

Power transformers —

Part 3: Specification for insulation levels and dielectric tests

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Committee (PEL/-) to Technical Committee PEL/113, upon which the following bodies were represented:

- Association of Consulting Engineers
- British Railways Board
- Bureau of Engineer Surveyors
- Electricity Supply Industry in England and Wales
- Transmission and Distribution Association (BEAMA Limited)

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Foreword

This revision of BS 171:1970, of which this is Part 3, was prepared under the direction of the Power Electrical Engineering Standards Committee. In the revision the standard was divided into five Parts, Parts 1, 2, 4 and 5 of which were identical with the corresponding Parts of Publication 76 “Power transformers”, of the International Electrotechnical Commission (IEC). Part 3 implements the requirements of IEC Publication 76-3:1980 (including Amendment No. 1 of November 1981) as modified by CENELEC HD 398.3 including amendment A1:1995. These Parts are as follows:

IEC 76	BS 171
76-1:1976-1: <i>General</i>	Part 1:1978
76-2:1976-2: <i>Temperature rise</i>	Part 2:1978
76-3:1980-3: <i>Insulation levels and dielectric tests</i>	Part 3:1987
76-4:1976-4: <i>Tappings and connections</i>	Part 4:1978
76-5:1976-5: <i>Ability to withstand short circuit</i>	Part 5:1978

Supplementary material relating to power transformers can be found in BS 5953 “*Guide on power transformers*” — Part 1 “*Application of power transformers*”, which is identical with IEC Publication 606. Pending the publication of additional supplementary material, information from the appendices of BS 171:1970 remains valid for power transformers for guidance only, as explained in Amendment No. 3 of that standard.

The text of IEC Publication 76-3:1980 (including Amendment No. 1 of November 1981) as modified by CENELEC HD 398.3 has been approved as suitable for publication. Some terminology and certain conventions are not identical with those used in British Standards.

Cross-references. The following international standards are referred to in the text for information purposes, and for each there is a corresponding British Standard; these are as listed below:

International standard	Corresponding British Standard
IEC 60	BS 923 <i>Guide on high-voltage testing techniques</i> (Identical)
IEC 60-2:1973	Part 2:1980 <i>Test procedures</i> (Identical) BS 5622 <i>Guide for insulation coordination</i>
IEC 71-1:1976	Part 1:1979 <i>Terms, definitions, principles and rules</i> (Identical)
IEC 71-2:1976	Part 2:1979 <i>Application guide</i> (Identical) BS 171 <i>Power transformers</i>
IEC 76-1:1976	Part 1:1978 <i>General</i> (Identical)
IEC 137:1984	BS 223:1985 <i>Bushings for alternating voltages above 1 000 V</i> (Technically equivalent)
IEC 270:1981	BS 4828:1985 <i>Guide for partial discharge measurements</i> (Technically equivalent)

The Technical Committee has reviewed the provisions of the International Electrotechnical Vocabulary (IEV) and IEC 722, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

The International Electrotechnical Vocabulary (IEV) is related to BS 4725 “*Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms*”. It is expected that IEC 722 will be published as a dual numbered British Standard at a future date.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their 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, pages i to iv, the HD title page, pages 2 to 30, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

Power transformers — Part 3: Insulation levels and dielectric tests (includes amendment A1:1995)

(IEC 76-3:1980 + Amendment 1:1981, mod.)

Transformateurs de puissance
Partie 3: Niveaux d'isolement et essais
diélectriques

(inclut l'amendement A1:1995)

(CEI 76-3:1980 + amendment 1:1981, modifiée)

Leistungstransformatoren

Teil 3: Isolationspegel und
Spannungsprüfungen

(enthält Änderung A1:1995)

(IEC 76-3:1980 + Änderung 1:1981, modifiziert)

This Harmonization Document was approved by CENELEC on 1985-12-03. Amendment A1 was approved by CENELEC on 1995-03-06. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

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

This Harmonization Document exists in three official versions (English, French, German).

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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

This Harmonization Document was prepared by CENELEC TC 14, following the decisions taken at the meeting in Paris on 9-10th December 1982, in Milan on 6th June 1984 and in Frankfurt am Main on 4th June 1985, on the results of a CENELEC questionnaire on IEC Publication 76.3 (1980) and Amendment No. 1 (1981). The complete text of this IEC Standard, modified as stated in Amendment No. 1, is endorsed as HD 398.3 with the exception of the commonly agreed CENELEC modifications to clauses **2, 3, 5** (including Table II), **6, 11, 13, 14, A.3**.

The text takes into account the decisions taken at the 43rd and 44th meetings of the Technical Board, with some editorial variations decided unanimously during Frankfurt meeting of TC 14.

The following dates were fixed:

- latest date of announcement of the HD at national level (doa) 1986-06-01
- latest date of publication of a harmonized national standard (dop) 1987-01-01
- latest date of withdrawal of conflicting national standards (dow) 1987-01-01

Foreword of amendment A1

This amendment was prepared by the Technical Committee CENELEC TC 14, Power transformers.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as amendment A1 to HD 398.3 S1:1986 on 1995-03-06.

The following dates were fixed:

- latest date by which the existence of the amendment has to be announced at national level (doa) 1995-09-15
- latest date by which the amendment has to be implemented at national level by publication of a harmonized national standard or by endorsement (dop) 1996-03-15
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1996-03-15

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1 Definitions

For the purposes of this part of the standard the following definitions apply. Other terms used have the meanings ascribed to them in Publication 76-1: Power Transformers, Part 1: General, or in the International Electrotechnical Vocabulary (I.E.V.)¹⁾.

1.1

highest voltage for equipment applicable to a transformer winding U_m

the highest r.m.s. phase-to-phase voltage for which a transformer winding is designed in respect of its insulation

NOTE U_m is the maximum value of the highest voltage of a system to which the winding may be connected, in respect of its insulation.

1.2 rated insulation level

two alternative definitions are used:

- a) The rated lightning impulse and short duration power frequency withstand voltages.

NOTE Definition a) applies for all windings with highest voltage for equipment U_m lower than 300 kV, and for windings with U_m equal to or greater than 300 kV that are specified according to Method 1 — see Clause 5.

- b) The rated lightning and switching impulse withstand voltages (phase-to-earth).

NOTE Definition b) applies for windings with U_m equal to or greater than 300 kV that are specified according to Method 2 — see Clause 5.

1.3

uniform insulation of a transformer winding

the insulation of a transformer winding when all its ends connected to terminals have the same power frequency withstand voltage to earth

1.4

non-uniform insulation of a transformer winding

the insulation of a transformer winding when it has an end intended for direct or indirect connection to earth, and is designed with a lower insulation level assigned to this earth or neutral winding end

2 General

The insulation requirements for power transformers and the corresponding insulation tests are given with reference to specific windings and their terminals.

For oil-immersed transformers, the requirements apply to the internal insulation only. Any additional requirements or tests regarding external insulation which are deemed necessary shall be subject to agreement between manufacturer and purchaser.

NOTE Where appropriate these tests can be type tests on a suitable model of the configuration.

If the user intends to make the connections to the transformer in a way which may reduce the clearances provided by the transformer alone, this should be brought to attention in the enquiry.

When an oil-immersed transformer is specified for operation at an altitude higher than 1 000 m, clearances shall be designed accordingly. It may then be necessary to select bushings designed for higher insulation levels than those specified for the internal insulation of the transformer windings (see Clause 42 of IEC Publication 137, Bushings for Alternating Voltages above 1 000 V).

Bushings are subject to separate type and routine tests according to IEC Publication 137, which verify their phase-to-earth insulation, external as well as internal.

It is presupposed that bushings and tap-changers are specified, designed and tested in accordance with relevant IEC standards. The insulation tests on the complete transformer, however, constitute a check on the correct application and installation of these components.

The insulation tests shall generally be made at the manufacturer's works with the transformer approximately at ambient temperature.

The transformer shall be completely assembled as in service, except that for oil-immersed transformers the fitting of external cooling is not necessary while some supervisory equipment may be desirable.

¹⁾ Note concerns French text only.

If a transformer fails to meet its test requirements and the fault is in a bushing, it is permissible to replace this bushing temporarily with another bushing and continue the tests on the transformer to completion without delay. A particular case arises for tests with partial discharge measurements, where certain types of commonly used high-voltage bushings create difficulty because of their relatively high level of partial discharge in the dielectric. When such bushings are specified for the transformer, it is permitted to exchange them for bushings of a partial discharge free type during the testing of the transformer (see Appendix A).

Transformers for cable box connection or direct connection to metal-enclosed SF₆ installations should be designed so that temporary connections can be made for insulation tests, using temporary bushings if necessary.

When the manufacturer intends to use non-linear elements or surge arresters — built into the transformer or externally fitted — for the limitation of transferred overvoltage transients, this shall be brought to the user's attention.

3 Highest voltage for equipment and insulation level

To each winding of a transformer is assigned a value of "highest voltage for equipment" U_m (Sub-clause 1.1). The rules for co-ordination of transformer insulation with respect to transient overvoltages are formulated differently depending on the value of U_m . When rules about specific tests for different windings in a transformer are in conflict, the rule for the winding with the highest U_m value shall apply.

Rules for a number of special cases are given in Clause 4.

Standardized values of U_m are listed in Table II to Table V. The value to be used for a transformer winding is the one equal to, or nearest above, the rated voltage of the winding.

NOTE 1 Single-phase transformers intended for connection in star to form a three-phase bank are designated by phase-to-earth rated voltage — for example $400/\sqrt{3}$ kV. The phase-to-phase value determines the choice of U_m — in this case, consequently, $U_m = 420$ kV.

NOTE 2 It may happen that certain tapping voltages are chosen slightly higher than a standardized value of U_m , but that the system to which the winding will be connected has a system highest voltage which stays within the standard value. The insulation requirements are to be co-ordinated with actual system conditions, and therefore this standard value should be accepted as U_m for the transformer, and not the nearest higher value.

NOTE 3 In certain applications with very special system conditions the specification of other combinations of withstand voltages may be justified. In such cases general guidance shall be obtained from Publication 71-1.

The rated withstand voltages for the winding which constitute its insulation level are verified by a set of dielectric tests, and the set of tests is different depending on the value of U_m (Clause 5).

The value U_m and the insulation level which are assigned to each winding of a transformer are part of the information to be supplied with an enquiry and with an order. If there is a winding with non-uniform insulation, the insulation level of the neutral terminal shall also be specified by the purchaser (Sub-clause 5.5.3). If there is a winding with non-uniform insulation and $U_m \geq 300$ kV, it shall be tested according to Method 1 or Method 2 (Clause 5, Table I), and in the case of Method 2 further information shall be given about the choice of certain alternative procedures in the induced overvoltage withstand test (Sub-clause 11.4).

The rated withstand voltages for all windings shall appear on the rating plate. The principles of the standard abbreviated notation are shown by the following examples:

NOTE The abbreviations used in examples 1 to 3 have the following meanings:

LI = lightning impulse withstand voltage.

SI = switching impulse withstand voltage.

AC = power frequency withstand voltage.

Example 1:

A transformer having windings with $U_m = 72.5$ and 12 kV, both uniformly insulated.

INSULATION LEVELS: LI 325 AC 140/LI 60 AC 28
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Data for different windings are separated by a stroke, and the impulse level is put first.