

INCH-POUND

MIL-T-8504B
25 July 1991
SUPERSEDING
MIL-T-8504A
22 September 1966

MILITARY SPECIFICATION

TUBING, STEEL, CORROSION-RESISTANT (304), AEROSPACE VEHICLE HYDRAULIC SYSTEMS, ANNEALED, SEAMLESS AND WELDED

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

1. SCOPE

1.1 Scope. This specification covers requirements for special-quality, seamless and welded corrosion-resistant steel tubing in the annealed condition (see 6.1).

1.2 Classification. The tubing shall be of the following types, as specified (see 6.2):

- a. Type I – Seamless
- b. Type II – Welded and drawn

NOTE: Either type I or II may be supplied, unless a specific type is ordered.

2. APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation. (see 6.2)

SPECIFICATION

FEDERAL

QQ-P-35 Passivation Treatments for Austenitic, Ferritic, and
 Martensitic Corrosion-Resisting Steel

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASD/ENES Wright-Patterson AFB OH 45433-6503, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 4710

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

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STANDARD

FEDERAL

FED-STD-151 Metals; Test Methods
 FED-STD-183 Continuous Identification Marking of Iron and
 Steel Products

MILITARY

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
 AND10104 Tubing, Steel, Corrosion-Resistant, Round, Standard
 Dimensions for
 MS33584 Tubing End – Standard Dimensions for Flared

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 262 Steels, Austenitic Stainless, Detecting
 Susceptibility to Intergranular Attack in
 ASTM E 112 Estimating the Average Grain Size of Metals

(Application for copies should be addressed to ASTM, 1916 Race Street, Philadelphia PA 19103.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B 46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

(Application for copies should be addressed to ANSI, 1430 Broadway, New York, NY 10018.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulation unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Materials. Heating of material shall be accomplished in air or protective atmosphere which will provide a smooth gray surface free from carburization, nitriding, or other deleterious surface effects.

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3.1.1 Chemical composition. The chemical composition shall be as specified in table I.

TABLE I. Chemical composition of the tubing.

Element	Limits (percent)	Check analysis tolerance ^{1/} (under min. or over max.)	
Carbon	0.08 (max)	—	0.01
Manganese	2.00 (max)	—	0.04
Phosphorus	0.04 (max)	—	0.005
Sulfur	0.030 (max)	—	0.005
Silicon	1.00 (max)	—	0.05
Chromium	18.00 – 20.00	0.20	0.20
Nickel	8.00 – 12.00	0.10	0.15
Molybdenum	0.50 (max)	—	0.03
Copper	0.75 (max)	—	0.03
^{1/} Individual determination may vary from the specified range to the extent shown in the check analysis column, except that elements in any heat shall not vary both above and below the specified range.			

3.1.2 Grain size. The grain size of the steel in the as-received condition shall be predominantly no. 5 or finer, in accordance with ASTM E 112.

3.2 Mechanical properties. The mechanical properties shall be as specified in table II.

TABLE II. Mechanical properties of tubing.

Nominal outside diameter (inch)	Nominal wall thickness (inch)	Ultimate tensile strength (psi) (psi)	Yield strength 0.2 percent offset (min) Full	Elongation in 2 inches (min) percent	
				section	strip
0.187 and less	0.016 and less	115,000 (max)	30,000	35	35
	Over 0.016	75,000 – 100,000	30,000	40	35
Over 0.187 to 0.500, incl.	0.012 and less	110,000 (max)	30,000	37	37
	Over 0.012	75,000 – 100,000	30,000	40	35
Over 0.500	All	75,000 – 100,000	30,000	40	35

MIL-T-8504B**3.3 Performance**

3.3.1 Flarability. Tubing 0.125 inch outside diameter, and over, shall flare to the respective dimensions of MS33584, when tested as specified in 4.3.6. The flared zones shall be uniform and smooth, and capable of forming pressure-tight joints with standard fittings.

3.3.2 Flattening. Tubing shall not develop cracks, tears, or other flaws when subjected to the flattening test specified in 4.3.7.

3.3.3 Bending. Tubing shall not develop cracks tears, breaks, or other flaws when subjected to the bending test specified in 4.3.8.

3.4 Corrosion resistance

3.4.1 Resistance to acidified copper-sulfate solution. The tubing shall exhibit no evidence of cracks due to intergranular attack when subjected to the examination after exposure to boiling acidified copper-sulfate solution at the conditions specified in method E of ASTM A 262 and 4.3.9.

3.4.2 Passivation treatment. Treatment of inner and outer surfaces by other than picking shall be followed by a passivation treatment in accordance with QQ-P-35. The surfaces shall be passive to tests as specified in 4.3.10.

3.5 Surface conditions. Surface shall be smooth, have a grey metallic appearance and be free from surface films, scale, flakes, or loose or adherent particles of foreign matter. All chemical bath residues shall have been removed by rinsing in flowing water, followed by thorough drying. Compliance shall be determined as specified in 4.3.2.3.

3.5.1 Surface roughness. 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 B 46.1. The maximum depth of individual surface discontinuities shall not exceed the limits of table III.

TABLE III. Limits of depth of discontinuities.

Nominal wall thickness (inch)	Maximum permissible depth of discontinuities (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 through 0.085	0.006

3.5.2 Discontinuities. Discontinuities of equal or less depth in the outer surfaces of tubes shall be removed by light belt polishing or buffing; except that discontinuities having large root radii plainly visible to the unaided eye, whose surfaces blend smoothly into the normal tube surface, need not be removed. Passivation treatment shall follow any surface polishing or buffing operation.

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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 to 0.002 inch per inch of diameter is acceptable. Hydrostatic test pressure shall be calculated according to the following formula:

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

Where: P = test pressure in psi.

S = specified minimum tensile yield strength, psi.

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

d = maximum permissible inside diameter (computed as D less twice the minimum permissible wall thickness), inch.

3.7 Dimensions and tolerances

3.7.1 Dimensions. Tubing shall be furnished in the standard diameters and wall thickness specified in AND10104, as specified by the contract or purchase order. (see 6.2).

3.7.2 Tolerances. The outside diameter shall not vary from the nominal dimensions by more than the permissible limits of table IV. Wall thickness variations shall not exceed ± 10 percent of the nominal wall thickness.

TABLE IV. Outside diameter tolerance

Size range, outside diameter (inch)	Tolerance (inch)
to 0.187 exclusive	+0.003 – 0.000
0.187 to 0.500 exclusive	+0.004 – 0.000
0.500 to 1.500 exclusive	+0.005 – 0.000
1.500 to 2.500 exclusive	+0.010 – 0.000
2.500 to 3.000 exclusive	+0.010 – 0.010
Over 3.000 thru 5.000	+0.015 – 0.015

3.8 Weld bead. When tubing is fabricated by welding, it shall be so processed as to remove the bead or any dimensional indication of the presence of the weld.

3.9 Straightness. In no portion of any piece of tubing shall the departure from straightness exceed 0.060 inch in a length of 3 feet.

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3.10 Length

3.10.1 Exact lengths. Tubing of all sizes may be ordered to exact lengths or in lengths expressed as a multiple of a definite unit, with tolerances as specified in the contract or purchase order (see 6.2).

3.10.2 Mill lengths. When exact or multiple lengths are not specified (see 6.2) tubing will be accepted in mill lengths of 5 to 20 feet, but not more than 10 percent of any order shall be furnished in lengths shorter than 12 feet.

3.11 Identification of product. Tubing shall be marked in accordance with FED-STD-183. The following additional marking items shall be included:

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Nominal outside diameter
Nominal wall thickness

3.11.1 Marking of tubing less than 1/4 inch outside diameter. 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 3.11, and securely attached near each end of the bundle.

3.12 Workmanship. Surfaces shall be free from discontinuities, such as; seams, tears, laminations, pits, or other injurious defects of depth in excess of the limits as specified in table III. Centerless grinding and grit blasting of outer and inner surfaces shall not be acceptable. Light belt polishing or buffing shall be permissible.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use their 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 ensure that the supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as quality conformance inspections (see 4.3).

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4.3 Quality conformance inspection. Quality conformance inspection shall consist of sampling plans A through J specified herein. Samples shall be labeled completely with information identifying the purpose of the sample, name of product, specification number, lot number, date of sampling and contract number.

4.3.1 Inspection

4.3.1.1 Inspection lot. A lot shall consist of one size and wall thickness from one heat of steel, and annealed in the same charge (batch anneal) or all tubing of the same size and heat annealed at the same temperature, time and atmosphere, without interruption, in a continuous furnace.

4.3.2 Surface condition

4.3.2.1 Conditioning of surface. A 1-foot section shall be selected from each lot of tubing and split lengthwise. One-half shall be immersed in an aqueous solution of 15 percent nitric acid and 3 percent hydrofluoric acid by volume at 100°F to 120°F for 15 minutes. After immersion, the specimen shall be washed and dried. The two halves shall then be compared as to the appearance of inner and outer surfaces. Difference in color and appearance, other than minor changes in shade and texture, shall be cause for rejection.

4.3.2.2 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 x magnification for the presence of grit, metallic flakes, or other detrimental materials. The presence of such particles shall be cause for rejection.

4.3.2.3 Surface roughness. A 1-foot section shall be selected from each lot of tubing and split lengthwise. The inner and outer surfaces of both halves shall be examined for surface waviness and lay in accordance with ANSI B 46.1. The failure of any tubing to meet the requirements of 3.5.1 shall be cause for rejection.

4.3.2.4 Examination of samples. Samples selected in accordance with table V shall be examined for conformance to dimensions and tolerances (3.7), weld bead (3.8), straightness (3.9), length (3.10) identification marking (3.11), workmanship requirements (3.12) and preparation for delivery (section 5).

TABLE V. Sampling plan

Lot size	Sample size	Acceptance No.
1 to 110	5	0
111 to 500	7	0
501 to 800	10	0
801 to 1200	15	0
Over 1200	25	0

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4.3.3 Sampling plan A for chemical tests. A sample consisting of not less than 2 ounces of material (see 3.1) shall be selected and prepared in accordance with method 111 of 112 of FED-STD-151.

4.3.3.1 Waiver of samples for check chemical analysis. Samples for check chemical analysis may be waived, provided 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.

4.3.3.2 Analysis. Analysis shall be by method III or II2 of FED-STD-151. In the event of dispute, analysis shall be by method III.

4.3.4 Sampling plan B for grain size. One specimen shall be selected to represent each lot of tubing.

4.3.4.1 Average grain size. Specimens shall be prepared and tested in accordance with method 311 of FED-STD-151. In the event of doubt concerning grain size as determined by comparison with the grain size chart of method 311, the Heyn Intercept method of ASTM E 112 shall be used. The average grain size shall be the average of five fields of view on each specimen.

4.3.5 Sampling plan C for mechanical properties. Two samples shall be selected to represent each 2000 feet of tubing of each lot up to 5000 feet, and two additional samples from each additional 5000 feet of the lot.

4.3.5.1 Full-tube specimens. Samples shall be tested as full-tube specimens with a test section of not less than 6 inches between plugs, as required by figure 1, method 211 of FED-STD-151, entitled, "Metal Plugs Used for Testing Tubing, Location of Plugs in Tubular Specimen, and Proper Location of Specimens in Heads of Testing Machine." In larger diameters of tubing, type T1 or T2 specimens may be used. Tests shall comply with the applicable requirements of method 211 of FED-STD-151.

4.3.6 Sampling plan D for flaring test. One end of each tube or specimen cut therefrom shall be flared by spinning or by forcing axially over a tapered pin, except that not less than 13 samples from each lot, or one from each tube comprising lots of less than 13, shall be tested by the latter method. For flare test without spinning, the specimen shall be 1 inch or 1.5 diameters in length.

4.3.6.1 Flaring the ends of each specimen. The end of each specimen to be flared without spinning shall be cut square, with the cut end smooth and free from burrs but the corners not rounded. The specimen shall at room temperature, be forced axially by steady pressure over a hardened and polished tapered steel pin to produce the tubing flare configuration specified by MS33584. Both the tube and pin shall be clean and dry during the flaring operation. Surfaces of flares shall be examined at magnification of 3 diameters for freedom from cracks and other defects.

4.3.6.2 Removal of flare. Removal of the flare portion after inspection and prior to shipping is optional, unless otherwise specified.

4.3.7 Sampling plan E for flattening test. Specimens 1 inch or more in length shall be cut from sample tubing selected in accordance with table V

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4.3.7.1 Flattening of specimens. Specimens shall be flattened cold between parallel plates until the distance between the plates is not greater than four times the nominal wall thickness. When testing welded tubing, the specimens shall be so positioned that any detectable weld shall be in the area of smaller bend radii. When the tubing inner diameter is less than three times the wall thickness, the specimen shall be flattened until the flattened sides of the inside diameter are not less than 0.060 inch apart. Bend areas shall be examined visually for the presence of cracks or tears.

4.3.8 Sampling plan F for bending test. One specimen of suitable length shall be selected from each lot.

4.3.8.1 Cold bend of specimen. The specimen shall be bent cold 180 degrees around a suitable mandrel of diameter equal to three times the outside diameter of the tubing.

4.3.9 Sampling plan G for Corrosion resistance (acidified copper-sulfate test). Two specimens shall be selected from each lot.

4.3.9.1 Preparation of specimen. Specimens of the as-received tubing (Full sections whenever possible) shall be treated for 48 hours in a boiling copper-sulfate, sulfuric acid solution of the following formula:

Copper sulfate ($\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$), 10 gm.
Sulfuric acid (H_2SO_4) sp. gr. 1.84, 10 ml.
Water (distilled), 90 ml.

The specimens shall be covered with a minimum of 30 milliliters (ml.) of this solution per square inch of specimen surface area. A reflux condenser, or similar device, shall be used to prevent change in concentration of the solution.

4.3.9.2 Examination. After exposure, full-section specimens shall be flattened between parallel plates by a gradually applied load normal to the axis of the tubing until the distance between the pressure plates is not greater than four times the wall thickness. Strip section specimens shall be bent cold 180 degrees around a suitable mandrel of diameter equal to 3 times the outside diameter of the tubing. In either flattening or bending, the fold shall be along a weld zone if the specimen is of welded tubing. The folded areas shall be examined at a magnification of 20 x to determine compliance with 3.3.2.

4.3.10 Sampling plan H for passivation. One sample shall be selected to represent each lot of tubing.

4.3.10.1 Test for plan H. Tests shall be in compliance with method 102 or 103 of MIL-STD-753.

4.3.11 Sampling plan J for hydrostatic pressure resistance. Two samples shall be selected to represent each lot.

4.3.11.1 Sample subject to internal hydrostatic pressure. Sample tubing shall be subjected to internal hydrostatic pressure calculated in accordance with 3.6. The pressure shall be applied at least two successive times for a minimum of 2 minutes duration each application. The rate of pressure rise shall not exceed 25000 psi per minute.

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5. PACKAGING

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

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The tubing procurable to this specification is intended for use in high-pressure hydraulic systems, including those conforming to MIL-H-5440, MIL-H-8891, and MIL-H-25475. The tubing is not suitable for use in applications assembled by welding or brazing, or exposed to temperature higher than 800°F, because of impaired resistance to corrosion.

6.2 Acquisition requirements. Acquisition requirements documents should specify:

- a. Title, number, and date of this specification
- b. Diameter, wall thickness, length (random mill lengths or exact lengths as desired) (see 3.10) (see 1.2)
- c. Whether removal of flare is required (see 4.3.6.2)
- d. Level of preservation, packaging, and packing required (see 5.1).

6.3 Subject term (key word) listing

Corrosion resistance
Flarability
Hydrostatic pressure resistance
Passivation treatment
Surface conditions and roughness

6.4 Change from previous issue. Marginal notations not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:

Army – AV
Navy – AS
Air Force – II

Preparing activity:

Air Force – II
(Project 4710-0002)

Review activities:

Army – MR
Navy – AS
Air Force – 82, 84, 99
DLA – CS

User activities:

Army – AV
Navy – SH
Air Force – 84