Dew Point Corrosion – A Case Study

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Dew point corrosion (also called low temperature corrosion) results from the attack of acidic vapors that condense over the surface of the material due to cooling down of the acidic gases. One of the more common situations involving dew point corrosion is in coal fired electric utility flue gas or air pre-heaters. This happens when the temperatures fall below the acid dew point, and in most industrial scenarios, sulfuric acid forms. Other moisture along with sulfurous ash deposits can form "acidic vapors" and attack a susceptible metal.

Some reasons why dew point corrosion occurs are:

- Air leaking from inlet to outlet—this cooling is partly caused by cold air leaking in and decreasing the gas temperature, such that it drops below the dew point temperature. The drop in temperature allows the formation of acidic vapors condensing over the surface of the material.
- Idle periods—as the boiler cools, the temperature of the external surface drops below the dew point, allowing moisture to form on the surfaces of the tubes.

One failed air heater tube made from COR-TEN™ B steel was received for corrosion analysis and examination.

The tube came from a boiler that burns bark, tire-derived fuel, and gas fuels. It has a flue gas temperature between 480 and 500°F during normal operating conditions. The as-received tube section is shown in Figure 1.

The air heater tube section exhibited corrosion on the external surface of the tube. The ends of the tube were badly damaged. In addition, the wall thickness was extremely low. A perforation was noted over most of the length of tube. Cross-sections from the air heater tube were removed at the failed area and at an area remote to the failure. The cross-sections were prepared using standard metallographic techniques of mounting, grinding, polishing, and etching. Severe wall thinning of the air heater tube was observed in the perforated area (Figure 3). The cross-section opposite from the perforation revealed deposit accumulation as well as severe wall thinning. The typical microstructure for all the air heater tube sections consisted of pearlite and carbides in a ferrite matrix. There was no heat damage observed in the microstructure of the air heater tube. In addition, no material defects were noted that contributed to the failure.

The deposits collected from the internal surface of the tube were analyzed *in-situ* using the scanning electron microscope (SEM), where elemental analysis was performed using energy dispersive X-ray spectroscopy (EDS) to determine their composition. The EDS spectrum of the chemical composition of the internal deposits is shown in Figure 2.

The deposits consist mostly of iron and oxygen. Lesser amounts of carbon, aluminum, silicon, sodium, calcium, and zinc were present. In addition, trace amounts of sodium, magnesium, phosphorus, chlorine, potassium, and chromium were present. In this case of dew point corrosion, elements such as sulfur and chlorine in a wet environment can react with the cooled vapors to form acidic compounds such as a low concentration of sulfuric acid, which is very corrosive to carbon and low alloy steels such as COR-TEN™.

In this particular case, the dew point corrosion occurred in an air heater tube. Dew point corrosion can occur in other areas of the system, such as air heaters, feed water heaters, and boilers. This section below discusses some mitigation measures to prevent dew point corrosion.

Mitigation

The following items are measures that can be used to prevent or minimize dew point corrosion are:

- Using a steam preheater to heat incoming air before it enters the preheater.
- Addition of neutralizing fuel additives like calcium or magnesium oxide/hydroxide. Such additives prevent an acidic environment.
- Controlling air leakage from perforated cold end tubes.
- Using fuels with lower sulfur content.
- Injection of ammonia to reduce the acidity of the flue gas.
    - The drawback in using ammonia is that it forms bisulfate deposits, which can lead to fouling.
- Employing a high pressure water spray of deposits on the fire side after boiler shutdown, followed by a lime wash to neutralize acidic substances.

Figure 1. **The air heater tube section in the as-received condition.**

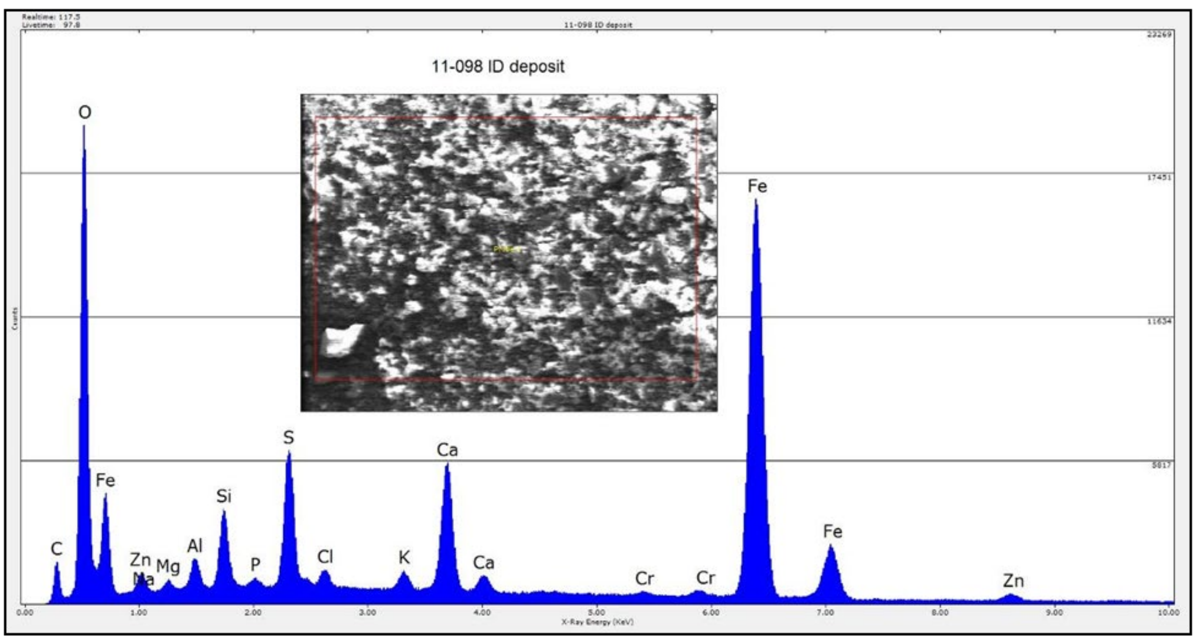
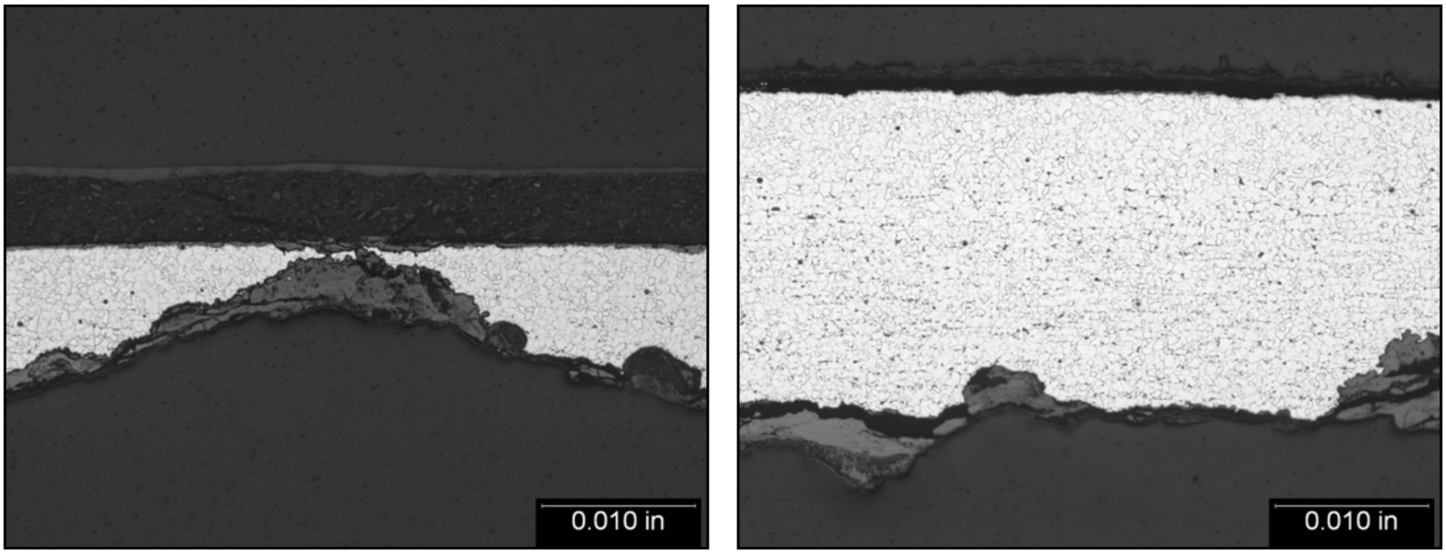


Figure 2. **EDS spectrum of the chemical composition of the deposits collected from the internal surface of the heater tube.**

Perforated Area



Opposite from Perforated Area

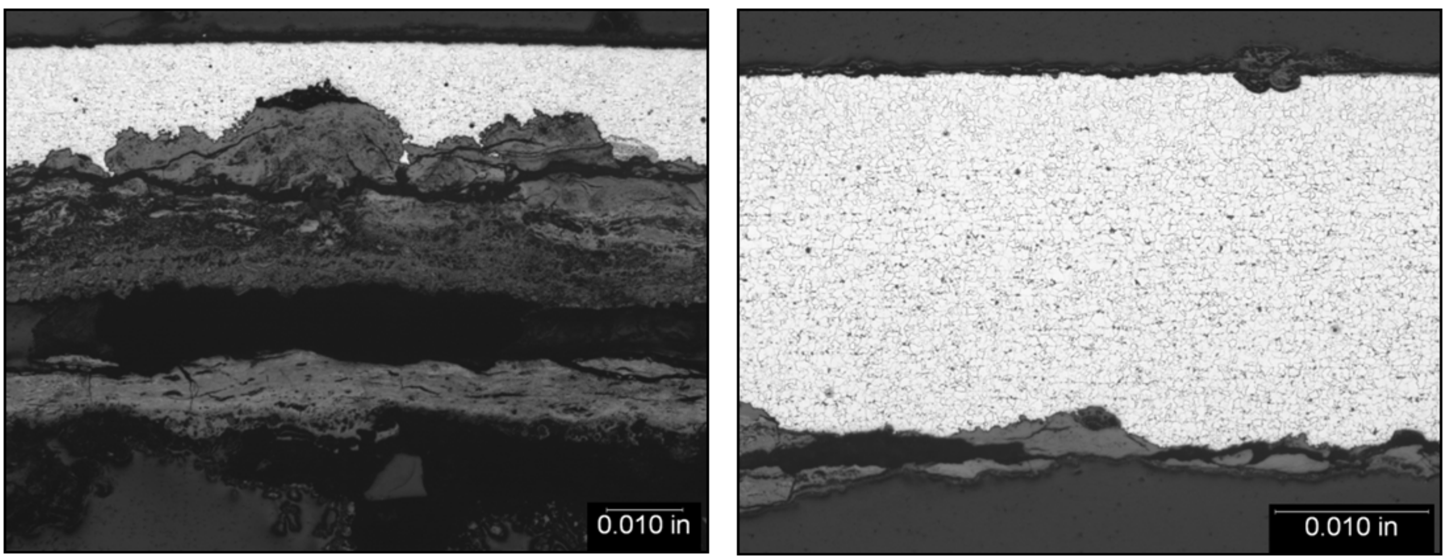


Figure 3. Micrographs show the typical view of the perforated area (top images) and remote from the failure (bottom image) of the primary heater tube.