Engineering Standard
Electrical

EP 16 00 00 02 SP

OUTDOOR GROUND TYPE DISTRIBUTION TRANSFORMER

Version 2.0

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Engineering Standard

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Document control

Version	Date	Summary of change
	August 2002	Last Technical Review
2.0	May 2010	Application of TMA 400 format

Contents

1 Introduction

This document details the whole of life performance requirements for the purchase and maintenance of 2 and 3 phase outdoor, ground mounted distribution transformers for use in the RailCorp 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 design is based on oil-immersed transformers but this document does not exclude other types of transformers. This document includes transformers for use in padmount substations.

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 outdoor, ground 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 2067 -1984 Switchgear assemblies and ancillary equipment for alternating voltages above 1 kV.

AS 2105 -1992 Inorganic zinc silicate paint.

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 2374.3.1 -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 2735 -1984 Dry-type power transformers.

AS 4680 -1999 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles.

2.2 RailCorp Documents

EP 02 00 00 01 SP - “Transformer Loss Evaluation”

2.3 Drawings

The following drawings form part of this document:

- None.

The following drawings can provide further information:

C 87206 Earthing system for fibreglass padmount substation.

3 Definitions & Abbreviations

For the purpose of this document 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.

Distribution Transformer A transformer that transforms and controls the system voltages to a secondary voltage of nominally 433 V, 250 V or 125 V.

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

Outdoor ground mounted transformers are used on RIC'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 low voltage 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 minimising 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 EP 02 00 00 01 SP - "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 phases	2 or 3.
Frequency	50 Hz.
Type	Outdoor, Ground type.
Type of cooling	Oil natural, air natural or Air natural.
Rated voltages	Refer to Table 1, below.
Tappings	Full kVA tappings on the primary winding at ± 2.5% and ± 5% of the principal tapping. Externally operated off-circuit switches, where used, shall be capable of being locked in position.
System highest voltage	Refer to Table 1 below.
System earthing	Non-effectively earthed.
Rated insulation level	Refer to Table 1 below.
Connection vector symbol	Dyn 1.
Neutral terminal	Star point of lower voltage winding shall be connected to a bushing and fully insulated from earth.
Impedance voltage at rated current and 75^{o}C	Refer to AS 2374.5, Table 1.
Sound pressure level	Refer to AS 2374.6, Appendix AA.
Special physical characteristics	Refer to Section 4.

Rated Voltage	System Highest Voltage	Rated Insulation Level	
		Lightning Impulse	Power Frequency
125 - 433 V_{rms}	1.1 kV_{rms}	-	5 kV_{rms}
11 kV_{rms}	12 kV_{rms}	95 kV_{pk}	28 kV_{rms}
33 kV_{rms}	36 kV_{rms}	200 kV_{pk}	70 kV_{rms}

Table 1 - Voltage and Insulation Levels

Note

The transformer vector connection Dyn 1 is used on all RailCorp transformers with a low voltage secondary winding.

6 Technical Characteristics

6.1 Rating Plate

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

6.2 Terminal Arrangement

The primary and secondary winding terminal bushings shall be mounted on opposite sides of the transformer enclosure. The arrangement for both sets of terminal bushings shall be A B C phases from left to right when viewed from the primary side (A and B only for a two phase transformer). When a neutral terminal is fitted, it shall be on the extreme left unless otherwise agreed to by RIC. The bushings shall comply with AS 1265 for normally polluted atmosphere.

Where a cable box is provided, provision shall be made to accommodate the termination of the required cables. Heat-shrink material may be used to obtain a satisfactory insulation level. Generally the cables terminated in a cable box shall enter from below.

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 for the transformer enclosure shall be located externally, near the bottom of the enclosure.

6.4 Lifting Attachments

Lifting lugs shall be provided for lifting the transformer. For a transformer of 500 kVA or greater rating, brackets shall be provided at each corner to allow the corner to be lifted by a jack. The brackets shall be not less than 200 mm from the ground.

6.5 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, Section 4.2.

6.6 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 it's finish the repair shall be to the original standard of finish.

6.7 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.

6.8 Dry Type Transformers

The requirements of Sections 6.9 to 6.14 shall not apply to dry type transformers.

6.9 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 mg/kg then the suppliers shall arrange for the oil to be “treated” as necessary to reduce the PCB level below 2 mg/kg.

6.10 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 6.11 to 6.14 shall not apply to sealed transformers.

6.11 Valves and Plugs

A drain valve 25 mm 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 mm nominal bore pipe internal thread with flanged plug shall be fitted above the maximum oil level of the transformer tank for filling purposes.

6.12 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.

6.13 Breather

Dehydrating breathers that incorporate consumable components, for example silica gel, shall be of a type that allows easy replacement of the consumable components.

6.14 Pressure Relief Vent

A pressure relief vent may be fitted.

7 Maintenance

7.1 General

The relevant RailCorp 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 type of transformer currently detailed in the RailCorp Technical Maintenance Plan.

7.2 Oil Testing

No oil testing is carried out on dry type transformers, sealed transformers and ventilated transformers under 100 kVA.

8 Tests

8.1 Acceptance Tests

Routine tests shall be carried out on each transformer to AS 2374.1 Section 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 Section 10.1.2 shall also be available for each transformer.

Where a transformer has a metal screen, refer to Section 5.7, the metal screen shall be connected to the high voltage earth during the acceptance tests.

8.2 Periodic Tests

Refer to RailCorp 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 RailCorp 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.

Appendix A Technical Schedule

Manufacturer .....

Serial number .....

Year of manufacture .....

Oil preservation system (refer to AS 2374.1 Section 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

Power frequency voltage test which the bushings will withstand without puncture or flashover in accordance with Section 21 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)

- Power frequency withstand voltage ..... kV_{rms}

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.