



Magnesium Alloy Ingots for High Pressure Die Casting

1 Scope

This material specification covers the basic requirements for magnesium alloy ingots and is to be used for initial source validation of the ingot manufacturing process. It is implicit in this specification that the magnesium alloy ingots shall be of acceptable quality such that they can be cast into parts that will meet all relevant GM mechanical, chemical, and performance requirements. Magnesium alloy ingots are specified by chemical composition.

Reference GMW16744 defines the process and requirements a magnesium producer must satisfy to qualify their ingot production process.

1.1 Material Description. The systems of magnesium alloys commonly used for automotive high pressure die casting are: magnesium-aluminum-zinc (AZ), magnesium-aluminum-manganese (AM), magnesium-aluminum-silicon (AS) and magnesium-aluminum-rare earth (AE). The various grades of pressure die cast magnesium alloys can be referenced in GM Worldwide specification GMW3028.

1.1.1 Material Identification. Material shall be identified either by ASTM International or International Organization for Standardization (ISO) designations. A list of commonly used alloys in ASTM (USA) and ISO designations are shown in Table C1, Appendix C.

1.2 Symbols. Not applicable.

1.3 Applicability. Magnesium alloy ingots are used to as base melting stock to cast magnesium alloy parts for automotive usage. Various compositions are needed to meet performance requirements of the different high pressure die cast grades.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM B93/B93M	ASTM E385	ISO 16220
ASTM B117	ASTM G1	

2.2 GM Standards/Specifications.

GMW3028	GMW3286	GMW16744
GMW3059	GMW14729	

2.3 Additional References.

- Safety and Industrial Hygiene (S&IH) Technical Standard (TS), S&IH TS 3.4-160-02

3 Requirements

3.1 Requirements on Test Specimens.

3.1.1 Chemical Requirements. The ingot alloys shall meet the chemical composition requirements per ASTM B93/B93M and ISO 16220. Chemical composition limits are shown in Table 1.

Table 1: Chemical Composition for GMW3035 Magnesium Alloy Ingots Note 1, Note 2

Material GMW3035M- MG-I	Material ASTM ISO	Al	Mn	Zn	Si	Fe (Max.)	Cu (Max.)
Al9Zn1	AZ91D	8.5 to 9.5	0.17 to 0.40	0.45 to 0.9	0.08 max.	0.004	0.025
	MgAl9Zn1 (A)	8.5 to 9.5	0.17 to 0.40	0.45. to 0.9	0.08 max.	0.004	0.025
Al5Mn	AM50A	4.5 to 5.3	0.28 to 0.50	0.20 max.	0.08 max.	0.004	0.008
	MgAl5Mn	4.5 to 5.3	0.28 to 0.50	0.30 max.	0.08 max.	0.004	0.008
Al6Mn	AM60B	5.6 to 6.4	0.26 to 0.50	0.20 max.	0.08 max.	0.004	0.008
	MgAl6Mn	5.6 to 6.4	0.26 to 0.50	0.30 max.	0.08 max.	0.004	0.008
Al4Si	AS41B	3.7 to 4.8	0.35 to 0.6	0.10 max.	0.60 to 1.4	0.0035	0.015
	MgAl4Si	3.7 to 4.8	0.2 to 0.6	0.20 max.	0.7 to 1.2	0.004	0.008
Al4RE2	AE42	3.6 to 4.4	0.18 to 0.50	0.20 max.	0.05 max.	0.004	0.008
	MgAl4RE2	3.4 to 4.6	0.18 to 0.50	0.20 max.	0.05 max.	0.004	0.008
Al4RE4	AE44	3.6 to 4.4	0.18 to 0.50	0.20 max.	0.05 max.	0.004	0.008
	MgAl4RE4 Note 3	3.6 to 4.4	0.18 to 0.50	0.20 max.	0.05 max.	0.004	0.008
Material GMW3035M- MG-I	Material ASTM ISO	Ni (Max.)	Rare Earth (RE)	Other Metallic Impurities (Max. each)	RE/Al (Ratio Min.) Note 4	Mg	
Al9Zn1	AZ91D	0.001	-	0.01	-	Balance	
	MgAl9Zn1 (A)	0.001	-	0.01	-	Balance	
Al5Mn	AM50A	0.001	-	0.01	-	Balance	
	MgAl5Mn	0.001	-	0.01	-	Balance	
Al6Mn	AM60B	0.001	-	0.01	-	Balance	
	MgAl6Mn	0.001	-	0.01	-	Balance	
Al4Si	AS41B	0.001	-	0.01	-	Balance	
	MgAl4Si	0.001	-	0.01	-	Balance	
Al4RE2	AE42	0.001	2.0 to 3.0 Note 5	0.01	-	Balance	
	MgAl4RE2	0.001	2.0 to 3.0 Note 5	0.01	-	Balance	
Al4RE4	AE44	0.001	3.6 to 4.6 Note 5	0.01	0.9	Balance	
	MgAl4RE4 Note 3	0.001	3.6 to 4.6 Note 5	0.01	0.9	Balance	

Note 1: Composition limits in percent (%) by weight. Remainder is magnesium (Mg).**Note 2:** All alloys shall have a beryllium content of 5 to 15 ppm per ASTM B93/B93M.**Note 3:** Magontec composition list by ISO 16220.**Note 4:** Includes listed elements for which no specific limit is shown.**Note 5:** Total Rare Earth (TRE) additions are principally a mixture of Cerium, Lanthanum, Neodymium and Praseodymium with the following ranges: **Ce:** 60% to 70%, **La:** 30% to 40%, **Nd + Pr** < 1.0%.**Max.** = maximum; **Min.** = minimum; **Mg** = magnesium

3.1.2 Mechanical Requirements. Not applicable.

3.1.3 Physical Requirements. Not applicable.

3.1.4 Additional Requirements.

3.1.4.1 Cleanliness of Ingots.

3.1.4.1.1 Ingot regions to be sampled and evaluated are provided in Appendix A (reference Figure A1 and Figure A2). The ingots shall be selected from the start, middle, and the end of a lot or run. The type of ingot, sample location within the ingot, and number of lots or runs to be tested shall be approved by the supplier and purchaser (Nonferrous and Casting Materials Global Subsystem Leadership Team (GSSLT) designated representative). If the ingot size or geometry does not permit excising specimens for Fast Neutron Activation Analysis (FNAA), cleanliness and corrosion testing in the locations identified in Appendix A, an alternative sampling pattern has to be approved by the Nonferrous and Casting Materials GSSLT designated representative.

3.1.4.1.2 The average oxygen content of three ingots sampled, one each from the beginning, middle and end of the agreed upon production lot shall not exceed 300 ppm as measured by ASTM E385, FNAA. Alternatively, other methods for determining oxide inclusion content can be used if they have been calibrated against FNAA and approved by supplier and purchaser (Nonferrous and Casting Materials GSSLT designated representative). The average oxygen content is to be calculated by averaging the results from FNAA specimens excised from the three ingots sampled at the beginning, middle and end of the agreed upon batch, lot or run.

3.1.4.1.3 The chlorine content of each alloy shall not exceed 100 ppm.

3.1.4.2 Identification of Ingots. The alloy of the ingots shall be shown by cast, stamped or color identifications. If ingots are identified by color, the colors used shall be as shown in Table 2 below.

Table 2: Mg Alloy Ingot Identification by Color Code

GMW3035M-MG-I	ASTM	Color Code
Al9Zn1	AZ91D	Yellow
Al5Mn	AM50A	Black
Al6Mn	AM60B	White
Al4Si	AS41B	Red and white
Al4RE2	AE42	-
Al4RE4	AE44	Orange

3.2 Processing Requirements. Not applicable.

3.3 Performance Requirements.

3.3.1 Chemical Requirements.

3.3.1.1 Corrosion Resistance. The source shall demonstrate that the corrosion rate of the metal shall not exceed the maximum rates shown in Table 3. The corrosion testing method used shall be salt spray per GMW3286 (Reference ASTM B117) and humidity test as per GMW14729. Test duration shall be 100 h. Sample preparation, testing and evaluation shall be conducted per Appendix B.