Magnetec Monthly Chronicle

Issue No.12 " FROM THE FIELD " December 2005

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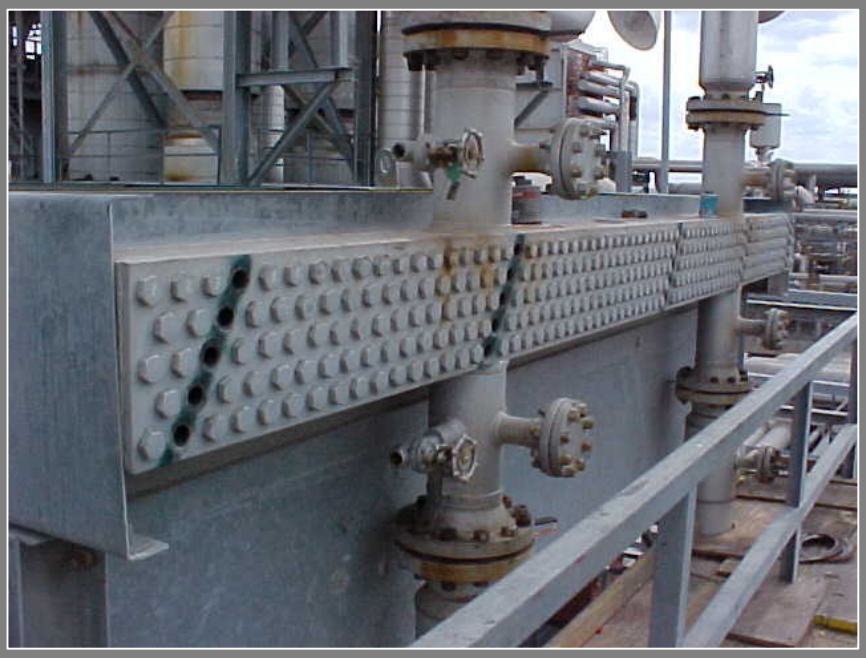
Magnetic Inspection, Inc.

Reactor Effluent Condensers



Excellence in Eddy Current Inspection Technology & Failure Analysis

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A Major Issue for the Refining Industry

Subject: Reactor Effluent Overhead Condensers
Ammonium Bisulfide Corrosion

The overhead finfan exchangers were located in a Hydrotreater unit in a major Southern coast refinery. The finfan was inspected due to recent tube leaks which had caused multiple unit crashes.

The units were inspected to determine if a 6 month run could be made with selective tube plugging. The exchangers operate in a 6 bank unit with reactor effluent overhead process feed. The tubing consists of 352 straight tubes – 1" X .125 min wall X SA-210 X 32 Foot long. The finfan banks had been previously inspected prior to current inspection and the active corrosion mechanism has been documented with depths of 55% in random tubing. The tubing was documented with severe pitting in the tube length with the greatest concentration of corrosion zones near/adjacent to the forced draft fans (Highest thermal differential). The inspection scheme was performed on 100% of the tubing across the entire bundle matrix to correlate the previously detected corrosion with current conditions. A review of operating conditions found the water wash injection to be at half rates in all of the condensers and completely blocked in one unit. Ammonium bisulfide corrosion of reactor effluent air coolers & stripper overhead condensers is

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a major issue for the refining industry. Most overhead systems have some degree of corrosion attack based operating conditions and corrosion control equipment. This type of corrosion has already resulted in major equipment failures, fires and explosions. Organic sulfur and nitrogen compounds are converted to hydrogen sulfide and ammonia in hydrotreater reactors. When the effluent is cooled below 250 F, the gases combine to form ammonium bisulfide (ABS) salt. To prevent accumulation of the salt, water is injected before the reactor effluent cools to the ammonium bisulfide deposition temperature. Change in feedstock, upset conditions and/or wash water injection problems result in plugging of some exchanger tubes causing under-deposit corrosion. The critical factor in controlling this type of corrosion is the design of a balanced (symmetrical) distribution piping of the air coolers and of an appropriate wash water injection.

Ammonium bisulfide corrosion is an aggressive corrosion occurring in several refinery units, including hydrotreaters. Common locations for corrosion are in the inlet header box of the reactor effluent F/F exchangers, piping elbows and welds with excessive I.D. weld metal penetration. Corrosion rates as high as 200 mpy have been observed in aggressive ammonium bisulfide solutions. Carbon steel is least resistant and can experience high corrosion rates in aggressive

solutions. The 300 series stainless steels, duplex stainless steels, aluminum alloys and nickel base alloys are more resistant, depending on ammonium bisulfide (NH4HS) concentration and velocity. Duplex stainless steels can experience sulfide stress cracking and/or hydrogen embrittlement.

Velocity is also a factor in ammonium bisulfide corrosion and limiting rates above which corrosion can be a problem have been published. Corrosion can occur in the presence of high concentrations and velocities of aqueous NH4HS or under deposited salts.

NH4HS salts precipitate in the reactor effluent streams when temperatures drop below the dew point at the prevailing partial pressures of ammonia and hydrogen sulfide. Corrosion may be found at the following locations:

1. Air cooler header boxes
2. Inlet and outlet piping of air coolers, as well as exchanger tubes
3. Piping into and out of the reactor effluent separators.
4. Sour water draw piping from reactor effluent separators (flashing may cause severe erosion-corrosion downstream of control valves)
5. Vapor line from the high pressure separators
6. Hydrocarbon lines from reactor effluent separators due to entrained sour water
7. Stripper column overhead sour water

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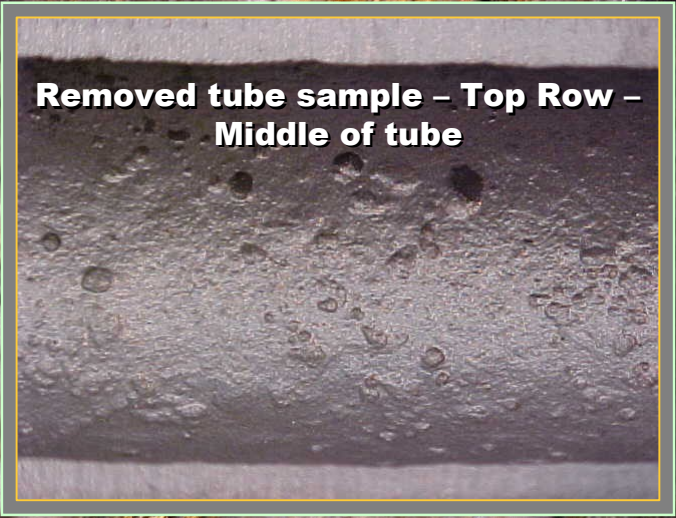
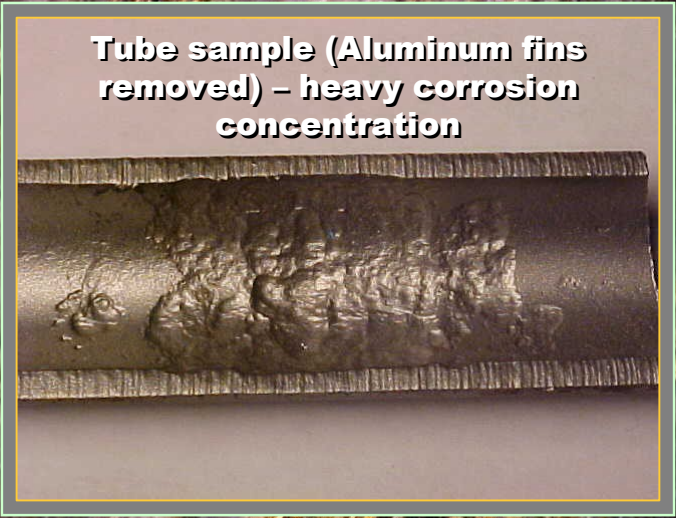
Ammonia bisulfide corrosion/pitting within roll area



Removed tube sample – Top Row – Middle of tube

Heavy fouling and tube end corrosion



Tube sample (Aluminum fins removed) – heavy corrosion concentration

Video probe view of corrosion zone

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