Bulletin Board

MAY 9—12, 2006

Louisville, Kentucky

September 26—29, 2006

Scottsdale Arizona

United Dynamics "AT" Corporation

&

David N. French Metallurgists

Present

A Practical Approach to Boiler Tube Failures

A four day combined class

Register online @ **www.udc.net**

NDE SERVICES

- Visual
- Liquid Penetrant Testing
- Magnetic Particle Testing
- Ultrasonic Testing

New Offerings

- Field Replications
- Oxide Thickness Measurements

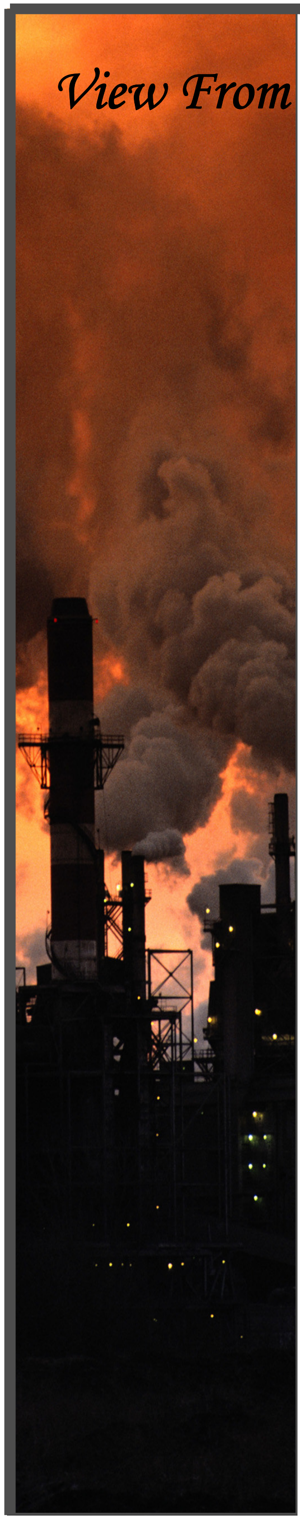
mpannell@udc.net *Sales @udc.net*

DAVID N. FRENCH METALLURGISTS
Corporate Headquarters
2681 Coral Ridge Road
Brooks, KY 40109

www.davidnfrench.com

UDC
United Dynamics Corporation
David N French Metallurgists
2681 Coral Ridge Road
Brooks, KY 40109

«AddressBlock»



View From the Penthouse

APRIL
2006

Second Quarter Topic

Waterside Deposits

DAVID
N.
FRENCH
METALLURGISTS

View From The Penthouse
The DNFM Quarterly Newsletter
DAVID N. FRENCH METALLURGISTS
Ph 502.955.9847 Fax 502.957.5441 www.davidnfrench.com

Waterside Deposits

Waterside deposits are the result of one of the following mechanisms:

(1) Iron oxide formed by the reaction of water and steel, usually referred to as scale
(2) Water impurities improperly or incompletely removed by treatment
(3) Water treatment chemicals intentionally added as part of the water conditioning
(4) Contaminated condensate
(5) Corrosion products

The detrimental effects of waterside deposits are the result of two factors. Invariably the thermal conductivity of these deposits is substantially less than that of steel. The thermal conductivity of carbon steel, commonly utilized for waterwall construction, is around 300 BTU/hr-sq. ft. °F/in. The majority of deposits have a conductivity in the range of less than 1 for a porous silicate scale, to around 25 BTU/hr-sq. ft.-°F/in. The net effect of this insulating barrier on the waterside of the tube is to raise the tube-metal temperature. Excessive scale and/or deposits can thus lead to creep failures within the furnace tubes of a boiler.

The second effect; porous deposits concentrate hydroxide (or acid where there is a pH upset) at the deposit/tube interface. This drastic change in pH leads to under-deposit corrosion and/ or hydrogen damage. The mechanism of concentration is: deposits become saturated with water at the metal deposit interface then steam is formed as the tube is hotter than the deposit and the water. The dissolved solids that were in the water, now steam, are left behind within the deposit, resulting in a concentration which may alter the pH to very corrosive levels. Normal pH conditions (8.5—9.5) where concentrated liquid has a pH in the 12—13 range, which is strongly basic. When acid enters the boiler during an upset, or is left behind after chemical cleaning, the concentrated liquid will have a pH in the 2—3 range, strongly acidic and will result in under-deposit corrosion, tube wastage, or hydrogen damage.

The effects and creep damage due to scale formation and under-deposit corrosion may occur in different locations within the same boiler. Observations have been made determining that depending on the heat flux, rate of corrosion, amount of scale, tube-metal temperature increase, etc., combinations of both creep failures and hydrogen damage are found in differing locations in the same boiler.

(1) The most common waterside scale component is iron oxide. Magnetite scales are endemic, as the boiler is built of ferrous alloys; even pure water will react with steel to form iron oxide. The oxide may be formed in place or elsewhere within the boiler then transported to deposit on the high-heat-flux regions of the furnace.

(2) Deposits formed from water impurities are associated with calcium or magnesium carbonate, the so-called “hardness salts,” silica, and magnesium chloride. Calcium with anions of carbonate, sulfate, chloride, bicarbonate, or silicates will form the insoluble salts: calcium carbonate, calcium sulfate, and calcium silicate. Magnesium with hydroxide, silicates, or phosphates, will also form insoluble forms of magnesium phosphate. When there are silicates present there may also be iron, sodium, aluminum and sodium cations. Under rarer and more unusual conditions, essentially pure silica deposits will form. When magnesium chloride intrudes into high-temperature boiler water resulting in a condenser leak for example, the precipitation of insoluble magnesium hydroxide will lead to the formation of hydrochloric acid. Hydrochloric acid will concentrate within the porous deposits, as previously mentioned, and lead to rapid acid attack, wall thinning, and hydrogen damage.

(3) Water treatment chemicals, in the presence of calcium and magnesium, will form insoluble calcium phosphate or magnesium phosphate.

(4) Waterside deposits forming as a result of contaminated condensate obviously depend on the form of contamination. Under unusual circumstances, oil may contaminate the boiler feedwater carbonizing on the hotter tube surfaces, thus depending on the level of contamination leaves a difficult-to-remove carbonaceous deposit. Further contamination may come from condenser leaks which would inject raw water and/or sea water, depending on the type of water used for condenser cooling.

(5) Products of the corrosion condensers or feedwater heaters will also show up within the waterside deposits. Condenser and feedwater heaters tubed with copper/zinc (brass) or copper/nickel (monel) alloys will lead to zinc, nickel, and metallic copper in the waterside deposits. In fact, detection of copper, zinc, or nickel will often be the first confirmation of corrosion within the condenser or feedwater heater. Soluble iron, as ferrous bicarbonate, on occasion may be found in make-up water. Iron in this form may precipitate when either heated or exposed to oxygen. Iron oxides (Fe^2O^3) will precipitate from the ferrous bicarbonate as it reacts with water to form ferrous hydroxide. The liberation of carbon dioxide gas in this reaction may also alter the pH and lead to corrosion.

Table I Deposit Analysis %

Fe…67.2	Ca...0.79	Mg...0.15	Si… 0.98	Mn… 0.40
Al… 0.29	Na...0.92	Mo...0.02	Ni… 1.25	Cr 0.07
Zn… 0.15	Cu...2.10	P…..0.47	Ti..< 0.01	Sn..< 0.10

The nickel, copper, and zinc presumably come from feedwater heaters or condenser corrosion. Manganese is present because the boiler steels contain somewhere between 0.4% and 0.8% manganese. It would be expected to be similar to iron in its oxidation behavior. The other elements detected , calcium, silicon, magnesium, and aluminum are likely to be water impurities. Sodium and phosphorus are from pH control compounds, sodium phosphates.

When waterside deposits reach some thickness whereby heat transfer is impeded and tube-metal temperatures may rise to dangerous levels, chemical cleaning is recommended. The Atwood and Hale analysis is the most widely used recommendation for determining the need for chemical cleaning. Basically, this technique removes the waterside deposit from the hot or fireside of the tube and measures the amount. At a deposit loading above 40 gms / sq. ft., immediate chemical cleaning is recommended. For deposit loadings between 15 and 40 gms / sq. ft., chemical cleaning is recommended at the next annual outage. Lastly, deposit loadings less than 15 gms/ sq. ft., require no chemical cleaning.

There may be variations in the actual measurements based on the method of removal of these waterside deposits. There may also be substantial variation in the amount of deposits, from the fireside and the cold side as well as along the fireside itself. The most severe deposits will be at the highest metal temperatures which are midway between the membranes. From a heat-transfer viewpoint a waterside deposit of 2—3 mils thick, may increase tube metal temperatures by 50°—100°F depending on the heat flux. Thus at a deposit thickness of 3 mils at the point thickest measurement, it is time for chemical cleaning.

Whatever technique is used to remove these deposits, the intent is to return the heat transfer surfaces to a clean condition thus preventing over heating and under-deposit corrosion of the furnace tubes.