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An American National Standard

Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics (Oxygen Index)[1]

This standard is issued under the fixed designation D 2863; 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.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method describes a procedure for measuring the minimum concentration of oxygen in a flowing mixture of oxygen and nitrogen that will just support flaming combustion.

1.2 This test method has been found applicable for testing various forms of plastics materials including film and cellular plastic.

1.3 **Warning:** During the course of combustion, gases or vapors, or both, are evolved which may be hazardous to personnel. **Precaution**—Adequate precautions should be taken to protect the operator.

NOTE 1—Although this test method has been found applicable for testing other materials, the accuracy of this test method has not been determined for these materials, or for specimen geometries and test conditions outside those recommended herein.

NOTE 2—Although this test method and ISO 4589-2 differ in approach or detail, data obtained using either are technically equivalent.

1.4 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazards statements are given in 1.3.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 1071 Method for Measurement of Gaseous Fuel Samples[3]

D 2444 Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)[4]

2.2 *ISO Standard:*

ISO 4589–2 Plastics-Determination of Burning Behavior by Oxygen Index (O.I.)—Part 2: Ambient Temperature Test[5]

3. Terminology

3.1 *Definition:*

3.1.1 *oxygen index*—the minimum concentration of oxygen, expressed as volume percent, in a mixture of oxygen and nitrogen that will just support flaming combustion of a material initially at room temperature under the conditions of this test method.

4. Summary of Test Method

4.1 The minimum concentration of oxygen in a mixture of oxygen and nitrogen flowing upward in a test column that will just support combustion is measured under equilibrium conditions of candle-like burning. The equilibrium is established by the relation between the heat generated from the combustion of the specimen and the heat lost to the surroundings as measured by one or the other of two arbitrary criteria, namely, a time of burning or a length of specimen burned. This point is approached from both sides of the critical oxygen concentration in order to establish the oxygen index.

5. Significance and Use

5.1 This test method provides for the measuring of the minimum concentration of oxygen in a flowing mixture of oxygen and nitrogen that will just support flaming combustion of plastics. Correlation with burning characteristics under actual use conditions is not implied.

6. Apparatus

6.1 *Test Column,* consisting of a heat-resistant glass tube of 75-mm minimum inside diameter and 450-mm minimum height. The bottom of the column or the base to which the tube is attached shall contain noncombustible material to mix and distribute evenly the gas mixture entering at this base. Glass beads 3 to 5 mm in diameter in a bed 80 to 100 mm deep have been found suitable (an example is shown in Fig. 1).

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[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties (Section D20.30.03).

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[2] *Annual Book of ASTM Standards,* Vol 08.01.

[3] *Annual Book of ASTM Standards,* Vol 05.05.

[4] *Annual Book of ASTM Standards,* Vol 08.04.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

TABLE 1 Specimen Dimensions, mm

Type	Plastic Form	Width	Thickness	Length
A	Physically self-supporting	6.5 ± 0.5	3.0 ± 0.5	70 to 150
B	Alternate for self-supporting flexible plastics	6.5 ± 0.5	2.0 ± 0.25	70 to 150
C	Cellular plastic	12.5 ± 0.5	12.5 ± 0.5	125 to 150
D	Film or thin sheet	52 ± 0.5	as received	140 ± 5

TABLE 2 Precision Results

Type	Laboratory-to-Laboratory Standard Deviation	Within Laboratory Standard Deviation
B	0.5 to 1.1	below 0.2
C	0.4 to 1.5	0.1 to 0.3 (est.)
D	0.5 to 1.4	below 0.6

NOTE 3—A column with a 95-mm inside diameter and 210 mm high with a restricted upper opening (diameter = 50 mm) has been found to give equivalent results.

NOTE 4—It is helpful to place a wire screen above the noncombustible material to catch falling fragments and aid in keeping the base of the column clean.

6.2 *Specimen Holder*—Any small holding device that will support the specimen at its base and hold it vertically in the center of the column is acceptable. For physically self-supporting specimens, a typical arrangement (Fig. 1) consists of a laboratory thermometer clamp inserted into the end of a glass tube held in place by glass beads or otherwise firmly supported. For other forms, such as film and thin sheet, the frame shown in Fig. 2 shall be used and held in place by the above tube. The test specimen must be held securely along both upright edges by the frame, using clips or other means.

6.3 *Gas Supply*—Commercial grade (or better) oxygen and nitrogen shall be used. If an air supply is used with oxygen or nitrogen, it must be clean and dry.

6.4 *Flow Measurement and Control Devices*—Suitable flow measurement and control devices shall be available in each line that will allow monitoring the volumetric flow of each gas into the column within 1 % in the range being used. After the flow is measured in each line, the lines should be joined to allow the gases to mix before being fed into the column.

NOTE 5—One satisfactory flow control system consists of calibrated jeweled orifices[6] pressure regulating devices, and gas gages. An equally satisfactory system consists of needle valves and rotameters meeting the requirements of 6.4.

6.5 *Ignition Source*—The igniter shall be a tube with a small orifice (1 to 3 mm in diameter) having a hydrogen, propane, or other gas flame at the end that can be inserted into the open end of the column to ignite the test specimen. A suitable flame may be from 6 to 25 mm long.

6.6 *Timer*—A suitable timer capable of indicating at least 10 min and accurate at 5 s shall be used.

6.7 *Soot, Fumes, and Heat Removal*—To ensure the removal of toxic fumes, soot, heat, and other possible noxious products, the column shall be installed in a hood or other facilities providing adequate exhaust.

[6] Andersen, J. W., and Friedman, R., "An Accurate Gas Metering System for Laminar Flow," RSINA, Vol 20, 1949, p. 61.

NOTE 6—If soot-generating specimens are being tested, the glass column becomes coated on the inside with soot and should be cleaned as often as necessary for good visibility.

7. Test Specimens

7.1 Cut a sufficient number of specimens (normally 5 to 10) from the material to be tested. Use Table 1 to determine specimen dimensions.

7.1.1 Test the specimens in the as-received condition unless otherwise agreed upon.

7.1.2 Moisture content of some materials has been shown to affect the oxygen index. Where a material is suspected to be affected by retained moisture, condition the specimens in accordance with Procedure A of Practice D 618.

NOTE 7—If nonstandard size specimens are used, a difference in oxygen index may result.

7.1.3 For Type C specimens, make comparisons only between materials of similar densities.

NOTE 8—For certain types of cellular plastics, the direction of anisotropy may have an effect and should be evaluated unless a particular direction has previously been agreed upon.

7.1.4 Test Type D materials in the as-received thickness, but make comparisons only between material of the same thickness.

7.1.5 The edges of the specimens shall be relatively smooth and free from fuzz or burrs of material left from machining.

8. Procedure

8.1 Calibrate the flow-measuring system using a water-sealed rotating drum meter (wet test meter) in accordance with Method D 1071 or by equivalent calibration devices. It is recommended that this calibration be repeated at least every six months.

NOTE 9—One step in the calibration should be to check carefully for leaks at all joints.

8.2 The test shall be conducted at room temperature conditions in accordance with Practice D 618.

8.3 Clamp the specimen vertically in the approximate center of the column with the top of the specimen at least 100 mm below the top of the open column.

NOTE 10—If a restricted opening column is used (see Note 3), the top of the specimen should be at least 40 mm below the opening.

8.4 Select the desired initial concentration of oxygen based on experience with similar materials. If there is no experience with similar material, light a specimen in the air and note the burning. If the specimen burns rapidly, start at a concentration of about 18 %, but if the specimen goes out, select a concentration of about 25 % or higher depending on the difficulty of ignition and time of burning.

8.5 Set the flow valves so that the desired initial concentration of oxygen is flowing through the column. The gas flow rate in the column shall be 4 ± 1 cm/s as calculated at