



[Print this article](#)

[Close](#)

---

## Combating Corrosion within Power Generation Facilities

*C. Karl Sauereisen*

### By C. Karl Sauereisen

Just about every utility facility that generates power or engages in some form of incineration must deal with corrosion issues.

Since the adoption of the Clean Air Act of 1990, gas-scrubbing technologies have increased the importance of preserving the assets of power plants and other incineration infrastructure. These demands will increase further with the advent of new mercury removal requirements to be phased in during the near future.

This article identifies common corrosive processes, the locations within plants most likely affected, and an overview of protective materials most often used to withstand the aggressive environment.

### Ramifications of Clean Air Legislation

The Clean Air Act of 1990 was one of the most comprehensive environmental laws ever written in the United States. It has had a more direct impact on our everyday lives than almost any other environmental regulation. The impact has been mostly positive in reducing the conditions that lead to acid rain and other associated problems. This occurred through the control of emissions of hazardous air pollutants, specifically the discharge of nitrogen oxide ( $\text{NO}_x$ ) and sulfur dioxide ( $\text{SO}_2$ ). Mercury (Hg) emissions will be the next hazardous air pollutant to be regulated.

To meet stringent air quality standards mandated by the Clean Air Act, public utilities must incorporate scrubber technologies on their power generation facilities to remove air pollution discharges, and/or have elected to switch to cleaner burning fuels. By using Flue Gas Desulfurization (FGD) scrubber technology and heat recovery units, utilities have lowered flue gas temperatures and increased condensation of corrosive acids within ducts and stacks. Scrubber modules and their associated tankage are also subject to chemical and physical attack because they handle abrasive, alkaline slurry mixtures. With increased chemical and physical attack more prevalent in FGD systems, proper selection of protective lining materials is critical.

### Identification of Corrosive Conditions

To fully understand the solutions to power plant corrosion, let's first review the basic operating conditions and components of a typical coal-fired power facility.

The fuel source, coal, is fed along a conveyor to a storage bunker or silo. From here, the coal is crushed or pulverized into a fine dust and blown into a boiler furnace where it is used to convert water to steam. The steam is exhausted to a turbine that spins a generator and the resulting power is fed to power utilities. The burned coal residue, called fly-ash, is collected and pumped to ash ponds or to other disposal sites.

The hot gases, called flue gas, are carried from the boiler through ductwork where they enter a scrubber module and are sprayed with an alkaline slurry solution. The alkaline slurry solution "scrubs" the gas to remove high levels of concentrated acids, chlorides and fluorides that form as a by-product of burning coal. The alkaline slurry solution reacts with the acids and forms a neutral salt which can then be safely disposed or converted to by-products such as gypsum wallboard.

Scrubbing these flue gases lowers their temperature, causing the acids to precipitate out of the gas stream and condense on the interior surfaces of the ducts and stack. These wet acids attack the surface and create a need for corrosion protection. The flue gas is much cooler than before it was scrubbed having gone from at least 700°F to less than 200°F. The gas is carried through ductwork into the stack where it is discharged into the air. In order to prevent the corrosive-laden gases from attacking the chimney, special corrosion resistant materials have to be used there as well.

## Areas in Need of Corrosion Protection

The following are specific areas typical of power generating facilities that are most vulnerable and in need of protection:

- **Flue Gas Inlet Ducts:** A network of ductwork directs flue gas from the boiler to various parts of the flue gas system or directly to the stack via a bypass duct in the event of an upset or bypass condition. In addition to high temperatures at the beginning of the process, the gases also contain acids and fly-ash which can attack the duct both chemically and physically.
- **Scrubber Outlet Ducts:** This structure carries the scrubbed flue gas from the scrubber to the stack. The gas temperature in the outlet duct is much lower (<200°F) than that in the inlet duct, and relatively free of abrasive fly-ash.
- **Bypass Ducts:** The duct has the same conditions as the inlet duct: high temperature, acidic and abrasive flue gas.
- **Stacks:** Flue gas is formed during fuel combustion and industrial chimneys carry away the gases formed by burning coal, oil, gas and refuse. Industrial stacks usually consist of a windshield, an annulus area and an independent liner or multiple liners. Some stacks are free standing and do not have windshields. Because of the potentially high temperatures and acidic environments found in flue gas applications, unprotected liners quickly suffer chemical attack as well as thermal shock.
- **Steel Liners:** Historically, carbon steel-lined stacks used traditional refractory linings-calcium aluminate-bonded cements, such as luminite-haydite and sodium silicate linings. In time, potassium silicates demonstrated improved properties. While this technology enabled longevity of the stack, it also permitted potential environmental hazards by allowing the escape of heated, unscrubbed gasses likely to initiate acid rain. This directly contributed to the passage of the aforementioned Clean Air Act of 1990.
- **Brick Liners:** These continue to be among the most durable methods of constructing new liners. Considerations of time, cost and seismological zones combine to make new brick liners somewhat rare today.
- **Fuel Handling Areas:** Coal, one of the primary fuels used in power generation, is extremely abrasive. In addition to its abrasiveness, coal can also leech sulfurous acid when wet. Regardless of whether coal is stored horizontally, as in a bunker, or vertically, such as silos and hoppers, environmental laws prevent it from being stored on unlined areas where the acid might ultimately combine with rainwater and leach out or run off.
- **Scrubber Module (Quencher, Absorber):** Scrubbers are the heart of the flue gas cleaning system. In addition to removing the acids, scrubbers reduce the heat of the gas and help strip it of abrasive fly-ash. Because of the many complex factors involved in the scrubbing process, some of the acid gets through, so the scrubber needs protection from this chemical and physical abuse.
- **Demineralized Water Areas:** Water used in the boiler must be demineralized and free of contaminants. This is accomplished by ion exchange cartridges which are, in turn, cleaned with sodium hydroxide and treated with sulfuric acid. Because of this aggressive process, the concrete and steel of these structures are subject to corrosion. Demineralized water is also very aggressive to concrete.
- **Collection Sumps/Neutralization Basis:** These structures are exposed to the chemical effluent of the water demineralization process. These environments can be both acidic and caustic. The method of protection used will depend on environmental conditions including temperature, substrate and chemical exposure.

## Materials to Protect Power Plant Assets

There are a variety of ways in which to prevent the corrosive-laden gases from attacking these structures and they fall into two main categories: Inorganic and organic systems.

### Brick and Mortar

One of the oldest protective systems in the power market is brick and mortar construction. These linings continue to provide the longest service life of any currently available corrosion protection system. This system has been used in new stack construction and is being used in stack repair more recently. Fuel handling areas, sumps, railcar & truck unloading pads, and collection areas are other common applications for brick systems.

In the 1930s, chemical-setting sodium silicate mortars were used. By the early 1970s potassium silicate bonded mortars were the material of choice, preferable because of their exceptional resistance to sulfation-hydration expansion. It's important to note that sodium and potassium silicate-bonded materials should not be used in alkaline (high pH) conditions. Both silicate varieties represent inorganic chemistries that withstand high temperatures above 1000°F.

Another mortar commonly used in brick and mortar construction is an organic, resin-based mortar known as furan. Furans are chemically setting materials that can be used in moderately high temperatures (450°), but more importantly it is ideal for where there is a fluctuation of pH conditions as furans perform well in both acidic and alkaline conditions.

An additional kind of organic mortar is a vinyl ester product. These mortars offer a broad range of chemical resistance, including exceptional performance in oxidizing environments, particularly those containing chlorine or bleach. This makes vinyl esters popular in the Pulp & Paper industry as well.

### Impervious Membranes

Membranes must be selected with the same considerations of temperature and chemical exposure that is given to the brick, mortar and refractories. Membranes are frequently incorporated as a final barrier against substrate exposure when masonry or a refractory is used as the primary protection. Since both brick and refractories have a fairly high degree of porosity, it is beneficial to have a protective layer of low permeable membrane beneath.

The membrane serves two purposes in that it will bridge minor cracks that develop in the substrate, preventing the crack from mirroring through the rigid primary protective system, as well as being an impermeable elastomeric barrier inert to the chemical environment. Membranes can be hot- or cold-applied materials and are usually asphalt-based. Asphaltic membranes resist a wide range of chemicals and temperatures up to 350°F and are generally applied by squeegee, spray or trowel.

### Inorganic Monolithic/Refractories

There are a host of inorganic monolithic/refractories. These are specified to resist high temperatures and to provide thermal insulation to the shell. Like a class of mortars identified previously, inorganic monolithics consist of potassium silicates, sodium silicates, and calcium aluminates. The thickness of these systems is dictated by the operating temperatures and subsequent thermal protection required by the underlying membrane or other considerations. While most inorganic monolithics are gunited, there are a few applications in which they can be cast or troweled.

Membranes typically accompany an inorganic monolith due to the absorption that occurs in the refractory. The selection of membranes for inorganic monolithics in flue gas applications is limited specifically to spray applied materials. The criteria of chemical-resistance, temperature-resistance, and application are considered equally in membrane selection.

### Borosilicate Glass Block

Glass block is sometimes considered an alternative to a gunited refractory or brick. The block provides similar

chemical resistance and thermal insulation. A thin layer of mastic mortar is used as a bonding agent. Application of glass block is very expensive and time-consuming. Concerns sometimes arise as the exposed mastic between block joints can be overheated and the abrasion of the glass block materials by flue gas particulates can result in the release of lead dust that may exceed environmental limitations.

## Polymer Concrete

Polymer concretes may be formulated in either organic or inorganic varieties. The most common are epoxies, vinyl esters, and potassium silicate. These materials resemble standard Portland concrete by exhibiting the same mixing and handling properties, but they consist of a chemically resistant matrix that requires no protective coating. Polymer concrete is becoming increasingly popular as an option for chimney floors because of its strength, chemical resistance, and ease of use.

## Organic Coatings/Linings

Organic coatings and linings offer the largest variety of applications, but still use the same selection criteria as any of the other systems discussed thus far. The primary organic coatings and linings for flue gas exposure include epoxies, Novolac epoxies, and Novolac vinyl esters. There are other variations, hybrids, and brand-name products rounding out the list.

Organic coatings and linings can be fiber reinforced, glass flake filled, layered with glass mats, or filled with aggregates. Typically these systems are quickly and efficiently spray-applied, rolled, troweled, cast or even poured and spread. Although the organic coatings mentioned here cannot handle high temperatures like the inorganic materials discussed, the lower temperature ranges now present in many flue gas applications make them a versatile and economically viable option. The organics frequently exhibit high physical properties, particularly resistance to abrasion, compression, and flexural forces. Additionally, they offer the lowest permeability available, aside from alloys.

## Fiberglass Reinforced Plastic

FRP, as it's commonly known, is a chemical resistant system that consists of wound fiberglass strands and catalyzed resin. FRP can be prefabricated to fit many shapes and structures. FRP offers good chemical resistance and can handle moderate temperature ranges. FRP is generally used for very specific applications. The resins most frequently used in FRP are polyester, furan, vinylester, and epoxy.

## Stainless Steel

This option is a proven but expensive alternative to lining flue gas systems. The stainless steel is generally not affected by the temperatures present in flue gas applications, however, certain chemicals such as chlorides and fluorides, either separately or in combination with each other, will attack stainless steel. Even sulfuric acid can have an adverse effect. Cost is perhaps the major reason that stainless steel is not used for all flue gas construction.

## Conclusion

Over the last 20 years, a significant shift has occurred in the operation of power generation facilities. Along with changes in attitudes towards the environment, resulting legislation and other market forces, the protection of these important facilities has gone from a line item on a balance sheet to an overall philosophy of asset management. Just as these facilities have evolved and innovated, so too have the products and methodologies used to protect them, to not only ensure the life of the structure itself, but to add to the long-term benefits of its maintained existence.

About the Author:

**C. Karl Sauereisen** is vice president of Sauereisen, Inc., a manufacturer and worldwide distributor of corrosion-resistant materials for a variety of industries since 1899. His areas of responsibility at Sauereisen include operations and marketing and he frequently contributes to professional journals on the areas of corrosion resistance and specialty materials. Karl received his masters degree in public management with highest distinction from Carnegie Mellon University.

---

To access this article, go to:

[http://www.utilityproducts.com /display\\_article/311353/129/none/none/Featu/Combating-Corrosion-within-Power-Generation-Facilities](http://www.utilityproducts.com /display_article/311353/129/none/none/Featu/Combating-Corrosion-within-Power-Generation-Facilities)

---

© 2007 PennWell Corporation, Tulsa, OK; All Rights Reserved.