

# AEROSPACE MATERIAL SPECIFICATION

**SAE**

**AMS 5346A**

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Superseding AMS 5346

Submitted for recognition as an American National Standard

STEEL, CORROSION RESISTANT, INVESTMENT CASTINGS  
15Cr - 4.6Ni - 0.22(Cb + Ta) - 2.8Cu  
Solution and Precipitation Heat Treated  
180 ksi (1241 MPa) Tensile Strength

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.

## 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 2248 Chemical Check Analysis Limits, Wrought 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, 1916 Race Street, Philadelphia, PA 19103-1187.

- ASTM E 8 Tension Testing of Metallic Materials
- 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

## 2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA. 19111-5094.

- MIL-H-6875 Heat Treatment of Steel, Process for
- MIL-STD-453 Inspection, Radiographic
- MIL-STD-1949 Inspection, Magnetic Particle
- MIL-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements
- MIL-STD-2175 Castings, Classification and Inspection of
- MIL-STD-6866 Inspection, Liquid Penetrant
- QQ-P-35 Passivation Treatments for Corrosion Resistant 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 + Tantalum | 0.15      | 0.30  |
| Copper               | 2.50      | 3.20  |
| Tantalum (3.1.2)     | --        | 0.10  |
| Nitrogen             | --        | 0.05  |
| Iron                 | remainder |       |

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 8.2.3).

3.1.2 Determination not required for routine acceptance.

3.1.3 Check Analysis: Composition variations shall meet the requirements of AMS 2248.

### 3.2 Melt Practice:

Castings and specimens shall be poured at 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.

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 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:

Solution and precipitation heat treated.

### 3.4 Test Specimens:

Specimens shall be either separately cast, integrally cast (See 8.2.7), or machined from castings, 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 property 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 qualification 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 a 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 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 as agreed upon by purchaser and vendor. (See 8.2.8 and 8.4.)

### 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 Specimens:

3.5.1.1 Solution Heat Treatment: Heat to  $1900^{\circ}\text{F} \pm 25$  ( $1038^{\circ}\text{C} \pm 14$ ), hold at heat for 60 minutes per inch (25 mm) of maximum cross-section, and cool to below  $90^{\circ}\text{F}$  ( $32^{\circ}\text{C}$ ) at a rate equivalent to an air cool or faster. Double solution treatment is acceptable.

3.5.1.2 Precipitation Heat Treatment: Heat to  $925^{\circ}\text{F} \pm 15$  ( $496^{\circ}\text{C} \pm 8$ ), hold at heat for not less than 90 minutes, 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 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 Table 2 or Table 3, determined in accordance with ASTM E 8. 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 Room Temperature Tensile Properties**

| Property                      | Value              |
|-------------------------------|--------------------|
| Tensile Strength              | 180 ksi (1241 MPa) |
| Yield Strength at 0.2% Offset | 160 ksi (1103 MPa) |
| Elongation in 4D              | 6%                 |
| Reduction of Area             | 15%                |

**3.6.1.2 Integrally-Cast Specimens or Specimens Machined from Castings:** Shall be as shown in Table 3.**TABLE 3 - Minimum Room Temperature Tensile Properties**

| Property                      | Value              |
|-------------------------------|--------------------|
| Tensile Strength              | 180 ksi (1241 MPa) |
| Yield Strength at 0.2% Offset | 160 ksi (1103 MPa) |
| Elongation in 4D              | 5%                 |
| Reduction of Area             | 12%                |

**3.6.2 Hardness:** Shall be as follows, determined in accordance with ASTM E 18.**3.6.2.1 Castings:** Castings, in the solution and precipitation heat treated condition of 3.5.1, shall have hardness not lower than 40 HRC and not higher than 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 QQ-P-35.
- 3.7.2 Acceptance standards for radiographic, magnetic particle, fluorescent penetrant, 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).
- 3.7.2.1 When acceptance standards are not specified, Grade C of MIL-STD-2175 shall apply.
- 3.7.3 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.
- 3.7.3.1 Radiographic inspection shall be conducted in accordance with MIL-STD-453 or other process method specified by purchaser.
- 3.7.4 When specified, additional nondestructive testing shall be performed as follows:
- 3.7.4.1 Fluorescent penetrant inspection in accordance with MIL-STD-6866 or other process method specified by purchaser.
- 3.7.4.2 Magnetic particle inspection in accordance with MIL-STD-1949 or other process method specified by purchaser.
- 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 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 performing 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 requirements of this specification.

##### 4.2 Classification of Tests:

- 4.2.1 Acceptance Tests: Tests for composition (3.1), tensile properties (3.6.1), hardness (3.6.2), and quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

- 4.2.2 Periodic Tests: Tests for corrosion resistance (3.7.1.3) and radiographic soundness (3.7.3) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests for 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.
- 4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.
- 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 property tests shall be conducted to determine conformance with Table 2 or Table 3. Sampling and test frequency is dependent upon the type and origin of 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 solution and precipitation heat treated condition of 3.5.1, at least one specimen from each master heat shall be tested to 3.6.1.
- 4.3.3.2 For integrally-cast specimens in the solution and precipitation heat treated condition of 3.5.1, at least two specimens from each lot (See 8.2.9) shall be randomly selected and tested to 3.6.1.
- 4.3.3.3 For specimens machined from casting, at least one casting shall be randomly selected from each lot and tested after solution and precipitation heat treatment of 3.5.1 at locations shown on the engineering drawing for conformance with 3.6.1.
- 4.3.3.3.1 When size and location of specimens are not shown, at least 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 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 to 4.3.3.2 or 4.3.3.3, sampling and testing shall be as 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. 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, determined on the casting from each heat treatment lot having the lowest hardness.

TABLE 4 - Hardness Test Schedule

| 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):

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  
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  
Time that molten metal is in the 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 shown above for which parameters are considered proprietary by the 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.