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400 Commonwealth Dr., Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5398D

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Superseding AMS 5398C

STEEL CASTINGS, SAND AND CENTRIFUGAL, CORROSION RESISTANT
16Cr - 4.1Ni - 0.22(Cb + Ta) - 2.8Cu
Solution Heat Treated, Precipitation Hardenable

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: Primarily for parts, such as accessory components, requiring corrosion resistance and strength up to 600°F (316°C). 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 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 documents shall be as specified in AMS 2350.

- 2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

- AMS 2350 - Standards and Test Methods
- AMS 2360 - Room Temperature Tensile Properties of Castings
- AMS 2633 - Ultrasonic Inspection, Centrifugally-Cast, Corrosion-Resistant Steel Tubular Cylinders
- AMS 2635 - Radiographic Inspection
- AMS 2640 - Magnetic Particle Inspection
- AMS 2645 - Fluorescent Penetrant Inspection
- AMS 2694 - Repair Welding of Aerospace Castings
- AMS 2804 - Identification, Castings

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2.1.2 Aerospace Recommended Practices:

ARP1110 - Minimizing Stress Corrosion Cracking in Heat Treatable Wrought Low Alloy and Martensitic Corrosion Resistant Steels

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products

ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

ASTM E446 - Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-H-6875 - Heat Treatment of Steel, Process for

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-2175 - Castings, Classification and Inspection of

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E353, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	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 + Tantalum	0.10 -	0.35
Copper	2.50 -	3.20
Aluminum	--	0.05
Tin	--	0.02
Nitrogen	--	0.05

3.2 Condition: Solution heat treated.

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, shape, and form.

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 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.

3.5 Heat Treatment: Castings and representative tensile coupons shall be heat treated as follows; castings and coupons may be given a homogenization heat treatment prior to solution heat treatment or may be given two solution heat treatments when permitted by purchaser, and shall be so treated when specified by purchaser; furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-6875. 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 $2100^{\circ}\text{F} \pm 25$ ($1149^{\circ}\text{C} \pm 14$), 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 $1900^{\circ}\text{F} \pm 25$ ($1038^{\circ}\text{C} \pm 14$), hold at heat for 60 minutes per inch (25.4 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 A370:

3.6.1 As Solution Heat Treated:

3.6.1.1 Hardness of Castings: Shall be not higher than 363 HB, or equivalent.

3.6.2 After Precipitation Heat Treatment: Castings and representative tensile specimens shall have the following properties after being heated to $925^{\circ}\text{F} \pm 15$ ($496^{\circ}\text{C} \pm 8$), 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 $925^{\circ}\text{F} \pm 15$ ($496^{\circ}\text{C} \pm 8$) shall be as agreed upon by purchaser and vendor.

3.6.2.1 Separately-Cast Coupons or Integrally-Cast Coupons:

3.6.2.1.1 Tensile Properties:

Tensile Strength, minimum	180,000 psi (1241 MPa)
Yield Strength at 0.2% Offset, minimum	150,000 psi (1034 MPa)
Elongation in 4D, minimum	6%
Reduction of Area, minimum	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 A370 shall be machined from castings selected at random from each lot. Properties of such specimens shall conform to 3.6.2.1.1 requirements. Definition may be as specified in AMS 2360.

3.6.2.2.2 Hardness: Should be not lower than 375 HB, or equivalent, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.2.2.1 are met.

3.7 Quality:

3.7.1 Castings, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials, cracks, and other imperfections detrimental to usage of the castings.

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 AMS 2635 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 AMS 2640, to fluorescent penetrant inspection in accordance with AMS 2645, 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 E446 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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. 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: 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.
- 4.2.2 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: 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 I. 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 I

Class 2		Class 3	
Lot Size	Sample Size	Lot Size	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.