Designation: D 1710 – 99

Standard Specification for Extruded and Compression Molded Polytetrafluoroethylene (PTFE) Rod and Heavy Walled Tubing[1]

This standard is issued under the fixed designation D 1710; 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 polytetrafluoroethylene (PTFE) rod and heavy-walled tubing manufactured from the PTFE resin of Specification D 4894 and reprocessed PTFE resin (as defined in Guide D 5033).

1.2 The specification covers rod 200-mm (8-in.) nominal diameter or under and heavy-walled tubing 100-mm outside diameter and with a wall thickness of 1.6 mm (1/16in.) or greater. These materials must be made wholly from PTFE and produced in accordance with good commercial practice.

NOTE 1—Although this specification and ISO/DIS 13000-1 (1997) and ISO/DIS 13000-2 (1997) differ in approach or detail, data obtained using either are technically equivalent.

1.3 The values stated in SI units, as detailed in IEEE/ASTM SI 10 are to be regarded as the standard. The inch-pound units given in parentheses are provided for information only.

1.4 The following precautionary caveat pertains to the test methods portion, Section 12, only 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies[2]

D 150 Test Methods for A-C Loss Characteristics and Permitivity (Dielectric Constant) of Solid Electrical Insulating Materials[2]

D 256 Test Method for Determining the Pendulum Impact Resistance of Notched Specimens of Plastics[3]

D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials[2]

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

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[3]

D 621 Test Methods for Deformation of Plastics Under Load[4]

D 638 Test Method for Tensile Properties of Plastics[3]

D 696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between –30 and 30°C[3]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[3]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[3]

D 883 Terminology Relating to Plastics[3]

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

D 1600 Terminology for Abbreviated Terms Relating to Plastics[3]

D 2240 Test Method for Rubber Property-Durometer Hardness[5]

D 3295 Specification for PTFE Tubing[6]

D 3892 Practice for Packaging/Packing of Plastics[6]

D 4591 Test Method for Determining Temperatures and Heats of Transitions of Fluoropolymers by Differential Scanning Calorimetry[7]

D 4894 Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials[7]

D 4895 Specification for Polytetrafluoroethylene (PTFE) Resins Produced from Dispersion[7]

D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics[7]

D 5740 Guide for Writing Material Standards in the Classification D 4000 Format[7]

E 94 Guide for Radiographic Testing[8]

F 36 Test Method for Compressibility and Recovery of Gasket Materials[9]

IEEE/ASTM SI 10 Standard for the Use of the International

[1] This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials (Section D20.15.12).

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

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

[4] Discontinued; see *1994 Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 09.01.

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

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

[8] *Annual Book of ASTM Standards*, Vol 03.03.

[9] *Annual Book of ASTM Standards*, Vol 09.02.

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

System of Units (SI): The Modern Metric System[10]

2.2 *ISO Standards:*[11]

ISO 13000-1 (1997) Plastics—Polytetrafluoroethylene (PTFE) Semi-Finished Products, Part 1: Basis for Specification

ISO 13000-2 (1997) Plastics—Polytetrafluoroethylene (PTFE) Semi-Finished Products, Part 2: Preparation of Test Specimen and Determination of Properties

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology D 883 unless otherwise specified.

3.1.1 *lot, n*—one production run or a uniform blend of two or more production runs. **(D 4895)**

3.2 *Abbreviations*—Abbreviations are in accordance with Terminology D 1600. PTFE is the acronym for polytetrafluoroethylene.

4. Classification

4.1 This specification covers three types of PTFE-fluorocarbon rod and heavy-walled tubing. They are as follows:

4.1.1 *Type I, Premium*—A type of rod or heavy-walled tubing having maximum physical and electrical properties to meet rigid requirements.

4.1.2 *Type II, General Purpose*—A type of rod or heavy-walled tubing having properties required of general electrical, mechanical, and chemical applications.

4.1.3 *Type III*—A type of rod or heavy-walled tubing for noncritical chemical, electrical, and mechanical applications.

4.2 A one-line system may be used to specify materials covered by this specification. The system uses predefined cells to refer to specific aspects of this specification, illustrated as follows:

		Specification			
	Standard Number Block	Type	Grade	Class	Special notes
Example:	Specification D 1710–XX	1	1	A	

4.2.1 For this example, the line callout would be Specification D 1710–XX, 11 A, and would specify that a rod or heavy-walled tubing has all of the properties listed for that type, grade, and class. A comma is used as the separator between the standard number and the type. Separators are not needed between the type, grade, and class. A provision for special notes is included so that other information can be provided when required. An example would be to specify the dimension tolerances for each size of rod or heavy-walled tubing. When special notes are used, they should be preceded by a comma.

4.3 The types are further subdivided into two grades:

4.3.1 *Grade 1*—Made only from virgin resin.

4.3.2 *Grade 2*—Made using reprocessed resin.

4.4 The grades are further subdivided into four classes:

4.4.1 *Class A*—Rod or heavy-walled tubing having normal dimensional stability.

4.4.2 *Class B*—Rod or heavy-walled tubing meeting the dimensional stability requirements of Table 1.

4.4.3 *Class C*—Same as Class A, but, in addition, completely examined for internal defects.

4.4.4 *Class D*—Same as Class B, but, in addition, completely examined for internal defects.

5. Materials and Manufacture

5.1 The rod or heavy-walled tubing from Types I, II, and III shall be made from unpigmented PTFE as free of foreign matter as commercially practical.

6. General Requirements

6.1 The rod covered by this specification shall meet the mechanical and electrical requirements specified in Table 1 and 6.1.1 when tested by the methods given in Section 12. The heavy-walled tubing covered by this specification shall meet the mechanical and electrical requirements in Table 2 and 6.1.1 when tested by the methods given in Section 12.

6.1.1 *Melting Point*—The melting point of all types of rod and heavy walled tubing shall be 327± 10°C when tested in accordance with 12.7.

7. Dimensions, Mass, and Permissible Variations

7.1 The dimensions and tolerances of heavy-walled tubing shall be in accordance with Table 3. Measurements shall be made in accordance with Method A of Test Methods D 374.

7.2 For rod and heavy-walled tubing, it may be necessary to center-less-grind the outside diameter for rod and heavy-walled tubing to meet the tolerances given in Table 3.

[10] *Annual Book of ASTM Standards*, Vol 14.04.

[11] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

TABLE 1 Detail Requirements of Extruded Rod

Properties	Type I			Type II			Type III		
	Rod Diameter, in.[A]			Rod Diameter, in.[A]			Rod Diameter, in.[A]		
	under ½	½to 1½	over 1½	under ½	½ to 1½	over 1½	under ½	½to 1½	over 1½
Specific gravity, min	2.14	2.15	2.15	2.12	2.13	2.14	2.12	2.13	2.14
Tensile strength, min, MPa	13.8	14.5	15.2	11.7	12.4	13.1	9.7	10.3	11.0
(psi)	(2000)	(2100)	(2200)	(1700)	(1800)	(1900)	(1400)	(1500)	(1600)
Elongation at Break, min,%	150	175	200	100	125	150	50	75	75
Dielectric strength, min, V/mil	700	750	800	600	650	700	250	250	250
Dimensional stability,[B] max, %									
Length	1.5	1.5	...	1.5	1.5	...	3.0	3.0	...
Diameter	0.5	0.5	...	0.5	0.5	...	1.0	1.0	...

[A] 1 in. = 25.4 mm.

[B] This requirement applies only to rod of Classes B and D that is under 25.4 mm (1 in.) in diameter.

TABLE 2 Properties of PTFE Heavy-Walled Tubing

Grade	Type I		Type II		Type III	
	Grade 1	Grade 2	Grade 1	Grade 2	Grade 1	Grade 2
Specific Gravity, min	2.15	2.14	2.15	2.14	2.14	2.13
Tensile Strength, min, MPA	13.8	10.4	12.4	9.7	11.0	9.0
(psi)	(2000)	(1500)	(1800)	(1400)	(1600)	(1300)
Elongation at break, min, %	150	140	130	120	100	80
Dielectric Strength, min						
1 mm (0.040 in.) kV/mm	29.5	27.5	25.6	23.6	12	10
Short Time (V/mil)	(750)	(700)	(650)	(600)	(325)	(250)
Dimensional Stability max, Classes B and D, %						
Length	1.5	1.5	2.0	2.0	2.5	2.5
Diameter	0.5	0.5	0.75	0.75	1.0	1.0

TABLE 3 Diameter and Tolerances for PTFE Rod and Heavy-Walled Tubing

Nominal Inside or Outside Diameter,[A] mm (in.)	Tolerance,[B] mm (in.)
1.6 (1/16)	0.13 (0.005)
3.2 (1/8)	0.18 (0.007)
4.8 (3/16)	0.23 (0.009)
6.3 (1/4)	0.30 (0.012)
9.5 (3/8)	0.30 (0.012)
12.7 (1/2)	0.36 (0.014)
15.8 (5/8)	0.41 (0.016)
19.1 (3/4)	0.43 (0.017)
25.4 (1)	0.51 (0.020)
31.8 (1 1/4)	0.64 (0.025)
38.1 (1 1/2)	0.76 (0.030)
44.4 (1 3/4)	0.89 (0.035)
50.8 (2)	0.89 (0.035)
57.2 (2 1/4)	1.02 (0.040)
63.5 (2 1/2)	1.14 (0.045)
76.2 (3)	1.14 (0.045)
101.6 (4)	1.14 (0.045)
203.2 (8)	1.14 (0.045)

[A] Intermediate diameters shall conform to the tolerances of the next larger diameter in the table.

[B] The tolerance is plus for outside diameters and minus for inside diameters.

7.2.1 *Eccentricity*—The eccentricity of the heavy-walled tubing, when measured as one half of the difference between the maximum and minimum wall thickness at either end of the tube, shall not exceed 10 % of the nominal wall thickness. Nominal wall thickness is one half the difference between the nominal outside diameter and the nominal inside diameter.

8. Workmanship, Finish and Appearance

8.1 *Color*—Type I shall be white to translucent but may have occasional spots. Types II and III typically are white but may vary to light gray or light brown. For Types II and III occasional small gray, brown, or black spots shall not be considered cause for rejection.

8.2 *Finish*—The rod or heavy-walled tubing shall be free from surface blisters, cracks, wrinkles, and other surface defects that might impair it for general use.

8.3 *Internal Defects*—Classes C and D shall be free of all macroscopic voids, cracks, and foreign inclusions, or the location of such defects shall be clearly marked or identified. The examination for internal defects shall be made in accordance with Guide E 94.

9. Sampling

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

10. Number of Tests and Retests

10.1 The tests listed in Table 1 and Table 2, as they apply, are sufficient to establish conformity of the PTFE rod or heavy-walled tubing to this specification. When the number of test specimens is not stated in the test method, single determination may be made. If more than single determinations on separate portions of the same sample are made, the results shall be averaged. The single or average result shall conform to the requirements prescribed in this specification.

11. Test Conditions

11.1 *Conditioning of Specimens*—The test specimens shall be conditioned in accordance with Procedure A of Practice D 618 for a period of at least 4 h prior to test.

11.2 *Standard Temperature*—The tests shall be conducted at the standard laboratory temperature of 23 ± 1°C (73.4 ± 1.8°F). Since the rod or heavy-walled tubing does not absorb water, the maintenance of constant humidity during testing is not important.

12. Test Methods

12.1 *Visual Inspection*—Visually inspect each of the samples of PTFE rod or heavy-walled tubing selected in accordance with Section 9 to verify its compliance with the requirements of this specification. Occasional superficial flaws in PTFE rod or heavy-walled tubing should be interpreted as not affecting the physical and electrical properties; however, if

there is an appearance of a transverse discontinuity or "poker chip," testing for tensile strength and elongation is imperative.

12.2 *Specific Gravity*—Determine the specific gravity of the rod or heavy-walled tubing in accordance with Method A of Test Methods D 792. Two drops of wetting agent should be added to the water in order to reduce the surface tension and ensure complete wetting of the specimens. Test two specimens representative of the cross section of the rod or heavy-walled tubing and average the results.

12.2.1 The gradient tube method of Test Method D 1505 may be used as an alternate on three specimens.

12.3 *Tensile Strength and Elongation*:

12.3.1 Determine the tensile strength and elongation of rods less than 38.1 mm (1½ in.) in diameter in accordance with Test Method D 638 modified as described below. Determine the tensile strength and elongation of rods 38.1 mm or more in diameter in accordance with Specification D 4894 modified as described below. Prepare the microtensile specimens from 1.59-mm (1⁄16-in.) thick wafers cut from a representative portion of the rod in a plane 90° to the axis. Coincide the center of the microtensile specimen with the axis of the rod. Test five specimens and average the results.

12.3.1.1 For rods with diameters less than 38.1 mm (1½ in.), prepare the test specimens in accordance with Fig. 1.

12.3.1.2 For rods with diameters 38.1 mm (1½ in.) or over, prepare the test specimens in accordance with Fig. 2 of Specification D 4894.

12.3.1.3 Test at a speed of 50.8 mm (2 in.)/min.

12.3.1.4 For rods with diameters less than 38.1 mm (1½ in.), the elongation measure between gage marks 50.8 mm (2 in.) apart.

12.3.1.5 For rods with diameters of 38.1 mm (1½ in.) or more, measure the elongation using an initial jaw separation of 22.22 mm (0.875 in.).

12.3.1.6 Rods of 6.35 mm (¼ in.) and smaller may be tested in full cross-section.

12.3.2 For the tensile strength and elongation of heavy-walled tubing, test five specimens in accordance with Test Method D 638 using specimens conforming to Fig. 2, Type IV, of that test method. The speed of testing shall be 50.8 mm (2 in.)/min.

12.3.3 *Precision and Bias*—The precision and bias data available is shown in Table 4 .

12.4 *Dielectric Strength*:

12.4.1 Determine the dielectric strength of the rod in accordance with the short-timed test of Test Method D 149. Cut a wafer 1.016 ± 0.0254 mm (0.040 ± 0.001 in.) thick from the rod stock and place between two electrodes that contact the wafer at its center point. The surfaces of the wafer adjacent to the electrodes shall be parallel and as plane and smooth as the material permits. Bevel the ends of the electrodes' edges where they impinge on the specimen. For rods with diameters less than 38.1 mm (1½ in.), the electrodes shall be 1.587 mm (1⁄16in.) in diameter, and for rods 38.1 mm or more in diameter, the electrodes shall be 6.35 mm (¼ in.) in diameter. On small-size rods, flashover may pose testing problems. Place the electrodes containing the rod specimens in an oil bath and determine the dielectric strength. If the dielectric strength test is conducted in oil, it must be noted on the test report since oil gives a substantially higher dielectric strength value than testing in air. When flashover interferes with obtaining satisfactory tests, the testing may be done with a modified specimen

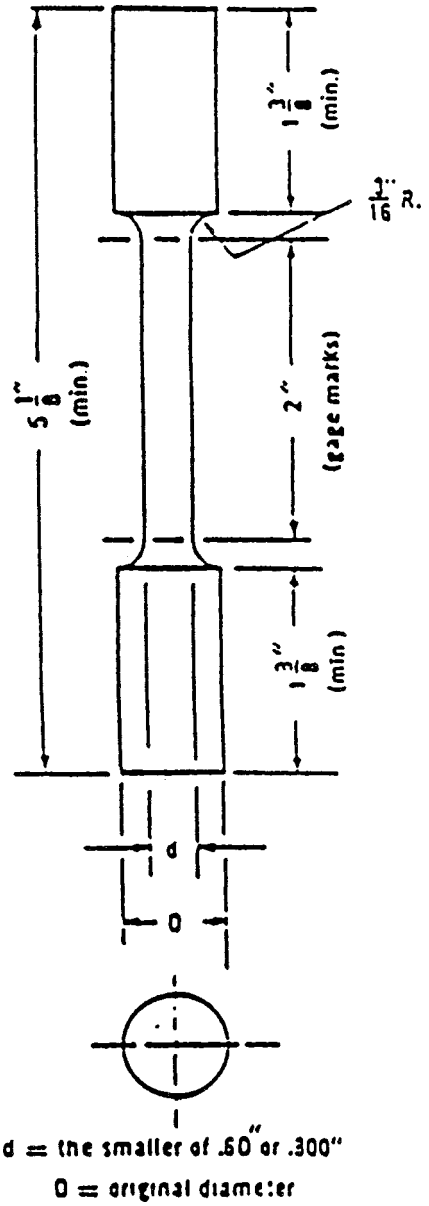

FIG. 1 Turned Dumbbell Specimen for Tensile Testing

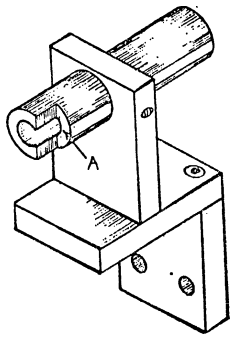

FIG. 2 Follower Assembly

TABLE 4 Precision Summary, Tensile Strength and Elongation at Break

NOTE 1—$I_r = 2.8 \times CV_r$; $I_R = 2.8 \times CV_R$

Material	Tensile Strength				
	Mean, psi	CV_r, %	CV_R, %	I_r, %	I_R, %
Granular PTFE	4801	2.79	8.85	7.81	24.78

TABLE 5 Percentage Elongation at Break

NOTE 1—$I_r = 2.8 \times CV_r$; $I_R = 2.8 \times CV_R$

Material	Mean, psi	CV_r, %	CV_R, %	I_r, %	I_R, %
Granular PTFE	337	2.83	16.43	7.92	46.00

prepared for use with a pin electrode. The specimen may be prepared by drilling holes from opposite ends of a rod section, leaving a 1.016-mm (0.040-in.) thick undrilled section between them. A flat-tipped drill must be used to ensure that a 1.016-mm thickness is left. The bottom of each hole shall be liberally coated with an electrically conductive silver paint. The opposing pin electrodes may then be inserted into the holes. The electrodes shall be 1.587 mm in diameter with beveled edges, and the spacing 1.016 ± 0.0254 mm. Test five specimens and average the results. On rods with diameters of 6.35 mm or less, the dielectric strength test cannot be performed due to electrode size. Then, the dielectric testing result on a coupon of 25.4-mm (1-in.) diameter with 1.016-mm thickness made from the resin may be supplied to the purchaser upon request.

12.4.2 *Dielectric Strength of Heavy-Walled Tubing*—Prepare three specimens in accordance with 12.4.2.1 or 12.4.2.2 as applicable, in accordance with Test Method D 149, using the short-time test. For flat specimens, the electrode shall be as specified in Table 1 of Test Method D 149. For tubular specimens, use a straight metal rod for the inner electrode. The rod shall be smooth and of a diameter such that it will fit tightly inside the tube without stretching it. Use a strip of metal foil 25 ± 1 mm (1 ± 0.01 in.) wide and not more than 0.12 mm (0.005 in.) thick as the outer electrode. Place a tubular specimen on the inner electrode, the latter being sufficiently long that a portion of it will be exposed for use in making the electrical connection. Wrap the outer electrode tightly around the middle of the specimen. Wrap a total of three turns of foil around the tubing, the first turn being wound tightest. Extend the coil approximately 12.5 mm (0.5 in.) beyond the end of the specimen in order to provide for the outer electrical connection.

12.4.2.1 *Flat Specimens*—Where diameter and wall thickness are sufficient, cut specimens perpendicular to the lengthwise axis as wafers 1 ± 0.02 mm (0.040 ± 0.001 in.) thick and of sufficient size to prevent flashover during the test.

12.4.2.2 *Tubular Specimens*—When tube or tubing dimensions are too small to allow preparation of specimens in accordance with 12.4.2.1, prepare specimens by cutting tubes or tubing into suitable short lengths. Lengths of specimens shall be sufficient to prevent flashover.

12.4.3 *Precision and Bias*—Preparation of a precision and bias statement is being studied by the task group for Project X-15-212.

12.5 *Dimensional Stability*—Determine the dimensional stability of the rod or heavy-walled tubing by cutting two sections of rod from each end 25.4 ± 0.127 mm (1 ± 0.005 in.) in length. Measure (see 7.1) their length and diameter to the nearest 0.0254 mm (0.001 in.) at the center point. Mark these points of original measurements so that measurement after heating and cooling is made at the same points. Place them in a heating chamber that can be elevated to a temperature of 290 ± 1°C (554 ± 5.4°F). The heating medium may be either oil or air. Hold the specimens at this temperature for at least 2 h for each 6.35 mm (0.25 in.) in diameter. Then lower the temperature at a rate not exceeding 30°C (54°F)/h until room temperature is reached. Measure the lengths and diameters of the specimens again to the nearest 0.0254 mm (0.001 in.) at the center point. Calculate the change in dimensions by the following formula and average the results:

12.6 *Examination for Internal Defects*—The examination for internal defects in the rod or heavy-walled tubing shall be in accordance with the method described in Guide E 94. X-ray the specimen in as many views as necessary to give complete coverage of the piece. Identify all fdm to correspond with the rod section or view, so that any defects may be located later. View the films for defects such as macroscopic voids, cracks, and inclusions. Films showing apparent defects should be checked against the corresponding specimen and position to ensure that such defects are not due to surface damage or surface contamination.

12.7 *Melting Point*—Determine the melting point on one specimen in accordance with Specification D 4894. As an alternative, the melting point may be determined by the procedure given in Test Method D 4591.

13. Inspection and Certification

13.1 Inspection and certification of the material supplied with reference to a specification based on this classification system shall be for conformance to the requirements specified herein.

13.2 Lot-acceptance shall be the basis on which acceptance or rejection of the lot is made. The lot-acceptance inspection shall consist of particle size determination.

13.3 Periodic check inspection with reference to a specification based on this classification system shall consist of the tests for all requirements of the material under the specification. Inspection frequency shall be adequate to insure the material is certifiable in accordance with 10.4

13.4 Certification shall be that the material was manufactured by a process in statistical control, sampled, tested, and inspected in accordance with this classification system, and that the average values for the lot meet the requirements of the specification (line callout).

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

14. Packaging and Marking

14.1 The provisions of Practice D 3892 apply to packaging, packing, and marking of containers for plastic materials.

15. Keywords

15.1 fluorocarbon polymer; fluoropolymers; granular PTFE; polytetrafluoroethylene; PTFE; PTFE heavy-walled tubing; PTFE rod

SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification. For the convenience of the user, Committee D-20 has highlighted those changes that may impact the use of this specification. This section also may include descriptions of the reasons for the changes, or both.

D 1710–99:

(*1*) Revised 1.2 to reference the diameter from a maximum of 4 in. to 8 in.

(*2*) Note 1 and ISO reference updated to proper designation and year.

(*3*) Reference changed from obsolete E 380 to current IEEE/ASTM S 10.

(*4*) Guide D 5033 added to 1.1 and 2.1.

(*5*) Upper limit in Table 3 changed from 4 in. to 8 in. (no change in required tolerance).

(*6*) Section 10.2, which referenced appendix, was deleted.

(*7*) Section 12.8 bend test was deleted.

(*8*) Sections 13–17 were deleted and replaced with new sections (from Guide D 5740) for these sections.

(*9*) Deleted the Appendix.

(*10*) Added Summary of Changes section.