IEC 60137

Edition 6.0 2008-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Insulated bushings for alternating voltages above 1 000 V

Traversées isolées pour tensions alternatives supérieures à 1 000 V

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3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
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COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSULATED BUSHINGS FOR ALTERNATING VOLTAGES ABOVE 1 000 V

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International Standard IEC 60137 has been prepared by sub-committee 36A: Insulated bushings, of IEC technical committee 36: Insulators.

This sixth edition cancels and replaces the fifth edition, published in 2003, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Long duration power-frequency for transformer bushings.
- Special requirements for type and acceptance tests applicable to transformer and GIS bushings.
- Specific insulation levels for bushings fitted to transformers and GIS.
- According to IEC Guide 111, clauses relating to safety and the environment have been added.
- The altitude correction procedure has been revised (> 1 000 m).

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

FDIS	Report on voting
36A/134/FDIS	36A/135/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 maintenance result 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

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- withdrawn,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

INTRODUCTION

In the preparation of this standard further consideration has been given to the test requirements for power transformers as described in IEC 60076-3:2000. Extensions have been made to the requirements for lightning impulse type testing and an additional test - long duration power-frequency withstand test - has been included.

In anticipation of changes in the creepage correction factors defined in IEC 60815 and currently under review by TC 36, details of the correction method have been removed from this standard.

INSULATED BUSHINGS FOR ALTERNATING VOLTAGES ABOVE 1 000 V

1 Scope

This International Standard specifies the characteristics and tests for insulated bushings.

This standard is applicable to bushings, as defined in Clause 3, intended for use in electrical apparatus, machinery, transformers, switchgear and installations for three-phase alternating current systems, having highest voltage for equipment above 1 000 V and power frequencies of 15 Hz up to and including 60 Hz.

Subject to special agreement between purchaser and supplier, this standard may be applied, in part or as a whole, to the following:

- bushings used in other than three-phase systems;
- bushings for high-voltage direct current systems;
- bushings for testing transformers;
- bushings for capacitors.

Special requirements and tests for transformer bushings in this standard apply also to reactor bushings.

This standard is applicable to bushings made and sold separately. Bushings which are a part of an apparatus and which cannot be tested according to this standard should be tested with the apparatus of which they form part.

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 60038:1983, *IEC standard voltages*
Amendment 2 (1997)

IEC 60050(212):1990, *International Electrotechnical Vocabulary – Part 212: Insulating solids, liquids and gases*

IEC 60059, *IEC standard current ratings*

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

IEC 60068-2-17:1994, *Basic environmental testing procedures – Part 2: Tests – Test Q: Sealing*

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60076-5, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-7: *Power transformers – Part 7: Loading guide for oil-immersed transformers*

IEC 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60376, *Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF6) taken from electrical equipment and specification for its re-use*

IEC 60505, *Evaluation and qualification of electrical insulation systems*

IEC 60815, *Guide for the selection of insulators in respect of polluted conditions*

IEC 61462, *Composite insulators – Hollow insulators for use in outdoor and indoor electrical equipment – Definitions, test methods, acceptance criteria and design recommendations*

IEC 61463, *Bushings – Seismic qualification*

IEC 62155, *Hollow pressurised and unpressurised 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 nominal voltage greater than 1 000 V – General definitions, test methods and acceptance criteria*

IEC 62271 (all parts), *High-voltage switchgear and controlgear*

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC Guide 109, *Environmental aspects – Inclusion in electrotechnical product standards*

IEC Guide 111, *Electrical high-voltage equipment in high-voltage substations – Common recommendations for product standards*

CISPR 16-1 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*

CISPR 18-2, *Radio interference characteristics of overhead power lines and high-voltage equipment – Parts 2: Methods of measurement and procedure for determining limits*

3 Terms and definitions

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

3.1
bushing
device that enables one or several conductors to pass through a partition such as a wall or a tank, and insulates the conductors from it; the means of attachment (flange or fixing device) to the partition forms part of the bushing

[IEV 471-02-01]

NOTE 1 The conductor may form an integral part of the bushing or be drawn into the central tube of the bushing.

NOTE 2 The bushing may be of the types as described in 3.2 to 3.21.

3.2
liquid-filled bushing
bushing in which the space between the inside surface of the insulating envelope and the solid major insulation is filled with oil

3.3
compound-filled bushing
bushing in which the space between the inside surface of the insulating envelope and the solid major insulation is filled with an insulating compound

3.4
liquid-insulated bushing
bushing in which the major insulation consists of oil or another insulating liquid

3.5
gas-filled bushing
bushing in which the space between the inside surface of the insulating envelope and the solid major insulation is filled with gas (other than ambient air) at atmospheric pressure or higher

NOTE This definition includes bushings which are intended to form an integral part of gas-insulated equipment, the gas of the equipment being in communication with that of the bushing.

3.6
gas-insulated bushing
bushing in which the major insulation consists of gas (other than ambient air) at atmospheric pressure or higher

NOTE 1 This definition includes bushings which are intended to form an integral part of gas-insulated equipment, the gas of the equipment being in communication with that of the bushing.

NOTE 2 A bushing which contains solid insulating materials other than the envelope containing the gas (e.g. support for conducting layers or insulating cylinder), is a combined insulation bushing (see 3.13).

NOTE 3 A bushing in which the desired voltage grading is obtained by an arrangement of conducting or semi-conducting layers incorporated in an insulating material (e.g. plastic film) is referred to as a gas insulated condenser graded bushing.

3.7
gas-impregnated bushing
bushing in which the major insulation consists of a core wound from paper or plastic film (GIF) and subsequently treated and impregnated with gas (other than ambient air) at atmospheric pressure or higher, the space between the core and the insulating envelope being filled with the same gas

3.8
oil-impregnated paper bushing
OIP
bushing in which the major insulation consists of a core wound from paper and subsequently treated and impregnated with an insulating liquid, generally transformer oil

NOTE The core is contained in an insulating envelope, the space between the core and the insulating envelope being filled with the same insulating liquid as that used for impregnation.

3.9
resin-bonded paper bushing
RBP
bushing in which the major insulation consists of a core wound from resin-coated paper

NOTE 1 During the winding process, each paper layer is bonded to the previous layer by its resin coating and the bonding achieved by curing the resin.

NOTE 2 A resin-bonded paper bushing can be provided with an insulating envelope, in which case the intervening space can be filled with an insulating liquid or another insulating medium.

3.10
resin-impregnated paper bushing
RIP
bushing in which the major insulation consists of a core wound from untreated paper and subsequently impregnated with a curable resin

NOTE A resin-impregnated paper bushing can be provided with an insulating envelope, in which case the intervening space can be filled with an insulating liquid or another insulating medium.

3.11
ceramic, glass or analogous inorganic material bushing
bushing in which the major insulation consists of a ceramic, glass or analogous inorganic material

3.12
cast or moulded resin-insulated bushing
bushing in which the major insulation consists of a cast or moulded organic material with or without an inorganic filler

3.13
combined insulation bushing
bushing in which the major insulation consists of a combination of at least two different insulating materials

3.14
capacitance graded bushing
bushing, in which a desired voltage grading is obtained by an arrangement of conducting or semiconducting layers incorporated into the insulating material

[IEV 471-02-03]

3.15
indoor bushing
bushing, both ends of which are intended to be in ambient air at atmospheric pressure, but not exposed to outdoor atmospheric conditions

[IEV 471-02-05]

3.16
outdoor bushing
bushing, both ends of which are intended to be in ambient air at atmospheric pressure and exposed to outdoor atmospheric conditions

[IEV 471-02-07]

3.17
outdoor-indoor bushing
bushing, both ends of which are intended to be in ambient air at atmospheric pressure. One end is intended to be exposed to outdoor atmospheric conditions, and the other end not to be exposed to outdoor atmospheric conditions

[IEV 471-02-09]

3.18
indoor-immersed bushing
bushing, one end of which is intended to be in ambient air but not exposed to outdoor atmospheric conditions and the other end to be immersed in an insulating medium other than ambient air (e.g. oil or gas)

[IEV 471-02-06]

NOTE This definition includes bushings operating in air at temperatures above ambient, such as occur with air-insulated ducting.

3.19
outdoor-immersed bushing
bushing, one end of which is intended to be in ambient air and exposed to outdoor atmospheric conditions and the other end to be immersed in an insulating medium other than ambient air (e.g. oil or gas)

[IEV 471-02-08]

3.20
completely immersed bushing
bushing, both ends of which are intended to be immersed in an insulating medium other than ambient air (e.g. oil or gas)

[IEV 471-02-04]

3.21
plug-in type bushing
bushing for separable connector
bushing, one end of which is immersed in an insulating medium and the other end designed to receive a separable insulated cable connector, without which the bushing cannot function

[IEV 471-02-02]

3.22
highest voltage for equipment
U_m
highest r.m.s. value of phase-to-phase voltage for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standard

[IEV 604-03-01]

3.23
rated phase-to-earth voltage
maximum r.m.s. value of the voltage which the bushing withstands continuously between the conductor and the earthed flange or other fixing device, under the operating conditions specified in Clause 5

3.24
rated current
I_r
maximum r.m.s. value of current which the bushing can carry continuously under the operating conditions specified in Clause 5, without exceeding the temperature rise limits of Table 2

3.25
rated thermal short-time current
I_{th}
r.m.s. value of a symmetrical current which the bushing withstands thermally for the rated duration (t_{th}) immediately following continuous operation at rated current with maximum temperatures of ambient air and immersion media in accordance with 5.3

3.26
rated dynamic current
I_d
peak value of a current which the bushing withstands mechanically

3.27
temperature rise
difference between the measured temperature of the hottest spot of the metal parts of the bushing which are in contact with insulating material and the ambient air temperature (see 4.8)

3.28
rated frequency
f_r
frequency at which the bushing is designed to operate

[IEV 421-04-03, modified]

3.29
rated filling pressure of gas for insulation
the pressure in Pascal (Pa) for insulation referred to the standard atmospheric conditions of +20 ºC and 101,3 kPa (or density), which may be expressed in relative or absolute terms, to which the bushing is filled before being put into service, or automatically replenished

3.30
maximum internal operating gas pressure
pressure, when the bushing is in operation, carrying rated current at the highest temperatures in accordance with 5.3

3.31
maximum external operating gas pressure
maximum pressure of the gaseous insulating medium in which the bushing is partially or completely immersed when in operation

3.32
design pressure (of the enclosure)
pressure used to determine the thickness of the enclosure

(see IEC 62271-203:2003, Definition 3.113, modified)

3.33
leak rate (of gas-filled, gas-insulated, gas-impregnated and gas-immersed bushings)
quantity of dry gas at a given temperature that flows through a leak per unit of time and for a known difference of pressure across the leak

(see IEC 60068-2-17)

NOTE The basic SI unit for leak rate is “Pascal cubic metre per second (Pa × m^3/s)”. The derived units “Pa × cm^3/s” and “bar × cm^3/s” are used in this standard, as they better conform to the orders of magnitude used in common industrial practice. It should be remembered that: 1 Pa × m^3/s = 10^6 Pa × cm^3/s = 10 bar × cm^3/s.

3.34
hollow insulator
insulator which is open from end to end, with or without sheds

[IEV 471-01-8 modified]

NOTE An insulating envelope may consist of one insulator unit or two or more permanently assembled insulator units.

3.35
creepage distance
shortest distance along the surface of an insulator between two conductive parts

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 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]

3.36
arcing distance
shortest distance in air external to the insulator between metallic parts which normally have the operating voltage between them

[IEV 471-01-01]

NOTE The terms “dry arcing distance” or “taut string distance” are also used.

3.37
test tap
measuring tap
tan δ tap
connection, accessible from outside the bushing, insulated from the flange or other fixing device, made to one of the outer conducting layers of a capacitance graded bushing in order to allow measurements of dissipation factor, capacitance and partial discharge whilst the flange of the bushing is earthed

NOTE 1 This connection should be earthed directly when it is not used.

NOTE 2 When the test tap is used for condition monitoring, in service, care should be taken to avoid an open circuit.

3.38
voltage tap
potential tap
capacitance tap
connection, accessible from outside the bushing, insulated from the flange or other fixing device, made to one of the outer conducting layers of a capacitance graded bushing in order to provide a voltage source whilst the bushing is in operation

NOTE 1 This connection should be earthed directly when it is not used.

NOTE 2 This tap can also be used for the measurement of dissipation factor, capacitance and partial discharge.

3.39
rated voltage of the voltage tap
maximum voltage at which the tap is designed to supply the associated equipment, with the rated load connected thereto, when the rated phase-to-earth voltage is applied to the bushing at the rated frequency

3.40
composite bushing
bushing with an insulating envelope consisting of a resin impregnated fibre tube with or without a rubber compound covering

NOTE For bushings defined in 3.9 to 3.12, the rubber may be applied directly on to the bushing major insulation.

3.41
capacitance (of bushing)

3.41.1
main capacitance C_1
capacitance between the high-voltage conductor and the test tap or the voltage tap of a capacitance-graded bushing

3.41.2
tap capacitance C_2
capacitance between the test tap or the voltage tap and the mounting flange of a capacitance-graded bushing

3.41.3
capacitance C
capacitance between the high-voltage conductor and the mounting flange of a bushing without a voltage tap or test tap

4 Ratings

4.1 Standard values of highest voltage for equipment (U_m)

The values of U_m of a bushing shall be chosen from the standard values of the highest voltage for equipment, defined in IEC 60038 as given below, in kilovolts:

3,6 – 7,2 – 12 – 17,5 – 24 – 36 – 52 – 72,5 – 100 – 123 – 145 – 170 – 245 – 300 – 362 – 420 – 550 – 800 kV.

NOTE The values 525 kV and 765 kV are also used.

4.2 Standard values of rated current (I_r)

The values of I_r of a bushing shall be chosen from the standard values as given below, in amperes:

100 – 250 – 315 – 400 – 500 – 630 – 800 – 1 000 – 1 250 – 1 600 – 2 000 – 2 500 – 3 150 – 4 000 – 5 000 – 6 300 – 8 000 – 10 000 – 12 500 – 16 000 – 20 000 – 25 000 – 31 500 – 40 000 A.

The above series of currents are in accordance with the values indicated in IEC 60059.

In the case of transformer bushings with the conductor drawn into the central tube, the supplier shall indicate the value of the cross-section, and the material of the conductor, which correspond to I_r in accordance with 4.8.

Bushings for transformers selected with I_r not less than 120 % of rated current of the transformer are considered to be able to withstand the overload conditions according to IEC 60076-7 without further clarification or tests.

4.3 Standard values of rated thermal short-time current (I_{th})

Unless otherwise specified, the standard value of I_{th} shall be 25 times I_r, t_{th} being 1 s. For bushings with I_r equal to or greater than 4 000 A, I_{th} shall always be 100 kA.

For transformer bushings, t_{th} shall be 2 s, unless otherwise stated, with reference to IEC 60076-5.

For durations of t_{th} greater than 1 s, the relationship between current and time is assumed to be in accordance with

$$I^2_{th} \times t_{th} = \text{constant}$$

NOTE For transformer bushings, where the conductor is drawn into the central tube, the conductor cross-section corresponding to the operating current may be less than that indicated in 4.2. In such a case, the operating current and cross-section should conform to the requirements of 8.7.

4.4 Standard values of rated dynamic current (I_d)

The standard value of I_d shall have an amplitude of the first peak of 2,5 times the value of I_{th} in accordance with 4.3.

NOTE In some cases, values greater than 2,5 times the value of I_{th} indicated in 4.3 may be necessary with respect to the transformer characteristics. The transformer manufacturer should stipulate such requirements in the bushing ordering information (see 6.1.3).

4.5 Minimum withstand values of cantilever load

The bushings shall withstand the cantilever load given in Table 1, Level I or II. Level I is normal load and shall be generally applied, unless a purchaser specifies a heavy load of Level II.

Table 1 – Minimum values of cantilever withstand load (see 4.5 and 8.9)

Highest voltage for equipment U_m kV	Rated current A							
	≤ 800		1 000 1 600		2 000 2 500		≥3 150	
	Cantilever operating load N							
	Bushing installed ≤30° from the vertical							
	I	II	I	II	I	II	I	II
≤36	500	500	625	625	1 000	1 000	1 575	1 575
52	500	800	625	800	1 000	1 250	1 575	1 575
72,5 to 100	500	1 000	625	1 000	1 000	1 575	2 000	2 000
123 to 145	625	1 575	800	1 575	1 250	2 000	2 000	2 000
170 to 245	625	2 000	800	2 000	1 250	2 500	2 000	2 500
≥300	1 250	2 000	1 250	2 000	1 575	2 500	2 500	2 500
	Cantilever test load N							
	I	II	I	II	I	II	I	II
≤36	1 000	1 000	1 250	1 250	2 000	2 000	3 150	3 150
52	1 000	1 600	1 250	1 600	2 000	2 500	3 150	3 150
72,5 to 100	1 000	2 000	1 250	2 000	2 000	3 150	4 000	4 000
123 to 145	1 250	3 150	1 600	3 150	2 500	4 000	4 000	4 000
170 to 245	1 250	4 000	1 600	4 000	2 500	5 000	4 000	5 000
≥300	2 500	4 000	2 500	4 000	3 150	5 000	5 000	5 000

NOTE 1 Cantilever operating loads include terminal load and wind pressure (70 Pa), reference IEC 61463.

NOTE 2 For bushings operating at an angle >30° to the vertical, the effect of bushing self-load should be considered when selecting test load and procedure. The values given above correspond to vertical bushings that are to be tested in a vertical position. If a tilted or horizontal bushing is to be tested vertically, then an equivalent force should be added to achieve the bending moment at the flange, caused by the weight of the bushing in its operating position. If a vertical bushing is to be tested horizontally, then the test load can be reduced in the same manner.

NOTE 3 Level I = normal load, Level II = heavy load.

NOTE 4 For bushings where upper and lower insulating envelopes are assembled by clamping force on the central fixing conductor, it is recommended to choose the cantilever test load, taking into account the thermal expansion of the conductor due to the rated current flow.

4.6 Angle of mounting

All bushings shall be designed for mounting at any angle of inclination not exceeding 30° from the vertical. Any other angle of mounting shall be subject to agreement between purchaser and supplier.

NOTE A bushing operating at an angle up to and including 30° from the vertical is considered a vertical bushing. A bushing operating at an angle equal to or greater than 70° from the vertical is considered a horizontal bushing. A bushing operating at any other angle is considered a tilted bushing (see 6.1.4).

4.7 Minimum nominal creepage distance

Unless otherwise agreed between purchaser and supplier, or demonstrated by a test, the creepage distance for ceramic insulating envelopes shall be in accordance with IEC 60815.

If artificial pollution tests are required, they shall be performed in accordance with IEC 60507.

NOTE 1 The actual value of creepage distance can differ from the nominal one by the manufacturing tolerances stated in IEC 62155.

NOTE 2 Requirements for composite insulators are under consideration by TC 36: Insulators.

4.8 Temperature limits and temperature rise

The temperature limits of metal parts in contact with insulating material under normal operating conditions are as follows:

– 105 °C for oil-impregnated paper: Class A;

– 120 °C for resin-bonded and resin-impregnated paper: Class E;

– 130 °C for gas-insulated: Class B.

The temperature rise above maximum daily mean ambient air temperature in accordance with 5.3 (30 ºC) of the hottest spot shall not exceed the values given in Table 2. In the case of other insulating materials, the temperature limits shall be stated by the supplier. Reference shall be made to IEC 60216-2 and IEC 60505.

For bushing terminals and connections, the temperature rises are also given in Table 2.

Bushings used as an integral part of apparatus, such as switchgear or transformers, shall meet the thermal requirements for the relevant apparatus. For transformer bushings, reference shall be made to 4.2.

NOTE For gaskets in contact with metallic parts, special attention should be paid to the ability of the material to withstand the temperature rise.

Table 2 – Maximum values of temperature and temperature rise above ambient air (see 4.8)

Description of component		Maximum temperature rise K	Maximum temperature °C	Comments[a]
Spring contacts	Copper and copper alloys, uncoated:			[d]
	- in air	45	75	
	- in SF_6	60	90	
	- in oil	50	80	[b]
	Tinned in air, SF_6 or oil	60	90	
	Silver/nickel-plated:			
	- in air or SF_6	75	105	
	- in oil	60	90	[b]
Screwed contacts	Copper, aluminium and their alloys, uncoated:			
	- in air	60	90	
	- in SF_6	75	105	
	- in oil	70	100	[b]
	Tinned:			
	- in air or SF_6	75	105	
	- in oil	70	100	[b]
	Silver/nickel-plated:			
	- in air or SF_6	85	115	
	- in oil	70	100	[b]
Terminals to be connected to exterior conductors by screws or bolts	Copper, aluminium and their alloys:			
	- uncoated	60	90	[c]
	– tinned	75	105	
	- silver or nickel-plated	75	105	
Metallic parts in contact with	Insulation class:			
	- A (OIP)	75	105	
	- E (RBP and RIP)	90	120	
	- (GIF)	[e]	[e]	
	- SF_6	100	130	
	- Oil		[e]	

[a] The temperature rise values are based on IEC 60943 with a maximum daily mean temperature of 30 °C. For further information reference should be made to IEC 60943, Table 6.

[b] For synthetic insulating liquids (silicone, esters), higher values may be agreed between purchaser and supplier.

[c] If heavy oxidation is to be expected, the temperature rise shall be limited to 50 K.

[d] A spring contact is a connection maintained by spring pressure for example a plug-in connection.

[e] The temperature limits shall be stated by the supplier.

Table 3 – Temperature of ambient air and immersion media (see 5.3)

Subject	Temperature °C
Ambient air:	
– maximum	40
– maximum daily mean (open air)	30
– maximum daily mean (air-insulated ducting)	70
– maximum annual mean	20
– minimum	
• Indoors Class 1 [a]	–5
Class 2	–15
Class 3	–25
• Outdoors Class 1 [a]	–10
Class 2	–25
Class 3	–40
Oil in transformers:	
– maximum	
• for normal load	100
• for emergency duty [b]	115
– maximum daily mean	90
Other media: (gaseous and non-gaseous)	[c]

[a] The normal minimum ambient air temperature is Class 1.

[b] The values for oil in transformers are in accordance with IEC 60076-1 and IEC 60076-2. The value for emergency duty is in accordance with IEC 60076-7

[c] In the absence of other information, reference should be made in principle to the corresponding IEC apparatus standard for which the bushing is intended, whereby particular attention should be paid to bushings one end of which is to be immersed in gas.

NOTE 1 The daily mean temperature of the immersion medium should be calculated by averaging 24 consecutive hourly readings.

NOTE 2 By agreement between purchaser and supplier, other temperature ranges may be adopted.

4.9 Standard insulation levels

The standard values of insulation level shall be chosen from the values given in Table 4.

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The specified standard values of insulation level are in accordance with IEC 60038 and IEC 60071-1.

Table 3 – Temperature of ambient air and immersion media (see 5.3)

Subject	Temperature °C
Ambient air:	
– maximum	40
– maximum daily mean (open air)	30
– maximum daily mean (air-insulated ducting)	70
– maximum annual mean	20
– minimum	
• Indoors Class 1 [a]	–5
Class 2	–15
Class 3	–25
• Outdoors Class 1 [a]	–10
Class 2	–25
Class 3	–40
Oil in transformers:	
– maximum	
• for normal load	100
• for emergency duty [b]	115
– maximum daily mean	90
Other media: (gaseous and non-gaseous)	[c]

[a] The normal minimum ambient air temperature is Class 1.

[b] The values for oil in transformers are in accordance with IEC 60076-1 and IEC 60076-2. The value for emergency duty is in accordance with IEC 60076-7

[c] In the absence of other information, reference should be made in principle to the corresponding IEC apparatus standard for which the bushing is intended, whereby particular attention should be paid to bushings one end of which is to be immersed in gas.

NOTE 1 The daily mean temperature of the immersion medium should be calculated by averaging 24 consecutive hourly readings.

NOTE 2 By agreement between purchaser and supplier, other temperature ranges may be adopted.

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