BOILER SYSTEM FAILURES

Analysis & Diagnostics Manual

EXAMPLES OF ISSUES IN SPECIFIC BOILER SYSTEM COMPONENTS

Metallurgy

Volume 2.0 | Boiler Systems

ChemTreat®

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Section I. Economizers

Economizer Tubes

Return bends outside the flue gas envelope.

Return bends outside of gas passage.
External surfaces prone to corrosion if not protected from moisture

Top view of finned economizer tubes

Section of fouled, finned economizer tubes

External deposits containing sulfur compounds—
from burning high sulfur oil

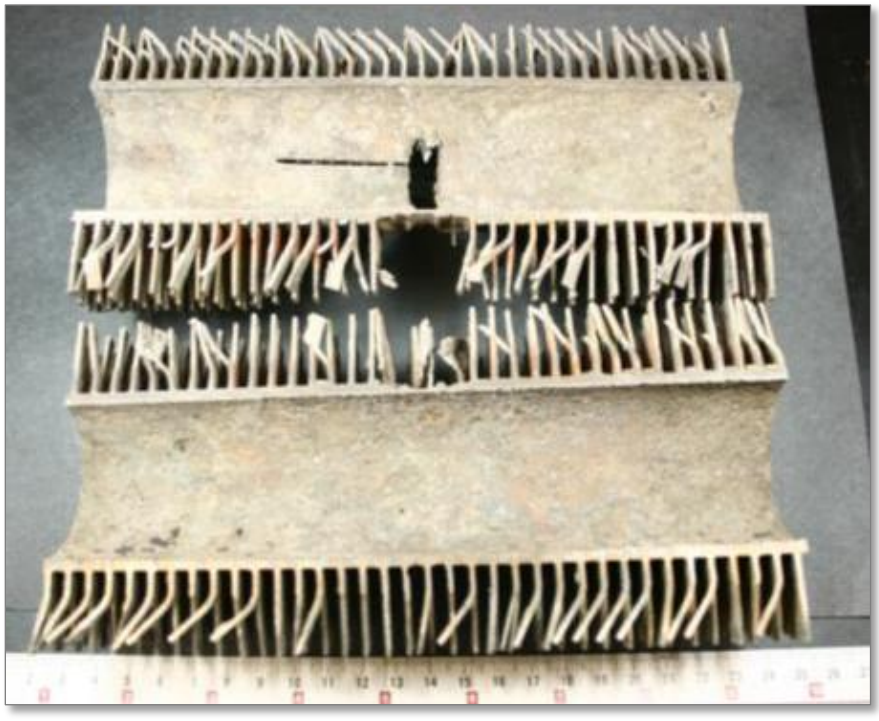
Bare economizer tube sections before cleaning

Close-up after cleaning, showing external surface metal loss

Economizer tube cross section after cleaning, showing surface metal loss due to burning high sulfur #6 oil. Sulfuric acid forms on the tube surface when operating below the H_2SO_4 dew point, ~ 267 °F.

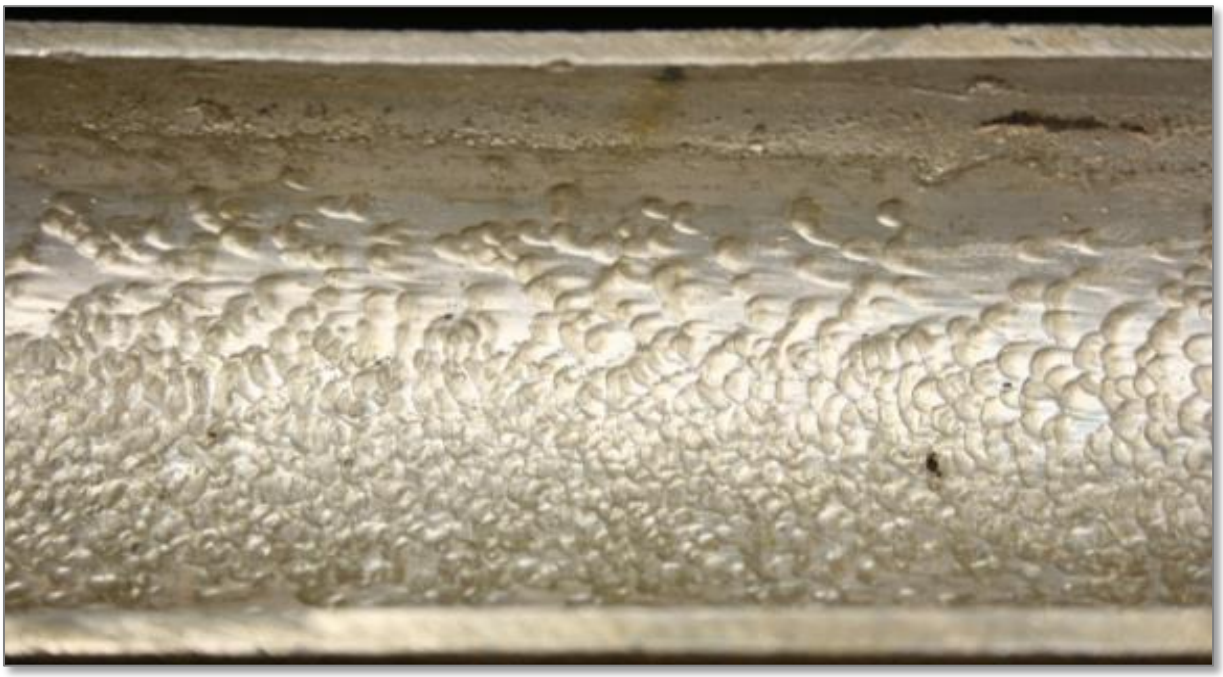
Finned economizer tube failure

Tube removed and split longitudinally, before cleaning



After cleaning with inhibited HCL

Tube section, cleaned in dilute inhibited hydrochloric acid
Oxygen pitting evident after cleaning



FAC in an economizer tube

Section II. Deaerators

Deaerator Trays & Spray Zone

Distorted and collapsed deaerator trays

Deaerator spray zone corrosion on SS shell due to high chlorides

Deaerator Inlet Header Spray Pipe

Deaerator inlet header spray pipe failure

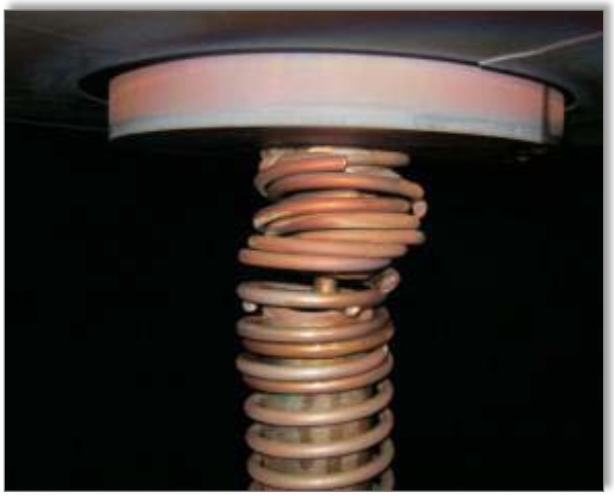
Deaerator inlet header spray pipe failure

Deaerator Venting: Steam Flow

Extreme, excessive deaerator venting: Standard vent line and 4" bypass line flowing at very high rates. Root cause was the deaerator steam supply PRV stuck open, over pressurizing the system and lifting the multiport bypass relief valve. Result: 24,000 lbs. per hour of steam being wasted to atmosphere

Normal venting: 4 inch bypass valve off and more normal vent line flow after replacing the pressure reducing valve

Deaerator Spray Valve Failures



Deaerator spray valve spring failure

Normal deaerator spray valve bell

Mechanically damaged deaerator spray valve

Section III. Firetube Boilers

Tubes showing surface iron deposits and flash rusting

Tubes viewed from man-way, white deposits from evaporation to dryness

Oxygen pitting, before cleaning

Oxygen pitting, after cleaning

Oxygen pitting before cleaning – resulting from oxygen intrusion during offline storage

Oxygen pitting after cleaning

Feedwater Line

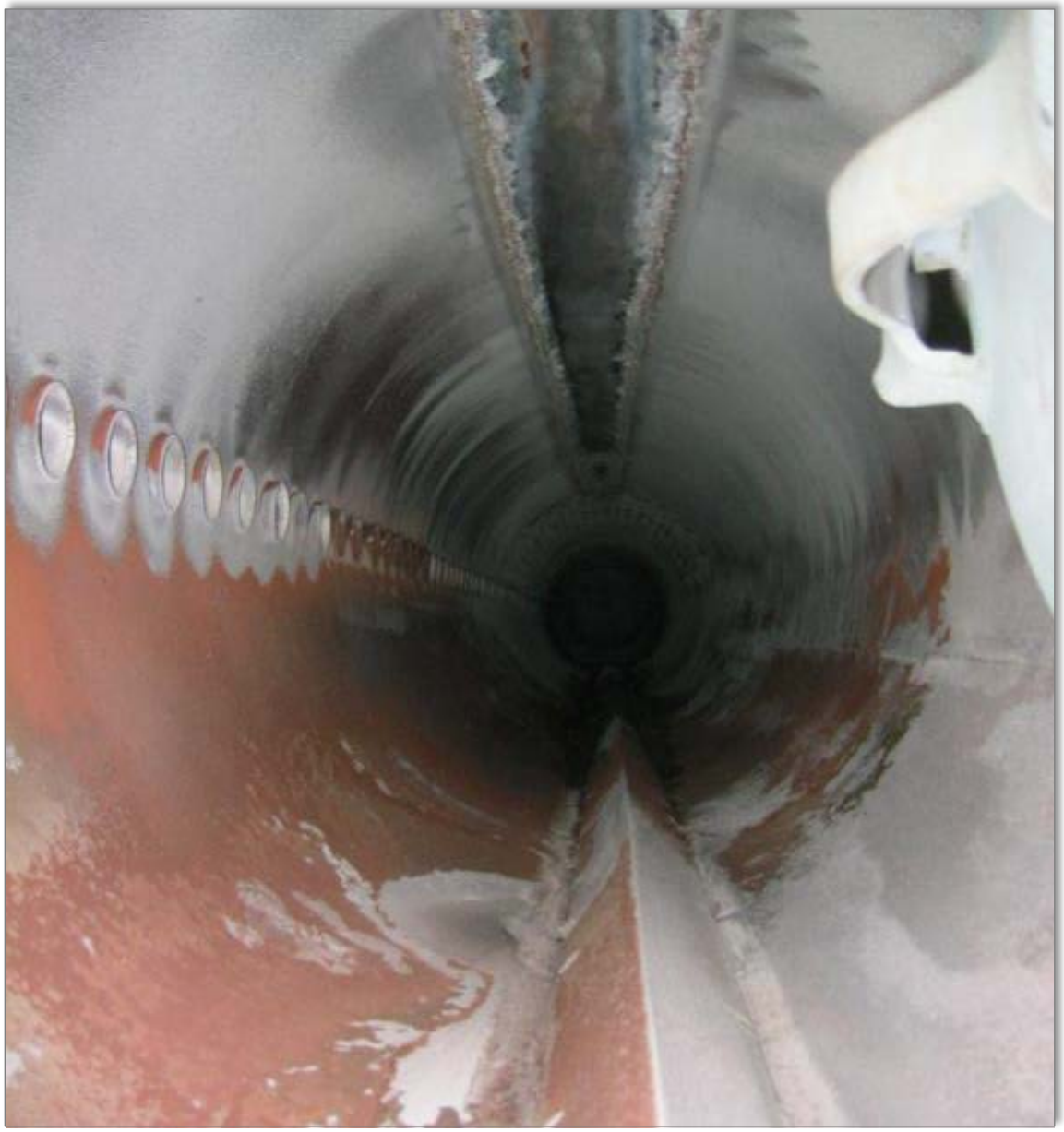
Feedwater line deposits – multiple hardness upsets in 100 year old system

Feedwater line deposits due to years of repetitive hardness intrusion

Boiler Lower Crossover Header

Overhead deposits due to external protective refractory loss allowed furnace gases to penetrate to top of the header and cause steam blanketing and concentration of boiler water, localized corrosion and evaporation to dryness on internal header surface.

Boiler Lower Drum



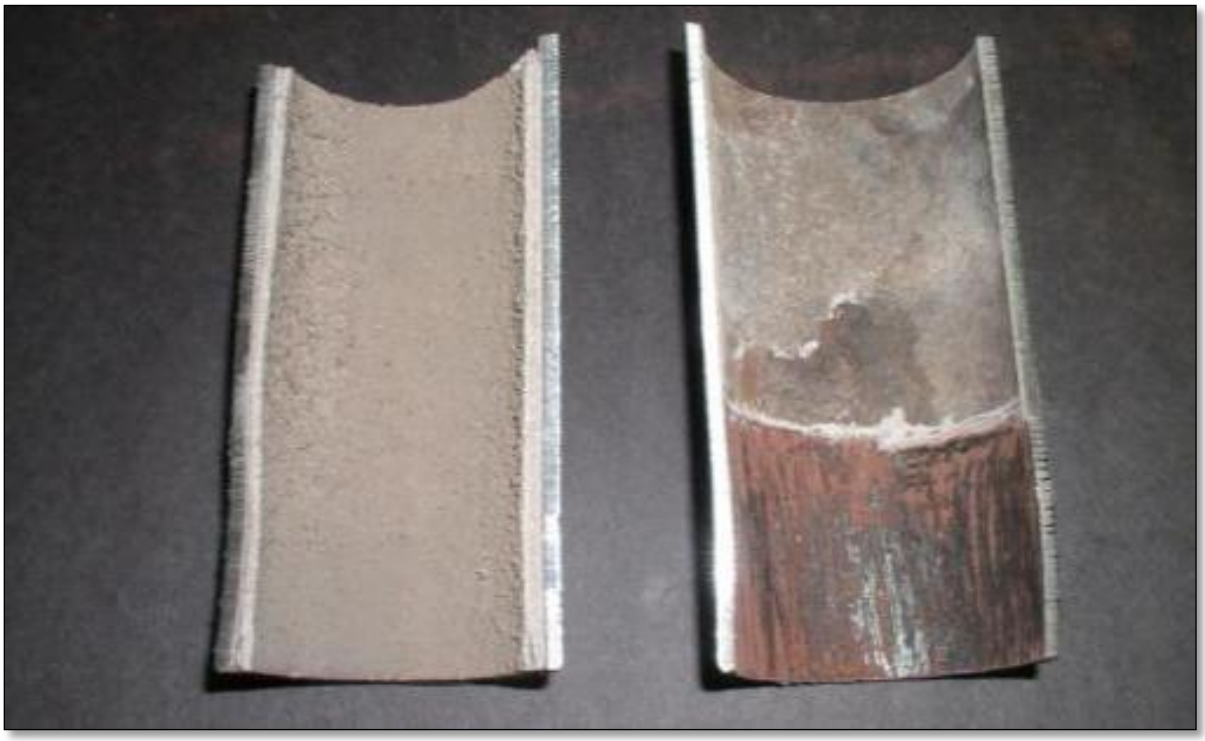
Deposits formed in the top of the drum due to refractory brick deterioration on the furnace floor above allowing hot combustion gases to penetrate through to top of the mud drum and cause steam blanketing and concentration of boiler water, localized corrosion and evaporation to dryness on internal drum surface. Deposits sloughed form tubes have accumulated at the bottom of the drum, partially blocking the inverted blowdown channel ports.

Boiler Tube Scale, Deposits & Blisters/Bulges

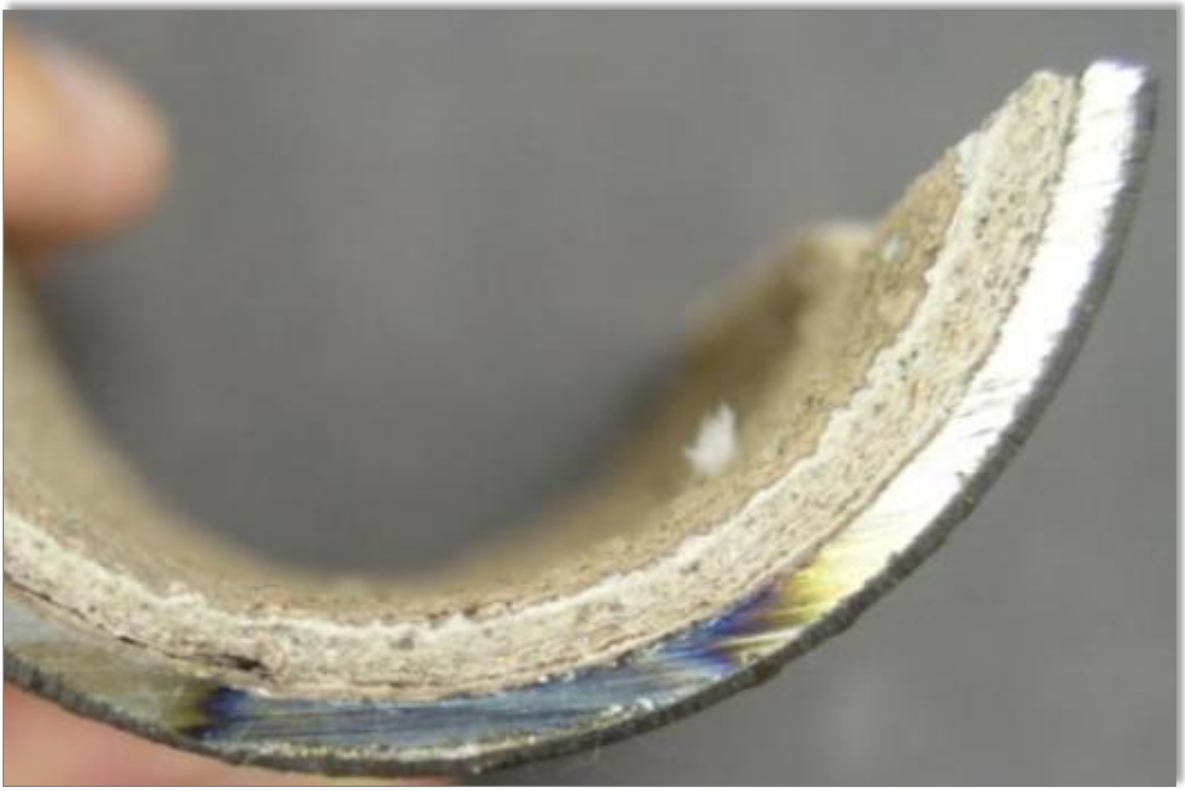
Boiler tube with iron and silica scale

1.5" diameter wall tube from watertube boiler. Layered phosphate and iron deposits from years of multiple feedwater hardness and internal water treatment chemistry upsets.

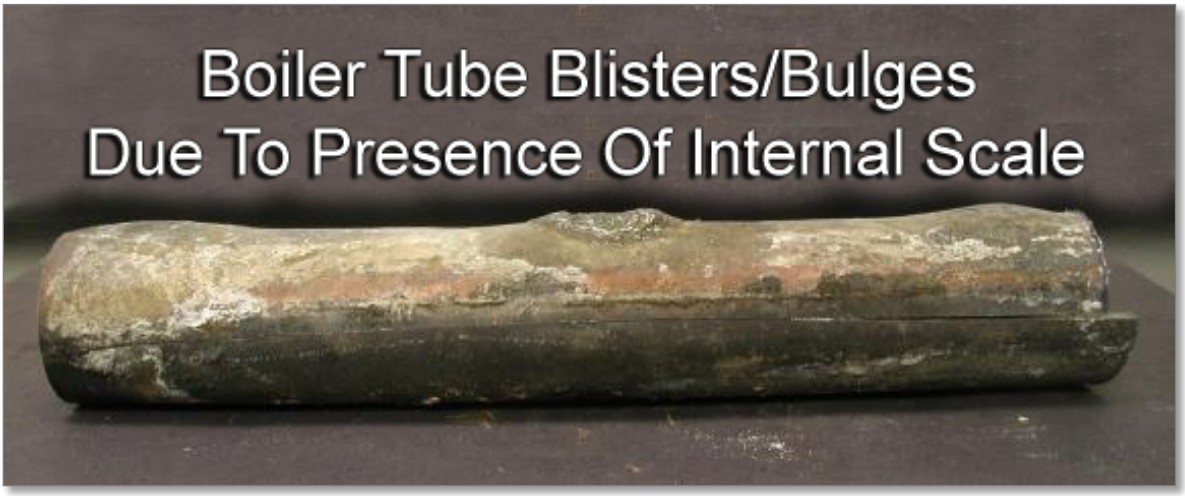
Inclined overhead boiler tube – deposits on the inside (bottom) surface facing the furnace



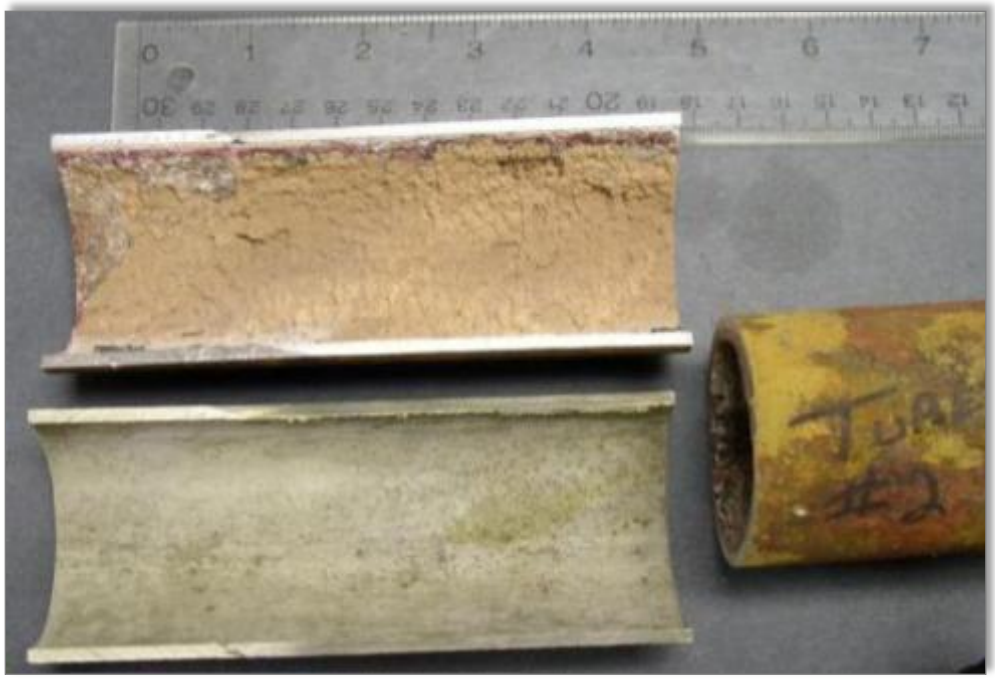
Tube mineral scale removed for deposit weight density determination. Scrape and weigh method vs. glass bead blasting



Tube scale layering due to multiple feedwater hardness excursions



Internal surface scale restricted thru-wall heat transfer causing the tube metal to overheat, bulge, and ultimately fail.



Tube with as-received (top) and as-cleaned (bottom) sections

Rare example of a furnace wall tube section showing the effect of differential deposition from furnace zone radiant heat input (top side) vs. convection zone return gas passage (bottom side).

Tube Failures: Long Term Creep & Thick Lip Failure

Generating tube elongated due to slow metal creep from long term overheating

Thick lip failure due to metal creep from long term overheating
Lines of stretch marks visible beside tube failure

Tube Failures: Thin Lip Failures

Thin lip failure due to rapid overheating

Thin lip failure due to rapid overheating

Tube Failures: Catastrophic Failure

Crossover tube from upper header failed due to internal corrosion caused by oxygen pitting during layup. Several tubes sagged over time and were not corrected, resulting in incomplete draining of boiler water when off-line. Oxygen pitting at the internal stagnant waterline ultimately resulted in sudden tube failure.

Top back plenum section of the 650 psig field erected boiler – severe damage caused by a single tube failure. The rapid steam release from the failed tube suddenly enveloped the plenum, momentarily raised the roof of the boiler and blew out the back wall.

Tube Failures: Stress Cracking

Stress crack opposite membrane weld, coincident with internal deposits which restricted heat transfer

Rifled, high pressure boiler generating tube, after cleaning. Damage from condenser leak introduced chlorides from the cooling water, lowered the pH and deposited copper in the valleys of the tube. Copper since removed by cleaning with inhibited HCL.

Tube Failures: Weld Overlay Leak Repair

Heavy weld overlay to repair a tube leak

Internal tube surface cracks developed under coincident external surface weld overlay to repair a tube leak.

Tube Failures: Hydrogen Damage

Hydrogen damage to high pressure boiler tube

Hydrogen damage to high pressure boiler tube

Tube Failures: Flame Impingement

Flame impingement – rear wall

Flame impingement – back corner of furnace

Tube surface metal exfoliation due to flame impingement, overheating

Tube metal creep and failure due to overheating from flame impingement

Tube surface damage resulting from flame impingement

Weld overlay to repair furnace tube bulges resulting from flame impingement

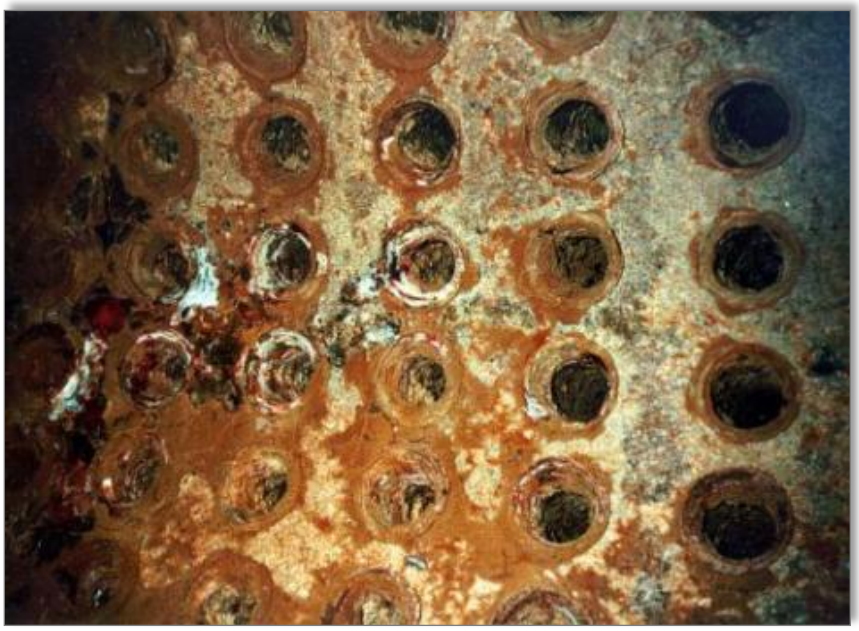
Section V. Steam Line Deposits

Deposits in 3 inch steam line, result of repeated instances of boiler water carryover

Deposits in 6 inch diameter steam line due to long term intermittent boiler water carryover

Steam line deposits

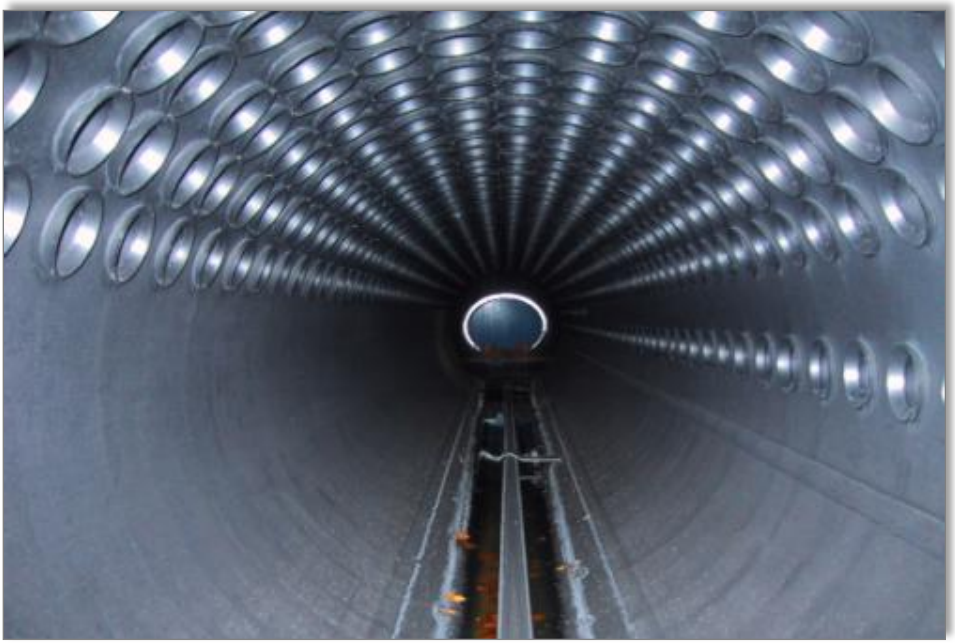
Section VI. Mud Drum & Steam Drum Conditions



Mud drum, interior overhead view: Heavy iron, calcium and silica deposits caused by years of poor feedwater quality resulting in deposition throughout the boiler

Steam drum: Extreme, excessive quantity of scale and surface deposits

Section VII. Boiler Drums & Tubes



Clean mud drum and tubes

Clean steam drum downcomer tubes, deposit fouled steam diffuser screen and boiler drum sidewalls

Steam drum surface deposition below waterline

Steam drum surface after two years on an internal cleanup program

Section VIII. Boiler Water Sight Glass Failure

Boiler sight glass deterioration due to high alkalinity boiler water. Failure due to crack in protective mica shield, allowing boiler water with high hydroxide alkalinity to have direct contact with and dissolve the borosilicate glass.

Section IX. Superheater Tube Failures

Crack initiation at radial weld

Spiral crack development

Back side of tube

Additional surface crack formation

Superheater tube showing crack initiation at surface weld, progressive spiral tube crack due to operational stress. Rear of tube shows additional crack formation in the tube metal due to stress – away from the field weld.

Finned superheater tube removed from a HSRG

Internal surface of finned SH tube showing deposits from boiler water carryover

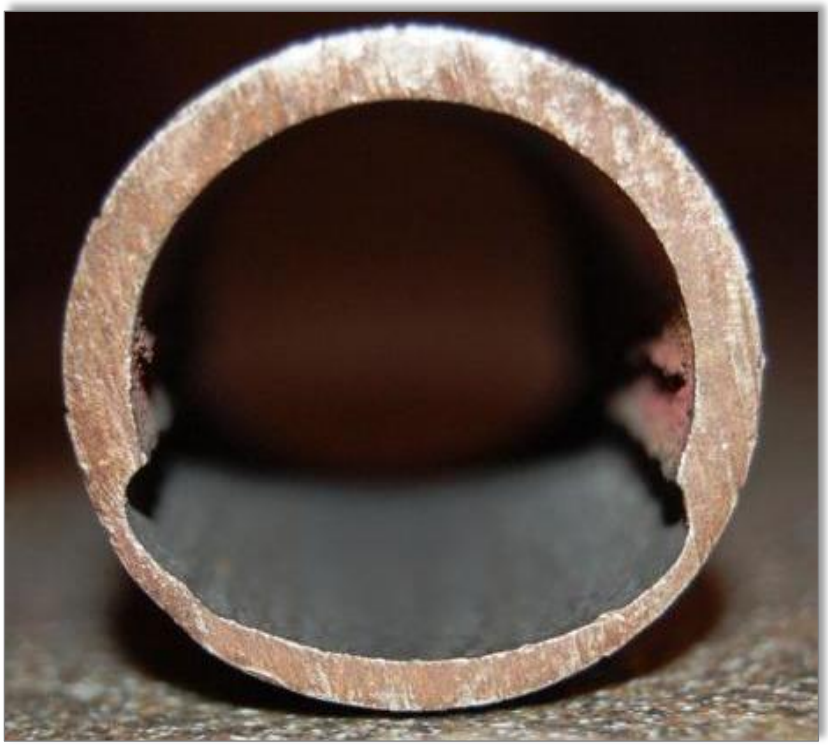
Heavy magnetite formation in a superheater tube

Superheater tube bulges

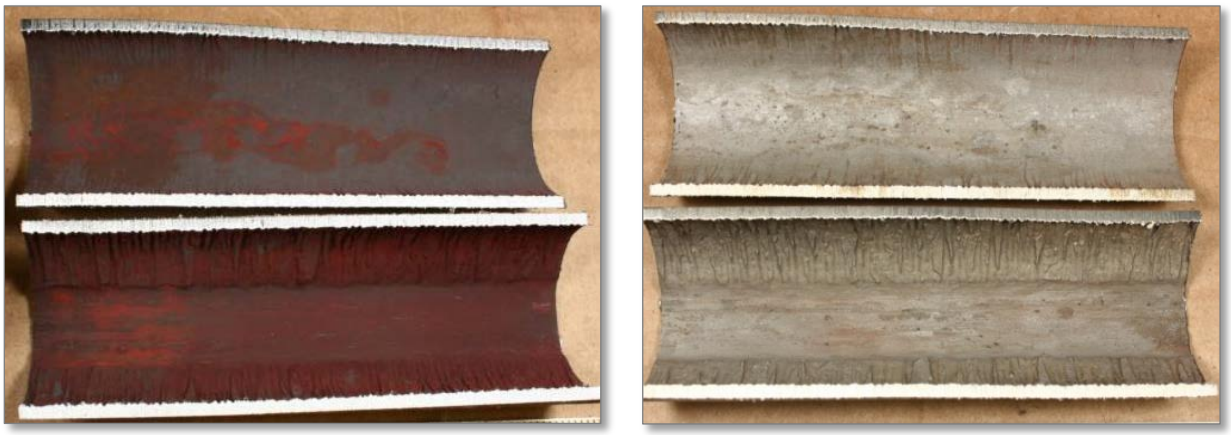
Superheater tube internal deposits

Superheater tube failure promoted by internal surface deposits

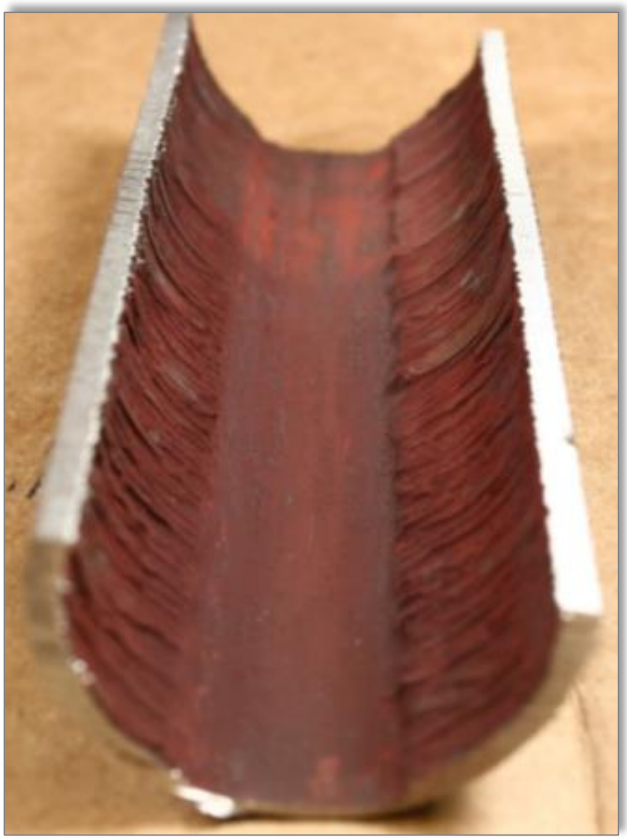
Section X. Condensate Lines Corrosion



Corrosion due to low pH (from carbonic acid) at the bottom of a condensate return line



Corrosion and failure on the lower surface of a horizontal line etched due to low pH when steam condensed



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Loss of metal from the horizontal pipe surface where low pH condensate flowed →

Horizontal finned tube from wood drying kiln. Insufficient amine to raise the low condensate pH resulted in corrosion on the internal pipe surface. Beginning in the top of the tube as steam condensed, CO_2 dissolved in the condensate as it formed and the acidic condensate flowed down the sides of the tube in rivulets, dissolving the steel pipe surface in the process, thinning the wall and sending iron back to the boiler. A rare example of the actual point at which steam condenses and low pH corrosion occurs.

TREATMENT RECOMENDATIONS

This manual illustrates a number of issues and failures that can adversely affect operational efficiency within boiler systems. ChemTreat provides the necessary solutions and services to take corrective and preventative action against these and other types of failures.

Contact ChemTreat today and get in touch with one of our Treatment Engineers or Technical Specialists for a chemical treatment program designed specifically for the needs of your equipment and boiler systems.

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