

# AEROSPACE MATERIAL SPECIFICATION

**SAE** AMS4444

REV. D

Issued 1960-01  
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Noncurrent 2006-10  
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Superseding AMS4444C

Magnesium Alloy Castings, Sand  
6.0Zn - 0.80Zr (ZK61A-T5)  
Precipitation Heat Treated

UNS M16610

## RATIONALE

AMS4444D 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 October, 2006. It is recommended, therefore, that this specification not be specified for new designs.

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<http://www.sae.org/technical/standards/AMS4444D>**

## 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 a combination of good yield strength and elongation, 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 10   | Brinell Hardness of Metallic Materials                                           |
| ASTM E 35   | Chemical Analysis of Magnesium and Magnesium Alloys                              |
| ASTM E 155  | Reference Radiographs for Inspection of Aluminum and Magnesium Castings          |

### 2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

### 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       | 6.5  |
| Zirconium, total                | 0.6       | 1.0  |
| Zirconium, soluble (3.1.1)      | 0.6       | —    |
| 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:

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 remelted or unless 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 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 and, when requested by purchaser, shall be supplied with the castings:

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 green 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 casting. 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 precipitation heat treated in accordance with MIL-M-6857; at least one set of tensile specimens shall 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.

#### 3.6 Properties:

Castings and separately-cast tensile specimens produced in accordance with 3.4.2 shall conform to the following requirements:

3.6.1 Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM B 557 or ASTM B 557M; conformance to the requirements of 3.6.1.1 shall be used as the basis for acceptance of castings except when purchaser specifies that the requirements of 3.6.1.2 apply:

##### 3.6.1.1 Separately-Cast Specimens:

TABLE 2 - Minimum Tensile Properties

| Property                      | Value              |
|-------------------------------|--------------------|
| Tensile Strength              | 40.0 ksi (276 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 Integrally-Cast Coupons: Shall be as shown in Table 3.

TABLE 3 - Minimum Tensile Properties

| Property                      | Value              |
|-------------------------------|--------------------|
| Tensile Strength              | 30.0 ksi (207 MPa) |
| Yield Strength at 0.2% Offset | 21.0 ksi (145 MPa) |
| Elongation in 4D              | 2%                 |

3.6.1.2.1 When properties other than those of 3.6.1.2 are required, tensile specimens as in 4.3.4 taken in 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 AMS 2360.

3.6.2 Hardness: Castings, except at gate and riser locations, should have hardness not lower than 65 HB/10/500 or 70 HB/10/1000, determined in accordance with ASTM E 10, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.1.2 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 sufficiently cleaned to permit fluorescent penetrant inspection.

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 inch (0.05 mm) of metal prior to protective treatment as in 5.2.

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 method 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 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 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 from 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 Periodic Tests: Tests for hardness (3.6.2) of castings 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: 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.

4.2.3.1 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, 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.
- 4.3.3 Two preproduction castings in accordance with 4.4.1 of each part number.
- 4.3.4 Except as specified in 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 the separately-cast specimen (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 by purchaser, 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 include, but are not limited to, the following:
- Type of furnace
  - Furnace atmosphere
  - Fluxing or oxide removal procedures
  - Gating and risering practices
  - Metal pouring temperature; variation of  $\pm 50^{\circ}\text{F}$  ( $\pm 28^{\circ}\text{C}$ ) is permissible
  - Solidification and cooling procedures
  - Precipitation heat treatment cycle
  - 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.