

MONOLITHIC REFRACTORIES FOR TODAY'S CEMENT PLANTS

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ABOUT RENO REFRACTORIES

Reno Refractories, Inc. began making its monolithic Refractories in the mid 1980's under the guidance of Mr. Sid Reno.

Reno Refractories has been, and to this day is, a leader in the development of the nano-bond or No-Cement technology concept. Reno continues to lead the way with the development of ElectroCast[™] a revolutionary bonding system that offers <u>major</u> <u>improvements</u> over cement and NC bonded products.

Reno Refractories is committed to developing new advancements in monolithic refractories to bring cost savings to their customers.

WHAT WE DO:

"INNOVATION" IS THE DRIVING FORCE FOR THE RENO REFRACTORIES TEAM. WE SERVICE MULTIPLE INDUSTRIES AND HAVE THE ABILITY TO OFFER HIGH QUALITY NEW PRODUCT DEVELOPMENTS THAT MEET THE CHANGING OPERATIONAL NEEDS OF OUR CUSTOMERS AND LOWER THEIR OVERALL OPERATING COST.

RESEARCH AND DEVLEOPMENT:

Reno Refractories R&D Department boasts extensive research capabilities and tools including Scanning Electron Microscopy, X-Ray Diffraction, Mercury Porosimetry, Thermo Gravimetric Analysis, Thermal Expansion, Optical Microscopy, Thermal Conductivity and Laser/Optical Analysis of Particle Sizing.

PRECAST:

Our precast division has the ability to cast anything ranging from 5 lbs. in weight to 25,000 lbs. We have three dry out ovens with a maximum temperature of 1093°C (2,000°F). With refractory production and lab facilities in house, the precast facility has an enormous advantage, over others, to meet and exceed the goals of our customers. We pride ourselves in quality and promptness to satisfy the needs of our customers.

QUALITY CONTROL:

Reno Refractories Quality Control has physical testing and analytical capabilities which are supported by high quality equipment operated by qualified technical personnel. A full range of analysis instrumentation is available for activities such as process control, verification of incoming raw materials and investigative activities.

SERVICE:

Reno Refractories has highly trained Salesmen and Installation Field Team Members with many years of experience that you can rely on to provide you with the optimum refractory products for Cement Plant Refractories.



There are many factors when considering the optimum refractory to use in a cement plant application. These can range from simple issues to more complex factors, like the following:

- 1. Fuel types used coal, petcoke, alternative fuels.
- 2. Atmosphere reducing or oxidizing.
- 3. Installation methods gunning, casting, shotcreting.
- 4. Dry-out method to use, independent or during startup.
- 5. Wear Mechanisms Alkali attack, abrasion, thermal shock, etc.
- 6. Thermal analysis assists in determining the anticipated shell temperatures to minimize shell corrosion by dew point corrosion from alkali/chloride condensation. Also addresses expansion allowance requirements.
- 7. Location to be installed upper stages, cooler, riser, etc.
- 8. Turnaround time how much time is practical for the installation method chosen and material to install.
- 9. Time of the year hot or cold temperatures affect the final properties.
- 10. Cost must be cost effective.

Fortunately, there are tools available to assist in addressing the refractory choice(s) based on the above.

- A. Recommended dry-out schedules.
- B. Installation guidelines, including cold/hot weather installations.
- C. Thermal conductivity and expansion calculations.
- D. Wear mechanisms, abrasion testing and alkali resistance.

A common test for alkali resistance or AR is the FLSmidth Alkali test. This is a very aggressive test that provides a starting point on whether a product meets satisfactory alkali resistance. There is no pass or fail it is rated as satisfactory or unsatisfactory.

This test procedure incorporates a standard cup test of the selected material by inserting a specific amount of Anhydrous Potassium Carbonate (K_2CO_3) into the cup and heating the sample to 1100°C (2012°F) for 5 hours. The sample is then cooled and cut with the depth of penetration measured. To meet satisfactory test results, the penetration must be <3mm (0.12") and not exhibit any expansion or cracking, i.e. Alkali Bursting.

Reno Refractories has conducted extensive alkali testing of our product line. One of the product lines that has obtained excellent results in cement plant operations is our NC products. The No-Cement bond does not contain calcium compounds (calcium silicate, calcium aluminate) which expand and cause cracking after reacting with sodium or potassium vapors. This bond is based upon amorphous silica and is much more resistant to reaction with alkali vapors in the 1100-2000°F temperature range of interest.

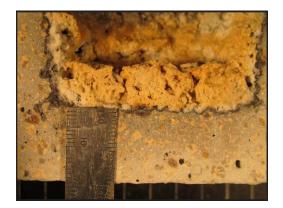
Common to all of Reno's No-Cement Castables which incorporate nano particles into the bond, the pore size openings are considerably smaller. Typically, the majority of pores in the bond phase are one to two microns in size, versus 10-30 microns for low cement castables of equal mineralogy. With smaller pores, the ability of vapors to enter the matrix and react with the refractory is reduced. This essentially makes the material "non-wetting" and less reactive to alkali attack. Below is a summary of the tests results of several products:



Alkali Resistance

| Sample | Potassium Carbonate (g) | Test Temperature (°C) | Test Time (hr.) | Depth of Reaction Zone ^(a) (mm) |
|--|-------------------------------|-----------------------------|-----------------------|---|
| Reno Cleancast 33 Z | 50 | 1100°C | 5 | 0.5 mm |
| Reno NC 52 AR (Formally Reno NC 5286) | 50 | 1100°C | 5 | 0.75 mm |
| Reno NC 6059 | 50 | 1100°C | 5 | 1 mm |
| Reno Pump 60 AZR | 50 | 1100°C | 5 | 2 mm |

^(a)Average of two penetration depths measured half way down the depth of the hole



ALKALI TEST RESULTS OF RENO NC 52 AR



ALKALI TEST RESULTS CLEANCAST 33 Z

Reno's NC or No-Cement castables incorporate a mullite forming, high temperature, ceramic bond. Due to this bond, improvements of hot strengths are seen for these products as exhibited by 100 to 300% increases in HMOR or hot modulus of rupture @ 1370°C (2500°F) when compared to low cement castables of equal density and mineralogy. Greater hot strengths provide less erosion by dust laden air streams at high temperatures.

Another key advantage of NC castables is that they retain more than 40% of their original strength when tested using the ASTM C-1171 thermal shock procedure. These values are usually 50 to 100% greater than competitive cement bonded materials. This improvement is due to the non-crystalline nature of the gel bond which is more "flexible" and resists damage due to expansion/contraction.

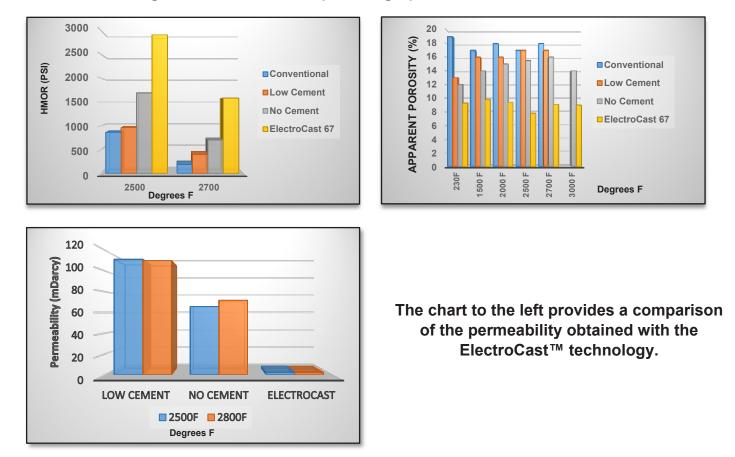


Reno's ElectroCast[™] technology is a totally new advancement over other bonding systems. This is achieved by employing an electro-chemical bond which yields properties far superior to other competitive NC and conventional cement bonded products.

Some of the advantages of the ElectroCast[™] bonding system are:

- ✓ Lower porosity and reduced pore sizes provides better alkali and vapor resistance.
- High hot strength that imparts higher load capacity with less cracking.
- ✓ Lower water demand 25-35%.
- Better corrosion resistance due to the higher purity bond.
- Lower abrasion.
- Lower permeability.

Improvements in the hot properties (HMOR) and apparent porosity (%) these are dramatically better than was previously attained due to synthetic mineralization driven by the Electro-Chemical bonding as shown in the comparison graphs below.



Consult with your Reno representative for additional information on the ElectroCast™ product line, support on Thermal Analysis, Dry-Out, Precast Shapes, Installation Guidelines and other product or services.



| SUMMARY OF PRODUCTS BY USE AREA AND VARIOUS INSTALLATION METHODS | | | | | |
|--|--|-------------------|---------------------------------|--|--|
| AREA | CASTABLE | SHOTCRETE | GUN MIX | | |
| STAGE 1 (TOP STAGE) | RENO PUMP CAST 26 | | RENO GUN 28 | | |
| STAGE 2 | RENO PUMP CAST 26 | | RENO GUN 28 | | |
| STAGE 3 | RENO ELECTROCAST SIL 99 | JET CAST 50 | RENO GUN 28 | | |
| STAGE 4 | RENO NC 52 AR | RENO CAST 40 AR | RENO NC GUN 18Z | | |
| CALCINER | RENO NC 52 AR | RENO CAST 40 AR | RENO NC GUN 18Z | | |
| RISER | CLEANCAST 33Z ELECTROCAST™ 25 SIC ELECTROCAST™ AZS | CLEANCAST 33Z | RENO NC GUN 18Z (Patching) | | |
| FEED SHELF | CLEANCAST 33Z | CLEANCAST 33Z | RENO NC GUN 18Z | | |
| FEED HOOD | ELECTROCAST™ AZS | JET CAST NC 52 AR | RENO NC GUN 18Z | | |
| TAIL RING | RENO NC 52 AR | RENO CAST SA 60Z | RENO NC GUN 18Z | | |
| FIRING HOOD | RENO NC 52 AR | JET CAST NC 52 AR | RENO NC GUN 18Z | | |
| FIRING HOOD- ALTERNATE | RENO CAST SUPER ABRADE 60Z | RENO CAST SA 60Z | RENO NC GUN 60 AZS | | |
| TA DUCT | ELECTROCAST™ AZS | JET CAST NC 52 AR | RENO NC GUN 18Z | | |
| NOSE RING | CLEANCAST 25 SIC | | RENO NC GUN 18Z | | |
| COOLER DROP WALL | ASAP CAST 60 LC | ASAP CAST 60 LC | RENO NC GUN 18Z | | |
| COOLER HOT WALLS | ASAP CAST 60 LC | ASAP CAST 60 LC | RENO NC GUN 18Z | | |
| COOLER CURBS | ASAP CAST 60 LC | ASAP CAST 60 LC | ASAP GUN 60Z LC | | |
| COOLER ROOF | JET CAST NC 6059 | JET CAST NC 6059 | RENO NC GUN 18Z | | |
| COOLER BULLNOSE | JET CAST NC 6059 | | | | |
| COOLER COLD ZONE | ASAP CAST 60 LC | ASAP CAST 60 LC | ASAP GUN 60Z LC | | |
| COOLER VENT DUCT | | | SUPER ABRADE LTMG | | |
| BURNER PIPE | RENO CAST 70 KH | | | | |
| BURNER PIPE TIP | RENO NC 90 AR | | | | |
| BACK UP INSULATION | RENO LITE CAST 22 | RENO PUMP 80 LWFF | GN 25 LW OR RENO LITE GUN 40 | | |
| HOT REPAIRS | | | MACH GUN 60P | | |
| KILN BRICK PATCH | | | RENO NC MAG GUN | | |
| HOT GAS GENERATOR | RENO NC PUMP 50 FS | | RENO NC GUN FS | | |
| COOLER CYCLONES | SUPER ABRADE RTG HP | | SUPER ABRADE RTG | | |
| RAW MILL/FINISH MILL | SUPER ABRADE RTG HP | | SUPER ABRADE RTG | | |

The above is not an all inclusive listing of all of the products Reno manufactures for cement applications or that can be used in any particular area. Please consult with your Reno Representative if you have any questions, have a particular need or require additional information.



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MAKE RENO YOUR FIRST CALL FOR ALL OF YOUR MONOLITHIC NEEDS!

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It is the mission of Reno Refractories, Inc. to investigate, develop, communicate and deliver valuable refractory products and services to our customers in North America. We have a responsibility to supply the best value in refractory technology by optimizing the profits and safety of our customers. We take pride in our reputation as a leader in these endeavors.