

ECONOMISER FAILURE IN A HIGH PRESSURE BOILER

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Photo 1- Tube exhibiting deposits



Photo 2- Failed portion from inside

I had been to a sugar mill last month on an assignment for boiler performance improvement. During the discussion the plant manager mentioned about the economizer tube failures due to external corrosion near support. I reacted that we can resort to washing if the left over ash is leading to corrosion during off season. The plant manager confirmed that the economizer was being washed since two seasons. He was smart in preserving the failed tube.

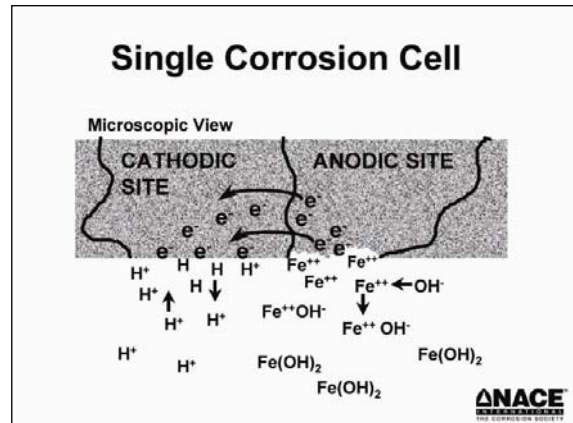
Seeing the tube I requested to have a longitudinal cut of the tube, so that we could see the inside of the tube. It was an internal corrosion at the weld. Its appearance of inside of the tubes confirmed that is a deposit induced corrosion. The photos above show what I stated here. I probed into the reasons possible for pre-boiler system corrosion. My queries and the answers were as below-

| <i>Query:</i> | <i>Answer:</i> |
|---|---|
| Is the condensate pH low? | : No. The pH is always above 8.5. |
| Is the condensate return line to feed water tank made of SS material? | : Very much. |
| Do you have a DM plant for make up? What is the pH? | : We have a DM plant. But before this season we had added a mixed bed and thus the pH is 6.5 to 7. |
| What is the DM water storage tank material? | : The tank is MS and rubber lined in sides. |
| What about the roof? Is it rubber lined? | : It is not. |
| Please check the condition of roof. It may corrode due to acidic vapor. | : During next shut we shall inspect. |
| What is the material used for make up water line? | : It is Stainless steel. |
| Where is the make up going to? | : It is to the feed water tank. Not to the Deaerator. |
| Where do you correct the pH? Is it in the feed water tank or in Deaerator storage tank? | : In the Deaerator we dose ammonia to correct the pH. |
| Please correct the pH at Feed water tank or preferably at DM plant outlet itself. Please inspect the Feed water tank for corrosion products in the next shut. | : We will take care. We even used DM water without raising pH in the beginning of the season due to limitation in dosing pump capacity. |

Why the failure should take place at the weld? The loose corrosion product which peeled off due to low pH / O₂ travels and halts at locations where surface irregularities are available. This is the site for corrosion where an electrode cell is formed.

WHAT HAPPENS WHEN THE PH WAS LOW?

The H⁺ ions in water are more when pH is low. The hydrogen ions are ready to acquire electrons from metal. Hence the Fe⁺⁺ ions break away from the Fe-FeC structure of steel. The figure by the side explains what happens when H⁺ ions are available. The iron hydroxide peels off and gets transported to other locations.



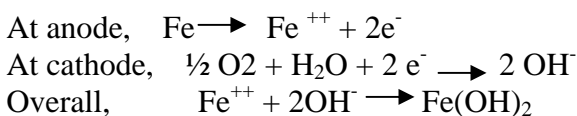
WHAT HAPPENS WHEN O2 IS AVAILABLE?

In the presence of oxygen, which is generally available in make up water tank, rust is formed. Rust is the common name for a very common compound, iron oxide. Iron oxide, the chemical Fe₂O₃, is common because iron combines very readily with oxygen -- so readily, in fact, that pure iron is only rarely found in nature.

Iron (or steel) rusting is an example of corrosion -- an electrochemical process involving an anode (a piece of metal that readily gives up electrons), an electrolyte (a liquid that helps electrons move) and a cathode (a piece of metal that readily accepts electrons). When a piece of metal corrodes, the electrolyte helps provide oxygen to the anode. As oxygen combines with the metal, electrons are liberated. When they flow through the electrolyte to the cathode, the metal of the anode disappears, swept away by the electrical flow or converted into metal cations in a form such as rust.

For iron to become iron oxide, three things are required: iron, water and oxygen. Here's what happens when the three get together:

When a drop of water hits an iron object, two things begin to happen almost immediately. First, the water, a good electrolyte, combines with carbon dioxide in the air to form a weak carbonic acid, an even better electrolyte. As the acid is formed and the iron dissolved, some of the water will begin to break down into its component pieces -- hydrogen and oxygen. The free oxygen and dissolved iron bond into iron oxide, in the process freeing electrons. The electrons liberated from the anode portion of the iron flow to the cathode, which may be a piece of a metal less electrically reactive than iron, or another point on the piece of iron itself.



WHAT HAPPENS AFTER THE CORROSION PRODUCTS ENTER THE BOILER?

It can damage the boiler easily with under deposit corrosion. The failure mechanism can be Oxygen pitting / Hydrogen embrittlement / phosphate attack.

Oxygen pitting is typically broad and shallow and it leads to pinhole leak. Sometimes the covering deposit may still remain at the failure site.

Hydrogen damage leads to inter granular cracking of metal. This can happen only in very low pH condition following heat as well. The deposits prevent the H₂ leaving to water side. Instead it travels through grains. It picks up carbon and forms CH₄- methane and causes fissures of metal.

Phosphate damage occurs beneath deposits when the water contains phosphates. Locally OH⁻ ions concentrate beneath deposits. The metal is pulled out in the form of Fe(OH)₂.

WHAT IS TO BE DONE NOW TO GET RID OF DEPOSITS?

Clean the tubes and keep it clean. It is a tough job. One has to do acid cleaning followed by passivation to get rid of the deposits and establish the uniform magnetite layer, Fe₃O₄.
