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NSP/007/005 – Guidance on Substation Design: Electrical Design Clearances

1. Purpose

The purpose of this document is to provide guidance on the application of electrical clearances to the design of substations containing exposed high voltage conductors and intended for connection to the Northern Powergrid network. This document has been prepared to satisfy the requirements of the Construction (Design and Management) Regulations (2015) ('CDM'), the Management of Health and Safety at Work Regulations (2014) and the Electrical Safety, Quality and Continuity Regulations (2006) ('ESQCR').

This document supersedes the following documents, all copies of which should be destroyed.

Reference	Version	Date	Title
NSP/007/005	2.0	Feb 2018	Guidance on Substation Design: Electrical Design Clearances

2. Scope

This document applies to the design of all substations intended for connection to the Northern Powergrid network and containing exposed HV conductors.

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3. Design Clearances

3.1. Introduction

Design clearances are set to allow safe access to outdoor compounds for routine operation, maintenance and repair work during the life of the substation. Design clearances shall be applied from exposed conductors and fixed access platforms or access ways within the substation. The Safety Clearances and Working and Access Clearances defined in the Distribution Safety Rules are an absolute requirement within the substation design.

Substation layouts shall ensure that sufficient clearances are maintained between conductors, equipment, buildings and fences to allow the safe installation and maintenance of plant without unnecessary interruption of supplies.

3.2. Principles

Design clearances are based on the requirements of the Northern Powergrid Distribution Safety Rules (DSR) and the recommendations of BS EN 61936-1 (2021) Table 2, in line with the impulse withstand voltages specified in IEC 60071-1:2019 Table 2.

Personal reach details have been carried forward from BS 7354 (1990).

Certain clearances have been enhanced above the figures specified in BS EN 61936-1 as described in later sections.

Table 1 - Design Clearances

Nominal System Voltage (Phase to Phase)	132kV	66kV	33kV	20kV	11kV
Standard Busbar Centres (mm)	2440 preferred 3050 to match existing	1675	1220	N/A	N/A
Live Metal & Earth (mm) (Basic electrical clearance - phase to earth)	1300	630	320	270	160
Phase to Phase clearance (mm)	1300	630	320	270	160
Vertical Safety Clearance (mm)	3800	3100	2900	2900	2900
Insulation Height (mm) (pedestrian access)	2400	2400	2400	2400	2400

3.3. Vertical Design Clearance

Two vertical design clearances are specified in Table 1:

- **Vertical Safety Clearance** - This is the distance from the substation datum or any raised area on which a person could stand to LIVE conductors (the basic electrical clearance from Table 2 of BS EN 61936-1 + vertical personal reach).

Note: the vertical safety clearances in Table 1 have been increased from their minimum values to match the previous version of this document, this is to avoid changing clearances that have already been established over recent years.

- **Insulation Height (pedestrian access)** - This is the distance from the bottom of any insulator supporting live conductors to the substation datum, or any adjacent raised area on which a person could stand. (see also 3.4 Personal Reach - horizontal reach).

In extreme cases where the specified design clearances cannot be achieved, then alternative arrangements such as the use of earthed metal screens, or special enclosures shall be incorporated into the design to

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maintain safety. Such situations should be risk-assessed and special measures agreed, documented and carried forward through the CDM process.

The minimum phase-to-earth and phase-to-phase clearances are specified in Table 1, they are taken from BS EN 61936-1:2021 Table 2 using the system impulse levels detailed in Table 2 of IEC 60071-1:2019.

3.4. Personal Reach

The vertical reach of a person with up stretched hand should be taken as 2.4m as detailed in Clause 5.2.5 of BS7354.

The horizontal reach should be taken as 1.4m as detailed in Clause 5.2.5 of BS7354.

3.5. Design Clearances for Working Access

Design clearances shall be related to typical routine maintenance or repair work necessary during the life of the substation, taking into account the fixed and portable access equipment required to carry out the works safely and in accordance with the DSR.

Where the design incorporates vehicular access within a live compound, the area required must allow for the **safe working and access clearance** to be maintained. This should be measured from the side of the vehicle.

Where it is not reasonably practicable to achieve the preferred horizontal clearance due to lack of space a reduced clearance may be selected from Table 2. Where a reduced clearance is used, the effect on future operation and maintenance in the substation must be risk-assessed and special measures agreed, documented and carried forward through the CDM process.

Table 2 - Design Clearances for Working Access

	Preferred Horizontal Design Clearance (m)	Reduced Horizontal Design Clearances (m)			
Nominal System Voltage	Allows for larger portable access equipment such as mobile elevated work platforms. Note 4	Allows for larger portable access equipment such as scaffolding. Note 3	Allows for light portable access equipment (e.g. step ladders) only. Note 2	No portable access equipment allowed in work zone. Note 1	Delineated barrier work zone. Clearance 'C' in Table 4 of Distribution Safety
Up to 33kV	7.3	3.8	3.3	3.05	2.3
66kV	7.5	4.0	3.5	3.25	2.5
132kV	7.9	4.4	3.9	3.65	2.9

Note:

Design clearances listed in Table 2 comprise basic Working and Access Clearance listed in the DSR plus the following factors:

- 1) Additional 0.75m where no portable access equipment is required.

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- 2) Additional 1.0m where the use of light portable access equipment such as step ladders is required.
- 3) Additional 1.5m where the use of larger portable access equipment such as scaffolding, staging boards, or ladders, are required.
- 4) Additional 5.0m where the use of larger portable access equipment such as Mobile Elevated Work Platforms (MEWPs), scaffolding, staging boards or ladders, are required.

3.6. Existing Substations

Existing substations may have been designed to earlier standards (BS162 or BS7354) using a radial design clearance. Retrospective application of the clearances specified in this document is not necessary unless an on-site risk assessment, or a design review associated with a new project indicates that a dangerous situation could occur resulting from the existing design. Although new work in an existing substation should use the clearances specified in this document, any reduction in clearance shall be considered on a project basis by the designated Principal Designer and Electrical Designer as required by the CDM regulations.

3.7. Wildlife and Windborne Debris

The minimum distance between any 2 outdoor terminations or insulators irrespective of phase or voltage shall be 360mm, this measurement should be taken from the closest point between the two terminations or insulators, this is to prevent problems associated with: birds perching or building nests on the conductors, vermin and other animals or windborne debris.

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4. References

4.1. External Documentation

Reference	Title
BS 162	Specification for Electric Power Switchgear and Associated Apparatus
BS 7354 (1990)	Code of Practice for Design of High Voltage Open Terminal Stations
BS EN 61936-1 (2021)	Power installations exceeding 1 kV AC and 1,5 kV DC
IEC 60071-1 (2019)	Insulation co-ordination

4.2. Internal Documentation

Reference	Title
DSR	Northern Powergrid Distribution Safety Rules

4.3. Amendments from Previous Version

Reference	Description
NSP 007/005 V3.0	References added/updated. Some text rewritten and notes added. 20kV phase-phase and phase-earth is now 270mm

5. Definitions

Reference	Definition
n/a	n/a

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6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	11/03/2024

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years	Non Standard Review Period & Reason	
Yes	Period: n/a	Reason: n/a
Should this document be displayed on the Northern Powergrid external website?		Yes
		Date
Mark Thompson	Major Projects Specification and Design Manager	13/03/2024

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Mark Hague	Substation Design Engineer	13/03/2024

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Dave Sillito	Head of Major Projects	21/03/2024

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Appendix 1 – Summary of Electrical Clearances Employed in Northern Powergrid

<u>Table 3 – 11kV & 20kV Clearances</u>	Clearance (mm)	Source
Basic Electrical Clearance Phase to Earth	160mm	11kV BS EN 61936-1:2021 Table 2
	270mm	20kV BS EN 61936-1:2021 Table 2
Safety Distance	800mm	DSR section 4.4.1 table 1 distance 'X'
Application Factor	2100mm	DSR Appendix D - Paragraph 1
Personal Vertical Reach	2400mm	BS7354 Section 5.2.5
Personal Horizontal Reach	1400mm	BS7354 Section 5.2.5
Insulation height pedestrian access	2400mm	BS162 & BS7354
Design Clearance Vertical - Working & Access Clearance	2900mm	DSR Appendix D - Table 4 Column E

<u>Table 4 - 33kV Clearances</u>	Clearance (mm)	Source
Basic Electrical Clearance Phase to Earth	320mm	BS EN 61936-1:2021 Table 2
Safety Distance	800mm	DSR section 4.4.1 table 1 distance 'X'
Application Factor	2100mm	DSR Appendix D - Paragraph 1
Personal Vertical Reach	2400mm	BS7354 Section 5.2.5
Personal Horizontal Reach	1400mm	BS7354 Section 5.2.5
Insulation height pedestrian access	2400mm	BS162 & BS 7354
Design Clearance Vertical - Working & Access Clearance	2900mm	DSR Appendix D - Table 4 Column E

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<u>Table 5 - 66kV Clearances</u>	Clearance (mm)	Source
Basic Electrical Clearance Phase to Earth	630mm	BS EN 61936-1:2021 Table 2
Safety Distance	1000mm	DSR section 4.4.1 table 1 distance 'X'
Application Factor	2100mm	DSR Appendix D - Paragraph 1
Personal Vertical Reach	2400mm	BS7354 Section 5.2.5
Personal Horizontal Reach	1400mm	BS7354 Section 5.2.5
Insulation height pedestrian access	2400mm	BS162 & BS 7354
Design Clearance Vertical - Working & Access Clearance	3100mm	DSR Appendix D - Table 4 Column E

<u>Table 6 - 132kV Clearances</u>	Clearance (mm)	Source
Basic Electrical Clearance Phase to Earth	1300mm	BS EN 61936-1:2021 Table 2
Safety Distance	1400mm	DSR section 4.4.1 table 1 distance 'X'
Application Factor	2100mm	DSR Appendix D - Paragraph 1
Personal Vertical Reach	2400mm	BS7354 Section 5.2.5
Personal Horizontal Reach	1400mm	BS7354 Section 5.2.5
Insulation height pedestrian access	2400mm	BS162 & BS 7354
Design Clearance Vertical - Working & Access Clearance	3500mm	DSR Appendix D - Table 4 Column E