Designation: D 3350 – 00

Standard Specification for Polyethylene Plastics Pipe and Fittings Materials[1]

This standard is issued under the fixed designation D 3350; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 This specification covers the identification of polyethylene plastic pipe and fittings materials according to a cell classification system. It is not the function of this specification to provide specific engineering data for design purposes, to specify manufacturing tolerances, or to determine suitability for use for a specific application.

1.2 Polyethylene plastic materials, being thermoplastic, are reprocessable and recyclable (Note 2). This specification allows for the use of those polyethylene materials, provided that all specific requirements of this specification are met.

NOTE 1—The notes in this specification are for information only and shall not be considered part of this specification.

NOTE 2—See Guide D 5033 for information and definitions related to recycled plastics.

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

1.4 *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 3—There is no similar or equivalent ISO standard.

1.5 For information regarding Molding and Extrusion Materials see D 4976 Specification for Polyethylene Plastics Molding and Extrusion Materials. For information regarding Wire and Cable Materials see D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics for Testing[2]
D 638 M/[Metric] Test Method for Tensile Properties of Plastics[2]
D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact[2]
D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]
D 883 Terminology Relating to Plastics[2]
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer[2]
D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable[2]
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[2]
D 1603 Test Method for Carbon Black in Olefin Plastics[2]
D 1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics[2]
D 1898 Practice for Sampling of Plastics[2]
D 1928 Practice for Preparation of Compression-Molded Polyethylene Test Sheets and Test Specimens[2]
D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]
D 3892 Practice for Packaging/Packing of Plastics[4]
D 4976 Specification for Polyethylene Plastics Molding and Extrusion Materials[5]
D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics[5]
F 1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins[3]

3. Terminology

3.1 *Definitions*—Terms as described in Terminology D 883 shall apply in this specification.

3.1.1 *polyethylene plastics*—as defined by this specification, plastics or resins prepared by the polymerization of no less than 85 % ethylene and no less than 95 % of total olefins with additional compounding ingredients.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *materials*—polyethylene (PE) resins with the added compounding ingredients.

3.2.2 *PE compounds*—has the same meaning as PE plastics materials, compounds, and plastics.

3.3 Historical usage and user group conventions have resulted in inconsistent terminology used to categorize and

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

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

[3] *Annual Book of ASTM Standards,* Vol 08.04.

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

[5] *Annual Book of ASTM Standards,* Vol 08.03.

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

describe polyethylene resins and compounds. The following terminology is in use in ASTM specifications pertaining to polyethylene:

3.3.1 *Specification D 1248*:

3.3.1.1 Type (0, I, II, III, IV) = density ranges (same, respectively, as Class in Specification D 4976).

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

3.3.1.3 Category (1, 2, 3, 4, 5) = melt index ranges (same as Grade in Specification D 4976).

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

3.3.2 *Specification D 3350*:

3.3.2.1 Type (I, II, III) = density ranges (same as Types I, II, and III in Specification D 1248 and Classes 1, 2, and 3 in Specification D 4976).

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

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

3.3.3 *Specification D 4976*:

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

3.3.3.2 Class (5, 1, 2, 3, 4) = density ranges (same, respectively, as Type in Specification D 1248).

3.3.3.3 Grade (1, 2, 3, 4, 5) = melt index ranges (same as Category in Specification D 1248).

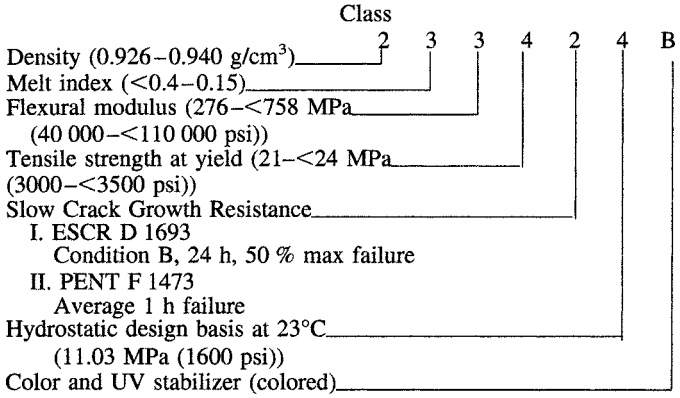
4. Classification

4.1 Polyethylene plastic pipe and fittings compounds are classified according to density, melt index, flexural modulus tensile strength at yield, environmental stress-crack resistance, and the hydrostatic design basis at 23°C in Table 1.

NOTE 4—It has been a long-standing practice to use the following terms in describing polyethylene plastics:

Type I (0.910 to 0.925) = Low Density
Type II (0.926 to 0.940) = Medium Density
Type III (0.941 to 0.965) = High Density

NOTE 5—The manner in which materials are identified in the cell classification is illustrated for Class PE233424B as follows (refer also to Table 1 and 6.2):



4.2 Materials used in polyethylene plastic pipe and fittings shall use a cell-type format for the identification, close characterization, and specification of material properties. The

TABLE 1 Primary Properties—Cell Classification Limits

	Property	Test Method	0	1	2	3	4	5	6	7
1	Density, g/cm³	D 1505	Unspecified	0.925 or lower	>0.925 – 0.940	>0.940 – 0.955	>0.955	. . .	. . .	specify value
2	Melt index	D 1238	Unspecified	>1.0	1.0 to 0.4	<0.4 to 0.15	<0.15	[A]		specify value
3	Flexural modulus, MPa (psi)	D 790	Unspecified	<138 (<20 000)	138 – <276 (20 000 to <40 000)	276 – <552 (40 000 to 80 000)	552 – <758 (80 000 to 110 000)	758 – <1103 (110 000) to <160 000)	>1103 (>160 000)	specify value
4	Tensile strength at yield, MPa (psi)	D 638	Unspecified	<15 (<2200)	15 – <18 (2200– <2600)	18 – <21 (2600– <3000)	21 – <24 (3000– <3500)	24 – <28 (3500– <4000)	>28 (>4000)	specify value
5	Slow Crack Growth Resistance									
	I. ESCR	D 1693	Unspecified							
	a. Test condition (100% Igepal.)			A	B	C	C	. . .	. . .	specify value
	b. Test duration, h			48	24	192	600			
	c. Failure, max, %		Unspecified	50	50	20	20			specify value
	II. PENT (hours)	F 1473								
	Molded plaque, 80°C, 2.4 MPa			0.1	1	3	10	30	100	
	Notch depth, F 1473, Table 1		Unspecified							specify value
6	Hydrostatic design basis, MPa (psi), (23°C)	D 2837	NPR[B]	5.52 (800)	6.89 (1000)	8.62 (1250)	11.03 (1600)	. . .	. . .	

[A] Refer to 10.1.4.1.
[B] NPR = Not Pressure Rated.

information from the format is to be used alone or in combination.

NOTE 6—This type format, however, is subject to possible misapplication since unobtainable property combinations can be selected if the user is not familiar with commercially available materials. The manufacturer should be consulted.

4.3 *Grade*—A code for polyethylene pipe and fittings materials that consists of the two letter abbreviation for polyethylene (PE) followed by two numbers that designate the density cell (Property 1) and the slow crack growth resistance cell (Property 5), as defined by either Test Method F 1473 or Test Method D 1693, of the thermoplastic, as specified in Table 1. For the requirements of Property 5 (slow crack growth resistance), consult the materials section of the appropriate ASTM standard specification for the end-use application.

NOTE 7—Grade designations were adapted from Specification D 1248 - 84 prior to the withdrawal of D 1248 - 84. Former Specification D 1248 - 84 grades for PE pipe materials were P14, P23, P24, P33, and P34. Equivalent Specification D 3350 grade designations for these materials are PE11, PE20, PE23, PE30, and PE33, respectively.

5. Materials and Manufacture

5.1 The molding and extrusion material shall be polyethylene plastic in the form of powder, granules, or pellets.

5.2 The molding and extrusion materials shall be as uniform in composition and size and as free of contamination as is achieved by good manufacturing practice. If necessary, the level of contamination may be agreed upon between the manufacturer and the purchaser.

5.3 When specified, the color and translucence of molded or extruded pieces formed, under the conditions specified by the manufacturer of the materials, shall be comparable within commercial match tolerances to the color and translucence of standard samples supplied in advance by the manufacturer of the material.

6. Physical Properties

6.1 *Cell Classification*—Test values for specimens of the PE material prepared as specified in Section 9 and tested in accordance with Section 10 shall conform to the requirements given in Table 1. A typical property value for a PE material is to be the average value from testing numerous lots or batches and determines the cell number (see Appendix X1). When, due to manufacturing tolerances and testing bias, individual lot or batch values fall into the adjoining cell, the individual value shall not be considered acceptable unless the user, or both the user and the producer, determine that the individual lot or batch is suitable for its intended purpose.

6.2 *Color and Ultraviolet (UV) Stabilizer*—The color and UV stabilization shall be indicated at the end of the cell classification by means of a letter designation in accordance with the following code:

Code Letter	Color and UV Stabilizer
A	Natural
B	Colored
C	Black with 2 % minimum carbon black
D	Natural with UV stabilizer
E	Colored with UV stabilizer

6.3 *Thermal Stability*—The PE material shall contain sufficient antioxidant so that the minimum induction temperature shall be 220°C when tested in accordance with 10.1.9.

6.4 *Brittleness Temperature*—The brittleness temperature shall not be warmer than −60°C when tested in accordance with Test Method D 746.

6.5 *Density*—The density used to classify the material shall be the density of the PE base resin (uncolored PE) determined in accordance with 10.1.3. When the average density of any lot or shipment falls within ±0.002 g/cm^3 of the nominal value, it shall be considered as conforming to the nominal value and to all classifications based on the nominal value.

6.5.1 For black compounds, containing carbon black, determine the density, *Dp*, and calculate the resin density, *Dr*, as follows:

$$Dr = Dp - 0.0044C$$

where:

C = weight percent of carbon black.

6.5.2 For colored compounds, the nominal density of the base resin shall be provided by the manufacturer, on request.

6.6 *Tensile Strength at Yield*—The tensile strength at yield used to classify the material shall be the tensile strength at yield of the PE resin determined in accordance with 10.1.6. When the average tensile strength at yield of any lot or shipment falls within ±3.45 MPa (±500 psi) of the nominal value, it shall be considered as conforming to the nominal value and to all classifications based on the nominal value.

6.7 *Elongation at Break*—As tested per 10.1.6, all pressure rated materials shall have a minimum extension at break of 500 % as determined by grip separation.

7. Sampling

7.1 A batch or lot shall be considered as a unit of manufacture and shall consist of one production run or as a blend of two or more production runs of material.

7.2 Unless otherwise agreed upon between the manufacturer and the purchaser, the material shall be sampled in accordance with the procedure described in Sections 9 through 12 of Practice D 1898. Adequate statistical sampling prior to packaging shall be considered an acceptable alternative.

NOTE 8—A sample taken from finished product may not necessarily represent the original batch or lot.

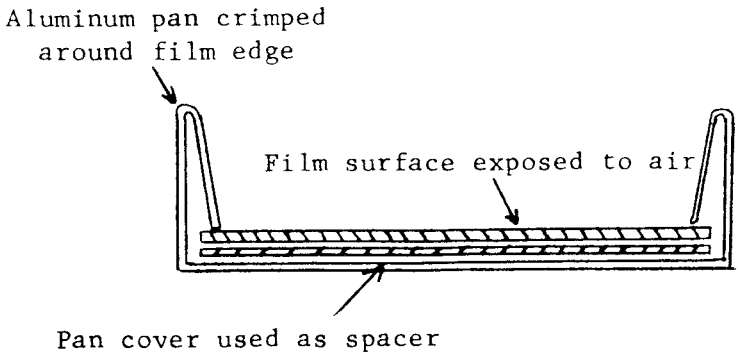
8. Number of Tests

8.1 The requirements identified by the material designation and otherwise specified in the purchase order shall be verified by tests made in accordance with 11.1. For routine inspection, only those tests necessary to identify the material to the satisfaction of the purchaser shall be required. One sample shall be sufficient for testing each batch or lot provided that the average values for all of the tests made on that batch or lot comply with the specified requirements.

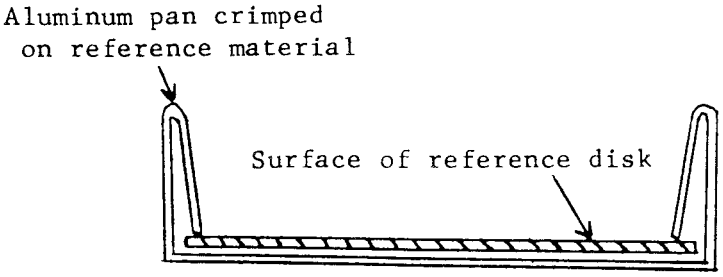
9. Specimen Preparation

9.1 Unless otherwise specified in Section 10, the test specimens shall be molded in accordance with Procedure C of Practice D 1928.

9.2 When pipe or fitting test specimens are required, they shall be extruded or molded in accordance with the specifications of the material manufacturer.



(*a*) Specimen in pan.



(*b*) *Reference*—Temperature standard shall be placed under reference disk in reference pan or alternatively under pan cover (spacer).

FIG. 1 Mounting Film Specimen in Cup

10. Test Methods

10.1 The properties enumerated in this specification shall be determined in accordance with the following test methods:

10.1.1 *Conditioning*— Unless otherwise specified in the test methods or in this specification, for those tests where conditioning is required, condition the molded test specimens in accordance with Procedure A of Practice D 618.

10.1.2 *Test Conditions*— Unless otherwise specified in the test methods or in this specification, conduct tests at the Standard Laboratory Temperature of 23 ± 2°C (73.4 ± 3.6°F).

10.1.3 *Density*—Test Method D 1505 or alternative methods providing equivalent accuracy as described in Methods A or B of Test Methods D 792. Make duplicate determinations using two separate portions of the same molding or from two moldings. The molded specimen thickness portions shall be 1.9 ± 0.2 mm (0.075 ± 0.008 in.). Calculate the average value.

10.1.4 *Melt Index*—Test Method D 1238, using Condition 190/2.16. Make duplicate determinations on the material in the form of powder, granules, or pellets, and calculate the average; no conditioning is required.

10.1.4.1 Classify materials having a melt index less than 0.15 (Cell 4) as Cell 5 only if they have a flow rate not greater than 4.0 g/10 min when tested in accordance with Test Method D 1238, Condition 190/21.6.

NOTE 9—Flow rate is the general term used for all results obtained with Test Method D 1238. Although the flow rate of polyethylene plastics may be measured under any of the conditions listed for it under 7.2 of Test Method D 1238, only measurements made at Condition 190/2.16 may be identified as "Melt Index."

10.1.5 *Flexural Modulus*— Test Methods D 790, using Method 1, Procedure B, and a 50-mm (2-in.) test span. Test five specimens, each 3.2 by 12.7 mm (⅛ by ½ in.) flatwise at a crosshead speed of 12.7 mm/min (0.5 in./min) and the average value of the secant modulus calculated at 2 % strain in the outer fibers.

10.1.5.1 The deflection of the test specimen corresponding to 2 % strain (0.02 mm/mm or in./in.) is calculated as follows:

$$D = rL^2/6d$$

where:

D = deflection of the center of the beam test specimen at 2 % strain, in.,
r = strain in the outer fibers = 0.02 mm/mm (0.02 in./in.),
L = test span = 50 mm (2 in.), and
d = specimen depth = 3.2 mm (⅛ in.).

10.1.5.2 The stress corresponding to 2 % strain is calculated as follows:

$$S = 3\,PL/2\,bd^2$$

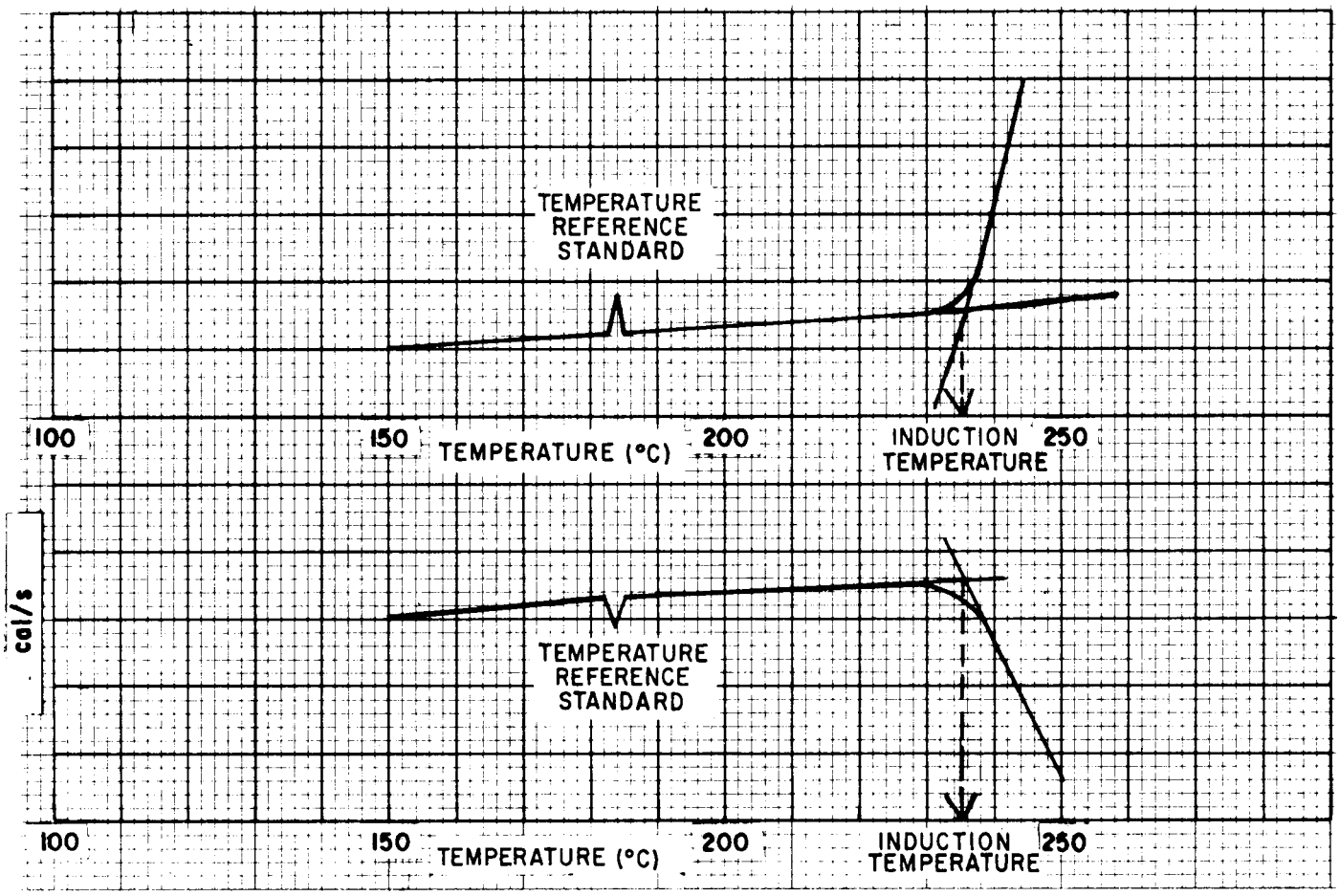


FIG. 2 Typical DSC Plots

where:

S = stress in the outer fiber at 2 % strain,
P = load corresponding to 2 % strain, N (lbf),
L = test span = 50 mm (2 in.),
d = specimen depth = 3.2 mm (⅛ in.), and
b = specimen width = 12.7 mm (½ in.).

The secant modulus at 2 % strain is the ratio of stress to strain or $S/0.02$.

10.1.6 *Tensile Strength at Yield*—The tensile strength at yield shall be determined in accordance with Test Method D 638 except that rate of grip separation shall be 500 mm/min (20 in./min for materials in the density range from 0.910 to 0.925 g/cm^3) and 50 mm/min (2 in./min for all others). Specimens shall conform to the dimensions given for Type IV in Test Method D 638 with a thickness of 1.9 ± 0.2 mm (0.075 ± 0.008 in.). Specimen shall be either die cut or machined.

10.1.7 *Slow Crack Growth Resistance*—One method shall be used to classify this material property.

10.1.7.1 *Slow Crack Growth Resistance*—The material's resistance shall meet the minimum requirement shown for the appropriate cell classification when tested in accordance with Test Method D 1693.

10.1.7.2 *Slow Crack Growth Resistance*—The average failure time from two test specimens shall meet the minimum requirement shown for the appropriate cell classification when tested in accordance with Test Method F 1473. Test at least four specimens in case of a dispute.

10.1.8 *Hydrostatic Design Basis*—Determine the hydrostatic design stress basis in accordance with Test Method D 2837, on pipe extruded from three different lots of material. Subject specimens from one lot to test for at least 10 000 h. Terminate the tests on the two additional lots after 2000 h. The results from each of the three lots shall be within the same or next higher cell limits.

NOTE 10—For pressure application at elevated temperatures, the hydrostatic design basis should be determined at that temperature in accordance with Test Method D 2837. The 100 000-h intercept should be categorized in accordance with Table 1 of Test Method D 2837.

10.1.9 *Thermal Stability*—Test specimens taken from pipe or fittings made from the virgin material with a differential scanning calorimeter (DSC).[6] The directions of the instrument manufacturer regarding calibration and operation shall be followed except when in conflict with other parts of this section.

NOTE 11—This test requires accurate temperature and atmosphere control on the DSC specimen compartment. The DSC manufacturers offer choices in cell configuration and temperature control parameters that may affect this required control. For example, in some power compensation

[6] Instruments are available from TA Instruments, Perkin-Elmer, and others.

DSCs, use of the two-hole platinum specimen holder lids with a special "flow-through" swing-away block cover is required. Therefore, the user may wish to consult equipment-specific literature and with the equipment manufacturer to optimize the operation of individual DSCs for this test.

10.1.9.1 *Specimens*—Press small pieces of the pipe into films 0.127 ± 0.013 mm (0.0050 ± 0.0005 in.) thick. Cut at least three disks 6.35 ± 0.13 mm (0.250 ± 0.005 in.) in diameter from the film.

10.1.9.2 *Procedure*—Place the disk of film in a small aluminum cup used in the DSC in a stretched condition, as shown in Fig. 1(*a*). Place a small piece of indium (melting point 156.6°C) or anisic acid (melting point 183.0°C) for a temperature reference standard contained in a similar cup (see Fig. 1(*b*)) in the reference position. Use an oxidized copper reference disk for black, filled, or dark brown test specimens and an aluminum disk for natural or light pigmented polymers. Place the specimen and reference standard cups in the instrument which is preset at approximately 150°C. The bottoms of the cups shall be pressed and rubbed securely against the flat surface so as to ensure that thermal contact is made. Allow 5 min for the cups to reach thermal equilibrium. Begin the programmed heating at approximately 150°C at a heating rate of 10.0°C/min in static air. Test at least three film specimens from each sample and use the average value for the induction temperature.

NOTE 12—Since the indium standard may change with use, it should not be used more than 30 times without confirming that no significant change in melting point has occurred. This check can be made by comparison with a fresh piece of indium.

10.1.9.3 *Results*—The temperature change (ΔT) or heat absorption rate (J/s) in the specimen plotted against temperature shall produce a line with a clear rise in slope. The induction temperature (degradation onset) is the intersection of the extended base line and a line tangent to the leading slope of the exothermic decomposition peak (see Fig. 2).

10.1.10 *Carbon Black Content*—Test Method D 1603 shall be used. Make duplicate determinations from a sample of the material in the form of powder, granules, or pellets.

11. Inspection

11.1 Inspection of the material shall be made as agreed upon between the purchaser and the manufacturer as part of the purchase contract.

12. Retest and Rejection

12.1 If any failure occurs, and when specified by the manufacturer, the material shall be retested to establish conformity in accordance with the agreement between the purchaser and the manufacturer.

13. Packaging and Marking

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

13.2 *Marking*—Unless otherwise agreed upon between the seller and the purchaser, shipping containers shall be marked with the name of the material, identification according to this specification, the lot or batch number and quantity contained therein, as defined by the contract or order under which shipment is made, and the name of the manufacturer.

13.3 All packing, packaging, and marking provisions of Practice D 3892 shall apply to this specification.

14. Keywords

14.1 cell classification system; pipe and fittings material; polyethylene; recycled

SUMMARY OF CHANGES

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

D 3350–99:
(*1*) Revised Table 1, Property 1, Cells 1, 2, and 3.

D 3350–00:
(*1*) Added 3.3.