



Pressure Die Casting Zinc Alloys

1 Scope

This material specification applies to zinc alloys for use in high pressure die cast automotive applications and other allied industries. Zinc die casting alloys are specified by chemical composition. The alloys indicated represent common materials for identical product requirements across GM worldwide.

1.1 Material Description. Zinc base casting alloys use aluminum and copper as the primary alloying elements with small amounts of magnesium added to minimize susceptibility to intergranular corrosion. The alloying elements determine the primary phases that give the material its mechanical and physical properties. The primary phases that are formed (see 3.3) results in three distinct alloy groups which are described in Table A1 in Appendix A. High pressure zinc die castings are also characterized by excellent castability and wear properties. Zinc alloy castings are to be made from ingots that meet the requirements of the global specification for Zinc Alloy Ingots for High Pressure Die Casting, GMW3344.

1.2 Symbols. Not applicable.

1.3 Applicability. Because of their higher density, zinc alloy castings are less widely used in automotive applications than they were historically. They still do have a place, however, where intricate castability and high strength coincide. Typical applications and alloy selection criteria for major subsystems are provided in Table B1 in Appendix B. Zinc alloys are capable of being die cast with complex details, close tolerances and thin walls, thus making them attractive for many automotive applications. Both Zamak and ZA alloys are used for decorative and non-structural applications and, in some cases, the ZA alloys are also used for structural components. ACuZinc is a patented family of zinc casting alloys developed by General Motors. The ACuZinc alloys have higher strength and hardness and better creep and wear properties than the Zamak and ZA alloys. This makes them suitable for a variety of applications where the Zamak and ZA alloys are unsuitable.

1.4 Remarks. Table A1 in Appendix A contains a cross reference between GMW3341 alloy grades and their respective commercial alloy designations, American and European standards and is presented for reference only. GMW3341 requirements may differ from those in other specifications. Cross referenced alloys are not interchangeable with their GMW3341 counterpart.

2 References

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

2.1 External Standards/Specifications.

ASTM B86	EN 12844	ISO 9915	SAE J468
ASTM B894	ISO 6506	ISO 9916	
ASTM E536	ISO 6892	KS D 6005	

2.2 GM Standards/Specifications.

GMW3059	GMW3344
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3 Requirements

3.1 Chemical Requirements. Castings furnished to this specification shall conform to the chemical composition limits shown in Table 1. Exceptions to GMW3341 composition requirements require agreement from purchaser (Design Responsible Engineer or delegate), and shall be explicitly documented on the GM engineering drawing and other equivalent part specification documents.

Table 1: Chemical Composition for GMW3341 Zinc Alloys ^{Note 1}

Element ^{Note 2}	Al	Cu	Mg	Fe	Pb	Cd	Sn
Al4Mg	3.5 to 4.3	0.25 max.	0.02 to 0.06	0.10 max.	0.005 max.	0.004 max.	0.003 max.
Al4Cu1Mg	3.5 to 4.3	0.75 to 1.25	0.02 to 0.08	0.10 max.	0.005 max.	0.004 max.	0.003 max.
Al4Cu3Mg	3.5 to 4.3	2.5 to 3.3	0.02 to 0.05	0.10 max.	0.005 max.	0.004 max.	0.003 max.
Al18Cu1Mg	8.0 to 8.8	0.8 to 1.3	0.015 to 0.03	0.075 max.	0.006 max.	0.006 max.	0.003 max.
Al11Cu1Mg	10.5 to 11.5	0.15 to 1.2	0.15 to 0.02	0.075 max.	0.006 max.	0.006 max.	0.003 max.
Al27Cu2Mg	25.0 to 28.0	2.0 to 2.5	0.01 to 0.02	0.075 max.	0.006 max.	0.006 max.	0.003 max.
Cu6Al3Mg	2.8 to 3.3	5.0 to 6.0	0.025 to 0.05	0.075 max.	0.005 max.	0.004 max.	0.003 max.
Cu10Al4Mg	3.0 to 4.0	10.0 to 11.0	0.025 to 0.05	0.075 max.	0.005 max.	0.004 max.	0.003 max.

Note 1: max. = maximum.

Note 2: Composition limits in % by weight. Remainder of each alloy is Zn.

3.1.1 Chemical Analysis. The casting producer shall control chemical composition with samples taken from the melt prior to casting and solidified in a metallic die. Chemistry shall be measured in accordance with procedures, master samples and calibration per ASTM E536, or equivalent.

3.2 Casting Requirements. Castings furnished shall be free from cold laps, misruns, hot tears, cracks, macroporosity, shrinkage, dross, mold material and lubricants, entrapped air and any other discontinuities, all to an extent that would be detrimental to machinability, appearance, or performance. These discontinuities, plus surface roughness, casting cleanliness and weight of retained material, may have maximum allowable limits specified. For any of the above casting requirements, a measurement system shall be agreed upon by supplier and purchaser (Design Responsible Engineer or delegate).

3.3 Microstructure Requirements. The microstructures of castings are influenced by alloy composition, casting process parameters and thermal history. The Zamak alloys are characterized by the primary η phase (zinc solid solution) while the ZA alloys are characterized by primary α phase the (aluminum solid solution). ACuZinc alloys are characterized by primary ϵ phase (copper rich phase; Zn4 Cu). Any special requirements with regards to microstructure shall be agreed upon between the purchaser and supplier and specified on the engineering drawing.

3.4 Mechanical Properties. This specification does not govern mechanical properties. Mechanical properties are significantly influenced by alloy composition and casting process parameters, such as molten metal handling practice, casting process and thermal history. Properties of test specimens excised from castings will differ from cast-to-shape test bars due to differences in solidification conditions and thermal history. Therefore, any specific property required from a particular casting or section of a casting shall be called out separately on the GM engineering drawing and other equivalent part specification documents. Typical mechanical properties associated with each alloy grade are shown in Table C1 in Appendix C.

3.4.1 Specification of Mechanical Properties. By agreement between supplier and purchaser (Design Responsible Engineer or delegate) hardness and mechanical property requirements may be specified on the GM engineering drawing and other equivalent part specification documents. Unless otherwise specified, testing shall be done in accordance with ISO 6506 for hardness and ISO 6892 for tensile properties. The supplier and purchaser (Design Responsible Engineer or delegate) shall agree on a sampling plan.

3.5 Physical Properties. By agreement between supplier and purchaser (Design Responsible Engineer or delegate) electrical conductivity requirements may be specified on the GM engineering drawing and other equivalent part specification documents. Typical physical properties associated with each alloy grade are shown in Table D1 in Appendix D.

4 Manufacturing Process

The selection of the casting process shall be a joint agreement between the purchaser and the supplier.

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4.1 Casting. Castings are made using the hot chamber, high pressure die casting and the cold chamber, high pressure die casting processes. The preferred die casting process for each grade is shown in Table 2.

Table 2: Alloys Listed by Casting Process

Hot Chamber Process ^{Note 1}	Cold Chamber Process ^{Note 2}
Al4Mg	Al11Cu1Mg
Al4Cu1Mg	Al27Cu2Mg
Al4Cu3Mg	Cu10Al4Mg
Al8Cu1Mg	
Cu6Al3Mg	

Note 1: Hot Chamber, High Pressure Die Casting – Utilizes high pressure and injection to fill the mold cavity that is made of tool steel. In addition, the hot chamber utilizes a metal pump that is immersed in the molten bath, to pump metal through a gooseneck and nozzle into the die cavity.

Note 2: Cold Chamber, High Pressure Die Casting – Utilizes a high pressure die cast machine that has the molten zinc poured by hand or by an automatic ladle into a separate non-immersed shot sleeve for each cycle.

4.2 Heat Treatment. The rapid chilling rate inherent in zinc die castings results in minor property and dimensional changes with time. Some zinc alloys undergo a slight shrinkage (0.5 µm to 1.0 µm per mm) when allowed to age at room temperature for period up to 6 months. For rigid dimensional requirements a stabilization anneal may be specified by adding an SA suffix to the alloy callout per Section 8. If specified, a stabilization anneal commonly recommended is a heat treatment consisting of 3 h to 6 h at 100 °C. Heat treatment time is measured from the time at which the castings reach the annealing temperature.

4.3 Post Processing. Post processing of castings is normally limited to a trimming operation. However, a variety of finishes are applicable for improved corrosion protection or appearance. Painting and electroplating are common. Chromating and phosphating are effective pre-treatments for paints and lacquers. Castings shall not be welded except with the permission of the purchaser.

4.4 Inspection. Visual inspection, dimensional or non-destructive evaluation such as radiography or radioscopy to ISO 9915, liquid penetrant inspection per ISO 9916 and pressure tightness may be specified.

5 Rules and Regulations

5.1 Legal Regulations. All materials must satisfy applicable laws, rules, regulations and recommendations valid in the country of usage.

5.2 Language. In the event of conflict between the English and domestic language, the English language shall take precedence.

5.3 Inspection and Rejection. Samples of components or materials released to a GM material specification shall be tested for conformity with the requirements of this material specification and approved by the responsible Engineering department prior to commencement of delivery of bulk supplies.

A new approval must be received for any changes, e.g., properties, manufacturing process, location of manufacture, etc. If not otherwise agreed, all testing and documentation normally required for initial release must be completed.

It is the responsibility of the supplier to inform the customer in a timely manner, without solicitation, and to include documentation of all modifications of materials and/or processes and to apply for a new release.

5.4 Material Safety Data Sheets/Safety Data Sheets (MSDS/SDS). For new product submissions, or when a change in chemical composition of an existing product has occurred, a complete copy of the Material Safety Data Sheet/Safety Data Sheet must be submitted in compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) requirements or other country-specific MSDS/SDS requirements.

5.5 All materials supplied to this standard must comply with the requirements of the International Material Data System (IMDS) and GMW3059, **Restricted and Reportable Substances**.