



Designation: B 403 – 9602

## Standard Specification for Magnesium-Alloy Investment Castings<sup>1</sup>

This standard is issued under the fixed designation B 403; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

### 1. Scope\*

1.1 This specification covers magnesium-alloy investment castings designated as shown in Table 1. ~~Note 1—The values stated in inch-pound units are to be regarded as the standard. The SI values in parentheses are for information only.~~

1.2 Alloy designations are in accordance with Practices B 275 and E 527; temper designations are in accordance with Practice B 296.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI values in parentheses are for information only.

### 2. Referenced Documents

2.1 The following documents of the issue in effect on the date of order acceptance form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee ~~B-7~~ B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.04 on Magnesium Alloy Cast and Wrought Products.

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**\*A Summary of Changes section appears at the end of this standard.**

**TABLE 1 Chemical Composition Limits<sup>A</sup>**

NOTE 1—Analysis shall regularly be made for the elements specifically mentioned in this table. If, however, the presence of other elements is suspected or indicated in amounts greater than the specified limits, further analysis shall be made to determine that these elements are not present in excess of the specified limits.

NOTE 2—The following applied to all specified limits in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis should be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

| Alloy Number <sup>B</sup> |                     | Composition, percent |                |               |                |          |           |                      |         |           |        |         | Total <sup>C</sup><br>Other<br>Impurities | Others<br>Each |
|---------------------------|---------------------|----------------------|----------------|---------------|----------------|----------|-----------|----------------------|---------|-----------|--------|---------|---|----------------|
| ASTM                      | UNS                 | Iron                 | Magne-<br>sium | Alu-<br>minum | Manga-<br>nese | Zinc     | Zirconium | Rare<br>Earths       | Thorium | Copper    | Nickel | Silicon |   |                |
| AM100A                    | M10100              | ...                  | remainder      | 9.3–10.7      | 0.10–0.35      | 0.30     | ...       | ...                  | ...     | 0.10      | 0.01   | 0.30    | 0.30                                      | ...            |
| AZ81A                     | M11810              | ...                  | remainder      | 7.0–8.1       | 0.13–0.35      | 0.40–1.0 | ...       | ...                  | ...     | 0.10      | 0.01   | 0.30    | 0.30                                      | ...            |
| AZ91C                     | M11914              | ...                  | remainder      | 8.1–9.3       | 0.13–0.35      | 0.40–1.0 | ...       | ...                  | ...     | 0.10      | 0.01   | 0.30    | 0.30                                      | ...            |
| AZ91E                     | M11919              | 0.005 <sup>D</sup> E | remainder      | 8.1–9.3       | 0.17–0.35      | 0.40–1.0 | ...       | ...                  | ...     | 0.015     | 0.0010 | 0.20    | 0.30                                      | 0.01           |
| AZ92A                     | M11920              | ...                  | remainder      | 8.3–9.7       | 0–0.35         | 1.6–2.4  | ...       | ...                  | ...     | 0.10      | 0.01   | 0.30    | 0.30                                      | ...            |
| EQ21A                     | M18330              | ...                  | remainder      | ...           | ...            | ...      | 0.40–1.0  | 1.5–3.0 <sup>F</sup> | ...     | 0.05–0.10 | 0.01   | ...     | 0.30                                      | ...            |
| EZ33A                     | M12330              | ...                  | remainder      | ...           | ...            | 2.0–3.1  | 0.50–1.0  | 2.5–4.0              | ...     | 0.10      | 0.01   | ...     | 0.30                                      | ...            |
| HK34A                     | M43340              | ...                  | remainder      | ...           | ...            | 0.30     | 0.40–1.0  | ...                  | 2.5–4.0 | 0.10      | 0.01   | ...     | 0.30                                      | ...            |
| K1A                       | M18010              | ...                  | remainder      | ...           | ...            | ...      | 0.40–1.0  | ...                  | ...     | ...       | ...    | ...     | 0.30                                      | ...            |
| K1A                       | M48040              | ...                  | remainder      | ...           | ...            | ...      | 0.40–1.0  | ...                  | ...     | ...       | ...    | ...     | 0.30                                      | ...            |
| QE22A <sup>G</sup>        | M18220 <sup>G</sup> | ...                  | remainder      | ...           | ...            | ...      | 0.40–1.0  | 1.8–2.5 <sup>F</sup> | ...     | 0.10      | 0.01   | ...     | 0.30                                      | ...            |
| QE22AG                    | M48220G             | ...                  | remainder      | ...           | ...            | ...      | 0.40–1.0  | 1.8–2.5 <sup>F</sup> | ...     | 0.10      | 0.01   | ...     | 0.30                                      | ...            |
| ZE41A                     | M16410              | ...                  | remainder      | ...           | 0.15           | 3.5–5.0  | 0.40–1.0  | 0.75–1.75            | ...     | 0.10      | 0.01   | ...     | 0.30                                      | ...            |
| ZK61A                     | M16610              | ...                  | remainder      | ...           | ...            | 5.5–6.5  | 0.6–1.0   | ...                  | ...     | 0.10      | 0.01   | ...     | 0.30                                      | ...            |

<sup>A</sup> Limits are in weight percent maximum unless shown as a range or stated otherwise.

<sup>B</sup> These alloy designations were established in accordance with Practice B 275.

<sup>C</sup> Includes listed elements for which no specific limit is shown.

<sup>D</sup> If iron content exceeds 0.005 %, the iron to manganese ratio shall not exceed 0.032.

<sup>E</sup> Silver content for Alloy EQ21A shall be 1.3 to 1.7 %.

<sup>F</sup> Rare earth elements are in the form of didymium.

<sup>G</sup> Silver content for Alloy QE22A shall be 2.0 through 3.0 %.

B 275 Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought<sup>2</sup>

B 296 Practice for Temper Designations of Magnesium Alloys, Cast and Wrought<sup>2</sup>

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products<sup>2</sup>

~~B 6640 Practices for Packaging/Packing of Aluminum and Magnesium Products<sup>2</sup>~~

~~B 661 Practice for Heat Treatment of Magnesium Alloys<sup>2</sup>~~

~~B 666/B 666M Practice for Identification Marking of Aluminum and Magnesium Products<sup>2</sup>~~

~~D 3951 Practice for Commercial Packaging<sup>3</sup>~~

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>4</sup>

E 35 Test Methods for Chemical Analysis of Magnesium and Magnesium Alloys<sup>5</sup>

E 88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition<sup>5</sup>

E 94 Guide for Radiographic Testing<sup>6</sup>

E 155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings<sup>6</sup>

E 165 Practice for Liquid Penetrant Examination<sup>6</sup>

E 527 Practice for Numbering Metals and Alloys (UNS)<sup>7</sup>

2.3 Federal Standards:

Fed. Std. No. 123 Marking for Shipping (Civil Agencies)

~~Fed. Std. No. 184 Identification Marking of Aluminum, Magnesium, and Titanium<sup>7</sup>~~

~~2.1.3 Military Standards:<sup>8</sup>~~

~~2.4 Military Standards:~~

~~MIL-STD-129 Marking for Shipment and Storage (Military Agencies)~~

~~MIL-STD-649 Preparation for Storage and Shipment of Aluminum and Magnesium Products<sup>7,8</sup>~~

### 3. Ordering Information

3.1 Orders for castings under this specification shall include the following information:

<sup>2</sup> Annual Book of ASTM Standards, Vol 02.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 14.02: 15.09.

<sup>4</sup> Annual Book of ASTM Standards, Vol 03.05: 14.02.

<sup>5</sup> Annual Book of ASTM Standards, Vol 03.035.

<sup>6</sup> Annual Book of ASTM Standards, Vol 01.01: 03.03.

<sup>7</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>8</sup> Annual Book of ASTM Standards, Vol 01.01.

<sup>8</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D700 Robbins Ave., Philadelphia, PA 19111-5098, Attn: NPODS.

- 3.1.1 Quantity of each casting,
- 3.1.2 Alloy (Section 6 and Table 1),
- 3.1.3 Temper (see 5.1 and Table 2),
- 3.1.4 Casting drawing giving all necessary dimensions and showing amount of finish left for machining,
- 3.1.5 Surface treatment (see 10.1),
- 3.1.6 Whether certification is required (see 11.1),
- 3.1.7 Whether inspection is required at the manufacturer's works (see 12.1), and
- 3.1.8 Special inspection requirements (see 12.3).

#### **4. Materials and Manufacture**

4.1 The responsibility for furnishing castings that can be laid out and machined to the finished dimensions within the permissible variations specified, as shown on the drawings, shall rest with the manufacturer, except where mold equipment is furnished by the purchaser. Sufficient stock shall be allowed for shrinkage and, where required, for finishing; but castings of excessive weight shall not be furnished.

#### **5. Treatment**

5.1 The castings may be subjected to such heat treatment as the manufacturer desires to produce material that will conform to the requirements specified. Heat treatment shall be performed on the whole of the casting, never on a part only, and shall be applied in a manner that will produce uniformity. Unless otherwise specified, treatment shall be in accordance with Practice B 661.

#### **6. Chemical Composition**

- 6.1 The castings shall conform to the chemical composition limits in Table 1.
- 6.2 The chemical analysis shall be made in accordance with Test Methods E 35, or by any other approved methods agreed upon by the manufacturer and the purchaser. The analysis may be made spectrochemically provided that, in case of disagreement, the results secured by Test Methods E 35 shall be the basis for acceptance.
- 6.3 The sampling shall be in accordance with Practice E 88.

#### **7. Tensile Properties**

7.1 *Limits*—The tension test specimens representing the castings shall conform to the requirements for tensile properties prescribed in Table 2.

##### *7.2 Number of Tests:*

7.2.1 At least two tension test specimens shall be cast from each melt of 2000 lb (907 kg) or fraction thereof to represent the castings poured from the same melt. If the castings are to be heat treated, the specimens shall be heat treated with production castings of the same alloy and in the same temper as the specimens.

7.2.2 Each heat-treating furnace charge shall include at least two tension test specimens poured from a production melt. Such specimens shall be of the same alloy and in the same temper as the castings, and shall be tested to judge the quality of the heat-treating operation given the furnace charge.

##### *7.3 Test Specimens:*

7.3.1 The tension test specimens shall be separately cast in the same refractory material as the castings. The specimen should be "cast to size" according to the dimensions of the 0.250-in. (6.35-mm) diameter round specimen shown in Fig. 8 of Test Methods B 557. They shall not be machined prior to test except to adapt the grip ends to the holders of the testing machine to assure axial loading.

7.3.2 If any tension test specimen is improperly machined or shows flaws upon testing, it may be discarded and another specimen from the same heat or melt used instead. If no additional specimen is available, the manufacturer and the purchaser shall agree on an alternative procedure.

7.4 *Test Methods*—The tension tests shall be made in accordance with Test Methods B 557.

#### **8. Retests**

8.1 If any test specimen fails to conform to the prescribed requirements, two additional representative specimens shall be selected and tested. If either of these specimens fails to conform to the requirements, the lot may be rejected. If, however, the specimen failure is due to inadequate thermal treatment, the material may be reheat-treated and resampled in accordance with 7.2. Castings may be reheat-treated no more than twice.

#### **9. General Quality**

9.1 The castings shall be of uniform quality and condition, free from cracks and other injurious defects, and shall be cleaned before inspection by blasting or other approved process.

9.2 Castings shall not be repaired by welding, impregnation, peening, or other method without permission of the purchaser.

#### **10. Finish**

10.1 Unless otherwise specified, the castings ~~shall~~ should be chrome pickled or coated with a corrosion inhibitive oil prior to shipment.

**TABLE 2 Tensile Requirements**

NOTE 1—For purposes of determining conformance with this specification, each value for tensile strength and yield strength shall be rounded off to the nearest 0.1 ksi (0.07 MPa), and each value for elongation shall be rounded off to the nearest 0.5 %, both in accordance with the rounding off method of Practice E 29.

| Alloy and Temper | Tensile Strength, min, ksi (MPa) | Yield Strength (0.2 % Offset), min, ksi | Elongation in 1 in. (25 mm) or 4× in. min, % |
|------------------|----------------------------------|---|--|
| AM100A-F         | 20.0 (138)                       | 10.0 (69)                               | <sup>A</sup>                                 |
| AM100A-T4        | 34.0 (234)                       | 10.0 (69)                               | 6  |
| AM100A-T6        | 34.0 (234)                       | 15.0 (103)                              | 2  |
| AM100A-T7        | 34.0 (234)                       | 17.0 (117)                              | <sup>A</sup>                                 |
| AZ81A-T4         | 34.0 (234)                       | 10.0 (69)                               | 7  |
| AZ91C-F          | 18.0 (124)                       | 10.0 (69)                               | <sup>A</sup>                                 |
| AZ91C-T4         | 34.0 (234)                       | 10.0 (69)                               | 7  |
| AZ91C-T5         | 20.0 (138)                       | 11.0 (76)                               | 2  |
| AZ91C-T6         | 34.0 (234)                       | 16.0 (110)                              | 3  |
| AZ91E-T6         | 34.0 (234)                       | 16.0 (110)                              | 3  |
| AZ92A-F          | 20.0 (138)                       | 10.0 (69)                               | <sup>A</sup>                                 |
| AZ92A-T4         | 34.0 (234)                       | 10.0 (69)                               | 6  |
| AZ92A-T5         | 20.0 (138)                       | 11.0 (76)                               | <sup>A</sup>                                 |
| AZ92A-T6         | 34.0 (234)                       | 18.0 (124)                              | <sup>A</sup>                                 |
| EQ21A-T6         | 34.0 (234)                       | 25.0 (172)                              | 2  |
| EZ33A-T5         | 20.0 (138)                       | 14.0 (97)                               | 2  |
| HK31A-T6         | <del>27.0 (186)</del>            | <del>13.0 (90)</del>                    | <del>4</del>                                 |
| K1A-F            | 22.0 (152)                       | 7.0 (48)                                | 14   |
| QE22A-T6         | 35.0 (241)                       | 25.0 (172)                              | 2  |
| <u>ZE41A-T5</u>  | <u>29.0 (200)</u>                | <u>19.5 (133)</u>                       | <u>2.5</u>                                   |
| <u>ZK61A-T6</u>  | <u>40.0 (276)</u>                | <u>25.0 (172)</u>                       | <u>5</u>                                     |

<sup>A</sup> Not required.

## 11. Certification

11.1 The supplier shall, on request, furnish to the purchaser a certificate stating that the material has been sampled, tested, and inspected in accordance with this specification, and has been found to meet the requirements.

## 12. Inspection

12.1 If the purchaser desires to make an inspection of the material at the manufacturer's works where the castings are made, it shall be so stated in the contract or purchase order.

12.2 If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

12.3 Special inspection requirements such as pressure testing, X-ray, or fluorescent penetrant must be stated on the order. Unless specific reference is made to the degree of discontinuity by reference to Reference Radiographs E 155, acceptance standards shall be agreed upon by the purchaser and the manufacturer. When specified, radiography shall be in accordance with Guide E 94 and penetrant inspection shall be in accordance with Practice E 165.

## 13. Rejection

13.1 Material failing to conform to the requirements of this specification, or in which defects are found during subsequent manufacturing operations may be rejected. If rejected, the manufacturer shall be responsible only for replacement of the material to the purchaser. All of the rejected original material shall be returned to the manufacturer.

## 14. Packaging and Marking

14.1 The material shall be packaged in such a manner as to prevent damage in ordinary handling and transportation. The type of packaging and gross weight of individual containers shall be left to the discretion of the manufacturer unless otherwise agreed upon.

14.2 Packages or containers shall be such as to ensure acceptance by common or other carriers for safe transportation to the point of delivery.

14.3 Each package or container shall be marked with the purchase order number, drawing number, and quantity. Additional information will be contained inside the package or container to identify the shipment by drawing number, quantity, alloy, and condition.

14.4 When specified in the contract or purchase order, castings shall be preserved, packaged, and packed in accordance with the requirements of ~~MIL-STD-649~~, Practices B 660. The applicable levels shall be specified in the contract or order. Marking for shipment of such material shall be in accordance with one of the following selected standards for civil agencies: Fed. Std. No. 123 for civil agencies and 123, Practice B 666/B 666M, or Practice D 3951. MIL-STD-129 is to be cited for marking supplies for military agencies only.

## **15. Keywords**

15.1 investment castings; magnesium alloy

## **SUMMARY OF CHANGES**

This section identifies

Committee B07 has identified the location of selected changes to this specification that have been incorporated standard since the last issue (B 403 – 96) that may impact the use of this standard.

- ~~(1) Number of tension test specimens in 7.2.1 increased Alloy HK31 was removed from the specification due to at least two: – the elimination of the commercial applications for thorium alloys.~~
- (2) Metric equivalents in Alloy ZE41A was added to Table 1 and Table 2.
- (3) In 10.1, the finishing requirement was changed from a mandatory chrome pickle to a recommended chrome pickle or coating of corrosion inhibitive oil.
- (4) References to canceled Federal Standard 184 and canceled Military Standard 649 were deleted from Sections 2 and 14.
- (5) Note 1 was removed and incorporated into 1.3.

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