Recommended Instructions for Made Grounds for Signal Systems Utilizing Earth Electrodes

Revised 2025 (5 Pages)

A. Purpose

This Manual Part recommends instructions for the design, installation, maintenance and testing of grounding equipment for providing a low resistance electrical path to earth from signal equipment for personnel and equipment protection.

B. General

1. A properly designed grounding system is essential for personnel protection.

2. Installation, wire connections and wire routing as well as periodic inspection and testing are important to assure the integrity of the grounding system.

3. An earth electrode is any metallic object placed in the soil for the purpose of grounding, such as ground rods with or without chemical enhancement. To minimize touch potential an earth electrode system should include a buried grounding ring around the metallic signal enclosure. Also see Manual Part 11.3.10 (Purpose and Meaning of Terms used in Surge Protection and Grounding).

4. Ground rod and ground rod connectors shall conform to Manual Part 11.3.4 (Recommended Design Criteria for Copper Clad Steel Ground Rods and Connections for Signal Systems) or Manual Part 11.3.5 (Recommended Design Criteria for Chemically Enhanced Ground Electrode Systems for Signal Systems).

C. Design and Installation of Standard Earth Grounding Electrodes

1. Grounding systems should be designed and installed to provide a minimum resistance to remote earth. This ground resistance should not exceed 25 ohms (Per NEC 250.53).

   The railroad can designate a different target resistance if desired, and the target resistance may change based on site conditions.

2. A lower ground resistance can reduce the risk of shock hazards under electrical fault conditions and improve personnel safety.

3. A lower ground resistance also can improve the protection of the equipment under surge events.

4. Where the ground resistance exceeds the target limit, additional ground rods, deep driven sectional ground rods or chemical enhancement systems may be used to achieve a lower ground resistance.

5. The optimum spacing for vertical multiple ground rods is twice the length of the rod, and not less than six feet. Reduced spacing will likely not significantly reduce resistance but may be considered for site-specific installations.

6. In instances where the track or signaling system are in proximity to high energy circuits (e.g. electrical utility or electrified rail) a grounding resistance target alone may not be sufficient to address possible touch and step voltage hazards introduced during faults on the power systems. Many factors may influence the hazard personnel may be exposed to during a fault on the power system including but not limited to, soil resistivity, fault clearing time, and the geometry of the installed grounding. IEEE Std 80 the *IEEE Guide for Safety in AC Substation Grounding* can be used to evaluate touch and step voltage hazards during faults on the power system.

7. Where signal enclosure or pole being grounded is on top of a fill and desired ground resistance cannot be obtained, supplemental earth electrodes may be used where better soil exists or ground rods may be positioned under the track at an angle, observing maintenance-of-way requirements.

8. All earth electrodes shall be bonded together at each site, using bare conductors.

9. Earth electrodes should be located approximately 3 ft. from signal enclosure, post or pole to minimize step and touch potential.

10. Ground rods should achieve a depth of at least 8 ft. below finished grade wherever practical except:

    a. Where underground obstructions are encountered at 4 ft. or more, the rods should be driven at an angle.

    b. Where rock is encountered at less than 4 ft., the rods should be buried as deep as possible in a horizontal trench.

11. The upper end of the earth electrodes should be flush with or below finished grade unless suitably protected to avoid personnel hazard or damage to wire. Where tops of the electrodes must be accessible for inspection, ground electrode boxes or ground wells may be used.

12. Wire connection between the single or multiple ground rods and the signal enclosure shall consist of solid or stranded soft drawn copper wire of not less than No. 6 AWG size or equivalent copper strap. Wire shall be run as directly as practical, avoiding sharp corners. Where corners are necessary, they should have a radius of 8 in. minimum.

13. Wire connections to the ground electrodes should have sufficient length to avoid breakage from the effects of frost. However, excess slack shall be avoided and not be coiled.

14. Wire connections to the ground electrodes and into or to the signal enclosure shall be securely clamped or exothermically welded conforming to manufacturer's instructions.

15. Salt or other corrosive chemicals shall not be used to attempt to reduce ground resistance unless specifically approved and instructed by the railroad.

16. Grounding conductors within a signal enclosure shall conform to Manual Part 11.4.2 (Recommended Instructions for Application of Electrical Surge Protection for Signal Systems).

17. When installation is completed, apparatus and surface of the ground that has been affected by the installation should be left in a neat and clean condition.

D. Design and Installation of a Conductive Backfill Earth Grounding System

Note: Refer to Figure 1141-1 for this procedure.

This method is suggested for use in areas with high soil resistivity and/or low moisture content and where conventional grounding methods were unsuccessful.

1. Begin by auguring the holes for the ground rods. A minimum hole diameter of 8 in. is recommended. The hole depth is 8 ft. (assuming a 10 ft. rod is used).

2. A trench 18 in. deep and 12 in. wide should be made between all rod holes.

3. Place a rod in the center of each augured hole and drive it into the earth 3 ft. This will put the head of each ground rod about 1 ft. below the ground surface (assuming a 10 ft. rod is used). The rods will sit concentrically in the augured holes and remain in place by the 3 ft. driven depth at the bottom of the hole.

4. All rods are then interconnected by 3 in. wide copper straps of at least 13 mil thickness. The connections are to be made using exothermic welding.

5. Once the welded connections are secured, the augured holes and interconnecting trenches are to be filled with the backfill material of choice to just cover the tops of the earth electrodes and interconnecting copper straps.

   If Sodium Bentonite is used, water must be added to it simultaneously as it is poured into the augured holes and interconnecting trenches. This material will swell to approximately 13 times its dry volume when it is saturated with water because of hygroscopic properties of this material.

6. Backfill with local soil to grade level.

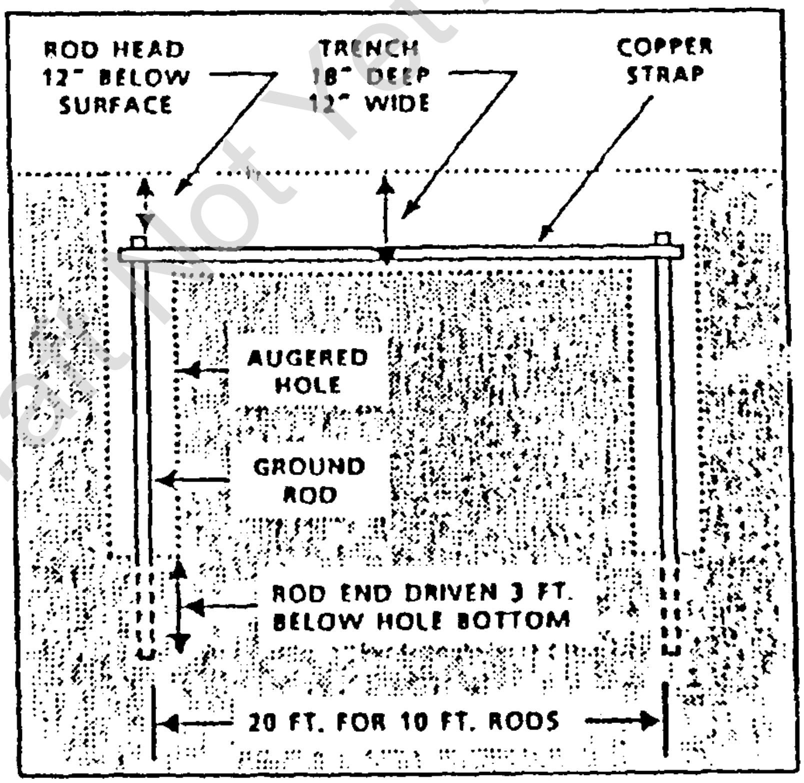

Figure 1141-1: Example of an Earth Electrode Installation for a conductive backfill system.

E. Inspection and Testing

1. Care must be exercised at any time when connecting or disconnecting a made ground at any part of a grounding system. Discharge or leakage through surge protectors, induced or lightning surges, or apparatus connected to the ac supply could cause the voltage on the disconnected part of the grounding system to reach dangerous levels.

2. Ground connections and wires from signal enclosure to ground electrodes should be periodically inspected as instructed by the railroad.

3. Tests should be made on installation with all other grounds removed and as instructed by the railroad to determine the resistance between the ground electrode system and remote earth.

4. Railroad approved instruments should be used and manufacturer's instructions for using the instruments followed.

5. Results of inspections and tests herein required and all other inspections and tests required by the railroad shall be recorded as instructed by the railroad.