EnviroAqua CONSULTANTS INC.

Water Talk

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Boiler Deposits

BOILER DEPOSITS

From Collection to Interpretation

Contemporary methods of treating boiler makeup water include softeners, reverse osmosis, demineralizers, etc. However, mechanical problems can occur with the pre-boiler treatment equipment, which results in hardness salts entering the boiler. Another possible source of feedwater contamination is hard water or corrosion products mixing with the condensate return. Leaking surface condensers or heating coils in process equipment can result in cooling tower water or process fluids being returned to the boiler along the steam condensate. All of these situations can result in the formation of deposits in the boiler.

If deposits are found on the internal surfaces of a boiler, a laboratory analysis is necessary to identify the source of the problem. The first step in identifying the problem is collecting the deposit for analysis. The recommended sample collection procedure is outlined below.

Deposit Sampling Methods

1. Deposits should be removed in such a manner as to maintain the original condition.
2. A sketch and photographs of the equipment should be made showing the physical location and appearance of the deposit.
3. Care should be used when collecting the deposit to avoid removing any substrate metal.
4. If tubes containing a deposit are removed from the equipment, they should be marked with the location and orientation.

The deposit sample should be sent to the laboratory for analysis. The analytical methods used for a boiler deposit can include wet analysis, microscopic evaluation, x-ray fluorescence and x-ray diffraction. The wet analysis is the most commonly used method for low-pressure boilers. The deposit is dissolved in acid and the metal ions and acid anions are determined, either gravimetrically or by titration. The results are typically expressed as metal oxides and acid anhydrides. Most probable combinations of the component ions can be calculated to determine the mineral composition of the deposit. Crystal structures observed under the microscope can augment the wet analysis. For high-pressure boilers, such as those used in utility power plants, x-ray fluorescence and x-ray diffraction methods can be used to determine crystal structure and composition.

The first step in interpreting the analytical results is to classify the boiler deposit. Steam boiler deposits can be classified into categories according to how they are formed. These categories are outlined below.

Classification of Boiler Deposits

1. **Scale** – These are deposits, which form on heat transfer surfaces. Scale is composed of inorganic minerals like calcium carbonate and calcium sulfate. Inorganic calcium compounds exhibit inverse solubility, which means that as the water temperature increases the solubility of the compound decreases. The location having the highest temperature is where the water surrounds the heat transfer surface. The calcium compounds are least soluble at the hot surface and will precipitate on the tube forming a dense, crystalline deposit.
2. **Sludge** – This is a waterborne sedimentary deposit, which is generally soft, hydrated and amorphous (non-crystalline). Sludge is generally formed from the precipitation of hardness compounds in the bulk water. Boiler sludge can also be formed from metal ions, such as iron, aluminum and copper, migrating from the feedwater into the boiler. Further, when a boiler is idle or off, sludge can settle onto the tubes. When the boiler is fired, the sludge will bake onto the tubes.
3. **Silicate Deposits** – These are deposits which form in boilers having high silica feedwater. Calcium and magnesium ions will form silicate sludges, which are gelatinous and readily adherent. When silicate deposits are baked onto the boiler tubes, a very highly insulating crust is formed with potentially damaging consequences. In boilers operating above 600 psig, silica will steam distill and accumulate in steam operated equipment.
4. **Dry Steam Deposits** – This type of deposit occurs in the boiler steam space or in the steam lines. It is a result of entrained boiler water being carried over with the steam. Dry steam deposits are usually composed of sodium chloride, sodium carbonate, sodium hydroxide and sodium sulfate. Dry steam deposits containing treatment components, such as chelating agents, can be damaging to the steam lines and equipment.

The next step in the interpretation of analytical results is to compare the "most probable combination" of chemical components to the list of boiler deposit components. Outlined below is a list of minerals commonly found as boiler deposits.

Typical Boiler Deposits

Mineral/Name	Formula
Acmite	$Na_2O\ Fe_2O_3\ 4SiO_2$
Analcite	$Na_2O\ A1_2O_3\ 4SiO_2\ 2H_2O$
Anhydrite	$CaSO_4$
Brucite	$Mg(OH)_2$
Calcite	$CaCO_3$
Cancrinite	$4Na_2O\ CaO\ 4A1_2O_3\ 2CO2\ 9SiO_2\ 3H_2O$
Hematite	Fe_2O3
Calcium Hydroxyapatite	$Ca_{10}(OH)_2\ (PO_4)_6$
Magnetite	Fe_3O_4
Noselite	$4Na_2O\ 3A1_2O_3\ 6SiO_2\ SO_4$
Pectolite	$Na_2O\ 4CaO\ 6Sio_2\ H_2O$
Quartz	SiO_2
Serpentine	$3MgO\ 2\ SiO_2\ 2H_2O$
Thenardite	Na_2SO_4
Xonotlite	$5CaO\ 5\ SiO_2\ H_2O$

Finally, the cause of mineral deposits can be summarized as follows:

1. **Calcium Deposits** – malfunctioning softener, insufficient polymeric dispersant or phosphate, and low hydrate alkalinity level.
2. **Magnesium Deposits** – insufficient hydrate alkalinity and/or excessive phosphate levels.
3. **Iron Deposits (except magnetite)** – corrosion in the condensate return system or iron in the makeup water.
4. **Magnetite** – this mineral normally forms on internal boiler surface. However, boiler water upset conditions resulting in a low pH condition or acid cleaning can strip the magnetite film.
5. **Aluminum Deposits** – excessive use of alum in the makeup water pre-treatment system.
6. **Silica Deposits** – excessive silica levels in the boiler water and/or low hydrate alkalinity levels.