Composite hollow insulators — Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V — Definitions, test methods, acceptance criteria and design recommendations

The European Standard EN 61462:2007 has the status of a British Standard

ICS 29.080.10

British Standards

National foreword

This British Standard is the UK implementation of EN 61462:2007. It is identical to IEC 61462:2007.

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 subclause **7.3.4** of BS EN 61462:2006, 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 99-4 surge arrestor specifications in addition to the test in **7.3.4**. 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.

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

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Composite hollow insulators - Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V - Definitions, test methods, acceptance criteria and design recommendations

(IEC 61462:2007)

Isolateurs composites creux -
Isolateurs avec ou sans pression interne pour utilisation dans des appareillages électriques de tensions nominales supérieures à 1 000 V -
Définitions, méthodes d'essais, critères d'acceptation et recommandations de conception
(CEI 61462:2007)

Verbundhohlisolatoren -
Druckbeanspruchte und drucklose Isolatoren für den Einsatz in elektrischen Betriebsmitteln mit Bemessungsspannungen über 1 000 V -
Begriffe, Prüfverfahren, Annahmekriterien und Konstruktionsempfehlungen
(IEC 61462:2007)

This European Standard was approved by CENELEC on 2007-10-01. 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

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 36C/167/FDIS, future edition 1 of IEC 61462, prepared by SC 36C, Insulators for substations, of IEC TC 36, Insulators, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61462 on 2007-10-01.

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)	2008-07-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2010-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61462:2007 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION

Composite hollow insulators consist of an insulating tube bearing the mechanical load protected by an elastomeric housing, the loads being transmitted to the tube by metal fittings. Despite these common features, the materials used and the construction details employed by different manufacturers may vary.

Some tests have been grouped together as "Design tests" to be performed only once for insulators of the same design and material. The design tests are performed in order to eliminate designs and materials not suitable for high-voltage applications.

The relevant design tests defined in IEC 62217 are applied for composite hollow insulators; additional specific mechanical tests are given in this standard. The influence of time on the electrical and mechanical properties of the complete composite hollow insulator and its components (tube material, housing material, interfaces, etc.) has been considered in specifying the design tests in order to ensure a satisfactory lifetime under normal service conditions. These conditions may also depend on the equipment inside or outside the composite hollow insulators; however, this matter has not been covered in this standard. Test methods not specified in this standard may be considered for specific combinations of materials and specific applications, and are a matter of agreement between manufacturers and users. In this standard, the term “user” in general means the equipment manufacturer using composite hollow insulators.

The practical use of composite hollow insulators covers 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.

This standard distinguishes between design tests and type tests because several general characteristics of a specific design and specific combinations of materials do not vary for different insulator types. In these cases results from design tests can be adopted for different insulator types.

Pollution tests according to IEC 60507 are not included in this standard as they are generally not applicable. 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.

The mechanical characteristics of composite hollow insulators are quite different compared to those of hollow insulators made of ceramics. In order to determine the onset of mechanical deterioration of composite hollow insulators under the influence of mechanical stress, strain gauge measurements are used.

This standard refers to different characteristic pressures which are used for design and testing of composite hollow insulators. The term "maximum service pressure" (MSP) is equivalent to the term "design pressure" which is used in other standards for ceramic hollow insulators; however, this latter term is not used in this standard in order to avoid confusion with "design" as used in "design tests".

General recommendations for the design and construction of composite hollow insulators are presented in Annex B.

COMPOSITE HOLLOW INSULATORS –

PRESSURIZED AND UNPRESSURIZED INSULATORS FOR USE IN ELECTRICAL EQUIPMENT WITH RATED VOLTAGE GREATER THAN 1 000 V – DEFINITIONS, TEST METHODS, ACCEPTANCE CRITERIA AND DESIGN RECOMMENDATIONS

1 Scope and object

This International Standard applies to composite hollow insulators consisting of a load-bearing insulating tube made of resin impregnated fibres, a housing (outside the insulating tube) made of elastomeric material (for example silicone or ethylene-propylene) and metal fixing devices at the ends of the insulating tube. Composite hollow insulators as defined in this standard are intended for general use (unpressurized) or for use with a permanent gas pressure (pressurized). They are intended for use in both outdoor and indoor electrical equipment operating on alternating current with a rated voltage greater than 1 000 V and a frequency not greater than 100 Hz or for use in direct current equipment with a rated voltage greater than 1 500 V.

The object of this standard is:

– to define the terms used;
– to prescribe test methods;
– to prescribe acceptance criteria.

This standard does not prescribe impulse voltage or power frequency voltage type tests, nor does it prescribe pollution tests because the withstand voltages are not characteristics of the hollow insulator itself, but of the apparatus of which it ultimately forms a part.

All the tests in this standard, apart from the thermal-mechanical test, are performed at normal ambient temperature. This standard does not prescribe tests that may be characteristic of the apparatus of which the hollow insulator ultimately forms a part. Further technical input is required in this area.

NOTE 1 "Pressurized" means a permanent gas or liquid pressure greater than 0,05 MPa (0,5 bar) gauge. The gas can be dry air or inert gases, for example sulphur hexafluoride, nitrogen, or a mixture of such gases.

NOTE 2 "Unpressurized" means a gas or liquid pressure smaller than or equal to 0,05 MPa (0,5 bar) gauge.

NOTE 3 Composite hollow insulators are intended for use in electrical equipment, such as, but not limited to

- circuit-breakers,
- switch-disconnectors,
- disconnectors,
- earthing switches,
- instrument- and power transformers,
- bushings.

Additional testing defined by the relevant IEC equipment committee may be required.

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 60060-1: *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-17: *Basic environmental testing procedures – Part 2: Tests – Test Q: Sealing*

IEC 60168: *Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1 000 V*

IEC 62155: *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*

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

ISO 1101: *Geometrical Product Specifications (GPS) – Geometrical tolerancing – Tolerancing of form, orientation, location and run out*

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

3 Terms and definitions

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

3.1
composite hollow insulator
insulator consisting of at least two insulating parts, namely a tube and a housing

NOTE The housing may consist either of individual sheds mounted on the tube, with or without an intermediate sheath, or directly applied in one or several pieces onto the tube. A composite hollow insulator unit is permanently equipped with fixing devices or end fittings and is open from end to end.

3.2
tube
core
internal insulating part of a composite hollow insulator designed to ensure the mechanical characteristics

NOTE 1 The tube is generally cylindrical or conical, but may have other shapes (for example barrel). The tube is made of resin impregnated fibres.

NOTE 2 Resin impregnated fibres are structured in such a manner as to achieve sufficient mechanical strength. Layers of different fibres may be used to fulfil special requirements.

3.3
fixing device
end fitting
part of a composite hollow insulator attached to the tube to transmit the mechanical load

3.4
coupling
part of the end fitting which transmits the load to the accessories extrernal to the insulator

[IEC 62217, definition 3.13]

3.5
connection zone
zone where the mechanical load is transmitted between the insulating body and the end fitting

[IEC 62217, definition 3.12]

3.6
housing
external insulating part of composite hollow insulator providing necessary creepage distance and protecting tube from environment

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

[IEC 62217, definition 3.6, modified]

3.7
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]

3.8
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]

3.9
creepage distance
shortest distance or the sum of the shortest distances along the surface on an insulator between two conductive parts which normally have the operating voltage between them

NOTE 1 The surface of cement or of any other non-insulating jointing material is not considered as forming part of the creepage distance.

NOTE 2 If a high resistance coating is applied to parts of the insulating part of an insulator, such parts are considered to be effective insulating surfaces and the distance over them is included in the creepage distance.

[IEV 471-01-04]

3.10
arcing distance
shortest distance in the air external to the insulator between the metallic parts which normally have the operating voltage between them
[IEV 471-01-01]

NOTE The term “dry arcing distance” is also used.

3.11
tracking
process which forms irreversible degradation by formation of conductive paths (tracks) starting and developing on the surface of an insulating material

NOTE These paths are conductive even under dry conditions.

[IEC 62217, definition 3.14]

3.12
erosion
irreversible and non-conducting degradation of the surface of the insulator that occurs by loss of material which can be uniform, localised or tree-shaped

NOTE Light surface traces, commonly tree-shaped, can occur on composite insulators as on ceramic insulators, after partial flashover. These traces are not considered to be objectionable as long as they are non-conductive. When they are conductive they are classified as tracking.

[IEC 62217, definition 3.15]

3.13
crack
any fracture or surface fissure of depth greater than 0,1 mm
[IEC 62217, definition 3.10]

3.14
interface
surface between the different materials

NOTE 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.

[IEC 62217, definition 3.10]

3.15
damage limit of the tube under mechanical stress
limit below which mechanical loads (pressure, bending load) can be applied, at normal ambient temperature, without micro damage to the composite tube

NOTE Applying such loads means that the tube is in a reversible elastic phase. If the damage limit of the tube is exceeded, the tube is in an irreversible plastic phase, which means permanent damage to the tube which may not be visible at a macroscopic level (for a quantitative definition see Annex C).

3.16
specified mechanical load (SML)
load specified by the manufacturer that is used in the mechanical tests

NOTE 1 The load is normally applied by bending at normal ambient temperature.

NOTE 2 The SML forms the basis of the selection of composite hollow insulators with regard to external loads.

3.17
maximum mechanical load (MML)
highest mechanical load which is expected to be applied to the hollow insulator in service and in the equipment in which it is used

NOTE This load is specified by the equipment manufacturer.

3.18
deflection under bending load
displacement of a point on an insulator, measured perpendicularly to its axis, under the effect of a load applied perpendicularly to this axis
[IEV 471-01-05]

NOTE Deflection/load relationships are determined by the manufacturer.

3.19
failing load
maximum load that can be reached when the insulator is tested under the prescribed conditions (valid for bending or pressure tests).

NOTE Damage to the core is likely to occur at loads lower than the insulator failing load.

3.20
residual deflection
difference between the initial deflection of a hollow insulator prior to bending load application, and the final deflection after release of the load

NOTE The measurement of residual deflection serves for comparison with strain gauge measurements.

3.21
specified internal pressure (SIP)
internal pressure specified by the manufacturer which is verified during a type test at normal ambient temperature

NOTE The SIP forms the basis of the selection of composite hollow insulators with respect to internal pressure.

3.22
maximum service pressure (MSP)
difference between the maximum absolute internal pressure, when the equipment (of which the hollow insulator is a part) is carrying its rated normal current at maximum operational temperature and the normal outside pressure

NOTE 1 The MSP of the hollow insulator is specified by the equipment manufacturer.

NOTE 2 The MSP is equivalent to "design pressure" as used for ceramic hollow insulators (see IEC 62155).

3.23
specified temperature
highest and/or lowest temperature permissible for the composite hollow insulator

NOTE The specified temperature is specified by the manufacturer.

3.24
manufacturer
individual or organization producing the composite hollow insulators

3.25
equipment manufacturer
individual or organization producing the electrical equipment utilizing the composite hollow insulators

4 Relationships of mechanical loads

4.1 Loads from outside the insulator

Table 1 – Mechanical loads applied to the insulator

Load	Relation	Tube is in:
Maximum mechanical load (MML) which is the design load for the equipment manufacturer	= 1,0 × MML	reversible elastic phase
Damage limit	> 1,5 × MML	reversible elastic phase
Type test SML bending load	= 2,5 × MML	irreversible plastic phase
Failure bending load	> 2,5 × MML	irreversible plastic phase

An overview of loads is shown in Figure B.1.

4.2 Pressures

Table 2 – Pressures applied to the insulator

Pressure	Relation	Tube is in:
Maximum service pressure (MSP) which is the design pressure for the equipment manufacturer	= 1,0 x MSP	reversible elastic phase
Routine test pressure	= 2,0 × MSP	reversible elastic phase
Damage limit	> 2,0 × MSP	reversible elastic phase
Type test pressure	= 4,0 × MSP	irreversible plastic phase
Specified internal pressure (SIP)	≥ 4,0 × MSP	irreversible plastic phase

An overview of pressures is shown in Figure B.2.

5 Marking

Each hollow insulator shall be marked with the name or trade mark of the manufacturer and the year of manufacture. In addition, each hollow insulator shall be marked with the type reference and serial numbers in order to allow identification. This marking shall be legible and indelible.

6 Classification of tests

The tests are divided into four groups as follows:

6.1 Design tests

These tests are intended to verify the suitability of the design, materials and manufacturing technology.

A composite hollow insulator design is defined by:

– materials and design of the tube, housing and manufacturing method,
– material of the end fittings, their design and method of attachment,
– layer thickness of the housing over the tube (including a sheath where used).

When changes in the design occur, re-qualification shall be done according to Table 3.

Table 3 – Tests to be carried out after design changes

IF the insulator design changes the...		**THEN** the following design tests shall be repeated :						
		7.2	7.3.1	7.3.2	7.3.3	7.3.4	7.4.1	7.4.2
		Interfaces and connections of end fittings (as per IEC 62217).	Hardness test (see IEC 62217)	Accelerated weathering (see IEC 62217)	Tracking and erosion test(see IEC 62217)	Flammability test (see IEC 62217)	Dye penetration test (see IEC 62217)	Water diffusion test (see IEC 62217)
1	Housing materials	X	X	X	X	X		
2	Housing profile[a]				X			
3	Tube material	X					X	X
4	Tube design[b]						X	X
5	Manufacturing process of housing[c]	X	X	X	X			
6	Manufacturing process of tube[d]	X					X	X
7	End fitting material	X						
8	End fitting method of attachment to tube[e]	X						
9	Tube-housing-end fitting interface design	X			X			

[a] The following variation of the housing profile within following tolerances do not constitute a change:

- Overhang of sheds: ± 10 %
- Spacing: ± 10 %
- Mean inclination of sheds: ± 3°
- Thickness at root and tip of sheds : ± 15 %
- Shed repetition : identical

[b] Liner, winding angle.

[c] Curing and moulding method (e.g. extrusion, injection, single shed assembly…).

[d] Pultrusion, wet filament winding, vacuum impregnation, surface preparation.

[e] Applications: bending, pressure, combined pressure-bending.

6.2 Type tests

These tests are intended to verify the mechanical characteristics of a composite hollow insulator which depends mainly on its tube and end fittings. Type tests shall be applied to the class of composite hollow insulators which have passed the design tests. The type test shall be repeated only when the type or the material or the manufacturing process of the composite hollow insulator is changed.

6.3 Sample tests

These tests are for the purpose of verifying the characteristics of composite hollow insulators which depend on the manufacturing quality and the material used. They shall be made on insulators taken at random from batches offered for acceptance.

6.4 Routine tests

These tests are for the purpose of eliminating composite hollow insulators with manufacturing defects. They shall be made on every composite hollow insulator.

7 Design tests

7.1 General

These tests consist of three parts as described in 7.2, 7.3 and 7.4. The design tests shall be 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 hollow insulator of a particular design shall be deemed accepted only when all insulators or test specimens pass the design tests in the given sequence within 7.2, 7.3 and 7.4.

All the design tests, apart from the thermal-mechanical test, are performed at normal ambient temperature.

Extreme service temperatures may affect the mechanical behaviour of composite insulators.

A general rule to define “extreme high or low” insulator temperatures is not available at this time, for this reason the supplier should always specify service temperature limitations. Whenever the insulators are subjected to very high or low temperatures for long periods of time, it is advisable that both manufacturer and user agree on a mechanical test at higher or lower temperatures than that mentioned in this standard.

7.2 Tests on interfaces and connections of end fittings

See IEC 62217.

These tests shall be performed in the given sequence on the same specimen. This standard does not use a separate reference specimen for these tests.

7.2.1 Test specimen

One hollow insulator assembled on the production line shall be tested. The tube's internal diameter shall be at least 100 mm and the wall thickness at least 3 mm. The insulation length (metal-to-metal spacing) shall be at least three times the tube's internal diameter but not less than 800 mm. Both end fittings shall have the same method of attachment and sealing as on standard production insulators. The hollow insulator shall be submitted to the routine tests (see Clause 10).

The manufacturer shall define the MML, SML, MSP and SIP for the test specimen.

7.2.2 Reference dry power frequency flashover test

The reference dry power frequency external flashover voltage (U_{ref}) shall be determined in accordance with IEC 60060-1 by averaging five flashover voltages. This average flashover voltage shall be corrected to normal standard conditions as described in IEC 60060-1. The flashover voltage shall be obtained by increasing the voltage linearly from zero to flashover within 1 min.

Means shall be employed to avoid internal flashover, for example by filling with insulating gas. Alternatively, the flashover voltage may be determined by splitting the arcing distance into two sections, as equal as possible, by the use of an additional external electrode.

7.2.3 Thermal-mechanical pre-stressing test

The specimen is sequentially submitted to a mechanical load in four directions and thermal variations.

The thermal variations consist of two cycles of heating and cooling. The duration of the cycle shall be not shorter than 24 h and not longer than 48 h (see Figure 1).

The cold period shall be at a temperature at least 85 K below the value actually applied in the hot period; however, the lowest temperature in the cold period shall not be lower than –50 °C. Each of the two temperatures of the hot and cold periods respectively shall be maintained for at least 33 % of the chosen cycle time.

The load applied to the test specimen corresponds to 0,5 × SML ± 5 %.

The load shall be applied perpendicularly to the insulator's axis either directly to the free end of the insulator (see Figure 2) or at a distance from the free end of the insulator if special reasons exist. When the load is not applied directly to the end fitting, the applied load shall be corrected to give the same bending moment at the base of the insulator.

The direction of the bending test load applied to the test specimen is changed four times corresponding to the duration of the temperature level and the corresponding time interval described in Figures 1 and 2.

The test may be interrupted for maintenance of the test equipment for a total duration of 4 h. The starting point after any interruption is the beginning of the interrupted cycle.

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

7.2.4 Water immersion pre-stressing test

See IEC 62217.

The ends of the specimen may be sealed and vented to atmospheric pressure.

7.2.5 Verification tests

See IEC 62217.

7.2.5.1 Visual examination

See IEC 62217.

7.2.5.2 Steep-front impulse voltage test

See IEC 62217.

7.2.5.3 Dry power frequency voltage test

See IEC 62217.

7.2.5.4 Internal pressure test

This test is not applicable for composite hollow insulators designed for unpressurized service conditions.

The test specimen shall be subjected to an internal pressure in two stages. The specimen shall remain tight.

For safety reasons, before starting the tests, the test specimen shall be subjected to $2{,}0 \times$ MSP for 5 min at normal ambient temperature using the procedure in 10.3 (routine pressure test).

7.2.5.4.1 Stage 1: gas leakage test

7.2.5.4.1.1 Procedure

The test shall be performed by placing the test specimen in an enclosure with a volume as small as possible, see Figure 3. An internal pressure of 1,0 x MSP shall be applied using a suitable gas as the pressure medium.

The leakage of gas from the test specimen into the surrounding enclosure shall be measured with a leakage meter. The leakage rate shall be given in a volume fraction in percent per year.

7.2.5.4.1.2 Acceptance criterion

The test is passed if the leakage rate is not more than the volume fraction of 0,5 % per year.

NOTE Guidance on leakage rate measurements can be found in IEC 60068-2-17, test Qm, test method 1.

7.2.5.4.2 Stage 2: water leakage test

7.2.5.4.2.1 Procedure

An internal pressure shall be applied and increased from zero to SIP at normal ambient temperature and maintained for 5 min. The inner pressure medium shall be water. Adequate safety precautions shall be taken for this inspection.

7.2.5.4.2.2 Acceptance criterion

The test is passed if, after 5 min, there is no failure and no water leakage at joints A and B as shown in Figure 4 or on the tube itself.

7.3 Tests on shed and housing material

7.3.1 Hardness test

See IEC 62217.

7.3.2 Accelerated weathering test

See IEC 62217.

7.3.3 Tracking and erosion test

See IEC 62217.

Only the 1 000 h salt fog test shall be applied.

7.3.4 Flammability test

See IEC 62217.

7.4 Tests on the tube material

See IEC 62217 (Tests on the core material).

The tests shall be carried out on specimens either with or without housing material.

7.4.1 Dye penetration test

See IEC 62217.

7.4.2 Water diffusion test

See IEC 62217.

8 Type tests (only mechanical tests)

The type tests consist of a pressure test, for pressurized insulators only, and a bending test.

8.1 General

An insulator type is mechanically defined by the tube inner diameters, the wall thickness of the tube, the tube lamination parameters, the method of attachment and material of the metal end fittings and the manufacturing process. The length of the insulator defines the type only for ratios of length between fittings to diameters of less than 2.

The tests shall be performed at normal ambient temperature to confirm the mechanical strength of the insulator by verifying the limit between reversible and irreversible phase in the tube (see Annex C).

Composite hollow insulators which have been subjected to the type tests shall not be used in service.

Bending forces shall be applied perpendicularly to the insulator's axis either directly to the front plane of the insulator (see Figure 2) or at a distance to the front plane of the top end fitting of the insulator if special reasons exist. When the load is not applied directly to the end fitting, the applied load shall be corrected to give the same bending moment at the base of the insulator.

8.2 Test specimens

The test specimens shall be either two full length insulators or two shorter, but otherwise identical, insulators made on the production line. The length of the latter specimens (metal-to-metal spacing) shall be not less than 800 mm. The applied load shall be adjusted for insulator length to obtain the required stress.

Both end fittings shall be the same as used on production line insulators. The insulator specimens used for these tests shall be with or without housing. Where the tests are made without housing, the thermal cycle of housing application shall be applied to the tube prior to testing.

8.3 Preparation of the test specimen

One specimen shall be subjected to an internal pressure test, the other to a bending test in accordance with 8.4.1 and 8.5.1, respectively (see Figure C.1). Each of the test specimens shall be equipped with two strain gauges (for example final elongation greater than or equal to 2 %, resistance greater than or equal to 120 Ω, length less than or equal to 12 mm). The housing, if present, shall be removed locally to allow installation of the gauges to the outside of the tube.

a) *For the internal pressure test*

The position of the strain gauges shall be

- outside on the tube;
- one gauge parallel, one gauge perpendicular to the axis of the tube;
- in the middle of the tube between the end fittings. In the case of a tapered tube, the gauges shall be installed at the location where the maximum stress is expected.

The internal pressure test specimen shall be mounted in an upright position, if possible. The ends of the test specimens shall be fitted with suitable end covers and seals. The inner pressure medium shall be a gas or a liquid and shall not affect the tube in any way, other than mechanically.

NOTE 1 When not testing in an upright position, the mass of the pressure medium has an influence on the stress applied to the tube.

NOTE 2 Stress simulation or experimental investigation can be used to determine the area of maximum strain for optimum positioning of the strain gauges. However, it should be noted that simple analytical calculation methods can give misleading results.

b) *For the bending test*

The position of the strain gauges shall be

- outside on the tube;
- parallel to the axis of the tube;
- positioned either near the fixed end of the insulator, generally with its centre 30 mm from the edge of the end fitting or at the location where the maximum stress is expected;
- in the plane of the bending force and diametrically opposite from each other.

NOTE 3 Stress simulation or experimental investigation can be used to determine the area of maximum strain for optimum positioning of the strain gauges. However, it should be noted that simple analytical calculation methods can give misleading results.

One end fitting of the bending test specimen shall be securely fixed. The bending force shall be applied at approximately 90° to the axis of the test specimen on the other fitting. The bending force shall be applied on or close to this end fitting taking care that the point at which the force acts remains fixed.

8.4 Internal pressure test

One specimen is subjected to an internal pressure test. This test is performed in two or possibly three stages. It is not necessary to perform this test for composite hollow insulators designed for unpressurized service conditions. The pressure medium shall be inside the sealed tube during all three test stages including the adjustment of the zero reference strain.

8.4.1 Test procedure

8.4.1.1 Stage 1: test at 2,0 × maximum service pressure

The internal pressure shall be increased rapidly but smoothly from zero to 2,0 × MSP at normal ambient temperature. When the 2,0 × MSP is reached, the pressure shall be maintained for 5 min. Then the pressure shall be released smoothly. The residual strain measurement shall be taken between 3 min and 5 min after pressure release.

8.4.1.2 Stage 2: test at 4,0 × maximum service pressure

After this initial pressure application, a pressure test at 4,0 × MSP shall be applied for at least 5 min. Then the pressure shall be released smoothly.

8.4.1.3 Stage 3: test at specified internal pressure level (if SIP > 4 x MSP)

If required for additional information, the Stage 2 procedure shall be used and SIP is applied for 5 min. Any findings shall be noted.

8.4.2 Acceptance criteria

8.4.2.1 Stage 1: test at 2,0 × maximum service pressure

The tube before and after pressure application shall be in the same strain condition within ±5 % of the maximum strain indicated by strain gauges. It shall be inferred that no damage has occurred (see Annex C).

NOTE A larger value than ±5 % may be tolerated for very low, non critical strain values.

8.4.2.2 Stage 2: test at 4,0 × maximum service pressure

After pressure application the residual strain is allowed to be greater than ±5 % of the maximum strain (see Annex C) but it shall be determined that no visible damage has occurred.

8.4.2.3 Stage 3: test at specified internal pressure level

Visible damage may arise and is allowed.

8.5 Bending test

8.5.1 Test procedure

One specimen is subjected to a bending test which is performed in three, or possibly four, stages.

8.5.1.1 Stage 1: test at maximum mechanical load

The bending load shall be increased smoothly from zero to MML within 30 s. When the MML is reached, it shall be maintained for at least 30 s. During this time the deflection shall be measured. The bending load shall be completely released and the residual deflection, taken between 3 min and 5 min after load release, shall be recorded.

8.5.1.2 Stage 2: test at 1,5 × maximum mechanical load

The bending load shall be increased smoothly to 1,5 × MML within 30 s and shall be maintained at this value for at least 60 s. During this time the deflection shall be measured. Then the load shall be released smoothly and the residual deflection, taken between 3 min and 5 min after load release, shall be recorded.

8.5.1.3 Stage 3: test at 2,5 × maximum mechanical load

Following completion of Stage 2, a bending load shall be reapplied. It shall be increased smoothly from zero to 2,5 × MML within 90 s and shall be maintained at this value for at least 60 s. Then the load shall be released smoothly.

After this load application, it shall be determined that no visible damage has occurred (see Annex C). Residual strain and deflection measurements, although of interest, are not necessary at this stage.

8.5.1.4 Stage 4: test to failure (optional)

In order to obtain more information, the load may be increased until failure of the insulator. The failing load value and the failure mode shall be recorded.

8.5.2 Acceptance criteria

8.5.2.1 Stage 1: test at maximum mechanical load

The test is passed if

- no fracture or pull out of the tube occurred;
- no visible damage of the end fittings was observed;
- the measured deflection does not exceed the value defined by the manufacturer;
- the residual deflection does not exceed the value agreed between the manufacturer and the user, when applicable.

8.5.2.2 Stage 2: test at 1,5 × maximum mechanical load

The test is passed if

- no fracture or pull out of the tube occurred;
- no visible damage of the end fittings was observed;
- after this load application the residual strain is not allowed to be greater than ±5 % of the maximum strain, and it is determined that no visible damage to the tube has occurred (see Annex C);
- the measured deflection does not exceed the value defined by the manufacturer;
- the residual deflection does not exceed the value agreed between the manufacturer and the user, when applicable.

NOTE A larger value than ±5 % may be tolerated for very low, non relevant absolute strain values.

8.5.2.3 Stage 3: test at 2,5 × maximum mechanical load

The test is passed if

- no fracture or pull out of the tube occurred.

9 Sample tests

9.1 Selection and number of insulators

The tests are made on a number of composite hollow insulators taken at random from the batch after passing the routine tests mentioned in 10.1. Unless otherwise specified, the number of samples shall be in accordance with Table 4.

Table 4 – Sample sizes

Number (n) of hollow insulators forming the batch	Number of hollow insulators to be taken for sample tests
12 or less	None, *provided that tests have already been made on hollow insulators of the same type and the test report is approved by the purchaser.* One, *if an approved test report is not available.*
13 to 100	One
101 to 200	Two
201 to 300	Three
301 to 500	Four
501 or more	The whole number equal to or next greater than $4 + \frac{1{,}5\,n}{1\,000}$

The insulator(s) submitted to the tests may be returned to the batch and used in service, if non-destructive tests are used.

9.2 Testing

The selected insulator shall be subjected to the following sequence of tests:

– verification of dimensions (9.3);
– mechanical tests (9.4);
– galvanizing test (9.5);
– check of the interface between end fittings and housing (9.6).

9.3 Verification of dimensions

9.3.1 Test procedure

On all selected insulators, the dimensions of the composite hollow insulator shall comply with the values shown on the drawing, within specified tolerances for geometry, form and position.

Unless otherwise specified, the tolerances given in Annex A shall be used.

For other dimensions d without tolerances in the drawing, the following tolerances are acceptable :

$\pm(0{,}04 \times d + 1{,}5)$ mm when $d \leq 300$ mm;

$\pm(0{,}025 \times d + 6)$ mm when $d > 300$ mm with a maximum tolerance of 50 mm.

The drawing can show the points between which the creepage distance is specified.

The measurement of creepage distance shall be related to the design dimensions as determined from the insulator drawing, even though this dimension may be greater than the value originally specified by the purchaser. When the creepage distance is specified as a minimum value, the negative tolerance is zero.

9.3.2 Acceptance criteria

The samples have passed these tests if

– the dimensions of the insulators conform with the drawing.

9.4 Mechanical tests

All the selected insulators shall be subjected to the following test, made in three stages, at normal ambient temperature.

9.4.1 Test procedure

9.4.1.1 Stage 1: test at 2,0 × maximum service pressure

The insulator is subjected to an internal pressure. The internal pressure shall be increased rapidly but smoothly from ambient atmosphere pressure to 2,0 × MSP. The internal pressure shall be maintained for at least 5 min.

It is not necessary to perform this test on composite hollow insulators designed for unpressurized conditions.

9.4.1.2 Stage 2: test at maximum mechanical load

The same insulator is then subjected to a sequential bending load according to the directions given in Figure 2 at normal ambient temperature. The bending load shall be increased rapidly but smoothly, from zero to MML. If MML is reached in less than 90 s, the load shall be maintained for the remainder of at least 90 s. During this time, the deflection shall be measured. The load is then completely released and the residual deflection recorded.

9.4.1.3 Stage 3: test at 1,5 × maximum mechanical load

Following completion of Stage 2, the same procedure is then repeated for the insulator at a load of 1,5 x MML.

9.4.2 Acceptance criteria

The samples have passed these tests if

– no fracture or pull out of the tube or fracture of the end fittings occur;
– the deflections do not exceed the predetermined level, as defined by the manufacturer;
– the length, concentricity and parallelism conform to the drawing.

NOTE Any insulator that meets the acceptance criteria may be returned to the batch.

9.5 Galvanizing test

This test shall be performed on all galvanized parts in accordance with IEC 62155.

9.6 Check of the interface between end fittings and the housing

This test is not required for insulators without housing.

9.6.1 Test procedure

Both ends of one of the selected insulators shall, at the end of the tests, be subjected to a crack indication test, by dye penetration in accordance with ISO 3452, on the housing in the vicinity of the metal fittings. The test 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;
– the surface shall be cleaned with the excess penetrant remover and dried;
– the developer shall be applied, if necessary;
– the surface shall be inspected.

Some housing materials may absorb the penetrant resulting in permanent staining. In such a case, evidence shall be provided to validate the interpretation of the results.

After the penetration test, the selected insulator shall be inspected for cracks and dye penetration of the housing to fitting interface.

9.6.2 Acceptance criteria

The samples have passed these tests if

– no cracks on the housing or interfaces occur, indicated by the dye penetration.

9.7 Re-test procedure

Two re-test procedures are possible according to the type of the test in which the composite hollow insulator failed to meet the requirements. Table 5 shows the re-test procedure to be applied.

Table 5 – Choice of re-test procedure

Requirements not met in:	Re-test procedure to be applied
Verification of dimensions (9.3)	A, on the non-conforming dimension(s)
Mechanical test (9.4)	B
Galvanizing test (9.5)	B
Interface test (9.6)	B

a) Re-test procedure A

If one or more composite hollow insulators fail to meet the requirements, agreement shall be reached between the manufacturer and the purchaser that each composite hollow insulator in the batch is to be re-examined for the non-conforming requirement(s). Any units which do not meet these requirements shall be rejected.

b) Re-test procedure B

If a single hollow insulator fails to pass one of these tests, the test in question shall be repeated on a sample twice the size of the first sample. If, during this new test, one or more of the results are unsatisfactory, the entire batch shall be rejected.

10 Routine tests

10.1 General

The routine tests are application dependant and comprise

- visual examination (10.2);
- routine pressure test (10.3);
- routine mechanical test (10.4);
- routine tightness test (10.5).

10.2 Visual examination

Each insulator shall be examined. The mounting of metallic parts on the insulator assembly shall be in accordance with the drawings. The colour of the insulator shall approximately be as specified in the drawing.

The following defects are not permitted:

- on the housing, superficial defects of an area greater than 25 mm^2 (the total defective area shall not exceed 0,2 % of the total insulator surface) or depth or height greater than 1 mm;
- internal tube defects of a depth greater than 1 mm, and of an area greater than 25 mm^2 However, if the tube has an internal liner e.g. polyester–mat, defects of a depth exceeding the internal liner thickness are not permitted;
- crack at the root of the shed;
- 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.

10.3 Routine pressure test

This test is applicable to composite hollow insulators which are stressed by pressure in service.

Every hollow insulator shall be subjected at normal atmospheric pressure and normal ambient temperature to a routine hydraulic or gas (e.g. air, SF_6, helium) test pressure corresponding to 2,0 × MSP for at least 1 min.

Failed insulators shall be rejected.

10.4 Routine mechanical test

This test is applicable to composite hollow insulators when they are stressed principally by bending or by other mechanical loads in service. It is also applicable to unpressurized composite hollow insulators.

The mechanical test is performed at normal ambient temperature.

The test method shall reproduce the maximum stress expected from service.

Failed insulators shall be rejected.

NOTE Loads, methods of testing and acceptance criteria are subject to agreement between the manufacturer of the insulator and the manufacturer of equipment.

10.5 Routine tightness test

This test is not applicable for composite hollow insulators designed for unpressurized service conditions. This test may also be omitted if under normal service conditions the interface is not used for sealing (see Figures 4c and 4d). In addition, the test may be omitted for composite hollow insulators whose design and manufacturing process are such to exclude any sealing and tightness action of the interface.

The tightness of the interface between tube and end fitting shall be checked at MSP using gas (e.g. air, SF_6 or helium) pressure. The internal pressure shall be maintained for at least 5 min.

NOTE Definition of tightness, methods of testing and acceptance criteria are subject to agreement between the manufacturer of the insulator and the manufacturer of equipment.

11 Documentation

The manufacturer shall maintain records of all serially produced composite hollow insulators in accordance with this standard for a minimum of 10 years. These records shall contain the following information:

– type reference number;
– serial number;
– date of manufacture;
– routine and sample tests, date and results.

The manufacturer of equipment shall be provided with extracts of the records upon request.

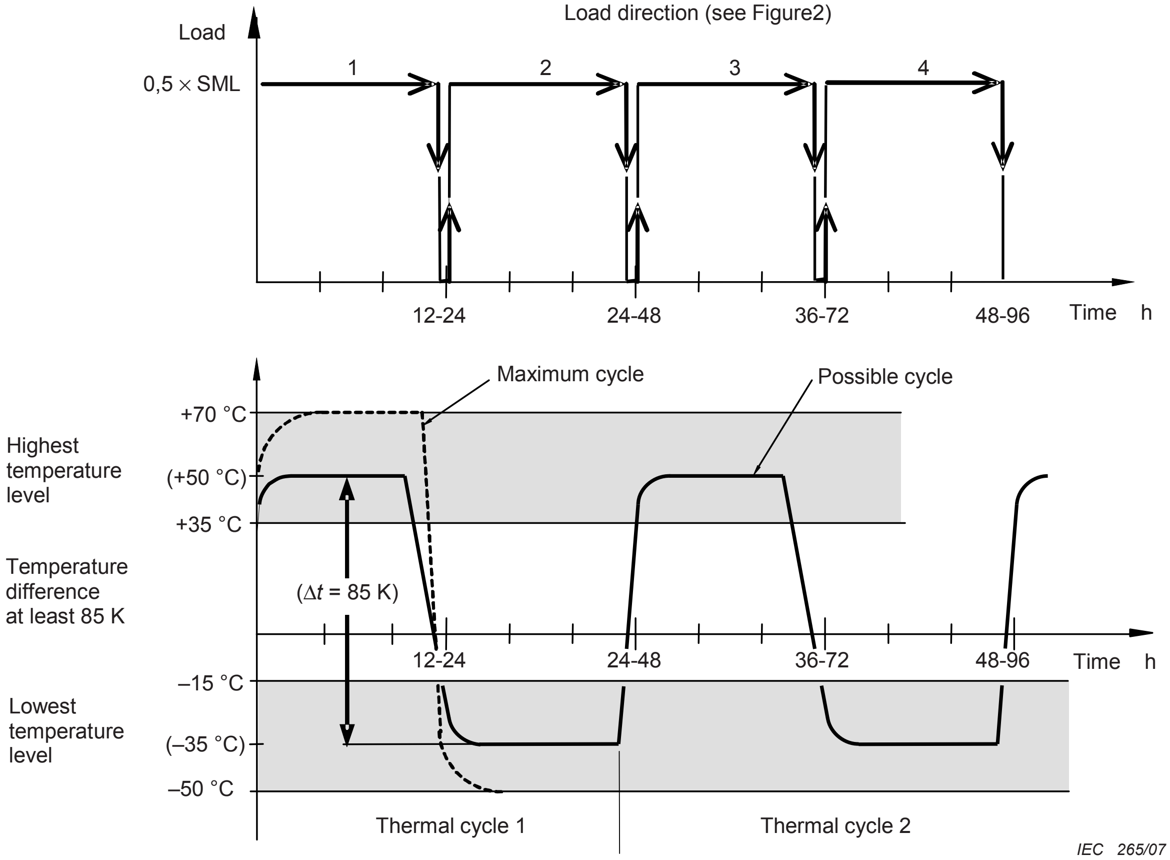


Figure 1 – Thermal-mechanical pre-stressing test – Typical cycles

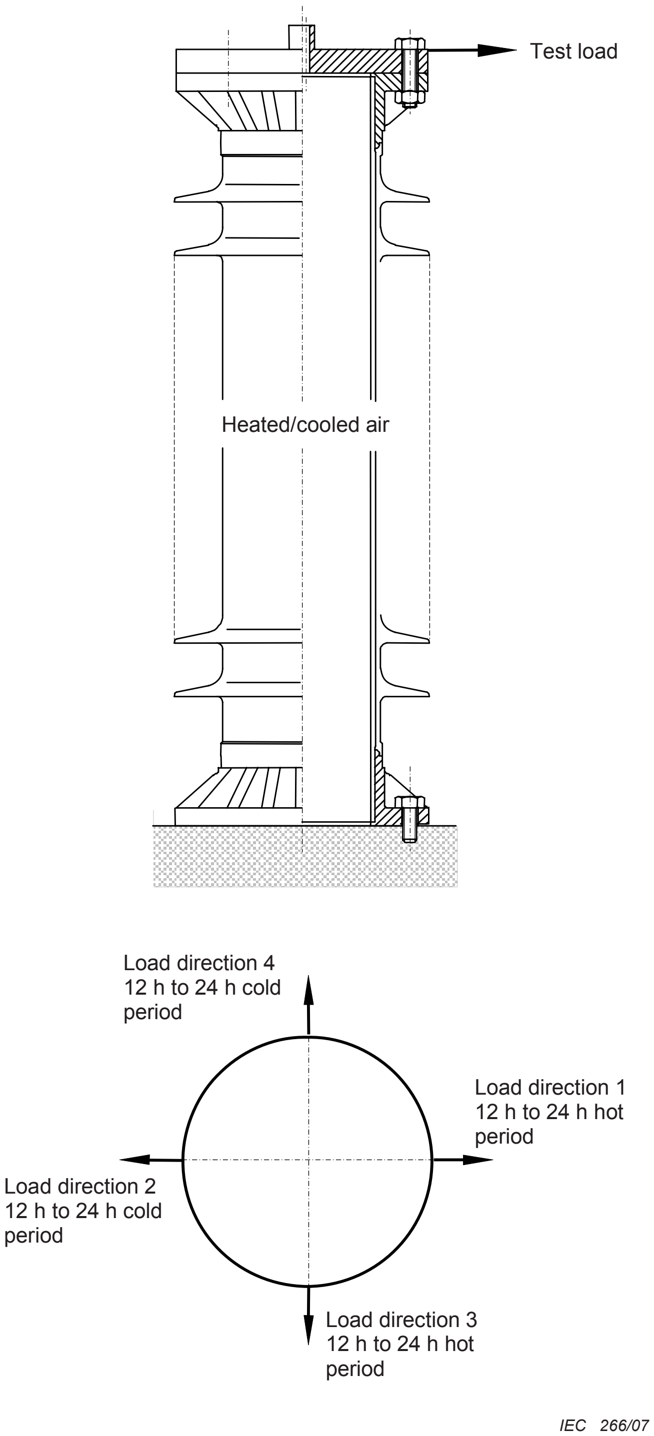


Figure 2 – Thermal-mechanical pre-stressing test – Typical test arrangement

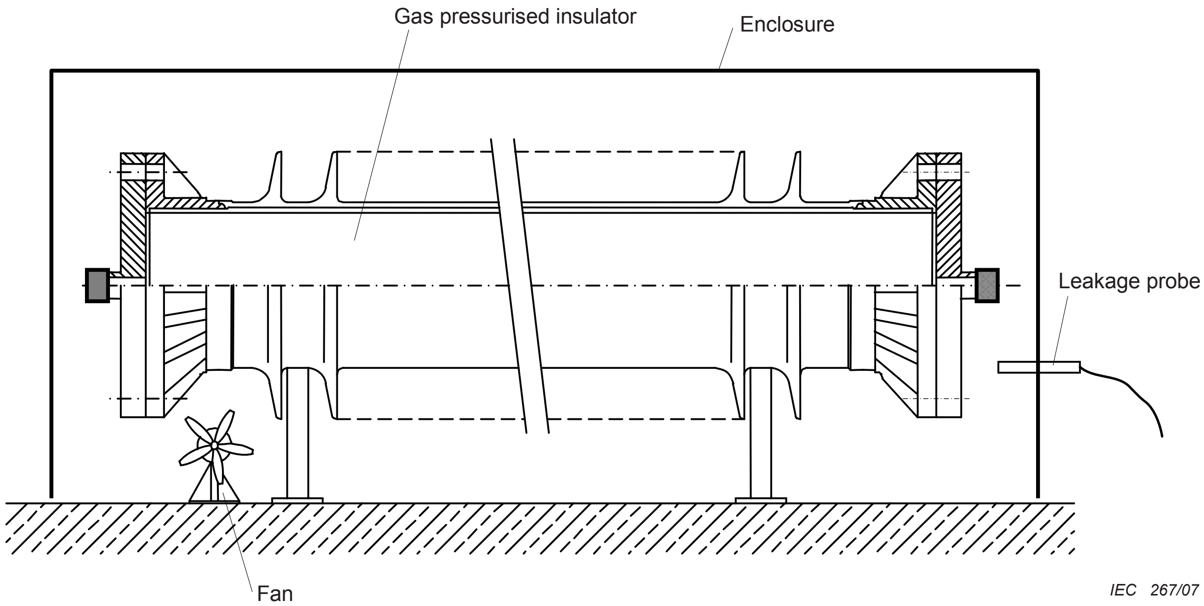


Figure 3 – Test arrangement for the leakage rate test

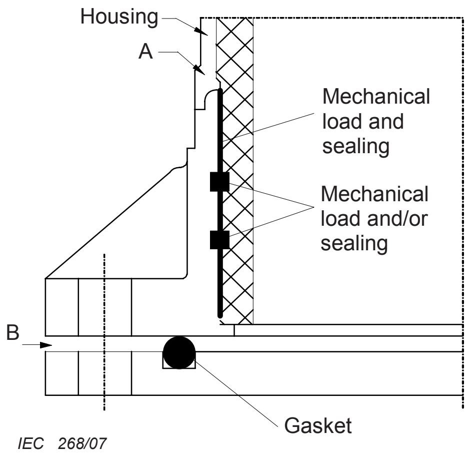


Figure 4a

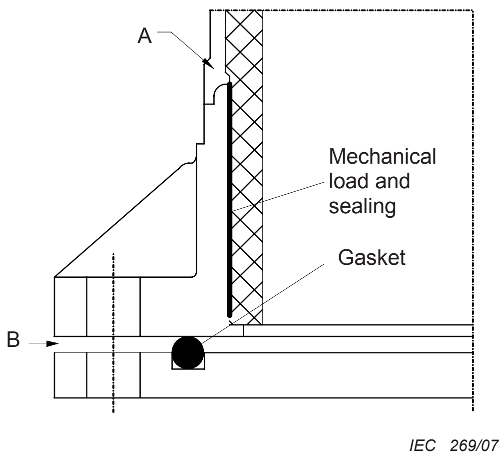


Figure 4b

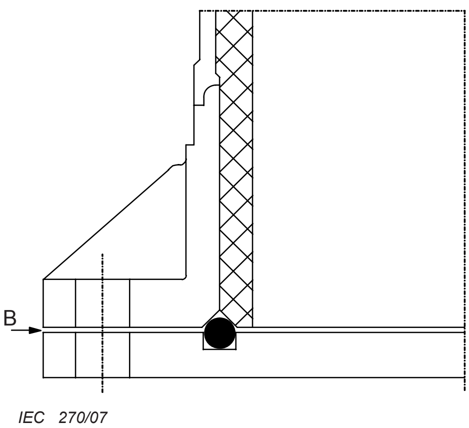


Figure 4c

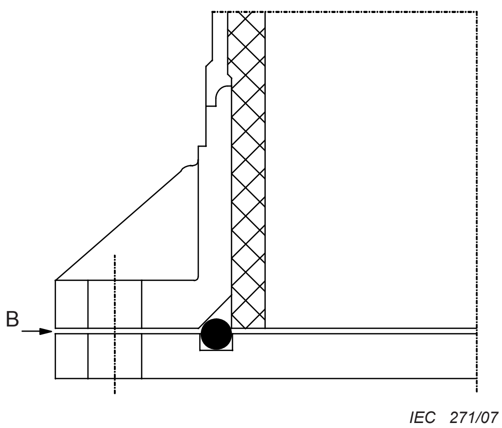


Figure 4d

Key:
A Joint tightness
B Gasket tightness

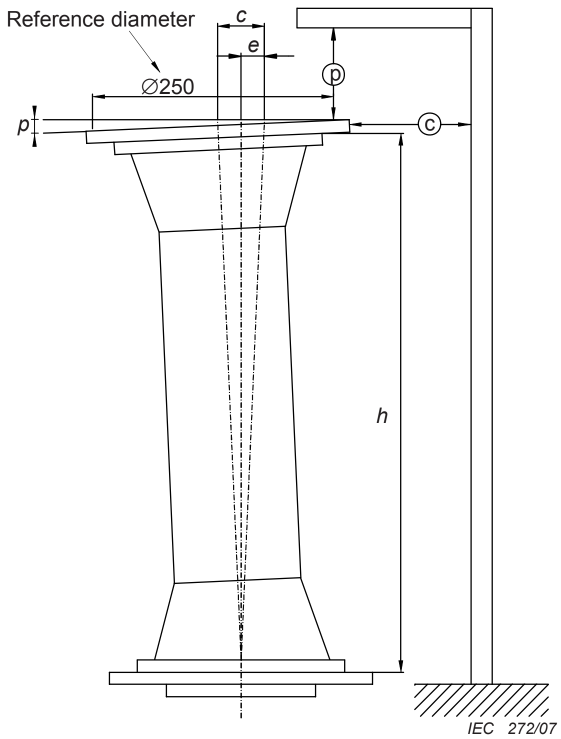
Figure 4 – Examples of sealing systems for composite hollow insulators

Annex A
(normative)

Tolerances of form and position

The following Figures A.1 to A.3 give tolerances of form and position for composite hollow insulators. Figure A.1 shows a typical jig for measurement of parallelism, coaxiality, concentricity and eccentricity along with the relative tolerances. Figures A.2 and A.3 show two examples of methods of measuring the angular deviation of the fixing holes; Figure A.4 summarizes the applicable tolerances according to standard drawing practice (ISO 1101).

Guidelines on the methods of measurement can be found in Annex A of IEC 60168.



Legend

Parallelism of the end faces:

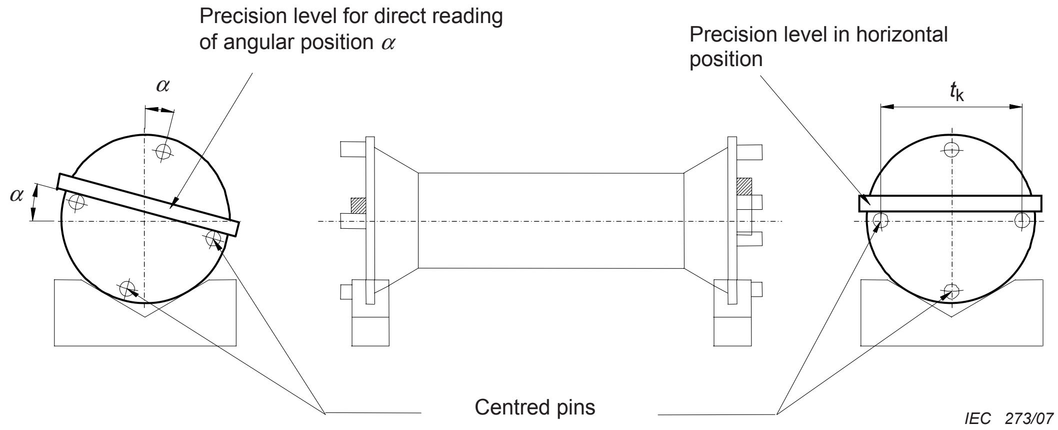
for $h \leq 1$ m, $p \leq 0{,}5$ mm
for $h > 1$ m, $p \leq 0{,}5$ h mm with "*h*" in meters

The tolerances of the parallelism are related to a diameter of 250 mm.

Coaxiality and concentricity: $C = 2 \times e$

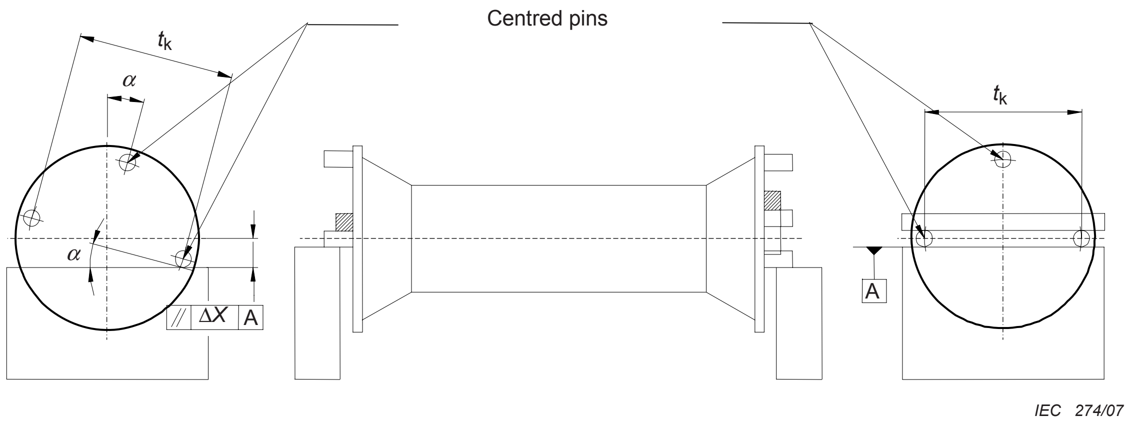
Eccentricity: $e \leq 2\,(1+h)$ mm with "*h*" in metres.

Figure A.1 – Parallelism, coaxiality and concentricity



Tolerance of the deviation: $\alpha \leq \pm 1°$

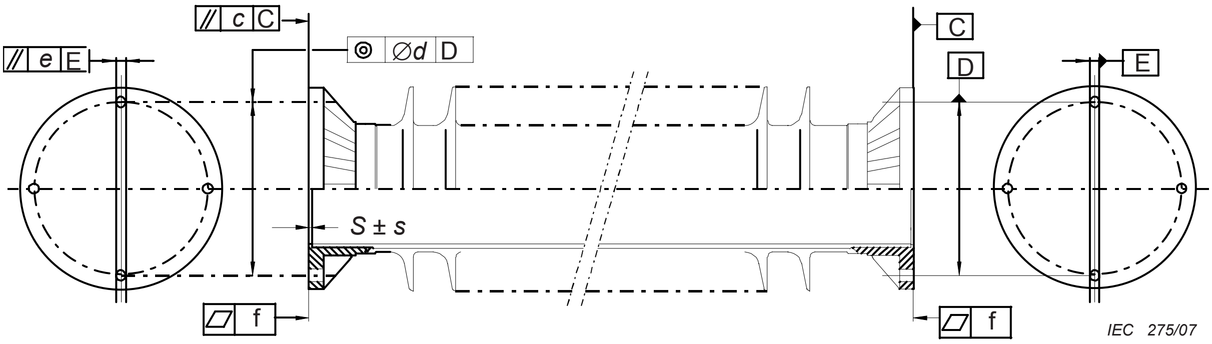
Figure A.2 – Angular deviation of fixing holes: Example 1



$\alpha = \tan^{-1}\left(\frac{\Delta x}{t_k}\right)$ where t_k is the distance between the centres of two opposite pins.

Tolerance of the deviation: $\alpha \leq \pm 1°$

Figure A.3 – Angular deviation of fixing holes: Example 2



c C — Parallelism: the upper face plane is parallel to the lower reference plane *C* within the indicated tolerances.

Ød D — Coaxiality and concentricity: the axes of the top fitting fixing holes have to be within a cylinder with a diameter as indicated by the numerical value.

f — Evenness: the numerical value indicates the maximum admissible unevenness of the face.

e E — Alignment of the fixing holes: the line between two opposite axes of holes of the top fitting have to be in line with the corresponding line of the bottom fitting with two parallels of specified distance "*e*".

$S \pm s$ — For proper sealing, the ground end faces have to be at a distance within specified tolerances from the fitting faces.

Figure A.4 – Tolerances according to standard drawing practice

Annex B
(informative)

General recommendations for design and construction

B.1 Guidance for design

Guidance for the design of gas-pressurized composite hollow insulators for high-voltage equipment given in this annex takes into account that these hollow insulators are subjected to particular operating conditions which distinguish them from compressed air receivers and similar storage vessels.

When designing composite hollow insulators the following points shall be taken into consideration:

– electrical strength, mechanical strength and technological problems including materials for fittings and jointing may influence the real construction, but due to the complexity of this subject no definitive guide can be given;

– a critical selection of materials for the insulating body is also necessary (see IEC 62039, as a guideline);

– a type of an insulating pressurized enclosure may be considered as appropriate for intended use only after the electrical equipment of which it is a part has satisfactorily passed the type tests called for by the particular standards with which the equipment must comply.

B.2 Guidance for the maximum service pressure

Usually the MSP is the "design pressure". Solar radiation shall be taken into account when it has a significant effect on the pressure of the gas.

NOTE In some special cases (for example circuit-breakers) the transient pressure rise occurring during breaking operation must be taken into account.

B.3 Guidance on sample testing of tube material

The following information is intended to guide the manufacturer and user of FRP tubes with a testing procedure to verify the quality of the tube material.

A test specimen is taken from the surplus of the tube from which the composite hollow insulator is manufactured.

One or both of the following methods of IEC 62217 may be used to check the quality of impregnation of the FRP tube:

– dye penetration;

– water diffusion.

In addition, to verify the minimum design value of the glass transition temperature, Tg, of the FRP tube, the Tg measurement method described in IEC 61006 can be used.

NOTE To evaluate the performance of the complete insulator, it is relevant to also verify the minimum design value of the Tg of the glue used to fasten the end fittings onto the FRP tube.

B.4 Guidance for the temperature required by the equipment manufacturer

The equipment manufacturer shall define the applicable service temperature values. These values shall be within the limits of the specified temperature(s).

B.5 Guidance for the mechanical loads required by the equipment manufacturer

The equipment manufacturer specifies the mechanical loads for the composite hollow insulator on the basis of weighted stresses arising from various service loads. Attention is drawn to the fact that the relative importance of each of these loads for composite hollow insulators may be different from that assigned to the same load on equivalent ceramic hollow insulators as suggested in IEC 62155.

In addition to operating loads, the following sources are recommended for determining the values necessary for calculating various loads:

– terminal loads: IEC 62271-100;
– wind loads: IEC 62271-100 and IEC 60694;
– ice loads: IEC 62271-100 and IEC 60694;
– short-circuit loads: IEC 60865-2;
– seismic loads: IEC 61166.

B.6 Summary of the tests

Table B.1 shows the different loads, pressure, and pre-stressing of the different tests for composite hollow insulators.

Table B.1 – Loads/stress and classification of tests

Clause	Test	Stress / Load	Internal pressure		Classification
			with a)	without b)	
7.2.2	Reference dry power frequency flashover	Electrical, U_{ref}	+	+	Design tests
7.2.3	Thermal mechanical pre-stressing	0,5 × SML bending in four directions, Δθ = 85 K, two 24 h – 48 h cycles	+	+	
7.2.4	Water immersion pre-stressing	See IEC 62217	+	+	
7.2.5.2	Steep-front impulse high voltage	Electrical, 1 000 kV/µs impulse voltage, 25 impulses ±	+	+	
7.2.5.3	Dry power frequency voltage	Electrical, 80 % U_{ref}, 30 min	+	+	
7.2.5.4 .1	Internal pressure – stage 1 – gas leakage	Pressure 0,25 × SIP, at least 60 min, gas (SF_6)	+	N/A	
7.2.5.4 .2	Internal pressure – stage 2 – water leakage	Pressure SIP 5 min, water	+	N/A	
7.3	Tests on shed and housing material	See IEC 62217	+	+	
7.4	Tests on the tube material	See IEC 62217	+	+	
8.4.1.1	Internal pressure test – stage 1	Pressure 2,0 × MSP for 5 min	+	N/A	Type tests
8.4.1.2	Internal pressure test – stage 2.	Pressure 4,0 × MSP for ≥ 5 min	+	N/A	
8.4.1.3	Internal pressure test – stage 3 (optional)	Pressure SIP for 5 min	+	N/A	
8.5.1.1	Bending test – stage 1	Bending MML,≥ 30 s	+	+	
8.5.1.2	Bending test – stage 2	Bending 1,5 × MML, ≥ 60 s	+	+	
8.5.1.3	Bending test – stage 3	Bending 2,5 × MML, ≥ 60 s	+	+	
8.5.1.4	Bending test – stage 4 (optional)	Test to failure	+	+	
9.4.1.1	Mechanical test – stage 1	Pressure 2,0 × MSP, ≥ 5 min	+	N/A	Sample tests
9.4.1.2	Mechanical test – stage 2	Bending MML, total 90 s, in four directions	+	+	
9.4.1.3	Mechanical test – stage 3	Bending 1,5 × MML , total 90 s, in four directions	+	+	
9.5	Galvanizing test	See IEC 60168	+	+	
9.6	Check of the interface between fittings/housing	Dye penetration, see ISO 3452	+	+	
10.3	Routine pressure test	Pressure 2,0 × MSP, ≥ 1min	+	N/A	Routine tests
10.4	Routine mechanical test	By agreement	N/A or + c)	+	
10.5	Routine tightness test	Pressure MSP, gas > 5 min	+	N/A	

a) Internal pressure means a permanent gas pressure greater than 0,05 MPa (0,5 bar) gauge. The gas can be dry air or inert gases, for example sulphur hexafluoride, nitrogen, or a mixture of such gases.

b) No internal pressure means gas pressure, or liquid pressure smaller than or equal to 0,05 MPa (0,5 bar) gauge.

c) The routine mechanical test is applicable to pressurized insulators when the principal service stress is due to mechanical loads.

Table B.2 shows a practical application of the values for pressure and mechanical loads.

Table B.2 – Example of pressure/bending values – Practical relationship of the values

			Tube in phase
Example values			
Maximum service pressure MSP = 1,00 MPa (design pressure)			Elastic
Specified internal pressure SIP = 4,5 MPa			Plastic
Maximum mechanical load MML = 2 000 N (design load)			Elastic
Specified mechanical load SML = 5 000 N			Plastic
Design tests			
Pressure			
0,25 × SIP gas leakage	= 0,25 × 4,5	= 1,12 MPa	Elastic
1,0 × SIP water tightness	= 1,0 × 4,5	= 4,5 MPa	Plastic
Bending			
0,5 × SML, four directions, Δθ = 85 K,		= 0,5 × 5 000 = 2 500 N	Elastic
Type tests			
Pressure			
2,0 × MSP	= 2,0 × 1,0	= 2,0 MPa	Elastic
4,0 × MSP	= 4,0 × 1,0	= 4,0 MPa	Plastic
1,0 × SIP	= 1,0 × 4,5	= 4,5 MPa	Plastic
Bending			
1,0 × MML	= 1,0 × 2 000	= 2 000 N	Elastic
1,5 × MML	= 1,5 × 2 000	= 3 000 N	Elastic
2,5 × MML	= 2,5 × 2 000	= 5 000 N	Plastic
Sample tests			
Pressure			
2,0 × MSP	= 2,0 × 1,0	= 2,0 MPa	Elastic
Bending			
1,0 × MML, four directions	= 1,0 × 2 000	= 2 000 N	Elastic
1,5 × MML, four directions	= 1,5 × 2 000	= 3 000 N	Elastic
Routine tests			
Pressure			
2,0 × MSP	= 2,0 × 1,0	= 2,0 MPa	Elastic
1,0 × MSP gas tightness	= 1,0 × 1,0	= 1,0 MPa	Elastic

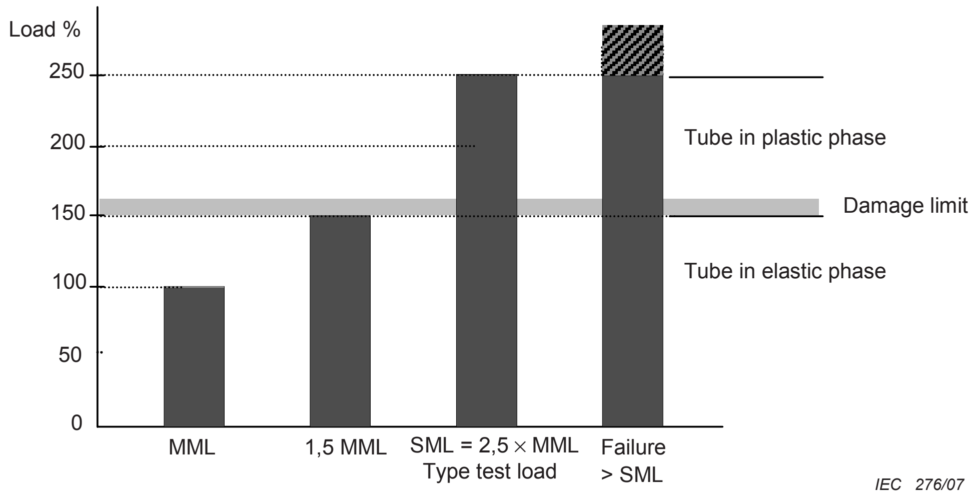


Figure B.1 – Relationship of bending loads

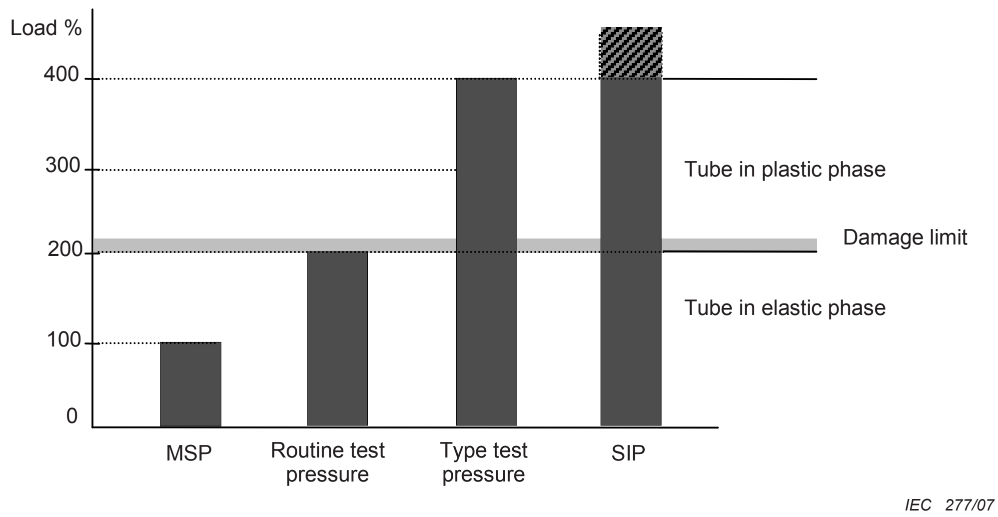


Figure B.2 – Relationship of pressures

Annex C
(informative)

Principles of damage limit and use of reversible and irreversible strain caused by internal pressure and/or bending loads on composite hollow insulator tubes

C.1 Introductory remarks

It is known that the time to failure of a composite insulator under a mechanical load such as a tension load depends on the load level. As the load approaches the ultimate strength of the insulator, the time to failure is reduced. However, the vast experience gained with composite insulators stressed by mechanical loads in service has shown that there is a load below which the insulator will not fail no matter how long the load is applied because that load does not damage the insulator. These findings are confirmed by laboratory tests. This load level is known as the damage limit.

Strain gauges are used to verify if a given load applied to a composite hollow insulator under test has damaged the tube of the insulator. The damage limit of the tube has not been exceeded when the residual strain is 0 ± 5% of the maximum strain measured during the test. If the residual strain is higher, it can be assumed that damage has occurred.

C.2 Definition

Strain measurement with strain gauges as shown in Figure C.1 (see 8.4.1 and 8.4.2):

– A reversible process without damage to the tube occurs, if, at the end of the test, the load is zero and the strain is also 0 ± 5 % of the maximum strain (see Figure C.2). In this case, the tube is considered to be in the elastic phase.

– An irreversible process with damage to the tube occurs, if, at the end of the test, the load is zero and the strain is greater than 0 ± 5 % of the maximum strain (see Figure C.3). In this case, the tube is considered to be in the irreversible plastic phase. Visible damage may not be apparent.

The reason for applying a tolerance of ±5 % of the maximum strain is due to the possibility that measurement inaccuracies may arise from

– test equipment inaccuracy;
– strain gauge inaccuracy;
– the method of attachment of accuracy and positioning the strain gauges;
– poor electrical contacts;
– the initial condition of the tube;
– any time-related relaxation.

C.3 Example of determining the strain tolerance

If the maximum (100 %) strain is 2 000 μm/m, then

tolerance = 2 000 μm/m × 5 % = 100 μm/m

NOTE A larger value than ±5 % may be tolerated for very low, non critical strain values.

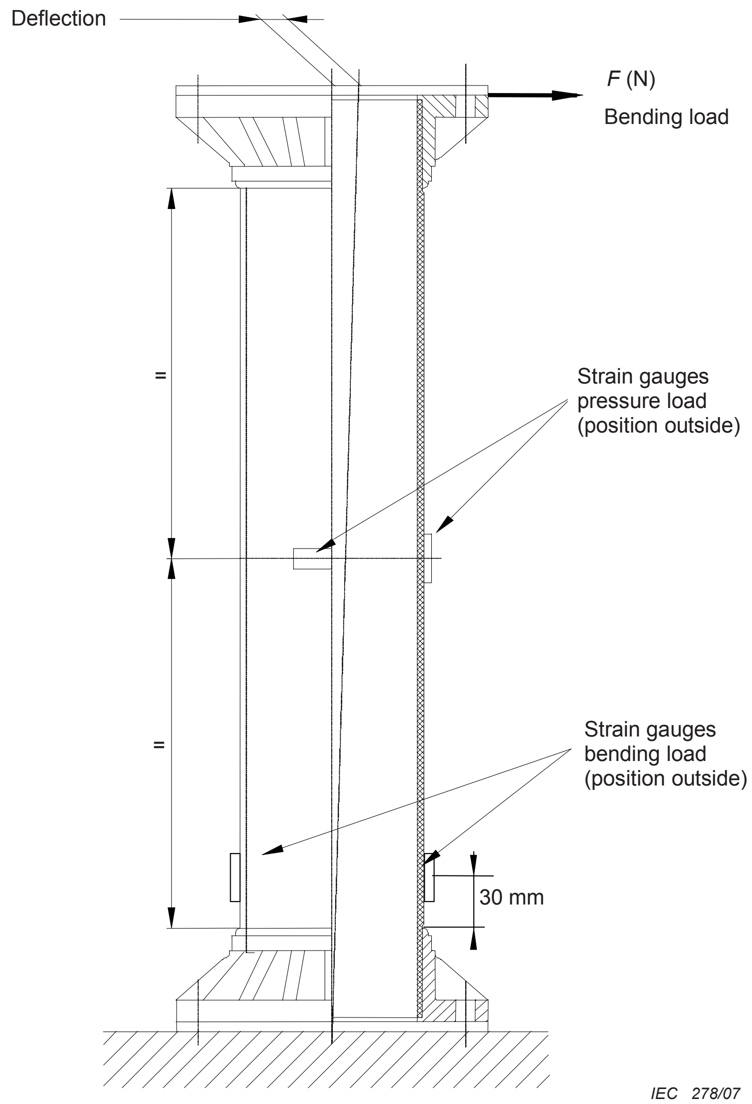


Figure C.1 – Position of strain gauges for pressure load and bending load

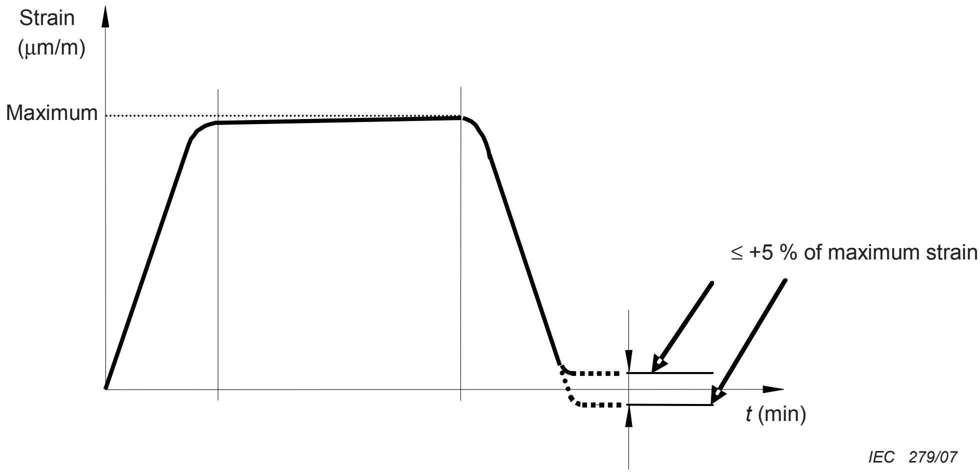


Figure C.2 – Strain/time curve, reversible elastic phase

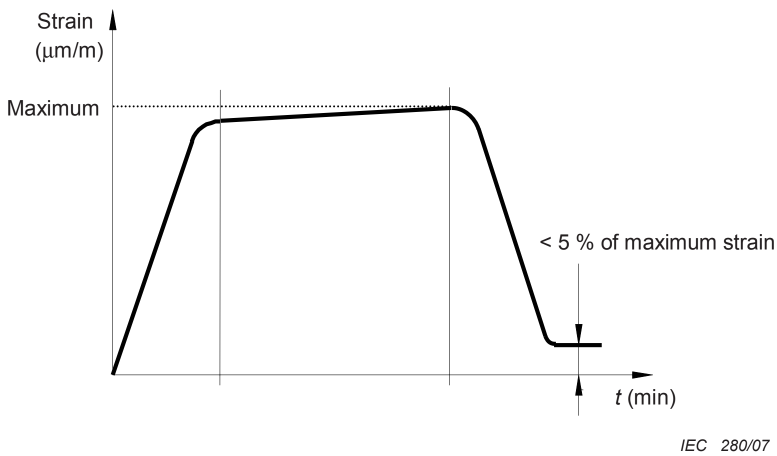


Figure C.3 – Strain/time curve, irreversible plastic phase, damage limit

Bibliography

IEC 60507, *Artifical pollution tests on high-voltage insulators to be used on a.c. systems*

NOTE Harmonized as EN 60507:1993 (not modified).

IEC 60694, *Common specifications for high-voltage switchgear and controlgear standards*

NOTE Harmonized as EN 60694:1996 (not modified).

IEC 60865-2, *Short-circuit currents – Calculation of effects*

IEC 61006:1991, *Electrical insulating materials – Methods of test for the determination of the glass transition temperature*

NOTE Harmonized as EN 61006:1993 (not modified).

IEC 61166:1993, *High-voltage alternating current circuit-breakers – Guide for seismic qualification of high-voltage alternating current circuit-breakers*

NOTE Harmonized as EN 61166:1993 (not modified).

IEC 62039, *Polymeric materials for outdoor use under HV stress*[1]

IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: High-voltage alternating-current circuit-breakers*

NOTE Harmonized as EN 62271-100:2001 (not modified).

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1 In preparation.

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 60060-1	– [1]	High-voltage test techniques - Part 1: General definitions and test requirements	HD 588.1 S1	1991 [2]
IEC 60068-2-17	– [1]	Environmental testing - Part 2: Tests - Test Q: Sealing	EN 60068-2-17	1994 [2]
IEC 60168	– [1]	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1 kV	EN 60168	1994 [2]
IEC 62155 (mod)	– [1]	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V	EN 62155	2003 [2]
IEC 62217	– [1]	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 [2] 2006
ISO 1101	– [1]	Geometrical Product Specifications (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out	EN ISO 1101	2005 [2]
ISO 3452	Series	Non-destructive testing - Penetrant inspection - General principles	EN ISO 3452	Series

[1] Undated reference.

[2] Valid edition at date of issue.

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