Are All Zinc Casting Alloys Created Equal?

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The answer is quite definitely *no*.

Purchasers of zinc alloys and zinc alloy components should always specify the relevant ASTM Standard thus ensuring that minimum quality levels are mandated to their supplier.

The ASTM Standards cover both ingot and casting grades separately for all of the zinc and ZA alloys. The standards lay down the maximum permissible tolerance levels for each chemical element and include standard techniques for the way the analysis shall be performed as well as other quality requirements.

There are two specifications for each grade.

- The ingot specifications have tight tolerances to permit some contamination to occur during the die casting process.
- The casting specifications, which are slightly looser, are the minimum requirements for castings delivered to the final user.

Primary Alloy

These alloys are produced from pure virgin zinc metal called Special High Grade Zinc or SHG zinc, for short. SHG zinc is at least 99.99% pure zinc. In this case the alloyer knows the exact composition of everything that goes into the alloying furnace and produces alloy ingot to very low impurity levels, usually much tighter than the ASTM specification. This gives added latitude to the die casting plant where slight metal contamination is likely to occur.

Additionally zinc alloys which are made mainly from primary materials will usually provide:

- the least amount of dross, hence less loss.
- better fluidity, therefore enabling the design of thinner walls, and providing superior die filling capability.
- more consistency in casting parameters between heats of metal, reducing the scrap production due to changes in process parameters.

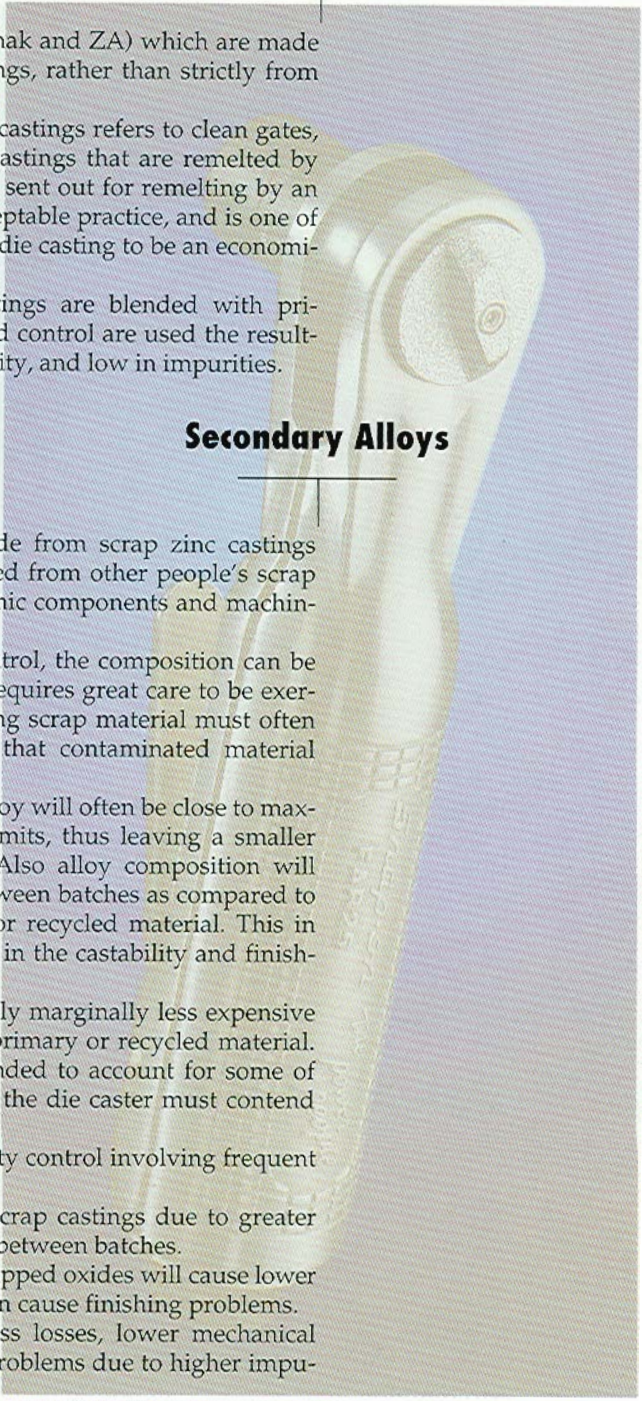
In short, better metal provides more design possibilities and lets you use the full potential of the die casting process.

Recycled Alloys

These are zinc alloys (Zamak and ZA) which are made from recycled zinc castings, rather than strictly from SHG.

The term, recycled zinc castings refers to clean gates, runners, sprues and scrap castings that are remelted by the die caster in his plant or sent out for remelting by an alloyer. This is standard acceptable practice, and is one of the features that allows zinc die casting to be an economical and competitive process.

Generally recycled castings are blended with primary zinc. If proper care and control are used the resulting alloy will be of high quality, and low in impurities.



Secondary Alloys

Secondary alloys are made from scrap zinc castings which have been removed from other people's scrap such as automobiles, electronic components and machinery.

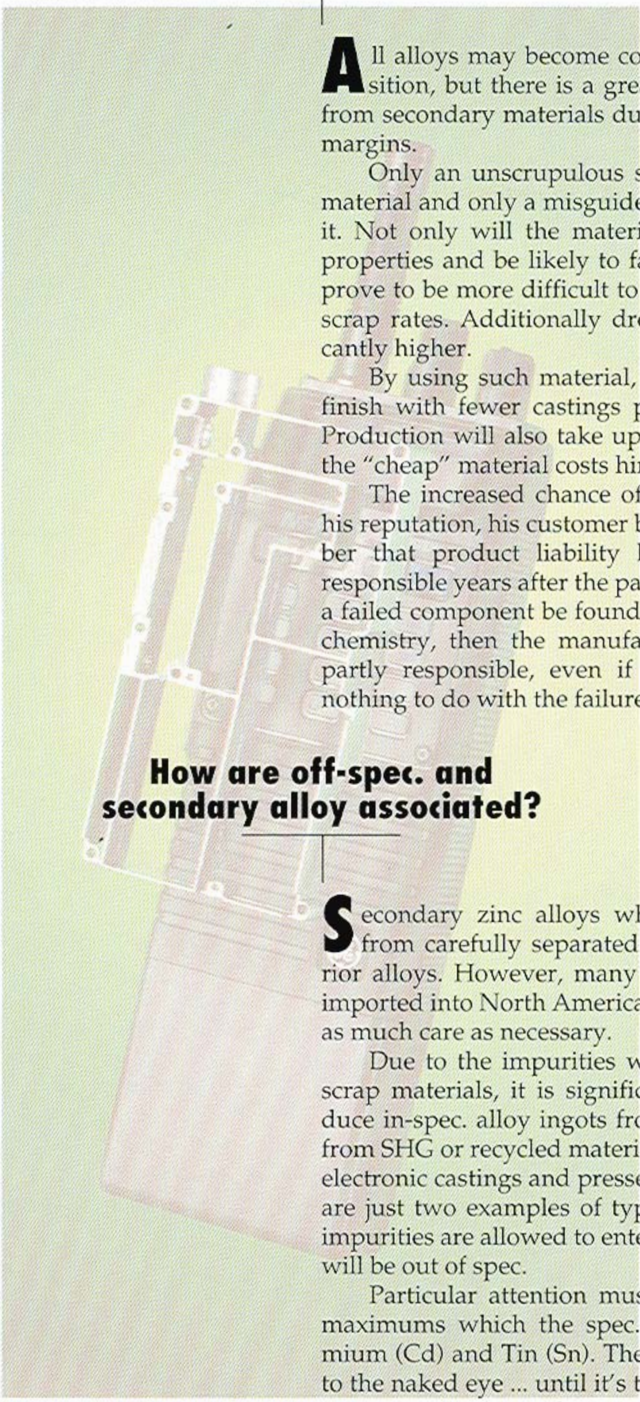
If done with proper control, the composition can be maintained. However, this requires great care to be exercised by the alloyer. Incoming scrap material must often be hand sorted, to ensure that contaminated material does not enter the system.

Even so, the resulting alloy will often be close to maximum allowable impurity limits, thus leaving a smaller margin for the die caster. Also alloy composition will tend to be more variable between batches as compared to alloys made from primary or recycled material. This in turn will produce variations in the castability and finishing.

Secondary alloy is usually marginally less expensive than alloys produced from primary or recycled material. This price difference is intended to account for some of the following aspects which the die caster must contend with:

- The need for greater quality control involving frequent spectrographic analysis.
- Increased production of scrap castings due to greater variations in composition between batches.
- Greater possibility of entrapped oxides will cause lower physical properties and can cause finishing problems.
- Probability of higher dross losses, lower mechanical properties and finishing problems due to higher impurity and oxide levels.
- An increased likelihood of contamination of a heat beyond the allowable ASTM limits due to the narrower available impurity margin.

Off-Specification Alloy



All alloys may become contaminated or loose composition, but there is a greater chance with alloy made from secondary materials due to their narrower impurity margins.

Only an unscrupulous supplier would sell off-spec. material and only a misguided die caster would purchase it. Not only will the material have inferior mechanical properties and be likely to fail in service, but it will also prove to be more difficult to cast thus resulting in higher scrap rates. Additionally drossing losses will be significantly higher.

By using such material, the die caster will probably finish with fewer castings per ton of metal purchased. Production will also take up more machine time, so that the "cheap" material costs him more in the long run.

The increased chance of part failure could cost him his reputation, his customer base and his market. Remember that product liability laws make a manufacturer responsible years after the parts have left his shop. Should a failed component be found to be out of specification for chemistry, then the manufacturer will be held at least partly responsible, even if the alloy composition had nothing to do with the failure.

How are off-spec. and secondary alloy associated?

Secondary zinc alloys which are properly produced from carefully separated scrap material are not inferior alloys. However, many secondary alloys which are imported into North America are often not produced with as much care as necessary.

Due to the impurities which are generally found in scrap materials, it is significantly more difficult to produce in-spec. alloy ingots from secondary materials than from SHG or recycled materials. Tin plating often used on electronic castings and pressed in leaded bronze bushings are just two examples of typical impurities. If too many impurities are allowed to enter the melt, the resulting alloy will be out of spec.

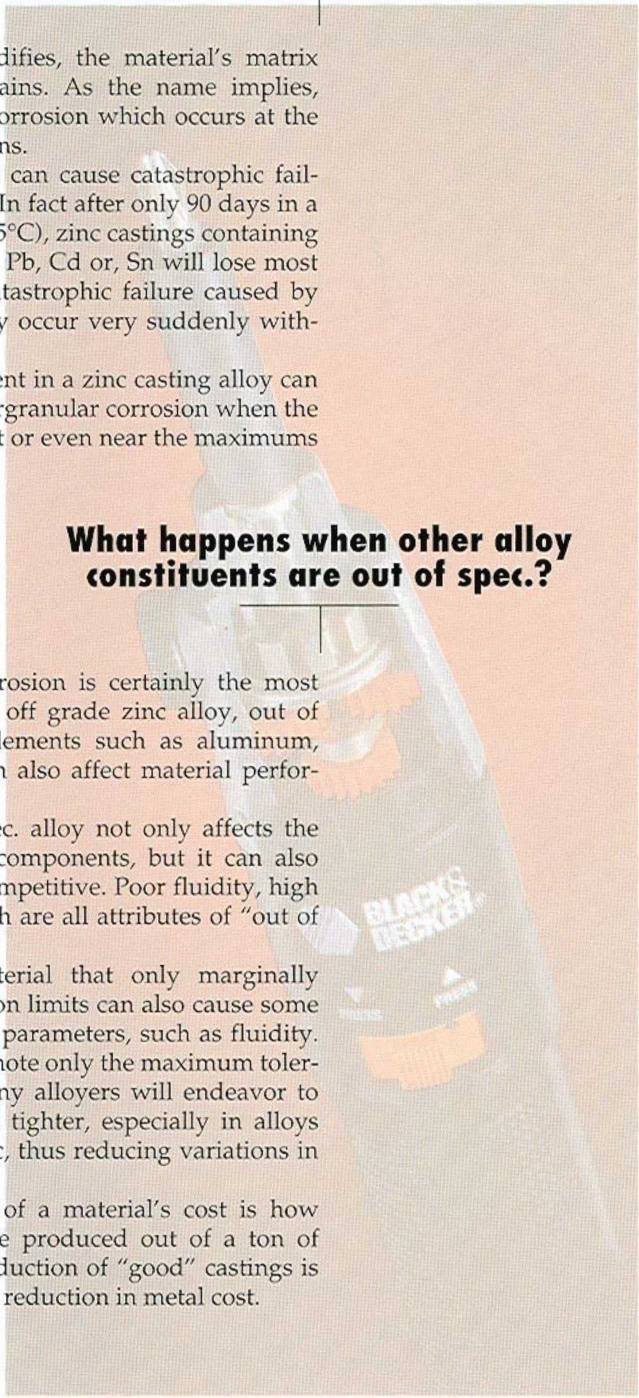
Particular attention must be paid to the very strict maximums which the spec. places on Lead (Pb), Cadmium (Cd) and Tin (Sn). The reason for this is not visible to the naked eye ... until it's too late. These three elements can cause intergranular corrosion in the Zamak and ZA alloys when any of these elements is present above the ASTM specification.

What is Intergranular Corrosion?

When a zinc alloy solidifies, the material's matrix forms microscopic grains. As the name implies, Intergranular Corrosion is corrosion which occurs at the boundaries between the grains.

Intergranular Corrosion can cause catastrophic failure in stressed applications. In fact after only 90 days in a humidity cabinet at 203°F (95°C), zinc castings containing only marginally out of spec. Pb, Cd or, Sn will lose most of their impact strength. Catastrophic failure caused by Intergranular Corrosion may occur very suddenly without any prior notice.

A low magnesium content in a zinc casting alloy can also promote the rate of intergranular corrosion when the levels of Pb, Cd and Sn are at or even near the maximums specified.



What happens when other alloy constituents are out of spec.?

While intergranular corrosion is certainly the most serious problem with off grade zinc alloy, out of spec. quantities of other elements such as aluminum, magnesium, and copper can also affect material performance.

Additionally out of spec. alloy not only affects the operations of the finished components, but it can also make a die caster very uncompetitive. Poor fluidity, high dross and poor surface finish are all attributes of "out of spec. material".

However, in-spec. material that only marginally meets the casting specification limits can also cause some variations in certain casting parameters, such as fluidity. The ASTM specifications denote only the maximum tolerance permitted for use. Many alloyers will endeavor to hold these tolerances much tighter, especially in alloys produced from primary zinc, thus reducing variations in casting parameters.

After all, the true test of a material's cost is how many good components are produced out of a ton of metal. A 1% increase in production of "good" castings is worth much more than a 1% reduction in metal cost.

How do I ensure that I produce and sell only In-spec. components?

The answer is simple.

- Ensure that all alloy deliveries are accompanied by an analysis certificate. Check that the ingots are marked and agree with the certification.
- Regularly check the analysis of incoming material either with your own equipment, or by a qualified independent lab near you. Occasionally, ask competing alloyers to analyze samples. Most alloyers will gladly do this.
- Check the composition of castings produced in your plant before you ship them.

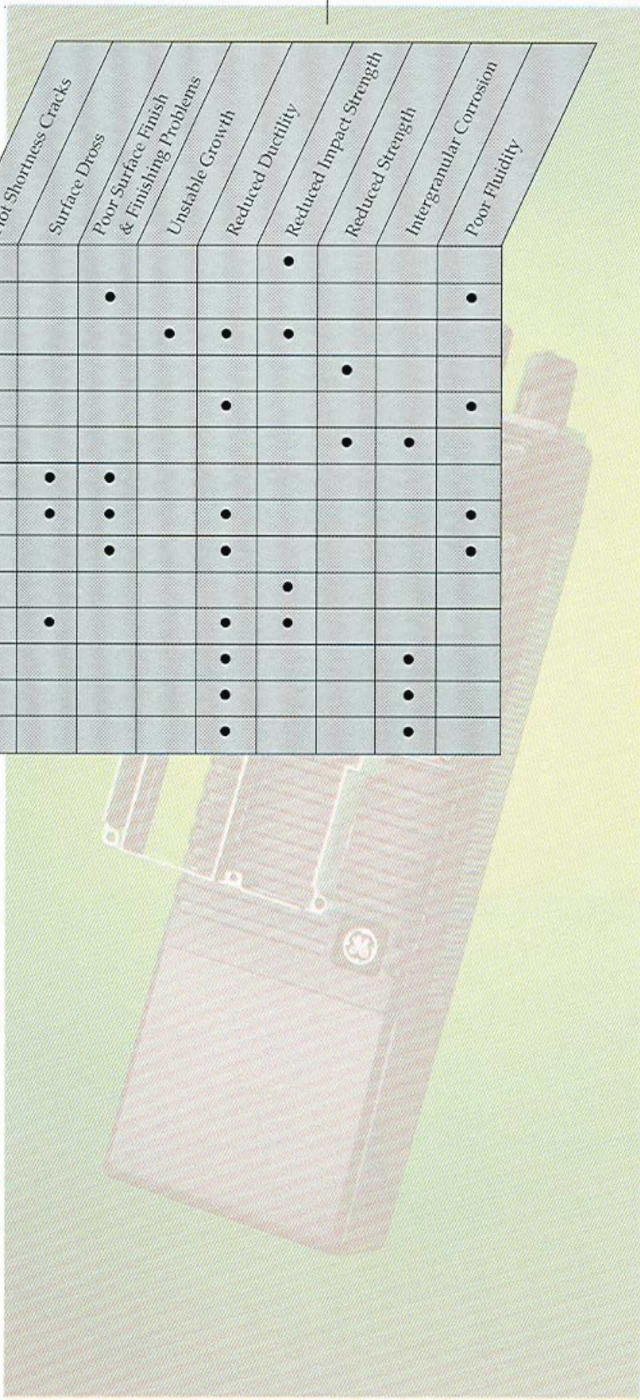
Who should I buy alloy from?

These are the "Golden Rules".

- Check your supplier's QA program. Deal only with alloyers who have a reputation for quality products backed up by a strict "written" quality assurance program.
- Have a written quality procedure. Ask your supplier to agree to it and sign it. Liaise with your supplier regularly to check that procedures are being followed.
- Visit your alloy supplier's plant. A reputable supplier has nothing to hide and will actively encourage you to look around his production facility and carry out a quality audit.
- Be careful with off-shore suppliers or traders. Plant visits, QA audits, and field service are only feasible with North American suppliers.
- Deal with suppliers who can provide technical support. Noranda will gladly provide technical support to die casters who regularly purchase alloy from our Alloyer customers. It is important that the people who supply your suppliers stand behind their products. We do!
- Be wary of discount alloy! Zinc is a world commodity. Large discounts are not a common phenomenon on quality "in-spec." material. If a real deal comes your way, double check the analysis certification before accepting delivery.

Figure 1

		Hot Shortness Cracks	Surface Dross	Poor Surface Finish & Finishing Problems	Unstable Growth	Reduced Ductility	Reduced Impact Strength	Reduced Strength	Intergranular Corrosion	Poor Fluidity
Aluminum	High						•			
	Low	•		•						•
Copper	High				•	•	•			
	Low							•		
Magnesium	High	•				•				•
	Low							•	•	
Nickel	High		•	•						
Iron	High		•	•		•				•
Chromium	High			•		•				•
Silicon	High						•			
Manganese	High	•	•			•	•			
Lead	High					•			•	
Cadmium	High					•			•	
Tin	High					•			•	



Zamak Alloys:
Ingot Specifications (ASTM B240)

This is the spec. to which your plant should be purchasing alloy.

	Zamak 2	Zamak 3	Zamak 5	Zamak 7
Aluminum (Al)	3.9-4.3	3.9-4.3	3.9-4.3	3.9-4.3
Copper (Cu)	2.6-2.9	0.1 max.	0.75-1.25	0.10 max.
Magnesium (Mg)	0.025-0.05 max.	0.025-0.05	0.03-0.06	0.010-0.02
Iron (Fe)	0.075 max.	0.075 max.	0.075 max.	0.075 max.
Nickel (Ni)	0.02 max.[a]	0.02 max.[a]	0.02 max.[a]	0.005-0.020
Chromium (Cr)[a]	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Silicon (Si)[a]	0.035 max.	0.035 max.	0.035 max.	0.035 max.
Manganese (Mn)[a]	0.05 max.	0.05 max.	0.05 max.	0.05 max.
Lead (Pb)	0.004 max.	0.004 max.	0.004 max.	0.002 max.
Cadmium (Cd)	0.003 max.	0.003 max.	0.003 max.	0.002 max.
Tin (Sn)	0.002 max.	0.002 max.	0.002 max.	0.001 max.
Zinc	Balance	Balance	Balance	Balance

[a] - Testing for these elements is not required according to ASTM specifications.

Zamak Alloys:
Casting Specifications (ASTM B86)

This is the spec. to which your plant should be selling castings.

	Zamak 2	Zamak 3	Zamak 5	Zamak 7
Aluminum (Al)	3.5-4.3	3.5-4.3	3.5-4.3	3.5-4.3
Copper (Cu)	2.5-3.0	0.25 max.	0.75-1.25	0.25 max.
Magnesium (Mg)	0.020-0.050	0.020-0.05	0.03-0.08	0.005-0.020
Iron (Fe)	0.100 max.	0.100 max.	0.100 max.	0.075 max.
Nickel (Ni)	0.02[a] max.	0.02[a] max.	0.02[a] max.	0.005-0.020
Chromium (Cr)[a]	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Silicon (Si)[a]	0.035 max.	0.035 max.	0.035 max.	0.035 max.
Manganese (Mn)[a]	0.06 max.	0.06 max.	0.06 max.	0.06 max.
Lead (Pb)	0.005 max.	0.005 max.	0.005 max.	0.0030 max.
Cadmium (Cd)	0.004 max.	0.004 max.	0.004 max.	0.0020 max.
Tin (Sn)	0.003 max.	0.003 max.	0.003 max.	0.0010 max.
Zinc	Balance	Balance	Balance	Balance

[a] - Testing for these elements is not required according to ASTM specifications.

ZA Alloys: Ingot Specifications (ASTM B669)

This is the spec. to which your plant should be purchasing alloy.			
	ZA-8	ZA-12	ZA-27
Aluminum (Al)	8.2-8.8	10.8-11.5	25.5-28.0
Copper (Cu)	0.8-1.3	0.5-1.2	2.0-2.5
Magnesium (Mg)	0.020-0.030	0.020-0.03	0.012-0.020
Iron (Fe)	0.065 max.	0.065 max.	0.072 max.
Nickel (Ni)[a]	0.01 max.	0.01 max.	0.01 max.
Chromium (Cr)[a]	0.01 max.	0.01 max.	0.01 max.
Manganese (Mn)[a]	0.01 max.	0.01 max.	0.01 max.
Lead (Pb)	0.005 max.	0.005 max.	0.005 max.
Cadmium (Cd)	0.005 max.	0.005 max.	0.005 max.
Tin (Sn)	0.002 max.	0.002 max.	0.002 max.
Zinc	Balance	Balance	Balance

[a] Testing for these elements is not required according to ASTM specifications.

ZA Alloys: Casting Specifications (ASTM B791)

This is the spec. to which your plant should be selling castings.			
	ZA-8	ZA-12	ZA-27
Aluminum (Al)	8.0-8.8	10.5-11.5	25.0-28.0
Copper (Cu)	0.8-1.3	0.5-1.2	2.0-2.5
Magnesium (Mg)	0.015-0.030	0.015-0.030	0.010-0.020
Iron (Fe)	0.075 max.	0.075 max.	0.075 max.
Nickel (Ni)[a]	0.01 max.	0.01 max.	0.01 max.
Chromium (Cr)[a]	0.01 max.	0.01 max	0.01 max.
Manganese (Mn)[a]	0.01 max.	0.01 max.	0.01 max.
Lead (Pb)	0.006 max.	0.006 max.	0.006 max.
Cadmium (Cd)	0.006 max.	0.006 max.	0.006 max.
Tin (Sn)	0.003 max.	0.003 max.	0.003 max.
Zinc	Balance	Balance	Balance

[a] Testing for these elements is not required according to ASTM specifications.