

What's In a Spinel?

Spinel is one of the building blocks of magnesia-based refractory brick used in cement kiln transition zones and rotary lime kiln burning zones. Spinel refers to a mineral with a specific crystal structure, a mixture of a divalent metal oxide and a trivalent metal oxide. Years ago, when magnesite-chrome brick were common in rotary kilns, the spinel component was chrome ore, an iron-chrome spinel of the formula, $\text{FeO-Cr}_2\text{O}_3$. Chrome ore is naturally occurring.

Modern spinel brick contain magnesia-alumina spinel, or $\text{MgO-Al}_2\text{O}_3$. There are no refractory grade deposits of magnesia-alumina spinel, so it has to be man-made (synthetic).

Purpose of Spinel

Modern magnesite-spinel brick are mostly magnesia (MgO), with smaller amounts of spinel. Spinel serves as a shock absorber in the brick structure, arresting cracks caused by thermal shock or mechanical stresses. Theoretically, the more spinel in a magnesite brick, the better the spalling resistance.

Spinel is also a better insulator than magnesia, so spinel helps improve the insulating value of a magnesite refractory. For insulating value, the more spinel, the better the insulating value.

Finally, spinel has a lower coefficient of thermal expansion than magnesia, so a magnesia brick that contains spinel can be more easily contained inside a steel shell.

Generations of Spinel Brick

The form of spinel varies. The earliest spinel brick date at least to the 1960's, and were used in white cement kiln burning zones. These types of brick were binary combinations of magnesia and high-purity alumina. When the brick are burned during manufacture, the magnesia and alumina combine to form the spinel. If the alumina grains are coarse enough, the resulting spinel grain becomes a hollow sphere. Under a microscope (in two dimensions), these grains look like doughnuts.

Spinel produced in a brick during firing stage of manufacture qualifies the refractory as a 1st generation product.

Forming spinel in the brick during firing is expansive, that is, the spinel grain has a larger volume than the parent alumina grain. This limits the amount of spinel that can be present in a 1st generation brick. In the mid-1970's, the Japanese pioneered 2nd generation technology that used a pre-formed synthetic spinel grain as the other component to magnesia. Without expansive spinel formation, much greater amounts of spinel could be present in the brick composition.

Today, 2nd generation brick can contain sintered spinel or fused spinel. Chemically similar, sintered and fused grains differ by manufacture method and chemical resistance. Sintered grains have small crystals bonded into large crystallites. They have moderate corrosion resistance. Fused grains have very large crystal size that gives these materials very high corrosion resistance.

1st or 2nd generation technology keeps spinel in the larger grains, or coarser fractions, of the brick. 3rd generation technology inserts spinel into the bond phase of the magnesite-spinel brick. The bond phase, or matrix, contains the smallest (finest) granular components of the brick.

When spinel is introduced into the brick matrix, several properties are enhanced. Crystalline spinel binds the brick matrix together, increasing hot strength. Crystalline spinel can also provide a barrier to attack from chlorine and sulfur. Exposure to sulfur and chlorine in the kiln environment can cause the brick matrix to weaken. (If you have ever removed magnesia brick with friable hot faces, sulfur compounds or chlorine may be the cause.)

(Continued on reverse side)

RESCO's Magnesite-spinel Products

For a growing refractory company, RESCO has a strong product line of magnesite-spinel brick. Contact us if you have a specific issue. Here's a guide:

GREENFREE™ 92 is a 1st generation brick, very useful for lime kiln burning zones, and general cement kiln applications. It has about the same thermal conductivity as a 85% MgO second generation brick, good mechanical strength and relatively good resistance to the a clinker liquid phase.

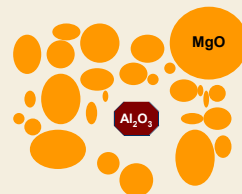
GREENFREE™ is a 2nd generation brick based primarily on natural magnesite and sintered spinel. It features good durability for shell stress applications especially in upper transitions, and moderate spinel content for relatively good shell temperatures in lime kiln burning zones.

RESCOMAG® 92 is a lower spinel content, 92% MgO third generation brick with fused spinel. Its primary use is the lower transition zone of cement kilns where the liquid phase is aggressive.

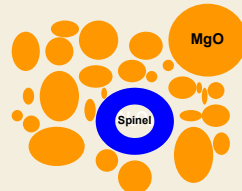
RESCOMAG® 85 is a high-spinel content 3rd generation brick with fused spinel. Use it in lower transition zones that do not have an aggressive liquid phase, in cement kiln upper transition zones and in rotary lime kiln burning zones.

RESCOMAG® 92 FMS is a variation of RESCOMAG® 92 that contains a very high content of fused grains. It is useful for lower transitions that see a severe liquid phase attack as well as zones that have a strong infiltration of sulfur and chloride compounds. Troublesome areas like a buffer between the burning zone and the upper transition are appropriate for this product.

1st Generation
Magnesite-Spinel Brick
Prior to Burning

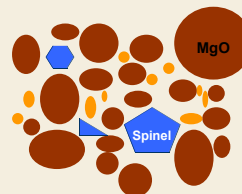


1st Generation
Magnesite-Spinel Brick
After Burning
GREENFREE™ 92



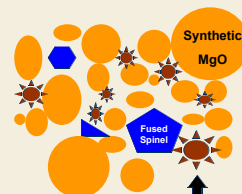
Spinel = $\text{MgO-Al}_2\text{O}_3$

2nd Generation
Magnesite-Spinel Brick
GREENFREE™



Spinel = $\text{MgO-Al}_2\text{O}_3$

3rd Generation
Magnesite-Spinel Brick
RESCOMAG™ 85
RESCOMAG™ 92



Matrix Spinel

What's In a Spinel? Con't.

Applying the Technology

With all the spinel products available to purchase, how can the correct product be selected? Here are some rules of thumb, based on the features of the brick.

One factor to consider is cost. If it is a general application, a good choice may be a 1st generation brick. Spinel is the more costly ingredient in magnesite-spinel brick, so less spinel means lower cost. Look for a brick with about 92% MgO content.

A second factor can be insulating value or thermal conductivity. This may be important over a tire. 3rd generation brick with higher spinel content brick (82% to 85% MgO) generally have better insulating value. Some 1st generation brick also have relatively good insulating value, so you have to review the thermal conductivity values.

A third factor is chemical resistance. If your operation burns a lot of petroleum coke, if there is excess sulfur in the process, or there is a lot of chloride in the raw materials or fuels, a 3rd generation brick may be better.

Another factor is the presence of an aggressive liquid phase. Spinel is more readily attacked by a clinker liquid phase, so a lower spinel content brick may be more resistant to this attack (MgO content of 92%). A brick with fused spinel will be more resistant.

A fifth consideration is mechanical strength. Lower spinel content brick, including 1st generation brick (92% MgO), tend to be stronger (fewer shock absorbers). Pure 2nd generation brick can also have higher strength at lower temperatures.

QUIKTURN™ 60G Shines in a Cement Kiln Firing Hood

The past two issues of THE RESCO LINE™ reported on the new product family called QUIKTURN™. This line of cement-bonded castables and gun mixes was developed to help customers achieve faster and simpler installations when cures and dry-outs could not be controlled. This story is a good illustration.

QUIKTURN™ 60G was selected for a cement kiln firing hood this past spring during a complete reline. Past experience taught that it was difficult coordinating a proper refractory cure in the firing hood - the last vessel lined - coupled with the difficulty in getting a good dry-out in this area. With the previous plastics, castables and gun mixes used, some wear was expected soon after start-up.

In this application, the refractory faces the 2500° F temperatures of the burning zone, high abrasion from clinker dust, and some amount of alkali. QUIKTURN™ 60G is rated for 3000° F, and shows an abrasion loss below 12 cc (ASTM C-704 test). It was decided to save time by gunning QUIKTURN™ 60G over 3" gunned RESCOCAST® 3.

After 6 months running, this kiln was brought down for other work, and the QUIKTURN™ 60G lining was inspected. There were no visible signs of erosion or cracking. It appears that QUIKTURN™ 60G is on the way to a good performance without the "air" cure and controlled dry-out.



QUIKTURN™ 60G was a good selection for the firing hood lining at this Lehigh Valley cement plant.

Editor's Corner

Haulin' the Freight

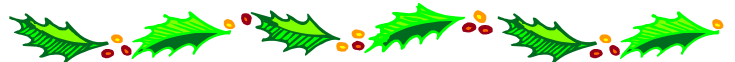


I happen to read of the passing of Max Ephraim in October. You probably don't know of him, but he was chief design engineer of a company that makes railroad freight locomotives. His SD 40-2 was ubiquitous on North American railroads, and twenty-five years later, thousands are still working today haulin' the freight. I admire him for creating an incredibly serviceable industrial design. Key to durability is simplicity and a solid understanding of the needs of his customer - a good model for us all.

Right now, the freight locomotive business looks a lot like the refractory business. Product life cycles are similar. Two huge companies dominate both businesses. Both the refractory and the locomotive businesses are cyclical in nature.

A look at the steel production chart tells the story. There's just not as much refractory freight to haul. As one of the two huge refractory companies noted to their customers, in the past year, twenty [steel] customers filed for bankruptcy protection. This includes the #2 producer in the U.S.

How is Resco weathering the cycle? We're OK. This past year, we spent a lot of effort reducing our outstanding debt, and doing so ahead of schedule. We worked hard on managing our assets. We made some reductions that were consistent with our level of business, but we also made investment in inventories that we think will create some sales opportunities. All this "to allow Resco to be a viable, vibrant company now and in the future," in the words of our CEO, Bill Brown. We'll be more than ready when there is more freight to haul.



I have had a very enjoyable year working for Resco with you. Thanks for the business you gave us, the good times and the surprises. We wish you a blessed holiday season.

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