

IEEE Guide for Protective Grounding of Power Lines

IEEE Standards Board

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Sponsor

**Transmission and Distribution Committee of the
of the
IEEE Power Engineering Society**

Abstract: IEEE Std 1048-1990, IEEE Guide for Protective Grounding of Power Lines, provides guidelines for safe protective grounding methods for persons engaged in de-energized overhead transmission and distribution line maintenance. This guide compiles state-of-the-art information on protective grounding practices employed by power utilities in North America.

Keywords: Protective grounding, grounding practices, power lines, transmission lines, distribution lines.

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Foreword

(This Foreword is not a part of IEEE Std 1048-1990, IEEE Guide for Protective Grounding of Power Lines).

Protective grounding methods have often not kept pace with their increasing importance in work safety as the available fault current magnitudes grow, sometimes to as high as 100 kA, and as rights-of-way become more crowded with heavily loaded circuits, leading to growing problems of electric or magnetic induction. This guide has, therefore, been prepared to compile state-of-the-art information on protective grounding practices currently employed by power utilities in North America.

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IEEE Guide for Protective Grounding of Power Lines

1. General

1.1 Scope

This guide aims to provide guidelines for safe protective grounding methods for persons engaged in de-energized overhead transmission and distribution line maintenance.

1.2 Purpose of Protective Grounding

The primary purpose of protective grounding is to limit the voltage difference between any two accessible points at the work site to a safe value.

1.3 References

This guide shall be used in conjunction with the following publications. For further information, consult the Bibliography in Section 10.

[1] ASTM F-855-1983, Specifications for Temporary Grounding Systems to Be Used on De-energized Electric Power Lines and Equipment.¹

[2] IEEE Std 100-1988, IEEE Standard Dictionary of Electrical and Electronics Terms, 4th ed. (ANSI).²

[3] Dalziel, Charles F., The Effects of Electric Shock on Man, *IRE Transactions on Medical Electronics* (PGME-S), May 1956.

1.3.1 Document in Preparation³

2 Definitions

Terminology for equipment and procedures associated with the installation of temporary grounding systems varies widely throughout the utility industry. Therefore, definitions have been included to provide a correlation between the terminology used in this guide and industry synonyms. Note that the synonyms are terms commonly used, although many are not necessarily good usage and should not be taken as equivalents to the guide terminology.

Many of the terms have additional meanings and usages that are defined in IEEE Std 100-1988 [2].⁴

1. ASTM publications are available from the Sales Department of the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

2. IEEE publications may be obtained from the IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 or from the Sales Department, American National Standards Institute, 1430 Broadway, New York, New York 10018.

3. When the following document is completed, approved, and published, it will become a part of the references of this standard: P524A, proposed title: Guide to Grounding During the Installation of Overhead Transmission Line Conductors.

accessible voltage drop. Voltage difference between any two points accessible to workers at the work site.

anchor. A device that serves as a reliable support to hold an object firmly in place. The term is normally associated with cone, plate, screw or concrete anchors, but the terms *snub*, *dead man* and *anchor log* are usually associated with pole stubs or log set or buried in the ground to serve as temporary anchors. The latter are often used at pull and tension sites. (*See: anchor log*, IEEE Std 100-1988 [2].) *Synonyms: anchor log; dead man; snub.*

bonded. The mechanical interconnection of conductive parts to maintain a common electrical potential. (*See: bonding*, IEEE Std 100-1988 [2].) *Synonym: connected.*

bundle, two-conductor, three-conductor, four-conductor, multiconductor. A circuit phase consisting of more than one conductor. Each conductor of the phase is referred to as a subconductor. A two-conductor bundle has two subconductors per phase. These may be arranged in a vertical or horizontal configuration. Similarly, a three-conductor bundle has three subconductors per phase. These are usually arranged in a triangular configuration with the vertex of the triangle up or down. A four-conductor bundle has four subconductors per phase. These are normally arranged in a square configuration. Although other configurations are possible, those listed are the most common. *Synonyms: twin-bundle; tri-bundle; quad-bundle.*

clamp, grounding. A device used in making a connection between the electrical apparatus or conductors, and the ground bus, or grounding electrode.

conductor. A wire or combination of wires not insulated from one another, suitable for carrying an electric current. However, it may be bare or insulated. *Synonyms: cable; wire.*

de-energized. Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the ground. The term is used only with reference to current-carrying parts that are sometimes alive (energized). (*See: dead*, IEEE Std 100-1988 [2].) To state that a circuit has been de-energized means that the circuit has been disconnected from all intended electrical sources. However, it could be electrically charged through induction from energized circuits in proximity to it, particularly if the circuits are parallel. *Synonym: dead.*

energized. Electrically connected to a source of potential difference, or electrically charged so as to have a potential different from that of the ground. (*See: alive*, IEEE Std 100-1988 [2].) *Synonyms: alive; current carrying; hot; live.*

equipotential. An identical state of electrical potential for two or more items.

fault (components). A physical condition that causes a device, a component, or an element to fail to perform in a required manner, for example, a short circuit, or a broken wire.

fault (current). A current that flows from one conductor to ground or to another conductor owing to an abnormal connection (including an arc) between the two.

ground (earth). A conducting connection, whether intentional or accidental, by which an electrical circuit or equipment is connected to earth, or to some conductive body of relatively large extent that serves in place of the earth.

ground grid (temporary). A system of interconnected bare conductors arranged in a pattern over a specified area and on or buried below the surface of the earth. Normally, it is bonded to ground rods driven around and within its perimeter to increase its grounding capabilities and provide convenient connection points for grounding devices. The primary purpose of the grid is to provide safety for workers by limiting potential differences within its perimeter to safe levels in case of high currents that could flow if the circuit being worked became energized for any reason, or if an adjacent energized circuit faulted. Metallic surface mats and grat-

4. The numbers in brackets correspond to those of the References in 1.3.

ings are sometimes utilized for this same purpose. When used, these grids are employed at pull, tension, and midspace splice sites. (See: *counterpoise*; *ground grid*; *ground mat*, IEEE Std 100-1988 [2].) *Synonyms*: *counterpoise*; *ground gradient mat*; *ground mat*.

ground, personal. A portable device designed to connect (bond) a de-energized conductor or piece of equipment, or both, to an electrical ground. Distinguished from a master ground in that it is utilized at the immediate site when work is to be performed on a conductor or piece of equipment that could accidentally become energized. *Synonyms*: *ground stick*; *working ground*.

ground rod. A rod that is driven into the ground to serve as a ground terminal, such as a copper-clad rod, solid copper rod, galvanized iron rod, or galvanized iron pipe. Copper-clad steel rods are commonly used during conductor stringing operations to provide a means of obtaining an electrical ground using portable grounding devices. *Synonym*: *ground electrode*.

ground, running. A portable device designed to connect a moving conductor or wire rope, or both, to an electrical ground. These devices are normally placed on the conductor or wire rope adjacent to the pulling and tensioning equipment located at either end of a sag section. Primarily used to provide safety for personnel during construction or reconstruction operations. *Synonyms*: *ground roller*; *moving ground*; *rolling ground*; *traveling ground*.

ground, structure base (temporary). A portable device designed to connect (bond) a metal structure to an electrical ground. Primarily used to provide safety for personnel during construction, reconstruction, or maintenance operations. *Synonyms*: *butt ground*; *ground chain*; *structure ground*; *tower ground*.

ground, traveler. A portable device designed to connect a moving conductor or wire rope, or both, to an electrical ground. Primarily used to provide safety for personnel during construction or reconstruction operations. This device is placed on the traveler (sheave, block, etc.) at a strategic location where an electrical ground is required. *Synonyms*: *block ground*; *rolling ground*; *sheave ground*.

induction, electrostatic (electric coupling). A common misnomer. There is no IEEE definition for *electrostatic*. The term *static* implies “at rest” or not varying with time. Therefore, this term may be construed to mean induced potential or current resulting from an object being placed in a dc electric field, but often the term is loosely used to include ac field effects.

induction (coupling). The process of generating time-varying voltages and/or currents in otherwise unenergized conductive objects or electric circuits by the influence of the time-varying electric and/or magnetic fields.

electric field induction (capacitive coupling). The process of generating voltages or currents or both in a conductive object or electric circuit by means of time-varying electric fields.

NOTES

1—*Electric field induction* is preferred over *electric induction* because the latter may be taken to mean electric flux density.

2—*Electric field induction* was formerly called *electrostatic induction*. This usage is deprecated because electrostatic fields are time invariant.

magnetic field induction (inductive coupling). The process of generating voltages and/or currents in a conductive object or electric circuit by means of time-varying magnetic fields.

NOTES

1—*Magnetic field induction* was formerly called *electromagnetic induction*. This usage is now deprecated because electromagnetic induction refers to combined electric and magnetic field effects.

2—*Magnetic field induction* is preferred over *magnetic induction* because the latter is reserved to mean magnetic flux density.

electromagnetic field induction (electromagnetic coupling). The induction process that includes both electric and magnetic fields.

isolated. (1) Physically separated, electrically and mechanically, from all sources of electrical energy. Such separation may not eliminate the effects of electromagnetic induction. (2) Not readily accessible to persons unless special means for access are used.

jumper. (1) A metallic wire connecting the conductors on opposite sides of a dead-end structure so that continuity is maintained. *Synonym: dead-end loop.* (2) A conductor placed across the clear space between the ends of two conductors or metal pulling lines that are being spliced together. Its purpose then is to act as a shunt to prevent workers from accidentally placing themselves in series between the two conductors.

line, pulling. A high-strength line, normally synthetic fiber rope or wire rope, used to pull the conductor. However, on reconstruction jobs where a conductor is being replaced, the old conductor often serves as the pulling line for the new conductor. In such cases, the old conductor must be closely examined for any damage prior to the pulling operations. *Synonyms: bull line; hard line; light line; sock line.*

overhead groundwire (OHGW) (lightning protection). Multiple grounded wires placed above phase conductors for the purpose of intercepting direct strokes in order to protect the phase conductors from the direct strokes. *Synonyms: earth wire; shield wire; skywire; static wire.*

resistance, body. Determined from the ratio of voltage applied to current flowing in a body, neglecting capacitive and inductive effects. That value impeding the current flow through the common body resulting from contact with an energized line.

sheave. (1) The grooved wheel of a traveler or rigging block. Travelers are frequently referred to as sheaves. *Synonyms: pulley; roller; wheel.* (2) A shaft-mounted wheel used to transmit power by means of a belt, chain, band, etc.

shock, primary. A shock of such a magnitude that it may produce direct physiological harm. Result of primary shock: fibrillation, respiratory tetanus, and/or muscle contraction.

shock, secondary. A shock of such a magnitude that it will not produce direct physiological harm, but it is annoying and may cause involuntary muscle reaction. Result of secondary shock: annoyance, alarm, and aversion.

static charge. Any electric charge at rest (e.g., charge on a capacitor), often loosely used to describe discharge conditions resulting from electric field coupling.

step potential. The potential difference between two points on the earth's surface separated by a distance of one pace (assumed to be one meter) in the direction of maximum potential gradient. This potential difference could be dangerous when current flows through the earth or material upon which a worker is standing, particularly under fault conditions. *Synonym: step voltage.*

stringing. The pulling of pilot lines, pulling lines, and conductors over travelers supported on structures of overhead transmission lines. Quite often, the entire job of stringing conductors is referred to as stringing operations, beginning with the planning phase and terminating after the conductors have been installed in the suspension clamps.

switching surge. A transient wave of over-voltage in an electrical circuit caused by a switching operation. When this occurs, a momentary voltage surge could be induced in a circuit adjacent and parallel to the switched circuit in excess of the voltage induced normally during steady-state conditions. If the adjacent circuit is under construction, switching operations should be minimized to reduce the possibility of hazards to the workers.

touch potential. The potential difference between a grounded metallic structure and a point on the earth's

surface separated by a distance equal to the normal maximum horizontal reach, approximately one meter. This potential difference could be dangerous and could result from induction or fault conditions, or both. *Synonym: touch voltage.*

traveler. A sheave complete with suspension arm or frame used separately or in groups and suspended from structures to permit the stringing of conductors. These devices are sometimes bundled with a center drum, or sheave and another traveler, and used to string more than one conductor simultaneously. For protection of conductors that should not be nicked or scratched, the sheaves are often lined with nonconductive or semi-conductive neoprene or with nonconductive urethane. Any one of these materials acts as a padding or cushion for the conductor as it passes over the sheave. Traveler grounds must be used with lined travelers in order to establish an electrical ground. *Synonyms: block; dolly; sheave; stringing block; stringing sheave; stringing traveler.*

3. Principles

3.1 Introduction

Voltage may appear at the work site due to accidental reenergization either through the isolating device or due to contact with another circuit, electric or magnetic induction from adjacent circuits, or a direct or indirect lightning stroke.

3.2 Voltages at the Work Site

When a grounded conductor becomes energized, the current flowing through grounded parts could result in potentially hazardous voltage differences between these parts if the protective grounding is inadequate. Figure 1 illustrates working positions aloft where abnormal voltages might appear. Figure 2 shows the step and touch voltages at the base of a line structure that could be of hazard to the groundman.

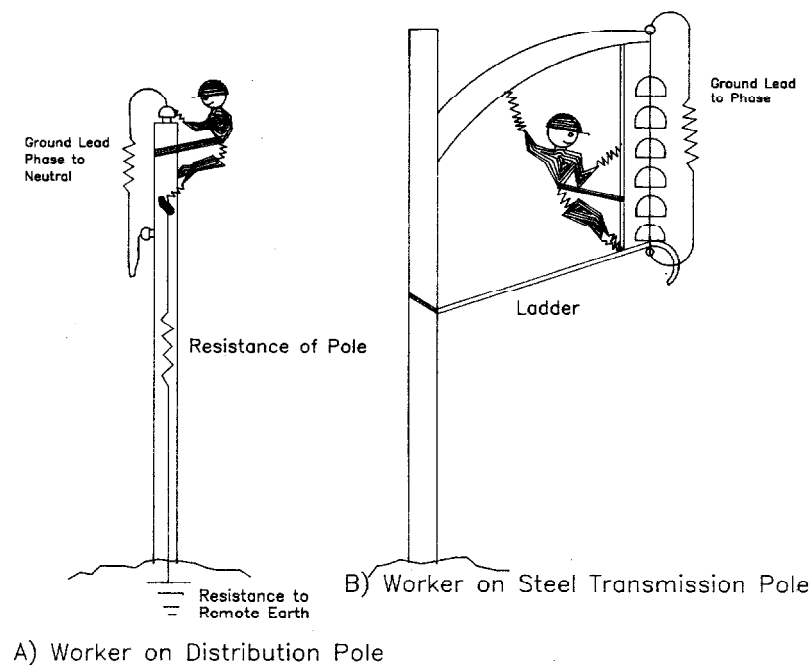


Figure 1 — Working Positions Aloft Where Abnormal Voltages Might Appear