

MIL-P-46129A(MR)
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SUPERSEDING
MIL-P-46129(MR)
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MILITARY SPECIFICATION

PLASTIC MOLDING AND EXTRUSION MATERIAL, POLYPHENYLENE OXIDE, MODIFIED

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

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers the requirements of modified polyphenylene oxide materials for use in moldings and extrusions (see 6.1).

1.2 Classification. The modified polyphenylene oxide material shall be of one type and of the following classes, as specified (see 6.2).

Class 1 - General purpose
Class 2 - Lowest flammability

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

PPP-D-723 - Drums, Fiber.
PPP-D-729 - Drums, Shipping and Storage, Steel, 55-Gallon.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-129 - Marking for Shipment and Storage.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

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American Society for Testing and Materials (ASTM) Standards:

- D 149 - Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies.
- D 150 - A-C-Loss Characteristics and Dielectric Constant (Permittivity) of Solid Electrical Insulating Materials.
- D 256 - Impact Resistance of Plastics and Electrical Insulating Materials.
- D 570 - Water Absorption of Plastics.
- D 618 - Conditioning Plastics and Electrical Insulating Materials for Testing.
- D 635 - Flammability of Rigid Plastics over 0.127 cm (0.050 inch) in Thickness.
- D 638 - Tensile Properties of Plastics.
- D 648 - Deflection Temperature of Plastics Under Load.
- D 792 - Specific Gravity and Density of Plastics by Displacement.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

Underwriters' Laboratories, Inc.:

- UL 94 - Test for Flammability of Plastic Materials, dated December 1973.

(Copies may be purchased directly from Underwriters' Laboratories, Inc., 207 E. Ohio Street, Chicago, Illinois 60611.)

National Motor Freight Traffic Association, Inc., Agent:

National Motor Freight Classification.

(Application for copies should be addressed to the American Trucking Associations Inc., Tariff Order Section, 1616 P Street, N.W., Washington, D.C. 20036.

Uniform Classification Committee, Agent:

Uniform Freight Classification.

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, Illinois 60606.)

3. REQUIREMENTS

3.1 Material. The material shall consist of modified polyphenylene oxide resin formulated for use in injection molding and extrusion.

3.2 Property values. Specimens prepared from the material, as specified in 4.3.1, shall conform to the property values specified in table I, when tested as specified in the applicable procedure of 4.3. When specified by the procuring activity (see 6.2), the electrical properties specified in table II shall be included as requirements.

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Table I. Property values

Property	Value	
	<u>Class 1</u>	<u>Class 2</u>
Specific gravity, minimum (min.)	1.05	1.05
Specific gravity, maximum (max.)	1.07	1.07
Melt viscosity, at a temperature of 282°C (540°F) and a shear rate of 1500 (seconds ⁻¹ , poises, min.	2000	2000
poises, max.	3000	3000
Deflection temperature under load, 1/4 inch thick, 264 psi., °C, min.	121	121
°F, min.	250	250
Impact strength, Izod, 1/4 inch thick, ft. lbs. per inch of notch, min.	1.3	1.3
Tensile yield stress, psi, min.	9000	9000
Ultimate elongation in tension, percent, min.	20	20
Water absorption, percent, max.	0.1	0.1
Flammability, max. by 4.3.9.1	Less than 4 inches ^{1/} NA ^{2/}	NA ^{2/}
by 4.3.9.2		94V-1 ^{3/}

^{1/} Burning extent of less than 4 inches by ASTM test specified in 4.3.9.1.^{2/} NA - not applicable.^{3/} 94V-1 by Underwriters' Laboratories test specified in 4.3.9.2.Table II - Electrical property values^{1/}

Property	Value	
	<u>Class 1</u>	<u>Class 2</u>
Dielectric constant at 1 megahertz max.	275	275
Dissipation factor at 1 megahertz max.	.003	.003
Dielectric strength, short time test on 1/8 inch thick specimen, volts per mil, min.	400	400

^{1/} Applicable only when specified by the procuring activity (see 6.2).

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3.3 Form. The material shall be furnished in the form of molding powder, granules or pellets, as specified (see 6.2). When a particular particle size is specified, the limits and method of testing shall be as specified by the procuring activity (see 6.2 and 6.3).

3.4 Color. The material shall be of the color and opacity specified. When close color limits are specified, color matching shall be performed on molded plaques of the thickness specified, in accordance with the method specified by the procuring activity (see 6.2).

3.5 Uniformity. The powder, granules or pellets shall be uniform in color within each container and from container to container. The form shall be uniform from container to container. The material shall be free from contamination as determined by visual examination.

3.6 Suitability (compatibility) for use with explosives. (Applicable only when specifically designated in the applicable contract, order, drawing or specification). When so specified, application shall be made to a Government laboratory or other Government approved laboratory designated by the procuring activity for determination or suitability of the material for use with a particular explosive or explosives (see 6.2 and 6.4).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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.

4.2 Sampling for inspection. Sampling for inspection shall be performed in accordance with the provisions set forth in MIL-STD-105, except where otherwise indicated. For purposes of sampling, an inspection lot for examination and tests shall consist of all material of the same class submitted for inspection at one time.

4.2.1 Inspection of materials and components. In accordance with 4.1 above, the supplier is responsible for insuring that materials and components used were manufactured, examined, and tested in accordance with the requirements of this specification and, to the extent specified, of all referenced subsidiary specifications and standards. In the event of conflict, this specification shall govern. A supplier's certificate of compliance with 3.1 shall be furnished.

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4.2.2 Inspection of material.

4.2.2.1 Examination of the material. Examination of the material shall be made in accordance with the classification of defects, inspection levels and acceptable quality levels (AQLs) set forth below. The lot size, for purpose of determining the sample size in accordance with MIL-STD-105, shall be expressed in units of 50 pounds for examination in 4.2.2.1.1, and in units of shipping containers for examination in 4.2.2.1.2.

4.2.2.1.1 Examination of the material for defects in appearance and workmanship. The sample unit for this examination specified in table III shall be approximately one pound.

Table III. Examination of the material for defects in appearance and workmanship

Examine	Defect
Appearance and workmanship	Form not as specified
	Color not as specified
	Form not uniform
	Color not uniform
	Not clean, presence of foreign material

4.2.2.1.2 Examination of the preparation for delivery requirements. An examination shall be made in accordance with table IV, to determine that packaging, 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 defects.

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Table IV. Examination of the preparation for delivery

<u>Examine</u>	<u>Defect</u>
Packing	Not level specified; not in accordance with contract requirements Any nonconforming component, component missing, damaged or otherwise defective affecting serviceability Inadequate application of components such as: incomplete closures of case liners; container flaps, loose or inadequate strappings, bulged or distorted containers
Quantity 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.

4.2.2.1.3 Inspection levels and acceptable quality levels (AQLs) for examinations. The inspection levels for determining the sample size and the acceptable quality level (AQL) expressed as defects per 100 units shall be as follows:

<u>Examination paragraph</u>	<u>Inspection level</u>	<u>AQL</u>
4.2.2.1.1	II	2.5
4.2.2.1.2	S-2	2.5

4.2.3 Classification of testing. All tests shall be classified as follows:

- (a) Lot acceptance tests (see 4.2.3.1).
- (b) Periodic lot check tests (see 4.2.3.2).
- (c) Electrical property tests (see 4.2.3.3).

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4.2.3.1 Lot acceptance tests. Lot acceptance tests shall be made on each lot of material and, in conjunction with the above examination, shall be the basis for acceptance or rejection of the lot except when periodic lot check tests are required. The lot acceptance tests shall consist of the tests shown in table V.

Table V. Lot acceptance tests

Test	Applicable to class	Test method paragraph
Specific gravity	1 & 2	4.3.3
Melt viscosity	1 & 2	4.3.4
Deflection temperature	1 & 2	4.3.5
Tensile yield stress	1 & 2	4.3.7
Elongation at break	1 & 2	4.3.7
Flammability	2 only	4.3.9.2 ^{1/}

^{1/} Unless otherwise specified (see 6.2)

4.2.3.2 Periodic lot check tests. Periodic lot check tests shall be made on the first lot of material furnished under this specification, and on any subsequent lot specified by the procuring agency (see 6.2). Periodic lot check tests shall consist of all the tests specified in table I. When periodic lot check tests are made, they shall be included in the basis for acceptance or rejection of the lot.

4.2.3.3 Electrical property tests. Electrical property tests shall be made on any lot specified by the procuring agency (see 6.2), and shall be included in the basis for acceptance or rejection of the lot.

4.2.4 Testing. The material shall be tested for the applicable characteristics listed in table I, in accordance with the test methods specified herein. The lot size for the purpose of determining the sample size for testing shall be expressed in units of 200 pounds of material. The sample unit shall consist of sufficient material to prepare all specimens required for testing. The inspection level shall be S-1 with an acceptance number of 0. The results for each test shall be the averaged results of the specimens, except for the impact strength determination (see 4.3.6).

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4.3 Test methods.

4.3.1 Preparation of specimens. Material in the form of pellets shall be used as such for the melt viscosity test. Material in the form of powder shall be injection molded into a massive form, such as tensile specimens, and then cut up into small pieces for use in the melt viscosity test. For all other tests, the material shall be injection molded into specimens as described in the individual test method using the technique of molding recommended by the supplier. In the absence of such instructions, the following procedure shall be used:

- (a) Dry material for 2 hours at $110^{\circ} \pm 2^{\circ}\text{C}$ ($230^{\circ} \pm 3.6^{\circ}\text{F}$).
- (b) Use a screw type injection molding machine under the following conditions:
 - (1) Melt temperature, 260 to 288°C (500 to 550°F)
 - (2) Mold temperature, 82 to 99°C (180 to 210°F)
 - (3) Cycle, seconds, minimum: 20
 - (4) Pressure: Sufficient to give 3 seconds or less injection time.

4.3.2 Conditioning. All specimens, except those for melt viscosity, water absorption and flammability, shall be conditioned in accordance with Procedure A of ASTM D618. The specimens for melt viscosity need only be sufficiently dry that moisture from them will not interfere with the test. When necessary, the drying procedure of 4.3.1 shall be used. The specimens for water absorption and flammability shall be dry-as-molded, except that half of the dry-as-molded specimens for use in 4.3.9.2 shall be subjected to the additional conditioning specified therein. (The "as received" referenced in 4.3.9.2 shall be interpreted as "dry-as-molded".)

4.3.3 Specific gravity. A minimum of 2 molded specimens of any convenient size shall be tested in accordance with method A-1 or A-2 of ASTM D 792.

4.3.4 Melt viscosity.

4.3.4.1 Apparatus. The apparatus shall be a piston plastometer consisting of a thermostatically controlled heated cylinder with an orifice at its lower end, a piston capable of being moved at a predetermined constant rate within the cylinder, and a means of determining the force required to move the piston (see 6.5). Its essential features shall be as follows:

- (a) The cylinder shall have sufficient mass and heat conductivity and shall be heated, insulated and controlled in such a manner that, when filled with molten plastic at equilibrium temperature, the average temperature as measured at a point just above the orifice and within 1/16 inch of the inside wall shall be $540^{\circ} \pm 0.5^{\circ}\text{F}$ and the variation of this temperature with time and with the position along the bore of the cylinder shall not exceed 1.0°F .

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(b) The nominal effective diameter "D" of the piston (one-half the sum of the actual piston diameter plus the inside diameter of the cylinder) shall be 0.375 (3/8) inch. The clearance between the piston and cylinder shall be large enough that the piston can slide without excessive friction but small enough to prevent molten plastic from extruding through the annular space (approximately 0.0007 inch).

(c) The orifice shall consist of a removable cylinder having a smooth straight bore with nominal dimensions of diameter "d" = 0.0500 (1/20) inch and length " ℓ " = 2.00 inches and shall have a 90 degree included entrance angle. The underside of the orifice shall be insulated to prevent excessive heat loss.

(d) Any significant departure of a dimension from its above-specified nominal value, either as originally made or as altered by corrosion, cleaning, or wear, shall be handled in the calculations. The diameter of the orifice is particularly critical since it enters into the formula as the third power. If the following tolerances are held, no correction for departures from the specified nominal dimensions need be made:

<u>Dimension</u>	<u>Tolerance, inches \pm</u>
ℓ	0.02000
D	0.00200
d	0.00035

(e) The rate of piston movement shall be controllable within ± 1.5 percent of the chosen speed and the force required to drive the piston at that rate shall be measurable with ± 1.5 percent of the value indicated.

4.3.4.2 Procedure: The test shall be performed as follows:

- (a) Check diameter and cleanliness of bore of orifice.
- (b) Establish temperature level in rheometer barrel and allow to equilibrate for a minimum of 20 minutes.
- (c) Calibrate the instrument.
- (d) Load the barrel of the rheometer with the sample, using sufficient material that a reliable load trace may be obtained but not filling so full that the piston will not be sufficiently supported at the start of the run. The filling shall be done in $2 \pm 1/2$ minutes.
- (e) Attach the plunger and hand guide it into the barrel. Pack the polymer until extrudate appears.
- (f) Allow $5 \pm 1/2$ minutes for the polymer to reach temperature equilibrium.
- (g) Start piston movement at speed corresponding to specified shear rate. Take load readings when the load equilibrates.

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(h) Repeat (b) through (g) with the orifice removed from the apparatus to determine the load required to overcome the friction between the piston and cylinder. The rheometer barrel must be clean and aligned properly. Subtract this load from that of the first (g).

(i) Convert load readings to poises or, if dimensions and piston speeds are correct, merely record the load.

(j) Report number of replicate tests run and the average value. Two readings checking each other within 2 percent, both being within the specification limits, shall be considered sufficient. Otherwise, at least 3 determinations shall be made.

(k) Report any abnormalities which may have occurred in any of the runs.

(l) Although not mandatory, it is recommended that several pounds of a given modified polyphenylene oxide material be set aside for use as a control. Running this sample from time to time will show up any abnormalities in the equipment or operating technique.

4.3.4.3 Calculations:

Symbols:

η_a = Apparent viscosity, poises = $\frac{\tau_w}{\dot{\gamma}_w}$

τ_w = Shear stress at wall of capillary, dynes/cm²

$\dot{\gamma}_w$ = Shear rate at wall of capillary, seconds⁻¹

Q = Volumetric flow rate, cu. in./second

r = Rate of motion of piston, inches/second

R = 60r = Rate of motion of piston, inches/minute

D = Effective diameter of piston, inches

d = Diameter of capillary, inches

l = Length of capillary, inches

Calculation of piston speed:

$$Q = \frac{\pi D^2 r}{4} = \frac{\pi D^2 R}{240}$$

$$V = \frac{32Q}{\pi d^3} = \frac{32D^2 R}{240d^3} = \frac{2D^2 R}{15d^3}$$

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$$R = \frac{15d^3 \dot{V}_w}{2D^2}$$

When $\dot{V}_w = 1500$, $d = 0.0500$ (1/20) and $D = 0.375$ (3/8),

$$R = \frac{(15)(1500)(64)}{(2)(9)(8000)} = 10.00 \text{ inches per minute.}$$

Therefore, with "d" and "D" having their nominal values, the cross head speed should be set at 10.00 inches per minute. Different values of "d" or "D" would require different cross head speeds.

Calculation of shear stress:

$$\tau_w = \frac{4}{\pi D^2} \frac{d}{4l} (F) (68,944), \quad \text{where}$$

F = Load on piston, pounds, and

68,944 = Constant for changing psi to dynes/cm².

When $l = 2.00$, $d = 1/20$ and $D = 3/8$,

$$\tau_w = \frac{(4)(64)(68,944)F}{(4)(20)(9)(2)\pi} = 3901.5F$$

Calculation of viscosity and of load limits:

When $\dot{V} = 1500$ and $\tau_w = 3901.5F$,

$$\eta_a = \frac{\tau_w}{\dot{V}} = \frac{3901.5F}{1500} = 2.601F, \text{ and}$$

When $\eta_a = 2000$, $F_{2000} = 770$ pounds, and

When $\eta_a = 3000$, $F_{3000} = 1150$ pounds

Therefore, when the dimensions of the apparatus and the piston speed all are at their specified nominal values, an average load on the cross head of the machine between the limits of 770 pounds and 1150 pounds would indicate that the melt viscosity of the material was between the specified limits of 2000 to 3000 poises.

The above calculations assume streamline flow, no slippage of the melt over the capillary wall, and no entrance or exit losses.

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4.3.5 Deflection temperature under load. A minimum of two 1/4-inch thick specimens shall be tested in accordance with Procedure A of ASTM D 648.

4.3.6 Impact strength. A minimum of 5 specimens, each 1/4-inch thick, shall be tested in accordance with method A of ASTM D 256. The median value, in foot pounds per inch of notch, shall be reported.

4.3.7 Tensile yield stress and elongation. Five specimens shall be tested for tensile yield strength and elongation at break in accordance with ASTM method D 638. The specimens shall be 1/8-inch thick and shall conform to the dimensions of Type I of Figure 1 of that method. Speed B shall be used. The yield strength is the stress at the first point at which the load vs extension curve becomes horizontal.

4.3.8 Water absorption. Three specimens shall be tested in accordance with ASTM D 570 using options 5(b) and 6(a), but without reconditioning (section 7).

4.3.9 Flammability.

4.3.9.1 ASTM D 635 (for class 1 material). A minimum of 10 specimens shall be tested in accordance with ASTM D 635. The specimens shall have nominal dimensions of 5 inches by 1/2 inch by 1/4 inch.

4.3.9.2 Underwriters' test (for class 2 material). Twelve specimens (6 of each of two different thicknesses, 3 of each thickness being subjected to one of two different conditioning procedures) shall be tested in accordance with the Underwriters' Laboratories UL 94 dated December 1973. All specimens shall meet the flammability requirement specified in table I.

4.3.10 Dielectric constant and dissipation factor. The dielectric constant and dissipation factor shall be determined on 5 specimens, each 4 inches in diameter and 1/8 inch thick, in accordance with ASTM D 150, using a frequency of one megacycle.

4.3.11 Dielectric strength. The dielectric strengths of 5 specimens, each 4 inches in diameter and 1/8 inch thick, shall be determined by the "short-time test" of ASTM D 149.

5. PREPARATION FOR DELIVERY

Application. The requirements of section 5 apply only to purchase by or direct shipment to the Government.

5.1 Packing. Packing shall be level A, B, or C 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:

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- (a) Fiber drums conforming to PPP-D-723, type II, grade A, or type III, grade A, in quantities of 200 pounds, maximum.
- (b) Metal drums conforming to PPP-D-729, type III or type IV, in quantities of 400 pounds, 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 0.004 inch thick polyethylene liner properly heat sealed.

5.1.2 Level B. 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 I, grade A in quantities of 200 pounds maximum.
- (b) Metal drums conforming to PPP-D-729, type III or type IV, in quantities of 400 pounds, 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 0.004 inch thick polyethylene liner properly heat sealed.

5.1.3 Level C. The material shall be packed in a manner to ensure carrier acceptance and safe delivery at destination at the lowest transportation rate for such supplies. Containers shall be in accordance with Uniform Freight Classification Rules or National Motor Freight Classification Rules, as applicable.

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

6. NOTES

6.1 Intended use. Material conforming to this specification is recommended for injection molding or extruding into items with good mechanical properties, good electrical properties in high humidity environments, self-extinguishing behavior, fungus resistance, hydrolytic stability, and good strength at elevated temperatures. This material has a maximum continuous use temperature of 100°C (212°F), at which temperature it retains more than half of its room temperature strength and stiffness. Exposure at temperatures up to its deflection temperature 121°C (250°F) are feasible for short times in air or for longer times in non-oxidizing environments. The material is resistant to most aqueous environments, but is swollen, dissolved, or stress cracked under some conditions in some chlorinated or aromatic organic environments. Specific end use testing is recommended to establish the effects of time, temperature, and environment on the molded item. Typical applications are: proximity fuse nose cones, flare housings, shells, connectors (requiring electrical properties), and surgical instruments (requiring strength and stiffness plus ability to resist repeated steam sterilizations). Class 2 material is recommended for handles of electrical power tools and similar applications requiring extremely low flammability.

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6.2 Ordering data. Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

- (a) Title, number, and date of this specification.
- (b) Class required (see 1.2).
- (c) Electrical property tests, if required (see 3.2 and table II).
- (d) Particle shape, size range and method of determining, if required (see 3.3 and 6.3).
- (e) Color and opacity required, and method determination if required (see 3.4 and 6.3).
- (f) Periodic lot check tests, when required (see 4.2.3.2).
- (g) Resistance to explosives, if required (see 3.6 and 6.4).
- (h) Level of packing required (see 5.1).
- (i) Special marking, if required (see 5.2).

6.3 Determination of form. When a particular form, particle size or color is required, a standard sample, accompanied by borderline standards or by a written statement defining the permissible tolerances and methods of determination, may be furnished by the procuring activity or furnished by the supplier and approved by the procuring activity. In the case of color, one standard may be required for use in judging the uniformity of the color of the powder or pellets under 3.4 while another standard may be required for judging the color of a plaque molded from the material.

6.4 Suitability for use with explosives. Information concerning the suitability of many plastics for use with various explosives and chemicals under various conditions is on file at Picatinny Arsenal, Dover, New Jersey. Procuring activities desiring information on this subject should first contact Picatinny Arsenal to determine whether the information is already available.

6.5 Melt rheometer. One instrument which has been found suitable for determining the melt viscosity of the material is the Capillary Rheometer made by Instron Corporation, Canton, Massachusetts, for use with their 5000-pound (or larger) capacity universal testing machine.

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