

IEEE Guide for Partial Discharge Measurement in Power Switchgear

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Abstract: This guide defines methods of measuring partial discharges that may occur in energized power switchgear apparatus in flaws, voids, and interfaces of non-self-restoring insulation that may then result in dielectric failure of the switchgear. Guidance on instrumentation and calibration technique is also given.

Keywords: calibration, corona, dielectric tests, partial discharge, switchgear

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Introduction

(This introduction is not a part of IEEE Std 1291-1993, IEEE Guide for Partial Discharge Measurement in Power Switchgear.)

A partial discharge is a localized dielectric breakdown of a section of dielectrically stressed insulation path that occurs generally in voids, cracks, or interfaces within that insulating system or from the sharp edges of energized apparatus parts. These discharges may or may not exhibit a glow discharge, based on location and the intensity of these discharges. The classic form of corona is usually denoted by a visual glow or dielectric breakdown of the insulating air or gas around overstressed conductors or the sharp edges of energized apparatus parts. Radio influence voltage (RIV) measurements are made to determine the extent of radio interference generated by this corona and the corrective measures that should be made. This corona, when associated with the self-restoring insulation of the apparatus, may not necessarily contribute to insulation damage.

In contrast, partial discharges, localized dielectric breakdowns of a section in an insulation path where the discharges occur in voids, cracks, or interfaces of solid and/or solid/gas dielectrics, are undesirable because of the possible deterioration of that insulation with the formation of ionized gas due to this breakdown that may accumulate at or in a critical stress region. This generally involves non-self-restoring insulation that may be subject to permanent damage.

Partial discharge measurements may be made on the basis of the resultant momentary change in the voltage at the terminals of the device. Such a change may be expressed as a voltage change [radio influence voltage (RIV) in microvolts] or by calibration as an apparent charge. When injected between the terminals of the device, this apparent charge, measured in picocoulombs, would cause the same voltage change as that resulting from the partial discharge.

The initial efforts at measuring partial discharge levels on apparatus to provide an acceptance criteria between user and manufacturer utilized NEMA 107-1987, Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus. However, it has been determined that this narrow frequency band measuring system has limitations and that measuring partial discharges in terms of apparent charge has many advantages over that of the RIV approach. These advantages include:

- a) The internal and stray capacitance of differing switchgear and/or components are accounted for by the calibration procedure. Thus, the measured value is related to the partial discharge level.
- b) The partial discharge measurements are, in most cases, not affected by local radio broadcast signals. It should be noted that apparent charge measurements may be made on either a wide-band or narrow-band basis. Both methods are included in this document.

In developing this guide, the working group followed the basic instrumentation, calibration, techniques described in IEEE C57.113-1991, IEEE Guide for Partial Discharge Measurements in Liquid-Filled Power Transformers and Shunt Reactors, to the extent that they could be adapted to partial discharge testing in power switchgear. This commonality should provide for an efficient application of laboratory test equipment and a better understanding of partial discharge testing on various types of apparatus.

It is expected that by the application of this guide, both users and manufacturers of switchgear and components will utilize the apparent charge measurements on their devices such that an adequate base of experience can be developed for the evaluation of this equipment.

This guide was prepared by the Partial Discharge Working Group of the ADSCOM Subcommittee of the IEEE Switchgear Committee, which consisted of members from the High-Voltage Circuit Breaker; High-Voltage Switches, Reclosers, and Sectionalizers; High-Voltage Fuses; and Switchgear Assemblies Subcommittees.

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IEEE Guide for Partial Discharge Measurement in Power Switchgear

1. Scope

This test procedure applies to the detection and measurement of partial discharges (corona) occurring in switchgear equipment and/or components during dielectric tests, where applicable. The following types of equipment are included: high-voltage fuses, high-voltage switches, high-voltage circuit breakers, reclosers and sectionalizers, and switchgear assemblies.

2. Purpose

Partial discharge measurement in switchgear equipment can be made on the basis of measurement of the apparent charge. Relevant measuring systems are classified as narrow-band or wide-band systems. Both systems are recognized and widely used. General principles of partial discharge measurement, including both broad and narrow-band methods, are covered in IEEE Std C57.113-1991 and IEC 270 (1981).¹

The use of partial discharge testing as a tool to assess the integrity of insulation systems requires a great deal of judgment. It should not be used as a general, all inclusive test such as the 60 Hz and impulse dielectric tests. Although it may be appropriate to perform a partial discharge test on an entire device for some types of equipment, practice tends to indicate that it should be used to evaluate component parts of apparatus. If partial discharges on apparatus are associated with self-restoring insulation, such as air, and do not affect nearby non-self-restoring insulation materials, then relatively high levels of partial discharge may be acceptable if the resultant radio influence voltage (RIV) level and the audible discharge noise level is acceptable, see NEMA 107-1987. It may be necessary to temporarily isolate areas of high partial discharge so that other more critical areas involving non-self-restoring insulations may be more carefully evaluated. Immersing components in oil or SF₆ gas is an accepted means of isolating noncritical areas so that critical areas can be tested. Thus, partial discharge testing is used more effectively to evaluate isolated areas of high dielectric stress that are judged to have the probability of deterioration of their non-self-restoring insulation.

¹Information on references can be found in clause 3.

3. References

This guide shall be used in conjunction with the following publications. When the following standards are superseded by a new revision approved by the relevant standards authority, the latest revision shall apply.

IEEE Std 4-1978, IEEE Standard Techniques for High-Voltage Testing.²

IEEE Std C57.19.00-1991, IEEE Standard General Requirements and Test Procedures for Outdoor Apparatus Bushings (ANSI).

IEEE Std C57.113-1991, IEEE Guide for Partial Discharge Measurements in Liquid-Filled Power Transformers and Shunt Reactors.

IEC 270 (1981), Partial discharge measurements.³

NEMA 107-1987, Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus.⁴

4. Definitions

4.1 partial discharge (PD), q : A localized electric discharge resulting from ionization in an insulation system when the voltage stress exceeds the critical value. This discharge partially bridges the insulation between electrodes.

4.2 apparent charge (terminal charge): A charge that, if injected instantaneously between the terminals of the test object, would momentarily change the voltage between its terminals by the same amount as the partial discharge itself. The apparent charge should not be confused with the charge transferred across the over-stressed insulation in the dielectric medium. Apparent charge within the terms of this document is expressed in picocoulombs, which is abbreviated as pC (10^{-12} Coulombs).

4.3 repetition rate, n : The average number of partial discharge pulses per second measured over a selected period of time.

4.4 acceptable terminal partial discharge level: The specified maximum terminal partial discharge level for which measured terminal partial discharge values exceeding this value are considered unacceptable. This level may be defined by the appropriate apparatus test standard or may be a level agreed to by the user and manufacturer. The method of measurement and the test voltage for a given test object must be specified with respect to the acceptable terminal partial discharge level.

4.5 test voltage related to partial discharges: The phase-to-ground alternating voltage whose value is expressed by its peak value divided by $\sqrt{2}$.

4.6 partial discharge-free test voltage: A specified voltage, applied in accordance with a specified test procedure, at which the test object should not exhibit partial discharges above the acceptable energized background noise level.

4.7 energized background noise level: Stated in pC, the residual response of the partial discharge measurement system to background noise of any nature after the test circuit has been calibrated and energized at 100% of the test voltage without the test object connected.

4.8 partial discharge inception voltage: The voltage that should be recorded on the device or system under test when raised to a point where the PD signal rises above the energized background noise level.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

³IEC publications are available from IEC Sales Department, Case Postale 131, 3 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

⁴NEMA publications are available from the National Electrical Manufacturers Association, 2101 L Street NW, Washington, DC 20037, USA.