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

The Equipment Strategy for Auxiliary 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 auxiliary 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, off-circuit regulated, distribution class transformers with primary rated voltages of 11kV, 19.1kV and 33kV. Secondary system control and protection philosophy and strategies have not been addressed within the scope of this document.

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/NZS 60076	Standards Australia (2014) *Power Transformers*
AS/NZS 2374	Standards Australia (2003) *Power transformers - Minimum Energy Performance Standard (MEPS) requirements for distribution transformers*
AS/NZS 2344	Standards Australia (1997) *Limits of Electromagnetic Interference from Overhead AC Powerlines and High Voltage Equipment Installations in the Frequency Range of 0.15 to 1000 MHz*

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 associated with this equipment as well as availability and service history.

The minimum records required are:

- Technical specification
- Tender evaluation report
- Period contract
- Purchase orders
- SAP equipment records
- Operation and Manufacturer Manual
- Nameplate details
- Factory Acceptance Test Report

1.6 Risk management

The risks considered in the development of this strategy are:

- **Financial and Contractual Risk & Network Operations Risk** – risks related to the loss of AC supply resulting in need to have supply either from diesel generator or battery bank. These can support protection system and circuit breaker motors only for a limited period of time. Then there is a requirement to send people to site or switch off substation, resulting in load or generation loss.
    - **In addition there are financial risks** associated with the inability to make warranty claims, request access to adequate technical support and spares, increased maintenance costs, additional capital investment costs.
- **Safety Risk** – risks associated with malfunction of auxiliary transformer or its bushings resulting in fire or injury caused by disintegrated parts in case of catastrophic failures.
- **Environmental Risk** – related to gas and oil leaks.

2. Strategy

The Asset Management vision and the Procurement Policy drive all equipment strategy documents. The following are the main features of the Asset Management vision for auxiliary transformers:

Vision

- Annual operation and maintenance costs less than 0.1% of the auxiliary transformer replacement asset value.
- High availability, reliability, and cost competitiveness on a whole of life basis.
- No service interval for the life of the asset based on a 45 year life span.
- Focus on performance of the whole auxiliary transformer installation 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 auxiliary transformers should align with the principles of Safety In Design and comply with the Asset Management and legislative requirements for safety, environmental and cultural & world heritage compliance.

- The probability of catastrophic failure should be kept 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 should be excluded.
- Where possible, the use of oil in the transformer design 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*.
- Suitable for use in cyclonic areas.

Maintenance

- Equipment Monitoring – limited to the information from current transformers used for protection.
- Maintenance Level - equipment is to have:
    - Auxiliary transformers should be designed and manufactured to require minimal intrusive maintenance and a minimum of routine inspections in their life cycle (not more frequent than once a year). The preferred technical solution is adoption of “fit and forget” transformers requiring no maintenance for 45 years.
    - Negligible maintenance requirements,
    - Least number of moving parts,
    - Simple but robust and reliable design,
    - Low electrical and thermal stresses,
    - Modularity of design,
    - Easy to use rotatable spare with minimum down time on site.

2.1 Projected use of equipment

Auxiliary transformers purchased under this equipment strategy will be;

- Used to provide station services 400V AC, 50Hz supply.
- Supplied with a primary voltage of 11kV, 19.1kV or 33kV.
- Supplied with a capacity rating of 315kVA or 500kVA,
- Procured in a pole mounted arrangement and low voltage isolation point with drop out fuses operable from ground level.

2.2 Design philosophy

2.2.1 Design Requirements

The key elements of the design philosophy for substation AC control are

1. The AC change-over board bus voltage will be controlled to operate between 1.0pu to 1.1pu (400V to 440V) and the auxiliary transformer secondary voltage range will be selected via the off-circuit tapping switch to meet this requirement.
2. The upper voltage threshold of 1.1pu at the AC Changeover Board is based on the maximum 1.1pu system voltage at the high voltage terminal of the auxiliary transformer and little or no-load at the auxiliary transformer low voltage terminal regardless of the supply source.
3. The lower voltage threshold of 1.0pu at the AC Changeover Board is based on the minimum 1.0pu system voltage at the high voltage terminal of the auxiliary transformer and maximum load at the auxiliary transformer low voltage terminal regardless of the supply source.
4. It is assumed that the auxiliary transformer connection to the AC Changeover Board bus offers negligible regulation.
5. The standard auxiliary transformer capacity ratings will either be 315kVA or 500kVA to suit the standard AC Changeover Board current ratings of 400Amps and 630Amps respectively.
6. The auxiliary transformer voltage will be tapped on the high voltage winding and will have a tapping range of +10% to -5% of the HV voltage in 6 off 2.5% steps affected by an off-circuit tap switch.
7. There will be no more than a maximum of 7% voltage drop between all points of utilisation and the AC change-over board bus.
8. No oil temperature monitoring is considered necessary.
9. Internal CTs are required.
10. Pressure relief devices are not considered necessary.
11. The main tank shall be hermetically sealed.
12. There will be provisions made to take oil sample without need to install additional parts (valves, for example).

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. It is envisaged that the auxiliary transformers will be installed outdoors and exposed to these elements.

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, as well as high winds (cyclonic areas).

2.2.3 Operating Context

The operating context for Powerlink auxiliary transformers will be:

1. Testing and operating performance to meet the requirements of AS/NZS 60076 and AS/NZS 2374. The transformer short circuit strength will be determined by the transformer impedance only with a maximum fault clearing time of 2 seconds and system impedance will be neglected.
2. Pole mounted arrangements that utilise overhead air connections are the only acceptable option, based on the experience with other arrangements (such as pad mount or integrated substation arrangements that utilising cable connections). If there are valid reasons to use a different arrangement, these will have to be recommended and approved.

2.3 Technologies used by Powerlink

Powerlink uses core type, mineral oil filled distribution class transformers in substation auxiliary supply applications and prefers to purchase off shelf products wherever possible.

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.

2.4 Technologies available now

The technologies available for the manufacture of auxiliary transformers are mature and have been refined and proven over many years. Distribution transformer manufacturers have an optimised range of designs typically aligned with current utility period contracts.

Auxiliary transformers can be manufactured as dry type or oil immersed transformers with either rectangular or wound 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. Transformers can be individually packaged or may be supplied in the form of a supplementary auxiliary winding on a power transformer or reactor.

The transformer mounting style can be pole mount, ground mount or a pad mounted integrated transformer arrangement complete with high and/or low voltage switchgear. 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.

Auxiliary transformers will be manufactured to meet the requirements of AS/NZS 60076 and AS/NZS 2374. In line with Government legislation, Powerlink expects all auxiliary transformer manufacturers to meet the requirements of AS/NZS 23741.2.2003 *Power Transformer Minimum Energy Performance Standard (MEPS) Requirements for Distribution Transformers*.

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

2.5 Equipment strategy elements

1. The Asset Management vision in operating and maintaining transformers is the major criteria in this strategy.
2. Auxiliary transformers shall include the following main features:
    - Mineral oil immersed,
    - Hermetically sealed,
    - Low loss, non-amorphous steel core,
    - Steel tank,
    - Off-circuit tap switch with +10% to -5% of the HV voltage in 6 off 2.5% steps,
    - Manufactured by a reputable and proven supplier, and
    - Where possible, gaskets are to be below oil level to assist in detecting future leaks in the hermetic seal.

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

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

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. Each time a new period contract is required, it is desirable that a review of the previous purchase is undertaken to correct any deficiencies.

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

2.7 Summary

This equipment strategy will be adopted for all future requirements for auxiliary transformers, unless separate approval is obtained 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.