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NOTICE OF
ADOPTION

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Title of Document: STEEL CASTINGS, INVESTMENT, CORROSION AND MODERATE HEAT RESISTANT, 12.5Cr (SAE 51410) Hardened and Tempered

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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5350G

Issued 12-1-47

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Superseding AMS 5350F

STEEL CASTINGS, INVESTMENT, CORROSION AND MODERATE HEAT RESISTANT
12.5Cr (SAE 51410)
Hardened and Tempered

UNS J91152

1. SCOPE:

1.1 Form: This specification covers a corrosion and moderate heat resistant steel in the form of investment castings.

1.2 Application: Primarily for small parts, such as compressor blades and vanes, for use up to 1000°F (540°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 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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2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products

ASTM E192 - Reference Radiographs of Investment Steel Castings for Aerospace Applications

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

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

3. TECHNICAL REQUIREMENTS:

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

	min	max
Carbon	0.05	0.15
Manganese	--	1.00
Silicon	--	1.00
Phosphorus	--	0.04
Sulfur	--	0.03
Chromium	11.50	13.50
Nickel	--	0.50
Molybdenum	--	0.50
Aluminum	--	0.05
Copper	--	0.50
Tin	--	0.05

3.2 Condition: Hardened (air-cooled from the austenitizing temperature) and tempered in accordance with MIL-H-6875 to a hardness of 90 - 105 HRB, or equivalent, determined in accordance with ASTM A370.

3.3 Casting: Castings shall be poured either from remelted metal from a master heat or directly from a master heat. In either case, metal for castings shall be qualified as in 3.4.

3.3.1 A master heat is refined metal of a single furnace charge or is metal blended as in 3.3.2. Gates, sprues, risers, and rejected castings shall be used only in preparation of master heats; they shall not be remelted directly, without refining, for pouring of castings.

3.3.2 Metal from two or more master heats may be blended provided that the composition of each master heat to be blended is within the limits of 3.1 and that the total weight of metal blended does not exceed 15,000 lb (6800 kg). When two or more master heats are blended, the resultant blend shall be considered a master heat.

3.4 Master Heat Qualification: Each master heat shall be qualified by evaluation of chemical analysis and tensile specimens conforming to 3.4.1 and 3.4.2, respectively. A master heat may be considered conditionally qualified if vendor's test results show conformance to all applicable requirements of this specification. However, except when purchaser waives confirmatory testing, final qualification shall be based on purchaser's test results. Conditional qualification of a master heat shall not be construed as a guarantee of acceptance of castings poured therefrom.

3.4.1 Chemical Analysis Specimens: Shall be of any convenient size, shape, and form.

3.4.2 Tensile Specimens: Shall be cast from remelted metal from each master heat except when castings are poured directly from a master heat, in which case specimens shall also be poured directly from the master heat. Specimens shall be of standard proportions in accordance with ASTM A370 with 0.250 in. (6.25 mm) diameter at the reduced parallel gage section. They shall be cast to size or shall be cast oversize and subsequently machined to 0.250 in. (6.25 mm) diameter. Center gating may be used.

3.5 Properties: Castings, integrally-cast coupons, 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:

3.5.1 After Rehardening: Castings shall have hardness not lower than 35 HRC after being heated to $1750^{\circ}\text{F} + 10$ ($955^{\circ}\text{C} + 5$), held at heat for 60 min. ± 5 per inch (25 mm) of maximum cross-section, and cooled in air.

3.5.2 After Rehardening and Tempering: Castings, integrally-cast coupons, and separately-cast specimens shall have the following properties after being rehardened by heating to $1750^{\circ}\text{F} + 10$ ($955^{\circ}\text{C} + 5$), holding at heat for 60 min. ± 5 per inch (25 mm) of maximum cross-section, and cooling in air and tempered by heating for 60 min. ± 5 at $1350^{\circ}\text{F} + 15$ ($730^{\circ}\text{C} + 8$):

3.5.2.1 Tensile Properties:

Tensile Strength, min	95,000 psi (655 MPa)
Yield Strength at 0.2% Offset, min	75,000 psi (515 MPa)
Elongation in 4D, min	8%
Reduction of Area, min	20%

3.5.2.1.1 Specimens cut from castings or from integrally-cast coupons are not required for routine acceptance; however, properties obtained from such specimens may be the basis for acceptance of castings.

3.5.2.2 **Hardness:** Should be 94 - 100 HRB, or equivalent, but castings shall not be rejected on the basis of hardness if the tensile property requirements are met.

3.6 Quality:

3.6.1 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.

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

3.6.2 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.

3.6.3 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.

3.6.4 Radiographic, magnetic particle, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E192 may be used to define radiographic acceptance standards.

3.6.5 Castings shall not be repaired by peening, plugging, welding, or other methods without written permission from purchaser.

3.6.5.1 When permitted in writing by purchaser, defects in castings may be removed and the castings repaired 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:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), condition (3.2), and hardness after rehardening (3.5.1) are classified as acceptance tests and shall be performed on each master heat or lot as applicable.

- 4.2.2 Periodic Tests: Except as specified in 4.2.2.1, tests to determine conformance to requirements for tensile properties (3.5.2.1) and hardness (3.5.2.2) after rehardening and tempering are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.2.1 Tensile properties of specimens cut from castings shall be determined only when specified by purchaser or when integrally-cast coupons or separately-cast specimens are not available. Tensile properties of integrally-cast coupons or separately-cast specimens need not be determined when tensile properties of specimens cut from castings are determined.
- 4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4.2, 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, the contracting officer, or the request for procurement.
- 4.3 Sampling: Shall be in accordance with the following; a lot shall be all
∅ castings of the same part number poured from a single master heat and heat treated as a batch:
- 4.3.1 Two chemical analysis specimens in accordance with 3.4.1 from each master heat or a casting from each lot.
- 4.3.2 Three tensile specimens in accordance with 3.4.2 from each lot except when
∅ properties of specimens machined from integrally-cast coupons or 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 or two or more integrally-cast coupons
∅ from each lot when properties of specimens machined from castings or from integrally-cast coupons are required. Size, location, and number of specimens machined from castings or from integrally-cast coupons 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 representing the thickest section and one representing the thinnest section, shall be cut from a casting or castings or from integrally-cast coupons from each lot.

4.4 Approval:

- 4.4.1 Sample castings from new or reworked master patterns 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, separately for tensile specimens used for master heat qualification and for production of sample castings of each part number, parameters for the process control factors which will produce tensile specimens meeting master heat qualification requirements and acceptable castings; these shall constitute the approved casting procedures and shall be used for producing master heat qualification specimens and 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, test specimens, 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 tensile specimens and castings include, but are not limited to, the following:
- Type of furnace and its capacity
 - Type and size of furnace charge
 - Time molten metal is in furnace
 - Furnace atmosphere
 - Fluxing or deoxidation procedure
 - Number of ladles used in pour
 - Mold refractory formulation
 - Mold back-up material
 - Gating practices
 - Mold preheat and metal pouring temperatures; variations of $\pm 25^{\circ}\text{F}$ ($\pm 15^{\circ}\text{C}$) from established limits are permissible
 - Solidification and cooling procedures
 - Hardening and tempering procedures
 - 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:

- 4.5.1 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 cast in a mold with parts, from each master heat represented and the results of tests on castings or separately-cast specimens to determine conformance to the hardness after rehardening requirements, and stating that the castings conform to the other technical requirements of this specification. This report shall include the purchase order number, master heat number or code symbol, AMS 5350G, part number, and quantity.