ElectraNet

Substation LV AC Supplies

Document Number: 1-11-FR-04

VERSION 1.0 June 2018

This functional requirements document is in line with the organisation's 1-11-ACS-04 LV AC Supplies Asset Class Strategy

Contents

1. Definitions

In this document the following words and expressions will have the following meanings:

Item	Meaning
AC	Alternating Current.
ADM	Asset Design Manual.
AS	Australian Standard, as publication by Standards Australia (Standards Association of Australia).
COB	Changeover Board. The substation Main Switchboard, containing the substation LV supply changeover system.
Contractor	A contractor engaged by ElectraNet or a Customer (including a third party IUSA provider engaged by a Customer or any contractor engaged by such third party IUSA provider) to perform any design, construction or related services in relation to assets or infrastructure which are connected, or to be connected, to ElectraNet's transmission network
Customer	A party who wants to establish or modify a connection to ElectraNet's transmission network but does not include a third party IUSA provider
DC	Direct Current.
DG	Diesel Generator.
HRC Fuse	High Rupture Capacity Fuse.
HV	High Voltage, as defined by AS 2067 (i.e. AC voltages exceeding 1,000 V).
IEC	International Electrotechnical Commission.
ITP	Inspection and Test Plan.
kA	kilo Amps.
kV	kilo Volts.
kVA	kilo Volt Amps.
LV	Low Voltage, as defined by AS/NZS 3000 (i.e. AC voltages equal to or below 1,000 V).
MSB or Main Switchboard	Main Switchboard, as defined by AS/NZS 3000. See also COB.
OLTC	On Load Tap Changer.
PVT	Power Voltage Transformer.
SAPN	South Australian Power Networks.
SCADA	Supervisory control and data acquisition.

Item	Meaning
SF6	Sulphur Hexafluoride (a gas with excellent insulating properties).
SMSC	System Monitoring and Switching Centre (“System Control”).
ST	Station Transformer.
Standard Drawing	A drawing developed by ElectraNet as a complete design to be used for construction. Standard Drawings are not intended to be revised or renumbered.
SWER	Single Wire Earth Return
Template Drawing	A drawing developed by ElectraNet as the basis for design. Template Drawings are intended to be revised and renumbered as required to complete the design.
third party IUSA	Has the same meaning as defined in the National Electricity Rules

2. Purpose and Scope

The purpose of this document is to provide the functional requirements for the design and construction requirements for the substation auxiliary AC Supplies Systems, more specifically how the auxiliary AC supplies are to be derived as well as the redundancy requirements.

This document will define the ElectraNet acceptable sources for the auxiliary supplies, the number required for various substation applications, the type of plant and equipment to be used to derive these sources as well the performance requirements for the LV system.

This document will describe the high level requirements of the auxiliary transformers, diesel generators and power voltage transformers used to provide the auxiliary supply for the ElectraNet's substations.

This document will not cover the detailed technical requirements for the individual pieces of equipment.

This document will not cover the detailed functional requirements for the AC COB and the associated sub-boards. This will be available in document 1-11-FR-05.

This document will describe the high level requirements for sizing and rating the downstream 400/230 V auxiliary supply distribution system.

The normal LV AC supply used by ElectraNet is 400 V for three phase loads and 230 V for single phase loads.

3. Referenced Documents

The table below lists applicable legislations, standards, referenced documents:

Legislation	
SAEA	Electricity Act 1996 (SA)
NER	National Electricity Rules
ETC	Electricity Transmission Code TC/08
SAA HB59:1994	Ergonomics - The human factor A practical approach to work systems design
ESCOSA	High Voltage Switching Manual
International Standards	
AS/ISO 1000:1998	The international system of units (SI) and its applications.
AS 2067 :2016	Substations and high voltage installations exceeding 1 kV AC.
AS/NZS 3000:2007	Electrical Installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3010:2017	Electrical Installations - Generating Sets
AS 3439:2002	AC Board Segregation Form
AS/NZS 5000.1:2005 (R2017)	Electric cables – Polymeric insulated
AS/NZS 5000.3:2003 (R2017)	Electric cables for control and protection circuits – Multicore control cables.
AS 60038:2012	Standard voltages
AS/NZS 61439.1:2016	Low-voltage switchgear and controlgear assemblies Part 1: General rules (IEC 61439-1, Ed. 2.0 (2011), MOD)
AS/NZS 61439.2:2016	Low-voltage switchgear and controlgear assemblies Part 2: Power switchgear and controlgear assemblies (IEC 61439-2, Ed. 2.0 (2011), MOD)
ElectraNet's Documentation	
1-11-FR-01	Substation Earthing
1-11-FR-05	Substation LV AC Boards
1-11-FR-06	Substation LV Cables, Conduits, Trenches and Pits
1-11-FR-07	Substation HV Cables

4. LV AC Supplies

4.1 General Requirements

4.1.1.1 The substation LV AC supplies must be derived from the following AC sources:

a) From a Loadable tertiary winding of a power transformer and an associated station transformer;

b) From the LV side of a power transformer and an associated station transformer;

c) From a street supply from a three phase distribution feeder associated distribution transformer;

d) From loadable power voltage transformers within the substation; and

e) From diesel generators.

4.1.1.2 A minimum of two independent sources of 400 V AC supply to supply the substation, designated as Supply 1 and Supply 2.

4.1.1.3 The supplies must be capable of continuously supplying 100% of the site AC load.

4.1.1.4 The AC system design must include the connection of a portable diesel generator during emergency situations when both Supply 1 and Supply 2 are lost.

4.1.1.5 If two local distribution supplies are utilised, they must either originate from different substations or at least be derived from two independent buses from the same substation.

4.1.1.6 The use of SWER distribution feeders is not acceptable as a source of auxiliary supply.

4.1.1.7 Critical substations must have in addition a permanently installed standby supply in the form of a diesel generator.

4.1.1.8 The following substations are considered critical sites and must have installed a 'standby' diesel generator sized to meet the essential bus load:

a) All substations included in the main grid 275 kV system;

b) All substations that are included in the power flow to the Heywood interconnector;

c) Sites supplying greater than 100 MW; and

d) Sites as being identified as critical in project specific documentation.

4.1.1.9 Segregation and redundancy built in to the AC supply system.

4.1.1.10 AC Supplies systems must be designed to meet the ultimate layout load requirements of the substation.

4.1.1.11 Where diesel generators are installed as the standby supply, they must be sized to supply all of the essential loads within the substation.

4.1.1.12 The main AC Changeover board must be:

a) Designed with three ports (Supply 1, Supply 2, and additional port for either a permanent or temporary diesel generator connection);

b) Designed as an automatic change over scheme, to allow for load transfer from one incoming supply to another, inclusive of diesel generator supplies where permanently installed; and

c) The auto changeover scheme must also cater for reverting to either Supply 1 or Supply 2 once either supply becomes available and will disconnect the diesel generator, including shutting down permanently connected diesel generators.

4.1.1.13 AC sub-boards are required to provide supply to loads located further away in the yard or other buildings within the same substation.

4.1.1.14 Alarms and indications are to be designed to align with the ElectraNet's latest alarming requirements. Failure of any AC Incomer supplies must provide station alarm indication and SCADA operations.

4.1.1.15 The target design life is 40 years for the station transformers, AC changeover board and main distribution board.

4.1.1.16 In determining which supply options will be used the following must be considered:

a) Reliability;

b) Initial Cost;

c) Operating and maintenance costs;

d) Voltage rise during faults between the substation and externally derived supplies; and

e) Different bus sections must be used when possible.

4.2 Safety and Regulatory Requirements

4.2.1.1 The LV AC supplies must comply with the SAEA and all the relevant legislation and regulations as referenced by the SAEA.

4.2.1.2 LV AC Supply systems must be designed in accordance with AS 3000 and integrated into the substation in accordance with AS 2067 (as per the SAEA).

4.2.1.3 Compliance with ESCOSA High Voltage Switching with respect to earthing and isolation facilities is required with reference to station transformers and PVTs.

4.2.1.4 The design of the station transformer, diesel generators (DGs) and loadable power transformer (PVTs) must comply with the design and working clearances as specified by ElectraNet's Design Standards, AS 3000 and AS 2067.

4.2.1.5 The AC supplies must be provided with HV and LV protection coordinated with the upstream and downstream protection systems.

4.2.1.6 The Contractor will be responsible to ensure that the HV and LV isolation points are visible and lockable, as provided in the ElectraNet Standard Drawings and Template Drawings.

4.2.1.7 Ganged three phased switching/isolating devices must be used to provide HV isolation points for station transformers and PVTs. They must be positioned as close as practicable to the power transformer former bushings or substation bus bars to which the station transformers or PVTs are connected. Any HV cables used to as part of the auxiliary supply power circuit must be downstream of the ganged three phase switching/isolating devices.

4.2.1.8 Portable earthing device connection points must be provided on the HV side of station transformers and PVTs.

4.2.1.9 ElectraNet will allow double lock off points (to prevent back energisation of HV equipment) on the LV side of station transformers or set of PVTs where it can be shown that attempting to install portable earthing devices on the LV side will pose a greater hazard than applying a double lock off process.

4.2.1.10 When applying an LV double lock off, both lock off points must be in close proximity to each other.

4.3 Maximum Demand

4.3.1.1 The Contractor must calculate the maximum demand for the substation. The calculations must be based on the actual loads as specified using ElectraNet's Maximum Demand Guideline incorporating utilisation and diversity factors.

4.3.1.2 Diversity factors must be applied to all loads with the exception of:

a) Transformer cooling pumps and fans (for substations where a number of transformers are installed full forced cooling will only be used by the remaining in service transformers following the loss of a transformer);

b) Battery chargers;

c) Air-conditioners; and

d) Switchyard floodlights.

4.3.1.3 Single phase loads must be balanced across the three phases so far as is reasonably practicable.

4.3.1.4 The final calculated maximum demand must incorporate a 'safety factor' and 'future growth factor' determined on a project basis, which must take into account the substation ultimate layout and projections from network planners. In lieu of specification values, the default value for safety factor will be 10 % and the default value for future growth factor will be 10 %.

4.3.1.5 The calculations must produce individual figures for Essential and Non-Essential loads and the combination of maximum demand for the substation.

4.3.1.6 Examples of Essential Loads include:

a) All station and telecommunications systems battery chargers;

b) All lighting in control and telecommunications buildings;

c) On load tap changer motors;

d) National Grid Metering (revenue metering);

e) On line condition monitoring equipment;

f) Power System and Performance Monitor;

g) Power supplies to substation security and fire protection systems;

h) 50 % of the Control building air-conditioning load; and

i) Substation Floodlights

4.3.1.7 Examples of Non-Essential Loads include:

a) Yard power sockets;

b) Yard equipment heater supplies;

c) Building power sockets;

d) 50 % of the Control building air-conditioning load;

e) Amenities air-conditioner; and

f) AC Supply for the workshop (where provided).

4.4 Supply Capacity

4.4.1.1 The Contractor must size the sources of AC supply including the transformer HV supply cables and LV main supply cables to the changeover board based on the combined maximum demand for the substation and must submit the calculations for review before procurement of the auxiliary transformers and associated cables.

4.4.1.2 Where fed from an auxiliary transformer, the transformer off load tap position must be determined by detailed design calculations to determine optimal voltage, taking into consideration transformer name-plate values for no-load voltage, rated LV current and transformer impedance. The Contractor must provide a calculated figure for the transformer's terminal voltage at maximum demand. During commissioning the tap must be confirmed and set.

4.4.1.3 The LV voltage rating of the AC Supplies must be 400 V for 3 phase and 230 V for single phase, at the point of connection of the load in accordance with AS 3000. Voltage supply tolerances must be in accordance with AS 60038 being, - 6 % to + 10 % of 400/230 V.

4.4.1.4 In accordance with AS 3000:2007 clause 3.6, the permissible LV drop within the substation must be limited to 7 % and demonstrated by the Contractor through calculations.

4.4.1.5 The station transformer rated voltage on the LV side must be provided at no-load.

4.4.1.6 The Contractor must conduct voltage drop calculations to ensure the voltage at the AC load is within the prescribed values.

4.4.1.7 The HV rating will vary with the type of AC Supply. For station transformers, the high voltage will normally be in the range of 11 kV to 33 kV. For PVTs this will be either 33 kV, 66 kV, 132 kV or 275 kV.

4.4.1.8 The current rating will be dependent on maximum demand calculations, and the kVA size rounded up to meet the maximum demand calculation with 20 % spare capacity. Typically kVA sizes for the station supplies are 100 kVA, 200 kVA and 300 kVA. The Contractor must confirm the prospective fault currents on the LV. In general, these will be less than 10 kA.

4.4.1.9 Where a substation is not classified as 'critical', the loading of the essential bus must be supplied by a portable generator. The loading of the essential bus must be carefully considered and labelled correctly.

4.5 Station (or Auxiliary) Transformers

4.5.1.1 Depending on site specifics, station transformers can either be Supply 1 or Supply 2.

4.5.1.2 Where ElectraNet owns 11/0.4 kV Delta – Star station transformers a vector group of Dyn5 must be provided. ElectraNet will nominate the vector group in site specific documentation for other operating voltages.

4.5.1.3 Station transformers must be of Kiosk type with the HV and LV switchgear enclosed or of pole/structure mounted type.

4.5.1.4 Where pole or structure mounted station transformers are used, an LV isolation kiosk, including the appropriately graded moulded cased circuit breaker for LV cable protection, must be installed as close as possible to the transformer. The required isolation and lock-off facilities must be provided inside this kiosk.

4.5.1.5 HV protection must be in the form of either circuit breaker or HRC fuse depending on technical requirements with the isolation facilities as covered in clauses 4.2.1.7 and 4.2.1.8 above.

4.5.1.6 The parameters of the station transformer include:

a) The Vector group;

b) Construction details;

c) Standard sizes; and

d) Standard voltage transformation.

4.6 Diesel Generators

4.6.1.1 Depending on site specifics, diesel generators must be used as Supply 1, or Supply 2, or as a Standby Supply.

4.6.1.2 Where a diesel generator is utilised, the essential load must be supplied for a minimum of 18 hours without refuelling.

4.6.1.3 Connection of the diesel generators to the AC COB must comply with the requirements of AS3010.

4.6.1.4 The Contractor must ensure that any diesel generating system is installed with due regard to minimising the risk of propagation of fire. Considerations must include:

a) adequate separation between the DGs and any combustible structures, and

b) adequate sealing of cable trenches and conduits.

4.7 Loadable Power Voltage Transformers

4.7.1.1 Depending on site specifics, loadable power voltage transformers must be used as Supply 1, Supply 2.

4.7.1.2 They can be of SF6 or oil filled type.

4.7.1.3 The PVTs are normally connected to the substation bus via a motorised disconnector with one earth switch.

4.7.1.4 Safety interlocking must be provided between the LV moulded case circuit breakers and the motorised HV disconnectors to ensure the correct energisation and de-energisation of the PVTs.

4.8 Revenue Metering

4.8.1.1 Revenue metering is not required if the auxiliary supply is provided from the tertiary of an ElectraNet owned power transformer or from an auxiliary transformer upstream of a connection point to a Customer or to an SA Power Networks substation. Substation auxiliary supply power consumption is equated to network losses.

4.8.1.2 In accordance with the NER, separate LV revenue metering must be provided where an AC supply is derived from an AC street supply from the distribution network. The LV revenue metering must be in accordance with the latest edition of the SA Power Networks Service & Installation Rules. The latest version of these rules is available for download from the SA Power Networks website. The web address is:

https://www.sapowernetworks.com.au/centric/industry/contractors_and_designers/service_and_installation_rules.jsp.

4.8.1.3 Where revenue metering is required, it must be a class 5 revenue which meters and monitors all supplies from other service providers. The monitoring point must be upstream of any loads and so positioned so that it cannot be bypassed.

4.8.1.4 The meter must be located in a suitable lockable enclosure, which is outdoor rated and designed to ensure the equipment can be accessed for calibration and maintenance outside or nearby the substation boundary fence and so that the meter can be read without access being required to the substation or the control building.

4.8.1.5 The metering cubicle must be located as closely as possible to the SAPN owned and supplied distribution transformer. The minimum separation distance must comply with the SA Power Networks Service & Installation Rules.

4.8.1.6 The meter current and voltage input circuits must be designed so that they can be sealed if required.

4.9 Protection Devices

4.9.1.1 All LV cables in the installation (including main supply cables, sub-main supply cables and final sub-circuit cables) must be protected against overcurrent and short circuit in accordance with the requirements of AS/NZS 3000.

4.9.1.2 Protective devices must be circuit breakers and/or residual current devices. Low voltage fuses must not be used within distribution boards or sub-boards.

4.10 Discrimination Study

4.10.1.1 The Contractor must undertake a discrimination study on the AC Supply network. The Contractor must ensure that all protective devices coordinate with each other such that effective isolation extends only to the faulty part of the network.

4.10.1.2 Low voltage circuit breakers must coordinate with the high side on the station supply transformer.

4.10.1.3 Verification must be undertaken through the use of device time / current curves. The use of the circuit breaker manufactures software is preferred.

4.10.1.4 The Contractor must perform the study for the detailed design submission and update though the project to ‘as built’.

4.11 Earthing

4.11.1.1 Earthing of the auxiliary supplies must follow the guidelines of AS 3000 and Figure B1 and Figure B2 of AS 2067:2016, and the following clarifications to minimise the risk of exposure to transferred step and touch potentials:

a) When all auxiliary AC supply sources originate within the substation via station transformers or PVTs, the LV neutral or LV star must be directly connected to the substation earth grid.

b) At the AC COB end of the supply cable, the neutral cable must also be connected to the MEN point of the switchboard.

c) Where a street supply is connection to the AC COB the neutral shall only be connected to earth at one point and in a manner consistent with SA Power Networks Service & Installation Rules

4.11.1.2 All other earthing shall be installed in accordance with Clause 4.11 above and 1-11-FR-01 ‘Substation Earthing’.

4.12 Procurement

4.12.1.1 The Contractor will be responsible for the sizing and procurement of all of the equipment required for the LV AC supply system. This will typically exclude the main power transformers and PVTs.

4.12.1.2 The equipment (ST and DG) technical specifications must be provided by ElectraNet. LV and HV cable procurement must be in accordance with the requirements of documents 1-11-FR-06 and 1-11-FR-07.

4.12.1.3 Where a street supply from the distribution network is utilised, SAPN will be responsible for carrying out any required feeder extensions, installation of HV cables, the provision of the distribution transformer (pole top or kiosk) and the service point. The Contractor will be responsible for supplying all of the equipment and cables downstream of the service point. SAPN will perform their required work following acceptance of a quotation to perform the work.

4.13 Installation Requirements

4.13.1.1 The Contractor must carry out all earthworks, civil, structural and electrical requirements required to complete the scope of works, including, but not limited to, the following:

a) excavation and construction of foundations and footings;

b) excavation and instruction of cable trenches and pits, and installation of conduits; and

c) supply and installation of any HV cable support structures.

4.13.1.2 The Contractor must install, terminate and test all HV and LV cabling required for the establishment of the 400V AC supply system.

4.13.1.3 LV Cable trenches and pits must be installed in accordance with 1-11-FR-06 ‘Substation LV Cables’.

4.13.1.4 When required HV cables must be installed in accordance with 1-11-FR-07 ‘Substation HV Cables’.

4.14 Testing Requirements

4.14.1.1 The Contractor must develop an Inspection and Test Plan (ITP) for the works.

4.14.1.2 The installation must be tested in accordance with AS 3000:2007.

4.14.1.3 At the completion of the testing of the installation of the AC system the Contractor must issue a Certificate of Compliance as required by legislation.

4.15 Documentation and Reporting Requirements

4.15.1.1 The documentation and reporting requirements must be as per the ElectraNet ADMs.

ElectraNet

Contact Us

52–55 East Terrace, Adelaide,
South Australia 5000
PO Box, 7096, Hutt Street Post Office,
Adelaide, South Australia 5000

Phone **+61 8 8404 7966** or toll-free **1800 243 853**

Fax **+61 8 8404 7956**

Visit us online **electranet.com.au**