External Network Connection

Earth System Design & Test Requirements CERM2456

Purpose of This Document

This document is intended to inform proponents of the system earthing design and verification test requirements when generation or large connected loads are to be connect to Essential Energy's High Voltage (HV) subtransmission or distribution networks.

Introduction

Effective earthing system design identifies the necessary components, materials, interconnections and earth grid layouts to achieve the necessary operational performance and compulsory industry safety requirements. These designs will vary significantly, requiring a parametric analysis of site-specific data to arrive at an economically prudent design that addresses the necessary Australian Standards and published Guidelines.

The federal model Work Health and Safety (WHS) Legislation as implemented by each of the states and territories has led to a greater emphasis on hazards being identified in the design process. This requires engineers to consider the potential risks involved in the life of a design, to ensure it is safe to build, operate, maintain, and demolish a structure/building/plant[1]. Essential Energy's approval of a submitted earthing system design does not absolve the proponent of the responsibility for the design and associated residual risks.

Earthing System Design Documentation

An earthing report submitted to Essential Energy for approval to progress a connection agreement must detail all relevant information regarding the electrical hazard characteristics for all possible earth fault scenarios. Earth faults occurring on the Essential Energy network must be assessed for transfer hazards impacting the interconnected earthing systems. Proposed mitigation strategies considered and or employed to reduce operational and safety risks to individuals to at So Far As Is Reasonably Practicable (SFAIRP) are to be included in the design analysis. Earthing systems intended to be bonded to Essential Energy's earthing network require pre-approval from the manager of Network Earthing before the completion of the design phase.

Analysis is to be performed by a suitably qualified, competent and experienced electrical engineer in the field of High Voltage (HV) earthing systems. Analysis prepared by non-engineering qualified staff is to be reviewed by a suitably qualified, competent and experienced electrical engineer.

The earthing system design report shall include the following detail.

[1] https://www.engineersaustralia.org.au/Event/safety-design-1

1. Signatures (either personally or electronically) of the author, reviewers and approvers, and be identifiable (full name) as required by WHS / safety in design requirements.
2. Design assessment analysis in accordance with the requirements and criteria as detailed in the relevant and most up to date Australian standards and Australian industry guides.
3. Earth fault protection study detailing fault levels, source impedances and expected clearing times for all primary and secondary earth fault scenarios.
4. Analytical evaluation as to ascertain the necessary installation characteristics with limited use of empirical methods. Curve matching, nomograms and tables listing generic information will not be accepted. Omissions from the listed requirements in § 4.1 are to be support by explanation.

   4.1. Industry recognised and capable software tools are to be employed when analysing site configurations to determine the necessary site parameters and results, for both primary and secondary circuit faults, which include but are not limited to: (where applicable)

   - Earth Grid Potential Rise (EGPR)
   - Earth Potential Rise (EPR)
   - EPR zone of influence
   - Earth network system impedance (Z_{system})
   - Individual earth grid impedance (Z_{grid})
   - Current Distribution in, but not limited to:
     - Over Head Earth Wire/s (OHEW's)
     - Cable sheaths
     - Counterpoise conductors
     - Multiple Earth Neutral (MEN) systems
     - Water pipes
     - Telecommunication circuits (including pilot wires)
     - Bonding conductors
     - Auxiliary conductive paths
   - Electrically Conductive Transfer Hazards
     - Hazards transferred from the primary zone substation to:
       - Connecting plant and / or Installations
       - Utility infrastructure (water, rail, gas, telecoms and mining)
     - Low Frequency Induction (LFI)
       - Utility infrastructure (water, rail, gas, telecoms and mining)
     - Capacitive Coupling
       - Utility infrastructure water, (rail, gas, telecoms and mining)
   - Derivation of Applicable Safety Criteria as per § 2. Examples provided but not limited to:
     - AS 2067
     - ENA EG0

- AS/NZS 3007
- AS/NZS 7000
- AS/NZS 60479
- AS/NZS 4853
- AS/NZS 3835
- AS/NZS 3000
- ENA EG1
- National Electricity Act and Regulation
- National Electricity (NSW) Law
- National Work Health and Safety ACT and Regulation

- Soil Resistivity Data and Resultant Models Produced
  - Data acquired relevant to the extent of the earthing system (Z_{system}) being designed or analysed. Several sets of soil data should be obtained for effective analysis with numerous intermediate measurement spacings (AB/3) extending out to 100 metres recommended.
- Touch Voltages
  - Internal to the site for all circuit configurations for all primary and secondary fault scenarios
  - External to the site for all circuit configurations for all primary and secondary fault scenarios
  - Modelled results compared against safety criteria to identify compliance.
- Surface Conditioning Requirement

5. The document must clarify any engineering considerations made. Assumptions and added conservatisms implemented in lieu of adequate data, software capability or engineering deficiencies will not be accepted.
6. The document must be clear and concise with all plots, images and tables explained as ambiguity will result in additional clarification being sought, extending approval times.
7. All relevant design information, general arrangements, earth grid layouts, construction requirements etc. to be included as appendices.
8. Identify the method and periodic inspection / testing of the asset for the intended lifespan.

Earthing System Test and Analysis Documentation

1. Essential Energy staff shall have the opportunity to witness the earthing system test at a time agreed by the proponent and Essential Energy's Manager Network Earthing. The inspection and test plan (ITP) shall be submitted for review prior to undertaking the testing.

2. Earthing system analysis reports are to be produced in accordance with the requirements outlined in the above sections. Approval of the report is required by Essential Energy's Network Earthing as per CEOF6720.
3. In addition to these requirements, a test report shall include as a minimum of but not limited to:
    - Test methodology
    - Site layout
    - Test circuit Layout
        - Corrections implemented for test lead interaction, induced voltage errors
        - Corrections implemented for Mutual Earth Resistance (MER)
    - All recorded test values
        - Measured as per § 4.1
        - A 200 Amp Micro-Ohm test of all connections fitted, above or below ground, for the purposes of earthing HV plant inclusive of all earth grid conductor connections
        - d.c. continuity assessment
        - Surface conditioning resistance measurement and integrity analysis
    - Any alterations (i.e. as built variations)
    - Comparative analysis with design
    - Residual risk evaluation and management strategy
    - Date of next inspection and date of next Current Injection Test (CIT) test and analysis
    - Any mitigation measures required to address design or construction departures