Ceramic Shell Investment Casting
An Introduction

Investing with Innovation™
**Glossary of Terms**

- **Binder** - colloidal silica binder is a suspension of solid amorphous silicon dioxide (SiO$_2$) particles (25%-30%) in water (70%-75%).
- **Binder Solids** - SiO$_2$, as well as other ingredients, in high performance binders that bond together refractory and sand to form a shell.
- **Refractory** - a fine, powder-like, heat resistant ceramic material.
- **Stucco** - a sand applied to an investment mold after it has been freshly dipped in a slurry and drained.
- **Slurry** - a combination of binder and flour materials.
- **Primary Slurry** - slurry used to apply the initial coat(s) to the pattern. These coat(s) determine the surface finish of the cast metal.
- **Backup Slurry** - slurry used to apply shell coats after the primary(ies) to build up a shell with adequate strength and thickness to withstand the stresses in the process.
- **Viscosity** - the resistance of a substance to flow.

**Binders**

For the new investment caster, casting ferrous metals and with limited controls in the slurry room, R&R recommends using one slurry tank with Primcote® binder. PRIMCOTE binder is formulated to eliminate buckling, lifting and cracking of the shell coats.

PRIMCOTE binder is a complete binder and contains proprietary additives, as well as a wetting agent, an antifoam and a color indicator to monitor shell dryness. To make slurry, simply add refractory powder.

For non-ferrous castings, R&R recommends using SuspendaSlurry® material.

SUSPENDASLURRY material is a pre-mixed, chemically suspended and ready-to-use ceramic shell slurry designed to simplify slurry make-up and maintenance and eliminate continuous slurry mixing; while offering proven casting performance.

SUSPENDASLURRY material can be remixed in minutes, often by hand, and used immediately upon opening.

**Refractories**

The refractory powder used depends on the alloy chosen. For ferrous alloys, a combination of zircon and fused silica is used. For non-ferrous alloys, fused silica flour is used. Therefore; depending on the alloy cast, the formula for five gallons (18.9 liters) of slurry is:

**Ferrous**

- PRIMCOTE binder: 22 pounds (9.9 kg)
- Zircon-200 mesh: 35 pounds (15.9 kg)
- Ranco-Sil™ 4 fused silica: 35 pounds (15.9 kg)

**Non-Ferrous**

- SUSPENDASLURRY material: 60 pounds (27.2 kg)

**Note:** SUSPENDASLURRY material contains refractory.
**Building a Slurry**

**Ferrous**

A good procedure for building a slurry is as follows:

- Weigh the binder and transfer into a mixing tank that is equipped with a moderate shear propeller mixer.
- Weigh the refractory powder.
- Start the mixer and sift the refractory powder into the binder so that the powder is pulled immediately into the liquid binder.

This procedure will allow the powder to wet into the liquid binder with the least amount of agglomeration and entrapped air.

Upon initial make up, the viscosity of the slurry will be high due to trapped air. Do not add additional liquids at this time, but allow the slurry to stabilize before attempting to dip your patterns. The slurry is considered to be stabilized when there is no more than a one second change in Zahn cup readings when measured after two-hour intervals. Stabilization normally takes overnight.

After a few hours of shearing the refractory powder with the mixer at high speed, it is advisable to either reduce the speed of the mixer with a rheostat, put a timer on the mixing motor at 5 minutes on and 5 minutes off, or transfer the slurry to a rotating tank with a plow. These procedures will reduce friction that causes elevated temperatures and evaporation rates. **Note:** If you are using a PKI teardrop tank and motor, this procedure is not necessary as the mixer speed is adjustable when the slurry is not in use.

If a mold release agent, such as silicone, is used on your wax patterns, it must be removed by a pattern cleaner. Failure to remove silicone or other wax surface contaminants will affect the ability of the slurry to coat the wax and can result in poor surface finish on the castings.

**Non-Ferrous**

- Remix the SUSPENDASLURRY material prior to use to ensure a homogeneous blend of material. Remixing time will vary with the size of the slurry, but should take minutes. Small slurries may be remixed by hand, larger slurries may require a propeller mixer.
- Remix until the liquid at the top of the slurry is blended and the mixture is creamy in appearance.
- Remove the propeller mixer from the tank after initial remixing.
- Patterns must be clean and free from silicones or other contaminants before dipping.
- It is not usually necessary to use a prewet between coats. If a prewet is needed, use deionized water only. Drain the pattern before dipping into the slurry.
- **Once finished dipping shells, replace slurry tank lid to prevent evaporation.**
- When using SUSPENDASLURRY material again, remix to a creamy consistency prior to dipping if there is a visual separation of liquid at the top of the tank. If there is no separation visible, dip without remixing.

**Stucco**

After the slurry is stabilized, the normal dipping sequence is to immerse the cleaned pattern in the slurry, drain until a uniform coat is formed with no dripping, and then apply stucco sand. The face coat, or primary sand, is RANCO-SIL A (50x100 mesh) fused silica (for ferrous alloys, zircon stucco should be used on the first and second coats). The stucco sand for backup coats is RANCO-SIL B (30x50 mesh) fused silica. Stucco sand is normally applied using one of the following methods:

1. **Rainfall Sanding** - sifting or sprinkling sand over a freshly dipped and drained pattern.
2. **Fluidized Bed** - compressed air passes through a porous stone or plate evenly distributing air through a bed of sand allowing a pattern or mold to be immersed into it.
3. **Cat Box Method** - placing the freshly dipped and drained mold on an open bed of sand with moderate side walls and flipping sand by hand onto the mold.
### Common Materials

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Ferrous</th>
<th>Non-Ferrous</th>
</tr>
</thead>
<tbody>
<tr>
<td>65136</td>
<td>PRIMCOTE binder (5 gallon [18.9 liter])</td>
<td>SUSPENDASLURRY material (60 pound [27.2 kg])</td>
</tr>
<tr>
<td>63204</td>
<td>RANCO-SIL 4 fused silica (1 bag)</td>
<td>RANCO-SIL A fused silica (1 bag)</td>
</tr>
<tr>
<td>69828</td>
<td>Zircon-200 mesh (1 bag)</td>
<td>RANCO-SIL B fused silica (1 bag)</td>
</tr>
<tr>
<td>69808</td>
<td>Zircon sand (1 bag)</td>
<td>SUSPENDASLURRY material (400 pound [181.4 kg])</td>
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<tr>
<td>63103</td>
<td>RANCO-SIL B fused silica (2 bags)</td>
<td>RANCO-SIL A fused silica (3 bags)</td>
</tr>
</tbody>
</table>

- Builds a 10 gallon (37.9 liter) slurry + corresponding stuccos
- Pre-mixed 5 gallon (18.9 liter) slurry + corresponding stuccos
- Pre-mixed 30 gallon (113.6 liter) slurry + corresponding stuccos

### Hints & Tips

If dipping will take place in the same slurry continuously, then a slurry control program should be instituted. When slurry is maintained over time, it is important to evaluate binder solids levels and replace the appropriate amount of water that has evaporated from the slurry mix. This must be done in a timely manner. High binder solids can result in gelation of the slurry. Slurry that has gelled or is gelling will produce substandard shells.

For the small investment foundry or art caster, slurry control can be avoided by mixing the appropriate amount of slurry to shell the current lot size. If necessary, apply the final slurry coats by pouring slurry on with a cup and scrap the remaining slurry after your shells have been completed. A new slurry can be built and stabilized a day before the next lot is to be dipped.

There are advantages to running a two-slurry system; however, this is only recommended if many parts are to be shelled, and a slurry control program is used.