THE HIGH PRESSURE ZINC DIE CASTING PROCESS: MATERIALS
Pressure die casting with zinc-based alloys is one of the most efficient and versatile high-production methods used for the manufacturing of strong, accurate, complex and intricately shaped metal components.

The process is carried out in an automatic machine suitable to withstand high pressure. The molten metal is pushed by a hydraulically actuated plunger into a two-piece steel die containing one or more cavities, each an exact inverse replica of the part or parts being produced. Because of the quick chill and rapid solidification that takes place when molten metal comes in contact with the relatively cool steel side, and because the fine metallurgical grain structure that results, the mechanical properties of pressure die castings are generally superior to castings produced by other methods.

Zinc pressure die castings, for example, are stronger than sand cast 356-T6 aluminum, SAE 40 bronze, and class 30 cast iron. Also, pressure die cast components produced using the ZA alloys are stronger than pressure die cast aluminum 380 alloy.

**ZAMAK ALLOYS**

The name “ZAMAK” is an acronym from the German words that make up the alloys main ingredients: Z (zinc) A (aluminum) M (magnesium) and K (copper). When the alloys were developed in the 1920s the first useable material was designated Zamak #1. With each subsequent iteration, the designations increased sequentially (1-2-3-4-5-6-7); only the most desirable alloys (2-3-5-7) remain in use presently.
ZAMAK 2
Zamak 2, a predecessor of the more widely used Zamak 3, has the highest strength and hardness in the 4% zinc, aluminum (Zamak) alloy family. Because of its relatively high copper content (3%), it is approx. 25% stronger, as cast, than Zamak 3, and almost 10% stronger than Zamak 5, with higher hardness than both. The high copper content, however, results in property changes upon long term aging. These changes include slight dimensional growth (.0014in/in after 20yrs), lower elongation and reduced impact performance (to levels similar to aluminum alloys) for die cast products. It does, however, provide some interesting characteristics which may assist designers. Its creep performance is rated higher than the other Zamaks and #2 maintains higher tensile strength and hardness levels after long term aging. Also, preliminary investigations suggest #2 is a good bearing material and may eliminate bushings and wear inserts in die designs. But it does give up impact strength and because of this limitation Zamak 2 is only used when the strength or hardness of Zamak 3 or 5 are not sufficient for long-term end use. Zamak 2 is sometimes referred to as Kirksite and is the only alloy used for gravity casting – mainly for metal forming dies or plastic injection molds.

ZAMAK 3
Of all the zinc casting alloys, Zamak 3 is the most widely used, accounting for approx. 85% of all zinc casting tonnage worldwide. It has the base composition for all the Zamak alloys (96% zinc, 4% aluminum). Its superb physical and mechanical properties, excellent castability and long term dimensional stability provide the basis for its broad usage. The ease it can be electroplated adds to the popularity of this alloy, with excellent finishing characteristics for plating, painting, and chromate treatments. It is the “standard” by which other zinc alloys are rated in terms of die casting and is, therefore, the most widely available alloy for die casting sources.
**ZAMAK 5**

Most often through casting design procedures, a Zamak 3 pressure die casting can be made to meet service or functional requirements. When this is not the case, especially where strength is concerned, Zamak 5 is the next choice. Except for a nominal 1% copper addition, the chemistry of Zamak 5 is comparable to that of Zamak 3. The composition modification results in higher tensile strength and increased hardness, but sacrifices elongation. Zamak 5 has significantly better creep resistance than the other alloys in the conventional group.

Zamak 5 is not as ductile as some of the other alloys, a factor to consider when post casting operations such as secondary bending, riveting, swaging or crimping are required. Because of 3's wide availability, material specifiers often strength components by design modification rather than Zamak 5. However, when an extra measure of tensile performance is needed, Zamak 5 castings are recommended. The alloy is readily plated, nished and machined, and is comparable to Zamak 3.

**ZAMAK 7**

The last of the original Zamak's, #7 alloy is a modification of #3 alloy in which lower magnesium content is specified in order to increase fluidity. To avoid issues with the inter-granular corrosion, lower levels of impurities are called for and a small amount of nickel is specified. Alloy #7 has slightly better ductility than #3 with the other properties remaining the same. The alloy is therefore popular for those special cases where the die caster is making thin walled components requiring a good surface finish. However, research testing has shown metal and die temperatures have a much larger effect than changing alloys. Close attention to control of the die casting process parameters is important to eliminate defects and achieve consistent quality.

**ZA 8**

Of all the zinc alloys which can be cast in hot-chamber machines, ZA-8 is the most creep resistant (3 times that of Zamak 3) and is the strongest and hardest in the Zamak family, with the exception of Zamak 2, which is very similar in performance. It is used principally in structural or highly stressed applications. In spite of its relatively high aluminum content, it can be electroplated using conventional plating techniques and finished using standard procedures for Zamaks. When the performance of alloys 3 and 5 are in question, ZA 8 is often the die casting choice because of high strength and creep properties because of its efficient hot-chamber castability.
**ACuZinc 5**

ACuZinc is another zinc alloy, developed by General Motors Research & Development engineering department. At the outset ACuZinc alloys were limited to production of GM specified parts. More recently, however, the GM licensing agreement has allowed for a broader scope of applications. With the addition of a higher percentage of copper, ACuZinc alloys were developed to improve the wear resistance and creep properties in the zinc alloy family. There are two ACuZinc alloys: ACuZinc 5 (5% copper) and ACuZinc 10 (10% copper) which are used in a variety of automotive applications. ACuZinc 5 is hot-chamber cast and ACuZinc 10 is cold-chamber cast. When casting ACuZinc 5, it is best practice to keep a mixer running constantly in the melting pot. This keeps the copper from separating and clogging the shot end components.

**EZAC**

EZAC™ is Eastern Alloys new high strength, creep resistant, hot-chamber zinc based die casting alloy. With excellent fluidity and a low casting temperature (780-825°F), EZAC is perfect for the hot-chamber die casting process. In addition, because of EZAC’s low melting temperature, it does not have the same casting difficulties, such as erosion and wear, that other similar high strength die casting alloys exhibit. Casting trials have shown negligible component wear in EZAC compared to the other high strength hot-chamber zinc die casting alloys.
# ZINC PROPERTIES

## Mechanical

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<tr>
<th>Alloy</th>
<th>Tensile Strength</th>
<th>Yield Strength (0.2%)</th>
<th>Impact Strength</th>
<th>Shear Strength</th>
<th>Elongation</th>
<th>Density</th>
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<tr>
<td></td>
<td>PSI x 10^3</td>
<td>PSI x 10^3</td>
<td>ft. lb.</td>
<td>PSI x 10^3</td>
<td>% in 50mm</td>
<td>lb/in^3</td>
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<td>57</td>
<td>2</td>
<td>–</td>
<td>6.7</td>
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