SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

AMS 3644G

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Superseding AMS 3644F

Plastic: Polyimide
For Molded Rod, Bar, and Tube, Plaque, and Formed Parts

RATIONALE

Property data contained in this Aerospace Material Specification has been upgraded after statistical analysis of results from extended property testing.

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 are 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 separately. Polyimide covered by this specification has a service temperature range of cryogenic to 500 °F (260 °C). These materials have no observable glass transition temperature (Tg) or melt temperature (Tm).

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.

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 purchase order date shall stipulate the published document that shall be in effect. The supplier may work to a subsequent revision unless a particular revision is specified. When the referenced document has been canceled and no superseding document has been specified, the last published revision shall apply.

2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 638	Tensile Properties of Plastics
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	Standard Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures
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.

3.2 Color

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

3.3 Properties

The product shall conform to the tables below when tested in accordance with 4.5.

TABLE 1 - PROPERTIES AT 73 °F ± 2, INCH/POUND UNITS AND AT 23 °C ± 1, SI UNITS

Class/ Form	Color	Tensile Strength, min ksi	Tensile Strength, min MPa	Elongation %, min	Compressive Strength, min ksi	Compressive Strength, min MPa	Flexural Strength, min ksi	Flexural Strength, min MPa	Specific Gravity min	Coefficient of Friction
1M	Brown	11.0	76	4.8	35.0	241	15.0	103	1.42	0.20 to 0.40
1P	Brown	8.5	59	4.5	27.0	186	12.0	83	1.40	0.20 to 0.40
1D	Tan/Brown	9.5	66	5.0	27.0	186	10.0	69	1.33	0.20 to 0.55
2M	Black	8.0	55	3.5	27.0	185	12.0	83	1.49	0.10 to 0.30
2P	Black	6.5	45	3.0	23.5	162	9.5	66	1.47	0.10 to 0.30
2D	Black	8.0	55	3.5	25.0	172	11.0	76	1.41	0.10 to 0.30
3M	Black	6.5	45	1.3	16.0	110	8.0	55	1.64	0.10 to 0.30
3P	Black	4.7	32	1.3	15.0	103	7.5	52	1.64	0.10 to 0.30
3D	Black	6.0	41	1.8	15.0	103	8.0	55	1.55	0.10 to 0.30
4M	Black	5.5	38	2.0	16.0	110	8.5	59	1.54	0.10 to 0.30
4P	Black	3.5	24	2.0	15.0	103	5.5	38	1.54	0.10 to 0.30
4D	Black	6.5	45	4.0	15.0	103	8.0	55	1.43	0.10 to 0.30
5M	Gray/Black	4.0	28	1.1		--	8.0	55	1.57	--
5P	Gray/Black	3.0	21	1.4		--	9.4	65	1.57	--

TABLE 2 - PROPERTIES AT 500 °F ± 5, INCH/POUND UNITS AND AT 260 °C ± 3, SI UNITS

Class/ Form	Tensile Strength, min ksi	Tensile Strength, min MPa	Elongation %, min	Compressive Strength, min ksi	Compressive Strength, min MPa	Flexural Strength, min ksi	Flexural Strength, min MPa
1M	5.0	34	4.0	12.0	83	8.0	55
1P	4.0	28	4.0	11.0	76	7.0	48
1D	5.0	34	4.5	10.0	69	6.0	41
2M	4.3	30	2.5	10.0	69	6.0	41
2P	3.7	26	2.0	10.0	69	5.0	34
2D	4.0	28	2.5	8.5	59	5.5	38
3M	3.0	21	0.8	10.0	69	4.5	31
3P	2.0	14	0.8	8.0	55	4.0	28
3D	3.5	24	1.0	9.0	62	5.0	34
4M	2.5	17	1.8	8.0	55	5.0	34
4P	2.0	14	1.5	8.0	55	3.5	24
4D	3.0	21	3.0	7.5	52	4.0	28

3.3.1 Dimensional stability 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 752 °F (400 °C).

3.3.3 Dynamic mechanical analysis in accordance with ASTM D 4065 at 1 Hz, 73 to 662 °F (23 to 350 °C) at 9 °F (5 °C) 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 (0.05 to 0.15 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 3 - FORMS M AND P MAXIMUM DIAMETER TOLERANCES, INCH/POUND UNITS AND SI UNITS

Nominal Diameter Inch	Nominal Diameter Millimeters	Tolerance Plus-Only Inch	Tolerance Plus-Only Millimeters
0.250 to 1.000, incl	6.35 to 25.40, incl	0.025	0.64
Over 1.000 to 2.000, incl	Over 25.40 to 50.80, incl	0.050	1.27
Over 2.000 to 3.500, incl	Over 50.80 to 88.90, incl	0.070	1.78
Over 3.500	Over 88.90	As specified by purchaser	As specified by purchaser

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

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

4.2 Classification of Tests

4.2.1 Acceptance Tests

Performed on each lot. The product shall conform to the table below.

TABLE 4 - ACCEPTANCE TESTS

Test	Requirement	Method
Tensile Strength	TABLE 1	4.3.1
Elongation	TABLE 1	4.3.1
Specific Gravity	TABLE 1	4.3.3

4.2.1.1 Random Sampling

The method shall be specified in a purchase order/contract, otherwise product shall be taken at random from each lot to perform all the required acceptance tests. The number of test iterations for each requirement shall be specified in the applicable test procedure.

4.2.1.1.1 Lot

A quantity of product processed and packaged as one production entity from a batch.

4.2.1.2 A statistical sampling plan, acceptable to purchaser, may be used in lieu of sampling as in 4.2.1.1 and the report of 4.5 shall state that such plan was used.

4.2.2 Preproduction Tests

All technical requirements 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 and when purchaser deems confirmatory testing to be required.

4.2.2.1 Manufacturer shall use ingredients, manufacturing procedures, processes, and methods of inspection on production product which are essentially the same as those used on the approval sample. If any change in ingredients, in type of equipment for processing, or in manufacturing procedures is necessary, 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.

4.2.2.2 Random Sampling

Shall be acceptable to purchaser.

4.3 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.

4.3.1 Tensile Strength and Elongation

Shall be determined in accordance with ASTM D 638 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 inch per minute (0.08 mm/s).

4.3.2 Compressive Strength at 73 °F (23 °C)

Shall be determined in accordance with ASTM D 695.

4.3.3 Flexural Strength

Shall be determined in accordance with ASTM D 790. Ultimate flexural strength may require the test to be run beyond 5% strain.

4.3.4 Specific Gravity at 73 °F (23 °C)

Shall be determined in accordance with ASTM D 792.

4.3.5 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.

4.4 Approval

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.

4.5 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 3644G, class and form, manufacturer's identification, size or part number, and quantity.