Designation: D6456 – 10

Standard Specification for Finished Parts Made from Polyimide Resin[1]

This standard is issued under the fixed designation D6456; 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 is intended to be a means of calling out finished plastic parts ready for industrial or consumer use.

1.2 This specification covers finished parts and shapes from which parts are machined, made from a semi-crystalline polyimide (PI).

1.3 This specification is intended to replace MIL-R-46198 and Provisional Standard Specification PS 93.

NOTE 1—There is no known ISO equivalent to this standard.

1.4 This specification covers parts made from semi-crystalline polyimide, which is a thermosetting material that shows no softening or melting by DMA (D4065) at or below 260°C (500°F).

1.5 Since PI is a thermoset resin, no provisions are included for recycled products.

1.6 The classification system outlined in this specification is intended to be identical to that used by Department of Defense for over 20 years. No changes are intended at this time.

1.7 The values are stated in SI units and are regarded as standard in all property and dimensional tables. For reference purposes, inch-pound units are stated in parentheses.

1.8 *Application*—Parts in this specification are generally used for applications requiring the following combination of properties: low coefficient of friction, and low thermal expansion coupled with heat resistance for continuous operation at temperatures up to 260°C (500°F) and for short-term excursions upward to 482°C (900°F).

1.9 The following precautionary caveat pertains only to the test method portion, Section 12, 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:*[2]

D638 Test Method for Tensile Properties of Plastics

D695 Test Method for Compressive Properties of Rigid Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens

D3892 Practice for Packaging/Packing of Plastics

D4065 Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures

E8 Test Methods for Tension Testing of Metallic Materials

2.2 *ANSI Standard:*

Z1.4 Standard for Sampling Plans and Tables for Inspection by Attributes[3,4]

2.3 *Military Standards:*[5]

MIL-R-46198 Resin, Polyimide, Hot Pressed or Pressed and Sintered

MIL-STD 129 Standard Practice, Military Marking for Shipment and Storage

3. Terminology

3.1 *Definitions*—Terms are defined in accordance with Terminologies D883 and D1600 unless otherwise indicated.

4. Classification

4.1 Product shape and size as defined in the applicable purchase order.

[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] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Replaced MIL-STD-105.

[5] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

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

4.2 The type of product shall be categorized by type and class depending on resin and filler compositions defined as follows:

Type I	Unfilled base resin
Type II	Resin with graphite filler
Class 1	15 % by weight graphite filler, nominal
Class 2	40 % by weight graphite filler, nominal
Class 3	15 % by weight graphite and 10 % by weight fluorocarbon fillers, nominal
Type III	15 % by weight molybdenum disulfide filler, nominal

NOTE 2—Filler contents shown above are approximate. See Table 1 for exact composition.

4.3 Polymer compositions shall be specified by use of type/class designations as described in Table 1.

4.4 Manufacturing method and product form shall be specified by use of a suffix letter as described in Table 2.

4.5 When applying the suffix letter, the type/class designation shall precede the letter.

5. Ordering Information

5.1 All shapes covered by this specification shall be ordered using the proper callout designation (see Section 4).

6. Material

6.1 The base material shall consist of semi-crystalline polyimide resins with a base polymer structure derived from pyromellitic dianhydride and 4,4'-diaminodiphenylether.

6.2 The base material shall conform to the composition requirements of Table 1. The base material, depending on type and class, contains up to 50 wt % pigments, fillers or lubricants, or a combination thereof, and no fibrous reinforcement.

6.3 Recycle of unworked resin, such as spills, shall be permitted to the extent that the resultant material meets all property requirements specified herein.

6.4 No reground material shall be permitted.

6.5 The basic material shall be free of major defects and contaminants that would be detrimental to fabrication or performance of a finished part.

TABLE 1 Polymer Composition and Form

Type/Class	Polymer Composition	Processing Release Agent
Type I	Unfilled polyimide polymer	0.5 % by weight of PTFE,[A] max
Type II Class 1	Filled polyimide polymer Containing 14–16 % by weight graphite	0.5 % by weight of PTFE,[A] max
Type II Class 2	Filled polyimide polymer Containing 35–39 % by weight graphite	2.0 % by weight of PTFE,[A] max
Type II Class 3	Filled polyimide polymer Containing 12–14 % by weight graphite and 9–11 % by weight PTFE[A]	N/A
Type III	Filled polyimide polymer containing 14–16 % by weight molybdenum disulfide	N/A

[A]Polytetrafluoroethylene compound.

TABLE 2 Manufacturing Method and Form

Suffix Letter	Product Form
M	Hot isostatically molded billet
P	Hot unidirectionally pressed slab
D	Direct-formed (pressed) and sintered parts

7. Physical Property Requirements

7.1 The physical property values listed within this specification's tables are to be considered minimum specification values. Any requirement for specific test data for a given production lot should be specified at the time of order.

8. Dimensional Requirements

8.1 Size, shape, dimensions, and tolerances are to be determined by agreement between purchaser and buyer.

9. Sampling

9.1 Sampling shall be statistically adequate to satisfy the requirements of this specification as applicable (see ANSI Z1.4).

9.2 For purposes of sampling, an inspection lot for examination and tests shall consist of all material of the same type, class, grade, and nominal size submitted for inspection at one time.

10. Number of Tests

10.1 Routine lot inspection shall be based upon tensile strength and tensile elongation at 23°C and specific gravity as specified in product Table 3.

10.2 When the number of test specimens is not stated in the test method, a single determination is sufficient. If more than single determinations and separate portions of the same sample are made, the results shall be averaged. The final result shall conform to the requirements prescribed in this specification.

11. Test Conditions

11.1 *Conditioning of Specimens*—The specification values and dimensions are based on dry-as-manufactured (<0.2 % moisture) or the test specimens are dried to that level at 65°C (149°F), 28 to 30 in. Hg vacuum.

11.2 *Standard Temperature*—The tests shall be conducted at the standard laboratory temperature of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity.

12. Test Methods

12.1 Testing shall be in accordance with the test methods specified herein.

12.1.1 *Tensile Strength*—Tensile strength shall be determined in accordance with Test Method D638 using Test Method D1708 (microtensile specimen), for "M" and "P" product, and Test Methods E8 (standard tension test specimens for powdered metal products) for "D" product. Crosshead speed shall be 5 mm/min for all product testing.

12.1.2 *Tensile Elongation at Break*—Tensile elongation shall be determined in accordance with Test Methods D638 using Test Methods D1708 for "M" and "P" product and Test

TABLE 3 Mechanical Properties (Minima)[A]

Type/Class	Tensile Strength, MPa (ksi)				Tensile Elongation, %		Specific Gravity,	Flexural Strength, MPa (ksi),		Compressive Strength, MPa (ksi),	
	@ 23 ± 2°C		@260 ± 3°C		@ 23 ± 2°C	@ 260 ± 3°C	@ 23 ± 2°C	@ 23 ± 2°C		@ 23 ± 2°C	
IM	76	(11)	34.5	(5.0)	4.8	4.0	1.42	103	(15)	241	(35)
IP	69	(10)	27.6	(4.0)	4.5	4.0	1.42	83	(12)	207	(30)
ID	65.6	(9.5)	34.5	(5.0)	5.0	4.5	1.33	69	(10)	186	(27)
II/1M	55.2	(8.0)	29.7	(4.3)	3.5	2.5	1.49	83	(12)	186	(27)
II/1P	44.8	(6.5)	25.5	(3.7)	3.0	2.0	1.49	65.5	(9.5)	172	(25)
II/1D	55.2	(8.0)	27.6	(4.0)	3.5	2.5	1.41	76	(11)	172	(25)
II/2M	44.8	(6.5)	20.7	(3.0)	1.3	0.8	1.64	55.2	(8.0)	110	(16)
II/2P	32.4	(4.7)	13.8	(2.0)	1.3	0.8	1.64	51.7	(7.5)	103	(15)
II/2D	41.5	(6.0)	24.1	(3.5)	1.8	1.0	1.55	55.2	(8.0)	103	(15)
II/3M	37.9	(5.5)	17.2	(2.5)	2.0	1.8	1.54	58.6	(8.5)	110	(16)
II/3P	24.1	(3.5)	13.8	(2.0)	2.0	1.5	1.54	37.9	(5.5)	103	(15)
II/3D	44.8	(6.5)	20.7	(3.0)	4.0	3.0	1.43	55.2	(8.0)	103	(15)
III/M	27.6	(4.0)	—		1.1	—	1.57	55.2	(8.0)	—	
III/P	20.7	(3.0)	—		1.4	—	1.57	65.5	(9.5)	—	

[A]For parts and specimens direct-formed (pressed and sintered) (Class D) from powder, tensile strength and elongation are measured perpendicular to the pressing direction. This is the direction for maximum strength so that the strength minima listed do not apply in other directions. Compressive strength is measured parallel to the pressing direction so that the strength levels listed are true minima.

For parts and specimens from Class P material tensile strength, elongation and compressive strength are measured parallel to the direction of compression. This is the direction of minimum strength so that properties in other directions can be greater.

Methods E8 (standard tension test specimens for powdered metal products) for "D" product.

12.1.3 *Specific Gravity*—Specific gravity shall be determined in accordance with Test Method D792, Method A.

12.1.4 *Flexural Strength*—Flexural strength shall be determined in accordance with Test Method D790, Method I, Procedure A.

12.1.5 *Compressive Strength*—Compressive strength shall be determined in accordance with Test Method D695.

13. Certification

13.1 When requested at the time of order, the purchaser shall be furnished a certification that the lot is made from the required plastic and meets the requirements of this specification.

14. Packaging

14.1 *Packing*—The material shall be packed in accordance with Practice D3892.

14.2 *Marking*—In addition to any special marking required by the contract or purchase order, shipping containers shall be marked for DoD orders in accordance with MIL-STD-129.

15. Keywords

15.1 polyimide parts; polyimide resins; high temperature plastics

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D6456 - 99 (2004)) that may impact the use of this standard. (August 1, 2010)

(1) Permissive language was revised to eliminate the word 'may.'

(2) Revised Note 1 to update to standard usage for the ISO equivalency statement.

(3) Section 11: Expanded allowable relative humidity range from 5 % to 10 %.