SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS3659D

Issued 1966-03
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Revised 2008-03

Superseding AMS3659C

(R) Polytetrafluoroethylene (PTFE) Extrusions Premium Strength, Sintered and Stress-Relieved

RATIONALE

AMS3659D results from a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

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

1.2 These products have been used typically for parts,such as seals, back-up rings, bearings, and insulators, requiring better chemical inertness and dimensional stability up to 500 °F (260 °C) than AMS3657 and better mechanical and electrical properties than AMS3656, but usage is not limited to such applications.

1.3 Classification

Extrusions are classified as follows:

Type 1 Parts, such as insulating bearings, bushings, and mounting posts requiring dielectric strength test (3.2.4). Testing of all other specified properties is required.

Type 2 Parts, such as seals, back-up rings, and bearings not requiring dielectric strength test (3.2.4).

1.3.1 Unless a specific type is ordered, Type 1 shall be supplied.

1.4 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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

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
AMS3657	Polytetrafluoroethylene Extrusions, Premium Strength, As Sintered

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 virgin PTFE powder in accordance with ASTM D 4894 Type IV or Type V without admixture of fillers, pigments, or adulterants, 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 production extrusions 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, tested 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 38.10), 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 as 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 ± 2 (23 °C ± 1)

Shall be as 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
Rods, Profiles	Up to 0.500 (12.70), excl	700 (27.6)
Rods, Profiless	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.

3.4 Tolerances

Unless otherwise agreed between purchaser and vendor, dimensional tolerances of moldings shall be as shown in Table 5, Table 6, and Table 7 and 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 plus only	Tolerance Millimeters 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 Table 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 to 2.000 (4.75 to 50.80), incl	0.062 (1.57)	0.062 (1.57)

TABLE 7 - MAXIMUM CONCENTRICITY TOLERANCES

Nominal ID Inches (Millimeters)	Variation from Concentricity Inch (Millimeters) (See 3.4.2.1)
Up to 0.500 (12.70), incl	0.020 (0.51)
Over 0.500 to 1.000 (12.70 to 25.40), incl	0.031 (0.79)
Over 1.000 to 1.750 (25.40 to 44.45), incl	0.045 (1.14)
Over 1.750 to 2.500 (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 be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any testing deemed necessary to ensure that the extrusions conform to AMS requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Each lot of product shall contorm to all technical requirements shall be performed prior to shipment of extrusions to a purchaser.

4.2.1.1 Sampling and Testing

Sufficient extrusions shall be taken at random from each 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.

4.2.1.2 A lot shall be all extrusions of the same configuration, made from the same batch of powder, In one production run. Where multiple shipments are made, lot traceability shall be maintained.

4.2.1.3 When a statistical sampling plan has been agreed upon by purchaser and vendor, sampling shall be in accordance with such plan and the report of 4.4 shall state that such plan was used.

4.3 Test Methods

4.3.1 Tensile Strength and Elongation

Where size permits, shall be determined in accordance with ASTM D 4894. Otherwise test specimens for rods, tubes and 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. All results shall be reported.

4.3.2 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.

4.3.3 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 midlength 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 approximately 73 °F (23 °C) 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 approximately 73 °F (23 °C). 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

4.4 Reports

The vendor of extrusions shall furnish with each shipment a report showing the results of tests on each lot, as applicable to the specified type, 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, AMS3659D, type, vendor's compound number, form and size or part number, and quantity.

4.5 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.

5. PREPARATION FOR DELIVERY

5.1 Packaging and Identification

5.1.1 Packaging shall be accomplished to ensure that the extrusions, during shipment and storage, will not be permanently distorted and will be protected against damage from exposure to weather or any other normal hazard.

5.1.1.1 A lot of extrusions may be packaged in small quantities and delivered under the basic lot approval provided lot identification is maintained.

5.1.2 Each package shall be permanently and legibly marked with not less than the following information:

POLYTETRAFLUOROETHYLENE EXTRUSIONS
Premium Strength, Sintered and Stress-Relieved
AMS3659D
Type (1 or 2)_____
SIZE OR PART NUMBER _____
OT NUMBER _____
PURCHASE ORDER NUMBER _____
QUANTITY _____
MANUFACTURER'S IDENTIFICATION _____

5.1.3 Packages of extrusions shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the extrusions to ensure acceptance and safe delivery.

6. ACKNOWLEDGMENT

A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS

Extrusions not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.