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Standard Specification for Polypropylene Injection and Extrusion Materials Using ISO Protocol and Methodology¹

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INTRODUCTION

This material specification is intended to provide a call out system for polypropylene based on ISO standards. This callout system is based on test data collected using ISO standards.

This specification is not intended for the determination of performance of materials in the final application. Selection of these materials is to be made by personnel with expertise in the plastics field in which the environment, inherent properties of the materials, performance of the parts, part design, manufacturing process, and economics are considered.

1. Scope *

1.1 This specification covers polypropylene materials suitable for injection molding and extrusion. Polymers consist of polypropylene homopolymers, polypropylene copolymers, and polypropylene-elastomer compounds produced with or without the addition of impact modifiers (ethylene-propylene rubber, polyisobutylene rubber, and butyl rubber), colorants, stabilizers, lubricants, or reinforcements.

1.2 This specification allows for the use of those polypropylene materials that can be recycled, reconstituted, and reground, provided that the following conditions are met:

1.2.1 The requirements as stated in this specification and other ISO guidelines pertaining to these types of materials are met, and

1.2.2 The material has not been modified in any way to alter its conformance to food contact regulations or similar requirements.

1.3 The proportions of recycled, reconstituted, and regrind material used, as well as the nature and the amount of any contaminant, cannot be practically covered in this specification. It is the responsibility of the supplier and buyer of recycled, reconstituted, and regrind materials to ensure compliance.

NOTE 1—The properties included in this specification are those required to identify the compositions covered. There may be other requirements necessary to identify particular characteristics important to specific applications. These will be designated by using the suffixes given in Section 4.

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

1.5 The following precautionary 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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 2—This specification is similar to both ISO 1873-1 and ISO 1873-2, but to different degrees. This specification resembles ISO/DIS 1873-1-1994 in title only. The content is significantly different. This specification and ISO/DIS 1873-2-1994 differ in approach or detail; data obtained using either are technically equivalent.

2. Referenced Documents

2.1 ASTM Standards:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
- D 883 Terminology Relating to Plastics²
- D 1600 Terminology for Abbreviated Terms Relating to Plastics²
- D 1898 Practice for Sampling of Plastics³
- D 1972 Practice for Generic Marking of Plastic Products²
- D 1999 Guide for the Selection of Specimens and Test Parameters from ISO/IEC Standards⁴
- D 3892 Practice for Packaging/Packing of Plastics⁵
- D 4000 Classification System for Specifying Plastic Materials⁵
- D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics⁶
- E 29 Practice for Using Significant Digits in Test Data to

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² *Annual Book of ASTM Standards*, Vol 08.01.

³ Discontinued. See *1998 Annual Book of ASTM Standards*, Vol 08.01.

⁴ Discontinued. See *1999 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.

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

Determine Conformance with Specifications⁷

2.2 *ISO Standards*:⁸

- ISO 62 Plastics—Determination of Water Absorption
- ISO 75-1 Plastics—Determination of Temperature of Deflection Under Load, Part 1: General Test Method
- ISO 75-2 Plastics—Determination of Temperature of Deflection Under Load, Part 2: Plastics and Ebonite
- ISO 105 Textiles—Tests for Color Fastness
- ISO 178 Plastics—Determination of Flexural Properties of Rigid Plastics
- ISO 179 Plastics—Determination of Charpy Impact Strength of Rigid Materials
- ISO 180 Plastics—Determination of Izod Impact Strength of Rigid Materials
- ISO 293 Plastics—Compression Moulding Test Specimens of Thermoplastic Material
- ISO 294 Plastics—Injection Moulding of Test Specimens of Thermoplastic Material
- ISO 306 Plastics—Thermoplastic Materials—Determination of Vicat Softening Temperature
- ISO 527-1 Plastics—Determination of Tensile Properties, Part 1: General Principles
- ISO 527-2 Plastics—Determination of Tensile Properties, Part 2: Test Conditions for Molding and Extrusion Plastics
- ISO 537 Plastics—Testing with Torsional Pendulum
- ISO 604 Plastics—Determination of Compressive Properties
- ISO 868 Plastics and Ebonite—Determination of Indentation Hardness by Means of a Durometer (Shore Hardness)
- ISO 899 Plastics—Determination of Tensile Creep
- ISO 974 Plastics—Determination of the Brittleness Temperature by Impact
- ISO 1133 Plastics—Determination of Melt Flow Rate of Thermoplastics
- ISO 1183A Plastics—Methods for Determining the Density and Relative Density of Non-Cellular Plastics
- ISO 1191 Plastics—Polyethylene and Polypropylenes in Dilute Solutions—Determination of Viscosity Number and of Limiting Viscosity Number
- ISO 1210 Plastics—Determination of Flammability Characteristics of Plastics in the Form of Small Specimens in Contact with a Small Flame
- ISO 1628-3 Plastics—Determination of Viscosity Number and Limiting Viscosity Number, Part 3: Polyethylene and Polypropylene Resins
- ISO 1873-1 Plastics—Polypropylene and Polypropylene-Copolymer Thermoplastics, Part 1: Designation
- ISO 1873-2 Plastics—Polypropylene (PP) and Polypropylene-Copolymer Thermoplastics, Part 2: Preparation of Test Specimens and Determination of Properties
- ISO 2039-1 Plastics—Determination of Hardness, Part 1: Ball Indentation Method
- ISO 2039-2 Plastics—Determination of Hardness, Part 2: Rockwell Hardness

- ISO 2818 Plastics—Preparation of Test Specimens by Machining
- ISO 3146 Plastics—Determination of Melting Behavior (Melting Temperature or Melting Range) of Semi-Crystalline Polymers
- ISO 3167 Plastics—Preparation and Use of Multipurpose Test Specimens
- ISO 3268 Plastics—Glass-Reinforced Materials—Determination of Tensile Properties
- ISO 3451-1 Plastics—Determination of Ash, Part 1: General Methods
- ISO 3795 Road Vehicles, and Tractors and Machinery for Agriculture and Forestry—Determination of Burning Behavior of Interior Materials
- ISO 4577 Plastics—Polypropylene and Propylene-Copolymers—Determination of Thermal Oxidative Stability in Air—Oven Method
- ISO 4589 Plastics—Determination of Flammability by Oxygen Index
- ISO 4607 Plastics—Methods of Exposure to Natural Weathering
- ISO 4892-2 Plastics—Methods of Exposure to Laboratory Light, Part 2: Xenon Arc Exposure
- ISO 4892-3 Plastics—Methods of Exposure to Laboratory Light, Part 3: Fluorescent UV Lamps
- ISO 4892-4 Plastics—Methods of Exposure to Laboratory Light, Part 4: Filtered Open Flame Carbon Arc Exposure
- ISO 6427 Plastics—Determination of Matter Extractable by Organic Solvents (Conventional Methods)
- ISO 6602 Plastics—Determination of Flexural Creep by Three-Point Loading
- ISO 6603-1 Plastics—Determination of Multiaxial Impact Behavior of Rigid Plastics, Part 1: Falling Dart Method
- ISO 6603-2 Plastics—Determination of Multiaxial Impact Behavior of Rigid Plastics, Part 2: Instrumented Puncture Test
- ISO 8256 Plastics—Determination of Tensile Impact Properties
- ISO 9113 Plastics—Polypropylene (PP) and Propylene-Copolymer Thermoplastics—Determination of Isotactic Index
- ISO 10350 Plastics—Acquisition and Presentation of Comparable Single-Point Data
- ISO 11403-1 Plastics—Acquisition and Presentation of Comparable Multi-Point Data, Part 1: Mechanical Properties

2.3 *IEC Standards*:⁸

- IEC 93 Recommended Methods of Test for Volume and Surface Resistivities of Electrical Insulation Materials
- IEC 112 Recommended Method for Determining the Comparative Tracking Index of Solid Insulation Materials Under Moist Conditions
- IEC 243-1 Recommended Methods of Test for Electric Strength of Solid Insulating Materials at Power Frequencies
- IEC 250 Recommended Methods for the Determination of the Permittivity and Dielectric Dissipation Factor of

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

⁸ Available through American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

Electrical Insulation Materials at Power, Audio, and Radio Frequencies Including Metre Wavelengths
IEC 296 Specification for Unused Mineral Insulating Oils for Transformers and Switchgear

2.4 SAE Standards:⁹

SAE J1545 Instrumental Color Difference Measurement for Exterior Finishes, Textiles and Color Trim

SAE J1885 Accelerated Exposure of Automotive Interior Materials Using Controlled Irradiance Water Cooled Xenon-Arc Apparatus

SAE J1960 Accelerated Exposure of Automotive Exterior Materials Using Controlled Irradiance Water Cooled Xenon-Arc Apparatus

SAE J2019 Accelerated Exposure of Automotive Exterior Materials Using Controlled Irradiance Air Cooled Xenon Arc Apparatus

SAE J2212 Accelerated Exposure of Automotive Interior Materials Using Controlled Irradiance Air Cooled Xenon Arc Apparatus

3. Terminology

3.1 *Definitions*—Definitions of terms and abbreviations applying to this specification appear in Terminologies D 883 and D 1600 and Guide D 5033.

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

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

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

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

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

3.2.6 *injection velocity, n*—the average velocity of the melt as it passes through the cross-sectional area of a cavity of a single- or multi-cavity mold at the position that forms the critical portion of the test specimen.

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

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

3.2.9 *mold temperature, n*—the temperature of the mold during the molding cycle, measured in all mold cavities and on both platens.

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

3.2.11 *polypropylene heterophasic copolymers (PP-B, PP+EPR, or PP+EPDM)*—a propylene plastic consisting of

two or more separate phases.

3.2.11.1 *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.

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

3.2.13 *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.

3.2.13.1 *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 D 1600, 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 (0) for group, class, and grade is indicated on the table with the basic properties to be obtained from Tables A or B, as they apply (see 4.3).

4.1.2 The values in Table PP are based on testing that was conducted 40 to 96 h after the specimens arrived in the standard laboratory atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity.

4.2 Reinforced versions of the polypropylene materials are classified in accordance with Tables PP and B. Tables PP and B specify the properties of the unreinforced material, and Table A specifies 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) shall be used for the major reinforcement or combinations thereof (see Table 1), along with two numbers that indicate the nominal percentage of addition by mass (see Table 2).

NOTE 4—This part of the system uses the type and percentage of additive to designate modification of the base material. To facilitate this designation, the type and percentage of additive may 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 4.

4.2.2 Specific requirements for reinforced, pigmented, filled, or lubricated polypropylene materials shall be shown by a six-character designation. The designation shall consist of the letter A or B and the five digits comprising the cell numbers for the property requirements in the order in which they appear in Tables A or B.

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

⁹ Available from Society for Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

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 shall 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 for Table A:

- PP0110 = general purpose polypropylene homopolymer from Table PP,
- M20 = mineral filled, 20 %,
- A = Table A property requirements,
- 2 = 35 MPa tensile strength, min,
- 1 = 1000 MPa flexural modulus, min,
- 1 = to be determined, Charpy Impact, min,
- 3 = 110°C deflection temperature, min, and
- 0 = unspecified

If no properties are specified, the designation would be PP0110M20A00000.

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 shall be used in a manner similar to Table A.

NOTE 6—The 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 PP0310B55443 would indicate the following with the material requirements from Table B:

- PP0310 = impact polypropylene copolymer,
- B = Table B property requirements,
- 5 = 25 MPa tensile strength, min,
- 5 = 1000 MPa flexural modulus (1 % secant), min,
- 4 = 25 kJ/m² Izod impact, min,
- 4 = 80°C deflection temperature, min, and
- 3 = >1.0 to 3.0 nominal flow rate.

5. Suffixes

5.1 When additional requirements are needed for the materials covered in this specification that are not covered in Tables PP, A, or B, those requirements shall be designated through the use of suffixes. The primary suffix list can be found in Classification System D 4000, Section 7, Suffix Requirements. Other suffixes that pertain only to the material requirements in this specification are listed below. 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 8—Suffixes from Classification System D 4000 contain two letters followed by three numbers, while suffixes from Specification D 5857 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 System D 4000 suffix.

Suffixes:

- E = electrical requirements as designated by the following digits:
First Digit
- 0 = to be specified.

- 1 = specimens preconditioned 40 h at 23°C and 50 % relative humidity, then 14 days in distilled water at 23 ± 1°C.
- 2 = specimens preconditioned 88 h at 23°C and 50 % relative humidity, then 14 days in distilled water at 23 ± 1°C.

Second Digit

- 0 = to be specified.
- 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. Specimen size and thickness shall be in accordance with Guide D 1999.

Electrical Properties:

Dielectric constant, max	IEC 250	2.3
Dissipation factor, max	IEC 250	0.0005
Volume resistance, min, ohm-cm	IEC 93	1 × 10 ¹⁵
Water immersion stability	IEC 250	^A

^AShall meet the dielectric constant and dissipation factor requirements.

W = weatherability requirements as designated by the following digits:

First Digit

- 1 = specimens exposed to conditions specified in SAE J1960 or SAE J2019.
- 2 = specimens exposed to conditions specified in SAE J1885 or SAE J2212.
- 3 = ISO 4607.
- 4 = ISO 4892-2.
- 5 = ISO 4892-3.
- 6 = ISO 4892-3.

Second Digit

- 0 = to be specified.
- 1 = 200 h exposure.
- 2 = 500 h exposure.
- 3 = 1000 h exposure.
- 4 = 2000 h exposure.
- 5 = 1250 kJ/m² at 340 nm.
- 6 = 2500 kJ/m² at 340 nm.

Third Digit

- 0 = to be specified.
- 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 shall be no less than 50 % of the original.
- 2 = ISO 105 grey scale rating.
- 3 = colorfastness by SAE J1545, CIELAB color space, 10 degrees observer, illuminant D65. E = 2.5, max.
- % = Other special requirements characteristics (for example, internal mold release agent) not covered by existing call out capabilities may be assigned. These shall be spelled out in detail and identified in sequence, that is, 01 ultraviolet (UV)-stabilized, 02 special color, and 03, etc.

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

6. Basic Requirements

6.1 The 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 callout.

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

8. Detail Requirements

8.1 Test samples for the various materials shall conform to the requirements prescribed in Tables PP, A, and B 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 E 29 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 Unless otherwise specified, the materials shall be sampled in accordance with the sampling procedure prescribed in Practice D 1898. Adequate statistical sampling shall be considered an acceptable alternative. A batch or lot of resin shall be considered as a unit of manufacture as prepared for shipment and may 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 the specific ISO test method.

11. Sample Preparation

11.1 The method of sample preparation and type of specimen used for each test is specified in Table 3.

11.2 Injection Molding:

11.2.1 *Specimen Mold*—Specimens shall be injection molded using a mold design specified in ISO 294. A mold of the same design as ISO 294, but with shutoff valves to allow balanced molding of single types of specimens without making a complete mold change, can be used if it can be shown that it provides specimens of the same quality with mechanical properties equivalent to specimens molded in the ISO 294 design.

11.2.2 *Cavity Gate Dimensions*—The gate height and width shall be a minimum of two-thirds of the height and width of the specimen.

11.2.3 *Injection Velocity*—The following calculations shall be used to determine the injection velocity:

$$V_1 = (\pi \times D^2 \times v_s) / (4 \times n \times A_c) \quad (1)$$

or

$$v_{av} = V_s / (t_1 \times A_c \times n) \quad (2)$$

where:

- V_1 = injection velocity, mm/s,
- D = screw diameter, mm,
- v_s = screw speed, mm/s,
- n = number of cavities,

- A_c = cross section at the position that forms the critical portion of the test specimen,
- V_s = shot volume, mm³, and
- t_1 = injection time, s.

NOTE 9—Eq 1 and 2 may give slightly different values to some extent due to different contributions of the compression of the whole melt in front of the screw and from different amounts of back flow.

11.2.4 For a given molding machine and given mold, the injection pressure and injection velocity shall be set to produce equal part weights, including sprue and runners, within 1 % regardless of the material's melt flow rate.

11.2.5 *Reporting*—Report the injection molding conditions in accordance with ISO 294 and 1873-2.

11.3 Compression Molding:

11.3.1 *Specimens*—For electrical testing or when the specimens cannot be injection molded, specimens shall be prepared by stamping or machining (see ISO 2818) from a compression-molded sheet. Compression molding of sheet shall be conducted in accordance with ISO 293, with the following additional points specified in ISO 1873-2:

11.3.1.1 *Mold*—A simple three-plate frame.

11.3.1.2 *Predrying*—No drying is normally necessary.

11.3.1.3 *Molding Temperature*— $210 \pm 5^\circ\text{C}$.

11.3.1.4 *Average Cooling Rate*—Method B; $15 \pm 5^\circ\text{C}/\text{min}$.

11.3.1.5 *Molding Procedure*—The contact pressure time shall be 5 to 10 min, and the full-pressure time shall be 2 to 5 min. The demolding temperature shall be less than or equal to 40°C .

11.4 The method of sample preparation may affect the level of crystallinity or orientation in the test specimen. As a consequence, test specimens may yield different test results. Thus, the method of preparation shall be taken into account when comparing results. In cases of disagreement, injection-molded specimens shall be the referee standard.

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 $23 \pm 2^\circ\text{C}$. 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 $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity (see Practice D 618, 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 procedure.

NOTE 10—When the temperature in the molding area exceeds 28°C or the humidity level exceeds 55 % (applies only to filled material) specimens shall be moved as quickly as possible to the controlled or standard laboratory atmosphere.

12.1.2 Testing, except for those tests where a test time is specified, shall be conducted within 40 to 96 h after molding. This test time range shall apply to all testing conducted for

development of a line callout, data for publication, for certification, or for cases of dispute over testing values.

12.1.3 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. Specimens shall be tested within 96 hours after molding.

NOTE 11—Extending the conditioning time may result in increased or decreased test results. 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:

12.2.1 Natural unfilled polypropylene shall be tested in a controlled laboratory atmosphere of $23 \pm 2^\circ\text{C}$. For filled and reinforced polypropylene or polypropylene blends that contain a hydrophilic comonomer or modifier, the specimens shall be tested in a standard laboratory atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ 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.

13. Test Methods

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

13.1.1 *Flow Rate*—Condition 12 (230°C with 2.16 kg load) of ISO 1133. Make two determinations on the material in the form that it is to be molded (such as powder, pellets, or granules).

NOTE 12—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, may be 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 *Tensile Strength*—Test an ISO 3167 Type A specimen using ISO 527. For materials that show a yielding and a breaking strain greater than 10 %, use a test speed of 50 mm/min. For materials that break at a strain less than 10 %, use a test speed of 2 mm/min.

13.1.3 *Flexural Modulus (Chord Modulus)*—Using ISO 178, determine a chord modulus between 0.0005 and 0.0025 mm/mm strain. Use a rectangular 80 by 10 by 4-mm specimen cut from the center of the ISO 3167 Type A multipurpose specimen. Set the test span at 64 mm and test speed to 2 mm/min. The support rods and loading nose shall be 5 ± 0.1 mm in radius.

NOTE 13—If the ISO 3167 Type A specimens were molded on a mold containing a draft angle, the specimens will be trapezoidal. Therefore, the flexural modulus may vary slightly, depending on which side is placed away from the loading nose.

13.1.4 *Charpy Impact Resistance*—The center section of the ISO 3167 Type A multipurpose bar shall be tested in accordance with ISO 179, Method 1A, with the V-notch having 0.25-mm radius at bottom. The test temperature is 23°C .

13.1.5 *Falling Mass Impact Resistance*—Testing shall be conducted in accordance with ISO 6603-1, with a 60-mm diameter by 2-mm thick specimen or a 60-mm square by 2-mm thick specimen (the square specimen is preferred as this specimen may also be used to measure mold shrinkage properties). The specimen is supported by a 40-mm diameter ring and impacted with a 20-mm diameter dart. The test may be conducted by a variable height or variable weight method. Determine the total energy to failure.

13.1.6 *Temperature of Deflection Under Load*—ISO 75-1 and 75-2 shall be used to test a rectangular 80 by 10 by 4-mm specimen in the flatwise position. A load is applied at the center of the specimen to give a fiber stress of 1.8 MPa.

13.1.7 Refer to Table 4, ISO 10350, and ISO 11403 for a listing of additional test methods that may be required to characterize the material.

14. Inspection and Certification

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

14.2 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 certifiability. Tests are melt flow rate, percent of reinforcement or filler, tensile strength at yield, flexural modulus, Charpy impact, and temperature of deflection under load (HDT).

14.3 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 that the material is certifiable in accordance with 14.4.

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

14.5 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 results of the most recent periodic-check inspection.

15. Rejection and Rehearing

15.1 Material that fails to conform to the requirements of this specification may not be certified. If any failure occurs, the materials may be retested to establish conformity. Rejection shall be reported to the supplier promptly and in writing. In case of dissatisfaction with the results of the test, a claim for a rehearing may be made.

16. Packaging and Package Marking

16.1 The provisions of Practices D 3892 and D 1972 apply for packaging, packing, and marking of plastic materials.

17. Keywords

17.1 injection and extrusion materials; polypropylene; recycled

TABLE PP Requirements for Unreinforced, Reinforced, and Filled Polypropylene (Natural Color Only)

Group	Description	Class	Description	Grade	Description	Nominal Flow Rate, ^A ISO 1133, Condition 230/2.16, g/10 min	Density, Maximum, ISO 1183, kg/m ³ , ^B (for reference only)	Tensile ^C Strength, ISO 527, minimum, MPa	Flexural Modulus ^{D,E} (Chord), ISO 178, minimum, MPa	Charpy Impact ^D Resistance at 23°C, ISO 179, minimum, kJ/m ²	Multi-axial Impact Behavior at -30°C, ISO 6603-2, minimum, ^F J	Deflection Temperature at 1.8 MPa Stress, ^D ISO 75-2 Flatwise, minimum, ^C °C			
01	Homopolymer	1	general-purpose	1	unfilled	≤0.3	910	26	1075	3.5		48			
				2	unfilled	>0.3 ≤1.0	910	26	1025	3.1		48			
				3	unfilled	>1.0 ≤3.0	910	26	1025	2.9		46			
				4	unfilled	>3.0 ≤7.0	910	26	975	2.5		45			
				5	unfilled	>7.0 ≤20	910	24.5	875	2.1		45			
				6	unfilled	>20 ≤40	910	23.5	825	1.9		43			
				7	unfilled	>40 ≤100	910	22.5	825	1.7		43			
				8	unfilled	>100 ≤200	910	21.5	875	1.7		43			
				9	unfilled	>200	910	20	875	1.4		46			
				0	other										
		2	nucleated	1	unfilled	>1.0 ≤3.0	915	31.5	1375	3.1			53		
				2	unfilled	>1.0 ≤3.0	915	29	1175	3.1			50		
				3	unfilled	>3.0 ≤7.0	915	29	1175	2.6			53		
				4	unfilled	>3.0 ≤7.0	915	29	1175	2.5			50		
				5	unfilled	>7.0 ≤20	915	28.5	1175	2.4			52		
				6	unfilled	>7.0 ≤20	915	28.5	1175	2.1			49		
				7	unfilled	>20	915	27	1075	2.1			47		
				0	other										
				3	high-crystallinity	1	unfilled	≤1.0	920	36	2050	2.5			53
						2	unfilled	>1.0 ≤3.0	920	34	1850	2.5			53
3	unfilled	>3.0 ≤7.0	920			34	1650	2.5			53				
4	unfilled	>7.0 ≤20	920			31	1425	2.6			52				
5	unfilled	>20 ≤40	920			28.5	1325	2.8			50				
6	unfilled	>40	920			24.5	1325	3.0			50				
0	other														
0	other														
02	Random Copolymer	1	general-purpose	1	unfilled	...	910	22.5	1025	3.3		47			
				2	unfilled	...	910	22.5	825	3.3		44			
				3	unfilled	...	910	21	700	3.3		44			
				4	unfilled	...	910	19	600	4.2		42			
				5	unfilled	...	910	16	525	4.6		42			
				6	unfilled	...	910	15	425	5.1		42			
				7	unfilled	...	910	14	350	5.1		42			
		0	other												
		2	nucleated	1	unfilled	...	915	24.5	1000	3.8			49		
				2	unfilled	...	915	22.5	700	4.2		46			
				3	unfilled	...	915	21	600	4.2		45			
				4	unfilled	...	915	20	400	5.1		44			
		0	other												
		0	other												
03	Copolymers or Impact Modified	1	low-impact	1	unfilled	...	...	24.5	1025	1.7		47	
				2	unfilled	...	...	20	875	1.6		43	
				3	unfilled	...	...	22	875	3.3		45	
				4	unfilled	...	...	17	675	3.3		43	
				5	unfilled	...	...	16	450	3.3		42	
				6	unfilled	...	...	22.5	825	5.1		46	
				7	unfilled	...	...	21	775	5.1		45	
				8	unfilled	...	...	19	775	5.1		45	
				9	unfilled	...	...	17	675	5.1		43	
				0	other										
		2	moderate impact	1	unfilled	25.5	1025	6.0			49		
				2	unfilled	...	...	23.5	875	6.9		47	
				3	unfilled	...	...	22	875	6.9		46	
				4	unfilled	...	...	20	775	6.9		45	
				5	unfilled	...	...	18	575	6.9		45	
				6	unfilled	...	...	18	575	6.9		42	
				7	unfilled	...	...	21	725	8.6		46	
				8	unfilled	...	...	16	675	8.6		43	
				9	unfilled	...	...	14	575	8.6		42	
0	other														
3	medium-impact	1	unfilled	...	...	23.5	1025	9.5			46		
		2	unfilled	...	...	22	925	11		45			
		3	unfilled	...	...	18	725	11		43			

TABLE PP Requirements for Unreinforced, Reinforced, and Filled Polypropylene (Natural Color Only)

Group	Description	Class	Description	Grade	Description	Nominal Flow Rate, ^A ISO 1133, Condition 230/2.16, g/10 min	Density, Maximum, ISO 1183, kg/m ³ , ^B (for reference only)	Tensile ^C Strength, ISO 527, minimum, MPa	Flexural Modulus ^{D,E} (Chord), ISO 178, minimum, MPa	Charpy Impact ^D Resistance at 23°C, ISO 179, minimum, kJ/m ²	Multi-axial Impact Behavior at -30°C, ISO 6603-2, minimum, ^F J	Deflection Temperature at 1.8 MPa Stress, ^D ISO 75-2 Flatwise, minimum, ^G °C
				4	unfilled	...	...	16	525	11		42
				5	unfilled	...	...	16	625	14		43
				6	unfilled	...	...	23.5	875	18		45
				7	unfilled	...	...	19	875	18		45
				8	unfilled	...	...	19	725	18		45
				9	unfilled	...	...	15	525	18		42
				0	other							
		4	high-impact	1	unfilled	...	...	22.5	825	27		47
				2	unfilled	...	...	20	825	27		46
				3	unfilled	...	...	20	575	27		45
				4	unfilled	...	...	16	525	27		43
				5	unfilled	...	...	14	475	27		42
				6	unfilled	...	...	15	525	36		43
				7	unfilled	...	...	22.5	775	53		45
				8	unfilled	...	...	19	725	53		43
				9	unfilled	...	...	18	525	53		42
				0	other							
		5	nucleated	1	unfilled	...	...	27.5	1025	1.6		46
				2	unfilled	...	...	25.5	1325	3.3		52
				3	unfilled	...	...	22	975	3.3		50
				4	unfilled	...	...	20	875	3.3		49
				5	unfilled	...	...	22	1075	5.1		49
				6	unfilled	...	...	18	825	5.1		49
				7	unfilled	...	...	24.6	1175	7.1		49
				8	unfilled	...	...	21	875	7.1		47
				9	unfilled	...	...	18	575	9.5		47
				0	other							
11	Glass-filled homopolymer	1	reinforced	1	...							
				2	...							
				3	...							
				4	...							
				5	...							
				6	...							
				7	...							
				8	...							
				9	...							
				0	other							
		2	chemically- coupled	1	...			45	2700	3		140
				2	...			55	3400	3		145
				3	...			60	4000	5		150
				4	...			65	4500	5		150
				5	...			70	5000	5		150
				6	...			75	5600	5		150
				7	...			80	6200	5		150
				8	...			85	6800	5		150
				9	...			90	7400	5		150
				0	other							
		3	heat- stabilized	1	...							
				2	...							
				3	...							
				4	...							
				5	...							
				6	...							
				7	...							
				8	...							
				9	...							
				0	other							
		4	chemically- coupled/ heat- stabilized	1	...							
				2	...							
				3	...							
				4	...							
				5	...							
				6	...							
				7	...							
				8	...							
				9	...							
				0	other							

TABLE PP Requirements for Unreinforced, Reinforced, and Filled Polypropylene (Natural Color Only)

Group	Description	Class	Description	Grade	Description	Nominal Flow Rate, ^A ISO 1133, Condition 230/2.16, g/10 min	Density, Maximum, ISO 1183, kg/m ³ , ^B (for reference only)	Tensile ^C Strength, ISO 527, minimum, MPa	Flexural Modulus ^{D,E} (Chord), ISO 178, minimum, MPa	Charpy Impact ^D Resistance at 23°C, ISO 179, minimum, kJ/m ²	Multi-axial Impact Behavior at -30°C, ISO 6603-2, minimum, ^F J	Deflection Temperature at 1.8 MPa Stress, ^D ISO 75-2 Flatwise, minimum, ^G °C		
12	Glass-filled copolymer	1	reinforced	1	...									
				2	...									
				3	...									
				4	...									
				5	...									
				6	...									
				7	...									
				8	...									
				9	...									
				0	other									
		2	chemically- coupled	1	...					37	3100	8		140
				2	...					41	4100	8		145
				3	...					48	4800	8		150
				4	...					58	5800	8		150
				5	...					68	7500	8		150
				6	...					35	3000	16		140
				7	...					42	4200	16		145
				8	...					50	5200	16		145
				9	...					65	6500	16		145
				0	other									
		3	heat- stabilized	1	...									
				2	...									
				3	...									
				4	...									
				5	...									
				6	...									
				7	...									
				8	...									
				9	...									
				0	other									
4	chemically- coupled/ heat- stabilized	1	...											
		2	...											
		3	...											
		4	...											
		5	...											
		6	...											
		7	...											
		8	...											
		9	...											
		0	other											
21	Talc-filled homopolymer	1	general	1	...			34	1350	2		85		
				2	...			33	1700	2		90		
				3	...			32	2000	2		95		
				4	...			31	2200	2		95		
				5	...			30	2350	2		100		
				6	...			29	2550	2		105		
				7	...			27.5	2650	2		110		
				8	...			25.5	2750	2		115		
				9	...			23.5	2900	2		125		
				0	other									
22	Talc-filled copolymer	1	general	1	...			27	1350	3		90		
				2	...			26	1450	3		100		
				3	...			23	1600	3		105		
				4	...			22	1850	3		110		
				5	...			21	2400	3		120		
				6	...			19	1100	8		85		
				7	...			16	1250	5		95		
				8	...			15	1500	4		100		
				9	...			14	2000	3		110		
				0	other									
31	Calcium carbonate- filled homopolymer	1	general	1	...			32	1350	2		85		
				2	...			30	1550	2		90		
				3	...			29	1700	2		95		
				4	...			28	1900	2		100		
				5	...			26	2050	2		100		
				6	...			25	2200	2		105		

TABLE PP Requirements for Unreinforced, Reinforced, and Filled Polypropylene (Natural Color Only)

Group	Description	Class	Description	Grade	Description	Nominal Flow Rate, ^A ISO 1133, Condition 230/2.16, g/10 min	Density, Maximum, ISO 1183, kg/m ³ , ^B (for reference only)	Tensile ^C Strength, ISO 527, minimum, MPa	Flexural Modulus ^{D,E} (Chord), ISO 178, minimum, MPa	Charpy Impact ^D Resistance at 23°C, ISO 179, minimum, kJ/m ²	Multi-axial Impact Behavior at -30°C, ISO 6603-2, minimum, ^F J	Deflection Temperature at 1.8 MPa Stress, ^D ISO 75-2 Flatwise, minimum, ^G °C	
32	Calcium carbonate-filled copolymer	1	general	7	...			24	2350	2		105	
				8	...			23.5	2450	2		105	
				9	...			23	2600	2		110	
				0	other								
				1	...			32.5	1450	2.5		85	
				2	...			30	1650	2.5		90	
				3	...			28	1850	3		95	
				4	...			27	1900	3		95	
				5	...			26	2000	3.5		100	
				6	...			25	2050	3.5		100	
	7	...			24	2050	3.7		100				
	8	...			23	2100	4.3		105				
	9	...			22	2150	4.8		105				
	0	other											
	1	chemically-reactive			1	...	20.5	1150	10.5		80		
	2	...			2	...	19	1250	9.5		85		
	3	...			3	...	17	1400	8		90		
	4	...			4	...	16.5	1700	6.5		90		
	5	...			5	...	15.5	1900	5		95		
	6	...			6	...	18	850	16		70		
7	...			7	...	16.5	1100	10		75			
8	...			8	...	14.5	1350	8		80			
9	...			9	...	13.5	1550	6		85			
0	other			0	other								
41	Mica-filled homopolymer	1	general	1	...								
				2	...								
				3	...								
				4	...			29	3400	2		125	
				5	...								
				6	...								
				7	...								
				8	...								
				9	...								
				0	other								
42	Mica-filled copolymer	1	general	1	...								
				2	...								
				3	...								
				4	...								
				5	...								
				6	...								
				7	...								
				8	...								
				9	...								
				0	other								
51	Glass/talc-filled homopolymer	1	general	1	...								
				2	...								
				3	...								
				4	...								
				5	...								
				6	...								
				7	...								
				8	...								
				9	...								
				0	other								

TABLE PP Requirements for Unreinforced, Reinforced, and Filled Polypropylene (Natural Color Only)

Group	Description	Class	Description	Grade	Description	Nominal Flow Rate, ^A ISO 1133, Condition 230/2.16, g/10 min	Density, Maximum, ISO 1183, kg/m ³ , ^B (for reference only)	Tensile ^C Strength, ISO 527, minimum, MPa	Flexural Modulus ^{D,E} (Chord), ISO 178, minimum, MPa	Charpy Impact ^D Resistance at 23°C, ISO 179, minimum, kJ/m ²	Multi-axial Impact Behavior at- 30°C, ISO 6603-2, minimum, ^F J	Deflection Temperature at 1.8 MPa Stress, ^D ISO 75-2 Flatwise, minimum, ^C °C	
52	Glass/talc- filled copolymer	1	general	1	...								
				2	...								
				3	...								
				4	...								
				5	...								
				6	...								
				7	...								
				8	...								
				9	...								
				0	other								
53	Glass/calcium carbonate filled homopolymer	1	general	1	...								
				2	...								
				3	...								
				4	...								
				5	...								
				6	...								
				7	...								
				8	...								
				9	...								
				0	other								
54	Glass/calcium carbonate filled copolymer	1	general	1	...								
				2	...								
				3	...								
				4	...								
				5	...								
				6	...								
				7	...								
				8	...								
				9	...								
				0	other								
00	Other	0	other	0	other								

^ANominal flow rate is as supplied by the manufacturer of the material. Maximum allowable tolerance $\pm 30\%$ per individual lot.

^BFor general information, not a requirement.

^CTest specimens are unannealed ISO 3167 Type A multi-purpose specimen and shall be tested at 50 mm/min, unless elongation at break is less than 10 %, then speed shall be 5 mm/min.

^DTest specimens are nominal 4.0 mm by 10 mm cross section and are cut from center section of unannealed ISO 3167 Type A multi-purpose specimen.

^ESpan is a nominal 64 mm. Rate of crosshead is 2.0 mm/min.

^FTest specimens are a nominal of 2.0 mm in thickness.

TABLE A Detail Requirements^A of Polypropylene Not Called Out by Tables B, C, G, or T

Designation or Order No.	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile stress at yield, ^B ISO 527, min, MPa	unspecified	20	33	47	60	75	90	105	120	specify value ^C
2	Flexural modulus (chord), ^{D,E} ISO 178, min, MPa	unspecified	1000	2000	3000	4000	5000	6000	7000	8000	specify value ^C
3	Charpy impact resistance ^D at 23°C, ISO 179, min, kJ/m ²	unspecified	2.0	3.3	4.7	6.0	8.6	12	17	23	specify value ^C
4	Deflection temperature at 1.8 MPa, ^D ISO 75-2 Flatwise, min, °C	unspecified	47	52	56	61	67	72	78	84	specify value ^C
5	To be determined	unspecified									specify value ^C

^AIt is recognized that detailed test values, particularly Charpy Impact, may not predict nor even correlate with performance of parts molded of these materials.

^BTest specimens are unannealed ISO 3167 Type A multi-purpose specimen and shall be tested at 50 mm/min, unless elongation at break is less than 10 %, then speed shall be 5 mm/min.

^CIf a specific value is required, it must appear on the drawing or contract.

^DTest specimens are the center of the unannealed ISO 3167 Type A multi-purpose specimen with a nominal 4.0 by 10.0-mm cross section.

^ESpan is a nominal 64 mm. Rate of crosshead is 2.0 mm/min.

TABLE B Detail Requirements^A of Unfilled and Unreinforced Polypropylene

Designation or Order No.	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile stress at yield, ^B ISO 527, min, MPa	unspecified	5	10	15	20	25	29	33	38	specify value ^C
2	Flexural modulus (chord), ^{D,E} ISO 178, min, MPa	unspecified	100	250	500	750	1000	1250	1500	1750	specify value ^C
3	Charpy impact resistance ^D at 23°C, ISO 179, min, kJ/m ²	unspecified	1.6	5.1	9.5	18	27	36	45	62	specify value ^C
4	Deflection temperature at 1.8 MPa, ^D ISO 75-2 Flatwise, min, °C	unspecified	39	42	47	49	50	55	58	60	specify value ^C
5	Flow rate, ^F ISO 1133 Condition 230/2.16, g/10 min	unspecified	<0.3	>0.3-1.0	>1.0-3.0	>3.0-10	>10-20	>20-40	>40-100	>100	specify value ^C

^AIt is recognized that detailed test values, particularly Charpy Impact, may not predict nor even correlate with performance of parts molded of these materials.

^BTest specimens are unannealed ISO 3167 Type A multi-purpose specimen and shall be tested at 50 mm/min, unless elongation at break is less than 10 %, then speed shall be 5 mm/min.

^CIf a specific value is required, it must appear on the drawing or contract.

^DTest specimens are the center of the unannealed ISO 3167 Type A multi-purpose specimen with a nominal 4.0 by 10.0-mm cross section.

^ESpan is a nominal 64 mm. Rate of crosshead is 2.0 mm/min.

^FNominal flow rate is as supplied by the manufacturer of the material. Allowable tolerance $\pm 30\%$ per individual lot.

TABLE C Detail Requirements^A of Calcium Carbonate Filled Polypropylene

Designation or Order No.	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile stress at yield, ^B ISO 527, min, MPa	unspecified	10	13	16	20	23	26	29	32	specify value ^C
2	Flexural modulus (chord), ^{D,E} ISO 178, min, MPa	unspecified	800	1100	1400	1750	1950	2250	2550	2750	specify value ^C
3	Charpy impact resistance ^D at 23°C, ISO 179, min, kJ/m ²	unspecified	2.0	3.8	5.5	7.3	8.6	10.4	12.6	14.4	specify value ^C
4	Deflection temperature at 1.8 MPa, ^D ISO 75-2 Flatwise, min, °C	unspecified	45	47	49	51	53	55	57	59	specify value ^C
5	To be determined	unspecified									specify value ^C

^AIt is recognized that detailed test values, particularly Charpy Impact, may not predict nor even correlate with performance of parts molded of these materials.

^BTest specimens are unannealed ISO 3167 Type A multi-purpose specimen and shall be tested at 50 mm/min, unless elongation at break is less than 10 %, then speed shall be 5 mm/min.

^CIf a specific value is required, it must appear on the drawing or contract.

^DTest specimens are the center of the unannealed ISO 3167 Type A multi-purpose specimen with a nominal 4.0 by 10.0-mm cross section.

^ESpan is a nominal 64 mm. Rate of crosshead is 2.0 mm/min.

TABLE G Detail Requirements^A of Glass Reinforced Polypropylene

Designation or Order No.	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile stress at yield, ^B ISO 527, min, MPa	unspecified	23	30	38	45	54	61	70	77	specify value ^C
2	Flexural modulus (chord), ^{D,E} ISO 178, min, MPa	unspecified	1000	1950	2850	3750	4700	5600	6500	7450	specify value ^C
3	Charpy impact resistance ^D at 23°C, ISO 179, min, kJ/m ²	unspecified	2.0	3.8	5.5	7.7	9.5	12	14	16	specify value ^C
4	Deflection temperature at 1.8 MPa, ^D ISO 75-2 Flatwise, min, °C	unspecified	50	70	90	100	110	120	130	140	specify value ^C
5	To be determined	unspecified									specify value ^C

^AIt is recognized that detailed test values, particularly Charpy Impact, may not predict nor even correlate with performance of parts molded of these materials.

^BTest specimens are unannealed ISO 3167 Type A multi-purpose specimen and shall be tested at 50 mm/min, unless elongation at break is less than 10 %, then speed shall be 5 mm/min.

^CIf a specific value is required, it must appear on the drawing or contract.

^DTest specimens are the center of the unannealed ISO 3167 Type A multi-purpose specimen with a nominal 4.0 by 10.0-mm cross section.

^ESpan is a nominal 64 mm. Rate of crosshead is 2.0 mm/min.

TABLE T Detail Requirements^A of Talc Filled Polypropylene

Designation or Order No.	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile stress at yield, ^B ISO 527, min, MPa	unspecified	11	15	19	23	26	30	34	38	specify value ^C
2	Flexural modulus (chord), ^{D,E} ISO 178, min, MPa	unspecified	650	1000	1350	1750	2100	2450	2800	3150	specify value ^C
3	Charpy impact resistance ^D at 23°C, ISO 179, min, kJ/m ²	unspecified	2.0	3.8	5.5	7.3	9.1	11	12.5	14.5	specify value ^C
4	Deflection temperature at 1.8 MPa, ^D ISO 75-2 Flatwise, min, °C	unspecified	44	47	50	53	56	59	62	65	specify value ^C
5	To be determined	unspecified									specify value ^C

^AIt is recognized that detailed test values, particularly Charpy Impact, may not predict nor even correlate with performance of parts molded of these materials.

^BTest specimens are unannealed ISO 3167 Type A multi-purpose specimen and shall be tested at 50 mm/min, unless elongation at break is less than 10 %, then speed shall be 5 mm/min.

^CIf a specific value is required, it must appear on the drawing or contract.

^DTest specimens are the center of the unannealed ISO 3167 Type A multi-purpose specimen with a nominal 4.0 by 10.0-mm cross section.

^ESpan is a nominal 64 mm. Rate of crosshead is 2.0 mm/min.

TABLE 1 Coding System for Fillers and Reinforcing Materials

Code	Material
B	boron
C	carbon
E	clay
F	flame retardant
G	glass
K	calcium carbonate
L	lubricants
M	minerals
N	other minerals
O	metals
P	mica
R	mixture of filler/reinforcement
S	organic synthetics
T	talc
U	wallastonite
W	wood
X	not specified
Y	proprietary
Z	others

TABLE 2 Coding System for the Mass Content of Fillers and Reinforcement

Code	Nominal Mass Content (%)
XX	proprietary
00	≤2.5
05	>2.5 to 7.5
10	>7.5 to 12.5
15	>12.5 to 17.5
20	>17.5 to 22.5
25	>22.5 to 27.5
30	>27.5 to 32.5
35	>32.5 to 37.5
40	>37.5 to 42.5
45	>42.5 to 47.5
50	>47.5 to 55
60	>55 to 65
70	>65 to 75
80	>75 to 85
90	>85

TABLE 3 Recommended Processing Conditions

Material MFR, g/10 min ^A	Melt Temperature, °C ^{B,C,D}	Mold Temperature, °C ^E	Cycle Time, s ^F	Hold Time, s	Injection Velocity, mm/s ^G	Injection and Hold Pressure, ^{G,H} MPa	Back Pressure, MPa	Demolding Temperature, °C
<1	255 ± 5	40 ± 5	60	40	200 ± 20	variable	7	60
≥1, ≤7	230 ± 5	40 ± 5	60	40	200 ± 20	variable	7	60
>7	200 ± 5	40 ± 5	60	40	200 ± 20	variable	7	60

^AThe MFR is determined in accordance with ISO 1133 at 230°C and load of 2.16 kg.

^BThe melt temperature shall be measured on cycle by taking the temperature of several successive free shots with a needle-type pyrometer to an accuracy of ±3°C. The needle shall 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 the 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. To avoid excessive thermal history, the shot size shall be kept to a minimum; therefore, the cushion shall be 5 to 10 mm.

^CIf other temperatures have to be used because of the nature of the polymer, they shall be reported, together with the reasons for use.

^DHeat-sensitive polymers may undergo molecular breakdown during molding; therefore, an increase in the MFR to 1.5 times the original value shall be avoided. If the MFR increases by more than 1.5 times the original value, the melt temperature shall be lowered, 10°C at a time, until the increase in MFR is <1.5 times the original value.

^ETemperature 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.

^FThe cycle time will be dependent on the time it takes the material to reach the demolding temperature.

^GFor a given molding machine and given mold, the injection pressure and injection velocity shall be set to produce equal part weights, including sprue and runners, within 1 % regardless of the material melt flow rate.

^HThe injection pressure and hold pressure shall be set at a level that does not produce flash, sink marks, or voids in the specimens. The maximum amount of flash shall not exceed 1 mm and shall be acceptable only in the nontesting areas of the specimen.

TABLE 4 Properties and Test Conditions

Number	Properties	Standard	Specimen Type, Dimensions, mm	Processing Method	Unit	Test Conditions and Supplementary Instructions
1.0	Rheological properties					
1.1	Melt flow rate—mass	ISO 1133	granule or powder		g/10 min	230°C, 2160 g
1.2	Melt flow rate—volume		granule or powder		ml/10 min	230°C, 2160 g
2.0	Mechanical Properties					
2.1	Tensile modulus	ISO 527-1, -2	ISO 3167 Type A	injection	MPa	for modulus, speed is 1 % of gage length/min. Test speed is 50 mm/min for ductile materials, 5 mm for brittle material, and 2 mm/min for glass-reinforced material; see Footnote A for definition of ductile and brittle failure; ^A see Footnote B for measurement of break properties. ^B
2.2	Tensile yield stress	ISO 3268	ISO 3167 Type B (also referred to as ISO 527 Type 1A or 1B)			
2.3	Tensile yield strain		Type B recommended for testing glass-filled materials and machined specimens			
2.4	Tensile break stress					
2.5	Tensile break strain					
2.6	Tensile creep modulus	ISO 899 ISO 11403-1	20 by 2.5 by 1.6	injection	MPa	Test at seven temperatures, one of which is +23°C. Temperature shall be selected to span the useful working range of the polymer. For PP, the following temperatures are recommended for use: -40, -20, 0, +23, +50, +80, and +100°C. For each temperature, test at five stress levels up to 10 000 h. Stress levels shall be 20, 40, 60, 80, and 100 % of the maximum stress that can be maintained for prolonged periods of time at the test temperature. Determine the creep modulus at 1 h and 1000 h at strain level less than 0.5 %.
2.7	Flexural modulus	ISO 178	center of ISO 3167 Type A	injection	MPa	test speed 2 mm/min, 64-mm span, and chord modulus between 0.0005 and 0.0025 mm/mm strain
2.8	Flexural strength					
2.9	Flexural creep modulus	ISO 6602	center of ISO 3167 Type A	injection	MPa	same requirements as tensile creep (2.6)
2.10	Compressive strength and modulus	ISO 604	for strength 10 by 10 by 4, for modulus 50 by 10 by 4	injection	MPa	speed of test 0.02 mm/min for modulus, 0.1 mm/min for brittle materials, and 0.5 mm/min for ductile materials
2.11	Shear modulus	ISO 537	60 by 10 by 1	injection	MPa	Method A at 1 Hz, from -100 to +150°C
2.12	Charpy impact strength	ISO 179	center of ISO 3167 Type A	injection	kJ/m ²	Method 1 unnotched (edgewise)
2.13	Charpy notched impact strength	ISO 179	center of ISO 3167 Type A	injection	kJ/m ²	Method 1A (edgewise)
2.14	Izod impact strength	ISO 180	center of ISO 3167 Type A	injection	kJ/m ²	Method 1A, V-notch 0.25 mm radius
2.15	Tensile impact strength	ISO 8256	80 by 10 by 4 Double-V notch, r = 1	injection	kJ/m ²	determined only when fracture cannot be achieved in the Izod or Charpy test
2.16	Falling dart impact	ISO 6603-1	60 by 60 by 2 (or 60 mm diameter by 2 mm)	injection	J	50 % failure energy, Method A
2.17	Instrumented falling dart impact	ISO 6603-2	60 by 60 by 2 (or 60 mm diameter by 2 mm)	injection	J	20 mm diameter dart, 40 mm support velocity 4.4 m/s, report peak and total values
2.18	Ball indentation hardness	ISO 2039-1	50 by 50 by 4	injection	N/mm ²	
2.19	Rockwell hardness	ISO 2039-2	min 50 by 50 by 6 (min)	injection	HRR	thickness can be achieved by plying
2.20	Shore A or D hardness	ISO 868	min 50 by 50 by 6 (min)	injection	Value A or D	value at 1 s, durometer A or D, thickness can be achieved by plying
3.0	Thermal Properties					
3.1	Melting temperature	ISO 3146	molding powder		°C	Method C
3.2	Temperature of deflection under load	ISO 75-1 ISO 75-2	120 by 10 by 4	injection	°C	stress level 0.45 MPa or 1.80 MPa, span 100 mm for specimens in edgewise position, 64 mm for specimens positioned flatwise
3.3	Vicat softening temperature	ISO 306	min 10 by 10 ² or 10 mm diameter disk by min 3 mm thickness	injection	°C	Method A with 10 N load at 50°C/h
3.4	Brittleness temperature	ISO 974	20 by 2.5 by 1.6	injection	°C	unnotched specimens

TABLE 4 *Continued*

Number	Properties	Standard	Specimen Type, Dimensions, mm	Processing Method	Unit	Test Conditions and Supplementary Instructions
3.5	Coefficient of linear thermal expansion	TMA	ISO 3167 Type A	injection	1/K	secant value over temperature range of 23 to 55°C
3.6	Flammability	ISO 1210 ISO 3795	120 by 10 by 4 356 by 100 by 1.5 min	injection or sheet	s	horizontal burn, either time or length of burn, 38 mm flame height, 15 s exposure to flame
3.7	Oxygen index	ISO 4589	80 by 10 by 4	injection	%	Procedure A—top surface ignition
4.0	Electrical Properties					
4.1	Relative permittivity	IEC 250	80 by 80 by 1	compression		frequency 1 MHz
4.2	Dissipation factor	IEC 250	80 by 80 by 1	compression		frequency 1 MHz
4.3	Volume resistivity	IEC 93	80 by 80 by 1	compression	ohm-m	voltage 500 V
4.4	Surface resistivity	IEC 93	80 by 80 by 1	compression	ohm	
4.5	Dielectric strength	IEC 243-1	80 by 80 by 1	compression	kv/mm	use electrode configuration 25 mm/75 mm coaxial cylinders; immersion in transformer oil IEC 296; use 20 step by step test
4.6	Comparative tracking index	IEC 112	100 by 100 by 3 (min) or 100 mm diameter disk by 3 (min) thickness	compression		use 0.1 % ammonium chloride (aqueous solution), at 50 Hz
5.0	Aging Properties					
5.1	Natural weathering	ISO 4607	dependent on secondary testing to be conducted	injection		
5.2	Artificial-light weathering	ISO 4892-2 ISO 4892-3 ISO 4892-4 ISO 11403-3	dependent on secondary testing to be conducted	injection		
5.3	Artificial-light weathering	SAE J1885 SAE J1960	60 by 60 by 2.0	injection		water-cooled xenon arc weathering device ^C light exposure 1250 kJ/m ² at 340 nm light exposure 2500 kJ/m ² at 340 nm
5.4	Artificial-light weathering	SAE J2019 SAE J2212	60 by 60 by 2.0	injection		air-cooled xenon arc weathering device ^C light exposure 1250 kJ/m ² at 340 nm light exposure 2500 kJ/m ² at 340 nm
5.5	Oven aging	ISO 4577	50 by 10 by 1	compression	days	150°C, or temperature to achieve failure at greater than or equal to 7 days
6.0	Other Properties					
6.1	Water absorption	ISO 62	50 mm square or disk by 3 mm	injection	%	24 h immersion at 23°C
6.2	Density	ISO 1183A	10 by 10 by 4	injection	kg/m ³	
6.3	Limiting viscosity number	ISO 1191 or 1628-3	granules or powder		mL/g	decalin at 135°C
6.4	Xylene solubles	ISO 6427 Appendix B	granules or powder		%	1 % solution of PP in xylene 30 min cooling time
6.5	Isotactic index	ISO 9113	granules or powder		%	solubility in boiling heptane 24 h extraction
6.6	Ash	ISO 3451	any form		%	

^ADuctile Failure—If the polymer shows ductile failure, that is, yielding or breaking strain beyond 10 %, the testing speed shall be 50 mm/min, and the values for yield stress and strain and the nominal strain at break are recorded. If breaking occurs above 50 % nominal strain, record >50 for the nominal strain at break. If no yielding is observed up to 50 % nominal strain, the stress at 50 % nominal strain shall be recorded. Determination of the nominal strain is based on the initial and final grip separations instead of the extensometer measurements. Brittle failure—If the polymer shows brittle failure, that is, breaking without yielding and with the strain at break less than 10 %, the testing speed shall be 5 mm/min, and the values for stress and strain at break shall be recorded.

^BThe measurement of break properties for polypropylene is not very reproducible and should not be reported unless requested.

^CSAE J1885 and SAE J1960 procedures are based on water-cooled xenon arc weathering devices, while SAE J2019 and SAE J2212 procedures are based on air-cooled xenon arc weathering devices. Due to differences in the spectral distribution of the filtered xenon light source, in terms of irradiance level and cut-on wavelength, different ratios of total light to dark time SAE J1885 and SAE J2212 can be expected to have different degrees of influence on spectral performance when weathered to the same total irradiant energy. SAE J1960 and SAE J2019 are different in irradiance level, spectral distribution, and rain simulation cycles, and specimens would be expected to have different performances at the same total irradiant energy.

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 5857 – 00:

(1) Section 3, Terminology—Added definitions for *polypropylene*, *polypropylene homopolymer*, *polypropylene random copolymer*, and *polypropylene heterophasic copolymers*.

(2) 12.1—Revised conditioning requirements and test atmosphere.

(3) 12.2—Revised testing atmosphere.

(4) Table PP—Added data values and revised footnotes.

(5) Table A—Added data values and revised footnotes.

(6) Table B—Added data values and revised footnotes.

(7) Added Table C.

(8) Added Table G.

(9) Added Table T.

D 5857 – 00a:

(1) “Propylene” and “propylene plastics” changed to “polypropylene” throughout.

D 5857 – 00b:

(1) Filled and reinforced product categories were added to Table PP.

(2) The dissipation factor requirement was changed in the electrical properties table (see Note 8) from 0.0001 max to 0.0005 max.

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