



Designation: **B199—12 B199 – 17**

Standard Specification for Magnesium-Alloy Permanent Mold Castings¹

This standard is issued under the fixed designation B199; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

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

1. Scope*

- 1.1 This specification covers magnesium alloy permanent mold casting alloys designated as shown in ~~Table 1~~ Table 1.
- 1.2 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information only.
- 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.*
- 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

- [B93/B93M Specification for Magnesium Alloys in Ingot Form for Sand Castings, Permanent Mold Castings, and Die Castings](#)
- [B296 Practice for Temper Designations of Magnesium Alloys, Cast and Wrought](#)
- [B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products](#)
- [B660 Practices for Packaging/Packing of Aluminum and Magnesium Products](#)
- [B661 Practice for Heat Treatment of Magnesium Alloys](#)
- [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](#)
- ~~[E8 Test Methods for Tension Testing of Metallic Materials](#)~~
- [E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)
- [E88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition](#)
- [E94 Guide for Radiographic Examination](#)
- [E155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings](#)
- [E165 Practice for Liquid Penetrant Examination for General Industry](#)
- [E527 Practice for Numbering Metals and Alloys in the Unified Numbering System \(UNS\)](#)

2.3 *Federal Standards:*

[Fed. Std. No. 123 Marking for Shipment \(Civil Agencies\)](#)³

2.4 *Aerospace Materials Specification:*⁴

[AMS 2768 Heat Treatment of Magnesium Alloy Castings](#)

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.

³ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

⁴ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

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

3. Terminology

3.1 Definitions:

3.1.1 *permanent mold casting*—*casting, n*—a metal object produced by introducing molten metal by gravity or low pressure into a mold constructed of durable material, usually iron or steel, and allowing it to solidify.

3.1.2 *semipermanent mold casting*—*casting, n*—a permanent mold casting which is made using an expendable core such as bonded sand.

4. Ordering Information

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

- 4.1.1 Quantity of each casting,
- 4.1.2 Alloy (Section 7 and Table 1),
- 4.1.3 Temper (Section 8 and Table 2),
- 4.1.4 Minimum properties of specimens cut from castings, if required (see section 9.3),
- 4.1.5 Drawing showing dimensions of the castings (the amount of stock left for machine finish should be indicated),
- 4.1.6 Surface treatment (see 10.1),
- 4.1.7 Whether inspection is required at the manufacturer’s works (see section 11.1.1),
- 4.1.8 Special inspection requirements (see 11.2),
- 4.1.9 Whether certification is required (see 13.1), and
- 4.1.10 Whether marking for identification is required (see 14.1).

TABLE 1 Chemical Composition Limits^A

NOTE 1—Analysis shall regularly be made only 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 applies to all specified limits in this table: For purposes of acceptance and rejection, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

Alloy Number ^B		Composition, %											Total ^C Other Impuri- ties	Others Each
ASTM	UNS	Iron	Magne- sium	Aluminum	Manga- nese	Zinc	Rare Earths	Zirconium	Silicon	Copper	Nickel	Total ^C Other Impuri- ties	Others Each	
ASTM	UNS	Magne- sium	Aluminum	Copper	Iron	Manga- nese	Nickel	Rare Earths	Silicon	Zinc	Zirco- nium	Total ^C Other Impuri- ties	Total ^C Other Impuri- ties	
AM100A	M10100	...	remainder	9.3 to 10.7	0.10-0.35	0.30	...	...	0.30	0.10	0.01	0.30	...
AM100A	M10100	remainder	9.3-10.7	0.10	...	0.10-0.35	0.01	...	0.30	0.30	...	...	0.30
AZ81A	M11810	...	remainder	7.0 to 8.4	0.13-0.35	0.40 to 1.0	...	...	0.30	0.10	0.01	0.30	...
AZ81A	M11810	remainder	7.0-8.1	0.10	...	0.13-0.35	0.01	...	0.30	0.40-1.0	...	...	0.30
AZ91C	M11914	...	remainder	8.1 to 9.3	0.13-0.35	0.40 to 1.0	...	...	0.30	0.10	0.01	0.30	...
AZ91C	M11914	remainder	8.1-9.3	0.10	...	0.13-0.35	0.01	...	0.30	0.40-1.0	...	...	0.30
AZ91E	M11919	0.005 ^D	remainder	8.1 to 9.3	0.17-0.35	0.40 to 1.0	...	...	0.20	0.015	0.0010	0.30	0.01
AZ91E	M11919	remainder	8.1-9.3	0.015	0.005 ^D	0.17-0.35	0.0010	...	0.20	0.40-1.0	...	0.01	0.30	
AZ92A	M11920	...	remainder	8.3 to 9.7	0.10-0.35	1.6 to 2.4	...	...	0.30	0.25	0.01	0.30	...
AZ92A	M11920	remainder	8.3-9.7	0.25	...	0.10-0.35	0.01	...	0.30	1.6-2.4	...	...	0.30
EQ21A ^E	M18330	...	remainder	...	...	...	1.5 to 3.0 ^F	0.40 to 1.0	...	0.05-0.10	0.01	0.30	...
EQ21A ^E	M18330	remainder	...	0.05-0.10	...	...	0.01	1.5-3.0 ^F	...	...	0.40-1.0	...	0.30
EZ33A	M12330	...	remainder	...	...	2.0 to 3.1	2.5 to 4.0	0.50 to 1.0	...	0.10	0.01	0.30	...
EZ33A	M12330	remainder	...	0.10	...	...	0.01	2.5-4.0	...	2.0-3.1	0.50-1.0	...	0.30
QE22A ^G	M18220 ^E	...	remainder	...	...	...	1.8 to 2.5 ^F	0.40 to 1.0	...	0.10	0.01	0.30	...
QE22A ^G	M18220 ^E	remainder	...	0.10	...	...	0.01	1.8-2.5 ^F	...	...	0.40-1.0	...	0.30

^A Limits—Limits are in weight percent max unless shown as a range or stated otherwise.

^B ASTM—ASTM alloy designations were established in accordance with Practice B951. UNS designations were established in accordance with Practice E527.

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

^D If iron exceeds 0.005 %, the iron to manganese ratio shall not exceed 0.032.

^E Silver—Silver content for Alloy EQ21A (M18330) shall be 1.3 to 1.7 %.

^F Rare earth elements are in the form of didymium.

^G Silver—Silver content for Alloy QE22A (M18220) shall be 2.0 to 3.0, inclusive.

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 to the nearest 0.1 ksi and each value for elongation shall be rounded to the nearest 0.5 % both in accordance with the rounding method of Practice E29.

Alloy Number		Temper ^A	Tensile Strength, min. ksi (MPa)	Yield Strength ^B (0.2 % offset) min. ksi (MPa)	Elongation in 2 in., (50.8 mm) min., %
ASTM	UNS				
AM100A	M10100	F	20.0 (138)	10.0 (69)	^C
		T4	34.0 (234)	10.0 (69)	6
		T6	34.0 (234)	15.0 (103)	2
		T61	34.0 (234)	17.0 (117)	^C
AZ81A	M11810	T4	34.0 (234)	11.0 (76)	7
		F	23.0 (158)	11.0 (76)	^C
AZ91C	M11914	T4	34.0 (234)	11.0 (76)	7
		T5	23.0 (158)	12.0 (83)	2
		T6	34.0 (234)	16.0 (110)	3
		T6	34.0 (234)	16.0 (110)	...
AZ91E	M11919	T6	34.0 (234)	16.0 (110)	...
AZ92A	M11920	F	23.0 (158)	11.0 (76)	^C
		T4	34.0 (234)	11.0 (76)	6
		T5	23.0 (158)	12.0 (83)	^C
		T6	34.0 (234)	18.0 (124)	^C
EQ21A	M18330	T6	34.0 (234)	25.0 (172)	...
EZ33A	M12330	T5	20.0 (138)	14.0 (96)	2
QE22A	M18220	T6	35.0 (241)	25.0 (172)	2

^A These temper designations were established in accordance with Practice B296.

^B See X1.3.

^C Not required.

5. Manufacture

5.1 The responsibility of furnishing castings that can be laid out and machined to the finished dimensions within the permissible variations specified, as shown on the blueprints or drawings, shall rest with the supplier, except when molds are furnished by the purchaser. Sufficient stock shall be allowed for shrinkage, and where requested, for finishing; castings of excessive weight shall not be furnished.

5.2 The castings may be subjected to the heat treatment necessary to produce material that will conform to the requirements specified. Heat treatment shall be performed on the whole of a casting, never on a part only, and shall be applied in a manner that will produce the utmost uniformity.

6. General Quality

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

7. Chemical Composition

7.1 *Limits*—The material shall conform to the chemical composition limits prescribed in Table 1. Conformance shall be determined by analyzing samples taken when the castings are poured, or by analyzing samples taken from the finished product. If the chemical composition has been determined during the course of manufacture, sampling and analysis of the finished product is not necessary.

7.2 *Number of Samples*—The number of samples taken for determination of chemical composition shall be as follows:

7.2.1 When samples are taken at the time the castings are poured, at least one sample shall be taken from each melt of 2000 lb (907 kg) or fraction thereof.

7.2.2 When samples are taken from the castings or test bars, a sample shall be taken to represent each 2000 lb (907 kg) or fraction thereof in the shipment except that not more than one sample shall be required per casting.

7.3 *Methods of Sampling*—Samples for determination of chemical composition shall be taken in accordance with one of the following methods:

7.3.1 Samples for chemical analysis shall be taken from the material by drilling, sawing, milling, turning, or clipping a representative piece or pieces to obtain a weight of prepared sample not less than 75 g. Sampling shall be in accordance with Practice E88.

7.3.2 Samples for spectrochemical analysis shall be in accordance with Practice B953, or other methods of analysis shall be taken by methods suitable for the form of material being analyzed and the type of analytical method used.

7.4 *Methods of Chemical Analysis*—Any suitable method of chemical analysis may be used. In case of dispute, the analysis shall be made by methods given in Test Method B954 or any other standard methods of analysis approved by ASTM unless some other method is agreed upon.

8. Heat Treatment

8.1 Unless otherwise specified, heat treatment for the applicable tempers designated in **Table 2** shall be in accordance with Practice **B661** or with AMS 2768.

9. Tensile Requirements

9.1 *Limits*—The tension test specimens representing the castings shall conform to the requirements of **Table 2**.

9.2 *Number of Tests*—At least one tension test specimen 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. The specimens shall then be tested to judge the response of their corresponding melts to the type of heat treatment to which the specimens were subjected.

9.2.1 Each heat-treating furnace charge shall include at least one tension test specimen 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.

9.3 If test bars are cut from castings, the number and location shall be as agreed upon between the supplier and the purchaser. Depending on the radiographic quality specified (see **11.4**), test bars cut from casting may not meet the requirements of **Table 2**. Mechanical property limits from cut bars shall be agreed to by the supplier and purchaser.

9.4 *Test Specimens*—The tension test specimens shall be separately cast in a permanent mold and shall be cast to size in accordance with the dimensions shown in Fig. 89 of Test Method **B557**. They shall not be machined prior to testing except to adapt the grip ends to the holders of the testing machine in such a manner as to ensure an axial load.

9.4.1 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 supplier and the purchaser shall agree on an alternative procedure.

9.5 *Test Methods*—The tension tests shall be made in accordance with Test Method **B557**.

10. Finish

10.1 Depending on casting processing and end use requirements, castings should be protected by the use of chrome pickling, anodizing, resin sealing, or other approved methods prior to shipment (see **X1.4**).

11. Inspection

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

11.1.1 If the purchaser elects to have the inspection made at the supplier's works, the supplier 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 inspections shall be so conducted as not to interfere unnecessarily with the operation of the works.

11.2 Special inspection requirements such as simulated service, pressure testing, X-ray, or fluorescent penetrant must be stated on the order.

11.3 *Liquid Penetrant Inspection:*

11.3.1 When specified, liquid penetrant inspection shall be in accordance with Test Method **E165**, and the required sensitivity shall be specified.

11.3.2 Acceptable standards for discontinuities shall be agreed upon, including size and frequency per unit area and location.

11.4 *Radiographic Inspection:*

11.4.1 When specified, radiographic inspection shall be in accordance with Guide **E94** and Reference **E155**.

TABLE 3 Discontinuity-Severity Level Requirements for Magnesium Castings (Reference Radiograph E155)

Discontinuity	Grade A		Grade B		Grade C		Grade D	
	Section Thickness, in.							
	1/4	3/4	1/4	3/4	1/4	3/4	1/4	3/4
Gas Holes	none		1	1	2	2	5	5
Microshrinkage (feathery)	none		1	1	2	2	4	3
Microshrinkage (sponge)	none		1	1	2	2	4	3
Foreign material (less dense)	none		1	1	2	2	4	4
Foreign material (more dense)	none		1	1	2	2	4	3
Cracks	none			none		none		none
Cold Shuts	none			none		none		none
Surface irregularity				not to exceed drawing tolerance				
Core Shift				not to exceed drawing tolerance				