Designation: D4883 – 18

Standard Test Method for Density of Polyethylene by the Ultrasound Technique[1]

This standard is issued under the fixed designation D4883; 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 density of polyethylene through the utilization of ultrasound equipment.

1.2 This test method is based on the distinct behaviors of the amorphous and crystalline phases of polyethylene in response to ultrasound. Polyethylene shall be viewed as a composite structure where high-density crystalline regions are connected by lower-density amorphous material. The ratio of crystalline to amorphous material determines the final density of the material. The amorphous and crystalline phases exhibit very distinct behaviors with regard to the propagation of sound waves. The propagation characteristics in the composite will depend on the relative amount of the two phases (the degree of crystallinity).

1.3 Inorganic materials increase density as measured by Test Methods D792 and D1505, but they have little or no effect on ultrasonic density. The ultrasonic measurement is basically a base resin density.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.*

NOTE 1—There is no known ISO equivalent to this standard.

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]

D618 Practice for Conditioning Plastics for Testing

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

D1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

D4703 Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets

D4976 Specification for Polyethylene Plastics Molding and Extrusion Materials

E494 Practice for Measuring Ultrasonic Velocity in Materials

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E2935 Practice for Conducting Equivalence Testing in Laboratory Applications

3. Terminology

3.1 *Definitions*—The definitions given in Terminology D883, as well as in Test Methods D792 and D1505, are applicable to this test method.

4. Significance and Use

4.1 The density of polyethylene is a conveniently measurable property which is frequently useful as a means of following physical changes in a sample, as an indication of uniformity among samples, and as a means of identification.

4.2 This test method is designed to yield results with a precision of ±0.08 % or better.

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.70 on Analytical Methods.

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[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.

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

5. Apparatus

5.1 Use an instrument which utilizes a sonic technique to evaluate the density of polyethylene. The DS 500 instrument[3] utilizes a sonic sensing head (transducer) which measures the velocity of sound in a molded specimen. Because sonic velocity is positively correlated to density in polyethylene, a measurement of this velocity is used to determine specimen density. The information from this transducer then must be electronically evaluated; in the DS 500 instance this is done with a computer, and the result is reported either through a display or printout.

5.2 Equipment specified in Test Method D1505.

5.3 Equipment specified in Test Methods D792.

5.4 Equipment specified in Practice D618.

5.5 Equipment specified in Practice D4703, Annex 1.

NOTE 2—The equipment specified in 5.2 or 5.3 is required for the initial calibration of the sonic equipment. Once the equipment is calibrated, this additional equipment is no longer required. It is recommended that the standards used for the initial calibration be retained for any additional calibration when needed. It is also recommended that one or more of the calibration standards be evaluated on a routine basis for calibration verification. The absolute accuracy of data produced will not be better than this initial calibration and continued verification. Samples for initial calibration are available from various sources (such as the National Institute of Standards and Technology (NIST), resin manufacturers, and so forth).

6. Test Specimens and Materials

6.1 Test plaques shall be prepared in accordance to the molding procedure specified in Practice D4703, Annex 1, Procedure C.

6.2 The test specimen shall consist of a piece of the material under test. Mold or cut the sample specimen to the specified dimensions. When a sample piece is cut from a molded plaque, care must be taken to avoid change in density resulting from compressive stress.

	Specimen Dimensions, mm (in.)	
Length	80–100	(3.15–3.94)
Width	35–45	(1.38–1.77)
Thickness	1.5–3	(0.06–0.12)

A minimum thickness of 1.5 mm is required to provide proper specimen stiffness and for the instrument to distinguish signal from echo. A maximum thickness of 3.0 mm is the thickness which the instrument sample holder allows.

6.3 A sample thickness of 1.9 ± 0.2 mm shall be used in order to be in compliance with Specifications D1248, D3350 and D4976 for Polyethylene Plastics.

6.4 Use the same plaque thickness for calibration samples and testing samples.

6.5 The specimen shall be free of foreign matter and voids and shall have no surface marks or other surface flaws.

6.6 Use demineralized water for the testing equipment's water bath.

7. Conditioning

7.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required. In cases of disagreement, specimens shall be conditioned at 23 ± 1°C and 50 ± 5 % relative humidity.

7.2 *Test Conditions*—Conduct tests in instrument's water bath at a temperature of 23 ± 2°C (73.4 ± 3.6°F) unless otherwise specified. In cases of disagreement, the tolerances shall be ±1°C (1.8°F).

7.3 Testing in normal plant operations frequently calls for testing before the sample has become fully conditioned. It will be necessary to establish a correlation between a predetermined conditioning time (that is, 30 minutes in a water bath at 23 ± 2°C (73.4 ± 3.6°F)) and measured density and the measured density when fully conditioned in accordance with Procedure A of Practice D618 and to apply the correlation to obtain the predicted density. Retain the sample and retest once the sample has been fully conditioned. If the measured density of the retained specimen does not fall within ±0.0004 of the predicted density then the conditioning time will need to be adjusted and a new correlation between measured and predicted density will need to be created.

8. Calibration

8.1 Refer to instrument's operating manual for details on operating the instrument.

8.2 The cleanliness of the demineralized water used in the water bath shall be monitored and the water be replaced on a regular basis to avoid erroneous testing results.

8.3 Resins to be utilized for calibration shall be molded into plaques in accordance with Practice D4703 Annex 1, Procedure C and be conditioned in accordance with Procedure A of Practice D618. Specimens to be used for calibration shall undergo full conditioning.

8.4 Determine the density value of the specimen in accordance with Test Methods D792 or D1505. Conduct the determinations as specified by the test methods, that is, two determinations for D792 or three determinations for D1505. Calculate a mean density value for the sample plaque.

8.5 Evaluate each plaque on ultrasound instrument and use the mean density obtained in 8.4 for calibration. Use either the same sample plaque used in 8.4 or another plaque molded from the same resin sample. This is considered as one data point. Six data points are recommended per resin sample.

8.6 The absolute accuracy of the data acquired is directly correlated to the accuracy of the calibration curve. This curve shall be made up of as many data points as possible and cover the entire density range of interest. A minimum of 30 data points per calibration curve is required. More data points are recommended if a broad density range is to be measured. These data points shall be evenly spread throughout the density range.

[3] The sole source of supply of the DS 500 instrument known to the committee at this time is Deguise Technologies, Inc., 11755 Rue de Guise, Quebec City (PQ), Canada, G2A 3K6; Phone: (418) 845-9064; (email:jraymond@b2b2c.ca). 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.