Experiences with on-site detection of intermetallic phases in super duplex stainless steel

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During service a leak occurred in a 4" SSDS (UNS S32760) well flowline connection from the christmas tree to the production manifold. The leak appeared as a circumferential crack with a length of approximately 90 mm. The elbow was cut out, replaced and sent to shore for full metallurgical examination.

The crack initiated and propagated from an external corrosion attack. At the time of failure, the size of the corrosion attack had grown above the critical flaw size. Dynamic loads due to slugging in the well flow line resulted in a sudden brittle fracture. The microstructure in the affected area had unwanted intermetallic precipitations. Such precipitations have a detrimental effect on the corrosion resistance and toughness of the super duplex material. The concerned elbow was cold bent from pipe material followed by a heat treatment. Ultimately the cause for the leak was identified as poor heat treatment during production of the elbow at the manufacturer.

As similar elbows with identical heat numbers from the same manufacturer were present in other flowlines, a larger investigation was initiated. Due to the laborious effort of positively detecting intermetallic precipitations non-destructively, a ferrite screening program was established. A procedure for ferrite screening was made in conjunction with the client.

Items with a ferrite content lower than 35% or higher than 65% were subjected to in-situ metallurgy. This entailed grinding, polishing, electrolytical etching with NaOH, followed by light optical microscope at 400x magnification.

In total 5681 items (elbows, hubs, etc.) were screened. Out of those 96 (1.7 %) had a ferrite content lower than 35%. Of these 96 items, 25 items were examined in-situ metallurgically and all 25 were found to have unwanted intermetallic precipitations. The remaining low-ferrite items were replaced.

In the later stages of testing, a new generation of USB portable microscope with was used to capture images. In parallel with this, a new rapid electrochemical test method has been shown to work on for QA-screening of new uninstalled SSDS items.