BS 3288-1:2014

BSI Standards Publication

Insulator and conductor fittings for overhead power lines

Part 1: Performance and general requirements

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 30, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 3288 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2014. It was prepared by Technical Committee PEL/11, *Overhead lines*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 3288 supersedes BS 3288-1:1997, which is withdrawn.

Information about this document

BS 3288 applies primarily to fittings for overhead electric power lines. The various parts of BS 3288 specify the performance, general requirements and dimensional requirements for insulator and conductor fittings. The general and dimensional requirements may be applied to similar fittings used on overhead railway electrification systems and in substations. This British Standard is not applicable to fittings exclusively intended for use on aerial bundled conductor systems or to low voltage connectors.

BS 3288-1 is part of a series that contains the following current parts:

- Part 2: *Specification for a range of fittings*;
- Part 3: *Dimensions of ball and socket couplings of string insulator units*.

The original suite of standards also contained BS 3288-4 but this has been superseded by BS EN 60372.

Use of this document

It has been assumed in the preparation of this part of BS 3288 that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause **J.1.1**, which states, "Requirements should be expressed using wording such as: 'When tested as described in Annex A, the product shall ...'". This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies performance and general requirements for insulator and conductor fittings for use on overhead power lines. It defines the relevant tests and test procedures together with the acceptance criteria.

The tests and test procedures may also be applied to similar fittings, outside the scope of this standard, intended for use in:

- the overhead equipment of electric traction lines;
- substations.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 3288-2, *Insulator and conductor fittings for overhead power lines – Part 2: Specification for a range of fittings*

BS 3288-3, *Insulator and conductor fittings for overhead power lines – Part 3: Dimensions of ball and socket couplings for string insulator units*

BS 4727, *Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms*

BS 4872-1:1982, *Specification for approval testing of welders when welding procedure is not required – Part 1: Fusion welding of steel*

BS EN 1562, *Founding – Malleable cast irons*

BS EN 1563, *Founding – Spheroidal graphite cast irons*

BS EN 60372:2004, *Locking devices for ball and socket couplings of string insulator units – Dimensions and tests*

BS EN 61284, *Overhead lines – Requirements and tests for fittings*

BS EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*

BS EN ISO 15620, *Welding – Friction welding of metallic materials*

PD 970, *Wrought steels for mechanical and allied engineering purposes – Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels*

3 Terms and definitions

For the purposes of this British Standard, the definitions given in BS 4727 and the following apply.

3.1 cap and pin insulator
insulator comprising an insulating part having the form of a disc or bell, with or without ribs on its lower surface, and fixing devices consisting of an outside cap and an inside pin attached axially

3.2 clamp
any fitting which can be fixed onto a conductor

3.3 earth conductor fitting
any component of an assembly for attaching an earth conductor to a supporting structure other than a suspension clamp, a tension termination or a mechanical protective fitting

3.4 electrical control fitting
any device for controlling the electrical characteristics of an insulator (i.e. arcing horn, combined corona arcing device, etc.)

3.5 factory formed helical conductor fitting
fitting in which the force necessary to grip the conductor is provided by helical wires which are self-tightening on the conductor

3.6 insulator pin
rigid fitting for attaching a pin insulator to a supporting structure

3.7 insulator set
assembly of one or more insulator strings suitably connected together, complete with fixing and protective devices as required in service

3.8 insulator set fitting
any component of a suspension or tension insulator set, other than a string insulator unit, a suspension clamp, a tension termination, an electrical control fitting or a mechanical protective fitting

3.9 insulator string
one, or more than one string insulator units coupled together and intended to give flexible support to overhead line conductors and stressed mainly in tension

3.10 long rod insulator
insulator comprising an insulating part having an approximately cylindrical core, with or without sheds, and external or internal fixing devices attached to each end

3.11 mechanical protective fitting
any device attached to a conductor for its mechanical protection

3.12 mid-span tension joint
joint inserted between two lengths of a conductor to provide electrical and mechanical continuity of the conductor

NOTE A dead end tension joint may additionally provide facilities for the connection of droppers or jumpers. Some types, e.g. bolted and wedge type might not need this facility. The joint can also be used on an earth conductor.

3.13 non-tension joint
fitting for the connection of two consecutive pieces of conductor which are to be held, but not at line tension

3.14 non-tension T-joint
fitting for the connection of the end of one conductor to a point on the length of a second conductor

NOTE The connection is not subject to line tension although the conductor to which the fitting is applied on its length may be at line tension.

3.15 pin insulator
rigid insulator consisting of an insulating component intended to be mounted rigidly on a supporting structure by means of a pin passing up inside the insulating component which consists of one or more pieces of insulating material permanently connected together

3.16 repair sleeve
special fitting which can be installed over a damaged conductor in order to restore its electrical and mechanical properties

3.17 rigid insulator
insulator intended to give rigid support to an overhead line conductor and which is stressed mainly by bending and compressive loads

3.18 spacer
device which keeps apart the sub-conductors of a bundle in a given geometrical configuration

3.19 specified minimum failing load
mechanical falling load specified by the purchaser or declared by the supplier as a design characteristic of the fitting

3.20 string insulator unit
cap and pin insulator or long rod insulator the fixing devices of which are suitable for flexible attachment to other similar string insulator units or to connecting accessories

3.21 suspension clamp
fitting which attaches a conductor to a suspension insulator set or an earth conductor fitting

3.22 tension set
insulator set complete with all fittings and accessories to secure a conductor or a bundle of conductors in tension

3.23 vibration damper
device attached to a conductor in order to suppress or minimize vibrations due to wind

4 General requirements

4.1 General

All insulator fittings, unless otherwise specified by the purchaser [see item b) of Annex C], shall conform to the coupling dimensions specified in BS 3288-3 and BS EN 60372.

When conductor fittings are installed for test as specified in Clause **7**, Clause **8** and Clause **9**, the fittings shall not damage the conductor except for any deformation necessary to attach the fitting. Fittings shall be made of material of sufficient ductility that the fittings can withstand the dynamic mechanical loads to which they are likely to be subjected in service. The fitting shall not give rise to the generation of visible or audible corona discharge at the specified test voltage.

The selection of materials and the design of security devices shall conform to BS EN 60372:2004, **10.3**.

4.2 Protection against corrosion

All parts of insulator, conductor and earth wire fittings shall be either inherently resistant to atmospheric corrosion or be suitably protected against corrosion, such as can occur in transport, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made of appropriate stainless steel, shall be protected by hot dip galvanizing in accordance with BS EN ISO 1461 or other means giving equivalent protection.

Moreover, unless special measures are taken, there shall never be contact between metals for which the difference in electrochemical potential can give rise to galvanic corrosion capable of impairing the efficiency of the whole equipment.

NOTE This applies especially to those parts of the fittings that are in direct contact with the conductor.

All external threads shall be cut or rolled before hot dip galvanizing.

Internal threads can be cut before or after hot dip galvanizing but if cut after galvanizing, they shall be oiled or greased.

4.3 Classification of tests

In the following clauses, in which the requirements for the various types of fittings are given, the tests are divided into three groups:

a) *Type tests.* Type tests are intended to establish design characteristics. They are normally made once only and repeated only when the design or the material of the fitting is changed.

b) *Sample tests.* Sample tests are intended to verify the quality of materials and workmanship. They are made on fittings taken at random from batches offered for acceptance.

c) *Routine tests.* Routine tests are intended to eliminate defective fittings. They are made on every fitting for which routine tests are specified in later clauses.

4.4 General requirements for tests

*COMMENTARY ON **4.4***

Additional non-destructive testing may be agreed between purchaser and supplier.

Tests might include: magnetic, eddy current, radiograph, ultrasonic, proof load, dye penetrant and hardness.

4.4.1 Type tests

Test certificates giving the results of the appropriate type tests, made on not less than three fittings identical in all essential details with those to be supplied, shall be regarded as evidence of conformity.

NOTE If alternative arrangements apply, this should be stated by the purchaser at the time of enquiry and order [see item c) of Annex C].

4.4.2 Sample tests

When the order is for one hundred or more identical fittings, the number of samples for these tests shall be p or the nearest whole number greater than p, as given by the following formulae, in which n is the number of fittings in the batch offered for inspection.

$$p = 4 \text{ when } 100 \leq n < 500$$

$$p = 4 + \frac{1.5n}{1000} \text{ when } 500 \leq n \leq 20\,000$$

$$p = 19 + \frac{0.75n}{1000} \text{ when } n > 20\,000$$

For batches of fewer than one hundred identical fittings, four samples shall be submitted to the specified non-destructive sample tests.

The samples shall be selected at random from fittings which have passed the appropriate routine test (if any).

NOTE 1 The purchaser has the right to make the selection.

If these samples meet the test requirements, the batch shall be deemed to conform to the requirements of the standard. In the event of a sample not meeting the test requirements, twice the original number of new samples shall be tested. If all these new samples meet the test requirements, the batch shall be deemed to conform to the requirements of the standard, but if any fail to do so the batch shall be deemed not to conform to the requirements of the standard.

NOTE 2 Any sampling tests not defined in this standard should be agreed between the purchaser and supplier.

4.4.3 Routine tests

Where routine tests are specified in the following clauses, they shall be applied to every fitting.

4.5 Verification of dimensions and materials

It shall be verified either that the test samples conform to the requirements of BS 3288-2 (if relevant) or that they are in accordance with the contract drawings, particularly as regards any dimensions to which special tolerances apply and details affecting interchangeability (e.g. dimensions for which gauges are specified).

The tolerances given in Table 1 shall be used on all dimensions to which special tolerances do not apply.

Table 1 **Tolerances**

Dimension	**Tolerance**
mm	
Up to and including 35	±0.7 mm
Over 35	±2%

NOTE Dimensions given in brackets in BS 3288-2 are given for guidance only and are not subject to strict tolerances. These dimensions might vary by twice the tolerances specified in Table 1.

Measuring devices/gauges shall be selected with regard to the required precision and accuracy. Documentary evidence of calibration of such devices shall be provided on request.

Type and sample tests shall also include verification of materials to ensure that they are in accordance with contract documents. This verification shall normally be carried out by the purchaser inspecting the supplier's documentation relative to material purchasing specifications, certificates of conformity or other quality documentation. When agreed between purchaser and supplier, material verification shall include tests appropriate to the material specification.

4.6 Verification of markings

It shall be verified that the marking on the test samples conforms to the requirements of BS EN 61284 for the standard range of fittings or is in accordance with the contract drawing.

4.7 Welding

All welds for ferritic steel or austenitic stainless steel fabrications shall be in accordance with BS 4872-1. All friction welds shall be in accordance with BS EN ISO 15620.

5 Requirements for insulator pins

5.1 General

Insulator pins and nuts shall be made of steel, or any other material capable of conforming to the requirements of **5.2** and **5.3**.

The collar, if integral with the pin, shall be finished with a radius not exceeding 2 mm between it and the shank. The collar shall bed down on to a cross-arm when fixed to it through a hole having a diameter 2 mm greater than the diameter of the shank.

5.2 Mechanical type tests

The shank of the insulator pin shall be rigidly attached to the testing machine. A rigid metal extension piece shall be attached direct to the head of the pin. A load shall be applied to the extension piece 25 mm above the top of the pin. The load, applied at right angles to the axis of the insulation pin, shall be increased to the specified minimum failing load at a steady rate. When the specified minimum failing load has been reached, the deflection measured at the top of the pin head shall not exceed 20% of the distance of this point from the support.

5.3 Sample tests

5.3.1 Verification of dimensions

The dimensions of the samples shall be verified as specified in **4.5**.

5.3.2 Mechanical tests

This test shall be the same as the type test specified in **5.2**.

5.3.3 Galvanizing test

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

5.4 Routine tests

No routine tests are specified for insulator pins.

6 Insulator set fittings and earth conductor fittings

6.1 General requirements

Insulator set fittings and earth conductor fittings shall conform to the requirements of the following tests. Ferrous castings shall be made either of malleable cast iron conforming to the requirements of BS EN 1562, or of cast iron containing spheroidal or nodular graphite, conforming to the requirements of BS EN 1563. Forged steel fittings shall be made from steel of a suitable grade, conforming to the requirements of PD 970.

NOTE If the purchaser or supplier uses other materials, they should state that at the time of enquiry and order [see item d) of Annex C].

6.2 Mechanical type test

The fitting shall be held in a tensile testing machine and the load shall be gradually increased until it reaches the specified minimum damage load (70% of the minimum failure load). This load shall be kept constant for a maximum of 60 s (or as agreed between the purchaser and supplier). It shall then be removed and the measurement of the permanent deformation of the fitting carried out. The dimensions shall remain within the tolerances stated on the drawing. Then the load shall be gradually increased until it reaches the specified minimum failure load (SMFL) at which it shall be kept constant for 60 s. Then the load shall be increased until the failure of the fitting occurs.

NOTE If the failure load exceeds 1.2 times the SMFL, the test may be stopped with the agreement of all parties in order to safeguard equipment and/or operators.

6.3 Sample tests

6.3.1 Verification of dimensions

The dimensions of the samples shall be verified as specified in **4.5**.

6.3.2 Mechanical test

This test shall be the same as the type test specified in **6.2** with the minimum damage load part of the test waived.

6.3.3 Galvanizing test

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

6.4 Mechanical routine tests

This test shall be applied only to castings and to fittings which are fabricated by welding, in which the weld is stressed when the fitting is in service. A tensile load equal to 50% of the specified minimum failing load shall be applied to the fittings and maintained for 30 s. The fitting shall not be damaged by the test.

7 Tension joints and tension clamps

7.1 General requirements

Tension joints and tension clamps shall be so designed that they meet the requirements of the following tests.

NOTE 1 Attention is drawn to the need for the designer to take into account the effects of vibration.

Mechanical type tests shall be carried out on not fewer than three fittings. Electrical type tests shall be carried out on not fewer than six fittings except for mid-span tension joints, where three samples shall be tested, measurements being taken on each half of each sample. Fittings supplied for test shall be identical with those to be supplied commercially. Fittings within a manufacturer's range shall normally be subject to individual type tests. However, it shall be permissible for these to be omitted in those instances where an identical compression tube is employed for different applications within a range of fittings. The manufacturer shall demonstrate to the purchaser's satisfaction, compliance with the requirements of this standard. Where a common compression tube is used with different die forms, each tube/die combination shall be tested.

If one size of fitting is offered for more than one size of conductor, the type test shall be carried out on both the largest and smallest of such conductor sizes or, in the case of T-joints, on both the largest and smallest combinations of conductors.

If a fitting is offered for application to conductors of more than one material [e.g. copper, copper cadmium, aluminium, aluminium alloy, aluminium conductor steel reinforced (ACSR)], the type tests shall be carried out on each conductor material and stranding.

NOTE 2 The purchaser should state the sizes (or combinations) for testing at the time of enquiry and order [see item e) of Annex C].

7.2 Mechanical type tests

*NOTE 1 See **7.3** for electrical tests.*

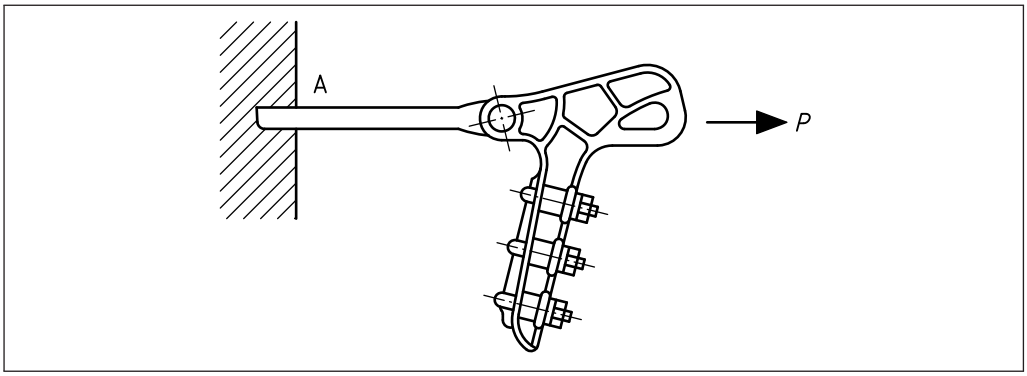
NOTE 2 The mechanical performance of a connector does not give a reliable indication of electrical performance.

7.2.1 Tension clamps

In the case of fittings that are provided with an attachment point for use during erection, this facility for attaching tensioning equipment shall be tested to 75% of the rated tensile strength of the strongest conductor for which the clamp is designed. The test shall be carried out prior to the test detailed in **7.2.2**.

The fitting shall be held in a tensile testing machine in a manner approximating, as nearly as possible, to the arrangement to be used in service (see Figure 1). A tensile load shall be applied to the attachment point for tensioning equipment and increased at a steady rate up to 75% of the rated tensile strength of largest conductor for which the tension termination is designed. Failure of the attachment point or fitting shall not occur at less than this load.

Figure 1 **Tension clamp and tension joints – Mechanical damage and failure load test of the attachment point used during erection: diagram showing the typical application of load**



7.2.2 Tension joints and tension clamps

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in a manner approximating, as nearly as possible, to the arrangement to be used in service, precautions being taken to avoid birdcaging of the conductor. The length of conductor between the fitting under test and any other clamp or joint in the test assembly shall be not less than 100 times the overall diameter of the conductor or 2.5 m, whichever is less.

A tensile load of about 50% of the SMFL of the conductor shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to the SMFL and maintained for 1 min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1 min and no failure of the fitting.

NOTE 1 Any suspected movement of the conductor due to permanent elongation which is not determined to be conductor slippage should be agreed between the purchaser and supplier.

When agreed between purchaser and supplier, the load shall then be gradually increased until failure of the clamp/joint or conductor wires occurs. The failure load shall be recorded for information purposes only.

NOTE 2 For the purposes of consistency, the term "Conductor Breaking Load" (CBL) is used to represent Rated Strength, Minimum Breaking Load or Nominal Breaking Load as defined in the appropriate conductor specifications.

The SMFL shall be taken as 90% of the CBL. The test shall be passed if there is no movement of the conductor relative to the fitting due to slip during the holding period and no failure occurs when the load is instantaneously held at 95% of the CBL.

Full details of the conductor used in the test, including details of the greasing, if any, shall be stated on the test certification.

7.2.3 Wedge clamps

7.2.3.1 Testing of wedge clamps

The wedge clamps tested shall include one with maximum size body and minimum size wedges and one with minimum size body and maximum size wedges.

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in a manner approximating, as nearly as possible, to the arrangement to be used in service, precautions being taken to avoid birdcaging of the conductor. The length of conductor between the fitting under test and any other clamp or joint in the test assembly shall be not less than 100 times the overall diameter of the conductor or 2.5 m, whichever is less.

A 5 kN load shall be applied to the assembly and the position of the wedges relative to the clamp body noted. Loads equivalent to normal everyday tension, maximum erection tension and maximum working tension of the conductor shall be applied to the conductors and the relative position of the wedges noted.

NOTE 1 If these values are not provided by the customer, the following may be used: normal every day tension = 20% NBL, maximum erection tension = 35% NBL and maximum working tension = 50% NBL).

After the application of each load, the clamp bodies shall be removed from the wedges using a wedge extractor tool.

A tensile load of about 50% of the SMFL of the conductor shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to the SMFL and maintained for 1 min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1 min and no failure of the fitting. The final position of the wedges shall be noted.

NOTE 2 Any suspected movement of the conductor due to permanent elongation which is not determined to be conductor slippage should be agreed between the purchaser and supplier.

When agreed between purchaser and supplier, the load shall then be gradually increased until failure of the clamp/joint or conductor wires occurs. The failure load shall be recorded for information purposes only.

The SMFL shall be taken as 90% of the CBL. The test shall be passed if there is no movement of the conductor relative to the fitting due to slip during the holding period and no failure occurs when the load is instantaneously held at 95% of the CBL. Full details of the conductor used in the test, including details of the greasing, if any, shall be stated on the test certification.

7.2.3.2 Clamp bolt tightening test

The test shall be performed by installing the clamp on a conductor with a diameter equal to that for which the clamp is intended to be used, the bolts and/or nuts being tightened with the installation torque specified by the supplier.

This torque shall be increased to the specified installation value times a factor of 1.1. The threaded connection shall remain serviceable for any number of subsequent installations or removals, and all components comprising the clamp shall be undamaged. No unacceptable damage shall occur to the conductor inside the clamp.

Lastly, the torque shall be increased up to either twice the specified installation value or the maximum torque value recommended by the bolt supplier, whichever is lower.

This increase shall not result in any breakage either to threaded parts or to the components connected to them.

7.2.4 Factory formed helical tension terminations

Factory made tension terminations shall be type tested as follows.

The fitting shall be assembled in accordance with **7.2.2**. A tensile load of 40% of the rated tensile strength of the conductor shall be applied and maintained for 1 min. The load shall be removed and the fitting then removed from the conductor in accordance with the manufacturer's instructions.

The fitting shall be reapplied to its original position on the conductor and the procedure repeated as detailed in the previous paragraph.

The fitting shall be reapplied to its original position on the conductor and the mechanical type test specified in **7.2.2** completed.

7.3 Electrical type tests

7.3.1 Resistance test

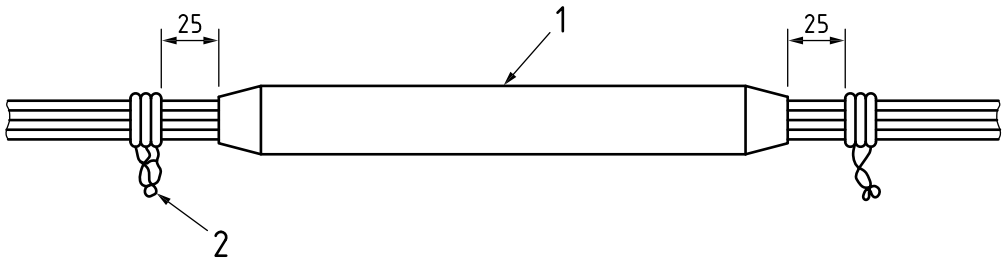
This test shall be made on tension joints and also on tension terminations (including any jumper connections which form part of the fitting), if the design is such that the conductor is not continuous through the clamp.

The test shall be carried out at an ambient temperature of between 15 °C and 30 °C.

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type for which it is to be used. The resistance shall be measured between the potential points defined in Figure 2. The conductor resistance per unit length (mm) shall be determined through measurement of a reference conductor. The conductor resistance over a length of 50 mm shall be calculated and the result subtracted from the measured resistance between the potential points to yield the joint resistance. This resistance shall not exceed 75% of the measured resistance of an equivalent length of conductor.

NOTE See BS EN 61284:1997, Annex A and Annex B, for joint types and a typical test circuit.

Figure 2 **Example of potential points**



Key

1	Typical joint	2	3 turns 18 SWG (Ø 1.22 mm) Copper wire twisted tight

For the purpose of resistance, the assembly shall contain a length of unjointed conductor which shall be used as the reference for resistance and temperature measurements. If a joint is such that two sizes of conductor are being connected into the assembly, the smaller of the two shall be used as the reference conductor. The length of the reference conductor shall be no less than 100 times its diameter, up to a maximum of 4 m long.

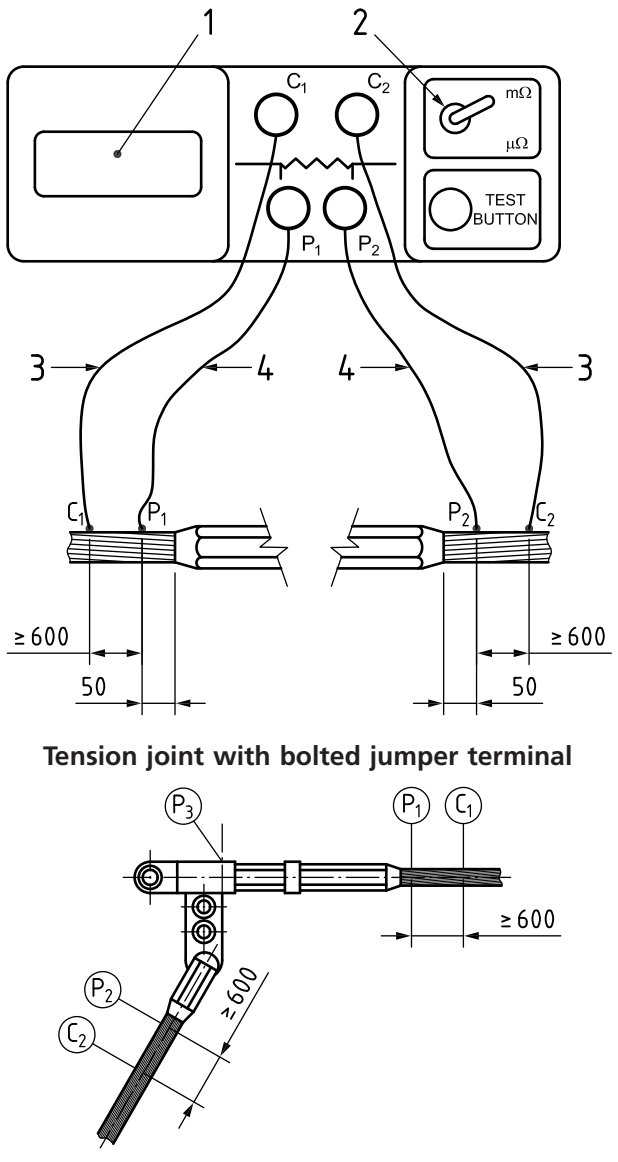
The test shall be made with direct current. The current connections shall be at a distance not less than 50 times the diameter of the conductor from the fitting and shall be made so that effective contact is made with all those strands of the conductor which would be taken into account in calculating its equivalent resistance.

The test shall be repeated with the polarity reversed and the average of the two results taken as the measured value.

An alternative test method shall be used if required and is described below.

The fitting shall be installed on a length of conductor. The electrical resistance shall be measured between points on the fitting as shown in Figure 3. In order to obtain the equivalent conductor length, the resistance of 100 mm of the relevant conductor shall be subtracted from the measured resistance. The test shall be made with direct current. The current connections shall be at a distance of not less than 650 mm from the fitting. A micrometer having an accuracy of 0.1% with current reversal and averaging shall be used for measurement. The mean of the measured resistance values between P1 and P2, P1 and P3 as shown in Figure 3 shall be recorded.

Figure 3 **Measuring electrical resistance between points**



Key

1	Digital display	3	Blue
2	Switch mΩ or $\mu\Omega$	4	Red

The mean resistance measurement shall not exceed 75% of the D.C. resistance of the equivalent length "e" of the conductor. In order to obtain the equivalent conductor length, "e", the resistance of 100 mm of the relevant conductor shall be subtracted from the measured resistance.

7.3.2 Electrical heating-cycle test

7.3.2.1 General

This test shall be made on all types of tension joints and also on tension terminations (including any jumper connections which form part of the fitting), if the design is such that the conductor is not continuous through the clamp.

7.3.2.2 Test conditions

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type with which it is to be used.

The test shall be carried out indoors in reasonably draught free conditions. The conductors shall be approximately horizontal and care shall be taken in the erection of the test assembly to ensure that the distances between the fittings(s) under test and other connections made to the conductor to facilitate testing are sufficient to minimize the possibility of thermal interference.

NOTE This can normally be achieved by making the distance between fitting(s) and connections not less than 50 times the conductor diameter with a maximum of 2 m.

The assembly may be tensioned to facilitate erection but such tension shall not exceed 20% of the conductor breaking load.

7.3.2.3 Test procedure

The test shall be carried out as follows.

a) The test shall be carried out on the fittings prepared as described in **7.3.2.2**. After the fittings have been placed in the test assembly, but prior to heat cycling, the resistance across each shall be measured as specified in **7.3.1**. The resistance of an equivalent length of conductor shall also be measured.

b) A test current shall then be passed through the assembly. The value and duration of the test current shall be such as to raise the conductor temperature to (70 ±5) °C above ambient and maintain this temperature for 30 min. The use of an initial current of value not greater than 150% of the test current, to reduce the time to raise the conductor to 70 °C above ambient, is not precluded.

NOTE 1 The conductor test temperature noted in this subclause assumes the use of "standard" Aluminium Conductor Steel Reinforced (ACSR), All Aluminium Alloy (AAA) or All Aluminium (AA) conductors. The conductor test temperature for specialist high temperature conductor fittings should have been earlier agreed between the supplier and purchaser.

c) At the end of the heating period, the current shall be interrupted and the conductor allowed to cool to within 5 °C above ambient.

d) This sequence of operation shall be repeated so that 100 cycles (±20 cycles) of heating and cooling are applied.

e) On one occasion during the last 5 cycles of the 100 cycles (±20 cycles), the conductor temperature and temperature of each fitting shall be measured during the last 15 min of the 30 min period.

f) The assembly shall then be allowed to cool to ambient and the resistance of each fitting measured.

g) Heat cycling shall then be continued with temperature and resistance measurement at the end of each 100 cycles (±20 cycles) until 500 cycles have been completed.

h) A further 500 cycles shall then follow with resistance measurements taken every 50 cycles (±10 cycles) and temperature measurement every 100 cycles (± 20 cycles). The fittings shall not be tightened or adjusted during the test.

NOTE 2 The above sequence is shown in diagrammatic form in Annex A.

7.3.2.4 Acceptance criteria

Each fitting shall meet the following criteria.

a) The temperature of the surface of the fitting, measured every 100 cycles (±20 cycles) when the test current is flowing, shall not exceed that of the conductor.

b) The electrical resistance of the fitting, measured at the end of every 100 cycles (±20 cycles) at ambient temperature, shall not exceed 75% of the measured resistance of the equivalent length of conductor.

c) The initial resistance of the fitting shall not differ by more than 50% from the mean of the overall resistance of each of the six fittings, or half fittings in the case of tension joints assembled for test.

d) The average resistance of the fitting measured over the last 500 cycles shall not exceed the initial resistance of the fitting by more than 50%.

e) A graph of resistance against number of cycles shall demonstrate with a reasonable probability that the rise in resistance over the last 500 cycles is not more than 15% of the average resistance over the same period. The method employed for the determination of this probability shall be in accordance with Annex B.

7.4 Sample tests

7.4.1 Verification of dimensions and materials

The dimensions of the samples shall be verified as specified in **4.5**.

NOTE Attention is drawn to the possible requirement for closer tolerances to be specified by the manufacturer for those dimensions which directly affect mechanical and/or electrical performance.

7.4.2 Mechanical and electrical tests

Mechanical and resistance tests shall be tested in accordance with **7.2** and **7.3**.

7.4.3 Galvanizing test

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

7.4.4 Clamp bolt tightening test

The wedge fixing bolts and the conductor guide bolts shall be as specified in **7.2.3.2**.

7.5 Routine tests

7.5.1 Mechanical test on tension clamps

This test shall be applied where possible to tension clamps incorporating load carrying castings and to those which are fabricated by welding, in which the weld is stressed in service.

Where a tension clamp is provided with an attachment point for use during erection and maintenance, the test load shall be applied between this point and the anchor point. Otherwise the test load shall be applied as nearly as possible between the points of attachment used in normal service.

A tensile load, which shall be equal to at least 50% of the specified minimum failing load shall be applied to the fitting and maintained for 30 s. The fitting shall not be damaged by the test.

The supplier shall inform the purchaser if the form of fitting is such that a test load cannot be applied.

7.5.2 Wedge clamp trunnions

A load equal to at least 50% of the minimum failing load of the conductor shall be applied to the trunnions of the clamp body and maintained for 30 s. The fitting shall not be damaged by the test.

7.5.3 Tension joints

No routine tests are specified for tension joints.

8 Non-tension joints

8.1 General requirements

Non-tension joints (including T-joints) shall be designed so that they meet the appropriate requirements of the following subclauses. Fittings intended to connect conductors of two dissimilar metals shall be designed to avoid harmful bi-metallic corrosion when erected in accordance with the manufacturer's recommendations.

Mechanical type tests shall be carried out on not fewer than three fittings. Electrical type tests shall be carried out on not fewer than six fittings except for non-tension joints, where three samples shall be tested, measurements being taken on each half of each sample. Fittings supplied for test shall be identical with those to be supplied commercially. Fittings within a manufacturer's range shall normally be subjected to individual type tests. However, these may be omitted in those instances where an identical compression tube is employed for different applications within a range of fittings. The manufacturer shall demonstrate to the purchaser's satisfaction, conformity to the requirements of this standard.

Where a common compression tube is used with different die forms, each tube/die combination shall be tested.

If one size of fitting is offered for more than one size of conductor, the type test shall be carried out on both the largest and smallest of such conductor sizes or, in the case of T-joints, on both the largest and smallest combinations of conductors.

If a fitting is offered for application to conductors of more than one material [e.g. copper, copper cadmium, aluminium, aluminium alloy, aluminium conductor steel reinforced (ACSR)], the type tests shall be carried out on each conductor material and stranding.

NOTE The purchaser should state the sizes (or combinations) for testing at the time of enquiry and order [see item e) of Annex C].

8.2 Mechanical requirements

NOTE The mechanical performance of a connector does not give a reliable indication of electrical performance.

8.2.1 Mechanical type test on joints other than T-joints

Non-tension joints other than T-joints shall meet the requirements of the following test.

NOTE The purchaser should state if this test is not required at the time of enquiry and order [see item h) of Annex C].

The joint shall be assembled in accordance with the manufacturer's recommendations on conductors of the sizes and types with which it is to be used. The assembly shall be mounted in a tensile testing machine and anchored in such a way that the test load is applied in the direction of the conductor.

A tensile load of about 5% of the CBL of the conductor shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 10% of the CBL. This load shall be maintained for 1 min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1 min and no failure of the fitting.

8.2.2 Mechanical type test on T-joints

When specified by the purchaser [see item i) of Annex C], non-tension T-joints shall meet the requirements of the following test.

A tensile load equal to 10% of its CBL shall be applied to a length of main conductor of the size and type with which the joint is to be used. The joint, complete with T-conductor, shall be assembled in accordance with the manufacturer's recommendations on the tensioned main conductor. The length of conductor on each side of the T-joint under test and any other clamp or joint in the test assembly shall be not less than 100 times the overall diameter of the conductor or 2.5 m, whichever is less.

Without any subsequent adjustment of the joint, the load in the main conductor shall be steadily increased to 95% of the CBL and then reduced to 90% of the CBL and maintained for 1 min. There shall be no failure of the main conductor.

The test specified in **8.2.1** shall be carried out with the tension applied between the joint and the T-conductor in the direction that the T-conductor emerges from the joint, the test load being determined, as in **8.2.1**, from the rated tensile strength of the T-conductor. There shall be no movement of the conductor relative to the joint due to slip and no failure of the joint.

8.3 Electrical type tests

8.3.1 Resistance test

This test shall be made on non-tension joints and T-connectors.

The test shall be carried out at an ambient temperature of between 15 °C and 30 °C.

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type with which it is to be used. The electrical resistance shall be measured between the points on the conductors on either side and 25 mm clear of the fitting (see Figure 2) and shall not exceed 75% of the measured resistance of the equivalent length of conductor. Where a fitting is composed of several parts, electrically in series, the resistance of each part shall not exceed 75% of the measured resistance of the equivalent length of conductor.

For the purpose of resistance, the assembly shall contain a length of unjointed conductor which shall be used as the reference for resistance and temperature measurements. If a joint is such that two sizes of conductor are being connected into the assembly, the smaller of the two shall be used as the reference conductor. The length of the reference conductor shall be no less than 100 times its diameter, up to a maximum of 4 m long.

The test shall be made with direct current. The current connections shall be at a distance not less than 50 times the diameter of the conductor from the fitting and shall be made so that effective contact is made with all those strands of the conductor which would be taken into account in calculating its equivalent resistance.

The test shall be repeated with the polarity reversed and the average of the two results taken as the measured value.

An alternative test method shall be used if required and is described below.

The fitting shall be installed on a length of conductor. The electrical resistance shall be measured between points on the fitting as shown in Figure 3. In order to obtain the equivalent conductor length, the resistance of 100 mm of the relevant conductor shall be subtracted from the measured resistance. The test shall be made with direct current. The current connections shall be at a distance of not less than 650 mm from the fitting. A micrometer having an accuracy of 0.1% with current reversal and averaging shall be used for measurement. The mean of the measured resistance values between P1 and P2, P1 and P3 as shown in Figure 3 shall be recorded.

The mean resistance measurement shall not exceed 75% of the D.C. resistance of the equivalent length "e" of the conductor. In order to obtain the equivalent conductor length, "e", the resistance of 100 mm of the relevant conductor shall be subtracted from the measured resistance.

8.3.2 Electrical heat cycle tests

8.3.2.1 General

Fittings shall be type tested by the electrical heat cycle method (1 000 cycles) followed by the current pulse test except in the case of fittings that will not experience high conductor temperatures in service, when the pulse test may be omitted.

NOTE The purchaser should state whether the fittings will experience high conductor temperatures in service in their enquiry and order [see item j) of Annex C].

8.3.2.2 Test conditions

The test shall be carried out in reasonably draught-free conditions. The test assembly shall be erected so that the distance between fittings, or any other connections introduced to facilitate testing, shall be sufficient to ensure negligible thermal interference. The assembly shall be supported roughly horizontal in such a way that air can freely circulate around the assembly to provide cooling by natural convection.

The fitting shall be assembled in accordance with the manufacturer's recommendations on a conductor or conductors of the size and type with which it will be used.

The test assembly shall be designed such that current is passed through the fittings from the main conductor to the jumper conductor on tension terminations and from the main conductor to the T-conductor by the T-joints.

8.3.2.3 Test procedure

The test shall be carried out as follows.

a) The test shall be carried out on the fittings prepared as described in **8.3.2.2**. After the fittings have been placed in the test assembly, but prior to heat cycling, the resistance across each shall be measured as specified in **7.3.1**. The resistance of an equivalent length of conductor shall also be measured.

b) A test current shall then be passed through the assembly. The value and

duration of the test current shall be such as to raise the conductor temperature to a minimum of 70 °C above ambient and maintain this temperature for 30 min. The use of an initial current of value not greater than 150% of the test current, to reduce the time to raise the conductor to 70 °C above ambient is not precluded.

c) At the end of the heating period, the current shall be interrupted and the conductor allowed to cool to within 5 °C above ambient.

d) This sequence of operation shall be repeated so that 100 cycles (±20 cycles) of heating and cooling are applied.

e) On one occasion during the last 5 cycles of the 100 cycles (±20 cycles), the conductor temperature and temperature of each fitting shall be measured during the last 15 min of the 30 min period.

f) The assembly shall then be allowed to cool to ambient and the resistance of each fitting measured.

g) Heat cycling shall then be continued with temperature and resistance measurement at the end of each 100 cycles until 500 cycles have been completed.

h) A further 500 cycles shall then follow with resistance measurements taken every 50 cycles (±10 cycles) and temperature measurement every 100 cycles (±20 cycles). The fittings shall not be tightened or adjusted during the test. The above sequence is shown in diagrammatic form in Annex A.

8.3.2.4 Acceptance criteria

The acceptance criteria shall be as follows.

a) The temperature of the surface of the fitting, measured every 100 cycles (±20 cycles) when the test current is flowing, shall not exceed that of the conductor.

b) The initial resistance of the fitting shall not differ by more than 50% from the mean of the overall resistance of each of the six fittings or half fittings in the case of non-tension joints assembled for test.

c) The average resistance of the fitting, measured over the last 500 cycles, shall not exceed the initial resistance of the fitting by more than 50%.

d) A graph of resistance against number of cycles shall demonstrate with a reasonable probability that the rise in resistance over the last 500 cycles is not more than 30% of the average resistance over the same period. The method employed for the determination of this probability shall be in accordance with Annex B.

8.3.3 Current pulse test

8.3.3.1 General

This test shall be carried out on the same assembly that has satisfactorily passed the electrical heat cycle test (specified in **8.3.2**).

8.3.3.2 Test conditions

The test conditions shall be as described in **8.3.2.2**.

8.3.3.3 Test procedure

The initial current shall be approximately four times the test current used for heat cycling. The duration of the pulse shall be chosen so as to heat the control conductor to (170 ±10) °C. Twenty pulses shall be applied to each fitting, the conductor being allowed to cool to within 5 °C above ambient between pulses. On completion of current pulse testing, each fitting shall be allowed to cool to ambient temperature and the resistance measured.

8.3.3.4 Acceptance criteria

On completion of the current pulse test the resistance of the fitting shall not exceed:

$$\frac{54 \times 10^3}{\text{Pulsetestcurrent(A)}}\mu\Omega$$

NOTE This criterion reflects the necessity to limit the interface temperature within the fitting to 150 °C. It has been shown that this temperature corresponds to an interface voltage of 54 mV when the test current is passing for overhead line fittings. Measurement of resistance is a convenient method of determining interface voltage and, hence, interface temperature. This criterion is valid for all combinations of material.

8.4 Sample tests

8.4.1 Verification of dimensions and measurements

The dimensions of the sample shall be verified, as specified in **4.5**.

8.4.2 Mechanical and electrical tests

Mechanical and resistance tests shall be tested in accordance with **8.2** and **8.3**.

8.4.3 Galvanizing tests

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

8.5 Routine tests

No routine test is required for non-tension joints.

9 Suspension clamps

9.1 General requirements

Suspension clamps shall be so designed that they meet the requirements of the following tests and so that the effects of vibration, both on the conductor and on the fitting itself, are minimized. They shall be designed, manufactured and finished so as to avoid sharp radii of curvature, ridges and excrescences which might lead to localized pressure on or damage to the conductor in service. The clamp shall permit the conductor to slip in accordance with **9.2.2**.

NOTE The fitting should have sufficient contact surface to minimize damage by fault currents.

9.2 Mechanical type tests

9.2.1 Tensile test

The fitting shall be held in a tensile testing machine in a manner approximating, as nearly as possible, to the arrangement to be used in service, the conductor being replaced by a rigid bar of suitable size. A tensile load equal to one-half of the specified minimum failing load shall be applied at 90° to the conductor axis and increased at a steady rate. Failure of the fitting shall not occur at a load less than the specified minimum failing load.

9.2.2 Conductor slip test

A length of conductor shall be fitted into the suspension clamp and the clamp bolts tightened to the recommended installation torque. An axial tensile load shall be applied either to the conductor or to the clamp.

The conductor shall not slip through the clamp below a load of 7 kN or 5% of the rated tensile strength of the conductor, whichever is the greater value.

The conductor shall slip through the clamp at a load not greater than 30% of the rated tensile strength of the conductor.

The conductor shall not be damaged other than some surface flattening of the strands.

9.2.3 Clamp bolt tightening test

The test shall be performed by installing the clamp on a conductor with a diameter equal to that for which the clamp is intended to be used, the bolts and/or nuts being tightened with the installation torque specified by the supplier.

This torque shall be increased to the specified installation value times a factor of 1.1. The threaded connection shall remain serviceable for any number of subsequent installations or removals, and all components comprising the clamp shall be undamaged. No unacceptable damage shall occur to the conductor inside the clamp.

Lastly, the torque shall be increased up to either twice the specified installation value or the maximum torque value recommended by the bolt supplier, whichever is lower.

This increase shall not result in any breakage either to threaded parts or to the components connected to them.

9.3 Sample tests

9.3.1 Verification of dimensions

The dimensions of the sample shall be verified, as specified in **4.5**.

9.3.2 Mechanical tests

If mechanical sample tests on suspension clamps are required, such tests shall be the same as the type tests specified in **9.2.1**, **9.2.2** and **9.2.3**.

NOTE The purchaser should state if these tests are not required at the time of enquiry and order [see item k) of Annex C].

9.3.3 Galvanizing test

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

9.3.4 Routine test

This test shall only be applied to suspension clamps incorporating castings as the principal load carrying members (e.g. integrally cast trunions) or those fabricated by welding in which the weld is stressed when the clamp is in service. The clamps shall be mounted as in service, with a rigid bar replacing the conductor, and a tensile load equal to at least 50% of the specified minimum failing load shall be applied at 90° to the conductor axis and maintained for 30 s. The fitting shall not be damaged by the test.

NOTE Suspension clamps incorporating steel forgings as load carrying members and utilizing castings to avoid localized pressures on the conductor should not be routine tested.

10 Electrical control fittings

10.1 General requirements

All electrical control fittings for insulator sets intended for use on systems operating at nominal voltages of 132 kV and above shall conform to all of the following tests. Fittings for use at voltages below 132 kV shall conform to **10.3.1** and **10.3.3**.

10.2 Mechanical type test

The fitting shall be rigidly supported and a specified load applied for 1 min. Unless otherwise specified on the drawing, this load, applied parallel to the centre line of the insulator set, shall be:

- for line end suspension horns: 1.8 kN on each tip;
- for line end tension horns: 0.9 kN on the tip;
- for earth end suspension horns: 0.9 kN on each tip;
- for earth end tension horns: 0.9 kN on the tip.

There shall be no failure of the fitting, but permanent deformation of the fitting after removal of the load is permitted.

10.3 Sample tests

10.3.1 Verification of dimensions and measurements

The dimensions of the samples shall be verified, as specified in **4.5**.

10.3.2 Mechanical test

This test shall be the same as the type test specified in **10.2**.

10.3.3 Galvanizing test

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

10.4 Routine test

This test shall be applied only to castings and to those fittings which are fabricated by welding. The fitting shall be rigidly supported and a specified load shall be applied as shown on the relevant drawing. The load shall be applied only momentarily.

There shall be no failure and no permanent deformation exceeding the permitted tolerance.

11 Mechanical protective fittings

11.1 General requirements

Mechanical protective fittings such as repair sleeves, armour rods, vibration dampers and spacers shall be designed to avoid damage to the conductor when erected in accordance with the manufacturer's recommendations.

Repair sleeves shall be designed to make good a conductor of which not more than one-third of the strands in the outermost layer have been severed. Repair sleeves shall meet the requirements of the mechanical type test specified in **11.2.2** and the electrical type test specified in **11.2.3**.

Vibration dampers shall meet the requirements of the mechanical type tests specified in **11.2.4**, **11.2.5** and **11.2.6**. Spacers shall meet the requirements of the mechanical type tests specified in **11.2.7** and **11.2.8**. Sample tests shall be made on mechanical protective fittings in accordance with **11.3**.

11.2 Type tests

11.2.1 Visible discharge type test (not applicable to armour rods)

This test shall be carried out in accordance to BS EN 61284.

NOTE Corona extinction value to be agreed between the purchaser and supplier.

11.2.2 Mechanical type test for repair sleeves

A length of conductor of the size and type which the sleeve is to be used shall be taken and a number of adjacent strands in the outermost layer shall be severed. The number of severed strands shall be the nearest whole number to one-third of the total number of strands in the outermost layer, and where more than one strand is severed, the cuts shall be dispersed over a conductor length of approximately three conductor diameters. The repair sleeve shall then be assembled to make good the damaged conductor, in accordance with the manufacturer's recommendations.

The assembly shall be mounted in a tensile testing machine and anchored so that service conditions are simulated, precautions being taken to avoid birdcaging of the conductor. The clear length of conductor on each side of the repair sleeve shall be not less than 100 times the overall diameter of the conductor or 2.5 m, whichever is less.

A tensile load of about 50% of the SMFL of the conductor shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to the SMFL and maintained for 1 min. There shall be no movement of the conductor relative to the sleeve during this period of 1 min and no failure of the sleeve.

NOTE Any suspected movement of the conductor due to permanent elongation which is not determined to be conductor slippage should be agreed between the purchaser and supplier.

When agreed between purchaser and supplier, the load shall then be gradually increased until failure of the clamp/joint or conductor wires occurs. The failure load shall be recorded for information purposes only.

The SMFL shall be taken as 90% of the CBL. The test shall be passed if there is no movement of the conductor relative to the fitting due to slip during the holding period and no failure occurs when the load is instantaneously held at 95% of the CBL.

Full details of the conductor used in the test, including details of the greasing, if any, shall be stated on the test certificate.

11.2.3 Electrical type test for repair sleeves – Resistance test

The test shall be carried out at an ambient temperature of between 15 °C and 30 °C.

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type with which it is to be used. The electrical resistance shall be measured between the points on the conductors on either side and 25 mm clear of the fitting (see Figure 2) and shall not exceed 75% of the measured resistance of the equivalent length of conductor. Where a fitting is composed of several parts, electrically in series, the resistance of each part shall not exceed 75% of the measured resistance of the equivalent length of conductor.

For the purpose of resistance, the assembly shall contain a length of unjointed conductor which shall be used as the reference for resistance and temperature measurements. If a joint is such that two sizes of conductor are being connected into the assembly, the smaller of the two shall be used as the reference conductor. The length of the reference conductor shall be no less than 100 times its diameter, up to a maximum of 4 m long.

The test shall be made with direct current. The current connections shall be at a distance not less than 50 times the diameter of the conductor from the fitting and shall be made so that effective contact is made with all those strands of the conductor which would be taken into account in calculating its equivalent resistance.

The test shall be repeated with the polarity reversed and the average of the two results taken as the measured value.

An alternative test method shall be used if required and is described below.

The fitting shall be assembled in accordance with the manufacturer's recommendations on conductors of the size and type for which it is to be used. The resistance shall be measured between the potential points defined in Figure 3. The conductor resistance per unit length (mm) shall be determined through measurement of a reference conductor. The conductor resistance over a length of 50 mm shall be calculated and the result subtracted from the measured resistance between the potential points to yield the joint resistance. This resistance shall not exceed 75% of the measured resistance of an equivalent length of conductor.

NOTE See BS EN 61284:1997, Annex A and Annex B, for joint types and a typical test circuit.

The test shall be made with direct current. The current connections shall be at a distance of not less than 650 mm from the fitting. A micrometer having an accuracy of 0.1% with current reversal and averaging shall be used for measurement. The mean of the measured resistance values between P1 and P2, P1 and P3 as shown in Figure 3 shall be recorded.

The mean resistance measurement shall not exceed 75% of the D.C. resistance of the equivalent length "e" of the conductor. In order to obtain the equivalent conductor length, "e", the resistance of 100 mm of the relevant conductor shall be subtracted from the measured resistance.

11.2.4 Longitudinal slip type test for vibration dampers

A coaxial force shall be applied to the clamp along the axis of the conductor. The minimum force required to cause the clamp to slip 1 mm in a 60 s interval shall be recorded. The minimum acceptable value shall be as given in Table 2.

Table 2 **Longitudinal slip**

Conductor diameter mm	Minimum force to cause longitudinal slip kN
12 to 19.49	0.4 plus 0.28 per mm above 12.0 mm
19.5 and above	2.5

11.2.5 Mechanical type test of messenger wire fastening for vibration dampers

The samples used for the clamp slip tests may also be used for this test. The axial tensile force required to pull the damper weights off the messenger wires shall be recorded.

The minimum acceptable value for messenger to weight shall be 5 kN for 1 min with a maximum slippage of 1 mm. The minimum acceptable value for the clamp to the messenger shall be 1.5 kN for 1 min with a maximum slippage of 1 mm.

11.2.6 Clamp bolt tightening test for vibration dampers

The test shall be performed by installing the clamp on a conductor with a diameter equal to that for which the clamp is intended to be used, the bolts and/or nuts being tightened with the installation torque specified by the supplier.

This torque shall be increased to the specified installation value times a factor of 1.1. The threaded connection shall remain serviceable for any number of subsequent installations or removals, and all components comprising the clamp shall be undamaged. No unacceptable damage shall occur to the conductor inside the clamp.

Lastly, the torque shall be increased up to either twice the specified installation value or the maximum torque value recommended by the bolt supplier, whichever is lower.

This increase shall not result in any breakage either to threaded parts or to the components connected to them.

11.2.7 Longitudinal slip test for spacer

A coaxial force shall be applied to the clamp along the axis of the conductor. The minimum force required to cause the clamp to slip shall be 5 kN for metal clamps or 1 kN for resiliently lined conductor clamps.

11.2.8 Clamp bolt tightening test for spacer

The test shall be performed by installing the clamp on a conductor with a diameter equal to that for which the clamp is intended to be used, the bolts and/or nuts being tightened with the installation torque specified by the supplier.

This torque shall be increased to the specified installation value times a factor of 1.1. The threaded connection shall remain serviceable for any number of subsequent installations or removals, and all components comprising the clamp shall be undamaged. No unacceptable damage shall occur to the conductor inside the clamp.

Lastly, the torque shall be increased up to either twice the specified installation value or the maximum torque value recommended by the bolt supplier, whichever is lower.

This increase shall not result in any breakage either to threaded parts or to the components connected to them.

11.3 Sample tests

11.3.1 Verification of dimensions

The dimensions of the sample shall be verified as specified in **4.5**.

11.3.2 Mechanical and electrical tests

NOTE Mechanical and electrical sample tests on repair sleeves are not specified in this standard.

Mechanical sample tests on vibration dampers and spacers shall be the same as type tests specified in **11.2.4**, **11.2.5**, **11.2.6**, **11.2.7** and **11.2.8**.

11.3.3 Galvanizing test

Galvanized parts shall be tested in accordance with BS EN ISO 1461 and shall conform to the requirements of that standard.

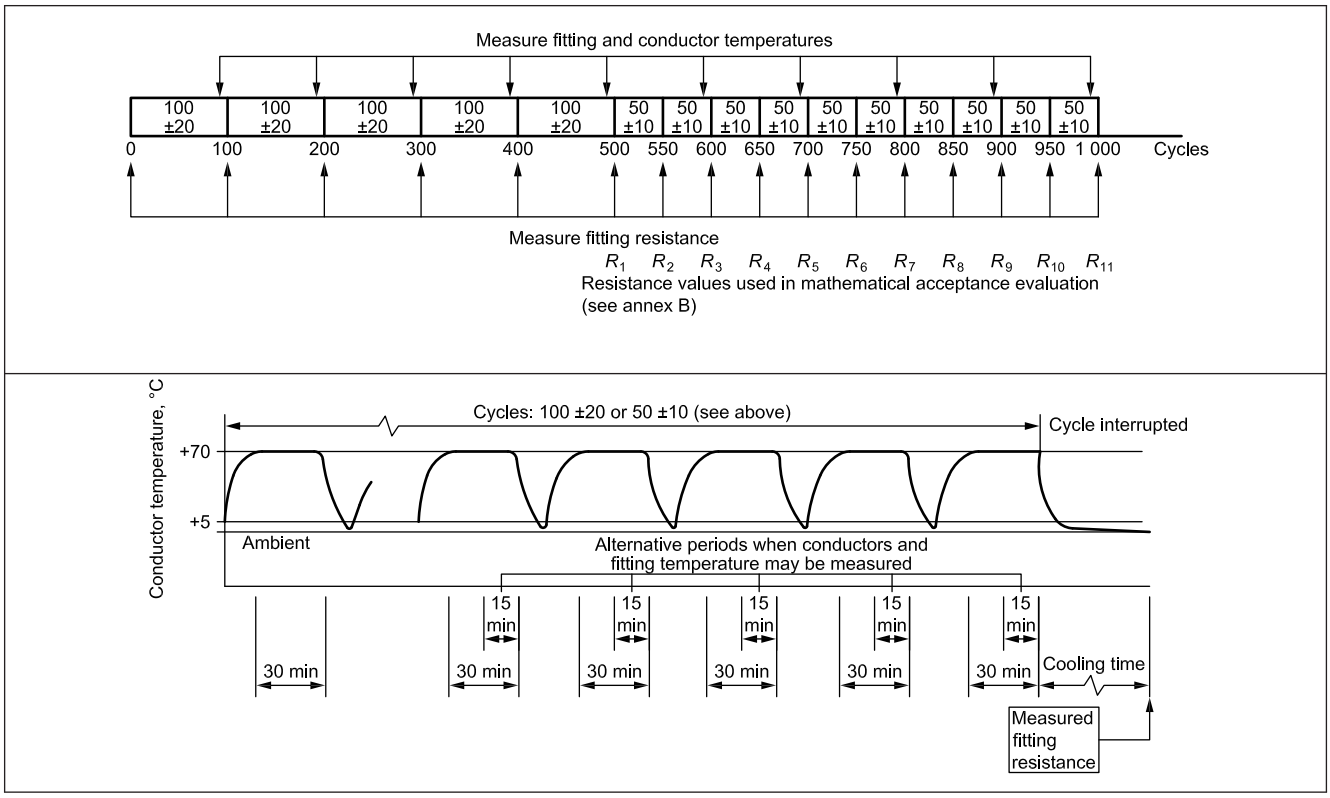
11.4 Routine test

No routine test is required for mechanical protective fittings.

Annex A (informative) Diagrammatic representation of electrical type test sequence

A diagrammatic representation of the test sequences for the electrical type test is shown in Figure A.1.

Figure A.1 **Diagrammatic representation of electrical type test sequence**



Annex B (normative) Mathematical acceptance criterion

B.1 General

*COMMENTARY ON **B.1**.*

*Throughout this Annex the word "acceptance" relates only to the requirements of **7.3.2.4** e) and **8.3.2.4** d). The mathematical acceptance method set out in this Annex is meant to provide a non-subjective means of assessing load cycling test results over the interval 500 cycles to 1 000 cycles inclusive when the assessment is not obvious from the inspection of the graphs. It is not intended, however, that the use of judgement in interpreting results should be entirely disregarded in favour of this mathematical assessment. Although each of the 11 test results is taken into account in the statistical assessment of a single sample, one reading that deviates appreciably from the line of best fit can have an overriding effect on the result, leading to a rejection indication. Where, for example, five samples out of six have definitely passed the test, and the sixth would pass but for a single reading, it is possible that the rogue reading is due to testing error; it would be contrary to common sense to reject a design on the basis of one bad resistance reading in 66. Continuation of the test, or even acceptance, despite the one bad reading, might be agreed between the parties to the test according to other evidence.*

The following is a step-by-step series of instructions written for direct application at a test site.

NOTE The full mathematical argument leading to the procedure given in this Annex is given in Appendix C of BS 4579-3:1976. When reference is made to that Appendix it should be noted that the test regimen specified in the present standard requires the taking of 11 readings between 500 cycles and 1 000 cycles. Consequently, the values of n and x (given in Appendix C of BS 4579-3:1976) are 11 and 0, ±1 to ±5 respectively. These values are incorporated arithmetically in the procedure given in the present Annex.

The following procedure shall be repeated for each test sample.

B.2 Designation of resistance measurements

Resistance measurements shall be designated as shown in Table B.1.

Table B.1 **Designation of resistance measurements**

Cycles	500	550	600	650	700	750	800	850	900	950	1 000
Resistance measurement	*R*1	*R*2	*R*3	*R*4	*R*5	*R*6	*R*7	*R*8	*R*9	*R*10	*R*11

B.3 Calculation of mean resistance

The mean resistance, $\bar{R}$ in micro-ohms, shall be calculated using the following formula:

$$\bar{R} = \frac{R_1 + R_{2...} + R_{11}}{11}$$

B.4 Calculation of slope of line of best fit for resistance measurements

The slope, *B*, of the line of best fit for the resistance measurements shall be calculated using the following formula:

$$B = \frac{-R_5 - 4R_2 - 3R_3 - 2R_4 - R_5 + R_7 + 2R_8 + 3R_9 + 4R_{10} + 5R_{11}}{110}$$

NOTE B may be positive or negative.

B.5 Calculation of change of resistance as fraction of mean resistance based on line of best fit

The change of resistance, *M*, as a fraction of mean resistance based on the line of best fit shall be calculated using the following formula:

$$M = \frac{10B}{\bar{R}}$$

B.6 Comparison of *M* with acceptance criterion

Calculate 0.4/*r*

where *r* is the equivalent conductor resistance in micro-ohms. The sample shall be provisionally accepted if:

$M \leq 0.15 + 0.4/r$ for tension fittings;

or

$M \leq 0.30 + 0.4/r$ for non-tension fittings.

Then proceed with **B.7**.

The sample shall be rejected if:

$M > 0.15 + 0.4/r$ for tension fittings;

or

$M > 0.30 + 0.4/r$ for non-tension fittings.

B.7 Calculation of the effect of the scatter of resistance readings

The effect, *S*, of the scatter of resistance readings around the line of best fit on the change of resistance calculation shall be calculated using the following formula:

$$S = \frac{2.07}{\bar{R}} \sqrt{\frac{A_1^2 + A_2^2 \ldots + A_{11}^2}{9}}$$

where

$A_1 = R_1 - \bar{R} + 5B$

$A_2 = R_2 - \bar{R} + 4B$

$A_3 = R_3 - \bar{R} + 3B$

$A_4 = R_4 - \bar{R} + 2B$

$A_5 = R_5 - \bar{R} + B$

$A_6 = R_6 - \bar{R}$

$A_7 = R_7 - \bar{R} - B$

$A_8 = R_8 - \bar{R} - 2B$

$A_9 = R_9 - \bar{R} - 3B$

$A_{10} = R_{10} - \bar{R} - 4B$

$A_{11} = R_{11} - \bar{R} - 5B$

B.8 Comparison of *M* + *S* with criterion for acceptance

The fitting shall be accepted if:

$M + S \leq 0.15 + 0.4/r$ for tension fittings;

or

$M + S < 0.30 + 0.4/r$ for non-tension fittings.

Annex C (informative)

Information to be supplied by the purchaser

The information supplied by the purchaser in his or her enquiry or order should include the following.

a) The number and date of this British Standard, i.e. BS 3288-1:2014 [1)].

b) If coupling dimensions of insulator fittings other than those specified in BS 3288-3 and BS EN 60372 are required (see **4.1**).

c) If evidence of conformity to type tests is required, other than that specified in **4.4.1**.

d) If the purchaser requires the use of materials other than those specified in **6.1**.

e) If a fitting is offered for application to conductors of more than one material, the sizes (or combination) to be type tested (see **7.1** and **8.1**).

f) The method of calculating the rated tensile strength (see **7.2.2**, **7.2.3.1** and **11.2.2**).

g) If the purchaser wishes to include mechanical and electrical sample tests (see **7.4.2** and **8.4.2**).

h) If the mechanical type test on joints other than T-joints is not required (see **8.2.1**).

i) If the mechanical type test on T-joints is required (see **8.2.2**).

j) For deciding the necessity or otherwise of carrying out the current pulse test, whether the fittings will experience high conductor temperatures in service (see **8.3.2**).

k) If mechanical sample tests on suspension clamps are not required (see **9.3.2**).

l) If the visible discharge type test is not required, or if it is required but a different test voltage is required (see **11.2.1**).

1) Marking BS 3288-1:2014 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 4579-3:1976, *Mechanical and compression joints in aluminium conductors (obsolete)*

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