Boiler water related problems

Power-Chemicals

Water Services LTD

www.arvanitakis.com www.power-chemicals.com www.refinery-chemicals.com www.paper-specialities.com

tel +30 6948 518699

e mails dennis@arvanitakis.com export@power-chemicals.com

www.arvanitakis.com

Boiler water related problems

Pure water simply does not exist in nature, and contains impurities. Specifically contains suspended solids, dissolved solids and dissolved gases.

We will try to explain how those impurities reduce efficiency and damage plant equipment.

The goal of boiler water treatment is the prevention of water related problems in steam generating systems and associated equipment. Those problems include corrosion, scale formation and carry-over.

Corrosion

Corrosion is a chemical attack on metal surfaces which results in the loss of metal. It is a naturally occurring phenomenon which poses a constant threat to plant equipment, involving costly replacement, repair and service down time.

If left unchecked, corrosion in boilers will eventually lead to tube ruptures and all the hazards they represent.

Most metals have a tendency to corrode and steel is a good example. Steel is processed from iron ore, which exists in its natural state as a reddish brown compound of oxygen and iron, iron oxide. To convert it into a usable metal the oxygen has to be removed.

However, iron is unstable and will naturally revert to its oxide form which we call rust.

Combining iron with other metals, to form alloys, slows down this process, but even alloys tend to oxidize when exposed to air, water and other metals.

As metals oxidize in a boiler, these is a loss of metal which may lead to tube ruptures and leaks. As metal particles are released, they travel through the system where they can do further damage.

A well maintained and treated boiler water system will promote the formation of a black magnetite iron oxide coating inside the boiler, which protects it from corrosion.

However, incorrect pH control and dissolved gases in the water will destroy its coating, leaving the system susceptible to corrosion. Above and below a pH of 10 the change of corrosion will increase.

In the low pH range, acidic attack breaks down the magnetite barrier and combines with the metal to release hydrogen and particles of iron into the system. Above a pH of 10, caustic attack results in the release of iron oxide and

hydrogen from the metal surfaces.

The second cause of corrosion is the presence of dissolved gases in the boiler water, particularly dissolved oxygen. Dissolved oxygen interferes with the formation of the magnetite coating and combines with iron in water resulting in the formation of iron oxide.

Oxygen corrosion takes place over a small area, with corrosion going deep into the metal causing severe pitting.

Pitting can occur within feedwater lines, economizers, along the water line of the boiler steam drum, and throughout the condensate system.

Failures due to oxygen attack can occur very rapidly.

Dissolved oxygen also contributes to other corrosion reactions including ammonia corrosion of copper alloy condenser tubes and chloride-induced corrosion of certain stainless steels.

Oxygen is not the only dissolved gas which can cause damage in the boiler. Hydrogen, which is a product of acid and caustic attack, combines with carbon in the boiler metal, causing the metal to weaken. This causes cracks to form, eventually leading to tube ruptures.

Carbon dioxide is yet another dissolved gas which, like oxygen, may enter the boiler water through open equipment or by the breakdown of carbonate and bicarbonate alkalinity. Carbon dioxide combines with water to form carbonic acid.

If enough acid is formed, the pH of the system can drop significantly, altering the system to a more corrosive environment.

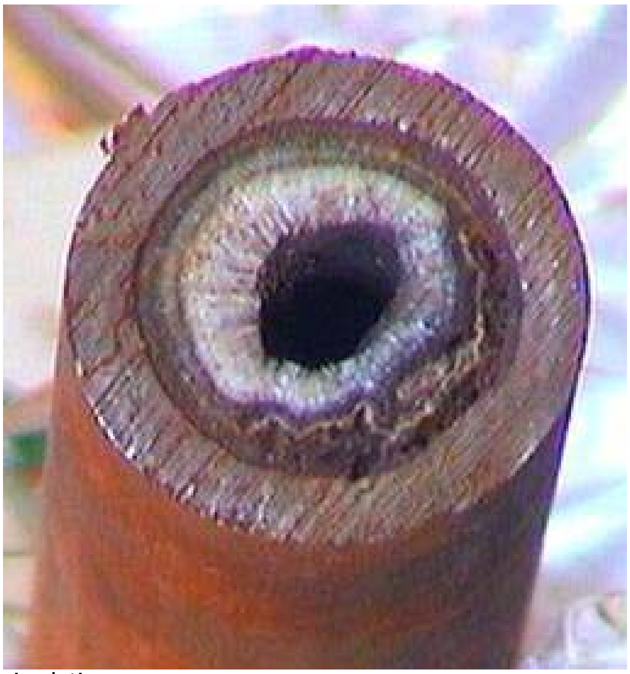
The removal of dissolved gases and the monitoring of pH within the system are critical steps in maintaining corrosion at acceptable levels.

Scale formation

The second major problem we deal with in steam generating systems is the formation of scale on metal surfaces.

Scale formation results from corrosion products in the water, along with impurities entering the boiler in the feedwater.

Preboiler section deposits can form in several locations. Each presenting specific problems. In deaerating heaters, they interfere with proper water distribution and deaeration. They can reduce the capacity of feedwater lines, reduce heat recovery and capacity of economizers or other feedwater heaters while increasing the danger of corrosion. And in feedwater regulators, deposits can cause water level control to become erratic, producing irregularities in



circulation.

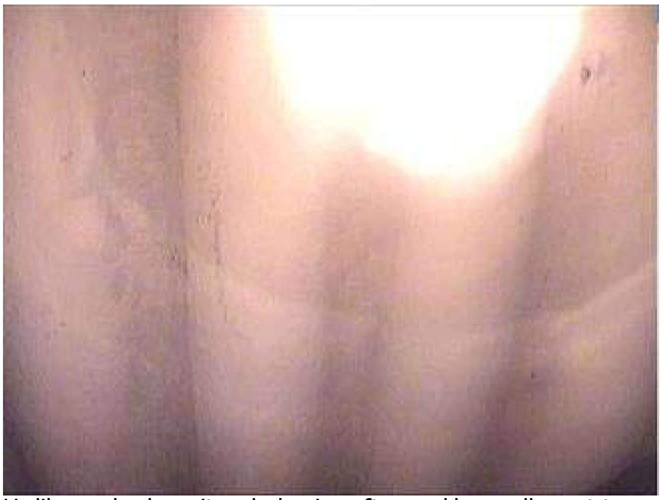
The most severe effects of deposits in steam generating systems occur within the boiler. The presence of deposits of heat transfer surfaces disrupts the boiler's basic function.

Deposits on tube surfaces prevent water from cooling the metals. Overheating results in metal softening, thinning, and ultimately in rupture. Even when rupture does not occur, the insulating effect of deposits results in wasted energy.

And finally, deposits may form in the afterboiler section, affecting turbines, steam handling equipment, and condensate lines.

Boiler deposits are classified as **scale** or **sludge**.

Scale is generally very hard and difficult to remove. Boiler scale results from the growth of crystals on tube surfaces and is most severe in areas where maximum heat transfer occurs. Riser tubes are most susceptible. Scale build-up is usually associated with compounds which become less soluble as temperature increases, such as calcium carbonate or calcium phosphate.



Unlike scale deposits, sludge is softer and less adherent to boiler surfaces. When the solubility of sludge-forming compounds is exceeded, they tend to precipitate out of the boiler water and settle in the mud drum.

Sludge build-up occurs when binders such as iron, copper, and oil are present and when water circulating is slow enough to allow settling. Sludge-forming impurities may also bake onto metal surfaces.

As boiler water passes over hot metal surfaces, steam may form directly on the metal. As the steam escapes, sludge-forming compounds remain behind and bake of the tube surface.

In addition to restricting flow and reducing heat transfer, boiler deposits contribute to corrosion. Corrosion sites form beneath deposits resulting in localized pitting of the metal. This is known as "under deposit corrosion".

As corrosion products are generated, they move through the water, adhering to other areas of the system and the process continues.

Deposits formed in condensate lines cause high localized corrosion. Return line failures result in the loss of valuable heat and high quality condensate. They may also be responsible for shut-downs.

Finally, deposits on surfaces in the steam drum can inhibit effective separation of the steam/water mixture. This permits water to carry over to the afterboiler section.

Carry-over

The third water related problem is "carry-over". Carry-over is the passage of impurities leaving the steam drum within the flow of steam.

It is caused either by water droplets trapped in the steam, or by impurities vaporizing as they reach their own boiling points.

The transport of water droplets in the steam is called "mechanical entrapment" of which there are two kinds, "priming" and "foaming".

Priming occurs when slugs of water are carried out of the boiler along with the steam. This can occur when turbulent water rises in the boiler and floods the steam drum. Water droplets are able to pass to the superheater and deposits form on superheater tubes.

Foaming, on the other hand, results from excessive amounts of alkalinity, dissolved solids, or water contaminations by oil.

In turbulent water, these impurities form a layer of bubbles on the water surface in the steam drum. A layer of foam on the water surface reduces the amount of space where steam can be released, allowing boiler water to enter the superheater along with the steam.

Mechanical entrainment is generally controlled through proper design of the boiler and steam drum, supplemented by the use of foam control agents in situations where foaming becomes a problem. Steam drums must be designed to provide sufficient volume and low enough velocity to allow separation of water from steam before the steam leaves the boiler. Because the size of the steam drum is fixed, the operating water level determines the separation space.

When the water level is high, the separation area and volume are minimized and continuous entrainment can result. This is corrected by simply lowering the operating water level back to the mid-drum level. Operating below the mid-drum level is inadvisable since the angle and point of entry of the steam/water mixture is important to efficient steam separation.

Carry-over can also result from the vaporization of impurities themselves.

An impurity present in water may reach its boiling point and turn to vapor. This is typically seen with silica, which turns to a vapor and carries over to the after boiler section. Silica changes back to a solid when it reaches cooler areas where it forms an extremely hard deposit. Silica deposits are of particular concern where steam is used to power turbines.

Turbines are very carefully balanced, and even small amounts of deposit can affect balance, resulting in vibration and turbine failure.

Problems resulting from carry-over can be minimized by monitoring and controlling the water level in your boiler along with an effective water treatment program.