

MIL-P-46183
20 June 1984

MILITARY SPECIFICATION

PLASTIC MOLDING and EXTRUSION MATERIAL,
POLYETHERETHERKETONE (PEEK)

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

1. SCOPE

1.1 Scope. This specification covers polyetheretherketone (PEEK) thermoplastic materials suitable for injection molding or extrusion (See 6.1).

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

Type I - Nonreinforced plastic

Type II - Glass fiber reinforced plastic (GFRP)

Class 1 10 \pm 2% GFRP (by wt)

Class 2 20 \pm 2% GFRP (by wt)

Class 3 30 \pm 2% GFRP (by wt)

Type III - Carbon fiber reinforced plastic (CFRP)

Class 1 20 \pm 2% CFRP (by wt)

Class 2 30 \pm 2% CFRP (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.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, U.S. Army Materials and Mechanics Research Center, ATTN: DRXMR-SMS, 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.

FSC 9330

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SPECIFICATIONS

FEDERAL

- PPP-D-723 - Drums, Fiber
- PPP-D-729 - Drums, Shipping and Storage, Steel, 55-Gallon, (208 Liters)

STANDARDS

MILITARY

- MIL-STD-129 - Marking for Shipment and Storage

(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 D149 - Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- ASTM D256 - Impact Resistance of Plastics and Electrical Insulating Materials
- ASTM D257 - D-C Resistance or Conductance of Insulating Materials
- ASTM D570 - Water Absorption of Plastics
- ASTM D638 - Tensile Properties of Plastics
- ASTM D648 - Deflection Temperature of Plastics Under Flexural Load
- ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics
- ASTM D792 - Specific Gravity and Density of Plastics by Displacement
- ASTM D2863 - Measuring the Minimum Oxygen Concentration to Support Candle Like Combustion of Plastics (Oxygen Index)
- ASTM D3171 - Fiber Content of Resin-Matrix Composites by Matrix Digestion
- ASTM D3418 - Transition Temperatures of Polymers by Thermal Analysis
- ASTM D3951 - Practice for Commercial Packaging
- ASTM E380 - Metric Practice
- ASTM F814 - Test Method for Specific Optical Density of Smoke Generated by Solid Materials for Aerospace Applications

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

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(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 PEEK thermoplastic granules, pellets or powder, with or without fiber reinforcement.

3.2 Physical and mechanical properties. The properties of the PEEK thermoplastic shall be as specified herein when tested in accordance with 4.3. Mechanical properties are to be measured on specimens that have been injection molded to net shape.

3.2.1 Nonreinforced PEEK (type I). The properties of the unpigmented, non-reinforced PEEK thermoplastic shall be as specified in table I.

TABLE I. Properties of nonreinforced PEEK (type I).^{1/}

Property	Property Values
Melting point (minimum)	334°C (633°F)
Glass transition temperature (T _g), min	143°C (289°F)
Specific gravity	1.30 ± 0.04
Tensile strength ^{2/} (minimum)	
(at 23°C)	90 MPa (13,000 psi)
(at 200°C)	20 MPa (2,900 psi)
Elongation at break (minimum)	10%
Flexural modulus (minimum)	3400 MPa (500,000 psi)
Heat deflection temperature (minimum)	
(at 1820 kPa)	149°C (300°F)
Water absorption (maximum)	
(24-h immersion)	0.2%

^{1/} Property values are expressed in SI units in accordance with ASTM E380.

^{2/} MPa x 145 = psi

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

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

Property	Property Values		
	Class 1 (10% glass fiber)	Class 2 (20% glass fiber)	Class 3 (30% glass fiber)
Glass fiber content	10 ± 2% (by wt)	20 ± 2% (by wt)	30 ± 2% (by wt)
Specific gravity	1.37 ± 0.04	1.44 ± 0.04	1.49 ± 0.04
Tensile strength ^{1/} (minimum)	110 MPa (16,000 psi)	120 MPa (17,400 psi)	152 MPa (22,000 psi)
Elongation at break (minimum)	5%	4%	3%
Flexural modulus (minimum)	5000 MPa (730,000 psi)	6200 MPa (900,000 psi)	6900 MPa (1,000,000 psi)
Impact strength ^{2/} (minimum)	50 J/m (0.9 ft-lbf/in)	60 J/m (1.1 ft-lbf/in)	80 J/m (1.5 ft-lbf/in)

^{1/} MPa x 145 = psi

^{2/} Notched, 0.25 in; J/m x 18.73 x 10⁻³ = ft-lbf/in

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

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

Property	Property Values	
	Class 1 (20% carbon fiber)	Class 2 (30% carbon fiber)
Carbon fiber content	20 ± 2% (by wt)	30 ± 2% (by wt)
Specific gravity	1.38 ± 0.04	1.42 ± 0.04
Tensile strength (minimum)	159 MPa (23,000 psi)	185 MPa (27,000 psi)
Elongation at break (minimum)	5%	2%
Flexural modulus (minimum)	10,300 MPa (1,500,000 psi)	12,800 MPa (1,850,000 psi)
Impact strength (minimum) (notched, 0.25 in)	45 J/m (0.8 ft-lbf/in)	50 J/m (0.9 ft-lbf/in)
(unnotched, 0.25 in)	400 J/m (8.0 ft-lbf/in)	530 J/m (10.0 ft-lbf/in)

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3.3 Form. The form of the PEEK 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 Flammability and burning.

3.4.1 Oxygen index. The oxygen index for all types of PEEK thermoplastic shall be 35% minimum (see 4.3). The thickness of the test specimen shall be 3.2 mm.

3.4.2 Specific optical density. The maximum specific optical density, D_{\max} , in the flaming mode for all types of PEEK thermoplastic shall be 25 (see 4.3 and 6.3). The D_{\max} in the nonflaming mode shall be 5. Samples for smoke emission tests in accordance with ASTM F 814 (see table V) shall be slabs 0.125 in thick x 3 in x 3 in (3.1 mm thick x 76.2 mm x 76.2 mm).

3.5 Electrical properties. The electrical properties of the PEEK thermoplastic shall be as specified in table IV (see 4.3).

TABLE IV. Electrical properties of PEEK.

Property	Minimum Property Values		
	Type I (nonreinforced)	Type II (30% glass fiber)	Type III (30% carbon fiber)
Volume resistivity <u>1/</u>	10^{15} ohm-cm	10^{15} ohm-cm	1200 ohm-cm
Dielectric strength <u>2/</u>	400 volts/mil (15.8 MV/m)	450 volts/mil (17.7 MV/m)	----

1/ Volume resistivity in ohm-m has a value of 1/100 of the value in ohm-cm.

2/ The thickness of the test specimen shall be 0.125 in (3.1 mm).

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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

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

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4.2.1 Preproduction tests. Unless otherwise specified (see 6.2), preproduction tests shall consist of tests for the following properties:

- a. Flexural modulus
- b. Heat deflection temperature
- c. Water absorption
- d. Impact strength
- e. Oxygen index
- f. Specific optical density
- g. Volume resistivity
- h. Dielectric strength

The supplier shall furnish to the procuring activity (in lieu of continuous lot-to-lot testing) a certificate of compliance, which certifies that the requirements for the properties listed in (a) through (h) above have been met (see 3.2 through 3.5).

4.2.2. Quality conformance tests. Unless otherwise specified (see 6.2), quality conformance tests shall consist of tests for the following properties:

- a. Melting point
- b. Specific gravity
- c. Tensile strength
- d. Elongation at break
- e. Fiber content

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 PEEK thermoplastic materials specified in 3.2 through 3.5 shall be determined in accordance with the applicable test method in table V.

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TABLE V. Test methods.

Property	Test Method
Melting point	ASTM D3418
Glass transition temperature	ASTM D3418
Specific gravity	ASTM D792
Tensile strength	ASTM D638
Elongation at break	ASTM D638
Flexural modulus	ASTM D790
Heat deflection temperature	ASTM D648
Water absorption	ASTM D570
Fiber content (types II and III only)	ASTM D3171
Izod impact strength	ASTM D256
Oxygen index	ASTM D2863
Specific optical density	ASTM F814
Volume resistivity	ASTM D257
Dielectric strength	ASTM D149

5. PACKAGING

5.1 Preservation. Preservation 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 ASTM D3951.

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 ASTM D3951 applies for industrial packaging only.

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6. NOTES

6.1 Intended use. Polyetheretherketone (PEEK) thermoplastic materials are intended for use as a matrix for glass fiber and carbon-graphite composites, for injection molded parts and monofilament, and as insulation for electrical wire and cable. The material has very low flammability, low smoke and toxic gas emission, and resistance to gamma radiation.

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. Quality conformance tests, if other than specified in 4.2.2.
- f. Sampling plan, if other than specified in 4.2.2.2.
- g. Level of packing required (see 5.1).

6.3 Specific optical density. The maximum specific optical density, D_{\max} , represents total smoke accumulation.

6.4 Gamma radiation resistance. Polyetheretherketone is extremely resistant to embrittlement by gamma radiation. Wire samples, coated with various grades (molecular weights) of PEEK polymer to a total diameter of 1.5 mm, have been exposed to gamma radiation from ^{60}Co spent fuel cells. Samples were removed at 250 Mrad intervals until a maximum dose of 2000 Mrad had been absorbed. The samples were subjected to a wrap test around a 1D mandrel followed by a standard dielectric test (1.5 kV for 1 minute in water). In the range suggested for high performance wire covering (melt viscosity = 0.4 to 0.5 kNsm^{-2}), the dosage level of gamma radiation required to cause failure of the insulation is of the order of 1100 Mrad (11 MGy). Note: 1 rad = 0.01 gray.

6.5 Sources of supply. PEEK materials may be obtained from:

- a. ICI Americas
Concord Pike and New Murphy Road
Wilmington, DE 19897
- b. LNP Corporation
412 King Street
Malvern, PA 19355

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Custodians:

Army - MR
Air Force - 11

Preparing activity:

Army - MR

Project 9330-0978

Review activities:

Army - GL, MD, ME, AT, AV
Air Force - 15

User activities:

Army - MI
Navy - SH