Designation: D3300 – 20

# Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids 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 liquids in a highly divergent field under impulse conditions and has been found applicable to liquids of petroleum origin, natural and synthetic esters.

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

1.4 *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]

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 needle or a sharp defined point to an opposing grounded sphere (NPS). The NPS breakdown voltage of fresh unused liquids measured in the highly divergent field in this configuration depends on the insulating liquid composition, decreasing with increasing concentration of aromatic, particularly polyaromatic, hydrocarbon molecules in liquids of petroleum origin and decreasing with ester molecular structure, either natural or synthetic.

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



3.3 Although polarity of the voltage wave has little or no effect on the breakdown strength of an insulating liquid in uniform fields, polarity does have a marked effect on the breakdown voltage 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:*

[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 Nov. 1, 2020. Published November 2020. Originally approved in 1974. Last previous edition approved in 2012 as D3300 – 12. DOI: 10.1520/D3300-20.

[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.

4.3.1 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.

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 insulating 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.

[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.

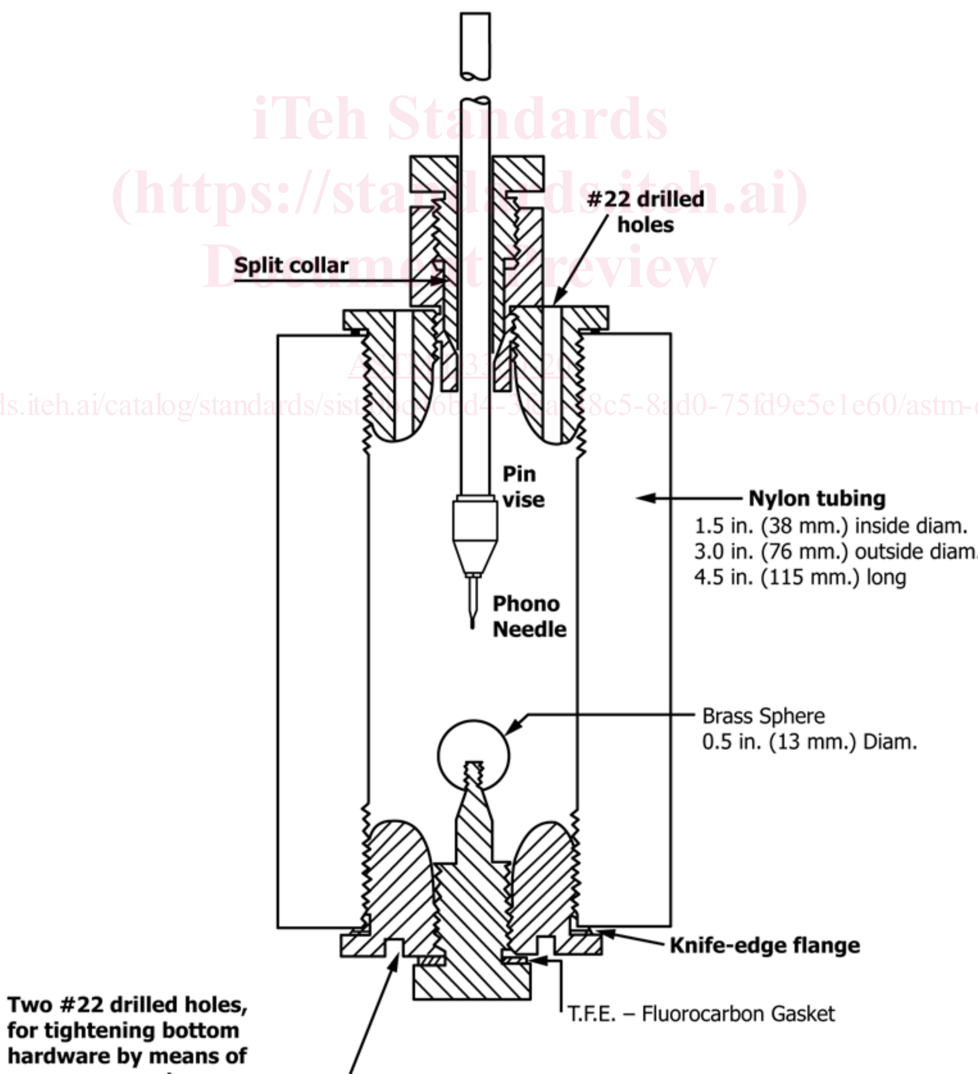


FIG. 1 Test Cell

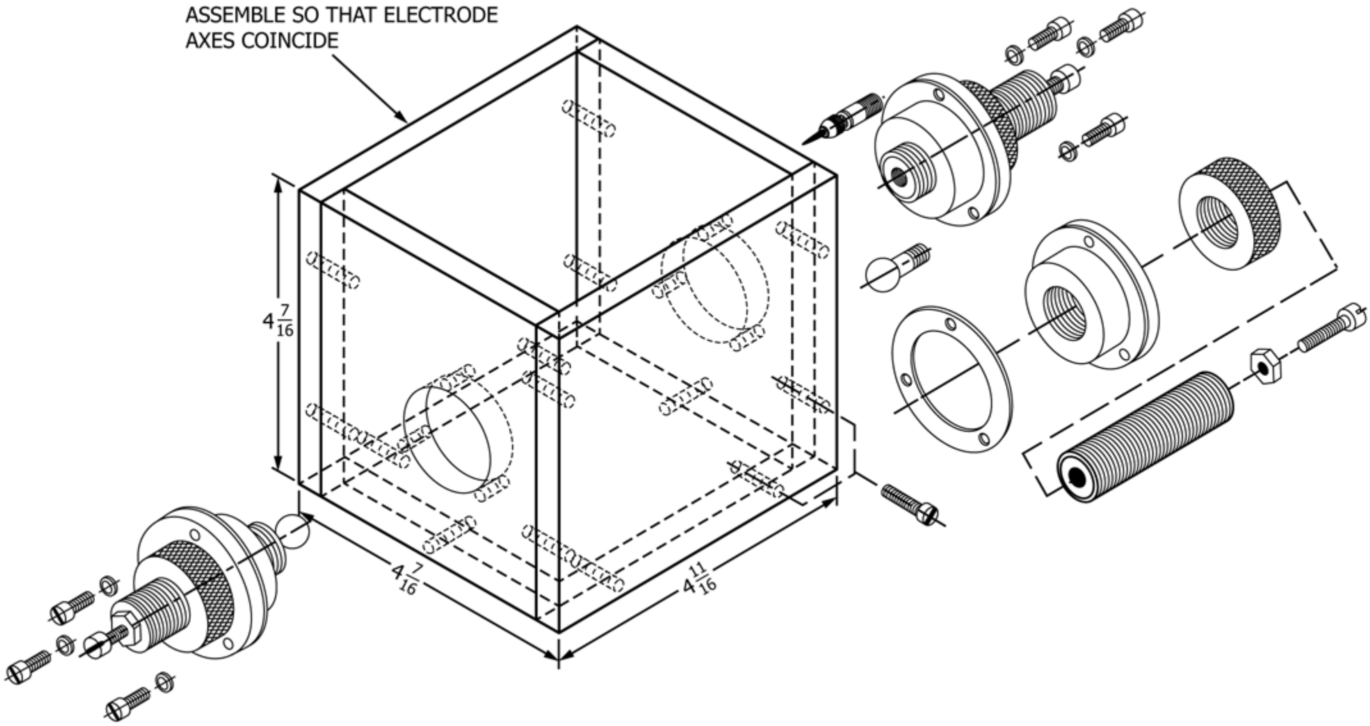


FIG. 2 Test Cell



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 or clean with acceptable hydrocarbon solvent such as heptane, hexane or pentane. Allow solvent to evaporate or place into oven to dry. Keep cell protected from outside contaminants.

6.3 *Daily Use*—Use new or polished sphere electrodes at the beginning of each day's testing. Discard the point or needle electrode and replace it after each breakdown. After 10 breakdowns, if possible, rotate the sphere 180° to reveal a clean surface or polish it and then replace the sphere after the next set of breakdowns. 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 at least 15 min prior to testing, especially for higher viscosity liquids such as esters. If testing liquid of petroleum origin, the set time after pouring the test specimen can be reduced to 5 min.

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. Allow any bubbles to dissipate before testing.

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 1 min relaxation time 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 (Note 1). It is necessary to have at least three withstand levels prior to breakdown for a valid test sequence.

NOTE 1—For liquids of petroleum origin, initial test voltages can start at 120 kV. For natural and synthetic ester liquids, a lower start voltage is necessary, such as 80 to 90 kV.

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

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