Designation: D3300 – 12

Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Under Impulse Conditions[1]

This standard is issued under the fixed designation D3300; 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 of insulating oils in a highly divergent field under impulse conditions.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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:*[2]

D923 Practices for Sampling Electrical Insulating Liquids

D2864 Terminology Relating to Electrical Insulating Liquids and Gases

2.2 *IEEE Documents:*

IEEE Standard 4-1995 Techniques for High-Voltage Testing[3]

3. Significance and Use

3.1 This test method is most commonly performed using a negative polarity point opposing a grounded sphere (NPS). The NPS breakdown voltage of fresh unused oils measured in the highly divergent field in this configuration depends on oil composition, decreasing with increasing concentration of aromatic, particularly polyaromatic, hydrocarbon molecules.

3.2 This test method may be used to evaluate the continuity of composition of an oil from shipment to shipment. The NPS impulse breakdown voltage of an oil can also be substantially lowered by contact with materials of construction, by service aging, and by other impurities. Test results lower than those expected for a given fresh oil may also indicate use or contamination of that oil.

3.3 Although polarity of the voltage wave has little or no effect on the breakdown strength of an oil in uniform fields, polarity does have a marked effect on the breakdown voltage of an oil in nonuniform electric fields.

3.4 Transient voltages may also vary over a wide range in both the time to reach crest value and the time to decay to half crest or to zero magnitude. The IEEE standard lightning impulse test (see 2.2) specifies a 1.2 by 50-μs negative polarity wave.

4. Apparatus

4.1 *Impulse Generator,* capable of producing a standard 1.2 by 50-μs full wave adjustable to positive or negative polarity. The generator shall have a nominal voltage rating of at least 300 kV adjustable in 10-kV steps. Generators having a capability of 1000 W·s (1000 J) at 300 kV have been found satisfactory.

4.2 *Voltage-Control Equipment*—The controls shall include a suitable measuring device for predetermining the crest voltage to within ±5 %. A voltage stabilizer is desirable at the input to the d-c power supply used for charging the impulse-generator capacitors.

4.3 *Electrodes:*

4.3.1 The electrodes shall consist of a polished steel or brass sphere of 0.5 in. (12.7 mm) diameter and a steel point. The point may be an ordinary steel phonograph needle with a 0.06 mm ± 20 % radius of curvature of point.[4] Needles with drawn tips are *not* recommended.

[1] This test method is under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.05 on Electrical Test.

Current edition approved Jan. 1, 2012. Published January 2012. Originally approved in 1974. Last previous edition approved in 2006 as D3300 – 00(2006). DOI: 10.1520/D3300-12.

[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 the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331.

[4] The following steel needle has been found satisfactory for this method: Type L Nickel Plated Steel Phonograph Needle.

The sole source of supply of the apparatus known to the committee at this time is Victrola Repair Service, 206 Cliff St., St. Johnsbury, VT, 05819. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

4.3.2 The effect of variation in the radius of curvature of point is subject to further investigation. Both electrodes shall be easily replaceable.

4.4 *Test Cell:*

4.4.1 The test cell shall be made of a material of high dielectric strength and of such dimensions that the electrical breakdown is restricted to the electrode gap. Test cell materials shall resist attack by, and be insoluble in, any of the cleaning or test liquids used. Test cells such as those shown in Fig. 1 and Fig. 2 have been found satisfactory.

4.4.2 The sphere electrode shall be rigidly fixed and the point electrode mounted such that the gap may be adjusted from zero to the required value.

5. Sampling

5.1 Obtain a sample of the liquid to be tested using appropriate ASTM sampling apparatus in accordance with Practices D923.

6. Adjustments and Care of Electrodes and Test Cell

6.1 *Electrode Spacing:*

6.1.1 For the cell shown in Fig. 1, reduce the electrode gap to zero spacing. Proceed very carefully to avoid damaging the point. The point of contact shall be established electrically with an ohmmeter. Open the gap to the specified spacing using a dial micrometer or other suitable method.

6.1.2 For the cell shown in Fig. 2, the gap may be set with a go-no-go gage.

6.1.3 The gap spacings shall be 1.0 in. (25.4 mm) for point-to-sphere and 0.15 in. (3.8 mm) for sphere-to-sphere electrode configuration.

6.2 *Cleaning*—Degrease the cell and electrodes by rinsing them with reagent grade petroleum ether, washing with detergent and hot water, rinsing thoroughly in hot tap water, and then rinsing them with distilled water. Dry the cell and hardware in an oven for 2 h at approximately 105 to 110°C, remove, and store in a desiccator until needed.

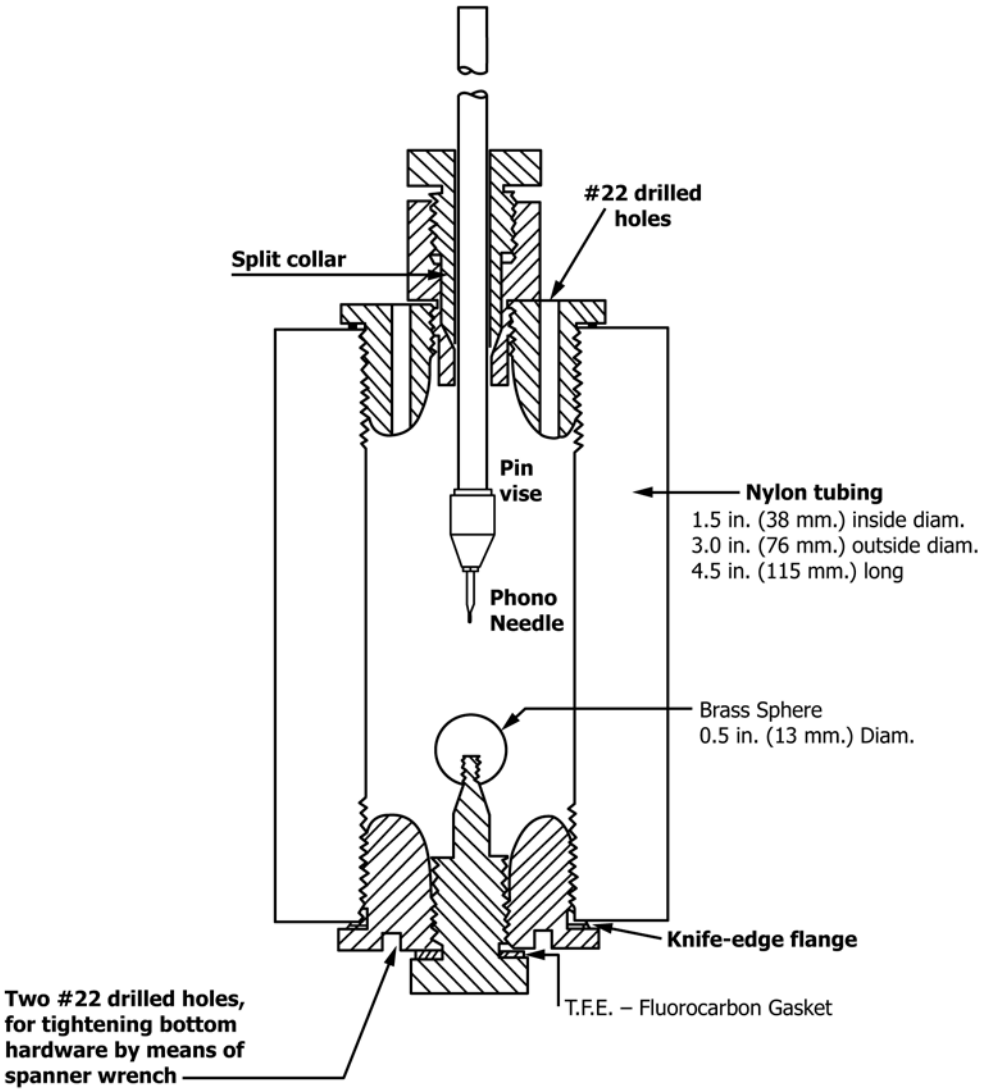

FIG. 1 Test Cell

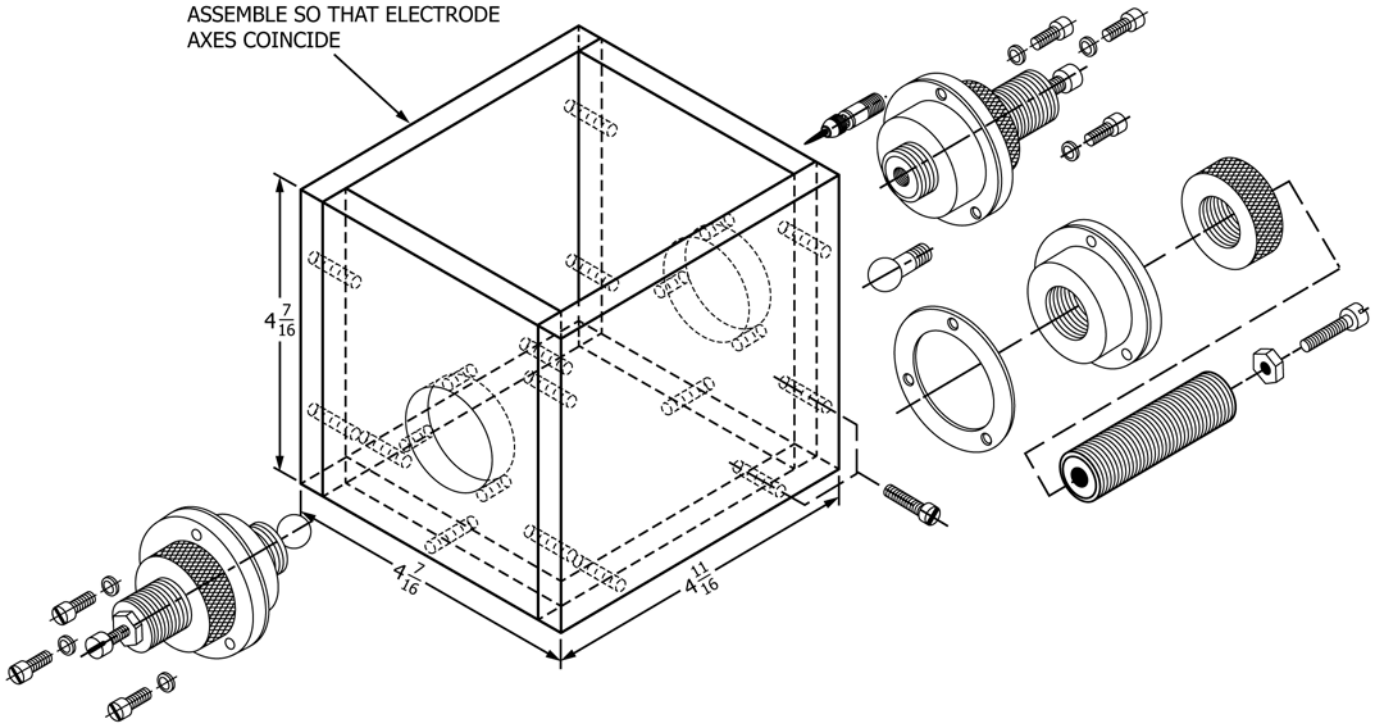

FIG. 2 Test Cell

6.3 *Daily Use*—Use new or polished sphere electrodes at the beginning of each day's testing. Discard the point electrode and replace it after each breakdown; replace the sphere electrodes after every five breakdowns when testing point-to-sphere. More frequent replacement may be necessary when testing sphere-to-sphere. Sphere electrodes may be cleaned and polished for reuse in point-to-sphere testing. However, the use of polished spheres is not recommended for sphere-to-sphere testing. When not in use, clean and store the cell in accordance with 6.2.

7. Test Temperature

7.1 Conduct the tests with the specimen at room temperature as defined in Terminology D2864. Testing liquids at temperatures lower than that of the room may give variable and unsatisfactory results. Record the test temperature.

8. Procedure

8.1 Set the electrode spacing to the desired value.

8.2 Rinse the test cell with a portion of the sample and discard this liquid. Slowly fill the cell with the test liquid, being careful to avoid entraining air bubbles. Allow it to set undisturbed for 2 min prior to testing.

8.2.1 For the test cell shown in Fig. 1, unscrew the upper electrode holding assembly to fill it with the sample oil while holding the cell at an angle to prevent splashing, which could create air bubbles. Screw the top portion down until the metal flange seats firmly.

8.3 Connect the fixed electrode to ground and the movable electrode to the impulse generator.

8.4 Apply the impulse wave of specified polarity starting approximately 40 kV below the expected breakdown level. Apply three impulse waves at each voltage level. Allow a minimum of 30 s between each test.

8.5 Increase the voltage level in steps of 10 kV or less until breakdown occurs, noting the crest voltage level at breakdown. It is necessary to have at least three withstand levels prior to breakdown.

8.5.1 Measure the breakdown voltage using techniques specified in IEEE Standard 4.

8.6 After each breakdown, change the point electrode and follow 8.1 and 8.2.

8.7 Make five breakdown tests on five specimens from the same sample. Maintain at least two significant digits in the results.

8.8 *Criterion for Statistical Consistency:*

8.8.1 Calculate the mean and standard deviation of the five breakdowns as follows:

$$\bar{X} = n^{-1}\left(\sum_{i=1}^{n} X_i\right) \quad (1)$$

where:

$\bar{X}$ = mean of the five individual values,
X_i = ith breakdown voltage, and
n = number of breakdowns either 5 or 10.

8.8.2 Using the impulse crest voltage breakdown values determined in 8.7, calculate the mean value using the equation in 8.8.1. Determine that the range of the five breakdowns is no greater than 33.3 % of the mean value. If the range is

acceptable, report this mean value as the impulse breakdown voltage. If the range exceeds 33.3 % of the mean value of the five breakdowns, then conduct five additional breakdowns and obtain a new mean breakdown value for the ten breakdowns. Determine the range of the ten breakdowns and if the range is less than 54.6 % of the mean of the ten breakdowns, report this mean value as the impulse breakdown voltage. If the allowable range is exceeded, the error is too large. Investigate the cause of the error and repeat the tests.

NOTE 1—The criterion for statistical consistency specified apply only to negative polarity waves if point-to-sphere electrodes are used.

8.9 It may be necessary to partially immerse the test cell in oil to prevent external flashover. This is necessary with the cell shown in Fig. 1.

8.10 If a second insulating liquid is to be tested, thoroughly clean the test cell in accordance with 6.2.

9. Report

9.1 Report the following information:

9.1.1 Sample identification,

9.1.2 Electrode configuration, polarity, and electrode spacing,

9.1.3 Impulse crest voltage for each breakdown (do not discard any data),

9.1.4 Wave shape identification,

9.1.5 Starting voltage crest level, voltage steps, and highest voltage withstand level,

9.1.6 Mean impulse breakdown value,

9.1.7 Sample water content,

9.1.8 Barometric pressure, and

9.1.9 Date of test.

10. Precision and Bias

10.1 This precision statement applies to new oil received from a supplier. Using the point-to-sphere electrode configuration, the following precision statements are applicable to both positive and negative polarity:

10.1.1 *Single Operator Precision* —The single operator % coefficient of variance of a single test result comprised of five breakdowns has been found to be 3.9 %. Therefore, results of two properly conducted tests by the same operator on the same sample should not differ by more than 11 % of the average of the two tests. The maximum allowable range for the series of five breakdowns comprising the test result should be less than 33.3 % of the average of the five breakdowns. In the case where a ten-breakdown average is used, the maximum allowable range of the individual tests comprising the result should be less than 54.6 % of the average of the ten breakdowns.

10.1.2 *Multilaboratory Precision* —The multilaboratory % coefficient of variance has been found to be 5.43 %. Therefore, results of two properly conducted tests in different laboratories on the same sample of oil should not differ by more than 15.4 % of the average of the two results.

10.2 No statement can be made about the bias of this test method because a standard reference material is not available.

11. Keywords

11.1 dielectric breakdown; impulse voltage; insulating oils