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A VIEW FROM THE PENTHOUSE: USEFUL INFORMATION FOR THE WORLD OF BOILERS

DEW POINT CORROSION

The combustion of most fossil fuels, natural gas being the obvious exception, produces flue gases that contain both sulfur dioxide (SO_2), sulfur trioxide (SO_3), water vapor (H_2O) and possibly hydrochloric acid (HCl). At some temperature, these gases condense to form sulfurous (H_2SO_3), sulfuric (H_2SO_4), and perhaps hydrochloric acid (HCl). The exact dew point depends on the concentration of these gaseous species, but is around 300°F. Thus surfaces cooler than saturation temperature are likely locations for dew-point corrosion. Any point along the flue-gas path from combustion in the furnace to the top of the chimney are possible sites.

In boiler terminology "acid dew point" refers to the H_2SO_4 dew point as this is the highest dew-point temperature. Both H_2SO_3 and HCl acids condense at lower temperatures than H_2SO_4. While the precise dew point for H_2SO_4 formation depends on the SO_3 concentration, at 10 ppm SO_3 in the flue gas, the dew point is 280°F. Most flue-gas compositions have less than 10 ppm SO_3 so the actual dew point is somewhat less.

Dew-point corrosion is exacerbated in coal-fired boilers by the presence of fly ash. Fly ash accumulates throughout the flue-gas path and the resultant fly-ash deposit acts like a sponge to collect both moisture and acid especially during shutdown cycles. Figures 1 and 2 present a finned-tube economizer that has suffered severe wastage due to dew-point corrosion. Figure 1 shows the loss of the fins and Figure 2 documents the wastage of the tube itself. Compare the tube-wall thicknesses on opposite sides of the tube. Fly ash remains between the fins to trap sulfuric acid. Acid smuts occur when the gas temperature is less than the dew point and H_2SO_4 forms on fly ash particles.

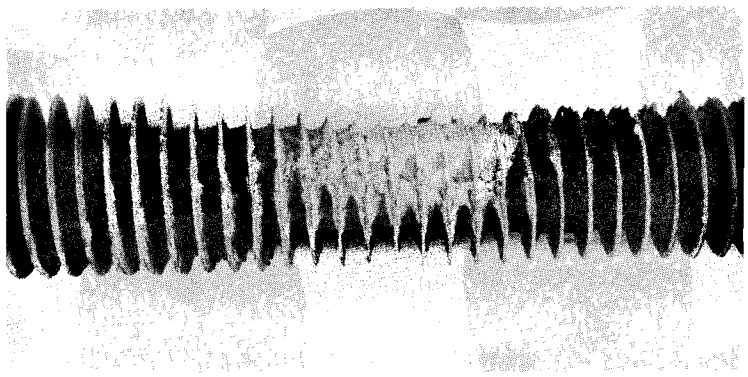

Figure 1.

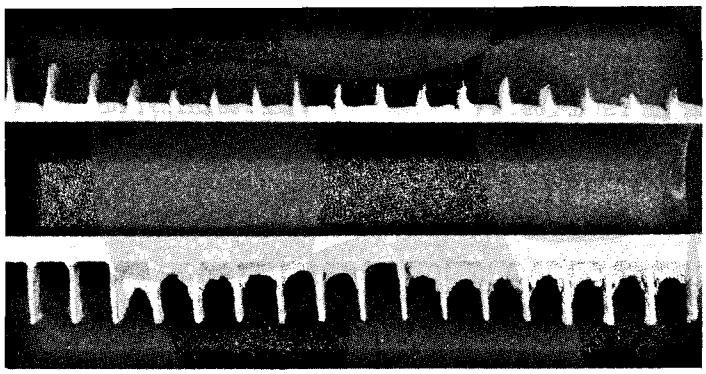

Figure 2.

The fly ash-sulfuric acid corrodes the steel in two ways: (1) the normal sulfuric acid corrosion of steel and (2) crevice corrosion which causes differential aeration and/or concentration cells that leads to a localized pitting attack. Thus the corrosion rate under the fly ash can be considerably faster than simple dew-point corrosion alone.

SUSCEPTIBLE AREAS

Any location where air in-leakage occurs that locally reduces metal temperatures to

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less than about 300°F are candidate sites. These locations would include: (1) the penthouse. Flue gas can leak into the penthouse from the furnace through broken or damaged seals surrounding superheater or reheater tubes. The flue-gas leakage will corrode the casing and support steel, especially those supports that pass through to the casing to the steel framework. These are apt to be cool enough to allow dew-point condensation. (2) Air Heater. The air heater cold end is perhaps the most obvious location for dew-point corrosion. The air heater is intended to take ambient air and raise its temperature to improve combustion efficiency. (3) Duct Work, Expansion Joints, Inspection Doors, Sampling Ports and Access Doors. Air and leakage from poor seals and weld defects cools these zones well below the dew point. (4) Electrostatic Precipitators and Filter Bag Houses. Dew-point corrosion in these components is usually caused by air in-leakage. Occasionally poor flue-gas circulation leaves dead zones that under low load conditions may cool enough to lead to dew-point corrosion. Corrosion is particularly difficult because many of the carbon steel structures are thin plates which can be perforated in a relatively short period of time. (5) Induced Fans. Poor housekeeping allows air in-leakage through defective seals, at which, again, if the metal temperature is less than about 300°F, dew-point corrosion occurs. (6) Chimneys: - Especially at the top, air temperatures are likely to be less than 300°F. At the very bottom where rain water can collect and air in-leakage through access doors are also principal sites for dew-point corrosion.

MATERIALS SELECTION

Expensive, high-alloy steels, similar to the austenitic stainless steels, or the nickel-base Incoloy or Hastaloy grades do not often work as well as expected. This is particularly true in coal-fired boilers where fly-ash accumulation causes differential aeration and concentration cells that lead to pitting attack. This form of corrosion is usually referred to as "crevice corrosion" or "crevice-corrosion attack". While these high alloys would be virtually immune to sulfuric acid corrosion alone, the fly-ash accumulation can cause severe wastage by crevice corrosion.

Coatings generally are not recommended on existing equipment to correct an existing problem. The coatings are impossible to apply thoroughly and poor surface preparation leads to poor coating quality. On new construction where the coating application is under better-controlled conditions, satisfactory service may be achieved.

Additives, usually based on MgO or $Mg(OH)_2$ have been used for a number of years with success. The MgO reacts with the SO_2-SO_3 to form magnesium sulfite ($MgSO_3$) or magnesium sulfate ($MgSO_4$). Without sulfur dioxide-sulfur trioxide present in the flue gas, no acid condensation can occur. The direct injection of NH_3 (ammonia) has been used to reduce acidity but forms other deposits. These may include bisulfates that become sticky and may lead to increased corrosion by a crevice corrosion mechanism.

In summary, the easiest way to prevent dew-point corrosion problems is to take care of the housekeeping to prevent air in-leakage. Keep metal temperatures about 300°F.

REMEMBER: FOR METALLURGICAL HELP WITH YOUR BOILER PROBLEMS, AFTER JULY 16, THE NUMBER TO CALL IS (508) 393-3635 THE NEW TELEPHONE NUMBER OF DAVID N. FRENCH, INC., METALLURGISTS

NAMES OF OTHERS WHO MIGHT BE INTERESTED IN RECEIVING OUR NEWSLETTER:

NAME:_____ COMPANY:_____

ADDRESS:_____

SUBJECTS YOU WOULD LIKE TO SEE ADDRESSED:_____