AEROSPACE MATERIAL SPECIFICATION

AMS5400	REV. C

Issued 1979-01
Revised 2014-07

Superseding AMS5400B

Steel, Corrosion-Resistant, Investment Castings
15Cr - 4.6Ni - 0.22Cb - 2.8Cu
Solution and Precipitation Heat Treated (H935)
170 ksi (1172 MPa) Tensile Strength
(Composition similar to UNS J92110)

RATIONALE

AMS5400C revises referenced standards, Reports (4.5) and Identification (5.1.2), and is a Five-Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers a corrosion-resistant steel in the form of investment castings.

1.2 Application

These castings have been used typically for parts requiring good corrosion resistance and strength up to 600 °F (316 °C), but usage is not limited to such applications (See 8.2).

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.

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), or 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

AMS2360 Room Temperature Tensile Properties of Castings

AMS2694 In-Process Welding of Castings

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/AMS5400C

AMS2700 Passivation of Corrosion Resistant Steels

AMS2804 Identification, Castings

AMS-H-6875 Heat Treatment of Steel Raw Materials

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, or www.astm.org.

ASTM E 8/E 8M Tension Testing of Metallic Materials

ASTM E 18 Rockwell Hardness of Metallic Materials

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

ASTM E 1417/E 1417M Liquid Penetrant Testing

ASTM E 1444/E 1444M Magnetic Particle Testing

ASTM E 1742/E 1742M Radiographic Inspection

3. TECHNICAL REQUIREMENTS

3.1 Composition

Castings 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 (See 8.3.1 and 8.3.2).

TABLE 1 - COMPOSITION

Element	min	max
Carbon	--	0.05
Manganese	--	0.60
Silicon	0.50	1.00
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	14.00	15.50
Nickel	4.20	5.00
Columbium	0.15	0.30
Copper	2.50	3.20
Tantalum	--	0.05
Nitrogen	--	0.05

3.1.1 Vendor may test for any element not otherwise listed in Table 1 and include this analysis in the report of 4.5. Limits of acceptability may be specified by purchaser (See 8.3.3).

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2248.

3.2 Melt Practice

Castings and specimens shall be poured at casting vendor's facility either from a melt (See 8.3.4) of a master heat or directly from a master heat (See 8.3.5).

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.

3.2.2 Portions of two or more qualified master heats (See 3.4.2) may be melted together and poured into castings using a procedure authorized by purchaser (See 8.3.6).

3.2.3 If modifications, such as alloy additions or replenishments, are made by the vendor at remelt, vendor shall have a written procedure acceptable to purchaser which defines the controls, test, 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 solution and precipitation heat treated, except as specified in 3.3.1 or 3.3.2.

3.3.1 When specified by or when acceptable to purchaser, castings shall be solution heat treated twice and precipitation heat treated.

3.3.2 When specified by purchaser, castings shall be homogenization, solution, and precipitation heat treated.

3.4 Test Specimens

Specimens shall be either separately-cast, integrally-cast (See 8.3.7), or machined from casting, and shall conform to 3.2.

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

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

3.4.2.1 If alloy additions or replenishments are made at remelt as in 3.2.3, the frequency of sampling and testing used by the vendor for qualification to 3.4.2 shall be acceptable to purchaser.

3.4.2.2 Tensile tests of 3.4.2 are not required if these tests are conducted using integrally-cast specimens (4.3.3.2) or specimens machined from casting (4.3.3.3).

3.4.3 Chemical Analysis Specimens

Shall be of any convenient size and shape.

3.4.4 Tensile Specimens

Shall be of standard proportions in accordance with ASTM E 8/E 8M with 0.250 inch (6.35 mm) diameter at the reduced parallel gage section.

3.4.4.1 Separately-cast and integrally-cast specimens may be either cast to size or cast oversize and subsequently machined to 0.250 inch (6.35 mm) diameter.

3.4.4.2 When integrally-cast specimens or specimens machined from casting are specified, specimen size and location shall be agreed upon by purchaser and vendor (See 8.3.8 and 8.5).

3.5 Heat Treatment

Castings and representative tensile specimens shall be heat treated in accordance with AMS-H-6875 except as specified in 3.5.1.

3.5.1 Castings and Tensile Specimens

3.5.1.1 Homogenization Heat Treatment (When Specified)

Heat to 2100 °F ± 25 (1149 °C ± 14), hold at heat for not less than 90 minutes, and cool as required.

3.5.1.2 Solution Heat Treatment

Heat to 1900 °F ± 25 (1038 °C ± 14), hold at heat for 60 minutes per inch (25.4 mm) of maximum cross-section, and cool to below 90 °F (32 °C) at a rate equivalent to an air cool or faster.

3.5.1.3 Precipitation Heat Treatment

Heat to 935 °F ± 15 (502 °C ± 8), hold at heat for 4 hours ± 0.25, and cool in air.

3.5.2 Tensile specimens used for master heat qualification may be heat treated separately from castings.

3.6 Properties

Conformance shall be based upon testing of separately-cast specimens unless purchaser specifies integrally-cast specimens or specimens machined from casting.

3.6.1 Room Temperature Tensile Properties

Shall be as specified in 3.6.1.1 or 3.6.1.2, determined in accordance with ASTM E 8/E 8M. Properties other than those listed may be defined as specified in AMS 2360.

3.6.1.1 Separately-Cast Specimens

Shall be as shown in Table 2.

TABLE 2 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	170 ksi (1172 MPa)
Yield Strength at 0.2% Offset	150 ksi (1034 MPa)
Elongation in 4D	7%
Reduction of Area	16%

3.6.1.2 Integrally-Cast Specimens or Specimens Machined from Castings

Shall be as shown in Table 3.

TABLE 3 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	170 ksi (1172 MPa)
Yield Strength at 0.2% Offset	150 ksi (1034 MPa)
Elongation in 4D	6%
Reduction of Area	14%

3.6.2 Hardness

Shall be as follows, determined in accordance with ASTM E 18:

3.6.2.1 Castings

Except as specified in 4.3.5.2, castings which are heat treated to the condition of 3.3 shall have hardness of 38 to 47 HRC.

3.6.2.2 Representative Specimens

Hardness not applicable.

3.7 Quality

Castings, 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 castings.

3.7.1 Unless otherwise specified by purchaser, the following shall apply:

3.7.1.1 Castings shall be free of cracks, laps, hot tears, and cold shuts.

3.7.1.2 Castings shall be free of scale and other process-induced surface contamination which would obscure defects.

3.7.1.3 Cast surfaces shall be sufficiently cleaned such that, after passivation by purchaser, the castings 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 E 1742/E 1742M or other method specified by purchaser.

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

3.7.3.1 Fluorescent penetrant inspection in accordance with ASTM E 1417/E 1417M or other method specified by purchaser.

3.7.3.2 Magnetic particle inspection in accordance with ASTM E 1444/E 1444M or other 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 vendor (See 8.3.8). 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.

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

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

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of castings 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 castings conform to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), tensile properties (3.6.1), hardness of castings (3.6.2), and quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests

Corrosion resistance (3.7.1.3) and radiographic soundness (3.7.2) are periodic tests and shall be performed at a frequency selected by vendor, 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

The minimum testing performed by vendor 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, unless 3.4.2.1 applies in which case test frequency shall be acceptable to purchaser.

4.3.2 One preproduction casting in accordance with 4.4 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 3.6.1 or 3.6.2. Sampling and test frequency is dependent upon the type and origin of the specimen specified by purchaser (See 3.6) or selected by vendor (See 4.3.3.4). When 3.4.2.1 applies, test frequency shall be acceptable to purchaser.

4.3.3.1 For separately-cast specimens in the fully heat treated condition (See 3.3 and 3.5.1), one specimen from each master heat shall be tested for conformance to 3.6.1.1.

4.3.3.2 For integrally-cast specimens in the fully heat treated condition (See 3.3 and 3.5.1), two specimens from each lot (See 8.3.9) shall be randomly selected and tested for conformance to 3.6.1.2.

4.3.3.3 For specimens machined from casting, one casting shall be randomly selected from each lot and tested after full heat treatment (See 3.3 and 3.5.1) at each location shown on the engineering drawing for conformance to 3.6.1.2.

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 vendor.

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 shall 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, vendor 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 vendor.

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 Castings shall be tested for hardness to determine conformance to 3.6.2.1. Unless otherwise specified by purchaser, the number of castings sampled from each lot shall be in accordance with Table 4.

4.3.5.1 In the event that a lot fails to meet the specified accept/reject number of Table 4, the entire lot shall be 100% inspected or reheat treated in accordance with 4.6.2.

4.3.5.2 Castings shall not be rejected on the basis of low hardness if tensile property requirements of Table 3 are met.

TABLE 4 - HARDNESS TEST SCHEDULE OF PRECIPITATION HEAT TREATED CASTINGS

Lot Size	Sample Size	Accept	Reject
1 to 8	All	0	1
9 to 50	8	0	1
51 to 90	13	0	1
91 to 150	20	0	1
151 to 280	32	0	1
281 to 500	50	0	1
501 to 1200	80	0	1
1201 to 3200	125	0	1
3201 and over	200	0	1

4.4 Approval

4.4.1 Sample casting(s) from new or reworked master patterns 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, vendor shall establish parameters for process control factors that will consistently 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, vendor shall submit a statement of the proposed changes for purchaser reapproval. When requested, vendor shall 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 vendor'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):

Composition of ceramic cores, if used
Arrangement and number of patterns in the mold (including integrally-cast specimens, if applicable)
Size, shape, and location of gates and risers
Mold refractory formulation
Grain refinement methods, if applicable
Mold back up material (weight, thickness, or number of dips)
Type of furnace, atmosphere, and charge for melting
Mold preheat and metal pouring temperatures
Fluxing or deoxidation procedure
Replenishment and alloy addition procedures, if applicable
Time molten metal is in furnace
Solidification and cooling procedures
Cleaning operations (mechanical and chemical)
Heat treatment
Straightening
Final inspection methods
Location of specimens machined from casting, if applicable

4.4.2.2.1 Any of the control factors for which parameters are considered proprietary by vendor 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 vendor, purchaser shall be entitled to review proprietary control factor details and coding at vendor's facility.

4.5 Reports

The producer of castings shall furnish with each shipment a certification document declaring that castings have been processed, tested, and inspected as specified and that the results of the inspections and tests conform to requirements.

4.5.1 Unless otherwise specified, vendor shall furnish test report(s) showing the results of tests and inspections conducted in accordance with 4.2 and 4.3.

4.5.1.1 Chemical analysis determinations, property test data, and the results of any retests conducted shall be expressed numerically to reflect actual quantitative test values.

4.5.1.2 Hardness test readings may be expressed as single values or as a range of values exhibited by results obtained from the sample size.

4.5.1.3 Inspection and preproduction results shall be reported at the frequency specified by, and in a format acceptable to purchaser.

4.5.1.4 Objective evidence of purchaser's review and acceptance of nonconforming material shall be provided with the certification document at each shipment. (See 7).

4.5.2 The certification document and test report(s) shall be traceable to the purchase order number, master heat identification, heat treat/lot number, AMS5400C, part number, quantity, and when required (See 5.1.2) the list of individual serial numbers or serial number range.

4.5.2.1 If 4.3.3.4.1 applies, the mechanical property test report shall denote the source of the specimens that were tested.

4.5.3 Test reports for acceptance testing of 4.2 shall be as follows:

4.5.3.1 For each master heat:

Composition (See 4.3.1)

4.5.3.2 For each lot:

Tensile properties (See 4.3.3.1, 4.3.3.2 or 4.3.3.3)
Inspection results (See 4.3.4)
Hardness (See 4.3.5)

4.5.4 The vendor shall retain records of processing and inspection in accordance with purchaser requirements.

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 in accordance with the applicable testing standard, including when failure is due to specimen mispreparation, test equipment malfunction, improper test procedure, or the presence of random process anomalies, 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 of 3.5.1.2 and 3.5.1.3 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.