BS EN 60076-3:2013



BSI Standards Publication

Power transformers

Part 3: Insulation levels, dielectric tests and external clearances in air

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 60076-3:2013. It is identical to IEC 60076-3:2013. It supersedes BS EN 60076-3:2001, which will be withdrawn on 4 September 2016.

The UK participation in its preparation was entrusted to Technical Committee PEL/14, Power transformers.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2013.
Published by BSI Standards Limited 2013

ISBN 978 0 580 72472 5
ICS 29.180

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 December 2013.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60076-3

November 2013

ICS 29.180

Supersedes EN 60076-3:2001

English version

Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air

(IEC 60076-3:2013)

Transformateurs de puissance - Partie 3: Niveaux d'isolement, essais diélectriques et distances d'isolement dans l'air (CEI 60076-3:2013)

Leistungstransformatoren - Teil 3: Isolationspegel, Spannungsprüfungen und äußere Abstände in Luft (IEC 60076-3:2013)

This European Standard was approved by CENELEC on 2013-09-04. 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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

© 2013 CENELEC - All rights of exploitation in any form and by any means reserved worldwide for CENELEC members.

Ref. No. EN 60076-3:2013 E

Foreword

The text of document 14/745/FDIS, future edition 3 of IEC 60076-3, prepared by IEC/TC 14 "Power transformers" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60076-3:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-06-04
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-09-04

This document supersedes EN 60076-3:2001.

EN 60076-3:2013 includes the following significant technical changes with respect to EN 60073-3:2001:

– Three categories of transformer are clearly identified together with the relevant test requirements, these are summarised in Table 1.
– Switching impulse levels are defined for all U_m>72,5kV.
– The procedure for Induced voltage tests with PD has been revised to ensure adequate phase to phase test voltages.
– The AC withstand test has been redefined (LTAC instead of ACSD).
– Induced voltage tests are now based on U_r rather than U_m.
– New requirements for impulse waveshape (k factor) have been introduced.
– Tables of test levels have been merged and aligned with IEC 60071-1:2010.
– Additional test levels have been introduced for U_m > 800kV.
– A new Annex E has been introduced, which sets out the principles used in assigning the tests, test levels and clearances in air.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60076-3:2013 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 60071-2	NOTE	Harmonized as EN 60071-2.
IEC 60076-4	NOTE	Harmonized as EN 60076-4.
IEC 60214-1	NOTE	Harmonized as EN 60214-1.
IEC 61083-1	NOTE	Harmonized as EN 61083-1.
IEC 61083-2	NOTE	Harmonized as EN 61083-2.
IEC 62271-1	NOTE	Harmonized as EN 62271-1.

Annex ZA
(normative)
Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-421		International electrotechnical vocabulary (IEV) - Chapter 421: Power transformers and reactors	-	-
IEC 60060-1		High-voltage test techniques – Part 1: General definitions and test requirements	EN 60060-1	
IEC 60060-2		High-voltage test techniques - Part 2: Measuring systems	EN 60060-2	
IEC 60071-1		Insulation co-ordination - Part 1: Definitions, principles and rules	EN 60071-1	
IEC 60076-1		Power transformers - Part 1: General	EN 60076-1	
IEC 60137		Insulated bushings for alternating voltages above 1 000 V	EN 60137	
IEC 60270		High-voltage test techniques - Partial discharge measurements	EN 60270	

CONTENTS

INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
4 General 8
5 Highest voltage for equipment and rated insulation level 10
6 Transformers with re-connectable windings 11
7 Dielectric tests 12
7.1 Overview 12
7.2 Test requirements 13
7.2.1 General 13
7.2.2 Test voltage levels 14
7.2.3 Test sequence 17
7.3 Test requirements for specific transformers 17
7.3.1 Tests for transformers with $U_m \leq 72,5$ kV 17
7.3.2 Tests on transformers with 72,5 kV $< U_m \leq 170$ kV 18
7.3.3 Tests on Transformers with $U_m > 170$ kV 19
7.4 Assigning U_m and test voltages to the neutral terminal of a winding 20
7.4.1 Transformers with $U_m \leq 72,5$ kV 20
7.4.2 Transformers with $U_m > 72,5$ kV 20
8 Dielectric tests on transformers that have been in service 20
9 Insulation of auxiliary wiring (AuxW) 21
10 Applied voltage test (AV) 21
11 Induced voltage tests (IVW and IVPD) 22
11.1 General 22
11.2 Induced voltage withstand test (IVW) 22
11.3 Induced voltage test with partial discharge measurement (IVPD) 23
11.3.1 General 23
11.3.2 Test duration and frequency 23
11.3.3 Test sequence 23
11.3.4 Partial discharge (PD) measurement 24
11.3.5 Test acceptance criteria 25
12 Line terminal AC withstand test (LTAC) 25
13 Lightning impulse tests (LI, LIC, LIN, LIMT) 26
13.1 Requirements for all lightning impulse tests 26
13.1.1 General 26
13.1.2 Tap positions 26
13.1.3 Records of tests 26
13.1.4 Test connections 27
13.2 Full wave lightning impulse test (LI) 28
13.2.1 Wave shape, determination of test voltage value and tolerances 28
13.2.2 Tests on transformers without non-linear elements 29
13.2.3 Tests on transformers with non-linear elements 30
13.3 Chopped wave lightning impulse test (LIC) 31

13.3.1 Wave shape 31
13.3.2 Tests on transformers without non-linear elements 31
13.3.3 Tests on transformers with non-linear elements 32
13.4 Lightning impulse test on a neutral terminal (LIN) 33
13.4.1 General 33
13.4.2 Waveshape 33
13.4.3 Test sequence 34
13.4.4 Test criteria 34
14 Switching impulse test (SI) 34
14.1 General 34
14.2 Test connections 34
14.3 Waveshape 35
14.4 Test sequence 35
14.5 Test criteria 35
15 Action following test failure 36
16 External clearances in air 36
16.1 General 36
16.2 Clearance requirements 37
Annex A (informative) Application guide for partial discharge measurements on transformers 40
Annex B (informative) Overvoltage transferred from the high-voltage winding to a low-voltage winding 45
Annex C (informative) Information on transformer insulation and dielectric tests to be supplied with an enquiry and with an order 47
Annex D (informative) Neutral insulation voltage level calculation 50
Annex E (informative) Basis for dielectric tests, insulation levels and clearances 53
Bibliography 56

Figure 1 – Time sequence for the application of test voltage for induced voltage test with partial discharge measurement (IVPD) 24
Figure A.1 – Calibration circuit for partial discharge measurement using the test tap of condenser type bushing 41
Figure A.2 – Circuit for partial discharge measurement using a high-voltage coupling capacitor 42
Figure B.1 – Equivalent circuit for capacitive transfer of overvoltage 46

Table 1 – Requirements and tests for different categories of windings 14
Table 2 – Test voltage levels *(1 of 2)* 15
Table 3 – Test voltage levels used in special cases 16
Table 4 – Minimum clearances in air *(1 of 2)* 38

INTRODUCTION

This part of IEC 60076 specifies the insulation requirements and the corresponding insulation tests with reference to specific windings and their terminals. It also recommends external clearances in air (Clause 16).

The insulation levels and dielectric tests which are specified in this standard apply to the internal insulation only. Whilst it is reasonable that the rated withstand voltage values which are specified for the internal insulation of the transformer should also be taken as a reference for its external insulation, this may not be true in all cases. A failure of the non-self-restoring internal insulation is catastrophic and normally leads to the transformer being out of service for a long period, while an external flashover may involve only a short interruption of service without causing lasting damage. Therefore, it may be that, for increased safety, higher test voltages are specified by the purchaser for the internal insulation of the transformer than for the external insulation of other components in the system. When such a distinction is made, the external clearances should be adjusted to fully cover the internal insulation test requirements.

Annex E sets out some of the principles used in assigning the tests, test levels and clearances in air to the transformer according to the highest voltage for equipment U_m.

POWER TRANSFORMERS –

Part 3: Insulation levels, dielectric tests and external clearances in air

1 Scope

This International Standard applies to power transformers as defined by and in the scope of IEC 60076-1. It gives details of the applicable dielectric tests and minimum dielectric test levels. Recommended minimum external clearances in air between live parts and between live parts and earth are given for use when these clearances are not specified by the purchaser.

For categories of power transformers and reactors which have their own IEC standards, this standard is applicable only to the extent in which it is specifically called up by cross reference in the other standards.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-421, *International Electrotechnical Vocabulary (IEV) – Chapter 421: Power transformers and reactors*

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

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

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

IEC 60076-1, *Power transformers – Part 1: General*

IEC 60137, *Insulated bushings for alternating voltages above 1 000 V*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60076-1, IEC 60050-421 and the following apply.

3.1
highest voltage for equipment applicable to a transformer winding
U_m
highest r.m.s. phase-to-phase voltage in a three-phase system for which a transformer winding is designed in respect of its insulation