

Power Transformers: 15MVA, 25MVA, 35MVA, 45MVA, 60MVA and 120MVA

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ETS 0006 – Power Transformers: 45MVA, 60MVA and 120MVA Am. 3

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Contents

1	PURPOSE	5
2	SCOPE	5
3	REFERENCES	5
4	DEFINITIONS AND ABBREVIATIONS	7
5	ACTIONS	8
5.1	General requirements	8
5.1.1	Work Health and Safety Requirements	9
5.1.2	Service conditions	9
5.2	Network operating conditions	10
5.2.1	Site conditions	10
5.2.2	Overload capacity and temperature rise limits	10
5.2.3	Short circuit withstand	10
5.2.4	Insulation coordination	11
5.2.5	Harmonics	11
5.2.6	Core excitation	11
5.2.7	Voltage regulation	12
5.2.8	Interchangeability	12
5.3	Health, Safety and Environmental requirements	12
5.3.1	Sound levels	12
5.3.2	Losses	12
5.3.3	Fall prevention and safe working at heights	12
5.3.4	Special environmental requirements: toxicology safety	13
5.3.5	Oil pollution	14
5.3.6	Fire and blast hazards	14
5.3.7	Design for safe maintenance	14
5.3.8	Life-cycle assessment	14
5.4	Technical requirements	14
5.4.1	General	14
5.4.2	Core	15
5.4.3	Windings	16
5.4.4	Transformer tank	16
5.4.5	Lifting facilities	20
5.4.6	Cooling system	20
5.4.7	Oil conservators	24
5.4.8	Insulating and cooling fluid	26
5.4.9	Fittings	26
5.4.10	On-load tap-changing facility	30
5.4.11	Bushings and main terminals	32
5.4.12	Rating plate	35
5.4.13	Labelling	36
5.4.14	Secondary wiring	36

5.4.15	Surface finish	36
5.5	Maintenance requirements	38
5.5.1	Spare parts and maintenance	38
5.5.2	Failure mode analysis and preventative maintenance	38
5.6	Transportation	38
5.6.1	Design for transport	39
5.6.2	Impact recorders	39
5.6.3	Transportation with or without oil	39
5.6.4	Loose equipment	40
5.6.5	Documentation	40
5.6.6	Storage	40
5.7	Quality assurance	40
5.7.1	Quality assurance plan	40
5.7.2	Quality Inspection and Test Plan (QITP)	41
5.7.3	Design and risk assessment review	43
5.7.4	Operations and maintenance manual	44
5.8	Testing	44
5.8.1	Factory testing	44
5.8.2	Site testing	51
5.9	Tender drawings	53
6	AUTHORITIES AND RESPONSIBILITIES	55
ANNEXURE 1 – TECHNICAL REQUIREMENTS		56
Annexure 1.1	Transformer guaranteed performance	56
Annexure 1.1.1	132/33/11kV 60MVA transformer	57
Annexure 1.1.2	132/33/11kV 120MVA transformer	65
Annexure 1.1.3	132/66/11kV 60MVA transformer	73
Annexure 1.1.4	132/66/11kV 120MVA transformer	81
Annexure 1.1.5	132/11kV 45MVA transformer	89
Annexure 1.1.6	132/22kV 45MVA transformer	97
Annexure 1.1.7	66/11kV 35MVA transformer	105
Annexure 1.1.8	66/11kV 25MVA transformer	113
Annexure 1.1.9	66/11kV 15MVA transformer	121
Annexure 1.1.10	33/11kV 35MVA transformer	129
Annexure 1.1.11	33/11kV 25MVA transformer	137
Annexure 1.1.12	33/11kV 15MVA transformer	145
Annexure 1.2	Graphical representation of required impedance	153

1 Purpose

To set out in detail the minimum technical requirements for power transformers as defined in Section 2, for use in zone and transmission substations in the Endeavour Energy network.

2 Scope

This Specification covers the design, manufacture, testing at factory, delivery, erection and site testing of the following power transformers:

- 33/11kV and 66/11kV 15MVA, 25MVA and 35MVA,
- 132/11kV and 132/22kV 45MVA and
- 132/33/11kV and 132/66/11kV 60MVA and 120MVA.

It is not the intention to specify all design and constructional details of the power transformers. However, the equipment supplied must meet all the requirements specified in the referenced standards and in this specification.

All supplied transformers and associated equipment must be manufactured and tested to the standards with the year of publication listed in Section 3. In some circumstances based on local network conditions and experience, this specification is more stringent or is inclusive of requirement not covered in Australian and International Standards; in this circumstance the requirements of this specification shall take precedence.

Tenderers must state any non-compliance with the specification in the tender submission and any alternative offers must be submitted in full and separately from the main offer. Any proposed variations from this specification must be referred to the Asset Engineering Manager for approval prior to acceptance.

3 References

External Regulations		
Electricity Supply Act 1995 (NSW)		
Work Health and Safety Act 2011 (NSW)		
Electricity Supply (Safety and Network Management) Regulation 2014 (NSW)		
Work Health and Safety Regulation 2017 (NSW)		
SafeWork Australia Code of Practice: Managing the Risk of Falls at Workplaces (2019 2019)		
ENA National Electricity Network Safety Code (Doc 01-2019)		
National Electricity (NSW) Law 1997		
National Electricity Rules		

External Standards		
AS 1627.4	2005 (R2017)	Metal finishing – Preparation and pre-treatment of surfaces - Abrasive blast cleaning of steel surfaces

AS 1657	2018	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1768	2021	Lightning protection requirements
AS 2067	2016	Substations and high voltage installations exceeding 1 kV ac
AS 2312.1	2014	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Paint coatings
AS 2700	2011	Colour standards for general purposes
AS 3000	2018	Electrical installations (Australian/New Zealand wiring rules)
AS 3750	-2021	Paints for steel structures
AS 4398.2	2005 (R2016)	Insulators, ceramic or glass, station post for indoor or outdoor use
AS 4680	2006	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
SA TS 60815	2020	Selection and dimensioning of high voltage insulators intended for use in polluted conditions
AS 5577	2013	Electricity network safety management systems
AS 61869.2	2021	Instrument transformers – Additional requirements for current transformers
AS 60076	2006-2023	Power transformers (All current parts)
AS 60137	2020	Insulated bushings for alternating voltages above 1000 V
AS 60214.1	2020	Tap-changers - Performance requirements and test methods
AS 60529	2004	Degrees of protection provided by enclosures (IP code)
AS 62271.301	2022	High voltage switchgear and controlgear- Dimensional standardization of terminals
AS/NZS CISPR 16.1.1	2020	Specification for radio disturbance and immunity measuring apparatus and methods
AS/NZS ISO 9001	2016	Quality Management Systems - Requirements
AS 60060-1	2018	High voltage test techniques – General definitions and test requirements
IEC 60071	2011	Insulation coordination – Definitions principles and rules
IEC 60296	2020	Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment
IEC 60567	2023	Sampling of free gases and analysis of free and dissolved gases in mineral oils and other insulating liquids – Guidance
IEC 61181	2007	Mineral oil-filled electrical equipment - Application of dissolved gas analysis (DGA) to factory tests on electrical equipment
IEC 61850–1		Communication networks and systems for power utility automation

IEEE C57.93	2019	IEEE guide for installation and maintenance of liquid-immersed power transformers
IEEE C57.130	2015	IEEE Guide for the Use of Dissolved Gas Analysis Applied to Factory Temperature Rise Tests for the Evaluation of Mineral Oil-Immersed Transformers and Reactors

Company Policies and Procedures	
Company Policy (Leadership) 1.1.1	Sub-Delegations of Authority by the Chief Executive Officer
Company Policy (Network) 9.2.5	Network Asset Design
Company Policy (Network) 9.7.1	Network Asset Construction
Company Procedure (Governance) GRM 0003	Risk Management

Company Standards	
Equipment Technical Specification ETS 0010	Mineral Insulating oil
Equipment Technical Specification ETS 0120	Synthetic Ester Insulating Fluid
Substation Design Instruction SDI 526	Control cabling, panels and terminations
Substation Design Instruction SDI 534	Manuals, test reports & photographs

4 Definitions and Abbreviations

Term	Definition
ANSI	American National Standards Institute
AS	Australian Standard
SA TS	Standards Australia Technical Specification
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
NATA	National Association of Testing Authorities
NZS	New Zealand Standard
EPA	Environmental Protection Agency
ETS	Equipment Technical Specification
CT	Current Transformer
CTC	Continuously Transposed Conductor
DLA	Dielectric Loss Angle (tangent), also referred to as Dielectric Dissipation Factor DDF
Fault Level	Three-phase balanced fault level
kA	kilo-Amps
kV	kilo-Volts
ONAN	Oil natural air natural, (KNAN for synthetic ester insulating fluid)

ODAN	Oil directed air natural, (KDAN for synthetic ester insulating fluid)
ODAF	Oil directed air forced, (KDAF for synthetic ester insulating fluid)
OLTC	On load tap changer
OTI	Oil Temperature Indicator
WTI	Winding Temperature Indicator
Redundant	One more than needed. A failure of one component will not result in the failure of the function, for example, if a fan is redundant it means that if one fan in the system fails, other fans will immediately take over its function. A component failure will not result in a functional failure.
SCADA	Supervisory Control and Data Acquisition
Ur	Nominal rated voltage

5 Actions

5.1 General requirements

The transformers supplied must conform to all the current requirements of AS 60076.1:2014, and all relevant Australian Standards.

The equipment supplied must meet the highest standards of engineering, design and manufacturing practices.

The insulating medium will generally be paper and mineral oil. Synthetic ester fluid may be required for specific sites where fire safety, environmental protection and cost benefits from civis and land acquisition will dictate the use of this type of fluid. For 11kV windings enamel insulated conductor may be used.

Tap changers will be suitable for high speed (≤ 20 ms) on-load switching duty: the specific requirements are set out in the table in Annexure 1.

The transformers will generally be mounted outdoors on concrete slabs. Transformers may be installed within sound enclosures having a height equal to or greater than the transformer.

The supplier must provide everything necessary, including any special tools, usually supplied for the operation of the equipment, whether directly specified or not.

All connections must be terminated using crimp lugs and grade 316 stainless steel or hot dip galvanised bolts rated for maximum worst case fault duty. Clamps or u-bolt connections are not acceptable.

All equipment, except the outdoor primary, secondary and tertiary bushing terminations, must be effectively earthed and enclosed in earthed enclosures, to the extent that there is no safety hazard to operating personnel, to prevent accidental shorts by human error, flying objects or by rodents, and to prevent mechanical damage to the devices.

Primary, secondary and tertiary bushings must be of the configuration outlined in Annexure 1.

Inspection hatches must be located above the level of the core and windings.

The design and construction must be in accordance with the technical requirements stated. All materials must be of a type and quality that will give a normal life expectancy of 50 years or more.

Dissimilar materials used in construction of equipment must be chosen and assembled to prevent galvanic corrosion at the point of contact.

Equipment/components from third party suppliers, such as tap changer, bushings, control relays/devices and the like, must not be modified without approval from the Asset Engineering Manager.

Where a particular brand or model number is specified, these are Endeavour Energy's preferred options. Other makes and models may be submitted for approval by the Asset Engineering Manager. These will be

evaluated on criteria such as quality, functionality, maintenance requirements, life cycle cost and the need to keep additional spares.

Note: All values submitted in the table in Annexure 1 must be guaranteed values and will be treated as such in the evaluation, and when assessing whether the delivered transformer meets the specification. Any proposed variations from this specification should be clearly stated and will be referred to the Asset Engineering Manager for approval prior to acceptance.

5.1.1 Work Health and Safety Requirements

Transformers must be designed in accordance with the NSW Work Health and Safety Act 2011 and NSW Work Health and Safety Regulation 2011 as well as relevant Safe Work Australia and NSW WorkCover codes of practice and relevant Australian safety standards. Compliance to the above requires the designer and supplier to identify and consult and design to reduce risks associated with its equipment to a level that is as low as reasonably practicable for the lifetime of the transformer and its associated equipment. The lifetime must include risk considerations for, but not be limited to the design, manufacture, delivery, installation, erection, commissioning, use, ongoing monitoring and repair, decommissioning, dismantling, storage and eventual disposal of the transformer and its associated equipment.

The supplier under this specification must develop a risk assessment to meet the minimum requirements of Endeavour Energy Company Procedure GRM 0003. The risk assessment for the power transformer and its associated equipment will be reviewed, discussed and agreed as part of the design review (refer 5.7.3). The supplier must compile a risk assessment and risk register listing all the risks identified for its and all associated equipment and the control measures implemented to eliminate and where not practicable, minimise identified risks to a level as low as reasonably practicable. The risk register must also form part of the supplied manual. Prior to the shipment of the power transformer, the supplier must hand over a copy of the agreed risk register that also specifically outlines all remaining risks for the installation, operation, ongoing maintenance and eventual disposal of the power transformer.

If the designer of the transformer identifies reasonably practicable risk measures that differ from the minimum requirements stated in this specification, such measures must be stated in writing for review by Endeavour Energy.

Additional specific health, safety and environmental requirements are detailed in 5.3.

5.1.2 Service conditions

The equipment must be suitable for use on Endeavour Energy's 3-phase 50Hz system. The system highest voltages, system earthing and fault levels are set out in Annexure 1. The service conditions in which the transformer will operate must be in accordance with AS 60076.1:2014 and as indicated in Table 1.

Table 1 – Service conditions

Description	Criteria
Altitude	<1000m
Maximum ambient temperature	45 deg. C
Minimum ambient temperature	–10 deg. C
Average annual lightning ground flash density	3 strikes per km ²
Solar radiation	1.1kW/m ²

Average index of mean relative humidity: 9am	95%
Seismic acceleration coefficient (maximum)	0.09
Pollution level	Very Heavy in accordance with SA TS 60815
Ice coating	1mm
Wind speed	34 m/s
Condensation/precipitation	Yes
Electromagnetic disturbance	AS 2650 cl. 2.1 (i)
Duration for temperature drop by 20 deg. C	20 minutes

5.2 Network operating conditions

5.2.1 Site conditions

The transformers will generally be mounted outdoors on concrete slabs inside an oil containment bund. The concrete plinth directly under the base of the transformer will be flat to a tolerance within ± 3 mm.

Transformers may also be installed within a sound enclosure having a height equal to or greater than that of the transformer. The tenderer must state any applicable de-rating factors in the tender submission if transformers are installed within a sound enclosure. In particular, a minimum clearance between sound walls and transformer should be specified so that the transformer rating is not affected including overload capacity and temperature rise limits in accordance with 5.2.2.

5.2.2 Overload capacity and temperature rise limits

The transformer must be capable of having its inherent cyclic and short-term emergency overload capacity used in accordance with AS 60076.7.

In particular, transformer components including tap-changers must be rated such as not to limit this capability. Terminations and internal cables and busbars and all current carrying components, must also be rated to suit this requirement. The bushings and tap-changer must have a continuous current rating not less than 150% of the full load rating of the transformer at the maximum operating temperature at the extreme tap position.

The temperature performance of the transformer must be tested and proven in accordance with AS 60076.2.

The transformer temperature rise limits must not exceed those values set out in Annexure 1. Alternative temperature rise limits in accordance with AS60076.2 may be offered. The life cycle performance of the offered temperature rise limits will be considered during tender evaluation.

5.2.3 Short circuit withstand

The transformer together with all equipment and accessories, on any tapping, must be capable of withstanding without deformation or damage the thermal and mechanical effects of external short circuits as may arise from any system fault with a capacity as set out in Annexure 1. External short circuits are not restricted to three-phase short circuits and therefore the thermal and dynamic stresses must be suitable for all possible unbalanced external faults.

Short circuit design must be as set out in AS 60076.5 and must be based on three (3) second duration. The manufacturer must provide calculations and demonstrate at design reviews that the transformer will withstand both dynamic and thermal short circuit forces imposed during its whole life of operation.

The manufacturer must supply details of a short circuit type test of a similar size and construction transformer. Where similar short circuit type testing cannot be provided, the manufacturer is to provide evidence through combination of like test and detailed model based calculation that their design and construction is suitable for the short circuit stresses applicable in Endeavour Energy's network to the satisfaction of the contract manager.

The insulation and coil design must be such that substantial coil clamping pressure is maintained throughout the life of the transformer, particularly in designs that do not allow for easy adjustment of coil pressure on site.

5.2.4 Insulation coordination

Suitable insulation levels and method of system earthing are as detailed in Annexure 1.

5.2.5 Harmonics

The transformer and associated equipment supplied must be suitable for harmonic loads in addition to power frequency requirements. The recommended planning levels for harmonic distortion on the network are shown in Table 2 (from ENA "Guideline For Power Quality: Harmonics").

Table 2 – Recommended planning levels for harmonic distortion

Harmonic No	Voltage Level (% of nominal voltage)					
	132 kV	66 kV	33 kV	22kV	11 kV	400 V
3	2.00	2.65	2.83	4.27	4.27	4.50
5	2.00	2.87	3.11	5.12	5.12	5.50
7	2.00	2.59	2.76	4.19	4.19	4.50
THD	3.0	4.1	4.4	6.6	6.6	7.3

The load loss, excitation capability and temperature rise limits must be guaranteed with this harmonic content.

5.2.6 Core excitation

The flux density in any part of the magnetic circuit including shunts should not attain a value that causes saturation. This applies to the specified voltage and frequency at any tap position and including transitory effects of combined system voltage, frequency fluctuations and harmonic load content.

The transformer supplied under this specification must be proven suitable for the greater of:

a) operating continuously above rated voltage or below rated frequency at maximum continuous rating and allowance for cyclic rating (refer 5.2.2) for any tap position, without exceeding the limits of temperature rise detailed in Annexure 1 with the following additional conditions:

- with secondary voltage and volts per hertz at 105% of rating;
- with load power factor at 0.86; and
- frequency is at 47.5Hz

Or

b) operating continuously above rated voltage or below rated frequency at no load for any tap position, without exceeding the limits of temperature rise detailed in Annexure 1 when neither the voltage nor volts per hertz exceed 110% of rated values.

The maximum flux density must be in accordance with the limits shown in Annexure 1 and this is to be proven in the design review. At flux densities exceeding 1.9 Tesla, design justification and precautions to control saturation must be explicitly detailed in the offer.

5.2.7 Voltage regulation

The transformer must be able to regulate the voltage on-load within the tapping ranges indicated in Annexure 1. The specified voltage, ratio, impedance and timing requirements must be met. Refer 5.4.10 for further detail.

5.2.8 Interchangeability

In order to manage network risks associated with transformer failures and spares management, the transformer and its parts including bushings, must meet the mandatory dimension, technical and configuration requirement detailed in this specification and its associated drawings referred in 5.9. Details of parts and accessories offered that are already in use by Endeavour Energy must be provided by the supplier.

5.3 Health, Safety and Environmental requirements

5.3.1 Sound levels

The transformer may be installed in a residential area in close proximity to family residences. As a result of strict noise requirements, Endeavour Energy requires sound levels that meet maximum requirements as set out in Annexure 1.

Low noise performance must be achieved by superior core and coil design (current and operating flux density). Sound level measurements for guaranteed performance must be taken prior to adding any sand to tank wall stiffeners.

All main and auxiliary equipment, including the tap changer, tap changer motor box and linkages mounted on or near the transformer, must be designed for operation within the specified noise limit, which includes both instantaneous and summated time noise levels.

A sound level test report must be provided and must be as set out in AS60076.10. The sound power level test report must be submitted for approval by the contract manager. All sound power level tests must satisfy the relevant validity parameters/conditions. If the parameters/conditions are not met, the testing method and or testing environment must be changed to provide legitimate test results.

Sound power levels exceeding the specified levels will not be accepted.

The low noise options (that is, option 2 or 3 from Annexure 1) shall only be used at sites identified to require low noise power transformers in accordance with Environmental Noise Impact Assessment.

5.3.2 Losses

For the minimal lifetime cost of any transformer as well as for environmental reasons, the no-load and load losses as well as cooling equipment losses must be guaranteed and will be evaluated in the financial assessment at the rates indicated in Annexure 1.

5.3.3 Fall prevention and safe working at heights

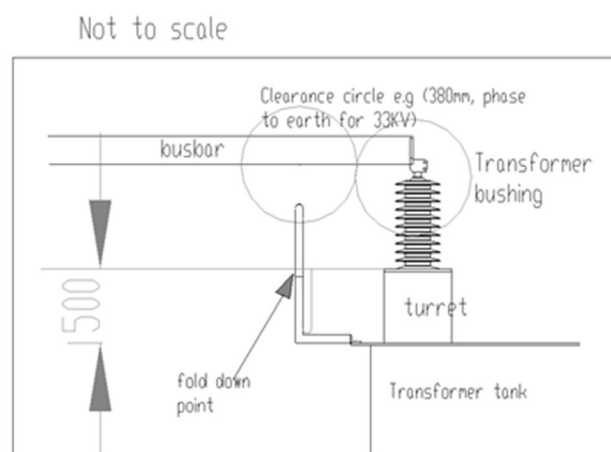
As far as practicable, the design of the power transformer must consider the requirement that all operational and maintenance work can be performed at ground level. Where it is necessary to perform work at heights exceeding two (2) metres, permanently fitted handrails must be provided along with a Maypole base for fall restraint. The safety at heights requirement must be in accordance with the NSW SafeWork Code of Practice: Managing the risk of falls at workplaces August 2019.

The permanently fitted handrail is required and must meet the requirements of AS1657, supplemented by a Maypole base to achieve the fall restraint systems for maintenance. It must be possible to place all handrails into an upright position without disconnecting any busbars, conductors or cables. Electrical clearances are to be maintained while the transformer is energised.

The handrail may need to be folded down to obtain phase to earth clearances to any live parts, including busbars, conductors, cables, or bushings when the transformer is energised. The busbars typically come onto the top of the bushings horizontally. The handrail should fold down about a horizontal line 500mm from the transformer lid, in line with the bushing turrets, as shown in Figure 1. It must be possible to fold the handrail up or down without exposing the operator/technician to risk of a fall. Means must be provided for locking the handrail when in the upright position.

Where a handrail is folded, it must be to the inside of the transformer. The force required to lift the handrail must not exceed 200N and the folding portion of handrail must be fitted with stops to prevent it from folding outwards. Details of handrail are subject to approval in the design review prior to the manufacture of the transformer.

Figure 1 – Handrail and clearance requirements



The risk of falls is increased by trip hazards particularly on the transformer lid and near where oil slips can occur. Trip hazards must be clearly identified and eliminated as far as reasonably practicable in the design process. Oil handling equipment should be positioned so that any oil leaks do not impact on the lid of the transformer in particular.

Notwithstanding any of the above, workers will require access to the top of the transformer tank. Provision must be made for a permanent ladder attachment and anchor points that will enable workers to have safe access to all elevated locations. Provisions for safe means of movement between different levels must be provided.

5.3.4 Special environmental requirements: toxicology safety

The supplier must provide with the offer, full details, including composition and toxicological information, regarding the health and safety aspects of all the materials offered in their products.

Recommended procedures must be provided for the safe handling, safe operation and maintenance of products supplied. The means of disposal of the materials must be clearly stated.

Safety data sheets (SDS) must be provided, with copies available on site, for materials that are supplied and subject to safety considerations in handling and use.

All equipment including gaskets and packing material used and provided must be asbestos free. Oil must be PCB free.

The above information is required as part of the offer and will be reviewed as part of the tender process.

5.3.5 Oil pollution

Joints between oil containing parts of the equipment must be leak tight under all circumstances. Gasket joints must be designed to avoid deterioration due to oil or excess strain.

Minimum gasket details are provided in 5.4.4.

5.3.6 Fire and blast hazards

The transformer and its components, and in particular the tap changer and bushings, must be designed in a manner to reduce the risk of rupture and explosive failure and subsequent fire risk.

The appropriate sizing and locations of pressure relief devices, main tank and tap changer pressure withstand capability must be key considerations in the design and be specifically addressed by the designer in the design review.

Suggested routine testing and maintenance regimes and limits must be provided to manage ongoing risk of transformer and component failure.

5.3.7 Design for safe maintenance

Construction features must be provided where necessary to enhance safe access to the tank lid, conservator, tap changer and gas accumulation relay for maintenance purposes. Suitable access points must be provided for easy access to winding tails for collecting paper samples for tests. The exact location for proposed paper sampling should be provided by the supplier and additional paper placed at this point to assist with the safe removal.

5.3.8 Life-cycle assessment

The supplier shall provide a Life Cycle Assessment (LCA) for the manufacture of the transformer, covering life cycle stages from raw material extraction through to delivery to site (modules A1 to A4). The LCA must be conducted in accordance with ISO 14040 and ISO 14044.

Where available, the LCA should be presented in the form of a verified Environmental Product Declaration (EPD) developed in accordance with ISO 14025. An EPD is a standardized and third-party verified summary of LCA results and is considered an acceptable format for meeting this requirement, provided it includes the relevant life cycle stages.

5.4 Technical requirements

5.4.1 General

The various technical components of the transformer supplied are specified in this section and in Annexure 1.

The key components in this section and reference clauses are provided in Table 3

Table 3 – Technical requirement reference summary

Transformer Component	Reference
Core	5.4.2
Windings	5.4.3
Tank	5.4.4
Cooling system	5.4.6
Oil conservators	5.4.7
Insulating and cooling liquid	5.4.8
Fittings	5.4.9
On-load tap-changer	5.4.10
Bushings and terminations	5.4.11
Rating plate and labelling	5.4.12
Secondary wiring	5.4.14
Surface finish	5.4.15

All bolts, screws and nuts must be ISO metric. All bolts must be no longer than necessary. All bolts, nuts and washers used outside the tank must be hot-dipped galvanised or grade 316 stainless steel. All connections must be terminated using crimp lugs rated for maximum worst case fault duty. Clamps or u-bolt connections are not acceptable. All nuts within the tank must be fitted with approved positive locking devices. Chemical locking is not permitted.

Bolts or studs of diameter less than 10mm must not be used without the approval of the contract manager.

Sharp edges and corners must be rounded off to avoid the risk of injury.

The general arrangement and configuration of all individual components must allow for easy dismantling and removal without the need for dismantling of other components.

Welded surfaces must be free of scale, dirt, grease, paint or heavy rust. The welding sequence to be adopted must be such as to reduce distortion to a minimum. All slag must be carefully removed after each run and all joints must be seal welded. Hidden welds that form part of the oil containment are not permitted.

All similar parts must be accurately machined and set up by the aid of jigs, so that they can be interchangeable between phases and transformers. All surfaces that will be connected together, or which must be accurate for the purpose of sealing, levelling or setting up during erection, must be accurately machined. Accurately set and machined dowels or holes must be provided for the correct and accurate fitting of all components.

5.4.2 Core

The core-form method of construction must be used.

Cores must be designed and constructed to withstand without deterioration the stresses imposed by service conditions, lifting, transport and handling.

The core must be insulated from its supporting frame, clamps and tank. The core and its frame must be individually earthed through a removable link, which is mounted on bushings external to the tank. The bushings and link must be contained on the external side of the tank compartment in a protective housing to IP55. Links must be readily accessible/ removable without the need to interfere with the oil system or ancillary equipment. The link and bushing must be rated for core insulation testing.

The stray flux from windings must not cause the core surface temperature or that of steel limb stiffeners or tie-rods to become excessive under any operating condition, including overloading. Temperature rises of these components must be in the general order of those of the windings.

The form of construction including core-bolts where applicable and core earthing method must be fully described in the tender.

5.4.3 Windings

The windings must be of the best modern design. Sufficient magnetic balance must be maintained to satisfy the short circuit withstand requirements. Insulation materials must be selected so that stable clamping pressure is maintained throughout the life of the transformer. The coil pressure ring at the top of the coils must be constructed of a single piece per phase and be capable of supporting the forces applied during short circuits.

Conductors must be free from scale and burrs and must have suitably rounded corners. Individual strands must not make inadvertent contact. This condition must be verified after drying and with the winding clamped to full design clamping pressure by application of a 500V insulation test between paper insulated strands or 250V for strands within continuously transposed cables (CTC). No shorts between strands are permitted.

When using enamel insulated stranded conductors, the strands must be separated by means of a radial spacer (e.g. centre-column paper) to prevent enamel to enamel contact in the axial direction (that is, direction of clamping pressure). Additional care is required for lead-outs when using enamel conductors and the design detail must be fully described in the tender offer.

The type of windings used, including the conductor type, method of conductor jointing and the location and arrangement of winding end connections must be fully described in the offer.

All packing materials at top and bottom of windings must be positively and permanently held in position irrespective of winding or core movements. Radial spacers must be lined up axially and vertical spacers/ribs must be lined up radially.

5.4.4 Transformer tank

The oil filled transformer may be jacked, lifted and hauled into place and this must not result in any permanent deformation or leakage to the tank. All metallic surfaces including the tank lid must be designed without any pockets or dips to prevent the accumulation of water.

Burrs and sharp edges on all steelwork must be removed. All steel fasteners must be either hot-dipped galvanised or grade 316 stainless steel.

All gasket joints must be scarf joint.

The main tank must have unpainted grade 316 stainless steel, or galvanised earthing terminals welded to each corner of the transformer near the bottom of the tank.

A continuous fillet weld must be used for stiffeners or attachments that are exposed to weather. Tack or intermittent welding must not be used under any circumstances. Tank wall stiffeners of the vertical type are preferred to minimise corrosion of the surfaces. Access covers must be provided on stiffeners to allow the option of sand filling if required, for future noise mitigation purposes.

Gaskets must be made of a high transformer grade neoprene impregnated cork material. Suitable alternatives to neoprene gaskets may be considered by the contract manager if their performance is superior

to neoprene and full details are provided e.g. use of stainless steel flanges with O-rings, (O-rings on a painted mild steel flanges are not acceptable). Gaskets must be weather resistant and must not deteriorate when exposed to high oil temperatures in accordance with this specification.

Suitable lugs must be provided on the tank (or the underframe) for the attachment of handling tackle.

Construction features must be provided where necessary to enhance safe access to the tank lid, conservator, tap changer and gas accumulation relay for maintenance purposes. Suitable access points must be provided for easy access to winding tails for collecting paper samples for tests.

5.4.4.1 Jacking pads

Four (4) jacking pads must be provided on the tank in locations to maximise the stability when lifting the transformer filled with oil.

The underside of each pad must be:

- free of gussets;
- at least 200 mm wide, project at least 280mm clear of the tank wall; and
- not less than 410 mm and not more than 500mm above the base of the tank.

Any other designs are subject to the approval of the contract manager.

5.4.4.2 Base

The base of the transformer must have adequate strength to support the transformer when placed on the ground and also allow the tank to be moved in any direction without damage using rails, rollers, plates etc. The base or welded plates must support the transformer through anti-vibration pads. The base or plate dimensions must be slightly larger than the anti-vibration pads.

5.4.4.3 Anti-vibration pads

Anti-vibration pads must be provided. They must be oil and weather resistant rubber or equivalent material. Their surface area and layered construction must be such that vibration attenuation at 100Hz is achieved (assuming infinite ground impedance). Details of the attenuation and design for anti-vibration must be provided by the supplier in the design review.

5.4.4.4 Lashing down/pulling lugs

Lugs be provided for:

- Lashing down the transformer securely when being carried on a road transporter.
- Enabling the transformer to be hauled in each direction along the lines of travel.

Pulling lugs must be located on the centre line of each tank side, near the base of the transformer.

5.4.4.5 Cover

The tank lid must be welded to the top of the tank. However, the active part assembly (core and windings) must not be supported by the lid. All metallic surfaces including the tank lid must be designed to prevent the accumulation of water i.e. built with sufficient slope to shed water.

The tank and lid must be designed so that all possible internally generated gases (including gases from spaces under access covers) will vent to the Buchholz relay.

Fixings must be provided for attachments for a safe working environment when personnel must work on the top of the transformer. All pipes and equipment on top of the transformer must be located in such a way as to maximise the safe movement of personnel.

5.4.4.6 Oil-tight joints

Oil leaks from the main tank-cover joint or other joints are unacceptable under any static oil-head or forced oil conditions or excess strain at any ambient and maximum operating temperatures. Only joints of proven design, capable of preventing deterioration of any seal or gasket materials must be supplied and guaranteed.

5.4.4.7 Air release plugs

Air release plugs must be provided at all points where air can be otherwise trapped during oil filling operations. This must include, but not be limited to; each radiator cell, pipework between radiators and main tank, headers pipes, tap changer, main tank and pump.

5.4.4.8 Vacuum and pressure requirements

The complete tank with all fittings and pipework must be designed to withstand without leakage and permanent deformation an overpressure of 50kPa over the top of the oil filled transformer, in accordance with the test requirements in accordance with relevant standards and must withstand full internal vacuum without oil.

5.4.4.9 Valves and oil facilities

All pipework is to be suitably braced and protected against being inadvertently stepped on and to allow safe unhindered access to personnel.

Pipework and associated valves must be extended to provide effective transformer and tap-changer filling, draining and filtering facilities at ground level. All pipework/valves are to be terminated 1200mm above ground level.

Valves must not be welded to the transformer main tank, and all valves must be easily accessible when all transformer auxiliaries are fitted.

Shut off valves must be provided on the end of each pipe connecting the main tank and separate radiator bank of the transformer to allow the relocation of main tank and radiator bank separately.

Filtering/draining/sampling valves must be provided on top and bottom headers of the separate radiator bank.

All terminating valves must be of the gate type and have a 40mm nominal bore and fitted with a flange on the open side of the valve and have blanking plate fitted. All valves must be fitted with a gasket between the valve flange and blanking plate. All blanking plates must be secured to the valve by a chain welded to the plate and valve flange.

All terminating valves must have permanent stainless steel labels adjacent to the valve clearly defining the valve function, for example, Main conservator fill, Tap-changer drain, Main tank filter, and so on.

An oil sampling valve, approximately 15mm nominal bore with a flange and a blanking plate, must be fitted in the bottom of the main tank and the radiator header pipes and located in an area that can be accessed without obstruction.

Oil draining valves must be provided at all locations where oil can be trapped while disassembling pipe-work.

All flange dimensions must be in accordance with “AS 2129-2000 Section 6 Dimension of Flanges” for flat flanges.

5.4.4.10 Circulating and eddy currents

The tank must be designed to minimise the losses caused by the leakage flux impinging onto metallic structural parts such as tank walls and cover resulting in circulating and eddy-currents. Elevated temperatures must be avoided at any part of the tank surface and at flanges between parts of the tank and its components including gasket sealed joints. High current internal connections between windings and bushings can also result in eddy current losses and localised heating in adjacent metallic parts such as turrets and details of all the control measures must be provided by the supplier in the design review.

5.4.4.11 Inspection and access covers

Suitable access must be provided for inspecting and servicing the tap switch selectors, internal bushing connections, CTs, winding tails, and earthing connections.

Access to these positions must be achieved without dropping the oil level below the core and winding and in particular the top of the winding clamping structure.

The openings must have dimensions that allow unimpeded access to carry out the intended works.

All access covers must be provided with lifting handles and must not exceed a weight of 20kg.

5.4.4.12 Conservator tanks

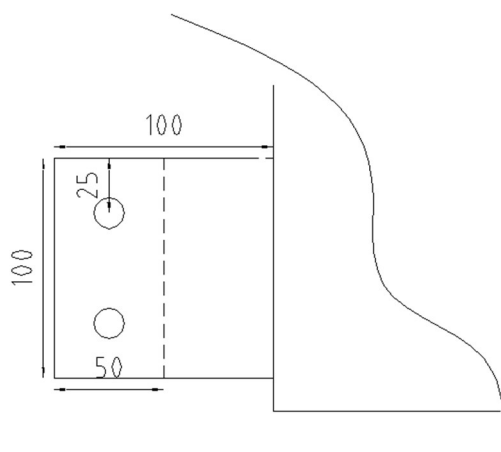
There must be an oil conservator for the main tank and another one for the OLTC. Refer 5.4.7

5.4.4.13 Tank earthing

The tank must have four (4) unpainted grade 316 stainless steel earthing terminals, each welded near the bottom on each of the corners of the tank.

The earthing terminal must match a type 4 terminal palm as set out in AS 62271.301, with the addition of a 50mm x 100mm extension shown in Figure 2. The earthing terminal must be drilled with two (2) x 14mm diameter holes at 50mm spacing to accept two (2) x M12 bolts.

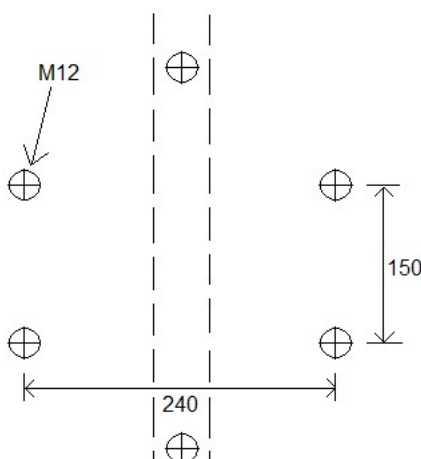
Figure 2 – Tank Earth Tag



Welded studs must be provided on the transformer tank to support the neutral leads/conductor from the transformer LV neutrals to the nearest earth terminals by a direct route. The studs must be capable of fitting low voltage support bushings or brackets.

Additional studs must be provided in the neutral/earth route for mounting of a toroidal neutral CT (dimensions as shown below, must be located in an area that can be accessed without obstruction).

Figure 3 – Neutral CT stud dimensions



There must be one suitable earthing terminal, as stated above, on each cooler bank support structures for connecting directly to an earth bar.

Where sections of the transformer tank are separated by a form of insulation, the sections must be electrically bridged by an earthing conductor that is minimum size 120mm² (95mm² for transformers 35MVA and below) copper with yellow/green insulation. Where the sections are welded together there is no additional requirement of an earthing conductor. Alternate methods of earthing removable panels may be submitted for approval.

Other internal and external metal parts of the transformer must be earthed to the tank or separated to an earth bar installed at this site. Closed circulating current loops must be avoided. All flanged joints, control cubicles, cubicle doors and inspection covers etc. must be electrically bridged to the tank.

5.4.4.14 Pressure relief for main tank

At least one pressure relief device must be fitted to the main tank and must be of a self-sealing spring design. The pressure relief device must preferably be located close to top of the main tank to allow the expulsion of gas and be located based on the pressure assessment performed by the designer. The pressure relief device must have an approved oil deflection collar and piping or appropriate coverage must be connected in order to direct oil down near the base of the transformer.

The device/devices must incorporate a switch having one (1) normally open contact capable of making, carrying and breaking 0.5 Amps in a typically inductive circuit at 120V dc. The switch must operate on activation of the pressure relief device.

5.4.4.15 Transformer on-line monitoring

On-line monitoring systems such as partial discharge (PD) or oil monitoring may be installed in future. The supplier shall provide provisions to install suitable PD or oil sensors e.g. Ultra High Frequency (UHF) for PD or Hydrogen (H₂) sensor for oil on the transformer tank if required in future. Amount and location of sensors shall ensure full coverage of the tank for detecting and localising PD sources and accurate readings of H₂ gas level. The range of sensor depths shall be considered and a clear space provided inside the tank with safe clearance between the sensor and any inside components such as core and windings including all cables, busbars, insulation and supports. There must be a laser etched stainless steel label, affixed by nickel plated brass screws or sealed stainless steel rivets stating the maximum insertion depth in mm for each sensor. Full details shall be confirmed by the supplier in the design review. The supplier may also provide details of the actual equipment and overall monitoring system that is suitable and compatible with the above mentioned provisions. These will be evaluated with a view to reduce costs associated with operation and maintenance of transformers and prevention of failures and outages.

Details must also be supplied of an option of a suitable online oil drying system that may be fitted to the transformer.

5.4.5 Lifting facilities

The tank, tank cover, core, radiators, conservator and the housings/covers of all accessory items, including the pressure relief device, must be provided with suitable lifting lugs or eyes. All lifting lugs or eyes must be appropriately rated and identified with a suitable lifting symbol. The tank lifting lugs or eyes are to be suitable for lifting the complete transformer when filled with oil.

The height required from floor to crane hook (including slings) when the core and winding assembly is being removed from the tank must not exceed nine (9) metres.

5.4.6 Cooling system

The temperature of the transformer is to be achieved by the use of any combination of natural convection, radiators, fans and pumps (natural thermosiphon flow or directed flow into the windings is preferred i.e. ON_

_ / OD __ designs; OF __ designs are considered undesirable). The proposed solution will be reviewed in terms of initial cost, entire asset lifecycle cost, maintenance requirements and environmental impacts.

5.4.6.1 Radiators

The tank design must be for either separate or attached radiators excluding power transformers rated 35MVA and below where only attached radiators are required. Refer to 5.9 for further detail.

The exterior of all radiators must be hot dipped galvanised. The interior of all radiators must be varnished and painted. Radiators must be cleared of excess varnish and contaminants.

Extruded aluminium radiators are not acceptable.

Valves must be provided on the inlet and outlet sides of each radiator to allow isolation of radiators. These valves are to be flanged butterfly valves with compatible proven seals. No valves are to be welded to the tank header pipes or radiators.

Valves are to be permanently fitted to the tank wall or header pipes to allow removal of the radiator while the transformer is filled with oil. The purchaser reserves the right to remove radiators and test the integrity of the butterfly valves. Valves found to be leaking will require replacement.

One (1) redundant radiator must be provided. This radiator must be isolated during temperature rise testing. The guaranteed performance must be met with any one of the radiators isolated. The Endeavour Energy representative attending the factory acceptance tests will decide which radiator will be isolated during testing.

Radiator pipework and headers must be fitted with drain valves with flanges and blanking plates that effectively drain each section of pipe to facilitate removal of the pipe work without loss of oil. All valves must be fitted with a gasket between the valve flange and blanking plate. All blanking plates must be secured to the valve by a chain welded to the plate and attached to the valve independently to the valve mounting bolts. Isolation of a bank of detached radiators must be achieved by means of gate valves.

All flange dimensions must be in accordance with AS 2129 Section 6 Dimensions of Flanges for flat flanges.

5.4.6.2 Cooler control and motor drive box cubicles

All 230V/400V terminals must be shrouded and fitted with a warning label. The terminals for these devices must be segregated from all other terminals, shrouded against direct contact and provided with red-white warning labels.

These labels must be white letters engraved in red laminated PVC stating 'Warning 230V AC'

5.4.6.2.1 Mechanical requirements

Cubicles including the motor drive box must be arranged to accept bottom entry cabling and must be provided with 4mm thick aluminium or brass gland plates, suitably sized to accept all the required cables and still have at least 50% spare capacity.

Enclosures must be separated from each other to allow safe and ready access to electrical controls, be supplied complete with a weather hood, and must be vermin proof.

Vertically hinged doors must be provided to allow access to all equipment in the cubicle. Each door must be of full height and not exceed 1000mm in width.

The doors must open through 120° and be provided with a device to secure the door in an open position, and be secured closed by not more than two (2) hand-operated lockable handles suitable for Lockwood 234/45 (8mm shank) locks. All doors must be provided with grade 316 stainless steel or other non-corroding lift off hinges.

Outdoor cubicles must be provided with a low surface temperature thermostatically controlled anti-condensation heater, interior cubicle light and associated control switches.

In addition, cooler control cubicle must be provided with a swing out panel and have allocated space behind it for Endeavour Energy to mount process interface unit and associated switches and terminals. Please refer to clause 5.9 for cut and drill drawing details including dimensions.

All cubicles must be protected to IP55 and must be located in a position so that its gland plate is no lower than 800mm and its top no higher than 2000mm (1800mm preferred) from the floor level of the transformer installation.

5.4.6.2.2 Equipment in cubicles

All cubicles must be mounted in such a position that there is clear unimpeded access to the cabinet and all equipment mounted in the cabinet.

Control cubicles must be provided to house terminal strips, CT test links, monitoring equipment and protection and control equipment of each transformer.

Isolating switches must be provided in the cabinet to enable all control circuits in the cabinet to be isolated during maintenance.

These switches will be Kraus and Naimer C26 or equivalent, as approved by the contract manager.

The control cubicle must be fitted with a double 15 Amp single phase GPO protected and supplied in accordance with AS/NZS 3000-2007 from the substation distribution board.

The supplier is also required to supply a phase voltage supply monitor to connect to the AC supply failure alarm terminal. The device must have an adjustable setting between 340 and 440V (phase-to-phase) and confirm phase to earth volts are healthy.

5.4.6.2.3 Secondary wiring and termination

All wiring (internal panel wiring and external control cables) must be carried out in accordance with SDI 526 – Control cabling, panels and terminations. Alternative type tested connections can be utilised as approved by the contract manager.

The supplier must make themselves aware of these requirements before submitting the tender.

5.4.6.2.4 Control wiring terminal blocks

The terminals will be Weidmueller WDU series or Klippon, Entrelec M series, Phoenix UT series or equivalent, as approved by the contract manager.

Current transformer terminal blocks must be of the stud type, minimum diameter 5mm, or tunnel connectors. Where tunnel connectors are used, they must be of the spring pressure type, for example, WDU SL.

Protection circuit terminal blocks must be tunnel connectors of the spring pressure type for example, WDU SL.

Control wiring terminal blocks must be suitable for the size of conductor being used and the type of terminal strip employed.

Suitable plastic shrouds must be provided for all control wiring terminal blocks.

5.4.6.3 Directed oil and air auxiliaries (where applicable)

5.4.6.3.1 Oil pump

Where a pump is offered, low oil flow rates are preferred. A non-return valve/s must be provided on the tank inlet/s without the pump. The minimum Ingress Protection rating of the pump control box must be IP55.

Where a pump is installed, valves must be fitted on both sides of the pump so that the pump can be removed without the need to drain oil from the main transformer tank or radiator as follows:

Rising spindle gate valves are required on both sides of the pump, both the tank side and the radiator side. For power transformers 35MVA and below, rising spindle gate valve on the tank side and butterfly valve on the radiator side of the pump is acceptable.

The operation of the oil pump (starting, stopping and running) must not cause the Buchholz (oil surge component) relay to operate. This may be achieved by using soft starters. A pump fail alarm must be raised in the instance where the pump has failed to run as required by the control system.

Multiple pumps should not be offered and are undesirable.

5.4.6.3.2 Oil Flow Switch

An oil flow switch must be fitted in each oil pump pipework.

These switches must initiate an alarm in the event of low oil flow after an oil pump initiation. An additional clean set of normally open contacts must be provided for monitoring this operation. The switch contacts must be suitable for making, carrying and breaking one (1) Amp in a typically inductive (magnet coil) circuit at 250V ac or 120V dc.

5.4.6.3.3 Fans

Fans must be low noise with non-ferrous metal blades and heavy gauge galvanised wire mesh guards for safety. Bearings must be fully sealed.

The motors must be corrosion resistant and totally enclosed to AS 60529:2004. The minimum Ingress Protection rating of the fans must be IP55.

One (1) redundant fan must be installed. The redundant fan is to be isolated during temperature rise testing. The guaranteed performance must be met with any one of the fans isolated.

Each fan must have an isolating switch. The failure of a fan should initiate an alarm and the redundant fan should be made available.

The preferred location for fans is underneath the radiators.

5.4.6.3.4 Order of operation

Directed oil cooling is required to operate before forced air-cooling.

5.4.6.3.5 Fan and pump control

A multi-position switch - Kraus and Naimer C26 or equivalent, as approved by the contract manager - must be provided to operate the fans and pumps in the following manner:

- Position 1: Auto - fans and pump
- Position 2: Off - fans and pump
- Position 3: Manual - pump
- Position 4: Manual - fans
- Position 5: Manual - fans and pumps

5.4.6.3.6 Control and auxiliaries

A separate weatherproof control cubicle, protected to IP 55, complete with cooling control equipment as shown on the typical schematic drawing, must be supplied. The cubicle must be mounted on the transformer tank.

A contact for monitoring the status of the fans and pumps must be provided. The contact must be suitable for making, carrying and breaking one (1) Amp in a typically inductive (magnetic coil) circuit at 250V ac or 120V dc.

The supplier must take into account the starting and running currents of all pump and fan motors to be used in the cooling system when determining suitable motor protection requirements.

This auxiliary equipment must be controlled from the winding temperature indicator or associated equipment which has provision for independently adjusting both the cut-in and cut-out of the fan motors and pump motors. Additionally, a facility must be provided in the control system for SCADA control of the cooling system.

Hysteresis should be applied in the fan and pump control circuits to prevent the motors from hunting. To achieve this, the fans and pumps, will be turned on by the WTI and turned off by the OTI.

For control and auxiliary wiring a maximum of two (2) wires on each terminal are allowed.

The control system must be implemented using relay logic. Micro-controllers must not be utilised.

5.4.7 Oil conservators

There must be an oil conservator for the main tank and a separate oil conservator for the OLTC. The main tank conservator must be fitted with an oil preservation bag or diaphragm (rubber air cell) as outlined in section 5.4.7.3 below. Each conservator must have one end bolted to allow removal for maintenance access purposes.

5.4.7.1 Main tank and tap-changer conservator

The main tank and tap-changer conservator must be designed for a temperature range of –5 deg. C to 120 deg. C.

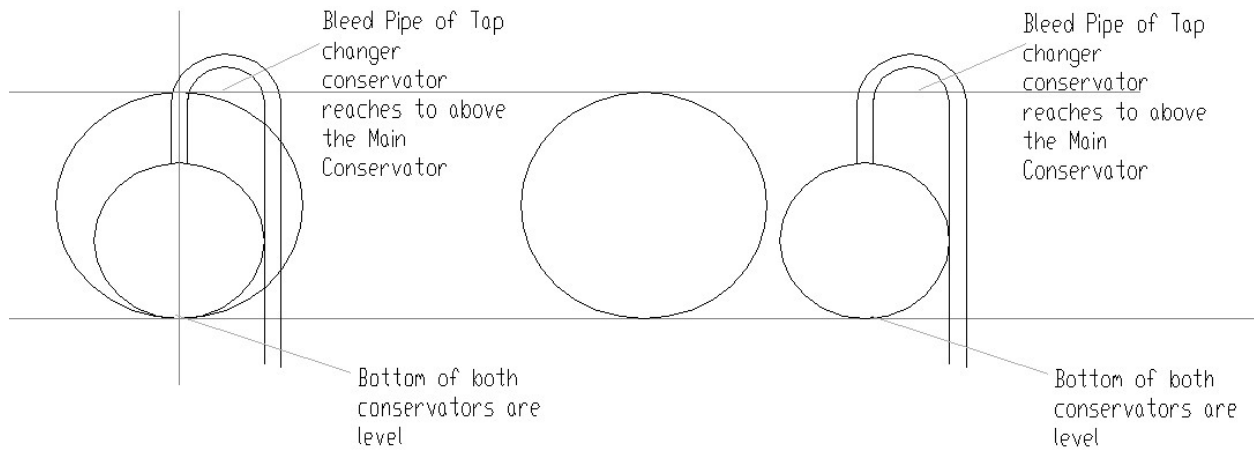
The capacity is to be such that with the transformer operating at top oil temperature of 95 deg. C, the volume occupied by the oil must not exceed 90% of the total capacity of the conservator.

The pipe to the gas relay must finish 25mm above the bottom of the main conservator, providing a sump to retain any heavy contaminants.

The bottom oil level of conservator is to be not less than 75mm above the highest point of the gas and oil relay.

The bottom of the both the main conservator and the tap changer conservator should be level. The bleed pipe from the tap changer conservator must reach above the top of the main tank conservator. Both conservators should be mounted adjacent to each other on the same side of the transformer.

Figure 4 – Conservators level and bleed pipe



5.4.7.2 Main tank and tap-changer oil level indicator

The oil level indicator must be clearly visible from ground level without the aid of optical devices and be suitably marked to indicate the correct level at 20 deg. C, 60 deg. C and 90 deg. C.

Electromechanical oil level indicators must be provided. The maximum and minimum oil level must trigger alarms at the control panel; these will be wired to Endeavour Energy's SCADA system.

Each contact must be suitable for making, carrying and breaking one (1) Amp in a typically inductive (magnet coil) circuit at 250V ac or 120V dc.

5.4.7.3 Rubber air cell

The main tank conservator must be equipped with a rubber air cell together with a leakage monitor. The rubber air cell must be made from oil and ozone resistant material so that oil may not come into contact with air. Means must be provided to prevent damage to the rubber air cell during extreme oil temperature situations and during the application of vacuum. The leakage monitor must alarm when the rubber air cell develops a leak. The leak detector must be of a type that does not require air to be bled from the device. It must be located so that erroneous alarms are not caused by inadvertent ingress of air such as during Buchholz relay maintenance, yet will indicate an alarm should the bag develop a leak. Protection must be provided for the leak detector inlet and outlet to prevent obstruction by the oil preservation bag. This system must be commissioned by the supplier during transformer installation.

5.4.7.4 Main tank and tap-changer dehydrating breather

The main tank and tap-changer conservator must be fitted with dehydrating breather(s). The breathers must be securely anchored and accessible for maintenance and located 1200mm above the ground level. The capacity of the charge must be at least equal to that recommended by the breather manufacturer for the respective oil volume and sufficient to last 12 months in the environment indicated in 5.1.2. Silica gel breathers must be appropriately coloured to indicate water saturation.

5.4.7.5 Main tank and tap-changer conservator fill/drain/oil filtering

The main tank and tap changer, including conservators, must be provided with oil filling/drainage/filtering pipe work and termination valves located 1200mm above ground level to allow for effective oil filling/drainage/filtering from ground level.

An equalising valve, connecting the main tank dehydrating breather pipe and main conservator filling/filtering pipe, must be provided for equalising the pressures in the main conservator when pulling vacuum before oil filling. This valve must also be located 1200mm above ground level.

All valves are to be appropriately labelled to describe their function.

5.4.7.6 Connection and removal

Bolted flanged joints on pipe work and bolted mounting on a horizontal surface must be used so that the conservators can be readily removed with a minimum of disturbance to other equipment.

5.4.8 Insulating and cooling fluid

5.4.8.1 Insulating fluid requirements

The fluid used for factory testing and to fill the transformer onsite must be new fluid meeting the minimum requirements of ETS 0010 for inhibited mineral oil, and for transformers where the synthetic ester fluid is requested, it must meet the minimum requirements of ETS 0120. The inhibited mineral oil must not contain PCB or other contaminants and must not have traces of chemicals having a corrosive sulphur tendency.

Details of the fluid, including test results for the fluid used during factory testing and filling onsite, must be provided to the contract manager to verify the compatibility of the test fluid and the final installed fluid. The miscibility statement must also be provided from the oil supplier to show to Endeavour Energy's satisfaction, that mixing the fluid that remains absorbed in the insulation after the factory testing with new fluid on site will result in a final mixture that is a homogeneous single phase liquid with no decrease or change to any parameters or performance that still fulfills the relevant standards.

Under no circumstance will any degree of forced-fluid circulation create a static electrification hazard in any part of the transformer under any operating condition.

The main transformer tank as well as the tap changer must each have a label affixed to their respective fluid filling points. The label must read as follows:

'Use inhibited oil only' or 'Use synthetic ester fluid only.'

5.4.8.2 Fluid filling

Filling of new approved insulating fluids must be performed under vacuum. The vacuum held on the tank must not exceed the design strength capability of the transformer. Filling must be performed with clean hoses and through a filtration unit. The temperature of the new fluid in the filtration plant must at no time exceed 60°C.

The full pressure testing and vacuum filling process (including pressures and hold times) shall be provided during the tender stage.

5.4.9 Fittings

5.4.9.1 Buchholz relay

A double float relay of the Buchholz type, depending for its operation upon the formation of gas or an oil surge in the main tank of the transformer, must be fitted. It must also operate in the event of loss of oil from the relay. The surge sensitivity level of the relay must be set by the supplier. The switch must be of the reed type with contacts suitable for making, carrying and breaking one (1) Amp in a typically inductive (magnet coil) circuit at 250V ac or 120V dc.

It must be located so that the relay mechanism may be readily removed without the need to disconnect the relay casing from the pipework.

Spindle gate valves must be provided on the inlet and outlet side of the relay so that the relay can be removed without dropping oil level.

The Buchholz relay must be positioned over the main tank in a convenient, safe access position for maintenance. Where it is not practical to mount the Buchholz relay over the tank, a maintenance platform and handrails must be fitted allowing clear unimpeded access to the relay.

A ground level gas receiver must be fitted.

5.4.9.2 Oil spray nozzle

Oil spray nozzles installed in the transformer for the purpose of paper insulation dry out and desludging may be offered as an option.

5.4.9.3 Temperature control and indication

A winding temperature indicator and top oil temperature indicator must be provided. The temperature indicators must be mounted in a separate glass fronted weatherproof enclosure, protected to IP 55, mounted on the transformer using vibration-dampening supports.

Fibre optic temperature sensors must also be provided. A temperature monitor for the fibre optic sensors may be specified at the time of order.

5.4.9.3.1 Winding temperature indicator (WTI) and Top oil temperature indicator (OTI)

The measuring system must consist of Bourdon tube (or expansion bellows including compensation for ambient temperature), stainless steel capillary tube and temperature sensor such that the secondary outputs are driven via the pressure sensor attached to the capillary tube and are independent of the indication needle movement. A reset pointer for indicating maximum reading must also be provided. Alternative technologies may be offered and will be considered where proven reliable and cost effective and approved by the Asset Engineering Manager.

The measuring sensor / bulb will generally be located in the oil flow path between the B-phase winding and the radiator inlet pipe of the transformer. The sensing bulb must be housed in a pocket sealed from the main tank and located in the tank cover in a position that has clear access for maintenance.

The system must require no periodic readjustment or recalibration during the lifetime of the transformer i.e. no maintenance requirement and it must retain its mechanical characteristics throughout its entire service life.

The device must be suitable for sensing temperatures between 0 deg. C to 160 deg. C and have a linear output signal of 4mA to 20mA corresponding to the above temperature range. The device must be designed to operate correctly and without damage at up to 20% in excess of these temperature parameters.

Where a needle indication display is utilised, it must have a scale length not less than 150mm. The accuracy of the temperature measurements must be +/- 3 deg. C.

A digital communication interface must also be tendered. The required mandatory communication link is RS485 and Ethernet. Communication protocols requirement is for DNP3 with the option for Modbus and IEC61850 protocols. The tender submission should clearly indicate exactly what is being offered as part of the tender which will be considered in the design review.

Four (4) adjustable change-over microswitches, circuit closing, that can be separately adjusted to operate at any temperature setting, must be provided.

Two (2) of these contacts must be suitable for setting to a fixed value for alarm and trip, and two (2) must be suitable for fan and pump control. Each contact must be suitable for making, carrying and breaking one (1) Amp in a typically inductive (magnet coil) circuit at 250V ac or 120V dc.

The output signal must be electrically isolated from other signals, power supplies and earth.

Additional requirements for the winding temperature indicator (WTI):

A current transformer (CT) is necessary for operation of the WTI to accurately simulate the winding temperature based on the transformer load. The CT must be incorporated in the transformer design and located on HV, B phase and be of the bar primary or through type.

Facilities must be provided to set the degree of boost on the WTI to suit the CT to sense transformer load current. Suitable control circuits must be supplied so that the correct boost is in the circuit for all modes of transformer operation.

The following information must be provided for WTI setting verification for all operating conditions (i.e. ONAN, ODAN, ODAF):

- the winding hot spot temperature gradient must be based on the higher value of the heat run measured or the calculated value using a hot spot factor of 1.3 in accordance with AS 60076.7-2013 (the temperature gradient is to be included on the nameplate);
- the current required to heat up the WTI heating element;
- the resistance of the heating element;
- the current available from CT to drive the heating element;
- amount of current to be shunted;
- Ohmic value of the shunt resistor;
- the CT ratio;
- the total resistance connected to the CT (the parallel resistance of the heating element and its shunt resistor) - associated formula for the above calculation must be provided. The shunt resistance must be set at the factory during the heat run test so that the correct current is passed to the heating element; and
- in order for Endeavour Energy to check the WTI at commissioning, the supplier must indicate the amount of current to be injected and the corresponding °C temperature rise expected.

The WTI CT must have links provided to allow for testing of the entire circuit and for insulation resistance tests to earth.

5.4.9.3.2 *Fibre optic temperature sensors*

The fibre optics must be 62.5 µm fibres only. The preferred manufacturer is Nortech, but alternative offerings will be assessed.

Fibre optic probes must be embedded in the transformer with a minimum of one probe on each of the phases of both the HV and LV windings and B phase of RV and TV windings.

The sensing end of the probes must be positioned at calculated hot spots within the selected windings. The exact locations of the temperature sensing probes must be agreed by the contract manager during design review.

The probes must be used for Hot Spot temperature measurement during the testing of the transformer, and may be subsequently used for Hot Spot measurement during service.

The contractor must supply the thermometer for the fibre optic temperature measurement during the factory testing to monitor all temperature probes simultaneously. The temperature readings of all fibre optic probes must be logged at a maximum of two (2) minute intervals for the first 30 minutes, and at a maximum of 15 minutes thereafter until the completion of the heat run tests.

Details of the fibre optic sensor, including brand and type, must be supplied on the transformer nameplate. A diagrammatic representation of the external connection terminals of the fibre optic sensor must be included on the transformer nameplate.

The oil to air interface of the fibre optic probes must be mounted at a level above the top of the windings and terminated in a separate junction box mounted on the exterior of the tank. A user interface for the fibre optics must be mounted in the control cubicle for the purposes of taking online temperature measurements. All fibres from the fibre optic probes should be brought down to the fibre optic interface.

The fibre optic extension cables between the transformer tank wall optical feedthrough and the control cubicle must be run in separate conduits. Care must be taken so that the fibre cables are not damaged during installation. Examples of this include not bending the fibres more than the minimum bending radius, avoid twisting and placing cables in tension. The tender submission must clearly indicate the number of fibres and the connection type at the transformer fibre interface as part of the tender.

5.4.9.3.3 *Fibre optic temperature monitor*

A fibre optic monitor, as approved by the contract manager, may be installed. The monitor must be capable of retransmitting temperature information to the SCADA system as well as providing local information and control. The monitor must be installed in the control cubicle with easy access from the front to connect the fibres to the user interface. The number of fibre optic patch leads supplied should match the number of channels of the monitor.

The monitor must be suitable for sensing temperatures between 0 deg. C and 160 deg. C and have a digital communication interface. The required mandatory communication link is RS485 and Ethernet. In terms of communication protocols, preference is for DNP3 with the option for Modbus and IEC61850 protocols. The tender submission should clearly indicate as exactly what is being offered as part of the tender.

The device must be designed to operate correctly and without damage at up to 20% in excess of the above parameters, and to operate in an environment where the ambient temperatures may exceed 50 deg. C. The output signal must be electrically isolated from other signals, power supplies and earth.

Where the fibre optics are available, but no sensing device is offered, there should be adequate space within the control cubicle for retrofitting a fibre optic monitor. The tender submission should clearly indicate the number of fibres and the connection type at the transformer fibre interface as part of the tender. If the tender submission offers the installation of extension leads from the transformer interface and the control cubicle.

Commissioning tests must be completed on all fibre extension cables to prove the fibre optic losses are within acceptable tolerances.

5.4.9.3.4 Temperature and control settings

The specified differential in the cut in and cut out temperatures for Pumps and/or Fans controls can be implemented by using WTI/OTI control contacts with adjustable hysteresis. A control scheme based on Pumps and/or Fans' cut in by WTI contact and cut out by OTI is the preferred option. Alternatively, the winding temperature indicator (WTI) can be the device to turn on the cooler controls. The operation method must be of a hysteresis setting to prevent cycling based on the transformer cooling design. The supplier must submit the proposed scheme in the tender process.

Table 4 – Typical fan and pump control settings

	Control	WTI driven (°C)	OTI driven (°C)
Pumps and fans	Pumps on/off	65/55	55/45
	Fans on/off	70/60	60/50
Fans or pumps only	Fans or pumps on/off	65/55	55/45

An alarm must be wired to indicate if either or both the pumps and/or fans are not running.

The transformer must have alarm and trip settings based on the design with an example outlined in Table 5:

Table 5 – Typical alarm and trip settings of WTI / OTI

WTI driven (°C)		OTI driven (°C)	
Alarm	Trip	Alarm	Trip
120	130	90	Non-auto

5.4.10 On-load tap-changing facility

5.4.10.1 General construction

The transformer must be fitted with an external bolt-on, on-load tap-changer (OLTC) having the operation details as set out in Annexure 1. An internal tank on-load tap-changer is not acceptable unless it is of the vacuum diverter type and will only be considered where maximum rated through-current requirements cannot be achieved with an external bolt-on type OLTC.

For power transformers rated 45MVA and below, the OLTC will generally be placed in the centre of the delta winding. For power transformers rated 60MVA and 120MVA the OLTC will generally be placed at the star point. Where alternative positions are offered by the supplier, additional voltage transfer tests in excess of those detailed in 5.8.1 will be required which must also measure output on the open tap windings to determine whether the equipment can withstand the voltages imposed.

The arc chamber must be pressure proof, gas proof and fully isolated from the main tank oil. There must not be any intermix of tap changer switch oil and cooling oil or possible contamination of the cooling oil with gases derived from the tap-changer.

Maintenance of the tap-changer must be possible without disturbance of the main transformer oil system. Barriers must be rated for full tank and conservator oil pressure and overpressure (50kPa over pressure) and withstand full internal vacuum.

Endeavour Energy prefers the ABB UC or UZ tap changers. Other types are subject to approval by the Asset Engineering Manager. The base offer must include the ABB UC or UZ tap changer as applicable. Tap changers offered must be of a type with non-proprietary support and have market accessible parts and servicing. Technical support of the tap-changer and its maintenance should be provided over the asset lifecycle.

Prices may also be provided for a vacuum tap changer with indications of the savings that may be experienced over the life cycle with this option.

A separate pricing schedule and technical details for an offer based on an alternative automatic on-load tap changing scheme may be submitted. The scheme must be functionally similar to the scheme described above. Full details of the alternative scheme must be supplied with the tender and acceptance of the alternative is subject to the approval of the Asset Engineering Manager.

5.4.10.2 Tap changer pressure relief device

A pressure relief device/s must be fitted to the tap changer tank.

The device/s must be fitted with a cover designed to direct oil discharges towards the ground in the bund area and away from all manual control points. The device/s must be self-sealing spring design.

5.4.10.3 Motor drive cabinet

The tap changer operation must be designed for control by the following and must be wired in accordance with the enclosed typical schematic drawings for 230V AC operation. The features must include:

- raise and lower control switch at the transformer. Each switching operation must initiate only one tap-change such that the switch must be turned to the off-position and the tap-change completed before initiating a new tap-changing operation;
- raise and lower operation from remote control equipment to be provided and installed by Endeavour Energy;
- automatic voltage regulation apparatus to be provided and installed by Endeavour Energy;
- manual handle for emergency and maintenance operation. Insertion of the handle must lock out by automatic mechanical means, all electrical operation; and
- additional weatherproof labelling must be permanently attached to the tap changer control cubicle to warn service personnel of the existence of AC control systems.

All control and auxiliary equipment associated with the tap changer must be mounted in a separate weatherproof motor drive cabinet and is to be within the area designated on the typical arrangement drawing. All SCADA signal terminals in the cabinet must be wired back to the transformer control cubicle.

5.4.10.4 Electrical operation and control

The general requirements for operation and control are indicated in the drawings in section 5.9.

The transformer will be required to operate automatically, either individually or in parallel with other units.

The tap changing equipment must be arranged for single step operation so that, once an operation is initiated, the completion of the operation is outside the control of the operator, who must first release the control switch before a further tap changing operation can be initiated.

A 'tap change in progress' physical flag preferably or lamp must be fitted to indicate the complete period of a tap changing operation and it must remain flagged or alight if the tap changing operation is incomplete for any reason. The arrangements must be such that immediately after the tap change in progress flag or light is switched off; the push button can be pressed for a further tap change.

A LOCAL/REMOTE changeover switch, Kraus and Naimer C26 or equivalent must be provided in the transformer control cabinet so that the equipment may be placed under the control of either the local or remote operating switches. At the remote control point, a changeover switch will be installed (by others) to select manual or automatic control.

5.4.10.5 Ancillary equipment to be included in control cabinet

The weatherproof control cabinet must house the following:

- a mechanical tap position indicator;
- a manually reset Range of Operation indicator to indicate the range of tappings over which the equipment has operated since the indicator was last set;
- an operation counter;
- adequate auxiliary switches to carry out all functions necessary for the operation of the transformer tap changer and control and indication as set out in the attached drawings plus:
 - Four (4) sets of contacts to close and remain closed whilst a tap changing operation is in progress;
 - Four (4) sets of contacts to open and remain open whilst a tap changing operation is in progress;
 - The auxiliary switches must be capable of making, carrying and breaking one (1) Amp in a typically inductive (magnet coil) circuit at 250V ac or 120V dc;
- limit switches to prevent over-travel of the tap changing gear, the switches being provided in the motor supply circuit and also in the motor control circuit;
- facilities must be provided to limit the tap range between any two (2) selected taps;
- access must be provided to carry out the necessary adjustments without the need to dismantle equipment. There must be a minimum of 900mm unimpeded access in front of the motor box with the door opening 120° toward the transformer to allow access.
- one (1) multi-contact tap position indication switch, having at least as many contacts as tapping switch positions, and in which the contact corresponding to the actual tap position at any time is bridged to a common centre contact. The switch is to be BREAK BEFORE MAKE, and its contacts are to be wired to accessible terminals in the cabinet in accordance with the typical schematic drawing. The contacts must be suitable for 230V ac or 120V dc and must have a rating of one (1) Amp in a typically inductive (magnet coil) circuit at 120V dc; and
- A tap position encoder must be installed to convert the 21 (max) tap positions into a five (5) digit binary output. The five (5) outputs will represent the following values:

Table 6 – Tap changer encoder 5 digit binary output mapping

Output	Value	Description
1	1	least significant bit
2	2	
3	4	
4	8	
5	16	most significant bit

- Maintenance light - lighting must be provided inside the cabinet to assist maintenance when required outside daylight hours.

5.4.11 Bushings and main terminals

Bushings must comply with the requirements of AS 60137:2020.

For each transformer voltage level the following terminations may be required:

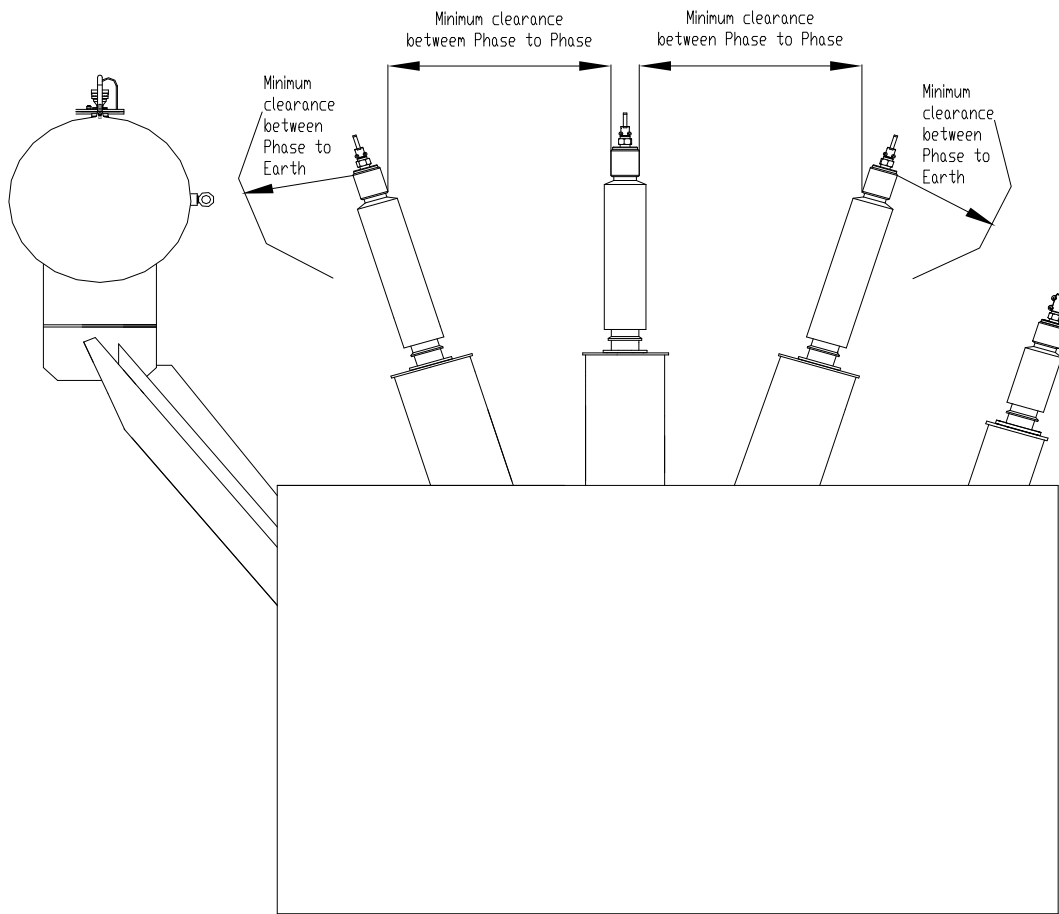
- 132kV side – bushing.
- 66kV side – bushing.
- 33/22/11kV side - bushing or air insulated cable box.

The transformer terminations must be in accordance with the requirements set out in Annexure 1. The internal termination on bushings must be as set out in Table 1 and Table 2 in AS 62271.301:2022.

5.4.11.1 Bushings

All bushings 33kV and above, must be fitted on a turret not less than 500mm in height. The bushing locations must be in accordance with drawings listed in section 5.9.

Figure 5 – Primary side bushing typical locations and clearance requirements



Bushing minimum nominal creepage lengths must be as provided in Annexure 1.

The primary bushings must be arranged so that all three (3) bushings must be on the vertical plane with reference to ground and not more than 13 degrees off the vertical.

External clearances must not be less than those specified in AS 60076.3 or in Annexure 1, whichever is the greatest. Oil pipe to live metal clearances must be at least equal to the appropriate phase-to-phase clearances. Where the specified clearances to oil pipes cannot be achieved conveniently, the oil pipes must be protected with a metal shield of approved configuration, but the clearances under this condition must not be less than the specified phase-to-earth clearances. The shields, if fitted, are required as protection against the possibility of a phase-to-earth arc puncturing an oil pipe.

Bushings with rated voltage (U_m) equal to or exceeding 72.5kV must be capacitance graded outdoor with resin impregnated paper (RIP) or resin impregnated synthetic (RIS) as the major insulation. A test point must be available to measure the bushing DDF. The external insulation may be porcelain or polymer subject to approval by the Asset Engineering Manager. Polymer housings must be of the high temperature vulcanised type and proven unsusceptible to animal caused breakdown and clearances can be maintained if porcelain bushings were to replace the polymer bushings. The insulator colour must be light grey, similar to T33 Mist Blue, as in AS 2700. The HV bushings are to be partial discharge free and meet all the requirements of AS/NZS 60137. As an option, oil impregnated paper bushings can be offered but must be separate to the main offer.

RIP bushing must remain dry and must be tested at site for variation of capacitance and dissipation factor prior to acceptance. A capacitance increase of 3% from nameplate will require the bushing to be dried using an approved method in agreement with the Asset Engineering Manager prior to acceptance by Endeavour Energy.

Preference for bushings with rated voltage up to and including 36kV is also RIP or RIS depending on constructions that are available for different voltage levels. However, oil filled porcelain bushings will also be considered, preferably of the ESAA standard type or a suitable complete ceramic type. Options should also be provided for other suitable alternatives including a cast or moulded resin-insulated bushing for consideration by the Asset Engineering Manager.

All sealed oil-filled bushings must have sight glasses to enable the oil level to be monitored. The bushings must have a continuous current rating not less than 150% of the full load rating of the transformer at the maximum operating temperature. Neutral bushing current ratings must be no less than that of the associated line termination. They must also be suitable for a through fault current equal to the standard ratings indicated in this Specification.

A flat termination palm must be provided. The palm size must be in accordance with details specified in the drawings in section 5.9 or as approved by the contract manager.

5.4.11.2 Cable terminations

Cables must be supported in a manner so that no undue mechanical stress is applied to any cable termination. The weight of the cables must be taken by cable clamps, and no pressure or tension must be exerted on the termination.

5.4.11.3 Air insulated cable box

The air insulated cable box, where required, must be provided for connecting high voltage single or three phase cables to the transformers. The transformer must be supplied with a cable box set out in Annexure 1 to allow the cable terminations.

All 33kV, 22kV and 11kV cable box arrangements must be designed so the transformer can still function as normal with the bushing terminations, should the cable box be removed.

The box must be designed for air insulation with cross flow ventilation and be attached directly to the transformer tank. It must have interior and external surfaces painted to the same requirement as the main tank external surface (see 5.4.15). Oil or pitch filled cable boxes will not be accepted.

The box must be sufficiently strong to be self-supporting and not sag with the maximum number of cables fitted, or have appropriate bracing that does not interfere with the installation and clamping of cables.

An un-drilled solid busbar must be provided for the connection of the HV cables.

Removable flexible connections are to be provided between the solid busbars and the bushings.

A flag with a hole suitable for one (1) M12 bolt is to be provided internally in the base of the box for cable sheath earthing.

The cable box dimensions are to be adequate to allow cable AC test for five (5) minutes, with the highest phase to phase voltage of the system applied between the conductor and the metallic screen/sheath after cable jointing is complete.

The minimum phase to earth clearances and the phase to phase clearances must be those set out in Annexure 1.

These clearances are to be achieved with the cable box fully assembled and cables fitted with associated lugs, nuts, lock nuts, bolts and washers. The clearances must also be maintained for back to back cable arrangement on each busbar.

The cable box must have unrestricted access for cable jointing. A removable cover to the whole front of the box must be provided.

Removable covers must be provided with lifting handles. Where the cover weighs more than 20kg, it is to be slit horizontally into portions weighing not more than 20kg each, with each portion being fitted with lifting handles.

A multi-section gland plate constructed of non-magnetic material is to be provided. This plate must be constructed of sections or slats whereby the cables can enter the box through holes drilled by Endeavour Energy (using glands) between the section or slats.

In this way, the back section can be installed, followed by the first set of three phase cables, followed by the next section of plate, the next cable set and so on until the final section of plate is installed.

The number of sections or slats can be determined from the technical schedules in Annexure 1.

Endeavour Energy must supply the glands and cable lugs.

The box must be constructed so that adequate space is provided for cable terminating and gland centre lines must be on the same centre line as the cable lugs such that no setting of the cable core is necessary.

The cable box height from the gland plate to the centre of the terminal palm must be at least as indicated in Annexure 1, section 35 (e). The cable box location must be in accordance with drawings listed in section 5.9.

Facilities must be provided to support/clamp the cables within one (1) metre of the termination. The bracket must be constructed so as to prevent sagging while supporting the cables.

Access to the cable terminations in the cable box must only be possible through the removable covers and the whole cable box must be vermin proof after all the cables are installed.

5.4.12 Rating plate

An indelibly etched, engraved or stamped, grade 316 stainless steel rating plate must be installed to each transformer. It must comply with AS 60076.1:2014, Clauses 8.1 and 8.2, with the following exceptions and additions:

- % impedance of the transformer at minimum, nominal and maximum tap;
- top oil, average winding and hot spot temperature rises for each cooling mode;
- sound power levels at 100% and 105% excitation levels;
- current transformer ratios, class, thermal limit, polarity and diagrammatic location of the CTs;
- fan quantity and air flow rate (M3/min) for each fan;
- radiator quantity;
- pump oil flow rate (L/min);
- a notation that one (1) fan is standby;
- a notation that one (1) radiator is standby (if applicable);
- customer number, contract number, and space for the customer number to be inserted;
- oil quantity in tap changer;
- transport mass (without conservator, top header, radiators) including oil in main tank and without oil in main tank;
- mass of core and winding including all cables, busbar, insulation and supports;
- permissible maximum tank pressure;
- a connection diagram, including a plan view of the transformer showing the correct physical relationship of the terminals, tap-changer, control panels and radiators; and
- primary and secondary voltages and tap changer terminal connections are to be shown for each tap.

A second plate with the same grade 316 stainless steel must be installed showing oil piping and the location and function of all valves, indicators, relays, vents etc. At the bottom it must have a table showing the

open/closed status of all valves for normal service, filling under vacuum, filtering under vacuum, during transport and also to warn operators to refer to the maintenance manual before applying vacuum treatment.

5.4.13 Labelling

All equipment must be clearly labelled to show its function. All labels must indicate the device name and functionality, for example, 4R OLTC RAISE RELAY.

Labels used inside the control cubicle(s) must be of laminated plastic having black upper-case letters on a white background and must be affixed using double sided foam tape suitable for the lifetime of the equipment.

Lettering and numbering on labels must be as large as practical and preferably not less than 5mm high. It is preferred that all labels are of the same size, or at least the number of sizes is kept to a minimum. Labels must not be directly affixed to items that are readily removable or interchangeable.

All external labels must be of laser etched stainless steel type and be affixed by nickel plated brass screws or sealed stainless steel rivets.

Drawings of labels must be submitted for approval by the contract manager.

5.4.14 Secondary wiring

5.4.14.1 Conduits for secondary wiring

All conduits and fittings on horizontal surfaces exposed to foot traffic must be weatherproof and fixed with galvanised screws, or equivalent. All external wiring on the transformer must be installed in steel conduits. Flexible terminations to accessories (i.e. fans or pumps) may be made by flexible conduit that is UV rated and prevent water ingress.

Where steel wire armoured cable is used, adequate support must be provided. Protection must be given where any cable touches sharp corners. Support must be given in areas where cables are exposed to walking.

5.4.14.2 Secondary wiring termination

All wiring (internal panel wiring and external control cables) must be carried out in accordance with SDI 526 – Control cabling, panels and terminations. Alternative methods of secondary cable terminations can be approved by the contract manager, where type tests and mechanical calculations have suitably proven the termination type.

5.4.15 Surface finish

5.4.15.1 General

The proposed paint system must be specified in complete detail at the time of tendering. One (1) supplier must supply all coatings. Notwithstanding this, equivalent proprietary coats may be used subject to the approval of the contract manager. All of the paint system components must be readily available in Australia. The supplier must also provide evidence to Endeavour Energy's satisfaction that H&S is not compromised for their employees when applying paint on the transformer and its components. The following are some of the recognised paint manufacturers that have been approved by Endeavour Energy: Dulux, Hempel, International.

Paints must be in accordance with AS/NZS 3750. The painting, preparation and application requirements must be in accordance with AS/NZS 2312.1: with extra long term durability 25+ years before first major maintenance in a atmospheric corrosivity category of C4: High. All surfaces must be designed and built to prevent corrosion from occurring and to avoid accumulation of moisture including condensation.

Sharp edges should be radiused to a minimum 2mm to ensure adequate paint thickness.

Both internal and external surface preparation prior to the application of paints must be in accordance with AS 1627.4. In particular, surface must be thoroughly cleaned of all grease, oil deposits, rust, loose millscale, welding slag and any other foreign particles or residue by abrasive blast cleaning to a minimum Class Sa 2½. Paint must be applied with the least possible delay after the surface is cleaned and inspected. There must not be any visible deterioration and discoloration when compared to a freshly cleaned area and the surface must not stand overnight without being coated. Relative humidity and ambient temperature must be within paint manufacturers recommendations.

5.4.15.2 Radiators

The exterior of radiators must be hot-dip galvanised and the interior must be varnished. The galvanising must comply with the requirements of AS 4680 and AS 2312.2 including surface preparation, application, coverage and coating thickness. The minimum durability before first major maintenance must be extra long 25+ years in a atmospheric corrosivity category of C4: High. Only approved methods in accordance with AS 4680 must be used to carry out any on-site repairs to damaged, corroded or uncoated parts provided that the area does not exceed the maximum repairable areas specified in the same standard. The supplier must provide a certificate of conformance showing minimum spot and average thickness measured in accordance with the above mentioned standard.

5.4.15.3 Tank, accessories, pipe-work and external surfaces

Each coat of paint must have a contrasting colour with the paint sequence as follows:

Priming coat: Approved zinc rich epoxy, anti-corrosive structural priming paint or an equivalent.

Intermediate coat: After the priming coat has been fully dried, second compatible coat must be applied.

Finish coat: The finish coat must be full gloss, colour N35 – light grey to AS 2700 and be compatible with undercoat.

Areas such as lap joints, sharp corners, edges etc. must be stripe coated prior to application of each coat to ensure adequate paint thickness. Paint manufacturers recommendations must be followed and full details of the proposed paint scheme must be provided by the supplier at tender stage to allow evaluation of the proposed paint system including:

- Description of the base metal to be coated;
- Product datasheets;
- Details of the surface preparation, coating application process including measures taken to ensure adequate coating of sharp corners, edges, welds etc.;
- Details of all paint tests performed which prove the effectiveness of the proposed paint system;
- The standards and test criteria used to check acceptance of each stage of the process;
- Estimated life of the proposed paint system in the environment specified.

5.4.15.4 Touch up work

After erection, all damaged paintwork must be touched up with the coating system as detailed in the clause above. Recommendations for on-site repair of damaged coating to achieve the same estimated life must be provided at tender stage.

If a total of more than eight (8) sections or a cumulative area of 0.5m² is found to have unsatisfactory surface paint finish, the Supplier will be required to steam clean and repaint the whole transformer according to the above specifications and full satisfaction of the contract manager.

5.4.15.5 Paint thickness test

The supplier must carry out paint thickness test if required by Endeavour Energy. All film thickness measurements must be made with Tinsley gauge or Microtest gauge.

5.4.15.6 Internal surfaces including clamps and other components internal to tank

The interior of all oil filled chambers including the main tank (excluding radiators) must be painted with an oil resistant white paint. Full details of the internal paint are to be provided at tender stage.

Clamps and other painted components within the tank must utilise the same paint used for the internal of the transformer.

5.4.15.7 Welded lid

The tank lid will be welded to the top of the tank after successful completion of factory tests. The tank surface area near the lid that has been painted previously must be protected against weld splatter during welding of the lid e.g. welding blankets are recommended. Any damaged area must have the paint removed back to bare metal. All welded areas must be sanded to a profile finish recommended by the paint manufacturer and must be cleaned in accordance with paint manufacturers recommendations. The same three coat paint system used on the tank and external surfaces must be applied to the welded lid and bare metal areas. The supplier must also provide details for the high temperature chord used between the lid weld and an oil O-ring.

5.5 Maintenance requirements

5.5.1 Spare parts and maintenance

The supplier must supply a list of recommended spare parts, special tools and appliances required for the whole of life operation and maintenance of the transformer installation. The list, together with prices, must be indicated in the appropriate schedule. The supplier must also provide details of the recommended maintenance and the frequency at which it must be carried out. Special tools are to be part of the main contract.

The items nominated must allow most common defects to be repaired and recommended maintenance to be carried out expeditiously over the whole life of the transformer. Recommended tests to be carried out throughout the life of the transformer and its components, including the pass/caution/fail criteria for each test must be included in the offer.

Predicted availability of ex-stock parts over the life of the transformer is to be considered. Lists must be complete with part numbers and current prices for each item. Where identical items have been supplied to Endeavour Energy as spares on previous contracts, details of the quantity and type supplied must be provided.

The final quantities of spares to be supplied will be decided as part of contract negotiations.

5.5.2 Failure mode analysis and preventative maintenance

The supplier must indicate and provide updates to Endeavour Energy the mean time between failures (MTBF) of the transformer and its components including the recommended maintenance regime and maintenance tasks and intervals. This regime must be based on the mean time between failure (MTBF) and the critical failure modes identified by the failure mode, effects and criticality analysis (FMECA) of the equipment. Details substantiating the FMECA analysis must be included in the offer.

5.6 Transportation

The supplier to this specification is responsible for the transportation between a manufacturer's works and the site nominated by Endeavour Energy within Endeavour Energy's franchise area.

The costs, risks and responsibilities for transportation are the responsibility of the supplier and must be agreed prior to contract acceptance. This include the responsibility for the load profile for each transport mode, transport route, the means of transport, any necessary route alteration, statutory approval or licenses,

shipping reservations and documentation or any other requirement concerning the delivery of the transformer to the nominated site.

5.6.1 Design for transport

The transformer with its active part (windings, core, framework, clamping arrangements and general structure) and tap changer must be of a robust design and safeguarded for transportation, capable of withstanding any shock to which it may be subjected to during transport taking all planned transport modes into consideration. Necessary mechanical withstand capability must be built into the design without any in-tank temporary bracings, supports or reinforcements.

All tubing, valves, cable connections and fittings attached to the load must be adequately protected to minimise the risk of damage during loading, transport and unloading. All components that have oil flow inside them must be transported air tight.

5.6.2 Impact recorders

Table 7 – Transformer g-shock design ratings

Axis	Max g-forces used for the design	Duration (cont. or msec)	Comments
Longitudinal			
Vertical			
Lateral			

In addition to the above, all transformers requiring shipping by sea will require an additional recorder to measure relative angle in pitch, roll and yaw which must be recorded against the design rating in time-synchronous event logs.

The impact recorders must be bolted rigidly to the transformer tank at or near the location where the transformer is supported by the transport vehicle and as close as possible to the corner of three intersecting surfaces. The mounting orientation must align with the axis of the transformer.

A report indicating the above information and transportation events must be provided to Endeavour Energy to prove suitability prior to acceptance for installation at the nominated site. The report must contain a graph of the magnitude v's time and must be provided within 7 days of delivery of the transformer.

5.6.3 Transportation with or without oil

If the transformer is transported without oil, provision must be made to prevent the ingress of moisture. In addition, the transformer must be filled with dry air and maintained at a continuous positive pressure (or nitrogen if it is safe to do so). The air pressure and dew point must be monitored continuously through the period immediately after the oil is removed until the transformer is refilled with approved oil at site. At all times, alternative standby means should be provided to restore any loss of pressure immediately.

The dew point of the dry air should be measured and recorded such that it remains below -40°C at all times. If the dew point readings indicate an average moisture level at the surface of the transformer insulation higher than 0.5%, the supplier must dry the transformer prior to Endeavour Energy acceptance.

One means of providing a dry environment is by having a dry air cylinder and regulator permanently attached and turned on to automatically replenish the dry air based on pressure. The transformer tank must be fitted with a gauge that is clearly visible without climbing to show the dry air pressure within the tank. If the supplier

chooses to transport the transformer with the dry air turned off or disconnected; the dry air pressure is to be recorded daily from the time oil is removed until oil is refilled into the transformer. A report of the dry air pressure is to be provided detailing this within 7 days of re-filling and prior to acceptance for installation. Refer 5.6.6 for transformers that require storage for more than 4 months without oil.

5.6.4 Loose equipment

Other transformer equipment such as bushings, cooling equipment, tap changers, power and control cabinets may be shipped disassembled and transported and secured in accordance with the manufacturer's shipment and storage guidelines and precautions. Where required, airtight seals or cover should be used.

Parts such as instruments, cabinets, terminal boxes etc. that are mounted on the main tank must be attached by means of anti-vibration mountings and be protected with enclosures to prevent physical damage during transport.

5.6.5 Documentation

The supplier must provide for approval, documentation which fully describes the transport arrangements and specifies all the instructions and requirements necessary so that the transformer and all its equipment will be delivered to site properly and with any necessary and statutory approvals.

5.6.6 Storage

Transformers may require being stored for short or long periods of time. Transformers should not be stored for more than 6 months without oil unless alternative means of management is provided and agreed by the Asset Engineering Manager. All transformer parts and accessories (including bushings if installed) should be properly earthed.

All blanking plates used for long term storage and covers must be designed for long-term outdoor storage and have surface treatment as required in this specification. Heaters within all control cubicles where used must remain energised during any storage period to prevent condensation.

5.7 Quality assurance

Quality assurance certification is required to prove the manufacturer's ability to design and consistently manufacture transformers to this specification. The supplier and all its contractors must have a quality system which complies with the requirements of AS/NZS ISO 9001 or other comparable Australian or International equivalent.

All nominated drawings and documents that have to be reviewed by Endeavour Energy are to be submitted as complete packages using document controls systems such that all the relevant information to enable the design to be reviewed is available. Design suitability approval will not relieve the supplier of its responsibilities for the correctness and appropriateness of the design of their design or their responsibility to conform to this specification.

5.7.1 Quality assurance plan

A quality assurance plan is a document subject to approval of Endeavour Energy and must contain as a minimum the following information:

- a) The suppliers organisational structure for the works
- b) A planned outline meeting the requirements and all stages of the scope and specification
- c) An index showing all existing procedures, inspection and test plans and drawings

- d) AS/NZS ISO 9001 certification for itself and subcontractors
- e) A plan detailing the design, ordering of materials, manufacturing and test plans

5.7.2 Quality Inspection and Test Plan (QITP)

A quality inspection and test plan must be developed and agreed which contains sufficient details of the workflow so that Endeavour Energy can advise inspecting, witness and hold points. The test plan must be prepared in accordance with AS/NZS ISO 9001. Where interstate or international inspections are required, a minimum of four weeks' notice must be given in writing.

As a minimum, Endeavour Energy nominates the inspection and hold points listed in Table 8:

Table 8 – Inspection and hold points (QITP)

ID	Subject	Inspect / hold	Timeframe
	Design verification		(from order)
D1	Technical assessment and agreement on guaranteed performance	Hold	Prior to award of contract
D2	Quality assurance plan	Hold	<2 weeks
D3	Quality inspection and test plan	Hold	<2 weeks
D4	Initial drawings / information - Detail for the design of the concrete plinth and bund including final transformer dimensions - General arrangement showing location and weight of all accessories and interface details	Hold	<4 weeks
D5	Production plan	Hold	<4 weeks
D6	Design data	Hold	<7 weeks
D7	Transformer risk assessment	Hold	<7 weeks
D8	Design and risk assessment review	Hold	<9 weeks
D9	Completed design data and drawings - General arrangement (s) - Control drawings	Hold	<11 weeks
	Inspection and factory testing		
F1	Core strand insulation resistance	Inspect	As agreed
F2	Core and coil assembly, inspection of individual coils, check that all winding sticks and spacers are aligned and each winding is strong and tight Coils installed on limbs, upper insulation and pressure boards not installed so that Endeavour Energy can examine the oil ducts from the top of the winding assembly	Hold	As agreed
F3	Pre-tanking	Hold	As agreed

F4	Oil acceptance prior to filling	Hold	As agreed
F5	Certified factory test certificates	Hold	Prior to dispatch from factory
	Transportation and delivery		
T1	Transport arrangement / documentation	Hold	Prior to dispatch from factory
T2	Operation and Maintenance manuals	Hold	Prior to acceptance of delivery
T3	Dew point measurement and proof of moisture content less than 0.5%	Hold	Prior to acceptance of delivery to nominated site
T4	Impact and tilt recorder report and graphs	Hold	Prior to acceptance of delivery to nominated site
	Installation and commissioning		
C1	Worksite hazard and risk assessment provided	Hold	1 week prior to installation
C2	Dew point / moisture indication test results Supply oil test results Site testing procedure and schedule	Hold	Prior to installation and filling
C3	Site test report	Hold	Within 21 days of commencement of installation
C4	Formal hand-over	Hold	As agreed

Important: Work must not proceed past a hold or inspection point until formal written approval from Endeavour Energy has been provided to proceed.

It is the supplier's responsibility to arrange all inspections. Final inspection of the transformer is to be made by Endeavour Energy at the workshop of the supplier, or elsewhere as may be mutually arranged after Endeavour Energy has received notice that the transformer is ready for inspection.

The test plan must as a minimum comprise the following information:

- a) A summary sheet listing the transformer being tested
- b) A summary of all the test activities including daily activities and order / duration of tests
- c) Details of each tests including but not limited to the following information:
 - i. Type of test
 - ii. Test procedure and test circuit diagram

- iii. Applied specification of standard
- iv. Criteria used to assess test results including the guaranteed values
- v. List of instruments to be used including manufacturer's name, type, model number and accuracy
- vi. Details of the current equipment accreditation

Routine, type and special tests will be carried out in the presence of the Endeavour Energy's inspecting officer, unless otherwise agreed by the Contract manager.

Where possible, the supplier may be requested to utilise video conferencing system to allow remote inspections for the transformers active part assembly, pre-tanking and factory acceptance testing.

Where rework of the power transformer is required, the nominated inspection and hold point must be repeated at the Supplier's expense.

5.7.3 Design and risk assessment review

A design and risk assessment review meeting is required under this specification to be held at Endeavour Energy's office and must be attended by the supplier's Design Engineer. Design and risk reviews for power transformers will be attended by the at least the Engineer Transmission Substation Assets from Endeavour Energy.

The design review must cover mechanical, electrical, thermal and acoustic / sound level design and provide evidence of the short circuit performance. The risk assessment review will cover the risk register and design proposed by the supplier.

Where a design change is required for any reason, the proposed design change along with all supporting documentation for the change must be submitted for review and approval prior to proceeding with the change. The design change will be subject to the same review and approval procedures as the initial risk assessment and design review.

Prior to the design and risk review meeting, the following documented information is to be provided at least 10 business days prior to the design review in order for Endeavour Energy to be familiar with the detail to be discussed:

- general arrangement drawing;
- materials used for construction of the transformer;
- construction types, methods and procedures;
- final short circuit strength;
- calculated forces and locations, temperatures and locations, sound levels, losses, electrical stresses (power frequency and impulse), flux paths and flux control;
- electrical clearances;
- hot spot calculations and fibre optic locations;
- detailed drawings of core and coil construction;
- impedance curve for all tap positions;
- graph of the sound performance versus load (and no-load);
- design risk assessment for lifecycle risk management;
- shock level design criteria and expected transportation mode; and
- data sheets clearly marked for each component utilised to construct the transformer (including primary and secondary systems).

5.7.4 Operations and maintenance manual

The manufacturer/supplier must submit the following documentation prior to delivery of the equipment to Endeavour Energy as follows:

One (1) hard copies and one (1) electronic copy of the complete installation, operation and maintenance manual must be provided for the complete transformer supplied for each contract. Each manual must relate specifically to the equipment supplied and must not contain any material that is not applicable. The manual must be A4 size and all drawings must be suitably folded or reduced for filing within the manual. Each manual must include:

- a hard cover to withstand normal handling;
- a comprehensive index;
- installation instructions;
- operating instructions;
- instructions for the routine maintenance of the equipment and associated auxiliary equipment;
- recommended maintenance schedules;
- tests after maintenance work;
- type test reports;
- a complete list of parts with serial numbers;
- copies of detailed drawings;
- drawings of auxiliary equipment;
- routine factory tests;
- data sheets for each piece of equipment used in the transformer clearly marking the components used, including o-rings and gaskets;
- material Safety Data Sheets for all hazardous or flammable materials
- design and ongoing risk assessment;
- details of any test failures including the test failure report and photos of the failed components to be included in the report for future reference.

5.8 Testing

5.8.1 Factory testing

5.8.1.1 General

All routine, type and special tests must be conducted with the transformer completely assembled in the factory with all protection devices, oil level gauges, control cubicles, handrails and cable boxes fully installed and operational. Gland plates may be removed for test cable access.

Reports written in any language other than English will not be accepted by Endeavour Energy unless such reports are translated into English by a sworn translator.

Type tests and routine tests must be carried out on the first unit under the contract.

The tests to be carried out on the first unit, and the suggested sequence, are set out in the Tables 9 and 10. Test items 13-21 immediately followed by 26-38 of the table must be carried out in sequence.

Tests on all subsequent units and the suggested sequence are set out in Table 10. Test Items 13 to 21 immediately followed by 24-34 of Table 10 must be carried out in sequence.

Sound level tests must be carried out without interfering with the sequence.

All test results must be included in the maintenance manuals with a note indicating that the test results relate to the original unit.

One (1) copy of all test results must be provided to the contract manager within one (1) week of the completion of the tests for approval, and must include a cover page that lists all the tests and a statement indicating that all tests have passed including guaranteed values. The transformer must only be shipped from the factory after the test reports have been approved by Endeavour Energy.

Should there be a discrepancy or a test failure, this should be noted on the cover sheet and the test results and failure report included in the maintenance manual.

Where a test failure has occurred, the recovery plan and design modifications must be approved by the Purchaser before proceeding with rectification works.

5.8.1.2 Type Tests

The tests in Table 9 must be carried out the first unit under the contract, together with the Routine Tests specified in section 5.8.1.3.

Table 9: Type Tests to be performed on the first unit under the contract

Item No	Description of test	Acceptable value	Test method reference.
1	a) A temperature rise test must be carried out under all implemented cooling conditions, and to the criteria specified in Annexure 1. Temperature rise test may be conducted only with the radiators that belong to the finished unit. Sharing radiator banks is not permitted and redundant fans and radiators are not to be utilised. b) A temperature rise test must be performed starting from 100% CMR (continuous maximum rating) with stable temperature and followed by a step to 130% CMR on the same (maximum loss) tapping position as the other temperature rise tests. The test is to be stopped once temperature of the winding via fibre optic measurement reaches 130 degC. The Endeavour Energy representative will indicate which radiator and fan will be isolated during the temperature rise test.	As set out in Annexure 1 limits for each transformer	AS/NZS60076.2 all clauses
2	An oil sample must be taken from the transformer bottom sample point just prior to the temperature	Gas generation rates guidelines based on each gas increase between	AS/NZS 60076.1:2014 Cl.11.1.4 IEC 61181

	rise test sequence (1a and 1b above) and at the end of the test. The sample is to be tested for dissolved gas for the following gases: - Hydrogen H₂ - Methane CH₄ - Ethane C₂H₆ - Ethylene C₂H₄ - Acetylene C₂H₂ - Carbon monoxide CO - Carbon dioxide CO₂	samples (ppm) divided by temperature rise test interval in hours: H₂ < 1.0 ppm/h CH₄ + C₂H₆ + C₂H₄ < 0.4 ppm/h CO < 2.0 ppm/h CO₂ < 18.0 ppm/h C₂H₂ Not detectable	IEEE C57.130
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5.8.1.3 Routine Tests

The routine tests in Table 10 must be carried out on all transformers.

Test items 13-21 must be immediately sequentially followed by items 26-36.

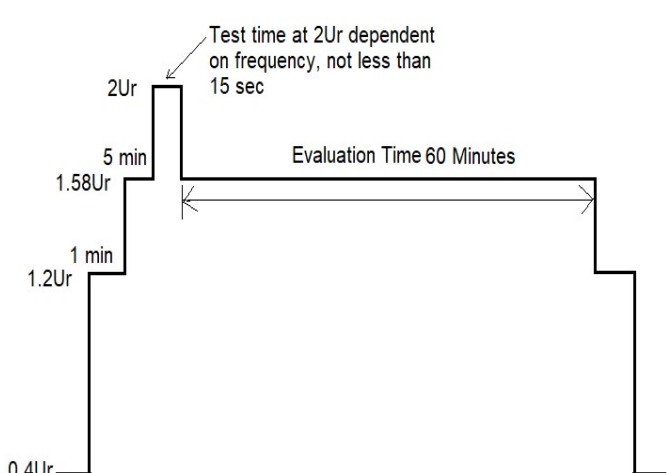
Table 10: Factory test requirements

Item No	Description of test	Acceptable value	Test method reference.
1	Degree of polymerization test of insulation paper, new paper before drying and after drying.	>1000 (DPv) after drying/vapor phase drying	IEC 60450
2	Oil tests prior to filling of transformer – initial oil sample must be taken from the bulk oil prior to filling. • PCB. Levels equal to or greater than 0.02 parts per million of PCB shall not be accepted. • Moisture • Breakdown voltage (12mm diam. electrodes, stirred, 2.5mm distance between electrodes) • Acidity • Interfacial tension • Furans • DDF • Colour	Not detectable (<2mg/kg) <20mg/kg >70 kV <0.01mgKOH/g >40mN/m Nil (<0.05 mg/kg) <5mRad 0.5	Endeavour Energy Specification. ETS 0010
3	Routine tests on winding temperature indicator current transformers, in accordance with AS 60044.1-2007.	In accordance with standard's requirements	AS/NZS 61869.2 Cl 7.2.2, 7.23, 7.2.201, 7.2.6 and 7.3.204
4	Perform insulation resistance test between conductor to conductor and conductor to earth on all control wiring,	>1 MΩ	AS3000:2018 Cl 8.3.6.3

	including tap changer control wirings and CT secondary wirings applied at 500V DC.		
5	Power frequency voltage withstand tests on secondary wiring installation at 2 kV for one (1) minute.	No insulation breakdown	AS/NZS 60076.3:2017 Cl.9
6	The functional test of secondary wiring circuits.	Full functionality confirmed.	AS/NZS 60076.1:2014 Cl.11.7
7	Measurement of the power taken by the fan and oil pump motors if utilised.	-	AS/NZS 60076.1:2014 Cl.11.1.4
8	Gas and oil actuated relay stability where xFxx or xDxx cooling is utilised. (Tested when the oil is at ambient temperature and at elevated temperature after heat run test at maximum rating).	Non-operation of Gas relay	-
9	Paint thickness test at points selected by the Endeavour Energy's representative.	ref 5.4.15	AS 2700:2011
10	Measurement of the winding resistance on each tap (tabular and graphical results in Excel required).	Differential resistance <5%	AS/NZS 60076.1:2014 Cl.11.2
11	Measurement of voltage ratio and check of phase displacement (tabular and graphical representation required).	Conforms to specification	AS/NZS 60076.1:2014 Cl.11.3
12	Tests on on-load tap-changers (operational checks).	No failure or voltage fluctuation	AS/NZS 60076.1:2014 Cl.11.7
13	Core to frame and core plus frame to tank insulation. Test at 2.5kV (liquid filled) for one (1) minute. If the core and frame earth connections are not accessible when the transformer is liquid filled, test at 500V for one (1) minute Tests must be carried out when the temperature of transformer including windings and cores is no more than 5 deg. C hotter than the ambient temperature.	No insulation breakdown	AS/NZS 60076.1:2014 Cl.11.12
14	tan δ and capacitance of bushings. Partial discharge of bushings ($U_m \mid 1.5U_m/\sqrt{3} \mid 1.05U_m/\sqrt{3}$) Capacitance	< 7 mRad 10 / 10 / 5pC As per design and within 3% of nameplate	AS/NZS 60137:2020
15	Determination of capacitances winding-to-earth, and between windings	Based on design	AS/NZS 60076.1:2014 Cl.11.1.4 c)
16	Measurement of insulation resistance (5kV dc for one [1] minute) and measurement of dissipation factor (tan δ) of the	>5 G Ω @ 20C	AS/NZS 60076.1:2014

	insulation system (10kV) and capacitances. Tests must be carried out when the temperature of transformer including windings and cores is no more than 5 deg. C hotter than the ambient temperature. The insulation resistance test must be carried out from: - Each winding to all other winding(s) plus earth/tank, - Each pair of windings to all other winding(s) plus earth/tank, - All windings to earth/tank. Measurements of $\tan \delta$ and capacitances as per design. Winding DLA:	>5 GΩ @ 20C >5 GΩ @ 20C < 4.5 mRad	Cl.11.1.4 d), h), o)
17	An oil sample must be taken from the transformer bottom sample point just prior to HV testing and at the end of each HV test. Each sample is to be tested for dissolved gas for the following gases: - Hydrogen H₂ - Methane CH₄ - Ethane C₂H₆ - Ethylene C₂H₄ - Acetylene C₂H₂ - Carbon monoxide CO - Carbon dioxide CO₂	Gas generation rates guidelines based on each gas increase between samples (ppm): H₂ < 15 ppm CH₄ < 4 ppm C₂H₆ < 1.5 ppm C₂H₄ < 1 ppm CO < 15 ppm C₂H₂ Not detectable	AS/NZS 60076.1:2014 Cl.11.1.4 n) IEC 61181:2007 IEEE C57.130:2015
18	Measurement of no-load loss and current at 90%, 100% and 110% of excitation.	Based on guaranteed values	AS/NZS 60076.1:2014 Cl.11.5
19	Measurements of the harmonics of the no-load current.	Based on guaranteed values	AS/NZS 60076.1:2014 Cl.11.1.4
20	Measurement of zero - sequence impedances on three-phase transformers.	< positive sequence impedance in Annexure 1	AS/NZS 60076.1:2014 Cl.11.6
21	Measurement of short-circuit impedance and load loss. The supplier is required to prove the impedance curve submitted in Annexure 1.2 and test and plot impedance values on all taps. This requirement may be reduced to less taps as identified during design review, but the minimum and maximum short circuit impedance values of the impedance curve are to be tested and recorded including impedance values at maximum, nominal and minimum taps.	As set out in Annexure 1 envelope for each transformer.	AS/NZS 60076.1:2014 Cl.11.4
21A	Measurement of leakage / short circuit impedance using a low current device (2 to 40A) which can be repeated at site test in accordance with Cl. 5.8.2.3.	Comparable to test 20 above.	AS/NZS 60076.1:2014 Cl.11.4
22	Oil sample to be taken from the transformer sample valve and temperature recorded.	-	A/NZS S60076.1:2014 Cl.11.1.4

23	Sound power level tests must be conducted on the transformers at 100% and 105% core excitation with all cooling equipment de-energised (ONAN).	As set out in Annexure 1 limits for each transformer	AS/NZS 60076.10-2023
24	Sound power level tests must be conducted on the transformers at 100% and 105% core excitation with pumps and fans (if any) energised (ODAF).	As set out in Annexure 1 limits for the transformer	AS/NZS 60076.10-2023
25	Sound level test must be conducted on the transformers for measurement of noise due to 2/3 rated load currents.	As set out in Annexure 1 limits for each transformer	AS/NZS 60076.10-2023
26	A transformer sound spectrum measurement must be carried out at 100% core excitation on ODAF.	As set out in Annexure 1 limits for each transformer	AS/NZS 60076.10-2023
27	a) A temperature rise test must be carried out on the full rating condition (e.g. ODAF) and to the criteria specified in Annexure 1. Temperature rise test may be conducted only with the radiators that belong to the finished unit. Sharing radiator banks is not permitted and redundant fans and radiators are not to be utilised. The Endeavour Energy representative will indicate which radiator and fan will be isolated during the temperature rise test.	As set out in Annexure 1 limits for each transformer	AS/NZS 60076.2:2013 all clauses
28	Oil sample to be taken from the transformer sample valve.	-	AS/NZS 60076.1:2014 Cl.11.1.4
29	Lightning impulse voltage withstand full wave test (LI) for the three phases of the transformer and each phase (HV, LV and /or TV windings) to be tested once on one different tap position of maximum tap, principal tap and minimum tap with average oil rise greater than 40 deg. C with the transformer fully assembled.	No disruptive discharge. Waveform comparison in accordance with AS60076. Waveforms to be provided.	AS/NZS 60076.3:2017 Cl 13.2
30	Lightning impulse voltage withstand chopped wave test (LIC) for the three phases of the transformer and each phase (HV, LV and /or TV windings) to be tested once on one different tap position of maximum tap, principal tap and minimum tap with average oil rise greater than 40 deg. C with the transformer fully assembled.	No disruptive discharge. Waveform comparison in accordance with AS60076. Waveforms to be provided	AS/NZS 60076.3:2017 Cl 13.3
31	Lightning impulse voltage withstand tests for neutral (LIN) on maximum tap position with the transformer fully assembled.	No disruptive discharge	AS/NZS 60076.3:2017 Cl 13.3.2
32	Oil sample to be taken from the transformer sample valve	-	AS/NZS 60076.1:2014 Cl.11.1.4

33	The separate source voltage withstand test (AV) to be carried out.	No voltage collapse	/NZS 10
34	Oil sample to be taken from the transformer sample valve.	-	AS60076.1:2014 Cl.10.1.3
35	Induced over voltage withstand test (can be combined with partial discharge test),	No voltage collapse at 2 x rated voltage	AS/NZS 60076.3:2017 Cl. 11
36	Oil sample to be taken from the transformer sample valve.	-	AS/NZS 60076.1:2014 Cl.11.1.4
37	Partial discharge tests (IVPD) on all terminals with the transformer fully assembled.  The maximum apparent charge (q) must not be greater than 50 pC at 1.58 x rated voltage on nominal tap, with 60 minute evaluation time. Sources of discharge if any must be located and rectified if greater than 50pC. Where the manufacturer is not able to monitor all winding terminals in one test, the test must be repeated until all terminals have been tested. A recording of the test over the 60-minute interval is to be included in the test report.	<50pC @ 1.58Ur	AS/NZS 60076.3:2017 Cl.11.3.
38	Oil sample to be taken from the transformer sample valve.	-	AS/NZS 60076.1:2014 Cl.11.1.4
39	Frequency Response Analysis (FRA) of the transformer at factory. After the dielectric tests, the transformer must not be subject to any movement prior to FRA analysis,	Tracing to be compared with site test tracing	AS/NZS 60076.1:2014 Cl.11.1.4
40	Oil pressure test of 50 kPa over the top of the oil filled transformer for 24 hours.	Tank withstands pressure.	AS/NZS 60076.1:2014 Cl.11.8

41	Dew Point measurement as in IEEE C57.93 for moisture determination of cellulose insulation of transformer (in main tank and OLTC tank) prior to shipping if the transformer is shipped under gas. Dew point measurement also required prior to filling at site. The measurement must be carried out after a state of moisture equilibrium between insulation surface and the surrounding gas is achieved and insulation temperature to be accurately determined. Temperature is to be no more than 2 degC different between winding fibre optics and the gas temperature.	-40 deg. Celsius	IEEE C57.93
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Note: The handrails must be in place for sound level test and all dielectric tests, including lightning impulse test, separate source test, induced voltage test and partial discharge test.

Oil samples are to be taken from the transformer bottom sample point after completion of tests as shown in Tables 1. The final sample after testing (item No. 37) must be analysed for dissolved gas.

If the final oil sample is outside any of the limits, the other oil samples will also require analysis to determine the test that caused the evolution of the gas and subsequent determination of the root cause.

5.8.2 Site testing

5.8.2.1 Dew point measurement

If the transformer is shipped under gas, a Dew point measurement according to IEEE C57.93 must be carried out for determining the surface moisture level of cellulose insulation of transformer immediately prior to degassing of the transformer.

The measurement must be carried out after a state of moisture equilibrium between insulation surface and the surrounding gas has been achieved and insulation temperature has been accurately determined. Temperature is to be no more than 2 degC different between winding fibre optics and the gas temperature.

The test result must be submitted to the contract manager, for approval prior to oil filling. Filling must be performed in accordance with 5.4.8.2.

5.8.2.2 Oil

The following oil samples must be taken on site and the test results submitted to the contract manager for approval after each sample is taken. The test requirements and acceptable values are as set out in the attached Endeavour Energy's insulating oil and insulating fluid Equipment Technical Specifications (ETS 0010 and ETS 0120):

- from the bulk oil tank on arrival at site immediately prior to filling.
- after degassing on site, DGA test must be carried out for main tank oil and OLTC to show non-detectable gas concentrations.
- after oil impregnation period (24 hours after filling), the main tank oil and OLTC oil must be tested.

5.8.2.3 Tests after erection by supplier

On completion of delivery and erection of the works, the following tests must be carried out by the supplier and witnessed by Endeavour Energy's representative to demonstrate readiness for service. The supplier's tests must include the following:

- Dew Point Test;
- measurement of voltage ratio (within $\pm 0.5\%$ of the design nameplate values;

- confirmation of vector group;
- measure excitation current;
- measure single phase and three phase impedance (maximum 3% difference for single phase impedance and between phases and 3% variation from nameplate for three phase equivalent);
- measurement of winding resistance on all taps and all windings (differential resistance maximum 5%);
- insulation resistance between all windings and to earth at 5kV dc. The insulation resistance temperature correction formula must be submitted with the tender offer (test results must not be less than the value obtained in the factory test results with all results corrected to 20°C;
- measure core to core frame insulation resistance and core frame to tank insulation resistance with the guaranteed values of minimum 1GΩ @ 20 deg. C for one (1) minute, tested using 1kV dc test voltage (reference ASNZS 60076.1:2014 1 Cl.11.12);
- perform insulation resistance test between conductor to conductor and conductor to earth on all control wiring, including tap changer control wirings and CT secondary wirings with the guaranteed value of minimum 1MΩ @ 20 deg. C for one (1) minute, tested using 500Vdc test voltage;
- Frequency Response Analysis (FRA) and comparison report; and
- Polarisation and Depolarisation Current variation (time domain - PDC) and/or capacitance and dissipation factor variation (frequency domain – FDS) for determination of moisture content and other by-products.

All site test results must be forwarded to the contract manager for approval within seven (7) days of tests being completed on site.

The test result of the on-site FRA compared with the factory results on a phase by phase basis must be submitted for approval by the contract manager before commissioning. It is the supplier's responsibility to compare the test results both at factory and on-site to demonstrate that the transformer was not subject to any core and winding movement/deformation arising from transportation. Endeavour Energy will also carry out a separate evaluation of the SFRA results from the electronic data and applicable software submitted by the supplier.

It is the supplier's responsibility that the transformer is in a state fit for service. This must be confirmed by the supplier in writing.

5.8.2.4 Tests after erection by Endeavour Energy

Endeavour Energy will also carry out the following tests:

- perform separate source AC withstand voltage test. The test must satisfy no disruptive discharge at 100% of factory test voltage (AS/NZS 60076.3:2017, clause 12).
- perform PD test on the complete transformer, including bushings, with the guaranteed values of maximum 50pC at 1.58 times rated voltage.
- perform DDF test on all windings, including bushings with guaranteed values as per Table 11

Table 11: Winding DLA Acceptance Criteria

Winding DDF / DLA	Criteria
$\leq 4.5\text{mrad @ } 20 \text{ deg. C}$	Acceptable
Between 4.5mrad - 5 mrad @ 20 deg. C	Extend transformer warranty by five (5) years during which the DDF must be $< 5\text{mrad @ } 20 \text{ deg. C}$.

≥ 5mrad @20 deg. C	Unacceptable (supplier to rectify and / or replace)
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- measure the winding to earth and inter-winding capacitances. Test results must be consistent with the values obtained in the factory test results.
- perform DDF test on bushings with DDF test point. Test results must be less than 7 mRad @ 20 deg. C
- measure the capacitance of bushings with DDF test point. Test results must be less than 3% variation from nameplate values.

Endeavour Energy will provide all labour, material and equipment necessary for these tests. The supplier may witness these tests at the supplier's cost.

Should the plant or any portion thereof fail under the supplier's or Endeavour Energy's tests, the cost of replacements, repairs and any further tests will be borne by the supplier.

Any expense by the supplier in having representatives present during tests must be borne by the supplier.

5.9 Tender drawings

Drawings appropriate to this specification are listed in Table 12.

Table 12: Drawings

No	Drawing no.	Admt no.	Title
1.	357328	B	General arrangement – 33/11kV 15MVA, 25MVA, 35MVA (HV cable/bushings and LV cable box)
2.	357331	B	General arrangement – 66/11kV 15MVA, 25MVA, 35MVA (HV bushings and LV cable box)
3.	365350	B	General arrangement – 132/11kV 45MVA, (HV bushings and LV cable box), Detached radiators
4.	536523	A	General arrangement – 132/11kV 45MVA, HV bushings and LV cable box, Attached radiators
5.	536524	A	General arrangement – 132/22kV, 45MVA, HV bushings and LV cable box, Attached radiators
6.	365353	A	General arrangement – 132/33/11kV 60MVA, (with attached radiator and HV and LV bushing)
7.	365354	A	General arrangement – 132/33/11kV 60MVA, (with detached radiator and HV and LV bushings)
8.	365356	A	General arrangement – 132/33/11kV 60MVA, (with detached radiator and HV bushing and LV cable box)
9.	365357	A	General arrangement – 132/33/11kV 120MVA, (with detached radiator and HV bushing and LV bushing)
10.	365358	A	General arrangement – 132/33/11 kV 120MVA, (with detached radiator and HV bushing and LV cable box)

11.	536525	A	General arrangement – 132/33/11 kV 120MVA, HV bushing and LV cable box, attached radiators
12.	365360	A	General arrangement – 132/66/11 kV 60MVA & 120MVA, (with attached radiator and HV bushing and LV bushing)
13.	365339 sheet 1 of 3	A	Typical Transformer tap changer control diagram
14.	365339 sheet 2 of 3	A	Typical transformer cooling and tap changer indication circuit diagram
15.	365339 sheet 3 of 3	A	Typical transformer alarms circuit diagram.
16.	356535	B	Endeavour Energy interface terminal block rail connection diagram.
17.	536526	A	Transformer cooling control PIU panel fabrication details.

6 Authorities and Responsibilities

General Manager Future Grid and Asset Management has the authority and responsibility for:

- approving major changes to this instruction in accordance with Table 4 of GAM 0001;
- making all decisions concerning compliance in respect to this Specification;
- approving nominations of Endeavour Energy's representatives; and
- delegating any of these authorities and responsibilities to the Head of Asset Management and Digital.

Head of Asset Management and Digital has the authority and responsibility for:

- approving minor changes to this instruction in accordance with Table 4 of GAM 0001;
- making recommendations to the General Manager Future Grid & Asset Management for major changes in respect to this instruction.

Asset Engineering Manager has authority and responsibility for:

- periodic review of and any required amendments to this instruction;
- managing dispensation requests for variations to requirements of this instruction.
- clarifying all the technical aspects of this specification to the stakeholders;
- approving the relevant actions required and outlined in this specification.

Project Manager has the authority and responsibility to certify that:

- all equipment installed complies with the requirements of this specification.

Contract Manager has the authority and responsibility for:

- determining the equipment procured complies with the requirements of this specification;
- reviewing all test reports and alternative proposals submitted;
- referring non-compliances to the Asset Engineering Manager; and
- approving the relevant actions required and outlined in this specification.

Manufacturers/suppliers are responsible for:

- being aware of their responsibilities under this Specification;
- confirming that the supplier/s under their control have provided suitable training for their staff;
- having an effective safety, environmental and quality auditing system in place; and
- implementing this Specification and keeping Endeavour Energy or other responsible equivalent officers informed of any factors that may prevent them from accepting responsibility for its full implementation.

Annexure 1 – Technical requirements

Annexure 1.1 Transformer guaranteed performance

Table 13: Summary

Technical requirement	Unit	Annexure 1.1.1	Annexure 1.1.2	Annexure 1.1.3	Annexure 1.1.4
Voltage Rating (No Load)	kV	132/33/11	132/33/11	132/66/11	132/66/11
Rated Continuous Power	MVA	60	120	60	120
Vector connection		YNyn0d1	YNyn0d1	YNyn0d1	YNyn0d1
HV-LV Impedance @ full rating & 75°C - principal tap	%	17.75	21.46	10.94	21.46
On-load tapping range – Option 1		+7 x 1.25%, -13 x 1.25%	+7 x 1.25%, -13 x 1.25%	+7 x 1.25%, -13 x 1.25%	+7 x 1.25%, -13 x 1.25%
On-load tapping range – Option 2		+4 x 1.25%, -16 x 1.25%	+4 x 1.25%, -16 x 1.25%	+4 x 1.25%, -16 x 1.25%	+4 x 1.25%, -16 x 1.25%
Sound Options		1,2,3	1,2,3	1,2,3	1,2,3

Technical requirement	Unit	Annexure 1.1.5	Annexure 1.1.6	Annexure 1.1.7	Annexure 1.1.8
Voltage Rating (No Load)	kV	132/11	132/22	66/11	66/11
Rated Continuous Power	MVA	45	45	35	25
Vector connection		Dyn1	Dyn1	Dyn1 or Dyn11	Dyn1 or Dyn11
HV-LV Impedance @ full rating & 75°C - principal tap	%	32.59	27.73	24.72	17.57
On-load tapping range – Option 1		+10 x 1.5%, -10 x 1.5%	+10 x 1.5%, -10 x 1.5%	+10 x 1.5%, -10 x 1.5%	+10 x 1.5%, -10 x 1.5%
On-load tapping range – Option 2		+7 x 1.5%, -15 x 1.5%	+7 x 1.5%, -15 x 1.5%	+7 x 1.5%, -14 x 1.5%	+7 x 1.5%, -14 x 1.5%
Sound Options		S,1,2,3	S,1,2,3	S,1,2,3	S,1,2,3

Technical requirement	Unit	Annexure 1.1.9	Annexure 1.1.10	Annexure 1.1.11	Annexure 1.1.12
Voltage Rating (No Load)	kV	66/11	33/11	33/11	33/11
Rated Continuous Power	MVA	15	35	25	15
Vector connection		Dyn1 or Dyn11	Dyn1 or Dyn11	Dyn1 or Dyn11	Dyn1 or Dyn11
HV-LV Impedance @ full rating & 75°C - principal tap	%	10.59	24.72	17.57	10.59
On-load tapping range – Option 1		+10 x 1.5%, -10 x 1.5%	+10 x 1.5%, -10 x 1.5%	+10 x 1.5%, -10 x 1.5%	+10 x 1.5%, -10 x 1.5%
On-load tapping range – Option 2		+7 x 1.5%, -14 x 1.5%	+7 x 1.5%, -14 x 1.5%	+7 x 1.5%, -14 x 1.5%	+7 x 1.5%, -14 x 1.5%
Sound Options		S,1,2,3	S,1,2,3	S,1,2,3	S,1,2,3

Annexure 1.1.1 132/33/11kV 60MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		132/33/11		
6.	Vector connection		YNyn0d1		
7.	Rated voltage (Ur)				
	a) HV	kV	132		
	b) LV	kV	33		
	c) TV	kV	11		
8.	System highest voltage (Um)				
	a) HV	kV	145		
	b) LV	kV	36		
	c) TV	kV	12		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 40/40/10 or 50/50/10		
	b) ODAN- HV/LV/TV	MVA	e.g. 50/50/10 or 60/60/10		
	c) ODAF - HV/LV/TV	MVA	e.g. 60/60/10		
10.	System fault levels (3 sec)				
	a) HV	kA	40		
	b) LV	kA	31.5		
	c) TV	kA	20		
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6.	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	18.83
	b) HV - LV, maximum tap, minimum including tolerances	%	16.2
	c) HV - LV, principal tap, within the specified impedance envelope	%	17.75
	d) HV - LV, minimum tap, maximum value including tolerances	%	18.83
	e) HV - LV, minimum tap, minimum value including tolerances	%	16.2
	f) HV – TV, principal tap	%	>60
	g) LV - TV	%	>48
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+7 x 1.25%, -13 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	143.55
	Nominal tap position (Tap 8) - HV voltage	kV	132
	Minimum tap position (Tap 21) - HV voltage	kV	110.55
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+4 x 1.25%, -16 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	138.6
	Nominal tap position (Tap 5) - HV voltage	kV	132
	Minimum tap position (Tap 21) - HV voltage	kV	105.6
18.	System earthing		

Ref no.	Item description	Unit	Requirement		
	HV neutral		Effectively Earthed		
	LV neutral		Effectively Earthed		
	TV		One phase of Delta earthed		
19.	Sound power level (max acceptable):		Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤85	≤75	≤70
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤87	≤77	≤72
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load.	dBA	-	-	≤70
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load.	dBA	-	-	≤72
20.	Radio interference voltage levels		Comply with AS2344-2016		
21.	Insulation level				
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	145 / 650 / 275		
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70		
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	24 / 145 / 50		
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	52 / 250 / 95		
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70		
22.	Over-excitation	%Ur	Refer section 5.2.6		
23.	Maximum flux density				
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
24.	Maximum internal partial discharge @ 120% UM/√3	pC	50		
25.	On-load tap changer- high speed resistor type				
	a) Type		ABB UZ preferred		
	b) Location		HV star point		
	c) Rated current	Amp	≥500		

Ref no.	Item description	Unit	Requirement
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Refer section 5.4.6.1
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7.
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required`		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	145
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	36
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		24
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
30.	Bushings HV		

Ref no.	Item description	Unit	Requirement
	a) Rated voltage (phase to phase)	kV	145
	b) Continuous current rating	Amps	≥500
	c) Current rating of stem/rod	Amps	≥500
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	650
	• Power frequency	kV	275
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	4495
	i) Minimum phase to phase clearance ^(Note 1)	mm	1495 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	1300 (live parts to earth)
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	36
	b) Continuous current rating	Amps	≥1600
	c) Current rating of stem/rod	Amps	≥1600
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1116
	i) Minimum phase to phase clearance ^(Note 1)	mm	370 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	320 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled

Ref no.	Item description	Unit	Requirement
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	24
	b) Continuous current rating	Amps	>800
	c) Current rating of stem/rod	Amps	>800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	145
	• Power frequency	kV	50
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	744
	i) Minimum phase to phase clearance ^(Note 1)	mm	325 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	280 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	52
	b) Continuous current rating	Amps	>500
	c) Current rating of stem/rod	Amps	>500
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	250
	• Power frequency	kV	95
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1612
	i) Minimum phase to earth clearance	mm	480 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled

Ref no.	Item description	Unit	Requirement
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	36
	b) Continuous current rating	Amps	≥1600
	c) Current rating of stem/rod	Amps	≥1600
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance (Note 1)	mm	1116
	i) Minimum phase to earth clearance (Note 1)	mm	320 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (33kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box TV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm		700

Ref no.	Item description	Unit	Requirement
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		≥1
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.2 132/33/11kV 120MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		132/33/11		
6.	Vector connection		YNyn0d1		
7.	Rated voltage (Ur)				
	a) HV	kV	132		
	b) LV	kV	33		
	c) TV	kV	11		
8.	System highest voltage (Um)				
	a) HV	kV	145		
	b) LV	kV	36		
	c) TV	kV	12		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 60/60/10 or 95/95/10		
	b) ODAN- HV/LV/TV	MVA	e.g. 95/95/10 or 120/120/10		
	c) ODAF - HV/LV/TV	MVA	e.g. 120/120/10		
10.	System fault levels (3 sec)				
	a) HV	kA	40		
	b) LV	kA	31.5		
	c) TV	kA	20		
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	23.71
	b) HV - LV, maximum tap, minimum including tolerances	%	20.4
	c) HV - LV, principal tap, within the specified impedance envelope	%	21.46
	d) HV - LV, minimum tap, maximum value including tolerances	%	23.71
	e) HV - LV, minimum tap, minimum value including tolerances	%	20.4
	f) HV – TV, principal tap	%	>60
	g) LV - TV	%	>48
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+7 x 1.25%, -13 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage		143.55
	Nominal tap position (Tap 8) - HV voltage		132
	Minimum tap position (Tap 21) – HV voltage		110.55
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+4 x 1.25%, -16 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	138.6
	Nominal tap position (Tap 5) - HV voltage	kV	132
	Minimum tap position (Tap 21) – HV voltage	kV	105.6
18.	System earthing		

Ref no.	Item description	Unit	Requirement		
	HV neutral		Effectively Earthed		
	LV neutral		Effectively Earthed		
	TV		One phase of Delta earthed		
19.	Sound power level (max acceptable – refer transformer cost assessment clause):		Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤85	≤75	≤70
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤87	≤77	≤72
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	≤70
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	≤72
20.	Radio interference voltage levels		Comply with AS2344-2016		
21.	Insulation level				
	• HV – system highest voltage (UM) / LI / Ud	kV/kVp/kV	145 / 650 / 275		
	• LV – system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70		
	• TV – system highest voltage (UM) / LI / Ud	kV/kVp/kV	24 / 145 / 50		
	• HVN – system highest voltage (UM) / LI / Ud	kV/kVp/kV	52 / 250 / 95		
	• LVN – system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70		
22.	Over-excitation	%Ur	Refer section 5.2.6		
23.	Maximum flux density				
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
24.	Maximum internal partial discharge @ 120% UM/√3	pC	50		
25.	On-load tap changer- high speed resistor type				
	a) Type		ABB UZ or UC preferred		
	b) Location		HV star point		

Ref no.	Item description	Unit	Requirement
	c) Rated current	Amp	≥ 1000
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Refer section 5.4.6.1
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required`		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	145
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	e) Rated voltage (phase to phase)	kV	36
	f) Termination type		Air insulated cable box
	g) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	h) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		24
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	145
	b) Continuous current rating	Amps	≥1000
	c) Current rating of stem/rod	Amps	≥1000
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	650
	• Power frequency	kV	275
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	4495
	i) Minimum phase to phase clearance ^(Note 1)	mm	1495 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	1300 (live parts to earth)
	k) Cantilever Strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	36
	b) Continuous current rating	Amps	≥3150
	c) Current rating of stem/rod	Amps	≥3150
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1116
	i) Minimum phase to phase clearance ^(Note 1)	mm	370 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	320 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	24
	b) Continuous current rating	Amps	>800
	c) Current rating of stem/rod	Amps	>800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	145
	• Power frequency	kV	50
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	744
	i) Minimum phase to phase clearance (Note 1)	mm	325 (between live parts)
	j) Minimum phase to earth clearance (Note 1)	mm	280 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	52
	b) Continuous current rating	Amps	>1000
	c) Current rating of stem/rod	Amps	>1000
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	250
	• Power frequency	kV	95
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1612
	i) Minimum phase to earth clearance	mm	480 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
34.	Bushings LV-N		
	k) Rated voltage (phase to phase)	kV	36
	l) Continuous current rating	Amps	≥3150
	m) Current rating of stem/rod	Amps	≥3150
	n) Three (3) second current rating	kA	31.5
	o) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	p) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	q) Colour		Light grey
	r) Minimum creepage distance	mm	1116
	s) Minimum phase to earth clearance (Note 1)	mm	320 (live parts to earth)
	t) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (33kV)		
	f) Termination type		Air insulated
	g) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	h) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	i) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	j) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box TV (11kV)		
	f) Termination type		Air insulated
	g) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	h) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	i) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9

Ref no.	Item description	Unit	Requirement
	j) Min. distance gland plate to centre of term. Palm		700
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		≥1
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	c) Ex works		As nominated in the Works Section.
	d) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	c) Ki = No load Loss	A\$/KW	\$12,800
	d) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.3 132/66/11kV 60MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		132/66/11		
6.	Vector connection		YNyn0d1		
7.	Rated voltage (Ur)				
	a) HV	kV	132		
	b) LV	kV	66		
	c) TV	kV	11		
8.	System highest voltage (Um)				
	a) HV	kV	145		
	b) LV	kV	72.5		
	c) TV	kV	12		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 40/40/10 or 50/50/10		
	b) ODAN- HV/LV/TV	MVA	e.g. 50/50/10 or 60/60/10		
	c) ODAF - HV/LV/TV	MVA	e.g. 60/60/10		
10.	System fault levels (3 sec)				
	a) HV	kA	40		
	b) LV	kA	31.5		
	c) TV	kA	20		
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	11.85
	b) HV - LV, maximum tap, minimum including tolerances	%	10.2
	c) HV - LV, principal tap, within the specified impedance envelope	%	10.94
	d) HV - LV, minimum tap, maximum value including tolerances	%	11.85
	e) HV - LV, minimum tap, minimum value including tolerances	%	10.2
	f) HV – TV, principal tap	%	>60
	g) LV - TV	%	>48
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+7 x 1.25%, -13 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage		143.55
	Nominal tap position (Tap 8) - HV voltage		132
	Minimum tap position (Tap 21) - HV voltage		110.55
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+4 x 1.25%, -16 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	138.6
	Nominal tap position (Tap 5) - HV voltage	kV	132
	Minimum tap position (Tap 21) - HV voltage	kV	105.6
18.	System earthing		

Ref no.	Item description	Unit	Requirement		
	HV neutral		Effectively Earthed		
	LV neutral		Suitable for effectively and non-effectively earthed		
	TV		One phase of Delta earthed		
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤85	≤75	≤70
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤87	≤77	≤72
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	≤70
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	≤72
20.	Radio interference voltage levels		Comply with AS2344-2016		
21.	Insulation level				
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	145 / 650 / 275		
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5/ 325 / 140		
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	24 / 145 / 50		
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	52 / 250 / 95		
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5/ 325 / 140		
22.	Over-excitation	%Ur	Refer section 5.2.6		
23.	Maximum flux density				
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.6.6		
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
24.	Maximum internal partial discharge @ 120% UM/√3	pC	50		
25.	On-load tap changer- high speed resistor type				
	a) Type		ABB UZ preferred		
	b) Location		HV star point		

Ref no.	Item description	Unit	Requirement
	c) Rated current	Amp	≥500
	d) Power supply	V (rms)	415/240 ± 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Refer section 5.4.6.1
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	145
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	66
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		24
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	145
	b) Continuous current rating	Amps	≥500
	c) Current rating of stem/rod	Amps	≥500
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	650
	• Power frequency	kV	275
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	4495
	i) Minimum phase to phase clearance ^(Note 1)	mm	1495 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	1300 (live parts to earth)
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥800
	c) Current rating of stem/rod	Amps	≥800
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	2248
	i) Minimum phase to phase clearance ^(Note 1)	mm	725 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	630 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	24
	b) Continuous current rating	Amps	>800
	c) Current rating of stem/rod	Amps	>800
	d) Three(3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	145
	• Power frequency	kV	50
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	744
	i) Minimum phase to phase clearance ^(Note 1)	mm	325 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	280 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	52
	b) Continuous current rating	Amps	>500
	c) Current rating of stem/rod	Amps	>500
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	250
	• Power frequency	kV	95
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1612

Ref no.	Item description	Unit	Requirement
	i) Minimum phase to earth clearance	mm	480 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥800
	c) Current rating of stem/rod	Amps	≥800
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	2248
	i) Minimum phase to earth clearance (Note 1)	mm	630 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (66kV)		
	a) Termination type		-
	b) No of cables		-
	c) Size of single core cables (design must be able to accommodate all options)		-
	d) Location of cable entry centres (mandatory requirements)		-
	e) Min. distance gland plate to centre of term. Palm	mm	-
36.	Cable box TV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 800 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9

Ref no.	Item description	Unit	Requirement
	e) Min. distance gland plate to centre of term. Palm		700
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		≥1
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.4 132/66/11kV 120MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		132/66/11		
6.	Vector connection		YNyn0d1		
7.	Rated voltage (Ur)				
	a) HV	kV	132		
	b) LV	kV	66		
	c) TV	kV	11		
8.	System highest voltage (Um)				
	a) HV	kV	145		
	b) LV	kV	72.5		
	c) TV	kV	12		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 60/60/10 or 95/95/10		
	b) ODAN- HV/LV/TV	MVA	e.g. 95/95/10 or 120/120/10		
	c) ODAF - HV/LV/TV	MVA	e.g. 120/120/10		
10.	System fault levels (3 sec)				
	a) HV	kA	40		
	b) LV	kA	31.5		
	c) TV	kA	20		
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	23.71
	b) HV - LV, maximum tap, minimum including tolerances	%	20.4
	c) HV - LV, principal tap, within the specified impedance envelope	%	21.46
	d) HV - LV, minimum tap, maximum value including tolerances	%	23.71
	e) HV - LV, minimum tap, minimum value including tolerances	%	20.4
	f) HV – TV, principal tap	%	>60
	g) LV - TV	%	>48
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+7 x 1.25%, -13 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage		143.55
	Nominal tap position (Tap 8) - HV voltage		132
	Minimum tap position (Tap 21) - HV voltage		110.55
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+4 x 1.25%, -16 x 1.25%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	138.6
	Nominal tap position (Tap 5) - HV voltage	kV	132
	Minimum tap position (Tap 21) - HV voltage	kV	105.6
18.	System earthing		

Ref no.	Item description	Unit	Requirement		
	HV neutral		Effectively Earthed		
	LV neutral		Effectively Earthed		
	TV		One phase of Delta earthed		
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤85	≤75	≤70
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤87	≤77	≤72
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	≤70
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	≤72
20.	Radio interference voltage levels		Comply with AS2344-2016		
21.	Insulation level				
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	145 / 650 / 275		
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5 / 325 / 140		
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	24 / 145 / 50		
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	52 / 250 / 95		
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5 / 325 / 140		
22.	Over-excitation	%Ur	Refer section 5.2.6.		
23.	Maximum flux density				
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6		
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6		
24.	Maximum internal partial discharge @ 120% UM/√3	pC	50		
25.	On-load tap changer- high speed resistor type				
	a) Type		ABB UZ or UC preferred		
	b) Location		HV star point		

Ref no.	Item description	Unit	Requirement
	c) Rated current	Amp	≥ 1000
	d) Power supply	V (rms)	$415/240 \pm 10\%$
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Refer section 5.4.6.1
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required`		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	145
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		24
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	145
	b) Continuous current rating	Amps	≥1000
	c) Current rating of stem/rod	Amps	≥1000
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	650
	• Power frequency	kV	275
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	4495
	i) Minimum phase to phase clearance ^(Note 1)	mm	1495 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	1300 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥1600
	c) Current rating of stem/rod	Amps	≥1600
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	2248
	i) Minimum phase to phase clearance ^(Note 1)	mm	725 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	630 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	24
	b) Continuous current rating	Amps	>800
	c) Current rating of stem/rod	Amps	>800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	145
	• Power frequency	kV	50
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	744
	i) Minimum phase to phase clearance (Note 1)	mm	325 (between live parts)
	j) Minimum phase to earth clearance (Note 1)	mm	280 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	52
	b) Continuous current rating	Amps	>1000
	c) Current rating of stem/rod	Amps	>1000
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	250
	• Power frequency	kV	95
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1612

Ref no.	Item description	Unit	Requirement
	i) Minimum phase to earth clearance	mm	480 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥1600
	c) Current rating of stem/rod	Amps	≥1600
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1116
	i) Minimum phase to earth clearance (Note 1)	mm	630 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (66kV)		
	a) Termination type		-
	b) No of cables		-
	c) Size of single core cables (design must be able to accommodate all options)		-
	d) Location of cable entry centres (mandatory requirements)		-
	e) Min. distance gland plate to centre of term. Palm	mm	-
36.	Cable box TV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9

Ref no.	Item description	Unit	Requirement
	e) Min. distance gland plate to centre of term. Palm		700
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		≥1
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.5 132/11kV 45MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		132/11		
6.	Vector connection		Dyn1		
7.	Rated voltage (Ur)				
	a) HV	kV	132		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	145		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 30/30 or 30/30		
	b) ODAN- HV/LV/TV	MVA	e.g. 40/40 or 45/45		
	c) ODAF - HV/LV/TV	MVA	e.g. 45/45		
10.	System fault levels (3 sec)				
	a) HV	kA	40		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	35.04
	b) HV - LV, maximum tap, minimum including tolerances	%	30.15
	c) HV - LV, principal tap, within the specified impedance envelope	%	32.59
	d) HV - LV, minimum tap, maximum value including tolerances	%	34.29
	e) HV - LV, minimum tap, minimum value including tolerances	%	30.15
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	151.8
	Nominal tap position (Tap 11) - HV voltage	kV	132
	Minimum tap position (Tap 21) - HV voltage	kV	112.2
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -15 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	145.86
	Nominal tap position (Tap 8) - HV voltage	kV	132
	Minimum tap position (Tap 23) - HV voltage	kV	102.3

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤82	≤72	≤64	≤64
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-		-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-		-	≤64
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	145 / 650 / 275			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-- / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6.			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 300
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Refer section 5.4.6.1
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	145
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9.
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		-
	b) Termination type		-
	c) No of conductors		-
	d) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	145
	b) Continuous current rating	Amps	≥400
	c) Current rating of stem/rod	Amps	≥400
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	650
	• Power frequency	kV	275
	f) Bushing type		Resin impregnated synthetic, Resin impregnated paper, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	4495
	i) Minimum phase to phase clearance (Note 1)	mm	1495 (between live parts)
	j) Minimum phase to earth clearance (Note 1)	mm	1300 (live parts to earth)
31.	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥3600
	c) Current rating of stem/rod	Amps	≥3600
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance (Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance (Note 1)	mm	160 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance ¹⁴	mm	-
	j) Minimum phase to earth clearance ¹⁴	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-

Ref no.	Item description	Unit	Requirement
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥ 3600
	c) Current rating of stem/rod	Amps	≥ 3600
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance (Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box TV		
	a) Termination type		-
	b) No of cables		-
	c) Size of single core cables (design must be able to accommodate all options)		-
	d) Location of cable entry centres (mandatory requirements)		-
	e) Min. distance gland plate to centre of term. Palm		-

Ref no.	Item description	Unit	Requirement
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.6 132/22kV 45MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		132/22		
6.	Vector connection		Dyn1		
7.	Rated voltage (Ur)				
	a) HV	kV	132		
	b) LV	kV	22		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	145		
	b) LV	kV	24		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 30/30 or 30/30		
	b) ODAN- HV/LV/TV	MVA	e.g. 40/40 or 45/45		
	c) ODAF - HV/LV/TV	MVA	e.g. 45/45		
10.	System fault levels (3 sec)				
	a) HV	kA	40		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	29.81
	b) HV - LV, maximum tap, minimum including tolerances	%	25.65
	c) HV - LV, principal tap, within the specified impedance envelope	%	27.73
	d) HV - LV, minimum tap, maximum value including tolerances	%	29.81
	e) HV - LV, minimum tap, minimum value including tolerances	%	25.65
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	151.8
	Nominal tap position (Tap 11) - HV voltage	kV	132
	Minimum tap position (Tap 21) - HV voltage	kV	112.2
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	145.86
	Nominal tap position (Tap 8) - HV voltage	kV	132
	Minimum tap position (Tap 22) - HV voltage	kV	102.3

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤82	≤72	≤64	≤64
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤64
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	145 / 650 / 275			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	24 / 145 / 50			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-- / 145 / 50			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 400
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Refer section 5.4.6.1
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	145
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	24
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		-
	b) Termination type		-
	c) No of conductors		-
	d) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	145
	b) Continuous current rating	Amps	≥400
	c) Current rating of stem/rod	Amps	≥400
	d) Three (3) second current rating	kA	40
	e) Insulation levels:		
	• Impulse	kVp	650
	• Power frequency	kV	275
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	4495
	i) Minimum phase to phase clearance ^(Note 1)	mm	1495 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	1300 (live parts to earth)
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 5 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	24
	b) Continuous current rating	Amps	≥1800
	c) Current rating of stem/rod	Amps	≥1800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	145
	• Power frequency	kV	50
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	744
	i) Minimum phase to phase clearance ^(Note 1)	mm	325 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	280 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance	mm	-
	j) Minimum phase to earth clearance	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-

Ref no.	Item description	Unit	Requirement
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	24
	b) Continuous current rating	Amps	≥1800
	c) Current rating of stem/rod	Amps	≥1800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	145
	• Power frequency	kV	50
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	744
	i) Minimum phase to earth clearance ^(Note 1)	mm	280 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (22kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box TV		
	a) Termination type		-
	b) No of cables		-
	c) Size of single core cables (design must be able to accommodate all options)		-
	d) Location of cable entry centres (mandatory requirements)		-
	e) Min. distance gland plate to centre of term. Palm		-

Ref no.	Item description	Unit	Requirement
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.7 66/11kV 35MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		66/11		
6.	Vector connection		Dyn1 or Dyn11		
7.	Rated voltage (Ur)				
	a) HV	kV	66		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	72.5		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 22/22 or 27/27		
	b) ODAN- HV/LV/TV	MVA	e.g. 27/27 or 35/35		
	c) ODAF - HV/LV/TV	MVA	e.g. 35/35		
10.	System fault levels (3 sec)				
	a) HV	kA	31.5		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	27.25
	b) HV - LV, maximum tap, minimum including tolerances	%	23.45
	c) HV - LV, principal tap, within the specified impedance envelope	%	24.72
	d) HV - LV, minimum tap, maximum value including tolerances	%	27.25
	e) HV - LV, minimum tap, minimum value including tolerances	%	23.45
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	75.9
	Nominal tap position (Tap 11) - HV voltage	kV	66
	Minimum tap position (Tap 21) - HV voltage	kV	56.1
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	72.93
	Nominal tap position (Tap 8) - HV voltage	kV	66
	Minimum tap position (Tap 22) - HV voltage	kV	52.14

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤81	≤71	≤63	≤63
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤63
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5 / 325 / 140			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 350
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Attached cooler bank
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	e) Rated voltage (phase to phase)		-
	f) Termination type		-
	g) No of conductors		-
	h) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥600
	c) Current rating of stem/rod	Amps	≥600
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	2248
	i) Minimum phase to phase clearance ^(Note 1)	mm	725 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	630 (live parts to earth)
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥2800
	c) Current rating of stem/rod	Amps	≥2800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance ^(Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	l) Rated voltage (phase to phase)	kV	-
	m) Continuous current rating	Amps	-
	n) Current rating of stem/rod	Amps	-
	o) Three (3) second current rating	kA	-
	p) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	q) Bushing type		-
	r) Colour		-
	s) Minimum creepage distance	mm	-
	t) Minimum phase to phase clearance	mm	-
	u) Minimum phase to earth clearance	mm	-
	v) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	k) Rated voltage (phase to phase)	kV	-
	l) Continuous current rating	Amps	-
	m) Current rating of stem/rod	Amps	-
	n) Three (3) second current rating	kA	-
	o) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	p) Bushing type		-
	q) Colour		-
	r) Minimum creepage distance	mm	-
	s) Minimum phase to earth clearance	mm	-
	t) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-

Ref no.	Item description	Unit	Requirement
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥2800
	c) Current rating of stem/rod	Amps	≥2800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
37.	Insulating medium		Paper and oil
38.	Pressure relief device (main tank)		Qualitrol or equivalent
39.	Separate freestanding control cubicle for the temperature indicators		Not essential
40.	Local oil and winding temperature indicators with remote signal		Required
41.	Remote oil temperature signal		Required
42.	Fibre-optic temperature sensors		Required

Ref no.	Item description	Unit	Requirement
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
43.	Top oil temperature indicator and associated micro switches		Required
44.	Condition monitoring equipment		Optional
45.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits.
46.	Delivery address		As nominated in the Works Section.
	Delivery date		
	c) Ex works		As nominated in the Works Section.
	d) On site completed with all tests		As nominated in the Works Section.
47.	Capitalised cost assessment		
	c) Ki = No load Loss	A\$/KW	\$12,800
	d) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.8 66/11kV 25MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		66/11		
6.	Vector connection		Dyn1 or Dyn11		
7.	Rated voltage (Ur)				
	a) HV	kV	66		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	72.5		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 15/15 or 19/19		
	b) ODAN- HV/LV/TV	MVA	e.g. 19/19 or 25/25		
	c) ODAF - HV/LV/TV	MVA	e.g. 25/25		
10.	System fault levels (3 sec)				
	a) HV	kA	31.5		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	19.47
	b) HV - LV, maximum tap, minimum including tolerances	%	16.75
	c) HV - LV, principal tap, within the specified impedance envelope	%	17.57
	d) HV - LV, minimum tap, maximum value including tolerances	%	19.47
	e) HV - LV, minimum tap, minimum value including tolerances	%	16.75
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	75.9
	Nominal tap position (Tap 11) - HV voltage	kV	66
	Minimum tap position (Tap 21) - HV voltage	kV	56.1
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	72.93
	Nominal tap position (Tap 8) - HV voltage	kV	66
	Minimum tap position (Tap 22) - HV voltage	kV	52.14

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤81	≤71	≤63	≤63
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤63
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5 / 325 / 140			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% UM/√3	pC	50			
25.	On-load tap changer- high speed resistor type					

Ref no.	Item description	Unit	Requirement
	a) Type		ABB UZ preferred
	b) Location		HV centre of winding
	c) Rated current	Amp	≥250
	d) Power supply	V (rms)	415/240 ± 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Attached cooler bank
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	i) Rated voltage (phase to phase)		-
	j) Termination type		-
	k) No of conductors		-

Ref no.	Item description	Unit	Requirement
	l) Location of termination centres (mandatory requirements)	mm	-
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥420
	c) Current rating of stem/rod	Amps	≥420
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	2248
	i) Minimum phase to phase clearance ^(Note 1)	mm	725 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	630 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥1200
	c) Current rating of stem/rod	Amps	≥1200
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance ^(Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Cantilever strength	N	2000
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance	mm	-
	j) Minimum phase to earth clearance	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-

Ref no.	Item description	Unit	Requirement
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥2000
	c) Current rating of stem/rod	Amps	≥2000
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
37.	Insulating medium		Paper and oil
38.	Pressure relief device (main tank)		Qualitrol or equivalent
39.	Separate freestanding control cubicle for the temperature indicators		Not essential
40.	Local oil and winding temperature indicators with remote signal		Required

Ref no.	Item description	Unit	Requirement
41.	Remote oil temperature signal		Required
42.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥ 3
	• LV winding (a, b, c phases)		≥ 3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥ 1
43.	Top oil temperature indicator and associated micro switches		Required
44.	Condition monitoring equipment		Optional
45.	Maximum overall height	mm	≤ 6100 preferred
	Max. transport height		To permit transport without special permits.
46.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
47.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.9 66/11kV 15MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		66/11		
6.	Vector connection		Dyn1 or Dyn11		
7.	Rated voltage (Ur)				
	a) HV	kV	66		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	72.5		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 10/10 or 15/15		
	b) ODAN- HV/LV/TV	MVA	e.g. 12.5/12.5 or 15/15		
	c) ODAF - HV/LV/TV	MVA	e.g. 15/15		
10.	System fault levels (3 sec)				
	a) HV	kA	31.5		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	11.68
	b) HV - LV, maximum tap, minimum including tolerances	%	10.05
	c) HV - LV, principal tap, within the specified impedance envelope	%	10.59
	d) HV - LV, minimum tap, maximum value including tolerances	%	11.68
	e) HV - LV, minimum tap, minimum value including tolerances	%	10.05
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	75.9
	Nominal tap position (Tap 11) - HV voltage	kV	66
	Minimum tap position (Tap 21) - HV voltage	kV	56.1
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	72.93
	Nominal tap position (Tap 8) - HV voltage	kV	66
	Minimum tap position (Tap 22) - HV voltage	kV	52.14

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤81	≤71	≤63	≤63
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤63
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	72.5 / 325 / 140			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 150
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Attached cooler bank
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required`		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Termination type		Bushing
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		-
	b) Termination type		-
	c) No of conductors		-
	d) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	72.5
	b) Continuous current rating	Amps	≥300
	c) Current rating of stem/rod	Amps	≥300
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	325
	• Power frequency	kV	140
	f) Bushing type		Resin impregnated paper, Resin impregnated synthetic, insulated capacitor porcelain or silicone.
	g) Colour		Light grey
	h) Minimum creepage distance	mm	2248
	i) Minimum phase to phase clearance ^(Note 1)	mm	725 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	630 (live parts to earth)
	k) Cantilever		
	l) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥1200
	c) Current rating of stem/rod	Amps	≥1200
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance ^(Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)

Ref no.	Item description	Unit	Requirement
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance	mm	-
	j) Minimum phase to earth clearance	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-

Ref no.	Item description	Unit	Requirement
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥1200
	c) Current rating of stem/rod	Amps	≥1200
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 630 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC
37.	Insulating medium		Paper and oil
38.	Pressure relief device (main tank)		Qualitrol or equivalent
39.	Separate freestanding control cubicle for the temperature indicators		Not essential
40.	Local oil and winding temperature indicators with remote signal		Required
41.	Remote oil temperature signal		Required
42.	Fibre-optic temperature sensors		Required

Ref no.	Item description	Unit	Requirement
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
43.	Top oil temperature indicator and associated micro switches		Required
44.	Condition monitoring equipment		Optional
45.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits.
46.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
47.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.10 33/11kV 35MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		33/11		
6.	Vector connection		Dyn1 or Dyn11		
7.	Rated voltage (Ur)				
	a) HV	kV	33		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	36		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 22/22 or 27/27		
	b) ODAN- HV/LV/TV	MVA	e.g. 27/27 or 35/35		
	c) ODAF - HV/LV/TV	MVA	e.g. 35/35		
10.	System fault levels (3 sec)				
	a) HV	kA	31.5		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	27.25
	b) HV - LV, maximum tap, minimum including tolerances	%	23.45
	c) HV - LV, principal tap, within the specified impedance envelope	%	24.72
	d) HV - LV, minimum tap, maximum value including tolerances	%	27.25
	e) HV - LV, minimum tap, minimum value including tolerances	%	23.45
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	37.95
	Nominal tap position (Tap 11) - HV voltage	kV	33
	Minimum tap position (Tap 21) - HV voltage	kV	28.05
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	36.465
	Nominal tap position (Tap 8) - HV voltage	kV	33
	Minimum tap position (Tap 22) - HV voltage	kV	26.07

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤81	≤71	≤63	≤63
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤63
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 675
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Attached cooler bank
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	36
	b) Termination type		Bushing / air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		-
	b) Termination type		-
	c) No of conductors		-
	d) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	36
	b) Continuous current rating	Amps	≥ 1170
	c) Current rating of stem/rod	Amps	≥ 1170
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1116
	i) Minimum phase to phase clearance ^(Note 1)	mm	370 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	320 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥ 2800
	c) Current rating of stem/rod	Amps	≥ 2800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance ^(Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled

Ref no.	Item description	Unit	Requirement
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance	mm	-
	j) Minimum phase to earth clearance	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12

Ref no.	Item description	Unit	Requirement
	b) Continuous current rating	Amps	≥2800
	c) Current rating of stem/rod	Amps	≥2800
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box HV (33kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 800 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC

Ref no.	Item description	Unit	Requirement
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits.
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.11 33/11kV 25MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		33/11		
6.	Vector connection		Dyn1 or Dyn11		
7.	Rated voltage (Ur)				
	a) HV	kV	33		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	36		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 15/15 or 19/19		
	b) ODAN- HV/LV/TV	MVA	e.g. 19/19 or 25/25		
	c) ODAF - HV/LV/TV	MVA	e.g. 25/25		
10.	System fault levels (3 sec)				
	a) HV	kA	31.5		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	19.47
	b) HV - LV, maximum tap, minimum including tolerances	%	16.75
	c) HV - LV, principal tap, within the specified impedance envelope	%	17.57
	d) HV - LV, minimum tap, maximum value including tolerances	%	19.47
	e) HV - LV, minimum tap, minimum value including tolerances	%	16.75
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	37.95
	Nominal tap position (Tap 11) - HV voltage	kV	33
	Minimum tap position (Tap 21) - HV voltage	kV	28.05
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	36.465
	Nominal tap position (Tap 8) - HV voltage	kV	33
	Minimum tap position (Tap 22) - HV voltage	kV	26.07

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤81	≤71	≤63	≤63
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤63
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 500
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Attached cooler bank
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	36
	b) Termination type		Bushing / air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		-
	b) Termination type		-
	c) No of conductors		-
	d) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	36
	b) Continuous current rating	Amps	≥840
	c) Current rating of stem/rod	Amps	≥840
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1116
	i) Minimum phase to phase clearance ^(Note 1)	mm	370 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	320 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥2000
	c) Current rating of stem/rod	Amps	≥2000
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance ^(Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled

Ref no.	Item description	Unit	Requirement
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance	mm	-
	j) Minimum phase to earth clearance	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12

Ref no.	Item description	Unit	Requirement
	b) Continuous current rating	Amps	≥2000
	c) Current rating of stem/rod	Amps	≥2000
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box HV (33kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 800 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC

Ref no.	Item description	Unit	Requirement
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits.
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.1.12 33/11kV 15MVA transformer

Ref no.	Item description	Unit	Requirement		
1.	Standard		AS 60076		
2.	Type		Outdoor mineral oil immersed		
3.	No of phases		3		
4.	Rated frequency	Hz	50		
5.	Rated voltage ratio		33/11		
6.	Vector connection		Dyn1 or Dyn11		
7.	Rated voltage (Ur)				
	a) HV	kV	33		
	b) LV	kV	11		
	c) TV	kV	-		
8.	System highest voltage (Um)				
	a) HV	kV	36		
	b) LV	kV	12		
	c) TV	kV	-		
9.	Rated power (for each cooling mode)				
	a) ONAN - HV/LV/TV	MVA	e.g. 10/10 or 15/15		
	b) ODAN- HV/LV/TV	MVA	e.g. 12.5/12.5 or 15/15		
	c) ODAF - HV/LV/TV	MVA	e.g. 15/15		
10.	System fault levels (3 sec)				
	a) HV	kA	31.5		
	b) LV	kA	20		
	c) TV	kA			
11.	Maximum temperature rises limitations for continuous loadings		ONAN	ODAN	ODAF
	Top oil by thermometer	deg. C	52	49	49
	Windings by resistance	deg. C	63	68	68
	Winding hot spot by fibre optic	deg. C	78	78	78
	Localised heating of any metal part in contact with insulation or gasket	deg. C	70		
	Localised heating of any metal part in contact with oil only	deg. C	80		

Ref no.	Item description	Unit	Requirement
	Core hot spot temperature rise at over excitation as in clause 5.2.6	deg. C	75
12.	Impedance @ full rating, 75 deg. C ref temp (refer to Figure 1 for allowable tolerance envelope)		
	a) HV - LV, maximum tap, maximum value including tolerances	%	11.68
	b) HV - LV, maximum tap, minimum including tolerances	%	10.05
	c) HV - LV, principal tap, within the specified impedance envelope	%	10.59
	d) HV - LV, minimum tap, maximum value including tolerances	%	11.68
	e) HV - LV, minimum tap, minimum value including tolerances	%	10.05
	f) HV – TV, principal tap	%	-
	g) LV - TV	%	-
13.	Impedance variation over the range		Suitable for parallel operation
14.	Category of voltage variation		CFVV
15.	Type of tap-changing		On-load and bolt-on
16.	On-load tapping range – Option 1		
	Winding		HV
	Range and step voltage		+10 x 1.5%, -10 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	37.95
	Nominal tap position (Tap 11) - HV voltage	kV	33
	Minimum tap position (Tap 21) - HV voltage	kV	28.05
17.	On-load tapping range – Option 2		
	Winding		HV
	Range and step voltage		+7 x 1.5%, -14 x 1.5%
	Tapping power		Full rating on all tap positions
	Maximum tap position (Tap 1) - HV voltage	kV	36.465
	Nominal tap position (Tap 8) - HV voltage	kV	33
	Minimum tap position (Tap 22) - HV voltage	kV	26.07

Ref no.	Item description	Unit	Requirement			
18.	System earthing					
	HV neutral		-			
	LV neutral		Suitable for effectively and non-effectively earthed			
	TV		-			
19.	Sound power level (max acceptable - refer transformer cost assessment clause):		Opt S	Opt 1	Opt 2	Opt 3
	Sound power limitation @ 100% Ur no-load with cooling for maximum rating	dBA	≤80	≤70	≤62	≤62
	Sound power limitation @ 105% Ur no-load with cooling for maximum rating	dBA	≤81	≤71	≤63	≤63
	Sound power limitation @100% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤62
	Sound power limitation @105% Ur no-load and 2/3 rated load with cooling configuration for 2/3 rated load	dBA	-	-	-	≤63
20.	Radio interference voltage levels		Comply with AS2344-2016			
21.	Insulation level					
	• HV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	36 / 200 / 70			
	• LV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
	• TV - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• HVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	-			
	• LVN - system highest voltage (UM) / LI / Ud	kV/kVp/kV	12 / 95 / 28			
22.	Over-excitation	%Ur	Refer section 5.2.6			
23.	Maximum flux density					
	• 100 % Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 110% Ur @ no load	Tesla	1.7 Refer section 5.2.6			
	• 105% LV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
	• 130% HV Ur @ full rating and load power factor of 0.86	Tesla	Without saturation of the core Refer section 5.2.6			
24.	Maximum internal partial discharge @ 120% Um/√3	pC	50			
25.	On-load tap changer- high speed resistor type					
	a) Type		ABB UZ preferred			

Ref no.	Item description	Unit	Requirement
	b) Location		HV centre of winding
	c) Rated current	Amp	≥ 300
	d) Power supply	V (rms)	415/240 $\pm$ 10%
	e) Control supply	V (dc)	96 – 125
26.	Cooling		
	a) Radiator mounting		Attached cooler bank
	b) Cooler location		Refer to typical transformer GA drawing listed in section 5.9
	c) Conservator type (main tank)		Refer section 5.4.7
	d) Stand-by pump required		No
	e) Stand-by fan required		Yes
	f) Stand-by radiator required		Yes
27.	Primary line terminations		
	a) Rated voltage (phase to phase)	kV	36
	b) Termination type		Bushing / air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
28.	Secondary line terminations		
	a) Rated voltage (phase to phase)	kV	12
	b) Termination type		Air insulated cable box
	c) No of conductors		Refer to typical transformer GA drawing listed in section 5.9
	d) Location of termination centres (mandatory requirements)	mm	Refer to typical transformer GA drawing listed in section 5.9
29.	Tertiary line terminations		
	a) Rated voltage (phase to phase)		-
	b) Termination type		-
	c) No of conductors		-
	d) Location of termination centres (mandatory requirements)	mm	-

Ref no.	Item description	Unit	Requirement
30.	Bushings HV		
	a) Rated voltage (phase to phase)	kV	36
	b) Continuous current rating	Amps	≥500
	c) Current rating of stem/rod	Amps	≥500
	d) Three (3) second current rating	kA	31.5
	e) Insulation levels:		
	• Impulse	kVp	200
	• Power frequency	kV	70
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	1116
	i) Minimum phase to phase clearance ^(Note 1)	mm	370 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	320 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
31.	Bushings LV		
	a) Rated voltage (phase to phase)	kV	12
	b) Continuous current rating	Amps	≥1200
	c) Current rating of stem/rod	Amps	≥1200
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to phase clearance ^(Note 1)	mm	185 (between live parts)
	j) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled

Ref no.	Item description	Unit	Requirement
32.	Bushings TV		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to phase clearance	mm	-
	j) Minimum phase to earth clearance	mm	-
	k) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
33.	Bushings HV-N		
	a) Rated voltage (phase to phase)	kV	-
	b) Continuous current rating	Amps	-
	c) Current rating of stem/rod	Amps	-
	d) Three (3) second current rating	kA	-
	e) Insulation levels:		
	• Impulse	kVp	-
	• Power frequency	kV	-
	f) Bushing type		-
	g) Colour		-
	h) Minimum creepage distance	mm	-
	i) Minimum phase to earth clearance	mm	-
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		-
34.	Bushings LV-N		
	a) Rated voltage (phase to phase)	kV	12

Ref no.	Item description	Unit	Requirement
	b) Continuous current rating	Amps	≥1200
	c) Current rating of stem/rod	Amps	≥1200
	d) Three (3) second current rating	kA	20
	e) Insulation levels:		
	• Impulse	kVp	95
	• Power frequency	kV	28
	f) Bushing type		Oil filled porcelain / ceramic / cast or moulded resin
	g) Colour		Light grey
	h) Minimum creepage distance	mm	372
	i) Minimum phase to earth clearance ^(Note 1)	mm	160 (live parts to earth)
	j) Terminal palm to AS62271.301-2022, Table 1, Figure 1		No 8 copper, undrilled
35.	Cable box HV (33kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 800 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
36.	Cable box LV (11kV)		
	a) Termination type		Air insulated
	b) No of cables		Refer to typical transformer GA drawing listed in section 5.9
	c) Size of single core cables (design must be able to accommodate all options)		Suitable for copper XLPE up to 1200 mm ²
	d) Location of cable entry centres (mandatory requirements)		Refer to typical transformer GA drawing listed in section 5.9
	e) Min. distance gland plate to centre of term. Palm	mm	700
37.	Alarm and trip contact making, carrying and breaking capacity		1A in typically inductive (magnet coil) circuit at 250V AC or 120V DC

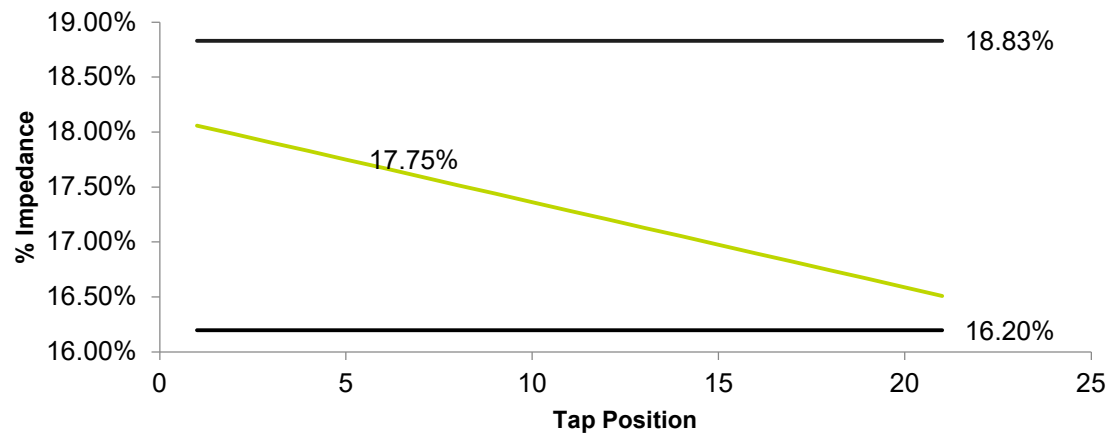
Ref no.	Item description	Unit	Requirement
38.	Insulating medium		Paper and oil
39.	Pressure relief device (main tank)		Qualitrol or equivalent
40.	Separate freestanding control cubicle for the temperature indicators		Not essential
41.	Local oil and winding temperature indicators with remote signal		Required
42.	Remote oil temperature signal		Required
43.	Fibre-optic temperature sensors		Required
	• HV winding (A, B, C phases)		≥3
	• LV winding (a, b, c phases)		≥3
	• TV winding (b phases only)		-
	• RV winding (b phases only)		≥1
44.	Top oil temperature indicator and associated micro switches		Required
45.	Condition monitoring equipment		Optional
46.	Maximum overall height	mm	≤6100 preferred
	Max. transport height		To permit transport without special permits.
47.	Delivery address		As nominated in the Works Section.
	Delivery date		
	a) Ex works		As nominated in the Works Section.
	b) On site completed with all tests		As nominated in the Works Section.
48.	Capitalised cost assessment		
	a) Ki = No load Loss	A\$/KW	\$12,800
	b) Kc = Load loss on principal tap at CMR	A\$/KW	\$2,050

Note: Refer to the requirements outlined in air insulated cable box section and refer to GA drawing listed in section 5.9.

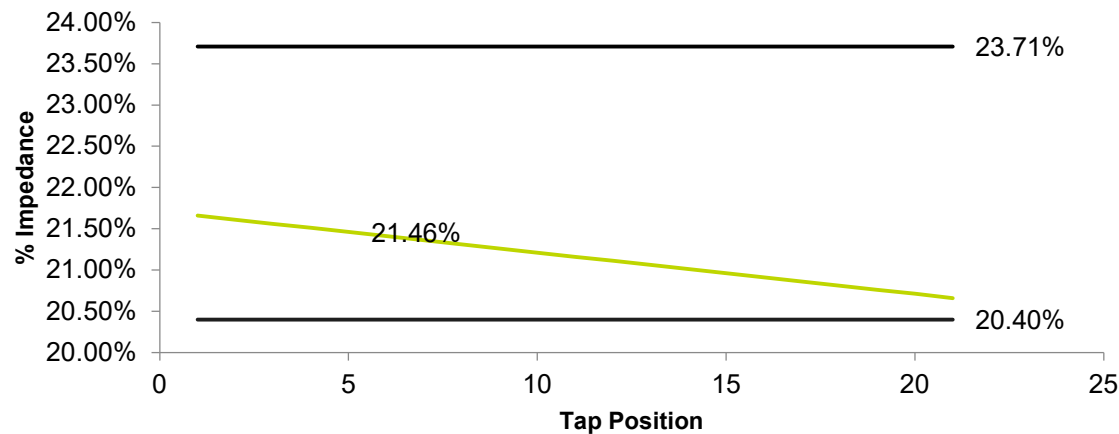
Note 1: Table 3.1 AS 2067:2016 Substations and high voltage installations exceeding 1 kV ac

Annexure 1.2 Graphical representation of required impedance

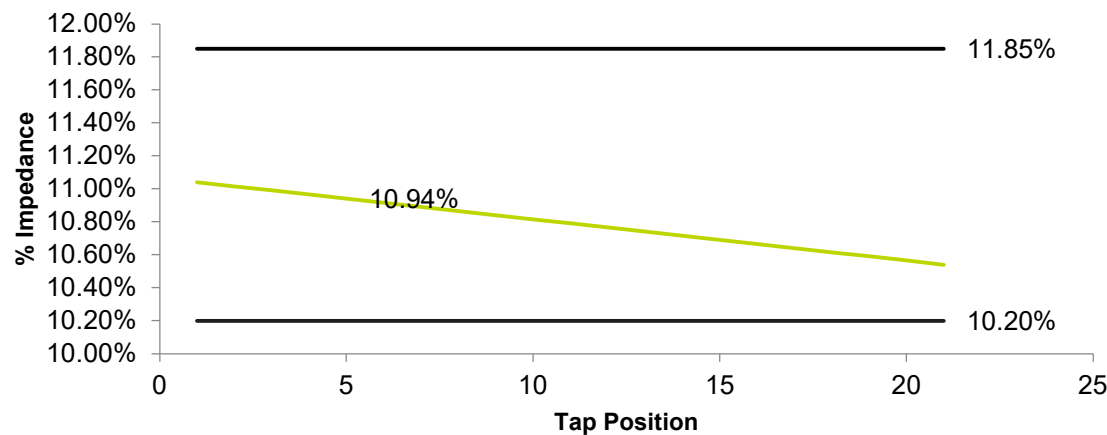
132/33/11kV 60MVA transformer



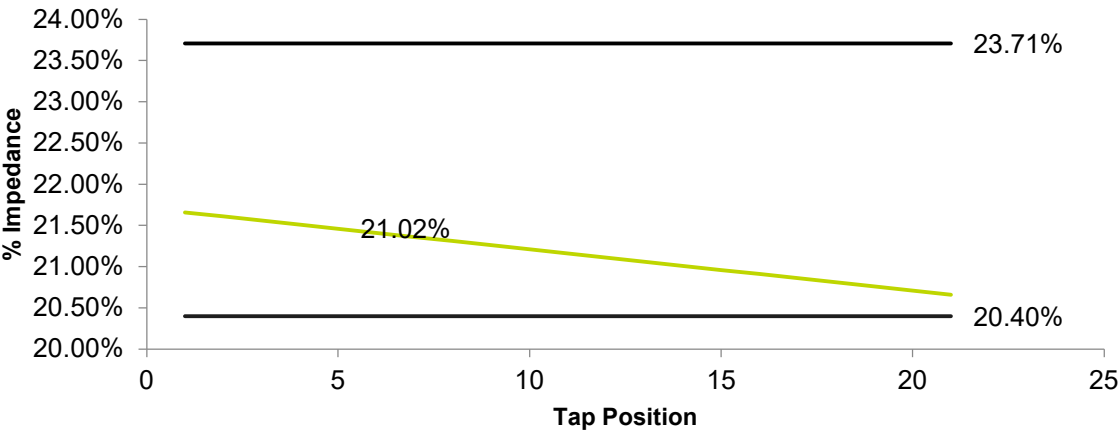
132/33/11kV 120MVA transformer



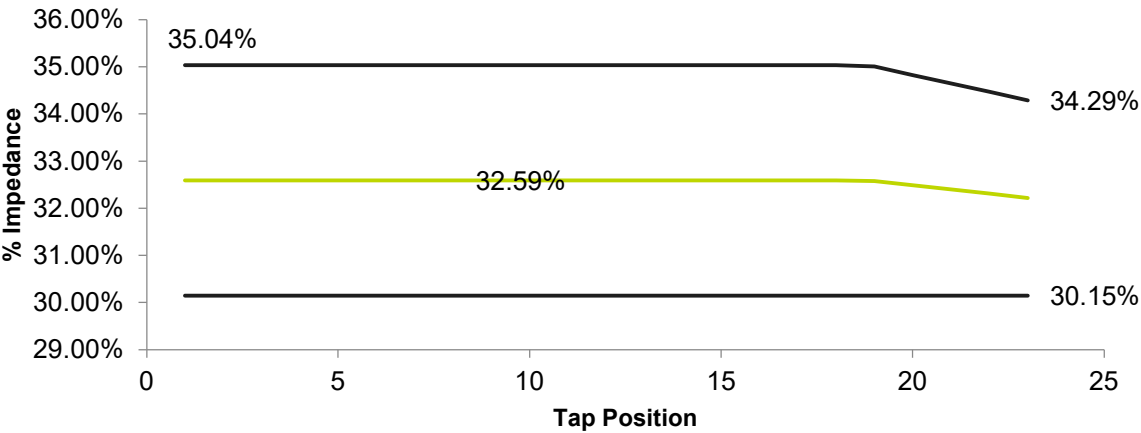
132/66/11kV 60MVA transformer



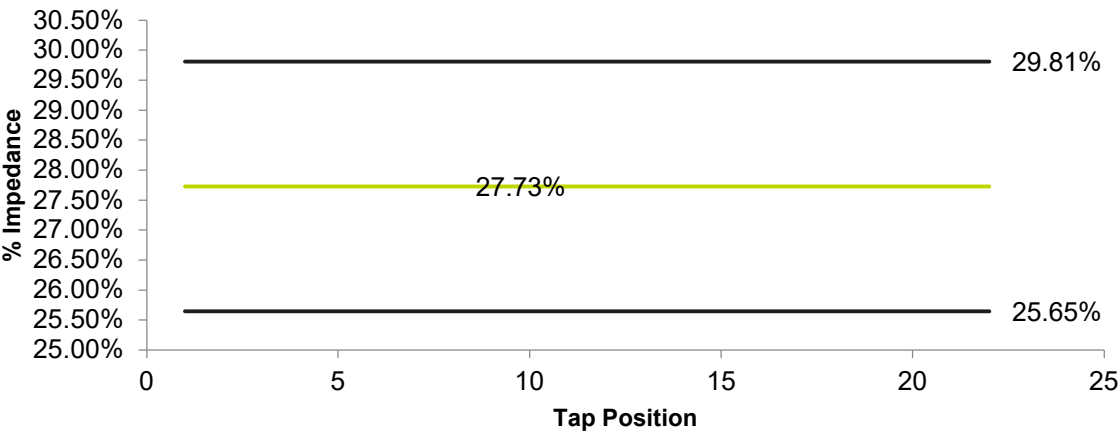
132/66/11kV 120MVA transformer



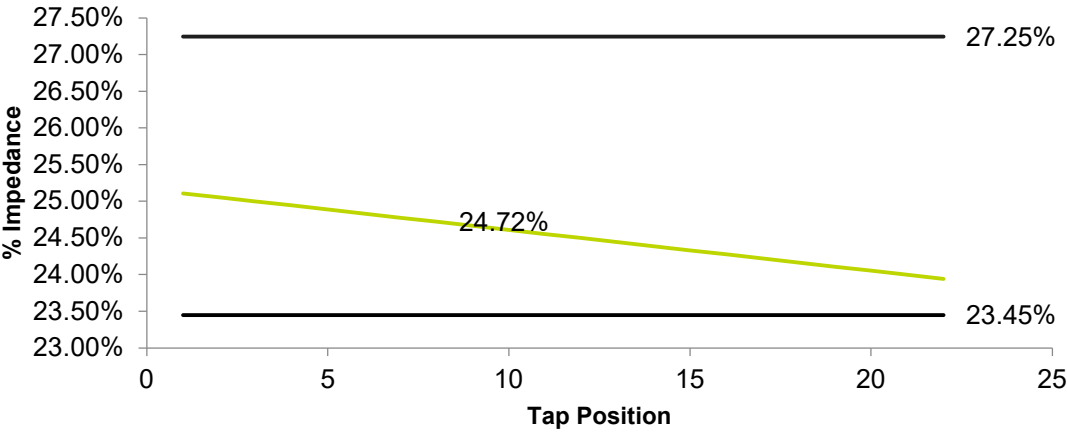
132/11kV 45MVA transformer



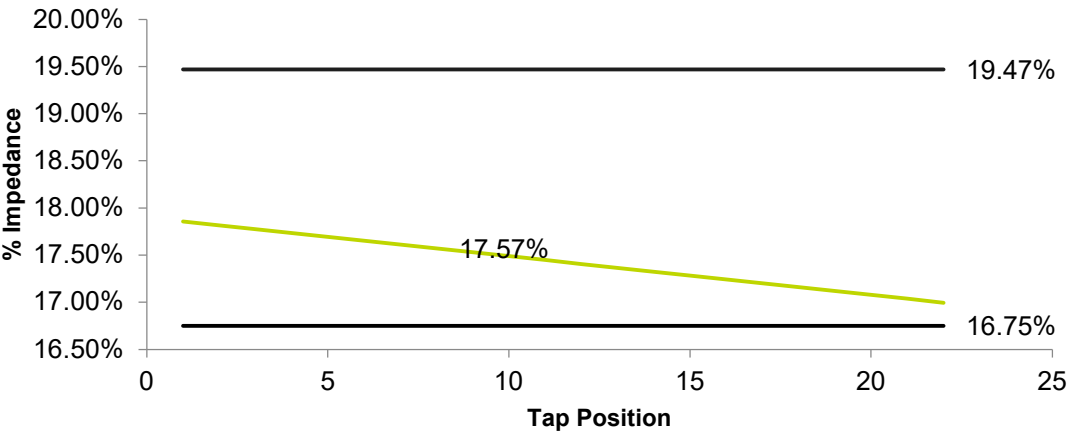
132/22kV 45MVA transformer



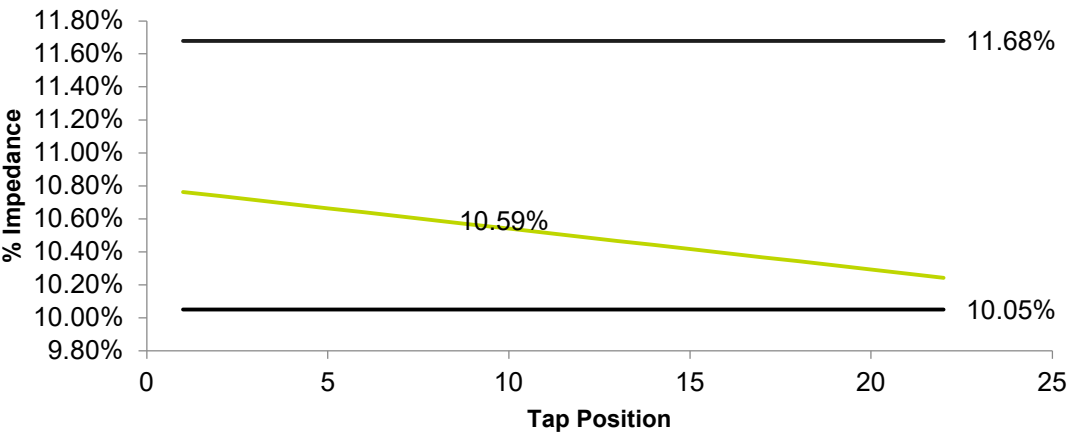
66/11kV 35MVA transformer



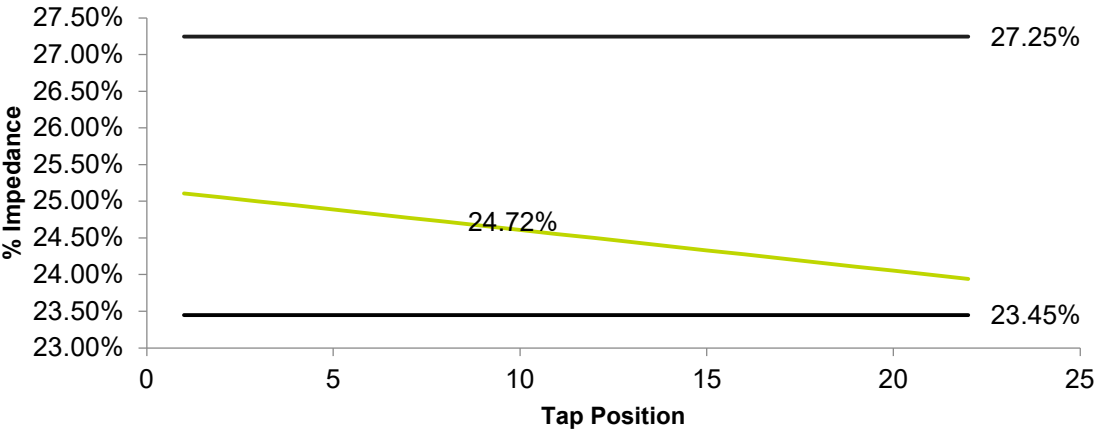
66/11kV 25MVA transformer



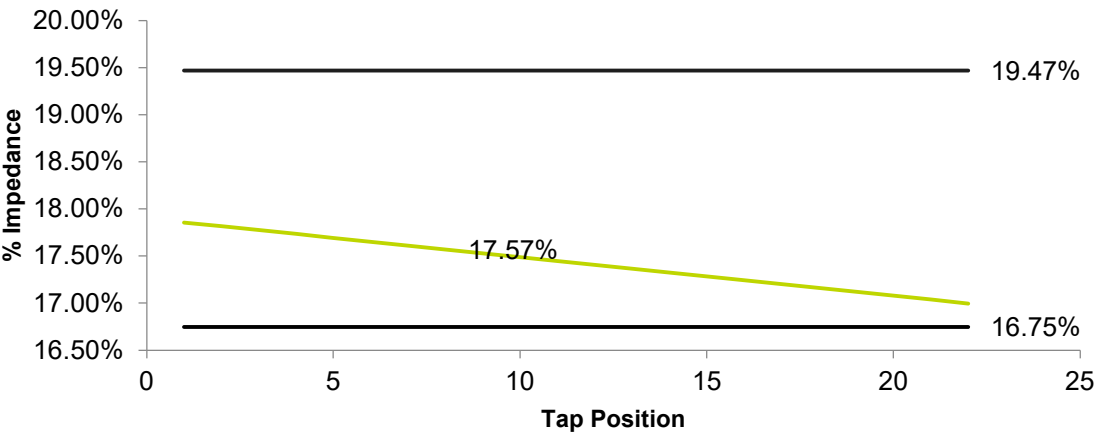
66/11kV 15MVA transformer



33/11kV 35MVA transformer



33/11kV 25MVA transformer



33/11kV 15MVA transformer

