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ELECTIRAL GROUNDING CRITERIA

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standard and Specification prescribes minimum mandatory requirements for design and installation of grounding systems and lightning protection systems

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. American National Standards Institute (ANSI)

   ANSI C2 National Electrical Safety Code

2. American Petroleum Institute (API)

   API RP 2003 Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents

3. Institute of Electrical and Electronics Engineers (IEEE)

   IEEE 80 Guide for Safety in Alternating-Current Substation Grounding
   IEEE 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
   IEEE 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems
   IEEE 399 IEEE Recommended Practice for Power Systems Analysis (Brown Book)
   IEEE 1100 Powering and Grounding Sensitive Electronic Equipment

4. International Electrotechnical Commission (IEC)

   IEC 61662 Assessment of Risk of Damage Due to Lightning
   IEC 61024-1 Protection of Structures Against Lightning
   IEC 61024-1-1 Protection of Structures Against Lightning Part 1: General Principles Section 1: Guide A – Selection of Protection Levels for Lightning Protection Systems

5. National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 99	Health Care Facilities
NFPA 780	Lightning Protection Code

6. Underwriters Laboratories (UL)

UL 96	Lightning Protection Components
UL 96A	Installation Requirements for Lightning Protection Systems
UL 467	Grounding and Bonding Equipment

GENERAL

1. Except as noted below, grounding and ground system installation shall be designed in accordance with IEEE 142 and meet the requirements of ANSI/NFPA 70 (NEC), and ANSI C2, as supplemented or amended by this Standard. Requirements for specific facilities are as Health Care Facility grounding shall meet additional requirements of NFPA 99.
2. Except as specifically noted, electrical installations in residential facilities, recreational facilities, schools and office buildings (including office buildings associated with plants and industrial facilities) shall be grounded and are not required to meet the additional requirements contained in this standard.
3. Measurements of earth resistivity and ground impedance shall be made in accordance with IEEE 81 or by a non-contacting ground resistivity mapping instrument (Geonics or equal). In soils exceeding 5000 ohm-cm. the measurements shall be taken or verified by a non-contacting ground resistivitymapping instrument.
4. Calculations of allowable and actual step and touch potentials shall be done in accordance with IEEE 80 using the following parameters:
   a. A body weight of 50 kg shall be assumed.
   b. Duration of ground faults used in calculations for maximum allowable step and touch potential shall be the time (based on known operating conditions) it would take for the backup breaker to clear the fault with a minimum of 0.25 sec. and a maximum of 1.0 sec.
   c. Ground fault current shall be the higher of the line to line to ground or the symmetrical line to ground fault current.
   d. In calculations of the grid current, the current division factor must be assumed to be 1.0 unless calculations based on known actual site conditions are provided to justify a lower number.
   e. For calculations of allowable step and touch potentials, the resistivity of the surface material (rho sub s) shall be assumed to be 3,000 ohm-meters for a minimum 75 mm thick pad of clean crushed rock, 10,000 ohmmeters

for a minimum 50 mm layer of asphalt, and 200 ohm-meters for a minimum 75 mm layer of concrete. For all other surface materials, the lower of 100 ohm-meters or the actual measured top layer (minimum 0.3 m layer thickness) soil resistivity shall be used.

f. Calculations of mesh voltage and ground potential rise (See IEEE 80) shall be based on actual measured soil resistivity. If native material is replaced by fill, calculations shall incorporate the effect of the measured soil resistivity of the fill.
g. Soil resistivity of backfill material used for ground grids and ground rods shall be the same as or less than that of the surrounding soil.
h. Commissioning tests shall be performed to verify that resistance to remote earth of substation ground grids and/or ground electrodes used for system grounding meet design requirements.

MATERIALS AND INSTALLATION

This section also applies to electrical installations in residential facilities, recreational facilities and office buildings.

1. Conductors used as grid conductors, grounding electrode conductors, equipment ground conductors, or bonding conductors in grounding systems shall:

   - Be soft or annealed copper.
   - If larger than 35 mm² (#2 AWG) be stranded.
   - Except for grid conductors used in substations for potential control purposes be insulated when used in direct contact with soil less than 70 ohm-meters resistivity.
   - If used for grid conductors in substations for potential control purposes be bare and if used in soils less than 70 ohm-meters resistivity be tinned.
   - If insulated have a green jacket or a green jacket with yellow stripes. When isolated ground equipment grounding conductors are installed per IEEE 1100, they must be labeled or color coded to distinguish them from standard equipment grounding conductors.
   - If exposed above grade in a severe corrosion area be insulated.
   - If buried and used for grids and/or interconnection of ground rods be minimum 70 mm² (2/0 AWG).
   - If used for connection of equipment to ground rods or ground grid be minimum 25 mm² (#4 AWG).

2. Ground rods shall have the following characteristics:
   - Be copper or copper jacketed steel or galvanized steel. Copper jacketed steel ("Copperweld" or equivalent) shall meet the requirements of UL 467.
   - If galvanized steel, only be used in areas protected by cathodic protection.
   - Have a minimum length of 2.4 meters. Jointed rods are permitted but each joint must be at least 2.4 meters long.
   - For copper or copper jacketed steel rods be a minimum of 16 mm in diameter and for galvanized steel rods be a minimum of 19 mm in diameter.
   - When grounding is required at pipeline valve stations, zinc or magnesium anodes interconnected with insulated copper cable may be used in lieu of copper clad or galvanized steel ground rods. Each required ground rod shall be replaced with a zinc or magnesium anode and a minimum of two zinc or magnesium anodes spaced a minimum of 2 meters apart shall be installed.
3. Below ground connections to grounding grids and ground rods or between conductors and/or grounding rods shall be made using one of the following methods:
   - By thermite welding or brazing.
   - By approved compression grounding connectors.
   - For connections at ground test stations only where it is necessary to disconnect ground conductors for tests, approved mechanical connectors may be used.
4. Above ground grounding system connections shall be made by one of the following:
   - In accordance with the NEC
   - By thermite welding or brazing.
   - To structural steel using compression type connectors bolted to bare steel, by thermite welding, or by other approved means.
5. Grounding conductors which do not accompany associated power conductors in the same conduit shall not be installed in metallic conduit except where PVC conduit is not suitable and it is necessary to protect the conductor from mechanical damage. Grounding conductors installed in metallic conduit or sleeves that do not accompany associated power conductors shall be bonded to both ends of the conduit.
6. Grounding conductors extending through concrete or asphalt shall be run in PVC conduit (preferred) or PVC coated rigid steel conduit. Grounding conductors in steel conduit shall be bonded as noted above.

7. Underground ground conductors shall be insulated when within 3 meters of a buried metal pipeline or metal piping.
8. Underground ground conductors electrically connected to buried metal pipelines, buried metal vessels, or metal tanks sitting on grade shall be insulated. The associated ground rods shall be galvanized steel if the area is subject to cathodic protection.

SUBSTATION GROUNDING

For substations having equipment operating at a nominal system voltage exceeding 1,000 Volts, a ground grid meeting the requirements of IEEE 80 for step and touch potential shall be installed. Design for the substation grid and the associated overall plant grounding system shall account for hazards due to transferred potentials caused by a fault in the substation. All electrical equipment in the substation, substation yard, and within 5 meters of the substation fence shall be connected to the grid or to a ground bus connected to the grid.
The design package for ground grids and systems for substations with equipment operating at above 15 kV shall be submitted to the Coordinator, Electrical Systems Division, Consulting Services Department for review.
Substation ground grids shall be constructed of minimum 70 mm² (2/0 AWG) stranded bare copper cable.

GROUNDING ELECTRODES

Grounding electrode systems, including those for residential facilities, recreational facilities, schools, and office buildings, shall be in accordance with the NEC with the following additions:

1. Reinforcing bar of buildings shall not be used as a grounding electrode. Structural steel of a building may be used as a grounding electrode in accordance with the NEC provided it is continuous and effectively grounded by connecting at least every other structural steel column on the perimeter of the building to a concrete-encased electrode or a ground ring installed per the NEC and this standard.
2. If a concrete-encased electrode is used, the conductor must be bare copper.
3. The ground electrode for system grounding shall consist of either (1) rod or pipe electrode(s), or (2) a combination of rod or pipe electrodes and a grid or loop of bare copper conductors buried a minimum of 460 mm. Multiple rod or pipe electrodes shall be interconnected by bare or insulated copper conductors using thermite welding or approved connectors. Conductors used to interconnect rod or pipe electrodes shall be buried a minimum of 460 mm.