



AEROSPACE MATERIAL SPECIFICATION	AMS4235	REV. C
	Issued 1980-04 Reaffirmed 2013-05 Revised 2015-06 Superseding AMS4235B	
Aluminum Alloy Castings 4.6Cu - 0.35Mn - 0.25Mg - 0.22Ti (A206.0-T7) Solution and Precipitation Heat Treated (Composition similar to UNS A12060)		

RATIONALE

AMS4235C results from a Limited Scope Ballot to revise the Title and Heat Treatment (3.4).

1. SCOPE

1.1 Form

This specification covers an aluminum alloy in the form of sand, permanent mold, and composite mold castings.

1.2 Application

This product has been typically used for components requiring high strength and moderate ductility at both room and elevated temperatures, but usage is not limited to such applications.

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.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

- AMS2175 Castings, Classification and Inspection of
- AMS2360 Room Temperature Tensile Properties of Castings
- AMS2694 In-Process Welding of Castings
- AMS2771 Heat Treatment of Aluminum Alloy Castings

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AMS2804 Identification, Castings

AS1990 Aluminum Alloy Tempers

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.

ASTM B557 Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

ASTM B660 Packaging/Packing of Aluminum and Magnesium Products

ASTM E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

ASTM E34 Chemical Analysis of Aluminum and Aluminum-Base Alloys

ASTM E101 Spectroscopic Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique

ASTM E227 Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique

ASTM E607 Atomic Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere

ASTM E716 Sampling of Aluminum and its Alloys for Spectrochemical Analysis

ASTM E1251 Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge

ASTM E1417 Liquid Penetrant Testing

ASTM E1742 Radiographic Examination

ASTM G44 Alternate Immersion Stress Corrosion Testing in 3.5% Sodium Chloride Solution

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the following percentages by weight as shown in Table 1, determined by wet chemical methods in accordance with ASTM E34 or by spectrochemical methods in accordance with ASTM E101, ASTM E227, ASTM E607, or ASTM E1251, or by other analytical methods acceptable to purchaser (See 3.3.1).

Table 1 - Composition

Element	min	max
Silicon	--	0.05
Copper	4.2	5.0
Manganese	0.20	0.50
Magnesium	0.15	0.35
Titanium	0.15	0.30
Iron	--	0.10
Zinc	--	0.10
Nickel	--	0.05
Tin	--	0.05
Other Elements, each	--	0.05
Other Elements, total	--	0.15
Aluminum	remainder	

3.1.1 Test results may be rounded in accordance with the "rounding off" method of ASTM E29.

3.2 Condition

Solution and precipitation heat treated to the T71 temper (See AS1990).

3.3 Castings shall be produced from metal conforming to 3.1, determined by analysis of a specimen (3.3.1) cast after the last melt addition.

Chemical analysis specimens, and tensile specimens shall be cast as follows:

3.3.1 Chemical Analysis Specimens

Shall be cast from each melt after the last melt addition and shall be tested to qualify the melt lot as in 3.1. Spectrochemical samples shall be prepared in accordance with ASTM E716.

3.3.2 Tensile Specimens shall be produced as follows:

3.3.2.1 Specimens Cut from Castings

Shall be removed after heat treatment and machined to conform to ASTM B557, and shall be either 0.500 inch (12.70 mm) diameter at the reduced parallel gage section, subsize specimens proportional to the standard, or standard sheet-type specimens, as required by 3.5.1.1.

3.3.2.2 Separately-Cast Specimens

Shall conform to ASTM B557 and shall be cast from each melt, after the last melt addition. Specimens shall be cast in molds representing the mold used for castings. Chills are not permitted on test specimen cavity except on the end face of the specimen when approved in accordance with 4.4.2.

3.4 Heat Treatment

Castings and representative tensile specimens shall be solution and precipitation heat treated in accordance with AMS2771, except as required by 3.4.1.1 and 3.4.1.2, to produce the properties specified in 3.5.1 and 3.5.2 (See 8.5 and 8.6). For specific castings, in lieu of the changes introduced by AMS4235C, it is permissible to continue using heat treating process parameters which were previously approved per 4.4.

3.4.1 Solution Heat Treatment

3.4.1.1 Soak at 910 °F ± 10 (488 °C ± 6) for 2 hours ± 0.25, raise temperature to 950 °F ± 10 (510 °C ± 6) and soak for 2 hours ± 0.25, raise temperature to 985 °F ± 10 (529 °C ± 6) and soak for not less than 12 hours, and quench and age at room temperature for not less than 72 hours.

3.4.1.2 When approved by the cognizant engineering organization, soak at 950 °F ± 10 (510 °C ± 6) for 2 hours ± 0.25, raise temperature to 985 °F ± 10 (529 °C ± 6), soak for not less than 8 hours, and quench and age at room temperature for not less than 72 hours.

3.4.2 Precipitation Heat Treatment

Soak at 390 °F ± 10 (199 °C ± 5) for 4 hours minimum, and cool in air.

3.5 Properties

Castings and representative tensile specimens produced in accordance with 3.3.2 shall conform to the following requirements (See 8.4):

3.5.1 Tensile Properties

Shall be as follows, determined in accordance with ASTM B557; conformance to the requirements of 3.5.1.1 shall be used as basis for acceptance of castings except when purchaser specifies that the requirements of 3.5.1.2 apply. Castings with nominal wall thickness greater than 1.0 inch (25.4 mm) shall have properties as specified by the cognizant engineering organization.

3.5.1.1 Specimens Cut From Castings

The average of not less than 4, and preferably 10, specimens cut from thick and thin sections of a casting or castings shall be as follows:

3.5.1.1.1 Designated Casting Areas

Shall be as shown in Table 2:

Table 2 - Designated casting areas

Property	Value
Tensile Strength, min	54.0 ksi (370 MPa)
Yield Strength at 0.2% Offset, min	45.0 ksi (310 MPa)
Elongation in 2 inches or 4D, min	3%

3.5.1.1.2 Casting Areas Other than Designated Areas

Shall be as shown in Table 3:

Table 3 - Casting areas other than designated areas

Property	Value
Tensile Strength, min	50.0 ksi (345 MPa)
Yield Strength at 0.2% Offset, min	40.0 ksi (275 MPa)
Elongation in 2 inches or 4D, min	1.5%

3.5.1.1.3 When properties other than those of 3.5.1.1.1 or 3.5.1.1.2 are required, tensile specimens as in 4.3.3 taken from locations indicated on the drawing, from a casting or castings chosen at random to represent the lot, shall have the properties indicated on the drawing for such specimens. Property requirements for such specimens may be designated in accordance with AMS2360.

3.5.1.2 Separately-Cast Specimens

Shall be as shown in Table 4:

Table 4 - Separately-cast specimens

Property	Value
Tensile Strength, min	50.0 ksi (345 MPa)
Yield Strength at 0.2% Offset, min	40.0 ksi (275 MPa)
Elongation in 2 inches or 4D, min	3%

3.5.2 Stress-Corrosion Resistance

Specimens as in 4.3.5, cut from castings and tested in accordance with ASTM G44 at a stress of 75% of the specified minimum yield strength, shall meet the requirements of ASTM G44.

3.6 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.

3.6.1 When acceptance standards are not specified, Grade C of AMS2175 shall apply.

3.6.2 Methods of inspection and frequency of inspection shall be as agreed upon by purchaser and vendor. A "Casting Class" of AMS2175 may be selected to specify the method and frequency of inspection.

3.6.3 Castings shall be produced under radiographic control. This control shall consist of 100% radiographic inspection of castings until process control factors (4.4.2) have been established to ensure production of acceptable castings. Unless otherwise specified by purchaser, continued radiographic inspection of production castings shall be performed at a frequency determined by the vendor to ensure continued maintenance of internal quality.

3.6.3.1 Radiographic inspection shall be conducted in accordance with ASTM E1742, unless otherwise specified by purchaser.

3.6.4 When specified by purchaser, castings shall be fluorescent penetrant inspected using a method specified by purchaser, or, if not specified, a method in accordance with ASTM E1417.

3.6.5 Castings shall not be peened, plugged, impregnated, or welded unless authorized by purchaser.

3.6.5.1 When welding is authorized by purchaser, it shall be done in accordance with AMS2694 or other welding program approved by purchaser.

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 of specimens cut from castings (3.5.1.1) or, when specified, tensile properties of separately-cast specimens (3.5.1.2), and quality (3.6) are classified as acceptance tests and shall be performed to represent each melt or lot as applicable.

4.2.2 Periodic Tests

Stress-corrosion resistance (3.5.2) and radiographic inspection (3.6.3) following the establishment of process foundry control factors (4.4.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests

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. Any change in material, processing, or both requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.3 Sampling

Shall be in accordance with the following:

- 4.3.1 One chemical analysis specimen from each melt for conformance to 3.1.
- 4.3.2 One or more preproduction castings in accordance with 4.4.1 of each part number.
- 4.3.3 Not less than four tensile specimens machined from castings from each lot except when purchaser specifies use of separately-cast specimens. If specimen locations are not shown on the drawing, not less than four specimens, two from the thickest section and two from the thinnest section, shall be cut from a casting or castings from each lot.
- 4.3.4 One tensile specimen in accordance with 3.3.2 representing each lot when purchaser specifies use of separately-cast specimens.
- 4.3.5 Specimens for stress-corrosion tests shall be tensile specimens taken from the same areas of castings as the tensile tests of specimens cut from castings. When practicable, specimens shall be not less than 0.250 inch (6.25 mm) in diameter at the reduced parallel gage section. If tensile specimens are not cut from castings but are separately cast, the stress-corrosion specimen can be taken from the separately-cast tensile specimens.

4.4 Approval

- 4.4.1 Sample castings from new or reworked tooling (i.e., patterns, molds, dies, etc.) 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, 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 castings include, but are not limited to, the following. Supplier's procedure shall identify tolerances, ranges, and/or control limits, as applicable.

Type of furnace

Furnace atmosphere

Mold composition and molding practices

Alloy additions, fluxing or deoxidation, and gas removal procedures

Gating, risering, and chilling practices

Core composition and fabrication method, when applicable

Metal pouring temperature, variation of ± 50 °F (± 30 °C) from the established limit is permissible

Solidification and cooling procedures

Solution and precipitation heat treat cycles

Cleaning operations

Methods of inspection

Radiographic inspection sampling plan, if used.

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 of each melt and the results of tests for tensile properties of specimen cut from castings from each heat treat lot, or when specified, of separately-cast specimen representing each heat treat lot. This report shall include the purchase order number, melt and heat treat lot numbers, AMS4235C, part number, and quantity.