

This is a preview of "IEC 60076-21 Ed. 1.0...". [Click here to purchase the full version from the ANSI store.](#)



Edition 1.0 2011-12

INTERNATIONAL STANDARD

IEEE Std C57.15™

**Power transformers –
Part 21: Standard requirements, terminology, and test code for step-voltage
regulators**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XD**

ICS 29.180

ISBN 978-2-88912-848-8

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
1.3 Word usage	1
2. Normative references	2
3. Definitions	3
4. Service conditions	9
4.1 Usual service conditions	9
4.2 Loading at other than rated conditions	10
4.3 Unusual service conditions	10
4.4 Frequency	12
5. Rating data	12
5.1 Cooling classes of voltage regulators	12
5.2 Ratings	13
5.3 Supplementary continuous-current ratings	17
5.4 Taps	18
5.5 Operating voltage limits	18
5.6 Voltage supply ratios	20
5.7 Insulation levels	20
5.8 Losses	21
5.9 Short-circuit requirements	22
5.10 Tests	23
6. Construction	24
6.1 Bushings	24
6.2 Terminal markings	25
6.3 Diagram of connections	26
6.4 Nameplates	26
6.5 Tank construction	27
6.6 Components and accessories	31
7. Other requirements	32
7.1 Other supplementary continuous-current ratings	32
7.2 Other components and accessories	32
8. Test code	33
8.1 Resistance measurements	34
8.2 Polarity test	36
8.3 Ratio tests	37
8.4 No-load losses and excitation current	40
8.5 Load losses and impedance voltage	45
8.6 Dielectric tests	51
8.7 Temperature-rise tests	64
8.8 Short-circuit tests	73
8.9 Calculated data	77
9. Control systems	81

9.1 General	81
9.2 Control device construction.....	81
9.3 Control system requirements	82
9.4 Tests.....	83
Annex A (informative) Unusual temperature and altitude conditions.....	87
Annex B (informative) Field dielectric tests.....	89
Annex C (informative) Bibliography.....	90
Annex D (informative) IEEE List of Participants	92

INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER TRANSFORMERS –

**Part 21: Standard requirements, terminology,
and test code for step-voltage regulators**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60076-21/IEEE Std C57.15 has been processed through IEC technical committee 14: *Power transformers*.

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

IEEE Std	FDIS	Report on voting
C57.15-2009	14/688/FDIS	14/697/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.

A list of all the parts in the IEC 60076 series, published under the general title *Power transformers* can be found on the IEC website.

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

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

IEC/IEEE Dual Logo International Standards

This Dual Logo International Standard is the result of an agreement between the IEC and the Institute of Electrical and Electronics Engineers, Inc. (IEEE). The original IEEE Standard was submitted to the IEC for consideration under the agreement, and the resulting IEC/IEEE Dual Logo International Standard has been published in accordance with the ISO/IEC Directives.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEC/IEEE Dual Logo International Standard is wholly voluntary. The IEC and IEEE disclaim liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEC or IEEE Standard document.

The IEC and IEEE do not warrant or represent the accuracy or content of the material contained herein, and expressly disclaim any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEC/IEEE Dual Logo International Standards documents are supplied "AS IS".

The existence of an IEC/IEEE Dual Logo International Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEC/ IEEE Dual Logo International Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEC and IEEE are not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Neither the IEC nor IEEE is undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEC/IEEE Dual Logo International Standards or IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations – Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments for revision of IEC/IEEE Dual Logo International Standards are welcome from any interested party, regardless of membership affiliation with the IEC or IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board, 445 Hoes Lane, Piscataway, NJ 08854, USA and/or General Secretary, IEC, 3, rue de Varembé, PO Box 131, 1211 Geneva 20, Switzerland.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

NOTE Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

IEEE Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators

Sponsor

Transformers Committee
of the
IEEE Power & Energy Society

Approved 11 September 2009

IEEE-SA Standards Board

Abstract: Description of design types, tables of 50 Hz and 60 Hz ratings, supplementary ratings, construction, and available accessories are provided. Methods for performing routine and design tests applicable to liquid-immersed single and three-phase step-voltage regulators are described. Winding resistance measurements, polarity tests, insulation power factor and resistance tests, ratio tests, no load loss and excitation current measurements, impedance and load loss measurements, dielectric tests, temperature tests, routine and design impulse tests, short-circuit tests, control tests, calculated data, and certified test data are covered.

Keywords: control, design tests, position indicator, routine tests, series transformer, tap changer, Type A, Type B, voltage regulator

IEEE Introduction

This introduction is not part of IEEE Std C57.15-2009, IEEE Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators.

The Working Group has undertaken the task to update this standard to:

- a) Reflect the latest revisions of referenced documents IEEE Std C57.12.00™ [B13] and IEEE Std C57.12.90™ [B16], and eliminate references to these standards in this standard IEEE Std C57.15-2009 and duplicate applicable text.¹
- b) Adapt the new IEEE approved format to ensure compatibility with the latest ISO and IEC standards.
- c) Include references to applicable IEC standards and keep IEEE standard references to a minimum. This assists in setting up document as a possible candidate for a dual logo (IEC/IEEE).
- d) Update tables of preferred ratings; include 50 Hz ratings. Ratings of 2.4 kV (45 BIL), 46 kV (250 BIL), and 69 kV (350 BIL) have been removed from the three-phase 60 Hz voltage regulator rating Table 5 (Table 4 in 1999 edition) due to historical inactivity of requests from users for ratings.
- e) Add bushing terminal connectors for current ratings of 669 A to 2000 A.
- f) Clarify Type A and Type B designs and their resulting voltage regulation per extreme tap positions.
- g) Review short-circuit requirements for distribution and substation applications and revise where applicable.

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

¹ The numbers in brackets correspond to those of the bibliography in Annex C.

Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at <http://ieeexplore.ieee.org/xpl/standards.jsp>, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at <http://standards.ieee.org>.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection in all circumstances. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

POWER TRANSFORMERS –

Part 21: Standard requirements, terminology, and test code for step- voltage regulators

1. Overview

1.1 Scope

This standard describes electrical and mechanical requirements of liquid-immersed, single- and three-phase, step-voltage regulators, not exceeding a regulation of 3000 kVA (for three-phase units) or 1000 kVA (for single-phase units). This standard does not apply to load tap-changing power transformers.

1.2 Purpose

This standard is intended as a basis for the establishment of performance, limited electrical and mechanical interchangeability, and general requirements of equipment described. It also assists in the proper selection of such equipment.

1.3 Word usage

When this standard is used on a mandatory basis, the word *shall* indicates mandatory requirements. The words *should* or *may* refer to matters that are recommended or permitted but not mandatory.

2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used; therefore, each referenced document is cited in text and its relationship to this standard is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

Where references to both IEC and IEEE standards are made, users shall specify the standard they require, and equipment shall be manufactured to meet that standard.

IEC 60068-2-1, Environmental testing—Part 2-1: Tests—Test A: Cold.¹

IEC 60068-2-2, Environmental testing—Part 2-2: Tests—Test B: Dry heat.

IEC 60068-2-30, Environmental testing—Part 2-30: Tests—Test Db: Damp heat, cyclic (12 h + 12 h cycle).

IEC 60214-1, Tap-changers—Part 1: Performance requirements and test methods.

IEC 60255-5, Electrical Relays—Part 5: Insulation coordination for measuring relays and protection equipment—Requirements and tests.

IEC 60255-21-1, Electrical Relays—Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment—Section one: Vibration tests (sinusoidal).

IEC 60255-22-1, Measuring relays and protection equipment—Part 22-1: Electrical disturbance tests—1 MHz burst immunity tests.

IEC 60255-22-2, Measuring relays and protection equipment—Part 22-2: Electrical disturbance tests—Electrostatic discharge tests.

IEC 60255-22-3, Measuring relays and protection equipment—Part 22-3: Electrical disturbance tests—Radiated electromagnetic field immunity.

IEC 60255-22-4, Measuring relays and protection equipment—Part 22-4: Electrical disturbance tests—Electrical fast transient/burst immunity test.

IEC 60255-22-5, Measuring relays and protection equipment—Part 22-5: Electrical disturbance tests for measuring relays and protection equipment—Surge immunity test.

IEC 60255-22-6, Electrical relays—Part 22-6: Electrical disturbance tests for measuring relays and protection equipment—Immunity to conducted disturbances induced by radio frequency fields.

IEEE Std 4™, IEEE Standard Techniques for High-Voltage Testing.^{2, 3}

¹ IEC publications are available from the Central Office of the International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211, Geneva 20, Switzerland (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

² IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

³ The IEEE standards or products referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

IEEE Std C37.90.1™, IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

IEEE Std C37.90.2™, IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

IEEE Std C37.90.3™, IEEE Standard Electrostatic Discharge Tests for Protective Relays.

IEEE Std C57.12.31™, IEEE Standard for Pole-Mounted Equipment—Enclosure Integrity.

IEEE Std C57.91™, IEEE Guide for Loading Mineral-Oil-Immersed Transformers.

IEEE Std C57.98™, IEEE Guide for Transformer Impulse Tests.

IEEE Std C57.131™, IEEE Standard Requirements for Load Tap Changers.