



Designation: B 93/B 93M – 003

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~~^{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.

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:*

B 275 Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought²

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.

Current edition approved ~~Dec.~~ Aug. 10, 2000³. Published ~~Septem~~ September 2000³. Originally published as B 93–34, approved in 1934. Last previous edition approved in 2000 as B 93/B 93M–9800.

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

- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications³
 E 35 Test Methods for Chemical Analysis of Magnesium and Magnesium Alloys⁴
 E 88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition⁴
 E 527 Practice for Numbering Metals and Alloys (UNS)⁵

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 2¾ by 1¾ (583 by 70 by 44) | 5 (2.3) |
| Four-segment | 28 by 4½ by 4 (711 by 114 by 102) | 20 (9.1) |
| Self-Palletizing | 26½ by 6¾ by 2¾ (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).

NOTE 2—Analysis shall regularly be made only for the elements specifically mentioned in the tables. If, however, the presence of other elements is suspected or indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements is not in excess of the limits specified in the last column of the table.

NOTE 3—The following applies to all specified limits in the tables: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis shall be rounded off in accordance with the rounding off method of Practice E 29 to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

5. Workmanship, Finish and Appearance

5.1 The ingots shall be uniform in quality and shall be commercially free of slag or other foreign material.

6. Sampling for Chemical Analysis

6.1 Sufficient samples shall be taken by the manufacturer to ensure conformance to the chemical composition requirement of the alloy.

6.1.1 Samples may be taken from the molten metal when the ingot is poured or from the ingots. Samples shall be representative of the material.

6.2 In case of dispute, the sampling for chemical analysis shall be according to the requirements of Practice E 88.

6.2.1 If the shipment is in less than carload lots and also in the case of magnesium-zirconium alloys, one ingot section shall be taken for sampling for each 2200 lb (1000 kg) or fraction thereof.

7. Methods of Chemical Analysis

7.1 Any suitable method of chemical analysis may be used. In case of dispute, the analysis shall be made by methods given in Test Methods E 35 or any other standard methods of analysis approved by ASTM unless some other method is agreed upon between the purchaser and vendor.

8. Inspection

8.1 If the purchaser desires that inspection be made at the manufacturer's works where the material is made, it shall be so stated in the contract or purchase order.

8.1.1 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.

² Annual Book of ASTM Standards, Vol 02.02.

³ Annual Book of ASTM Standards, Vol 14.02.

⁴ Annual Book of ASTM Standards, Vol 03.05.

⁵ Annual Book of ASTM Standards, Vol 01.01.

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

| Alloy ^A ASTM | UNS | Magnesium | Aluminum | Manganese | Zinc | Thorium | Rare Earths | Zirconium | Silicon | Copper | Nickel | Silver | Iron | Others | Total Others |
|----------------------------|--------|-----------|----------|-----------|----------|----------------------|------------------------------------|----------------------|---------|-----------|--------|---------|-------|--------|------------------|
| | | max | max | max | max | max | max | max | max | max | max | max | max | max | max ^B |
| AM100A | M10101 | remainder | 9.4–10.6 | 0.13–0.35 | 0.2–max | ... | ... | ... | 0.20 | 0.08 | 0.040 | ... | ... | ... | 0.30 |
| AM100A | M10101 | remainder | 9.4–10.6 | 0.13–0.35 | 0.2 max | ... | ... | ... | 0.20 | 0.08 | 0.010 | ... | ... | ... | 0.30 |
| AZ63A | M11631 | remainder | 5.5–6.5 | 0.15–0.35 | 2.7–3.3 | ... | ... | ... | 0.20 | 0.20 | 0.040 | ... | ... | ... | 0.30 |
| AZ63A | M11631 | remainder | 5.5–6.5 | 0.15–0.35 | 2.7–3.3 | ... | ... | ... | 0.20 | 0.20 | 0.010 | ... | ... | ... | 0.30 |
| AZ84A | M11811 | remainder | 7.2–8.0 | 0.15–0.35 | 0.5–0.9 | ... | ... | ... | 0.20 | 0.08 | 0.040 | ... | ... | ... | 0.30 |
| AZ84A | M11811 | remainder | 7.2–8.0 | 0.15–0.35 | 0.5–0.9 | ... | ... | ... | 0.20 | 0.08 | 0.010 | ... | ... | ... | 0.30 |
| AZ91C | M11915 | remainder | 8.3–9.2 | 0.15–0.35 | 0.45–0.9 | ... | ... | ... | 0.20 | 0.08 | 0.040 | ... | ... | ... | 0.30 |
| AZ91C | M11915 | remainder | 8.3–9.2 | 0.15–0.35 | 0.45–0.9 | ... | ... | ... | 0.20 | 0.08 | 0.010 | ... | ... | ... | 0.30 |
| AZ91E | M11918 | remainder | 8.3–9.2 | 0.17–0.50 | 0.45–0.9 | ... | ... | ... | 0.20 | 0.015 | 0.0010 | ... | 0.005 | 0.01 | 0.30 |
| AZ92A | M11921 | remainder | 8.5–9.5 | 0.13–0.35 | 4.7–2.3 | ... | ... | ... | 0.20 | 0.20 | 0.040 | ... | ... | ... | 0.30 |
| AZ92A | M11921 | remainder | 8.5–9.5 | 0.13–0.35 | 1.7–2.3 | ... | ... | ... | 0.20 | 0.20 | 0.010 | ... | ... | ... | 0.30 |
| E624A | M18330 | remainder | ... | ... | ... | ... | 4.5–3.0 ^C | 0.3–1.0 | 0.04 | 0.05–0.40 | 0.04 | 4.3–1.7 | ... | ... | 0.30 |
| E233A | M12331 | remainder | ... | ... | 2.0–3.0 | ... | 1.5–3.0 ^C | 0.3–1.0 | 0.01 | 0.05–0.10 | 0.01 | 1.3–1.7 | ... | ... | 0.30 |
| E233A | M12331 | remainder | ... | ... | ... | ... | 2.6–3.9 | 0.3–1.0 | 0.01 | 0.03 | 0.010 | ... | ... | ... | 0.30 |
| HK34A | M13341 | remainder | ... | ... | 0.25–max | 2.6–3.8 | ... | 0.3–1.0 | 0.04 | 0.40 | 0.040 | ... | ... | ... | 0.30 |
| HZ32A | M13321 | remainder | ... | ... | 1.8–2.4 | 2.6–3.8 | 0.10–max | 0.3–1.0 | 0.04 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| K1A | M18011 | remainder | ... | ... | ... | ... | ... | 0.3–1.0 | 0.01 | 0.03 | 0.010 | ... | ... | ... | 0.30 |
| KE22A | M18221 | remainder | ... | 0.15–max | 0.2–max | ... | 4.0 ^C –2.4 ^C | 0.3–1.0 | 0.04 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| QE22A | M18221 | remainder | ... | 0.15 max | 0.2 max | ... | 1.9 ^C –2.4 ^C | 0.3–1.0 | 0.01 | 0.03 | 0.010 | ... | ... | ... | 0.30 |
| QH24A | M18411 | remainder | ... | 0.15 max | 0.2 max | 0.6–1.6 ^D | 0.6 ^C –1.5 ^C | 0.3–1.0 | 0.04 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| WE43A ^{DE} | M18431 | remainder | ... | 0.15 max | 0.20 max | 3.7–4.3 | 2.4–4.4 ^E | 0.3–1.0 | 0.01 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| WE43A ^{EE} | M18430 | remainder | ... | 0.15–max | 0.20–max | ... | 3.7–4.3 | 2.4–4.4 ^G | 0.3–1.0 | ... | 0.01 | ... | 0.03 | ... | 0.30 |
| WE43B ^{DE} | M18433 | remainder | ... | 0.03 max | 0.20 max | ... | 3.7–4.3 | 2.4–4.4 ^F | 0.3–1.0 | ... | 0.01 | ... | 0.03 | ... | 0.30 |
| WE54A ^{EE} | M18410 | remainder | ... | 0.15 max | 0.20 max | ... | 4.5–4.0 ^G | 0.3–1.0 | 0.04 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| WE54A ^{DE} | M18410 | remainder | ... | 0.15 max | 0.20 max | ... | 1.5–4.0 ^F | 0.3–1.0 | 0.01 | 0.03 | 0.005 | ... | ... | ... | 0.30 |
| ZG63A | M16331 | remainder | ... | 0.25–0.75 | 5.5–6.5 | ... | ... | ... | 0.20 | 2.4–3.00 | 0.004 | ... | ... | ... | 0.30 |
| ZG63A | M16331 | remainder | ... | 0.25–0.75 | 5.5–6.5 | ... | ... | ... | 0.20 | 2.4–3.00 | 0.001 | ... | ... | ... | 0.30 |
| ZG63A | M16331 | remainder | ... | 0.25–0.75 | 5.5–6.5 | ... | ... | ... | 0.20 | 2.4–3.00 | 0.001 | ... | ... | ... | 0.30 |
| ZE41A | M16411 | remainder | ... | 0.15 max | 3.7–4.8 | ... | 4.0–1.7 ^G | 0.3–1.0 | 0.04 | 0.03 | 0.010 | ... | ... | ... | 0.30 |
| ZE41A | M16411 | remainder | ... | 0.15 max | 3.7–4.8 | ... | 1.0–1.7 ^G | 0.3–1.0 | 0.01 | 0.03 | 0.010 | ... | ... | ... | 0.30 |
| ZE63A | M16631 | remainder | ... | ... | 5.5–6.0 | 4.5–2.4 | 2.0–3.0 | 0.3–1.0 | 0.04 | 0.03 | 0.010 | ... | ... | ... | 0.30 |
| ZH62A | M16621 | remainder | ... | ... | 3.8–6.3 | ... | ... | 0.3–1.0 | 0.04 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| ZK64A | M16511 | remainder | ... | ... | 5.7–6.3 | ... | ... | 0.3–1.0 | 0.01 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| ZK64A | M16511 | remainder | ... | ... | 5.7–6.3 | ... | ... | 0.3–1.0 | 0.04 | 0.03 | 0.040 | ... | ... | ... | 0.30 |
| ZK61A | M16611 | remainder | ... | ... | 5.7–6.3 | ... | ... | 0.3–1.0 | 0.01 | 0.03 | 0.010 | ... | ... | ... | 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 % Nd balance substantially Pr.

^D The thorium content plus the rare earth elements must be more than 1.5 % but less than 2.4 %.

^E Yttrium content for WE43A and WE54A shall be 3.7 to 4.3 and 4.75 to 5.5 %, respectively.

^F Lithium content for WE43A and WE54A shall be 0.20 % max.

^G Rare earths are 2.0 to 2.5 % and 1.5 to 2.0 % neodymium for WE43A and WE54A, respectively, the remainder being heavy rare earths.

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

| Alloy | | Composition, % | | | | | | | | | | |
|--------------------------|--------|----------------|-----------|----------|-------------|-----------|----------|-------------|--------------|--|-----------------------|-----------|
| Designation ^B | UNS | Aluminum | Manganese | Zinc | Copper, max | Iron, max | Silicon | Nickel, max | Beryllium | Other Metallic impurities, max each ^C | Other Impurities, max | Magnesium |
| AS41A | M10411 | 3.7–4.8 | 0.22–0.48 | 0.10 max | 0.04 | ... | 0.60–1.4 | 0.01 | ... | ... | 0.30 | remainder |
| AS41B | M10413 | 3.7–4.8 | 0.35–0.6 | 0.10 max | 0.015 | 0.0035 | 0.60–1.4 | 0.001 | 0.0005-0.003 | 0.01 | ... | remainder |
| AM50A | M10501 | 4.5–5.3 | 0.28–0.50 | 0.20 max | 0.008 | 0.004 | 0.08 max | 0.001 | 0.0005-0.003 | 0.01 | ... | remainder |
| AM60A | M10601 | 5.6–6.4 | 0.15–0.50 | 0.20 max | 0.25 | ... | 0.20 max | 0.01 | ... | ... | 0.30 | remainder |
| AM60B | M10603 | 5.6–6.4 | 0.26–0.50 | 0.20 max | 0.008 | 0.004 | 0.08 max | 0.001 | 0.0005-0.003 | 0.01 | ... | remainder |
| AZ91A | M11911 | 8.5–9.5 | 0.15–0.40 | 0.45–0.9 | 0.08 | ... | 0.20 max | 0.01 | ... | ... | 0.30 | remainder |
| AZ91B | M11913 | 8.5–9.5 | 0.15–0.40 | 0.45–0.9 | 0.25 | ... | 0.20 max | 0.01 | ... | ... | 0.30 | remainder |
| AZ91D | M11917 | 8.5–9.5 | 0.17–0.40 | 0.45–0.9 | 0.025 | 0.004 | 0.08 max | 0.001 | 0.0005-0.003 | 0.01 | ... | remainder |

^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.

8.1.2 All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

9. Rejection

9.1 Material that does not conform to the requirements of this specification may be rejected and, if rejected, the seller's responsibility shall be limited to replacing the rejected material. The full weight of the rejected material shall be returned to the manufacturer.

10. Product Marking

10.1 Identification shall be by stamping with the alloy designation in Table 1 and Table 2.

11. Packaging and Package Marking

11.1 Ingots shall be packaged in such a manner as to prevent damage in ordinary handling and transportation. The type of packing and gross weight of individual containers or bundles shall be left to the discretion of the supplier unless otherwise agreed upon. Packaging methods shall be so selected as to permit maximum utility of equipment in unloading and subsequent handling. Each container or bundle shall contain only one size and alloy when packaged for shipment unless otherwise agreed upon.

11.2 Each package shall be marked with the purchase order number, quantity, specification number, alloy, gross or net weights, and, also, the name of the manufacturer.

11.2.1 Each package shall be color-coded on two opposite corners, visible from four sides, with the colors listed in Table 3 when stated as a purchase order requirement.

11.3 Packages shall be such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery.

11.4 For those alloys listed, the various national regulations concerning the transportation of these alloys will be complied with in regard to hazardous materials.

12. Keywords

12.1 composition; die casting; high pressure die cast alloy; magnesium; permanent mold casting; sand casting

TABLE 3 Color Code

| Alloy | Color Code |
|-------|------------------|
| AM50A | Black |
| AM60A | Green and White |
| AM60B | White |
| AS41A | Red |
| AS41B | Red and White |
| AZ91B | Blue and Yellow |
| AZ91C | Brown |
| AZ91D | Yellow |
| AZ91E | Brown and Yellow |

SUMMARY OF CHANGES

Committee B07 has identified the location of selected changes to this standard since the last issue (B 93/B 93M-98) that may impact the use of this standard.

- (1) Added Paragraph 11.2.1.
- (2) Revised order of listed alloy elements in Table 2.
- (3) Revised maximum Si level in alloys AM50A, AM60B, and AZ91D to 0.08.
- (4) Added Beryllium to list of elements.
- (5) Removed footnote D from Table 2.

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