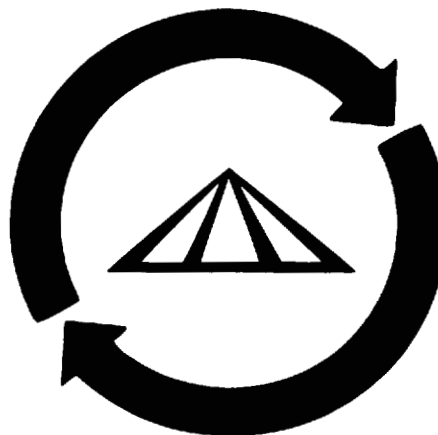


Guidelines for Aluminum Sow Casting and Charging

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GUIDELINES FOR ALUMINUM SOW CASTING AND CHARGING

These *Guidelines* have been developed by the Aluminum Association with oversight by the Task Force on Sow Casting and Charging.

The *Guidelines* are based on information believed to be reliable and are offered in good faith but without any guarantee. The conditions which exist in individual plants vary widely, and thus no uniformly applicable standards exist for casting or charging aluminum sows. Accordingly, the Aluminum Association and its member companies assume no responsibility or liability for the general applicability of the guidelines and recommendations herein, which though based on state-of-the art knowledge may not be appropriate in all situations. Users of these Guidelines should adapt the recommendations herein, as appropriate, to the precise conditions of the individual facility and should always exercise independent discretion in establishing plant or facility operating practices.

No warranty, expressed or implied, is made of this information by the Aluminum Association or by any of its member companies.

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GUIDELINES FOR ALUMINUM SOW CASTING AND CHARGING

I. INTRODUCTION

A. Purpose of these Guidelines

Numerous explosions have been caused by wet or contaminated sows being charged into molten aluminum in melting furnaces. These Guidelines have been prepared and published with the aim of helping companies that produce and/or melt aluminum sows to prevent equipment damage and injuries associated with the explosions. A second objective is to promote the cooperation and understanding of all personnel that handle, transport and store this type of material to help prevent incidents from these hazards. These Guidelines are safety related and are not intended to provide commercial advice or guidance of any kind.

The Guidelines offer information and suggestions derived from industry experience for individual plants to consider in designing and operating their own safety programs related to aluminum sow casting, inspection and melting.

All plant personnel are expected to follow specific safety procedures established by their management. These Guidelines are not intended to preempt or replace those procedures.

B. Scope

Bulk aluminum intended for remelting is often cast in the form of large shapes, weighing from 700 to 2000 pounds (320 to 900 kg), known as "sows." Because of the normal geometry of these sows and how they are cast, shrinkage cavities are frequently unavoidable. These shrinkage cavities can often become reservoirs for collecting large amounts of water depending on how the sows are stored. The sows are also subject to surface moisture and other contaminants.

The introduction of water into molten aluminum can result in an explosion ranging from a small one to a very violent one causing extensive equipment damage and endangering human life. Therefore every effort should be made to avoid charging sows that contain moisture, either entrapped or surface, into molten aluminum.

The sows must also be free of any surface contaminants such as oxidizing agents and hygroscopic salts which can cause explosions. Many

oxidizing agents can act as catalysts that can create an explosion. Some of these may be nitrate bearing fertilizers, metallic oxides, rust and fluxing salts. This is why visual inspection is so important.

Specific guidelines on sow casting techniques, storage methods, pre-heating, charging and melting practices can help reduce the risk of explosions. Each facility should develop specific procedures and standard practices to ensure that sows are completely dry and free of all surface contaminants before charging them into a furnace that contains molten aluminum.

The Aluminum Association discourages the procedure of drying sows by placing them on sills of furnaces that contain molten aluminum because the risk is too great that a sow will slip into the molten bath before it is fully dry. There is also the possibility that water will condense between sows stacked on the furnace sill during the early stages of heating. Serious explosions have occurred because of this practice.

General safety practices are discussed in the Aluminum Association's Guidelines for Handling Molten Aluminum, Second Edition (ref. 1). The hazards that cause explosions with aluminum sow must be eliminated in the casting, storage, transport, charge preparation and charging of the material.

These Guidelines deal with practices to minimize or eliminate shrinkage cavities in aluminum sow as well as methods and procedures for storage, transportation, inspection, drying and charging.

II. SOW CASTING

Aluminum sows are produced by pouring molten aluminum into open top cast iron or cast steel molds. Sows vary in size and shape and can range from a height to width ratio of 1:1 to 1:6 (low profile). The design of the mold has a significant impact on the soundness of the sows produced. Mold designs with a high height to width ratio produce sows with the largest internal shrinkage cavities.

During the cooling process the outermost surfaces of the aluminum begin to solidify while the center remains molten for some period of time. Thus a solid aluminum shell is formed around the last remaining molten aluminum. As the remaining aluminum solidifies it shrinks, thereby forming a shrinkage cavity. This cavity is not easily visible. However, small fissures or cracks form in the top surface as it partially collapses into the shrinkage cavity. These fissures, although small enough to be almost invisible to the eye, may form passageways into the cavity which can

allow water to collect. Because these fissures are relatively small the water in the cavity does not evaporate very quickly. The size of the cavity generally has a direct relationship to the geometry of the mold and the casting technique used. Older molds were generally made of heavy cast iron, to produce sows weighing 1000, 1200 and 2000 pounds (450, 550 and 900 kg). They have a high height to width ratio. Many of these molds are still in use.

Considerable research has been performed to reduce shrinkage cavities in sows. This work involves computer modeling as well as casting metal in special molds to validate the model. References (2) and (3) provide detailed information on two projects the Aluminum Association has funded. This work clearly demonstrates how difficult it is to produce sows free of internal cavities. Most of the production sow molds in use today are not capable of producing a cavity free sow in a warm mold even if all other influencing factors are carefully controlled.

There are many factors that influence the solidification of a sow. They include: metal temperature, mold temperature, mold mass, mold depth to width ratio, ambient air temperature, air circulation, external cooling of mold, external cooling of sow, etc.

There are a number of things that can be done to prevent or minimize the formation of shrinkage cavities. They include:

1. Increase the mold bottom mass.
2. Put cooling fins on the mold.
3. Circulate air under the mold.
4. Cool the bottom of the mold with water.
5. Insulate the mold sides.
6. Pour the metal in the mold at a constant temperature.
7. Do not circulate air over the top of the poured sow until it is 100% solid.
8. Do not water cool the top of the poured sow until it is 100% solid.
9. Never multiple pour sows.
10. Keep mold temperature a constant for all pours.
11. Heat the top of the poured sow during solidification.
12. Insulate the top of the mold during solidification.

Some sow molds in use today produce sows that are cavity-free most of the time. There is no way to guarantee that they are always void free due to deviations in the production cycle. When sow molds are used to cast aluminum alloys, one normally would expect to have large shrinkage cavities due to the long solidification range of the alloys and the resulting erratic feeding of the shrinkage by the molten pool.

T-ingot is an alternate and preferred form of primary metal. It is produced by the direct chill process and as a result does not have large shrinkage cavities. However, the top end of each cast length of T-ingot may be porous and can hold moisture. The most common defect in T-ingot is cracks. Most of these ingot are sawed with a water soluble oil lubricant. This lubricant will collect in the internal cracks during the sawing operation.

III. STORAGE

Ideally all aluminum sows should be stored in a dry, heated area where the temperature of the aluminum never drops below the dew point of the surrounding air. Unfortunately, very few plants have space for this type of storage. If dry storage areas are not available, furnace drying is required before charging sows into molten metal.

Aluminum sows should be considered wet if you do not know the complete history of the material from pouring to the present. This means that all sows shipped from the producing plant to another plant or customer must be considered wet and furnace drying is required if the sows will be charged into molten aluminum.

There are numerous problems in production plants that interfere with dry storage. They include: roof leaks, opening of truck doors, opening of doors for ventilation, inadequate interior space, unheated buildings, etc. At the minimum every plant that plans to charge sows into molten aluminum should have a furnace for drying sows and a heated room to store the dry sows after they are removed from the furnace.

Temperature variations even inside a closed space will often result in condensation on the surface. Condensation is caused by major temperature changes in the presence of humid air. As a matter of fact, if there are shrinkage cavities present heavy condensation over an extended period will fill the cavity with water. This is a good argument for practicing FIFO (first in first out) in sow storage. Sows that have been furnace dried prior to charging, and then allowed to cool below the dew point of the air in the storage area, can collect condensation and should be redried prior to charging.

Plants that produce sows can immediately store their hot material removed from the molds in a dry, heated storage location. This material can be safely charged into molten aluminum without going through a furnace drying operation if water was not used to cool the top surface of the sow