## DIE CASTING ALLOYS

Die casting alloys are normally non-ferrous and there is a large number available with a wide range of physical and mechanical properties covering almost every conceivable application a designer might require. Aluminum and zinc alloys are the most widely used. Followed by magnesium, zinc-aluminum (ZA) alloys, copper, tin and lead. Zinc, lead and tin based alloys are classified as low melting point metals because they turn melt at less than 725°F (385°C). Zinc-aluminum (ZA) alloys have a slightly higher melting range of 800°F to 900°F (426°C to 482°C). Aluminum and magnesium alloys are considered to be moderate melting point alloys, being cast in the 1150°F to 1300°F (621°C to 704°C) range. Copper alloys are considered to be high melting point alloys, over 1650°F (899°C). Low melting point alloys are cast in hot chamber machines. Intermediate and high melting point alloys are cast in cold chamber machines.

## ALUMINUM ALLOYS

Aluminum die casting alloys (Table 1) are lightweight, offer good corrosion resistance, ease of casting, good mechanical properties and dimensional stability. Although a variety of aluminum alloys can be die cast from primary or recycled metal, most designers select a standard alloy listed below. Special alloys for special applications are available but their use usually involves significant cost premiums:

**A360** -- Selected for best corrosion resistance and pressure tightness.

**A380** -- The most common and cost effective of all die casting alloys. Provides the best combination of utility and cost.

**A383 & A384** -- These alloys are a modification of 380. Both provide better die filling but with a moderate sacrifice in mechanical properties such as toughness.

**A390** -- Selected for special applications where high strength, fluidity and wear-resistance/bearing properties are required.

**A413 (A13)** -- Used for maximum pressure tightness and fluidity.

**Table 1**
**ALUMINUM DIE CASTING ALLOYS**
(Composition, Properties & Characteristics)

| **ALLOY**<br><br>**COMPOSITION (% max or range)** | **A360** | **A380** | **A383** | **A384** | **A390** | **A413 (A13)** |
|---|---|---|---|---|---|---|
| Silicon | 9-10 | 7.5-9.5 | 9.5-11.5 | 10.5-12 | 16-18 | 11-13 |
| Iron | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Copper | 0.6 | 3-4 | 2-3 | 3-4.5 | 4-5 | 1.0 |
| Manganese | 0.35 | 0.50 | 0.50 | 0.50 | 0.50 | 0.35 |
| Magnesium | 0.4-0.6 | 0.10 | 0.10 | 0.10 | 0.45-0.65 | 0.10 |
| Nickel | 0.50 | 0.50 | 0.30 | 0.50 | 0.10 | 0.50 |
| Zinc | 0.50 | 3.0 | 3.0 | 3.0 | 1.5 | 0.50 |
| Tin | 0.15 | 0.35 | 0.15 | 0.35 | 0.20 | 0.15 |
| Titanium | — | — | — | — | 0.20 | — |
| Total others | 0.25 | 0.50 | 0.50 | 0.50 | 0.20 | 0.25 |
| Aluminum | Bal. | Bal. | Bal. | Bal. | Bal. | Bal. |
| **PROPERTIES** | | | | | | |
| Ultimate tensile strength (ksi) | 46 | 47 | 45 | 48 | 40.5 | 42 |
| Tensile yield strength (ksi) | 24 | 23 | 22 | 24 | 35 | 19 |
| Elongation (% in 2" G.L.) | 3.5 | 3.5 | 3.5 | 1-2.5 | | 3.5 |
| Hardness (HB) | 75 | 80 | 80 | | 85 | 120 |
| Shear strength (ksi) | 26 | 27 | 25 | | | 29 |
| Charpy impact strength (ft. lb.—unnotched) | 4.2 | 3.5 | | | | 2.0 |
| Fatigue strength (ksi) (limit @ 500 | 18 | 20 | 19 | 20 | | 20 |

| | | | | | | |
|---|---|---|---|---|---|---|
| million cycles) | | | | | | |
| Density (lb./in.$^3$) | 0.095 | 0.098 | 0.097 | 0.098 | 0.099 | 0.096 |
| Melting range ($^o$F) approx. | 1035-1105 | 1000-1100 | 960-1080 | 960-1080 | 945-1200 | 1065-1080 |
| Specific heat (Btu/lb.$^o$F) | 0.23 | 0.23 | | | | |
| Coefficient of thermal expansion (in./in./$^o$F) | 11.8 | 11.7 | 11.5 | 11.3 | 11.7 | 10.3 |
| Thermal conductivity (Btu/fthr.$^o$F) | 65.3 | 55.6 | 55.6 | 56 | 78.6 | 67.7 |
| Electrical conductivity (% IACS) | 29 | 31 | 23 | 23 | 25 | 31 |
| Modulus of elasticity ($10^6$ psi) | 10.3 | 10.3 | 10.3 | 10.3 | 11.9 | 10.3 |
| **CHARACTERISTICS (1-most desirable; 4–least desirable)** | | | | | | |
| Resistance to Hot Cracking | 2 | 2 | - | 2 | - | 1 |
| Pressure Tightness | 1 | 2 | 2 | 2 | - | 1 |
| Polishing | 3 | 3 | - | 3 | - | 4 |
| Fluidity | 2 | 2 | 1 | 1 | - | 1 |
| Corrosion Resistance | 3 | 4 | 3 | 4 | - | 2 |
| Machine-ability | 2 | 2 | 2 | 3 | - | 4 |
| Strength at Elev. Temp. | 3 | 2 | 2 | 1 | - | 2 |
| Anti-Die Soldering Tend. | 3 | 1 | 2 | 2 | - | 2 |
| Electroplating | 1 | 1 | - | 2 | - | 3 |
| Anodizing Appearance | 4 | 4 | - | 4 | - | 4 |

## ZINC ALLOYS

Zinc-based alloys (Table 2) are the easiest to die cast. Ductility is high and impact strength is excellent, making these alloys suitable for a wide range of products. Zinc alloys can be cast with thin walls and excellent surface smoothness making preparation for plating and painting relatively easy. It is essential that only high purity (99.99+ %) zinc metal be used in the formulation of alloys. Low limits on lead, tin and cadmium ensure the long-term integrity of the alloy's strength and dimensional stability.

## ZINC-ALUMINUM (ZA) ALLOYS

ZA alloys represent a new family of zinc-based die casting materials that contain higher aluminum content than standard zinc alloys. These alloys provide high strength characteristics plus high hardness and good bearing properties (Table 2). Thin wall castability characteristics and die life are similar to zinc alloys. ZA-8 is recommended for hot chamber die casting. ZA-12 and ZA-27 must be cast by the cold chamber die casting process. All ZA alloys offer similar creep properties and are superior to standard zinc alloys.

**ZA-8** -- Provides strength, hardness and creep properties.

**ZA-12** -- Provides excellent bearing properties with strength and hardness characteristics between ZA-8 and ZA-27. Good dimensional stability properties and somewhat better castability than ZA-27.

**ZA-27** -- Offers the highest mechanical properties of the ZA family and is therefore recommended when maximum performance is required.

**Table 2**
**ZINC DIE CASTING ALLOYS**
(Composition, Properties and Characteristics)

| **ALLOY**<br><br>**COMPOSITION (% max or range)** | **Zinc #3** | **Zinc #5** | **Zinc #7** | **ZA-8** | **ZA-12** | **ZA-27** |
|---|---|---|---|---|---|---|
| Aluminum | 3.5-4.3 | 3.5-4.3 | 3.5-4.3 | 8-8.8 | 10.5-11.5 | 25-28 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Copper | 0.25 | 0.75-1.25 | 0.25 | 0.8-1.3 | 0.5-1.25 | 2-2.5 |
| Magnesium | 0.02-0.05 | 0.03-0.08 | 0.005-0.020 | 0.015-0.030 | .015-030 | .010-.020 |
| Iron | 0.100 | 0.100 | 0.075 | 0.10 | 0.075 | 0.10 |
| Lead | 0.005 | 0.005 | 0.0030 | 0.004 | 0.004 | 0.004 |
| Cadmium | 0.004 | 0.004 | 0.0020 | 0.003 | 0.003 | 0.003 |
| Tin | 0.003 | 0.003 | 0.0010 | 0.002 | 0.002 | 0.002 |
| Nickel | — | — | 0.005-0.020 | — | — | — |
| Zinc | Bal. | Bal. | Bal. | Bal. | Bal. | Bal. |
| **PROPERTIES** | | | | | | |
| Ultimate tensile strength (ksi) | 40 | 48 | 41 | 54 | 58.5 | 61 |
| Tensile yield strength (ksi) | — | — | — | 42 | 46 | 53 |
| Elongation (% in 2" (55 mm)) | 10 | 7 | 13 | 6-10 | 4-7 | 1-3 |
| Hardness (HB) | 82 | 91 | 80 | 95-110 | 95-115 | 105-125 |
| Shear strength (ksi) | 31 | 38 | — | 35 | 37 | 42 |
| Charpy impact strength (ft. lb.—unnotched) | 43 | 48 | 43 | 31 | 21 | 3 |
| Fatigue strength (ksi) (limit @ 500 million cycles) | 6.9 | 8.2 | — | 7.5 | 15 | 25 |
| Density (lb./in.$^3$) | 0.24 | 0.24 | 0.247 | 0.227 | 0.218 | 0.181 |
| Melting range ($^o$F) | 718-728 | 717-727 | 718-728 | 707-759 | 710-810 | 708-903 |
| Specific heat (Btu/lb.$^o$F) | 0.10 | 0.10 | 0.10 | 0.104 | 0.107 | 0.125 |
| Coefficient of thermal expansion (in./in./$^o$F) | 15.2 | 15.2 | 15.2 | 12.9 | 13.4 | 14.4 |
| Thermal conductivity (Btu/fthr.$^o$F) | 65.3 | 62.9 | 65.3 | 66.3 | 67.1 | 72.5 |
| Electrical conductivity (% IACS) | 27.0 | 26.0 | 27.0 | 27.7 | 28.3 | 29.7 |
| Modulus of rupture ($10^6$ psi) | 95,000 | 105,000 | — | — | — | — |
| Modulus of elasticity ($10^6$ psi) | — | — | — | 10.2 | 10.3 | 10.3 |
| Die shrinkage (in./in.) | 0.007 | 0.007 | 0.007 | 0.007 | 0.0075 | 0.008 |
| **CHARACTERISTICS (1-most desirable; 4–least desirable)** | | | | | | |
| Resistance to Hot Cracking | 1 | 1 | 1 | | | |
| Pressure Tightness | 1 | 1 | 1 | | | |
| Polishing | 1 | 1 | 1 | | | |
| Fluidity | 1 | 2 | 1 | | | |
| Corrosion Resistance | 1 | 1 | 1 | | | |
| Machine-ability | 1 | 1 | 1 | | | |
| Strength at Elev. Temp. | 4 | 4 | 4 | | | |
| Anti-Die Soldering Tend. | 1 | 1 | 1 | | | |
| Electroplating | 1 | 1 | 1 | | | |
| Anodizing Appearance | - | - | - | | | |