WHAT IS REFRACTORY?
Its Uses / Installation Methods / Anchoring Systems

JACKSON ESPINOZA, Refractory Division Manager at Sentinel Integrity Solutions
WHAT IS REFRACTORY?
Its Uses / Installation Methods / Anchoring Systems

BY: JACKSON ESPINOZA, Refractory Division Manager at Sentinel Integrity Solutions

INTRODUCTION
What is refractory? This is a question I am frequently asked when I tell people what I do. I often say it’s a manmade rock and depending upon the type has various degrees of resistance to heat, abrasion, and chemical attack. Of course refractory is a little more complex than this over-simplified response.

Refractory has been used for temperature control since as early as the Bronze Age (circa 4000 BC). During this time, refractory came in the form of a pit dug in the soil that was used to fire earthenware (a low-fired pottery). The soil used was found to be resistant to heat and did not deform, which is the main purpose of refractory. Refractory can be defined as a non-metallic material with both chemical and physical properties that make them applicable for structures exposed to environments above 1000˚F.

Today, refractories are used in many different industries around the world, such as: petroleum refining, petrochemicals, power generation, cement, metals and mining, and many more. These refractories are used as a critical component inside high temperature processing equipment. For example, in fluid catalytic cracking (FCC) units in oil refineries, refractory is primarily used for its abrasion and heat resistant properties. It is also used for its chemical and heat resistant properties in other processing units such as sulfur recovery units.

Overall, refractory is commonly used to line the insides of pressure vessels, piping, furnaces, flue gas ducting, and other process equipment. The main characteristics of refractory, including abrasion-resistance, heat-insulation, and anti-chemical-attack properties, are critical for ensuring the base metals in processing equipment are protected.

Since the Bronze Age, and especially during the past 20 years, refractory has benefitted from significant advancements in materials science and applications. Some of these advancements include breakthrough technologies for abrasion-resistant materials, dry-out/cure times, improved installation methods, and anchoring systems.

ABRASION-RESISTANT REFRACTORIEST
One of the major improvements in refractories in recent years is in the area of abrasion resistance. As recently as 20 years ago, the standard cubic-centimeters loss experienced when testing refractory materials by the ASTM C-704 standard test method of abrasion resistance require losses less than 4.0 cc. Now, the standard acceptable loss is less than 3.0 cc, with most of the materials used today averaging between 2.5 cc and 3.0cc. In fact, sometimes it seems that the abrasion materials are often harder than the hex-metal steel that anchors it onto the vessel walls. In some cases, I have found the hex-metal to be severely eroded with the adjacent refractory in perfect condition with no signs of surface erosion.

DRY-OUT
Another fairly recent improvement is the dry-out time or cure for refractory material. In some applications, the refractory requires little to no dry-out time and effort. In most applications, the drying time has been reduced from an average of 75-80 hours to an average of 40-45 hours. Compared to the past, modern refractory has a dry-out time almost 50% shorter than it had 20 years ago — a significant improvement and cost saver for owner-users.

CHEMICAL BONDING REFRACTORIES
Another advancement in refractory materials is its chemical bonding properties. Manufactures have discovered ways of adhering new refractory to existing refractory by chemical bonding. This allows overlaying new refractory on top of existing damaged refractory to avoid full replacements that can kill a budget or schedule. For example, if a specific equipment unit is missing a certain percentage of refractory material, perhaps 20%, then these chemically bonded materials can be overlaid on top of the existing refractory to make up the desired 100% lined thickness. Not an API 936 recommended practice, but I have seen it work if applied correctly. As always, just as with coatings, surface preparation and environmental conditions can make the difference between a job well done and one that will fail in a short time. Make sure to follow the manufacturer’s recommendations for surface preparation and application.

DUAL-COMPONENT LININGS
Also in a break from the past, many dual-component refractory linings have been replaced with single-component linings, especially in FCCU flue gas lines in oil refineries. In the past, one refractory formula was needed to perform as insulation, while another was used to prevent abrasion, creating two separate layers of refractory to perform as an insulator and abrasion resistant lining. Today, one refractory formula can perform both functions simultaneously. This comes from scientific advancement in refractory materials that are now more abrasion and heat-resistant, and serve both functions with one material.

INSTALLATION METHODS
In addition to new refractory technology for abrasion, drying, and dual-component formulations, companies have developed newer and more efficient refractory installation methods. In the past, most refractory materials were installed into service as bricks or as refractory castings to later place inside the vessels or piping.

In the early 1990s companies began experimenting with pumping refractory materials into place to line vessel and piping walls. The learning curve took several years, but this has ultimately proven very successful. Today, under proper conditions and good technique, refractory can be pumped as far as 400 vertical feet.
Over time, companies developed new and less time consuming installation methods, including dry gunning and/or pneumatic gunning, or “gunite”. With gunite, the material is in the form of powder, and is transferred from a hose through a pressurized double-chambered gun. Water is added at the end of the nozzle through a water ring. At this time, the mixing of dry to wet ratio is all in the hands of the applicator, or “nozzle-man” as the industry would call it.

With the advancement of pumping came the “wet-gun” and “shotcrete” refractory installation method. Installers can now use the same pumping method and add a nozzle at the end of the hose with air and an activator. This method is similar to dry gunning, except everything is wet as it travels through the hose to the end of the nozzle. At that point, an activator is used to make the refractory material adhere to the wall of the vessel. The main advantage of wet-gunning is that the material properties are almost the same as casting without the additional prep work of installing and removing forms, which is very costly and time consuming.

ANCHORING SYSTEMS
Meanwhile, the systems used to permanently install the refractory material onto vessels and piping has greatly improved over time. For example, the hex metals that are typically used as anchors for the refractory in FCCUs (fluidized catalytic cracking units) have evolved with the various positioning of the lances. The lances are the tabs in the hex metal that help anchor the refractory material to the hex-metal and also serve as gauges to determine the remaining refractory thickness. The typical arrangement of these tabs was in an offset position.

Today, a center-tab hex arrangement is more commonly used. Also, in the past, hex metal material was usually a standard ¾-inch high. Now, most are 1-inch high with some exceeding 2 inches in high-wear areas to support refractory of greater thickness.

Other advancements for hex-metal are hex-alternative systems. These hex-alternative systems are more commonly used during facility turnarounds to perform localized patch repairs to the existing hex-metal areas. At one time there was only one choice of hex for this alternative, which was the S-bar.
Since then, we have a variety of hex-alternative systems and the S-bar has been slowly eliminated due to its lack of anchoring effectiveness. Better anchoring systems have been introduced to the industry, such as curl anchors, hex-cell, half cells, D-bars, K-bars. Of course some perform better than others, but all take the place of installing hex-metal, which is very costly and time consuming during a turnaround. In some cases, such as coking service on FCCs, I believe that the hex-alternative systems are a more effective anchoring system then the hex-metal, due to the individual attachments.

For example, sometimes regular hex metal sheets, typically sized 4 feet by 8 feet, are installed in the reactors of FCCUs. During operation, the fluidized coke gets behind the sheets, pushing the entire sheet of hex away from the base steel. Using the hex-alternative anchors, this type of damage is minimized because the hex-alternative systems are not connected and are individually attached to the base metal. Thus, any detachment can be contained to a small section. I find these anchoring systems to be a major improvement for erosion resistant refractories.

RAPID ARC WELDING

Another major advancement in refractory is the rapid arc welding (RAW) of anchoring systems. Although stud welding has been around for some time, these new RAW machines are computerized and more advanced than the conventional spring-loaded stud gun. These machines have lowered the percentage of inferior welds to approximately 1%-3% failure rate. Compared to hand welding or conventional stud welders, whose failure percentage rates could reach anywhere from 20%-30%, RAW is far superior.

With this new technology, the industry can rely on a more cost-effective way to install anchoring systems to their equipment. Not only is the failure rate percentage lower with this technology, the productivity improvement is phenomenal. If area size permits, using the new stud-welding system can enable installation of anywhere from 500 to 1,000 anchors during a 12-hour shift, compared to about 400 when hand welding.

Another advantage of RAW is that the stud welders do not need to be a certified welder, but do need to be qualified to install anchors using the RAW system. This allows contractors to train competent employees on this new stud-welding system and eliminate the high costs of hiring certified welders.

CONCLUSION

Reliable refractory is an important consideration for asset integrity managers in refining and petrochemical facilities. Without the proper refractory system installed and of sufficient quality for each processing service, owner-operators would not be able to run their equipment safely, reliably, properly or efficiently, and would require much more available capital for steel repairs and replacement due to damage or degradation caused by heat, chemicals, and abrasion. With adequate, specific, fit-for-purpose, new-generation refractory systems, facility managers can be confident that their operations will not be impaired or compromised by refractory failures.

For more information on this subject or the author, please email us at inquiries@inspectioneering.com.
JACKSON ESPINOZA
Jackson Espinoza is the Refractory Division Manager at Sentinel Integrity Solutions, Inc. He possesses over 24 years of experience with refractory installations in refineries, power plants, and other facilities. Jackson is a certified API 936 refractory inspector and bricklayer journeyman, with experience as an inspector, foreman, and superintendent on numerous refractory projects and turnarounds.
Turnaround Inspection
Mechanical Integrity
Visual Inspection
Tubing Testing
NDT Services
RBI Program
CUI Program
PMI Program
HFA Program
Advanced NDT
Tank Inspection
Quality Assurance
PV Design Analysis
Fitness For Service
OSHA-PSM & NEP Auditing
Refractory Inspection &
Testing Laboratory

Inspection professionals protecting your interests in all segments of the stream.

Sentinel Integrity Solutions is a full service inspection company.

We pride ourselves on unsurpassed reliability, dedication, and professionalism exhibited by our personnel.

We distinguish ourselves through customer-centric service and unparalleled responsiveness.

**HOUSTON**
📍 6606 Miller Road 2
📍 Houston, Texas 77049
📞 281.457.2225

**CORPUS CHRISTI**
📍 3038 Leopard
📍 Corpus Christi, Texas 78408
📞 361.887.2014

**BATON ROUGE**
📍 2044 Lobdell Highway
📍 Port Allen, Louisiana 70767
📞 225.421.8640