Failure Analysis Associates

PG&E Line 118B Fresno In-Service Rupture Analysis

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Contents

Executive Summary

This Executive Summary contains only a portion of Exponent's technical evaluations, analyses, or conclusions. Hence, the main body of this report is at all times the controlling document.

Exponent Failure Analysis Associates (Exponent) was retained to help determine the cause of the April 17, 2015, in-service rupture of Pacific Gas and Electric (PG&E) Line 118B near Fresno, CA. Our analysis included accident scene and visual inspection, nondestructive examination (NDE), as well as metallurgical and fractographic evaluation. Our investigation also included chemical analysis and mechanical testing of selected portions of the subject pipe for comparison with American Petroleum Institute (API) specifications.

Our investigation indicates that PG&E Line 118B ruptured when it was struck by a front loader that was operating in the area at the time of the incident. The significant gouging, scraping and deformation present at the Line 118B rupture location could have only been caused by contact with the front-loader bucket. The pipe was found to have minimal depth of cover at the strike location, on the uphill side of the dirt road cut into the hillside. Away from where the road intersected the pipe, the depth of burial was measured to be between 44 and 46 inches, both upstream and downstream from the rupture. The bucket punctured the pipeline and formed two cracks: each propagated circumferentially in opposite directions around the pipe. The crack that propagated in a clockwise direction traveled approximately 1.5 inches where it intersected the longitudinal weld seam. This crack then propagated upstream and downstream along the seam in a relatively brittle manner for approximately 19 inches before turning into the base metal during final fracture. The other circumferential crack propagated counter-clockwise from the puncture in a ductile manner until final fracture.

Mechanical testing indicated that the subject pipe tensile properties met historical and current API specifications for Grade X-42 pipe. Chemical analysis indicated that the subject pipe elemental composition met API specifications, both historical and current.

NDE and metallographic examination showed that three locations along the subject pipe weld seam away from the rupture exhibited small lack-of-fusion indications. These indications had been present since pipe manufacture, and showed no evidence of growth. No evidence of any similar lack-of-fusion flaws was observed along the fractured portion of the weld seam. Impact fracture toughness testing showed that the longitudinal seam regions exhibited lower impact toughness properties compared to the base metal. This finding is consistent with normal pipeline manufacturing processes, particularly the 1960 electric-resistance weld (ERW) seams. This expected lower weld toughness influenced the rupture propagation path, but did not affect the accident in a meaningful way. The front-end bucket punctured the pipe and initiated ductile tears in both circumferential directions that would have ultimately resulted in a rupture, regardless of the crack propagation path. Thus, the seam weld fracture was a consequence, not a cause, of the rupture. Although the subject pipe was located near a shooting range, no evidence of any bullet or projectile contact on any portion of the pipe was observed.

Background

On the afternoon of April 17, 2015, a rupture occurred on PG&E natural gas Line 118B near Fresno, CA. The rupture ignited and resulted in a fire which caused a death and multiple injuries. The incident occurred just north of Fresno, near Highway 99. Due to the rupture's proximity to the highway, multiple pictures were taken, an example is shown in Figure 1. Although details were lacking, it was understood early on that a front loader was operating in the area at the time of the incident. PG&E retained Exponent to perform an investigation into the cause of the rupture. Although initiated by PG&E, the California Public Utilities Commission (CPUC) has taken over direction and oversight of the investigation.

Exponent personnel arrived onsite Sunday, April 19, to perform a field investigation and to provide guidance related to pipe excavation and evidence preservation. The incident pipe was removed from the ground and shipped to Exponent's laboratory in Menlo Park, CA. Nondestructive and destructive testing was performed according to the approved testing protocol between May 11, 2015, and June 2, 2015. Exponent led the investigation, attended by numerous people each day from parties involved in the matter.

Exponent's laboratory investigation encompassed nondestructive and destructive testing, including magnetic particle inspection and visual, dimensional, stereomicroscopic, metallographic, scanning electron microscopic (SEM), and energy-dispersive spectroscopic (EDS) analyses. Chemical analysis and mechanical testing of selected portions of the subject pipe were conducted for comparison with American Petroleum Institute (API) specifications.

The accident portion of Line 118B was reported to have a nominal diameter of 12 inches, be made from API Grade X-42 pipe, and to have been installed in 1962.

Figure 1. Photograph of the fire associated with the rupture taken from Highway 99. Photo: Kevin Ling / Associated Press.

Field Investigation

On Sunday April 19, 2015, Exponent arrived at the incident site to inspect the ruptured pipeline and to provide guidance on pipe removal and evidence preservation. The incident occurred in the Herndon neighborhood of Fresno, between North Weber Avenue and Highway 99. An aerial photo of the area, shown in Figure 2, was taken a few days after the incident and pipe removal. Upstream of the incident location, the pipeline runs southwest along a flat region of higher ground before turning roughly 90 degrees to the northwest and angling downward approximately 20 degrees beneath a slope. The pipeline extends down the slope for roughly 80 feet before leveling off and continuing on to the northwest beneath flat ground. The rupture occurred near the middle of the 80-foot run down the slope. The location of the sloped section of the pipeline is indicated by a red dotted line in Figure 2. A shooting range is adjacent to the rupture location, and the shooting "lanes," divided by low walls, are visible in Figure 2 just to the northeast of the rupture site.

Gas flow at the specific incident location is downhill from southeast to northwest. A front loader was observed at the rupture location. Plan-view aerial images are shown in Figure 3, where the pipe location is indicated by the dotted line and the front loader is visible. A dirt road runs along the hillside roughly perpendicular to the pipeline at the rupture location.

A large crater was generated as a result of the rupture, exposing a length of pipe on the upstream (uphill) and downstream (downhill) sides of the fracture. A portion of pipe was ejected from the rupture location. Photographs of the fractured ends of pipe are shown in Figure 4 through Figure 6. The ejected piece was found approximately 20 feet away from the crater rim to the northwest (downstream), as shown by Figure 7, having been expelled from the crater by gas pressure following the initial rupture. For subsequent discussion, this piece will be called the "Ejected Segment."

The rupture crater and the pipe fracture location were in line with the dirt road as evident in Figure 8 and Figure 9. Specifically, the pipe rupture location was aligned with the up-slope side of the dirt road, which is shown in Figure 9. A view of the dirt road from the level of the shooting range is shown in Figure 10, with freshly moved dirt visible on and around the dirt road, indicative of recent activity. Depth of cover was measured where the pipe entered the soil on both the upstream and downstream sides of the crater. Approximately 44–45 inches of cover was measured on the upstream side of the crater, and approximately 46 inches of cover was measured on the downstream side of the crater. However, it is evident that the depth of cover was not consistently 44–46 inches across the ruptured location: substantial amounts of soil had been removed to create the dirt road, particularly on the uphill side. This reduced depth of cover on the uphill side of the road is most evident in Figure 9.

Pipeline markers were observed in close proximity to the rupture location. One pipeline marker was observed at the top of the hill at the same location as the upstream elbow, and another was observed at the bottom of the hill where the pipe leveled off. These markers were approximately 80 feet apart.

The front-loader bucket was inspected for signs of damage. As shown in Figure 11, the far left-hand (uphill) side of the bucket leading edge exhibited signs of contact with hard materials and local deformation. Nondestructive x-ray fluorescence (XRF) measurements were taken on the subject front–loader bucket. This analytical technique gives the approximate chemical composition from a handheld device that can be used in the field. Although multiple measurements were taken at various locations on the bucket, all areas showed similar chemical composition. The data is summarized in Table 1 and exhibited an elemental composition consistent with carbon steel.

Table 1. Summary of XRF data taken from six different locations on the bucket of the front loader. Level of detection denoted by "LOD."

Sample	Fe	Si	Mn	Cu	Cr	S	Ni	Ti	Al	P
1	95.06	2.81	0.95	0.35	0.12	0.09	0.18	< LOD	< LOD	0.02
2	95.99	1.98	0.91	0.24	0.06	0.08	< LOD	< LOD	< LOD	< LOD
3	95.32	2.10	0.94	0.32	0.13	0.06	0.14	0.08	< LOD	< LOD
4	96.36	1.67	0.87	0.23	0.07	0.07	< LOD	< LOD	< LOD	< LOD
5	94.30	3.02	0.90	0.43	0.12	0.15	0.19	0.07	0.72	0.04
6	94.34	3.15	0.84	0.29	0.11	0.12	0.13	< LOD	0.90	0.05

A photograph of the Ejected Segment, taken immediately following removal from its original location is shown in Figure 12. An inward puncture and corresponding fold was evident on the Ejected Segment, while the remainder of the piece was expanded outward by the release of internal gas pressure in the line. Mechanical damage in the form of scrapes, dents, and gouges was evident at and near the punctured/folded area on Ejected Segment. This damage and folded area will be described in greater detail later in this report.

Two roughly 40-foot lengths of the pipeline adjacent to the rupture location were excavated and removed for analysis. In total, just over 80 feet of pipe was extracted, comprising the entire length of pipe beneath the 20-degree slope. The upstream cut location was just upstream of the elbow at the top of the slope, and the downstream cut location was just downstream of the elbow at the bottom of the slope. Aside from the elbows, each of the two excavated segments of the pipeline was made up of single pieces, or "sticks," of pipe. The rupture occurred near the girth weld that connected these two sticks of pipe. After excavation, the coating was stripped, and the five exposed girth welds were x-rayed. A light coating of oil was applied to the fracture surfaces prior to transport to minimize exposure to moisture and possible corrosion.

For ease of transport, each 40-foot stick of pipe was further sectioned into two 20-foot lengths. From upstream to downstream, these four pipe lengths were labeled Segments A, B, C, and D, respectively. Care was taken to excavate the pipes without introducing further damage. The fracture surfaces on Segments B and C and on the Ejected Segment (from between Segments B and C) were well packaged for protection during shipping to Exponent in Menlo Park, CA.

The front loader and its bucket were laser scanned for subsequent analysis. A laser-scan image of the bucket is shown in Figure 13.

Figure 2. Aerial photograph of the incident site after the incident and pipe excavation. The area of pipe rupture is shown by a dotted red line.

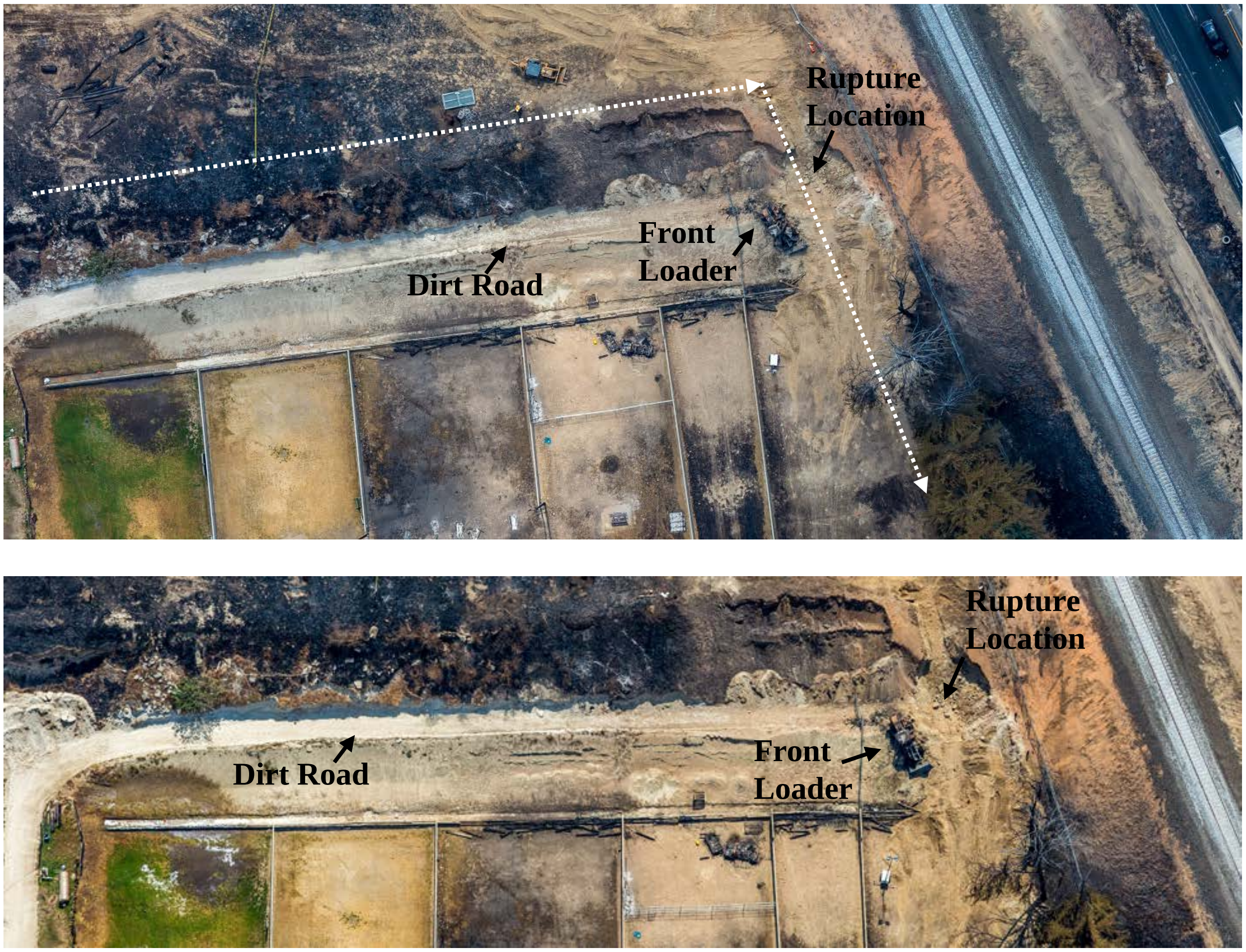


Figure 3. Aerial photographs of the incident scene taken after the incident and pipe excavation.

Figure 4. Photograph of the ruptured pipe segments taken looking upstream (southeast).

Figure 5. Photograph of the ruptured pipe segments looking northeast toward the dirt road and away from the railroad and Highway 99.

Figure 6. Photograph of the ruptured pipeline looking southwest toward the railroad and Highway 99.

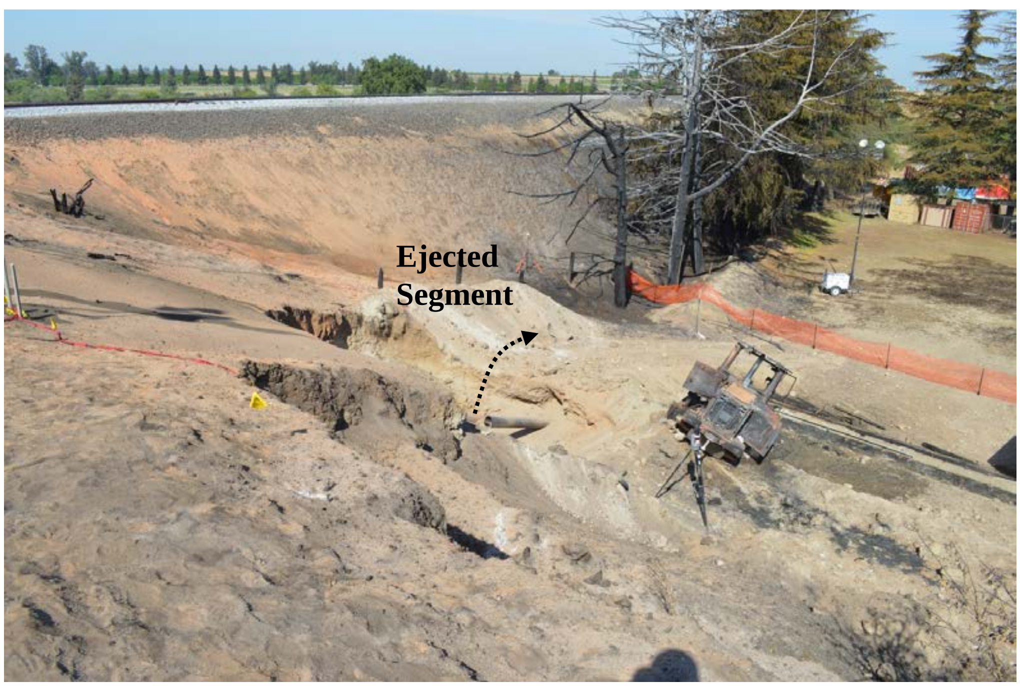


Figure 7. Photograph looking west toward the rupture crater from the top of the slope. The Ejected Segment is visible northwest of the crater.

Figure 8. Photograph of the incident site taken from the dirt road looking southwest toward Highway 99 and the railroad.

Figure 9. Photograph looking northeast at the ruptured pipeline and crater with the dirt road in the background. The uphill side of the road is coincident with the rupture location.

Figure 10. Photograph looking south from the shooting range toward the slope behind the range. This image, taken after the rupture occurred, shows the dirt road cut into the slope and extending from the near left toward the far right, where the front loader is visible.

Figure 11. Photograph showing the left front corner of the bucket blade of the front loader.

Figure 12. Photograph of the Ejected Segment. The piece was found approximately 20 feet from the nearest edge of the rupture crater.

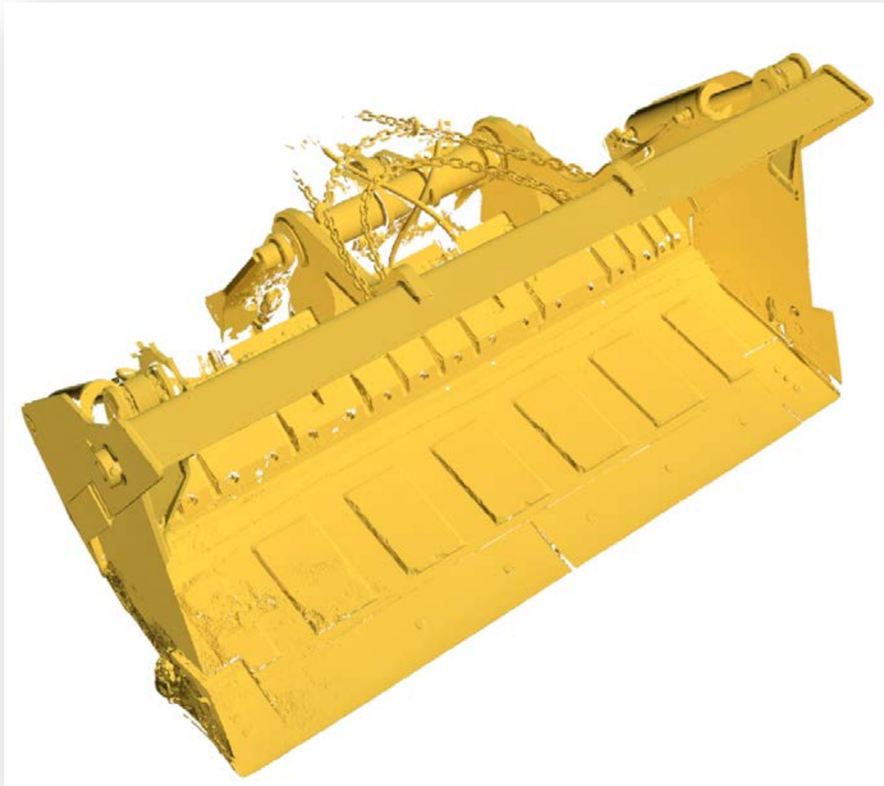


Figure 13. Laser-scan image of the front-loader bucket.

Nondestructive Examination

Visual and Dimensional Inspection

Five pipe segments were removed from the accident scene and shipped to Exponent for analysis, as listed below:

- Pipe Segment A—the farthest upstream segment; contains elbow
- Pipe Segment B—directly upstream of rupture
- Ejected Segment—a small piece 1.5 to 3 feet in length, found 20 feet from crater
- Pipe Segment C—directly downstream of rupture
- Pipe Segment D—the farthest downstream segment; contains segmented elbow

Each of the non-ejected pipe segments was approximately 20 feet in length. All pieces were received in wooden crates, well protected from potential damage during transport. On receipt, the pipes were reassembled in their pre-rupture positions, with the top of the pipe facing up, as shown in Figure 14. The ruptured area, which contained the Ejected Segment and portions of Segments B and C, is shown in Figure 15. This image shows the Ejected Segment in the correct (approximate) position relative to Segments B and C. The Ejected Segment came entirely from Segment B, as the full girth weld was contained within Segment C. It can be seen from the orientation shown in Figure 15 that the inward puncture/fold in the Ejected Segment roughly corresponds to the 12:30 position (when looking in a downstream direction) on the pipeline. Figure 16 provides another view of the two pieces relative to one another; it is evident that the mechanical damage on Segment B is aligned with the puncture. Visual inspection indicated that the rupture area clearly experienced damage from a mechanical equipment.

The fracture surfaces at the puncture/fold location were oriented at a 45-degree angle with respect to the pipe wall thickness, indicative of ductile tearing. The rest of the rupture surfaces also exhibited primarily ductile tearing fracture morphology, except for a 19-inch length of relatively flat fracture that occurred along the seam weld contained within the Ejected Segment and Segment B. A more detailed fractographic analysis was conducted on the seam weld fracture and will be discussed later in this report.

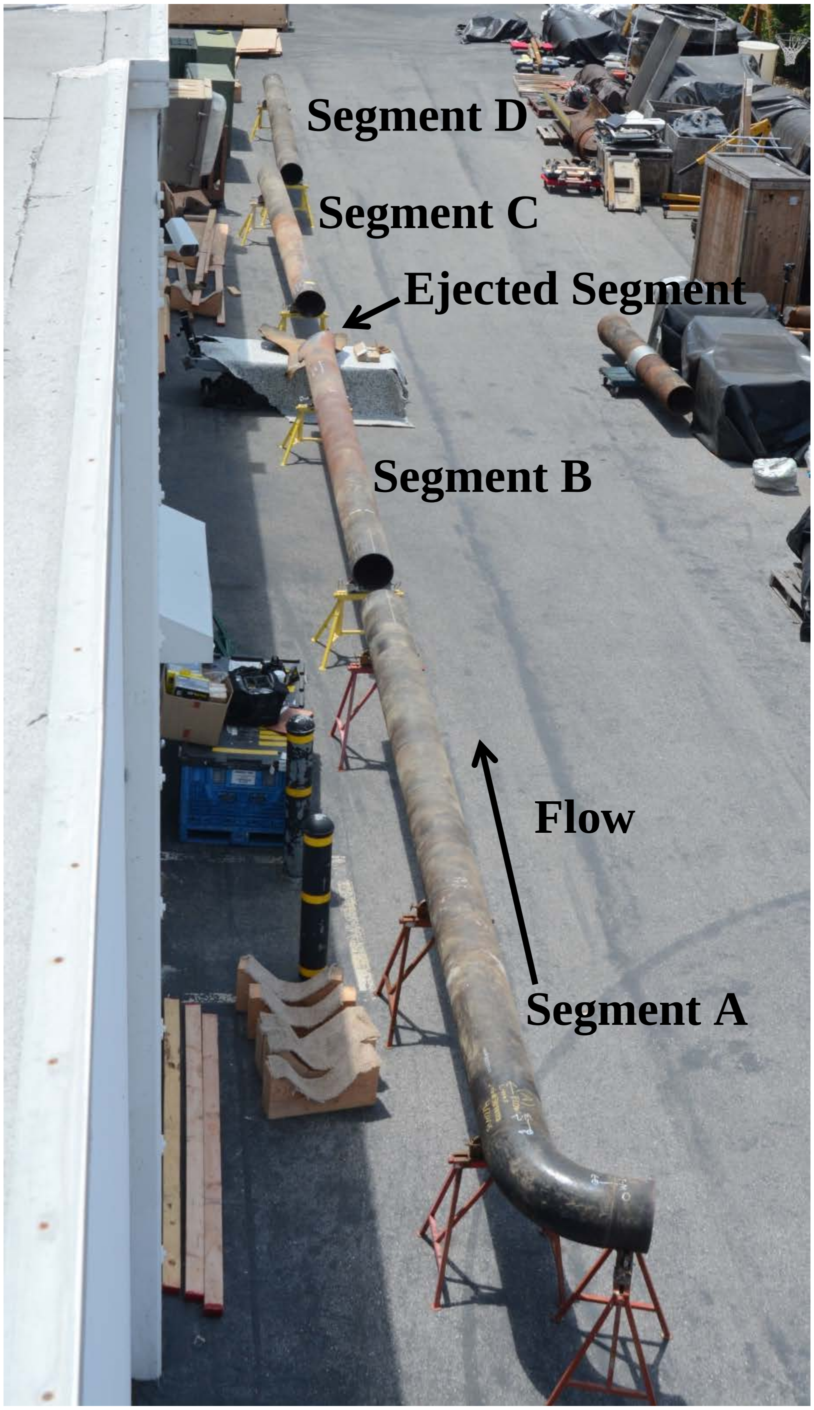


Figure 14. Photograph showing the five pipe pieces shipped to Exponent for analysis. From upstream to downstream, they include Segment A, Segment B, the Ejected Segment, Segment C, and Segment D.

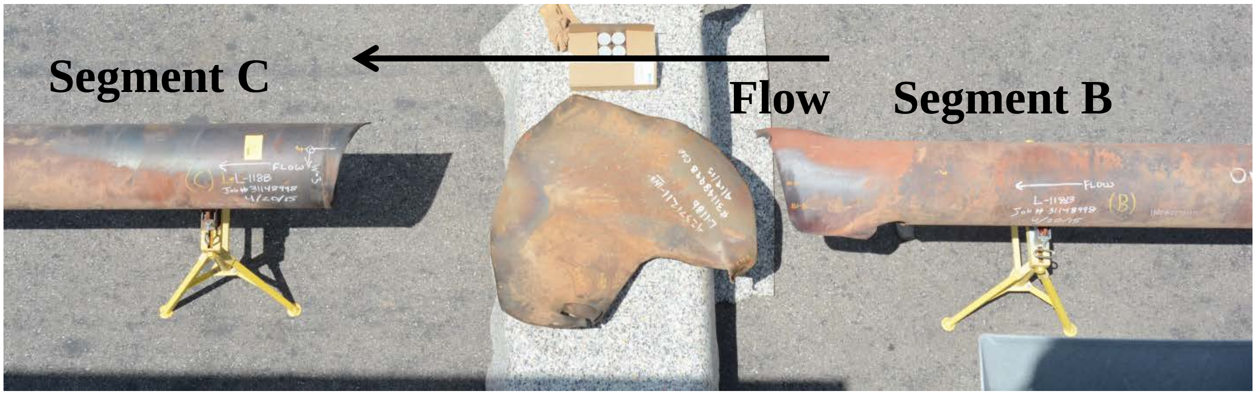


Figure 15. The Ejected Segment is shown in its correct orientation (approximate) with respect to adjacent pipe Segments B and C.

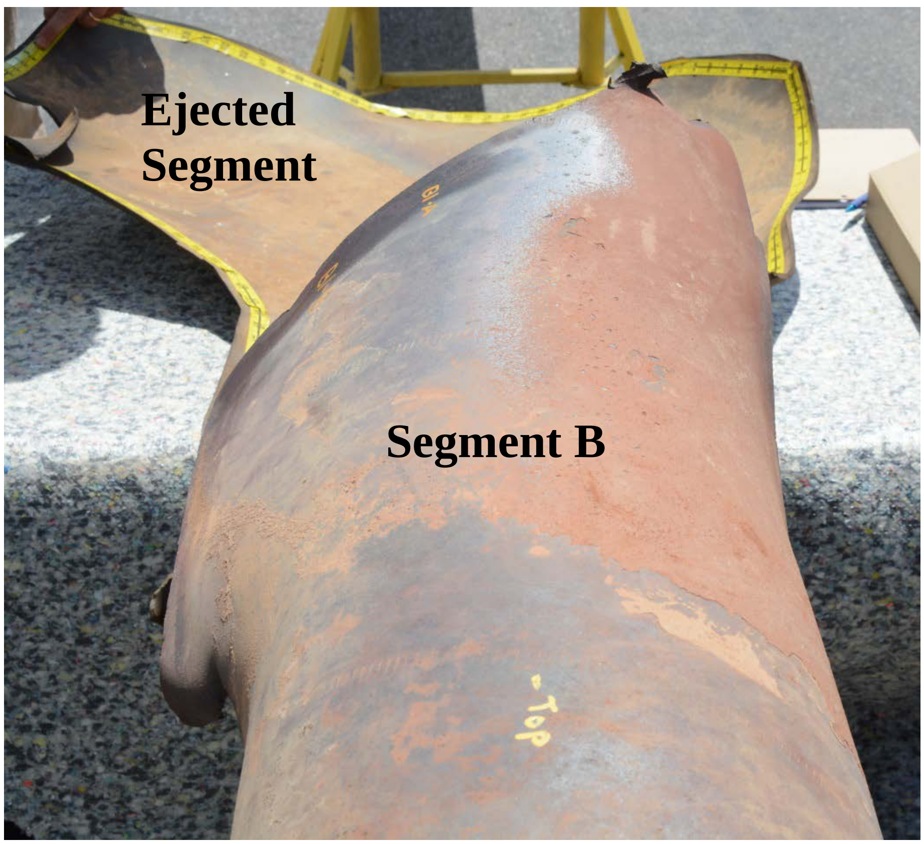


Figure 16. Photograph taken looking downstream along Segment B toward the Ejected Segment.

Nondestructive Testing

After initial visual inspection and photo documentation, pipe Segments A, B, C, and D were subjected to sandblasting, detailed visual inspection, ultrasonic thickness measurements, magnetic particle inspection, and laser scanning. This work was performed by the Mears Group at Exponent's facility. The fracture surfaces on Segments B and C were masked to protect from sandblasting. The Ejected Segment was not sandblasted. Regions not sandblasted were not subjected to magnetic particle examination.

Figure 17 through Figure 20 summarize the results of the inspections. They include schematics of the four pipe segments with specific findings marked with different colors. Detailed descriptions of the nondestructive inspections are provided later in this report. The following color convention was used:

- Purple: Mechanical damage (MD)
- Green: Magnetic particle (MP) indication
- Red: External corrosion (EC)
- Purple grid: Ultrasonic thickness (UT) grid at 6 o'clock for possible internal corrosion

The details of each finding are provided by the Mears reports in Appendix A.

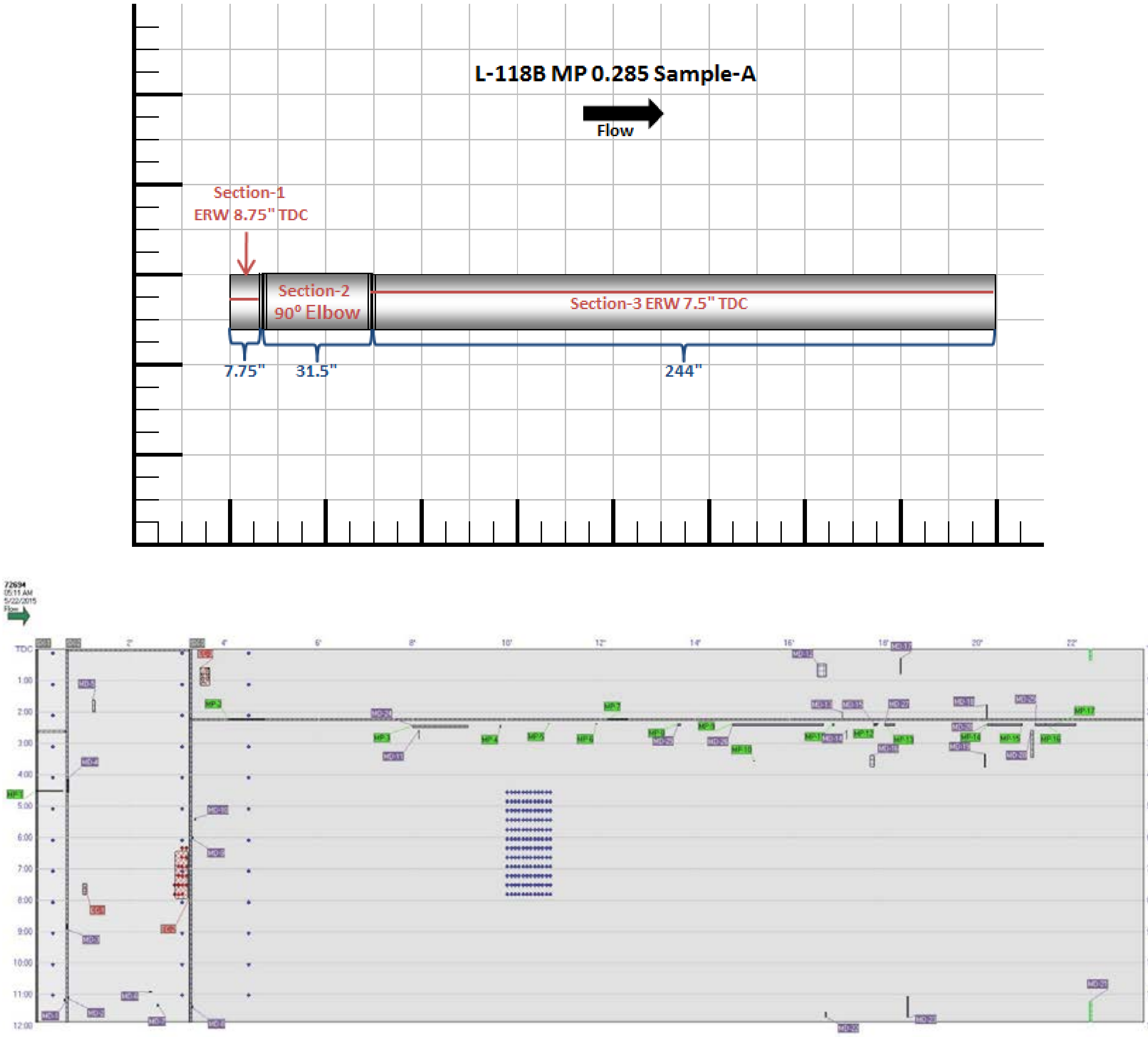


Figure 17. Overview of pipe Segment A. Indications are shown on the bottom image, with full details contained in Appendix A.

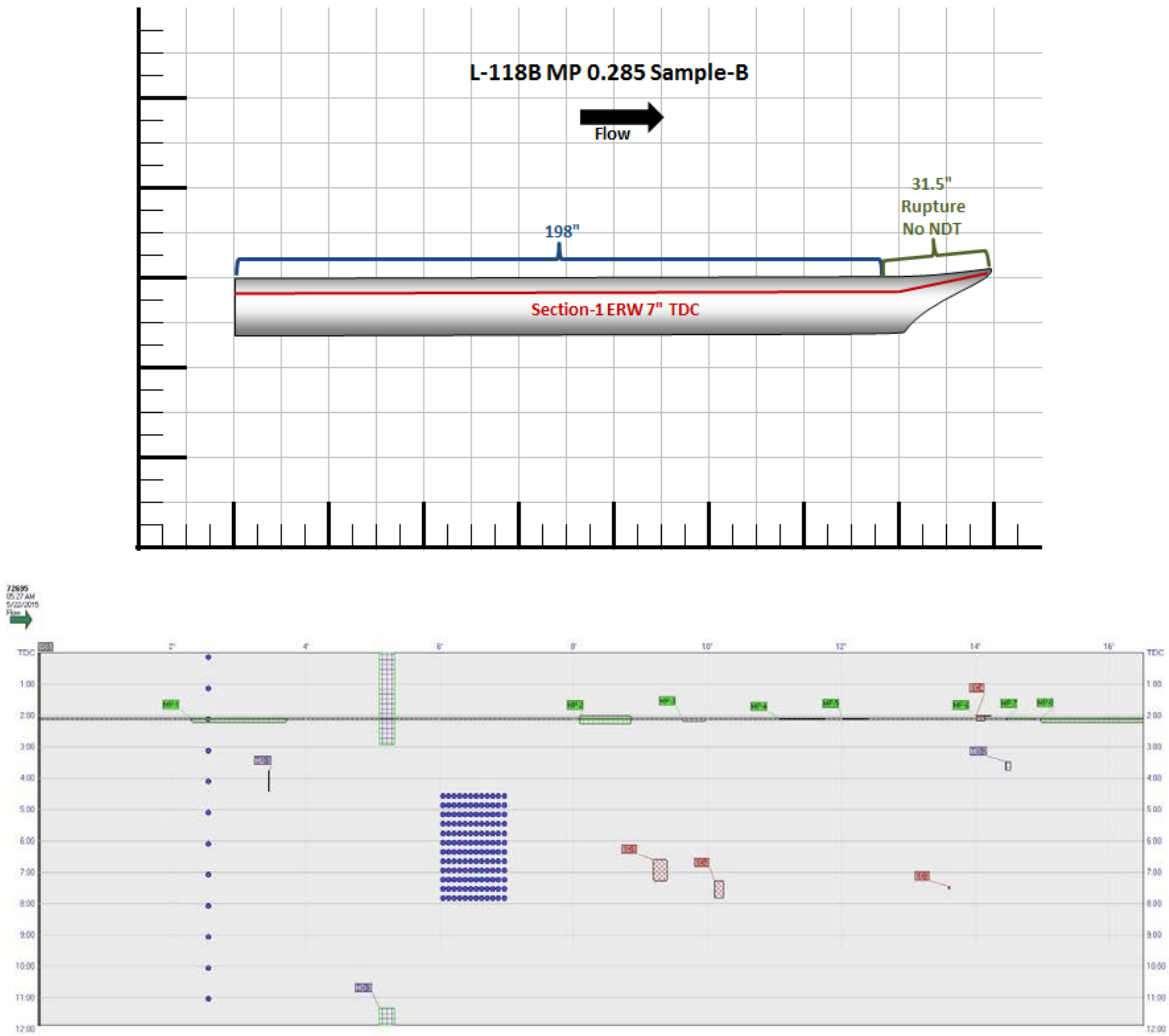


Figure 18. Overview of pipe Segment B. Indications are shown on the bottom image, with full details contained in Appendix A.

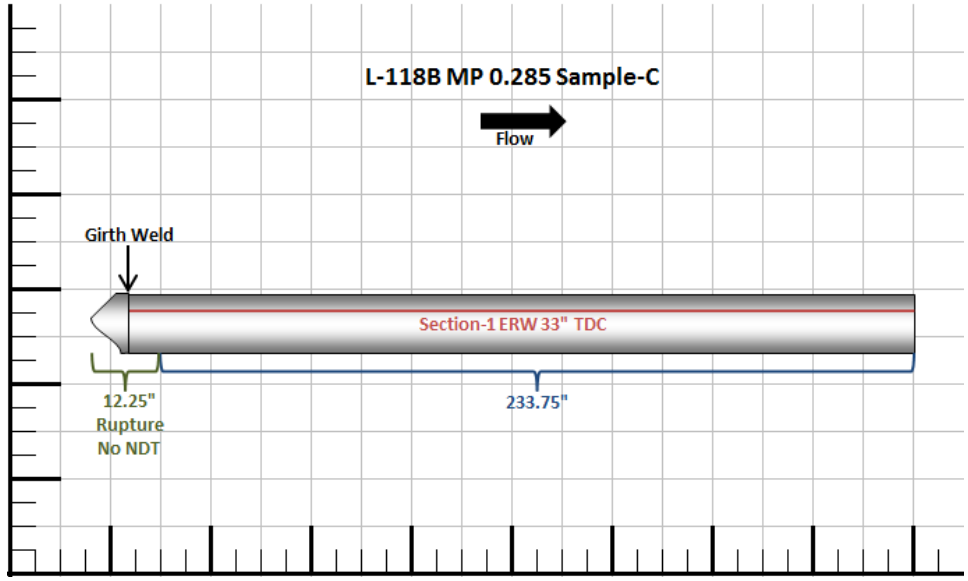
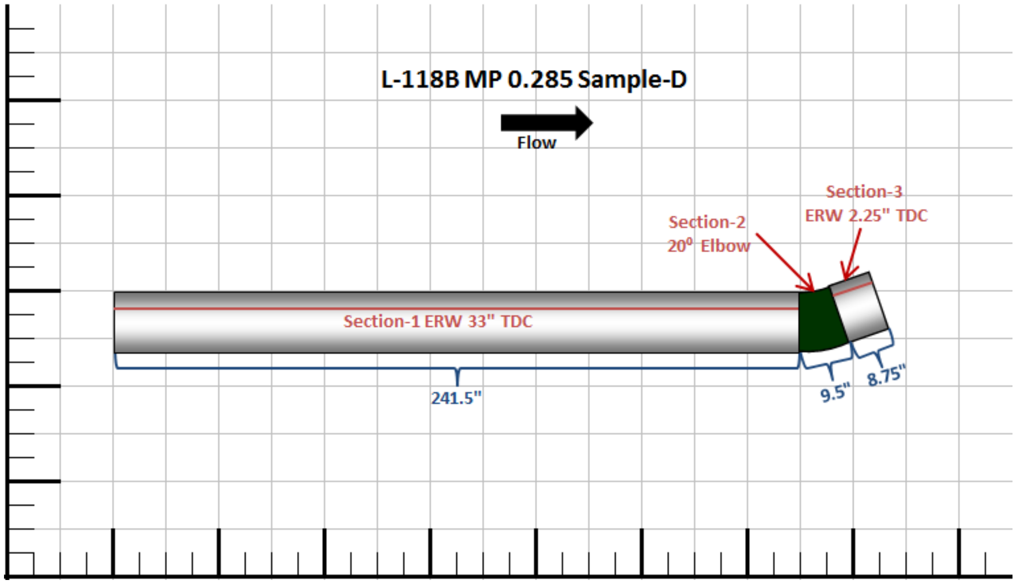


Figure 19. Overview of pipe Segment C. Indications are shown on the bottom image, with full details contained in Appendix A.



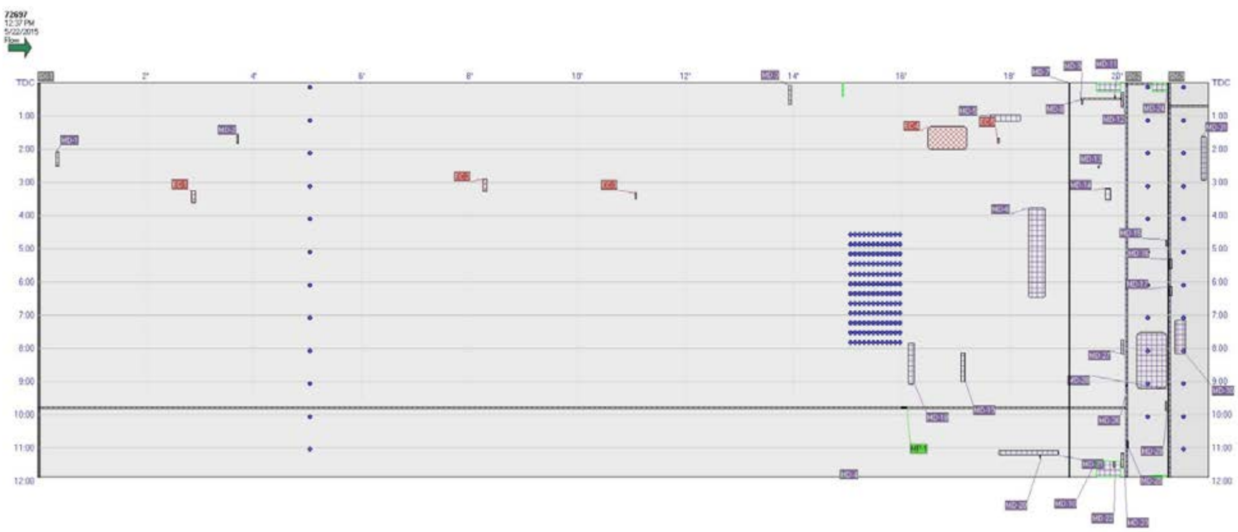


Figure 20. Overview of pipe Segment D. Indications are shown on the bottom image, with full details contained in Appendix A.

Ultrasonic Thickness Inspection

Ultrasonic wall thickness measurements were performed on each of the four pipe segments. Twelve measurements were taken on each segment, evenly spaced around the circumference. Table 2 summarizes the thickness measurement data, and the complete set of data is included in Appendix A. Average pipe wall thicknesses ranged from 0.254 to 0.256 inches. No wall thickness outliers were observed, and the data exhibited very low scatter relative to the averages.

Table 2. Summary of ultrasonic wall thickness (WT) measurements. For each pipe segment, 12 measurements were made around the circumference. Complete data is available in Appendix A.

	Average WT (in.)	Min WT (in.)	Max WT (in.)
Segment A	0.254	0.251	0.256
Segment B	0.254	0.249	0.257
Segment C	0.255	0.252	0.263
Segment D	0.256	0.254	0.262

Detailed Visual and Magnetic Particle Inspection, Laser Scanning

After sandblasting, the four pipe segments (A, B, C, and D) were subjected to detailed visual inspection, magnetic particle inspection (MPI), and laser scanning. Three types of indications were recorded: mechanical damage (MD), external corrosion (EC), and magnetic particle (MP) indications. All three indication types were marked on the pipes and photographed. This section summarizes findings from these inspections.

The nondestructive inspection results for external corrosion and mechanical damage on Segments A, B, C, and D are summarized in Table 3, including a count of each indication type and minimum, maximum, and average depths. Relatively few instances of external corrosion were noted. Segments A and D showed numerous instances of mechanical damage, primarily in the form of scratches; however, most of these indications were small. The complete set of visual inspection results is included in Appendix A.

A representative example of the limited external corrosion is shown in Figure 21 (Segment A-EC3). The most substantial external/ mechanical damage (other than the front loader-induced damage) is shown in Figure 22 (Segment A-MD8). This mechanical damage is close in proximity to a girth weld and was determined by the Mears group to be an arc burn from welding. A more representative example of the mechanical damage observed on the pipe segments is shown by Figure 23 (Segment A-MD14). A periodic array of indents appears to wrap around the pipe at various locations, as shown by Figure 22. This indent array is likely the result of the pipe-wrapping process, given that the pitch of the indents appeared to match that of the wrap.

A summary of the MP analysis is shown in Table 4. Due to the nature of MP testing, the depths of these indications could not be determined at this point in the investigation (nondestructively), as with external corrosion and mechanical damage. To determine depth, selected indications were removed from the pipe for metallographic analysis, the results of which are presented subsequently in this report. All but one of these MP indications (A-MP10) was found along the long seam for each stick of pipe.

Each of the pipe segments was laser scanned to generate three-dimensional models prior to any destructive testing. An example is shown in Figure 29, with Segment B, the Ejected Segment, and Segment C. The Ejected Segment is positioned in the approximate correct location relative to Segments B and C. These three-dimensional shape files were also used to reconstruct the pipe segments to a roughly pre-rupture condition, as shown by Figure 30. In this image, the actual shape file from each deformed pipe piece has been modified slightly to recreate the roundness of the original pipe shape. This image clearly shows the area of the metal fold on the Ejected Segment and its proximity to the top of the pipe and the longitudinal seam.

Table 3. Summary data of visual inspection results for mechanical damage (MD) and external corrosion (EC).

	Segment A		Segment B		Segment C		Segment D	
Damage Type	MD	EC	MD	EC	MD	EC	MD	EC
Count	29	3	3	4	5	1	31	5
Average Depth (in.)	0.008	0.030	0.005	0.018	0.004	0.015	0.008	0.016
Min Depth (in.)	0.001	0.023	0.003	0.011	0.002	0.015	0.002	0.008
Max Depth (in.)	0.040	0.044	0.007	0.022	0.006	0.015	0.035	0.025
Average Wall Loss (%)	2.9	8.8	1.8	7.4	1.6	6.0	2.9	6.2
Min Wall Loss (%)	0.4	6.1	1.2	4.6	0.8	6.0	0.8	3.0
Max Wall Loss (%)	15.7	11.3	2.8	8.7	2.4	6.0	13.7	9.8

Table 4. Summary of magnetic particle examination results.

	Segment A	Segment B	Segment C	Segment D
Count	17.0	8.0	3.0	1
Average Length (in.)	4.2	8.7	1.4	1.3
Min Length (in.)	0.1	2.8	1.0	1.3
Max Length (in.)	23.3	18.5	1.8	1.3

Figure 21. A representative example of minor external corrosion from Segment A (A-EC3).

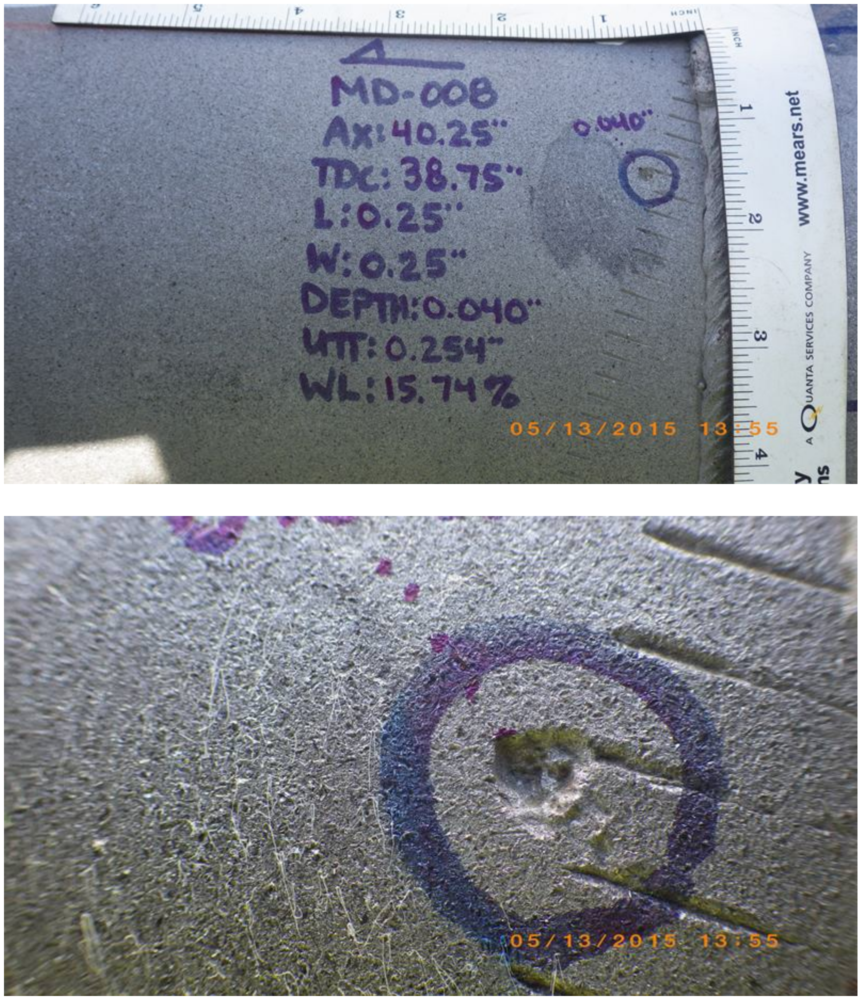


Figure 22. Arc-weld damage A-MD8 exhibited the greatest wall loss of any MD or EC at 16 percent.

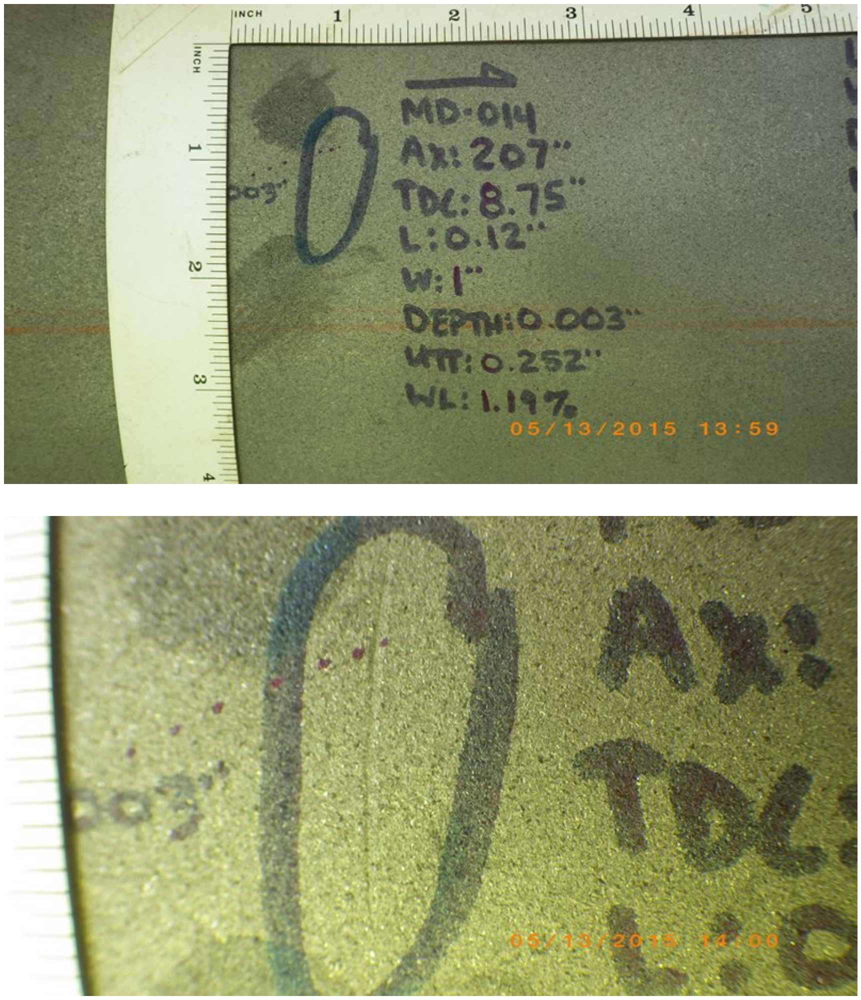


Figure 23. A representative instance of mechanical damage (A-MD14).

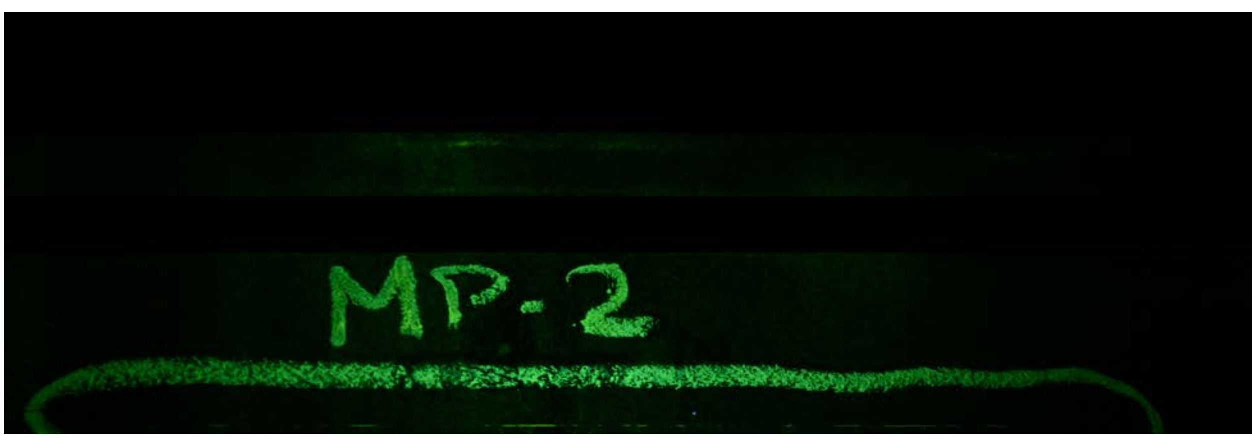


Figure 24. Magnetic particle indication A-MP2.

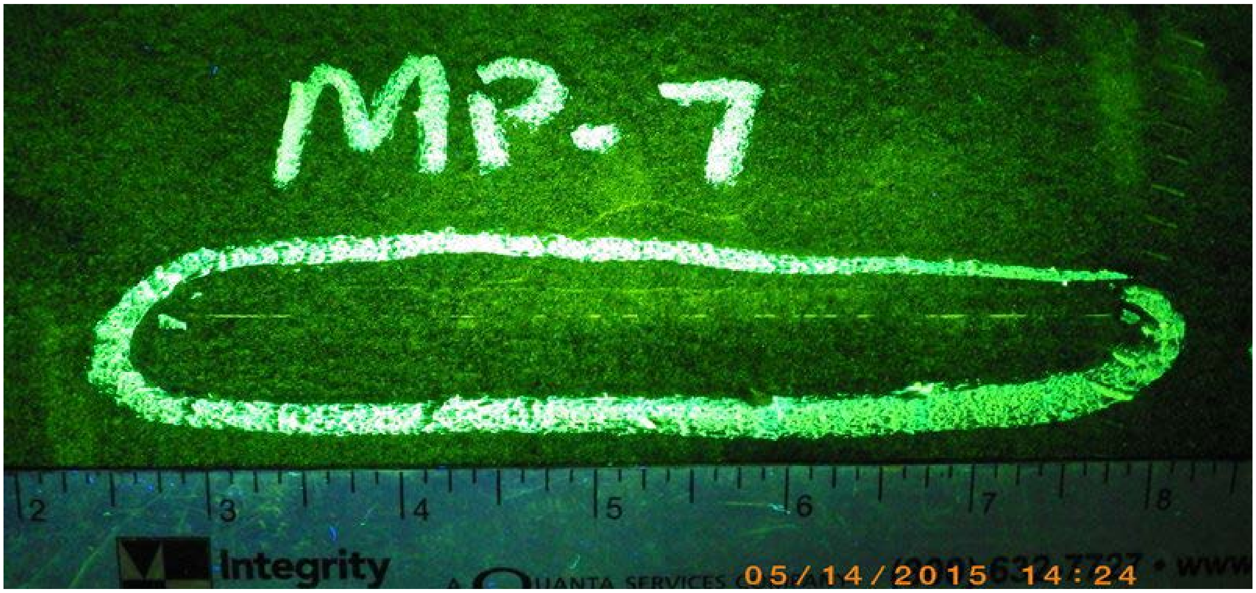


Figure 25. Magnetic particle indication A-MP7.

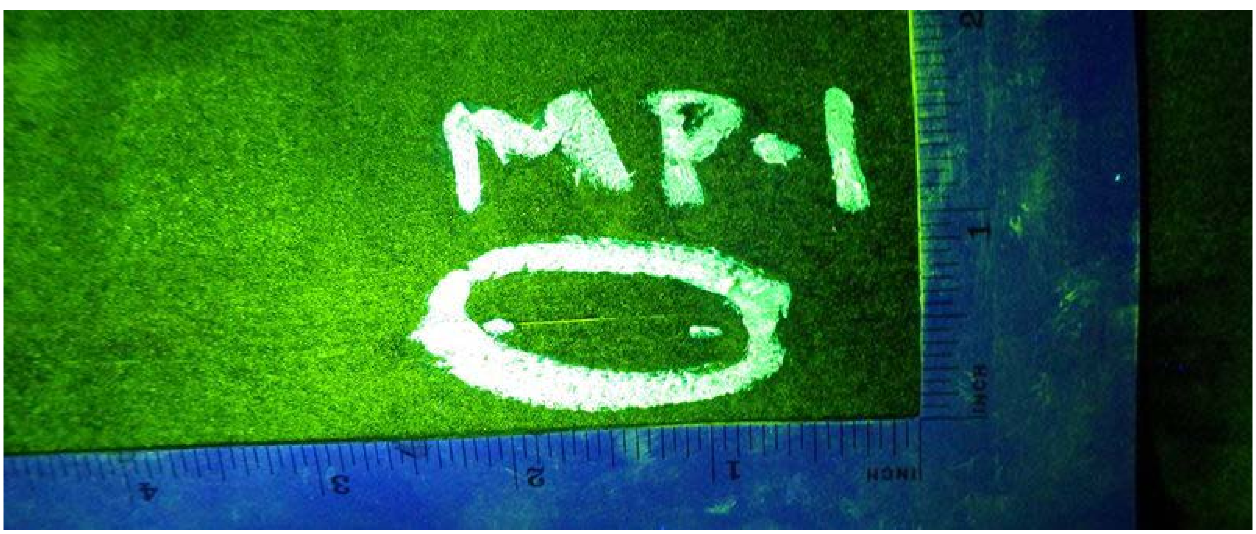


Figure 26. Magnetic particle indication C-MP1.

Figure 27. Magnetic particle indication C-MP3.

Figure 28. Magnetic particle indication D-MP1.

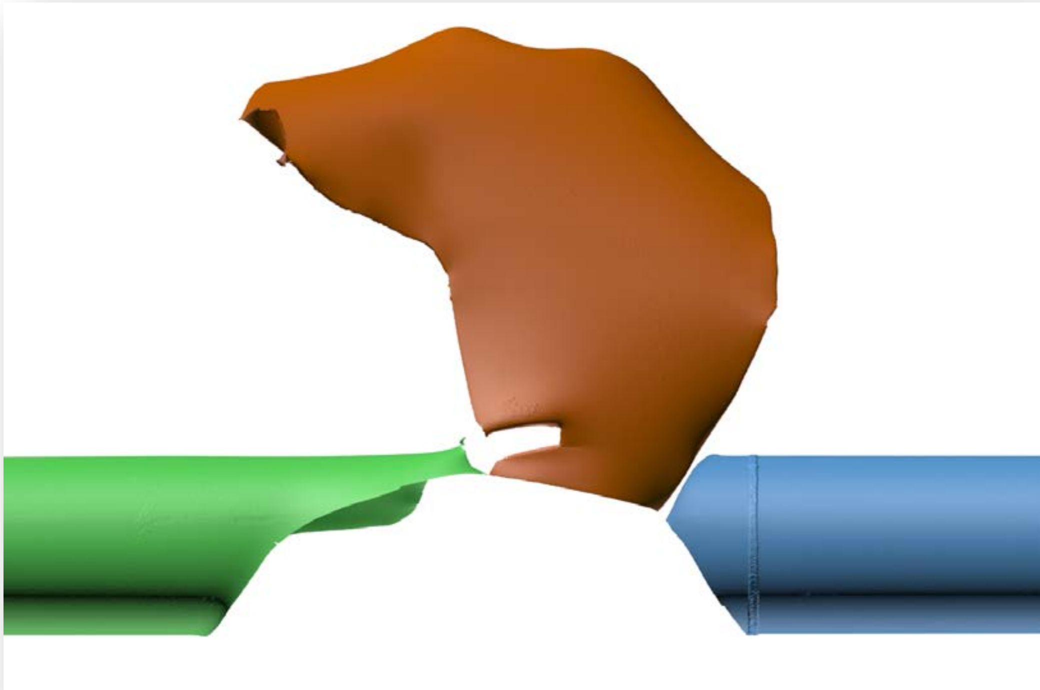


Figure 29. Laser scan view of the 3:00 position of Segment B (green), the Ejected Segment (middle, brown), and Segment C (blue).

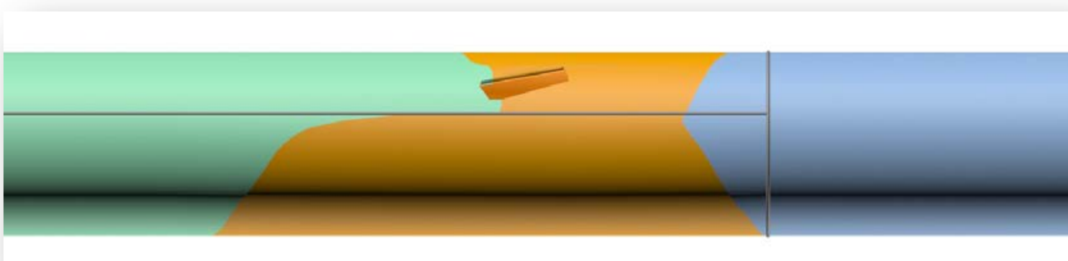


Figure 30. Laser-scan reconstruction of the pipeline viewed at the 3:00 location with Segment B (green), the Ejected Segment (middle, orange/brown), and Segment C (blue).

Girth-Weld Radiographic Inspection

Radiographic inspection was performed on five girth welds that were exposed during the excavation of the incident pieces. The five girth welds include the two on either side of the upstream elbow (Segment A), the two on either side of the downstream elbow (Segment D), and the girth weld near the rupture location on Segment C. Radiography was performed at the incident site directly after excavation and coating removal. The girth welds were found to contain areas of incomplete penetration, slag inclusions, and porosity. Full details are available in Appendix B. None of the fractures at the rupture location originated from or passed through any of the girth weld anomalies.

Fractography

Sectioning

To allow for high-magnification microscopy and more detailed inspection, samples of the fracture surfaces were cut from the larger rupture pieces. Two samples, named “EJ Frac 1” and “EJ Frac 2,” were cut from the Ejected Segment, as shown in Figure 31. These two samples included matching fracture surfaces along the long seam, as well as the area of mechanical damage and the inward puncture/fold of the pipe. A third sample, called “B Frac 1,” was removed from Segment B. The area of Segment B that was removed contained an area of mechanical damage and fracture surface, and was near the 12:30 position of the pipe. The parent-child relationships of samples used in the analysis is shown below:

- B Frac 1
  - B Frac 1 Met
- EJ Frac 1
  - EJ Frac 1 SEM
    - EJ Frac 1 SEM A
    - EJ Frac 1 SEM B
  - EJ Frac 1-Linear
- EJ Frac 2
  - EJ Frac 2-2
    - EJ Frac 2-2 Met
  - EJ Frac 2-3
    - EJ Frac 2-3 Met

Figure 33 shows the three fractographic samples positioned in the same relative orientations as they were in the pipeline, wherein gas flow would have been from right to left. In this image, B Frac 1 is clearly differentiated by the red coloring on the outer diameter, whereas the two samples cut from the Ejected Segment are gray/brown in color. The difference in coloring is a result of a large oxide scale that formed on Segment B during the post-rupture fire. In contrast, the Ejected Segment was apparently exposed to lower temperatures than Segment B, and therefore did not form the same oxide scale layer. In Figure 33, the gas flow is from right to left, the railroad and Highway 99 would be behind the camera, and the dirt road would be in front of the pipe pieces.

These three pieces (EJ Frac 1, EJ Frac 2, and B Frac 1) represent the initial cuts performed to initiate the fractographic analysis. From these three pieces, detailed visual examination was performed, as well as subsequent cuts for microscopy.

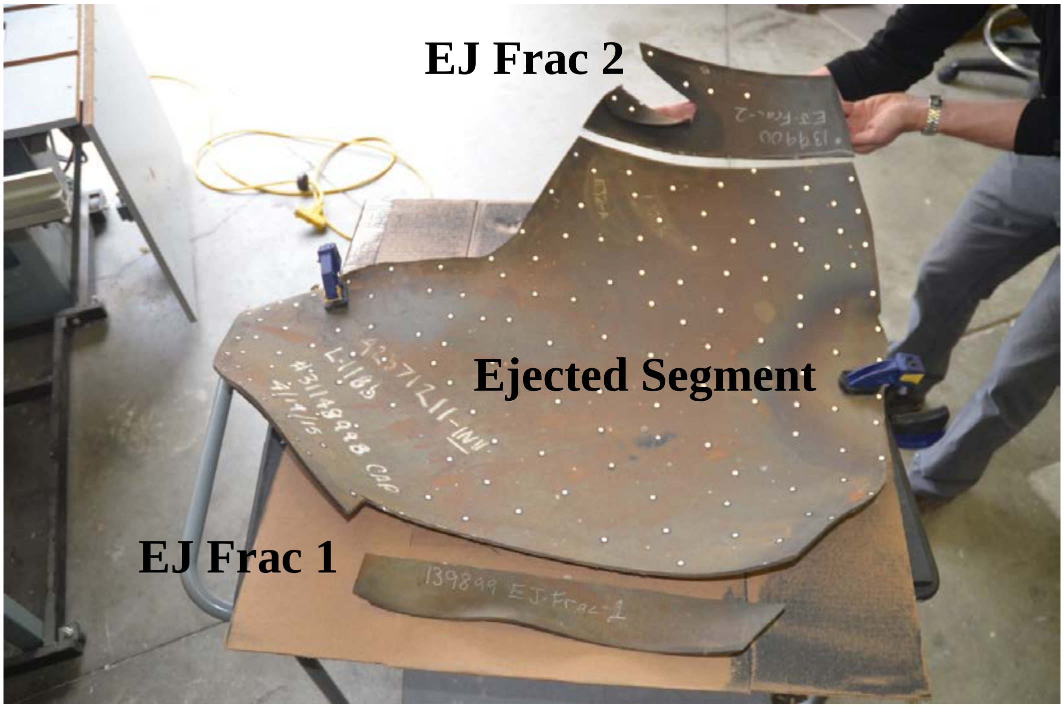


Figure 31. Initial sectioning of the Ejected Segment (center) to remove fractographic samples EJ Frac 2 (top) and EJ Frac 1 (bottom).

Figure 32. Initial sectioning, showing how sample B Frac 1 was removed from Segment B.

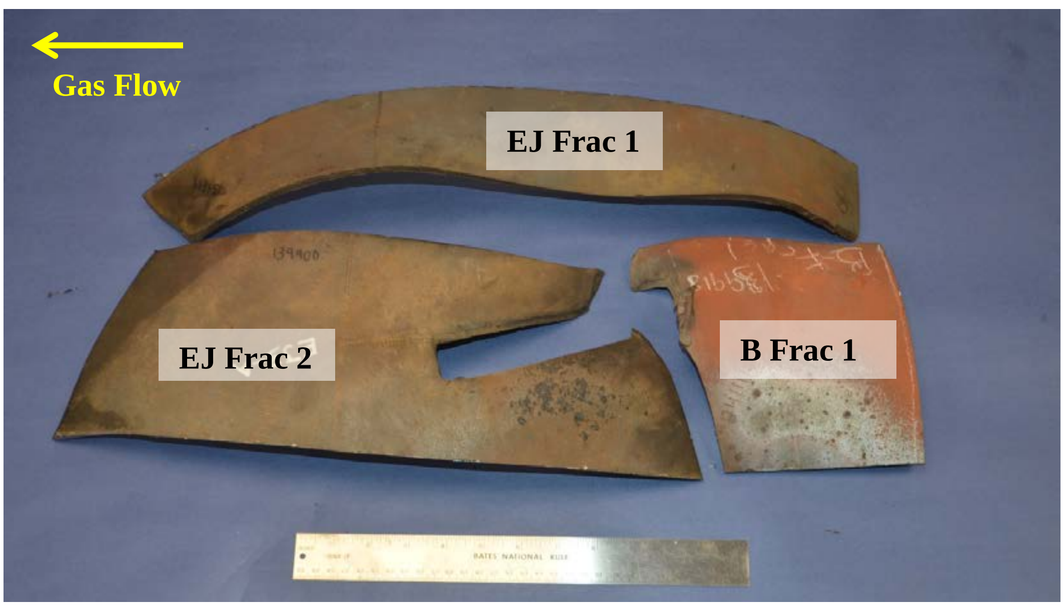


Figure 33. Image showing the outside surfaces of the three fractographic samples oriented as they were in the pipeline. Samples EJ Frac 1 (top) and EJ Frac 2 (lower left) were removed from the Ejected Segment (see Figure 31), and fractographic sample B-Frac 1 (lower right) was removed from Segment B and exhibits a reddish-orange color on the outer surface.

Detailed Visual Inspection of Fractographic Samples

Each of the three fractographic samples was examined in detail prior to further cutting. The inward fold on the Ejected Segment exhibited scrape marks perpendicular to the length of the pipe on the outer diameter. These marks were relatively uniform in nature and ran approximately 1–2 inches before ending at the ductile tear. The marks are shown on sample EJ Frac 2 in Figure 34. The inward fold is indicative of a puncture; otherwise, the expansion of gas would force metal to open in the opposite direction of the observed fold. The puncture and scrape marks conclusively indicate that the pipeline was subjected to an externally applied force from heavy equipment. This force would have had to have been of sufficiently large to puncture the line and leave the observed scrapes and gouges.

Given the visual inspection and the observations outlined in the Field Investigation section of this report, it is clear that the pipe was struck with the bucket of the front loader. Although a more detailed analysis is provided in the Discussion section, selected comments regarding the cause of the rupture will be provided here and throughout the remainder of the report to provide context for the analyses.

It can be seen in Figure 33 that the "hole" associated with the puncture is rectangular/linear in nature, consistent with the edge of the bucket striking the pipe. Further, the hole begins relatively abruptly on the upstream side, with no marks or damage upstream of the hole. The extent of folding of the flap created by the puncture is reduced moving from upstream to downstream. A linear scrape extends for 2.5 to 3 inches downstream of the puncture site and decreases in severity. These observations are consistent with a bucket that struck the pipeline at an angle such that more contact occurred on one side than the other, as shown in Figure 35.

Four stages of crack growth associated with the rupture following initial puncture are shown by Figure 36. First, the initial puncture of the pipe by the bucket occurred in the approximately 5-inch length of the metal fold. In Figure 36, the loader and bucket would have been moving toward the reader (i.e., toward the railroad tracks), given that flow is from right to left. This is evident by the scrape marks on the outer diameter, the inward fold, the shape and orientation of the puncture itself, and the position and orientation of the fracture relative to the dirt road. Second, after initial puncture, the crack propagated via ductile tearing in both circumferential directions. This circumferential crack initiated at the area struck most severely by the bucket, namely the upstream/uphill side. Third, one of the circumferential cracks intersected the long seam after traveling approximately 1.5 inches in the clockwise direction. Given that ERW welds can have reduced toughness [1-3] (resistance to crack propagation) relative to base metal, it is not surprising that the crack then traveled along the long seam for a total of 19 inches prior to the fourth stage of rupture: final ductile overload in the base metal. Figure 37 shows the fracture along the longitudinal seam and chevron marks at each end of the long seam fracture. The chevron marks point back to the location of crack origin on the long seam, which is the same location where the circumferential crack intersects the long seam. Although four stages of fracture are outlined in this report, fracture occurred nearly instantaneously: the rupture was not the result of progressive crack growth or other time-dependent phenomena.

A photograph of Segments B and C taken after the incident is shown in Figure 38 along with annotations that indicate general directions of crack propagation. Most of the fracture paths outlined in this image are ductile tears that comprise the fourth stage of fracture discussed in the previous section. Approximately six inches of Segment B fracture surface occurred along the seam weld, as shown by Figure 36. The Segment C fracture surface is shown in Figure 38 in the clockwise direction, looking downstream. It is possible the fracture that separated Segments EJ and C occurred in the counter-clockwise direction; however, the direction was not significant to the investigation.

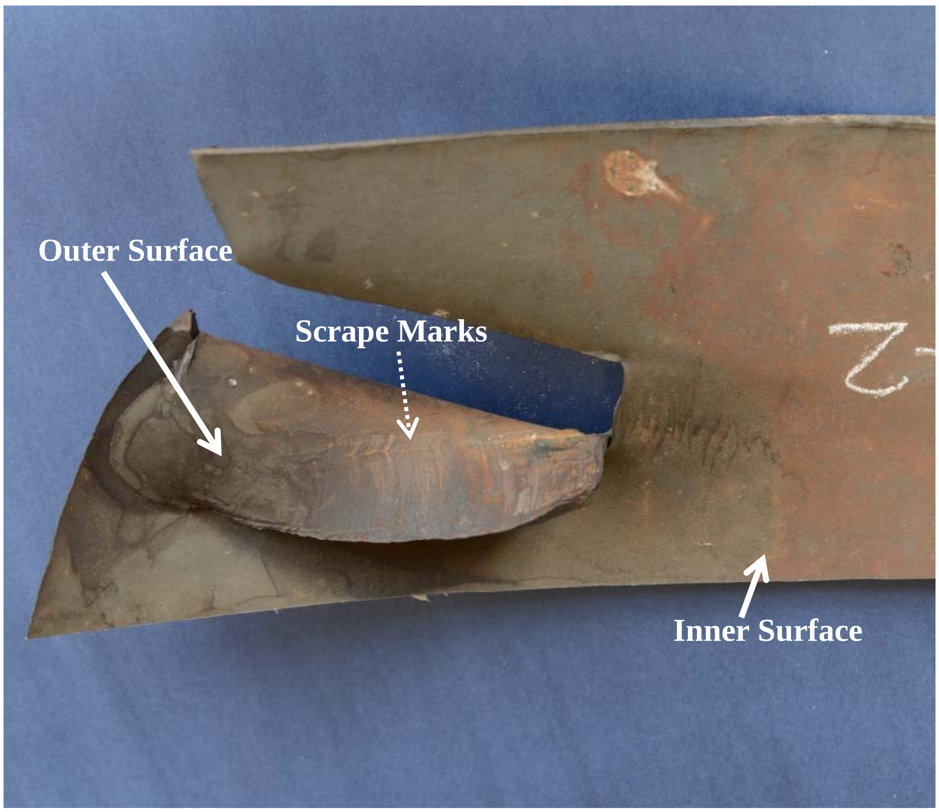
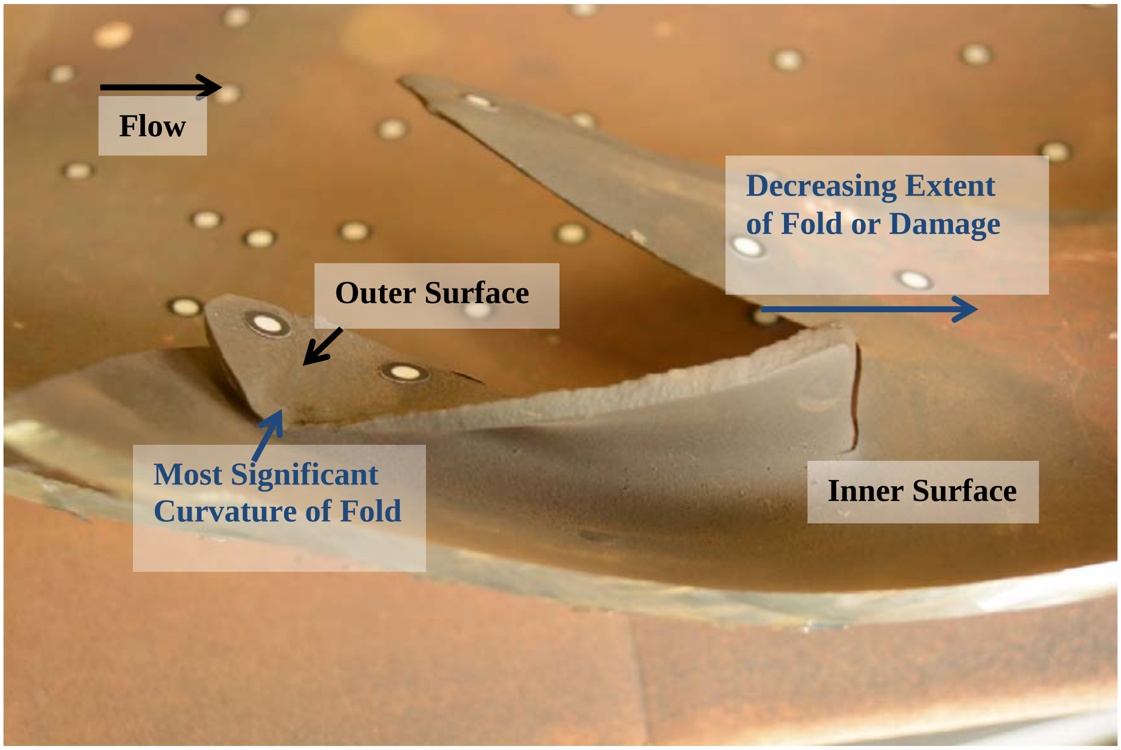


Figure 34. Photograph of the apparent puncture location that exhibits scrape marks on the outside surface of the inward-folded flap. The flap is approximately 5 inches long.



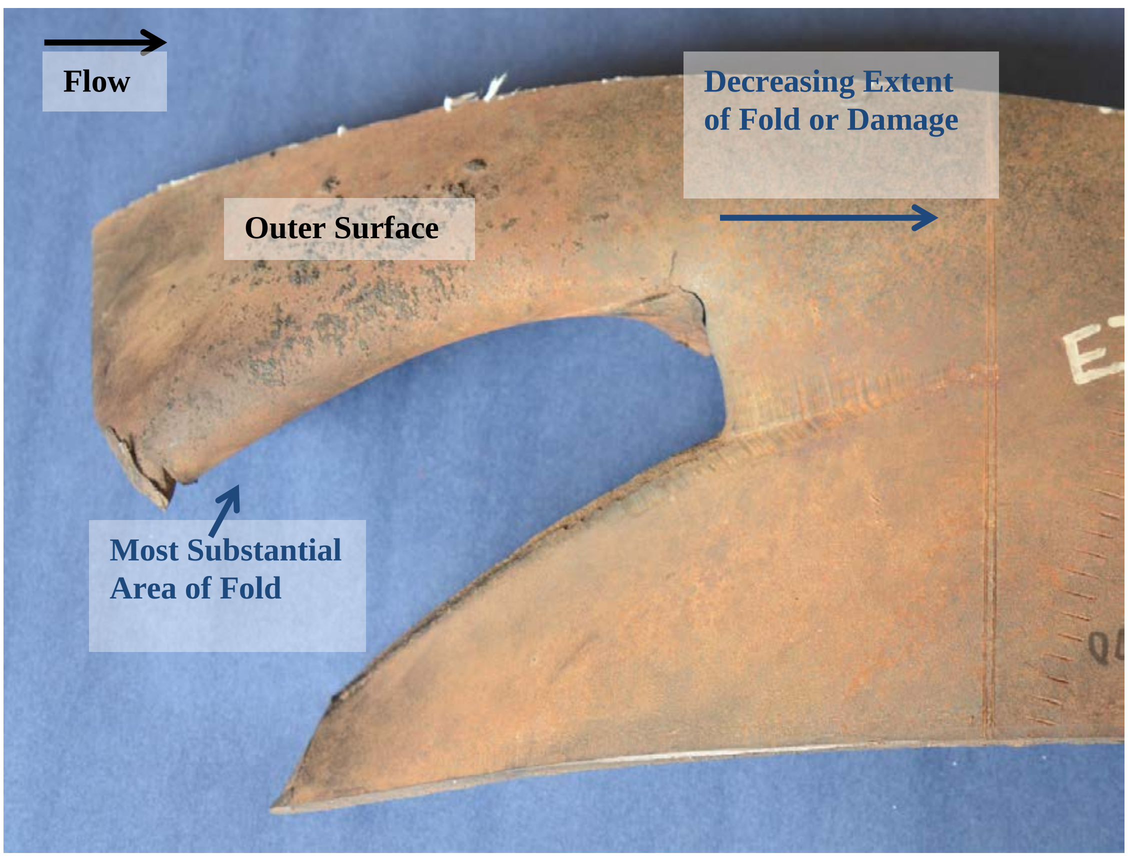


Figure 35. Photographs of the fold showing a decreasing extent of damage in the downstream direction.

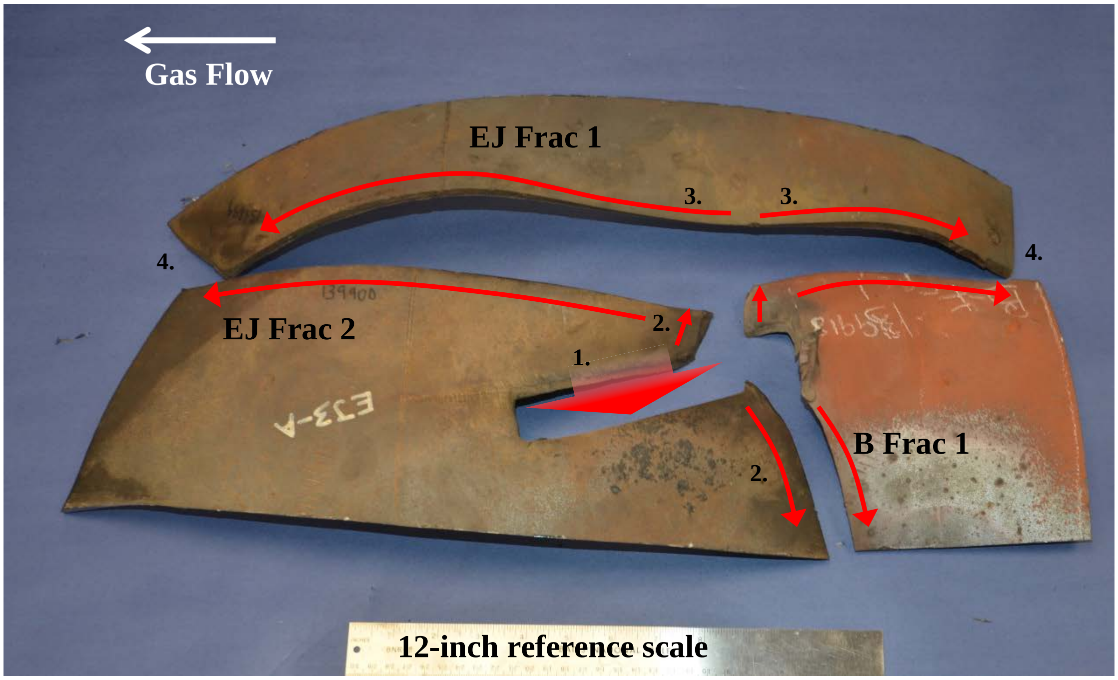


Figure 36. Fracture occurred in four stages: (1) initial puncture, (2) crack bi-frication in a circumferential orientation away from initial puncture in both directions, (3) crack propagation along the long seam for 19 inches in total, and (4) final ductile tearing (not shown).

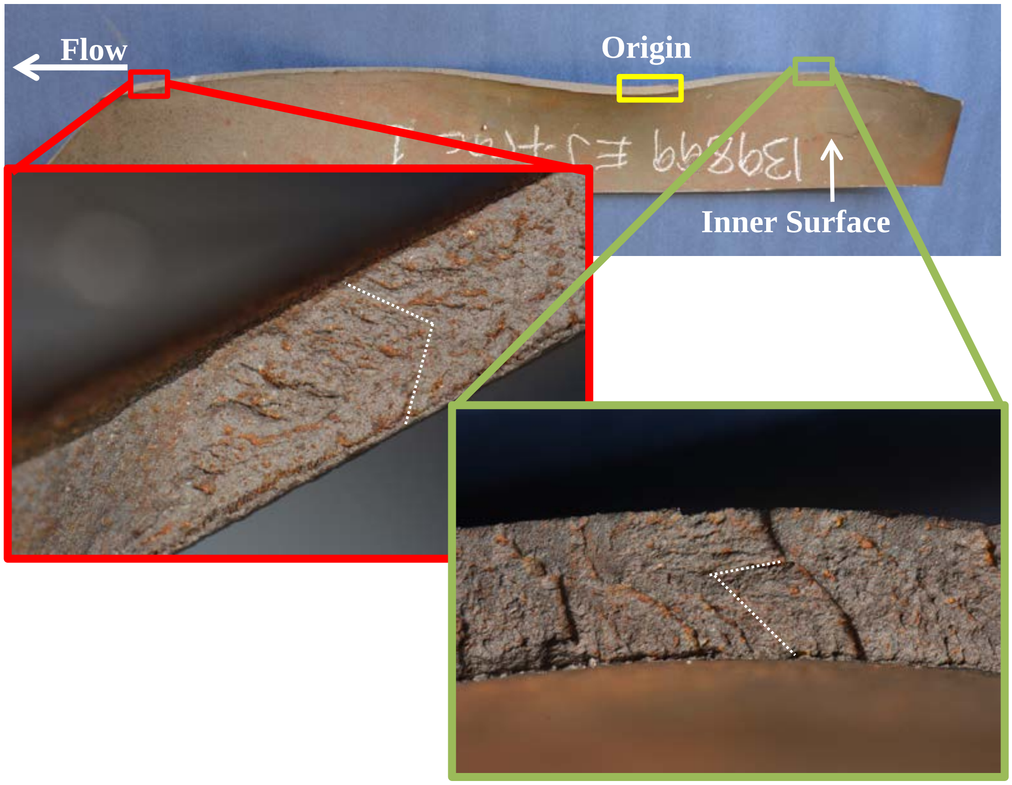


Figure 37. Chevrons on the long seam fracture of EJ Frac 1.

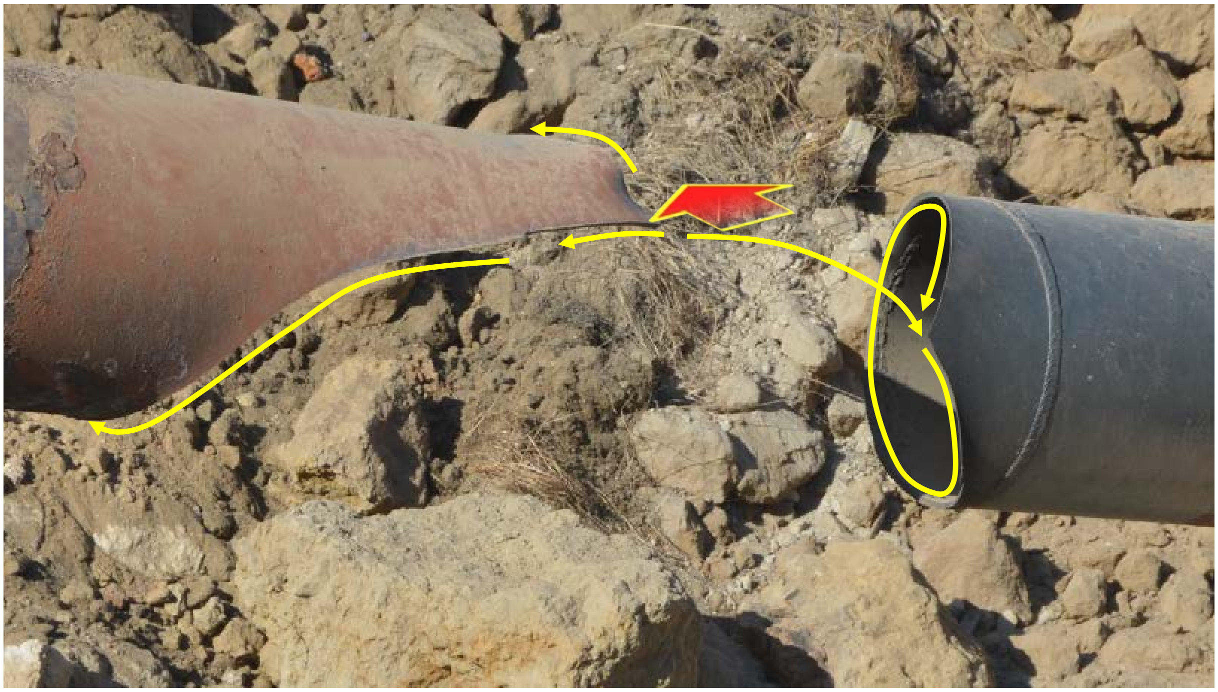


Figure 38. Photograph of the pipeline rupture location prior to removal from the incident site. The yellow arrows trace the likely fracture path following initial puncture (shown by the red arrow).

Mechanical Damage

Visual

After the initial visual fractographic examination, small pieces were sectioned to allow for higher-magnification examination and microscopy. Two pieces were sectioned to investigate mechanical damage on Ejected Segment metal fold (EJ Frac 2), and one piece was sectioned to investigate the fracture along the long seam (EJ Frac 1—SEM). The two pieces extracted for mechanical damage investigation will be presented first. Sample EJ Frac 2-2 was sectioned as shown by the white cut marks shown in Figure 39. This sample represents the furthest downstream side of the metal fold. The piece contains scrape marks on the outer diameter, and fracture surfaces on two sides where it was separated from the mating piece, as shown in Figure 39.

EJ Frac 2-2 sample, after cutting, is shown in Figure 40, where the scrape marks are clearly visible along the outer diameter of the pipe. The bucket would have first made contact with the pipe (along the line shown at the bottom of the image), and then scraped in an upward direction until fracture occurred at the top of the sample. As the pieces were arranged in the ground, this would correspond to scraping in a direction roughly perpendicular to the length of the pipe toward the railroad and Highway 99, consistent with the apparent direction of travel of the subject front loader. Three regions on this piece were imaged using high-magnification optical microscopy, and are shown in Figure 40, Figure 41, and Figure 42. The two fracture surfaces shown in Figure 42 (A and B), show fracture on a 45-degree plane to the pipe wall thickness, which is indicative of ductile shear/tearing. The line shown at Area C is the location where the bucket first struck the pipe.

Figure 39. Sample extraction for sample labeled: EJ Frac 2-2. The piece was removed from the Ejected Segment.

Figure 40. Photo documentation of EJ Frac 2-2 showing scrapes from third-party damage along the outer diameter of the pipe.

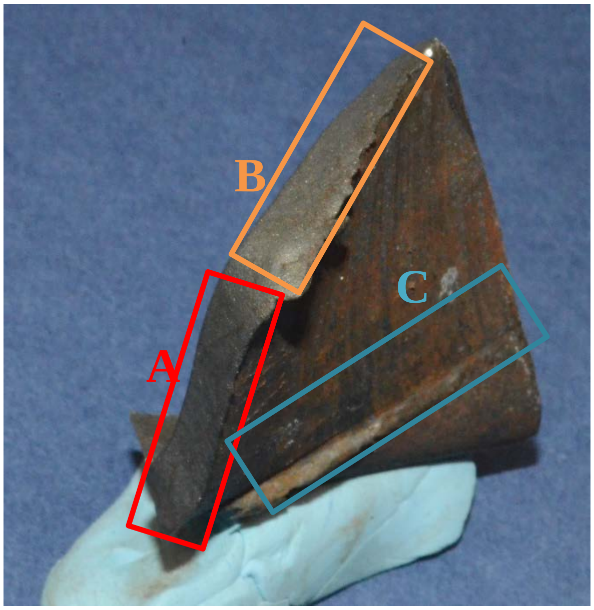


Figure 41. Photo documentation of EJ Frac 2-2 showing areas of further analysis (Figure 42).

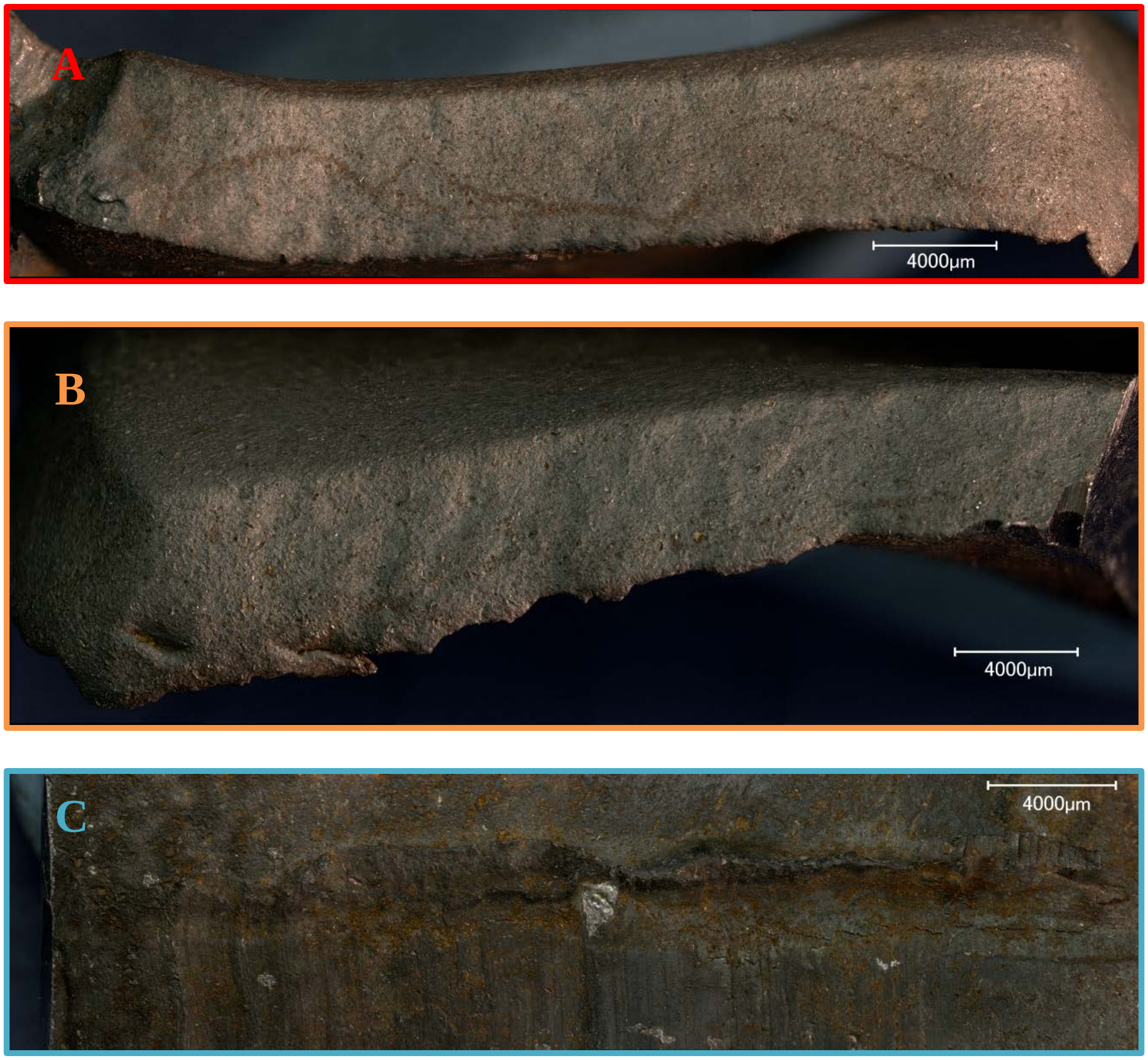


Figure 42. Detailed light images of the fracture surfaces (A) and (B) of EJ Frac 2-2, and mechanical damage on the outer diameter (C).

The second sample extracted for mechanical damage investigation was identified as EJ Frac 2-3, and is shown in Figure 43. This sample corresponds to the most upstream portion of the metal fold. Figure 44 shows two images of the piece after it was cut from EJ Frac 2. It is clear that the significant inward deformation corresponds to the location where the bucket first struck the pipe. More images of the fracture surfaces are shown in Figure 45, which indicate significant plastic deformation, as well as some amount of thinning in the wall thickness due to the dent/gouge.

Figure 43. Extraction of sample EJ Frac 2-3. Sample was cut from the Ejected Segment.

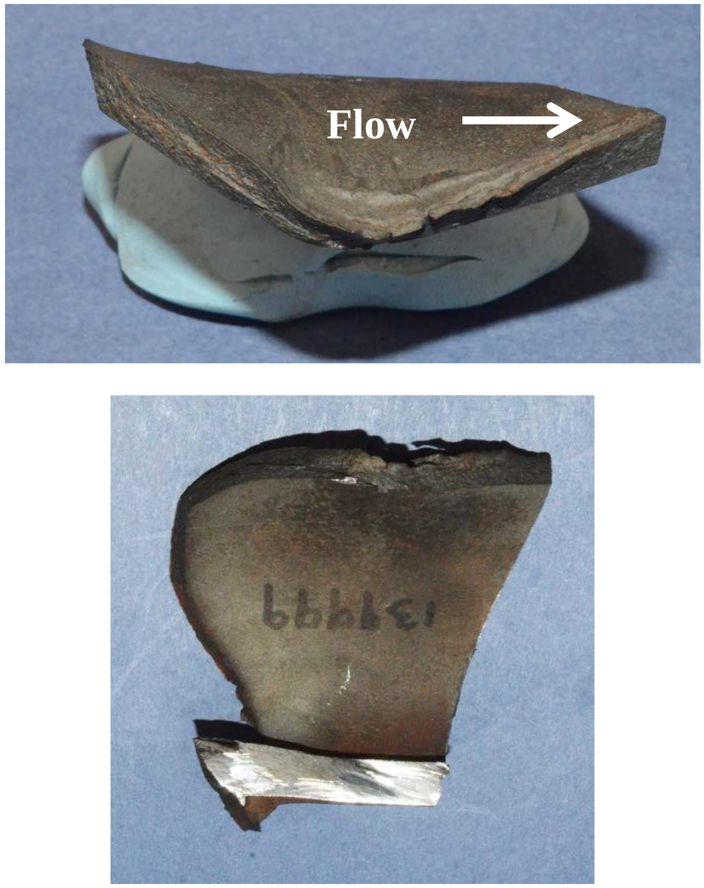


Figure 44. General photo documentation of sample EJ Frac 2-3.

Figure 45. Images of EJ Frac 2-3 that show significant plastic deformation along the outer diameter, causing an inward bend of the metal.

Microscopy and Energy Dispersive Spectroscopy

Both EJ Frac 2-2 and EJ Frac 2-3 samples were imaged in the scanning electron microscope (SEM). Various methods of fracture surface cleaning were employed before and during imaging. These methods included manual brushing with a nylon brush, ultrasonic cleaning in a warm Alconox solution, and, finally, acetate replica removal.

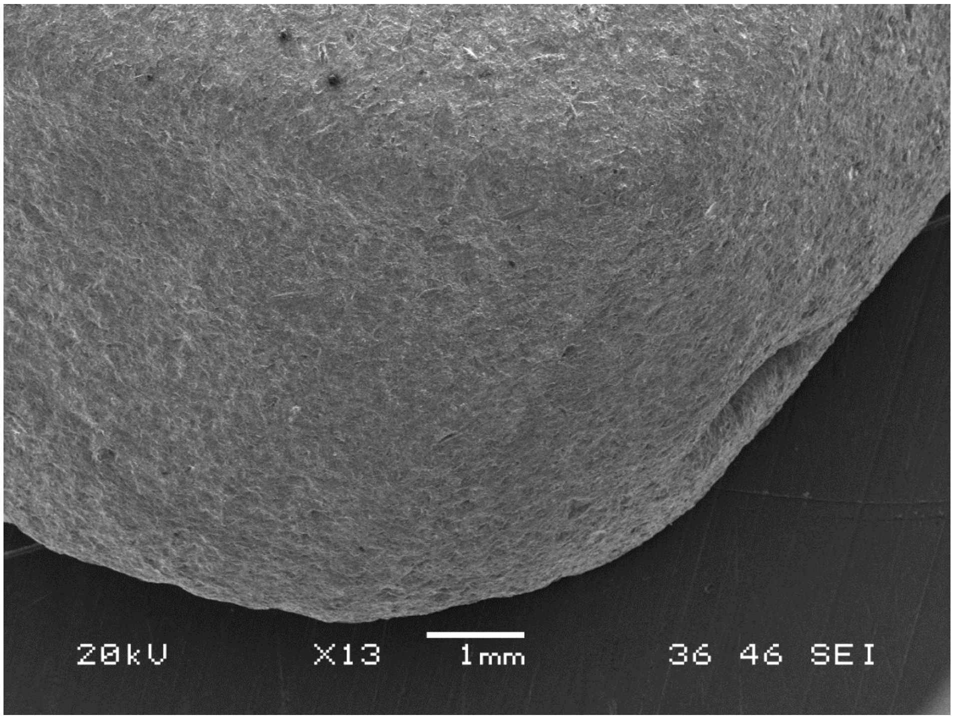
Figure 46 shows the fracture surface of the EJ Frac 2-2 sample in the area of the intersection of Areas A and B, as shown in Figure 41. Both low- and high-magnification images are shown.

Unfortunately, the microscopic fracture surface features were significantly degraded, which prevented meaningful SEM-based fractographic interpretation of sample EJ Frac 2-2. However, given the macroscopic angled-shear morphology, the failure mode on these specimens can be definitively characterized as ductile tearing. Thus, these fractures occurred in a ductile manner due to the application of a single, large force that exceeded the strength of the pipe.

The outer diameter of the EJ Frac 2-2 sample was also imaged (in addition to the fracture surface), as shown in Figure 47. In this image, we see Area C of Figure 41, which is the location the bucket first made contact with the pipe. Cracks are visible at this location, penetrating into the wall thickness. The same scrapes that were visible during visual examination are shown in Figure 47. Energy dispersive spectroscopy (EDS) was performed in this area and is shown in Figure 48. Although silicon, aluminum, and trace amounts of other elements were shown in this EDS spectrum, the primary constituent is iron oxide, the expected product on the surface of an uncoated steel pipe that has been exposed to the environment for many days.

After the SEM examination of the fracture surface, a section was extracted for metallographic analysis, as shown by Figure 49. For this sample, and for all samples prepared during this work, metallographic mounts were prepared in the downstream orientation (all metallographic images were taken as if the viewer is looking in a downstream direction). Selected images were taken on an inverted metallograph; in these images, the orientation appears reversed (i.e., if the fracture surface was on the left when looking downstream, it would appear on the right in the inverted metallographic image).

A metallographic image of the EJ Frac 2-2 mounted specimen is shown in Figure 50. The fracture surface is on the left. Significant plastic deformation along the outer diameter (top of image) is visible by the highly deformed grain structure in the 200–300 μm nearest the outer diameter. The metallographic mount was imaged in the SEM for possible evidence of metal transfer along the outer diameter. As shown in Figure 51, little evidence of metal transfer was noted. Figure 52 and Figure 53 show three EDS spectra in this area along the pipe outer diameter. These spectra show that the surface area contains more oxygen than the bulk, which is expected. No other metal elements were noted in significant quantities.



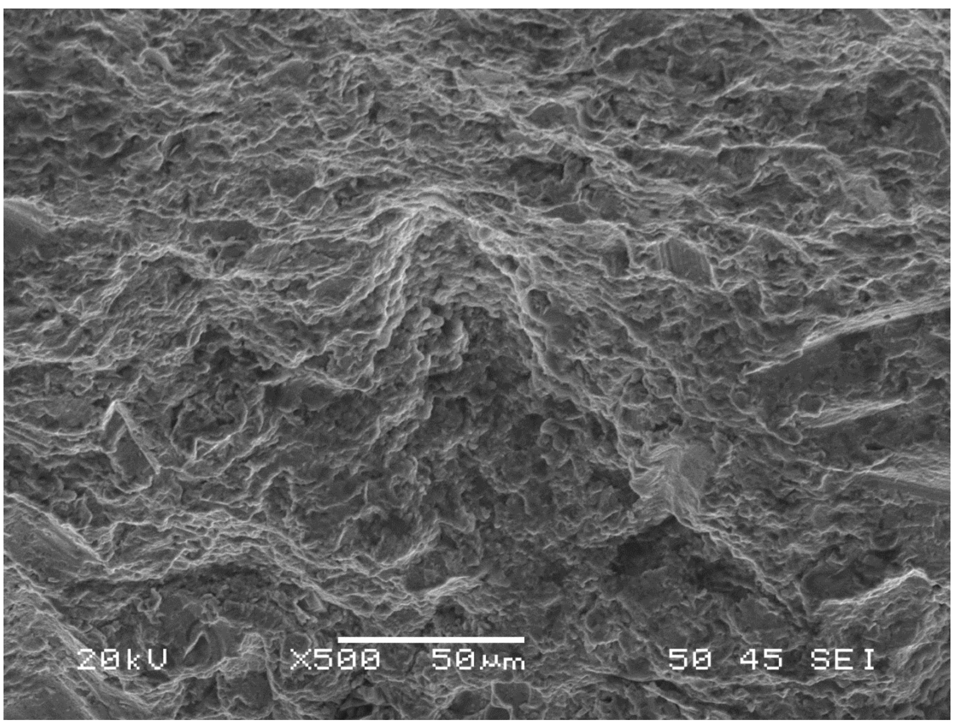
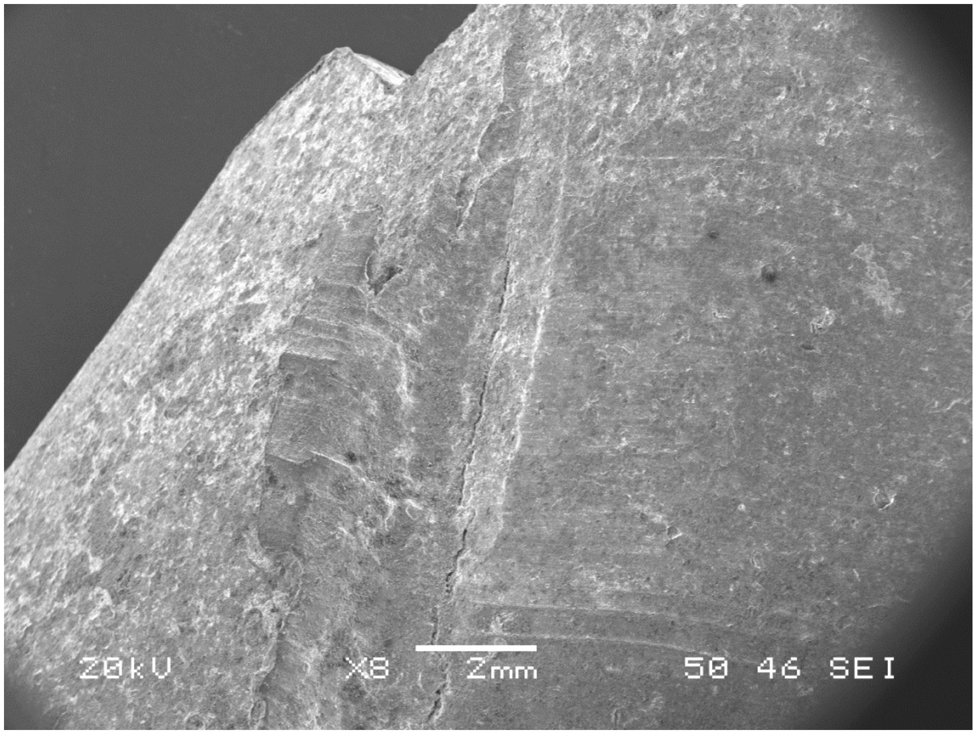


Figure 46. SEM images of the fracture surface of sample EJ Frac 2-2.



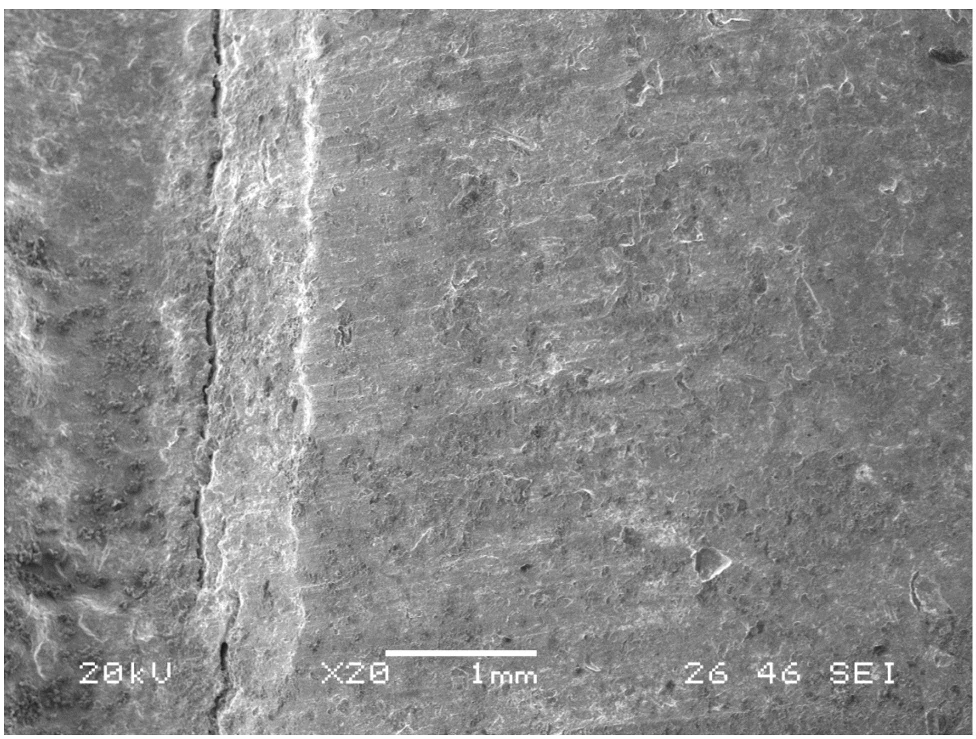


Figure 47. SEM image of the outer diameter of EJ Frac 2-2 showing scrapes and damage from mechanical contact.

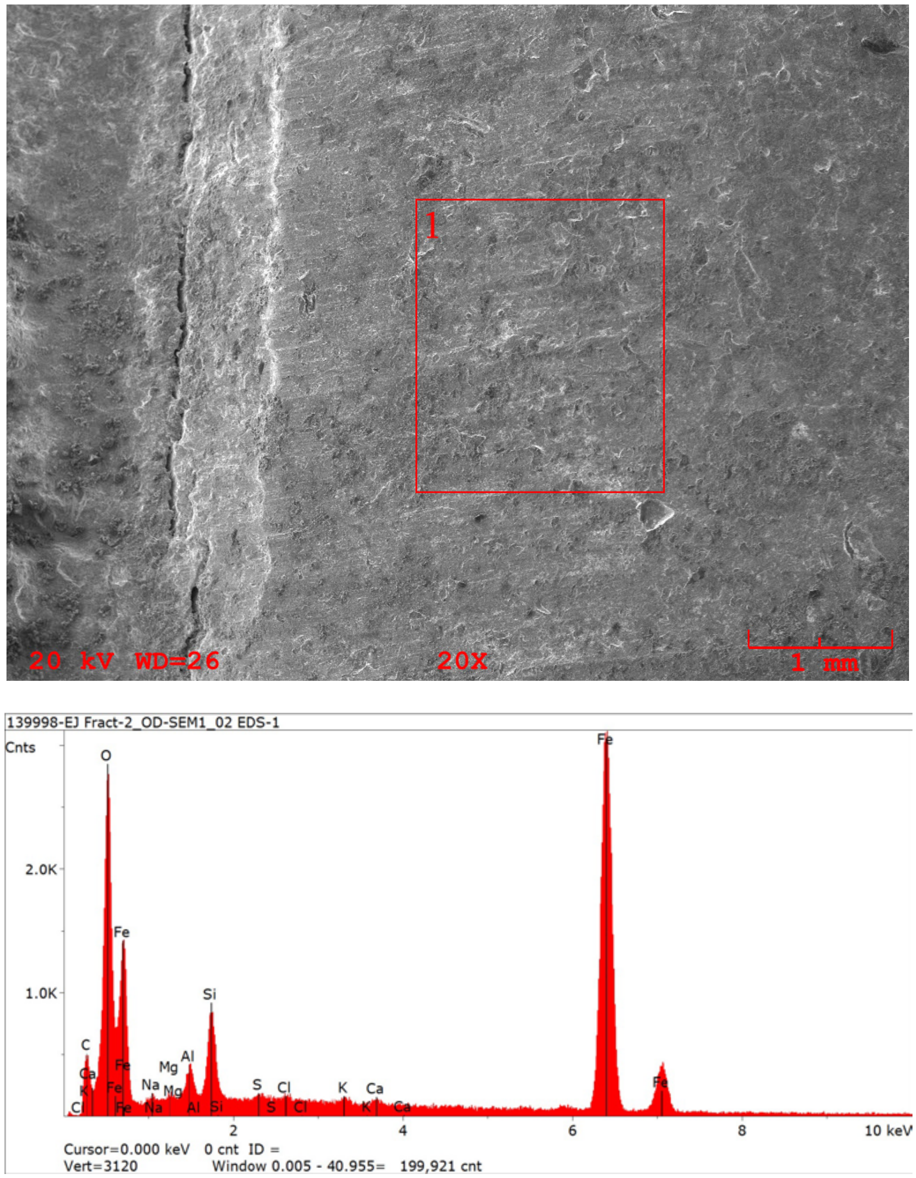
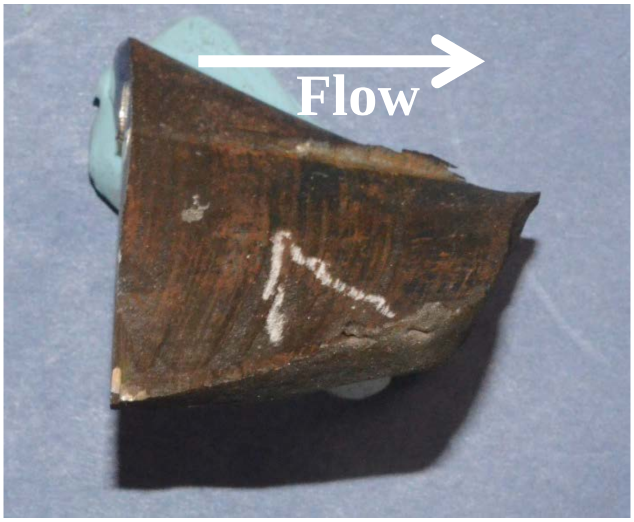


Figure 48. Area EDS scan of the outer diameter of EJ Frac 2-2.



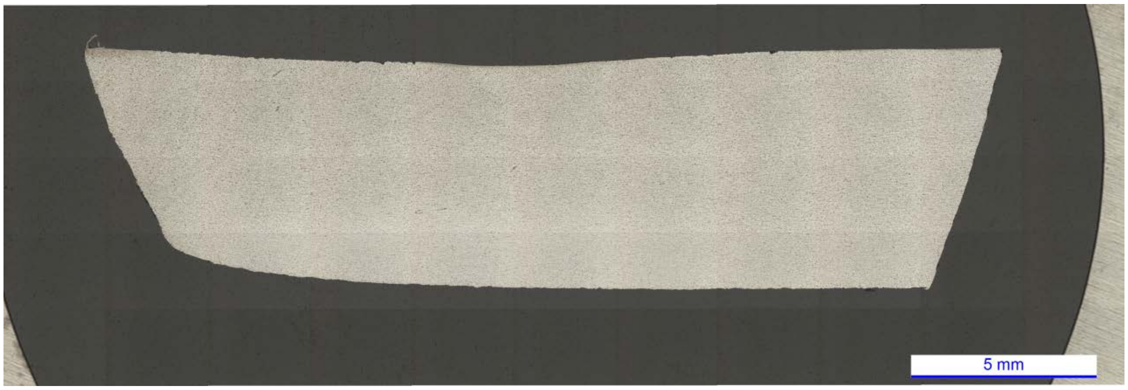


Figure 49. Metallographic sample extraction and mount from EJ Frac 2-2. The outer diameter is at the top of the sample, the inner diameter is at the bottom, and the fracture surface is on the left.

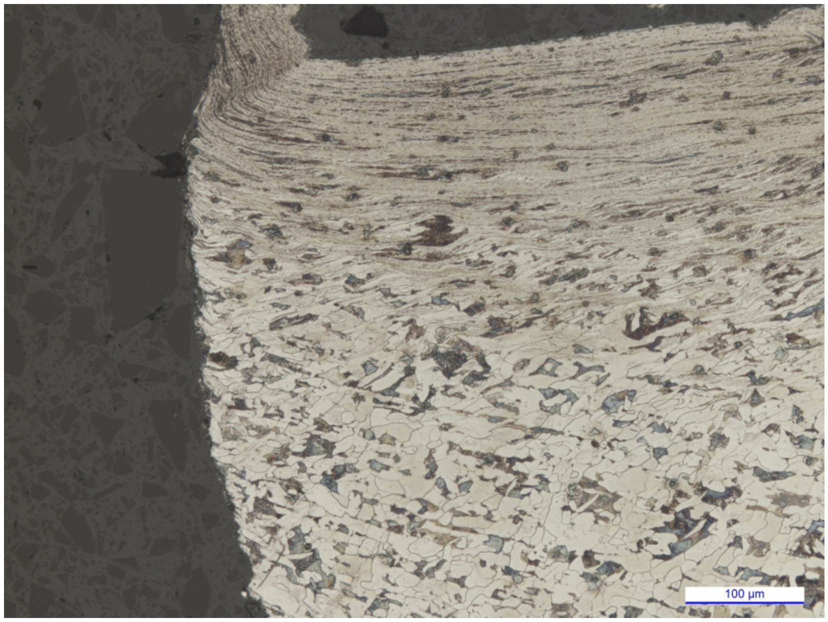


Figure 50. Metallographic image of EJ Frac 2-2 that shows significant plastic deformation on the outer diameter, evident by the highly-deformed grain structure along the top of the sample.

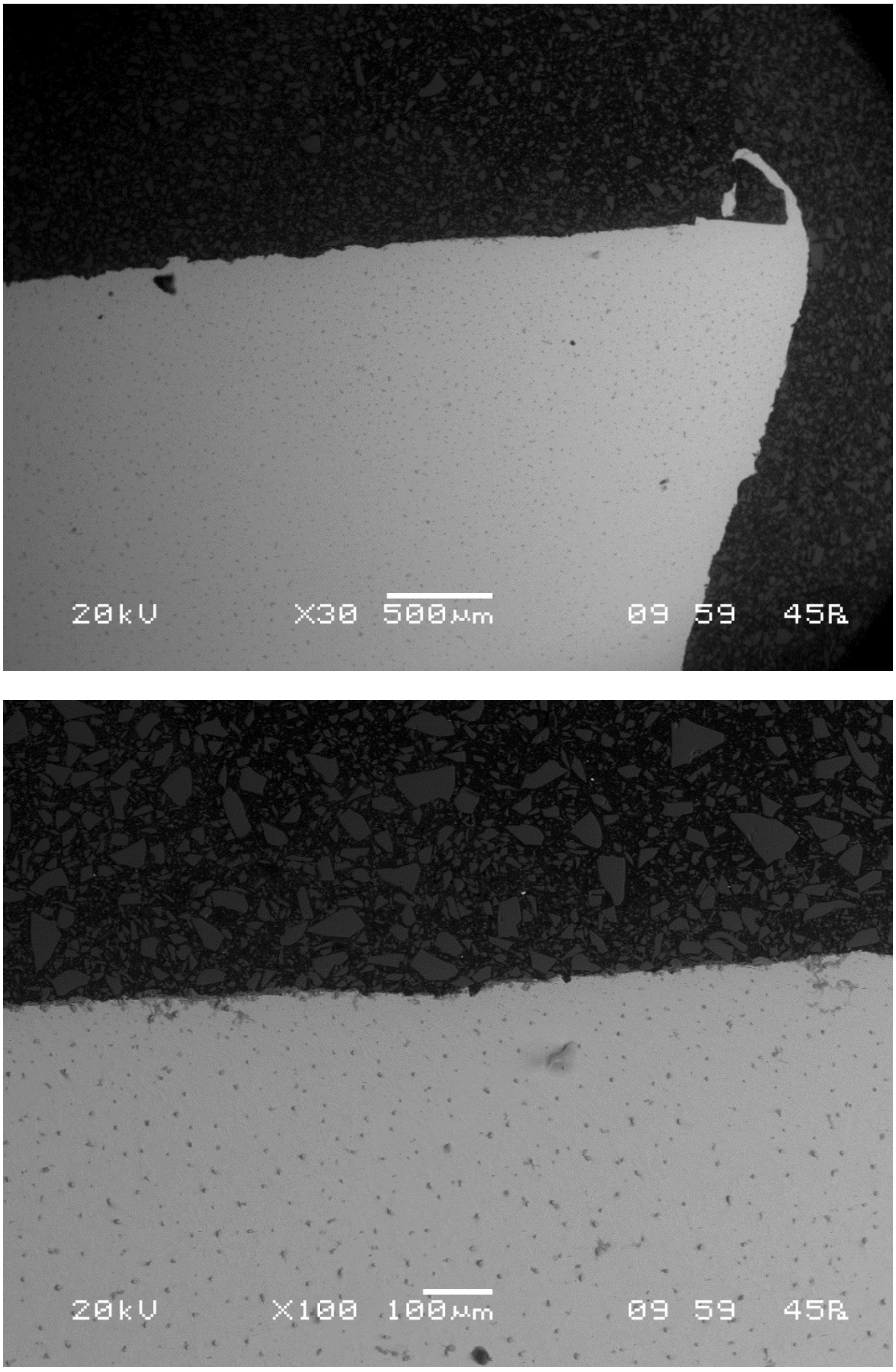


Figure 51. SEM images of EJ Frac 2-2. The top image shows the outer diameter on the top and the fracture surface on the right. The bottom image shows the outer diameter along the top.

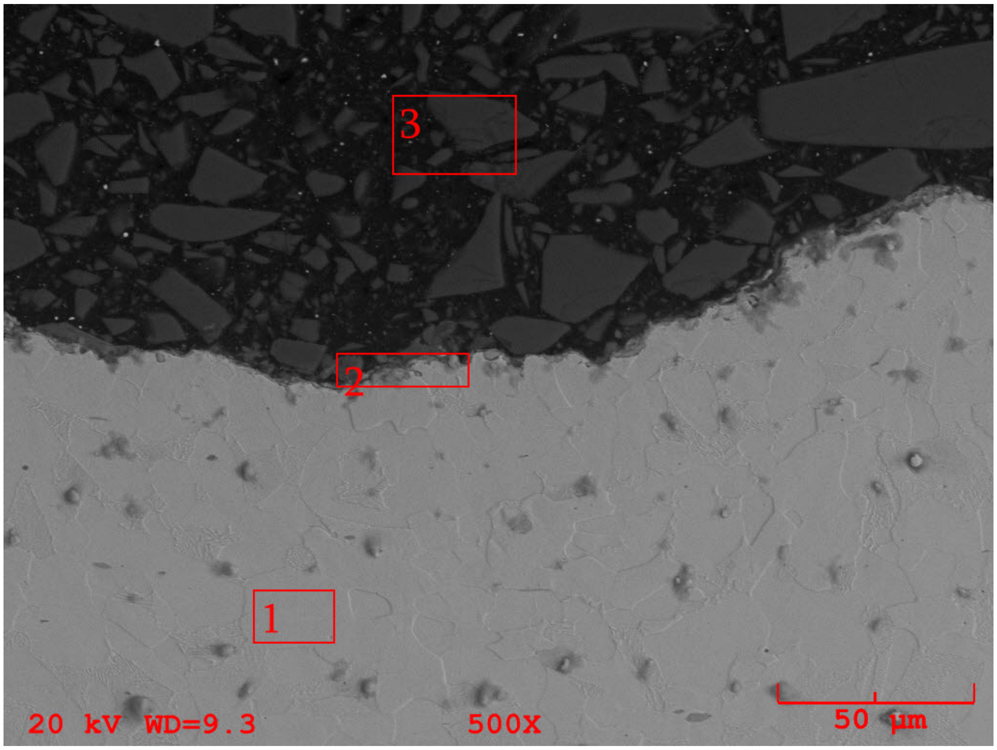


Figure 52. SEM image of EJ Frac 2-2 showing areas of EDS spectra presented in Figure 53. The black area at the top is the mounting medium.

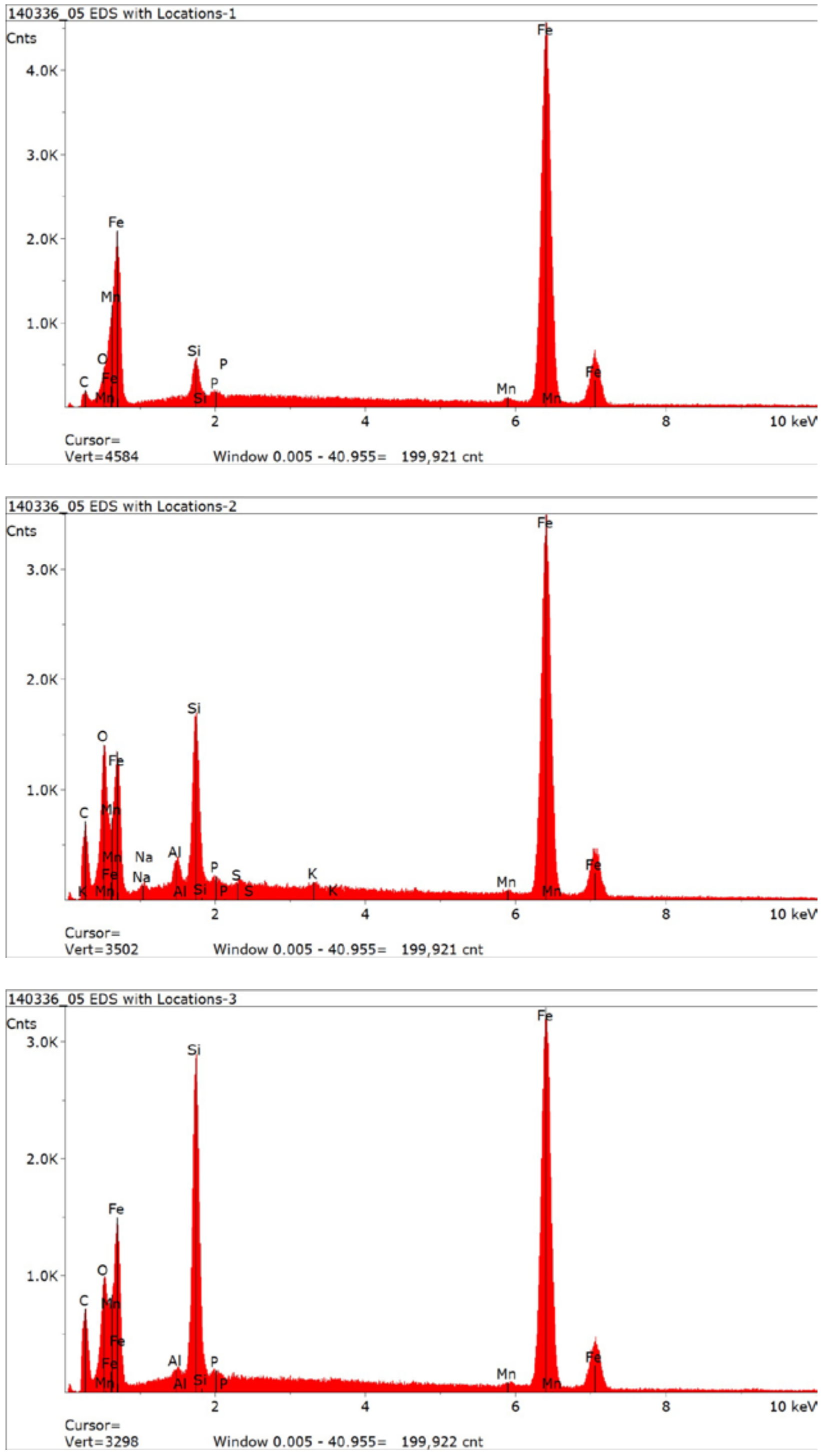
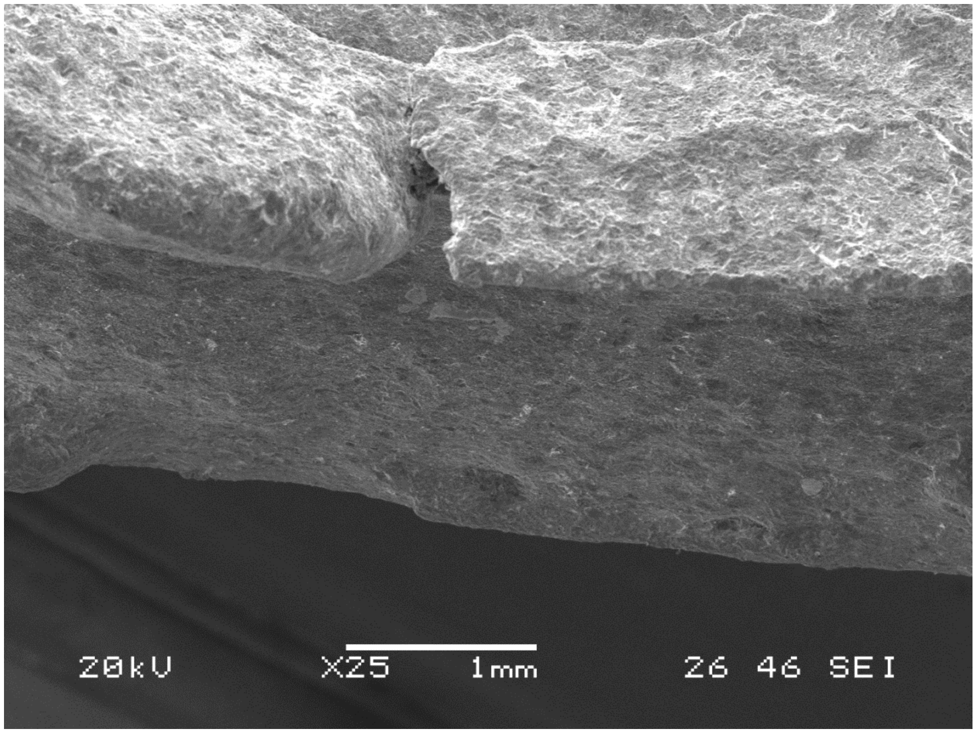


Figure 53. EDS spectra corresponding to the locations of EJ Frac 2-2 shown in Figure 52.

Specimen EJ Frac 2-3 was analyzed in the SEM, and selected images are presented in Figure 54. Similar to EJ Frac 2-2, the high-magnification image showed no definitive microscopic fracture morphology. An EDS scan was performed on the outer diameter of the piece and is shown in Figure 55. Iron oxide is the predominant result in this spectrum, and small amounts of silicon and aluminum are shown. The metallographic mount extracted from this piece is shown in Figure 56. A large dent that resulted from contact with the bucket is evident along the outer diameter. Figure 57 shows a high-magnification metallographic image of the area where the fracture surface meets the outer diameter. It also shows a deformed grain structure (though less obvious than in the micrograph of EJ Frac 2-2 shown in Figure 50), indicative of plastic deformation caused by external contact. SEM and EDS results for EJ Frac 2-3 are shown in Figure 58 through Figure 60. The EDS spectra show that the surface area contains more aluminum, silicon, and oxygen compared to the base metal. The silicon is likely background from the polishing medium shown in Figure 53. The oxygen is from oxide on the surface of the outer diameter, and aluminum may also be present as a result of polishing media used during sample preparation.



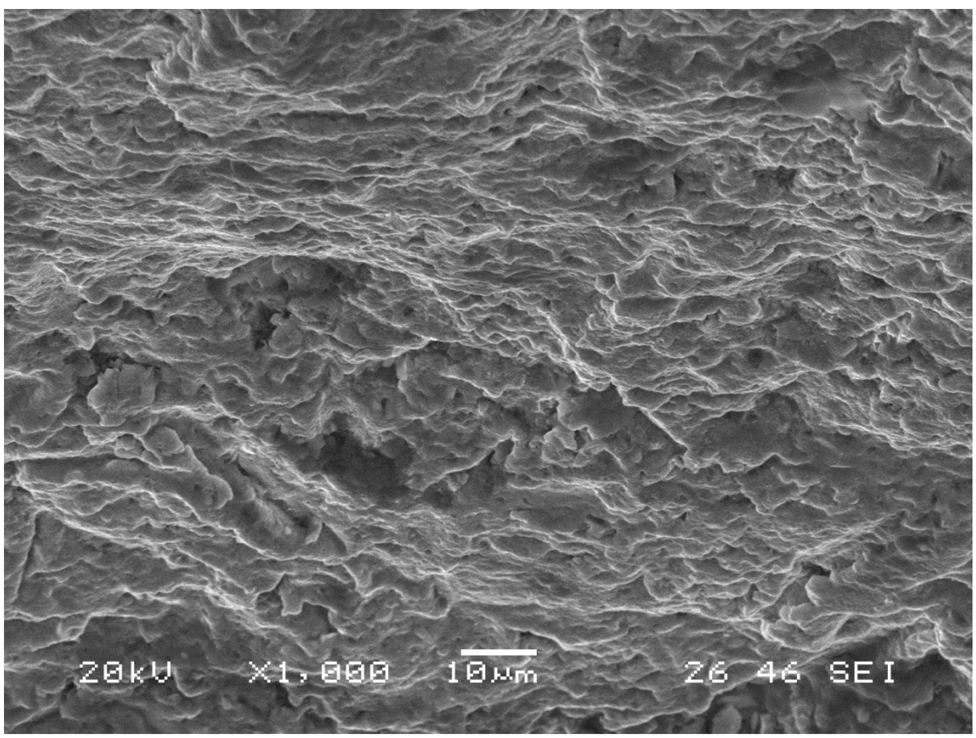
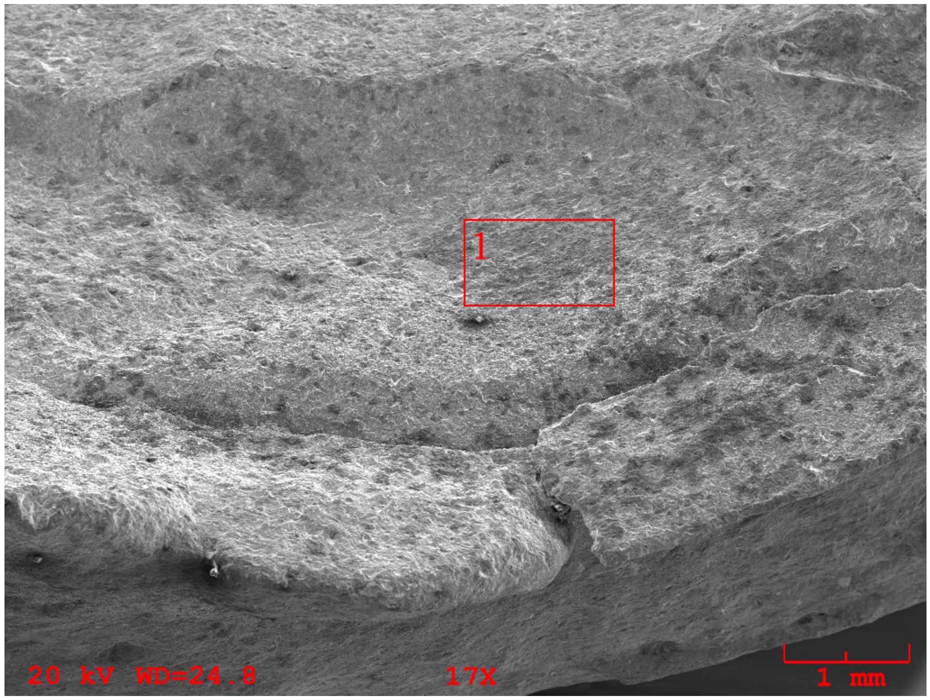


Figure 54. SEM images of EJ Frac 2-3.



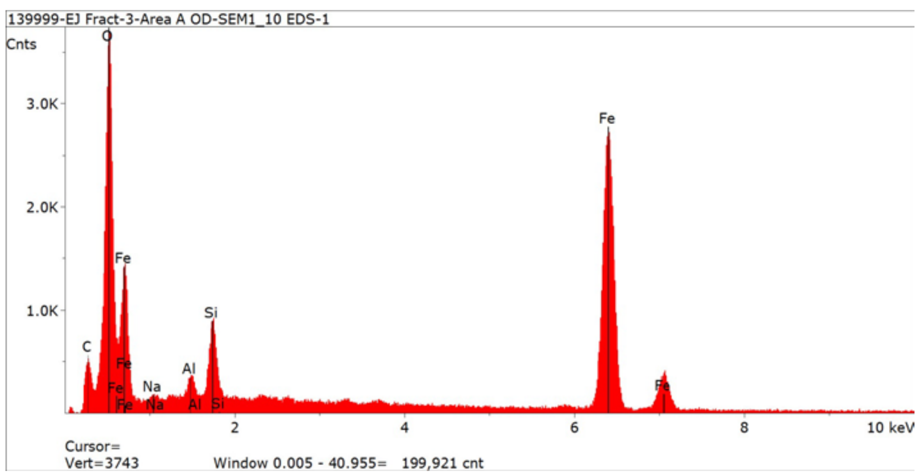


Figure 55. SEM image and EDS spectra of EJ Frac 2-3.

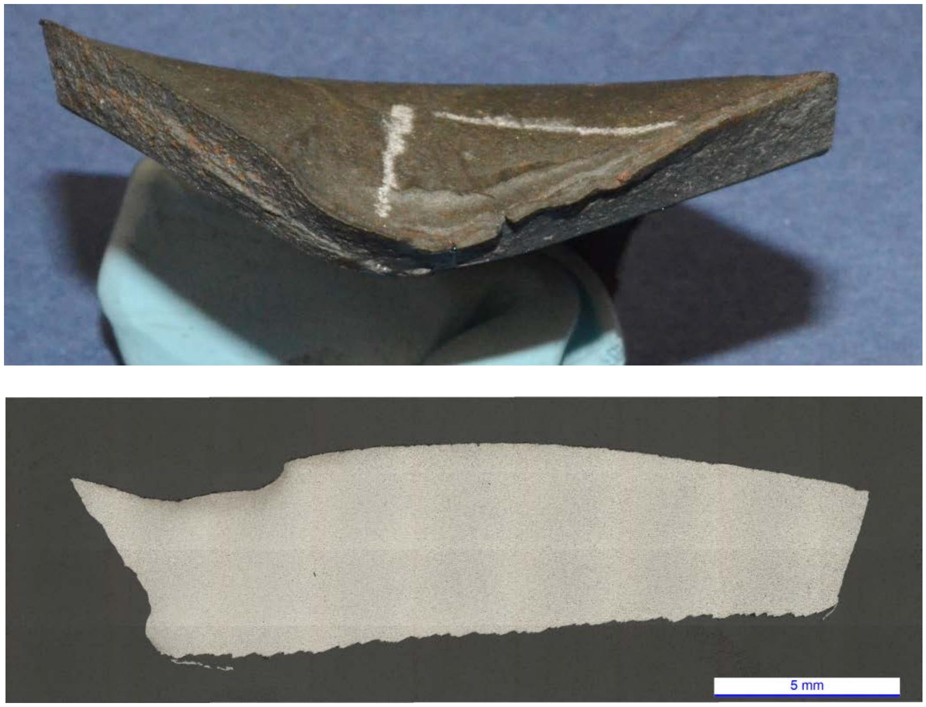


Figure 56. Metallographic sample extraction and mount from EJ Frac 2-3.

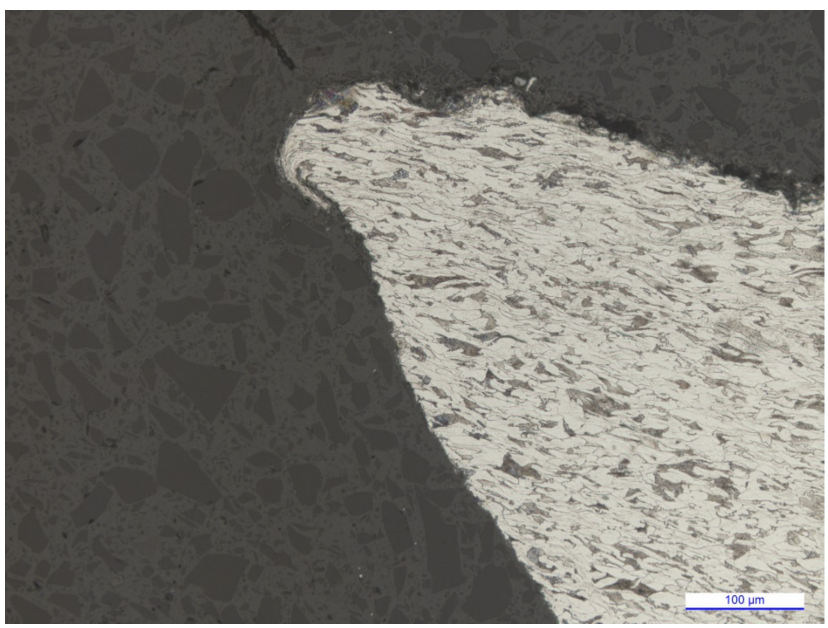


Figure 57. Light optical image of EJ Frac 2-3 showing the outer diameter along the top, and the fracture surface on the left. Grain deformation is visible along the outer diameter of the pipe, indicative of mechanical damage.

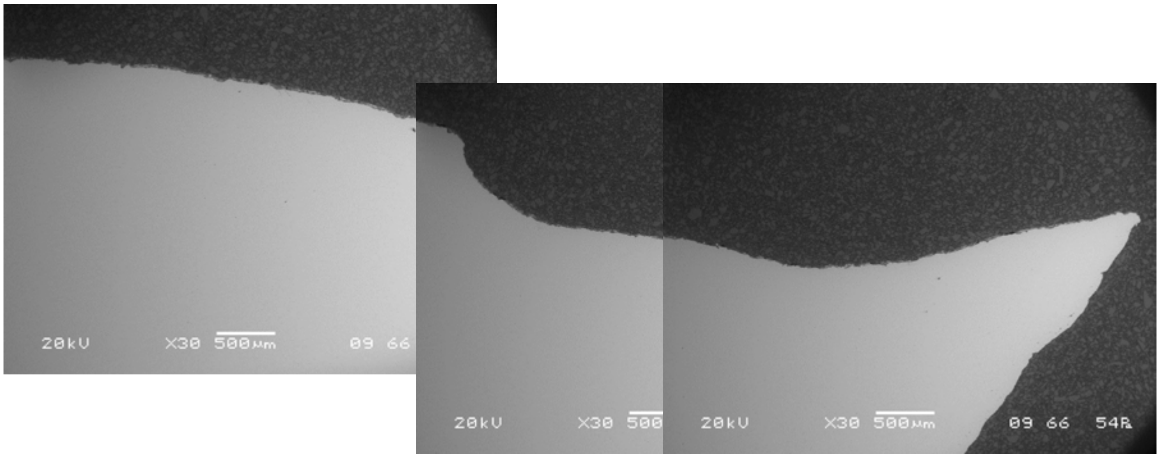


Figure 58. SEM images of EJ Frac 2-3 showing the outer diameter of the pipe along the top and the fracture surface on the right. Significant dents are observed along the outer diameter.

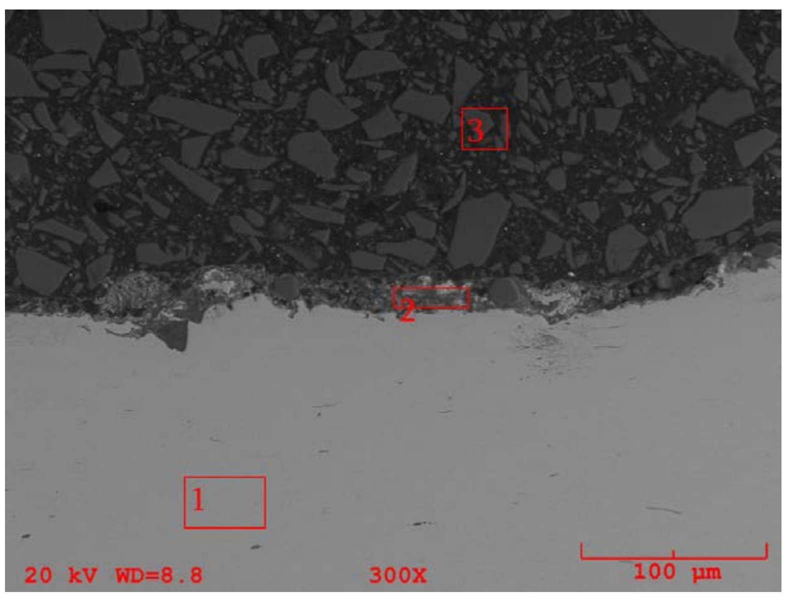


Figure 59. SEM image showing areas of EDS spectra identified in Figure 60.

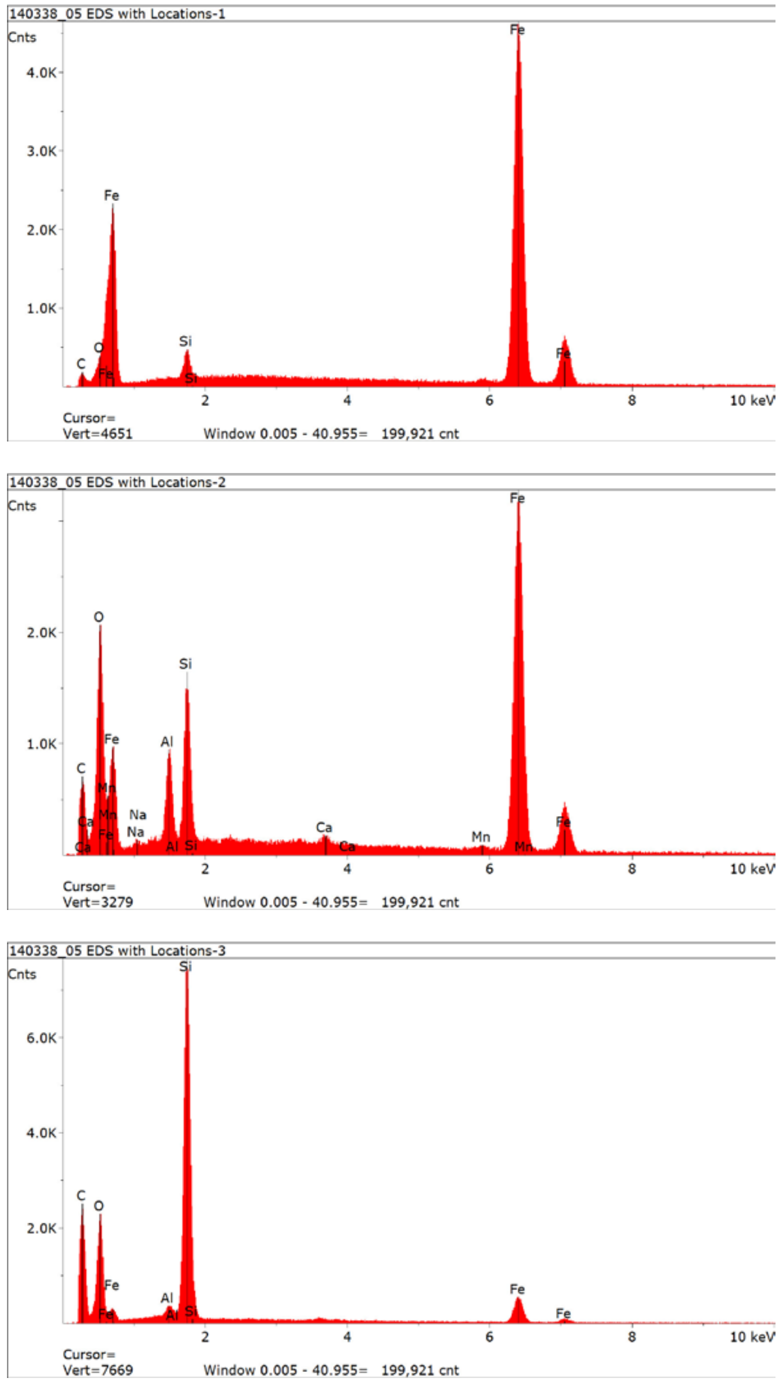


Figure 60. EDS spectra of the EJ Frac 2-3 metallographic mount for locations 1, 2, and 3 shown in Figure 59.

Long Seam Fracture

Visual

A sample labeled EJ Frac 1-SEM was extracted from the EJ Frac 1 along the long seam fracture, as shown in Figure 61, which also shows a triangular piece that was extracted for a metallographic mount, called EJ Frac 1-Linear. Images of this mount will be presented later in this report. EJ Frac 1-SEM contained about four inches of long seam fracture surface and corresponds to the location where the already-propagating circumferential crack intersected the long seam. This is the start of the third fracture stage discussed previously, and shown in Figure 36. An optical microscope image montage of EJ Frac 1-SEM is shown in Figure 62, where a dent can be seen near the center along the outer diameter. This dent occurred after the fracture, as shown by the metal pile-up around the dent. The approximate initiation site on this piece is just downstream of the dent, as shown by Figure 63. This initiation area is relatively flat and featureless. As shown in Figure 63, the fracture origin is the location where radial lines emanate both in the upstream and downstream directions. Additionally, this location corresponds to the location where the circumferential crack met the longitudinal seam, as shown by Figure 64. It should be noted that this is not the initiation area of the rupture as a whole, but rather where the crack intersected this fracture surface and began to propagate upstream and downstream along the long seam.

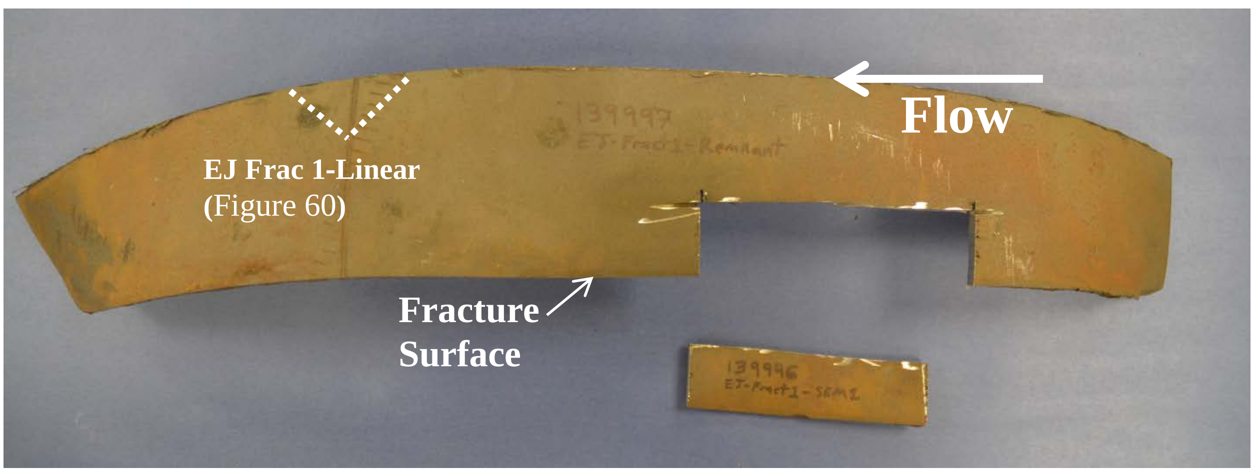


Figure 61. Photo documentation showing the area of the long seam fracture extracted for further analysis. This piece was labeled EJ Frac 1-SEM.

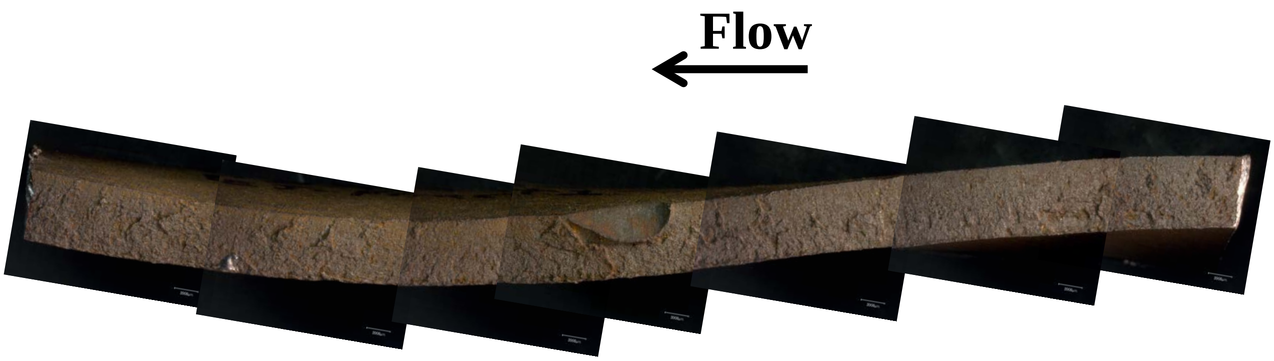


Figure 62. Light optical images stitched together to complete the fracture surface for EJ Frac 1-SEM. The large dent in the center along the outer diameter of the piece occurred after the initial fracture.

Figure 63. High-magnification image of sample EJ Frac 1-SEM showing the area in which the crack met the long seam and started to propagate in either direction.

Figure 64. Photograph showing that the circumferential crack intersects the longitudinal seam at a distance of just over six inches downstream from the start of the seam fracture. On EJ Frac 1 (bottom), the dent shown in Figure 63 can be observed at the six-inch mark, and therefore the initiation site identified in Figure 63 as just downstream of the dent corresponds to the location of the circumferential crack.

Microscopy and Energy Dispersive Spectroscopy

High-magnification SEM was performed on the fractured long seam, as shown by the montage in Figure 65. Two areas were investigated corresponding to the outer and inner diameters near the long-seam initiation location. These two locations were labeled as Areas A and B, respectively.

Area A is shown in Figure 66, where surface products (iron oxide) make it difficult to discern specific fracture morphologies. Similarly, Area B is shown in Figure 67, where specific fracture details are difficult to discern. These pieces were cleaned using the methods previously discussed, including manual brushing with a nylon brush, sonication in a warm Alconox solution, and, finally, acetate replica removal. An EDS spectrum was gathered on the dent surface, as shown in Figure 68. Aluminum, silicon, and a trace amount of chromium were noted in the dent area.

Two metallographic samples, labeled A and B, were extracted from EJ Frac 1-SEM, and are shown in Figure 69. Location A contains two matched fracture surfaces from both sides of the seam weld in one metallographic mount. Location B in Figure 69 is at the long-seam fracture origin, as analyzed in Figure 65 through Figure 67. The matching fracture surface to this initiation location could not be included due to the nature of the fracture: this is the location where the circumferential fracture (Step 2 in Figure 36) propagated into the long seam.

The cross sections of the matched fracture surfaces are shown in Figure 70 through Figure 72. In the metallographic images (Figure 70 and Figure 71), substantial differences between the Segment B and Ejected Segment cross sections exist. A continuous oxide layer was observed on the Segment B surfaces. Further, the Segment B microstructure exhibits a relatively equiaxed microstructure of ferrite grains and partially-spheroidized pearlite/cementite colonies, consistent with exposure to elevated temperatures. In contrast, the microstructure of the Ejected Segment shows a less uniform microstructure with Widmanstätten ferrite gains of varying sizes and morphologies. This microstructure is consistent with ERW type seams, and indicates this piece did not experience the high temperatures that Segment B experienced. These microstructural differences occurred after the rupture and were not a factor in the incident. Figure 70 shows that the fracture propagated along the fusion line nearest the outer diameter, before moving into Segment B to varying extents through the remainder of the pipe wall thickness.

Figure 73 and Figure 74 show EDS spectra for the oxide layer on Segment B (Area 2), as well as the Segment B base metal (Area 1) and the Ejected Segment base metal (Area 3). The compositions of the base metals (Ejected Segment and Segment B), as shown by the EDS data, are nearly identical; whereas the oxide layer contained significant oxygen and trace amounts of aluminum and silicon.

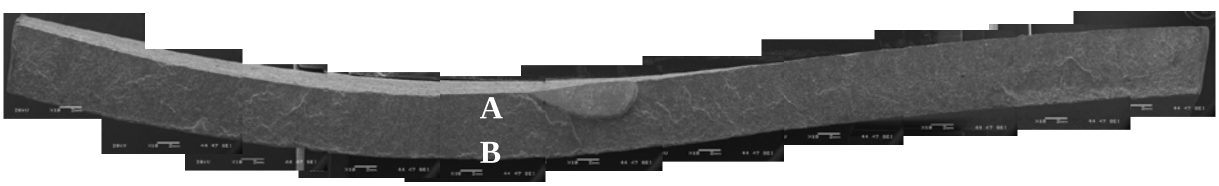


Figure 65. SEM montage showing the fracture surface of EJ Frac 1-SEM. Higher magnification images of areas (A) and (B) are shown in Figure 66 and Figure 67.

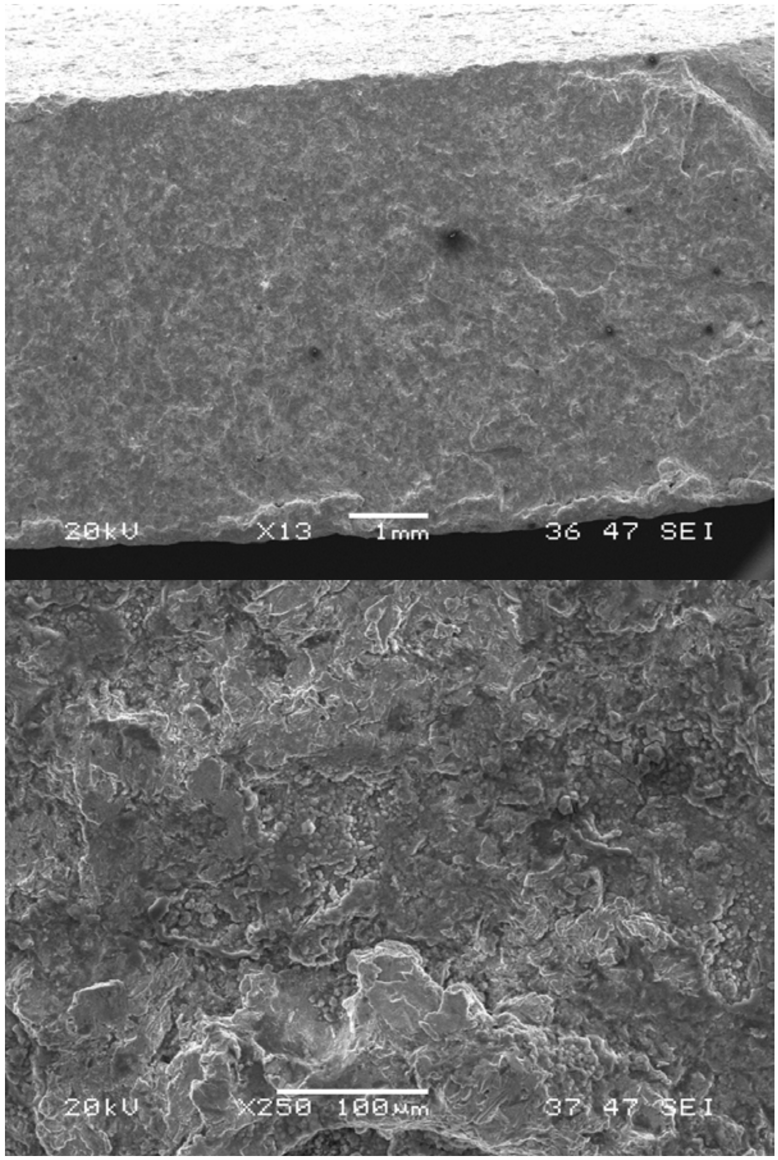


Figure 66. SEM images of the fracture surface near the area of crack intersection, labeled as A in Figure 65.

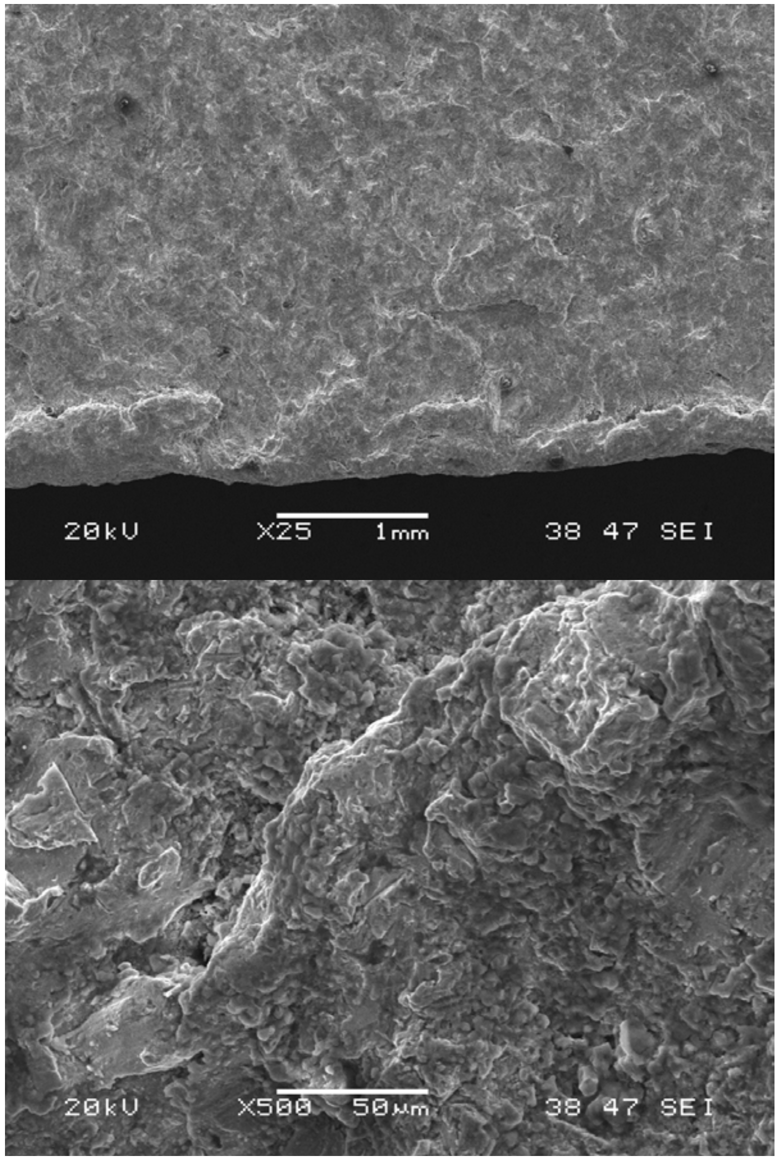


Figure 67. SEM images of the fracture surface along the inner diameter, labeled as B in Figure 65.

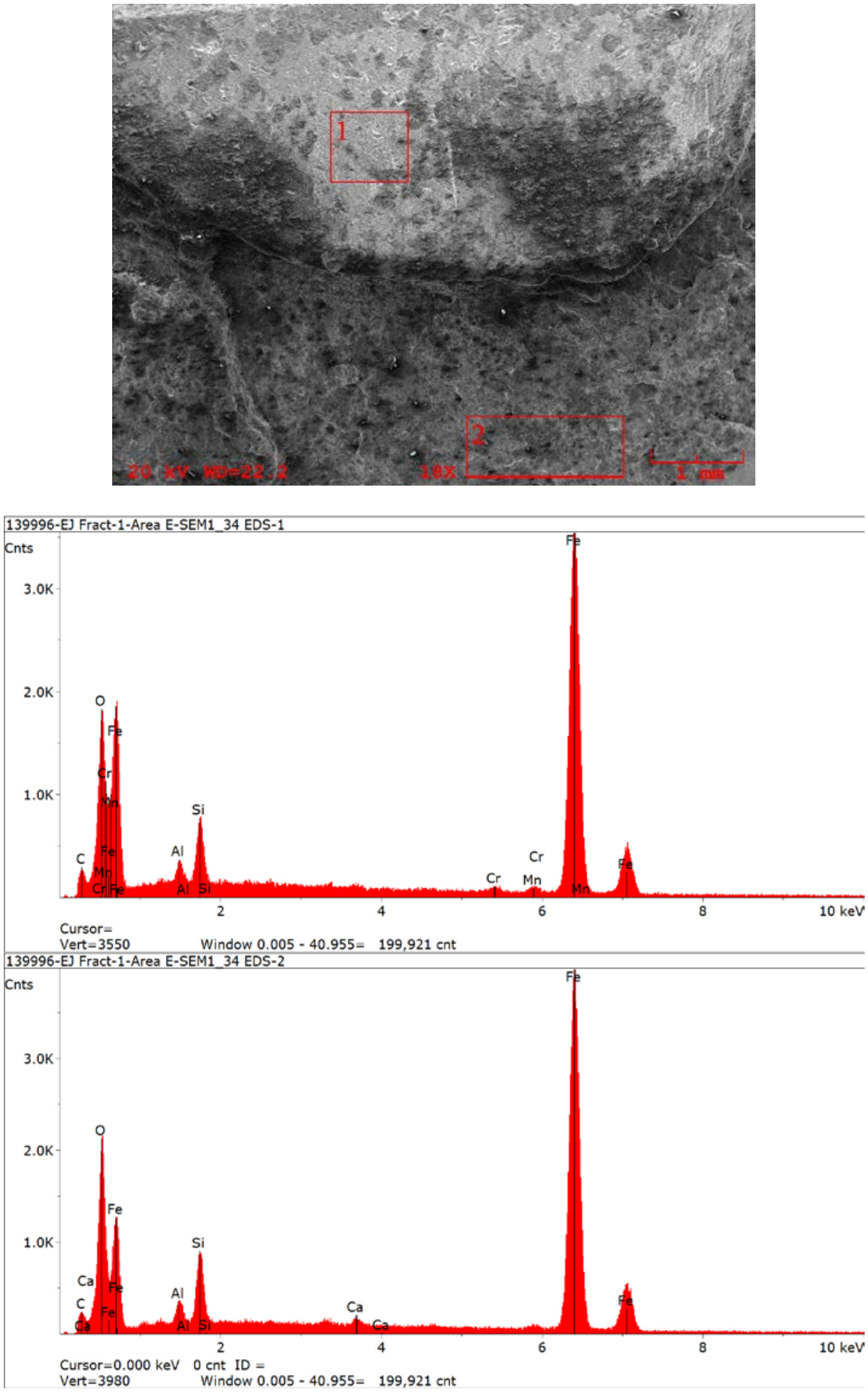


Figure 68. SEM image and EDS spectra of the dent area on sample EJ Frac 1-SEM.

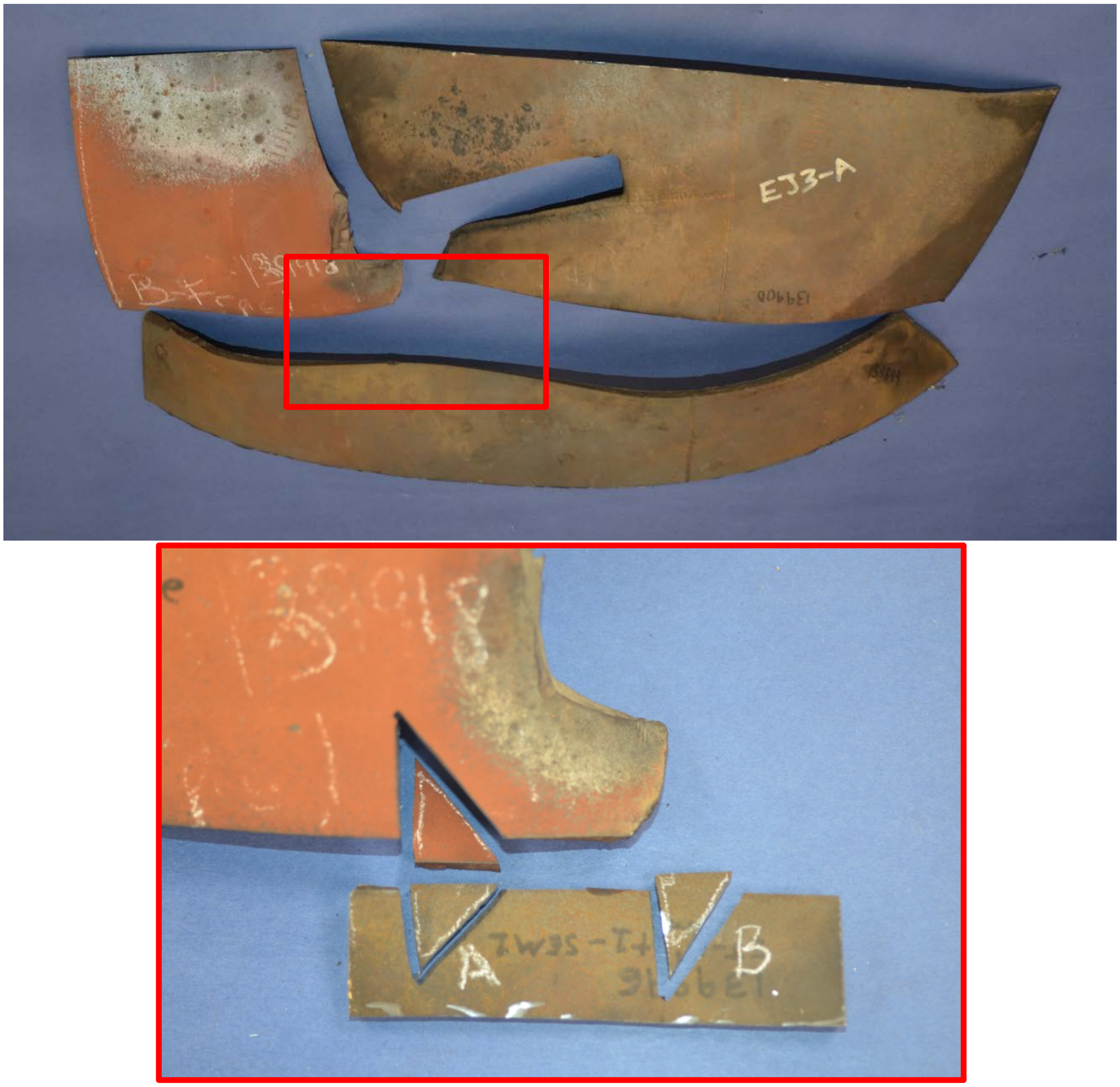


Figure 69. Photo documentation showing metallographic sample extraction from the long seam fracture.

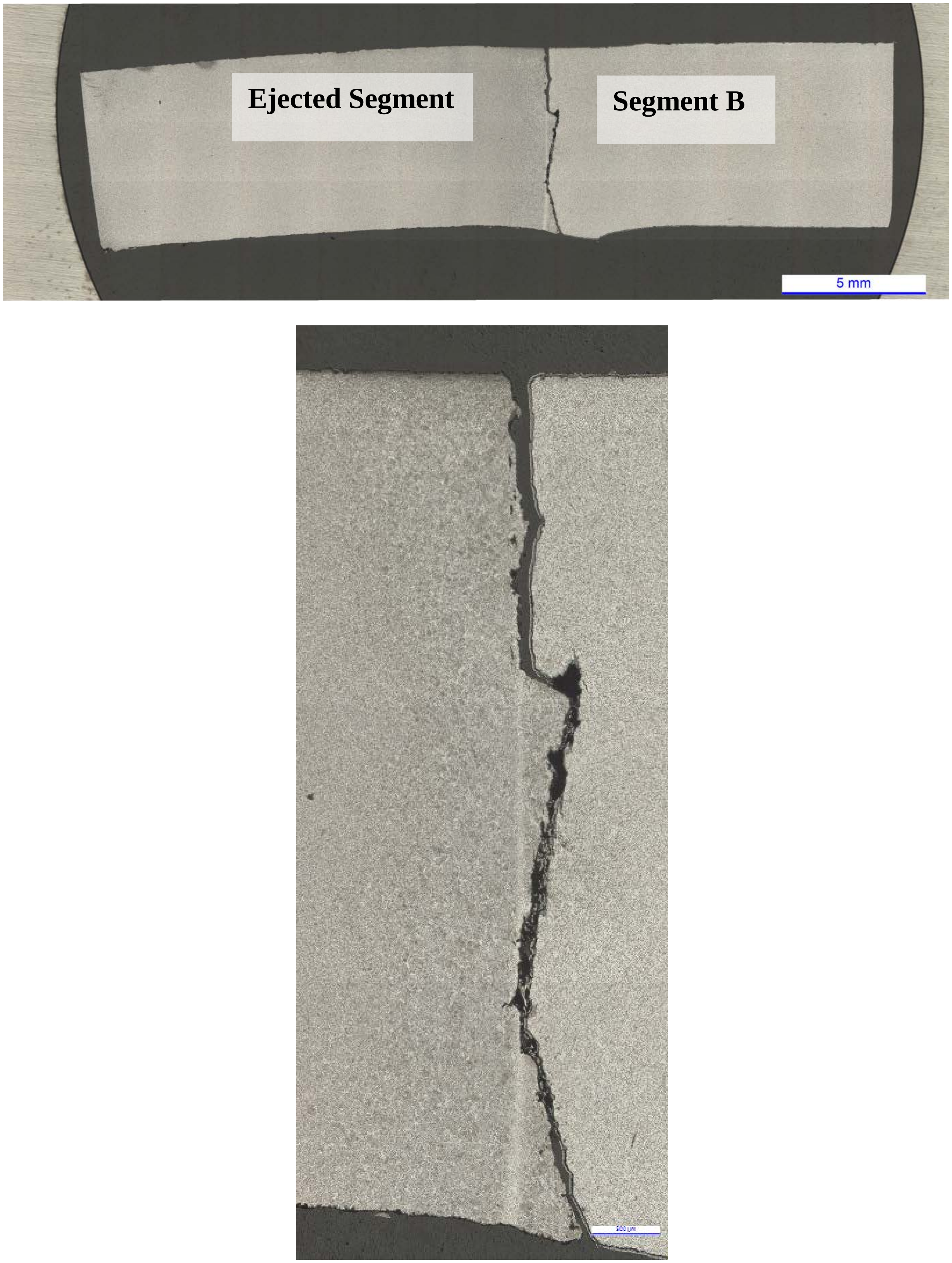


Figure 70. Metallographic images of the matched fracture surfaces shown in Figure 69.

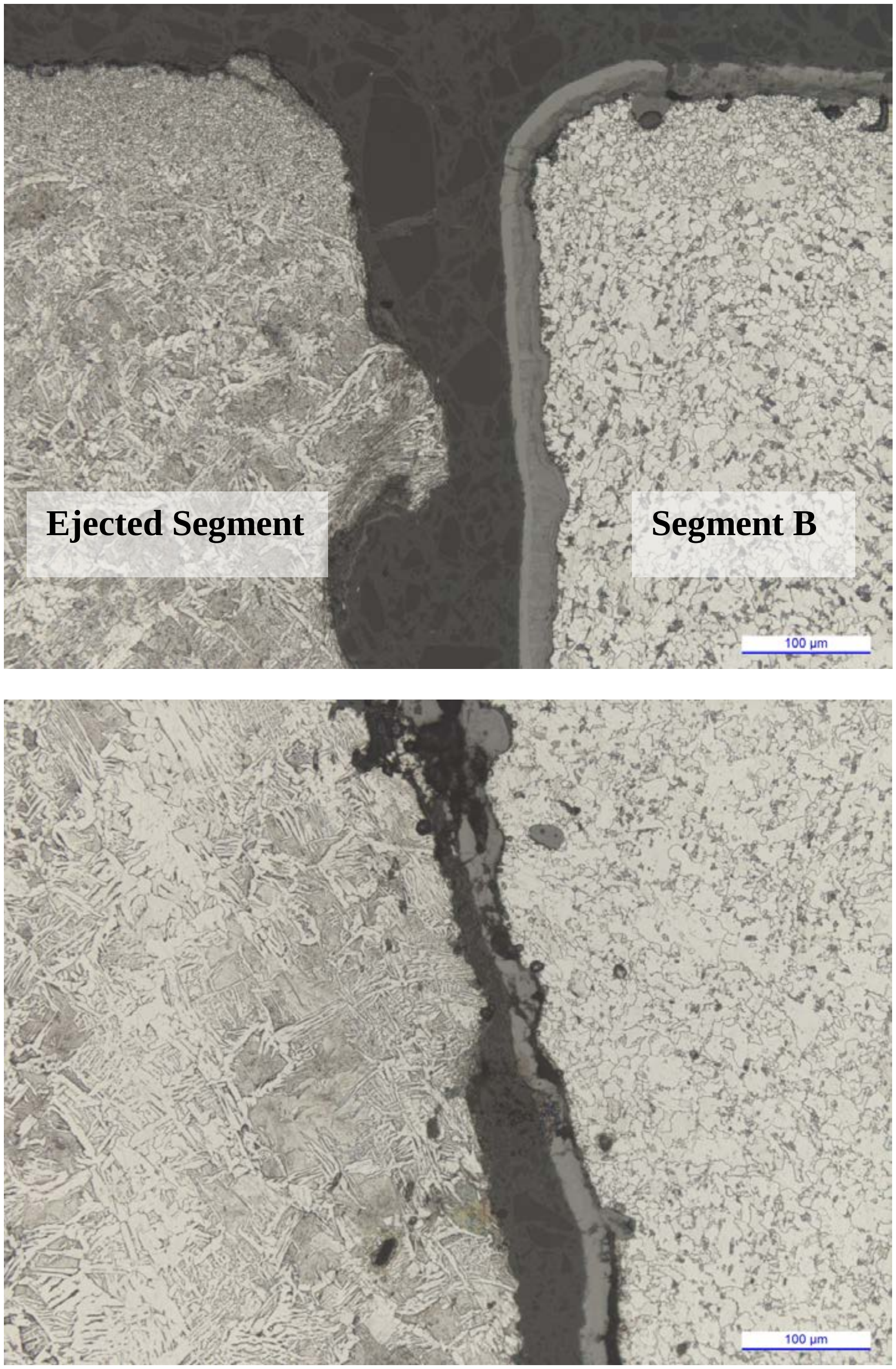


Figure 71. Metallographic images of the matched fracture surfaces shown in Figure 69. The right-hand piece, which was extracted from pipe Section B, has a well-defined oxide layer. Segment B was exposed to the fire during the incident.

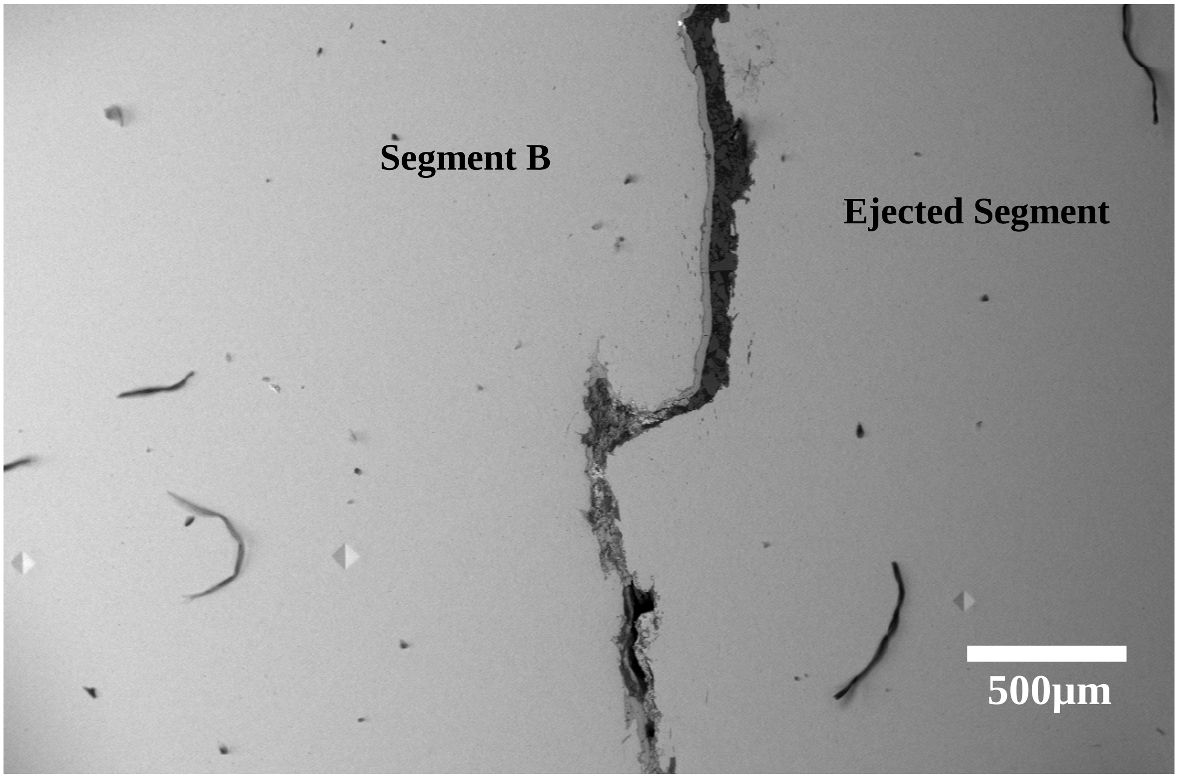


Figure 72. SEM image of the matched fracture surfaces of the long seam fracture.

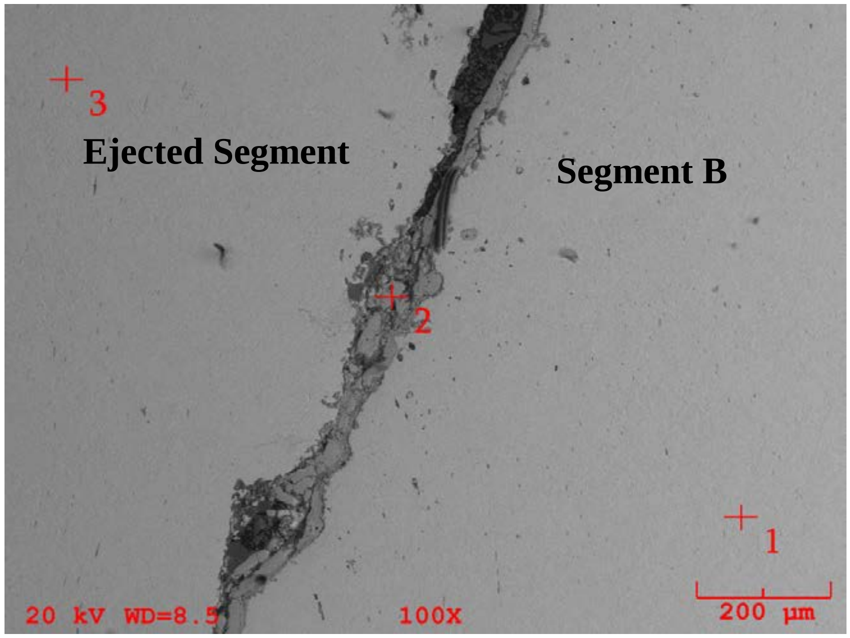


Figure 73. SEM image of the matched fracture surfaces of the long seam fracture. EDS spectra for the areas identified by Numbers 1 (Segment B), 2 (Segment B oxide), and 3 (Ejected Segment) are shown in Figure 74.

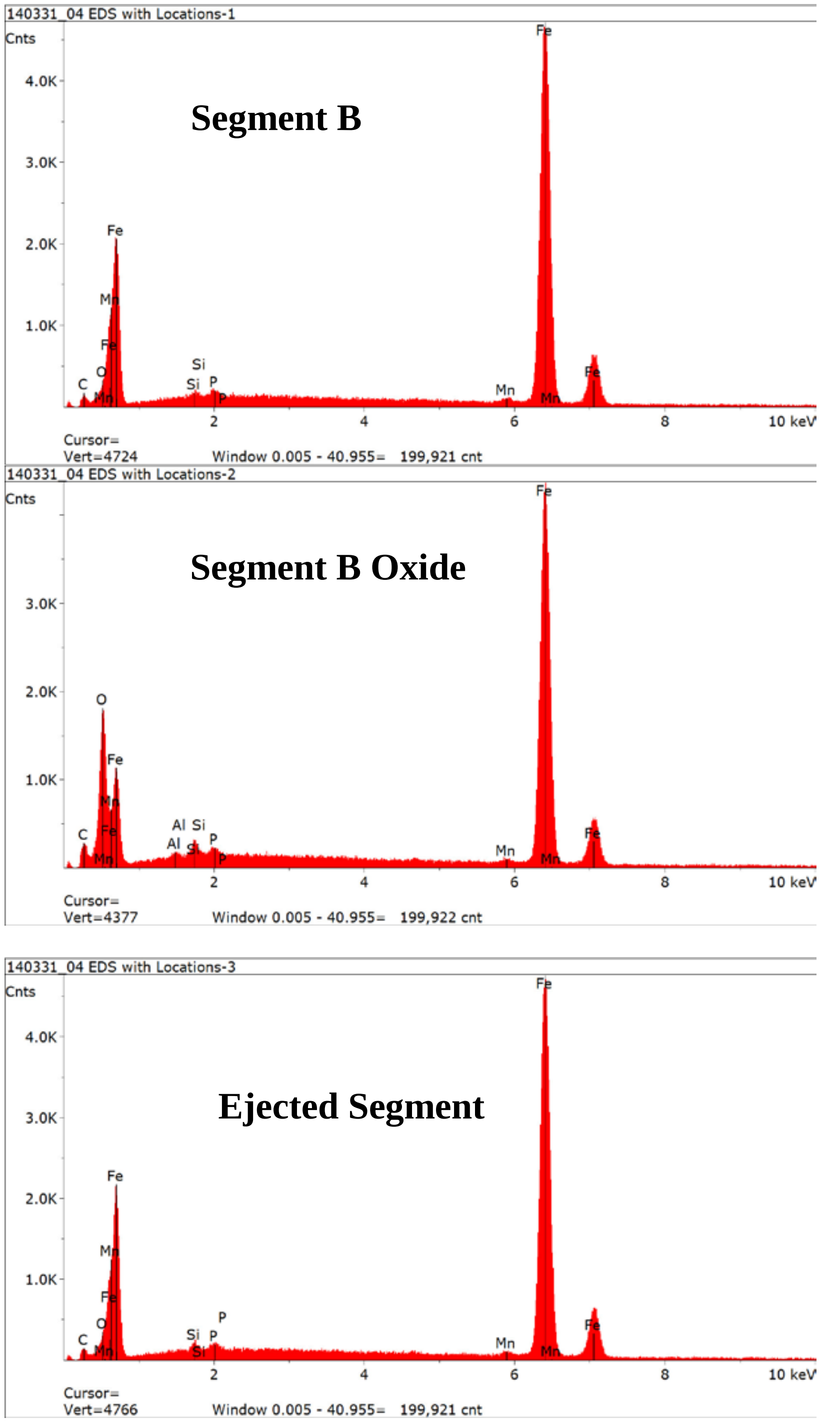


Figure 74. EDS spectra shown for areas of the matched fracture surfaces in Figure 73.

The metallographic mount corresponding to EJ Frac 1-SEM B, as shown in Figure 69, is at the origin of the long seam fracture. A metallographic image of this sample is shown in Figure 75; the outer diameter is at the top, and the fracture surface is on the right side of the image. In this etched microstructure, the heat-affected zone of the weld can be distinguished by the gradual darkening of the sample surface on the right, at the same location as the fracture. Other images of this area are shown in Figure 76 and Figure 77. No evidence of an oxide layer, such as would be present with a lack-of-fusion flaw, was observed. As the Indication Examination section of this report explains, instances of lack-of-fusion have been noted. However, none were noted at the longitudinal seam fracture origin.

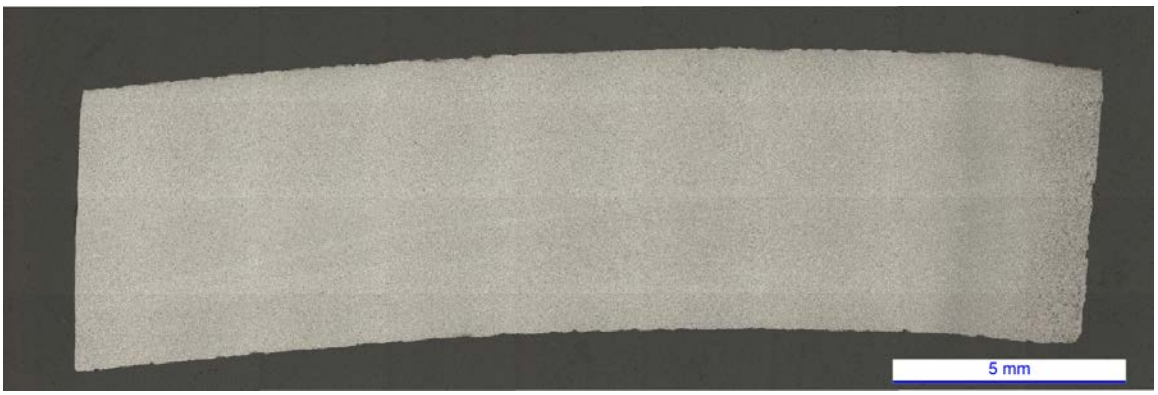


Figure 75. Metallographic mount of the B location in Figure 69, EJ Frac 1-SEM B. This location corresponds to the area where the crack joined the long seam and began to propagate in either direction along the long seam per Figure 36 and Figure 63. The outer diameter of the pipe is at the top, and the fracture surface is on the right.

Figure 76. The fracture surface area of the previous image (Figure 75), EJ Frac 1-SEM B.

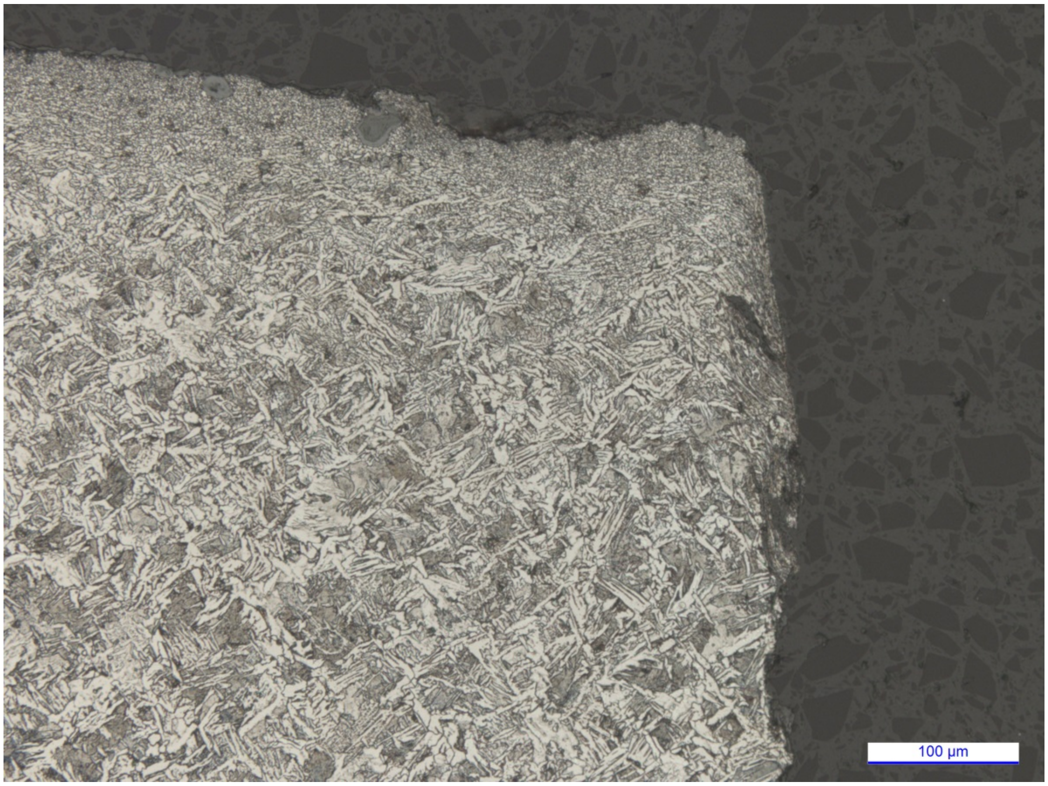
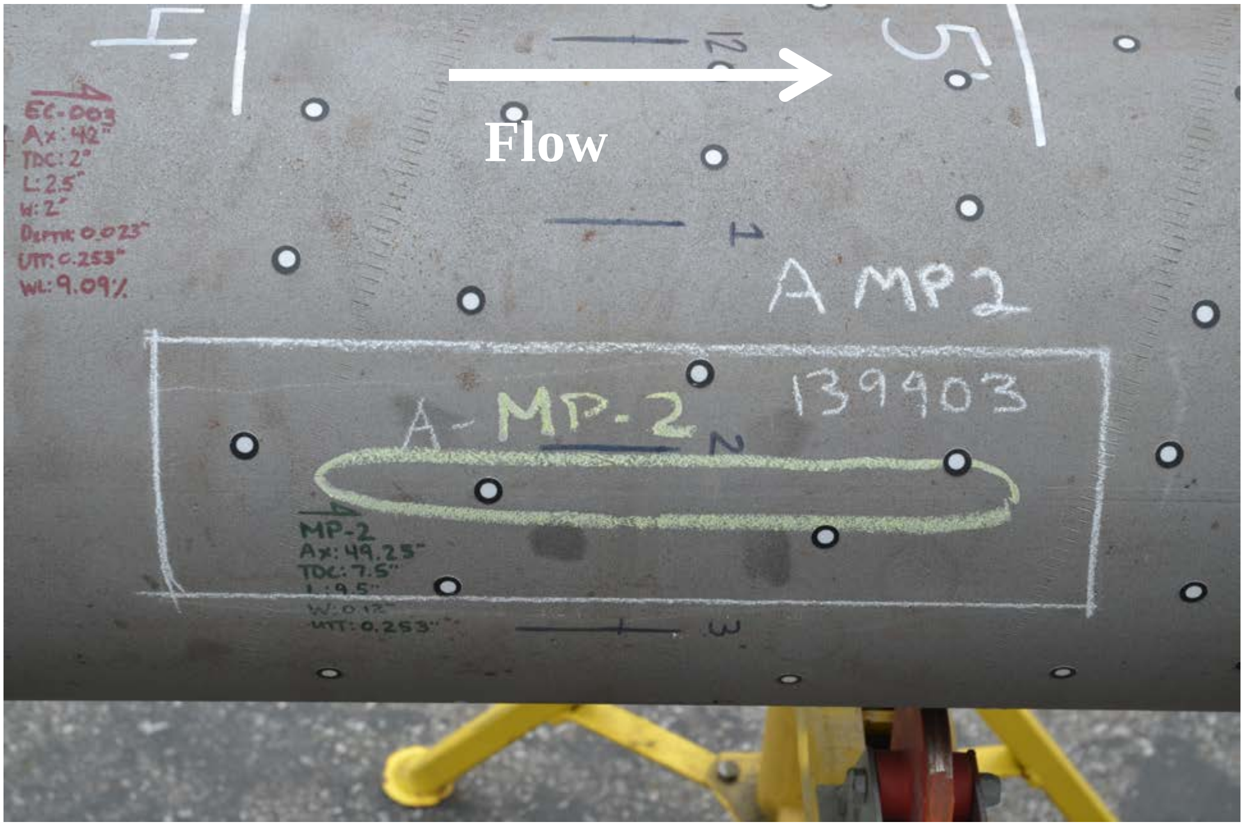


Figure 77. A high-magnification metallographic image of the fracture surface and outer diameter of EJ Frac 1-SEM B.

Indication Examination

Sectioning

In parallel to the fractographic examination, selected indications identified during the nondestructive examination were sectioned from the pipe segments for further analysis. Linear magnetic particle indications were of particular interest. Of all indications, 40 were selected for sectioning and further analysis. The process for sectioning included: (1) using a grinder or an oxy-acetylene flame torch to cut out a window from the pipe; (2) using a band saw to extract a small piece; and (3) mounting the piece using standard metallographic techniques. All mount preparations have a downstream orientation. An example of this extraction process is shown in Figure 78 for Indication A-MP2.



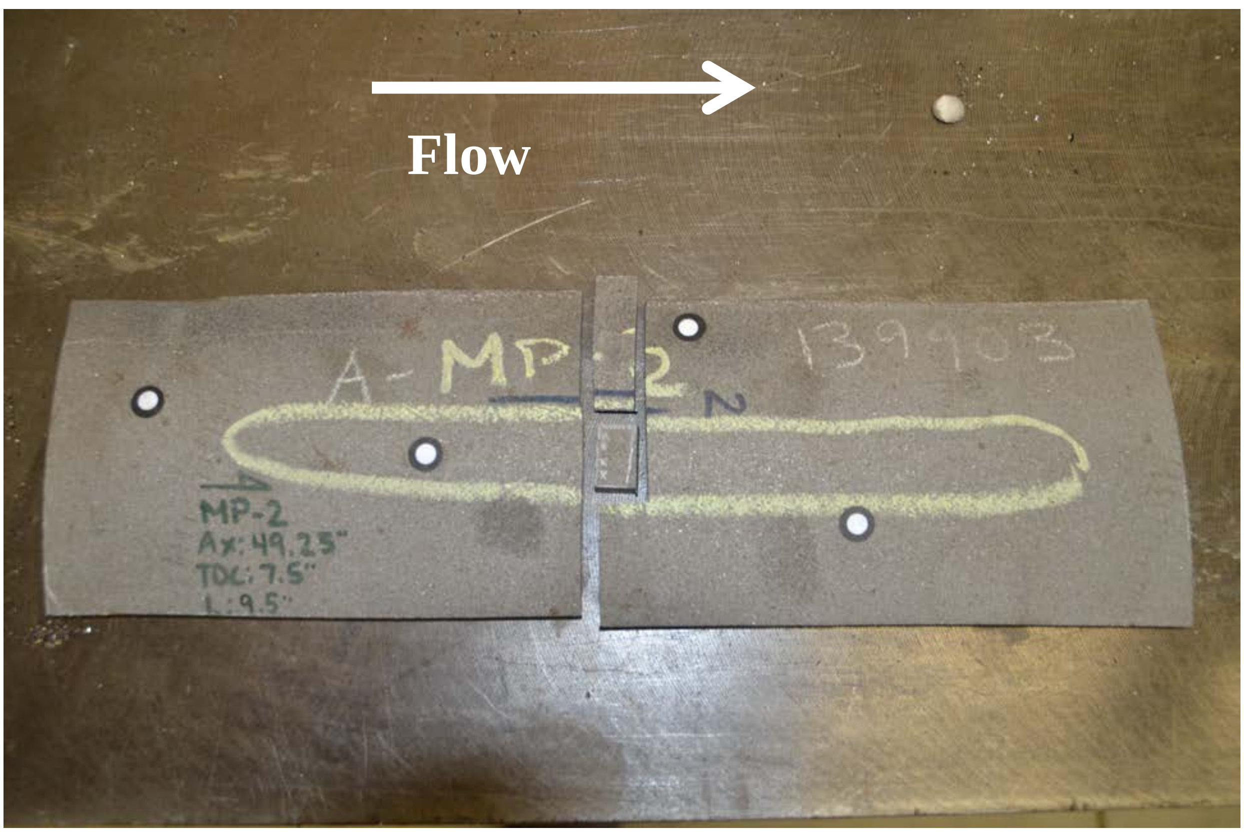


Figure 78. A photo series showing the sample extraction process for selected indications.

Microscopy of Indications

A summary of all indications selected for metallographic analysis is shown in Table 5, which shows that most indications were either scabs or surface laps, or did not show any observable crack-like features. Some indications did exhibit crack-like features, as the notes and indication depth columns of Table 5 indicate. Metallographic images of the most substantial crack-like indications are shown in Figure 79 through Figure 86. These indications were largely lack-of-fusion along the electric-resistance weld (ERW) seam.

The most significant indication was Specimen A-MP2, shown in Figure 79. This indication was identified by magnetic particle testing on the long seam in Segment A, and is the result of lack-of-fusion during the original pipe welding process. An oxide layer is shown in the indication between the sides of the steel base metal. This oxide was formed during original pipe manufacture, by exposure of the steel to high temperatures in air during the welding process. Oxide was observed along the entire depth of the indication. The indication was measured to be approximately 0.063 inch (~1600 µm) in depth. EDS was performed on the sample to characterize the oxide present in the crack. EDS data, shown in Figure 80 and Figure 81, were gathered at specific locations. Representative areas are presented in Figure 81, where the base metal is shown (Area 1), as well as a dark oxide constituent and a lighter colored oxide constituent. Both areas show significantly elevated oxygen peaks.

Indication A-MP7 is shown in Figure 82 and is similar in nature to A-MP2. The crack-like indication was also the result of lack-of-fusion during the original pipe manufacture. Indication depth was determined to be 0.03 inch (~760 µm). Indication B-MP7 is shown in Figure 83. Figure 83 shows an oxide layer embedded along the fusion lines. This indication was not surface-connected at the location shown. The lack of surface connection is likely a result of the polishing plane, and if the metallographic specimen were ground further, the indication may have become surface-connected. Indications C-MP1, C-MP3, and D-MP1 are shown in Figure 84, Figure 85, and Figure 86, respectively. These indications are minor laps that only extend approximately 100–200 µm in depth. They are not related to the long seam or lack-of-fusion.

Finally, Indication D-MD7 (Figure 87) was investigated. This was a circumferential anomaly made up of two small parallel grooves. This was limited to the material nearest the outer diameter of the pipe, and was associated with localized plastic deformation. The grooves were not a factor in the rupture and likely resulted from handling the pipe during manufacture or installation. Similar grooves were noted on the Ejected Segment, as will be shown subsequently.

Cross sections taken from intact long seams are shown in Figure 88 and Figure 89. At both cross-section locations, the appearance of the seam weld is consistent with typical ERW seams, and no cracking is evident at these locations. The lip observed on the inner diameter of the seam weld is visible in both long-seam cross sections and is an artifact from the trimming process during fabrication. A representative microstructure in the weld area of an intact seam at higher magnification is shown by Figure 90, which shows a Widmanstätten structure. This is consistent with the microstructures observed on the Ejected Segment (Figure 71). A representative microstructure of the base metal, away from the weld area is shown by Figure 91, which shows a traditional ferrite-pearlite microstructure.

Table 5. Summary of findings in the metallurgical investigation of the NDE indications. Not all indications found during the NDE examination were sectioned for metallographic analysis.

Sample Name	Segment	Sample Type	Notes	Indication Depth, µm (if applicable)
A-MP2	A	MP	Linear indication	1640
A-MP3	A	MP	Scab	
A-MP4	A	MP	Scab	
A-MP5	A	MP	Scab	
A-MP6	A	MP	Surface lap	
A-MP7	A	MP	Linear indication	720
A-MP8	A	MP	Scab	
A-MP9	A	MP	Surface lap	
A-MP11	A	MP	No clear indication	
A-MP12	A	MP	Surface lap	
A-MP13	A	MP	Surface lap	
A-MP14	A	MP	Linear indication	
A-MP15	A	MP	Surface lap	
A-MP16	A	MP	Surface lap	
A-MP17	A	MP	Scab	
B-MP1	B	MP	No clear indication	
B-MP2	B	MP	Scab, surface lap	
B-MP3	B	MP	Surface lap	
B-MP4	B	MP	No clear indication	
B-MP5	B	MP	No clear indication	
B-MP6	B	MP	No clear indication	
B-MP7	B	MP	Oxide in seam	
B-MP8	B	MP	Scab	
C-MP1	C	MP	Linear indication	103
C-MP2	C	MP	Surface lap	
C-MP3	C	MP	Linear indication	130
C-MD5	C	MD	Dent on surface	
C-MD3	C	MD	Dent on surface	
C-MD1	C	MD	Dent on surface	
C-WELD	C	WELD	Void in weld	
D-MP1	D	MP	Linear indication	185
D-MD5	D	MD	Dent on surface	
D-EC5	D	EC	Slight depression in OD	
D-MD21	D	MD	Small dents	
D-MD8	D	MD	No clear indication	
D-MD9	D	MD	Small dents	
D-MD11	D	MD	Light surface deformation	
D-MD22	D	MD	Light surface deformation	
D-MD23	D	MD	Light surface deformation	
D-MD7	D	MD	Small dents/gouges	

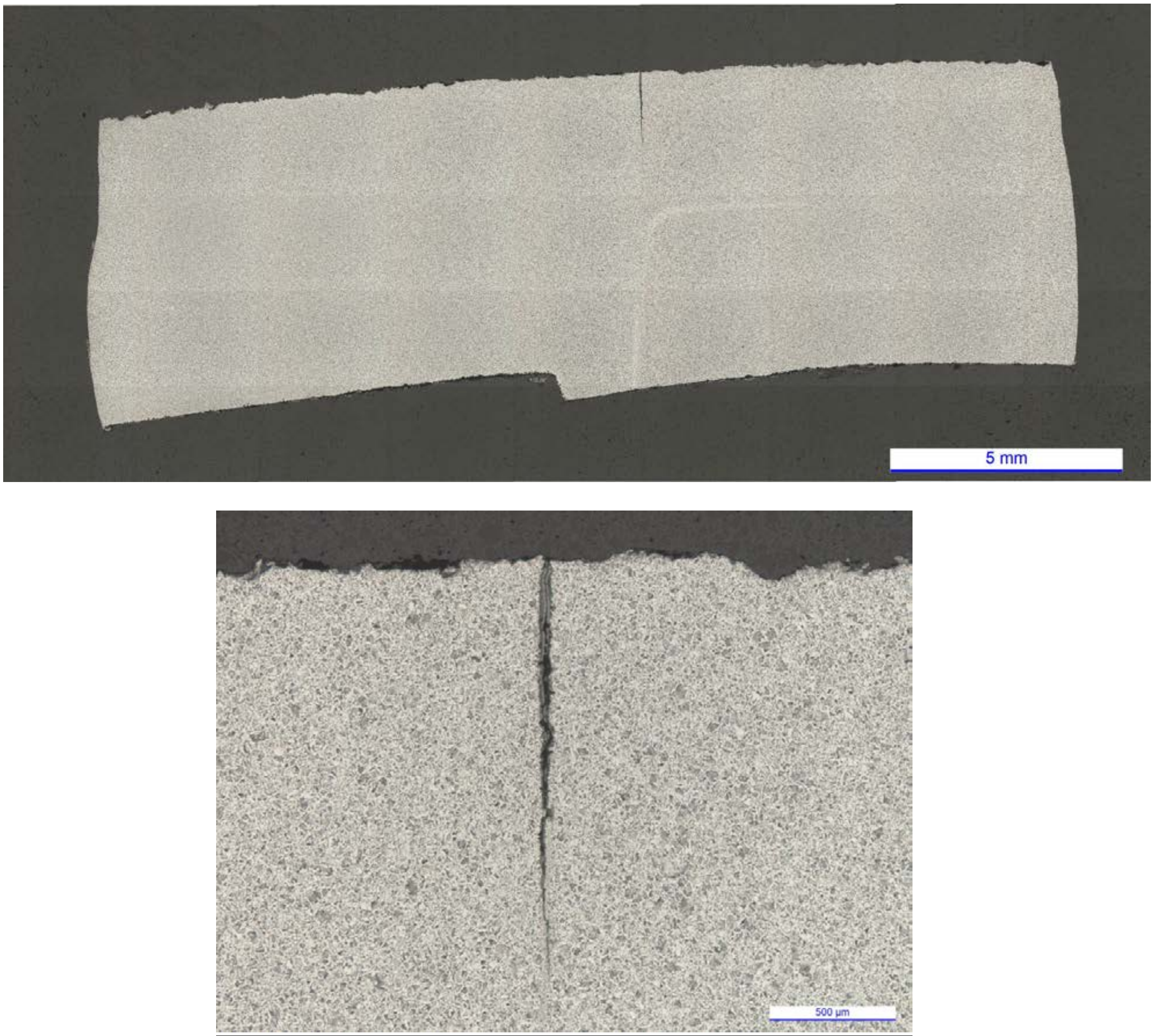


Figure 79. Metallographic image of indication A-MP2. Indication was measured to be 0.063 inches.

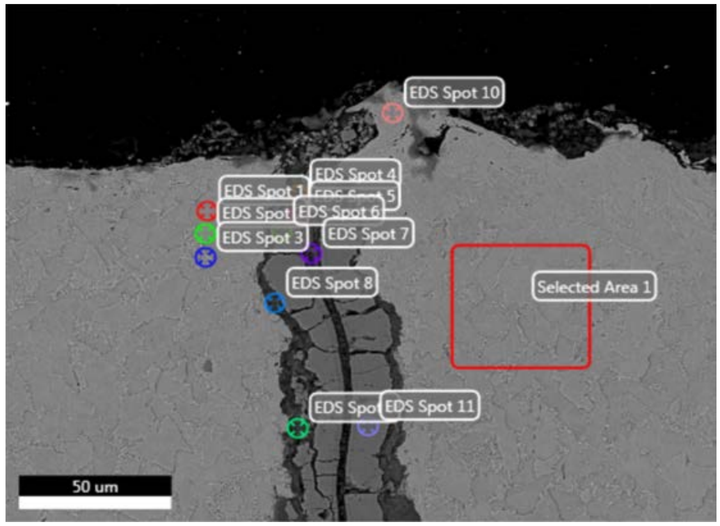


Figure 80. SEM image of indication A-MP2 showing areas of EDS spectra. Selected EDS spectra corresponding to these locations are shown in Figure 81.

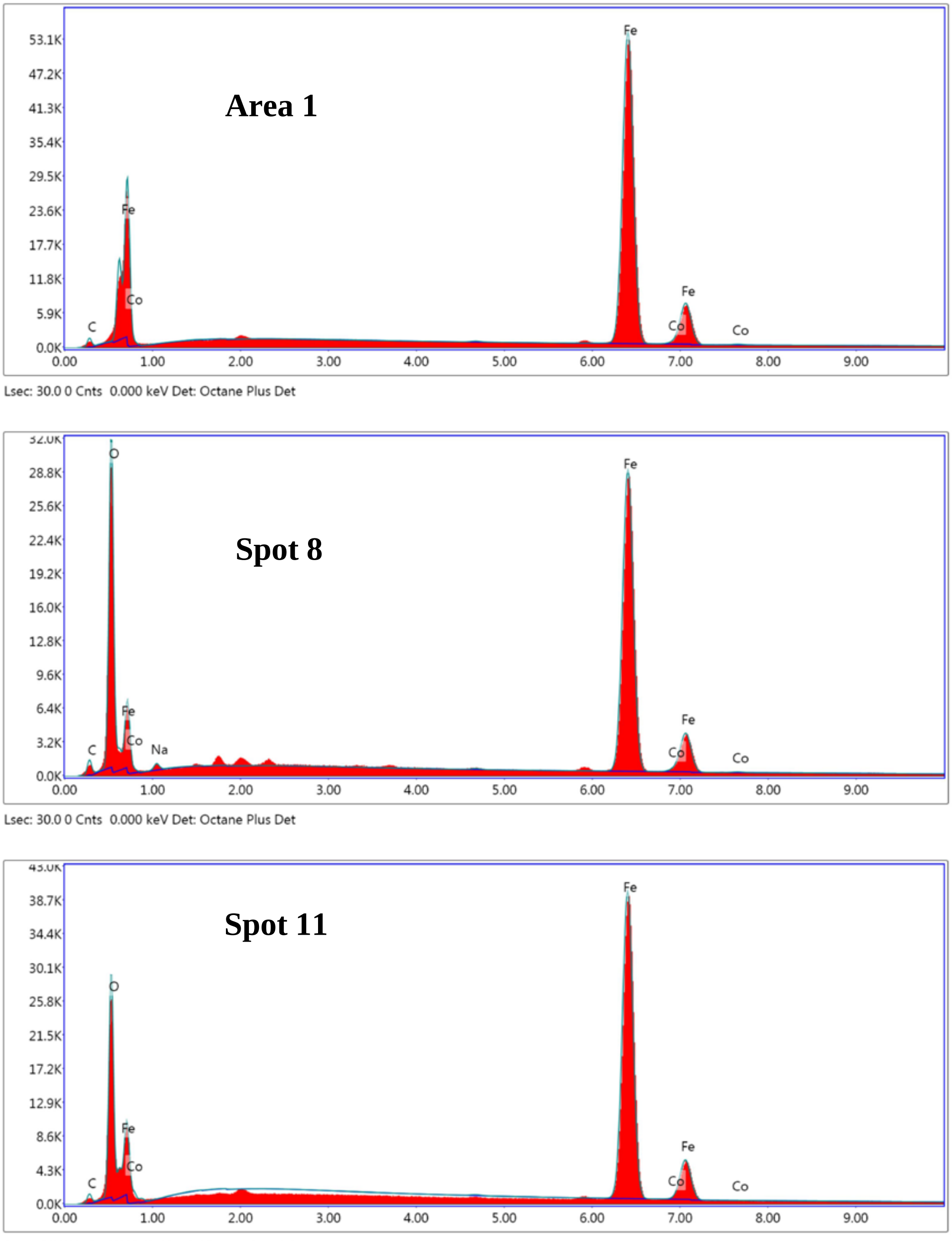


Figure 81. EDS spectra of indication A-MP2, corresponding to locations shown in Figure 80. Representative areas are shown.

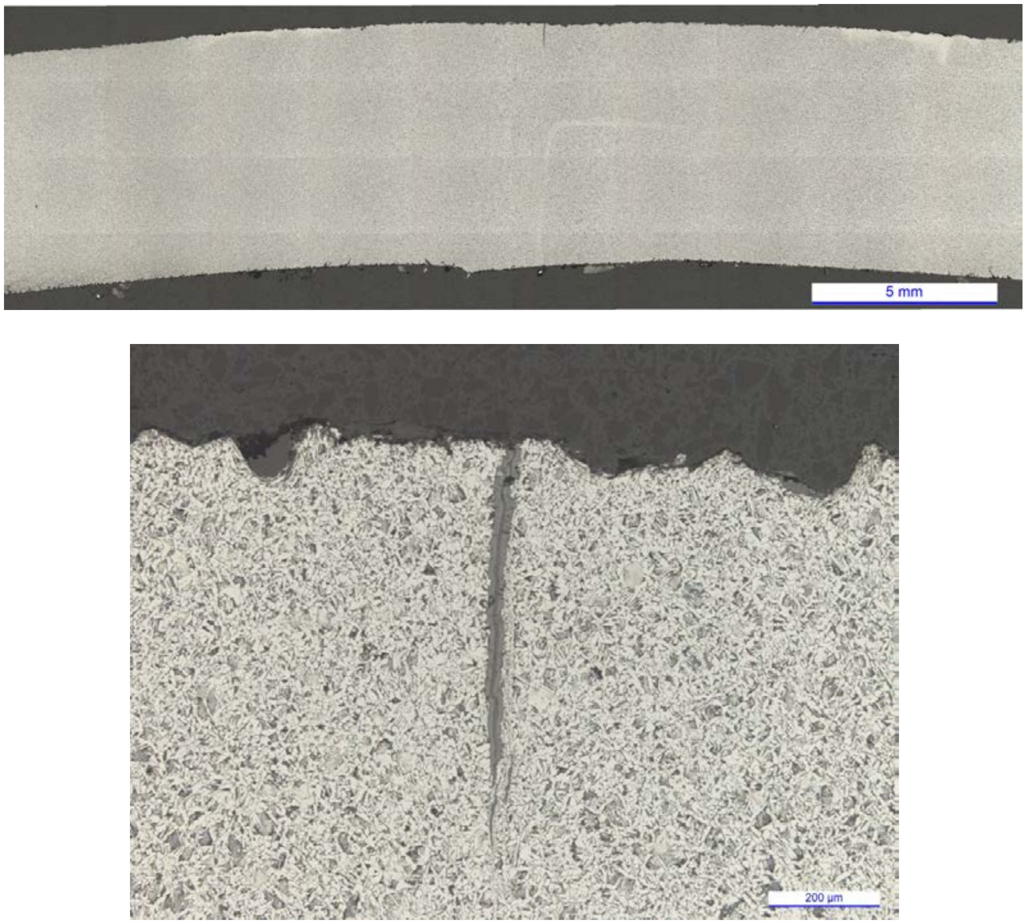
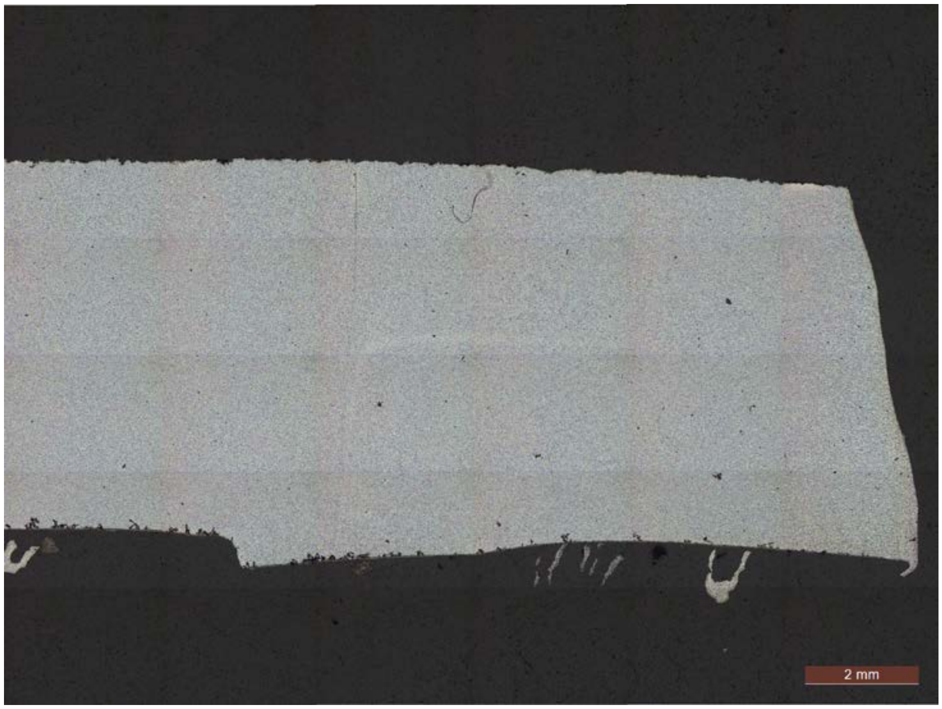


Figure 82. Metallographic images of indication A-MP7. Indication depth was measured to be 0.03 inch (720 µm).



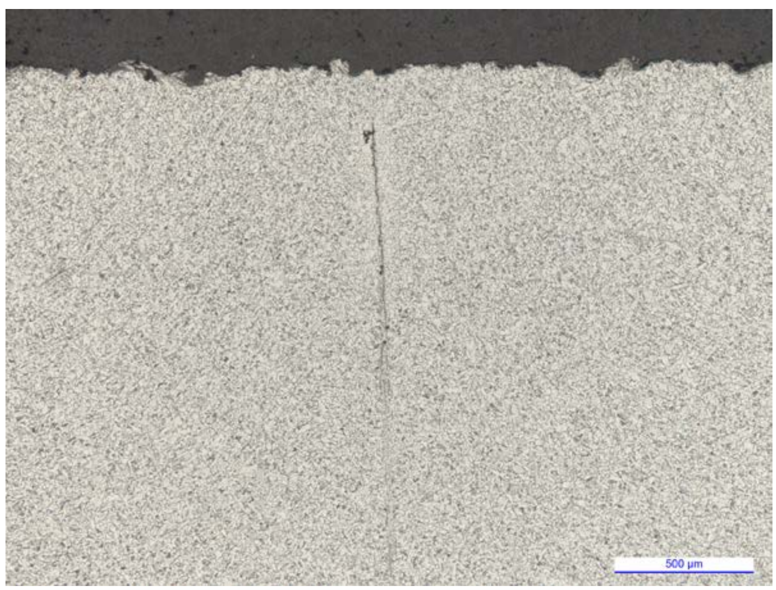


Figure 83. Metallographic images of indication B-MP7, showing oxide in the long seam. A surface-connecting crack was not observed at the viewing location.

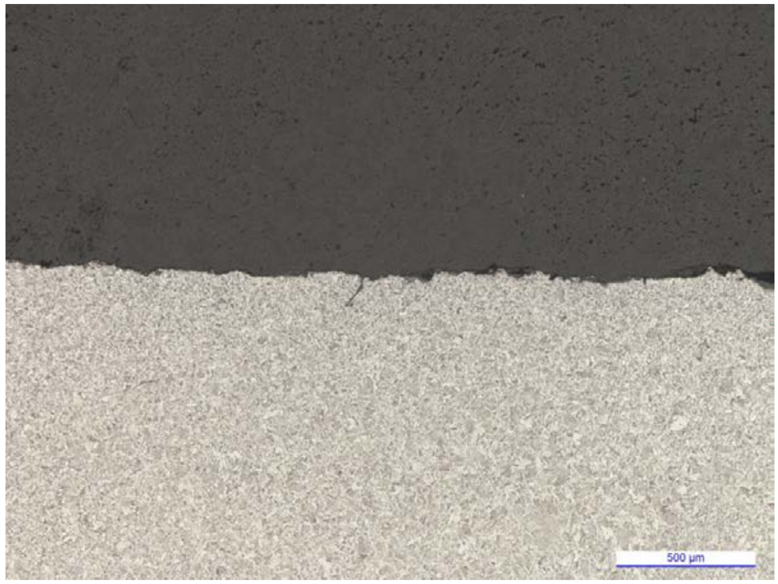


Figure 84. Metallographic image of indication C-MP1. Indication depth was measured to be 0.004 inch (~103 µm).

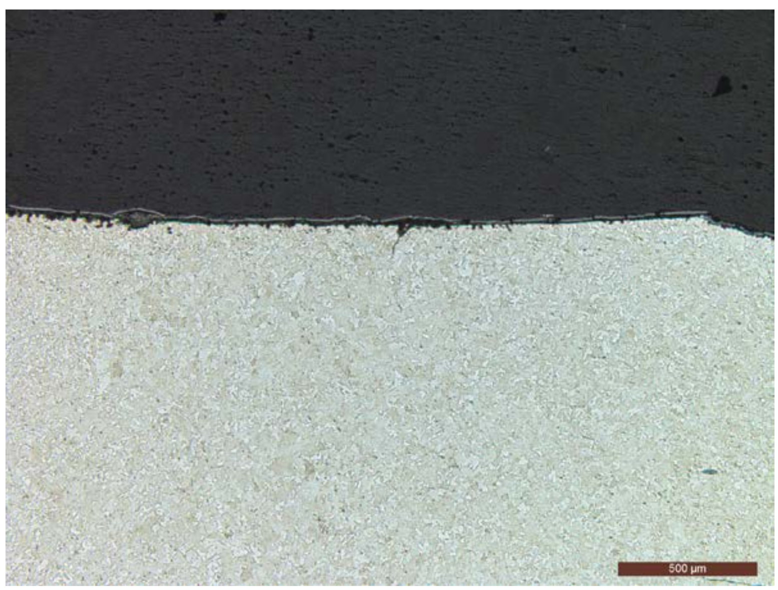


Figure 85. Metallographic image of indication C-MP3. Indication depth was measured to be 0.005 inch (~130 µm).

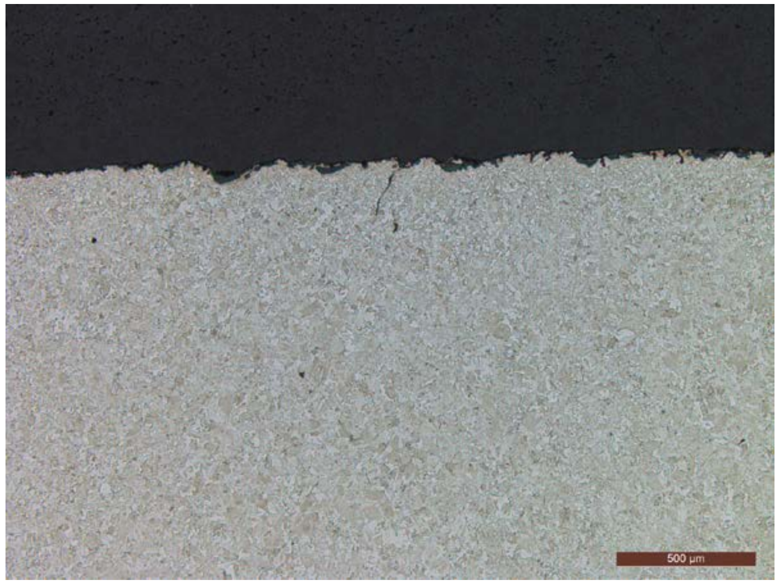


Figure 86. Metallographic image of indication D-MP1. Indication depth was measured to be 0.007 inch (~185 µm).

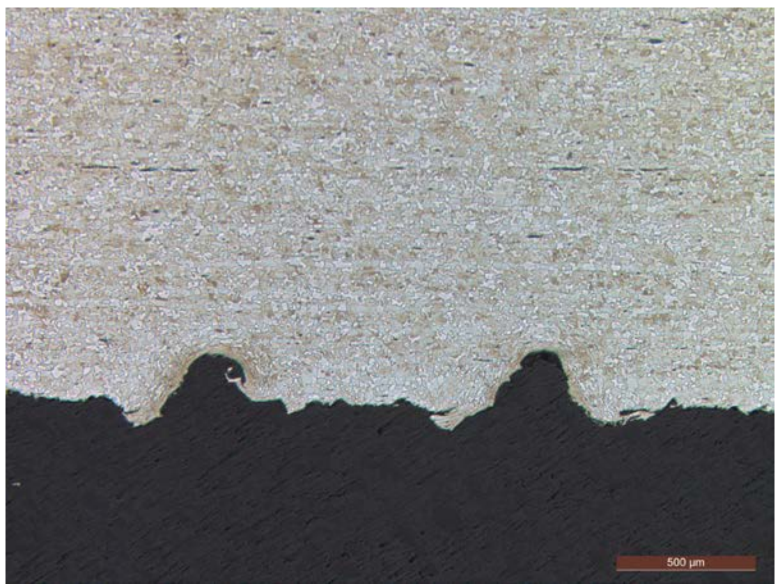


Figure 87. Photograph and metallographic image of Indication D-MD7. This indication ran along a large portion of the pipe circumference. A similar indication was observed on the Ejected Segment and is shown in Figure 94 through Figure 96.

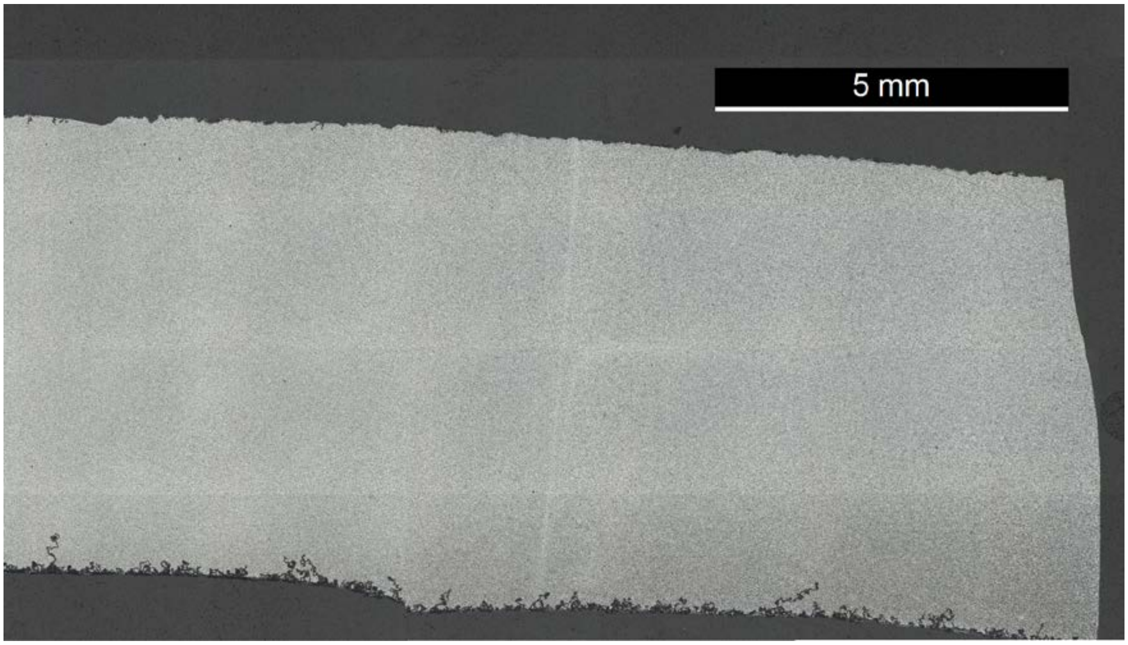


Figure 88. Metallographic image of typical ERW seam in Segment B shown by indication B-MP1.

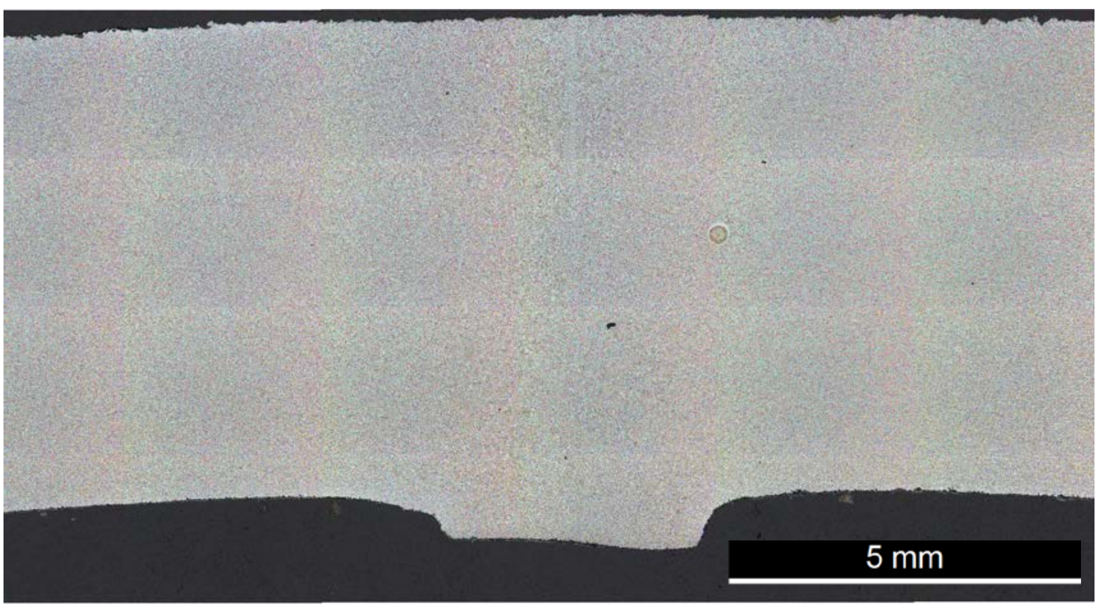


Figure 89. Metallographic image of typical ERW seam in Segment C shown by indication C-MP2.

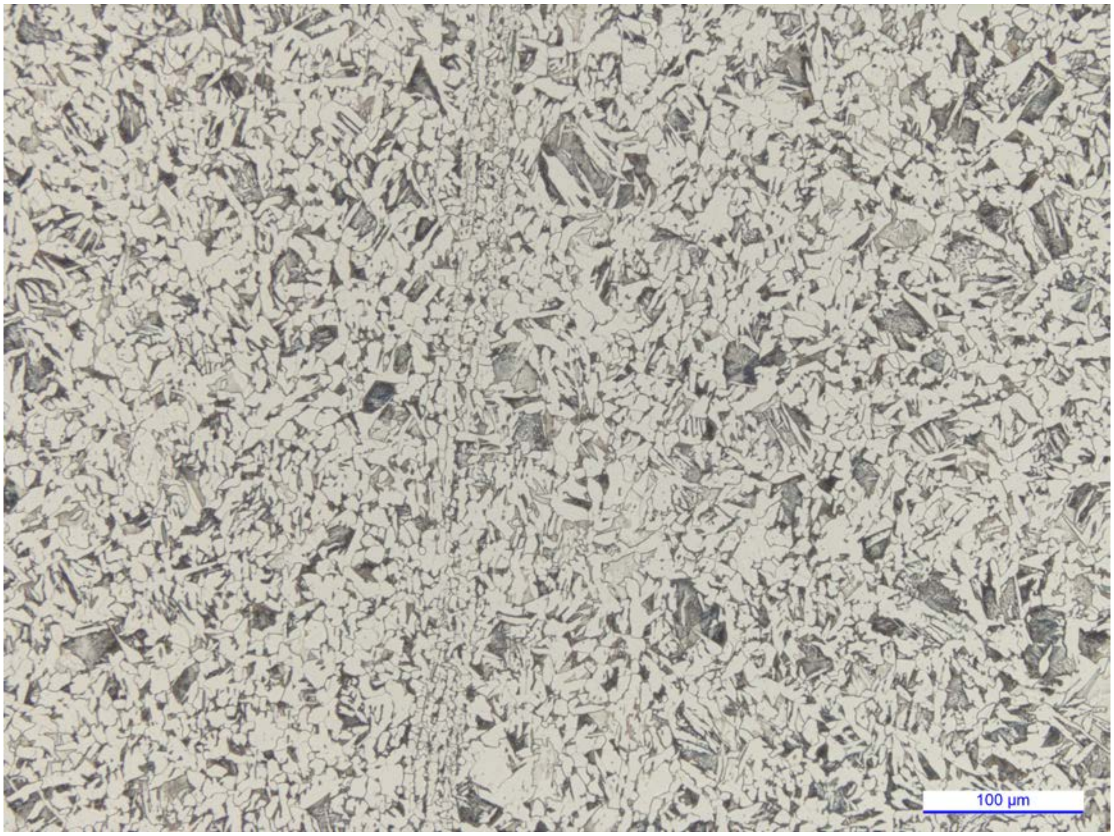


Figure 90. Metallographic image of typical ERW seam microstructure (A-MP2 shown). A Widmanstätten morphology is shown.

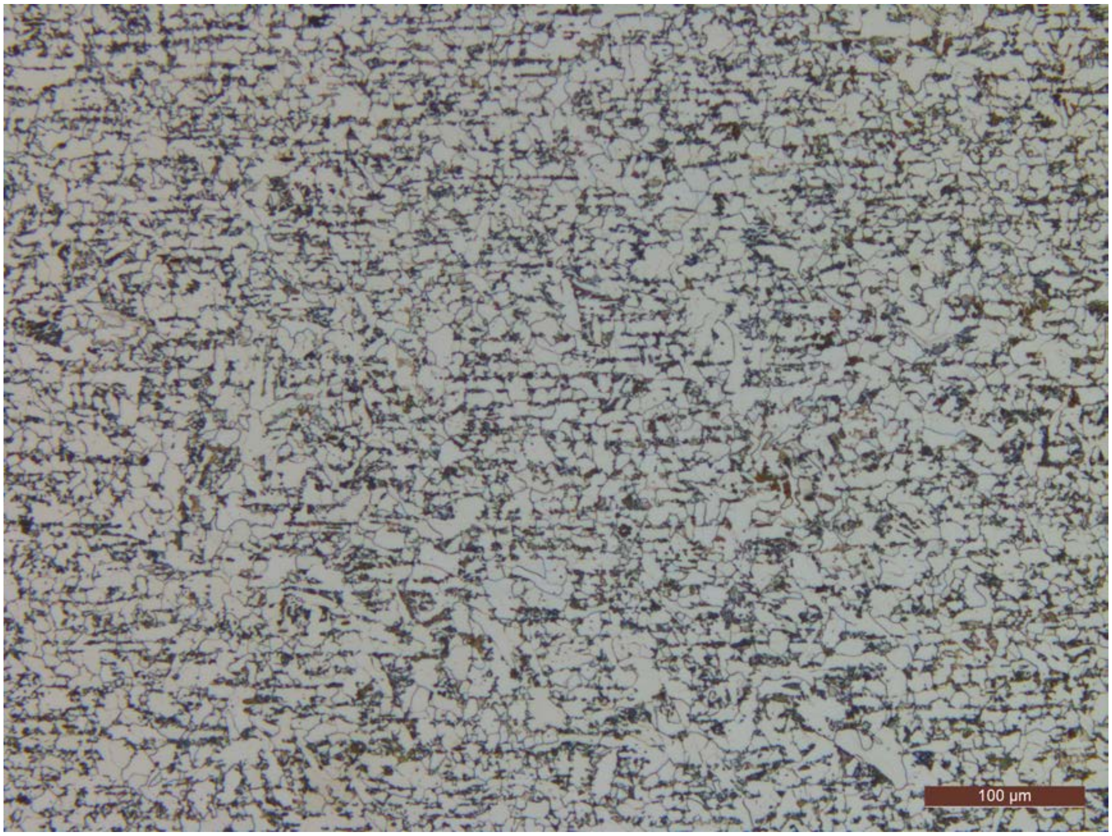


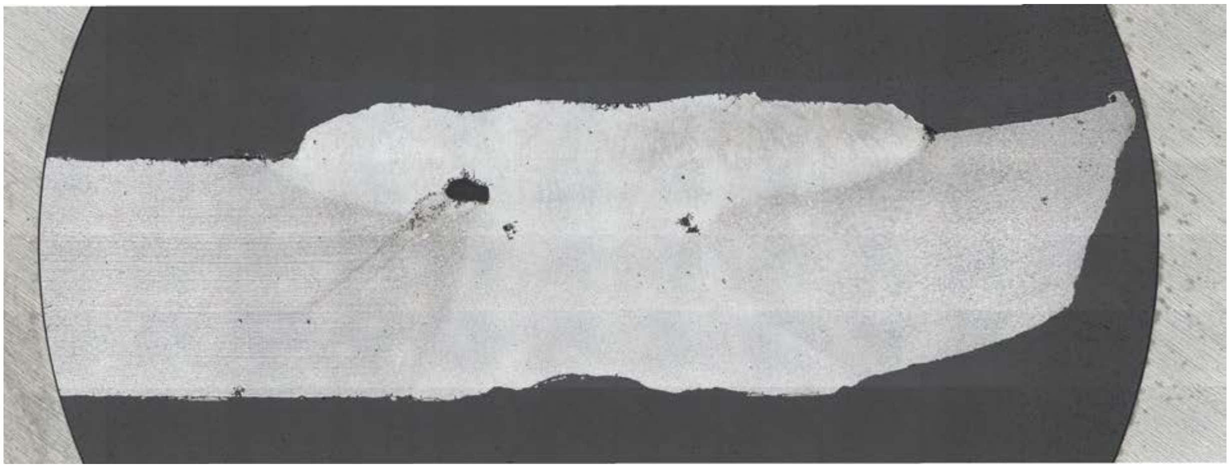
Figure 91. Metallographic image of typical base metal microstructure (A-MP2 shown, away from weld). A typical ferrite-pearlite microstructure is shown.

Microscopy of Other Samples

Two additional areas were analyzed using metallographic techniques. First, a metallographic sample of the girth weld that connected Segments B and C was prepared. Because this was the only girth weld investigated using metallography during the analysis, it was labeled simply "girth weld." The sample was extracted from the area where the rupture ran closest to the girth weld. This location corresponded to the 8:00 position (approximately), as shown in Figure 92. Figure 93 shows low- and high-magnification metallographic images of the girth weld, where the fracture surface can be seen on the right side of the image. The fracture was found to have run along the edge of the heat-affected zone, where the microstructure transitions to base metal. Pores are evident in the weld metal. Because the fracture did not propagate through these pores or the weld metal, neither were factors in the fracture of the pipe.

Lastly, a metallographic mount was prepared to investigate a circumferential linear feature on the outer diameter of the Ejected Segment. The location of the sample is shown in both Figure 61 and Figure 94. Based on visual examination prior to sectioning, the linear feature was similar in appearance to D-MD7, identified on Segment D during the nondestructive evaluation and shown in Figure 87. The sample was labeled EJ Frac 1-Linear. Micrographs of the sample are depicted in Figure 95 and Figure 96. As expected, these micrographs show that the feature is consistent with D-MD7, presented in Figure 87. These features are linear grooves caused by minor, local mechanical deformation that ran circumferentially around the pipe at various locations, and likely occurred during pipe manufacture, handling, or installation.

Figure 92. Sectioning of the Segment B–C girth weld. The sample was taken from a region where the fracture was closest to the weld. The pipe is shown in the correct orientation with the sample taken at about the 8:00 position.



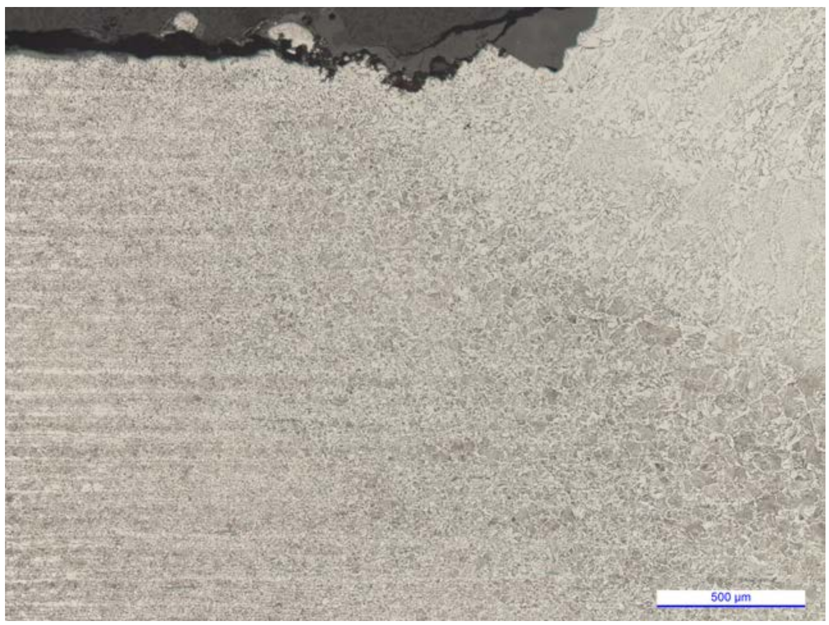


Figure 93. Metallographic images of the girth weld connecting pipe Segments B and C. The fracture surface can be seen on the right in the top image.

Figure 94. Photo documentation of metallographic sample extraction for an indication labeled EJ Frac 1-Linear. This metallographic mount was prepared for the purpose of investigating the linear indication running from the top of the image to the bottom on the outer surface of the Ejected Segment. The piece was cut from the Ejected Segment per Figure 61.

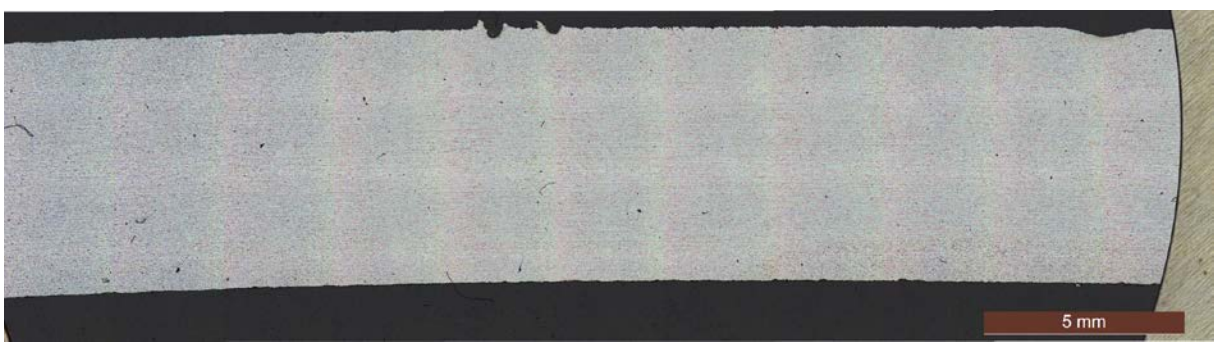


Figure 95. The EJ Frac 1-Linear metallographic mount. The feature can be observed along the outer diameter as two small indents.

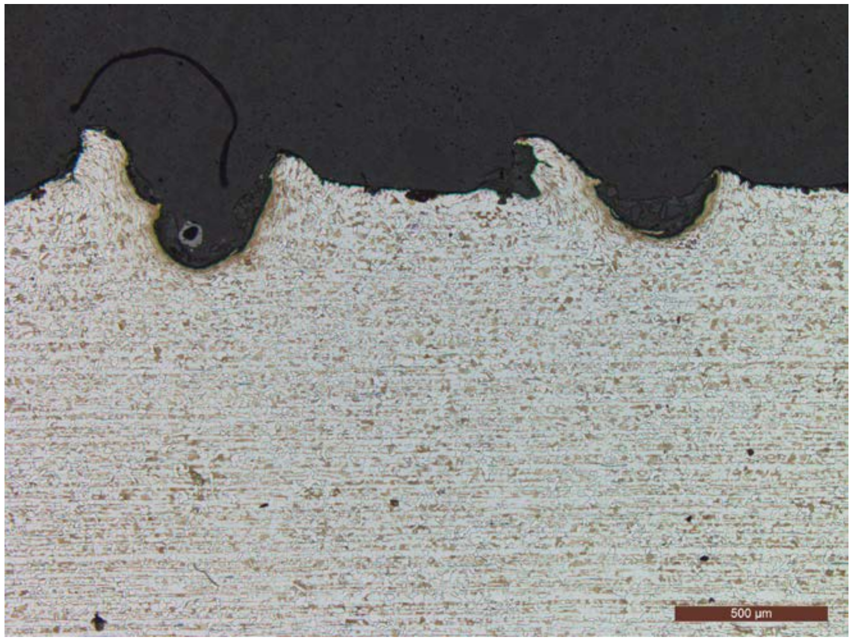


Figure 96. Higher-magnification metallographic image of the EJ Frac 1-Linear sample. The feature is consistent with D-MD7.

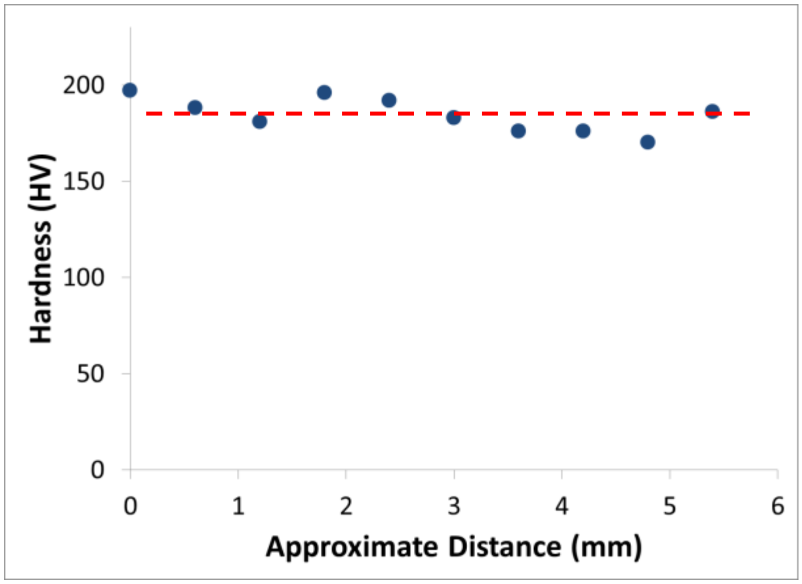
Mechanical Testing

Microhardness

Vickers microindentation tests were performed on the base metal, across selected welds, and on rupture surface pieces to characterize hardness. The average base metal hardness was 185 HV, consistent with Grade X-42 material and a tensile strength above 60 ksi. A characteristic base metal hardness test was performed on metallographic Specimen A-MP2, in an area far from the weld. This mount and microhardness transverse are shown in Figure 97. In addition to the base metal hardness, traverses were performed on representative welds from Segment B and Segment C, shown in Figure 98 and Figure 99 respectively. Although the traverse from Segment C (Figure 99) may show a slight increase in hardness near the fusion line, the traverse from Segment B (Figure 98) showed relatively consistent hardness values across the heat-affected zone and fusion line. It is not known how much heat these locations on Segments B and C might have seen during the fire, or for how long. Exposure to post-rupture heat has the potential to alter weld and base metal hardness properties.

Hardness traverses were performed on the matched fracture surfaces shown in Figure 70. Traverses were done on both the Ejected Segment and Segment B, as shown in Figure 100. It is clear that the sample extracted from Segment B showed significantly reduced hardness compared to that of the Ejected Segment. The average hardness value for the Segment B side of the matched fracture was 138 HV, whereas the average value for the Ejected Segment side of the matched fracture was found to be 178 HV. This finding is consistent with the previous observation that the Segment B side had an oxide layer and pearlite spheroidization, indicating that it was exposed to heat from the fire during the incident. Heat from the fire on Segment B reduced tensile strength and hardness of the steel at that location, as shown by the microhardness data in Figure 100.

A hardness traverse was performed on EJ Frac 1-SEM B, shown in Figure 101. This sample corresponds to the long seam fracture origin. The metallographic mount shows the fracture surface on the right-hand side of the image. Hardness is shown to increase slightly near the fusion line or fracture surface. This expected hardness increase is due to the original welding of the pipe, similar to the intact weld from Segment C. Figure 102 and Figure 103 show microhardness traverses on specimens EJ Frac 2-2 and EJ Frac 2-3, respectively. In both samples, it is clear that the hardness increases in close proximity to the fracture surface, which is expected, given local work hardening associated with the plastic strain from tearing. A summary of microhardness data is shown in Table 6.



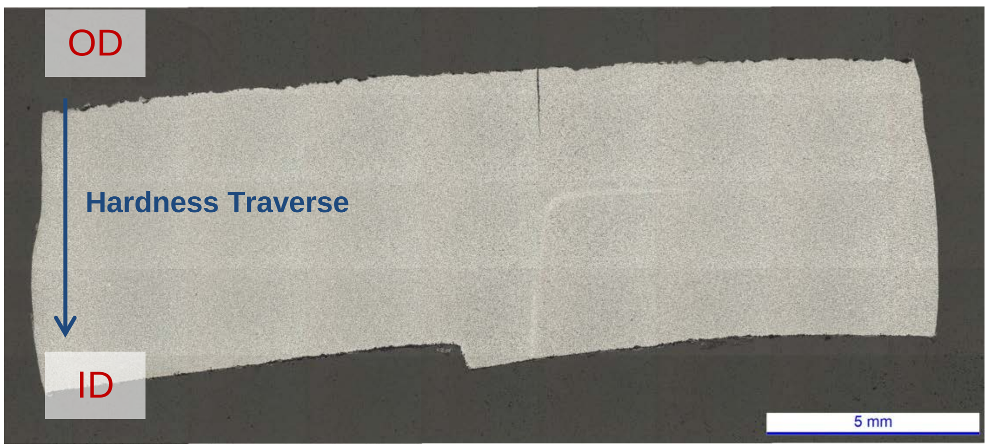


Figure 97. An optical micrograph of the cross section associated with indication A-MP2 and microhardness traverse. Etched with 2 percent Nital. This microhardness traverse was performed to characterize base metal hardness.

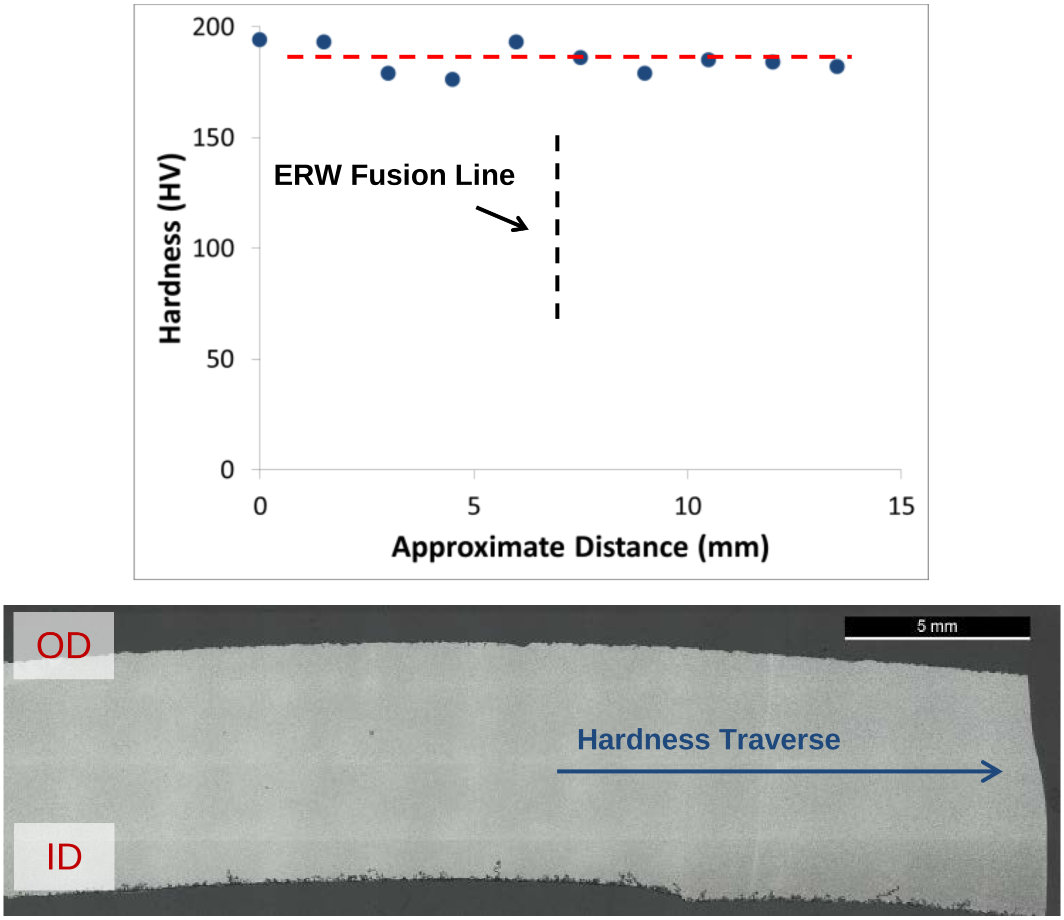
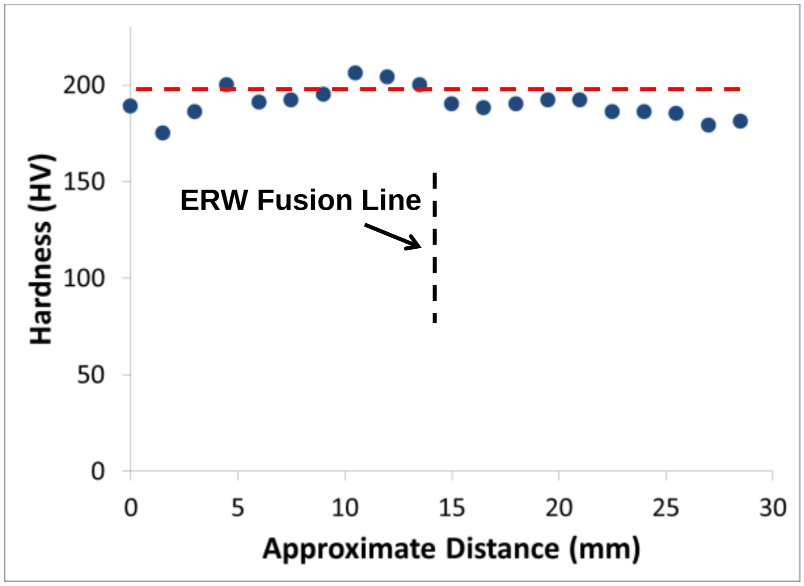


Figure 98. An optical micrograph of the cross section associated with indication B-MP1 and microhardness traverse. Etched with 2 percent Nital. For microhardness purposes, this cross section is considered representative of the ERW weld in Segment B.



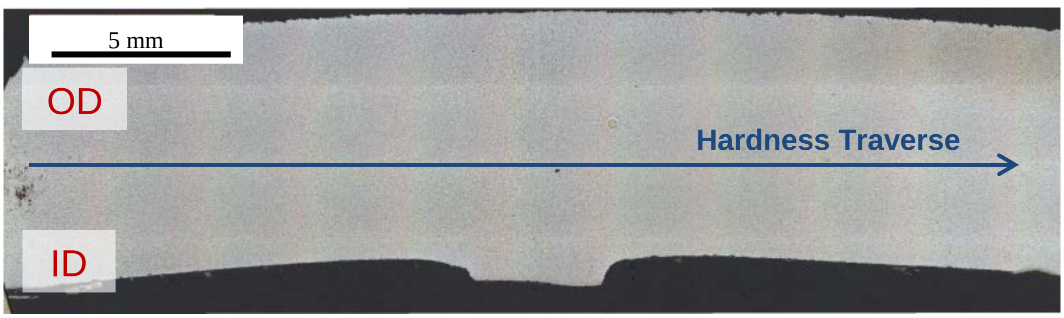


Figure 99. An optical micrograph of the cross section associated with indication C-MP2 and microhardness traverse. Etched with 2 percent Nital. For microhardness purposes, this cross section is considered representative of the ERW weld in Segment C.

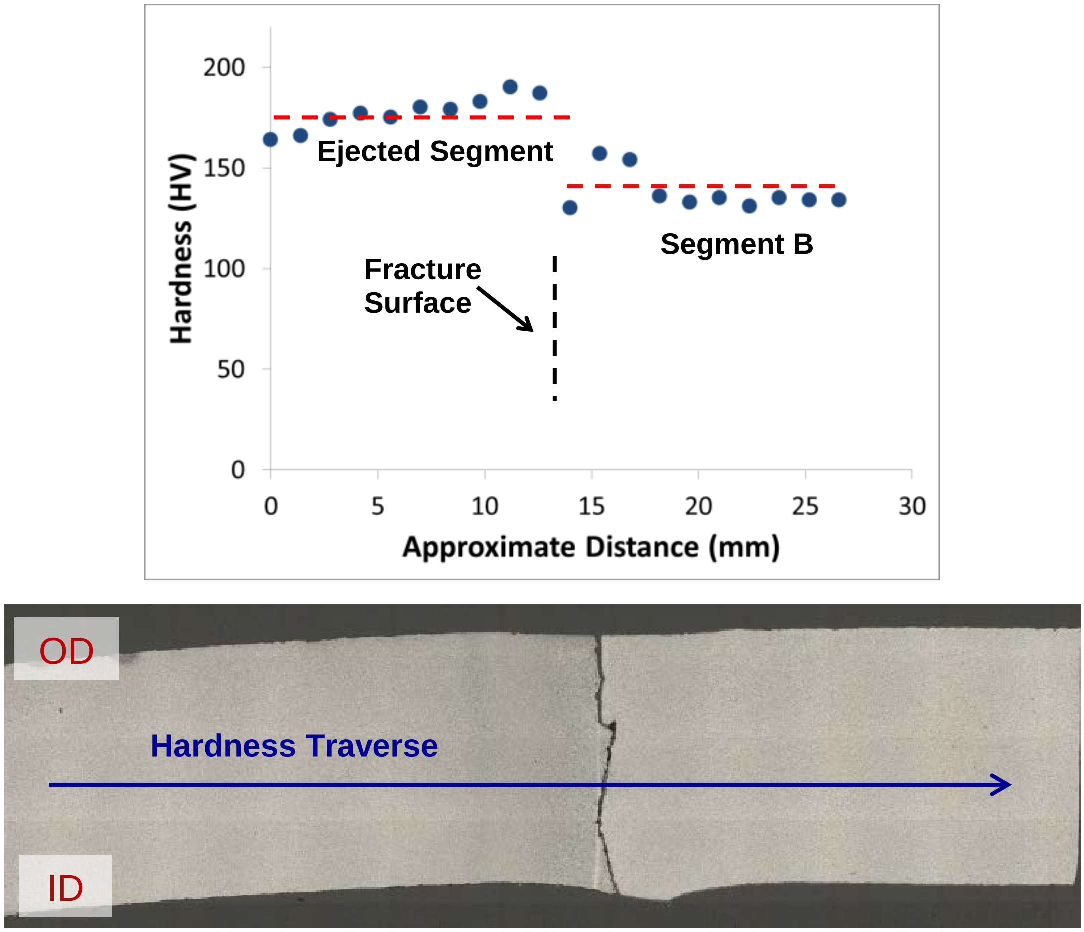


Figure 100. An optical micrograph and microhardness traverse of the matched fracture surfaces shown in Figure 70. The right-hand side corresponds to the piece extracted from Segment B, whereas the left-hand side corresponds to a sample taken from the Ejected Segment. Segment B shows significantly lower hardness than the Ejected Segment due to exposure to the fire's high heat.

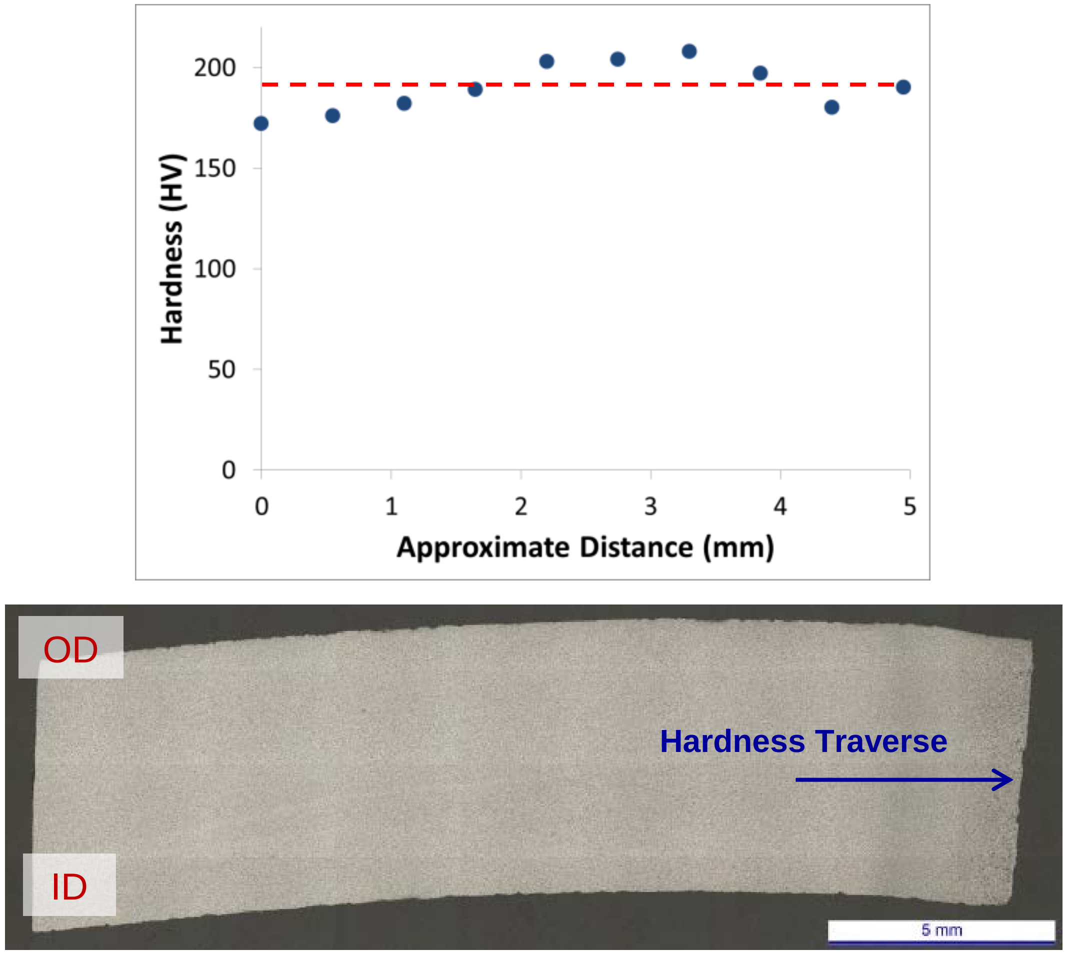
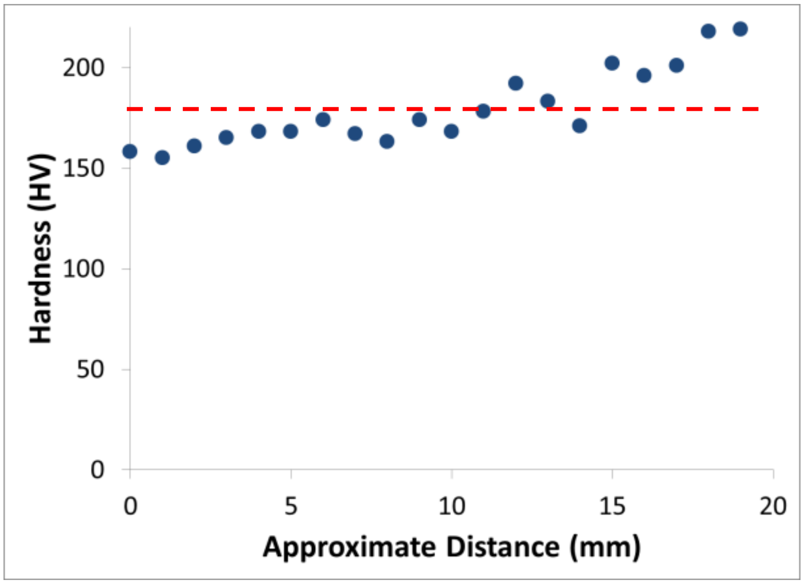


Figure 101. An optical micrograph and microhardness traverse of EJ Frac 1-SEM B (i.e., Location B shown in Figure 69). The fracture surface at the long seam is on the right-hand side of the sample. Etched with 2 percent Nital.



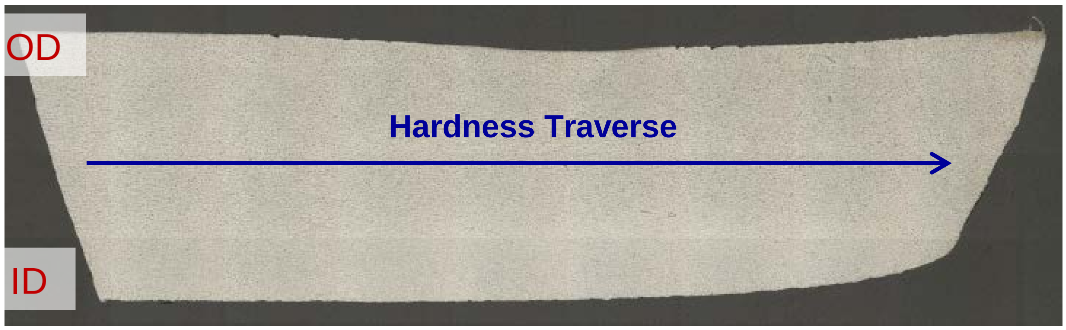


Figure 102. An optical micrograph and microhardness traverse of the EJ Frac 2-2 sample, where increasing hardness is observed approaching the fracture surface on the left-hand side of the micrograph. Etched with 2 percent Nital.

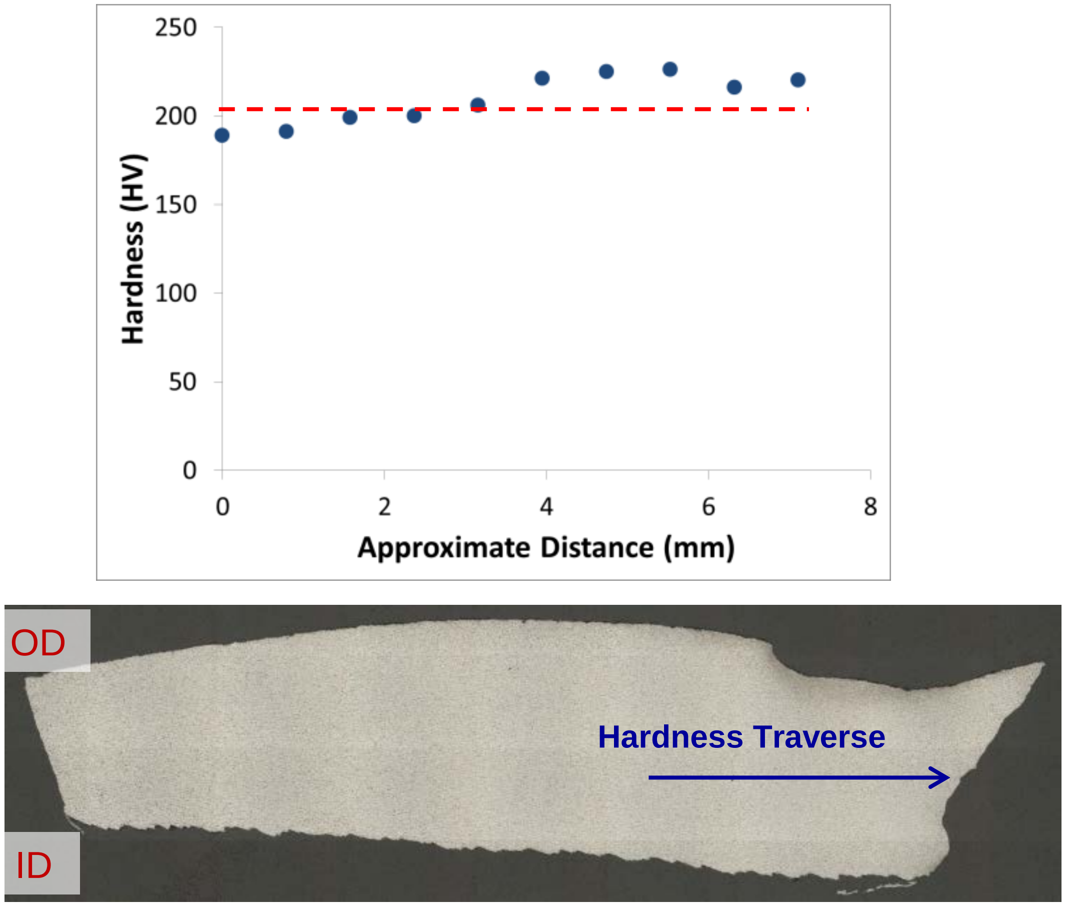


Figure 103. An optical micrograph and microhardness traverse of the Fracture 3 sample. Similar to EJ Frac 2-3, hardness increases closer toward the fracture surface. Etched with 2 percent Nital.

Table 6. A summary of microhardness data.

Sample	Average (HV)	Min (HV)	Max (HV)
A-MP2 (Base Metal)	185	170	197
B-MP1	185	176	194
C-MP2	190	175	206
Matched Fracture (Ejected Segment)	178	164	190
Matched Fracture (Segment B)	138	130	157
Ejected Segment (Location “B”)	190	172	208
Fracture 2	179	155	219
Fracture 3	209	189	226

Tensile Testing

Anamet Inc. (Anamet) performed transverse tensile testing. (See Appendix C for the report.) Three areas were extracted from the pipes for analysis. These included sections from pipe Segment A, Segment B, and Segment C. The areas from which mechanical testing specimens were extracted are shown in Figure 104 through Figure 106. All of these areas were buried following the incident and were still covered with coating and dirt following the rupture and fire. The results are given below in Table 7, which compares properties of the tested segments and current and historical API standards for X-42 pipe. Specifically, the 1960 API 5LX standard was used (ninth edition) for Grade X-42 pipe. Results indicate that strength levels for Segment B base material were lower than anticipated. Samples extracted from Segment A show higher tensile and yield strengths compared to Segment B. Given that these samples (A and B) were extracted from the same stick of pipe, the results indicate that the location of the Segment B samples was softened by the heat associated with the post-rupture fire (Segment B samples were buried approximately two feet from the edge of the rupture crater). Results from Segments A and C are consistent with both historical (1960) and current API standards for X-42 grade pipe. Two transverse base metal samples were tested from Segment A, one sample exhibited a yield strength one ksi below the X-42 specification. All other Segment A and Segment C tensile properties exceeded API X-42 requirements. Two sets of specimens from Segments A, B, and C were tested: one from the base metal and one that included the seam weld. The values listed in Table 7 are the average from each set; Appendix C includes the full results.

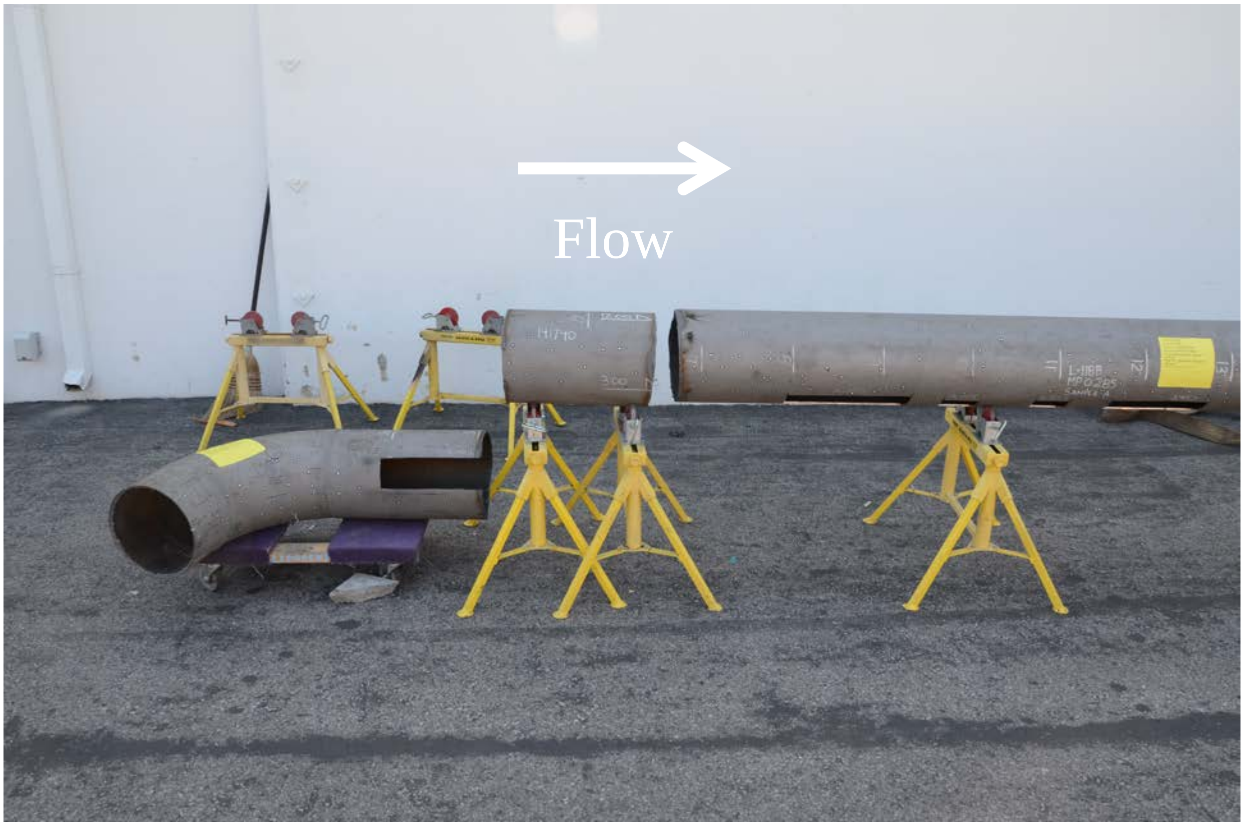


Figure 104. Photo documentation showing the location used for the Segment A mechanical testing specimens on the upstream side of Segment A.

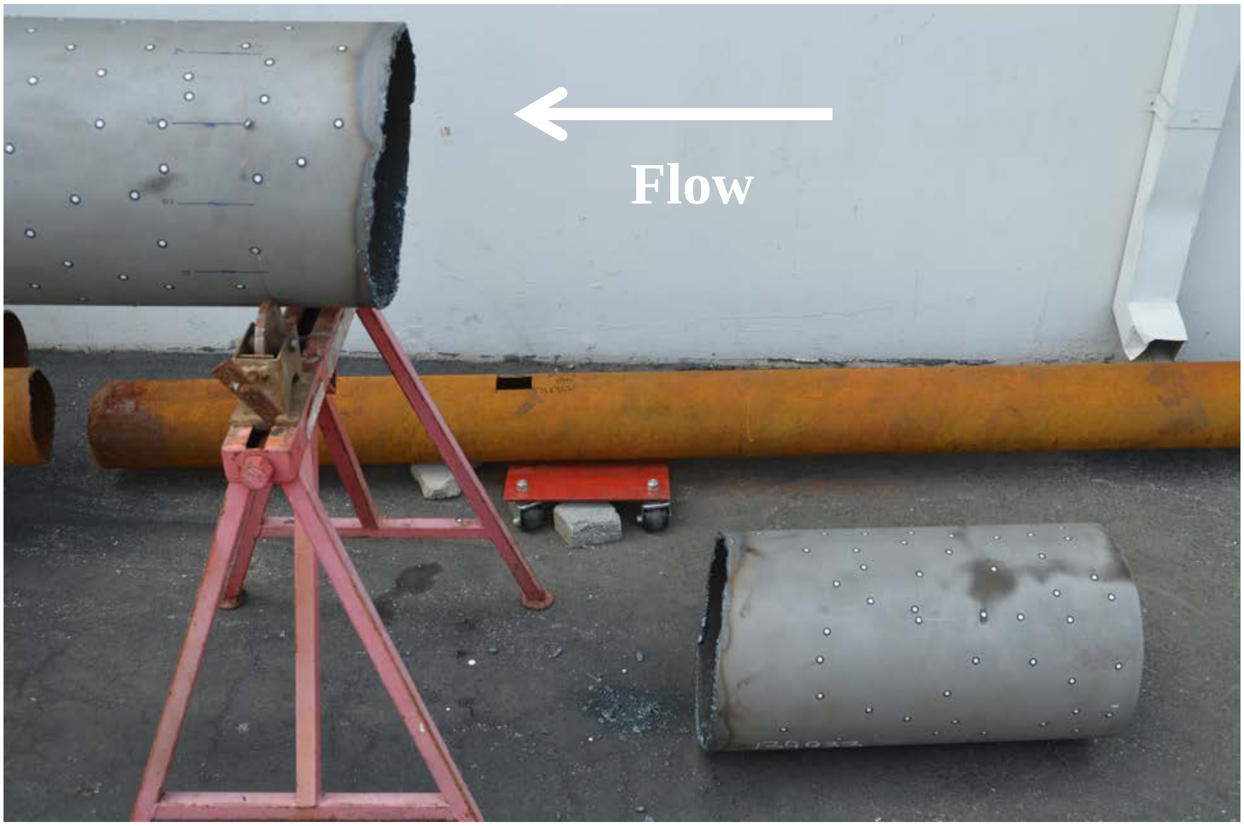


Figure 105. Photo documentation showing the location used for the Segment B mechanical testing specimens on the upstream side of Segment B.

Figure 106. Photo documentation showing the location used for the Segment C mechanical testing specimens on the downstream side of Segment C.

Table 7. Transverse tensile testing (ASTM A370-12 and API 5L) of base and seam weld metal from a sample taken from Segments A, B, and C of Line 118B. (The values shown are an average of two different tests.)

	Section A BM	Section A Seam	Section B BM	Section B Seam	Section C BM	Section C Seam	1960 API Base-Metal Specification	2014 API Base-Metal Specification*
Tensile Strength (ksi)	63.40	72.95	64.25	76.40	72.95	79.25	60.0	60.2
Yield Strength at 0.5% E.U.L.(ksi)	41.55	54.65	37.30	46.85	44.15	46.10	42.0	42.1
Elongation in 2” Gage (%)	30.75	6.75	33.5	19.75	29.25	21.5	22.5	26
Fracture Location		Weld		B.M.		B.M.		
Fracture Characteristic		Ductile		Ductile		Ductile		

* Per Product Specification Level 1 (PSL 1)

Charpy Impact Testing

Charpy impact testing was performed on the same three pipe segments outlined in the tensile testing section—namely, a section from the upstream side of Segment A, a section from the upstream side of Segment B, and a section from the downstream side of Segment C. Impact tests were performed in the base metal in both the transverse-longitudinal (T-L) and longitudinal-transverse (L-T) orientations. Additionally, tests were performed in the transverse-longitudinal orientation of the longitudinal seam weld. In all cases, full transition curves were generated by testing specimens at a wide range of temperatures. Due to the relatively thin pipe wall thickness, sub-sized specimens were used (5 mm x 10 mm x 55 mm). Plots in the body of the report summarize the results of these tests. Full reports, including the data in tabular format, are included in the Appendix. Table 8 summarizes the test results. Although conducted for this analysis, API does not specify Charpy toughness values for Grade X-42 pipe.

All data is shown in Figure 107 through Figure 115. As Table 8 describes, Figure 107 through Figure 109 give Charpy impact results for Segment A; Figure 110 through Figure 112 for Segment B; and Figure 113 through Figure 115 for Segment C. The different plots for a given pipe segment correspond to different orientations and testing areas of the pipe (weld or parent material). These plots are summarized in tables of the Charpy impact data provided in Table 9 through Table 11.

The weld metal in Segments A and B exhibits reduced upper-shelf impact toughness compared to the base metal in the same T-L orientation. Similarly, the weld metal in Segment C exhibited reduced upper-shelf impact toughness compared to the base metal, as well as a higher ductile-to-brittle transition temperature. A significant increase in upper-shelf impact toughness was observed in all Segments in the L-T orientation compared to the T-L orientation. Segment C also showed a reduced transition temperature in the L-T orientation compared to the T-L orientation. All Segments showed similar upper shelf energies in the parent metal of a given orientation. The weld metal of C shows a higher transition temperature compared to that of A and B. Tensile testing suggested that the material extracted from Segment B may have been affected by the heat of the fire during the incident. Therefore, the properties obtained from Segment B should not necessarily be considered representative of the pipe material as manufactured.

Table 8. Summary of figures containing results from Charpy impact tests.

Segment	Location and Orientation	Figure Number
A	Parent Metal T-L	Figure 107
A	Weld T-L	Figure 108
A	Parent Metal L-T	Figure 109
B	Parent Metal T-L	Figure 110
B	Weld T-L	Figure 111
B	Parent Metal L-T	Figure 112
C	Parent Metal T-L	Figure 113
C	Weld T-L	Figure 114
C	Parent Metal L-T	Figure 115

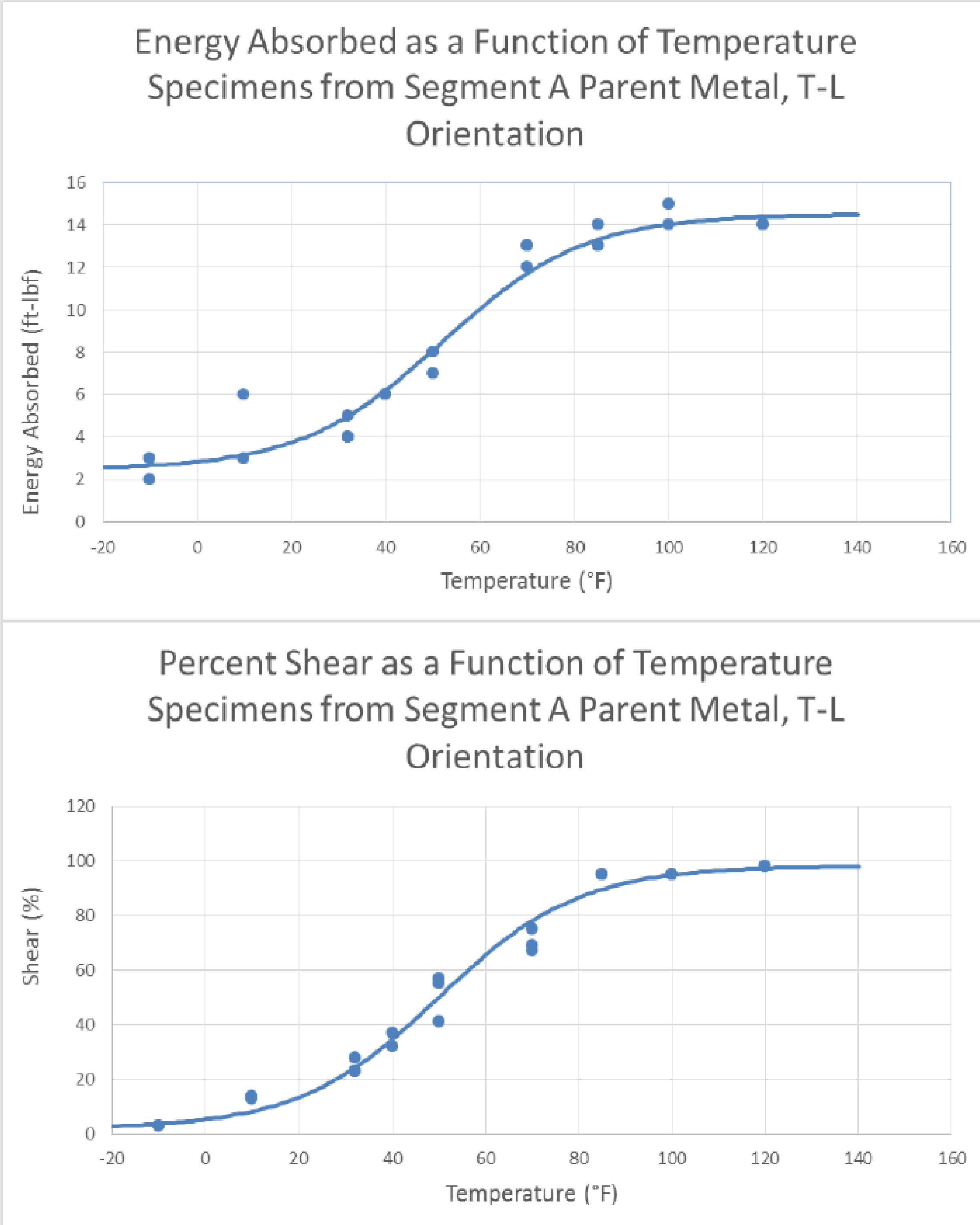


Figure 107. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment A base metal (T-L orientation).

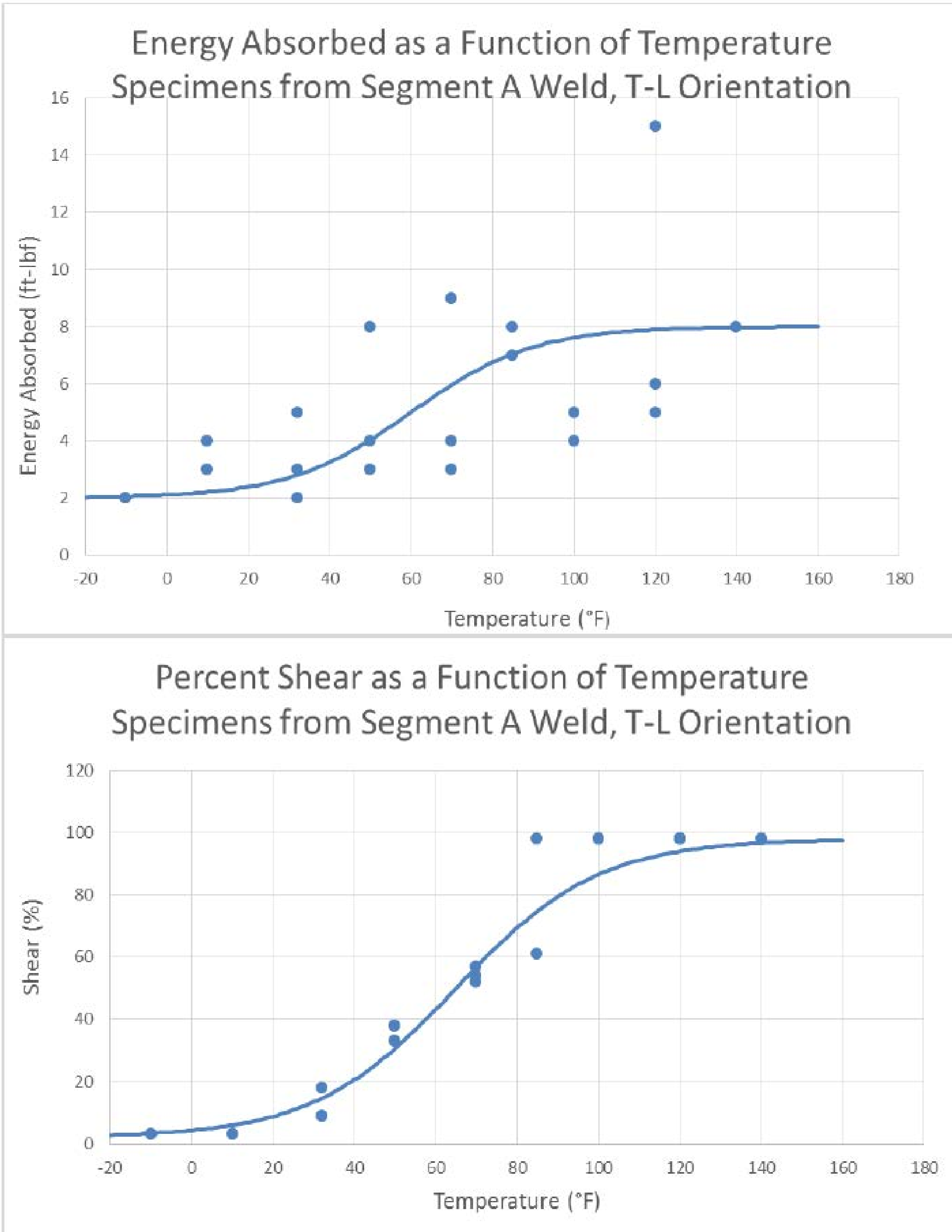


Figure 108. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment A weld metal (T-L orientation).

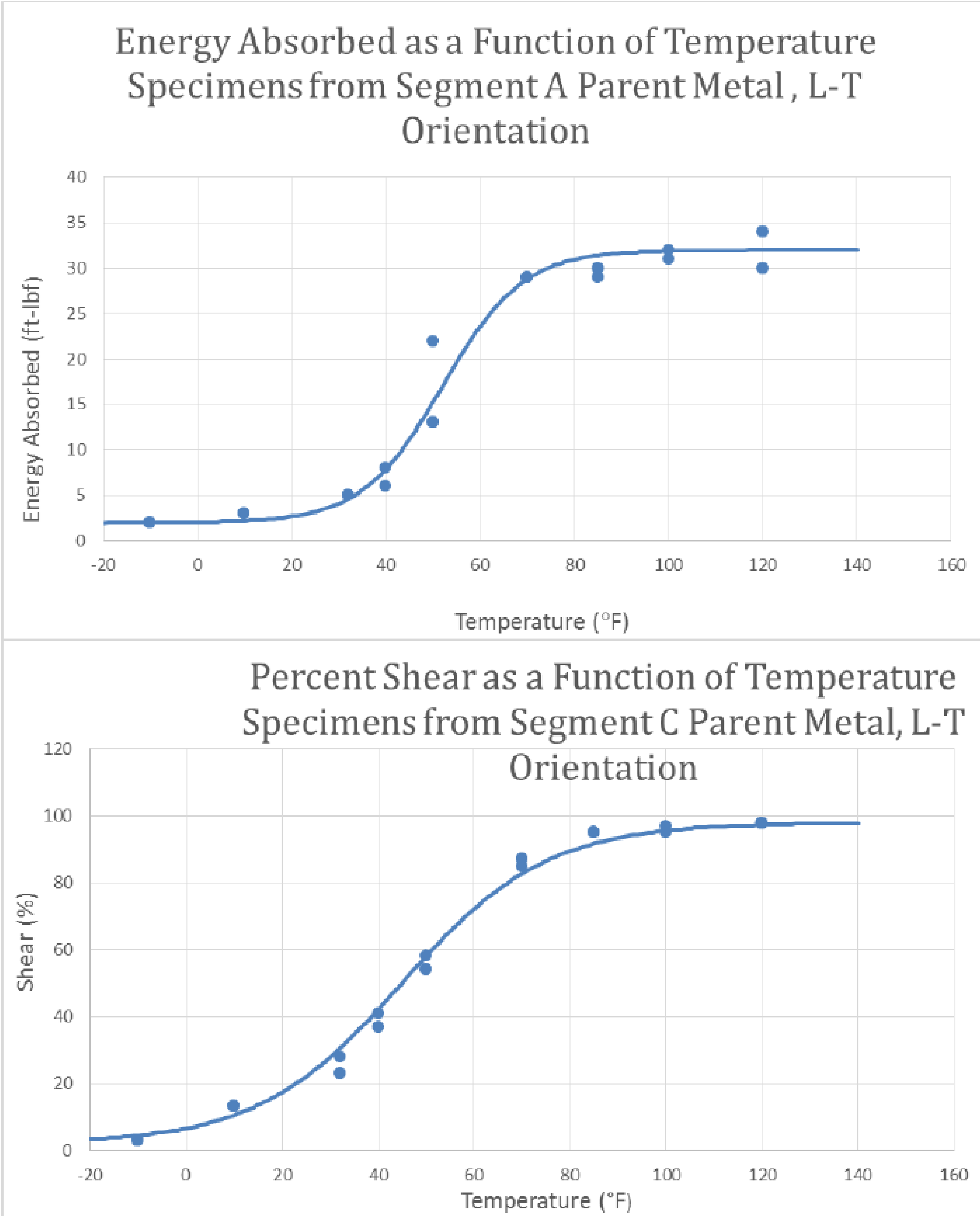
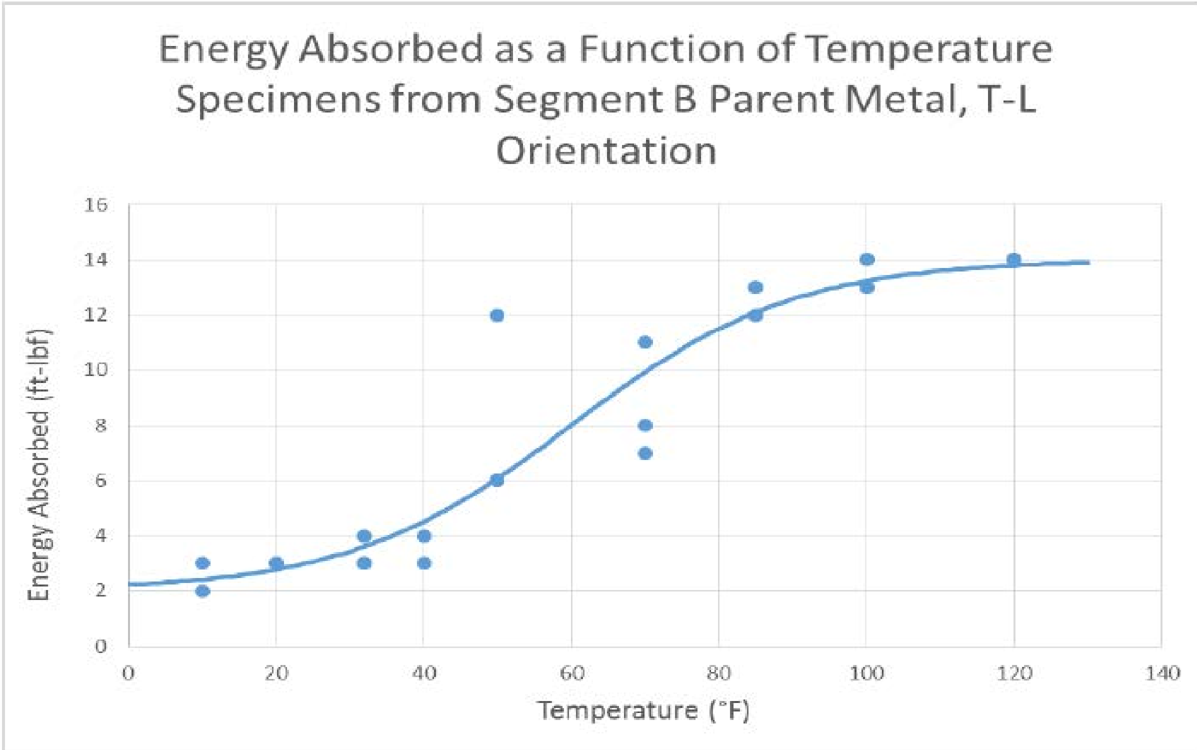


Figure 109. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment A base metal (L-T orientation).



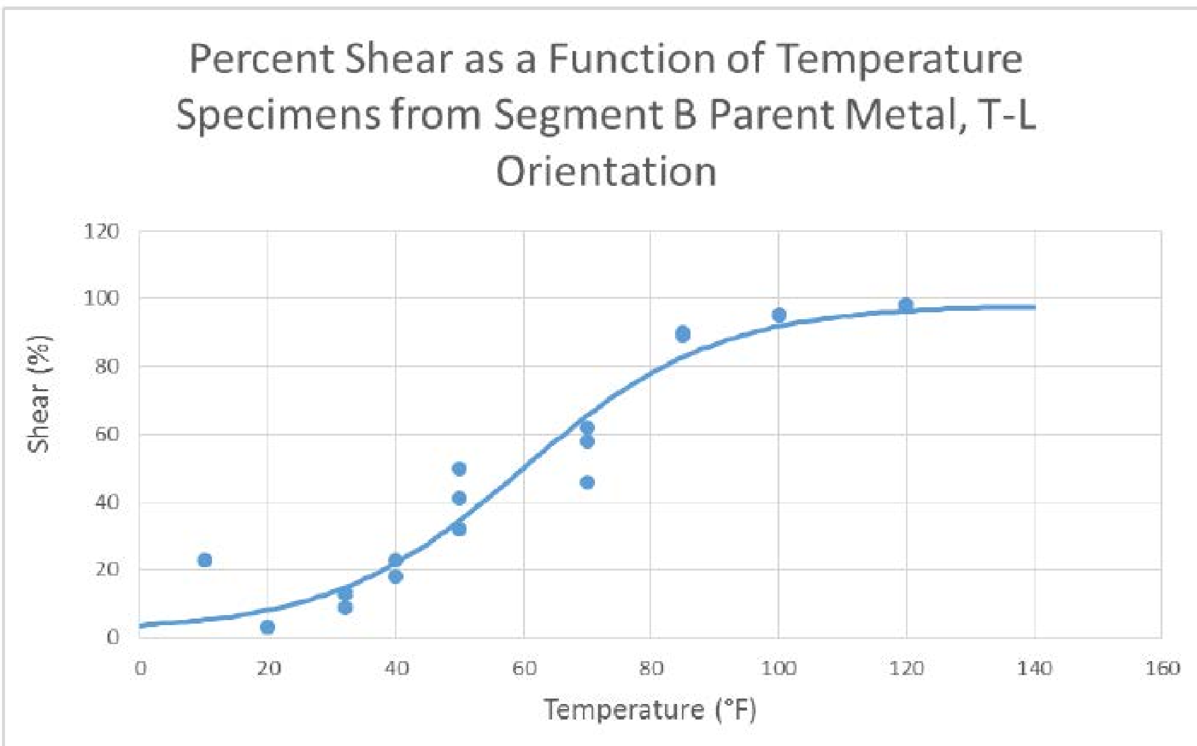


Figure 110. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment B base metal (T-L orientation).

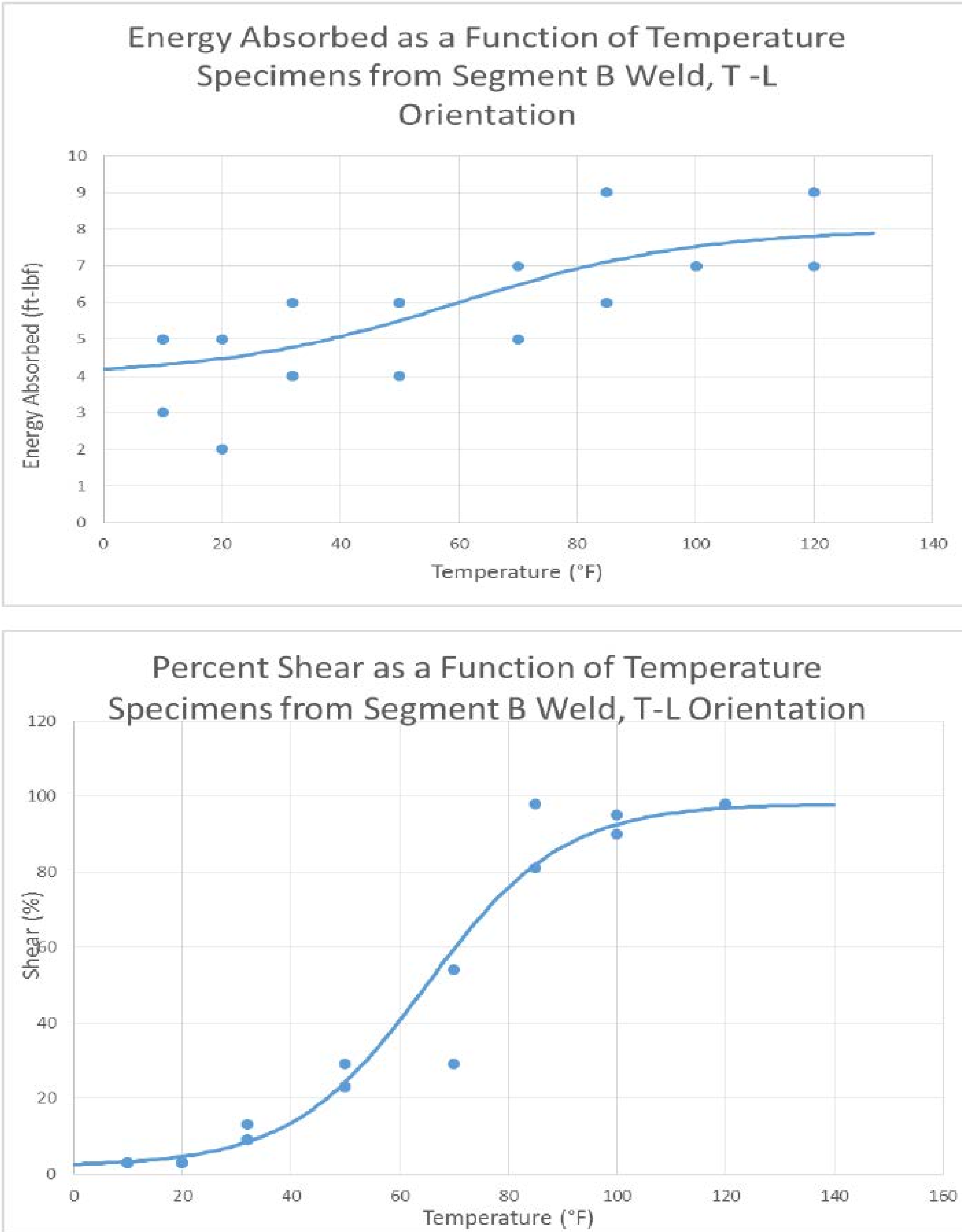
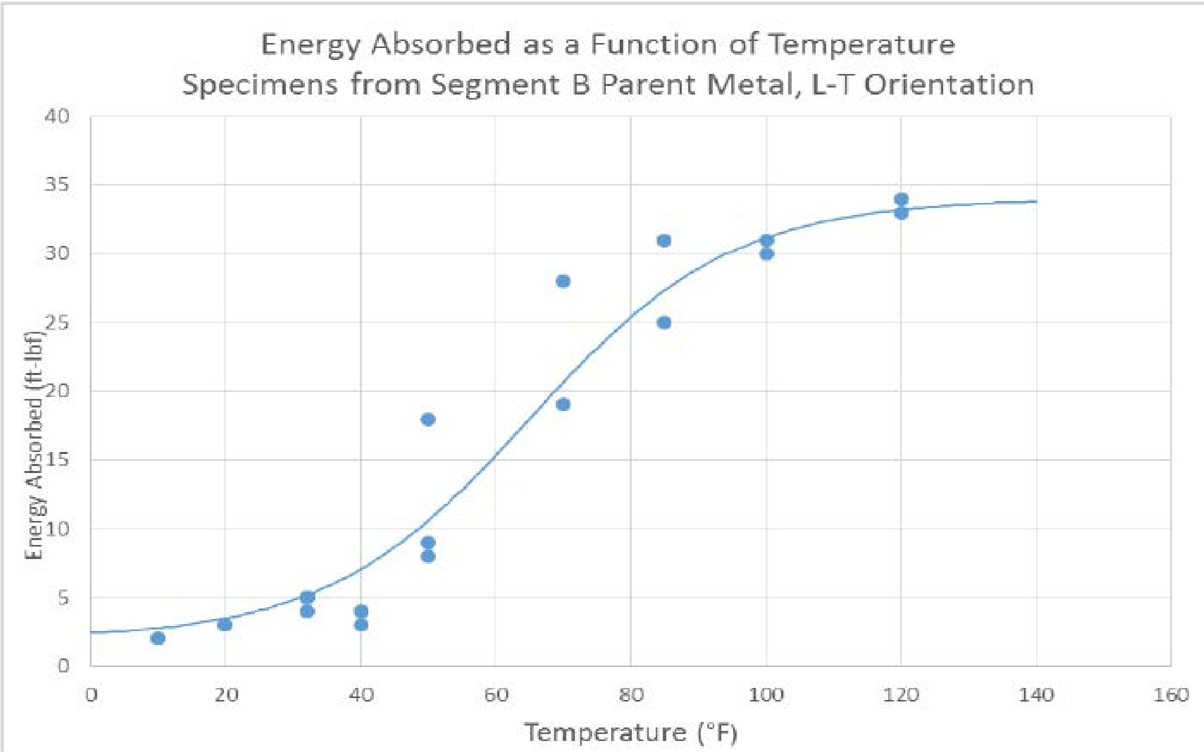


Figure 111. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment B weld metal (T-L orientation).



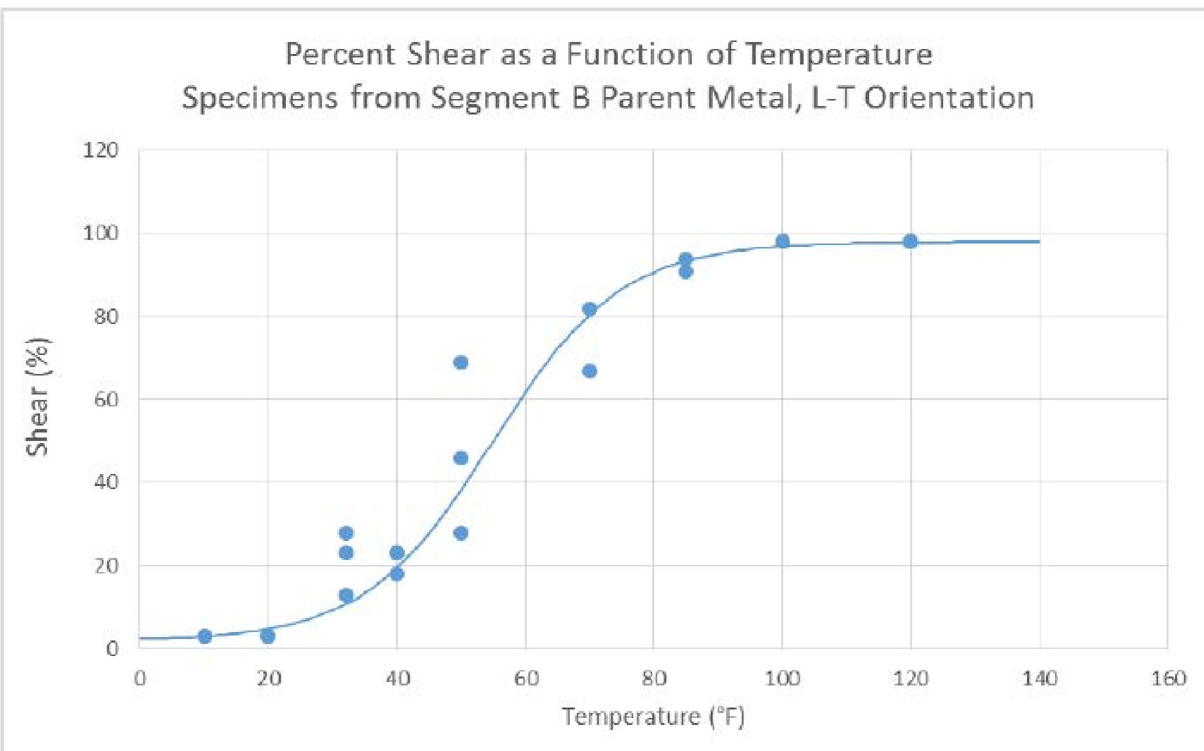
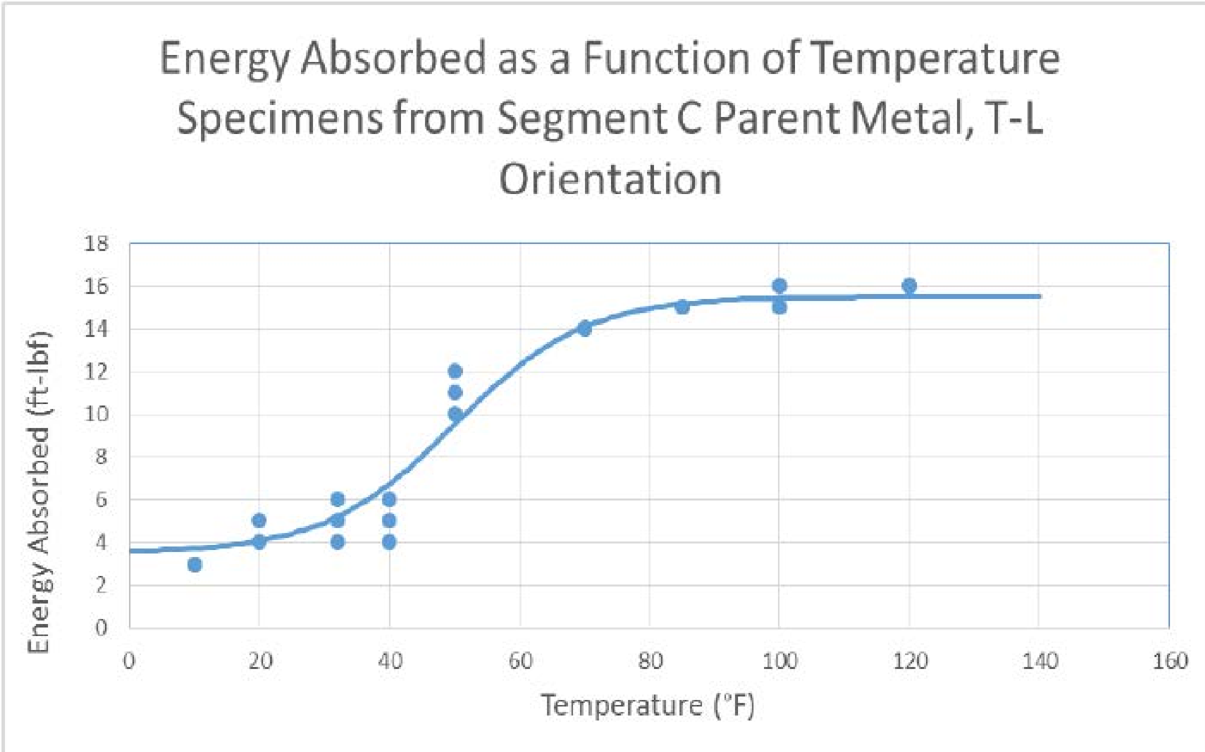


Figure 112. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment B base metal (L-T orientation).



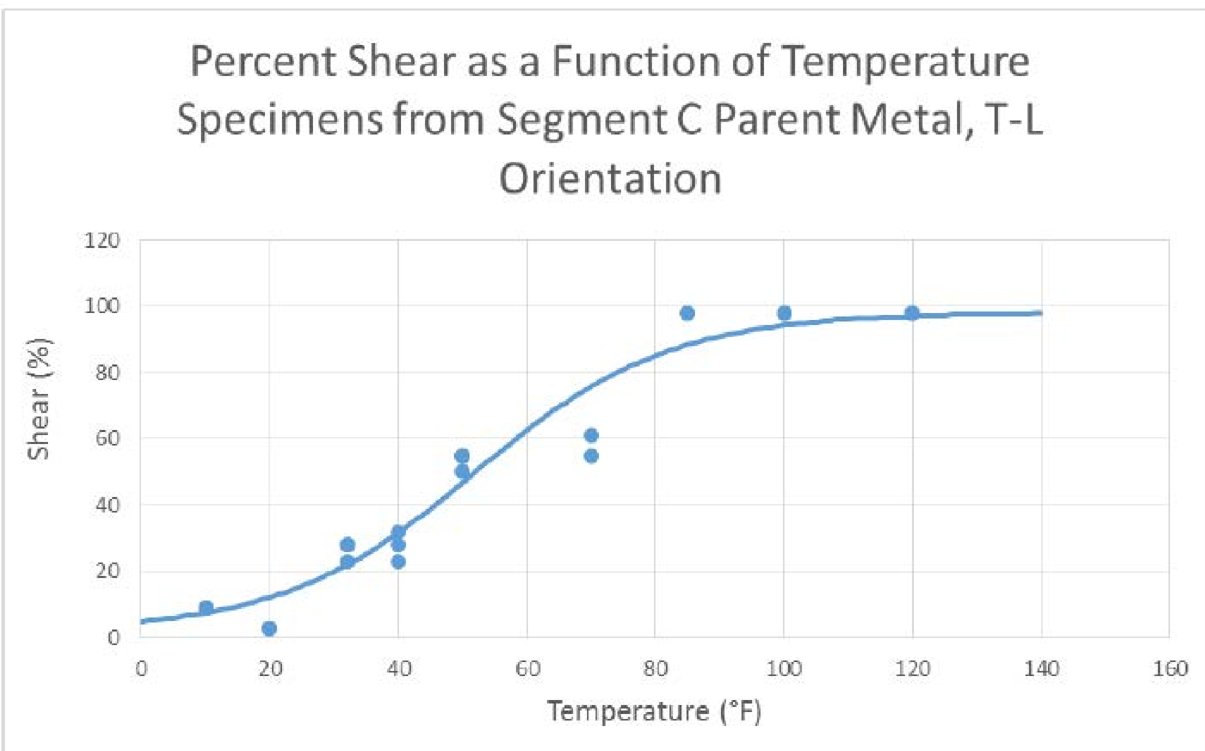
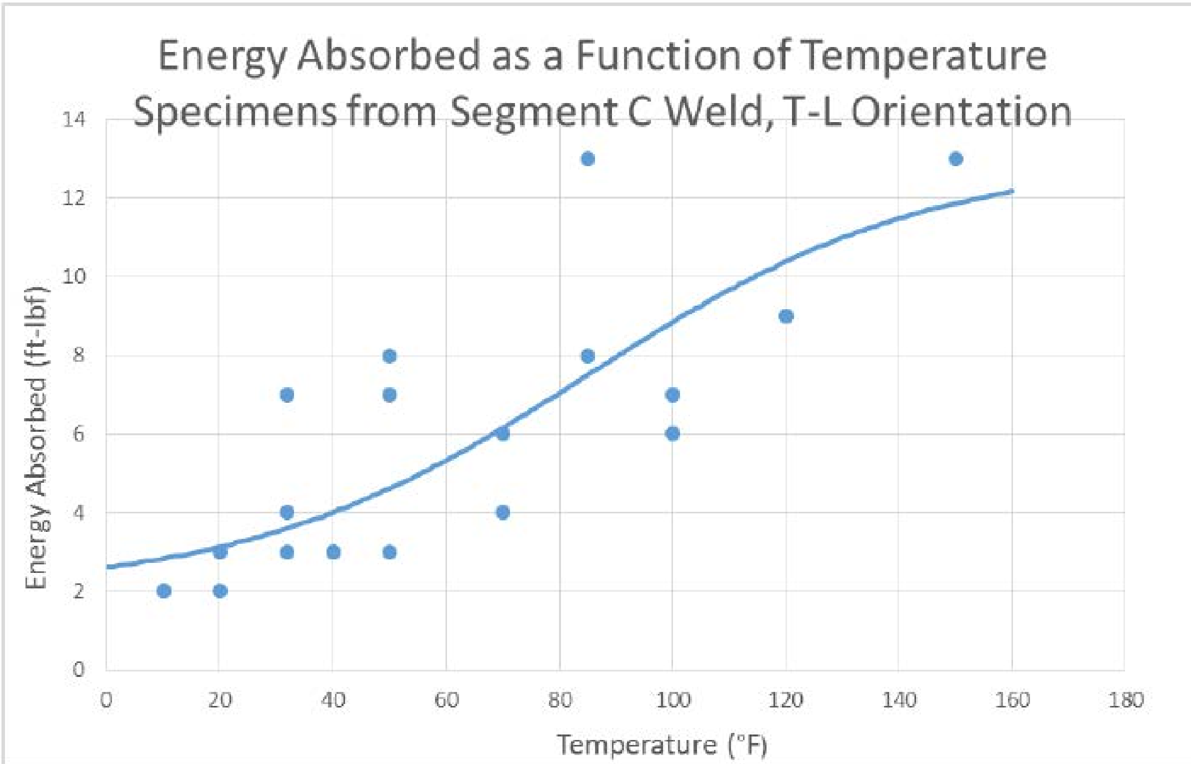


Figure 113. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment C base metal (T-L orientation).



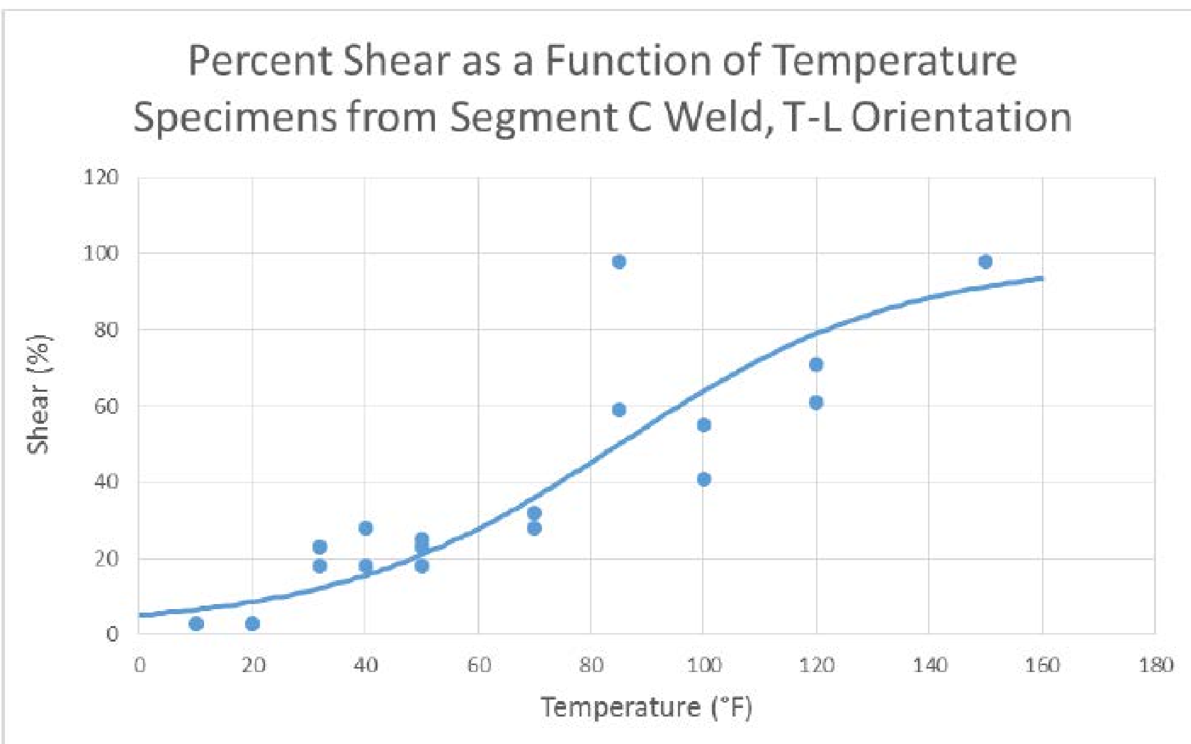
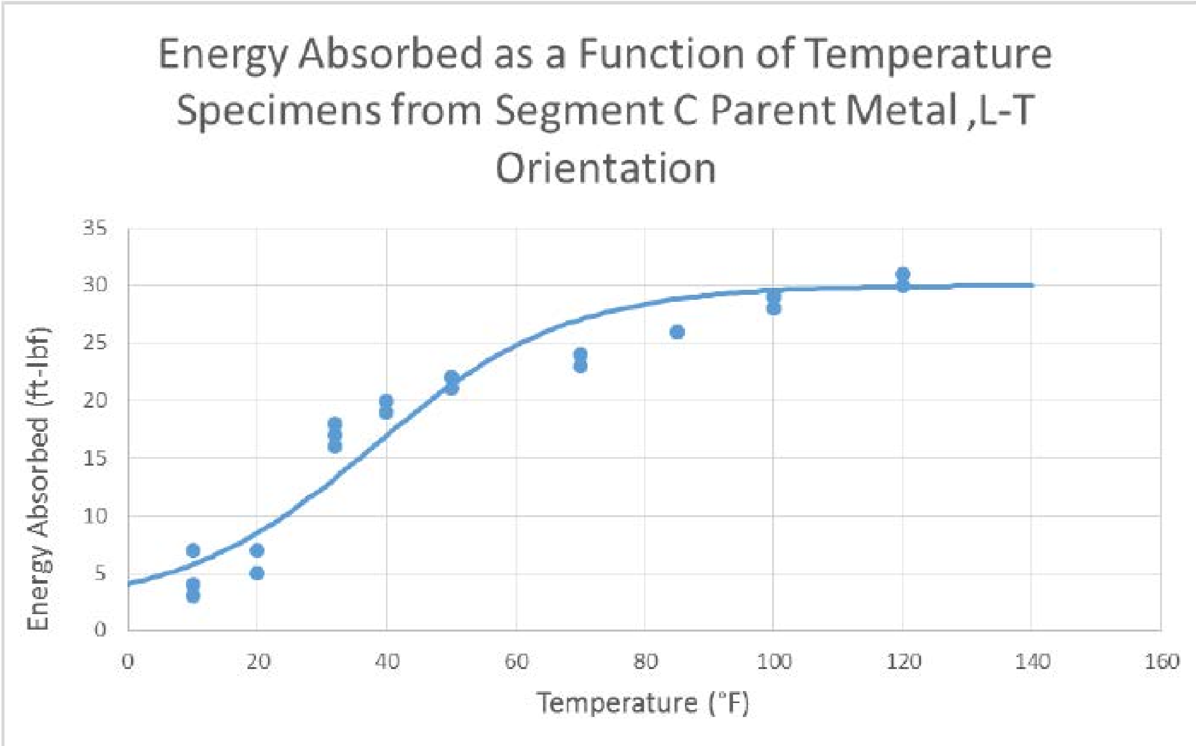


Figure 114. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment C weld metal (T-L orientation).



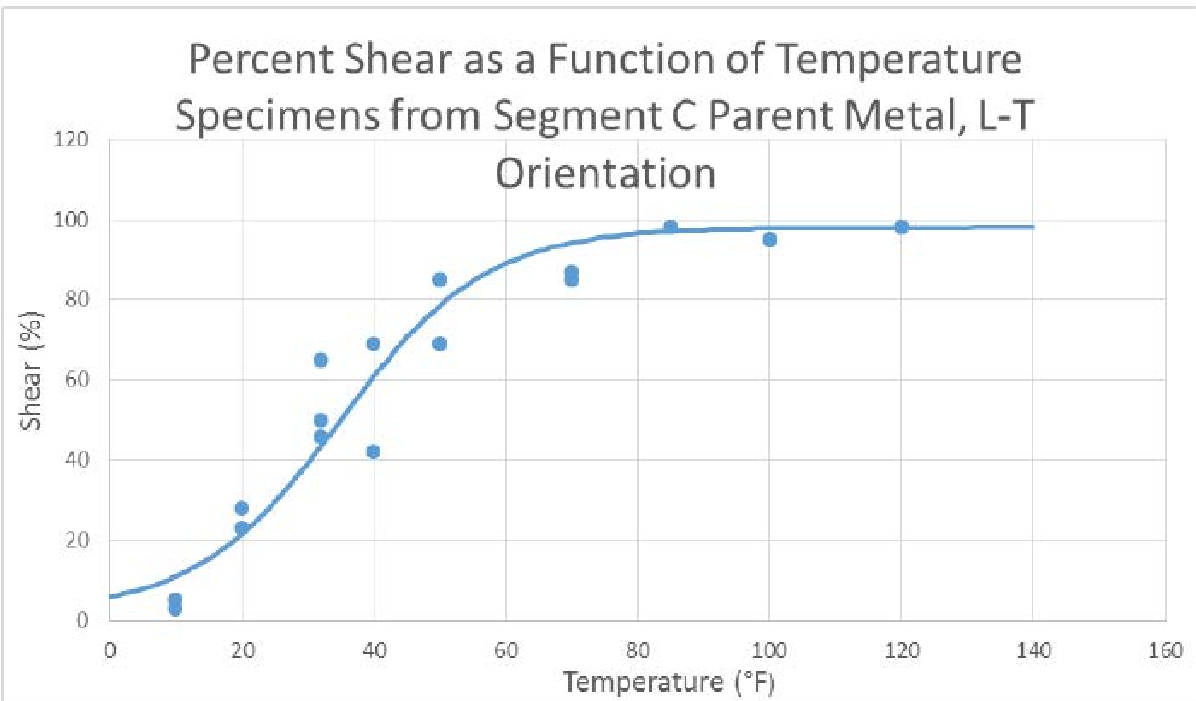


Figure 115. Plots showing the energy absorbed and percent shear as a function of temperature for specimens taken from Segment C base metal (L-T orientation).

Table 9. Summary of Charpy impact data for Segment A.

	Units	A: L-T PM	A: T-L PM	A: T-L Weld
Upper-Shelf Energy	ft-lbf	32	14.5	8
Lower-Shelf Energy	ft-lbf	2	2.5	2
Ductile to Brittle Transition Temperature	°F	52	52	60
Temperature at 15 ft-lbf Energy*	°F	39	47	96
Temperature at 50% Shear	°F	45	50	65
Temperature at 80% Shear	°F	67	72	91

*Based on full-size specimen

Table 10. Summary of Charpy impact data for Segment B.

	Units	B: L-T PM	B: T-L PM	B: T-L Weld
Upper-Shelf Energy	ft-lbf	34	14	8
Lower-Shelf Energy	ft-lbf	2	2	4
Ductile-to-Brittle Transition Temperature	°F	65	60	60
Temperature at 15 ft-lbf Energy*	°F	41	57	99
Temperature at 50% Shear	°F	55	60	65
Temperature at 80% Shear	°F	70	82	83

*Based on full-size specimen

Table 11. Summary of Charpy impact data for Segment C.

	Units	C: L-T PM	C: T-L PM	C: T-L Weld
Upper-Shelf Energy	ft-lbf	30	15.5	13
Lower-Shelf Energy	ft-lbf	2	3.5	2
Ductile-to-Brittle Transition Temperature	°F	38	50	85
Temperature at 15 ft-lbf Energy*	°F	17	43	85
Temperature at 50% Shear	°F	35	52	85
Temperature at 80% Shear	°F	51	74	122

*Based on full-size specimen

Chemical Analysis

The elemental composition of Line 118B steel was analyzed for comparison to API elemental composition specifications for Grade X-42 pipe. (Appendix C provides a report.) Similar to the mechanical testing discussed previously, three areas were analyzed: one from Segment A, one from Segment B, and one from Segment C. The compositions of the three samples from Line 118B, along with the 1960 and current API specifications for X-42 pipe are shown in Table 12. With one exception, all samples met all requirements for X-42 pipe, both historical and current. The one exception is that Segment C exhibited a carbon content of 0.26 weight percent: one of the manufacturing processes outlined in the 1960 API specifications for X-42 pipe lists a maximum carbon content of 0.23 weight percent. It could not be determined which manufacturing process was used and, therefore, which of these maximum carbon contents is most applicable. Regardless, this difference in carbon content is likely within the error of measurement and is not significant or relevant to the incident.

Table 12. Spectrochemical analysis (ASTM E415-08) of samples removed from Segments A, B, and C of Line 118B.

	Segment A	Segment B	Segment C	1960 API Specification (max) Option 1*	1960 API Specification (max) Option 2**	2014 API Specification (max)***
Carbon****	0.22	0.22	0.26	0.28	0.23	0.28
Chromium	0.02	0.02	0.03			0.5
Copper	0.04	0.04	0.09			0.5
Manganese	0.75	0.75	0.90	1.25	1.25	1.30
Molybdenum	<0.005	<0.005	<0.005			0.15
Nickel	0.08	0.07	0.07			0.5
Phosphorous	0.013	0.015	0.017	0.04	0.1	0.03
Silicon	0.06	0.06	0.08			
Sulfur****	0.022	0.023	0.022	0.05	0.05	0.03
Titanium	<0.005	<0.005	<0.005			Note 1
Vanadium	<0.005	<0.005	<0.005			Note 1
Columbium	<0.005	<0.005	<0.005			
Aluminum	<0.005	<0.01	<0.01			

* For steel manufactured using electric-furnace; open-hearth; or killed, deoxidized, basic-bessemer processes.

** For steel manufactured using killed, deoxidized, acid bessemer, or killed deoxidized, basic bessemer processes.

*** Per Product Specification Level 1 (PSL 1).

**** Determined by LECO combustion.

Note 1: Total sum of niobium, vanadium, and titanium to be ≤0.15%.

Discussion

Overall

Our analysis indicated that the Line 118B ruptured when it was struck and punctured by a front loader. The front left corner (uphill side) of the front loader bucket punctured the pipe, folding approximately 4 to 5 inches of steel pipe inward, creating the breach. After initial puncture, cracks propagated circumferentially in both directions from the mechanical damage site. In the clockwise orientation, the crack intersected the long seam after traveling 1.5 inches. This crack then propagated upstream and downstream along the longitudinal seam for a total of 19 inches before transitioning to ductile tearing through base metal leading to final separation. The circumferential crack that traveled in the counter-clockwise direction from the puncture propagated in a ductile manner toward final fracture.

Physical Evidence

From the field investigation, it is clear that the presence of the dirt road that cut into the hillside led to significantly reduced depth of cover, particularly on the uphill side. The history behind the dirt road is not known and was not investigated as part of this effort. It was noted, however, that fresh dirt was present on and around the road, indicating recent activity that resulted in the movement of soil. The fracture location is in line with the uphill side of the road, where the pipe had the least cover. The relative position of the fracture location with respect to the uphill side of the road was evident based on physical observation and incident scene photographs. Figure 116 shows a laser-scan reproduction where the position of the pipe relative to the ground was estimated based on the photograph and laser scan matching. Given the 20-degree slope of the pipe, the pipe beneath the downhill portion of the road had more cover, and fracture was not observed at those locations. Similarly, the 4-to-5-inch puncture itself showed greater deformation on the uphill side of the pipe. This finding is consistent with the geometry of the horizontal bucket and angled pipeline.

This series of events is further supported by the damage observed on the bucket, as shown in Figure 11. In this image, damage is observed on the leading edge of the bucket, on the far left-hand side, where contact occurred with the uphill portion of the pipeline. Although the cause of the damage on the bucket cannot be determined conclusively (nor can we determine when the damage occurred), the length of damage on the bucket is consistent with the length of the metal fold on the Ejected Segment. Specifically, approximately 5 inches of damage were observed on the bucket leading edge (Figure 11), and metal fold was found to be the same length (approximately 5 inches).

The puncture occurred at the 12:30 position (approximately), which is consistent with the front loader approaching from the northeast to the southwest, toward the railroad and Highway 99. Scrape marks on the pipe confirm the direction of impact. As previously discussed, the observed metal fold inward is a clear indication of externally applied force, as the remainder of the Ejected Segment flared outward with the expansion of gas. Although the pipe was in the general proximity of a shooting range, there was no evidence of bullets marks or other related damage on the pipeline.

The accident scene was reconstructed using three-dimensional laser-scan data of the surrounding area, the pipe itself, and the front loader. The relative position of the pipe to the ground was estimated based on photograph and laser scan matching. The reconstruction (Figure 116) shows that the impact occurred when the bucket corner struck the pipe on the uphill side of the dirt road. A laser-scan reconstruction of the fractured pipe pieces is shown in Figure 117, similar to Figure 36 presented earlier. A full accident reconstruction was performed; the relative position of the loader to the pipe was estimated based on the provided laser-scan data. Images of this reconstruction are shown in Figure 118 and Figure 119. The relative position of the bucket to the pipe is consistent with the observed damage.

Figure 116. A three-dimensional reconstruction of the pipe overlaid on a photograph of the incident scene. The relative position of the pipe pieces to the ground was estimated based on laser scan and photography matching.

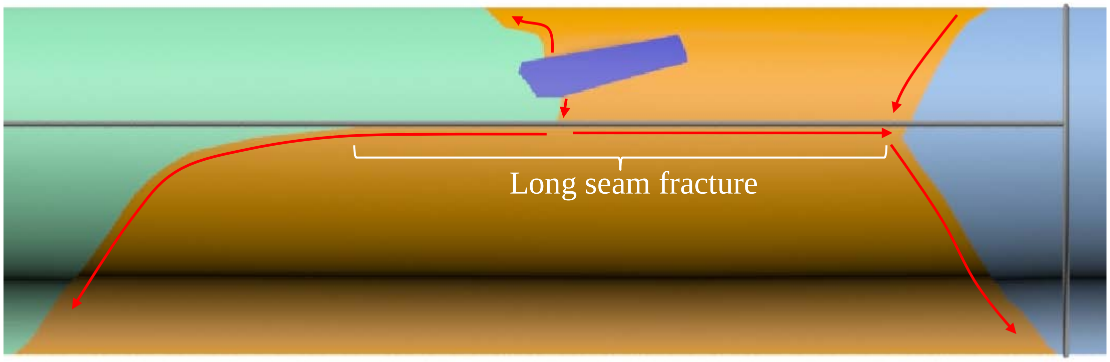


Figure 117. Laser-scan reconstruction of the fractured pieces, with the metal fold shown in purple. The direction of crack propagation is shown by the red arrows.

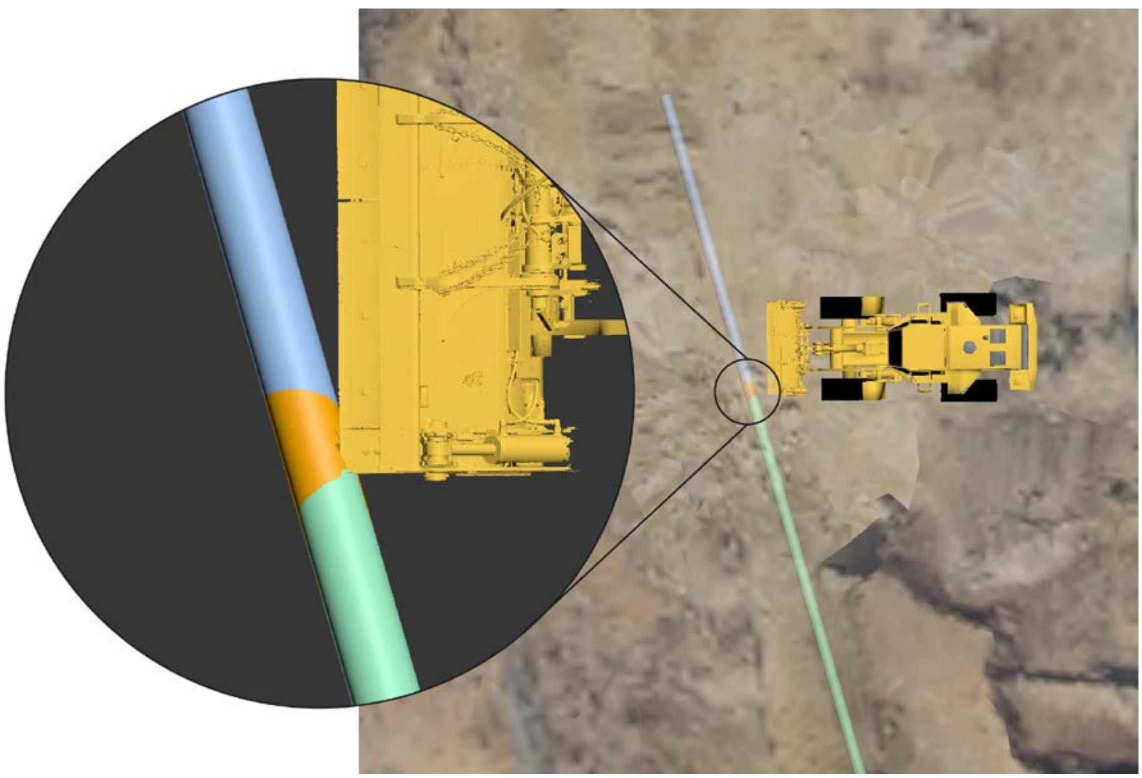


Figure 118. Plan-view laser-scan reconstruction of the front loader bucket striking the pipe, based on laser-scan data. The position of the pipe with respect to the ground was estimated based on laser scan and photography matching.

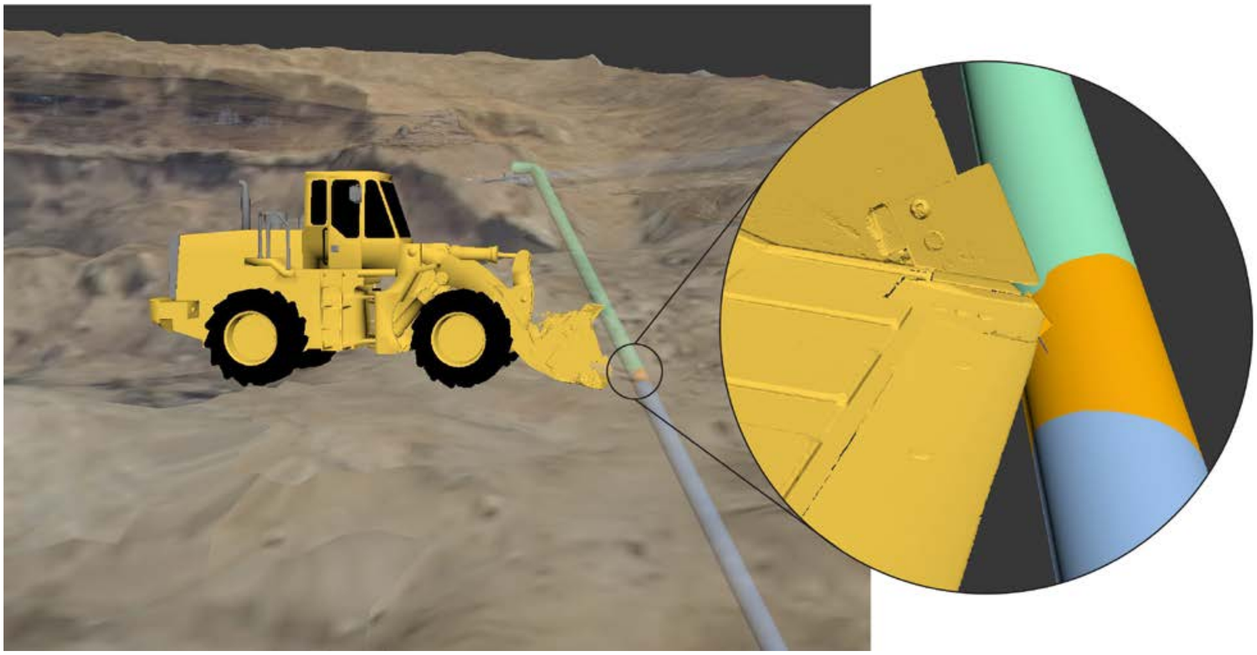


Figure 119. Profile-view laser-scan reconstruction of the front loader bucket striking the pipe, based on laser-scan data. The position of the pipe with respect to the ground was estimated based on laser scan and photography matching.

Fractography

Investigation of the fracture surfaces show that the puncture location was ductile in nature, which indicates that the metal deformed and fractured due to the application of forces that exceeded the strength of the material. That is, the puncture did not exhibit signs of embrittlement, brittle fracture, or progressive cracking. Chevrons and radial lines were observed on the longitudinal seam fracture surface, which showed that the origin of the long seam fracture was collocated with the intersection of the short circumferential crack that emanated from the puncture. After the initial puncture, the fracture propagated in both circumferential directions. One of the cracks propagated through the base metal in a ductile manner, while the other ran toward the less-tough long seam. The long-seam crack ran upstream and downstream for 19 inches prior to ductile tearing during final fracture, as indicated by the 45-degree shear angle observed on the remainder of the fracture surfaces. On the downstream side of the fracture, the crack propagated along the edge of the heat-affected zone of the girth weld. Any flaws or imperfections within the girth weld did not contribute to the rupture.

While the longitudinal seam weld fracture exhibited significantly less ductility than the base metal, no evidence of any flaws or anomalies was observed fracture surface. Typically, dark oxides are observed on fractures associated with lack-of-fusion in seam welds [4]. These dark oxides are formed when steel is subjected to very high temperatures in air during the welding process. As discussed below, these oxides were observed metallographically on linear lack-of-fusion seam weld indications at other pipe locations. No evidence of any progressive cracking was observed at any location along the rupture or in any pipe segment analyzed.

Metallography

Microstructural cross sections were taken at areas of mechanical damage and long seam fracture. The pipe base metal was found to be a ferrite-pearlite microstructure, the expected microstructure for X-42 line pipe steel. Figure 50 and Figure 57 show this microstructure, in which the ferrite grains appear white and the pearlite colonies appear dark.

The metallographic cross section of the matched fracture surfaces shows a Widmanstätten microstructure in the Ejected Segment, which is consistent with ERW welds in general [5] and with others analyzed in this examination. Segment B in the matched fracture surface (shown in Figure 71) shows a partially-spheroidized microstructure. This type of microstructure consists of islands of cementite in matrices of ferrite grains. Spheroidization can be achieved in various ways, one of which is to heat a ferrite-pearlite microstructure to a subcritical temperature for extended periods of time [5]. This subcritical temperature would be near but below the austenite start temperature for the particular alloy. This elevated temperature allows for sufficient kinetics for the pearlite constituent to decompose into cementite spheres. Although the rate of spheroidization is influenced by many factors—including the temperature, the amount of prior cold work, and the deoxidizing elements used in the steel-making process—complete spheroidization can occur in less than 10 hours [5]. The microstructures of Segment B shown in Figure 71 are partially spheroidized. The observed microstructural differences occurred as a result of the incident and were not a factor in the rupture itself. Specifically, the Ejected Segment separated from the main pipeline early in the incident and landed 20 feet away from the crater's edge. Therefore, the Ejected Segment did not see the significant heat from the fire that Segment B experienced in the crater. The observed microstructures are consistent with the facts of the incident.

Grain flattening and elongation were observed on the outer surface of the pipe, on the two metallographic specimens sectioned from mechanical damage areas, EJ Frac 2-2 and EJ Frac 2-3, which are shown in Figure 50 and Figure 57. This grain flattening and elongation is consistent with mechanical damage on pipelines [6, 7]. As such, the observed grain deformation further confirms that the pipeline was subjected to significant outside forces.

Metal Transfer

Various tests were conducted to investigate the possibility of metal transfer between the bucket and pipe, including x-ray fluorescence (XRF), energy dispersive spectroscopy (EDS), and metallography. None of these tests conclusively showed evidence of metal transfer. The XRF data of the loader bucket showed a composition typical of carbon steel and did not show the presence of hardenability elements such as chromium or nickel. EDS data collected on the outer surface of the pipe in the area of scrapes showed compositions consistent with relatively plain, carbon steel. Although no unanticipated elements were detected on the surface of the pipe, none would be expected given that the bucket itself had a similar composition to the steel pipe. Metallography of the damaged areas did not show any evidence of metal transfer.

Nondestructive Examination Indications

Following thorough visual and nondestructive examination, areas of mechanical damage and external corrosion were characterized and documented on the 80 feet of pipe received at Exponent's labs. Magnetic particle inspection (MPI) was performed, and selected indications were noted and photographed. A representative population of indications was cut out of each pipe segment for metallographic analysis.

Areas of mechanical damage and external corrosion were limited to approximately 16 percent (or less) of the wall thickness and were not found to be crack-like in nature. Nearly all MP indications were cut out for metallographic inspection. All MP indications were located along longitudinal weld seams except for one (A-MP10). Most of these indications were small surface features of 100 µm or less. Three indications were crack-like with lengths greater than 100 µm. These indications resulted from lack-of-fusion along ERW seam, which occurred during pipe manufacture. These indications were filled with oxide, consistent with lack-of-fusion in air and at high temperatures during the welding process. No evidence of progressive cracking was observed at any of the investigated locations.

These indications show that the longitudinal seam in Segments A and B had occasional areas of lack-of-fusion resulting from original pipe manufacture. This observation is consistent with pre-1970 ERW long seams [1, 8, 9]. The ERW process entails locally heating the edges of the steel plate to a suitable forging temperature and mechanically pressing the pipe edges together, upsetting the pipe wall thickness and thereby forming the bond [4, 10]. ERW is an autogenous process in which no filler metal is added. After cooling, the flash is often trimmed [6].

The ERW pipe fabrication processes before 1960 typically utilized either low frequency (<360 cycles/second) or direct current. The low-frequency process has been known to exhibit selected issues. Starting in 1960, manufacturers began to produce some pipe using a high-frequency process (>450,000 cycles / second). However, not all manufacturers were consistently using the high-frequency process until 1978 [1]. The high-frequency process is generally believed to have fewer issues than the low-frequency process.

Common issues associated with the low-frequency process include cold welds, hook cracks, insufficient upset, stitching, and plate misalignment [1, 4, 6, 10]. Cold welds (or lack-of-fusion) can result from insufficient heat input, power fluctuations, or insufficient pressure application to the skelp during the forging process. Additionally, dirt, grease, or other contaminants on the surface of the skelp can affect the ability for the bond to form during the welding process [1]. It is not known which of these specific causes may have resulted in the observed lack-of-fusion in magnetic particle indications A-MP2, A-MP7, and B-MP7.

Mechanical Properties

The pipe material was tested for comparison with PG&E reported specifications as well as conformance with the pertinent API specifications. Both the incident stick of pipe was tested (Segments A and B) as well as the downstream stick of pipe (Segments C and D). In both cases, the pipe was consistent with PG&E's information and met past and current API specifications.

The downstream stick was found to meet the mechanical property requirements for current and 1960 API 5LX Grade X-42 pipe. The composition of this pipe also met API specifications. It is shown in Table 12 that two different compositional requirements are listed by the 1960 API standard for two different manufacturing processes. The only difference between these compositional requirements is the carbon content, which is not significant and was not a factor in the rupture.

Two pieces were tested from the upstream stick; one section from Segment A and one from Segment B. Compositions for both pieces were found to be consistent with the API standards. The section removed from Segment B showed yield strengths lower than expected. The section removed from Segment A showed properties consistent with X-42 steel. Given that the test specimens from Segment B were approximately 20 feet from the rupture and those from Segment A were 40 feet from the rupture, the reduction in properties can be attributed to heat from the fire. This heat resulted in spheroidization of the pearlite and reduced strength and hardness.

Tensile and Charpy impact tests have shown that the weld areas exhibit decreased elongation values and decreased impact toughness compared to the parent material. This is expected, because welds often have reduced toughness compared to base material in line pipe [1-3]. The reduced toughness can be due to various factors, which may include rapid cooling and thermal gradients, chemical segregation, and differences in microstructure and constituents. Therefore, the reduced toughness of the weld area determined by mechanical testing is consistent with the observed fracture path (i.e., the crack propagated along the long seam after the initial puncture of the pipeline). After the 19 inches of fracture on the longitudinal seam, ductile tearing proceeded through the base metal during final fracture.

Summary

Line 118B ruptured due to a strike from the front-loader bucket operating in the area at the time of the incident. The front loader struck the pipe and punctured it, nearly instantaneously causing the rupture. The cause of the rupture cannot be attributed to inadequate material properties or to manufacturing defects. There is no evidence that progressive damage such as corrosion, stress corrosion, or fatigue was present or contributed to the rupture.

Conclusions

- The April 17, 2015, PG&E Line 118B rupture was caused by a strike from a front loader operating in the area at the time of the incident. The front-loader bucket struck the pipe, causing a near-instantaneous rupture.

- Fracture geometry, location and orientation, as well as the location scrapes, dents, and gouges indicate that the front left portion of the bucket's leading edge punctured the pipe at the uphill side of the dirt road while the loader was moving in a forward direction (toward the railroad and Highway 99).

- Following the initial strike, cracks propagated from the puncture site in both circumferential directions. One of the cracks ran through base metal in a ductile manner, whereas the other intersected the longitudinal seam. Following the intersection with the seam, this crack ran longitudinally along the seam for 19 inches before final fracture in the base metal.

- Mechanical testing and chemical analysis indicated that the subject pipe met 1960 and current API specifications for Grade X-42 pipe. Testing of the longitudinal seam showed reduced absorbed energy and higher transition temperatures compared to the parent material. This reduced seam impact toughness is expected in 1950- and 1960-vintage ERW pipe.

- Lower seam weld toughness compared to the base metal allowed for a preferential crack propagation path following the initial puncture. The 19-inch fracture in the longitudinal seam was a consequence of, but not the cause of, the initial rupture.

- No evidence of progressive cracking such as stress corrosion cracking or fatigue was observed. Only minor areas of corrosion were observed.

- Magnetic particle inspection found three crack-like indications that were the result of lack-of-fusion during original pipe manufacture. These indications did not contribute to the rupture. No evidence of lack-of-fusion was observed along the fractured portion of the seam weld.

Limitations

At the request of the CPUC and PG&E, Exponent has conducted an investigation into the metallurgical cause of the in-service rupture on Line 118B that occurred near Fresno, CA, on April 17, 2015. Exponent investigated specific issues relevant to this rupture, as requested by the CPUC and PG&E. The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any reuse of this report or its findings, conclusions, or recommendations presented herein is at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The findings presented herein are made to a reasonable degree of engineering certainty. We have made every effort to accurately and completely investigate all areas of concern identified during our investigation. If new data become available or there are perceived omissions or misstatements in this report regarding any aspect of those conditions, we ask that they be brought to our attention as soon as possible so we have the opportunity to fully address them.

References

1. M. Baker, *Low Frequency ERW and Lap Welded Longitudinal Seam Evaluation*, April, USDOT Research and Special Programs Administration.
2. Det Norske Veritas, *Characterization of the Toughness of Pipe Containing ERW Seam Defects, Report number TAOUS813GTQU (PP017533)*, Pipeline Hazardous Materials Safety Administration, US DOT: Washington, DC.
3. E.N. Pugh R.J. Fields, D.T. Read, J.H. Smith, *An Assessment of the Performance and Reliability of Older ERW Pipelines, Report number NISTIR 89-4136, 1989*, US Department of Commerce, National Institute of Standards and Technology: Gaithersburg, MD.
4. B.C. Rollins G.T. Quickel, J.A. Beavers, *Analysis of Seam Weld Related Pipeline Failures*, in *Materials Science and Technology (MS&T)*2008: Pittsburgh, Pennsylvania. p. 513-523.
5. L.E. Samuels, *Optical Microscopy of Carbon Steels* 1980, Metals Park, OH: American Society of Metals (ASM).
6. J. Kiefner R. Eiber, *Failures of Pipelines*, in *Metals Handbook Ninth Edition: Volume 11: Failure Analysis and Prevention* 1986, ASM International Materials Park, OH. p. 695-706.
7. B.A. James, R.A. Sire, R.D. Caligiuri, *Determination of the Failure Mode and the Rupture Pressure in a Mechanically Damaged Pipeline.* Journal of Failure Analysis and Prevention 2008. **8**: p. 223-230.
8. *The State of the National Pipeline Infrastructure*, October 31, US Departement of Transportation.
9. R. Dalasio, *PHMSA Comprehensive Study to Understand Longitudinal ERW Seam Failures*, in *API Conference* 2013.
10. E.B. Clark J.F. Kiefner, *History of Line Pipe Manufacturing in North America*. Vol. 43. 1996, New York, NY: American Society of Mechanical Engineers (ASME).

Appendix A

Mears Nondestructive Examination Reports

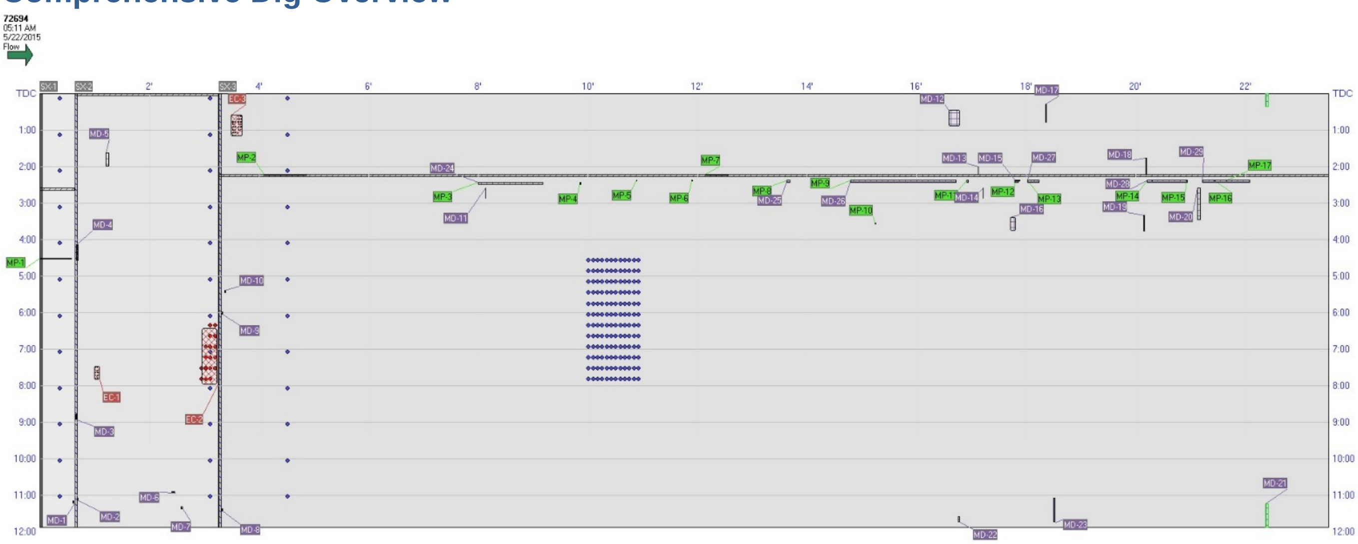
Line # / Position	118B @0.285 Sample A	N-Segment	N/A	ILI Log Distance	-- Feet
Examination Date	5/14/2015	IMA Number	N/A	RMP-11 Ref. Section	N/A
Exam Performed By	Mike Wilson	Region Number	N/A	Reference Girth Weld	N/A
Project Manager	James Halloway	Sub # (ICDA)	N/A	Dist. From Girth Weld	-- Feet
Order Number	41449650	Stationing	N/A		

Excavation Details

Excavation Priority	N/A	Excavation Reason	N/A
P/S or CIS reads before excavation (ON) mV	--	P/S or CIS (OFF) mV	--
PS/CIS Comments	N/A		
Planned Inspection Length (Feet)	--	Nominal Wall Thickness (Inches)	0.250
Actual Inspection Length (Feet)	23.60	Nominal Pipe Diameter (Inches)	12.000
		SMYS	--
Installation Year	Not provided	MAOP	--
GPS File Name	N/A	Design Factor	--

Planned Centerline GPS Coordinates (Based on GIS):	Northing (m)	N/A
	Easting (m)	N/A
Planned Centerline GPS Coordinates (Based on GIS):	Latitude	N/A
	Longitude	N/A
Centerline GPS Coordinates (Uncorrected Field Measurement):	Northing (m)	N/A
	Easting (m)	N/A
Centerline GPS Coordinates (Corrected Field Measurement):	Northing (m)	N/A
	Easting (m)	N/A

Comprehensive Dig Overview



Prior To Coating Removal

Site Data

Evidence of Encroachment	N		
Encroachment Comments	N/A		
Primary Native Soil Type	N/A	Mixed Soil Types Explanation	N/A
Backfill Material as found	N/A	Depth of Cover (Feet)	--
Backfill Comments	N/A		
Is Rock Shield present?	N		
Coating Type	N/A	Additional Coatings Found	N/A
Coating Type Comments	N/A		
Coating Thickness (Mils)	--	Number of Coating Layers	--
Holiday Testing Performed	N	Holiday Testing Voltage Used VOLTS	--
Holiday Testing Device Used	N/A		
Holiday Testing Comments	N/A		
Soil Sample Location	N/A		
Location notes	N/A		
Ground Water Present	N	Sample Collected	N
Sample pH	--		
Coating Conditions	N/A		
Coating Condition Comments	N/A		
Coating Degradation Map Zero Reference Point	N/A	Photos Taken	Y
Coating Sample Taken	N	Location of Coating Sample	N/A
Liquid Underneath Coating	N	If Yes, pH of Liquid	--
Corrosion Product Present	N	If Yes, Corrosion Sample Taken	N
Comments	None.		
Soil pH (Sb Electrode) U/S	--	Soil pH (Sb Electrode) D/S	--

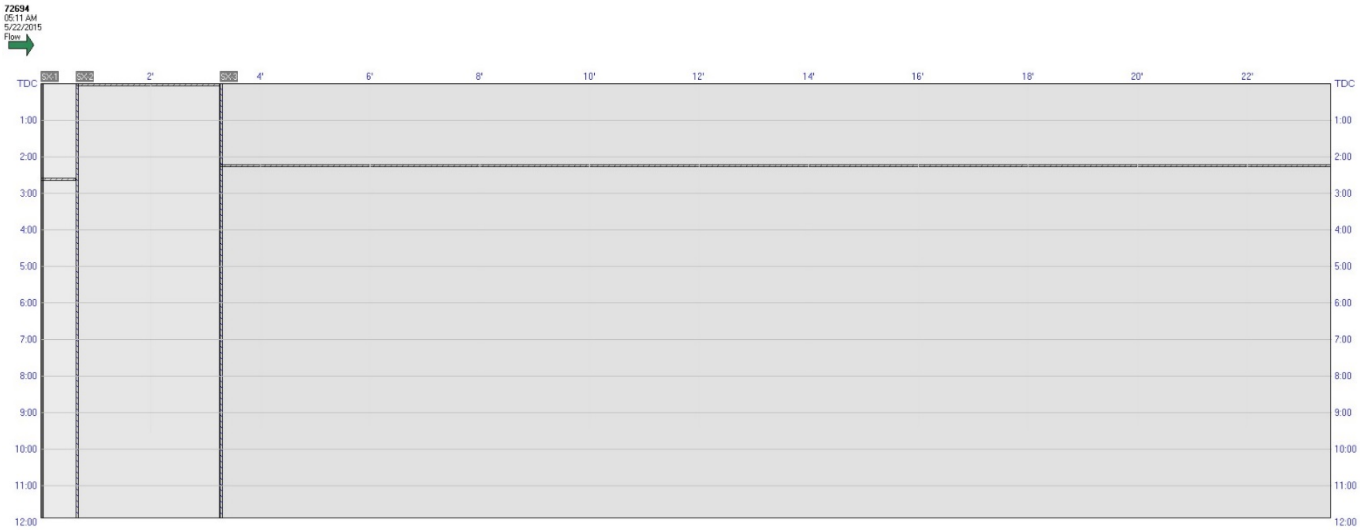
Coating Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Form H: Direct Examination Data Sheet
Event 72694 on 118B @0.285 Sample A

PG&E *5/22/2015 5:11:39 AM* Status: 55-QCed

Map of Coating Degradation



P/S Potential Measurements

Pipe to Soil Potential in Ditch (mV)-Upstream	--
Pipe to Soil Potential in Ditch (mV)-Downstream	--
Pipe to Soil Potential in Ditch (mV) Comments	N/A

Soil Resistivity

4-Pin Multiplier	--	Soil Box Multiplier	--
4-Pin Ohms	--	Soil Box Ohms	--
4-Pin Spacing Distance in Feet	--		
4-Pin Resistivity	--	Soil Box Resistivity	--
Soil Resistivity Comments	N/A		

Data After Coating Removal

Pipe Temperature (°F)	68.7	Measured Pipe Diameter (Inches)	12.818
Girth Weld Coordinates:		Measured Pipe Circumference (Inches)	40.25
Northing (m)	N/A	Easting (m)	N/A
Girth Weld Elevation (m)	--		
Corrosion Damage	Y	Mechanical Damage	Y
Other Damage Notes	None		
Wet Fluorescent Mag. Part. Test Performed?	Y	Were there any linear indications?	Y
WFMT Comments	Performed by Mike Wilson (Mears) on 5/14/15.		

Pipe Sections

ID	Weld Location (Inches from Ref.)	Long Seam (Inches from TDC)	Seam Type	Circumference (Inches)	Nominal Wall (Inches)	Description/Notes
SX-001	0.00	8.75 2:30	ERW	40.25	0.250	Straight pipe, 7.75" long
SX-002	7.75		N/A	40.25	0.250	90 degree elbow, 31.5" long
SX-003	39.25	7.5 2:15	ERW	40.25	0.250	Straight pipe, 244" long

UT - Section O'Clocks (UTC)

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	UT Thickness (Inches)	UT Section / O'Clock Position
SX-001	4.00	0.00	0.249	UT Wall Thickness-TDC
SX-001	4.00	3.35	0.250	UT Wall Thickness-1 O'clock
SX-001	4.00	6.71	0.252	UT Wall Thickness-2 O'clock
SX-001	4.00	10.06	0.250	UT Wall Thickness-3 O'clock
SX-001	4.00	13.42	0.247	UT Wall Thickness-4 O'clock
SX-001	4.00	16.77	0.246	UT Wall Thickness-5 O'clock
SX-001	4.00	20.13	0.251	UT Wall Thickness-6 O'clock
SX-001	4.00	23.48	0.249	UT Wall Thickness-7 O'clock
SX-001	4.00	26.83	0.250	UT Wall Thickness-8 O'clock
SX-001	4.00	30.19	0.251	UT Wall Thickness-9 O'clock
SX-001	4.00	33.54	0.253	UT Wall Thickness-10 O'clock
SX-001	4.00	36.90	0.250	UT Wall Thickness-11 O'clock
SX-002	37.00	0.00	0.450	SX-002 UT Wall Thickness-TDC
SX-002	37.00	3.35	0.437	SX-002 UT Wall Thickness-1 O'clock
SX-002	37.00	6.71	0.436	SX-002 UT Wall Thickness-2 O'clock
SX-002	37.00	10.06	0.426	SX-002 UT Wall Thickness-3 O'clock
SX-002	37.00	13.42	0.428	SX-002 UT Wall Thickness-4 O'clock
SX-002	37.00	16.77	0.409	SX-002 UT Wall Thickness-5 O'clock
SX-002	37.00	20.13	0.396	SX-002 UT Wall Thickness-6 O'clock
SX-002	37.00	23.48	0.390	SX-002 UT Wall Thickness-7 O'clock
SX-002	37.00	26.83	0.382	SX-002 UT Wall Thickness-8 O'clock
SX-002	37.00	30.19	0.377	SX-002 UT Wall Thickness-9 O'clock
SX-002	37.00	33.54	0.397	SX-002 UT Wall Thickness-10 O'clock
SX-002	37.00	36.90	0.419	SX-002 UT Wall Thickness-11 O'clock
SX-003	54.00	0.00	0.254	SX-003 UT Wall Thickness-TDC
SX-003	54.00	3.35	0.255	SX-003 UT Wall Thickness-1 O'clock
SX-003	54.00	6.71	0.255	SX-003 UT Wall Thickness-2 O'clock
SX-003	54.00	10.06	0.253	SX-003 UT Wall Thickness-3 O'clock
SX-003	54.00	13.42	0.255	SX-003 UT Wall Thickness-4 O'clock
SX-003	54.00	16.77	0.254	SX-003 UT Wall Thickness-5 O'clock
SX-003	54.00	20.13	0.256	SX-003 UT Wall Thickness-6 O'clock
SX-003	54.00	23.48	0.251	SX-003 UT Wall Thickness-7 O'clock
SX-003	54.00	26.83	0.253	SX-003 UT Wall Thickness-8 O'clock
SX-003	54.00	30.19	0.251	SX-003 UT Wall Thickness-9 O'clock
SX-003	54.00	33.54	0.254	SX-003 UT Wall Thickness-10 O'clock
SX-003	54.00	36.90	0.255	SX-003 UT Wall Thickness-11 O'clock

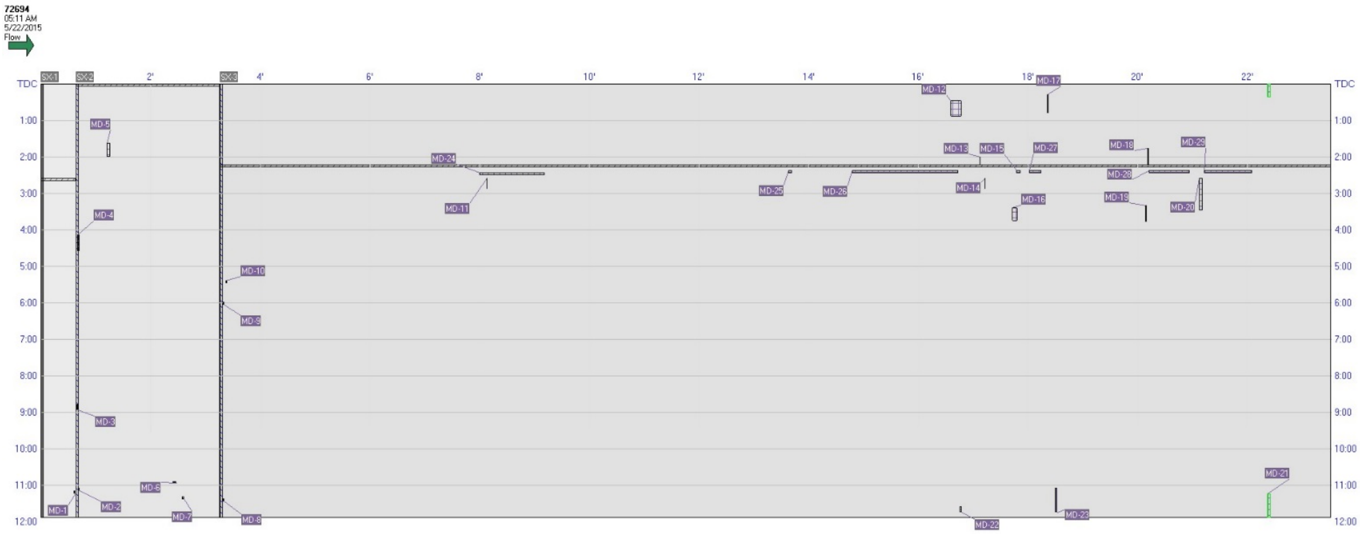
PG&E **5/22/2015 5:11:39 AM** Status: 55-QCed

Mechanical Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
MD-001	7.50	38 11:15	Arc Burn	0.25	0.25	0.022	8.62% measurable wall loss	
MD-002	8.50	37.75 11:15	Arc Burn	0.25	0.25	0.014	3.53% measurable wall loss	
MD-003	8.25	30.25 9:00	Arc Burn	0.25	0.50	0.012	2.90% measurable wall loss	
MD-004	8.00	14 4:15	Arc Burn	0.50	1.50	0.007	1.70% measurable wall loss	
MD-005	14.50	5.5 1:45	Scrape	0.75	1.25	0.012	2.83% wall loss	
MD-006	29.75	37 11:00	Scrape	0.75	0.12	0.016	3.98% wall loss	
MD-007	31.50	38.5 11:30	Gouge	0.50	0.25	0.008	1.88% wall loss	
MD-008	40.25	38.75 11:30	Arc Burn	0.25	0.25	0.040	15.74% measureable wall loss	
MD-009	40.25	20.5 6:00	Arc Burn	0.25	0.25	0.018	7.14% measureable wall loss	
MD-010	40.50	18.25 5:30	Arc Burn	0.25	0.25	0.010	3.95% measureable wall loss	
MD-011	97.75	8.75 2:30	Scrape	0.12	1.00	0.002	0.80% wall loss	
MD-012	199.50	1.5 12:30	Scrape	2.50	1.50	0.006	2.36% wall loss	
MD-013	206.00	6.75 2:00	Scrape	0.12	0.75	0.001	0.39% wall loss	
MD-014	207.00	8.75 2:30	Scrape	0.12	1.00	0.003	1.19% wall loss	
MD-015	214.00	8 2:30	Scrape	1.00	0.25	0.011	4.38% wall loss, Interacting with MP-012	
MD-016	213.00	11.5 3:30	Scrape	1.25	1.25	0.003	1.18% wall loss	
MD-017	220.75	1 12:15	Scrape	0.25	1.75	0.003	1.19% wall loss	
MD-018	242.75	6 1:45	Scrape	0.25	1.50	0.004	1.59% wall loss	
MD-019	242.25	11.25 3:15	Scrape	0.25	1.50	0.001	0.40% wall loss	
MD-020	254.00	8.75 2:30	Scrape	0.75	3.00	0.002	0.79% wall loss	
MD-021	269.00	38 11:15	Scrape	0.75	3.50	0.001	0.39% wall loss	
MD-022	202.00	39.75 11:45	Scrape	0.50	0.50	0.007	2.73% wall loss	
MD-023	223.00	39.75 11:45	Scrape	0.50	2.25	0.003	1.17% wall loss	
MD-024	96.25	8.25 2:30	Other	14.25	0.25	0.007	Lap, 2.82% wall loss, Interacting with MP-003	
MD-025	164.00	8 2:30	Other	0.75	0.25	0.004	Lap, 1.60% wall loss, Interacting with MP-008	
MD-026	178.00	8 2:30	Other	23.25	0.25	0.004	Lap, 1.60% wall loss, Interacting with MP-009	
MD-027	216.75	8 2:30	Other	2.75	0.25	0.002	Lap, 0.80% wall loss, Interacting with MP-013	

MD-028	243.00	8 2:30	Other	9.00	0.25	0.015	Lap, 5.97% wall loss, Interacting with MP-014 and MP-015
MD-029	255.25	8 2:30	Other	10.50	0.25	0.002	Lap, 0.80% wall loss, Interacting with MP-016 and MP-017

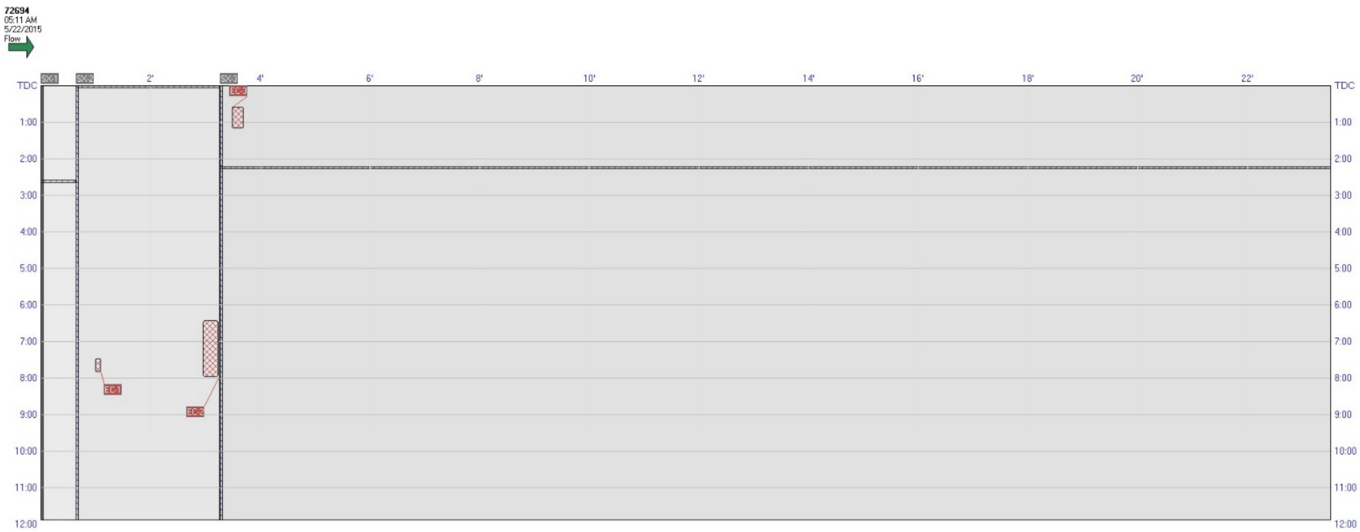
Map of Mechanical Damage



External Corrosion Mapping

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
EC-001	13.25	26.5 8:00	General	1.25	1.25	0.024	6.08% wall loss	
EC-002	39.00	27 8:00	General	3.50	5.25	0.044	11.31% wall loss	
EC-003	42.00	2 12:30	General	2.50	2.00	0.023	9.09% wall loss	

Map of Corroded Area



External Pit Depth

EC-001	From TDC	1	2	3	4	5
A	26.5	-	-	.004	.001	.012
B	26.25	.003	.009	.013	.013	.024
C	26	.001	.007	.001	.002	.002
D	25.75	-	.012	.001	.002	.001
E	25.5	.002	-	.002	.001	-

EC-002	From TDC	1	2	3	4
A	27	-	.002	.025	.004
B	26	.013	.012	.044	.002
C	25	.025	.011	.003	-
D	24	.010	.014	.001	-
E	23	.009	.003	-	-
F	22	.004	.006	-	-

EC-003	From TDC	1	2	3	4	5	6	7	8	9	10
A	2	-	-	-	-	-	-	-	.001	.001	.001
B	2.25	-	-	-	-	-	.002	.002	.002	.007	.003
C	2.5	-	.003	.001	.002	.002	.002	.002	.007	.009	.001
D	2.75	-	.001	.001	.001	-	-	.004	.004	.015	.001
E	3	.001	.018	.023	.009	.001	-	.009	.007	.002	.001
F	3.25	.002	.010	.015	.015	.001	-	.001	.001	.001	-
G	3.5	.001	.002	.009	.009	.001	.001	.001	-	-	-
H	3.75	-	.001	.002	.002	.002	-	-	-	-	-

MD-001	Explanation
Details Not Provided - Max Depth: 0.022	8.62% measurable wall loss

MD-002	Explanation
Details Not Provided - Max Depth: 0.014	3.53% measurable wall loss

MD-003	Explanation
Details Not Provided - Max Depth: 0.012	2.90% measurable wall loss

MD-004	Explanation
Details Not Provided - Max Depth: 0.007	1.70% measurable wall loss

MD-005	Explanation
Details Not Provided - Max Depth: 0.012	2.83% wall loss

MD-006	Explanation
Details Not Provided - Max Depth: 0.016	3.98% wall loss

MD-007	Explanation
Details Not Provided - Max Depth: 0.008	1.88% wall loss

MD-008	Explanation
Details Not Provided - Max Depth: 0.04	15.74% measureable wall loss

MD-009	Explanation
Details Not Provided - Max Depth: 0.018	7.14% measureable wall loss

MD-010	Explanation
Details Not Provided - Max Depth: 0.01	3.95% measureable wall loss

MD-011	Explanation
Details Not Provided - Max Depth: 0.002	0.80% wall loss

MD-012	Explanation
Details Not Provided - Max Depth: 0.006	2.36% wall loss

MD-013	Explanation
Details Not Provided - Max Depth: 0.001	0.39% wall loss

MD-014	Explanation
Details Not Provided - Max Depth: 0.003	1.19% wall loss

MD-015	Explanation
Details Not Provided - Max Depth: 0.011	4.38% wall loss, Interacting with MP-012

MD-016	Explanation
Details Not Provided - Max Depth: 0.003	1.18% wall loss

MD-017	Explanation
Details Not Provided - Max Depth: 0.003	1.19% wall loss

MD-018	Explanation
Details Not Provided - Max Depth: 0.004	1.59% wall loss

MD-019	Explanation
Details Not Provided - Max Depth: 0.001	0.40% wall loss

MD-020	Explanation
Details Not Provided - Max Depth: 0.002	0.79% wall loss

MD-021	Explanation
Details Not Provided - Max Depth: 0.001	0.39% wall loss

MD-022	Explanation
Details Not Provided - Max Depth: 0.007	2.73% wall loss

MD-023	Explanation
Details Not Provided - Max Depth: 0.003	1.17% wall loss

MD-024	Explanation
Details Not Provided - Max Depth: 0.007	Lap, 2.82% wall loss, Interacting with MP-003

MD-025	Explanation
Details Not Provided - Max Depth: 0.004	Lap, 1.60% wall loss, Interacting with MP-008

MD-026	Explanation
Details Not Provided - Max Depth: 0.004	Lap, 1.60% wall loss, Interacting with MP-009

MD-027	Explanation
Details Not Provided - Max Depth: 0.002	Lap, 0.80% wall loss, Interacting with MP-013

MD-028	Explanation
Details Not Provided - Max Depth: 0.015	Lap, 5.97% wall loss, Interacting with MP-014 and MP-015

MD-029	Explanation
Details Not Provided - Max Depth: 0.002	Lap, 0.80% wall loss, Interacting with MP-016 and MP-017

MP-001	Explanation
Details Not Provided - Max Depth: 0.251	

MP-002	Explanation
Details Not Provided - Max Depth: 0.253	

MP-003	Explanation
Details Not Provided - Max Depth: 0.248	Interacting with MD-024

MP-004	Explanation
Details Not Provided - Max Depth: 0.251	

MP-005	Explanation
Details Not Provided - Max Depth: 0.253	

MP-006	Explanation
Details Not Provided - Max Depth: 0.25	

MP-007	Explanation
Details Not Provided - Max Depth: 0.252	

MP-008	Explanation
Details Not Provided - Max Depth: 0.25	Interacting with MD-025

MP-009	Explanation
Details Not Provided - Max Depth: 0.249	Interacting with MD-026

MP-010	Explanation
Details Not Provided - Max Depth: 0.255	

MP-011	Explanation
Details Not Provided - Max Depth: 0.253	

MP-012	Explanation
Details Not Provided - Max Depth: 0.251	Interacting with MD-015

MP-013	Explanation
Details Not Provided - Max Depth: 0.249	Interacting with MD-027

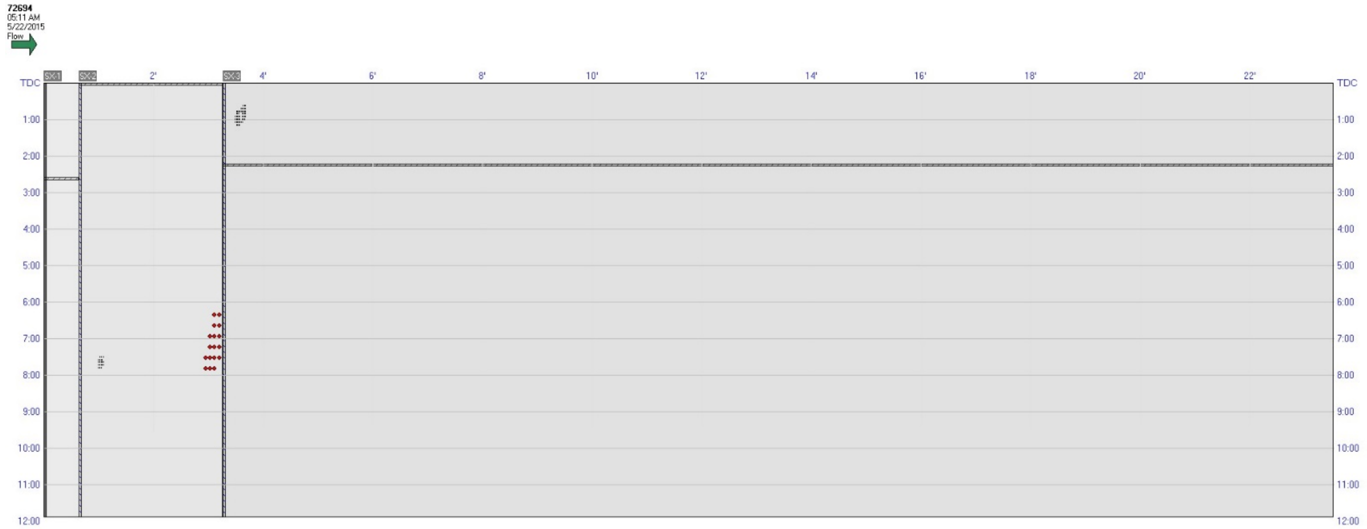
MP-014	Explanation
Details Not Provided - Max Depth: 0.251	Interacting with MD-028

MP-015	Explanation
Details Not Provided - Max Depth: 0.252	Interacting with MD-028

MP-016	Explanation
Details Not Provided - Max Depth: 0.25	Interacting with MD-029

MP-017	Explanation
Details Not Provided - Max Depth: 0.253	Interacting with MD-029

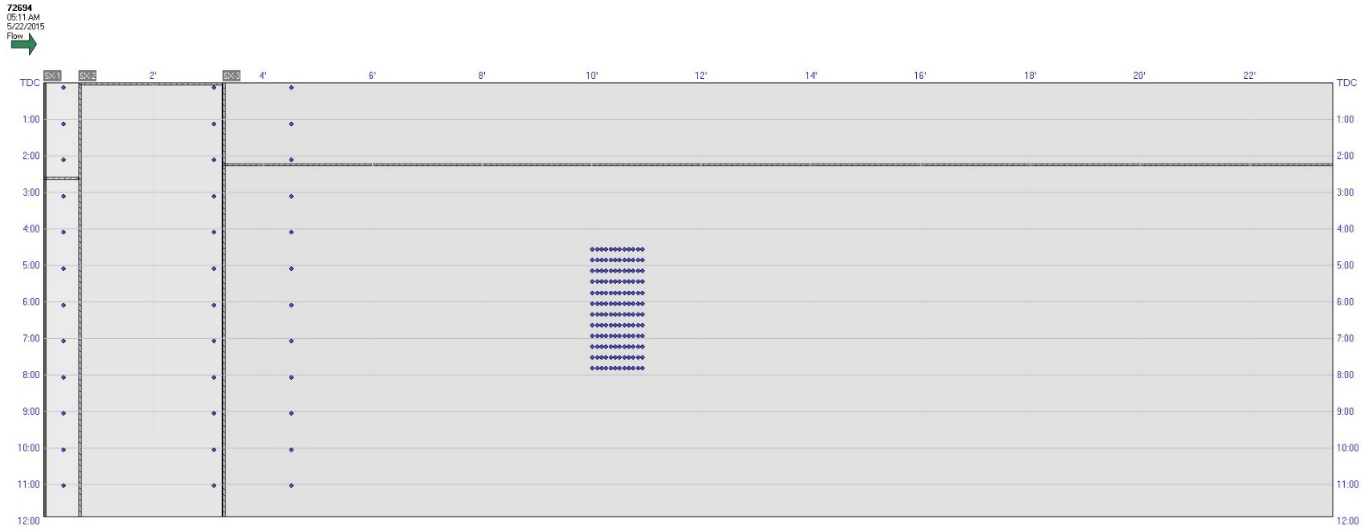
External Pit Depth Measurement Grids



UT - Internal Corrosion Grid (UTG)

Axial Location (Inches from Ref.)	Circ. Location (Inches/Clock from TDC)	UTT Column Minimum (Inches)	UTT Column Average (Inches)	UTT Column Maximum (Inches)
120.00	15.00 to 26.00	0.250	0.252	0.253
121.00	15.00 to 26.00	0.250	0.252	0.255
122.00	15.00 to 26.00	0.250	0.252	0.254
123.00	15.00 to 26.00	0.249	0.252	0.256
124.00	15.00 to 26.00	0.249	0.252	0.254
125.00	15.00 to 26.00	0.248	0.252	0.254
126.00	15.00 to 26.00	0.249	0.252	0.256
127.00	15.00 to 26.00	0.248	0.252	0.256
128.00	15.00 to 26.00	0.250	0.252	0.256
129.00	15.00 to 26.00	0.249	0.252	0.257
130.00	15.00 to 26.00	0.250	0.252	0.255
131.00	15.00 to 26.00	0.249	0.252	0.256

UTGrid	1	2	3	4	5	6	7	8	9	10	11	12
A	0.251	0.250	0.251	0.249	0.250	0.248	0.249	0.248	0.251	0.249	0.250	0.251
B	0.252	0.255	0.252	0.251	0.251	0.250	0.251	0.251	0.254	0.250	0.251	0.249
C	0.253	0.253	0.250	0.252	0.249	0.251	0.250	0.249	0.251	0.250	0.252	0.250
D	0.252	0.252	0.251	0.249	0.251	0.251	0.252	0.251	0.250	0.252	0.251	0.249
E	0.253	0.255	0.252	0.251	0.253	0.252	0.253	0.255	0.250	0.251	0.252	0.251
F	0.252	0.252	0.252	0.251	0.250	0.251	0.252	0.251	0.251	0.251	0.251	0.252
G	0.252	0.252	0.253	0.256	0.253	0.253	0.254	0.256	0.253	0.251	0.253	0.253
H	0.252	0.252	0.253	0.254	0.252	0.252	0.254	0.253	0.256	0.257	0.255	0.253
I	0.251	0.251	0.254	0.253	0.252	0.253	0.251	0.253	0.253	0.253	0.255	0.254
J	0.251	0.250	0.251	0.253	0.251	0.254	0.253	0.255	0.251	0.254	0.252	0.253
K	0.251	0.252	0.253	0.252	0.253	0.252	0.253	0.254	0.255	0.255	0.254	0.256
L	0.250	0.253	0.251	0.252	0.254	0.253	0.256	0.253	0.254	0.252	0.253	0.253



Recoat Data

CLIENT Rep. Approved to Proceed with Recoat	**N/A**	MEARS Foreman Approved to Proceed with Recoat	**N/A**
Sandblast Media	**N/A**	Anchor Profile Measurement (mils)	**--**
Pipe Recoated With	**N/A**		
Recoat Comments	**N/A**		
Air Temperature (°F)	**--**	Pipe Temperature (°F)	**--**
Time of Day	**N/A**	Dew Point (°F)	**--**
Relative Humidity (%)	**--**	Repair Coating Hardness (if ARC Coating)	**--**
Measured DFT - 3:00 (mils)	**--**	Measured DFT - 6:00 (mils)	**--**
Measured DFT - 9:00 (mils)	**--**	Measured DFT - 12:00 (mils)	**--**
Holiday Tested	**--**	Holiday Test Device Used	**N/A**
Voltage Used for Holiday Testing (Volts)	**--**		
Coupon Test Station Installed	**N**	ETS Installed	**N**
If Yes, Date Installed	**N/A**		
Surface Configuration	**N/A**		
Surface Configuration Comments	**N/A**		
Backfill Material	**N/A**		
Backfill Material Comments	**N/A**		
Coating Protection	**N/A**		
P/S Reading Over Bell Hole After Backfill (mV)	**--**		
Post Backfill P/S Reading Comments	**N/A**		

Magnetic Particle Examination

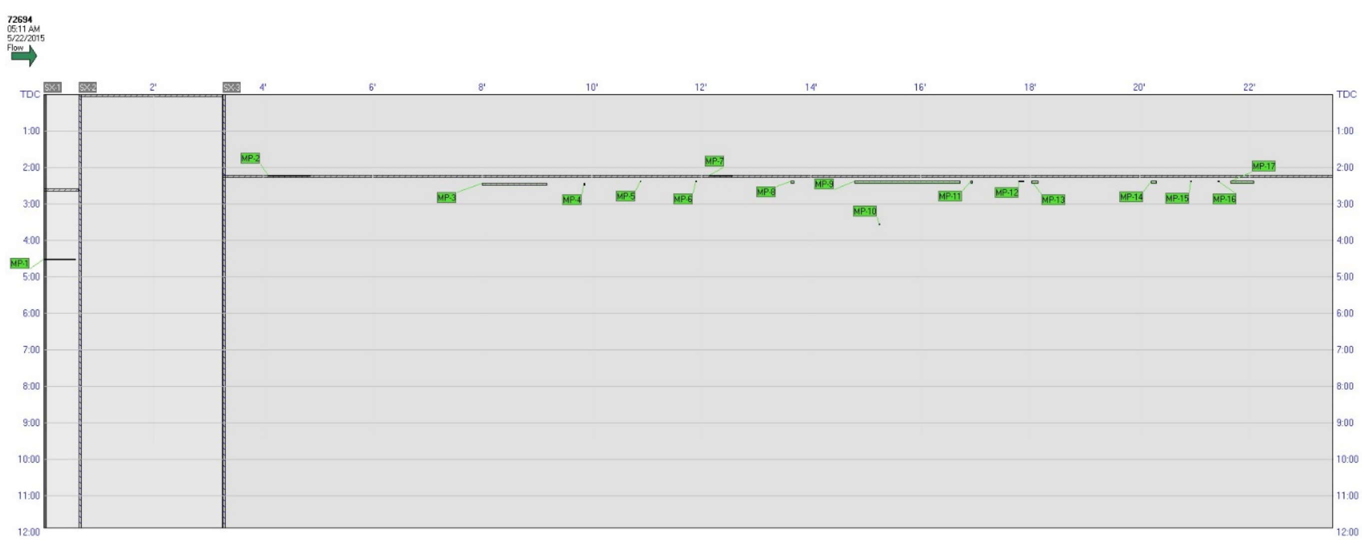
Magnetic Particle Data Available	Y	Examination Date	5/14/2015
Test Equipment	Yoke	Serial No.	7693
Technique	AC-Continuous	Test Medium	Wet-Fluorescent
Quality Control - Batch #	13G113		
Surface Condition	As Blasted NACE 2		
Reference GPS: Northing (m)	N/A	Easting (m)	N/A
Acceptance Criteria	No indications allowed.	Mag. Results Accepted	N

Form H: Direct Examination Data Sheet
Event 72694 on 118B @0.285 Sample A

PG&E ***5/22/2015 5:11:39 AM*** Status: 55-QCed

Magnetic Particle Anomaly Table

Ind. ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Indication	Length (Inches)	Width (Inches)	Local Min. UTT (Inches)	Description/Notes	Image Link
MP-001	0.00	15.25 4:30	Singular	7.00	0.12	0.251		
MP-002	49.25	7.5 2:15	Multiple	9.50	0.12	0.253		
MP-003	96.25	8.25 2:30	Multiple	14.25	0.25	0.248	Interacting with MD-024	
MP-004	118.50	8.25 2:30	Singular	0.25	0.25	0.251		
MP-005	131.00	8 2:30	Singular	0.12	0.12	0.253		
MP-006	143.00	8 2:30	Singular	0.25	0.12	0.250		
MP-007	146.00	7.5 2:15	Multiple	5.25	0.12	0.252		
MP-008	164.00	8 2:30	Singular	0.75	0.25	0.250	Interacting with MD-025	
MP-009	178.00	8 2:30	Multiple	23.25	0.25	0.249	Interacting with MD-026	
MP-010	183.25	12 3:30	Singular	0.25	0.12	0.255		
MP-011	203.50	8 2:30	Singular	0.50	0.25	0.253		
MP-012	214.00	8 2:30	Multiple	1.25	0.12	0.251	Interacting with MD-015	
MP-013	216.75	8 2:30	Singular	1.50	0.25	0.249	Interacting with MD-027	
MP-014	243.00	8 2:30	Singular	1.25	0.25	0.251	Interacting with MD-028	
MP-015	251.75	8 2:30	Singular	0.25	0.12	0.252	Interacting with MD-028	
MP-016	257.75	8 2:30	Singular	0.50	0.12	0.250	Interacting with MD-029	
MP-017	260.50	8 2:30	Singular	5.25	0.25	0.253	Interacting with MD-029	



Comments **WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection. (17) MP indications were found within the inspection area.**

Technician Name	**Mike Wilson**	Mears Level	**MT LEV II-Limited**
Assistant	**N/A**	Mears Level	**N/A**

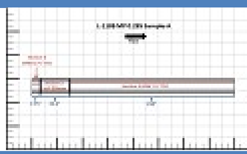
Repair Data

Repair Made	N	Number of Repairs Made	--
Repair Type	N/A	Damage Repaired	N/A
Misc. Comments/Information	N/A		

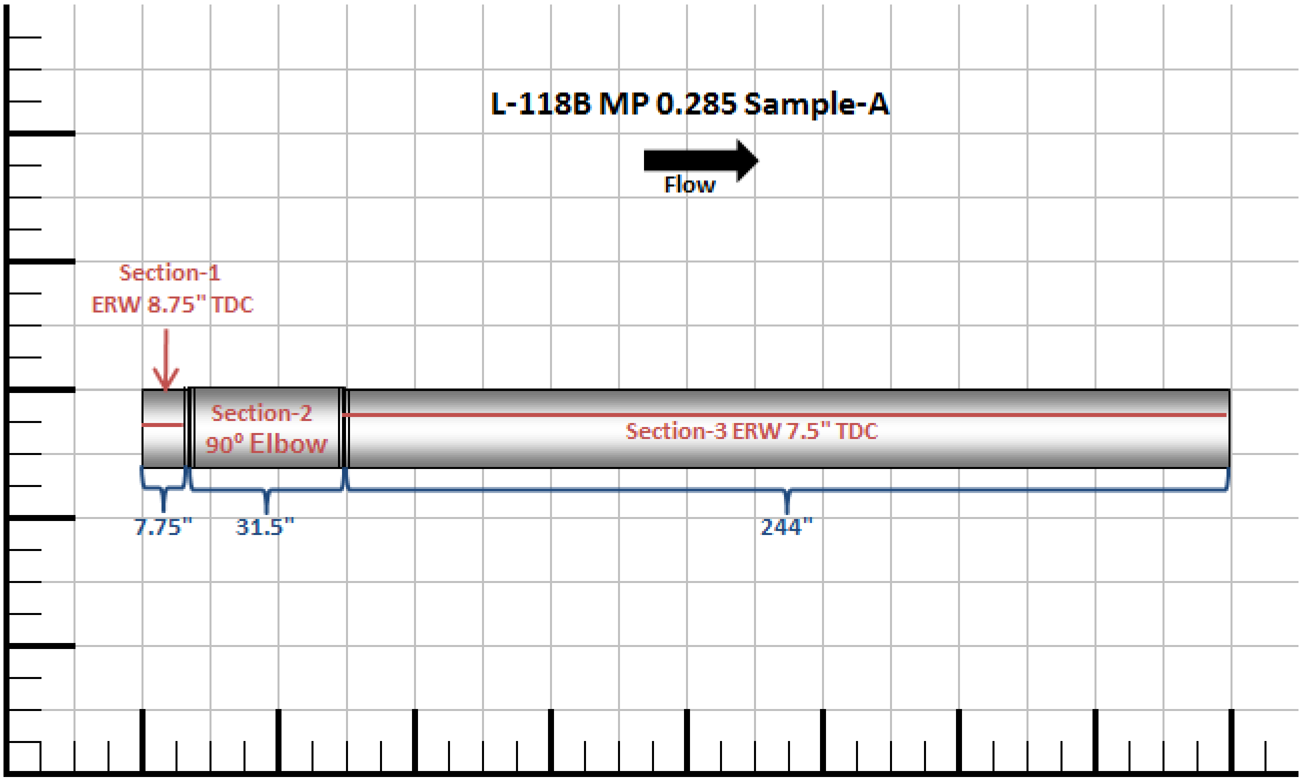
Repair Details

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Repair Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Photo Log

ID	Photo (CTRL-Click for Full Resolution)	Description
037		Excavation Diagram
UTG-001	C:\SQL\Images\Assigned\72694\72694_72694_L118B__A__GRID.CSV	C:\SQL\Images\Assigned\72694\72694_72694_L118B__A__GRID.CSV ' ; Grid Name: L118B (A) GRID; Note: ; Job Name: ; Date: ; Operator: ; Comments:

Excavation Diagram



Site Map

Misc. Information/Comments

	Notes
2015-05-14 KZuker	Provided Inspection Information - ID Sample A Line/Route: 118B, MP 0.285, Nominal Diameter: 12", Nominal WT: 0.250" DE Type: Exponent NDT. Comments: Perform Laser Scan Mapping, NDT, and H-Form Inspections. PE: David Aguiar (DJA4) PC: James Halloway (jameshalloway@gtsinc.us) Work Order Number: 41449650.
2015-05-15 MWilson	This pipe sample was identified as Sample-A. Located at the Exponent facility in Menlo Park, CA the pipe was in the as found condition with the existing coating removed on 5/11/15. A visual inspection of the OD surface did not locate any significant defects prior to sandblast. This sample consists of three pipe sections totaling 283.25" in length. Section-1 is straight pipe 7.75" long with an ERW LSW visually identified from the ID, 8.75" from TDC. Section-2 is a 90 degree elbow with intrados measurement of 14.75", and extrados of 31.5". Section-3 is straight pipe, 244" long with an ERW LSW visually identified from the ID, 7.5" from TDC. The end of Section-3 of Sample-A is the start of inspection on Sample-B. This sample was sandblasted for inspection on 5/11/15.
2015-05-17 MWilson	Visual inspection identified a total of (29) Mechanical damages within the inspection area of Sample-A. The most significant in terms of external wall loss being MD-008 with a max depth of 0.040", and 15.74% wall loss. (3) External Corrosion features were visually identified. EC-002 was the most significant in terms of external wall loss with a max depth of 0.044", and 11.31% wall loss. Creaform laser scan analysis of the external corrosion was not performed due to the presence of the 90 degree elbow. Pit depth grid measurements were gathered with a digital pit depth gauge. WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection on 5/14/15. A total of (17) MP indications were found within the inspection area. MD-002 through MD-009 and MD-011 through MD-017 were visually determined to be interacting with the ERW LSW of Section-3 A. 3D surface scan of Sample-A was created on 5/16/15 using the Creaform VxElements software.
2015-05-17 MWilson	Please note that this inspection was performed on a cut out section of pipe, therefore there is a number of N/A fields within the Form H that do not apply to this inspection process.

Form H: Direct Examination Data Sheet
Event 72695 on 118B @0.285 Sample B

PG&E *5/22/2015 5:27:36 AM* Status: 55-QCed

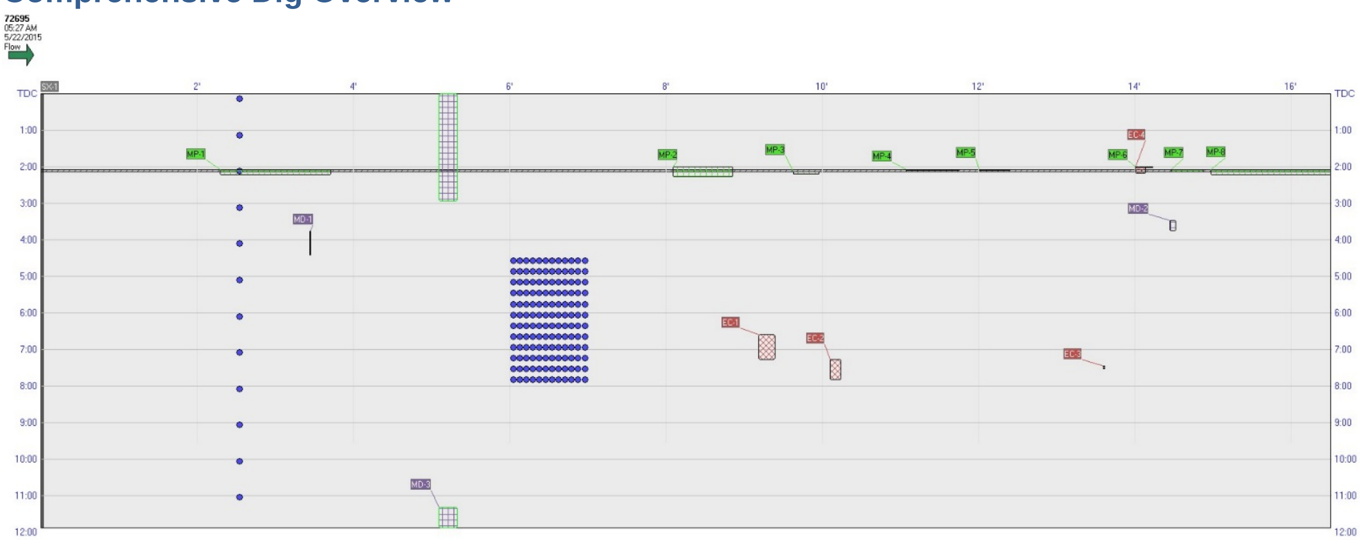
Line # / Position	**118B @0.285 Sample B**	N-Segment	**N/A**	ILI Log Distance	**-- Feet**
Examination Date	**5/14/2015**	IMA Number	**N/A**	RMP-11 Ref. Section	**N/A**
Exam Performed By	**Mike Wilson**	Region Number	**N/A**	Reference Girth Weld	**N/A**
Project Manager	**James Halloway**	Sub # (ICDA)	**N/A**	Dist. From Girth Weld	**-- Feet**
Order Number	**41516466**	Stationing	**N/A**		

Excavation Details

Excavation Priority	**N/A**	Excavation Reason	**N/A**
P/S or CIS reads before excavation (ON) mV	**--**	P/S or CIS (OFF) mV	**--**
PS/CIS Comments	**N/A**		
Planned Inspection Length (Feet)	**--**	Nominal Wall Thickness (Inches)	**0.250**
Actual Inspection Length (Feet)	**16.50**	Nominal Pipe Diameter (Inches)	**12.000**
		SMYS	**--**
Installation Year	**Not Provided**	MAOP	**--**
GPS File Name	**N/A**	Design Factor	**--**

Planned Centerline GPS Coordinates (Based on GIS):	Northing (m)	**N/A**
	Easting (m)	**N/A**
Planned Centerline GPS Coordinates (Based on GIS):	Latitude	**N/A**
	Longitude	**N/A**
Centerline GPS Coordinates (Uncorrected Field Measurement):	Northing (m)	**N/A**
	Easting (m)	**N/A**
Centerline GPS Coordinates (Corrected Field Measurement):	Northing (m)	**N/A**
	Easting (m)	**N/A**

Comprehensive Dig Overview



Prior To Coating Removal

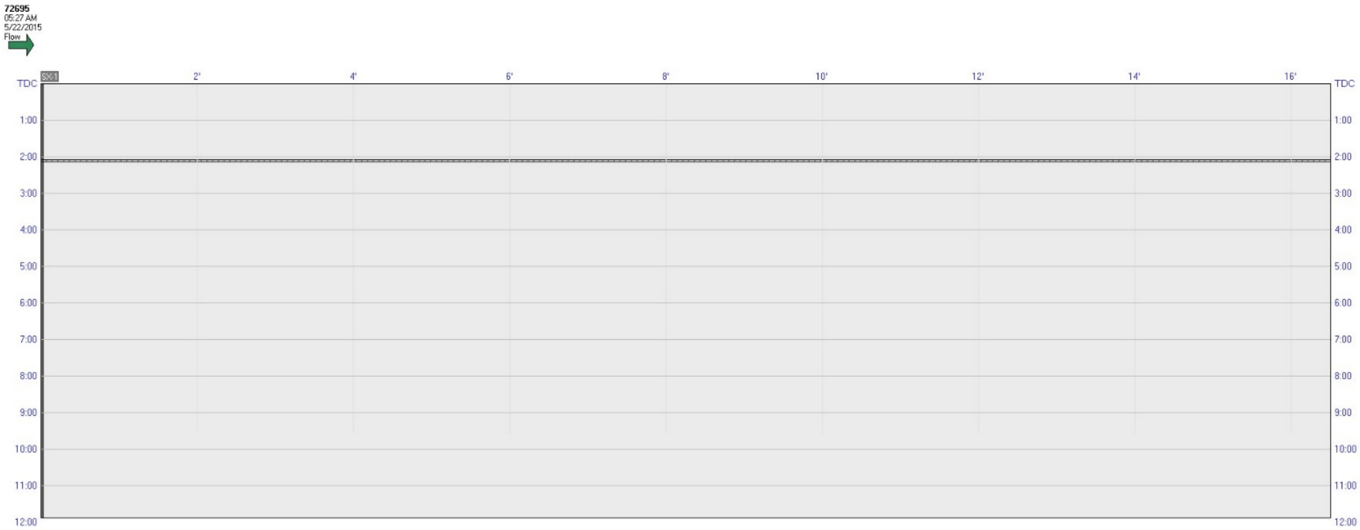
Site Data

Evidence of Encroachment	N		
Encroachment Comments	N/A		
Primary Native Soil Type	N/A	Mixed Soil Types Explanation	N/A
Backfill Material as found	N/A	Depth of Cover (Feet)	--
Backfill Comments	N/A		
Is Rock Shield present?	N		
Coating Type	N/A	Additional Coatings Found	N/A
Coating Type Comments	N/A		
Coating Thickness (Mils)	--	Number of Coating Layers	--
Holiday Testing Performed	N	Holiday Testing Voltage Used VOLTS	--
Holiday Testing Device Used	N/A		
Holiday Testing Comments	N/A		
Soil Sample Location	N/A		
Location notes	N/A		
Ground Water Present	N	Sample Collected	N
Sample pH	--		
Coating Conditions	N/A		
Coating Condition Comments	N/A		
Coating Degradation Map Zero Reference Point	Upstream Edge of Coating Removal	Photos Taken	N
Coating Sample Taken	N	Location of Coating Sample	N/A
Liquid Underneath Coating	N	If Yes, pH of Liquid	--
Corrosion Product Present	N	If Yes, Corrosion Sample Taken	N
Comments	N/A		
Soil pH (Sb Electrode) U/S	--	Soil pH (Sb Electrode) D/S	--

Coating Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Map of Coating Degradation



P/S Potential Measurements

Pipe to Soil Potential in Ditch (mV)-Upstream	--
Pipe to Soil Potential in Ditch (mV)-Downstream	--
Pipe to Soil Potential in Ditch (mV) Comments	N/A

Soil Resistivity

4-Pin Multiplier	--	Soil Box Multiplier	--
4-Pin Ohms	--	Soil Box Ohms	--
4-Pin Spacing Distance in Feet	--		
4-Pin Resistivity	--	Soil Box Resistivity	--
Soil Resistivity Comments	N/A		

Data After Coating Removal

Pipe Temperature (°F)	65.4	Measured Pipe Diameter (Inches)	12.818
Girth Weld Coordinates:		Measured Pipe Circumference (Inches)	40.25
Northing (m)	N/A	Easting (m)	N/A
Girth Weld Elevation (m)	--		
Corrosion Damage	Y	Mechanical Damage	Y
Other Damage Notes	None		
Wet Fluorescent Mag. Part. Test Performed?	Y	Were there any linear indications?	Y
WFMT Comments	Performed by Mike Wilson (Mears) on 5/14/15.		

Pipe Sections

ID	Weld Location (Inches from Ref.)	Long Seam (Inches from TDC)	Seam Type	Circumference (Inches)	Nominal Wall (Inches)	Description/Notes
SX-001	0.00	7 2:00	ERW	40.25	0.250	Straight pipe, 198" long inspection U/S of Rupture

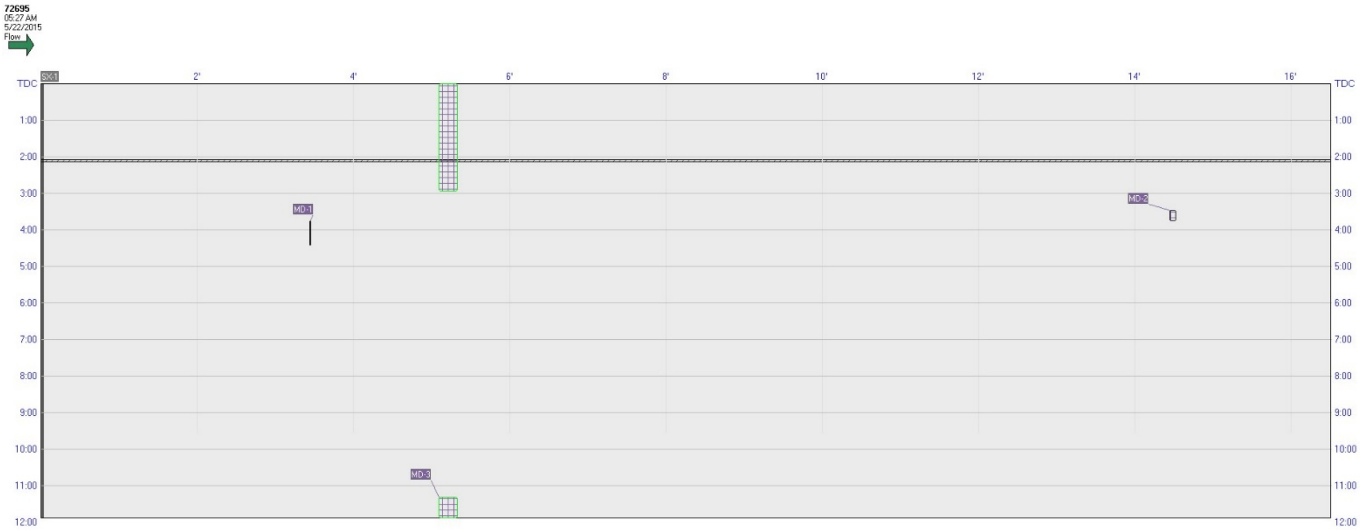
UT - Section O'Clocks (UTC)

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	UT Thickness (Inches)	UT Section / O'Clock Position
SX-001	30.00	0.00	0.251	UT Wall Thickness-TDC
SX-001	30.00	3.35	0.254	UT Wall Thickness-1 O'clock
SX-001	30.00	6.71	0.257	UT Wall Thickness-2 O'clock
SX-001	30.00	10.06	0.254	UT Wall Thickness-3 O'clock
SX-001	30.00	13.42	0.249	UT Wall Thickness-4 O'clock
SX-001	30.00	16.77	0.251	UT Wall Thickness-5 O'clock
SX-001	30.00	20.13	0.256	UT Wall Thickness-6 O'clock
SX-001	30.00	23.48	0.254	UT Wall Thickness-7 O'clock
SX-001	30.00	26.83	0.255	UT Wall Thickness-8 O'clock
SX-001	30.00	30.19	0.257	UT Wall Thickness-9 O'clock
SX-001	30.00	33.54	0.257	UT Wall Thickness-10 O'clock
SX-001	30.00	36.90	0.255	UT Wall Thickness-11 O'clock

Mechanical Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
MD-001	41.25	12.75 3:45	Scrape	0.25	2.25	0.003	1.18% wall loss	
MD-002	173.25	11.75 3:30	Scrape	1.00	1.00	0.007	2.78% wall loss	
MD-003	61.00	38.25 11:30	Scrape	3.00	12.00	0.004	1.58% wall loss	

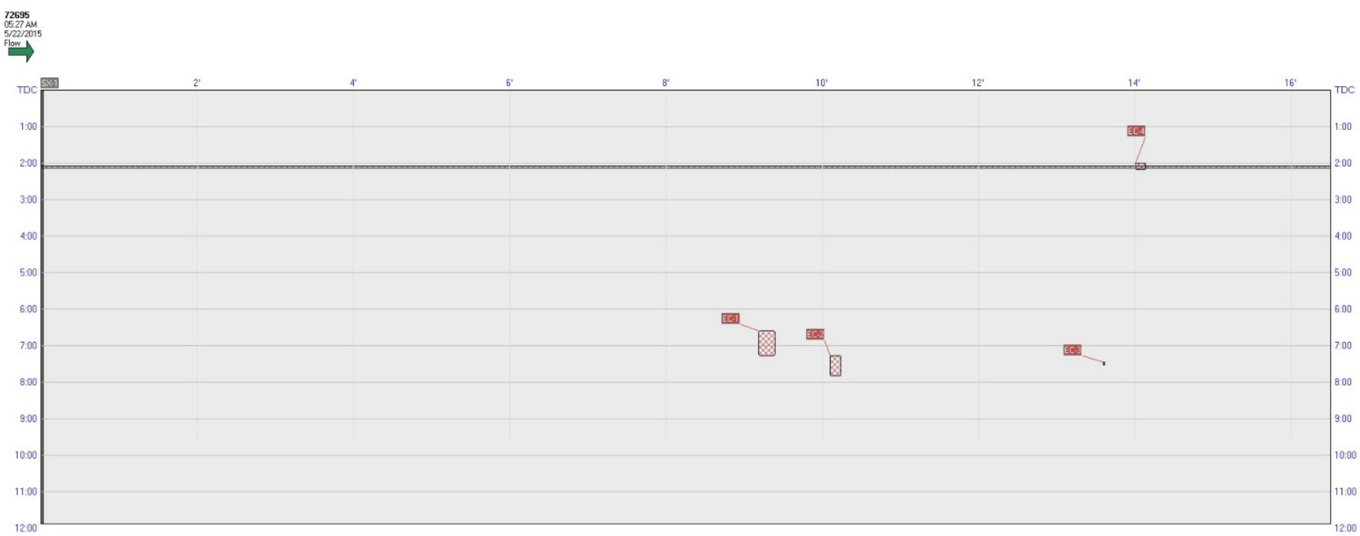
Map of Mechanical Damage



External Corrosion Mapping

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
EC-001	110.10	22.27 6:45	General	2.65	2.42	0.022	8.69% wall loss	
EC-002	121.10	24.58 7:15	General	1.71	1.89	0.019	7.76% wall loss	
EC-003	163.05	25.17 7:30	General	0.29	0.35	0.021	8.58% wall loss	
EC-004	168.01	6.75 2:00	General	1.65	0.65	0.011	4.57% wall loss, Interacting with MP-006	

Map of Corroded Area



External Pit Depth

EC-001	Explanation
Details Not Provided - Max Depth: 0.022	8.69% wall loss

EC-002	Explanation
Details Not Provided - Max Depth: 0.019	7.76% wall loss

EC-003	Explanation
Details Not Provided - Max Depth: 0.021	8.58% wall loss

EC-004	Explanation
Details Not Provided - Max Depth: 0.011	4.57% wall loss, Interacting with MP-006

MD-001	Explanation
Details Not Provided - Max Depth: 0.003	1.18% wall loss

MD-002	Explanation
Details Not Provided - Max Depth: 0.007	2.78% wall loss

MD-003	Explanation
Details Not Provided - Max Depth: 0.004	1.58% wall loss

MP-001	Explanation
Details Not Provided - Max Depth: 0.25	

MP-002	Explanation
Details Not Provided - Max Depth: 0.25	

MP-003	Explanation
Details Not Provided - Max Depth: 0.248	

MP-004	Explanation
Details Not Provided - Max Depth: 0.249	

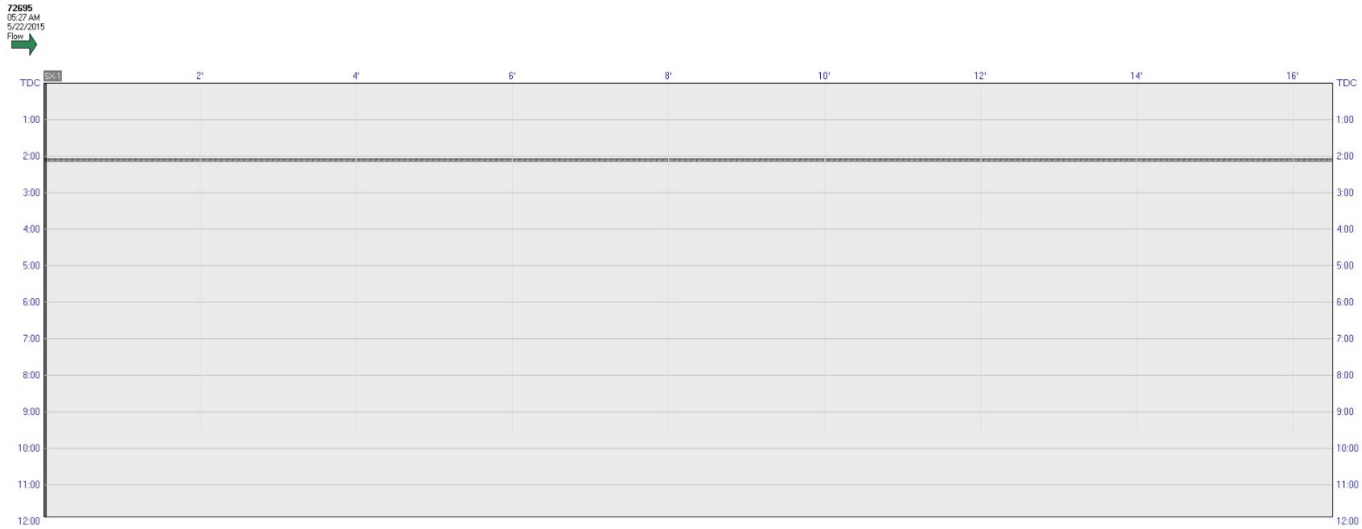
MP-005	Explanation
Details Not Provided - Max Depth: 0.248	

MP-006	Explanation
Details Not Provided - Max Depth: 0.249	Interacting with EC-004

MP-007	Explanation
Details Not Provided - Max Depth: 0.248	

MP-008	Explanation
Details Not Provided - Max Depth: 0.247	

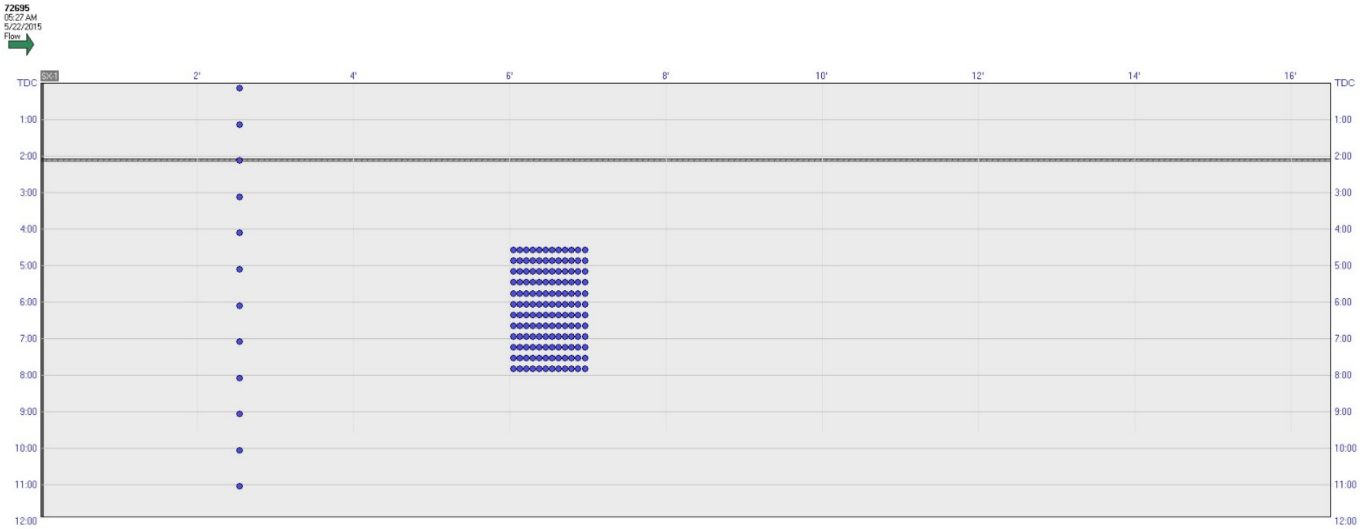
External Pit Depth Measurement Grids



UT - Internal Corrosion Grid (UTG)

Axial Location (Inches from Ref.)	Circ. Location (Inches/Clock from TDC)	UTT Column Minimum (Inches)	UTT Column Average (Inches)	UTT Column Maximum (Inches)
72.00	15.00 to 26.00	0.255	0.257	0.258
73.00	15.00 to 26.00	0.255	0.256	0.258
74.00	15.00 to 26.00	0.255	0.257	0.258
75.00	15.00 to 26.00	0.255	0.256	0.257
76.00	15.00 to 26.00	0.255	0.257	0.258
77.00	15.00 to 26.00	0.254	0.256	0.258
78.00	15.00 to 26.00	0.255	0.257	0.258
79.00	15.00 to 26.00	0.255	0.257	0.258
80.00	15.00 to 26.00	0.254	0.256	0.258
81.00	15.00 to 26.00	0.255	0.256	0.258
82.00	15.00 to 26.00	0.255	0.257	0.258
83.00	15.00 to 26.00	0.254	0.256	0.258

UTGrid	1	2	3	4	5	6	7	8	9	10	11	12
A	0.255	0.256	0.256	0.255	0.255	0.255	0.256	0.257	0.254	0.255	0.257	0.255
B	0.255	0.256	0.257	0.256	0.257	0.256	0.257	0.255	0.257	0.257	0.258	0.255
C	0.257	0.256	0.258	0.256	0.257	0.257	0.257	0.257	0.257	0.256	0.256	0.256
D	0.257	0.257	0.257	0.257	0.256	0.257	0.256	0.257	0.255	0.258	0.257	0.257
E	0.257	0.257	0.257	0.256	0.257	0.257	0.257	0.257	0.258	0.257	0.258	0.257
F	0.258	0.257	0.258	0.256	0.258	0.257	0.258	0.258	0.257	0.258	0.258	0.257
G	0.258	0.258	0.257	0.257	0.257	0.258	0.256	0.258	0.256	0.257	0.258	0.258
H	0.257	0.257	0.257	0.256	0.257	0.258	0.258	0.258	0.258	0.256	0.257	0.256
I	0.257	0.256	0.257	0.255	0.256	0.256	0.256	0.256	0.257	0.255	0.257	0.257
J	0.257	0.255	0.256	0.257	0.257	0.254	0.256	0.255	0.257	0.256	0.256	0.255
K	0.256	0.255	0.256	0.255	0.256	0.256	0.255	0.256	0.255	0.255	0.255	0.254
L	0.255	0.255	0.255	0.255	0.255	0.255	0.257	0.258	0.255	0.255	0.255	0.256



Recoat Data

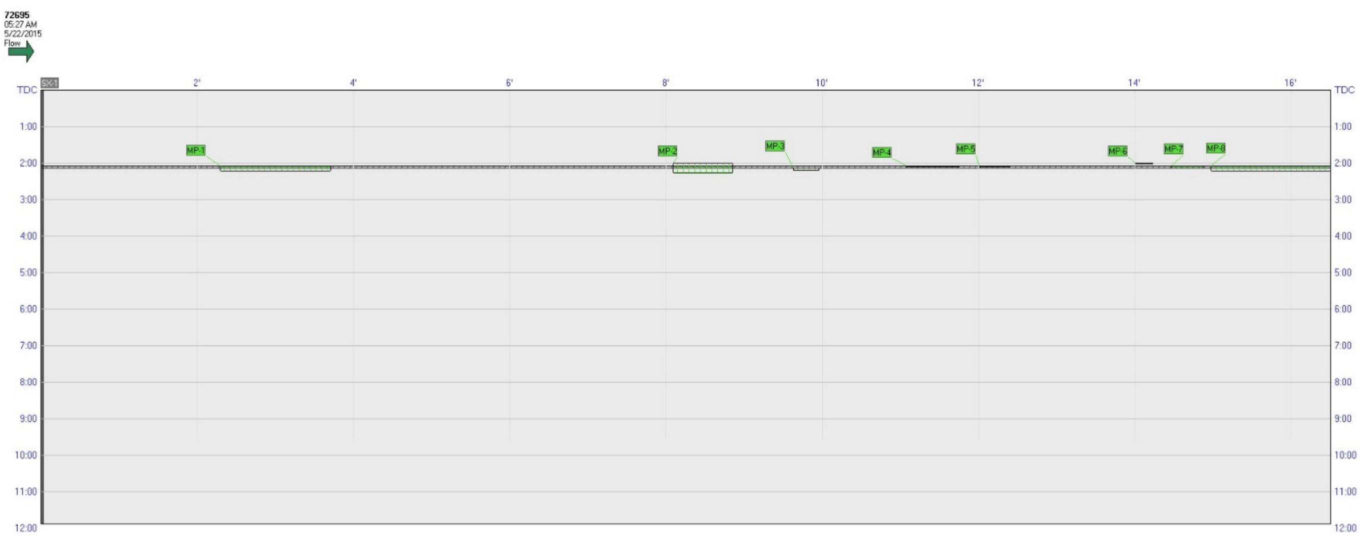
CLIENT Rep. Approved to Proceed with Recoat	**N/A**	MEARS Foreman Approved to Proceed with Recoat	**N/A**
Sandblast Media	**N/A**	Anchor Profile Measurement (mils)	**--**
Pipe Recoated With	**N/A**		
Recoat Comments	**N/A**		
Air Temperature (°F)	**--**	Pipe Temperature (°F)	**--**
Time of Day	**N/A**	Dew Point (°F)	**--**
Relative Humidity (%)	**--**	Repair Coating Hardness (if ARC Coating)	**--**
Measured DFT - 3:00 (mils)	**--**	Measured DFT - 6:00 (mils)	**--**
Measured DFT - 9:00 (mils)	**--**	Measured DFT - 12:00 (mils)	**--**
Holiday Tested	**--**	Holiday Test Device Used	**N/A**
Voltage Used for Holiday Testing (Volts)	**--**		
Coupon Test Station Installed	**N**	ETS Installed	**N**
If Yes, Date Installed	**N/A**		
Surface Configuration	**N/A**		
Surface Configuration Comments	**N/A**		
Backfill Material	**N/A**		
Backfill Material Comments	**N/A**		
Coating Protection	**N/A**		
P/S Reading Over Bell Hole After Backfill (mV)	**--**		
Post Backfill P/S Reading Comments	**N/A**		

Magnetic Particle Examination

Magnetic Particle Data Available	**Y**	Examination Date	**5/14/2015**
Test Equipment	**Yoke**	Serial No.	**7693**
Technique	**AC-Continuous**	Test Medium	**Wet-Fluorescent**
Quality Control - Batch #	**13G113**		
Surface Condition	**As Blasted NACE 2**		
Reference GPS: Northing (m)	**N/A**	Easting (m)	**N/A**
Acceptance Criteria	**No indications allowed.**	Mag. Results Accepted	**N**

Magnetic Particle Anomaly Table

Ind. ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Indication	Length (Inches)	Width (Inches)	Local Min. UTT (Inches)	Description/Notes	Image Link
MP-001	27.50	7 2:00	Multiple	17.00	0.50	0.250		
MP-002	97.00	6.75 2:00	Multiple	9.25	1.00	0.250		
MP-003	115.50	7.25 2:15	Singular	4.00	0.25	0.248		
MP-004	132.75	7 2:00	Multiple	8.25	0.12	0.249		
MP-005	144.00	7 2:00	Multiple	4.75	0.12	0.248		
MP-006	168.00	6.75 2:00	Multiple	2.75	0.12	0.249	Interacting with EC-004	
MP-007	173.50	7 2:00	Multiple	5.00	0.25	0.248		
MP-008	179.50	7 2:00	Multiple	18.50	0.50	0.247		



Comments **WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection. (8) MP indications were found within the inspection area.**

Technician Name	**Mike Wilson**	Mears Level	**MT LEV II-Limited**
Assistant	**N/A**	Mears Level	**N/A**

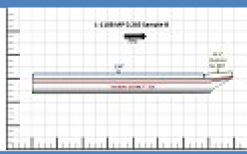
Repair Data

Repair Made	N	Number of Repairs Made	--
Repair Type	N/A	Damage Repaired	N/A
Misc. Comments/Information	N/A		

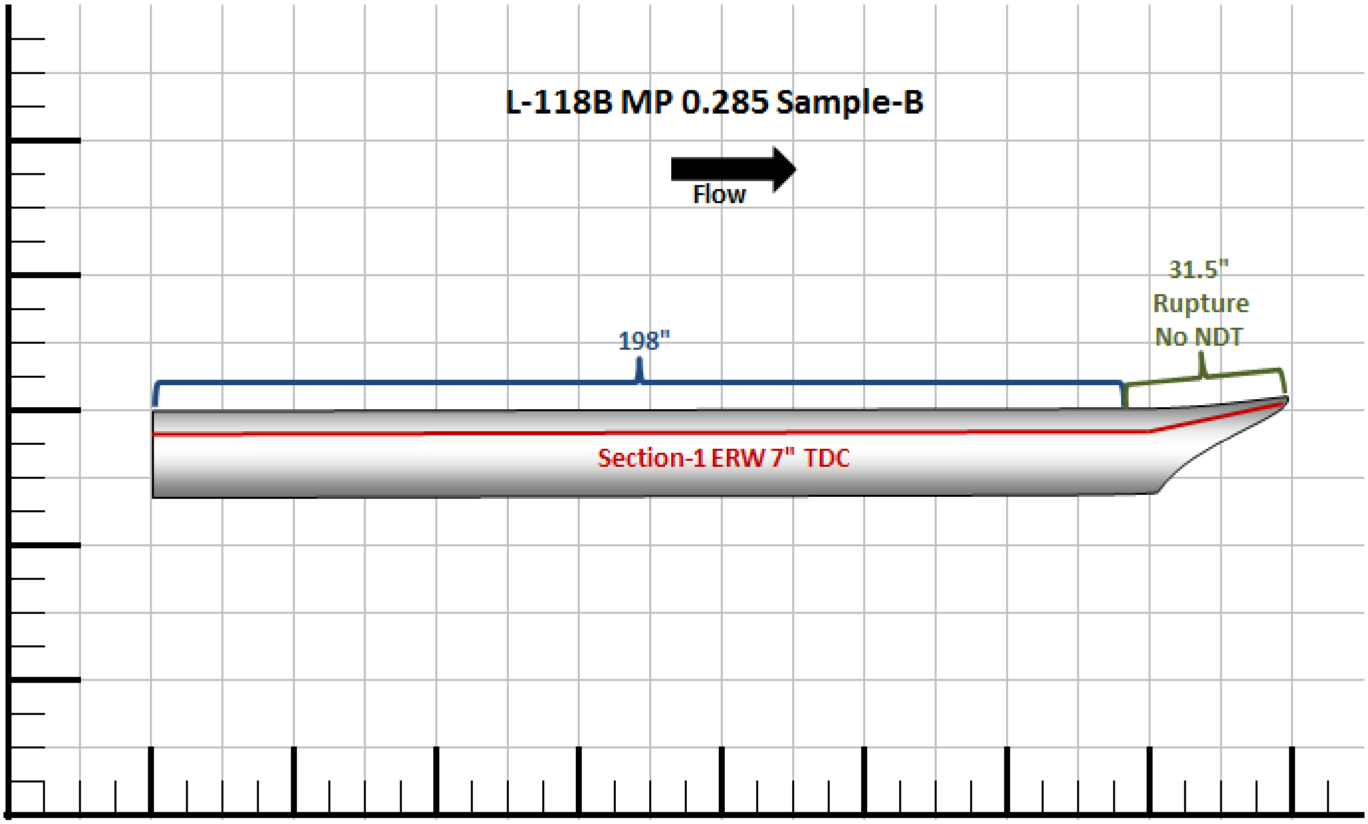
Repair Details

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Repair Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Photo Log

ID	Photo (CTRL-Click for Full Resolution)	Description
037		Excavation Diagram
UTG-001	C:\SQL\Images\Assigned\72695\72695_72695_L118B__B__GRID.CSV	C:\SQL\Images\Assigned\72695\72695_72695_L118B__B__GRID.CSV ' ; Grid Name: L118B (B) GRID; Note: ; Job Name: ; Date: ; Operator: ; Comments:

Excavation Diagram



Site Map

Misc. Information/Comments

	Notes
2015-05-14 KZuker	Provided Inspection Information - ID Sample B Line/Route: 118B, MP 0.285, Nominal Diameter: 12", Nominal WT: 0.250" DE Type: Exponent NDT. Comments: Perform Laser Scan Mapping, NDT, and H-Form Inspections. PE: David Aguiar (DJA4) PC: James Halloway (jameshalloway@gtsinc.us) Work Order Number: 41516466.
2015-05-19 MWilson	This pipe sample was identified as Sample-B. The pipe was in the as found condition with the existing coating removed on 5/11/15, located at the Exponent facility in Menlo Park, CA. A visual inspection of the OD surface did not locate any significant defects prior to sandblast. This pipe sample consists of one straight pipe section with a Rupture on the downstream end of the sample. A measured 229.5" total length of the sample. To ensure no tampering to the effected rupture area, a 16.5' inspection was measured from the upstream edge of the sample. No NDT was performed over the Rupture area. An ERW LSW visually identified from the ID, 7" from TDC. This sample was sandblasted for inspection on 5/11/15.
2015-05-19 MWilson	Visual inspection identified a total of (3) Mechanical damages within the inspection area of Sample-B. The most significant in terms of external wall loss being MD-002 with a max depth of 0.007", and 2.78% wall loss. (4) External Corrosion features were visually identified. EC-001 was the most significant in terms of external wall loss with a max depth of 0.022", and 8.69% wall loss. The Creaform Pipecheck software was used to analyze the External Corrosion features. WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection on 5/14/15. A total of (8) MP indications were found within the inspection area. All MP indications were visually determined to be interacting with the ERW LSW of Section-1. A 3D surface scan of Sample-B was created on 5/16/15 using the Creaform VxElements software.
2015-05-19 MWilson	Please note that this inspection was performed on a cut out section of pipe, therefore there is a number of N/A fields within the Form H that do not apply to this inspection process.

Form H: Direct Examination Data Sheet
Event 72696 on 118B @0.285 Sample C

PG&E *5/22/2015 9:28:24 AM* Status: 55-QCed

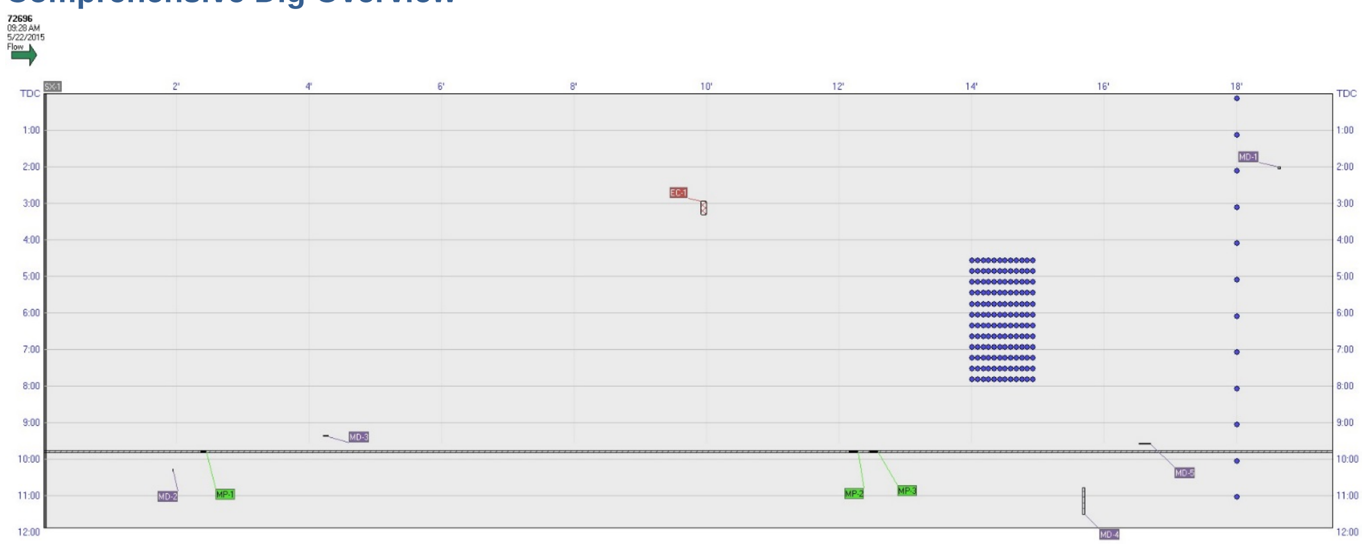
Line # / Position	**118B @0.285 Sample C**	N-Segment	**N/A**	ILI Log Distance	**-- Feet**
Examination Date	**5/18/2015**	IMA Number	**N/A**	RMP-11 Ref. Section	**N/A**
Exam Performed By	**Mike Wilson**	Region Number	**N/A**	Reference Girth Weld	**N/A**
Project Manager	**James Halloway**	Sub # (ICDA)	**N/A**	Dist. From Girth Weld	**-- Feet**
Order Number	**41516466**	Stationing	**N/A**		

Excavation Details

Excavation Priority	**N/A**	Excavation Reason	**N/A**
P/S or CIS reads before excavation (ON) mV	**--**	P/S or CIS (OFF) mV	**--**
PS/CIS Comments	**N/A**		
Planned Inspection Length (Feet)	**--**	Nominal Wall Thickness (Inches)	**0.250**
Actual Inspection Length (Feet)	**19.47**	Nominal Pipe Diameter (Inches)	**12.000**
		SMYS	**--**
Installation Year	**Not Provided**	MAOP	**--**
GPS File Name	**N/A**	Design Factor	**--**

Planned Centerline GPS Coordinates (Based on GIS):	Northing (m)	**N/A**
	Easting (m)	**N/A**
Planned Centerline GPS Coordinates (Based on GIS):	Latitude	**N/A**
	Longitude	**N/A**
Centerline GPS Coordinates (Uncorrected Field Measurement):	Northing (m)	**N/A**
	Easting (m)	**N/A**
Centerline GPS Coordinates (Corrected Field Measurement):	Northing (m)	**N/A**
	Easting (m)	**N/A**

Comprehensive Dig Overview



Prior To Coating Removal

Site Data

Evidence of Encroachment	**N**		
Encroachment Comments	**N/A**		
Primary Native Soil Type	**N/A**	Mixed Soil Types Explanation	**N/A**
Backfill Material as found	**N/A**	Depth of Cover (Feet)	**--**
Backfill Comments	**N/A**		
Is Rock Shield present?	**N**		
Coating Type	**N/A**	Additional Coatings Found	**N/A**
Coating Type Comments	**N/A**		
Coating Thickness (Mils)	**--**	Number of Coating Layers	**--**
Holiday Testing Performed	**N**	Holiday Testing Voltage Used VOLTS	**--**
Holiday Testing Device Used	**N/A**		
Holiday Testing Comments	**N/A**		
Soil Sample Location	**N/A**		
Location notes	**N/A**		
Ground Water Present	**N**	Sample Collected	**N**
Sample pH	**--**		
Coating Conditions	**N/A**		
Coating Condition Comments	**N/A**		
Coating Degradation Map Zero Reference Point	**N/A**	Photos Taken	**Y**
Coating Sample Taken	**N**	Location of Coating Sample	**N/A**
Liquid Underneath Coating	**N**	If Yes, pH of Liquid	**--**
Corrosion Product Present	**N**	If Yes, Corrosion Sample Taken	**N**
Comments	**N/A**		
Soil pH (Sb Electrode) U/S	**--**	Soil pH (Sb Electrode) D/S	**--**

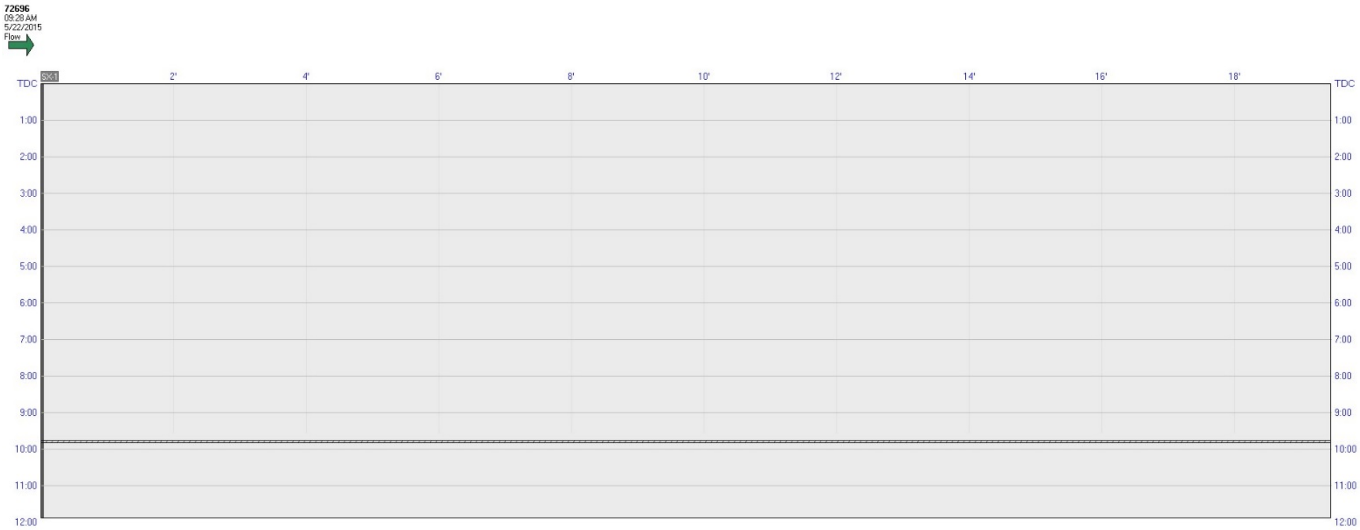
Coating Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Form H: Direct Examination Data Sheet
Event 72696 on 118B @0.285 Sample C

PG&E *5/22/2015 9:28:24 AM* Status: 55-QCed

Map of Coating Degradation



P/S Potential Measurements

Pipe to Soil Potential in Ditch (mV)-Upstream	--
Pipe to Soil Potential in Ditch (mV)-Downstream	--
Pipe to Soil Potential in Ditch (mV) Comments	N/A

Soil Resistivity

4-Pin Multiplier	--	Soil Box Multiplier	--
4-Pin Ohms	--	Soil Box Ohms	--
4-Pin Spacing Distance in Feet	--		
4-Pin Resistivity	--	Soil Box Resistivity	--
Soil Resistivity Comments	N/A		

Data After Coating Removal

Pipe Temperature (°F)	67.2	Measured Pipe Diameter (Inches)	12.818
Girth Weld Coordinates:		Measured Pipe Circumference (Inches)	40.25
Northing (m)	N/A	Easting (m)	N/A
Girth Weld Elevation (m)	--		
Corrosion Damage	Y	Mechanical Damage	N
Other Damage Notes	None.		
Wet Fluorescent Mag. Part. Test Performed?	Y	Were there any linear indications?	Y
WFMT Comments	Performed by Mike Wilson (Mears) on 5/20/15.		

Pipe Sections

ID	Weld Location (Inches from Ref.)	Long Seam (Inches from TDC)	Seam Type	Circumference (Inches)	Nominal Wall (Inches)	Description/Notes
SX-001	0.00	33 9:45	ERW	40.25	0.250	Straight pipe, 233.75" long

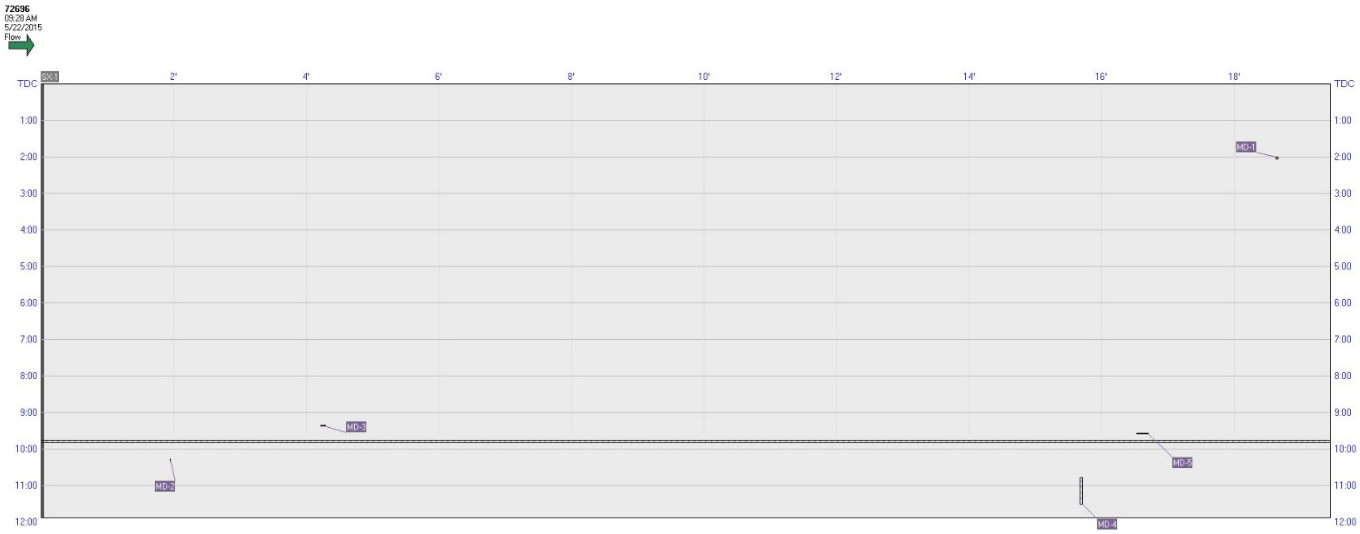
UT - Section O'Clocks (UTC)

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	UT Thickness (Inches)	UT Section / O'Clock Position
SX-001	216.00	0.00	0.255	UT Wall Thickness-TDC
SX-001	216.00	3.35	0.254	UT Wall Thickness-1 O'clock
SX-001	216.00	6.71	0.255	UT Wall Thickness-2 O'clock
SX-001	216.00	10.06	0.255	UT Wall Thickness-3 O'clock
SX-001	216.00	13.42	0.255	UT Wall Thickness-4 O'clock
SX-001	216.00	16.77	0.254	UT Wall Thickness-5 O'clock
SX-001	216.00	20.13	0.253	UT Wall Thickness-6 O'clock
SX-001	216.00	23.48	0.253	UT Wall Thickness-7 O'clock
SX-001	216.00	26.83	0.252	UT Wall Thickness-8 O'clock
SX-001	216.00	30.19	0.255	UT Wall Thickness-9 O'clock
SX-001	216.00	33.54	0.263	UT Wall Thickness-10 O'clock
SX-001	216.00	36.90	0.255	UT Wall Thickness-11 O'clock

Mechanical Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
MD-001	224.00	6.75 2:00	Scrape	0.50	0.25	0.004	1.57% wall loss	
MD-002	23.50	35 10:30	Gouge	0.12	0.25	0.006	2.38% wall loss	
MD-003	51.75	31.75 9:30	Scrape	1.00	0.12	0.004	1.57% wall loss	
MD-004	189.00	39 11:45	Scrape	0.50	2.50	0.004	1.58% wall loss	
MD-005	201.00	32.5 9:45	Scrape	2.25	0.12	0.002	0.79% wall loss	

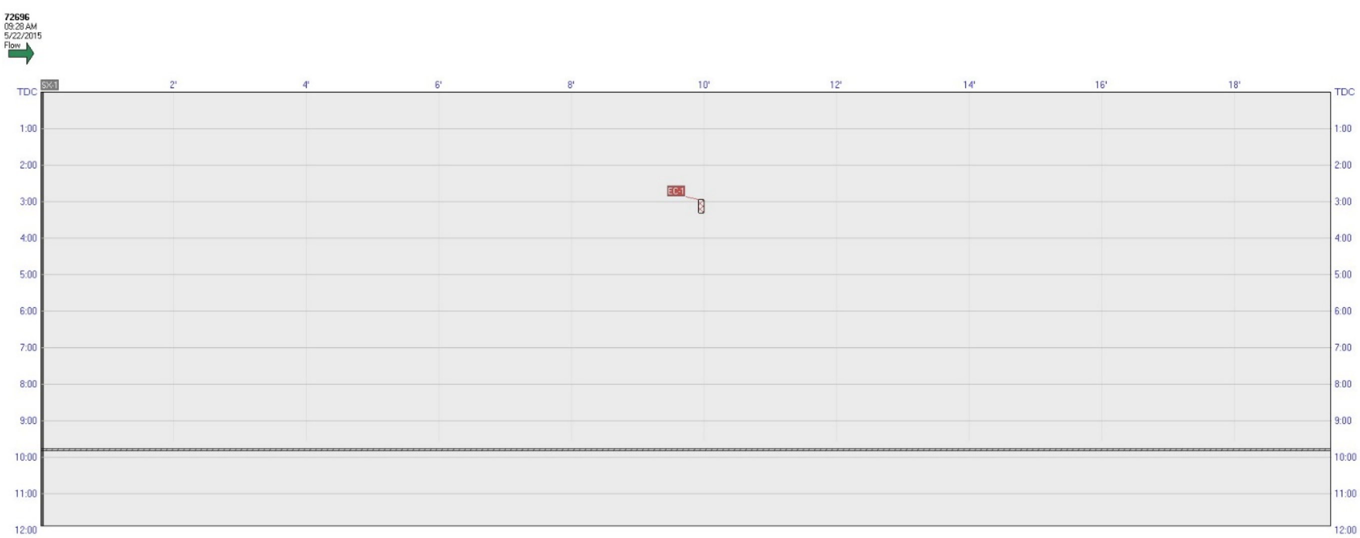
Map of Mechanical Damage



External Corrosion Mapping

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
EC-001	119.24	9.92 3:00	General	1.18	1.30	0.015	6.03% wall loss	

Map of Corroded Area



External Pit Depth

EC-001	Explanation
Details Not Provided - Max Depth: 0.015	6.03% wall loss

MD-001	Explanation
Details Not Provided - Max Depth: 0.004	1.57% wall loss

MD-002	Explanation
Details Not Provided - Max Depth: 0.006	2.38% wall loss

MD-003	Explanation
Details Not Provided - Max Depth: 0.004	1.57% wall loss

MD-004	Explanation
Details Not Provided - Max Depth: 0.004	1.58% wall loss

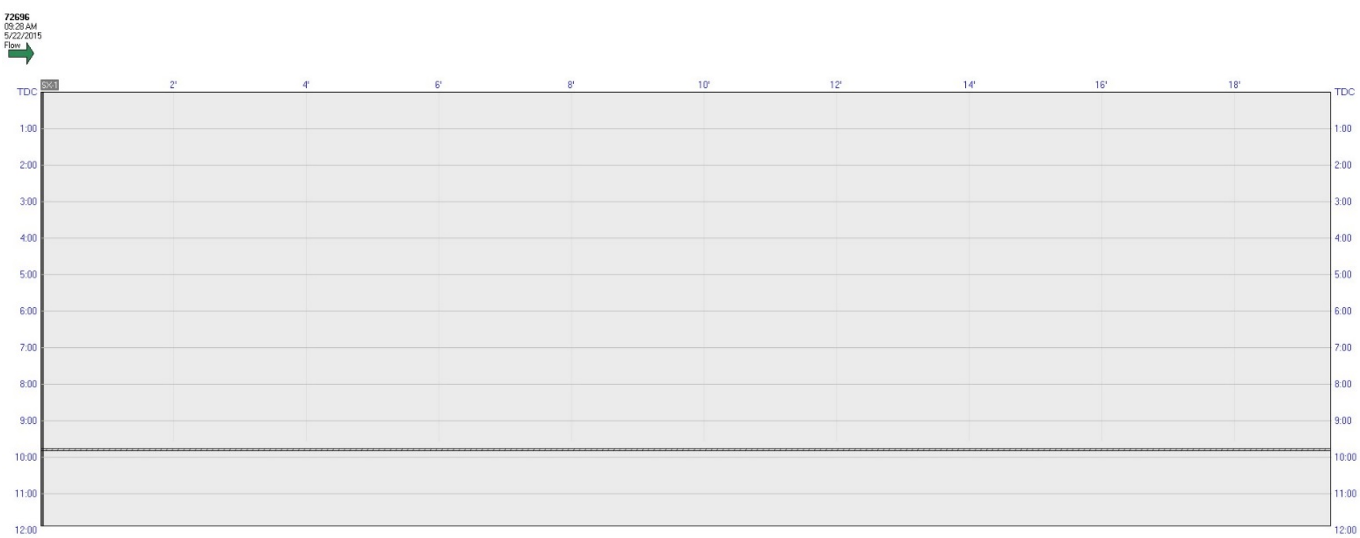
MD-005	Explanation
Details Not Provided - Max Depth: 0.002	0.79% wall loss

MP-001	Explanation
Details Not Provided - Max Depth: 0.25	

MP-002	Explanation
Details Not Provided - Max Depth: 0.256	

MP-003	Explanation
Details Not Provided - Max Depth: 0.257	

External Pit Depth Measurement Grids



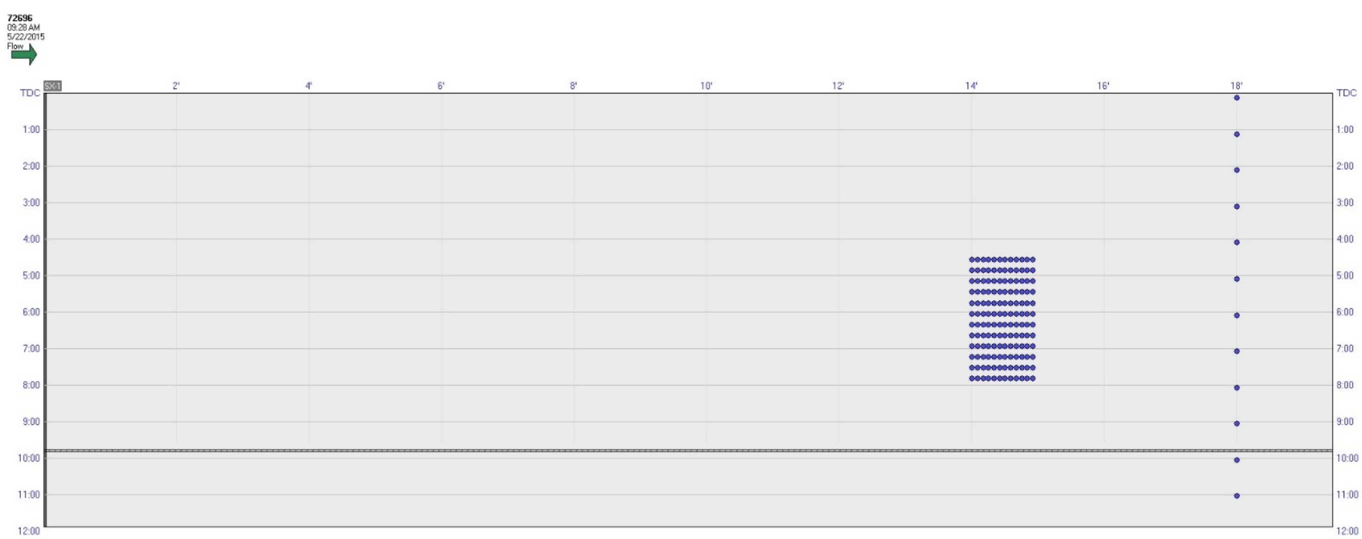
Form H: Direct Examination Data Sheet
Event 72696 on 118B @0.285 Sample C

PG&E ***5/22/2015 9:28:24 AM*** Status: 55-QCed

UT - Internal Corrosion Grid (UTG)

Axial Location (Inches from Ref.)	Circ. Location (Inches/Clock from TDC)	UTT Column Minimum (Inches)	UTT Column Average (Inches)	UTT Column Maximum (Inches)
168.00	15.00 to 26.00	0.253	0.256	0.258
169.00	15.00 to 26.00	0.254	0.257	0.259
170.00	15.00 to 26.00	0.255	0.257	0.260
171.00	15.00 to 26.00	0.253	0.256	0.259
172.00	15.00 to 26.00	0.254	0.257	0.260
173.00	15.00 to 26.00	0.255	0.257	0.259
174.00	15.00 to 26.00	0.254	0.257	0.259
175.00	15.00 to 26.00	0.254	0.257	0.260
176.00	15.00 to 26.00	0.253	0.256	0.259
177.00	15.00 to 26.00	0.254	0.257	0.259
178.00	15.00 to 26.00	0.254	0.257	0.259
179.00	15.00 to 26.00	0.254	0.257	0.260

UTGrid	1	2	3	4	5	6	7	8	9	10	11	12
A	0.257	0.256	0.256	0.254	0.254	0.255	0.257	0.256	0.254	0.256	0.254	0.256
B	0.255	0.256	0.255	0.255	0.255	0.256	0.256	0.254	0.257	0.257	0.257	0.257
C	0.257	0.258	0.256	0.255	0.256	0.256	0.255	0.257	0.256	0.256	0.256	0.257
D	0.255	0.255	0.256	0.259	0.259	0.258	0.257	0.258	0.259	0.258	0.259	0.259
E	0.258	0.257	0.257	0.259	0.258	0.257	0.259	0.259	0.259	0.259	0.259	0.259
F	0.258	0.259	0.258	0.258	0.258	0.259	0.259	0.260	0.256	0.259	0.259	0.259
G	0.258	0.257	0.256	0.258	0.259	0.258	0.257	0.258	0.259	0.259	0.257	0.258
H	0.257	0.257	0.260	0.258	0.260	0.257	0.259	0.258	0.258	0.259	0.259	0.260
I	0.256	0.255	0.255	0.255	0.255	0.256	0.256	0.254	0.255	0.257	0.255	0.256
J	0.253	0.254	0.257	0.254	0.256	0.257	0.258	0.256	0.253	0.256	0.256	0.256
K	0.255	0.259	0.257	0.253	0.254	0.255	0.255	0.255	0.256	0.257	0.254	0.257
L	0.255	0.256	0.255	0.257	0.256	0.259	0.254	0.255	0.253	0.254	0.254	0.254



Recoat Data

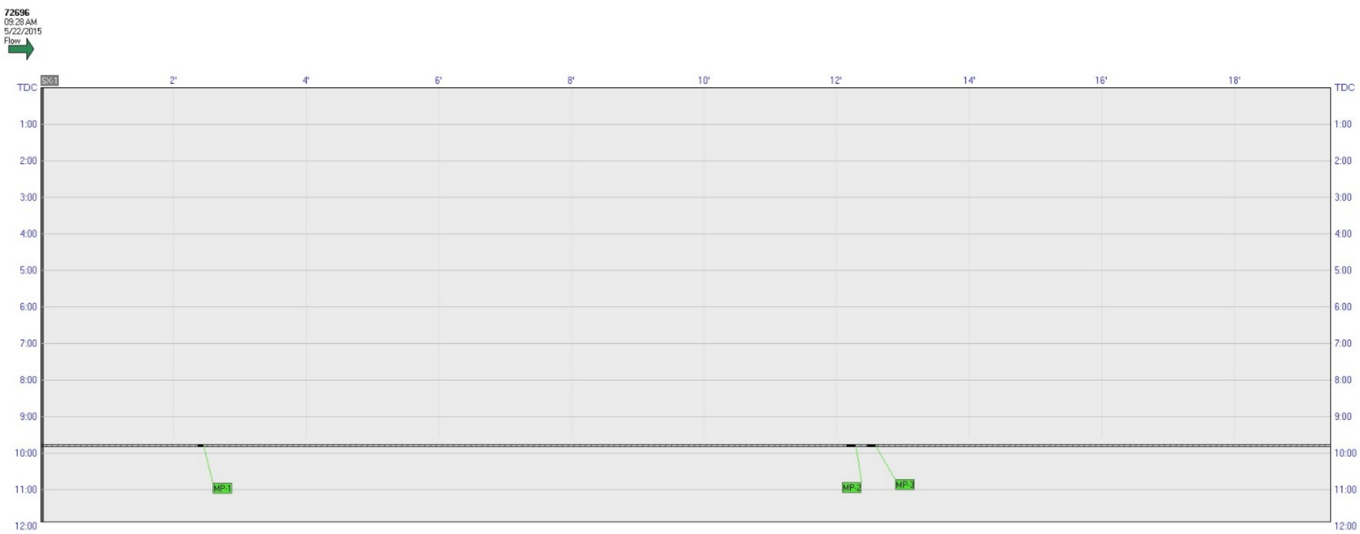
CLIENT Rep. Approved to Proceed with Recoat	N/A	MEARS Foreman Approved to Proceed with Recoat	N/A
Sandblast Media	N/A	Anchor Profile Measurement (mils)	--
Pipe Recoated With	N/A		
Recoat Comments	N/A		
Air Temperature (°F)	--	Pipe Temperature (°F)	--
Time of Day	N/A	Dew Point (°F)	--
Relative Humidity (%)	--	Repair Coating Hardness (if ARC Coating)	--
Measured DFT - 3:00 (mils)	--	Measured DFT - 6:00 (mils)	--
Measured DFT - 9:00 (mils)	--	Measured DFT - 12:00 (mils)	--
Holiday Tested	--	Holiday Test Device Used	N/A
Voltage Used for Holiday Testing (Volts)	--		
Coupon Test Station Installed	N	ETS Installed	N
If Yes, Date Installed	N/A		
Surface Configuration	N/A		
Surface Configuration Comments	N/A		
Backfill Material	N/A		
Backfill Material Comments	N/A		
Coating Protection	N/A		
P/S Reading Over Bell Hole After Backfill (mV)	--		
Post Backfill P/S Reading Comments	N/A		

Magnetic Particle Examination

Magnetic Particle Data Available	**Y**	Examination Date	**5/20/2015**
Test Equipment	**Yoke**	Serial No.	**7693**
Technique	**AC-Continuous**	Test Medium	**Wet-Fluorescent**
Quality Control - Batch #	**13G113**		
Surface Condition	**As Blasted NACE 2**		
Reference GPS: Northing (m)	**N/A**	Easting (m)	**N/A**
Acceptance Criteria	**No indications allowed.**	Mag. Results Accepted	**N**

Magnetic Particle Anomaly Table

Ind. ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Indication	Length (Inches)	Width (Inches)	Local Min. UTT (Inches)	Description/Notes	Image Link
MP-001	29.50	33.25 10:00	Singular	1.00	0.12	0.250		
MP-002	147.75	33.25 10:00	Singular	1.75	0.12	0.256		
MP-003	151.50	33.25 10:00	Singular	1.50	0.12	0.257		



Comments **WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection. (3) MP indications were found within the inspection area.**

Technician Name	**Mike Wilson**	Mears Level	**MT LEV II-Limited**
Assistant	**N/A**	Mears Level	**N/A**

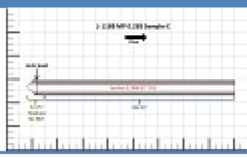
Repair Data

Repair Made	**N**	Number of Repairs Made	**--**
Repair Type	**N/A**	Damage Repaired	**N/A**
Misc. Comments/Information	**N/A**		

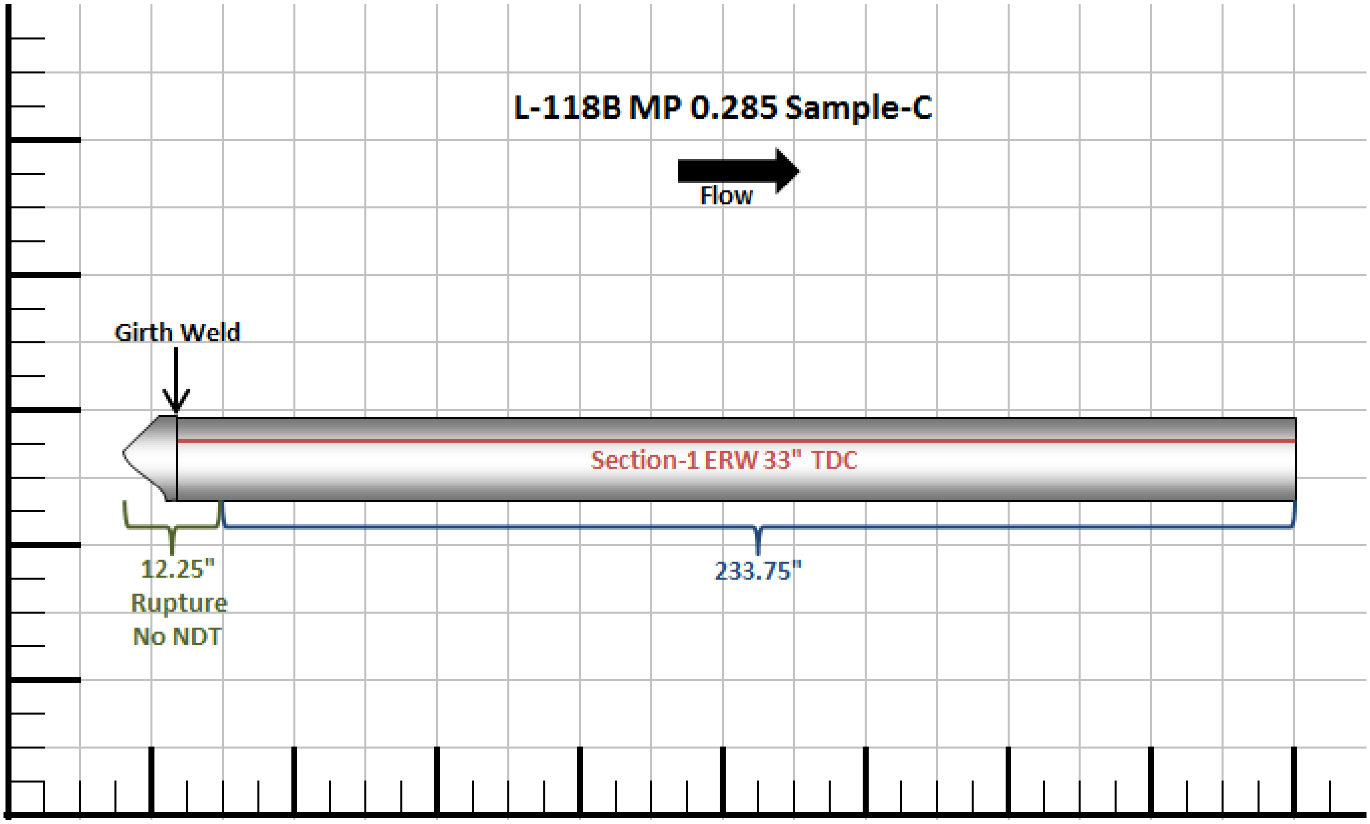
Repair Details

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Repair Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Photo Log

ID	Photo (CTRL-Click for Full Resolution)	Description
037		Excavation Diagram
UTG-001	C:\SQL\Images\Assigned\72696\72696_72696_L118B__C__GRID.CSV	C:\SQL\Images\Assigned\72696\72696_72696_L118B__C__GRID.CSV ' ; Grid Name: L118 (C) GRID; Note: ; Job Name: ; Date: ; Operator: ; Comments:

Excavation Diagram



Site Map

Misc. Information/Comments

	Notes
2015-05-18 KZuker	Provided Inspection Information - ID Sample C Line/Route: 118B, MP 0.285, Nominal Diameter: 12", Nominal WT: 0.250" DE Type: Exponent NDT. Comments: Perform Laser Scan Mapping, NDT, and H-Form Inspections. PE: David Aguiar (DJA4) PC: James Halloway (jameshalloway@gtsinc.us) Work Order Number: 41516466.
2015-05-21 MWilson	This pipe sample was identified as Sample-C. The pipe was in the as found condition with the existing coating removed on 5/18/15, located at the Exponent facility in Menlo Park, CA. A visual inspection of the OD surface did not locate any significant defects prior to sandblast. This sample consists of two pipe sections totaling 246" in length. The upstream edge of inspection starts 12.25" from the furthest upstream point of the rupture. No NDT was performed on the rupture area. An ERW LSW visually confirmed on the ID 33" from TDC for Section-1 identified within the inspection area. This sample was sandblasted for inspection on 5/18/15.
2015-05-21 MWilson	Visual inspection identified a total of (5) Mechanical damages within the inspection area of Sample-C. The most significant in terms of wall loss being MD-002 with a max depth of 0.006", and 2.38% wall loss. (1) External Corrosion feature was visually identified. EC-001 had a max depth of 0.015", and 6.03% wall loss. The Creaform Pipecheck software was used to analyze the External Corrosion features. WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection on 5/20/15. A total of (3) MP indications were found within the inspection area. All MP Indications were visually determined to be interacting with the ERW LSW of Section-1. A 3D surface scan of Sample-C was created on 5/20/15 using the Creaform VXelements software.
2015-05-21 MWilson	Please note that this inspection was performed on a cut out section of pipe, therefore there is a number of N/A fields within the Form H that do not apply to this inspection process.

Form H: Direct Examination Data Sheet
Event 72697 on 118B @0.285 Sample D

PG&E *5/22/2015 12:37:05 PM* Status: 55-QCed

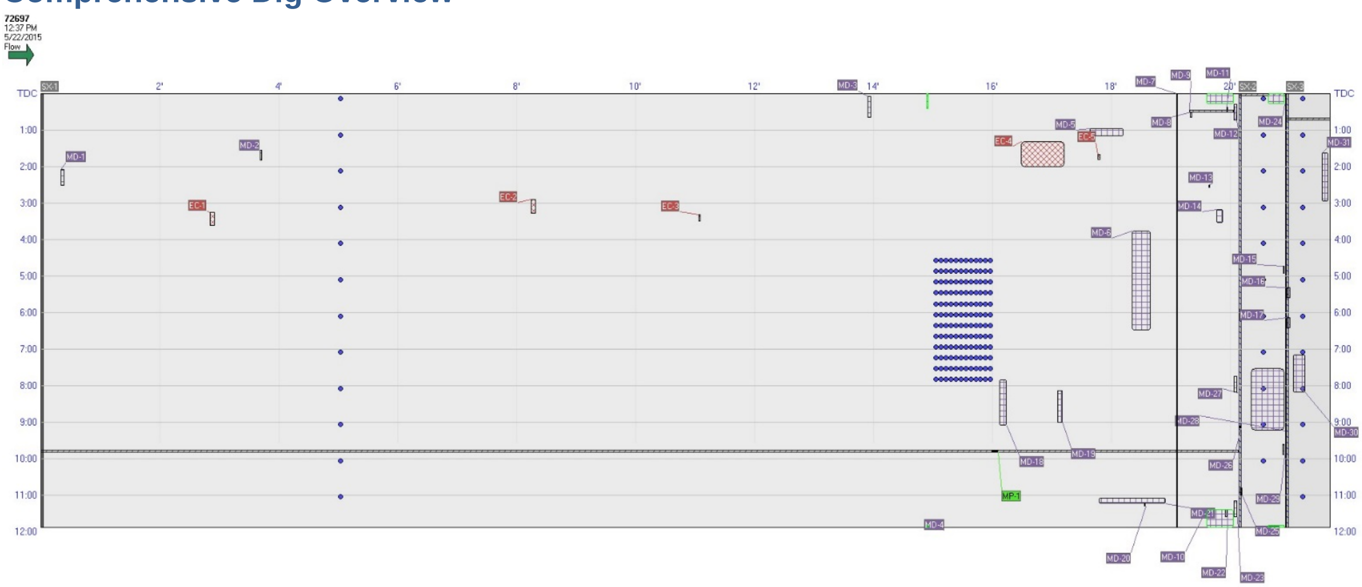
Line # / Position	**118B @0.285 Sample D**	N-Segment	**N/A**	ILI Log Distance	**-- Feet**
Examination Date	**5/18/2015**	IMA Number	**N/A**	RMP-11 Ref. Section	**N/A**
Exam Performed By	**Mike Wilson**	Region Number	**N/A**	Reference Girth Weld	**N/A**
Project Manager	**James Halloway**	Sub # (ICDA)	**N/A**	Dist. From Girth Weld	**-- Feet**
Order Number	**41516466**	Stationing	**N/A**		

Excavation Details

Excavation Priority	**N/A**	Excavation Reason	**N/A**
P/S or CIS reads before excavation (ON) mV	**--**	P/S or CIS (OFF) mV	**--**
PS/CIS Comments	**N/A**		
Planned Inspection Length (Feet)	**--**	Nominal Wall Thickness (Inches)	**0.250**
Actual Inspection Length (Feet)	**21.64**	Nominal Pipe Diameter (Inches)	**12.000**
		SMYS	**--**
Installation Year	**Not Provided**	MAOP	**--**
GPS File Name	**N/A**	Design Factor	**--**

Planned Centerline GPS Coordinates (Based on GIS):	Northing (m)	**N/A**
	Easting (m)	**N/A**
Planned Centerline GPS Coordinates (Based on GIS):	Latitude	**N/A**
	Longitude	**N/A**
Centerline GPS Coordinates (Uncorrected Field Measurement):	Northing (m)	**N/A**
	Easting (m)	**N/A**
Centerline GPS Coordinates (Corrected Field Measurement):	Northing (m)	**N/A**
	Easting (m)	**N/A**

Comprehensive Dig Overview



Prior To Coating Removal

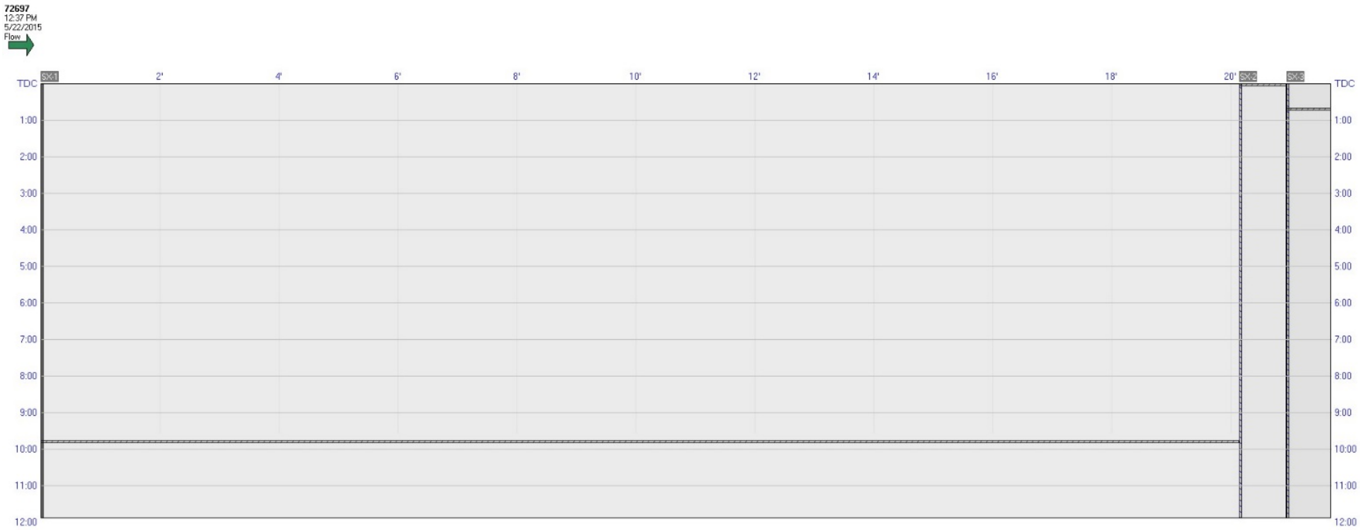
Site Data

Evidence of Encroachment	N		
Encroachment Comments	N/A		
Primary Native Soil Type	N/A	Mixed Soil Types Explanation	N/A
Backfill Material as found	N/A	Depth of Cover (Feet)	--
Backfill Comments	N/A		
Is Rock Shield present?	N		
Coating Type	N/A	Additional Coatings Found	N/A
Coating Type Comments	N/A		
Coating Thickness (Mils)	--	Number of Coating Layers	--
Holiday Testing Performed	N	Holiday Testing Voltage Used VOLTS	--
Holiday Testing Device Used	N/A		
Holiday Testing Comments	N/A		
Soil Sample Location	N/A		
Location notes	N/A		
Ground Water Present	N	Sample Collected	N
Sample pH	--		
Coating Conditions	N/A		
Coating Condition Comments	N/A		
Coating Degradation Map Zero Reference Point	N/A	Photos Taken	Y
Coating Sample Taken	N	Location of Coating Sample	N/A
Liquid Underneath Coating	N	If Yes, pH of Liquid	--
Corrosion Product Present	N	If Yes, Corrosion Sample Taken	N
Comments	N/A		
Soil pH (Sb Electrode) U/S	--	Soil pH (Sb Electrode) D/S	--

Coating Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Map of Coating Degradation



P/S Potential Measurements

Pipe to Soil Potential in Ditch (mV)-Upstream	--
Pipe to Soil Potential in Ditch (mV)-Downstream	--
Pipe to Soil Potential in Ditch (mV) Comments	N/A

Soil Resistivity

4-Pin Multiplier	--	Soil Box Multiplier	--
4-Pin Ohms	--	Soil Box Ohms	--
4-Pin Spacing Distance in Feet	--		
4-Pin Resistivity	--	Soil Box Resistivity	--
Soil Resistivity Comments	N/A		

Data After Coating Removal

Pipe Temperature (°F)	69.9	Measured Pipe Diameter (Inches)	12.818
Girth Weld Coordinates:		Measured Pipe Circumference (Inches)	40.25
Northing (m)	N/A	Easting (m)	N/A
Girth Weld Elevation (m)	--		
Corrosion Damage	Y	Mechanical Damage	Y
Other Damage Notes	None.		
Wet Fluorescent Mag. Part. Test Performed?	Y	Were there any linear indications?	Y
WFMT Comments	Performed by Mike Wilson (Mears) on 5/20/15.		

Pipe Sections

ID	Weld Location (Inches from Ref.)	Long Seam (Inches from TDC)	Seam Type	Circumference (Inches)	Nominal Wall (Inches)	Description/Notes
SX-001	0.00	33 9:45	ERW	40.25	0.250	Straight pipe, 241.5" long
SX-002	241.50		N/A	40.25	0.250	20 degree elbow, 9.5" long
SX-003	251.00	2.25 12:45	ERW	40.25	0.250	Straight pipe, 8.75" long

UT - Section O'Clocks (UTC)

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	UT Thickness (Inches)	UT Section / O'Clock Position
SX-001	60.00	0.00	0.256	UT Wall Thickness-TDC
SX-001	60.00	3.35	0.255	UT Wall Thickness-1 O'clock
SX-001	60.00	6.71	0.255	UT Wall Thickness-2 O'clock
SX-001	60.00	10.06	0.254	UT Wall Thickness-3 O'clock
SX-001	60.00	13.42	0.256	UT Wall Thickness-4 O'clock
SX-001	60.00	16.77	0.255	UT Wall Thickness-5 O'clock
SX-001	60.00	20.13	0.255	UT Wall Thickness-6 O'clock
SX-001	60.00	23.48	0.254	UT Wall Thickness-7 O'clock
SX-001	60.00	26.83	0.254	UT Wall Thickness-8 O'clock
SX-001	60.00	30.19	0.254	UT Wall Thickness-9 O'clock
SX-001	60.00	33.54	0.262	UT Wall Thickness-10 O'clock
SX-001	60.00	36.90	0.256	UT Wall Thickness-11 O'clock
SX-002	246.00	0.00	0.425	SX-002 UT Wall Thickness-TDC
SX-002	246.00	3.35	0.428	SX-002 UT Wall Thickness-1 O'clock
SX-002	246.00	6.71	0.409	SX-002 UT Wall Thickness-2 O'clock
SX-002	246.00	10.06	0.411	SX-002 UT Wall Thickness-3 O'clock
SX-002	246.00	13.42	0.407	SX-002 UT Wall Thickness-4 O'clock
SX-002	246.00	16.77	0.397	SX-002 UT Wall Thickness-5 O'clock
SX-002	246.00	20.13	0.363	SX-002 UT Wall Thickness-6 O'clock
SX-002	246.00	23.48	0.377	SX-002 UT Wall Thickness-7 O'clock
SX-002	246.00	26.83	0.385	SX-002 UT Wall Thickness-8 O'clock
SX-002	246.00	30.19	0.407	SX-002 UT Wall Thickness-9 O'clock
SX-002	246.00	33.54	0.393	SX-002 UT Wall Thickness-10 O'clock
SX-002	246.00	36.90	0.400	SX-002 UT Wall Thickness-11 O'clock
SX-003	254.00	0.00	0.253	SX-003 UT Wall Thickness-TDC
SX-003	254.00	3.35	0.254	SX-003 UT Wall Thickness-1 O'clock
SX-003	254.00	6.71	0.254	SX-003 UT Wall Thickness-2 O'clock
SX-003	254.00	10.06	0.254	SX-003 UT Wall Thickness-3 O'clock
SX-003	254.00	13.42	0.255	SX-003 UT Wall Thickness-4 O'clock
SX-003	254.00	16.77	0.257	SX-003 UT Wall Thickness-5 O'clock
SX-003	254.00	20.13	0.256	SX-003 UT Wall Thickness-6 O'clock
SX-003	254.00	23.48	0.255	SX-003 UT Wall Thickness-7 O'clock
SX-003	254.00	26.83	0.256	SX-003 UT Wall Thickness-8 O'clock
SX-003	254.00	30.19	0.255	SX-003 UT Wall Thickness-9 O'clock
SX-003	254.00	33.54	0.254	SX-003 UT Wall Thickness-10 O'clock
SX-003	254.00	36.90	0.253	SX-003 UT Wall Thickness-11 O'clock

Form H: Direct Examination Data Sheet
Event 72697 on 118B @0.285 Sample D

PG&E *5/22/2015 12:37:05 PM* Status: 55-QCed

Mechanical Damage

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Damage Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
MD-001	4.00	7 2:00	Scrape	0.75	1.50	0.002	0.79% wall loss	
MD-002	44.25	5.25 1:30	Scrape	0.50	1.00	0.006	2.36% wall loss	
MD-003	166.75	0.25 12:00	Scrape	0.75	2.00	0.007	2.77% wall loss	
MD-004	178.50	40 12:00	Scrape	0.50	1.75	0.006	2.37% wall loss	
MD-005	211.50	3.25 1:00	Gouge	6.75	0.75	0.011	4.35% wall loss	
MD-006	220.00	12.75 3:45	Scrape	3.75	9.25	0.007	2.76% wall loss	
MD-007	229.00	0 12:00	Scrape	0.25	40.25	0.003	1.19% wall loss	
MD-008	231.75	1.75 12:30	Arc Burn	0.50	0.50	0.007	2.77% measurable wall loss	
MD-009	231.50	1.5 12:30	Scrape	9.00	0.25	0.003	1.19% measureable wall loss	
MD-010	235.00	38.5 11:30	Gouge	5.50	2.75	0.017	6.70% wall loss	
MD-011	239.00	1.25 12:15	Arc Burn	0.25	0.50	0.008	3.16% measurable wall loss	
MD-012	240.50	1 12:15	Arc Burn	0.75	1.50	0.007	2.77% measurable wall loss	
MD-013	235.50	8.5 2:30	Arc Burn	0.25	0.25	0.006	2.36% measureable wall loss	
MD-014	237.00	10.75 3:15	Scrape	1.25	1.25	0.002	0.79% wall loss	
MD-015	250.50	16 4:45	Arc Burn	0.25	0.75	0.009	2.37% measureable wall loss	
MD-016	251.25	18 5:15	Arc Burn	0.75	1.00	0.023	8.91% measureable wall loss	
MD-017	251.25	20.75 6:15	Arc Burn	0.75	1.00	0.017	6.64% measureable wall loss	
MD-018	194.75	30.75 9:15	Scrape	1.50	4.25	0.005	1.94% wall loss	
MD-019	206.00	30.5 9:00	Scrape	1.00	3.00	0.003	1.17% wall loss	
MD-020	222.75	38.25 11:30	Gouge	0.25	0.25	0.008	3.15% wall loss	
MD-021	226.75	38 11:15	Scrape	13.50	0.50	0.003	1.18% wall loss	
MD-022	239.25	39.25 11:45	Arc Burn	0.50	0.75	0.035	13.67% measureable wall loss	
MD-023	241.25	39.25 11:45	Arc Burn	0.75	1.50	0.005	1.96% measureable wall loss	
MD-024	250.75	1 12:15	Scrape	3.25	1.25	0.004	0.97% wall loss	
MD-025	242.25	37.25 11:00	Arc Burn	0.50	0.75	0.005	1.26% measureable wall loss	
MD-026	242.00	31 9:15	Arc Burn	0.25	0.25	0.004	0.98% %measureable wall loss	
MD-027	241.25	27.75	Arc Burn	0.75	1.50	0.009	3.52%	

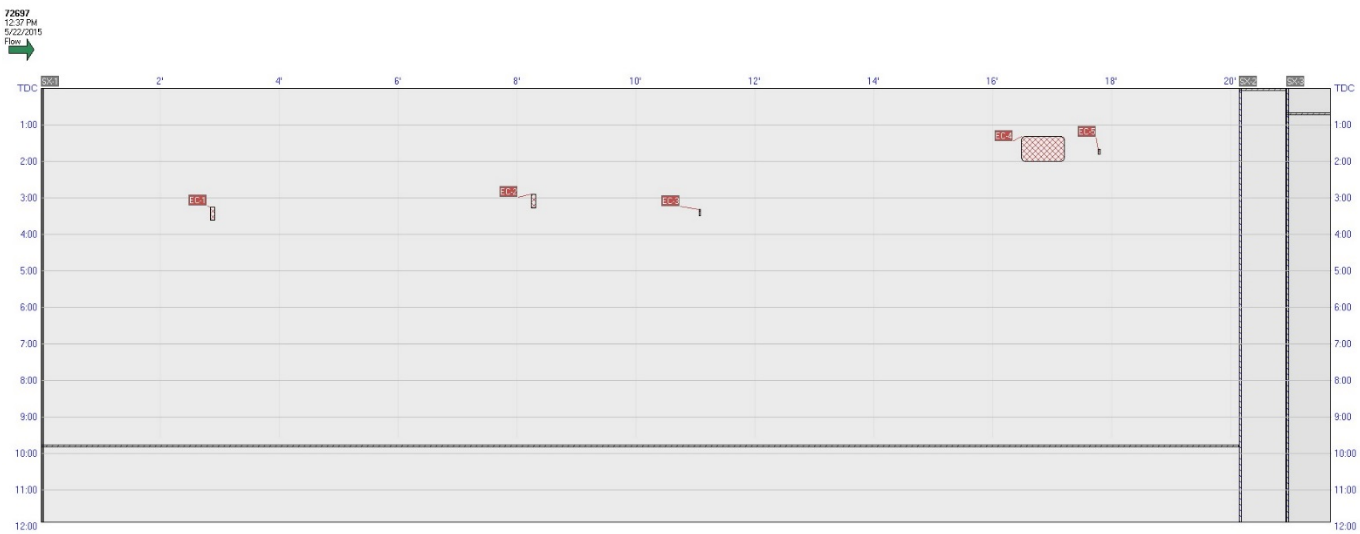
		8:15					measureable wall loss
MD-028	250.75	31.25 9:15	Scrape	6.75	5.75	0.004	1.10% wall loss
MD-029	250.75	33.5 10:00	Arc Burn	0.50	1.00	0.006	1.48% measureable wall loss
MD-030	255.00	27.75 8:15	Scrape	2.50	3.50	0.005	1.97% wall loss
MD-031	258.25	5.5 1:45	Scrape	1.25	4.50	0.006	2.36% wall loss

Map of Mechanical Damage

External Corrosion Mapping

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Type	Length (Inches)	Width (Inches)	Max Depth (Inches)	Description/Notes	Image Link
EC-001	34.07	10.98 3:15	General	0.94	1.24	0.008	3.00% wall loss	
EC-002	98.84	9.8 3:00	General	1.00	1.35	0.024	9.64% wall loss	
EC-003	132.56	11.22 3:15	General	0.47	0.65	0.012	4.80% wall loss	
EC-004	197.63	4.42 1:15	General	8.79	2.36	0.010	3.95% wall loss	
EC-005	212.99	5.66 1:45	General	0.53	0.53	0.025	9.84% wall loss	

Map of Corroded Area



External Pit Depth

EC-001	Explanation
Details Not Provided - Max Depth: 0.008	3.00% wall loss

EC-002	Explanation
Details Not Provided - Max Depth: 0.024	9.64% wall loss

EC-003	Explanation
Details Not Provided - Max Depth: 0.012	4.80% wall loss

EC-004	Explanation
Details Not Provided - Max Depth: 0.01	3.95% wall loss

EC-005	Explanation
Details Not Provided - Max Depth: 0.025	9.84% wall loss

MD-001	Explanation
Details Not Provided - Max Depth: 0.002	0.79% wall loss

MD-002	Explanation
Details Not Provided - Max Depth: 0.006	2.36% wall loss

MD-003	Explanation
Details Not Provided - Max Depth: 0.007	2.77% wall loss

MD-004	Explanation
Details Not Provided - Max Depth: 0.006	2.37% wall loss

MD-005	Explanation
Details Not Provided - Max Depth: 0.011	4.35% wall loss

MD-006	Explanation
Details Not Provided - Max Depth: 0.007	2.76% wall loss

MD-007	Explanation
Details Not Provided - Max Depth: 0.003	1.19% wall loss

MD-008	Explanation
Details Not Provided - Max Depth: 0.007	2.77% measurable wall loss

MD-009	Explanation
Details Not Provided - Max Depth: 0.003	1.19% measureable wall loss

MD-010	Explanation
Details Not Provided - Max Depth: 0.017	6.70% wall loss

MD-011	Explanation
Details Not Provided - Max Depth: 0.008	3.16% measurable wall loss

MD-012	Explanation
Details Not Provided - Max Depth: 0.007	2.77% measurable wall loss

MD-013	Explanation
Details Not Provided - Max Depth: 0.006	2.36% measureable wall loss

MD-014	Explanation
Details Not Provided - Max Depth: 0.002	0.79% wall loss

MD-015	Explanation
Details Not Provided - Max Depth: 0.009	2.37% measureable wall loss

MD-016	Explanation
Details Not Provided - Max Depth: 0.023	8.91% measureable wall loss

MD-017	Explanation
Details Not Provided - Max Depth: 0.017	6.64% measureable wall loss

MD-018	Explanation
Details Not Provided - Max Depth: 0.005	1.94% wall loss

MD-019	Explanation
Details Not Provided - Max Depth: 0.003	1.17% wall loss

MD-020	Explanation
Details Not Provided - Max Depth: 0.008	3.15% wall loss

MD-021	Explanation
Details Not Provided - Max Depth: 0.003	1.18% wall loss

MD-022	Explanation
Details Not Provided - Max Depth: 0.035	13.67% measureable wall loss

MD-023	Explanation
Details Not Provided - Max Depth: 0.005	1.96% measureable wall loss

MD-024	Explanation
Details Not Provided - Max Depth: 0.004	0.97% wall loss

MD-025	Explanation
Details Not Provided - Max Depth: 0.005	1.26% measureable wall loss

MD-026	Explanation
Details Not Provided - Max Depth: 0.004	0.98% %measureable wall loss

MD-027	Explanation
Details Not Provided - Max Depth: 0.009	3.52% measureable wall loss

MD-028	Explanation
Details Not Provided - Max Depth: 0.004	1.10% wall loss

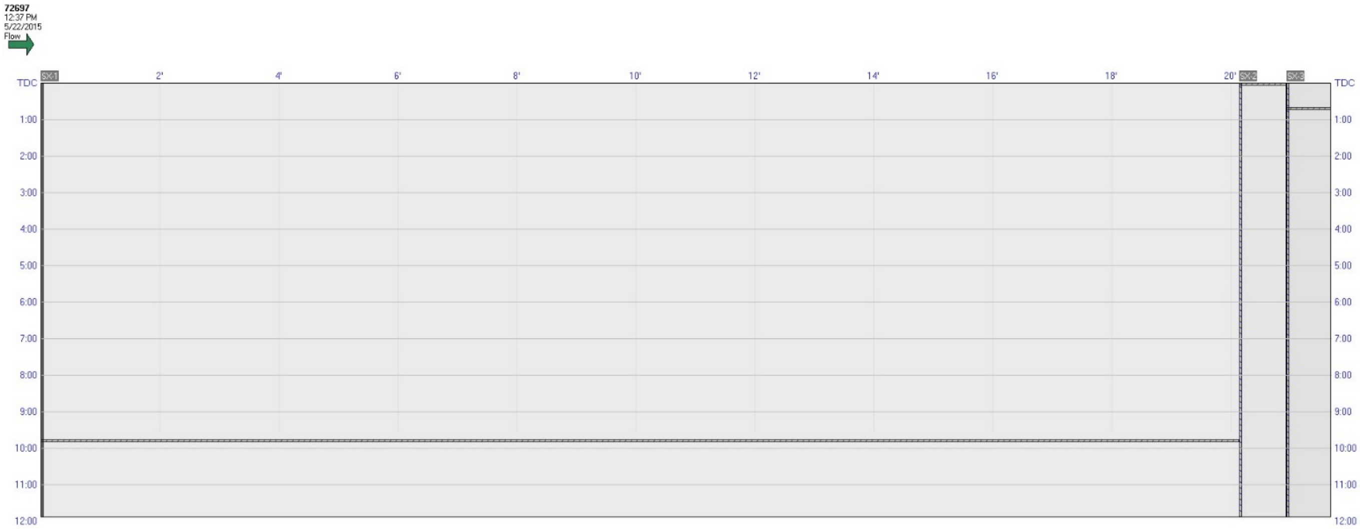
MD-029	Explanation
Details Not Provided - Max Depth: 0.006	1.48% measureable wall loss

MD-030	Explanation
Details Not Provided - Max Depth: 0.005	1.97% wall loss

MD-031	Explanation
Details Not Provided - Max Depth: 0.006	2.36% wall loss

MP-001	Explanation
Details Not Provided - Max Depth: 0.254	

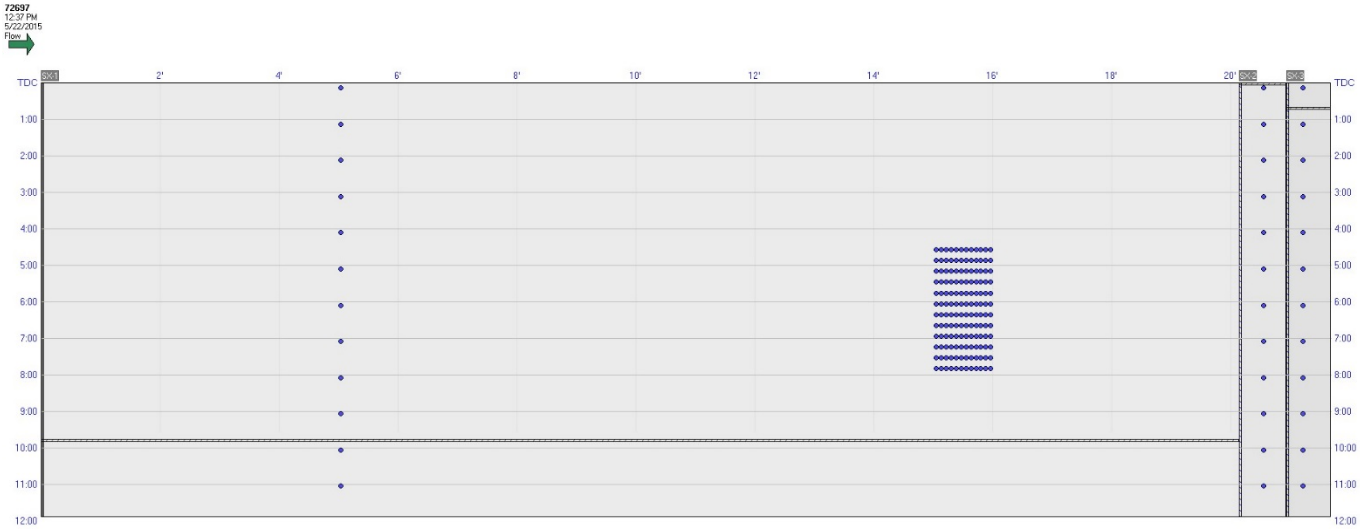
External Pit Depth Measurement Grids



UT - Internal Corrosion Grid (UTG)

Axial Location (Inches from Ref.)	Circ. Location (Inches/Clock from TDC)	UTT Column Minimum (Inches)	UTT Column Average (Inches)	UTT Column Maximum (Inches)
180.00	15.00 to 26.00	0.253	0.255	0.256
181.00	15.00 to 26.00	0.252	0.255	0.256
182.00	15.00 to 26.00	0.253	0.255	0.256
183.00	15.00 to 26.00	0.253	0.255	0.256
184.00	15.00 to 26.00	0.252	0.254	0.255
185.00	15.00 to 26.00	0.253	0.254	0.256
186.00	15.00 to 26.00	0.253	0.255	0.257
187.00	15.00 to 26.00	0.253	0.255	0.256
188.00	15.00 to 26.00	0.253	0.255	0.257
189.00	15.00 to 26.00	0.253	0.255	0.257
190.00	15.00 to 26.00	0.254	0.255	0.256
191.00	15.00 to 26.00	0.253	0.255	0.256

UTGrid	1	2	3	4	5	6	7	8	9	10	11	12
A	0.254	0.255	0.256	0.254	0.255	0.255	0.254	0.255	0.255	0.254	0.255	0.256
B	0.255	0.256	0.256	0.256	0.254	0.254	0.255	0.255	0.255	0.255	0.255	0.254
C	0.256	0.255	0.254	0.255	0.255	0.256	0.254	0.256	0.254	0.255	0.255	0.255
D	0.255	0.256	0.256	0.255	0.255	0.255	0.257	0.256	0.256	0.256	0.255	0.256
E	0.255	0.255	0.255	0.254	0.254	0.255	0.256	0.254	0.254	0.255	0.254	0.254
F	0.254	0.253	0.253	0.254	0.253	0.253	0.253	0.255	0.255	0.255	0.255	0.254
G	0.254	0.254	0.255	0.253	0.252	0.253	0.253	0.253	0.253	0.253	0.254	0.254
H	0.256	0.254	0.255	0.256	0.255	0.255	0.256	0.256	0.257	0.257	0.256	0.256
I	0.256	0.256	0.255	0.255	0.255	0.255	0.256	0.256	0.256	0.255	0.256	0.255
J	0.255	0.255	0.255	0.254	0.255	0.256	0.253	0.255	0.256	0.253	0.254	0.256
K	0.255	0.252	0.254	0.253	0.252	0.254	0.254	0.254	0.253	0.254	0.255	0.254
L	0.253	0.253	0.254	0.255	0.254	0.253	0.254	0.254	0.255	0.255	0.255	0.253



Recoat Data

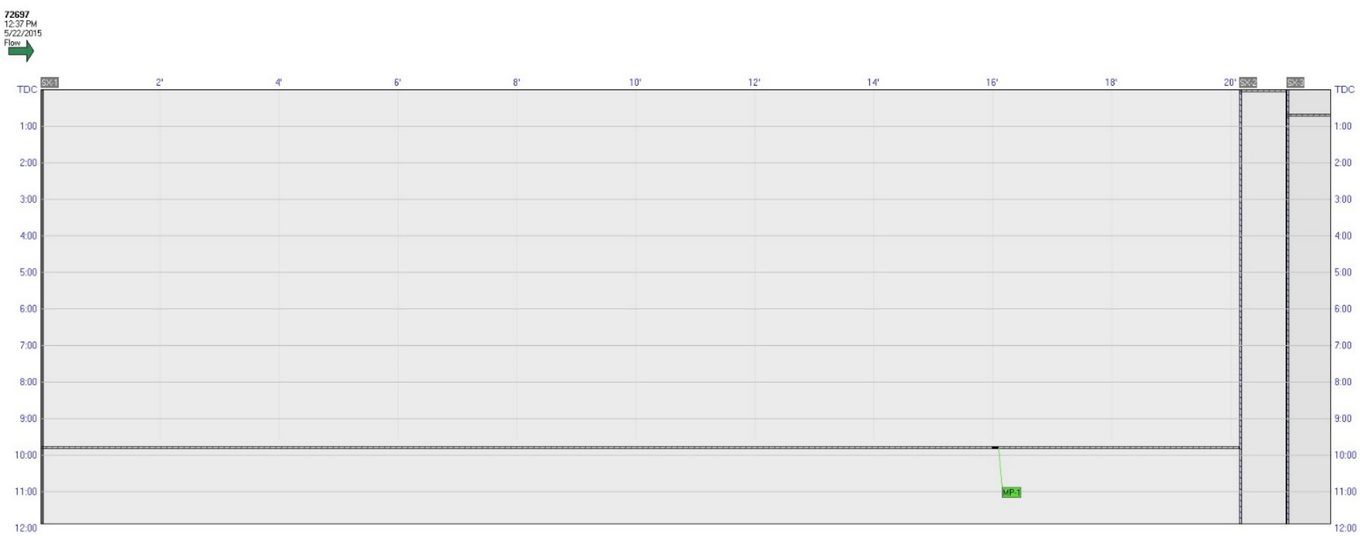
CLIENT Rep. Approved to Proceed with Recoat	N/A	MEARS Foreman Approved to Proceed with Recoat	N/A
Sandblast Media	N/A	Anchor Profile Measurement (mils)	--
Pipe Recoated With	N/A		
Recoat Comments	N/A		
Air Temperature (°F)	--	Pipe Temperature (°F)	--
Time of Day	N/A	Dew Point (°F)	--
Relative Humidity (%)	--	Repair Coating Hardness (if ARC Coating)	--
Measured DFT - 3:00 (mils)	--	Measured DFT - 6:00 (mils)	--
Measured DFT - 9:00 (mils)	--	Measured DFT - 12:00 (mils)	--
Holiday Tested	N	Holiday Test Device Used	N/A
Voltage Used for Holiday Testing (Volts)	--		
Coupon Test Station Installed	N	ETS Installed	N
If Yes, Date Installed	N/A		
Surface Configuration	N/A		
Surface Configuration Comments	N/A		
Backfill Material	N/A		
Backfill Material Comments	N/A		
Coating Protection	N/A		
P/S Reading Over Bell Hole After Backfill (mV)	--		
Post Backfill P/S Reading Comments	N/A		

Magnetic Particle Examination

Magnetic Particle Data Available	Y	Examination Date	5/20/2015
Test Equipment	Yoke	Serial No.	7693
Technique	AC-Continuous	Test Medium	Wet-Fluorescent
Quality Control - Batch #	13G113		
Surface Condition	As Blasted NACE 2		
Reference GPS: Northing (m)	N/A	Easting (m)	N/A
Acceptance Criteria	No indications allowed.	Mag. Results Accepted	N

Magnetic Particle Anomaly Table

Ind. ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Indication	Length (Inches)	Width (Inches)	Local Min. UTT (Inches)	Description/Notes	Image Link
MP-001	193.00	33.25 10:00	Singular	1.25	0.12	0.254		



Comments **WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection. (1) MP indication was found within the inspection area.**

Technician Name	Mike Wilson	Mears Level	MT LEV II-Limited
Assistant	N/A	Mears Level	N/A

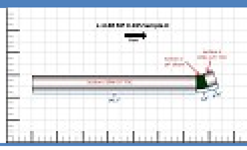
Repair Data

Repair Made	**N**	Number of Repairs Made	**--**
Repair Type	**N/A**	Damage Repaired	**N/A**
Misc. Comments/Information	**N/A**		

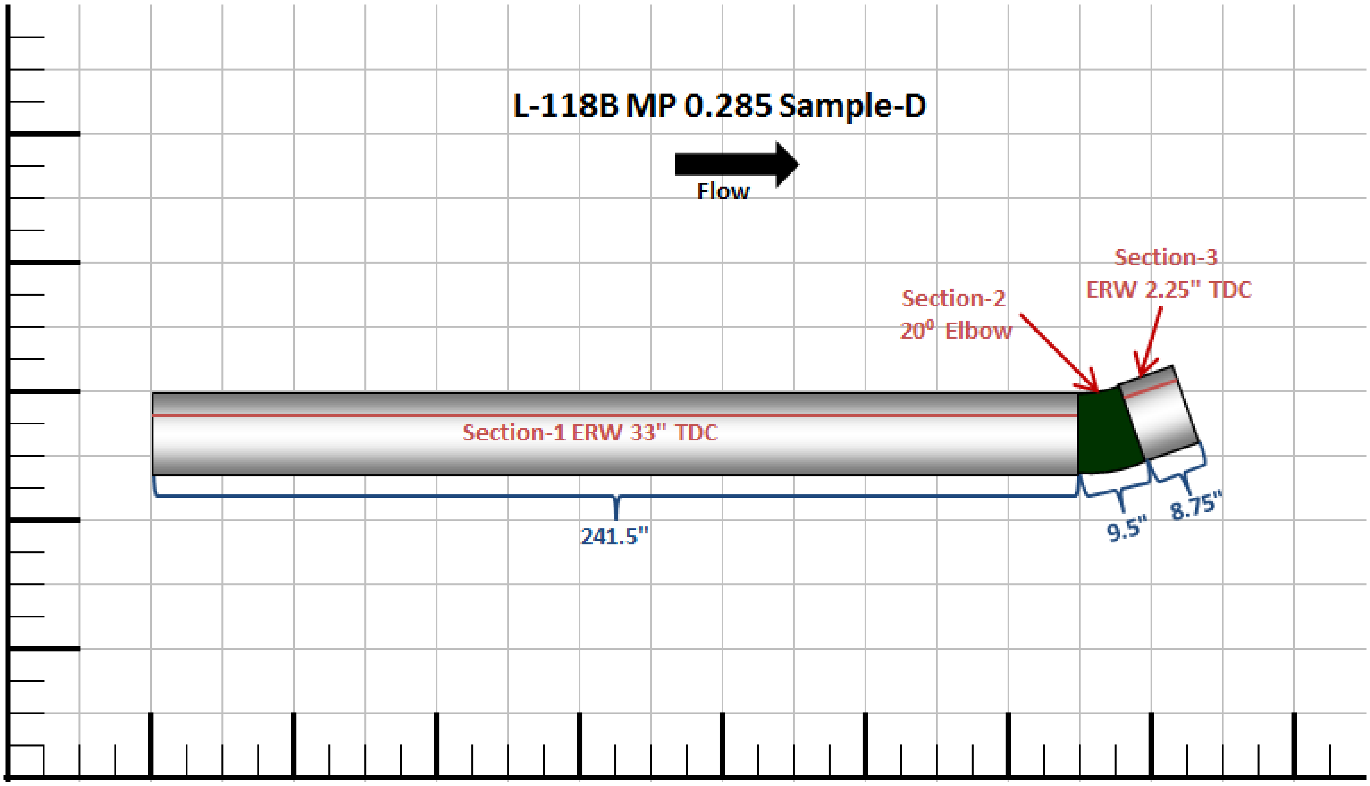
Repair Details

ID	Axial Location (Inches from Ref.)	Circ. Location (Inches from TDC)	Repair Type	Length (Inches)	Width (Inches)	Description/Notes	Image Link

Photo Log

ID	Photo (CTRL-Click for Full Resolution)	Description
037		Excavation Diagram
UTG-001	C:\SQL\Images\Assigned\72697\72697_72697_L118B__D__GRID.CSV	C:\SQL\Images\Assigned\72697\72697_72697_L118B__D__GRID.CSV ' ; Grid Name: L118B (D) GRID; Note: ; Job Name: ; Date: ; Operator: ; Comments:

Excavation Diagram



Site Map

Misc. Information/Comments

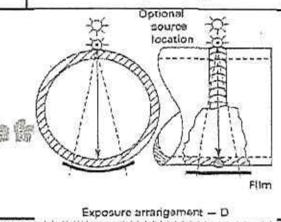
	Notes
2015-05-18 KZuker	Provided Inspection Information - ID Sample D Line/Route: 118B, MP 0.285, Nominal Diameter: 12", Nominal WT: 0.250" DE Type: Exponent NDT. Comments: Perform Laser Scan Mapping, NDT, and H-Form Inspections. PE: David Aguiar (DJA4) PC: James Halloway (jameshalloway@gtsinc.us) Work Order Number: 41516466.
2015-05-21 MWilson	This pipe sample was identified as Sample-D. The pipe was in the as found condition with the existing coating removed on 5/18/15, located at the Exponent facility in Menlo Park, CA. A visual inspection of the OD surface did not locate any significant defects prior to sandblast. This sample consists of three pipe sections totaling 259.75" in length. Section-1 is straight pipe 241.5" long with an ERW LSW visually identified from the ID 33" from TDC, Section-2 is a 20 degree elbow with an extrados measurement of 9.5", and intrados measurement of 4.5". Section-3 is straight pipe 8.75" long with an ERW LSW visually identified from the ID 2.25" from TDC. This sample was sandblasted for inspection on 5/18/15.
2015-05-21 MWilson	Visual inspection identified a total of (31) Mechanical damages within the inspection area of Sample-D. The most significant in terms of wall loss being MD-022 with a max depth of 0.035", and 13.67% wall loss. (5) External Corrosion features were visually identified. EC-005 was the most significant in terms of wall loss with a max depth of 0.025", and 9.84% wall loss. The Creaform Pipecheck software was used to analyze the External Corrosion features. WFMT was performed in accordance with Mears Procedure MPE-01 Rev.6, full circumference for the entire length of inspection on 5/20/15. A total of (1) MP indication was found within the inspection area. MP-001 was visually determined to be interacting with the ERW LSW of Section-1. A 3D surface scan of Sample-B was created on 5/21/15 unsing the Creaform VXelements software.
2015-05-21 MWilson	Please note that this inspection was performed on a cut out section of pipe, therefore there is a number of N/A fields within the Form H that do not apply to this inspection process.

Appendix B

Radiograph Film Summary

Radiographic Technique and Examination Report

Project Information		Radiographic Technique & Processing								PAGE 1 OF 2	
Report Date	4/21/2015	Material Type	CS	IQI Type	ASTM 1B	Qty of IQI(s)	3	Developer Time	5 Min.		
NDE Job No.	L-118B	Pipe Diameter or component type	12"	Placement	Across Weld	Xray (KV/MA)	N/A	Developer Temperature	68	Drying	Open Air
CWA No.	Fresno Incident	Wall Thk + Reinf.	.250/.125	Source Side	Shim N/A	Source & Curies	IR 192 / 70ci	Shooting Sketch Area. Sketch, photo paste, or enter Standard Shooting Technique A-G:_____			
NDE Vendor	JANX	Grade	CS	Film Side	X Shim N/A	Focal Spot Sz (F)	0.149				
Project ID	L-118B	Object-Film Distance (D)	0.313"	Src.-Obj.Dist	12.437"	Exp Time	0:50				
Project Order No.	31148998	Geometric Unsharpness (Ug) [(F*d)/D]	0.003		Essential Wire/Hole		0.010				
Line No.	L-118B	Screen Type	Pb	Thk. Front	0.005"	Thk. Int. N/A	Thk. Back 0.005"				
City	Fresno , CA	Film Manufacturer	AGFA	Speed	D5	Film Size	70 mm				
Mile Point	N/A	Exp. (Sgl./Double)	D	Viewing (Sgl./Dbl.)	S	Film Load (single/multiple)	Single D5				
Construction Org	PG&E GC/GT	Reference Markers & Interval (inches)		Pb / 3" / 0-A , A-B , B-0				Procedure	RT-1-PG&E	Rev.	Rev. 1
		Heat shield (Y/N)	N	Heat shield info.	N/A			Acceptance Criteria	API 1104	Rev.	20th



Component Numbers	Weld Number	Welder Identification Number	View(s)*	PM/IQI Density	Weld Density	Original / Repair/Reshoot	Accept	Reject	Incomp Pen Without Hi-Lo (IP)	Inc. Pen Hi-Lo (IPD)	Inadeq. Cross Pen (ICP)	Incomplete Fusion (IF)	I F Due To Cold Lap (IFD)	Internal Concavity (IC)	Burn Through (BT)	Elong Slag Inclusion (ESI)	Isolated Slag Inclusion (ISI)	Individual or Scattered Porosity (P)	Cluster Porosity (CP)	Hollow Bead Porosity (HB)	Crack (C)	External Undercut (EU)	Internal Undercut (IU)	Accum. of Imperfections (AI)	Pipe / Fitting Imperfections	Excessive Pen (EP)	Film Artifacts	Remarks For each discontinuity type in view, grade severity under each category as follows: 1) Light, 2) Medium, 3) Rejectable
N/A	W 1	N/A	0-A	2.7	2.3	O		X		3						1		1										IPD 1-6
			A-B	2.7	2.3	O		X		3						3		3										ESI 13-16,18 , IPD16.5-19.5 , P 21.25
			B-0	2.7	2.3	O		X		3								2		1								IPD 37.5-38.5
N/A	W 2	N/A	0-A	2.7	2.3	O		X		3								3	3									IPD 10-13 , CP 1-2 , P @ 7
			A-B	2.7	2.3	O		X		3					2	2		2										IPD 13-20,21-27
			B-0	2.7	2.3	O		X		3						1		2										IPD 27-37.5
N/A	W 3	N/A	0-A	2.7	2.3	O		X	1						3	2		3		1	3							CR @ 8 , P 2-5 , BT @3
			A-B	2.7	2.3	O		X							3	1		3		1								P@21 , BT@21
			B-0	2.7	2.3	O	X		1									1										
N/A	W 4	N/A	0-A	2.7	2.3	O		X		1						2	2		3									CP 10-12
			A-B	2.7	2.3	O		X								3		2										ESI 13-16.5,@19,21-22.5,@25.5
			B-0	2.7	2.3	O		X		3										2								IPD 31.5-39

Comments:

Radiographer - I Certify that each radiograph was exposed, processed and Interpreted in accordance with the applicable procedure, code and standard.

Radiographer Name: Martin Hudgens   Radiographer Signature: [signature]   Level: II   PG&E End. No.: 1009   Date: 4/21/2015

Radiographer Assistant: Shawn Hannahs   Radiographer Asst. Signature: [signature]   Level: I   PG&E End. No.: N/A   Date: 4/21/2015

PG&E Representative: DON HENDRIX   PG&E Representative Signature: [signature]   LAN ID: DPH8   Stencil No.: ______   Date: 4/21/2015

Radiographic Technique and Examination Report - *Continuation - (Note: NOT ACCEPTABLE WITHOUT TECHNIQUE FOR EACH JOINT TYPE)*

Form: GO-TS-001-F1-RT

Project Information — PAGE 2 OF 2

Report Date	4/21/2015	NDE Job No.	31148998	CWA No.	Fresno Incident	NDE Vendor	JANX
Project ID & Project Order No.	Fresno Incident L-118B						
Line No.	L-118B	City	Fresno,CA	Mile Point	N/A	Construction Org	PG&E GC / GT

Image Details				Density		Weld Discontinuity Details																					
Component Numbers	Weld Number	Welder Identification Number	View(s)		Weld Density	Original / Repair/Reshoot	Accept	Reject	Incomp Pen Without Hi-Lo (IP)	Inc. Pen Hi-Lo (IPD)	Inadeq. Cross Pen (ICP)	Incomplete Fusion (IF)	I F Due To Cold Lap (IFD)	Internal Concavity (IC)	Burn Through (BT)	Elong Slag Inclusion (ESI)	Isolated Slag Inclusion (ISI)	Individual or Scattered Porosity (P)	Cluster Porosity (CP)	Hollow Bead Porosity (HB)	Crack (C)	External Undercut (EU)	Internal Undercut (IU)	Accum. of Imperfections (AI)	Pipe / Fitting Imperfections	Excessive Pen (EP)	Film Artifacts	Remarks For each discontinuity type in view, grade severity under each category as follows: 1) Light, 2) Medium, 3) Rejectable
N/A	W 5	N/A	0-A	2.7	2.3	Original /		X		2						3		3										P@11 , ESI 8.5-12.5
			A-B	2.7	2.3	Original /	X									2		2										
			B-0	2.7	2.3	Original /	X			1					2	2		2										

Comments:

Radiographer - I Certify that each radiograph was exposed, processed and Interpreted in accordance with the applicable procedure, code and standard.

Level II RT Name:	Martin Hudgens	Level II RT Signature:	[signature]	Level: II	PG&E End. No.:	1009	Date:	4/21/2015
Radiographer Assistar	Shawn Hannahs	Radiographer Asst. Signature:	[signature]	Level: I	PG&E End. No.:	N/A	Date:	4/21/2015
PG&E Representative	DON HENDRIX	PG&E Representative Signature:	[signature]	LAN ID: DPH8	Stencil No.:		Date:	4/21/2015

Appendix C

Anamet Mechanical and Chemical Testing Report

Anamet, inc

June 30, 2015

LABORATORY NUMBER:	5005.1891
CUSTOMER AUTHORIZATION:	Project 1502991.000
DATE SUBMITTED:	June 18, 2015
REPORT TO:	Exponent Attn: Ryan Birringer 149 Commonwealth Drive Menlo Park CA 94025

SUBJECT:
One pipe section was submitted for chemical analysis and mechanical testing. The samples were identified as: Pipe A Seg. from L188B (Fresno CA); ID 141740, Item name: Upstream of Rupture.

SPECTROCHEMICAL ANALYSIS (ASTM E415-11)
(Reported as Wt.%)

Aluminum	(Al)	<0.005
Antimony	(Sb)	<0.005
Arsenic	(As)	0.01
Boron	(B)	<0.0003
Calcium	(Ca)	<0.005
Carbon*	(C)	0.22
Chromium	(Cr)	0.02
Cobalt	(Co)	0.02
Columbium	(Cb)	<0.005
Copper	(Cu)	0.04
Manganese	(Mn)	0.75
Molybdenum	(Mo)	<0.005
Nickel	(Ni)	0.08
Phosphorus	(P)	0.013
Silicon	(Si)	0.06
Sulfur*	(S)	0.022
Tantalum	(Ta)	0.01
Tin	(Sn)	<0.005
Titanium	(Ti)	<0.005
Tungsten	(W)	<0.01
Vanadium	(V)	<0.005
Zirconium	(Zr)	<0.005
Carbon equivalent (C.E.) per API Eq.3		0.36

*Determined by LECO combustion (ASTM E1019-11)

Anamet, inc

Lab No. 5005.1891

TRANSVERSE TENSILE TEST
(ASTM A370-14)

Seg. A PM.	1	2
Dimensions of Specimen (in.)		
Width	1.505	1.503
Thickness	0.254	0.254
Area (sq. in.)	0.382	0.382
Tensile Strength (psi)	63600	63200
Yield Strength @ 0.5% EUL (psi)	41000	42100
Elongation in 2.0″ Gage (%)	27-1/2	34

Seg. A Weld	1	2
Dimensions of Specimen (in.)		
Width	1.501	1.505
Thickness	0.255	0.255
Area (sq. in.)	0.383	0.384
Tensile Strength (psi)	73400	72500
Yield Strength @ 0.5% EUL (psi)	55900	53400
Elongation in 2.0″ Gage (%)	6-1/2	7
Fracture Location	Weld	Weld
Fracture Characteristic	Ductile	Ductile

Lab No. 5005.1891

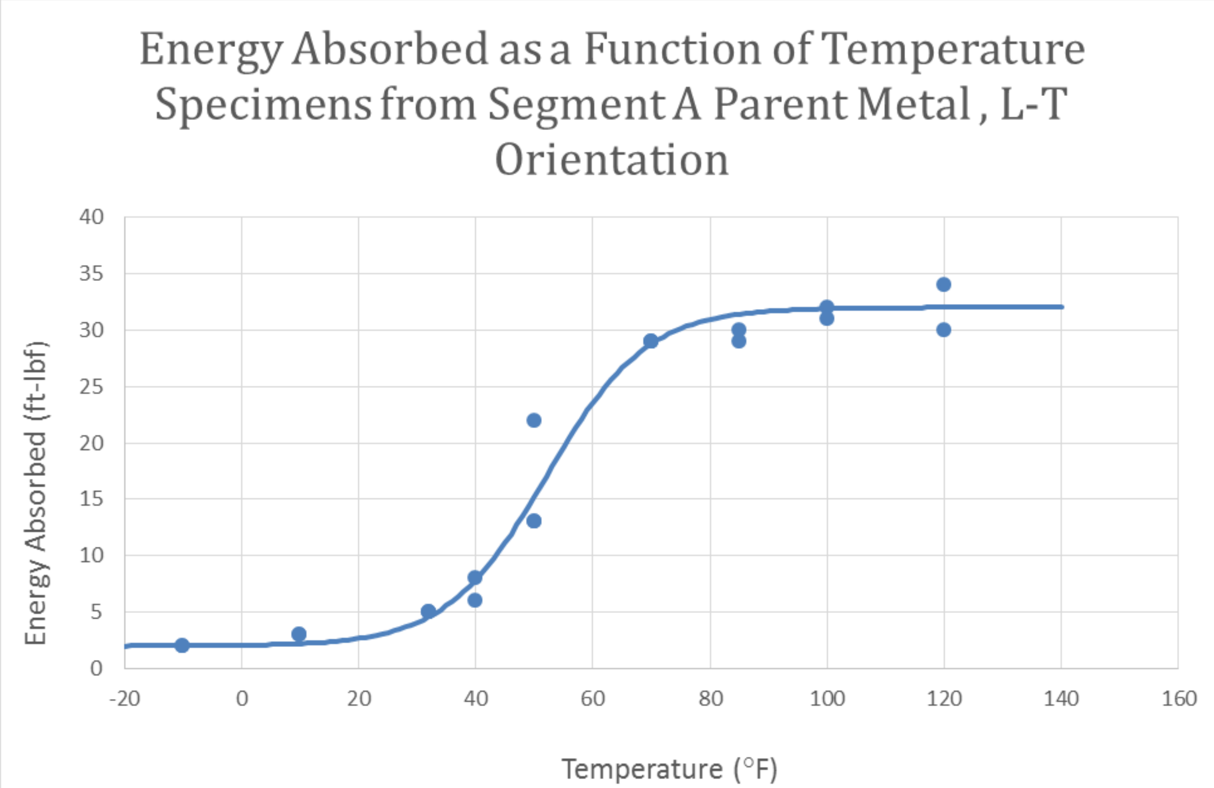
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

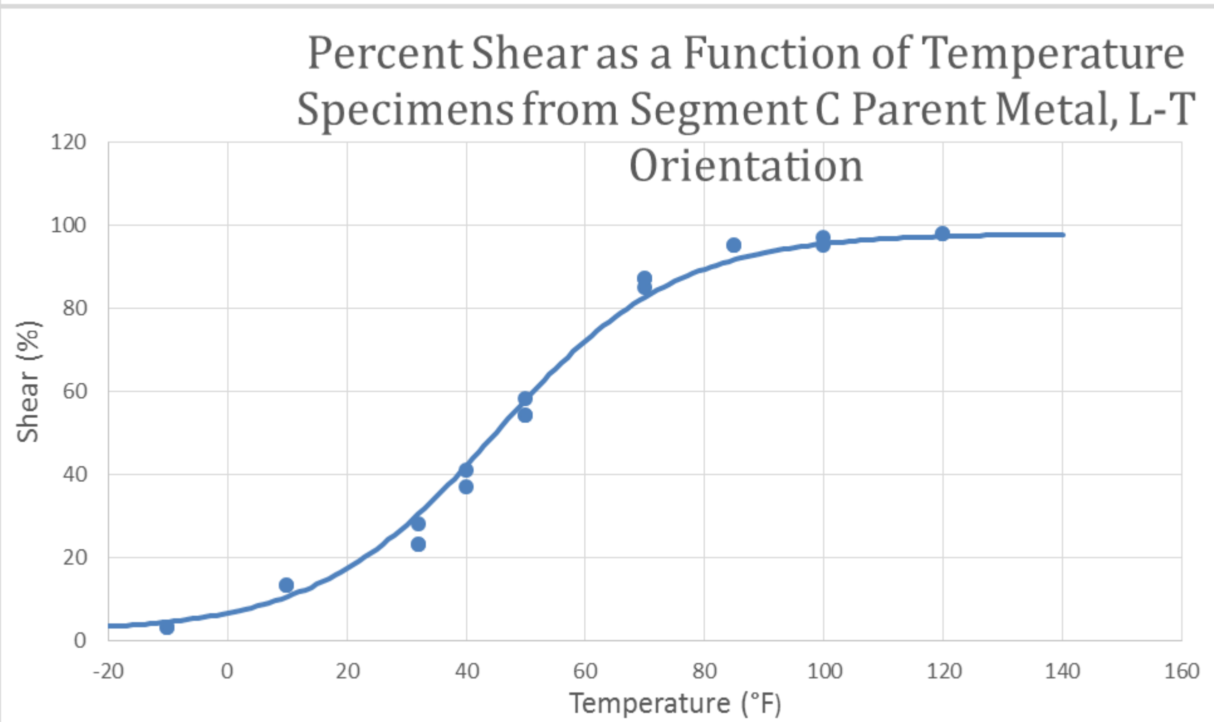
"A" 141740 , Type: V-Notch, Orientation: L-T Transition Curve,
Location**: P.M.**, Size: 5mm x 10mm x 55mm

Specimen ID	Temperature (F)	Energy (ft-lbf)	L.E. (mils)	Shear (%)
10-1	10	3	8	13
10-2	10	3	7	13
32-1	32	5	13	23
32-2	32	5	13	28
32-3	32	5	13	23
40-1	40	8	20	41
40-2	40	6	14	37
50-1	50	22	52	58
50-2	50	13	34	54
50-3	50	13	36	54
70-1	70	29	61	87
70-2	70	29	61	85
70-3	70	29	65	87
85-1	85	29	62	95
85-2	85	30	64	95
100-1	100	32	69	97
100-2	100	31	69	95
120-1	120	30	67	>98
120-2	120	34	74	>98
-10-1	-10	2	3	<3
-10-2	-10	2	1	<3

Anamet, inc

Lab No. 5005.1891





Anamet, inc

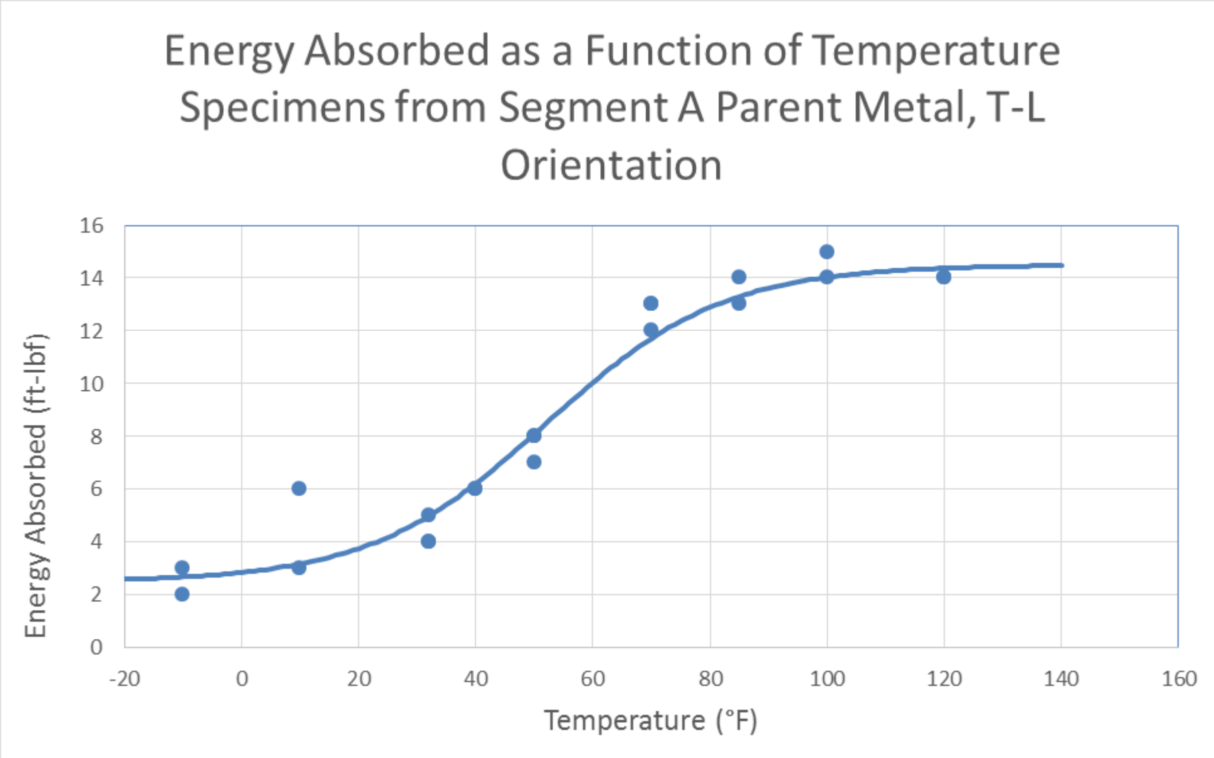
Lab No. 5005.1891

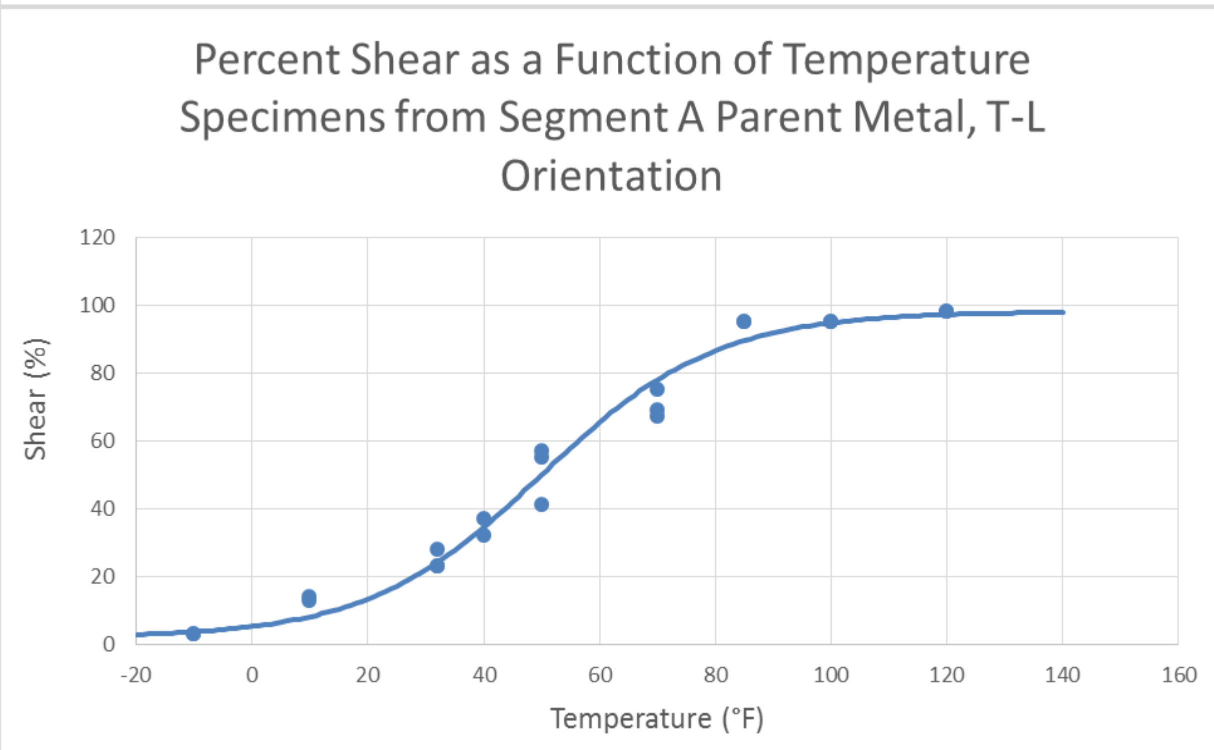
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"A" 141740 , Type: V-Notch, Orientation: T-L Transition Curve,
Location**: P.M.**, Size: 5mm x 10mm x 55mm

Specimen ID	Temperature (F)	Energy (ft-lbf)	L.E. (mils)	Shear (%)
10-1	10	6	12	14
10-2	10	3	10	13
32-1	32	4	11	23
32-2	32	4	13	23
32-3	32	5	14	28
40-1	40	6	14	37
40-2	40	6	6	32
50-1	50	8	22	57
50-2	50	8	23	41
50-3	50	7	21	55
70-1	70	13	38	67
70-2	70	13	37	69
70-3	70	12	36	75
85-1	85	14	32	95
85-2	85	13	30	95
100-1	100	14	37	95
100-2	100	15	39	95
120-1	120	14	29	>98
120-2	120	14	33	>98
-10-1	-10	3	2	<3
-10-2	-10	2	1	<3

Lab No. 5005.1891





Lab No 5005.1891

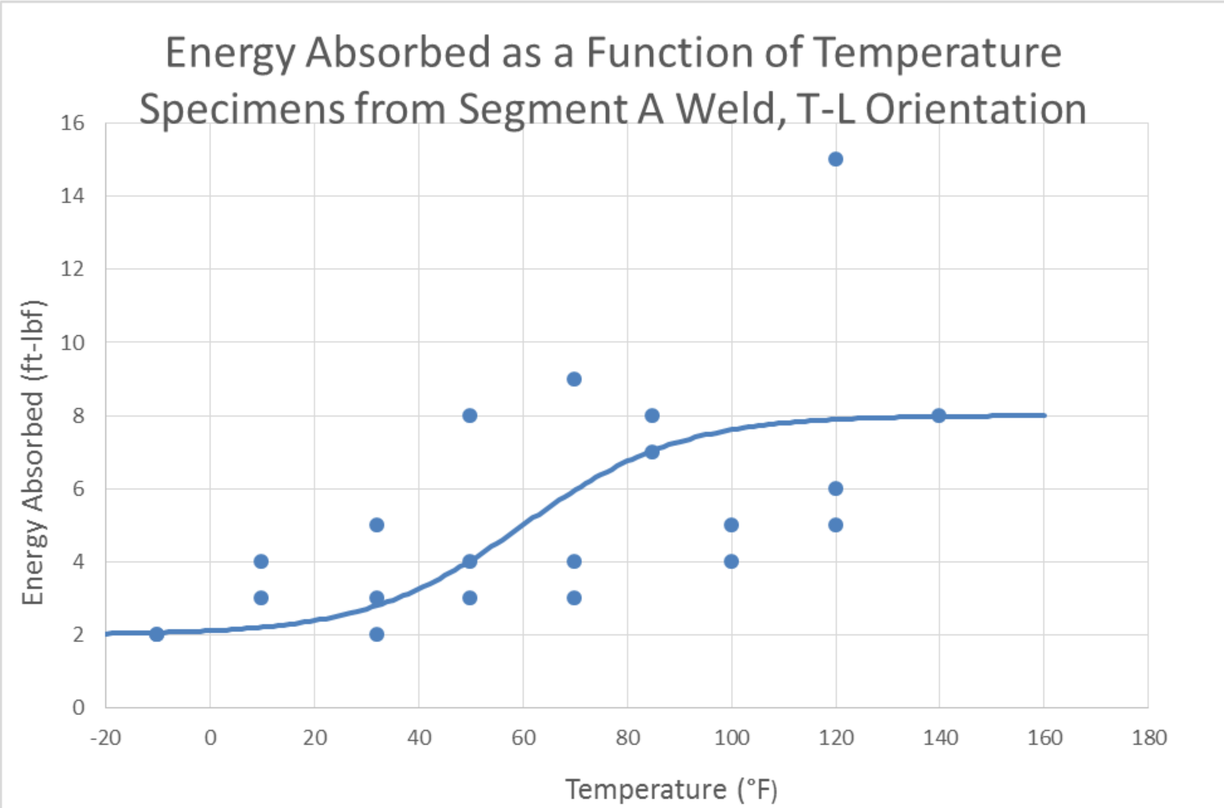
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

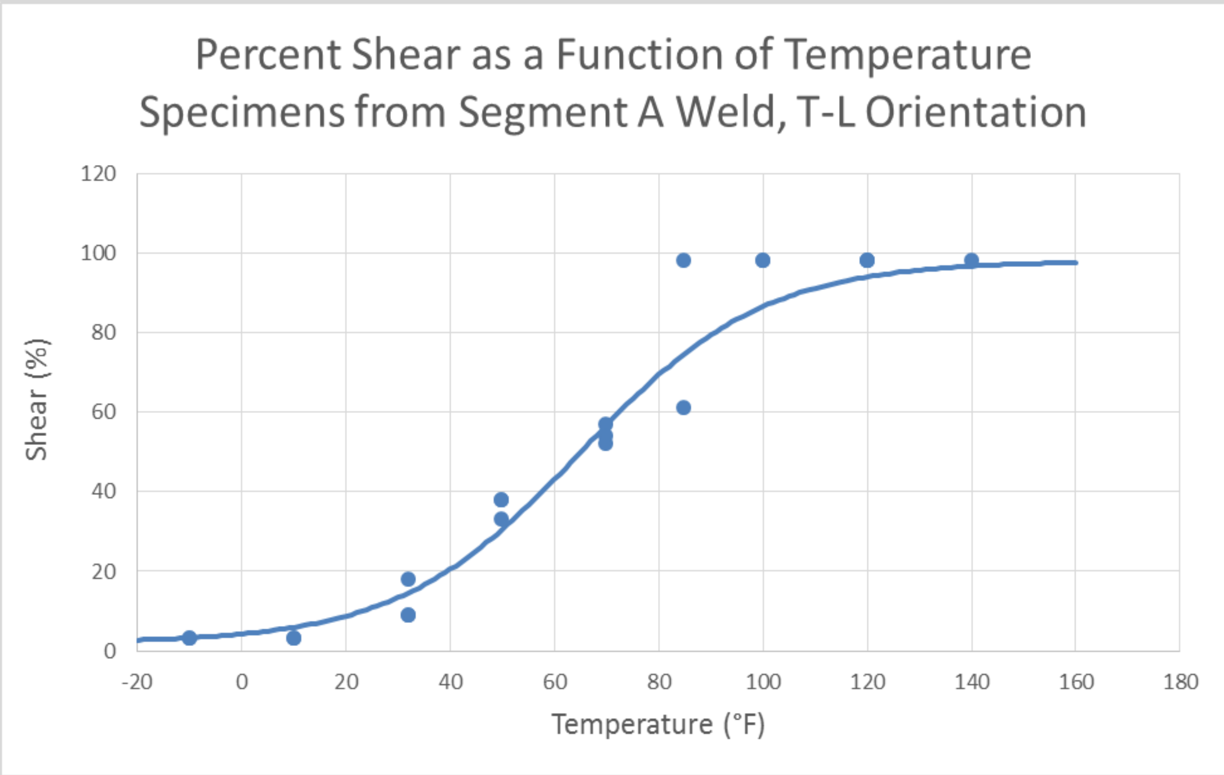
"A" 141740 , Type: V-Notch, Orientation: T-L Transition Curve,
Location**: Weld**, Size: 5mm x 10mm x 55mm

Specimen ID	**Temperature (F)**	**Energy (ft-lbf)**	**L.E. (mils)**	**Shear (%)**
10-1	10	4	6	3
10-2	10	3	4	3
32-1	32	2	2	9
32-2	32	5	10	18
32-3	32	3	5	9
50-1	50	8	20	38
50-2	50	3	7	33
50-3	50	4	8	38
70-1	70	3	7	52
70-2	70	9	22	57
70-3	70	4	10	54
85-1	85	8	13	*
85-2	85	7	11	61
100-1	100	5	11	*
100-2	100	4	11	*
120-1	120	15	33	>98
120-2	120	5	5	*
120-3	120	6	11	>98
140-1	140	8	21	*
-10-1	-10	2	2	<3
-10-2	-10	2	3	<3

* No distinct cleavage area visible (>98)

Lab No. 5005.1891





Anamet, inc

Lab No. 5005.1891

Identification	Units	A L-T PM	A T-L PM	A T-L WM
Upper Shelf Energy	ft-lbf	32	14.5	8
Lower Shelf Energy	ft-lbf	2	2.5	2
Transition Temperature	°F	52	52	60
Equivalent of Full Size 15 ft-lbs Absorbed Impact Energy	°F	39	47	96
Temperature at 50% Shear	°F	45	50	65
Temperature at 80% Shear	°F	67	72	91

This testing was completed on July 29, 2015 and was performed in accordance with customer's authorization.

Best fit curves for Charpy impact data were curve fitted using the hyperbolic tangent function described in API 579.

Submitted by:

Edward A. Foreman
Quality Manager

tr

Anamet, inc

	June 8, 2015
LABORATORY NUMBER:	5005.1779
CUSTOMER AUTHORIZATION:	PO# 00013469
DATE SUBMITTED:	May 26, 2015
REPORT TO:	Exponent Attn: Ryan Birringer 149 Commonwealth Drive Menlo Park CA 94025

SUBJECT:
Two pipe lengths were submitted for chemical analysis and mechanical testing. The samples were identified as: 12” Diameter x 0.24” Wall ERW Pipe, L118B (Fresno CA); ID 139931 Item name C-MECH1 and ID 139933 Item name B-MECH1.

SPECTROCHEMICAL ANALYSIS (ASTM E415-11)
(Reported as Wt.%)

		‘B’ 136633	‘C’139931
Aluminum	(Al)	<0.01	<0.01
Arsenic	(As)	0.01	0.01
Boron	(B)	<0.0003	<0.0003
Calcium	(Ca)	<0.002	<0.002
Carbon*	(C)	0.22	0.26
Chromium	(Cr)	0.02	0.03
Cobalt	(Co)	0.02	0.02
Columbium	(Cb)	<0.005	<0.005
Copper	(Cu)	0.04	0.09
Manganese	(Mn)	0.75	0.90
Molybdenum	(Mo)	<0.005	<0.005
Nickel	(Ni)	0.07	0.07
Phosphorus	(P)	0.015	0.017
Silicon	(Si)	0.06	0.08
Sulfur*	(S)	0.023	0.022
Tin	(Sn)	<0.005	0.01
Titanium	(Ti)	<0.005	<0.005
Vanadium	(V)	<0.005	<0.005
Carbon Equivalent (C.E.) per API 5L Eq. 3		0.36	0.43

*Determined by LECO combustion

Lab No. 5005.1779

TRANSVERSE TENSILE TEST
(ASTM A370-14)

Seg. B PM.	1	2
Dimensions of Specimen (in.)		
Width	1.503	1.505
Thickness	0.252	0.254
Area (sq. in.)	0.379	0.382
Tensile Strength (psi)	63200	65300
Yield Strength @ 0.5% EUL (psi)	35900	38700
Elongation in 2.0″ Gage (%)	33-1/2	33-1/2

Seg. B Weld	1	2
Dimensions of Specimen (in.)		
Width	1.506	1.510
Thickness	0.251	0.241
Area (sq. in.)	0.378	0.364
Tensile Strength (psi)	74700	78100
Yield Strength @ 0.5% EUL (psi)	52100	41600
Elongation in 2.0″ Gage (%)	20	19-1/2
Fracture Location	P.M	P.M.
Fracture Characteristic	Ductile	Ductile

Lab No. 5005.1779

TRANSVERSE TENSILE TEST
(ASTM A370-14)

Seg. C PM.	1	2
Dimensions of Specimen (in.)		
Width	1.502	1.503
Thickness	0.253	0.255
Area (sq. in.)	0.380	0.383
Tensile Strength (psi)	73100	72800
Yield Strength @ 0.5% EUL (psi)	43900	44400
Elongation in 2.0″ Gage (%)	31-1/2	27

Seg. C Weld	1	2
Dimensions of Specimen (in.)		
Width	1.499	1.499
Thickness	0.256	0.260
Area (sq. in.)	0.384	0.390
Tensile Strength (psi)	79900	78600
Yield Strength @ 0.5% EUL (psi)	46900	45300
Elongation in 2.0″ Gage (%)	22	21
Fracture Location	P.M	P.M.
Fracture Characteristic	Ductile	Ductile

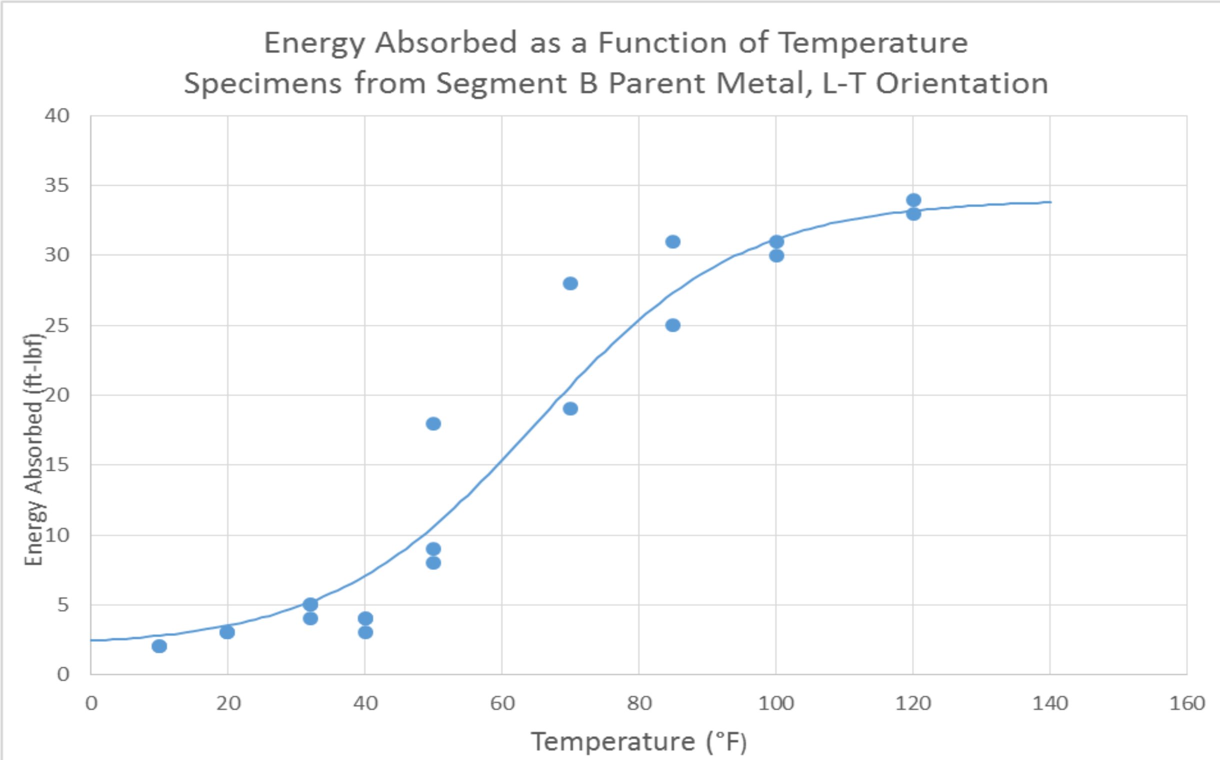
Lab No. 5005.1779

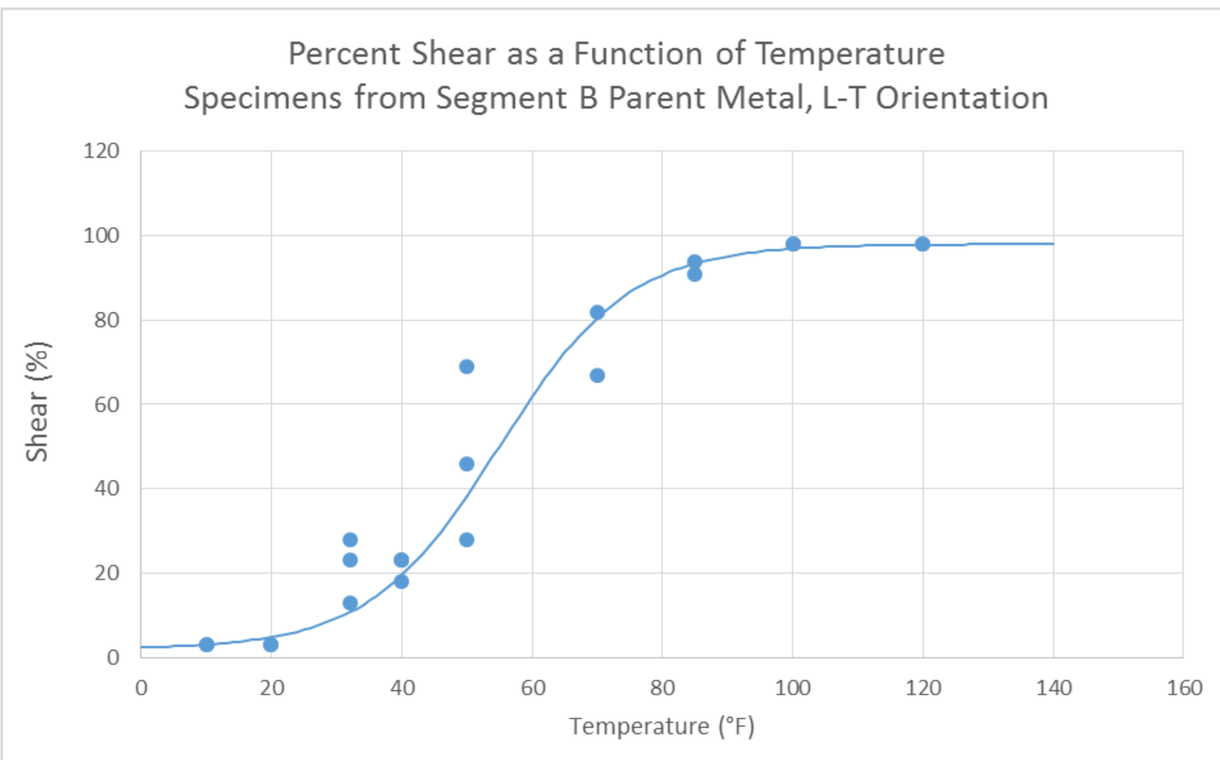
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"B" 139933, Type: V-Notch, Orientation: L-T Transition Curve,
Location**: P.M.**, Size: 5mm x 10mm x 55mm

Specimen ID	Temperature (F)	Energy (ft-lbf)	L.E. (mils)	Shear (%)
10-1	10	2	2	3
10-2	10	2	3	3
20-1	20	3	3	3
20-2	20	3	8	3
32-1	32	4	13	28
32-2	32	5	16	23
32-3	32	5	14	13
40-1	40	3	23	23
40-2	40	4	13	23
40-3	40	4	13	18
50-1	50	9	26	46
50-2	50	8	29	28
50-3	50	18	43	69
70-1	70	19	51	67
70-2	70	28	60	82
85-1	85	31	68	91
85-1	85	25	58	94
100-1	100	30	66	98
100-2	100	31	66	98
120-1	120	34	68	98
120-2	120	33	73	98

Lab No. 5005.1779





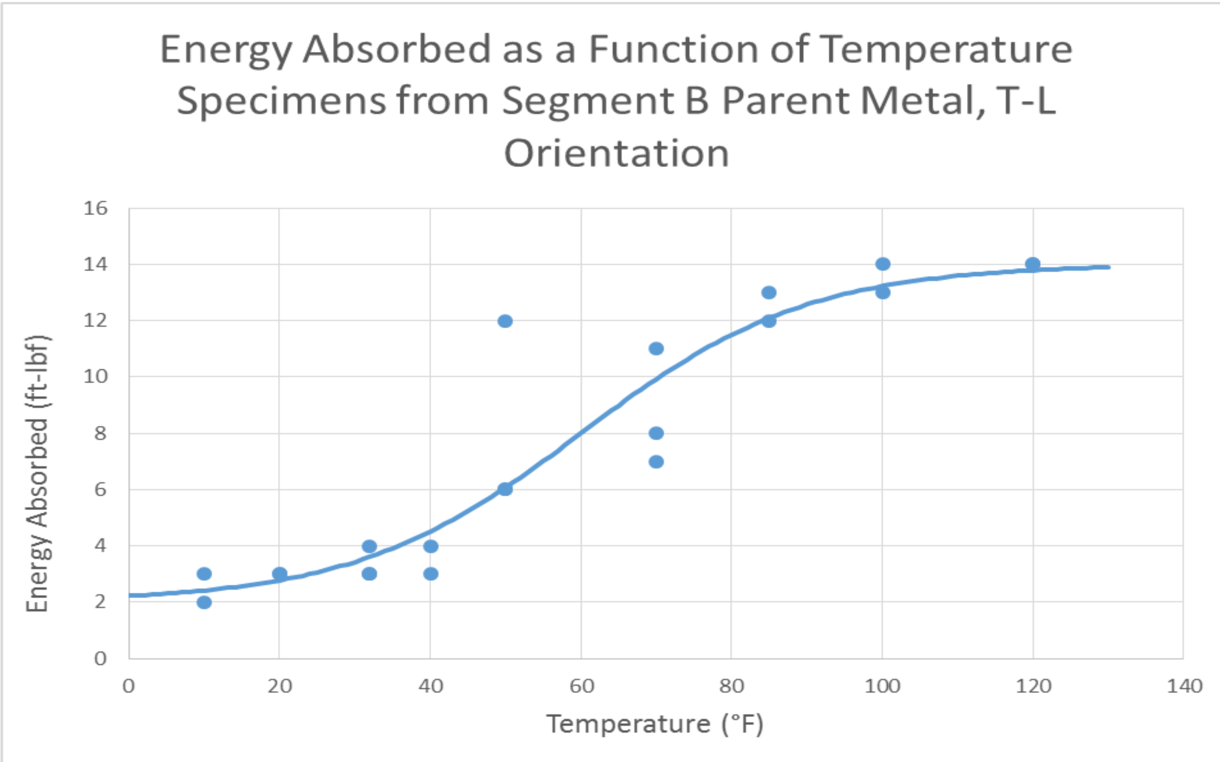
Lab No. 5005.1779

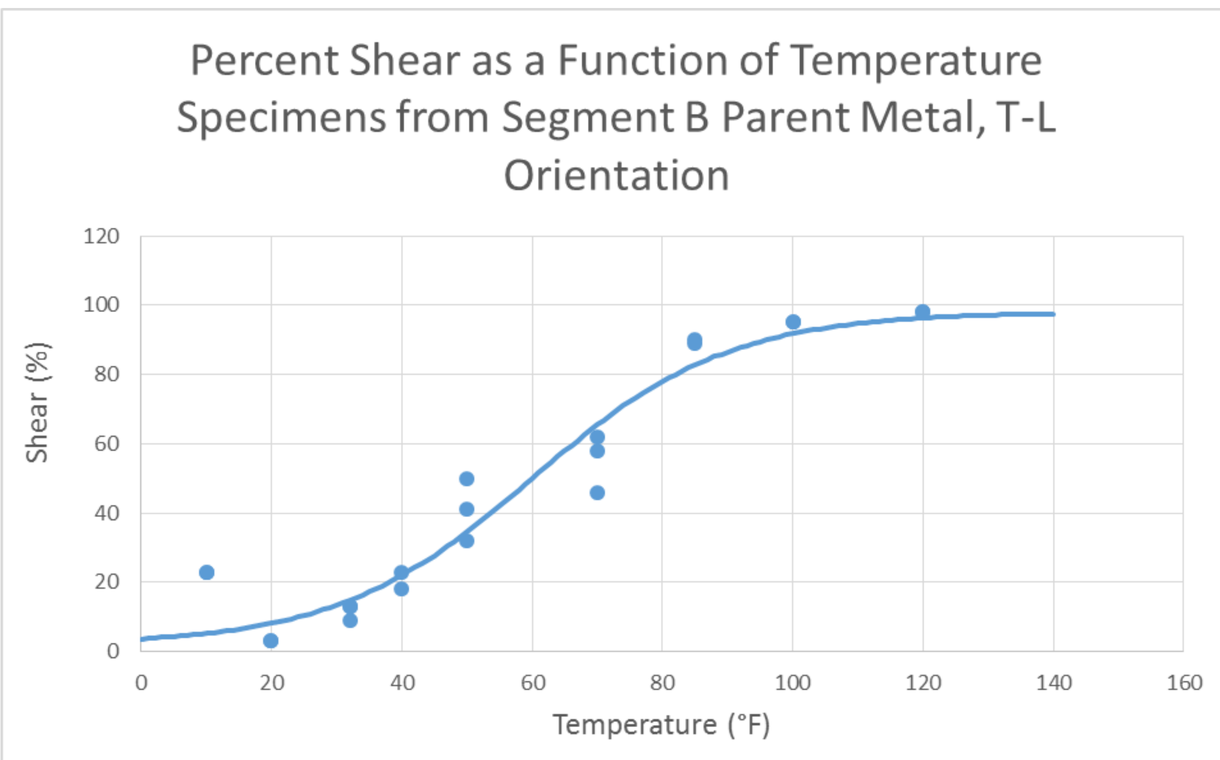
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"B" 139933, Type: V-Notch, Orientation: T-L Transition Curve,
Location**: P.M.**, Size: 5mm x 10mm x 55mm

Specimen ID	**Temperature (F)**	**Energy (ft-lbf)**	**L.E. (mils)**	**Shear (%)**
10-1	10	3	4	23
10-2	10	2	4	23
20-1	20	3	6	3
20-2	20	3	7	3
32-1	32	4	8	13
32-2	32	3	9	9
32-3	32	3	9	13
40-1	40	4	12	23
40-2	40	3	9	18
50-1	50	6	17	32
50-2	50	6	15	41
50-3	50	12	31	50
70-1	70	7	23	58
70-2	70	8	25	46
70-3	70	11	32	62
85-1	85	12	37	89
85-2	85	13	39	90
100-1	100	14	40	95
100-2	100	13	40	95
120-1	120	14	39	98
120-2	120	14	39	98

Lab No. 5005.1779





Anamet, inc

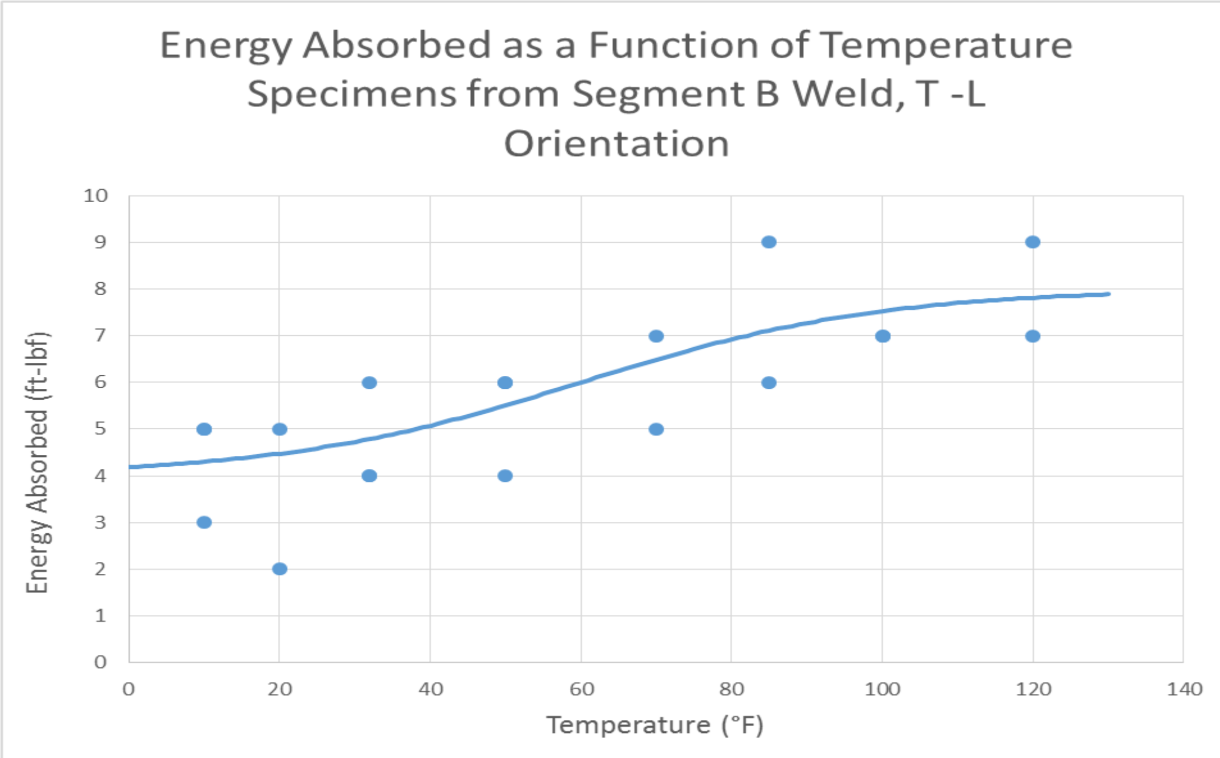
Lab No. 5005.1779

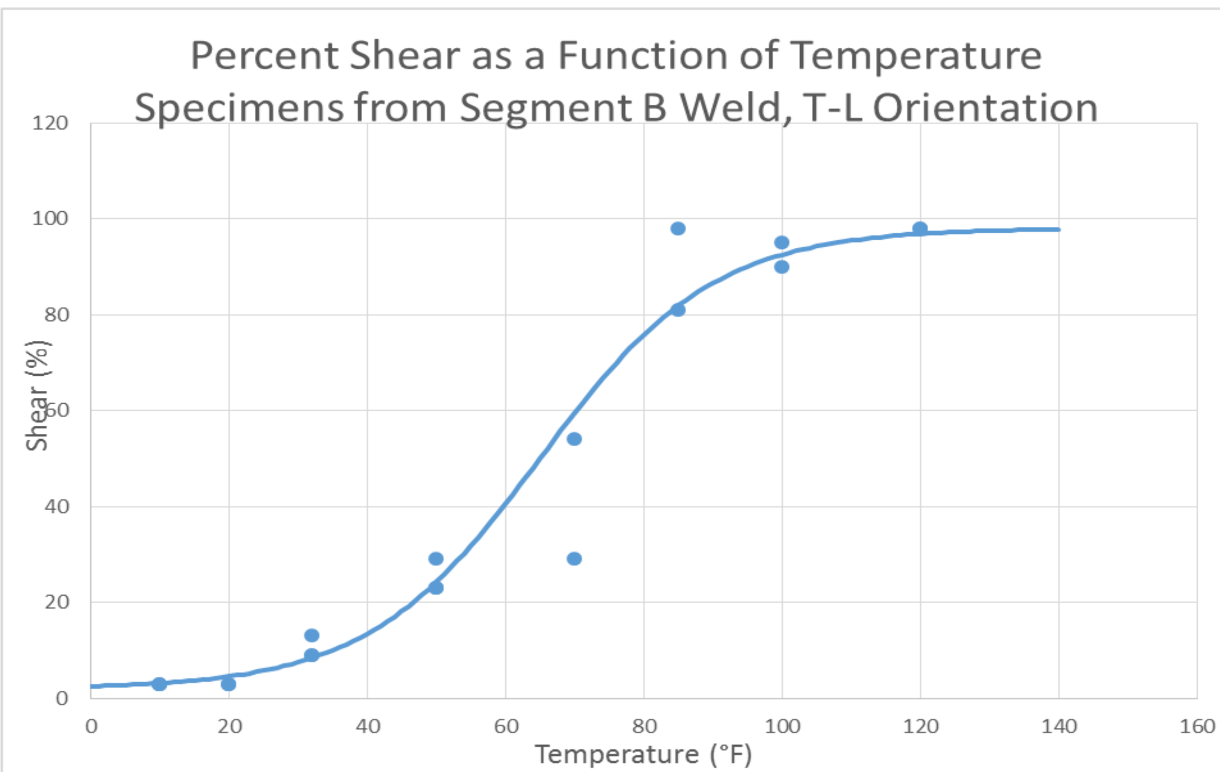
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"B" 139933, Type: V-Notch, Orientation: T-L Transition Curve,
Location: **WELD**, Size: 5mm x 10mm x 55mm

Specimen ID	**Temperature (F)**	**Energy (ft-lbf)**	**L.E. (mils)**	**Shear (%)**
10-1	10	5	7	3
10-2	10	5	9	3
10-3	10	3	3	3
20-1	20	5	11	3
20-2	20	2	2	3
32-1	32	6	12	9
32-2	32	4	12	13
32-3	32	4	10	9
50-1	50	6	13	23
50-2	50	4	8	23
50-3	50	6	16	29
70-1	70	7	17	29
70-2	70	5	12	54
85-1	85	9	25	98
85-2	85	6	15	81
100-1	100	7	15	90
100-2	100	7	20	95
120-1	120	7	20	98
120-2	120	9	24	98

Lab No. 5005.1779





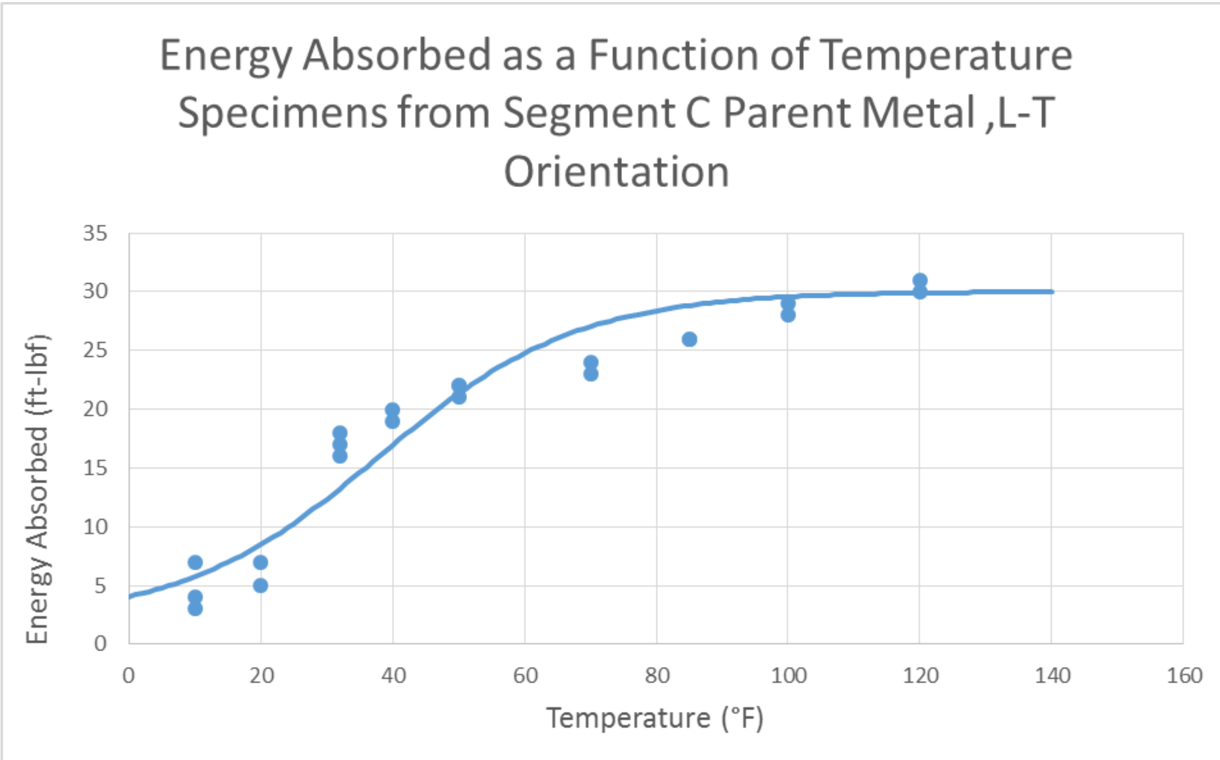
Lab No. 5005.1779

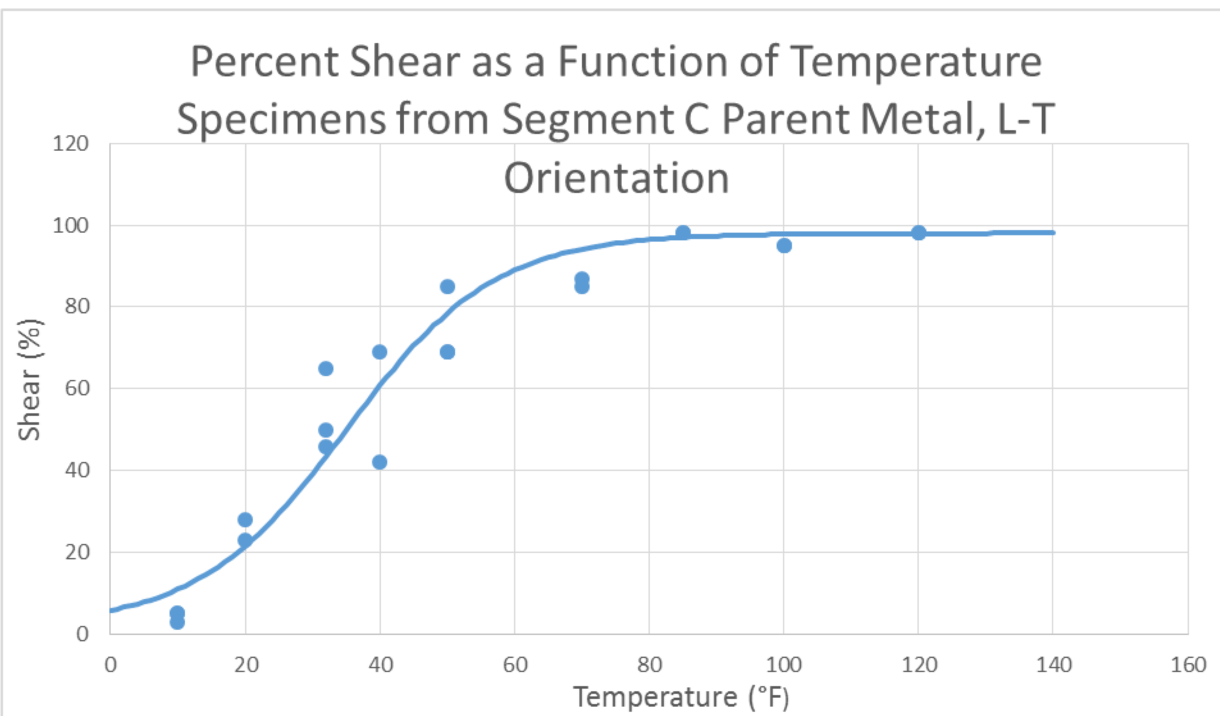
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"C" 139931, Type: V-Notch, Orientation: L-T Transition Curve,
Location: P.M., Size: 5mm x 10mm x 55mm

Specimen ID	Temperature (F)	Energy (ft-lbf)	L.E. (mils)	Shear (%)
10-1	10	7	16	5
10-2	10	4	8	5
10-3	10	3	5	3
20-1	20	7	18	28
20-2	20	5	14	23
32-1	32	16	30	50
32-2	32	17	39	46
32-3	32	18	35	65
40-1	40	20	41	69
40-2	40	19	41	42
50-1	50	21	46	69
50-2	50	22	48	85
50-3	50	22	58	69
70-1	70	23	49	85
70-2	70	24	50	87
85-1	85	26	57	98
85-2	85	26	53	98
100-1	100	29	59	95
100-2	100	28	62	95
120-1	120	31	60	98
120-2	120	30	60	98

Lab No. 5005.1779





Anamet, inc

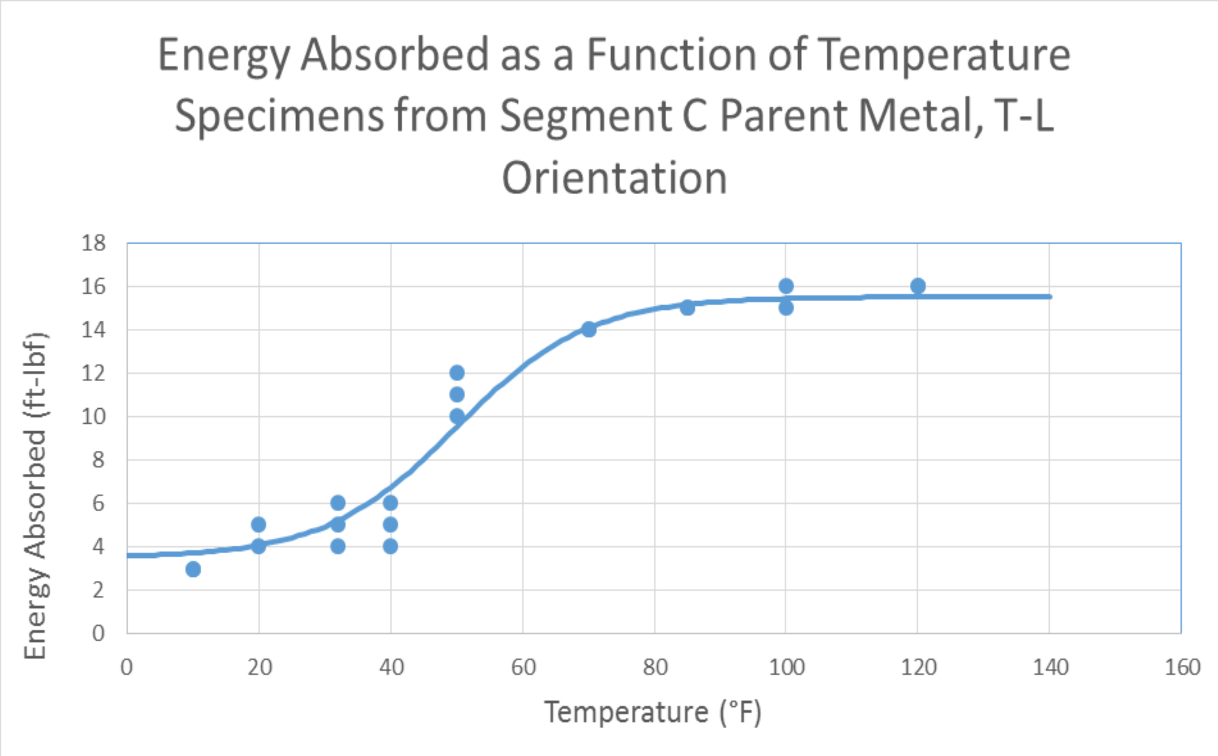
Lab No. 5005.1779

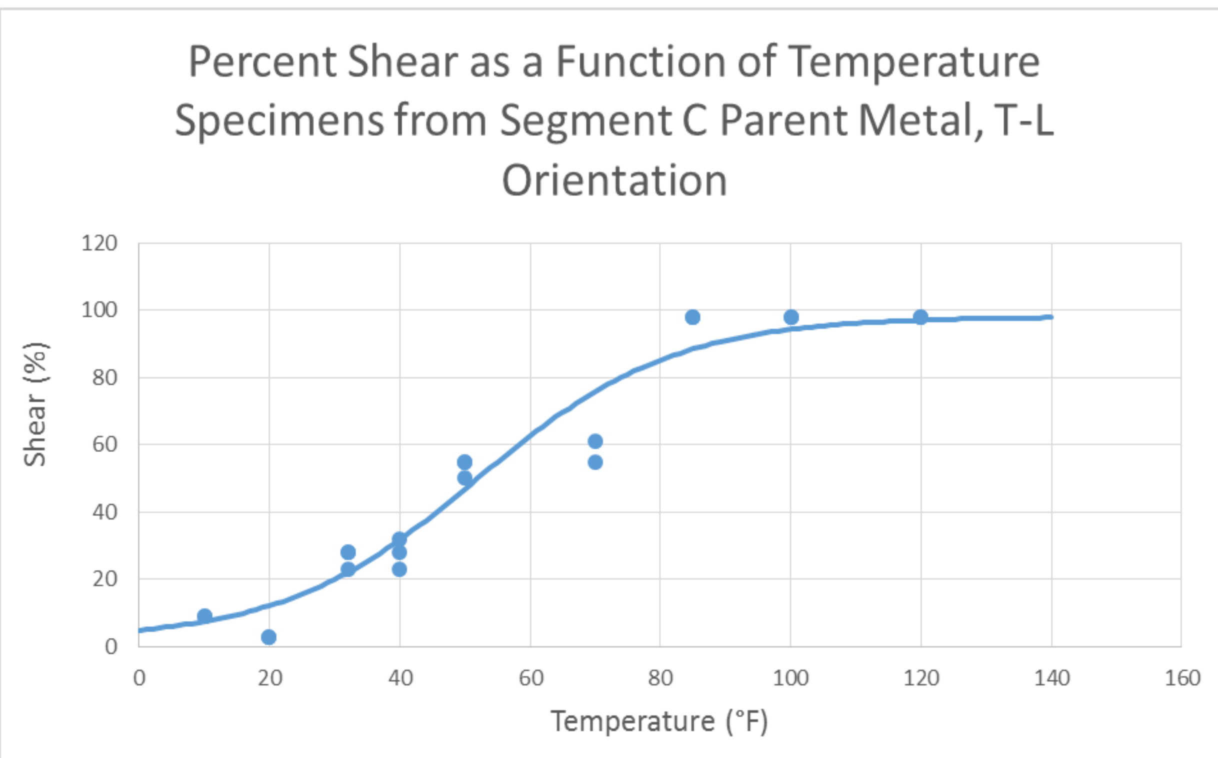
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"C" 139931, Type: V-Notch, Orientation: T-L Transition Curve,
Location: **P.M.**, Size: 5mm x 10mm x 55mm

Specimen ID	Temperature (F)	Energy (ft-lbf)	L.E. (mils)	Shear (%)
10-1	10	3	7	9
10-2	10	3	7	9
20-1	20	4	11	3
20-2	20	5	12	3
32-1	32	4	12	28
32-2	32	5	16	23
32-3	32	6	17	28
40-1	40	4	14	28
40-2	40	6	19	32
40-3	40	5	15	23
50-1	50	10	29	55
50-2	50	11	26	55
50-3	50	12	28	50
70-1	70	14	35	61
70-2	70	14	35	55
85-1	85	15	35	98
85-2	85	15	37	98
100-1	100	16	42	98
100-2	100	15	42	98
120-1	120	16	45	98
120-2	120	16	41	98

Lab No. 5005.1779





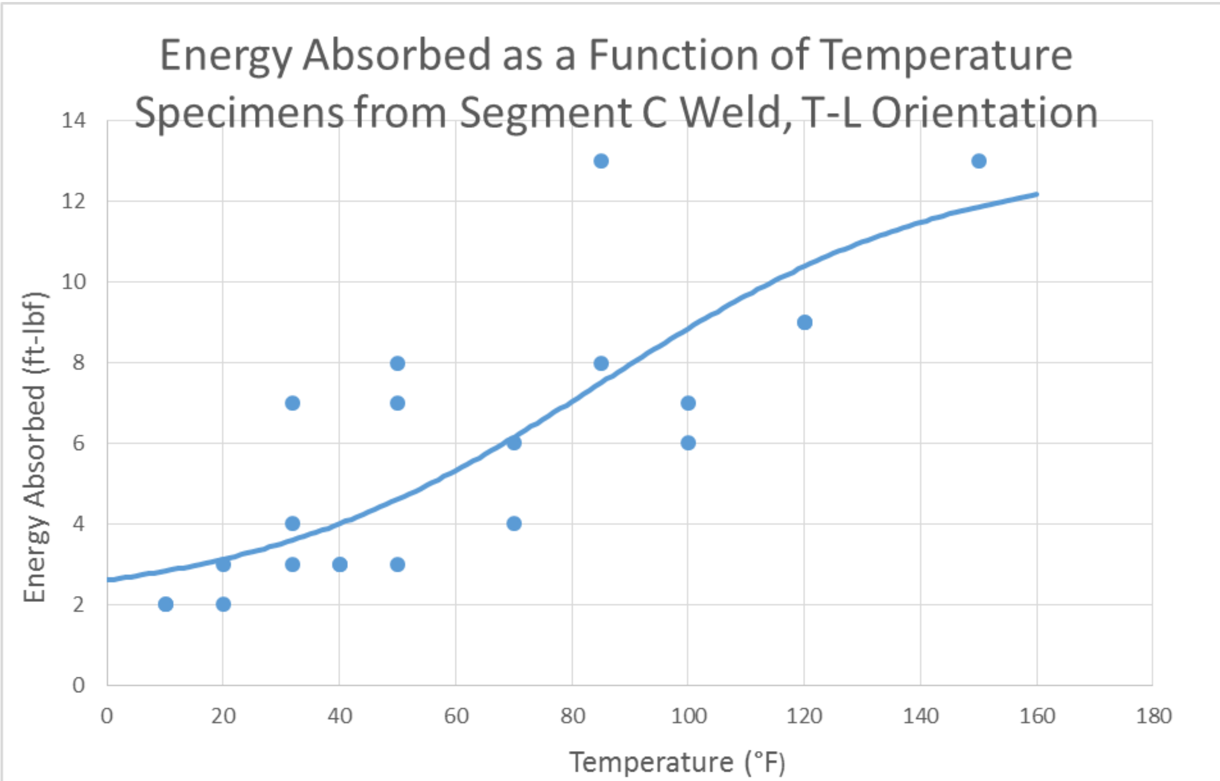
Lab No. 5005.1779

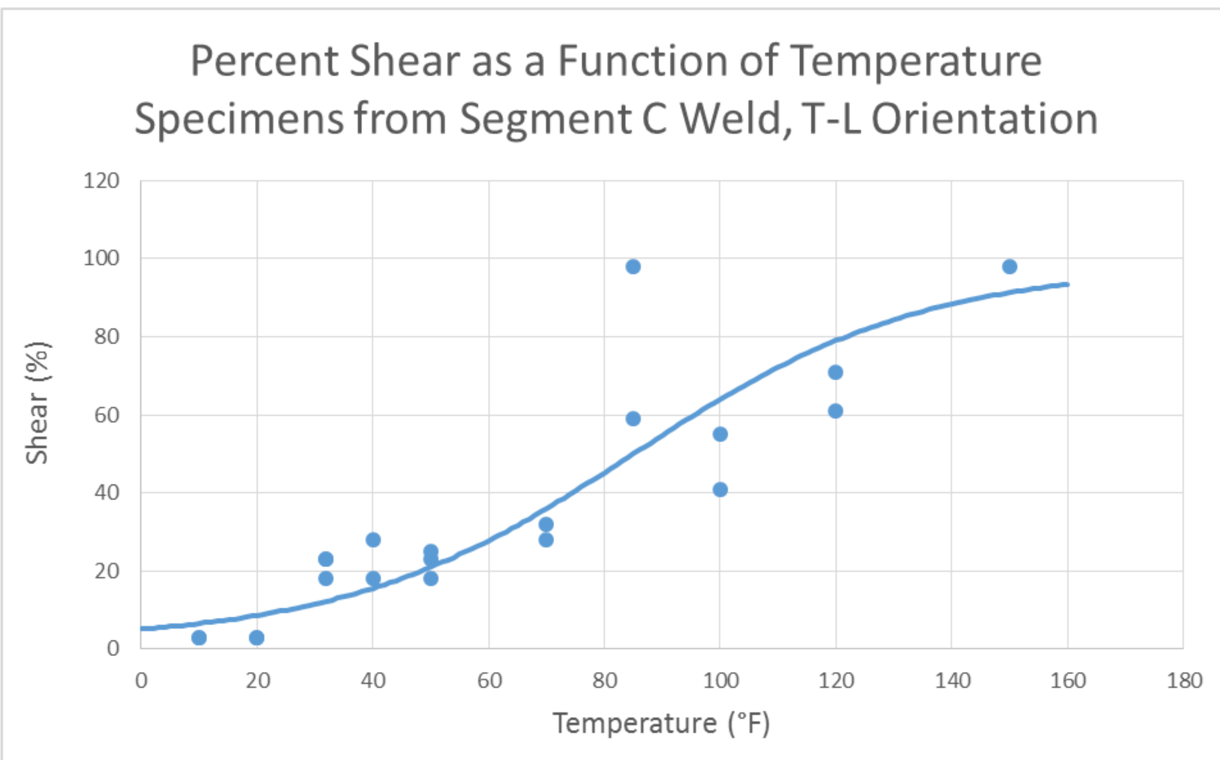
CHARPY IMPACT TRANSITION TEST (ASTM A370-14)

"C" 139931, Type: V-Notch, Orientation: T-L Transition Curve,
Location: **WELD**, Size: 5mm x 10mm x 55mm

Specimen ID	**Temperature (F)**	**Energy (ft-lbf)**	**L.E., mils (mils)**	**Shear (%)**
10-1	10	2	3	3
10-2	10	2	3	3
20-1	20	3	4	3
20-2	20	2	5	3
32-1	32	7	15	18
32-2	32	3	7	23
32-3	32	4	5	23
40-1	40	3	10	18
40-2	40	3	6	28
50-1	50	8	16	25
50-2	50	3	7	23
50-3	50	7	15	18
70-1	70	4	7	32
70-2	70	6	15	28
85-1	85	13	31	98
85-2	85	8	18	59
100-1	100	7	16	55
100-2	100	6	14	41
120-1	120	9	24	71
120-2	120	9	24	61
150-1	150	13	32	98

Lab No. 5005.1779





Lab No. 5005.1779

CHARPY IMPACT TRANSITION TEST DATA SUMMARY, SEGMENT B, ID 139933

Identification	Units	B L-T PM	B T-L PM	B T-L WM
Upper Shelf Energy	ft-lbf	34	14	8
Lower Shelf Energy	ft-lbf	2	2	4
Ductile-to-Brittle Transition Temp.	°F	65	60	60
Temperature at 15 ft-lbf Energy*	°F	41	57	99
Temperature at 50% Shear	°F	55	60	65
Temperature at 80% Shear	°F	70	82	83

*Based on full size specimen

CHARPY IMPACT TRANSITION TEST DATA SUMMARY, SEGMENT C, ID 139931

Identification	Units	C L-T PM	C T-L PM	C T-L WM
Upper Shelf Energy	ft-lbf	30	15.5	13
Lower Shelf Energy	ft-lbf	2	3.5	2
Ductile-to-Brittle Transition Temp.	°F	38	50	85
Temperature at 15 ft-lbf Energy*	°F	17	43	85
Temperature at 50% Shear	°F	35	52	85
Temperature at 80% Shear	°F	51	74	122

*Based on full size specimen

This testing was completed on June 8, 2015 and was performed in accordance with customer’s authorization.

Best fit curves for Charpy impact data were curve fitted using the hyperbolic tangent function described in API 579.

Submitted by:

Edward A. Foreman

Edward A. Foreman
Quality Manager

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Appendix D

Chain-of-Custody Documents

Pacific Gas and Electric Company	Record of Material Removed from Existing Gas Transmission Pipelines	Gas T&D TD-4100P-14-F01 04/12

Refer to TD-4100P-14, "Removing, Documenting and Preserving Gas Transmission Pipe and Components" and Job Aid TD-4100P-14-JA01, "Record of Material Removed From Existing Natural Gas Transmission Pipelines Instructions for Form TD-4100P-14-F01."

1. USE ONE RECORD PER SAMPLE OF MATERIAL REMOVED. If material is subdivided into smaller pieces, each subdivided piece must have its own record. If subdivided pieces are further cut into pieces for testing, then each cut test sample must have its own "Cut Test Sample #" and record.
2. Complete the record in ink, including the signature blocks. Attach additional sheets if needed. EACH SHEET OF THE RECORD MUST INCLUDE THE UNIQUE IDENTIFIER AND SHEET (PAGE) NUMBER.
3. Give the completed record to the individual to whom you are releasing the material. DO NOT attach to the material itself.
4. Attach photos documenting material removal to this record.
5. INSPECTOR MUST BE PRESENT PRIOR TO LOADING OF MATERIAL ON TRUCK.

MATERIAL IDENTIFICATION

UNIQUE IDENTIFIER:

SAP PM Order #		Transmission Line #		Mile Point		Dig Site #		Sample #		Cut Test Sample # (If Applicable)
42371211 31148998	–	L 118b	–	MP ~~0.2~~	–	N/A	–	N/A A	–	N/A

GPS Coordinates	36.8420~~9~~8 -119.929394 ☐ **Latitude/Longitude** ☐ **Northing/Easting**
Nearest Street Address or Location Info	7633 N Weber Ave, Fresno, CA (Fresno Sheriff's Foundation)

MATERIAL REMOVAL INFORMATION (UPPER SECTION / SOUTH)

Date of Material Removal	~~04/19/2015~~ 4/20/15
Reason for Removal	☒ ~~L432~~ PIPE INTEGRITY FAILURE INVESTIGATION
	☐ **Suspected Anomaly or Indication**
	☐ **Existing Anomaly or Indication**
	☐ **Hydrotest – Test Segment Number:**
	☐ **Asset Knowledge**
Pre-1972 Pipe Wrap ?	~~☒ NO~~ ☒ YES – Follow WP4711-01, "Gas Pipe Wrap Removal, Handling and Disposal Procedures"

Depth of material (from surface to top of material removed)	
Direction of gas flow in pipeline (e.g. north-to-south)	South to North

MATERIAL DESCRIPTION

Pipe or component specifications	Diameter (in.): 12 Wall Thickness (in.): .24 Length Removed (ft./in.): 21'
Description – fitting *(e.g. Elbow, etc.)*	N/A
Description – other *(e.g. Valve, etc.)*	
Installation information (if known)	Seam Type: ~~N/A~~ ERW
	Year of Install: 1962
	Installation Job Number: Unknown

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A A	–	N/A

RADIOGRAPHY INFORMATION	
Radiography performed by: (Signature of qualified individual) REFER TO GO-TS-001	Date: ~~N/A~~ MARTIN HUDGINS 4/21/15
	Name of Qualified Individual: MARTIN HUDGINS LAN ID: —
	Title: RADIOGRAPHER
	Name of ☐ PG&E Department or ☒ Contractor Company JANX
	Address:
	Phone: UNK

QUALIFIED PERSONNEL AND WITNESSES TO MATERIAL REMOVAL	
Material REMOVED By: (Signature of qualified individual)	Material Removal Date: ~~04/18/2014~~ 4/20/14 Time:
	Name of Qualified Individual: SHELDON AUTER LAN ID: STA2
	Title: APPRENTICE WELDER
	Name of ☒ PG&E Department or ☐ Contractor Company
	Address: FRESNO YARD
	Phone: (530)519-3775
Material Removal WITNESSED By: (Signature of witness)	Name of Witness: STEVE CLEAVER LAN ID: R8CB
	Title: INVESTIGATOR
	Name of ☒ PG&E Department or ☐ Contractor Company
	Address: 705 P ST FRESNO, CA 93727
	Phone: 559/593-5728

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A A	–	N/A

TRANSFER OF CUSTODY

1. MATERIAL TRANSFERRED From Field to Transporter ***(to be completed by field personnel)***

BY: (Signature of individual who transported material) [signature] EPPLER'S TOWING (WITNESSED)	Date: 4/20/15
	Transported By: ☐PG&E ☒Contract transporter EPPLER'S TOWING
	Material Received FROM: LOCATION OF FAILURE LAN ID: —
	Material Received BY: ISOLATION AREA (STEVE CLEAVER) LAN ID: R8CB
	Location Transported FROM: LOCATION OF FAILURE
	Location Transported TO: ISOLATION AREA

2. MATERIAL RECEIVED From Transporter At Storage Facility ***(to be completed by storage facility personnel)***

BY: (Signature of individual who received material) [signature]	Date: 4/22/15
	Material Received FROM: LOCATION OF FAILURE LAN ID: —
	Material Received BY: CLEAVER LAN ID: R8CB
	Location Transported FROM: N WEBBER INCIDENT
	Location Transported TO: EPPLER'S TOWING/TRANSPORT
BY: (Signature of individual who received material)	Date:
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

3. CUT TEST SAMPLE ***(to be completed by storage facility personnel)***

(NOTE: If multiple samples are removed for testing/evaluation from original piece of material, then a new Record must be used to maintain chain of custody for each Cut Test Sample.)

BY: (Signature of individual who cut sample)	Date:
	Test Sample Cut/Removed By: ☐PG&E ATS ☐ Testing contractor ____________
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A (A)	–	N/A

TRANSFER OF CUSTODY
(Copies of this sheet may be used if documentation for additional chain of custody transfer is required)

ACTION/Authorized Signature	DETAILS
ACTION: TRANSPORTED TO EXPONENT	Date: 4/22/15
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S
	Material Received FROM: S. CLEAVER LAN ID: R8C8
Authorized Signature: [signature] (559)960-3408	Material Received BY: JOHN SULLIVAN LAN ID: —
	Location Transported FROM: N. WEBBER INCIDENT POST
	Location Transported TO: 149 COMMONWEALTH, MENLO PARK, CA
ACTION: RECEIVED PIPE	Date: 4/22/15
	Transported By: ☐PG&E ☒ Contract transporter EPPLERS
	Material Received FROM: JOHN SULLIVAN LAN ID:
Authorized Signature: [signature] 303 476 8748	Material Received BY: ALEX HUDGINS, EXPONENT LAN ID:
	Location Transported FROM: N WEBBER INCIDENT POST
	Location Transported TO: EXPONENT 149 COMMONWEALTH DR MENLO PARK CA
ACTION:	Date:
	Transported By: ☐PG&E ☐ Contract transporter ________
	Material Received FROM: LAN ID:
Authorized Signature:	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:
ACTION:	Date:
	Transported By: ☐PG&E ☐ Contract transporter ________
	Material Received FROM: LAN ID:
Authorized Signature:	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

Pacific Gas and Electric Company	**Record of Material Removed from Existing Gas Transmission Pipelines**	Gas T&D TD-4100P-14-F01 04/12

Refer to TD-4100P-14, "Removing, Documenting and Preserving Gas Transmission Pipe and Components" and Job Aid TD-4100P-14-JA01, "Record of Material Removed From Existing Natural Gas Transmission Pipelines Instructions for Form TD-4100P-14-F01."

1. USE ONE RECORD PER SAMPLE OF MATERIAL REMOVED. If material is subdivided into smaller pieces, each subdivided piece must have its own record. If subdivided pieces are further cut into pieces for testing, then each cut test sample must have its own "Cut Test Sample #" and record.
2. Complete the record in ink, including the signature blocks. Attach additional sheets if needed. EACH SHEET OF THE RECORD MUST INCLUDE THE UNIQUE IDENTIFIER AND SHEET (PAGE) NUMBER.
3. Give the completed record to the individual to whom you are releasing the material. DO NOT attach to the material itself.
4. Attach photos documenting material removal to this record.
5. INSPECTOR MUST BE PRESENT PRIOR TO LOADING OF MATERIAL ON TRUCK.

MATERIAL IDENTIFICATION

UNIQUE IDENTIFIER:

SAP PM Order #		Transmission Line #		Mile Point		Dig Site #		Sample #		Cut Test Sample # (If Applicable)
42371211 3148998	-	L 118b	-	MP ~~0.2~~	-	N/A	-	~~N/A~~ B	-	N/A

GPS Coordinates	36.842098, -119.929394 ☐ Latitude/Longitude ☐ Northing/Easting
Nearest Street Address or Location Info	7633 N Weber Ave, Fresno, CA (Fresno Sheriff's Foundation)

MATERIAL REMOVAL INFORMATION (UPPER SECTION / SOUTH)

Date of Material Removal	~~04/19/2015~~ 4/20/15
Reason for Removal	☒ ~~L432~~ PIPE INTEGRITY FAILURE INVESTIGATION
	☐ Suspected Anomaly or Indication
	☐ Existing Anomaly or Indication
	☐ Hydrotest – Test Segment Number:
	☐ Asset Knowledge
Pre-1972 Pipe Wrap ?	~~☒ NO~~ ☒ YES – Follow WP4711-01, "Gas Pipe Wrap Removal, Handling and Disposal Procedures"
Depth of material (from surface to top of material removed)	
Direction of gas flow in pipeline (e.g. north-to-south)	South to North

MATERIAL DESCRIPTION

Pipe or component specifications	Diameter (in.): 12 Wall Thickness (in.): .24 Length Removed (ft./in.): 20'8"
Description – fitting (*e.g. Elbow, etc.*)	N/A
Description – other (*e.g. Valve, etc.*)	
Installation information (if known)	Seam Type: ~~N/A~~ ERW
	Year of Install: 1962
	Installation Job Number: Unknown

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	~~N/A~~ B	–	N/A

RADIOGRAPHY INFORMATION

Radiography performed by: (Signature of qualified individual)	
Refer to GO-TS-001	Date: ~~N/A~~ 4/21/15
	Name of Qualified Individual: Martin Hudgons LAN ID: –
	Title: Radiographer
	Name of ☐ PG&E Department or ☒ Contractor Company JANX
	Address:
	Phone: UNK

QUALIFIED PERSONNEL AND WITNESSES TO MATERIAL REMOVAL

Material REMOVED By: (Signature of qualified individual)	
	Material Removal Date: ~~04/18/2014~~ 4/20/14 Time:
	Name of Qualified Individual: LAN ID:
	Title:
	Name of ☐ PG&E Department or ☐ Contractor Company
	Address:
	Phone:
Material Removal WITNESSED By: (Signature of witness)	Name of Witness: Steve Cleaver LAN ID: R8CB
	Title: Investigator
	Name of ☒ PG&E Department or ☐ Contractor Company
	Address: 705 P St Fresno, CA 93727
	Phone: 559/593-5728

MATERIAL IDENTIFIER:

SAP PM Order #	Transmission Line #	Mile Point	Dig Site #	Sample #	Cut Test Sample # (If Applicable)
42371211	L 118b	MP	N/A	N/A (B)	N/A

TRANSFER OF CUSTODY

1. MATERIAL TRANSFERRED From Field to Transporter ***(to be completed by field personnel)***

BY: (Signature of individual who transported material) [signature] EPPLER'S TOWING (WITNESSED)	Date: 4/20/15
	Transported By: ☐PG&E ☒Contract transporter EPPLER'S TOWING
	Material Received FROM: LOCATION OF FAILURE LAN ID: —
	Material Received BY: ISOLATION AREA (STEVE CLEAVER) LAN ID: R8CB
	Location Transported FROM: LOCATION OF FAILURE
	Location Transported TO: ISOLATION AREA

2. MATERIAL RECEIVED From Transporter At Storage Facility ***(to be completed by storage facility personnel)***

BY: (Signature of individual who received material) [signature]	Date: 4/22/15
	Material Received FROM: LOCATION OF FAILURE LAN ID: —
	Material Received BY: CLEAVER LAN ID: R8CB
	Location Transported FROM: N WEBBER INCIDENT
	Location Transported TO: EPPLER'S TOWING/TRANSPORT
BY: (Signature of individual who received material)	Date:
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

3. CUT TEST SAMPLE ***(to be completed by storage facility personnel)***

(NOTE: If multiple samples are removed for testing/evaluation from original piece of material, then a new Record must be used to maintain chain of custody for each Cut Test Sample.)

BY: (Signature of individual who cut sample)	Date:
	Test Sample Cut/Removed By: ☐PG&E ATS ☐ Testing contractor ____________
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

MATERIAL IDENTIFIER:

SAP PM Order #		Transmission Line #		Mile Point		Dig Site #		Sample #		Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	B N/A	–	N/A

TRANSFER OF CUSTODY
(Copies of this sheet may be used if documentation for additional chain of custody transfer is required)

ACTION/Authorized Signature	DETAILS	
ACTION: TRANSPORTED TO EXPONENT (VOID)	Date: 4/22/15	
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S	
	Material Received FROM: S. CLEAVER	LAN ID: R8CB
Authorized Signature: [signature]	Material Received BY: PHILLIP VINCENT	LAN ID: —
(559) 367-1868	Location Transported FROM: N WEBBER INCIDENT IC POST	
	Location Transported TO: 149 COMMONWEALTH, MENLO PARK, CA	
ACTION: TRANSPORTED TO EXPONENT	Date: 4/22/15	
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S	
	Material Received FROM: S. CLEAVER	LAN ID: R8CB
Authorized Signature: [signature]	Material Received BY: ~~N WEBBER INCIDENT~~ JOHN SULLIVAN	LAN ID: —
(559) 960-3408	Location Transported FROM: N WEBBER INCIDENT	
	Location Transported TO: 149 COMMONWEALTH, MENLO PARK, CA	
ACTION: RECEIVED PIPE	Date: 4/22/15	
	Transported By: ☐PG&E ☑ Contract transporter EPPLERS	
	Material Received FROM: JOHN SULLIVAN	LAN ID:
Authorized Signature: [signature]	Material Received BY: ALEX HUDGINS, EXPONENT	LAN ID:
303 476 8748	Location Transported FROM: N WEBER INCIDENT SITE	
	Location Transported TO: EXPONENT 149 COMMONWEALTH DR MENLO PARK CA 94025	
ACTION:	Date:	
	Transported By: ☐PG&E ☐ Contract transporter	
	Material Received FROM:	LAN ID:
Authorized Signature:	Material Received BY:	LAN ID:
	Location Transported FROM:	
	Location Transported TO:	

Pacific Gas and Electric Company	Record of Material Removed from Existing Gas Transmission Pipelines	Gas T&D TD-4100P-14-F01 04/12

Refer to TD-4100P-14, "Removing, Documenting and Preserving Gas Transmission Pipe and Components" and Job Aid TD-4100P-14-JA01, "Record of Material Removed From Existing Natural Gas Transmission Pipelines Instructions for Form TD-4100P-14-F01."

1. USE ONE RECORD PER SAMPLE OF MATERIAL REMOVED. If material is subdivided into smaller pieces, each subdivided piece must have its own record. If subdivided pieces are further cut into pieces for testing, then each cut test sample must have its own "Cut Test Sample #" and record.
2. Complete the record in ink, including the signature blocks. Attach additional sheets if needed. EACH SHEET OF THE RECORD MUST INCLUDE THE UNIQUE IDENTIFIER AND SHEET (PAGE) NUMBER.
3. Give the completed record to the individual to whom you are releasing the material. DO NOT attach to the material itself.
4. Attach photos documenting material removal to this record.
5. INSPECTOR MUST BE PRESENT PRIOR TO LOADING OF MATERIAL ON TRUCK.

MATERIAL IDENTIFICATION

UNIQUE IDENTIFIER:

SAP PM Order #		Transmission Line #		Mile Point		Dig Site #		Sample #		Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP ~~0.2~~ 0.2	–	N/A	–	N/A C	–	N/A

GPS Coordinates	36.842108 -119.929394 ☐ Latitude/Longitude ☐ Northing/Easting
Nearest Street Address or Location Info	7633 N Weber Ave, Fresno, CA (Fresno Sheriff's Foundation)

MATERIAL REMOVAL INFORMATION (LOWER SECTION/NORTH)

Date of Material Removal	~~04/19/2015~~ 4/20/2015
Reason for Removal	☐ ~~L132~~ PIPE INTEGRITY FAILURE INVESTIGATION
	☐ **Suspected Anomaly or Indication**
	☐ **Existing Anomaly or Indication**
	☐ **Hydrotest – Test Segment Number:**
	☐ **Asset Knowledge**
Pre-1972 Pipe Wrap ?	~~☒ NO~~ ☒ YES Follow WP4711-01, "Gas Pipe Wrap Removal, Handling and Disposal Procedures"
Depth of material (from surface to top of material removed)	
Direction of gas flow in pipeline (e.g. north-to-south)	South to North

MATERIAL DESCRIPTION

Pipe or component specifications	Diameter (in.): 12 Wall Thickness (in.): .24 Length Removed (ft./in.): 20'6"
Description – fitting *(e.g. Elbow, etc.)*	N/A
Description – other *(e.g. Valve, etc.)*	
Installation information (if known)	Seam Type: ~~N/A~~ [redacted]
	Year of Install: 1962
	Installation Job Number: Unknown

MATERIAL IDENTIFIER:

SAP PM Order #	Transmission Line #	Mile Point	Dig Site #	Sample #	Cut Test Sample # (If Applicable)
42371211	L 118b	MP	N/A	C N/A	N/A

RADIOGRAPHY INFORMATION

Radiography performed by: (Signature of qualified individual)	
REFER TO 610-TS-001	Date: ~~N/A~~ ~~[illegible]~~ 4/21/2015
	Name of Qualified Individual: MARTIN HUDGENS LAN ID: —
	Title: RADIOGRAPHER
	Name of ☐ PG&E Department or ☒ Contractor Company JANX
	Address:
	Phone: UNK

QUALIFIED PERSONNEL AND WITNESSES TO MATERIAL REMOVAL

Material REMOVED By: (Signature of qualified individual)	
	Material Removal Date: ~~04/18/2014~~ 4/20/15 Time:
	Name of Qualified Individual: TODD BARKER LAN ID: TJBH
	Title: WELDER
	Name of ☒ PG&E Department or ☐ Contractor Company
	Address: HINKLEY YARD
	Phone: (661) 858-7628

Material Removal WITNESSED By: (Signature of witness)	
[signature]	Name of Witness: STEVE CLEMOR LAN ID: R8CB
	Title: INVESTIGATOR
	Name of ☒ PG&E Department or ☐ Contractor Company
	Address: 705 P ST FRESNO, CA 93721
	Phone: 559/593-5728

MATERIAL IDENTIFIER:

42371211	– L 118b	– MP	– N/A	– N/A (C)	– N/A
SAP PM Order #	Transmission Line #	Mile Point	Dig Site #	Sample #	Cut Test Sample # (If Applicable)

TRANSFER OF CUSTODY

1. MATERIAL TRANSFERRED From Field to Transporter ***(to be completed by field personnel)***

BY: (Signature of individual who transported material) [signature] EPPLER'S TOWING (WITNESSED)	Date: 4/20/2015
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S TOWING
	Material Received FROM: LOCATION OF FAILURE LAN ID: —
	Material Received BY: ISOLATION AREA (STEVE CLEAVER) LAN ID: R8CB
	Location Transported FROM: LOCATION OF FAILURE
	Location Transported TO: ISOLATION AREA

2. MATERIAL RECEIVED From Transporter At Storage Facility ***(to be completed by storage facility personnel)***

BY: (Signature of individual who received material) [signature]	Date: 4/22/15
	Material Received FROM: ~~___~~ LOCATION OF FAILURE LAN ID:
	Material Received BY: CLEAVER LAN ID: R8CB
	Location Transported FROM: N WEBBER AVE INCIDENT
	Location Transported TO: EPPLER'S TOWING / TRANSPORT
BY: (Signature of individual who received material)	Date:
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

3. CUT TEST SAMPLE ***(to be completed by storage facility personnel)***

(NOTE: If multiple samples are removed for testing/evaluation from original piece of material, then a new Record must be used to maintain chain of custody for each Cut Test Sample.)

BY: (Signature of individual who cut sample)	Date:
	Test Sample Cut/Removed By: ☐PG&E ATS ☐ Testing contractor ____________
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

MATERIAL IDENTIFIER:

SAP PM Order #	Transmission Line #	Mile Point	Dig Site #	Sample #	Cut Test Sample # (If Applicable)
42371211	L 118b	MP	N/A	N/A C	N/A

TRANSFER OF CUSTODY
(Copies of this sheet may be used if documentation for additional chain of custody transfer is required)

ACTION/Authorized Signature	DETAILS	
ACTION: TRANSPORTED TO EXPONENT	Date: 4/22/15	
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S	
	Material Received FROM: S. CLEAVER	LAN ID: RBCB
Authorized Signature: [signature]	Material Received BY: PHILIP PETRILLE	LAN ID:
	Location Transported FROM: N. WEBBER INCIDENT IC POST	
(559) 367-1868	Location Transported TO: 149 COMMONWEALTH, MENLO PARK, CA	
ACTION: TRANSPORTED TO EXPONENT, PIPE RECIEVED	Date: 4/22/15	
	Transported By: ☐PG&E ☑ Contract transporter EPPLER'S	
	Material Received FROM: PHILIP PETRILLE	LAN ID:
Authorized Signature: [signature]	Material Received BY: ALEX HUDGINS	LAN ID:
	Location Transported FROM: N WEBBER INCIDENT SITE	
303 476 8748	Location Transported TO: EXPONENT 149 COMMONWEALTH DR MENLO PARK CA 94025	
ACTION:	Date:	
	Transported By: ☐PG&E ☐ Contract transporter	
	Material Received FROM:	LAN ID:
Authorized Signature:	Material Received BY:	LAN ID:
	Location Transported FROM:	
	Location Transported TO:	
ACTION:	Date:	
	Transported By: ☐PG&E ☐ Contract transporter	
	Material Received FROM:	LAN ID:
Authorized Signature:	Material Received BY:	LAN ID:
	Location Transported FROM:	
	Location Transported TO:	

Pacific Gas and Electric Company	Record of Material Removed from Existing Gas Transmission Pipelines	Gas T&D TD-4100P-14-F01 04/12

Refer to TD-4100P-14, "Removing, Documenting and Preserving Gas Transmission Pipe and Components" and Job Aid TD-4100P-14-JA01, "Record of Material Removed From Existing Natural Gas Transmission Pipelines Instructions for Form TD-4100P-14-F01."

1. USE ONE RECORD PER SAMPLE OF MATERIAL REMOVED. If material is subdivided into smaller pieces, each subdivided piece must have its own record. If subdivided pieces are further cut into pieces for testing, then each cut test sample must have its own "Cut Test Sample #" and record.
2. Complete the record in ink, including the signature blocks. Attach additional sheets if needed. EACH SHEET OF THE RECORD MUST INCLUDE THE UNIQUE IDENTIFIER AND SHEET (PAGE) NUMBER.
3. Give the completed record to the individual to whom you are releasing the material. DO NOT attach to the material itself.
4. Attach photos documenting material removal to this record.
5. INSPECTOR MUST BE PRESENT PRIOR TO LOADING OF MATERIAL ON TRUCK.

MATERIAL IDENTIFICATION

UNIQUE IDENTIFIER:

SAP PM Order #		Transmission Line #		Mile Point		Dig Site #		Sample #		Cut Test Sample # (If Applicable)
~~42371211~~ 31148998	-	L 118b	-	MP ~~02~~ 0.2	-	N/A	-	~~N/A~~ D	-	N/A

GPS Coordinates	36.842108 -119.929394 ☐ Latitude/Longitude ☐ Northing/Easting
Nearest Street Address or Location Info	7633 N Weber Ave, Fresno, CA (Fresno Sheriff's Foundation)

MATERIAL REMOVAL INFORMATION (LOWER SECTION/NORTH)

Date of Material Removal	~~04/19/2015~~ 4/20/2015
Reason for Removal	☐ ~~L132~~ PIPE INTEGRITY FAILURE INVESTIGATION
	☐ Suspected Anomaly or Indication
	☐ Existing Anomaly or Indication
	☐ Hydrotest – Test Segment Number:
	☐ Asset Knowledge
Pre-1972 Pipe Wrap ?	~~☒ NO~~ ☒ YES Follow WP4711-01, "Gas Pipe Wrap Removal, Handling and Disposal Procedures"
Depth of material (from surface to top of material removed)	
Direction of gas flow in pipeline (e.g. north-to-south)	South to North

MATERIAL DESCRIPTION

Pipe or component specifications	Diameter (in.): 12 Wall Thickness (in.): .24 Length Removed (ft./in.): 21'
Description – fitting *(e.g. Elbow, etc.)*	N/A
Description – other *(e.g. Valve, etc.)*	
Installation information (if known)	Seam Type: ~~N/A~~ [redacted]
	Year of Install: 1962
	Installation Job Number: Unknown

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A D	–	N/A

RADIOGRAPHY INFORMATION

Radiography performed by: (Signature of qualified individual) REFER TO GO-TS-001	Date: ~~N/A~~ 4/21/15
	Name of Qualified Individual: MARTIN HUDGENS LAN ID: —
	Title: RADIOGRAPHER
	Name of ☐ PG&E Department or ☒ Contractor Company JANX
	Address:
	Phone: UNK

QUALIFIED PERSONNEL AND WITNESSES TO MATERIAL REMOVAL

Material REMOVED By: (Signature of qualified individual)	Material Removal Date: ~~04/18/2014~~ 4/20/15 Time:
	Name of Qualified Individual: LAN ID:
	Title:
	Name of ☐ PG&E Department or ☐ Contractor Company
	Address:
	Phone:
Material Removal WITNESSED By: (Signature of witness)	Name of Witness: STEVE CLEMOR LAN ID: R8CB
	Title: INVESTIGATOR
	Name of ☒ PG&E Department or ☐ Contractor Company
	Address: 705 P ST FRESNO, CA 93721
	Phone: 559/593-5728

MATERIAL IDENTIFIER:

SAP PM Order #		Transmission Line #		Mile Point		Dig Site #		Sample #		Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A (D)	–	N/A

TRANSFER OF CUSTODY

1. MATERIAL TRANSFERRED From Field to Transporter ***(to be completed by field personnel)***

BY: (Signature of individual who transported material)	
[signature] EPPLER'S TOWING (WITNESSED)	Date: 4/21/2015
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S TOWING
	Material Received FROM: LOCATION OF FAILURE LAN ID: —
	Material Received BY: ISOLATION AREA (STEVE CLEAVER) LAN ID: R8CB
	Location Transported FROM: LOCATION OF FAILURE
	Location Transported TO: ISOLATION AREA

2. MATERIAL RECEIVED From Transporter At Storage Facility ***(to be completed by storage facility personnel)***

BY: (Signature of individual who received material)	
[signature]	Date: 4/22/15
	Material Received FROM: ~~ISO~~ LOCATION OF FAILURE LAN ID:
	Material Received BY: CLEAVER LAN ID: R8CB
	Location Transported FROM: N WEBBER AVE INCIDENT
	Location Transported TO: EPPLER'S TOWING / TRANSPORT
BY: (Signature of individual who received material)	Date:
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

3. CUT TEST SAMPLE ***(to be completed by storage facility personnel)***

(NOTE: If multiple samples are removed for testing/evaluation from original piece of material, then a new Record must be used to maintain chain of custody for each Cut Test Sample.)

BY: (Signature of individual who cut sample)	
	Date:
	Test Sample Cut/Removed By: ☐PG&E ATS ☐ Testing contractor ________________
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A D	–	N/A

TRANSFER OF CUSTODY
(Copies of this sheet may be used if documentation for additional chain of custody transfer is required)

ACTION/Authorized Signature	DETAILS
ACTION: TRANSPORT TO EXPONENT	Date: 4/22/15
	Transported By: ☐PG&E ☒Contract transporter EPPLER'S
	Material Received FROM: S. CLEAVER LAN ID: R8CB
Authorized Signature: [signature]	Material Received BY: PHILLIP PETRILLE LAN ID: —
	Location Transported FROM: N. WEBBER INCIDENT IC POST
(559)367-1868	Location Transported TO: 149 COMMONWEALTH, MENLO PARK
ACTION: RECEIVED PIPE SECTION	Date: 4/22/15
	Transported By: ☐PG&E ☑Contract transporter EPPLERS
	Material Received FROM: PHILLIP PETRILLE LAN ID:
Authorized Signature: [signature]	Material Received BY: ALEX HUDGINS, EXPONENT LAN ID:
	Location Transported FROM: N WEBBER INCIDENT SITE
303 476 8748	Location Transported TO: 149 COMMONWEALTH DR MENLO PARK CA 94025
ACTION:	Date:
	Transported By: ☐PG&E ☐ Contract transporter
	Material Received FROM: LAN ID:
Authorized Signature:	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:
ACTION:	Date:
	Transported By: ☐PG&E ☐ Contract transporter
	Material Received FROM: LAN ID:
Authorized Signature:	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

Pacific Gas and Electric Company	Record of Material Removed from Existing Gas Transmission Pipelines	Gas T&D TD-4100P-14-F01 04/12

Refer to TD-4100P-14, "Removing, Documenting and Preserving Gas Transmission Pipe and Components" and Job Aid TD-4100P-14-JA01, "Record of Material Removed From Existing Natural Gas Transmission Pipelines Instructions for Form TD-4100P-14-F01."

1. USE ONE RECORD PER SAMPLE OF MATERIAL REMOVED. If material is subdivided into smaller pieces, each subdivided piece must have its own record. If subdivided pieces are further cut into pieces for testing, then each cut test sample must have its own "Cut Test Sample #" and record.
2. Complete the record in ink, including the signature blocks. Attach additional sheets if needed. EACH SHEET OF THE RECORD MUST INCLUDE THE UNIQUE IDENTIFIER AND SHEET (PAGE) NUMBER.
3. Give the completed record to the individual to whom you are releasing the material. DO NOT attach to the material itself.
4. Attach photos documenting material removal to this record.
5. INSPECTOR MUST BE PRESENT PRIOR TO LOADING OF MATERIAL ON TRUCK.

MATERIAL IDENTIFICATION

UNIQUE IDENTIFIER:

SAP PM Order #	Transmission Line #	Mile Point	Dig Site #	Sample #	Cut Test Sample # (If Applicable)
42371211	L 118b	MP 0.2	N/A	N/A	N/A

GPS Coordinates	[ ] , [ ] TO N/W OF RUPTURE POINT ☐ **Latitude/Longitude** ☐ **Northing/Easting**
Nearest Street Address or Location Info	7633 N Weber Ave, Fresno, CA (Fresno Sheriff's Foundation)

MATERIAL REMOVAL INFORMATION

Date of Material Removal	04/19/2015
Reason for Removal	☐ ~~L432~~ PIPE INTEGRITY FAILURE INVESTIGATION
	☐ **Suspected Anomaly or Indication**
	☐ **Existing Anomaly or Indication**
	☐ **Hydrotest – Test Segment Number:**
	☐ **Asset Knowledge**
Pre-1972 Pipe Wrap ?	☒ **NO** ☐ **YES** – Follow WP4711-01, "Gas Pipe Wrap Removal, Handling and Disposal Procedures"
Depth of material (from surface to top of material removed)	
Direction of gas flow in pipeline (e.g. north-to-south)	South to North

MATERIAL DESCRIPTION

Pipe or component specifications	Diameter (in.): 12 Wall Thickness (in.): .24 Length Removed (ft./in.): 36" x 41"
Description – fitting *(e.g. Elbow, etc.)*	N/A
Description – other *(e.g. Valve, etc.)*	CURVED IRREGULAR PIECE OF METAL
Installation information (if known)	Seam Type: ~~N/A~~ [redacted]
	Year of Install: 1962
	Installation Job Number: Unknown

MATERIAL IDENTIFIER:

42371211	- L 118b	- MP 0.2	- N/A	- N/A	- N/A
SAP PM Order #	– Transmission Line #	– Mile Point	– Dig Site #	– Sample #	– Cut Test Sample # (If Applicable)

RADIOGRAPHY INFORMATION

~~Radiography performed by:~~ (Signature of qualified individual) PHOTOGRAPHED IN PLACE BY	Date: N/A 4/18/2014
	Name of Qualified Individual: JOEL E. SIPE LAN ID: N/A
	Title: SENIOR ENGINEER / EXPONENT
	Name of ☐ PG&E Department or ☒ Contractor Company EXPONENT
	Address: 149 COMMONWEALTH DR. MENLO PARK, CA
	Phone: 650-476-8748

QUALIFIED PERSONNEL AND WITNESSES TO MATERIAL REMOVAL

Material REMOVED By: (Signature of qualified individual)	Material Removal Date: 04/18/2014 Time: 2230 HRS
	Name of Qualified Individual: JOEL E SIPE LAN ID: N/A
	Title: SENIOR ENGINEER
	Name of ☐ PG&E Department or ☒ Contractor Company EXPONENT
	Address: 149 COMMONWEALTH DR MENLO PARK, CA
	Phone: 650-476 8748
Material Removal WITNESSED By: (Signature of witness)	Name of Witness: STEVE CLEAVER LAN ID: R8CB
	Title: SR. DAMAGE PREVENTION INVESTIGATOR
	Name of ☒ PG&E Department or ☐ Contractor Company DAMAGE PREVENTION
	Address: 705 P ST. FRESNO, CA 320 FLR 164A
	Phone: (559) 593-5728

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP .2	–	N/A	–	N/A	–	N/A

TRANSFER OF CUSTODY

1. MATERIAL TRANSFERRED From Field to Transporter ***(to be completed by field personnel)***

BY: (Signature of individual who transported material) [signature]	Date: 4/19/2015
	Transported By: ☒PG&E ☐ Contract transporter S. CLEAVER
	Material Received FROM: CLEAVER LAN ID: R8CB
	Material Received BY: CLEAVER LAN ID: R8CB
	Location Transported FROM: LOCATION OF RECOVERY
	Location Transported TO: ISOLATION AREA

2. MATERIAL RECEIVED From Transporter At Storage Facility ***(to be completed by storage facility personnel)***

BY: (Signature of individual who received material)	Date: N/A
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:
BY: (Signature of individual who received material)	Date: N/A
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

3. CUT TEST SAMPLE ***(to be completed by storage facility personnel)***
(NOTE: If multiple samples are removed for testing/evaluation from original piece of material, then a new Record must be used to maintain chain of custody for each Cut Test Sample.)

BY: (Signature of individual who cut sample)	Date:
	Test Sample Cut/Removed By: ☐PG&E ATS ☐ Testing contractor ______
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP	–	N/A	–	N/A	–	N/A

TRANSFER OF CUSTODY
(Copies of this sheet may be used if documentation for additional chain of custody transfer is required)

ACTION/Authorized Signature	DETAILS	
ACTION: PLACED IN SITE QUARANTINE	Date: 4/19/15	
	Transported By: ☐PG&E ☐ Contract transporter ________	
	Material Received FROM: [signature] CLEAVER	LAN ID: R8CB
Authorized Signature: [signature]	Material Received BY: ISOLATED QUARANTINE	LAN ID: N/A
	Location Transported FROM: SCENE	
	Location Transported TO: ISOLATED QUARANTINE	
ACTION: TRANSPORTED TO EXPONENT	Date: 4/22/15	
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S	
	Material Received FROM: S. CLEAVER	LAN ID: R8CB
Authorized Signature: [signature] (559) 940-3408	Material Received BY: JOHN SULLIVAN	LAN ID: —
	Location Transported FROM: N. WEBBER INCIDENT IC POST	
	Location Transported TO: 149 COMMONWEALTH, MENLO PARK, CA	
VOID		
ACTION: TRANSPORTED TO EXPONENT	Date: 4/22/15	
	Transported By: ☐PG&E ☒ Contract transporter EPPLER'S	
	Material Received FROM: S. CLEAVER	LAN ID:
Authorized Signature: [signature] (559) 367-1968	Material Received BY: PHILLIP PETRILLE	LAN ID:
	Location Transported FROM: N. WEBBER INCIDENT IC POST	
	Location Transported TO: 149 COMMONWEALTH, MENLO PARK, CA	
ACTION: TRANSPORTED TO EXPONENT	Date: 4/22/15	
	Transported By: ☐PG&E ☑ Contract transporter EPPLER'S	
	Material Received FROM: PHILLIP PETRILLE	LAN ID:
Authorized Signature: [signature] 303 476 8748	Material Received BY: ALEX HUGGINS	LAN ID:
	Location Transported FROM: N. WEBBER INCIDENT SITE	
	Location Transported TO: 149 COMMONWEALTH DR MENLO PARK CA	

Pacific Gas and Electric Company	Record of Material Removed from Existing Gas Transmission Pipelines	Gas T&D TD-4100P-14-F01 04/12

Refer to TD-4100P-14, "Removing, Documenting and Preserving Gas Transmission Pipe and Components" and Job Aid TD-4100P-14-JA01, "Record of Material Removed From Existing Natural Gas Transmission Pipelines Instructions for Form TD-4100P-14-F01."

1. USE ONE RECORD PER SAMPLE OF MATERIAL REMOVED. If material is subdivided into smaller pieces, each subdivided piece must have its own record. If subdivided pieces are further cut into pieces for testing, then each cut test sample must have its own "Cut Test Sample #" and record.
2. Complete the record in ink, including the signature blocks. Attach additional sheets if needed. EACH SHEET OF THE RECORD MUST INCLUDE THE UNIQUE IDENTIFIER AND SHEET (PAGE) NUMBER.
3. Give the completed record to the individual to whom you are releasing the material. DO NOT attach to the material itself.
4. Attach photos documenting material removal to this record.
5. INSPECTOR MUST BE PRESENT PRIOR TO LOADING OF MATERIAL ON TRUCK.

MATERIAL IDENTIFICATION

UNIQUE IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP 0.2	–	N/A	–	Pipe Wrap	–	N/A

GPS Coordinates	[ ] , [ ] ☐ **Latitude/Longitude** ☐ **Northing/Easting**
Nearest Street Address or Location Info	7633 N Weber Ave, Fresno, CA (Fresno Sheriff's Foundation)

MATERIAL REMOVAL INFORMATION

Date of Material Removal	04/21/2015
Reason for Removal	☐ **L132**
	☐ **Suspected Anomaly or Indication**
	☐ **Existing Anomaly or Indication**
	☐ **Hydrotest – Test Segment Number:**
	☒ **Asset Knowledge**
Pre-1972 Pipe Wrap ?	☐ **NO** ☒ **YES –** Follow WP4711-01, "Gas Pipe Wrap Removal, Handling and Disposal Procedures"
Depth of material (from surface to top of material removed)	N/A
Direction of gas flow in pipeline (e.g. north-to-south)	South to North

MATERIAL DESCRIPTION

Pipe or component specifications	Diameter (in.): 12 Wall Thickness (in.): .24 Length Removed (ft./in.):
Description – fitting *(e.g. Elbow, etc.)*	N/A
Description – other *(e.g. Valve, etc.)*	Pipe Wrap removed by Jose Zavala
Installation information (if known)	Seam Type: N/A
	Year of Install: 1962
	Installation Job Number: Unknown

MATERIAL IDENTIFIER:

42371211	–	L 118b	–	MP .02	–	N/A	–	Pipe Wrap	–	N/A
SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)

RADIOGRAPHY INFORMATION	
Radiography performed by: (Signature of qualified individual)	Date: N/A
	Name of Qualified Individual: LAN ID:
	Title:
	Name of ☐ PG&E Department or ☐ Contractor Company ____________
	Address:
	Phone:

QUALIFIED PERSONNEL AND WITNESSES TO MATERIAL REMOVAL	
Material REMOVED By: (Signature of qualified individual) Jose L. ZAVALA [signature]	Material Removal Date: 04/21/2014 Time:
	Name of Qualified Individual: Jose Zavala LAN ID: JLZ3
	Title: Working Foreman B
	Name of ☒ PG&E Department or ☐ Contractor Company ____________
	Address: 3121 N Orange Ave, Fresno, CA
	Phone: 559-970-4764
Material Removal WITNESSED By: (Signature of witness)	Name of Witness: S. Cleaver LAN ID: R8CB
	Title: Damage Prevention Investigator
	Name of ☒ PG&E Department or ☐ Contractor Company ____________
	Address: 705 P Street 3rd Floor, 164a, Fresno, CA
	Phone: 559-593-5728

MATERIAL IDENTIFIER:

SAP PM Order #	–	Transmission Line #	–	Mile Point	–	Dig Site #	–	Sample #	–	Cut Test Sample # (If Applicable)
42371211	–	L 118b	–	MP 0.2	–	N/A	–	Pipe Wrap	–	N/A

TRANSFER OF CUSTODY

1. MATERIAL TRANSFERRED From Field to Transporter *(to be completed by field personnel)*

BY: (Signature of individual who transported material) JOSE L ZAVALA [signature]	Date: 04/22/2015
	Transported By: ☒PG&E ☐ Contract transporter ________________
	Material Received FROM: Jose Zavala LAN ID: JLZ3
	Material Received BY: Jose Zavala LAN ID: JLZ3
	Location Transported FROM: Location of removal (Isolation Area)
	Location Transported TO: 3121 N Orange Ave, Fresno, CA (Fenced Yard in Half Box)

2. MATERIAL RECEIVED From Transporter At Storage Facility *(to be completed by storage facility personnel)*

BY: (Signature of individual who received material) [signature]	Date: 04/22/2015
	Material Received FROM: Jose Zavala LAN ID: JLZ3
	Material Received BY: JOSE ZAVALA / CHRIS PARIS LAN ID:
	Location Transported FROM: 3121 N Orange Ave, Fresno, CA (Fenced Yard in Half Box)
	Location Transported TO: 3121 N Orange Ave, Fresno, CA (Evidence)
BY: (Signature of individual who received material)	Date:
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

3. CUT TEST SAMPLE *(to be completed by storage facility personnel)*

(NOTE: If multiple samples are removed for testing/evaluation from original piece of material, then a new Record must be used to maintain chain of custody for each Cut Test Sample.)

BY: (Signature of individual who cut sample)	Date:
	Test Sample Cut/Removed By: ☐PG&E ATS ☐ Testing contractor ________________
	Material Received FROM: LAN ID:
	Material Received BY: LAN ID:
	Location Transported FROM:
	Location Transported TO:

MATERIAL IDENTIFIER:

SAP PM Order #	Transmission Line #	Mile Point	Dig Site #	Sample #	Cut Test Sample # (If Applicable)
42371211	L 118b	MP 0.2	N/A	Pipe Wrap	N/A

TRANSFER OF CUSTODY
(Copies of this sheet may be used if documentation for additional chain of custody transfer is required)

ACTION/Authorized Signature	DETAILS
ACTION: TRANSPORT FROM FRESNO TO EXPONENT **Authorized Signature:** [signature]	Date: 5/4/2015 Transported By: ☐PG&E ☒ Contract transporter EPPLER'S Material Received FROM: S. CLEAVER [signature] LAN ID: R8CB Material Received BY: T. SHEPARD LAN ID: — Location Transported FROM: 2141 S. ORANGE AVE, FRESNO (EVIDENCE) Location Transported TO: 149 COMMONWEALTH, MENLO PARK
ACTION: RECEIVED AT EXPONENT **Authorized Signature:** [signature]	Date: 5/4/2015 Transported By: ☐PG&E ☒ Contract transporter EPPLER'S Material Received FROM: T SHEPARD LAN ID: Material Received BY: ALEX HUDGINS LAN ID: Location Transported FROM: 2141 S ORANGE AVE FRESNO Location Transported TO: 149 COMMONWEALTH DR MENLO PARK CA
ACTION: **Authorized Signature:**	Date: Transported By: ☐PG&E ☐ Contract transporter Material Received FROM: LAN ID: Material Received BY: LAN ID: Location Transported FROM: Location Transported TO:
ACTION: **Authorized Signature:**	Date: Transported By: ☐PG&E ☐ Contract transporter Material Received FROM: LAN ID: Material Received BY: LAN ID: Location Transported FROM: Location Transported TO: