

IEEE Guide for the Installation of Overhead Transmission Line Conductors

IEEE Power and Energy Society

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Transmission & Distribution Committee

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IEEE Guide for the Installation of Overhead Transmission Line Conductors

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**Transmission & Distribution Committee
of the
IEEE Power and Energy Society**

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Abstract: General recommendations for the selection of methods, equipment, and tools that have been found to be practical for the stringing of overhead transmission line conductors and overhead groundwires are provided.

Keywords: IEEE 524™, overhead groundwires, overhead transmission line conductors

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Introduction

This introduction is not part of IEEE Std 524-2016, IEEE Guide for the Installation of Overhead Transmission Line Conductors.

This guide provides general recommendations for the selection of methods, equipment, and tools that have been found to be practical for the stringing and grounding of overhead transmission line conductors and overhead groundwires. The following revisions have been made and are intended to improve the usefulness of the document:

The definitions in 3.1 have been expanded.

The acronyms in 3.2 have been expanded. The drawings throughout the guide have been updated.

Reel handling has been expanded in 7.2.

The section on the use of the stopwatch method for sag measurements has been expanded.

The section on the use of dynamometers for sag measurements has been expanded.

Sagging on flexible structures has been expanded in 10.5.2.

The wind effects on sag measurements have been added to 10.5.14.

Aluminum conductor, steel supported has been expanded in 11.1.

T-2 conductor has been changed to its current twisted pair designation and 11.2 on TP conductors have been expanded.

Aluminum conductor composite reinforced has been added in 11.6.

Aluminum conductor composite core has been added in 11.7.

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IEEE Guide for the Installation of Overhead Transmission Line Conductors

1. Overview

1.1 Scope

This guide provides general recommendations for the selection of methods, equipment, and tools that have been found to be practical for the stringing of overhead transmission line conductors and overhead groundwires. The guide also includes a comprehensive list of definitions for equipment and tools used in stringing and for stringing terms commonly employed. This guide does not address special conductors such as those used for river and canyon crossing. These conductors may be custom designed and often may require special considerations.

1.2 Purpose

The purpose of this guide is to present in one document sufficient details of present day methods, materials, and equipment to outline the basic considerations necessary for maintaining safe and adequate control of conductors during stringing operations. References are given in Clause 2 for those desiring more detailed information. Because the terminology used for many hardware items and for many stringing terms varies from place to place, a list of definitions is included to provide correlation and clarification of the terms most commonly employed.

1.3 Application

This guide is broad enough yet specific enough to be applicable to the stringing of conventional overhead transmission conductors and overhead groundwires (OHGW) of the following types: AAAC, AAC, AACSR, ACAR, ACSR, ACSR/TW, ACSS, ACCR, ACCC, CU, OPGW, aluminum-clad steel OHGW, and galvanized steel OHGW¹. Since stringing practices for different projects will be strongly influenced by the magnitude and nature of each project and by local circumstances, alternate methods that have been successfully employed are presented. Information contained in this guide may not be sufficient for certain

¹ See 3.2 for definitions of all acronyms.

special cases, such as when stringing extremely long spans, severe line angles, high tensions, or special conductors. In these cases, the manufacturer should be consulted. The practices that are described in this guide provide for continuous control of the conductor from the initial setup to the ready-for-service condition. Any legal requirements of national, state, or local regulations must, of course, be observed. The approach used within this guide is first to describe, in general terms, the stringing methods most commonly employed, then the specific requirements of the various tools and equipment used. Finally, the application of the methods and equipment to the process of stringing is described.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

This guide shall be used in conjunction with the following publications. If the following publications are superseded by an approved revision, the revision shall apply.

ASTM F855-97e1, Standard Specifications for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment.

IEC 61230 (1993-09), Live working—Portable equipment for earthing or earthing and short-circuiting.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.²

Aerex: *See:* **explosives.**

aerial platform: A device designed to be attached to the boom tip of a crane or aerial lift and support a worker in an elevated position. Platforms may be constructed with surrounding railings that are fabricated from aluminum, steel, or fiber reinforced plastic. Occasionally, a platform is suspended from the load line of a large crane. *Syn:* **cage, platform.**

alive: *See:* **energized.**

all-terrain vehicle (ATV): *See:* **off-road vehicle.**

alligator: *See:* **running board.**

aluminum alloy conductor, steel reinforced: A composite conductor made up of a combination of aluminum alloy and coated steel wires. In the usual construction, the aluminum wires surround the steel.

²IEEE Standards Dictionary Online subscription is available at: <http://dictionary.ieee.org>.

aluminum conductor, aluminum alloy reinforced: A composite conductor made up of a combination of aluminum and aluminum alloy wires. In the usual construction, the aluminum wires surround the aluminum alloy.

aluminum conductor, composite core: A composite conductor that consists of annealed aluminum strands surrounding a single strand carbon and glass fiber core. In the usual construction, the aluminum wires surround the steel.

aluminum conductor, steel reinforced: A composite conductor made up of a combination of aluminum and coated steel wires. In the usual construction, the aluminum wires surround the steel. In the usual construction, the aluminum wires surround the steel.

aluminum conductor, steel supported: A composite conductor similar in construction to aluminum conductor, steel reinforced (ACSR) but with the aluminum wires annealed. In the usual construction, the aluminum wires surround the steel.

American Society for Testing and Materials: Founded in 1898, the society is a scientific and technical organization formed for the development of standards on characteristics and performance of materials, products, systems, and service; and the promotion of related knowledge.

American Wire Gage: Also known as the Brown and Sharp gage, the gage was devised in 1857 by J. R. Brown. This gage has the property such that its sizes represent approximately the successive steps in the process of wire drawing. Also, its numbers are retrogressive; a larger number denotes a smaller wire corresponding to the operations of drawing. These gage numbers are not arbitrarily chosen, but follow the mathematical law upon which the gage is founded.

anchor: A device that serves as a reliable support to hold an object firmly in place. The general term “anchor” is normally associated with cone, plate, screw, or concrete anchors. The terms *snub*, *deadman*, and *anchor log* are usually associated with pole stubs or logs set or buried in the ground to serve as temporary anchors. The latter are often used at pull and tension sites. *Syn:* **anchor log, deadman, snub.**

anchor log: *See:* **anchor.**

anchor site: The location along the line where anchors are installed to temporarily hold the conductors in facilitating splicing, pulling, or tensioning.

baker board: *See:* **lineperson’s platform.**

basket: *See:* **bucket, woven wire grip.**

bell lifter: *See:* **insulator lifter.**

bicycle: *See:* **cable car.**

binder: *See:* **load, binder.**

bird: *See:* **running board.**

bird caging: Loosening of the outer strands of the conductor.

birdie: *See:* **running board.**

block: A device designed with one or more single sheaves, a wood or metal shell, and an attachment, hook or shackle. When rope is reeved through two of these devices, the assembly is commonly referred to as a block and tackle. A set of fours refers to a block and tackle arrangement utilizing two 10 cm double sheave

blocks to obtain four load-bearing lines. Similarly, a set of fives or a set of sixes refers to the same number of load-bearing lines obtained using two 12.5 cm or two 15 cm double sheave blocks, respectively. *Syn:* **traveler, set of fours, set of fives, set of sixes.**

block ground: *See* **traveler ground.**

boatswain's chair: A seat designed to be suspended on a line reeved through a block and attached to a pulling device to hoist a workman to an elevated position. *Syn:* **bosun's chair.**

body resistance: Determined from the ratio of voltage applied to current flowing in a human body, neglecting capacitive and inductive effects.

bonded: The mechanical interconnection of conductive parts to maintain a common electrical potential. *Syn:* **connected.**

bosun's chair: *See:* **boatswain's chair.**

boxing glove: *See:* **conductor lifting hook.**

brake: *See:* **bullwheel tensioner.**

bucket: A device designed to be attached to the boom tip of a line truck, crane, or aerial lift to support workers in an elevated working position. It is normally constructed of fiberglass to reduce its physical weight, maintain strength, and obtain good dielectric characteristics. *Syn:* **basket.**

buffalo: *See:* **conductor grip.**

bull line: A high-strength line, normally synthetic fiber rope, used for pulling and hoisting large loads. *Syn:* **bull rope, pulling line, threading line.**

bull rope: *See:* **bull line.**

bullet: *See:* **connector link.**

bullwheel: A wheel incorporated as an integral part of a bullwheel puller or tensioner to generate pulling or braking tension on conductors or pulling lines, or both, through friction. A puller or tensioner normally has one or more pairs of wheels arranged in tandem incorporated in its design. The physical size of the wheels will vary for different designs, but 43 cm face widths and diameters of 150 cm are common. The wheels are power driven or retarded and lined with single or multiple groove neoprene or urethane linings. Friction is accomplished by reeving the pulling line or conductor around the groove of each pair.

bullwheel puller: A device designed to pull pulling lines and conductors during stringing operations. It normally incorporates one or more pairs of urethane- or neoprene-lined, power-driven, single- or multiple-groove bullwheels in which each pair is arranged in tandem. Pulling is accomplished by friction generated against the pulling line or conductor that is reeved around the grooves of a pair of the bullwheels. The puller is usually equipped with its own engine which drives the bullwheels mechanically, hydraulically, or through a combination of both. Some of these devices function as either a puller or tensioner. *Syn:* **puller.**

bullwheel tensioner: A device designed to hold tension against a pulling line or conductor during the stringing phase. Normally, it consists of one or more pairs of urethane- or neoprene-lined, power-braked, single- or multiple-groove bullwheels in which each pair is arranged in tandem. Tension is accomplished by friction generated against the conductor or pulling line that is reeved around the grooves of a pair of the bullwheels. Some tensioners are equipped with their own engines which retard the bullwheels mechanically, hydraulically, or through a combination of both. Some of these devices function as either a

puller or tensioner. Other tensioners are equipped with only friction type retardation. *Syn:* **brake, retarder, tensioner.**

bundle, two-conductor, three-conductor, four-conductor, multi-conductor: 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 usually are arranged in a triangular configuration with the vertex of the triangle up or down. A four-conductor bundle has four subconductors per phase. These normally are arranged in a square configuration. Although other configurations are possible, those listed are the most common. *Syn:* **twin-bundle, tri-bundle, quad-bundle.**

butt ground: *See:* **structure base ground.**

cable: *See:* **conductor.**

cable buggy: *See:* **conductor car.**

cable car: A seat or basket-shaped device, designed to be suspended by a framework, and two or more sheaves arranged in tandem to enable a workman to ride a single or bundled conductor, wire, or cable. *Syn:* **bicycle, cable trolley, conductor car.**

cable clamp: A device designed to clamp cables together. It consists of a “U” bolt threaded on both ends, two nuts, and a base, and is commonly used to make temporary bend back eyes on wire rope. *Syn:* **clip, Crosby, Crosby clip.**

cable trolley: *See:* **cable car.**

cage: *See:* **aerial platform.**

carrying: *See:* **energized.**

carrying current: *See:* **energized.**

cat: *See:* **crawler tractor.**

chain binder: *See:* **load, binder.**

chain hoist: *See:* **hoist.**

chain tugger: *See:* **hoist.**

Chinese finger: *See:* **woven wire grip.**

Chicago grip: *See:* **conductor grip.**

choker: *See:* **traveler sling.**

clamping-in: *See:* **clipping-in.**

clearance: **(A)** The condition in which a circuit has been de-energized to enable work to be performed more safely. A clearance is normally obtained on a circuit presenting a source of hazard prior to starting work. *Syn:* **outage, permit, restriction.** **(B)** The separation between two conductors, between conductors and supports or other objects, or between conductors and ground or the clear space between any objects.

clip: *See:* **cable clamp.**

clipping: *See:* **clipping-in.**

clipping-in: The transferring of sagged conductors from the travelers to their permanent suspension positions and the installing of the permanent suspension clamps. *Syn:* **clamping-in, clipping.**

clipping offset: A calculated distance, measured along the conductor from the plumb mark to a point on the conductor at which the center of the suspension clamp is to be placed. When stringing in rough terrain, clipping offsets may be required to balance the horizontal forces on each suspension structure.

clock: *See:* **dynamometer.**

coffing: *See:* **hoist.**

coffing hoist: *See:* **hoist.**

come-along: *See:* **hoist.**

compression joint: A tubular compression fitting designed and fabricated from aluminum, copper, or steel to join conductors or overhead groundwires. It is usually applied through the use of hydraulic or mechanical presses. However, in some cases, automatic, wedge, and explosive-type joints are utilized. *Syn:* **conductor splice, sleeve, splice.**

conductor: A wire, or combination of wires not insulated from one another, suitable for carrying an electric current. It may be, however, bare or insulated. *Syn:* **cable, wire.**

conductor car: A device designed to carry workmen and ride on sagged bundle conductors, thus enabling them to inspect the conductors for damage and install spacers and dampers where required. These devices may be manual or powered. *Syn:* **cable buggy, cable car, spacer buggy, spacer cart, spacing bicycle.**

conductor grip: A device designed to permit the pulling of conductor without splicing on fittings, eyes, etc. It permits the pulling of a continuous conductor where threading is not possible. The designs of these grips vary considerably. Grips such as the Klein (Chicago) and Crescent utilize an open-sided rigid body with opposing jaws and swing latch. In addition to pulling conductors, this type is commonly used to tension guys and, in some cases, pull wire rope. The design of the come-along (pocketbook, suitcase, four bolt, etc.) incorporates a bail attached to the body of a clamp that folds to completely surround and envelope the conductor. Bolts are then used to close the clamp and obtain a grip. *Syn:* **buffalo, crescent, four bolt grip, Chicago grip, Klein, pocketbook, seven bolt, six bolt, slip-grip, suitcase.**

conductor hook: *See:* **conductor lifting hook.**

conductor lifting hook: A device resembling an open boxing glove designed to permit the lifting of conductors from a position above them. It is normally used during clipping-in operations. Suspension clamps are sometimes used for this purpose. *Syn:* **boxing glove, conductor hook, lifting shoe, lip.**

conductor payout station: *See:* **tension site.**

conductor safety: A sling arranged in a vertical basket configuration, with both ends attached to the supporting structure and passed under the clipped-in conductor(s). These devices, when used, are normally utilized with bundled conductors to act as a safety device in case of insulator failure while workers in conductor cars are installing spacers between the subconductors, or as an added safety measure when crossing above energized circuits. These devices may be fabricated from synthetic fiber, rope or wire rope.

conductor splice: *See:* **compression joint.**

connected: *See:* **bonded.**

connector: *See:* **connector link.**

connector link: A rigid link designed to connect pulling lines and conductors together in series. It will not spin and relieve torsional forces. *Syn:* **bullet, connector, link, slug.**

control span: *See:* **sag span.**

counterpoise: *See:* **ground grid.**

crawler: *See:* **crawler tractor.**

crawler tractor: A tracked unit employed to pull pulling lines, sag conductor, level or clear pull and tension sites, and miscellaneous other work. It is also frequently used as a temporary anchor. Sagging winches on this unit are usually arranged in a vertical configuration. *Syn:* **cat, crawler, tractor, dozer.**

crescent: *See:* **conductor grip.**

Crosby: *See:* **cable clamp.**

Crosby clip: *See:* **cable clamp.**

crossing structure: A structure built of poles and, sometimes, rope nets. It is used whenever conductors are being strung over roads, power lines, communications circuits, highways, or railroads, and is normally constructed in such a way as to prevent the conductor from falling onto or into any of these facilities in the event of equipment failure, broken pulling lines, loss of tension, etc. *Syn:* **guard structure, H-frame, rider structure, temporary structure.**

current carrying: *See:* **energized.**

D-board: *See:* **lineperson's platform.**

dead: *See:* **de-energized.**

deadend board: *See:* **lineperson's platform.**

deadend loop: *See:* **jumper.**

deadend platform: *See:* **lineperson's platform.**

deadman: *See:* **anchor.**

de-energized: Free from any electric 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). 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. *Syn:* **dead.**

diving board: *See:* **lineperson's platform.**

dolly: *See:* **traveler.**

dolly car: *See:* **traveler rack.**

double drum hoist: *See:* **puller, two drum, three drum.**

double drum winch: *See:* **puller, two drum, three drum.**

dozer: *See:* **crawler tractor.**

drum puller: A device designed to pull conductor(s) during stringing operations. It is normally equipped with its own engine which drives the drum(s) mechanically, hydraulically, or through a combination of both. It may be equipped with synthetic fiber rope or wire rope to be used as the pulling line. The pulling line is payed out from the unit, pulled through the travelers in the sag section, and attached to the conductor. The conductor is then pulled in by winding the pulling line back onto the drum. This unit is sometimes used with synthetic fiber rope acting as a pilot line to pull heavier pulling lines across canyons, rivers, etc. *Syn:* **hoist, single drum hoist, single drum winch, tugger.**

dynamite: *See:* **explosives.**

dynamometer: A device designed to measure loads or tension on conductors. Various models of these devices are used to tension guys or sag conductors. *Syn:* **clock, load cell.**

earth wire: *See:* **overhead groundwire.**

electric field induction (capacitive coupling): The process of generating voltages and/or currents in conductive objects or electrical circuits by the induction process that results from time-varying quasi-static electric fields.

NOTE 1—The term “electric field induction” is preferred over “electric induction” because the latter may be taken to mean electric flux density.

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

electromagnetic field induction (electromagnetic coupling): The induction process that results from time-varying electromagnetic fields.

energized: Electrically connected to a source of potential difference, or electrically charged so as to have a potential different from that of the ground. *Syn:* **alive, carrying current, current carrying, hot, live.**

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

equipotential work zone (area, site): A work zone (area, site) where all equipment is interconnected by jumpers, grounds, ground rods, and/or grids that will provide acceptably small potential differences between all parts of the zone under worst-case conditions of energization.

explosives: Mixtures of solids, liquids, or a combination of the two that, upon detonation, transform almost instantaneously into other products that are mostly gaseous and that occupy much greater volume than the original mixtures. This transformation generates heat, which rapidly expands the gases, causing them to exert enormous pressure. Dynamite and Primacord® are explosives as manufactured. Aerex®, Triex®, and Quadrex® are manufactured in two components and are not true explosives until mixed. Explosives are commonly used to build construction roads, blast holes for anchors, structure footings, etc. *Syn:* **Aerex®³, dynamite, fertilizer, powder, Primacord®, Quadrex®⁴, Triex®⁵.**

³ Aerex is a registered trademark of Precision Castparts Corporation.

⁴ Quadrex is a registered trademark of Quadrex Corporation.

⁵ Triex is a registered trademark of Silevo, Inc.

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, a broken wire, and an intermittent connection.

fault current (general): A current that flows from one conductor to ground or to another conductor owing to an abnormal connection (including an arc) between the two. A fault current flowing to ground may be called a ground fault current.

fertilizer: *See: explosives.*

finger line: A lightweight line, normally sisal, manila, or synthetic fiber rope, that is placed over the traveler when it is hung. It usually extends from the ground and passes through the traveler and back to the ground. It is used to thread the end of the pilot line or pulling line over the traveler and eliminates the need for workmen on the structure. These lines are not required if pilot lines are installed when the travelers are hung. *Syn: finger rope.*

finger rope: *See: finger line.*

four bolt grip: *See: conductor grip.*

grip: *See: conductor grip.*

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

NOTE—It is used for establishing and maintaining the potential of the earth (or of the conducting body) or approximately that potential, on conductors connected to it, and for conducting body current to and from the earth (or the conducting body).⁶

ground chain: *See: structure base ground.*

ground electrode: *See: ground rod.*

ground gradient mat: *See: ground grid.*

ground grid: A system of interconnected bare conductors arranged in a pattern over a specified area either 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 workmen 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 gratings are sometimes utilized for this same purpose. When used, these grids are employed at pull, tension, and midspan splice sites. *Syn: counterpoise, ground gradient mat, ground mat.*

ground mat: *See: ground grid.*

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. *Syn: ground electrode.*

ground roller: *See: running ground.*

⁶ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

ground set: *See:* master ground.

ground source: *See:* ground (earth).

ground stick: *See:* personal ground.

ground system (general): Consists of all interconnected grounding connections in a specific area. *Syn:* **grounding system.**

grounded: Connected to earth or to some extended conducting body that serves instead of the earth, whether the connection is intentional or accidental.

grounded (conductor stringing equipment): Connected to earth or to some extended conducting body that serves instead of the earth, whether the connection is intentional or accidental.

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

guard structure: *See:* crossing structure.

H-frame: *See:* crossing structure.

hard line: *See:* pulling line.

harpoon: A spear-like device used for stringing conductors through a structure window using the needle method of helicopter stringing. The middle and one end of the harpoon are affixed with hooks and used for threading through the structure window, while the other end of the harpoon is attached to the pulling line.

hoist: An apparatus for moving a load by the application of a pulling force and not including a car or platform running in guides. These devices are normally designed using roller or link chain and built-in leverage to enable heavy loads to be lifted or pulled. They are often used to deadend a conductor during sagging and clipping-in operations and during the tensioning of guys. *Syn:* **chain hoist, chain tugger, coffer, coffer hoist, come-along, drum puller.**

hold-down block: A device designed with one or more single grooved sheaves to be placed on the conductor and used as a means of holding it down. This device functions essentially as a traveler used in an inverted position. It is normally used in midspan to control conductor uplift caused by stringing tensions, or at splicing locations to control the conductor as it is allowed to rise after splicing is completed. *Syn:* **splice release block, hold-down roller, hold-down traveler.**

hold-down roller: *See:* hold-down block.

hold-down traveler: *See:* hold-down block.

hook ladder: *See:* tower ladder.

hose clamp: *See:* strand restraining clamp.

hot: *See:* energized.

hub: A reference point established through a land survey. A hub or point on tangent (POT) is a reference point for use during construction of a line. The number of such points that are established will vary with the job requirements. Monuments, however, are usually associated with state or federal surveys and are intended to be permanent reference points. Any of these points may be used as a reference point for transit

sagging operations, provided that all necessary data pertaining to them is known. It is quite common to establish additional temporary hubs as required for this purpose. *Syn:* **monument, point on tangent.**

Insulated Cable Engineers Association: Founded in 1925, the Insulated Cable Engineers Association is a professional society of insulated cable engineers to promote the reliability of covered and insulated conductors for the transmission and distribution of electric energy, control, and instrumentation of equipment and communications.

insulated ground stick: An insulated rod, fabricated from fiberglass reinforced plastic, with specialized connection hardware, operating mechanism, and of sufficient length to allow for safe gripping and installation of grounding clamps.

insulator lifter: A device designed to permit insulators to be lifted in a *string* to their intended position on a structure. *Syn:* **insulator saddle, potty seat, bell lifter.**

insulator saddle: *See:* **insulator lifter.**

isolated: **(A)** Physically separated, electrically and mechanically, from all sources of electrical energy. Such separation may not eliminate the effects of electrical induction. **(B)** An object that is not readily accessible to persons unless special means for access are used.

Jacob's ladder: *See:* **rope ladder.**

jumper: **(A)** The conductor that connects the conductors on opposite sides of a deadend structure. *Syn:* **deadend loop.** **(B)** 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.

kellem: *See:* **pulling grip, woven wire grip.**

Klein: *See:* **conductor grip.**

leader: *See:* **pilot line.**

leader cone: A tapered cone made of rubber, neoprene, or polyurethane that is used to lead a conductor splice through the travelers, thus making a smooth transition from the smaller diameter conductor to the larger diameter splice. It is also used at the connection point of the pulling line and running board to assist in a smooth transition of the running board over the travelers, thus significantly reducing the shock loads. *Syn:* **nose cone, tapered hose.**

lead line: *See:* **pilot line.**

level: *See:* **transit.**

life line: *See:* **safety life line.**

lifting shoe: *See:* **conductor lifting hook.**

light line: *See:* **pulling line.**

lineperson's platform: A device designed to be attached to a wood pole or metal structure to serve as a supporting surface for workers engaged in deadending operations, clipping-in, insulator work, etc. The designs of these devices vary considerably. Some resemble short cantilever beams, others resemble swimming pool diving boards, and still others as long as 40 ft (12 m) are truss structures resembling

bridges. Materials commonly used for fabrication are wood, fiberglass, and metal. *Syn:* **baker board, D-board, deadend board, deadend platform, diving board.**

link: *See:* **connector link.**

lip: *See:* **conductor lifting hook.**

live: *See:* **energized.**

load binder: A toggle device designed to secure loads in a desired position. It is normally used to secure loads on mobile equipment. *Syn:* **binder, chain binder.**

load cell: *See:* **dynamometer.**

logger: *See:* **wheel tractor.**

magnetic field induction (inductive coupling): The process of generating voltages and/or currents in conductive objects or electric circuits by the induction process that results from time-varying quasi-static magnetic fields.

NOTE 1—"Magnetic field induction" was formerly called "electromagnetic induction." This usage is now depreciated because electromagnetic induction refers to the combined electric and magnetic field effects.

NOTE 2—The term "magnetic field induction" is preferred over "magnetic induction" because the latter may be taken to mean magnetic flux density.

NOTE 3—The fields in the vicinity of a transmission line can be adequately described as an electric field and a magnetic field. Electromagnetic may imply one or both of these fields. There should be no questions as to what is meant when the electric field or the magnetic field is discussed.

marker: *See:* **plumb marker pole.**

master ground: A portable device designed to short circuit and connect (bond) a de-energized circuit or piece of equipment, or both, to an electrical ground. Normally located remote from, and on both sides of, the immediate work site. The master ground is primarily used to provide safety for personnel during construction, reconstruction, or maintenance operations. *Syn:* **ground set, ground stick.**

monkey tail: *See:* **running board.**

monument: *See:* **hub.**

moving ground: *See:* **running ground.**

needle method: A method of stringing conductors with a helicopter by using a harpoon to thread the pulling line through the structure window.

nose cone: *See:* **leader cone.**

O structure: *See:* **snub structure.**

off-road vehicle: A vehicle specifically designed and equipped to traverse sand, swamps, muddy tundra, or rough mountainous terrain. Vehicles falling into this category are usually all wheel drive or tracked units. In some cases, units equipped with special air bag rollers having a soft footprint are utilized. *Syn:* **all-terrain vehicle (ATV), swamp buggy.**

offset marker (pole): *See:* **plumb marker pole.**

optical ground wire: Concentric-lay-stranded composite conductor for use as overhead groundwire with telecommunication capability. The conductor is constructed with a central optical fiber core surrounded by helically laid aluminum-clad wires, aluminum alloy wires, galvanized steel wires, or combinations thereof.

outage: *See:* **clearance.**

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

payout site: *See:* **tension site.**

peanut: *See:* **rope connector.**

permit: *See:* **clearance.**

personal ground: A portable device designed to connect (bond) a de-energized conductor or piece of equipment, or both to a ground. The personal ground is 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. *Syn:* **ground stick, working ground, red head.**

pilot line: A lightweight line, normally synthetic fiber rope, used to pull heavier pulling lines that, in turn, are used to pull the conductor. Pilot lines may be installed with the aid of finger lines or by helicopter when the insulators and travelers are hung. *Syn:* **lead line, leader, P-line, pilot rope, straw line.**

pilot-line winder: A device designed to payout and rewind pilot lines during stringing operations. It is normally equipped with its own engine, which drives a drum or a supporting shaft for a reel mechanically, hydraulically, or through a combination of both. These units are usually equipped with multiple drums or reels, depending upon the number of pilot lines required. The pilot line is payed out from the drum or reel, pulled through the travelers in the sag section, and attached to the pulling line on the reel stand or drum puller. It is then rewound to pull the pulling line through the travelers. A pilot-line winder can be a unit similar to a bullwheel puller and often has the reel winder as an integral part of the machine.

pilot rope: *See:* **pilot line.**

platform: *See:* **aerial platform.**

P-line: *See:* **pilot line.**

plier clamp: *See:* **strand restraining clamp.**

plumb mark: A mark placed on the conductor located vertically below the insulator point of support for steel structures and vertically above the pole center line at ground level for wood pole structures used as a reference to locate the center of the suspension clamp.

plumb marker pole: A small diameter, lightweight pole with a marking device attached to one end, having sufficient length to enable a worker to mark the conductor directly below him/her from a position on the bridge or arm of the structure. This device is utilized to mark the conductor immediately after completion of sagging. *Syn:* **marker, offset marker (pole).**

pocketbook: *See:* **conductor grip.**

point on tangent: *See:* **hub.**

potty seat: *See:* **insulator lifter.**

powder: *See:* **explosives.**

Primacord®: *See:* **explosives.**⁷

protector joint: A split sleeve that fits over a conductor compression joint used to protect the joint from bending or damage if the joint must pass through travelers. The joint protector usually has split rubber collars at each end to protect the conductor from damage where it exits at each end of the sleeve.

pull setting: *See:* **sag section.**

pull site: The location on the line where the puller, reel winder, and anchors (snubs) are located. This site may also serve as the pull or tension site for the next sag section. *Syn:* **reel setup, tugger setup.**

puller: *See:* **bullwheel puller.**

puller, two drum, three drum: The definition and application for this unit is essentially the same as that for the drum puller. It differs in that this unit is equipped with two or three drums and thus can pull one, two, or three conductors individually or simultaneously. (*See:* **drum puller.**) *Syn:* **double drum hoist, triple drum hoist, double drum winch, three drum winch, triple drum winch, two drum winch, tugger.**

pulley: *See:* **sheave.**

pulling grip: A device used for pulling conductor over the stringing travelers. *Syn:* **kellem, woven wire grip.**

pulling line: A high-strength line, normally synthetic fiber rope or wire rope, used to pull the conductor. However, on reconstruction jobs in which 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. *Syn:* **bull line, hard line, light line, sock line, pulling rope.**

pulling rope: *See:* **pulling line.**

pulling vehicle: Any piece of mobile ground equipment capable of pulling pilot lines, pulling lines, or conductors. However, helicopters may be considered as a pulling vehicle when utilized for the same purpose.

quad-bundle: *See:* **bundle, two-conductor, three-conductor, four-conductor, multi-conductor.**

Quadrex®: *See:* **explosives.**

red head: *See:* **personal ground.**

reel puller: A device designed to pull a conductor during stringing operations. It is normally equipped with its own engine, which drives the supporting shaft for the reel mechanically, hydraulically, or through a combination of both. The shaft, in turn, drives the reel. The application of this unit is essentially the same as that for the drum puller. Some of these devices function as either a puller or tensioner. *See:* **drum puller.**

reel setup: *See:* **pull site, tension site.**

reel stand: A device designed to support one or more conductor or groundwire reels having the possibility of being skid, trailer, or truck mounted. These devices may accommodate rope or conductor reels of varying sizes and are usually equipped with reel brakes to prevent the reels from turning when pulling is

⁷ Primacord is a registered trademark of Dyno Nobel.

stopped. They are used for either slack or tension stringing. The designation of reel trailer or reel truck implies that the trailer or truck has been equipped with a reel stand (jacks) and may serve as a reel transport or *payout* unit, or both, for stringing operations. Depending upon the sizes of the reels to be carried, the transporting vehicles may range from single-axle trailers to semitrucks with trailers having multiple axles. *Syn: reel trailer, reel transporter, reel truck.*

reel trailer: *See reel stand.*

reel transporter: *See reel stand.*

reel truck: *See reel stand.*

reel winder: A device designed to serve as a recovery unit for a pulling line. It is normally equipped with its own engine, which drives a supporting shaft for a reel mechanically, hydraulically, or through a combination of both. The shaft, in turn, drives the reel. It is normally used to rewind a pulling line as it leaves the bullwheel puller during stringing operations. This unit is not intended to serve as a puller, but sometimes serves this function where only low tensions are involved. *Syn: take-up reel.*

restriction: *See clearance.*

retarder: *See bullwheel tensioner.*

rider structure: *See crossing structure.*

roller: *See sheave.*

rolling ground.: *See running ground, traveler ground.*

rope connector: A special high strength steel link used to join two lengths of pulling rope by means of the eye splice at each end. Although designed to pass easily through the grooves of the bullwheels on the puller, it should not be passed under full load. *Syn: peanut.*

rope ladder: A ladder having vertical synthetic or manila suspension members and wood, fiberglass, or metal rungs. The ladder is suspended from the arm or bridge of a structure to enable workers to work at the conductor level, hang travelers, perform clipping-in operations, etc. *Syn: Jacob's ladder.*

ruling span: A calculated span length that will have the same changes in conductor tension due to changes of temperature and conductor loading as will be found in a series of spans of varying lengths between deadends.

running board: A pulling device designed to permit stringing more than one conductor simultaneously with a single pulling line. For distribution stringing, it is usually made of lightweight tubing with the forward end curved gently upward to provide smooth transition over pole crossarm rollers. For transmission stringing, the device is either made of sections hinged transversely to the direction of pull or of a hard nose rigid design, both having a flexible pendulum tail suspended from the rear. This configuration stops the conductors from twisting together and permits smooth transition over the sheaves of bundle travelers. *Syn: alligator, bird, birdie, monkey tail, sled.*

running ground: 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. It is primarily used to provide safety for personnel during construction or reconstruction operations. *Syn: ground roller, moving ground, rolling ground, traveling ground.*

safety life line: A safety device normally constructed from synthetic fiber rope and designed to be connected between a fixed object and the body belt of a worker working in an elevated position when his/her regular safety strap cannot be utilized. *Syn:* **life line; safety line; scare rope.**

safety line: *See safety life line.*

sag: The distance measured vertically from a conductor to the straight line joining two points of support. Unless otherwise stated, the sag referred to is at the midpoint of the span.

sag board: *See sag target.*

sag section: The section of line between snub structures. More than one sag section may be required in order to sag properly the actual length of conductor that has been strung. *Syn:* **pull setting, stringing section.**

sag span: A span selected within a sag section and used as a control to determine the proper sag of the conductor, thus establishing the proper conductor level and tension. A minimum of two, but normally three, sag spans are required within a sag section in order to sag properly. In mountainous terrain or where span lengths vary radically, more than three sag spans could be required within a sag section. *Syn:* **control span.**

sag target: A device used as a reference point to sag conductors. It is placed on one structure of the sag span. The sagger, on the other structure of the sag span, can use it as a reference to determine the proper conductor sag. *Syn:* **sag board, target.**

sagger: *See wheel tractor.*

scare rope: *See safety life line.*

scope: *See transit.*

secondary shock: A shock of a magnitude such that it will not produce direct physiological harm, but may cause involuntary muscle reactions. The results of secondary shock are annoyance, alarm, and aversion (see Dalziel [B5] and Electronic Power Research Institute [B26]).⁸

self-damping conductor: An aluminum conductor steel reinforced that is designed to control aeolian vibration by integral damping. Trapezoidal aluminum wires and annular gaps are utilized.

set of fives: *See block.*

set of fours: *See block.*

set of sixes: *See block.*

seven bolt: *See conductor grip.*

shaped wire compact conductor: *See trapezoidal wire.*

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

sheave ground: *See traveler ground.*

⁸ The numbers in brackets correspond to those of the bibliography in Annex A.

shield wire: *See* overhead groundwire.

single drum hoist: *See* drum puller.

single drum winch: *See* drum puller.

site marker: *See* transit.

six bolt: *See* conductor grip.

skidder: *See* wheel tractor.

skookum: *See* snatch block.

skywire: *See* overhead groundwire.

slack stringing: The method of stringing conductor slack without the use of a tensioner. The conductor is pulled off the reel by a pulling vehicle and is dragged along the ground, or the reel is carried along the line on a vehicle and the conductor is deposited on the ground. As the conductor is dragged to, or past, each supporting structure, the conductor is placed in the travelers, normally with the aid of finger lines.

sled: *See* running board.

sleeve: *See* compression joint.

sleeving trailer: *See* splicing cart.

slip-grip: *See* conductor grip.

slug: *See* connector link.

snatch block: A device normally designed with a single sheave, wood or metal shell, and hook. One side of the shell usually opens to eliminate the need for threading of the line. It is commonly used for lifting loads on a single line or as a device to control the position or direction, or both, of a fall line or pulling line. *Syn:* skookum, Washington, Western.

snub: *See* anchor.

snub structure: A structure located at one end of a sag section and considered as a *zero* point for sagging and clipping offset calculations. The section of line between two such structures is the sag section, but more than one sag section may be required in order to sag properly the actual length of conductor that has been strung. *Syn:* O structure, zero structure.

sock: *See* woven wire grip.

sock line: *See* pulling line.

spacer buggy: *See* conductor car.

spacer cart: *See* conductor car.

spacing bicycle: *See* conductor car.

splice: *See* compression joint.

splice release block: *See hold-down block.*

splice site: The location along the line where the conductors are temporarily anchored to join the conductors together to form a splice.

splicing cart: A unit that is equipped with a hydraulic compressor (press) and all other necessary equipment for performing splicing operations on conductor. *Syn:* **sleeving trailer, splicing trailer, splicing truck.**

splicing trailer: *See splicing cart.*

splicing truck: *See splicing cart.*

static charge: Any electric charge at rest, e.g., charge on capacitor. Static charge is often loosely used to describe discharge conditions resulting from electric field coupling.

static wire: *See overhead groundwire.*

step potential: *See step voltage.*

step voltage: The potential difference between two points on the earth's surface separated by a distance of one pace (assumed to be 1 m) 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. *Syn:* **step potential.**

strand restraining clamp: An adjustable circular clamp commonly used to keep the individual strands of a conductor in place and to prevent them from spreading when the conductor is cut. *Syn:* **block, cable binding, hose clamp, plier clamp.**

straw line: *See pilot line.*

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.

stringing block: *See traveler.*

stringing section: *See sag section.*

stringing sheave: *See traveler.*

stringing traveler: *See traveler.*

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

structure ground: *See ground structure base.*

suitcase: *See conductor grip.*

swamp buggy: *See off-road vehicle.*

switching surge: A transient wave of overvoltage 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 workmen.

swivel: *See* swivel link.

swivel link: A swivel device designed to connect pulling lines and conductors together in series or to connect one pulling line to the drawbar of a pulling vehicle. The device will spin and help relieve the torsional forces that build up in the line or conductor under tension. *Syn:* **swivel**.

T-2®: A two-conductor twisted construction designed to control wind-induced motion.⁹

tag line: A control line, normally manila or synthetic fiber rope, attached to a suspended load to enable a worker to control its movement. *Syn:* **tag rope**.

tag rope: *See* tag line.

takeup reel: *See* reel winder.

tapered hose: *See* leader cone.

target: *See* sag target.

temporary structure: *See* crossing structure.

tension site: The location on the line where the tensioner, reel stands, and anchors (snubs) are located. This site may also serve as the pull or tension site for the next sag section. *Syn:* **conductor payout station, payout site, reel setup**.

tension stringing: The use of pullers and tensioners to keep the conductor under tension and positive control during the stringing phase, thus keeping it clear of the earth and other obstacles that could cause damage.

tensioner: *See* bullwheel tensioner.

threading line: A lightweight flexible line, normally manila or synthetic fiber rope, used to lead a conductor through the bullwheels of a tensioner or pulling line through a bull wheel puller. *Syn:* **bull line; threading rope**.

threading rope: *See* threading line.

three drum winch: *See* puller, two drum, three drum.

touch potential: *See* touch voltage.

touch voltage: 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 3 ft (1 m). This potential difference could be dangerous and could result from induction or fault conditions, or both. *Syn:* **touch potential**.

tower ground: *See* structure base ground.

⁹ T-2 Conductor is a registered trademark of General Cable Technologies, Inc.

tower ladder: A ladder complete with hooks and safety chains attached to one end of the side rails. These units are normally fabricated from fiberglass, wood, or metal. The ladder is suspended from the arm or bridge of a structure to enable workers to work at the conductor level, to hang travelers, perform clipping-in operations, etc. In some cases, these ladders are also used as lineperson's platforms. *Syn:* **hook ladder**.

tractor: *See* **crawler tractor, wheel tractor**.

transit: An instrument primarily used during construction of a line to survey the route, to set hubs and point on tangent (POT) locations, to plumb structures, to determine downstrain angles for locations of anchors at the pull and tension sites, and to sag conductors. *Syn:* **level, scope, site marker**.

trapezoidal wire: Conductors that are designed to increase the aluminum area for a given diameter of conductor by the use of trapezoidal shaped aluminum strands.

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 are 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 semiconductive neoprene or 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. *Syn:* **block, dolly, sheave, stringing block, stringing sheave, stringing traveler**.

traveler ground: 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. *Syn:* **block ground, rolling ground, sheave ground**.

traveler rack: A device designed to protect, store, and transport travelers. It is normally designed to permit efficient use of transporting vehicles, spotting by helicopters on the line, and stacking during storage to utilize space. The exact design of each rack is dependent upon the specific travelers to be stored. *Syn:* **dolly car**.

traveler sling: A sling of wire rope, sometimes utilized in place of insulators, to support the traveler during stringing operations. Normally, it is used when insulators are not readily available or when adverse stringing conditions might impose severe downstrains and cause damage or complete failure of the insulators. *Syn:* **choker**.

traveling ground: *See* **running ground**.

tri-bundle: *See* **bundle, two-conductor, three-conductor, four-conductor, multi-conductor**.

Triex®: *See* **explosives**.

triple drum hoist: *See* **puller, two drum, three drum**.

triple drum winch: *See* **puller, two drum, three drum**.

tugger: *See* **drum puller, puller, two drum, three drum**.

tugger setup: *See* **pull site**.

twin-bundle: *See* **bundle, two-conductor, three-conductor, four-conductor, multi-conductor**.

twisted pair conductor: A two-conductor twisted construction designed to control wind-induced motion.

two drum winch: *See puller, two drum three drum.*

uplift roller: A small single-grooved wheel designed to fit in or immediately above the throat of the traveler and keep the pulling line in the traveler groove when uplift occurs due to stringing tensions.

Washington: *See snatch block.*

Western: *See snatch block.*

wheel: *See sheave.*

wheel tractor: a wheeled unit employed to pull pulling lines, sag conductor, and miscellaneous other work. Sagging winches on this unit are usually arranged in a horizontal configuration. It has some advantages over crawler tractors in that it has a softer footprint, travels faster, and is more maneuverable. *Syn:* **logger, sagger, skidder, tractor.**

wire: *See conductor.*

wire mesh grip: *See woven wire grip.*

wire rope splice: The point at which two wire ropes are joined together. The various methods of joining (splicing) wire ropes together include hand tucked woven splices, compression splices that utilize compression fittings but do not incorporate loops (eyes) in the ends of the ropes, and mechanical splices that are made through the use of loops (eyes) in the ends of the ropes held in place by either compression fittings or wire rope clips. The latter are joined together with connector links or steel bobs and, in some cases, are rigged eye to eye. Woven splices are often classified as short or long. A short splice varies in length from 2 m to 5 m for 6 mm to 38 mm diameter ropes, respectively, while a long splice varies from 4 m to 14 m for the same size ropes.

working ground: *See personal ground.*

woven wire grip: A device designed to permit the temporary joining or pulling of conductors without the need of special eyes, links, or grips. *Syn:* **basket, Chinese finger, wire mesh grip, Kellem, sock.**

zero structure: *See snub structure.*

3.2 Acronyms and abbreviations

AAAC	all aluminum alloy conductor, concentric-lay-stranded
AAC	all aluminum conductor, concentric-lay-stranded
AACSR	aluminum alloy conductor, steel reinforced
ACAR	aluminum conductor, aluminum alloy reinforced
ACCC®	aluminum conductor, composite core
ACCR®	aluminum conductor, composite reinforced
ACSR	aluminum conductor, steel reinforced
ACSR/TP	aluminum conductor, steel reinforce twisted pair

ACSS	aluminum conductor, steel supported
ADSS	all-dielectric self supporting optical cable
ATV	all-terrain vehicle
AWG	American Wire Gage
CU	copper conductor
GTACSR	gap-type aluminum conductor, steel reinforced
GZTACSR	gap-type ZT-aluminum conductor, steel reinforced
OHGW	overhead groundwire
OPGW	optical groundwire
SDC	self-damping conductor
TP	twisted pair
TW	trapezoidal wire

3.3 Acronyms for grades of steel

AS	Mexican and South American reference for aluminum clad steel, commonly referred to in the U.S. as AW steel
AW2	ASTM regular strength aluminum clad steel (ASTM B502), (formerly called AW)
AW3	ASTM high strength aluminum clad steel (ASTM B502)
GA2	ASTM regular strength steel, zinc Class A galvanized (ASTM B498) (formerly called GA)
GA3	ASTM high strength steel, zinc Class A galvanized (ASTM B 606), (formerly called HS)
GA4	ASTM extra high strength steel, zinc Class A galvanized (ASTM spec B957)
GA5	ASTM ultra high strength steel, zinc Class A galvanized (ASTM spec B957)
MA2	ASTM regular strength steel, zinc-5% aluminum mischmetal alloy coated (ASTM B802) (formerly called MA)
MA3	ASTM high strength steel, zinc-5% aluminum mischmetal alloy coated (ASTM B803) (formerly called MS)
MA4	ASTM extra high strength steel, zinc-5% aluminum mischmetal alloy coated (ASTM B958)

MA5 ASTM ultra high strength steel, zinc-5% aluminum mischmetal alloy coated (ASTM B958)

4. Conductor stringing methods

Unless specifically stated otherwise, all references to the term “conductor” in this document include overhead groundwires (OHGWs). Conductor stringing systems currently employed in the power industry are almost as numerous as the organizations that string conductors. Outlined below are the basic methods currently in use, but they are invariably modified to accommodate equipment readily available and the ideas and philosophies of the responsible supervisors. In addition to a description of the various methods being used are comments relative to application and a listing of equipment applicable to each method. This list is not all inclusive since, for example, a reel winder would not be necessary as a separate piece of equipment if this function is designed into the puller or tensioner being used, nor would a loader be required if the reel stand were self-loading.

4.1 Slack or layout method

Using this method, the conductor is dragged along the ground by means of a pulling vehicle, or the reel is carried along the line on a vehicle and the conductor is deposited on the ground. The conductor reels are positioned on reel stands or jacks, either placed on the ground or mounted on a transporting vehicle. These stands are designed to support the reel on an arbor, thus permitting it to turn as the conductor is pulled out. Usually, a braking device is provided to prevent overrunning and backlash. When the conductor is dragged past a supporting structure, pulling is stopped and the conductor is placed in travelers attached to the structure before proceeding to the next structure.

This method is chiefly applicable to the construction of new lines in cases in which maintenance of conductor surface condition is not critical and where terrain is easily accessible to a pulling vehicle. The method is not usually economically applicable in urban locations where hazards exist from traffic or where there is danger of contact with energized circuits, nor is it practical in mountainous regions inaccessible to pulling vehicles.

Major equipment required to perform slack stringing includes reel stands, pulling vehicle(s), and a splicing cart.

4.2 Tension method

Using this method, the conductor is kept under tension during the stringing process. Normally, this method is used to keep the conductor clear of the ground and obstacles, which might cause conductor surface damage, and clear of energized circuits. It requires the pulling of a light pilot line into the travelers, which in turn is used to pull in a heavier pulling line. The pulling line is then used to pull in the conductors from the reel stands using specially designed tensioners and pullers. For lighter conductors, a lightweight pulling line may be used in place of the pilot line to directly pull in the conductor. A helicopter or ground vehicle can be used to pull or lay out a pilot line or pulling line. The tension method of stringing is applicable where it is desired to keep the conductor off the ground to minimize surface damage or in areas where frequent crossings are encountered. The amount of right-of-way travel by heavy equipment is also reduced. Usually, this method provides the most economical means of stringing conductor. The helicopter use is particularly advantageous in rugged or poorly accessible terrain.

Major equipment required for tension stringing includes reel stands, tensioner, puller, reel winder, pilot line winder, splicing cart, and helicopter or pulling vehicle.

5. Grounding equipment and methods

5.1 Protective grounding principles

A grounding system shall be established at transmission line construction sites that will provide a safe environment for the transmission line construction workers. The grounding system and equipment to be used for each situation should be established by the user knowing the degree of exposure to electrical hazards and the soil conditions for that site. Generally, the most significant hazard results from work in proximity to energized lines.

The approach used within this guide is first to present methods of protecting personnel, develop electrical concepts, and describe hazards during transmission line construction. Then, in conjunction with ASTM F855-97e1¹⁰, specific criteria and testing requirements of the grounding equipment to be met are discussed. And finally, the application of methods and equipment to the process of grounding during the installation of overhead transmission lines is described.

All equipment, conductors, anchors, and structures within a defined work area must be bonded together and connected to the ground electrode. The recommended procedures of personnel protection are the following:

- Establishment of equipotential work zones
- Selection of grounding equipment for the worst-case fault
- Discontinuation of all work when the possibility of lightning exists, which may affect the work site

In addition to the grounding system, the best safety precaution is to treat all equipment as if it could become energized.

5.2 Protection of personnel

The main concern of this guide is the protection of personnel from injury. The personnel at the work site must be protected against electric field coupling and magnetically induced voltages and currents caused by energized adjacent lines. Personnel must be protected from the hazards that result from accidental line energization or faults. Personnel protection can be achieved by placing adequate protective ground systems at the work area.

All appropriate line components and equipment within the work area should be bonded together to create an equipotential work zone. A non-conductive barrier (see Figure 6) placed around the work area (includes the ground electrode) will reduce the exposure to touch and step voltages. Grounding equipment should be selected and installed in a manner that will minimize the likelihood of cables striking personnel during fault conditions.

¹⁰ Information on references can be found in Clause 2.

5.3 Hazards and electrical concepts

5.3.1 Source of hazards

Electrical charges may appear on a de-energized transmission line due to one or a combination of the following factors:

- Charges induced by electric or magnetic field coupling, or both, with energized adjacent lines especially under fault conditions and lightning strikes
- De-energized lines accidentally energized
- Static charge induced on de-energized lines due to atmospheric conditions

In addition to electrical hazards, there is the hazard posed by violent mechanical movements of cables during fault current exposure.

5.3.2 Ground protection

The purpose of grounds and grounding procedures is to reduce electrical shock hazards to an absolute minimum. Unfortunately, people who work on and around high voltage equipment can falsely assume that only energized high-voltage circuits are really dangerous. Shocks from voltages well below 50 V can:

- Cause surprise to the extent that balance may be lost and falls may occur, with the risk of bodily injury
- Cause an involuntary recoil so that physical contact with moving machinery may occur, with the risk of bodily injury
- Cause a muscular paralysis so that release of grip on the source of shock cannot occur

Adequate grounding shall be established at construction work areas. The methods required and equipment used should be based on exposure to maximum system electrical hazards and soil conditions at the site.

All equipment, conductors, anchors, and structures within the work area shall be bonded together and grounded. The recommended method of personnel protection is the establishment of equipotential work zones to limit touch and step voltage to a safe level. An acceptable equipotential zone may be accomplished by the proper use of low-resistance shunts, jumpering, and grounding equipment. Grounding equipment includes personal grounds, master grounds, structure base grounds, running grounds, traveler grounds, ground grids, and ground rods. Definitions and discussions of these terms can be found in Clause 3 of this guide.

5.4 Grounding equipment, methods, and testing

5.4.1 Equipment

All grounding equipment must be sized to carry the maximum steady-state induced currents as well as the largest fault current and clearing time likely to be encountered for a time period long enough to allow the line protection system to operate. After the grounding equipment has carried fault current, all components of the grounding system should be immediately replaced, and later inspected and reconditioned, if necessary, before reuse. Ground cables that have carried fault current should be replaced and not reused.

Personal grounds, master grounds, structure base grounds, running grounds, traveler grounds, ground grids, and ground rods are devices used in a grounding system.

High-quality clamps with a steady-state and fault-current capability equal to the grounding cables should be used. They should clamp positively on the object being grounded. Clamps with serrated clamping jaw inserts are preferred to ensure proper contact.

Resistance readings for all grounding systems should be established and all grounding electrodes used should be checked to ensure that their resistance is below an acceptable maximum value. Resistance from the main contact to the attached cable contact should be less than that for an equal length of maximum size cable(s) for which a clamp is rated.

5.4.1.1 Grounding cable

Grounding cables should be flexible and be of Type I, Type II, or Type III per 32.3 of ASTM F855-15. Cable size should be capable of sustaining maximum fault current, with full asymmetry, when part of a portable grounding assembly, as demonstrated by tests per 12.3 of ASTM F855-15 or per 6.6 of IEC 61230-2008.

5.4.1.2 Master ground

A master ground (see Figure 1) is a portable device designed to short circuit and connect (bond) a de-energized circuit or piece of equipment, or both, to a ground source. It is normally located remote from, and on both sides of, the immediate work site, and primarily used to provide safety for personnel during construction, reconstruction, or maintenance operations.

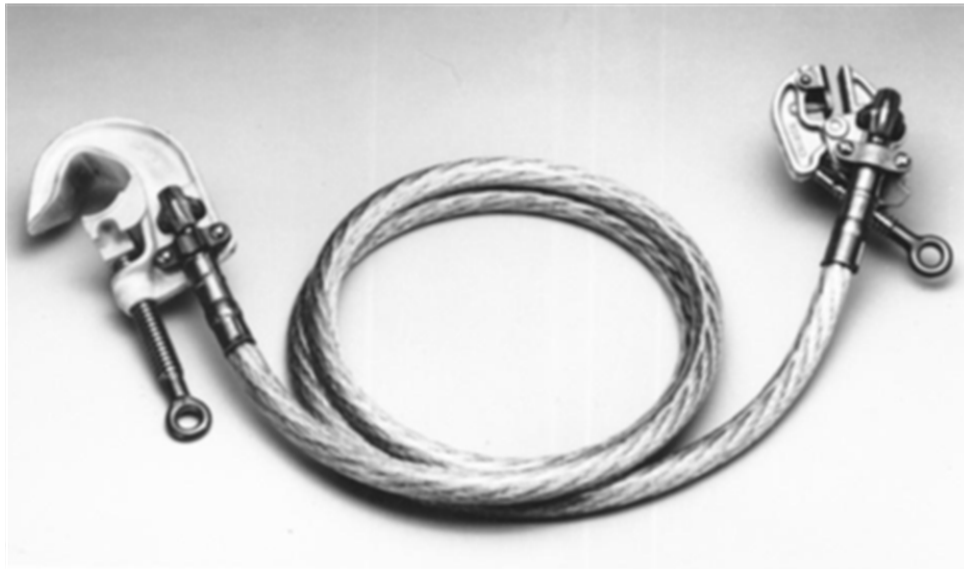
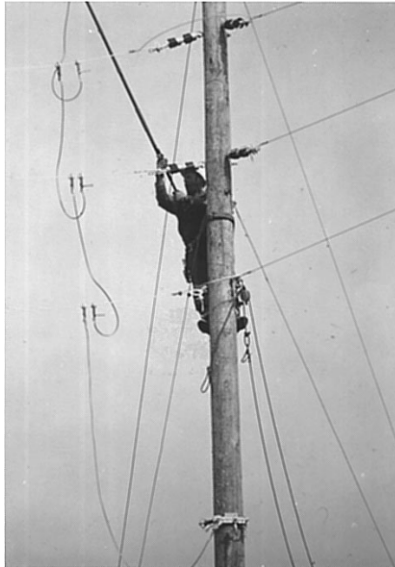


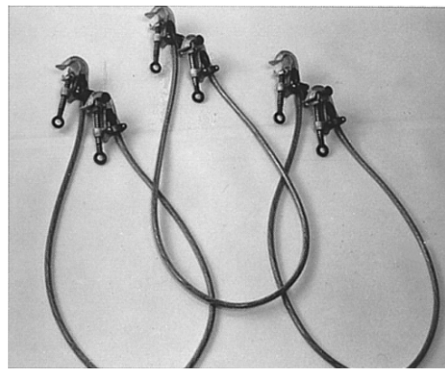
Figure 1—Master ground

5.4.1.3 Personal ground

A personal ground (see Figure 2a and Figure 2b) is a portable device designed to connect (bond) a de-energized conductor or piece of equipment, or both, to a ground electrode. It is 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.



a)



b)

Figure 2—Personal ground

5.4.1.4 Structure base ground

A structure base ground (see Figure 3) is a portable device designed to connect (bond) equipment to a metal structure. It is primarily used to provide safety for personnel during construction, reconstruction, or maintenance operations.

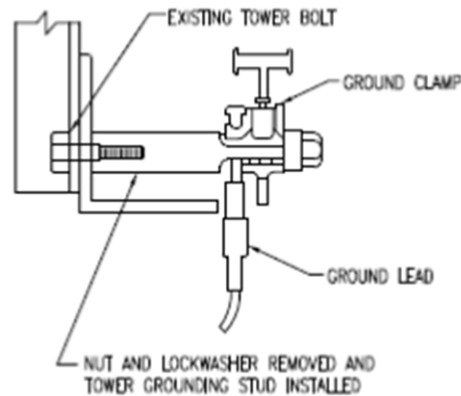


Figure 3—Structure base ground

5.4.1.5 Running ground

A running ground (see Figure 4) is a portable device designed to connect a moving conductor or wire rope, or both, to a ground electrode. This device is normally placed on the conductor or wire rope adjacent to the pulling and tensioning equipment located at either end of a sag section. It is primarily used to provide safety for personnel during construction or reconstruction operations.



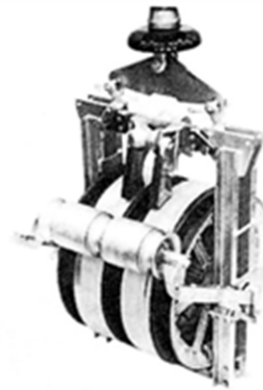
Figure 4—Running ground

5.4.1.6 Traveler ground

A traveler ground (see Figure 5) is a portable device designed to connect a moving conductor or wire rope, or both, to a ground electrode. It is primarily used to provide safety for personnel during construction or reconstruction operations. This device is placed on the traveler (sheave, block, etc.) at strategic locations where electrical grounds are required.



a) Application of traveler ground



b) Individual traveler ground

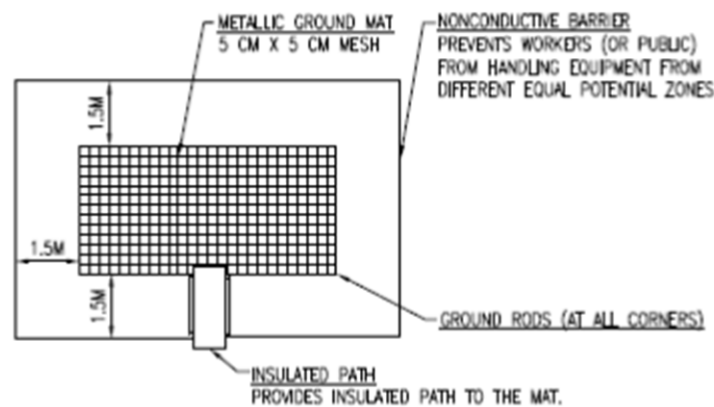
Figure 5—Traveler ground

A traveler with a ground is usually sensitive to direction of pull. Care shall be exercised in hanging the traveler. Usually the ground is to the pulling end. It shall be connected with temporary grounding, or to some conductive medium that is at ground potential. Care shall be taken in regard to the length of the grounding cable and the anchor point. Too short of a cable may pull with block movement, and too long of a cable may become entangled with the sheaves and rollers, thus destroying the cable and conductor. The

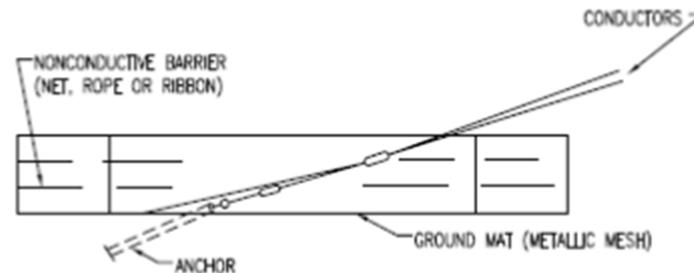
traveler ground should have a suitable grounding stud located in an accessible position to enable placing and removing the ground clamps, with a ground stick when necessary. The traveler ground will also help protect the sheave linings.

5.4.1.7 Ground grids

A ground grid (see Figure 6a and Figure 6b) is a system of interconnected bare conductors, metallic surface mats, and/or grating, arranged in a pattern over a specified area. 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 which could flow if the circuit being worked became energized for any reason or if an adjacent energized circuit faulted. When used, these grids are employed at pull, tension, and splice sites.



Plan view



Elevation

Figure 6—Ground grid

5.4.1.8 Ground rod

A ground rod (see Figure 7) is 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. The ground rod is commonly used during conductor stringing operations to provide a means of obtaining a ground electrode using portable grounding devices.

If a ground rod is free of paint, grease, and oil, the contact resistance between the rod and the earth is negligible. Therefore, the main resistance is contained in the body of earth immediately surrounding the ground rod.

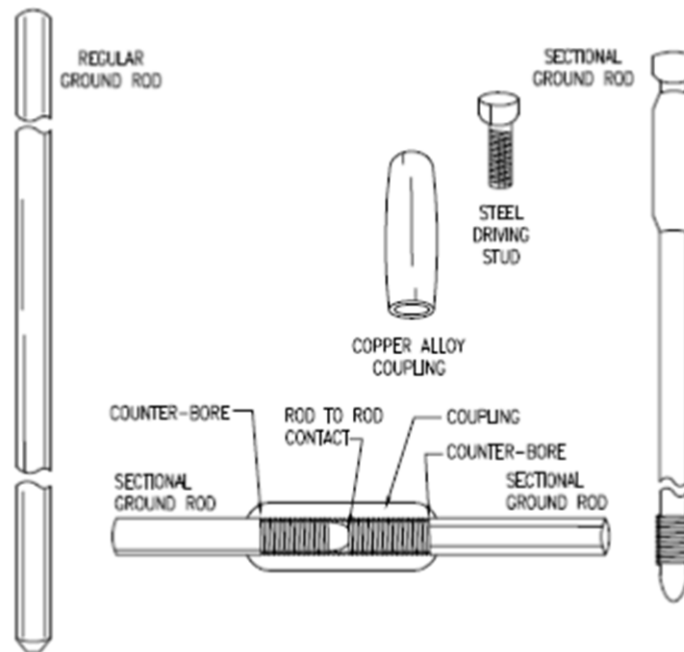


Figure 7—Ground rods

When a current flows from a ground rod into the earth, it flows outward in all directions. It can be assumed that the current flows through a series of concentric spherical-like shells, surrounding the ground rod (see Figure 8).

The shell immediately surrounding the electrode has the smallest cross sectional area (highest resistance); as the distance from the electrode is increased, each shell is correspondingly larger in cross section (lower resistance). Therefore, when a current flows, the voltage drop next to the ground rod is very high and decreases as it moves out from the rod.

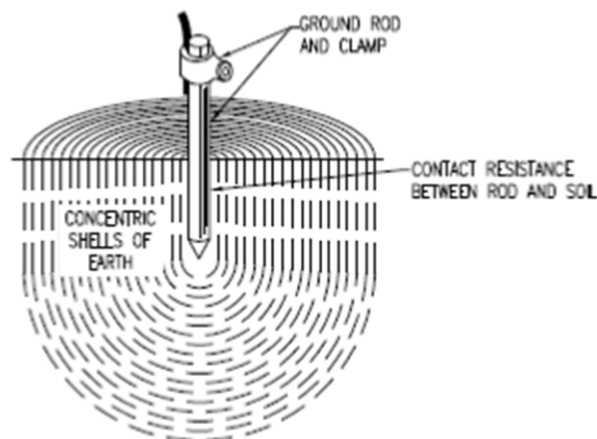


Figure 8—Resistive components of a ground rod

CAUTION

Care must be taken during the installation of ground rods to avoid damage to underground utilities.

5.4.2 Methods

5.4.2.1 Soil resistance and use of ground rods

The resistivity of the earth plays a significant role in how effectively a fault current or induced current is drained off. The resistivity of the ground varies with the type, moisture content, and temperature of the soil. These variables affect the ground resistance in a direct, proportionate relationship. Therefore, seasonal changes cause major fluctuations in the ground resistance.

A grounding system with a low resistance when the soil moisture content is high could easily exhibit an excessively high resistance and hence, an unsafe condition during the drier part of the year when the soil moisture content is very low.

The resistance of the grounding system is very important as it determines the voltage rise between the ground rods, grids, and the earth, as well as the voltage gradients that will be created when the current flows into the ground.

The following three components contribute to the resistance of the grounding system:

- The resistance of the connections between the grounding leads, phase conductor, and the ground rod(s), and the resistance of the grounding lead itself.
- The contact resistance between the ground rod and the soil.
- The resistance of the body of earth immediately surrounding the rod. Of the three components involved in “resistance,” the resistance of the earth is the most critical and the most difficult to calculate and minimize.

To achieve the best results, ground rods should be driven into undisturbed earth. The practice of placing rods adjacent to poles or footing is the least effective. Methods of installation vary from sledge hammer to sophisticated hydraulic equipment. Some types of power installation enable driving multiple sectional rods easily and effectively in undisturbed earth (see Figure 9).



a)



b)



c)



d)

Figure 9—Power driven ground rod

5.4.2.2 Effect of rod depths and multiple rods

The distance a ground rod extends into the earth has a great effect on its measured ground resistance. A shallow driven rod will usually have a high year-round resistance because of its small effective resistance area, and will always be subject to excessive seasonal variations due to varying moisture contents in the soil. Multiple sectional deep rods will have a larger effective resistance area and may approach a permanent moisture level; therefore, its resistance will be much lower.

In effect, a series of multiple-driven rods becomes a set of resistances in parallel; however, the parallel resistance law is not precisely applicable (because of the concentric shells of earth are overlapping). For the

best results from a practical point of view, the spacing between the rods should not be less than the depth of the individual rods.

5.4.2.3 Recommended methods

The following are recommended methods on the use of ground rods in grounding:

- Use deep driven multiple sectional ground rods where soil conditions permit or they are required.
- Use additional multiple sectional ground rods to increase the current capacity of ground electrode.

Add additional grounds where possible along the line under construction to decrease the current flow through the individual ground connection source.

5.4.3 Testing

It is essential that equipment used in grounding during stringing provide adequate performance for a given application. Therefore, determination of the equipment performance characteristics should be made either by the user or provided by the manufacturer or both. This subclause includes recommended test procedures for equipment used in overhead stringing that are not covered in other standards.

This guide makes no attempt to establish ratings, safety factors, categories, or classes of grounding equipment.

5.4.3.1 Testing of grounding equipment

Grounding electrode installations for electrical equipment and systems are necessary to protect personnel and equipment. In order to accomplish this purpose, the grounding installation should provide an adequately low ground resistance and be capable of conducting the available current without causing damage to itself or creating a hazard to equipment or personnel.

The currents that a grounding electrode may be required to carry can be considered to be the following:

- Low ac of long duration—such as unbalance, low fault current, or induced current that occurs when the current is not large enough to interrupt the supply.
- High ac of short duration—such as fault current that occurs when protective equipment operates normally.
- Impulse current—such as surge current that occurs during a lightning stroke.

All components of the grounding system should be of a design that has been tested and proven to have adequate current-carrying capabilities as well as very low resistance.

5.4.3.2 Information to be obtained from tests

In order to evaluate the operational characteristics of grounding equipment, the relationship between current levels, duration of applied current voltage drop across the device, and mechanical durability must be obtained. This information is best obtained from manufacturer's design test information.

5.4.4 Examples of test setups

Figure 10, Figure 11, and Figure 12 are recommended test setups for traveler grounds, running grounds, clamps, and ground rods.

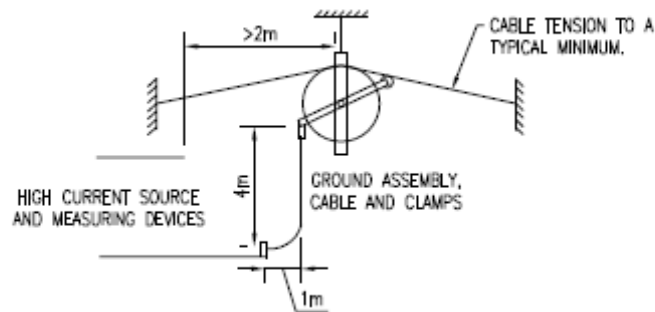


Figure 10—Typical electrical and mechanical arrangement for testing traveler grounds

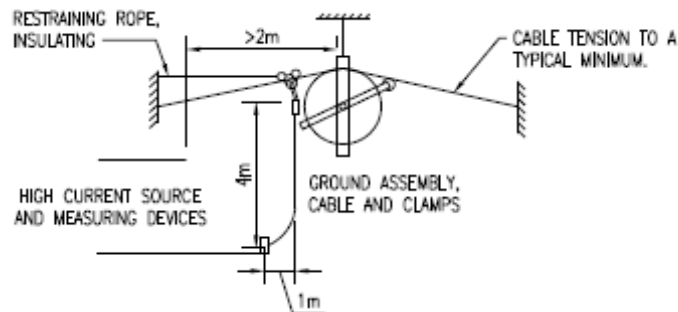


Figure 11—Typical electrical and mechanical arrangement for testing running grounds

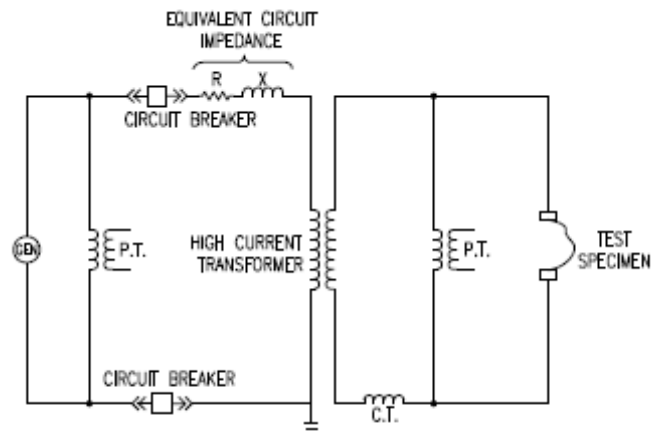


Figure 12—Typical electrical arrangement for testing clamps

5.5 Transmission line construction grounding systems

5.5.1 General

In order to have a totally effective grounding system, the grounding system shall:

- Protect personnel from step and touch voltages by providing an equipotential zone(s) or a low-impedance path to ground, thereby reducing step and touch voltages to an acceptable level to protect personnel and equipment.
- Withstand and dissipate fault and surge currents.
- Provide rugged mechanical properties.

The value of a grounding system depends on a low-resistance path. All equipment shall be kept in excellent condition. All surfaces to which grounding clamps are to be connected shall be cleaned to ensure proper contact. Frequent inspection of all components is essential.

5.5.1.1 Metering

Resistance readings for designing all grounding systems should be established and all grounding electrodes used should be checked to ensure that their resistance is below an acceptable maximum value.

5.5.1.2 Ground equipment

The installation and removal of grounding devices should be performed with an insulated ground stick.

CAUTION

Grounding cables must be connected to the ground electrode first, then to the object being grounded. Personnel should never be in series with a ground lead. When removing grounds, the ground must be removed from the grounded object first and then from the ground electrode.

The object being grounded with an insulated ground stick should not be teased or buzzed with the grounding clamp. The clamp should be poised by the object, snapped on quickly and firmly, and tightened. If an arc is drawn, the clamp should not be withdrawn, but kept on the conductor, thus grounding the line.

When induced currents are of such magnitude that they will cause a hazardous arc during ground removal, a load interrupter device may be used in conjunction with the grounding equipment.

Ferrules pressed onto the cable should be used to join the cable to the connector. Grounding cables should not be coiled in order to reduce their length or wrapped around any metallic objects.

5.5.1.3 Mechanical restraint

It is very important to give attention to restraint of grounding jumpers to minimize possible severe mechanical movement should a fault occur.

5.5.1.4 Ground wires

Grounding methods and procedures when stringing ground wires are the same as those for conductors.

5.5.2 Grounding of stringing equipment

For any given situation, the bonding together of all stringing and related equipment and electrical grounds in a common array is of major importance. The degree of grounding protection required for a given stringing operation is dependent upon the exposure to electrical hazards that exist within the project area. For a project in a congested area with exposure to numerous parallel lines and crossing situations, or with probability of adverse weather conditions or both, extensive grounding requirements are called for (i.e., use of ground grids). At locations where ground grids are deemed necessary, adequate measures must be utilized to ensure effective contact with the ground electrode. Burying the grid conductor or placing metallic grid mats on the ground surface and the using of ground rods may accomplish these measures. All grid conductors and ground rods shall be interconnected, and all equipment, structures, anchors, metallic pulling lines, conductor, and overhead ground wire within the area shall be bonded to the grid.

The area of the grid shall be sufficient to enable all equipment to be placed and all work performed within its perimeter. It is desirable to install temporary barriers to control access to the grid area. In addition, an insulated walkway should be provided for isolation of personnel from step voltage while walking to and from the work area.

5.5.2.1 Pull site

Puller equipment should be effectively grounded to a driven rod, rods, or other suitable grounding sources, in the following order of preference:

- Substation ground grids
- Ground grid mats, where deemed necessary
- Tower or steel pole grounds
- Pole ground

The first tower away from the puller should use traveler grounds, and the puller should incorporate the use of a running ground bonded to the grounding subconductors, which should be bonded together. Clearly marked warning barriers should be used at the puller site to identify the hazardous areas. Rubber gloves and protectors (overgloves) should be worn by personnel working on the ground in the designated area during stringing operations.

5.5.2.2 Tension site

Tensioning equipment should be effectively grounded to the best source in order of preference during stringing operations. Tensioners, reel carts, and reel trailers should be connected to a ground electrode and bonded together. The first tower away from the tensioner should incorporate the use of a traveling ground bonded to the grounding source used at the tension site. When pulling bundled conductors, the subconductors should be bonded together. Clearly marked barriers should be used at the tensioner site to identify the hazardous areas. Rubber gloves and protectors (overgloves) should be worn by personnel working on the ground in the designated area during stringing operations.

5.5.2.3 Anchor site

In addition to the grounding system at the anchor site, the first tower in either direction should have grounds in use until clipping-in has been accomplished. All subconductors and all phases should be jumpered together at the anchor site and connected to the ground electrode. Bypass jumpers should be installed to tie each end of each phase together.

5.5.2.4 Splicing site

Splicing vehicles should be effectively grounded prior to making splices in the conductors. The ground system should remain in place until the spliced conductors are raised to clear the splicing site. When the splice is completed, the jumper connecting the phases and subconductors together may be removed prior to raising the conductor with the winch line above the splicing site and out of reach of all ground personnel. These procedures should be repeated until all splices are complete and all phases are raised to clear the splice site.

5.5.3 Grounding during stringing operation

5.5.3.1 Installation of pilot and pulling line

During installation of conductive pulling lines, running grounds should be installed on the pulling line at the tensioner and puller sites. In addition, traveler grounds should be used on the first tower away from the tensioner or puller or both, on either side of energized line crossings, and at intervals of not more than 3 km (2 miles) along the line being strung. The tensioner and puller machines should be effectively grounded and bonded to the wire rope and reel stands.

When installing semiconducting lines, care should be taken to prevent deterioration of lines due to excessive leakage currents that may occur at traveler or running ground locations.

5.5.3.2 Installation of conductors and ground wire

During stringing operations, conductors and ground wire should be used at the first tower away from the tensioner and puller and on either side of energized line crossings and at intervals of not more than 3 km (2 miles) apart along the line while pulling. When pulling a bundled conductor, all subconductors shall be grounded and bonded together. Reel stands should be bonded to tension machines and connected to a ground electrode during stringing operations.

IF WIRE ROPE IS USED FOR A PULLING LINE, THEN A RUNNING GROUND IS REQUIRED.

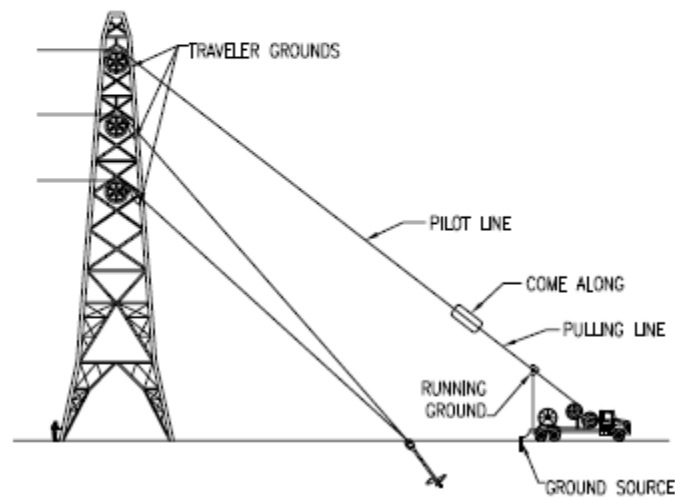


Figure 13—Puller equipped with pulling line connected to pilot line

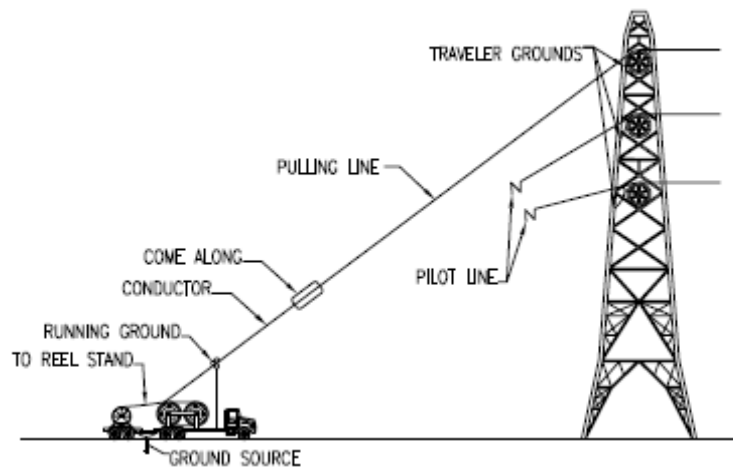


Figure 14—Tensioner with conductor connected to pulling line and ground connection between conductor tensioner and reel trailer

5.5.3.3 Conductor in field snubs

At the field snub site, a driven rod or rods are used as a grounding source in addition to the first tower in either direction having traveler grounds in use until clipping-in has been accomplished. All subconductors and all phases should be jumpered together at the field snub site and connected to the ground electrode. Bypass jumpers should be installed to tie each end of each phase together.