Title:
IEC 61952, Ed.2: Composite line post insulators for a.c. overhead lines with a nominal voltage greater than 1 000 V definitions, test methods and acceptance criteria

(Titre) :
IEC 61952, Ed.2: Isolateurs composites rigides à socle destinés aux lignes aériennes à courant alternatif de tension nominale supérieure à 1000 V – définitions, méthodes d'essai et critères d'acceptation

Introductory note

This draft was prepared by MT10 of IEC SC 36B.

This revision of IEC 61952 has been made in order to align the publication with the new common clauses for composite insulators given in IEC 62217 (See 36/213/CDV).

No major technical changes have been made with respect to the previous edition, some prescriptions have been aligned with current practice and other composite insulator product standards.

This draft will be discussed at the SC 36B meeting in Korea in October 2004.
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMPOSITE LINE POST INSULATORS FOR A.C. OVERHEAD LINES WITH A NOMINAL VOLTAGE GREATER THAN 1 000 V
DEFINITIONS, TEST METHODS AND ACCEPTANCE CRITERIA

FOREWORD

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International Standard IEC 61952 has been prepared by subcommittee 36B: Insulators for overhead lines, of IEC technical committee 36: Insulators.

The text of this standard is based on the following documents:

<table>
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<th>Report on voting</th>
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<td>36B/XX/FDIS</td>
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Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.
Annexes A, B and C are for information only.

The committee has decided that the contents of this publication will remain unchanged until ______. At this date, the publication will be

- • reconfirmed;
- • withdrawn;
- • replaced by a revised edition, or
- • amended.
INTRODUCTION

Composite line post insulators consist 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. Despite these common features, the materials used and the construction details employed by different manufacturers may be different.

Some tests have been grouped together as "Design tests", to be performed only once on insulators which satisfy the same design conditions. All the design tests defined in IEC 62217 are applied for composite line post insulators; additional specific mechanical tests are given in this International Standard. As far as practical, the influence of time on the electrical and mechanical properties of the components (core material, housing, interfaces etc.) and of the complete composite insulators has been considered in specifying the design tests to ensure a satisfactory life-time under normally known stress conditions of transmission lines.

The approach for mechanical testing under bending loads used in this standard is based on the work of CIGRE [1]. This approach uses the concept of a damage limit which is the maximum stress which can be developed in the insulator before damage begins to occur. Annex A gives some notes on the mechanical loads and tests used in this standard.

Line post insulators are often used in braced structures whose geometry varies from line to line. A combined loading test to reproduce the complex loading cases in such structures is outside the scope of this standard and it would be very difficult to specify a general test which covers the majority of geometry and loading cases. In order to give some guidance, annex B explains how to calculate the moment in the insulators resulting from combined loads. This moment can then be equated to an equivalent bending load or stress for design purposes. Further information is available from CIGRE [2].

Compression load tests are not specified in this standard. The mechanical loads expected from service stress acting on line post insulators are mostly combined loads. These loads will cause some deflection on the insulator. Compression loads applied on pre-deflected insulators will lead to results largely dependent on the pre-deflection. Therefore a pure compression test has little meaning since the deflection prior to the cantilever load test cannot be specified.

Pollution tests, as specified in IEC 60507 [3], are not included in this standard, their applicability to composite line post insulators not having been proven. Such pollution tests performed on insulators made of non-ceramic materials do not correlate with experience obtained from service. Specific pollution tests for non-ceramic insulators are under consideration.

It has not been considered useful to specify a power arc test as a mandatory test. The test parameters are manifold and can have very different values depending on the configurations of the network and the supports and on the design of arc-protection devices. The heating effect of power arcs should be considered in the design of metal fittings. Critical damage to the metal fittings, resulting from the magnitude and duration of the short-circuit current can be avoided by properly designed arc-protection devices. This standard, however, does not exclude the possibility of a power arc test by agreement between the user and manufacturer. IEC 61467 [4] gives details of a.c. power arc testing of insulator sets.
Radio interference and corona tests are not specified in this standard since the RIV and corona performance are not characteristics of the insulator alone.

Composite hollow core line post insulators are currently not dealt with in this standard. IEC 61462 [5] gives details of tests on hollow core composite insulators, many of which can be applied to such line post insulators.

Torsion loads are not dealt with in this standard since they are usually negligible in the configuration in which line post insulators are generally used. Specific applications where high torsion loads can occur are outside the scope of this standard.
1 Scope and object

This International Standard applies to composite line post insulators consisting of a load-bearing cylindrical insulating solid core consisting of fibres - usually glass - in a resin-based matrix, a housing (outside the insulating core) made of polymeric material and end fittings permanently attached to the insulating core.

Composite line post insulators covered by this standard are subjected to cantilever, tensile and compressive loads, when supporting the line conductors. They are intended for use on a.c. overhead lines with a rated voltage greater than 1 000 V and a frequency not greater than 100 Hz.

The object of this standard is:

– to define the terms used,
– to prescribe test methods,
– to prescribe acceptance or failure criteria.

This standard does not include requirements dealing with the choice of insulators for specific operating conditions.

2 Normative references

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

IEC 60383-1: Insulators for overhead lines with a nominal voltage above 1 000 V - Part 1: Ceramic or glass insulator units for a.c. systems – Definitions, test methods and acceptance criteria

IEC 60383-2: Insulators for overhead lines with a nominal voltage above 1 000 V - Part 2: Insulator strings and insulator sets for a.c. systems – Definitions, test methods and acceptance criteria

IEC 62217:, Polymeric insulators for indoor and outdoor use with a nominal voltage above 1 000 V – General definitions, test methods and acceptance criteria

ISO 3452: Non-destructive testing – Penetrant inspection – General principles

3 Definitions

For the purpose of this document the following apply in addition to the terms and definitions given in IEC 60050 (471). Some definitions from IEC 62217 are reproduced here for ease of reference. (PL Note: The final decision on inclusion of definitions from 62217 to be taken later):
3.1 composite line post insulator
insulator consisting of a load-bearing cylindrical insulating solid core, a housing and end fittings attached to the insulating core. It is intended to be subjected to cantilever, tensile and compressive loads.

3.2 core of a composite insulator [62217]
the internal insulating part of a composite insulator which is designed to ensure the mechanical characteristics. The core usually consists of either fibres (e.g. glass) which are positioned in a resin-based matrix or a homogeneous insulating material (e.g. porcelain or resin).

3.3 shank of a polymeric insulator [62217]
the section between two adjacent sheds (also known as trunk on larger insulators).

3.4 housing [62217]
the external insulating part of polymeric insulators which provides the necessary creepage distance and protects (in the case of composite insulators) the core from the environment. Any intermediate sheath made of insulating material is a part of the housing.

3.5 shed [62217]
an insulating part, projecting from the insulator shank, intended to increase the creepage distance. The shed can be with or without ribs.

3.6 interfaces [62217]
the surface between the different materials. Various interfaces occur in most composite insulators, e.g.:
- between housing and end fittings;
- between various parts of the housing; e.g. between sheds, or between sheath and sheds;
- between core and housing.

3.7 end fitting [62217]
device forming part of an insulator, intended to attach it to a supporting structure, or to a conductor.

3.8 connection zone [62217]
the zone where the mechanical load is transmitted between the insulating body and the end fitting.

3.9 coupling [62217]
the part of the end fitting which transmits the load to the accessories external to the insulator.

3.10 crack [62217]
any fracture or surface fissure of depth greater than 0,1 mm.
3.11 delamination of the core
irreversible loss of bonding within fibre laminates perceivable by the naked eye.

3.12 failing load
maximum load that is reached when the insulator is tested under the prescribed conditions.

3.13 specified mechanical load (SML)
a load, specified by the manufacturer, which is used for mechanical tests in this standard.

3.14 routine test load (RTL)
load applied to all assembled composite insulators during a routine mechanical test.

3.15 specified cantilever load (SCL)
cantilever load which can be withstanded by the insulator at the line end fitting when tested under the prescribed conditions. This value is specified by the manufacturer.

3.16 maximum design cantilever load (MDCL)
load level above which damage to the core begins to occur and which is the ultimate limit for service loads. This value and direction of the load are specified by the manufacturer.

3.17 specified tensile load (STL)
tensile load which can be withstood by the insulator when tested under the prescribed conditions. This value is specified by the manufacturer.

4 Identification

In addition to the requirements of IEC 62217, each insulator shall be marked with the MDCL or with the relevant IEC designation.

It is recommended that each insulator be marked or labelled by the manufacturer to show that it has passed the routine mechanical test.

NOTE – At present there is no IEC standard giving designations of composite line post insulators.

5 Environmental conditions

The normal environmental conditions to which line post insulators are submitted in service are defined in IEC 62217.

6 Transport, storage and installation

In addition to the requirements of IEC 62217, information on handling of composite insulators can be found in CIGRE Technical Brochure 184 [6]. During installation, composite line post insulators may be submitted to high torsion loads for which they are not designed. In the absence of specific guidance from the manufacturer, torsion loads leading to stress in the core above 15 MPa shall be avoided. Ref. [6] also gives guidance on reducing torsion loads during installation.
7 Tolerances

Unless otherwise agreed, a tolerance of

- $\pm (0,04 \times d + 1,5)$ mm when $d \leq 300$ mm,
- $\pm (0,025 \times d + 6)$ mm when $d > 300$ mm with a maximum tolerance of 50 mm,

shall be allowed on all dimensions for which specific tolerances are not requested or given on the insulator drawing ($d$ being the dimension in millimetres).

The measurement of creepage distances shall be related to the design dimensions and tolerances as determined from the insulator drawing, even if this dimension is greater than the value originally specified. When a minimum creepage is specified, the negative tolerance is also limited by this value.

In the case of insulators with creepage distance exceeding 3m, it is allowed to measure a short section around 1 m long of the insulator and to extrapolate.

8 Classification of tests

The tests are divided into four groups as follows:

8.1 Design tests

These tests are intended to verify the suitability of the design, materials and method of manufacture (technology). A composite line post insulator design is defined by:

- materials of the core, housing and manufacturing method;
- material of the end fittings, their design and method of attachment (excluding the coupling);
- layer thickness of the housing over the core (including a sheath where used);
- diameter of the core.

When changes in the design occur, re-qualification shall be carried out in accordance with table 1.

When a composite line post insulator is submitted to the design tests, it becomes a parent insulator for a given design and the results shall be considered valid for that design only. This tested parent insulator defines a particular design of insulators which have all the following characteristics:

a) same materials for the core and housing and same manufacturing method;
b) same material of the fittings, the same design and the same method of attachment;
c) same or greater minimum layer thickness of the housing over the core (including a sheath where used);
d) same or smaller stress under mechanical loads;
e) same or greater diameter of the core,
f) equivalent housing profile parameters, see Note (1) in table 1.
Table 1 – Tests to be carried out after design changes

<table>
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<th>IF the change in insulator design concerns:...</th>
<th>THEN the following design tests shall be repeated:</th>
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<td>2 Housing profile 1)</td>
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<tr>
<td>3 Core material</td>
<td>X</td>
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<td>4 Core diameter</td>
<td>X</td>
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<td>5 Core and end-fitting manufacturing process</td>
<td>X</td>
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<td>7 Housing manufacturing process</td>
<td>X</td>
</tr>
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<td>8 Housing assembly process</td>
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<tr>
<td>9 End fitting material</td>
<td>X</td>
</tr>
<tr>
<td>10 End fitting connection zone design</td>
<td>X</td>
</tr>
<tr>
<td>11 Base end fitting coupling design</td>
<td>X</td>
</tr>
<tr>
<td>12 Core/housing/end fitting interface design</td>
<td>X</td>
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</tbody>
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1) Variations of the profile within following tolerances do not constitute a change:
   - Overhang: ±15%
   - Diameter: +15 %, -0 %
   - Thickness at base and tip: ±15%
   - Spacing: ±15%
   - Mean shed inclination: ±3°
   - Shed repetition: Identical

8.2 Type tests

These tests are intended to verify the main characteristics of a composite line post insulator which depend mainly on its shape and size. Type tests shall be applied to composite insulators, the class of which has passed the design tests. They shall be repeated only when the type or material of the composite insulator is changed (see clause 10).

8.3 Sample tests

The sample tests are for the purpose of verifying other characteristics of composite insulators, including those which depend on the quality of manufacture and on the materials used. They are made on insulators taken at random from lots offered for acceptance.

8.4 Routine tests

These tests are intended to eliminate composite line post insulators with manufacturing defects. They shall be made on every composite line post insulator offered for acceptance.
9 Design tests

9.1 General

These tests consist of the tests prescribed in IEC 62217 as listed in table 2 below and a specific assembled core load-time test. The design tests are performed only once and the results are recorded in a test report. Each part can be performed independently on new test specimens where appropriate. The composite line post insulator of a particular design will be qualified only when all insulators or test specimens pass the design tests.

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</tr>
<tr>
<td>Control of the slope of the strength-time curve of the insulator</td>
</tr>
</tbody>
</table>

9.2 Test specimens for IEC 62217

9.2.1 Tests on interfaces and connections of end fittings

Three insulators assembled on the production line shall be tested. The insulation length (metal to metal spacing) shall be at least 15 times the core diameter. Both metal fittings shall be the same as on standard production insulators. The end fittings shall be assembled so that the insulating part from the fitting to the closest shed shall be identical to that of the production line insulator.

If the manufacturer only has facilities to produce insulators shorter than 15 times the core diameter, the design tests may be performed on insulators of those lengths available to him, but the results are only valid for up to the lengths tested.
9.2.2 Tracking and erosion test

IEC 62217 specifies that the creepage distance of the specimen shall be between 500 mm and 800 mm. If the manufacturer only has facilities to produce insulators with creepage shorter than 500 mm, the design tests may be performed on insulators of those lengths he has available, but the results are only valid for up to the tested lengths.

9.2.3 Tests on core material

The specimens shall be as specified in IEC 62217. However if the housing material is not bonded to the core, then it shall be removed and the remaining core thoroughly cleaned to remove any traces of sealing material before testing.

9.3 Product specific pre-stressing for IEC 62217 tests on interfaces and connections of end fittings

The pre-stressing shall be carried out on the three specimens as indicated below.

9.3.1 Thermal-mechanical pre-stressing

The three specimens shall be submitted to a mechanical load in two opposite directions and to temperature cycles as described in figure 1. The 24 h temperature cycle shall be performed twice. Each temperature cycle has two temperature levels with a duration of at least 8 h, one at +50 °C ± 5 K, the other at −35 °C ± 5K. The cold period shall be at a temperature at least 85 K below the value actually applied in the hot period. The pre-stressing can be conducted in air or any other suitable medium.

The load applied to the specimens shall correspond to the MDCL.

The load shall be applied perpendicularly to the insulator's axis as near as possible to the normal load application point, either directly at the normal conductor position or at a hardware attachment point. When the load is not applied at the normal application point, it shall be corrected to produce the same bending moment at the base of the insulator as the one exerted by the MDCL.

The direction of the cantilever load applied to the specimens shall be reversed once, generally at the cooling passage through ambient temperature as described in figure 1.

The cycles may be interrupted for the load direction reversal and for maintenance of the test equipment for a total duration of 2 h. The starting point after any interruption shall be the beginning of the interrupted cycle.

NOTE The temperatures and loads in this pre-stressing are not intended to represent service conditions, they are designed to produce specific reproducible stresses in the interfaces on the insulator.

9.4 Assembled core load tests

9.4.1 Test for the verification of the maximum design cantilever load (MDCL)

9.4.1.1 Test specimens and test procedure

Three insulators made on the production line using standard end fittings shall be selected. The overall length of the insulators shall be between 15 and 18 times the diameter of the core, unless the manufacturer does not have facilities to make such a length. In this case, the length of insulator shall be as near as possible to the prescribed length range.
If not already routine tested, the insulators shall be examined visually and their conformity with the drawing shall be checked. They shall then be subjected to the tensile load routine test according to 12.1.

The insulator shall be gradually loaded to 1.1 times the MDCL at a temperature of 20 °C ± 10 K. This load shall be maintained for 96 h. The load shall be applied to the insulator at the conductor position, in the direction appropriate for the end fittings, and initially perpendicular to the core of the insulator.

After removal of the load, the steps below shall be followed:

- visually inspect the base end fitting for cracks or permanent deformation,
- check that threads of the end fitting are re-usable.

Cut each insulator at 90º to the axis of the core and about 50 mm from the base end fitting, then cut the base end fitting longitudinally into two halves in the plane of the previously applied cantilever load. The cut surfaces shall be smoothed by means of fine abrasive cloth (grain size 180).

- visually inspect the cut halves for cracks and delamination,
- perform a dye penetration test according to ISO 3452 to the cut surfaces to reveal cracks.

9.4.1.2 Acceptance criteria

Non-compliance with any of the above points shall constitute failure.

9.4.2 Tensile load test

9.4.2.1 Test procedure

Three insulators made on the production line using the standard end fittings shall be selected.

If not already routine tested, the insulators shall be examined visually and their conformity with the drawing shall be checked. They shall then be subjected to the tensile load routine test according to 12.1.

The tensile load shall be applied in line with the axis of the core of the insulator, at or near the intended service attachment point. The load shall be increased rapidly but smoothly from zero to approximately 75 % of the STL and shall then be gradually increased in a time between 30 s and 90 s until the STL is reached. If the STL is reached in less than 90s, the load shall be maintained for the remainder of the 90 s.

9.4.2.2 Acceptance criteria

The test shall be regarded as passed if there is no evidence of:

- pull-out of the core from the end fitting,
- breakage of the end fitting.
10 Type tests

An insulator type is electrically defined by the arcing distance, creepage distance, shed inclination, shed diameter and shed spacing. The electrical type tests shall be performed only once on insulators satisfying the above criteria for one type and shall be performed with arcing devices, if they are an integral part of the insulator type.

The electrical type tests shall be repeated only when one or more of the above characteristics is changed.

An insulator type is defined for the mechanical type tests, by the:
- SCL,
- core material,
- core diameter,
- method of attachment of the end fittings,
- coupling zone of the base end fitting.

The mechanical type tests shall be performed only once on insulators satisfying the above criteria for each type.

The mechanical type tests shall be repeated only when one or more of the above characteristics is changed.

If not already routine tested, the insulators shall be examined visually and their conformity with the drawing shall be checked using the tolerances given in 7. They shall then be subjected to the mechanical routine test according to 12.1.

10.1 Electrical tests

The electrical tests in table 3 shall be performed according to either 10.1.1, 10.1.2 or IEC 60383-2, according to whether the insulator is to be tested with or without line accessories, to confirm the specified values. Interpolation of electrical test results may be used for insulators of intermediate length, provided that the factor between the arcing distances of the insulators whose results form the end points of the interpolation range is less than or equal to 1.5. Extrapolation is not allowed.

The electrical tests shall be performed with the insulator either vertical or horizontal, in the position nearest that in which it will be used in service. If field grading devices are used in service they shall be used in the tests.

<table>
<thead>
<tr>
<th>Test</th>
<th>Mounting arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry lightning impulse withstand voltage test</td>
<td>Standard mounting arrangement of a line post insulator (10.1.1 or 10.1.2) or insulator set (IEC 60383-2) when switching impulse tests are not required</td>
</tr>
<tr>
<td>Wet power - frequency test</td>
<td>Standard mounting arrangement of a line post insulator (10.1.1 or 10.1.2) or insulator set (IEC 60383-2) when switching impulse tests are not required</td>
</tr>
<tr>
<td>Wet switching impulse withstand voltage test</td>
<td>Standard mounting arrangement of a line post insulator set (IEC 60383-2) when switching impulse tests are required</td>
</tr>
</tbody>
</table>

For insulators intended for systems with $U_m \geq 300$ kV.
10.1.1 Vertical mounting arrangement

The insulator shall be mounted according to IEC 60383-1.

10.1.2 Horizontal mounting arrangement

The insulator shall be mounted in a horizontal position on a vertical earthed metallic structure, typically made from U channel. This metallic structure shall have a width approximately equal to the diameter of the base of the insulator under test and shall have a height at least equal to twice the insulator length. The insulator shall be placed at least 1 m or 1,5 times the length of the insulator, whichever is the greater, above the ground. The insulator shall be mounted on the flat side of the U-channel.

If the insulator has an integral angled base it shall be mounted at that angle, rather than horizontally.

No other object shall be nearer to the insulator than 1 m or 1,5 times the length of the insulator, whichever is the greater.

A horizontal conductor not less than 13 mm diameter and extending in both directions at least twice the insulator length beyond the top shed shall be secured to the insulator. It shall be of such length that flashover will not be initiated at its ends.

If the insulator has a clamp, the conductor shall be placed in this clamp.

If the insulator does not have an integral clamp, a suitable clamp shall be used and shall be attached to the insulator by an appropriate means.

If the insulator has a grooved head the conductor shall be placed in the upper side groove. It shall be secured by means of a metallic wire of approximately 2,5 mm diameter wrapped around the conductor for a distance of approximately twice the diameter of the top shed and extending equally on each side of the insulator.

For wet tests the insulator shall be placed so that its axis is approximately perpendicular to the direction of the rain.

10.2 Mechanical tests

Interpolation of mechanical test results may be used for insulators of intermediate length provided that the factor between the moment arm of the insulators whose results form the end points of the interpolation range is less than or equal to 1,5. Extrapolation is not allowed.

10.2.1 Cantilever failing load test

This test shall be performed at 20 °C ± 10 K and is used to determine the failing load of a complete line post insulator assembly, as shown on the manufacturer’s drawing. Since composite insulators may exhibit large deflections, the apparatus used to apply the load shall have sufficient stroke to ensure failure of the insulator.

10.2.1.1 Test specimens

Three insulators made on the production line using the standard base fitting shall be selected.
10.2.1.2 Test procedure

It may be necessary to use special bolts or a special arrangement to securely hold the base plate to the test jig. The cantilever load shall be applied in the direction foreseen in service. The cantilever load shall be increased rapidly but smoothly from zero to approximately 75 % of SCL and then shall be gradually increased in a time between 30 s and 300 s until breakage of either the core or the end fitting occurs. Precautions shall be taken to keep the direction of application of the load as parallel as possible to initial direction. The cantilever failing load is the maximum load that is measured during the test.

The failure mode shall be recorded in the test report.

10.2.1.3 Acceptance criteria

The three failing load values shall be greater than the SCL.

11 Sample tests

11.1 General rules

For the sample tests, two groups of samples shall be used, E1 and E2. The sizes of these samples are indicated in table 4 below. If more than 10 000 insulators are concerned, they shall be divided into an optimum number of lots comprising between 2 000 and 10 000 insulators. The results of the tests shall be evaluated separately for each lot.

The insulators shall be selected from the lot at random. The purchaser has the right to make the selection. The samples shall be subjected to the applicable sample tests.

The sample tests are:

- verification of dimensions (E1 + E2)
- galvanizing test (E1 + E2)
- verification of the SCL (E1)

In the event of a failure of the sample to satisfy a test, the re-testing procedure shall be applied as prescribed in 11.5.

Only insulators of sample E2 may be used in service and that only if the galvanizing test is performed with the magnetic method.

<table>
<thead>
<tr>
<th>Lot size (N)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>E2</td>
</tr>
<tr>
<td>N ≤ 100</td>
<td>By agreement</td>
</tr>
<tr>
<td>100 &lt; N ≤ 300</td>
<td>2</td>
</tr>
<tr>
<td>300 &lt; N ≤ 2 000</td>
<td>4</td>
</tr>
<tr>
<td>2 000 &lt; N ≤ 5 000</td>
<td>8</td>
</tr>
<tr>
<td>5 000 &lt; N ≤ 10 000</td>
<td>12</td>
</tr>
</tbody>
</table>
11.2 Verification of dimensions (E1 + E2)

The dimensions given in the drawings shall be verified. The tolerances given in the drawing are valid. If no tolerances are given in the drawings, those given in 7 shall be used.

11.3 Galvanizing test (E1 + E2)

This test shall be performed on all galvanized parts in accordance with IEC 60383-1.

11.4 Verification of the SCL (E1)

11.4.1 Test procedure

The cantilever load shall be applied to the insulator at the conductor position, in the direction foreseen in service.

The load shall be increased rapidly but smoothly from zero to approximately 75% of the SCL and then shall be gradually increased in a time between 30 s and 90 s until the SCL is reached. If the SCL is reached in less than 90 s, the load shall be maintained for the remainder of the 90 s. Precautions shall be taken to keep the direction of application of the load as parallel as possible to initial direction.

In order to obtain more information from the test, the load may then be increased until failure of the core or breakage of the end fitting occurs. The failing load values and the failure modes shall be recorded.

11.4.2 Acceptance criteria

The insulator shall be regarded as passed if the SCL can be maintained for the required time.

11.5 Re-testing procedure

If only one insulator or fitting fails to comply with the sample tests, a new sample equal to twice the quantity originally submitted to the tests shall be subjected to re-testing.

The re-testing shall comprise the test in which failure occurred.

If two or more insulators or fittings fail to comply with any of the sample tests, or if any failure occurs during the re-testing, the complete lot shall be considered as not complying with this standard and shall be withdrawn by the manufacturer.

Provided the cause of the failure can be clearly identified, the manufacturer may sort the lot to eliminate all the insulators with this defect. The sorted lot may then be resubmitted for testing. The number then selected shall be three times the first quantity chosen for tests. If any insulator fails during this re-testing, the complete lot shall be considered as not complying with this standard.

12 Routine tests

12.1 Tensile load test

Every insulator shall be subjected, at ambient temperature, to a tensile load equal to or greater than either 50 % of STL or 5 kN, whichever is the greater, for at least 10 s. The tensile load shall be applied between the normal attachment points.
No partial or complete pull-out of the core from the end fitting shall occur. Nor shall deformation or cracking of the end fittings occur.

### 12.2 Visual examination

Each insulator shall be examined. The mounting of the end fittings on the insulating parts shall be in accordance with the drawings. The colour of the insulator shall be approximately as specified in the drawings. The markings shall be in conformance with the requirements of this standard (see clause 4).

The following defects are not permitted:

- superficial defects of an area greater than 25 mm$^2$ (the total defective area not to exceed 0.2 % of the total insulator surface) or of depth greater than 1 mm;
- crack at the root of the sheds, notably next to the metal fittings;
- separation or lack of bonding at the housing to metal fitting joint (if applicable);
- separation or bonding defects at the shed to sheath interface,
- moulding flashes protruding more than 1 mm above the housing surface.
Figure 1 – Thermal-mechanical pre-stressing test – Typical cycles
Annex A
(Informative)
Notes on the mechanical loads and tests

This annex presents some comments on the various mechanical tests of this specification.

A.1 Design tests

For a family of line post insulators, the maximum design bending stress or moment (generally expressed in megapascals or newton metres respectively) limits the cantilever loads. The core and the end fittings define a line post insulator family as each family may contain insulators of different length.

The maximum design bending stress (resulting from a test to verify MDCL) is the maximum useable bending stress of the insulator. For each family of line post insulators, a 96 h cantilever load test verifies that the core can sustain the maximum design bending stress without damage. This test, as a design test, needs to be performed only once on a representative length insulator for each insulator family.

In addition, a tensile load test is required to verify the design of the end fittings together with the method of attachment.

A.2 Type tests

The core diameter, insulator coupling length and method of attachment of the end fittings mechanically define a line post insulator type. A maximum design cantilever load (MDCL), in kilonewtons, is assigned to each line post insulator type, usually by interpolation from the Design MDCL verification test. For each line post insulator type, the assigned MDCL is the ultimate limit for service loads. A test to verify the MDCL for each line post insulator type is not included in this standard as such a type test would be uneconomic and time consuming.

The cantilever failing load is determined by a short time failing load test. This Standard requires that the cantilever failing load shall exceed the Specified Cantilever Load, which is the short time withstand strength of the insulator. The cantilever failing load test verifies that the rod or base end fitting does not fail at the Specified Cantilever Load, though damage to the core may occur.

A.3 Sample Test

A short time cantilever load test has been included as a sample test to verify the Specified Cantilever Load (SCL), This test is performed on production insulators complete with production end fittings. It is simple and relatively quick to perform.
A.4 Routine tensile test

A routine tensile test is specified instead of a routine bending test. This test provides some verification of the end fitting attachment process during production and is similar to the routine tensile test performed on composite suspension insulators. This test is used since, unlike porcelain, composite line post insulators are not made with brittle materials, and consequently a routine bending test at any level below the MDCL would not give any useful information.

By contrast with suspension insulators, this test may be more difficult to perform with some designs of end fittings and mounting bases. This difficulty arises since some designs of end fittings impose an unbalanced tensile load on the insulator. Care should be taken to ensure that the resulting load is applied in line with the axis of the insulator.
B.1 Introduction

Line post insulators are rated according to their maximum design cantilever load \( MDCL \). In service the cantilever load on a horizontal insulator may be the load resulting from the combination of a vertical load and a longitudinal load. In addition to this cantilever load an axial (compression or tension) load may also be present. The bending moment corresponding to the combination of these loads must not exceed the moment which corresponds to the \( MDCL \).

Line post insulators are also often used with a tension brace in order to be able to support higher vertical loads. The line post insulator in this structure is usually angled upwards by a few degrees. In this case a vertical load creates compressive stresses in the line post insulator.

The following clauses give information on calculating the approximate equivalent bending moment when line post insulators are submitted to combined loads, either alone or when part of a braced structure.

The following notation is used:

- \( C, T, V, L \) applied compressive, tensile, vertical, longitudinal load in newtons
- \( P_p \) resulting compressive load in the line post
- \( P_b \) resulting tensile load in the brace
- \( M_C \) resulting moment in the post under compression
- \( M_T \) resulting moment in the post under tension
- \( d \) distance from the point of application of the load to the top edge of the base fitting in metres
- \( E \) longitudinal Young's modulus [Pa] or [N m\(^{-2}\)]
- \( I \) moment of inertia of the rod in metres to the fourth power (for a solid round rod of diameter \( D \): \( I = \pi D^4/64 \))

NOTE The values for Young’s modulus and for the moment of inertia (or the real diameter) should be supplied by the manufacturer.

B.2 Maximum allowable bending moment, \( M_{\text{max}} \)

The maximum design cantilever load of a composite line post insulator induces the maximum allowable bending moment \( M_{\text{max}} = MDCL \times d \). The maximum stress associated with this bending moment must not produce any damage to the insulator FRP core.

The maximum combined stress is the maximum stress resulting from the simultaneously applied cantilever and compression (or tension) loads. In service the various combinations of loads must not produce a bending moment that is greater than the bending moment induced by the \( MDCL \).
B.3 Combined loading of line post insulators without a brace

The following formulae allow determination of the moment in the insulator when submitted to single or combined loads. It should be noted that the accuracy of these formulae depends on the deflection. The more the moment approaches the MDCL, the less accurate they become.

It should also be noted that the applied loads can result in damaging stress levels in the end fittings or accessories even when the moment in the insulator is at an acceptable level.

Figure B.1 – Combined loads applied to unbraced insulators

**Horizontal insulators**

In service the insulator may be subjected to a combination of a vertical load \( V \), a longitudinal load \( L \) and a compression \( C \) or a tension \( T \) load. The vertical load is usually the main load and sometimes the only load.

**A – Compression case**

The sum of the vertical \( V \) and longitudinal \( L \) components of the loads applies a cantilever load to the insulator; the compression load \( C \) is taken as being applied to the head of the insulator toward its base. The moment resulting from the application of these three forces is given by:

\[
M_c = \left( (V^2+L^2)EI / C \right)^{1/2} \tan \left[ d \left( C / EI \right)^{1/2} \right]
\]

In service: \( M_c \) should not exceed \( M_{max} \)

**B – Tension case**

The sum of the vertical \( V \) and longitudinal \( L \) components of the loads applies a cantilever load to the insulator; the tension load \( T \) is taken as being applied to the head of the insulator away from its base. The moment resulting from the application of these three forces is given by:

\[
M_t = \left( (V^2+L^2)EI / T \right)^{1/2} \tanh \left[ d \left( T / EI \right)^{1/2} \right]
\]

In service: \( M_t \) should not exceed \( M_{max} \)
Vertical insulators

The above formula for the compression case may be applied to vertical insulators. Care should then be taken to use the proper load values: the vertical load is now the compression load $C$; $V$ and $L$ loads are the loads applied to the insulator perpendicular to the insulator axis.

### B.4 Combined loading of line post insulators with a brace

The moment induced in braced line post insulators can be determined by formulae only for very low loads or displacements. Since such low loads are of little use in determining the moment at working or ultimate loads they are voluntarily not reproduced here in order to avoid any risk of error in designing braced insulating structures.

CIGRE has published information [2] on the application of finite element calculations with large displacements for the design and load determination of braced line post insulating structures.

Figure B.2 is intended to give a common reference when defining or specifying combined loads on braced line post insulators.

![Figure B.2 – Combined loads applied to braced insulators](image)

**Key**

- $P_p$: Resultant compressive load in the line post insulator
- $P_b$: Resultant tensile load in the brace insulator
Annex C
(Informative)
Bibliography


[3] IEC 61467: Insulators for overhead lines with a nominal voltage above 1 000 V - AC Power arc tests

[4] IEC 60507: Artificial pollution tests on high-voltage insulators to be used on a.c. systems
