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Live working — Guidelines for the installation of distribution line conductors — Stringing equipment and accessory items

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British Standards

National foreword

This Published Document reproduces verbatim IEC/TR 61911:2003. It supersedes PD IEC TR 61911:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/78, Tools for live working, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Equipement de déroulage et accessoires

Live working –
Guidelines for the installation of distribution line conductors –
Stringing equipment and accessory items

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LIVE WORKING – GUIDELINES FOR THE INSTALLATION OF DISTRIBUTION LINE CONDUCTORS – STRINGING EQUIPMENT AND ACCESSORY ITEMS

FOREWORD

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IEC 61911, which is a technical report, has been prepared by IEC technical committee 78: Live working.

This second edition cancels and replaces the first edition published in 1998. It incorporates some technical changes to update work methods and procedures. It also expands the information on the use of earth rods. It comments on the use of conductor earths when a synthetic pulling rope is used.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
78/440/DTS	78/485/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2010. At this date, the publication will be

- transformed into an International Standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

With the increased difficulty of de-energizing existing overhead lines, installing or removing conductors nearby, or crossing these existing circuits, creates hazards requiring special considerations, particularly with regard to earthing and bonding. Hazardous work conditions can also arise from induction, lightning strikes or electrostatic charging.

These potential electrical hazards demand that certain requirements be observed when choosing equipment and work methods for the protection of personnel or equipment.

This technical report has been prepared in accordance with the requirements of IEC 61477, where applicable.

LIVE WORKING – GUIDELINES FOR THE INSTALLATION OF DISTRIBUTION LINE CONDUCTORS – STRINGING EQUIPMENT AND ACCESSORY ITEMS

1 Scope

The present Technical Report provides recommendations for the selection and testing, where necessary, of conductor stringing equipment and accessory items used for the installation of bare and insulated overhead distribution conductors.

Procedures are recommended for proper earthing in order to protect equipment, components and personnel from currents which can result from accidental contact with nearby energized conductors, or induced voltage from adjacent energized lines, lightning strikes, switching errors or electrostatic charging.

The equipment under consideration in this Technical Report is used for distribution voltages, usually considered to be below 50 kV.

However, for voltages of 50 kV and above, use of IEC 61328 may be more appropriate. The choice of whether IEC 61328 or this Technical Report applies to the work being considered will usually depend on the physical size of the conductors, the size of the structures and the average span between supports.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050(466):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 466: Overhead lines*

IEC 60050(651):1999, *International Electrotechnical Vocabulary (IEV) – Chapter 651: Live working*

IEC 60743:2001, *Live working – Terminology for tools, equipment and devices*

IEC 61230, *Live working – Portable equipment for earthing or earthing and short-circuiting*

IEC 61328, *Live working – Guidelines for the installation of transmission line conductors and earthwires – Stringing equipment and accessory items*

IEC 61477:2001, *Live working – Minimum requirements for the utilization of tools, devices and equipment*

3 Terms and definitions

Terminology for equipment and procedures associated with the installation of overhead conductors varies widely throughout the utility industry. See also IEC 60050(466), IEC 60050(651), and IEC 60743 for supplementary definitions.

For the purposes of this Technical Report, the following definitions apply.

3.1
anchor site
location along the distribution line where anchors are placed to temporarily hold the conductors in order to facilitate splicing, pulling or tensioning work

3.2
birdcaging
opening up of the outer layers of a conductor to form a bulge in the conductor

NOTE This usually occurs with multilayer large diameter conductors as they are passed through the tensioner bullwheels. Birdcaging may be controlled by increasing the tension in the conductor as it leaves the reel stand.

3.3
bond
equipotential connection, connection
electrical connection putting various exposed conductive parts at an equal potential

NOTE Bonding is used to bring all personnel and objects in the work area to the same potential.

3.4
bucket
basket
device designed to be attached to the boom tip of a line truck, crane or aerial lift to support workmen in an elevated working position

NOTE It is normally constructed of fibreglass to reduce its physical weight, maintain strength and obtain good dielectric characteristics.

3.5
bullwheel
wheel incorporated as an integral part of a puller or tensioner to generate pulling or braking tension on conductors or pulling ropes, through friction

NOTE A puller or tensioner normally has one or more bullwheels incorporated in its design. The physical size of the bullwheels will vary depending on the diameter of conductor or rope to be used. The wheels are power driven or retarded. Tensioner bullwheels are usually lined with polychloroprene or polyurethane. Puller bullwheels usually have hardened steel grooves.

3.6
circuit (of an overhead line)
conductor or system of conductors through which an electric current is intended to flow

[IEV 466-01-07]

NOTE In transmission and distribution lines, a circuit usually consists of three phases for a.c. lines, and two phases for d.c. lines.

3.7
clearance
minimum separation between two conductors operating at different voltages, between conductors and supports or other objects, or between conductors and the earth

3.8
clipping-in
clamping-in, clipping
transferring of sagged conductors from the stringing blocks to their permanent suspension positions and the installing of the permanent suspension clamps

3.9
clipping offset
calculated distance, measured along the conductor from the plumb mark to a point on the conductor at which the centre of the suspension clamp is to be placed

NOTE When stringing in rough terrain, clipping offsets may be required to balance the horizontal forces on each suspension structure.

3.10
compression joint
conductor splice, sleeve, splice
tubular compression fitting designed and fabricated from aluminium, copper or steel to join or terminate conductors

NOTE It is usually applied through the use of hydraulic or mechanical presses. However, in some cases explosive type joints are utilized.

3.11
conductor
cable, wire
component intended to carry electric current. A wire, usually bare, or combination of wires not insulated from one another, suitable for carrying an electric current. A conductor may be bare or insulated

3.12
conductor cover
line hose, line guard
protective cover used to shroud the conductor

NOTE It may be flexible or rigid, according to the insulating material used.

[Definition 5.1.3 of IEC 60743, note modified]

3.13
conductor grip
Chicago grip, conductor clamp, come-along, come-along clamp, Klein
device designed to permit the pulling or temporary holding of the conductor without splicing on fittings, eyes, etc.

NOTE The conductor grip permits attachment to a continuous conductor where threading is not possible. The design of these grips varies considerably. Most common grips are those which utilize an open sided rigid body with opposing mobile jaws and a swing latch. In addition to pulling or temporary holding of conductors, this type is commonly used to tension guys and, in some cases, pull or temporarily hold wire rope.

3.14
conductor thermometer
accurate thermometer permanently attached to a short sample of conductor and used to determine ambient temperature for correcting sag charts to actual conditions during the sagging operation

3.15
conductor trimmer
tool used to trim the aluminium wires from around the core of ACSR (aluminium conductor steel reinforced) conductors in preparation for the splicing process

3.16
connector link
pulling rope connector, link, peanut
rigid link designed to connect pulling ropes and usually designed to pass through the grooves of bullwheels on the puller when under load

NOTE It will not spin to relieve torsional forces.

3.17
crossing structure
guard structure, H-frame, rider pole structure, scaffolding, temporary structure
structure built of poles, tubes, or other specialized equipment such as a crane, sometimes using rope nets

NOTE Crossing structures are used whenever conductors are strung over roads, power lines, communications circuits, highways or railroads and 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 ropes, loss of tension, etc.

3.18
dead-ending
procedure which results in the termination of conductors at an anchor structure

3.19
de-energized
dead
at a potential equal to or not significantly different from that of the earth at the worksite

[IEV 651-01-15, modified]

3.20
dynamometer
load cell
device designed to measure mechanical loads or tension on conductors

NOTE Various models are used to tension guys or sag conductors.

3.21
earth
ground
conducting connection by which an electric circuit or equipment is connected to the earth, or to some conduction body of relatively large extent that serves in place of the earth

3.22
earth cable
ground cable
flexible conductor usually of stranded copper with a transparent cable protective sheath, and attached at both ends to clamps, designed to connect conductors or equipment to earth or to an earth mat

[Definition 15.1 of IEC 60743, modified]

3.23
earth clamp
ground clamp
component for connecting an earthing cable, short-circuiting cable or connecting cluster to an earthing conductor or an earth electrode

[IEV 651-14-07 and definition 15.6 of IEC 60743]

NOTE The earth clamp is used for making connections between the conductors, stringing equipment, pulling/pilot ropes and the earth.

3.24
earth mat
counterpoise, earth grid, ground gradient mat, ground mat
system of interconnected bare conductors arranged in a pattern over a specified area on, or buried below, the surface of the earth

NOTE Normally, an earth mat is bonded to earth rods driven around and within its perimeter to increase its earthing capabilities and provide convenient connection points for earthing devices. The primary purpose of the mat is to provide safety for workmen by limiting potential differences within its perimeter to safe levels in case of high currents which may flow if the circuit or conductor being worked became energized for any reason. Metallic surface mats and gratings are sometimes utilized for this same purpose. When used, these mats are employed at pull, tension and midspan splice sites.

3.25
earth rod
earth electrode, ground electrode
rod driven into the earth to serve as an earthing terminal, such as a copper-clad steel rod, solid copper rod or galvanized steel rod

NOTE Copper-clad steel rods are commonly used during conductor stringing operations to provide a means of obtaining an electrical earth using portable earthing devices.

3.26
earthing stick
earthing pole, ground stick
device comprising an insulating stick equipped with a permanent or detachable coupling for installing line clamps, short-circuiting bars, or conductive extension components

[IEV 651-14-10 and definition 15.8 of IEC 60743]

NOTE The earthing stick is made of fibreglass, reinforced plastic or similar, with a particular, highly resistant connection and is of sufficient length to allow safe gripping and installation of earth clamps.

3.27
earthing system
ground system
system consisting of all interconnected earthing connections in a specific area, such as a pull section

3.28
electromagnetic field induction
electromagnetic coupling
phenomenon that produces both an induced voltage and current

NOTE 1 When the predominant effect is due to voltage, this is known as **electric field induction**.

NOTE 2 When the predominant effect is due to current, this is known as **magnetic field induction**.

3.29
electric field induction
capacitive coupling
process of generating voltages and/or currents in a conductive object or electrical circuit by means of time-varying electric fields

3.30
energized
alive, current-carrying, hot, live
at a potential significantly different from that of the earth at the worksite and which presents an electrical hazard

NOTE A part is energized when it is electrically connected to a source of electric energy. It can also be energized when it is electrically charged under the influence of an electric or magnetic field.

[IEV 651-01-14]

3.31
equipotential
set of points all of which have the same potential

3.32
equipotential work zone area/site
work zone where all equipment is interconnected or bonded by jumpers, earths, earth rods and/or mats that will minimize voltage differences between all parts of the zone under worst case conditions of energization

3.33
factor of safety, mechanical
ratio of breaking strength or yield strength to the maximum allowable applied force or load

3.34
fault
any undesired change that impairs normal operation. A physical condition that causes a device, a component, or an element to fail to perform in a required manner

NOTE An example of a fault might be a short circuit, a broken wire or an intermittent connection.

3.35
fault current
current flowing at a given point of a network resulting from a fault at another point of this network

NOTE A fault current flowing to earth may be called an earth fault current.

3.36
finger rope
finger line
lightweight rope, normally natural fibre or synthetic fibre rope, placed over the stringing block when it is hung

NOTE The finger rope usually extends from the ground, passes through the stringing block and back to the ground. It is used to thread the end of the pilot rope or pulling rope over the stringing block and eliminates the need for workmen on the structure. These ropes are not required if pilot ropes are installed when the stringing blocks are hung.

3.37
hoist
chain, cable, coffing hoist, ratchet hoist, pull lift, tirfor
device normally designed using roller or link chain or wire rope and having built-in leverage to enable heavy loads to be lifted or pulled

NOTE The hoist is often used to dead-end a conductor during sagging and clipping-in operations and when tensioning guys.

3.38
hold down block
hold down roller, splice release block
device designed with one or more single groove sheaves to be placed on the conductor and used as a means of holding it down

NOTE The hold down block functions essentially as a stringing block used in an inverted position. It is normally used in midspan to control pilot rope, pulling rope or conductor uplift caused by stringing tensions, or at splicing locations to control the conductor as it is allowed to rise after splicing is completed.

3.39
isolate
to disconnect completely a device or circuit from other devices or circuits, separating it physically, electrically and mechanically from all sources of electrical energy

NOTE Such separation may not eliminate all effects of electromagnetic induction.

3.40
Jumper
dead-end loop
a) conductor that connects the conductors on opposite sides of a dead-end structure

b) conductor placed across the clear space between the ends of two conductors or metal pulling ropes which are being spliced together

NOTE Its purpose is to act as a shunt to prevent workmen from accidentally placing themselves in series between the two conductors.

3.41
magnetic field induction
inductive coupling
process of generating voltages and/or currents in an electrical circuit by means of time-varying magnetic fields

3.42
outage
condition where a circuit has been isolated to enable work to be performed which usually cannot be performed with the circuit energized

NOTE Such isolation may not eliminate all effects of electromagnetic induction.

3.43
pilot rope
lead line/rope, leader, P-line/rope, straw line/rope
lightweight rope, normally a synthetic fibre rope, used to pull heavier pulling ropes which in turn are used to pull the conductor

NOTE 1 Pilot ropes may be installed with the aid of finger ropes or by helicopter when the insulators and stringing blocks are hung.

NOTE 2 In some countries this rope is called a pre-pilot rope.

3.44
pilot rope puller
device designed to payout and rewind pilot ropes during stringing operations

NOTE A pilot rope puller can be either a bullwheel type design, usually with the take-up winder as an integral part of the machine, or a multiple drum type machine. It is usually located at the tensioner site.

3.45
portable earth interrupter tool
portable switching device designed to break high circulating currents, and which prevents an unmanageable large arc from occurring in the removal of the last earth in an earthing system

3.46
pulling rope
bull line/rope, hard line/rope, sock line/rope
high strength rope, normally synthetic fibre rope or wire rope, used to pull the conductor

NOTE 1 On reconstruction jobs where a conductor is being replaced, the old conductor often serves as the pulling rope for the new conductor. In such cases, the old conductor should be closely examined for any damage prior to the pulling operations.

NOTE 2 In some countries this rope is called a pilot rope.

3.47
pull section
pull setting, stringing section
section of line where the conductor is pulled into place by the puller and tensioner

3.48
pull site
puller set-up, tugger set-up
location in a pull section where the puller, reel winder and anchors (snubs) are located

NOTE This site may also serve as the pull site for the next pull section.

3.49
puller/bullwheel
equipment designed to pull pulling ropes and conductor(s) during stringing operations. The pulling rope is wound up under low mechanical tension on the drum in a take-up winder after passing through the puller bullwheels

NOTE The take-up winder may be incorporated as part of the bullwheel puller or may be a separate equipment.

[Definition 14.5 of IEC 60743]

3.50
puller/drum
hoist, tugger
equipment designed to pull pulling ropes and conductor(s) during stringing operations. The pulling rope is wound directly on the drum of the puller at high mechanical tension

NOTE It may have more than one drum, one for each phase.

[Definition 14.6 of IEC 60743, note modified]

3.51
puller tensioner
equipment which can be used either as a puller or tensioner

NOTE 1 The puller tensioner is usually designed for a single conductor only, but equipment exists that performs either the pulling or tensioning functions on bundle conductors.

NOTE 2 This equipment is desirable particularly for reconductoring work or where work flexibility is important. It may be of either the bullwheel or drum type, with the drum type used mainly for distribution work.

3.52
pulling vehicle
pulling tractor
any piece of mobile ground equipment capable of pulling pilot ropes, pulling ropes or conductors

NOTE Helicopters may be considered as a pulling vehicle when utilized for the same purpose.

3.53
reel stand
reel elevator, reel trailer, reel truck
device designed to support one or more reels and having the possibility of being skid, trailer or truck mounted

NOTE Usually located behind the tensioner, this device pays out the conductor from the reel under low tension to the bullwheels of a tensioner for transmission line work, or directly to the stringing blocks for distribution line work. This device can accommodate rope or conductor reels of varying sizes and is usually equipped with reel brakes to prevent the reels from turning when pulling is stopped. It is used for either the slack or tension stringing method.

3.54
reel winder
take-up reel winder, take-up stand, take-up winder
machine designed to work in conjunction with a bullwheel puller and serve as a recovery unit for a pulling rope

NOTE It is normally powered hydraulically from the puller, but is sometimes equipped with its own engine. It can be skid, trailer or truck mounted.

3.55
ruling span
equivalent span
fictitious single span in which tension variations due to load or temperature changes are nearly the same as in the actual spans in a section

NOTE The approximate value a_c of the equivalent span is calculated from :

$$a_c \cong \frac{\sqrt{\sum a_i{}^3}}{\sqrt{\sum a_i}}$$

where a_i is the length of the span i in the section.

[IEV 466-03-12]

3.56
running board
headboard
pulling device designed to permit stringing several conductors simultaneously with a single pulling rope

NOTE 1 The device is shaped to pass smoothly through the stringing block during the stringing process. The running board usually has a flexible pendulum tail suspended from the rear to prevent the conductors from twisting together during the pulling process.

NOTE 2 The conductors and pulling rope are normally connected to the running board with swivels to prevent twisting loads being transferred to the running board.

[IEV 651-13-04 and definition 14.4 of IEC 60743]

3.57
running earth
ground roller, moving ground, rolling ground, travelling ground, running ground
portable device designed to connect a moving conductor or a pulling/pilot rope to an electrical earth

NOTE These devices are normally placed on the conductor or pulling/pilot rope adjacent to the pulling and tensioning equipment located at either end of a pull section. They are primarily used to provide safety for personnel during construction or reconstruction operations.

[Definition 14.2 of IEC 60743]

3.58
sagging
process of pulling conductors up to their final tension or sag

3.59
sag section
section of line between snub or dead-end structures

NOTE More than one sag section in a pull section may be required in order to sag properly the actual length of conductor which has been strung.

3.60
sag span
control span
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

NOTE 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 may be required within a sag section.

3.61
sag target
sag board, target
device used as a reference point to sag conductors and placed on one structure of the sag span

NOTE The person, on the other structure of the sag span, can use it as a reference to determine the proper conductor sag.

3.62
slack stringing
method of stringing conductor(s) slack without the use of a tensioner, but some minimal braking may be applied to the conductor reel

NOTE This usually means the conductor touches the ground between support structures. The conductor is pulled off the reel by a pulling vehicle and dragged along the ground, or the reel is carried along the line on a vehicle and the conductor deposited on the ground. As the conductor is dragged to, or past, each supporting structure, the conductor is placed in the stringing blocks, normally with the aid of finger ropes.

3.63
splicing
jointing
process of joining the ends of conductor lengths to form a continuous mechanical and electrical connection

NOTE This is usually done by pressing aluminium or aluminium and steel sleeves over the ends of both conductors.

3.64
stringing
process of pulling pilot ropes, pulling ropes and conductors over stringing blocks supported on structures of overhead lines

NOTE Quite often, the entire job of stringing conductors is referred to as a stringing operation, beginning with the installation of insulators and stringing blocks on the erected structures, and terminating after the conductors have been put in the suspension clamps and spacers or spacer dampers installed.

3.65
stringing block
block, conductor running block, dolly, running out block, sheave, stringing sheave,
stringing traveller, traveller
sheave, or sheaves, complete with a frame used separately or in groups and suspended from structures to permit the stringing of conductors

NOTE These devices are sometimes bundled with a centre sheave for the pulling rope and two or more conductor sheaves, and used to string more than one conductor simultaneously. For protection of conductors that should not be mechanically damaged, the conductor sheaves are often lined with non-conductive or semiconductive polychloroprene or polyurethane.

[Definition 14.3 of IEC 60743,]

3.66
stringing block earth
block ground, conductor running block earth, sheave ground, stringing block ground, traveller ground
portable device attached to a stringing block and designed to connect a moving conductor or pulling/pilot rope to an electrical earth

NOTE A stringing block earth is primarily used to provide safety for personnel during construction or reconstruction operations. This device is placed on the stringing block at a strategic location where an electrical earth is required.

3.67
structure
pole, tower
wood, metal, synthetic, or concrete tower or pole which supports the conductors on insulators

3.68
structure base earth
butt ground, ground chain, portable earthing device, structure base ground, tower ground
portable device designed to connect (bond) a metal structure to an electrical earth and primarily used to provide safety for personnel during construction, reconstruction or maintenance operations

3.69
switching surge
transient overvoltage in an electrical circuit caused by a switching operation

NOTE When this occurs, a momentary voltage surge may be induced in a circuit adjacent and parallel to the switched circuit in excess of the voltage induced normally during steady-state conditions.

3.70
swivel
bullet, swivel joint
device designed to connect the conductors' ends or connect one pulling rope to a conductor or conductors to a running board

NOTE 1 It is not designed to pass through the bullwheels of a puller or a tensioner under any significant load.

NOTE 2 The device will spin and help relieve the torsional forces which build up in the rope or conductor during the stringing process.

3.71
tension site
conductor payout station, payout site, reel set-up, tensioner set-up
location on a pull section where the tensioner, reel stands, conductor reels and anchors (snubs) are located

NOTE The site may also serve as the tension site for the next pull section.

3.72
tension stringing
process of using pullers and tensioners to give the conductor sufficient tension and positive control during the stringing operation, to keep it clear of the ground surface and other obstacles which could cause damage to the surface of the conductor

3.73
tensioner, bullwheel
brake, retarder
equipment designed to hold tension against a pulling rope or conductor(s) during the stringing operation

NOTE Normally, it consists of one or more pairs of polyurethane or polychloroprene lined bullwheels with single or multiple grooves. Tension is accomplished by friction generated against the conductor which is reeved around the groove(s) of the bullwheel(s). Tensioners are available for single conductor stringing or multiconductor bundle stringing.

[Definition 14.1 of IEC 60743]

3.74
threading rope
reeving rope, thread line
lightweight flexible rope, normally natural fibre or synthetic fibre rope, used to lead a conductor through the bullwheels of a tensioner or pulling rope through the bullwheels of a puller

3.75
touch voltage
touch potential
potential difference between an earthed metallic structure and a point on the earth's surface separated by a distance equal to the normal maximum horizontal reach, approximately 1 m

NOTE This potential difference may be dangerous and may result from induction or fault conditions, or both.

3.76
ultimate strength, mechanical
strength of a member, or part of an assembly at which failure of that member or part of the assembly occurs, and as a result it can no longer support a load or perform its intended function

3.77
uplift roller
small single-grooved wheel designed to fit above the throat of the stringing block to keep the pulling rope or pilot rope in its sheave groove when uplift occurs due to stringing tensions

3.78
working load limit
allowable load, maximum load, safe working load
limit of load that can be imposed safely on a member or assembly

NOTE This is usually calculated by dividing either the yield strength or the ultimate strength of the member or assembly by the accepted factor of safety. In the case of ropes, the working load is usually calculated by dividing the ultimate or breaking strength by the accepted factor of safety.

3.79
woven wire grip
Kellem, mesh sock, sock, stocking, wire mesh grip
device designed to allow the temporary joining or pulling of conductors without the need of special eyes, links or grips

3.80
yield strength, mechanical
strength of a member or part of an assembly at which permanent deformation of that member or part of the assembly occurs, and as a result it can no longer perform its intended function

4 Understanding the hazard – Basic theory

The protection of personnel from injury during the process of installing conductors on distribution lines is most important. The personnel at the work site installing these new conductors shall be protected against induced voltages and currents caused by energized adjacent lines. The personnel shall also be protected from the hazards which can result from accidental line energization. Personnel protection can be achieved by properly applying adequate protective earthing systems at the work area, by the use of correct work methods and specialized training, and by the use of equipment, which incorporates devices to protect against these types of hazards.

Electrical charges or voltage may appear on a conductor being installed, or on the other equipment and components involved in the conductor stringing process, due to one or more of the following factors:

a) accidental contact by the new conductor with existing live conductors adjacent to the work site. This is the most likely cause of electrical hazard, particularly when new distribution conductors are being installed in crowded urban areas where existing circuits cannot be shut down;
b) switching error, in which the conductor being installed is accidentally energized;
c) electromagnetic induction (i.e. capacitive and/or inductive coupling) due to an adjacent energized line;
d) lightning strikes in the vicinity, or a lightning strike to the conductor being installed or to other equipment and components such as the ropes involved in the stringing process;
e) electrostatic charging (i.e. conductive coupling) of the conductors or ropes by atmospheric conditions or by an adjacent high-voltage direct current (HVDC) transmission line.

The hazards caused by lightning strikes, accidental contact with a live conductor, electrostatic charging, and switching errors, are generally understood. However, the hazards caused by induced voltages and currents are probably less understood and are therefore explained in some detail here. It is important to note that the basic difference between the hazard caused by induction, and the other sources given above, is that the induction is continuous as long as the source line is energized, rather than instantaneous or transient in the case of lightning or a fault current.

NOTE In the following examples, induction is shown as occurring on a conductor; however, the same result and hazard will occur for other components used in the conductor stringing process such as conducting (metallic) pulling or pilot ropes.

4.1 Electric field induction from nearby circuits

There are two common types of induction problems caused by nearby energized a.c. lines: electric field and magnetic field. Each has both voltage and current implications.

If the nearby line is an energized d.c. transmission line, the induced voltage is the result of ion drift, and can result in even higher voltages than if the nearby line was an a.c. line. Magnetic induction would only be related to the ripple effect, and is therefore much less than would be the case if the nearby line was an a.c. line.

4.1.1 Induced voltage

The electric field around an energized conductor produces a voltage on an isolated and unearthed nearby conducting object (see Figure 1).

The voltage produced depends on the source voltage magnitude and the geometry of the system but not on the length of the parallel between the energized line and the new conductor being installed.

If the circuit is unearthed, the induced voltage may be as much as 30 % of the energized line voltage. This induced voltage can be calculated, but it is generally not necessary to do so. If the new conductor being installed is earthed at any point, the charge is reduced to a much lower steady-state value, depending on the resistance to earth of the earth path.

4.1.2 Induced current

With an a.c. system, the energized lines and the earthed conductor being installed act like the plates of a condenser or capacitor, and a charging current flows across the air gap between them (see Figure 2).

The following two aspects should be considered.

a) A current flows through the temporary earth from the conductor to earth. It is proportional to the length of parallel between the energized conductor and the new conductor being installed. This current may amount to several amperes.

b) If the temporary earth becomes defective, is dislodged, or removed, the capacitive voltage is immediately re-established. Thus, if a worker is in fairly solid contact with the system and the only earth is dislodged, the worker can be exposed to a dangerous voltage and current. If the worker attempts to contact the conductor or connected parts, he will receive a dangerous discharge current, followed by a steady-state current. Thus, the worker shall avoid coming in close proximity to the conductor or connected parts since the induced voltage may be high enough to cause arc-over. Also, it should be noted that the steady-state capacitive current occurring after the contact may reach a dangerous level.

4.2 Magnetic field induction from nearby circuits

4.2.1 Induced current

In addition to the electric field caused by the voltage of the adjacent energized line, another effect is caused by the current flowing in the energized line.

The energized, current-carrying conductor and the nearby conductor being installed may be looked upon as the primary and secondary windings of an air-core transformer.

If the new conductor is earthed at two places, it acts like the secondary of an air-core transformer, short-circuited through the earth. A circulating current will flow along the new conductor, through one earth connection, back through the earth and up the other earth to complete the loop (see Figure 3a). This electromagnetic current is proportional to the current in the energized line and is dependent on the geometry and impedance of the system.

If a series of earths is applied, a series of loops is formed, each carrying current (see Figure 3b).

It would appear that the currents would cancel in the intermediate earths.

If there is a great difference in impedance of the earths in adjacent loops, for example a lake in the earth return of one, and rock in the other, the intermediate earth can carry almost the full circulating current.

If there are transpositions in the energized circuit, the phase angle of the induced current will be different along the line and can also create large circulating currents in the earthing system.

When work is carried out in the vicinity of a heavily loaded energized line, or a fault occurs on the adjacent energized line, the current induced in the new conductor being installed can be very large and can affect the choice of earthing assemblies.

4.2.2 Induced voltage

Continuing the analogy of an air-core transformer, if the new conductor being installed becomes earthed at one point only, for example by the removal of the last but one temporary earth, an open circuit secondary voltage to earth appears on the line. This voltage is essentially zero at the location of the remaining earth, and increases in proportion to the length of the parallel (see Figure 4a).

At the moment of removing the last but one earth, the circulating electromagnetic current is broken and a voltage appears across the gap. This voltage can become dangerously high, in the case of a long parallel between the energized line and the new conductor being installed. It may have to be limited by a technique of sequential earthing, in which the new conductor is subdivided by intermediate earths. The sections are then short enough to limit the open circuit voltage because the earths are sequentially removed (see Figure 4b).

4.3 Electrostatic charging

It should be noted that a potential hazard exists where a distribution line to be worked on, which is still insulated but has been isolated, may have a voltage due to electrostatic charging resulting from atmospheric conditions, or a remaining charge from an adjacent line which has been de-energized. Therefore, before starting any work operation on the distribution line, it shall be earthed at least at one point to discharge the electrostatic charge.

4.4 Re-energization

Due to accidental contact with an energized conductor, or a switching error, a circulating current may flow in the earth loop of the conductor being worked on. This could be in addition to steady-state induction currents. Where long sections of the distribution line are being worked on, a dangerous potential difference can occur in the work site because of the loop impedance.

Therefore, appropriate earth systems, such as equipotential earth systems, shall be applied on each site, as it is not sufficient to rely on remote earths applied when the line was regionally isolated and earthed.

5 Conductor stringing methods and equipment

The stringing methods used to install the distribution conductors currently employed in the electric power industry are many and varied. Outlined below are the basic methods currently in use, but they are invariably modified to accommodate equipment readily available. The methods also depend somewhat on the type and size of the distribution line to be built, the terrain over which the line is to be built, and whether the line is to be built in a congested urban area, or a relatively open rural area.

Installation of distribution conductors is usually made one conductor at a time. However, some utilities prefer to install all three phases plus neutral at one time with a multi-conductor tensioner and a running board. Insulated conductors may be in the form of three or four conductors with a messenger wire twisted together as a bundle. This bundle is usually installed on the structures in the same manner as one conductor.

There are some mechanical and electrical characteristics which are important in the choice of stringing equipment. They are detailed in this clause.

5.1 Slack stringing method

The slack stringing method is illustrated in Figures 5a and 5b.

There are two commonly used methods for slack stringing.

a) **Stationary reel method**

This method is when the conductor reels are located at one end of the pull section. The conductor is dragged along the ground of the right of way by means of a towing vehicle (see Figure 5a).

b) **Rolling reel method**

Another variation of the slack stringing method is when the reels are towed along the right of way on a trailer behind a towing vehicle, or on the back of a truck, and the conductor is paid out along the right of way (see Figure 5b).

The conductor reels are held in reel stands, placed either on the ground or mounted on a trailer (reel carrier). These stands are designed to support the reel on a shaft, permitting it to turn as the conductor is pulled out. Usually a braking device is provided to prevent overrunning of the reel when the pulling is stopped.

When the conductor is towed past each supporting structure or tower, the towing vehicle is stopped and the conductor placed in stringing blocks attached to the structure before proceeding to the next structure.

This method is chiefly applicable to the construction of rural distribution lines, where the line right of way is easily accessible to a towing vehicle. The method is not practical to use in congested urban locations, where hazards exist from road or rail traffic, where there is danger of contact with energized circuits. Nor is the slack stringing method practical in mountainous regions where the towing vehicle cannot proceed along the right of way.

5.2 Tension stringing method

A typical example of this method is illustrated in Figures 6a, 6b, 6c and 6d.

Using this method, the conductor is kept under tension during the stringing process to keep the conductor from contacting the existing energized electrical circuits which may cross over or under the conductor to be installed. Also, the conductor being installed is kept high, allowing normal traffic on railway or road crossings.

With the typical tension stringing method shown, a light synthetic pilot rope is pulled into the stringing blocks first – one for each phase plus neutral (if used). This is normally done using the slack stringing stationary reel method, either by pulling the pilot ropes into place on each support structure manually, or with a towing vehicle (see Figure 6a).

The pilot rope is used to pull in a heavier pulling rope (see Figure 6b). The pulling rope is then used to pull in the conductor(s) (see Figure 6c).

For single conductor per phase installations, where the pulling rope can be quite small, the pulling rope may be installed directly with a towing vehicle, eliminating the use of a pilot rope completely.

Where a distribution line is to be reconductored, often the old conductor is used as a pulling rope to pull in the new conductor. Since the mechanical strength of the old conductor, and particularly the existing joints, may be very questionable, this procedure may require extra caution. Passing old joints around the bullwheels of the puller, where the joints are bent and then straightened, can cause sudden failure of the joints and the conductor may drop, causing electrical contact with adjacent energized conductors, or damage to the conductor being installed.

A preferred procedure is to cut out the joint when it arrives in front of the puller, and to fit a woven wire grip on both ends of the severed conductor. This grip is passed through the bullwheels, and can be removed before the conductor is wound on the reel winder.

5.3 Stringing equipment

This subclause deals with the equipment used in the tension stringing method of installing conductors, and gives some general criteria for choosing these machines, including safety measures for protection of personnel from electrical hazards. The same basic criteria will also apply to this equipment used with the slack stinging method.

5.3.1 Tensioners

For distribution conductors, where the tension used to string conductors is usually less than 5 kN, a drum type tensioner or reel stand is normally used. The conductor reel itself is inserted in the machine and the reel is retarded or braked to the stringing tension.

For distribution conductors where the tension needed to string the conductor is more than 5 kN to give the desired clearance, a bullwheel type tensioner and reel stand are normally used.

There are two types of bullwheel tensioners:

a) multigroove tensioners with two bullwheels having four or more grooves per bullwheel;

b) V-groove tensioners with one bullwheel having a single V-groove. Machines have been made with two or more bullwheels each having a single V-groove.

Caution is recommended when using a V-groove tensioner particularly for multilayer conductors. Birdcaging of the conductor has a greater possibility of occurring because the stress on the conductor due to the tensioning process is imparted to the conductor over a shorter length than is the case with multigroove bullwheels.

5.3.1.1 General criteria

General and desirable characteristics that apply to machines used as tensioners are the following.

a) It is important, particularly when working near or adjacent to energized conductors, that the new conductor be installed smoothly without jerking or bouncing, which may cause contact with adjacent energized conductors. Therefore, fully hydraulic braked tensioners are recommended. The braking system should provide for a good control of the tension in the conductor at all stringing speeds and should hold this tension even when the pull is stopped.

b) Mechanical braking of the tensioner has been used in rural areas where there is no possibility of contact with existing energized conductors. Generally, mechanical braking gives a less smooth control of the tension than does full hydraulic braking.

5.3.1.2 Choosing the correct capacity of the tensioner

Bullwheel tensioners are usually rated by the maximum tension that can be accomplished for each conductor. Drum puller/tensioners or tensioners are rated by the maximum retarding torque that can be applied to the conductor reel.

It is important that the tensioner chosen for each project should have the capacity to tension the conductor continuously, with sufficient clearance from energized circuit underbuild, and to clear traffic on road or rail crossings.

5.3.1.3 Other criteria for the selection of tensioners

If a bullwheel tensioner or puller/tensioner is used, the following specific criteria should be considered.

a) The bullwheel grooves should be lined with a material which will prevent damage to the surface of the conductor.

b) The minimum bullwheel diameter at bottom of groove = 35 times the conductor diameter.

c) The minimum bullwheel groove diameter = 1,1 times the conductor diameter.

d) The tensioner bullwheels and linings should preferably provide for reeving and stringing the normal right-hand outer lay conductor. This means that, standing behind the tensioner looking towards the tower in the direction of stringing, the conductor should enter the tensioner bullwheels on the left, be wound on the bullwheel pair from left to right, and exit to the tower on the right. This will tend to tighten the outer layer of normal right-hand lay conductor as the conductor passes through the bullwheels.

e) It is recommended that the conductor be guided into the correct groove of the bullwheel linings from the conductor reel with fairlead sheaves or rollers placed below and on each side of the conductor.

For bullwheel, drum-tensioners or drum puller-tensioners, the following additional criteria should be considered.

f) There shall be a holding brake incorporated in the drive train, which is usually a hydraulic off spring applied type so as to hold the conductor at stringing tension in case of a drive train or hydraulic component failure. The operator shall also be able to apply and release the holding brake from the control console.

g) The tensioner control console should have a tension indicating gauge or gauges showing the tension in each conductor being installed.

h) The tensioner control console should be located so that the operator is up on the frame, and has good visibility of the conductor reel and the stringing process. This will also ensure that the operator will be at the same voltage potential as the tensioner machine in case of an accidental electrical contact, or where induction is occurring.

i) The tensioner frame should incorporate adequately sized anchor lugs for attachment of ground anchors to hold the machine in place on the job site. Since tensioners are typically trailer mounted, and will move easily on wet or unstable ground, holding anchors are recommended where the unit is not left attached to the towing vehicle.

j) The tensioner frame shall incorporate an earthing lug or bar, free of paint or other coating or surface contamination, which would prevent a good electrical connection specifically when attaching an earth clamp.

k) If the tensioner has an operator's cab, engine or other component with rubber mounts to isolate noise or vibration, then an earthing strap shall be installed from the isolated component to the frame.

l) The operator's ability to clearly hear work instructions while the tensioner is operating is important. A suitable communication system with ability to communicate clearly with the puller operator and other persons participating in the stringing process shall be provided.

5.3.2 Pullers

Four basic types of conductor pullers exist:

a) drum pullers with either single drum, or one for each conductor to be pulled;

b) bullwheel pullers with separate reel winder;

c) bullwheel pullers with integral reel winder;

d) puller tensioners.

The first three types are designed to act primarily as pullers for the pilot rope or pulling rope only.

Puller tensioners can be either of the drum type, which are normally used for work on distribution lines, or of the bullwheel type for work on transmission lines. These machines can act as pullers to wind in the pulling rope. The same machine, acting at the other end of the pull section, can be used to tension out the conductor. If the machine has a level winder, and it is used as a tensioner, the level winder should be moved to one side and not used to pass the conductor, since the levelwind sheaves or rollers are typically too small in diameter.

5.3.2.1 General criteria

General and desirable characteristics that apply to pullers are the following.

a) It is important that the conductor be pulled smoothly, without jerking or bouncing. Therefore, puller speed changes should be smooth.

b) The puller shall have sufficient pulling power to start the conductor moving at full stringing tension after a stop.

5.3.2.2 Choosing the correct capacity of puller

Bullwheel pullers are usually rated according to the maximum linepull that can be accomplished at low speed. Drum pullers are usually rated by output torque. This output torque rating should be converted to maximum linepull at the diameter of the pulling rope on the drum when the drum is fully wound with the rope.

The puller size chosen for any particular project shall take into account the stringing tension per conductor, the number of conductors to be pulled at one time and the length of the pull section.

5.3.2.3 Other criteria for the selection of pullers

Other criteria for the selection of pullers are as follows.

a) If a bullwheel puller is chosen, the puller-bullwheels should have hardened steel grooves for maximum wear characteristics.

b) The diameter of the puller-bullwheels is not as important as that of the tensioner. However, it is usually not recommended to use a puller with bullwheel diameter of less than 20 times the rope diameter.

   If the puller is to be used to pull out the old conductor, and this old conductor is used as the pulling rope to pull in the new conductor, then the puller bullwheel diameter should be a minimum of **30 times the conductor diameter**.

For both bullwheel and drum type pullers, the following additional criteria should be considered.

c) There shall be a holding brake incorporated in the puller drive train. This can be a hydraulic off spring applied type so as to hold the pulling rope at stringing tension in case of a drive train failure, or during a normal stop sequence. The operator shall also be able to apply and release the holding brake from the control console.

d) The puller control console should preferably have a linepull indicating gauge, including an overload device, which can be preset by the operator to a maximum pulling value. Pullers fitted with an overload device shall automatically stop when this level of linepull is reached. This will prevent the puller from continuing to pull up to dangerous levels if the conductor, rope or running board become snagged and held somewhere along the pull section.

e) The controls for the reel winder (if used with a puller) should be incorporated in the control console of the puller for bullwheel type pullers. This will give the puller operator full control of the pulling rope winding operation.

f) The puller control console should be located so that the operator is up on the frame, and has good visibility of the pulling rope and the stringing process. This will ensure that the operator and the puller frame will be at the same voltage potential in case of an accidental electrical contact or when induction is present.

g) The pulling rope should be guided into the correct groove of the bullwheel (for bullwheel pullers) from the structure with fairlead sheaves or rollers placed below and on each side of the pulling rope. It is also preferable that similar fairlead rollers be used to guide the pulling rope from the bullwheels to the reel winder.

   For drum type pullers, a level winder is recommended to ensure that the pulling rope is guided from the structure to the pulling rope drum, and evenly wound across the width of the drum. This makes for smooth pulling and eliminates tangles with the rope on the drum.

h) The puller frame should incorporate adequately sized anchor lugs for attachment of earth anchors to hold the machine in place on the job site. Since pullers are typically trailer mounted, and will move easily on wet or unstable earth, holding anchors are recommended if the puller is not left attached to the towing vehicle.

i) The puller frame shall incorporate an earthing lug or bar, free of paint or other coating or surface contamination, which would prevent a good electrical connection, specifically when attaching an earth clamp.

j) If the puller has an operator's cab, engine or other component with rubber mounts to isolate noise or vibration, then an earthing strap shall be installed from the isolated component to the frame.

k) The operator's ability to clearly hear work instructions while the puller is operating is important. A suitable communication system with ability to communicate clearly with the tensioner operator and other persons participating in the stringing process shall be provided.

5.3.3 Reel winders

Reel winders are used to wind up a pulling rope behind bullwheel pullers. They are not required for drum pullers.

Reel winders are sometimes incorporated on the same frame as the bullwheel pullers, but usually for larger pullers, the reel winder is a completely separate machine to reduce overall weight of each component.

They can have their own power source for driving the rope drum, or they may be powered from a hydraulic drive on the puller by means of hydraulic hose connections.

In any case, they are always driven so that they tend to wind up the pulling rope faster than the puller is able to feed the rope to the reel winder. This ensures that the pulling rope always remains taut between the puller and the reel winder so that the rope does not loosen on the puller bullwheels.

5.3.3.1 Criteria for choosing reel winders

The criteria for choosing reel winders are as follows.

a) Reel winders sometimes have a levelwind system to help wind the pulling rope evenly across the rope drum and prevent uneven build-up that could cause snarling of the rope on the drum.
b) The reel winder should be able to accommodate the size and weight of the pulling rope drum to be used on the project.
c) It is necessary to disconnect the take-up drive on the reel winder for the part of the stringing process when the pulling rope is being installed from the puller end to the tensioner end of the pull section. In this case, the reel winder usually has an overspin brake to prevent the rope drum from continuing to turn when the rope pulling operation has stopped.
d) There shall be a holding brake or reverse motion brake incorporated in the reel winder drive train so as to hold the pulling rope at normal tension between the reel winder and the puller bullwheels in case of a drive train failure, or during a normal stop sequence.
e) If the reel winder is not an integral part of the puller, the reel winder frame should incorporate adequately sized anchor lugs for attachment of anchors to hold the machine in place on the job site. Since separate reel winders are typically trailer mounted, and will move easily on wet or unstable earth, holding anchors are recommended.
f) If the reel winder is not an integral part of the puller, the reel winder frame shall incorporate an earthing lug or bar, free of paint or other coating or surface contamination, which would prevent a good electrical connection specifically when attaching an earth clamp.

5.3.4 Reel stands

Reel stands or reel carriers are used to hold the conductor reels. They can be used to directly tension the distribution conductor when such conductors are small, usually 13 mm or less, and where there is no possibility of contact between the new conductor being installed and existing energized conductors. When used with a bullwheel tensioner, they are positioned behind the tensioner, and used to wind off the conductor from the reel as it is fed to the tensioner. They can be self-loading, but usually the reels are loaded into the reel stands by crane, or other lifting means. They usually have a mechanical type brake to retard the reel during stringing.

It is recommended that a hydraulic drive drum tensioner be used for stringing projects with larger conductors, or when installing conductors in the vicinity of other energized conductors.

Reel stands are sometimes incorporated on the same frame as the tensioner, but usually only for single conductor tensioners.

The reel stand will require a brake to hold a tension in the conductor between the reel stand and the tensioner. This brake should be of sufficient size to hold this tension at normal stringing speeds until the reel has been emptied of conductor.

5.3.4.1 Criteria for choosing reel stands

Criteria for choosing reel stands are as follows.

a) The reel stand shall be able to accommodate the size and weight of the conductor reel to be used on the project.
b) If the reel stand is not an integral part of the tensioner, the reel stand frame should incorporate adequately sized anchor lugs for attachment of earth anchors to hold the machine in place on the job site. This is especially required if the reel stands are trailer mounted, and will move easily on wet or unstable earth. Holding anchors are recommended.
c) If the reel stand is not an integral part of the tensioner, the reel stand frame shall incorporate an earthing lug or bar, free of paint or other coating or surface contamination, which would prevent a good electrical connection, specifically when attaching an earth clamp.

5.3.5 Pilot rope puller

Pilot rope pullers used to construct distribution lines are usually the removable drum type and are powered from a drive shaft on the tensioner or puller/tensioner.

The pilot rope system is used to pull the pulling rope from the puller of the pull section to the tensioner end.

5.3.6 Pilot rope, pulling rope

Pilot ropes and pulling ropes for distribution line work are usually high strength synthetic ropes, specially constructed for this purpose. It is recommended that each pilot rope be a different colour for each phase plus neutral (if used), so that the pilot rope is always put in the same phase stringing block during installation.

One of the most important characteristics of a pilot or pulling rope is its non-twisting capability, especially since the rope is stretched over long distances when used. The rope should not impart excessive twist or spin to the conductor or the running board.

Where synthetic ropes are used as pulling or pilot ropes, they should not be considered as insulating. They may initially present a high resistance electrical path, but experience has shown that over time and with use, the surface of the synthetic rope becomes sufficiently contaminated to be conductive, particularly in wet conditions.

It is recommended that synthetic ropes used as pulling or pilot ropes should be chosen to have a stretch or elongation not exceeding 3 % at the maximum working load or at 20 % of the rope breaking strength. Excessive stretch means the rope stores considerable elastic energy which can be dangerous in case of rope breakage, and which requires heavy storage reels to resist the crushing forces resulting from this elastic energy.

The recommended factor of safety for pulling and pilot ropes is:

– steel ropes: the rope breaking strength shall be not less than three times the expected maximum working load;
– synthetic ropes: the rope breaking strength shall not be less than five times the expected maximum working load. Some high strength synthetic ropes have been used successfully at a breaking strength of four times the expected maximum working load. The manufacturer should specifically approve the maximum working load on these ropes.

NOTE In some jurisdictions, safety codes may require a working load to breaking strength ratio higher than the above values.

5.3.7 Stringing blocks

Stringing blocks are installed on each structure, usually at the end of each phase insulator or near the insulator on a crossarm or insulator bracket. They are used to position and pass the conductor as it is being strung.

Stringing blocks for distribution conductor usually have an unlined sheave with a smooth groove surface to protect against damage to the conductor. Blocks with an elastomer lining are also used.

Sheave linings may be of rubber, neoprene, urethane or other elastomer.

The sheave lining material should not be considered as conductive, even if it contains a conductive element. Experience has shown that so-called “conductive linings” become essentially non conductive after a period of use.

It is recommended that the stringing block sheaves be provided with high quality roller or ball bearings to minimize the rolling and frictional resistance of the block during stringing. The bearings should be either of the sealed type, greased by the manufacturer or lubricated by means of a grease fitting.

The load rating specified by the manufacturer for the stringing block shall not be exceeded. Special care shall be taken with the stringing blocks used on angle structures or on the structure in front of the tensioner and puller to ensure that they are not overloaded during the stringing process. These blocks are usually chosen with a larger load rating and a larger sheave diameter.

5.3.7.1 Criteria for choosing stringing blocks

Criteria for choosing stringing blocks are as follows.

a) For distribution lines where the conductor diameter is less than 25 mm, and the average span length is 80 m or less, a minimum stringing block root diameter of 115 mm is acceptable for use on tangent structures.

Due to the loads imposed on stringing blocks located on angle structures with more than a 20° breakover angle, and on the structures in front of the puller and tensioner, a larger stringing block should be used. In this case, a minimum root diameter of 200 mm with larger load rating is required.

Where the conductor used is larger than 25 mm, or the average span length is more than 80 m, it is recommended that the criteria for stringing blocks as specified in IEC 61328 be used.

The groove profile and the groove radius should be wide enough to allow the passage of conductor swivels and woven wire grips without these riding high in the groove and imparting a shock load to the sheave. It is important also to consider the shape of the sheave groove if it is desired to make conductor compression joints in front of the tensioner and pass these through the stringing blocks. In this case, a wide sheave groove should be considered.

b) The stringing block frame should allow for opening of the top or side for easy removal of the conductors during the clipping-in operation.

c) The throat of a multi-conductor stringing block, or the area where the conductor passes through, should be designed to allow for the smooth passage of a running board.

5.3.8 Stringing block earth

Stringing block earths are attached to the stringing block. They are used to provide an electrical path to earth. They can consist of a separate roller which contacts the conductor if the stringing block has a lined conductor sheave. However, it is acceptable to attach the earth clamp directly to the stringing block via a special frame earthing attachment point if the block has an unlined conductor sheave.

Some important characteristics of a stringing block earth are:

a) it shall be capable of withstanding a current of 20 000 A symmetrical for 20 cycles;

b) it shall have an earthing bar, free of paint or other coating or surface contamination, which would prevent a good electrical connection, specifically when attaching an earth cable with earth clamp as shown in Figure 7f;

c) compression joints, woven wire mesh joints with swivels, or rope joints shall pass through or over the stringing block earth easily. The stringing block earth shall be held tightly on the rope or conductor;

d) the stringing block earth sheaves are normally of aluminium.

5.3.9 Running earth

Running earths are placed on moving conductors or metallic pulling/pilot ropes and used to provide an electrical path to earth. They are normally used at the pull and tension sites.

Some important characteristics of a running earth include:

a) it shall be capable of withstanding a current of 20 000 A symmetrical for 20 cycles;

b) it shall have an earthing bar, free of paint or other coating or surface contamination, which would prevent a good electrical connection, specifically when attaching an earth cable with earth clamp as shown in Figure 7b;

c) it shall be of such a design that conductor compression joints, woven wire mesh joints with swivels, or rope joints will pass through the running earth without having to be removed from the conductor or rope. The running earth shall be held tightly on the rope or conductor;

d) the sheaves are normally of aluminium for running earths used on conductors, and of hardened steel for running earths used on steel pulling/pilot rope;

e) the running earth shall have an attachment point for an anchor rope which will hold the earth stationary while the conductor or rope moves through it. The earthing cable shall never be used as an anchor.

5.4 Communications

The ability of the equipment operators, supervisory personnel, and observers at critical points in the pull section (such as at energized line crossings), to communicate clearly and quickly with one another is extremely important when using the tension stringing method of installing conductors.

These personnel shall each have a radio system with a channel that is free from outside interference, and is located at their operating position. Included in this communication channel should be the puller operator, the tensioner operator, the supervisor(s) and, if applicable, the person following the running board as it moves from structure to structure, and persons at intermediate check points.

Failure of any radio in the system shall be cause for immediate stoppage of the pulling operation.

The radio or telecommunication system used by the puller operator and the tensioner operator shall be a portable set with earphones and microphone, but with no conductive wire connection to the machine, which could become a dangerous electrical path to the operator in case of electrical contact during stringing and if the operator were to leave the bonded area with his radio still attached to his person.

6 Special earthing requirements

This clause provides recommended temporary earthing systems for each of the work procedures used in the installation of distribution conductors.

Most of the earthing protection described below applies to bare distribution conductors. However, it is important to realize that an insulated or covered overhead conductor is subject to many of the same hazards during installation.

It is generally recognized that the insulation on these conductors should not be relied on for protection of equipment and personnel if a direct contact with an energized conductor occurs. Also, during the stringing process, the core of an insulated conductor is exposed at the pulling end where a metallic woven wire grip is often used.

Where special techniques are required for insulated overhead conductors, they will be mentioned herein.

The degree of earthing protection required for a given conductor installation project depends upon the exposure to electrical hazards which exist within the particular work area on the project.

When new distribution conductors are installed in an area remote from other energized lines, or parallel adjacent lines, and with no thunderstorm activity present, the **minimum** earthing requirements, at least, shall be used. These minimum requirements include bonding and earthing of all equipment involved at pull and tension sites. In addition, running earths should be installed on all metallic pulling or pilot ropes, and on the conductor in front of the pulling and tensioning equipment. When **minimum** earthing requirements are used, it should be noted that protection of workers from step and touch potential does not exist.

In contrast to the above, for a project located in a congested area involving the crossing of existing energized lines, or the building of a new circuit on the same structure over or under an existing energized parallel line, or where there is a high probability of thunderstorm activity and adverse weather conditions, **maximum** earthing requirements shall be used.

Such maximum earthing requirements include bonding and earthing of equipment, the use of running earths, earth mats at work sites, and stringing block earths. These earths and mats shall be sized and designed for a fault current where direct contact with an energized line is possible.

Sizing of the individual earth clamps, earth cable, or earth rods are not detailed here, but some general guidelines can be found in Annex A.

Figures 6a, 6b and 6c show the recommended earthing procedures for the conductor stringing sequence of the work, where the electrical hazards due to any of the possibilities described in Clause 4 are severe and require **maximum** earthing requirements.

In addition to making sure switches on the new line under construction are open, earthing and other protective measures shall be employed to ensure reasonable and adequate protection to all personnel. The best safety precaution is to consider all equipment as if it could become energized at any time. The degree of protection provided for a specific project shall be a decision made by the project supervisor, subject only to the applicable regulations in force for that situation, and based on a clear understanding of the potential hazards. However, this Technical Report gives recommendations on earthing systems that have been developed over a number of years and have proved effective.

When working in populated areas where onlookers could inadvertently wander into work site areas, additional measures for isolating the work site, such as safety observers and warning signs, are required. Work sites shall be surrounded with fence and warning signs prominently posted to alert onlookers to the danger.

6.1 Work site earthing systems

The following subclauses give specific earthing system recommendations for the equipment and other components used in the conductor stringing process.

6.1.1 General considerations

6.1.1.1 Earth to system neutral

Where a system neutral conductor which is already earthed is available on an adjacent circuit, it is preferable to interconnect the earth mat, the conductors and the equipment earths to this existing system neutral, since the neutral provides a known low resistance path to earth.

6.1.1.2 Use of earth rods

Where earth rods are used instead of earthing to a system neutral, the resistance of the earth rods shall be electrically tested (meggered) to ensure that the resistance of the earth rod is less than 25 Ω.

NOTE It is important to check that protection on any energized line which could contact the conductor being installed, is designed to clear the fault current if the impedance of the earth rod is as high as 25 Ω.

If an earth rod resistance of less than 25 Ω cannot be obtained, an earth mat (see Figure 7g) shall be used at the work site when the work site is at ground level, or an equipotential earthing system shall be used for elevated work sites.

In addition, if there is the possibility of an electrical contact during the work process, then any energized line which has the possibility of contact with the line being worked on shall have its reclosing device locked out.

In order to ensure that the different ground rods at each work site have the same potential, they shall be bonded together with full sized earth clamps and earth cables.

When installing earth rods, caution should be taken to avoid all underground utilities such as existing energized underground electric lines, gas, sewer, and water pipes, communications cables, etc. A check of underground utility services in the area may be needed before earth rods are installed.

6.1.1.3 Use of earthing sticks

All earth clamps used shall be designed so they can be applied and removed with an insulated earthing pole.

6.1.1.4 Cleaning of connections

Since the value of the earthing system depends on a low resistance path, a good electrical contact shall be ensured between the earth clamp and the surface to which it is to be applied.

6.1.1.5 Installation/removal of earth clamps

Earth clamps and cables shall first be connected to the earth rod or earthing source, and then to the object to be earthed. When removing earths, the earth clamp shall first be removed from the earthed object and then from the earthing source or earth rod. The object being earthed shall not be damaged from using the earth clamp.

When applying the earth clamp with an earthing stick, the clamp shall be held in position near the conductor, then snapped on quickly and firmly, and tightened. If an arc is drawn, the clamp shall not be withdrawn, but kept on the conductor, thus earthing the conductor.

In cases of **maximum** hazard from induction, earth clamps shall be installed and removed sequentially as detailed in 4.2.2.

6.1.2 Equipment earths

All equipment used in the process of stringing conductors should have at least one earth attachment point, usually at some convenient point on the frame. It is recommended that a special earthing bar be welded to the frame of all conductor stringing equipment during manufacture for attachment of the earth clamp.

A typical earth clamp, cable and earth rod for earthing of equipment at the pull and tension sites, or other work locations, are shown in Figure 7a. This earth clamp should also be bonded via an earth cable to the earth mat and running earths where used, and preferably to the system neutral conductor or to earth rods.

6.1.3 Conductor earths

It is recommended that a running earth be used on each conductor being installed. This running earth is placed on the conductor immediately in front of the tensioner at the tension site and on the metallic rope in front of the puller (if a metallic pulling rope is used). The running earth should also be bonded to the earth mat, the equipment earths, and preferably to the system neutral, or to earth rods.

A typical running earth, cable, and earth rod arrangement or neutral conductor arrangement is shown in Figure 7b.

NOTE Where a synthetic rope is used as a pulling rope or as a pilot rope, the use of running earths or stringing block earths is not recommended where it is known there will be induction from adjacent energized lines. Over time, it has been found that synthetic ropes have become high resistance conductors. Also, the surface of the rope may become wet from rain during use.

If running earths or stringing block earths are used on synthetic ropes, they will be the focal point for draining to earth of the electric field induced current. Experience has shown that, if the synthetic rope is stretched from the pull site to the tension site and is allowed to sit for a period of time, localized heating of the surface of the rope will occur at all contact points with an earth. In severe cases, this will cause localized burning of the rope, and may result in the rupture of the rope while under tension.

Also, if a synthetic rope is used to pull a metallic rope or a conductor which is earthed with a running earth, an insulating link should be used to connect the two. Otherwise, localized heating and burning of the synthetic rope eye due to induction will occur.

6.1.4 Earths for earth mat and conductors

A typical earth clamp, cable and earth rod for earthing of the earth mat, or conductors at the puller and tension sites, are shown in Figure 7a. This earth clamp should also be bonded via the earth cable to the equipment and running earths.

6.1.5 Earths for mid-span joining of conductors

A typical earth clamp, cable and earth rod system for earthing of the conductors, when making mid-span joints either on the ground or from an aerial device, is shown in Figure 7c.

The earths are always placed on each conductor with an earthing stick, before any workman makes contact with any conductor. If this is not done, the workman could find himself placed in a series connection with the conductor ends and be subject to dangerous levels of voltage and current from induction.

6.1.6 Earths for clipping in the conductors

A typical earth clamp, cable and tower connection system for earthing of the conductors, when removing the conductor from the stringing blocks and placing it in the insulator clamps, is shown in Figure 7d.

6.1.7 Earths for installation of jumper loops for the conductors

A typical earth clamp, cable and structure connection system for earthing of the conductors, when making jumper loops in the conductor at dead-end structures, is shown in Figure 7e.

6.1.8 Stringing block earths

A typical earth clamp, cable and tower connection system for earthing of the conductors or pulling rope via a stringing block earth is shown in Figure 7f.

Stringing block earths are used on stringing blocks with a sheave lining, at intermediate poles, to drain to earth the effect of electrical contact or excessive induction from adjacent energized circuits.

If the stringing block has unlined metallic sheaves, with a good earthing path through the sheave to the block frame, then it is acceptable to earth the frame with a special earth clamp connection, provided the block and earth attachment passes the acceptance test for stringing block earths as detailed in Clause 7.

6.1.9 Earth mat

A typical earth mat system with double barrier is shown in Figure 7g. Other earth mat designs with a different mesh size and construction are acceptable provided they meet the following criteria.

The earth mat is a system of interconnected bare conductors and a metallic mesh with connection to the system neutral conductor, if possible, or with earth rods. The earth mat is placed on the ground under the equipment at pull and tension sites.

The purpose of the earth mat is to provide equipotential protection for personnel, and the mat itself shall never be installed in such a way that it could carry fault current.

Four earth rods shall be used, i.e. one at each corner of the earth mat.

The mat should be of sufficient size so that all conductor stringing equipment can be situated entirely on the mat, and is contained within the inner barrier, and allow the required work to be accomplished.

The matting material and earth cables shall be of sufficient size and durability to withstand both the physical requirements of the movement, and the support of the equipment.

Mat conductors and earth rods or the neutral conductor shall be interconnected. All equipment, ropes, conductor anchors at ground level as well as the conductor shall be within the mat area and bonded to it. The equipment shall be connected by type A earths to the earth rods or the neutral conductor directly, and not via the earth mat mesh.

There shall be a double barrier, as shown in Figure 7g, around the earth mat, with restricted access to the inner earth mat area over an insulating mat. The double barrier prevents contact between a person or object inside the mat area with someone outside the mat area. should the work site become energized.

Earth mats shall be used at pull and tension sites and at any point in the pull section where ground level work is being carried out, where there is any possibility of contact with an existing energized conductor at any point in the pull section, where there is any possibility of a switching error, or where induction is present.

6.2 General procedures and use of earthing systems

This subclause details which earthing system should be used for each of the separate work sites of the conductor stringing process, and how it should be applied. For an overall review of earthing procedures, see Figures 5a, 5b, 6a, 6b and 6c.

NOTE Where a change in earthing system is required when one step of the conductor stringing process is completed and another begins, the new earth system specified is installed **before** the original earth system is removed. In this way, conductor, ropes or equipment are always earthed and never left in an unearthed condition.

6.2.1 General procedures

Before work begins, there are some general procedures, detailed below, which are to be followed for all operations in order to protect personnel and equipment from electrical hazards, particularly when maximum earthing procedures are required.

6.2.1.1 Choosing the correct equipment

It is important to choose equipment with sufficient capacity to perform the work to be done (see 5.3). This should ensure a margin of safety beyond the actual requirements of the work.

6.2.1.2 Pre-work check of equipment

When installing new conductors near existing energized circuits where electrical contact may occur, it is especially important that the equipment used such as pullers, tensioners, and pilot rope pullers be thoroughly checked beforehand by competent trained persons to ensure they are functioning properly. In particular, braking systems should be checked to ensure correct operation and maximum load holding capability.

Pulling and pilot ropes should be examined for possible damage that may severely reduce their strength. It is recommended that a sample of synthetic ropes used as pulling or pilot ropes be taken at least once each year and tested for ultimate strength. Weak or damaged ropes should be replaced.

Running earths, earth cables, earth clamps, and stringing block earths should be checked to ensure they are operating correctly and have no broken or damaged parts that would negatively affect the desired low resistance earth path.

6.2.1.3 Pre-work conference

Where the possibility of conductors being installed becoming energized through induction, or when working near existing energized conductors, it is especially important that all members of the work crew understand the hazards involved. They should have the work procedures and their duties clearly explained immediately before work begins. They should be aware of the necessity of using the earthing and bonding systems described herein, and they should know how to install them properly.

If the scope of the job changes, or if job personnel changes, work procedures and duties shall be explained once again to all personnel affected.

Before work begins, the project supervisor should travel the work site from puller site to tensioner site. This is done to ensure that all potential contact points with existing energized equipment or conductors are adequately protected from contact with the conductor being installed by clearance, by insulating covers, or rider poles and nets.

6.2.1.4 Trained operators

The specialized equipment used in the stringing of conductors requires that operators be given special training beforehand in its safe and proper use. This is particularly important when they will be working on projects where maximum earthing procedures are required, due to the possibility of the conductors or equipment becoming energized.

6.2.2 Installation of the pilot or pulling rope

When installing the pilot or pulling rope in the stringing blocks on each structure from the tension site to the pull site, the following is required.

Minimum

- an open switch (isolator) at all ends of the line being worked on. Secure against re-connection, and verify that the installation is isolated.
- all conductor stringing equipment at ground level, plus temporary anchors for equipment, metallic rope or conductors at pull and tension sites shall be earthed with a type A earth system (see Figure 7a);
- running earths should be used on all metallic ropes and conductors (see Figure 7b).

Maximum

In addition to the above, add:

- the automatic recloser disabled on all energized lines being crossed or on energized lines in parallel where physical contact may occur as a result of an accident;
- crossing structures (rider poles) over all energized lines being crossed;
- an insulating conductor cover shall be installed on all energized conductors being crossed for a minimum horizontal distance of 1,0 m on each side of the position where the new conductors are to be installed. The relative height distance between the new and existing conductors and the effect of side wind should be taken into account when deciding on the length of insulating conductor cover to be used. Crossing structures (rider poles) with guard nets over all energized conductors being crossed are an acceptable alternative;

- where an existing energized circuit is below or above the new conductors being installed, and on the same pole, each energized conductor should be temporarily offset, with earthing poles a minimum horizontal distance of 1,0 m from the position where the new conductor is to be installed. This operation is to be carried out before the installation of pilot rope, pulling rope or the new conductors (see Figure 6d);
- all stringing equipment, plus temporary anchors for equipment, rope or conductors, shall be located in a type G earth mat area (see Figure 7g);
- all stringing blocks on the first structure in front of the puller, and the first structure in front of the tensioner, as well as every fifth structure, should have a type F stringing block earth (see Figure 7f). In severe cases of induction, it is recommended to have stringing block earths at every structure, unless other methods of compensating for the induction are used. If the stringing blocks have unlined sheaves, they can be earthed through their frames. However, it should be noted that earthing through the frame may provide a slightly higher resistance path to earth compared to earthing directly on the conductor. Where synthetic pulling or pilot ropes are used, stringing block earths shall not be used.

6.2.3 Stringing of conductors

When the conductor is being pulled into place from the tension site to the pull site, the following is required.

Minimum

- an open switch (isolator) at all ends of the line being worked on. Secure against re-connection, and verify that the installation is isolated;
- all conductor stringing equipment, plus temporary anchors for equipment, rope or conductors at pull and tension sites shall be earthed with a type A earth system (see Figure 7a);
- while stringing, all bare conductors shall have a running earth type B earth system (see Figure 7b), located in front of the tensioner. All metallic pulling ropes shall have a running earth type B earth system (see Figure 7b), located in front of the puller;
- when stringing is completed, and the conductors tied down waiting for sagging, all conductors shall have a type A earth system (see Figure 7a);
- the conductors shall be pulled high enough before anchoring that they clear the ground level at all points so accidental contact by persons or equipment on the ground is prevented at any place along the line.

Maximum

In addition to the above, add:

- the automatic recloser disabled on all energized lines being crossed or on energized lines in parallel where physical contact may occur as a result of an accident;
- an insulating conductor cover shall be installed on all energized conductors being crossed for a minimum horizontal distance of 1,0 m on each side of the position where the new conductors are to be installed. The relative height distance between the new and existing conductors and the effect of side wind should be taken into account when deciding on the length of insulating conductor cover to be used. Crossing structures (rider poles) with guard nets over all energized conductors being crossed are an acceptable alternative;

- where an existing energized circuit is below or above the new conductors being installed, and on the same pole, each energized conductor should be temporarily offset, with earthing sticks a minimum horizontal distance of 1,0 m from the position where the new conductor is to be installed. This operation is to be carried out before the installation of pilot rope, pulling rope or the new conductors (see Figure 6d);
- all stringing equipment, plus temporary anchors for equipment, rope or conductors, shall be located in a type G earth mat area (see Figure 7g);
- all stringing blocks on the first structure in front of the puller, and the first structure in front of the tensioner, as well as every fifth structure, should have a type F stringing block earth (see Figure 7f). In severe cases of induction, it is recommended to have stringing block earths at every structure, unless other methods of compensating for the induction are used. If the stringing blocks have unlined sheaves, they can be earthed through their frames. However, it should be noted that earthing through the frame may provide a slightly higher resistance path to earth compared to earthing directly on the conductor. Where synthetic pulling or pilot ropes are used, stringing block earths shall not be used;
- all insulated overhead conductors shall have the tail end of the conductor on the reel at the drum tensioner or at the reel stand earthed by means of a slip ring device and type A earth system (see Figure 7a).

6.2.4 Splicing of conductors

When the conductor joint or splice is made at the pull or tension sites, or in mid-span locations, the following is required.

Minimum

- an open switch (isolator) at all ends of the line being worked on. Secure against re-connection, and verify that the installation is isolated;
- all conductors shall be earthed before splicing with a type C earth system (see Figure 7c) or similar.

Maximum

In addition to the above, add:

- the automatic recloser disabled on all energized lines being crossed or on energized lines in parallel where physical contact may occur as a result of an accident;
- all splicing in front of the tensioner, or in mid-span, shall be done within a type G earth mat (see Figure 7g). All temporary anchors for conductors shall be located in the earth mat area;
- the conductor shall be earthed on each side of a mid-span splicing area using a type C earth system (see Figure 7c). The earth rod shall be connected to the earth mat;
- all stringing blocks on the first structure in front of the puller, and the first structure in front of the tensioner, as well as every fifth structure, should have a type F stringing block earth (see Figure 7f). In severe cases of induction, it is recommended to have stringing block earths at every structure, unless other methods of compensating for the induction are used. If the stringing blocks have unlined sheaves, they can be earthed through their frames. However, it should be noted that earthing through the frame may provide a slightly higher resistance path to earth compared to earthing directly on the conductor. Where synthetic pulling or pilot ropes are used, stringing block earths shall not be used.

6.2.5 Sagging of conductors

When the conductor is to be pulled up to the final sag, the following is required.

Minimum

- an open switch (isolator) at all ends of the line being worked on. Secure against re-connection and verify that the installation is isolated;
- during sagging, all conductors shall have either a type A or a type B earth system (see Figures 7a and 7b), located in front of the sagging position.

Maximum

In addition to the above, add:

- the automatic recloser disabled on all energized lines being crossed or on energized lines in parallel where physical contact may occur as a result of an accident;
- all temporary anchors for conductors shall be located in an earth mat area (see Figure 7g).

6.2.6 Clipping-in conductors

When the conductor is transferred from the stringing blocks to the conductor clamp at the end of the insulator string after sagging is complete, the following is required.

Minimum

- an open switch (isolator) at all ends of the line being worked on. Secure against re-connection and verify that the installation is isolated;
- at the tower where the clipping-in takes place, all bare conductors shall be earthed before clipping-in with a type D earth system (see Figure 7d).

Maximum

In addition to the above, add:

- the automatic recloser disabled on all energized lines being crossed or on energized lines in parallel where physical contact may occur as a result of an accident;
- all temporary anchors for conductors shall be located in an earth mat area (see Figure 7g).

6.2.7 Dead-ending and installation of jumper loops or other work at structures

When, after sagging has been completed, the conductor is terminated and anchored at an anchor structure, or when the anchor structure jumper loops are installed, or when connecting the conductor to a transformer or underground cables or similar work, the following is required.

Minimum

- an open switch (isolator) at all ends of the line being worked on. Secure against re-connection and verify that the installation is isolated;
- when the conductor is ready to be attached to the anchor structure, and/or the jumper loops are ready to be installed, all bare conductors on each side of the anchor structure shall be earthed with a type E earth system (see Figure 7e) or similar. The earth clamps shall be placed on the conductor outside the work area.

Maximum

In addition to the above, add:

– the automatic recloser disabled on all energized lines being crossed or on energized lines in parallel where physical contact may occur as a result of an accident;

– if personnel are working at the base of the structure, installing apparatus or similar devices on the structure which may become energized, the work area shall be within an earth mat (see Figure 7 g).

6.2.8 Fuelling

When fuelling equipment from fuel trucks at pull and tension sites, the following is required.

Minimum

– an open switch (isolator) at all ends of the line being worked on. Secure against re-connection and verify that the installation is isolated;

– before the fuel nozzle is inserted in the equipment fuel tank, the fuel truck or container shall first be bonded with a type A earth system (see Figure 7a) to the earth rod to which the equipment being refuelled is bonded.

Maximum

– all equipment is to be within a type G earth mat system (see Figure 7g).

7 Testing of equipment

This clause details the recommended electrical type tests required for stringing block earths and running earths. Type tests for earth clamps, earth cable, etc. are detailed in IEC 61230.

7.1 Number of type tests

Each new design of stringing block earth or running earth shall undergo the type tests detailed in this clause. At least two successful tests on these earths, effected in sequence, shall be accomplished to ensure their design is satisfactory.

Once the equipment has passed the type test, it is not considered necessary to test additional production units, unless the design is altered in a substantial way that would affect the earthing capabilities.

7.2 Type test set-up

The stringing block earth and the running earth shall be tested in essentially the same test set-up, as detailed in Figures 8 and 9.

7.3 Type test acceptance criterion

The type test acceptance criterion for stringing block earths and running earths is that they shall withstand a test current of 20 000 A symmetrical for 20 cycles.

In this test, the word "withstand" is interpreted to mean that the earth shall continue to pass current for the time period specified without interruption. Physical damage to the earth at this level of amperage is to be expected, but the earth parts shall survive long enough to hold their current path.

NOTE The stringing block earths and running earths accepted by this criterion will be suitable for the following:

a) fault currents caused by accidental contact of the conductor being installed with existing live distribution lines. This may occur when the new conductors are being installed above energized conductors on the same pole;

b) lightning strikes;

c) induced voltages and currents.

WARNING: There may be cases where accidental contact could occur with an existing live transmission line. Special care must be taken to choose stringing block earths and running earths which will carry the potential fault current, if such earths are required for this type of contact. The acceptance criterion described above may not be sufficient for these special cases.

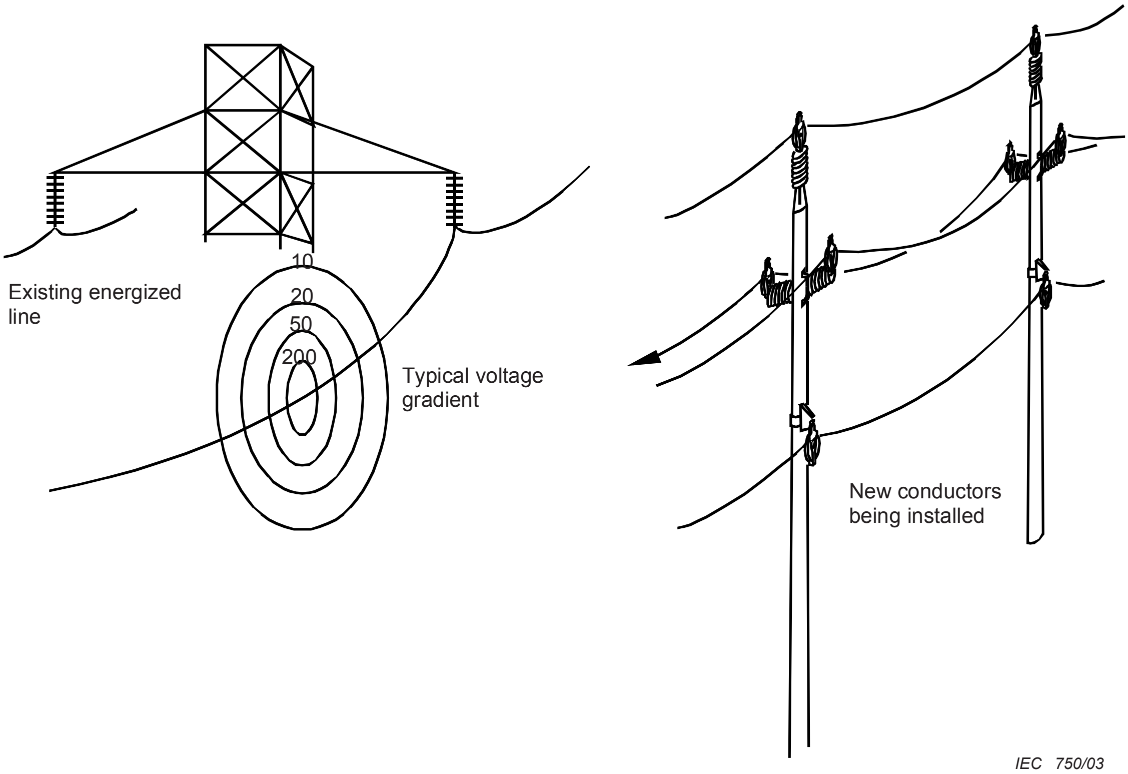


Figure 1a – Pictorial view

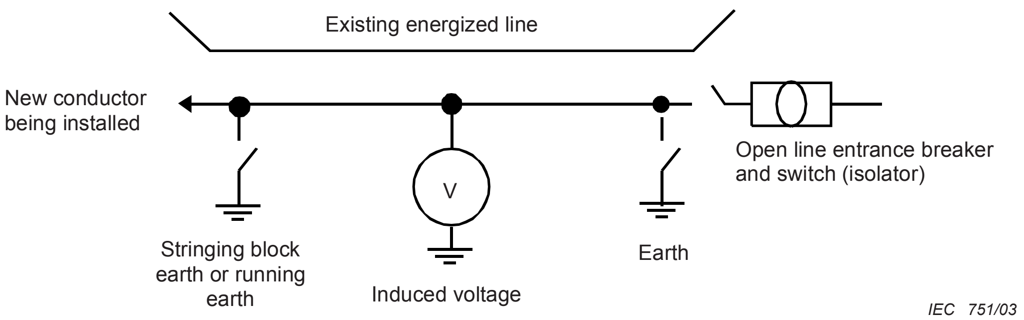


Figure 1b – Diagrammatic view

NOTE This figure is simplified. The three phases of the existing energized line are involved in the induction.

Figure 1 – Electric field induced voltage on a parallel conductor

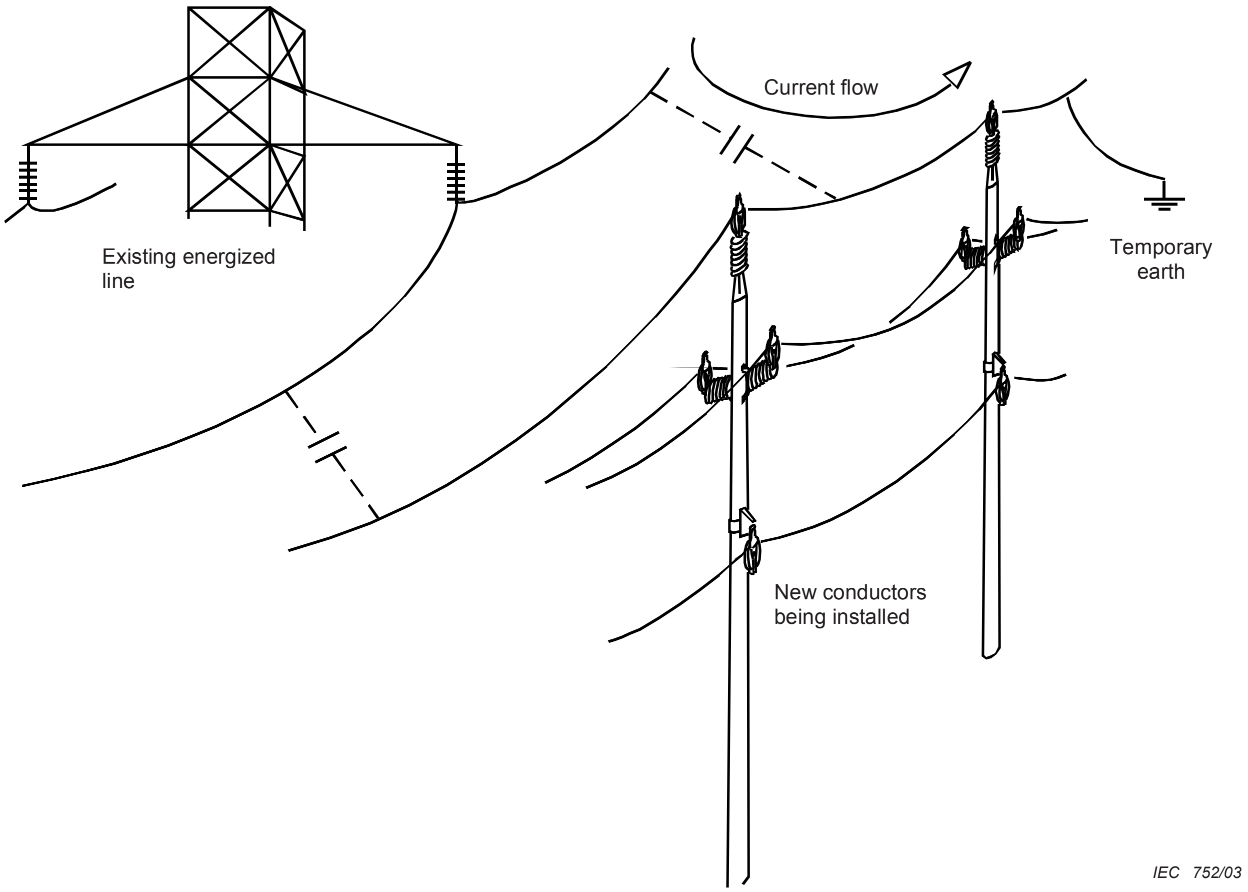


Figure 2a – Pictorial view

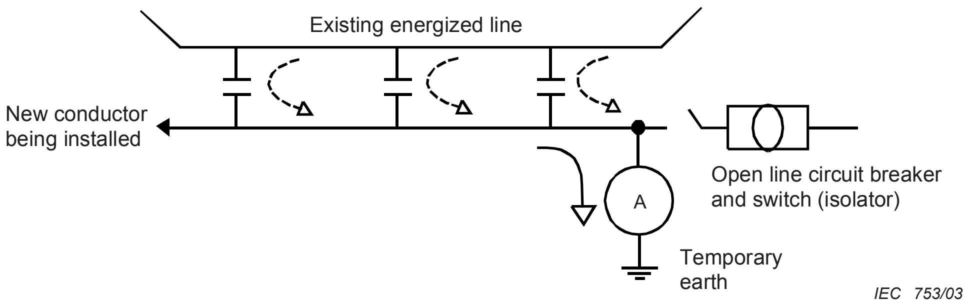


Figure 2b – Diagrammatic view

NOTE This figure is simplified. The three phases of the existing energized line are involved in the induction.

Figure 2 – Electric field induced current on a parallel conductor

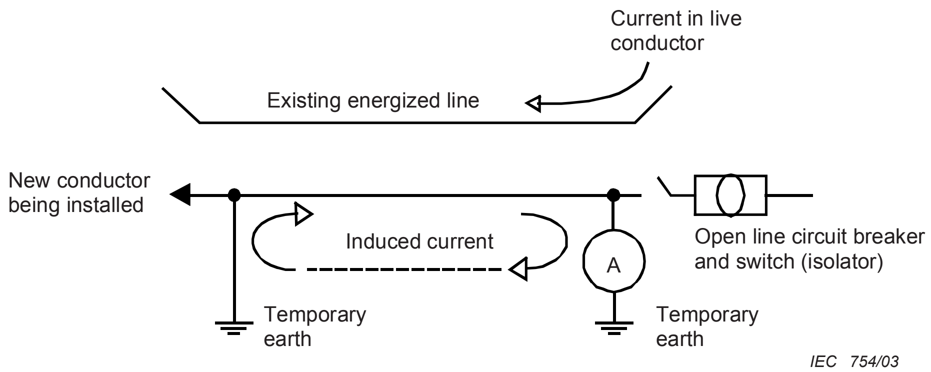


Figure 3a – Circulating current with two earths on new conductor

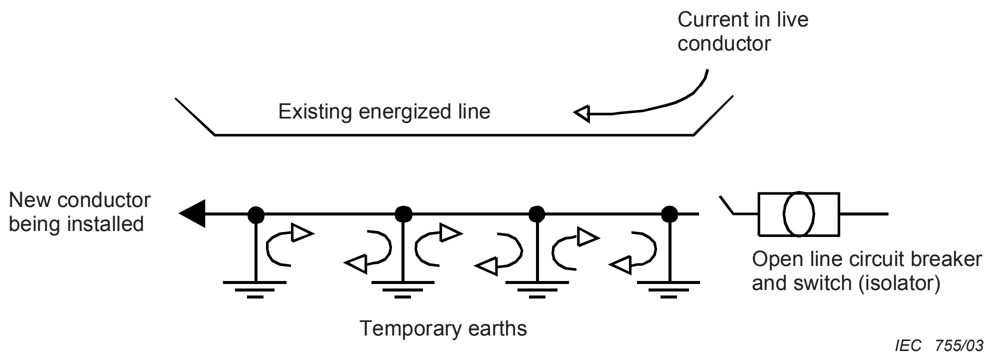


Figure 3b – Circulating currents with multiple earths

NOTE This figure is simplified. The three phases of the existing energized line are involved in the induction.

Figure 3 – Magnetic field induced current on a parallel conductor

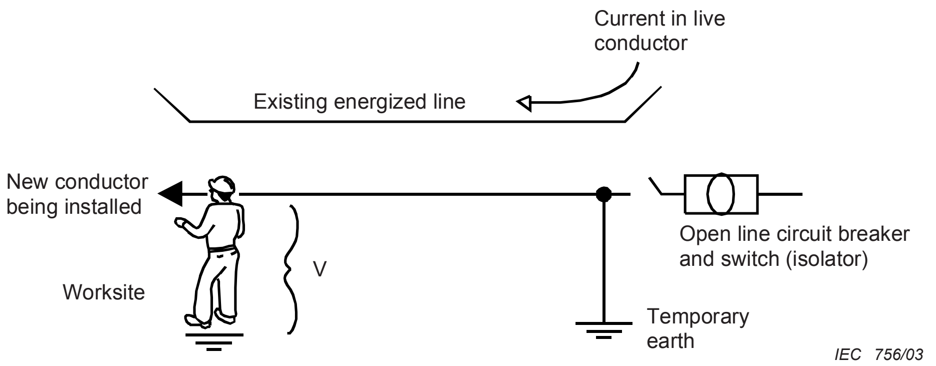
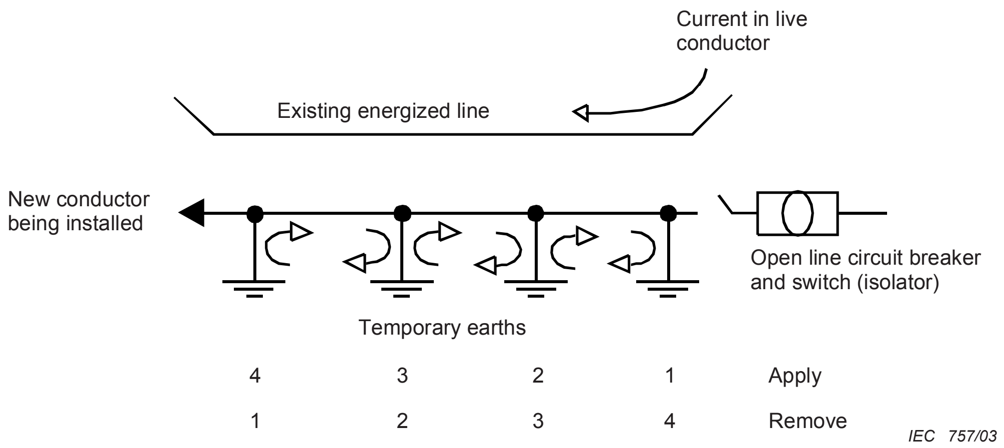


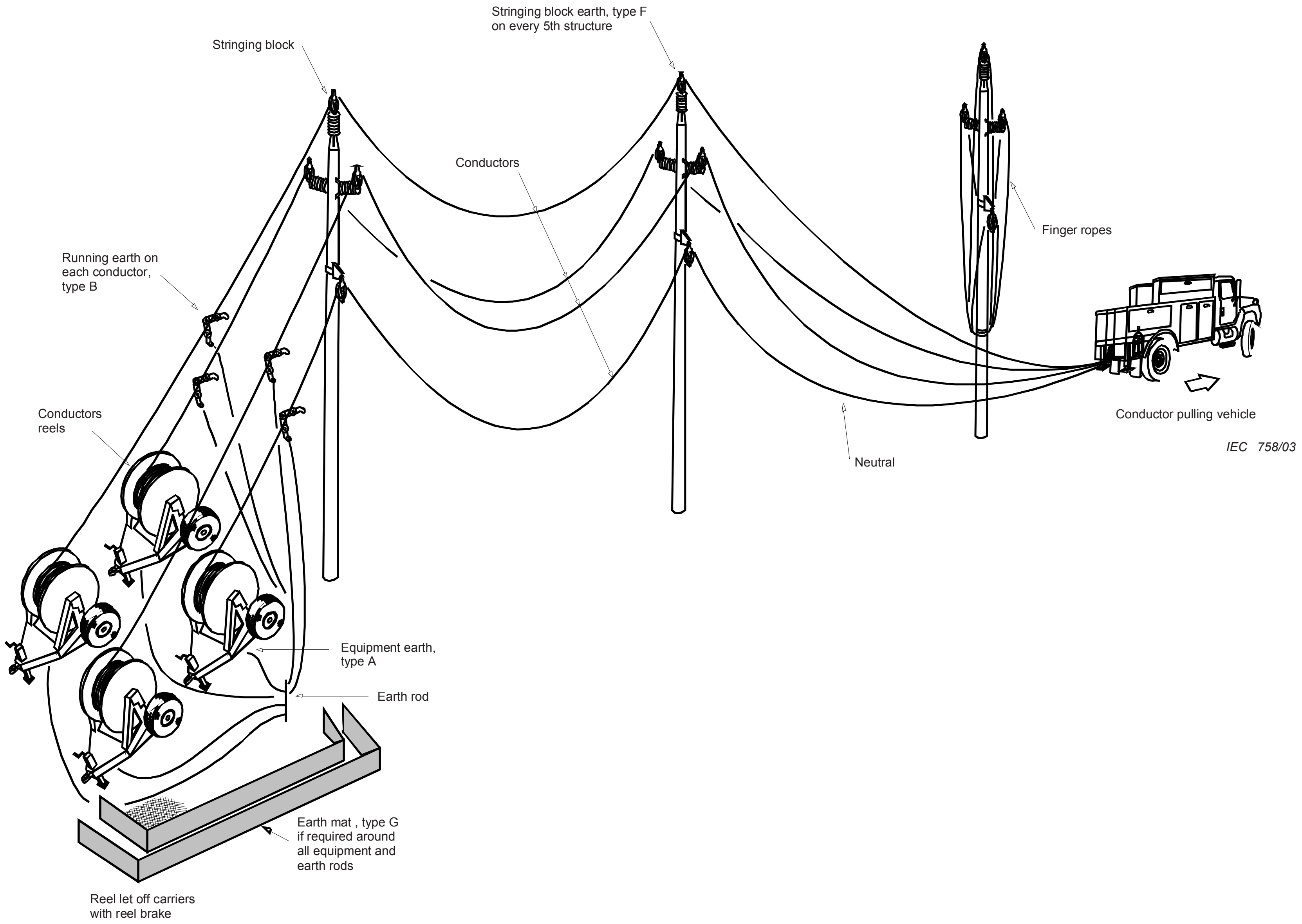
Figure 4a – Open circuit voltage with one earth only



NOTE In areas of high induction, the last earth removed should be done so with a portable earth interrupter tool.

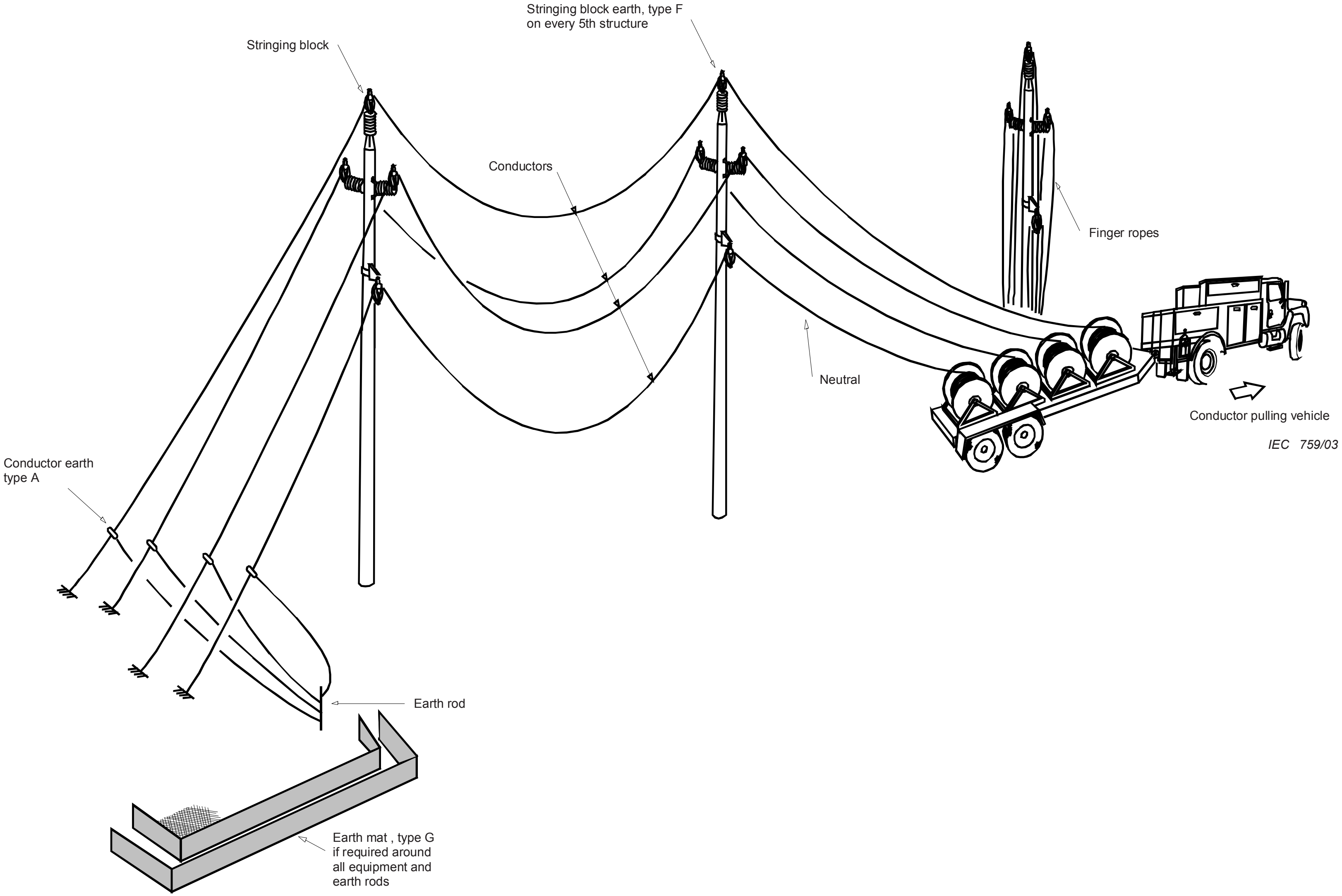
Figure 4b – Temporary earths to be applied and removed sequentially

Figure 4 – Magnetic field induced voltage on a parallel conductor



NOTE This method is not recommended in areas where high induction is possible.

Figure 5a – Installing conductor – Stationary reel



NOTE This method is not recommended in areas where high induction is possible.

Figure 5b – Installing conductor – Rolling reel

Figure 5 – Slack stringing method

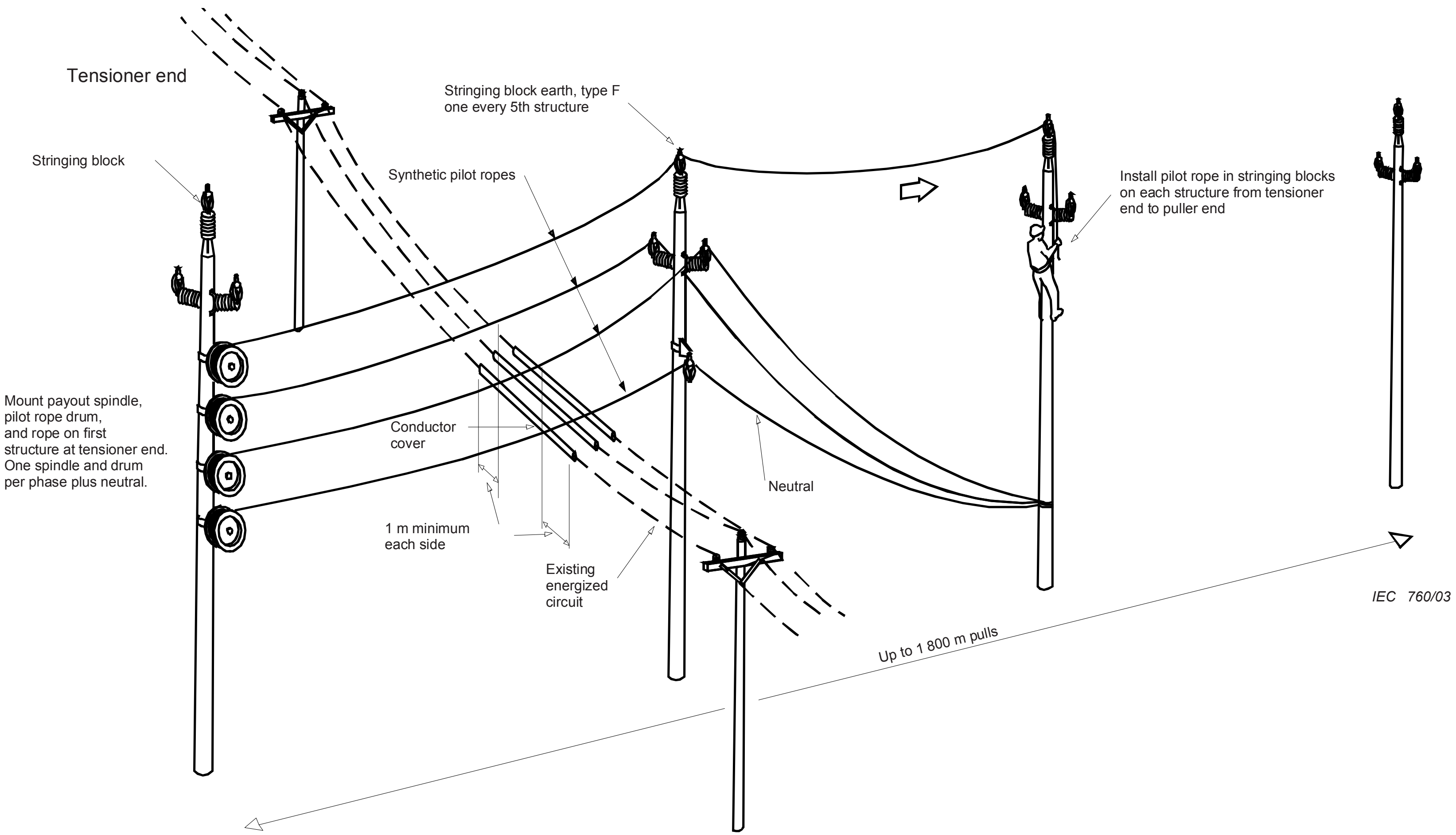
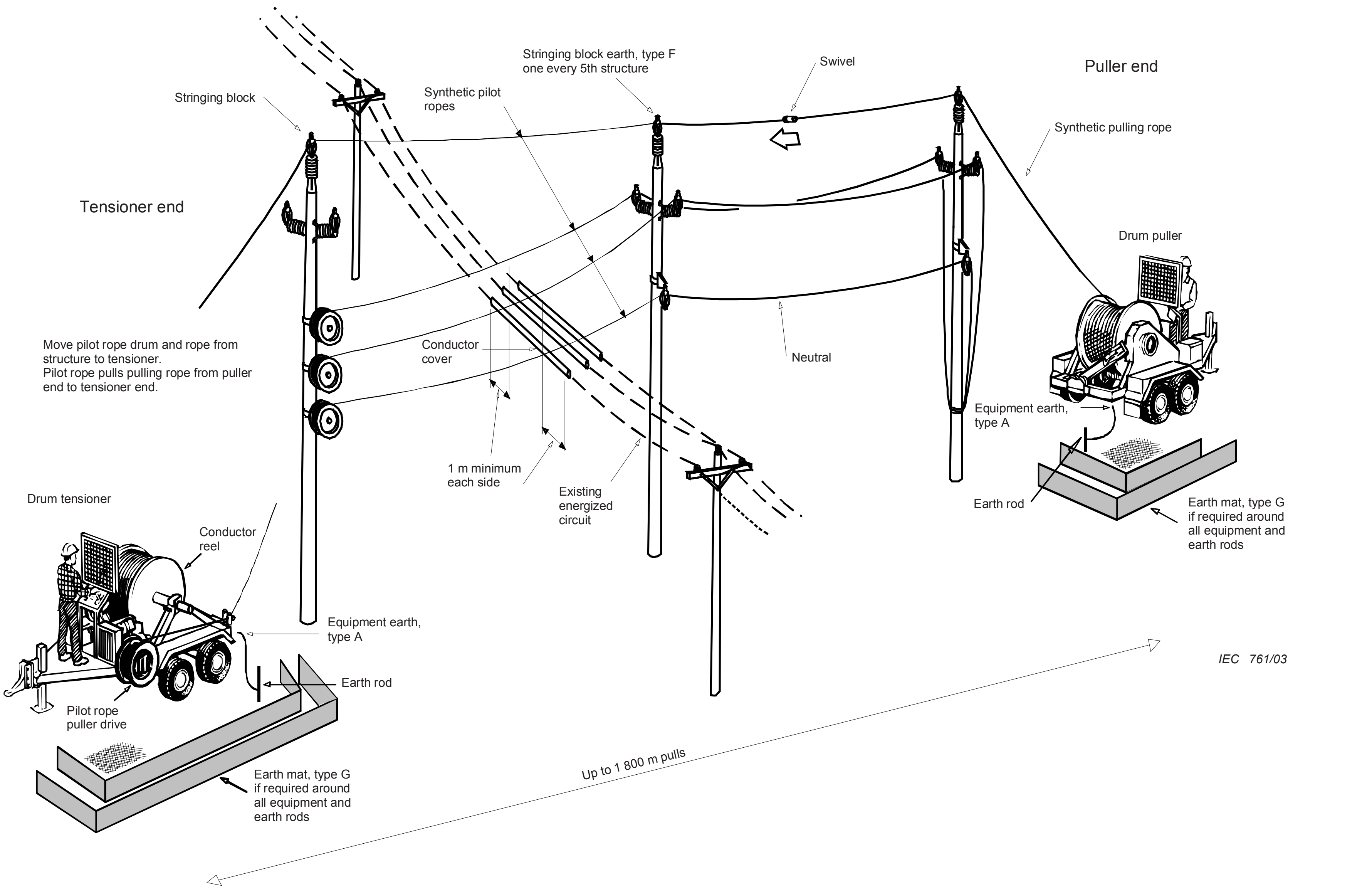
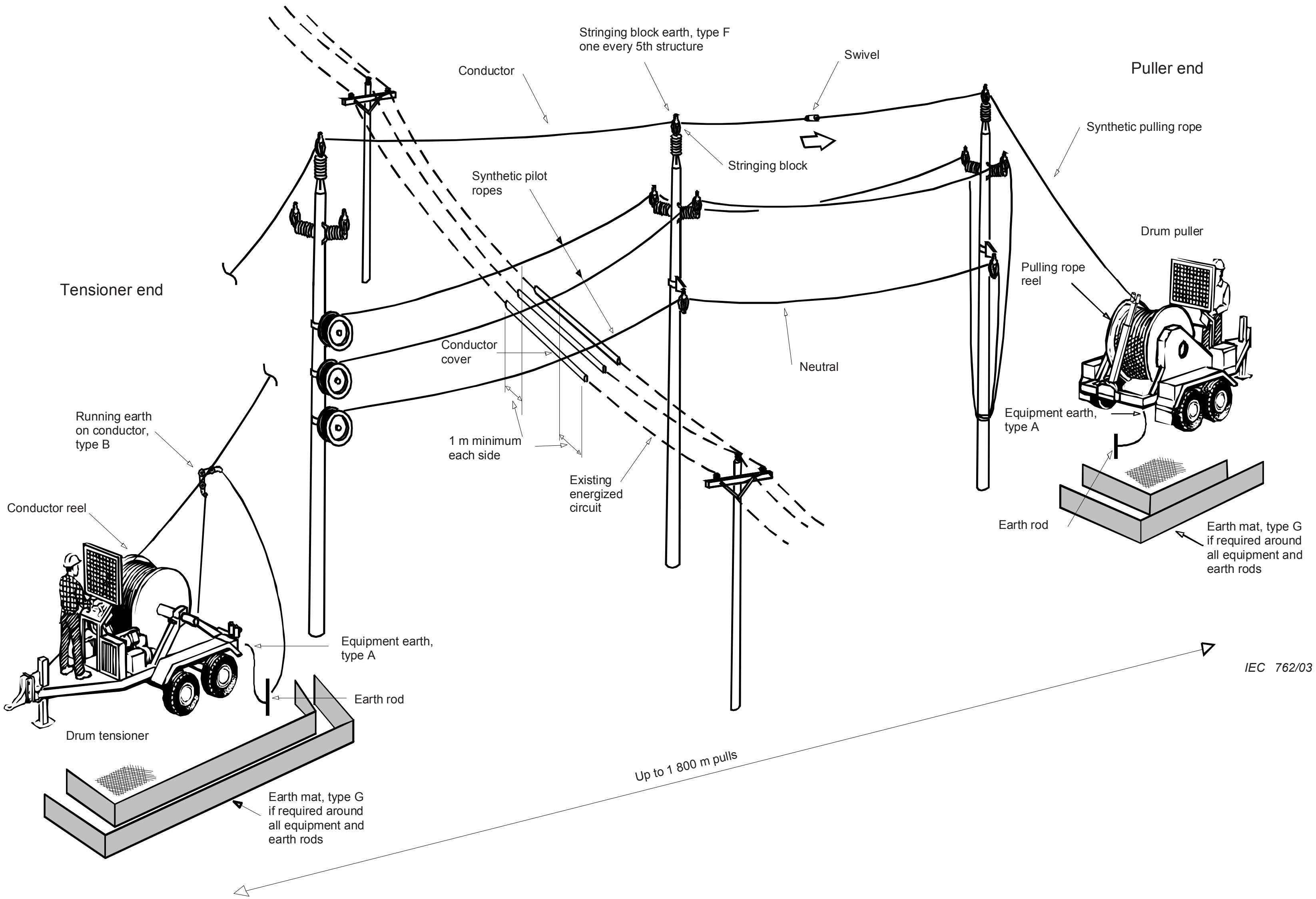


Figure 6a – Installing pilot rope on structure



NOTE The puller and tensioner shall be located at a minimum distance from the first and last structure of three times the height of the stringing block above the machines.

Figure 6b – Installing the pulling rope



NOTE The puller and tensioner shall be located at a minimum distance from the first and last structure of three times the height of the stringing block above the machines.

Figure 6c – Installing conductor

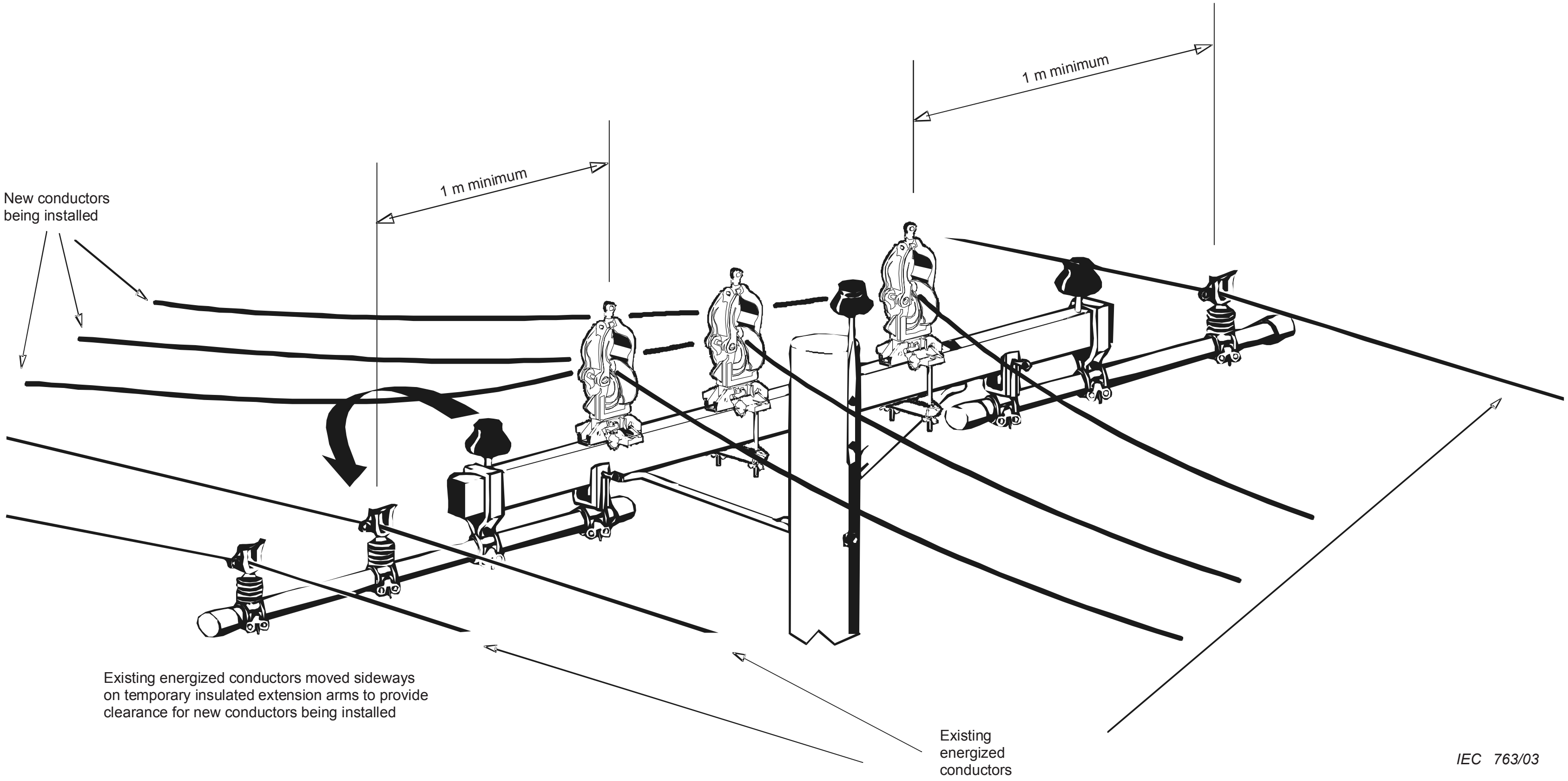


Figure 6d – Reconductoring project with existing circuit energized

Figure 6 – Typical tension stringing method

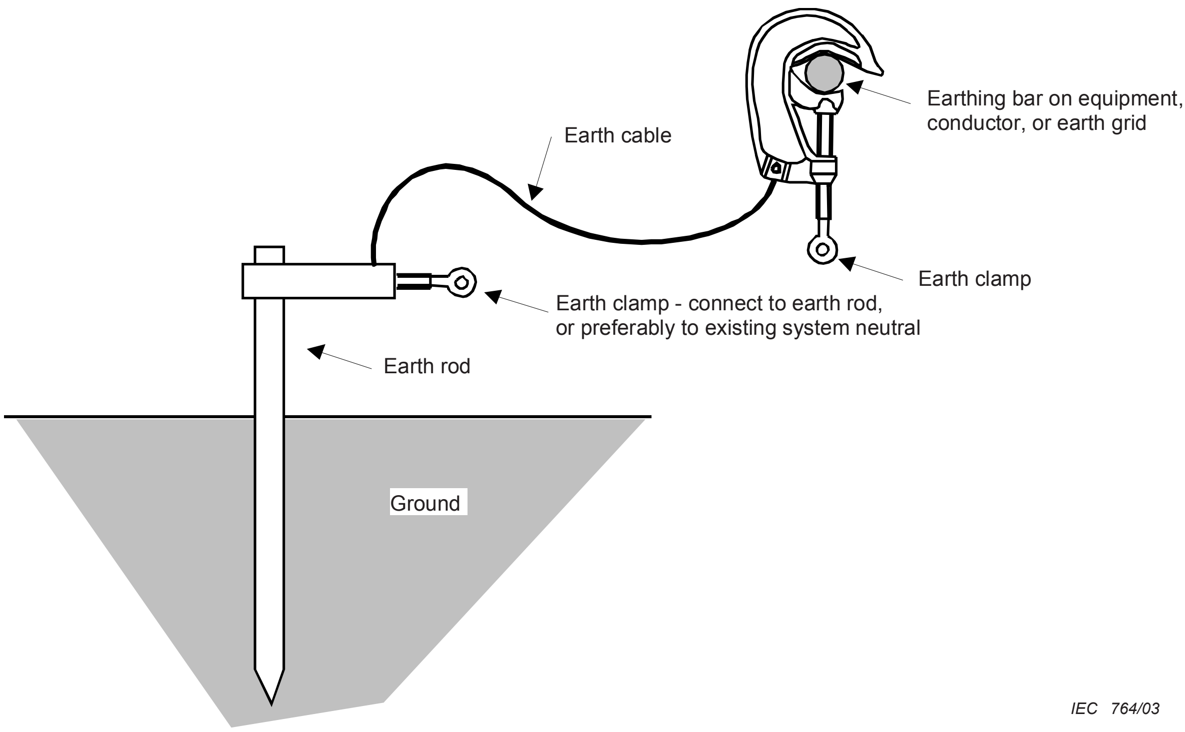


Figure 7a – Equipment or conductor earth system – Type A

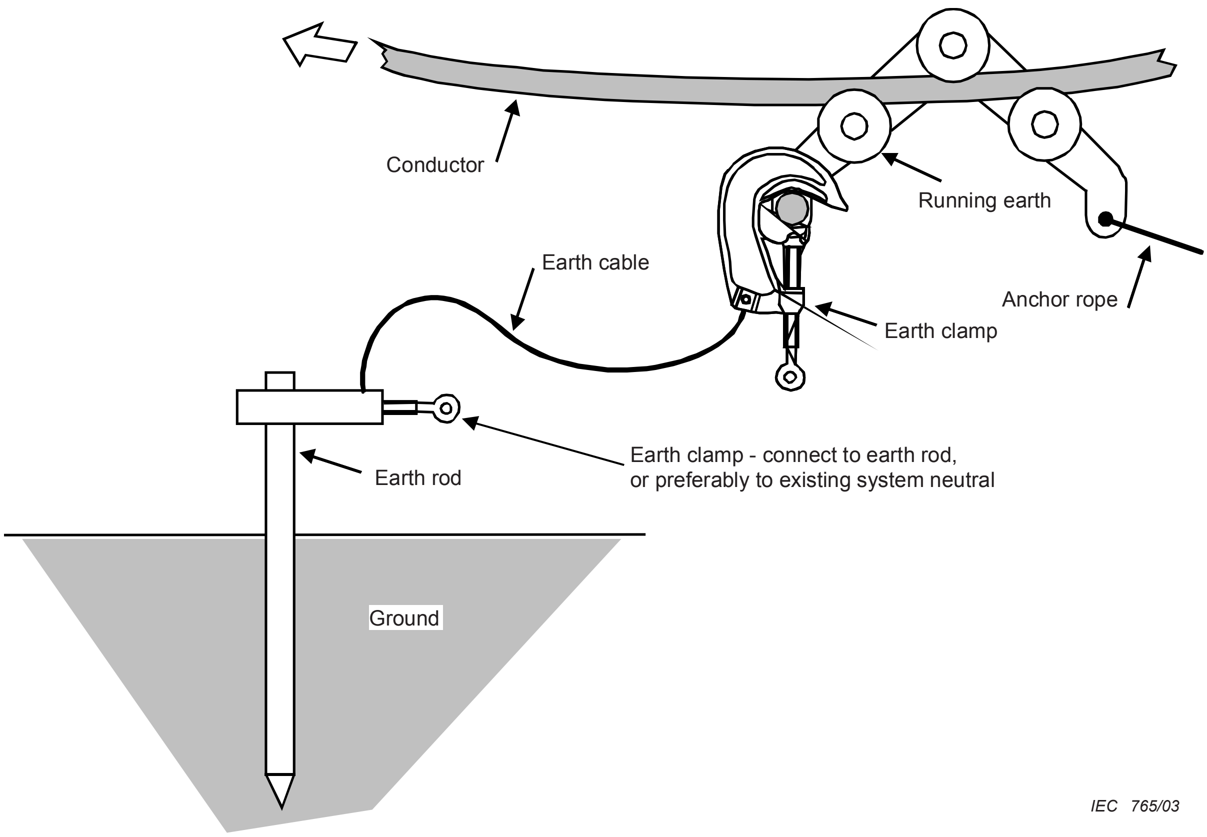
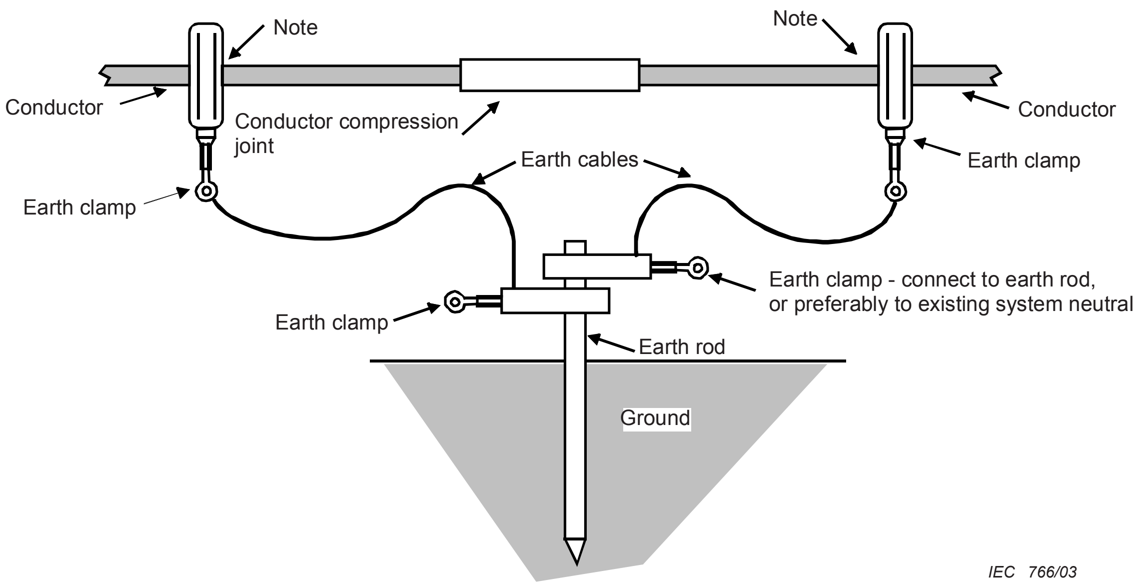
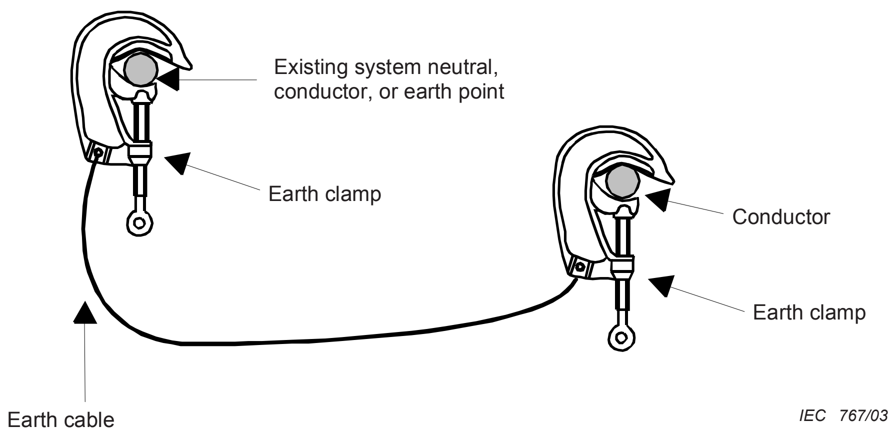


Figure 7b – Running earth system – Type B



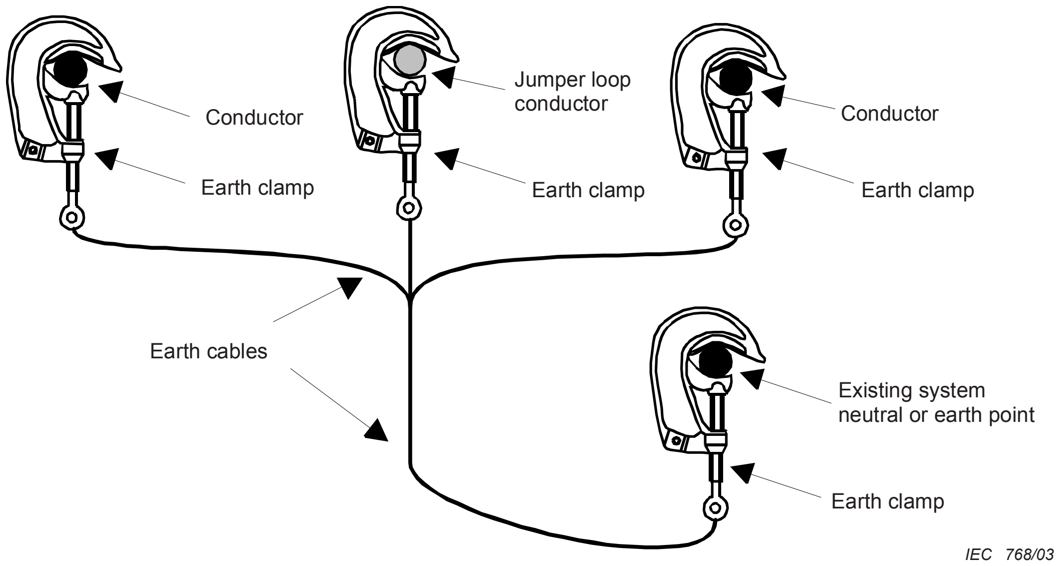
NOTE Conductor grips and work area shall be between earth clamps.

Figure 7c – Earthing system for conductor compression joints – Type C



NOTE Work area shall be between earth clamps.

Figure 7d – Earthing system for clipping in conductors – Type D



NOTE Work area shall be between earth clamps.

Figure 7e – Earthing system for conductor jumper loops – Type E

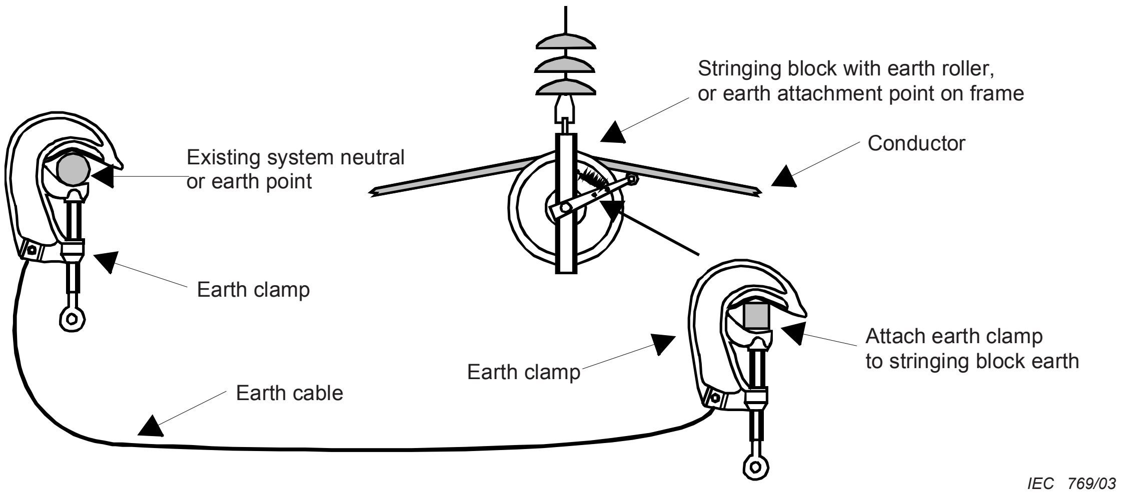
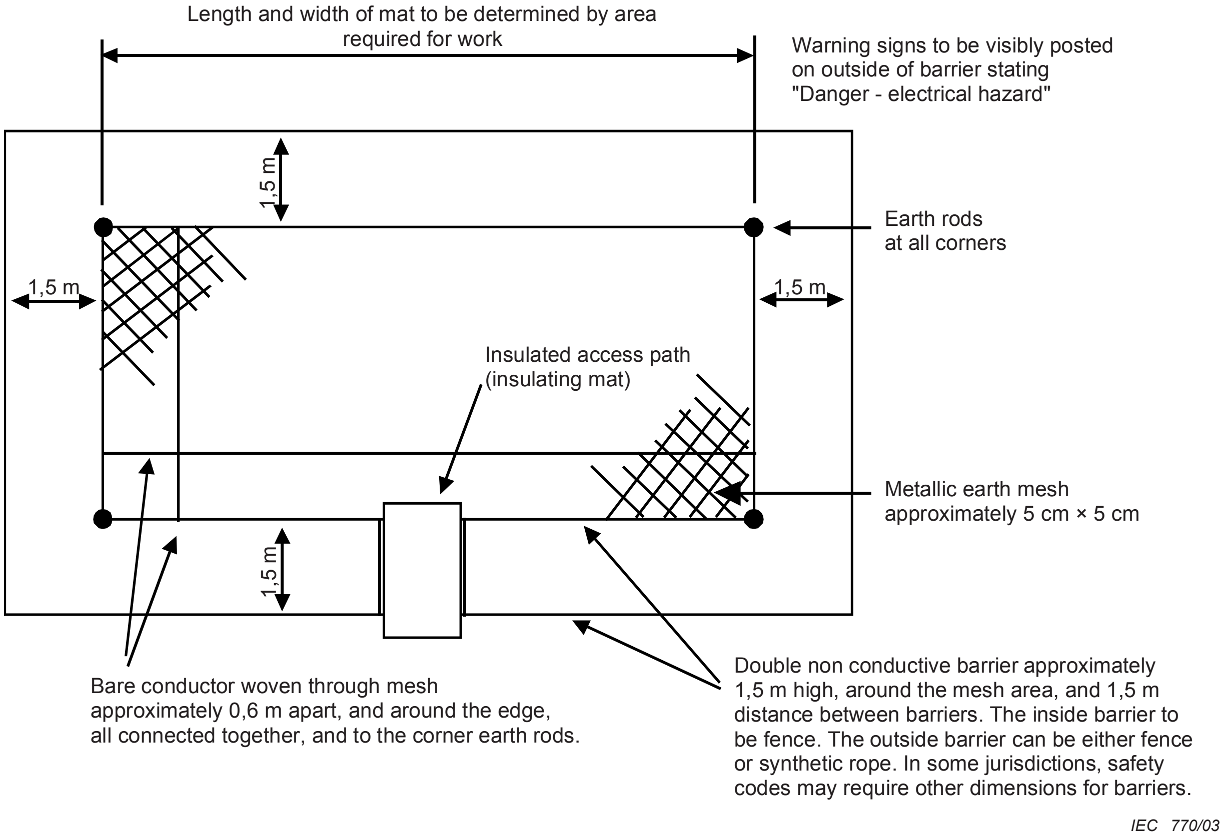


Figure 7f – Earthing system for stringing block earths – Type F



NOTE The work area shall be within the inner barrier, which shall contain all equipment, anchors and earths.

Figure 7g – Typical earth mat – Type G

Figure 7 – Earthing systems

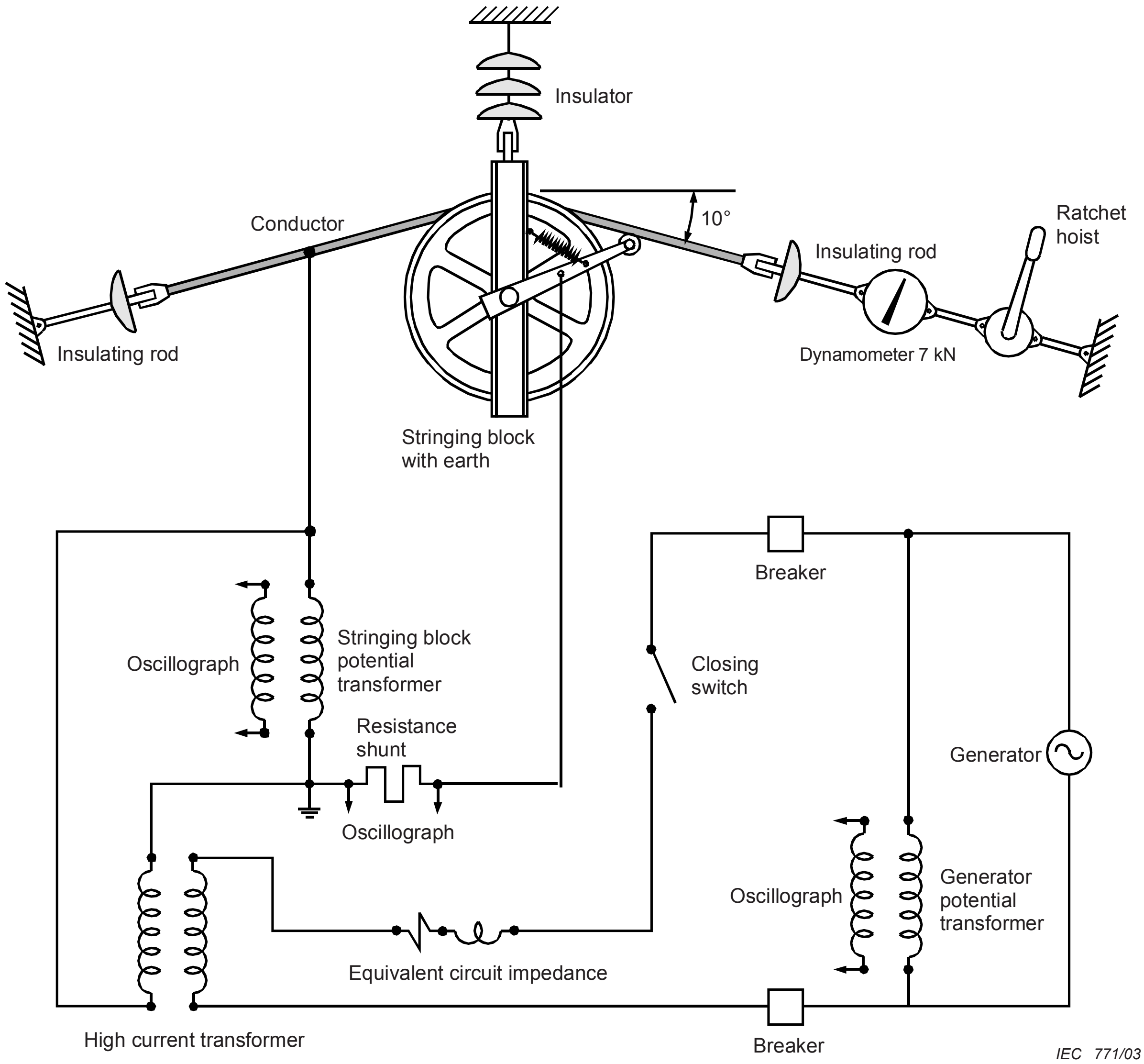


Figure 8 – Typical test set-up for stringing block earth

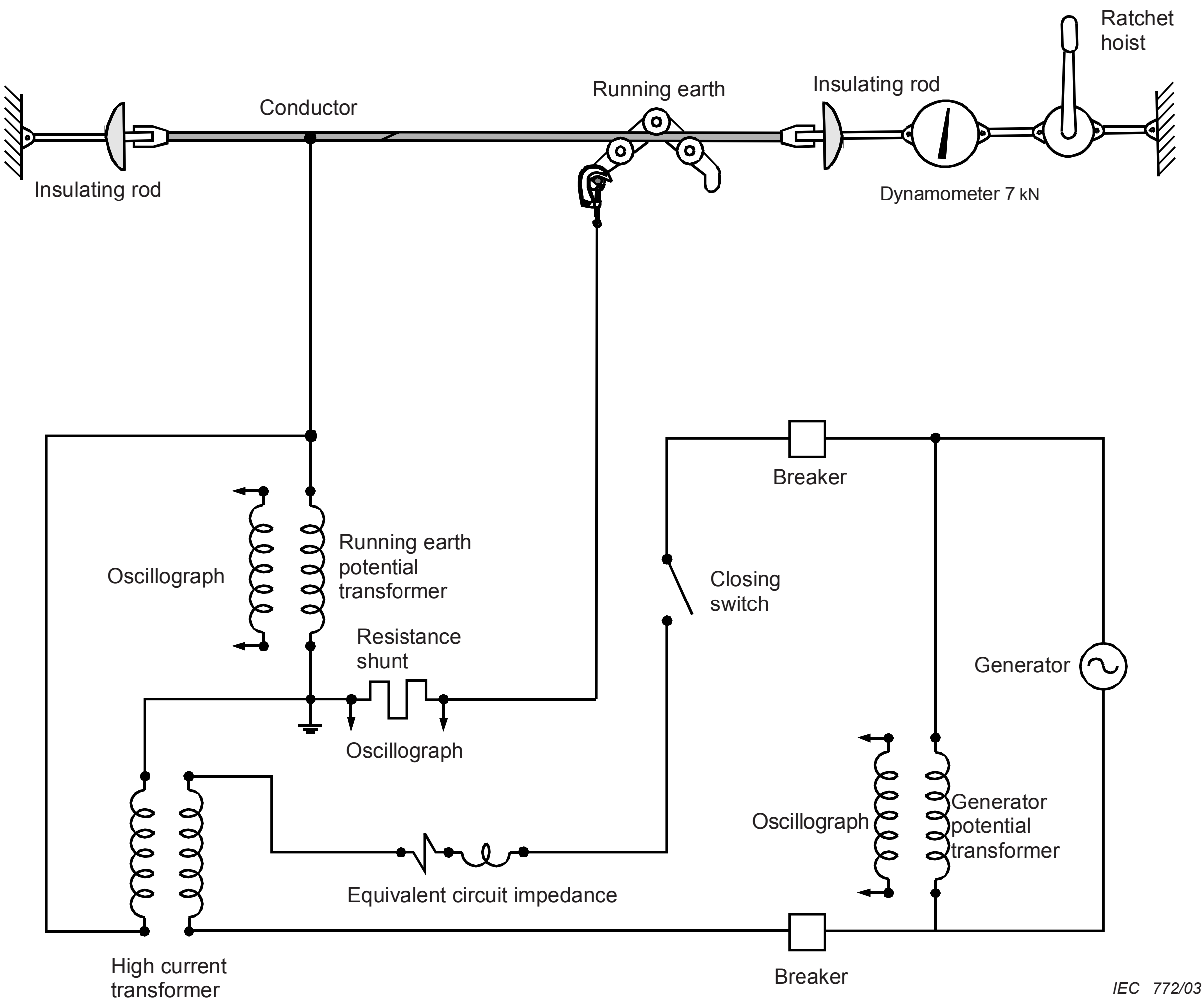


Figure 9 – Typical test set-up for running earth

Annex A
(normative)

Choosing the size of earths, earth cables and bonds

The size of earth cables, earth clamps, earthing lugs and earth attachment points for bonding and earthing shall be adequate for the maximum steady-state induced currents, as well as the largest fault currents to which they are likely to be exposed. See also IEC 61230.

The three categories of possible current exposure are as follows:

– lightning current;
– fault current;
– induced current.

Where a fault current is a possibility, the earthing equipment shall carry that current long enough to allow the line protection system to operate. After the earthing equipment has carried a fault current, all components of the earthing system so exposed shall be immediately replaced.

All components of the earthing system shall be sized to carry a current of 20 000 A symmetrical for 20 cycles and still continue to pass the steady-state current induced without interruption. This will protect against most instances of the above possibilities of current exposure. However, the possibility of a larger fault current occurring deserves special attention.

When the possibility exists of the conductor coming into contact with an existing live conductor during the new conductor installation process, the earthing system shall be capable of carrying the maximum expected phase-to-earth or phase-to-phase fault current which the live circuit may deliver.

Such possibilities of contact occur when the new distribution line passes over an existing transmission or distribution line, and it is not feasible to de-energize the circuit.

NOTE 1 In cases of severe or maximum induction, the above current-carrying capability may not be adequate, and the magnitude of the induced current should be determined by measurement or calculation, and appropriately sized earthing and bonding cables selected.

NOTE 2 In cases where accidental contact could occur with an existing energized circuit, the potential fault current should be checked to ensure it is less than the acceptance test ratings of running earths and stringing block earths given above. If not, special running earths and stringing block earths may be required.

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