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Small additions of beryllium have long been proven to be highly beneficial to aluminum and magnesium alloys, but new applications continue to be found for this unique alloying element. This article reviews some of the reasons for its common use.

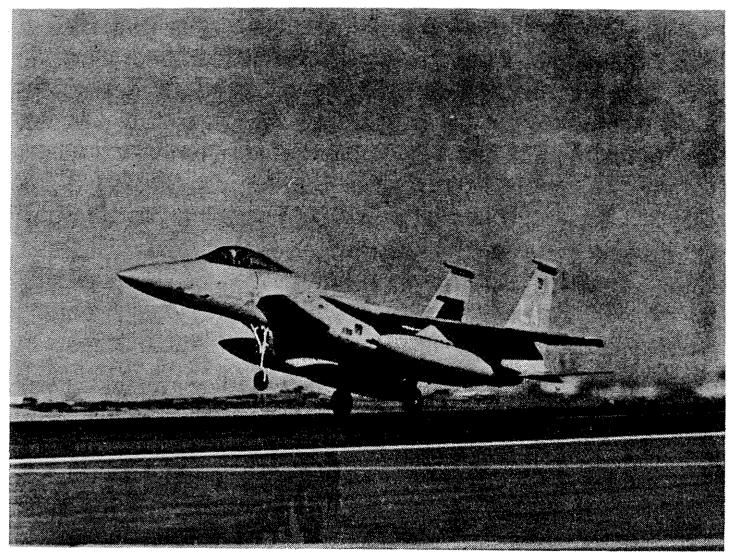
Aluminum Alloys

When as little as 0.005 – 0.05 wt.% Be is added to aluminum base alloy melts, it causes a protective beryllium oxide film to form on the surface. This film reduces drossing, increases metal yield and cleanliness, and improves fluidity. This results in cleaner, higher quality castings with better surface finish, higher strength, and improved ductility. The protective BeO film may also reduce absorption of hydrogen in the melt. Be also acts to reduce metal reaction with sand molds during casting, and prevents preferential oxidation of magnesium because the BeO film provides good control over the Mg content.

Without the protection that Be provides, significant Mg and Na losses can occur, because Mg and Na are highly reactive with oxygen. Magnesium oxide by itself does not form a protective barrier to prevent or lessen continued Mg loss, making Mg loss in an unprotected heat variable with hold time. At 1300 F, the BeO film also provides a significant barrier to vapor loss. This benefit may be of greater significance to the caster then oxidation loss and is also a function of hold time.

Additions of as little as 0.005 – 0.02% Be to Al base alloys provide other benefits. Slight increases in Be content reduce tarnishing and corrosion of the Al alloy at room and elevated temperatures. Beryllium also improves the polishing and buffing characteristics of the material. The percentage of Be should be adjusted in accordance with the Mg content of the Al alloy and the properties required.

The addition of 0.1 – 0.3% Be to premium quality Al castings for aerospace applications provides a protective surface BeO layer. In addition, the Be changes the brittle Fe intermetallic crystals from large needle and plate-like shapes to small equiaxed crystals. This improves both strength and ductility. Therefore, a higher level of residual Fe can be tolerated with Be additions. When combined with a 0.02% sodium addition, the Be shifts the Al-Si eutectic permitting higher Si levels, thus providing increased fluidity. This same protective BeO film prevents Mg from diffusing to the surface of a billet during casting, and forming a MgO layer on the surface. Since MgO on the surface of the billet contributes to poor surface quality, the addition of beryllium improves



Beryllium is a common addition to many aluminum aerospace alloys.

Reprinted from the February 1988 issue of *Metals and Materials* magazine.

product yield. When Na is used to modify the silicon phase in Al alloys, a thick oxide layer will sometimes appear on castings; this can be prevented by adding small quantities of Be. In addition to the improved surface quality of the castings, Be will also improve the castability of the product.

Two recent papers [1,2] presented findings on Be as a grain refiner. Commercially pure aluminum was superheated to various temperatures with additions of Ti and Be. The grain refining effect of Be when combined with Ti was found to be similar to that of the traditional Ti and B combination under comparable conditions. The grain refining mechanism observed appeared to be independent of impurity levels. Up to 800 C, the degree of grain refinement was found to be independent of melt superheat, mold temperature, and holding time. In addition, the research suggested that rolling Al-Ti-Be into oil would cause less roller wear and would in turn produce better foil surface quality than Al-Ti-B. The Be additions were made with 5% BeAl master alloy.

The effect of beryllium in Al-Cu alloys has also been the subject of numerous investigations. Additions of 1 – 2% Be to a binary Al-4.3%Cu alloy showed a substantial increase in fluidity. Of the additions studied (Fe, Mn, Co, Cr, Be, Si, Mg, Ca, Cu), the maximum gains in fluidity were achieved with Co and Be. The gains measured were 28% and 25%, respectively. R.H. Harrington[3] reported that beryllium additions of 0.2 – 0.5% have improved the tensile and yield strength in Al-4Cu-1.3Co alloy. In addition, four year exposure tests in an industrial atmosphere showed the alloy to have excellent resistance to thermal oxidation corrosion. Be has also been found to accelerate the age hardening process in Al-Cu alloys[4].

It is important when making Be additions to Al alloys that it is added prior to the Mg and Na. The Be addition can be made by adding BeAl, BeCu, or BeMg master alloy to the Al. The Be-containing master should be plunged into the melt and kept submerged until the master has melted to ensure minimum initial Be loss to oxidation. The recommended temperature range for the melt when making these additions is 675 – 705 C. The percentage of Be should be adjusted in accordance with the Mg content of the alloy.

Master Alloys	% Beryllium*	Common Product Forms**
Beryllium Aluminum	5	shot 1 & 3 ounce sheared 5 pound ingot
	2.6	3 ounce sheared rod 5 pound ingot
	1	5 pound ingot
Beryllium Copper	4	shot 3 ounce sheared rod 3 and 5 pound ingot
Beryllium Magnesium	5	pellet

* Special compositions can be made to meet customer needs.

**These are the most commonly stocked product forms. Other forms can be supplied upon request.

Magnesium Alloys

Magnesium alloys are particularly sensitive to both oxidation and actual burning when Mg comes in contact with oxygen. The addition of as little as 0.001% Be will increase the ignition temperature of Mg by as much as 200 C and may help prevent ignition. Although fluxes that cover the melt and prevent contact with oxygen can

1. M. Abdel-Reihim, N. Heb, and W. Reif, Improvement of the Grain Refinement Effect of Titanium in Commercially Pure Aluminum by Additions of Alkali Earth Metals, 1st Int. Ain Shams Univ. Conf. on Prod. Eng. and Design for Development, December 27 – 29, 1984.

2. W. V. Youdelis and C. S. Yang, "Beryllium–Enhanced Grain Refinement of Aluminum–Titanium Alloys", Metal Science, Vol. 76, pp 275 – 281, 1982.

3. R.H. Harrington, "New Aluminium Alloys Containing Small Amounts of Beryllium", Trans. ASM, p. 311, 1946.

4. J. Karov and W. V. Youdelis, "The Effect of Be on Theta Phase Precipitation in Al-3%Cu Alloy", TMS paper F84 – 9, 1984.

be used, it can be advantageous to minimize their use because of the added cost, possible corrosion of equipment, and the possibility of inclusions caused by entrapped flux. Small Be additions control and minimize Mg loss making fluxes unnecessary without causing unfavorable side effects, because Be is one of the few elements that is more reactive to oxygen than Mg. Beryllium provides the further advantage of precipitating Fe and Mg impurities from the melt. These benefits carry over to casting. The increase in ignition temperature may help prevent burning during pouring and in the mold itself. It will also reduce reaction with moisture in the mold so that green sand can be used without inhibitors. In wrought alloys, Be provides improved resistance to high temperature oxidation and sea water corrosion which may offer processing and service advantages.

Beryllium is usually added to Mg alloys in the form of BeMg or BeAl master alloy in concentrations ranging from 0.001 – 0.01%. The actual concentration required will vary with the application. Small additions of titanium or zirconium may be desirable since Be will adversely affect the grain size of Mg alloys when concentrations exceed 0.005%. As with the Al alloys, additions of Be-containing master alloys should be made by holding the addition under the surface until it has melted. The recovery rate is usually about 40%. The presence of Al will help to increase the solubility of beryllium in the melt. The normal solubility of Be in Mg at melt temperatures of 620 – 650 C has been estimated to be 0.0003 to 0.001%. Increased melt temperatures will increase the solubility.

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