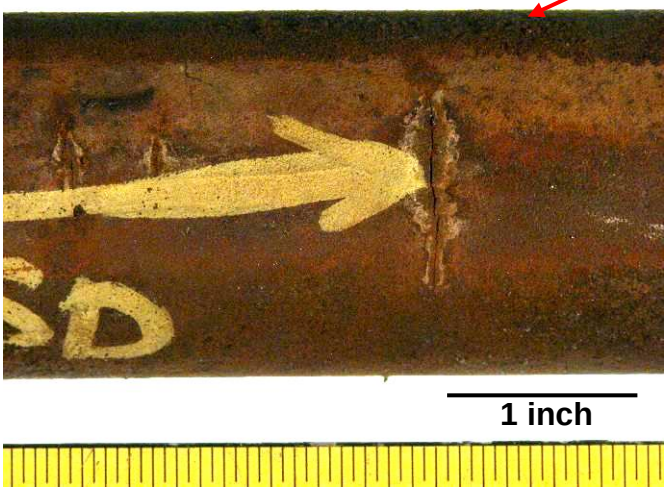
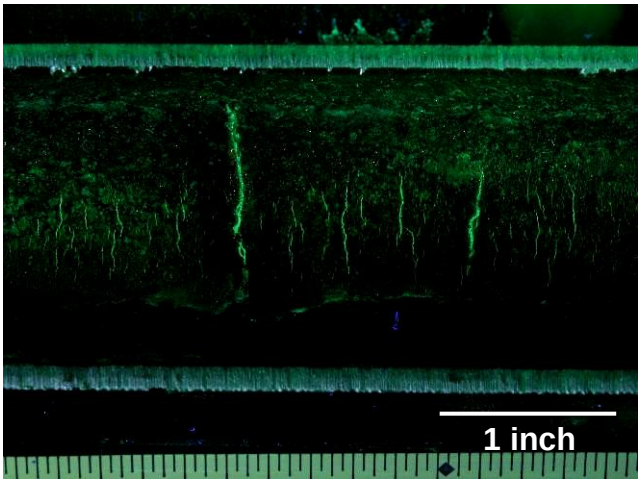
# Analysis of a Leaking Hog Fuel Boiler Floor Tube

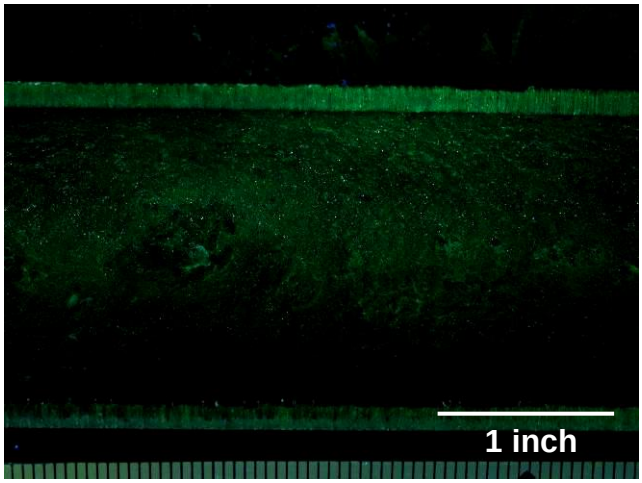
Analysis of a leaking boiler tube revealed definitive evidence of cracking due to thermal fatigue. Thermal fatigue refers to crack initiation and growth due to repeated heating and cooling cycles. Thermal fatigue was the result of variable boiler firing and transient periods of excessive heat input combined with poor water chemistry control and excessive water side deposition. Abbreviated results of the failure analysis are shown below:


A leaking floor tube was received from a 100,000 lb/hr lumber mill hog fuel boiler. Visual inspection revealed multiple transverse cracks on the top (hot) side of the tube. An absence of crack branching suggests that fracture was not the result of stress corrosion cracking. An absence of deformation adjacent to the cracks suggests that cracking was not the result of a gross single event overload. The circumferential orientation of the cracks is indicative of an axial tensile stress.



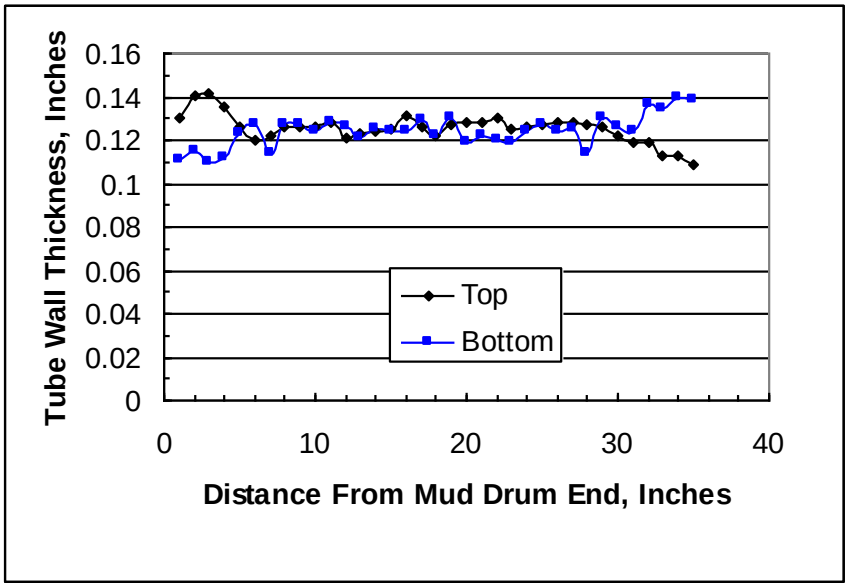

Hot Side



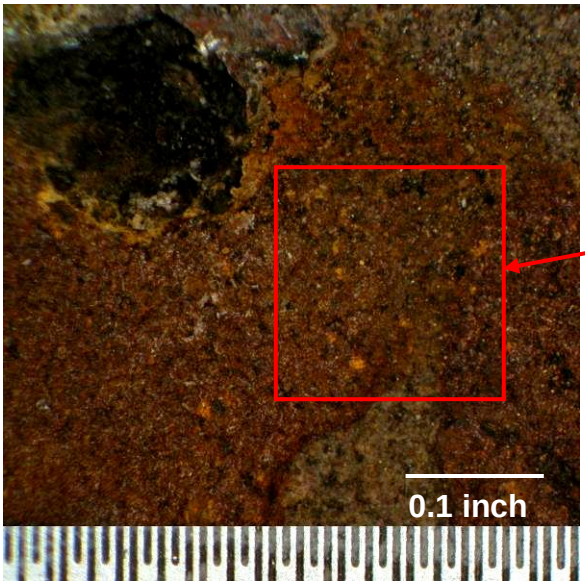

Cold Side

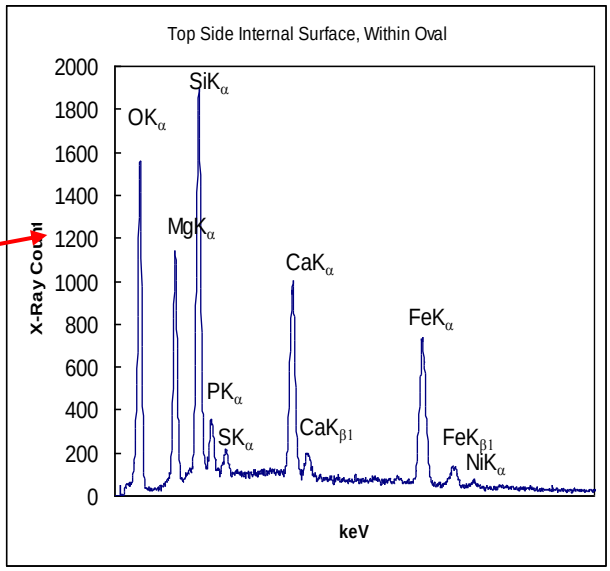
Wet fluorescent magnetic particle inspection of the tube ID surface revealed a dense distribution of transverse crack indications. The crack distribution is characteristic of thermal fatigue. Thermal fatigue refers to crack initiation and growth due to repeated thermal cycles (e.g. hot-cold-hot-cold...).


The tube interior at the crack locations exhibited an oval patch of heavy localized deposition. Deposition was heaviest on the hot (top) side surface. A central patch of brown deposit was surrounded by a white deposit perimeter. The deposit appearance was characteristic of steam blanketing. Steam blanketing refers to the formation of an insulating steam layer on the internal surface of a water cooled tube due to excessive heat input. Steam blanketing occurs most often on horizontal or near horizontal tubes such as floor tubes and can lead to tube damage due to excessive water side deposition, overheating, or thermal fatigue. Local deposit weight density values in excess of 100 grams per square foot were measured.

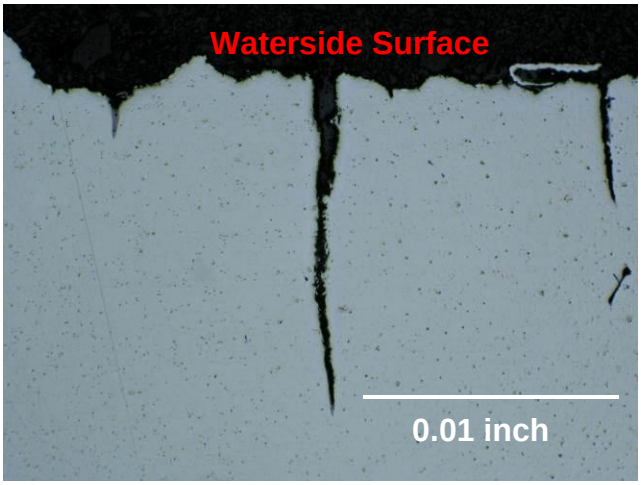


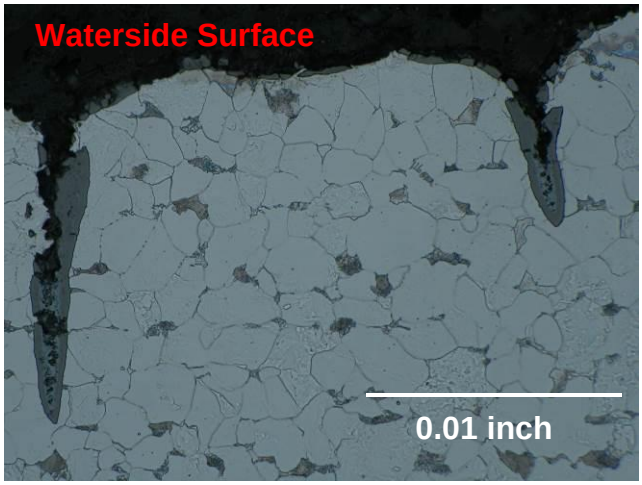

Ultrasonic wall thickness inspection revealed a nominal wall thickness of approximately 0.12 inch. Significant wall thinning was not revealed by the inspection. Cracking was clearly not the result of internal or external corrosion or erosion.




Energy dispersive x-ray spectroscopy of internal deposits within the area of steam blanketing revealed substantial deposition of water-borne solids, including magnesium, silicon, and calcium. Deposits outside of the steam blanketing consisted almost entirely of iron oxide. Heavy deposition acts as a thermal insulator and promotes elevated tube wall temperatures.




Metallographic examination of longitudinal sections through the crack indications revealed numerous wedge-shaped, oxide filled cracks. The features are characteristic of thermal fatigue. Cracking at sites of minor pitting corrosion suggests that waterside corrosion was a secondary contributor to cracking. The microstructure of the tube consisted of lamellar pearlite in a ferrite matrix. The microstructure is characteristic of a plain carbon steel boiler tube in essentially the as-manufactured condition. Evidence of overheating damage was not revealed by the metallographic examination. As-polished (left) and 2% nital etch (right).