Designation: B93/B93M – 21

Standard Specification for Magnesium Alloys in Ingot Form for Sand Castings, Permanent Mold Castings, and Die Castings[1]

This standard is issued under the fixed designation B93/B93M; 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 U.S. 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 B80, B94, B199, and B403.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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]

B80 Specification for Magnesium-Alloy Sand Castings

B94 Specification for Magnesium-Alloy Die Castings

B199 Specification for Magnesium-Alloy Permanent Mold Castings

B403 Specification for Magnesium-Alloy Investment Castings

B660 Practices for Packaging/Packing of Aluminum and Magnesium Products

B666/B666M Practice for Identification Marking of Aluminum and Magnesium Products

B951 Practice for Codification of Unalloyed Magnesium and Magnesium-Alloys, Cast and Wrought

B953 Practice for Sampling Magnesium and Magnesium Alloys for Spectrochemical Analysis

B954 Test Method for Analysis of Magnesium and Magnesium Alloys by Atomic Emission Spectrometry

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (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).

3.1.3 Form, as agreed upon between the purchaser and seller.

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.

[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 May 1, 2021. Published June 2021. Originally approved in 1934. Last previous edition approved in 2015 as B93/B93M – 15. DOI: 10.1520/B0093_B0093M-21.

[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	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[F]	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	1.9–2.4[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	1.9[G]	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	1.9[G]	...	...[H]	3.7–4.3	...[H]	0.3–1.0	0.01	...
WE54A	M18410	remainder	...	0.03	...	...	0.20	0.15 max	1.5–2.0	0.005	2.0[G]	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[F]	0.01	...	...	3.7–4.8	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 B951. UNS designations were established in accordance with Practice E527.
[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] Total Rare Earths (TRE) are principally a mixture of Cerium, Lanthanum, Neodymium, and Praseodymium. The Cerium content should not be less than 45 % of TRE.
[G] 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.
[H] Zinc + Silver shall be 0.15 % max.

TABLE 2 Chemical Requirements for Alloys Used for Die Castings[A]

Alloy		Composition, %												
Designation[B]	UNS	Magnesium	Aluminum	Beryllium	Copper, max	Iron, max	Manganese	Nickel, max	Rare Earth	Silicon	Strontium	Zinc	Other Metallic impurities, max each[C]	Other Impurities, max
AS41A	M10411	rem*	3.7–4.8	...	0.04	...	0.22–0.48	0.01	...	0.60–1.4	...	0.10 max	...	0.30
AS41B	M10413	rem	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	rem	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	rem	5.6–6.4	...	0.25	...	0.15–0.50	0.01	...	0.20 max	...	0.20 max	...	0.30
AM60B	M10603	rem	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	rem	8.5–9.5	...	0.08	...	0.15–0.40	0.01	...	0.20 max	...	0.45–0.9	...	0.30
AZ91B	M11913	rem	8.5–9.5	...	0.25	...	0.15–0.40	0.01	...	0.20 max	...	0.45–0.9	...	0.30
AZ91D	M11917	rem	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	rem	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	rem	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	rem	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	rem	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	...

* *rem = 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 E29.

[B] ASTM alloy designations were established in accordance with Practice B951. UNS Numbers were established in accordance with Practice E527.

[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.

4.2 The alloys shall conform to the chemical composition requirements prescribed in Tables 1 and 2 (Notes 2 and 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 E29 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 Standard Practice B953.

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 ASTM Standard Test Method B954 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.

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.