WESTERN POWER DISTRIBUTION

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Company Directive

STANDARD TECHNIQUE: TP21GB/1

Standard Earthing Designs
Part B
Unit Substation Integrated Within A Larger Building

Summary

This Standard Technique describes the standard earthing design to be employed on a 'unit' type substation which is integrated within a larger building and which is to be owned or adopted by Western Power Distribution.

Author: **Graham Brewster**

Implementation Date: **April 2022**

Approved By:

Carl Ketley-Lowe
Engineering Policy Manager

Date: **13th April 2022**

Target Staff Group	**Network Services Teams, Engineering Trainers & ICPs**
Impact of Change	**AMBER - The changes have an impact of current working practices that are not safety critical – Communication at next team meeting or as part of a retraining programme**
Planned Assurance Checks	**Policy Compliance Specialists shall confirm whether the requirements have been complied with during their sample checking of completed jobs**

IMPLEMENTATION PLAN

Introduction

This Standard Technique describes the standard earthing design to be employed on a 'unit' type substation which is integrated within a larger building and which is to be owned or adopted by Western Power Distribution.

This Standard Technique applies where the WPD HV switchgear is close-coupled to a WPD HV/LV transformer and LV cabinet.

This Standard Technique does not apply where the WPD HV switchgear is close-coupled to an IDNO HV/LV transformer & LV Cabinet and the IDNO has responsibility for all of the customers and LV network fed from the substation. In these instances the HV and LV earth electrodes shall be owned, designed, installed and maintained by the IDNO.

Main Changes

- Revised Earthing Design Tool (Version 2)
- Requirements for substations supplying IDNOs aligned with ENA ER G88
- Amendment to definition of 'hot' and 'cold' sites and inclusion of new definitions for 'high EPR' and 'low EPR' sites. All references to 'hot' and 'cold' changed to 'high EPR' and 'low EPR' respectively

Impact of Changes

Target Staff Group	Network Services Teams, Engineering Trainers & ICPs involved with the design and construction of earthing systems for ground mounted distribution substations
Impact of Change	AMBER - The changes have an impact of current working practices that are not safety critical – Communication at next team meeting or as part of a retraining programme

Implementation Actions

- Managers to notify relevant staff that this document has been published
- Relevant staff to watch this Policy Update Briefing
- Former versions of the Earthing Design Tool (i.e. Version 1) should no longer be used
- This document, the associated 'Earthing Design Tool' and the 'Policy Update Briefing' to be made available to ICPs on the www.westernpowertechinfo.co.uk website
- There are no retrospective actions

Implementation Timetable

This ST shall be implemented with immediate effect.

REVISION HISTORY

Document Revision & Review Table		
Date	**Comments**	**Author**
Apr 2022	Issue of Version 1 • Revised Earthing Design Tool (Version 2) • Requirements for substations supplying IDNOs aligned with ENA ER G88 • Amendment to definition of 'hot' and 'cold' sites and inclusion of new definitions for 'high EPR' and 'low EPR' sites in section 2.0. All references to 'hot' and 'cold' throughout the document changed to 'high EPR' and 'low EPR' respectively.	Graham Brewster
Aug 2021	Initial issue	Graham Brewster

Contents

1.0 INTRODUCTION

This Standard Technique describes the standard earthing design to be employed on a 'unit' type substation which is integrated within a larger building and which is to be owned or adopted by Western Power Distribution.

This Standard Technique applies where the WPD HV switchgear is close-coupled to a WPD HV/LV transformer and LV Cabinet.

Where the WPD HV switchgear is close coupled to an IDNO HV/LV transformer and LV Cabinet and the IDNO has responsibility for all of the customers and LV network fed from the substation, the HV and LV earth electrodes shall be owned, designed, installed and maintained by the IDNO. [1]

2.0 DEFINITIONS

For the purpose of this document the following definitions are employed:

TERM	DEFINITION
Unit Substation	A HV/LV substation with close coupling of the HV/LV transformer, HV switchgear and LV cabinet i.e. where the HV switchgear and LV cabinet are bolted to, and supported by, the HV/LV transformer.
Substation Integrated Within A Larger Building	A substation which is contained within, and employs the foundations of, a building or structure used for residential, commercial, institutional or industrial occupancy, or a combination thereof.
Substation Compartment	That portion of the larger building which has been set aside to house the HV/LV substation and which is of a fire-resisting construction.
Cold Site [2]	A site where the potential rise is less than 430V, or less than 650V where the earth fault causing the potential rise is cleared by fast acting, high reliability protection which limits the fault duration to 200ms or less.
Hot Site [2]	A site which is not a cold site. i.e. a site where the potential rise is greater than 430V, or greater than 650V where the earth fault causing the potential rise is cleared by fast acting, high reliability protection which limits the fault duration to 200ms or less.

[1] To align with ENA ER G88

[2] The 430V and 650V values derive from telecommunication standards relating to voltage withstand on equipment. These thresholds were also formerly applied as design limits for EPR, however, they no longer relate directly to safe limits for touch and step potentials

TERM	DEFINITION
Low EPR Site [3]	A site where the potential rise is less than the permissible touch voltage limit or telecommunication equipment limit at third-party LV installations beyond the boundary of the site. In other words, a site where the potential rise is: • Less than 1150V, or less than 1700V [4] where the earth fault causing the potential rise is cleared by fast acting, high reliability protection which limits the fault duration to 200ms or less, and • Less than the touch voltage limit for shoes on soil or outdoor concrete, except where the LV system neutral is connected to earth at multiple locations, in which case the applicable value is less than 2x the touch voltage limit for shoes on soil or outdoor concrete.
High EPR Site [3]	A site which is not a low EPR site. i.e. a site where the potential rise is greater than the permissible touch voltage limit or telecommunication equipment limit at third-party LV installations beyond the boundary of the site. In other words, a site where the potential rise is: • Greater than 1150V, or greater than 1700V [4] where high reliability protection with a fault clearance time less than 200ms is employed, and • Greater than the touch voltage limit for shoes on soil or outdoor concrete, except where the LV system neutral is connected to earth at multiple locations, in which case the applicable value is greater than 2x the touch voltage limit for shoes on soil or outdoor concrete.
Secondary Substation	An 11kV or 6.6kV substation excluding 11kV or 6.6kV switchboards directly associated with a 132kV, 66kV or 33kV transformer.

[3] This is a WPD definition which differs slightly from that in ENA TS 41-24. It is important to ensure that third-party LV installations are not adversely affected by the conveyance of potential via combined HV & LV earthing systems, or by the conveyance of potential via the soil. Mitigating measures are necessary at 'High EPR sites'.

[4] The 1150V and 1700V values are limits for telecommunication equipment derived from ENA EREC S36 and ENA EREP 129.

3.0 REFERENCES

This document makes reference to, or should be read in conjunction with, the documents listed below. The issue and date of the documents listed below shall be those applicable at the date of issue of this document, unless stated otherwise.

3.1 British Standards

NUMBER	TITLE
BS EN 50522	Earthing of power installations exceeding 1 kV ac

3.2 Energy Networks Association

NUMBER	TITLE
ENA TS 41-24	Guidelines for the design, installation, testing and maintenance of main earthing systems in substations
ENA EREC G88	Principles for the planning, connection and operation of electricity distribution networks at the interface between distribution network operators (DNOs) and independent distribution network operators (IDNOs)

4.0 DESIGN REQUIREMENTS

4.1 Preamble

The earthing design requirements in this document are based upon the use of bare earth electrode laid with incoming HV cables to achieve the requisite electrode resistance.

The use of the building foundations as an earth electrode[5] or earth rods which penetrate through the ground floor slab[6] and into the soil beneath is outside the scope of this document. Where this approach is proposed an earthing specialist must be employed to carry out the design.

The earthing design in this document is predicated on the exterior walls and doors of the compartment housing the substation being electrically non-conductive and forming a barrier which prevents anyone external to the compartment from touching any metalwork which is bonded to the substation HV earth electrode.

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[5] Such an earthing design will need to consider the effects of the passage of fault current through the foundations (thermal cracking of concrete), electro-chemical corrosion of earthing conductor (i.e. by concrete or concrete additives, and by connections between dissimilar metals), and other factors which may reduce the efficacy of the earth electrode system (use of waterproof concrete, externally applied bitumen sealing, below slab thermal insulation, below slab damp-proof membranes, dimpled membrane tanking, below slab soil layers formed from recycled materials with poor electrical conductivity etc).

[6] The building owner's consent for these must be sought, and they must also accept responsibility for the measures necessary to prevent groundwater penetration via these points.

In the event that the compartment housing the substation has externally accessible metallic parts then the design requirements specified in the following document shall additionally apply:

- Standard Technique TP21G-I: Standard Earthing Designs - Part I - Additional Requirements For Substations With Externally Accessible Metallic Parts

This document contains an abridged version of the design requirements pertaining to 'unit' substations accommodated within a larger building. Comprehensive earthing design requirements are specified in the following document:

- Standard Technique TP21D-D: Design Of Earthing Systems - Part D - Ground Mounted Distribution Substations.

4.2 Earthing Design Tool

The following Earthing Design Tool (Microsoft Excel Workbook) shall be employed in order to design and analyse the performance of a proposed earthing system for 'unit' type substation incorporated within a larger building.

Earthing Design Tool (TP21G Version 2)

4.3 Principal Requirements For The HV Earth Electrode

The HV earth electrode shall comply with the following principal requirements:

a) The HV earth electrode shall consist of a horizontal electrode laid in a radial direction away from the substation, buried at a depth of 600mm (1000mm in arable land). The electrode shall be insulated where it is laid within the building and be uninsulated (bare) where it is laid in the soil.

b) The conductors employed for the HV earth electrode system shall have a minimum cross sectional area of 70mm^2

c) The HV electrode shall have a resistance not greater than 20Ω for 11kV substations and 15Ω for 6.6kV substations. This resistance shall be determined solely by the installed electrode system i.e. shall not include any parallel contribution from network. [7]

d) The surface area of the HV earth electrode in contact with the soil shall be large enough to prevent the soil around the electrode drying and increasing in resistance during a fault.

e) All equipment / conductive parts within the substation compartment, excluding rebar but including the galvanised steel apron (where installed), shall be bonded to the HV earth electrode.

[7] The parallel contribution from the network can be utilised to reduce the resistance of the HV earth electrode below this 20Ω / 15Ω level.

f) When the doors to the housing are closed, there shall be no metal parts which are bonded to the HV earth electrode which can be touched from outside the housing. [8] [9]

g) When the doors to the housing are open, there shall be an above ground separation of at least 2.5m between any metallic part which is bonded to the HV earth electrode any exposed conductive part[10] or extraneous conductive part[11] located outside of the housing.

h) The earth potential rise shall be 3kV or less.

4.4 Additional Requirements For Combined HV & LV Earth Electrodes ('Low EPR' Sites)

At 'Low EPR' sites (see Section 2.0 above) the following additional earthing requirements will apply:

a) A combined HV & LV earth electrode shall be employed.

b) The HV/LV earth link in the LV Cabinet shall be inserted.

4.5 Additional Requirements For Separate HV & LV Earth Electrodes ('High EPR' Sites)

At 'High EPR' sites (see Section 2.0 above) the following additional earthing requirements will apply:

a) Separate HV & LV earth electrodes shall be employed.

b) The HV/LV earth link in the LV Cabinet shall be removed.

c) HV electrode shall be separated by sufficient below-ground distance from (i) the LV earth electrode, (ii) from customer buildings and enclosures supplied from the LV system, and (iii) from other specified installations[12], in order to ensure that the potential impressed on third party personnel and equipment, in the event of a HV fault or source substation fault, does not exceed safe limits or limits for telecommunication equipment.

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[8] The compartment housing the substation is an integral part of the arrangements for ensuring safety i.e. non-conductive material for the outer walls which prevents earthed metal parts from being touched from outside and extraneous conductive parts being touched from the inside. The substation must not be energised with the compartment walls missing or in a compromised state.

[9] Earthed telecoms aerials/masts require special consideration, especially at 'high EPR' sites. They shall be positioned not less than 2.5m above ground level and not less than 2.5m away from any exposed conductive part or extraneous conductive part.

[10] A conductive part which can be touched and which is not normally live, but which can become live under fault conditions, for example, light switch, electrical equipment enclosure, etc.

[11] A conductive part liable to introduce a potential, generally earth potential, for example, metal fences, crash barriers, etc.

[12] Customer TT electrode, railway, tramway, telephone exchange, pipeline with cathodic protection, outdoor swimming pool, outdoor paddling pool, outdoor shower, zoo, stable, pond/lake used for commercial fishing, buried metalwork associated with the hazardous zone in a fuel filling station.

d) The LV earth electrode shall consist of a horizontal electrode laid in a radial direction away from the substation, buried at a depth of 600mm (1000mm in arable land). It shall be insulated and laid within a 38mm diameter, Class 3, general purpose duct for buried electric cables where it is within the building or within the HV separation distance of the HV earth electrode. The length of the uninsulated / 'bare' section of the LV earth electrode shall never be less than 10m.

e) The conductors employed for the LV earth electrode shall have a minimum cross sectional area of 70mm^2.

f) The LV electrode shall have a resistance as low as is reasonably practicable but not greater than 20Ω for 11kV substations and 15Ω for 6.6kV substations. This resistance shall be determined solely by the installed electrode system.

g) When required by the earthing design, a galvanised steel apron shall be laid in the substation compartment around the HV switchgear, HV/LV transformer & LV cabinet and be bonded to the HV earth bar.

5.0 CONSTRUCTION DRAWINGS

This section contains the following drawings:

5.1 HV Earthing Arrangement

WPD Drawing Number TP21G-B Drg 1 (Revision 1)

5.2 HV Separation Distance

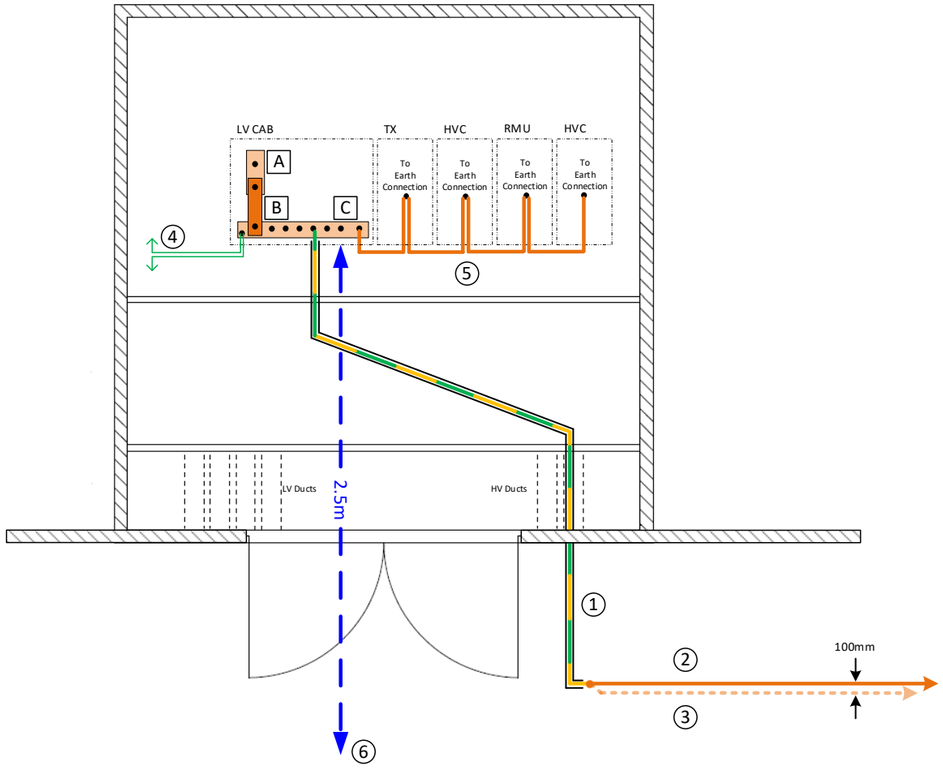
WPD Drawing Number TP21G-B Drg 2

5.3 LV Earthing Arrangement

WPD Drawing Number TP21G-B Drg 3 (Revision 1)

5.4 Galvanised Steel Apron

WPD Drawing Number TP21G-B Drg 4



LV CAB	=	LV Cabinet
TX	=	HV/LV Transformer
RMU	=	Ring Main Unit
HVC	=	HV Cable Box
A	=	LV Neutral Earth Bar
B	=	HV / LV Earth Link – INSERTED on 'low EPR' sites and REMOVED on 'high EPR' sites
C	=	HV Earth Bar
(1)	=	70mm^2 Insulated Stranded Copper Conductor Within Duct For Electrical Cable To Exterior Of Larger Building
(2)	=	70mm^2 Bare Stranded Copper Conductor To Achieve Electrode Resistance And/Or Surface Area Requirement
(3)	=	Conductor (2) Doubled-Up, Or Trebled-Up, When Necessary In Order To Achieve Surface Area Requirement. Laid 100mm Away From Conductor (2) And 'C' Crimped Onto It Adjacent To The Insulated Conductor
(4)	=	16mm^2 Green / Yellow Insulated Stranded Copper Conductor To Metallic Fittings
(5)	=	3x25mm^2 Copper Tape Connections To Earth Points On Plant Items
(6)	=	No extraneous conductive parts within 2.5m reach of any metalwork bonded to HV Earth bar when doors to housing are open

- See WPD Drawing Number TP21G-B Drg 2 for details of HV separation distance
- See WPD Drawing Number TP21G-B Drg 3 for details of LV earthing arrangement
- See WPD Drawing Number TP21G-B Drg 4 for details of galvanised steel apron

NOTES

Electrode (2) to be one continuous length and laid in direct contact with the soil at a depth of 600mm. The electrode shall preferably be laid in same trench as the HV cable, but separated from it by not less than 150mm.

All items of plant to be bonded to the HV Earth bar in the LV Cabinet.

Where metallic fittings are employed (for example, ventilation panels, door frames etc), these shall be bonded to the HV Earth bar using 16mm2, green/yellow PVC insulated, stranded copper conductor.

Resistance of HV earth electrode to be less than 20Ω (11kV) or 15Ω (6.6kV) before HV & LV cables are connected.

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1	GPB			11/21	'Hot' and 'Cold' changed to 'High EPR' and 'Low EPR' respectively

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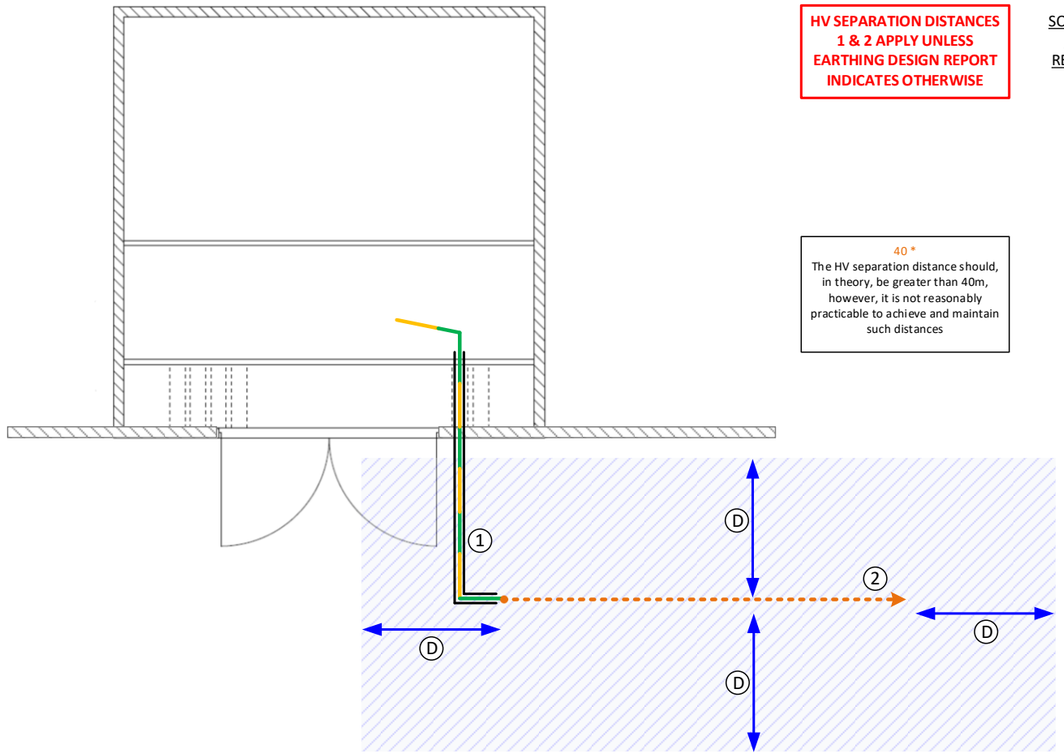
WESTERN POWER DISTRIBUTION

Title: HV Earthing Arrangement For A Unit Substation Integrated Within A Larger Building

Drg. No. TP21G-B Drg 1

Rev No. 1



HV SEPARATION DISTANCES 1 & 2 APPLY UNLESS EARTHING DESIGN REPORT INDICATES OTHERWISE

40 *
The HV separation distance should, in theory, be greater than 40m, however, it is not reasonably practicable to achieve and maintain such distances

SOIL UPPER/ LOWER RESISTIVITY RATIO	HV SEPARATION DISTANCE 1 (m)				HV SEPARATION DISTANCE 2 (m)			
	EPR UPTO 500V	EPR UPTO 1000V	EPR UPTO 2000V	EPR UPTO 3000V	EPR UPTO 500V	EPR UPTO 1000V	EPR UPTO 2000V	EPR UPTO 3000V
10:1	3	3	4	6	3	4	8	12
5:1	3	3	4	6	3	4	8	12
1:1	3	4	8	14	4	8	18	28
1:2	3	6	14	22	6	14	28	40 *
1:3	3	8	18	28	8	18	36	40 *
1:4	3	8	20	32	8	20	40 *	40 *
1:5	3	10	24	38	10	24	40 *	40 *
1:6	3	10	26	40 *	10	26	40 *	40 *
1:7	3	12	30	40 *	12	28	40 *	40 *
1:8	4	12	32	40 *	12	32	40 *	40 *
1:9	4	14	34	40 *	14	34	40 *	40 *
1:10	4	14	36	40 *	14	36	40 *	40 *

NOT PERMITTED WITHIN HV SEPARATION DISTANCE 1:

(1) WPD multiply-earthed LV system (i.e. CNE or SNE derived from CNE) along with buildings and enclosures equipped with an electrical system supplied from this system. This includes any part of bare LV earth electrode, LV PILC / PILCSWA cable, PME electrodes, LV joint electrodes (including stop ends)

NOT PERMITTED WITHIN HV SEPARATION DISTANCE 2:

(1) Railway or tramway

(2) Telephone exchange

(3) Pipeline

(4) Zoo, stable or pond/lake used for commercial fishing

(5) Outdoor swimming pool, outdoor paddling pool or outdoor shower

(6) Customer TT electrode

(7) Buried metalwork associated with hazardous zone in fuel filling station

(7) WPD single-point-earthed LV system (i.e. pure SNE) along with buildings and enclosures equipped with an electrical system supplied from this system. This includes any part of bare LV earth electrode and LV PILC / PILCSWA cable)

KEY

(1) = Insulated & Ducted Section Of HV Electrode

(2) = Bare Section Of HV Electrode

(D) = HV Separation Distance 1 or 2

- See WPD Drawing Number TP21G-B Drg 1 for details of HV earthing arrangement
- See WPD Drawing Number TP21G-B Drg 3 for details of LV earthing arrangement
- See WPD Drawing Number TP21G-B Drg 4 for details of galvanised steel apron

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Title: HV Separation Distance For A Unit Substation Integrated Within A Larger Building

Drg. No.: TP21G-B Drg 2

Rev No.: 0

KEY

LV CAB = LV Cabinet

A = LV Neutral – Earth Bar

B = HV / LV Earth Link

C = HV Earth Bar

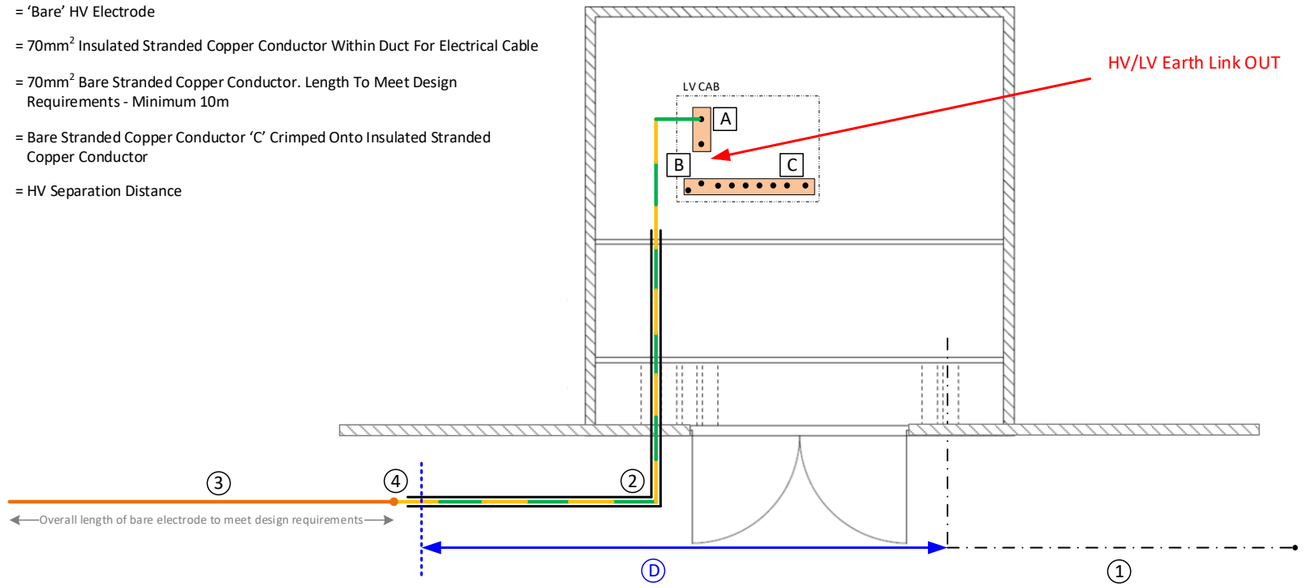
① = 'Bare' HV Electrode

② = 70mm² Insulated Stranded Copper Conductor Within Duct For Electrical Cable

③ = 70mm² Bare Stranded Copper Conductor. Length To Meet Design Requirements - Minimum 10m

④ = Bare Stranded Copper Conductor 'C' Crimped Onto Insulated Stranded Copper Conductor

Ⓓ = HV Separation Distance



Separate LV electrode required if:

- EPR or transfer voltage from source substation > 1150V (or 1700V if fault clearance time is less than 200ms), or
- Duration and magnitude of EPR exceeds following limits

FAULT CLEARANCE TIME (s)	EPR LIMIT FOR LV SYSTEM NEUTRAL EARTHED AT SINGLE POINT (V)	EPR LIMIT FOR LV SYSTEM NEUTRAL EARTHED AT MULTIPLE POINTS (V)
0.2	1570	3140
0.3	1179	2358
0.4	837	1674
0.5	578	1156
0.6	420	840
0.7	332	664
0.8	281	562
0.9	250	500
1.0	233	466
1.1	219	438
1.2	209	418
1.3	200	400
1.4	193	386
1.5	188	376
2	173	346
3	162	324

NOTES

HV/LV earth link [B] removed.

Insulated & ducted section of LV electrode (2) to buried at a depth of 600mm and to terminate no closer to any part of the HV electrode than the HV separation distance.

Bare section of LV electrode (3) to be laid in direct contact with the soil, at a depth of 600mm, and no closer to any part of the HV electrode than the HV separation distance. Overall length of bare electrode to meet the design requirements, with a minimum length of 10m.

Resistance of LV earth electrode to be less than 20Ω (HV=11kV) or 15Ω (HV=6.6kV) before HV & LV cables are connected.

- See WPD Drawing Number TP21G-B Drg 1 for details of HV earthing arrangement
- See WPD Drawing Number TP21G-B Drg 2 for details of HV separation distance
- See WPD Drawing Number TP21G-B Drg 4 for details of galvanised steel apron

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1	GPB			11/21	Voltages when separate LV electrode required amended

Date

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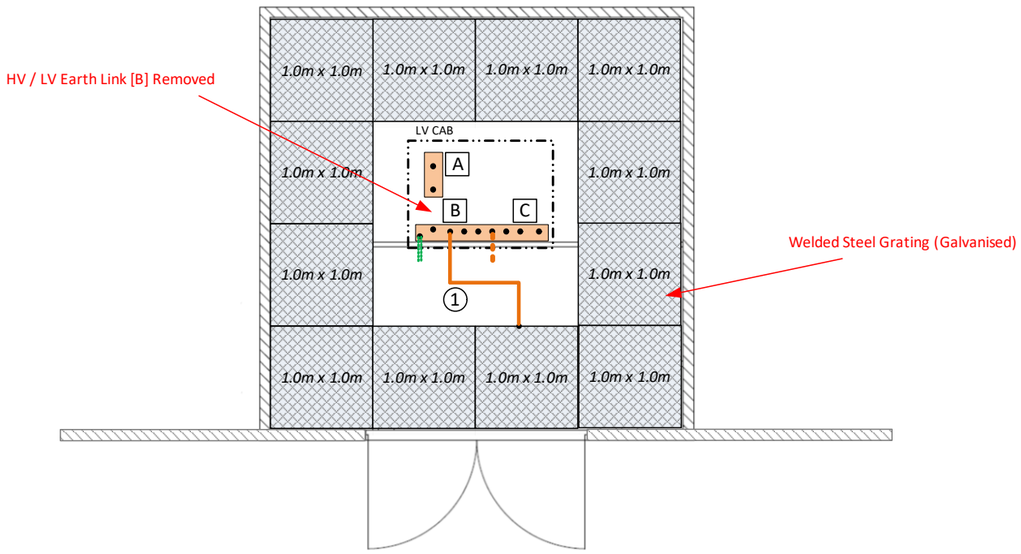
Title: LV Earthing Arrangement For Unit Substation Integrated Within A Larger Building

Drg. No.: TP21G-B Drg 3

Rev No.: 1



- See WPD Drawing Number TP21G-B Drg 1 for details of HV earthing arrangement
- See WPD Drawing Number TP21G-B Drg 2 for details of HV separation distance
- See WPD Drawing Number TP21G-B Drg 3 for details of LV earthing arrangement

NOTES

Galvanised steel grating apron to be installed only when required by earthing design .

Gratings to be bolted together using five stainless steel fixings per side (comprising nut , bolt, two plain washers & spring washer). Mating surfaces of grating to be smeared with contact grease prior to bolting together .

70mm^2 bare stranded copper conductor with copper compression lug on each end to be connected between HV Earth bar and the grating immediately below the RMU / HV switchgear.

LV CAB = LV Cabinet

A = LV Neutral - Earth Bar

B = HV / LV Earth Link

C = HV Earth Bar

1 = 70mm^2 Bare Stranded Copper Conductor

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Title: Galvanised Steel Grating Apron For Unit Substation Integrated Within A Larger Building

Drg. No. TP21G-B Drg 4

Rev No. 0

6.0 CONSTRUCTION REQUIREMENTS

6.1 Preamble

This section should be read in conjunction with the construction drawings in Section 5.0 and the following documents:

- Standard Technique NC1V: Standard Foundation and Enclosure Details and Specifications for HV Substation Plant [13]
- Engineering Equipment Specification 132: Earthing Materials and Associated Sundry Items.

6.2 Common Construction Requirements

The earthing system for unit substations integrated within a larger building shall comply with the following common construction requirements.

6.2.1 HV Electrode System

The location of the HV electrode system shall comply with any HV separation distance requirement.

The HV electrode system shall minimise the number of below ground, and maximise the number of above ground, joints and connections in order to facilitate joint resistance measurements during planned routine maintenance of the earthing system.

6.2.1.1 'HV Earth' Bar

A HV Earth bar (also known as HV Steelwork Earth bar) shall be provided in the LV Cabinet. The earth bar shall be mounted above floor level and shall not restrict access to other equipment.

The earth bar shall be manufactured from copper, have a cross section of not less than 50mm x 6mm, and be provided with six M10 studs at 50mm centres for the connection of cable lugs associated with the HV electrode system.

6.2.1.2 Insulated Section Of HV Electrode

A single continuous length of 70mm^2 insulated, stranded, copper conductor shall be connected to the HV Earth bar and laid radially away from the Unit substation until it is outside the building and in the surrounding soil.

The insulated conductor shall be laid for its entire length in a 38mm diameter, Class 3, general purpose duct for buried electric cables (see Engineering Equipment Specification 113 for further details).

[13] The earthing arrangements are based around drawings EKV0016, EKV0098 and EKV0099.

The insulated conductor and the duct shall be buried at a depth of 600mm (1000mm in arable land) when it is located within the soil.

6.2.1.3 Bare Section Of HV Electrode

A single continuous length of 70mm^2 bare, stranded, copper conductor shall be exothermically welded or 'C' crimped to the end of the insulated conductor at one end, and laid radially away from the Unit substation for the requisite distance in direct contact with soil at a depth of 600mm (1000mm in arable land). The requisite distance shall never be less than 20m.

Where the bare HV electrode is laid in the same trench as a cable, the bare conductor shall be laid not less than 150mm away from the cable.

When required by the earthing design, the bare section of HV electrode shall be doubled-up or trebled-up by laying additional lengths of 70mm^2 bare, stranded, hard-drawn copper conductor in parallel with it. These extra conductors shall be laid 100mm away from the HV electrode and be 'C' crimped onto it adjacent to the start of the bare section.

6.2.2 Rebar

No connection shall be provided between the HV Earth bar and the foundation rebar.

6.2.3 HV Cables & Cable Boxes

All HV cable sheaths / screen wires shall be bonded to the HV Earth bar, as shown in Figure 1 below. The bonding conductors shall have a cross sectional area not less than 70mm^2.

Where a HV cable passes through an earth fault passage indicator (EFI) CT, the cable sheath / screen wires for that cable shall be brought back through the CT before being connected to the HV Earth bar.

It is not acceptable for HV cable sheaths / screen wires to be directly connected to the cable box and rely on a fortuitous connection to the HV earth electrode system.

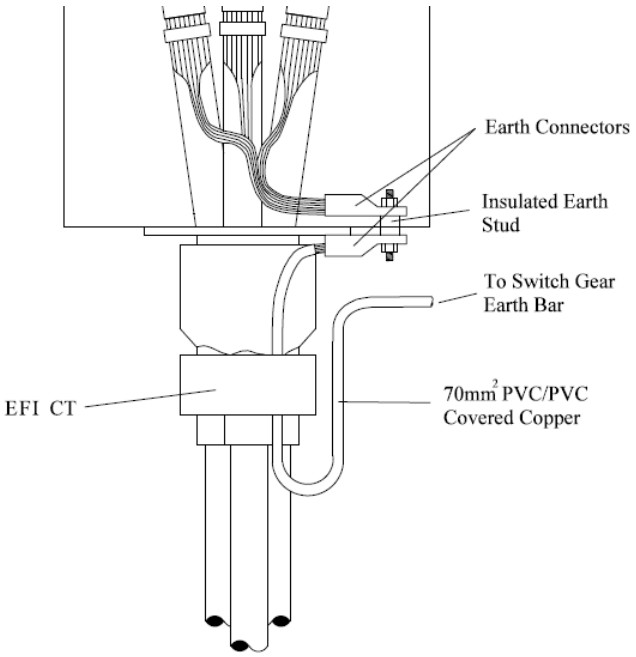


Figure 1: HV Cable Sheath Bonding Arrangement

6.2.4 LV Cables

The outer screen wires of CNE cable shall be connected to the LV Neutral - Earth bar in the LV cabinet, as shown in Figure 2 below.

Both the outer screen wires of SNE cable and the neutral conductor shall be connected to the LV Neutral - Earth bar in the LV cabinet, as shown in Figure 2 below.

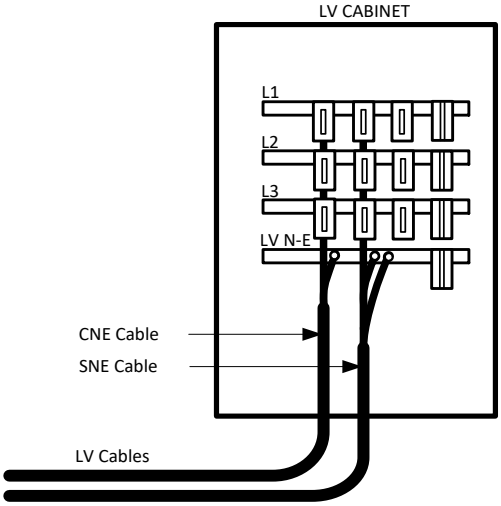


Figure 2: LV Cable Sheath Bonding Arrangement

6.2.5 RMU / HV Switchgear

The RMU / HV switchgear earth terminal shall be bonded to the HV Earth bar. The bonding conductors shall have a cross sectional area not less than 70mm^2.

6.2.6 HV/LV Transformer

The HV/LV transformer earth terminal shall be bonded to the HV Earth bar. The bonding conductors shall have a cross sectional area not less than 70mm^2.

6.2.7 LV Cabinet

The LV cabinet shall be bonded to the HV Earth Bar. The bonding conductor shall have a cross sectional area not less than 70mm^2.

6.2.8 Other Metal Boxes / Cabinets Within The Substation Compartment

6.2.8.1 Metal Boxes / Cabinets Mounted On HV Switchgear, HV/LV Transformer Or LV Cabinet

Metal boxes or cabinets which are bolted to the RMU / HV switchgear, HV/LV transformer, or the LV cabinet are effectively bonded to the HV earth electrode via the equipment they are mounted on. Consequently there is no requirement to provide a discrete bonding cable between the metal box/cabinet and the HV Earth bar.

6.2.8.2 Freestanding Metal Boxes / Cabinets

Metal boxes or cabinets which are freestanding shall be bonded to the HV Earth bar using a minimum of 16mm^2 insulated stranded copper cable.

6.2.9 Substation compartment

The walls and doors of the substation compartment shall be electrically non-conductive.

Small metallic parts that form part of the substation compartment do not need to be bonded to the HV Earth bar.

When the doors to the substation compartment are closed it shall not be possible, from a position outside the substation compartment, to touch any metal parts which are bonded to the HV Earth bar.

6.2.10 Extraneous Conductive Parts Located Outside Of The Substation Compartment

When the doors to the substation compartment are open, there shall be a minimum above ground separation of at least 2.5m between any metallic part which is bonded to the HV Earth bar and any extraneous conductive part[14] located outside of the substation compartment.

6.3 Additional Construction Requirements For Combined HV & LV Earth Electrodes ('Low EPR' Sites)

[14] A conductive part liable to introduce a potential, generally earth potential, for example, metal fences, crash barriers, street lighting columns etc.

The earthing system shall comply with the following additional construction requirements where a combined HV & LV earth electrode is to be employed (i.e. at a 'low EPR' site):

6.3.1 HV-LV Earth Link

The link between the HV Earth bar and the LV Neutral-Earth bar shall be inserted.

6.3.2 LV Electrode System

A separate LV earth electrode system is not required.

6.3.3 Substation LV Auxiliary Power Supplies

LV auxiliary supplies for the unit substation (e.g. for lighting, sockets, etc.) may be derived directly from the LV busbars in the LV cabinet via suitably fused connections.

6.4 Additional Construction Requirements For Segregated HV & LV Earth Electrodes ('High EPR' Sites)

The earthing system shall comply with the following additional construction requirements where segregated HV & LV earth electrodes are to be employed (i.e. at a 'high EPR' site):

6.4.1 HV-LV Earth Link

The link between the HV Earth bar and the LV Neutral-Earth bar shall be removed.

6.4.2 LV Electrode System

A separate LV electrode system is required.

6.4.2.1 Insulated Section

A single continuous length of 70mm^2 insulated, stranded, copper conductor shall be connected to the LV Neutral-Earth bar in the LV cabinet at one end, and laid radially away from the unit substation such that the other end is not closer to any part of the HV earth electrode than the HV separation distance.

The insulated conductor shall be laid for its entire length in a 38mm diameter, Class 3, general purpose duct for buried electric cables (see Engineering Equipment Specification 113 for further details) and at a depth of 600mm (1000mm in arable land).

6.4.2.2 Bare Section

A single continuous length of 70mm^2 bare, stranded, copper conductor shall be exothermically welded or 'C' crimped to the end of the insulated conductor at one end, and laid radially away from the unit substation for the requisite distance in direct contact with soil at a depth of 600mm (1000mm in arable land). The requisite distance shall never be less than 10m.

Where the bare LV electrode is laid in the same trench as a cable, the bare conductor shall be laid not less than 150mm away from the cable.

6.4.3 LV Cables

6.4.3.1 LV PILC Cable

No LV PILC cable shall be located closer to any part of the HV earth electrode than the HV separation distance.

6.4.3.2 LV Joints

No LV joints, including stop ends, shall be located closer to any part of the HV earth electrode than the HV separation distance.

Guidance Note
Note that LV joints which do not have an associated earth electrode would be acceptable within the HV separation distance. However, the option to omit the earth electrode does not currently feature in WPD LV Jointing Procedures.

6.4.3.3 PME Electrodes

No PME electrodes shall be located closer to any part of the HV earth electrode than the HV separation distance.

6.4.4 Other LV Electrode Systems

6.4.4.1 Customer LV Earth Electrodes

No customer earth electrodes (for example, TT electrodes) shall be located closer to any part of the HV earth electrode than the HV separation distance.

6.4.4.2 Other Substation LV Electrodes

In the event that another HV/LV substation is located nearby, then no LV earth electrode or combined HV & LV electrode associated with that other substation shall be located closer to any part of the HV earth electrode associated with the Unit substation than the HV separation distance.

6.4.5 Galvanised Steel Apron

When required by the earthing design, a galvanised steel 'apron' shall be provided around the HV switchgear, HV/LV transformer and LV cabinet.

The apron shall consist of a number of galvanised steel gratings bolted together such that they extend not less than 1m away from any metalwork which is bonded to the HV Earth bar.

The gratings shall be bolted together using five stainless steel fixings per side (comprising nut, bolt, two plain washers & spring washer). Mating surfaces of the gratings shall be smeared with contact grease prior to bolting together.

A length of 70mm^2 bare stranded copper conductor with a copper compression lug on each end shall be connected between the HV Earth bar and the grating immediately below the RMU / HV switchgear.

6.4.6 Substation LV Auxiliary Power Supplies

LV auxiliary supplies for the unit substation shall not be derived directly from the LV busbars in the LV cabinet, but indirectly via a 230V/230V isolation transformer, as shown in Figure 3 below.

The isolating transformer shall be capable of providing 7kV galvanic isolation between its primary and secondary windings in order to ensure HV and LV earthing systems are segregated.

The isolating transformer shall have a VA rating in excess of the maximum anticipated LV auxiliary supply load. Standard values used by WPD include 500VA (2A), 3.7kVA (16A) and 7.4kVA (32A).

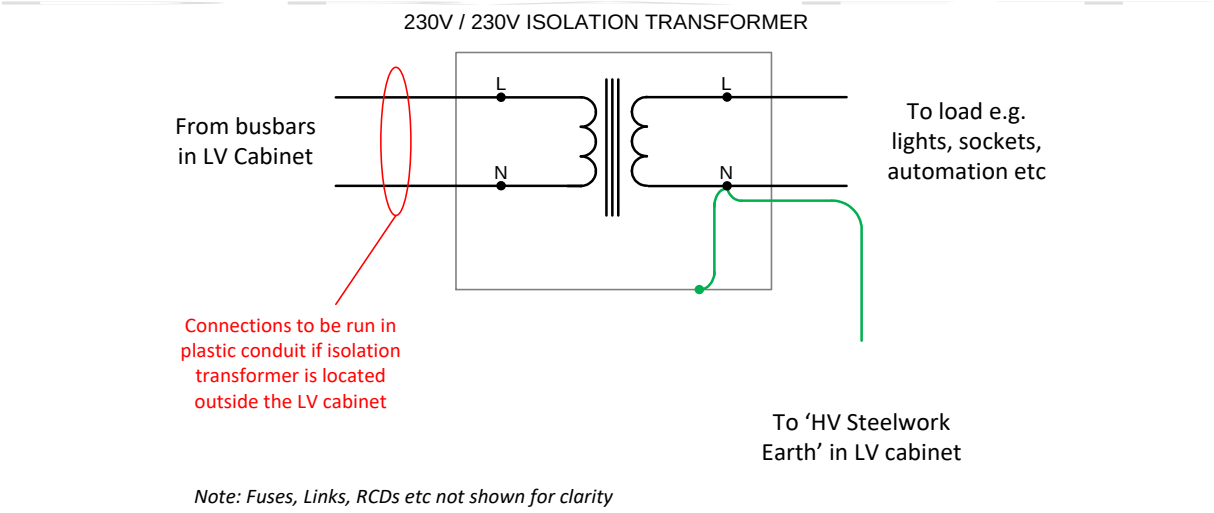


Figure 3: Isolation Transformer Arrangement

7.0 COMMISSIONING REQUIREMENTS

The earthing system associated with the unit substation shall be commissioned in accordance with Standard Technique TP21T-A: Commissioning of Earthing Systems - Part A - Ground-Mounted Secondary System Substations.

The commissioning tests shall include the following:

a. The resistance of the complete HV electrode shall be measured prior to the connection of any HV or LV cable onto the unit substation. For 11kV substations the measured resistance shall be 20 ohms or less, and for 6.6kV substations the measured resistance shall be 15 ohms or less.

b. Where a separate LV electrode is required, the resistance of the complete LV electrode shall be measured prior to the connection of any HV or LV cable onto the unit substation. For 11kV substations the measured resistance shall be 20 ohms or less, and for 6.6kV substations the measured resistance shall be 15 ohms or less.

c. Where a separate LV electrode is provided, the resistance of the HV and LV electrodes connected in series shall be measured prior to the connection of any HV or LV cables onto the unit substation. The HV and LV electrodes are adequately separated when the measured resistance is not less than 0.9x the sum of the resistances measured in a. and b. above.

d. The resistance of the complete HV electrode shall be measured again once all HV and LV cables have been connected to the unit substation. The measured resistance shall be not greater than the calculated design value for the substation.

Electrode resistance measurements shall be carried out in accordance with Standard Technique TP21O-B: Earthing System Measurements - Part B - Electrode Resistance.

Electrode separation tests shall be carried out in accordance with Standard Technique TP21O-F: Earthing System Measurements - Part F - Electrode Separation Tests.

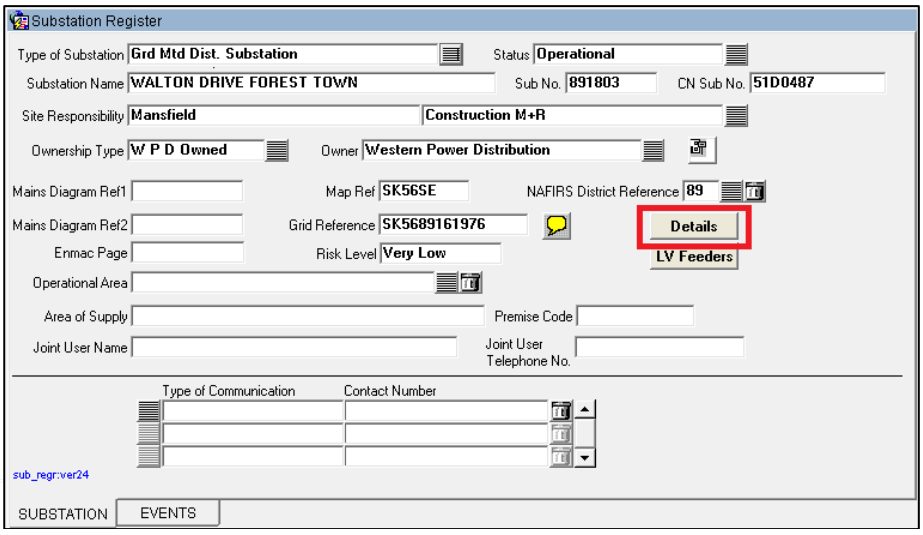
8.0 RECORDS

8.1 CROWN Records

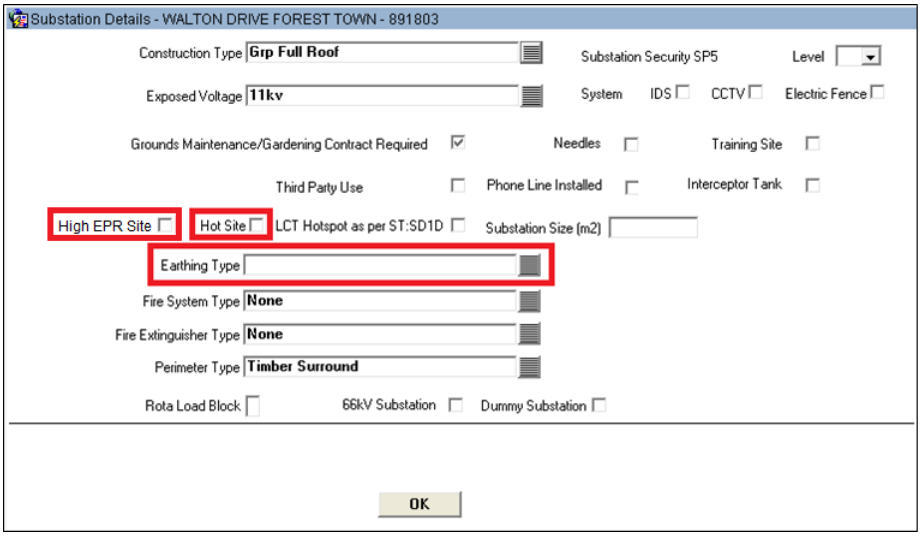
A copy of the 'Earthing Design Report' for the unit substation shall be included within 'DOCS' against the 'Commission' event for the Substation Register, following the process shown below:

a) In CROWN select 'Asset Management' and then 'Substations'. Click on 'Action' and then 'Find'. Search for the unit substation.

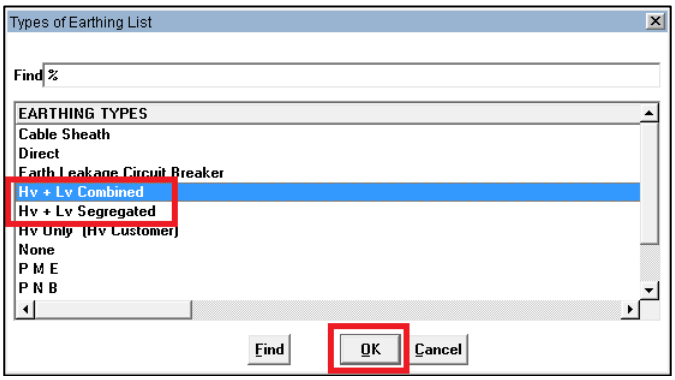
b) On the 'Substation Register' for the site and click on the 'Details' button.



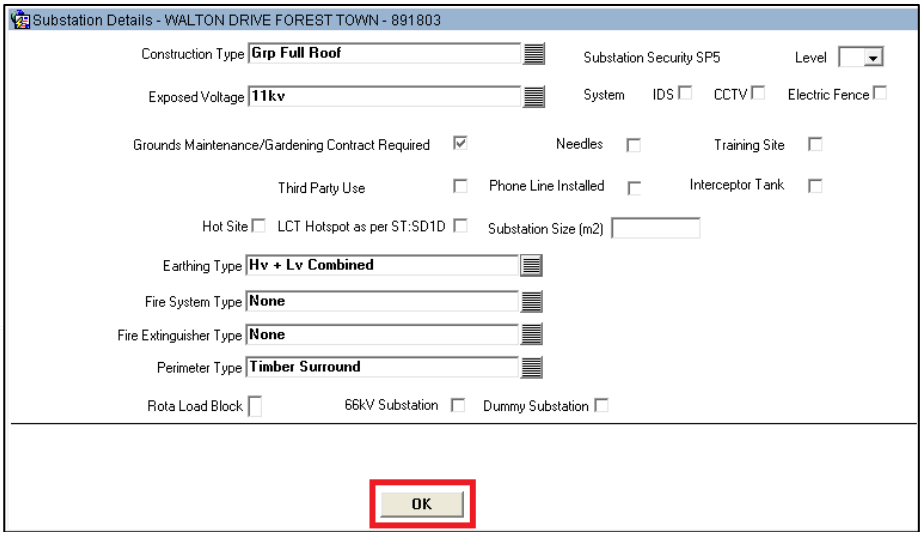
c) Check the 'High EPR Site' and 'Hot Site' boxes (where applicable). Click on the list of values (LOV) adjacent to 'Earthing type'.



d) Select either ‘Hv + Lv Combined’ or ‘Hv + Lv Segregated’ from the drop down list (as applicable) and click ‘OK’.

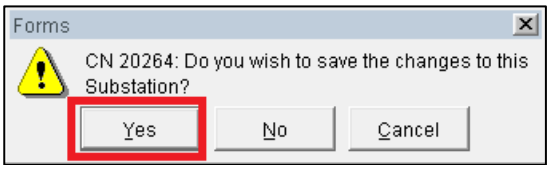


e) Click ‘OK’.

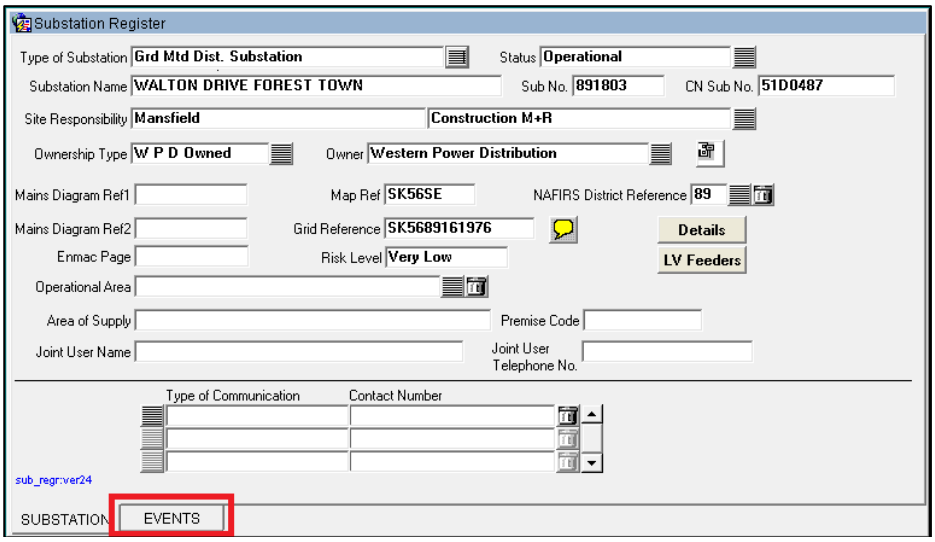


f) Click ‘Action’ and then ‘Save’.

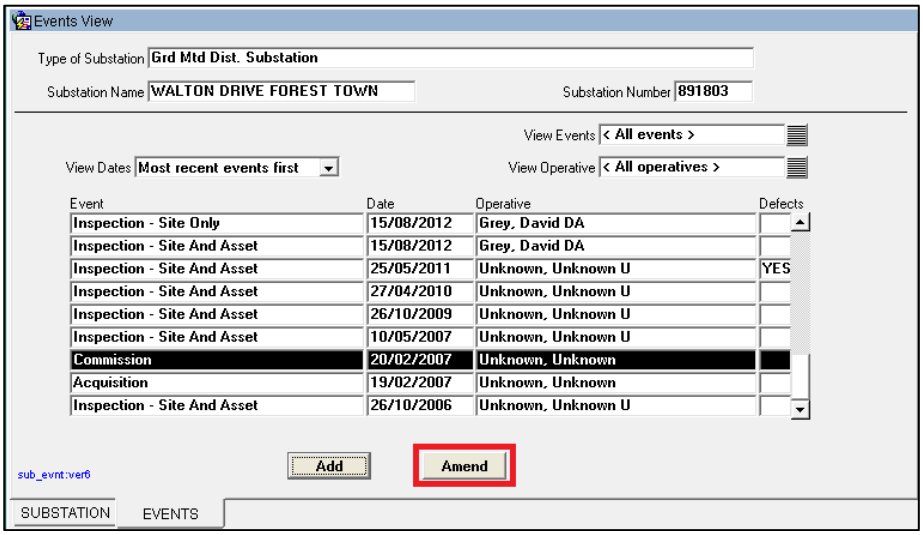
g) Click ‘Yes’ to confirm.



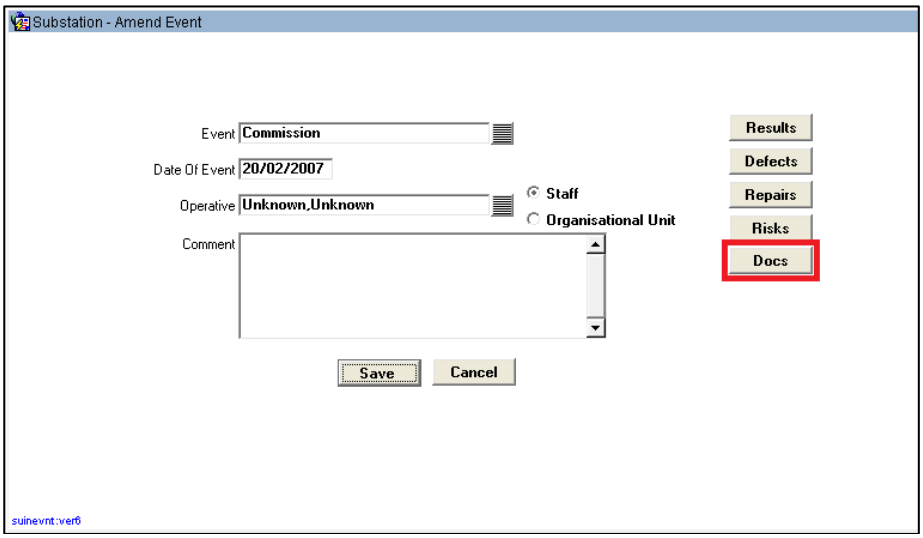
h) Click on the ‘events’ tab



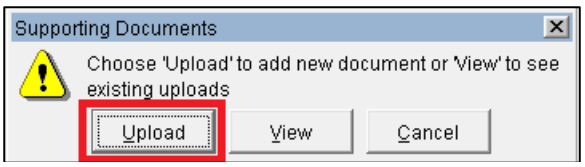
i) Select the ‘Commission’ event and click on the ‘Amend’ button



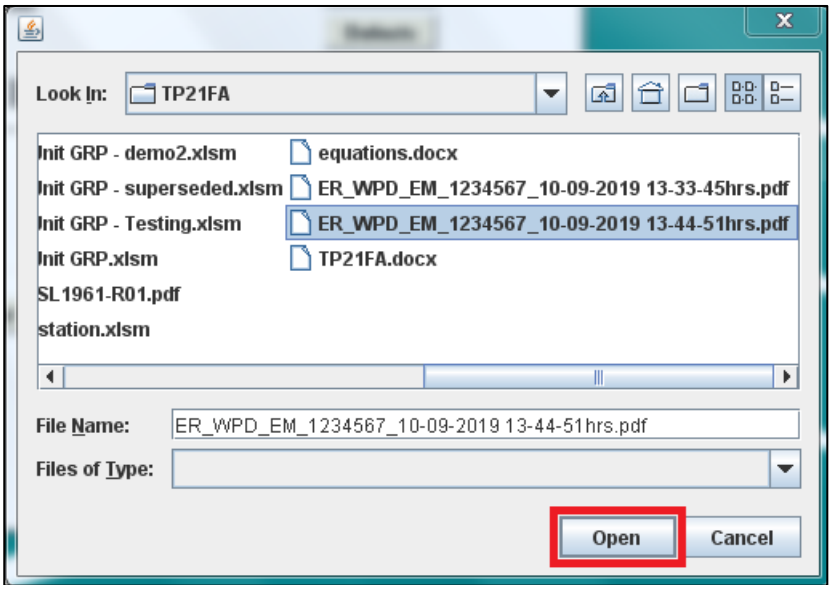
j) Click on the ‘Docs’ button



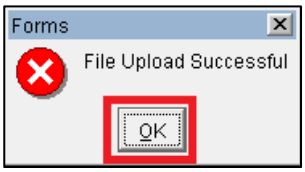
k) Click on the ‘Upload’ button



l) Find the Earthing Design Report in the folder system and click on the ‘Open’ button



m) Click ‘OK’ button to acknowledge.



8.2 EMU Records

The route of HV and LV earth electrodes shall be recorded in EMU using the same methodology employed for cables.

The following information shall be recorded immediately adjacent to the HV earth electrode:

- The ‘as commissioned’ resistance of the complete HV electrode system prior to the connection of any HV or LV cable onto the unit substation.
- The HV separation distance

The following information shall be recorded immediately adjacent to the LV earth electrode:

- The ‘as commissioned’ resistance of the complete LV electrode system prior to the connection of any LV cable onto the unit substation

APPENDIX A

SUPERSEDED DOCUMENTATION

This document supersedes ST: TP21GB dated June 2021 which has now been withdrawn.

APPENDIX B

RECORD OF COMMENT DURING CONSULTATION

No comments received.

APPENDIX C

ANCILLARY DOCUMENTATION

POL: TP21 Fixed Earthing Systems

APPENDIX D

KEYWORDS

Design; Standard; Earthing; Distribution; Substation; Ground; Mounted; Masonry; Brick; Block; Stone;