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AEROSPACE MATERIAL SPECIFICATION

AMS 4445E
Superseding AMS 4445D

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MAGNESIUM ALLOY CASTINGS, SAND
3.3Th - 0.75Zr (HK31A-T6)
Solution and Precipitation Heat Treated

UNS M13310

1. SCOPE:

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

1.2 Application: Primarily for parts operating in service up to 350° - 600°F (175° - 315°C).

1.3 Material covered by this specification is radioactive. All applicable rules and regulations, including those of the Nuclear Regulatory Agency, pertaining to handling of radioactive material and all licensing provisions for use of such material should be observed.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2360 - Room Temperature Tensile Properties of Castings
AMS 2361 - Elevated Temperature Tensile Properties of Castings
AMS 2475 - Protective Treatments, Magnesium Alloys
AMS 2635 - Radiographic Inspection
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2646 - Contrast Dye Penetrant Inspection
AMS 2694 - Repair Welding of Aerospace Castings
AMS 2804 - Identification, Castings

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B557 - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E21 - Elevated Temperature Tension Tests of Metallic Materials
ASTM E35 - Chemical Analysis of Magnesium and Magnesium Alloys
ASTM E155 - Reference Radiographs for Inspection of Aluminum and Magnesium Castings

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Specifications:

MIL-M-6857 - Magnesium Alloy Castings, Heat Treatment of

2.3.3 Military Standards:

MIL-STD-649 - Aluminum and Magnesium Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E35, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max
Thorium	2.5	4.0
Zirconium, total	0.50	1.0
Zirconium, soluble (3.1.1, 3.1.2)	0.50	--
Zinc	--	0.30
Copper (3.1.2)	--	0.10
Nickel (3.1.2)	--	0.01
Other Impurities, total	--	0.20
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 in lots from metal conforming to 3.1. Metal remelted from previously analyzed ingot may be poured directly into castings. Furnace or ladle additions of grain-refining elements or alloys are permissible. Unless otherwise agreed upon by purchaser and vendor, 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 remelted 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 lb (900 kg) or less as melted for pouring castings or, when permitted by purchaser, a melt shall be 4000 lb (1800 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 treatment 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 a size and shape agreed upon by purchaser and vendor.

3.4.2 Tensile Specimens: Shall be cast with each lot of castings, shall be of standard proportions conforming to ASTM B557 with 0.500 in. (12.50 mm) diameter at the reduced parallel gage section, and shall be cast to size in molds made with 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. If the metal for castings is given any treatment, such as fluxing or cooling and reheating, the metal for the specimens shall be a portion of the metal so treated and, during such treatment, shall be heated to the same maximum temperature and held for approximately the same time as the molten 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 heat treated as follows; at least one set of tensile specimens shall, during each stage of heat treatment, be put into a batch-type furnace with each load of castings or into a continuous furnace at intervals of not longer than three hours. Furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-M-6857.

3.5.1 Solution Heat Treatment: Heat to 1050°F ± 15 (565°C ± 8), hold at heat for not less than 2 hr, and cool in air.

3.5.2 Precipitation Heat Treatment: Heat to 400°F ± 10 (205°C ± 5), hold at heat for not less than 16 hr, and cool in air.

3.6 Properties: Castings and representative tensile specimens produced in accordance with 3.4.2 shall conform to the following requirements:

3.6.1 Tensile Properties: Conformance to the requirements of 3.6.1.1.1 shall be used as a basis for acceptance of castings except when purchaser specifies that the requirements of 3.6.1.1.2 or 3.6.1.3 apply.

3.6.1.1 At Room Temperature: Shall be as follows, determined in accordance with ASTM B557:

3.6.1.1.1 Separately-Cast Specimens:

Tensile Strength, min	27,000 psi (185 MPa)
Yield Strength at 0.2% Offset, min	13,000 psi (90 MPa)
Elongation in 4D, min	4%

3.6.1.1.2 Specimens Cut From Castings:

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

Tensile Strength, min	23,000 psi (160 MPa)
Yield Strength at 0.2% Offset, min	11,700 psi (80 MPa)
Elongation in 4D, min	2%

3.6.1.1.2.2 Any specimen cut from a casting shall meet the following:

Tensile Strength, min	19,000 psi (130 MPa)
Yield Strength at 0.2% Offset, min	10,500 psi (70 MPa)

3.6.1.2 At 600°F (315°C): Shall be as follows, determined in accordance with ASTM E21 on specimens heated to 600°F ± 5 (315°C ± 3), held at heat for 10 to 20 min. before testing, and tested at 600°F ± 5 (315°C ± 3):

3.6.1.2.1 Separately-Cast Specimens:

Tensile Strength, min	19,000 psi (130 MPa)
Yield Strength at 0.2% Offset, min	12,000 psi (85 MPa)

3.6.1.2.2 Specimens Cut From Castings:

Tensile Strength, psi	13,000 psi (90 MPa)
Yield Strength at 0.2% Offset, psi	9,500 psi (65 MPa)

3.6.1.3 When properties other than those specified in 3.6.1.1.2 and 3.6.1.2.2 are required, tensile specimens as in 4.3.4 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 at room temperature may be designated in accordance with AMS 2360 and at elevated temperatures in accordance with AMS 2361.

3.6.2 Hardness of Castings: Castings, except at sprue and riser locations, Ø should have hardness of 45 - 70 HB/10/500 or 50 - 75 HB/10/1000, determined in accordance with ASTM E10, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.1.1.2 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.

3.7.1.1 Castings shall have smooth surfaces and shall be well cleaned.

3.7.1.2 Castings cleaned by blasting shall be pickled in a sulfuric or sulfuric/nitric acid solution to remove not less than 0.002 in. (0.05 mm) of metal before protective treatment as in 5.2, unless otherwise specified by purchaser.

3.7.2 Castings shall be produced under radiographic control. This control shall consist of radiographic examination of castings in accordance with Ø AMS 2635 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, to contrast dye penetrant inspection in accordance with AMS 2646, or to both.

3.7.4 Radiographic, fluorescent penetrant, contrast dye penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E155 may be used to define radiographic acceptance 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 Ø 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 Ø required tests. Results of such tests shall be reported to the purchaser as required by 4.5. 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 to determine conformance to requirements for composition (3.1), room temperature tensile properties (3.6.1.1.1 or 3.6.1.1.2), hardness (3.6.2), and quality (3.7) are classified as 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 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 are determined.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for tensile properties at 600°F (315°C) (3.6.1.2) are classified as 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: Tests to determine conformance to all technical Ø 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, when a change in material or processing, or both, requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.3.1 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, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following:

4.3.1 Two chemical analysis specimens in accordance with 3.4.1 from each melt or a casting from each lot.

4.3.2 Three tensile specimens in accordance with 3.4.2 from each lot.

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

4.3.4 One or more castings from each lot when properties of specimens machined from castings are required. Specimens shall conform to ASTM B557 and shall be either 0.500 in. (12.50 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 3.6.1.3, 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.

4.4 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 Control factors for producing castings include, but are not limited to, the following:

Type of furnace
Furnace atmosphere
Fluxing or oxide removal procedure
Gating and risering practices
Metal pouring temperature (variation of ±50°F [±30°C] from the established limit is permissible)
Solidification and cooling procedures
Solution and precipitation 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: