

MIL-T-8606C  
18 June 1973

SUPERSEDING  
MIL-T-8606B  
22 May 1967

## MILITARY SPECIFICATION

- \* TUBING, STEEL, CORROSION-RESISTANT (18-8 STABILIZED  
AND EXTRA LOW CARBON)

This specification is approved for use by all  
Departments and Agencies of the Department of Defense.

### 1. SCOPE

1.1 Scope. This specification covers seamless or welded and drawn tubing of stabilized corrosion-and-heat-resistant steel in the annealed condition.

- \* 1.2 Classification. Tubing shall be of the following alloy steels, as specified:

347 Niobium or niobium plus tantalum stabilized  
321 Titanium stabilized  
304L Low carbon

### 2. APPLICABLE COCUMENTS

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.

#### SPECIFICATIONS

##### Military

MIL-H- 6875

Heat Treatment of Steels (Aircraft  
Practice), Process for

#### STANDARDS

##### Federal

Fed. Test Method  
Std No. 151

Metals; Test Methods

FSC 4710

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FED-STD-183

Continuous Identification Marking of  
Iron and Steel ProductsMilitary

MIL-STD-163

Steel Mill Products, Preparation for  
Shipment and Storage

MIL-STD-753

Corrosion-Resistant Steel Parts,  
Sampling, Inspection and Testing  
for Surface Passivation

MS33534

Standard Dimensions for Streamline  
and Oval Tubular ShapesANA Design Standard

AND10102

Tubing - Standard Dimensions for  
Round Seamless Alloy Steel

(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 date of invitation for bids or request for proposal shall apply.

## AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B46.1 Surface Texture (Surface Roughness, Waviness and Lay)

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.)

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A370 Mechanical Testing of Steel Products

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

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(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

### 3. REQUIREMENTS

**3.1 Materials.** The steel shall be manufactured by the electric-furnace process and shall conform to this specification. Heat-treating equipment used in connection with tubing production shall be capable of meeting the temperature control requirements of section 3 of MIL-H-6875. Heating shall be accomplished in an atmosphere which will provide a smooth gray or bright surface free from carburization, nitriding, or other deleterious surface effects.

**3.1.1 Chemical composition.** The chemical composition shall conform to table I.

Table I. Chemical composition limits.

Element	Composition limits (percent)			Check Analysis tolerance (percent)
	304L	347	321	
Carbon	0.03 (max)	0.08 (max)	0.08 (max)	+0.01
Manganese	2.00 (max)	2.00 (max)	2.00 (max)	+0.04
Phosphorus	0.040 (max)	0.040 (max)	0.040 (max)	+0.005
Sulfur	0.030 (max)	0.030 (max)	0.030 (max)	+0.005
Chromium	18.0 - 20.0	17.0 - 20.0	17.0 - 20.0	+0.20
Nickel	8.0 - 11.0	9.0 - 13.0	9.0 - 13.0	+0.15
Silicon	1.00 (max)	1.00 (max)	1.00 (max)	+0.05
Copper	0.50 (max)	0.70 (max)	0.70 (max)	+0.05
* Niobium <sup>1/</sup>		1.10 (max) <sup>2/</sup>	--	+0.05
Titanium		--	0.75 (max) <sup>3/</sup>	+0.05
Molybdenum	0.50 (max)			
Iron	Remainder	Remainder	Remainder	

(See footnotes on page 4)

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- \* 1/ Niobium or niobium plus tantalum. The determination of tantalum is not required. The ratio of tantalum to the total of tantalum plus niobium shall not exceed 0.4.
- 2/ The sum of the niobium content plus the tantalum content shall be not less than 10 times the carbon content.
- 3/ The ratio of titanium to carbon shall be not less than 5 to 1.

\*3.2 Surface condition. Tube surfaces shall be smooth and have a bright or gray metallic appearance and be free from surface films, discoloration, scale, flakes, or loose or adherent particles. All chemical bath residues shall have been removed by rinsing in flowing water, followed by thorough drying. Surfaces shall comply with 4.8.

3.2.1 Passivity. Surfaces shall be passive when tested in accordance with Method 102 or 103 of MIL-STD-753.

\*3.2.2 Surface texture. Surface roughness shall not exceed an arithmetical average roughness height rating (RHR) of 70 on inside surfaces or RHR 40 on outside surfaces as defined by ANSI B46.1. The maximum depth of individual surface discontinuities shall not exceed the limits of table II.

\*3.2.2.1 Discontinuities of equal or less depth than table II limits in the outer surfaces of tubes shall be removed by light belt polishing and buffing, except that discontinuities having large root radii plainly visible to the unaided eye, whose surfaces blend smoothly into the normal tubing surfaces, need not be removed. Passivation treatment shall follow any surface polishing or buffing operation.

Table II. Limits of depth of discontinuities.

Nominal wall thickness	Maximum permissible depth of discontinuities (inch)
0.020 and under	10 percent of nominal wall thickness
.021 through .030	0.002
.031 through .040	.0025
Over .040	.003

3.3 Mechanical properties. The mechanical properties of the tubing shall conform to table III.

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Table III. Mechanical properties.

Nominal outside diameter	Nominal wall thickness (inch)	Ultimate tensile strength (psi) (max)	Elongation in 2 inches minimum percent	
			Full Section	Strip
0.187 and less	0.016 and less	115,000	35	35
	Over 0.016	105,000	35	30
Over 0.187 to 0.500, inch	0.010 and less	110,000	37	37
	Over 0.010	105,000	35	30
Over 0.500	All	105,000	35	30

3.4 Flanging properties. Tubing over 5/16 inch outside diameter shall be capable of being deformed to the extent required by the flanging test specified in 4.7 without cracking or indication of defects.

3.5 Flattening. Tubing shall be capable of withstanding flattening under the conditions specified in 4.10 without cracking or other indications of defects.

3.6 Hydrostatic pressure resistance. When subjected to an internal pressure P or 15,000 pounds per square inch (psi), whichever is less, tubing shall show no bulging, leakage, or other defects, except that a diametric permanent set of 0.002 inch per inch of diameter is acceptable. Hydrostatic test pressure shall be calculated according to the following formula:

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

Where P=test pressure in psi

S=specified minimum tensile yield strength, psi

D=maximum permissible outside diameter (nominal OD plus tolerance), in inches

d=maximum permissible inside diameter (computed as D less twice the minimum permissible wall thickness) in inches

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**3.7 Dimensions.** The dimensions of round tubing shall conform to the standard dimensions shown on AND10102. The dimensions of streamline and oval tubing shall be as specified in MS33534. The dimensions for rectangular or square tubing shall be as specified in the contract or order (see 6.2).

**3.8 Length.** Unless otherwise specified (see 6.2) tubing shall be furnished in random lengths of 5 to 24 feet, but not more than 10 percent of any order may be furnished in lengths shorter than 12 feet.

**\*3.9 Identification of product.** Tubing 1/4 inch and over in outside diameter shall be marked in accordance with FED-STD-183. The following additional marking items shall be included:

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Alloy designation.

Nominal outside diameter

Nominal wall thickness

**3.9.1** In lieu of continuous marking, tubing less than 1/4 inch outside diameter may be bundled and each bundle identified by metal tags, impression stamped with the legend specified in FED-STD-183 and 3.9 and securely attached near each end of the bundle.

**3.10 Workmanship.** Tubing shall have good workmanlike surfaces conforming to the best practice for aircraft quality pneumatic or hydraulic tubing. Surfaces shall be free from discontinuities such as seams, tears, laminations, pits, or other injurious defects of depth in excess of those specified in table II. Centerless grinding and grit blasting of outer and inner surfaces are not acceptable. Light belt polishing or buffing is permissible; however, tubing shall not be sized by metal removal methods. (See 6.1.1)

#### 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 in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by 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.

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- \* 4.2 Classification of Inspections. All inspections and examinations specified herein are classified as quality conformance inspections.
- \* 4.3 Inspection lot. A lot shall consist of tubing of one size and wall thickness from one heat of steel, one method of manufacture, and annealed in the same charge (batch anneal), or annealed at the same temperature, time, and atmosphere, without interruption within a 4 hour period (continuous anneal).
- \* 4.4 Examination of product. Each length of tubing shall be visually examined for compliance with surface condition and workmanship requirements. Samples selected from each lot at random in accordance with table IV shall be examined for conformance to dimensions and tolerances, identification marking, and preparation for delivery.

Table IV. Sampling plan.

Lot size (tubes)	Sample size	Acceptance number <u>1/</u>	Rejection number <u>1/</u>
1 to 3	All	0	1
4 to 25	4	0	1
26 to 65	6	0	1
66 to 180	13	0	1
181 to 300	20	1	2
301 to 800	32	2	3
Over 800	50	3	4

1/ Applied to the number of tubes found defective.

#### 4.5 Chemical analysis

4.5.1 Sampling. A sample for chemical analysis shall be selected, as specified in method 111 of Fed Test Method Std No. 151, to represent each heat in the shipment.

4.5.1.1 Waiver. Samples for chemical analysis may be waived, provided that all of the material under inspection can be identified as being made from a heat previously analyzed and found to conform to the chemical composition specified herein.

4.5.2 Analysis. Analysis shall be by Method 111 or 112 Federal Test Method Standard No. 151. In the event of a dispute, analysis shall be by Method 111, as applicable.

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**4.6 Mechanical properties**

**4.6.1 Sampling.** Two samples shall be selected to represent each 2,000 feet of tubing of each lot up to 5,000 feet, and two additional samples from each additional 5,000 feet of the lot.

**\*4.6.2 Specimens.** One specimen shall be cut from each piece of tubing comprising the sample. Specimens shall consist of a full section of tubing, when practicable, or may be machined to conform to specimen No. 2 in Supplement II of ASTM A370.

**\*4.6.3 Method.** Specimens shall be tested as detailed in ASTM A370.

**4.7 Flanging**

**4.7.1 Sampling.** Unless otherwise specified, samples shall be selected at random from various lengths of tubing in accordance with table V.

Table V. Sampling plan

Lot size (Tubes)	Sample size	Acceptable No. rejectable
1 to 25	4	0
26 to 65	6	0
66 to 180	8	0
181 to 300	9	0
301 to 800	10	0
Over 800	15	0

**4.7.2 Specimens.** Flanging test specimens shall be cut from each piece of tubing comprising the sample. Specimens shall be full cross sections of tubing not less than 4 inches in length.

**4.7.3 Method.** Specimens shall have a flange turned to a position perpendicular to the body of the tubing by means of a flare tool and die block. The height of the flange shall be not less than 15 percent of the nominal diameter for tubing 2-1/2 inches or less in diameter, and not less than 10 percent of the nominal diameter for larger tubing, except that in no case shall the height of the flange be greater than 1/4 inch, as measured from the outer surface of the tubing.



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**4.8 Surface condition.** Two one-foot sections shall be selected from each lot of tubing and split lengthwise. The exposed inner surface shall be examined for surface roughness. One half shall be immersed in an aqueous solution of 15 percent nitric acid and 3 percent hydrofluoric acid by volume at 100°F for a period of 15 minutes. After immersion, the half tube shall be washed and dried. The two halves shall then be compared as to the appearance of inner and outer surfaces. Differences in color and appearance, other than minor changes in shade and texture, shall be cause for rejection.

**4.8.1 Loose material.** Wads of firmly compacted clean white cloth or fibrous material shall be forced through the bore of each of two sample tubes selected from each lot, and any soiled areas examined at 10 diameter magnification for the presence of grit, metallic flakes, or other detrimental materials. The presence of such particles shall be cause for rejection.

**4.9 Hydrostatic pressure resistance**

**4.9.1 Sampling.** Two samples shall be selected to represent each lot, one early and the other late in the production sequence.

**4.9.2 Method.** Sample tubes shall be subjected to internal hydrostatic pressure calculated in accordance with 3.6. Each specimen shall be subjected to two pressure applications, with the calculated pressure to be maintained at least 2 minutes during each cycle. The rate of pressure change shall not exceed 25,000 psi per minute.

**4.10 Flattening**

**\*4.10.1 Sampling.** Unless otherwise specified, samples shall be selected from each lot in accordance with table V.

**4.10.2 Specimens.** A specimen shall be cut from each length of tubing comprising the sample. Specimens shall be full sections of tubing of a length not less than 1-1/2 times the diameter, and in no case less than 2 inches.

**4.10.3 Method.** Specimens shall be flattened between parallel flat plates by a gradually applied load normal to the axis of the tubing, until the distance between the faces of the plate is equal to three times the wall thickness of the tubing. Specimens of welded tubing shall be so located that the weld will lie at the point of maximum bending.

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4.11 Passivation.

4.11.1 Sampling. One sample shall be selected to represent each lot of tubing.

4.11.2 Method. Tests shall be in accordance with method 102 or 103 of MIL-STD-753.

- \* 4.12 Rejection and retest. Failure of a specimen to meet the test requirements shall be cause for rejection of the lot. At the discretion of the supplier retest will be permitted. A retest sample of five specimens shall be tested to replace each failed specimen of the original sample. If one of the retest specimens fails, the lot shall be rejected with no further retesting permitted.

## 5. PREPARATION FOR DELIVERY

5.1 Preparation for shipment. Preservation, packaging, and packing shall be level A or C, as specified (see 6.2). Tubing shall be preserved, packaged, packed, and marked for shipment in accordance with applicable requirements of MIL-STD-163.

## 6. NOTES

- \*6.1 Intended use. The tubing is intended for applications which require a high level of resistance to corrosion, to temperatures below 1500°F, and which involve welded joints. It is suitable for use in mechanical and in hydraulic systems in tank-automotive applications.

6.1.1 When systems are to be assembled with welded joints between tubes and fittings, MIL-T-8808 tubing is recommended. When brazed sleeve joints are called for, close-tolerance tubing conforming to MIL-T-8973 is recommended.

6.2 Ordering data. Procurement documents should specify:

- (a) Title, number, and date of this specification.
- (b) Alloy designation (see 1.2).
- (c) Outside diameter, wall thickness, and length (when exact lengths are required) (see 3.8 and 3.9) .
- (d) Level of preservation, packaging, and packing desired .

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- \* 6.3 Marginal indication. The margins of this specification are marked with an asterisk (\*) to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This is done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship of the last previous issue.

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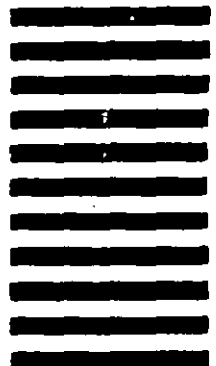
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