

# **Transmission Owners Applicable Electrical Standard NGET, SHETL & SPT**

## **Version History**

<b>Version</b>	<b>Date</b>	<b>Amendment</b>
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## Contents

1.	Introduction.....	6
1.1	Background and Purpose.....	6
1.2	Scope.....	6
1.3	Objectives .....	6
2.	Interface Zone.....	7
2.1	Interface Zone Description.....	7
2.2	Interface Zone Requirements .....	8
3.	Reference and Related Documents .....	9
3.1	Legislation .....	9
3.2	Standards.....	10
3.3	ENA Specifications & Engineering Recommendations .....	12
3.4	Operational Health & Safety Documents .....	13
3.5	National Energy System Operator (NESO) Codes .....	14
3.6	Other Documents .....	<b>Error! Bookmark not defined.</b>
4.	Climatic & Environmental.....	14
4.1	Indoor Requirements .....	14
4.2	Outdoor Requirements.....	14
4.3	Pollution .....	14
4.4	Altitude.....	14
4.5	Exposure to Abnormal Vibrations, Shock or Tilting .....	14
4.6	Wind Load .....	14
4.7	Ice Load.....	15
4.8	Flood Resilience .....	15
4.9	Environmental impact .....	15
5.	Electrical System .....	16
5.1	System Voltage .....	17
5.2	Rated Insulation Level.....	17
5.3	Rated Frequency.....	18
5.4	Rated Continuous Current.....	18
5.5	Rated Short-circuit and Short-time Withstand Current.....	19
5.6	Substation Auxiliary Supplies .....	19
5.6.1	DC Auxiliary Supply Requirements .....	19
6.	Substation.....	20
6.1	Design Clearances .....	20

6.2 Earthing.....	21
6.3 Interlocking .....	22
6.3.1 Interlocking Switchgear .....	22
6.3.2 Interlocking Protection .....	23
6.4 Security.....	24
6.5 Conductor Jointing in Substations .....	24
6.6 Insulation and Interruption Gases (IIG) .....	24
6.7 Ancillary Equipment .....	24
6.8 Maintenance .....	24
7. Bushings & Insulators.....	25
7.1 Bushings .....	25
7.1.1 Bushing Specifications.....	25
7.1.2 Bushing Design & Construction .....	25
7.2 Post Insulators .....	25
7.2.1 Post Insulator Standards .....	25
7.2.2 Insulators Design & Construction .....	25
7.2.3 Insulators Type Tests .....	25
7.2.4 Insulators Routine Tests .....	26
8. Cables.....	26
8.1 Cable Standards & Specifications.....	26
8.2 Cable Design & Construction .....	26
8.3 Earthing and Bonding of High Voltage Power Cables .....	26
8.4 Cable Installation & Commissioning .....	27
9. Instrument Transformers .....	27
9.1 Current Transformers (CTs).....	27
9.1.1 CT Specifications.....	27
9.1.2 CT Design & Construction .....	28
9.1.3 CT Routine Tests .....	28
9.2 Voltage Transformers (VTs) .....	<b>Error! Bookmark not defined.</b>
9.2.1 VT Specifications.....	<b>Error! Bookmark not defined.</b>
10. Protection & Control .....	28
10.1 Protection Types .....	28
10.1.1 Protection Environmental Requirements .....	29
10.1.2 Protection Functional Requirements .....	29
10.1.3 DC Trip Relay Requirements.....	29
10.1.4 Tele-protection Communications .....	29

10.2	Circuit-Breaker Fault Protection and Clearance Times .....	30
10.3	Multi-Pole Opening/Tripping and Auto-Reclosing .....	30
10.4	Dynamic System Monitoring.....	<b>Error! Bookmark not defined.</b>
10.5	SCADA .....	30
11.	Surge Arrestors.....	31
11.1	Surge Arrestors Standards & Specifications .....	31
11.2	Surge Arrestors Design & Construction .....	<b>Error! Bookmark not defined.</b>
12.	Switchgear .....	31
12.1	Switchgear Ratings .....	31
12.2	Gas Insulated Switchgear (GIS) .....	31
12.2.1	GIS Standards & Specifications .....	31
12.2.2	GIS Design & Construction .....	31
12.3	Circuit-Breakers .....	33
12.3.1	Circuit-Breaker Standards & Specifications .....	33
12.3.2	Circuit-Breaker Design & Construction .....	33
12.3.3	Circuit-breaker Type Test.....	33
12.4	Disconnectors & Earthing Switches .....	33
12.4.1	Disconnectors & Earthing Switches Standards & Specifications .....	33
13.	Transformers & Reactors.....	35
13.1	Transformer & Reactor Standards & Specifications .....	35
13.2	Transformer & Reactors Design & Construction.....	35
13.3	Transformer & Reactor Type Test.....	35
13.4	Protection Against Leakage of Insulating Liquid.....	35
14.	Abbreviations & Conventions .....	36
15.	TSO Sign-Off.....	38

## Tables

Table 1 — Apparatus Voltage Requirements .....	17
Table 2 — Rated Insulation Level Requirements.....	18
Table 3 — Typical Continuous Current Requirements.....	19
Table 4 — Maximum rated Short-Circuit Current Requirements.....	19
Table 5 — Typical Operating Voltages and Auxiliary Control Circuits .....	20
Table 6 — Substation Design Clearances .....	21
Table 7 — Neutral Earthing Requirements .....	21
Table 8 — Protection Function Testing Compliance Requirements .....	29
Table 9 — Circuit-Breaker Fault Clearance Times.....	30
Table 10 — Transformer Test Voltages .....	<b>Error! Bookmark not defined.</b>
Table 11 — Abbreviations, Terms and Definitions .....	36

## Figures

Figure 1 – Electrical boundary for Gas Insulated Switchgear.....	8
Figure 2 — Disconnecter Auxiliary Switch Positions in Relation to Main Contact Position .....	34

# 1. Introduction

## 1.1 Background and Purpose

This Applicable Electrical Standard (AES) defines relevant standards, specifications and Engineering Recommendations for Users to follow when connecting or seeking connection to the National Electricity Transmission System (NETS) as set out under CC.6.2.1.2 of the Grid Code Connection Conditions (CCs) or ECC.6.2.1.2 of the European Connection Conditions (ECCs), and as applicable and pursuant to the terms of any Bilateral Agreement.

Hereafter, this Applicable Electrical Standard will be referred to as ‘this document’.

It is important that all users demonstrate that electrical infrastructure directly connected to the NETS is fit for its intended purpose and shall be maintained as required in CC.7.7 or ECC.7.7 of the Grid Code. It shall comply with both statutory and GB Grid Code requirements, and comply with the requirements contained within this document.

NGET, SHET and SPT comprise the majority of the GB’s Onshore Transmission Owners (TOs) and have produced this common document. This document defines the performance requirements and minimum technical requirements for Plant and Apparatus directly connected to the NETS within the interface zone

This document applies to transmission connected Users in GB that have a Bilateral Agreement with NESO

## 1.2 Scope

The scope of this document applies to all onshore AC electrical infrastructure connected to the NETS in GB.

The requirements of this document apply only to Plant and Apparatus owned by the User within the interface zone and directly connected to Assets owned by NGET, SHETL or SPT (see Section 2 of this document).

The requirements of this document do not apply to Plant and Apparatus which are installed by the User to be adopted by the TO.

The key requirement of this document is to ensure that network performance is maintained within design requirements.

## 1.3 Objectives

The objective of this document is to set standards of apparatus so that it provides a satisfactory level of reliability and security for the NETS within the interface zone. This document provides the minimum criteria to ensure that Users’ Plant and Apparatus directly connected to the NETS meets at least the same standard of construction, manufacturing and installation quality as that employed consistently by GB TOs. This also ensures compatibility and interoperability between the TO and User.

The objective of this document is to ensure:

- i) a single common set of requirements apply across GB TOs; and

- ii) Plant and Apparatus owned by the User does not pose a risk to the GB NETS in terms of ensuing a satisfactory level of reliability and network security and provides the minimum strength and capability requirements; and
- iii) the safety of personnel working at the electrical boundary or across the electrical boundary; and
- iv) there is minimisation of risk to TOs' personnel within ownership boundaries at shared sites.

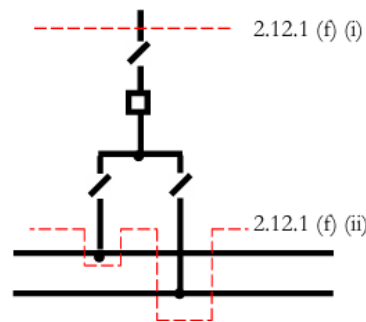
This document is not a “purchasing specification” and it is the responsibility of any Users to have their own appropriate design and specification(s).

## 2. Interface Zone

### 2.1 Interface Zone Description

The interface zone is defined as the User's network in the protection zone between the electrical boundary as defined in Section 2.12 of the CUSC (or any contrary agreement in the Bilateral Agreement or any other agreement on the division of ownership) and the User's circuit-breaker(s). The Plant and Apparatus in this zone shall be electrically protected by both parties.

The Plant and Apparatus in the interface zone and protected by the TO shall be restricted to busbars, cables or transformers.



**Figure 1 –Indicative Electrical**

In the case of Gas Insulated Switchgear (GIS), the electrical boundary shall be as defined in Section 2.12.1 (f) (i) of the CUSC and as shown in Figure 1 above.

The Bilateral Agreement may define further specific requirements, with respect to Plant and Apparatus , which are not defined in this document that shall also be complied with

## 2.2 Establishing the Interface Zone

The interface agreement shall be defined as part of the Bilateral Agreement and shall be in accordance with Section 2.11 of the CUSC.

The TO will propose the division of ownership and determine the extent of an interface zone as part of the relevant Transmission Owner Connection Agreement (TOCA) which is reflected in the Bilateral Agreement between NESO and the User.

The TO's electrical boundary of the interface zone will depend on the asset type, i.e.:

- i) Air Insulated Switchgear (AIS); or
- ii) Gas Insulated Switchgear (GIS); or
- iii) metal enclosed switchgear that is not GIS.

## 2.3 Functional Requirements

The User shall retain ownership and asset management responsibility of all assets owned by the User within the interface zone for the lifetime of the asset.

The User shall not rely on the TO's circuit-breaker(s) and associate protection to be the sole means of protecting the User's network beyond the interface zone.

The User shall not solely rely on isolation and earthing facilities to be provided by the TO's Plant and Apparatus .

The User shall also provide suitable and appropriate facilities for safe isolation and earthing of Plant and Apparatus to ensure safety from the system for work in the interface zone as required.

The User's shall have a means of isolation, earthing and a point of testing to allow operation and maintenance of the User's network beyond the interface zone to be carried out by the User. This shall not be dependent on the TO's attendance at site.



Where work is required on either TO's assets or the User's asset within the interface zone, attendance from both the TO's personnel and the User's personnel shall be provided.

## 2.4 Users Apparatus

For all Users Apparatus applicable in this document, the following applies:

- i) All assets in the interface zone shall, as far as practicable, conform to published national and international standards and, as required, by appropriate legislation. These assets shall be suitable under the conditions in which they are used to minimise risk to staff. This requirement shall also apply to Users assets beyond the interface zone which are located within the boundary of the TO's property; and
- ii) Apparatus shall be manufactured in manufacturing facilities certified by a recognised accreditation organisation to ISO 9001; and
- iii) the User shall have in place, or be working towards, installation of Management systems compatible with the International Environmental Management System Standard ISO 14001; and
- iv) all electrical infrastructure shall meet statutory requirements for safety as specified in Clause 3 of this document; and
- v) it is the User's responsibility to ensure that their installation and commissioning meets the minimum requirements as agreed by each TO and does not pose a risk to the NETS. The TO reserves the right to witness commissioning of all Apparatus in the interface zone.

## 3. Reference and Related Documents

The principles of design, manufacture, testing and installation of transmission electrical infrastructure, including quality requirements, shall conform to applicable statutory obligations and shall comply with relevant International, European and British Standards. Maintenance requirements shall be in accordance with CC.7.7 or ECC.7.7 of the Grid Code.

This document takes precedence over International, European and British Standards requirements.

It is important that Users ensure that they are applying the most recent editions of all standards, specifications and other listed documents together with any amendments. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Users shall comply with the documents specified in Clauses 3.1 – 3.6.

### 3.1 Legislation

Construction (Design and Management) Regulations 2015.

Control of Electromagnetic Fields at Work Regulations 2016.

Electricity at Work Regulations 1989.

Electricity Safety Quality and Continuity Regulations 2002.

Health and Safety at Work etc Act 1974.

Health and Safety (Safety Signs and Signals) Regulations 1996.

Lifting Operations and Lifting Equipment Regulations 1998.

Management of Health and Safety at Work Regulations 1999.

Personal Protective Equipment at Work (Amendment) Regulations 2022.

Pressure Equipment Regulations 2016.

Pressure Systems Safety Regulations 2000.

Provision and Use of Work Equipment Regulations 1998.

The Fluorinated Greenhouse Gases (Amendment) Regulations 2023.

Waste Electrical and Electronic Equipment Regulations 2013.

Work at Height Regulations 2005.

## 3.2 Standards

BS EN 1990	<i>Eurocode — Basis of structural and geotechnical design</i>
BS EN 1991	<i>Eurocode 1. Actions on structures</i>
BS EN 1992	<i>Eurocode 2. Design of concrete structures</i>
BS EN 1993	<i>Eurocode 3. Design of steel structures</i>
BS EN 1997	<i>Geotechnical Design</i>
BS EN 1998-1:2004	<i>Eurocode 8: Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings</i>
BS EN 50522	<i>Earthing of power installations exceeding 1 kV</i>
BS EN 60076-1	<i>Power transformers. General</i>
BS EN 60099-4	<i>Surge arresters. Metal-oxide surge arresters without gaps for a.c. systems</i>
BS EN 60137	<i>Insulated bushings for alternating voltages above 1 000 V</i>
BS EN 60168	<i>Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V</i>
BS EN 60222	<i>Measuring relays and protection equipment</i>
BS EN 60296	<i>Fluids for electrotechnical applications. Mineral insulating oils for electrical equipment</i>
BS EN 60437	<i>Radio interference test on high-voltage insulators</i>

Transmission Owners: Applicable Electrical Standard

BS EN 60529	<i>Degrees of protection provided by enclosures (IP code)</i>
BS EN 61000-4-30	<i>Electromagnetic compatibility (EMC) - Testing and measurement techniques. Power quality measurement methods</i>
BS EN 61099	<i>Insulating liquids. Specifications for unused synthetic organic esters for electrical purposes</i>
BS EN 61462	<i>Composite hollow insulators. Pressurized and unpressurized insulators for use in electrical equipment with AC rated voltage greater than 1 000 V AC and D.C. voltage greater than 1500V. Definitions, test methods, acceptance criteria and design recommendations</i>
BS EN 61869-1	<i>Instrument transformers. General requirements</i>
BS EN 61869-2	<i>Instrument transformers. Additional requirements for current transformers</i>
BS EN 61869-3	<i>Instrument transformers. Additional requirements for inductive voltage transformers</i>
BS EN 61869-4	<i>Instrument transformers. Additional requirements for combined transformers</i>
BS EN 61869-5	<i>Instrument transformers. Additional requirements for capacitor voltage transformers</i>
BS EN 61936-1	<i>Power installations exceeding 1 kV a.c. Common rules</i>
BS EN 62155	<i>Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V</i>
BS EN 62217	<i>Polymeric HV insulators for indoor and outdoor use. General definitions, test methods and acceptance criteria</i>
BS EN 62231	<i>Composite station post insulators for substations with AC voltages greater than 1 000 V up to 245 kV. Dimensional, mechanical and electrical characteristics</i>
BS EN 62271-1	<i>High-voltage switchgear and controlgear – Part 1: Common specifications</i>
BS EN 62271-100	<i>High-voltage switchgear and controlgear. Alternating-current circuit- breakers</i>
BS EN 62271-102	<i>High-voltage alternating current disconnectors and earthing switches</i>
BS EN 62271-203	<i>High-voltage switchgear and controlgear – Part 203: Gas-insulated metal- enclosed switchgear for rated voltages above 52 kV</i>

BS EN 62271-209	<i>Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV</i>
BS EN 62772	<i>Composite hollow core station post insulators with a.c. voltage greater than 1 000 V and d.c. voltage greater than 1 500 V. Definitions, test methods and acceptance criteria</i>
BS EN 60214	<i>TAP-changers. Application guidelines</i>
IEC 60050	<i>IEC Electrotechnical Vocabulary</i>
IEC 60273	<i>Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V</i>
IEC 60840	<i>Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV). Test methods and requirements</i>
IEC 62067	<i>Power cables with extruded insulation and their accessories for rated voltages above 150 kV (Um = 170 kV) up to 500 kV (Um = 550 kV)</i>
ISO 9001	<i>Quality management systems. Requirements</i>
ISO 14001	<i>Environmental management systems. Requirements with guidance for use</i>
NA to BS EN 1991-1-4	<i>UK National Annex to Eurocode 1 – Actions on structures. Part 1-4: General actions – Wind actions</i>
PD IEC/TR 61000-3-13	<i>Electromagnetic compatibility (EMC). Limits. Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems</i>
PD IEC/TS 60815	<i>Selection and dimensioning of high-voltage insulators intended for use in polluted conditions. Insulators for d.c. systems</i>
PD IEC/TS 62896	<i>Hybrid insulators for a.c. and d.c. high-voltage applications. Definitions, test methods and acceptance criteria</i>
PD 6698:2009	<i>Recommendations for the design of structures for earthquake resistance to BS EN 1998</i>

### 3.3 ENA Specifications & Engineering Recommendations

ENA EREC C55	<i>Insulated Sheath Power Cable Systems</i>
ENA EREC G5	<i>Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom</i>
ENA EREC G91	<i>Substation Black Start Resilience</i>
ENA EREC G110	<i>Instantaneous high-impedance differential protection</i>
ENA EREC P24	<i>AC supplies to railway systems</i>

ENA EREC S36	<i>Identification and recording of 'hot' sites - joint procedure for Electricity Industry and Communications Network Providers</i>
ENA ETR 138	<i>Resilience to Flooding of Grid and Primary Substations</i>
ENA TS 09-2	<i>Specification for the supply, delivery &amp; installation of land based power cables with operating voltages in the range 11 kV to 400 kV and associated auxiliary cables</i>
ENA TS 41-24	<i>Guidelines for the design, installation, testing and maintenance of main earthing systems in substations</i>
ENA TS 41-37	<i>Switchgear for use on 66 kV to 132 kV distribution systems Part 1: Common Clauses</i>
ENA TS 41-38	<i>Power installations exceeding 1 kV a.c. – Design of high-voltage open-terminal stations</i>
ENA TS 41-40	<i>Ground Mounted Major Substation 12 to 36 kV Rated Indoor Fixed Pattern Switchgear</i>
ENA TS 48-4	<i>DC trip relays associated with a tripping function in protection systems</i>
ENA TS 48-5	<i>Environmental test requirements for protection and control equipment and systems</i>
ENA TS 48-6-1	<i>Functional Test Requirements – Distance Protection</i>
ENA TS 48-6-2	<i>Functional Test Requirements – Line Differential Protection</i>
ENA TS 48-6-3	<i>Functional Test Requirements – Transformer Differential Protection</i>
ENA TS 48-6-4	<i>ENA Protection Assessment Functional Test Requirements – Busbar Protection</i>
ENA TS 48-6-5	<i>Functional Test Requirements – Voltage Protection</i>
ENA TS 48-6-6	<i>Functional Test Requirements – Overcurrent and Earth Fault Protection</i>
ENA TS 48-6-7	<i>Digital communications services for teleprotection systems</i>
ENA TS 48-6-8	<i>Functional Test Requirements – Frequency Protection</i>
ENA TS 50-18	<i>Application of ancillary electrical equipment</i>
ENA TS 50-19	<i>Standard numbering for small wiring (for switchgear and transformers together with their associated relay panels)</i>

### 3.4 Operational Health & Safety Documents

The following electrical safety rules are typically followed, and relevant aspects should be applied, where applicable.

ENA	<i>SHE Standard 07: Model Distribution Safety Rules</i>
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NGET	<i>The Electricity Transmission Safety Rules Fifth Edition</i>
Scottish Power	<i>Safety Rules (Electrical and Mechanical) Fifth Edition.</i>
SSEN Transmission	<i>Operational Safety Rules.</i>

### 3.5 National Energy System Operator (NESO) Codes

NESO	<i>Connection and Use of System Code (CUSC)</i>
NESO	<i>Grid Code (GC)</i>

## 4. Climatic & Environmental

The common GB requirements are listed below. Where more stringent values are required on a site-by-site basis, these will be confirmed with the TO and recorded in the Bilateral Agreement with the User.

### 4.1 Indoor Requirements

Plant and Apparatus shall be capable of operating within the range +40 °C to -5 °C temperature limits and at a humidity that does not exceed 95%.

Plant and Apparatus housed indoors shall have a minimum degree of protection of IP2X as defined in BS EN 60529.

### 4.2 Outdoor Requirements

Plant and Apparatus shall be capable of operating within the range +40 °C to -25 °C temperature limits.

Plant and Apparatus housed outdoors shall have a minimum degree of protection of IP55 as defined in BS EN 60529.

### 4.3 Pollution

The minimum pollution performance level shall be Class D as according to PD IEC/TS 60815.

### 4.4 Altitude

This document is for Plant and Apparatus installed at altitudes up to 1000 m above sea level.

### 4.5 Exposure to Abnormal Vibrations, Shock or Tilting

The User shall comply with BS EN 1990:2002, BS EN 1998-1:2004 and PD 6698-2009 in regard to seismic requirements.

As a minimum, the User shall comply with the seismic hazard map for Peak Ground Acceleration with a 2500-year return period in accordance with PD 6698-2009.

### 4.6 Wind Load

For operation of plant, Outdoor equipment shall be capable of withstanding a maximum wind speed of 34m/

In case of structural design (including AIS busbar systems), the maximum site-specific wind loading shall be determined for the relevant ultimate and serviceability states, based on the substation location according to the wind speed maps from the National Annex to BS EN 1991-1-4.

## 4.7 Ice Load

For operation of plant, the operational environment (service liability state) shall be based on an ice coating that does not exceed 10 mm for operation and 20 mm for static and dynamic equipment and structures.

In case of structural design (including AIS busbar systems), the combination of wind and ice shall be applied in accordance with the National Annex to BS EN 1993-3-1 in relevant ultimate and serviceability limit states. The conditions shall consider the following conditions:

- The unit weight of ice in the absence of wind, based on  $r_o$  is taken as  $5 \text{ kN/m}^3$ ;
- The unit weight of ice in conjunction with wind, based on  $r_w$  is taken as  $9 \text{ kN/m}^3$ . This is due to the 0.5 reduction factor on wind force (not wind speed) and wind applied to the iced section.

## 4.8 Flood Resilience

Plant and Apparatus shall be protected against the level of flooding that may occur within a 1 in a 1,000 year flood contour for fluvial, pluvial and coastal flooding in accordance with ENA ETR 138. The design shall ensure that the reliability and security of Plant and Apparatus is not deleteriously affected by flood levels up to 600 mm above the estimated flood level.

Based on consideration of the above flood levels, the User shall declare the maximum depth of water, measured from the base of the Plant and Apparatus (including transformers, marshalling kiosks, relay cabinets etc.) at which:

- i) full functionality is retained; and
- ii) the Plant and Apparatus can immediately be returned to service with full functionality, if it is de-energised prior to the flooding, at the point when the water depth is at the base of the Plant and Apparatus level, with no intervention necessary.

The User shall clearly define in the installation, commissioning and maintenance documents for the equipment and Apparatus any special installation measures that are required to achieve the above declared depths.

## 4.9 Environmental impact

The design of substation and associated Apparatus in the interface zone shall give due regard to protecting and enhancing the environment and shall minimise emissions such as noise, vibration, light, heat and electric and magnetic fields as far as reasonably practicable.

Appropriate on-site water pollution prevention measures shall be employed (e.g. oil containment on large transformers etc.).

## 5. Electrical System

Electrical infrastructure shall be suitable for use at the operating frequency, within the intended operating voltage range and at the design short-circuit rating of the NETS to which it is connected having due regard to the following rated requirements:

- i) environmental as specified in this document; and
- ii) fault carrying capabilities; and
- iii) making and breaking duties; and
- iv) short-time withstand current; and
- v) continuous current; and
- vi) mechanical duties (where applicable).

Normal and abnormal system conditions shall be considered.

NOTE 1: Connections at 25 kV for traction supplies are common, however they are not included in this document. This is due to such connections being a site-specific connection. The guidelines in ENA EREC P24 shall be used.

NOTE 2: Other voltages are deemed as 'specific' connections with the TO e.g. 20kV and shall be subject to a bespoke consideration of the connection requirements.



## 5.1 System Voltage

Apparatus shall satisfy their specified functional and performance requirements over the range of system nominal voltages given in Table 1 and in accordance with Clause CC.6.1.4 or ECC.6.1.4 of the Grid Code.

**Table 1 — Apparatus Voltage Requirements**

System Nominal Voltage (kV)	Normal Operating Range	Minimum Continuous System Voltage (kV)	Maximum Continuous System Voltage (kV)	Rated Voltage of Apparatus (kV)
400	-10% to +5%	360	420 <sup>1</sup>	420
275 <sup>2</sup>	-10% to +10%	247	303	300
220	-10% to +10%	198	242	245
132	-10% to +10%	119	145	145
66	-6% to +6%	62	70	72.5
33	-6% to +6%	31	35	36
11	-6% to +6%	10.3	11.7	12

NOTE: Apparatus for use on the 400 kV system shall also operate safely and without any degradation in performance when operated in the range 420 kV to 440 kV for periods of up to 15 minutes.

In accordance with Clause CC.6.1.5 a) or ECC.6.1.5 a) of the Grid Code, Apparatus shall satisfy their specified functional and performance requirements when exposed to harmonic distortion levels in the voltage waveform up to the compatibility levels specified in ENA EREC G5.

In accordance with Clause CC.6.1.5 b) or ECC.6.1.5 b) of the Grid Code, Apparatus shall satisfy their specified functional and performance requirements with phase voltage unbalance Calculated in accordance with EC 61000-4-30 and IEC 61000-3-13.

## 5.2 Rated Insulation Level

The rated insulation levels of Apparatus shall be in accordance with Table 2, where applicable. These values shall apply unless explicitly modified in Standards, specifications and documents pertaining to Apparatus types. Apparatus shall be type tested to demonstrate they meet the required rated insulation levels.

**Table 2 — Rated Insulation Level Requirements**

System Voltage (kV)	Rated short duration power frequency withstand voltage (kV peak) <sup>2</sup>			Rated switching impulse withstand voltage (kV peak) <sup>3</sup>			Rated lightning impulse withstand voltage (kV peak) <sup>4</sup>		
	Common value/ phase to earth & between phases	Across open switching device	Across the isolating distance	Phase to earth	Between Phases	Across open switching device and/or isolating distance	Common value/ phase to earth & between phases	Across open switching device	Across the isolating distance
400	520	610	610	1050	1575	900 (+345) <sup>1</sup>	1425	1425 (+240) <sup>1</sup>	1425 (+240) <sup>1</sup>
275	395	435	435	850	1275	700 (+245) <sup>1</sup>	1050	1050 (+170) <sup>1</sup>	1050 (+170) <sup>1</sup>
220	460	460	530	n/a	n/a	n/a	1050	1050	1200
132	275	315	315	n/a	n/a	n/a	650	650	750
66	140	140	160	n/a	n/a	n/a	325	325	375
33	70	80	80	n/a	n/a	n/a	170	170	195
11	28	32	32	n/a	n/a	n/a	95	95	110

NOTE 1: Values in brackets are the peak values of the power-frequency voltage applied to the opposite terminal with impulse voltage applied to other terminal of open switching device. See BS EN 62271-1.

NOTE 2: Dry withstand voltage for minimum duration of 1 minute. Power frequency wet withstand voltages may be specified for outdoor Apparatus. Longer durations for power frequency tests for some Apparatus (e.g. cables) may be specified in standards and specifications.

NOTE 3: Impulse wave shape – 250 / 2500 µs.

NOTE 4: Impulse wave shape - 1.2 / 50 µs.

## 5.3 Rated Frequency

The frequency of the NETS shall be nominally 50 Hz and shall be controlled within the limits of 49.5 - 50.5 Hz. The System Frequency could rise to 52 Hz or fall to 47 Hz in exceptional circumstances as specified in Clause CC.6.1.3 or ECC.6.1.2 of the Grid Code.

User's Apparatus shall satisfy their specified functional and performance requirements over the range of frequencies specified in Clause CC 6.1.3 or ECC.6.1.2 of the Grid Code.

## 5.4 Rated Continuous Current

The maximum values of continuous currents applicable to each voltage level are given in Table 3.

Lower rated continuous currents may be allowed as agreed with NESO to suit the installation requirements.

Higher rated continuous current ratings may be used by agreement between NESO and the User on a site-by-site basis.

The rated continuous currents shall be selected from the standard values given in relevant Standards to meet the required circuit ratings.

**Table 3 — Maximum Continuous Current Requirements**

System Voltage (kV)	Rated Continuous Current (A)
400	5000
275	3150
220	2000
132	3150
66	2000
33	2500
11	2500

## 5.5 Rated Short-circuit and Short-time Withstand Current

The maximum rated short-circuit requirements are shown in Table 4. Ratings shall be determined on a site-by-site basis.

**Table 4 — Maximum rated Short-Circuit Current Requirements**

System Voltage (kV)	Single Phase Short-circuit Current (kA)	Three Phase Short-circuit Current (kA)	Short-time Withstand Duration (s)	DC Time Constant <sup>1</sup> (ms)
400	63	63	1	45
275	40	40	1	45
220	40	40	1	45
132	40 31.5	40 31.5	3 3	45 135
66	31.5	31.5	3	45
33	20	20	3	45
11	13.1	13.1	3	45

NOTE 1: The rated peak withstand current of Apparatus shall be defined according to the system DC time constant (See BS EN 62271-1). At some sites significantly higher system DC time constants may be experienced.

NOTE 2: Apparatus for use on the 132 kV system is required to meet both short-time withstand current ratings and time constants as detailed above.

## 5.6 Substation Auxiliary Supplies

The LVAC and LVDC supplies for the User's Apparatus shall be the User's responsibility.

### 5.6.1 DC Auxiliary Supply Requirements

TO's are required to ensure that Critical Tools and Facilities are resilient for a 72-hour period<sup>1</sup> following a Partial or Total Shutdown event.

NOTE 1: Standby period detail is provided in ENA EREC G91.

User's DC Auxiliary Apparatus shall have the capability to open and close all the connected User's circuit-breakers (within the interface zone) at the end of the 72-hour period<sup>1</sup>.

TOs' DC supplies are 48 V DC or 110 V DC within the range shown in Table 5 and in accordance with ENA TS 41-37 Part 1.

**Table 5 —Operating Voltages and Auxiliary Control Circuits**

Nominal Voltage (V)	Criteria for rated supply voltage operating range	Closing and opening releases and operating devices		Other operating devices (V)
		Closing (V)	Opening (V)	
110	Maximum operating voltage (max battery charging voltage)	137.5	137.5	137.5
	Minimum operating voltage	87.5 (80% of nominal)	77 (70% of nominal)	87.5
48	Maximum operating voltage (max battery charging voltage)	53	53	53
	Minimum operating voltage	38.5	33.6	38.5

## 6. Substation

### 6.1 Design Clearances

Within the interface zone in AIS, safety to personnel shall normally be achieved by the provision of adequate design clearances to live parts based on operational safety distances. The design clearances employed at a site may depend on the TO who own the site or may need to be coordinated with previous design practise. The design clearances for safety employed shall consider the need for construction, modification and maintenance and requirements for vehicular and pedestrian access.

Where adequate design clearances for safety to live parts cannot be maintained without limiting access, fixed barriers or fences shall be provided.

**Table 6** specifies the minimum design clearances for safety where only pedestrian access is permitted. Lower values may be accepted on a site-per-site basis if agreed between the User and NESO and recorded in the Bilateral Agreement.

Where the design of the substation requires the use of mobile equipment platforms or passage of vehicles, the design clearances for safety shall be increased by 2 m.

Exposed live conductors that cross perimeter fences shall, under worst-case conditions, be at a height no less than the minimum height above ground of overhead lines as defined in The Electricity Safety, Quality and Continuity Regulations 2002 (including all subsequent amendments).

**Table 6 — Substation Design Clearances**

System Voltage (V)	Highest voltage For installation (kV)	Design Clearance for Safety Vertical (m)	Design Clearance for Safety Horizontal (m)	Insulation height (m)
11	12	3.2	2.3	2.55
33	70	3.2	2.3	2.55
66	72.5	3.4	2.5	2.55
132	145	3.85	3.1	2.55
220	245	4.8	3.9	2.55
275	300	4.8	3.9	2.55
400	420	5.5	4.6	2.55

NOTE 1: Persons should not allow any part of their body or any object to infringe the design clearance for safety, to exposed conductors operated at high voltage.

NOTE 2: Design Clearance for Safety Vertical values deducted from personal reach of 2.25 m + 0.3 m + phase-to-earth clearances from BS EN 61939-1.

NOTE 3: Design Clearance for Safety Horizontal values deducted from: 1.5 m + 0.3 m + phase-to-earth clearances from BS EN 61939-1. Where 1.5 m is the horizontal application factor (horizontal reach) as described in ENA TS 41-38.

NOTE 4: When practicable the vertical design clearance should be applied in all directions.

NOTE 5: Distances for 220 kV systems based on 275 kV to align with TO Safety Distances.

NOTE 6: "Insulation height" is the lowest part of any insulation from ground level and is based on personal reach of 2.25 m plus safety distance of 0.3 m (see Figure D.1 of ENA TS 41-38).

## 6.2 Earthing

Apparatus shall satisfy their specified functional performance requirements under the neutral earthing conditions. Indicative values given in Table 7 below:

**Table 7 — Neutral Earthing Requirements**

System Voltage (kV)	Maximum Earth fault Factor (EFF)	Type of Neutral Earthing
400	1.4	Solid (Multiple Direct)
275	1.4	Solid (Multiple Direct)
220	1.4	Solid (Multiple Direct)
132	1.4	Solid (Multiple Direct)
66	1.73	Impedance Earthing
33	1.73	Impedance Earthing
20	1.9	Impedance Earthing
11	1.9	Impedance Earthing

NOTE: Impedance Earthing is via resistor, earthing transformer, reactor or Peterson coil (Arc Suppression coil).

NOTE: Common voltages across UK are specified in this table. Specific voltages will be specified in connection offer.

System earthing varies according to voltage and location across the network and shall be defined in the Bilateral Agreement. The earthing design shall be in accordance with BS EN 50522, ENA EREC S36 and ENA TS 41-24 unless modified by other specific TO documents.

Earthing design including interfaces shall be discussed and agreed with the TO.

The design of the earthing system shall comply with the safety criteria for the safety of personnel as laid down in ENA TS 41-24. The User shall ensure the earthing modelling calculations are carried out to show that step and touch potentials are within the prescribed safety limits specified in ENA TS 41-24.

The current rating of earthing conductors and earthing electrodes shall be calculated based on the highest applicable system design fault level of each location as recommended in ENA TS 41-24.

Consideration shall be given to future network alterations and alternative running arrangements which may lead to a rise in site fault level. A margin should be added to allow for future changes without detailed assessment (e.g. typical 15 % increase, unless more accurate information is available). The User shall assess the rating of the earthing system in event of any increase in earth fault level and shall carry out any modifications as required to ensure that the rating of the earthing system is sufficient, and the safety criteria is met.

User and TO earthing systems should where reasonably practicable be designed to be safe in the absence of any (electrode) contribution from the other party's system.

Where the User's and the TO's sites are on the same site, or are in close proximity, then a separate earthing system shall enclose each site/substation and these earthing systems shall be connected together by at least two fully rated conductors taking separate, secure routes.

Further information on cable earthing and bonding is given in Clause 8.3.

The User shall also carry out a post installation resistance measurements and checks on the earthing system to verify the earthing system design and to prove the adequacy of the earthing system to protect personnel and equipment. These tests shall be confirmed with the TO and fully completed prior to first energisation.

## 6.3 Interlocking

All types of interlocking schemes shall operate satisfactorily under the full range of environmental conditions specified for the associated primary Apparatus. All interlocking shall comply with the existing TO requirements.

### 6.3.1 Interlocking Switchgear

In substations where the TO is a joint user and/or has operational responsibility for switchgear then the interlocking shall also be designed with consideration of personnel safety.

Interlocking schemes shall cover the following conditions within the interface zone:

- i) interlocking between circuit-breakers and disconnectors to ensure disconnectors do not operate outside their rating (i.e. make or break load currents); and

- ii) interlocking between disconnectors and earthing switches to ensure that earthing switches cannot be closed on to a locally energised circuit and cannot be energised, when closed, by operation of disconnectors; and
- iii) interlocking between disconnectors and adjacent earthing switches to permit operation of the disconnector when earthing switches are closed on both sides of the disconnector. Such interlocking is not required for Apparatus below 132 kV; and
- iv) to ensure the correct sequence of on load busbar transfer switching operations at multiple busbar substations; and
- v) to ensure that a bus-coupler or bus-section circuit-breaker is only closed with its associated disconnectors being either both open or alternatively, both closed; and
- vi) for Apparatus at sites where the TO is the user, to restrict access to areas of the substation where safety clearances may be infringed unless appropriate safety measures, such as isolation and earthing, have been taken.

The correct interlocking status shall be confirmed automatically on initiation of an operation from any control position or from auto-switching or sequential-isolation equipment.

The interlocking of switching sequences involving manually operated switchgear may be by electrical or mechanical means. The interlocking shall be designed such that the correct interlocking status must be confirmed immediately before an operation.

Interlocking systems shall, where reasonably practicable, be fail-safe. They shall not be defeated without the use of tools, clip leads etc. or a purpose designed override facility.

In some designs of GIS, manufacturers may provide an interlock override facility used during commissioning etc. This shall be lockable with a padlock. Interlock override facilities shall not be provided in AIS Apparatus.

Partial interlocking of earthing switches at circuit-entries to the substation is acceptable where it is not reasonably practicable to extend the interlocking to the remote end disconnectors. Any partially interlocked earthing switch shall be provided with a warning label stating, "Warning: This Earthing Switch is not fully interlocked."

Interlocking shall be effective for switching and operating sequences when they are being followed in either direction (e.g. if an earthing switch must be closed before an access gate can be opened, then the gate must be secured closed before the earthing switch can be opened).

Interlocking schemes shall, where reasonably practicable, provide the maximum operational flexibility and shall not unnecessarily impose fixed operating sequences.

Where an interlocking scheme is being supplied for an extension to an existing substation at the same operating voltage then, unless otherwise agreed by the TO, the interlocking philosophy shall match that of the existing substation.

Interlocking for a substation extension shall be fully interfaced with the existing interlocking scheme to achieve the functional requirements specified in this document.

Interlocking may, in certain circumstances, have to be by-passed by auto-reclose schemes.

### 6.3.2 Interlocking Protection

Any interlocking signalling scheme shall provide the following key facilities.

- i) the fibre optic link shall be supervised; and
- ii) the IED used to facilitate the interlocking signalling scheme shall have self-checking facilities to indicate IED health; and
- iii) all disconnector and earth switch position information shall be double point connected for additional signalling security, i.e. both open and closed contacts shall be used; and
- iv) the TO's IED shall pass the position of the circuit disconnector and circuit earth switch to the User's IED to provide position information for the User's interlocking system; and
- v) the User's IED shall pass the position of the circuit disconnector and circuit earth switch to the TO's IED to provide position information for the TO's interlocking system; and
- vi) in the event that the fibre optic link fails, or if either IED fails, or if there is some discrepancy in switchgear status, the scheme shall indicate failure at both ends.

There is no requirement for the interlocking signalling scheme to be duplicated. In the event of a scheme failure a coordinated approach to ensuring safety shall be agreed between both parties

## 6.4 Security

For information, security should meet the minimum requirements of the site and be advised by the TO (this could be a CNI site).

## 6.5 Conductor Jointing in Substations

See Clause 8 for cable requirements.

## 6.6 Insulation and Interruption Gases (IIG)

The TO preference is that SF<sub>6</sub> Free solutions should be used where technically viable. In case of GIS installations, The User shall agree the GIS solution (including type of IIG used) with the TO.

Where applicable, the User shall be responsible for the management of fluorinated gases associated with Apparatus owned by the User.

## 6.7 Ancillary Equipment

Ancillary equipment shall comply with ENA TS 50-18.

Insulation displacement type terminal blocks are not acceptable for internal wiring (e.g. control, protection and SCADA) associated with HV Apparatus.

## 6.8 Maintenance

It is the User's responsibility to ensure that all its Plant and Apparatus on a Transmission Site is tested and maintained adequately for the purpose for which it is intended, and to ensure that it does not pose a threat to the safety of any Transmission Plant, Apparatus or personnel on the



Transmission Site. The NESO will have the right to inspect the test results and maintenance records relating to such Plant and Apparatus at any time.

## 7. Bushings & Insulators

Where there is a risk of internal pressure rise in the event of internal arcing leading to disruptive failure of the insulator and ejection of parts which is hazardous to both personnel and other equipment within the TO's substation. The following options are permissible.

- Pressurised porcelain insulators (including bushings used on transformers, switchgear, instrument transformers, surge arresters and AIS cable terminations) shall use pressurised relief devices to ensure safety of personal on site.
- Alternatively Polymeric insulation shall be deployed.

### 7.1 Bushings

#### 7.1.1 AIS Bushing Specifications

Bushings shall comply with BS EN 60137.

#### 7.1.2 Bushing Design & Construction

See Clause 10.1 of this document for Bushing CT requirements.

The minimum unified specific creepage distance (USCD) of outdoor insulators and bushings used at outdoor installations shall be 43.3 mm/kV.

### 7.2 Post Insulators

#### 7.2.1 Post Insulator Standards

Ceramic insulators as a minimum shall be in accordance with IEC 60273 or BS EN 62155.

Composite insulators as a minimum shall be in accordance with BS EN 62231 or BS EN IEC 62772.

Hybrid insulators as a minimum shall be in accordance with PD IEC/TS 62896.

Polymer insulators as a minimum shall be in accordance with BS EN 62217.

Resin insulators as a minimum shall be in accordance with BS EN 62217.

#### 7.2.2 Insulators Design & Construction

As a minimum, all insulators shall be suitable for use in Site Pollution Severity (SPS) Class D (Heavy), with reference to PD IEC/TS 60815-1. Where required according to the substation environment, insulators shall be suitable for use in SPS Class E (Very Heavy).

Glass insulators shall not be used.

#### 7.2.3 Insulators Type Tests

Testing on ceramic insulation shall be according to BS EN 60168, for solid insulation, or BS EN 62155, for hollow ceramic insulation.

Testing on polymeric insulators shall be according to BS EN IEC 61462 and BS EN 62217.

#### *7.2.3.1 Dry or Wet Switching-Impulse Voltage Test*

The dry and wet switching impulse test in BS EN 60168 shall be carried out in wet conditions.

#### *7.2.3.2 Mechanical Failing Load Test*

In addition to the bending test, the tension and torsion tests shall be carried out during type testing described in BS EN 60168.

#### *7.2.3.3 Test for Deflection Under Load*

The test shall be carried out during type tests to determine the flange deflection obtained as a result of applying 70% of the specified mechanical failing load.

#### *7.2.3.4 Radio Interference Test*

A radio interference test shall comply with BS EN 60168 and BS EN IEC 60437.

### **7.2.4 Insulators Routine Tests**

BS EN 60168 applies and the routine mechanical test on a complete post shall be performed with a load applied of 70% of the specified mechanical failing load.

## **8. Cables**

Designers shall allow for the specified maximum ambient temperature, ground temperature and temperature rise due to passage of rated continuous current when determining maximum conductor temperature.

### **8.1 Cable Standards & Specifications**

Cables and cable accessories shall comply with IEC 60840 for rated voltages above 60 kV ( $U_m = 72.5$  kV) up to 150 kV ( $U_m = 170$  kV), IEC 62067 for rated voltages above 150 kV ( $U_m = 170$  kV) up to 500 kV ( $U_m = 550$  kV), and the additional requirements of this document.

### **8.2 Cable Design & Construction**

Users shall be responsible for ensuring the satisfactory performance of all aspects of the cable system design.

All testing of cables and cable accessories shall be carried out in accordance with IEC 60840 or IEC 62067 as relevant for the cable system design.

In addition, the physical separation of such channels outside the perimeter of the TO's managed site shall be at least 5 m.

### **8.3 Earthing and Bonding of High Voltage Power Cables**

The earthing and bonding of high voltage cables shall be designed and installed in a manner to avoid conditions which could cause danger due to induced voltages or currents, differences in earth potential or voltage differences across any break in the conductive path.

It may be necessary to employ the use of special bonding methods as described in ENA EREC C55 when bonding and earthing single-core cables in order to limit sheath circulating currents. Cable sheath bonding and earthing arrangements shall be designed such that the

standing sheath voltage at maximum declared full load current shall not exceed the values for safety specified in ENA EREC C55.

Where the steady state voltage at a termination may exceed 10 V, suitable precautions shall be taken to prevent accidental contact to any exposed metalwork outside the safety clearance distance.

In order to reduce the magnitude of sheath voltages resulting from steep fronted transient phenomena, (e.g. switching operations, flashovers on or near the cable terminations, internal cable faults, etc.) it may be necessary to install sheath overvoltage limiting devices (SVLs) at certain positions.

## 8.4 Cable Installation & Commissioning

The supply, delivery and installation of cable systems shall be in accordance with ENA TS 09-2.

Cables and pipes passing through external walls of substation buildings shall have suitable seals to prevent the ingress of moisture, gas or vermin into buildings. They shall have a fire resistance appropriate to the building.

On GIS where the connection between the User's GIS and TO's GIS is provided by a cable directly terminated into the TO's GIS, the cable screen connection and main earthing conductor shall be insulated to meet the requirements of sheath insulation systems and to allow DC insulated sheath testing of power cable. Screen sectionalising insulation links shall be provided to allow both earthing systems to be connected.

## 9. Instrument Transformers

Where the Bilateral Agreement specifically identifies that metering is required within the interface zone, CTs and VTs used for metering purposes shall be compliant with the Balancing and Settlement Code, and its associated Codes of Practice.

### 9.1 Current Transformers (CTs)

#### 9.1.1 CT Specifications

CTs shall comply with BS EN 61869-1 and BS EN 61869-2.

Where the CT is part of a combined instrument transformer, it shall also comply with BS EN 61869-4.

User CTs forming part of the TO's interface protection scheme shall comply entirely with the TO's core winding ratio class and output requirements which are in each bilateral connection agreement.

User CTs forming part of the TO's interface protection scheme shall have no disconnecting links in the current carrying path.

User CTs forming part of the TO's interface protection scheme shall be shorted and earthed until they are configured and commissioned at site. The shorting and earthing shall be provided via removable wire links at the CT terminal box (see ENA TS 50-18). The terminals for shorting and earthing shall be clearly marked.

Where the User is required to install Fault Recording and/or Dynamic System Monitoring (DSM) in accordance with Grid Code ECC.6.6.1, the User shall install the required CTs and equipment. The TO shall not make any instrument transformers or space available to the User for this purpose.

### 9.1.2 CT Design & Construction

A CT Primary test loop of an approved type, shall be made available on a transformer or reactor intended for connection, to allow the TO to verify protection configurations in order to ensure that the TO can verify that any integrated protection schemes operate as intended.

### 9.1.3 CT Routine Tests

The TO requires all CT magnetisation characteristics (factory test certificates) for all CTs used in the interface zone.

## 10. Protection & Control

Adequate Protection systems should be developed to fulfil the requirements of the ESQCR for all applications.

Apparatus owned by the TO should be physically segregated from that owned by Users, however, it is accepted that this is not always possible/practical in which case the following clauses are applicable:

- i) where switchgear local controls are grouped on a bay control panel (or similar) then control of Apparatus owned by the TO shall be segregated from that owned by the User. Separate individually lockable local/remote control selector switches shall be provided for the TO and Apparatus owned by the User such that personnel with authority to only operate Apparatus owned by the User are unable to access control of the Apparatus owned by the TO and vice versa; and
- ii) facilities provided for substation level control of Apparatus owned by the User shall have no facilities to operate Apparatus owned by the TO. This may not be the case where there are local contractual agreements in place; and
- iii) any electrical/mechanical supplies which are provided by the TO for Apparatus owned by the User shall be equipped with segregated, clearly labelled isolation facilities.

### 10.1 Protection Types

Adequate protection systems should be developed to fulfil the requirements of the ESQCR for all applications. Documentary evidence showing compliance for all protection types shall be provided to the TO.

The User and TO shall agree the respective protection and control relay settings in accordance with CC.6.2.2, CC.6.2.3 or ECC.6.2.2 and fault clearance times to be operated by each of them and record this information in the format set out in Appendix F4 of the relevant Bilateral Agreement and accordingly the CUSC and applicable section of CC/ECC.6.2 of the Grid Code.

Ancillary electrical equipment associated with the protection, automation and control system, shall be in accordance with ENA TS 50-18.

All cables and conductors associated with the protection, automation and control system, switchgear, and transformers, shall be labelled in accordance with the principles described in ENA TS 50-19.

As a minimum, the schemes shall match the existing TO protection requirements. These shall be coordinated, tested and accepted by the appropriate TO.

### 10.1.1 Protection Environmental Requirements

All devices used for protection, automation, and control purposes shall comply with all applicable requirements of ENA TS 48-5 Environmental test requirements for protection and control equipment and systems.

All devices used for protection, automation, and control purposes shall comply with the latest safety and EMC legislation and be “CE” and/or “UKCA” marked.

### 10.1.2 Protection Functional Requirements

Protection functions shall be tested in accordance with the ENA and international standards listed in Table 8.

**Table 8 — Protection Function Testing Compliance Requirements**

Protection Function	ENA Test Specification	International Standard
High Impedance Differential	ENA EREC G110	-
Distance Protection	ENA TS 48-6-1	BS EN 60255-121
Unit Feeder Protection	ENA TS 48-6-2	-
Double-wound & Auto Transformers	ENA TS 48-6-3	BS EN IEC 60255-187-1
Busbar Protection	ENA TS 48-6-4	-
Voltage Protection	ENA TS 48-6-5	BS EN 60255-127
Overcurrent & Earth Fault Protection	ENA TS 48-6-6	BS EN 60255-151
Frequency & RoCoF Protection	ENA TS 48-6-8	BS EN IEC 60255-181

### 10.1.3 DC Trip Relay Requirements

DC trip relays shall be tested in accordance with ENA TS 48-4 where they interface with the TO. Where electronic devices provide similar functionality to traditional DC trip relays, the User shall coordinate with the TO to ascertain the relevant parts of ENA TS 48-4 that shall be applied to the electronic device.

### 10.1.4 Tele-protection Communications

Tele-protection communication shall be in accordance with ENA TS 48-6-7.

Where the interface protection system utilises protection communications, e.g. fibre optic link, where TO protection systems gather information from the User’s equipment, the communication link shall as a minimum be in accordance with Category 1 links defined by ENA TS 48-6-7. In accordance with ENA TS 48-6-7, where two or more communication channels are required to have specified spatial separation, no single failure mode shall simultaneously affect the specified channels.

## 10.2 Circuit-Breaker Fault Protection and Clearance Times

Apparatus shall be suitable for operation under the conditions detailed in Table 9. In the event of a circuit-breaker failure on the 400 kV, 275 kV, 220 kV, and 132 kV systems, circuit-breaker fail protection shall trip all necessary contiguous circuit-breakers capable of supplying a fault infeed within a target fault clearance time of 300 ms.

**Table 9 — Circuit-Breaker Fault Clearance Times**

System Voltage (kV)	Target fault interruption time of main in-feeding circuit (ms)	Target total fault clearance time for all infeeds (ms)	Target back-up clearance time (ms)
400	80	140	500(1000) <sup>1</sup>
275	100	160	500(1000) <sup>1</sup>
220	100	160	500(1000) <sup>1</sup>
132	120	180	1500
66	120	200	<1500
33	200	250	<1500 (5000) <sup>2</sup>
11	500(200) <sup>3</sup>	600(200) <sup>3</sup>	<1500

NOTE1: Fault Clearance times of 1 second for Zone 3 distance protection and REF protection on feeder circuits are acceptable.

NOTE2: Fault Clearance time for SBEF Stage 1.

NOTE3: Interconnected circuits only (SPT).

## 10.3 Multi-Pole Opening/Tripping and Auto-Reclosing

Apparatus shall be suitable for operation under the following circuit-breaker operating conditions, unless otherwise stated by the Bilateral agreement;

- i) simultaneous three-phase opening/tripping; and
- ii) simultaneous three-phase auto-reclosing on overhead line feeder circuits.

The switching of transformers, shunt capacitor banks and shunt reactors may require the use of circuit-breakers with intentionally non-simultaneous pole operation. Single-phase high-speed auto-reclose may be required on a circuit specific basis.

## 10.4 SCADA

The SCADA facilities to be provided by the User shall be covered by the Bilateral agreement.

The User shall be responsible for the provision, termination and testing of all necessary cables and associated facilities required to satisfy the SCADA system interface requirement, to an agreed interface point, in the Bilateral agreement.

## 11. Surge Arresters

### 11.1 Surge Arresters Standards & Specifications

Surge arresters shall comply with BS EN 60099-4.

Where abnormal circuit conditions are prevalent then an insulation coordination study will be carried out between TO and user

## 12. Switchgear

### 12.1 Switchgear Ratings

The design of the User's network in the interface zone shall permit the use of common switchgear ratings for standard applications as listed in BS EN 62271-1, BS EN 62271-102 and BS EN 62271-100.

The User shall not install Apparatus in the interface zone that imposes switching duties on TO switchgear which may exceed the ratings specified in Clause 5 of this document.

### 12.2 Gas Insulated Switchgear (GIS)

#### 12.2.1 GIS Standards & Specifications

GIS shall meet the requirements of BS EN IEC 62271-203.

#### 12.2.2 GIS Design & Construction

The point of connection between the TO's plant to the User's GIS shall be in accordance with the CUSC. Different solutions shall only be used by agreement with the TO in exceptional circumstances.

In circumstance which the User's GIS is connected to the TO's GIS in a GIB/GIL connection, therefore without an AIS interface, the following requirements shall apply:

- i) a gas zone with gas tight barriers shall exist between the TO's and the User's compartments. Where access is required adjacent to this gas compartment for maintenance or repair, this compartment shall be reduced to atmospheric pressure to avoid personnel working against the fully pressurised compartments; and
- ii) the gas tight support insulating barriers shall be capable of withstanding a pressure differential of atmospheric pressure on one side, and on the other side a pressure equal to the design gas pressure or the maximum gas pressure under conditions of an internal fault, if this is greater; and
- iii) the User's GIS design shall not affect the User's minimum service continuity level which permits installation, extension, safe operation and maintenance (preventative and corrective) with a maximum of one circuit (inclusive of the circuit being worked upon) and one busbar section out of service simultaneously; and

- iv) the User shall not rely on any operational status in the TO's disconnectors, gas barriers or insulations links to comply with the previous requirement (e.g. reducing the pressure of the TO's adjacent compartment); and
- v) it is acceptable that a double busbar section outage is required for the duration of dielectric tests on the main circuit only, according to BS EN 62271-203, following works that involve the opening of gas compartments, provided that a three-hour emergency return to service time is demonstrated for all circuits other than the parts that are subject to test. Sufficient isolating distances shall be included to facilitate this test. This shall include two disconnectors in the reserve bus section. In the context of this clause, a double busbar section outage refers to two busbar sections on the same side of a bus section (or between two bus sections), but not two busbars on different sides of a bus section; for example, an outage of main busbar one and reserve busbar one is compliant to this requirement, whereas an outage of main busbar one and main busbar two is not compliant to this requirement; and
- vi) the User shall not rely on any operational status in The TO's disconnectors, gas barriers or insulations links to comply with the previous requirement (e.g. reducing the pressure of the TO's adjacent compartment); and
- vii) a double busbar section outage is also acceptable for testing of interlocking and busbar protection during extension, provided that a three-hour emergency return to service time is demonstrated for all circuits other than the extension; and
- viii) for the avoidance of doubt, the above clauses are also applicable to control and protection equipment, gas density monitoring systems, access platforms and any other equipment necessary for the operation of the GIS; and
- ix) the TO's Safety Procedures requires operators to check correct operation of gas density/pressure alarms whenever a gas insulated disconnector is used to provide a Point of Isolation. To ensure compliance with this Safety Procedure, a suitable test facility on all disconnector gas compartments shall be provided on User's GIS where this Disconnector may be used as a Point of Isolation for work on User's Apparatus; and
- x) outages shall not be required for routine inspections of GIS that are required at less than five-year intervals, for example switching device drives and corrosion protection; and
- xi) outages shall not be required for maintenance to or inspections of the building or building services; and
- xii) the internal arc pressure relief device solution of the GIS shall not compromise the exit routes within the substation - such that venting arrangements don't impact access and egress routes; and
- xiii) where the connection between the User's GIS and TO's GIS is provided by a cable directly terminated into the TO's GIS, the cable connection arrangement and cable connection enclosure shall comply with the requirements of BS EN IEC 62271-209. The dimensions of the cable connection assembly and limits of supply of GIS manufacturer and cable termination manufacturer shall be in accordance with the relevant figures in BS EN IEC 62271-209. The type tests on the cable termination and cable enclosure shall



be carried out according to the type tests defined in BS EN IEC 62271-209. The tests shall be carried out using the identical IIG gas mixture and at the specified minimum functional pressure for insulation specified by the GIS manufacturer.

## 12.3 Circuit-Breakers

### 12.3.1 Circuit-Breaker Standards & Specifications

Circuit-breakers shall meet the requirements of BS EN IEC 62271-100.

### 12.3.2 Circuit-Breaker Design & Construction

See Clause 13 for reactor switching requirements.

### 12.3.3 Circuit-breaker Type Test

Only standard type tested circuit-breaker switching requirements are required in the interface zone.

Circuit-breakers requiring non-testing for special switching requirements as requested on a site-by-site basis by the User, shall be agreed in the connection agreement.

## 12.4 Disconnectors & Earthing Switches

### 12.4.1 Disconnectors & Earthing Switches Standards & Specifications

Disconnectors and earthing switches shall meet the requirements of BS EN IEC 62271-102.

Disconnectors forming parts of metal-enclosed switchgear for use on systems with nominal voltage of 33 kV and 11 kV shall meet the requirements of ENA TS 41-40.

The number and type of each auxiliary switch will be specified on a site-specific basis.

Auxiliary switches on disconnectors are used to switch current transformer secondary circuits as part of the interface protection scheme (e.g. Disconnectors intended for bus-transfer or mesh-corner switching in high impedance busbar) shall comply with the following requirements:

- i) the auxiliary switch shall have a contact travel related to disconnector main contact travel as shown in Figure 2 for auxiliary switch variant “Type (vii)” as below; and
- ii) the auxiliary contact must close before the primary contacts start conducting current during a normal closing operation and must open after the primary contacts have stopped conducting current during a normal opening operation; and
- iii) auxiliary switches shall have sufficient rating to carry and make/break the associated CT secondary circuit current; and auxiliary switches shall be positively driven in both directions and compliant with BS EN IEC 62271-102.

iv)

Auxiliary switch type	Auxiliary switch contact position (I = Closed; O = Open)				
Type (iii)	O	I	I	I	I
Type (iv)	I	O	O	O	O
Type (v)	I	I	I	I	O
Type (vi)	O	O	O	O	I
Type (vii)	O	O	I	I	I

1

2

Open ← Main contacts position → Closed

3

4

5

Disconnecter main contact positions:

1. Disconnecter fully open. Travel complete.
2. Disconnecter can withstand rated power frequency and impulse withstand voltages across main contacts.
3. Point at which current can commence during a closing operation or ceases to flow during an opening operation.
4. Disconnecter can carry rated current and rated withstand current.
5. Disconnecter fully closed. Travel complete.

**Figure 2 — Disconnecter Auxiliary Switch Positions in Relation to Main Contact Position**

*TOs Specify the following when users are required to interface with these arrangements, disconnectors shall be fitted with a locking facility to secure the disconnector in the open position using a safety padlock with 41 mm square body and with a 4 mm to 7 mm diameter shackle having a clear inside width of 21 mm and an inside length of 16 mm to 45 mm. The holes provided for the shackle shall not be less than 8 mm diameter.*

## 13. Transformers & Reactors

### 13.1 Transformer & Reactor Standards & Specifications

Definitions given in IEC 60050 and BS EN 60076 relevant parts shall apply.

Mineral insulating oil shall be tested in accordance with all of the relevant parts of BS EN IEC 60296.

Unused synthetic organic esters shall be tested in accordance with all relevant parts of IEC 61099.

Tap-changers shall be tested in accordance with all relevant parts of BS IEC/IEEE 60214.

### 13.2 Transformer & Reactors Design & Construction

All bushings shall be in accordance with Clause 7 of this document.

### 13.3 Transformer & Reactor Type Test

**Error! Reference source not found.** shows the minimum test voltages that shall be used.

**Table 10 — Transformer Test Voltages**

System Voltage (kV)	Lightning Impulse Voltage Withstand (kV peak)	Induced Overvoltage Withstand (kV rms)	Applied Voltage Withstand (kV rms)	Switching Impulse Voltage Withstand (kV peak)	Core to Frame and Core to Earth (kV r.m.s)		
					Oil	Oil	Air
400	1425	630	45	1050	5	5	3
275	1050	460	45	850	5	5	3
220	950	395	45	750	5	5	3
132	550	230	45	460	5	5	3
66	325	132	140	n/a	2	2.5	0.5
33	170	66	70	n/a	2	2.5	0.5
11	75	22	28	n/a	2	2.5	0.5

### 13.4 Protection Against Leakage of Insulating Liquid

In TO substations, appropriate measures shall be taken to contain any leakage from liquid-immersed Apparatus so as to prevent environmental damage in accordance with BS EN IEC 61936-1. The quantity of insulating liquid in the Apparatus, volume of water from rain and fire protection systems, the proximity to water courses and soil conditions shall be considered in the selection of any containment system.

## 14. Abbreviations & Conventions

**Table 11 — Abbreviations, Terms and Definitions**

<b>Abbreviation / Term</b>	<b>Description</b>
<b>Apparatus</b>	All HV equipment in which electrical conductors are used, supported or of which they may form a part.
<b>AC</b>	Alternating Current
<b>AES</b>	Applicable Electrical Standard
<b>AIS</b>	Air Insulated Switchgear
<b>BS</b>	British Standard
<b>CE</b>	Conformité Européenne
<b>CNI</b>	Critical National Infrastructure
<b>CUSC</b>	Connection and Use of System Code
<b>CT</b>	Current Transformer
<b>DC</b>	Direct Current
<b>DNO</b>	Distribution Network Operator
<b>DSM</b>	Dynamic System Monitoring
<b>ECC</b>	European Connection Conditions
<b>EHV</b>	Extra High Voltage
<b>EMC</b>	Electro Magnetic Compatibility
<b>EMF</b>	Electro Magnetic Field
<b>EN</b>	Euro Norm (European Standard)
<b>ENA</b>	Energy Networks Association
<b>EREC</b>	Engineering Recommendation
<b>ESQCR</b>	Electricity Safety Quality & Continuity Regulations
<b>ETR</b>	Engineering Technical Report
<b>GB</b>	Great Britain
<b>GC</b>	Grid Code - The Grid Code details the technical requirements for connecting to and using the National Electricity Transmission System (NETS). Compliance with the Grid Code is one of the requirements of the Connection and Use of System Code (CUSC).
<b>GIB</b>	Gas Insulated Busbar
<b>GIL</b>	Gas Insulated Line
<b>GIS</b>	Gas Insulated Switchgear
<b>H&amp;S</b>	Health & Safety
<b>HV</b>	High Voltage (above 1 kV)
<b>IEC</b>	International Electrotechnical Commission
<b>IED</b>	Intelligent Electronic Device

## Transmission Owners: Applicable Electrical Standard

IEEE	Institute of Electrical and Electronic Engineers
IIG	Insulation and Interruption Gases
IP	Ingress Protection
ISO	International Standards Organisation
LV	Low Voltage
LVAC	Low Voltage Alternating Current
LVDC	Low Voltage Direct Current
NESO	National Energy System Operator
NETS	National Electricity Transmission System
NG	National Grid
NGET	National Grid Electricity Transmission
PD	Partial Discharge
PD IEC/TS	Published Document IEC/TS
PPE	Personal Protective Equipment
PTO	Public Telecommunications Operator
ROEP	Rise of Earth Potential
SBEF	Standby Earth Fault
REF	Restricted Earth Fault
SCADA	Supervisory Control and Data Acquisition
SF <sub>6</sub>	Sulphur hexafluoride gas
SHETL	Scottish Hydro Electric Transmission Limited
SPS	Site Pollution Severity
SPT	Scottish Power Transmission
STANDARD (International)	A document that has been developed through the consensus of experts from many countries and is approved and published by a globally recognized body. It comprises rules, guidelines, processes, or characteristics that allow users to achieve the same outcome time and time again.
SQSS	Security and Quality of Supply Standard
SVL	Sheath Voltage Limiter
TO	Transmission Owner (NGET, SHETL or SPT)
TOCA	Transmission Owner Connection Agreement
TRV	Transient Recovery Voltage
TS	Technical Specification
UKCA	UK Conformity Assessed
USCD	Unified Specific Creepage Distance
User	Any person (other than a Transmission Owner) who is authorised to generate, participate in the transmission of, distribute or supply electricity or who is included in a class of person or persons which has been granted an exemption from section 6 of the Act and any person engaged in the sale or purchase of electricity or who otherwise purchases or acquires for purchase electricity; The term User includes an EU Code User and a GB Code User.
VT	Voltage Transformer

## 15. TSO Sign-Off

X

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Mark Waldron  
Technical Leader – Net Zero Asset Strategy

**nationalgrid**

X

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Fabian Koehler  
Lead Subject Matter Expert (Primary Plant)



X

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Fraser Ainslie  
Head of Engineering Design & Standards

