Government of South Australia
Department for Infrastructure and Transport

Auxiliary Supply Transformer

Engineering Specification

Rail Commissioner

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Note: This engineering specification is based on and supersedes Rail Revitalisation specification *AR-MW-PM-SPE-02170320 Auxiliary Supply Transformer Equipment Specification.*

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1. Introduction

The Department of Infrastructure and Transport (DIT) owns the Adelaide Metropolitan Passenger Rail Network (AMPRN) currently operated and maintained under the Rail Accreditation of third party. This specification lists the technical requirements for the Auxiliary Supply Transformers (ASTs) for use on the AMPRN Electrified Rail Network.

1.1. System Assurance

This engineering specification is produced to ensure that each technical requirement is:

1. Unique;
2. Unambiguous;
3. Understandable;
4. Achievable (feasible);
5. Traceable;
6. Complete;
7. Correct;
8. Consistent;
9. Concise;
10. Design independent;
11. Verifiable

2. Scope

The specification applies to Auxiliary Supply Transformers.

This document is to be read in conjunction with the documents listed in Section 3.

3. References

- AS/NZS 60076 Power transformers
- AS/NZS 60076.10 Power transformers, Part 10: Determination of sound levels
- AS 60296 Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
- AS 1319 Safety signs for the occupational environment
- AR-EL-STD-0102 Guidelines for the protective provisions related to electrical earthing and bonding for The Adelaide metro electrified rail network

4. Acronyms

ACRONYM	FULL NAME
AMPRN	Adelaide Metropolitan Passenger Rail Network
AST	Auxiliary Supply Transformer

5. Requirements

5.1. General

1. Auxiliary Supply Transformers (ASTs) shall comply with the requirements outlined in this specification.

2. ASTs shall be pad mounted.

3. This design and construction of the ASTs should be standardised to achieve interchangeability.

   All like equipment shall be interchangeable as a whole or in part.

   Any change or replacement shall not reduce the capability of the equipment to conform to the requirements of this Specification.

5.2. Electrical Data

1. The AST shall be 50 Hz single phase, of the Oil Natural Air Natural (ONAN) type and be suitable for outdoor pad mounted installations.

2. The nominal primary voltage of the AST shall be 25 kV producing a secondary voltage of 415 V. The AST shall be rated at the following preferred capacities; 50 kVA.

3. The primary and secondary windings including any bushings shall meet the following insulation voltages.

   a) Primary Impulse Voltage: 200 kV
   b) Primary Separate Source Voltage: 95 kV for 1 minute
   c) Secondary Impulse Voltage: 20 kV
   d) Secondary Separate Source Voltage: 10 kV for 1 minute

4. The impedance of the AST primary, with the secondary short-circuited and the load losses at rated current shall not exceed the values given below.

   a) Rated Current: 120 A (r.m.s)

   b) Maximum 50 Hz Impedance: 3.9%

5. The AST shall be designed to ensure that the saturation flux density is not exceeded during operating conditions.

5.3. Cable Compartments

1. ASTs shall incorporate separate HV and LV cable compartments. The cable compartments shall be of a design suitable for terminating the HV supply and LV feeder cables. The disposition of all bushing and pal points within the cable compartment shall such as to allow ease of connection of the cables to these points.

2. The compartments shall be of suitable construction to ensure personnel standing adjacent to the AST enclosure are not put at any risk

3. All cables shall enter cable compartments from below via ducts incorporated into the pad’s foundation.

4. Support of the cables shall be provided in such a manner that the cable insulation is not degraded by virtue of the stress placed on the AST terminations.

5.4. Connections

5.4.1. Primary Connections

1. The primary HV AST connections within the HV compartment shall be palms or other suitable means for terminating the cable connections from the 25 kV supply and return conductors and in addition, they shall provide a point of attachment for the clamps of portable Earthing leads for Earthing during maintenance. The cable connections shall be such that there are no exposed live parts within the enclosure.

5.4.2. Secondary Connections

1. The Secondary LV AST connections within the LV compartment shall be by palms or other suitable means for terminating the cable connections to the 415/240 V feeder cable conductors and, in addition, they shall provide a point of attachment for the clamps of portable Earthing leads for Earthing during maintenance.

5.5. Clearance

1. ASTs shall be mounted within the enclosure to achieve a minimum air clearance to other components:

    a) Not less than 480 mm from metal energised at 25 kV
    b) Not less than 150 mm from metal energised at return conductor voltage.

5.6. Earthing

1. The AST pad shall require a local buried Earthing system to comply with the requirements of AR-EL-STD-0102 Earth Bar
    1. An equipment Earth Bar shall be mounted on the inside of the enclosure on standoffs to facilitate termination of lugged cables. The equipment Earth Bar shall have a minimum continuous rating of 1000 A and a fault rating of 6 kA for 3 seconds. The equipment Earth Bar shall be carried through to all compartments requiring an Earth connection.

    2. The equipment Earth Bar shall be sized to accommodate a bond from the Traction Earth system, a bond from the pad Earthing system, duplicate bonds to the AST tank, duplicate bonds to the enclosure, and connection to the primary neutral terminal.

    3. Provision shall be made for connection of each cable screen to suitable Earth terminal.

5.7. Construction Data

1. ASTs shall be either of the sealed tank type, mineral oil or synthetic liquid filled or of the free breathing type, mineral oil filled.

2. The ASTs shall be of an outdoor type suitable for a pad mounted arrangement having an integral base frame in an overall self bunded and weatherproof enclosure. The pad shall be located at least 200 mm above the finished ballast level and be designed to ensure that no water can pool against the AST steelwork.

5.8. Noise Emission

1. The ASTs shall operate with a level of noise and vibration not exceeding 56 dB(A) when measured in accordance with AS 600076.10 when operating at peak rated current.

5.9. Types

5.9.1. Sealed Types

1. The internal pressure, in service, of sealed-tank ASTs shall not exceed 0.35 bar. The expansion space above the insulation fluid level shall be filled with dry inert gas. Sealed-tank type ASTs shall be equipped with a pressure bursting disc with flag indicator visible from ground level.

2. Sealed-tank type ASTs shall be delivered filled with insulating fluid to normal level with a further 5 litres added to allow for sampling.

5.9.2. Free Breathing Type

1. Free breathing type ASTs shall incorporate an expansion tank (conservator) and a desiccant filled type breather to ensure only dry air is in contact with the insulating fluid.

2. The breather shall be fitted such that its base is just above the base of the AST. The bottom end of the breather pipe shall be robustly supported and its termination at the breather shall be suitable for the fitting of an extension tube to enable the breather to be reached from ground level.

3. ASTs shall be delivered filled with insulation fluid to normal level. Any additional oil which may be required for topping up free breathing ASTs shall be delivered in sealed containers with the AST.

5.10. Fittings

1. ASTs shall be supplied with the following standard fittings and features:

    a) metallic rating and connection plates
    b) means of identification of each main terminal
    c) provision for slinging and uplifting by crane and securing for transport
    d) provision for draining, sampling, filling and filtering of oil
    e) tank earthing terminals on diagonally opposite corners
    f) over-pressure relief device with visual indicator and alarm contacts
    g) oil level indication, marked to indicate normal level at 25°C.

2. Any lifting accessories included shall be marked with their safe working load and provided with valid certificates. They shall be removable for testing.

3. Visual indicators (oil and pressure relief valve), shall be positioned so that they can be observed without opening the doors of the enclosure.

4. The insulating of oil filling and sampling points shall be positioned to be accessible for use without the removal of the outer enclosure.

5.11. AST Tanks

1. AST tanks and covers, which are exposed to the weather, shall be so constructed as to prevent the accumulation of moisture thereon. Covers may be welded to a flange on the tank top to form a sealed joint, or may be bolted using a high quality gasket to seal the joint.

2. All AST tanks, covers and flanges shall be of sufficient rigidity to prevent distortion. To ensure sufficient rigidity of the tank, continuously welded tank stiffeners or gussets shall be provided where appropriate. Corrugated transformer tanks shall not be employed.

3. The centre lines, the centre of gravity and oil level to just cover the top of the windings shall be marked on the outside of the tank. These markings shall be permanent and shall not deteriorate with time.

4. AST tanks shall be capable of withstanding full vacuum without permanent distortion and shall be constructed so as to withstand all the stresses likely to be encountered during transport, erection and service.

5.12. Gasket Seal

1. Gasket seals shall be constructed, as far as practicable, to ensure that leakage does not occur during the service life of the AST. If leakage does occur the seal shall be repairable. Where a seal must be broken to gain access to equipment, restoration to its original sealing performance shall be practicable.

5.13. Radiators

1. Removable AST radiators are preferred. These shall be connected to the tank via tamperproof oil shut-off valves giving reliable external visual indication of fully OPEN and fully CLOSED positions. These valves SHALL allow the radiator unit(s) to be removable without lowering the insulating fluid level in the tank.

2. Each radiator bank shall be fitted with a means of venting trapped air and draining insulating fluid prior to removal. Radiators shall be designed and positioned so as to prevent the accumulation of moisture but allow inspection and the application of a protective finish without their removal from the AST tank.

5.14. Enclosure

1. The AST weatherproof enclosure shall be designed to prove:

    a) mechanical protection to reduce the risk of damage due to vandalism.
    b) convenient access to the terminals for the connection of cables
    c) convenient access for all necessary maintenance activities
    d) free air movement around the unit to ensure that the specified maximum temperature rise is not exceeded.

2. Bolted removable covers or lockable doors shall be provided for maintenance and inspection; these shall comply with all relevant regulations pertaining to access to High Voltage chambers from a public access area. Guillotine style doors are not acceptable.

5.15. Insulating Oil

1. The interior of an oil filled chamber on the AST or heat exchanger shall be cleaned of all scale or rust by blast-cleaning or other approved method and given an oil resistant coating prior to being filled with oil.

2. ASTs shall be filled to their normal energised operating levels with either inhibited mineral oil or synthetic liquid.

3. Mineral oil shall comply with AS 1767 and be certified to be free of polychlorinated biphenyls.

4. Synthetic liquids shall have suitable electrical insulating properties, have a flash point of not less than 2150°C, and a fire point of greater than 300°C. The liquid shall be of minimum toxicity and shall be certified to be free of polychlorinated biphenyls.

5. The supplier shall nominate the brand and grade of oil to be supplied with the ASTs.

5.16. Finish

1. Enclosures, equipment metalwork, components, accessories, fittings and fastenings (e.g. nuts, bolts, washers etc.) shall be protected against corrosion, including galvanic corrosion of dissimilar materials, for the life of the equipment at the specified location.

2. All external nuts and bolts and washers shall be of non-ferrous metal or of steel galvanised and shall not require painting.

3. External surfaces of the ASTs enclosure and tanks may be finished in accordance with the manufacturers' standard procedure provide such procedures are in accordance with the best modern practice and can achieve the finish and longevity of the coatings required.

4. The finish used shall be capable of being restored to its full protective standard on site. Routine inspection of areas susceptible to corrosion shall be made possible without the need to remove the equipment from service.

5. Damage to paintwork incurred during transport shall be made good by thoroughly cleaning the damaged area and using the same number of paint coats applied before the damage was caused.

5.17. Logistic Data

5.17.1. Reliability

1. The design of the ASTs should be such that they operate maintenance free and reliably between the designated inspection periods.

2. The Supplier shall nominate the mean Time Between Failure (MTBF) for reliability and incorporate this into the calculation of the device availability.

3. For equipment where insufficient historical data is available, the Supplier shall state the methods used to determine Reliability performance.

5.17.2. Maintainability

1. The equipment shall be designed for Minimum maintenance.

2. The Supplier shall nominate the Mean Time To Repair (MTTR) for Maintainability and incorporate this values into the calculation of the device availability.

3. The Supplier shall provide and Equipment Maintenance Plan for the ASTs necessary to meet the nominate service life Reliability.

4. Access for maintenance will be with the AST under isolation and/or de-energised.

5.17.3. Availability

1. The Availability (including MTBF and MTTR) of ASTs shall be declared and incorporated in the calculation of the system Availability to meet requirements of the Installation Specification.

5.17.4. Service Life

1. The equipment, including components but excluding consumable items, shall be capable of complying with the requirements of this document for

at least 30 years without deterioration in Reliability and Preventive Maintenance in excess of that nominated in 'Maintainability'.

5.17.5. Identification

1. Each AST shall be provided with a rating plate containing the relevant information required by AS/NZS 60076.

5.17.6. Labels

1. All access doors to High Voltage compartments or equipment shall be provided with durable 'Danger High Voltage' warning labels that comply with Standard AS1319.

5.17.7. Spare Parts List

1. The Supplier is to supply as full list in the AST O&M Manual of manufacturer's recommended spares for normal maintenance and repair purposed of Auxiliary Supply Transformers in continuous operation, identifying;
   a) part numbers
   b) catalogue numbers
   c) supplier
   d) approximate lead time (at time of purchase)

2. Where possible an exploded view of any components with multiple parts is to be supplied to aid identification.

5.17.8. Weight

1. The Supplier shall provide the total weight of an AST when filled with oil as nominated on the data sheet.

5.17.9. Special Tools and Equipment

1. The supplier shall advise of any special tools and test equipment required for the installation, operation and maintenance of the equipment.

2. To enable the equipment to be operated and maintained, two sets of special tools and test/inspection equipment shall be provided including oil sampling, testing and filtering devices.

5.18. Factory Tests

5.18.1. Factory Tests

1. The equipment and components or sub-assemblies shall be made available for routine inspections during assembly and final inspection on completion at the manufacturer's Works.

2. Valid calibration certificates, from an accredited calibration service, shall be made available for inspection for all test equipment prior to the performance of any testings.

5.18.2. Routine Tests

1. The ASTs and their associated components or sub-assemblies shall be made available for final inspection upon completion. The equipment shall be subject to the following routine tests, in accordance with AS/NZS 60076 prior to dispatch:

   a) separate source AC rated frequency withstand voltage test
   b) short duration induced AC withstand voltage tests, including measurement of partial discharge

c) measurement of winding resistance
d) winding ration
e) measurement of no-load loss and current
f) measurement of full load loss
g) measurement of short circuit impedance
h) measurement of insulation resistance to Earth of the windings
i) Dissolved Gas Analysis (DGA) and oil property tests
j) function tests including simulated operation of all external devices
k) additional tests specified in the System Design Specification.

5.18.3. Type Tests

1. Type Tests shall be carried out on one sample of each size and rating of AST in accordance with the relevant Australian Standard, European Standard, International Standard or Nation Standard.

2. The equipment shall be subject to Type Tests in accordance with AS/NZS 60076 including the following:

   a) temperature rise tests, suitable to verify the specified load cycle
   b) lightning impulse tests to the primary winding
   c) short circuit tests
   d) noise level tests

3. Test equipment used for measuring test values shall be calibrated and have valid calibration certificates from an accredited calibration service.

4. Test certificates shall be provided in duplicate and shall include both test results and all other relevant data.

5.19. Documentation

1. The supplier is to supply the following design documentation:
   c) general arrangement of the AST*****
   d) section drawings of AST and its enclosure
   e) drawings of equipment foundation requirements with loadings
   f) tank design drawings
   g) transportation dimension drawing (including component weights)
   h) insulation assemblies, core and coil arrangement drawing(s).
   i) schematic/circuit diagrams*****
   j) name and rating plates*****
   k) details of HV and LV cable boxes and terminations

*****Note: These documents to be provided with asset numbers incorporated into test certificates and drawings. Where applicable these should reference typical or generic drawings and Type Test certificates.

2. The Supplier shall provide two complete hard copy sets and electronic files of operating and maintenance manuals for each type AST. The manuals shall include adequate information relating to individual items of equipment to assist the Principal in becoming familiar with the plant.

3. In addition to any other details identified in the Installation Specification, Operating and Maintenance manuals shall include, but not be limited to, the following:

   a) Technical Summary outlining the transformer's key parameters
   b) The manufacture/type/model/ratings of all auxiliary and ancillary items and weights.

c) Detailed diagrams and exploded drawings of plan and ancillaries.
d) Complete sets of preliminary erection, operating, and maintenance instructions.

   In Particular comprehensive and detailed instructions on:

   (i) nitrogen and dry air equipment
   (ii) handling and installation of bushings and draw leads
   (iii) vacuum treatment, oil filling, and maintenance of oil
   (iv) full details of precautions and procedures to be following for the application of vacuum
   (v) specific requirements for blanking off plates
   (vi) pressure equalisation to be applied for isolatable sections of the cooling system conservator
   (vii) all inspections and test required during erection and prior to commissioning the plant.

e) Equipment maintenance plan defining:
   (i) methodologies and frequency of all Preventative Maintenance to achieve the design life
   (ii) methodology of key Corrective Maintenance tasks.
f) A complete list of handling equipment, tools, and test equipment.
g) Provision to include the factory and site test reports and manufacture's test reports for all other purchased items supplied as part of the transformer.
h) Full details for the calibration of oil and winding temperature thermometers (if applicable).
i) Specification sheets, and the setting and testing guides for the winding and oil temperature thermometers and the gas actuated relays (if applicable).
j) Spare parts listing.

6. Bibliography

• TP1-DOC-000390 Overhead wiring system requirements for the 25kV electrified train network