



Equipment Strategy For Earthing Transformers – Strategy

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1. Introduction

1.1 Purpose

Equipment Strategies document Powerlink's vision for equipment technologies, to provide both Powerlink and Suppliers with consistent planning and project management platforms for the life of the strategy.

The Equipment Strategy for Earthing Transformers has been developed with input from the teams of Asset Management, Engineering, Network Maintenance, and Procurement.

1.2 Scope

This document covers the equipment requirements for earthing transformers for use in new substations, substations requiring major refurbishment or rebuild, and existing substations requiring minor refurbishment, augmentation or maintenance replacement.

This scope is applicable for mineral oil filled, core type, distribution class transformers with rated voltages of 11kV, 22kV and 33kV. Secondary system control and protection philosophy strategies have not been addressed within the scope of this document.

The equipment strategy will be reviewed on a regular basis to incorporate changes at the most opportune time. This equipment strategy will have a life of five years with a significant review in the fourth year. During the review, technologies which have matured during the life of the strategy will be incorporated if they have merit in Powerlink's context.

1.3 References

Document code	Document title
AS 2374 1.2.2003	Standards Australia (2003) <i>Power Transformer Minimum Energy Performance Standard (MEPS) Requirements for Distribution Transformers</i>
AS/NZS 60076	Standards Australia (2014) <i>Power Transformers General</i>
AS1028	Standards Australia (1992) <i>Power reactors and earthing transformers</i>

1.4 Defined terms

Terms	Definition
SAP	Software package used for computerised maintenance management system and asset register

1.5 Monitoring and compliance

This equipment strategy will guide development of the technical specification. The success is monitored through regulatory information notice, annual reporting and SAP records review of installed equipment.

The success of this strategy is measured by monitoring life cycle costs as well as availability and service history associated with this equipment.

The minimum records required are:

- Technical specification
- Tender evaluation report

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- Period contract
- Purchase orders
- SAP equipment records
- Operation and Manufacturer Manual
- Nameplate details
- Factory Acceptance Test Report
- Short-Circuit design type test report

1.6 Risk management

The risks considered in the development of this strategy are:

- **Network Operations Risk** – risk related to the increased probability of damages caused by high ground fault currents leading to the unplanned network outages and their impact on customers and stakeholders.
- **Safety Risk** – risk associated with increased probability of exceeding allowable step and touch potential and increased probability of equipment damage resulting in fire or destruction causing injuries to personnel or public.
- **Environmental Risk** – related to oil leaks and potential of damages caused by fire.
- **Financial and Contractual Risk** – risk associated with potential equipment damage or inability to make warranty claims, request access to adequate technical support and spares, increased maintenance costs, additional capital investment costs.

2. Strategy

The document expresses Powerlink's vision in terms of the equipment performance requirements. It is not a detailed contract specification.

The Vision

The following are the main features of the Asset Management vision for earthing transformers:

- Annual operation and maintenance costs less than 0.1% of the equipment replacement value.
- Very high availability, reliability, and cost competitiveness on a whole of life basis.
- Minimal routine maintenance mainly based on visual inspection with additional testing/service requirements kept to minimal.
- No service interval for the life of the asset based on a 40 year life span.
- Focus on performance of the whole earthing transformer rather than design of individual elements or components.
- Reliability centred design principles incorporated.
- Safety in design principles incorporated.

Safety and the environment

The design, operation and maintenance of earthing transformers should align with the principles of Safety in Design and comply with Asset Management and legislative requirements for safety, environmental and cultural & world heritage compliance.

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- The probability of explosive failure should be as low as possible.
- Failure modes should be non-life threatening and as safe as possible for personnel working in the substation yard and the general community.
- Where possible, the use of porcelain in the transformer design should be excluded.
- Where possible, the use of oil should be kept to a minimum.
- Sound levels should be limited to an economically minimum standard without becoming a major design driver.
- Electromagnetic interference should be limited in accordance with the requirements of AS/NZS 2344 *Limits of Electromagnetic Interference from Overhead AC Powerlines and High Voltage Equipment Installations in the Frequency Range 0.15 to 1000MHz*.

Maintenance

Maintenance Level

Earthing transformers should be designed and manufactured to require minimal intrusive maintenance and a minimum of routine inspections in their life cycle. The preferred technical solution is adoption of “fit and forget” transformers requiring no maintenance for 40 years. Equipment is to have:

- Negligible maintenance requirements,
- Least number of moving parts,
- Simple but robust and reliable design,
- Low electrical & thermal stresses,
- Modularity of design,
- Free standing ground or pole mounted units are preferred with provision for adaptation to suit power transformer tank mounted arrangements (transformer tank mounted arrangement is to be avoided wherever possible), and
- “Plug and Play” termination connections suitable for cable connection to the power transformer are preferred and earthing transformers will not have cable boxes.

Equipment Monitoring

- Only local temperature monitoring is required, no remote indication.
- Internal CTs are required.
- Pressure relief devices required below oil level for the main tank (with alarm contact).
- Ready to use facility to take oil samples is required.

2.1 Projected use of equipment

Earthing transformers purchased in accordance with this equipment strategy will be:

- Used to provide an earth reference with earth fault current limiting capability,
- Supplied with a primary voltage of 11kV, 22Kv or 33kV,
- Be supplied without secondary or auxiliary windings,

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- Procured in a pole or ground mounted arrangement with provision to be adapted to a power transformer tank mounted arrangement if required and with aerial or plug in cable connection bushings (aerial being preferred connection).

2.2 Design philosophy

2.2.1 Design requirements

The key elements of the design philosophy for an earthing transformer are:

1. Earthing transformer short time neutral current rating of 2475 Amps for 2 seconds for 11kV system or 8660 Amps for 2 seconds for 22kV system and 2858 Amps for 2 seconds for 33kV system.
2. Earthing transformer continuous neutral current rating of 150Amps for 11kV system and 120 Amps for 22kV and 33kV systems.
3. Connection Group ZN interconnected star.
4. Zero sequence impedance as defined by the transformer specification.
5. Supplied with voltage surge protection.
6. The flux density should be such that the core does not saturate during a through fault and a constant zero sequence impedance is maintained under through fault conditions.
7. To be of a proven short-circuit tested design.
8. Naturally cooled.
9. Only local temperature monitoring is required, no remote indication.
10. Internal CTs are required.
11. Pressure relief devices required below oil level for the main tank (with alarm contact).
12. The main tank shall be hermetically sealed.

2.2.2 Service environment

Powerlink substations may be located in areas that experience a hot, humid summer, high average temperatures, high or very high numbers of rainfall days and high or very high rainfall. These conditions combined with the network's proximity to the coast produce high corrosion rates for exposed components that are not UV stabilised or adequately protected from the environment.

The network is also located in areas of high thunder-days with the potential to expose high voltage plant to hazardous voltages which may impact on equipment and network performance.

In addition the design and construction have to be suitable for installation in cyclonic areas with high wind speeds.

2.2.3 Operating context

The operating context for Powerlink earthing transformers will be;

- Testing and operating performance to meet the requirements of AS/NZS 60076 / AS 2374 / AS 1028.

2.3 Technologies traditionally used by Powerlink

Powerlink uses core type, mineral oil filled, distribution class transformers in substation earthing transformer applications.

Powerlink has Pre-Approved suppliers of bushings, oil, conductors, core steel, and pressure relief valves. The list is regularly reviewed and updated based on engineering evaluation and in-service experience.

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2.4 Technologies available now

The technologies available for the manufacture of earthing transformers are mature and have been refined and proven over many years. Design changes to incorporate improvements in technology can be short circuit tested to prove their performance under fault conditions. Distribution transformer manufacturers have an optimised range of designs typically aligned with current utility period contracts.

Earthing transformers are usually manufactured as oil immersed transformers with a rectangular core design. Oil types can include mineral, vegetable, synthetic and silicon fluid. Windings are manufactured from aluminium or copper conductor that can be enamel or paper covered or bare. Earthing transformers can be individually packaged or may be supplied in the form of a supplementary winding on an auxiliary or power transformer.

The earthing transformer mounting style can be pole mount, ground mount or tank mounted on a larger transformer. A range of sealing arrangements and surface preparation methods & coatings are available in an effort to delay the onset of transformer defects associated with oil leaks and surface corrosion which may impact on the expected transformer life span.

Earthing transformers will be manufactured to meet the requirements of AS/NZS 60076 / AS2374 / AS1028 as applicable. In accordance with Government legislation, Powerlink requires distribution class transformers to meet the requirements of AS2374 1.2.2003 *Power Transformer Minimum Energy Performance Standard (MEPS) Requirements for Distribution Transformers*.

The Powerlink Specification for Earthing Transformers specifies additional requirements aimed to ensure that reliable, low maintenance devices are purchased.

2.5 Equipment strategy elements

- The Asset Management vision in operating and maintaining transformers is that earthing transformers include the following main features:
 - Mineral oil immersed,
 - Hermetically sealed and naturally cooled,
 - Low loss, non-amorphous steel core,
 - Steel tank,
 - Pressure relief device fitted below minimum oil level,
 - Manufactured by a reputable and proven supplier,
 - Provision of internal toroidal current transformers,
 - Provision for oil sampling,
 - Termination connections suitable for cable connection are preferred.

Technological advances in sealing arrangements and surface preparation and coatings are to be pursued opportunistically where possible to delay the onset of transformer defects associated with oil leaks and surface corrosion.

Technological advances in winding design arrangements are to be pursued opportunistically where possible to delay the premature failure of the windings associated with repetitive through faults.

All transformer components and materials including the active part, ancillary equipment, oil, bushings and tank / enclosure must strictly conform to the requirements detailed in the technical specification.

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2.6 Concurrent investigations:

Continuous technological advancements in the manufacture and procurement of transformer raw materials (steel, conductor, insulation, and oil), sealing arrangements, surface coatings, manufacturing tooling / methods and design / modelling tools are prevalent throughout the industry.

It is imperative that close examination of the available technologies be made to ensure that they meet Powerlink requirements and adopt the most appropriate technology.

The Equipment Strategy itself is to be reviewed in four years to leverage the evolving technological advancements and to include service experience.

2.7 Summary

This equipment strategy will be adopted for all future requirements for earthing transformers, unless otherwise approved for specific and explicit reasons, so as to achieve the minimum whole of life cost as well as ensuring the benefits of ease of commissioning, operating and maintenance are obtained.

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