BS EN 61109:2008

BSI Standards Publication

Insulators for overhead lines — Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V — Definitions, test methods and acceptance criteria

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National foreword

This British Standard is the UK implementation of EN 61109:2008. It is identical to IEC 61109:2008.

The UK participation in its preparation was entrusted to Technical Committee PEL/36, Insulators for power systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

The attention of users is drawn to the flammability test in Tables 1 and 2 of BS EN 61109:2008, which references BS EN 62217:2005, and is used as an indicator of power arc ignition and extinction performance. The UK Committee is of the opinion that work carried out before and after BS EN 62217:2005 was published shows that the flammability test is not suitable for assessing the power arc performance of insulators. The correlation between performance in different flammability tests, laboratory power arc tests and behaviour in service is currently under investigation by the International Council on Large Electric Systems study committee on Materials and Emerging Technologies (CIGRE SC D1). When applying this standard, users are recommended to consult the power arc tests in ANSI C29.18 or IEC 60099-4 surge arrestor specifications in addition to the test in Tables 1 and 2. The ANSI test also usefully includes an end fitting seal test after power arc damage.

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

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English version

Insulators for overhead lines - Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V - Definitions, test methods and acceptance criteria
(IEC 61109:2008)

Isolateurs pour lignes aériennes -
Isolateurs composites de suspension
et d'ancrage destinés aux systèmes
à courant alternatif de tension nominale
supérieure à 1 000 V -
Définitions, méthodes d'essai
et critères d'acceptation
(CEI 61109:2008)

Isolatoren für Freileitungen -
Verbund-Hänge- und -Abspannisolatoren
für Wechselstromsysteme
mit einer Nennspannung über 1 000 V -
Begriffe, Prüfverfahren
und Annahmekriterien
(IEC 61109:2008)

This European Standard was approved by CENELEC on 2008-09-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC
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Foreword

The text of document 36B/274/FDIS, future edition 2 of IEC 61109, prepared by SC 36B, Insulators for overhead lines, of IEC TC 36, Insulators, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61109 on 2008-09-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2009-06-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-09-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61109:2008 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60383-1	- [1]	Insulators for overhead lines with a nominal voltage above 1 kV - Part 1: Ceramic or glass insulator units for a.c. systems - Definitions, test methods and acceptance criteria	EN 60383-1 + A11	1996 [2] 1999
IEC 60383-2	- [1]	Insulators for overhead lines with a nominal voltage above 1 kV - Part 2: Insulator strings and insulator sets for a.c. systems - Definitions, test methods and acceptance criteria	EN 60383-2	1995 [2]
IEC 61466-1	- [1]	Composite string insulator units for overhead lines with a nominal voltage greater than 1 kV - Part 1: Standard strength classes and end fittings	EN 61466-1	1997 [2]
IEC 62217	2005	Polymeric insulators for indoor and outdoor use with a nominal voltage > 1 000 V - General definitions, test methods and acceptance criteria	EN 62217 + corr. December	2006 2006
ISO 3452	Series	Non-destructive testing - Penetrant inspection	EN ISO 3452	Series

[1] Undated reference.

[2] Valid edition at date of issue.

CONTENTS

INTRODUCTION

Composite insulators consist of an insulating core, bearing the mechanical load protected by a polymeric housing, the load being transmitted to the core by end fittings. Despite these common features, the materials used and the construction details employed by different manufacturers may be quite different.

Some tests have been grouped together as "Design tests", to be performed only once on insulators which satisfy the same design conditions. For all design tests of composite suspension and tension insulators, the appropriate common clauses defined in IEC 62217 are applied. 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. An explanation of the principles of the damage limit, load coordination and testing is presented in Annex A.

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 [1][1] gives details of a.c. power arc testing of insulator sets.

Composite insulators are used in both a.c. and d.c. applications. In spite of this fact, a specific tracking and erosion test procedure for d.c. applications as a design test has not yet been defined and accepted. The 1 000 h a.c. tracking and erosion test of IEC 62217 is used to establish a minimum requirement for the tracking resistance of the housing material.

The mechanism of brittle fracture has been investigated by CIGRE B2.03[2] and conclusions are published in [2, 3]. Brittle fracture is a result of stress corrosion induced by internal or external acid attack on the resin bonded glass fibre core. CIGRE D1.14 has developed a test procedure for core materials based on time-load tests on assembled cores exposed to acid, along with chemical analysis methods to verify the resistance against acid attack [4]. In parallel IEC TC36WG 12 is studying preventive and predictive measures.

Composite suspension/tension insulators are not normally intended for torsion or other non-tensile loads. Guidance on non-standard loads is given in Annex C.

Wherever possible, IEC Guide 111 [5] has been followed for the drafting of this standard.

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1 Figures in square brackets refer to the bibliography.

2 International Council on Large High Voltage Electric Systems: Working Group B2.03.

INSULATORS FOR OVERHEAD LINES – COMPOSITE SUSPENSION AND TENSION INSULATORS FOR A.C. SYSTEMS WITH A NOMINAL VOLTAGE GREATER THAN 1 000 V – DEFINITIONS, TEST METHODS AND ACCEPTANCE CRITERIA

1 Scope and object

This International Standard applies to composite suspension/tension 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 insulators covered by this standard are intended for use as suspension/tension line insulators, but it should be noted that these insulators can occasionally be subjected to compression or bending, for example when used as phase-spacers.

This standard can be applied in part to hybrid composite insulators where the core is made of a homogeneous material (porcelain, resin), see Clause 8.

The object of this standard is to

– define the terms used,
– prescribe test methods,
– prescribe acceptance 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 61466-1, *Composite string insulator units for overhead lines with a nominal voltage greater than 1 000 V – Part 1: Standard strength classes and end fittings*

IEC 62217:2005, *Polymeric insulators for indoor and outdoor use with a nominal voltage > 1 000 V – General definitions, test methods and acceptance criteria*

ISO 3452 (all parts), *Non-destructive testing – Penetrant testing*

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply.

NOTE Certain terms from IEC 62217 are reproduced here for ease of reference. Additional definitions applicable to insulators can be found in IEC 60050-471 [6].

3.1 Terms and definitions

3.1.1
polymeric insulator
insulator whose insulating body consists of at least one organic based material

NOTE Polymeric insulators are also known as non-ceramic insulators.

NOTE 2 Coupling devices may be attached to the ends of the insulating body.

[IEV 471-01-13]

3.1.2
composite insulator
insulator made of at least two insulating parts, namely a core and a housing equipped with metal fittings

NOTE Composite insulators, for example, can consist either of individual sheds mounted on the core, with or without an intermediate sheath, or alternatively, of a housing directly moulded or cast in one or several pieces on to the core.

[IEV 471-01-02]

3.1.3
core of a composite insulator
internal insulating part of a composite insulator which is designed to ensure the mechanical characteristics

NOTE 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).

[IEV 471-01-03, modified]

3.1.4
insulator trunk
central insulating part of an insulator from which the sheds project

NOTE Also known as shank on smaller insulators.

[IEV 471-01-11]

3.1.5
housing
external insulating part of a composite insulator providing the necessary creepage distance and protecting core from the environment

NOTE An intermediate sheath made of insulating material may be part of the housing.

[IEV 471-01-09]

3.1.6
shed of an insulator
insulating part, projecting from the insulator trunk, intended to increase the creepage distance.

NOTE The shed can be with or without ribs

[IEV 471-01-15]

3.1.7
interfaces
surface between the different materials

NOTE Various interfaces occur in most composite insulators, e.g.

– between housing and fixing devices,
– between various parts of the housing, e.g. between sheds, or between sheath and sheds,
– between core and housing

[Definition 3.10 of IEC 62217]

3.1.8
end fitting
integral component or formed part of an insulator intended to connect it to a supporting structure, or to a conductor, or to an item of equipment, or to another insulator

NOTE Where the end fitting is metallic, the term “metal fitting” is normally used.

[IEV 471-01-06]

3.1.9
connection zone
zone where the mechanical load is transmitted between the insulating body and the end fitting

[Definition 3.12 of IEC 62217]

3.1.10
coupling
part of the end fitting which transmits the load to the accessories external to the insulator

[Definition 3.13 of IEC 62217, modified]

3.1.11
specified mechanical load
SML
load, specified by the manufacturer, which is used for mechanical tests in this standard

3.1.12
routine test load
RTL
load applied to all assembled composite insulators during a routine mechanical test

3.1.13
failing load
maximum load that is reached when the insulator is tested under the prescribed conditions

3.2 Abbreviations

The following abbreviations are used in this standard:

E1, E2	Sample sets for sample tests
M_{AV}	Average 1 min failing load of the core assembled with fittings
RTL	Routine test load
SML	Specified mechanical load

4 Identification

In addition to the requirements of IEC 62217, each insulator shall be marked with the SML.

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

5 Environmental conditions

The normal environmental conditions to which 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 [7]. During installation, or when used in non-standard configurations, composite suspension insulators may be submitted to high torsion, compression or bending loads for which they are not designed. Annex C gives guidance on catering for such loads.

7 Hybrid insulators

As stated in Clause 1, this standard can be applied in part to hybrid composite insulators where the core is made of a homogeneous material (porcelain, resin). In general, the load-time mechanical tests and tests for core material are not applicable to porcelain cores. For such insulators, the purchaser and the manufacturer shall agree on the selection of tests to be used from this standard and from IEC 60383-1.

8 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 $\pm$ 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 3 m, it is allowed to measure a short section around 1 m long of the insulator and to extrapolate.

9 Classification of tests

9.1 Design tests

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

– materials of the core, housing and their 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 suspension 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 connection zone design, and the same housing-to-fitting interface geometry;
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 (a) in Table 1.

9.2 Type tests

The type tests are intended to verify the main characteristics of a composite insulator, which depend mainly on its shape and size. They also confirm the mechanical characteristics of the assembled core (see Clause A.4). They are made on insulators whose class has satisfied the design tests, more details are given in Clause 11.

9.3 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.

9.4 Routine tests

The aim of these tests is to eliminate composite insulators with manufacturing defects. They are made on every composite insulator offered for acceptance.

Table 1 – Tests to be carried out after design changes

IF the change in insulator design concerns:		**THEN** the following tests shall be repeated:									
		Design tests								**Type tests**	
		62217	61109	62217 Tests on housing material				62217 Tests on the core material		61109	
		Interfaces and connections of end fittings	Assembled core load–time tests	Hardness test	Accelerated weathering test	Tracking and erosion test	Flammability test	Dye penetration test	Water diffusion test	Electrical type tests	Mechanical type tests
1	Housing materials	X	X[c)]	X	X	X	X				
2	Housing profile[a)]	X				X				X	
3	Core material	X	X					X	X		X
4	Core diameter[b)]	X	X					X	X		X
5	Core and end-fitting manufacturing process	X	X					X	X		X
6	Core and end-fitting assembly process	X	X								X
7	Housing manufacturing process	X	X[c)]	X	X	X	X				X[c)]
8	Housing assembly process	X	X[c)]			X					X[c)]
9	End fitting material	X	X								X
10	End fitting connection zone design	X	X								X
11	Core/housing/end fitting interface design	X	X[c)]			X					X[c)]
12	Coupling type										X

a) Variations of the profile within following tolerances do not constitute a change:
- overhang : ± 10 %
- diameter : +15 %, -0 %
- thickness at base and tip : ± 15 %
- spacing : ± 15 %
- shed inclinations : ± 3°
- shed repetition : identical

b) Variations of the core diameter within ± 15 % do not constitute a change.

c) Not necessary if it can be demonstrated that the change has no influence on the assembled core strength.

10 Design tests

10.1 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 insulator of a particular design shall be qualified only when all insulators or test specimens pass the design tests.

Table 2 – Design tests

Tests on interfaces and connections of end fittings
Pre-stressing – Sudden load release pre-stressing Thermal-mechanical pre-stressing (see 10.2.1 and 10.3 below)
Water immersion pre-stressing
Verification tests
Visual examination
Steep-front impulse voltage test
Dry power-frequency voltage test
Tests on shed and housing material
Hardness test
Accelerated weathering test
Tracking and erosion test – see 10.2.2 below for specimens
Flammability test
Tests on the core material – see 10.2.3 below for specimens
Dye penetration test
Water diffusion test
Assembled core load-time test
Determination of the average failing load of the core of the assembled insulator
Control of the slope of the strength-time curve of the insulator

10.2 Test specimens for IEC 62217

10.2.1 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 not less than 800 mm. Both end 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 spacers, joining rings or other features are used in the insulator design (notably for longer insulators), the sample shall include any such devices in a typical position.

NOTE If the manufacturer only has facilities to produce insulators shorter than 800 mm, 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.

10.2.2 Tracking and erosion test

If spacers, joining rings or other features are used in the insulator design (notably for longer insulators), the samples for this test shall include any such devices in a typical position.

IEC 62217 specifies that the creepage distance of the sample shall be between 500 mm and 800 mm. If the inclusion of spacers or joints, as mentioned above, requires a longer creepage distance, the design tests may be performed on insulators of lengths as close to 800 mm as possible. 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.

10.2.3 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 cutting and testing.

10.3 Product specific pre-stressing for IEC 62217

The tests shall be carried out on the three specimens in the sequence as indicated below.

10.3.1 Sudden load release

With the insulator at –20 °C to –25 °C, every test specimen is subjected to five sudden load releases from a tensile load amounting to 30 % of the SML.

NOTE 1 Annex B describes two examples of possible devices for sudden load release.

NOTE 2 In certain cases, a lower temperature may be selected by agreement.

10.3.2 Thermal-mechanical pre-stress

Before commencing the test, the specimens shall be loaded at the ambient temperature by at least 5 % of the SML for 1 min, during which the length of the specimens shall be measured to an accuracy of 0,5 mm. This length shall be considered to be the reference length.

The specimens are then submitted to temperature cycles under a continuous mechanical load as described in Figure 1, the 24 h temperature cycle being perfomed four times. Each 24 h cycle has two temperature levels with a duration of at least 8 h, one at (+50 ± 5) °C, the other at (–35 ± 5) °C. 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 applied mechanical load shall be equal to the RTL (at least 50 % of the SML) of the specimen. The specimen shall be loaded at ambient temperature before beginning the first thermal 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.

The cycles may be interrupted 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.

After the test, the length shall again be measured in a similar manner at the same load and at the original specimen temperature (this is done in order to provide some additional information about the relative movement of the metal fittings).

10.4 Assembled core load-time tests

10.4.1 Test specimens

Six insulators made on the production line shall be tested. The insulation length (metal to metal spacing) shall be not less than 800 mm. Both end fittings shall be identical in all aspects to those used on production line insulators, except that they may be modified beyond the end of the connection zone in order to avoid failure of the couplings.

The six insulators shall be examined visually and a check made that their dimensions conform with the drawing.

NOTE If the manufacturer only has facilities to produce insulators shorter than 800 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.

10.4.2 Mechanical load test

This test is performed in two parts at ambient temperature.

10.4.2.1 Determination of the average failing load of the core of the assembled insulator M_{AV}

Three of the specimens shall be subjected to a tensile load. The tensile load shall be increased rapidly but smoothly from zero to approximately 75 % of the expected mechanical failing load and shall then be gradually increased in a time between 30 s and 90 s until breakage of the core or complete pull-out occurs. The average of the three failing loads M_{AV} shall be calculated.

10.4.2.2 Verification of the 96 h withstand load

Three specimens shall be subjected to a tensile load. The tensile load shall be increased rapidly but smoothly from zero up to 60 % of M_{AV}, as calculated in 10.4.2.1 and then maintained at this value for 96 h without failure (breakage or complete pull-out). If for any reason the load application is interrupted, then the test shall be restarted on a new specimen.

11 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 conditions above and shall be performed with arcing or field control devices (which are generally necessary on composite insulators at transmission voltages) if they are an integral part of the insulator type.

Furthermore, Table 1 outlines the insulator design characteristics that, when changed, also require a repeat of the electrical type tests.

An insulator type is **mechanically** defined principally by a maximum SML for the given core diameter, method of attachment and coupling design.

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

Furthermore, Table 1 indicates additional insulator design characteristics that, when changed, require a repeat of the mechanical type tests.

11.1 Electrical tests

The electrical tests in Table 3 shall be performed according to IEC 60383-2 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.

Table 3 – Mounting arrangements for electrical tests

Test	Mounting arrangement
Dry lightning impulse withstand voltage test	Standard mounting arrangement of an insulator string or insulator set when switching impulse tests are not required
Wet power-frequency test	Standard mounting arrangement of an insulator string or insulator set when switching impulse tests are not required
Wet switching impulse withstand voltage test for insulators intended for systems with $U_m \geq 300$ kV	Standard mounting arrangement of an insulator string or insulator set when switching impulse tests are required

11.2 Damage limit proof test and test of the tightness of the interface between end fittings and insulator housing

11.2.1 Test specimens

Four insulators taken from the production line shall be tested. In the case of long insulators, specimens may be manufactured, assembled on the production line, with an insulation length (metal to metal spacing) not less than 800 mm. Both end fittings shall be the same as on standard production insulators. The fittings shall be assembled such that the insulating part from the fitting to the closest shed is identical to that of the production line insulator. The insulators shall be examined visually and checked to see that the dimensions conform with the drawing; they shall then be subjected to the mechanical routine test according to 13.1.

NOTE If the manufacturer only has facilities to produce insulators shorter than 800 mm, 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.

11.2.2 Performance of the test

a) The four specimens are subjected to a tensile load applied between the couplings at ambient temperature. The tensile load shall be increased rapidly but smoothly from zero up to 70 % of the SML and then maintained at this value for 96 h.

b) Both ends of one of the four specimens shall, at the end of the 96 h test, be subjected to crack indication by dye penetration, in accordance with ISO 3452, on the housing in the zone embracing the complete length of the interface between the housing and metal fitting and including an additional area, sufficiently extended, beyond the end of the metal part.

   The indication shall be performed in the following way:

   – the surface shall be properly pre-cleaned with the cleaner;
   – the penetrant shall be applied on the cleaned surface and left to act for 20 min;
   – the surface shall be cleaned of the excess penetrant and dried;
   – the developer shall be applied, if necessary;
   – the surface shall be inspected.

   Some housing materials may be penetrated by the penetrant. In such cases, evidence shall be provided to validate the interpretation of the results.

   After the penetration test the specimen shall be inspected. If any cracks are visible, the housing and, if necessary, the metal fittings and the core shall be cut perpendicular to the crack in the middle of the widest of the indicated cracks, into two halves. The surface of the two halves shall then be investigated to measure the depth of the cracks.

c) The three remaining specimens are then again subjected to a tensile load applied between the couplings at ambient temperature. The tensile load shall be increased rapidly but smoothly from zero to approximately 75 % of the SMS and then gradually increased in a time between 30 s to 90 s to the SMS. If 100 % of the SML is reached in less than 90 s, the load (100 % of SML) shall be maintained for the remainder of the 90 s (this test is considered to be equivalent to a 1 min 100 % withstand test at SML).

In order to obtain more information from the test, unless special reasons apply (for instance the maximum tensile load of the test machine), the load may be increased until the failing load is reached and its value recorded.

11.2.3 Evaluation of the test

The test is passed if

- no failure (breakage or complete pull-out of the core, or fracture of the metal fitting) occurs either during the 96 h test at 70 % of the SML (11.2.2 a)) or during the 1 min 100 % withstand test at SML (11.2.2 c)),
- no cracks are indicated by the dye penetration method described in 11.2.2.2 b),
- the investigation of the halves described in 11.2.2.2 b) shows clearly that the cracks do not reach the core.

12 Sample tests

12.1 General rules

For the sample tests, two samples are 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 sampling tests.

The sampling tests are as follows:

a) verification of dimensions ………………………………………………. (E1 + E2)
b) verification of the locking system ……………………………………. (E2)
c) verification of the tightness of the interface between end fittings and insulator housing ……………………………………. (E2)
d) verification of the specified mechanical load, SML ………………… (E1)
e) galvanizing test ………………………………………………………… (E2)

In the event of a failure of the sample to satisfy a test, the re-testing procedure shall be applied as prescribed in 12.6.

Insulators of sample E2 only can be used in service and only if the galvanizing test is performed with the magnetic method.

Table 4 – Sample sizes

Lot size N	**Sample size** E1	E2
N ≤ 300	Subject to agreement	
300 < N ≤ 2 000	4	3
2 000 < N ≤ 5 000	8	4
5 000 < N ≤ 10 000	12	6

12.2 Verification of dimensions (E1 + E2)

The dimensions given in the drawings shall be verified. The tolerances given in the drawings are valid. If no tolerances are given in the drawings the values mentioned in Clause 8 shall be used.

12.3 Verification of the end fittings (E2)

The dimensions and gauges for end fittings are given in IEC 61466-1. The appropriate verification shall be made for the types of fitting used including, if applicable, verification of the locking system in accordance with IEC 60383-1.

12.4 Verification of tightness of the interface between end fittings and insulator housing (E2) and of the specified mechanical load, SML (E1)

a) One insulator, selected randomly from the sample E2, shall be subjected to crack indication by dye penetration, in accordance with ISO 3452, on the housing in the zone embracing the complete length of the interface between the housing and metal fitting and including an additional area, sufficiently extended, beyond the end of the metal part.

   The indication shall be performed in the following way:

   – the surface shall be properly pre-cleaned with the cleaner;
   – the penetrant, which shall act during 20 min, shall be applied on the cleaned surface;
   – within 5 min after the application of the penetrant, the insulator shall be subjected, at the ambient temperature, to a tensile load of 70 % of the SML, applied between the metal fittings; the tensile load shall be increased rapidly but smoothly from zero up to 70 % of the SML, and then maintained at this value for 1 min;
   – the surface shall be cleaned with the excess penetrant removed, and dried;
   – the developer shall be applied, if necessary;
   – the surface shall be inspected.

   Some housing materials may be penetrated by the penetrant. In such cases, evidence shall be provided to validate the interpretation of the results.

   After the 1 min test at 70 % of the SML, if any cracks occur, the housing and, if necessary, the metal fittings and the core shall be cut perpendicular to the crack in the middle of the widest of the indicated cracks, into two halves. The surface of the two halves shall then be investigated to measure the depth of the cracks.

b) The insulators of the sample E1 shall be subjected at ambient temperature to a tensile load, applied between the couplings. The tensile load shall be increased rapidly but smoothly from zero to approximately 75 % of the SML and then gradually increased to the SML in a time between 30 s to 90 s.

   If 100 % of the SML is reached in less than 90 s, the load (100 % of the SML) shall be maintained for the remainder of the 90 s (this test is considered to be equivalent to a 1 min withstand test at the SML).

   In order to obtain more information from the test, unless special reasons apply (for instance the maximum tensile load of the test machine), the load may be increased until the failing load is reached, and its value recorded.

The insulators have passed this test if

– no failure (breakage or complete pull-out of the core, or fracture of the metal fitting) occurs either during the 1 min 70 % withstand test (a)) or during the 1 min 100 % withstand test (b)),
– no cracks are indicated after the dye penetration method described in 12.4 a),
– the investigation of the halves described in 12.4 a) shows clearly that the cracks do not reach the core.

12.5 Galvanizing test (E2)

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

12.6 Re-testing procedure

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

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

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

13 Routine tests

13.1 Mechanical routine test

Every insulator shall withstand, at ambient temperature, a tensile load at RTL corresponding to $0,5 \times \text{SML} \; (^{+10}_{\ 0})$ % for at least 10 s.

13.2 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:

a) 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;
b) cracks at the root of the shed, notably next to the metal fittings;
c) separation or lack of bonding at the housing to metal fitting joint (if applicable);
d) separation or bonding defects at the shed to sheath interface,
e) moulding flashes protruding more than 1 mm above the housing surface.

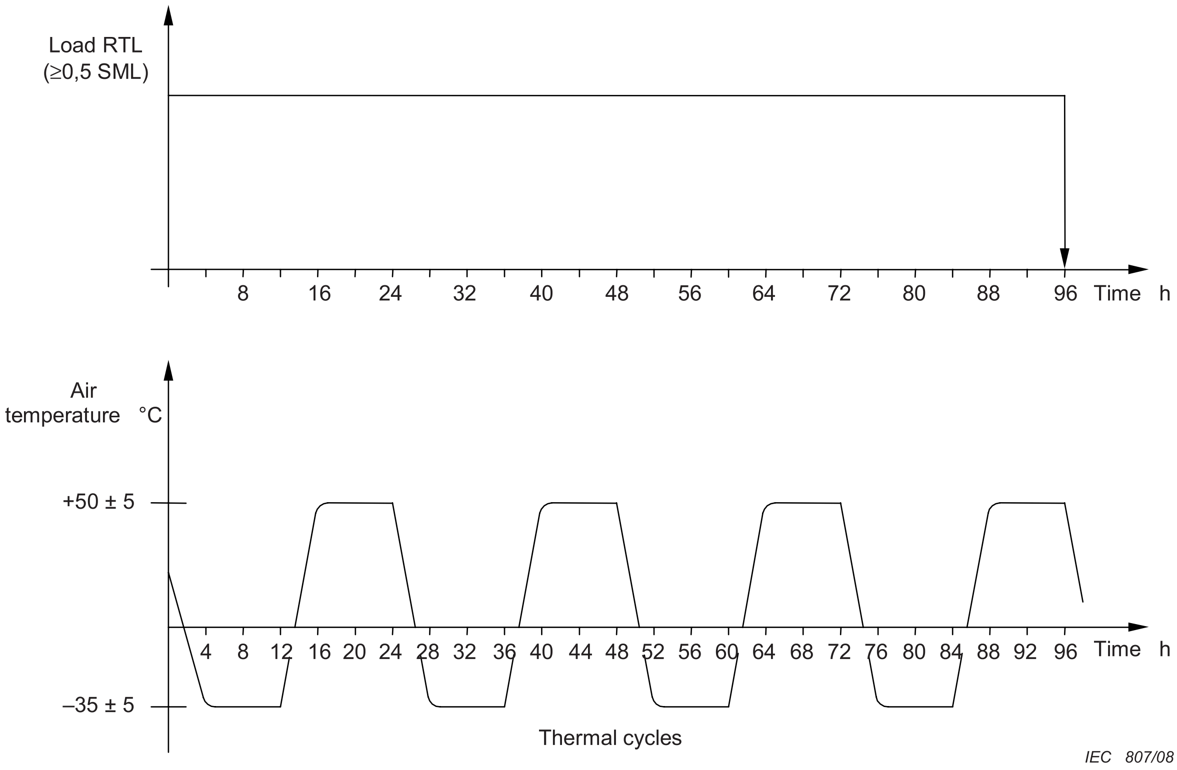

Figure 1 – Thermal-mechanical test

Annex A
(informative)

Principles of the damage limit, load coordination and testing for composite suspension and tension insulators

A.1 Introductory remark

This annex is intended to explain the long-term behaviour of composite suspension and tension insulators under mechanical load, to show typical coordination between SML and service loads and to explain the mechanical testing philosophy.

A.2 Load-time behaviour and the damage limit

An essential part of the mechanical behaviour of resin bonded fibre cores, typically used for composite insulators, is their load-time behaviour, which deserves some explanation.

The vast experience gained with composite insulators loaded with tension loads, both in the laboratory and confirmed in service, has shown that the load-time curve is indeed a curve, and not a straight line as was presented in the first version of IEC 61109. This straight line had often been misinterpreted, leading to the deduction that a composite insulator would only retain a small fraction of its original mechanical strength after a period of 50 years, whatever the applied load.

It is now known that the time to failure of composite insulators under static tensile loads follows a curve such as that presented in Figure A.1. To take into account the dispersion in the tensile characteristic of the insulator, the withstand curve is positioned, as shown in Figure A.1, below the failure curve. Being asymptotic, it shows that for a given insulator, there is a load below which the insulator will not fail no matter how long the load is applied since there is no damage to the core. This load level is known as the damage limit. Typically the damage limit lays around 60 % to 70 % of the ultimate strength of the core when assembled with fittings.

The damage limit depends on the kind of core material, on the type of end fitting and on the design of the connection zone. The damage limit represents the load value which causes inception of microscopic mechanical damage within the core material.

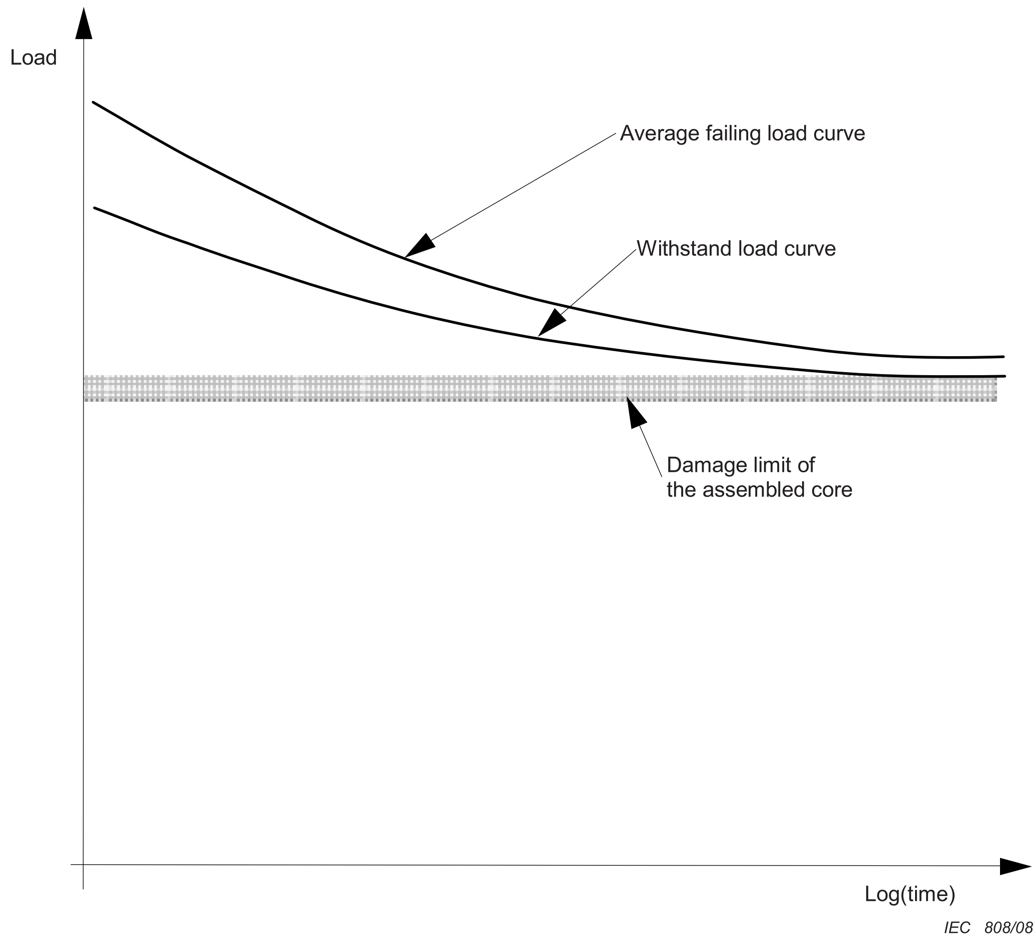

Figure A.1 – Load-time strength and damage limit of a core assembled with fittings

A.3 Service load coordination

For both short- and long-term mechanical loading of the entire composite insulator, the mechanical properties of the individual end fitting types also have to be considered. The maximum admissible working load value for the metal end fittings is limited by the elastic limit of the metal material and the design (mechanically stressed cross-section) of the weakest end fitting part. The maximum admissible load for the entire insulator is therefore given either by the elastic limit of the end fittings or by the damage limit of the assembled core (under normal environmental conditions as given in IEC 62217).

Figure A.2 shows a graphical representation of the typical relationship of the damage limit to the mechanical characteristics of an insulator with a 16 mm diameter core for typical service loads.

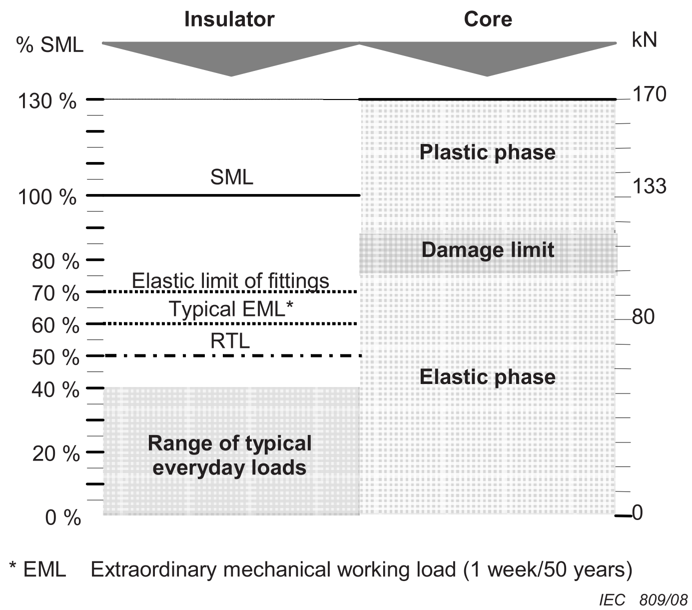

Figure A.2 – Graphical representation of the relationship of the damage limit to the mechanical characteristics and service loads of an insulator with a 16 mm diameter core

In all cases, the maximum working load (static and dynamic) shall be below the damage limit of the insulator. It is normal practice to adopt a safety factor of at least 2 between the SML and the maximum working load; this generally ensures that there is also a sufficient margin between the damage limit of the insulator and all service loads. IEC 60826 [8] gives guidance for calculation of loads and application of proper safety factors.

A.4 Verification tests

Two tests are prescribed in this standard to check mechanical strength and damage:

– a design test “96 h withstand load test” (load/time pairs D1 and D2 in Figure A.3) to check the position of the strength/time curve of the insulator (see 10.4.2);

– a type test ”damage limit proof test” (load/time pairs T1 and T2 in Figure A.3) to check the damage limit after loading with a constant load of 0,7 SML for 96 h (see 11.2).

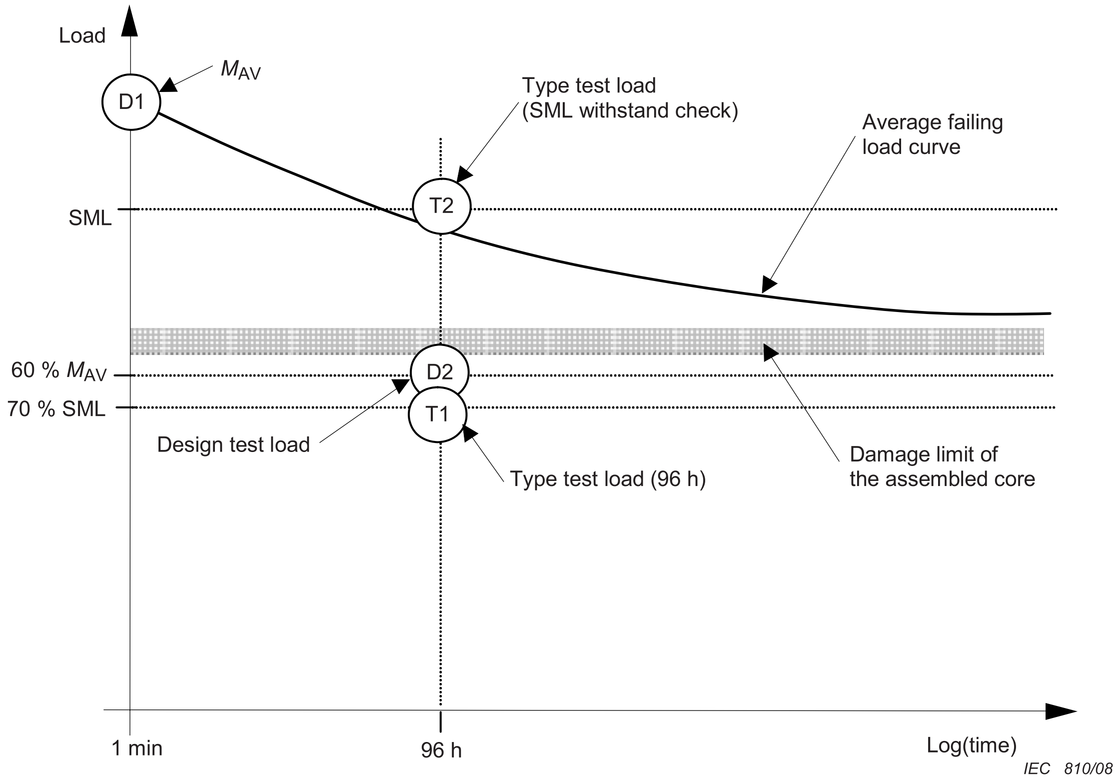

Figure A.3 – Test loads

The design test verifies the starting point of the actual initial load time curve by using M_{AV} (average failing load of the assembled core) and the minimum position of the damage limit by a withstand test for 96 h at 0,6 M_{AV}.

The choice of the SML with respect to M_{AV} is made by the manufacturer as a function of statistical data, design and process. There is no simple rule governing this relation. In order to check the coherence of the chosen SML with respect to the damage limit of the assembled insulator, the type test requires the insulator to withstand 70 % of the SML during 96 h followed by the SML for one min. If the strength coordination is correct then the insulator will not suffer any damage during the 96 h and will still be able to withstand the SML.

NOTE In some cases, depending on the chosen SML level, it is possible for the 96 h load for the type test to be higher than the 96 h load for the design test. This does not preclude the need for the design test.

Annex B
(informative)

Example of two possible devices for sudden release of load

B.1 Device 1 (Figure B.1)

The device consists of a hook A, a release lever B and a mounting plate C. Hook A can rotate on its pivot which is attached to the mounting plate. Tension is applied to the insulator by means of a suitable bolt or shackle, D.

During the time the insulator is under load, the release lever is retained in the position shown by the unbroken lines. Due to the length of the release lever B, a small force is sufficient to move it to the position shown by a broken line, rotating it on its pivot and moving the pivot in the direction X.

This operation of the release lever causes the hook to rotate on its pivot, hence releasing the bolt or shackle, D.

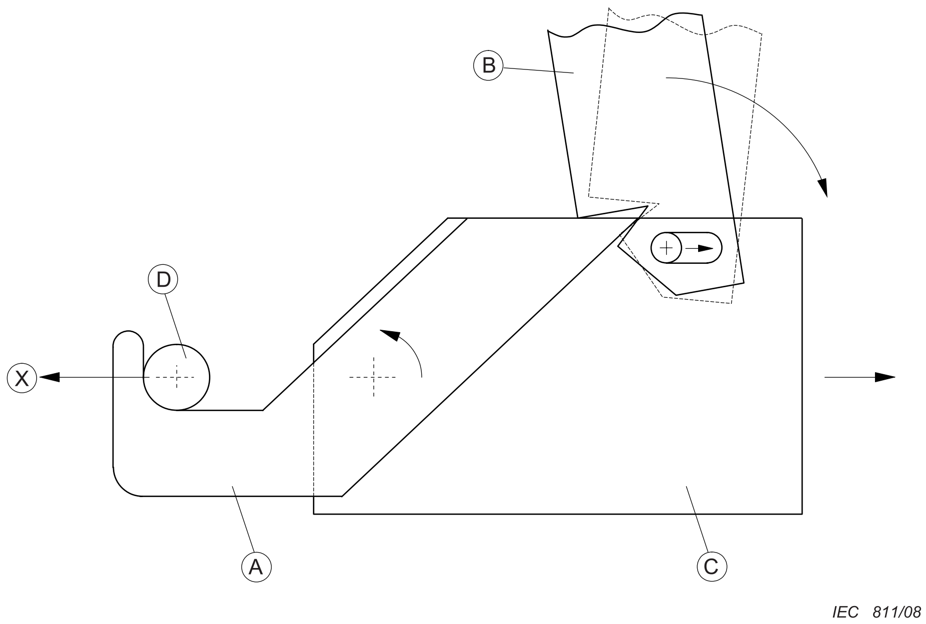

Figure B.1 – Example of possible device 1 for sudden release of load

B.2 Device 2 (Figure B.2)

The device consists of a breakage piece E screwed into two metallic extremities F and G which link the insulator to the tensile machine.

The breakage piece E is in the form of a dumb bell whose diameter is calibrated as a function of the steel used and of the desired breaking load.

The steel utilized for the piece E shall have a yield stress close to the ultimate tensile stress.

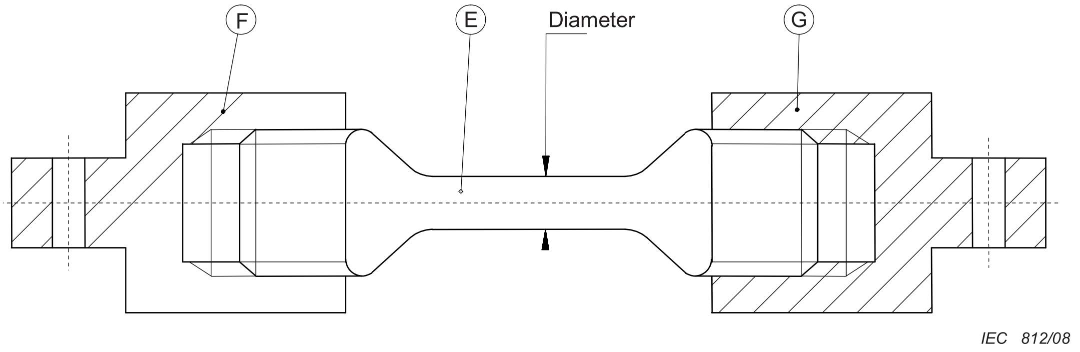

Figure B.2 – Example of possible device 2 for sudden release of load

Annex C
(informative)

Guidance on non-standard mechanical stresses and dynamic mechanical loading of composite tension/suspension insulators

C.1 Introductory remark

This annex provides guidance on service conditions where non-standard mechanical loads are introduced to the composite suspension/tension insulator. Examples of such non-standard mechanical loads are torsion, compression (buckling) and bending stress loads. Reference is made, based on insulator field experience to date, on the expected mechanical performance of composite insulators subjected to in-service dynamic mechanical loads.

Composite suspension/tension insulators are primarily designed to operate under mechanical tensile loads/stresses. However, in certain operations/applications, additional non-standard loads can be applied to the insulator. Avoidance of subjecting tension/suspension insulators to these non-standard loads should be made where possible. Guidance on minimizing the introduction of such load conditions is given in the CIGRE Composite Insulator Handling Guide [7].

C.2 Torsion loads

In line stringing operations, if twisting of the conductor bundle occurs and it is attempted to be corrected by rotation of the composite insulator, then a torsion stress can be introduced to the composite insulator. Furthermore, the probability of damage to the insulator is increased if a single strain insulator is used to support a twin conductor bundle. In such cases, the use of two insulators, either with or without inter-connecting yoke plates, is preferred. The introduction of torsion stresses should be avoided as much as possible during conductor stringing. Subjecting the insulators to excess torsion loads can lead to a reduction in the mechanical integrity of the composite insulator.

C.3 Compressive (buckling) loads

Special conditions arise in the case of insulator V-string applications where the suspension insulator may be subjected to compressive loads (if the wind load is greater than the mass supported, then the leeward insulator carries no load and the unit goes into compression). As a result of critical buckling loads being introduced to the insulator, significant damage may occur.

C.4 Bending loads

Long rod insulators may be subjected to critical bending loads during stringing operations. The introduction of such bending stresses should be avoided as much as possible. Subjecting the insulator to critical bending stresses can cause large deflection of the insulator, which can cause damage and loss of mechanical integrity of the insulator.

C.5 Dynamic mechanical loads

Service experience to date indicates that dynamic loads are unlikely to be of amplitude or duration to be detrimental to the mechanical performance of composite suspension/tension insulators.

C.6 Limits

It is difficult to give general limiting values for non-standard stresses due to the varied designs and materials used for composite suspension insulators. The intrinsic maximum stress for common core materials, before damage occurs, is of the order of 400 MPa in bending and 60 MPa in torsion – where the strength of the end fitting assembly onto the rod also comes into play. However, the often large displacements caused by non-standard loads can induce stress in the housing materials and their interfaces with the core or fittings, leading to their damage.

For example, at a stress of 400 MPa, a 2 m long insulator with a 16 mm diameter core would have a deflection of 1,8 m. For this reason it is recommended that the purchaser bring to the attention of the manufacturer, whenever possible, any anticipated non-standard loads or displacements in order to determine if they are critical for the product. In this way, working loads/displacements, the need for a test, the test procedure and the test loads/displacements can then be determined by agreement.

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