

Metallurgical Analysis of Hydrotested 20-Inch Natural Gas Pipeline

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ABSTRACT

Hydrostatic testing of pipelines is critical during construction and maintenance. It is an important pre-commission test and destructive tool which validates the integrity of the pipeline prior to actual service with flammable fluids at high pressures. Hydrotesting provides the quality control needed to ensure that the required pipeline tensile strength is available to sustain the operating pressure, and that the welds and joints are defect free.

In this paper, we discuss a recent case study wherein metallurgical analysis was performed at our lab on a 20-inch API 5L X65 carbon steel pipeline. A leak was detected during the commissioning hydrotest of a newly constructed pipeline in the field at a client site. Dye penetrant testing, x-ray radiography and phased array UT inspection techniques revealed the presence of a defect at the electric resistance weld (ERW) seam. Based on the analyses, it was confirmed that the defect was due to incomplete fusion at the long seam weld during the ERW welding process.

Key words: Metallurgical analysis, hydrostatic testing, pipeline welding defects, lack of fusion, ERW weld.

INTRODUCTION

Hydrotesting and the resulting corrosion (MIC) problems have been well documented in the past, leading to a sharper focus on the quality of water used for such tests, as well as the post-test operations.¹ Hydrotesting can expose any anomalies present in the pipe that may fail at or just above the operating pressure. In most situations, hydrotesting provides a successful result. A pipe that has no failure demonstrates that it is safe to operate at the maximum operating pressure or maximum allowable operating pressure (MOP/MAOP), while one with a failure identifies defects that would have likely failed in operation and caused costly downtimes.

Material failures account for up to 25% of pipeline failures in oil and gas operations.^{2,3} Pipelines are inspected for welding defects using a variety of techniques, such as, radiographic testing (RT), ultrasonic testing (UT), magnetic testing (MT) and penetrant testing (PT).⁴⁻⁶ Axial defects, such as those occurring along seam welds, have the lowest safety factors⁷ and cause pipeline failures in the field.⁸ In this case study, we highlight the importance of ensuring quality control of the manufacturing processes during

pipeline fabrication. This work will add to metallurgy side of hydrotesting operations, and emphasize the role played by hydrotesting in assessing the integrity of a pipeline prior to installation. We evaluated a long seam weld defect that was detected during hydrostatic testing of a repaired 20" natural gas pipeline at a client site. The electric resistance welded (ERW) pipeline was reported to be API 5L X65 PSL2 steel with a nominal wall thickness of 0.375". This pipeline was new, likely manufactured in 2018 and installed in 2019. Dye penetrant testing, x-ray radiography and phased array UT inspection all indicated that the defect was a lack of fusion (LOF) at the seam weld, located about 3" from the girth weld. Figure 1 shows a picture indicating the location of the defect.

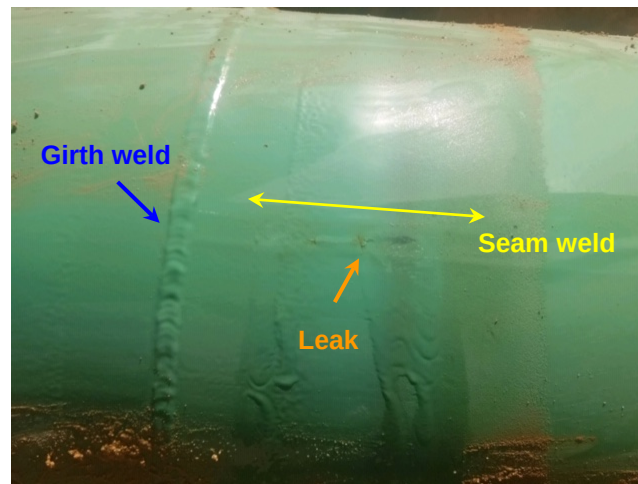


Figure 1. Photograph taken in the field showing the location of the defect.

LABORATORY RESULTS

Visual Examination

SES received the 6' ¼" long section, as shown in the Figure 2. Dimensional analysis and magnetic particle inspection (MPI) were performed prior to sectioning the pipeline for further destructive analyses.

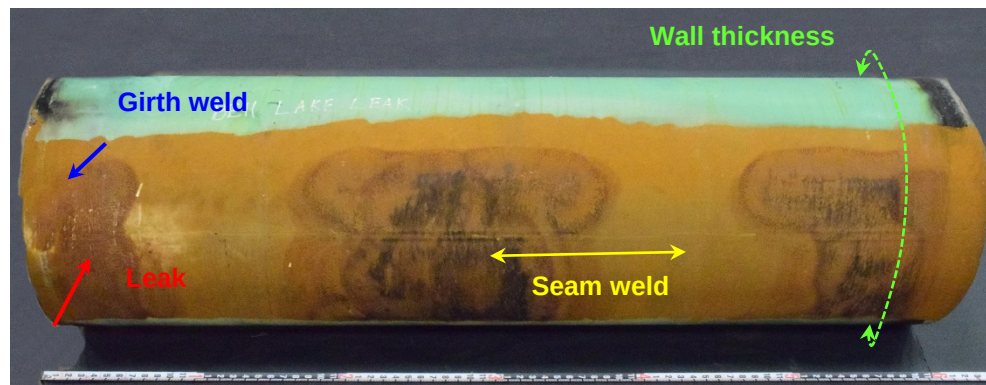


Figure 2. As-received photo of the leaked pipeline section sent to SES. Numbered scale divisions are feet.

The leak was located 3-3½" from the girth weld. The pipeline showed no deformation across the length. The outside diameter (OD) was at the leak 20.06". Wall thickness measurements were taken around the circumference on the other end of the leaked region (green dotted line in Figure 2). The OD at this location was 20.03". The average wall thickness (8 readings) in this region was 0.379".

Figure 3 shows a picture of the defect following MPI testing. The region containing the defect was sectioned off for metallography and scanning electron microscopy (SEM). The section containing the

defect was cleaned and wire brushed on the outside and inside surfaces. Figure 4 shows a picture of the defect. The defect measured 0.28 inch on the outside surface and ~0.5 inch on the inside surface.

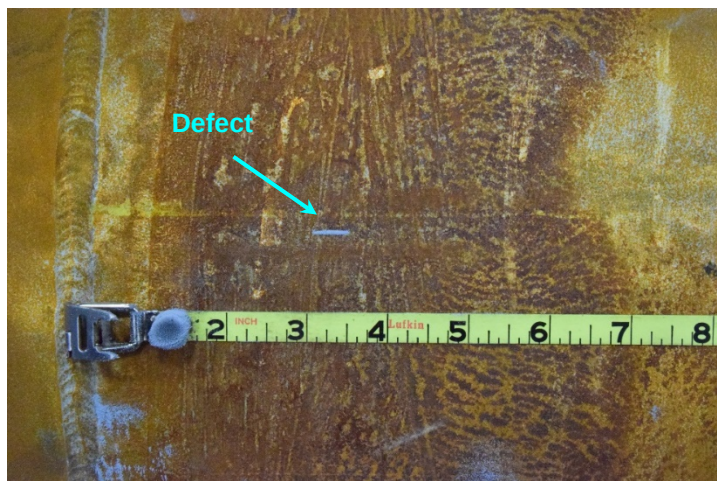


Figure 3. Photograph taken following MPI testing. Numbered scale divisions are inches.

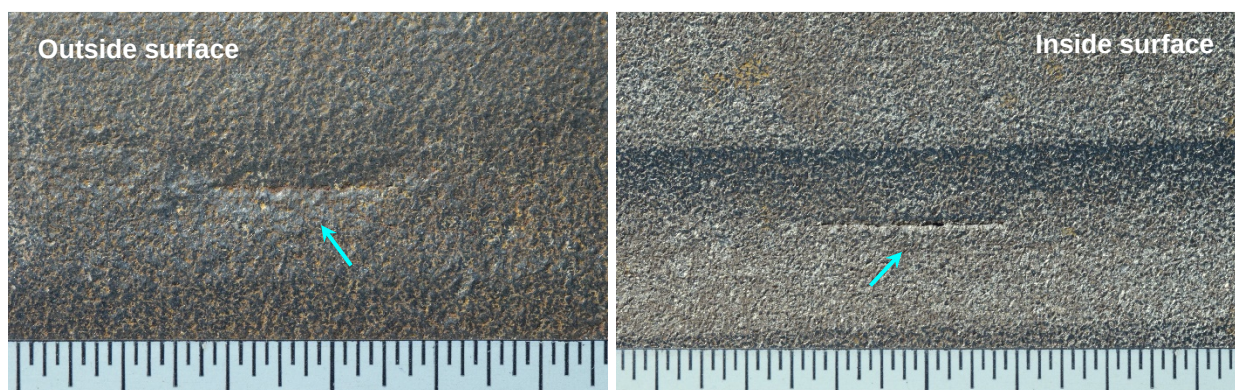


Figure 4. Close-up photographs of outside and inside surfaces containing the defect (marked by arrows). Scale divisions are $\frac{1}{32}$ inch.

The defect area was then broken open in order to expose the defect surfaces. The two matching surfaces obtained are shown in Figure 5. One of these matching pieces was cleaned in Alconox to remove the brown corrosion product. A photo of the section after the cleaning process is shown in Figure 6.

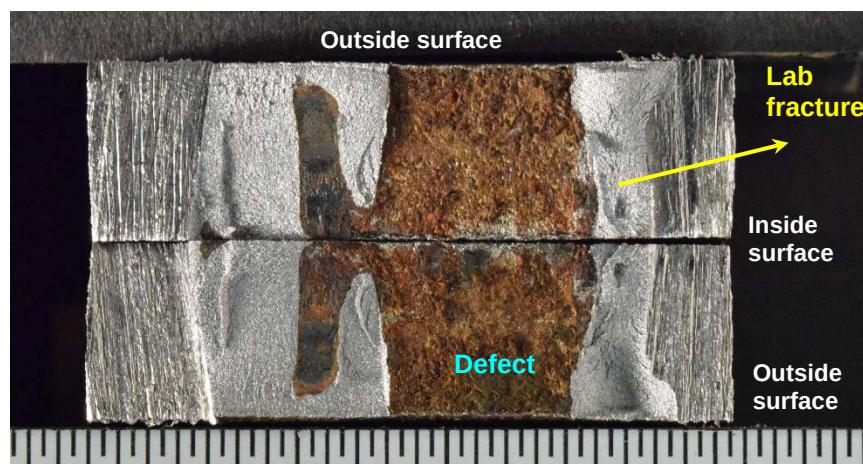


Figure 5. Photograph of matching surfaces following lab fracture. Scale divisions are $\frac{1}{32}$ inch.