



Designation: B 93/B 93M – 05

Standard Specification for Magnesium Alloys in Ingot Form for Sand Castings, Permanent Mold Castings, and Die Castings¹

This standard is issued under the fixed designation B 93/B 93M; 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 (ϵ) 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 alloys in ingot form for remelting for the manufacture of sand castings, permanent mold castings, investment castings, and die castings.

NOTE 1—Supplementary information pertaining to the alloys covered by this specification when used in the form of castings is given in Specifications B 80, B 94, B 199 and B 403.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

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

2.2 *ASTM Standards:*²

- B 80 Specification for Magnesium-Alloy Sand Castings
- B 94 Specification for Magnesium-Alloy Die Castings
- B 199 Specification for Magnesium-Alloy Permanent Mold Castings
- B 275 Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought

- B 403 Specification for Magnesium-Alloy Investment Castings
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E 35 Test Methods for Chemical Analysis of Magnesium and Magnesium Alloys
- E 88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition
- E 527 Practice for Numbering Metals and Alloys (UNS)

3. Ordering Information

3.1 Orders for ingot to this specification shall include the following information:

- 3.1.1 Quantity in pounds (kilograms)
- 3.1.2 Alloy (Section 4 and Table 1 or Table 2), and
- 3.1.3 Form: as agreed upon between the purchaser and seller. Some forms in commercial use are:

| Form | Approximate Size Length by Width by Height, in. (mm) | Approximate Weight, lb (kg) |
|------------------|---|-----------------------------|
| Five-segment | 23 by 2 $\frac{3}{4}$ by 1 $\frac{1}{4}$ (583 by 70 by 44) | 5 (2.3) |
| Four-segment | 28 by 4 $\frac{1}{2}$ by 4 (711 by 114 by 102) | 20 (9.1) |
| Self-Palletizing | 26 $\frac{1}{2}$ by 6 $\frac{5}{8}$ by 2 $\frac{5}{8}$ (672 by 168 by 67) | 25 (11.3) |

3.1.4 Inspection required at the manufacturer's works (see 8.1).

3.1.5 For inch-pound orders specify B93; for metric orders specify B93M. Do not mix units.

4. Chemical Composition

4.1 The ingots shall conform to the chemical composition limits prescribed in Table 1 for sand cast alloys and permanent mold-cast alloys and in Table 2 for die-cast alloys. Conformance shall be determined by the manufacturer by analyzing samples taken at the time the ingots are poured or samples taken from the ingots. If the manufacturer has determined the chemical composition of the material during manufacture, he shall not be required to sample and analyze the ingots.

4.2 The alloys shall conform to the chemical composition requirements prescribed in Table 1 and Table 2 (Note 2 and Note 3).

¹ This specification is under the jurisdiction of ASTM Committee 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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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

TABLE 1 Chemical Requirements for Alloy Ingot for Remelt to Sand, Permanent, Mold and Investment Castings—Composition %

| Alloy ^A ASTM | UNS | Mag- nesium | Alumi- num | Copper, max | Gadol- inium | Iron, max | Lithium, max | Manga- nese | Neody- mium | Nickel, max | Rare Earths | Silicon, max | Silver | Yttrium | Zinc | Zir- conium | Others each max ^B | Total Others, max ^B |
|----------------------------|--------|----------------|---------------|----------------|-----------------|--------------|-----------------|----------------|----------------|----------------|------------------------------------|-----------------|-------------|----------|-----------|----------------|------------------------------------|--------------------------------------|
| AM100A | M10101 | remainder | 9.4–10.6 | 0.08 | ... | ... | ... | 0.13–0.35 | ... | 0.010 | ... | 0.20 | ... | ... | 0.2 max | ... | ... | 0.30 |
| AZ63A | M11631 | remainder | 5.5–6.5 | 0.20 | ... | ... | ... | 0.15–0.35 | ... | 0.010 | ... | 0.20 | ... | ... | 2.7–3.3 | ... | ... | 0.30 |
| AZ81A | M11811 | remainder | 7.2–8.0 | 0.08 | ... | ... | ... | 0.15–0.35 | ... | 0.010 | ... | 0.20 | ... | ... | 0.5–0.9 | ... | ... | 0.30 |
| AZ91C | M11915 | remainder | 8.3–9.2 | 0.08 | ... | ... | ... | 0.15–0.35 | ... | 0.010 | ... | 0.20 | ... | ... | 0.45–0.9 | ... | ... | 0.30 |
| AZ91E | M11918 | remainder | 8.3–9.2 | 0.015 | ... | 0.005 | ... | 0.17–0.50 | ... | 0.0010 | ... | 0.20 | ... | ... | 0.45–0.9 | ... | 0.01 | 0.30 |
| AZ92A | M11921 | remainder | 8.5–9.5 | 0.20 | ... | ... | ... | 0.13–0.35 | ... | 0.010 | ... | 0.20 | ... | ... | 1.7–2.3 | ... | ... | 0.30 |
| EQ21A | M18330 | remainder | ... | 0.05–0.10 | ... | ... | ... | ... | ... | 0.01 | 1.5–3.0 ^C | 0.01 | 1.3–1.7 | ... | ... | 0.3–1.0 | ... | 0.30 |
| EV31A ^D | M12311 | remainder | ... | 0.01 max | 1.0–1.7 | 0.010 | ... | ... | 2.6–3.1 | 0.0020 | 0.4 ^E | ... | 0.05 max | ... | 0.20–0.50 | 0.3–1.0 | 0.01 | ... |
| EZ33A | M12331 | remainder | ... | 0.03 | ... | ... | ... | ... | ... | 0.010 | 2.6–3.9 | 0.01 | ... | ... | 2.0–3.0 | 0.3–1.0 | ... | 0.30 |
| K1A | M18011 | remainder | ... | 0.03 | ... | ... | ... | ... | ... | 0.010 | ... | 0.01 | ... | ... | ... | 0.3–1.0 | ... | 0.30 |
| QE22A | M18221 | remainder | ... | 0.03 | ... | ... | ... | 0.15 max | ... | 0.010 | 0.9 ^C –2.4 ^C | 0.01 | 2.0–3.0 | ... | 0.2 max | 0.3–1.0 | ... | 0.30 |
| WE43A | M18431 | remainder | ... | 0.03 | ... | ... | 0.18 | 0.15 max | 2.0–2.5 | 0.005 | 2.4–4.4 ^F | 0.01 | ... | 3.7–4.3 | 0.20 max | 0.3–1.0 | ... | 0.30 |
| WE43B | M18433 | remainder | ... | 0.01 | ... | ... | 0.18 | 0.03 max | 2.0–2.5 | 0.004 | 2.4–4.4 ^F | ... | ... | 3.7–4.3 | ... | 0.3–1.0 | 0.01 | ... |
| WE54A | M18410 | remainder | ... | 0.03 | ... | ... | 0.20 | 0.15 max | 1.5–2.0 | 0.005 | 1.5–4.0 ^F | 0.01 | ... | 4.75–5.5 | 0.20 max | 0.3–1.0 | ... | 0.30 |
| ZC63A | M16331 | remainder | ... | 2.4–3.00 | ... | ... | ... | 0.25–0.75 | ... | 0.001 | ... | 0.20 | ... | ... | 5.5–6.5 | ... | ... | 0.30 |
| ZE41A | M16411 | remainder | ... | 0.03 | ... | ... | ... | 0.15 max | ... | 0.010 | 1.0–1.75 | 0.01 | ... | ... | 3.7–4.8 | 0.3–1.0 | ... | 0.30 |
| ZE63A | M16631 | remainder | ... | 0.03 | ... | ... | ... | ... | ... | 0.010 | 2.0–3.0 | 0.01 | ... | ... | 5.5–6.0 | 0.3–1.0 | ... | 0.30 |
| ZK51A | M16511 | remainder | ... | 0.03 | ... | ... | ... | ... | ... | 0.010 | ... | 0.01 | ... | ... | 3.8–5.3 | 0.3–1.0 | ... | 0.30 |
| ZK61A | M16611 | remainder | ... | 0.03 | ... | ... | ... | ... | ... | 0.010 | ... | 0.01 | ... | ... | 5.7–6.3 | 0.3–1.0 | ... | 0.30 |

^A These alloy designations were established in accordance with Practice B 275. UNS designations were established in accordance with Practice E 527.

^B Includes listed elements for which no specific limit is shown.

^C Rare earth elements are in the form of didymium, not less than 70 % Neodymium balance substantially Praseodymium.

^D Alloy EV31A is a patented composition, suitable for elevated temperature applications. Interested parties are invited to submit information regarding the identification of alternatives to these compositions to ASTM International. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this specification. Users of this specification are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

^E Other Rare Earths may also be present to a total maximum of 0.4 %. These Rare Earths shall principally be Cerium, Lanthanum, and Praseodymium.

^F Other Rare Earths shall be principally heavy rare earths, such as, gadolinium, dysprosium, erbium, and ytterbium. Other Rare Earths are derived from the yttrium, typically 80 %, and 20 % heavy rare earths.

^G Zinc + Silver shall be 0.15 % max.

TABLE 2 Chemical Requirements for Alloys Used for Die Castings^A

| Alloy | | Composition, % | | | | | | | | | | | | |
|-------------------------------|--------|----------------|---------------|-------------------|----------------|--------------|----------------|----------------|---------------|----------|-----------|----------|--|----------------------------------|
| Designa- tion ^B | UNS | Magnesium | Alumi- num | Beryllium | Copper, max | Iron, max | Manga- nese | Nickel, max | Rare Earth | Silicon | Strontium | Zinc | Other Metallic impuri- ties, max each ^C | Other Impuri- ties, max |
| AS41A | M10411 | remainder | 3.7–4.8 | ... | 0.04 | ... | 0.22–0.48 | 0.01 | ... | 0.60–1.4 | ... | 0.10 max | ... | 0.30 |
| AS41B | M10413 | remainder | 3.7–4.8 | 0.0005- 0.0015 | 0.015 | 0.0035 | 0.35–0.6 | 0.001 | ... | 0.60–1.4 | ... | 0.10 max | 0.01 | ... |
| AM50A | M10501 | remainder | 4.5–5.3 | 0.0005- 0.0015 | 0.008 | 0.004 | 0.28–0.50 | 0.001 | ... | 0.08 max | ... | 0.20 max | 0.01 | ... |
| AM60A | M10601 | remainder | 5.6–6.4 | ... | 0.25 | ... | 0.15–0.50 | 0.01 | ... | 0.20 max | ... | 0.20 max | ... | 0.30 |
| AM60B | M10603 | remainder | 5.6–6.4 | 0.0005- 0.0015 | 0.008 | 0.004 | 0.26–0.50 | 0.001 | ... | 0.08 max | ... | 0.20 max | 0.01 | ... |
| AZ91A | M11911 | remainder | 8.5–9.5 | ... | 0.08 | ... | 0.15–0.40 | 0.01 | ... | 0.20 max | ... | 0.45–0.9 | ... | 0.30 |
| AZ91B | M11913 | remainder | 8.5–9.5 | ... | 0.25 | ... | 0.15–0.40 | 0.01 | ... | 0.20 max | ... | 0.45–0.9 | ... | 0.30 |
| AZ91D | M11917 | remainder | 8.5–9.5 | 0.0005- 0.0015 | 0.025 | 0.004 | 0.17–0.40 | 0.001 | ... | 0.08 max | ... | 0.45–0.9 | 0.01 | ... |
| AJ52A ^D | M17521 | remainder | 4.6–5.5 | 0.0005- 0.0015 | 0.008 | 0.004 | 0.26–0.5 | 0.001 | ... | 0.08 max | 1.8–2.3 | 0.20 max | 0.01 | ... |
| AJ62A ^D | M17621 | remainder | 5.6–6.6 | 0.0005- 0.0015 | 0.008 | 0.004 | 0.26–0.5 | 0.001 | ... | 0.08 | 2.1–2.8 | 0.20 max | 0.01 | ... |
| AS21A | M10211 | remainder | 1.9–2.5 | 0.0005- 0.0015 | 0.008 | 0.004 | 0.2–0.6 | 0.001 | ... | 0.7–1.2 | ... | 0.20 max | 0.01 | ... |
| AS21B ^D | M10213 | remainder | 1.9–2.5 | 0.0005- 0.0015 | 0.008 | 0.0035 | 0.05–0.15 | 0.001 | 0.06–0.25 | 0.7–1.2 | ... | 0.25 max | 0.01 | ... |

^A The following applies 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 in accordance with the rounding-off procedure prescribed in Practice E 29.

^B ASTM alloy designations were established in accordance with Practice B 275. UNS Numbers were established in accordance with Practice E 527.

^C Includes listed elements for which no specific limit is shown.

^D Alloys AJ52A, AJ62A, and AS21B are patented compositions for elevated temperature applications. Interested parties are invited to submit information regarding the identification of alternatives to these compositions to ASTM International. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this specification. Users of this specification are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.