1 SCOPE

This section of the Power Systems Live Working Manual details the procedures to be followed to achieve **Safety from the System** when carrying out examination, testing and remedial work on PTE (Pole Transformer Equipment) **HV** and **LV** Earthing**,** where the PTE is connected to the **System** and is **Live** at normal **System** voltage.

2 ISSUE RECORD

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5 DANGERS

The main **Dangers** to personnel carrying out examination testing and remedial work on PTE Earthing are electric shock and burns arising from:

(i) Infringing **Safety Distances.**

(ii) Incorrect application of equipment.

(iii) Inadequate connections to permanent **System** Earths or Temporary Earths.

(iv) Failure to make proper use of appropriate PPE.

6 DEFINITIONS

Terms printed in **bold type** are as defined in the ScottishPower Safety Rules (Electrical and Mechanical) 4th Edition

7 GENERAL REQUIREMENTS

This Section lays down the general requirements for the Examination of the Earthing arrangements at pole transformer equipments (PTE's) and shall include testing the Earth resistance values of both the **HV** steelwork and the **LV** neutral Earths.

The acceptable conditions allowed in this Section of the Manual must not be taken as being acceptable for new lines, which must be to the standards laid down in the Distribution Construction Manual.

This Section also provides guidance on the action to be taken to correct situations where the Earthing arrangements are not acceptable.

All work associated with the Examination must be carried out in accordance with the Safety Rules and Safety Instructions when testing Earth values with the transformer **Live,** strictly in accordance with the Procedure WL-1.28 laid down in this Section of the Manual.

The Examination requirements are summarised in Maintenance Procedure Check Sheet No. D4.4/A which also serves as an Examination Report Sheet. See Appendix 1.

8 EARTHING LEADS AND CONNECTIONS

8.1 General

Unless the combined resistance of the **HV** steelwork and **LV** neutral Earth Systems is one ohm or less, the electrode Systems must be separate. Such a figure will not normally be obtainable on overhead line **Systems**, therefore unless information is available to the contrary it can be assumed that the electrode Systems will be separate. Where it is practical to do so, the **LV** neutral Earth electrode should be installed at the first **LV** pole out from the transformer, and will in any case have a minimum separation of 8metres (Scotland), 10metres (Manweb) from any other **System** Earth.

Where the neutral Earth is installed on the transformer support, check to ensure that the **HV** steelwork and **LV** neutral Earth Systems are separate. Where the Earth conductors are bare, there should be at least 150mm separation across a wood pole surface and 50mm in air. Check to ensure that any anti-climbing device, wire or bracket on the pole does not come into contact with a bare Earthing lead. It is particularly important that metallic objects do not form a short circuit between the **HV** and **LV** Earthing leads.

Note: Unless insulation is a minimum of 0.8mm thick PVC, Earthing leads should be considered as bare and where bare Earth leads are found, arrangements shall be made to replace them with insulated leads at the earliest opportunity.
Check to ensure that the bottom section of any Earthing lead on a wood pole is protected by a non-metallic guard. Check to ensure that aluminium Earthing leads do not go into the ground and that any bi-metallic joints are adequately taped and sealed against ingress of moisture.

Only copper is acceptable for Earthing leads and conductors below the ground.

8.2 HV Earthing Leads and Bonding

Check all Earthing leads and bonding above ground to ensure that they are undamaged, corrosion free and adequately fixed and that they are of the correct size for the line specification. Check that steelwork is bonded correctly.

Guidance on Earthing and bonding lead sizes and the **Plant** and **Apparatus** to be bonded is given below.

8.2.1 **HV** Earthing and Bonding Leads

Type of Line Specification	**Minimum Cross Section Area (Copper Equivalent)**	**Present Standard**
Light Lines (e.g. L10 or similar; 32mm^2 copper equiv. conductor and below)	16mm^2 (0.025in^2)	35mm^2 copper green/yellow PVC Insulated
Heavy Lines (all above 32mm^2 copper equivalent conductor)	70mm^2 (0.1in^2)	70mm^2 copper green/yellow PVC Insulated

8.2.2 **Plant** and **Apparatus** to be bonded to the **HV** Steelwork Earth at Transformer Poles, **HV** Cable Box Poles and Air Break Switch Poles.

(i) Transformer tank and supporting steelwork

(ii) Pole mounted auto reclosers and other pole mounted switchgear and supporting steelwork

(iii) **HV** cable box

(iv) **HV** cable sheath

(v) **HV** fusegear steelwork and mountings

(vi) Steel crossarms

(vii) Pilot insulator pins and brackets

(viii) **HV** stay tops

Note:

(a) An air-break switch disconnector handle shall be bonded to an Earth mat which must be kept separate from other Earth electrodes.

(b) Anti-climbing devices shall not be connected with Earth.

(c) Metallic cable guards (on **HV** or **LV** cables) shall not be connected with Earth

8.3 LV Neutral Earthing Conductors and Bonding

8.3.1 Guidance on Plant and Apparatus to be bonded to the LV neutral Earth is as follows:

(i) **LV** metallic cable box

(ii) **LV** metallic cable sheath

(iii) **LV** fusegear metallic mountings

(iv) **LV** insulator brackets ('D' irons)

(v) **LV** stay tops

8.4 Stays

8.4.1 Check to ensure that the top portions of all **HV** stays are bonded to the **HV** steelwork Earth and report where there is not an insulator in the stay. Where an insulator is fitted, check to ensure that the insulator is so placed that if the stay broke, that part of the stay below the insulator would not come into contact with **Live** conductors. Also check that stay insulators are at a minimum height of 3m above ground level.

8.4.2 Check to ensure that all **LV** stays have an insulator fitted and that the top of the stay above the insulator is bonded to the **LV** neutral Earth. Check to ensure that the insulator is so placed that if the stay broke, that part of the stay below the insulator would not come into contact with **Live** conductors.

8.4.3 Where there are **HV** and **LV** conductors on a pole, stays associated with the **HV** conductors require 2 insulators.

9 PROCEDURE WL-1.28 TESTING PTE EARTHING

9.1 Scope

This procedure describes the methods and precautions to be followed when testing **HV** steelwork and **LV** neutral Earths of PTE's with the **System Live**, in order to determine their respective resistance values. The maximum acceptable values are given in the table below. Where practicable, action should be taken immediately to correct unacceptable values at the time of the test, particularly if **Danger** exists.

Table – Maximum Earth Resistance Values

Earth Electrode	**Max. Value (OHMS)**		
	Scotland	**Manweb**	
		Where protected by 25A Slow Blow Fuse	All other locations
HVSteelwork	40	11Kv, 40. 6.6 Kv, 20	11Kv, 20. 6.6Kv,10
LV Neutral			
- Direct **Earthed**	1	1	
- Continuous Earth Wire	40	20	
- PNB (Protective Neutral Bonding, single customer)	40	20	
- PME single electrode	40	40	
- PME combined electrodes	20	20	

9.2 HV Steelwork Earth Test

(a) Set up the Earth test instrument with its auxiliary electrodes 23 and 46 metres from the instrument.

(b) Establish a temporary reference Earth at least 5 metres from the base of the pole and check with the Earth tester that it has a resistance at or below the maximum permitted value. If it proves impossible to obtain a temporary Earth with a resistance at or below the maximum permitted value, arrangements must be made to conduct the test with the line and pole transformer dead.

(c) With the temporary reference Earth established, using an **Approved** tester check that there is no detectable voltage between the Earth lead on the pole and the temporary reference Earth. If no voltage is detectable on the high voltage indicator, then take a second measurement using an **Approved** multimeter. If there is an indication of voltage from either of these tests then the test procedure shall stop and arrangements made to conduct the test with the line and pole transformer dead.

(d) If zero volts is detected, connect an insulated lead first to the test instrument and then to the Earth conductor on the support. The most convenient point will usually be immediately above the protective capping. It is not necessary to disconnect the Earth from the pole where there is no **HV** aerial Earth wire on the **System**.

(e) If the Earth resistance measurement is higher than the maximum permitted value, make a secure connection between the temporary reference electrode and the Earth conductor on the support to provide a safe by-pass to the permanent Earth. It will then be safe to investigate the underground part of the Earth system with a view to ascertaining the cause of the high reading. Any necessary repairs may then be made or additional rods installed with a view to reducing the Earth resistance to an acceptable value. The Earth resistance should then be re-measured having first removed the temporary connection to the reference Earth.

9.3 LV Neutral Earth Test

(a) Set up the test instrument with its auxiliary electrodes at 23 and 46 metres from the instrument.

(b) Establish a temporary Earth not less than 5 metres from the pole and check with the test instrument that it has a resistance not exceeding the maximum permitted value.

Note: In situations where the neutral is **Earthed** at the transformer pole the temporary reference Earth already set up for measuring the **HV** steelwork Earth will also suffice for this test.

(c) With the aid of an **Approved** multimeter and a low range clip on ammeter, check for voltage between the temporary Earth and the permanent Earth and for current in the permanent Earth conductor. If there is an indication of more than 10 volts or 1 amp then do not proceed until the cause of the leakage has been ascertained.

(d) If the above tests are satisfactory, then securely connect an insulated lead (minimum size 70 mm^2 Cu.) from the temporary Earth to a point immediately above the test point, or above the position where a test point should be.

Note: Where no disconnectable test point exists, then one shall be introduced using the following procedure:

First connect a bridging conductor across the points where the test point is be formed so as to maintain the continuity of the Earth System, then cut the Earth wire and crimp two double hole lugs to the ends so that they can bolted together, thus forming a disconnecting link for future use. Remove the bridging conductor on completion of the disconnecting link.

(e) Open the disconnecting link to leave the neutral connected to the temporary Earth. Measure the resistance of the **LV** Earth electrode as quickly as practicable then reconnect the link immediately, so that the **System** will not be dependent on the temporary Earth for longer than necessary.

(f) If the resistance value obtained is higher than the maximum permitted value as defined in the table above, the existing installation must be examined to determine:

(i) If the installation requires repair (e.g. corroded connections), or

(ii) If the installation of a reasonable number of additional rods will achieve the desired level, or

(iii) If one of the alternative methods of Earthing detailed in 10.2 below would be more practicable.

Note: The temporary Earth must be connected in parallel as a precautionary measure before the established Earth electrode is disturbed.

10 CORRECTIVE ACTION

10.1 HV Steelwork

Where the **HV** steelwork Earth value is above the maximum permitted value, steps shall be taken to investigate the reason and where necessary carry out appropriate repairs or install additional Earth rods.

10.2 LV Neutral Earth

Where the **LV** neutral Earth value is above that given in the Table in this Section of the Manual, the corrective action to be taken shall be in accordance with the following guidelines.

10.2.1 If the existing **System** Earthing is CEW (Continuous Earthwire) PME or PNB, no change should be made to the method of Earthing. The installation must be examined for any corroded connections or other defects and corrective action taken to meet the maximum permitted value.

10.2.2 If the existing method of Earthing is direct Earthing**,** consideration can be given to an alternative method of Earthing after the installation has been examined for any corroded connections or defects, and the corrective action required to achieve the maximum permitted value of direct Earthing is considered excessive.

It is recognised that the one ohm maximum value of direct Earthing installations will be difficult to achieve in the majority of existing installations. The preferred alternative Earthing arrangement should include a continuous metallic return for customers' Earth fault current from an Earth terminal provided and connected by the Company at the customers' supply point to the LV System neutral Earth. This principle is embodied in PME and CEW arrangements. Although PME can readily be adopted for the overhead lines of most **LV Systems**, its application for existing services depends on the condition of the customers' installation. Work on the customers' installation could be as expensive as the measures to meet the one ohm criteria, and in these cases PME is not an acceptable economic solution.

APPENDIX 1

PTE Earthing Check Sheet PTE Name……Ref No…….. Examination Frequency – 8years

Maintenance Checks / Actions (Ref Section R 4 of Maintenance Manual)	**Condition**		**Remedial work date**	**Acceptable Conditions**
	Correct	**Incorrect**		
General : 1. **HV** and **LV** neutral earths at same pole, check to ensure that sufficient separation exists between uninsulated leads				One or both uninsulated – separation 50mm in air; 150mm across wood surface
2. Anti-climbing device; check clear of **HV** and **LV** earths				Must not be bonded to earths
3. Protective capping;				Covers earth leads to a height 2.5m (min) from ground level
3. Aluminium earth wires; check that they do not enter ground				
HV Earth Wires and Bonding 1. Check leads and connections for signs of corrosion or damage				
2. Check conductor size; - Light Lines, BS 1320; 32mm Cu or less - Heavy Lines , above 32mm Cu				Minimum – 16mm (0.25) Cu equivalent Minimum – 70mm (0.1) Cu equivalent

Check Items Bonded to HV Steelwork Earth	Condition		Remedial work date	Acceptable Conditions
	Correct	Incorrect		
1. Transformer tank				At earth stud or bolt between tank and support steelwork
2. Transformer support steelwork				
3. **HV** Cable boxes (Metallic)				Box bonded to support steelwork
4. **HV** Cable sheath				Sheath plumbed to box gland or Flexible lead bonded to support steelwork
5. **HV** fusegear mountings and support steelwork				
6. Steel crossarms and tie straps				Sufficient to have tie straps bonded
7. Pilot insulator pins and brackets				
8. Stay tops				One strand of stay wire to tie strap / crossarm bolt
9. **HV** Air-break switch mountings and support steelwork				Items above operating rod insulator only
10. **HV** Air break switch operating handle and mounting				Bonded to separate earth mat below operating position

LV Neutral Earth Wires and Bonding: Above ground, check leads and connections for corrosion, damage, fixings, etc.	**Condition**		**Remedial work date**	**Acceptable conditions**
	Correct	**Incorrect**		
Check size of earth wire				Min 32mm
Check Items Bonded to LV Neutral				
1. **LV** cable boxes (Metallic)				
2. **LV** Cable sheath				
3. **LV** Fusegear (Metallic mounts)				For all insulated, do not bond coach bolts
4. **LV** Insulator Brackets (‘D’ Irons)				
5. **LV** Stay Tops				
6. Check **HV** Stay Insulator(s) and position of same if applicable				Insulators in stays must be positioned such that if stay broke, part below insulator would not contact live conductors.
7. Check **LV** Stay Insulator(s) and position of same if applicable				As for **HV** stays

APPENDIX 1

Measure Earth Resistance Values	Condition		Remedial work date	Max. Value (Ohms)		
	Correct	Incorrect		Scotland	Manweb	
				At All Locations	25A Fuse Protection	All Other Locations
HV Steelwork Earth (Correct if necessary)				40	11Kv, 40 6.6Kv, 20	11Kv, 20 6.6Kv, 10
LV Neutral Earth (Correct if necessary) 1. Direct **Earthed**				1	1	1
2. CEW (Continuous Earth Wire)				40	20	20
3. PNB (Protective Neutral Bonding, single customer)				40	20	20
4. PME Single Electrode				40	40	40
PME Combined Electrodes				20	20	20