Designation: ~~D4101 – 17$^{\varepsilon 1}$~~ D4101 – 24

Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials[1]

This standard is issued under the fixed designation D4101; 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.

~~ε1 NOTE—Editorially corrected Table X1.1 in June 2019.~~

INTRODUCTION

This classification system 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 and specification of these materials is to be made by personnel with expertise in the plastics field where other factors including the use environment, inherent properties of the materials, performance of the part, part design, manufacturing process, and economics are considered.

1. Scope*

1.1 This classification system covers polypropylene materials suitable for injection molding and extrusion. Polymers consist of homopolymer, copolymers, and elastomer compounded with or without the addition of impact modifiers, for example, ethylene-propylene rubber, polyisobutylene rubber, and butyl rubber, colorants, stabilizers, lubricants, or reinforcements.

1.2 This classification system allows for the use of those polypropylene materials that can be recycled, reconstituted, and reground, provided that: (*1*) the requirements as stated in this classification system are met, and (*2*) the material has not been modified in any way to alter its conformance to food contact regulations or similar requirements. The proportions of recycled, reconstituted, and reground material used, as well as the nature and the amount of any contaminant, cannot be practically covered in this classification system. It is the responsibility of the supplier and the buyer of recycled, reconstituted, and reground materials to ensure compliance. (See Guide D7209.)

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 1—The properties included in this classification system are those required to identify the compositions covered. If other requirements are necessary to identify particular characteristics important to specific applications, these shall be designated by using the suffixes given in Section 1.

1.4 The following safety hazards caveat pertains only to the test methods portion, Section 13, 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.*

NOTE 2—This classification system and ISO 19069-1 and -2 address the same subject matter, but differ in technical content.

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

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

1.5 *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]

- C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
- D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
- D257 Test Methods for DC Resistance or Conductance of Insulating Materials
- D495 Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation
- D523 Test Method for Specular Gloss
- D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- D570 Test Method for Water Absorption of Plastics
- D618 Practice for Conditioning Plastics for Testing
- D638 Test Method for Tensile Properties of Plastics
- D648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
- D695 Test Method for Compressive Properties of Rigid Plastics
- D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between −30°C and 30°C with a Vitreous Silica Dilatometer
- D732 Test Method for Shear Strength of Plastics by Punch Tool
- D746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
- D785 Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials
- D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- 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
- D1435 Practice for Outdoor Weathering of Plastics
- D1505 Test Method for Density of Plastics by the Density-Gradient Technique
- D1525 Test Method for Vicat Softening Temperature of Plastics
- 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 (Withdrawn 2024)[3]~~
- D1822 Test Method for Determining the Tensile-Impact Resistance of Plastics
- D2117 Test Methods for Carbon Black—Surface Area by Nitrogen Adsorption (Withdrawn 1999)[3]
- D2240 Test Method for Rubber Property—Durometer Hardness
- D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
- D2584 Test Method for Ignition Loss of Cured Reinforced Resins
- D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
- D3012 Test Method for Thermal-Oxidative Stability of Polypropylene Using a Specimen Rotator Within an Oven
- D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
- D3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials
- D3763 Test Method for High Speed Puncture Properties of Plastics Using Load and Displacement Sensors
- D3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer
- 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
- D4364 Practice for Performing Outdoor Accelerated Weathering Tests of Plastics Using Concentrated Sunlight
- ~~D4805 Terminology for Plastics Standards (Withdrawn 2002)[3]~~

[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.

D4812 Test Method for Unnotched Cantilever Beam Impact Resistance of Plastics
D5279 Test Method for Plastics: Dynamic Mechanical Properties: In Torsion
D5420 Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)
D5630 Test Method for Ash Content in Plastics
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens
D6110 Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics
D6290 Test Method for Color Determination of Plastic Pellets
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
E313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates
E831 Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis

2.2 *Military Standard:*
MIL-STD-105 Sampling Procedure and Tables for Inspection by Attributes[4]

2.3 *SAE Standards:*[5]
SAE J1545 Instrumental Color Difference Measurement for Exterior Finishes, Textiles and Color Trim
SAE J1767 Instrumental Color Difference Measurement for Colorfastness of Automotive Interior Trim Materials
SAE J2412 Accelerated Exposure of Automotive Interior Trim Components Using a Controlled Irradiance Xenon-Arc Apparatus
SAE J2527 Performance Based Standard for Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Xenon-Arc Apparatus
SAE J1976 Outdoor Weathering of Exterior Materials

2.4 *ISO Standards:*
ISO 19069-1 Plastics—Polypropylene (PP) moulding and extrusion materials—Part 1: Designation system and basis for specifications
ISO 19069-2 Plastics—Polypropylene (PP) moulding and extrusion materials—Part 2: Preparation of test specimens and determination of properties

3. Terminology

3.1 *Definitions*— ~~See Terminologies~~For definitions of ~~D883 and~~terms pertaining ~~D4805 for definitions of terms related to this specification.~~to plastics used in this test method, refer to Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *back pressure, n*—the constant pressure that is applied to the end of the screw while the screw is rotating and retracting to prepare for the next injection.

3.2.2 *brittle failure, n*—one where the specimen test area is broken into two or more pieces, with sharp edges and shows almost no plastic flow.

3.2.3 *cooling time, n*—the time in which the material is in the closed mold with no pressure applied.

3.2.4 *cycle time, n*—the time required to complete a full injection molding cycle, including injection time, cooling time, and mold open time.

3.2.5 *ductile brittle transition temperature, n*—the temperature at which a 80% of the specimens exhibit ductile failure

3.2.6 *ductile failure, n*—one where the specimen deforms plastically before fracturing or one where the puncture of a test plaque does not have cracks radiating more than 10 mm beyond the center of the impact point.

3.2.7 *injection pressure, n*—the constant pressure that is applied to the end of the screw causing the melted material to fill the mold.

3.2.7.1 *Discussion*—
The injection pressure along with the injection speed determines the volumetric fill rate of the mold.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094.
[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

3.2.8 *injection speed, n*—the forward velocity of the screw during the injection step.

3.2.8.1 *Discussion*—
Injection speed is a set position on the injection molding machine ranging from slow to fast. The injection speed along with the injection pressure determines the volumetric fill rate of the mold.

3.2.9 *injection time, n*—the time in which a constant specified pressure is applied to the melted material.

3.2.10 *melt temperature, n*—the temperature of the material as it is being injected into the mold, measured by a pyrometer, or equivalent.

3.2.11 *mold open time, n*—the time beginning when the mold is opened and ending when the mold is closed.

3.2.12 *mold temperature, n*—the temperature of the mold during the molding cycle, measured in all mold cavities and on both platens, measured by a pyrometer, or equivalent.

3.2.13 *polypropylene (PP)*—a propylene plastic prepared by the polymerization of propylene or propylene with other alpha olefins. (See also PP-B, PP-H, and PP-R.)

3.2.14 *polypropylene heterophasic copolymers (PP-B, PP+EPR, or PP+EPDM)*—a propylene plastic consisting of two or more separate phases.

3.2.14.1 *Discussion*—
The phases consist of a polypropylene homopolymer (PP-H) or a polypropylene random copolymer (PP-R) matrix containing a dispersed olefinic elastomer having no other functional group, added in situ or physically blended into the polypropylene matrix.

3.2.15 *polypropylene homopolymer (PP-H)*—a propylene plastic prepared by the polymerization of propylene only.

3.2.16 *polypropylene random copolymer (PP-R)*—a propylene plastic containing another olefinic monomer (or monomers) having no functional group other than the olefinic group copolymerized with propylene.

3.2.16.1 *Discussion*—
Polypropylene random copolymers containing more than one additional monomer are often called "terpolymers."

4. Classification

4.1 Unreinforced polypropylene materials are classified into groups according to basic composition. These groups are subdivided into classes and grades, as shown in Table PP.

NOTE 3—An example of this classification system is as follows. The designation PP0113 would indicate: PP = polypropylene, ~~as found in Terminology D1600,~~ 01 (group) = homopolymer, 1 (class) = general purpose, and 3 (grade) = with requirements given in Table PP.

4.1.1 To facilitate the incorporation of future or special materials not covered by Table PP, the "other/unspecified" category for group (00), class (0), and grade (0) is shown on the table with the basic properties to be obtained from Table A, Table B, Table C, Table G, Table H, and Table T, as they apply (see 4.3).

4.2 Reinforced versions of the polypropylene materials are classified in accordance with Table PP, Table A, Table C, Table G, and Table T. Table PP, Table B, and Table H specify the properties of the unreinforced material, and Tables A, C, G, or T specify the properties after the addition of reinforcements, pigments, fillers, or lubricants, at the nominal level indicated (see 4.2.1)

4.2.1 *Reinforcements and Additive Materials*—A symbol (single letter) will be used for the major reinforcement or combinations thereof, along with two numbers that indicate the percentage of addition by mass, with the tolerances as tabulated as follows:

Symbol	Material	Tolerance
G	Glass reinforced—	
	<15 %	±2 percentage points
	>15 %	±3 percentage points
L	Lubricant (that is, graphite, silicone, and stearates)	to be specified
M	Mineral-reinforced—	
	<15 %	±2 percentage points
	>15 %	±3 percentage points
R	Reinforced-combinations/ mixtures of reinforcements or other fillers/reinforcements	±3 percentage points based on the total reinforcement

NOTE 4—This part of the system uses the type and percentage of additive to designate the modification of the base material. To facilitate this designation, the type and percentage of additive can be shown on the supplier's Technical Data Sheet, unless it is proprietary in nature. If necessary, additional requirements shall be indicated by the use of the suffix part of the system as given in Section 5.

4.2.2 Specific requirements for reinforced, pigmented, filled, or lubricant polypropylene materials will be shown by a six-character designation. The designation will consist of the letter A, B, C, G, or T and the five digits comprising the cell numbers for the property requirements in the order in which they appear in Table A, Table B, Table C, Table G, or Table T. For Table H the designation will consist of the letter H and three digits comprising the cell numbers for the property requirements in the order in which they appear in Table H.

4.2.2.1 Although the values listed are necessary to include the range of properties available in existing materials, they should not be interpreted as implying that every possible combination of the properties exists or can be obtained.

4.2.3 When the grade of the basic materials is not known or is not important, the use of "0" grade classification is to be used for reinforced materials in this system. (See Note 5.)

NOTE 5—An example of this classification system for a reinforced-polypropylene material is as follows. The designation PP0110M20A21130 would indicate the following, with the material requirements from Table A:

PP0110	=	General-purpose polypropylene homopolymer from Table PP
M20	=	Mineral reinforced, 20 %,
A	=	Table A property requirements.
2	=	35-MPa tensile stress, min,
1	=	1000-MPa flexural modulus (1 % secant), min,
1	=	15-J/m Izod impact, min,
3	=	110°C deflection temperature, min, and
0	=	Unspecified.

If no properties are specified, the designation would be PP0110M20-A00000.

4.3 Table B has been incorporated into this specification to facilitate the classification of special materials where Table PP does not reflect the required properties of that unreinforced material. This table is to be used in a manner similar to Tables A, C, G, and T. Table H has been incorporated into this specification to improve the callout of random copolymers and impact copolymers. Table H has a reduced callout based on flexural modulus, Izod impact, and the Multiaxial Impact Ductile-Brittle Transition Temperature. If a full line callout is required, use Table B.

NOTE 6—Mechanical properties of polypropylene materials with pigments or colorants can differ from the mechanical properties of natural material, depending on the choice and the concentration.

NOTE 7—An example of a special material using this classification system is as follows. The designation PP0110B67253 would indicate the following with the material requirements from Table B:

PP0110	=	homopolymer, general purpose, other,
B	=	Table B property requirements,
6	=	30-MPa tensile stress at yield, min,
7	=	1500-MPa flexural modulus, min,
2	=	50-J/m Izod impact resistance, min,
5	=	90°C deflection temperature, min, and

3 = >1.0 to 3.0 nominal melt flow rate.

NOTE 8—An example of a polypropylene copolymer material using Table H would be as follows. The designation PP0500H585 would indicate a material with the following requirements:

PP0500 = copolymer or impact modified,
H = Table H property requirements,
5 = 1200-MPa flexural modulus, min,
8 = Izod impact resistance, non-break failure mode, no value reported, and
5 = <–30°C ductile-brittle transition temperature

5. Suffixes

5.1 When additional requirements are needed for the materials covered in this specification that are not covered in Table PP, Table A, Table B, Table C, Table G, Table H, and Table T, those requirements shall be designated through the use of suffixes. The primary suffix list can be found in Suffix Requirements, Section 7, of Classification D4000. Other suffixes that pertain only to the material requirements in this specification are listed as follows. 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.

NOTE 9—Suffixes from Classification D4000 will contain two letters followed by three digits while suffixes from this specification will contain a single letter followed by two or three numbers. An example would be weatherability; a designation of WA510 would indicate that it is a Classification D4000 suffix with the following requirements:

W = Weather resistant,
A = Practice D1435,
5 = Elongation properties, and
10 = 10 % change.

A designation of W110 would indicate that it is a Specification D4101 suffix with the following requirements:

W = Weatherability,
1 = Practice D2565, Test Cycle 1, specimens exposed in a xenon-arc accelerated test apparatus,
1 = 200-h exposure, and
0 = Change in properties to be specified.

Suffixes:

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 = Insulation resistance, dielectric constant, and dissipation factor meet property limits as shown below. These are electrical limits usually applied to unreinforced polypropylene when control of their electrical properties is required.

Electrical Properties:

Dielectric constant, max	Test Methods D1531 or D150	2.30
Dissipation factor, max	Test Methods D1531	0.0005
Insulation resistance, min,	Test Methods D257	1×10^{15}
Water immersion stability	Test Methods D1531 or D150	Shall meet the dielectric constant and dissipation factor requirements

W = Weatherability requirements as designated by the following digits:

First Digit

0 = To be specified.
1 = Specimens exposed in a xenon arc accelerated test apparatus that conforms to Practice D2565 using Test Cycle 1 for exterior applications.
2 = Specimens exposed in a fluorescent UV/condensation accelerated test apparatus that conforms to Practice D4329 using Test Cycle A for exterior applications.
3 = Specimens exposed in a xenon-arc accelerated test apparatus that conforms to SAE J2527 or equivalent for exterior applications.
4 = Specimens exposed in a xenon-arc accelerated test apparatus that conforms to SAE J2412 or equivalent for interior applications.
5 = Specimens exposed to concentrated natural sunlight in accordance with Practice D4364 without water spray.
6 = Specimens exposed to concentrated natural sunlight in accordance with Practice D4364 with water spray (Table 1, Cycle 1).
7 = Specimens exposed to natural sunlight in accordance with Practice D1435 using a rack angle of 45° from the horizontal facing the equator , unless specified otherwise.
8 = Specimens exposed to natural sunlight in accordance with SAE J1976 Procedure A, unless specified otherwise.

Second Alphanumeric

0 = To be specified by user.
1 = 200-h exposure.
2 = 500-h exposure.
3 = 1000-h exposure.
4 = 2000-h exposure.
5 = 1240.8 kJ/(m^2.nm) at 340 nm.
6 = 2500 kJ/(m^2.nm) at 340 nm.
7 = 1000 MJ/m^2 solar total UV irradiation (approximately 3 years).
8 = 336-h exposure
9 = 720-h exposure
A = 5000-h exposure
B = 10000-h exposure
C = 225.6 kJ/(m^2.nm) at 340 nm
D = 601.6 kJ/(m^2.nm) at 340 nm.

NOTE 10—Conversion from hours to kilojoules (kJ) varies with irradiance and the light/dark cycle. Conversion to kJ from actual light hours (h) is based on the following relation:

$$kJ = Irradiance\ in\ Watts \times 3.6\ kJ/h \times h\ of\ light$$

Thus, at an irradiance level of 0.55 W/(m^2.nm) at 340 nm, the multiplication factor for converting light hours to kJ is 1.98 (0.55 × 3.6). Therefore, 100 light hours is equivalent to 396 kJ/(m^2.nm) at 340 nm at this irradiance level.

Third Alphanumeric

0 = To be specified by user.
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).
2 = The tensile strength after exposure must be no less than 50 % of the original.
3 = The tensile strength after exposure must be no less than 90 % of the original.
4 = American Association of Textile Chemists and Colorists (AATCC) rating 4 to 5.
5 = Colorfastness by SAE J1545, for exterior materials, CIELAB color difference, 10° observer, Illuminant D65, specular included, ΔE = 2.5 max.
6 = Colorfastness by SAE J1545, for exterior materials, CIELAB color difference, 10° observer, Illuminant D65, specular included, ΔE = 2.0 max.
7 = Colorfastness by SAE J1545, for exterior materials, CIELAB color difference, 10° observer, Illuminant D65, specular included, ΔE = 3.0 max.
8 = Colorfastness by SAE J1767, for interior materials, CIELAB color difference, 10° observer, Illuminant D65, specular included, ΔE = 2.5 max.
9 = Colorfastness by SAE J1767, for interior materials, CIELAB color difference, 10° observer, Illuminant D65, specular included, ΔE = 3.0 max.
Z = Reserved for other special requirement characteristics (for example, internal mold release agent) not covered by existing call-out capabilities. These are to be assigned and be spelled out in detail and identified in sequence, that is, 01 UV-stabilized, 02 special color, and 03, etc.

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

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 in the "Line Call-Out."

7. General Requirements

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 specified. Note specification changes due to the effects of colorants and, when necessary, cover them by suffixes.

7.2 For recycled, reconstituted, and reground materials the level of contamination by nonpolymeric materials other than fillers and additives shall not be of a significant level that it prevents the product from meeting the performance criteria for which it was manufactured.

8. Detail Requirements

8.1 Test specimens for the various materials shall conform to the requirements prescribed in Table PP, Table A, Table B, Table C, Table G, Table H, Table T and to the suffix requirements as they apply.

8.2 Observed or calculated values obtained from analysis, measurement, or test shall be rounded in accordance with 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 Sampling shall be statistically adequate to satisfy the requirements of 14.4. A batch or lot of resin shall be considered as a unit of manufacture as prepared for shipment and can consist of a blend of two or more production runs of material.

10. Number of Tests

10.1 The number of tests conducted shall be consistent with the requirements of Section 13.

11. Specimen Preparation

11.1 All test specimens other than those for heat stability testing (see 11.2) shall be injection molded in accordance with the following specific procedures:

NOTE 11—Physical and mechanical properties are dependent upon the technique of specimen preparation. Specimen preparation by means other than those described as follows can lead to significant variation in test results, with resultant departure from specification values.

NOTE 12—Limited data have shown that, for Polypropylenes, mechanical test values can be significantly affected by the cross sectional area of the runner. Specimens molded using the specified minimum runner size of 5 mm D (~20 mm^2) exhibited lower values of most mechanical properties than specimens molded using runners with cross-sectional areas of 50 and 80 mm^2. Higher viscosity (lower MFR) materials appear to be more sensitive. This effect needs to be considered when comparing data obtained from different sources.

11.1.1 *Specimen Mold*—Molds designed in compliance with Practice D3641 to mold the following test specimens:

11.1.1.1 A Test Method D638, Type I tension test specimen with a thickness of 3.2 ± 0.1 mm.

11.1.1.2 A rectangular bar, with dimensions of 127 mm by 12.7 mm by 3.2 ± 0.1 mm.

11.1.1.3 Plate, with minimum dimensions of 100 mm^2 or 100-mm diameter with a thickness of 3.2 ± 0.2 mm.

11.1.2 *Mold Temperature*—The temperature of the mold shall be 60 ± 3°C. Temperature measurements shall be made in each cavity of the mold after machine conditions are at equilibrium and shall be made with a surface-type pyrometer, or equivalent, to an accuracy of ±2°C after equilibrium or cycle conditions have been established.

11.1.3 *Cycle*—The total molding cycle time shall be 45 s, consisting of 20-s injection, 20-s cooling, and 5-s mold open.

11.1.4 *Melt Temperature*—The melt temperature for molding test specimens for materials with melt flows of 1 to 30 g/10 min shall correlate with the polymer melt flow (Test Method D1238, Condition 230/2.16) as shown in Table 1. Melt temperatures shall be measured on cycle by taking the temperatures of several successive free shots with a needle-type pyrometer, or equivalent, to an accuracy of ±3°C.

NOTE 13—The needle should be moved around in the plastic mass, and a sufficient number of measurements be made to establish a reliable result. To minimize heat loss from the plastic during measurement, the mass should be collected in a heated container, or in one made from material of low thermal conductivity. The quantity of plastic in the free shot should be controlled to be equivalent to the weight of a complete injection-molded shot.

11.1.4.1 To avoid excessive thermal history the shot size shall be kept to a minimum and the cushion shall be 5 to 10 mm.

11.1.4.2 For materials with melt flows less than 1 g/10 min, raise the temperature of the melt in 5°C increments from 250°C until the part weight of the entire shot is equivalent to the part weight of a 1 to 5-g/10 min material.

NOTE 14—Due to degradation and thermal expansion of the material, the melt temperature should not exceed 270°C. If unable to obtain the weight at 270°C, slight adjustments can be made in the injection pressure to achieve the proper weight.

11.1.4.3 The melt temperature shall be 190°C for materials with melt flows greater than 30 g/10 min.

11.1.4.4 Since the needle-type pyrometer technique is somewhat tedious, a second technique using an infrared pyrometer is an acceptable alternative. The infrared pyrometer used must have an accuracy of 1 % of reading or ±2°C, whichever is smaller, a response time of at least 0.5 s, and a distance to target ratio of at least 30:1. It is recommended that the infrared pyrometer have a laser beam to establish the position being measured on the molten mass of polymer. This second technique shall only be used after a correlation between the needle-type pyrometer and the infrared pyrometer has been established. This correlation shall be verified at least every six months. The correlation shall be re-established each time either pyrometer is recalibrated.

11.1.5 *Back Pressure*—The back pressure shall be set at 0.7 MPa (gage).

11.1.6 *Injection Pressure and Speed*—All materials less than 30-g/10 min melt flow shall be molded using a single stage pressure. For a given machine and a given mold, the injection pressure and the injection speed controls shall be set to produce equal part weights, including sprue and runners (±2 %) regardless of material flow rates. The injection speed and injection pressure shall be set to minimize sink and flash. The maximum amount of flash shall not exceed 1 mm and will only be acceptable in the nontesting area. Once the injection speed and pressure are determined for a given machine and mold they shall not be varied by more than ±2 %. A single stage pressure can be obtained in two different ways.

11.1.6.1 Set the injection pressure to a specified pressure then allow a shift over to a hold pressure; the hold pressure maintains the pressure at the maximum pressure generated by the injection pressure, fill the cavity using hold pressure only.

11.1.6.1.1 *Discussion*—

The first method is the preferred method. For materials with melt flow rates above 30 g/10 ~~min the~~min, different injection and hold pressures ~~may be set to different pressures.~~ are permitted. Normally the hold pressure is set lower than the injection pressure, but must be high enough to finish filling out the molded part. It is recommended that, for these high melt flow rate materials, the manufacturer be contacted for guidance in establishing the injection and hold pressures. It is also recommended that screw rotation speed be set to a minimum to allow the screw to rotate for 17 to 19 s of the 20-s cooling time. This slower screw speed will provide greater uniformity of the melt with respect to viscosity and temperature. If necessary, adjust the screw rotation speed for the various material types in order to achieve the 17 to 19-s time frame. The rate of screw movement backwards away from the mold is dependent on the back pressure, frictional effects, various additive types, and melt viscosity.

11.1.7 *Reporting*—Report the injection molding conditions in accordance with Practice D3641.

11.2 Prepare test specimens for heat stability testing in accordance with Test Method D3012.

12. Conditioning

12.1 *Conditioning:*

12.1.1 Once specimens are molded, they shall be moved to a standard laboratory atmosphere or a controlled laboratory atmosphere. For natural unfilled polypropylene the controlled laboratory atmosphere shall be 23 ± 2°C. Specimens shall be stored in storage medium, such as boxes, paper bags or envelopes, plastic bags, or racks, whichever is most practical for the laboratory storing the specimens. It is recommended that specimens be allowed to cool for about 30 min on a bench or in a rack before they are placed in any container where the specimens might come in contact with each other. For filled and reinforced polypropylene or polypropylene blends, which contain a hydrophilic comonomer or modifier the specimens shall be conditioned in a standard laboratory atmosphere of 23 ± 2°C and 50 ± 10 % relative humidity, unless sufficient testing has been conducted that indicates that specific material type's properties are not affected by humidity. In those cases, the storage medium can be the same as for unfilled materials. Materials whose properties are affected by humidity, must be stored in accordance with 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.

12.1.2 When the temperature in the molding area exceeds 28°C or the humidity level exceeds 60 % (applicable only to materials that contain a hydrophilic comonomer or modifier) specimens shall be moved as quickly as possible to the standard laboratory atmosphere.

12.1.3 Testing, except for those tests where a test time is specified, shall be conducted not less than 40 h after molding. The aging times as specified in this and subsequent sections shall apply to all testing conducted for development of a line callout, data for publication, or for cases of dispute over testing values.

12.1.4 Specimens that are to be tested for Izod or Charpy impact shall be notched within 1 to 16 h after molding. Once notched the specimens shall condition for a minimum of 40 h before testing.

NOTE 15—Data have shown that, for some polypropylene impact copolymers with higher xylene solubles or higher rubber content, Izod impact values can vary significantly over time.

12.1.5 Specimens that are to be tested for tensile or flexural properties shall be tested within 40 to 96 h after molding.

NOTE 16—Polypropylene properties change with time as a result of amorphous densification and, in some cases, due to a small degree of secondary crystallization in the rubbery phase.

12.2 *Test Conditions*—Natural unfilled polypropylene shall be tested in a controlled laboratory atmosphere of 23 ± 2°C. For filled and reinforced polypropylene and polypropylene blends, which contain a hydrophilic comonomer or modifier the specimens shall be tested in a standard laboratory atmosphere of 23 ± 2°C and 50 ± 10 % relative humidity, unless sufficient testing has been conducted that indicates that specific materials type's properties are not affected by 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.

13. Test Methods [6]

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

13.1.1 *Flow Rate*—Condition 230/2.16 of Test Method D1238. Make two determinations on the material in the form that it is to be molded (such as powder, pellets, or granules).

NOTE 17—This test method 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, in this case, is only indicative of the degree of uniformity of molded specimens, and therefore other properties. However, uniformity of flow rate among various polymers of various manufacturers as made by various processes does not, in the absence of other tests, indicate uniformity of other properties and vice versa.

13.1.2 *Measurement of Test Specimen Dimensions*—The width and thickness of the test specimen shall be measured to an incremental discrimination of at least 0.025 mm. Measurements shall be made with a micrometer, preferably with ratchet, having a movable circular contact foot and a lower anvil foot, both 6.35 ± 0.025 mm in diameter. Specimens shall be measured in accordance with Test Methods D5947.

13.1.3 *Tensile Stress (Yield)*—Test Type I specimens using Test Method D638. The material shall be tested at 50 mm/min when the material is one that shows a breaking strain greater than 10 %, or at 5 mm/min when the material breaks at a strain equal to or less than 10 %.

13.1.4 *Flexural Modulus (1 % Secant)*—Test Methods D790, Method I, Procedure A, with a 50-mm span, a 5.0 ± 0.1-mm radius support and loading nose, and a 1.3-mm/min testing speed using the center test region of a Test Method D638, Type I specimen. It is mandatory that the toe correction be made to correct for the slack in the test fixture and load cell. Center the specimen between

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D20-1213.