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# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

**Railway applications – Fixed installations – Electric traction – Specific requirements for composite insulators used for overhead contact line systems**

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**Applications ferroviaires – Installations fixes – Traction électrique – Exigences particulières pour les isolateurs composites destinés aux réseaux de lignes aériennes de contact**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRIC TRACTION – SPECIFIC REQUIREMENTS FOR COMPOSITE INSULATORS USED FOR OVERHEAD CONTACT LINE SYSTEMS

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International Standard IEC 62621 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This standard is based on EN 50151:2003.

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

| FDIS | Report on voting |
|---|---|
| 9/1539/FDIS | 9/1560/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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# INTRODUCTION

This standard specifies requirements for the design and testing of composite insulators used on railway electric traction overhead contact line systems. Such insulators, which are installed at relatively low heights in the harsh environment of railway infrastructures, require specific considerations during design to reduce the effects of vandalism and environmental pollution from railway operations, especially when combined with a lack of natural washing. Insulators may be included in arrangements in tunnels and over bridges or be in contact with traction unit pantographs where combined mechanical loading (tension, bending and torsion) may require special consideration.

The standard is intended to allow the manufacturer to comply with local working practices, to ensure compatibility with existing electric traction overhead contact line systems, and provide an insulator which will give reliable service over its target life span with minimum maintenance.

Insulators intended for overhead lines are predominately designed to resist tension and/or bending loads and are not designed to resist torsional loads. Mitigating measures to reduce torsional loading are generally introduced by the overhead contact lines design engineer. Some combined loading (tension, compression and torsion) can be experienced and this is represented in the testing procedure specified in this document.

The testing procedures given for railway applications in this standard are predominately referenced from IEC 61109, IEC 61952 and IEC 62217.

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# RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRIC TRACTION – SPECIFIC REQUIREMENTS FOR COMPOSITE INSULATORS USED FOR OVERHEAD CONTACT LINE SYSTEMS

## 1 Scope

This International Standard specifies characteristics for composite insulators of electric traction overhead contact line systems for railways, as defined in IEC 60913. Insulators specified in this standard are applied for electric traction supply voltages with a nominal voltage greater than 1 000 V for a.c. or a nominal voltage greater than 1 500 V for d.c.. Specific applications where high torsional loads can occur are outside the scope of this standard and particular tests are agreed between the supplier and customer to represent the critical loading arrangements.

This International Standard applies to composite insulators as defined in 3.1 below and not to other polymeric insulators.

The provisions contained in this standard are intended for the design and construction of new electric traction overhead contact line systems using insulators, or when complete refurbishment of existing overhead contact line systems takes place.

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This standard provides the purchaser and manufacturer with a range of tests which are used to evaluate the suitability of an insulator product for a given railway environment. Additional tests may be specified by the client to measure the compliance of the insulator under particular operating conditions.

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The standard establishes the product characteristics, the test methods and acceptance criteria.

The object of this standard is to stipulate the provisions for the design and provision of the service indicated by the manufacturer to the customer or informed buyer for application on the railway infrastructure.

## 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 60587, *Electrical insulating materials used under severe ambient conditions – Test methods for evaluating resistance to tracking and erosion*

IEC 60815-1:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC 60815-3:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

IEC 60826, *Design criteria of overhead transmission lines*

IEC 60850:2007, *Railway applications – Supply voltages of traction systems*

IEC 60913, *Electric traction overhead lines*

IEC 61109:2008, *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 61467:2008, *Insulators for overhead lines – Insulator strings and sets for lines with a nominal voltage greater than 1 000 V – AC power arc tests*

IEC 61952:2008, *Insulators for overhead lines – Composite line post insulators for A.C. systems with a nominal voltage greater than 1 000 V – Definitions, test methods and acceptance criteria*

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

IEC 62497-1:2010, *Railway applications – Insulation cordination – Part 1: Basic requirements Clearances and creepage distances for all electrical and electronic equipment*

ISO 34-1, *Rubber, vulcanized or thermoplastic- determination of tear strength – Part 1: Trouser, angle and crescent test pieces*

ISO 37, *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

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## 3 Terms and definitions

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

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NOTE Certain terms from IEC 62217:2005 are reproduced here for ease of reference. Additional definitions applicable to insulators can be found in IEC 60050-471[1][1], IEC 61109:2008 and IEC 61952:2008.

**3.1**
**composite insulator**
insulator made of at least two insulating parts, namely a core and a housing equipped with end fittings

NOTE Composite insulator, 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.

**3.2**
**nominal design load**
load, specified by the customer, corresponding to the normal everyday permanent and dynamic loads

1 Figures in square brackets refer to the bibliography.

# 4 Characteristics of composite insulators for overhead contact line systems

## 4.1 General

Composite materials and polymers permit the manufacture of insulators for use on outdoor overhead contact line systems. The insulators consist of an insulating core which bears the mechanical load, a polymeric housing which protects the core, and end fittings by which the load is transmitted to the core. These materials allow special applications in overhead contact line systems (including in-running section insulation and flexible supports) and are also used for their advantages of lightness, resistance to vandalism and pollution performance. Despite many common features of design, the materials used and the construction details employed by different manufacturers may be quite different and may lead to different performance parameters.

Electric traction overhead contact line systems applied for railways have several characteristics not associated with power lines. They are of low height and run through urban areas, making them targets for vandalism. They are incorporated in bridges and tunnels, built for rolling stock only, and fit into small spaces. They suffer close proximity to railway generated pollution and, in tunnels and bridges are not washed by natural rainfall. They suffer movement and snatch loads due to normal pantograph contact with the wires. When used as in-running insulators, they suffer mechanical forces and abrasion by the pantograph passing at high speed where the polymeric housing may suffer deformation, tearing and parting from the core (see 4.10).

Some tests have been grouped together in this standard as “design tests”, to be performed only once on insulators which satisfy the same design conditions. As far as practical, the influence of time, circumstance and climate on 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 so that a satisfactory life-time may be expected under normally known stress conditions of overhead contact line systems.

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The high number of insulators installed in a restricted environment of an operational railway with limited access for maintenance or installed in harsh environmental conditions, requires a high level of reliability at the appropriate electrical insulation level for the system voltage, including temporary and transient overvoltages, and a high level of mechanical integrity. In this case, a reasonable safety factor for mechanical and electrical properties of the insulators shall be agreed between the manufacturer and customer.

## 4.2 Environmental conditions

Environmental conditions such as temperature, humidity, vibration, solar radiation, pollution, etc., can have serious effects on the electrical and mechanical properties of insulators. The aging of housing material and interfaces, exposure of the core to environment and the corrosion of end fittings shall be given special consideration. When used for lower temperature, the behaviour or brittle property of the housing material and interfaces shall be considered.

NOTE When temperature falls below the crystallisation or glass transition temperature of the housing, its elasticity becomes lost. This change is reversible if a temperature increase takes place.

The normal environmental conditions to which insulators are submitted in service are defined in IEC 62217:2005.

Since the insulators are intended for outdoor use and may be installed in harsh environmental conditions, pollution shall be considered. The pollution degrees are defined in Table A.4 of IEC 62497-1:2010.

### 4.3 System voltages and frequencies

System voltages and frequencies specified by IEC 60850:2007 are generally applied for this standard. Values of standard system voltages (phase to ground) and the correlation between nominal voltages of the railway power distribution system and the required insulation voltages for circuits of equipment which are intended to be connected to these systems are shown in Table 1 of IEC 60850:2007.

The purchaser shall provide information on the railway electrification system and operating requirements which may affect the design of insulators.

NOTE Purchaser requirements are given in Annex A.

The dry lightning impulse withstand voltage shall be at least equal to the rated impulse voltage defined in IEC 62497-1:2010. The wet power frequency withstand voltage shall be at least equal to the short duration power frequency test level defined in IEC 62497-1:2010.

The rated impulse voltage for circuits powered by electric traction contact lines are shown in Table A.2 of IEC 62497-1:2010. Overhead lines are considered a case of inherent control. The rated insulation level is based on statistical and risk considerations. Therefore the rated impulse voltage is chosen among the preferred values given in Table A.2 of IEC 62497-1:2010, but irrespective of the correspondence with the insulation voltages and of the overvoltage levels stated in said table.

Table A.2 of IEC 62497-1:2010 is based on the worst dielectric conditions of electrodes. In overhead lines, different conditions are present and by consequence different clearances given in established standards or regulations such as IEC 60913 are allowed.

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### 4.4 Creepage distance

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The dry arcing distance, creepage distance and geometrical shed profile electrically define an insulator. Creepage distances shall be dimensioned according to the highest permanent voltage of the system. Consideration shall also be given to the insulation material and its behaviour in polluted conditions. The manufacturer may recommend greater than the minimum creepage distance to give adequate life for that material.

The overall shape and size of the insulator is defined by the customer's spatial requirements, the mechanical and electrical performance requirements and its compatibility with existing equipment. The manufacturer can decide on shed profile.

Additional railway environmental pollution may be generated by traction braking systems, diesel and steam trains which run under electrified lines. The exhaust from steam trains is very hot (> 200 °C) and should not be allowed to play on insulators. This can be prevented by careful positioning of insulators on the line or by a restriction on train movements and stopping positions. The exhaust from diesel trains is less severe, but contains oil and carbonaceous deposits, which can contaminate insulators. No additional creepage is necessary for diesel usage but it is important to ensure that the diesel exhaust does not dwell on the insulators by checking stopping positions etc.

Insulators positioned under bridges and in tunnels are not washed by natural rainfall which can lead to pollution accumulation. In these harsh environmental conditions and in order to minimise the degradation of the housing material, the creepage distance and the design need to cover the specific application. This will also be particularly applicable to insulators which are used in contact with the pantograph collector unit and which may require increased creepage distance to allow for the width of the pantograph (see 4.10).

Operating conditions and pollution level are specified in Table A.4 of IEC 62497-1:2010. Dimensioning of creepage distance versus rated insulation voltage, as given in IEC 62497-1:2010, is as follows:

– normal operating conditions: 24 mm/kV to 33 mm/kV;
– unfavourable operating conditions: 36 mm/kV to 40 mm/kV;
– extremely unfavourable operating conditions: > 48 mm/kV.

NOTE 1 Normal operating conditions exist when there is low industrial pollution, a low population density and no thermal engines.

NOTE 2 Unfavourable operating conditions exist when there is high industrial pollution and industrial gases, a high population density, mixed railway operation, road traffic and frequent fog.

NOTE 3 Extremely unfavourable operating conditions exist when large power plants, chemical industry, smelting works near the ocean with frequent fog are close by.

NOTE 4 Clearances and creepage distances may be reduced by agreement between customer and supplier or in product standards.

Composite insulators present certain advantages over ceramic and glass insulators due to their form and materials. These advantages include a generally improved pollution withstand behaviour when compared to similar ceramic or glass insulators of equal creepage distance; this improvement is even more enhanced by use of hydrophobicity transfer material (HTM). In principle and purely from a pollution withstand or flashover point of view, it can thus be concluded that a reduced creepage distance may be used for such insulators. However, compared to traditional insulating materials, polymer materials are more susceptible to degradation by the environment, electric fields and arc activity which may, in certain conditions, reduce insulator pollution performance or lifetime. Subclause 9.4 of IEC 60815-1:2008 gives the considerations and Subclause 5.2 of IEC 60815-3:2008 gives issues specific to reduction of creepage distance for polymeric housing materials.

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For d.c. system voltages, some insulation may require a somewhat higher value of unified specific creepage distance compared to a.c. insulation under the same conditions.

NOTE 5 This effect will be dealt with in detail in a forthcoming part of IEC 60815 for d.c. systems.

### 4.5 Mechanical requirements

The withstand loads defined by the manufacturer shall take into account the characteristics shown in Table 1.

**Table 1 – Definition of relevant mechanical characteristics according to insulator type**

| Type of insulator | Mechanical characteristics | Definitions |
|---|---|---|
| Stressed mainly in tension | SML (specified mechanical load) /RTL (routine test load) | According to IEC 61109:2008 |
| Stressed mainly in bending | SCL (specified cantilever load) /MDCL (maximum design cantilever load) /STL (specified tensile load) /RTL (routine test load) | According to IEC 61952:2008 |

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 2,5 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 and IEC 60913 give guidance for calculation of loads and application of proper safety factors.

NOTE The MDCL may additionally be adjusted by any angular deflection criteria or bending deflection defined in the client requirements.

### 4.6 Corrosion

The end fittings shall be suitably protected from corrosion and be electrochemically compatible with interface connections. Particular attention shall be made to the protection of the end fittings and connecting zone sealing against moisture ingress, chemical activity or degradation under temperature variations or unidirectional current flow.

### 4.7 Fire safety

The composite insulators shall not exhibit sustained self ignition, such as when subjected to a power arc test. The location, maintenance, creepage distance and overvoltage protection shall be chosen to minimise the possibility of a power arc flashover.

When used in particular environments or applications, particularly in tunnels and station areas, composite insulators may be required to have safety behaviour in terms of flammability, smoke emission and toxicity.

Flammability tests are intended to verify the housing material for ignition, flame propagation and self-extinguishing properties. Flammability requirements are defined in the testing requirements (see Clause 5).

Smoke emission tests are intended to identify the opacity of the smoke emission when the insulator material burns.

Toxicity tests are intended to verify the toxicity of the smoke emission when the insulator material burns.

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### 4.8 Tracking and erosion

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Surface damage may arise in severe environmental conditions due to surface leakage currents and partial arcing.

Tracking and erosion tests are given in IEC 62217:2005. These tests are better described as screening tests, which can be used to reject materials, or designs, which are inadequate.

NOTE 1 For further information, refer to Annex C of IEC 62217:2005 and CIGRE Technical Brochure No. 142: "*Natural and artificial ageing and pollution testing of polymeric insulators*", June 1999 [2].

NOTE 2 A review of the representativity, repeatability and reproducibility of ageing tests is under consideration and guidance will be given in the future in a new Technical Report prepared by IEC TC 36. In the meantime, it is recommended that particular care should be taken when specifying the type and parameters of such tests.

### 4.9 Arc protection

The heating effect of power arcs shall 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.

It has not been considered useful to specify a power arc test as a mandatory test for suspension/tension and post insulators. 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. This standard, however, does not exclude the possibility of a power arc test by agreement between the manufacturer and customer.

IEC 61467:2008 gives details of a.c. power arc testing of insulator sets and tests for sustained ignition.

In-running insulator arrangements regularly receive power arcs and the full insulating assembly shall be power arc tested (see 4.10).

### 4.10 In-running insulators

In railway applications, it is essential to divide the overhead contact lines into discrete electrical sections. This requires breaks or insulators in the contact wire, on which the traction pantograph runs. Composite insulators can provide versatile section insulators with a small mass to minimise pantograph impacts and damage.

Insulators in the overhead contact lines which are designed to work in contact with the traction pantograph unit require additional creepage distances depending upon the pantograph width, system voltage and operating speed. The requirements for insulation length may exceed the values in this standard and shall be agreed separately between the supplier and purchaser.

If the insulator surface wears, it may not accumulate pollution and testing for pollution deposits may not be required. Alternatively if the surface does not wear, pollution can build up from the pantograph strips, which could lead to flashover or surface degradation. This shall be borne in mind when designing the insulators and drafting maintenance instructions or determining life cycle costs.

In-running insulator arrangements regularly receive power arcs and the full insulating assembly shall be power arc tested on the basis of Clause 8 of IEC 61467:2008 or by a field test according to IEC 60913. In order to remove power arcs from insulators, arc extinguishing horn gaps may be used.

Testing shall be in accordance with the requirements defined in Clause 5.

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## 5 Testing

### 5.1 General

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All tests, appropriate to the design requirements of the insulator, shall be undertaken in accordance with current recognised international standards, such as IEC 61109:2008 which applies for composite suspension/tension insulators, or IEC 61952:2008 which applies for composite line post insulators.

For use in special environments, test conditions shall be agreed between manufacturer and purchaser.

### 5.2 Design tests

These tests are intended to verify the suitability the design, materials and method of manufacture (technology). A manufacturer is likely to have a family of composite insulator designs which are defined by:

– materials of the core, housing and manufacturing method;
– material of the end fittings, their design and method of attachment;
– layer thickness of the housing over the core;
– diameter of the core.

The parameters of the design insulator shall be identified on the manufacturer's drawing giving all dimensional tolerances. Design tests shall be performed according to Table 2.

**Table 2 – Design tests**

| Test contents | Test methods or standards |
|---|---|
| **Tests on interfaces and connections of end fittings** | **IEC 62217:2005** |
| Pre-stressing | IEC 61109:2008 or IEC 61952:2008 |
| Water immersion pre-stressing | IEC 62217:2005 |
| Verification tests<br>– Visual examination<br>– Steep-front impulse voltage test<br>– Dry power-frequency voltage test | IEC 62217:2005 |
| **Tests on shed and housing material** | **IEC 62217:2005** |
| Hardness test | IEC 62217:2005 |
| Mechanical properties test [a]<br>– Tension test (tension strength)<br>– Tear test (tear strength, angle test pieces) | ISO 37<br>ISO 34-1 |
| Accelerated weathering test | IEC 62217:2005 |
| Housing tracking and erosion test | IEC 62217:2005 |
| Fire test | IEC 62217:2005 |
| Shed and housing material tracking and erosion test [b] | IEC 60587 |
| **Tests on the core material** | **IEC 62217:2005** |
| Dye penetration test | IEC 62217:2005 |
| Water diffusion test | IEC 62217:2005 |
| **Assembled core load-time test** | **IEC 61109:2008 or IEC 61952:2008** |
| NOTE Test methods or standards are referred to IEC 62217:2005 for general parts, IEC 61109:2008 for composite suspension/tension insulators and IEC 61952:2008 for composite post insulators. | |
| [a] The range of the tension strength and the tear strength can be agreed between customer and supplier.<br>[b] The test method, end-point criteria and classification of the material can be agreed between customer and supplier. | |

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When a composite insulator is submitted to the design tests, it becomes a parent insulator for a design class and the results shall be considered valid for the whole class. This tested parent insulator defines a design of insulators which have the following characteristics:

A: same materials for the core and housing and same manufacturing method;

B: same material for the end fittings, same design and same method of attachment;

C: same or greater minimum layer thickness of the housing over the core (including an intermediate sheath where used) within a tolerance of 15 %;

D: same or smaller stress under mechanical loads;

E: same or greater diameter of the core;

F: same housing profile parameters within a tolerance of 15 %. For equivalent housing profile parameters refer to footnote a) in Table 1 of IEC 61109:2008.

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 for composite suspension/tension insulators is presented in Annex B.