ZA CASTING ALLOYS

ZA Casting alloys are a family of new high strength zinc-aluminum engineering materials. They were developed as general purpose casting alloys and are now being used in sand and permanent mold casting, die casting, and the new graphite mold process, as well as investment, centrifugal, plaster and rubber mold casting.

The ZA alloys are alternative alloys which compete with and replace such materials as cast iron, bronze, aluminum, plastics and steel fabrications. They feature clean, low-temperature, energy-saving melting, excellent castability, high strengths and bearing properties equivalent and often superior to standard bronze bearings.

There are three ZA casting alloys: ZA-8, ZA-12 and ZA-27. These alloys are zinc based and contain high aluminum contents with minor alloying elements being copper and magnesium. The numerical digits (8, 12, and 27) represent the approximate percentage of aluminum in each. It is this fact, along with improved properties and wider casting process choice, which distinguishes ZA from standard zinc "ZAMAK" die casting alloys. High aluminum content is the reason the ZA family are called "zinc-aluminum" alloys.

DESIGN FEATURES

Strength and Hardness: ZA alloys possess high tensile strength and hardness, which make them suitable as alternative materials to cast iron, bronze, aluminum and steel fabrications. Strengths range up to 64,000 psi depending upon alloy and process selection.

Bearing and Wear Resistant Properties: ZA alloys have inherent bearing properties and are being used as direct substitutes for larger bronze industrial bushings and bearings. ZA alloys are substantially lower in cost than bronze and up to 43% lighter. For smaller components, ZA's natural lubricity may permit the elimination of small bushings and wear inserts, thus lowering secondary fabrication costs. The alloys can replace aluminum or hard coat anodized aluminum parts because of ZA's superior galling and wear resistance. In some cases, cast iron parts have been converted to ZA because of similar wear resistant properties.

Machining: ZA alloys machine rapidly, with minimal tool wear. Machining rates are often equivalent to free machining brass and can be three times faster than for cast iron. Ease of machining and elimination of tool breakage problems have often influenced ZA alloy selection over cast iron.

Non-Sparking: Aluminum alloy components, when struck with rusty iron or steel, can generate a hot exothermic reaction which can cause an explosion of flammable gas/air mixtures. ZA-8 and ZA-12 are recommended as non-sparking alloys for mine, marine or other potentially hazardous locations. Copper base alloys are also non-sparking; however, ZA alloys are lower cost and lighter.

Pressure-Tightness: Sand and permanent mold cast ZA-12 components can be considered where pressure tightness is important. Gravity cast ZA-12 has demonstrated good pressure tightness for such applications as oil and gasoline valves.

Corrosion Resistance: ZA materials possess good corrosion resistance under atmospheric conditions, and in various aqueous solutions and industrial and petroleum products. Corrosion resistance of the ZA materials is similar to common grades of aluminum. Surface treatments such as chromating, plating, painting and zinc anodizing provide additional corrosion protection.

Finishing: ZA materials can be polished to a bright lustrous chrome-like finish which can be lacquered for longevity. Plating, chromating and painting are other conventional finishes that can be applied. Zinc anodizing is a special finish (not to be confused with aluminum anodizing) recommended for marine atmospheres or for more aggressive environments. The green ceramic-like coating is nonconductive and is particularly resistant to salt water.

Dimensional Stability: Dimensional change due to residual stress or metallurgical instabilities can result in change of critical dimensions in many alloy systems. Fortunately, residual stresses in ZA alloy are usually minimal due to low casting temperatures. Dimensional change upon aging (metallurgical instabilities), however, is an important consideration. ZA-12 offers the best dimensional stability after aging. ZA-27, on the other hand, can grow up to 0.12% when aged at elevated temperatures (200^0 F). However, ZA-27 can be given a stabilization heat treatment (12 hours at 480^0 F.) to minimize aging effects. Aging characteristics of ZA-8 are similar to ZA-12.

Temperature Limitations: A design limitation of ZA alloys is their use at elevated temperatures. ZA's low melting point is an energy saving advantage for foundrymen. However, at moderately elevated temperatures, strength and hardness decrease. The ZA alloys are subject to plastic deformation (creep) when stressed at elevated temperatures. In general, applications which are above 200^0 F and under high constant stress should be avoided. Moderately stressed parts at ambient temperature up to 120^0 F are best suited for ZA alloys.

ALLOY SELECTION

Numerous factors influence material selection. Most important are mechanical properties, choice of casting process, secondary machining and finishing characteristics, corrosion resistance and material and manufacturing costs. Described are the general design features of the ZA alloy family and their differences, which can influence material selection.

COMPARISON RATINGS	ZA-8	ZA-12	ZA-27
Sand Castability	G	E	F
Perm. Moldability	VG	E	F
Die Castability	E	VG	G
Strength	G	VG	E
Ductility	VG	G	F
Bearing/Wear	G	E	E
Machinability	E	VG	G
Pressure Tightness	VG	E	F
Plating	E	G	F
Zinc Anodizing	E	E	VG
Chromating	E	G	F
Painting	E	E	E
Dimensional Stability	VG	VG	F

E-Excellent VG-Very Good G-Good F-Fair

GENERAL COMMENTS

ZA-8

Offers best plating and finishing characteristics and good permanent mold characteristics. Can be hot chamber die cast with improved strength, hardness and creep properties compared to conventional zinc and ZAMAK die casting alloys. Major application area is expected to be for die casting where improved properties over ZAMAK's are required, particularly performance at elevated temperatures.

ZA-12

A first choice when considering ZA alloys. An excellent alternate to cast iron, bronze, aluminum and fabrications. ZA-12 provides the best gravity casting capabilities, particularly for sand, permanent mold and the new graphite process. Die castability (cold chamber) is somewhat easier than ZA-27. Offers best pressure tightness using gravity casting methods and good dimensional stability. Provides good bearing properties. Best fabrication characteristics for heavy-walled section gravity casting. Can be plated and readily chromated.

ZA-27

Recommended when highest mechanical properties are needed. Best properties but difficult to gravity cast in heavy sections. Preferred for even sections under 3/8". In general, good die castability (cold chamber) but more difficult than ZA-12 die casting. Offers excellent bearing properties but may require stabilization heat treatment for dimensional stability. Difficult to chrome plate. Special foundry and casting procedures may be necessary with this alloy, particularly for heavy sections.

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ZA ALLOYS: ENGINEERING PROPERTIES

	ZA-8			ZA-12			ZA-27		
	Sand	**Perm**	**Die**	**Sand**	**Perm**	**Die**	**Sand**	**Perm**	**Die**
Ultimate Tensile Strg (psix1000)	36-40	32-37	53-56	40-46	45-50	57-60	58-64	61.5	59-64
Yield Strength 0.2% offset psi x 1000	28-29	29-31	41-43	30-31	36-40	45-48	53-54	53	52-55
Compressive Yield Strength 0.1% Offset (psi x 1000)	28-30	29-32	35-38	32-34	33-35	38-40	47-48	-	51-53
Shear Strength (psi x 1000)	-	35	38-42	36-38	-	41-44	41-43	-	46-48
Youngs Modulus	12.7×10^6	12.4×10^6	11.2×10^6	12×10^6	12×10^6	11.2×10^6	11.3×10^6	-	11.3×10^6
Fatigue Strength, Rotary Bending (psi x 1000)	-	7.5	15	15	-	17	25	-	21
Brinell Hardness (500-10-30 Sec.)	82-89	85-90	99-107	92-96	85-95	95-105	110-120	110-120	116-122
Elongation (% in 2 inches)	1-2	1-2	6-10	1-2	1.5-2.5	4-7	3-6	1	2-3.5
Impact Strength [1] 68^0 (ft. - lb)	13-18	-	24-35	17-22	-	20-37	25-40	-	7-12
Design Stress [2] in Tension 68^0 F (psi x 1000)	-	10	9	10	10	8.3	11.5	-	9.0
Design Stress [2] in Tension 212^0 F (psi x 1000)	-	-	-	1.3	-	-	1.5	-	1.3
Design Stress [2] in Tension 300^0 F (psi x 1000)	-	.6	-	.5	-	-	0.75	-	-

1 10mm sq. (.394 in. sq.) ASTM unnotched specimen

2 Stress to produce a steady creep rate of 1% strain per 100,000 hours. (11.4 years) as per ASME boiler code.

ZA ALLOYS: ENGINEERING PROPERTIES cont.

	ZA-8	ZA-12	ZA-27
Specific Gravity	6.3	6.03	5.0
Density	.227 lb/ in^3	.218 lb/in3	.181 lb/in3
Melting Range	707 - 759^0 F	710 - 810^0 F	708 - 903^0 F
Coefficient of Expansion 68-212^0 F	12.9 x 10^{-6} / ^{0} F	13.4 x 10^{-6} / ^{0} F	14.4 x 10^{-6} / ^{0} F
Electrical Conductivity at 68^0 F	27.7% IACS	28.3% IACS	29.7% IACS
Thermal Conductivity at 75^0 F	795 BTU · in/hr · ft^2 · ^{0} F	805 BTU · in/hr · ft^2 · ^{0} F	870 BTU · in/hr · ft^2 · ^{0} F
Specific Heat 75 - 198^0 F	0.104 BTU/lb. ^{0} F	0.107 BTU/lb. ^{0} F	0.125 BTU/lb. ^{0} F

ZA ALLOYS: CHEMICAL COMPOSITION (%)

	AL	CU	MG	FE (max)	PB (max)	SN (max)	CD (max)
Ingot (ASTM B240-13)							
ZA-8	**8.2-8.8**	**0.9-1.3**	**0.020-0.030**	**0.035**	**0.005**	**0.002**	**0.005**
ZA-12	**10.8-11.5**	**0.5-1.2**	**0.020-0.030**	**0.05**	**0.005**	**0.002**	**0.005**
ZA-27	**25.5-28.0**	**2.0-2.5**	**0.012-0.020**	**0.07**	**0.005**	**0.002**	**0.005**
Casting (ASTM B86-13)							
ZA-8	**8.0-8.8**	**0.8-1.3**	**0.01-0.030**	**0.075**	**0.006**	**0.003**	**0.006**
ZA-12	**10.5-11.5**	**0.5-1.2**	**0.01-0.030**	**0.075**	**0.006**	**0.003**	**0.006**
ZA-27	**25.0-28.0**	**2.0-2.5**	**0.010-0.020**	**0.075**	**0.006**	**0.003**	**0.006**

Data Source: *Die Cast Development Council DDC*
International Lead and Zinc Research Organization (ILZRO)
ASM Metals Handbook, 9th Edition Volume 15
ASTM B86-13 / ASTM B240-13

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