

AEROSPACE MATERIAL SPECIFICATION



AMS 5356B

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Reaffirmed APR 2006

Superseding AMS 5356A

Steel, Corrosion Resistant, Investment Castings
15Cr - 4.6Ni - 0.22Cb - 2.8Cu
Solution and Precipitation Heat Treated (H1100)
130 ksi (896 MPa) Tensile Strength
(Composition similar to UNS J92110)

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 8.3).

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications:

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

AMS 2248	Chemical Check Analysis Limits, Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS 2360	Room Temperature Tensile Properties of Castings
AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings

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2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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 353	Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1444	Magnetic Particle Examination
ASTM E 1742	Radiographic Examination

2.3 U.S. Government Publications:

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

MIL-H-6875	Heat Treatment of Steels, Process for
MIL-STD-2175	Castings, Classification and Inspection of
QQ-P-35	Passivation Treatments for Corrosion-Resisting Steel

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 8.2.1 and 8.2.2).

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 listed in Table 1 and include this analysis in the report of 4.5. Limits of acceptability may be specified by purchaser (See 8.2.3).
- 3.1.2 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2248.
- 3.2 Melting Practice:
- Castings and specimens shall be poured at the casting vendor's facility either from a melt (See 8.2.4) of a master heat or directly from a master heat (See 8.2.5).
- 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. Melting of revert creates a new master heat.
- 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 8.2.6).
- 3.2.3 If modifications such as alloy additions or replenishments are made at remelt by the vendor, vendor 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 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 8.2.7), 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 The 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 castings (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 or ASTM 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 8.2.8 and 8.5).

3.5 Heat Treatment:

Castings and representative tensile specimens shall be heat treated in accordance with MIL-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 \pm 25 (1149 °C \pm 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 \pm 25 (1038 °C \pm 14), hold at heat for 60 minutes per inch (25 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 1100 °F \pm 15 (593 °C \pm 8), hold at heat for 4 hours \pm 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 castings.

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 or ASTM 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	130 ksi (896 MPa)
Yield Strength at 0.2% Offset	120 ksi (827 MPa)
Elongation in 4D	8%
Reduction of Area	20%

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	130 ksi (896 MPa)
Yield Strength at 0.2% Offset	120 ksi (827 MPa)
Elongation in 4D	6%
Reduction of Area	18%

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

3.6.2.1 Castings: Castings which are heat treated in accordance with 3.3 shall have hardness of 33 to 40 HRC (See 4.3.5.2).

3.6.2.2 Representative Specimens: Not applicable.

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, and 3.7.4, or in supplemental standards specified by the purchaser, be free from porosity, foreign materials, and 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 be sufficiently cleaned such that, after passivation by purchaser, the cast surfaces shall meet the corrosion test requirement of QQ-P-35.

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 or another 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 or another method specified by purchaser.

3.7.3.2 Magnetic particle inspection in accordance with ASTM E 1444 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 vendor (See 8.2.8). MIL-STD-2175 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 MIL-STD-2175 shall apply for each applicable method of inspection.

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 AMS 2694 or another 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 (3.6.2.1), and applicable requirements of quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests: Corrosion resistance (3.7.1.1) 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; if 3.4.2.1 applies, 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. 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 (See 8.2.5).
 - 4.3.3.2 For integrally-cast specimens in the fully heat treated condition (See 3.3 and 3.5.1), two specimens shall be randomly selected from each lot (See 8.2.9).
 - 4.3.3.3 For specimens machined from castings, 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.
 - 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 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, 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 with 3.6.2.1. Unless otherwise specified by purchaser, the number of castings sampled from each lot shall be in accordance with Table 4.

TABLE 4 - Hardness Test Schedule of Heat Treated Castings

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

- 4.3.5.1 If a single casting from the inspection lot fails to meet the specified requirement, the entire lot shall be 100% inspected or reheat treated in accordance with 4.6.2.
- 4.3.5.2 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.
- 4.4 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 change 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 procedure, if applicable

Time molten metal is in furnace

Solidification and cooling procedures

Cleaning operations (mechanical and chemical)

Heat treatment for delivery

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 vendor of castings shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements. This report shall include the purchase order number, master heat identification, heat treat/lot identification, AMS 5356B, part number, quantity, and source of any tensile property specimens used according to 4.3.3.4.1.

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.