Designation: D 2477 – 96

Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Insulating Gases at Commercial Power Frequencies [1]

This standard is issued under the fixed designation D 2477; 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 This test method covers the determination of the dielectric breakdown voltage and dielectric strength of insulating gases used in transformers, circuit breakers, cables, and similar apparatus as an insulating medium. The test method is applicable only to gases with boiling points below room temperature at atmospheric pressure.

1.2 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 2864 Terminology Relating to Electrical Insulating Liquids and Gases [2]

2.2 *IEEE Standard:*

No. 4 Measurement of Test Voltage in Dielectric Tests [3]

3. Terminology

3.1 *Definitions*—See Terminology D 2864 for definitions.

4. Significance and Use

4.1 The dielectric breakdown voltage and dielectric strength of an insulating gas in a uniform field depends primarily on the molecular structure of the gas. As different gases are mixed either by plan or by contamination, any change in dielectric breakdown voltage and dielectric strength will depend on both the nature and proportion of the individual gases. This test method uses plane and spherical electrodes which provide a nearly uniform field (see Appendix) in the area of electrical discharge. It is suitable for determining the dielectric breakdown voltage and dielectric strength of different gases and mixtures thereof for research and application evaluations and also as a field test. A more complete discussion of the significance of the dielectric strength test is given in the Appendix.

5. Apparatus

5.1 *Electrical Apparatus*:

5.1.1 *Transformer*—The desired test voltage may be most readily obtained by a step-up transformer energized from a variable low-voltage commercial power frequency source. The transformer and controlling element shall be of such size and design that, with the test specimen in the circuit, the crest factor (ratio of maximum to mean effective) of the 60-Hz test voltage does not differ by more than ± 5 % from that of a sinusoidal wave over the upper half of the range of test voltage. The crest factor may be checked by means of an oscilloscope, a sphere gap, or a peak-reading voltmeter in conjunction with an rms voltmeter. Where the waveform cannot be determined conveniently, a transformer having a rating of not less than ½ kVA at the usual breakdown voltage shall be used. Transformers of larger kVA capacity may be used, but in no case should the power frequency short circuit current in the specimen circuit be outside the range of 1 to 10 mA/kV of applied voltage. This limitation of current may be accomplished by using a suitable external series resistor or by employing a transformer with sufficient inherent reactance.

5.1.2 *Circuit-Interrupting Equipment*—The test transformer primary circuit shall be protected by an automatic circuit-breaking device capable of opening (as nearly instantaneously as possible) on the current produced by the breakdown of the test specimen; a circuit breaker that opens within 5 cycles may be used if the short-circuit current as described in 5.1.1 does not exceed 200 mA. A prolonged flow of current at the time of breakdown causes contamination of the gases and damage of the electrodes, thereby affecting the subsequent test results, and increasing the electrode and test cell maintenance and time of testing.

5.1.3 *Voltage-Control Equipment*—The rate of voltage rise shall be ½ kV/s ± 20 %. Voltage control may be secured by a motor-driven variable-ratio-autotransformer. Preference is given to equipment having an approximately straight-line voltage-time curve over the desired operating range. Motor drive is preferred to manual drive because of the ease of maintaining a reasonably uniform rate-of-voltage rise with this test method. The rate-of-voltage rise may be calculated from measurements of the time required to raise the voltage between

[1] This test method is under the jurisdiction of ASTM Committee D-27 on Electrical Insulating Liquids and Gasesand is the direct responsibility of Subcommittee D27.05on Electrical Tests.

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[2] *Annual Book of ASTM Standards*, Vol 10.03.

[3] Available from The Institute of Electrical and Electronic Engineers, Inc., P.O. Box 1331, Piscataway, NJ 08855.

two prescribed values. When motor-driven equipment is used, calibrate the speed control rheostat in terms of rate-of-voltage rise for the test transformer used.

5.1.4 *Voltmeter*—Measure the voltage by a method that fulfills the requirements of IEEE Standard No. 4, giving crest and also (if available) rms values, preferably by means of:

5.1.4.1 A voltmeter connected to the secondary of a separate potential transformer, or

5.1.4.2 A voltmeter connected to a well-designed tertiary coil in the test transformer, or

5.1.4.3 A voltmeter connected to the low-voltage side of the test transformer.

5.1.5 *Accuracy*—The combined accuracy of the voltmeter and voltage divider circuit is not to exceed 5 % at the rate of voltage rise specified in 5.1.3.

5.2 *Evacuation and Filling Apparatus*:

5.2.1 *Vacuum Pump*—The vacuum pump shall have sufficient pumping capacity to be able to evacuate the test cell to a pressure below 1 torr.

5.2.2 *Vacuum and Pressure Gage*—Either a mercury manometer, or one or more gages, capable of measuring pressures below 1 torr and also near atmospheric pressure. The manometer, or vacuum and pressure gages, shall be calibrated in millimetres of mercury (torr).

5.2.3 *Connections*—Vacuum-tight tubing and valves shall be used while evacuating and purging the test cell and filling it with the gas sample.

5.3 *Electrodes and Test Cell:*[4]

5.3.1 The sphere and plane electrodes shall be mounted vertically as shown in Fig. 1. The sphere shall be a precision steel bearing ball 0.75 in. (19.1 mm) in diameter. The plane electrode shall be of brass 1.50 in. (38.1 mm) in diameter. The gap setting shall be 0.100 ± 0.001 in. (2.54 ± 0.025 mm). The tolerance of all dimensions is ±2 %, unless otherwise stated.

5.3.2 The cell shall consist of a borosilicate glass cylinder clamped by flanges to end plates which seal the cell and support the electrodes.[5] The lower plane electrode shall be fixed. The sphere electrode, held in place by a magnet, shall be adjustable by means of a micrometer screw suitably mounted through the top plate. The micrometer screw must be suitable for setting the electrodes to within the specified tolerance. The bottom plate shall have a valved port for evacuation and admission of the sample. If considered more convenient, two ports, one in the top for evacuation and one in the bottom for admission of the sample may be used. The dimensions are shown in Fig. 1.

6. Sampling

6.1 Obtain the gas sample from the gas cylinder or gas-filled equipment through a pressure-reducing regulator valve so that

[4] Detailed drawings of this apparatus are available at a nominal cost from ASTM. Request ADJD2477.

[5] Standard laboratory borosilicate glass pipe and connecting flanges may be used.

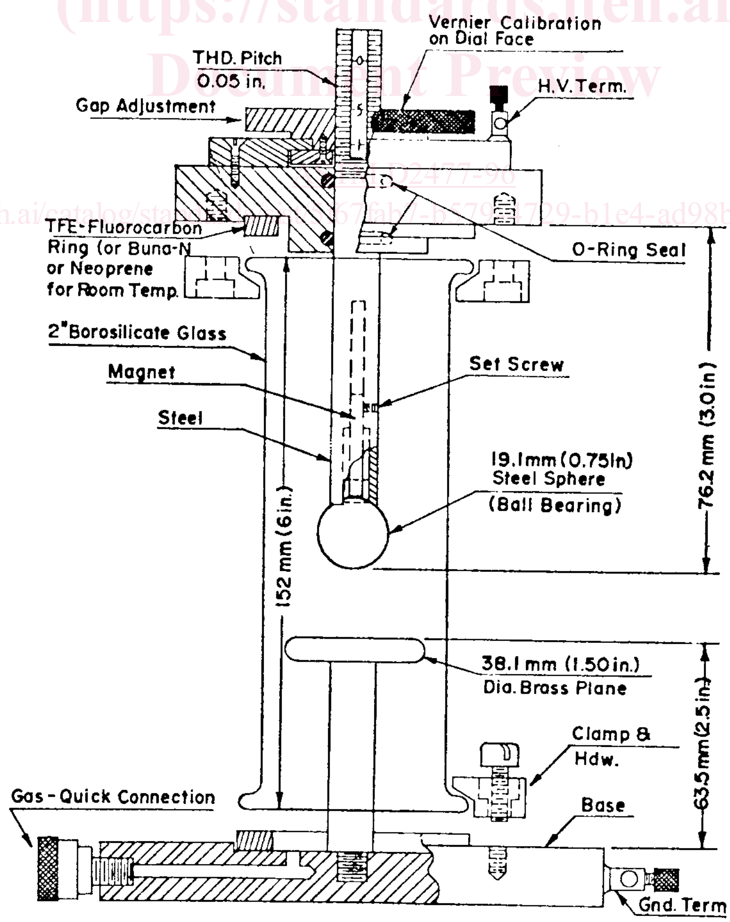

FIG. 1 Test Cell