

## Care and Use - Crucibles

### Key Steps To Maximizing Your Crucible's Service Life

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Crucibles that provide a consistently long service life are highly valued by melting facility managers. Such crucibles allow managers to plan longer production campaigns, to schedule crucible replacement times that minimize downtime and to reduce replacement frequency, cutting crucible purchase costs. While the product quality built into a crucible by its manufacturer is one key to long service life, another key is held by metal casters themselves. That key is providing the best possible crucible care on the job.

#### Choosing the Right Crucible

Achieving a long and consistent service life for your crucibles starts before any crucible arrives on your receiving dock. It begins with a comprehensive consultation with your crucible supplier to select a crucible precisely matched to your application. The specific alloy or range of alloys you melt, the type of furnace you operate, the melting and/or holding temperatures you maintain, the rate of temperature change the crucible will experience, how the crucible is charged, the fluxes used, how slag or dross is removed and how the crucible is poured are just a few of the many factors that must be taken into account when selecting a crucible. But selecting the right crucible for your application would be an article all by itself. This article begins with the arrival of the crucible you selected at your facility.

#### Handling Your Crucible with Care

Taking steps to maximize your crucible's service life begins when it arrives on your receiving dock. It's particularly important to inspect the crucible to verify that it did not suffer any shipping damage. First make sure that it was well protected with packing materials during its shipment and that these are intact. Next, clear away enough of the packing to gain a clear view of the entire crucible. Examine the crucible as you would a new car delivered to you off the showroom floor. Look for chips, visible cracks, abrasions or other surface damage. If you see any damage or suspect hidden damage, contact your crucible supplier. Never place a crucible with shipping damage in service. It is likely to fail and represents a serious safety hazard.

If the new crucible passes your close inspection, exercise great care in moving it to storage or to the furnace. Ideally, crucibles should be moved on the pallet or in the shipping carton used for delivery to your facility. But note that there are certain things that must never be done in moving a crucible:

1. Never roll the crucible. While a crucible's round shape may seem conducive to rolling it from place to place, rolling it on its side, base or top will crush the crucible's protective glaze and possibly damage the underlying material. Damage to the glaze will lead to oxidation of the crucible.
2. Never stack one crucible inside another. The weight of the top crucible can fracture the lower crucible while abrasion where the inner and outer surfaces make contact will damage the protective glaze. When stacking crucibles, separate them with hardboard or similar material.

**Figure 1. Improper stacking will damage crucibles.**



3. Never stand crucibles directly on the floor. The hard surface can damage the bottom of the crucible. But even more important, the crucible may absorb humidity coming from the floor and create thermal shock when heated. Stand the crucibles on pallets.

4. Never use banding to secure the crucible during movement without adding padding under the band to protect the crucible's surface.

Even seemingly minor damage inflicted by poor handling will shorten a crucible's service life and may lead to crucible failure, creating a safety hazard if molten metal is released. Never use a damaged crucible.

Also note that crucibles must always be stored at temperatures above 32°F/0°C and in a dry area. Cold and/or wet crucibles must not be placed in service. They could cause dangerous water/molten metal explosions.

### Installing Your Crucible

If your crucible is to be permanently placed in a furnace, proper installation will make an important contribution to crucible service life. While furnace crucible installation processes differ, depending on the furnace type, size and design, there are several standard practices that must be followed.

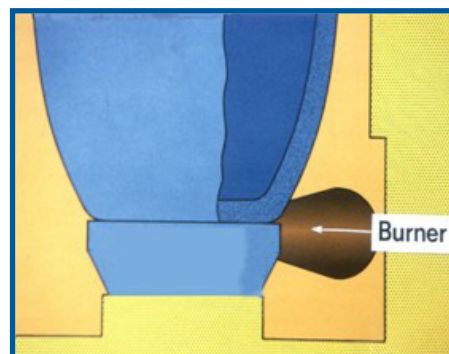
1. Inspect the crucible again immediately before installation to be certain:

a. That the crucible temperature is above the freezing point of water. If the crucible has been subject to high humidity, it could be damaged by thermal expansion (ice) in the walls of the crucible if the temperature drops below the freezing point.

b. It has not been damaged by handling or storage. A damaged crucible must not be installed.

2. Make sure that the base block is level, properly centered in the furnace, the correct height and larger than the crucible bottom.

**Figure 2. Crucible mounted on a properly positioned base.**



3. For larger crucibles, use secure straps or a lifting mechanism designed for your crucible to carefully lift the crucible into the furnace. Center it on the base block and ensure that it is level.

4. Provide at least a 1/3 in. (8mm) gap between the crucible and top and sides of the furnace to allow for crucible expansion. An insufficient expansion gap will result in crucible cracking.

5. If the crucible has a spout, be sure there is at least a 1 1/2 in. (38mm) gap between the spout and the furnace spout tray to allow for crucible expansion.

6. Use a ceramic fiber blanket to seal the space between the furnace top and the top edge of the crucible.

7. In a tilting furnace, use locating bricks designed to hold the crucible in position while allowing for crucible expansion. Allow a 1/4 in.-3/8 in. (6-10mm) expansion gap between the crucible and the grip bricks (use combustible spacer).

**Figure 3. Gripping blocks located too close to the top of the crucible produced a vertical crack.**



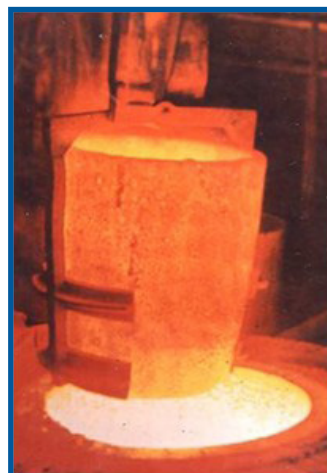
8. In gas or oil fired furnaces, ensure that the furnace flame travels in a tangential pattern around the crucible and does not overheat one spot on its surface. Even heating is essential to achieving a long service life.

**Figure 4. Flame directed to one spot on a crucible produced this damage.**



9. Furnace drain holes allow molten metal to flow out of the furnace shell into a containment area in the event a crucible fails during melting or holding operations. However, these drain holes must be properly sealed (refer to furnace manufacturer for proper sealing method) during furnace operation to prevent crucible damage. In general, for electric fired furnaces, the drain hole is sealed using a thin (1mm or less) Zinc plate. In gas or oil fired furnaces, a drain hole gate is used. In a removable crucible furnace, the key installation consideration is to be sure the crucible is undamaged and properly sized for your furnace. Also verify that the lifting shanks are properly sized for the crucible. For safety, lifting shanks must adequately support the entire crucible.

**Figure 5. Lifting shanks must be properly sized for your crucible and must provide adequate support.**



### Preheating Your Crucible Before First Use

All new crucibles and crucibles that have been allowed to cool completely must be preheated empty before being placed in service for melting or holding operations. To maximize crucible reliability and service life, the preheating cycle specified by the crucible manufacturer must be followed exactly and never rushed. The proper preheating cycle specified for your crucible will depend on the crucible material, the metal it will hold, whether it will be used for melting or holding and the furnace type.

For induction furnaces, the preheating cycle also takes into account the furnace frequency, coil dimensions and the resistivity of the metal being melted.

In all cases, preheating should be done gradually in its early stages to prevent thermal shock damage to the crucible.

**Figure 6. Thermal stress caused this crack extending across the bottom of the crucible.**



Proper preheating also is required for crucibles used to transfer molten metal.

### Caring for Your Crucible During Normal Operations

It's comparatively easy to exercise care when handling or installing a new crucible. It doesn't happen every day and workers are focused on not damaging their new crucible. But the truth is, most damage that reduces a crucible's service life happens during normal operations. It happens amid the rush to meet production schedules, when workers simply are not thinking about caring for the crucible. That's why managers who want to maximize crucible service life and prevent in-service crucible failure emphasize practicing proper crucible care in their operational and safety training programs.

#### Here are some operational practices every furnace operator should follow:

- **Charging Your Crucible** – Improper charging practices are crucible killers. Physical damage caused by dropping heavy charge materials into an empty crucible will not simply reduce crucible service life, it also can cause sudden crucible failure. When charging an empty crucible, small scrap materials and returns first should be carefully placed in the bottom of the crucible to protect that interior surface. Then ingots can be carefully added. If only ingots are being charged, they should be slowly lowered vertically into the furnace, using tongs if the furnace is deep. Do not pack metal tightly, allow room for the metal to expand and to reduce the likelihood of bridging. Some crucible materials are more resistant to physical damage than others. Know how resistant your crucible is to physical damage and respect its limitations.

**Figure 7. The impact of charge material dropped into the crucible produced this damage.**



- **Heating Your Crucible** – Even a warm, recently emptied crucible requires gradual and controlled heating before full melting heat is applied. Proper heating will prevent damage from thermal shock. Different crucible types require different heating cycles because some crucible materials are more sensitive to rapid temperature changes than others. Know and follow the heating guidance provided by your crucible manufacturer.
- **Protecting Your Crucible From Chemical Attack** – If your melting or holding application requires the heavy use of fluxes or produces large amounts of slag or dross, you must use a crucible type that provides resistance to chemical attack and erosion. But you can help any crucible type resist chemical attack and slag and dross accumulation by using the minimum quantity of flux required and only adding flux after the metal is fully molten. It is also important to carefully clean your crucible every day while it is still in a red hot condition. Dross has a high expansion rate and causes internal pressure that can damage the crucible. It also accelerates chemical attack.

**Figure 8. Overfilling caused flux to chemically attack the exterior of these crucibles.**



- **Never Overheat Your Crucible** – Every crucible has a maximum temperature limit. You must know that limit and operate below it. Exceeding that limit will damage the crucible, reduce its service life and can lead to crucible failure. The best defense against crucible overheating is to follow a practice of taking frequent temperature readings of the molten bath with a portable or fixed pyrometer. Remove from service any crucible that has been subjected to temperatures above its maximum limit.

### In Summary

Work closely with your crucible supplier to select the right crucible for your melting, holding or metal transfer operation. Inspect the new crucible carefully and handle it with care when moving it to storage or to your furnace. Install it properly. Preheat it according to the manufacturer's guidelines. Operate it within its design parameters. Protect it from physical and thermal damage. And replace it immediately when it is damaged or worn. Follow these rules and your crucibles will provide excellent service life, operational efficiencies and significant economies.



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