

Insulated bushings for alternating voltages above 1 000 V

The European Standard EN 60137:2003 has the status of a
British Standard

ICS 29.080.20

National foreword

This British Standard is the official English language version of EN 60137:2003. It is identical with IEC 60137:2003. It supersedes BS EN 60137:1996 which is withdrawn on 2006-10-01.

The UK participation in its preparation was entrusted by Technical Committee PEL/36, Insulators for power systems, to Subcommittee PEL/36/1, Bushing insulators, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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 does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 51 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 25 November 2003

© BSI 25 November 2003

ISBN 0 580 42967 9

English version

**Insulated bushings for alternating voltages above 1 000 V
(IEC 60137:2003)**

Traversées isolées pour tensions
alternatives supérieures à 1 000 V
(CEI 60137:2003)

Isolierte Durchführungen für
Wechselspannung über 1 000 V
(IEC 60137:2003)

This European Standard was approved by CENELEC on 2003-10-01. 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 36A/111/FDIS, future edition 5 of IEC 60137, prepared by SC 36A, Insulated bushings, of IEC TC 36, Insulators, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60137 on 2003-10-01.

This European Standard supersedes EN 60137:1996.

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) 2004-07-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2006-10-01

This edition includes the following significant technical changes with respect to EN 60137:1996:

- standard values of highest voltage for equipment of 550 kV and 800 kV to replace 525 kV and 765 kV;
- consideration of the development in the use of non-ceramic insulating envelopes and to special requirements for bushings used in air-insulated ducting;
- special requirements for bushings fitted to transformers.

Annexes designated "normative" are part of the body of the standard.

In this standard, annex ZA is normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60137:2003 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60076-1	NOTE	Harmonized as EN 60076-1:1997 (modified).
IEC 60076-2	NOTE	Harmonized as EN 60076-2:1997 (modified).
IEC 60076-3	NOTE	Harmonized as EN 60076-3:2001 (not modified).
IEC 60517	NOTE	Harmonized as HD 358 S3:1992 (not modified).
IEC 60694	NOTE	Harmonized as EN 60694:1996 (not modified).

CONTENTS

INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	8
4 Ratings.....	14
4.1 Standard values of highest voltage for equipment (U_m)	14
4.2 Standard values of rated current (I_r).....	14
4.3 Standard values of rated thermal short-time current (I_{th})	14
4.4 Standard values of rated dynamic current (I_d)	14
4.5 Minimum withstand values of cantilever load	15
4.6 Angle of mounting	15
4.7 Minimum nominal creepage distance	15
4.8 Temperature limits and temperature rise	15
4.9 Standard insulation levels	16
4.10 Test tap on transformer bushings	16
5 Operating conditions	16
5.1 Temporary overvoltages	16
5.2 Altitude.....	17
5.3 Temperature of ambient air and immersion media	17
5.4 Seismic conditions	17
6 Ordering information and markings	17
6.1 Enumeration of characteristics	17
6.2 Markings	19
7 Test requirements	20
7.1 General requirements.....	20
7.2 Test classification.....	20
7.3 Condition of bushings during dielectric and thermal tests	21
8 Type tests	22
8.1 Dry or wet power-frequency voltage withstand test	22
8.2 Dry lightning impulse voltage withstand test (BIL).....	23
8.3 Dry or wet switching impulse voltage withstand test (SIL).....	24
8.4 Thermal stability test	25
8.5 Temperature rise test	26
8.6 Verification of thermal short-time current withstand	28
8.7 Cantilever load withstand test.....	29
8.8 Tightness test on liquid-filled, compound-filled and liquid-insulated bushings	30
8.9 Internal pressure test on gas-filled, gas-insulated and gas-impregnated bushings	30
8.10 External pressure test on partly or completely gas-immersed bushings	31
8.11 Verification of dimensions	31

9	Routine tests	31
9.1	Measurement of dielectric dissipation factor ($\tan \delta$) and capacitance at ambient temperature	32
9.2	Dry lightning impulse voltage withstand test (BIL).....	32
9.3	Dry power-frequency voltage withstand test	33
9.4	Measurement of partial discharge quantity	33
9.5	Tests of tap insulation	34
9.6	Internal pressure test on gas-filled, gas-insulated and gas-impregnated bushings	34
9.7	Tightness test on liquid-filled, compound-filled and liquid-insulated bushings	35
9.8	Tightness test on gas-filled, gas-insulated and gas-impregnated bushings	35
9.9	Tightness test at the flange or other fixing device	36
9.10	Visual inspection and dimensional check.....	37
10	Requirements and tests for bushings of highest voltages for equipment equal to or less than 52 kV made of ceramic, glass or inorganic materials, resin or combined insulation.....	37
10.1	Temperature requirements	37
10.2	Level of immersion medium	37
10.3	Markings	38
10.4	Test requirements	38
	Annex ZA (normative) Normative references to international publications with their corresponding European publications	49
	Bibliography.....	51
	Figure 1 – Marking plate for bushings for highest voltage for equipment greater than 100 kV (see 6.2)	39
	Figure 2 – Marking plate for bushings for highest voltage for equipment equal to or less than 100 kV, except for bushings for which Figure 3 is applicable (see 6.2).....	39
	Figure 3 – Marking plate for bushings for highest voltage for equipment equal to or less than 52 kV made of ceramic, glass or inorganic materials, resin or composite insulation (see 10.3)	39
	Table 1 – Minimum values of cantilever withstand load (see 4.5 and 8.7).....	40
	Table 2 – Maximum values of temperature and temperature rise above ambient air (see 4.8)	41
	Table 3 – Temperature of ambient air and immersion media (see 5.3)	42
	Table 4 – Correction of test voltages (see 7.3).....	43
	Table 5 – Maximum values of $\tan \delta$ and $\tan \delta$ increase (see 9.1)	43
	Table 6 – Maximum values of partial discharge quantity (see 9.4).....	44
	Table 7 – Standard insulation levels for highest voltage for equipment less than 300 kV (see 4.9, 8.1, 8.2, 9.2 and 9.3)	45
	Table 8 – Standard insulation levels for highest voltage for equipment equal to or greater than 300 kV (see 4.9, 8.2, 8.3 and 9.2)	46
	Table 9 – Dry power-frequency withstand test voltages for highest voltage for equipment equal to or greater than 300 kV (see 9.3).....	47
	Table 10 – Applicability of type tests (see 7.2.1, excluding bushings according to Clause 10)	47

Table 11 – Applicability of type tests for bushings according to Clause 10 (see 10.4.1)	48
Table 12 – Applicability of routine tests (see 7.2.2, excluding bushings according to Clause 10)	48
Table 13 – Applicability of routine tests for bushings according to Clause 10 (see 10.4.2)	48

INTRODUCTION

To reflect the current usage of the term “composite bushing”, the definition has been changed to mean a bushing with an insulating envelope consisting of a resin impregnated fibre tube with rubber compound covering. The previous definition of a multi-dielectric bushing is given the term “combined insulation bushing”.

For bushings operating in air-insulated ducting, locally high ambient air temperatures have a significant effect on their current rating. This edition defines a limit to this temperature and specifies corresponding test conditions.

The term “highest voltage for equipment” is introduced into this standard in preference to “rated voltage”. This change is in line with other equipment standards.

Gas-insulated and gas-impregnated bushings have become a mature technology, for use in gas insulated switchgear. Limiting values for temperature rise and dielectric dissipation factor have therefore been introduced.

The special requirements addressed for bushings fitted to transformer have not been considered necessary for bushings fitted to switchgear or used for other applications. A high level of integrity is needed to ensure that the bushing will not fail, or be the initiator of internal flashover in the transformer under test. Dry power-frequency withstand test voltage levels for transformers bushings should be increased according to 9.3. Extension of the range of application of lightning impulse and switching impulse tests, included in IEC 60076-3, is not considered technically or commercially justified for bushing routine or type tests.

The dynamic current withstand test is not mentioned in the text, because insufficient experience has so far been collected to design a realistic test.

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;
- terminals for power cables (potheads);
- 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 (IEV) – Chapter 212: Insulating solids, liquids and gases*

IEC 60059:1999, *IEC standard current ratings*

IEC 60060-1:1989, *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 60071-1:1993, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60076-5:2000, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60216-2:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 2: Choice of test criteria*

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

IEC 60354:1991, *Loading guide for oil-immersed power transformers*

IEC 60505:1999, *Evaluation and qualification of electrical insulation systems*

IEC 60507:1991, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems*

IEC 60815:1986, *Guide for the selection of insulators in respect of polluted conditions*

IEC 61462:1998, *Composite insulators – Hollow insulators for use in outdoor and indoor electrical equipment – Definitions, test methods, acceptance criteria and design recommendations*

IEC 61463:1996, *Bushings – Seismic qualification*

IEC 62155:2003, *Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V*

3 Terms and definitions

For the purposes of this document, the following 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, modified]

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 prescribed 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).

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 471-02-02, modified]

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 471-02-03]

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 471-02-04]

3.17

outdoor-indoor bushing

bushing, both ends of which are intended to be in ambient air at atmospheric pressure

NOTE One end is intended to be exposed to outdoor atmospheric conditions, and the other end not to be exposed to outdoor atmospheric conditions.

[IEV 471-02-05]

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 471-02-07]

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 471-02-08, modified]

3.21

bushing for separable connector

plug-in type bushing

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

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**minimum operating pressure of gas for insulation**

minimum pressure, referenced to 20 °C, assigned by the bushing supplier, at which the rated insulating level applies

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 60517)

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 ($\text{Pa} \times \text{m}^3/\text{s}$)". The derived units " $\text{Pa} \times \text{cm}^3/\text{s}$ " and " $\text{bar} \times \text{cm}^3/\text{s}$ " are used in this standard, as they better conform with the orders of magnitude used in common industrial practice. It should be remembered that: $1 \text{ Pa} \times \text{m}^3/\text{s} = 10^6 \text{ Pa} \times \text{cm}^3/\text{s} = 10 \text{ bar} \times \text{cm}^3/\text{s}$.

3.34**insulating envelope**

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

[IEV 471-01-17, 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 471-01-08]

3.36**arcing distance**

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

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

[IEV 471-01-07, modified]

3.37

test tap

measuring tap

$\tan \delta$ 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 60354 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

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

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 with the requirements of 8.6.

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.

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 in accordance with IEC 60815 is determined by

$$d_{cs} \text{ (mm/ kV)} \times U_m \text{ (kV)} \times k_D$$

where

d_{cs} is the minimum nominal specific creepage distance, the values of which for the various pollution levels are

I light:	16 mm/ kV
II medium:	20 mm/ kV
III heavy:	25 mm/ kV
IV very heavy:	31 mm/ kV

k_D is the correction factor depending on the averaged diameter D_m of the insulator, the classes of which are

<300 mm	$k_D = 1$
300 mm to 500 mm	$k_D = 1,1$
>500 mm	$k_D = 1,2$

D_m shall be determined 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-impregnated film: Class B.