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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4443E

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Superseding AMS 4443D

Submitted for recognition as an American National Standard

Magnesium Alloy Castings
4.5Zn - 0.75Zr (ZK51A-T5)
Precipitation Heat Treated

UNS M16510

1. SCOPE:

1.1 Form:

This specification covers a magnesium alloy in the form of 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 Treatments, Magnesium Alloys
AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings
AMS-M-6857	Magnesium Alloy Castings, Heat Treatment of

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2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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 E 10	Brinell Hardness of Metallic Materials
ASTM E 29	Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E 35	Chemical Analysis of Magnesium and Magnesium Alloys
ASTM E 155	Reference Radiographs for Examination of Aluminum and Magnesium Castings
ASTM E 1417	Liquid Penetrant Examination

2.3 U.S. Government Publications::

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-453	Inspection, Radiographic
MIL-STD-2175	Casting, Classification and Inspection 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, or by spectrochemical or other analytical methods acceptable to purchaser (See 3.4.1).

TABLE 1 - Composition

Element	min	max
Zinc	3.6	5.5
Zirconium, total	0.50	1.0
Zirconium, soluble (3.1.1)	0.50	--
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.

3.1.3 Test results may be rounded by the “rounding off” method of ASTM E 29.

3.2 Condition:

Precipitation heat treated.

3.3 Casting:

Castings shall be produced from metal conforming to 3.1 determined by analysis of a specimen (3.4.1) cast after the last melt addition.

3.4 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 after the last melt addition and shall be tested to qualify the melt lot as in 3.1.

3.4.2 Tensile Specimens: Shall be prepared as follows and tested for conformance to 3.6.1:

3.4.2.1 Unless specimens cut from castings are specified by the purchaser, separately cast specimens, conforming to ASTM B 557 or ASTM B 557M, shall be cast from each melt after the last melt addition. Specimens shall be cast in molds representing the mold formulation 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. Tensile specimens shall be processed with each heat treat lot.

3.4.2.2 When purchaser specifies specimens cut from castings or from integrally cast coupons, such specimens shall be removed after heat treatment, shall be machined to 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.

3.5 Heat Treatment:

Shall be in accordance with AMS-M-6857. Unless specimens cut from castings or from integrally-cast coupons are specified, 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.

3.6 Properties:

Castings, integrally-cast coupons, and representative separately-cast tensile specimens shall conform to the following requirements:

3.6.1 Tensile Properties: Shall be as follows, 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 specimens shall be cut from castings (See 3.6.1.2) or from integrally-cast coupons (See 3.6.1.2).

3.6.1.1 Separately-Cast Specimens: Shall have the properties shown in Table 2.

TABLE 2 - Minimum Tensile Properties

Property	Value
Tensile Strength	34.0 ksi (234 MPa)
Yield Strength at 0.2% Offset	20.0 ksi (138 MPa)
Elongation in 4D	5%

3.6.1.2 Specimens Cut from Castings or from Integrally-cast Coupons: When specified by purchaser, specimens obtained by sampling in accordance with 4.3.4 shall meet the requirements of Table 3, unless otherwise specified as in 3.6.1.2.1.

TABLE 3 - Minimum Tensile Properties

Property	Value
Tensile Strength	24.0 ksi (165 MPa)
Yield Strength at 0.2% Offset	14.0 ksi (96 MPa)
Elongation in 4D	1.25%

3.6.1.2.1 Properties other than those shown in Table 3, may be specified for specific casting locations. Properties 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 from imperfections detrimental to usage of the castings.

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

3.7.1.2 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 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 the purchaser, continued radiographic inspection of production castings shall be performed at a frequency determined by the vendor to assure continued maintenance of internal quality.

3.7.3 Methods of inspection and frequency of inspection shall be as agreed upon by purchaser and vendor. A “Casting Class” of MIL-STD-2175 may be selected to specify the method and frequency of inspection.

3.7.4 When acceptance standards are not specified, Grade C of MIL-STD-2175 shall apply. ASTM E 155 may be used to define radiographic acceptance standards.

3.7.5 Radiographic inspection shall be conducted in accordance with MIL-STD-453, unless otherwise specified by purchaser.

3.7.6 When specified by purchaser, castings shall be fluorescent penetrant inspected using a method specified by the purchaser, or, if not specified, a method in accordance with ASTM E 1417.

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

3.7.7.1 When authorized by purchaser, welding in accordance with AMS 2694 or other welding program approved by the purchaser 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 the specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Except as specified in 4.2.1.1, 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 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: Radiographic inspection (3.7.2) following the establishment of process control (4.4.2) is a periodic test 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 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.

4.3 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 for conformance to 3.1.

4.3.2 Three separately-cast tensile specimens in accordance with 3.4.2 from each heat treat lot except when purchaser requires properties of specimens machined from castings or from integrally-cast coupons.

4.3.3 One or more 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. For determining conformance to the requirements of 3.6.1.2, if specimen locations are not shown on the drawing, two specimens 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. Vendor shall also establish a single procedure for production of separately-cast tensile specimens. Method for production of separately-cast tensile specimens shall be consistent for all material cast to this specification. Control factors for separately cast tensile specimens must generally represent, but need not be identical to, those factors used for 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; supplier's procedures shall identify tolerances, ranges, and/or control limits, as applicable:

Type of furnace
Furnace atmosphere
Maximum amount of alloy per melt lot
Alloy additions, fluxing, deoxidation, and gas removal procedures
Gating and risering practices
Mold composition and molding practice
Core composition and fabrication method, when applicable
Metal pouring temperature; variation of ±50 °F (±28 °C) is permissible
Solidification and cooling procedures
Precipitation heat treatment cycle
Cleaning operations
Methods of inspection
Radiographic inspection sampling plan, if used

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.