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Microbially Induced Rupture of a Heat Exchanger Shell

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1 Abstract

Microbially induced corrosion (MIC) has been identified as the main cause of the rupture of a key heat exchanger shell at a local refinery. The failure occurred at the 6 o'clock position, close to the girth weld, halfway along the length of the carbon steel shell. An ultrasonic survey revealed up to 90% wall thinning in the ruptured zone.

Despite extensive crystallization at the external cooling seawater inlet of the cooling system tubing, there was no evidence of internal leakage of seawater into the shell compartment. The total dissolved solids in the condensate dropout sample was found to be 262 mg/L. The investigation also confirmed that the girth weld had been satisfactorily conducted, including post heat treatment, and that the failure occurred outside the heat affected zone (HAZ). Quantitative polymerase chain reaction (qPCR) analysis of the dry surface film from a crack in the ruptured area confirmed the suitability of the operating environment for prokaryotic growth and the presence of both groups of highly corrosive acid producing bacteria (APB) and denitrifying bacteria (DNB) in moderate numbers ($1.92x10^3$ APB/gram and $1.81x10^5$ DNB/gram respectively).

The highly aggressive metabolic by-products of the detected groups of microorganisms, in addition to the presence of H_2S in the processed gas caused substantial localized wall thinning, leading to the rupture of the shell due to loss of pressure retention capacity.

Keywords: Heat-exchanger failure, bacterial corrosion, failure analysis, non-destructive inspection, pitting corrosion, crack arrest.