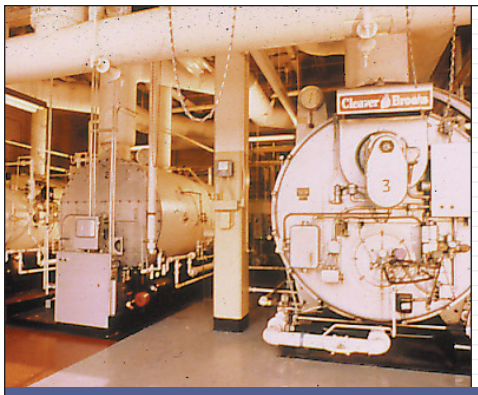

Understanding the Hazard

Boiler Feedwater Treatment

Equipment

A lack of, or improper, boiler feedwater treatment can be a hazard to the boilers at your facility, the processes and equipment receiving steam from them, and the condensate return system. Further, it may put your company's continuity of operation at risk.

UTH topic categories:

- Construction
- ▶ **Equipment**
- Fire Protection
- Human Element
- Natural Hazards
- Process Hazards

This series of publications is designed to help you understand the everyday hazards present at your company's facilities. For more information on how you can better understand the risks your business and operations face every day, contact FM Global.

The Hazard

Boiler feedwater treatment is essential to maintaining steam purity and long-term, pressure-part integrity. A lack of feedwater treatment, or providing improper treatment, can result in failure of waterside controls, safety devices, and the pressure parts of firetube and watertube boilers. Failure to provide adequate treatment will leave minerals and other harmful dissolved compounds in the water, leading to the formation of scale as well as an increased chance of overheating, and corrosion and pitting of the boiler components.

Adding excessive chemicals or failure to blow down the boiler regularly can be just as serious as not providing enough treatment. Overtreating can lead to sludge accumulation and increased amounts of suspended solids. When sludge is allowed to accumulate and suspended solids bake onto pressure parts, water circulation and pressure part cooling is inhibited, causing tube overheating. Deposits and sludge also can disable low water cutouts and prevent safety valves from relieving dangerous overpressure conditions. In addition, solids can be transported with the steam and will coat superheater tubes and downstream process equipment, such as steam turbines.

Failure to remove oxygen from the incoming boiler feedwater will cause serious and widespread pitting and corrosion in boiler tubes, especially in the economizer section of watertube boilers, drastically reducing their useful life expectancy.

Science of the Hazard

Water is the universal solvent; and all fresh water, whether from streams, lakes or wells, contains impurities. Some of these can be very harmful to a boiler and all downstream equipment receiving the steam and/or condensate (condensed steam). Suspended solids will cause tube erosion and can settle in mud drums and other low points, affecting water circulation. Dissolved gas, such as oxygen and carbon dioxide, cause pitting corrosion. Dissolved gas can also be carried over with steam and will then combine with condensate to form highly corrosive carbonic acid. Dissolved solids, such as magnesium and calcium carbonate, precipitate out of the water at high temperatures and adhere to boiler tube walls, both reducing boiler efficiency and increasing tube metal temperatures.

What You Can Do in Your Facility

Now:

- Test your boiler water regularly.
- Follow your water-treatment company's advice for the types and quantities of chemicals to add to your boiler water.
- Document chemical use. Verify actual use matches expected use.
- Inspect water-treatment system piping and valves. Make sure there are no obvious leaks.
- Ensure instrumentation is working, and automatic controls are functioning properly.

Soon:

- Check that all shutoff valves are leak-tight, in conformance with the equipment supplier's procedures.
- Make sure a representative from your water-treatment company is present at the time of the next boiler internal inspection.
- Calibrate water-treatment system instrumentation, and verify alarm settings.
- Implement continuous monitoring of pH level and conductivity where contamination of condensate or leakage of chemicals is possible.

Boiler water has to be treated in several ways to obtain the desired purity. Suspended solids are removed by filtering. The design and size of the filter and filter media are dependent on the characteristics of the solids present in the raw water, and the desired purity of the filtered water. Dissolved gas is removed by deaeration (vacuum or steam), or by oxygen-scavenging chemicals. For higher-pressure boilers, steam deaeration and oxygen-scavenging chemicals are the most economical means of removing all detectable oxygen.

Control of dissolved solids is more complex. For lower-pressure situations, water softeners can be used to replace magnesium and calcium ions (the predominant agents that cause water hardness) with sodium. At higher pressures, however, sodium carries over with the steam and causes harm to downstream process equipment. Therefore, in high-pressure applications, ion exchange is the method used to replace magnesium and calcium with hydrogen ions, and to replace carbonate and sulfate ions with hydroxyl (OH^-).

Boiler water pH also must be controlled to prevent acid attack at lower pH values, and foaming at high pH levels. Typical acceptable pH levels register in the 8 – 10 range.

In some cases, additional chemical treatment will be required. Chemical treatment is the process of adding chemicals to the boiler feedwater before or after it enters the economizer, or directly injecting chemicals into the boiler drum. With this treatment, most dissolved solids will not volatilize (pass off in vapor) or carry over with the steam. This results in a concentration of solids that is controlled by continuous or periodic blowdown of the boiler water.

Loss Experience

Analysis of losses experienced by FM Global clients during the past 15 years demonstrates that improper boiler feedwater treatment affects all types of boilers. In most cases, scale on tube or tubesheet surfaces or sludge accumulation has caused overheating of pressure parts, diminishing their ability to contain the water or steam at normal operating pressure. In other cases, scale or sludge disabled the water-level control system and low-water fuel cutoff, leading to dry-firing and overheating of pressure parts.

Also, some types of process equipment, such as steam turbines and heat exchangers, have displayed corrosion and erosion damage, resulting in mechanical breakdown or pressure integrity failure. Losses were even reported at condensate-return systems used to collect condensed steam.

But What About…

… adding extra chemicals just to be sure?

Many companies and facilities often succumb to the temptation to add a bit more "just to be sure." This practice is not only fruitless, but it can be harmful to your boiler and the process equipment receiving the steam. Excess chemicals will add to the quantity of dissolved solids in your boiler water. This, in turn, increases the likelihood of foaming and water-carryover with the steam. To control the higher

Water Treatment for Out-of-Service Boilers

Corrosion damage is the result of oxygen attack on wetted surfaces during idle periods. Because oxygen is soluble in water, special precautions are required to protect boilers during extended periods when not in operation.

Boilers can be idled when dry or wet. In a dry layup, the unit is drained, and in a wet layup it is filled with water. It is not possible to remove all the water in a dry layup, nor is it possible to remove all the air in a wet layup. Additional precautions are necessary.

For a dry layup, a material that absorbs moisture, such as silica gel or hydrated lime, is placed in trays inside the boiler drums (or inside the shell of a firetube boiler). After the trays are inserted, the boiler is tightly sealed to prevent air and moisture from leaking in. Periodic inspection and replacement of the drying agent is necessary during long storage periods.

For a wet layup, extra chemicals, usually caustic, organic and/or sodium sulfite, are added to the boiler water. Take precautions to prevent the boiler water from entering superheaters, especially those of the nondrainable pendant design. Either demineralized water or pure condensate treated with hydrazine and neutralizing amine is acceptable for use in superheaters. A positive pressure should be maintained by using a nitrogen cap to prevent air (oxygen) from leaking in.

concentration of solids, an increase in the frequency or amount of blowdown will be required. Viewed economically, even if no damage is done, money would be spent needlessly through the purchase of excess chemicals and in the energy removed by the additional blowdown.

… the frequency of testing? How will I know how often to test my boiler water?

For boilers where adding chemicals is the only type of treatment, daily testing is recommended. And, when operation is steady-state, weekly testing likely will be sufficient, as long as no upset is discovered. Following an upset, more frequent testing is needed to ensure the problem is corrected. For more complex water-treatment systems, such as those with water softeners, and especially ion exchange units with automatic regeneration, more frequent testing may be necessary, possibly even every several hours.

Regeneration chemicals are extremely harmful to a boiler and can cause serious corrosion or tube overheating in a matter of hours. FM Global loss experience shows that valves in regeneration systems can, and do, leak or malfunction, allowing the chemicals to contaminate boiler feedwater. Process applications where steam is condensed in heat exchangers create other situations that require more frequent testing. In these instances, tube leaks in a heat exchanger will result in contamination of the condensate by the fluid being heated. Leakage of regeneration chemicals and leakage from the heat exchanger will result in a sudden deterioration in boiler feedwater quality and must be quickly detected to prevent damage to the boiler. When a boiler is critical to facility operation, feedwater pH and conductivity should be monitored continuously, with excursion alarms installed.

… criteria for selecting a water-treatment company?

The best way to choose a firm is to ask for references from other facilities in your geographic area with similar boilers. Find out the level of success the treatment company has in preventing scale and sludge formation, and its track record in preventing tube pitting and corrosion/erosion on waterside surfaces. Also, find out how responsive the company is in sending a qualified representative to a boiler internal (jurisdictional) inspection, or when water-treatment problems are being observed. A company knowledgeable about the water quality in your area, and experienced in how to treat it for use in your boiler, is your best choice.

… water carryover, why is it harmful?

Water carryover is the entrainment, or transport, of water with steam as it leaves the steam drum or steam space of your boiler. Boiler water may contain high levels of dissolved solids that don't evaporate as steam is generated. When water is carried over with the steam, these dissolved solids are separated from the water as the water turns to steam. This causes the dissolved particles to become solid particles. The solid particles stick to the inside of the superheater tubes, and can cause erosion and/or corrosion damage in process equipment such as steam turbines or heat exchangers. When steam is used directly in a process, the solids will cause product contamination and may render the product useless.

Need More Information?

Ask your FM Global engineer or client service team about the following:

- Examples of what to look for when examining boiler waterside surfaces
- The best ways to document your boiler feedwater treatment program
- Additional resources for understanding boiler feedwater treatment options for your boiler

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… nonchemical water treatment?

Nonchemical water treatment includes magnetic, electrostatic, radio frequency and other electronic devices. Nonchemical water treatment has been attempted in one way or another over the past 100 years. Until recently, most of these products were decidedly unsuccessful and appeared to have "worked" only when no treatment was really needed in the first place. Magnetic water treatment is an area in which there is some scientific evidence to support claims of success in removing magnetic solids. Other methods have not been shown to provide results that would be adequate for industrial locations. If considering these methods of water treatment, consult your FM Global engineer or client service team for guidance.

Don't Let This Happen to You

This tube comes from a watertube boiler where internal scale insulated the tube metal from the cooling effects of the water passing through. Overheating and the effects of corrosion led to the sudden fishmouth failure. Remember, pressure is elevated inside a boiler. When it is released, an explosive expansion occurs. As the water escapes and flashes into steam, it will expand nearly 1,700 times, quickly filling a boiler house with large quantities of hot steam.