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Specification

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Revision A

**VERSAFIT® TUBING**  
**Polyolefin, Flexible, Heat-Shrinkable, Flame Retardant**

**1. SCOPE**

This specification covers the requirements for one type of flexible electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 90°C (194°F). This tubing meets the requirements of SAE-AMS-DTL-23053/5 with a continuous operating temperature range of -55° C to +135° C. Versafit is free of polybrominated biphenyls (PBB) and polybrominated biphenyl oxides (PBBO). Versafit is also a 125°C, VW-1 rated, UL recognized tubing meeting the requirements of UL 224 as well as meeting the requirements of Standard C22.2 No. 198.1 and is CSA certified.

**2. APPLICABLE DOCUMENTS**

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

**2.1 UNDERWRITERS LABORATORIES, INCORPORATED**

UL Subject 224 Extruded Insulating Tubing

(Copies of UL publication may be obtained from Underwriters Laboratories, Inc., 1285 Walt Whitman Road, Melville, Long Island, New York 11746.)

**2.2 CANADIAN STANDARDS ASSOCIATION**

C22.2 No. 198.1 Extruded Insulating Tubing

(Copies of CSA publications may be obtained from Canadian Standards Association, 1897 Rexdale Boulevard, Rexdale, Ontario, Canada M9W 1R3.)

**2.3 OTHER PUBLICATIONS**

ISO 846 Plastics-Evaluation of the action of microorganisms.

American Society for Testing and Materials (ASTM)

ASTM D 2671 Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use

(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 thermally stabilized, flame-retardant, modified polyolefin and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

#### 3.2 PROPERTIES

The tubing shall meet the requirements of Table 2.

#### 3.3 COLOR

The tubing shall be available in black, white, red, yellow, blue, green, brown, orange, violet and gray.

### 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  
Ultimate Elongation

Statistical process control data may be used to demonstrate conformance for dimensions.

#### 4.2 SAMPLING INSTRUCTIONS

##### 4.2.1 Qualification Test Samples

Qualification test samples shall consist of 15mm (50 feet) of tubing of the size and color specified. Qualification of one size or color shall qualify all sizes and colors.

##### 4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of not less than 5 m (16 feet) 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 in accordance with 4.3.1. Prior to all testing, the test specimen (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  $50 \pm 5$  percent relative humidity. All ovens shall be of the mechanical convection type in which air passes the specimens at a velocity of 30 - 60 m (100 to 200 feet) per minute.

#### 4.3.1 Dimensions and Longitudinal Change

Three 150-mm (6-inch) specimens of tubing, as supplied, shall be measured for length, to an accuracy of  $\pm 1$  mm ( $\pm 1/32$  inch), and inside diameter in accordance with ASTM D 2671. The specimens then shall be conditioned for 3 minutes in a  $200 \pm 3^{\circ}\text{C}$  ( $392 \pm 5^{\circ}\text{F}$ ) oven, removed from the oven, cooled to  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ), re-measured for length, inside diameter, and wall thickness in accordance with ASTM D 2671. The longitudinal change shall be calculated as follows:

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

Where: C = Longitudinal Change (percent)  
L<sub>0</sub> = Length Before Conditioning [mm (inches)]  
L<sub>1</sub> = Length After Conditioning [mm (inches)]

#### 4.3.2 Tensile Strength and Ultimate Elongation

The tensile strength and ultimate elongation of the tubing shall be determined in accordance with ASTM D 2671 using 25-mm (1-inch) benchmarks and a 25-mm (1-inch) initial jaw separation. The speed of jaw separation shall be  $500 \pm 50$  mm ( $20 \pm 2$  inches) per minute.

#### 4.3.3 Secant Modulus

The secant modulus of the tubing shall be tested using tubing as supplied in accordance with ASTM D 2671.

#### 4.3.4 Copper Stability

Three 150-mm (6-inch) specimens of tubing shall be slipped over a snug fitting, straight, clean, bare copper conductor. For tubing sizes 1/4 and smaller a solid conductor shall be used; for tubing sizes 3/8 and larger a solid or tubular conductor shall be used. The specimens on the conductors shall be conditioned for 24 hours in a desiccator or similar humidity chamber at 90 to 95 percent relative humidity and  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ). Three specimens shall be conditioned for 7 days in  $158.0 \pm 1.0^{\circ}\text{C}$  ( $316.4 \pm 1.8^{\circ}\text{F}$ ) 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 conductor then shall be removed from the tubing, and the tubing and conductor shall then be examined. Darkening of the copper due to normal air oxidation shall not be cause for rejection. The tubing then shall be conditioned at room temperature for 16 to 96 hours and tested for ultimate elongation in accordance with 4.3.2.

#### 4.3.5 Dielectric Withstand, Breakdown, and Strength

The dielectric strength of the tubing shall be measured under oil in accordance with ASTM D 2671. Five 150-mm (6-inch) specimens of tubing shall be recovered over a metal mandrel by conditioning for 3 minutes in a  $200 \pm 3^{\circ}\text{C}$  ( $392 \pm 5^{\circ}\text{F}$ ) oven. The mandrel diameter shall be slightly larger than the fully recovered inside diameter of the tubing being tested. The metal mandrel shall serve as one electrode and a 25mm (1-inch) wide strip of lead foil wrapped around the outside of the tubing as the other electrode. The test voltage shall be applied at a rate of rise of 500 volts per second. Thickness measurements for calculating dielectric strength shall be made adjacent to the point of breakdown. Specimens for dielectric withstand shall be held for 60 seconds at 2500 volts.

#### 4.3.6 Corrosive Effect

Three specimens of tubing shall be tested for copper contact corrosion in accordance with ASTM D 2671, Procedure B. Three specimens shall be conditioned for 7 days in a  $158.0 \pm 1.0^{\circ}\text{C}$  ( $316.4 \pm 1.8^{\circ}\text{F}$ ) oven. After conditioning, the specimens shall be visually examined for evidence of corrosion.

#### 4.4 REJECTION AND RETEST

Failure of any samples of tubing to conform to 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 resubmitted 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

The tubing shall be supplied on spools, unless otherwise specified.

#### 5.2 PACKAGING

Packaging shall be in accordance with good commercial practice.

#### 5.3 MARKING

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

**TABLE 1**  
**Versafit**  
**TUBING DIMENSIONS,**  
**IMPERIAL**  
**(USA CUSTOMARY)**

| Size  | AS SUPPLIED     |            | RECOVERED       |       |                |      |         |      |         |      |
|-------|-----------------|------------|-----------------|-------|----------------|------|---------|------|---------|------|
|       | Inside Diameter |            | Inside Diameter |       | Wall Thickness |      |         |      |         |      |
|       | Maximum         |            | Maximum         |       | Minimum        |      | Maximum |      | Nominal |      |
|       | Mm              | in         | mm              | in    | mm             | in   | mm      | in   | mm      | in   |
| 3/64  | 1.63±.2         | .064±.008  | 0.58            | .023  | 0.32           | .013 | 0.48    | .019 | 0.40    | .016 |
| 1/16  | 1.85±.2         | .073±.007  | 0.79            | .031  | 0.35           | .014 | 0.51    | .020 | 0.43    | .017 |
| 3/32  | 2.79±.2         | .110±.007  | 1.17            | .046  | 0.43           | .017 | 0.59    | .023 | 0.51    | .020 |
| 1/8   | 3.43±.2         | .135±.007  | 1.57            | .062  | 0.43           | .017 | 0.59    | .023 | 0.51    | .020 |
| 3/16  | 5.21±.3         | .205±.010  | 2.36            | .093  | 0.43           | .017 | 0.59    | .023 | 0.51    | .020 |
| 1/4   | 7.11±.3         | .280±.010  | 3.17            | .125  | 0.56           | .022 | 0.72    | .028 | 0.64    | .025 |
| 3/8   | 10.16±.4        | .400±.015  | 4.74            | .187  | 0.56           | .022 | 0.72    | .028 | 0.64    | .025 |
| 1/2   | 13.72±.4        | .540±.015  | 6.35            | .250  | 0.56           | .022 | 0.72    | .028 | 0.64    | .025 |
| 5/8   | 16.90±.4        | .665±.015  | 8.0             | .315  | 0.68           | .027 | 0.84    | .033 | 0.76    | .030 |
| 3/4   | 20.45±.4        | .805±.015  | 9.52            | .375  | 0.68           | .027 | 0.84    | .033 | 0.76    | .030 |
| 1     | 26.80±.4        | 1.055±.015 | 12.70           | .500  | 0.76           | .030 | 1.01    | .040 | 0.88    | .035 |
| 1-1/4 | 33.40±.7        | 1.315±.025 | 15.88           | .625  | 0.86           | .034 | 1.17    | .046 | 1.01    | .040 |
| 1-1/2 | 39.88±.8        | 1.570±.030 | 19.05           | .750  | 0.86           | .034 | 1.17    | .046 | 1.01    | .040 |
| 2     | 52.83±1.0       | 2.080±.040 | 25.40           | 1.000 | 0.96           | .038 | 1.32    | .052 | 1.14    | .045 |
| 3     | 78.49±1.0       | 3.090±.040 | 38.10           | 1.500 | 1.17           | .046 | 1.47    | .058 | 1.32    | .052 |
| 4     | 104.14±1.3      | 4.100±     | 50.80           | 2.000 | 1.17           | .046 | 1.63    | .064 | 1.39    | .055 |

**Versafit 3X**

| Size | AS SUPPLIED     |      | RECOVERED       |     |                |      |         |      |         |      |
|------|-----------------|------|-----------------|-----|----------------|------|---------|------|---------|------|
|      | Inside Diameter |      | Inside Diameter |     | Wall Thickness |      |         |      |         |      |
|      | Minimum         |      | Maximum         |     | Minimum        |      | Maximum |      | Nominal |      |
|      | in.             | mm.  | in.             | mm. | in.            | mm.  | in.     | mm.  | in.     | mm.  |
| 1/8  | .125            | 3.2  | .042            | 1.1 | .020           | 0.50 | .026    | 0.66 | .023    | 0.58 |
| 1/4  | .250            | 6.4  | .083            | 2.2 | .020           | 0.50 | .026    | 0.66 | .023    | 0.58 |
| 3/8  | .375            | 9.5  | .125            | 3.2 | .021           | 0.53 | .027    | 0.69 | .024    | 0.61 |
| 1/2  | .500            | 12.7 | .166            | 4.3 | .021           | 0.53 | .027    | 0.69 | .024    | 0.61 |
| 3/4  | .750            | 19.1 | .250            | 6.4 | .021           | 0.53 | .027    | 0.69 | .024    | 0.61 |
| 1    | 1.000           | 25.4 | .333            | 8.5 | .022           | 0.56 | .028    | 0.72 | .025    | 0.64 |

**TABLE 2**  
**Requirements**

| PROPERTY                                                            | UNIT                 | REQUIREMENT                                                                                              | TEST METHOD                  |
|---------------------------------------------------------------------|----------------------|----------------------------------------------------------------------------------------------------------|------------------------------|
| <b>PHYSICAL</b>                                                     |                      |                                                                                                          |                              |
| Dimensions                                                          | mm(inches)           | In accordance with Table 1                                                                               | Section 4.3.1<br>ASTM D 2671 |
| Dimensional Recovery                                                |                      |                                                                                                          |                              |
| Longitudinal Change                                                 |                      |                                                                                                          | Section 4.3.1                |
| ASTM D 2671                                                         | Percent              | +1, -5                                                                                                   | ASTM D 2671                  |
| ASTMD 2671 (Over-expanded sizes)                                    | Percent              | +0, -15                                                                                                  | ASTMD 2671                   |
| UL 224                                                              | Percent              | +3, -3                                                                                                   | UL 224                       |
| Eccentricity (Recovered)                                            | Percent              | 30 maximum                                                                                               | ASTM D 2671                  |
| Tensile Strength                                                    | MPa (psi)            | 10.3 minimum (1500)                                                                                      | Section 4.3.2                |
| Ultimate Elongation                                                 | Percent              | 200 minimum                                                                                              | ASTM D 2671                  |
| Secant Modulus (expanded)                                           | MPa (psi)            | 172 maximum(2.5 x 10 <sup>4</sup> )                                                                      | Section 4.3.3<br>ASTM D 2671 |
| Low Temperature Flexibility<br>1 hour at -30°C (-22°F)              | --                   | No cracking                                                                                              | UL 224                       |
| Heat Shock<br>4 hours at 250°C (482°F)                              | --                   | No cracking                                                                                              | UL 224                       |
| Heat Aging<br>7 days at 158°C (316°F)<br>Followed by tests for:     | --                   | --                                                                                                       | UL 224                       |
| Tensile Strength                                                    | MPa (psi)            | 70% minimum of unaged specimens                                                                          | Section 4.3.2<br>UL 224      |
| Ultimate Elongation                                                 | Percent              | 100 minimum                                                                                              |                              |
| Flexibility                                                         | --                   | No cracking                                                                                              |                              |
| Dielectric Withstand at 2500 V                                      | Seconds              | 60 minimum                                                                                               | Section 4.3.5<br>ASTM D 2671 |
| Dielectric Breakdown                                                | Volts                | 50% minimum of unaged specimen                                                                           |                              |
| Dielectric Strength                                                 | kV/mm<br>(Volts/mil) | 19.7 minimum (500)                                                                                       |                              |
| Copper Stability<br>7 days at 158°C (316°F)<br>Followed by test for |                      | No brittleness, glazing, cracking or severe discoloration of tubing. No pitting or blackening of copper. | Section 4.3.4<br>ASTM D 2671 |
| Ultimate Elongation                                                 | Percent              | 100 minimum                                                                                              | Section 4.3.2                |
| Restricted Shrinkage                                                | --                   | Pass                                                                                                     | UL 224                       |
| <b>ELECTRICAL</b>                                                   |                      |                                                                                                          |                              |
| Dielectric Withstand at 2500 V                                      | Seconds              | 60 minimum                                                                                               | UL 224                       |
| Dielectric Strength                                                 | kV/mm<br>(Volts/mil) | 19.7 minimum (500)                                                                                       | Section 4.3.5                |
| Volume Resistivity                                                  | Ohm-cm               | 10 <sup>14</sup> minimum                                                                                 | ASTM D 2671                  |

**TABLE 2**  
**Requirements**  
**(continued)**

| PROPERTY                                               | UNIT                                     | REQUIREMENT                   | TEST METHOD                  |
|--------------------------------------------------------|------------------------------------------|-------------------------------|------------------------------|
| <b>CHEMICAL</b> (continued)                            |                                          |                               |                              |
| Corrosive Effect<br>7 days at 158°C (316°F)            | --                                       | No Corrosion                  | Section 4.3.6<br>ASTM D 2671 |
| Flammability                                           | --                                       | Pass                          | UL 224, VW-1                 |
| Water Absorption (Recovered)<br>24 hrs. at 23°C (73°F) | Percent                                  | 0.5 maximum                   | ASTM D 2671                  |
| Fungus Resistance                                      |                                          |                               | ISO 846<br>Method B          |
| Followed by tests for:                                 |                                          |                               |                              |
| Tensile Strength                                       | psi ( <i>Mpa</i> )                       | 1500 minimum ( <i>10.3</i> )  | Section 4.3.2                |
| Ultimate Elongation                                    | percent                                  | 200 minimum                   | ASTM D 2671                  |
| Dielectric Strength                                    | Volts per mil<br>( <i>volts per mm</i> ) | 500 minimum ( <i>19,700</i> ) | ASTM D 2671                  |