THE BUZZ

October, 2020

SPECIAL FUSED SILICA EDITION

THERMAL SHOCK

Fused silica is a fascinating and extremely useful refractory material. Made from very pure quartz (crystalline silica) sources, it has several unique properties that make it invaluable for certain ceramic applications.

One of its unique properties is its incredibly low thermal expansion. Its thermal expansion coefficient is approximately 5.5 x 10^{-7}. To put that in perspective, an average fireclay brick would be 6.2 x 10^{-6}, which is over 10 times as much expansion. In refractories, thermal shock is caused by differential expansion or contraction caused by a temperature gradient through the refractory. The less the product changes size with temperature, the less stress, the less thermal shock damage.

Have you ever seen checkerboard cracking in a roadway or sidewalk? Believe it or not, this is caused by thermal shock of growing and shrinking due to temperature fluctuations. Sidewalks and concrete, like refractories, are ceramic and are prone to this cycling wear. If it occurs in a 100ºF range you might see in say Pittsburgh, imagine how much more severe this cycling can be in a furnace that goes from room temperature to 1800ºF back down to room temperature. Every cycle you have does some degree of damage. Unless, of course, you are using fused silica. With virtually no grain growth, you get virtually no stress. If your lining is made from “zero growth” material like fused silica you get no stress and no damage.

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Thermal Shock Continued from pg 1

Fused silica has several other interesting properties that are explored in other areas of this special addition Buzz Newsletter. Mt. Savage Specialty Refractories is very good at making fused silica specialty products. If you see your refractory lining has checker-board cracking causing premature wear, perhaps you might benefit by using a fused silica product in your application.

ACID RESISTANCE

Silica and fused silica are resistant to most acids except for hydrofluoric acid (that is some nasty stuff). In areas where chloride or sulfur vapors may form hydrochloric or sulfuric acid, fused silica is impervious to reaction.

Mt. Savage's Savage X FS line is ideal in acid proofing applications. As long as the lining gets above 500 F, an insoluble gel bond makes a fused silica Savage X an ideal product against acid and chloride attack. They also provide superior thermal shock resistance so are ideal for quenching areas where acid may be an issue. Standard acid proofing products are often quite expensive and thus Savage X FS products may be economical solutions for your acid containment issues.

ALKALI RESISTANCE

Silica is known for its resistance to acid attack, yet it is also a perfect selection for alkali environments. To a chemist, that is at first a little counter intuitive. Normally you expect a reaction particularly at higher temperatures between an acid (silica) and a base (alkali). At the temperatures that alkali vapors condense you can indeed get a reaction. This reaction tends to be beneficial in that is produces a slightly expansive solid phase that seals off the rest of the lining from alkali intrusion.

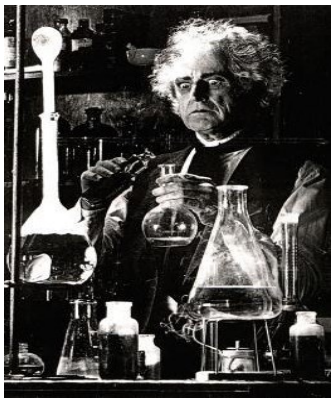
With alumina, the reaction with alkali is quite severe, transforming alpha alumina to beta alumina which is very expansive. Alumina refractories can be protected from this expansive reaction with certain additives, but fused silica materials are already protected!

This sample shows what happens when alkali reacts with alumina to form beta alumina. A very expansive reaction that is destructive to the refractory.

ASK DR. DIRT

Dear Dr. Dirt: I have a duct to reline that sees significant thermal shock and some abrasion with a maximum temperature of about 1600º F. I know that fused silica based refractories are both thermal shock and abrasion resistant and I am considering using one. Since fused silica grows so little, should I be worried about a greater shear plane between the refractory and the steel shell due to the metal growth of the shell?
Duct Lining in the Desert

Dear Duct; A very good question. Steel has a coefficient of thermal expansion 10 times that of a high alumina refractory and over 50 times that of a fused silica refractory. Thus, at a refractory/steel interface there is always going to be shear stress caused by the steel growing more than the adjacent refractory. One might think that the stress would be more with fused silica because it grows less than other refractories. That, however, is not the case. Fused silica products have significantly lower thermal conductivity than higher alumina linings, so if you replace a high alumina lining with a fused silica lining, the shell temperature would go down significantly. The steel, being cooler, grows far less and the differential growth between the refractory and the steel will be less. Not only will your fused silica handle the abrasion and thermal shock, it will lower your shell temperature with a direct replacement of high alumina refractory saving in fuel costs! Go ahead and use fused silica for your duct.



The 48's

It is often thought that the higher the alumina content the better the refractory. I believe all of the other articles in this newsletter tell you that is not always true. Sometimes, however, fused silica isn't the perfect material for a given application. Perhaps the temperature may go above 2000° F. Perhaps thermal shock is minimal and it doesn't offer enough value. That doesn't mean that you can't use some of the principles of higher alumina not always being better. For that we developed a family of products called the 48's.

For many years the standard products for minerals processing, boilers, and incinerators were often based on 60% alumina-mullite grain. This, however, is sometimes overkill. The temperatures in these applications are not very high, so fireclay aggregates can be cost effective. Lower alumina products can be more naturally alkali resistant and have lower density, meaning a ton of material would fill more volume. They also have lower thermal conductivities saving in fuel costs during operation. Oh, and they cost less too.

With added processing capabilities at our plants, Mt. Savage has been able to develop a series of lower alumina products with the same excellent installation characteristics as our high alumina specialties. Based on a low alkali fireclay aggregate these products can be pumped high, install smoothly, and offer excellent alkali resistance, strength and thermal shock resistance for your applications. These products are:

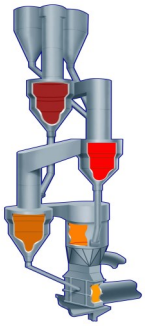
ULTRA TEK 48

ULTRA TEK 48 GM

SAVAGE X™ 48

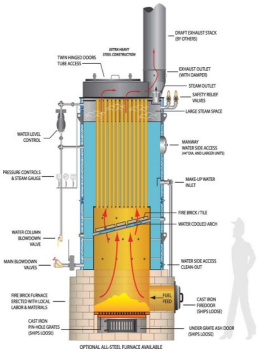
SAVAGE X™ 48 GM

SAVAGE X-II™ 48



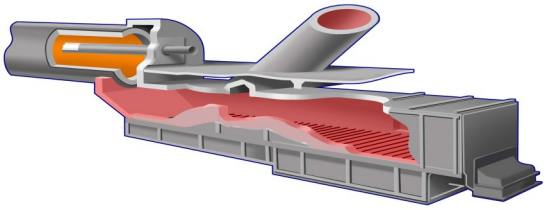
Cement Preheat Towers

Incineration



Wood Boilers

Coke Oven Repairs



Cement Kiln Cooler

Aluminum Launders

FUSED SILICA APPLICATIONS

Elsewhere in this newsletter we discussed some of the interesting and unique properties of fused silica compared to other refractory materials. Why, then, do we not use fused silica more than we do? This author does think that we should use fused silica more, but like any other refractory material it does have limitations. The two that need be most considered is the fact that at temperatures over 2000º F or so, fused silica will start to crystalize. When the fused silica crystalizes, it is not destructive, but when it cools down it turns into much denser phases that cause cracking and failure. Thus you either need to use them in applications that are under 2000º F or not cool them off for applications that are higher than that. The second issue is silica is an acidic material, meaning it will resist acids and acidic slags, but will have a tendency to react with basic slags in certain applications.

What does that leave us with. In the minerals processing industry there are huge potential areas for fused silica that are currently being attacked by thermal shock that are below 2000º F. These include first through fourth stages of preheat towers, TA ducts, alkali bypass ducts, and coolers. It includes many incinerators and boilers. It includes hoods for much hotter applications like steel melting vessels and cooler parts of reheat and forge furnaces. Launders for the aluminum industry are often made of fused silica materials. Ash hoppers in power plants shot with fused silica last much longer than conventional fireclay ash hopers.

In conclusion, silica, and particularly fused silica have some extremely unique refractory properties. As seen in other articles, these include resistance to acids and alkalis, tremendous thermal shock resistance with its “zero growth” grain, and its total resistance to creep almost up to its melting temperature. Do your applications have one or more of these refractory wear mechanisms? Maybe fused silica is the answer.

Buzzi says for wide temperature changes, you should consider fused silica products!