IN-SITU METALLOGRAPHY OF DEAERATOR CRACKS

EXAMPLE REPORT

OVERVIEW & OUTCOME

A thirty-year old deaerator had run without significant issue until recently. Over the past two years, several dozen had cracks formed. In-situ metallography was used to diagnose the type of cracking.

The cracks were found to be corrosion fatigue cracks preferentially forming at corrosion pits. Although corrosion had been a contributor to cracking, the primary cause of cracking was attributed to operational changes that had increased the pressure cycling. To prevent cracking, the User reduced the pressure fluctuations within the deaerator.
IN-SITU METALLOGRAPHY OF DEAERATOR CRACKS

SUMMARY

Magnetic particle inspection had found numerous cracks within a deaerator. In-situ metallography was conducted to determine the nature of cracking. Evaluation was conducted at three locations within the Deaerator Storage Drum (locations marked in Appendix A).

Location #1, on the Circumferential Weld R2, consisted of two transverse cracks limited to the weld metal (Figure 1). Examination of the replications taken found these two cracks to be transgranular, filled with oxide corrosion product and preceded by corrosion at the crack tips (Figures 2 and 3). This cracking morphology was consistent with corrosion fatigue. One crack exhibited a corrosion pit at the center of the crack while the second spanned from a corrosion pit. The surrounding vicinity exhibited corrosion pitting along the circumferential weld.

Excavation attempts had already been made to remove the transverse weld cracks at Location #2 along the east side fillet weld of the Stiffener Ring #2 (Figure 4). Efforts to replicate this crack were only partly successful due to the restrictive geometry. Examination did find that these cracks exhibited similar corrosion fatigue features, consisting of oxidized/corrosion product ahead of branched crack tips (Figure 5).

Location #3 corresponded to a series of cracks within the fillet weld on the eastern side of Stiffener Ring #2 near the tank bottom (Figure 6). Excavation attempts had also been made on these cracks. Examination of these replications also found micro-features consistent with corrosion fatigue, comprising of transgranular cracks filled with oxides and all branches/crack tips were preceded by corrosion (Figure 7).

CONCLUSIONS

The evaluated cracks within deaerator were corrosion fatigue cracks. Such cracking occurs as a result of (a) a corrosive environment (oxygen content, etc) and (b) cyclic stresses caused by pressure changes (rapid starts/stops, pressure fluctuations, water hammering, etc). Given the nature and age of this unit, the primary driving force for cracking was likely attributed to a recent increase in cyclic loading during service.

Note that pitting would also act as stress concentrators, decreasing the cyclic loading threshold required for crack initiation.
Figure 1: Photographs of two transverse cracks in Circumferential Weld R2. The larger crack was referred to as Location #1A. The second, smaller crack was referred to as Location #1B. The cracks were located within pits in the weld.
Figure 2: Micrographs taken from replications of a crack at Location #1A. The transgranular crack was filled with oxide corrosion product. The crack tips were preceded by corrosion. These crack features were consistent with corrosion fatigue cracking. A deep pit was present at the center of the crack, likely from where the crack initiated from. Etched using 3% nital.
Figure 3: Micrographs of the crack at Location #1B. This transverse crack spanned from a corrosion pit. The crack consisted of corrosion fatigue features. The crack was filled with oxide, had grown straight/transgranular and corrosion preceded the crack tip. (c-e) Images taken from replications, etched using 3% nital.
Figure 4: Photographs of the cracks at Location #2 along the east side fillet weld of Stiffener Ring #2. This region had already been ground in an excavation attempt. Due to the geometry, efforts to replicate this region were only partly successful.

Figure 5: Micrographs at mid-crack of Location #2 illustrating this crack to have also been filled with corrosion product similar to the corrosion fatigue cracks observed at Location #1. Images taken from replications, etched using 3% nital.
Figure 6: Photographs displaying the cracks evaluated at Location #3 corresponding to the east side fillet weld of the Stiffener Ring #2.

a) Location #3, Retainer Fillet Weld, MPI

b) After In-Situ Preparation
Figure 7: Micrographs displaying the cracking at Location #3 to also exhibit features consistent with corrosion fatigue. The cracks were transgranular, filled with oxide/corrosion product and preceded by corrosion. (b-e) Images taken from replications, etched using 3% nital.
APPENDIX A – LOCATIONS EVALUATED