



IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors

IEEE Power & Energy Society

Sponsored by the
Transformers Committee

IEEE
3 Park Avenue
New York, NY 10016-5997, USA

20 August 2010

IEEE Std C57.113™-2010
(Revision of
IEEE Std C57.113-1991)

Currently in preview, click buy full version

IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors

Sponsor

Transformers Committee
of the
IEEE Power & Energy Society

Approved 17 June 2010

IEEE-SA Standards Board

Abstract: Wideband measurement of the apparent charge of partial discharges (PDs) that may occur in liquid-filled power transformers and shunt reactors excited by ac test voltages between 40 Hz and 400 Hz are discussed. The major components of the PD measuring circuit including the calibrator are specified in compliance with IEC 60270. The PD test procedure is described and recommendations for the evaluation of PD test results are presented.

Keywords: apparent charge, IEEE C57.113, partial discharge (PD), power transformer, shunt reactor, wideband PD measurement

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

Copyright © 2010 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 20 August 2010. 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 978-0-7381-6383-3 STD96098
Print: ISBN 978-0-7381-6384-0 STDPD96098

IEEE prohibits discrimination, harassment and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>. No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

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 or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims 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 IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims 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. IEEE Standards documents are supplied "AS IS."

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. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, 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 IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her 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.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretation 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. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the 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, explanation, or interpretation of the IEEE.

Comments for revision of IEEE standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretation, should be addressed to:

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

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.

Introduction

This introduction is not part of IEEE Std C57.113-2010, IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors.

The detection of partial discharges (PDs) was introduced for quality assurance tests of high-voltage (HV) apparatus at the beginning of 1960. Originally this technique was based on the measurement of radio interference voltages (RIV) in terms of microvolts (μV) as recommended by NEMA TR1-1974 [B112], NEMA 107-1964 [B113], and CISPR 16-1-1993 [B42].^a This quantity, however, is weighted according to the acoustical noise impression of the human ear, which is not a measure of the PD activity in the insulation of HV apparatus. As a consequence, Technical Committee No. 42 of IEC decided to prepare a separate standard for PD measurements associated with the apparent charge, which was first published in 1968. Since that time, this technology is considered as an indispensable tool for an enhancement of the reliability of HV apparatus. IEEE Std C57.113-2010 covers the wideband method for apparent charge measurements in compliance with the third edition of IEC 60270, published in 2000.^b

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 with 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 quotations 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.

^a The numbers in brackets correspond to those of the bibliography in Annex H.

^b Information on references can be found in Clause 2.

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 recommended practice may require use of subject matter covered by patent rights. By publication of this recommended practice, 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 Patent 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 recommended practice 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 recommended practice was submitted to the IEEE-SA Standards Board for approval, the Dielectric Tests—TF on PD Measurement Working Group had the following membership:

Bertrand Poulin, Chair

Raymond Bartnikas
Alain Bolliger
Carl Bush
Alan Darwin
Reto Fausch
Marcel Fortin
John Harley
Peter Heinzig
Thang Hochanh

Stephen Jordan
Vladimir Khalin
Eberhard Lemke
Paul Millward
Arthur Molden
Martin Navarro
Ron Nicholas
Mark Perkins
Gustav Preininger

Dirk Russwurm
Hemchandra Shertukde
Charles Sweetser
Juan Luis Thierry
Subash Tuli
Dharam Vir
Loren Wagenaar
Hanxin Zhu
Waldemar Zionsch

Most of the work in writing this document was done by the TF Chair Eberhard Lemke and TF Members Marcel Fortin, John Harley, Thang Hochanh, Stephen Jordan, Vladimir Khalin, Mark Perkins, Bertrand Poulin, and Loren Wagenaar.

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

Samuel H. Aguirre
Stan Arnot
Carlo Arpino
Javier Arteaga
Ali Al Awazi
Martin Baur
Barry Beaster
Stephen Beattie
W. J. Bill Bergman
Steven Bezner
Wallace Binder
Thomas Blackburn
Thomas Blair
David Blew
William Bloethe
W. Boettger
Paul Boman
Harvey Bowles
Jeffrey Britton
Chris Brooks
Ken Brown
Carl Bush
Donald Cash
Alexiang Chen
Bill Chiu
Craig Colopy
Tommy Cooper
Jerry Corkran
John Crouse
Alan Darwin

John Densley
Dieter Dohnal
Randall Dotson
Donald Dunn
Fred Ebert
Gary Engmann
Donald Gallon
Rabiz Roda
Joseph Foldi
Bruce Forsyth
Marcel Fortin
Saurabh Ghosh
Jalal Gohari
Eduardo Gomez-Hennig
Edwin Goodwin
James Graham
Randall Groves
Bal Gupta
Kenneth Hanus
David Harris
Robert Hartgrove
Roger Hayes
Peter Heinzig
Gary Heuston
James Huddleston III
Wayne Johnson
James Jones
Stephen Jordan
Lars Juhlin
C. Kalra

Gael Kennedy
Sheldon Kennedy
Vladimir Khalin
Joseph L. Koepfinger
Jim Kulchisky
Saumen Kundu
John Lackey
Chung-Yiu Lam
Stephen Lambert
Thomas La Rose
Raymond Lings
Maurice Linker
Thomas Lundquist
G. Luri
Keith Malmedal
J. Dennis Marlow
John W. Matthews
Joseph Melanson
Gary Michel
Daleep Mohla
Daniel Mulkey
Jerry Murphy
Michael S. Newman
Raymond Nicholas
Miklos Orosz
J. Patton
Brian Penny
Patrick Picher
Paul Pillitteri
Alvaro Portillo

Bertrand Poulin
Paulette Payne Powell
Gustav Preininger
Iulian Profir
Pierre Riffon
Michael Roberts
Oleg Roizman
Marnie Roussel
Thomas Rozek
Dinesh Sankarakurup

Daniel Sauer
Gregg Sauer
Bartien Sayogo
Hyeong Sim
Tarkeshwar Singh
Charles Smith
James Smith
Jerry Smith
John Stein

John Sullivan
S. Thamilarasan
James Thompson
Subhash Tuli
Joe Uchiyama
John Vergis
Jane Verner
Loren Wagenaar
Barry Ward
Thomas Wier

When the IEEE-SA Standards Board approved this recommended practice on 17 June 2010, it had the following membership:

Robert M. Grow, *Chair*
Richard H. Hulett, *Vice Chair*
Steve M. Mills, *Past Chair*
Judith Gorman, *Secretary*

Karen Bartleson
Victor Berman
Ted Burse
Clint Chaplin
Andy Drozd
Alexander Gelman
Jim Hughes

Young Kyun Kim
Joseph L. Koepfinger*
John Kulick
David J. Law
Hung Ling
Oleg Logvinov
Ted Olsen

Ronald C. Petersen
Thomas Rost
John Walter Rosdahl
Sal Sciaccia
Mike Seavey
Curtis Siller
Don Wright

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Michael J. Hezic, *NIST Representative*

Don Messina
IEEE Standards Program Manager, Document Development

Matthew J. Ceglia
IEEE Standards Program Manager, Technical Program Development

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
2. Normative references.....	2
3. Definitions	2
4. Specification of PD measuring circuits	3
4.1 General	3
4.2 Coupling capacitor.....	4
4.3 Measuring impedance.....	5
4.4 PD measuring instrument	5
4.5 PD calibrator.....	7
4.6 Maintaining the specified parameters of PD measuring circuits	8
5. PD test procedure	8
5.1 Calibration	8
5.2 PD measurement.....	9
Annex A (informative) Design of PD coupling units.....	12
Annex B (informative) Response of PD measuring instruments.....	17
Annex C (informative) Calibration of PD measuring circuits.....	20
Annex D (informative) Basic sensitivity check.....	21
Annex E (informative) Bushing tap ratio measurement	23
Annex F (informative) Noise identification	24
Annex G (informative) PD pattern recognition	27
Annex H (informative) Bibliography	29

IEEE Recommended Practice for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors

IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection. 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>.

1. Overview

1.1 Scope

This recommended practice describes the test procedure for the detection and measurement by the wideband apparent charge method of partial discharges (PDs) occurring in liquid-filled power transformers and shunt reactors during dielectric tests, where applicable.

1.2 Purpose

PD measurements in transformers and shunt reactors should preferably be made on the basis of measurement of the apparent charge. Relevant measuring systems are classified as narrowband or wideband systems. Both systems are recognized and widely used. Without giving preference to one or the other, it is the object of this document to describe the wideband method. General principles of PD measurements, including the narrowband method, are covered in IEC 60270 and IEC 60076-3 [B71].^{1, 2}

¹ Information on references can be found in Clause 2.

² The numbers in brackets correspond to those of the bibliography in Annex H.