Case Study: Condensate Pump Corrosion

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Originally Published: CSTN – April 2003

A client had a gas plant that produced hydrogen gas using steam, natural gas, and a catalyst. The condensate receiver pump wasn't working properly. The pump was taken apart and the impeller was found to be badly damaged.

Take a look at the following diagram and the pump impeller pictures on the next page to see if you can figure out what caused this damage.
As the pictures show, a significant amount of the impeller was missing. No wonder the pump wasn't working properly.

**Background Information**

This gas plant was moved to this location from another plant that had closed. As a result, boiler feedwater from the main powerhouse was used, and the deaerator that came with the plant was only used as a feedwater storage tank for the Reformer Hot Off Gases Waste Heat Exchanger. All the boiler treatment including chelant, polymers, phosphate, sulfite, and amines were added at the main powerhouse to the boiler feedwater.

**Possible Causes for the Damage**

- **Cavitation:** When microscopic vapor bubbles form due to low pressure and high temperature, they collapse on the high pressure side of the pump. Bubbles that form on the impeller surface collapse into themselves and send jets of water at velocities of 600 mph directly onto the surface of the impeller. Repeated collapsing of these microbubbles can quickly erode away an impeller.

- **Low pH:** Acidic conditions are corrosive to carbon steel which is the material of construction for this impeller.

**Causes Revealed**

The Gas Plant operators were questioned, and the water flow and uses were traced down. Come to find out, both of these causes were happening together!
• **Cavitation:** The condensate tank was run dry or low numerous times due to level control problems. When proper head pressure is not maintained on a hot liquid to a centrifugal pump, cavitation can occur.

• **Low pH:** This is where understanding the client's process paid off. As part of the hydrogen gas production, the raw hydrogen gas stream is purified. At one step, the gas stream is cooled down to remove water in the Knockout Gas Cooler. This water was being returned to the condensate receiving tank. This is a great water reclamation idea! The catch is that carbon dioxide is another reaction by-product of producing hydrogen gas. This water was being condensed in a carbon dioxide-rich environment forming carbonic acid in the water. When the pH of this condensed water was measured, it had a pH of approximately 5!!! As a matter of fact, I had installed a corrosion coupon in this condensate line. When I came back 90 days later to change out the coupon, not only was the corrosion coupon gone, but the coupon holder was corroded down to just a nub! Wow!

**Solution**

The Knockout Gas Cooler's condensed water was diverted to the drain instead of the condensate receiving tank. Later, because this water was also corroding the drain, this water was piped to the boiler feedwater line instead via stainless steel lines. The deaerator that was previously being used only as a feedwater storage tank was utilized once again to drive off the carbon dioxide from the addition of this condensed water. The level control problems in the condensate receiving tank were also fixed.

**Conclusion**

The client was much calmer once the reasons for the damaged impeller were found and discussed. The client went from yelling over the bad water treatment to praising for the intimate knowledge of his water-related processes. Proof once again that our Water Management Specialists should know their client's water-related processes as good as or better than the client itself.