Engineering Procedure
Electrical Distribution Unit

PR D 78204

Earthing of High Voltage Equipment Using Portable Earthing Equipment

Version 1.2

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Procedure

Transport Sydney Trains

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Version	Date	Author/ Prin. Eng.	Summary of change
1.0	18 August 2015	Chris Leung	First issue as a Sydney Trains document, rebranded from previous RailCorp SMS-06-EN-0563 V1.1
1.1	14 August 2018	Chris Leung	3 Yearly review – no technical changes
1.2	19 February 2019	Nick Loveday	Updated PR D 78204 "Approved by" to Associate Director Electrical Distribution Unit

Summary of changes from previous version

Summary of change	Section

Table of Contents

1. Purpose and Scope

This document describes the procedure for the earthing of high voltage electrical equipment in the field using portable earthing equipment, including the use of portable earthing sets in substations. It covers,

a) equipment to be used,
b) procedure for installation and removal of portable earths, and
c) hazards related to the use of portable earthing equipment and techniques to control the associated risks.

2. General Requirements

Prior to performing any of the earthing procedures covered by this document, all relevant procedures shall be followed. Relevant procedures are identified in **PR D 78000 Electrical Network Safety Rules**, section 3.3 Part B – High Voltage.

NOTE:
The diagrams shown in this document are guides only and each situation shall be individually assessed.

3. Hazards

The procedure outlined in this document shall be strictly followed to avoid the possibility of burns, other physical injury or electric shock whilst applying portable earths.

Appropriate personal protective equipment, including hard hats, shall be worn whilst connecting and disconnecting portable earthing equipment to reduce the risk of injury due to falling equipment. Refer **PR D 78101 General Requirements for Electrical Work**, sections 11, 15 and 16.

A person using portable earthing equipment could be at risk of cutting their hand or have a protruding glass fibre penetrating the skin of the hand. An initial inspection of the operating stick shall be conducted to identify any such conditions prior to it being further handled. Refer **PR D 78205 Inspection and Care of Portable Earthing Equipment for the High Voltage System**, sections 4 and 5. Working gloves shall be worn whilst working with portable earths.

To avoid the hazard of possible electric shock during the application of portable earthing equipment, the steps as described in Section 4.2 shall be strictly adhered to.

4. High Voltage Aerial Lines Outside Substations

4.1. Earthing Equipment

The earthing equipment consists of:

a) an earth spike,
b) flexible insulated cable fitted with a conductor clamp for connection to the earth spike or permanent earth when available, and
c) insulated stick(s).

Earthing sets for aerial lines are either connected in a series or star configuration. Appendix A and B show the standard arrangements for the series and star connected earthing sets respectively. The series and star connected earthing equipment shall meet the requirements of **RailCorp Standard EP 95 10 00 06 'Requirements for Portable Earthing Equipment for the High Voltage System'.**

Care shall be taken to ensure that the Earthing Equipment is rated for the fault level / clearing time at the location where it is to be applied.

If a set of portable earthing equipment has been subjected to fault current, the earthing set shall be immediately replaced by a set with a rated current/rated time classification not less than the set being replaced. The faulted set shall be withdrawn from service, and all current carrying components, excluding the earth spike, shall be destroyed and disposed of in accordance with Sydney Trains procedure **IRD–MPE–PR–006 Minor Plant & Equipment Procedure**.

4.2. Application of Portable Earths

Pre-use inspection of earthing set in accordance with **PR D 78205 Inspection and Care of Portable Earthing Equipment for the High Voltage System** shall be carried out prior to the application of portable earths.

The procedure for the application of portable earths shall be carried out strictly in the following order:

4.2.1. Establish an earth

If a suitable permanent earth is present, check for continuity and connect the earth end of the flexible cable to the permanent earth as close as possible to the pole base concrete or structure footing.

If a suitable permanent earth is unavailable, an earth connection is to be made to an earth spike driven at least **600 mm** into the ground, as illustrated in Figure 1.

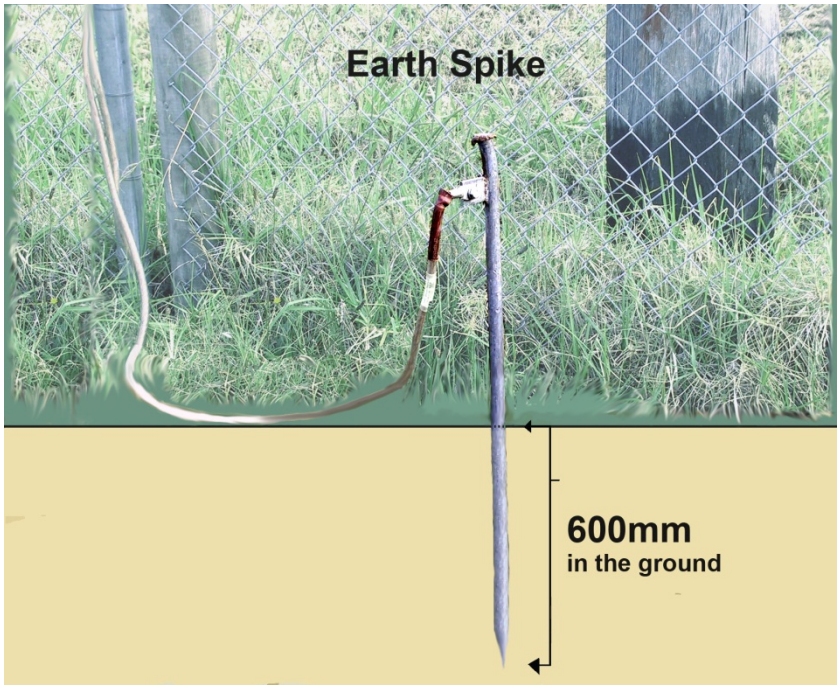

Figure 1 – Earth spike driven into the ground

Warning
Connection to earth via a permanent earth is the preferred method. If an earth spike is to be used in conjuction with the permanent earth for whatever reason (eg the integrity of the permanent earth is in doubt), the two shall be bonded together before applying the portable earths (see Section 4.6).

When driving the temporary earth spike, care shall be taken to avoid striking any underground assets. It is preferred that a assets search be completed in the area where the earth spike is to be driven. The search should be undertaken in accordance with the SMS-06-GD-3144 Guide to Excavations and Earthworks.

Warning
Under emergency conditions, it may not be possible to complete an underground assets search. In this case, a detailed search of the surrounding area for signs of underground assets is critical.

Notwithstanding the results of underground assets searches, inspect the locality of the site for evidence of underground assets such as marker pegs, pits, conduits going into the ground from poles, fire hydrants, etc. No work should be undertaken until any discrepancy between the features evident on site and the search results have been resolved.

The final location for the earth spike should be clear of any discovered assets and,

a) as close as possible to the pole base concrete or structure footing but not more than 1 metre away if practical,
b) on the opposite side of the pole to any cables/services running down the pole,
c) within the alignment of the conductors above, preferably on the opposite side to the placement of any ladders.

Seek advice from the Line Manager or ICON Electrical Operating Centre (EOC) if the above requirements cannot be met.

If an underground asset is struck, follow the instructions set out **SMS-06-GD-3144 Guide to Excavations and Earthworks**. In addition, you should report all workplace incidents (accidents and near misses) to your Line Manager and to the Safety Incident and Injury Hotline on phone: 1800 772 779.

4.2.2. Connect the Earthing Set to the earth

Connect the earthing set conductor to the permanent earth or temporary earth spike already driven into the ground.

4.2.3. Prove dead

Ensure that the aerial conductors are proven de-energized with a high voltage detector in accordance with **PR D 78203 High Voltage Operating Procedures**, example Figure 2.

Figure 2 – Testing with high voltage detector

4.2.4. Earth the conductors

Warning
Connection to any conductors SHALL NOT be made until the earth end of the bridging conductor has been bonded to the common earth.

Warning
Aerial conductors to be bonded to earth shall be proved dead prior to connection of any earthing equipment.

Prior to commencing application, arrange the earthing set in an accessible position, eg park heads on the pole step first.

Elevate the insulated operating stick and connect the conductor clamp to each aerial conductor in turn, ensuring that connection is made to the nearest aerial conductor first. As illustrated in Figure 3 the middle conductor is the nearest conductor in this case. This allows all further earthing connections to be subsequently made in a safe manner.

Figure 3 – Application of earths

Connection to an aerial conductor shall be made by drawing the hooked section of the conductor clamp firmly and smartly onto the aerial conductor. Then, if screw-type earth clamps are used, tighten the connection clamp by rotating the insulated stick in a clockwise direction (Figure 4).

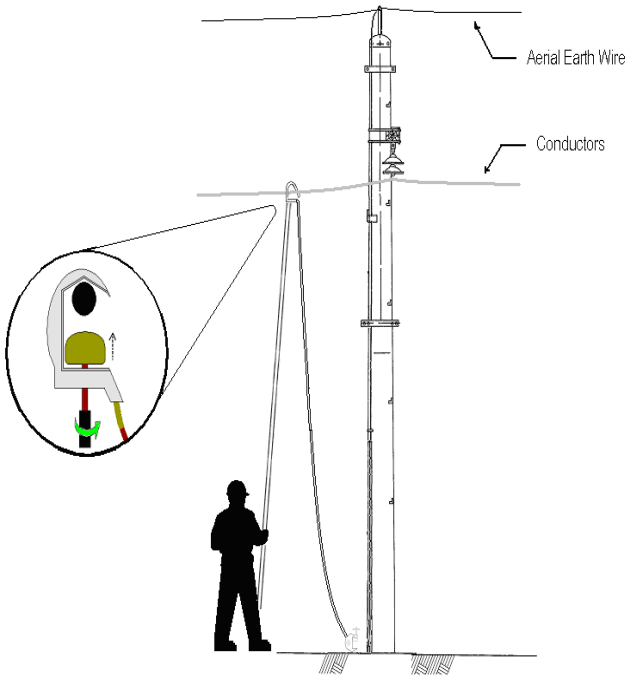

Figure 4 – Attaching to aerial conductors using portable earths

NOTE:
Figure 4 is for illustration purposes only, the use of an elevated work platform or climbing devices may be required to connect the earths to aerial conductors.

During the procedure, only the ends of the operating sticks away from the conductor clamps are to be handled. Additionally, the person applying the earths shall ensure that the earthing equipment does not come within the minimum Safe Approach Distances (SADs) of any live conductor or Exposed Equipment, including low voltage and communications circuits; as set out in PR D 78700 Working around Electrical Equipment.

The person applying the earths shall maintain the minimum SADs set out in PR D 78700 Working around Electrical Equipment from the conductors to which the earths have not yet been applied.

An example of earthed aerial conductors is shown on Figure 5.

Figure 5 – Earthed aerial conductors

4.3. Earthing One Circuit on a Pole Carrying Multiple Circuits

When earthing the lower circuit at a pole carrying multiple vertically spaced circuit lines and the upper circuit is live, a dangerous potential could exist between earth and the pole at the height of the lower circuit.

An additional earth connection clamp shall be applied to a pole band or a pole step at or above the height of the lower circuit before a person bridges the pole and the earthed conductors (Figure 6).

This hazard does not exist if a bare earthing "down wire" has been installed on the pole.

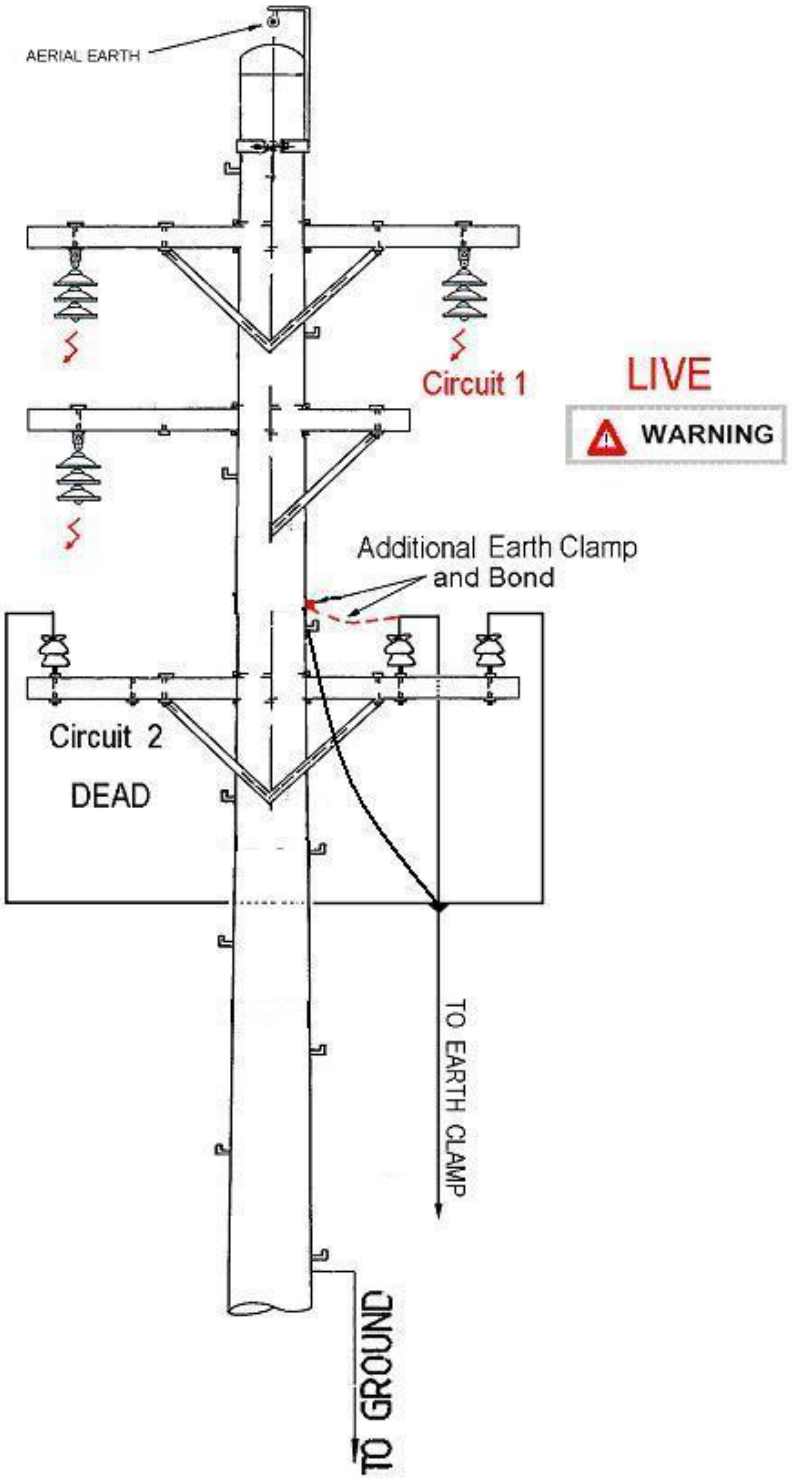

Figure 6 – Earthing vertically spaced multiple circuit poles with one circuit live

All earthed conductors at the worksite shall be connected to a common earth to ensure equipotential conditions.

4.4. Earthing Multiple Circuits

Where earths are applied to multiple circuits at a work location, they shall be connected to either a common earth spike or alternatively their individual earth spikes shall be connected together onto an equipotential bond (Figure 7).

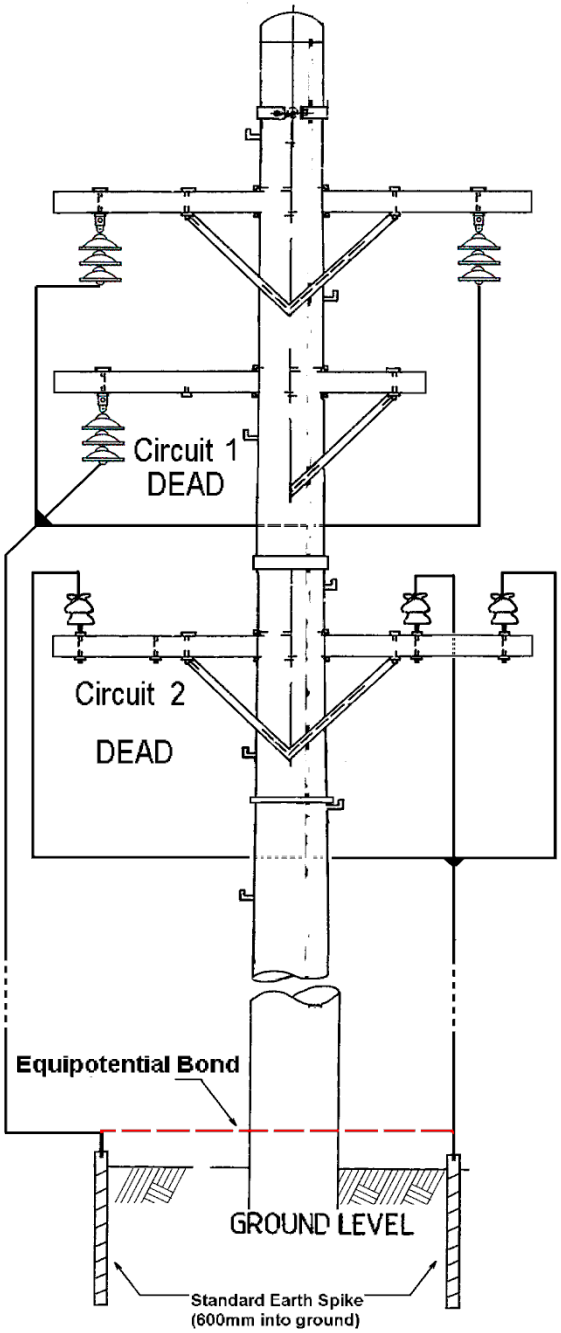

Figure 7 – Earthing multiple circuits at a work location

4.5. Aerial Earth Wires

At locations where aerial earth wires are present, the aerial earth wire shall be bonded together with the other earthed conductors (Figure 8 Earthing on a pole with an aerial earth wire).

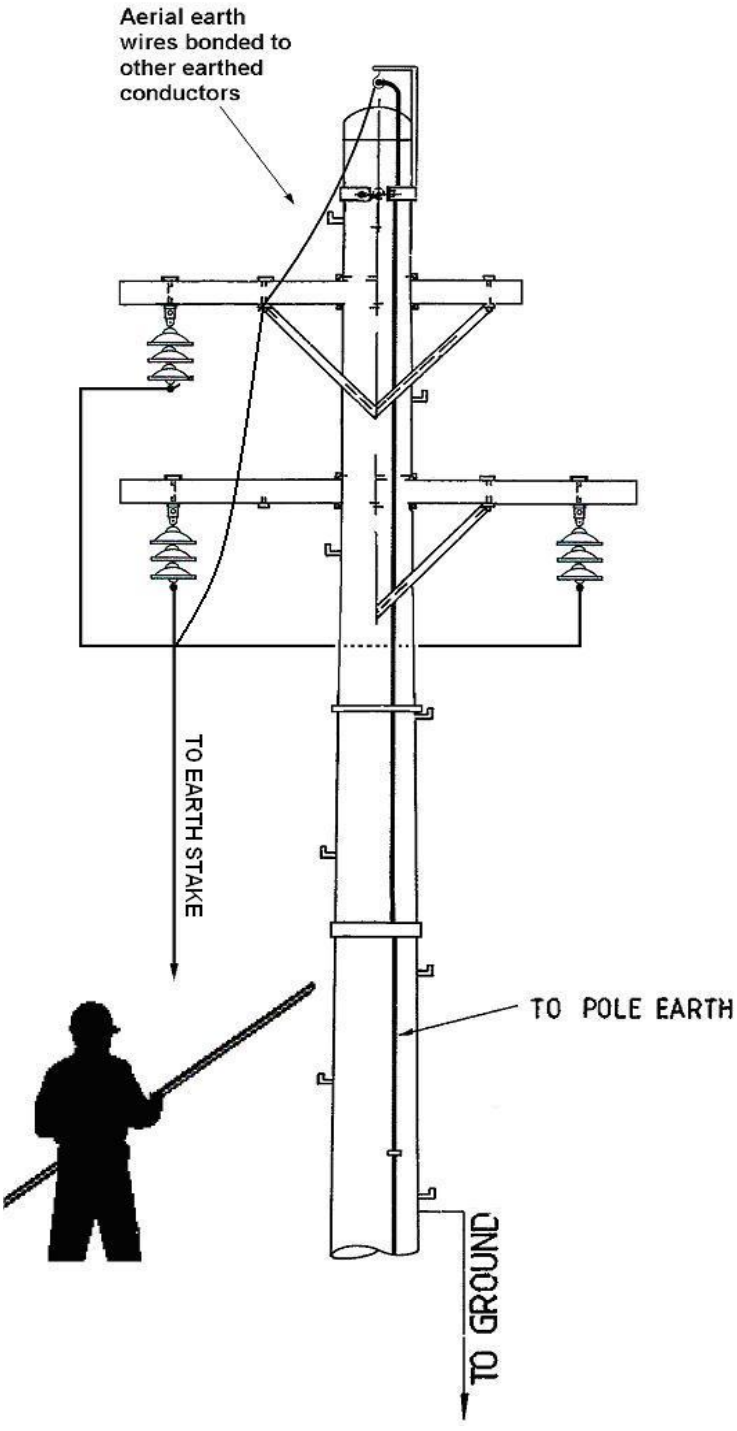

Figure 8 – Earthing on a pole with an aerial earth wire

4.6. Bare Down Leads

If there is a bare down lead present on the pole and a driven earth spike is also to be used, then the down lead and the earth spike shall be bonded together at ground level **before** any earthing equipment is attached to the earth spike.

For ease of installation, the connection to the down lead may be made above the cover board (Figure 9 Earthing on a pole with a bare down lead)

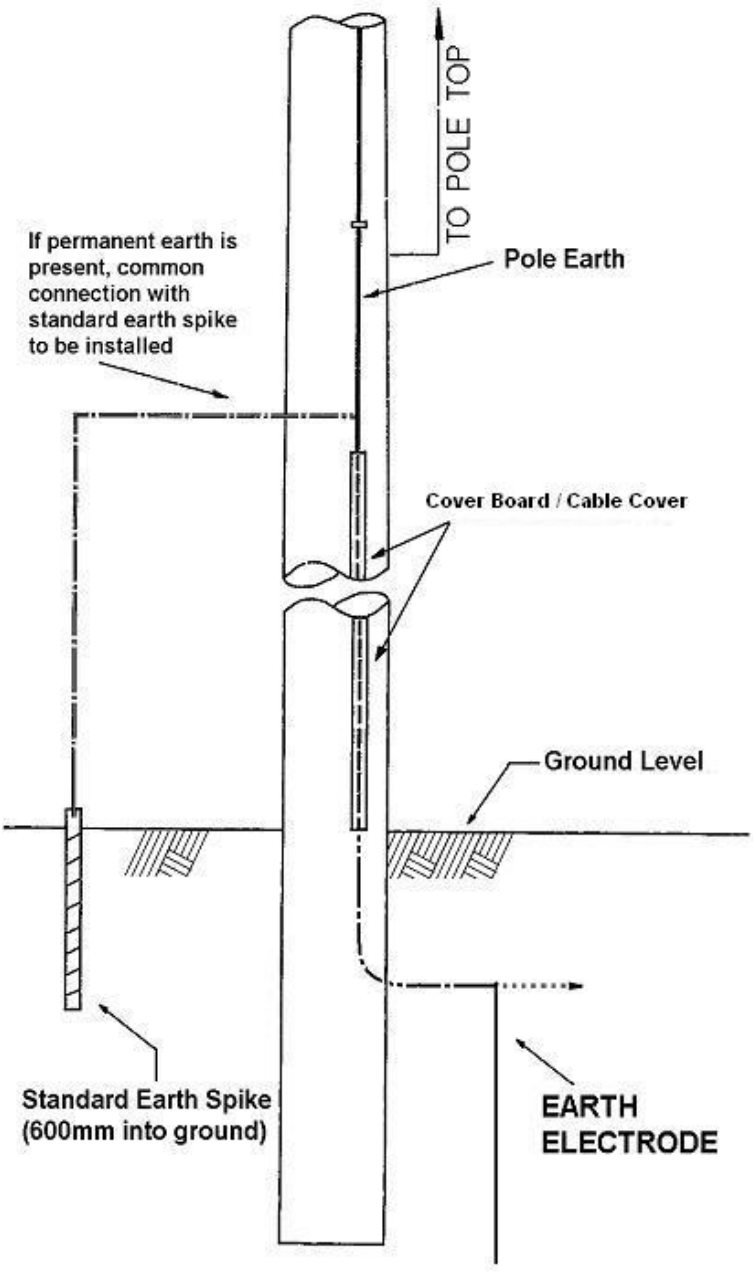

Figure 9 – Earthing on a pole with a bare down lead

4.7. Breaking of Earthed Conductors

If an earthed conductor is broken or is to be broken, the two sides are to be bridged together via conductive bonds before bridging the two sides of the broken conductor by the body or hand; including via tools held by the hand. The bridging may be via another unbroken earthed phase or an unbroken aerial earth conductor (Figure 10).

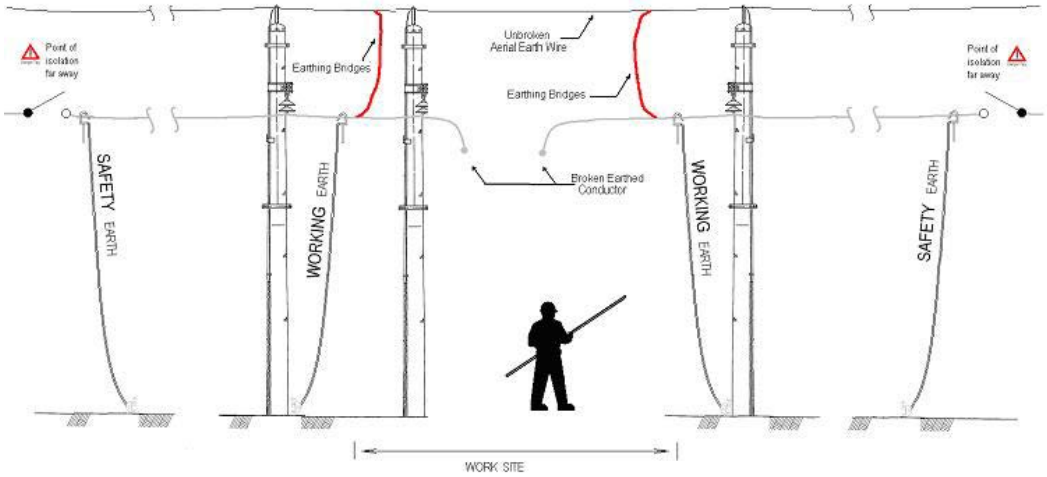

Figure 10 – Bridging broken earthed conductors

4.8. Raising or lowering of aerial conductors

In cases where aerial conductors are being lowered to or raised from the ground in the vicinity of other services, an earth shall be attached to the conductor throughout the operation.

4.9. Areas Subject to Induced Voltages or an Increased Risk of Lightning Strikes

Additional working earths shall be applied where there is a risk of dangerous voltages being induced in the conductors being worked on from live aerial conductors in the area.

If it is necessary to work on an aerial conductor at a time when there is an increased risk due to lightning, all conductors, including aerial earth wires, shall be short-circuited together and earthed at **each** pole or structure being worked on.

NOTE:
In general, only emergency work is permitted to continue at times when there is an increased risk due to lightning.

4.10. Removal of Portable Earths

Warning

Connection to the permanent earth or earth spike, as applicable, shall not be broken until earthing connections to all aerial conductors have been removed first.

High voltage aerial conductor earths shall be removed strictly in the following order:

a) Loosen the conductor clamps by rotating the insulated operating sticks in an anti-clockwise direction. If screw type earth clamps are used, disconnect the conductor clamps from the aerial conductors. Ensure that only the ends of the operating sticks away from the conductor clamps are handled and that the earthing equipment does not come within the SADs set out in **PR D 78700 Working around Electrical Equipment** of any live conductor or Exposed Equipment, including low voltage and communications circuits. Disconnection shall first be made from the **highest** aerial conductor.

   The person removing the earths shall maintain the SADs set out in **PR D 78700 Working around Electrical Equipment** from the conductors from which earths have been removed.

b) Lower the insulated sticks ensuring that the earthing equipment does not come within the Safe Approach Distances set out in **PR D 78700 Working around Electrical Equipment** of any live conductor or Exposed Equipment, including low voltage and communications circuits.

After all earthing connections to aerial conductors have been removed, disconnect the earth end of the flexible cable from the permanent earth or the standard earth spike. Then remove the earth spike.

5. High Voltage Underground Cables to Aerial Equipment

NOTE:
The following earthing method is to be used to perform cable testing.

5.1. Cable earthing from Pole A to Pole B

a) Perform the appropriate proving dead and earthing method in accordance with Section 4 of this document.

b) Place temporary bridging bonds from each cable end on the pole to the equipotential earth. Drawing No. **EL0052208 HV Aerial Lines - 66kv Polymeric Termination Underground To Overhead Poletop Arrangement** shows the typical arrangement for bridging all "Cable to Aerial Termination Plates" (item 47) with "Connecting Plate for Earthing" (item 16). Similar arrangements for 11 kV and 33 kV are shown in Drawings No. **EL0186406**, **EL0160722** and **EL0455661**. Other arrangements will require a risk assessment and SWMS to determine the best safe method to perform this step.

c) Disconnect and remove bridges between the cables to the HV aerial line.

d) Repeat steps (i) to (iii) for Pole B.

e) Conduct the cable tests at the appropriate pole as required.

f) To remove earths, conduct the relevant steps of this procedure in the reverse order, i.e. step (iv), then (iii) and then step (ii).

NOTE:
Where practicable, cable tests should be performed inside the substation instead of the pole to remove the risk of working at heights.

5.2. Cable earthing from Pole to substation

a) Perform the appropriate proving dead and earthing method in accordance with Section 4 of this document.

b) Place temporary bridging bonds from each cable end on the pole to the equipotential earth. Drawing No. **EL0052208 HV Aerial Lines - 66kv Polymeric Termination Underground To Overhead Poletop Arrangement** shows the typical arrangement for bridging all "Cable to Aerial Termination Plates" (item 47) with "Connecting Plate for Earthing" (item 16). Similar arrangements for 11 kV and 33 kV are shown in Drawings No. **EL0186406** and **EL0160722** and **EL0455661**. Other arrangements will require a risk assessment and SWMS to determine the best safe method to perform this step.

c) Disconnect and remove bridges between Cables to HV Aerial Line.

d) Conduct the cable tests from inside the substation.

e) To remove earths, conduct the relevant steps of this procedure in the reverse order, i.e. step (iii) and then step (ii).

6. Equipotential Bonding for Work on Conductive Poles/Structures

For work to be carried out on conductive poles / structures, it is essential to bond the earthed conductors to be worked on and the conductive pole / structure via the use of portable bonding equipment as shown in Appendix C.

7. Exposed High Voltage Outdoor Busbars at Substations

7.1. Earthing Equipment

The earthing equipment consists of:

a) Three insulated sticks each fitted with a conductor connection clamp.
b) An earth trifurcating plate.
c) Flexible insulated cable for connection between the conductor clamp and the earth trifurcating plate.

If a set of portable earthing equipment has been subjected to fault current, the earthing equipment shall be immediately replaced with a set having equivalent rated current/rated time classification. The faulted set shall be withdrawn from service and all current carrying components shall be destroyed.

Warning
Care shall be exercised when carrying earthing equipment to ensure that the equipment does not come within the Safe Approach Distances, specified in PR D 78700 Working around Electrical Equipment, of any live conductor or Exposed Equipment. Earth sticks shall be carried below shoulder level with the connection clamp end in front of the person carrying them.

7.2. Earthing Procedure

Ensure that the earthing equipment does not come within the Safe Approach Distances (SADs) of any live conductor or Exposed Equipment, as specified in **PR D 78700 Working around Electrical Equipment**. All phases of the HV equipment shall be **proved dead** before the **short circuiting** and **earthing** procedure is carried out, **strictly** in the following order:

a) Check that the cable connections to the conductor clamps and the trifurcating plate are tight and that the cables are of sufficient length in accordance with **PR D 78205 Inspection and Care of Portable Earthing Equipment for the High Voltage System**.
b) Connect the trifurcating plate to the appropriate substation earth point. See Figure 11.
c) Connect the conductor clamps to each phase conductor of the HV equipment.

   Connection to an overhead line conductor shall be made by drawing the hooked section of the conductor clamp firmly and smartly onto the overhead line conductor. Tighten the screw type earth connection clamps by rotating the insulated operating stick in a clockwise direction.

   Earthing points are provided on certain HV equipment for the attachment of the earthing clamps.

Figure 11 – Typical Substation Earthing disc and Earthing Point

7.3. Removal of Earths

Ensure that the earthing equipment does not come within the SADs of any live conductor or Exposed Equipment, as specified in **PR D 78700 Working around Electrical Equipment**. HV overhead line earths shall be removed **strictly** in the following order:

a) Loosen screw type earth connection clamps by rotating the insulated operating stick in an anti-clockwise direction. Disconnect the conductor clamps from the overhead line conductors ensuring that only the ends of the operating sticks away from the conductor clamps are handled.
b) Disconnection shall first be made from the highest overhead line conductor.
c) Disconnect the trifurcating plate from the substation earth point.

7.4. Connection to High Busbars

In some substations, there are high level conductors that are too high to allow a person to safely and/or practically connect the earthing set to them.

In cases such as this, the earth can be connected from the closest accessible area at ground level as long as there is an electrically continuous connection to the point that they would have normally been connected.

The typical arrangement for earthing high level busbars in a substation is illustrated in Figure 12, next page.

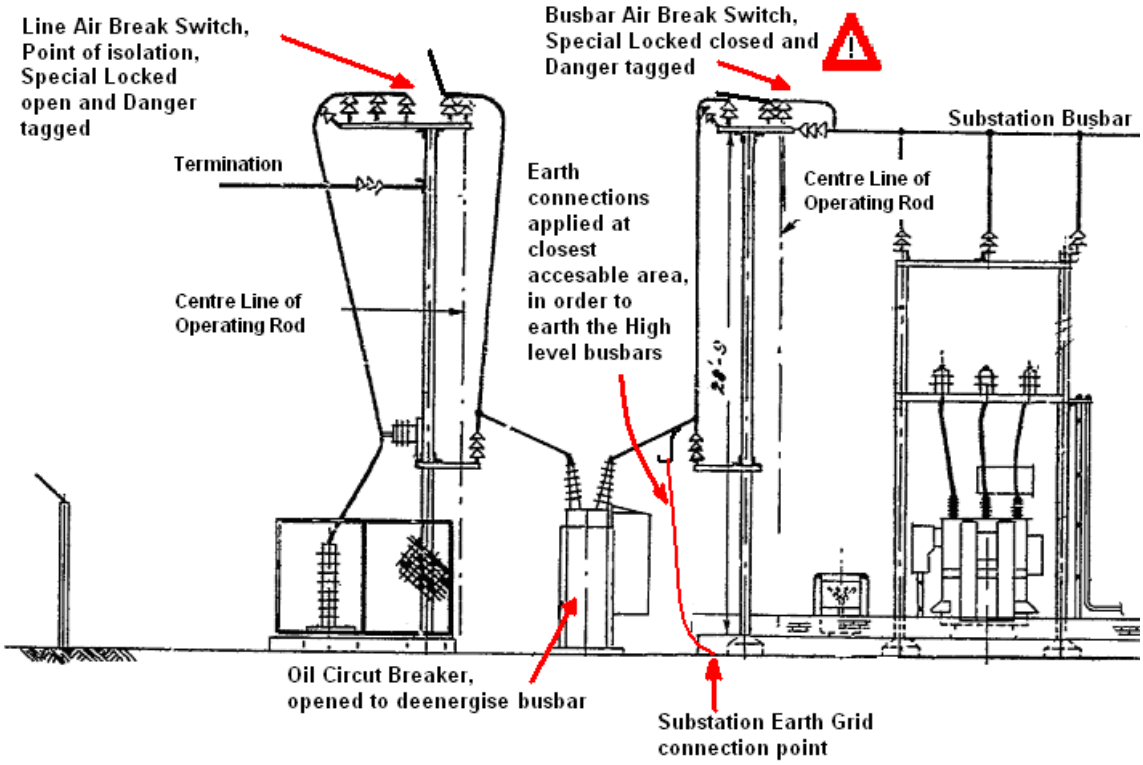

Figure 12 – Typical arrangement for earthing high level bus bars in a substation

Warning

Any switch that shall be closed in order to maintain an electrically continuous connection for earthing, shall be Special Locked and Danger Tagged closed. Refer PR D 78104 Locking Systems for Electrical Equipment and PR D 78105-Danger Tags for Electrical Equipment.

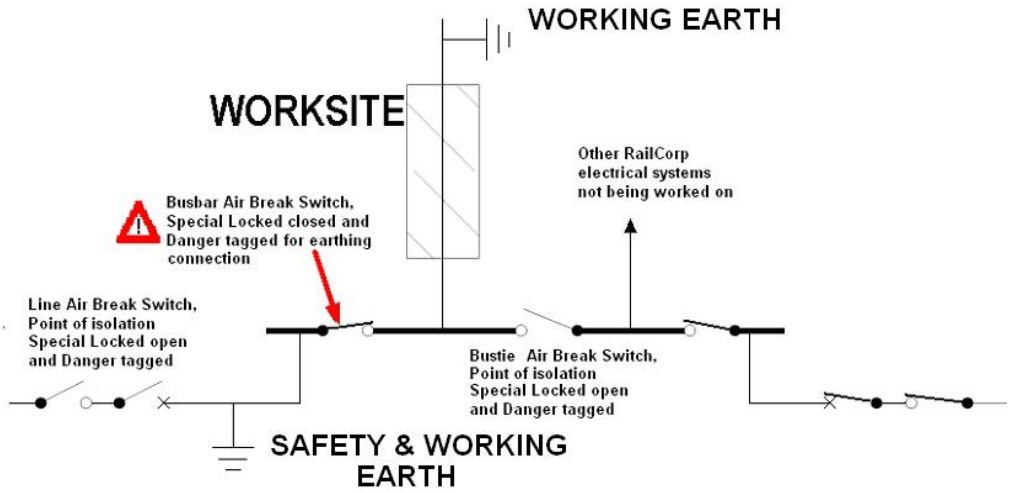

Figure 13 – Applying safety and working earths on high level busbars

8. References

EP 95 10 00 06 SI	Requirements for Portable Earthing Equipment for the High Voltage System
Drg. EL0052208	HV Aerial Lines - 66kv Polymeric Termination Underground to Overhead Poletop Arrangement
Drg. EL0186406	HV Aerial Lines – 11 kV Polymeric Termination Underground to Overhead Pole Top Arrangement
Drg. EL0160722	33 kV Polymeric Termination Overhead to Underground Pole Top Arrangement
Drg EL 0455661	HV Aerial Lines – 33kV Polymeric Termination Underground to Overhead (UG/OH) Pole Top Arrangement
PR D 78000	Electrical Network Safety Rules
PR D 78101	General Requirements for Electrical Work
PR D 78104	Locking Systems for Electrical Equipment
PR D 78203	High Voltage Operating Procedures
PR D 78205	Inspection and Care of Portable Earthing Equipment for the High Voltage System
PR D 78105	DANGER Tags for Electrical Equipment
PR D 78700	Working around Electrical Equipment
SMS-06-GD-3144	Guide to Excavation and Earthworks

9. Appendices

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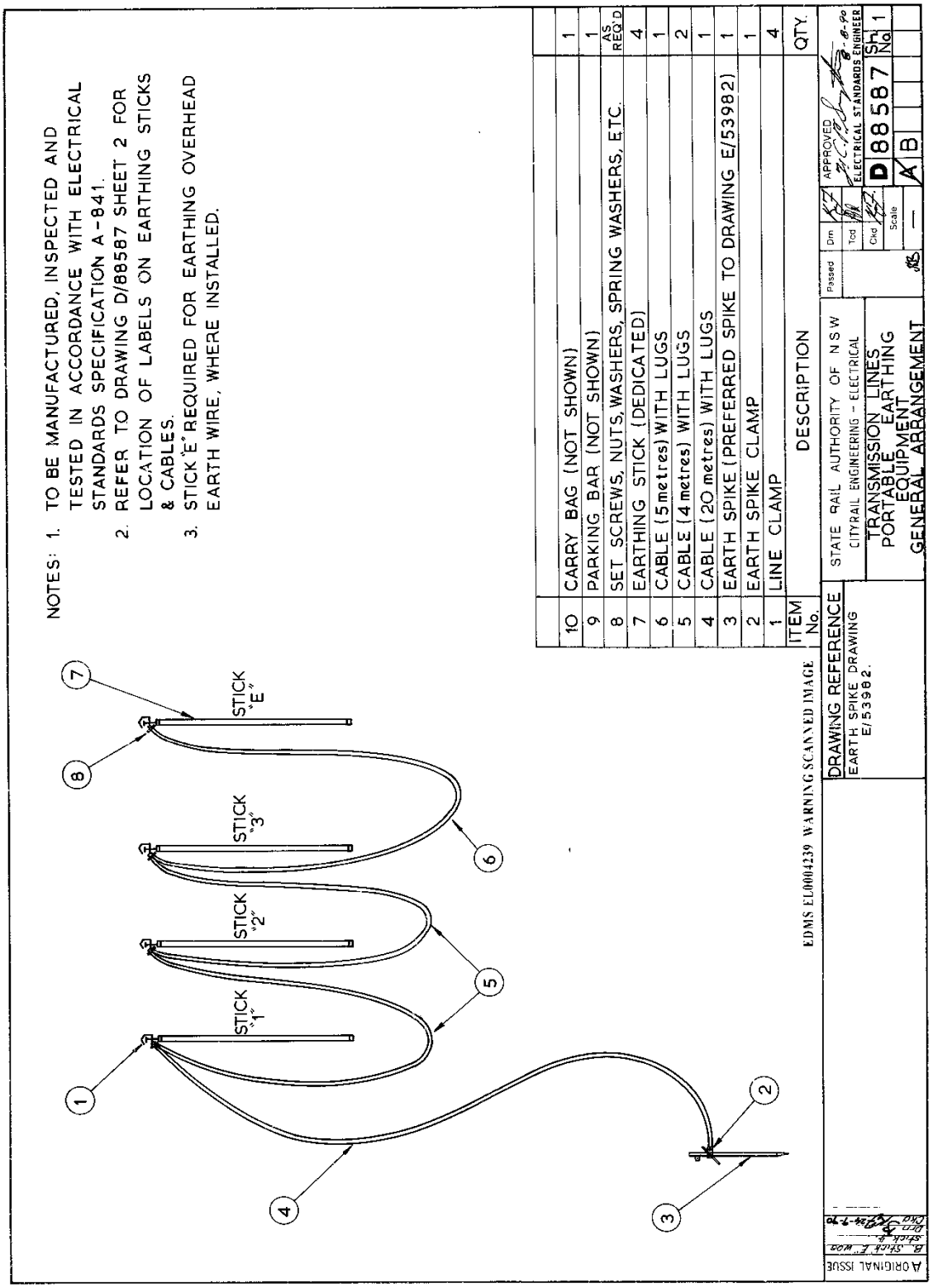
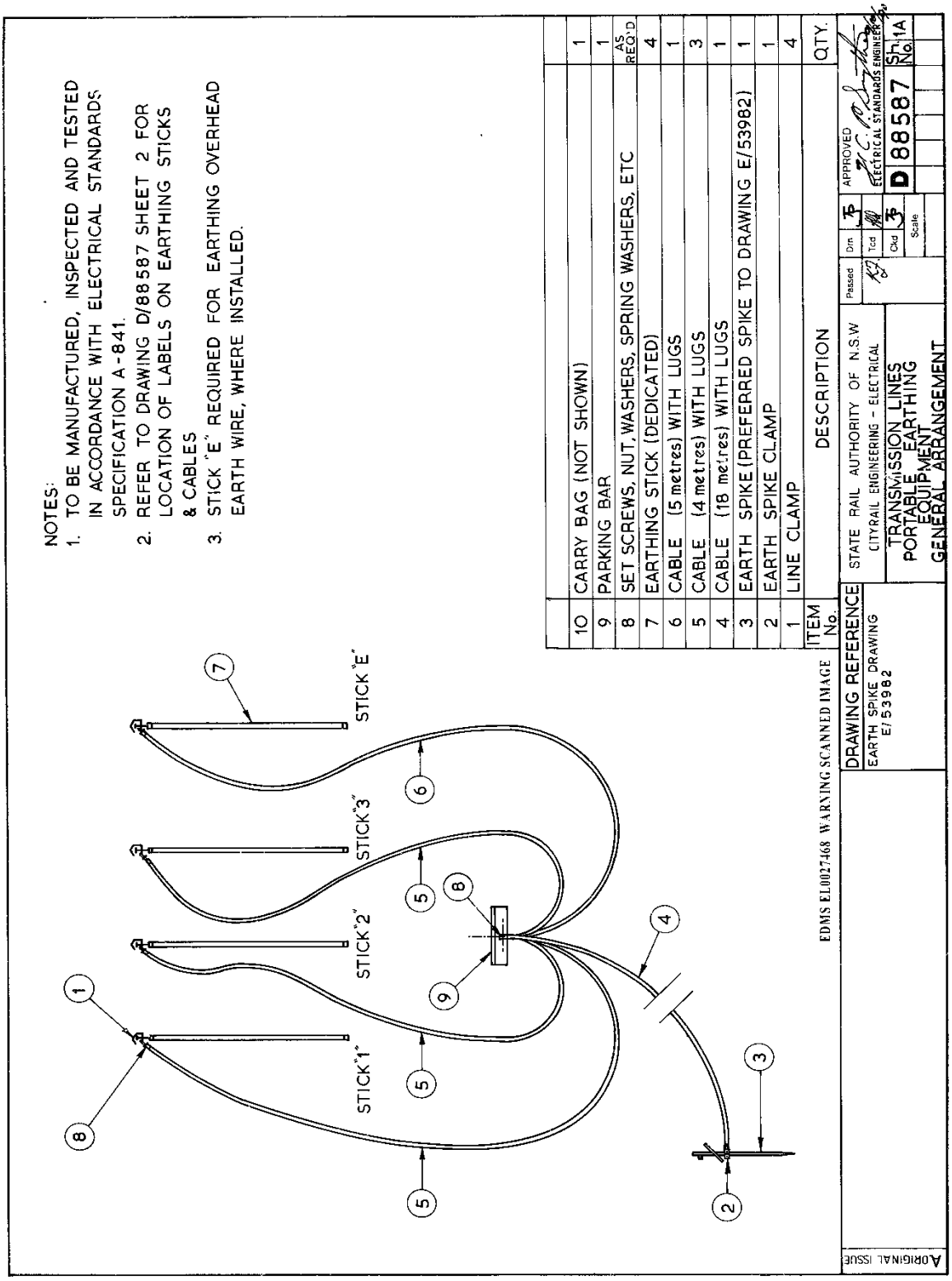
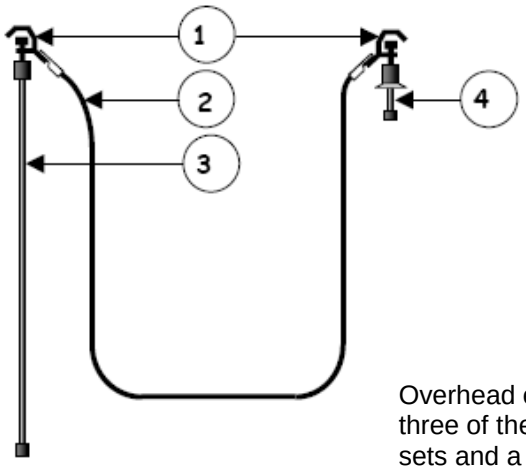
Appendix A Overhead Line Series Connected Earthing Equipment



Appendix B Overhead Line Star Connected Earthing Equipment



Appendix C Portable Bonding Equipment



Overhead earthing sets consist of three of these portable bonding sets and a forth with an earth spike instead of the earthing clamp.

Item No.	Description	Quantity
6	Carry bag (not shown)	1
5	Set screws, nuts, washers, spring washers etc.	As required
4	Dedicated insulated handle or Detachable insulated handle	1
3	Dedicated insulated stick or Detachable insulated stick	1
2	5 metres Cable with lugs	1
1	Line clamp	2