

# AEROSPACE MATERIAL SPECIFICATION



AMS 5398E

Issued AUG 1955  
Revised FEB 2000

Superseding AMS 5398D

Steel, Corrosion Resistant, Sand and Centrifugal Castings  
16Cr - 4.1Ni - 0.22(Cb + Ta) - 2.8Cu  
Solution Heat Treated

UNS J92200

## 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, such as accessory components, 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 form 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, 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 2633	Ultrasonic Inspection, Centrifugally-Cast, Corrosion-Resistant Steel Tubular Cylinders
AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings
ARP1110	Minimizing Stress Corrosion Cracking in Heat Treatable Wrought Low Alloy and Martensitic Corrosion Resistant Steels

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## 2.2 ASTM Publications:

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

ASTM A 370	Mechanical Testing of Steel Products
ASTM E 353	Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E 446	Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness
ASTM E 1417	Standard Practice for Liquid Penetrant Examination
ASTM E 1444	Standard Practice for Magnetic Particle 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 Steel, Process for
MIL-STD-453	Inspection, Radiographic
MIL-STD-2175	Castings, Classification and Inspection of

## 3. TECHNICAL REQUIREMENTS:

## 3.1 Composition:

Castings shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM E 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Carbon	--	0.06
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	0.10	0.35
Copper	2.50	3.20
Tantalum	--	0.05
Aluminum	--	0.05
Tin	--	0.02
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 8.2.1).
- 3.1.2 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2248.
- 3.2 Condition:
- Castings shall be delivered in the solution heat treated condition.
- 3.3 Casting:
- A melt shall be the metal poured from a single furnace charge of 15,000 pounds (6804 kg) or less.
- 3.4 Test Specimens:
- 3.4.1 Chemical Analysis Specimens: Shall be of any convenient size and shape.
- 3.4.2 Tensile Coupons: Shall be attached to castings, as prolongation or integral, if practicable, or shall be standard keel blocks conforming to ASTM A 370, 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 A 370 shall be machined from the coupons after heat treatment as in 3.5.
- 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 AMS 2750. 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 not longer than three hours.
- 3.5.1 Homogenization Heat Treatment: Heat to 2100 °F ± 25 (1149 °C ± 14), 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 °F ± 25 (1038 °C ± 14), 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 3.4.2 shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A 370.

### 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  $925\text{ }^{\circ}\text{F} \pm 15$  ( $496\text{ }^{\circ}\text{C} \pm 8$ ), 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  $925\text{ }^{\circ}\text{F} \pm 15$  ( $496\text{ }^{\circ}\text{C} \pm 8$ ) shall be as agreed upon by purchaser and vendor.

3.6.2.1 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 Castings:

3.6.2.2.1 Tensile Properties: When specified on the drawing or when agreed upon by purchaser and vendor, tensile specimens conforming to ASTM A 370 shall be machined from castings selected at random from each lot. Properties of such specimens shall conform to Table 2 requirements.

3.6.2.2.2 Hardness: Should be not lower than 375 HB, or equivalent (See 8.3), but castings shall not be rejected on the basis of hardness if the tensile property requirements of Table 2 are met.

### 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 subsequent paragraphs or in supplemental standards specified by purchaser be free from foreign materials, cracks, and other imperfections detrimental to their performance.

3.7.1.1 Castings shall have smooth surfaces and shall be well cleaned. Metallic shot or grit shall not be used for final cleaning.

3.7.2 Castings shall be produced under radiographic control. This control shall consist of radiographic examination of castings in accordance with MIL-STD-453 or other method specified by purchaser, until proper foundry technique, which will produce castings free from harmful internal imperfections, is established for each part number and of production castings as necessary to ensure maintenance of satisfactory quality. Castings designated as MIL-STD-2175, Class 4, do not require radiographic control unless specified by the cognizant design activity.

- 3.7.3 When specified, castings shall be subjected to magnetic particle inspection in accordance with ASTM E 1444, to fluorescent penetrant inspection in accordance with ASTM E 1417, or to both.
- 3.7.3.1 Centrifugal castings shall be ultrasonically tested in accordance with AMS 2633 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 AMS 2633 shall be as agreed upon by purchaser and vendor.
- 3.7.4 Radiographic, magnetic particle, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E 446 shall be used to define radiographic acceptance standards.
- 3.7.5 Castings shall not be peened, plugged, welded, or repaired by other methods without written permission from purchaser.
- 3.7.5.1 When permitted in writing by purchaser, defects in castings may be removed and the castings reworked by welding in accordance with AMS 2694.

#### 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 the specified requirements.

##### 4.2 Classification of Tests:

Except as specified in 4.2.1, tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, on each melt or lot as applicable, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

- 4.2.1 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.

##### 4.3 Sampling and Testing:

Shall be in accordance with the following; a lot shall be all castings from a single melt solution heat treated as a heat treat batch.

- 4.3.1 One or more chemical analysis specimens in accordance with 3.4.1 from each melt or a casting from each lot.
- 4.3.2 Three tensile coupons in accordance with 3.4.2 or three integrally-cast specimens representing each lot except when properties of specimens machined from castings are required.
- 4.3.3 Two preproduction castings in accordance with 4.4.1 of each part number.
- 4.3.4 One or more castings from each lot when properties of specimens machined from castings are required. Size, location, and number of specimens machined from castings shall be as specified on the drawing or as agreed upon by purchaser and vendor. When size, location, and number of specimens are not specified, not less than two tensile specimens, one from the thickest section and one from the thinnest section, shall be cut from a casting or castings from each lot.
- 4.3.5 When MIL-STD-2175 Class is specified, castings shall be ultrasonically inspected in accordance with requirements of 4.3.5.1, 4.3.5.2, and Table 3. When a class is not specified, castings shall be considered as Class 1, unless otherwise approved by the cognizant engineering organization.
- 4.3.5.1 For Class 1 - Each casting.
- 4.3.5.2 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 - 5	All	2 - 4	All
6 - 8	5	5 - 6	4
9 - 11	6	7 - 11	5
12 - 15	7	12 - 17	6
16 - 20	8	18 - 27	7
21 - 26	9	28 - 48	8
27 - 36	10	49 and Over	9
37 - 51	11		
52 - 82	12		
83 - 162	13		
163 - 971	14		
972 and Over	15		

#### 4.4 Approval:

- 4.4.1 Sample castings from new or reworked patterns or molds and the casting procedure shall be approved by purchaser before castings for production use are supplied, unless such approval be waived by purchaser.
- 4.4.2 Vendor shall establish, for production of sample castings of each part number, parameters for the process control factors which will produce acceptable castings; these shall constitute the approved casting procedure and shall be used for producing production castings. If necessary to make any change in parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, tensile coupons, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.
- 4.4.2.1 Control factors for producing castings include, but are not limited to, the following:
- Type of furnace
  - Furnace atmosphere
  - Fluxing or deoxidation procedure
  - Gating and risering practices (for sand castings)
  - Mold set-up and rotational speed (for centrifugal castings)
  - Metal pouring temperature; variation of  $\pm 50^{\circ}\text{F}$  ( $\pm 28^{\circ}\text{C}$ ) from the established limit is permissible
  - Solidification and cooling procedures
  - Heat treatment cycles
  - Cleaning operations
  - Methods of inspection
- 4.4.2.1.1 Any of the above process control factors 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.

#### 4.5 Reports:

The vendor of castings shall furnish with each shipment a report showing the results of tests for chemical 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, AMS 5398E, precipitation heat treatment temperature if other than  $925^{\circ}\text{F} \pm 15$  ( $496^{\circ}\text{C} \pm 8$ ), part number, and quantity.