Portable Earthing Of High Voltage Conductors

CONTROLLED DOCUMENT

Summary

This work instruction supports the Power System Safety Rules and its requirements assembled under:

- Making High Voltage Apparatus Safe for Work – Category 5.5; and
- Making Overhead Lines Safe for Work – Categories 6.4 & 6.5

It describes equipment which has been approved for portable earthing of high voltage electrical conductors and the manner in which this equipment shall be used. This work instruction also includes methods for checking equipment along with inspection and maintenance requirements.

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Contents

1. Overview

This work instruction supports the Power System Safety Rules and its requirements assembled under

- Making High Voltage Apparatus Safe for Work – Category 5.5; and
- Making Overhead Lines Safe for Work – Categories 6.4, 6.5.

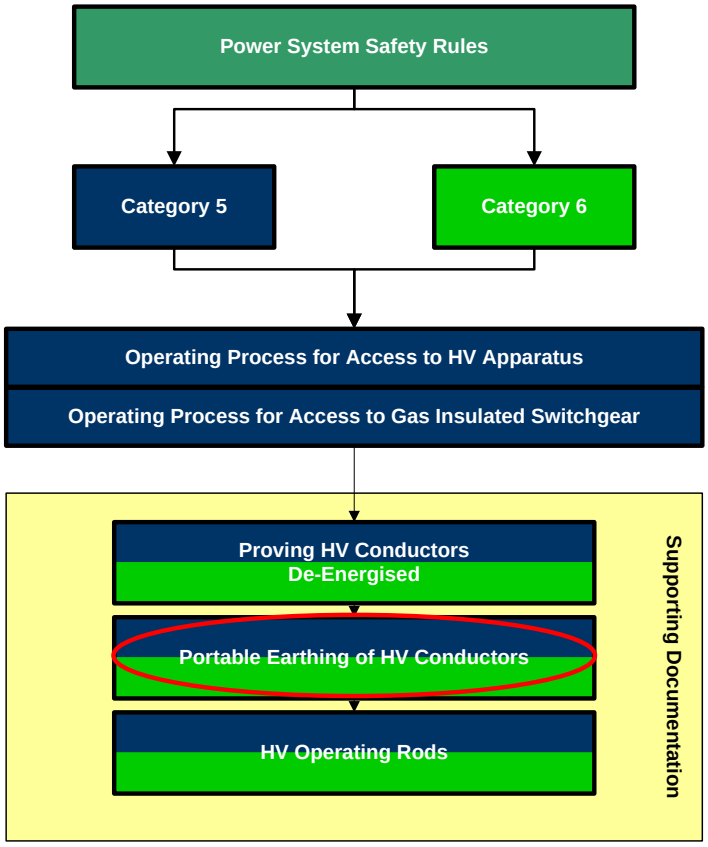
1.1. Scope

This work instruction describes equipment which has been approved for portable earthing of high voltage electrical conductors and the manner in which this equipment shall be used. This work instruction also includes methods for checking equipment along with inspection and maintenance requirements.

This work instruction does not deal with equipment permanently installed for the purpose of earthing; e.g. substation earth switches. These switches are manufacturer and equipment specific, with their own operational methods and parameters, and are outside the scope of this work instruction.

1.2. Document Location

The following diagram describes the relationship between this and other relevant PSSR procedures and work instructions.

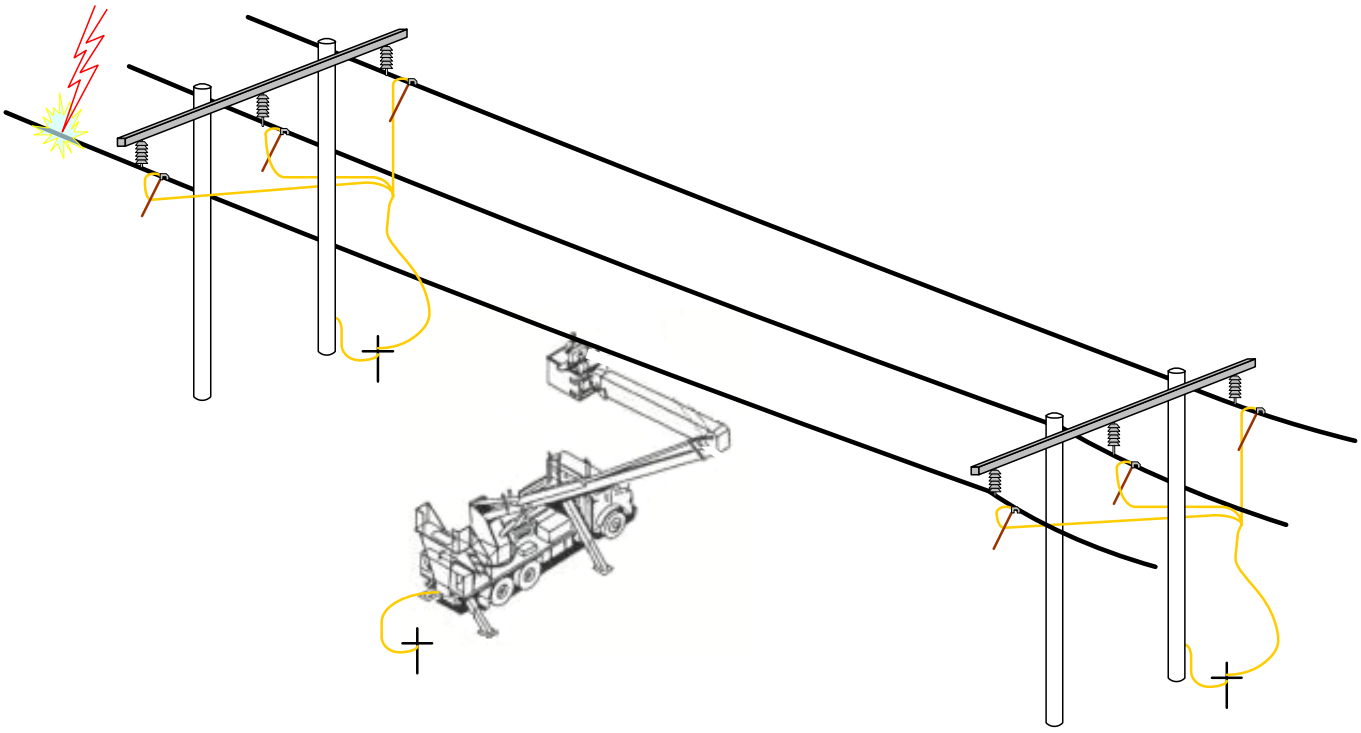


2. Introduction

Prior to the issue of an Access Authority, appropriate earths must be applied to High Voltage Equipment. These are referred to as Access Authority earths under the Power System Safety Rules. Where fixed earthing switches are either not available or not suitable for the planned work, portable earths may be used. Such portable earths can be applied to:

- transmission lines;
- substation apparatus;
- switchboards; and
- cables.

The objective of earthing equipment is to provide a pathway for unanticipated electrical current to flow safely to earth, the current flowing through the earth causes protection systems to operate, tripping circuit breakers and so removing the source of supply. Earthing is also used to manage induced voltages and currents.



The earthing equipment described in this work instruction has been designed and tested for use with standard Transgrid conductors and fittings such as stirrups, stubs etc.

3. Use of Earthing Equipment

The application of earthing on high voltage conductors is controlled in accordance with the provisions of the Power System Safety Rules.

The following general requirements and principles are applicable for portable earthing.

3.1. Safety

Handling earthing equipment in substations or near transmission lines:

- Always carry earthing equipment below shoulder level;
- Ensure that clamps and leads are kept a safe distance from any high voltage conductor;
- Assemble and inspect earthing equipment on the ground; and
- Extend or otherwise prepare any earthing equipment such as shot gun sticks on the ground.

3.1.1. Prove de-energised

Refer “Proving High Voltage Conductors De-Energised”.

3.1.2. Applying Portable Earths

Do not allow any part of the earthing system to encroach on the Safe Approach Distances of apparatus which has not been proven de-energised.

- Where practicable, keep the earthing leads away from the body;
- Apply clamps to stirrup (if provided) or a horizontal conductor where possible;
- Avoid clamp application to bushing caps and to braids; and
- Position clamp so that tension on the earth lead is minimised.

3.1.3. Removing Portable Earths

Earthing equipment is to be removed carefully from high voltage conductors to prevent the equipment encroaching on or coming into contact with adjacent live high voltage conductors.

3.1.4. Discharging HV Equipment

In cases where a circuit could potentially discharge through the earthing system, sufficient time must be allowed between the de-energising of the conductors and the application of the earthing system to permit any residual charge to be dissipated.

3.1.5. Equipment that Experiences a Fault

Any portable earthing equipment that experiences a fault or over current shall be withdrawn from service immediately.

3.2. Application Accessories

Earthing shall be installed using approved applicators suitable for the task.

3.3. Rating

Check that the rating of the earthing equipment is appropriate for the fault level at the location at which it is to be applied.

The equipment used for earthing shall have a fault withstand rating greater than that of the location in which it is used. Information about the expected fault currents and back-up protection times at particular locations is available from Network Operations staff.

Where the fault rating of the location exceeds that of the equipment, multiple sets may be used to increase the rating of the earthing system:

- In switchyards this information will be included on the High Voltage Preparation and Restoration Instruction (HVPRI);
- On transmission lines where the fault rating of the line exceeds the fault rating of the earthing set, multiple sets of MT 815S clamps and associated earth end clamps may be used.

3.4. Equipment and Connections

Check that the earthing system is complete, i.e. that all components are present. Check that all bolted connections are tight and that any electrical connection is positive and mechanically sound.

Ensure that leads are sufficiently long for the proposed task.

3.4.1. Inspect for Damage

Ensure that the earthing equipment is in a serviceable condition. Any portable earthing equipment found to be defective shall be removed from service for repair or disposal.

3.4.2. Connection of portable earths

Connection at the earth end point shall be performed prior to any connection to a conductor.

3.4.3. Disconnection of portable earths

Portable earths shall be disconnected from all conductors prior to being disconnected from the earth end point.

3.5. Use of the MT-815S Clamp

The MT 815S clamp is applied to and removed from conductors using a 'shotgun' application stick of appropriate length. Once the clamp is placed onto the apparatus to be earthed, the shotgun stick is removed.

3.6. Use of the MT-815E Clamp

The MT 815E clamp is applied to and removed from conductors using the attached CATU CM-4130-E application stick.

3.7. Use of the MT-701 clamp

The MT-701 clamp is a V-shaped cast aluminium earth clamp that maintains contact with the conductor via a spring loaded jaw that is pre-set by a latching mechanism. The clamp is 'snapped' onto the conductor by a quick pulling action that triggers the jaw mechanism. The clamp is designed to be applied to and removed from conductors using haulage and release cords.

3.7.1. Arming the MT-701 clamp

Lay the clamp on the ground so that the tail of the tongue points vertically upwards. Holding the earth lead in one hand to stabilise the clamp, use the heel of your shoe to compress the tongue down against the body of the clamp until it latches. Ensure that the clamp is securely latched before handling.

3.7.2. Applying the MT-701:

- Pass the haulage cord over the conductor or through the stirrup by the using a sandbag;
- Arm the clamp;
- Hoist the clamp to the conductor using the haulage cord; then
- Latch the clamp to the conductor with a quick pull on the cord.

3.7.3. Removing the MT-701:

- Take the weight of the clamp and lead on the haulage cord;
- Pull the release cord until the clamp releases from the conductor;
- Lower the clamp and lead/s on the haulage cord; and
- Pull the haulage cord over the conductor or through the stirrup.

3.8. Application of Earth Systems from Elevating Work Platforms

3.8.1. General Principles

Application of portable earthing equipment, both in substations and on transmission lines, can involve hazards from manual handling and working at heights, as well as those associated with high voltage apparatus. In some situations manual handling and working at heights hazards may be reduced by using elevating work platforms (EWPs) during the earthing process.

The term EWP, used hereafter, includes scissor lifts, boom lifts, man-boxes suspended from cranes and other height access equipment used in accordance with Transgrid procedure 'Managing the Risk of Falls'.

3.8.2. Earth Systems to be Used

Any approved earth system may be applied from an EWP, provided that the general application principles of section 3.1, 3.9 or 3.10 and the requirements of this section are complied with.

3.8.3. Approach Distances to Unearthed HV Conductors

The process of applying a portable earth to a HV conductor requires that a conductive object be brought into contact with that conductor after it has been proven de-energised using approved procedures. Transgrid's Safety Rules 5.5.1 (c) and 6.5.1 (c) make provision for this, in that carrying out electrical operating work in accordance with approved procedures is not regarded as work on or near HV exposed conductors and Safe Approach Distances are not required to be maintained.

After being proven de-energised the conductors to be earthed may still be subject to significant induced or transferred voltages. Therefore during the earthing process for 220kV, 330kV and 500kV conductors *Note 1* no part of the authorised person's body or uninsulated parts of the EWP shall approach closer than 2,000mm to the unearthed HV conductors, provided that the EWP is operated from the platform *Note 2*.

Note 1: For voltages lower than 220kV Transgrid's Safe Approach Distances (Mobile Plant +) shall apply.

Note 2: Due to the greater potential for inadvertent movement when EWP's are operated from the ground or when using man boxes, the minimum approach distance in these circumstances shall be increased to 2,500mm. Once each phase conductor is earthed, the EWP and the authorised person may approach closer to that phase but may not contact it until an Access Authority is issued for those conductors.

At all times the relevant Safe Approach Distance must be maintained to any other HV conductors in the vicinity of the earthing process (e.g. adjacent bays in substations or the other circuit on a double circuit transmission line).

3.8.4. Process for Earthing from Elevated Work Platforms

The process for earthing from an EWP shall comply with the general principles in section 3.1 and the relevant specific procedures in sections 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.9 or 3.10.

1. Inspect the earthing equipment for damage and serviceability and check all bolted connections.
2. For pole structures, drive an earth stake and connect it to the structure earth system.
3. Connect the EWP to the structure earth system using approved earthing leads, approved applicators, PPE and clamps.
4. Prove each phase de-energised, maintaining the relevant Safe Approach Distance for mobile plant to all exposed HV conductors.
5. Attach the earthing clamp(s) to the structure earth point or earth before applying the earth to the phase conductors.
6. Apply the earth clamp to each phase conductor in an unhesitating manner. During the process, approach distance shall be maintained as follows;
    a. 2,000mm or 2,500mm (see 3.8.3) to all unearthed conductors of the circuit being earthed
    b. and the Safe Approach Distance for mobile plant to any exposed HV conductors of other circuits, and
    c. avoid contact with earthed conductors of the circuit being earthed.

When removing earths, they should be removed in an unhesitating manner. A clearance of 2,000mm or 2,500mm (see 3.8.3) shall be maintained to each conductor once its earth has been removed.

3.9. Application of Portable Earthing in Switchyards

3.9.1. Connection to Earth End Point

Earthing stubs shall be used for all earth end connections within Switchyards and these are generally installed on structures in the area where it is normally necessary to apply portable earths. It is important to ensure that the stub is not corroded and that it is securely mounted on the structure. Only use the CATU MT-815S clamps with earth stubs.

At the earth end, the MT-815S clamp can be applied with a shotgun stick or the MT-815S application handle.

3.9.2. Use of the MT 815S Clamp in Switchyards

Refer Use of the MT-815S Clamp.

3.9.3. Use of the MT-701 Snap Action Clamp in Switchyards

Refer Use of the MT-701 clamp.

3.9.4. Use of the Wooden Rod Clamp in Switchyards

This clamp is applied to and removed from conductors using the permanently attached wooden rod.

3.10. Application of Portable Earthing on Overhead Transmission Lines

3.10.1. Connection to Earth End Point on Steel Tower Overhead Lines

For steel tower earthing systems, the tower itself is used as the earth point. CATU MT-847 surface penetrating clamps shall be used on painted or galvanised surfaces. When applying earth end clamps to a steel tower the clamps should be attached to a flat part of the tower structure and screwed up as tightly as practicable by hand.

3.10.2. Connection to Earth End Point on Wood or Concrete Pole Overhead Lines

Pole earthing systems involve the use of both the pole earth and an independent temporary earth electrode (earth stake). The earth stake is to be positioned approximately 1.3m from the pole and driven 600mm into the ground then bonded to the pole earth using a standard portable earth lead with either MT-815S clamps applied with a shotgun stick or MT-815S application handle.

3.10.3. Use of the MT-815S Clamp on Overhead Lines

Refer Use of the MT-815S Clamp.

3.10.4. Use of the Wooden Rod Clamp on Overhead Lines

This clamp is applied to and removed from conductors using the permanently attached wooden rod.

3.10.5. Use of the MT-815E Clamp on Overhead Lines

This clamp is applied to and removed from conductors using the permanently attached fibreglass rod.

3.10.6. Use of the MT-701 Snap Action Clamp on Overhead Lines

The haulage cord can be placed directly over the conductors or attached to a sandbag and thrown over. The method used to apply the MT-701 clamp will depend on the position from which the earth is to be applied. When earthing the jumper sections of an overhead line, the clamp may be lowered into place by using the haulage and release cords as guides. The clamp is then activated by 'dropping into place' onto the conductor.

3.11. Application of Portable Earthing on Indoor Switchgear

The information contained in this Section should be read in conjunction with the Section "General Principles for Application".

In general, indoor switchgear is provided with manufacturers specific earthing systems. However, the dedicated earthing system provided maybe inadequate or non-functioning. The application of portable earthing systems in indoor situations is usually limited by physical clearances. The choice of earthing system used will therefore be determined by the geometry of the switchgear involved and the practicality of applying the available earthing equipment within restricted spaces.

Any of the earth systems covered in this work instruction, when used with clamps approved for indoor use, can be implemented in indoor situations. The Bridge Method is commonly used where the fault rating of the indoor switchgear is less than or equal to the 25 *kA 0.5* second rating.

3.11.1. Connection to Earth End Point

Earthing stubs shall be used for all earth end connections and these are generally installed on structures in the area where it is normally necessary to apply portable earths. It is important to ensure that the stub is

not corroded and that it is securely mounted on the structure. Only use the CATU MT-815S clamps with earth stubs.

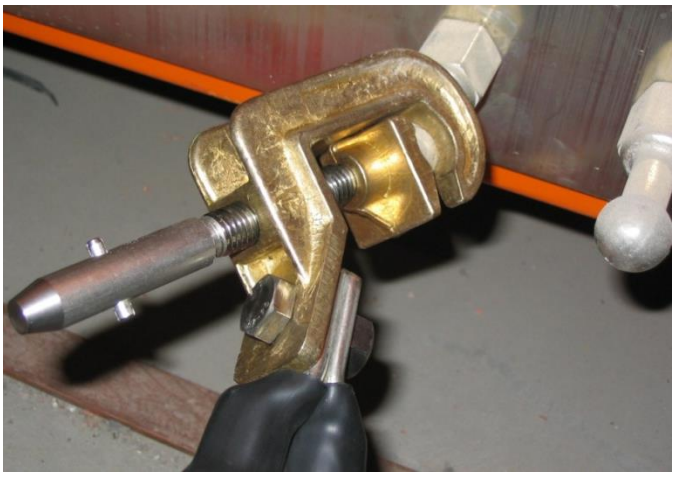
At the earth end, the MT-815S clamp can be applied with a shotgun stick or the MT-815S application handle.

3.11.2. Use of the MT 815S Clamp on Indoor Switchgear

Clamps can be applied to stirrups and conductors. In certain indoor situations, an 'Earth Stub' may have been installed on the bus bar or conductor to enable the application MT-815S clamps. Refer Use of the MT-815S Clamp.

3.11.3. Use of the Pfisterer 360333333 Clamp on Indoor Switchgear

Known as universal angle clamps these are applied to ball stubs using a CM 710 E application handle. Once the clamp is placed onto the apparatus to be earthed, the application handle is removed.



3.12. Portable Earthing Equipment Summary Table

The following table lists approved portable earthing equipment to be used in various earthing situations.

Earthing Situations	Line End			Earth End			Reference
	Connection	Clamp	Application	Connection	Clamp	Application	
Conductors in Substations	Earthing Stirrup	MT815S	Shotgun Stick	Earth Stub	Screw Action Clamp MT815S	MT 815S application handle.	• Application of Portable Earthing in Switchyards
	Earthing Stirrup	Wooden Rod Clamp	Attached wooden rod				
	Conductor	Wooden Rod Clamp	Attached wooden rod				
	Conductor	MT-701	Haulage and Release Cord, Sandbag, HV Operating Rod				
Steel Tower Overhead Lines	Conductor	MT815S	Shotgun Stick	Tower Structure	Surface Penetrating Clamp	By Hand	• Application of Portable Earthing on Overhead Transmission Lines • Connection to Earth End Point on Steel Tower Overhead Lines
	Conductor	MT815E	CATU CM-4130-E application stick				
	Conductor	Wooden Rod Clamp	Attached wooden rod				
	Conductor	MT-701	Haulage and Release Cord, Sandbag, HV Operating Rod				
Wood and Concrete Pole Overhead	Conductor	MT815S	Shotgun Stick	Earth Stake	Screw Action Clamp MT815S	MT 815S application handle.	• Application of Portable Earthing on Overhead Transmission Lines • Connection to Earth End Point on Wood or
	Conductor	MT815E	CATU CM-4130-E application stick				

Lines	Conductor	Wooden Rod Clamp	Attached wooden rod				Concrete Pole Overhead Lines
	Conductor	MT-701	Haulage and Release Cord, Sandbag, HV Operating Rod				
Indoor Switchgear	Conductor	MT815S	Shotgun Stick	Earth Stub	Screw Action Clamp MT815S	MT 815S application handle.	• Application of Portable Earthing on Indoor Switchgear
	Ball point	Universal Angle Clamps	CM710E application stick				
Mobile Plant	Earth Stub on mobile plant chassis	MT815S	MT 815S application handle – See Attachment 2	Earth Stub	Screw Action Clamp MT815S	MT 815S application handle.	• Mobile Plant in the Vicinity of High Voltage Conductors
	Mobile Plant chassis or boom	Surface Penetrating Clamp	By Hand – See Attachment 2	Earth Stub	Screw Action Clamp MT815S	MT 815S application handle.	
				Tower Structure	Surface Penetrating Clamp	By Hand	
				Earth Stake	Screw Action Clamp MT815S	MT 815S application handle.	

4. Earthing Systems, Equipment and Maintenance

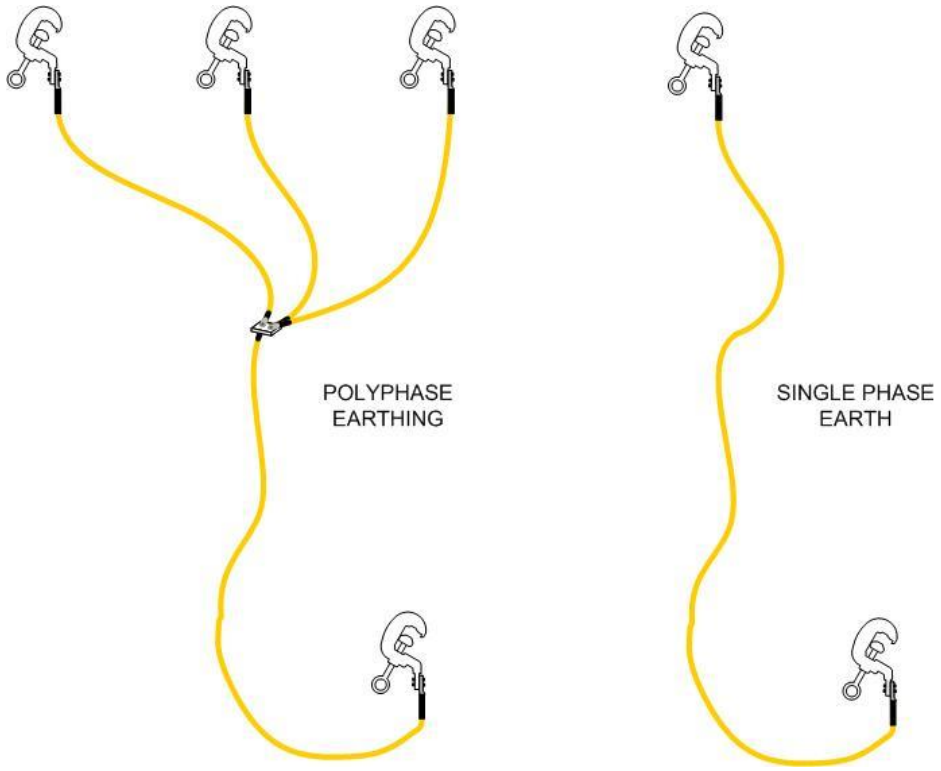
Only the approved earthing equipment and accessories described in this work instruction shall be used for the portable earthing of high voltage electrical equipment.

4.1. Earthing Systems

An earthing system is a recognised set of components to perform the function of earthing. The components are assembled into either polyphase earthing systems (usually three phase) or single phase earthing systems.

An earthing system comprises of:

- Line end clamp or clamps;
- earthing leads;
- earth end clamp or clamps;
- possibly a short circuiting point (trifurcating plate);
- connecting hardware; and
- an applicator.

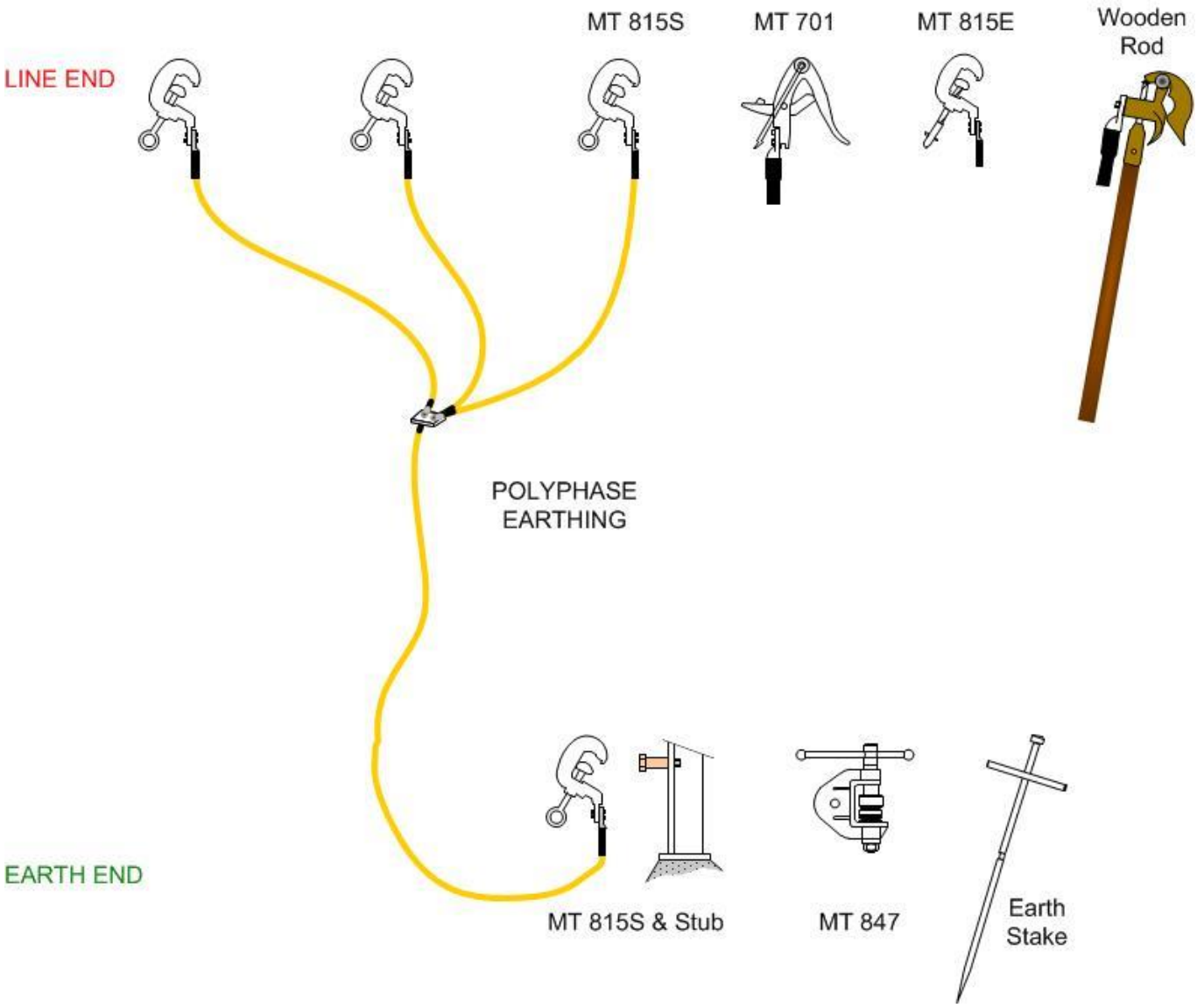


Typical Polyphase and Single Phase Earth Systems

Note: Three phase earth systems shall be used when earthing conductors. It is not acceptable to earth only the phase/s on which work is being performed.

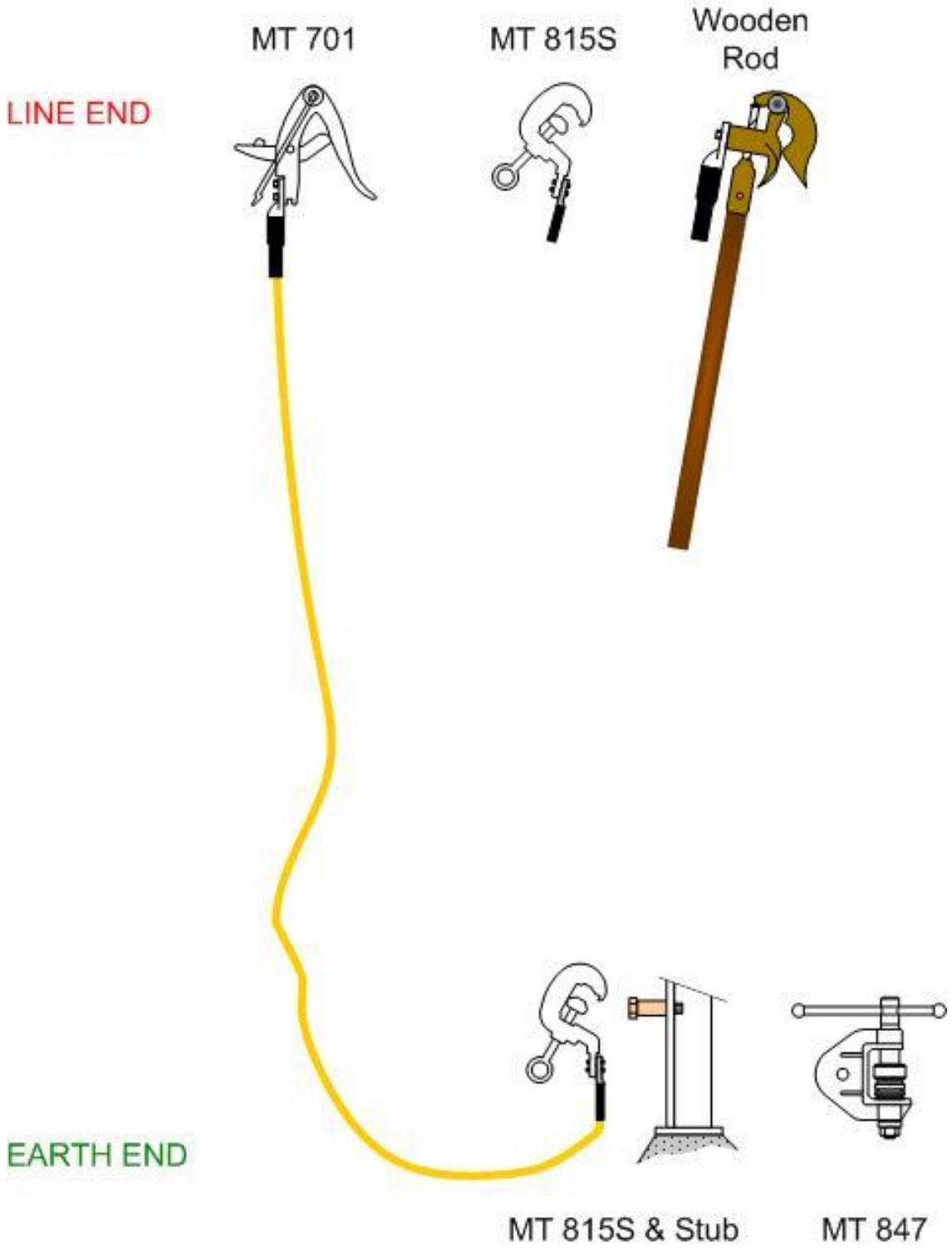
The following earthing systems are approved for use on Transgrid's Power System.

4.1.1. Trifurcated Earth System



Approved Rating 25 kA/0.5 seconds

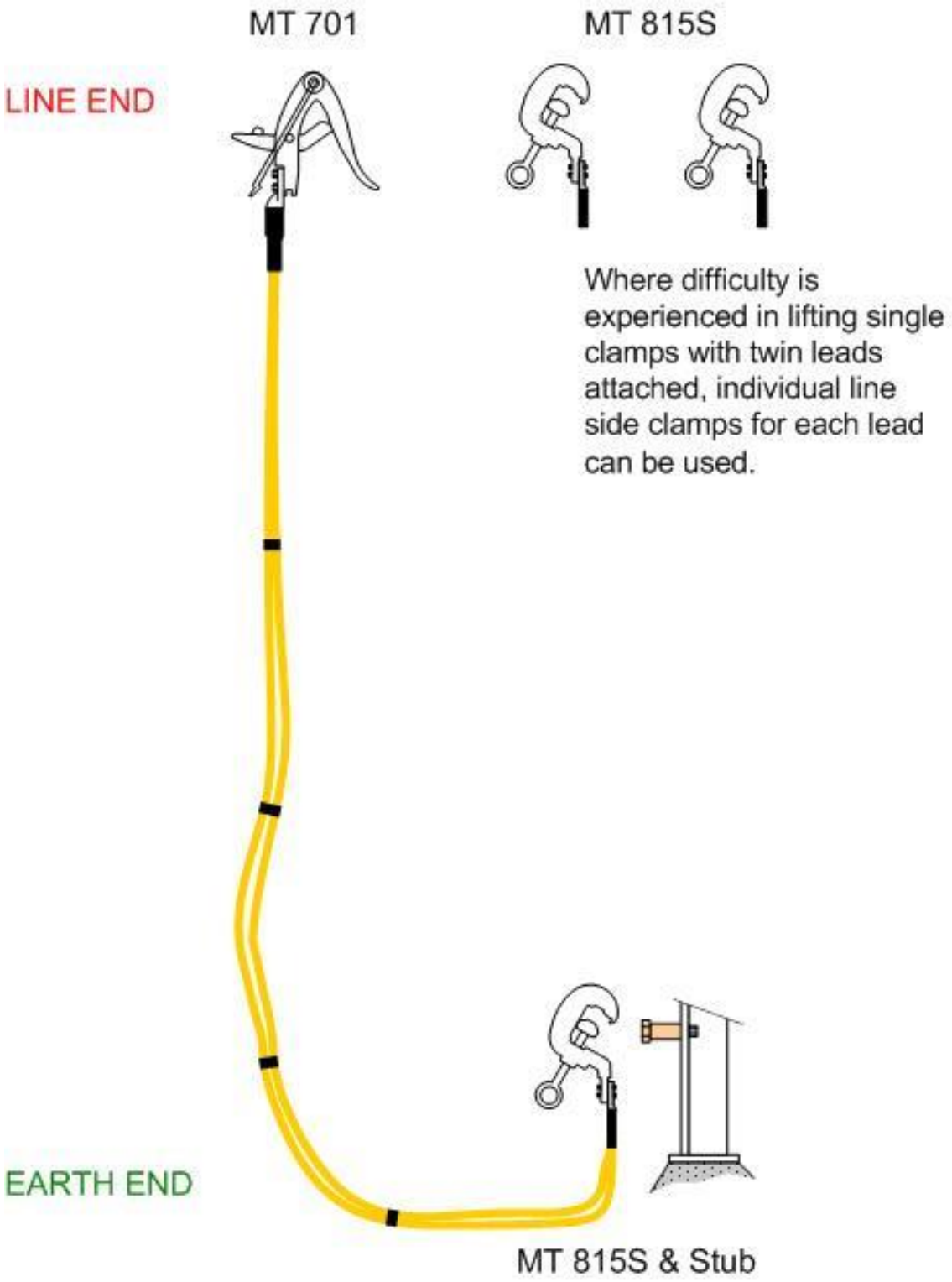
4.1.2. Single Phase, Single Lead Earth System



Approved Rating 25 kA/0.5 seconds

Note: Three Single Phase leads as described above shall be used to earth all three phases.

4.1.3. Single Phase, Twin Lead Earth System



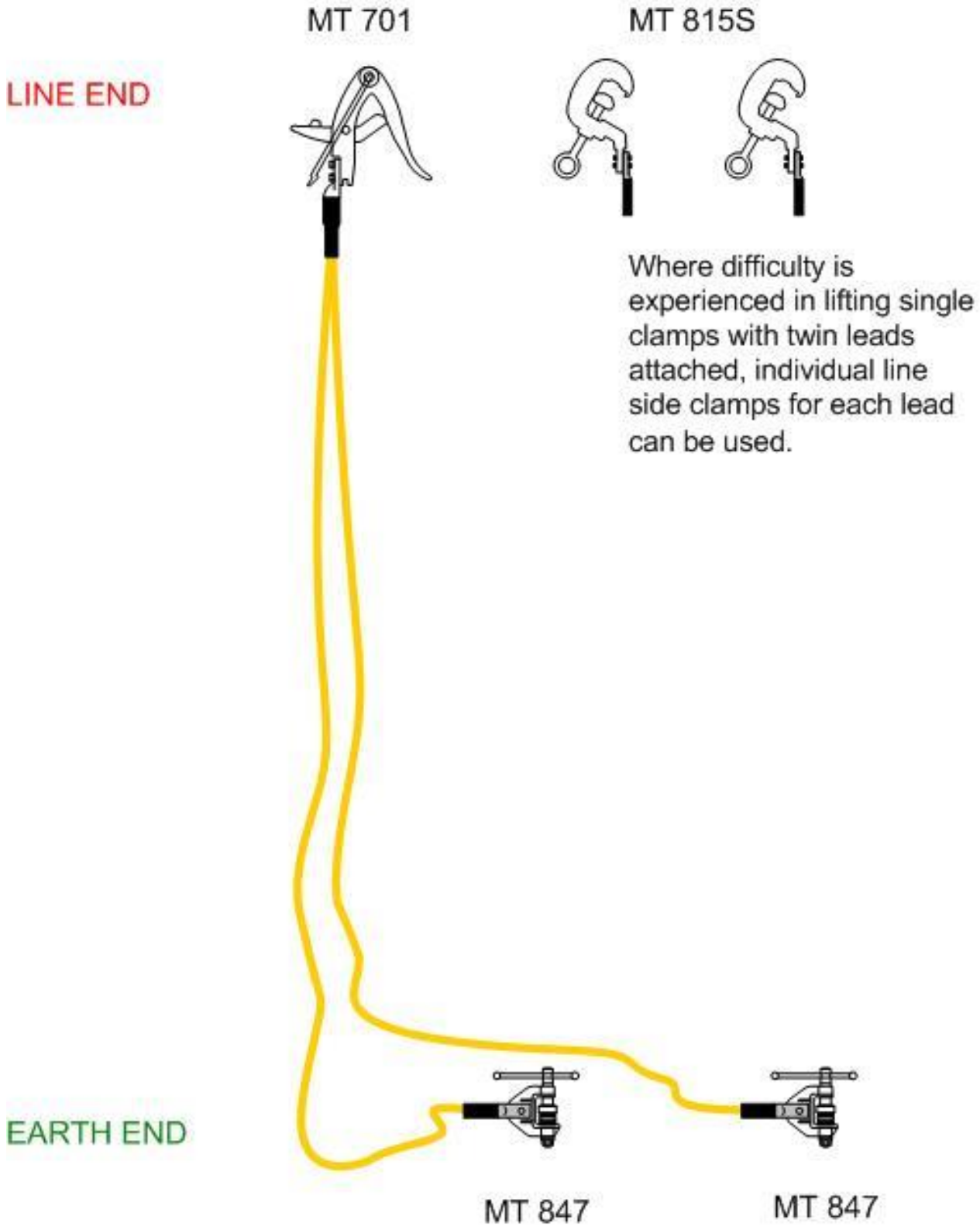
proved Rating

40 kA/0.5 seconds

Approved Rating 40 kA/0.5 seconds

Note: Three single phase leads as described above shall be used to earth all three phases.

4.1.4. Single Phase, Twin Lead, Twin Clamp Earth System

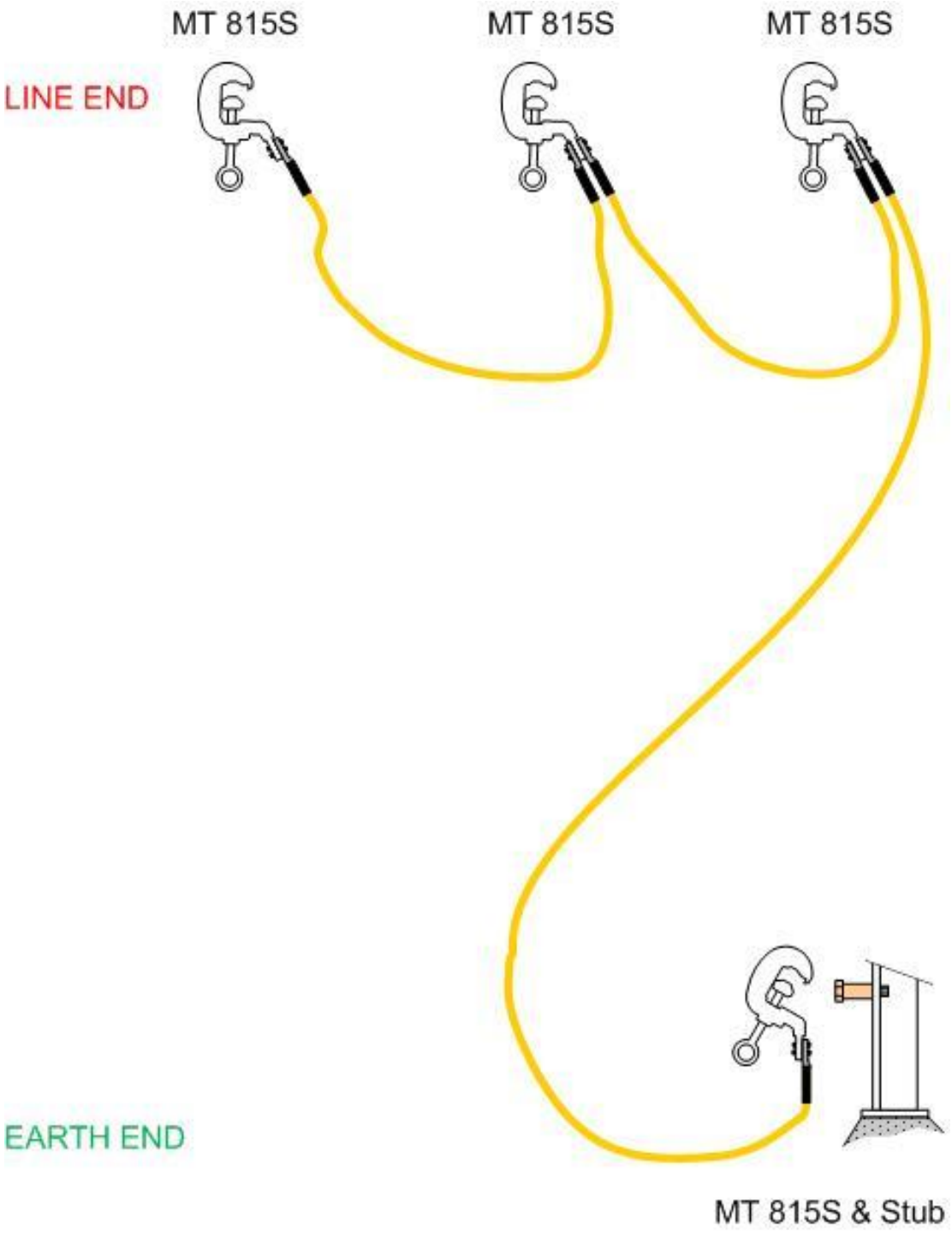


Approved Rating 40 kA/0.5 seconds

Three single phase leads as described above shall be used to earth all three phases.

4.1.5. Bridge Method

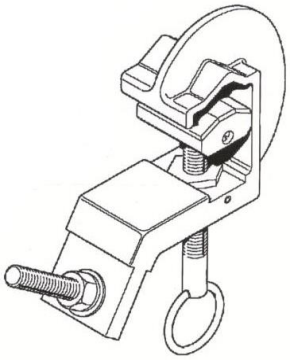
This method is only applicable if the fault rating of the switch gear is less than or equal to 25 *kA 0.5* second rating. This method uses the earthing leads and one phase of the apparatus to be earthed as the short circuit point as shown below.



4.2. Earthing Equipment

The portable earthing equipment detailed in this section is approved for use on Transgrid's Power System.

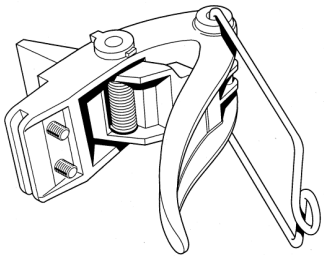
Screw Action Clamp – MT815S	
Approved Rating	40 kA/0.5 seconds
Use	Line or Earth end connections for Earthing, Bonding and Bridging
Limitations of Use	Round Conductor up to 44mm in diameter, Flat Conductor from 3mm to 40mm in thickness
Drawing Number	STD-647175
Stockcode	3180437
Associated Equipment	Shotgun Stick or Hand Application Tool



Screw Action Clamp – MT815E	
Approved Rating	25 kA/0.5 seconds
Use	Line end connections for transmission line earthing
Limitations of Use	Round Conductor up to 44mm in diameter
Drawing Number	-
Stockcode	
Associated Equipment	CATU CM-4130-E application stick

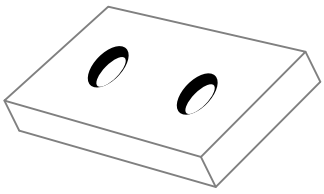
Universal Angle Clamp – Pfisterer 360 333 333	
Approved Rating	40 kA/0.5 seconds
Use	Line end connections for Indoor Earthing
Limitations of Use	Haymarket 11kV
Drawing Number	-
Stockcode	Not stocked
Associated Equipment	CM 710 E application stick

Snap Action Line Clamp - MT-701	
Approved Rating	40 kA/0.5 seconds
Use	Line end earthing connections only
Limitations of Use	Round Conductors 20 to 40 mm diameter
Drawing Number	STD-197006
Stockcode	986968 ea 986901 complete set with single leads 986893 complete set with twin leads
Associated Equipment	Haulage and Release Cord

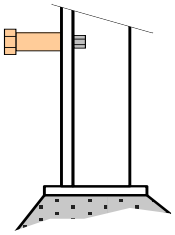


Surface Penetrating Clamp – MT847	
Approved Rating	25 kA/0.5 seconds
Use	Earth end earthing connections on painted or galvanised steel and Mobile Plant
Limitations of Use	Maximum parallel flat plate 5 to 30 mm thick
Drawing Number	STD-647162
Stockcode	3512027
Associated Equipment	Nil

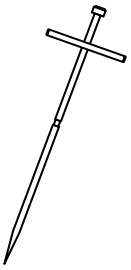
Trifurcating Plate	
Approved Rating	25 kA/0.5 seconds
Use	Polyphase earthing systems
Limitations of Use	-
Drawing Number	STD-647176
Stockcode	986844
Associated Equipment	Nil



Earth Stub	
Approved Rating	40 kA/0.5 seconds
Use	Structure earth point
Limitations of Use	Used only with MT815S clamp
Drawing Number	STD-647067
Stockcode	3512472
Associated Equipment	MT815S clamp



Independent temporary earth electrode (Earth Stake)	
Approved Rating	40 kA/0.5 seconds
Use	Earth end earthing connection point (Field)
Limitations of Use	Used only with MT815S clamp
Drawing Number	STD-647252
Stockcode	3512464
Associated Equipment	MT815S clamp



Wooden Earth Rod and Clamp	
Approved Rating	25 kA/0.5 seconds – Single Lead
Use	Any Earthing, Bridging or Bonding situations
Limitations of Use	Round Conductor up to 40 mm in diameter
Stockcode	No longer stocked

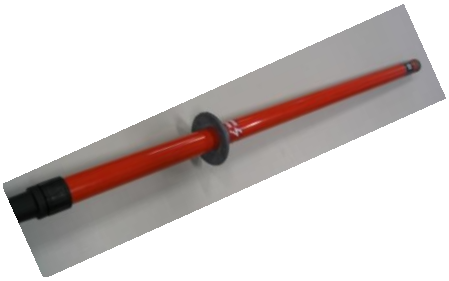
Portable Earth Lead – 125mm2 - 130mm2	
Approved Rating	25 kA/0.5 seconds – Single Lead 40 kA/0.5 seconds – Twin Leads
Use	Any Earthing, Bridging or Bonding situations
Limitations of Use	Where fault rating is exceeded, twin leads or multiple sets are to be used.
Stockcode	1m 003591849 7m 000986810 9m 000986885 19m 000986828
Associated Equipment	All Clamps

Notes	Either size of lead is acceptable for the fault ratings indicated above. The continuous current rating of both lead types is 300 Amps. Portable earthing leads shall be yellow in colour.

Haulage and Release Cord	
Approved Rating	N/A
Use	Application accessory
Limitations of Use	With Snap Action Line Clamp
Drawing Number	STD-647195
Stockcode	987321 (18m) 3592383 (9m)
Associated Equipment	Snap Action Line Clamp - MT-701

Application Handle	
Approved Rating	Not applicable
Use	Any Earthing, Bridging or Bonding situations
Limitations of Use	Must be used only with MT815S clamp
Stockcode	3512449
Associated Equipment	MT815S Clamp

CM 710 E Application Handle	
Approved Rating	Not applicable
Use	Haymarket 11kV Indoor
Limitations of Use	Must be used only with Pfisterer 360 333 333
Stockcode	Not stocked
Associated Equipment	Pfisterer 360 333 333 clamp

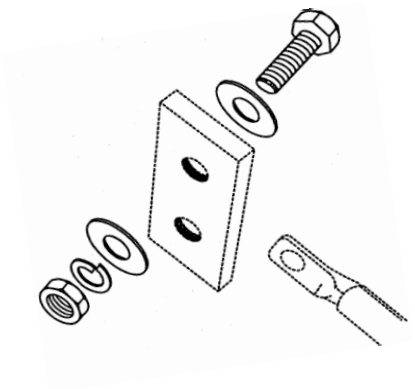


CM 4130 E Application Handle		
Approved Rating	Not applicable	
Use	Line end connections for transmission line earthing	
Limitations of Use	Must be used only with MT815E clamps	
Stockcode		
Associated Equipment	MT815E clamps	

Shotgun Stick		
Approved Rating	Not applicable	
Use	Any Earthing, Bridging or Bonding situations	
Limitations of Use	Must be used only with MT815S clamp	
Associated Equipment	MT815S clamp	
Stockcode	3512498	

4.2.1. Assembly Hardware for Earth Systems

When connecting components, use only stainless steel connecting hardware in the following order:



- Stainless steel (SS) set screw;
- flat washer;
- items to be connected (e.g. lug to trifurcating plate); then
- SS flat Washer;
- SS spring washer; and
- SS nut.

When assembling the hardware, the contact areas of the lugs, clamps and trifurcating plate shall be scratch brushed and coated with Penetrox ' A ' or Alminox Jointing Compound prior to connection of the earth leads. The bolts or screws shall be tightened to a torque of 60 Nm and any excess compound wiped off.

4.2.2. Traceability

A register of all portable earthing equipment shall be maintained by their relevant custodians. The register shall contain the equipment type, location, unique identification number and date when the earthing device was last maintained and tested.

Each component shall have a unique identifier that is not to be re-used even if the component is subsequently withdrawn from service. Marking shall be permanent, indelible and not interfere with the functionality or integrity of the component. As leads used for portable earthing, bridging and bonding may have different fault ratings, fault rating identification, current and duration, is to be included on leads.

4.2.3. Storage

All portable earthing equipment should be stored so the effects of weathering are minimised. Earth leads, with clamps permanently connected shall be rolled up, taped and stored in cubicles or indoors.

Application handles such as shotgun sticks are to be stored indoors or within vehicles.

4.2.4. Disposal

Earthing equipment that has become unsalvageable can be disposed of by returning to Store as scrap.

4.3. Maintenance

4.3.1. Responsibilities

Periodic testing, maintenance and inspection of portable earthing equipment is the responsibility of the relevant equipment custodian.

4.3.2. Periodic Maintenance and Testing

All portable earthing equipment shall be inspected and tested every three years for damage, condition and electrical conductivity. Equipment that fails inspection or test shall be removed from service for repair or disposal. Repaired equipment shall only be returned to service after passing inspection and any specified test.

Refer also to the ‘Inspection, Test, Licencing and Competency Procedure’

4.3.3. Guidelines for Inspection and Maintenance

The following table provides guidelines for the physical inspection, testing and maintenance of earthing equipment.

Equipment	Physical inspections	Measurements	Maintenance
Aluminium Earthing Leads	Cable sheath is intact with no score marks, cuts or tears along its length; Heat shrink is sound in its sealing of both the lug and the cable; and Check lugs for elongation of hole, corrosion, pitting or flaking of the contact surfaces.	Voltage drop per attachment 1	• Tears in the sheath where conductor strands are not damaged may be repaired with heat-shrink tubing in conjunction with a sealant. • Problems with the lugs or terminations are to be repaired by re-terminating the lead.
Clamps	Clamp body is intact with no signs of mechanical damage or corrosion; and Moving parts operate freely and free of corrosion, shafts not bent, threads in good order, welds or brazing solid.	Nil	• The springs of snap action earthing equipment may require lubrication with grease to prevent corrosion. • Handles or spindles from otherwise damaged clamps may be salvaged and kept for use as spares for repairs to other clamps. Parts from different types of clamps are not be intermixed
Shotgun sticks	Fibre glass body and extension are intact and free from cracks or chips; No evidence of moisture exists with the telescopic section fully extended; All locking devices operate correctly and are not badly scored or gouged; All metal parts for corrosion; Hook mechanism operates freely and locks into position and the release mechanism operates correctly; and Hook is firmly attached to the shaft of the stick and is not damaged or bent	Nil	• Lubricate sectional stick metal locking devices. • Clean fibreglass exterior on all sticks and telescoping sections of telescopic stick. • If parts are damaged then contact the supplier for spares or replace stick. • If fibreglass is damaged superficially, repair with a fibreglass repair kit.
Earth Stub	Ensure stub does not have signs of mechanical wear or	Nil	• Tighten Stub onto copper strap with spanner if

Equipment	Physical inspections	Measurements	Maintenance
	corrosion; and Check tightness of stub onto copper strap.		necessary ensuring mating surfaces are clean and not corroded. • If stub cylindrical surface or electrical contact surface is mildly scored then clean with abrasive paper and/or file as necessary.
Application Handles	Check handle for cracks and degrading of material; and Clamps can be securely held in an inverted position	Nil	• Replace if not satisfactory
Trifurcating Plate	Ensure all surfaces are free from the effects of corrosion or mechanical damage. Check connection holes are clear to accept set screw	Nil	• Replace if not satisfactory
Connecting hardware	Check for damage	Nil	• Replace any item that shows signs of corrosion. • Lubricate as necessary
Haulage & Release Cords	Check outer sheath for damage or ingress of moisture. Sister clip or dog clip connections intact	Nil	• Replace if not satisfactory
Earth Stake	Ensure integrity of stake material and welds	Nil	• Replace if not satisfactory
Wooden Rods	Ensure stick surface is not scored or cracked. Ensure that stick is not chipped or split. Check rivets at head of clamp for tightness. Check thread of screw mechanism for ease of operation. Inspect clamp head for signs of mechanical damage. Check mating surface for pitting or corrosion.	Nil	• If varnish on rod requires work then prepare wooden surface by smoothing with abrasive paper then varnishing with a liberal amount of material. Ensure rod is kept dry throughout operation. • Rivets may be replaced with copper rivets or another suitable substitute, preparing the end of the rod if necessary (including revarnishing). • If a wooden stick is to be replaced, copper rivets or another suitable substitute may be used.

5. Definitions

Some of the terms used in this standard are explained in the Safety Rules or in other standards associated with those Rules.

Terms that are specifically applicable to this standard are explained here with some associated guidance notes.

Term	Definition
Earth Stake	A steel rod driven into the ground to provide an earth point for portable earthing equipment.
Earth Lead	A yellow flexible cable that connects the conductors of equipment required to be earthed through clamps or other means to the general mass of earth.
Bridging	The process of placing a Conductor (or Bridge) across a break in an electrical circuit (HV Conductor, Neutral or Earthing System) in order to maintain electrical continuity.
Fault Current	Abnormally high current that flows due to partial or complete failure of insulation at one or more points.
Earthing System	A group of components that performs a short circuiting or earthing function.
Earthing Equipment	Any piece of equipment used for the purpose of earthing, either individually or combination.
Line End	That part of an earthing set connected to conductors or other apparatus that may be energised.
Earth End	That part of an earthing set connected to the general mass of earth directly, or through an "earthed" piece of equipment e.g. structure or earth grid.
Trifurcating Plate	An aluminium plate used to connect the earthing leads and provides a short circuiting point for the phases.
Screw Action Clamp	A clamp in which the mechanism of attachment to conductors is carried out by a positive acting screw thread.
Snap Action Clamp	A clamp by which attachment to the conductors is carried out by a spring operated mechanism.
Haulage & Release Cord	Associated with snap action clamps, enables the clamp to be hauled up and applied to the conductor to be earthed.

6. Implementation

Training material will be modified to reflect any changes in this work instruction.

An alert will be sent to all staff outlining the change (along with a link to the new work instruction).

Leaders will advise staff and contractors of the changes at meetings and/or toolbox talks.

7. Monitoring and Review

The Power System Safety Rules Manager is responsible for the ongoing monitoring and review of the documents associated with the Power System Safety Rules. This can include but is not limited to:

a. Requesting regular feedback on the effectiveness of procedures and work instructions. Appropriate feedback tools include focus groups and WHS consultative committees.
b. Where a change has occurred in our processes; and
c. Recommendations arising from incidents.

8. Change history

Revision no	Approved by	Amendment
4	Krista-Lee Fogarty, Head of HSE	• Section 3.4.3: Addition of procedure requirements for connection and disconnection of portable earths • Update template to 2021 Transgrid branding version

9. Attachments

Attachment 1 - Appendix A - Earth lead voltage drop tables

Attachment 2 - Appendix B - Applying a trailing earth lead

Appendix A Earth lead voltage drop tables

Maximum Permissible Voltage Drop For Earth Leads

Lead: 125 sq mm - 250 Amps

Lead Length metres	Table of Lead Voltage Drop vs Temperature of Lead in Degrees Celsius			
	10	20	30	40
4	0.247	0.257	0.267	0.277
4.2	0.26	0.27	0.281	0.291
4.4	0.272	0.283	0.294	0.305
4.6	0.284	0.296	0.307	0.319
4.8	0.297	0.309	0.321	0.333
5	0.309	0.322	0.334	0.347
5.2	0.321	0.334	0.347	0.361
5.4	0.334	0.347	0.361	0.374
5.6	0.346	0.36	0.374	0.388
5.8	0.358	0.373	0.388	0.402
6	0.371	0.386	0.401	0.416
6.2	0.383	0.399	0.414	0.43
6.4	0.396	0.412	0.428	0.444
6.6	0.408	0.424	0.441	0.458
6.8	0.42	0.437	0.454	0.471
7	0.433	0.45	0.468	0.485
7.2	0.445	0.463	0.481	0.499
7.4	0.457	0.476	0.494	0.513
7.6	0.47	0.489	0.508	0.527
7.8	0.482	0.502	0.521	0.541
8	0.494	0.515	0.535	0.555
8.2	0.507	0.527	0.548	0.568
8.4	0.519	0.54	0.561	0.582
8.6	0.532	0.553	0.575	0.596
8.8	0.544	0.566	0.588	0.61
9	0.556	0.579	0.601	0.624
9.2	0.569	0.592	0.615	0.638
9.4	0.581	0.605	0.628	0.652
9.6	0.593	0.617	0.641	0.666
9.8	0.606	0.63	0.655	0.679
10	0.618	0.643	0.668	0.693
10.5	0.649	0.675	0.702	0.728
11	0.68	0.707	0.735	0.763
11.5	0.711	0.74	0.768	0.797
12	0.742	0.772	0.802	0.832
12.5	0.773	0.804	0.835	0.867
13	0.803	0.836	0.869	0.901
13.5	0.834	0.868	0.902	0.936
14	0.865	0.9	0.935	0.971
14.5	0.896	0.933	0.969	1.005
15	0.927	0.965	1.002	1.04
16	0.989	1.029	1.069	1.109
17	1.051	1.093	1.136	1.179
18	1.112	1.158	1.203	1.248
19	1.174	1.222	1.27	1.317
20	1.236	1.286	1.336	1.387
25	1.545	1.608	1.671	1.733
30	1.854	1.929	2.005	2.08

Maximum Resistance of Lead at 20 degrees C 0.245 **mohm/m** alpha = 0.0039 for Aluminium
Based on a Full Wave Rectified DC Current of 250 **Amps** Ro 0.245 mOhm @ 20 deg C
These figures include an error of 5 **%**
Equation Used for Calculation of Voltage Drop Variation with Temperature: V = I * Rt * Lead Length * 1.05 (error)
Equation used to Calculate Resistance at temp t Rt = Ro(1 + alpha*td) td = diff in temp from ref

Maximum Permissible Voltage Drop For Earth Leads

Lead: 130 sq mm - 250 Amps

Lead Length metres	Table of Lead Voltage Drop vs Temperature of Lead in Degrees Celsius			
	10	20	30	40
4	0.236	0.246	0.255	0.265
4.2	0.248	0.258	0.268	0.278
4.4	0.26	0.27	0.281	0.291
4.6	0.272	0.283	0.294	0.305
4.8	0.283	0.295	0.306	0.318
5	0.295	0.307	0.319	0.331
5.2	0.307	0.319	0.332	0.344
5.4	0.319	0.332	0.345	0.358
5.6	0.331	0.344	0.357	0.371
5.8	0.342	0.356	0.37	0.384
6	0.354	0.369	0.383	0.397
6.2	0.366	0.381	0.396	0.411
6.4	0.378	0.393	0.408	0.424
6.6	0.39	0.405	0.421	0.437
6.8	0.401	0.418	0.434	0.45
7	0.413	0.43	0.447	0.464
7.2	0.425	0.442	0.46	0.477
7.4	0.437	0.455	0.472	0.49
7.6	0.449	0.467	0.485	0.503
7.8	0.46	0.479	0.498	0.516
8	0.472	0.491	0.511	0.53
8.2	0.484	0.504	0.523	0.543
8.4	0.496	0.516	0.536	0.556
8.6	0.508	0.528	0.549	0.569
8.8	0.519	0.541	0.562	0.583
9	0.531	0.553	0.574	0.596
9.2	0.543	0.565	0.587	0.609
9.4	0.555	0.577	0.6	0.622
9.6	0.567	0.59	0.613	0.636
9.8	0.578	0.602	0.625	0.649
10	0.59	0.614	0.638	0.662
10.5	0.62	0.645	0.67	0.695
11	0.649	0.676	0.702	0.728
11.5	0.679	0.706	0.734	0.761
12	0.708	0.737	0.766	0.795
12.5	0.738	0.768	0.798	0.828
13	0.767	0.799	0.83	0.861
13.5	0.797	0.829	0.862	0.894
14	0.826	0.86	0.893	0.927
14.5	0.856	0.891	0.925	0.96
15	0.885	0.921	0.957	0.993
16	0.944	0.983	1.021	1.059
17	1.004	1.044	1.085	1.126
18	1.063	1.106	1.149	1.192
19	1.122	1.167	1.213	1.258
20	1.181	1.229	1.276	1.324
25	1.476	1.536	1.596	1.655
30	1.771	1.843	1.915	1.986

Maximum Resistance of Lead at 20 degrees C	0.234 mohm/m	alpha =	0.0039 for Aluminium
Based on a Full Wave Rectified DC Current of	250 Amps	Ro	0.234 mOhm @ 20 deg C
These figures include an error of	5 %		
Equation Used for Calculation of Voltage Drop Variation with Temperature:		V = I * Rt * Lead Length * 1.05 (error)	
Equation used to Calculate Resistance at temp t		Rt = Ro(1 + alpha*td)	td = diff in temp from ref

Maximum Permissible Voltage Drop For Earth Leads

Lead: 125 sq mm - 500 Amps

Lead Length metres	Table of Lead Voltage Drop vs Temperature of Lead in Degrees Celsius			
	10	20	30	40
4	0.494	0.515	0.535	0.555
4.2	0.519	0.54	0.561	0.582
4.4	0.544	0.566	0.588	0.61
4.6	0.569	0.592	0.615	0.638
4.8	0.593	0.617	0.641	0.666
5	0.618	0.643	0.668	0.693
5.2	0.643	0.669	0.695	0.721
5.4	0.667	0.695	0.722	0.749
5.6	0.692	0.72	0.748	0.776
5.8	0.717	0.746	0.775	0.804
6	0.742	0.772	0.802	0.832
6.2	0.766	0.797	0.829	0.86
6.4	0.791	0.823	0.855	0.887
6.6	0.816	0.849	0.882	0.915
6.8	0.841	0.875	0.909	0.943
7	0.865	0.9	0.935	0.971
7.2	0.89	0.926	0.962	0.998
7.4	0.915	0.952	0.989	1.026
7.6	0.939	0.978	1.016	1.054
7.8	0.964	1.003	1.042	1.082
8	0.989	1.029	1.069	1.109
8.2	1.014	1.055	1.096	1.137
8.4	1.038	1.08	1.123	1.165
8.6	1.063	1.106	1.149	1.192
8.8	1.088	1.132	1.176	1.22
9	1.112	1.158	1.203	1.248
9.2	1.137	1.183	1.23	1.276
9.4	1.162	1.209	1.256	1.303
9.6	1.187	1.235	1.283	1.331
9.8	1.211	1.261	1.31	1.359
10	1.236	1.286	1.336	1.387
10.5	1.298	1.351	1.403	1.456
11	1.36	1.415	1.47	1.525
11.5	1.421	1.479	1.537	1.595
12	1.483	1.544	1.604	1.664
12.5	1.545	1.608	1.671	1.733
13	1.607	1.672	1.737	1.803
13.5	1.669	1.736	1.804	1.872
14	1.731	1.801	1.871	1.941
14.5	1.792	1.865	1.938	2.011
15	1.854	1.929	2.005	2.08
16	1.978	2.058	2.138	2.219
17	2.101	2.187	2.272	2.357
18	2.225	2.315	2.406	2.496
19	2.349	2.444	2.539	2.634
20	2.472	2.573	2.673	
25				
30				

Maximum Output Voltage of AES Portable Earth Tester is Approximately 2.7 Volts

Maximum Resistance of Lead at 20 degrees C	0.245 mohm/m	alpha =	0.0039 for Aluminium
Based on a Full Wave Rectified DC Current of	500 Amps	Ro	0.245 mOhm @ 20 deg C
These figures include an error of	5 %		
Equation Used for Calculation of Voltage Drop Variation with Temperature:		V = I * Rt * Lead Length * 1.05 (error)	
Equation used to Calculate Resistance at temp t		Rt = Ro(1 + alpha*td) td = diff in temp from ref	

Maximum Permissible Voltage Drop For Earth Leads

Lead: 130 sq mm - 500 Amps

Lead Length metres	Table of Lead Voltage Drop vs Temperature of Lead in Degrees Celsius				
	10		20	30	40
		calculated	using ref		
4	0.472	0.492	0.491	0.511	0.53
4.2	0.496	0.516	0.516	0.536	0.556
4.4	0.519	0.541	0.541	0.562	0.583
4.6	0.543	0.566	0.565	0.587	0.609
4.8	0.567	0.59	0.59	0.613	0.636
5	0.59	0.615	0.614	0.638	0.662
5.2	0.614	0.639	0.639	0.664	0.689
5.4	0.638	0.664	0.663	0.689	0.715
5.6	0.661	0.688	0.688	0.715	0.742
5.8	0.685	0.713	0.713	0.74	0.768
6	0.708	0.738	0.737	0.766	0.795
6.2	0.732	0.762	0.762	0.791	0.821
6.4	0.756	0.787	0.786	0.817	0.848
6.6	0.779	0.811	0.811	0.842	0.874
6.8	0.803	0.836	0.835	0.868	0.901
7	0.826	0.861	0.86	0.893	0.927
7.2	0.85	0.885	0.885	0.919	0.954
7.4	0.874	0.91	0.909	0.945	0.98
7.6	0.897	0.934	0.934	0.97	1.006
7.8	0.921	0.959	0.958	0.996	1.033
8	0.944	0.983	0.983	1.021	1.059
8.2	0.968	1.008	1.007	1.047	1.086
8.4	0.992	1.033	1.032	1.072	1.112
8.6	1.015	1.057	1.057	1.098	1.139
8.8	1.039	1.082	1.081	1.123	1.165
9	1.063	1.106	1.106	1.149	1.192
9.2	1.086	1.131	1.13	1.174	1.218
9.4	1.11	1.156	1.155	1.2	1.245
9.6	1.133	1.18	1.179	1.225	1.271
9.8	1.157	1.205	1.204	1.251	1.298
10	1.181	1.229	1.229	1.276	1.324
10.5	1.24	1.291	1.29	1.34	1.391
11	1.299	1.352	1.351	1.404	1.457
11.5	1.358	1.414	1.413	1.468	1.523
12	1.417	1.475	1.474	1.532	1.589
12.5	1.476	1.537	1.536	1.596	1.655
13	1.535	1.598	1.597	1.659	1.722
13.5	1.594	1.66	1.658	1.723	1.788
14	1.653	1.721	1.72	1.787	1.854
14.5	1.712	1.783	1.781	1.851	1.92
15	1.771	1.844	1.843	1.915	1.986
16	1.889	1.967	1.966	2.042	2.119
17	2.007	2.09	2.088	2.17	2.251
18	2.125	2.213	2.211	2.298	2.384
19	2.243	2.336	2.334	2.425	2.516
20	2.361	2.459	2.457	2.553	2.649
25					
30					

Maximum Output Voltage of AES Portable Earth Tester is Approximately 2.7 Volts

Maximum Resistance of Lead at 20 degrees C	0.234	mohm/m	alpha =	0.0039 for Aluminium
Based on a Full Wave Rectified DC Current of	500	Amps	Ro	0.234 mOhm/m @ 20 deg C
These figures include an error of	5	%		
Approximate Lay Ratio of Cable:	1.133			
Equation Used for Calculation of Voltage Drop Variation with Temperature:			V = I * Rt * Lead Length * 1.05 (error)	
Equation used to Calculate Resistance at temp t			Rt = Ro(1 + alpha*td) td = diff in temp from ref	

Stranding of Lead	666	0.5 Resistance /metre	rho * I =	0.000207	k (Al)	3.70E+07 S/m @ 20 Deg C
Calculated Area	0.000131		A		Rho (Al)	2.7E-08 Ohm.m @ 20 Deg C
Resistance / m taking into account assumed lay ratio				0.234166	mOhm/metre at 20 Deg C	

Appendix B Applying a trailing earth lead

Purpose:

A trailing earth lead serves two functions:

1. Provides a low resistance connection to earth to operate high speed protection in the event of inadvertent contact or flashover from High Voltage equipment to the item of mobile plant.
2. Provides a low resistance connection to earth to discharge any induced voltage on the mobile plant.

Hazard:

Typically, an item of mobile plant will be insulated from the ground by its tyres. An item of mobile plant which is not earthed and located in close proximity to high voltage electrical equipment could have an induced voltage on it due to capacitive coupling generated by the presence of the electric field. The application of a trailing earth will discharge the induced voltage, however, if the trailing earth is applied incorrectly, the current could discharge through a person's body giving them an electric shock. The magnitude of the electric shock will depend on a number of different parameters but can be completely mitigated by applying the trailing earth in the correct way.

When subjected to fault current, portable earths move rapidly and with significant force. If incorrect clamps are used or not sufficiently tightened then there is a risk of them disconnecting in the event they experience a fault causing danger to persons in the vicinity and potentially hindering the operation of the high speed protection.

Method:

Use the following method to correctly apply a trailing earth:

Step 1: Connect the trailing earth to the earth electrode. The earth electrode can be any of the following: A copper earth strap, a transmission line tower or an earth stake. The connection to the earth electrode can with either the MT815S clamp or the MT847 clamp.

Step 2: Determine where on the mobile plant to connect the trailing earth. If there is an earth stub then connect to this using the MT815S clamp, otherwise use an MT847 clamp. The MT847 clamp must be applied to parallel plate 5 – 30mm thick. Choose a location which will have a good electrical connection with the rest of the mobile plant.

Step 3: Do not touch any part of the mobile plant with your body when making the initial connection between the trailing earth and the mobile plant. This is to ensure that any capacitive charge built up on the mobile plant discharges through the trailing earth and not your body. Once connection is made tighten the trailing earth clamp connection. If applying the MT847 surface penetrating clamp then insulating gloves can be used as an additional

safeguard to prevent the risk of a shock due to inadvertent contact. If applying an MT815S clamp use the insulated application handle.