

# IEEE Standard for Submersible Equipment—Enclosure Integrity

IEEE Power and Energy Society

Developed by the  
Transformers Committee

# IEEE Standard for Submersible Equipment—Enclosure Integrity

Developed by the

**Transformers Committee**  
of the  
**IEEE Power and Energy Society**

Approved 21 May 2019

**IEEE-SA Standards Board**

**Abstract:** Design and production tests and requirements for the integrity of submersible electrical equipment intended for installation in submerged or partially submerged environments are covered in this standard. These enclosures contain energized electrical apparatus, typically not accessible to the general public including, but not limited to, the following types of equipment: submersible distribution transformers; submersible network transformers; submersible network protectors; submersible switchgear; submersible capacitors or inductors; submersible junction enclosures; submersible metering equipment; and submersible control boxes.

**Keywords:** capacitors, coating integrity, control boxes, enclosure integrity, IEEE C57.12.32™, network protectors, submersible equipment, switches, transformers

---

The Institute of Electrical and Electronics Engineers, Inc.  
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2019 by The Institute of Electrical and Electronics Engineers, Inc.  
All rights reserved. Published 7 August 2019. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-1-5044-5898-6 STD23725  
Print: ISBN 978-1-5044-5899-3 STDPD23725

*IEEE prohibits discrimination, harassment, and bullying.*  
For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

## Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notices and Disclaimers Concerning IEEE Standards Documents." They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/ipr/disclaimers.html>.

## Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE 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 IEEE 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.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

## Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

## Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

## Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive 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 comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board  
445 Hoes Lane  
Piscataway, NJ 08854 USA

## Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document 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

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted 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 these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

## Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, 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.

## Updating of IEEE Standards documents

Users of IEEE Standards documents 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. A current 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.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 years old and has not undergone a revision process, 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 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 IEEE Xplore at <http://ieeexplore.ieee.org/> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

## Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

## 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 by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. 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.

## Participants

At the time this IEEE standard was completed, the Enclosure Integrity Working Group had the following membership:

**Dan Mulkey, *Chair***  
**Jerry Murphy, *Vice Chair***  
**Jeremy Van Horn, *Secretary***

Scott Abbott	Thomas Holifield	Ronald Stahara
Omar Ahmed	Gael Kennedy	Robert Stinson
Israel Barrientos	Gary King	Wes Suddarth
Darren Brown	Brian Klaponski	Babanna Suresh
Thomas Callsen	Maria Lamorey	Giuseppe Termini
John Chisholm	Alejandro Macias	Michael Thibault
Rhett Chrysler	Justin Minikel	Alan Traut
John Crotty	Charles Morgan	Donnie Trivitt
Michael Dahlke	Michael Morgan	Reinaldo Valentin
Anil Dhawan	Dwight Parkinson	John Vartanian
Benjamin Garcia	Martin Rave	Joshua Verdell
James Gardner	Stephen Shull	Shelby Walters
Carlos Gaytan	Audrey Siebert-Timmer	Lee Welch
Ali Ghafourian	Igor Simonov	Alan Wilks
Said Hachichi	Edward Smith	William Wimmer
	Travis Spooone	

The Enclosure Integrity Working Group gratefully acknowledges the contributions of the following additional participants in this revision:

Adam Bromley	James Gardner	Robert Olen
Michael Faulkenberry	Rebecca Giang	Justin Pezzin
Fredric Friend	Thomas Goiner	Juan Saldivar
Jean-Francois Gagnon	Kent Miller	Sanjib Som

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Chris Ambrose	Craig DeRouen	John Kay
Peter Balma	James Dorsten	Gael Kennedy
Paul Barnhart	Edgar Dullni	Sheldon Kennedy
Israel Barrientos	William Elliott	Gary King
Barry Beaster	Michael Faulkenberry	Boris Kogan
Steven Bezner	Derek Foster	Jim Kulchisky
Thomas Blackburn	Paul Found	John Leach
Darren Brown	Fredric Friend	Lee Matthews
Demetrio Bucaneg Jr.	Carlos Gaytan	Justin Minikel
William Byrd	Ali Ghafourian	Charles Morgan
Thomas Callsen	Saurabh Ghosh	Dan Mulkey
Paul Cardinal	Edwin Goodwin	Jerry Murphy
Suresh Channarasappa	Randall Groves	K.R.M. Nair
Arvind Chaudhary	Said Hachichi	Michael Newman
Paul Chisholm	John Harley	Joe Nims
C. Clair Claiborne	Thang Hochanh	Dwight Parkinson
Kent Coldsnow	Werner Hoelzl	Bansi Patel
Douglas Craig	Philip Hopkinson	Dhiru Patel
Thomas Dauzat	Richard Jackson	Howard Penrose

Alvaro Portillo  
Larry Putman  
James Ratty  
Martin Rave  
Timothy Robirds  
Ryandi Ryandi  
Pedro Salgado  
Daniel Sauer  
Bartien Sayogo  
Robert Seitz

Stephen Shull  
Jerry Smith  
Gary Smullin  
Sanjib Som  
Francois Soulard  
Travis Spooner  
Ronald Stahara  
Robert Stinson  
Giuseppe Termini  
Alan Traut  
Donnie Trivitt

Karla Trost  
James Van De Ligt  
Ajith Varghese  
Jason Varnell  
John Vergis  
David Wallace  
Shelby Walters  
Lee Welch  
Alan Wilks  
Terry Woodyard

When the IEEE-SA Standards Board approved this standard on 21 May 2019, it had the following membership:

**Gary Hoffman**, *Chair*

**Ted Burse**, *Vice Chair*

**Jean-Philippe Faure**, *Past Chair*

**Konstantinos Karachalios**, *Secretary*

Masayuki Ariyoshi  
Stephen D. Dukes  
J. Travis Griffith  
Guido Hiertz  
Christel Hunter  
Thomas Koshy  
Joseph L. Koepfinger\*  
Thomas Koshy

John D. Kulick  
David J. Law  
Joseph Levy  
Howard Li  
Xiaohui Liu  
Kevin Lu  
Daleep Mohla  
Andrew Myles

Annette D. Reilly  
Dorothy Stanley  
Sha Wei  
Phil Wennblom  
Philip Winston  
Howard Wolfman  
Feng Wu  
Jingyi Zhou

\*Member Emeritus

## Introduction

This introduction is not part of IEEE Std C57.12.32-2019, IEEE Standard for Submersible Equipment—Enclosure Integrity.

The Accredited Standards Committee on Transformers, Regulators, and Reactors, C57, originally developed and correlated standards on these products, together with the Accredited Standards Committee on Power Switchgear, C37, through the Joint ASC C57/C37 Working Group on Enclosures with Joseph Martin and then with Robert C. Olen as chairman. This group is now the Enclosure Integrity Working Group of the IEEE Transformers Committee.

The data used in this work have been gathered from many sources, including the standards of the Institute of Electrical and Electronics Engineers and the National Electrical Manufacturers Association, reports of committees of the Edison Electric Institute, and others.

This IEEE standard is a voluntary consensus standard. Its use becomes mandatory only when required by a duly constituted legal authority or when specified in a contractual relationship. To meet specialized needs and to allow innovation, specific changes are permissible when mutually determined by the user and the producer, provided such changes do not violate existing laws and are considered technically adequate for the function intended.

## Contents

1. Overview .....	10
1.1 Scope .....	10
1.2 Purpose .....	10
2. Normative references .....	10
3. Definitions .....	11
4. Enclosure design .....	12
4.1 Enclosure design requirements objective .....	12
4.2 Production submersibility testing .....	13
4.3 Substrate requirements .....	13
5. Coating system requirements .....	15
5.1 General .....	15
5.2 Holiday test .....	15
5.3 Coating system test specimens .....	15
5.4 Coating system performance requirements .....	19
6. General .....	22
6.1 Shipment .....	22
6.2 Coating repair procedure .....	22
6.3 Coating touch-up prior to shipment .....	22
6.4 Installation—maintenance of coating integrity .....	22
Annex A (normative) Procedure for comparative weight loss .....	23
Annex B (normative) Simulated corrosive atmospheric breakdown (SCAB) procedure .....	24
Annex C (informative) Bibliography .....	25

# IEEE Standard for Submersible Equipment—Enclosure Integrity

## 1. Overview

### 1.1 Scope

This standard covers conformance tests and requirements for the integrity of submersible electrical equipment intended for installation in submerged or partially submerged environments. These enclosures contain energized electrical apparatus, typically not accessible to the general public, including, but not limited to, the following types of equipment:

- a) Submersible distribution transformers
- b) Submersible network transformers
- c) Submersible network protectors
- d) Submersible switchgear
- e) Submersible capacitors or inductors
- f) Submersible junction enclosures
- g) Submersible metering equipment
- h) Submersible control box

### 1.2 Purpose

The purpose of this standard is to describe the requirements for a comprehensive enclosure integrity system for submersible equipment providing long field life with minimum maintenance.

## 2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document 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.

ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.<sup>1</sup>

---

<sup>1</sup>ASTM publications are available from the American Society for Testing and Materials (<http://www.astm.org/>).