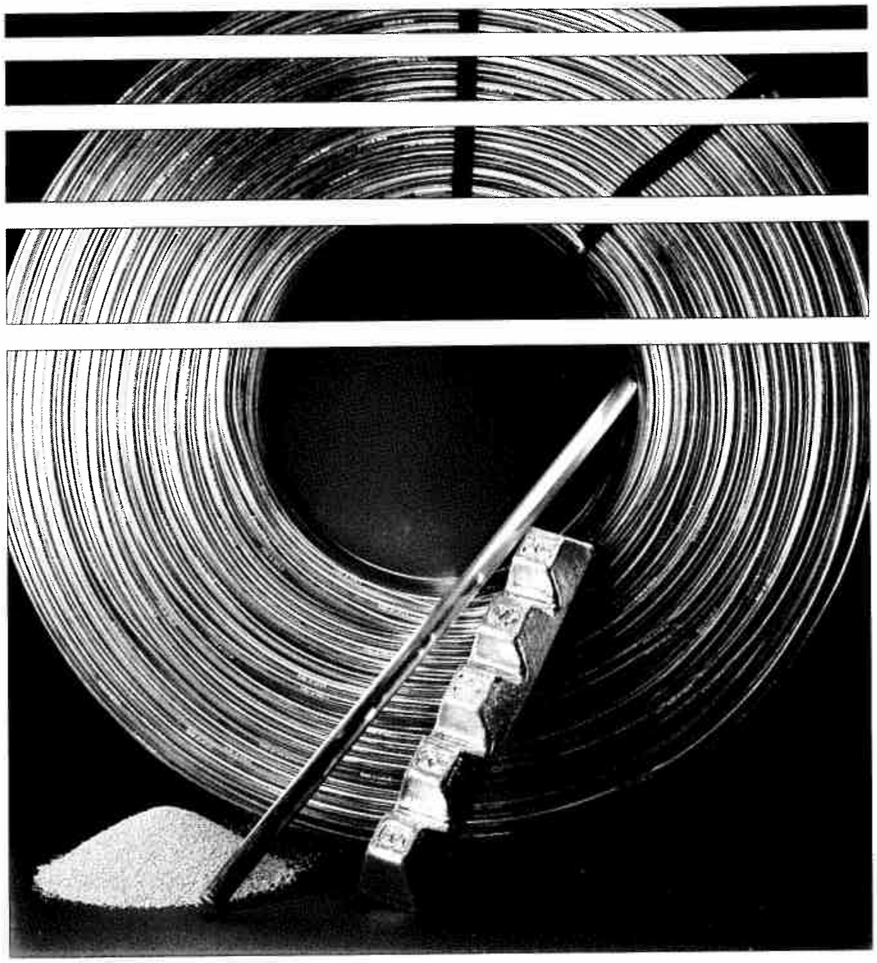

BRUSH

The Cost Effective Additive for Improved Yield and Product Quality.

Small quantities of beryllium, when introduced to magnesium and aluminum melts, provide substantial manufacturing benefits in terms of direct cost savings and product quality.

When beryllium is added to the melt in small quantities much of it forms beryllium oxide. As a surface film, beryllium oxide creates a superior barrier to further oxidation. The improved barrier inhibits dross formation, limits magnesium ignition and improves metal yield. By preventing oxygen migration into the melt, the beryllium addition enhances metal cleanliness leading to improved mechanical properties and visual characteristics of the casting. Additional benefits include reduced skimming, shorter inert gas processing time, lower dross processing cost and decreased furnace power consumption.

ADDITIONS TO ALUMINUM ALLOYS

The benefits of beryllium additions in the production of aluminum alloys can be accomplished in three major processes:

- Melting
- Casting
- Wrought Processing

During melting and casting, the advantage lies in the oxide film stabilization by beryllium. This oxide inhibits the path for oxygen to react with aluminum or magnesium and subsequently reduces dross formation by as much as 70%. The beryllium-bearing surface film protects the melt from disturbances such as alloying, stirring, skimming and from turbulence occurring in pouring.

Because the magnesium content within an aluminum alloy is otherwise preferentially oxidized, the small beryllium addition prevents magnesium fade. The use of beryllium allows melt temperature to be almost 200°C (392°F) higher while still inhibiting magnesium ignition. Effectively, the ignition temperature of magnesium is raised by the same amount. Better control of the magnesium alloying process and reduction of magnesium fade provide greater control of melt chemistry. Additionally, there is a reduction in oxide patch defects and entrainment of oxygen and nitrogen in the casting.

When casting, beryllium additions improve fluidity and reduce dissolved gas which shortens the time for inert gas treatments. Castings have improved ductility, higher yield strength and toughness, better surface finish, finer detail retention and reduced porosity. The improvements resulting from beryllium additions allow thinner sections to be successfully cast with less of an adverse reaction between the molten metal and sand or mold coatings.

In wrought product processing, the microstructure modification of silicon particles provides for better roll and die life. Hot workability, surface quality and weldability are also improved with small beryllium additions.

For aluminum magnesium alloys the opportunity for cost savings lies in preventing both magnesium loss and aluminum oxidation. Alloys treated with a beryllium addition result in less dross formation and drier drosses which contribute to lower dross treatment or disposal cost. Reducing dross saves metal and the power cost associated with melting.

ADDITIONS TO MAGNESIUM ALLOYS

Benefits for magnesium alloys arise from the same principles governing the aluminum-based alloys.

For liquid metal processing, the greatest benefit arises from reducing the oxidation loss of magnesium by either burning or surface diffusion of oxygen into the bath. Economic and processing benefits may be measurably increased in melting, holding, transferring and casting magnesium treated with small amounts of beryllium. By reducing the tendency for magnesium ignition, the safety of the operation is enhanced.

Castings are improved by tighter chemistry control, in turn reducing variability. Green sand molds may be used without the inhibitors normally added to prevent the reaction between moisture in the sand and the magnesium alloy being cast.

Wrought product quality is enhanced when stable

beryllides of iron and nickel are precipitated thus scavenging impurities from the bath. Reducing iron and nickel improves resistance to corrosion and high temperature oxidation. Beryllium additions generate a cleaner, purer magnesium which is achieved without the use of fluxes and their long-term negative influence.

IMPACT OF BERYLLIUM CONCENTRATION

The use of beryllium in large quantities, to achieve structural modification of silicon-aluminum eutectic in casting alloys, should not be confused with lesser additions made specifically to prevent melt degradation.

The following table describes the impact of beryllium concentration on the alloy properties. It provides a guideline for estimating the amount of master alloy to use.

Beryllium Concentration (Weight Percent)	Impact
0.001-0.005	• Increases ignition temperature of magnesium • Reduces the need for inert atmosphere
0.005-0.01	• Reduces gas pickup • Magnesium oxidation and fade is reduced • Dross formation is reduced • Oxide patch defects are reduced
0.02-0.05	• Improves cast alloy fluidity
0.05-0.1	• Silicon-aluminum micro-structural modifications

USE INCREMENT ADVANTAGES OF ACU-STIX®

Operators using aluminum beryllium master alloy are required to be extremely precise and accurate to achieve best results. Therefore, it is important that the physical material added to the furnace agree with the calculated needs of the process. To assist the operator, Brush Wellman offers 5% aluminum beryllium as an extruded ACU-STIX®. The extruded form optimizes the metallurgical properties of elemental beryllium distribution aiding dissolution and recovery. Uniformity of cross-section allows precise weight measurements to correspond with precise length measurements. One inch of ACU-STIX® is one ounce of alloy.

The reliability of a process to ensure that the physical volume of material entering the bath is consistent with the calculated beryllium requirement is crucial. The correlation of the two depends mostly on how consistently the composition of the master alloy meets the nominal weight percent of the specification and how consistently the cut piece weight meets the nominal weight specification. Brush Wellman uses stringent Statistical Process Control to assure all master alloy meets requirements.

FIGURE 1

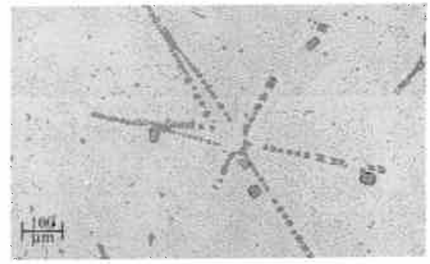

FIGURE 2

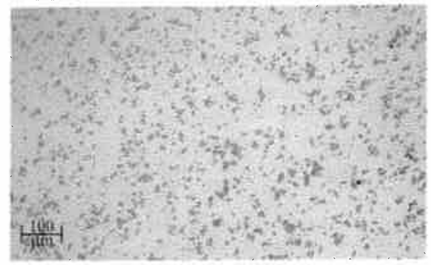

FIGURE 3

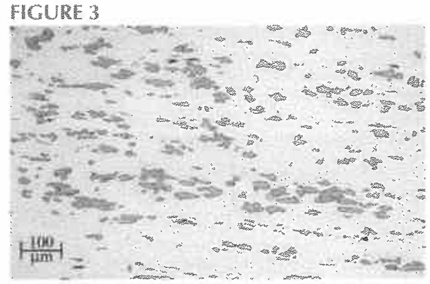

FIGURE 1 (100x)
Dilute Keller's etch; H2005 5% Be-Al as cast; The dark grey particles making up the starburst pattern are primary beryllium phase. The pinpoint particles are secondary Be precipate condensed from the alpha aluminum matrix.

FIGURE 2 (100x)
Dilute Keller's etch; H2005 5% Be-Al extruded ACU-STIX; This transverse section of extruded 5% Be-Al ACU-STIX reveals the homognized and refined particle distribution of the primary beryllium. This increased dispersion of individual beryllium particles dramatically improves the dissolution rate of the beryllium and gives impetus to the homogenization of the finished alloy bath.

FIGURE 3 (100x)
Dilute Keller's etch; H2005 5% Be-Al extruded ACU-STIX; This longitudinal section of an extruded 5% Be-Al ACU-STIX reveals the primary beryllium particles retain a slightly banded structure aligned with the rod forming process. The discreet particles show an inter-particle separation of about 1 particle diameter within the band. The dispersion of the Be and the complete surrounding of individual particles by the white alpha aluminum indicates the dissolution for ACU-STIX is superior to as-cast 5% Be-Al.

PROCESS CAPABILITY FOR ADDITION USE INCREMENTS

Product Form	Be Content Tolerance ± from nominal	C_{pk}	Percent of Time within Specification
ACU-STIX®	10%	0.61	96.1
ACU-STIX®	15%	0.98	99.8
Competitive alloy	10%	0.10	31.0
Competitive alloy	15%	0.19	45.0

ACU-STIX® exhibits outstanding accuracy and consistency when compared to competitive master alloy products.

METHODS OF ADDITION AND GUIDELINES

Master alloys of aluminum beryllium offer the easiest method of adding beryllium to a melt. Master alloy may be added in the furnace, launder or ladle. Additions made to affect the castability should be made after degassing. Additions to reduce long-term oxidation losses must be added before the degassing process. However, prolonged vigorous degassing processes can remove beryllium from the melt. Timing must, therefore, be considered to receive the full benefit of beryllium.

Master alloy should be stored in clean, dry, secure containers. Additions suspected of being wet or subjected to cold storage temperatures should be preheated prior to their introduction to the molten alloy. Precise control of the additive weight is the key factor for effectively controlling the melt chemistry. Master alloy composition and the preciseness of the piece weight combined with the forced submersion of the product into the liquid metal provides for the optimized process predictability and control. Master alloy additions allowed to float atop the bath, because of their higher beryllium concentration, will suffer increased oxidation of the beryllium. Beryllium oxide so formed will not be dispersed to act as a stabilizer for the metal oxide skin. Addition of pure metallic beryllium to molten alloy will result in very low recoveries and is not recommended.

Aluminum melt temperatures should be between 675 and 750°C (1250 and 1380°F). The disintegration of the master alloy occurs at any temperature where the bath is molten. Since 0.87% beryllium is soluble in aluminum at 645°C (1250°F), typical beryllium additions, below 0.01%, will dissolve nearly instantaneously.

AVAILABLE MASTER ALLOY FORMS

The following chart lists the forms and nominal composition of aluminum beryllium master alloys available from Brush Wellman. Special compositions can be supplied to meet specific customer needs.

Percent Beryllium	Common Product Forms
5	• Shot • 5 lb. ingot • ACU-STIX®
2.6	• 5 lb. ingot • ACU-STIX®
1	• 5 lb. ingot

TECHNICAL ASSISTANCE

Detailed information regarding material properties, safe handling, specific applications and fabrication assistance is available from Brush Wellman's Customer Technical Service Department in Cleveland, Ohio at 800-375-4205 or 216-486-4200.

HEALTH AND SAFETY

Handling aluminum beryllium master alloy in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on aluminum beryllium master alloy, contact Brush Wellman Inc. in Cleveland, Ohio at 800-321-2076.

AVAILABILITY

For information on product availability or to place an order, contact:

In North America:

Brush Wellman Inc.
Warren, Michigan
Service Center
800-521-8800
810-772-2700

Outside North America:

Brush Wellman Inc.
Export Sales
Cleveland, Ohio
800-321-2076
216-486-4200

Photo Credits: **Milward Alloys, Inc.**
Quality, Innovation & Excellence Since 1948