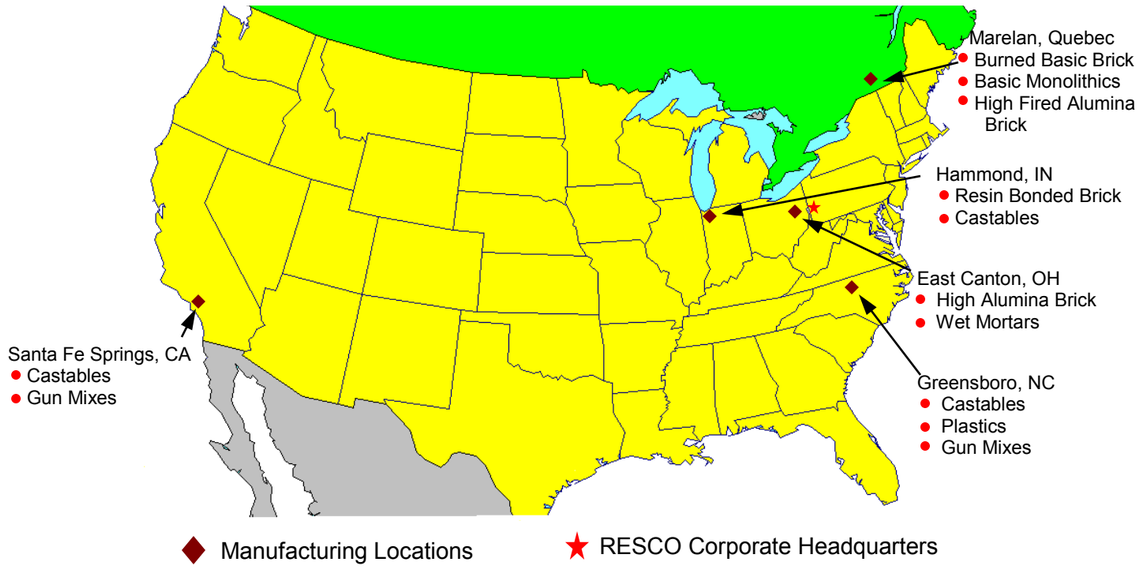
Resco Manufacturing Locations



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RESCO *for the Long Run*

Founded in 1946, Resco has served its markets with specialized products ever since, initially, with the refining industry and later in the steel industry. Innovations have been key to Resco's long success, including AA-22 and the original patent on semi-universal ladle brick.

Recent acquisitions have diversified Resco into many new refractory markets. The addition of National's product lines allows Resco to offer a comprehensive range of products.

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TRI MEMBER

K/R INDUX® 98

K/R PATCH-BOND

ProCast 96 GR

INSTALLATION GUIDE FOR BASIC LININGS IN INDUCTION FURNACES

AN AMERICAN-OWNED REFRACTORY COMPANY

TRI MEMBER

RESCO® PRODUCTS, INC.

Foreword

This booklet contains suggestions for installing and maintaining basic linings in air and vacuum types of high frequency induction furnaces. Since no attempt has been made to account for variables in each shop, we suggest you contact your RESCO Products' sales representative for more specific recommendations applying to your operation.

Introduction

A high frequency induction furnace is essentially a transformer encased in a cubical box or frame. A helical coil of copper tubing, through which cooling water flows, forms the primary circuit. A charge of metal forms the secondary. The charge is held in a refractory lining, which also separates and insulates the charge from the coil. When high frequency alternating current is passed through the primary coil, currents are set up in the charge that can produce temperatures up to 3300°F in a matter of minutes. At these temperatures the charge quickly melts and is ready for processing.

Need for Refractory Linings

One of the challenges in obtaining top efficiency and maximum production from a high frequency induction furnace is that of constructing a satisfactory refractory lining that can withstand great thermal, mechanical, chemical, and electrical abuse.

To be effective, a lining for this type of furnace ideally must:

- Withstand high temperatures.
- Provide chemical inertness to the metals, their oxides, and slags.
- Withstand frequent and rapid changes in temperature.
- Withstand mechanical abuse during charging and pouring.
- Have volume stability in use.
- Be free of electrically conductive or water-absorbing materials.

Notice

These procedures are not a guarantee or warranty, nor are they intended to cover every installation of Resco Products, Inc materials. They are to be used only as a general guide and are not necessarily applicable to all installation conditions. Installation should only be done by experienced, qualified personnel. Consult your Resco Products, Inc representative for assistance in your specific circumstance.

PATCHING

1. Patching should only be used for repairing fine cracks of small areas (less than 6 square inches) less than one inch thick.
2. Force the K/R PATCHBOND-water mixture into the area being patched with a trowel or by hand. Rubber gloves should be worn.
3. Knit the material together, being careful not to cause any laminations in the patch.
4. When completed, the patch can be worked smooth with a slight amount of water.

DRYING

When installation is complete, heat should be applied to the furnace using the following guidelines:

1. Thickness greater than½ inch must be vented.
   a) Poke holes in the patch using 18 or 20 gauge wire.
   b) Holes should be on 2 inch centers no deeper than ½ the thickness.
2. The patch should be dried without direct flame impingement on the lining.
3. Heat to 250°F @ 100°F per hour and dry a minimum of eight hours.
4. The furnace is now ready to be charged. However, it must be remembered that there is only a surface hardness on the patch until the patch is exposed to heat. Reasonable care should be taken when charging the first heat.

High purity periclase is an excellent raw material for the preparation of high quality refractory linings because of its natural ability to withstand high temperatures and its ability to absorb large quantities of metallic oxides and their slags without volume change. Low electrical conductivity is also an attribute of periclase.

To further improve the natural qualities of periclase , K/R INDUX® 98 was developed. Grains used in K/R INDUX® 98 are produced from magnesia grain with very low porosity.

Next, these well crystallized, high purity periclase grains (98% MgO) are optimally sized and blended into a material capable of producing an unusually dense lining when rammed – K/R INDUX® 98.

When subjected to induction furnace temperatures, K/R INDUX® 98 develops a ceramic bond on the hot surface, but retains a back-up of granular, unbonded periclase which develops the same ceramic bond if material wear is present on the working surface—thus providing a “self-sealing” lining. This bond results from the crystal growth characteristics of K/R INDUX® 98 and offers a rugged, dense working surface.

To the natural qualities of high purity periclase, K/R INDUX® 98 adds the properties of volume stability and the ability to withstand considerable mechanical abuse. Linings made with K/R INDUX® 98 will give long service life at low cost.

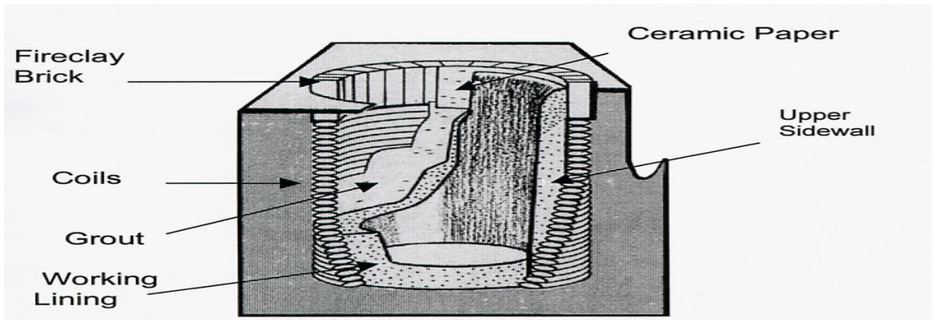
Typical Properties of K/R INDUX® 98

Chemical Analysis	98.5% MgO
Chemical Nature	Basic
Pyrometric Cone Equivalent	Over 42
Electrical Resistance	Good (40,000 ohms/cm^3 @2550°F)
Volume Stability	Good
Slag Resistance	Excellent against basic slags
Thermal Conductivity	20 btu-in/ft^2-hr-°F @2500°F
Mean Specific Heat	0.32 btu/lb-°F @2500°F
Bulk Density	175 lbs/ft^3 Rammed

Coil Grout

Coil grout (outer coil linings) should protect the coil, provide a backing for the working lining, and provide electrical insulation.

The grout material is installed and dried, if required, according to the grout manufacturer and furnace manufacturer recommendations. RESCO's ProCast 96 GR can be used in this application.



Cutaway of typical high frequency induction furnace.

Working Lining

The "working lining" is that part of the lining which is in contact with the molten charge, that is the bottom and the sidewalls up to the top of the coil. A rammed working lining has proved superior and more economical in most operations than any other type of lining.

K/R INDUX® 98 can be rammed dry as shipped. K/R INDUX® 98 should be dry-mixed prior to installation in case of any segregation that may have occurred during transit.

Patching with K/R PATCHBOND

MIXING

1. All tools and equipment must be clean.
2. Water must be clean, fresh, and potable.
3. Add 5 to 10% water by weight, and mix with the K/R PATCH-BOND to obtain a thick troweling consistency.
4. Only mix the amount of material required for the patch.
5. K/R PATCHBOND does not require any tempering and can be used immediately after mixing.

SURFACE PREPARATION

Carefully remove all loose material, dust, and slag from the area of the lining to be patched, but do not remove or disturb the hardened surface of the K/R INDUX® 98.
A slurry mix of K/R PATCHBOND should be brushed over the surface of the material to be patched to aid adherence of the patch.

It is important to work the mix well into the area to be patched so it adheres to the wall.

SINTERING

For better lining life, the furnace should be burned-in using the following schedule:

1. Raise the temperature to 400°F @ 100°F per hour
2. Hold at 400°F for one hour
3. Raise the temperature to 1000°F @ 300°F per hour (Make certain that the lining is at uniform temperature. There should not be a major temperature difference (>100°F) between the top, center, or bottom of the furnace)
4. Hold at 1000°F for one hour
5. Raise the temperature uniformly to 2700°F @ 300°F per hour
6. Hold at 2700°F for two hours
7. Charge with molten or scrap metal and increase the temperature slowly to completely melt the form. It may be desirable to make the first heat a wash heat. Try not to exceed normal operating temperatures by more than 150°F. The first heat should extend 1 to 2 inches above the normal metal line and have an extended soak time. The lining is now ready for normal use.

Failure to follow the ramming, drying, and sintering instructions may reduce the lining safety and life.

Operation

Whenever possible, it is a good practice to vary the metal line from heat to heat to reduce the concentrated wear at the metal/slag interface.

Very fine cracks may sometimes develop after the first few heats; these are normally not harmful. Minor repairs can be made to the lining using wet mixed K/R PATCHBOND. Dry well after repair before charging.

RAMMING

Use a rammer with a flat, rounded, steel head with about eight square inches of surface for the bottom. The face of the tool for the sidewall should be 2/3 the wall thickness wide by three to four inches long and should be curved to follow the contour of the coils and the mandrel form.

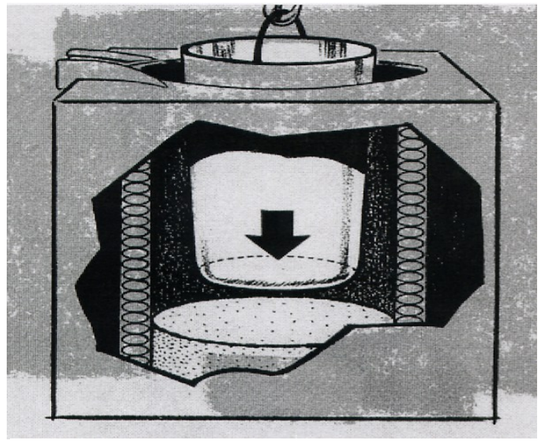
The shell floor should be filled initially with 4 inches of K/R INDUX® 98. A forked or pronged tool should be used to de-air this layer of material. Spread out and level the material. If ground fault detectors are being used, make sure they are in position.

Use the rammer manually (turned off) to tamp material into place using an up and down motion. Then use the rammer lightly at first by working the head slowly, back and forth, halfway into the loose material. Tamp lightly across the diameter of the furnace floor. Concentrate first in the center and then work towards the shell. Each pass with the tool head should overlap half of the previous pass and each series of passes should be at 90° (perpendicular) to the previous series. As the density of the K/R INDUX® 98 increases, more force can be applied to achieve maximum density. The layer is satisfactorily compacted when you cannot force your thumb more than ¼ inch to ½ inch into the rammed surface.

Before adding more material, roughen up the compacted surface by scarfing the surface with a forking tool. Only a 4 to 6 inch loose fill layer of material should be installed at a time. Repeat the de-airing, compaction, and scarfing operations. Add as many layers as necessary to reach the total bottom thickness recommended by the furnace manufacturer.

A 1/16 to 1/8 inch layer of ceramic cloth is suggested for use against the coil grout to act as a slip plane between the grout and the lining. The cloth will also allow for easier lining tear out or removal at the end of the campaign. The ceramic cloth for this application should be recommended by the furnace manufacturer.

Level the bottom before installing the burnout form. This will help to insure equal spacing of the form top to bottom. Wall thickness should follow the furnace manufacturer's specifications. The form should then be centered in the furnace. Centering of the form is critical to promote even sintering and to insure that the sidewall thickness does not vary. Small billets, scrap castings, or other charge material can be used to anchor the form in place. This minimizes movement of the form when installing the sidewall material.

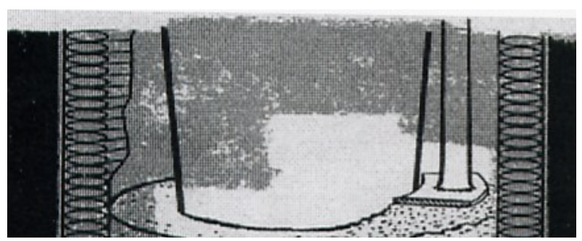


To provide equal wall thickness, the burnout form should be centered

After installing the form, the floor area around the form should be lightly forked. Add 1 inch of loose K/R INDUX® 98 at the base of the liner and blend this material well into the lower layer. This is an extremely important step which insures a good, strong, homogeneous mix between the floor and the sidewall of the furnace lining.

Add 3 inches of loose material evenly around the liner. The face of the tool for the sidewall should be 2/3 the wall thickness wide by three to four inches long and should be curved to follow the contour of the coils and the mandrel form. Ram the material using the curved tool. The layer is satisfactorily compacted when you cannot force your thumb more than ¼ to ½ inch into the rammed surface.

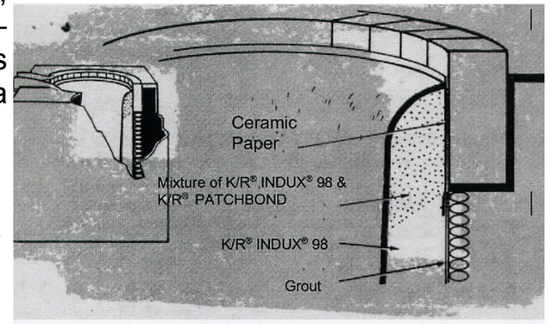
Before adding more material, roughen up the compacted surface by scarfing the surface with the forking tool. Only a 4 to 6 inch loose fill layer of material should be installed at a time. Repeat the de-airing, compaction, and scarfing operations. Add as many layers as necessary to reach the top of the coil, then hand pack to form a bevel from the inner to the outer surface.



Sidewalls should be rammed well since density is of prime importance.

Upper Sidewall, Lip, and Spout

The working lining for this area presents a slightly different situation since it does not reach an operating temperature high enough to achieve a strong ceramic bond, but is too hot for a hydraulic bond to be effective. For this intermediate temperature zone, use a mixture of 40% K/R INDUX® 98 and 60% K/R PATCHBOND, adding 4 to 4½% fresh, clean, potable water. For best results this should be thoroughly mixed in a clean mixer for several minutes.



Upper sidewall, lip, and spout area requires special handling.

Expansion and contraction of the working lining, due to rapid heating and cooling, often causes cracking which separates the lip area from the rest of the lining. Keeping the upper portion of the lining independent of the furnace case or back-up brick with ceramic paper can minimize this. Thus, the entire lining will move as a single unit. Place the mixture of K/R INDUX® 98 and K/R PATCHBOND on the beveled section in layers 4 inches deep. Each layer should be rammed and scarfed before the following layer is started. The upper area containing K/R INDUX® 98 and K/R PATCHBOND combination should be vented to allow moisture to escape. Use 18 or 20 gauge wire and space holes 2 inches on center no deeper than half of the thickness.

DRYING

After the installation is completed, heat can be applied to the furnace according to the following schedule:

1. Air dry for at least four hours minimum,
   OR
2. Heat to 250°F @ 100°F per hour and dry until all of the moisture has escaped from the cap and spout.

- After air setting or forced drying, remove the top form or extension if applicable.
- The furnace is now ready for burn-in/sintering.