SAE Aerospace
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# AEROSPACE MATERIAL SPECIFICATION

SAE AMS3658 REV. F

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Superseding AMS3658E

## Polytetrafluoroethylene (PTFE) Extrusions Premium Strength, Sintered and Stress-Relieved Radiographically Inspected

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

STABILIZED NOTICE

This document has been declared "Stabilized" by SAE AMS P, Polymeric Materials Committee, and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.





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## 1. SCOPE

### 1.1 Form

This specification covers virgin, unfilled polytetrafluoroethylene (PTFE) in the form of extruded rods, tubes, and profiles.

### 1.2 Application

These products have been used typically for parts such as insulators and bushings requiring chemical inertness and dimensional stability up to 500 °F (260 °C) and better mechanical and/or electrical properties than AMS3656, but usage is not limited to such applications.For applications such as seals, back-up rings, and bearings that do not require dielectric properties and radiographic inspection it is recommended to use AMS3678/1 Grade B.

### 1.3 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.

1.4 Types 1 and 2, which were defined in previous revisions of this specification, have been combined. for documentation which specifies Type 1 or Type 2 of this specification, all of the requirements of this specification now apply.

## 2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS3656 Polytetrafluoroethylene Extrusions, Normal Strength, As Sintered
AMS3678 Polytetrafluoroethylene (PTFE) Moldings and Extrusions, Unfilled, Pigmented and Filled Compounds

2.2 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 149 Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 4894 Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials

3. TECHNICAL REQUIREMENTS

3.1 Material

The product shall be extruded from PTFE powder conforming to ASTM D 4894 Type IV or Type V without admixture of fillers, pigments, or adulterants, and shall be sintered and stress-relieved.

3.1.1 Color

Shall be opaque white. Minor discolorations or contamination are acceptable provided they do not have a detrimental effect on the finished product.

3.2 Properties

Extrusions shall conform to requirements shown in Table 1, Table 2, Table 3, Table 4, and 3.2.5; tests shall be performed on the extrusions supplied and in accordance with specified test methods, insofar as practicable. Properties are applicable to both types except as specified in 3.2.4.

3.2.1 Tensile Strength at 73 °F ± 2 (23 °C ± 1)

Shall be as shown in Table 1, determined in accordance with 4.3.1.



TABLE 1 - MINIMUM TENSILE STRENGTH

| Form | Nominal Diameter or Distance Between Parallel Sides Inches (Millimeters) | Tensile Strength psi (MPa) |
|---|---|---|
| Rods, Profiles | Up to 0.500 (12.70), excl | 1800 (12.4) |
| Rods, Profiles | 0.500 to 1.500 (12.70 to 13.10), incl | 1900 (13.1) |
| Rods, Profiles | Over 1.500 (38.10) | 2000 (13.8) |
| Tubes | All sizes | 1800 (12.4) |

3.2.2 Elongation at 73 °F ± 2 (23 °C ± 1)

Shall be shown in Table 2, determined in accordance with 4.3.1.

TABLE 2 - MINIMUM ELONGATION

| Form | Nominal Diameter or Distance Between Parallel Sides Inches | Nominal Diameter or Distance Between Parallel Sides Millimeters | Elongation % |
|---|---|---|---|
| Rods, Profiles | Up to 0.500, excl | Up to 12.70, excl | 150 |
| Rods, Profiles | 0.500 to 1.500, incl | 12.70 to 38.10, incl | 175 |
| Rods, Profiles | Over 1.500 | Over 38.10 | 200 |
| Tubes | All sizes | All sizes | 150 |

3.2.3 Specific Gravity at 73 °F ± 5 (23 °C ± 3)

Shall be shown in Table 3, determined in accordance with ASTM D 792, Method A, with two drops of wetting agent added to the water.

TABLE 3 - SPECIFIC GRAVITY

| Form | Nominal Diameter or Distance Between Parallel Sides Inches | Nominal Diameter or Distance Between Parallel Sides Millimeters | Specific Gravity |
|---|---|---|---|
| Rods, Profiles | Up to 0.500, excl | Up to 12.70, excl | 2.14 - 2.19 |
| Rods, Profiles | 0.500 and over | 12.70 and over | 2.15 - 2.20 |
| Tubes | All sizes | All sizes | 2.14 - 2.19 |

3.2.4 Dielectric Strength, Short Time Test

Shall be as shown in Table 4, determined in accordance with 4.3.2; applicable only to Type 1 extrusions.

TABLE 4 - MINIMUM DIELECTRIC STRENGTH

| Form | Nominal Diameter or Distance Between Parallel Sides Inches (Millimeters) | Dielectric Strength Volts/mil (kV/mm) |
|---|---|---|
| Rods, Profiles | Up to 0.500 (12.70), excl | 700 (27.6) |
| Rods, Profiles | 0.500 to 1.500 (12.70 to 38.10), incl | 750 (29.5) |
| Rods, Profiles | Over 1.500 (38.10) | 800 (31.5) |
| Tubes | All sizes | 700 (27.6) |



3.2.5 Dimensional Stability

Rods and shapes up to 1.500 inches (38.10 mm), inclusive, in nominal diameter or distance between parallel sides and all tubes shall not change in length by more than 1.5% and in diameter or distance between parallel sides by more than 0.5%, determined as in 4.3.3. Dimensional stability of rods and shapes over 1.500 inches (38.10 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.3 Quality

Extrusions, as received by purchaser, shall be uniform in quality and condition, smooth, and free from foreign materials and from imperfections detrimental to usage of the extrusions.

3.3.1 Extrusions shall be radiographically inspected. Radiographic procedures and standards for acceptance shall be as agreed upon by purchaser and vendor.

3.4 Tolerances

Unless otherwise agreed between vendor and purchaser, dimensional tolerances of extrusions shown in Table 5, Table 6, and Table 7 apply at 73 to 86 °F (23 to 30 °C):

3.4.1 Rods and shapes shall be in accordance with Table 5:

TABLE 5 - DIAMETER TOLERANCES

| Nominal Diameter or Distance Between Parallel Sides Inches | Nominal Diameter or Distance Between Parallel Sides Millimeters | Tolerance Inch (Millimeter) plus only |
|---|---|---|
| Up to 0.250, incl | Up to 6.35, incl | 0.008 (0.20) |
| Over 0.250 to 0.500, incl | Over 6.35 to 12.70, incl | 0.016 (0.41) |
| Over 0.500 to 0.750, incl | Over 12.70 to 19.05, incl | 0.020 (0.51) |
| Over 0.750 to 1.000, incl | Over 19.05 to 25.40, incl | 0.024 (0.61) |
| Over 1.000 to 1.250, incl | Over 25.40 to 31.75, incl | 0.030 (0.76) |
| Over 1.250 to 1.500, incl | Over 31.75 to 38.10, incl | 0.038 (0.97) |
| Over 1.500 to 1.750, incl | Over 38.10 to 44.45, incl | 0.046 (1.17) |
| Over 1.750 to 2.000, incl | Over 44.45 to 50.80, incl | 0.052 (1.32) |
| Over 2.000 to 2.250, incl | Over 50.80 to 57.15, incl | 0.068 (1.73) |
| Over 2.250 to 2.500, incl | Over 57.15 to 63.50, incl | 0.076 (1.93) |

3.4.2 Tubes shall be in accordance with Tables 6 and 7:

TABLE 6 - DIAMETER TOLERANCES

| Nominal OD or ID Inches (Millimeters) | ID Tolerance Inch (Millimeter) minus only | OD Tolerance Inch (Millimeter) plus only |
|---|---|---|
| Over 0.187 (4.75) to 2.000 (50.80), incl | 0.062 (1.57) | 0.062 (1.57) |

TABLE 7 - MAXIMUM CONCENTRICITY TOLERANCES

| Nominal ID Inches | Nominal ID Millimeters | Variation from Concentricity Inch (Millimeter) (See 3.4.2.1) |
|---|---|---|
| Up to 0.500, incl | Up to 12.70, incl | 0.020 (0.51) |
| Over 0.500 to 1.000, incl | Over 12.70 to 25.40, incl | 0.031 (0.79) |
| Over 1.000 to 1.750, incl | Over 25.40 to 44.45, incl | 0.045 (1.14) |
| Over 1.750 to 2.500, incl | Over 44.45 to 63.50, incl | 0.062 (1.57) |

3.4.2.1 With a zeroed dial indicator on the OD of a tube segment mounted on a tight-fitting mandrel, rotate the tube about the centerline of the ID. Alternatively, with zeroed dial indicator on the ID of a tube, rotate the tube in a V-block. In either case, note the highest positive and negative dial indicator readings; the sum of these numerical values is the maximum variation from concentricity.

Example: Highest positive reading: 0.005 inch (0.13 mm)
Highest negative reading: 0.003 inch (0.08 mm)
Maximum variation from concentricity: 0.008 inch (0.20 mm)

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The manufacturer of extrusions shall supply all test coupons and shall be responsible for the performance of all required tests for each lot of extrusions. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the extrusions conform to the specified requirements. Manufacturer of machined parts shall furnish substantiating test data acquired by the manufacturer of extrusions. Purchaser of parts machined from extrusions also reserves the right to perform confirmatory testing provided the parts will yield test coupons that conform to the testing procedure(s) listed in 4.5.

### 4.2 Classification of Tests

#### 4.2.1 Acceptance Tests

All technical requirements are acceptance tests and shall be performed on each lot of extrusions (See 4.3.1).

### 4.3 Sampling and Testing

Shall be as follows

4.3.1 Sufficient test coupons shall be taken at random from each production extrusion lot to perform all required tests. Otherwise, test samples shall be machined from a sample test or other suitable extrusion from the same resin lot. The number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three.

4.3.2 A lot shall be all extrusions all the rods, tubes or profiles of the same configuration, made from the same batch of PTFE resin, in one continuous run and presented for manufacturer's inspection at one time. Where multiple shipments are made, lot traceability shall be maintained.

4.3.3 A statistical sampling plan, acceptable to purchaser, may be used in lieu of sampling as in 4.3.1 and the report of 4.6 shall state that such plan was used.

### 4.4 Approval

4.4.1 Test results from sample product shall be approved by purchaser before production extrusions are supplied, unless such approval is waived by purchaser. Results of the tests on samples from the production lot shall be essentially equivalent to those on the approved sample. Production product made by a revised procedure shall not be shipped prior to receipt of reapproval. If necessary to make any change in parameters for the process control factors, manufacturer shall submit for reapproval a statement of the proposed changes in ingredients and/or processing and, when requested, sample product or test coupons shall be provided.

4.4.2 Manufacturer of the product shall make no significant change in material, processes, or control factors from those on which the approval was based, unless the change is approved by the purchaser's engineering department. A significant change is one which, in the judgment of the purchaser's engineering department, could affect the properties or performance of the product.

### 4.5 Test Methods

Shall be as follows

#### 4.5.1 Tensile Strength and Elongation

Tensile strength and elongation shall be determined in accordance with ASTM D 4894 and the test specimens shall be prepared from either a sample extrusion as specified or from a production extrusion of sufficient size. Test specimens for rods, tubes and profiles, where size permits, shall conform to ASTM D 4894, Figure 11. For smaller sizes the test specimen for rod and for shapes shall conform to Figure 1 of this specification except that rods 0.250 inch (6.35 mm) and under in diameter may be tested in full cross-section. The initial jaw separation shall be 0.875 inch ± 0.005 (22.2 mm ± 0.13) and the speed of testing shall be 2 inches (50 mm) per minute. All results shall be reported.

4.5.2 The tensile strength coupon shall be pulled in the direction of molding (axial direction). The values shown for each type are the minimum values required.

4.5.3 Specific Gravity shall determined in accordance with ASTM D 792, Method A, with two drops of wetting agent added to the water.

4.5.4 Dielectric Strength

Shall be determined in accordance with ASTM D 149 on specimens 0.040 inch ± 0.001 (1.02 mm ± 0.03) thick. The test shall be conducted under oil using 0.062 inch (1.57 mm) diameter corrosion-resistant steel electrodes with rounded edges. If flash-over is a problem on small diameter rod or on shapes, specimens shall be prepared by drilling holes from opposite ends of a piece of product, leaving a web, 0.040 inch ± 0.001 (1.02 mm ± 0.03) thick, in the middle of the specimen. Electrodes shall be the same as used for the wafer specimen and shall be inserted in the holes in the specimen.

4.5.5 Dimensional Stability

Cut specimens from the product, each 1.500 inches ± 0.005 (38.10 mm ± 0.13) in length, and measure their length and their diameter or distance between parallel sides at mid-length to the nearest 0.001 inch (0.025 mm). Mark the points of original measurement so that measurements after heating and cooling can be made at the same points. Place the specimens in a heating chamber which is at ambient temperature and raise the temperature of the chamber to 554 °F ± 5 (290 °C ± 3) and hold at heat for 120 minutes ± 5. Lower the temperature at a rate not greater than 54 °F (30 °C) degrees per hour to ambient. Measure the length and diameter of the specimens to the nearest 0.001 inch (0.025 mm) at the same points as used for the original measurements. Calculate the changes in dimensions using Equation 1 and average the results for each dimension:

$$D = \frac{L_n - L_i}{L_i} \times 100\% \qquad \text{(Eq. 1)}$$

where:

D = dimensional change in %
$L_n$ = dimension of section after heating
$L_i$ = dimension of section before heating

4.6 Reports

The supplier of extrusions shall furnish with each shipment a report from the manufacturer showing the results of tests on each lot to determine conformance to tensile strength, elongation, specific gravity, and dielectric strength and stating that the extrusions conform to the other technical requirements. This report shall include the purchase order number, lot number, AMS3658F, and its applicable type or detail specification number, vendor's compound number, form and size or part number, and quantity.

4.7 Resampling and Retesting

If any specimen used in the above tests fails to meet the specified requirements, disposition of the extrusions may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the extrusions represented. Results of all tests shall be reported.