Designation: D3382 – 22

# Standard Test Methods for Measurement of Energy and Integrated Charge Transfer Due to Partial Discharges (Corona) Using Bridge Techniques[1]

This standard is issued under the fixed designation D3382; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope*

1.1 These test methods cover two bridge techniques for measuring the energy and integrated charge of pulse and pseudoglow partial discharges:

1.2 Test Method A makes use of capacitance and loss characteristics such as measured by the transformer ratio-arm bridge or the high-voltage Schering bridge (Test Methods D150). Test Method A has been found useful to obtain the integrated charge transfer and energy loss due to partial discharges in a dielectric from the measured increase in capacitance and tan δ with voltage. (See also IEEE 286 and IEEE 1434)

1.3 Test Method B makes use of a somewhat different bridge circuit, identified as a charge-voltage-trace (parallelogram) technique, which indicates directly on an oscilloscope the integrated charge transfer and the magnitude of the energy loss due to partial discharges.

1.4 Both test methods are intended to supplement the measurement and detection of pulse-type partial discharges as covered by Test Method D1868, by measuring the sum of both pulse and pseudoglow discharges per cycle in terms of their charge and energy.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precaution statements are given in Section 7.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D1711 Terminology Relating to Electrical Insulation

D1868 Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems

2.2 *IEEE Documents*[3]

IEEE 286 Recommended Practice for Measurement of Power Factor and Power Factor Tip-up for Rotating Machine Stator Coil Insulation

IEEE 1434 Guide to the Measurement of Partial Discharges in Rotating Machinery

IEEE C57.113 Guide for PD Measurements in Liquid-Filled Power Transformers

IEEE Standard C57.124 Recommended Practice for the Detection of PD and the Measurement of Apparent Charge in Dry-Type Transformers

2.3 *AEIC Documents*[4]

AEIC T-24-380 Guide for Partial Discharge Procedure

AEIC CS5-87 Specifications for Thermoplastic and Cross-linked Polyethylene Insulated Shielded Power Cables Rated 5 through 35 kV, 9th Edition, 1987

## 3. Terminology

3.1 *Definitions:*

3.1.1 *pseudoglow discharge, n*—a type of partial discharge, which takes place within an expanded discharge channel and is characterized by pulses of relatively low magnitude and long rise time.

3.1.1.1 *Discussion*—Pseudoglow discharges occur within a diffused discharge channel, whose emitted glow fills the entire

[1] These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.12 on Electrical Tests.

Current edition approved Jan. 1, 2022. Published February 2022. Originally approved in 1975. Last previous edition approved in 2013 as D3382 – 13. DOI: 10.1520/D3382-22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331, http://www.ieee.org.

[4] Available from The Association of Edison Illuminating Companies (AEIC), 600 N. 18th St, Birmingham, AL 35291, www.aeic.org.

***A Summary of Changes section appears at the end of this standard**

intervening gap or cavity space (**1**).[5] The discharge rate behavior as a function of applied voltage is similar to that of the rapid rise time pulse (spark-type) discharges. The successive pseudoglow discharge pulses occur over the first quadrant of each half cycle and in some gases, notably helium, their magnitude is found to diminish to zero. At this point, a transition to a pulseless glow discharge has been observed. Its occurrence, which is manifest by distortion in the sinusoidal voltage wave, is rare. At discharge inception of a single cavity, the pattern of pseudoglow discharges consists of a single long rise time discharge current pulse in each half-cycle. It has become common practice to refer to this particular type of pattern as that of a glow discharge.

Pseudoglow partial discharges, which occur at low gas pressures, such as in insulating systems of electrical equipment for aerospace applications, have unduly long rise times and a frequency spectrum that falls bellow the bandwidth of conventional partial discharge pulse detectors (**2**). As a consequence, the partial discharge detectors specified in Test Method D1868 are not suitable for this purpose; however Methods A or B of Test Methods D3382 have been found suitable for use.

3.1.2 *pulse discharge, n*—a type of partial-discharge phenomenon characterized by a spark-type breakdown which occurs in a narrow constricted channel.

3.1.2.1 *Discussion*—The resultant detected pulse discharge has a short rise time and its Fourier frequency spectrum has been observed at times to extend as far as 1 GHz. Such a pulse discharge has been readily detected on occasion by conventional pulse detectors, that are generally designed for partial-discharge measurements within the frequency band from 30 kHz to several megahertz. (See also IEEE 1434, IEEE C57.113, IEEE C57.124, AEIC T-24-380, and AEIC CS5-87.)

3.1.3 *pulseless-glow discharge, n*—an uncommon type of partial discharge , whose existence is manifest not by the usual abrupt voltage fall discontinuities in the sinusoidal voltage wave at each discharge epoch but rather by distortions in the waveform.

3.1.3.1 *Discussion*—It is generally found that the pulseless glow region develops only when preceded by a pseudoglow discharge in which the abrupt voltage collapse magnitudes at each discharge have gradually diminished in the limit to zero. The nature of this pulseless glow region is not fully understood, but it is believed to consist of a very weakly ionized gas volume. Further increases in the applied voltage have been found to potentially lead to more complex partial discharge patterns, consisting of regions of pseudoglow, pulseless and pulse type discharges (**3**). Pulse type partial discharge detectors of the type described in Test Method D1868 are not suitable to detect pulseless glow discharges.

3.1.4 See (**1**) and (**3**) for more information on the previous definitions.

3.1.5 For definitions of other terms pertaining to this standard refer to Terminology D1711.

3.2 *Symbols:*

3.2.1 Refer to Annex A1 for symbols for mathematical terms used in this standard.

## 4. Summary of Test Methods

4.1 It is possible to represent the dielectric characteristics of a specimen of solid insulating material by a parallel combination of capacitance and conductance. The values of capacitance and conductance remain practically constant over the useful range of alternating voltage stress at a fixed frequency. If, however, the specimen contains gaseous inclusions (cavities), incremental increases in capacitance and conductance occur as the voltage stress is raised above the value necessary to initiate partial discharges in the cavities. The energy loss in the incremental conductance is considered to be that dissipated by the partial discharges.

4.2 In Test Method A an initial measurement is made of the capacitance and loss characteristic of the specimen at an applied voltage below the discharge inception level. The voltage is then raised to the specified test value and a second measurement made. The energy loss due to partial discharges is calculated from the results of the two measurements.

4.3 In Test Method B a special bridge circuit is balanced at a voltage below the discharge inception level. The voltage is then raised to the specified test value, but the bridge is not rebalanced. Any unbalanced voltage at the detector terminals is displayed in conjunction with the test voltage on an oscilloscope. The oscilloscope pattern approximates a parallelogram, the area of which is a measure of the energy loss due to partial discharges.

## 5. Significance and Use

5.1 These test methods are useful in research and quality control for evaluating insulating materials and systems since they provide for the measurement of charge transfer and energy loss due to partial discharges(**4**) (**5**) (**6**).

5.2 Pulse measurements of partial discharges indicate the magnitude of individual discharges. However, if there are numerous discharges per cycle it is occasionally important to know their charge sum, since this sum is related to the total volume of internal gas spaces that are discharging, if it is assumed that the gas cavities are simple capacitances in series with the capacitances of the solid dielectrics (**7**) (**8**).

5.3 Internal (cavity-type) discharges are mainly of the pulse (spark-type) with rapid rise times or the pseudoglow-type with long rise times, depending upon the discharge governing parameters existing within the cavity. If the rise times of the pseudoglow discharges are too long , they will evade detection by pulse detectors as covered in Test Method D1868. However, both the pseudoglow discharges irrespective of the length of their rise time as well as pulseless glow are readily measured either by Method A or B of Test Methods D3382.

5.4 Pseudoglow discharges have been observed to occur in air, particularly when a partially conducting surface is involved. It is possible that such partially conducting surfaces will develop with polymers that are exposed to partial discharges for sufficiently long periods to accumulate acidic degradation products. Also in some applications, like

[5] The boldface numbers in parentheses refer to a list of references at the end of this standard.