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Standard Specification for Polyolefin Monofilaments[1]

This standard is issued under the fixed designation D3218; 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 specification covers polyolefin monofilament yarn materials, and test methods for standard polyolefin monofilaments. While designed primarily for testing standard polyolefin monofilaments, many of the procedures can be used, with little or no modification, for other polyolefin monofilaments. However, testing on non-standard polyolefin monofilaments should be conducted with caution. See 3.1 for a definition of standard polyolefin monofilament.

1.2 Only on condition that interlaboratory precision data are available for the specific procedure is any test method described, or referenced in this specification, recommended for acceptance testing of commercial shipments of polyolefin monofilaments.

1.3 The specification for polyolefin raw materials appears in Section 4.

1.4 The test methods for individual properties appear in the following sections:

Property	Section
Breaking Force	10
Breaking Tenacity	10
Elongation	10
Gloss	13
Hot Water Shrinkage	14
Initial Modulus	10
Polyolefin-Material Cleanliness	17
Resistance to Ultraviolet Radiation	15
Stability to Thermal Oxidation	16
Tensile Properties	10
Thickness	12
Width	11
Yarn Number	9

NOTE 1—In most instances, the suitability of these procedures for polymeric yarns in general, and polyolefin monofilaments in particular, is already accepted in commercial transactions (see 6.1).

1.5 The values stated in SI units are to be regarded as standard; the values in English units are provided as information only and are not exact equivalents.

1.6 The following safety hazards caveat pertains only to the test methods described in this specification: *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems, 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]

D123 Terminology Relating to Textiles

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]

D1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

D1776 Practice for Conditioning and Testing Textiles

D1907 Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method

D1921 Test Methods for Particle Size (Sieve Analysis) of Plastic Materials

D2146 Specification for Propylene Plastic Molding and Extrusion Materials (Withdrawn 1986)[3]

D2256 Test Method for Tensile Properties of Yarns by the Single-Strand Method

D2258 Practice for Sampling Yarn for Testing

D2259 Test Method for Shrinkage of Yarns

D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications

D4101 Specification for Polypropylene Injection and Extrusion Materials

D4849 Terminology Related to Yarns and Fibers

E203 Test Method for Water Using Volumetric Karl Fischer Titration

G26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials (Discontinued 2001) (Withdrawn 2000)[3]

[1] This specification is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarns and Fibers.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

2.2 *Other Documents:*

Federal Test Method Standard No. 141a, Sept. 1, 1965, Section 6000, Method 6101 "60-Degree Specular Gloss"[4]

Technical Report 24— "A Rapid Method for the Determination of Moisture in Pigmented Polyethylene Coating Materials," Eastman Chemical Products Inc.[5]

3. Terminology

3.1 For all terminology relating to D13.58, Yarns and Fibers, refer to Terminology D4849.

3.1.1 The following terms are relevant to this standard: breaking force, draw ratio, drawing, elongation at break, gloss, heat shrinkage, initial modulus, monofilament, polyolefin, resistance to ultraviolet radiation, polyolefin-material cleanliness, stability to thermal oxidation, standard polyolefin monofilament, tape yarn.

3.2 For all other terminology related to textiles, refer to Terminology D123.

4. Polyolefin-Monofilament Raw Materials

4.1 *Polyolefin Monofilaments* shall be made from either polypropylene as specified in 4.2, or polyethylene as specified in 4.3.

4.2 *Polypropylene* shall meet the requirements for Group 1 or 2, as detailed in Specification D4101.

4.3 *Polyethylene* shall have a *density* higher than 940 kg/m^3 and shall meet the requirements for polyethylene plastics, as detailed in Specification D1248.

4.4 *Flow Rate* of the polyolefin materials shall be agreed upon by the purchaser and the supplier, and shall be determined as directed in either Specification D1248 or D2146, whichever is applicable.

4.5 *Particle Size*—Shipments of polyolefin raw materials may be rated for particle size. When specified, particle size shall be determined by the multi-sieve analysis described in Method A of Test Methods D1921.

4.6 *Polyolefin-Material Cleanliness*—Although resin cleanliness is not a structural or chemical characteristic, shipments may be advisable to rate shipments for the amount of foreign matter in, or on, delivered polyolefin raw materials.

4.6.1 When specified, polyolefin-material cleanliness shall be determined by the procedure described in Section 17 of this specification.

4.7 *Moisture Content*—Some monofilament-extrusion processes may be sensitive to slight amounts of moisture, inherently or otherwise present in the polyolefin raw material. In such cases, shipments may be rated for moisture content.

4.7.1 *Superficial Moisture Content* of polyolefin materials, when specified, shall be determined in accordance with the Procedure for Insoluble Solids in Test Method E203.

4.7.2 *Total Moisture Content,* when specified, shall be determined in accordance with a method to be agreed upon between the purchaser and the supplier. The technique illustrated in Eastman Technical Report 24,[6] based on gas chromatography of vaporized moisture, is an acceptable analytical approach.

TEST METHODS

5. Summary

5.1 Summaries of the various testing procedures are included in the referenced test methods, or in pertinent sections of this specification.

6. Significance and Use

6.1 *Acceptance Testing*—The test methods in Specification D3218 for the determination of the properties of polyolefin monofilaments are considered satisfactory for acceptance testing of commercial shipments of polyolefin monofilaments, unless specified in the individual test method. These test methods are the best available and are used extensively in the trade.

6.1.1 If there are differences or practical significance between reported test results for two laboratories (or more) comparative test should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, test samples that are as homogeneous as possible, drawn from the material from which the disparate test results were obtained, and randomly assigned in equal numbers to each laboratory for testing. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found either its cause must be found and corrected or future test results for that material must be adjusted in consideration of the known bias.

7. Sampling and Number of Specimens

7.1 Take samples as directed in the applicable material specification, or as agreed upon by the purchaser and the supplier. In the absence of an applicable material specification, or other agreement, take a lot sample and laboratory samples as directed in Practice D2258.

NOTE 2—An adequate specification or other agreement between the purchaser and the supplier requires taking into account variability between shipping units, between packages, or ends within a shipping unit, and between specimens from a single package so as to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 The required number of specimens is covered in the referenced methods, or in the pertinent sections.

8. Conditioning

8.1 Expose the specimens in the standard atmosphere for testing textiles, as defined in Practice D1776; except that it is not essential to control humidity.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[5] Available from Eastman Chemical Products, Inc., Subsidiary of Eastman Kodak Co., P. O. Box 431, Kingsport, TN 37662.

[6] The Gardner Automatic Photometer Unit, Model AUX-3, available from Gardner Laboratory, Inc., P. O. Box 5728 (5221 Landy Lane), Bethesda, MD 20014, or its equivalent, has been found satisfactory for this method.

9. Yarn Number

9.1 *Procedure*—Determine the direct yarn number in tex or denier to three significant figures as directed in Option 1 of Test Method D1907.

9.2 *Report:*

9.2.1 State that the specimens were tested as directed in Section 9 of Specification D3218. Describe the material or product sampled and the method of sampling used.

9.2.2 Report the direct yarn number in tex, or in denier.

10. Tensile Properties

10.1 *Apparatus*—Tensile testing machine of a type as specified in Test Method D2256. All types of tensile machines described in Test Method D2256 are adequate to test polyolefin monofilaments with a draw ratio between 5:1 and 7:1. Polyolefin monofilaments with draw ratios outside this range cannot be tested with assurance of correct results, by all tensile machines specified in Test Method D2256.

10.2 *Procedure*—Determine the breaking force, the breaking tenacity, and the elongation of adequately conditioned polyolefin monofilaments, using configuration A, condition 1 of Test Method D2256.

10.3 *Report:*

10.3.1 State that the specimens were tested as directed in Section 10 of Specification D3218. Describe the material or product sampled and the method of sampling used.

10.3.2 Report the following information for each laboratory sampling unit and for the lot:

10.3.2.1 Breaking force,

10.3.2.2 Breaking tenacity,

10.3.2.3 Elongation at break, as a percentage of the nominal gage length, and

10.3.2.4 Initial modulus.

11. Width

11.1 *Scope*—This test method covers the measurement of the width of polyolefin monofilaments, by means of a calibrated microscope.

11.2 *Summary of Test Method*—A specimen is placed on the microscope stage and is viewed under a magnification of 25×. The width of the specimen is measured using a reticle scaled eyepiece or filar micrometer eyepiece.

11.3 *Apparatus:*

11.3.1 Microscope designed for a magnification of 25×. With an eyepiece having a calibrated linear grid.

11.4 *Calibration of Apparatus*—Adjust the microscope, to secure the design magnification of 25×, and measure the total eyepiece scale using a stage micrometer, graduated in micrometers or mils. Calculate the conversion factor, F, to convert the eyepiece units to mils, using Eq 1:

$$F = M/N \quad (1)$$

where:

M = stage micrometer readings, in micrometers (mils), and
N = corresponding number of units in the eyepiece grid.

11.5 *Procedure:*

11.5.1 Adjust the microscope to the design magnification of 25×.

11.5.2 Place a specimen of the monofilament on the microscope stage, and set the scale of the eyepiece perpendicular to the long axis of the monofilament specimen.

11.5.3 Measure the width of the specimen monofilament, to the nearest eyepiece division. Repeat the width measurement three times, on different segments of the same specimen. Record the three width measurements.

11.5.4 Test four monofilament specimens.

11.6 *Calculation:*

11.6.1 Calculate the average width of the four specimens, in micrometers or mils, to three significant digits, using Eq 2:

$$\bar{X} = \left(\sum X\right)F/12 \quad (2)$$

where:

$\bar{X}$ = average width of the four monofilaments,
$\sum X$ = sum of the twelve observed individual measurements, in eyepiece units, and
F = conversion factor, as derived in 11.4.

11.7 *Report:*

11.7.1 State that the specimens were tested as directed in Section 11 of Specification D3218. Describe the material or product sampled and the method of sampling used.

11.7.2 Report the average width of the four specimens, in micrometers or mils.

11.8 *Precision and Bias:*

11.8.1 *Precision*—The precision of this test method has not been established.

11.8.2 *Bias*—The procedure in Specification D3218 for testing width has no known bias and is generally used as a reference method.

12. Thickness

12.1 *Scope*—This test method covers the determination of the thickness of flat polyolefin monofilaments, by a micrometer.

12.2 *Procedure:*

12.2.1 Determine the thickness of the monofilaments, as directed in Method C of Test Methods D374. If it is necessary to test very narrow monofilaments, or round filaments, lay out several parallel specimens on the anvil.

12.2.2 Measure the thickness of the specimen to the nearest 2.5 µm (0.1 mil). Repeat the thickness measurement three times on different segments of the same specimen. Record the three thickness measurements.

12.2.3 Make four tests for a total of 16 observations.

12.3 *Calculation:*

12.3.1 Calculate the average thickness of the four specimens, in µm (mils), to two significant figures.

12.4 *Report:*

12.4.1 State that the specimens were tested as directed in Section 12 of Specification D3218. Describe the material or product sampled and the method of sampling used.

12.4.2 Report the average thickness of the four specimens.

12.5 *Precision and Bias*—The precision and bias of the procedures in Specification D3218 for testing thickness are as specified in Test Methods D374.

13. Gloss

13.1 *Summary of Test Method:*

13.1.1 Gloss is measured on both sides of a specimen formed by winding three layers of the polyolefin monofilaments, in a standard pattern, on a yarn board. This procedure is especially designed for pigmented polyolefin monofilaments.

13.1.2 Basically, the method is derived from Federal Test Method Standard No. 141a, Method 6101.

13.2 *Significance and Use:*

13.2.1 The degree of gloss is important in many applications of polyolefin monofilament. This test method is used to provide a measure of this characteristic, from gloss readings on panels of polyolefin monofilaments wound on a yarn board.

13.2.2 Gloss readings are affected by many factors, such as: the degree of pigmentation of the specimen; the direction of the plane of the angle of incidence, relatively to the direction of the wind of the outer layer of monofilaments on the yarn board, when measuring unpigmented specimens with high gloss. When all these factors cannot be controlled, test results by this test method should be viewed with caution.

13.3 *Apparatus:*

13.3.1 *Gloss-Meter*[6], graduated in 0.1-gloss units.

13.3.2 *Yarn Board Winder*—A small machine, usually operated by a hand crank, to rotate a yarn board end-over-end, and fitted with a traversing guide capable of spacing the yarn evenly across the board, as it is wound.

13.3.3 *Package Holders*—Vertical spindles for bobbins or cones, and shafts on which tubes or flanged spools can turn freely.

13.3.4 *Yarn Board*—Rectangle of stiff gray cardboard approximately 100 by 150 mm (4 by 6 in.).

13.4 *Procedure:*

13.4.1 Clamp one narrow end of the yarn board in the yarn board winder. The protruding end of the board in the clamp should extend about 100 mm (4 in.).

13.4.2 Lead the monofilament from the yarn package through the pigtail guide. Pass the first wrap of yarn around the width of the board and attach it to the upper right side of the yarn board. Push the pigtail guide to the extreme right on the traverse rod, and make sure the yarn is not twisted. Turn the yarn board slowly with the hand crank. After a few wraps, check the yarn on the board again, to see that it is not twisted. Wrap the yarn around the board neatly, so that each spiral of yarn lays immediately adjacent to the last previous wound spiral of yarn. Continue wrapping until the exposed area of the board is completely covered.

13.4.3 Remove the board from the winder, turn the board through a right angle and clamp the board, again, to the winder. Wrap a second layer of yarn at right angles to the first layer. Wrap the yarn across the board neatly, so that each spiral of yarn lays immediately adjacent to the next spiral of yarn. Cover as much as possible of the first layer.

13.4.4 Remove the board from the winder and turn the board to the position described in 13.4.1. Wrap the last layer of yarn (third layer) in the same manner described in 13.4.2 for the first layer.

13.4.5 Place the gloss-meter on the monofilament specimen (yarn board). Take six gloss readings at different places on one side, three longitudinally, and three transversely taking the readings directly from the instrument dial. Record the readings to the nearest 0.1-gloss unit.

13.4.6 Turn the board over and repeat 13.4.5.

13.5 *Calculation:*

13.5.1 Calculate the average of the 12 gloss readings for each of the laboratory sampling units to the nearest 0.1 unit and the average for the lot.

13.6 *Report:*

13.6.1 State that the specimens were tested as directed in Section 13 of Specification D3218. Describe the material or product sampled and the method of sampling used.

13.6.2 Report the gloss for each laboratory sampling unit and for the lot.

13.7 *Precision and Bias:*

13.7.1 *Precision*—The precision of this test method has not been established.

13.7.2 *Bias*—No justifiable statement can be made on the bias of this method for determining gloss, since the true value of the property cannot be determined by an acceptable referee method.

14. Hot Water Shrinkage

14.1 *Procedure*—Determine the shrinkage in boiling distilled (or demineralized) water as directed in Test Method D2259, except that the test specimens are single ends of polyolefin monofilament 1 m (39 in.) long rather than skeins, and the boiling time is 10 min. Measure the total length of each sample with a metre stick before and after shrinking. Apply a tension of 1 mN/tex (0.1 gf/tex) to remove any wrinkles that may be present. Test three specimens, and record the individual results.

14.2 *Report:*

14.2.1 State that the specimens were tested as directed in Section 14 of Specification D3218. Describe the material or product sampled and the method of sampling used.

14.2.2 Report the average shrinkage of the three specimens, to the nearest 0.1 percentage point.

15. Resistance to Ultraviolet Radiation

15.1 *Summary of Test Method:*

15.1.1 The specimens are exposed to a xenon arc weatherometer source. The test conditions of temperature and humidity approximate those encountered in actual outdoors in subtropical regions.

15.1.2 Breaking tenacity is determined at regular intervals, during the laboratory exposure program and on an unexposed control yarn. The average breaking-tenacity values, obtained at each scheduled interval, are plotted versus the corresponding exposure times, in graph form. The graph is used to estimate