# ADOPTION NOTICE

SAE-AMS5586, "NICKEL ALLOY, CORROSION AND HEAT RESISTANT, WELDED TUBING 57NI - 19.5CR - 13.5CO - 4.2MO - 2.9TI - 1.4AL - 0.006B 0.08ZR CONSUMABLE ELECTRODE OR VACUUM INDUCTION MELTED, ANNEALED", was adopted on 20-DEC-91 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: ASC/ENOI, Building 560, 2530 Loop Road West, Wright-Patterson AFB, OH 45433-7101. Copies of this document may be purchased from the Society of Automotive Engineers 400 Commonwealth Drive Warrendale, Pennsylvania, United States, 15096-0001. http://www.sae.org/

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# AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5586E

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Submitted for recognition as an American National Standard

Superseding AMS 5586D

## NICKEL ALLOY, CORROSION AND HEAT RESISTANT, WELDED TUBING
57Ni - 19.5Cr - 13.5Co - 4.2Mo - 2.9Ti - 1.4Al - 0.006B - 0.08Zr
Consumable Electrode or Vacuum Induction Melted, Annealed

UNS NO7001



1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat resistant nickel alloy in the form of welded tubing.

1.2 Application:

This tubing has been used typically for parts requiring high strength up to 1500 °F (816 °C) and oxidation resistance up to 1750 °F (954 °C), but usage is not limited to such applications.

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 publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

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

AMS 2263 Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
MAM 2263 Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
AMS 2269 Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys
AMS 2371 Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2634 Ultrasonic Inspection, Thin Wall Metal Tubing
AMS 2807 Identification, Carbon and Low-Alloy Steels, Corrosion and Heat Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

| | |
|---|---|
| ASTM E 8 | Tension Testing of Metallic Materials |
| ASTM E 8M | Tension Testing of Metallic Materials (Metric) |
| ASTM E 18 | Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials |
| ASTM E 112 | Determining the Average Grain Size |
| ASTM E 139 | Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials |
| ASTM E 354 | Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys |
| ASTM E 426 | Electromagnetic (Eddy-Current) Testing of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys |
| ASTM E 1417 | Liquid Penetrant Examination |

2.3 U.S. Government Publications:

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

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

| Element | min | max |
|---|---|---|
| Carbon | 0.02 | 0.10 |
| Manganese | -- | 0.10 |
| Silicon | -- | 0.15 |
| Phosphorus | -- | 0.015 |
| Sulfur | -- | 0.015 |
| Chromium | 18.00 | 21.00 |
| Cobalt | 12.00 | 15.00 |
| Molybdenum | 3.50 | 5.00 |
| Titanium | 2.50 | 3.25 |
| Aluminum | 1.20 | 1.60 |
| Boron (3.1.1) | 0.003 | 0.010 |
| Zirconium | 0.02 | 0.15 |
| Iron | -- | 2.00 |
| Copper | -- | 0.10 |
| Nickel | remainder | |

3.1.1 Boron may be less than 0.003% by weight, determined on tubing having nominal wall thickness under 0.050 inch (1.27 mm), provided the specified requirement is met on the stock from which sheet or strip for making tubing is rolled.

3.1.2 Check Analysis: Composition variations shall meet the requirements of AMS 2269.

3.2 Melting Practice:

Alloy shall be produced by multiple melting using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used for remelting.

3.3 Condition:

Annealed and descaled. Annealing shall be performed in a suitable protective atmosphere at such temperature and for such time as will produce tubing meeting the requirements of 3.5. Cooling from the annealing temperature shall be at a rate equivalent to an air cool or faster.

3.4 Fabrication:

Tubing 2.00 inches (50.8 mm) and under in nominal OD shall be cold worked after welding and prior to annealing.

3.5 Properties:

Tubing 0.125 inch (3.18 mm) and over in nominal OD and 0.015 inch (0.38 mm) and over in nominal wall thickness shall conform to the following requirements:

3.5.1 As Annealed:

3.5.1.1 Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2 - Tensile Properties

| Property | Value |
|---|---|
| Tensile Strength, max | 145 ksi (1000 MPa) |
| Yield Strength at 0.2% Offset, max | 80.0 ksi ( 552 MPa) |
| Elongation in 2 Inches (50.8 mm) or 4D, min | 35% |

3.5.1.2 Flarability: Specimens as in 4.3.1 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 1.2 times the nominal OD.

3.5.1.3 (R) Average Grain Size: Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112 (See 8.2).

3.5.2 After Solution, Stabilization, and Precipitation Heat Treatment: Tubing shall meet the requirements of 3.5.2.1, 3.5.2.2, and 3.5.2.3 after being solution heat treated by heating in a suitable atmosphere to 1825 °F ± 25 (996 °C ± 14), holding at heat for 2 hours ± 0.25, and cooling at a rate equivalent to an air cool or faster; stabilization treated by heating to 1550 °F ± 15 (843 °C ± 8), holding at heat for 4 hours ± 0.25, and cooling in air; and precipitation treated by heating to 1400 °F ± 15 (760 °C ± 8), holding at heat for 16 hours ± 1, and cooling in air.

3.5.2.1 Tensile Properties: Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 3 - Minimum Tensile Properties

| Property | Value |
|---|---|
| Tensile Strength | 160 ksi (1103 MPa) |
| Yield Strength at 0.2% Offset | 105 ksi ( 724 MPa) |
| Elongation in 2 Inches (50.8 mm) | 15% |

3.5.2.2 (R) Hardness: Shall be 34 to 44 HRC, or equivalent (See 8.3), determined in accordance with ASTM E 18.

3.5.2.3 Stress-Rupture Properties: Shall be as follows, determined in accordance with ASTM E 139; the test at 1500 ºF (816 ºC) (3.5.2.3.2) need be run only if the tubing fails to pass the test at 1350 ºF (732 ºC) and tubing which passes the test of 3.5.2.3.2 will be acceptable:

3.5.2.3.1 At 1350 ºF (732 º C): A tensile specimen, maintained at 1350 ºF ± 3 (732 ºC ± 2) while a load sufficient to produce the initial axial stress shown in Table 4 is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not less than shown in Table 4.

TABLE 4A - Stress Rupture Requirements, Inch/Pound Units

| Nominal Wall Thickness Inch | Stress ksi | Elongation in 2 Inches %, min |
|---|---|---|
| 0.015 to 0.020, incl | 62.5 | 4 |
| Over 0.020 to 0.030, incl | 65.0 | 4 |
| Over 0.030 to 0.050, incl | 67.5 | 4 |
| Over 0.050 | 70.0 | 5 |

TABLE 4B · Stress Rupture Requirements, SI Units

| Nominal Wall Thickness Millimeters | Stress MPa | Elongation in 50.8 %, min |
|---|---|---|
| 0.38 to 0.51, incl | 431 | 4 |
| Over 0.51 to 0.76, incl | 448 | 4 |
| Over 0.76 to 1.27, incl | 465 | 4 |
| Over 1.27 | 483 | 5 |



3.5.2.3.2 (R) At 1500 ºF (816 ºC): A tensile specimen, maintained at 1500 ºF ± 3 (816 ºC ± 2 ) while a load sufficient to produce an initial axial stress of 37.5 ksi (259 MPa) or higher is aplied continuously, shall not rupture in less than 23 hours. Elongation after rupture, measured at room temperature, shall be not less than 5% in 2 inches (50.8 mm).

3.5.2.3.2.1 (R) The test of 3.5.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 37.5 ksi (259 MPa) or higher shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 to 16 hours, preferably 8 to 10 hours, thereafter, the stress shall be increased in increments of 2.5 ksi (17 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.2.3.2.

3.6 Quality:

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, 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.

3.6.1 If weld reinforcement is present at the weld on the inner surface of tubing over 2.00 inches (50.8 mm) in nominal OD, such weld reinforcement shall be not thicker than 0.010 inch (0.25 mm). The outer surface of all tubing and the inner surface of tubing 2.00 inches (50.8 mm) and under in nominal OD shall be free from weld reinforcement.

3.6.2 When specified by purchaser, tubing shall be subjected to fluorescent penetrant inspection in accordance with ASTM E 1417, to ultrasonic inspection in accordance with AMS 2634, to electromagnetic (eddy-current) inspection in accordance with ASTM E 426, or to any combination thereof. Tubing shall meet the requirements of 3.6 and other acceptance criteria established by the cognizant engineering organization.

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2263 or MAM 2263.

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. 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: The following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 (R) Tensile properties (3.5.1.1) average grain size (3.5.1.3) and tolerances (3.7) of each lot as annealed.

4.2.1.3 Tensile properties (3.5.2.1), hardness (3.5.2.2), and stress-rupture properties (3.5.2.3) of each lot after solution, stabilization, and precipitation heat treatment.