SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4425 | REV. C

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Superseding AMS 4425B

Magnesium Alloy Castings, Sand
5.8Zn - 2.5RE - 0.70Zr (ZE63-T6)
Solution and Precipitation Heat Treated

UNS M16630

RATIONALE

This document has been reaffirmed to comply with the SAE five-year review policy.

NONCURRENT NOTICE

This specification has been declared “NONCURRENT” by the Aerospace Materials Division, SAE, as of June, 2006. It is recommended, therefore, that this specification not be specified for new designs.

“NONCURRENT” refers to those specifications which have previously been widely used and which may be required for production or processing of existing designs in the future. The Aerospace Materials Division, however, does not recommend these specifications for future use in new designs. “NONCURRENT” specifications are available from SAE upon request.

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1. SCOPE:

1.1 Form:

This specification covers a magnesium alloy in the form of sand castings.

1.2 Application:

These castings have been used typically for parts requiring freedom from microporosity combined with a high level of mechanical properties, but usage is not limited to such applications.

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 2360	Room Temperature Tensile Properties of Castings
AMS 2475	Protective Treatment, Magnesium Alloys
AMS 2635	Radiographic Inspection
AMS 2645	Fluorescent Penetrant Inspection
AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 557	Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
ASTM B 557M	Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)
ASTM B 660	Packaging/Packing of Aluminum and Magnesium Products
ASTM E 35	Chemical Analysis of Magnesium and Magnesium Alloys
ASTM E 155	Reference Radiographs for Inspection of Aluminum and Magnesium Castings

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 35, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Zinc	5.5	6.0
Rare Earths	2.1	3.0
Zirconium, total	0.40	1.0
Zirconium, soluble (3.1.1)	0.40	--
Copper (3.1.2)	--	0.10
Nickel (3.1.2)	--	0.01
Other Impurities, each (3.1.2)	--	0.10
Other Impurities, total (3.1.2)	--	0.30
Magnesium	remainder	

3.1.1 Soluble zirconium is that portion of the zirconium which is soluble in 1:4 hydrochloric acid held below its boiling point.

3.1.2 Determination not required for routine acceptance.

3.2 Condition:

Solution and precipitation heat treated.

3.3 Casting:

Castings shall be produced from metal conforming to 3.1. Furnace or ladle additions of grain-refining elements or alloys shall be added to the melt. Molten metal taken from alloying furnaces, with or without additions of foundry operating scrap (gates, sprues, risers, and rejected castings), shall not be poured into castings unless first converted to ingot, analyzed, and re-melted, or unless the composition of a sample taken after the last addition to the melt conforms to 3.1.

3.3.1 A melt shall be the metal withdrawn from a batch-furnace charge of 2000 pounds (907 kg) or less as melted for pouring castings or, when permitted by purchaser, a melt shall be 4000 pounds (1814 kg) or less of metal withdrawn from one continuous furnace in not more than eight consecutive hours.

3.3.2 A lot shall be all castings poured from a single melt in not more than eight consecutive hours and solution and precipitation heat treated in the same heat treat batch.

3.4 Cast Test Specimens:

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

3.4.1 Chemical Analysis Specimens: Shall be cast from each melt and shall be of any suitable size, shape, and form.

3.4.2 Tensile Specimens: Shall be cast with each lot of castings, shall be of standard proportions conforming to ASTM B 557 or ASTM B 557M with 0.500 inch (12.70 mm) diameter at the reduced parallel gage section, and shall be cast to size in molds made of the regular foundry mix of sand without using chills. Metal for the specimens shall be part of the melt which is used for the castings and shall be subjected to the same grain-refining or alloying treatment given the metal for the castings. The temperature of the metal during pouring of the specimens shall be not lower than that during pouring of the castings

3.5 Heat Treatment:

Castings and representative tensile specimens shall be solution heat treated as in 3.5.1 and precipitation heat treated as in 3.5.2. At least one set of tensile specimens shall, during each stage of heat treatment, be placed into a batch-type furnace with each load of castings or into a continuous furnace at intervals of not longer than three hours. Pyrometry shall be in accordance with AMS 2750.

3.5.1 Hydriding and Solution Heat Treatment: Heat in a hydrogen atmosphere to 900 °F ± 10 (482 °C ± 6), hold at heat for sufficient time (See 3.5.1.1) to produce full hydriding of the rare earth metals and zirconium and to provide solution heat treatment, and cool rapidly to room temperature (See 3.5.1.2).

3.5.1.1 Suggested holding periods are as shown in Table 2; longer holding times may be required for castings with heavier sections:

TABLE 2 - Holding Periods

Nominal Section Thickness Inch	Nominal Section Thickness Millimeters	Time at Temperature Hours
0.25	6.4	10
0.50	12.7	24
0.75	19.0	72

3.5.1.2 It is recommended that castings be either water spray quenched within 30 seconds of opening the furnace and that they achieve room temperature in less than two minutes, or the castings and tensile specimens may be furnace cooled at any convenient rate to any convenient temperature and then re-solution heat treated in protective atmosphere at 900 °F ± 10 (482 °C ± 6), holding at heat for not less than 2 hours, and water spray quenched within 30 seconds of opening the furnace, achieving room temperature in less than two minutes.

3.5.2 Precipitation Heat Treatment: Heat to a suitable temperature, hold at heat for sufficient time to develop properties of 3.6, and cool in air. Conditions which have been used satisfactorily are:

72 hours at 255 °F (124 °C), or
48 hours at 285 °F (141 °C), or
24 hours at 205 °F (96 °C) plus 4 hours at 355 °F (179 °C)

3.5.3 After heat treatment, castings shall be cleaned by pickling in a sulfuricnitric acid solution to remove not less than 0.002 inch (0.05 mm) of metal before protective treatment as in 5.2. Shot or grit blasting prior to degreasing or pickling is permissible.

3.6 Properties:

Castings and representative separately-cast tensile specimens produced in accordance with 3.4.2 shall conform to the requirements of 3.6.1.1.

3.6.1 Tensile Properties: Shall be as specified in 3.6.1.1 and 3.6.1.2, determined in accordance with ASTM B 557 or ASTM B 557M; conformance to the requirements of 3.6.1.1 shall be the basis for acceptance of castings except when purchaser specifies that requirements of 3.6.1.2 apply.

3.6.1.1 Separately-Cast Specimens:

TABLE 3 - Minimum Tensile Properties

Property	Value
Tensile Strength	39.0 ksi (269 MPa)
Yield Strength at 0.2% Offset	26.0 ksi (179 MPa)
Elongation in 4D	5%

3.6.1.2 Specimens Cut From Castings or From Integrally-Cast Coupons: Specimens as in 4.3.4 shall meet the following requirements:

TABLE 4 - Minimum Tensile Properties

Property	Value
Tensile Strength	32.0 ksi (221 MPa)
Yield Strength at 0.2% Offset	22.0 ksi (152 MPa)
Elongation in 4D	2.5%

3.6.1.2.1 When properties other than those of 3.6.1 and 3.6.1.2 are required, tensile specimens as in 4.3.4 machined 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 may be designated in accordance with AMS 2360.

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 imperfections detrimental to usage of the castings.

3.7.1.1 Castings shall have smooth surfaces sufficiently cleaned to permit fluorescent penetrant inspection.

3.7.2 Castings shall be produced under radiographic control. This control shall consist of radiographic examination of castings, in accordance with AMS 2635 or other radiographic procedures acceptable to purchaser, 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.

3.7.3 When specified, castings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645.

3.7.4 Radiographic, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E 155 may be used to define radiographic standards.

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

3.7.5.1 When permitted in writing by purchaser, defects in castings may be removed and the castings repaired by welding in accordance with AMS 2694.

3.7.6 Castings shall not be impregnated, chemically treated, or coated to prevent leakage unless specified or allowed by written permission of purchaser designating the method to 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: Except as specified in 4.2.1.1 tests for composition (3.1), tensile properties of separately-cast specimens (3.6.1.1) or, when specified, tensile properties of specimens cut from castings or integrally-cast coupons (3.6.1.2), and quality (3.7) are acceptance tests and shall be performed to represent each melt or lot as applicable.

4.2.1.1 Tensile properties of specimens cut from castings or from integrally-cast coupons shall be determined only when specified by purchaser or when separately-cast specimens are not available. Tensile properties of separately-cast specimens need not be determined when tensile properties of specimens cut from castings or from integrally-cast coupons are determined.

4.2.2 Preproduction Tests: Tests for all technical requirements are 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 and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.3 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, contracting officer, or request for procurement.

4.3 Sampling and Testing:

Shall be in accordance with the following:

4.3.1 One chemical analysis specimen in accordance with 3.4.1 from each melt or a casting from each lot.

4.3.2 One separately-cast tensile specimen in accordance with 3.4.2 from each lot except when purchaser requires properties of specimens cut from castings or from integrally-cast coupons.

4.3.3 Two preproduction castings in accordance with 4.4.1 of each part number.

4.3.4 Except as permitted by 4.3.4.1, one or more castings from each lot when tensile properties are required from specimens machined from castings. Specimens shall conform to ASTM B 557 or ASTM B 557M 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. For determining conformance to the requirements of 3.6.1.2.1, if specimen locations are not shown on the drawing, not less than four tensile specimens, two from the thickest section and two from the thinnest section, shall be cut from a casting or castings from each lot.

4.3.4.1 When permitted by purchaser, tensile specimens conforming to ASTM B 557 or ASTM B 557M excised from integrally-cast coupons may be used in lieu of separately-cast specimens (4.3.2) or specimens cut from a casting or castings (4.3.4). Size, number, and location of integrally-cast coupons shall be as specified by purchaser.

4.4 Approval:

4.4.1 Sample castings from new or reworked 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 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, 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 Process control factors for producing castings include, but are not limited to, the following:

Type of furnace
Furnace atmosphere
Sand formulation
Ladle addition or grain refining practice
Fluxing or oxide removal procedure
Gating and risering practices
Metal pouring temperature; variation of ±50 °F (±30 °C) is permissible
Solidification and cooling procedures
Heat treat furnace atmosphere composition
Time and temperature of hydriding solution heat treatment
Time and temperature of re-solution heat treatment
Cooling medium and delay time
Time and temperature of precipitation heat treatment
Cleaning operations
Methods of inspection