

Equipment Technical Specification

11/22kV padmount autotransformer

IMPORTANT DISCLAIMER

As the information contained in this publication is subject to change from time to time, Endeavour Energy gives no warranty that the information is correct or complete or is a definitive statement of procedures. Endeavour Energy reserves the right to vary the content of this publication as and when required. You should make independent inquiries to satisfy yourself as to correctness and currency of the content. Endeavour Energy expressly disclaims all and any liability to any persons whatsoever in respect of anything done or not done by any such person in reliance, whether in whole or in part, on this document.

EQUIPMENT TECHNICAL SPECIFICATION

ASSET STANDARDS & DESIGN	Document no.	ETS 0073
	Amendment no.	1
	Approved by	GMAM
	Approval date	08/08/2016
	Review date	08/08/2021

ETS 0073 11/22kV padmount autotransformer

Contents

1.0	PURPOSE	4
2.0	SCOPE.....	4
3.0	REFERENCES	4
4.0	DEFINITIONS AND ABBREVIATIONS.....	5
5.0	ACTIONS	6
5.1	General requirements.....	6
5.1.1	<i>Service conditions</i>	<i>7</i>
5.1.2	<i>Transformer environment.....</i>	<i>7</i>
5.2	Health, safety and environment (HSE) requirements	8
5.2.1	<i>Special environmental requirements - toxicology safety</i>	<i>8</i>
5.2.2	<i>Sound levels.....</i>	<i>8</i>
5.2.3	<i>Oil pollution.....</i>	<i>8</i>
5.2.4	<i>Noise levels and radio interference voltage (RIV)</i>	<i>8</i>
5.2.5	<i>Fire and blast hazards.....</i>	<i>8</i>
5.3	Technical requirements	9
5.4	Transformer fittings.....	10
5.4.1	<i>Rating plate details.....</i>	<i>10</i>
5.4.2	<i>Transformer terminals</i>	<i>10</i>
5.4.3	<i>Transformer tap changer.....</i>	<i>10</i>
5.4.4	<i>Core and coils</i>	<i>11</i>
5.4.5	<i>Transformer oil</i>	<i>11</i>
5.4.6	<i>Oil level indicator</i>	<i>11</i>
5.4.7	<i>Oil drain valve and thermometer pocket</i>	<i>11</i>
5.4.8	<i>Oil filler cap.....</i>	<i>11</i>
5.4.9	<i>Transformer lifting points.....</i>	<i>11</i>
5.4.10	<i>Transformer end flanges</i>	<i>12</i>
5.5	Loss capitalisation	12
5.6	Transformer loss performance acceptance.....	12
5.7	Current transformers.....	12
5.8	Surface finish	13
5.9	Drying out and oil filling before delivery	13
5.10	Testing	13
5.10.1	<i>General.....</i>	<i>13</i>

5.10.2	Type tests.....	15
5.10.3	Routine tests	16
5.10.4	Submission of test result	17
5.11	Maintenance requirements	18
5.11.1	Spare parts and maintenance.....	18
5.11.2	Failure mode analysis and preventative maintenance	18
5.12	Quality assurance	18
5.12.1	Quality assurance plan.....	18
5.12.2	Quality Inspection and Test Plan (QITP)	19
5.13	Product approval	19
5.13.1	Product approval and audit forms	19
5.13.2	Product approval process	19
5.14	Drawings.....	19
6.0	AUTHORITIES AND RESPONSIBILITIES	19
7.0	DOCUMENT CONTROL	20
Annexure 1 – Transformer routine test report.....		21

1.0 PURPOSE

To set out in detail the minimum technical requirements for 11/22kV padmount autotransformers for use on Endeavour Energy's distribution network.

2.0 SCOPE

This Specification covers the design, engineering, manufacture, testing, supply and delivery of 11/22kV padmount type autotransformers. The scope is for autotransformers with a rating of 3000kVA. It is not the intention to specify all design and constructional details of the autotransformers. However, the equipment supplied must meet the highest standards of design, engineering and manufacturing practices.

All supplied transformers and associated equipment must be manufactured and tested to the standards with the year of publication listed in 3.0 below. 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 will take precedence.

The tenderer shall 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 Network Substations Manager for approval prior to acceptance.

3.0 REFERENCES

Internal

- Company Policy 9.2.2 – Network Protection
- Company Policy 9.2.5 – Network Asset Design
- Company Policy 9.7.1 – Network Construction
- Company Policy 9.8.3 – Network Operations
- Company Policy 9.9.1 – Network Asset Maintenance
- Company Procedure GRM 0003 – Risk Management
- Company Procedure GSY 0026 – Work Health and Safety Risk Assessment
- Company Form FSY 0138 – Risk Register
- Network Management Plan December 2013 Review
- Branch Procedure PAE 1004 – Product Approval Process
- Branch Form FAE 3069 – 11/22kV padmount autotransformer: Product approval and audit form
- Environmental Management Standards EMS 0001 – Environmental impact assessment and environmental management plans
- Earthing Design Instruction EDI 100 – Distribution earthing design, construction and test
- Engineering Technical Specification ETS 0010 – Mineral Insulating oil
- Engineering Technical specification ETS 0032 – Natural ester insulating oil
- Mains Construction Instruction MCI 0006 – Underground distribution construction standards manual

External

- *Electricity Supply Act 1995* (as amended)
- *Work Health and Safety Act 2011 (NSW)*
- ENA Doc 001-2008 National Electricity Network Safety Code
- Service and Installation Rules of NSW Amendment 2: January 2009
- AS 1111:2002 - ISO Metric hexagon bolts and screws
- AS 1112:2000 - ISO Metric hexagon nuts

- AS 1194:1996 - Winding Wires Parts 1 - 4
- AS 1214:1983 - Hot dipped galvanised coatings on threaded fasteners (ISO metric coarse thread series)
- AS 1580:2004 - Paints and related materials - Methods for test
- AS 1627:1997 - Metal finishing - Preparation and Pre-treatment of Surfaces
- AS 1767:1999 - Insulating liquids Part 1: Specification for unused mineral insulating oils for transformers and switchgear
- AS 2067:2008 - Substations and high voltage installations exceeding 1kV a.c.
- AS 2374.1.2:2003 - Power transformers Part 1.2: Minimum Energy Performance Standard (MEPS) requirements for distribution transformers
- AS 2374.8:2000 - Power transformers Part 8: Application guide
- AS 2629:2008 - Separable insulated connectors for power distribution systems above 1kV
- AS 2700S:2011 (N42) - Colour Standards for general purposes – Storm Grey
- AS 2700S: 2011 (G62) - Colour Standards for general purposes – Rivergum
- AS/NZS 2312:2014 - Guide to protection of iron and steel against exterior atmospheric corrosion
- AS/NZS 2344:1997 – Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installations in the frequency range 0.15 to 1000MHz
- AS/NZS 3750.23:2008 - Paints for steel structures Part 23: Semi-gloss enamel-Solvent borne
- AS/NZS 4680:2006 - Hot Dipped Galvanised (zinc) Coatings on fabricated ferrous articles
- AS/NZS 60044.1:2007 - Instrument transformers – Current transformers
- AS/NZS 60076.1:2014 - Power transformers: General
- AS/NZS 60076.2:2013 – Power transformers – Temperature rise for liquid immersed transformers
- AS/NZS 60076.3:2008 - Power transformers Part 3: Insulation levels, dielectric tests and external clearances in air
- AS 60076.4:2006 - Power transformers - Guide to the lightning impulse and switching impulse testing: Power transformers and reactors
- AS/NZS 60076.5:2012 - Power transformers – Ability to withstand short circuit
- AS/NZS 60076.7:2013 - Power transformers – Loading guide for oil immersed power transformers
- AS/NZS 60076.10:2009 - Power transformers Part 10: Determination of sound levels
- AS/NZS 60076.10.1:2009 - Power transformers Part 10.1: Determination of sound levels - Application guide
- AS/NZS 60137:2008 - Insulated bushings for alternating voltages above 1000V
- AS/NZS ISO 9000:2016 - Quality management systems - Fundamentals and vocabulary
- AS/NZS ISO 9001:2016 – Quality management systems - Requirements
- IEC 62770:2013 – Fluids for electrotechnical applications – Unused natural esters for transformers and similar electrical equipment

4.0 DEFINITIONS AND ABBREVIATIONS

CT current transformer

**Indoor
substation**

An electrical substation housed in a building designed in accordance with the Building Regulations of NSW. They are generally of brick and concrete construction with gutters and drainage, or a room that is part of a larger building.

MSDS	Material Safety Data Sheet
NATA	National Association of Testing Authorities
Padmount substation	An electrical substation housed in an outdoor enclosure that is designed to prevent the ingress of moisture from rain and storms but is subject to water rise at ground level, and high levels of humidity. The enclosure can be made from fibreglass, stainless steel or aluminium
PCB	polychlorinated biphenyls
Plinth	concrete or steel base which the transformer will be on when in service
ppm	parts per million
Shall	Indicates a statement is mandatory
UV	ultra violet

Type tests – Tests carried out on a specific type of a transformer before supply on a commercial basis to Endeavour Energy demonstrating that the design, equipment and material used and the manufacturing process will deliver the intended transformer. It will be reasonably assumed that the test outcomes reflect the transformer type rather than the unit.

Once successfully completed, these tests need not be repeated unless changes are made to the manufacturing material, design or the manufacturing process which may change the performance characteristics or Endeavour Energy requests additional test/s. Endeavour Energy **must** specify the required type tests and the acceptable limits for each test.

Routine tests – Tests made to ascertain the quality of the transformer which in turn is a measure of the control of the quality of the manufacturing process of the transformer. These tests need to be carried out for each transformer.

The outcomes of these tests, together with the outcomes of type tests, will reasonably **determine** the safe application of the transformer in the system.

Special tests – Any other relevant test prescribed to ascertain the quality of the transformer that does not fall into the above categories of tests

5.0 ACTIONS

5.1 General requirements

The transformer could be mounted on a pole, in a padmount or in an indoor substation.

When installed in a padmount the unit will be mounted in an outdoor fibreglass or sheet steel enclosure. The transformer shall be designed to fit into Endeavour Energy's Size 16 enclosure, however other designs will be considered.

Note: Endeavour Energy's standard size 16 enclosure is for a conventional padmount substation. One end of the enclosure houses HV switchgear (11kV or 22kV) and the other end houses LV switchgear (415V). This design shall be modified to house HV switchgear (11kV or 22kV) in both ends. The physical arrangement of both 11kV and 22kV ends of padmount autotransformers substation shall be the same. Design of the substation plinth shall also be modified accordingly.

When used in a pole mounted situation the transformer will typically be mounted on a platform between two (2) poles.

The general arrangement of the transformers shall comply with Endeavour Energy drawings as listed in section 5.14 of this Specification. The transformers for outdoor,

indoor or padmounts shall be the same and interchangeable.

MCI 0006 sets out in detail the on site and constructional requirements for padmounts and indoor substations in respect to, installation, easement and accommodation.

On-site earthing requirements are covered in EDI 100.

The transformer insulation at both 12kV and 24kV shall be designed for a non-effectively earthed network.

5.1.1 Service conditions

The transformers shall be suitable for use on Endeavour Energy's 11kV or 22kV, 3-phase, 50Hz system.

Service conditions shall be in accordance with the requirements of clause 4 of AS/NZS 60076.1. The padmount transformers shall be designed for use in outdoor, all-weather conditions and to operate in service conditions given in the table below:

Service condition	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- maximum	1.1 kW/m ²
Average index of mean relative humidity: 9:00am	95%
Seismic acceleration coefficient (maximum)	0.09
Pollution level	Level IV in accordance with AS4436:1996
Wind speed	34m/s

5.1.2 Transformer environment

All ferrous parts shall be treated to provide acceptable surface finish and protection. The manufacturer shall provide full details of the surface finishing provided. Where required, equipment may need to be raised or have extra treatment to minimise corrosion on all metal components, particularly those in contact with the plinth.

Transformers containing mineral oil shall be of sealed tank type construction.

Transformers with bio degradable oil or natural esters, such as Envirotemp FR3 fluid, shall be sealed with a suitable gas, such as nitrogen, to fill the void.

The lid of the transformer must not be welded to the tank: instead, it must be affixed with nuts and bolts.

The core shall be bonded to the tank at one point. The facility to disconnect the bond (for testing purposes) via a readily accessible bolt shall also be provided.

A suitable oil level indicator must be provided on all transformers, to confirm that the oil level can be checked with the transformer in its service position. The gauge shall not discolour due to exposure to sunlight or due to reaction with the insulation oil.

Where possible all penetrations of the tank must be above the oil level in the transformer.

All component parts shall be supplied and tested in accordance with the appropriate Australian Standard. The transformer shall include everything necessary or usually supplied for the operation, whether directly specified or not.

The insulation level shall be in accordance with the technical requirements stated and all components, including insulation, shall be fit for purpose for the life expectancy of the transformer, that is, 45 years, without maintenance.

All equipment **must** be enclosed to the extent that there is no safety hazard to operating personnel when the cubicle door is removed. The equipment shall be fully shrouded to prevent accidental short circuits by human error, flying objects, rodents or similar.

The manufacturer **must** provide details of the recommended maintenance procedures for the equipment.

5.2 Health, safety and environment (HSE) requirements

5.2.1 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 offer or supplied equipment regardless of content.

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.

Material safety data sheets (MSDS) must be provided for materials that are supplied and subject to safety considerations in handling and use.

All equipment, packaging and all other accessories provided shall be asbestos free.

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

5.2.2 Sound levels

Each transformer shall be designed and constructed so that its sound power level, measured in accordance with the AS 60076.10:2009, shall be no greater than the *reduced limit* as set out in clause 5.3 of this Specification.

Additionally, tenderers are required to offer an alternative price for sound power levels not exceeding 60dBA

5.2.3 Oil pollution

Joints between oil containing parts of the equipment shall be leak tight and shall be pressure tested. Gasket joints shall be designed to avoid deterioration due to oil or excess strain.

5.2.4 Noise levels and radio interference voltage (RIV)

The padmount substation transformer may be installed in a residential area in close proximity to residences. Therefore, it is necessary to **determine** the noise level complies with this specification and the radio interference is 17µV/m for 11kV and 22µV/m for 22kV, as specified in AS/NZS 2344:1997.

5.2.5 Fire and blast hazards

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

5.3 Technical requirements

Description		
Applicable Standards		AS 60076 and AS 2374 (refer to section 3 of this Specification)
Transformer type		Auto
No. of phases		Three
Frequency		50 Hz
Type of cooling		ONAN or KNAN
Breathing		Sealed
Mineral Insulating fluid		Passivated-inhibited mineral oil in accordance with ETS 0010
Natural ester oil		Natural ester oil that complies to ETS 0032 and IEC 62770: 2013
Temperature rise limits		(O class liquid) (K class natural ester) Winding 65°C Winding 75°C Top oil 60°C Top oil 90°C
Outdoor		Outdoor or outdoor in an enclosure
Tapping range		+5% to - 5% in 2.5% steps
Connection symbol		YNa0
Tapped winding		22kV
System short circuit current		16kA/1 second for both 11kV and 22kV
External connections		
22kV		DIN plug in bushings - refer Drawing no. 245887
11kV		DIN plug in bushings - refer Drawing no. 245887
Fittings		See details below
Nominal voltage		
HV winding		22,000 V
LV winding		11,000 V
Method of earthing 11kV - 22kV		Refer to EDI 100 – Drawing no.: 248266
Insulation level:		
22kV	Rated voltage	24kV
	Power frequency withstand	50 kV rms for 1 minute
	Lightning impulse withstand	125 kVp 1.2/50µs wave
11kV	Rated voltage	12kV
	Power frequency withstand	28 kV rms for 1 minute
	Lightning impulse withstand	95 kVp 1.2/50µs wave

Description	
Rated power	3000kVA
Impedance voltage at 75 deg. C @ principle tapping	2.8% ± 7.5% or lower

Description	
<i>Current transformers on 11kV side</i>	
Location	Internal
Ratio	200/5 A
Output (0.2 Ohms)	5 VA
Accuracy class	1.0
Rated extended primary current	200%
Maximum sound power level (AS 60076.10:2009)	64.5 dBA (alternative prices for ≤60 dBA to be given)
Maximum oil volume	1000 litre
Maximum lift weight (with oil)	5000kg

5.4 Transformer fittings

Special mention is made below of transformer fittings, with reasons given. The fittings shall conform to AS 60076.1:2005 and the additional requirements specified below.

5.4.1 Rating plate details

The rating plate shall be located on the middle to lower part of the 11kV end of the tank. In addition to the information requirements specified in AS 60076.1 – 2005, the rating plate shall state the following:

- Manufacturer's design number.
- Endeavour Energy approval number.
- Endeavour Energy plant number.
- Minimum and maximum withstand pressures (kPa absolute) of the transformer tank.

If a separate current transformer rating plate is provided, it **must** be located adjacent to the transformer rating plate.

In addition, the following shall be indelibly marked on the transformer tank in 75mm high black letters:

- kVA rating.
- Endeavour Energy plant number.
- PCB FREE MINERAL OIL or NATURAL ESTER OIL, whichever is applicable.

5.4.2 Transformer terminals

11kV and 22kV terminals shall be bushing wells to AS 2629:2008. Drawing no. 245887 shows the terminal arrangement, position and hole size for the HV terminals on a standard distribution transformer. The terminals on both the 11kV and 22kV sides shall be the same.

The appropriate designating letter shall be permanently marked adjacent to the respective terminal. The transformers are to be supplied with dead-break bushing inserts and they must be securely covered with an appropriate cover.

5.4.3 Transformer tap changer

The tap selector switch shall be located in the 11kV end near the top of the transformer and be accessible with the substation fully assembled. The tap selector switch shall be capable of being locked in each position; however, it shall not be possible to lock between taps.

The tap changer interface with the tank is to be made of brass or stainless steel so that in

the event of a fire in the 11kV end, the tap changer will not melt and oil will be contained in the tank.

5.4.4 Core and coils

Endeavour Energy prefers core type transformers with cylindrical concentric coils. However, other designs may be considered provided the mechanical integrity of the coils can be suitably demonstrated through test results, especially the short circuit test set out in clause 5.10.2.

The core shall be bonded to the tank at one point. The facility to disconnect the bond (for testing purposes) via a readily accessible bolt shall also be provided.

Complete information on the core, insulating paper and conductor materials shall be provided in the schedules.

5.4.5 Transformer oil

5.4.5.1 Mineral oil

Each transformer shall be supplied with new mineral based, passivated-inhibited, naphthenic insulating oil. The oil shall be free of PCB. Specification for mineral based oil shall be in accordance with ETS 0010.

Transformers shall be thoroughly dried out and will be oil filled under vacuum. The moisture content of the oil at the time of filling shall not be more than 30 ppm.

Refer to clause 5.9 for the transformer drying and oil filling requirements.

The transformers shall be of a sealed tank construction type and only air is between the oil and the top cover of the transformer tank.

5.4.5.2 Natural ester oil

Transformers used in environmentally sensitive areas (for example, fire risk areas, water catchments) will require special insulating oil.

At present, Envirotemp FR3 fluid is the approved product that may be specified instead of mineral oil. Transformers using Envirotemp FR3 shall be of sealed design. Nitrogen gas shall be filled between the oil and the top cover of the sealed transformer tank.

Alternative natural ester oil will be considered subject to the approval of the Network Substations Manager but must comply with the requirements and performance criteria of ETS 0032 and IEC 62770:2013.

5.4.6 Oil level indicator

Facilities shall be provided to check for the correct oil level without disassembling the transformer from the cubicle, and allowing for 0 deg. C to 110 deg. C bandwidth. The oil level indicator shall have a brass body with toughened glass viewing window to withstand high temperatures. Suitable alternatives will be considered but subject to approval by the Network Substations Manager.

5.4.7 Oil drain valve and thermometer pocket

An oil drain valve is not required.

A thermometer pocket shall be provided and be located close to the oil level indicator.

5.4.8 Oil filler cap

The liquid filler cap shall screw onto a male threaded pipe on the lid and must be located so that a 20mm outside diameter pipe may be passed through it to the bottom of the tank. The liquid filler cap shall be located so that it does not foul the cubicle.

5.4.9 Transformer lifting points

Lifting lugs/eyes are required for the tank, core/windings and lid. Jacking pads are

required on the transformers, and lugs shall be provided on the transformer for bolting to the plinth. The arrangement shall be similar to that shown on Drawing no. 245887.

Lugs shall be provided on the transformer for lashing to the vehicle during transport.

Adequate clearance shall be allowed for the ease of installing a D-shackle onto the lugs.

The transformer shall be suitable for transportation with or without the plinth.

The transformer design shall allow for forklift handling without a pallet and also allow rollers to be used to move the transformer.

5.4.10 Transformer end flanges

The transformer is to be fitted with an end flange as shown on Drawing no. 245887, to achieve wire proofing when installed in a cubicle. The cubicle has been designed to facilitate this. The wire proofing shall confirm that it is not possible to insert wire or other materials into the cubicle end sections from the vented centre section.

5.5 Loss capitalisation

When evaluating the transformer, Endeavour Energy will capitalise the guaranteed losses of the transformer in order to make a fair economic comparison.

The formula used for comparison must be:

$$K = C + LSi \times Wi + LSc \times Wc$$

Where,

K is the total capitalised cost (\$)

C is the initial or purchase cost of the transformer (\$)

LSi is the capitalised cost per kW of no-load loss (\$)

LSc is the capitalised cost per kW of load loss (\$)

Wi is the no-load loss (kW) corresponding to the transformer nominal size

Wc is the load dependent loss (kW) corresponding to the transformer nominal size @ 75 deg. C

The following factors must be used:

$$LSi = \$6,300/kW$$

$$LSc = \$1,800/kW$$

5.6 Transformer loss performance acceptance

Where a transformer's load or no load losses exceed the contract guaranteed values by 7.5%, or the transformer's total loss exceeds the guaranteed loss by 5%, Endeavour Energy will not accept the transformer.

5.7 Current transformers

Current transformers shall be mounted internal to the transformer tank. The secondary terminals required are one (1) to each phase, one (1) common and one (1) earthing, and are to be located at the front of the 11kV compartment above oil level. Sliding shorting links shall be provided for each CT. The CTs are used for maximum demand indication and shall comply to AS 60044.1:2007.

All terminals are to be identified. The required parameters are listed in clause 5.3. The CT secondaries will be short-circuited at manufacture before delivery.

5.8 Surface finish

Endeavour Energy requires all internal and external surfaces to be treated with a coating that provides protection against corrosion induced by water, salt-laden atmosphere and industrial pollutants. Finished coatings must be oil resistant, heat resistant and non-corrosive.

The resulting surface coating inside the transformer tank must not react with transformer oil or its additives. All coatings (except the interior surface of the transformer) must be capable of being easily maintained and repaired on-site.

As the expected life of the transformer is in excess of 45 years, the life requirements for the coating system to first maintenance must be classified as very long-term, in accordance with clause 1.6 of AS/NZS 2312:2014. The costs of recoating the transformer during its life will be considered when calculating the transformer's life cycle cost.

Alternative surface coating systems may be considered by Endeavour Energy if full details are provided.

Full details of the protective coating system and its ability to resist corrosion under the specified environmental conditions; taking into account expected surface wear due to usual transportation, lifting and installation procedures (excepting malicious damage), must be given. The supplier must provide details on the method of protective coating repair to allow Endeavour Energy to carry out field maintenance as required.

Details of all tests (such as accelerated ageing, scab corrosion, salt spray, fog, and impact) performed to prove the effectiveness of the proposed protective coating, and how the proposed protective coating compared with other test samples, must be provided.

The final colours of transformers **must** be:

N42 to AS 2700S:2011 - STORMY GREY for mineral oil filled transformers.

G62 to AS 2700S:2011 - RIVERGUM for Envirotemp FR3 filled transformers.

5.9 Drying out and oil filling before delivery

The **manufacturer shall confirm** that the transformers are thoroughly dried out at the supplier's works and are delivered filled with oil to the correct level and ready for service.

The **manufacturer shall** provide production details of:

- The methods used for drying transformers prior to filling with oil.
- The maximum moisture content of the transformer after drying.
- The methods used to **determine** that the moisture content has been reduced below the maximum moisture level stated above.

The manufacturer shall also provide a detailed procedure of drying transformers and the oil filling process which shall demonstrate that the transformer is in a dry state at the time of filling it with oil. The procedure shall also demonstrate how the moisture content of the oil is less than **30ppm** at the time of filling.

5.10 Testing

5.10.1 General

The following clauses set out the testing requirement for transformers.

Endeavour Energy places a very high emphasis on the quality of materials and equipment installed in its network. Any relaxation of these standards by Endeavour Energy or the manufacturer/supplier will be at a heavy cost to the industry.

In order to ascertain and **determine** that the quality of the products manufactured for

Endeavour Energy are to the expected standard or better, Endeavour Energy seeks active cooperation from suppliers/manufacturers of Transformers by agreeing to following conditions:

1. The supplier/mmanufacturer is AS/NZS ISO 9001:2016 accredited and actively and enthusiastically follows these standards, or similar criteria acceptable to Endeavour Energy.
2. The manufacturer agrees to visits by Endeavour Energy staff for inspections of the transformer manufacturing process.

To assist with these inspections, the manufacturer **must** provide Endeavour Energy with a production schedule indicating the dates when the transformers under a specific contract to Endeavour Energy are being manufactured.

Any supplier intending to supply transformers to this specification **must** prepare and submit a complete document with the heading Testing Code describing the test methods listed in clauses 5.10.2, 5.10.2.1 and 5.10.3 of this document.

The document **must** clearly indicate, with necessary and sufficient sketches, drawings, circuit diagrams, and/or photographs, the equipment used, the test methodology (with relevant theory), and other relevant information.

3. The type tests and special tests specified are to be conducted for all transformers. Endeavour Energy **must** be advised of the type test program at least four (4) weeks prior to the tests so that Endeavour Energy personnel can witness the tests. The cost of type tests **must** be borne by the manufacturer.
4. Endeavour Energy may conduct type or special tests for a randomly selected sample from each or any type of the supplied transformers at Endeavour Energy's expense, in addition to the type tests conducted by the manufacturer.

The manufacturer will be informed four (4) weeks prior to these tests being conducted so that they can witness the tests if desired. Production schedules **must** be provided.
5. In the event that any type or special test conducted by Endeavour Energy fails to conform to specifications, depending on the nature of the failure, Endeavour Energy will, in consultation with the manufacturer, carry out further type tests on one or more transformers of the type at the manufacturer's expense. If the tested transformer fails to meet the acceptable criteria, the cost of tests carried out by Endeavour Energy **must** also be borne by the manufacturer.

The outcome of these tests will decide the acceptance of transformers by Endeavour Energy. Costs pertaining to all transactions resulting from these failures **will** be borne by the manufacturer.

6. Routine and special tests specified by Endeavour Energy shall be carried out for each transformer, and only those transformers that pass these tests will be accepted.
7. Endeavour Energy may conduct tests specified as routine performance or special tests for a randomly selected sample from each or any category of the supplied transformers, at Endeavour Energy's expense.

The manufacturer will be informed four (4) weeks prior to these tests being conducted so that they can witness the tests if desired. Production schedules **must** be provided.
8. Any transformer tested according to item 7 that fails to comply with the specifications will be returned to the manufacturer and further similar tests will be conducted on other selected samples, depending on the nature of the failure.

This process continues at the manufacturer's expense until such time that Endeavour Energy can ascertain the integrity of the transformers supplied under a specific contract.

The manufacturer shall provide two (2) copies of certified test reports for type, routine and special tests.

Depending upon the extent of these non-conformances, Endeavour Energy may remove or rectify equipment already in service. In such an event, all costs **must** be at the manufacturer's expense.

All tests shall be carried out by a testing authority holding appropriate accreditation:

- by NATA Australia; or,
- by an accreditation authority recognised by NATA Australia.

Tests from other testing authorities, such as KEMA, may be accepted at the discretion of Network Substations Manager Endeavour Energy.

Type tests more than five (5) years old may be acceptable at the discretion of the Network Substations Manager.

5.10.2 Type tests

The offered transformer shall be subjected to the following type tests:

No.	Type test	Acceptable value	Test method reference
1.	Temperature rise test (The test must be repeated with the transformer in Endeavour Energy's standard padmount fibreglass cubicle or other approved equivalent.)	Section 5.3 of this specification.	Clause 7 of AS/NZS 60076.2:2013
1a.	Temperature rise test (1.5 x normal rated load) (The test must be repeated with the transformer in Endeavour Energy's standard padmount fibreglass cubicle or other approved equivalent.)	Clause 6.3.5 of ENA Doc 007-2006	Clause 7 of AS/NZS 60076.2:2013
2.	Lightning impulse voltage withstand tests including chopped wave tests. (required on 11kV and 22 kV windings)	No disruptive discharge and comparable wave shapes (before / after)	Clauses 13 &14 of AS/NZS 60076.3:2008
3.	Sound level test (The test will be conducted when ambient noise is less than 30dB. The noise level readings will be recorded at 1m, 2m, 3m, 4m and 5m distance from the transformer in all four (4) directions, that is, a total of	Section 5.3 of this specification.	AS 60076.10.1:2009

	20 readings.) (The test must be repeated with the transformer in Endeavour Energy's standard padmount fibreglass cubicle or other approved equivalent.)		
4.	Short circuit test (Endeavour Energy may accept "short circuit withstand calculations" that prove that the transformer has adequate strength to withstand the short circuit forces.)	Circular concentric coils – reactance change < 2% Non circular concentric coils – reactance change < 4%	Clause 4.2.7.4 of AS/NZS 60076.5:2012
5.	Pressure test on sealed transformers	Clause 6.4 of ENA Doc 007:2006	Clause 11.8 of AS/NZS 60076.1:2014
6.	Testing on the protective coating of the tank shall be carried out according to the relevant Australian or International standard.	Manufacturer to verify to Endeavour Energy's satisfaction.	-

Endeavour Energy will not purchase or accept any transformer that has undergone type testing.

5.10.2.1 Special test

The following special tests shall be conducted on each transformer supplied to Endeavour Energy.

No.	Special test	Acceptable value	Test method reference
1.	Partial discharge test	$\leq 50\text{pC @ } 1.1\text{Um}/\sqrt{3}$	Clause 12.2.2 of AS/NZS 60076.3:2008
2	Mass of transformer (complete with oil and current transformer)	Section 5.3 of this specification.	

Endeavour Energy may accept results of previously conducted type tests provided the offered transformers are the same as the type tested transformer, and the type tested transformers are in accordance with this specification.

Where the offered transformers have not been successfully type tested, or the tests results do not meet the technical requirements of this specification, fresh type tests **must** be conducted at the manufacturer's expense.

Endeavour Energy reserves the right to witness type tests, for which a minimum of four (4) weeks' notice **must** be given.

5.10.3 Routine tests

The following routine tests shall be conducted on each transformer supplied to

Endeavour Energy:

No.	Routine test	Acceptable value	Test method reference
1.	Measurement of winding resistance	Specified by the manufacturer.	Clause 11.2 of AS/NZS 60076.1:2014
2.	Measurement of voltage ratio and check of phase relationship	Specified by the manufacturer.	Clause 11.3 of AS/NZS 60076.1:2014
3.	Measurement of short circuit impedance and load loss	The tolerance for percentage impedance is $\pm 7.5\%$ of the nominal value in section 5.3 of this specification. .	Clause 11.4 of AS/NZS 60076.1:2014
4.	Measurement of no load loss and current	Section 5.6 of this specification.	Clause 11.5 of AS/NZS 60076.1:2014
5.	Induced over voltage withstand test	No collapse in test voltage.	Clause 12 of AS.NZS 60076.3:2008
6.	Separate source voltage withstand test	Section 5.3 of this specification.	Clause 11 of AS.NZS 60076.3:2008
7.	Insulation resistance	$\geq 1\text{G}\Omega$	Clause 11.12 of AS/NZS 60076.1:2014
8.	Tightness test	No leaks.	Clause 11.8 of AS/NZS 60076.1:2014
9.	Transformer oil test	Table 1 of ETS 0010 Mineral oil: Table 1 of ETS 0010 Natural ester: Table 1 of ETS 0032	ETS 0010 ETS 0032 and IEC62770:2013

5.10.4 Submission of test result

The following information in printed or electronic (printable) format **must** be submitted for all the tests that need be performed.

1. The test method used. This may be a reference to an AS/NZ, IEC, IEEE or BS standard or to authenticated document or book or a method acceptable to Endeavour Energy.
2. Clearly stated and descriptive document with necessary diagrams, sketches, circuit diagrams and photographs, and the like describing the test method.
3. Test results
4. Acceptable criteria

Duplicate copies of routine test certificates **must** be supplied with each transformer in the format shown in Annexure 1. An electronic copy of the routine test certificate in .csv format shall also be sent by e-mail to Distribution Manager Support Services.

Endeavour Energy reserves the right to witness routine tests, for which at least two (2) weeks' notice **must** be given

5.11 Maintenance requirements

5.11.1 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 (if required) of the recommended maintenance and the frequency at which it must be carried out.

5.11.2 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.

5.12 Quality assurance

Quality assurance certification is required to establish 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 or their responsibility to conform to this specification.

5.12.1 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:

- The supplier's organisational structure for the works.
- A planned outline meeting the requirements and all stages of the scope and specification.
- An index showing all existing procedures, inspection and test plans and drawings.
- AS/NZS ISO 9001 certification for itself and subcontractors.
- A plan detailing the design, ordering of materials, manufacturing and test plans.

5.12.2 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 (4) weeks' notice must be given in writing.

5.13 Product approval

5.13.1 Product approval and audit forms

In addition to all transformer technical data, complete information on items such as the core, insulating paper and conductor materials used shall be provided on Branch Form FAE 3069.

5.13.2 Product approval process

Endeavour Energy will approve the equipment/components for use on the network. The transformer shall be evaluated under the product approval process set out in PAE 1004.

5.14 Drawings

The transformers shall comply with the following drawings:

Note: These drawings are for Endeavour Energy's standard padmount distribution substation and are to be used as a reference only for autotransformer substations. The tenderer is expected to submit detailed drawings for approval before manufacture.

Drawing	Amend.	Title
245887	G	Size 14 - 315, 500kVA & Size 16 - 1000, 1500kVA Padmount and Indoor Transformer Typical Requirements
264786	A	Size 14 & 16 padmount and indoor substation exploded view

6.0 AUTHORITIES AND RESPONSIBILITIES

General Manager Asset Management has the authority and responsibility for:

- approving this Specification, including any variations;
- making all decisions concerning compliance in respect to this Specification;
- nominating Endeavour Energy's representative(s) for either the manufacturing facility inspection and/or witness testing; and,
- delegating any of these authorities and responsibilities to the Manager Asset Standards & Design.

Manager Asset Standards & Design has the authority and responsibility for:

- reviewing this specification and making recommendations to the General Manager Asset Management; and,
- making recommendations concerning compliance in respect of this Specification; and,
- making nominations of Endeavour Energy's representatives.

Network Substations Manager has authority and responsibility for:

- reviewing all type and routine test reports and alternative proposals submitted for evaluation, and making recommendations to the Manager Asset Standards & Design.
- clarifying all the technical aspects of this specification to the stakeholders; and
- approving the relevant actions required and outlined in this specification.

Distribution Manager Support Services will be responsible for:

- receiving and accepting transformers that conform to Endeavour Energy specifications.
- determining all routine tests comply with Endeavour Energy's requirement.
- implementing only approved transformers are used in Endeavour Energy's distribution network.
- comparing NLL and LL with the guaranteed values.
- notifying manufacturers/suppliers and relevant sections regarding non-conformance.
- determining that all test results received are uploaded to Endeavour Energy's database within seven (7) days of receipt of the information.

Contractor Operations Manager, Network Connections will be responsible for that all transformers installed by Level 1 Accredited Service Providers comply with the requirements of this Specification.

Commercial Manager has the authority and responsibility to certify that the transformers purchased through the tender process complies with the requirements of this specification.

Manufacturers/suppliers will be responsible for:

- establishing awareness of their responsibilities under this specification;
- determining that the contractor/s under their control have provided suitable training for their staff;
- implementing an effective safety, environmental and quality auditing system is 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.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Substations Manager

Documentation process coordinator: Standards Process Coordinator

Annexure 1 – Transformer routine test report**TRANSFORMER ROUTINE TEST REPORT**

Manufacturer: _____

Date of Test: _____

Transformer Serial No: _____

**TRANSFORMER RATING DETAILS**

Capacity: _____ Volts H.V. _____ Amps H.V. _____

Phases: _____ Volts L.V. _____ Amps L.V. _____

Frequency: _____

Tapping: _____

Vector Group Connection: _____

VOLTAGE RATIO TEST

Taps	A-Phase	B-Phase	C-Phase
1			
2			
3			
4			
5			
6			
7			

INDUCED OVERVOLTAGE TEST

Duration:	Pass/Fail
Voltage:	
Frequency:	

APPLIED VOLTAGE TEST

Duration:	Pass/Fail
HV to LV & E:	
LV to HV & E:	

INSULATION RESISTANCE TEST

at _____ kV D.C.	Pass/Fail
_____ M Ohms	
HV to LV & E:	
LV to HV & E:	

RESISTANCE TEST

at _____ °C			
HV Terminals	Ohms	LV Terminals	Ohms
A-B		a-b	
A-C		a-c	
B-C		b-c	

NO LOAD LOSSES

Frequency	Voltage	Current a	Current b	Current c	Mean Current	Current %	No Load Loss

FULL LOAD LOSSES

at _____ °C					
Test Voltage	Current A	Current B	Current C	Current Mean	Measured Loss

at 75°C	
Full Load Loss	Impedance

TRANSFORMER TESTED POWER EFFICIENCY: _____

ADDITIONAL NOTES:
