



AEROSPACE MATERIAL SPECIFICATION

AMS5398™

REV. H

Issued 1955-08
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Reaffirmed 2023-11

Superseding AMS5398G

Steel, Corrosion-Resistant, Sand and Centrifugal Castings
16Cr - 4.1Ni - 0.22Cb (Nb) - 2.8Cu
Solution Heat Treated
(Composition similar to UNS J92200)

RATIONALE

AMS5398H introduces Exceptions (3.8), revises Composition analysis standard (3.1), Quality (3.7.2.1), and Reports (4.5.1), and is a Five-Year Review and update of this specification.

AMS5398H has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

1.1 Form

This specification covers a corrosion-resistant steel in the form of sand or centrifugal castings.

1.2 Application

These castings have been used typically for parts requiring corrosion resistance and strength up to 600 °F (316 °C), but usage is not limited to such applications. Certain processing procedures and service conditions may cause these products to become subject 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.

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For more information on this standard, visit
<https://www.sae.org/standards/content/AMS5398H/>

SAE WEB ADDRESS:

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2175	Castings, Classification and Inspection of
AMS2248	Chemical Check Analysis Limits Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS2633	Ultrasonic Inspection Centrifugally-Cast, Corrosion-Resistant Steel Tubular Cylinders
AMS2694	In-Process Welding of Castings
AMS2700	Passivation of Corrosion Resistant Steels
AMS2750	Pyrometry
AMS2804	Identification Castings
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
ARP1110	Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys

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 A370	Mechanical Testing of Steel Products
ASTM A751	Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM E140	Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
ASTM E446	Reference Radiographs for Steel Castings up to 2 inches (51 mm) in Thickness
ASTM E1417/E1417M	Liquid Penetrant Testing
ASTM E1444/E1444M	Magnetic Particle Testing
ASTM E1742/E1742M	Radiographic Examination

3. TECHNICAL REQUIREMENTS

3.1 Composition

Castings shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	--	0.06
Manganese	--	0.70
Silicon	0.50	1.00
Phosphorus	--	0.04
Sulfur	--	0.03
Chromium	15.50	16.70
Nickel	3.60	4.60
Columbium (Niobium)	0.10	0.35
Copper	2.50	3.20
Aluminum	--	0.05
Tin	--	0.02
Nitrogen	--	0.05

3.1.1 Producer may test for any element not listed in Table 1 and include this analysis in the report of 4.5. Limits of acceptability may be specified by purchaser (see 8.2.2).

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248.

3.2 Melting Practice

Castings and specimens shall be poured at the casting producer's facility either from a melt (see 8.2.3) of a master heat or directly from a master heat (see 8.2.4).

3.2.1 Revert (gates, sprues, risers, and rejected castings) may be used only in the preparation of master heats; revert shall not be remelted directly, without refining, for pouring of castings. Melting of revert creates a new master heat.

3.2.2 Portions of two or more qualified master heats (see 3.4.1) may be melted together and poured into castings using a procedure authorized by purchaser.

3.2.3 If modifications such as alloy additions or replenishments are made at remelt by the producer, producer shall have a written procedure acceptable to purchaser which defines the controls, tests, and traceability criteria for both castings and separately-cast specimens. Control factors of 4.4.2.2 shall apply.

3.3 Condition

Castings shall be delivered in the solution heat treated condition.

3.4 Test Specimens

3.4.1 Each master heat shall be qualified by evaluation of chemical and tensile specimens.

3.4.1.1 If alloy additions or replenishments are made at remelt as in 3.2.3, the frequency of sampling and testing used by the producer for qualification shall be acceptable to purchaser.

3.4.1.2 The tensile tests of 3.4.1 are not required if these tests are conducted using integrally-cast specimens (4.3.3.2) or specimens machined from castings (4.3.3.3).

3.4.2 Chemical Analysis Specimens

Shall be of any convenient size and shape.

3.4.3 Tensile Coupons

Shall be attached to castings, as prolongation or integral, if practicable, or shall be standard keel blocks conforming to ASTM A370, unless purchaser permits use of cast-to-size specimens. Coupons shall be cast with each melt of metal for castings, shall be cast in molds made of suitable core sand, shall be poured from the same ladles as the castings, and shall be kept in the mold until black. Metal for the coupons shall be part of the melt which is used for the castings. Tensile specimens in accordance with ASTM A370 shall be machined from the coupons after heat treatment as in 3.5.

3.4.3.1 If specimens are separately-cast, producer shall have a written procedure acceptable to purchaser. Control factors of 4.4.2.2 shall apply.

3.5 Heat Treatment

Castings and representative tensile coupons shall be given a homogenization heat treatment prior to solution heat treatment or, when permitted by purchaser, may be given two solution heat treatments. Pyrometry shall be in accordance with AMS2750. At least one set of tensile coupons shall, during each stage of heat treatment, be put into a batch-type furnace with each load of castings or into a continuous furnace at intervals of no longer than 3 hours.

3.5.1 Homogenization Heat Treatment

Heat to $2100^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($1149^{\circ}\text{C} \pm 14^{\circ}\text{C}$), hold at heat for not less than 90 minutes, and cool as required to below 70°F (21°C).

3.5.2 Solution Heat Treatment

Heat to $1900^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($1038^{\circ}\text{C} \pm 14^{\circ}\text{C}$), hold at heat for 60 minutes per inch (25 mm) of maximum cross-section, but not less than 30 minutes, and cool as required to below 70°F (21°C).

3.6 Properties

Castings and representative tensile specimens produced in accordance with 3.4.3 shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A370.

3.6.1 As Solution Heat Treated

3.6.1.1 Hardness of Castings

Shall be not higher than 363 HB, or equivalent (see 8.3).

3.6.2 After Precipitation Heat Treatment

Castings and representative tensile specimens shall have the following properties after being heated to $925^{\circ}\text{F} \pm 15^{\circ}\text{F}$ ($496^{\circ}\text{C} \pm 8^{\circ}\text{C}$), held at heat for not less than 90 minutes, and cooled in air to room temperature. Properties after precipitation heat treatment at temperatures other than $925^{\circ}\text{F} \pm 15^{\circ}\text{F}$ ($496^{\circ}\text{C} \pm 8^{\circ}\text{C}$) shall be as agreed upon by purchaser and producer.

3.6.2.1 Tensile Properties of separately-cast coupons or integrally-cast coupons shall be as shown in Table 2.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	180 ksi (1241 MPa)
Yield Strength at 0.2% Offset	150 ksi (1034 MPa)
Elongation in 4D	6%
Reduction of Area	12%

3.6.2.2 Tensile Properties of Castings

When specified on the drawing or when agreed upon by purchaser and producer, tensile specimens conforming to ASTM A370 shall be machined from castings selected at random from each lot and heat treated in accordance with 3.6.2. Properties of such specimens shall conform to Table 2 requirements.

3.6.2.3 Hardness

Shall be not lower than 375 HB, or equivalent (see 8.3).

3.7 Quality

3.7.1 Castings, as received by purchaser, shall be uniform in quality and condition. Castings shall, to the extent defined in 3.7.2, 3.7.3, 3.7.4, and 3.7.5, or in supplemental standards specified by purchaser be free from porosity, foreign materials, cracks, and other imperfections detrimental to their performance. Castings shall be free of cracks, laps, hot tears, and cold shuts, and free of scale and other surface contamination which would obscure defects.

3.7.1.1 Unless otherwise specified, castings shall have smooth surfaces and shall be sufficiently cleaned such that, after passivation by the purchaser, cast surfaces shall meet the corrosion test requirement of AMS2700.

3.7.2 Castings shall be produced under radiographic control. This control shall consist of radiographic examination of each casting part number until foundry manufacturing controls in accordance with 4.4.2 have been established. Additional radiography shall be conducted in accordance with the frequency of inspection specified by purchaser or as necessary to ensure continued maintenance of internal quality.

3.7.2.1 Radiographic inspection shall be conducted in accordance with ASTM E1742/E1742M or another method specified by purchaser. ASTM E446 may be used to define radiographic acceptance standards.

3.7.3 When specified, additional nondestructive testing shall be performed as follows:

3.7.3.1 Fluorescent penetrant inspection in accordance with ASTM E1417/E1417M or another method specified by purchaser.

3.7.3.2 Magnetic particle inspection in accordance with ASTM E1444/E1444M or another method specified by purchaser.

3.7.4 Acceptance standards for radiographic, fluorescent penetrant, magnetic particle, visual, and other inspection methods shall be as agreed upon by purchaser and producer. AMS2175 may be used to specify acceptance standards (casting grade) and frequency of inspection (casting class).

3.7.4.1 When acceptance standards are not specified, Grade C of AMS2175 shall apply for each applicable method of inspection.

3.7.5 Centrifugal castings shall be ultrasonically tested in accordance with AMS2633 and shall conform to the requirements of ultrasonic discontinuity Grade A for longitudinal and shear modes. Testing and acceptance of parts outside of the dimensional limits defined in AMS2633 shall be as agreed upon by purchaser and producer.

3.7.6 Castings shall not be peened, plugged, impregnated, or welded unless authorized by purchaser.

3.7.6.1 When authorized by purchaser, welding in accordance with AMS2694 or another welding program acceptable to purchaser may be used.

3.8 Exceptions

Any exceptions shall be authorized by purchaser and reported as in 4.5.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of castings shall supply all samples for producer'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 castings conform to the specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), hardness after solution heat treatment (3.6.1.1), tensile properties after precipitation heat treatment (3.6.2.1), hardness after precipitation heat treatment (3.6.2.3), and applicable requirements of quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

- 4.2.1.1 Tensile properties of specimens cut from castings shall be determined only when specified by purchaser or when separately-cast coupons or integrally-cast specimens are not available. Tensile properties of separately-cast coupons or integrally-cast specimens need not be determined when tensile properties of specimens cut from castings are determined.

4.2.2 Periodic Tests

Corrosion resistance (3.7.1.1) and radiographic soundness (3.7.2) are periodic tests and shall be performed at a frequency selected by producer unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests

All technical requirements are preproduction tests and shall be performed on sample castings (4.3.2), when a change in control factors occurs (4.4.2.2), and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing

Shall be in accordance with the following:

- 4.3.1 One chemical analysis specimen or a casting from each master heat shall be tested for conformance with Table 1; if 3.4.1.1 applies, test frequency shall be acceptable to purchaser.
- 4.3.2 One preproduction casting in accordance with 4.4.1 shall be tested to the requirements of the casting drawing and to all technical requirements.
 - 4.3.2.1 Dimensional inspection sample quantity shall be as specified by purchaser.
 - 4.3.3 Tensile tests shall be conducted to determine conformance with 3.6.2. Sampling and test frequency is dependent upon the type and origin of the specimen specified by purchaser (see 3.6.2) or selected by producer (see 4.3.3.4).
 - 4.3.3.1 For separately-cast specimens (see 3.4.3.1 and 3.6.2.1), one specimen from each master heat (see 8.2.4) in the precipitation heat treated condition (see 3.6.2).
 - 4.3.3.2 For integrally-cast specimens (see 3.4.3 and 3.6.2.1), two specimens from each lot (see 8.2.6) in the precipitation heat treated condition (see 3.6.2).
 - 4.3.3.3 For specimens machined from castings (see 3.6.2.2), one casting from each lot (see 8.2.6) in the precipitation heat treated condition (see 3.6.2), tested at each location shown on the engineering drawing.
 - 4.3.3.3.1 When size and location of specimens are not shown, two test specimens shall be tested, one from the thickest section and one from the thinnest section. Once established under 4.4.2.2, test locations may be changed only as agreed upon by purchaser and producer.
 - 4.3.3.4 When acceptable to purchaser, specimens machined from casting may be used in lieu of both separately-cast and integrally-cast specimens, and integrally-cast specimens may be used in lieu of separately-cast specimens. In each case, the resultant properties must conform to the requirements of 3.6 for that type of specimen.
 - 4.3.3.4.1 When specimens are selected for test as in 4.3.3.4 from an origin other than that specified by purchaser, producer shall include in the report of 4.5 a description of the origin of the specimen that was tested.
 - 4.3.3.5 When casting size, section thickness, gating method, or other factors do not permit conformance with 4.3.3.2 or 4.3.3.3, sampling and testing shall be agreed upon by purchaser and producer.

4.3.4 Castings shall be inspected in accordance with 3.7 to the methods, frequency, and acceptance standards specified by purchaser.

4.3.5 Each tensile specimen shall be tested for hardness to determine conformance with 3.6.2.3.

4.3.5.1 Product shall not be rejected on the basis of hardness if the tensile properties are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness, or another sample with similar nonconforming hardness.

4.3.6 When an AMS2175 Class is specified for a centrifugal casting, the castings shall be ultrasonically inspected in accordance with requirements of 3.7.5, 4.3.6.1, 4.3.6.2, and Table 3. When a class is not specified, castings shall be considered as Class 1, unless otherwise approved by the cognizant engineering organization.

4.3.6.1 For Class 1 - Each casting.

4.3.6.2 For Class 4 - None required.

Table 3 - Ultrasonic inspection schedule

Class 2 Lot Size	Class 2 Sample Size	Class 3 Lot Size	Class 3 Sample Size
2 to 5	All	2 to 4	All
6 to 8	5	5 to 6	4
9 to 11	6	7 to 11	5
12 to 15	7	12 to 17	6
16 to 20	8	18 to 27	7
21 to 26	9	28 to 48	8
27 to 36	10	49 and Over	9
37 to 51	11		
52 to 82	12		
83 to 162	13		
163 to 971	14		
972 and Over	15		

4.4 Approval

4.4.1 Sample casting(s) from new or reworked master patterns or molds produced under the casting procedure of 4.4.2 shall be approved by purchaser before castings for production use are supplied, unless such approval be waived by purchaser.

4.4.2 For each casting part number, producer shall establish parameters for the process control factors that will produce castings and test specimens meeting the requirements of the casting drawing and this specification. These parameters shall constitute the approved casting procedure and shall be used for production of subsequent castings and test specimens. If necessary to make any change to these parameters, producer shall submit a statement of the proposed change for purchaser reapproval. When requested, producer will also submit test specimens, sample castings, or both to purchaser for reapproval.

4.4.2.1 Production castings produced prior to receipt of purchaser's approval shall be at producer's risk.

4.4.2.2 Control factors for producing castings and separately-cast specimens include, but are not limited to, the factors shown below. Supplier's procedures shall identify tolerances, ranges, and/or control limits, as applicable. Control factors for separately-cast specimens must generally represent, but need not be identical to, those factors used for castings (see 3.2.3 and 3.4.1.1).

Type of melting furnace
Melting furnace atmosphere
Fluxing or deoxidation procedure
Gating and risering practices (for sand castings)
Mold set-up, reheat temperature, and rotational speed (for centrifugal castings)
Metal pouring temperature; variation of ± 50 °F (± 28 °C) from the established limit is permissible
Solidification and cooling procedures
Heat treatment cycles
Cleaning operations
Methods of inspection

4.4.2.2.1 Any of the control factors for which parameters are considered proprietary by the producer may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation.

4.4.2.2.1.1 Unless otherwise agreed upon by purchaser and producer, purchaser shall be entitled to review proprietary control factor details and coding at producer's facility.

4.5 Reports

The producer of castings shall furnish with each shipment a report showing the results of tests for composition of at least one casting, or of specimens as in 3.4.1 from each melt, for tensile properties of separately-cast coupons or integrally-cast specimens representing each lot, and stating that the castings conform to the other technical requirements of this specification. When properties of specimens cut from castings are specified, the report shall include the results of tests to determine conformance to such requirements. This report shall include the purchase order number, heat and lot numbers, AMS5398H, precipitation heat treatment temperature if other than 925 °F ± 15 °F (496 °C ± 8 °C), part number, and quantity.

4.5.1 When castings produced to this specification have exceptions authorized by purchaser taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS5398H(EXC) because of the following exceptions." and the specific exceptions shall be listed.

4.6 Resampling and Retesting

If the results of a valid test fail to meet requirements, two additional specimens in accordance with 4.3 from the same master heat, modified melt (see 3.2.3), or lot, as applicable, shall be tested for each nonconforming characteristic. The results of each additional test, and the average of the results of all tests (original and retests) shall meet the specified requirements; otherwise, the master heat or lot shall be rejected. Results of all tests shall be reported.

4.6.1 A test may be declared invalid if failure is due to specimen mis-preparation, test equipment malfunction, improper test procedure, or the presence of random process defects such as inclusions or gas holes in a tensile specimen.

4.6.2 Unless otherwise authorized by purchaser, castings and specimens may be subjected to not more than one reheat treatment cycle in event of hardness and/or property failure. Upon reheat treatment, castings and specimens shall be submitted for testing in accordance with 4.3.3, 4.3.4, and 4.3.5.

5. PREPARATION FOR DELIVERY

5.1 Identification

If not otherwise specified by purchaser, individual castings shall be identified in accordance with AMS2804.

5.2 Traceability

Individual castings shall be traceable to their conditions of manufacture and inspection up to and including the point of acceptance by purchaser.