

1. SCOPE

The requirements of this document apply to all Plant and Apparatus which is directly connected to The Company's distribution and transmission systems. Requirements contained herein may be modified on a more specific basis by lower level specifications issued by The Company. Unless such modifications are explicitly detailed in these lower level specifications, then the requirements of this document shall apply.

Ratings are explicitly specified for Plant and Apparatus to be employed on The Company's systems with nominal system voltages of 6.0 kV and above.

Derogation from the requirements of this document will normally be permitted only where it can be demonstrated that the proposed derogation is not detrimental to the safety, reliability and availability of The Company's system.

2. ISSUE RECORD

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| 23/08/2018 | 1 | Kevin Butter | This document replaces BETTA-11-001. Minor changes have been made to include GB Grid Code requirements. System voltages 6.6 kV and 25 kV added. |
| 13/08/2021 | 2 | Kevin Butter | Minor update. Characteristics added for 6.0kV system. |
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3. ISSUE AUTHORITY

| Author | Owner | Issue Authority |
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4. REVIEW

This is a Controlled document and shall be reviewed as dictated by business / legislative changes but at a period of no greater than 3 years from the last issue date.

5. DISTRIBUTION

This document is not part of a Manual maintained by Document Control and does not have a maintained distribution list. This document is published to the SPEN website.

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7. REFERENCE AND RELATED DOCUMENTS

This specification refers to, or implies reference to, the following documents. This document is intended to amplify and/or clarify the requirements of those documents where alternative arrangements are permitted by those documents and/or where further information is required.

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

UK Safety Legislation

Health and Safety at Work etc. Act 1974.

Electricity at Work Regulations 1989.

Construction (Design and Management) Regulations 2015.

SP Energy Networks Policies and Specifications

ScottishPower Safety Rules (Electrical and Mechanical) 5th Edition.

Energy Networks Association Documents

ER G5/5 Engineering Recommendation G5 Issue 5, 2020: Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom.

National Documents

The Grid Code. The technical code for connection and development of the National Electricity Transmission System (NETS).

National Grid Insulators and insulator sets for overhead lines.
TS 3.04.36

International Electrotechnical Commission (IEC) Standards, EN Standards

IEC 60529 Degrees of protection provided by enclosures (IP Code).

IEC 60815-1 Selection and dimensions of high voltage insulators intended for use in polluted conditions – Definitions, information and general principles.

IEC 61936-1 Power installations exceeding 1 kV a.c. – Part 1: Common rules.

IEC 62271-1 High-voltage switchgear and controlgear – Part 1: Common specifications.

EN 50163 Railway applications. Supply voltages of traction systems.

BS EN 50152 Railway applications – Fixed installations – Particular requirements for alternating current switchgear – Part 2: Disconnectors, earthing switches and switches with nominal voltage above 1 kV.

BS EN 50341-1 Overhead electrical lines exceeding AC 1 kV. General requirements. Common specifications.

BS EN 50341-2-9 Overhead electrical lines exceeding AC 1 kV. National Normative Aspects (NNA) for Great Britain and Northern Ireland.

8. DEFINITIONS

For the purpose of this specification, the following definitions shall apply:

| | |
|---------------------|--|
| The Company | Refers to SP Distribution plc, SP Transmission plc and SP Manweb plc. |
| SP Distribution plc | The Distribution Licence Holder for the distribution service area formerly known as ScottishPower. |
| SP Transmission plc | The Transmission Licence Holder for the transmission service area formerly known as ScottishPower. |
| SP Manweb plc | The Distribution Licence Holder for the distribution service area formerly known as Manweb. |
| SP Energy Networks | The brand name for the division of the ScottishPower Group of Companies that encompasses SP Distribution plc, SP Transmission plc, SP Manweb plc and SP Power Systems Ltd. |
| Plant | Fixed and moveable items, other than Apparatus, which may or does form part of the System. |
| Apparatus | All equipment in which electrical conductors are used, supported, or of which they may form a part, and for which The Company has a maintenance responsibility. |

9. INTRODUCTION

This document is the highest level specification. Lower level Company specifications provide greater detail for specific categories of Plant and Apparatus. Collectively, these documents define The Company's technical requirements for Plant, and Apparatus for use on, or for connection to, The Company's system. These documents translate the actual operating characteristics of The Company's system into standardised values that assure safe and reliable operation.

Where reasonably practicable, ratings and requirements for all Plant shall be selected from the standard values given in the appropriate IEC standards. Deviations from these standards may be required to meet particular requirements of The Company's system configurations or operational and safety procedures.

10. HEALTH, SAFETY AND ENVIRONMENT

All Plant and Apparatus shall be designed for operation where safety is the primary consideration. All Plant and Apparatus shall be designed to minimise, as far as reasonably practicable, health and safety risks to personnel, contractors and members of the public.

The design of all Plant and Apparatus shall meet the requirements of the Health and Safety at Work Act 1974 and the Electricity at Work Regulations 1989 for the maximum safety of all personnel. The Regulations made under the Health and Safety at Work Act imposes specific duties on the installers and operators of Plant and Apparatus in the UK. These duties apply irrespective of the origin of the Plant and Apparatus. The Supplier shall take account of these requirements in the design of the Plant and Apparatus.

All installations shall be designed, constructed and installed so as to reduce the potential for accidents; injury and ill health in accordance with the principles of Construction (Design and Management) Regulations 2015 (CDM) to ensure that persons are not exposed to unreasonable risks when carrying out any work on the installation including, operations, inspection and maintenance of Plant and Apparatus.

To ensure safety of operational staff and contractors employed by The Company, Plant and Apparatus that is intended to be operated by The Company shall comply with ScottishPower Safety Rules (Electrical and Mechanical) and associated Operational Procedures.

Suitable and sufficient environmental assessments covering all stages of the product lifecycle shall be submitted for all Plant and Apparatus.

Details of any materials or components requiring special precautions or handling shall be submitted for all products.

11. CLIMATIC AND ENVIRONMENTAL CONDITIONS

11.1 General

Unless specified otherwise by a lower level Company specification pertaining to particular Plant and Apparatus types, the following requirements define the climatic and environmental conditions for all Plant and Apparatus which is directly connected to The Company's system.

All Plant and Apparatus shall be suitable for climatic and environmental conditions specified in clause 4.4 of IEC 61936-1.

11.2 Normal conditions

The normal service conditions for Plant and Apparatus are defined in clause 4.4.2 of IEC 61936-1 with the following additions/modifications.

11.2.1 Indoor Plant and Apparatus

Indoor Plant and Apparatus shall be suitable for normal service conditions as defined in clause 4.4.2.1 of IEC 61936-1 and as defined below:

- (i) The ambient air temperature does not fall below -5 °C (Class "-5 indoor").
- (ii) The ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h, does not exceed 35 °C.
- (iii) The average value of the relative humidity, measured over a period of 24 h, does not exceed 95 %.

All Plant and Apparatus housed indoors shall have a minimum degree of protection of IP21 as defined in IEC 60529. Higher degrees of protection are required for some types of Plant and Apparatus as specified in lower level specifications pertaining to that type of Plant and Apparatus.

11.2.2 Outdoor Plant and Apparatus

All Outdoor Plant and Apparatus shall be suitable for normal service conditions as defined in clause 4.4.2.2 of IEC 61936-1 and as defined below:

- i) The ambient air temperature does not fall below -25 °C (Class "-25 outdoor").
- ii) The ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h, does not exceed 35 °C.
- iii) Solar radiation up to a level of 1000 W/m² (on a clear day at noon) shall be considered.
- iv) Ice coating up to 10 mm (Class 10)¹⁾.
- v) Wind speeds up to 34 m/s¹⁾.

¹⁾ The values given for ice loading and wind speed are relevant to Type tested Plant only. These are not applicable to the structural design of busbar systems (including structures and foundations) used in air insulated substations (AIS). The level of ice and wind loading is dependent on local topographic influences, height of the structures etc. Values of ice and wind loading used for calculating mechanical requirements of busbar systems in AIS substations shall be in accordance with BS EN 50341-1 and the associated National Normative Annex as specified in lower level specifications. Modified design values for ice thickness, ice density, and the wind speed occurring simultaneously may be specified in the lower level Company specifications (e.g. for overhead lines).

Plant and Apparatus housed outdoors shall have a minimum degree of protection of IP54 as defined in IEC 60529. The site pollution severity (SPS) according to IEC 60815-1 applicable to non-coastal sites shall be a minimum of Class "d" (heavy) according to IEC 60815-1. The minimum unified specific creepage distance (USCD) of outdoor insulators and bushings used at these sites shall be 43.3 mm/kV.

11.3 Special conditions

It can be expected that pollution may be deposited onto external insulator surfaces at coastal locations or some industrial sites, Outdoor insulation used at coastal locations shall be designed for Type B pollution and a SPS Class "e" (very heavy) according to IEC 60815-1. Insulators and bushings used at these sites shall have a minimum USCD of 53.7 mm/kV. SPS Class "e" may also be specified for some non-coastal sites due to pollution conditions prevalent at that site and for the purposes of equipment standardisation considered for wider applications.

12. ELECTRICAL REQUIREMENTS

This document specifies the electrical characteristics for Plant and Apparatus to be employed on The Company's distribution and transmission systems operating at standard system voltages as given in Table 2.

Additionally, The Company owns and operate low voltage (LV) systems. The characteristics of Plant and Apparatus for use on the LV system are not covered by this document and are specified in lower level specifications for particular applications.

12.1 System frequency

The frequency of the system shall nominally be 50 Hz and shall normally be controlled within the limits of 49.5 Hz and 50.5 Hz unless exceptional circumstances prevail. All Plant and Apparatus shall satisfy their specified functional and performance requirements over the range of continuous frequencies of between 49.5 Hz and 50.5 Hz unless specified otherwise by lower level Company specifications pertaining to particular Plant and Apparatus.

12.1.1 System frequency variations

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.

In addition to the continuous frequency ranges for specified functional and performance requirements as stated above, all Plant and Apparatus shall operate safely and without any degradation of the equipment within the frequency ranges and durations specified in clause CC.6.1.3 of The Grid Code and as detailed in Table 1.

| Frequency range | Requirements |
|-------------------|---|
| 51.5 Hz - 52 Hz | Operation for a period of at least 15 minutes is required each time the Frequency is above 51.5Hz |
| 51 Hz - 51.5 Hz | Operation for a period of at least 90 minutes is required each time the Frequency is above 51Hz |
| 49.0 Hz - 51 Hz | Continuous operation is required |
| 47.5 Hz - 49.0 Hz | Operation for a period of at least 90 minutes is required each time the Frequency is below 49.0Hz |
| 47 Hz - 47.5 Hz | Operation for a period of at least 20 seconds is required each time the Frequency is below 47.5Hz |

Table 1: System Frequency range

12.2 System Voltage

All Plant and Apparatus shall satisfy their specified functional and performance requirements over the normal operating range of nominal system voltages given in Table 2.

Nominal system voltages stated in this document are phase-phase voltages apart from the 25 kV system where the system voltage is quoted as a single phase-earth voltage. The 25kV system is utilised to provide supplies to single-phase AC traction systems.

| Nominal system voltage (kV) | 400 | 275 | 220 | 132 | 33 | 25 | 11 | 6.6 | 6.0 |
|--|-------------------|-----|-----|-----|------|--------------------|--------------------|------------------|------------------|
| Maximum continuous System voltage (kV) | 420 ¹⁾ | 303 | 242 | 145 | 35.0 | 27.5 ³⁾ | 11.7 ²⁾ | 7.0 | 6.36 |
| Minimum continuous System voltage (kV) | 360 | 247 | 198 | 119 | 31.0 | 22.5 | 10.3 | 6.2 | 5.64 |
| Rated voltage of Plant (kV) | 420 | 300 | 245 | 145 | 36 | 27.5 | 12 | 12 ⁴⁾ | 12 ⁴⁾ |

Table 2: System voltage levels

- 1) In addition to the above requirements, all Plant and Apparatus for use on the 400 kV system shall also operate safely and without any degradation in performance when operated in the range 420kV to 440 kV for periods up to 15 minutes. Operation of equipment between 420kV and 440kV shall be minimised and particular attention given to any switchgear movement under these conditions, as the probability of circuit breaker restrikes and high voltage transients is increased as the system voltage is increased.
- 2) To ensure that the low voltage system voltage is kept within limits, the maximum 11 kV system voltage should typically not exceed 11.2 kV.
- 3) This is the highest non-permanent system voltage. For the 25 kV system this shall not exceed 29 kV for a maximum duration of five minutes in accordance with Table 1 of EN 50163.
- 4) The rated voltage of Plant and Apparatus used on the 6.6 kV and 6.0 kV systems shall be 12 kV to facilitate future upgrading to 11 kV.

12.2.1 Harmonic content

All Plant and Apparatus shall satisfy their specified functional and performance requirements with levels of distortions of the voltage waveform in respect of harmonic content as specified in clause CC.6.1.5 of The Grid Code and up to the compatibility levels specified in Section 5.3 of ER G5/5.

12.2.2 Phase (Voltage) Unbalance

All Plant and Apparatus shall satisfy their specified functional and performance requirements with phase voltage unbalance up to a maximum of 2% in accordance with clauses CC.6.1.5(b) and CC.6.1.5 of The Grid Code.

12.2.3 System voltage fluctuations

In addition to the normal operating range specified in Table 2, all Plant and Apparatus shall be capable of withstanding the range of voltage changes with the stated frequency of occurrence, as specified in clause CC.6.1.7 and in Table CC.6.1.7 of the Grid Code.

12.3 Rated insulation levels

The rated insulation levels of all Plant and Apparatus shall be in accordance with Table 3. These values shall apply unless explicitly modified in lower level Company specifications and documents pertaining to particular Plant and Apparatus types.

| Nominal system voltage (kV) | Rated voltage (kV) | Rated short duration power frequency withstand voltage ⁴⁾ (kV) | | | Rated switching impulse withstand voltage ²⁾ (kV peak) | | | Rated lightning impulse withstand voltage ³⁾ (kV peak) | | |
|-----------------------------|--------------------|---|------------------------------|-------------------------------|---|----------------|--|---|------------------------------|-------------------------------|
| | | Common value/ Phase to earth and 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 and between phases | Across open switching device | Across the isolating distance |
| 400 | 420 | 520 | 610 | 610 | 1050 | 1575 | 900 (+345) ¹⁾ | 1425 | 1425 (+240) ¹⁾ | 1425 (+240) ¹⁾ |
| 275 | 300 | 395 | 435 | 435 | 850 | 1275 | 700 (+245) ¹⁾ | 1050 | 1050 (+170) ¹⁾ | 1050 (+170) ¹⁾ |
| 220 | 245 | 460 | 460 | 530 | N/A | N/A | N/A | 1050 | 1050 | 1200 |
| 132 | 145 | 275 | 275 | 315 | N/A | N/A | N/A | 650 | 650 | 750 |
| 33 | 36 | 70 | 70 | 80 | N/A | N/A | N/A | 170 | 170 | 195 |
| 25 ⁵⁾ | 27.5 | 95 | 95 | 110 | N/A | N/A | N/A | 200 | 200 | 220 |
| 11 | 12 | 28 | 28 | 32 | N/A | N/A | N/A | 75 | 75 | 85 |
| 6.6 | 12 | 28 | 28 | 32 | N/A | N/A | N/A | 75 | 75 | 85 |
| 6.0 | 12 | 28 | 28 | 32 | N/A | N/A | N/A | 75 | 75 | 85 |

Table 3: Rated insulation level Requirements

- 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 IEC 62271-1.
- 2) Switching impulse wave shape – 250 / 2500 μ s
- 3) Lightning impulse wave shape – 1.2 / 50 μ s
- 4) Dry withstand voltage for minimum duration of 1 minute. Power frequency wet withstand voltages may be specified for outdoor Plant. Longer durations for power frequency tests for some Plant (e.g. cables) may be specified in lower level Company specifications.
- 5) Rated insulation levels for 25 kV system for supply to single-phase AC traction systems for supply to shall be in accordance with Table 1 of BS EN 50152-2.

12.4 Earthing of system neutral

All Plant and Apparatus shall satisfy their specified functional performance requirements under the neutral earthing conditions given in Table 4.

| Nominal system voltage (kV) | Maximum Earth Fault Factor ²⁾ | Type of neutral earthing |
|-----------------------------|--|--------------------------|
| 400 | 1.5 ¹⁾ | Multiple Direct |
| 275 | 1.5 ¹⁾ | Multiple Direct |
| 220 | 1.5 ¹⁾ | Multiple Direct |
| 132 | 1.5 ¹⁾ | Multiple Direct |
| 33 (Tertiary) | 1.9 | Resistance |
| 33 | 1.9 | Multiple Resistance |
| 25 | N/A ³⁾ | Multiple Direct |
| 11 | 1.73 | Multiple Direct |
| 6.6 | 1.73 | Multiple Direct |
| 6.0 | 1.73 | Multiple Direct |

Table 4: Earthing of system neutral

- ¹⁾ All Plant and Apparatus operating at nominal system voltages of 132 kV and above shall be designed to be earthed with an Earth Fault Factor below 1.5 in accordance with clause CC.6.2.1.1 of the Grid Code.
- ²⁾ These values shall apply unless explicitly modified in lower level Company specifications and documents pertaining to particular Plant types.
- ³⁾ Single-phase system.

12.5 Fault clearance times

All Plant and Apparatus shall be suitable for operation under the conditions detailed in Table 5.

| Nominal system voltage (kV) | Target fault interruption time of main infeed circuit (ms) | Target total fault clearance time for all infeeds (ms) | Target back-up clearance time ⁴⁾ (ms) |
|-----------------------------|--|--|--|
| 400 | 80 | 140 | 500 (1000) ¹⁾ |
| 275 | 100 | 160 | 500 (1000) ¹⁾ |
| 220 | 100 | 160 | 500 (1000) ¹⁾ |
| 132 | 120 | 180 | 1500 |
| 33 | 200 | 300 | 1500 (5000) ²⁾ |
| 25 | 200 | 600 | 1000 |
| 11 | 500 (200) ³⁾ | 600 (200) ³⁾ | 1500 |
| 6.6 | 500 (200) ³⁾ | 600 (200) ³⁾ | 1500 |
| 6.0 | 500 (200) ³⁾ | 600 (200) ³⁾ | 1500 |

Table 5: Target fault clearance times

- ¹⁾ Fault clearance times of 1 s for Zone 3 distance protection and REF protection on feeder circuits are acceptable.
- ²⁾ Fault clearance time for SBEF Stage 1.
- ³⁾ Interconnected circuits only.

- 4) In the event of a circuit-breaker failure on the 132 kV, 220 kV, 275 kV and 400 kV systems, circuit-breaker fail protection shall trip all necessary circuit-breakers capable of supplying a fault infeed within a target fault clearance time of 300ms.

12.6 Short-circuit currents

All Plant and Apparatus shall be capable of carrying the short-circuit current for the duration given in Table 6. The rated short-time withstand current of Plant and Apparatus shall be selected from the standard values given in IEC standards to meet the ratings given in Table 6.

The system short-circuit current at some sites exceed the standard values in Table 6. At such sites, Plant and Apparatus with higher rated short-time withstand current shall be specified.

Unless lower level Company specifications for Plant and Apparatus allow different values of rated short-time withstand currents for single-phase and three-phase, the rated short-time withstand of Plant and Apparatus shall be selected to meet the higher of the two ratings given in Table 6.

| Nominal system voltage (kV) | Single-phase short-circuit current (kA rms) | Three-phase short-circuit current (kA rms) | Duration of short-circuit (s) | DC time constant (ms) | Peak withstand current (kA peak) ²⁾ |
|-----------------------------|---|--|-------------------------------|-----------------------|--|
| 400 | 63 | 63 | 1 | 45 | 157.5 |
| 275 | 40 | 40 | 1 | 60 | 108 |
| 220 | 40 | 31.5 | 1 | 60 | 108 |
| 132 | 40 | 40 | 3 | 45 | 100 |
| | 31.5 | 31.5 | 3 | 120/135 ⁴⁾ | |
| 25 | 15 | N/A | 3 | 45 | 37.5 |
| 33 | 4.2 ¹⁾ | 17.5 | 3 | 135 ³⁾ | 47.25 |
| 11 | 13.1 | 13.1 | 3 | 60 | 35.37 |
| 6.6 | 13.1 | 13.1 | 3 | 60 | 35.37 |
| 6.0 | 13.1 | 13.1 | 3 | 60 | 35.37 |

Table 6: Short-circuit current requirements

- 1) Single-phase short-circuit current on 33 kV system is based on a maximum of two 120 MVA 275/33 kV transformers operating in parallel at a Grid Supply Point.
- 2) The rated peak withstand current of Plant and Apparatus shall be defined according to the system DC time constant (See IEC 62271-1). At some sites (especially those associated with generator connections), significantly higher system DC time constants may be experienced.
- 3) At sites remote from Grid Supply Points, lower values of 33 kV system DC time constant may be specified.
- 4) In some cases, DC time constants of 135ms may be specified on a site-specific basis.

12.7 Normal current

The maximum values of normal currents applicable to each voltage level are given in Table 7. The rated normal current of particular Plant and Apparatus types are specified in lower level Company specifications and are selected from the standard values given in IEC standards to meet the required circuit ratings.

12.8 Protective gap settings

All equipment fitted with protective gaps shall conform with the requirements specified in National Grid TS 3.04.36. New transformers and reactors shall be protected from overvoltages by surge arresters and shall not be fitted with protective gaps.

12.9 Multi-pole opening/tripping and auto-reclosing

Plant and Apparatus shall be suitable for operation under the following circuit-breaker operating conditions, unless stated otherwise in lower level specifications.

- i) Simultaneous three-phase opening/tripping
- ii) Simultaneous three-phase auto-reclosing on overhead line feeder circuits

The switching of shunt capacitor banks and shunt reactors may require the use of circuit-breakers with intentional non-simultaneity of poles. In such cases these requirements will be modified by lower level Company specifications. Single-phase high-speed auto-reclose may be required on a circuit specific basis.

| Nominal system voltage (kV) | Maximum normal current (A) |
|-----------------------------|----------------------------|
| 400 | 5000 ¹⁾ |
| 275 | 3150 |
| 220 | 2000 |
| 132 | 2500 |
| 33 | 2500 |
| 25 | 1250 |
| 11 | 2000 |
| 6.6 | 1250 |
| 6.0 | 1250 |

Table 7: Normal current requirements

¹⁾ At 400kV, a lower rated normal current may be specified on an application basis.