

Transmission Owners Relevant Electrical Standards

NGET, SHET & SPT

Version History

Version	Date	Amendment
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Contents

1. Introduction.....	68
1.1 Background and Purpose	68
1.2 Scope.....	68
1.3 Objectives	68
2. Interface Zone.....	79
2.1 Interface Zone Description	79
2.2 Interface Zone Requirements	79
3. Reference and Related Documents	84
3.1 Legal	84
3.2 Standards	91
3.3 ENA Specifications & Engineering Recommendations	114
3.4 Operational Health & Safety Documents.....	124
3.5 National Energy System Operator (NESO) Codes	124
3.6 Other Documents	135
4. Climatic & Environmental.....	135
4.1 Indoor Requirements	135
4.2 Outdoor Requirements.....	135
4.3 Pollution	135
4.4 Altitude.....	135
4.5 Exposure to Abnormal Vibrations, Shock or Tilting	135
4.6 Wind Load	135
4.7 Ice Load.....	146
4.8 Flood Resilience	146
4.9 Environmental impact	146
5. Electrical System	146
5.1 System Voltage	157
5.2 Rated Insulation Level	157
5.3 Rated Frequency	168
5.4 Rated Continuous Current	168
5.5 Rated Short-circuit and Short-time Withstand Current	179
5.6 Substation Auxiliary Supplies	179
5.6.1 DC Auxiliary Supply Requirements	179
6. Substation	182
6.1 Clearances	192

6.3 Interlocking	2022
6.3.1 Interlocking Switchgear	2123
6.3.2 Interlocking Protection	2224
6.4 Security.....	2224
6.5 Conductor Jointing in Substations	2224
6.6 Insulation and Interruption Gases (IIG)	2224
6.7 Ancillary Equipment	2325
6.8 Maintenance	2325
7. Bushings & Insulators.....	2325
7.1 Bushings	2325
7.1.1 Bushing Specifications.....	2325
7.1.2 Bushing Design & Construction	2325
7.2 Post Insulators	2325
7.2.1 Post Insulator Standards	2325
7.2.2 Insulators Design & Construction	2426
7.2.3 Insulators Type Tests	2426
7.2.4 Insulators Routine Tests	2426
8. Cables.....	2426
8.1 Cable Standards & Specifications.....	2426
8.2 Cable Design & Construction	2426
8.3 Earthing and Bonding of High Voltage Power Cables	2527
8.4 Cable Installation & Commissioning	2527
9. Instrument Transformers	2527
9.1 Current Transformers (CTs).....	2628
9.1.1 CT Specifications.....	2628
9.1.2 CT Design & Construction	2628
9.1.3 CT Routine Tests	2628
9.2 Voltage Transformers (VTs)	2628
9.2.1 VT Specifications.....	2628
10. Protection & Control.....	2729
10.1 Protection Types	2729
10.1.1 Protection Environmental Requirements	2729
10.1.2 Protection Functional Requirements	2830
10.1.3 DC Trip Relay Requirements.....	2830
10.1.4 Tele-protection Communications	2830
10.2 Circuit-Breaker Fault Protection and Clearance Times	2830

10.3	Multi-Pole Opening/Tripping and Auto-Reclosing	2931
10.4	Dynamic System Monitoring.....	2931
10.5	Electronic Equipment Requirements	2931
10.6	SCADA	2931
11.	Surge Arrestors.....	2931
11.1	Surge Arrestors Standards & Specifications	2931
11.2	Surge Arrestors Design & Construction	3032
12.	Switchgear	3032
12.1	Switchgear Ratings	3032
12.2	Gas Insulated Switchgear (GIS)	3032
12.2.1	GIS Standards & Specifications	3032
12.2.2	GIS Design & Construction	3032
12.3	Circuit-Breakers	3234
12.3.1	Circuit-Breaker Standards & Specifications	3234
12.3.2	Circuit-Breaker Design & Construction	3234
12.3.3	Circuit-breaker Type Test.....	3234
12.4	Disconnectors & Earthing Switches	3234
12.4.1	Disconnectors & Earthing Switches Standards & Specifications	3234
13.	Transformers & Reactors.....	3335
13.1	Transformer & Reactor Standards & Specifications	3335
13.2	Transformer & Reactors Design & Construction	3335
13.3	Transformer & Reactor Type Test.....	3335
13.4	Protection Against Leakage of Insulating Liquid	3436
14.	Abbreviations & Conventions	3537
15.	TSO Sign-Off.....	3739

Tables

Table 1 — Apparatus Voltage Requirements	15
Table 2 — Rated Insulation Level Requirements	15
Table 3 — Rated Continuous Current Requirements	16
Table 4 — Rated Short-Circuit Current Requirements	17
Table 5 — Operating Voltages and Auxiliary Control Circuits.....	18
Table 6 — Substation safety clearances	19
Table 7 — Neutral Earthing Requirements	19
Table 8 — Protection Function Testing Compliance Requirements	28
Table 9 — Circuit-Breaker Fault Clearance Times	28

Table 10 — Transformer Test Voltages	34
Table 11 — Abbreviations and Terms	35

Figures

Figure 1- Electrical boundary for Gas Insulated Switchgear	7
Figure 2 — Disconnecter Auxiliary Switch Positions in Relation to Main Contact Position	33

1. Introduction

1.1 Background and Purpose

This document 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 or ECC.6.2.1.2 of the Grid Code Connection Conditions, as applicable and pursuant to the terms of the Bilateral Connection Agreement (BCA).

Apparatus commissioned prior to the implementation date of this Relevant Electrical Standard (RES) will continue to be subject to the Standards applicable at the time of commissioning of that Apparatus.

It is important that all Users demonstrate that electrical infrastructure directly connected to the NETS in Great Britain (GB) has adequate strength and is fit for purpose. It shall comply with both statutory and GB Grid Code requirements capability, meet manufacturers' stated performance characteristics and shall comply with the requirements contained within this RES.

NGET, SHET and SPT form the GB's Onshore Transmission Owners (TOs) and have produced this common RES. This RES document defines the performance requirements and minimum technical requirements for Apparatus directly connected to the TOs' systems.

This Standard applies to transmission connected Users in GB.

The Grid Code details the technical requirements for connecting to and make use of the NETS.

Compliance with the Grid Code is one of the requirements of the Connection and Use of System Code (CUSC).

1.2 Scope

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

The requirements of this document apply only to Apparatus owned by the User within the interface zone and does not apply to Apparatus owned by the User and connected to Apparatus owned by other Transmission Licensees.

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

The key requirement of this RES is to ensure that Network Performance is maintained within design requirements.

1.3 Objectives

The purpose of this RES is to provide a satisfactory level of reliability and security for the NETS in GB at the interface zone. This document provides the minimum criteria to ensure that User electrical infrastructure directly connected to the NETS at least meets the same standard of construction, manufacturing and installation quality as that employed by the GB TOs.

The objectives of this RES are to ensure:

Commented [MC1]: Duplicate words, should be 'this'

Commented [KO2R1]: Agreed

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

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

Commented [MC3]: At within? Should be 'within'

Commented [KO4R3]: Agreed.

2. Interface Zone

This Section provides detail of where on the NETS this Standard applies.

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 document (or any contrary agreement in the BCA or any other agreement on the division of ownership) and the User's circuit-breaker(s). The Apparatus in this zone shall be electrically protected by both parties.

TO owned assets installed between extremity of the busbar protection zone and the User electrical boundary (i.e. outside the interface zone) shall be protected by the User in accordance with the requirements of this document, including the provision of monitoring alarms.

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

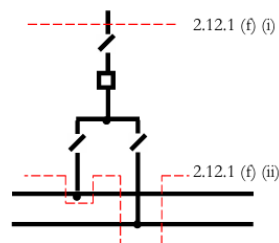


Figure 1- Electrical boundary for Gas Insulated Switchgear

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 document and as shown in [Figure 1](#) above.

The BCA may define further specific requirements, with respect to Apparatus, which are not defined in this RES and may be needed to comply with site-specific conditions.

2.2 Interface Zone Requirements

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

The TO shall determine the principles 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 BCA.

The TO's electrical boundary of the interface zone shall be dependent on the asset type, i.e.:

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

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, as defined in the BCA.

The TO shall not be responsible for the User relying on the TO's circuit-breaker(s) to be the sole means of protecting the User's network beyond the interface zone.

The TO's Apparatus shall not provide the sole means to facilitate safe isolation and earthing of the TO network.

The User's connection 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 be independent of the TO's attendance at site.

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

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.

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.

Documents in the following sections shall apply.

3.1 Legal

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.

Commented [HA5]: Should we provide more information at this point to define what an acceptable connection point would be on GIS, in line with the Ofgem ruling for Liric connecting into KILS400, to prevent future debate?

Commented [MC6R5]: The principle is that the TOCO will define that. This document should be limited to setting out the technical requirements for assets within the 'zone of interest'.

Commented [KB7R5]: Is this not as per section 2.12 of the CUSC?
To be discussed at sign-off meeting

Commented [KB8R5]: As above

Commented [MC9]: They will be reliant on the TO CB protecting the interface zone.s

Commented [KB10R9]: Agreed. This sentence relates to "beyond the interface zone". Do we want to reinforce difference between equipment in the interface zone and beyond the interface zone?

Commented [KB11]: Is this what we intended or should this be "safe isolation and earthing of the SO network? Is this the same as the following clause?

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>
BS EN 60529	<i>Degrees of protection provided by enclosures (IP code)</i>
BS EN 61099	<i>Insulating liquids. Specifications for unused synthetic organic esters for electrical purposes</i>

Commented [KB12]: This is the latest UK legislation on F-Gases I can find. The latest EU Regs do not apply in UK.
Do any of the WG members have any information that updates this?

Commented [KO13R12]: Now updated as discussed.

Commented [SC14]: What is the intended revision date of this doc? The 2nd gen eurocode is planned for transition by 2028 and this should be caveated to reflect this.

Commented [KB15R14]: Issue date removed. This document states a general requirement that all reference documents shall be to the most recent issue.

Commented [SC16]: This is not a complete list of civil standards, BS EN 1991, 1992, 1993, 1997 should be included as a minimum

Commented [KB17R16]: BS EN 1991, 1992, 1993 and 1997 now included in references

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/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 C55/6	<i>Insulated Sheath Power Cable Systems</i>
ENA EREC G5/5	<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 P29	<i>Planning limits for voltage unbalance in the UK for 132 kV and below</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 & 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>
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>

Commented [HA18]: Why are these relevant?

Commented [KB19R18]: To be discussed

Commented [KO20R18]: Agreed in meeting that these are necessary for this document

3.6 Other Documents

NESO *Bilateral Connection Agreement (BCA) for NGET, SHET or SPT.*

4. Climatic & Environmental

The common GB requirements are listed below. Where higher values are required on a site-by-site basis, these will be confirmed with the TO.

4.1 Indoor Requirements

It is not anticipated that Apparatus will be required to operate outside the +40 °C to -5 °C temperature limits or in humidity which exceed 95%.

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

4.2 Outdoor Requirements

It is not anticipated that Apparatus will be required to operate outside the +40 °C to -25 °C temperature limits.

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 in accordance with PD IEC/TS 60815.

4.4 Altitude

This document is for 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, the operational environment (service liability state) shall be based on a wind speed of 34 m/s.

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.

Commented [HA21]: Does this sentence make sense? Should it not be : 'The common GB requirements are listed below. Where higher values are required on a site-by-site basis, these will be confirmed with the TO.'

Commented [KO22R21]: Agreed and amended.

Commented [K(23): doesnt define below 1000m from where suggest wording the verifies its up to 1000m above sea level. Also what applies above 1000m?

Commented [KB24R23]: Reworded. I don't think substations at altitudes above 1000 m is realistic in UK considering maximum heights of mountains in Scotland, England and Wales. Special calculations are needed in such cases

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:

- Ice thickness in the absence of wind, based on r_o with an ice density of 5 kN/m^3
- Ice thickness in conjunction with wind, based on r_w with ice density 9 kN/m^3 , reduced wind using 0.5 reduction factor on wind force (not wind speed) and wind applied to the iced section.

4.8 Flood Resilience

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 Engineering Technical Report 138. The design shall ensure that the reliability on security of Apparatus is not deleteriously impacted 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 Apparatus (including transformers, marshalling kiosks, relay cabinets etc.) at which:

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

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

4.9 Environmental impact

The design of substation and associated Apparatus in the interforce 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:

- environmental as specified in this document;

Commented [SC25]: Who is defined as the User?

Our flood levels are defined as 600mm above 1 in 1000 year events, this should be reflected where we are adopting plant.

Commented [KB26R25]: This wording has been taken from an ENA document and it's intended to put the responsibility on the equipment provider to confirm applicability of their equipment. I agree that if we have a common national requirement then this should be specified in this clause.
To be discussed at meeting

Commented [KB27R25]: Clause reworded

- ii) fault carrying capabilities;
- iii) making and breaking duties;
- iv) short-time withstand current;
- v) continuous current;
- vi) mechanical duties (where applicable);

Normal and abnormal system conditions shall be considered.

NOTE: Connections at 25 kV for traction supplies are common, however they are not included in this document. This is due to being a site-specific connection and hence use the guidelines in ENA EREC P24.

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 ECC.6.1.4.1 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 ¹	420
275 ²	-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 1: 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 up to 15 minutes.

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 Clause 5 of ENA EREC G5/5.

Apparatus shall satisfy their specified functional and performance requirements with phase voltage unbalance up to a maximum of 2% as according to ENA EREC P29.

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 particular Apparatus types. Apparatus shall be type tested to demonstrate they meet the required rated insulation levels.

Table 2 — Rated Insulation Level Requirements

System Voltage	Rated short duration power frequency withstand voltage (kV peak) ²	Rated switching impulse withstand voltage (kV peak) ³	Rated lightning impulse withstand voltage (kV peak) ⁴
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Commented [VG28]: How do these compare with variations specified in ECC.6.1.4 (and CC.6.1.4)?

Commented [KB29R28]: These values are the same as those specified in clause ECC 6.1.4.1 of Grid Code. I've added the % operating range from Table in ECC.6.1.4.1 to clarify this.

Commented [HA30]: Should similar consideration not be given to 275kV equipment?

Commented [KB31R30]: The 15 minutes period of operation is applicable to system voltages greater than 300 kV only

(kV)	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) ¹	1425	1425 (+240) ¹	1425 (+240) ¹
275	395	435	435	850	1275	700 (+245) ¹	1050	1050 (+170) ¹	1050 (+170) ¹
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 μ s.
- NOTE 4: Impulse wave shape - 1.2 / 50 μ s.

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 outlined in Clause CC.6.1.3 of the Grid Code.

User's Apparatus shall satisfy their specified functional and performance requirements over the range of frequency ranges described in Clause CC 6.1.3 of the Grid Code.

5.4 Rated Continuous Current

The maximum typical values of continuous currents applicable to each voltage level are given in [Table 3](#).

Lower rated continuous currents may be selected to suit the installation requirements.

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

Higher rated continuous current ratings may be used by agreement on a site-by-site basis.

Table 3 — Rated Continuous Current Requirements

System Voltage (kV)	Rated Continuous Current (A)
------------------------	------------------------------------

400	5000
275	3150
220	2000
132	3150
66	2000
33	1250
11	2500

5.5 Rated Short-circuit and Short-time Withstand Current

Typical short-circuit requirements are shown in [Table 4](#) and shall be determined on a site-by-site basis.

Table 4 — Rated Short-Circuit Current Requirements

System Voltage (kV)	Single Phase Short-circuit Current (kA)	Three Phase Short-circuit Current (kA)	Short-time Withstand Current (s)	DC Time Constant ¹ (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, especially those associated with User connections, significantly higher system DC time constants may be experienced.

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

Commented [MC32]: Do we need to include the additional higher dc time constant requirement at 132kV?, 31.5kA/3s @ 120ms

5.6 Substation Auxiliary Supplies

The operational security of the NETS, and availability of High Voltage Apparatus is dependent upon reliable and secure auxiliary supplies.

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

LVDC supplies shall not be provided by the TO.

5.6.1 DC Auxiliary Supply Requirements

Auxiliary supply requirements shall be required to open all the connected User's circuit-breakers (within the interface zone) at the end of the 72-hour period¹.

Auxiliary supply requirements shall be required to open all the connected User's circuit-breakers (within the interface zone) at the end of a 72-hour period¹ following loss of AC supplies.

Commented [HA33]: Is this an extract from a standard, if so should be qualified as such. As a stand alone sentence it doesn't make sense. Should it not be ;'Auxiliary supply requirements shall be required to open all the connected User's circuit-breakers (within the interface zone) at the end of a 72-hour period¹ following loss of AC supplies.'

Users shall ensure that there is the capability to operate and maintain their auxiliary supplies for operation and protection control systems for a 72-hour period¹ after the loss of AC supplies.

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

The relevant DC supplies shall be agreed on a site-specific basis.

TOs typical DC supplies are 48 V DC or 110 V DC within the range as shown by [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

For all electrical infrastructure applicable in this document, the following applies:

i) 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 prevent danger 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;

ii) manufacturing facilities shall be certified by a recognised accreditation organisation to ISO 9001;

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;

iv) all electrical infrastructure shall meet statutory requirements for safety as specified in Clause 3 of this RES;

v) it is the User's responsibility to ensure 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 for all Apparatus in the interface zone.

6.1 Clearances

In open-terminal substations within the interface zone, safety to persons shall normally be achieved by the provision of adequate design clearances to live parts based on operational safety distances applicable to a specific substation and the TO. 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. The values quoted permit a consistent approach to be adopted across the GB TOs. Lower values may be accepted on a site-per-site basis if agreed by the appropriate TO.

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.

Table 6 — Substation safety clearances

System Voltage (V)	Highest voltage For installation (kV)	Design Clearance for Safety Vertical (m)	Design Clearance for Safety Horizontal (m)	Insulation height (mm)
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

NOTE1: Persons should not allow any part of their body or any object to infringe this distance 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.

NOTE4: 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 given in **Table 7** below:

Table 7 — Neutral Earthing Requirements

System Voltage (kV)	Maximum Earth Factor	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 or via Earthing Transformer
33	1.73	Impedance Earthing
11	1.9	Impedance Earthing or Direct

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

System earthing varies according to voltage and location across the network and shall be defined as part of the BCA. 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 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. Neither party should rely on the other's earthing system unless regular maintenance/testing of both systems can be assured.

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 0.

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.

Commented [FK34]: Can we also write a sentence that it's the users responsibility to upgrade their earthing system if network fault levels rise?

Commented [KB35R34]: Agreed. Clause added to state that User shall assess the design of the earthing system and modify as required should fault level increases

6.3.1 Interlocking Switchgear

In substations where the TO is a joint occupier 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:

- i) interlocking between circuit-breakers and disconnectors to ensure disconnectors do not operate outside their rating (i.e. make or break load currents);
- 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;
- 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 145 kV;
- iv) to ensure correct sequence of on load busbar transfer switching operations at multiple busbar substations;
- v) to ensure that a bus-coupler or bus-section circuit-breaker is only closed with its associated disconnectors are both open or alternatively, are both closed;
- vi) for Apparatus at sites where the TO is the Occupier, 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.

Commented [HA36]: We should be clear this would only be accepted on GIS. Why does this lock need to be unique any use of this facility should be governed by procedure. A safety padlock should not be used for this feature, this is not the intent of a safety padlock, an operational padlock type 'M' in SPT should be used. By their nature this type of padlock cannot be unique.

Commented [KB37R36]: Agreed. Amended accordingly.

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;
- ii) the IED used to facilitate the interlocking signalling scheme shall have self-checking facilities to indicate IED health;
- 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;
- 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;
- 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;
- 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, and in the event of scheme failure, both the TO and the User shall revert to process based interlocking between sites.

6.4 Security

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).

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

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 0 for cable requirements.

6.6 Insulation and Interruption Gases (IIG)

The TO preference is that SF₆ Free solutions should be used where technically viable. Apparatus owned by the TO that contain SF₆ should only be employed where the market demonstrates that

Commented [HA38]: Is this a colloquialism can we be sure this will be understood? If we want to retain the term DBI we need to define what that stands for.

Commented [KO39R38]: This stated in the definitions.

Commented [KB40R38]: Term DBI appears in some NGET Protection specs but I have removed this term in this document for clarity

this is impractical. In case of Gas Insulated Switchgear 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

The User shall make the TO aware of all maintenance requirements and procedures on Apparatus connected in the interface zone.

The User's responsibility is to maintain the Apparatus to ensure safe operation. The TO should have the right to request evidence that the Apparatus has been maintained in line with Users maintenance regime.

7. Bushings & Insulators

Pressurised porcelain insulators (including bushings used on transformers, switchgear, instrument transformers, surge arresters and AIS cable terminations) shall not be used in the TO substation and interface zone.

Polymeric insulation shall be employed in the TO substation and Interface Zone 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.

7.1 Bushings

7.1.1 Bushing Specifications

Bushings shall comply with BS EN 60137.

7.1.2 Bushing Design & Construction

See Clause 10.1 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.

Commented [HA41]: Is this the declared strategy for all TO's? Are some potentially still intending to install SF⁶ at 275kV until a solution is available due to the cost differential?

Commented [KB42R41]: All TO have similar policies to avoid the use of SF₆ where technically viable. Changed paragraph to highlight this is applicable to TO owned equipment only.

Commented [KB43R41]: Agreed to leave this clause but to add sentence to clarify that in case of GIS that solution needs to be agreed.

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

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

Connectors 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.

Commented [KB44]: There are BS EN equivalents of these IECs for cables. Should we not be referring to BS EN rather than IEC?

Commented [KB45R44]: I've checked these are there are no equivalent BS ENs

Commented [K(46): should there not be something in here about ducting and sealing of ducts especially in situations where the ducts enter SPT buildings

Commented [KB47R46]: Clause included

As 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.

In addition, the physical separation of such channels outside the perimeter of the TO's managed site shall be at least 5 m. The PTO (Public Telecommunications Operator) shall be able to provide documentary evidence of the separation provided.

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 historically accepted values for safety specified in 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.

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.

Wherever practicable multicore cables shall be run on wall or compound surface mounted cable tray that does not present a trip hazard.

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.

8.4 Cable Installation & Commissioning

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

9. Instrument Transformers

Where the BCA specifically identifies that metering is required at 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.

Commented [KO48]: Kevin Butter - I have revised this section to make reference to ENA EREC C55 and avoid any repetition to wording in C55. I have concentrated on safety aspects that might impact TO staff

Commented [BM49]: National Grid ignore the C55 limits and specify that the induced voltage must not damage the oversheath. Separate email sent to KB.

Commented [KB50R49]: Wording changed to address safety issues associated with access to sheath earthing systems

Commented [MC51]: Metering Code of Practice 5 relates to energy transfers up to, and including, 1MW. In general CTs and VTs used for metering purposes shall be compliant with the Balancing and Settlement Code, and its associated Codes of Practice.

Commented [KB52R51]: Agreed

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 available in each particular connection agreement, as a minimum.

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), the User shall install the required CTs and equipment within their own site. 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 by the TO 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.

9.2 Voltage Transformers (VTs)

9.2.1 VT Specifications

Inductive VTs shall comply with BS EN 61869-1 and BS EN 61869-3.

Capacitive VTs shall comply with BS EN 61869-1 and BS EN 61869-5.

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

Where the User is required to install Fault Recording and/or Dynamic System Monitoring (DSM), the User shall install the required VTs within their own site. The TO shall not make any VTs available to the User for this purpose.

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;
- 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 unlicensed local agreements in place;
- 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, in accordance with the minimum requirements in the CUSC.

The User and TO shall, between them, agree the respective protection and control relay settings 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 BCA and accordingly the CUSC document.

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 9~~.

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 it interfaces 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 specified interface protection system utilises protection communications, e.g. fibre optic link, to gather information from the User's site, the communication link shall as a minimum be in accordance with Category 1 links defined by ENA TS 48-6-7.

10.2 Circuit-Breaker Fault Protection and Clearance Times

Apparatus shall be suitable for operation under the conditions detailed in [Table 9](#)~~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) ¹
275	100	160	500(1000) ¹
220	100	160	500(1000) ¹
132	120	180	1500
66	120	200	<1500

Commented [MC53]: NGET TS1(RES) Table 6 details requirement, at 66kV, as 120ms, N/A, <1500ms

Commented [KB54R53]: Table updated

33	200	250	<1500 (5000) ²
11	500(200) ³	600(200) ³	<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 TO;

- i) simultaneous three-phase opening/tripping;
- 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.

Commented [HA55]: Is this a term commonly used in engineering? I am only aware of it being used in the context of society and not electrical equipment. Should 'non simultaneous operation of poles not be used'? I

Commented [KO56R55]: Amended.

10.4 Dynamic System Monitoring

Where the User is required to install Fault Recording and/or Dynamic System Monitoring (DSM), the User shall install the required CTs and associated equipment within their own site. The TO shall not make any instrument transformers or space available to the User for this purpose.

10.5 Electronic Equipment Requirements

10.6 SCADA

SCADA facilities shall be provided for control, alarms, indications and analogue information from all items of Apparatus. The SCADA facilities to be provided by the User shall be defined by the TO and/or NESO.

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.

See Clause 0 for SCADA termination limitations.

11. Surge Arrestors

11.1 Surge Arrestors Standards & Specifications

Surge arresters shall comply with BS EN 60099-4.

An insulation coordination study shall be carried out to determine surge arrester characteristics which shall agree to the TO's surge arresters rating values.

11.2 Surge Arrestors Design & Construction

Surge arresters with polymeric insulators shall be used in the TO substation and Interface Zone. Further information can be found in Clause 7.

Commented [K(57): what about connection of the User's High frequency cable from the SA is this allowed to the SPT earth mat?

Commented [KB58R57]: I would think this is acceptable but it would be User's responsibility to make sure that impedance of earthing connections to surge arresters ensure correct operation

12. Switchgear

12.1 Switchgear Ratings

The design of the User's network in the interface zone shall permit the use common ratings of switchgear 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 switchgear which may exceed the ratings specified in Clause 5 of this RES or require the TO to employ switchgear designs intended for special applications (e.g. special DC time constants, special TRV characteristics, switching of inductive or capacitive switching).

The TO shall not be required to modify the duty of the switchgear (e.g. by delaying opening time, by connecting an additional damping devices, opening circuit-breakers in sequence or use of controlled switching) to ensure that the rating of any switchgear forming part of the TOs network is not exceeded.

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

See Clause 0 for GIS cable connection requirements in substations.

The point of connection between the TO's plant to the User's GIS shall be carried out using an interface specified in the CUSC. Different solutions shall only be used by agreement with the TO in exceptional circumstances.

In the exceptional 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;
- 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
- iii) the User's GIS design shall not have impact the User's minimum Service Continuity level which permits installation, extension, safe operation and maintenance (preventative

Commented [HA59]: Does this mean CUSC arrangement or the contractual agreement between parties? If referring the contractual agreement between parties then the sentence following this one should be removed.

Commented [KB60R59]: Agreed. This is the interface shown in 2.1.2 and Schedule 1 of the CUSC

and corrective) with a maximum of one circuit (inclusive of the circuit being worked upon) and one busbar section out of service simultaneously;

- 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);
- 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;
- 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);
- 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;
- 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;
- 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;
- 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;
- xi) outages shall not be required for maintenance to or inspections of the building or building services;
- 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;
- 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

Commented [HA61]: Is this the service continuity that will be applied to all installations? Can the Scottish TO's comply with this statement at 132kV or is the intention this documents only applies at 275 & 400kV?

Commented [KB62R61]: The minimum Service Continuity requirements differ across the TOs (especially at 132 kV). Also this is in GIS section but equally applies to AIS. I think that the User can decide what to do for own circuits but should not impact minimum service continuity of TOs equipment. To be discussed

Commented [KB63R61]: Reworded

Commented [HA64]: Do all TO's currently stipulate this service continuity requirement?

Commented [KB65R64]: As above

Commented [HA66]: SPT require to be able to test gas alarms on GIS disconnectors when being used as a point of isolation. Is there or should there be a requirement to be able to do this on the users equipment?

Commented [KB67R66]: I think that where Disconnectors on User's GIS may be used to provide Points of Isolation for work on TO equipment then we should insist on this. I have added a clause for discussion

Commented [KB68R66]: Agreed

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.

Circuit-breakers for use on systems with nominal voltage of 33 kV and 11 kV shall meet the requirements of ENA TS 41-40.

12.3.2 Circuit-Breaker Design & Construction

See Clause 0 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;
- 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;
- iii) auxiliary switches shall have sufficient rating to carry and make/break the associated CT secondary circuit current.
- iv) auxiliary switches shall be positively driven in both directions and compliant with BS EN IEC 62271-102

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 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

Disconnecters 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.

drainage interceptors – environmental requirements NG TS 2.01- Only applies in the TO compound

13.2 Transformer & Reactors Design & Construction

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

13.3 Transformer & Reactor Type Test

Table 10 shows the minimum test voltages that shall be used.

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.

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

14. Abbreviations & Conventions

Table 11 — Abbreviations and Terms

Abbreviation	Description
Apparatus	All HV equipment in which electrical conductors are used, supported or of which they may form a part.
AC	Alternating Current
AIS	Air Insulated Switchgear
BCA	Bilateral Connection Agreement - the Bilateral Connection Agreement entered into between NESO and the User
BS	British Standard
CC	Connection Conditions
CNI	Critical National Infrastructure
CUSC	Connection and Use of System Code
CT	Current Transformer
DC	Direct Current
DNO	Distribution Network Operator
DSM	Dynamic System Monitoring
ECC	European Connection Conditions
EHV	Extra High Voltage
EMC	Electro Magnetic Compatibility
EMF	Electro Magnetic Field
EN	Euro Norm (European Standard)
ENA	Energy Networks Association
EREC	Engineering Recommendation
NESO	National Electricity System Operator
ESQCR	Electricity Safety Quality & Continuity Regulations
GB	Great Britain
GC	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).
GIB	Gas Insulated Busbar
GIL	Gas Insulated Line
GIS	Gas Insulated Switchgear
H&S	Health & Safety
HV	High Voltage (above 1 kV)
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronic Engineers

Commented [VG69]: what parties? The User will enter into an agreement with the ESO (and the ESO with the TO?)

Commented [KB70R69]: Agreed

Abbreviation	Description
IP	Ingress Protection
ISO	International Standards Organisation
LV	Low Voltage
LVAC	Low Voltage Alternating Current
LVDC	Low Voltage Direct Current
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
RES	Relevant Equipment Standard
ROEP	Rise of Earth Potential
SBEF	Standby Earth Fault
REF	Restricted Earth Fault
SCADA	Supervisory Control and Data Acquisition
SF ₆	Sulphur hexafluoride gas
SHET	Scottish Hydro Electric Transmission
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
TO	Transmission Owner (NGET, SHET or SPT)
TOCA	Transmission Owner Connection Agreement
TS	Technical Specification
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



X



X

