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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS-T-6845

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Submitted for recognition as an American National Standard

Tubing, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System 1/8 Hard Condition

NOTICE

This document has been taken directly from U.S. Military Specification MIL-T-6845D, Notice 2 and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-T-6845D, Notice 2. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this SAE technical document.

1. SCOPE:

1.1 Scope:

This specification presents requirements for thin-walled (inside diameter greater than four times the wall thickness and outside diameter 1/4 inch and larger) corrosion-resistant steel tubing in approximately the 1/8 hard condition, of special quality, suitable for use in high-pressure hydraulic systems.

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1.2 Classification:

Tubing shall be furnished in the following types and classes. Unless otherwise specified, either of the types and classes indicated may be furnished at the option of the contractor, provided that all material furnished on an individual order shall be of one type and class only.

Manufacturing process type

Type I - Seamless
Type II - Welded and drawn

Ultrasonic Class, Type II only

Class 1 - 0.125 Inch length ultrasonic calibration standard
Class 2 - 0.060 inch length ultrasonic calibration standard
Class 3 - Ultrasonic testing not required

2. APPLICABLE DOCUMENTS:

The following publications, 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.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2243 Tolerances - Corrosion and Heat Resistant Steel Tubing

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

QQ-P-35 Passivation Treatments for Corrosion-Resisting Steel

MIL-H-6875 Heat Treatment of Steels

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

MIL-STD-129 Marking for Shipment and Storage
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

MS33584 Tubing End, Standard Dimensions for Flared

AND10104 Tubing, Steel, Corrosion-Resistant, Round Standard Dimensions For

2.3 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 112 Estimating the Average Grain Size of Metals
ASTM A 370 Mechanical Testing of Steel Products

2.4 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI B46.1 Determining Average Grain Size

3. REQUIREMENTS:

3.1 Material:

The material shall be manufactured by the electric-furnace process and shall conform to this specification. Heat-treating shall be in accordance with the requirements 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 defects.

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

3.1.2 Grain size: The grain size in the "as received" condition shall average 5 or higher, as determined by method in 4.5.

3.1.3 Mechanical properties: The mechanical properties shall be as specified in Table II.

TABLE I. Chemical composition limits

Element	Percent			Check analysis tolerance (percent)
	Min.		Max.	
Carbon			0.08	+0.01
Manganese			2.00	+0.04
Phosphorous			0.04	+0.005
Sulfur			0.03	+0.005
Chromium	18.00	-	20.00	±0.20
Nickel	8.00	-	10.50	±0.15
Molybdenum			0.75	+0.05
Copper			0.75	+0.05
Silicon			1.00	+0.05

TABLE II. Mechanical properties

Nominal outside diameter (inch)	Nominal wall thickness (inch)	Ultimate tensile Strength (psi)	Yield strength 0.2 percent offset (psi)	Elongation in 2 inches minimum (percent)
0.250 and over	All	105,000 - 140,000	75,000 - 110,000	20

3.2 Flarability:

One end of each piece of tubing of inside diameter 0.093 inch and larger shall be flared to the dimensions of MS33584 without cracking or forming other defects. Tubing with intermediate nominal OD shall be flared to the same percentage increase in diameter as required for the next larger nominal size. Removal of the flared portion after inspection is optional.

3.2.1 Leakage: Tubing shall be subjected to a low and high pressure application without leakage as required in 4.7.1.

3.3 Bending:

Tubing shall not develop cracks, tears, breaks or other flaws when subjected to the bending test specified in 4.8.

3.4 Corrosion resistance:

The tubing shall exhibit no evidence of cracks or intercrystalline surface attack when tested in accordance with requirements in 4.10

3.5 Ultrasonic testing:

Ultrasonic inspection indications for Type II Classes 1 and 2 tubing shall be not greater than those from the calibration notches when the signal amplitude from the calibration notches is set at not less than 50 percent of full scale. The noise amplitude during inspection of tubes shall not be greater than 25 percent of full scale. Ultrasonic inspection shall be conducted as specified in 4.10.

3.6 Hydrostatic pressure resistance:

Tubing shall be capable of withstanding an internal hydrostatic pressure P, without bulging, leakage, or other defects, except that any 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 yield strength, psi.
D = maximum permissible outside diameter (nominal OD plus tolerance), inch.
d = maximum permissible inside diameter, inch, (computed as D less twice the minimum permissible wall thickness).

3.7 Surface condition:

Surface shall be smooth, have a gray metallic appearance and be free from surface films, scale, flakes, or loose 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 4.12.

3.7.1 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 B46.1. The maximum depth of individual surface discontinuities for Type I and Class 3 shall not exceed the limits of Table III.

3.7.2 Discontinuities removal: Discontinuities of equal or less depth into 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.

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
.021 through .030	0.002
.031 through .040	0.0025
.041 through .050	0.003
.051 through .066	0.004
.067 through .085	0.006

3.8 Passivation treatment:

Treatment of inner and outer surfaces by other than pickling shall be followed by a passivation treatment in accordance with QQ-P-35. Surfaces shall be passive when tested as specified in 4.13.

3.9 Dimensions and tolerances:

3.9.1 Sizes: Tubing shall be furnished in standard outside diameters 1/4 inch and over and wall thicknesses indicated in AND10104, or as specified by contract or purchase order. (see 6.2).

3.9.2 Tolerances: The variation between measured dimensions and nominal dimensions shall not exceed the tolerances of AMS 2243.

3.9.3 Weld bead: Welded (Type II) tubing shall be processed to remove the bead and any dimensional indications of the presence of welds.

3.9.4 Straightness: No portion of any piece of tubing shall have departure from straightness exceeding 0.060 inch in a length of 3 feet.

3.9.5 Length:

3.9.5.1 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).

3.9.5.2 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.

3.10 Identification of product:

Tubing shall be marked in accordance with FED-STD-183. The markings shall include the following:

AMS-T-6845
Type I or Type II (seamless or welded)
Class (Class 1, 2, or 3)
Nominal outside diameter
Nominal wall thickness
Heat number manufacturer

3.11 Responsibility for specification compliance:

When defects, as defined herein, are found or exposed subsequent to delivery but prior to placing the tubes in service, the contractor shall replace the defective material without expense to the procuring activity,

3.12 Workmanship:

Tubing, as received by purchaser, shall be uniform in quality and condition and shall have a finish conforming to the best practice for high quality tubing. It shall be smooth, and free from heavy scale or oxide, burrs, seams, tears, grooves. laminations, slivers, pits, and other injurious conditions. Surface imperfections such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale pattern will not be considered injurious if the imperfections are removable within the tolerances specified for wall thickness but removal of such surface imperfections is not required. Tubing shall be free from grease or other foreign matter. No metallic flakes or particles shall be collected by a clean cloth when it is drawn through the length of the bore of a test sample. Discoloration of the cloth, without the presence of flakes or grit, is acceptable.

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 as specified herein. Except as otherwise specified in the contract or purchase order, the contractor 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.

4.2 Lot:

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

4.3 Examination of product:

Each length of tubing shall be visually examined for compliance with surface condition and workmanship requirements. Samples selected in accordance with Table IV shall be examined for conformance with dimensions and tolerances (3.9), identification marking (3.10), and preparation for delivery (section 5).

TABLE IV. Sampling plan

Lot size	Sample size	Acceptance number	Rejection number
1 to 8 incl.	All	0	1
over 8	8	0	1

4.4 Chemical tests:

Samples for chemical analysis shall be selected to represent each heat in the shipment. The sample shall consist of not less than 2 ounces.

4.4.1 Method: Analysis shall be by Method 111.2 or 112.2 of FED-STD-151. In the event of a dispute, analysis shall be by Method 111, as applicable.

4.4.2 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 Grain size:

4.5.1 Sampling: Two specimens shall be selected to represent each lot of tubing.

4.5.2 Method: Specimens shall be prepared and tested in accordance with ASTM E 112 and the grain size evaluated using plate 2 of E 112 for comparison. In the event of doubt concerning grain size as determined by comparison with plate 2, the Heyn Intercept Method of E 112 shall be used. The average grain size shall be the average of five fields of view on each specimen.

4.6 Tensile test:

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.

4.6.2 Method: Samples shall be tested as full-tube specimens with a test section of not less than 6 inches between plugs, as required by ASTM A 370, Supplement II.

4.7 Flarability Inspection:

After flaring, the inner and outer surfaces shall be smooth and sound, and capable of forming pressure tight joints with standard fittings when tested as specified in 4.7.1.

4.7.1 Leakage tests: Two or more samples shall be selected at random to represent each 1000 linear feet or less of tubing of the same lot. The tubing shall be tested at a low pressure (250 to 400 psi) to check for leakage and then proof pressure tested at a pressure as determined in 3.6. Pressure shall be held for at least 30 seconds without leakage. If leakage is observed from either of the two samples, an additional four samples shall be tested in the same manner. Unless all the additional four samples from the second sampling pass the tests as outlined, the lot represented by these samples shall be rejected.

4.8 Bend test:

One specimen of suitable length shall be selected from each lot.

4.8.1 Method: The specimen shall be bent cold 180 degrees around a suitable mandrel of diameter equal to three times the outside diameter of the tubing.

4.9 Embrittlement:

One or more samples shall be selected to represent tubing of one size and wall thickness, from the same heat of steel heat-treated in the same charge, and submitted for inspection at one time. Duplicate specimens of the "as received" tubing (full sections whenever practicable) shall be treated for a period of 48 hours in a boiling copper sulfate sulfuric-acid solution of the following formula:

Copper sulfate ($CuSo_4$ $5H_20$)	10 g
Sulphuric acid (H_2S0_4 - sp gr 1.84)	10 ml
Distilled water	90 ml

Specimens shall be covered with a minimum of 30 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. 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 more than four times the wall thickness. Sector specimens of tubing over 0.625 inch in outside diameter shall be bent around a diameter equal to double the wall thickness of the tubing. The outside surface of the tube shall be on the outside of the bend. In either flattening or bending, the fold shall be along a weld zone if the specimen is of welded tubing. There shall be no evidence of cracks or defects due to bending.

4.10 Ultrasonic procedures:

4.10.1 Ultrasonic inspection: Ultrasonic inspection shall be conducted as follows:

Tubing shall be inspected by ultrasonic, immersion, pulse echo methods. A calibration shall be performed at the start of operations and periodically reestablished at least once each hour of continuous operation. Separate calibration standards as in 4.10.2 shall be used for each tubing size. The arrangement of transducers shall be such that no cross-talk is encountered. Tube supporting equipment shall provide in-line stability throughout the complete length of each tube. For the disclosure of discontinuities, a shear mode shall be employed. The equipment shall be such that transducers functioning in a clockwise and counterclockwise direction may be separately gated and recorded. The pulse rate of the equipment shall provide 100 percent coverage at maximum tube rotational rates. The helix feed angle shall be such that a rejectable signal from the longitudinal calibration notch is produced on two consecutive powered turns of the tube.