

INSULATORS AND INSULATOR SETS FOR OVERHEAD LINES

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PURPOSE AND SCOPE

This specification forms part of a suite of documents, which define National Grids functional, and performance requirements for new plant and equipment associated with electricity transmission.

This specification defines the characteristics and performance requirements of single insulator units and complete insulator sets procured for use on overhead lines owned or directly connected to the National Grid transmission system operating at 132kV, 275kV and 400kV.

PART 1 – PROCEDURAL

1. GENERAL REQUIREMENTS

Insulator units and insulator strings shall be type registered in accordance with UKBP/TP183 Type Registered Equipment Procedural Requirements.

All insulators shall meet the requirements of the relevant standards and the additional requirements stated within this specification.

1.1 Insulation Levels and Dimensions

The rated insulation level and withstand voltages are specified in TS1 'Ratings and General Requirements for Plant, Equipment and Apparatus for the National Grid System'.

Insulator dimensions shall be chosen such that the electrical test requirements of this specification are satisfied. Tolerances shall conform to the following unless otherwise specified.

BSEN 60305 Cap and Pin Insulators

BSEN 62217 Composite Long Rod Insulators

BSEN 62772 Composite Hollow Core Station Post Insulators Nominal insulator string length and minimum creepage length shall comply with this specification.

The minimum creepage length of an insulator unit shall be obtained by dividing the minimum creepage length of the string by the number of units in the string. **No tolerance is permitted on the minimum creepage length of the unit.**

For cap and pin design all suspension insulators shall be anti-fog profile and tension insulators shall be of open profile.

The maximum external diameter of the insulator unit shall be such that sufficient clearance is maintained between adjacent insulators in a multi-string set to avoid insulator clashing and to facilitate installation and replacement activities. During the design and testing stage consideration shall be given to installation and replacement activities and non standard equipment.

For cap and pin suspension insulators the maximum projection of the shed profile below the bottom of the pin shall not restrict assembly and shall ensure clearance to other fittings. There shall be no projection of the shed profile below the bottom of the pin on tension insulator units.

1.2 Insulator String **Length and Minimum Creepage**

The minimum creepage length and length of the insulator string will be as specified in Tables 1, 2, 3 and 4 below.

Note 1: There is no tolerance permitted on the minimum creepage length of the insulator string.

The overall length of the insulator string shall be measured from the bottom of the ball of the last insulator to the bottom of an imaginary ball fitted into the socket of the first insulator. In the case of a composite unit the length is measured from the bottom of the ball to the bottom of an imaginary ball fitted into the socket end fitting.

	Minimum creepage length (mm)	Insulator string length (mm) $\pm 2\%$
Tension	7200	3400
Suspension	10000	3400

Table 1 – Overhead Line 400kV Insulator String

	Minimum creepage length (mm)	Insulator string length (mm) $\pm 2\%$
Tension	5300	2850 (See Note 2)
Suspension	7700	2750 (See Note 3)

Table 2 – Overhead Line 275kV Insulator String

	Minimum creepage length (mm)	Insulator string length (mm) $\pm 2\%$
Tension	2900	1600 (See Note 2)
Suspension	4200	1540

Table 3 – Overhead Line 132kV Insulator String

	Minimum creepage length (mm)	Insulator string length (mm) $\pm 2\%$
Upper Diamond (A)	12400	4500
Lower Diamond (B)	17320	5590
Horizontal (Phase to Phase) (C)	17320	5540
Horizontal (Phase to Earth) (D)	12400	4500
Pilot Insulator (D30)	12400	5200

Table 4 – T Pylon 400kV Insulator Arrays (See Note 4)

Note 2: For composite insulator sets the tension string length may be decreased to match that of the suspension string.

Note 3: The insulator string length may be reduced to ensure that minimum clearances between phase and earth are maintained. The requirements for minimum creepage must still be met.

Note 4: See Appendix D for Insulator array drawing.

1.3 Description and Material

1.3.1 Toughened Glass and Porcelain

All glass and porcelain insulator units shall comply with the general requirements of BSEN 60305 and shall meet the requirements of BSEN 60383 Parts 1 and 2.

Glass insulators shall be green or clear and porcelain insulators shall be munsell grey in colour unless specified otherwise by National Grid.

Toughened glass shells are known to suffer from post installation shattering; nominal values are 1:10000. Manufacturers of glass shells must be able to provide evidence of the performance of their units if requested.

1.3.2 Composite

All composite insulator units shall comply with the requirements of BSEN 62217 and the following;

Long rod insulators BSEN 61109, solid core post insulators BSEN 61952 or BSEN 62231 and hollow core insulators BSEN 62272.

Composite insulators shall be light grey or blue in colour unless specified otherwise by National Grid.

The composite long rod insulator shall comprise a stress corrosion crack resilient, electrical grade corrosion resistant (ECR), glass-fibre reinforced polymer rod on to which is bonded a silicone rubber housing that provides both environmental protection of the rod and the electrical performance characteristic of the insulator. The housing shall be effectively bonded to the rod along its entire length and provide unbroken coverage of the rod.

The composite solid core post insulators shall comprise of a cylindrical solid insulating core, bearing the mechanical load, protected by a polymeric housing, the loads being transmitted to the core by metal fittings.

The composite hollow core post insulators shall comprise of an insulating hollow core (tube), bearing the mechanical load protected by a polymeric housing, the load being transmitted to the core by end fitting. The hollow core is filled entirely with a solid insulating material and must be sealed for life. The core is made of resin impregnated fibres.

The insulator shed arrangement on all types of composite insulators shall meet the requirements of IEC 60815.

Stress devices (grading rings) shall be installed to each end of the insulator unit and shall not be used as arc horns unless designed and positioned to do so (see note 5). If the stress devices are mounted on the insulator end fittings the short circuit test defined in cl. 2.3.4 must be completed to demonstrate that the passage of power frequency current and/or lightning/switching surge currents where the arc has rooted on the stress device does not compromise the mechanical strength of the insulator either during or after the event.

The interface between the rod and the end fitting shall be sealed to effectively eliminate the possibility of moisture ingress into the unit. Evidence that supports the life-time performance of the sealing mechanism shall be provided.

Note 5: Combined grading ring arc horns shall not be installed onto the end of the composite rods.

1.4 Couplings

1.4.1 Cap and Pin

String units shall be interconnected by ball and socket couplings which shall be secured using a locking device.

All insulators shall be fitted with ball and socket couplings in accordance with IEC 60120 and Table 5 of this document.

Min Failing Load (kN)	Ball & Socket Size (mm)
80	Socket 16B & Ball 16
125	20
190	24
300	24

Table 5: Overhead Line Insulator Set Ball and Socket Dimensions

Sockets shall be lightly greased using general purpose grease which aids articulation and provides corrosion protection for the life of the fitting.

Note 6: The grease used must have the following basic physical and chemical properties;

Colour – non transparent
Melting Point / Range – 130 °C
Density - <1g/cm³ at 20 °C
Penetration (mm) – 120 at 25 °C

A visible protective coating (e.g. bitumen or varnish) shall be applied to the pin in such a way so as to protrude beyond the layer of cement.

All locking devices shall be of the 'R pin' format and shall conform to IEC 60372.

1.4.2 Composite

Composite units may be connected as follows;

Ball and sockets as per 1.5.1 of this specification
Clevis/tongue designs in accordance with BSEN 61466-1

Flange design as required.

1.5 Zinc Collared Pins (Cap and Pin only)

All glass and porcelain suspension units and porcelain tension units for 275 & 400kV applications shall be fitted with zinc collared pins, all zinc collars shall conform to this specification.

The zinc collar shall be at least 25mm long, of minimum 4 mm radial thickness, and metallurgically bonded to the insulator pin. The collar shall be tapered to relieve stress on the cement under load.

The outer edges of the collar shall be radiused, all mould lines shall be removed and the surface finish sufficiently smooth to prevent corona in service.

In the assembled insulator, the zinc collar shall be partially enclosed in the cement to a depth between 13mm and 19mm.

The zinc collar shall not be porous and the zinc ingot shall conform to BSEN 1179, having a total impurity not exceeding 0.05%.

1.6 Cement

Suitable cement which meets the required mechanical and electrical performance must be specified and applied to the insulator such to give a smooth finish without the presence of surface holes.

1.7 Arc Horns

Arc horns conforming to TS 3.04.35 shall be fitted to both the live end and earth end of all insulator sets except where noted below. Arc gaps shall be in accordance with the distances stated in TS 1 and a tolerance of +/- 3% should be applied.

Arc horns may be omitted from the earth end of Pilot sets and from the earth end of Low Duty sets installed on gantries.

Low Duty sets installed on towers require arc horns on both the live and earth end as standard.

Arc horns may be omitted from the insulator strings which form the lower half of the T-Pylon insulator diamond.

1.8 Special requirement for GZTACSR (gap-type) semi-tension suspension set.

All semi tension installations shall contain a current breaking link that shall have a minimum creepage distance of 50mm between conducting parts. The current breaking link shall not prejudice the mechanical strength of the assembly.

1.9 Audible Noise

Insulator designs shall be wind tunnel tested in accordance with clause 2.1 to ensure they do not generate audible tones likely to cause nuisance under expected wind conditions in general use.

1.10 Galvanising

Galvanising shall be in accordance with BS EN ISO 1461.

1.11 Marking

Each insulator unit shall be marked legibly and indelibly and shall include identification of the manufacturer, date of manufacture, and rated mechanical load.

In addition each unit shall be marked with an identification code in accordance with the following format: F (anti-fog), N (normal)/unit length/drawing number. (For example: 190N/200/1234E will be marked on a 190kN normal profile unit, of 200 mm centres, to the manufacturers drawing 1234E).

1.12 Packaging

Insulator units shall be packed in accordance with the National Grid packaging specification.

1.13 Drawings

1.13.1 Cap and Pin Insulators

A drawing of the cap and pin insulator must be provided and shall conform to Appendix B of this specification and shall include the following;

The drawing shall include principal dimensions of the insulator unit (i.e. pitch, diameter, minimum creepage length, etc.) and shall be representative of the actual shed profile. The drawing shall also include:

- a) A list of application data, giving the number of insulators to be used in each applicable National Grid string design.
- b) Approximate weight of the insulator unit.
- c) Test voltage for single unit RIV sample tests.
- d) Single unit puncture voltage.

1.13.2 Composite Insulators

A drawing of the composite insulator must be provided and shall conform to Appendix C of this specification and shall include the following;

The drawing shall include principal dimensions of the unit (i.e. pitch, diameter, minimum creepage length, clevis/flange detail if applicable etc.) and shall be representative of the actual shed profile. The drawing shall also include:

- a) A list of application data, giving the number of units to be used in each applicable National Grid line design.
- b) The approximate weight of one unit.
- c) Basic electrical characteristics of the unit.
- d) The type and manufacturer of the compound used for the sheath and watersheds.
- e) Fibre rod type and manufacturer.

- f) Stress device material and manufacturer.
- g) The in-service position of the stress devices shall be shown.
- h) The arc horn profile shall also be shown to indicate that it provides electrical shielding of the stress devices.

1.13.3 Insulator Set

Drawings of the insulator set shall conform to clause 1.2 of UKBP/TP183 and shall include the following:

- a) Approximate weight of the components that make up the complete set.
- b) Nominal length from tower attachment to the attachment point of the conductor fitting.
- c) Conductor systems or line designs it can be used with (e.g. L2/4, L6/5 etc.).
- d) Tower attachment swivel or shackle reference. Note this may include multiple references where the set can be used on a number of different tower designs.

1.14 Installation and Removal

Proposed procedures and any special or bespoke equipment for installation and removal of insulators shall be in place prior to the completion of Type Registration.

The supplier shall provide instructions for handling, storage and pre-installation inspection of the insulators as required.

Consideration should be given to the environmental impact following removal from the National Grid system and subsequent disposal.

2 DESIGN AND TYPE TEST REQUIREMENTS

Cap and pin insulator units shall be subject to type tests according to IEC 60383 Part 1, Table 3, and any additional test requirements specified in this document.

Composite insulators shall be subject to design and type tests according to the following and any additional requirements specified in this document;

Design tests - BSEN 62217

Type tests – as defined in Appendix A Table A2 of this specification.

Results from design tests may in agreement between manufacturer and National Grid be accepted in lieu of certain type tests with the exception of those detailed in Appendix A of this document.

In addition to the single unit type tests the insulator units must satisfy the requirements of the assembled set tests specified in 2.4 of this specification.

All insulator units selected for type test shall conform to the agreed design and be representative of those in manufacture.

Type tests shall be completed in accordance with Appendix A of this specification and they shall be repeated when the design, manufacturing process or manufacturing location is changed.

2.1 Audible Noise Compliance

To ensure the design does not generate inherent unacceptable audible tones each design must undergo and successfully pass a series of wind tunnel tests.

The test should be undertaken on a representative short string (circa 12 units), the exact number of units shall be agreed with the National Grid representative prior to the test. The string shall be secured in the wind tunnel under sufficient tension to prevent undue deflection or vibration and be representative of service conditions.

The test should be carried out over a range of angles starting at 0° and repeated up to 30° in the downwind direction only at wind speeds up to 30 m/s. The angles between 1° and 15° shall be in 1° steps, the angles between 15° and 30° shall be in 5° steps.

The background noise of the wind tunnel shall be measured over the full range of wind speeds with the test rig in place and without insulators to identify the presence or absence of any audible tones, this shall be documented. The microphone set up within the tunnel

The initial identification of the generation of distinguishable audible tones shall be determined by ear. Any audible tones identified shall be measured, recorded and documented to enable a full analysis to be completed regarding the suitability for installation onto the National Grid network. The presence of the audible tone(s) should be confirmed using a fully calibrated class-1 analyser capable of logging third octave spectra and performing narrow band Fast Fourier Transforms (FFT) and taking high quality recordings.

Documented data shall include the presence or absence of a tone and the frequency of the tone (Hz) where one occurs, at each angle and wind speed.

Acceptance criteria - During the testing no audible tones shall be identified below 10° or 15m/s inclusive. Where tones occur outside these conditions National Grid shall consider the suitability for installation onto the network.

2.2 Single Unit Tests (Mechanical)

The samples for the required tests should be selected randomly from a representative manufacturing batch of at least 3 times the required test sample size, unless otherwise agreed by National Grid and the supplier this should be done by a representative of National Grid.

2.2.1 Visual Inspection and Verification of Dimensions

All insulator units shall be visually inspected for quality and conformance with the relevant drawing(s). Major dimensions including pitch, diameter and creepage shall be checked in accordance with the stated tolerances.

Ball and socket couplings shall be gauged using approved go/no-go gauges as detailed in IEC 60120.

- a) Cap and Pin: - 10 units shall be inspected in accordance with the tolerances stated in BSEN 60383-1 clause 17 unless otherwise stated.
- b) Composite: - 3 units shall be inspected in accordance with the tolerances stated in the relevant specification identified in cl. 1.1 of this document unless otherwise stated.

Acceptance criteria – The entire surface of the insulator shall be smooth and free from imperfections, for glass insulators there shall be no bubbles greater than 5mm in diameter. All dimensions must be in accordance with the relevant drawing and must be within the identified tolerances.

2.2.2 Verification of Locking Device

For cap and pin insulators 10 units shall be tested and for composite insulators 3 units shall be tested.

Each unit should be subjected to 3 operations moving the locking pin from the locking position to the coupling position. On completion of the last operation the locking device shall be removed completely from the insulator.

Acceptance criteria – the values of load F for three operations shall lie between the values of F_{min} (50N) and F_{max} (500N). The load required to completely remove the locking pin must be greater than F_{max} .

2.2.3 Verification of Displacements

The axial (A) and radial (B) displacements of 10 insulator units shall be checked for conformance.

Acceptance criteria;

Variation on A: 4% of the nominal insulator diameter.

Variation on B: 3% of the nominal insulator diameter.

2.2.4 Mechanical Failing Load Test