

# AEROSPACE MATERIAL SPECIFICATION

**SAE** AMS5412

REV. A

Issued 1990-07  
Reaffirmed 2007-09  
Revised 2012-04

Superseding AMS5412

Steel Castings, Vacuum Melted, Vacuum Cast, Investment, Corrosion-Resistant  
13Cr - 8.0Ni - 2.2Mo - 1.1Al  
(195 ksi (1344 MPa) Tensile Strength (Condition H1000)  
Homogenized, Solution, and Precipitation Heat Treated

(Composition similar to UNS N13800)

## RATIONALE

AMS5412A updates referenced standards, clarifies that separately cast specimens are the default for master heat qualification (3.4.2), revises pre-production requirements to allow integrally-cast specimens when permitted by purchaser (3.8.2), revises acceptance tests (4.2.1) and approval requirements (4.4.2), and results from a Five Year Review and update of this specification.

### 1. SCOPE

#### 1.1 Form

This specification covers a corrosion-resistant steel in the form of investment castings.

#### 1.2 Application

Primarily for parts requiring corrosion resistance and strength up to 600 °F (316 °C).

### 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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2012 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

**TO PLACE A DOCUMENT ORDER:** Tel: 877-606-7323 (inside USA and Canada)  
Tel: +1 724-776-4970 (outside USA)  
Fax: 724-776-0790  
Email: CustomerService@sae.org  
SAE WEB ADDRESS: <http://www.sae.org>

**SAE values your input. To provide feedback  
on this Technical Report, please visit  
<http://www.sae.org/technical/standards/AMS5412A>**

## 2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

AMS2175	Castings, Classification and Inspection of
AMS2635	Radiographic Inspection
AMS2640	Magnetic Particle Inspection
AMS2645	Fluorescent Penetrant Inspection
AMS2694	In-Process Welding of Castings
AMS2759	Heat Treatment of Steel Parts, General Requirements
AMS2804	Identification, Castings
AMS-H-6875	Heat Treatment of Steel Raw Materials

## 2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

ASTM A370	Mechanical Testing of Steel Products
ASTM E192	Reference Radiographs of Investment Steel Castings of Aerospace Applications
ASTM E353	Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

## 3. TECHNICAL REQUIREMENTS

### 3.1 Composition

Shall conform to the following percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E353, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

TABLE 1 - COMPOSITION

Element	min	max
Carbon	--	0.05
Manganese	--	0.15
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.008
Chromium	12.25	13.25
Nickel	7.50	8.50
Molybdenum	2.00	2.50
Aluminum	0.90	1.35
Nitrogen	--	0.010

### 3.2 Condition

Homogenized, solution heat treated, refrigerated, and precipitation heat treated.

### 3.3 Casting

3.3.1 The metal for castings shall be melted and poured under vacuum without loss of vacuum between melting and pouring. When permitted by purchaser, high purity argon may be used in lieu of vacuum for pouring of castings but not for the melting operation.

3.3.2 Castings shall be poured either from remelted metal from a master heat or directly from a master heat. In either case, metal for casting shall be qualified as in 3.4.

3.3.3 A master heat is refined metal of a single furnace charge, melted and cast into ingots under vacuum. Gates, sprues, riser, and rejected castings shall be used only in preparation of master heats; they shall not be remelted directly, without refining, for pouring of castings.

3.3.4 Unless prohibited by purchaser, 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 pounds (6804 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 from the master heat.

#### 3.4.1 Chemical Analysis Specimens

Shall be of any convenient size, shape, and form.

#### 3.4.2 Tensile Specimens

Separately cast specimens shall be cast from remelted metal from each master heat, except that when castings are poured directly from a master heat the specimens shall also be poured directly from the master heat. Specimens shall be of standard proportions in accordance with ASTM A370 with 0.250 inch (6.35 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 inch (6.35 mm) diameter. Center gating may be used.

3.4.2.1 Integrally-cast coupons (See 8.3.1) or specimens excised from the body of a cast part may be used for evaluating acceptance of the master heat in lieu of separately-cast specimens.

### 3.5 Part Acceptance Test Coupons

For cast part acceptance, specimens excised from the body of a cast part shall be used. Integrally-cast coupons shall be used when specified on the engineering drawing. Separately-cast tensile specimens are to be used only when permitted and specified by purchaser. Specimen proportions shall be in accordance with ASTM A370 and the largest size possible shall be used. Specimens excised from the body of a cast part are preferred and take precedence over other test specimens.

### 3.6 Heat Treatment

Castings and representative separately-cast or integrally-cast tensile specimens shall be heat treated together as follows; all thermal treatments above 1200 °F (649 °C) shall be performed in a protective atmosphere of vacuum, argon, or equivalent. Heat treating equipment shall conform to AMS2759 or AMS-H-6875.

#### 3.6.1 Homogenization

Heat to 2100 °F  $\pm$  25 (1149 °C  $\pm$  14), hold at heat for 60 minutes per inch (25 mm) maximum cross-section but not less than 90 minutes, and force air cool to room temperature.

#### 3.6.2 Solution

Heat to 1700 °F  $\pm$  25 (927 °C  $\pm$  14), hold at heat for 60 minutes per inch (25 mm) of maximum cross-section but not less than 30 minutes, and cool to below 90 °F (32 °C) at a rate equivalent to an air cool or faster. Below 1200 °F (649 °C), a rapid air cool is acceptable.

#### 3.6.3 Refrigeration

Cool to 60 °F (16 °C) or lower, hold at temperature for not less than 30 minutes, and warm in air (See 8.2).

#### 3.6.4 Precipitation

Heat to 1000 °F  $\pm$  10 (538 °C  $\pm$  6), hold at heat for not less than 4 hours, and cool in air to room temperature.

### 3.7 Properties

Specimens removed from castings, including first article preproduction, integrally-cast coupons, and separately-cast specimens shall conform to the following requirements: hardness and tensile testing shall be performed in accordance with ASTM A370.

#### 3.7.1 Tensile Properties

Shall be as shown in Table 2.

TABLE 2 - TENSILE PROPERTIES

Property	Value
Tensile Strength	195 to 215 ksi (1345 to 1482 MPa)
Yield Strength at 0.2% Offset, minimum	180 ksi (1241 MPa)
Elongation in 4D, minimum	5%
Reduction of area, minimum	20%

#### 3.7.2 Hardness

Castings shall be 42 to 46 HRC, or equivalent, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.7.1 are met.

### 3.8 Quality

3.8.1 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.

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

### 3.8.2 Preproduction

Prior to production, non-destructive test inspection and mechanical property control shall be established. Castings shall be examined by non-destructive test inspection methods to ensure the required integrity (See 3.8.3.2 and 3.8.3.3). In addition, tensile specimens removed from the full size casting, or from integrally cast specimens when permitted by the purchaser, shall be tested for conformance to the required mechanical properties. After the foundry practice has been established, the production methods shall not be changed without requalification by the same test procedures.

### 3.8.3 Production Castings

3.8.3.1 Castings shall be subjected to 100% radiographic inspection in accordance with AMS2635. When permitted by purchaser, a radiographic sampling plan may be used after a proper foundry technique has been established, which will produce castings free from harmful internal imperfections. This plan shall be established for each part number of the production castings as necessary to ensure maintenance of satisfactory quality.

3.8.3.2 Each casting shall be subjected to 100% magnetic particle inspection in accordance with AMS2640, to 100% fluorescent penetrant inspection in accordance with AMS2645, or to both as specified by purchaser. If neither is specified, the producer may select either.

3.8.3.3 Radiographic, magnetic particle, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. Imperfections revealed by radiographic inspection shall be compared to the ASTM E192 reference radiographs for a particular imperfection. Acceptance shall be made in accordance with the acceptance standards specified on the engineering drawing. When no acceptance standards are specified, Grade C, as defined by AMS2175, shall apply to all areas.

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

3.8.4.1 When permitted in writing by purchaser, in-process welding in accordance with AMS2694 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

Tests for all technical requirements are acceptance tests and shall be performed on each master heat or lot as applicable.

#### 4.2.2 Preproduction Tests

All technical requirements are preproduction tests (See 3.8.2) and shall be performed prior to or on the first-article shipment of a casting to a purchaser, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

### 4.3 Sampling and Testing

Shall be in accordance with the following; a lot shall be all castings of the same part number poured from the same master heat, heat treated in a single heat treat batch, and presented for vendor's inspection at one time. Other sampling plans may be established as agreed upon by purchaser and vendor and approved in writing.

- 4.3.1 One or more chemical analysis specimens in accordance with 3.4.1 from each master heat or a casting from each lot.
- 4.3.2 Three or more integrally-cast coupons representing each lot when specified by purchaser or three or more separately-cast coupons when permitted and specified by purchaser.
- 4.3.3 Two preproduction castings in accordance with 4.4.1.
- 4.3.4 One or more castings from each lot or other approved sampling plan unless properties from integrally-cast coupons are permitted and specified. Size, location, and number of specimens shall be as specified on the engineering drawing or as agreed upon by purchaser and vendor. When the location and number of test specimens are not specified, not less than four tensile specimens, two representing the thickest section and two representing the thinnest section, shall be tested from a casting or castings 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 the requirements of 3.7 and castings meeting the requirements of 3.8; these shall constitute the approved casting procedures and shall be used for producing subsequent 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, sample castings, test specimens, 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  
Vacuum level  
Mold refractory formulation  
Mold back-up material  
Mold dimensions  
Gating practices  
Mold preheat and metal pouring temperatures; variations of  $\pm 25$  °F ( $\pm 14$  °C) from established limits are 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 composition from each master heat represented and the results of tests on each lot to determine conformance to the other technical requirements. This report shall include the purchase order number, master heat number or code symbol, AMS5412A, lot number, part number, and quantity.