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GROUNDING AND OVERVOLTAGE PROTECTION

(PROJECT STANDARDS AND SPECIFICATIONS)

TABLE OF CONTENT

SCOPE

This Project Standard and Specification covers requirements governing the grounding, over voltage protection, and lighting protection facilities for electrical power system and equipment, structures and buildings. This Project Standard and Specification does not cover process instrumentation system.

REFERENCES

Lighting protection for structures without metallic frames or siding shall be in accordance with ANSI Standard C5.1, Lighting Protection Code, or equivalent national standard.

DEFINITIONS AND TERMINOLOGY

Acceptable and preferred practices - Where this Project Standard and Specification list more than one type of equipment or method as acceptable, the Contractor shall make the selection based on the installed cost. Where one particular type of equipment or method is listed as preferred, it shall be selected, provided it is lower or equivalent in installed cost than other acceptable type or methods.

Bonding - Two or more objects are considered to be bonded if connected together through a conducting path. Objects which are not inherently in contact with each other through a conducting path may be bonded by connecting them together with a bonding conductor.

Equipment - The term equipment as used in this Project Standard and Specification applies to all electrical distribution, control and utilization components and includes such as transformers, panel boards, lighting fixtures, receptacles, switching devices, and motors.

Ground return path - A metallic connection between the metal enclosure of electrical equipment and the system neutral ground of the power supply to the equipment. If the system neutral is grounded through impedance, the ground return path must connect on the ground side of the impedance.

Grounding - An object is considered to be grounded when connected by a conducting connection, either inherently or by a grounding conductor, to the earth.

Grounds - Grounding electrodes, buried grounding conductors, or underground metallic water piping.

Liquids - Are classified as accumulators if their conductivity is 50 picomhos/meter or less. Distilled petroleum products including petroleum solvents, are generally accumulators. Crude oil, residual fuel oil, asphalt (both penetration or cutback), Bunker C, residual products with Conradson carbon above 1% and water soluble products such as alcohol have high conductivity and are classified as non-accumulators.

Switch loading - Loading a high flash cargo into a shipping vessel previously containing a low flash cargo, without cleaning or gas freeing the vessel. The high flash cargo must be treated as low flash during loading in such cases.

The zone of lighting protection - The space enclosed by a cone with its apex at the highest point of a properly grounded rod, wire, or metal structure and has a radius at its base of twice the height of the rod.

BONDING AND GROUNDING MATERIALS AND METHODS

Bonding shall be provided where necessary to insure the electrical continuity of grounding circuits and where necessary to provide a path for the dissipation of static charges. Bonds provided for the dissipation of static charges shall have a resistance of one meg ohm or less.

Bonding and Grounding Conductors

1. Bonding, grounding, and buried ground return conductors shall be bare stranded medium-hard-drawn copper. Minimum sizes shall be 2 Awg. (32 mm2, 0.05 in^2) for underground conductors and 6 Awg. (13 mm^2 , 0.02 in^2) for aboveground conductors.
2. Ground return conductors located within cable assemblies may be uninsulated and shall be of the same material and stranding as the cable line conductors.
3. Conductors sizes shall be increased above the minimum sizes if required to:
   - Insure adequate mechanical strength.
   - Withstand the thermal stresses of ground fault currents.
4. Grounding conductor burial depths shall be at least 18 inches. Burial depths in switch or transformer yards graded with stone shall be at least 12 inches below the stone.

5. If the wiring method is buried cable, grounding conductors shall be laid in the cable trenches as far as routing permits.
6. If the wiring method is underground conduit, grounding conductors shall be laid along a formed side of the duct banks as far as routing permits.
7. Where grounding cables cross under railroads, main roads, paved roads, or concrete paved areas, they shall be run in rigid metal conduit, pipe sleeves, or duct banks as required for wiring and cable systems.
8. Where grounding cables cross secondary roads which are not paved, burial depth or design of cable protective covering or both shall prevent damage either to the cables or to the covering from anticipated heavy loads such as mobile cranes or equipment transport vehicles. A safety factor of 1.5 shall be applied to the total loads.
9. Grounding conductors leaving the ground at grade shall be protected as follows:
    a. Conductors except those used for lightning protection shall be protected by rigid metal conduit or pipe sleeves where they are extended above grace. Lightning protection conductors shall be protection conductors shall be protected by non-metallic conduit sleeves.
    b. Sleeves shall extend a minimum of 6 in. below grade and 10 in. above grade.
    c. Metal sleeves shall be encased in concrete 3 in. thick all around.
    d. Concrete encasement shall extend 6 in. above grade.
    e. Non-metallic sleeves shall be rigidly heavy wall polyvinyl chloride or high density polyethylene conduit.
    f. Sleeves not required within switch or transformer yards or under elevated substations.

Bonding and Grounding Connections

All conductors connection to structures and equipment shall be made above ground as follows:

a. Conductors shall be installed in one length between aboveground connection points.
b. Single cable lengths shall also be installed between aboveground connection points and grounding electrodes or taps on common ground return cables.
c. If splices or taps are required on underground runs, they shall be made with tool-installed compression connectors or by brazing or welding.
d. Screw-type solderless connectors shall not be used underground.
e. Splices or taps in underground runs shall be buried.

On equipment, conductor connections which are regularly disconnected for maintenance of the equipment shall be made with screw type solderless connectors. Other connections shall be made solderless connectors or by brazing or welding.
All welded connections shall be made by a welding process equivalent to Cadweld or Thermoweld.

Grounds

1. Grounds shall meet the resistances to earth specified herein throughout the year considering seasonal variation in soil conditions.
2. Buried grounding conductors serving as grounds shall have a length of not less than 25 ft.
3. Grounding Electrodes. If permanently installed and located within a reasonable distance of the equipment or structure to be grounded, the following may be used as grounding electrodes:
   - Underground metallic water piping if buried portion is greater than 10 ft. length.
   - Large underground metallic objects in intimate contact with earth such as pile casings or building frames.
4. Artificial grounding electrodes shall consist of driven rods and shall be as follows:
   a. Rods shall be copper clad steel 1 equivalent to Copperweld and shall have a minimum diameter of 5.8 in.
   b. Top of rods shall be at least 18 inches below grade.
   c. A grounding conductor shall connect the top of each rod to an accessible aboveground connection point. The connection point may be located on the structure or equipment to be grounded or on a nearby permanent structure to serve as a tie-in point for other grounding conductors. At tie-in points, conductors from rods shall be identified with corrosion resistant metal bands to facilitate their removal for test purposes.
   d. The grounding conductor shall be connected to the rod by brazing or welding and to the connection points by a screw type solderless connector.
   e. Rod top and its grounding conductor shall be buried.
   f. If more than one artificial electrode is connected to a ground system, the electrodes shall be spaced at least 10 ft. apart.

Substation and Generating Station Grounds

All grounding electrodes at substations and generating stations shall be interconnected by grounding conductors. If grounding conductors are used in lieu of electrodes, all conductors shall be interconnected.

SYSTEM NEUTRAL GROUNDS

Ground Resistance

Grounds for system neutrals shall have a resistance to earth as follows:

System Operating Voltage Between Line Conductors	Resistance
600 volts or less	15 ohms max.
High resistance grounded systems, 601 volts or higher	15 ohms max.
Low resistance grounded systems, 601 volts or higher	2 ohms max.

For impedance-grounded system (such as low resistance, high resistance, and reactance), the values above apply to the resistance to earth from the grounded side of the impedance, and do not include the impedance which is specified separately.

Grounding Conductor Size

1. Grounding conductors used to ground power transmitter or generator neutrals shall have a cross sectional size not less than 32 mm^2 (0.05 in^2, 2-Awg.). In addition, the size shall limit temperature reached by the conductor, when carrying maximum ground fault current for the time allowed by the slowest responsive relay, to the following:
   a. For insulated conductors, to within the transient temperature for no damage to the insulation.
   b. For bare conductors: to 250°C if connections to cable are made with pressure connectors; to 450°C rise if connections to cable are brazed or welded. For copper conductor and 26°C ambient, required size is