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## WEAPON SPECIFICATION

**TYPE**  
MATERIAL SPECIFICATION

**TITLE**  
TUBING, HEAT SHRINKABLE, POLYOLEFIN  
(4 TO 1 SHRINK RATIO)

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FSCM 53711

MATERIAL SPECIFICATION

TUBING, HEAT SHRINKABLE, POLYOLEFIN,  
(4 TO 1 SHRINK RATIO)

1. SCOPE

1.1 Scope. This specification establishes requirements for flexible, electrically insulating, 4 to 1 shrink ratio tubing, the diameter of which can be reduced to a predetermined size upon the application of heat.

2.0 APPLICABLE DOCUMENTS

2.1 Government documents. The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

O-A-51                      Acetone, Technical

Military

MIL-I-7444                 Insulation Sleeving, Electrical, Flexible

Department of the Navy

WS6788                     Hydraulic Fluid, Petroleum Base, Missile Use

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids shall apply.

American Society for Testing and Materials

ASTM D257	DC Resistance or Conductance of Insulating Materials
ASTM D412	Test Methods for Rubber Properties in Tension
ASTM D624	Tear Resistance of Vulcanized Rubber
ASTM D792	Specific Gravity and Density of Plastics by Displacement
ASTM D876	Testing Non-rigid Vinyl Chloride Polymer Tubing
ASTM D882	Tensile Properties of Thin Plastic Sheeting
ASTM D2671	Standard Test Methods for Heat – Shrinkable Tubing for Electrical Use

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA. 19103.)

ISO Specifications

ISO 846	Plastics – Evaluation of the action of microorganisms
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2.3 Order of precedence. In the event of a conflict between the text of this specification and the References cited herein, the text of this specification shall take precedence.

3.0 REQUIREMENTS

3.1 Qualification. The material furnished to the requirements of this specification shall be a product which has been tested and has passed the qualification tests specified herein. Any subsequent change in material or method of manufacture shall require re-qualification of the product.

3.2 Material. The material shall be an irradiated, thermally-stabilized, modified polyolefin composition, substantially of a polyethylene type. It shall be flexible in the as supplied (expanded) condition.

3.3 Configuration and dimensions.

3.3.1 Configuration. The configuration of the “as supplied” or expanded tubing and the tubing after application of heat, which is commonly referred to as the recovered condition, is depicted in Figure 1.

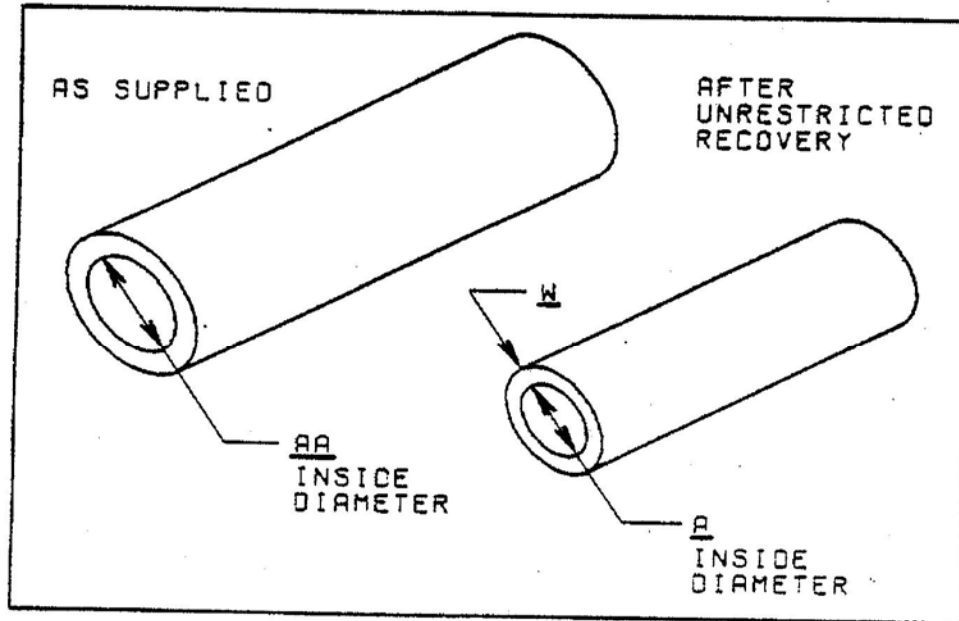


Figure 1. Tubing configuration

3.3.1.1 Inside diameter and wall thickness. The inside diameter (AA) of the expanded tubing as well as the inside diameter (A) and the wall thickness (W) of the recovered tubing with their applicable tolerances shall be in accordance with Table I.

TABLE I. Inside diameter and wall thickness of tubing  
(4 to 1 shrink ratio)

Size	EXPANDED (as supplied)		RECOVERED (after heating)	
	Inside Diameter Minimum (inches)	Inside Diameter Maximum (inches)	Inside Diameter Maximum (inches)	Wall Thickness (inches)
0.75	0.750	.180		$0.045 \pm 0.007$
1	1.000	.275		$0.052 \pm 0.014$
1.5	1.500	.375		$0.052 \pm 0.014$
2	2.000	.550		$0.052 \pm 0.014$
3	3.000	.810		$0.052 \pm 0.014$
4	4.000	1.050		$0.052 \pm 0.014$

3.3.2 Length. The tubing specified herein shall be supplied in standard lengths as shown in Table II or in continuous lengths wound on spools.

TABLE II. Tubing length

Size	Length (as supplied) (inches)
0.75, 1, 1.5, 2, 3, 4	$48 \pm 1$

3.4 Color. The color of the tubing shall be black, red or white as specified (See 6.2 and 4.6.3).

3.5 Physical and electrical properties. The physical and electrical properties of the material shall conform to the requirements in Table III and to paragraphs 3.6, 3.7, and 3.8.

TABLE III. Material properties

PROPERTY	UNITS	TUBING CONDITION	REQUIREMENT	TEST
<b><u>Physical</u></b>				
Longitudinal Change	percent	Recovered	+5 % to -10%*	4.6.2
Secant Modulus	psi	Recovered	$2.5 \times 10^4$ (max.)	4.6.4
Tensile Strength	psi	Recovered	1500 (min.)	4.6.5
Ultimate Elongation	percent	Recovered	200 (min.)	4.6.6
Tear Strength	lb/inch	Recovered	275 (min.)	4.6.7
Specific gravity	unitless	Either	1.03 – 1.35	4.6.8
<b><u>Electrical</u></b>				
Dielectric Strength	volts/mil	Recovered	250 (min.)	4.6.9
Volume resistivity	ohm-cm.	Recovered	$1 \times 10^{12}$ (min.)	4.6.10
<b><u>Fluid Resistance</u></b>				
Hydraulic Oil Resistance:				4.6.11
Tensile Strength	psi	Recovered	750 (min.)	
Dielectric Strength	volts/mil	Recovered	300 (min.)	
Water Absorption	percent	Recovered	0.5 (max.)	4.6.12
<b><u>Environmental</u></b>				
Heat aging at 302°F				4.6.13
Elongation after 168 hours.	percent	Recovered	100 (min.)	
Elongation after 336 hours.	percent	Recovered	100 (min.)	
Heat shock 4 hrs. @ $440 \pm 10^\circ\text{F}$ .	N/A	Recovered	No drip, flow or cracking	4.6.14

\* For size 0.75 in. expanded diameter only, -10% Max.

3.6 Corrosion. The tubing shall not cause pitting of metal test plates when prepared and tested in accordance with 4.6.15. Discoloration or tarnishing of the test plates shall not be cause for rejection.

3.7 Heat recoverability. The expanded tubing shall recover to within 10 percent of the value specified in Table I when tested in accordance with 4.6.16.

3.8 Workmanship. Tubing shall be uniform in quality and construction and shall be free of blisters, pin holes, seams, cracks, inclusions of foreign matter, and other defects affecting fabrication, appearance, or performance of parts.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all examinations and tests specified herein. Except as otherwise specified, the supplier may use his own or any other inspection facilities and services acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure that supplies conform to the prescribed requirements.

4.2 Classification of tests. The inspection and testing of tubing shall be classified as follows:

- a. Qualification tests: Tests performed on samples of material submitted for approval as qualified products.
- b. Acceptance tests: Tests performed on all individual lots of qualified products submitted for acceptance on contract bids.

4.2.1 Lot. A lot shall consist of all tubing of the same size, color and formulation, produced in a single plant run from a single lot of material.

4.3 Qualification tests. Qualification tests shall consist of all of the tests prescribed herein for all of the requirements of this specification.

4.3.1 Qualification sampling instructions. The qualification test sample shall consist of 10 feet of tubing of one size and color.

4.4 Acceptance tests. Acceptance tests shall consist of those specified in Table IV:

Table IV. Acceptance tests

REQUIREMENTS	TEST PARAGRAPH
Visual Examination	4.6.1
Dimensions	4.6.2
Longitudinal Change	4.6.2
Color, Expanded tubing	4.6.3
Tensile Strength	4.6.5
Ultimate Elongation	4.6.6
Specific Gravity	4.6.8
Dielectric Strength	4.6.9
Heat Shock	4.6.14

4.4.1 Acceptance sampling instructions. Samples for tests shall consist of not less than eight feet in total length of tubing selected at random from each lot.



4.5 Test conditions. Unless otherwise specified herein, tests shall be performed at standard laboratory conditions.

4.6 Test methods. Recovered specimens required by test methods shall be obtained by conditioning the specimens in an oven in accordance with 4.6.2.

4.6.1 Visual examination. All tubing shall be visually examined to assure conformance to this specification with respect to all requirements not covered by specific test methods.

4.6.2 Dimensions. The inside diameter of the as received expanded tubing (see figure 1) shall be determined using pin gauges and micrometers. The length of as received tubing shall be measured to an accuracy of  $\pm 1$  inch and shall conform to the requirements shown in Table II. Three specimen samples of tubing that are 5 inches long shall be measured to an accuracy of  $\pm 0.050$  inches. These measurements shall be recorded as original length. The samples shall then be suspended in an air circulating oven for a period of 3 minutes  $\pm 10$  seconds at a temperature of  $392 \pm 5^\circ\text{F}$ . Upon removal, the specimens shall be cooled to  $72 \pm 5^\circ\text{F}$ . The inside diameter, wall thickness and length shall all be measured. The inside diameter and wall thickness as measured with pin gauges and micrometers shall conform to the requirements shown in Table I for recovered tubing. The change in length calculated as a percentage of the original length shall comply with the longitudinal change requirement specified in Table III.

4.6.3 Color. All tubing shall be visually examined to assure conformance to 3.4 and to color specified on the purchase order.

4.6.4 Secant modulus. The secant modulus of the recovered tubing shall be tested in accordance with ASTM D882, Method A at two percent strain. The test specimens shall be full sections of tubing for inside diameters of 1/4-inch and smaller and longitudinally cut specimens for inside diameter of 3/8-inch and larger.

4.6.5 Tensile strength. The tensile strength of the recovered tubing shall be determined in accordance with ASTM D412 using a dumbbell-shaped specimen.

4.6.6 Ultimate elongation. The ultimate elongation of the recovered tubing shall be determined in accordance with ASTM D412 using the same specimen as described for tensile strength.

4.6.7 Tear resistance. The tear resistance of the recovered tubing shall be determined in accordance with ASTM D624 using die B.

4.6.8 Specific gravity. The specific gravity of the tubing shall be determined in accordance with ASTM D792, Method A-1 except that samples weighing two to three grams shall be used.

4.6.9 Dielectric strength. The dielectric strength of the recovered tubing shall be determined on three one-foot samples and tested in accordance with ASTM D876.

4.6.10 Volume resistivity. The volume resistivity of the recovered tubing shall be determined in accordance with ASTM D257.

4.6.11 Hydraulic fluid resistance. Three recovered tubing specimens, each approximately three inches long, shall be immersed in the hydraulic fluid shown in Table V for the time and temperature indicated. Upon removal, the test specimens shall be carefully wiped dry and allowed to remain at room temperature for one hour. At the end of this period, each specimen shall be subjected to the dielectric strength test and the tensile strength test of this specification. The test results shall comply with hydraulic oil resistance requirements specified in Table III.

TABLE V. Immersion Fluid

FLUID	SPECIFICATION	HOURS	TEMPERATURE (°F)
Hydraulic	WS 6788	20 (+1/2, -0)	68 to 77°F.

4.6.12 Water absorption. Three weighed, recovered tubing specimens, each approximately three inches long, shall be totally immersed vertically in distilled water, and maintained at a temperature of  $72 \pm 5^\circ\text{F}$  for at least 20 hours. At the end of the 20 hour immersion period, the specimens shall be removed from the water one at a time, all surface water wiped off with a dry cloth, and immediately reweighed. The percentage change in weight of each specimen, resulting from water absorption, shall be calculated.

4.6.13 Heat aging. Four recovered tubing specimens, each six inches in length, shall be suspended in an air-circulating oven at a temperature of  $302 \pm 5^\circ\text{F}$ . Two specimens shall be withdrawn after  $168 \pm 2$  hours, cooled to  $72 \pm 5^\circ\text{F}$ , and then tested for ultimate elongation. The remaining two specimens shall be heat aged for a total of 336 hours before removal from the oven, cooled to  $72 \pm 5^\circ\text{F}$  and then tested for ultimate elongation. The test results shall comply with heat aging requirements specified in Table III.

4.6.14 Heat shock. Two recovered tubing specimens, each at least six inches in length, shall be suspended in an air-circulating oven maintained at a temperature of  $440 \pm 10^\circ\text{F}$  for a period of four hours (+15 minutes, -0). After removal from the oven, cool to  $72 \pm 5^\circ\text{F}$  and visually inspect for dripping, flowing and/or cracking. The result of the visual inspection shall comply with requirements in Table III.

4.6.15 Corrosion. Two samples of slit, expanded tubing approximately one square inch in area shall be washed with acetone conforming to O-A-51 and allowed to air dry. The samples shall then be tested for corrosion in accordance with MIL-I-7444, with the following exceptions. The test plates, with tubing in place, shall be conditioned in an air gravity oven maintained at a temperature of  $302 \pm 5^\circ\text{F}$ , and a pressure of  $4 \pm 1/2$  pounds per square inch gage, for one hour prior to seven day exposure to the conditions stated in MIL-I-7444. The samples shall be maintained at the above pressure during exposure to high humidity. After the exposure period, the metal plates shall be visually examined for pitting. Discoloration or tarnishing of the metal shall not be cause for rejection.

4.6.16 Heat recoverability. A section of the expanded tubing shall be recovered by suspending the samples in an air circulating oven for a period of 3 minutes  $\pm 10$  seconds at a temperature of

250 ± 10°F. Upon removal, the samples shall be cooled to 72 ± 5°F. Measure the recovered inside diameter for conformance to 3.7 and Table I requirements.

## 5. PACKAGING

5.1 Packaging. The heat shrinkable tubing specified herein shall be packaged in standardized short lengths only. Sizes 0.75, 1, 1.5, 2, 3, and 4 shall be packaged in four foot lengths (see Table II). The lengths shall be placed in polyethylene bags which are laid flat in commercial cardboard boxes and then shipped to the using facility.

5.1.1 Length. The total length required, expressed in feet, shall be as specified on the purchase order. Unless otherwise specified, minimum lengths for spools shall be full spools. One short length may be supplied to fulfill total length requirements.

5.2 Marking. Each bundle or container of tubing shall be distinctly identified with a tag or label containing the following information:

- a. Tubing, Heat Shrinkable, Polyolefin (4 to 1 Shrink Ratio)
- b. Specification number and revision letter (if applicable)
- c. Manufacturer's name.
- d. Manufacturer's product lot number.
- e. Total length (see 5.1.1)
- f. Size (see Table I)
- g. Color (see 3.4)

## 6. NOTES

6.1 Intended use. The products covered in this specification are intended for use as heat shrinkable electrical insulation on wires, and the identification of cables and electrical connectors.

6.2 Ordering data. Procurement documents should specify:

- a. Title, number, and revision of this specification.
- b. Size required (see Table I)
- c. Color required (see 3.4 and 4.6.3)
- d. Total length of each size required (see 5.1 and 5.1.1)

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