

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

CORROSION FATIGUE

Corrosion fatigue, sometimes called stress-enhanced or stress-assisted corrosion, describes that water-side condition that leads to steam leaks due to localized cracking in the regions of high stress. The cracks are a series of connected pits that in cross section are suggestive of oxygen attack. The problem occurs in water-wetted tubes in both waterwalls and economizers at attachments, e.g., buck-stay clips, on the colder side of the tube. A view from the ID surface coincides with the attachment, as the cracks are limited to the area of the OD weld. On occasion the damage is a series of concentric rings of cracks that outline the attachment weld on the outside. More typically, the damage is axial cracks. Figure 1 is one such example.

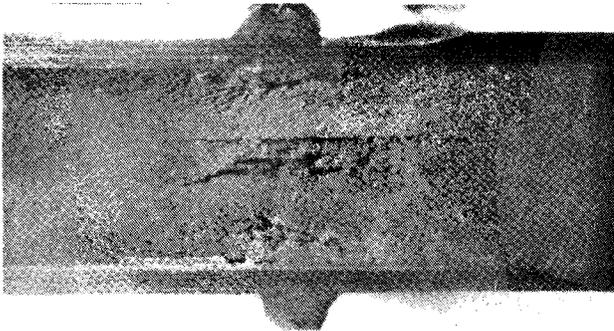


Figure 1

Depending on the precise state of stress, the confluence of several attachments at the circular cross section may be the site for several concentrated regions of cracking.

Start-up conditions consist of a hot waterwall and a relatively cool support structure. The cooler buck-stays prevent thermal expansion of the tubes, which leads to a

compression along the membranes. In the wind box, the preheater combustion air may expand the support steel faster than the waterwalls and stretch the tubes parallel to the membranes. Regardless of the temperature differentials, an applied strain is generated within the furnace. Figure 2 presents an example of longitudinal cracking on the ID about 90° apart, indicative of both a push and a pull along the membranes.

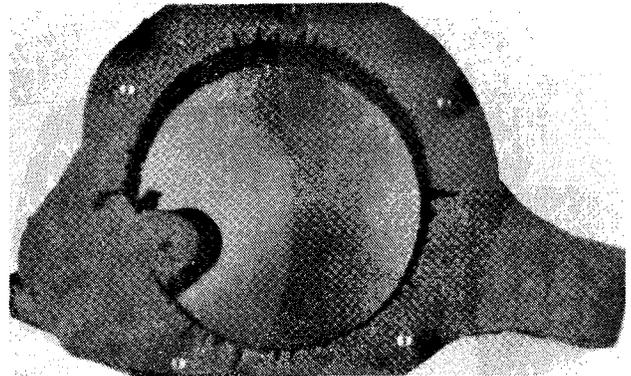


Figure 2

A cross section through a corrosion-fatigue crack shows a wide, irregular, bulbous form, or shape, to the crack surfaces; the crack tip is often blunt or rounded, see for example Figure 3.



Figure 3

The non-uniformity to the sides of the crack suggest several episodes of corrosion occurred even after the crack was well established. Such cracks may be widened during a chemical cleaning. A rash of leaks may be found after cleaning, as the removal of oxide or corrosion debris has removed the "plug". Cracks of this morphology are more common in cycling units.

The examination of the water-side surfaces throughout the boiler would indicate a roughened, pitted condition that is usually associated with oxygen corrosion. Thus the two conditions required are 1) oxygen concentrations within the boiler water that are in excess of the water-chemistry control guidelines, and 2) a region of higher-than-normal stress. The highly stressed regions create the anode of a corrosion cell, and the corrosion occurs more rapidly than in the surrounding area.

This form of corrosion fatigue has sometimes been called stress-enhanced or stress-assisted corrosion. However, the most likely scenario in an operating system is that the unit comes on line before the oxygen concentration in the boiler water is stabilized within the control range. The thermal-expansion stresses of the start-up and the oxygen within the boiler water lead to the formation of these localized regions of preferential corrosion. Once the oxygen concentrations reach the proper level, the corrosion stops until the next cycle. In those portions of the boiler where the stress is not excessive or is quite uniform, the oxygen corrosion leads to a

roughened surface but no localized deep pitting or cracks, as shown for example in Figure 4 from an economizer tube. While stresses are necessary, the important variable is the oxygen concentration in the water. Corrosion fatigue is a better description than stress-enhanced or stress-assisted corrosion.

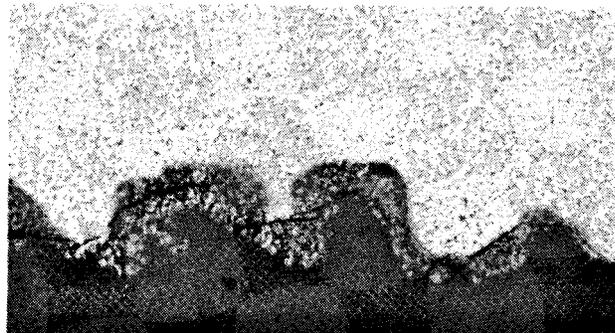


Figure 4

Corrosion fatigue occurs in those regions of water-touched or steam-generating tubes where there is the highest local stress, often at the water side of buck-stay attachment clips, or membrane welds surrounding openings from burner or wind-box attachments.

While the term *fatigue* usually is associated with a variable stress, in this case the stress may be quite uniform; but the corrosive environment, that is, the oxygen levels within the boiler water, are the variable. The most severe damage occurs during start-up when the oxygen concentration is not under proper control. The phenomenon is also most severe in those boilers that are subject to frequent start-ups.

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