Designation: D 3981 – 03

Standard Specification for Polyethylene Films Made from Medium-Density Polyethylene for General Use and Packaging Applications[1]

This standard is issued under the fixed designation D 3981; 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 unpigmented, unsupported, sheet or tubular, medium-density polyethylene films (here-after referred to as film or films) from resins having densities in the range from 926.0 to 938.0 kg/m^3 (0.926 to 0.938 g/cm^3), inclusive, as measured on molded plaques.

1.2 This specification is applicable to homopolymer polyethylene but is not restricted to it.

1.3 This specification is also applicable to films made from copolymer polyethylene commonly referred to in industry as low-pressure polyethylene.

1.4 This specification is also applicable to films made from blends of homopolymers and copolymers, including ethylene/vinyl-acetate copolymers.

1.5 This specification allows for the use of recycled polyethylene film or resin as feedstock, in whole or in part, as long as all the requirements of this specification are met and as long as any specific requirements as governed by the producer and end user are also met (see Note 1).

NOTE 1—Guide D 5033 contains terminology and definitions relating to recycled plastics.

1.6 Special care must be exercised if this specification is applied to colored or pigmented films. This specification does not address specific problems associated with coloring, such as, quantity and quality of pigment dispersion, optical properties, and increase in density. These and other areas must be taken into account by mutual agreement between the supplier and the purchaser.

1.7 The thickness of the films covered by this specification range from 25 to 100 μm [0.001 to 0.004 in.], inclusive. The maximum width of the sheet or lay-flat is 3.05 m [120 in.].

1.8 This specification does not cover oriented heat-shrinkable films.

1.9 This specification defines the levels of various physical properties from which specifications for specific films are to be described. The levels of physical properties required by a film for a given application are selected from Section 6 and the corresponding tables. However, Sections 7.2-7.5 relating to tolerances shall apply without change to all film falling within the scope indicated by the title and 1.1-1.4.

1.10 This specification covers dimensional tolerances, classification, intrinsic quality requirements, and test methods. The dimensional tolerances include thickness, width, and length or yield. Classification defines types, classes, surfaces, and finishes. The intrinsic quality requirements include density, workmanship, impact strength, tensile strength, heat sealability, and odor, as well as the classification properties for stiffness, coefficient of friction, optical properties, and surface treatment. A sampling method is included.

1.11 The values stated in SI units are to be regarded as standard. The values in brackets are given for information only.

1.12 The following precautionary caveat pertains only to the test methods portion, Section 10, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 *ASTM Standards:*

D 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 618 Practice for Conditioning Plastics for Testing[3]

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting[3]

D 883 Terminology Relating to Plastics[3]

D 1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics[3]

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[3]

D 1709 Test Methods for Impact Resistance of Plastic Film by the Free Falling Dart Method[3]

D 1894 Test Method for Static and Kinetic Coefficients of

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film and Sheeting.

Current edition approved March 10, 2003. Published May 2003. Originally approved in 1981. Last previous edition approved in 1995 as D 3981 – 95.

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

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

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

Friction of Plastic Film and Sheeting[3]
D 1898 Practice for Sampling of Plastics[4]
D 2103 Specification for Polyethylene Film and Sheeting[3]
D 2457 Test Method for Specular Gloss of Plastics Films and Solid Plastics[5]
D 2578 Test Method for Wetting Tension of Polyethylene and Polypropylene Films[5]
D 4321 Test Method for Package Yield of Plastic Film[5]
D 4703 Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets[6]
D 5033 Guide for the Development of ASTM Standards Relating to Recycling and Use of Recycled Plastics[6]
E 462 Test Method for Odor and Taste Transfer from Packaging Film[7]
F 88 Test Methods for Seal Strength of Flexible Barrier Materials[8]

NOTE 3—Relevant government regulations also apply to this specification.

NOTE 4—If this product is intended for packaging foods, medicines, drugs, and cosmetics it is subject to applicable regulations of the Food and Drug Administration or the Department of Agriculture and must comply with such regulations. If it is necessary to comply with regulations of other government agencies, such as the Consumer Product Safety Commission, Environmental Protection Agency, Department of Transportation, Federal Trade Commission, etc., such compliance shall be arranged between the purchaser and the seller prior to placing an order.

3. Terminology

3.1 Unless otherwise indicated the terminology used in this specification is in accordance with definitions given in Terminology D 883.

4. Classification

4.1 The medium-density film is, by this specification, classified by Types: 0, 1, 2, and 3; Surfaces: 0, 1, 2, and 3; Classes: 0, 1, 2, and 3; and Finishes: 1, 2, 3, and 4. These classifications are described in detail in 6.1.

5. Materials

5.1 The film shall be made from a homopolymer polyethylene, copolymer polyethylene (see Note 5), or blends of homopolymers or copolymers, or both, so that it meets the density and other film requirements listed herein.

NOTE 5—From a polyethylene, polyethylene plastic, or an ethylene plastic as defined in Terminology D 883.

5.2 The film shall be made from resins having a density between 926.0 and 938.0 kg/m^3 [0.926 and 0.938 g/cm^3], inclusive.

5.3 The film shall be natural in color (essentially colorless) unless a color has been agreed upon between the supplier and the purchaser. If colored, the quality and uniformity of coloring shall be by agreement between the supplier and the purchaser. Also, if added colorants or pigments are used in an amount such that some film properties are affected, this shall be taken into account by mutual agreement between the supplier and the purchaser.

6. Physical Requirements

6.1 *Classification Properties*:

6.1.1 *Type*—The 1 % secant modulus for all thicknesses of film shall be as specified in Table 1 for Types 0, 1, 2, and 3.

6.1.2 *Surface*—The kinetic coefficient of friction shall be as specified in Table 2 for Surfaces 0, 1, 2, and 3.

6.1.3 *Class*—The optical properties shall be as specified in Table 3 of Classes 0, 1, 2, and 3. The three optical properties of clarity, gloss, and haze do not always correlate. The particular property of most importance for the specific application shall be established and the value for this property shall then govern, in case of any inconsistency.

6.1.4 *Finish*—The surface treatment level of the film shall be as specified in Table 4 for Finishes 1, 2, 3, and 4.

6.2 *Other Physical Properties*:

6.2.1 *Impact Resistance*—Impact resistance of the film shall be established by mutual agreement between the supplier and the purchaser if this property is required.

NOTE 6—Dart-impact resistance of medium-density polyethylene films can be substantially less than that of low-density polyethylene films.

6.2.2 *Tensile Properties*—The tensile strength and elongation at break for all thicknesses shall be as specified in Table 5.

6.2.3 *Heat Sealability*—The minimum ratio of heat-seal strength to the film strength in the two principal directions shall be as specified in Table 6.

6.2.4 *Odor*—The odor level of the film shall average no more than a 3.5 rating level.

7. Dimensions

7.1 *Size*—The nominal thickness, width, length per roll or roll diameter, and yield of the film shall be established by mutual agreement between the purchaser and the supplier.

7.2 *Thickness Tolerance*—The average thickness and the thickness variation across the film shall be within the tolerances given in Table 7.

7.3 *Width Tolerance*—The width shall be within the tolerances given in Table 8.

7.4 *Yield Tolerance*—The deviation of the actual yield from nominal yield shall be within the tolerances given in Table 9.

7.5 *Flatness*—The flatness of the film shall be within limits as mutually agreed upon between the purchaser and the supplier.

8. Workmanship, Finish, and Appearance

8.1 *Film*—The film shall have workmanship qualities conforming to good commercial practice. The quality of film with regard to gels, streaks, pinholes, particles of foreign matter,

TABLE 1 Classification for Type

Type	1 % Secant Modulus, MPa [psi]
0	170 [25 000] or less
1	>170 to 240 [25 000 to 35 000]
2	>240 to 345 [35 000 to 50 000]
3	345 [50 000]

[4] Discontinued; see *1997 Annual Book of ASTM Standards*, Vol 08.01.
[5] *Annual Book of ASTM Standards*, Vol 08.02.
[6] *Annual Book of ASTM Standards*, Vol 08.03.
[7] Discontinued; see *1998 Annual Book of ASTM Standards*, Vol 15.08.
[8] *Annual Book of ASTM Standards*, Vol 15.09.

TABLE 2 Classification for Surface

Surface	Coefficient of Friction
0	greater than 0.7
1	>0.4 to 0.7
2	>0.2 to 0.4
3	0.2 or less

TABLE 3 Classification for Class

Class	Clarity[A]	Gloss Units	Haze %
0	—	30 or less	greater than 25
1	low	>30 to 50	>10 to 25
2	moderate	>50 to 70	>5 to 10
3	high	greater than 70	0 to 5

[A] As yet undefined but refers to degree of see-through visual acuity.

TABLE 4 Classification for Finish

Finish	Wetting Tension, dynes/cm
1	32, 33, 34
2	35, 36, 37
3	38, 39, 40
4	41 and over

TABLE 5 Tensile Properties

Property	Units	Machine Direction	Transverse Direction
Minimum tensile strength	MPa [psi]	14.1 [2000]	10.5 [1500]
Minimum elongation	%	100	300

TABLE 6 Heat Sealability

Finish of Contact Surfaces[A]	Minimum Ratio of Heat Seal Strengths[B]
2 to 2	0.60
1 to 2	0.60
1 to 1	0.75

[A] Heat sealability is not applicable to films with finish greater than 2.
[B] The ratio is:

$$\frac{\text{average stress (force/unit width) for seal break}}{\text{average stress (force/unit width) for film break}}$$

in the same film orientation.
Care shall be taken that the film samples for the ratio measurement are representative of each other.

undispersed raw materials, holes, tears, and blisters shall be mutually established between the purchaser and the supplier.

8.2 *Roll Formation*:

8.2.1 The diameter of cores upon which film is wound shall be established by mutual agreement between the purchaser and the supplier. Cores upon which film is wound must not be recessed at either edge of the roll and shall not extend more than 6 mm [¼ in.] beyond either edge of the roll.

8.2.2 Ridges and soft spots that result in bagginess and looseness of the unwound film are grounds for rejection by the purchaser on a roll-to-roll basis if the conditions contribute to poor performance of the film and end-use application.

8.2.3 The edges of the roll must be free of nicks and cuts, and the general condition of roll edges must not interfere with the unwinding of the rolls.

8.2.4 The type and number of splices and flaggings of splices or breaks (if unspliced) in rolls of more than one piece shall be established by mutual agreement between the supplier and the purchaser.

9. Sampling

9.1 Statistically based sampling plans that are appropriate for each particular product or quantity shall be used to obtain samples for use in determining compliance with this specification. Refer to Practice D 1898 for guidance.

9.2 For the purposes of developing supplier or purchaser specifications a lot size generally refers to the number of rolls in a lot. Sampling units are those rolls selected by random numbers from the lot. A unit sample is the sample of film taken from the roll. Take care in taking unit samples. Unwind and discard several turns from the roll and then take more than enough sample to run all specified tests. Do not allow the sample to become soiled. Ensure that the sample is not folded or creased excessively.

10. Test Methods

10.1 *Conditioning*—Condition the samples or test specimens, or both, to 23 ± 2°C [73.4 ± 3.6°F] before testing. In cases of disagreement, condition the test specimen for not less than 40 h prior to test, in accordance with Procedure A of Practice D 618 for those tests where conditioning is required.

10.2 *Test Conditions*—Conduct tests at the standard laboratory temperature of 23 ± 2°C [73.4 ± 3.6°F]. Close humidity control is unnecessary for polyethylene film tests.

10.3 *Width*—Measure the width with a metal rule capable of measuring to an accuracy of ±1 mm [or 1/16 in.].

10.4 *Thickness*—Measure the thickness in accordance with Test Method D 374 using Method A, B, C, or D, as appropriate, for the specimen thickness. The specimen shall be taken as a 50-mm [2-in.] strip across the web and measured at intervals of not more than 50 mm [2 in.].

10.5 *Yield*—Measure by Test Method D 4321.

10.6 *Flatness*—Measure the flatness using a method mutually agreed upon between the purchaser and the seller.

10.7 *Density*—The density of resins from which the film is made shall be measured in accordance with Test Method D 1505. Density specimens shall be prepared according to Practice D 4703, Annex A1, Procedure C.

10.8 *Stiffness*—Measure the secant modulus in accordance with Test Methods D 882 at the 1 % strain point of the specimen.

10.9 *Coefficient of Friction*—Measure the kinetic coefficient of friction in accordance with Test Method D 1894.

10.10 *Optical Properties*:

10.10.1 *Clarity*—Determine the clarity of the film by visual or instrumented means, as agreed upon between the purchaser and the supplier.

10.10.2 *Gloss*—Measure the gloss of the film in accordance with Method D 2457, using a 45° gloss head.

10.10.3 *Haze*—Measure the haze in accordance with Test Method D 1003.

10.11 *Wetting Tension*—Measure the finish of the film by wetting tension, in accordance with Test Method D 2578.

TABLE 7 Tolerance, Percent from Nominal Thickness[A]

Film Width		Nominal Thickness		Across Film % Tolerance[B]
mm	in.	μm	in.	
1270 or less	50 or less	25 to 65	0.001 to 0.0025	±20
1270 or less	50 or less	>65 to 100	>0.0025 to 0.004	±15
>1270 to 3050	>50 to 120	25 to 65	0.001 to 0.0025	±25
>1270 to 3050	>50 to 120	>65 to 100	>0.0025 to 0.004	±20

[A] This table does not mention the average thickness of the film. The entire film shall be within − 20 %, − 15 %, − 25 %, or − 20 % of nominal, respectively, to be acceptable. The controlling table for average thickness is Table 9 in terms of yield. If there are minimum thickness requirements, order film specifying a nominal thickness greater than the required minimum by at least the % tolerance set above.

[B] No single measurement shall differ from the nominal thickness by more than the tolerance listed above.

TABLE 8 Width Tolerances

Film Widths[A]		Sheeting	Lay-Flat Tubing
375 mm or less	[15 in. or less]	−0, + 5 mm [3/16 in.]	±5 mm [3/16 in.]
375 to 750 mm	[15 to 30 in.]	−0, + 6 mm [¼ in.]	±10 mm [⅜ in.]
>750 mm to 1.5 m	[30 to 60 in.]	−0, + 10 mm [⅜ in.]	±16 mm [⅝ in.]
>1.5 to 3 m	[60 to 120 in.]	−0, + 13 mm [½ in.]	±25 mm [1 in.]

[A] Across sheet or lay-flat tubing.

TABLE 9 Deviation[A], Actual Yield from Nominal Yield

Quantity	Tolerances
Any one roll	±10 %
500 kg [1000 lb] or less	±10 %
>500 to 1000 kg [1000 to 2500 lb]	±5 %
Over 1000 kg [2500 lb]	±3 %

[A] Negative deviation generally infers that the average thickness is greater than nominal.

Positive deviation generally infers that the average thickness is less than nominal.

10.12 *Impact Resistance*—Measure the dart impact resistance in accordance with Test Methods D 1709, except use Method A for all thicknesses of film.

10.13 *Tensile Properties*—Measure the tensile strength and elongation at break in accordance with Test Methods D 882.

10.14 *Heat Sealability*—Measure the heat sealability in accordance with Test Methods F 88, Method B, Dynamic Load Test.

10.15 *Odor*—Determine the odor level of the film in accordance with Test Method E 462, low to moderate scale.

11. Inspection and Certification

11.1 Inspection and certification of the material supplied under this specification shall be for conformance to the requirements specified herein.

11.2 *Lot*—Acceptance inspection shall be the basis on which acceptance or rejection of the lot is made. The lot-acceptance inspection shall consist of those tests that ensure process control during manufacture as well as those necessary to ensure certification in accordance with 11.4.

11.3 Periodic check inspection shall consist of the tests specified for all requirements of the material under this specification. Inspection frequency shall be adequate to ensure the material is certifiable in accordance with 11.4.

11.4 Certification shall be that the material was manufactured, sampled, tested, and inspected in accordance with this specification and that average values meet the requirements at a confidence level of 95 %.

11.5 A report of the test results shall be furnished when requested. The report shall consist of results of the lot-acceptance inspection for the shipment and the results of the most recent periodic-check inspection.

12. Packaging and Marking

12.1 *Packaging*—The film shall be packaged in standard commercial containers, so constructed as to ensure acceptance by common or other carriers for transportation to the point of delivery, unless otherwise specified in the contract or order.

12.2 *Labels and Literature*—If agreed upon between seller and purchaser, an appropriate statement to the effect that the film was manufactured in compliance with this specification shall be included on labels, invoices, etc.

12.3 *Identification*—Identification of the film shall include:

12.3.1 Manufacturer's name,

12.3.2 Type,

12.3.3 Surface,

12.3.4 Class,

12.3.5 Finish (if treated, the treated side of the film shall be clearly identified), and

12.3.6 Reference to this specification.

13. Keywords

13.1 film; general use; medium-density; packaging; polyethylene; recycled

SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this specification. This section may also include descriptions of the changes or reasons for the changes, or both.

D 3981 - 03:

(*1*) Five year review conducted.
(*2*) Editorial changes.
(*3*) Updated Referenced Documents Section.
(*4*) Changed references to thickness measurement method in 10.4.
(*5*) Added information on sample preparation of density specimens in 10.7.
(*6*) Removed mN/M unit designation from Table 4.
(*7*) Corrected value in Table 7 in "Nominal Thickness, in." column.
(*8*) Added Summary of Changes section.
(*9*) Eliminated permissive language in paragraphs 1.6, 1.9, 5.3, 8.2.1, 8.2.2, 9.1, 12.2, Note 4, Footnote B of Table 6, and Footnote A of Table 7.
(*10*) Changed all occurrences of "gage" to "thickness."