Chapter E 103

PROTECTIVE GROUNDING

E 103.01 Grounding general. (1) This chapter (Wis. Adm. Code sections E 103.01 through E 103.10) treats of protection by grounding of electrical generation, transmission, distribution, and some utilization facilities, the general requirements of which are covered in other chapters of this code. The orders in this section do not apply to the grounded return of electric railways, to the grounding of lightning protection wires which are independent of electric circuits and equipment, nor to the grounding of communication circuits and equipment.

(2) In general the rules in this chapter cover methods of grounding and such requirements that would have to be repeated if placed in the various parts of the code.

(3) Additional rules covering grounding will be found in all parts of the code. In general grounding requirements covering interior wiring will be found in chapter E 250; the grounding of lightning rods in chapters E 160 through E 172; grounding in connection with radio in chapter E 810; grounding communication systems in chapter E 800; and signal circuits in chapters E 720 and 725.

(4) Insulation and guarding are suitable alternatives to grounding under certain conditions.

(5) Circuits are grounded for the purpose of limiting the voltage on the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 103.02 Grounding electric systems. (1) DIRECT CURRENT DISTRIBUTION SYSTEMS. (a) Two-wire direct-current systems supplying interior wiring systems and operating at not to exceed 300 volts between conductors shall be grounded on one conductor at one or more supply stations but not at individual services or elsewhere on the interior systems unless such system is used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector. It is recommended that two-wire direct-current systems operating at more than 300 volts between conductors be grounded if a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. It is recommended that two-wire

direct-current systems be not grounded if the voltage to ground of either conductor would exceed 300 volts after grounding.

(b) Three-wire direct-current systems supplying interior wiring systems shall be grounded on the neutral at one or more supply stations but not at individual services or elsewhere on the interior systems.

(2) ALTERNATING CURRENT DISTRIBUTION SYSTEMS. (a) Secondary alternating-current distribution systems supplying wiring systems serving utilization equipment and interior alternating-current systems shall be grounded if they can be so grounded that the maximum voltage to ground does not exceed 300 volts.

(b) In alternating-current distribution systems ground connections shall be made at the building service and near the transformer (or transformers) either by direct ground connection through an extended metallic water piping system or made electrode or by the use of a system ground wire to which are connected the grounding conductors of many secondary mains, and which is itself effectively grounded at intervals that will fulfill for any secondary utilizing the system ground wire the resistance and current carrying capacities of sections E 103.07 and E 103.09.

1. In single-phase, 3-wire systems the ground connection shall be made on the neutral conductor.

2. In single-phase, 2-wire systems the ground connection shall be made on the neutral point or on either conductor. If the ground is made at the neutral point the neutral shall be run to each individual service.

3. In 2-phase, 3-wire systems, the ground connection shall be made to the conductor common to both phases. In 2-phase 4-wire systems, a ground connection shall be made to the neutral point of each phase.

4. In 3-phase, 3-wire, delta systems, the ground connection shall be made on one conductor or on the neutral point of one phase. If the ground is made at the neutral of one phase the neutral shall be run to each individual service.

5. Where one phase of a 2 or 3 phase system is used for lighting, that phase shall be grounded at only one point, at the neutral conductor, if one is used, or at one of the phase wires.

6. In 3-phase, 3-wire or 4-wire, star connected systems, the ground connections shall be made at the point common to all the phases.

7. Alternating current secondary circuits supplied from a transformer outside the building shall not be grounded inside buildings except at the service entrance.

(c) 1. For an interior system not electrically connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard and on the supply side of the first switch controlling the system.

2. Where transformers supply a common set of distribution mains, such fuses as are installed shall be so placed as not to leave any portion of the secondary system without grounding protection after the fuses have opened.

3. In the absence of a direct ground connection at all building services, ground connections shall be made to the grounded neutral or other grounded conductor of a secondary system supplying more than one utilization equipment, at intervals that will fulfill the resistance and current-carrying requirements of E 103.09. This is to take care of older installations without grounded services.

4. Where more than one building is served from a single service the conductor and equipment enclosures, and the neutral shall be grounded at each building.

(d) The primary neutral of a single or 3 phase supply system operating at not to exceed 22,000 volts between neutral and any phase conductor may be interconnected solidly with the secondary neutrals provided.

1. The customer's service entrance and the supply end are grounded in such a way that the requirements of section E 103.09 are met and 2. or 3. below are complied with.

2. The neutral is connected to an extended metallic underground water piping system or made electrodes complying with the resistance requirements of section E 103.09 at each transformer location and at a sufficient number of additional points to total 4 ground connections per mile.

3. The neutral is connected to single made electrodes complying with the dimensions specified in section E 103.08 (4) at each transformer location and at a sufficient number of additional points to total 9 grounds per mile. The additional grounds shall be placed first on poles adjacent to each customer's location, and then approximately equally spaced between the transformer locations.

(e) 1. A neutral conductor grounded as specified in section E 103.02(2)(d) is considered to be effectively grounded throughout its length.

2. A continuous metal sheath cable or supporting messenger is considered effectively grounded throughout its length if:

a. Connections are made to an extended metallic underground water piping system or to made electrodes complying with the resistance requirements of section E 103.09 at the beginning and at the end and at a sufficient number of additional points to total 4 ground connections per mile, or

b. Connections are made to single made electrodes complying with the dimensions specified in section E 103.08 (4) at a sufficient number of points to total 9 grounds per mile.

(f) The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected solidly or through a gap with the grounded conductor of such transformer, provided that in addition to the direct grounding connection at the arrester either:

1. The secondary has elsewhere 2 grounding connections at least 20 feet apart to extended underground metallic water piping systems or to made electrodes complying with the resistance requirements of section E 103.09. One or both of these connections may be at customers' entrances.

2. The secondary neutral is common with the primary neutral and is grounded in the manner specified in section E 103.02 (2) (d).

Note: The lightning arrester must be an acceptable lightning protective device having valve characteristics. See definition in chapter E 100.

(3) CURRENT IN GROUNDING CONDUCTOR. Grounds shall be so arranged that under normal conditions of service there will be no objectionable passage of current over the grounding conductors. The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective functions, are not to be considered as objectionable. If an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds a. one or more of such grounds shall be abandoned, or b. their location shall be changed, or c. the continuity of the conductor between the grounding connections shall be suitably interrupted, or d. other means satisfactory to the authority enforcing this code shall be taken to limit the current.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 103.03 Grounding conductor enclosures. The grounding of lighting and utilization wiring systems as well as metal envelopes containing supply conductors must comply with chapter E 250 even though in locations used exclusively by supply facilities.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 103.04 Grounding of fixed equipment. (1) Fixed equipment which is a part of or used in connection with utilization wiring shall be grounded as required even if in locations used for supply facilities.

(2) Fixed non-current carrying parts on poles which are more than 8 feet from the ground such as transformer cases may or may not be grounded depending on the company's rules. The company shall follow a standardized practice and make their operating rules conform to the practice adopted. If any portion of these non-current carrying parts are located within 8 feet of the ground they shall be grounded.

(3) Instruments, meters, or relays which operate with windings or working parts at 300 volts or more to ground shall have the cases and other exposed bare metal parts grounded unless isolated by elevation or protected by suitable insulating barriers or guards. An exception is made where the equipment is inaccessible to other than qualified persons, in which case the above protection is not required up to and including 750 volts. Above 750 volts, cases shall be isolated by elevation or protected by suitable barriers, grounded metal, or insulating covers or guards, where instruments, meters, or relays are operated from current or potential instrument transformers on circuits of 300 volts or more to ground, having ungrounded secondary circuits and ungrounded primary circuits, the cases and other exposed bare metal parts shall be grounded (See section E 103.06 (2)).

(4) Non-current carrying parts of fixed equipment may be grounded by metallically connecting them to the grounded metal raceway or cable armor, or otherwise as provided in section E 250.057.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 103.05 Grounding of portable equipment. The grounding of portable equipment is required by chapter 250 and such portable equipment must be grounded even though in locations used exclusively by supply facilities.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 103.06 Grounding conductors. (1) MATERIAL AND CONTINUITY. In all cases the grounding conductor shall be of copper or of other

metals or combination of metals which will not corrode excessively under the existing conditions. If joints are unavoidable they shall be so made and maintained as to not materially increase the resistance of the grounding conductor. Devices necessary for the proper operation of a supply system may be placed in a grounding conductor but no automatic cutout or switch shall be placed in the grounding conductor unless the opening of the cutout switch disconnects all sources of energy. For lightning arresters and ground detectors the grounding conductor shall be as short and straight as practicable and free from short bends.

(2) SIZE AND CAPACITY. The grounding conductor shall conform to the following:

(a) *For direct current circuits.* A grounding conductor for a direct-current supply system shall have a current-carrying capacity not less than that of the largest conductor supplied by the system and in no case less than that of No. 8 copper.

(b) *For alternating current circuits.* A grounding conductor for an alternating-current system shall have a current-carrying capacity not less than one-fifth that of the conductor to which it is attached but in no case shall the conductivity or tensile strength be less than that of No. 8 copper. See chapter E 250 for conductor size for grounding utilization equipment in interior wiring.

(c) *For instrument transformers.* The grounding conductor for instrument cases and secondary circuits of instrument transformers shall not be smaller than No. 12 if of copper or, if of other metal, shall have equivalent current-carrying capacity.

(d) *For primary lightning arresters.* The grounding conductor or conductors shall have a current-carrying capacity sufficient to insure continuity and continued effectiveness of the ground connection under conditions of excess current caused by or following discharge of the arrester. No individual grounding conductor shall have less conductance than No. 6 (0.162-inch) copper wire.

(e) *Interior utilization wiring, raceways, etc.* For conductor sizes for grounding utilization wiring, raceways, equipment, and portable and pendent equipment see chapter E 250.

(3) MECHANICAL PROTECTION AND GUARDING AGAINST CONTACT. (a) For a distance of 8 feet above the ground, floor, or platform, from which grounding conductors are accessible to the public, the conductors shall be protected by a substantial insulating conduit or wood molding.

1. Where the ground resistance is less than 3 ohms a metallic guard may be used provided that in the case of lightning arrester ground the ground conductor must be electrically connected to both ends and the metallic guard covered by an insulating conduit or molding.

2. In rural areas other than in farm and school yards, or spaces where people congregate, ground conductors of a multigrounded system may be of weatherproof insulation instead of a insulating conduit or molding.

3. Grounding conductors whose only purpose is to protect a pole against lightning need not be protected.

(b) The grounding wire must also be protected near supply and communication lines. (See section E 123.10).

(4) UNDERGROUND. Wires used for grounding conductors, if laid underground, shall, unless otherwise mechanically protected, be laid slack to prevent their being readily broken; and shall have joints carefully painted or otherwise protected against corrosion.

(5) COMMON GROUNDING CONDUCTOR FOR CIRCUITS, METAL RACEWAYS AND EQUIPMENT (See chapter E 250).

(6) BUSSES. In supply stations, manholes, and vaults accessible to qualified persons substantial bare busses may be used. Care should be taken to place them where accidental contact while working on live parts is difficult or they should be guarded.

History: Cr. Register, January, 1968, No. 145, eff. 2–1–68.

E 103.07 Ground connections. The ground connection shall be permanent and effective, and be made as indicated below, but always to underground metallic water piping systems, if available. Where the alternating current system is connected to a grounding electrode in or at a building, the same electrode shall be used to ground the conductor enclosure and equipment in or on that building.

(1) PIPING SYSTEMS. For circuits, equipment, and arresters at supply stations, connections shall be made to all available active metallic underground water-piping systems between which no appreciable difference of potential normally exists, if the pipe is of sufficient capacity, and to one such system if appreciable differences of potential do exist between them. At other places connections shall be made to at least one such system if available. Gas piping should be avoided.

Note: The protective grounding of electric circuits and equipment to underground metallic water-pipe systems in accordance with these rules should always be permitted, since such grounding offers the most effective protection to life and property and is not injurious to the piping systems.

Note: Ground connections from circuits should not be made to jointed piping within buildings except water piping.

(2) ALTERNATE METHODS. Where underground metallic water-piping systems are not available, other methods which will secure the desired permanence and conductance may be permitted. Buried metal structures of considerable extent may be used. In some cases ground connection may be made to the steel frame of a building containing the grounded circuits or equipment, to which frames of machines and other noncurrent-carrying surfaces should also then be grounded. In such cases the building frame should be itself well grounded by effective connection to the ground. This may require made electrodes for steel frame buildings supported on masonry or concrete footings.

(3) MADE ELECTRODES. If resort must be had to made (buried or driven) electrodes the number should be determined by the following requirements:

(a) Not more than one such ground is required for lightning arresters, except where needed for large current capacity.

(b) At least 2 grounds are required for low-voltage alternating-current distribution circuits, one at the transformer or elsewhere and one at each customer's service.

(c) Where no part of the circuit or equipment protected can be reached by persons while they are standing on the ground or damp