature measurement devices**

A suitable oil tight thermometer pocket shall be provided for top oil temperature and winding temperature devices. The location of the pockets shall be carefully chosen to enable the measurements of the hottest top oil temperature. The design of the transformer tank shall be such as to prevent the build-up of pockets of still hot oil. The thermometer pockets shall be provided with a sealing cap to prevent moisture ingress.
9.3.7. **Cable cleats**

Unistrut supports shall be provided below the HV and LV cable connection location for attachment of cable cleats.

9.3.8. **Pressure relief valve**

An extra high flow pressure relief device complete with directional discharge shield and highly visible semaphore shall be provided to minimise the build-up of pressure within the main tank in the event of an internal fault.

Vented oil shall have provisions made to direct its flow to ground level in the bunded area within a control gully or pipe. Vented oil shall not be directed over manual control points of the transformer.

Pressure relief valves shall be rated such that internal transformer faults do not cause structural damage to the tank.

Alarm and Indication contacts shall be provided, integral with the pressure relief valve and shall be wired back to terminals in the transformer marshalling box in accordance with Section 9.7 and Section 9.8.

9.4. **Surge arrester mounting**

Where the transformer configuration is for connection of 66 kV busbar, appropriate mounting brackets shall be affixed to the tank for the mounting of suitable surge arresters adjacent to the HV bushings.

9.5. **Valves and pipework**

All valves shall be labelled as to their function and readily operable with the transformer fully assembled. In this regard it may be necessary to provide extension handles on radiator valves so that inner radiators may be isolated while outer radiators are mounted.

All valves which are mounted near the base of the transformer shall have mechanical protection provided to prevent damage during transport and so on.

No valves shall exit the transformer tank under the high voltage cable bushings.

All radiator isolation valves shall have visual indications of 'open' and 'shut' and shall be labelled as to their function. All other valves shall have clear indication of direction to open and close valve.

The Buchholz isolation valve shall be located on the conservator side of the relay. In case of necessary removal of the Buchholz relay, this isolation valve may be turned off and the main tank oil level lowered slightly to drain the Buchholz relay prior to its removal. The procedure shall be included in the operation and maintenance manual.
A drain valve 50 mm nominal bore pipe internal thread with flanged plug suitable for quick release fittings shall be fitted at the bottom of the transformer tank and the radiators to allow the oil and any moisture to be withdrawn.

An oil-sampling valve shall be provided at the bottom of the tank.

9.6. **Lifting attachments and wheels**

Lifting attachments of appropriate capacity shall be provided on all devices that have to be removed for inspection purposes. This includes the tank top lid if this is capable of removal from the tank.

Unless otherwise noted in the RFT, bi-directional wheels shall be provided for rolling the transformer full of oil into position. Wheels shall be of solid construction, flanged wheels are not acceptable.

Skid mounting facilities on the transformer in lieu of wheels may be required and will be included in the RFT if necessary. The relative heights of the transformer for the skid base option shall be as for the wheel option.

Lifting lugs shall be fitted to the transformer which allow the transformer to be lifted into or out of place while full of oil. Lifting lugs shall be located so that the transformer can be lifted without removal or fouling of any part.

Jacking plates shall be provided approximately 500 mm from the transformer foundation. The jacking plates shall be suitable for jacking the transformer when full of oil, and must be accessible when the transformer is installed at site.

9.7. **Marshalling box**

A marshalling box with a suitable ingress protection (IP) rating as detailed in EP 00 00 00 13 SP shall be provided for connection of alarms and indications. All wiring shall be terminated on standard DIN rail terminals and labelled with non-ferrous labels. The terminals shall also be clearly labelled as detailed in EP 00 00 00 15 SP *Common Requirements for Electrical Power Equipment*.

The marshalling box shall contain the following:

- vertically hinged doors
- thermostatically controlled anti-condensation heater (appropriate warning label to be installed in the marshalling cubicle)
- door operated light
- double general purpose outlet (GPO) that can be locked and be protected by a residual current device (RCD) in accordance with AS 3000 *Electrical Installations*
Wiring from the marshalling box to other substation equipment shall be installed by others (including supply of cable glands). A removable undrilled gland plate shall be supplied by the transformer manufacturer for the entry of cables and shall be located to permit cable entry from below.

9.8. Control wiring

Control wiring shall comply with the relevant sections of EP 00 00 00 15 SP.

9.9. Alarm and indication contacts

For each alarm or indication, one normally closed contact and one normally open contact shall be provided.

The contacts shall be suitable for making and breaking at least 100 mA in a 125 V dc circuit and shall be suitable for switching relay coils and similarly inductive loads.

9.10. Cable tray

100 mm stainless steel cable trays or ‘J’ hooks shall be provided. The cable trays shall be attached to the side walls for the purpose of routing small wiring between equipment items.

The manufacturer may recommend an alternative system for routing of cables between equipment; however, the alternative system shall allow for removal of the main tank cover at site.

9.11. Conservator

An appropriately sized conservator shall be fitted to the main tank. The conservator shall meet the following requirements:

- Maintain positive oil pressure in the main tank.
- Appropriately sized for the rating of the transformer and be suitable for the ambient conditions specified in in EP 00 00 00 13 SP.
- Flanged pipes of 50 mm in diameter shall be fitted at each end of the conservator so that oil can be completely drained and all sludge and foreign matter can be extracted by filtering. The pipes shall be fitted with 50 mm valves.
- Internal surfaces shall be treated with an approved oil resistant coating sufficient to ensure that the conservator meets the specified design life.
- Where the chamber of the tap changer containing the load making and breaking contacts requires it, an additional conservator shall be provided. This may take the form of an extension to the main conservator. The oil shall not be allowed to mix with the main tank oil.
• Lifting eyes shall be fitted to the conservator of sufficient capacity to allow removal of a full conservator.

• Oil level indicators shall be provided as detailed in Section 9.20.

9.12. Radiators

The radiators shall be designed to adequately dispose of all heat generated inside and outside the transformer to maintain the top oil, winding and core temperature rises within the specified limits.

The main connection to the radiators shall be fitted with valves immediately adjacent to the tank to allow removal without lowering of the transformer oil level and without removal of other radiator sections.

A drain plug shall be fitted to the lowest point to allow removal of oil from individual radiators independent of the transformer tank oil and other radiator sections.

Valves shall not be welded to the tank or radiators.

The external surfaces of the radiators shall be hot dip galvanised to AS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles.

The internal surfaces of the radiator shall be flushed to remove any contamination then dried and treated with an approved oil resistant coating.

Extruded aluminium type radiators shall not be used.

Radiators shall be fitted with lifting eyes capable of supporting the combined weight of the radiator and oil.

9.13. 66 kV and 11 kV terminal arrangements

Connection to the 66 kV terminals shall be made by cables or bare conductors as indicated in the RFT. Connection to the 11 kV terminals shall be made by cables. The preferred cable quantities and sizes are detailed in T HR EL 20001 ST High Voltage AC and 1500 V DC Traction Power Supply Cable Requirements.

The design of the terminal arrangements shall minimise the mechanical loading of the connecting cables, including the allowance for the thermal expansion of the cables.

Minimum safety clearances in accordance with AS 2067 Switchgear Assemblies and Ancillary Equipment for Alternating Voltages Above 1 kV are required for the transformer configuration with 66 kV bushings. The minimum safety clearance is applicable for the transformer with wheels or when the wheels have been removed.

The manufacturers' scope includes the bushings or sockets, but not the external cable connection hardware. The manufacturer shall prove suitability of the arrangement during high
voltage testing. For example, temporary test cables or temporary oil-to-air test bushings may be used; however, sockets shall be installed and fitted with dummy plugs.

9.13.1. **66 kV aerial bushing**

Where the transformer configuration is for the connection of 66 kV busbar, the bushings shall comply with AS 60137 *Insulated Bushings for alternating voltages above 1000 V*. The bushings shall be suitable for a normally polluted atmosphere and fitted with flat connecting palms.

Oil filled bushings are not acceptable.

The clearance between the 66 kV bushings shall be in accordance with Table 5 of AS 60076.3.

9.13.2. **66 kV cable connector**

Where the transformer configuration is for connection of a 66 kV cable, a separable, screened, touch safe connector such as a Pfisterer Connex connector that is suitable for interfacing with a 66 kV, single core, XLPE Cu cable shall be provided for each phase. The connector shall comply with IEC 60840 *Power Cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements*.

9.13.3. **11 kV separable connectors**

The 11 kV separable connectors shall be appropriately rated Euromold or similar plug-in connectors comprising a separable bolted type connector attached to the high voltage cable and mating equipment bushings in accordance with I.S. EN 50180 *Bushings above 1 kV up to 52 kV and from 250 A to 31.5 kA for liquid filled transformers*.

9.13.4. **11 kV star point (neutral)**

The 11 kV star point (neutral) shall be brought out to a separable connector of the same type as the other 11 kV terminals.

9.14. **On load tap changer**

The transformer shall be provided with full output tap changing equipment suitable for regulating the three phases simultaneously under load. The OLTC shall be of the high-speed resistor type. Tap-changers with vacuum interrupters are acceptable subject to life cycle costing analysis.

The OLTC shall comply with the requirements of AS 60214.1.

Only a single tap change shall be possible with each operation.

It shall be possible to determine the tap position safely from the ground without isolating the transformer.
All leads and connections to fixed and moving contact assemblies shall be supported and adequately braced to withstand short circuit currents for which the transformer is designed.

The oil in the diverter switch compartment shall be completely separated from the oil in the main tank by oil tight barriers. Maintenance of the tap changer shall be possible without disturbing the main tank oil system.

The diverter switch shall be readily accessible and easily removable for maintenance.

Facilities shall be provided to permit ready inspection of the tapping connections and selector and diverter contacts without the necessity for removing the selector or diverter switches from their housing.

9.14.1. Tap changer control

The tap changer shall be fitted with the necessary controls and protective equipment for:

- completely automatic operation
- local manual push button operation
- local manual mechanical operation

The time between changes of position of the tap change shall be adjustable in the range of 0 seconds to 300 seconds.

A supply from an 11 kV / 110 V three-phase voltage transformer will be provided at the substation for the operation of voltage sensing equipment. The voltage sensing equipment shall prevent operation of the tap changer if the reference voltage is lost.

The tap change control circuit shall operate at 125 V dc. This supply will be provided from the substation distribution board.

A 415 V, three-phase and neutral, 50 Hz supply of the required capacity will be provided for the operation of the tap changing equipment. In the event that the transformer is required to operate at a substation without such a supply, details of the alternative supply will be included in the RFT.

The tap changer mechanism shall be designed such that, following the initiation of a change of tap position, the change will be completed, even with a complete loss of supply to the drive motor.

The tap changer control cabinet shall be a suitable IP rating as detailed in EP 00 00 00 13 SP and shall be bolted to the transformer main tank in a convenient position so that the operator standing at ground level can carry out maintenance on all equipment contained in the cabinet with the transformer energised.

The cubicle shall contain a thermostatically controlled anti-condensation heater, a door operated light, and a manual handle for emergency and maintenance operation.
9.14.2. Tap changer monitoring

Tap changers shall be fitted with the following:

- A mechanically operated tap position indicator which will provide a visible indication of the tapping in use. The tap position indicator shall also provide an indication into a SCADA system via a tap position encoder producing binary output or volt free contacts with shared common.

- A local cyclometer for recording the number of tap changing operations.

- Contacts for remote indication of either limit of travel.

- Local and remote 'tap change in progress' indication. A voltage free (normally closed) contact shall be provided for SCADA to indicate a tap change is in progress. The contact shall be in the open state while a tap change is in progress. The actual tap change shall commence not less than one second after the indication signal goes to the 'changing position' state.

- A common 'fault' signal for remote indication which shall incorporate all fault conditions that can reasonably be monitored, together with loss of motor and control power supply. This signal shall be a contact that is normally closed but opens upon fault.

- Alarm equipment which will operate if tap changing has not been completed within a predetermined time after being initiated. This equipment shall also operate if the ac control supply is lost. A set of changeover contacts capable of making and breaking 100 mA in a 125 V dc slightly inductive circuit shall be provided on this equipment for external alarm circuits.

9.15. Temperature monitoring and indication

The temperature of the transformer winding and oil shall be monitored with both local indication and remote indication to SCADA provided. The following temperature indications shall be provided:

- top oil temperature indication contact A and contact B
- top oil temperature local visual indicator
- top oil temperature remote analogue transducer
- winding hot spot temperature indication contact A and contact B
- winding hot spot temperature local visual indicator
- winding hot spot temperature remote analogue transducer

The temperature at which each set of indication contacts operate shall be independently adjustable over the range of 70 °C to 150 °C in 10 °C increments. It shall be possible to readily
set the operating point within ±2°C without the need for additional set up instruments. The winding and oil instruments shall be capable of operating in ambient conditions as specified in EP 00 00 00 13 SP, for auxiliary equipment located near heat emitting equipment.

One set of indication contacts shall be used to provide remote alarms of abnormal temperatures and the second set of contacts shall be set to operate at a higher temperature and be used to trip the transformer ac circuit breaker.

Winding hot spot temperature local visual indicators shall be provided with a resettable maximum indicator and shall have an accuracy of ±2°C or better.

Winding hot spot and top oil temperature remote analogue transducers shall provide a 0 mA to 20 mA output and shall have an accuracy of at least ±2°C. The transducers shall be capable of operation from the substation 125 V dc auxiliary supply. The output of the transducer shall be connected to the SCADA system.

The device shall be fixed on a flexible mounting to minimise the effects of transformer vibration. All set points shall be labelled as to their use (for example, ‘alarm’ or ‘trip’).

9.16. **Gas and oil actuated relays**

The transformer shall be equipped with earthquake proof devices which are actuated by the generation of gas or pressure in the transformer unit and have similar characteristics to a float and flap type Buchholz relay. If reed switch type relays are used, they shall not be affected by magnetic fields associated with fault levels stated in Section 8.

Each device shall be fitted with two independent sets of contacts which, when actuated as above, will perform the following functions:

- One set of normally open contacts to trip the HV circuit breaker controlling the transformer unit in the event of major faults.
- One set of normally open contacts to operate an alarm system in the case of faults of a minor nature that is not sufficiently serious to warrant isolation of the transformer unit. All necessary wiring shall be installed in accordance with Section 9.7 and Section 9.8.

The Buchholz relay operating mechanism shall be removable without the need to disconnect the relay casing from the pipe work.

9.16.1. **Test valve**

The gas pressure relay shall be fitted with a test valve to facilitate the injection of air onto the relay vane to prove trip operation under simulated fault conditions.
9.16.2. **Ground level gas receiver**

Provision shall be made to enable gas from the relays to be sampled at ground level and for injection and subsequent release of air for testing and setting of the alarm float.

9.16.3. **Location of relays**

The gas protective relays shall be inserted in sections of the pipe between the conservator and the transformer and tap changer tanks.

The relays shall be mounted in such a manner that withdrawal of the relay mechanism shall not be impeded by the presence of any other pipework. The pipework shall be suitably braced so that pipeline vibration cannot operate the relay contacts.

9.17. **Transformer oil**

The transformer oil shall be naphthenic, corrosive sulphur free, non-inhibited, unpassivated, and be compliant with IEC 60296 *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*. Detection of sulphur shall be in accordance with IEC 62535 *Insulating liquids – Test method for detection of potentially corrosive sulphur in used and unused insulating oil*.

Oil shall be polychlorinated biphenyl (PCB) free and any deliveries (including the transformer) shall be accompanied by a National Association of Testing Authorities, Australia (NATA) certificate confirming this requirement.

The transformer shall contain all required oil when despatched from the factory on delivery to site.

9.18. **Finish**

The main tank shall be shot blasted internally and externally to remove rust and scale in accordance with Class SA2½ ‘near white’ blast cleaning in accordance with the requirements of AS 1627.4 *Preparation and pre-treatment of surfaces, Part 4: Abrasive blast cleaning of steel*.

The finished surface shall provide good adhesion properties for the primary coat.

The internal and external surfaces shall be prepared and coated strictly in accordance with the manufacturer’s instructions. The preparation and method of application for the finish shall ensure that the transformer is corrosion free for its design life.

Any surface that has the potential come into contact with oil shall not be galvanised.

9.18.1. **Internal surfaces**

The main tank, tap changer enclosure, conservators and pipework internal steel surfaces shall be painted with an oil resistant paint immediately after abrasive cleaning.
The internal surfaces of the control cubicle and marshalling cabinet shall be finished with an oil resistant full gloss white coating, colour N 14. This requirement does not apply to stainless steel or aluminium marshalling cabinet with a natural finish.

9.18.2. **External surfaces**

The external steel surfaces shall be painted with an inorganic zinc rich paint immediately after abrasive cleaning. The preferred colour is storm grey, colour N°N42 in accordance with AS 2700 *Colour standards for general purposes*.

9.19. **Breathers**

Breathers shall be provided for the air space above the oil in the main tank and tap changer conservator. Dehydrating breathers shall be sized to allow for humid air conditions.

Breathers shall be provided with an effective oil seal and an inspection window so that the colour of the crystals can be observed. It shall be possible to replace the crystals in a simple and straightforward manner that does not require de-energisation of the transformer.

The breathers shall be arranged so that insects cannot enter the conservator air space. The breather shall be mounted in such a position that it can be serviced from ground level.

9.20. **Oil level indicators**

Site glass type oil level indicators shall be provided for both the main conservator and the on load tap changer conservator. The indicators shall be clearly readable with the naked eye from ground level. The oil level indicators shall have a minimum visible range of -5 °C up to 105 °C with intermediate temperature calibration marks.

9.21. **Rating plate**

A rating plate made of pacified stainless steel in accordance with the requirements of AS 60076.1 *Power Transformers, Part 1: General*, shall be firmly attached by screws at each corner to a bracket, externally on the transformer enclosure. The plate shall not be attached to any removable cover.

In addition to the requirements of AS 60076.1, the rating plate shall also include the following:

- a diagram of connections
- the TfNSW specification number and version

The rating plate shall be located so that it can be easily read from ground level with the naked eye.
9.22. **Fall arrest system**

Anchorage points and other fixings suitable for an industrial fall arrest system to permit a safe system of work for all maintenance actions identified in the equipment manual shall be fitted. The safe system of work shall meet the requirements of AS/NZS 1891.4 *Industrial fall-arrest systems and devices, Part 4: Selection, use and maintenance* and WorkCover NSW Regulations.

9.23. **Anti-vibration pads**

Anti-vibration pads are required for skid mounted units. The manufacturer shall provide details of pads if skids are specified.

9.24. **Current transformers**

The following sections provide detail on the current transformer to be fitted for the protection scheme and for the winding temperature indication.

9.24.1. **Neutral earth protection**

A current transformer (CT) shall be provided for neutral earth protection having the following characteristics:

- be an outdoor toroid type and mounted to the transformer tank that allows the fully rated neutral cable and separable connector to pass through the CT
- comply with AS 60044.1 *Instrument Transformers, Part 1: Current transformers*, with tests carried out and submitted in accordance with this standard
- have a ratio of 100/1 (class and ratio shall be confirmed at time of tender)
- secondary wiring shall be terminated in the marshalling box
- CT terminals and secondary wiring shall be in accordance with EP 19 00 00 02 SP *Protection System Requirements for the High Voltage Network*

9.24.2. **Winding temperature indication**

A CT shall be provided as part of the winding temperature indication equipment. The CT shall be located within the main tank and be accessible through the main tank cover without removing the core and coil assembly. The CT shall be wired to the marshalling box in accordance with Section 9.7 and Section 9.8 of this standard.
10. **Thermal model**

A thermal model that uses the transformer HV current, thermal time constants (for example tank and winding time constants) and ambient air temperatures to predict the winding hot spot, top oil temperature and insulation aging shall be provided by the transformer manufacturer.

The electrical and thermal equation shall be provided in differential form suitable for solving by entry of time varying values of HV current and ambient temperature as inputs. The model shall be suitable for implementation in Microsoft (MS) Excel.

This electrical/thermal model is to facilitate the prediction of the expected winding hot spot and top oil temperatures for varying load conditions and compare to specified thermal limits. The input data sampling time interval shall be selectable.

The manufacturer shall validate the thermal model against results from the temperature rise testing requirements specified in Section 11.3.

11. **Tests**

All tests conducted shall be carried out in accordance with a prepared test program. This program shall detail the sequence of tests.

The transformer shall be completely assembled in the factory with all protection devices and cubicles. TfNSW reserves the right to witness any of the tests. The manufacturer shall provide TfNSW with six weeks' notice of the test commencement date.

All test results including the routine test results of bushings and the tap changer shall be included in the maintenance manuals.

11.1. **Component tests**

Certified results of type tests on all valves, relays, gauges and other devices shall be available for inspection.

Current transformers shall be tested in accordance with their respective standard. The proper functioning of all protective, indicating and alarm devices shall be functionally tested.

The insulation between the built-up core laminations, the core clamping framework and the tank shall withstand a high voltage of 2.5 kV for one minute. The link between the core and core clamp shall be separable for testing and shall be accessible without removing the core assembly from the tank.
11.2. Routine tests

Routine tests to AS/NZS 60076.1 shall be carried out on each transformer. In addition to the 'routine tests' as listed in AS 60076.1 a thermal image scan shall be completed on each transformer. This test, using thermal imaging equipment, shall record the temperature image at the rated current for the following:

- each face of the tank
- each face of the cooling radiator
- bushings, where fitted

11.3. Type tests

Type tests to AS/NZS 60076.1 shall be carried out on one transformer of a batch. Type test certificates for each of these tests shall be accepted if it can be demonstrated that the transformer supplied is of a similar design to a previously type tested transformer.

An additional requirement for the temperature rise test (AS/NZS 60076.3) is to record the temperature, time and current reading for each of the devices (top oil and winding) in a MS Excel spread sheet so that they can be compared with the results predicted by the virtual model generated from the TfNSW transformer modelling software specified in Section 10.

The following additional tests shall be carried out on each transformer as follows:

- full dissolved gas analysis of the transformer oil both before and after the temperature rise test
- lightning impulse voltage withstand tests including chopped wave tests on maximum tap, mid tap and minimum tap positions for the three phases respectively, and 11 kV secondary connections

A short circuit withstand test is not required; however the designer is required to provide the short circuit design calculations.

11.4. Special test

Sound power level tests shall be conducted in accordance with AS 60076.10.

Sound pressure check readings shall be carried out at full rated output during load loss testing and shall be included in the determination of the sound power level as per AS 60076.10.

The hot insulation resistance shall be recorded on transformers subjected to a temperature rise test.
11.5. **Transport delivery and tests after erection**

The transformer shall be equipped with a time stamped data logging impact recorder immediately after factory testing. This shall remain operational up until final installation of the unit at site. The data log shall be provided to TfNSW on delivery of the unit. On completion of the delivery of the works, tests shall be carried out by the contractor to demonstrate readiness for service. These tests shall include (but not be limited) to the following:

- measurement of winding resistance on all taps and all windings
- measurement of voltage ratio and check of voltage vector relationship on all taps
- insulation resistance of all windings
- dielectric dissipation factor (DDF) tests of all winding configurations
- oil dielectric test and test for water content

ITPs and associated test sheets showing completion of all site tests and test results shall be provided to a TfNSW representative. The contractor is responsible for ensuring that the transformer is ready for service.

11.6. **Loss capitalisation**

The transformer loss capitalisation shall be evaluated in accordance with EP 02 00 00 01 SP *Transformer Loss Evaluation*.

12. **Human factors**

The transformers shall be designed in accordance with the human factors principles outlined in T MU HF 00001 ST *Human Factors Integration – General Requirements*.

The design of the transformer shall allow for good access and visibility to items that require access for operation and maintenance. The design shall consider the following:

- height of Buchholz gas sampling device
- location and height of breathers
- location and height of tap changer control
- location and height of marshalling cubicle (AS 3000 requirements also apply)
- location, visibility and legibility of signage
- location and visibility of temperature indicators (shall be visible from ground level)
Appendix A  Whole-of-life cost

This appendix is provided for use by the AEO in assessing the whole-of-life cost.

The selection of the most suitable transformer design will be made on the basis of minimising the whole-of-life cost. The following factors shall be considered in determining this:

- cost of changes to the technical maintenance plan and service schedules or the creation of new manuals and schedules
- cost of decommissioning and disposal
- cost of installation
- cost of inventory spares
- cost of maintenance
- cost of modifications to other parts of the installation
- cost of replacement parts
- cost of special tools
- cost of staff training
- discount rate
- electrical losses
- environmental costs
- initial purchase price
- lifetime of equipment
- reliability and cost of consequential damage after failure
- cost of optional tests

Preference will be given to tap changers that require minimum maintenance. The contact life of diverter contacts will be of particular interest in this regard. Alternative offers should be provided for consideration, if improved maintenance accessibility and performance can be achieved even if it will be at significant additional cost to the offered design.

If this transformer has not previously been type approved by ASA in accordance with TN 050: 2014, the costs for this process shall be included in the whole of life cost.
Appendix B  Data set associated with the equipment

The following data shall be supplied by the manufacturer and maintained for the transformer. This data shall remain the property of TfNSW.

B.1. Drawings and information

All drawings shall conform to the requirements of the TMD 0001 CAD and Drafting Manual – Electrical Design – Section 4. The following drawings are required:

- Transformer arrangement drawings. Arrangement drawings shall be drawn to scale with the following detail:
  - complete detail of the transformer with views of all sides of the transformer and detailed sections as required
  - dimensions, including overall size, position of HV connectors relative to the centre lines of the tank and the level of the foundations, marshalling cubicle height from base
  - position of the centre of gravity
  - mass of the transformer complete both with and without oil
  - mass of main tank (including tank fitted with accessories) and filled with oil
  - quantity of insulating oil required in each oil-holding compartment
  - jacking points to be identified
  - complete listing of all fittings, accessories and parts with the associated manufacturer, part or model number and relevant ratings

- Where the transformer is required to be shipped in a dismantled state, a separate outline drawing shall be produced detailing the dimensions and weight of the separated components.

- Drawings of any special slinging arrangement required for handling the transformer during shipment or erection.

- Foundation drawings showing detail of base for the main tank.

- Schematic and wiring diagrams. Schematic diagrams shall include the following:
  - schematic diagrams of the transformer windings showing connections, tappings and tabulations of current and voltage rating of all windings
  - schematic and wiring diagram of the tap changer control
  - schematic diagram of alarm and trip circuits
- schematic diagrams of control of auxiliary systems
- wiring diagrams including cable block diagram, cable schedule and cable termination schedule

- Marshalling cabinet arrangement drawing showing details of all components. This is to include an item list detailing the components, the manufacturer, part/serial number and rating (where applicable).
- Marshalling cabinet terminal layout.
- Drawings of the rating plate as specified in Section 9.21. Details shown on these drawings shall not vary from that shown on the plates fixed to the transformer.

Note: This list does not include component drawings which are required as part of the integrated support requirements and inclusion in the operations and maintenance manual.

All the above drawings shall bear the transformer serial numbers of all units.

The calculation of inrush current is also required.

B.2. Technical schedule

The information listed in the technical schedule in Appendix C, shall be supplied by the manufacturer and maintained for each transformer.

B.3. Life cycle costing

All the data and assumptions pertaining to the determination of the whole-of-life cost calculations of the transformer shall be recorded including the transformer loss calculations as detailed in EP 02 00 00 01 SP.

B.4. Test results

The results of all tests, including routine, type, special, acceptance, periodic and corrective maintenance tests shall be recorded and maintained.

Routine tests certificates showing the results of each test performed shall be supplied in duplicate and electronically, in English, and maintained for the life of the transformer.

Type tests certificates showing the results of each test shall be supplied in duplicate and electronically, in English, and maintained for the life of the equipment.
## Appendix C  Technical schedule

The tenderer shall supply the information listed in this Technical Schedule with the tender, for each transformer.

<table>
<thead>
<tr>
<th>Transformer details:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of manufacturer</td>
<td></td>
</tr>
<tr>
<td>Country of manufacture</td>
<td></td>
</tr>
<tr>
<td>Rated HV voltage</td>
<td>V</td>
</tr>
<tr>
<td>Rated LV voltage</td>
<td>V</td>
</tr>
<tr>
<td>Rated power</td>
<td>MVA</td>
</tr>
<tr>
<td>Connection symbol</td>
<td></td>
</tr>
<tr>
<td>No-load current with rated voltage applied to the principal tapping</td>
<td>%</td>
</tr>
<tr>
<td>No-load current with 110% rated voltage applied to the principal tapping</td>
<td>A</td>
</tr>
<tr>
<td>No-load loss</td>
<td>W</td>
</tr>
<tr>
<td>Load loss at 75 °C</td>
<td>W</td>
</tr>
<tr>
<td>Thermal time constant – Tank</td>
<td>Hrs</td>
</tr>
<tr>
<td>Thermal time constant – Winding</td>
<td>Mins</td>
</tr>
<tr>
<td>Impedance voltage at rated current and 75°C based on ONAN MVA Rating</td>
<td>%</td>
</tr>
<tr>
<td>Sound power level</td>
<td>dB(A)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Construction details:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of core steel - hot or cold rolled</td>
<td></td>
</tr>
<tr>
<td>Brand or trade name and grade of core steel</td>
<td></td>
</tr>
<tr>
<td>Maximum flux density on net cross-section of steel with rated volts at rated frequency applied to the centre tapping</td>
<td>T</td>
</tr>
<tr>
<td>Limbs</td>
<td></td>
</tr>
<tr>
<td>Yoke</td>
<td>T</td>
</tr>
<tr>
<td>Material used for HV winding</td>
<td></td>
</tr>
<tr>
<td>Material used for LV winding</td>
<td></td>
</tr>
<tr>
<td>Type and class of insulation on windings</td>
<td></td>
</tr>
<tr>
<td>Type of gasket material</td>
<td></td>
</tr>
<tr>
<td>Locking mechanism applied to all internal bolts</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Type of Locking mechanism used on internal bolts</td>
<td></td>
</tr>
</tbody>
</table>

© State of NSW through Transport for NSW
### Protective treatment applied to tank:
- Internal surfaces
- External surfaces

### Tap changer details:
- Manufacturer
- Manufacturer model
- Type
- Motor supply voltage \( V \)
- Power requirement of motor \( W \)
- Continuous rating of tap changer \( A \)
- Overload rating of tap changer and information to show that it is capable of carrying the overload specified:

### Transformer dimensions:
- Overall dimensions \( \text{mm} \times \text{mm} \)
- Extreme height from foundation level \( \text{mm} \)
- Extreme height from foundation level when stripped for transport \( \text{mm} \)
- Projected floor area \( \text{mm} \times \text{mm} \)

### Transformer mass:
- Mass of transformer complete with oil \( \text{kg} \)
- Mass of transformer core and windings only \( \text{kg} \)
- Mass of windings only \( \text{kg} \)
- Volume of oil required to fill transformer, complete \( \text{Litres} \)

### Oil brand and type

### 66 kV bushing details (where applicable):
- Manufacturer
- Manufacturer's type number
- Insulator material
- Continuous current rating \( A \)
- Lightning impulse flashover \( \text{kVp} \)
- Creepage distance \( \text{mm} \)
- Minimum air clearance between phases \( \text{mm} \)
- Minimum air clearance phase to earth \( \text{mm} \)
- Palm dimensions \( \text{mm} \times \text{mm} \)
### 11 kV separable connectors:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Manufacturers model number</th>
<th>Continuous current rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
</tbody>
</table>

### 66 kV separable connectors (where applicable):

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Manufacturers model number</th>
<th>Continuous current rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
</tbody>
</table>

### Miscellaneous equipment:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage regulator</td>
<td></td>
</tr>
<tr>
<td>Buchholz relay</td>
<td></td>
</tr>
<tr>
<td>Temperature indicators</td>
<td></td>
</tr>
<tr>
<td>Overpressure relay</td>
<td></td>
</tr>
</tbody>
</table>

The transformer reliability data is required to be submitted. Refer to T MU AM 01002 MA *Maintenance Requirements Analysis Manual* for further details of TfNSW requirements. This manual supports the TfNSW Asset Management Policy with detailed processes for undertaking a maintenance requirement analysis.

### Transformer reliability data (use separate sheet if necessary):

<table>
<thead>
<tr>
<th>Design life</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure modes (for early, normal life and wear out periods): a)</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
</tr>
<tr>
<td>Mean operating hours between failures: a)</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
</tr>
<tr>
<td>Time to repair: a)</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
</tr>
</tbody>
</table>
C.1. Drawings and information to be submitted with the tender

In addition to the technical schedule, the following information shall also be submitted with the tender.

- Outline drawings: Fully dimensioned outline drawings showing all fittings, terminal arrangements, radiator equipment, tap changer equipment, and marshalling cubicle. The general arrangements and layouts shall be adhered to in the final design unless written approval is obtained from TfNSW.

- Foundation drawings: Foundation drawings showing detail of the base for the main tank and radiators (if these are separately mounted) including dimensions.

- Core material characteristics: Typical curves of flux density versus ampere turns per metre for the core material.

- Core information: Detailed description of the core type, methods of making joints, insulation between laminations, treatment of edges, core bolt insulation and method for minimising hot spots in limbs. Include details of the proposed method for verifying core hot spot temperature and method for how the core is earthed.

- Temperature indicators: A full description of temperature indicators and transducers including detailed design information of the type of pocket to be used.

- Tap changer details: A full description of the tap changer proposed including type test certificates.

- Other information: Any other information considered necessary by the manufacturer.

- Features of the transformer design: Provide details of the transformer design. This should include a description of:
  - the overall transformer design
  - the method for electrically, thermally and structurally modelling the design
  - lessons learnt from previous similar designs and how this has been addressed in this design
  - quality processes during design and manufacture to ensure the design will meet the TfNSW and appropriate Australian and international standards and how the manufacture of the transformer will be in accordance with the design

- Conservator sizing: Provide detailed calculations for the sizing of the conservator.

- Fall-Arrest system: Provide details of the proposal for the industrial fall-arrest system as required in Section 9.22.
• Departures from standard: Are there any departures from the requirements of this Standard? If there are departures, include details on a separate sheet.

• Special delivery requirements: Any special requirements that are envisaged for the safe delivery of the transformer to the specified site shall be stated at tender stage. For example, removal of the conservator could be necessary due to a low bridge on the delivery route. These costs shall be provided separately at the tender stage.
Appendix D  Options to be priced at tender

The following items should be priced at the time of tender and based on life cycle assessment and functional requirements recommended to ASA for inclusion.

D.1.  Winding and oil fibre optic temperature indicators

The provision of a minimum of four fibre optic temperature sensors to monitor the winding hot spot, average winding, tap winding and top oil temperature. The manufacturer is responsible for the recommendation and justification of the proposed locations.

The fibre optic sensors shall be brought out to the marshalling cubicle where a data logger can be placed while the unit is in service.

The provision of a logging device for monitoring fibre optic temperature sensors above, including any patch leads. The unit will have the ability to interface to the SCADA RTU for remote monitoring and be capable of having the data downloaded via a portable computer. The make and type of unit shall be clearly specified.

D.2.  Hermetically sealed tank with no conservator

Provide detailed calculations for the sizing of the tank for this option, in particular how the required operating temperature range is met, with associated minimum and maximum allowed deflection in the tank and margins.

D.3.  Conservator membrane

Provision of conservator fitted with a membrane or bag for sealing of oil to air interface. The membrane shall be vented through a breather pipe fitted with a silica gel breather.
Appendix E  Integrated system support requirements

The transformer manufacturer shall establish and provide the information required to operate and maintain the equipment throughout its operational life, in a cost effective manner and to a level that is consistent with the planned operational performance and usage of the transformer.

This includes the following:

- specifying maintenance requirements
- spares support
- operations and maintenance manuals
- training
- support equipment and tooling

E.1. Equipment supplier deliverable

The integrated support requirements are a significant deliverable in the procurement of new transformer. Manuals, training, documentation and other support deliverables shall be in accordance with T HR EL 00002 PR Electrical Power Equipment – Integrated Support Requirements.

E.2. Operation and maintenance manual

An operation and maintenance manual shall be provided for the equipment in accordance with the requirements of T HR EL 00002 PR. The requirements for the scope of the operation and maintenance manual are as detailed in T HR EL 00002 PR. The following additional content is also required:

- Photographs showing the winding and core taken during manufacturing of the transformer.
- Detailed description and overall transformer oil system diagram (with valves identified) including the required plant for the vacuum and oil filling procedure.
- Detailed step by step instruction for sampling gas from the Buchholz relay.
- Detailed step by step instruction for obtaining oil samples.
- Drawings necessary to install, maintain, dismantle, reassemble or adjust the transformer and fittings and to repair or replace all parts liable to wear and failure. In particular, this applies to fixed and moving contacts of the OLTC unit and auxiliary switches and special gaskets (being those that cannot be hand cut from sheet materials such as moulded gaskets and ‘O’ rings).
• Procedure to open the tank.

• OLTC operation and maintenance manual.

All operation instructions and associated descriptions of equipment shall be accompanied by colour photos of the actual equipment installed on the transformer that is being described.
Appendix F  Information requirements for the request for tender

This appendix provides a summary of the information requirements for the request for tender. The information includes both technical details in Table 5 and site specific information in Table 6.

Table 5 – Technical details to include in the RFT

<table>
<thead>
<tr>
<th>Transformer item</th>
<th>Technical details to include in the RFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer HV configuration</td>
<td>Indicate whether the configuration is bushing or separable connection</td>
</tr>
<tr>
<td>Tap changer ac motor supply</td>
<td>Indicate whether 415 V ac or 220 V ac (unearthed)</td>
</tr>
<tr>
<td>Transformer mounting</td>
<td>Wheels or mounting plates with anti-vibration pads</td>
</tr>
</tbody>
</table>

Table 6 – Site specific information to consider including in the RFT

<table>
<thead>
<tr>
<th>Site specific information</th>
<th>Information to include in the RFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site specific limitations on size or arrangement</td>
<td>Indicate whether there are size limitations imposed by surrounding infrastructure</td>
</tr>
<tr>
<td>Foundation</td>
<td>Type of foundation (plinth or slab)</td>
</tr>
<tr>
<td>Access and transportation limits</td>
<td>Access road weight limit</td>
</tr>
<tr>
<td></td>
<td>Maximum road width</td>
</tr>
<tr>
<td></td>
<td>Maximum standard height above road</td>
</tr>
<tr>
<td>Access road alongside operating railway</td>
<td>Provide details of whether or not the access road to the site is within the rail corridor and adjacent to an operating railway track</td>
</tr>
</tbody>
</table>