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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3644C

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Submitted for recognition as an American National Standard

Superseding AMS 3644B

(R) POLYIMIDE, MOLDED ROD, BAR, AND TUBE, PLAQUE, AND FORMED PARTS

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1. SCOPE:

1.1 Form:

This specification covers a polyimide plastic in the form of isostatically molded rod, bar, and tube, unidirectionally molded plaque, and direct formed parts.

1.2 Application:

These products have been used typically for bushings, bearings, seals, and thermal-electrical insulators requiring a combination of toughness, low coefficient of friction, low wear, low creep, and good solvent resistance, but usage is not limited to such applications.

1.3 Classification:

Product is classified on the amount of filler used with the base polyimide polymer as follows:

Class 1 Unfilled
Class 2 15% ± 3 by weight graphite
Class 3 37% ± 3 by weight graphite
Class 4 15% ± 3 by weight graphite plus 10% ± 3 by weight polytetrafluoroethylene (PTFE)
Class 5 15% ± 3 by weight molybdenum disulfide

and by the process used to produce the product as follows:

Form M Isostatically molded rod, bar, and tube
Form P Unidirectional molded plaque
Form D Direct formed parts

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1.3.1 The class and form of product supplied shall be as ordered by purchaser.

1.4 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

2.1 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 638	Tensile Properties of Plastics
ASTM D 638M	Tensile Properties of Plastics (Metric)
ASTM D 695	Compressive Properties of Rigid Plastics
ASTM D 695M	Compressive Properties of Rigid Plastics (Metric)
ASTM D 790	Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 790M	Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (Metric)
ASTM D 792	Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 1708	Tensile Properties of Plastics by Use of Microtensile Specimens
ASTM D 2714	Calibration and Operation of the Alpha Model LFW-1 Friction and Wear Testing Machine
ASTM E 8	Tensile Testing of Metallic Materials
ASTM E 8M	Tensile Testing of Metallic Materials (Metric)

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-2073-1	DOD Materiel, Procedures for Development and Application of Packaging Requirements

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3. TECHNICAL REQUIREMENTS:

3.1 Material:

Moldings shall be manufactured from virgin, unplasticized polyimide polymer, produced as poly,N,N'-(p,p' -oxidiphenylene) pyromellitimide, unfilled or filled, ready for machining and use. These materials have no observable glass transition temperature (Tg) or melt temperature (Tm) and have demonstrated consistent long-term performance at temperatures ranging from cryogenic to 260 °C (500 °F) in many applications.

3.2 Color:

Shall be natural and may vary, as specified in Table 1, depending on the filler material used.

3.3 Properties:

Moldings shall conform to the requirements shown in Table 1, Table 2, and 3.3.1. Tests shall be performed on the product supplied and in accordance with specified test methods.

TABLE 1A - Properties at 73 °F ± 2, Inch/Pound Units

Class/ Form	Color	Tensile Strength ksi, min	Elongation %, min	Compressive Strength ksi, min	Flexural Strength ksi, min	Specific Gravity min	Coefficient of Friction
1M	Brown	11.0	4.8	35.0	15.0	1.42	0.20 to 0.40
1P	Brown	10.0	4.5	30.0	12.0	1.42	0.20 to 0.40
1D	Tan/Brown	9.5	5.0	27.0	10.0	1.33	0.20 to 0.55
2M	Black	8.0	3.5	27.0	12.0	1.50	0.10 to 0.30
2P	Black	6.5	3.0	25.0	9.5	1.49	0.10 to 0.30
2D	Black	8.0	3.5	25.0	11.0	1.41	0.10 to 0.30
3M	Black	6.5	1.3	16.0	8.0	1.65	0.10 to 0.30
3P	Black	4.7	1.3	15.0	7.5	1.64	0.10 to 0.30
3D	Black	6.0	1.8	15.0	8.0	1.55	0.10 to 0.30
4M	Black	5.5	2.0	16.0	8.5	1.54	0.10 to 0.30
4P	Black	3.5	2.0	15.0	5.5	1.54	0.10 to 0.30
4D	Black	6.5	4.0	15.0	8.0	1.43	0.10 to 0.30
5M	Gray/Black	4.0	1.1	--	8.0	1.57	--
5P	Gray/Black	3.0	1.4	--	9.4	1.57	--

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TABLE 1B - Properties at 23 °C ± 1, SI Units

Class/ Form	Color	Tensile Strength MPa, min	Elongation %, min	Compressive Strength MPa, min	Flexural Strength MPa, min	Specific Gravity min	Coefficient of Friction
1M	Brown	76	4.8	241	103	1.42	0.20 to 0.40
1P	Brown	69	4.5	207	83	1.42	0.20 to 0.40
1D	Tan/Brown	66	5.0	186	69	1.33	0.20 to 0.55
2M	Black	55	3.5	186	83	1.50	0.10 to 0.30
2P	Black	45	3.0	172	66	1.49	0.10 to 0.30
2D	Black	55	3.5	172	76	1.41	0.10 to 0.30
3M	Black	45	1.3	110	55	1.65	0.10 to 0.30
3P	Black	32	1.3	103	52	1.64	0.10 to 0.30
3D	Black	41	1.8	103	55	1.55	0.10 to 0.30
4M	Black	38	2.0	110	59	1.54	0.10 to 0.30
4P	Black	24	2.0	103	38	1.54	0.10 to 0.30
4D	Black	45	4.0	103	55	1.43	0.10 to 0.30
5M	Gray/Black	28	1.1	--	55	1.57	--
5P	Gray/Black	21	1.4	--	65	1.57	--

TABLE 2A - Properties at 500 °F ± 5, Inch/Pound Units

Class/ Form	Tensile Strength ksi, min	Elongation %, min	Compressive Strength ksi, min	Flexural Strength ksi, min
1M	5.0	4.0	12.0	8.0
1P	4.0	4.0	11.0	7.0
1D	5.0	4.5	10.0	6.0
2M	4.3	2.5	10.0	6.0
2P	3.7	2.0	10.0	5.0
2D	4.0	2.5	8.5	5.5
3M	3.0	0.8	10.0	4.5
3P	2.0	0.8	8.0	4.0
3D	3.5	1.0	9.0	5.0
4M	2.5	1.8	8.0	5.0
4P	2.0	1.5	8.0	3.5
4D	3.0	3.0	7.5	4.0

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TABLE 2B - Properties at 260 °C ± 3, SI Units

Class/ Form	Tensile Strength MPa, min	Elongation %, min	Compressive Strength MPa, min	Flexural Strength MPa, min
1M	34	4.0	83	55
1P	28	4.0	76	48
1D	34	4.5	69	41
2M	30	2.5	69	41
2P	26	2.0	69	34
2D	28	2.5	59	38
3M	21	0.8	69	31
3P	14	0.8	55	28
3D	24	1.0	62	34
4M	17	1.8	55	34
4P	14	1.5	55	24
4D	21	3.0	52	28

3.3.1 Dimensional Stability: Dimensions of raw stock or fabricated parts shall not change more than 0.0015 inch per inch (0.038 mm per mm), measured at 68 to 86 °F (20 to 30 °C) before and after being held for 24 hours ± 0.5 at 500 °F ± 9 (260 °C ± 5) in air. Before initial measurement, specimens shall be conditioned at 302 °F ± 9 (150 °C ± 5) for 24 hours ± 0.5.

3.4 Quality:

The product, as received by purchaser, shall be uniform in quality and condition, smooth, and free from foreign materials and from imperfections detrimental to usage of the product.

3.5 Tolerances:

Shall be as shown in Table 3 for forms M and P. Tolerances for form D shall be in the range 0.002 to 0.006 inch per inch (0.002 to 0.006 mm per mm) of dimension. Measurements shall be made at 68 to 86 °F (20 to 30 °C) except that closer temperature control may be required for large dimensions.

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TABLE 3A - Forms M and P Maximum Diameter Tolerances, Inch/Pound Units

Nominal Diameter, Inches	Tolerance, Inches Plus Only
0.250 to 1.000, incl	0.025
Over 1.000 to 2.000, incl	0.050
Over 2.000 to 3.500, incl	0.070
Over 3.500	As specified by purchaser

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TABLE 3B - Maximum Diameter Tolerances, SI Units

Nominal Diameter, Millimeters	Tolerance, Millimeters Plus Only
6.35 to 25.40, incl	0.64
Over 25.40 to 50.80, incl	1.27
Over 50.80 to 88.90, incl	1.78
Over 88.90	As specified by purchaser

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of the product shall supply all samples and shall be responsible for all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tensile strength, elongation, and specific gravity (Table 1) are acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of the product to a purchaser, when a change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling and Testing:

Shall be as follows:

4.3.1 For Acceptance Tests: Each lot of product shall be sampled at random to provide sufficient product to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

4.3.1.1 A lot shall be all molded product produced in a single production run from the same batch of polymer and presented for manufacturer's inspection at one time.

4.3.1.2 A statistical sampling, acceptable to purchaser, may be used in lieu of sampling as in 4.3.1 and the report of 4.6 shall state that such plan was used.

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4.3.2 For Preproduction Tests: Shall be acceptable to purchaser.

4.4 Approval:

4.4.1 Sample product shall be approved by purchaser before product for production use is supplied, unless such approval be waived by purchaser.

4.4.2 Manufacturer shall use ingredients, manufacturing procedures, processes, and methods of inspection on production product which are essentially the same as those used on the approved sample product. If necessary to make any change in ingredients, type of equipment for processing, and/or manufacturing procedures, manufacturer shall submit for reapproval a statement of the proposed changes in ingredients and/or processing and, when requested, sample product. Production product made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

Property tests shall be performed in accordance with the following test methods and 3.3.1. All specimens shall be equilibrated as described in the appropriate ASTM or other method. Elevated temperature test specimens shall equilibrate at least 30 minutes at temperature before testing.

4.5.1 Tensile Strength and Elongation: Shall be determined in accordance with ASTM D 638 or ASTM D 638M with Forms M and P tensile bars fabricated according to ASTM D 1708 and form D tensile bars fabricated according to ASTM E 8 or ASTM E 8M powdered metal products test specimen. Crosshead speed for types M and P specimens shall be 0.05 inch per minute (0.02 mm/s) and for type D specimens 0.2 inches per minute (0.008 mm/s).

4.5.2 Compressive Strength at 73 °F (23 °C): Shall be determined in accordance with ASTM D 695 or ASTM D 695M.

4.5.3 Flexural Strength: Shall be determined in accordance with ASTM D 790 or ASTM D 790M. Ultimate flexural strength may require the test to be run beyond 5% strain.

4.5.4 Specific Gravity at 73 °F (23 °C): Shall be determined in accordance with ASTM D 792.

4.5.5 Coefficient of Friction: Shall be determined using the equipment described in ASTM D 2714 with a conforming block. Normal force readings from a time 1.5 hours after test start to at least 8 hours after test start are used to determine the coefficient of friction. An alternate method agreed upon by purchaser and manufacturer is acceptable.

4.6 Reports:

The supplier of the product shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS 3644C, class and form, manufacturer's identification, size or part number, and quantity.

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