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Services Division

Application Brief

Case Study: Ultrasonic Phased Array Inspection of Stainless Steel Piping for Stress Corrosion Cracking

Current Condition

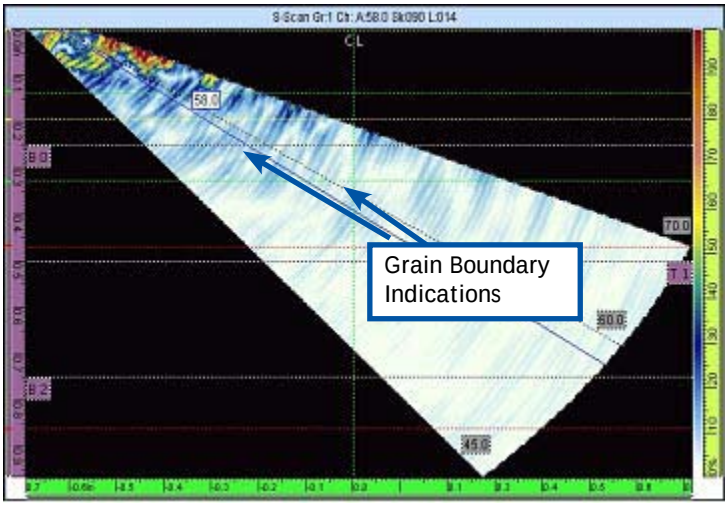
A petrochemical company has experienced failure issues caused by Stress Corrosion Cracking (SCC) of their stainless steel piping (thickness of about 0.25 inches). These indications are typically formed along the grain boundaries and are accelerated by the presence of chlorides. There is no regular failure mechanism for this cracking and the only way to avoid this is to accurately scan the material for any micro-fracture boundaries. To a certain extent, ultrasonic shear wave predicts the micro-structure failure. However, the diverging beam of a shear wave makes it difficult to identify smaller size indications. Also, multiple reflections from grain boundaries can become difficult to interpret on a single A-scan.

Phased Array Recommendation

MISTRAS Group Inc. was requested to provide alternate inspection techniques that would allow a quicker inspection method while providing the client with robust and more sensitive scans. Seeing as the client required a more accurate prediction of crack growth, Phased Array Inspection was suggested since it has the advantages of electronic steering and focusing of the beam. The focusing of the beam provides increased penetration through large grain structure steel and higher resolution of micro-cracking. The steering provides easier viewing of the scans and improved interpretation in the visual sector scan. The technique increase the probability of detection utilizing Advanced Tomoview Software for post processing of the data like CAD drawing superimposition on the UT signal/ image, etc.

Results

As a result of the inspection, a leaking area in one of the piping systems caused a temporary shut down of the unit. The area where the leak was found was de-insulated after the pipes were brought down to ambient temperature from the standard operating temperature of 900°F. The initial part of the piping from the process unit experienced Stress Corrosion Cracking caused by the penetration of chlorides into the stainless steel. This section of piping was removed and observed under a microscope. There were multiple smaller indications of cracking including three areas of through-wall indications where the leak had developed.



General reflections from grain boundary as captured in the sector scan for the base metal and verified under a microscope.

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Verification of the cracking was done by sectioning the pipe and viewing the material through a microscope. The cracking was determined to occur along the grain boundaries but randomly oriented around the pipe. The scope of the project was to determine if there were any similar areas of cracking on the remaining de-insulated piping. The cracked samples were used as a baseline for the initial calibration of the instrument. A clean section of pipe was also provided in order to calibrate the instrument for the grain boundary and other material reflections which may be displayed utilizing Phased Array UT.

The focusing and phasing of the beam through various angles proved to be beneficial from both a penetration and probability of detection standpoint. There were no relevant indications found in two other sections of piping which were scanned using Phased Array UT. Approximately 95% of the circumference of the pipe wall was inspected during the test. After reporting our findings to plant reliability engineering personnel, it was postulated that at this point in time, the chlorides had not traveled down the length of the pipe to the area of interest. The accurate detection and sizing utilizing Phased Array UT, made it easy to find initiation points for Stress Corrosion Cracking. This was critical in order to estimate the remaining life of the piping.

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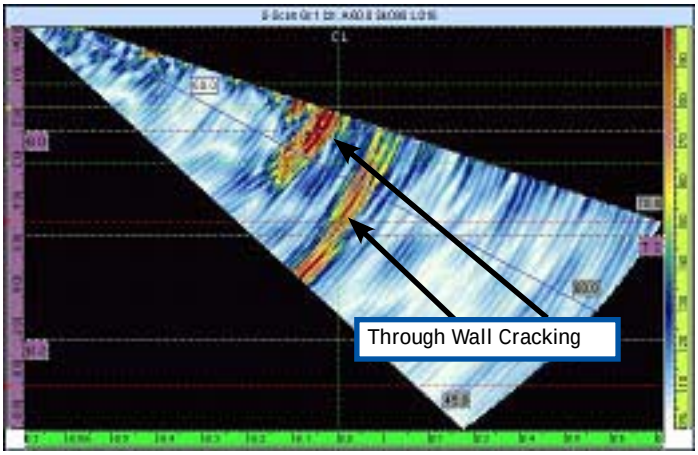
Typical responses from a cracked specimen are shown. The figure above shows the initiation of stress corrosion cracking on the ID of the piping.

The figure below shows the through-wall indication going from the root to the cap on the second leg of the scan. The coarseness of the grain structure is obvious from the distortion in the reflected signal. Focusing of the beam has greatly minimized this distortion.



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