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Specification
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Thermofit® Zerohal™ Polyolefin Molded Components Halogen-Free, Flame Retarded, Semi-Flexible, Heat-Shrinkable

1. SCOPE

This specification covers the requirements for one type of semi-flexible electrical insulating molded component whose dimensions will reduce to a predetermined size upon the application of heat in excess of 121°C (250°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-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for

2.2 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

D 149	Standard Methods of Test for Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
D 257	Standard Methods of Test for D-C Resistance or Conductance of Insulating Materials
D 412	Standard Test Method for Rubber Properties in Tension
D 570	Standard Methods of Test for Water Absorption of Plastics
D 635	Standard Methods of Test for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
D 792	Standard Methods of Test for Specific Gravity and Density of Plastics by Displacement
D 882	Standard Test Methods for Tensile Properties of Thin Plastic Specimens
D 2671	Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use
D 2863	Standard Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
D 3487	Specification for Mineral Insulating Oil Used in Electrical Apparatus
E 662	Test Method for Specific Optical Density of Smoke Generated by Solid Materials

(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 molded components shall be fabricated from a crosslinked, halogen- free, thermally stabilized, flame-retarded, modified polyolefin composition. They shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

3.2 COLOR

The molded components shall be black, unless otherwise specified.

3.3 PROPERTIES

The molded components and the material from which they are fabricated shall meet the requirements of Table 1.

4. QUALITY ASSURANCE PROVISIONS

4.1 CLASSIFICATION OF TESTS

4.1.1 Qualification Tests

Qualification tests are those performed on molded slabs and components submitted for qualification as satisfactory products and shall consist of all tests listed in this specification.

4.1.2 Acceptance Tests

Acceptance tests are those performed on molded slabs and components submitted for acceptance under contract. Acceptance tests shall consist of the following: dimensions, dimensional recovery, tensile strength, ultimate elongation, secant modulus, specific gravity and dielectric strength.

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

Qualification test samples shall consist of molded slabs, $6 \times 6 \times 0.075 \pm 0.010$ inches ($152 \times 152 \times 1.9 \pm .25$ mm) and the number of molded components specified. The molded slabs shall be fabricated from the same lot of material and shall be subjected to the same degree of crosslinking as the molded components.

4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of specimens cut from a molded slab, $6 \times 6 \times 0.075 \pm 0.010$ inches ($152 \times 152 \times 1.9 \pm .25$ mm), and molded components selected at random. The molded slab shall be fabricated from the same lot of material and shall be subjected to the same degree of crosslinking as the molded components.

A lot of components shall consist of all molded components from the same lot of material, from the same production run, and offered for inspection at the same time.

4.3 TEST PROCEDURES

4.3.1 Dimensional Recovery

Samples of molded components, as supplied, shall be measured for dimensions in accordance with ASTM D 2671. The samples then shall be conditioned for 10 minutes in a $150 \pm 2^\circ\text{C}$ ($302 \pm 4^\circ\text{F}$) oven or equivalent, cooled to room temperature, and remeasured.

4.3.2 Tensile Strength and Ultimate Elongation

Three specimens cut from a molded slab using die D of ASTM D 412 shall be tested for tensile strength and ultimate elongation in accordance with ASTM D 412.

4.3.3 Secant Modulus

Five specimens, $6 \times 3/4 \times 0.075$ inches ($150 \times 19 \times 1.9$ mm) cut from a molded slab shall be tested for secant modulus at two percent strain in accordance with ASTM D 882. Use an initial jaw separation of 4 inches (100 mm) and a crosshead speed of 0.4 inches (10 mm) per minute.

4.3.4 Low Temperature Flexibility

Three 6 x 1/4 inch (152 x 6.3 mm) specimens cut from a slab shall be conditioned, along with a 3-inch (75-mm) mandrel, in a cold chamber at $-20 \pm 2^{\circ}\text{C}$ ($-4 \pm 4^{\circ}\text{F}$) for 4 hours. After completion of the conditioning, and while still in the cold chamber, each specimen shall be bent around the mandrel through not less than 360 degrees within 10 ± 2 seconds. The specimens then shall be visually examined for cracks.

4.3.5 Heat Shock

Three 6 x 1/4 inch (152 x 6.3 mm) specimens cut from a molded slab shall be conditioned for 4 hours in a $225 \pm 5^{\circ}\text{C}$ ($437 \pm 9^{\circ}\text{F}$) mechanical convection oven with an air velocity of 100 to 200 feet (30 to 60 m) per minute past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and then shall be visually examined for evidence of dripping, flowing, or cracking.

4.3.6 Heat Aging

Three specimens prepared and measured in accordance with 4.3.2, shall be conditioned for 168 hours in a $150 \pm 3^{\circ}\text{C}$ ($302 \pm 5^{\circ}\text{F}$) mechanical convection oven in which air passes the specimens at a velocity of 100 to 200 feet (30 to 60 m) per minute. 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.

4.3.7 Fluid Resistance

Three specimens prepared in accordance with 4.3.2, shall be completely immersed in each of the fluids listed in the applicable section of Table 1 for 24 hours at the specified temperature. The volume of the fluid shall be not less than 20 times that of the specimens. After conditioning, the specimens shall be lightly wiped and air dried for 30 to 60 minutes at room temperature. The specimens then shall be tested for tensile strength and ultimate elongation in accordance with 4.3.2.

4.3.8 Oxygen Index at Elevated Temperature

Determine the oxygen index using the apparatus described in ASTM D 2863 with the exception of a special double wall glass chimney replacing the standard chimney. This chimney must be equipped with a heating element and temperature controller capable of maintaining the temperature of the gas atmosphere in the chimney to $\pm 2^{\circ}\text{C}$ ($\pm 4^{\circ}\text{F}$).

With the gas supply regulated to 21% oxygen content, determine the temperature, within 10°C (18°F), at which the specimen will burn 3 minutes or 2 inches (50 mm), whichever occurs first, using the endpoint criteria of ASTM D 2863. Report this temperature as the oxygen index at elevated temperature.

4.4 **REJECTION AND RETEST**

Failure of any samples to comply with any one of the requirements of this specification shall be cause for rejection of the lot represented. Material 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** **PACKAGING**

If not specified, packaging of molded components shall be in accordance with good commercial practice. The exterior shipping container shall be not less than 125 pound-test fiberboard.

5.2 **MARKING**

Each molded component shall be distinctly identified on the part and/or package with the manufacturer's name or symbol, the manufacturer's part number, and lot number.

TABLE 1
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
PHYSICAL			
Dimensions	in (<i>mm</i>)	In accordance with applicable specification control drawing.	Sec. 4.3.1
Dimensional Recovery	in (<i>mm</i>)	In accordance with applicable specification control drawing.	
Tensile Strength, min.	psi (<i>MPa</i>)	1000 minimum (7)	Sec. 4.3.2
Ultimate Elongation, min.	Percent	250 minimum	ASTM D 412
Secant Modulus at 2% Strain	psi (<i>MPa</i>)	7250-17400 (50-120)	Sec. 4.3.3 ASTM D 882
Specific Gravity	---	1.5 maximum	ASTM D 792
Low Temperature Flexibility 4 hours at -20°C (-4°F)	---	No cracking	Sec. 4.3.4
Heat Shock 4 hours at 225°C (437°F)	---	No dripping, flowing or cracking	Sec. 4.3.5
Heat Aging 168 hr. at 150°C (302°F) Followed by tests for:	---	---	Sec. 4.3.6
Tensile Strength	psi (<i>MPa</i>)	1000 minimum (7)	
Ultimate Elongation	Percent	100 minimum	
ELECTRICAL			
Dielectric Strength	V/mil (<i>kV/mm</i>)	380 minimum (15)	ASTM D 149 Short time test
Volume Resistivity	ohm-cm	10 ¹² minimum	ASTM D 257
CHEMICAL			
Water Absorption 24 hours at 23°C (73°F) 24 hours at 70°C (158°F)	Percent	0.5 maximum 1.5 maximum	ASTM D 570
Limiting Oxygen Index	Percent	30 minimum	ASTM D 2863
Oxygen Index at Elevated Temperature	°C	250 minimum	Sec. 4.3.8
Flammability Average Time of Burning Average Extent of Burning	seconds in (<i>mm</i>)	100 maximum 1 maximum (25)	ASTM D 635
Smoke Density, Ds 4 minutes, flaming mode	---	60 maximum	ASTM E 662
Acid Gas Generation HCl Equivalent	Percent	1.5 maximum	MIL-C-24643

TABLE 1
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
CHEMICAL (continued)			
Fluid Resistance	---	---	Sec. 4.3.7
24 hours at 23°C (73°F)			
Hydraulic Fluid (MIL-H-5606)			
JP-4 Fuel (MIL-T-5624)			
*Skydrol 500			
Hydraulic Fluid			
ASTM Fuel B			
Water			
24 hours at 50°C (122°F)			
Lube Oil (MIL-L-23699)			
Insulating Oil (ASTM D 3487)			
24 hours at 100°C (212°F)			
ASTM #2 Oil			
Followed by tests for:			
Tensile Strength	psi (MPa)	725 minimum (5)	
Ultimate Elongation	Percent	150 minimum	

*TM Monsanto Co.