Bulletin Board

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View From the Penthouse

July 2006

Third Quarter Topic

Oil Ash Corrosion

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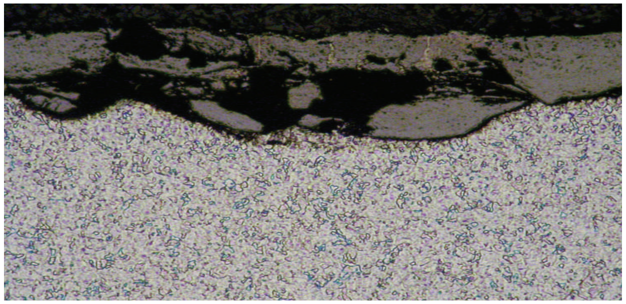
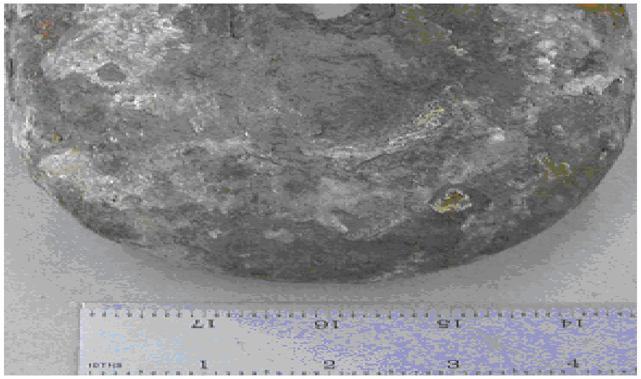
OIL ASH CORROSION

Oil ash corrosion typically occurs with fuel oil that is contaminated with a combination of sulfur, sodium, potassium, and/or vanadium. The resulting molten salts (slags) dissolve the surface oxide and enhance transportation of oxygen to the surface re-forming the iron oxide at the expense of the tube wall and or component. The liquid species of oil ash are mixtures of vanadium pentoxide, and sodium oxide, or vanadium pentoxide, and sodium sulfate so melting points below 1000ºF (538ºC) are possible depending on the precise composition. Critical factors of oil ash corrosion include concentration of molten salt forming contaminants, any metal temperatures. Reducing conditions will exacerbate oil ash corrosion. Alternate oxidizing and reducing conditions are not proven to be of any benefit in reducing oil ash corrosion.

The appearance of the oil ash deposit is found in at least two distinct layers for superheaters and reheaters. The important deposit is adjacent to the component and will appear dark gray or blackish at room temperature. The liquid sulfates sinter the corrosion debris to the surface of the tube and a hard, glassy, tenacious scale is formed. When removed, the surface of the steel will have an "alligator hide" appearance formed as shallow grooves have penetrated the steel in a cross hatched pattern.



The oxide that forms during oxygen-rich cycles is reduced or made less sound during the reducing part of the cycle. Each cycle of scale formation and removal reduces the wall thickness until the boiler tube is too thin to contain the fluid pressure, and failure occurs. The actual cause of the wastage is the rapid oxidation of clean, unprotected steel.



Corrosion on the higher-temperature regions of the superheater tubes depends on the fuel and impurities in the fuel. The culprits that lead to rapid corrosion wastage for oil-fired boilers are ash constituents of vanadium, sodium, and sulfur. Impurities and the compounds they form cause corrosion and are exacerbated by the addition of chlorine. Seawater in oil that is transported in ocean-going vessels will find a way to the ash deposits after combustion. The most serious form of fire-side corrosion develops when low melting-point species of sulfur (and chlorine) form at the operating temperatures. The "bad actors" for oil-fired boilers, are sulfates. The low melting-point sulfur compounds that form depend on the furnace location of the component affected. For superheaters, the liquid species are the sodium and potassium iron trisulfates, which have melting points between 1030°F and 1130 °F, depending on the atomic ration of sodium and potassium. It might be pointed out here the volumes of these liquid species may be small, only a few percent of the total ash volume. The low melting-point chlorides may have melting temperatures as low as 550° F for fuels with chlorine. In oil-fired boilers, vanadium pentoxide, sodium oxide, and sodium sulfate form liquids which melt at temperatures of about 1000°F, dependant on the composition. The corrosion mechanism is similar regardless of the low melting-point species that form. The protective iron oxide dissolves in these sulfate, vanadate, and chloride liquids. The metal re-forms an oxide; and the wastage rate is perhaps in an order of magnitude faster than without low-melting point species.