

MIL-P-46184
1 November 1982

MILITARY SPECIFICATION

PLASTIC MOLDING and EXTRUSION MATERIAL,
POLYETHERIMIDE (PEI)

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

1. SCOPE

1.1 Scope. This specification covers three types of polyetherimide (PEI) thermoplastic materials suitable for injection molding, extrusion, solvent casting or blow molding.

1.2 Classification. The PEI thermoplastic materials shall be of the following types and classes (see 6.2):

Type I Unfilled (nonreinforced)

Type II Glass fiber reinforced (GFR)

Class 1 10% GFR (by wt)

Class 2 20% GFR (by wt)

Class 3 30% GFR (by wt)

Type III Carbon fiber reinforced (CFR) (40% CFR by wt)

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

PPP-D-723 - Drums, Fiber

PPP-D-729 - Drums: Metal, 55-gallon (for Shipment of Noncorrosive Material)

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 Materials and Mechanics Research Center, ATTN: DRXMR-SSS, Watertown, MA 02172 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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STANDARDS

MILITARY

- MIL-STD-129 - Marking for Shipment and Storage
- MIL-STD-1188 - Commercial Packaging of Supplies and Equipment

(Copies of specifications and standards required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM D 149 - Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- ASTM D 150 - A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials
- ASTM D 257 - D-C Resistance or Conductance of Insulating Materials
- ASTM D 638 - Tensile Properties of Plastics
- ASTM D 648 - Deflection Temperature of Plastics Under Flexural Load
- ASTM D 790 - Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- ASTM D 792 - Specific Gravity and Density of Plastics by Displacement
- ASTM D 1672 - Exposure of Polymeric Materials to High-Energy Radiation
- ASTM D 2863 - Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- ASTM D 3171 - Fiber Content of Resin-Matrix Composites by Matrix Digestion
- ASTM E 662 - Specific Optical Density of Smoke Generated by Solid Materials

(Applications for copies of ASTM publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

UNDERWRITERS LABORATORIES

- UL 746B - Polymeric Materials - Long Term Property Evaluations

(Applications for copies should be addressed to the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Material. The material shall consist of PEI thermoplastic granules, pellets or powder, with or without fiber reinforcement.

3.2 Properties of PEI thermoplastic materials. Unless otherwise specified, the properties of the PEI thermoplastic shall be as specified herein, when tested in accordance with 4.3.

3.2.1 Unfilled PEI (type I). The properties of the unfilled PEI thermoplastic shall be as specified in table I.

TABLE I. Properties of unfilled (nonreinforced) PEI (type I).

Properties	Property Values
Mechanical:	
Tensile strength, yield, min <u>1</u> /	103 MPa (15,000 psi)
Tensile elongation, ultimate, min	30%
Flexural modulus, tangent, min	3034 MPa (440,000 psi)
Thermal:	
Deflection temperature, unannealed, min (1820 kPa, width 6.4 mm)	196°C
Electrical:	
Dielectric strength, min <u>2</u> / (1.6 mm thickness, in oil, S/T)	23.6 kV/mm
Dielectric constant, max (at 1kHz, 50% RH, 23°C)	3.2
Dissipation factor, max (at 1 kHz, 50% RH, 23°C)	0.0015
(at 2450 MHz, 50% RH, 23°C)	0.003
Volume resistivity, min	10 ¹⁶ ohm-cm
Flammability:	
Oxygen index, min	44%
Specific optical density, flaming mode, max	
D ₄	2
D _{max}	50
Other:	
Specific gravity	1.27 ± 0.02

1/ MPa x 145 = psi

2/ kV/mm x 25.4 = V/mil

3.2.2 Glass fiber reinforced PEI (type II). The properties of the glass-reinforced PEI thermoplastic shall be as specified in table II.

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TABLE II. Properties of glass fiber reinforced PEI (type II).

Properties	Property Values		
	Class 1 (10% glass fiber)	Class 2 (20% glass fiber)	Class 3 (30% glass fiber)
Mechanical:			
Tensile strength, yield, min <u>1</u> /	110 MPa (16,000 psi)	129 MPa (18,700 psi)	159 MPa (23,000 psi)
Tensile elongation, ultimate, min	5.5%	2.5%	2.0%
Flexural modulus, tangent, min	4,345 MPa (630,000 psi)	5,793 MPa (840,000 psi)	7,586 MPa (1,100,000 psi)
Thermal:			
Deflection temperature, unannealed, min (1820 kPa, width 6.4 mm)	205°C	207°C	208°C
Electrical:			
Dielectric strength, min <u>2</u> / (1.6 mm thickness, in oil, S/T)	23.0 kV/mm	22.0 kV/mm	21.0 kV/mm
Dielectric constant, max (at 1kHz, 50% RH, 23°C)	3.7	3.7	3.8
Dissipation factor, max (at 1 kHz, 50% RH, 23°C)	0.0016	0.0017	0.0017
Volume resistivity, min	10 ¹⁶ ohm-cm	10 ¹⁶ ohm-cm	10 ¹⁶ ohm-cm
Other:			
Specific gravity	1.34 ± 0.02	1.42 ± 0.02	1.51 ± 0.02
Glass fiber content, by weight	10 ± 2%	20 ± 2%	30 ± 2%

1/ MPa x 145 = psi2/ kV/mm x 25.4 = V/mil

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3.2.3 Carbon fiber reinforced PEI (type III). The properties of the carbon fiber reinforced PEI thermoplastic shall be as specified in table III.

TABLE III. Properties of carbon fiber reinforced PEI (type III).

Properties	Property values (40% carbon fiber)
Mechanical:	
Tensile strength, yield, min $\frac{1}{2}$	214 MPa (31,000 psi)
Tensile elongation, ultimate, min	2-3%
Flexural modulus, tangent, min	19,310 MPa (2,800,000 psi)
Flexural strength, min	310 MPa (45,000 psi)
Thermal:	
Deflection temperature, unannealed, min (1820 kPa, width 6.4 mm)	215°C
Other:	
Specific gravity	1.44 \pm 0.02
Carbon fiber content, by weight	40 \pm 2%

$\frac{1}{2}$ MPa x 145 = psi

3.3 Form. The form of the PEI thermoplastic shall be granules, pellets or powder. When specified by the procuring activity, the form shall be in the size and shape specified (see 6.2).

3.4 Gamma radiation resistance. The tensile strength of the unfilled (nonreinforced) PEI thermoplastic shall be 96 MPa (14,000 psi), minimum, after exposure to 500×10^6 rads of ^{60}Co gamma radiation, at an exposure rate of 1 megarad/hour (see 4.3).

3.5 Temperature index. The UL temperature index (continuous use temperature) for all types of PEI thermoplastic shall be 170°C, minimum (see 4.3).

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 Government. The Government 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.

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4.2 Classification of tests. The examination and testing of the plastic molding and extrusion material shall be classified as follows:

- a. Preproduction tests
- b. Quality conformance tests

4.2.1 Preproduction tests. When specified (see 6.2.1), preproduction tests shall consist of tests for one or more of the following properties:

- a. Flexural modulus, tangent
- b. Temperature index
- c. Dielectric strength
- d. Dielectric constant
- e. Dissipation factor
- f. Volume resistivity
- g. Oxygen index
- h. Specific optical density, flaming mode
- i. Specific gravity
- j. Glass fiber content
- k. Gamma radiation resistance

4.2.2 Quality conformance tests. Quality conformance tests shall consist of tests for the following properties, except as otherwise specified by the contracting officer:

- a. Tensile strength, yield
- b. Tensile elongation, ultimate
- c. Deflection temperature

4.2.2.1 Lot size. Lot size shall consist of all the molding or extrusion material manufactured at one time, from one batch, forming part of one contract or order, and submitted for acceptance at the same time and place.

4.2.2.2 Sampling. Unless otherwise specified (see 6.2), a sufficient quantity of material from one unit representative of each lot (4.2.2.1) shall be selected at random for quality conformance testing. Each container of material shall be considered as a unit of product. Failure of sample to meet the quality conformance requirements shall be cause for lot rejection.

4.3 Test methods. The properties of the PEI thermoplastic materials specified in 3.2 shall be determined in accordance with the applicable test method in table IV.

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TABLE IV. Test methods.

Property	Test Method
Tensile strength, yield	ASTM D 638
Tensile elongation, ultimate	ASTM D 638
Flexural modulus, tangent	ASTM D 790
Deflection temperature	ASTM D 648
Dielectric strength	ASTM D 149
Dielectric constant	ASTM D 150
Dissipation factor	ASTM D 150
Volume resistivity	ASTM D 257
Oxygen index	ASTM D 2863
Specific optical density	ASTM E 662
Specific gravity	ASTM D 792
Glass fiber content	ASTM D 3171
Gamma radiation resistance	ASTM D 1672
Temperature index	UL 746B

5. PACKAGING

5.1 Packing. Packing shall be level A, or Industrial as specified (see 6.2).

5.1.1 Level A. Unless otherwise specified, the material shall be packed in one of the following types of containers:

- a. Fiber drums conforming to PPP-D-723, type II, grade A, or type III, grade A in quantities of 90 kg (200 lbs) maximum.
- b. Metal drums conforming to PPP-D-729, type III or type IV, in quantities of 181 kg (400 lbs), maximum.

Insofar as practical, drums shall be of uniform shape and size, with minimum cube and tare consistent with the protection required. Drums shall contain identical quantities and shall be closed in accordance with the applicable container specification. Fiber drums shall be furnished with a 4 mil thick polyethylene liner properly heat sealed.

5.1.2 Industrial. The material shall be packed in accordance with MIL-STD-1188.

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, with the exception that industrial marking in accordance with MIL-STD-1188 applies for industrial packaging only.

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6. NOTES

6.1 Intended use. Polyetherimide (PEI) resins are intended for use in a wide range of critical environments. Although amorphous materials, PEI resins are resistant to most mineral acids and salt solutions, dilute bases, aliphatic hydrocarbons, and perfluorocarbon type cleaners. Solubility in methylene chloride allows the use of solvent bonding, casting and impregnation techniques. Polyetherimide is inherently flame resistant with a UL 94 V-0 rating at 0.64 mm (25 mils), and a high oxygen index of 47% combined with extremely low levels of smoke emission. The material exhibits high mechanical strengths at elevated temperatures and offers excellent electrical properties which remain stable over wide temperature and frequency ranges extending into the microwave and radar regions. Polyetherimide resin has a UL continuous thermal use rating of 170°C, a heat deflection temperature of 196°C at 1820 kPa (264 psi), and has excellent resistance to gamma radiation.

Applications include numerous electrical/electronic, aircraft, automotive, and lighting components. Other uses include advanced composites, films, and printed wiring boards.

Polyetherimide resin may be processed by all conventional injection molding, extrusion, blow molding and solvent casting techniques.

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.
- c. Specific pellet size, if required (see 3.3)
- d. Whether a preproduction sample is required and, if so, pertinent details (see 4.2.1).
- e. Sampling plan, if other than specified in 4.2.2.2.
- f. Level of packing required (see 5.1)
- g. Color

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