

MIL-R-46198  
7 January 1988

MILITARY SPECIFICATION

RESIN, POLYIMIDE, HOT PRESSED OR PRESSED AND SINTERED

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Form. This material specification covers molded, unfilled or filled polyimide resin in the form of rod, bar, tube or slab, parts machined therefrom, and parts direct-formed from powder.

1.2 Application. The materials covered in this specification are used primarily for parts requiring a combination of properties including self-lubricity and low coefficients of friction and thermal expansion coupled with heat resistance for continuous operations at temperatures up to 500°F (260°C) and for short-term excursions to 900°F (482°C).

1.3 Classification. The polyimide resin shall be of the following types and classes, as specified (see 6.2):

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

Note: Filler contents shown above are approximate. See Table I for exact composition.

1.3.1 Polymer composition shall be specified by use of type/class designations as described in Table I.

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

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

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Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Laboratory Command, Materials Technology Laboratory, ATTN: SLCMT-MEE, Watertown, MA 02172-0001 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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## 2. APPLICABLE DOCUMENTS

### 2.1 Government documents.

2.1.1 Standards. The following standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

#### MILITARY STANDARDS

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-129 - Marking for Shipment and Storage

MIL-STD-1189 - Bar Code Symbology, Standard Department of Defense

(Copies of military standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-government documents which is current on the date of the solicitation.

#### AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D638 - Standard Test Method for Tensile Properties of Plastics

ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics

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

ASTM D792 - Standard Test Methods for Specific Gravity and Density of Plastics by Displacement

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

ASTM D3892 - Standard Practice for Packaging/Packing of Plastics

ASTM E8 - Standard Methods of Tension Testing of Metallic Materials

(Application for copies of ASTM standards should be addressed to the ASTM, 1916 Race Street, Philadelphia, PA 19103.)

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2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

### 3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.2.1 and 6.2).

3.2 Material. The material shall consist of polyimide resins with a base polymer structure derived from pyromellitic dianhydride and 4,4'-diaminodiphenylether or other equivalent polyimide resins which meet the requirements of this specification. The material shall conform to the composition requirements of Table I. The resins, depending on type and class, may contain up to 50 weight percent pigments, fillers or lubricants, and no fibrous reinforcement. Recycle of unworked resin from mold filling overflow shall be permitted to the extent that the resultant material meets all property requirements specified herein. No reground material shall be permitted.

3.3 Workmanship. The polyimide plastic material shall be free of major defects and contaminants that would be detrimental to fabrication or performance of a finished part.

### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the procuring activity. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the procuring activity for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the procuring activity to acceptance of defective material.

4.1.2 Certificate of compliance (COC). Unless otherwise specified in the contract or purchase order, the supplier shall furnish with each shipment, a certificate of compliance (in triplicate) signed by a duly authorized representative of the supplier, stating compliance with the requirements specified herein and listing the specific results of all the acceptance tests. The certificate of compliance shall also include this specification number, the purchase order number, and the batch number.

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4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

- a. First article (i.e., preproduction) inspection (see 4.2.1)
- b. Quality conformance (i.e., lot acceptance) inspection (see 4.2.2)

4.2.1 First article inspection. First article inspection shall consist of all the quality assurance tests contained in this specification. First article tests shall be performed on initial material or in the event of a formulation change. In the absence of a formulation change, first article inspection shall be performed only when specified (see 6.2).

4.2.2 Quality conformance inspection. Lot acceptance tests shall be made on each lot of material and shall be the basis for acceptance or rejection of the lot except when first article tests are performed. Lot acceptance tests shall consist of testing, at  $75^{\circ}\text{F} + 5^{\circ}\text{F}$  ( $24 + 2^{\circ}\text{C}$ ) for tensile strength, tensile elongation at break, and specific gravity (see 4.4) and the dimensional, visual and packaging inspections specified herein.

4.2.2.1 Dimensional and visual inspections.

4.2.2.1.1 "P" product. Dimensional and visual inspection shall be performed on 100% of all shapes designated as "P" product.

4.2.2.1.2 "M" product. Dimensional inspection shall be performed on shapes designated as "M" product.

4.2.2.1.3 "D" product. Unless otherwise specified, dimensional and visual inspection of material designated as "D" product shall be performed using MIL-STD-105, Level I, 2.5% AQL.

4.2.2.2 Packaging inspection. An inspection shall be made in accordance with Table IV to determine that packing and marking comply with Section 5 requirements. The sample unit for this examination shall be one shipping container fully packed selected just prior to the closing operation. Shipping containers fully prepared for delivery shall be examined for closure defect.

4.3 Sampling for inspection. Sampling for inspections and acceptance shall be performed in accordance with MIL-STD-105, unless otherwise specified.

4.4 Test methods. Testing shall be in accordance with the test methods specified herein for each lot submitted for inspection. The material for testing shall be molded or machined from molded shapes and tested for the characteristics listed in Table III, as applicable.

4.4.1 Tensile strength. Tensile strength shall be determined in accordance with ASTM D638 using ASTM D1708, (micro-tensile specimen), for "M" and "P" product, and ASTM E8 (standard tension test specimens for powdered metal products) for "D" product. Crosshead speed shall be 5 mm/min for "D" product and 1.3 mm/min for "M" and "P" product.

4.4.2 Tensile elongation at break. Tensile elongation shall be determined in accordance with ASTM D638 using ASTM D1708 for "M" and "P" product and ASTM E8 (standard tension test specimens for powdered metal products) for "D" product.

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4.4.3 Specific gravity. Specific gravity shall be determined in accordance with ASTM D792, Method A.

4.4.4 Flexural strength. Flexural strength shall be determined in accordance with ASTM D790, Method I, Procedure A.

4.4.5 Compressive strength. Compressive strength shall be determined in accordance with ASTM D695.

## 5. PACKAGING

5.1 Packing. The material shall be packed in accordance with ASTM D3892.

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

## 6. NOTES

6.1 Intended use. The polyimide materials covered by this specification are used to make parts for military jet engines and in many other military applications. End uses for parts made from this material include the following:

- a. Vane bushings in jet engines
- b. Piston rings in tank shock absorbers
- c. Thrust washers in tanks and armored vehicle transmissions
- d. Valve seats in the stabilizing system of missiles

Other end uses include various bushings, bearings, thrust washers, seal rings, wear strips and pads, lock nut and lock bolt inserts, balls, valve seats, and thermal and electrical insulators.

### 6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number and date of this specification
- b. Type and class of material (see 1.3)
- c. Whether first article inspection is required (see 3.1)
- d. Level of packing required (see 5.1)

### 6.3 Subject term (key word) listing

Polyimide resin  
High temperature plastic  
Jet engine parts

6.4 Material supplier(s). Dupont Company certifies material to this specification under the tradename Vespel. However, this specification is not limited to any single proprietary product.

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TABLE I. Polymer composition and form.

| Type/<br>Class     | Polymer Composition<br>"M" and "P" Forms  | "D" Form   |
|--------------------|---|--|
|                    |   | Same composition as "M" and "P" forms except up to the following amounts of PTFE* is added for mold release. |
| Type I             | Unfilled polyimide polymer  | 0.5% by weight   |
| Type II<br>Class 1 | Filled polyimide polymer containing 14-16% by weight graphite.                          | 0.5% by weight   |
| Type II<br>Class 2 | Filled polyimide polymer containing 35-39% by weight graphite.                          | 2.0% by weight   |
| Type II<br>Class 3 | Filled polyimide polymer containing 12-14% by weight graphite and 9-11% by weight PTFE. | - - - - -  |
| Type III           | Filled polyimide polymer containing 14-16% by weight molybdenum disulfide.              | +  |
|                    | * Polytetrafluoroethylene compound  |  |
|                    | + No "D" product form in Type III   |  |

TABLE II. Manufacturing method and form.

| <u>Suffix Letter</u> | <u>Product Form</u>                         |
|----------------------|---|
| M                    | Hot isostatically molded billet             |
| P                    | Hot unidirectionally pressed slab           |
| D                    | Direct-formed (pressed) and sintered parts. |

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TABLE III. Mechanical properties (minima).

| Type/<br>Class    | Tensile Strength |                     | Tensile Elongation<br>% | Specific<br>Gravity | Flexural<br>Strength  |          | Compressive<br>Strength |
|-------------------|------------------|---------------------|-------------------------|---------------------|-----------------------|----------|-------------------------|
|                   | MPa (ksi)        | 500+50F<br>(Note 2) |                         |                     | MPa (ksi)<br>(Note 2) | 75+50F   |                         |
| IM                | 76 (11)          | 34.5 (5.0)          | 4.8                     | 1.42                | 103 (15)              | 241 (35) |                         |
| IP                | 69 (10)          | 27.6 (4.0)          | 4.5                     | 1.42                | 83 (12)               | 207 (30) |                         |
| ID<br>(Note 1)    | 65.5 (9.5)       | 34.5 (5.0)          | 5.0                     | 1.33                | 69 (10)               | 186 (27) |                         |
| II/1M             | 55.2 (8.0)       | 29.7 (4.3)          | 3.5                     | 1.49                | 83 (12)               | 186 (27) |                         |
| II/1P             | 44.8 (6.5)       | 25.5 (3.7)          | 3.0                     | 1.49                | 65.5 (9.5)            | 172 (25) |                         |
| II/1D<br>(Note 1) | 55.2 (8.0)       | 27.6 (4.0)          | 3.5                     | 1.41                | 76 (11)               | 172 (25) |                         |
| II/2M             | 44.8 (6.5)       | 20.7 (3.0)          | 1.3                     | 1.64                | 55.2 (8.0)            | 110 (16) |                         |
| II/2P             | 32.4 (4.7)       | 13.8 (2.0)          | 1.3                     | 1.64                | 51.7 (7.5)            | 103 (15) |                         |
| II/2D<br>(Note 1) | 41.5 (6.0)       | 24.1 (3.5)          | 1.8                     | 1.55                | 55.2 (8.0)            | 103 (15) |                         |
| II/3M             | 37.9 (5.5)       | 17.2 (2.5)          | 2.0                     | 1.54                | 58.6 (8.5)            | 110 (16) |                         |
| II/3P             | 24.1 (3.5)       | 13.8 (2.0)          | 2.0                     | 1.54                | 37.9 (5.5)            | 103 (15) |                         |
| II/3D<br>(Note 1) | 44.8 (6.5)       | 20.7 (3.0)          | 4.0                     | 1.43                | 55.2 (8.0)            | 103 (15) |                         |
| III/M             | 31.1 (4.5)       | -----               | 2.7                     | 1.57                | 55.2 (8.0)            | -----    |                         |
| III/P             | 31.1 (4.5)       | -----               | 2.7                     | 1.57                | 65.5 (9.5)            | -----    |                         |

Note 1: For parts and specimens direct-formed (pressed and sintered) from powder, tensile strength, elongation, and flexural strength are measured perpendicular to the pressing direction. This is the direction for maximum strength so that the strength minima listed may not apply in other directions. Compressive strength is measured parallel to the pressing direction so that the strength levels listed are true minima.

Note 2: Shall be tested for initial acceptance of material, if requested by procuring activity, or in event of formulation change. Material must be capable of meeting or exceeding minimum requirements when tested at option of procuring activity.

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TABLE IV. Examination of packaging.

| <u>Examine</u>  | <u>Defects</u>   |
|---|--|
| Packing   | Not level specified; not in accordance with contract requirements. Any nonconforming component, component missing, damage or otherwise defective affecting serviceability. Inadequate application of components such as:<br><br>Incomplete closures of case liners; container flaps, loose or inadequate slappings, bulged or distorted container. |
| Quantity<br>of material   | Less than specified or indicated quantity.   |
| Weight  | Gross weight exceeds specified requirements.   |
| Markings  | Interior or exterior markings omitted, illegible, incorrect, incomplete, of improper size, location, sequence, method of application, or not in accordance with contract requirements.   |
| Custodians:<br>Army - MR<br>Navy - AS<br>Air Force - 20<br>DLA - GS | Preparing Activity:<br>Army - MR<br><br>Project No. 9330-1031  |

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