Designation: D 3218 – 93

Standard Specification for Polyolefin Monofilaments[1]

This standard is issued under the fixed designation D 3218; 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 3.2.3 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
Heat Shrinkage	14
Initial Modulus	10
Polyolefin-Material Cleanliness	17
Resistance to Ultraviolet Radiation	15
Stability to Thermal Oxidation	16
Tensile Properties	10
Thickness	9
Width	11
Yarn Number	12

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:*

D 76 Specification for Tensile Testing Machines for Textiles[2]

D 123 Terminology Relating to Textiles[2]

D 374 Test Methods for Thickness of Solid Electrical Insulation[3]

D 1248 Specification for Polyethylene Plastics Molding and Extrusion Materials[4]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 1907 Test Method for Yarn Number by the Skein Method[2]

D 1921 Test Methods for Particle Size (Sieve Analysis) of Plastic Materials[4]

D 2256 Test Method for Tensile Properties of Yarns by the Single-Strand Method[2]

D 2258 Practice for Sampling Yarn for Testing[2]

D 2259 Test Method for Shrinkage of Yarns[2]

D 2565 Practice for Operating Xenon-Arc Type Light-Exposure Apparatus With and Without Water for Exposure of Plastics[5]

D 4101 Specification for Propylene Plastic Injection and Extrusion Materials[5]

E 203 Test Method for Water Using Karl Fischer Reagent[6]

G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[7]

G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials[7]

2.2 *Other Documents:*

Federal Test Method Standard No. 141a, Sept. 1, 1965, Section 6000, Method 6101 "60-Degree Specular Gloss"[8]

[1] This specification is under the jurisdiction of ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D13.58 on Yarn Test Methods, General.

Current edition approved July 15, 1993. Published September 1993. Originally published as D 3218 – 73 T. Last previous edition D 3218 – 87.

[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 10.01.

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

[5] *Annual Book of ASTM Standards*, Vol 08.02.

[6] *Annual Book of ASTM Standards*, Vol 15.05.

[7] *Annual Book of ASTM Standards*, Vol 14.02.

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

Technical Report 24— "A Rapid Method for the Determination of Moisture in Pigmented Polyethylene Coating Materials," Eastman Chemical Products Inc.[9]

3. Terminology

3.1 *Definitions:*

3.1.1 *breaking force*, *n*—the maximum force applied to material carried to rupture.

3.1.2 *breaking tenacity*, *n*—the tenacity at the breaking force.

3.1.3 *draw ratio (DR)*, *n*—the relation of the final length per unit mass to original length per unit mass of a material resulting from drawing.

3.1.4 *drawing*, *n—in textile processing*, the process of stretching or attenuating a material to increase the length per unit mass.

3.1.4.1 *Discussion*—Drawing orients the molecular chains in the length direction of the monofilament.

3.1.5 *elongation at break*, *n*—the elongation corresponding to the breaking force.

3.1.5.1 *Discussion*—Elongation is expressed as a percentage of the length of the original specimen.

3.1.6 *gloss*, *n*—the luminous fractional reflectance of a material in the specular direction. (*Syn.* specular gloss)

3.1.7 *heat shrinkage*, *n*—a decrease in one or more dimensions of an object or material exposed to heat.

3.1.8 *initial modulus*, *n*—the slope of the initial straight portion of a stress-strain or force-elongation curve.

3.1.9 *monofilament*, *n*—a single filament which can function as a yarn in commercial textile operations, that is, it must be strong and flexible enough to be woven, knitted or braided, etc.

3.1.9.1 *Discussion*—(1) When a monofilament is drawn or in use, it does not fibrillate into (essentially) reticulate multifilaments. (2) A flat polyolefin monofilament can be called a tape yarn.

3.1.10 *polyolefin*, *n*—any long-chain synthetic polymer composed of at least 85 wt % of ethylene, propylene, or other olefin units (monomers), except amorphous (noncrystalline) polyolefin qualifying under Rubber 1, as defined by the Federal Trade Commission. (*Syn.* olefin)

3.1.10.1 *Discussion*—The generic term olefin has been adopted by the Federal Trade Commission in place of the technically correct term polyolefin.

3.1.11 *resistance to ultraviolet radiation*, *n*—the time to failure of yarns exposed to xenon-arc weathering.

3.1.11.1 *Discussion—In polyolefin tape yarns*, the failure criterion for resistance to ultraviolet radiation is the loss of 50 % of the original breaking tenacity.

3.1.12 For definitions of other textile terms used in this specification, refer to Terminology D 123.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *polyolefin-material cleanliness*, *n*—the degree to which a polymer melt is free of filterable particles which remain insoluble in the melt under the specified test condition.

3.2.2 *stability to thermal oxidation*, *n—for polyolefin monofilaments*, the time-to-failure, when polyolefin monofilaments are exposed to circulating air at 125°C.

3.2.2.1 *Discussion*—The failure criterion for thermal oxidative stability is the mechanical breakdown described in Section 16.

3.2.3 *standard polyolefin monofilament*, *n—as used in this specification*, a flat polyolefin strand, approximately 0.05 mm (2 mils) thick by 2.5 mm (100 mils) wide and oriented with a draw ratio between 5:1 and 7:1.

3.2.3.1 *Discussion*—The strand is produced through slitting an extruded polyolefin film, and when drawn or in use does not fibrillate into (essentially) reticulate multifilaments.

3.2.4 *tape yarn*, *n*—yarn of a flat, tape-like character produced by slitting an extruded film.

SPECIFICATIONS

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 D 4101.

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 D 1248.

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 D 1248 or D 2146, 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 D 1921.

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 E 203.

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,[10] based on gas chromatography of vaporized moisture, is an acceptable analytical approach.

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

[10] 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.

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 D 3218 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 In cases of a dispute arising from differences in reported test results when using Specification D 3218 for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens which are as homogeneous as possible and which are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's t-test for unpaired data and an acceptable probability level chosen by the two parties before the testing begins. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results in the light 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 seller. In the absence of an applicable material specification, or other agreement, take a lot sample and laboratory samples as directed in Practice D 2258.

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 D 1776; except that it is not essential to control humidity.

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 D 1907.

9.2 *Report*:

9.2.1 State that the specimens were tested as directed in Section 9 of Specification D 3218. 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 D 2256. All types of tensile machines described in Test Method D 2256 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 D 2256.

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 D 2256.

10.3 *Report*:

10.3.1 State that the specimens were tested as directed in Section 10 of Specification D 3218. 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:

$$\bar{X} = (\Sigma X)F / 12 \quad (2)$$

where:

$\bar{X}$ = average width of the four monofilaments,
ΣX = 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 D 3218. 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 D 3218 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 D 374. 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 D 3218. 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 D 3218 for testing thickness are as specified in Test Methods D 374.

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*[10], 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*: