

IEEE Recommended Practice for the Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers

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Abstract: IEEE Std C57.124-1991 covers the detection of partial discharges occurring in the insulation of dry-type transformers of their components and the measurement of the associated apparent charge at the terminals when alternating test voltage is applied. The wideband method is used. The detection system and calibrator characteristics are described, and the test procedure is established.

Keywords: Apparent charge, corona, cost coil transformers, dry-type transformers, partial discharge, ventilated dry-type transformers

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Foreword

(This foreword is not a part of IEEE Std C57.124-1991, IEEE Recommended Practice for the Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers.)

This recommended practice for measuring partial discharge of dry-type transformers was conceived for the purpose of establishing a standardized method for conducting partial discharge tests of dry-type transformers. The results of the tests may be compared with various transformer designs and manufacturers to establish a partial discharge limit for dry-type transformers.

This recommended practice follows the format of IEEE Std 454, IEEE Recommended Practice for the Detection and Measurement of Partial Discharge (Corona) During Dielectric Tests, and IEEE Std C57.113, IEEE Guide for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors. Sections on current detection were purposely omitted, as this technique is normally not used for dry-type transformers.

There is no recognized definition of "partial discharge-free" when referring to partial discharge inception voltage or extinction voltage. An arbitrary sensitivity of 10 pC is suggested until such time as a more definitive standard is established.

Various specifications are already written specifying partial discharge-free transformers from 1.1 p.u. operating voltage to 2.0 p.u. operating voltage. It is the intent of this recommended practice to encourage manufacturers of dry-type transformers and users of dry-type transformers to investigate and report the results of factory tests and field experience of partial discharge in dry-type transformers. It is recognized that Paschen's Law applies to the partial discharge intensity and extinction voltage of dry-type transformers. It is conceivable that a dry-type transformer would test partial discharge-free at 1.65 p.u. voltage at room temperature and be barely partial discharge-free at operating temperature for a Class 220C. system. This correlation should be verified with field experience and reported.

The guide specifies no particular discharge testing instruments and systems. Several commercially available units are being used. A measuring system of discreet components readily available has been used for measuring partial discharge. Most manufacturers' laboratories have partial discharge-free HV test sets and oscilloscopes. The only additional components required to complete the detection circuit are a partial discharge-free coupling capacitor composed of two 60 kV, .002 mfd capacitors in series, and an inductance composed of a coil of magnet wire. Calibration is accomplished using a calibrated square wave generator and a calibrated coupling capacitor of .0001 mfd.

The following two test procedures are proposed:

- 1) To test partial discharge between the coil and ground, normally accomplished during the applied voltage test.
- 2) The test procedure takes place during the induced voltage test to detect partial discharge within a coil. It is suggested that partial discharge measurements be made in both modes. The partial discharge measurement may be made during the normal sequence of tests, while the applied and induced voltage tests are being made. An alternative sequence is to conduct the partial discharge test immediately following the applied voltage test and induced voltage test.

The high-voltage bus bars of high-voltage transformers sometimes cause nondestructive partial discharge. This partial discharge in no way affects the reliability of the transformer coils. It may be necessary to disconnect the bus bar from the coils before conducting the partial discharge test on only the coils in order to test for partial discharge in the transformer coils. A note should be added to any test reports stating that the bus bar was removed for the test.

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IEEE Recommended Practice for the Detection and the Measurement of Partial Discharge in Dry-Type Transformers

1. Scope

This recommended practice applies to the detection of partial discharges occurring in the insulation of dry-type transformers or their components, and to the measurement of the associated apparent charge at the terminals when an alternating test voltage is applied.

2. Purpose

Partial discharge measurements in dry-type transformers may preferably 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. Without giving preference to one or the other, it is the object of this document to describe the wide-band method. General principles of partial discharge measurements, including the narrow-band method, are covered in IEEE Std 454-1973¹ [8]², IEC 270 (1981) [6]³ and IEC 76-3 (1980) [5].

3. References

The following publications should be used in conjunction with this document. When the standards referred to in this guide are superseded by a new revision approved by the relevant standards authority, the latest revision should apply.

[1] ANSI C68.1-1968, Standard for Measurement of Voltage In Dielectric Tests.⁴

¹This standard has been withdrawn, however, copies are available from the Institute of Electrical and Electronics Engineers, Inc., Service Center, 445 Hoes Lane, Piscataway, N.J. 08855, U.S.A.

²The numbers in brackets refer to those listed in Section 4.

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.

⁴ANSI publications are available from the American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

- [2] ASTM D1868-81 (1990-E01), Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems.⁵
- [3] ASTM STP-669, Engineering Dielectrics, Vol. 1, Corona Measurement and Interpretation.
- [4] CIGRE Working Group 21-03, "Recognition of Discharges," *Electra*, No. 11, pp. 61-98, Dec, 1969.⁶
- [5] IEC 76-3 (1980), Power Transformers, Part 3: Insulation Levels and Dielectric Tests.⁷
- [6] IEC 270 (1981), Partial Discharge Measurements.
- [7] IEEE Std 436-1991, IEEE Guide for Making Corona (Partial Discharge) Measurements of Electronics Transformers (ANSI).⁸
- [8] IEEE Std 454-1973, IEEE Recommended Practice for the Detection and Measurement of Partial Discharge (Corona) During Dielectric Tests.
- [9] IEEE Std C57.113-1991, IEEE Guide for Partial Discharge Measurement in Oil-Filled Power Transformers and Shunt Reactors (ANSI).

4. Definitions

partial discharge: A partial discharge within the terms of this document is an electric discharge that only partially bridges the insulation between conductors. The term "corona" has also been used frequently with this connotation. Such usage is imprecise and is gradually being discontinued in favor of the term "partial discharge."

apparent charge (terminal charge): The apparent charge (q) of a partial discharge is that charge which, if it could be 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 discharging cavity in the dielectric medium. Apparent charge within the terms of this document is expressed in coulombs, abbreviated C. One pC is equal to 10^{-12} coulombs.

repetition rate(n): The partial discharge pulse repetition rate (n) is the average number of partial discharge pulses per second measured over a selected period of time.

acceptable terminal partial discharge level: The acceptable terminal partial discharge level is that specified maximum terminal partial discharge value for which measured terminal partial discharge values exceeding the said value are considered unacceptable. The method of measurement and the test voltage for a given test object should be specified with the acceptable terminal partial discharge level.

voltage related to partial discharges: Voltage within the terms of this document is the phase-to-ground alternating voltage for applied tests (Fig 1) or terminal to terminal alternating voltage for induced voltage tests (Fig 8). Its value is expressed by its peak value divided by the square root of two.

partial discharge inception voltage: The lowest voltage at which partial discharges exceeding a specified level are observed under specified conditions when the voltage applied to the test object is gradually increased from a lower value. This voltage is expressed as the peak value divided by the square root of two.

⁵ASTM publications are available from the American Society for Testing and Materials, Customer Service Dept., 916 Race Street, Philadelphia, P. A. 19103, U.S. A.

⁶CIGRE publications are available from the International Conference on Large-Voltage Electric Systems, 112 Boulevard Haussman, F-75008 Paris, France.

⁷IEC 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.

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