SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS5955

Issued 2013-01

Steel, Corrosion-Resistant, Bars, Wire, and Forgings
10Cr - 12Ni - 2Mo – 1.45Al – 1.15Ti
Vacuum Induction Plus Vacuum Consumable Electrode Melted
Solution Heat Treated, Precipitation Hardenable

(Composition similar to UNS S11902)

RATIONALE

AMS5955 is a new specification for a corrosion-resistant steel in the form of bars, wire, forgings, and forging stock, and is intended to replace the cancelled AMS5938.

1. SCOPE

1.1 Form

This specification covers a corrosion-resistant steel in the form of bars, wire, forgings, and forging stock.

1.2 Application

These products have been used typically for heat-treated parts requiring stress corrosion resistance, along with a combination of high strength and high toughness up to 800 °F (427 °C) with good ductility and strength in the transverse direction, but usage is not limited to such applications.

1.2.1 Certain design, processing procedures, or environmental conditions may cause these products to become susceptible to stress-corrosion cracking; ARP1110 recommends practices to minimize such conditions.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS5955

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2241 Tolerances, Corrosion and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire

AMS2248 Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

AMS2300 Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure

AMS2371 Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock

AMS2374 Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steel and Alloy Forgings

AMS2750 Pyrometry

AMS2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys

AMS2808 Identification, Forgings

AS1182 Standard Stock Removal Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A 370 Mechanical Testing of Steel Products

ASTM A 604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets

ASTM E 353 Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

ASTM E 399 Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

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 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - COMPOSITION

Element	min	max
Carbon	--	0.02
Manganese	--	0.25
Silicon	--	0.25
Phosphorus	--	0.015
Sulfur	--	0.010
Chromium	9.50	10.50
Nickel	11.50	13.00
Molybdenum	1.75	2.25
Titanium	0.95	1.50
Aluminum	1.30	1.70
Nitrogen	--	0.01

3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248.

3.2 Melting Practice

Product shall be multiple melted using vacuum induction melting followed by vacuum consumable electrode remelt practice.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Bars, Wire, and Forgings

Bar shall not be cut from plate (See 4.4.7).

3.3.1.1 Rounds

Solution heat treated and turned, centerless ground, and polished.

3.3.1.2 Hexagons

Solution heat treated and descaled.

3.3.1.3 Squares and Flats

Hot finished, solution heat treated, and machined or descaled.

3.3.1.4 Wire

Cold finished, solution treated and unless heat treated in an atmosphere producing a bright finish, descaled.

3.3.1.5 Forgings

Solution heat treated and descaled.

3.3.2 Forging Stock

As ordered by the forging manufacturer.

3.4 Heat Treatment

Bars, wire, and forgings shall be solution heat treated by heating to 1560 °F ± 25 (850°C ± 14), holding at heat for 90 minutes ± 15, and quenching in oil or water, cooling to -100 °F (-73 °C) or colder, holding at that temperature for not less than sixteen hours, and warming in air to room temperature. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements; tensile and hardness testing shall be performed in accordance with ASTM A 370.

3.5.1 All Products

3.5.1.1 Macrostructure

Visual examination of transverse full cross-sections from bars, billets, and forging stock, etched in hot hydrochloric acid in accordance with ASTM A 604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM A 604 shown in Table 2.

TABLE 2 - MACROSTRUCTURE LIMITS

Class	Condition	Severity
1	Freckles	A
2	White Spots	A
3	Radial Segregation	A
4	Ring Pattern	B

3.5.2 Bars, Wire, and Forgings

3.5.2.1 As Solution Heat Treated

3.5.2.1.1 Tensile Strength

Wire shall have tensile strength not higher than 160 ksi (1103 MPa).

3.5.2.1.2 Hardness

3.5.2.1.2.1 Bars

Not higher than 331 HB, or equivalent (See 8.2), determined at mid-radius or quarter thickness.

3.5.2.1.2.2 Forgings

Not higher than 331 HB, or equivalent (See 8.2).

3.5.2.2 After Precipitation Heat Treatment

The solution heat treated product, 10 inches (254 mm) and under in nominal diameter or maximum cross-sectional dimension, precipitation heat treated to the temperature and time shown in Table 3 and cooled in air, oil, or other suitable liquid quench (See 8.3), shall have the properties specified in 3.5.2.2.1, 3.5.2.2.2, and 3.5.2.2.3.

TABLE 3 - PRECIPITATION HEAT TREATING PARAMETERS

Condition	Temperature	Time
H950	950 °F ± 10 (510 °C ± 6)	16 hours ± 0.3

3.5.2.2.1 Tensile Properties

Shall be as shown in Table 4.

TABLE 4A - MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS

Condition	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %	Reduction of Area %
H950	Longitudinal	268	249	9	40
	Transverse	268	248	7	35

TABLE 4B - MINIMUM TENSILE PROPERTIES, SI UNITS

Condition	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %	Reduction of Area %
H950	Longitudinal	1850	1715	9	40
	Transverse	1850	1710	7	35

3.5.2.2.1.1 Longitudinal tensile property requirements apply to specimens taken in the longitudinal direction from bars and wire and to specimens taken from forgings with axis of specimen in the area of gage length varying not more than 15 degrees from parallel to the forging flow lines.

3.5.2.2.1.2 Transverse tensile property requirements apply to specimens taken approximately perpendicular to the longitudinal direction of bars and to specimens taken from forgings with axis of specimens in the area of gage length varying not more than 15 degrees from perpendicular to the forging flow lines.

3.5.2.2.1.3 Transverse tensile property requirements apply only to products from which a test specimen not less than 2.5 inches (63.5 mm) long can be taken. If the cross-sectional dimensions of the product permit, the transverse testing shall be of the short-transverse (ST) direction; otherwise, the orientation shall be long transverse (LT).

3.5.2.2.1.4 Products tested in the transverse direction need not be tested in the longitudinal direction.

3.5.2.2.2 Hardness

Shall not be lower than shown in Table 5, or equivalent (See 8.2). Product shall not be rejected on the basis of hardness if the tensile property requirements of Table 4 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

TABLE 5 - MINIMUM HARDNESS

Condition	Hardness, HB	HRC
H950		52.1

3.5.2.2.3 Fracture Toughness

Shall not be lower than shown in Table 6, determined in accordance with ASTM E 399 on specimens in the longitudinal LT or LR orientation from product 3.00 inches (76.2 mm) and over in nominal section thickness. If product size precludes use of specimens which will provide valid K_{Ic} results, use of K_Q values for acceptance is permissible.

TABLE 6 - MINIMUM FRACTURE TOUGHNESS, K_{IC}

Condition	Fracture Toughness ksi$\sqrt{inch}$	Fracture Toughness MPa$\sqrt{m}$
H950	41	45

3.5.3 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4 and 3.5.2.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.2.2.1, 3.5.2.2.2, and 3.5.2.2.3. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.2.2 conform to the requirements of 3.5.2.2.1, 3.5.2.2.2 and 3.5.2.2.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.6 Quality

3.6.1 Steel shall be premium aircraft quality conforming to AMS2300.

3.6.2 The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.6.3 Bars and wire ordered hot rolled or cold drawn, or ground, turned, or polished shall, after removal of the standard stock removal allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.

3.6.4 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of reentrant grain flow.

3.7 Tolerances

Bars and wire shall conform to all applicable requirements of AMS2241.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of the product shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

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) and macrostructure rating (3.5.1.1) of each heat.

4.2.1.2 Tensile properties (3.5.2.1.1) of wire as solution heat treated.

4.2.1.3 Hardness (3.5.2.1.2) of bars and forgings, as solution heat treated.

4.2.1.4 Tensile properties (3.5.2.2.1) and hardness (3.5.2.2.2) of bars, wire, and forgings after precipitation heat treatment at 950 °F (510 °C).

4.2.1.5 Tolerances (3.7) of bars and wire.

4.2.1.6 Ability of forging stock (3.5.3) to develop required properties.

4.2.2 Periodic Tests

The following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.2.1 Fracture toughness (3.5.2.2.3) of bars and forgings after heat treatment.

4.2.2.2 Frequency-severity cleanliness rating (3.6.1).

4.2.2.3 Grain flow of die forgings (3.6.4).

4.3 Sampling and Testing

4.3.1 Bars, Wire, and Forging Stock

In accordance with AMS2371.

4.3.2 Forgings

In accordance with AMS2374.

4.4 Reports

The vendor of the product shall furnish with each shipment a report showing the following results of tests and relevant information:

4.4.1 For each heat

Composition (3.1) and macrostructure (3.5.1.1).

4.4.2 For each lot of wire, bars, and forgings

If wire, tensile strength as solution heat treated (3.5.2.1.1)
If bar or forgings, hardness solution heat treated (3.5.2.1.2)
Tensile properties (3.5.2.2.1) and hardness (3.5.2.2.2) after precipitation heat treatment to the H950 hardened condition.

4.4.3 A statement that the product conforms to the other technical requirements.

4.4.4 Purchase Order Number
Heat and lot numbers
AMS5955
Size
Quantity.

4.4.5 If forgings are supplied, the size and melt source of stock used to make the forgings.

4.4.6 The vendor of stock for forgings shall furnish with each shipment a report showing the results of test for the composition of each heat and of the ability of the forging stock to develop the required properties (3.5.3). This report shall include the purchase order number, heat and lot number, AMS5955, size and quantity.

4.4.7 If the ship size/shape is cut from a larger cross section, report the nominal metallurgically worked size (See 3.3.1).

4.5 Resampling and Retesting

4.5.1 Bars, Wire, and Forging Stock

In accordance with AMS2371.