Substation Insulation Coordination

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This functional requirement document is in line with the organisation's 1-11-ACS-10 Substation Insulation Coordination Asset Class Strategy

Contents

1. Definitions

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

Item	Meaning
AS	Australian Standard, as publication by Standards Australia (Standards Association of Australia).
CIGRE	International organisation providing technical standards.
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
high voltage or HV	Nominal voltage exceeding 1000 volts alternating current or exceeding 1500 volts direct current.
IEC	International Electrotechnical Committee.
PSCAD	Proprietary computer software able to undertake insulation coordination studies.
SAP	SAP is an acronym for Systems, Applications and Products, which is a software application used by ElectraNet for asset management functions.
SPF	Smart Plant Foundation, a system for managing ElectraNet technical standards, documents and drawings
third party IUSA	Has the same meaning as defined in the National Electricity Rules
TS	Technical Standard.
U_m	Highest value of phase-to-phase voltage (rms value) for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment Standards. Under normal service conditions specified by the relevant apparatus committee this voltage can be applied continuously to the equipment. The highest rms phase-to-phase voltage for which the equipment is designed, regarding, especially, its insulation – the highest voltage for equipment needs to be at least equal to the highest voltage of a system.
VI	Voltage / current characteristics.

2. Purpose and Scope

This document describes the functional requirements for substation insulation coordination and the integration of insulation coordination systems into a substation.

The design scope of works includes an insulation coordination study and report and a software design model.

The outcome of the design will influence the site single line diagram and the type, location and quantity of surge arresters required for the site.

3. Referenced Documents

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

Legislation	
SAEA	Electricity Act 1996 (SA)
SAER	South Australia Electricity (General) Regulations 2012 (SA) under the SAEA
NER	National Electricity Rules
ETC	Electricity Transmission Code TC/08
International Standards	
AS 1307.2:1996 (R2015)	Surge Arresters Part 2: Metal-oxide surge arresters without gaps for ac systems
AS 2067 :2016	Substations and high voltage installations exceeding 1 kV a.c.
AS 4436:1996 (R2016)	Guide for the selection of insulators in respect of polluted conditions.
IEC 60071.1:Ed 8.1 (Bilingual 2011)	Insulation Coordination Part 1: Definitions, principles and rules
IEC 60071.2:Ed 3.0 (English 1996)	Insulation Coordination Part 2: Application Guide
IEC 60071.4:Ed 1.0 (English 2004)	Insulation Coordination Part 4: Computational guide to insulation coordination and modelling of electrical networks
IEC/TS 60815-1:Ed 1.0 (English 2008)	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles
IEC 62271-100:2012-09	High-voltage switchgear and control gear - Part 100: Alternating-current circuit-breakers
ElectraNet's Documentation	
1-11-FR-11	Substation Lightning Protection

4. Insulation Coordination

4.1 General

4.1.1.1 The insulation coordination for the site must comply with IEC 60071.

4.1.1.2 The design must identify the insulation coordination requirements between the transmission line and substation assets.

4.1.1.3 Substations must be protected from direct lightning strikes by adequate shielding in accordance with the requirements of document 1-11-FR-11.

4.1.1.4 Design and safety clearances for all nominal voltage levels must be in accordance with Tables 3.1 and 3.2 of AS2067:2016.

4.1.1.5 Where Tables 3.1 and 3.2 of AS2067:2016 provide a number of options, the values selected for design and safety clearances as well as withstand voltages must correspond to those that would apply for the highest listed impulse and withstand voltages at that nominal voltage. As an example, for 132 kV applications all designs must be based upon the use of 275 kV as the short duration power frequency withstand voltage and 650 kV as the rated lightning impulse withstand voltage.

4.1.1.6 Equipment clearances must maintain electrical safety and maintenance requirements. Minimum air clearance requirements to meet ElectraNet maintenance requirements are provided in 1-11-ADM-09 'Substation Configurations'

4.2 Design

4.2.1 Introduction

4.2.1.1 Substation insulation coordination must insure that surge protection devices such as surge arresters are adequately rated and correctly positioned within a substation to limit transient over voltages to the levels specified within this document.

4.2.2 Study

4.2.2.1 The Contractor must undertake an insulation coordination assessment of the site unless the site specific documentation indicates that it is not required.

4.2.2.2 Lightning impulse and short duration power frequency withstand assessments must be undertaken for IEC 60071 range I voltages (Um up to 245 kV). Lightning and switching impulse assessments must be undertaken for range II voltages (U_m greater than 245 kV). In special cases ElectraNet may specify that switching studies will be required at lower voltages.

4.2.2.3 PSCAD software must be used where computer modelling is required.

4.2.2.4 ElectraNet will make existing technical documentation available to the Contractor for the purposes of the insulation coordination study. The information will include:

a) When plant data is unavailable Section 7.6 in IEC 60071-4:2004 provides equipment capacitances that must be used for conventional HV equipment in the model. Manufacturers' plant data sheets shall be used when modelling the capacitance to ground for the Capacitive Voltage Transformers; and

b) Surge Arresters must be modelled according to the VI characteristics for period contract surge arresters. If other types of surge arresters are required, then the studies must be based on the VI characteristics supplied by the manufacturer.

4.2.2.5 ElectraNet will provide the input data needed to carry out the insulation coordination study. The Contractor must identify missing or site-specific parameters and must seek additional information from ElectraNet prior to commencement of the study.

4.2.2.6 For the modelling of shielding failure within the substation, the lightning protection design must be utilised to determine the stroke current magnitude. If this is unavailable then the Contractor must seek guidance from ElectraNet confirming what stroke current magnitude should be used for the studies. Typically for a 275 kV substation a magnitude of 6.5 kA must be used. This corresponds to the minimum interception current for a lightning protection system based on a rolling sphere radius of 27 m. For lower operating voltages the stroke current magnitude may need to be even lower.

4.2.2.7 The lighting strike model peak current shall be 130 kA for the first stroke peak current and 40 kA for the subsequent stroke peak current based on the 1 % probability values in Table B1 of AS 1768:2007.

4.2.2.8 For the modelling of lightning surges, a CIGRE concave waveshape current source impulse model must be used, as per IEC 60071-4 Section C.2.1.1.

4.2.2.9 Lightning wave shape parameters must be calculated utilising the log-normal representation in CIGRE Technical Brochure 63 'Guide to Procedures for Estimating Lightning Performance of Transmission Lines, October 1991'. The first negative downstroke must be according to the parameters in Table 4. Subsequent stroke(s) must be according to the parameters in Table 5.

4.2.2.10 Insulators flashover trigger must be modelled in accordance with IEC 60071-4:2004 Section 7.6.5 using the area criterion method for air gaps less than one metre. The leader propagation method must be used to represent air gaps greater than or equal to one metre.

4.2.2.11 Lighting over voltages in the substation must be limited to 75% of the rated equipment withstand voltages. Sufficient points in the substation must be monitored during simulations to ensure that over voltages do not exceed this requirement.

4.2.2.12 Switching surge wave shape parameters must be automatically generated as a result of switching operations within the PSCAD software.

4.2.2.13 Switching over voltages in the substation must be limited to 80% of the rated equipment withstand voltages. Sufficient points in the substation must be monitored during simulations to ensure that over voltages do not exceed this requirement.

4.2.3 Requirements

4.2.3.1 The insulation levels of the equipment must be provided in accordance with AS 2067 and IEC 60071 for all ElectraNet voltage levels.

4.2.3.2 Pollution levels of the substation equipment must be provided in accordance with IEC/TS 60815-1:2008. Category d) and e) pollution levels must be used for the substation equipment insulation levels. Category d) can be considered as 25 mm/kV according to AS 4436-R2016. Category e) can be considered as 31 mm/kV according to AS 4436-R2016. ElectraNet will define the pollution levels to be applied for each substation in the specification.

4.2.3.3 The substation equipment must be protected from all forms of over-voltages that are likely to be experienced by the equipment including continuous and temporary over-voltages, slow front and fast front over-voltages.

4.2.3.4 Surge arresters must be installed at the transmission line entries to the substation and in the yard in front of the critical substation equipment for the protection of the internal insulation, such as near transformer bushings, HV cable terminations, reactors and capacitor banks.

4.2.3.5 Surge arresters must have a minimum 10 kA rating, unless the insulation coordination study indicates higher kA ratings are required.

4.2.3.6 Arcing horns are not acceptable for over voltage protection of equipment in new substation designs.

4.2.3.7 Arcing horns must be removed whenever surge arresters are installed in close proximity at brownfield sites. Examples of this include the removal of arcing horns on line disconnectors following the installation of surge arresters in the line exit position as well as the removal arcing horns mounted on transformer HV bushings when there are surge arresters in close proximity.

4.2.3.8 Surge arresters must be connected in the vicinity of primary plant such that through design, the surge would arrive at the surge arrester prior to the primary plant. Where this is not the case system studies / calculations may be performed to justify or otherwise the position of the surge arrester.

4.3 Data Capture Requirements

4.3.1.1 The following information will be stored in SAP associated with insulation coordination:

a) Functional location, number, serial numbers and physical parameters of the surge arresters.

4.3.1.2 The Insulation Coordination design report and associated software model, reflecting the as-built status, will be stored as separate objects under the same placeholder in ElectraNet's SPF electronic system.

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