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Specification

This Issue:

Date:

Replaces:

RT-1116

Issue 4

May 18, 2009

Issue 3

Thermofit DR-25 Tubing **Elastomeric, Fluid Resistant, Abrasion Resistant, Flexible, Heat-Shrinkable**

1. SCOPE

This specification covers the requirements for one type of highly flexible, electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 175°C (347°F).

2. APPLICABLE DOCUMENTS

This specification takes precedence over documents referenced herein. Unless otherwise specified, the latest issue of referenced documents applies. The following documents form a part of this specification to the extent specified herein.

2.1 GOVERNMENT-FURNISHED DOCUMENTS

Military

| | |
|----------------|---|
| MIL-PRF-5606 | Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance |
| MIL-DTL-5624 | Turbine Fuel, Aviation, Grades JP-4 and JP-5 |
| MIL-PRF-6083 | Hydraulic Fluid, Petroleum Base, for Preservation and Operation |
| SAE-AMS1424 | Anti-Icing and Deicing - Defrosting Fluid |
| MIL-PRF-23699F | Lubricating Oil, Aircraft Turbine Engines, Synthetic Base |
| MIL-PRF-46170D | Hydraulic Fluid, Rust Inhibited, Fire-Resistant, Synthetic Hydrocarbon Base |

Federal

| | |
|-----------|--|
| A-A-59133 | Cleaning Compound, High Pressure (Steam) Cleaner |
| A-A-52557 | Fuel Oil, Diesel |

2.2 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

| | |
|--------|--|
| D 257 | Standard Test Methods for D-C Resistance or Conductance of Insulating Materials |
| D 412 | Standard Test Methods for Rubber Properties in Tension |
| D 2240 | Standard Test Methods for Rubber Property - Durometer Hardness |
| D 2671 | Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use |
| G 21 | Standard Recommended Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi |

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103).

3. REQUIREMENTS

3.1 MATERIAL

The tubing shall be fabricated from a stabilized, flame resistant, modified elastomer and shall be radiation crosslinked. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

3.2 **COLOR**
The tubing shall be black.

3.3 **PROPERTIES**
The tubing shall meet all the requirements of Table 3.

4. **QUALITY ASSURANCE PROVISIONS**

4.1 **CLASSIFICATION OF TESTS**

4.1.1 Qualification Tests
Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and shall consist of all tests listed in this specification.

4.1.2 Acceptance Tests
Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall consist of the following: dimensions, longitudinal change, tensile strength, tensile stress, ultimate elongation, heat shock, hardness, flammability, and low temperature flexibility.

4.2 **SAMPLING INSTRUCTIONS**

4.2.1 Qualification Test Samples
Qualification test samples shall consist of 50 feet (15 m) of tubing of each size. Qualification of any size within each size range specified below will qualify all sizes in the same range.

| <u>Size Ranges</u> | |
|--------------------|-------------|
| 3/8 | through 3/4 |
| 1 | through 3 |

4.2.2 Acceptance Test Samples
Acceptance test samples shall consist of not less than 16 feet (5 m) of tubing selected at random from each lot. A lot shall consist of all tubing of the same size, from the same production run, and offered for inspection at the same time.

4.3 **TEST PROCEDURES**

Unless otherwise specified, tests shall be performed on specimens which have been fully recovered by conditioning for 10 minutes in a $200 \pm 2^{\circ}\text{C}$ ($392 \pm 4^{\circ}\text{F}$) oven. Prior to all testing, the test specimens (and measurement gauges, when applicable) shall be conditioned for 3 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) and 50 ± 5 percent relative humidity. All ovens shall be of the mechanical convection type in which air passes over the specimens at a velocity of 100 to 200 feet (30 to 60 m) per minute.

4.3.1 Dimensions and Longitudinal Change

Three 6-inch (150-mm) specimens of tubing, as supplied, shall be measured for length $\pm 1/32$ inch (± 1 mm) and inside diameter in accordance with ASTM D 2671, conditioned for 10 minutes in a $200 \pm 2^{\circ}\text{C}$ ($392 \pm 4^{\circ}\text{F}$) oven, cooled to $23 \pm 3^{\circ}\text{F}$ ($73 \pm 5^{\circ}\text{F}$) and then remeasured. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table 1 and the longitudinal change shall be in accordance with Table 3. Longitudinal change shall be calculated as follows:

$$C = \frac{L_1 - L_0}{L_0} \times 100$$

WHERE: C = Longitudinal Change (percent)
L₀ = Length Before Conditioning [inches (mm)]
L₁ = Length After Conditioning [inches (mm)]

4.3.2 Tensile Strength, Tensile Stress, and Ultimate Elongation

Three specimens of tubing shall be tested for tensile strength, tensile stress, and ultimate elongation in accordance with ASTM D 2671. For tubing size 3/8, the specimens shall be full sections of tubing. For sizes 1/2 and larger, the specimens shall be cut with Die D of ASTM D 412. The specimens shall have 1-inch (25-*mm*) bench marks, centrally located. The testing machine shall have an initial jaw separation of 1 inch (25-*mm*) for full sections of tubing and 2 inches (50 *mm*) for die cut specimens. The rate of jaw separation shall be 20 ± 2 inches (500 \pm 50 *mm*) per minute.

4.3.3 Low Temperature Flexibility

Three specimens, each 12 inches (300 *mm*) in length, and a mandrel selected in accordance with Table 2, shall be conditioned at $-55 \pm 3^{\circ}\text{C}$ ($-67 \pm 5^{\circ}\text{F}$) for 4 hours. For tubing sizes 3/4 or less, the specimens shall be whole sections of tubing recovered on a stranded wire (nearest AWG which is larger than the sleeving maximum inside diameter after unrestricted shrinkage). For tubing sizes larger than 3/4, the specimens shall be 1/4-inch (6.3-*mm*) wide strips cut from tubing which has been recovered in accordance with 4.3. After 4 hours conditioning, and while still at the conditioning temperature, the specimens shall be wrapped around the mandrel for not less than 360° in 10 ± 2 seconds. The specimens then shall be visually examined for evidence of cracking.

4.3.4 Heat Shock

Three 6-inch (150-*mm*) specimens of tubing shall be conditioned for 4 hours in a $225 \pm 3^{\circ}\text{C}$ ($437 \pm 5^{\circ}\text{F}$) oven. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and visually examined for evidence of dripping, flowing, or cracking.

4.3.5 Heat Resistance

Three specimens of tubing prepared and measured in accordance with 4.3.2, shall be conditioned for 168 hours in a $150 \pm 2^{\circ}\text{C}$ ($302 \pm 4^{\circ}\text{F}$) oven. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and tested for tensile strength and ultimate elongation in accordance with 4.3.2.

4.3.6 Copper Stability

Three 6-inch (150-*mm*) specimens of tubing shall be slid over snug- fitting, straight, clean, bare copper mandrels, either solid or tubular. The specimens on the mandrels shall be conditioned for 24 hours in a desiccator or similar humidity chamber at 90 to 95 percent relative humidity and $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$). The specimens on the mandrels then shall be conditioned for 168 hours in a $50 \pm 2^{\circ}\text{C}$ ($302 \pm 4^{\circ}\text{F}$) oven. After conditioning, the specimens shall be removed from the oven and cooled to $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$). The copper mandrels shall then be removed from the tubing and the tubing and copper mandrels shall be examined. Darkening of the copper due to normal air oxidation shall not be cause for rejection. The tubing shall be tested for ultimate elongation in accordance with 4.3.2.

4.3.7 Corrosive Effect

The tubing shall be tested for copper mirror corrosion in accordance with ASTM D 2671, Procedure A. The specimens shall be conditioned for 16 hours at $135 \pm 3^{\circ}\text{C}$ ($275 \pm 5^{\circ}\text{F}$).

4.3.8 Fluid Resistance

Six specimens, three 6-inch (*150-mm*) tubing specimens, which shall be weighed prior to immersion, and three tensile specimens prepared and measured in accordance with 4.3.2, shall be immersed for 24 hours in each of the test fluids listed in Table 3 at the temperature specified. The volume of the fluid shall not be less than 20 times that of the specimens. After conditioning, all the specimens shall be lightly wiped and air dried for 30 to 60 minutes at $23 \pm 3^{\circ}\text{C}$ ($73 \pm ^{\circ}\text{F}$). The three specimens intended for the tensile strength and elongation tests shall then be tested in accordance with 4.3.2. The other three specimens shall be weighed before and after immersion and the weight change calculated as a percentage.

4.4 **REJECTION AND RETEST**

Failure of any sample of tubing to comply with any one of the requirements of this specification shall be cause for rejection of the lot represented. Tubing which has been rejected may be replaced or reworked to correct the defect and then submitted for acceptance. Before resubmitting, full particulars concerning the rejection and the action taken to correct the defect shall be furnished to the inspector.

5. **PREPARATION FOR DELIVERY****5.1** **FORM**

Unless otherwise specified, the tubing shall be supplied on spools.

5.2 **PACKAGING**

Packaging shall be in accordance with good commercial practice. The shipping container shall be not less than 125 pound-test fiberboard.

5.3 **MARKING**

Each container of tubing shall be permanently and legibly marked with the size, quantity, manufacturer's identification, and lot number.

TABLE 1

TUBING DIMENSIONS

| Size | As Supplied | | As Recovered | | | | | | | |
|-------|-----------------|-------|-----------------|-------|----------------|------|---------|------|---------|------|
| | Inside Diameter | | Inside Diameter | | Wall Thickness | | | | | |
| | Minimum | | Maximum | | Minimum | | Maximum | | Nominal | |
| | in. | mm. | in. | mm. | in. | mm. | in. | mm. | in. | mm. |
| 3/8 | .375 | 9.50 | .187 | 4.75 | .032 | 0.81 | .048 | 1.21 | .040 | 1.02 |
| 1/2 | .500 | 12.70 | .250 | 6.35 | .040 | 1.02 | .056 | 1.42 | .048 | 1.21 |
| 3/4 | .750 | 19.05 | .375 | 9.50 | .046 | 1.16 | .068 | 1.72 | .057 | 1.45 |
| 1 | 1.000 | 25.40 | .500 | 12.70 | .059 | 1.49 | .081 | 2.05 | .070 | 1.78 |
| 1-1/2 | 1.500 | 38.10 | .750 | 19.05 | .079 | 2.00 | .111 | 2.81 | .095 | 2.41 |
| 2 | 2.000 | 50.80 | 1.000 | 25.40 | .094 | 2.38 | .126 | 3.20 | .110 | 2.79 |
| 3 | 3.000 | 76.20 | 1.500 | 38.10 | .105 | 2.66 | .145 | 3.68 | .125 | 3.18 |

**TABLE 2
MANDREL DIMENSIONS FOR BEND TESTING**

| Tubing Size | Mandrel Diameter | |
|-------------------|------------------|------|
| | in. | mm. |
| 3/8 through 1/2 | 3/8 | 9.5 |
| 3/4 through 1-1/2 | 5/8 | 15.9 |
| 2 through 3 | 7/8 | 22.2 |

**TABLE 3
REQUIREMENTS**

| PROPERTY | UNIT | REQUIREMENT | TEST METHOD |
|--|-------------------------------|---|------------------------------|
| PHYSICAL | | | |
| Dimensions | Inches (<i>mm</i>) | In accordance with Table 1 | Section 4.3.1 |
| Longitudinal Change | Percent | +1, -10 | ASTM D 2671 |
| Tensile Strength | psi (<i>MPa</i>) | 2000 minimum (<i>13.8</i>) | Section 4.3.2 ASTM D 2671 |
| Tensile Stress at 100 percent elongation | psi (<i>MPa</i>) | 1200 maximum (<i>8.3</i>) | |
| Ultimate Elongation | Percent | 300 minimum | |
| Specific Gravity | --- | 1.55 maximum | ASTM D 2671 |
| Hardness | Shore A | 80 ± 10 | ASTM D 2240 |
| Low Temperature Flexibility 4 hours at -55°C (<i>-67°F</i>) | --- | No cracking | Section 4.3.3 |
| Heat Shock 4 hours at 225°C (<i>347°F</i>) | | No dripping, flowing, or cracking | Section 4.3.4 |
| Heat Resistance 168 hours at 150°C (<i>302°F</i>) Followed by tests for: | --- | --- | Section 4.3.5 |
| Tensile Strength | psi (<i>MPa</i>) | 1500 minimum (<i>10.3</i>) | Section 4.3.2 |
| Ultimate Elongation | Percent | 300 minimum | |
| Copper Stability 168 hours at 150°C (<i>302°F</i>) Followed by test for; | | No brittleness, glazing or cracking of tubing; no pitting or blackening of copper | Section 4.3.6 |
| Ultimate Elongation | Percent | 200 minimum | Section 4.3.2 |
| ELECTRICAL | | | |
| Dielectric Strength | Volts/mil (<i>kV/mm</i>) | 300 minimum (<i>11.8</i>) | ASTM D 2671 |
| Volume Resistivity | ohm-cm | 10 ⁹ minimum | ASTM D 257 |

TABLE 3
REQUIREMENTS
(continued)

| PROPERTY | UNIT | REQUIREMENT | TEST METHOD |
|--|-----------|---------------------|------------------------------|
| CHEMICAL Corrosive Effect 16 hours at 135°C (275°F) | --- | Noncorrosive | Section 4.3.7 ASTM D 2671 |
| Flammability Average time of burning | Seconds | 15 maximum | ASTM D 2671 Procedure A |
| Fungus Resistance | --- | Rating of 1 or less | ASTM G 21 |
| Fluid Resistance 24 hours at 23°C (73°F) JP-4 Fuel (MIL-DTL-5624) Hydraulic Fluid (MIL-PRF-5606) Anti-Icing Fluid (SAE-AMS1424) Lubricating Oil (MIL-PRF-23699F) Cleaning Compound (A-A-59133) Water Followed by tests for: | --- | --- | Section 4.3.8 |
| Tensile Strength | psi (MPa) | 1500 minimum (10.3) | Section 4.3.2 |
| Ultimate Elongation | Percent | 300 minimum | Section 4.3.2 |
| Weight Increase | Percent | 15 maximum | Section 4.3.8 |
| Fluid Resistance 24 hours at 50°C (122°F) DF-2 (A-A-52557) JP-4 Fuel (MIL-DTL-5624) Followed by tests for: | --- | --- | |
| Tensile Strength | psi (MPa) | 1500 minimum (10.3) | Section 4.3.2 |
| Ultimate Elongation | Percent | 300 minimum | Section 4.3.2 |
| Weight Increase | Percent | 20 maximum | Section 4.3.8 |
| Fluid Resistance 24 hours at 71°C (160°F) Hydraulic Fluid (MIL-PRF-6083) Hydraulic Fluid (MIL-PRF-46170D) Followed by tests for: | --- | --- | Section 4.3.8 |
| Tensile Strength | psi (MPa) | 1500 minimum (10.3) | Section 4.3.2 |
| Ultimate Elongation | Percent | 300 minimum | Section 4.3.2 |
| Weight Increase | Percent | 15 maximum | Section 4.3.8 |