

STEEL TUBING, SEAMLESS, CORROSION AND HEAT RESISTANT  
9.0Mn - 20Cr - 6.5Ni - 0.28N  
Solution Heat Treated

UNS S21904

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant steel in the form of seamless tubing.

1.2 Application: Primarily for fluid-conducting lines requiring both corrosion and heat resistance, especially when such parts are welded or brazed during fabrication, and having strength higher than that of the 18-8 type steels. Parts requiring oxidation resistance up to 1100°F (593°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

- AMS 2243 - Tolerances, Corrosion and Heat Resistant Steel Tubing
- MAM 2243 - Tolerances, Metric, Corrosion and Heat Resistant Steel Tubing
- AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
- AMS 2350 - Standards and Test Methods
- AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Wrought Products Except Forgings and Forging Stock

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2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products

ASTM A708 - Detection of Susceptibility to Intergranular Corrosion in Severely Sensitized Austenitic Stainless Steel

ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

ASTM E426 - Electromagnetic (Eddy-Current) Testing of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E353, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Carbon	--	0.04
Manganese	8.00 -	10.00
Silicon	--	1.00
Phosphorus	--	0.060
Sulfur	--	0.030
Chromium	19.00 -	21.50
Nickel	5.50 -	7.50
Nitrogen	0.15 -	0.40
Molybdenum	--	0.75
Copper	--	0.75

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248.

3.2 Condition: Solution heat treated and descaled.

3.3 Fabrication: Tubing shall be produced by a seamless process. The external and internal surface finishes may be produced by pickling, bright annealing, or any method which will provide the required surface condition and which will not affect limits of wall thickness or corrosion resistance, with the exception that centerless ground finish is not acceptable. A light polish to improve surface appearance may be employed after solution heat treatment. Passivation treatment shall follow any surface treatment used.

3.4 Properties: Tubing shall conform to the following requirements:

3.4.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM A370:

Tensile Strength, minimum	90,000 psi (621 MPa)
Yield Strength at 0.2% Offset, minimum	50,000 psi (345 MPa)
Elongation in 2 Inches (50.8 mm), minimum	
Strip Specimens	40%
Full Tube Specimens	45%

3.4.2 Flarability: Specimens as in 4.3.1 from tubing 0.125 to 2.000 inches  $\emptyset$  (3.18 to 50.80 mm), incl, in nominal OD shall withstand flaring at room temperature, without formation of cracks or other visible defects, by being forced axially with steady pressure over a hardened and polished tapered steel pin having a 74-degree included angle to produce a flare having a permanent expanded OD not less than shown in Table I.

TABLE I

Nominal OD Inches	Expanded OD Inches	Nominal OD Inches	Expanded OD Inches
0.125	0.200	0.750	0.937
0.188	0.302	1.000	1.187
0.250	0.359	1.250	1.500
0.312	0.421	1.500	1.721
0.375	0.484	1.750	2.106
0.500	0.656	2.000	2.356
0.625	0.781		

TABLE I (SI)

Nominal OD Millimetres	Expanded OD Millimetres	Nominal OD Millimetres	Expanded OD Millimetres
3.18	5.08	19.05	23.80
4.78	7.67	25.40	30.15
6.35	9.12	31.75	38.10
7.92	10.69	38.10	43.71
9.52	12.29	44.45	53.49
12.70	16.66	50.80	59.84
15.88	19.84		

3.4.2.1 Tubing with nominal OD between any two standard sizes given in 3.4.2 shall take the same percentage flare as shown for the larger of the two sizes.

3.4.2.2 Flarability requirements for tubing under 0.125 inch (3.18 mm) or over 2.000 inches (50.80 mm) in nominal OD shall be as agreed upon by purchaser and vendor.

- 3.4.3 Pressure Test: The tubing shall show no bulges, leaks, pinholes, cracks, or other defects when subjected to an internal hydrostatic pressure (P), except that a diametric permanent set of 0.002 inch per inch (0.002 mm/mm) of diameter is acceptable. The hydrostatic pressure (P) shall be determined from the equation:

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

where, P = Test pressure in psi (MPa)  
S = Minimum yield Strength from 3.4.1  
D = Nominal OD  
d = Nominal ID

- 3.4.4 Embrittlement: Tubing, after being sensitized by heating to 1250°F ± 25 (677°C ± 14) in air, holding at heat for 60 minutes ± 5, and cooling in air, shall withstand exposure for 24 hours ± 0.25 to copper sulfate/sulfuric acid solution in accordance with ASTM A708 without evidence of intercrystalline surface attack. After exposure, full cross-sectional specimens of tubing 0.625 inch (15.88 mm) and under in nominal OD shall be flattened to a total thickness under load of three times the wall thickness of the tubing and 1 inch (25 mm) long specimens of tubing over 0.625 inch (15.88 mm) in nominal OD shall be split and bent 180 degrees with outside surface of tube on inside of bend, around a diameter equal to the nominal wall thickness without showing cracks or other defects. In either flattening or bending, the fold shall be made parallel to the axis of the tube.

### 3.5 Quality:

- 3.5.1 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 aircraft tubing. It shall be smooth and free from heavy scale or oxide, burrs, seams, tears, grooves, laminations, slivers, pits, and other imperfections detrimental to usage of the tubing. 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 imperfections is not required.
- 3.5.2 Tubing shall be free from grease or other foreign matter. Metallic flakes or particles shall not be collected by a clean white 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 particles, is acceptable.
- 3.5.3 When specified by purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645, to ultrasonic inspection in accordance with AMS 2632, to electromagnetic (eddy-current) inspection in accordance with ASTM E426, or to any combination thereof. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered. Straight tubing will be acceptable in mill lengths of 6 - 20 feet (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).

3.7 Tolerances: Shall conform to all applicable requirements of AMS 2243 or MAM 2243.

#### 4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of tubing shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.4. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the tubing conforms to the requirements of this specification.

#### 4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), tensile properties (3.4.1), pressure test (3.4.3), nondestructive inspection when specified (3.5.3), and tolerances (3.7) are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for flarability (3.4.2) and embrittlement (3.4.4) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be in accordance with AMS 2371 and the following:

4.3.1 Specimens for flarability test (3.4.2) shall be full tubes or sections cut from a tube. The end of the specimen to be flared shall be cut square, with the cut end smooth and free from burrs, but not rounded.

4.4 Reports: The vendor of tubing shall furnish with each shipment a report showing the results of tests for chemical composition of each heat for tensile properties and pressure test of each lot. This report shall include the purchase order number, lot number, AMS 5562B, size, and quantity.

4.5 Resampling and Retesting: Shall be in accordance with AMS 2371.

#### 5. PREPARATION FOR DELIVERY:

5.1 Identification: Shall be as follows: