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IN-SITU METALLOGRAPHY OF CRACKED CARBONATE REBOILER SHELL

EXAMPLE REPORT

Modified from Original Report

OVERVIEW & OUTCOME

This work was completed within 24 hours.

In-situ metallography found that the channel cracks were corrosion under insulation (CUI). Due to water ingress into the insulation and leaching, stress corrosion cracks (SCC) had formed. Repair would have been difficult and the refinery decided to replace the channel head.

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IN-SITU METALLOGRAPHY OF CRACKED CARBONATE REBOILER CHANNEL

SUMMARY

Penetrant inspection had found linear, crack-like indications on the external surface of a carbonate reboiler channel. The nature of these external cracks had not known at the time of discovery. In-situ metallography was used to determine the nature of cracking. The channel comprised of ASME SA240 304 stainless steel.

Figure 1a,b displays the indications found on the external surface adjacent the nozzle. The area of interest was lightly ground and polished to a 1µm finish. Replications were made in the as-polished and after electrolytically etching using 10% oxalic acid. After surface preparation and replication, the site near the nozzle was found to comprise of a high density of cracks. The severity and area of cracking was more extensive than first presented by penetrant inspection.

Optical examination of the replications found the networks of branched cracks to be consistent with stress corrosion cracking (SCC, **Figures 2 and 3**). The cracks tended to be transgranular in nature. Transgranular SCC cracking of 304 stainless steel is most often caused by aqueous chlorine/chlorides.

Examination of the replications from the two sites evaluated did not find any microstructural degradation of the core material (ie. no sensitization, sigma phase or other detrimental structures had formed during service).

CONCLUSIONS

Channel cracking had been caused by corrosion under insulation (CUI). Stress corrosion cracking of ASME SA240 304 stainless steel occurs as a result of the combination of (a) static stresses, (b) the presence of chlorides, (c) the presence of water and (d) is exacerbated by operating temperatures above 149°F (65°C). Specific to this case, the primary cause of external cracking was due to the introduction of water. Corrosion cracking indicated that copious amounts of water had penetrated through the exterior jacket and had leached the insulation. At temperatures above 149°F (65°C), even in the case of chloride-free insulation, prolonged soaking time and temperature is enough to provide sufficient corrosion agents to cause stress corrosion cracking.

Therefore, the primary contributor to cracking was the ingress path of water into the insulation. This damage is referred to as corrosion under insulation (CUI).

No material quality issues were observed or suspected. No microstructural degradation, such as sensitization or sigma phase formation, was observed that would have contributed to the corrosion cracking. Failure was not due to a material quality issue.

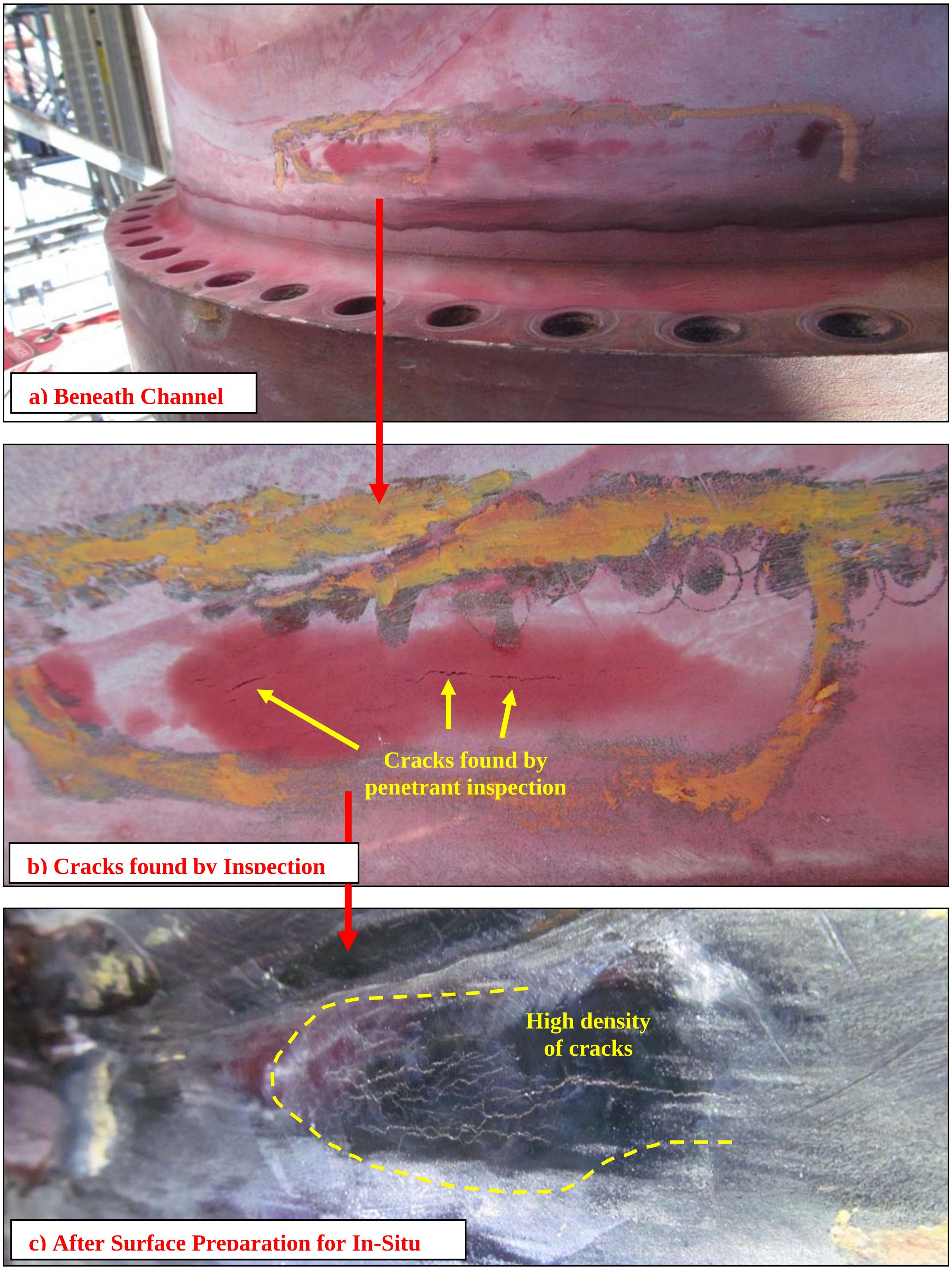

Figure 1: Photographs displaying the cracks on the external surface (a,b) as-found by penetrant inspection and (c) after surface preparation. The region comprised of a high density of cracks.

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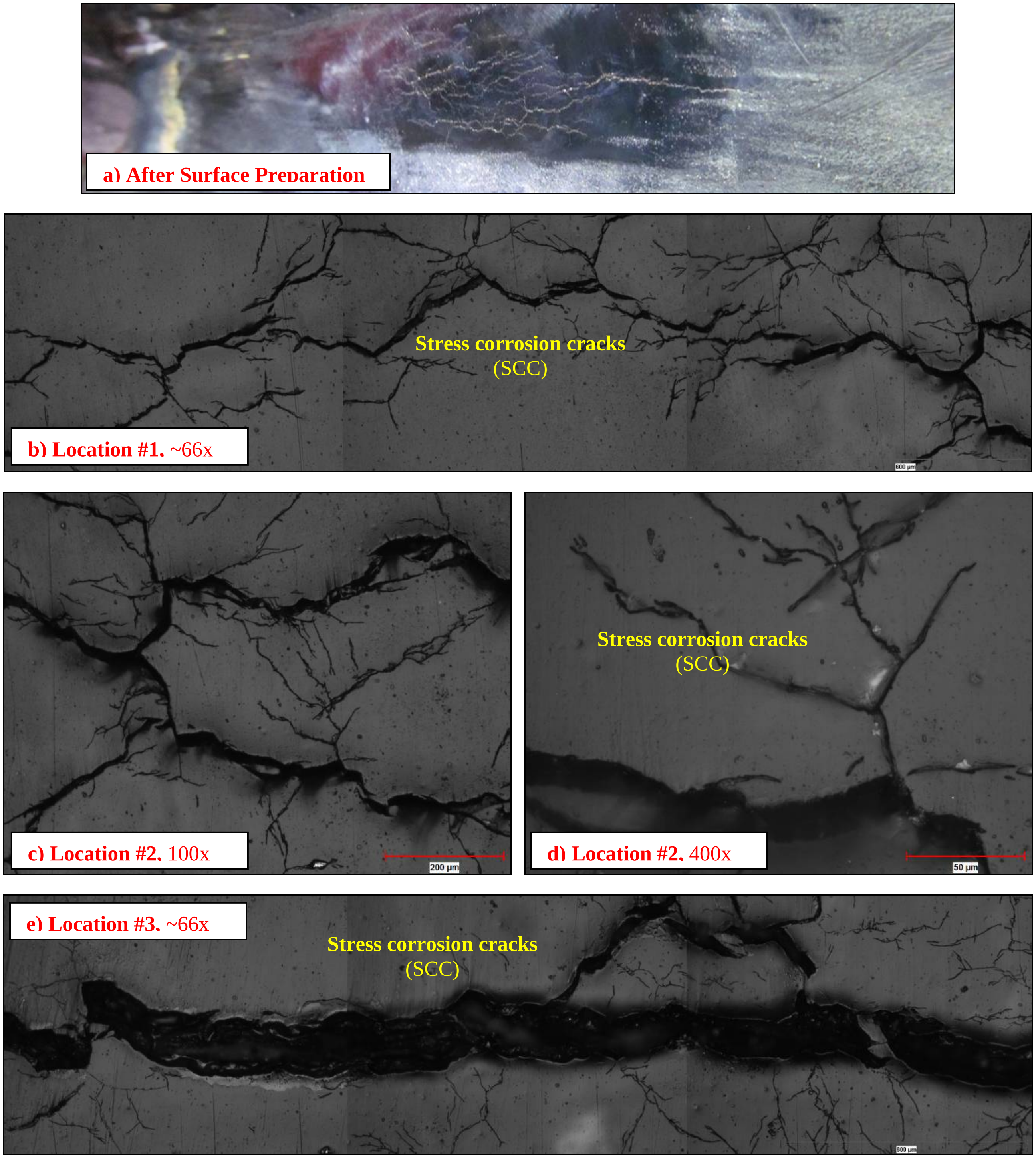

Figure 2: Micrographs displaying examples of the external cracks adjacent the nozzle. The branched nature of the cracks was consistent with stress corrosion cracking (SCC). The cracks were transgranular.

The external surface should have been dry and stress corrosion cracks indicated that copious amounts of water had been introduced over months if not years. Therefore, corrosion was consistent with corrosion under insulation (CUI). Images taken from replications.

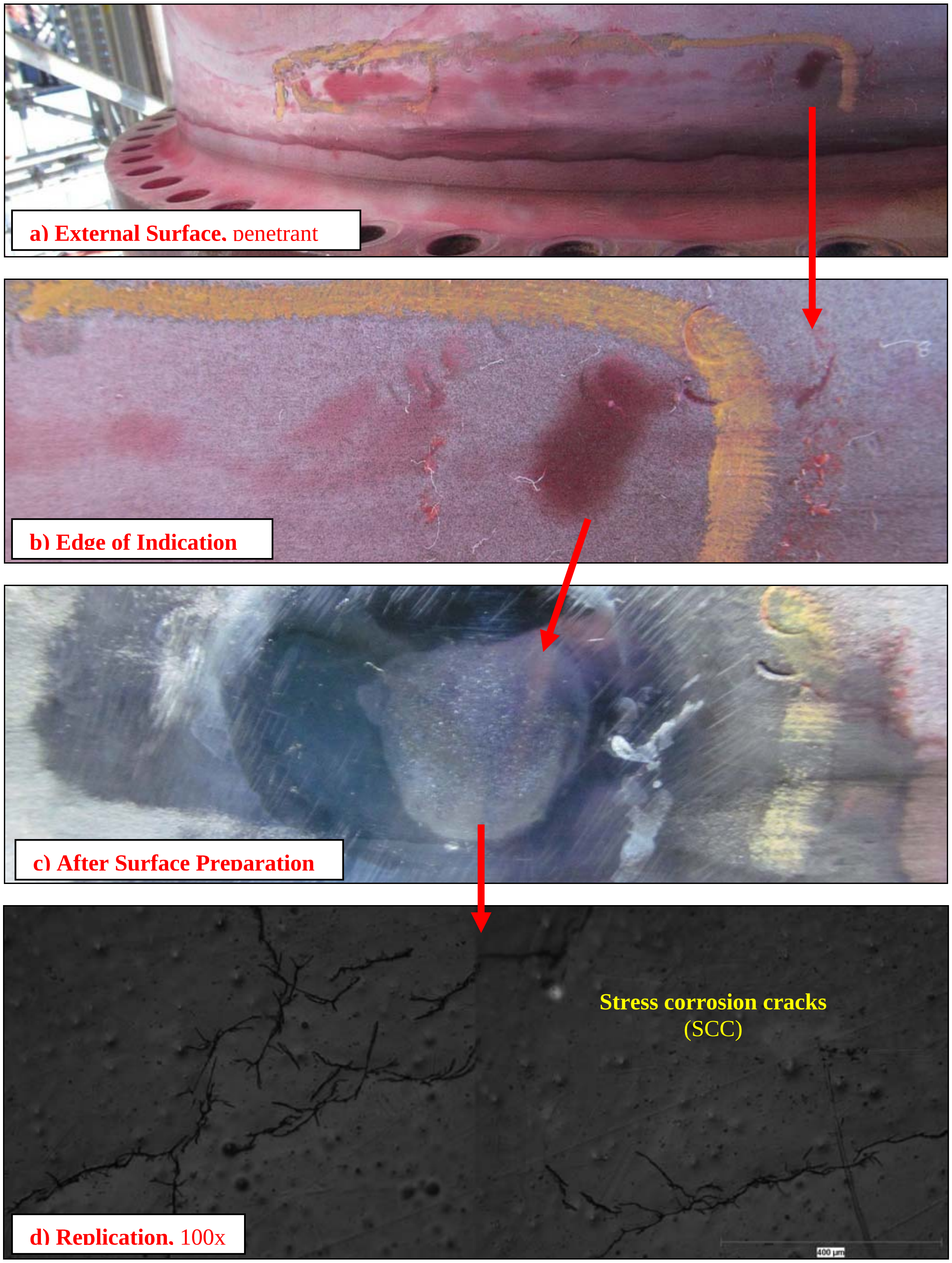

Figure 3: Photographs and micrograph of external cracks away from the nozzle, at the edge of the PT indication. Similar stress corrosion cracks were present at this location.