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Discipline

Engineering Standard – NSW

Category

Electrical

Title

Pole Mounted Distribution Transformer

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About This Standard

This document details the whole of life performance requirements for the purchase and maintenance of 2 and 3 phase pole mounted distribution transformers for use in the ARTC electrical network. It covers primary voltages of 11 kV and 33 kV and secondary voltages of 125 V, 250 V and 433 V. The standard ARTC pole mounted substation designs allow for a weight limit of 2240 kg which restricts the transformer rating to 250 kVA. The standard design is also based on oil-immersed transformers, but this document does not exclude other types of transformers.

This document does not cover transformers used on the 2 kV network as it is in the process of being phased out, any replacement transformers should be sourced from decommissioned stock.

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1.1	05/01/2005		Reformatted to ARTC Standard
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1 Scope and Application

This document details the whole of life performance requirements for the purchase and maintenance of 2 and 3 phase pole mounted distribution transformers for use in the ARTC electrical network. It covers primary voltages of 11 kV and 33 kV and secondary voltages of 125 V, 250 V and 433 V. The standard ARTC pole mounted substation designs allow for a weight limit of 2240 kg which restricts the transformer rating to 250 kVA. The standard design is also based on oil-immersed transformers, but this document does not exclude other types of transformers.

This document does not cover transformers used on the 2 kV network as it is in the process of being phased out, any replacement transformers should be sourced from decommissioned stock.

The requirements of this document apply to all new pole mounted distribution transformers.

2 References

2.1 Australian Standards

The following Australian Standards are either referenced in this document or can provide further information.

AS 1265	1990	Bushings for alternating voltages above 1000 V.
AS 1627.4	2002	Metal finishing – Preparation and pre-treatment of surfaces – Abrasive blast cleaning.
AS 1767.1	1999	Insulating liquids – Specification for unused minerals insulating oils for transformers and switchgear.
AS 2374.1	1997	Power transformers Part 1: General.
AS 2374.2	1997	Power transformers Part 2: Temperature rise.
AS 2374.3	1982	Power transformers Part 3.0: Insulation levels and dielectric tests – General requirements
AS 2374.1	1992	Power transformers Part 3.1: Insulation levels and dielectric tests – External clearances in air.
AS 2374.5	1982	Power transformers Part 5: Ability to withstand short-circuit
AS 2374.6	1994	Power transformers Part 6: Determination of transformer and reactor sound levels.
AS 2700	1996	Colour standards for general purposes.
AS 275	1984	Dry-type power transformers
AS 4680	1999	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles.

2.2 ARTC Documents

PDS 16 - "Transformer Loss Evaluation"

2.3 Drawings

The following drawings form part of this document:

- E 70490 G Train signalling. 11 kV / 120 V transformers. Single pole structure details.
- E 76065 D Substations 11 kV / 433 V transformer single pole structure, transformer mounting details.
- K 89091 A 33 kV / 415 V 3 phase transformer single pole structure arrangement.

The following drawings can provide further information:

- C 70372 Train signalling 11 kV / 120 V transformer. Single pole structure arrangement.
- B 76031 11 kV / 415 V transformer. Single pole structure arrangement.
- K 85401 33 kV / 500-250 V transformer single pole structure arrangement.
- K 85507 33 kV / 500-250 V transformer single pole structure operating notice.
- K 89069 11 kV / 500-250 V transformer single pole structure and 11 kV switchgear arrangement.
- K 89092 Frame assembly for 3 phase 36 kV 300 A sidebreak isolator - dual earth switch and fuse combination.
- A3 90094 Earthing arrangement substation on timber pole with low voltage earthed.
- A3 90095 Earthing arrangement substation on timber pole with low voltage unearthed.

3 Definitions & Abbreviations

For the purpose of this specification the definitions given in AS 2374 apply. In addition the following definitions also apply:

- 2 phase system Where the secondary of a transformer is a two wire system, that is it has a voltage of 250 V or 125 V, then the primary winding of the transformer is connected across two phases of the high voltage system.
- AN Air Natural cooling. The transformer windings and core are cooled by air (no oil) without the use of fans.
- Distribution Transformer A transformer that transforms and controls the system voltages to a secondary voltage of nominally 415 V, 240 V or 120 V.

NB	Normal bore (of pipe)
ONAN	Oil Natural, Air Natural cooling. The transformer windings and core are oil cooled and the oil is air cooled, without the use of pumps or fans.
Pole mounted	Mounted on a structure supporting an overhead line.
Primary winding	The winding that receives the active power from the supply system, usually the winding having the highest rated voltage.
Principal tapping	Is the mean tapping position. It is also the tapping to which the rated quantities are related.
Secondary winding	The winding that delivers the active power to the load circuit, usually the winding having the lowest rated voltage.

4 Functional Characteristics

4.1 General

Pole mounted substations are used on ARTC's 11 kV and 33 kV distribution networks in the area bounded by Muswellbrook (north), Kiama (south) and Wallerawang (west).

The transformers covered by this document supply railway stations, signals, workshops and various other AC loads. They are not used for supplying DC traction loads.

The transformers shall be in accordance with AS 2374, except as detailed in this document.

4.2 Whole-of-Life Cost

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

Initial purchase price.

Cost of changes to the Technical Maintenance Plan & Service Schedules or the creation of new manuals & schedules.

Cost of manuals.

Cost of maintenance.

Cost of replacement parts.

Cost of inventory spares.

Environmental costs.

Electrical Losses. Refer to document PDS 16 - "Transformer Loss Evaluation" for the method of evaluating transformer losses.

Cost of installation.

Reliability and cost of failures.

Cost of modifications to other parts of the installation.

Lifetime of equipment.

Discount Rate.

Cost of staff training.

Cost of Decommissioning and Disposal.

Cost of special tools.

Cost of changes and management of drawings.

5 Performance Characteristics

Number of phases2 or 3.

Frequency50 Hz

TypeOutdoor, Pole mounted.

Type of coolingONAN or AN.

Rated voltagesRefer to Table 1, below.

TappingsFull kVA tappings on the primary winding at $\pm 2.5\%$ and $\pm 5\%$ of the principal tapping. Externally operated off-circuit switches, where used, shall be capable of being locked in position.

System highest voltageRefer to Table 1, below.

System earthingNon-effectively earthed.

Rated insulation levelRefer to Table 1, below.

Connection vector symbolDyn 1.

Neutral terminalStar point of lower voltage winding shall be connected to a bushing and fully insulated from earth.

Impedance voltage at rated current and 75°C Refer to AS 2374.5, Table 1.

Sound pressure level.....Refer to AS 2374.6, Appendix AA

Special physical characteristicsRefer to section 6

Rated Voltage	System Highest Voltage	Rated Insulation Level	
		Lightning Impulse	Power Frequency
125 - 433 Vrms	1.1 kVrms	-	5 kVrms
11 kVrms	12 kVrms	95 kVpk	28 kVrms
33 kVrms	36 kVrms	200 kVpk	70 kVrms

Table 1 - Voltage and Insulation Levels

6 Technical Characteristics

6.1 Rating Plate

The rating plate shall meet the requirements of AS 2374.1, Clause 7, and shall include a diagram of connections. A terminal marking plate complying with the requirements of AS 2374.1, Clause ZC7, shall also be attached to the transformer. The plates shall not be attached to a removable cover.

6.2 Terminal Arrangement

The position of the primary winding terminal bushings shall be on the side of the transformer remote from the pole. The position of the secondary winding terminal bushings shall be on the left hand end of the transformer as viewed from the side containing the primary winding bushings. The bushings shall comply with AS 1265 for normally polluted atmosphere.

For connections using lugs or terminals not insulated to the appropriate voltage, the following minimum clearances shall apply:

33 kV terminals:	Between different phases	460 mm
	Between phase and earthed metal	380 mm
11 kV terminals:	Between different phases	185 mm
	Between phase and earthed metal	160 mm
415 / 433 V terminals:	Between different phases	110 mm
	Between phase and earthed metal	60 mm
125 / 250 V terminals:	Between different phases	70 mm
	Between phase and earthed metal	60 mm

6.3 Earth Terminal

A suitable earthing terminal shall be located near the bottom of the tank.

6.4 Lifting Attachments

Suitable lifting lugs shall be provided for lifting the transformer.

6.5 Hangers

If a transformer is a replacement for an existing pole mounted substation, and it is required that the transformer be physically interchangeable, then the bracket and hanger designs shown on the drawings that form part of this document may be used. Refer to drawing list in section 2.3.

6.6 Temperature-Rise Limits

The transformer shall be capable of continuous operation at rated power without exceeding the maximum temperature-rise limits as specified in AS 2374.2 Clause 4.2.

6.7 Finish

All external surfaces shall have welds made smooth, rough edges rounded and weld splatter removed. The transformer tank and cover shall remain corrosion free for the life of the transformer. The internal and external surfaces shall be prepared and the paint applied strictly in accordance with the manufacturer's instructions.

The expected minimum preparation for a new transformer is abrasive blast cleaning all steel surfaces in accordance with AS 1627, part 4 to Class 2.5. The internal steel surfaces painted with an oil resistant paint immediately after abrasive cleaning. The external steel surfaces painted with an inorganic zinc-rich paint immediately after abrasive cleaning.

When an existing transformer suffers damage to its finish the repair shall be to the original standard of finish.

6.8 Unearthed Secondary

Transformers used solely for supplying unearthed installations, such as signalling locations, shall be provided with a copper or aluminium metal screen located between the primary and secondary windings. The screen shall be at least 0.5 mm in thickness and is to be connected to a special insulated terminal. The metal screen shall be arranged to prevent leakage from any part of the primary windings to any part of the secondary windings of the transformers.

The manufacturer must be made aware that the secondary side of the transformer is not earthed under normal service conditions so that overvoltages due to the capacitances between windings and between windings and earth can be allowed for in the transformer design.

6.9 Dry Type Transformers

The requirements of sections 6.10 to 6.15 shall not apply to dry type transformers.

6.10 Insulating Oil

Insulating oil shall comply with the requirements of AS 1767.1.

In order to comply with NSW Environment Protection Agency guidelines for PCB free materials the transformer oil must contain less than 2 milligrams per kilogram of PCB. After the transformer has been delivered to site and any oil added, as may be necessary, the suppliers shall arrange for the oil to be tested for PCB content and a certificate issued to the Purchaser showing the PCB content. Should the PCB content exceed 2.0 mg/kg then the suppliers shall arrange for the oil to be “treated” as necessary to reduce the PCB level below 2 mg/kg.

6.11 Sealed Transformers

Where a sealed transformer construction design is used the space above the oil shall be filled with inert gas or dry air. The gland for the tap changer switch shall be located below cold oil level. The tank cover and bracing shall be designed to prevent the accumulation of water.

The requirements of sections 6.12 to 6.15 shall not apply to sealed transformers.

6.12 Valves and Plugs

A drain valve 25 NB (nominal bore) pipe internal thread with flanged plug shall be fitted at the bottom of the transformer tank to allow the oil and any moisture to be withdrawn.

A 25 NB pipe internal thread with flanged plug shall be fitted above the maximum oil level of the transformer tank for filling purposes.

6.13 Thermometer Pocket

The thermometer pocket shall be located as near as practicable to the hottest part of the oil. It shall be fitted with a flanged plug, having a 25 mm pipe thread.

6.14 Breather

The breather design shall not incorporate any consumable components, for example silica gel. The breather shall be maintenance free for the life of the transformer.

6.15 Pressure Relief Vent

A pressure relief vent may be fitted.

7 Maintenance

7.1 General

The relevant ARTC Technical Maintenance Plans shall be adhered to for the maintenance of the type of transformer. Where a new type of transformer is purchased and installed that is not covered by the TMP then a new service schedule shall be created and the TMP updated. This shall include:

- The “Maintenance Policy”, defining the practical means of maintaining the equipment.
- The tasks to be performed at each level of maintenance and staff skill levels required.

- Test equipment and tools.

It is preferable that the period for routine maintenance shall not be more frequent than for the types of transformers currently detailed in the ARTC Technical Maintenance Plan.

7.2 Oil Testing

No oil testing is carried out on dry type transformers, sealed transformers, ventilated transformers under 100 kVA and transformers with a primary voltage of 2 kV.

8 Tests

8.1 Acceptance Tests

Routine tests shall be carried out on each transformer to AS 2374.1 Clause 10.1.1. The results shall be recorded. A record of a test certificate for type tests carried out on a similar transformer to AS 2374.1 Clause 10.1.2 shall also be available for each transformer.

Where a transformer has a metal screen, refer to section 6.8, the metal screen shall be connected to the high voltage earth during the acceptance tests.

8.2 Periodic Tests

Refer to ARTC Technical Maintenance Plan.

9 Data Set associated with the Equipment

The following data shall be maintained for each transformer. This data shall be the property of ARTC and maintained by the Maintenance Provider responsible for the installation in which the transformer is installed.

9.1 Equipment Manuals

The Equipment Manuals must be provided for the installation and shall include full instructions for the preventative, surveillance and corrective maintenance, comprehensive fault diagnosis, rectification procedures and staff training requirements. It shall include all drawings needed for the above. All drawings shall show sufficient detail to enable satisfactory maintenance of the equipment.

9.2 Test Results

The results of all tests relating to the transformer and the insulating oil, including acceptance tests and periodic and corrective maintenance tests, shall be recorded.

9.3 Life Cycle Costing

All the data and assumptions pertaining to the determination of the whole-of-life cost calculations shall be recorded.

9.4 Technical Schedule

The information listed in the attached Technical Schedule shall be maintained for each transformer.

10 Technical Schedule

Manufacturer	_____	
Serial number	_____	
Year of manufacture	_____	
Oil preservation system (refer to AS 2374.1 clause 8.2)	_____	
Rated primary voltage.....	_____	V
Rated secondary voltage	_____	V
Rated power	_____	kVA
Connection vector symbol	_____	
Maximum temperature rise of windings	_____	°C
Impedance voltage at rated current and 75°C/115°C* (Expressed as percentage of rated voltage)	_____	%
No-load current with rated voltage applied to the principal tapping (Expressed as percentage of rated current)	_____	%
No-load current with 110% of rated voltage applied to the principal tapping (Expressed as percentage of rated current)	_____	%
No-load loss	_____	W
Load loss	_____	W
Type of core steel - hot or cold rolled	_____	
Brand or trade name and grade of core steel.....	_____	
Flux density based on net cross-section of steel with rated voltage at rated frequency applied to the principal tapping		
Limbs.....	_____	T
Yoke	_____	T
Mass of windings only.....	_____	kg
Mass of transformer core and windings only.....	_____	kg
Mass of one transformer complete with oil	_____	kg
Volume of oil required to fill one transformer.....	_____	litres

Is a pressure relief vent provided? * YES / NO

If so, what type _____

Mean audible sound level _____ db

Voltage withstand test which the bushings will withstand without puncture or flashover in accordance with Clause 21, Clause 22 and Table 1 of AS 1265.

primary bushings - Lightning impulse withstand voltage kV_p

- Power frequency withstand voltage kV_{rms}

secondary bushings - Lightning impulse withstand voltage kV_p
(if required)

Bushings, minimum clearance in air:	primary	secondary
between phases	_____ mm	_____ mm
phase to earth	_____ mm	_____ mm

Is heat-shrink material provided on the higher volt terminals?..... * YES / NO

Type of insulating material used for windings _____

Type of material used for windings - copper or aluminium _____

Temperature class of insulation _____

Insulating liquid (oil/synthetic) _____

Overall transformer dimensions:

Length mm

Width mm

Height mm

Protective treatment applied to:

Internal surfaces _____

External surfaces..... _____

* Cross out where not applicable.

Departures from Specification

Are there any departures from the requirements of this

Specification * YES / NO

Departures from the requirements of this Specification must be highlighted.