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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5349C

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Superseding AMS 5349B

(R)

Steel, Corrosion Resistant, Investment Castings
13Cr
Free Machining; Hardened and Tempered

UNS J91161

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 small parts up to 1000 °F (538 °C), but usage is not limited to such applications. Corrosion resistance is lower than that of AMS 5350, but machinability is better.

1.3 Classification:

Castings are classified by chemistry as follows:

Type 1 - Sulfur content
Type 2 - Selenium content

1.3.1 Unless a specific type is ordered, either type may be supplied.

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.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

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

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-STD-2175	Castings, Classification and Inspection of
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

	Type I min	Type I max	Type II min	Type II max
Carbon	--	0.15	--	0.15
Manganese	--	1.25	--	1.25
Silicon	--	1.50	--	1.50
Phosphorus	--	0.040	--	0.040
Sulfur	0.15	0.35	--	0.03
Selenium	--	--	0.10	0.30
Chromium	11.50	14.00	11.50	14.00
Nickel	--	0.50	--	0.50
Molydenum	--	0.50	--	0.50
Aluminum	--	0.05	--	0.05
Copper	--	0.50	--	0.50
Zirconium	--	0.50	--	0.50
Tin	--	0.05	--	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.

3.1.3 Unless otherwise specified by purchaser, either composition may be supplied.

3.2 Melting 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. Melting 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 (See 8.2.10), 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:

Castings shall be delivered in the hardened and tempered condition.

3.4 Test Specimens:

Specimens shall be separately cast, integrally-cast (See 8.2.7), or machined from a 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, hardness, 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 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 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 or ASTM E 8M with 0.250 inch (6.35 mm) diameter at the reduced parallel gage section (See 8.3).

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 and specimens machined from a casting are specified, specimen size and location shall be agreed upon by purchaser and vendor. (See 8.2.8 and 8.6)

3.4.5 Hardness Specimens for Response to Heat Treatment: May be a representative specimen or a casting.

3.5 Heat Treatment:

To produce the condition in castings for delivery, harden by cooling at a rate equivalent to air cool from the austenitizing temperature and temper at temperatures and for times to conform to hardness of 3.6.2.

3.5.1 Response to Heat Treatment: Castings or representative test specimens shall be heat treated as follows, for subsequent testing to demonstrate response to heat treatment.

3.5.1.1 Hardening and Tempering: Heat to 1750 °F ± 10 (954 °C ± 6), hold at heat for 60 minutes per inch of maximum cross section but not less than 30 minutes, and cool at a rate equivalent to air cool.

3.5.1.2 Hardening and Tempering: Heat to 1750 °F ± 10 (954 °C ± 6), hold at heat for 30 minutes ± 3, and cool at a rate equivalent to still air cool. Heat to 1100 °F ± 10 (593 °C ± 6), hold at heat for 60 minutes per inch of maximum cross section but not less than one hour, 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 a casting. Properties for integrally-cast specimens and specimens machined from a casting shall be as specified by purchaser (See 8.6).

3.6.1 Room Temperature Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M (See 8.3) after heat treatment in accordance with 3.5.1.2. 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	90.0 ksi (621 MPa)
Yield Strength at 0.2% Offset	65.0 ksi (448 MPa)
Elongation in 4D (See 8.3)	8%
Reduction of Area	15%

3.6.2 Hardness of Production Castings: Shall be 90 to 105 HRB or equivalent (See 8.4), determined in accordance with ASTM E18 for the heat treat condition of 3.3. and 3.5.

3.6.3 Hardnesses as a Response to Heat Treatment: Shall be as follows, determined in accordance with ASTM E 18.

3.6.3.1 Castings and Representative Specimens as Hardened (See 3.5.1.1): Shall have a hardness not lower than 35 HRC, or equivalent (See 8.4).

3.6.3.2 Castings and Representative Specimens as Hardened and Tempered (See 3.5.1.2): Should have a hardness of 90 to 100 HRB, or equivalent (See 8.4), but castings shall not be rejected on the basis of hardness if the tensile properties of 3.6.1 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 and from imperfections detrimental to usage of the castings. Castings shall be free of cracks, laps, hot tears, and cold shuts, and free of scale and other process induced 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 castings 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 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 as applicable to steel castings 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 production castings (3.6.2), response to heat treatment after hardening (3.6.3.1) and applicable requirements of quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests: Response to heat treatment after hardening and tempering (3.6.3.2) 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), or 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 Table 2. 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 fully heat treated condition of 3.5.1.2, one specimen from each master heat shall be tested for conformance to 3.6.1.

4.3.3.2 For integrally-cast specimens in the fully heat treated condition of 3.5.1.2, two specimens from each lot (See 8.2.9) shall be randomly selected and tested for conformance to properties specified by purchaser.

4.3.3.3 For specimens machined from a casting, one casting shall be randomly selected from each lot and tested after full heat treatment of 3.5.1.2 at each location shown on the engineering drawing for conformance to the properties specified by purchaser.

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 a 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 3.6.1, or to alternative requirements specified by purchaser (8.6).

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 in the heat treated condition of 3.5 for delivery shall be tested for hardness to determine conformance to 3.6.2. Unless otherwise specified by purchaser, the number of castings from each lot shall be in accordance with Table 3.

TABLE 3 - Hardness Test Schedule

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.

4.3.6 For the hardened condition of 3.5.1.1, one specimen from each master heat shall be tested for hardness to determine conformance to 3.6.3.1.

4.3.7 For the hardened and tempered condition of 3.5.1.2, one specimen shall be tested for hardness to determine conformance to 3.6.3.2.

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 test 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 procedures, if applicable
Time molten metal is in furnace
Solidification and cooling procedures
Cleaning operations (mechanical and chemical)
Heat treatment for delivery and response to heat treatment
Straightening
Final inspection methods
Location and size of integrally-cast specimens and specimens machined from a 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.