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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3644D

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Superseding AMS 3644C

Polyimide, Molded Rod, Bar, and Tube, Plaque, and Formed Parts

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. Each application should be considered individually.

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

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

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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 issue of the following documents in effect on the date of the purchase order form a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19429-2859.

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 790	Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 792	Density and Specific Gravity (Relative 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 Falex Block-on-Ring Friction and Wear Testing Machine
ASTM D 4065	Determining and Reporting Dynamic Mechanical Properties of Plastics
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 1545	Assignment of the Glass Transition Temperature by Thermomechanical Analysis

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, 3.3.2, and 3.3.3. 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	8.5	4.5	27.0	12.0	1.40	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	23.5	9.5	1.47	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	--

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	59	4.5	186	83	1.40	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	162	66	1.47	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

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.

3.3.2 Glass Transition Temperature shall be analyzed by ASTM E 1545 with no change in the slope of the curve between room temperature and 400 °C (752 °F).

3.3.3 Dynamic Mechanical Analysis at 1 Hz, 23 to 350 °C (-9.4 to +662 °F) at 5 °C (2.8 °F) per minute heat rate shall show no change in the slope of the modulus (E) versus temperature curve.

3.4 Quality:

The product, as received by purchaser, shall be uniform in quality and condition, smooth, as free from foreign material as commercially practicable, and free 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.

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

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 the performance of 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 specified requirements.

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 by the manufacturer, when a change in ingredients and/or processing requires reapproval as in 4.4.1, and when purchaser deems confirmatory testing to be required.

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.

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. Results of tests on production product shall be essentially equivalent to those on the approved sample. 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.

4.4.2 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.

4.5 Test Methods:

Property tests shall be performed in accordance with the following test methods and 3.3.1, 3.3.2, and 3.3.3. 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.