Designation: D4976 – 12a (Reapproved 2020)

Standard Specification for Polyethylene Plastics Molding and Extrusion Materials[1]

This standard is issued under the fixed designation D4976; 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 U.S. Department of Defense.

INTRODUCTION

This specification is not intended for the selection of materials, but only as a means to call out plastic materials to be used for the manufacture of parts. The selection of these materials is to be made by personnel with expertise in the plastics field where the environment, inherent properties of the materials, performance of the parts, part design, manufacturing process, and economics are considered. This specification does not specify the source of the resin to be used for the fabrication of any given article.

1. Scope*

1.1 This specification provides for the identification of polyethylene plastics molding and extrusion materials in such a manner that the supplier and the user can agree on the acceptability of different commercial lots or shipments. The tests involved in this specification are intended to provide information for identifying materials in accordance with the groups, classes, and grades covered. It is not the function of this specification to provide specific engineering data for design purposes.

1.2 Other requirements necessary to identify particular characteristics important to specialized applications shall be agreed upon between the user and the supplier, by using the suffixes given in Section 1.3.

1.3 Ethylene plastic materials, being thermoplastic, are reprocessable and recyclable (see Note 1). This specification allows for the use of those ethylene plastic materials, provided that any specific requirements as governed by the producer and the end user are met.

NOTE 1—See Guide D7209 for information and definitions related to recycled plastics.

1.4 The values stated in SI units are regarded as standard.

1.5 The following precautionary caveat pertains to the test method portion only, Section 12, of this specification. *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.*

1.6 For information regarding plastic pipe materials see Specification D3350. For information regarding wire and cable materials, see Specification D1248.

NOTE 2—There is no known ISO equivalent to this standard.

1.7 *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]

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D568 Method of Test for Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position (Withdrawn 1991)[3]

D618 Practice for Conditioning Plastics for Testing

D635 Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

Current edition approved Dec. 1, 2020. Published December 2020. Originally approved in 1995. Last previous edition approved in 2012 as D4976 - 12a. DOI: 10.1520/D4976-12AR20.

[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.

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

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
D1499 Practice for Filtered Open-Flame Carbon-Arc Exposures of Plastics
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
D1531 Test Methods for Relative Permittivity (Dielectric Constant) and Dissipation Factor by Fluid Displacement Procedures (Withdrawn 2012)[3]
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
D2839 Practice for Use of a Melt Index Strand for Determining Density of Polyethylene
D2951 Test Method for Resistance of Types III and IV Polyethylene Plastics to Thermal Stress-Cracking (Withdrawn 2006)[3]
D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
D3801 Test Method for Measuring the Comparative Burning Characteristics of Solid Plastics in a Vertical Position
D3892 Practice for Packaging/Packing of Plastics
D4000 Classification System for Specifying Plastic Materials
D4329 Practice for Fluorescent Ultraviolet (UV) Lamp Apparatus Exposure of Plastics
D4703 Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets
D4804 Test Method for Determining the Flammability Characteristics of Nonrigid Solid Plastics
D4883 Test Method for Density of Polyethylene by the Ultrasound Technique
D4986 Test Method for Horizontal Burning Characteristics of Cellular Polymeric Materials
D6360 Practice for Enclosed Carbon-Arc Exposures of Plastics
D7209 Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products (Withdrawn 2015)[3]
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
F1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins

2.2 *Military Standard:*
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes

NOTE 3—According to the DOD, "MIL-STD-105E, dated 10 May 1989, is hereby canceled without replacement" (1995).

2.3 *DOT Standard:*
Federal Motor Vehicle Safety Standard 302, Flammability of Interior Materials[4]

3. Terminology

3.1 *Definitions*—For definitions of technical terms pertaining to plastics used in this specification, see Terminology D883 and Terminology D1600.

3.2 Historical usage and user group conventions have resulted in inconsistent terminology used to categorize and describe polyethylene resins and compounds. The following terminology is in use in ASTM specifications pertaining to polyethylene:

3.2.1 *Specification D1248:*

3.2.1.1 Type (I, II, III, IV) = density ranges (same, respectively, as Classes 1, 2, 3, and 4 in Specification D4976).

3.2.1.2 Class (A, B, C, D) = composition and use.

3.2.1.3 Category (1, 2, 3, 4, 5) = melt index ranges (same as Grade in Specification D4976).

3.2.1.4 Grade (E, J, D, or W followed by one or two digits) = specific requirements from tables.

3.2.2 *Specification D3350:*

3.2.2.1 Type (I, II, III) = density ranges (same as Types I, II, and III in Specification D1248 and Classes 1, 2, and 3 in Specification D4976).

3.2.2.2 Class = a line callout system consisting of "PE" followed by six cell numbers from Table 1 plus a letter (A, B, C, D, E) denoting color and UV stabilizer.

3.2.2.3 Grade = simplified line callout system using "PE" followed by density and slow crack growth cell numbers from Table 1.

3.2.3 *Specification D4976:*

3.2.3.1 Group (1, 2) = branched or linear polyethylene.

3.2.3.2 Class (1, 2, 3, 4) = density ranges (same, respectively, as Types I, II, III, and IV in Specification D1248).

3.2.3.3 Grade (1, 2, 3, 4, 5) = melt index ranges (same as Category in Specification D1248).

4. Classification

4.1 Unreinforced polyethylene plastic materials are classified into groups in accordance with molecular structure. These groups are subdivided into classes and grades as shown in Table PE (Basic Property Table).

[4] Available from United States Department of Transportation, National Highway Traffic Safety Administration, Office of Public Affairs and Consumer Participation, 400 7th St., SW, Washington, DC 20590.

TABLE PE Basic Requirement of Polyethylene Plastics

Group	Description	Class	Description	Grade	Flow Rate, D1238, g/10 min	Tensile Stress at Yield, D638, MPa, min	Nominal Strain at Break, D638, min, %	Flexural Modulus at 2 % Strain, D790, MPa, min
1	Branched	1	low density	1	>25	8	70	100
			. . .	2	>10 to 25	8	90	125
			0.910–0.925	3	>1 to 10	8.5	100	125
			. . .	4	>0.4 to 1	9.5	300	125
			. . .	5	to 0.4	9.5	400	150
			. . .	0	. . .	. . .	. . .	. . .
		2	medium density	1	>25	8	40	200
			. . .	2	>10 to 25	11	50	200
			>0.925–0.940	3	>1 to 10	11	70	200
			. . .	4	>0.4 to 1	11	200	250
			. . .	5	to 0.4	12	400	300
			. . .	0	. . .	. . .	. . .	. . .
		0	. . .	0	. . .	. . .	. . .	. . .
2	Linear	1	low density	1	>25	10	300	300
			. . .	2	>10 to 25	10	300	325
			0.910–0.925	3	>1 to 10	10	300	350
			. . .	4	>0.4 to 1	10	400	350
			. . .	5	to 0.4	12	500	400
			. . .	0	. . .	. . .	. . .	. . .
		2	medium density	1	>25	14	90	500
			. . .	2	>10 to 25	14	100	500
			>0.925–0.940	3	>1 to 10	14	100	550
			. . .	4	>0.4 to 1	15	200	600
			. . .	5	to 0.4	19	400	600
			. . .	0	. . .	. . .	. . .	. . .
		3	high density	1	>25	17	10	400
			. . .	2	>10 to 25	17	50	400
			>0.a940–0.960	3	>1 to 10	18	200	450
			. . .	4	>0.4 to 1	19	400	500
			. . .	5	to 0.4	20	600	600
			. . .	0	. . .	. . .	. . .	. . .
		4	high density	1	>25	24	10	500
			. . .	2	>10 to 25	24	10	600
			>0.960	3	>1 to 10	25	30	800
			. . .	4	>0.4 to 1	28	300	900
			. . .	5	to 0.4	28	400	1000
			. . .	0	. . .	. . .	. . .	. . .
0		0	. . .	0	. . .	. . .	. . .	. . .

Cell Table A Detail Requirements for Polyethylene Plastics

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile Stress at Yield, Test Method D638, MPa, min	unspecified	4	8	12	16	21	30	35	. . .	specify value
2	Nominal Strain at Break, Test Method D638, %, min	unspecified	25	50	200	400	600	800	1000	. . .	specify value
3	Secant Flexural Modulus at 2 % Strain, D790, MPa, min	unspecified	50	100	200	400	600	800	1000	. . .	specify value
4	Thermal stress-crack resistance, D2951, hours without cracking, min	unspecified	24	48	96	168	. . .	. . .	. . .	. . .	specify value
5	Environmental stress-crack resistance, D1693, min F_{50}, h	unspecified	24	48	96	168	336	672	1008	. . .	specify value

Cell Table B Detail Requirements for Polyethylene Plastics

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile Stress at Yield, D638, MPa, min	unspecified	4	8	12	16	21	30	35	. . .	specify value
2	Nominal Strain at Break, D638, %, min	unspecified	25	50	200	400	600	800	1000	. . .	specify value
3	Secant Flexural Modulus at 2 % Strain, D790, MPa, min	unspecified	50	100	200	400	600	800	1000	. . .	specify value
4	Thermal stress-crack resistance, D2951, hours without cracking, min	unspecified	24	48	96	168	. . .	. . .	. . .	. . .	specify value
5	Slow Crack Growth Resistance, PENT-Test Method F1473, h, min	unspecified	0.3	1	3	10	30	100	300	. . .	specify value

NOTE 4—An example of this classification system is as follows: The designation PE 112 would indicate PE, polyethylene as found in Terminology D1600, 1 (group) branched, 1 (class) low density, 2 (grade) >25 melt index.

4.2 Cell Tables A or B shall be used to specify the physical property requirements that shall be shown by a five-digit designation. The designation shall consist of the letter A and the five digits comprising the cell numbers for the property requirements in the order they appear in Cell Table A.

4.2.1 Although the values listed are necessary to include the range of properties available in the existing materials, users should not infer that every possible combination of the properties exist or can be obtained.

NOTE 5—It is recognized that some high-density polyethylene plastics of very high molecular weight have densities slightly less than 0.960, yet in all other respects they are characteristic of Class 4 materials. Similarly, there are other polyethylene plastics of very high molecular weight having densities slightly less than 0.941 that, in all other respects, are more characteristic of Class 2 than of Class 3 materials.

NOTE 6—Use the following terms in describing polyethylene plastics:
Class 1 (0.910 to 0.925) = low density,
Class 2 (>0.925 to 0.940) = medium density,
Class 3 (>0.940 to 0.960) = high density,
Class 4 (>0.960) = high density, and
Although Classes 3 and 4 cover two ranges of density, both are described by the term "high density."

5. Suffixes

5.1 When using the call-out for the materials covered by this specification, the following suffixes can be used for specific requirements of the material for the application intended. In general, the suffix letter indicates the requirement needed; the first number (digit) indicates the test condition, and the second number (digit) indicates the specimen requirement. The suffixes are as follows:

5.1.1 *E* = Electrical requirements as designated by the following digits:

First Digit
0 = To be specified by user.
1 = Specimens preconditioned 40 h at 23°C and 50 % relative humidity, then 14 days in distilled water at 23 ± 1°C.

Second Digit
0 = To be specified by user.
1 = Volume resistivity, permittivity, and dissipation factor meet property limits as shown as follows. These are electrical limits usually applied to unreinforced polyethylene plastics when control of their electrical properties is required.

Electrical Properties:

	Test Methods	
Permittivity, max	D1531	2.30
Dissipation factor, max	D1531	0.001
Volume resistivity, min Ω-cm	D257	1×10^{15}
Water immersion stability	D1531	shall meet the dielectric constant and dissipation factor requirements

5.1.2 Flammability requirements for polyethylene plastics shall be assessed by one or more of the following small scale flammability tests:

5.1.2.1 The rate of burning and/or extent and time of burning in a horizontal orientation for polyethylene plastics shall be assessed by Test Method D635. A plastic shall be classified HB if: (a) the rate of burning in the test does not exceed 40 mm per minute over a 75 mm span for specimens having a thickness of 3.0 – 13 mm, or b) the rate of burning does not exceed 75 mm per minute over a 75 mm for specimens having a thickness less than 3.0 mm, or c) the test specimen ceases to burn before the 100 mm reference mark.

5.1.2.2 The rate of burning and/or extent and time of burning in a horizontal orientation for foamed polyethylene plastics shall be assessed by Test Method D4986. A foamed plastic shall be classified HBF if: (a) the rate of burning in the test does not exceed 40 mm per minute over a 100 mm span b) the test specimen ceases to burn before flaming or glowing reaches the 125 mm gage mark.

5.1.2.3 The burning characteristics in a vertical orientation of polyethylene plastics shall be assessed by Test Method D3801. A plastic shall be classified V0, V1 or V2 as indicated in Appendix X1 of Test Method D3801.

5.1.2.4 The burning characteristics in a vertical orientation of nonrigid polyethylene plastics that, due to specimen thickness or lack of rigidity, would distort or shrink when tested using Test Method D3801 shall be assessed by Test Method D4804. A plastic shall be classified VTM0, VTM1 or VTM2 as indicated in Appendix X1 of Test Method D4804.

5.1.2.5 *G* = Flammability requirements[5] as designated by the following digits: as designated by the following digits:

First digit
0 = To be specified by user.
1 = Rigid
2 = Foam
3 = Non-rigid

Second Digit
0 = To be specified by user.
1 = Meets the classification requirements for HB when tested per D 635
2 = Meets the classification requirements for HBF when tested per D4986
3 = Meets the classification requirements for V0 when tested per D3801
4 = Meets the classification requirements for V1 when tested per D3801
5 = Meets the classification requirements for V2 when tested per D3801
6 = Meets the classification requirements for VTM0 when tested per D4804
7 = Meets the classification requirements for VTM1 when tested per D4804
8 = Meets the classification requirements for VTM2 when tested per D4804

5.1.2.6 The above call-out table reflects changes due to the withdrawal of D568 in 1991. For reference, the original call-out table can be be found in Appendix X1 of this document. The table in Appendix X1 is included only for reference and shall not be used for future specification of materials.

5.1.2.7 If requested, the heat release rate and ignitability in a horizontal orientation of polyethylene plastics shall be assessed when tested using Test Method E1354.

5.1.3 *W* = Weatherability requirements as designated by the following digits:

First Digit
0 = To be specified by user.
1 = Specimens exposed to xenon-arc type light source, in accordance with Practice D2565, Type BH. Specimens shall be Test Method D638, Type IV tensile bars.
2 = Specimens exposed to enclosed carbon-arc type light source, in accordance with Practice D6360. Specimens shall be Test Method D638, Type IV tensile bars.
3 = Specimens exposed to fluorescent-UV-condensation type light source, in accordance with Practice D4329. Specimens shall be Test Method D638, Type IV tensile bars.
4 = Specimens exposed to filtered open-flame carbon arc type light source in accordance with Practice D1499. Specimens shall be Test Method D638, Type IV tensile bars

Second Digit
0 = To be specified by user.

[5] By publication of this specification and its use of flammability ratings, ASTM does not suggest that their use in any way reflects hazards presented under actual fire conditions.

1 = 200-h exposure.
2 = 500-h exposure.
3 = 1000-h exposure.
4 = 2000-h exposure.

NOTE 7—The exposure duration shall be that necessary to produce a measurable change in the property evaluated for a product known to perform poorly in the application of interest. It will assure that the duration is of sufficient length to identify an unacceptable material.

5.1.3.1 The exposed specimens shall not exhibit surface changes (such as, dulling and chalking) or deep-seated changes (such as, checking, crazing, warping, and discoloration). The tensile strength after exposure must be no less than 50 % of the original.

5.1.4 *Z* = Other special requirements (for example, internal mold release agent) not covered by existing call-out capabilities can be assigned by the user. These shall be spelled out in detail and identified in sequence, that is, 01 UV-stabilized, 02 special color, and 03 etc.

5.2 Additional suffixes will be added to this specification as test methods and requirements are developed or requested, or both.

5.3 Additional suffixes are listed in Table 3 of Classification D4000. These use the two-letter, three-digit suffix system as established for the classification system for plastic materials.

6. Basic Requirements

6.1 Basic requirements from property or cell tables, as they apply, are always in effect unless these requirements are superseded by specific suffix requirements, that always take precedence.

7. Chemical Composition

7.1 The plastic composition shall be uniform and shall conform to the requirements specified herein. The color and form of the material shall be as agreed upon between the supplier and the user. Specification changes due to the effects of colorants should be noted by both parties and, when necessary, covered by suffixes.

8. Other Requirements

8.1 Test specimens for the various materials shall conform to the requirements prescribed in Table PE and Cell Tables A and B, and to suffix requirements as they apply.

8.2 Observed or calculated values obtained from analysis, measurement or test, shall be rounded in accordance with the rounding method in Practice E29 to the nearest unit in the last right-hand place of figures used in expressing the specified limiting value. The value obtained is compared directly with the specified limiting value. Conformance or nonconformance with the specification is based on this comparison.

9. Sampling

9.1 A batch or lot shall be considered as a unit of manufacture and can consist of a blend of two or more production runs of the same material.

9.2 Sampling shall be statistically adequate to satisfy the requirements of 13.4.

10. Specimen Preparation

10.1 Unless otherwise specified, test specimens shall be compression molded in accordance with Annex A1, Procedure C of Practice D4703.

10.2 The specimen type and dimensions shall comply with those described in the test method section. Die-cut specimens are recommended; however, machine-cut specimens are acceptable.

11. Conditioning

11.1 *Conditioning*—Once specimens are molded, they shall be moved to a standard laboratory atmosphere or a controlled laboratory atmosphere. For natural unfilled polyethylene plastics the controlled laboratory atmosphere shall be 23 ± 2°C. Test specimens, 7 mm or under in thickness, shall be conditioned for a minimum of 40 h immediately prior to testing. For filled and reinforced polyethylene plastics or polyethylene plastic blends, which contain a hydrophilic co-monomer, pigment, or modifier the specimens shall be conditioned in a standard laboratory atmosphere of 23 ± 2°C and 50 ± 10 % relative humidity (see Practice D618, Procedure A). For all materials to be conditioned for electrical testing, conditioning shall comply with the requirements of the standard test methods for electrical testing. In all cases the laboratory shall report both the temperature and humidity conditions during the conditioning period.

11.2 *Test Conditions*—Natural unfilled polyethylene plastics shall be tested in a controlled laboratory atmosphere of 23 ± 2°C. For filled and reinforced polyethylene plastics and polyethylene plastic blends, which contain a hydrophilic co-monomer, pigment, or modifier the specimens shall be conditioned in a standard laboratory atmosphere of 23 ± 2°C and 50 ± 10 % relative humidity. For all materials to be tested for electrical properties, the laboratory shall comply with the requirements of the standard test methods for electrical testing. In all cases the laboratory shall report both the temperature and humidity conditions during testing.

11.3 *Dispute*—In cases of dispute, conditioning and testing shall be conducted in accordance with Procedure A of Practice D618.

12. Test Methods

12.1 Determine the properties enumerated in this specification in accordance with the ASTM methods as they apply, unless otherwise stated in this specification.

12.1.1 *Flow Rate*—Test Method D1238, using Condition 190°C/2.16 kg unless otherwise directed, (see Note 8). Make duplicate determinations on the material in the form of powder, granules, or pellets. No conditioning is required.

NOTE 8—Although the flow rate of polyethylene plastics can be measured under any of the conditions listed for it under 6.2 of Test Method D1238, only measurements made at Condition 190°C/2.16 kg are identified as "melt index."

This method of test serves to indicate the degree of uniformity of the flow rate of the polymer of a single manufacturer as made by an individual process and is not, by itself, indicative of the degree of uniformity of other properties. Additionally, uniformity of flow rate among various polymers of various manufacturers as made by various processes does not, in the