ADOPTION NOTICE

SAE-AMS5357, "Steel, Corrosion Resistant, Investment Castings 15Cr - 4.6Ni - 0.22Cb - 2.8Cu Solution Heat Treated, Precipitation Hardenable", was adopted on 22-MAY-95 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: ASC/ENOSD, Building 125, 2335 Seventh Street, Suite 6, Wright-Patterson AFB, OH 45433-7809. DoD activities may obtain copies of this standard from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. The private sector and other Government agencies may purchase copies from the Society of Automotive Engineers Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.

Custodians:
Army - MR
Navy - AS
Air Force - 11

Adopting Activities
Air Force - 11

FSC MECA

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5357A

Issued OCT 1978
Revised MAY 1995

Superseding AMS 5357

Submitted for recognition as an American National Standard

(R) STEEL, CORROSION RESISTANT, INVESTMENT CASTINGS 15Cr - 4.6Ni - 0.22Cb - 2.8Cu Solution Heat Treated, Precipitation Hardenable

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 which will be machined in the solution heat treated condition and, after precipitation heat treatment, will require good corrosion resistance and strength up to 600 ºF (316 ºC), but usage is not limited to such applications (See 8.4).

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, 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, 1916 Race Street, Philadelphia, PA 19103-l 187.

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 1444	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-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-Resisting 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	0.15	0.30
Copper	2.50	3.20
Tantalum	--	0.05
Nitrogen	--	0.05

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 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 8.25).

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 modifications such as 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:

Castings shall be solution heat treated, except as specified in 3.3.1 or 3.3.2.

3.3.1 When specified by or when acceptable to purchaser, castings shall be solution heat treated twice.

3.3.2 When specified by purchaser, castings shall be homogenization and solution heat treated.

3.3.3 Precipitation heat treatment of castings shall not be performed by vendor unless purchaser specifies that castings are to be supplied in one of the age conditions specified in 3.5.3 (See 8.6).

3.4 Test Specimens:

Specimens shall be either separately-cast, integrally-cast (See 8.2.7), or machined from 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 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 casting (4.3.3.3).

3.4.2.3 Tensile specimens will be heat treated to the H925 condition of 3.5.2. Qualifications of separately-cast specimens to conditions other than H925 need be performed only when specifically required by purchaser (See 8.6).

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 (See 8.3) 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 agreed upon by purchaser and vendor (See 8.2.8 and 8.6).

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 Homogenization Heat Treatment (When Specified): Heat to 2100 ºF ± 25 (1149 ºC ± 14), hold at heat for not less than 90 minutes, and cool as required.

3.5.1.2 Solution Heat Treatment: Heat to 1900 ºF ± 25 (1038 ºC ± 14), hold at heat for 60 minutes per inch (25.4 mm) of section thickness but not less than 30 minutes, and cool as required to below 90 ºF (32 ºC).

3.5.2 Specimens: After heat treatment in accordance with 3.5.1, specimens shall, unless otherwise specified, be heat treated in accordance with the following:

3.5.2.1 Precipitation Heat Treatment: Heat to 925 ºF ± 15 (496 ºC ± 8), hold at heat for not less than 90 minutes, and cool in air.

3.5.3 Alternative Precipitation Heat Treatments: Castings and representative tensile specimens, precipitation heat treated to a particular condition in accordance with the corresponding temperatures and times shown in Table 2 and cooled in air, shall exhibit the properties of Table 3 for the specified condition. Tensile and hardness tests shall be made in only one precipitation heat treated condition. Unless otherwise specified, the precipitation heat treated testing condition shall be H925 (See 3.3.3 and 3.4.2.3).

TABLE 2 - Precipitation Heat Treatment Parameters

Condition	Temperature	Time
H925	925 ºF ± 10 (496 ºC ± 6)	90 minutes min
H935	935 ºF ± 10 (502 ºC ± 6)	4 hours ± 0.25
H1000	1000 ºF ± 10 (538 ºC ± 6)	4 hours ± 0.25
H1100	1100 ºF ± 10 (593 ºC ± 6)	4 hours ± 0.25
H1150	1150 ºF ± 10 (621 ºC ± 6)	4 hours ± 0.25

3.5.4 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 or specimens machined from casting shall be specified by purchaser (See 8.6).

3.6.1 Room Temperature Tensile Properties: Shall be as specified in 3.6.1.1 determined in accordance with ASTM E 8 or ASTM E 8M (See 8.3). 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 3.

TABLE 3A - Minimum Tensile Properties, Inch/Pound Units

Condition (3.5.3)	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D, %	Reduction of Area, %
H925	180	160	6	15
H935	170	150	7	16
H1000	150	130	8	18
H1100	130	120	8	20
H1150	125	110	12	30

TABLE 3B - Minimum Tensile Properties, SI Units

Condition (3.5.3)	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D, %	Reduction of Area, %
H925	1241	1103	6	15
H935	1172	1034	7	16
H1000	1034	896	8	18
H1100	896	827	8	20
H1150	862	758	12	30

3.6.2 Hardness: Shall be as follows, determined in accordance with ASTM E 18:

3.6.2.1 Castings: Castings heat treated to the condition of 3.3 shall have hardness not higher than 31 HRC.

3.6.2.2 Alternative Hardness Requirements: Shall be as shown in Table 4 for the corresponding precipitation heat treated condition.

TABLE 4 - Hardness

Condition (3.5.3)	Hardness HRC
H925	40 to 47
H935	38 to 47
H1000	35 to 42
H1100	33 to 40
H1150	28 to 36

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 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 MIL-STD-453 or other process 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 MIL-STD-6866 or other process method specified by purchaser.

3.7.3.2 Magnetic particle inspection in accordance with ASTM E 1444 or other process method specified by purchaser.

3.7.4 Acceptance standards for radiographic, fluorescent penetrant, magnetic particle, 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).

3.7.4.1 When acceptance standards are not specified, Grade C of MIL-STD-2175 shall apply.

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: Composition (3.1), tensile properties (3.6.1), hardness of castings (3.6.2), and quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests: Tensile properties in other than condition H925 (3.5.3). corrosion resistance (3.7.1.3), 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), and 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, 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 tests shall be conducted to determine conformance with Table 3. Sampling and test frequency is dependent upon the type and origin of the 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 (See 3.3 and 3.5.2), at least one specimen from each master heat shall be tested for conformance to 3.6.1 in the H925 condition, or in the condition of 3.4.2.3 specified by purchaser.

4.3.3.2 For integrally-cast specimens in the heat treated condition (See 3.3 and 3.5.3), at least two specimens from each lot shall be randomly selected and tested for conformance to properties specified by purchaser.

4.3.3.3 For specimens machined from a casting, at least one casting shall be randomly selected from each lot and tested after full heat treatment (See 3.3 and 3.5.3) at each location shown on the engineering drawing for conformance to properties specified by purchaser.

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 the requirements of 3.6 for separately-cast specimens or to alternative requirements specified by purchaser (See 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 to 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 shall be tested for hardness to determine conformance with 3.6.2.1 or, as applicable, with 3.6.2.2.

4.3.5.1 If castings are supplied in the solution heat treated condition and unless otherwise specified by purchaser, one casting from each lot shall be hardness tested to determine conformance with 3.6.2.1.

4.3.5.1.1 In the event of failure, the entire lot shall be 100% inspected or reheat treated in accordance with 4.6.2.

4.3.5.2 If castings are supplied in the precipitation heat treated condition, the number of castings sampled from each lot unless otherwise specified by purchaser, shall be in accordance with Table 5 to determine conformance with 3.6.2.2.

4.3.5.2.1 In the event that a lot fails to meet the specified accept/reject number of Table 5, the entire lot shall be 100% inspected or reheat treated in accordance with 4.6.2.

TABLE 5 - Hardness Test Schedule of Precipitation Heat Treated Castings

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

4.3.6 Hardness testing of specimens is not required.

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 productions of subseqent 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. Suppliers 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 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
Straightening
Final inspection methods
Location of specimens machined from 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.