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Category
Electrical

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Low Voltage Isolating Transformer

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About This Standard

This document details the design, manufacture and whole of life performance requirements for single and three phase low voltage isolating transformers for use in the Australian Rail Track Corporation electrical network.

The transformers described in this document are associated with Local Electricity Distributor supplies, the 120V signalling system and supplies to buildings or structures in contact with the Australian Rail Track Corporation 1500 V system. The intention of this document is that the transformers will be dry-type. Oil filled transformers will not be acceptable.

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List of Amendments –

ISSUE	DATE	CLAUSE	DESCRIPTION
1.1	05/01/2005		Reformatted to ARTC Standard
1.2	11/03/2005	Disclaimer	Minor editorial change

Contents

1 Scope and Application

This document details the design, manufacture and whole of life performance requirements for single and three phase low voltage isolating transformers for use in the Australian Rail Track Corporation electrical network.

The transformers described in this document are associated with Local Electricity Distributor supplies, the 120V signalling system and supplies to buildings or structures in contact with the RailCorp1500 V system. The design is suitable for transformers rated at 25 kVA and larger. It is encouraged that 25 kVA be specified as a minimum size unless a smaller size is required by special circumstances. The intention of this document is that the transformers will be dry-type. Oil filled transformers are not acceptable.

The requirements of this document apply to all new single and three phase low voltage isolating transformers. Existing isolating transformers purchased under the former SRA specification A-844 should meet the basic double insulation requirements.

2 References

2.1 Australian Standards

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

AS 1627.4, 2002	Metal finishing - Preparation and pre-treatment of surfaces, - Abrasive blast cleaning
AS 1939, 1990	Degrees of protection provided by enclosures for electrical equipment (IP Code)
AS 2374.1, 1997	Power transformers - General requirements
AS 2374.5, 1982	Power transformers - Ability to withstand short-circuit
AS 2374.6, 1994	Power transformers - Determination of transformer and reactor sound levels
AS 2700, 1996	Colour standard for general purposes
AS 2735, 1984	Dry-type power transformers
AS/NZS 3000, 2000	Electrical installations (known as the Australian/New Zealand Wiring Rules
AS/NZS 3100, 2002	Approval and test specification - General requirements for electrical equipment
AS/NZS 3108, 1994	Approval and test specification - Particular requirements for isolating transformers and safety isolating transformers
AS/NZS 3750.15, 1998	Paint for steel structures - Inorganic zinc silicate paint

AS/NZS 4680, 1999	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS/NZS 61558.2.4, 2001	Safety of power transformers, power supply units and similar - Part 2.6: Particular requirements for isolating transformers for general use

2.2 Australian Rail Track Corporation Documents

The following Australian Rail Track Corporation documents are either referenced in this document or can provide further information.

PDS 16	Transformer Loss Evaluation
PDS 07	Low Voltage Distribution Earthing
PDS 08	Low Voltage Installations Earthing
EP 12 30 00 01 SP	Electrolysis From Stray DC Current (RailCorp publication)
SPS 23	Single Phase Air Cooled, Isolating Transformer for Signalling Applications

3 Definitions and Abbreviations

For the purpose of this specification the definitions specified in the referenced Australian Standards apply. The following definitions should particularly be noted:

Dry-Type Transformer: A transformer of which the core and windings are not immersed in an insulating liquid (from AS 2735 -1984).

Isolating Transformer: A transformer with protective separation between the input and output windings.

Primary Winding: The winding that receives the active power from the supply system.

Principal Tapping: Is the 0% 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.

Protective Separation: Denotes separation between circuits by means of basic and supplementary protection (basic insulation plus either supplementary insulation or protective screening) or by an equivalent protective provision (for example, reinforced insulation).

Protective screening: Denotes separation from live parts by means of an interposed conductive screen, connected to the means of connection for an external protective conductor.

4 Functional Characteristics

4.1 General

Isolating transformers are used in the Australian Rail Track Corporation network to ensure separation of different earth systems for electrolysis mitigation purposes and IT system of earthing, in particular:

- Provide galvanic isolation between the local electricity distributor's MEN earth system and Australian Rail Track Corporation's earth system. Australian Rail Track Corporation's earthing system has been designed for a dc traction environment.
- Provide for the unearthed 120 V_{ac} signalling IT system of earthing.
- Supplies to buildings or structures in contact with Australian Rail Track Corporation's 1500 V traction system.

For further information on the background for these requirements refer to 'PDS 07 - Low Voltage Distribution Earthing', 'PDS 08 - Low Voltage Installations Earthing' and RailCorp publication 'EP 12 30 00 01 SP – Electrolysis from Stray DC Current'.

5 Performance Characteristics

Number of phases …….	1 or 3.
Frequency ……..	50 Hz.
Type ……..……..	• Dry, suitable for either indoor or outdoor use • Isolation Transformer complying with AS 3108
Type of cooling ……	Air natural
Rated voltage ……..……...	415 V (3 phase), 240 V (single phase)
Tapping on primary winding ……	Full kVA tappings on the primary winding at ±2.5% and -±5% of the principal tapping
Secondary winding……	The secondary windings of the single phase transformers shall be arranged in two equal sections, each rated at 120 V, suitable for operation in series at 240 V or in parallel at 120 V by external connections.
Tap-changing device …….	Refer to Section 6.5
System highest voltage ……	1.1 kV
Connection symbol ……	Dyn1 (for 3-phase transformers)

Insulation ……..	Windings double insulated from earth
Rated insulation level ……..	5 kVrms
Reference temperature for determination of impedance voltage ……	115°C
Impedance voltage at rated current at reference temperature ……..	As per Table 1 of AS 2374.5

6 Technical Characteristics

6.1 General

Each transformer shall be so constructed as to be unaffected by normal handling during transport, installation, inspection and repair.

Due to the type of usage of the isolating transformers in the Australian Rail Track Corporation electrical network the following factors are considered important and should influence the design characteristics of the transformer. These aspects will be assessed as part of the technical schedule:

- Voltage regulation;
- Insertion loss;
- Protection coordination;
- Lightning protection.

6.2 Core

The core of the transformer is to be isolated from the external metal parts of the transformer with an insulation level of at least 5 kV. A test point for the application of high voltage test and insulation resistance test is to be provided on the core. Insulators shall be used to mount the core onto the frame of the transformer.

All nuts used in the construction of the core shall be adequately locked by means of spring washers, locknuts, or other approved locking devices.

6.3 Protective Screen

Each transformer shall be provided with a protective screen of copper or aluminium at least 0.5 mm in thickness with an insulation level of at least 5 kVrms, located between the primary and secondary windings.

The protective screen is to be connected to a special insulated terminal (5 kV insulation level) in the same enclosure as the primary terminals of the transformer.

The protective screen shall be arranged to prevent leakage from any part of the primary windings to any part of the secondary windings of the transformer.

The protective screen shall withstand a 5 kV voltage test applied for one minute between the screen terminal and primary and secondary windings.

The insulation level between the protective screen and the core and the frame shall be 5 kV for one minute.

For further information on the connection of the screen, refer to 'PDS 07 – Low Voltage Distribution Earthing' for supplies from a Local Electricity Distributor or 'PDS 08 – Low Voltage Installations Earthing' for Signalling supplies or supplies to buildings or structures in contact with the Australian Rail Track Corporation 1500 V system.

6.4 Internal Connections

The leads between the windings and the terminals (including protective screen terminal) shall be double insulated, in accordance with the requirements of the Clause covering Double Insulation in AS/NZS 3000–2000.

The leads shall be secured to prevent contact with the transformer casing if the connection becomes loose or breaks away from the terminal. The method of securing the leads shall be detailed in appendix A1.4.

Flexible leads shall be provided between the windings and terminals where the cross sectional area of the leads are less than 25 mm^2.

6.5 Terminals

The primary and secondary windings of the transformer shall be terminated onto screwed terminal studs suitably sized for the power rating of the transformer. The hardware used shall provide secure cable connections, 'locked' against loosening, for example by the use of star washers and nickel plated brass nuts.

The terminals shall be arranged so that all required interconnections of windings and adjustments of taps can be accomplished by the alteration of accessible tinned copper bolted links. The links shall be rated at the full transformer kVA rating. Access to the terminals and adjustment of links shall only be possible by the use of appropriate tools. The links shall be supplied with the transformer.

The primary and secondary terminals must be located within individual weatherproof polycarbonate enclosures. The polycarbonate enclosures are to be suitably sized to accommodate the appropriate installation of the terminals, links, glands and cables fitted with crimp lugs. The degree of protection to be provided from the exterior environment by the polycarbonate enclosure is to comply with AS 1939-1990 Table II and Table III as IP56. Removal of the terminal enclosure cover shall only be possible by the use of appropriate tools.

6.6 Transformer Case

6.6.1 Indoor Type

The terminal enclosures shall be mounted on opposite sides of the transformer outside, and close to the top, of the transformer casing. The casing shall be fabricated from galvanised steel sheet, minimum 2 mm thick and must comply with AS 1939-1990 Table II and Table III as IP33.

This design is for use indoors, such as within a traction substation or signalling hut, or within a fibreglass padmount structure.

6.6.2 Outdoor Type

The terminal enclosures shall be located within the transformer casing, which must comply with AS 1939-1990 Table II and Table III as IP56. Cable entry shall be provided on the primary and secondary sides of the transformer enclosure to allow for external cable connection within the primary and secondary terminal enclosure. The screwed holes shall be plugged using heavy-duty PVC plugs to maintain IP56 rating. The casing shall be vermin, insect and vandal resistant.

6.6.3 Mounting

The transformer case shall be fitted with suitable hot dipped galvanised mounting brackets suitable for floor mounting. The bracket design shall include 15 mm diameter mounting holes that are accessible when the transformer is floor mounted against a wall.

When specified wall mounting brackets shall be provided. The design shall allow for mounting without the removal of the transformer cover.

The mounting design must ensure that the clearance between the transformer enclosure and the mounting surface allows for sufficient ventilation to meet the heat rise requirements. Refer to clause 8.2 for heat rise tests. A minimum of clearance of 50 mm is required.

6.6.4 Lifting and Lashing Attachments

Suitable lifting lugs for attaching lashings shall be provided external to the transformer enclosure. They shall be affixed near the top of the transformer enclosure for securing it to a transport vehicle and for lifting the transformer.

6.6.5 Surface Finish

All external surfaces shall have welds made smooth, rough edges rounded and weld splatter removed. The transformer shall remain corrosion free for the life of the transformer.

All external steelwork shall be hot-dipped galvanised to AS/NZS 4680-1999. Alternatively for indoor transformers, the transformer casing may be powder coated after fabrication to colour 631 “transformer grey” (colour code N41 to AS 2700 or 631 to BS 381C).

6.7 Nameplate

The nameplate shall meet the requirements of AS 2374.1-1997, Clause 7, and shall include a diagram of connections including the primary tappings. The nameplate shall also indicate that a protective screen is fitted between the primary and secondary windings.

A terminal marking plate complying with the requirements of AS 2374.1-1997, Appendix ZC, Clause ZC7 shall also be attached to the transformer.

The plates shall not be attached to a removable cover.

As the transformer is a double insulated isolating transformer complying with AS/NZS 3108-1994, the labelling shall include the following marking:

"DOUBLE INSULATED ISOLATING TRANSFORMER TO AS/NZS 3108
DO NOT EARTH"

If the transformer has an actual design rating exceeding the rating ordered, the nameplate shall show the actual design rating and not the rating ordered.

6.8 Tolerances

The tolerances provided in Table 1 of AS 2374.1-1997, shall apply to the load loss and no-load loss. The tolerances applying to the voltage ratio and regulation shall comply also with Table 1.

6.9 Temperature Rise Limits

The transformer shall be capable of continuous operation at rated power without exceeding the maximum temperature-rise limits as specified in Table 3.3 of AS 2735-1984.

6.9.1 Sound Level

The mean audible sound level of the transformer shall not exceed the value specified in Appendix AA of AS 2374.6-1994, when measured in accordance with that Standard.

7 Maintenance Concept

The transformer shall be designed and constructed to require no maintenance.

8 Tests

8.1 Routine Tests

Routine tests as listed in AS 2374.1 clause 10.1.1 shall be carried out on each transformer. The routine test of clause 5.1.6 and clause 5.1.7 shall also be carried out on each transformer. These tests shall be carried out in conjunction with the following requirements:

	1	2	3	4	5	6	7
Test No.	Input Winding	Output Winding	Core	Protective Screen	(Frame) External Metal Parts	Applied HV Test 1 minute (kV)	Min. 500 V insulation resistance (Megohms)
1	HV	E	F	F	E	5.0	100
2	E	HV	F	F	E	5.0	100
3	E	E	F	HV	E	2.5	10
4	E	E	HV	F	F	2.5	10
5	F	F	HV	F	E	5.0	10
6	F	F	E	HV	E	5.0	100

Notes:

a) "HV" indicates that the high voltage test or the insulation resistance test is to be applied to the part.

b) "E" indicates that the part is to be connected to earth during the high voltage test and the insulation resistance test.

c) "F" indicates that the part is not to be connected to any supply or earth, ie, to be floating during the high voltage test and the insulation resistance test.

d) If the core is to be connected to the external metal parts (frame) delete Test Nos. 4 and 5 and Column 3.

The protective screen shall withstand a 2.5 kV voltage test applied for one minute between the screen terminal and primary and secondary windings. (Test 3)

The insulation level between the protective screen and the core and the frame shall withstand 5 kV applied for one minute. (Test 5)

8.2 Type Tests

Temperature rise type tests shall be carried out on one transformer of each type and rating in accordance with Clause 5.1.10 of AS 2735-1984.

The method of loading is to be either by the direct loading method (described in AS 2735-1984, Clause 5.1.10.2) or by the back-to-back method (described in Clause 5.1.10.3). The simulated load method (described in Clause 5.1.10.4) is not acceptable by Australian Rail Track Corporation.

The winding temperature rise is to be determined by the change of resistance method. The resistance is to be determined by d.c. volts/amps in which the current is to be substantial (ie greater than 10% of the current rating of the winding).

Type test certificates for each of these tests will be accepted where it can be demonstrated that the transformer supplied is of a similar design to a previously type tested transformer.

9 Data Set associated with the Equipment

The following data shall be supplied by the manufacturer and maintained for the isolating transformers. This data will remain the property of Australian Rail Track Corporation.

9.1 Equipment Manuals

No Equipment Manual is required for Isolating Transformers.

9.2 Drawings and Information

The following drawings are required.

- Outline Drawing, with external dimensions
- Nameplate drawing
- Terminal arrangement drawing

9.3 Test Results

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

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

Type Tests certificates showing the results of each test shall be supplied in duplicate and electronically, in English, and maintained for the life of the equipment.

9.4 Life Cycle Costing

All the data and assumptions pertaining to the determination of the whole-of-life cost calculations shall be recorded, including transformer loss calculations as detailed in PDS 16.

9.5 Technical Schedule

The information listed in the technical schedule of Appendix A, supplied by the manufacturer, shall be maintained for each isolating transformer.

Appendix 1 Technical Schedule

The Tenderer, shall supply the information listed in this Technical Schedule at tender stage, for each isolating transformer.

A1.1 Transformer Details

Model/Type number …… .....

Type of transformer (eg Air cooled/cast resin, suitable for indoor or outdoor use or both) …… .....

IP Rating of transformer casing …… .....

Rated primary voltage ……..... V

Primary voltage tappings …… .....%

Rated secondary voltage …… V

Rated power ……..... ... kVA

Number of phases …… .....

Connection symbol …… .....

Maximum temperature rise of windings …… .....°C

Impedance voltage at rated current and 115°C (expressed as …… .....%
percentage of rated voltage) …… .....°C

Regulation, no-load to full-load at 115°C and unity power …… .....%
factor …… .....°C

Efficiency, full-load at 115°C and unity power factor …… .....%
……..... °C

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) …… .....%

Maximum value of in-rush current …… ..... A

Describe the design features that have been used to reduce the in-rush current and provide any recommendations to coordinate protection settings including choice of circuit breakers.

……..... …

..... ……

.....

No-load loss ..... Watts

Load loss ..... Watts

Type of core steel - (hot or cold rolled) .....

Brand of 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

(a) Limbs ..... T

(b) Yoke ..... T

Mean audible sound level (to AS2374.6-1994) ..... db

Type of material used for windings - (copper or aluminium) .....

Type of insulating material used for windings .....

Temperature class of winding insulation .....

Type and size of material used for protective screen .....

Terminal details .....

Core insulator details (manufacturer and catalogue No) .....

Describe the design enhancements for reducing the prospective damage due to lighting strikes and list any recommended external components.

.....
.....
.....

A1.2 Overall Dimensions

(a) Length ..... mm

(b) Width ..... mm

(c) Height ..... mm

A1.3 Mass

Mass of windings only .....kg

Mass of transformer core and windings only .....kg

Total mass of transformer .....kg

A1.4 Terminals

Power frequency voltage test, which the windings and terminals will withstand without puncture or flashover Tests in accordance with Clause 21 and Table 1 of AS 1265.

Primary terminals

(a) Lighting impulse withstand voltage ..... kVp

(b) Power frequency withstand voltage .....kVms

Secondary terminals

(a) Lighting impulse withstand voltage ..... kVp

(b) Power frequency withstand voltage ..... kVrms

Terminals, minimum clearance in air:

Between phases

(a) Primary ..... mm

(b) Secondary ..... mm

Phase to earth

(a) Primary ..... mm

(b) Secondary ..... mm

(c) Heat-shrink material provided on the terminals? (YES/NO).....

Describe the method to be used for securing the leads (clause 6.4 Internal Connections)

.....
.....
.....

A1.5 Reliability Data

Design Life ..... Years

Failure Modes (for Early, Normal Life, & Wear Out periods) a).....
b).....
c).....

Mean Operating Hours Between Failures: a).....
b).....
c).....

Time to Repair a).....

b).....

c).....

A1.6 Departure from Standard

Are there any departures from the requirements of this Standard? * YES / NO

Appendix 2 Request for Tender Checklist

Where this standard is used as the basis for procurement of isolating transformers for a particular location, in addition to the general requirements in this standard the following information will need to be supplied related to the particular site:

- Number of isolating transformers required;
- Power rating (preferred minimum value of 25 kVA);
- Number of phases (single or 3 phase);
- Indoor / Outdoor Use;
- Maximum enclosure size (height x width x depth);
- Type of mounting (wall or floor);
- Any site specific limitations on size or arrangement;
- Limitations due to access or transport;
- Any exceptional service conditions.