

MIL-T-7081D (ASG)

2 NOVEMBER 1965

Superseding  
MIL-T-7081C (ASG)  
3 April 1959

## MILITARY SPECIFICATION

TUBE, ALUMINUM ALLOY, SEAMLESS, ROUND, DRAWN,  
6061, AIRCRAFT HYDRAULIC QUALITYThis specification has been approved by the Department  
of the Air Force and by the Bureau of Naval Weapons.

## 1. SCOPE

1.1 Scope.-- This specification covers 6061 aluminum alloy, round, drawn, seamless tube having outside diameters of 3/16 inch through 1-1/2 inches.1.2 Classification.-- Tubes shall be furnished in one of the following tempers, as specified (see 6.2):T4 (solution heat-treated)  
T6 (solution heat-treated and artificially aged)

## 2. APPLICABLE DOCUMENTS

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

SPECIFICATIONSMilitary

MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design, Installation and Data Requirements for
MIL-H-3088	Heat Treatment of Aluminum Alloys
MIL-H-25475	Hydraulic Systems, Missile, Design, Installation, Tests, and Data Requirements, General Requirements for

STANDARDSFederal

Fed. Test Method	Metals; Test Methods
Std. No. 151	
Federal Standard	Identification Marking of Aluminum, Magnesium
No. 184	and Titanium
Federal Standard	Tolerances for Aluminum Alloy and Magnesium Alloy
No. 245	Wrought Products

FSC 4710

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Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-649	Aluminum and Magnesium Products, Preparation for Shipment and Storage
MS33583	Tubing End, Double Flare, Standard Dimensions for
MS33584	Tubing End, Standard Dimensions for Flared

(Copies of documents 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 document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials

E215-63T      Standardizing Equipment for Electromagnetic Testing  
of Seamless Aluminum Alloy Tube

(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 Chemical composition.—

3.1.1 The chemical composition shall conform to table I.

TABLE I. Chemical composition 1/

Element	6061	
	Percent	
	Minimum	Maximum
Copper	0.15	0.40
Silicon	0.40	0.8
Iron	—	0.7
Manganese	—	0.15
Magnesium	0.8	1.2
Zinc	—	0.25
Chromium	0.15	0.35
Titanium	—	0.15
Other elements, each	—	0.05
Other elements, total	—	0.15
Aluminum	Remainder	

1/ Analysis shall regularly be made only for the elements specifically mentioned in table I. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine conformance to the limits specified for other elements.

3.2 Mechanical properties.—

3.2.1 Tensile strength.— The tensile properties of tube in the T6 temper or the T4 temper in accordance with MIL-H-6088 shall conform to table II.

3.2.2 Flattening.— Tube shall withstand, without cracking, the flattening test described in 4.4.3.2.

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TABLE II. Mechanical properties

Temper	Wall thickness (inch)	Tensile strength psi minimum		Elongation in 2 inches or 4D <sup>1/</sup>	
		Ultimate	Yield	Full section specimen <sup>2/</sup>	Cut-out specimen <sup>3/</sup>
T4--Solution heat treated	0.025 thru 0.049	30,000	16,000	16	14
	0.050 thru 0.259	30,000	16,000	18	16
	0.260 thru 0.500	30,000	16,000	20	18
T6--Solution heat treated and artificially aged	0.025 thru 0.049	42,000	35,000	10	8
	0.050 thru 0.259	42,000	35,000	12	10
	0.260 thru 0.500	42,000	35,000	14	12

<sup>1/</sup> D represents diameter of cut-out specimens.<sup>2/</sup> Tube shall be tested in full section unless the limitations of the testing machine preclude the use of such a specimen.<sup>3/</sup> Values apply to a cut-out specimen when a full-section specimen cannot be used.

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3.2.3 Test for leaks.- Unless otherwise specified, each length of tube shall be tested as specified in 3.2.3.1 or 3.2.3.2, consistent with the size limitations indicated for each method.

3.2.3.1 Pressure.- Each length of tube 1-1/2 inches or less in diameter shall withstand a pressure of 250 psi for a period of not less than 5 seconds (see 4.4.3.3.1).

3.2.3.2 Eddy current.- Each length of tube 1-1/2 inches or less in diameter and maximum wall thickness of 0.083 inch shall produce eddy current indications less than those from the 2A holes of the applicable reference standard of ASTM E215 or an equivalent secondary standard, when tested in accordance with 4.4.3.3.2.

3.2.4 Flaring.-

3.2.4.1 Single flare.- Tube with a diameter of 3/16 inch with a wall thickness of 0.049 inch and greater and tube with a diameter of 1/4 inch and over shall withstand being single-flared to the dimensions specified on MS33584 without signs of cracks or defects. The inside surface of the flare shall be smooth and show no evidence of a bead that might prevent the assembly being pressure-tight when subjected to proof pressure as specified in MIL-H-5440 or MIL-H-25475.

3.2.4.2 Double flare.- Tube with a diameter of 3/16 to 3/8 inch, inclusive, shall withstand being double-flared to the dimensions specified on MS33583 without signs of cracks or defects. The inside surface of the flare shall be smooth and shall show no evidence of a bead that might prevent the assembly being pressure-tight when subjected to proof pressure as specified in MIL-H-5440 or MIL-H-25475.

3.2.5 Hydraulic strength.- Tube shall be capable of withstanding, without diametral set exceeding 0.002 inch per inch of mean outside diameter, and internal hydrostatic pressure (P), calculated by the following formula. (See 6.3.) The mean outside diameter is the average of two diameter measurements taken at right angles to each other at any point along the length of the tube.

$$P = S \frac{D^2 - d^2}{D^2 + d^2}$$

Where: P = Test pressure in psi  
 S = Specified minimum yield strength, psi  
 D = Maximum OD (nominal OD plus tolerance), inch  
 d = Maximum ID (computed as D minus twice the minimum permissible wall thickness), inch

3.3 Cleanliness.- Tube shall be free from grease or other foreign matter. The inner bore shall show no metallic flakes nor particles.

3.4 Tolerances.- The tolerances shall not exceed those specified in Federal Standard No. 245 for outside diameter, wall thickness, straightness, and length of drawn tube, as applicable.

3.5 Requirements for tube in sizes not specifically covered.- The mechanical properties and tolerances of tube in sizes outside the limits covered in this specification shall be as specified in the contract or order.

3.6 Marking for identification.- Unless otherwise specified, tube shall be marked in accordance with Federal Standard No. 184.

3.7 Workmanship.- The tube shall be seamless and uniform in quality and temper. The exterior and interior surfaces shall be clean, smooth, and free from slivers, laminations, folds, grooves, cracks, and other injurious defects within the limits consistent with the best commercial practice. Discoloration due to heat treatment will not be cause for rejection. Ground tube shall not be acceptable.

#### 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 inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 General.- Sampling and inspection shall be in accordance with Federal Test Method Standard No. 151 and as specified herein.

#### 4.3 Sampling.-

4.3.1 Lot.- A lot shall consist of tube of the same temper and nominal size submitted for inspection at one time.

#### 4.3.2 Sampling for chemical analysis.-

4.3.2.1 Ingot analysis.- At least one sample shall be taken from each group of ingots of the same alloy poured simultaneously from the same source of molten metal by the producer and analyzed to determine conformance with 3.1. Ingots not conforming to the requirements of this specification shall be cause for rejection. Complete ingot analysis records shall be available to the procuring activity.

4.3.2.2 Finish product analysis.- When sampling has not been made in accordance with 4.3.2.1, a sample shall be selected in accordance with Method 111 or 112 of Federal Test Method Standard No. 151 for each 4,000 pounds or less of material comprising the lot, except that not more than one analysis shall be required per piece.

#### 4.3.3 Samples for mechanical property tests.-

4.3.3.1 Number of test samples in temper supplied.- From material having a nominal weight of less than 1 pound per lineal foot, one tension-test sample and one flattening-test sample shall be selected from each lot weighing 500 pounds or less; from lots weighing more than 500 pounds, one additional sample shall be taken from each 1,000 pounds or fraction thereof in excess of the first 500 pounds. For material having a nominal weight of 1 pound or more per lineal foot, one tension-test sample and one flattening-test sample shall be taken from each lot consisting of 500 feet or less; from lots consisting of more than 500 feet, one additional sample shall be taken for each 1,000 feet or fraction thereof in excess of the first 500 feet. Only one tension-test specimen and one flattening-test specimen shall be taken from a given piece when more than one piece is available.

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4.3.3.2 Samples for flaring test.- Five samples shall be selected from each lot.

4.3.4 Samples for cleanliness test.- At least one sample shall be selected from each 1,200 feet, or less, from each lot of tube in the shipment.

4.3.5 Rejection and retest.- When any lot fails to meet the requirements because of inadequate heat treatment, the material may be reheat-treated and resubmitted for test. Only two such reheat treatments shall be allowed. Tube not conforming to this specification shall be rejected. Tube which has been rejected may be reworked or replaced to correct the defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished the inspector. Retests are permitted in accordance with Federal Test Method Standard No. 151. Units rejected after retest shall not be resubmitted without specific approval of the procuring activity.

4.3.6 Rejectable defects.- Tube with discontinuities of depth which exceed the limits of table III shall be rejected.

TABLE III. Limits of depth of defects

Nominal wall thickness, inch	Maximum permissible depth of defect, inch
0.020 and under	10 percent of nominal wall thickness
0.021 through 0.030	0.002
0.031 through 0.040	0.0025
0.041 through 0.050	0.003
0.051 through 0.066	0.004
0.067 and over	0.006

#### 4.4 Inspection methods.-

4.4.1 Examination of product.- Each piece of tube shall be carefully examined to determine conformance to this specification with respect to workmanship. Sufficient spot checks shall be made to insure conformance to the tolerances specified. On approval of the procuring activity, a system of statistical quality control may be used for dimensional and workmanship inspection.

4.4.2 Chemical analysis.- Chemical analysis shall be made by wet chemical or spectrographic methods. In case of dispute, the chemical analysis by wet chemical methods shall be the basis for acceptance.

#### 4.4.3 Mechanical properties.-

##### 4.4.3.1 Tensile tests.-

4.4.3.1.1 Tensile strength.- Tensile strength shall be determined in accordance with Federal Test Method Standard No. 151, Method 211.

4.4.3.1.2 Yield strength.-- The yield strength shall be determined either by the offset method or the extension-under-load method in accordance with Federal Test Method Standard No. 151, Method 211. In case of dispute, the offset method shall be used.

4.4.3.2 Flattening test.--

4.4.3.2.1 Type of specimen.-- Flattening test specimens shall be of the full section of the material and shall be not less than 2 inches in length.

4.4.3.2.2 Tube shall be flattened between parallel plates under a gradual load applied perpendicularly to the longitudinal axis as follows:

- (a) Wall thickness less than 10 percent of the outside diameter: Flatten until outside dimension equals eight times the wall thickness.
- (b) Wall thickness 10 percent or more of the outside diameter: Flatten until outside dimension equals 90 percent of the outside diameter.

4.4.3.2.3 After the flattening test, the outer surface of the tube shall be examined for cracks, using a 10X illuminated magnifier.

4.4.3.2.4 Alternative flattening tests.-- In case the tube does not flatten uniformly, suitable jigs may be used to bring about this result, or a section of tube of not less than 1/2 inch length, with the subtended arc not greater than one-half nor less than one-third the circumference of the original tube, shall be removed from the material in question and without further treatment shall be bent around a mandrel having a diameter of four times the wall thickness for T4 temper tube and six times the wall thickness for T6 temper tube. The bend shall be made with the pin placed on the inside surface of the specimen and with the longitudinal axes of the pin and specimen parallel. The bend shall be continued until the specimen encloses at least 180 degrees of the pin.

4.4.3.3 Leak test.--

4.4.3.3.1 Pressure test.-- While the tube is completely immersed in water or other suitable liquid, an air pressure of 250 psi shall be applied to the inside of the tube for a period of not less than 5 seconds. The tube shall be subjected to this test after reduction to size. Any tube leakage, as indicated by the formation of air bubbles in the liquid, shall be cause for rejection.

4.4.3.3.2 Eddy current test.-- The eddy current test shall be conducted in accordance with ASTM E215. The reference standards described in Sections A1 to A6 of ASTM E215 Appendix shall be used to standardize the equipment and insure proper functioning.

4.4.3.4 Flaring test.-- The end of the specimen to be flared shall be cut square with the cut end smooth and free from burrs. The end of the tube may be chamfered to produce a satisfactory flare. The specimen shall be flared by either of the following methods:

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- (a) Single flare: The specimen shall, at room temperature, be single-flared either by using a spinning operation or by forcing the specimen axially with steady pressure over a hardened and polished tapered steel pin having a 74 degrees included angle to produce a flare in accordance with the applicable standard. A lubricant may be used to avoid aluminum pick-up on tools.
- (b) Double flare: The specimen shall, at room temperature, be double-flared using either suitable hand flaring or machine flaring equipment.

4.4.3.5 Hydraulic strength test.-- The samples selected for the flaring test of 4.4.3.4 shall be capable of withstanding for a period of 5 minutes an internal hydrostatic pressure calculated in accordance with the formula specified in 3.2.5. (See 6.3.)

4.4.4 Cleanliness test.-- A clean white cloth shall be drawn through the bore of a length of the test sample tube. The presence of metallic flakes or particles on the cloth shall be cause for rejection. Discoloration of the cloth without the presence of flakes or grit shall not be cause for rejection.

4.5 Reports of tests.-- When specified by the procuring activity, copies of certified reports showing in detail the results of all the tests required herein shall be submitted to the procuring activity at the time of shipment (see 6.2).

4.6 Preservation, packaging, and packing.-- Preservation, packaging, and packing shall be examined for conformance to section 5.

## 5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging.-- All tube shall be preserved and packed in accordance with MIL-STD-649. Unless otherwise specified by the procuring activity, tube shall be preserved, packaged, and packed in accordance with level C. In addition, tube ends shall be adequately sealed for protection from external dirt and dust.

5.2 Marking of shipments.-- In addition to any special marking required by the contract or order, shipping containers shall be marked in accordance with MIL-STD-129.

## 6. NOTES

6.1 Intended use.-- This tube is intended for use in hydraulic and pneumatic systems of aircraft covered by MIL-H-5440, including the 3,000-psi systems.

6.2 Ordering data.-- Procurement documents should specify:

- (a) Title, number, and date of this specification.
- (b) Size, thickness, type (when specific type is desired) and length desired (exact or multiple lengths should be specified only when mill lengths cannot be used).
- (c) Applicable level of packing (see 5.1).
- (d) Data requirements (see 4.5).



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6.3 Definition of term "capable". - The term "capable" as used in this specification shall mean that the test need not be performed by the producer of the tube. However, should subsequent testing by the procuring activity establish that the material does not meet these requirements the tube shall be rejected.

Custodians:

Navy - WP

Air Force - (11)

Preparing activity:

Air Force - (11)

Reviewer activities:

Navy - WP

Air Force - (11), (69)

