EXHIBIT NO. ___(KCG-3)
DOCKET NO. PG-041624
WITNESS: KEVIN C. GARRITY

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, Complainant, v. PUGET SOUND ENERGY, INC., Respondent.	Docket No. PG-041624

SECOND EXHIBIT TO THE PREFILED DIRECT TESTIMONY OF KEVIN C. GARRITY (NONCONFIDENTIAL) ON BEHALF OF PUGET SOUND ENERGY, INC.

AUGUST 15, 2005

FINAL REPORT

F 4434-01G

PREPARED
FOR
GORDON MURRAY TILDEN LLP
ON BEHALF OF
PUGET SOUND ENERGY

LABORATORY-BASED EVALUATION OF FAILED SERVICE LINE
BELLEVUE, WASHINGTON

FINAL REPORT
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LABORATORY-BASED EVALUATION OF FAILED SERVICE LINE

PREPARED FOR

GORDON MURRAY TILDEN LLP
ON BEHALF OF
PUGET SOUND ENERGY

PREPARED BY

CC TECHNOLOGIES LABORATORIES, INC.

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BACKGROUND

CC Technologies Laboratories, Inc. (CC Technologies) has been retained by Gordon Murray Tilden LLP on behalf of Puget Sound Energy (PSE) to conduct a laboratory-based evaluation of a section of an underground natural gas service line. The section was taken from the site of an incident at 16445 SE 26 Place in Bellevue, WA (see aerial photograph in Figure 1). The incident was reported to have occurred as a result of a gas leak and subsequent explosion that occurred on September 2, 2004. The pipe was removed from service on September 3, 2004.

Figure 1. Aerial view of the failure site location in Bellevue, WA (taken in 2002).

On November 23, 2004, the removed section of the nominal ¾-inch diameter carbon steel pipe was collected by CC Technologies' personnel to be transported to the CC Technologies Laboratories' offices in Dublin, OH. The overall length of the pipe section was approximately 62 feet; the section was comprised of 6 individual segments (Nos. 01 through 06). Segment 01 was a short 8-inch section nearest to the gas main; the other sections were several feet long. The cuts on Segment 01 were slanted and did not match the cuts on Segment 02. This does not impact the findings of this report. The pipe segments are shown at a storage facility in Figure 2; Segment 01 is not shown.

Figure 2. Pipeline sections at a storage facility (October 2004). Segment 01 is not shown.

To facilitate shipping, four of the six segments (Nos. 02, 03, 04, and 05, shown lying on the floor in Figure 2) were further cut to facilitate packaging in the shipping crates, thus producing a total of 10 segments. The sectioning, packaging, and crating of the segments was observed by the representatives from Washington Utilities and Transportation Commission and the representatives for PSE. The packing and crating procedure followed the Laboratory Examination Protocol (see Appendix A).

APPROACH

The procedure consisted of the following:

Primary methods of analysis:

1. Visual evaluation and photo documentation of the pipe segments in as-received condition
2. Visual evaluation and photo documentation of the pipe segments with the external coating and documentation of the extent of corrosion attack to the pipe
3. Cross-sectioning of selected corroded areas with subsequent metallographic evaluation of the transverse surfaces in as-polished and etched conditions using light microscope
4. Scanning electron microscopy of the polished cross-sections
5. Elemental analysis of the surface products from corrosion sites by means of energy dispersive spectroscopy (EDS)

Supplementary methods of analysis:

6. Chemical analysis of the steel segments
7. Ultrasonic measurements of remaining wall thickness at selected locations
8. Analysis of the surface products for the presence of microbiological organisms

The approach is described in greater detail in the Laboratory Examination Protocol (see Appendix A).

RESULTS

Visual examination and photo documentation in as-received condition

The box containing the pipe sections was received at CC Technologies on December 1, 2004. Figure 3[1] shows the crate in the as-received condition; Figure 4 shows the contents with lid removed showing how the pipe sections were packaged for shipping. Individual wrapped segments are displayed in Figure 5.

The pipe segments were labeled such that the sequential order corresponded to the segment position (while in service) to the relative distance from the gas main located at SE 26 Place. Thus, the original Segment 01 was the closest to the main, and the original Segment 06 was the farthest from the main and the closest to the house. The total length of the segments was 747.75 inches; the lengths of the individual segments are summarized in Table 1.

Figure 3. Shipping crate as-received at CC Technologies.

[1] Additional photographic documentation is located in Appendix B and Appendix C.

Figure 4. Crate after opening showing packaging of samples.

Figure 5. Individual pipe segments' packaging.

Table 1. Individual pipe segments' lengths.

ID	Length (inch)	Comments
Segment 1	8	As is, formerly Segment 01
Segment 2	88.5	Formerly Segment 02, cut in half forming Segments 2 and 3
Segment 3	70.5	
Segment 4	95	Formerly Segment 03, cut in half forming Segments 4 and 5
Segment 5	82.75	
Segment 6	59	Formerly Segment 04, cut in half forming Segments 6 and 7
Segment 7	70.5	
Segment 8	88	Formerly Segment 05, cut in half forming Segments 8 and 9
Segment 9	82	
Segment 10	103.5	As is, formerly Segment 06

The leak site was contained within Segment 10; the Segment contained a curved pipe portion ("riser") with the valve. The region with the failure site on Segment 10 had been covered with an additional plastic protector (see Figure 6).

As noted earlier, the transversely cut right-end surface of Segment 1 was not an apparent mate to the transversely cut left-end surface of Segment 2 (slanted cut on Segment 1 versus vertical one on Segment 2). The other cut surfaces had a good right end-left end match.

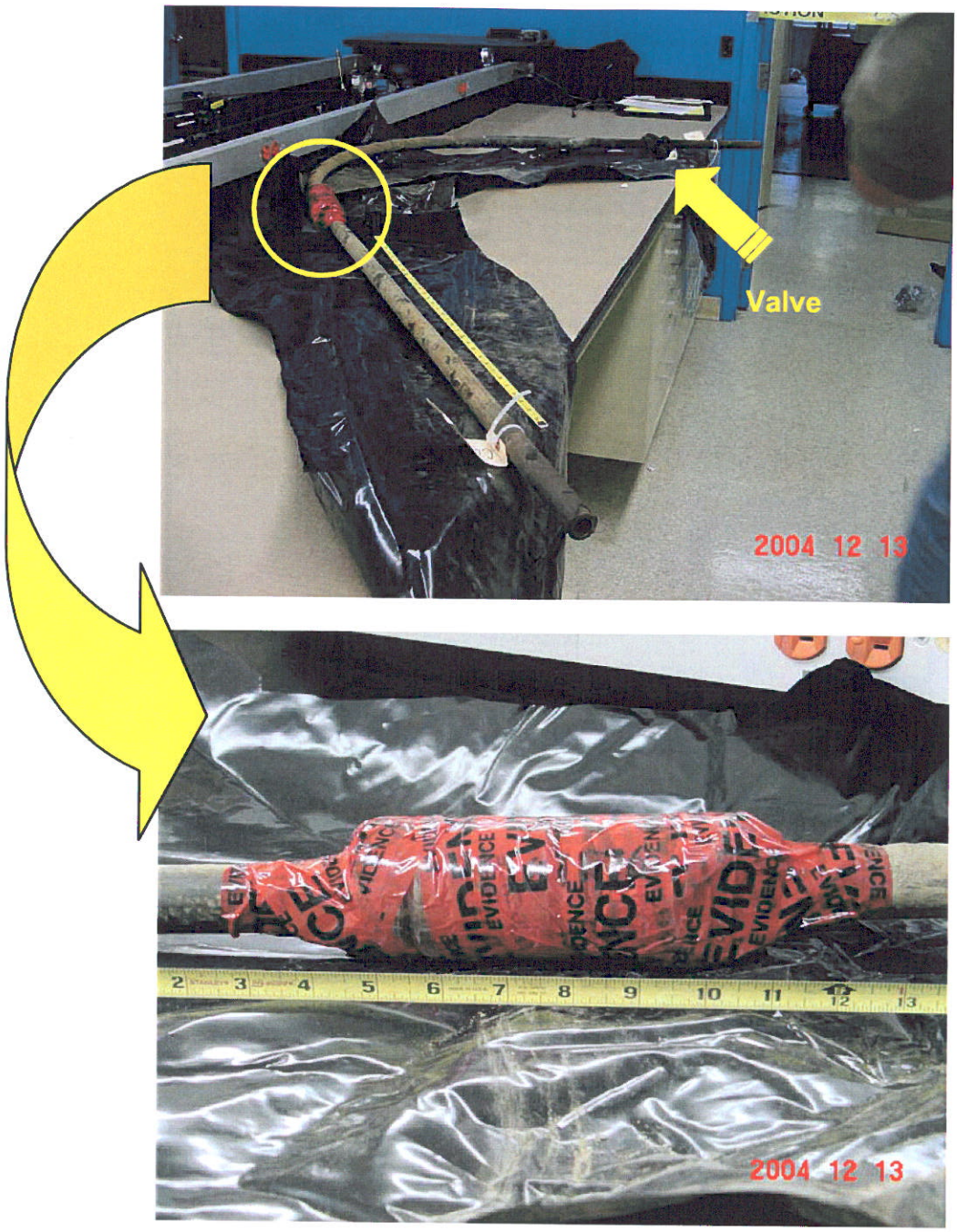


Figure 6. Segment 10 after removal of the protective wrapping for shipping. Lower photo shows the additional protector covering the failure site.

External coating assessment

The external coating appeared to be factory-applied coal tar enamel; two of the Segments (Segment 4 and Segment 8) contained field-applied coal tar wrap coating over the welds. The riser (Segment 10) also had an outer plastic tape wrap extending over approximately 10 inches adjacent to the bare region containing the valve.

The condition of each of the segments was assessed visually to establish the presence of coating defects ("holidays"). The overall condition of the coating was good; however, multiple locations were observed to contain holidays with products at the bottom of some holidays indicating a penetration of the coating to the pipe substrate. Figure 7 and Figure 8 show examples of coating damage.[2] The summary of the findings is presented in Table 2. Sketches of the coating anomalies are in Appendix E.

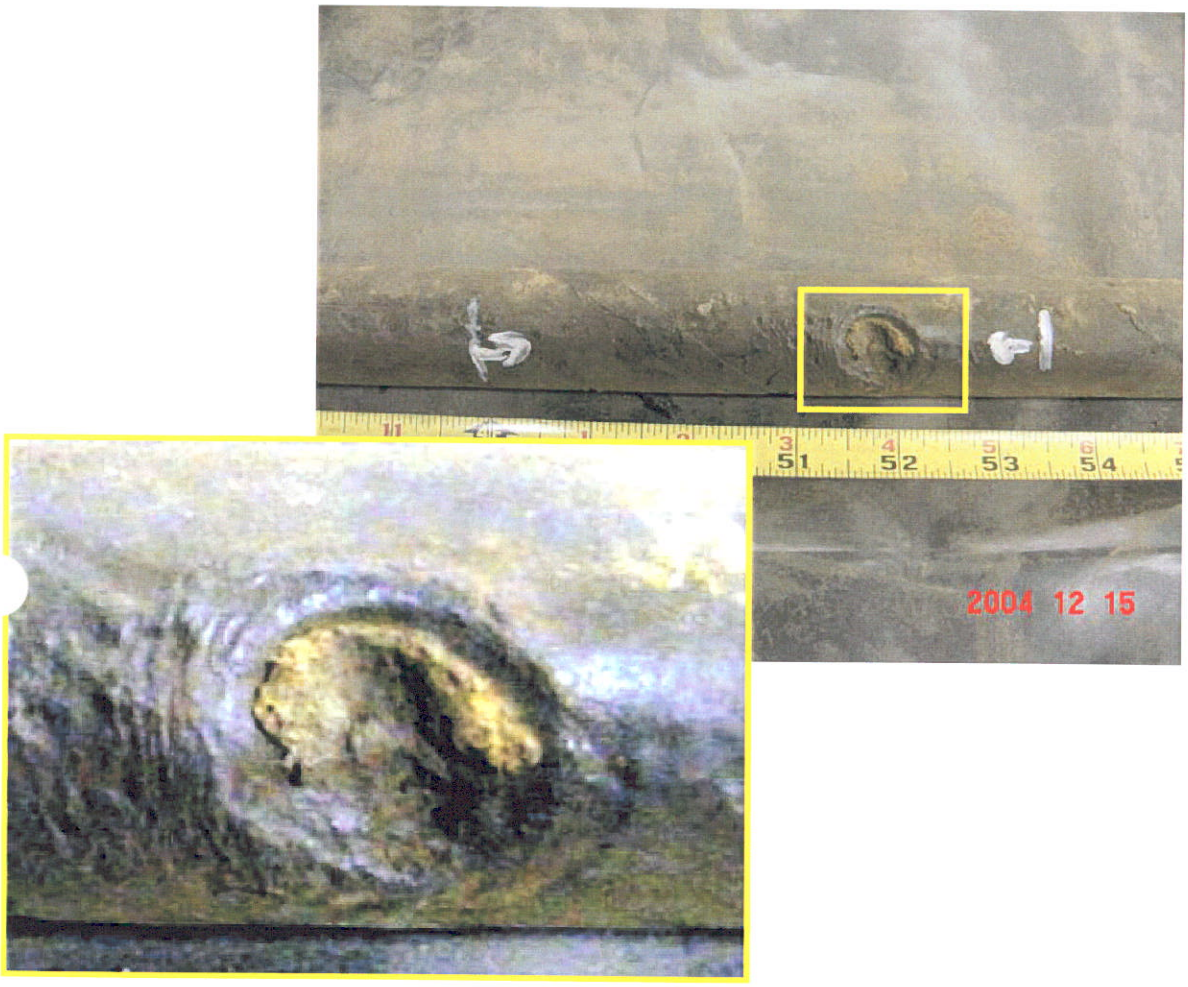


Figure 7. Photograph of Segment 4 showing a coating deformation at the 52-inch location. Inset shows a close-up of view of the region denoted by the yellow rectangle.

[2] Comprehensive photographic documentation of the as-received coating condition is presented in Appendix D.

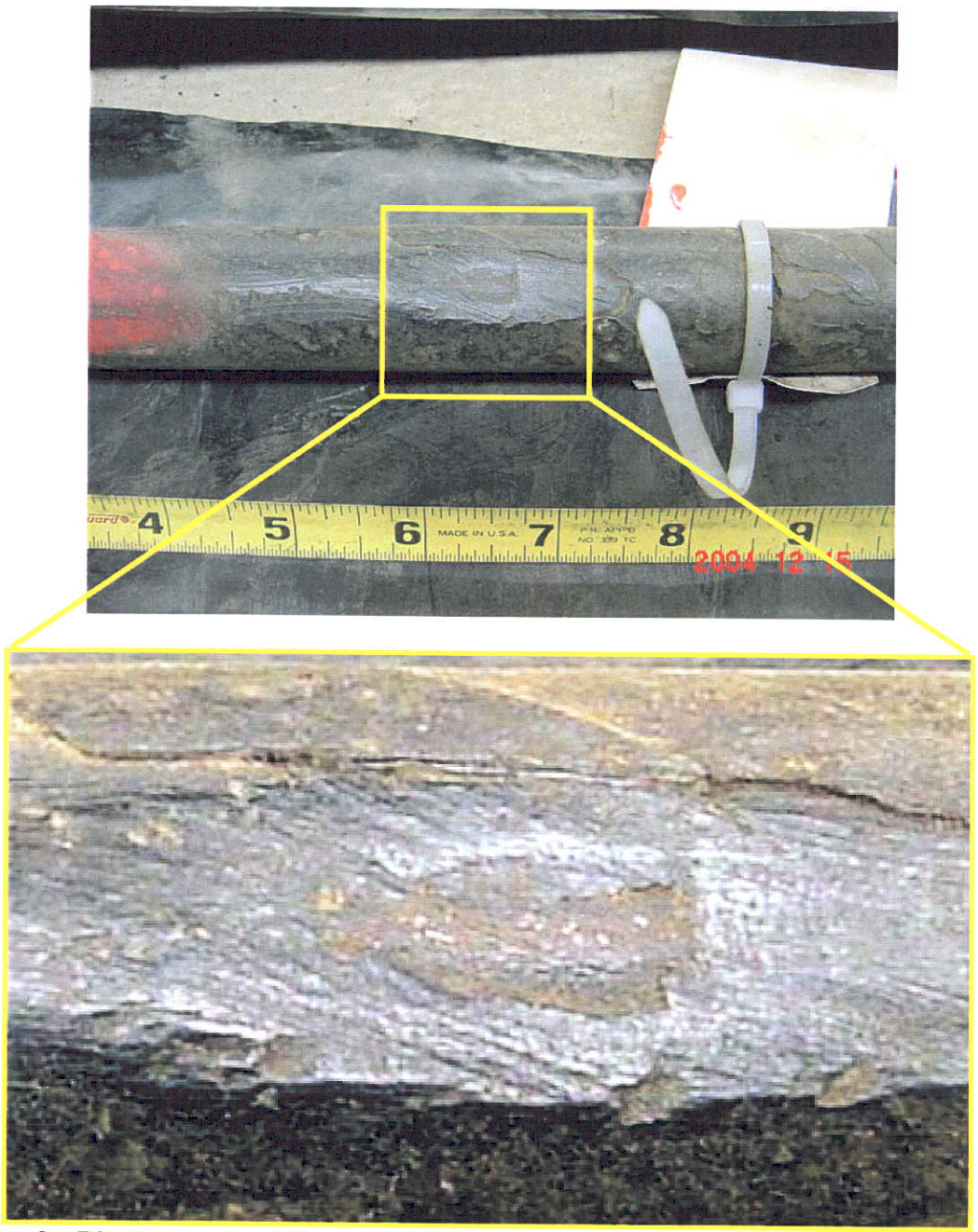


Figure 8. Photograph of Segment 7 showing gouge in coating from the 6-inch location to the 7.5-inch location with a 0.5-inch bare coating spot in the middle. Inset shows a close-up of view of the region denoted by the yellow rectangle.

Table 2. Summary of as-received external coating conditions.

Segment ID	Coating features	Distance away from Segment 2[3] (inches)	Distance away from valve on Segment 10 (inches)	Total Length of Segment (inches)
Segment 1	No coating present[4]	ND	ND	8
Segment 2	crimp at start, coating holiday	8	731.75	88.5
	scratched coating	40-53	686.75-699.75	
	crimp	57.5	682.25	
	scratched coating, deformation	73.5	666.25	
Segment 3	coating holiday	141-145.5	594.25-598.75	70.5
Segment 4	coating holiday	160.5	579.25	95
	0.5" coating deformation	211	528.75	
	coating wrap	219.5-247	492.75-520.25	
Segment 5	scratched coating	259-273	466.75-480.75	82.75
	scratched coating	299-316	423.75-440.75	
Segment 6	coating deformation	346.75	393	59
	coating deformation	352.25	387.5	
	coating deformation	364.75	375	
Segment 7	gouge	401.75	338	70.5
	scratched coating	402.75-414.75	325-337	
	gouge	420.75	319	
	scratched and deformed coating	437.25-450.75	289-302.5	
	coating deformation	461.75	278	
Segment 8	coating wrap	472.25-495.25	244.5-267.5	88
	scratched and deformed coating	495.25-554.25	185.5-244.5	
	coating deformation to bare metal	509.25	230.5	
	coating deformation to bare metal	512	227.75	
	coating deformation to bare metal	514.25	225.5	
Segment 9	1" coating deformation	570.25	169.5	82
	scratched and deformed coating	575.25-600.25	139.5-164.5	
Segment 10	2" area of coating holiday	636.25	103.5	103.5
	0.5"-2" long coating deformations	647.25+660.25	79.5-92.5	
	2" coating deformation	657.25	82.5	
	0.25"-0.5" long coating deformations	666.25-677.25	62.5-73.5	
	1" through wall indication	685.25	54.5	
	2" gouge to bare metal	714.25	25.5	
	"transition" coating	718.25-729.25	10.5-21.5	

The leak site (Segment 10) is described in greater detail further in the report.

[3] Because of the uncertainty regarding the relative positions of Segment 1 and other Segments, the distance was measured in reference to Segment 2.
[4] Most likely removed in the field.

Corrosion assessment

The external coating was removed from the areas where the coating exhibited more than a superficial damage. The steel surface was then cleaned by hand-held non-abrasive tools. An example of the cleaning sequence is shown in Figure 9.

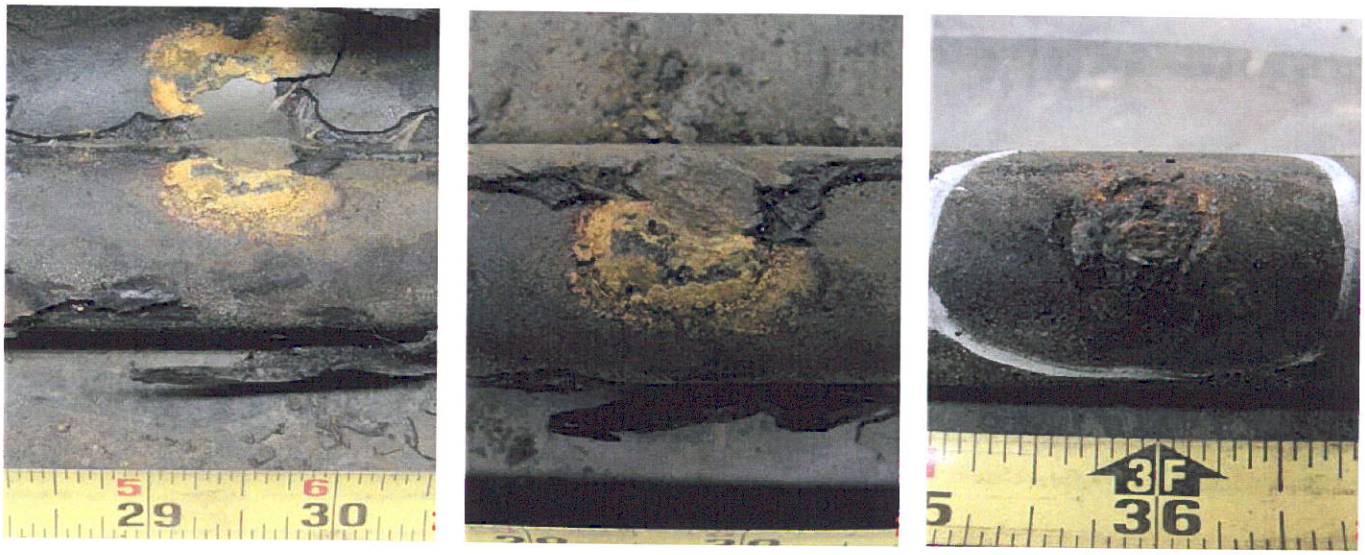


Figure 9. Example of external coating damage removal to expose the underlying steel condition (Segment 9).

The examination also included Segment 1, which was found to be uncoated. Cleaning of the surface debris on Segment 1 revealed a single deep corrosion anomaly that was within 10 mils (0.010-inch) of full pipe wall penetration. This corrosion anomaly is shown in Figure 10.

Other examples of the corrosion features observed after coating removal are shown in Figure 11 and Figure 12. Comprehensive photo documentation of the evaluated pipe surface after the coating removal is contained in Appendix F. Sketches of corrosion anomalies are included in Appendix G.

Figure 10. Corrosion site in Segment 1. Top photo shows the surface condition prior to the surface cleaning. Bottom photo shows the surface without the debris.

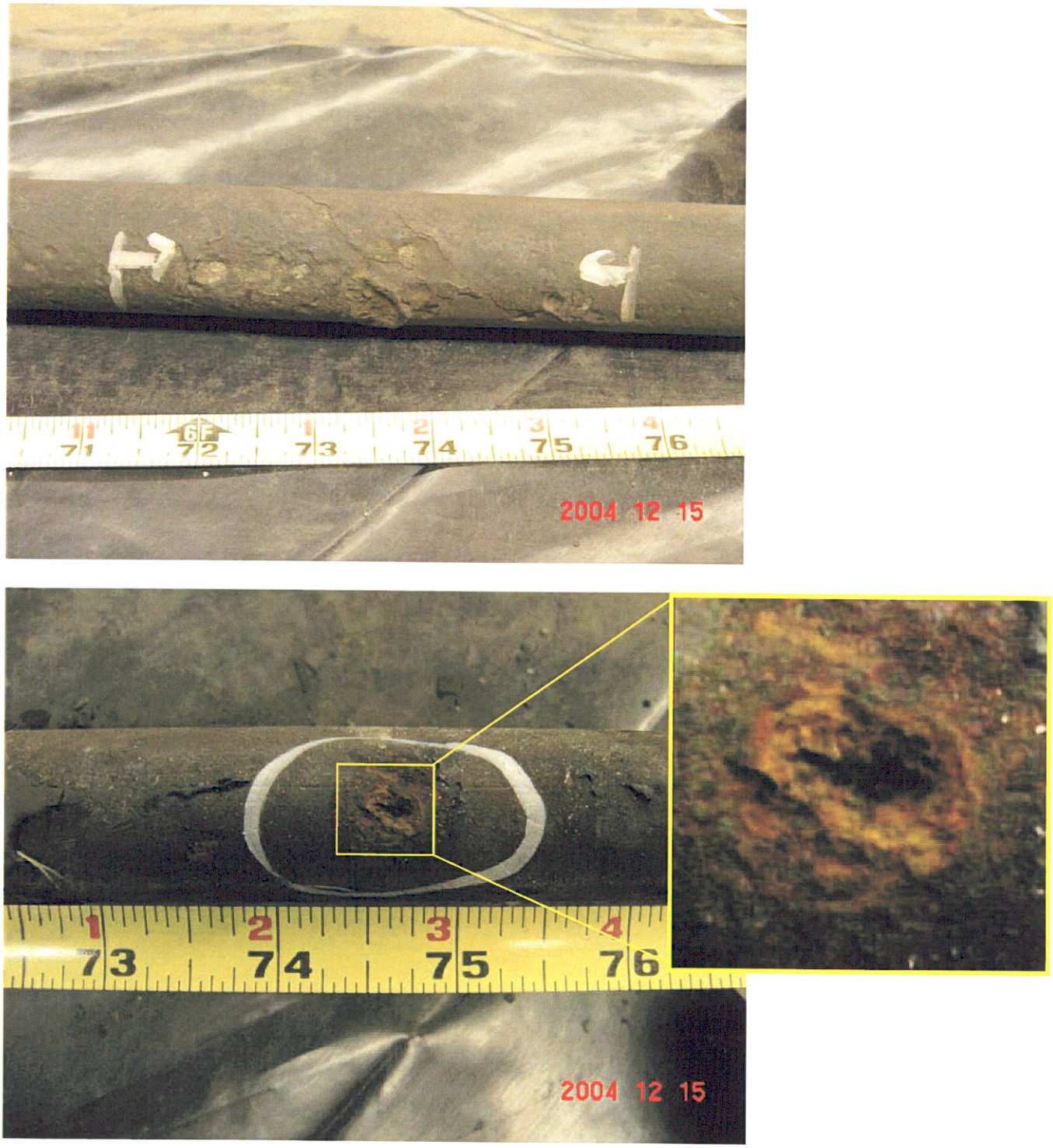


Figure 11. Segment 2 showing damage to the coating between the 71-inch and 75.5-inch locations with a holiday at the 73.5-inch location (top photo). Same location after a portion of the coating was removed showing a 0.25-inch indication at the 74.5-inch location. Inset shows a close-up view of the corroded area.

Figure 12. Segment 4 showing a coating holiday at the 52-inch location (left photo). Same location after a portion of the coating was removed showing a 0.25-inch indication at the 51.75-inch location. Inset shows a close-up view of the corroded area.

The examination indicated that corrosion pitting was not coincident with all areas of coating damage. An example of such a site (Segment 7) is shown in Figure 13.

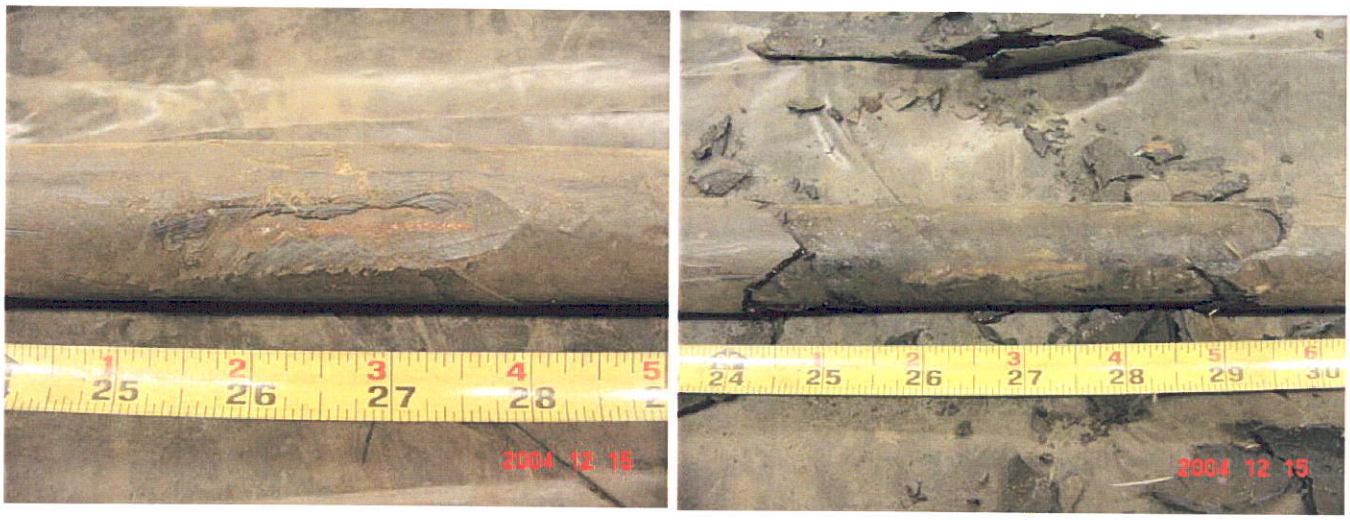


Figure 13. Location on Segment 7 showing a gouge in the coating from the 25-inch to 28-inch locations with a 1.75-inch area of bare area (left photo). The same area after removal of a portion of the coating showing no measurable corrosion damage under the gouge in the coating that was located at the 26-inch location (right photo).

The evaluation has shown that the only through-wall penetration was contained within Segment 10 (the presumed leak site). The appearance of the leak site is documented in Figure 14.

Figure 14. The leak site in Segment 10. Top photo – as received condition with protective plastic enclosure removed; bottom photo – debris and surface deposits removed.

Profile measurements of corrosion anomalies are given in Appendix L. Table 3 summarizes the measurements obtained after the removal of the external coating. Profile measurements of corrosion anomalies are given in Appendix L.

Table 3. Corrosion assessment.

Segment ID	Corrosion features	Distance away from Segment 2[5] (inches)	Distance away from valve on Segment 10 (inches)	Coating condition
Segment 1	1" x 2" anomaly	4	743.75	No coating present[6]
Segment 2	3 small indications	45	694.75	coating holidays
	0.25" indication	74.5	665.25	coating holidays, dent in coating
Segment 4	0.25" indication	210.75	529	0.5" coating holiday
	weld	234	505.75	field-applied coating
Segment 8	weld	485.75	254	field-applied coating
Segment 9	1" indication	583.75	156	coating holidays and dents
	0.75" indication	590.25	149.5	
Segment 10	0.5" indication	657.25	82.5	2" coating holiday
	1" through wall indication	685.25	54.5	bare pipe

The examination of the morphology at corrosion sites, particularly in Segment 1 and Segment 10, suggests that the corrosion progressed from the external pipe and extended into the pipe wall. In the case of the leak site at Segment 10, the corrosion progress through the pipe wall.

Metallographic evaluation, Scanning Electron Microscopy (SEM), and Energy Dispersive Spectroscopy (EDS)

Sectioning sequence, sample selection and labeling

Metallographic evaluation focused on the areas containing corrosion anomalies in Segments 1, 4, 9, and 10. The Segments were sectioned to produce smaller-sized samples (numbered sequentially for each Segment). The samples were then used to make metallographic mounts (labeled "mounts"; 4 mounts representing the four Segments were evaluated).

Segment 10 was further sectioned into six samples (Numbered Sample 10-1 through 10-6, with Sample 10-1 being the left-most upstream sample (closest to the gas main) and Sample 10-6 being the right-most downstream sample (closest to the valve).

[5] Because of the uncertainty regarding the relative positions of Segment 1 and other Segments, the distance was measured in reference to the end of Segment 2.
[6] Most likely removed in the field.

The above-ground section of Segment 10 (containing the soil-to-atmosphere transition plastic tape wrap and the valve) was not evaluated.

The 4 mounts were examined in the SEM at high magnification. Energy dispersive spectroscopy (EDS) analysis of the surface products was performed on the smaller portions of Segments 1 and 10 (labeled "surface"; 3 surfaces representing the two Segments were evaluated). The sectioning process is illustrated in Figure 15 through Figure 17. Detailed photographic documentation of the locations selected for metallographic, SEM, and EDS analyses is presented in Appendix H.

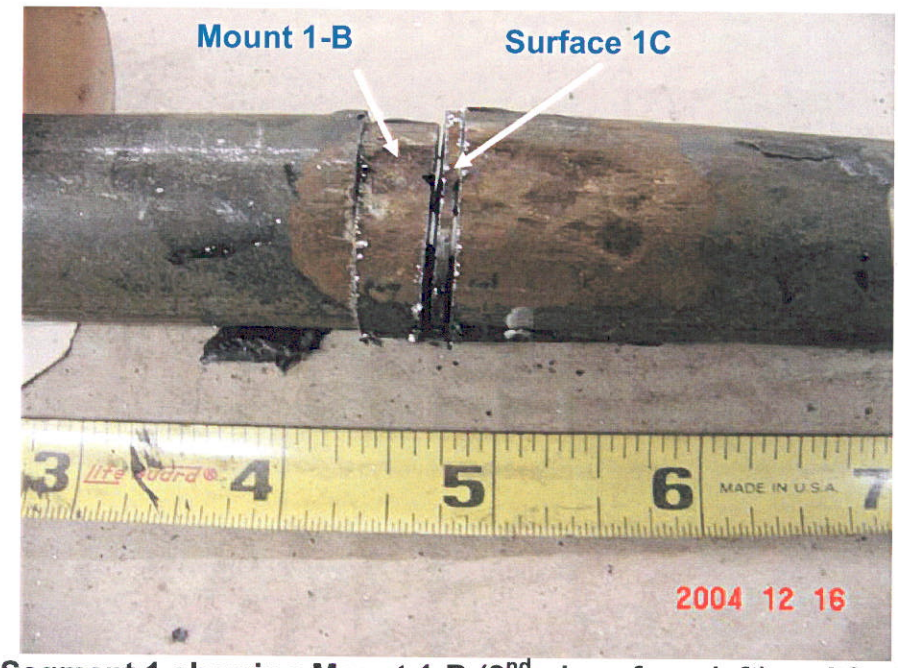


Figure 15. Segment 1 showing Mount 1-B (2nd piece from left) and Surface 1-C (3rd piece from left).

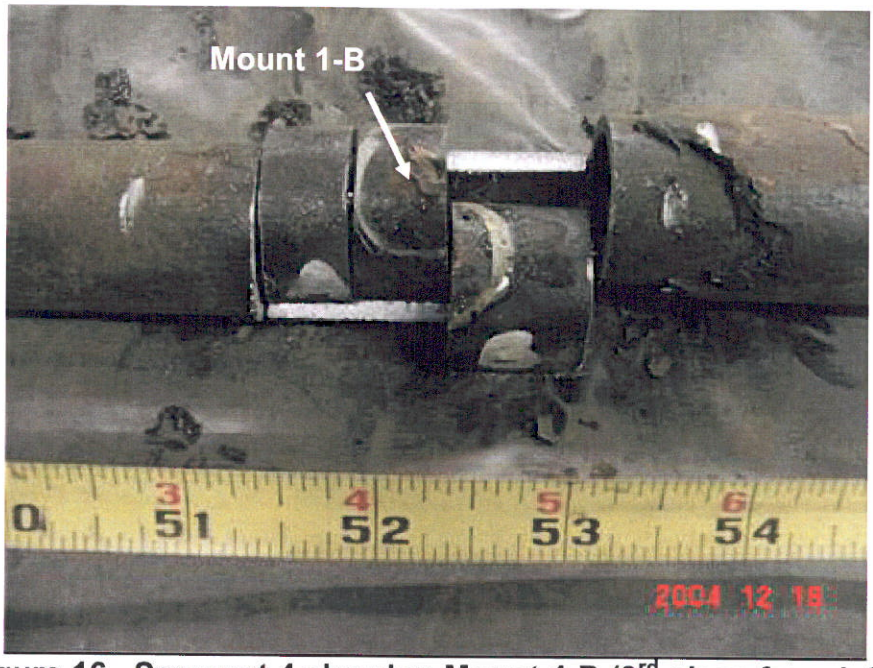


Figure 16. Segment 4 showing Mount 4-B (3rd piece from left).

Figure 17. Segment 9 showing Mount 9-B (2nd piece from left).

The sectioning sequence of Segment 10 is illustrated in Figure 18 through Figure 20.

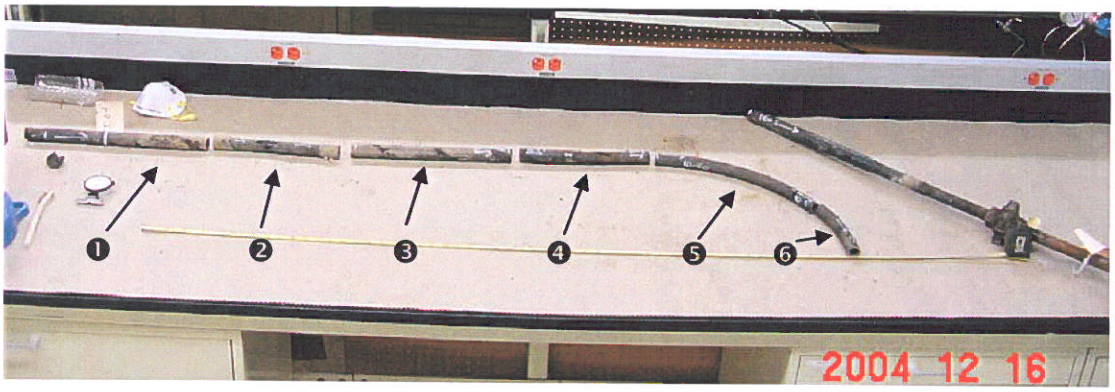


Figure 18. Photograph of Segment 10 showing how the Segment was sectioned; numbers indicate respective Samples. The leak site is in Sample 4.

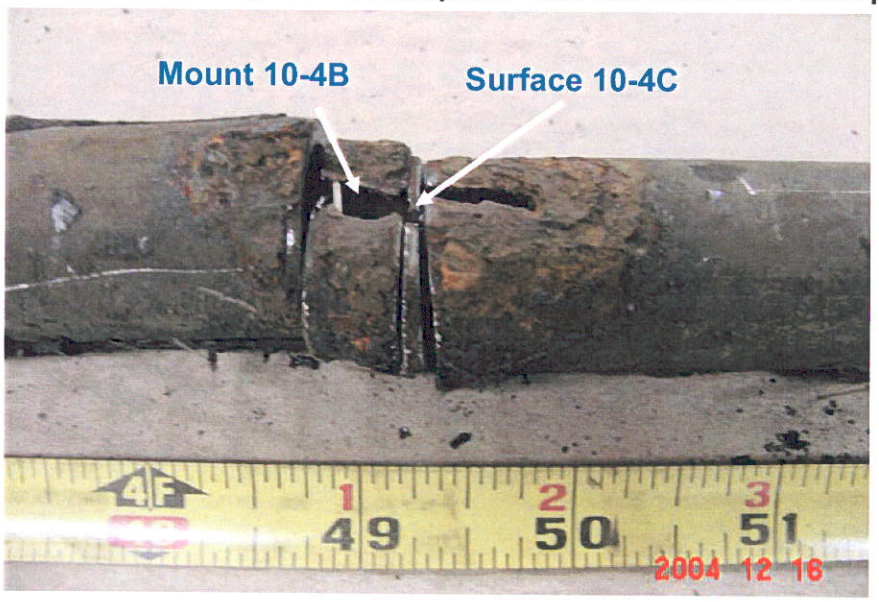


Figure 19. Segment 10 showing Mount 10-4B (2nd piece from left) and Surface 10-4C (3rd piece from left).

Figure 20. Segment 10 showing Surface 10-5B-2.

The Samples selected for metallographic evaluation (mounts) were encapsulated in epoxy and the transverse cross-section was polished and etched with nital (commonly used for etching carbon steel) to reveal the microstructure. Photomicrographs were obtained in both the as-polished and etched conditions.

Metallographic evaluation (light microscopy)

The cross-sectional view of corrosion site in Segment 1 is shown in Figure 21. As seen, there is little remaining wall thickness, and the thin remaining pipe wall ligament separated during the cutting.

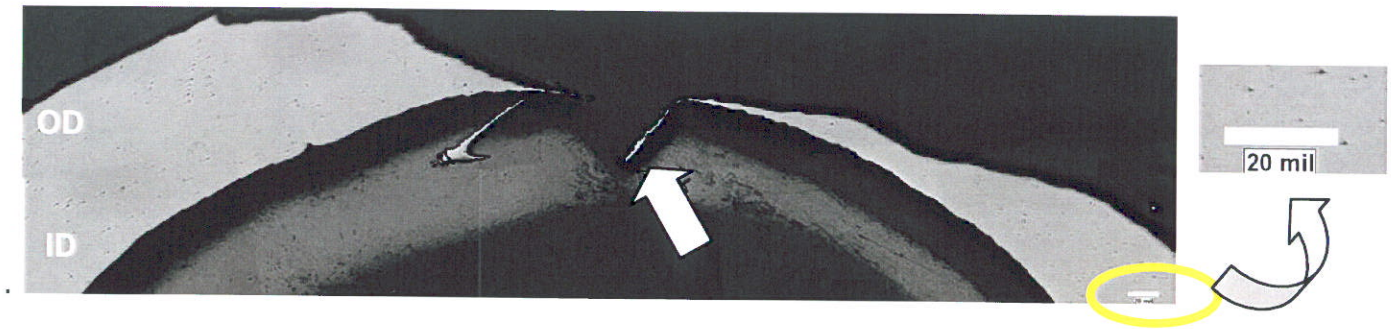


Figure 21. Montage of light photomicrographs of the as-polished Mount 1-B in the area of wall loss. Note the small metal pipe wall ligament on the right (arrow).

The appearance of the cross-sectional area from leak site (Segment 10), shown in Figure 22, is similar to that observed in Figure 21 (Segment 1). The metallographic observations corroborate the visual examination that the corrosion originated at the OD (outside diameter) pipe surface and progressed through the pipe wall thickness.

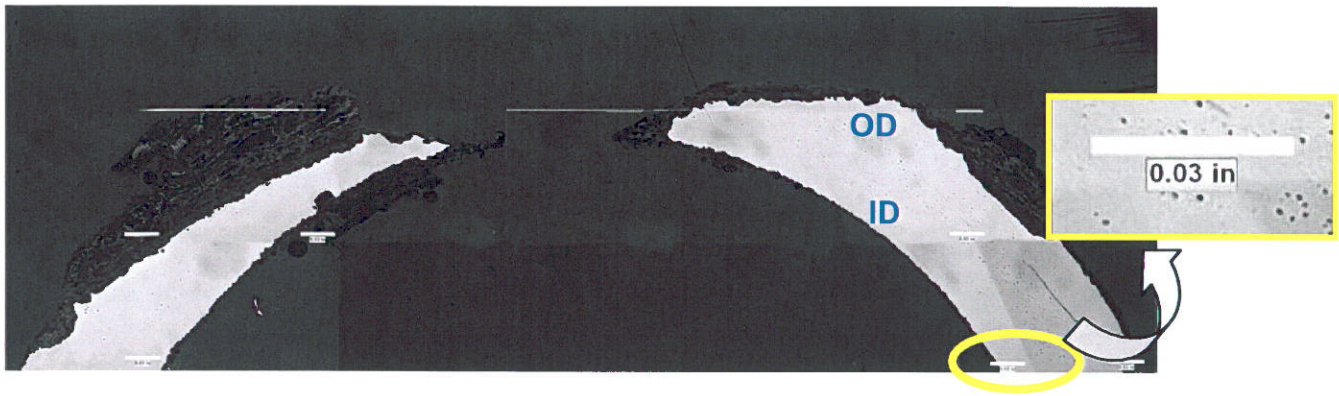


Figure 22. Montage of light photomicrographs of the as-polished Mount 10-4B in the area of the leak and wall loss.

The photomicrographs below (Figure 23 and Figure 24) show examples of the steel microstructure after etching[7]. The microstructure is consistent with that of typical low-strength carbon steel; the primary constituents are mostly ferrite (light areas) and pearlite (dark areas).

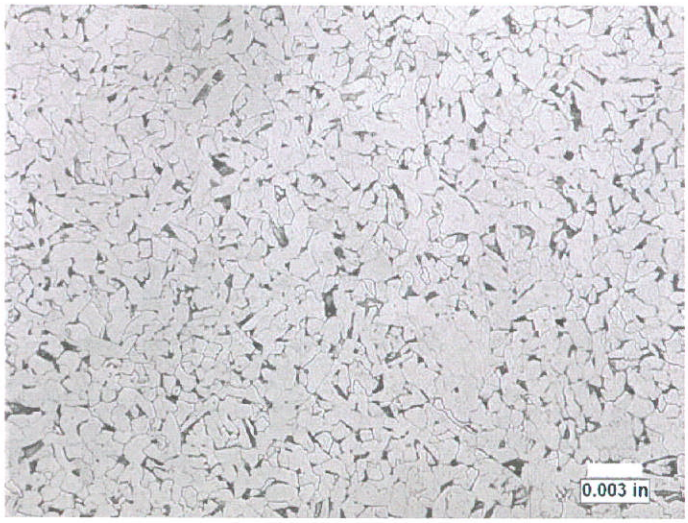


Figure 23. Light photomicrograph of etched Mount 1-B of typical base metal microstructure taken at 100X.

[7] Additional photo documentation is in Appendix I.

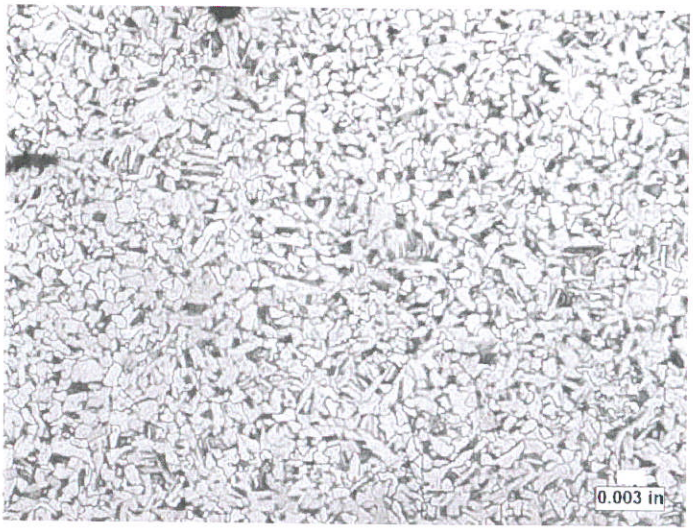
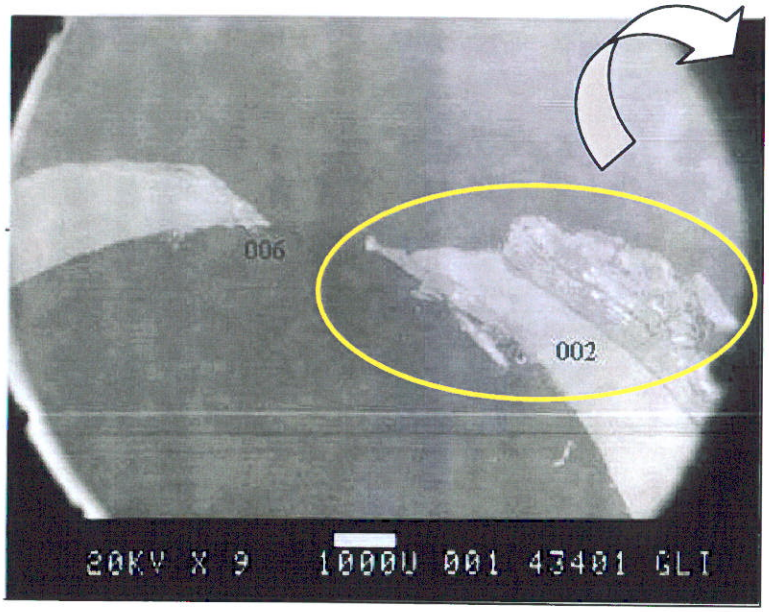


Figure 24. Light photomicrograph of etched Sample 9-B microstructure near maximum wall loss, taken at 100X.

Scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS)

The metallographic cross-sections in the as-polished condition were evaluated under a scanning electron microscope. The representative photomicrographs are presented below; additional photographs are included in Appendix J.



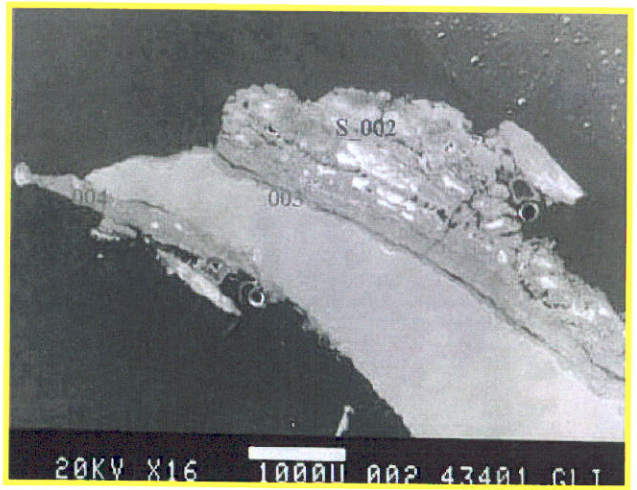


Figure 25. SEM photomicrograph of Mount 10-4B at leak site. Note deposits on OD and ID surfaces. S-002 EDS spectrum is shown in Figure 27.

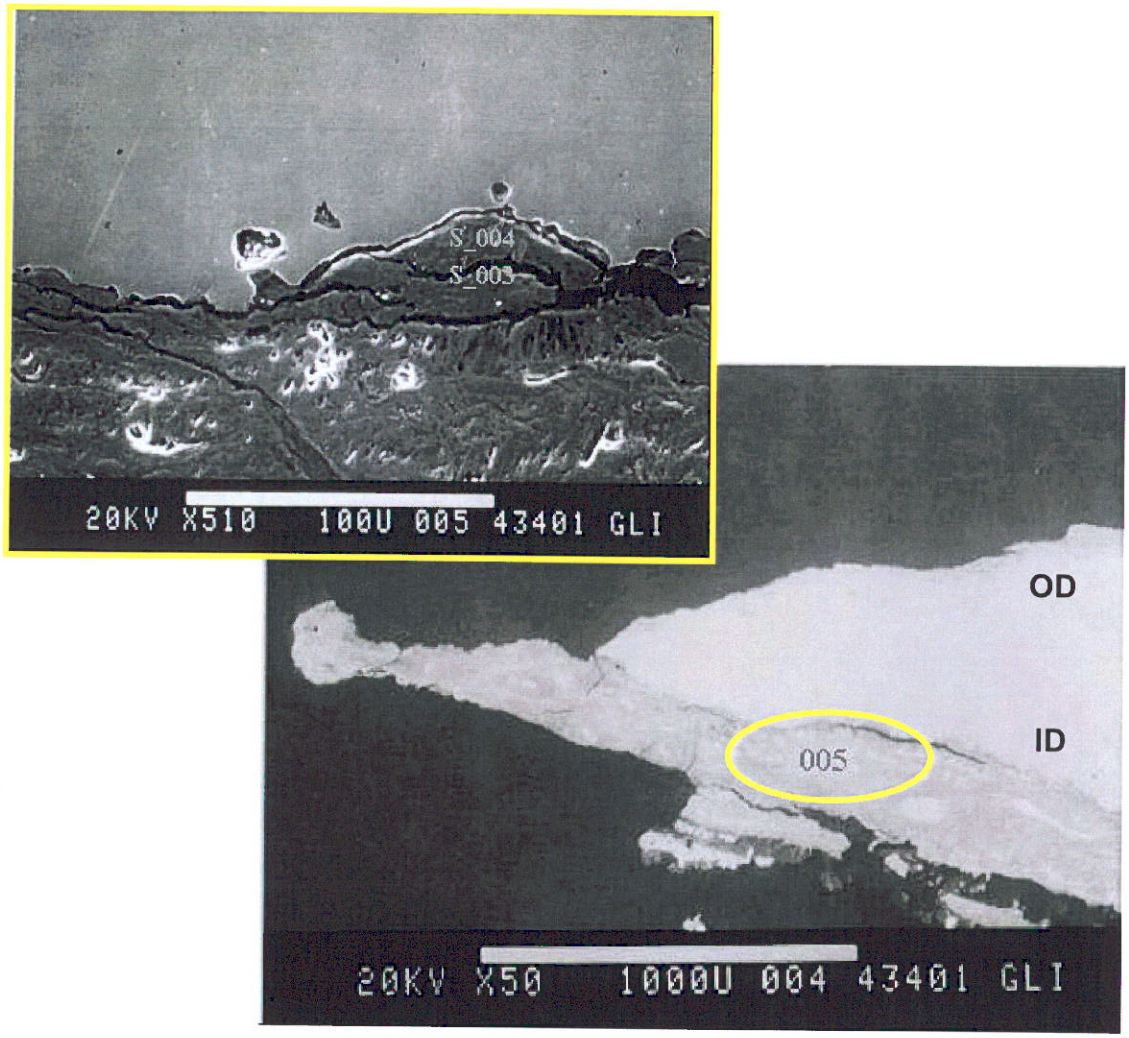


Figure 26. SEM photomicrograph of area marked "004" in inset in Figure 25; the encircled area of deposits at ID surface is shown at higher magnification in inset. S-003 spectrum is shown in Figure 28.

The EDS spectra from selected locations identified in the photomicrographs above are shown in Figure 27 and Figure 28[8]. The heights of the peaks are proportional to the concentration of the elements; however the results should be regarded as qualitative. The spectra are similar; the major element is iron (Fe), which corresponds to the composition of both the steel matrix and corrosion products. Another major peak is associated with carbon (C). The carbon peak may be associated with residual coal tar coating on the pipe surface. Other minor peaks are associated with the elements commonly found in soil (Al, Si, Cl).

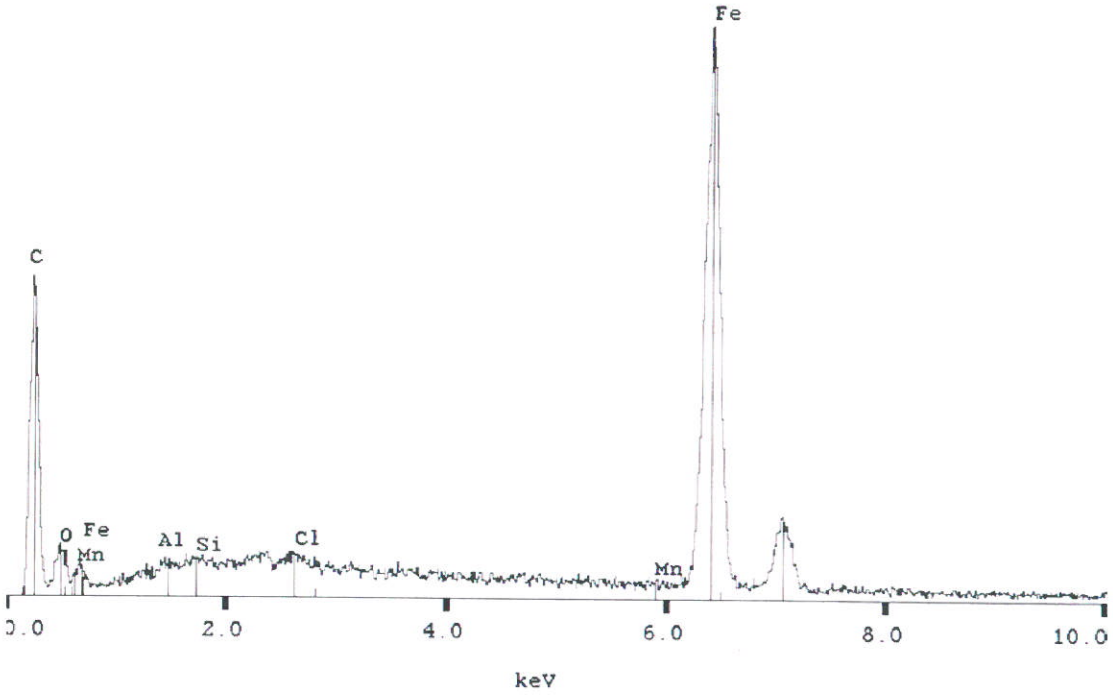


Figure 27. EDS scan of Mount 10-4B at spot S-002 (OD surface deposits) in inset in Figure 25.

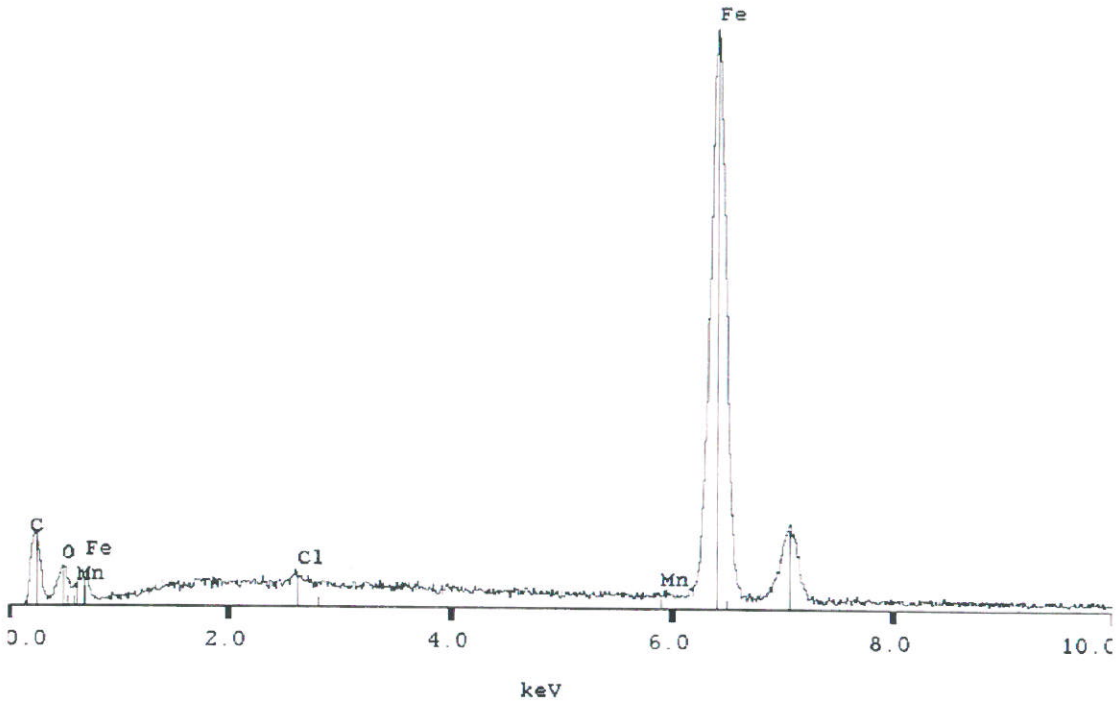


Figure 28. EDS scan of Mount 10-4B at spot S-003 (ID surface deposits) in inset in Figure 26.

[8] Additional spectra are presented in Appendix K.

These elements (Al and Si) are present as the major elements identified in the EDS spectra obtained from the loose soil collected from the plastic protector covering the leak site in Segment 10 (see Figure 29).

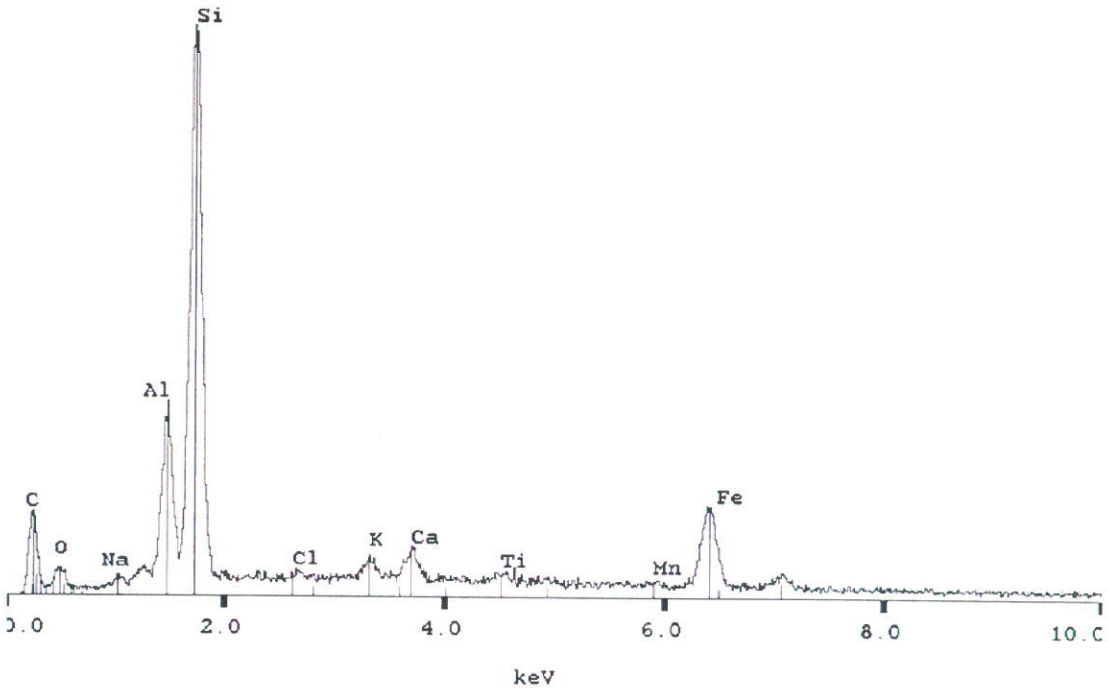


Figure 29. EDS scan of loose soil collected from the plastic protector covering leak area in Segment 10

Examination of Figure 25 and Figure 26 shows the presence of corrosion products on both the OD pipe surface and the ID pipe surface. Corrosion of this nature requires the presence of an electrolyte. The most plausible explanation for the ID corrosion is condensation near the leak location caused by local cooling of the steel wall due to the Joule-Thompson effect.

SUPPLEMENTARY EVALUATIONS: steel chemical composition, remaining wall thickness measurements, bacterial culture analysis

The results of the chemical composition analysis are summarized in Table 4. The locations were within Segment 4 and Segment 8. The samples for the analysis were taken at the distances indicated in the Table; the distances are in reference to Segment 2.

Table 4. Elemental composition (weight percent) of pipe samples at three different locations. Distances are in reference to Segment 2.

Element	108 inch	359.25 inch	600.25 inch	API 5L PS1
	Segment 3	Segment 6	Segment 9	maximum
Carbon	.127	.074	0.054	.280
Manganese	.538	.508	0.490	1.20
Phosphorus	.012	.008	0.007	.030
Sulphur	.025	.018	0.013	.030
Silicon	.002	.003	0.004	
Copper	.014	.044	0.041	
Tin	.009	.004	0.003	
Nickel	.006	.010	0.009	
Chromium	.022	.033	0.033	
Molybdenum	.004	.004	0.004	
Aluminum	.001	.003	0.007	
Vanadium	.001	.001	0.000	
Niobium	.001	.001	0.001	
Zirconium	.000	.000	0.000	
Titanium	.002	.002	0.002	
Boron	.0000	.0000	0.0000	
Calcium	.0000	.0000	0.0000	
Cobalt	.003	.004	0.004	

The results show that there is a variance in the chemical make up of the steel at the three analyzed locations. The elemental compositions are in compliance with the API 5L specification for Grade B steel (42nd Edition, 2000). There is no information regarding the actual grade of the pipe material; the API 5L specification is for reference purposes only.

Remaining wall thickness measurements were performed at 75 locations which were not affected by the external corrosion. The minimum wall thickness was 113 mils; the maximum wall thickness was 120 mils. Assuming that the nominal wall thickness is 113 mils +20%, -12.5% (API 5L for Grade B plain-end linepipe), the values are within the expected range. The measurements in the vicinity of corrosion anomalies are summarized in Appendix L.

Bacterial culture analyses were conducted on surface deposit samples collected from three locations on Segment 10. The results are summarized in Table 5.

Table 5. Bacteria count results from Segment 10 testing.

Bacteria type	Location 1	Location 2	Location 3
	21.5 inches downstream from cut on bottom of pipe at corrosion anomaly	49 inches downstream from cut at perforation	56 inches downstream from cut on bottom of pipe at corrosion anomaly
Aerobic	10	100	100
Anaerobic	0	100	0
Acid-Producing	10	10	10
Iron-Related	0	100	10
Sulfate-Reducing	0	0	0

The liquid bacteria cultures were inoculated with the slurry prepared using the surface deposits in accordance with the serial dilution method (API RP38). The cultures were monitored for 30 days.

CONCLUSIONS

The conclusions from the findings of the laboratory-based assessment are as follows:

- The leak on the gas service (Segment 10) occurred as a result of external corrosion[9] that may have initiated at a coating holiday at the outside diameter (OD) surface.
- Internal corrosion[10] at the inside diameter (ID) side at the leak site suggests that the leak may have existed for a period of time prior to the incident.
- There is no evidence to suggest that the ID corrosion contributed to the cause of the leak.
- The wall thickness of the pipe in the areas unaffected by corrosion was measured to be 0.113-inch.
- The external coating was found to be in good overall condition with some isolated holidays.
- Bacteria concentration in the analyzed deposits was low and suggests that microbially influenced corrosion was not a contributing factor.
- The composition and microstructure of the steel is typical for low strength (X52 grade and lower) carbon steel linepipe.

[9] External corrosion – degradation of metal resulting from contact of its external surface with corrosive environment.
[10] Internal corrosion – degradation of metal resulting form contact of its internal surface with corrosive environment.

EXHIBITS:
APPENDICES TO FINAL REPORT

F 4434-01G

PREPARED
FOR
GORDON MURRAY TILDEN LLP
ON BEHALF OF
PUGET SOUND ENERGY

LABORATORY-BASED EVALUATION OF FAILED SERVICE LINE
BELLEVUE, WASHINGTON

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F 4434-01G

LABORATORY-BASED EVALUATION OF FAILED SERVICE LINE

PREPARED FOR

GORDON MURRAY TILDEN LLP
ON BEHALF OF
PUGET SOUND ENERGY

PREPARED BY

CC TECHNOLOGIES LABORATORIES, INC.

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APPENDIX A – PSE FAILURE ANALYSIS PROTOCOL WITH COMMENTS

The following laboratory examination protocol is proposed for the corrosion and metallurgical investigation of the natural gas service line that was removed from the Schmitz property. In all cases companion split samples will be collected, documented, retained and preserved for analyses by other interested parties.

Before Shipment

1. Verify chain of custody for all pipe to be evaluated in the investigation
2. Make initial overall photographic documentation of pipe before packing, crating and shipping.
3. Wrap the entire pipe in 8 mil thick polyethylene sheets and over wrap with bubble wrap closely taped with duct tape.
4. Prepare wooden shipping crate and pack bubble wrapped pipe segment in crate with Styrofoam packing material to preserve the integrity of the pipe during shipment. Photo document the packing process.
5. Seal and secure wooden crate, photo document the sealing process, and deliver to Federal Express for ground shipment. Duplicate packing, shipping and chain of custody documents for all interested parties.

After Receipt at the Lab

6. Verify chain of custody for all pipe to be evaluated in the investigation
7. Photo document the shipping crate in the as-received condition and photo document the unpacking process.
8. Make a detailed drawing (with dimensions) of the pipe pieces and document locations of any welds and/or fittings, leak path, and later document the locations of removed samples on those drawings.
9. Perform visual examination of the pipe segments in the 'as-received' condition, and document any anomalies [e.g., hole, dent, buckle, gouge, scratch, wrinkle bend, pits, crevices, cracks, etc.] that may be present in these segments.
10. Measure pipe wall thickness at appropriate locations. These measurements should be taken at 4 locations equally spaced around the pipe circumference at the end of each pipe segment to establish the nominal wall thickness.
11. Measure pipe circumference at three locations on each pipe segment.
12. Acquire samples of deposits located within areas of wall loss. Areas of special interest are pits near leak location. Conduct elemental analysis of the samples. Conduct serial dilution microbial count analysis of the samples where practicable.
    a. Elemental analysis should be conducted by suitable means –by energy dispersive spectroscopy (EDS) or x-ray (fluorescence).

b. For the microbial testing procedures NACE Standard TM0194-94, Field Monitoring of Bacterial Growth in Oilfield Systems should be utilized.

13. Remove any disbonded coating on outside surface of pipe segment.

14. Clean outside pipe diameter surface in areas of coating disbondment area using a soft bristle brush and non-corrosive cleaning agents (e.g., methyl-ethyl ketone).

15. Document overall corrosion damage [e.g., pit/hole morphology, diameter, and depth]. Detailed depth measurements for any area where wall loss has been identified will be acquired in increments of ¼-inch for corrosion less than 3-inches long and ½-inch for longer areas of corrosion.

    a. Mapping of Corrosion/Pitting Profiles – After removal and preservation of any impacted or adhering soil, protective coating and surface or corrosion products (Steps 12, 13 and 14 above), ~~the entire length of~~ areas of corrosion or other damage along the service (all three sections) will be examined and the wall thickness measured at discrete locations around the area of interest using an ultrasonic thickness probe ~~at a 1-inch axial by 1/2 – inch circumferential grid spacing.~~ Areas of corrosion will be mapped with a dimensional assessment of depth, width and distribution. All wall thickness and corrosion measurements will be documented in a graphical display showing the pipe wall in a plan view and contour topographic display.

16. Identify locations and remove samples for metallographic examination. This should include:

    a. A transverse section through the leak origin.
    b. Transverse sections through selected pitting sites (for morphology).

17. Remove additional pitting samples adjacent to the metallographic samples for SEM analysis.

    a. Elemental analysis should be conducted by suitable means –by energy dispersive spectroscopy (EDS) or x-ray (fluorescence).
    b. Pit morphology should be analyzed in SEM.
        i. It might be necessary to clean pit with inhibited acid before morphology analysis in SEM.

18. Metallographic characterization should include the following:

    a. Mount and polish
    b. Obtain macrograph
    c. Examine under microscope and obtain micrographs
    d. Etch
    e. Obtain macrograph
    f. Examine under microscope and obtain micrographs

g. Perform hardness measurements through the wall thickness

h. Obtain final macrograph.

19. Characterization of the pipe material from a manufacturing standpoint and compare to the API- pipe specification in effect at the time of pipe manufacture

~~a.~~ Remove samples at locations defined by API for the purposes of conducting chemical ~~and mechanical~~ tests. ~~In the event that pipe deformation or potential thermal damage is identified at the specified locations, samples will be removed from alternative locations. These locations should be identified. Mechanical testing will include transverse tensile tests per ASTM A370 and Charpy V-notch impact tests (L-T orientation).~~

~~20. Conduct fracture mechanics analysis utilizing pitting profiles and other information obtained from testing.~~

APPENDIX B – WRAPPED PIPES

Figure 1. Photograph of the shipping crate as-received at CC Technologies.

Figure 2. Photograph of the opened shipping crate showing packaging of the pipes inside of crate.

Figure 3. Photograph of the pipe Segments 1 through 5 with Segment 10 in the background following removal from the shipping crate showing individual packaging.

Figure 4. Photograph of pipe Segments 6 through 9 with Segment 10 in the background showing how the individual pipes were wrapped individually in the shipping crate.

APPENDIX C – UNWRAPPED PIPES

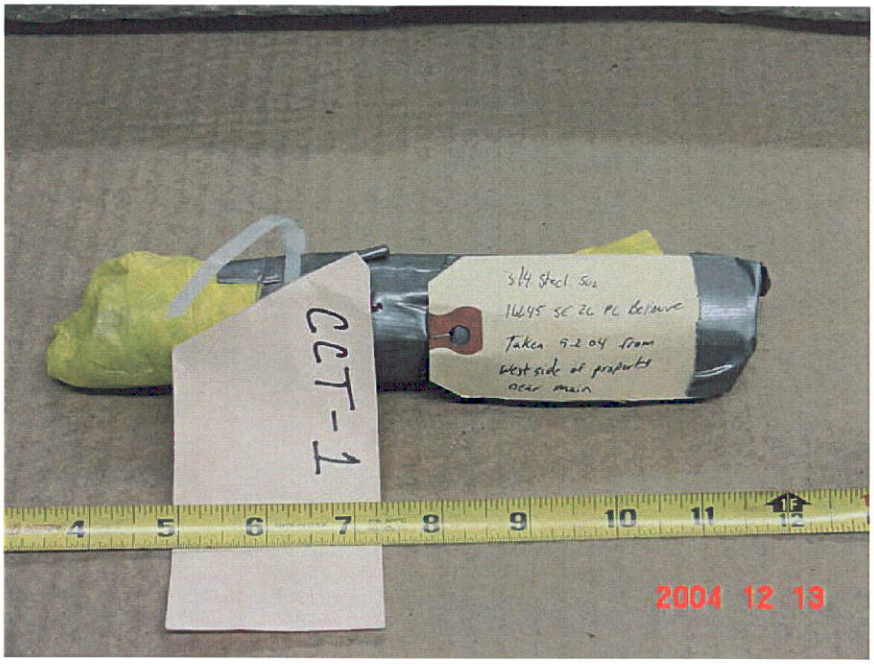


Figure 1. Photograph of Segment 1 as wrapped by PSE and shipped to CC Technologies.

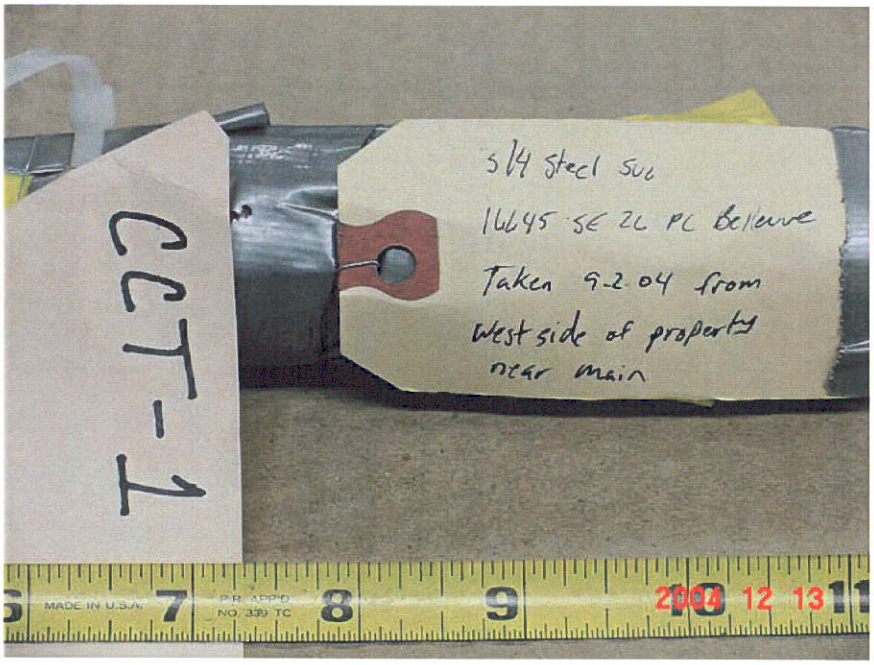


Figure 2. Photograph close up of Segment 1 as wrapped by PSE and shipped to CC Technologies.

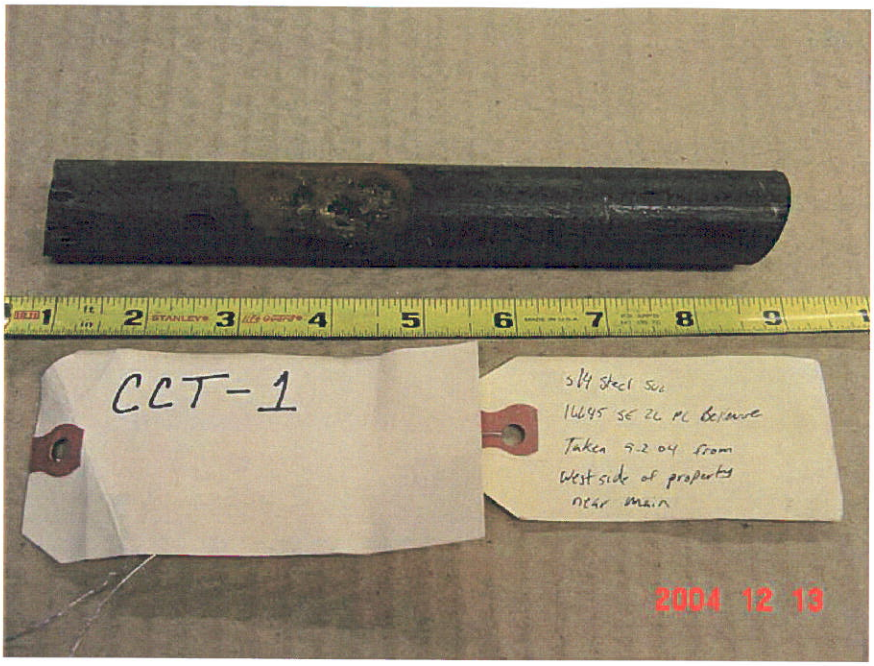


Figure 3. Photograph of Segment 1 after removal of protective wrapping for shipping.

Figure 4. Photograph close-up of Segment 1 after removal of protective wrapping for shipping.

Figure 5. Photograph of Segment 2 after removal of protective wrapping for shipping.

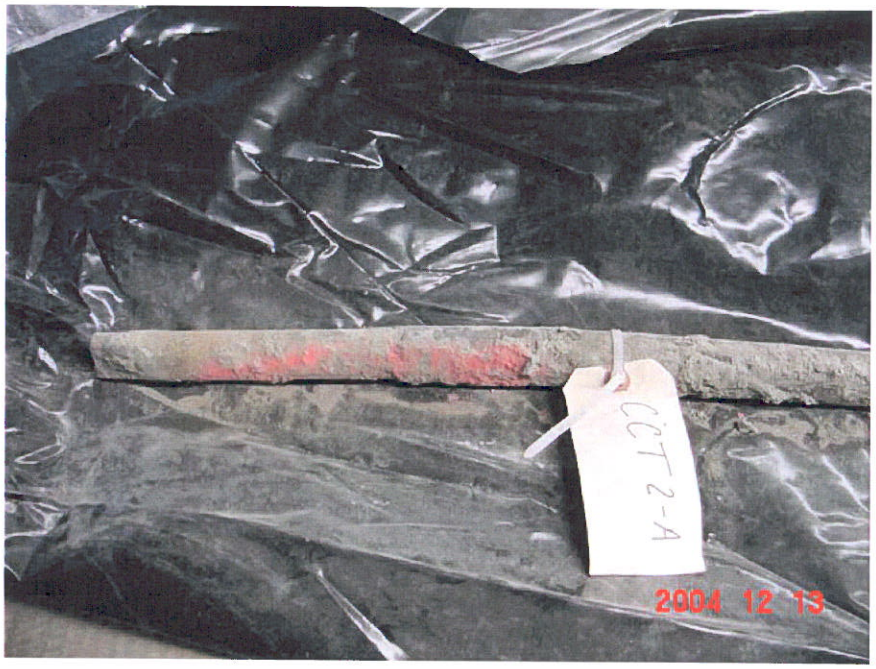


Figure 6. Photograph of unwrapped Segment 2 showing the upstream side of the pipe, CCT 2-A.

Figure 7. Photograph of unwrapped Segment 2 showing a crimp in the pipe located at 57.5-inches downstream from the end of the cut.

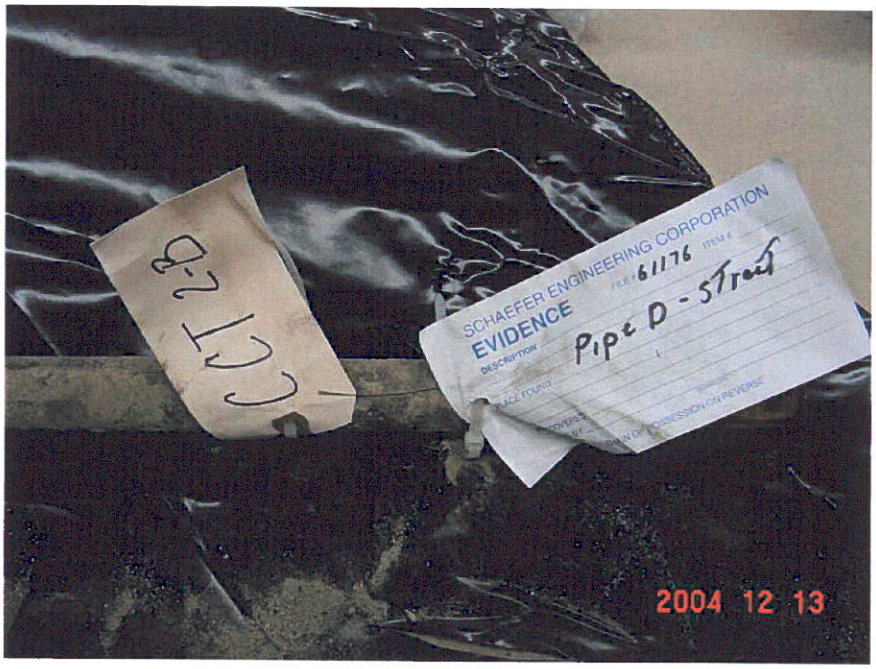


Figure 8. Photograph of unwrapped Segment 2 showing the downstream side of the pipe, CCT 2-B.

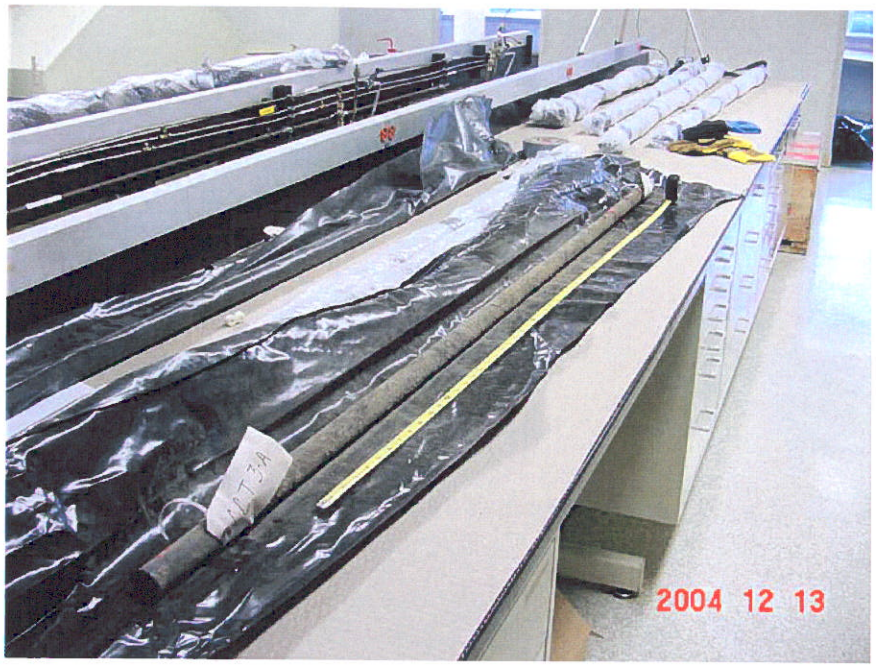


Figure 9. Photograph of Segment 3 after removal of protective wrapping for shipping.

Figure 10. Photograph of unwrapped Segment 3 showing the upstream side of the pipe, CCT 3-A.

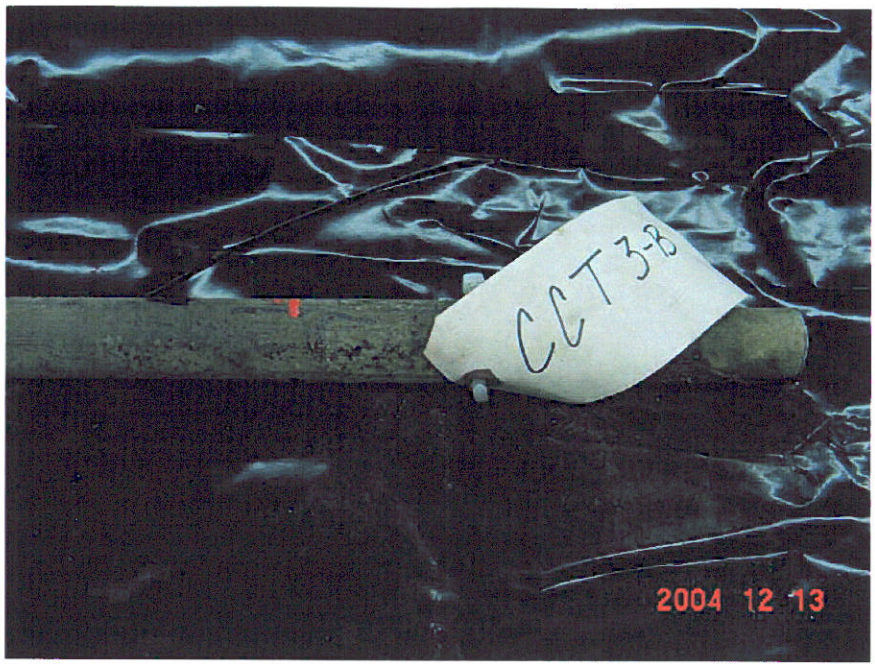


Figure 11. Photograph of unwrapped Segment 3 showing the downstream side of the pipe, CCT 3-B.

Figure 12. Photograph of Segment 4 after removal of protective wrapping for shipping.

Figure 13. Photograph of unwrapped Segment 4 showing the upstream side of the pipe, CCT 4-A.

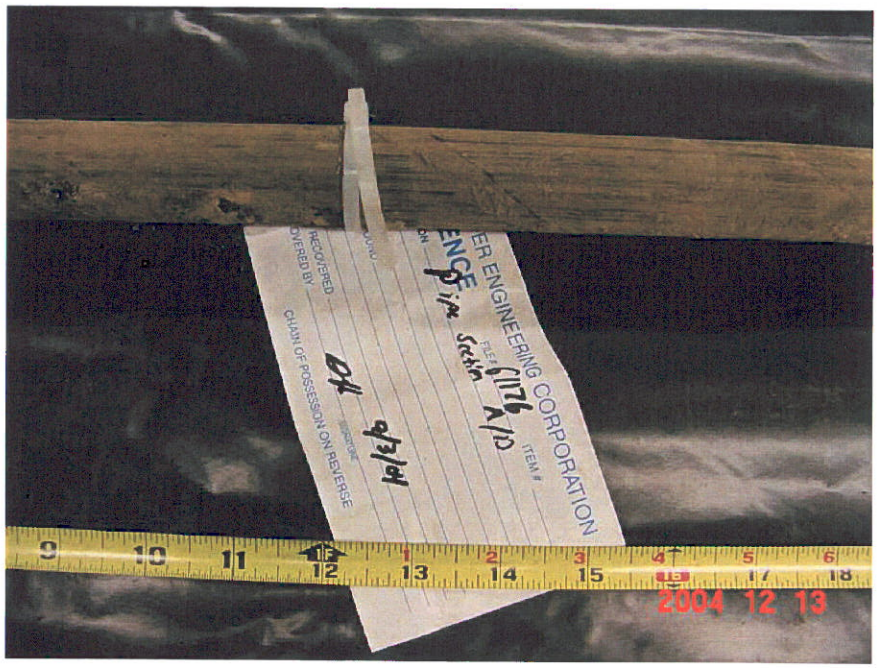


Figure 14. Photograph of unwrapped Segment 3 showing PSE identification tag for this pipe segment.

Figure 15. Photograph of unwrapped Segment 4 showing the downstream side of the pipe, CCT 4-B.

Figure 16. Photograph of Segment 5 after removal of protective wrapping for shipping.

Figure 17. Photograph of unwrapped Segment 5 showing the upstream side of the pipe, CCT 5-A.

Figure 18. Photograph of unwrapped Segment 5 showing the downstream side of the pipe, CCT 5-B.

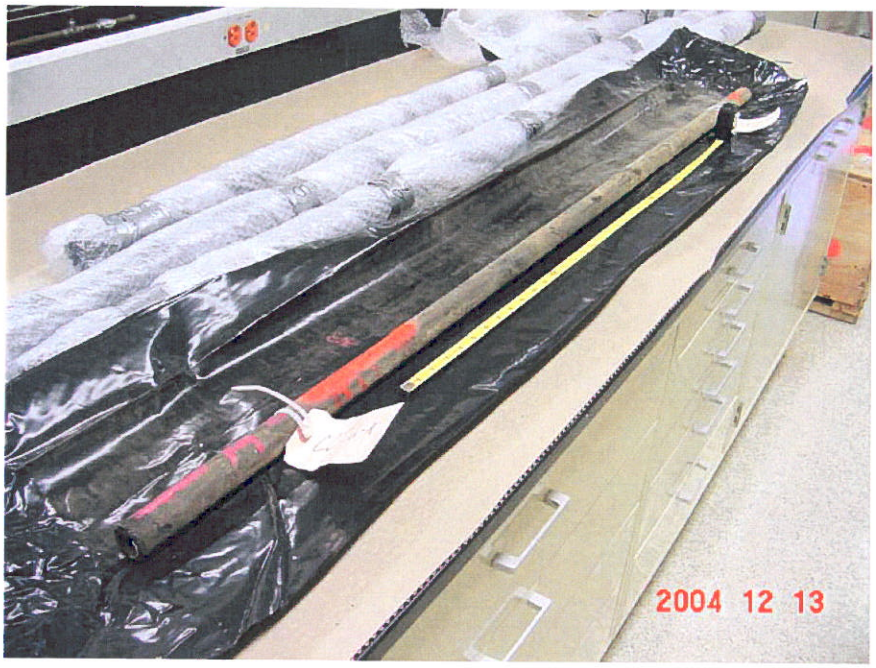


Figure 19. Photograph of Segment 6 after removal of protective wrapping for shipping.

Figure 20. Photograph of unwrapped Segment 6 showing the upstream side of the pipe, CCT 6-A.

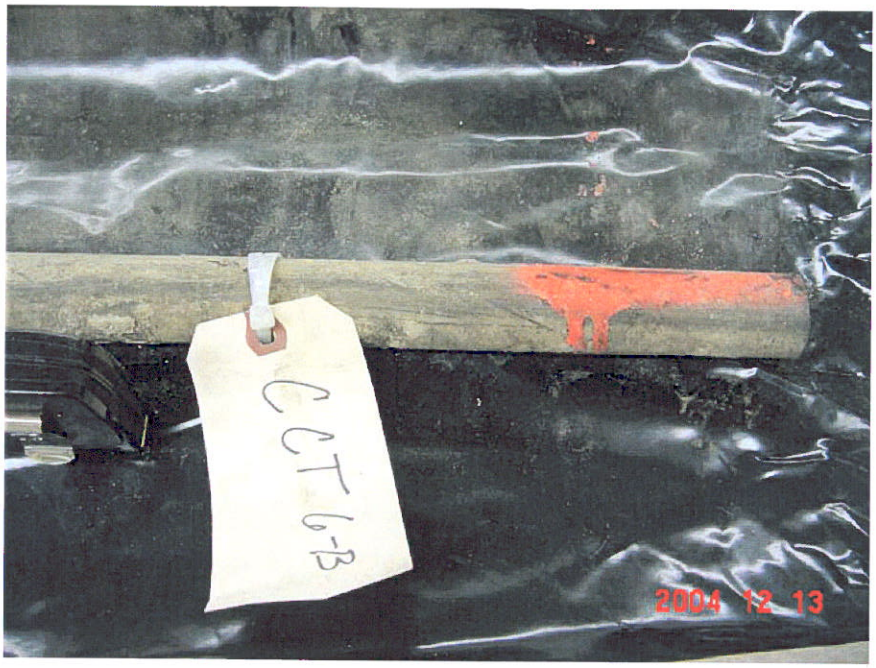


Figure 21. Photograph of unwrapped Segment 6 showing the downstream side of the pipe, CCT 6-B.

Figure 22. Photograph of Segment 7 after removal of protective wrapping for shipping.

Figure 23. Photograph of unwrapped Segment 7 showing the upstream side of the pipe, CCT 7-A.

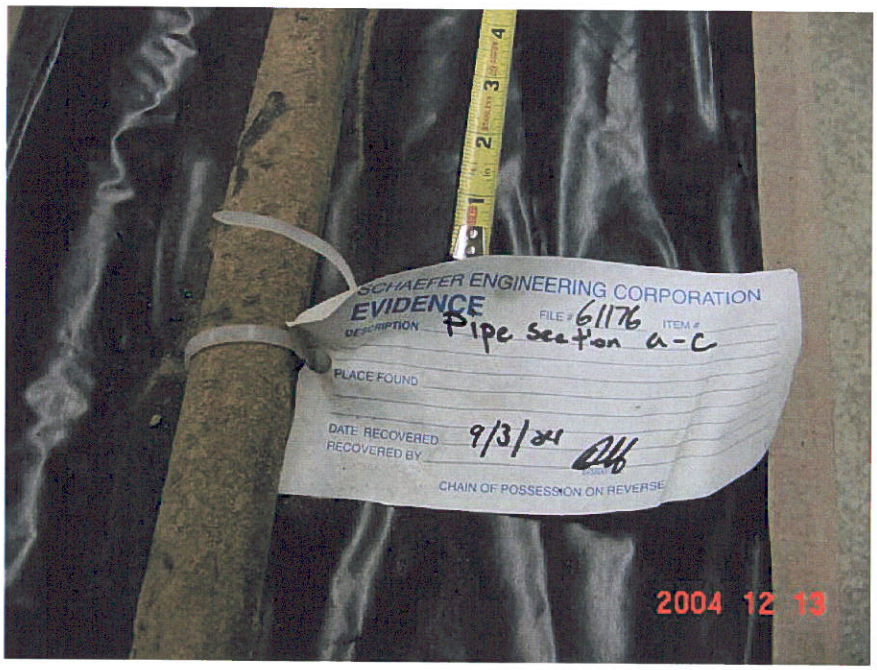


Figure 24. Photograph of unwrapped Segment 7 showing PSE identification tag for this pipe segment.

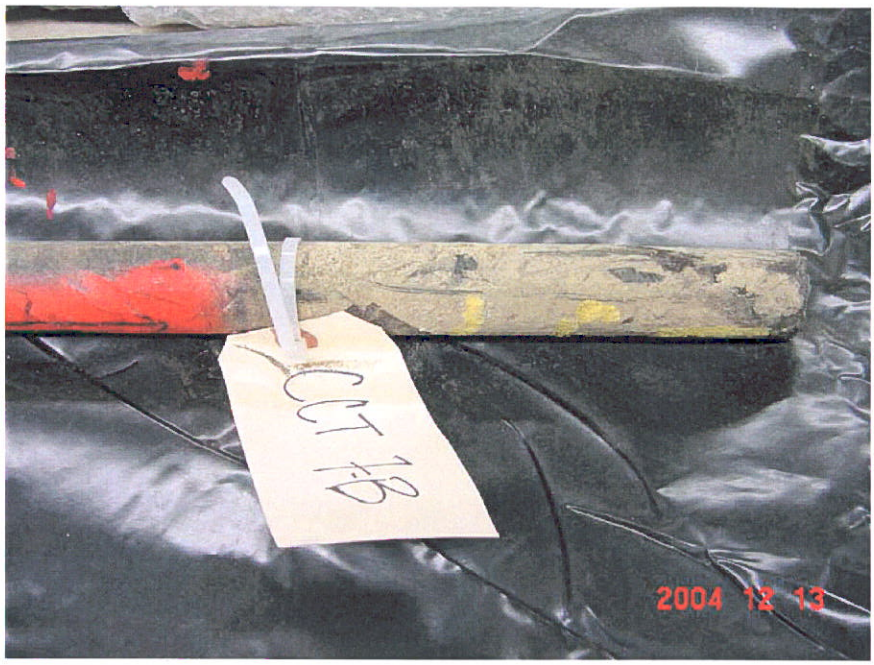


Figure 25. Photograph of unwrapped Segment 7 showing the downstream side of the pipe, CCT 7-B.

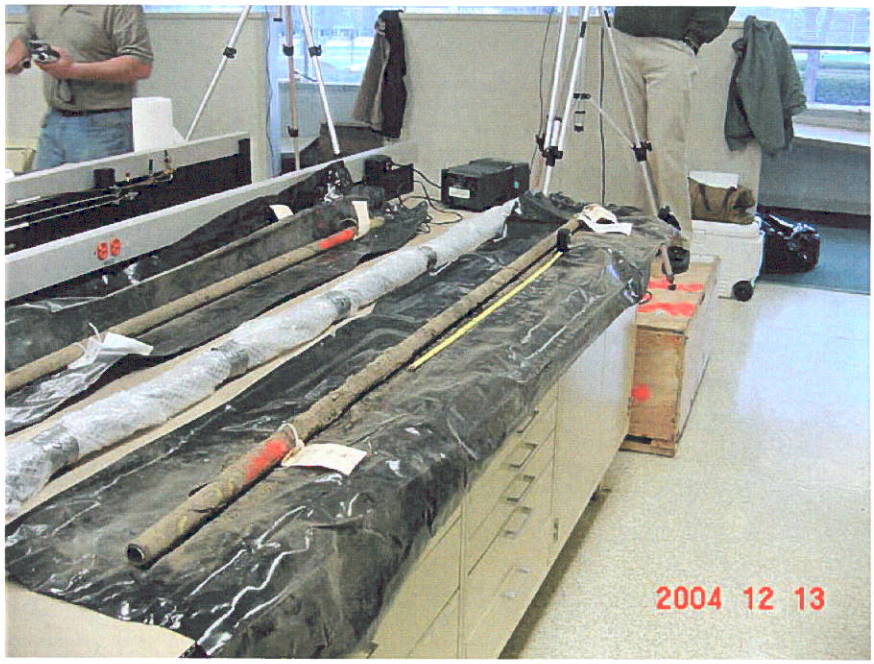


Figure 26. Photograph of Segment 8 after removal of protective wrapping for shipping.

Figure 27. Photograph of unwrapped Segment 8 showing the upstream side of the pipe, CCT 8-A.

Figure 28. Photograph of unwrapped Segment 8 showing the upstream side of the pipe, CCT 8-A.

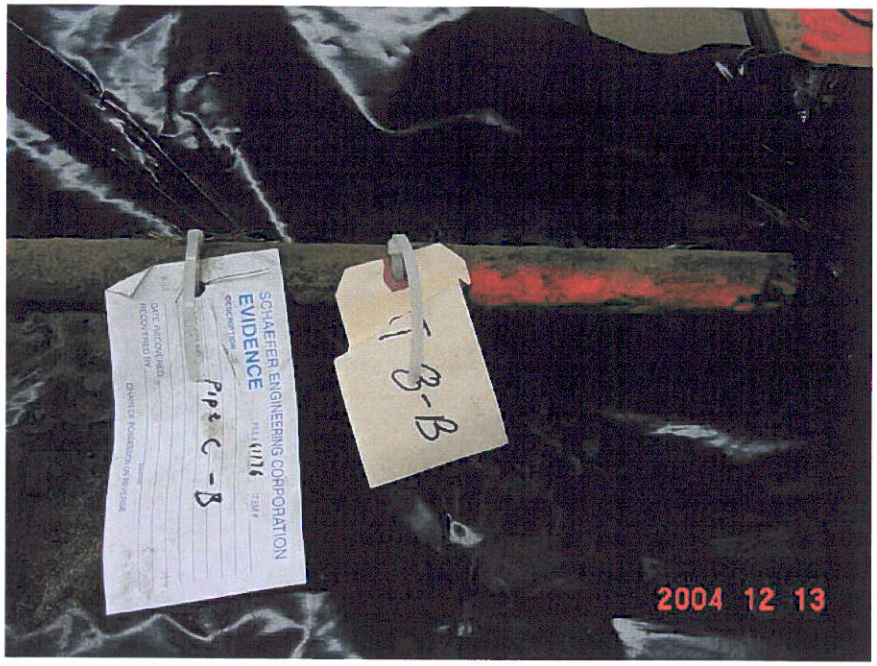


Figure 29. Photograph of unwrapped Segment 8 showing the downstream side of the pipe, CCT 8-B.

Figure 30. Photograph of Segment 9 after removal of protective wrapping for shipping.

Figure 31. Photograph of unwrapped Segment 9 showing the upstream side of the pipe, CCT 9-A.

Figure 32. Photograph of unwrapped Segment 9 showing the downstream side of the pipe, CCT 9-B.

Figure 33. Photograph of Segment 10 after removal of protective wrapping for shipping.

Figure 34. Photograph of unwrapped Segment 10 showing the upstream side of the pipe, CCT 10-A.

Figure 35. Photograph of unwrapped Segment 10 showing red evidence tape on a protective covering on the pipe.

Figure 36. Photograph of unwrapped Segment 10 showing red evidence tape on a protective covering on the pipe.

Figure 37. Photograph of unwrapped Segment 10 showing red evidence tape on a protective covering on the pipe.

Figure 38. Photograph of unwrapped Segment 10 showing a valve on the downstream side of the pipe, CCT 10-B.

Figure 39. Photograph of unwrapped Segment 10 showing the downstream side of the pipe, CCT 10-B.

APPENDIX D – COATING CONDITION

Figure 1. Photograph of Segment 01 showing the pipe as-received had little remaining coating.

Figure 2. Photograph of Segment 2 showing a crimp at the 0-inch location of the pipe and an area of bare pipe from 0 to 8-inches.

Figure 3. Photograph of Segment 2 showing deformations in the coating from the 40-inch mark to the 53-inch location.

Figure 4. Photograph of Segment 2 showing a crimp in the pipe at the 57.5-inch location.

Figure 5. Photograph of Segment 2 showing scratches in the coating between the 71-inch and 75.5-inch locations with a dent in the coating at the 73.5-inch location.

Figure 6. Photograph of Segment 3 showing an area of bare pipe located between the 52.5-inch and 57-inch locations.

Figure 7. Photograph of Segment 4 showing an area of bare pipe between the 0-inch and 1.5-inch locations.

Figure 8. Photograph of Segment 4 showing a coating deformation at the 52-inch location.

Figure 9. Photograph of Segment 4 showing a field applied outer wrap that covered the pipe between the 60.5-inch to 88-inch locations.

Figure 10. Photograph of Segment 5 showing an area with coating deformations that extended from the 5-inch location to the 19-inch location.

Figure 11. Photograph of Segment 5 showing an area of coating deformations that extended from the 45-inch location to the 62-inch location.

Figure 12. Photograph of Segment 6 showing a coating deformation at the 36-inch location.

Figure 13. Photograph of Segment 6 showing a dent in the coating at the 41.5-inch location.

Figure 14. Photograph of Segment 6 showing a coating deformation at the 54-inch location.

Figure 15. Photograph of Segment 7 showing a gouge in coating from the 6-inch location to the 7.5-inch location.

Figure 16. Photograph of Segment 7 showing scratched coating from the 7-inch location to the 19-inch location.

Figure 17. Photograph of Segment 7 showing a gouge in the coating from the 25-inch to 28-inch locations.

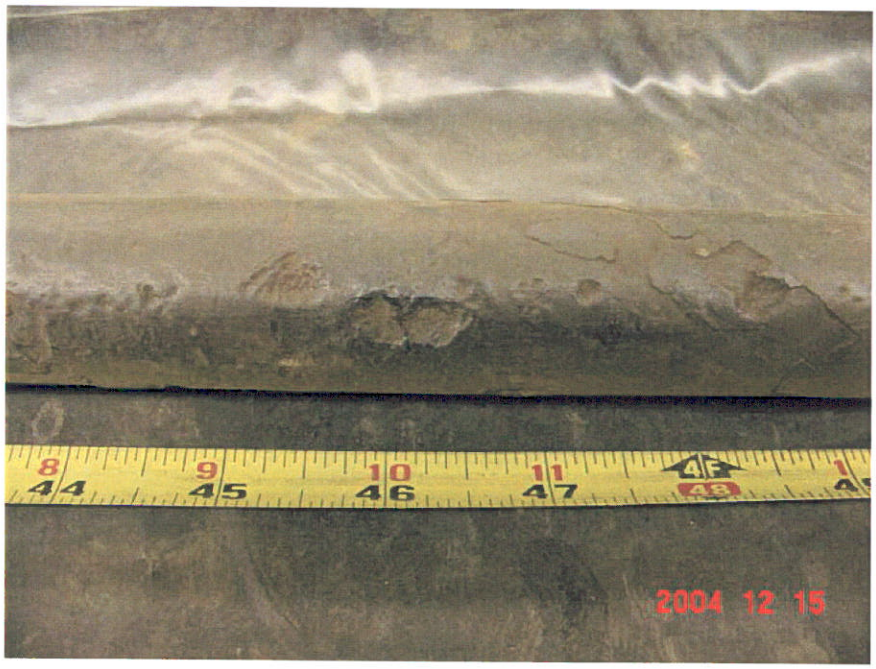


Figure 18. Photograph of Segment 7 showing coating deformations and dents in the coating that extended between the 41.5-inch to 55-inch locations.

Figure 19. Photograph of Segment 7 showing a deformation in the coating at the 66-inch location.

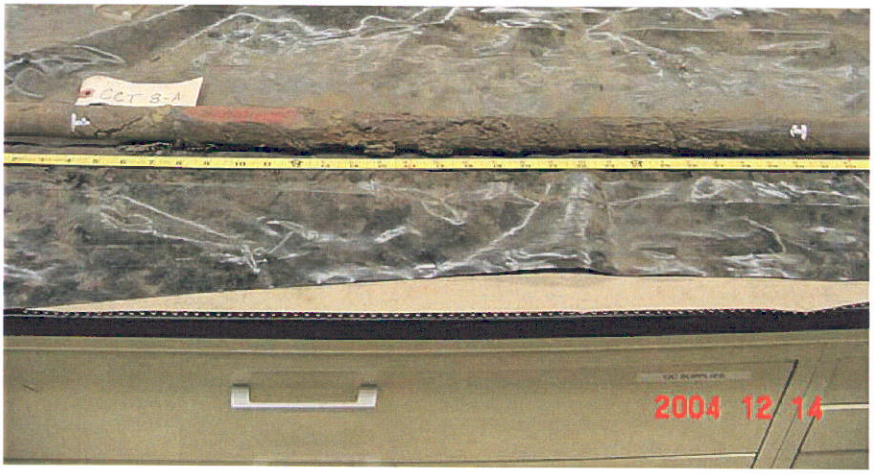


Figure 20. Photograph of Segment 8 showing a coating wrap located between the 6-inch to 29-inch location.

Figure 21. Photograph of Segment 8 showing an area of coating deformations and dents in the coating located at the end of the coating wrap to the end of the pipe at the 88-inch location (Figure 22 and Figure 23 detail some of the features).

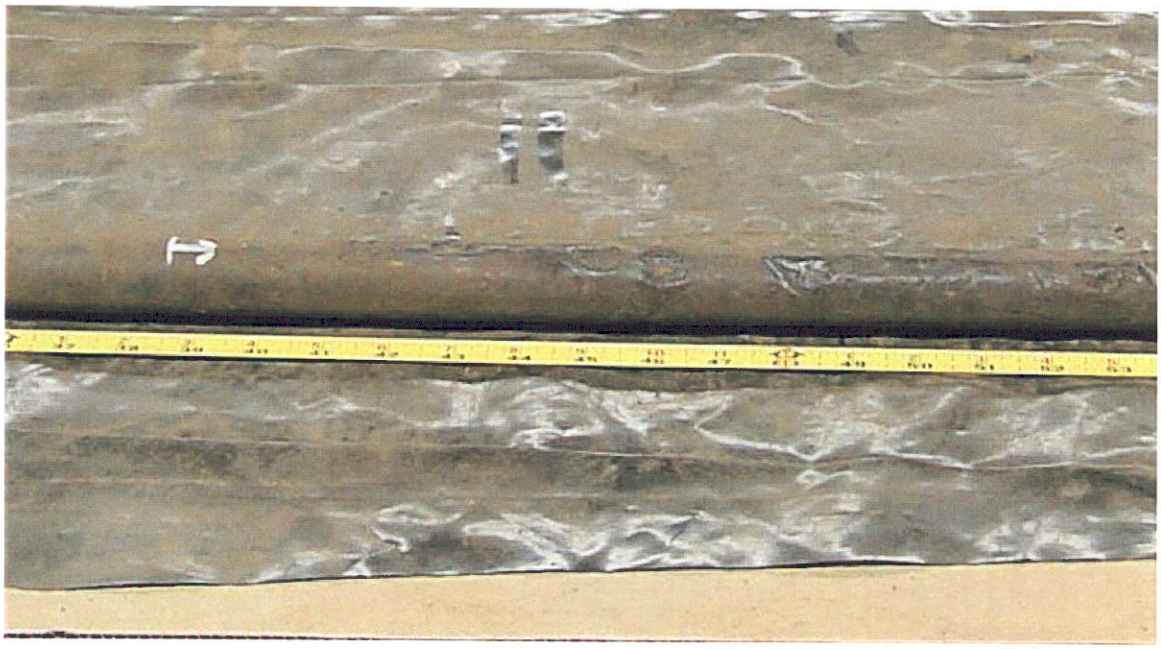


Figure 22. Left side of the photograph in Figure 21 showing coating deformations to at the 43-inch, 45.75-inch, and 48-inch locations.

Figure 23. Right side of the photograph in Figure 21 showing a coating deformation at the 57.75-inch location

Figure 24. Photograph of Segment 8 showing two of the coating deformations to bare metal.

Figure 25. Photograph of Segment 9 showing a 1-inch deformation in the coating at the 16-inch location.

Figure 26. Photograph of Segment 9 showing an area of scratches and dents in the coating between the 21-Inch location and the 34-inch location.

Figure 27. Photograph of Segment 9 showing deformations and dents in the coating between the 34-Inch location and the 46-inch location.

Figure 28. Photograph of Segment 10 showing a 2-inch area of bare pipe at the 0-inch location.

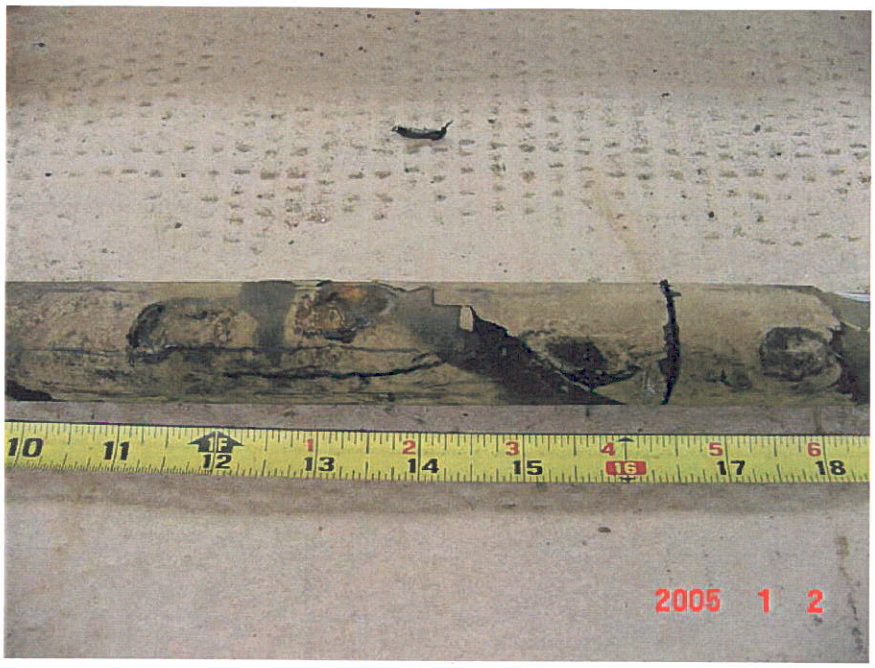


Figure 29. Photograph of Segment 10 showing coating deformations ranging from 0.5 to 2-inches long between the 11 and 24-inch locations.

Figure 30. Photograph of Segment 10 showing a 2-inch coating deformation at the 21-inch location.

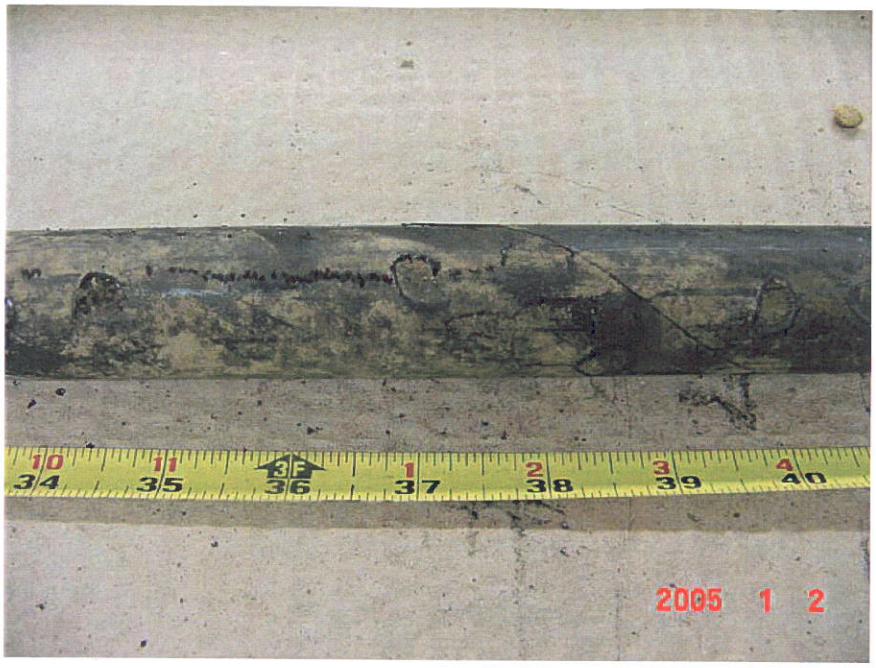


Figure 31. Photograph of Segment 10 showing small coating deformations ranging from 0.25 to 0.5-inches long between the 30 and 41-inch locations.

Figure 32. Photograph of Segment 10 showing a 1-inch through wall indication at the 48-inch location with granules around the indication.

Figure 33. Photograph of Segment 10 showing the bend in the pipe that contained 6 areas of coating deformations on the extrados starting at the 57.75-inch location.

Figure 34. Photograph of Segment 10 showing an example of the coating deformations that occurred on the extrados of the bend.

Figure 35. Photograph of Segment 10 showing the nodules that were in coating deformations on the extrados of the pipe.

Figure 36. Photograph of Segment 10 showing a 2-inch long gouge to bare metal in the coating at the 78-inch location.

Figure 37. Photograph of Segment 10 showing a "transition" coating between the 82 to93-inch locations.

Figure 38. Photograph of Segment 10 showing the valve that was located at the 102.5inch location.

APPENDIX E – COATING DEFECTS SCHEMATICS

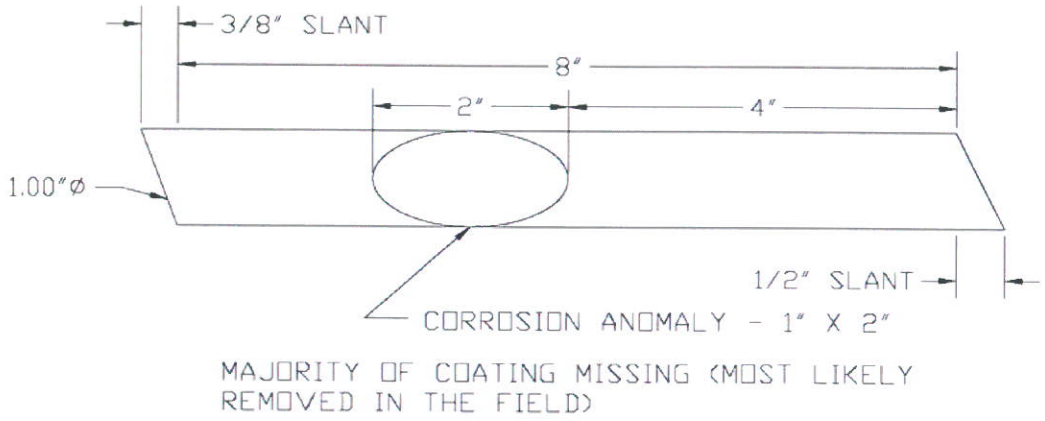


Figure 1. CAD schematic of Segment 1 showing a corrosion anomaly the majority of the coating was missing.

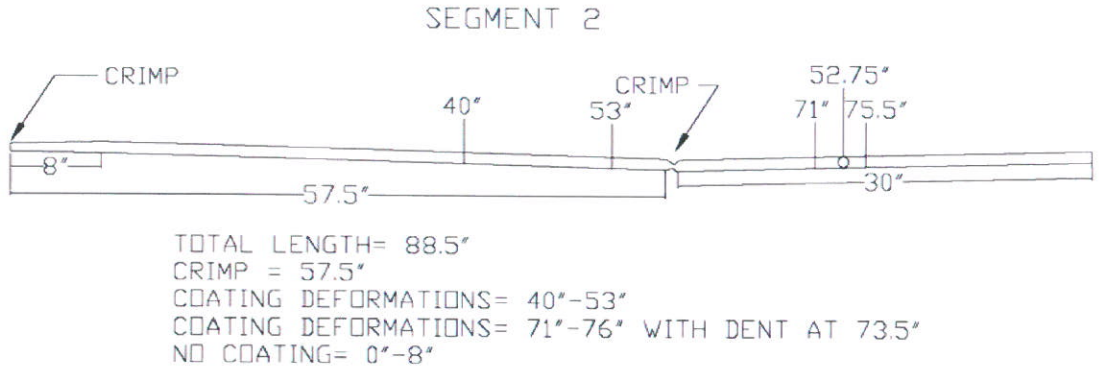


Figure 2. .CAD schematic of Segment 2 showing the locations of coating deformations.

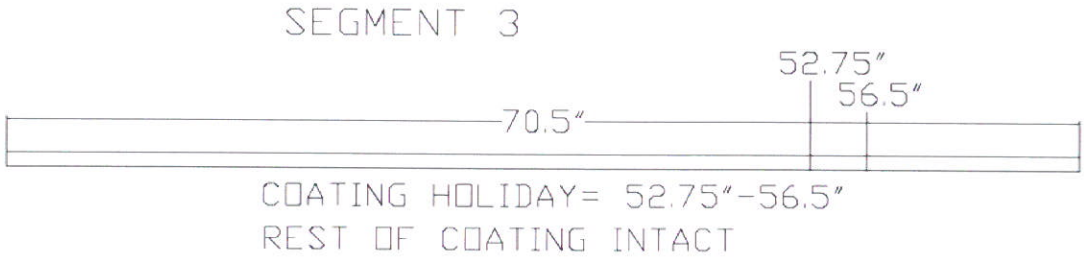


Figure 3. CAD schematic of Segment 3 showing the locations of coating holidays.

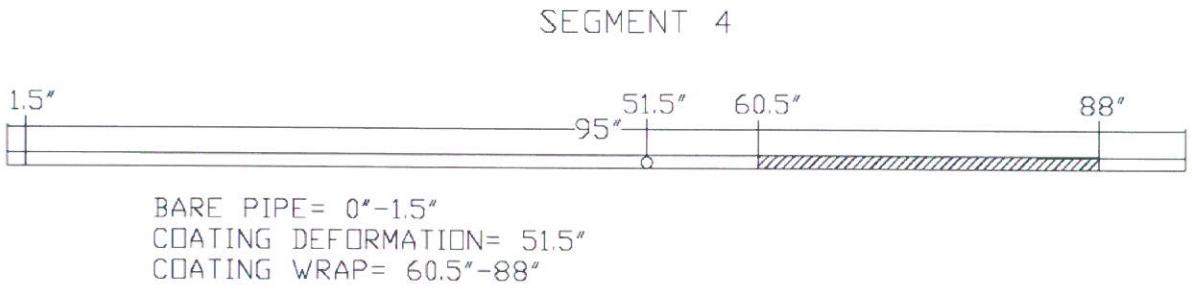


Figure 4. CAD schematic of Segment 4 showing the locations of coating deformations and coating wrap.

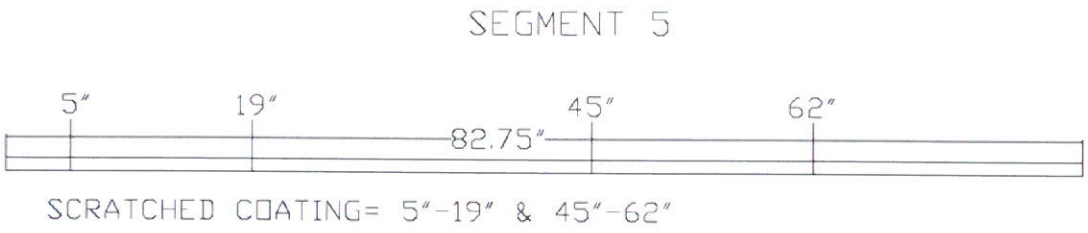


Figure 5. CAD schematic of Segment 5 showing areas of scratched coating.

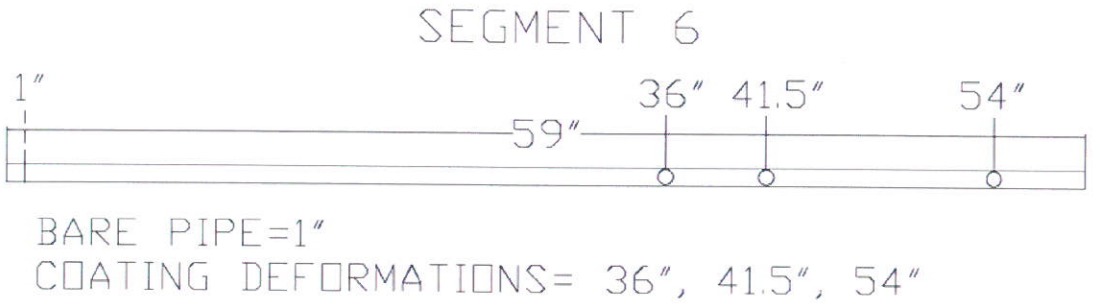


Figure 6. CAD schematic of Segment 6 showing the locations of coating deformations.

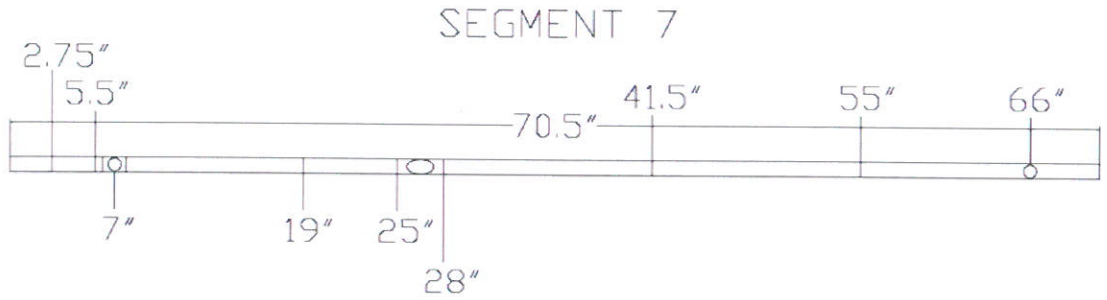


Figure 7. CAD schematic of Segment 7 showing the locations of coating deformations.

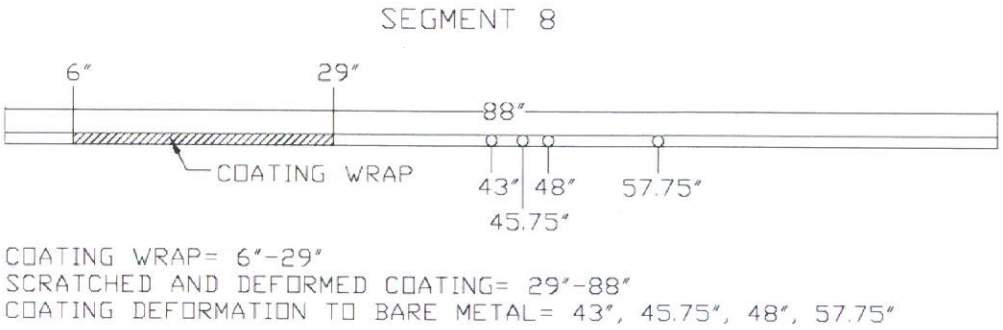


Figure 8. CAD schematic of Segment 8 showing the locations of coating deformations and coating wrap.

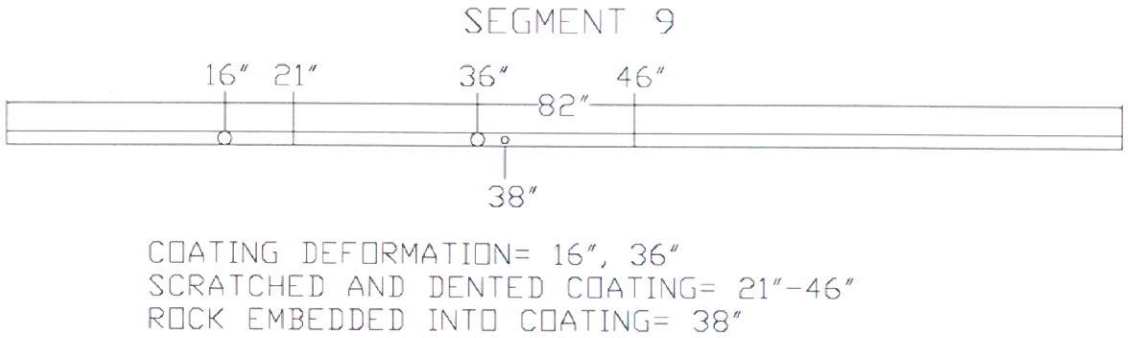


Figure 9. CAD schematic of Segment 9 showing the locations of coating deformations.

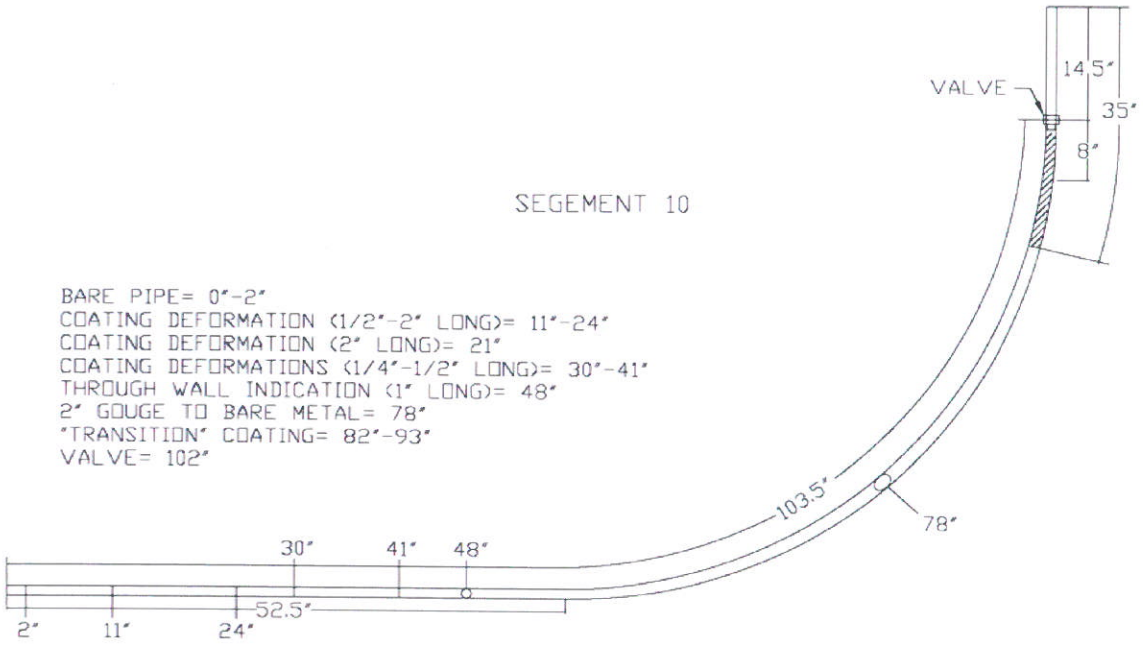


Figure 10. CAD schematic of Sample 10 showing the locations of coating deformations, through wall indication, and valve.

APPENDIX F – PIPE ASSESSMENT

Figure 1. Photograph of Segment 2 after a portion of the coating was removed showing 3 small anomalies at the 45-inch location.

Figure 2. Photograph of the Segment 2 after a portion of the coating was removed showing a 0.25-inch anomaly at the 74.5-inch location.

Figure 3. Photograph of Segment 4 after a portion of the coating was removed showing 1.5-inch anomaly area under disbonded coating.

Figure 4. Photograph of Segment 4 after a portion of the coating was removed showing a 0.25-inch anomaly at the 51.75-inch location.

Figure 5. Photograph of Segment 4 after the field applied outer wrap and coating was removed revealing a weld at the 75-inch location.

Figure 6. Photograph of Segment 4 after removal of a portion of the coating showing no corrosion underneath the coating holidays at the 6-inch location.

Figure 7. Photograph of Segment 7 after removal of a portion of the coating showing no corrosion under the gouge in the coating to bare pipe that was located at the 26-inch location.

Figure 8. Photograph of Segment 7 after removal of a portion of the coating showing no corrosion in the pipe underneath the coating holiday at the 48-inch location.

Figure 9. Photograph of Segment 7 after removal of a portion of the coating showing no corrosion underneath the coating holiday that was at the 66-inch location.

Figure 10. Photograph of Segment 8 after the coating wrap and coating was removed revealing a weld at the 19.5-inch location.

Figure 11. Photograph of Segment 9 after a portion of the coating was removed revealing an anomaly at the 29.5-inch location.

Figure 12. Photograph of Segment 9 after a portion of the coating was removed showing the top of the anomaly at the 29.5-inch location.

Figure 13. Photograph of Segment 9 after a portion of the coating was removed showing an anomaly at the 36-inch location.

Figure 14. Photograph of Segment 10 after a portion of the coating was removed showing an anomaly at the 21-inch location.

Figure 15. Photograph of Segment 10 after a portion of the coating was removed showing a through wall penetration at the 49-inch location.

Figure 16. Photograph of Segment 10 after a portion of the coating was removed showing the corrosion colored product that was present on the extrados of the bend in the pipe.

APPENDIX G – CORROSION ANOMALIES SCHEMATICS

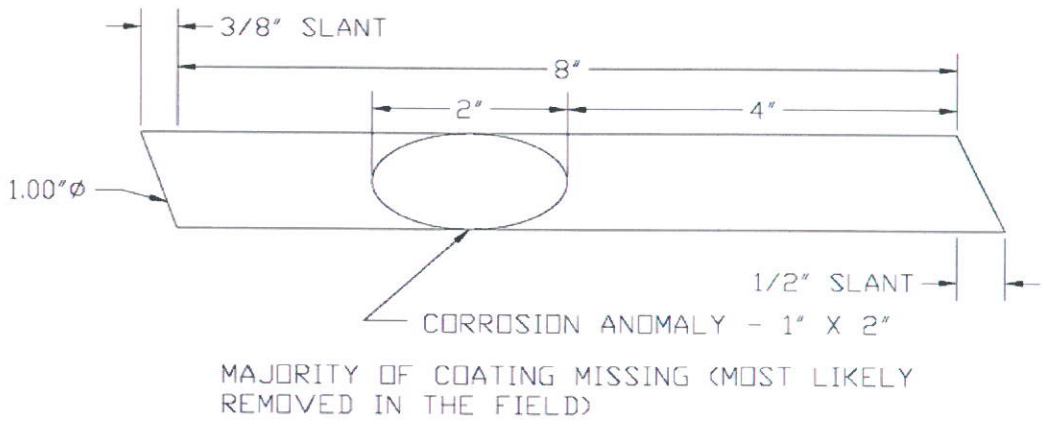


Figure 1. CAD schematic of Segment 1 a 1-inch by 2-inch corrosion anomaly.

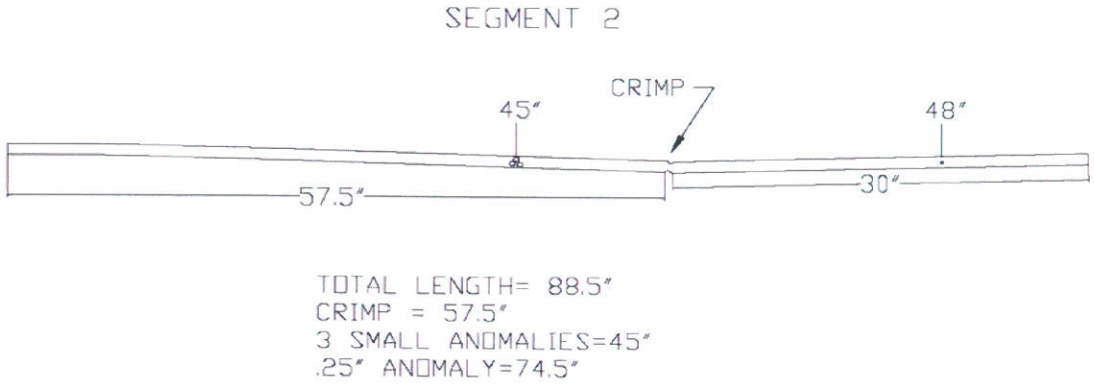


Figure 2. CAD schematic of Segment 2 showing 3 small anomalies after coating removal.

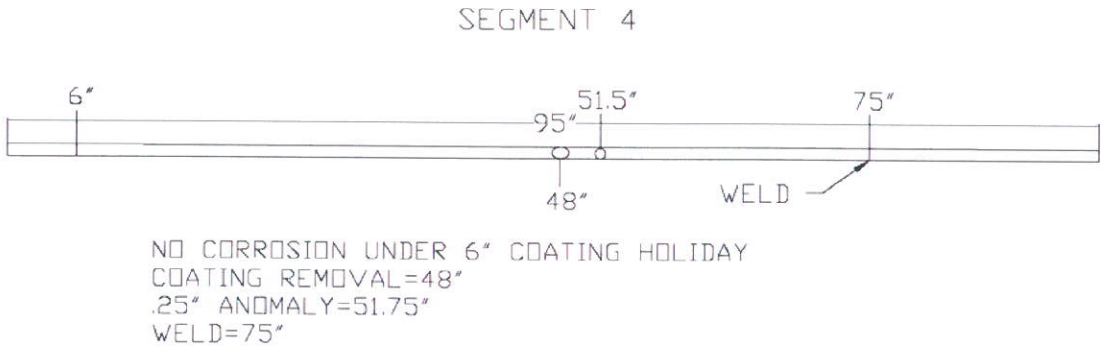


Figure 3. CAD schematic of Segment 4 showing anomalies and weld on pipe after coating removal.

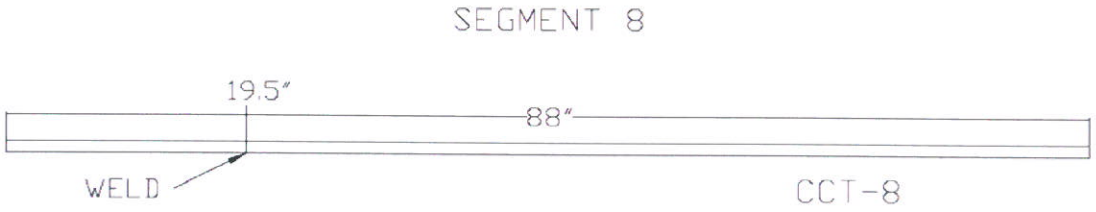


Figure 4. CAD schematic of Segment 8 showing location of weld after removal of coating.

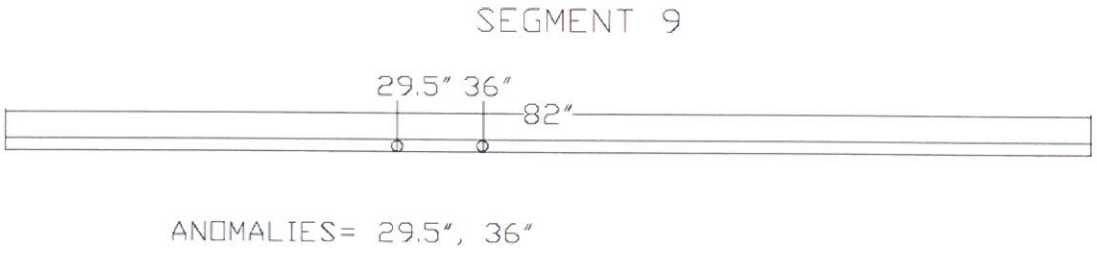


Figure 5. CAD schematic of Segment 9 showing anomalies on the pipe after coating removal.

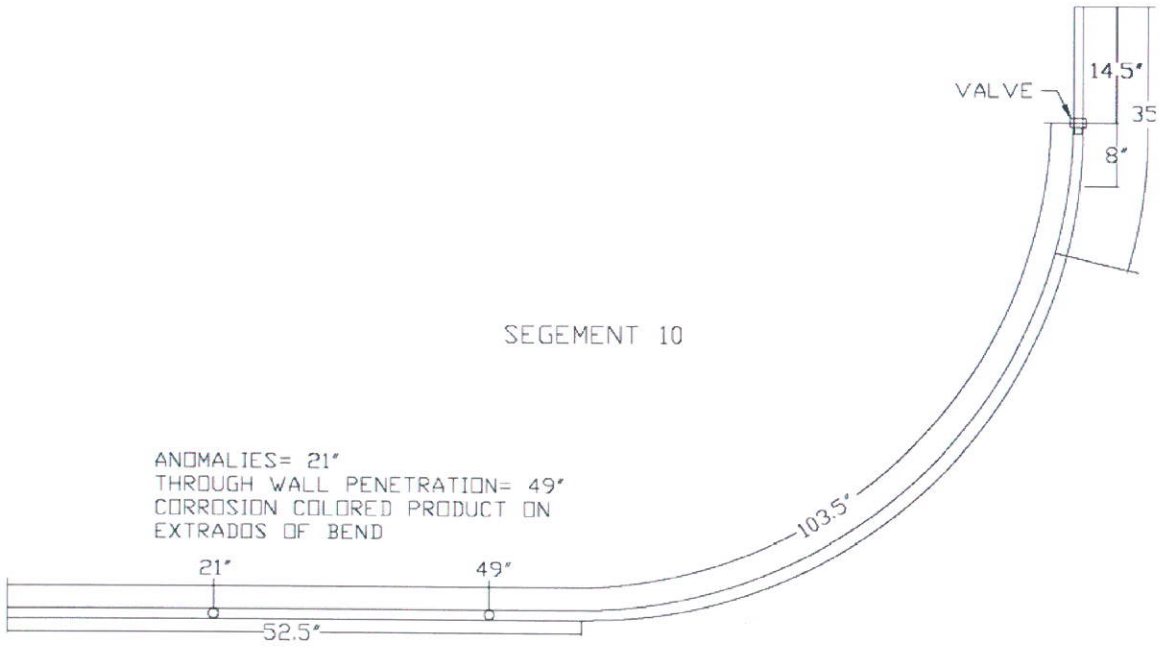


Figure 6. CAD schematic of Sample 10 showing anomalies, through wall penetration, and valve on pipe after coating removal.

APPENDIX H – SECTIONING

Figure 1. Photograph of Segment 1 showing an anomaly at the 4-inch location.

Figure 2. Photograph of Segment 1 showing where Mount 1-B (2nd piece from left) and Surface 01-C (3rd piece from left) were cut out of the pipe.

Figure 3. Photograph of Segment 1 showing an anomaly at the 51.75-inch location.

Figure 4. Photograph of Segment 4 showing where Mount 4-B (3rd piece from left) was cut out of the pipe.

Figure 5. Photograph of Segment 9 showing an anomaly at the 29.5-inch location.

Figure 6. Photograph of Segment 9 showing where Mount 9-B (2nd piece from left) was cut out of the pipe.

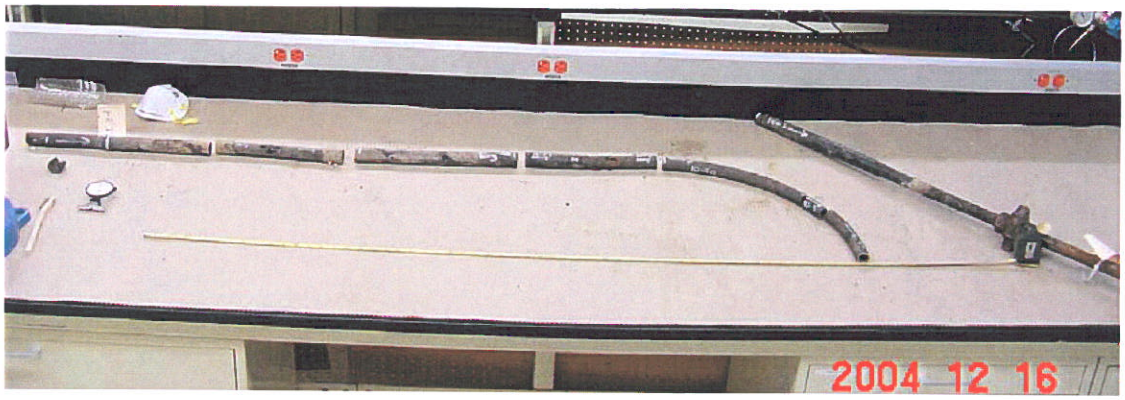


Figure 7. Photograph of Segment 10 showing how the sample was sectioned into 6 samples.

Figure 8. Photograph of Segment 10 showing where Mount 10-4B (2nd piece from left) and Surface 10-4C (3rd piece from left) were cut out of the pipe.

Figure 9. Photograph of Segment 10 showing where Surface 10-5B-2 (last piece on right) was removed from the pipe.

APPENDIX I – LIGHT MICROSCOPY

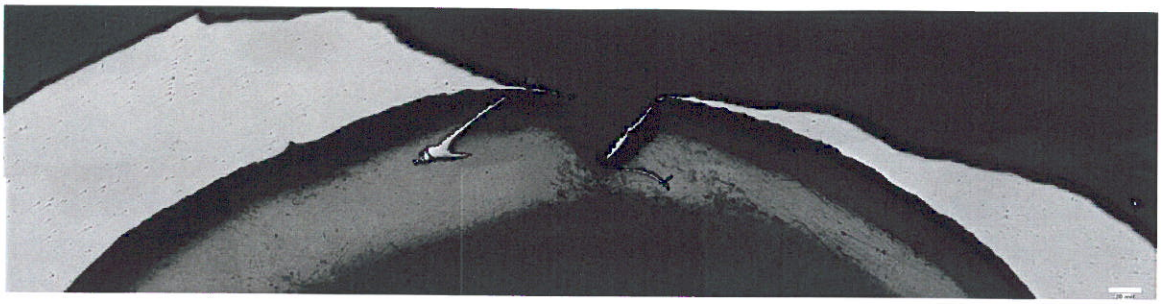


Figure 1. Montage of light photomicrographs of the as-polished Mount 1-B in the area of wall loss.

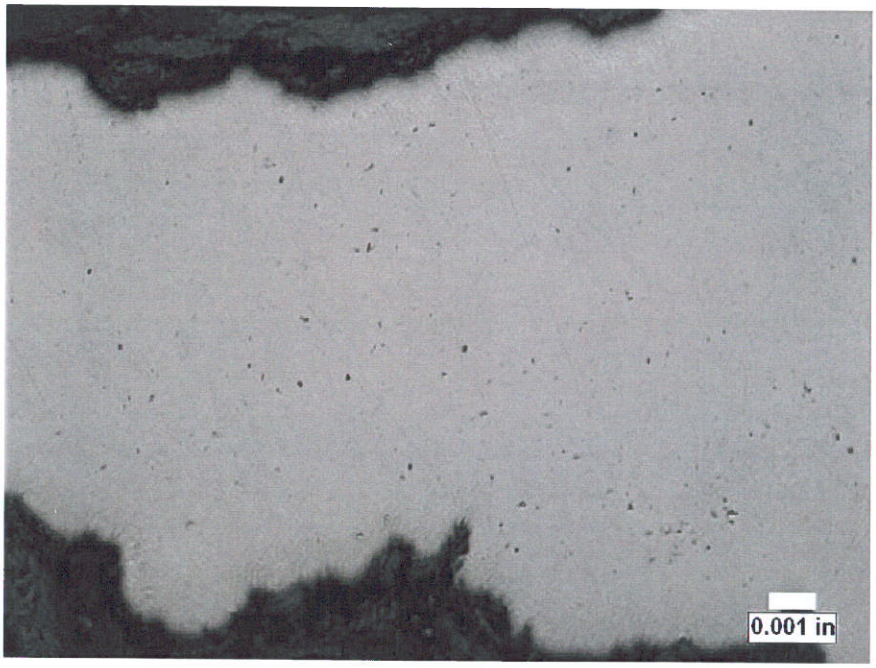


Figure 2. Light photomicrograph near maximum wall loss of the as-polished Mount 1-B taken at 200X.

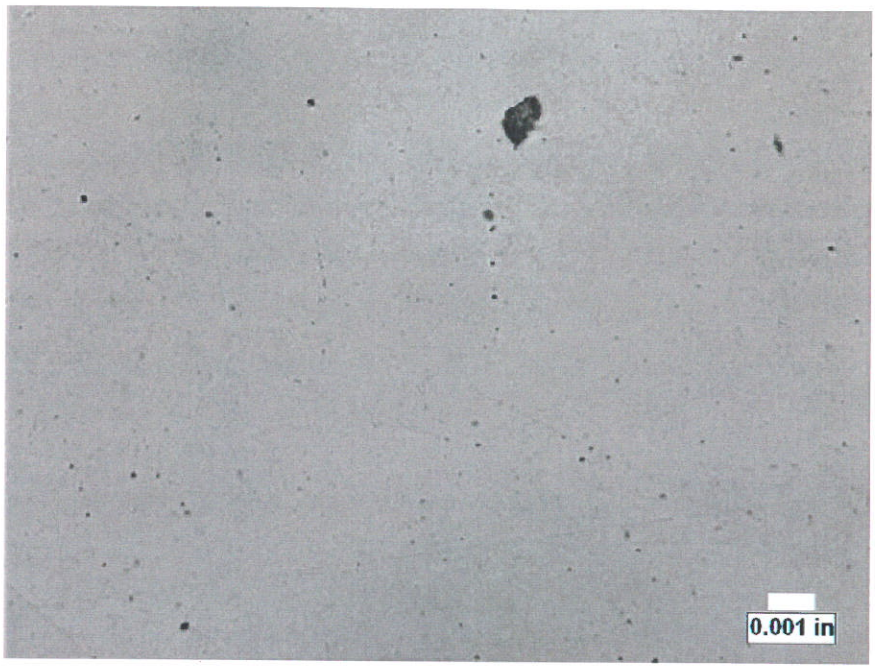


Figure 3. Light photomicrograph of the as-polished Mount 1-B away from the area of wall loss of taken at 200X.

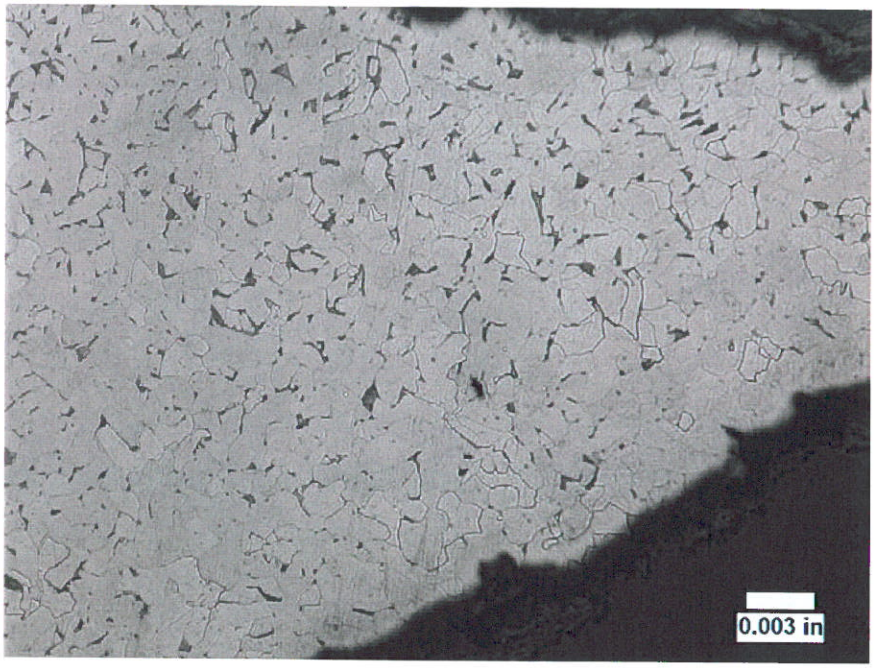


Figure 4. Light photomicrograph of etched Mount 1-B near maximum wall loss taken at 100X.

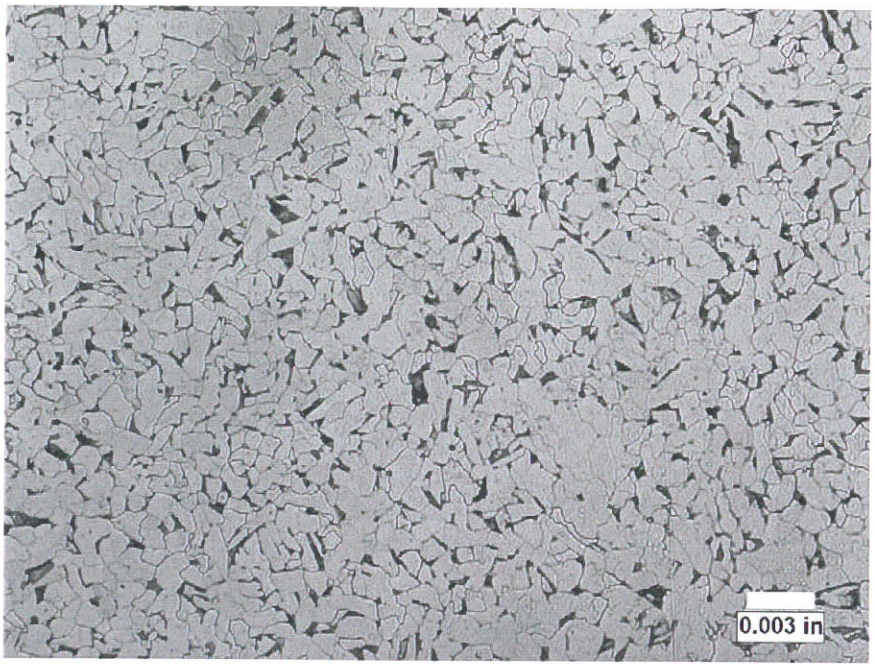


Figure 5. Light photomicrograph of etched Mount 1-B of typical base metal microstructure taken at 100X.

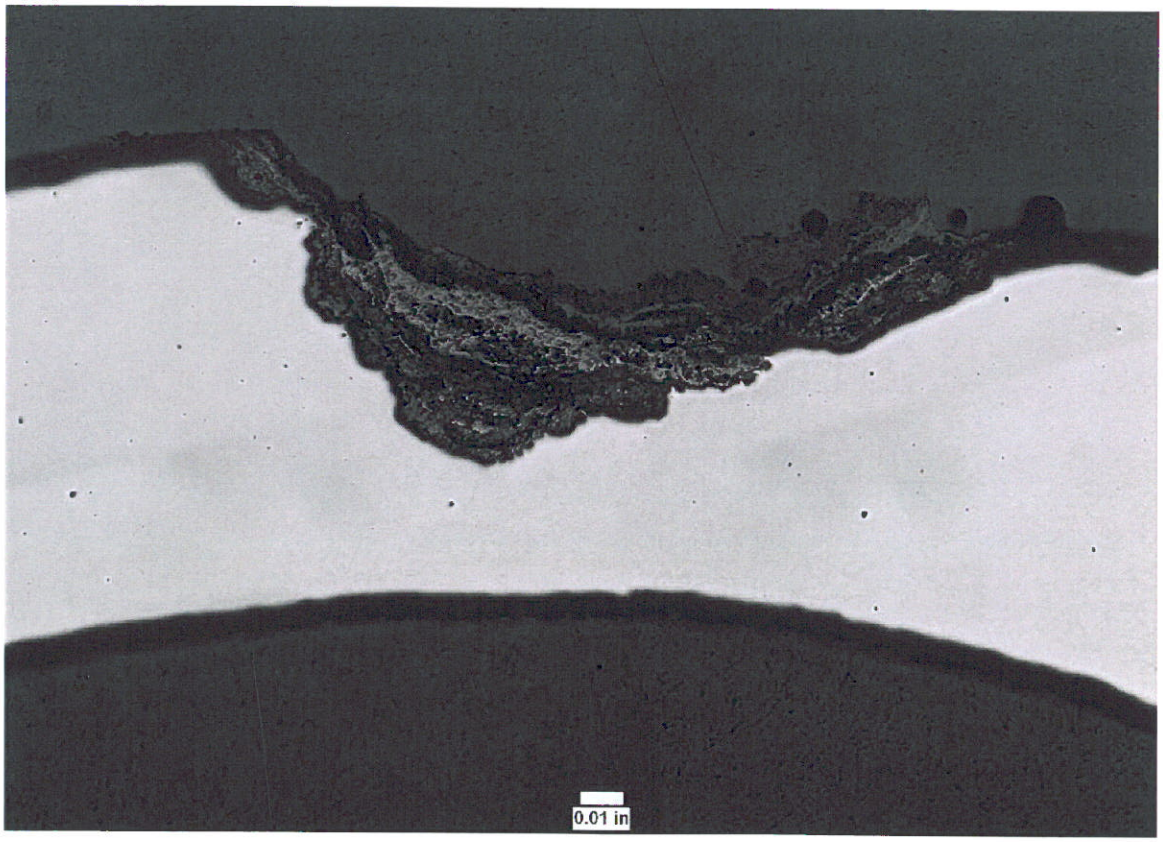


Figure 6. Montage of light photomicrographs of the as-polished Mount 4-B in the area of wall loss.

Figure 7. Light photomicrograph of as-polished Mount 4-B near maximum wall loss taken at 200X.

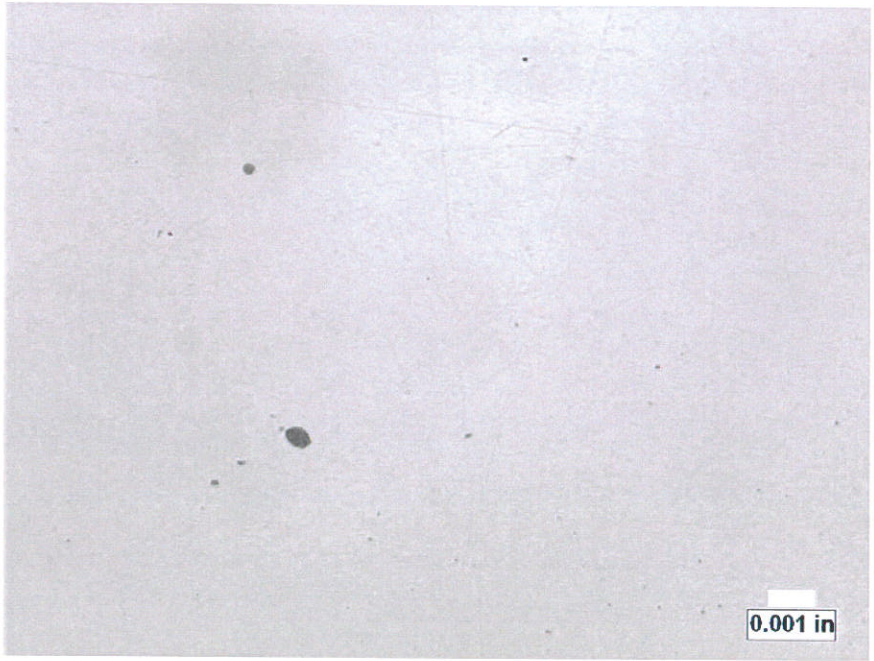


Figure 8. Light photomicrograph of as-polished Mount 4-B removed from maximum wall loss, taken at 200X.

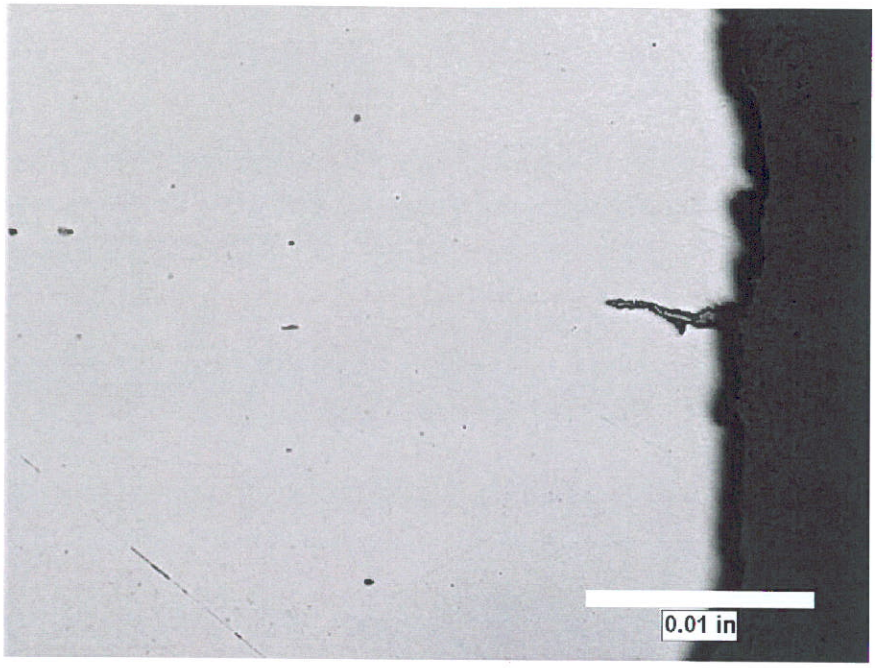


Figure 9. Light photomicrograph of as-polished Mount 4-B OD surface showing an indication, taken at 100X.

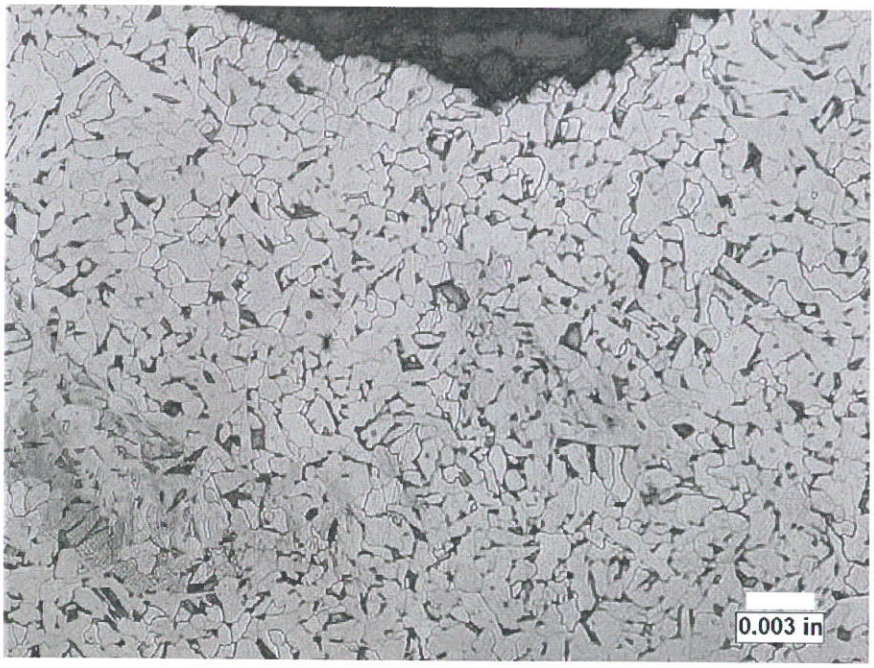


Figure 10. Light photomicrograph of etched Mount 4-B microstructure near the maximum wall loss taken at 100X.

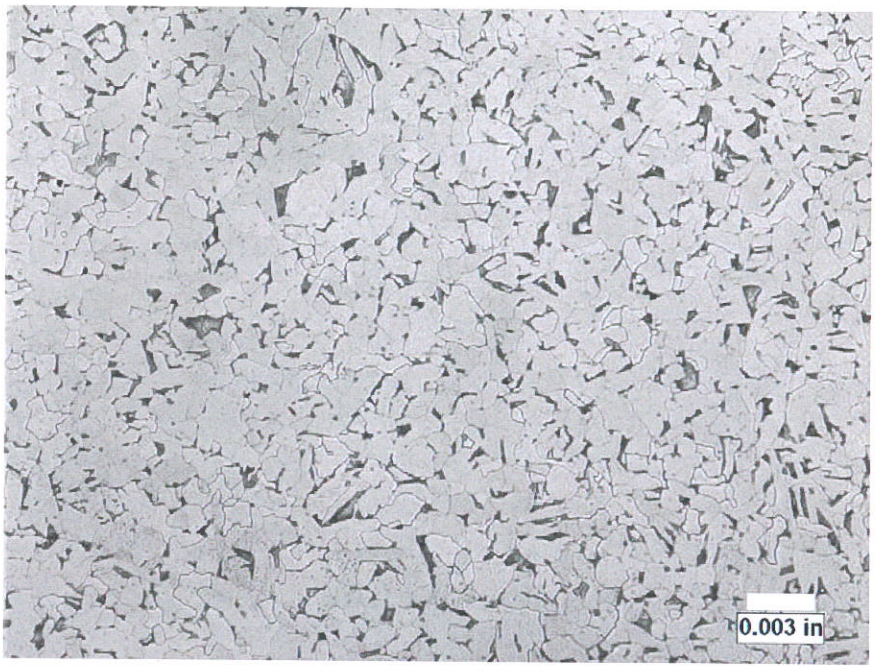


Figure 11. Light photomicrograph of etched Mount 4-B of typical base metal microstructure taken at 100X.

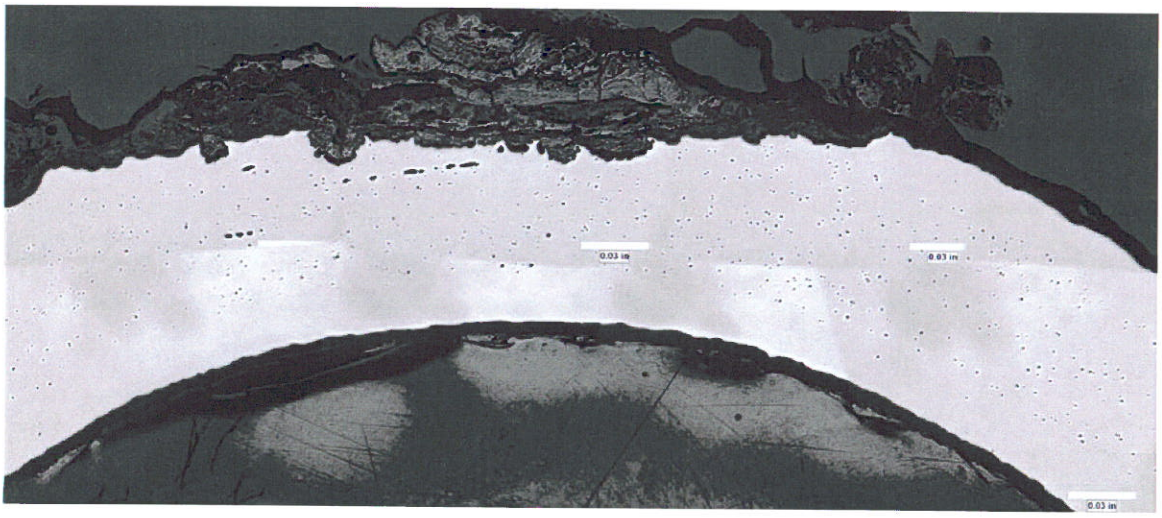


Figure 12. Montage of light photomicrographs of the as-polished Mount 9-B in the area of wall loss.

Figure 13. Light photomicrograph of as-polished Mount 9-B near maximum wall loss, taken at 200X.

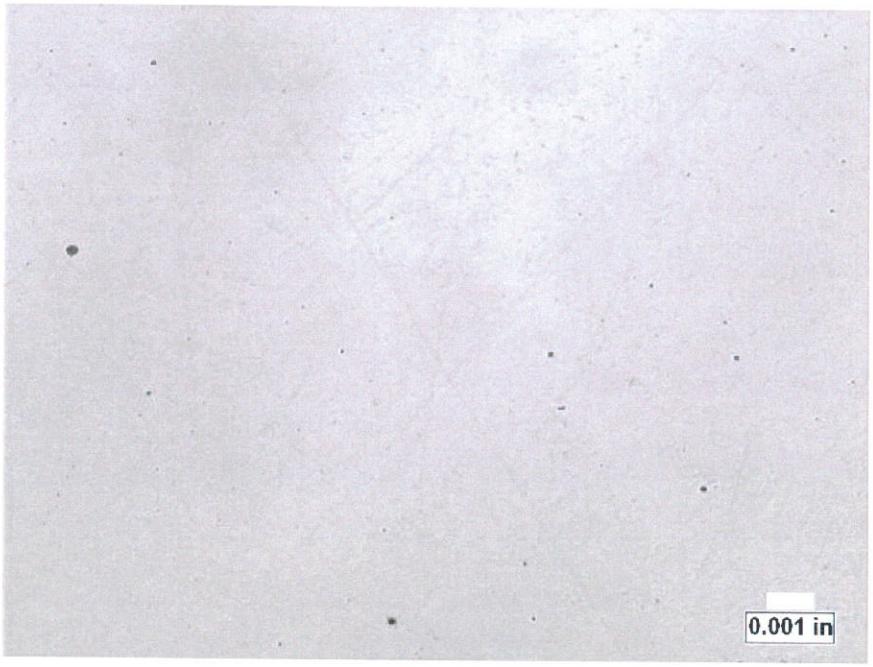


Figure 14. Light photomicrograph of as-polished Mount 9-B removed from maximum wall loss, taken at 200X.

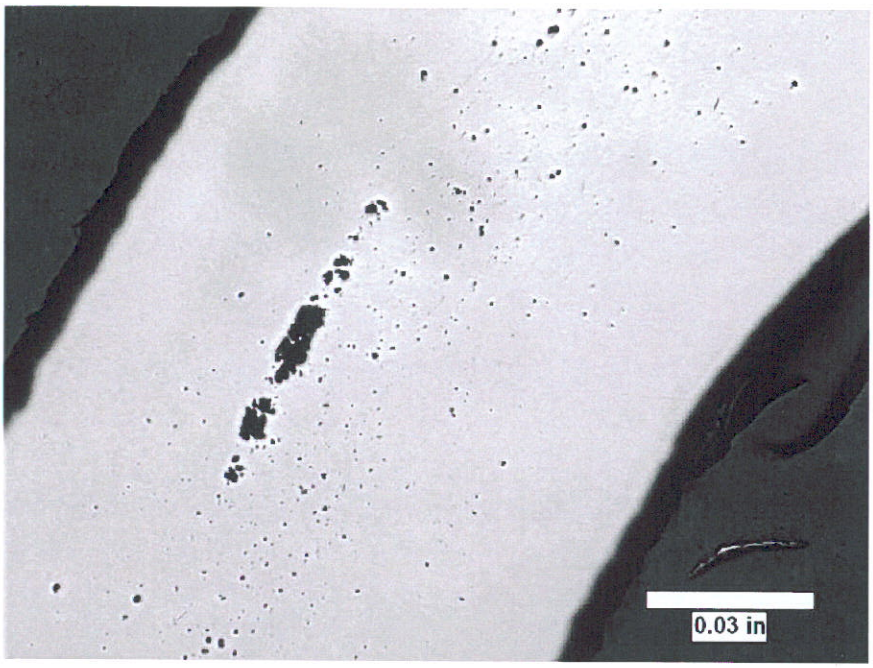


Figure 15. Light photomicrograph of as-polished Mount 9-B, taken at 25X.

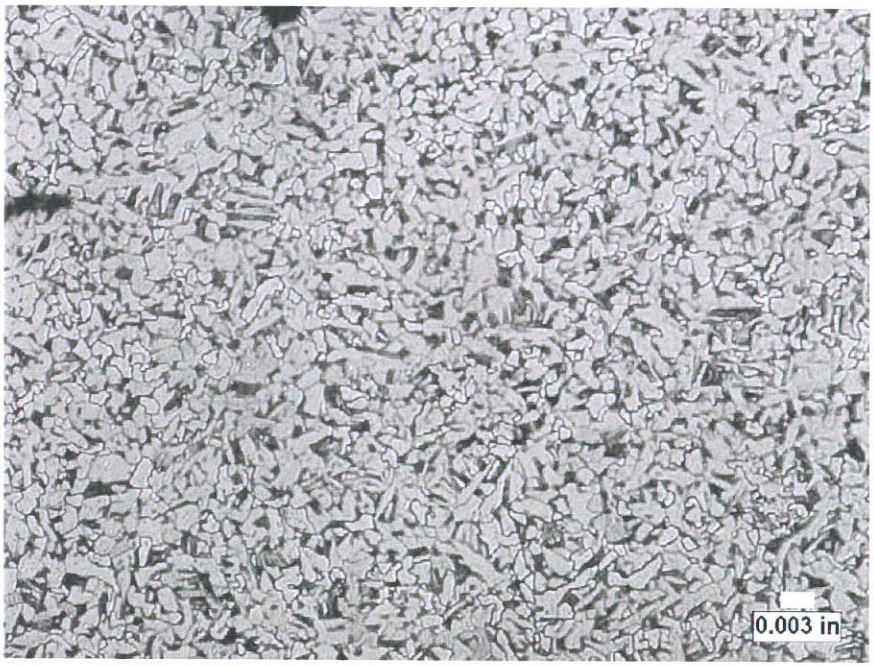


Figure 16. Light photomicrograph of etched Mount 9-B microstructure near maximum wall loss, taken at 100X.

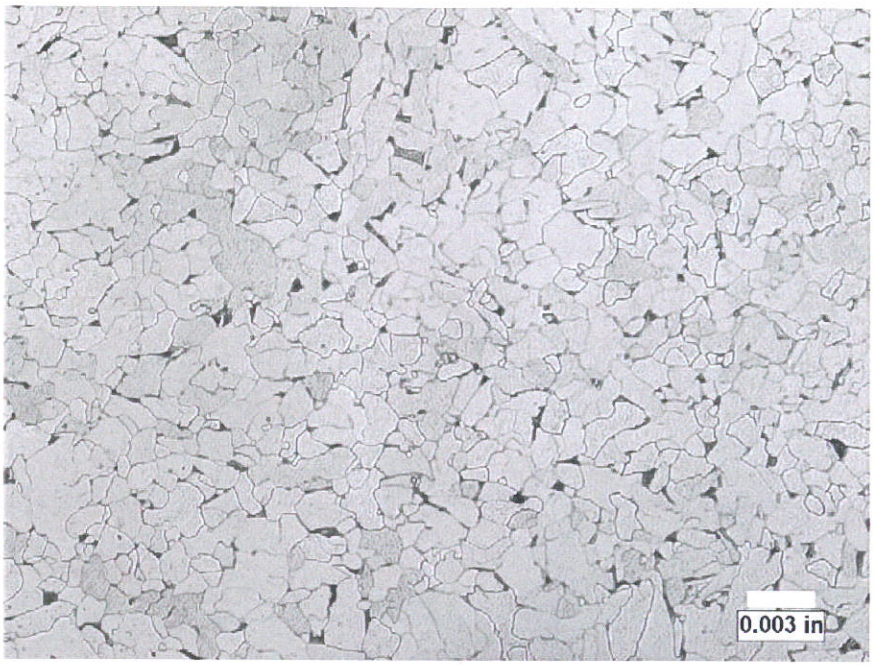


Figure 17. Light photomicrograph of etched Mount 9-B base metal microstructure, taken at 100X.

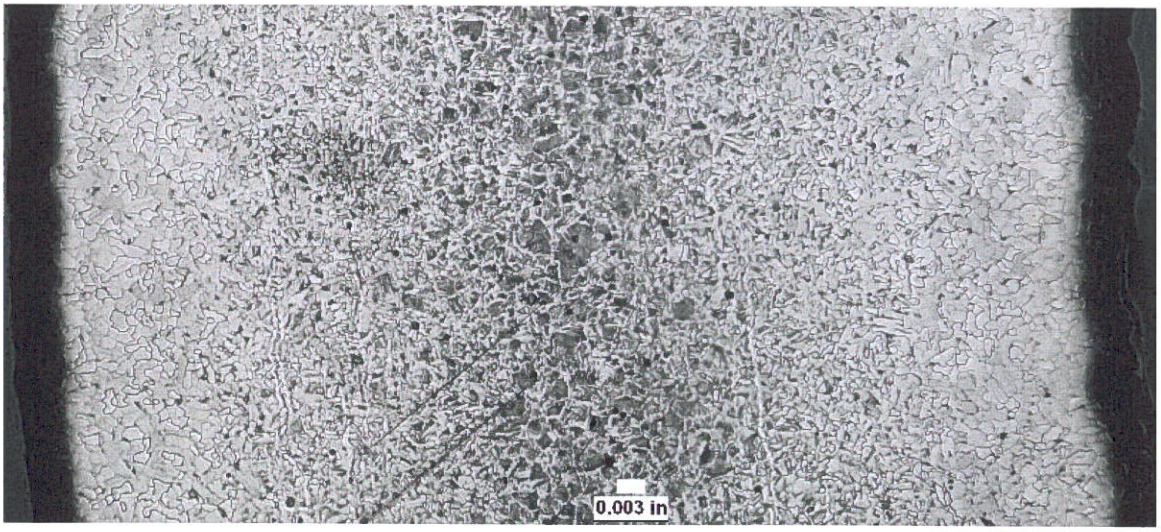


Figure 18. Montage of light photomicrographs of the etched Mount 9-B showing the microstructure transition between the ID and OD surfaces, taken at 50X.

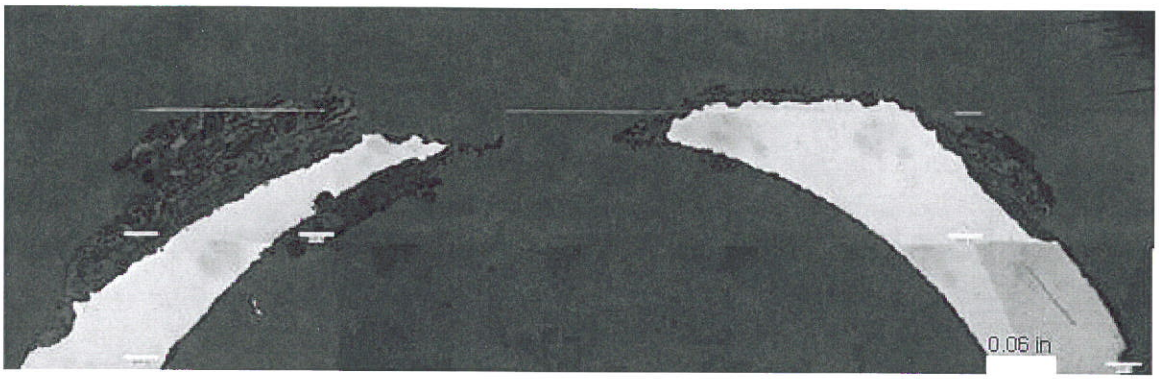


Figure 19. Montage of light photomicrographs of the as-polished Mount 10-4B in the area of the leak and wall loss.

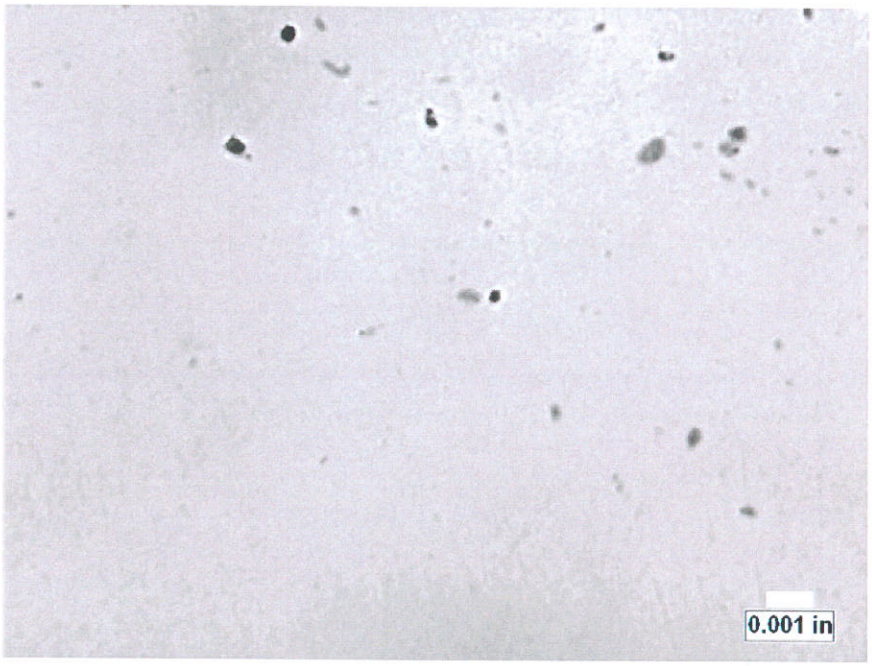


Figure 20. Light photomicrograph of as-polished Mount 10-4B near maximum wall loss, taken at 200X.

Figure 21. Light photomicrograph of as-polished Mount 9-B removed from maximum wall loss, taken at 200X.

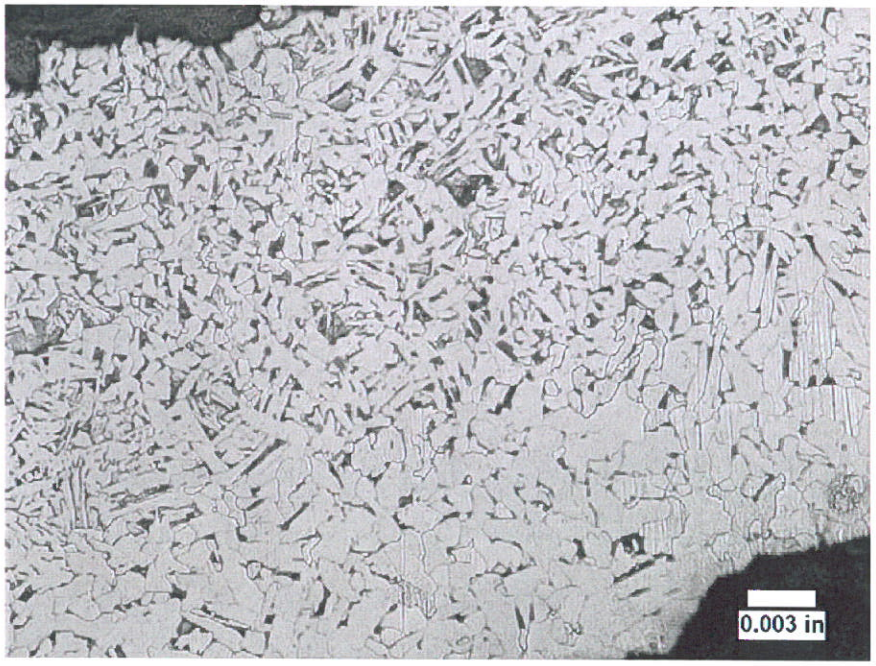


Figure 22. Light photomicrograph of etched Mount 10-4B microstructure near wall loss, taken at 100X.

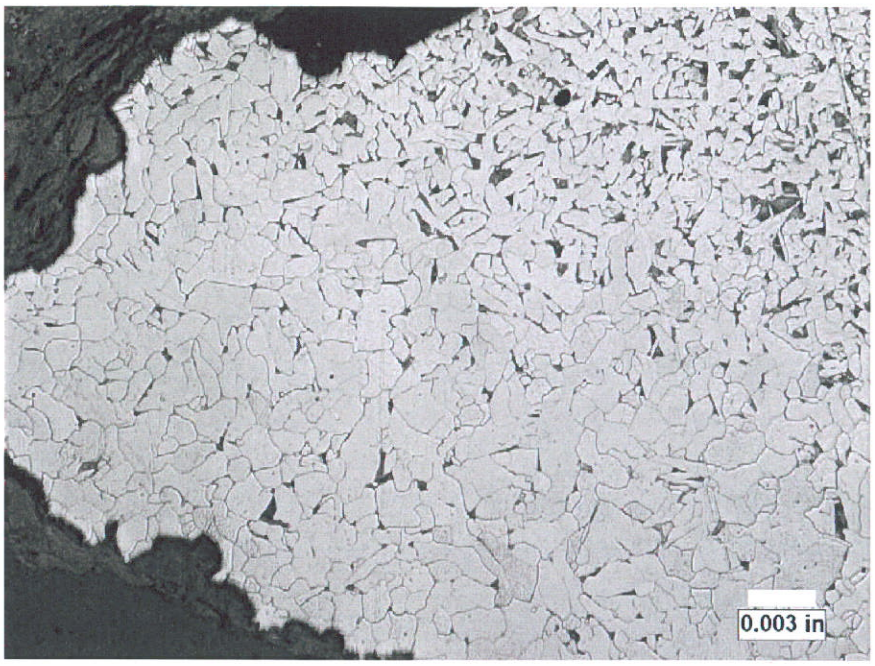


Figure 23. Light photomicrograph of etched Mount 10-4B microstructure near maximum wall loss, taken at 100X.

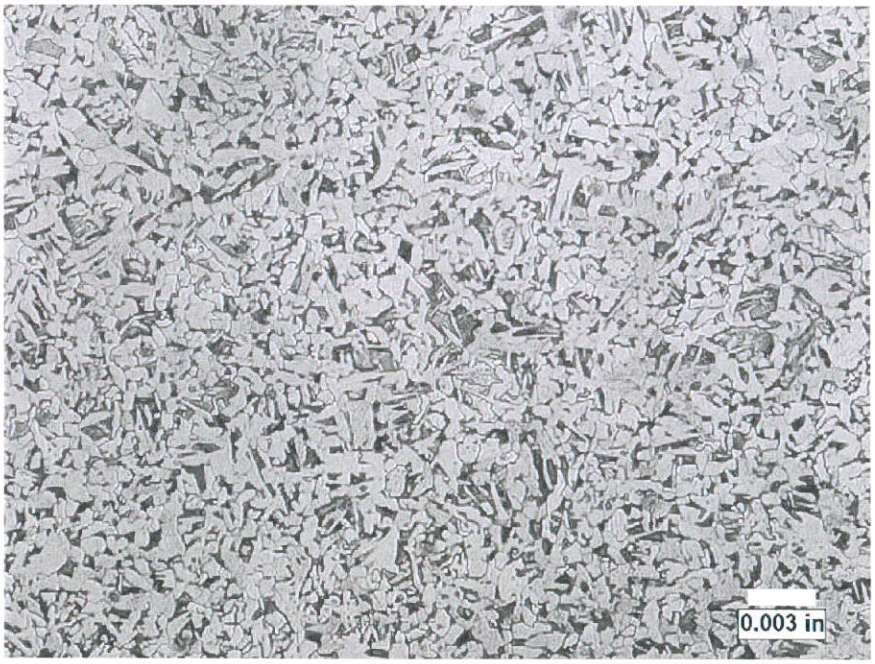


Figure 24. Light photomicrograph of etched Mount 10-4B base metal microstructure, taken at 100X.

APPENDIX J – SEM PHOTOMICROGRAPHS

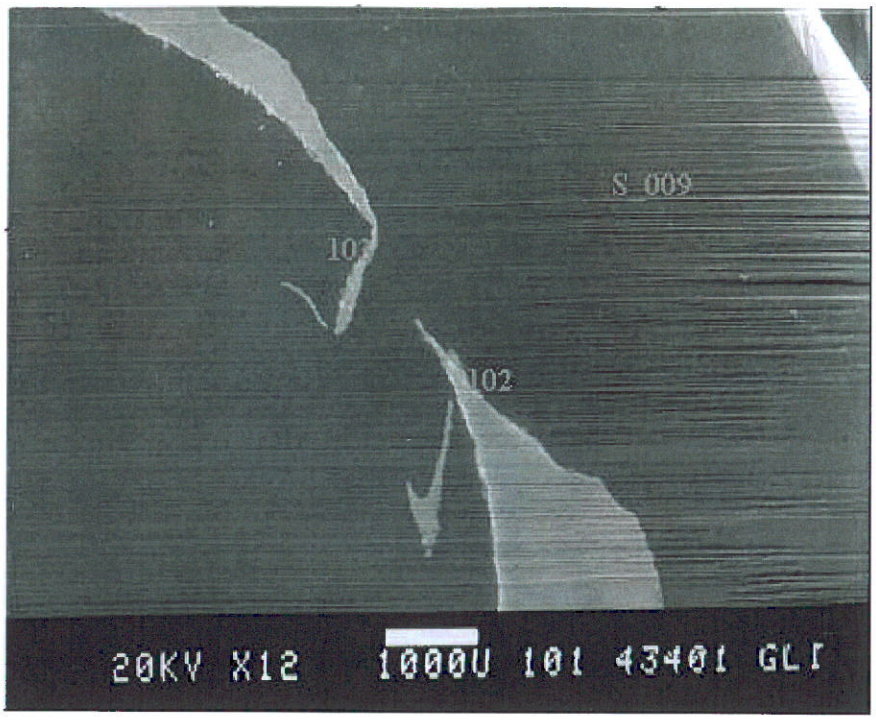


Figure 1. SEM photomicrograph 101 of Mount 1-B showing corrosion attack and the location of additional photomicrographs, 102 and 103, and EDS scan S-009.

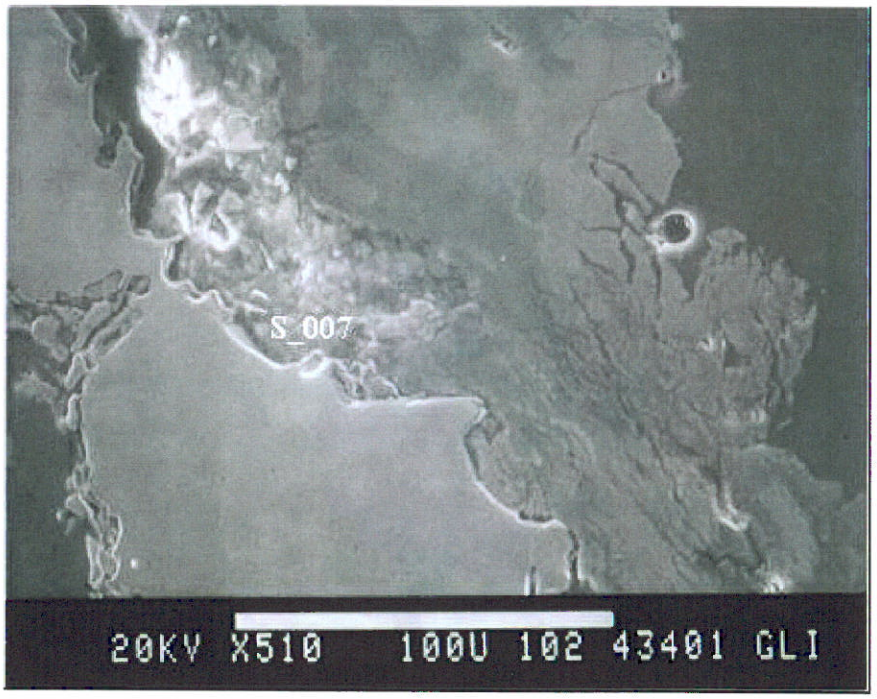


Figure 2. SEM photomicrograph 102 of Mount 1-B near the maximum wall loss showing debris on the OD surface and the location of the EDS scan S-007.

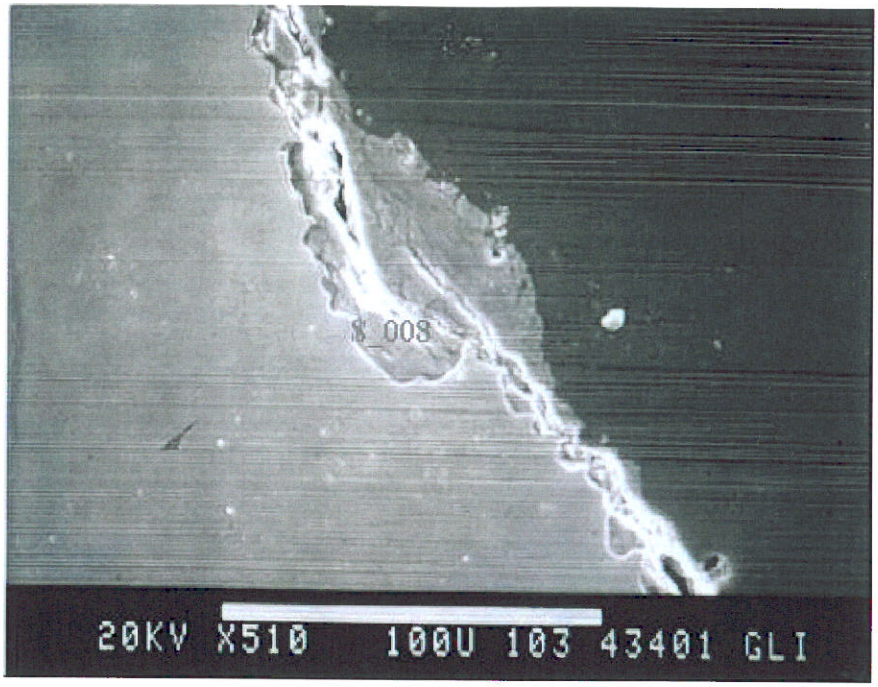


Figure 3. SEM photomicrograph 103 of Mount 1-B near the maximum wall loss showing debris on the OD surface and the location of the EDS scan S-008.

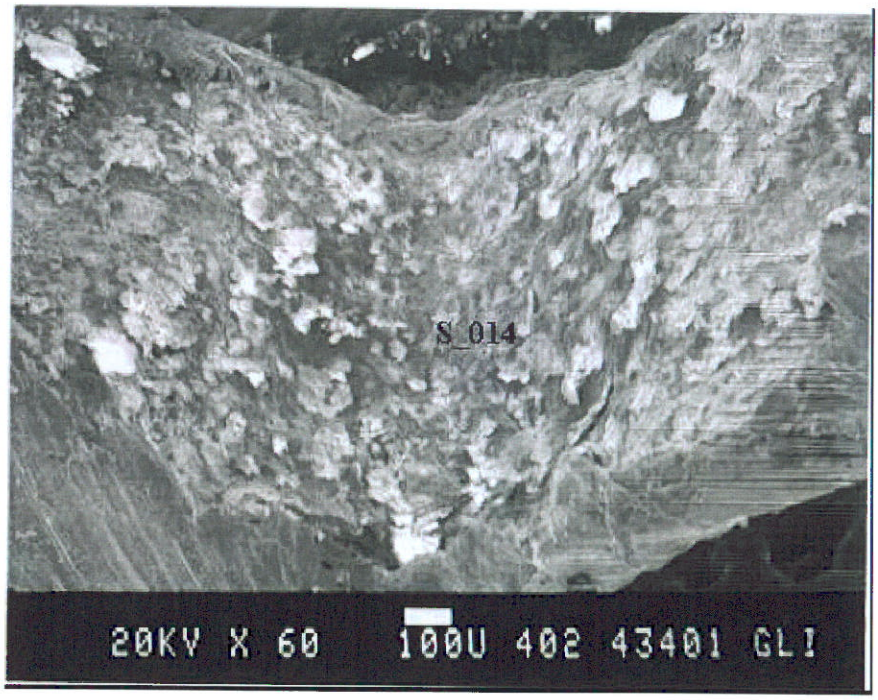


Figure 4. SEM photomicrograph 402 of Surface 01-C (right side) showing the OD surface adjacent to Mount 1-B and the location of EDS scan S-014.

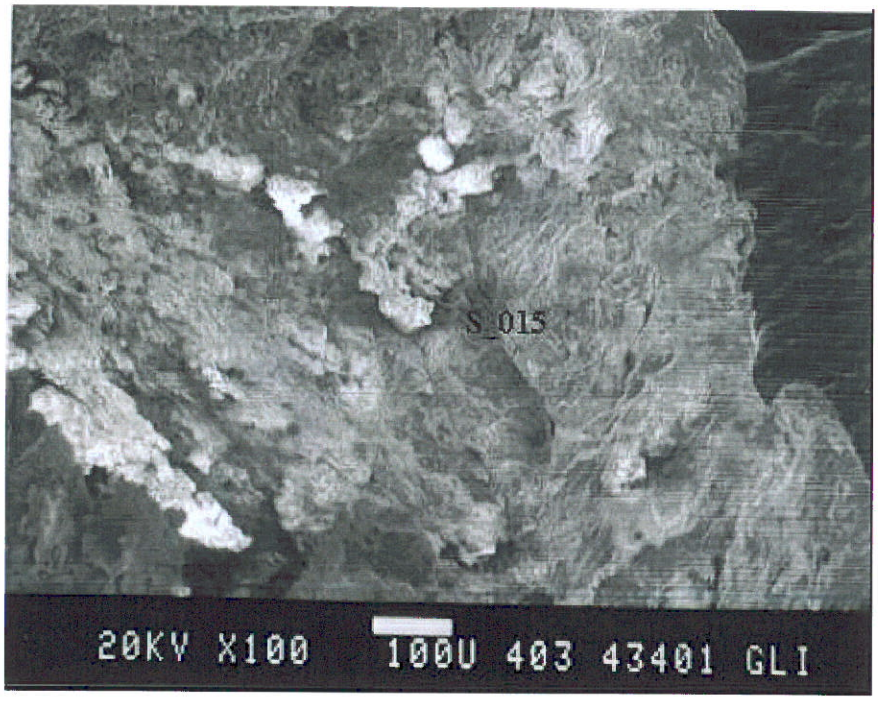


Figure 5. SEM photomicrograph 403 of Surface 01-C (left side) showing the OD surface adjacent to Mount 1-B and the location of EDS scan S-015.

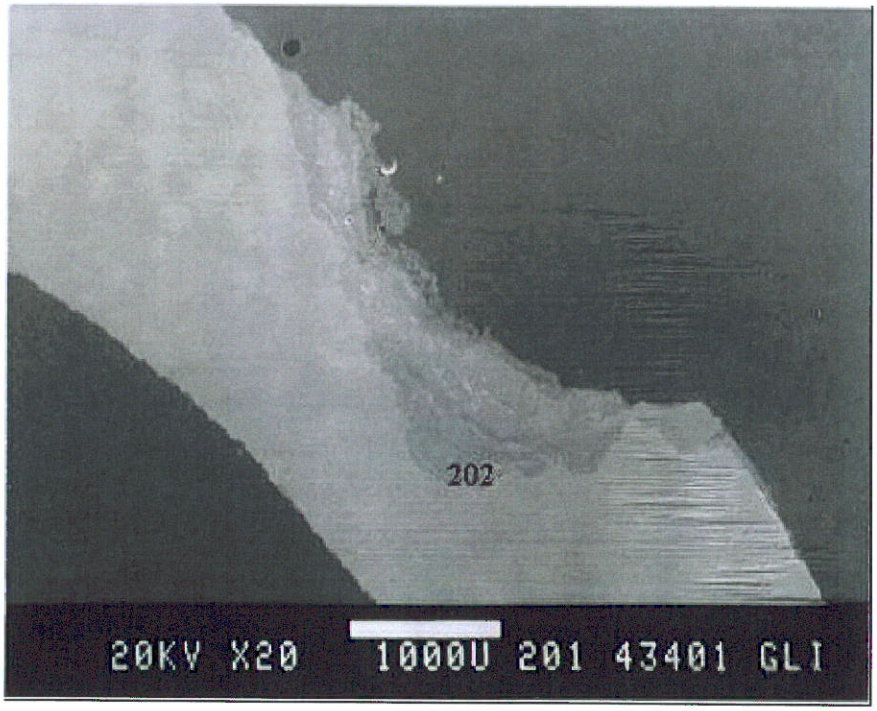


Figure 6. SEM photomicrograph 201 of Mount 4-B showing the anomaly and the location of photomicrograph 202.

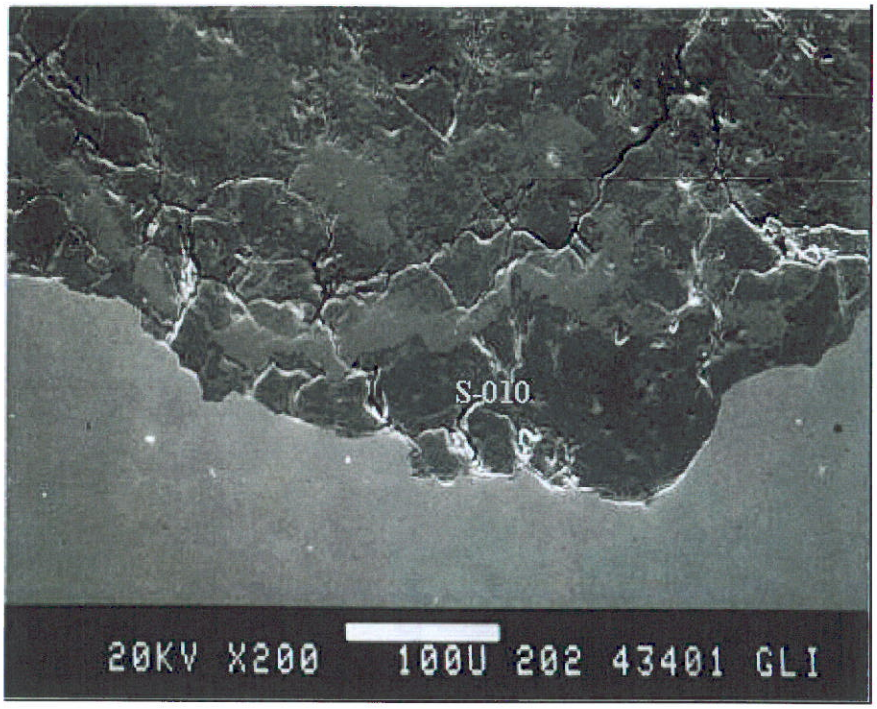


Figure 7. SEM photomicrograph 202 of Mount 4-B showing the maximum wall loss of the anomaly and the location of EDS scan S-010.

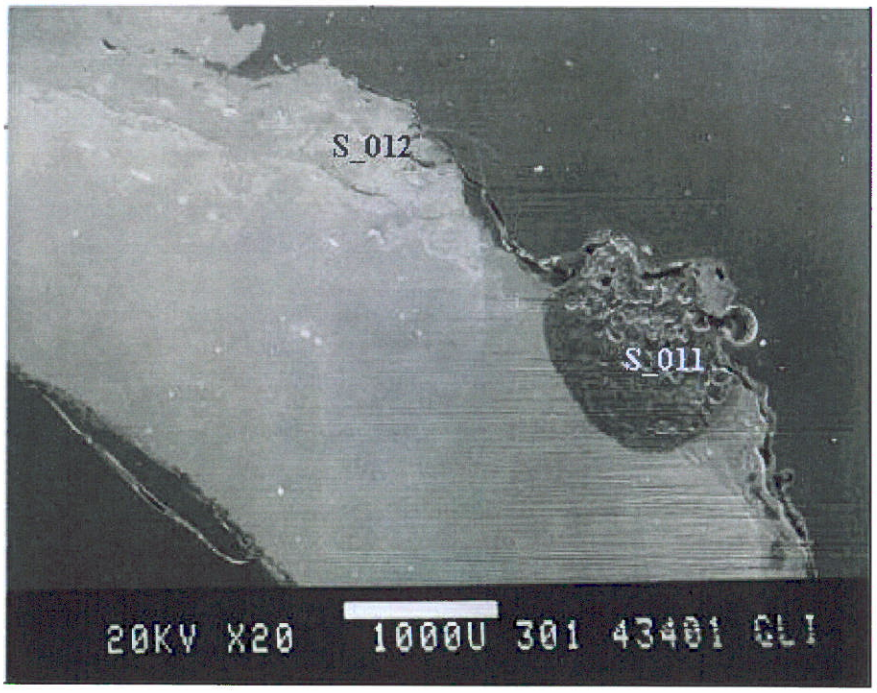


Figure 8. SEM photomicrograph 301 of Mount 9-B showing the anomaly and the locations of EDS scans S-011 and S-012.

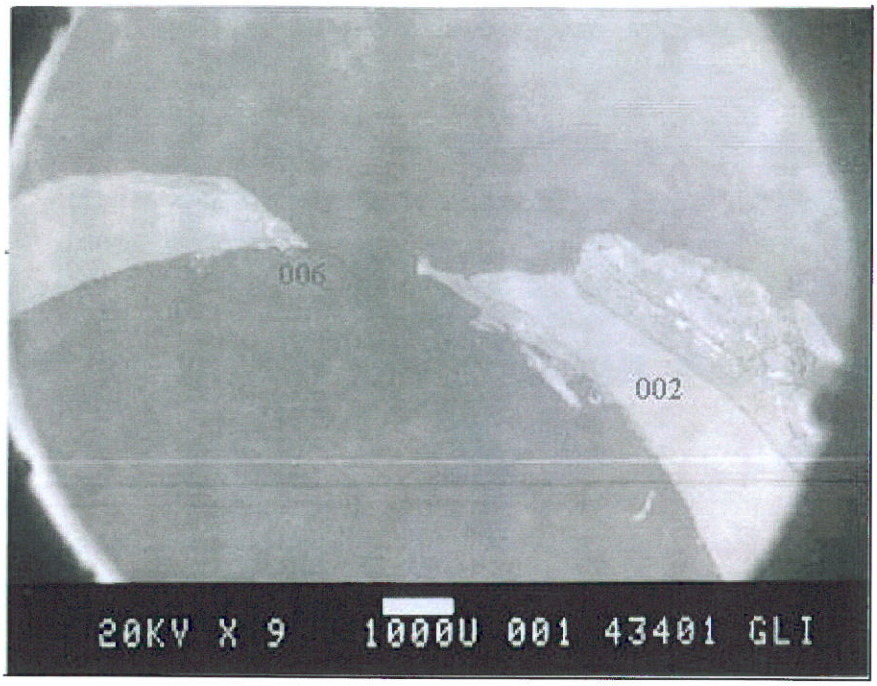


Figure 9. SEM photomicrograph 001 of Mount 10-4B showing the through wall penetration and the location of photomicrographs 002 and 006.

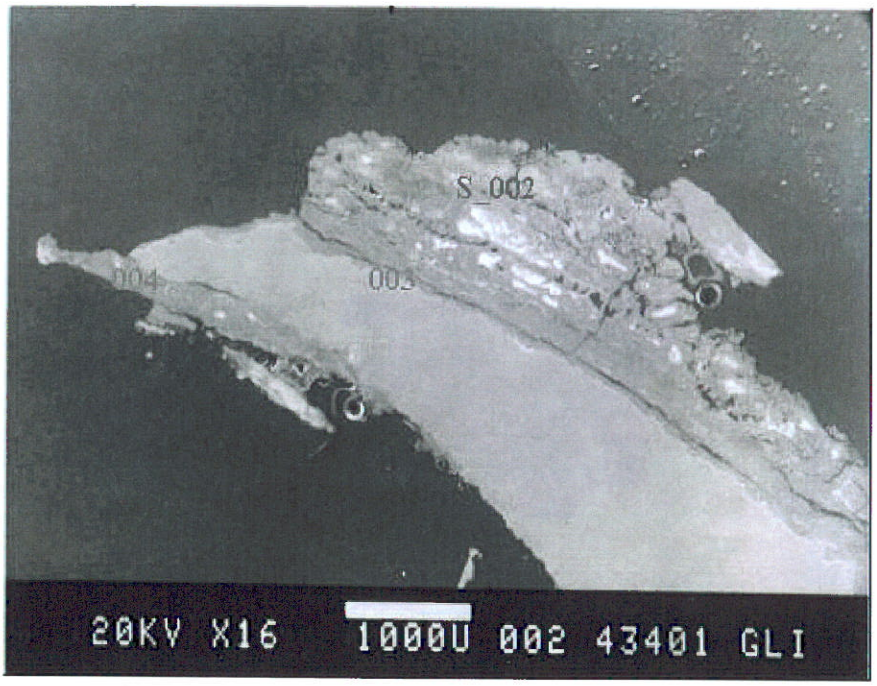


Figure 10. SEM photomicrograph 002 of Mount 10-4B showing the debris on the OD of the penetration plus the locations of photomicrographs 003 and 004 and EDS scan S-002.

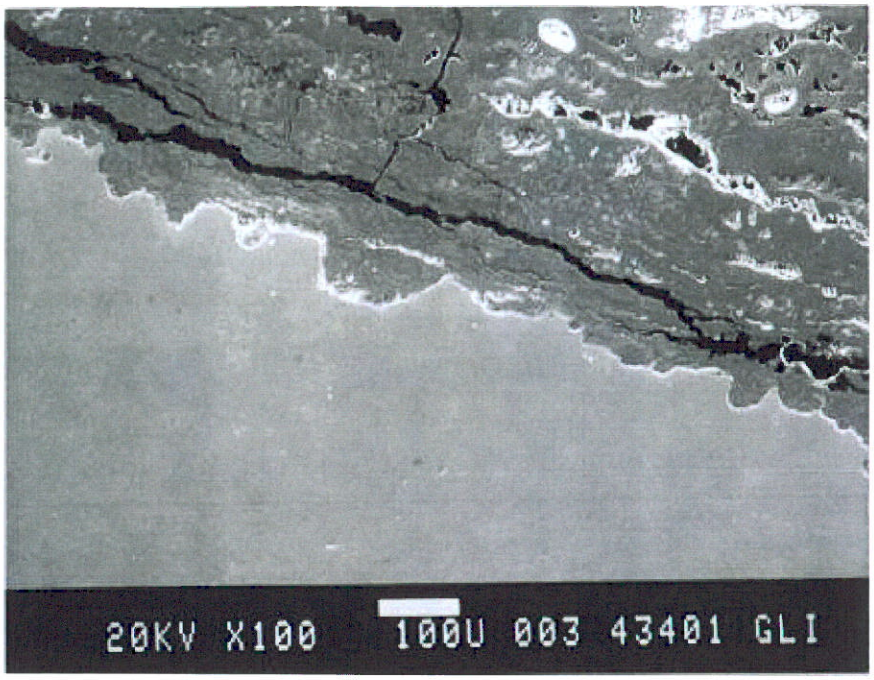


Figure 11. SEM photomicrograph 003 of Mount 10-4B showing the OD and debris.

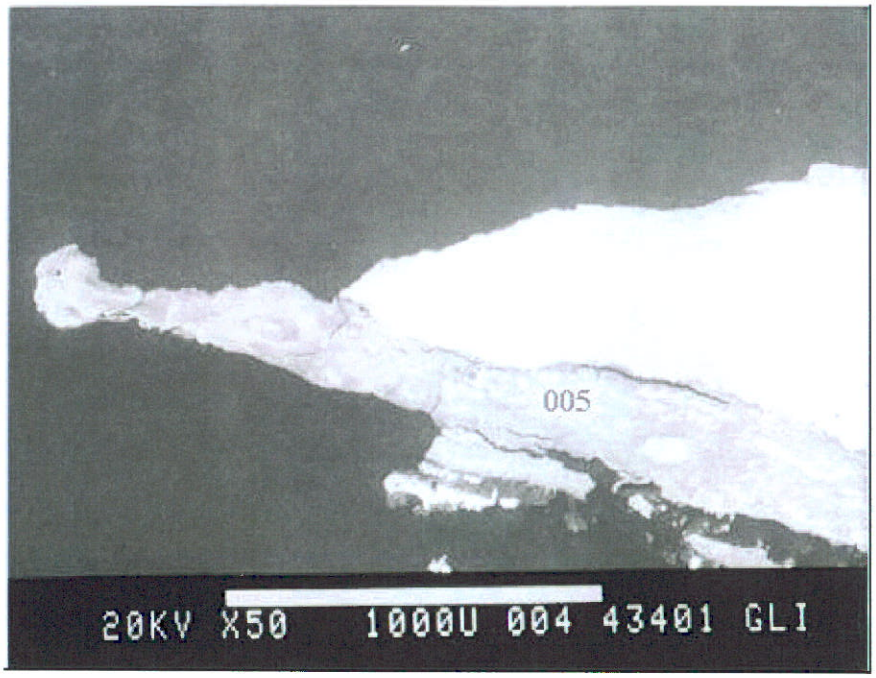


Figure 12. SEM photomicrograph 004 of Mount 10-4B showing the location of photomicrograph 005.

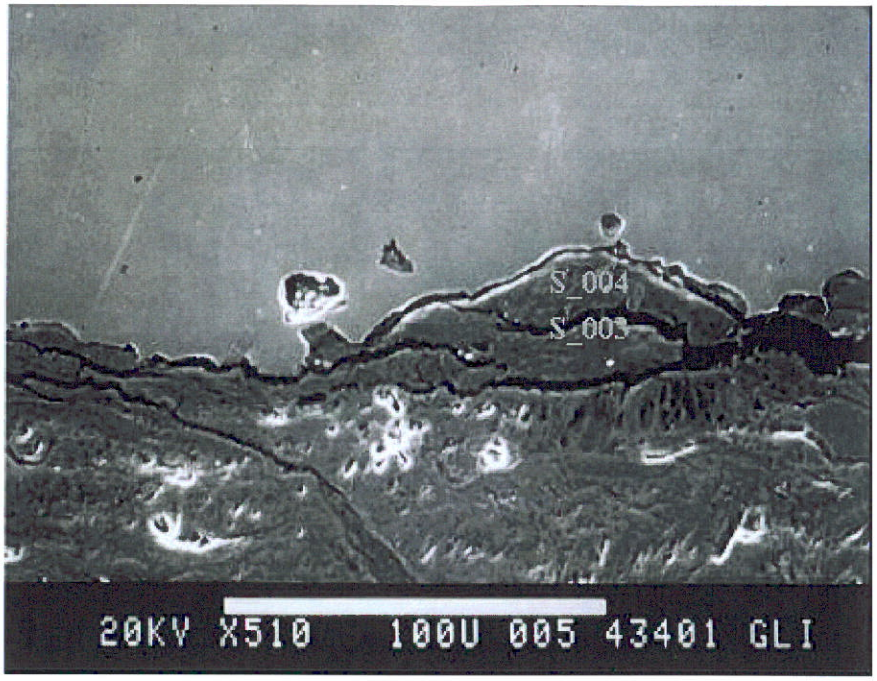


Figure 13. SEM photomicrograph 005 of Mount 10-4B showing the debris attached to the ID and the locations of EDS scans S-003 and S-004.

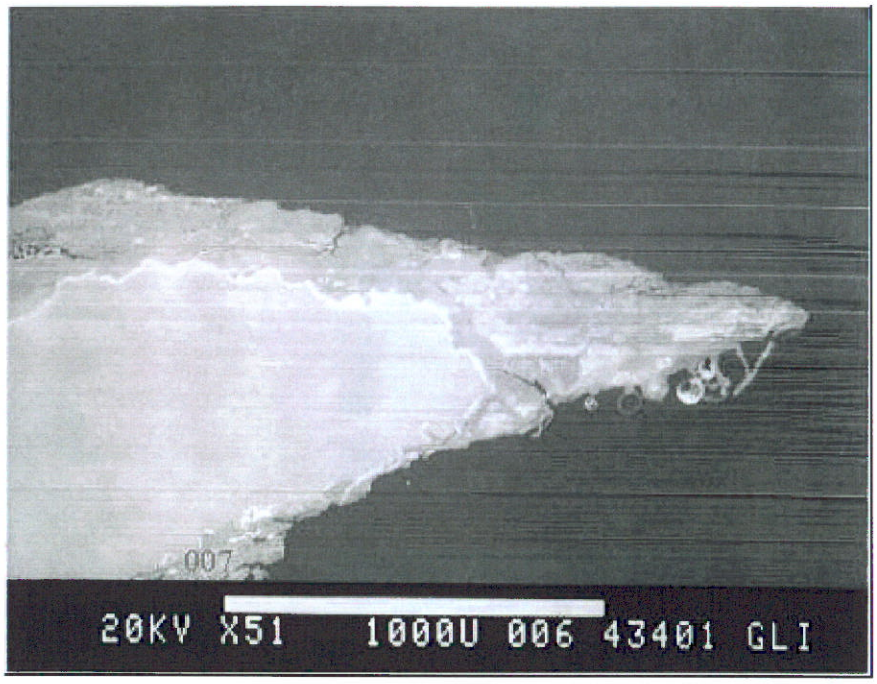


Figure 14. SEM photomicrograph 006 of Mount 10-4B showing the location of photomicrograph 007.

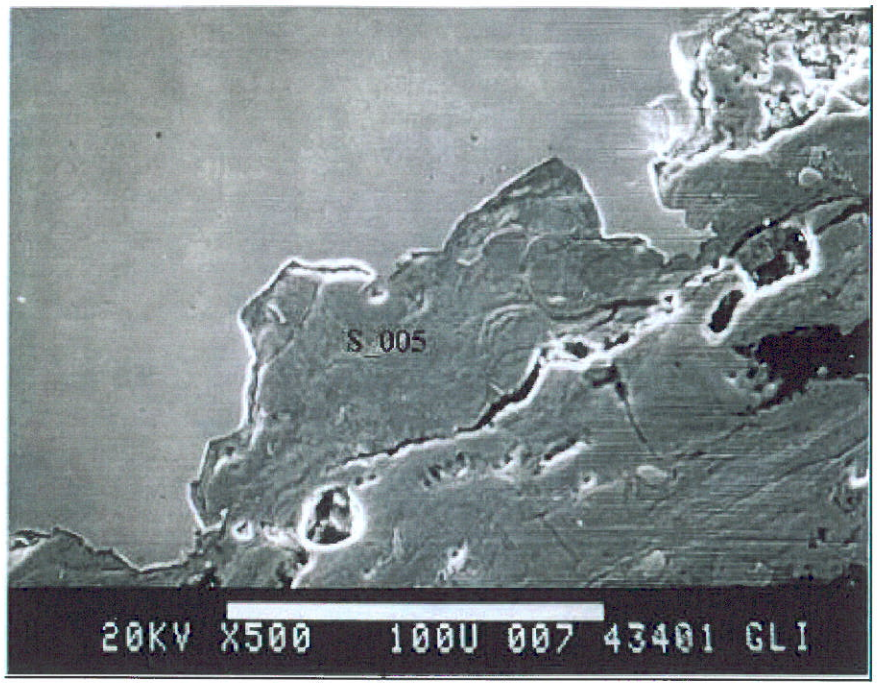


Figure 15. SEM photomicrograph 007 of Mount 10-4B showing the ID of the penetration and attached debris plus the location of the EDS scan S-005.

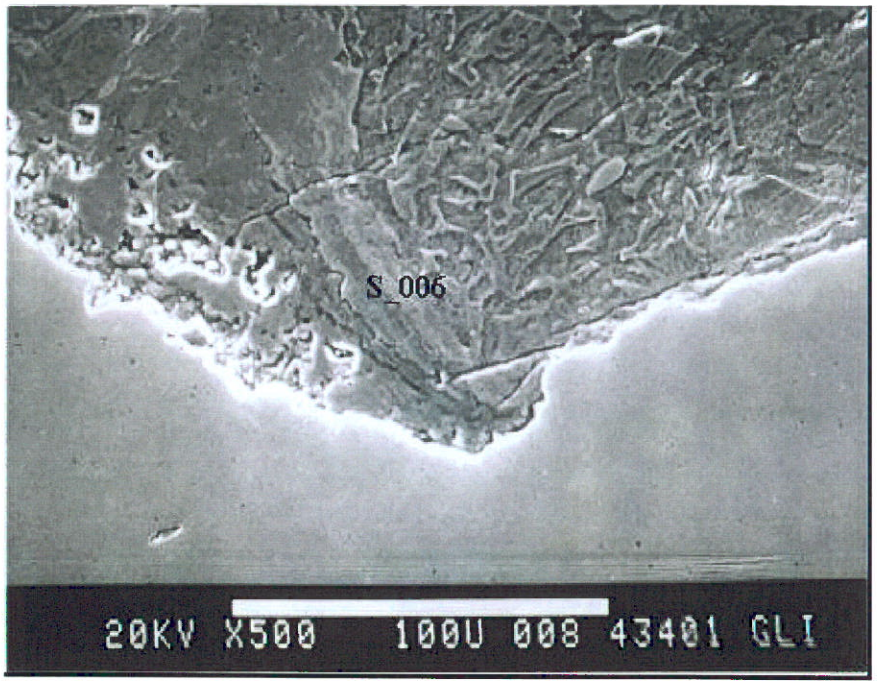


Figure 16. SEM photomicrograph 008 of Mount 10-4B showing attached debris and location of EDS scan S-006.

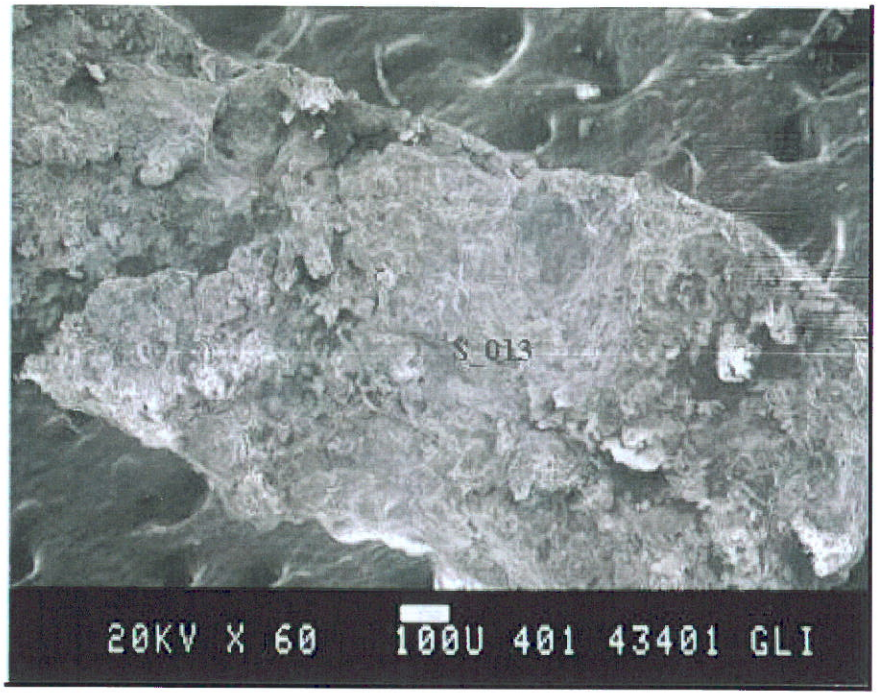


Figure 17. SEM photomicrograph 401 of Surface 10-4C showing the OD surface adjacent to Mount 10-4B and the location of the EDS scan S-013.

Figure 18. SEM photomicrograph 501 of 10-5B-2 showing the 0D surface.

APPENDIX K – EDS SPECTRA

Sample 01-B

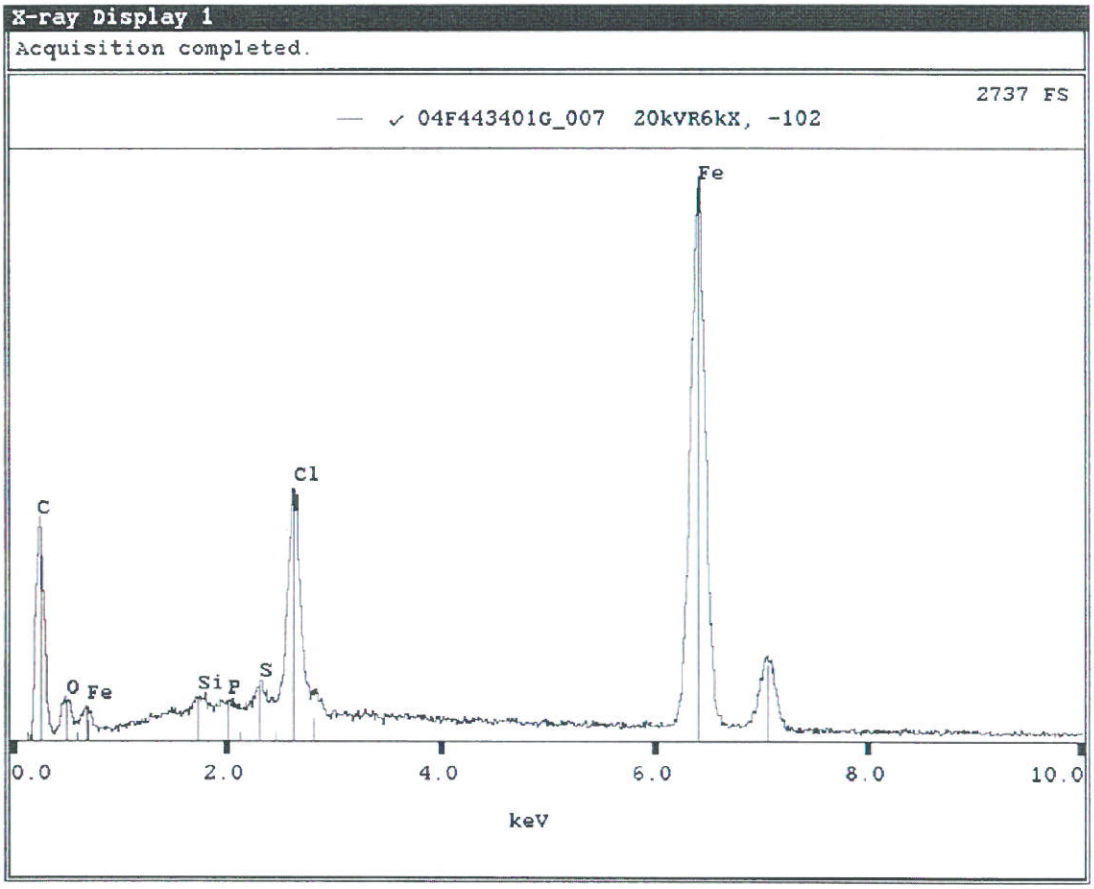


Figure 1. EDS spectra of Mount 1-B at spot S-007 in photomicrograph 102.

Sample 01-B

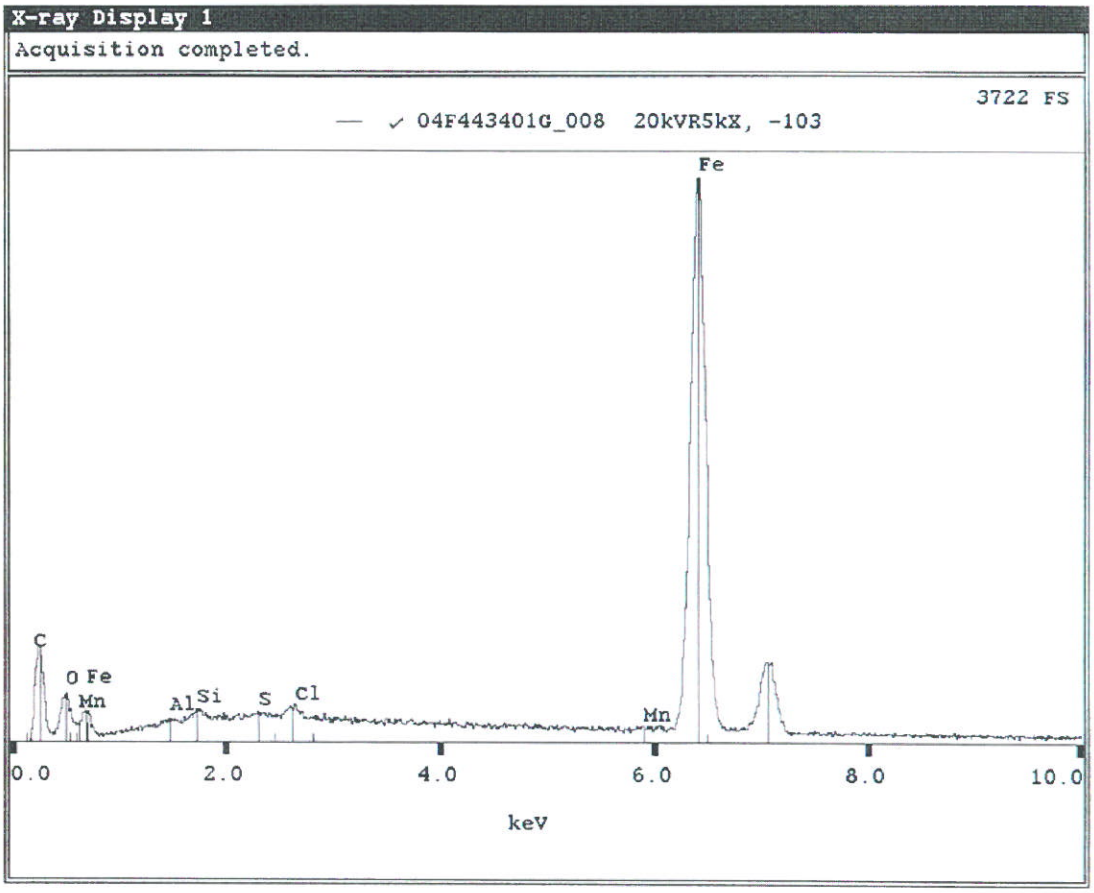


Figure 2. EDS spectra of Mount 1-B at spot S-008 in photomicrograph 103.

Sample 01-B

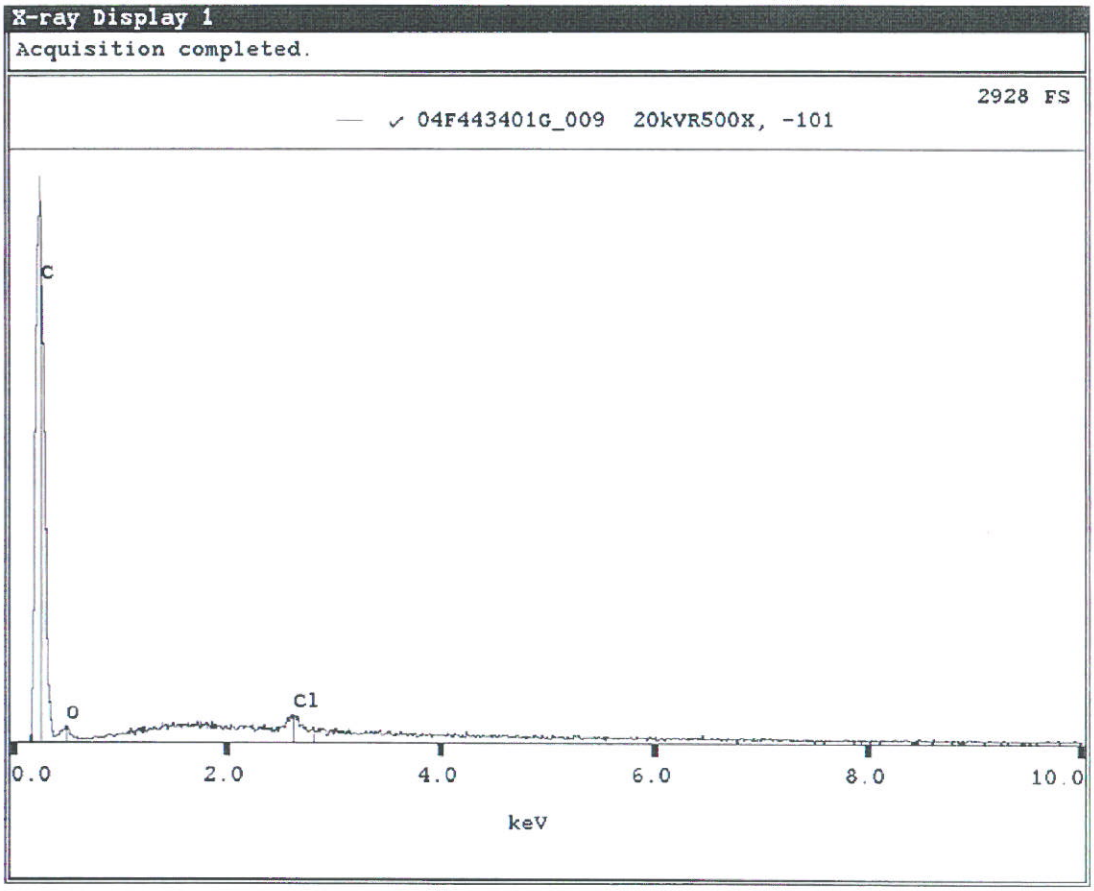


Figure 3. EDS spectra of Mount 1-B at spot S-009 in photomicrograph 101.

Sample 01-C R

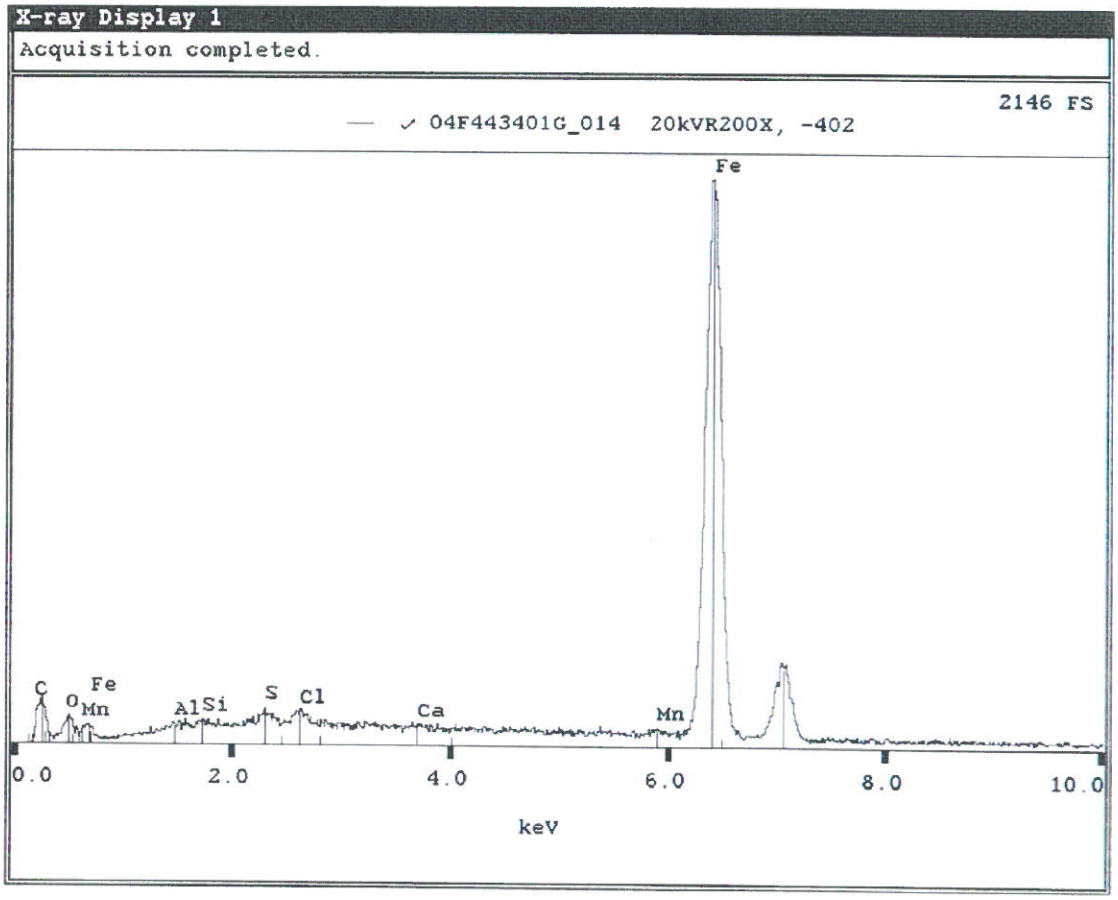


Figure 4. EDS spectra of Surface 01-C (right side) at spot S-014 in photomicrograph 402.

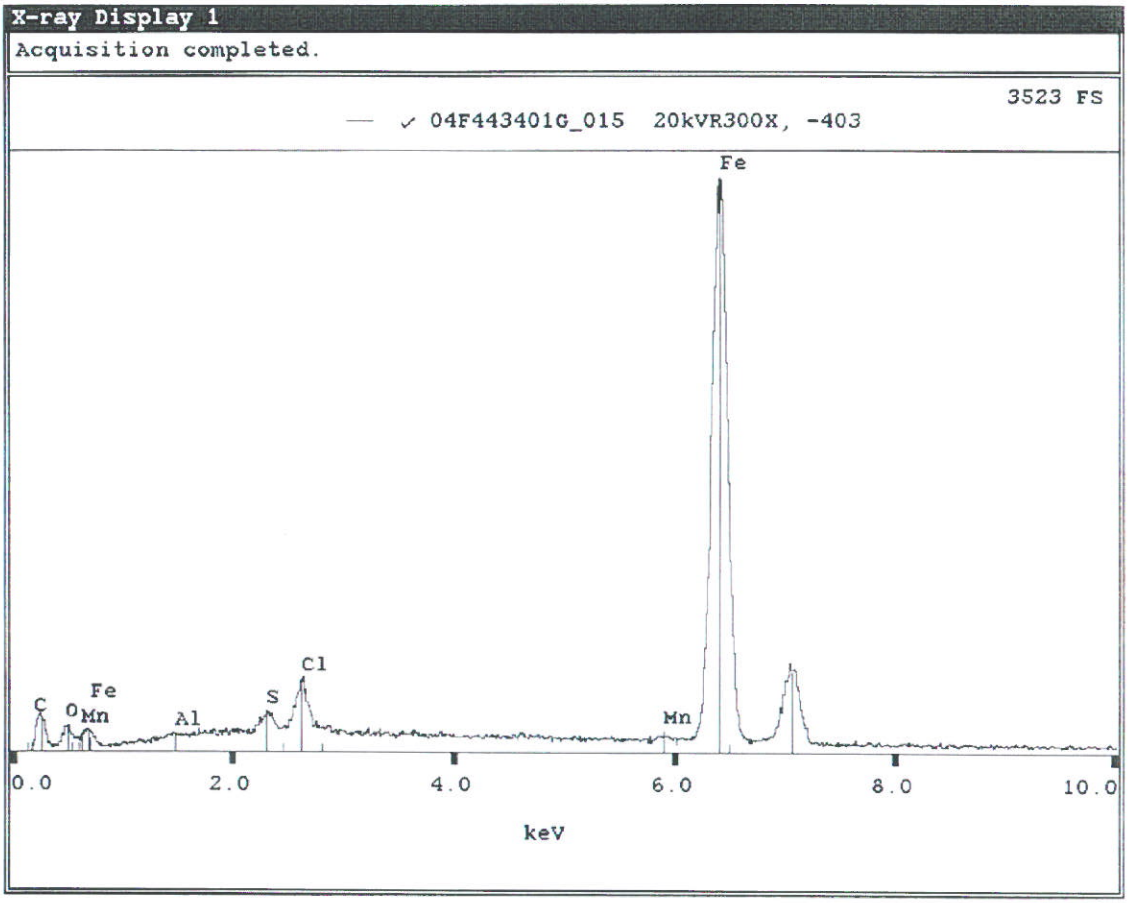


Figure 5. EDS spectra of Surface 01-C (left side) at spot S-015 in photomicrograph 403.

Sample 04-B

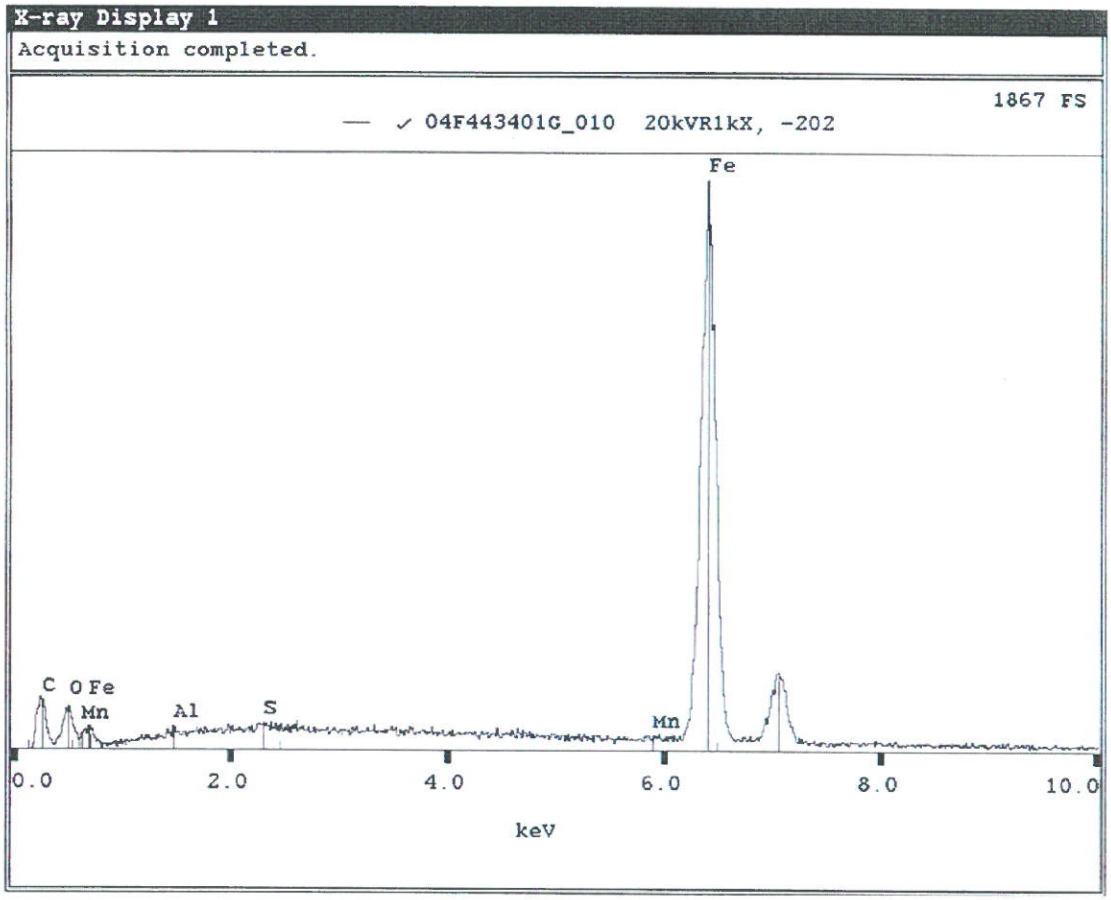


Figure 6. EDS spectra of Mount 4-B at spot S-010 in photomicrograph 202.

Sample 09-B

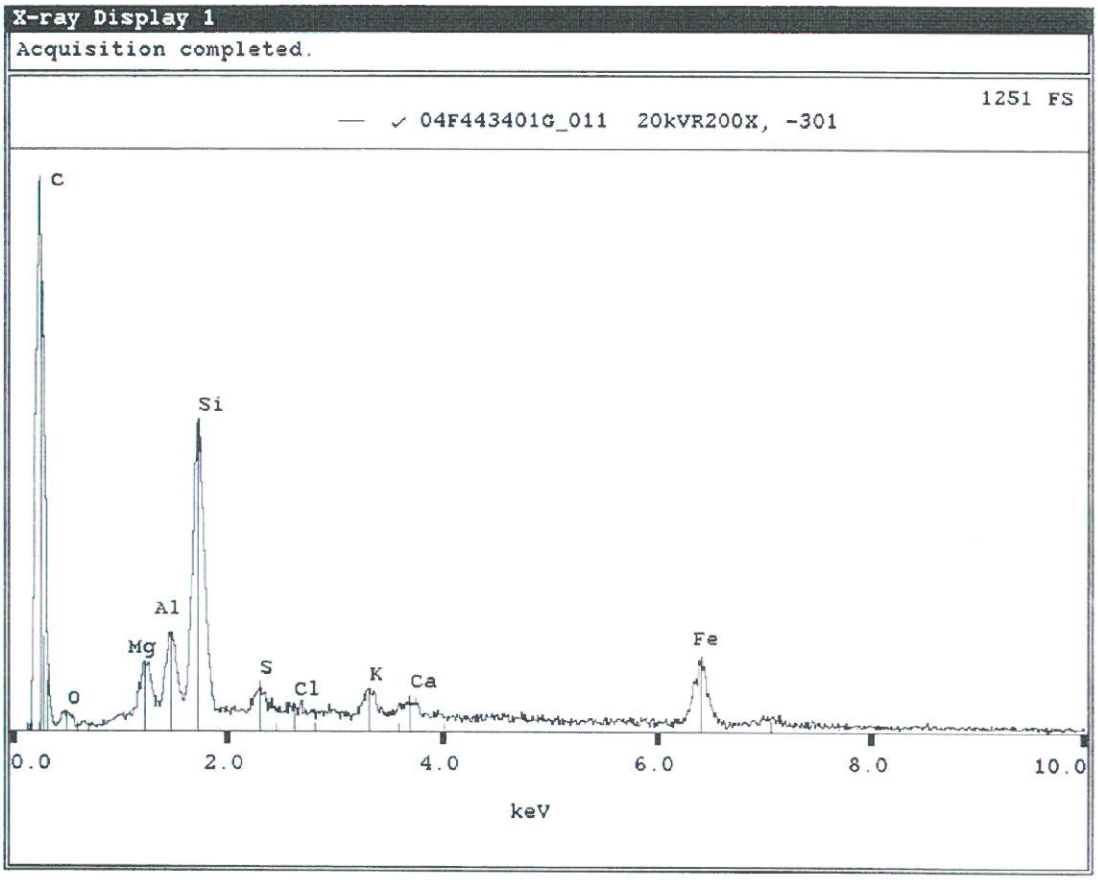


Figure 7. EDS spectra of Mount 9-B at spot S-011 in photomicrograph 301.

Sample 09-B

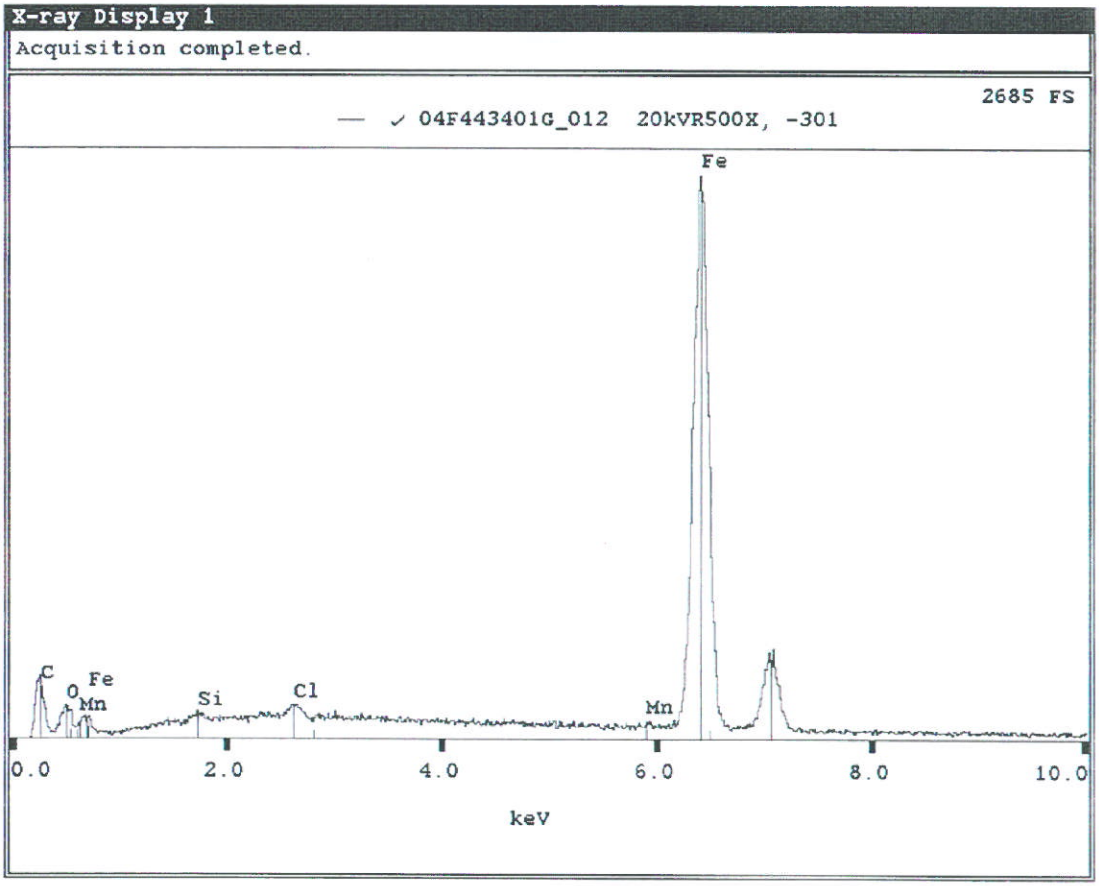


Figure 8. EDS spectra of Mount 9-B at spot S-012 in photomicrograph 301.

Scale Sample A 9, 29.5-in under product piercing

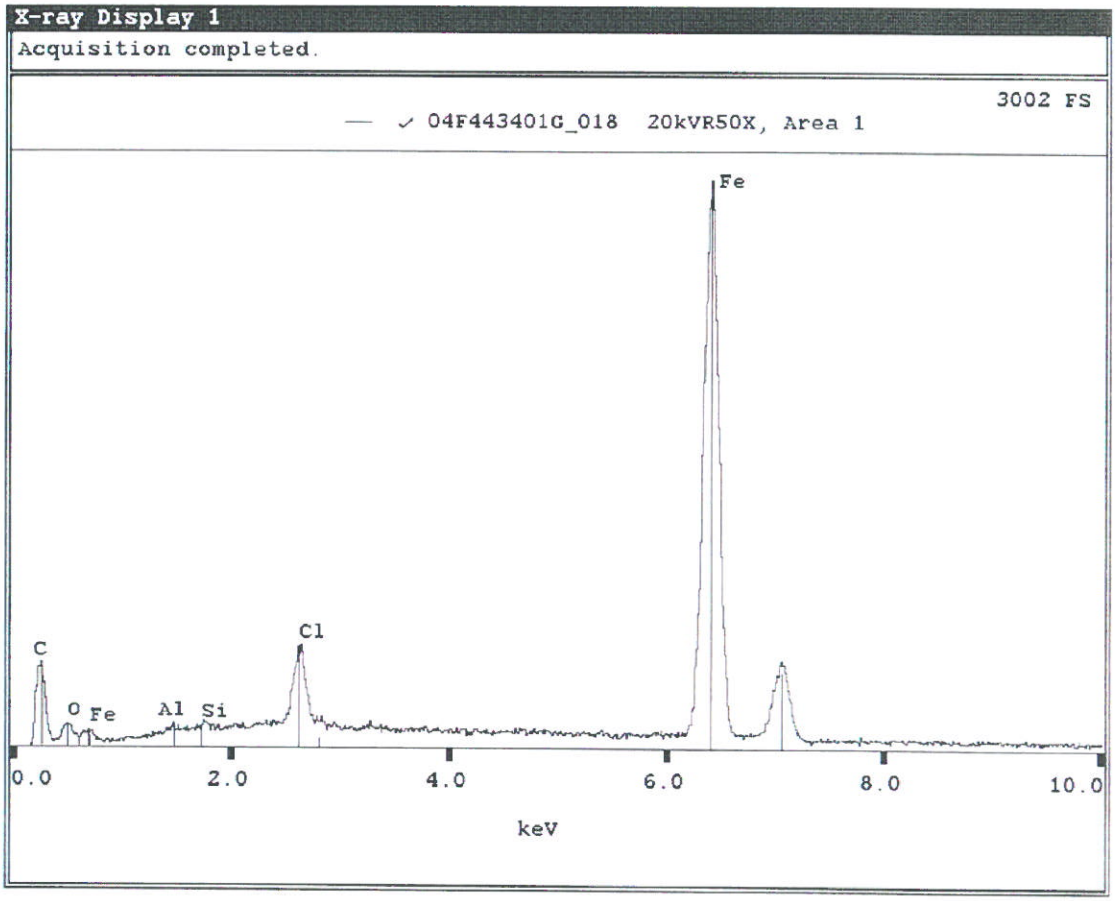


Figure 9. EDS spectra of scale product from underneath the coating piercing at the 29.5-inch location on Segment 9.

Scale Sample A 9, 29.5-in under product piercing

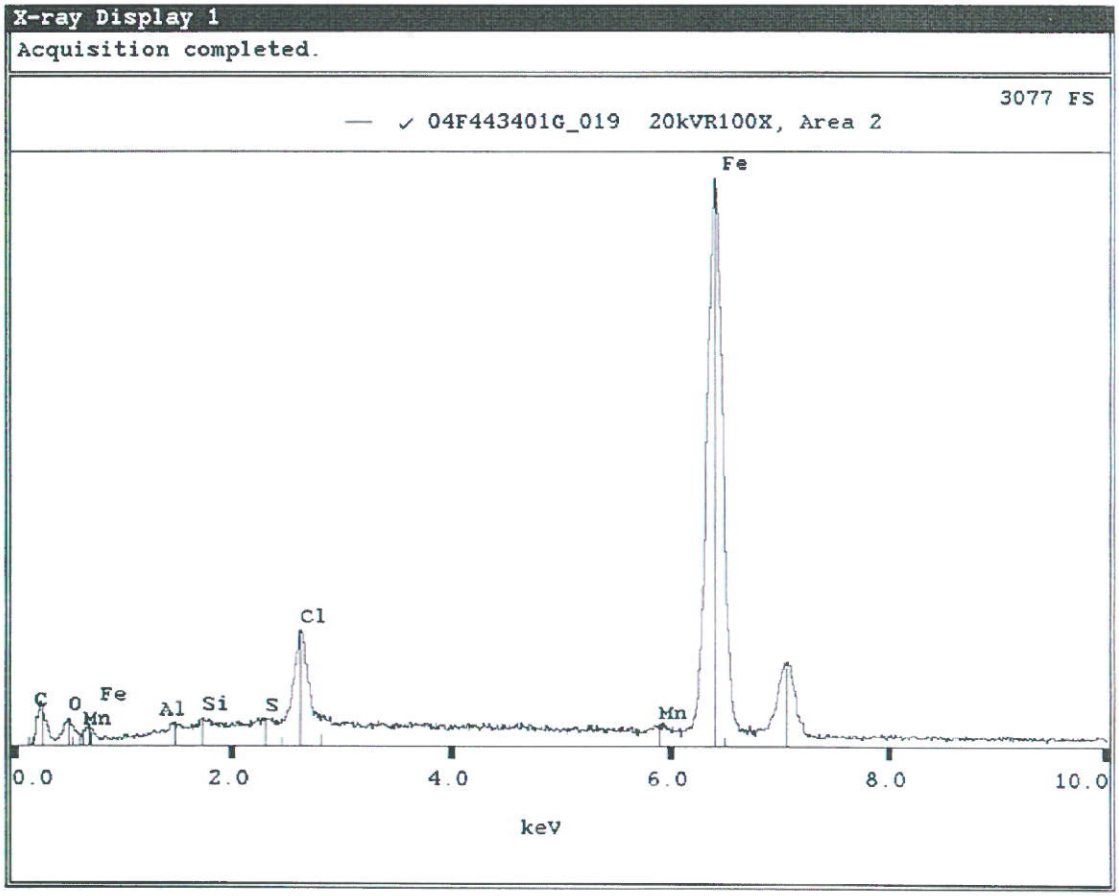


Figure 10. EDS spectra of scale product from underneath the coating piercing at the 29.5-inch location on Segment 9.

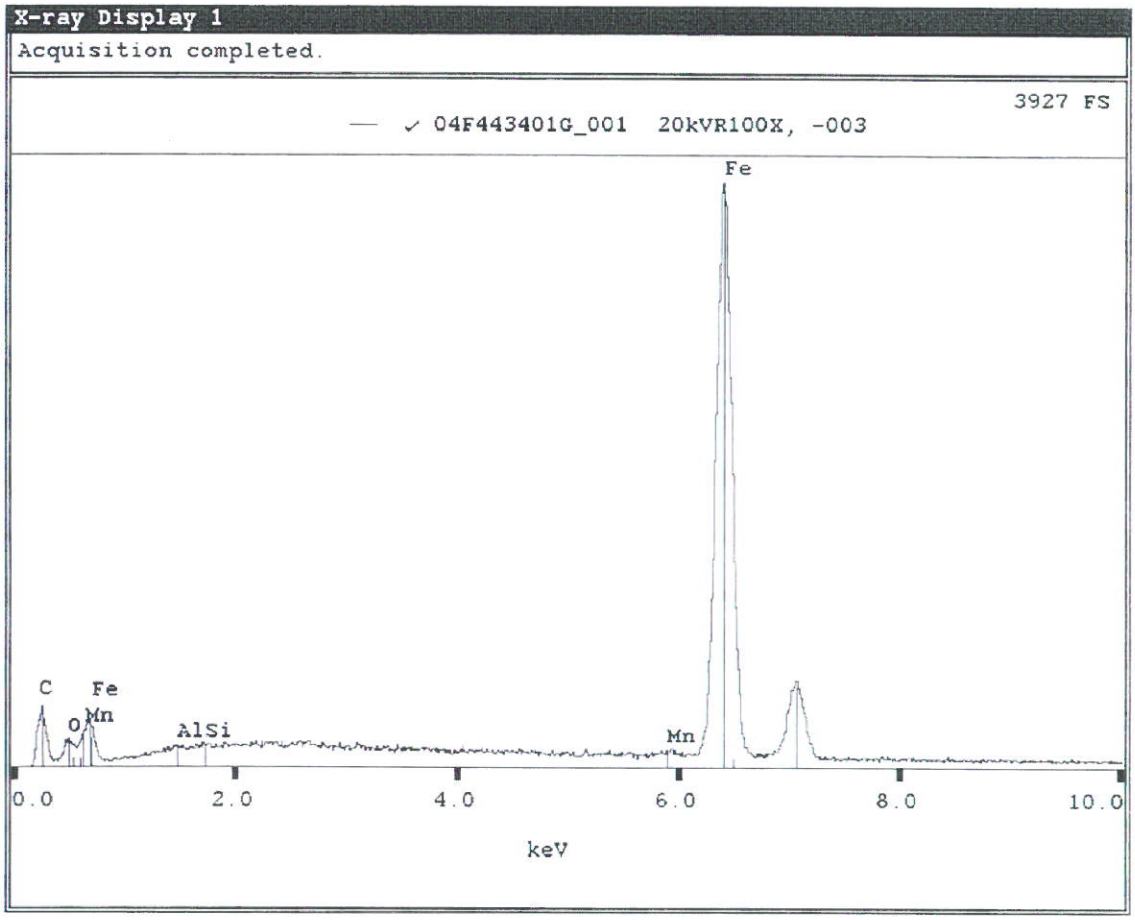


Figure 11. EDS spectra of Mount 10-4B at spot S-001 in photomicrograph 003.

Sample 10-4B

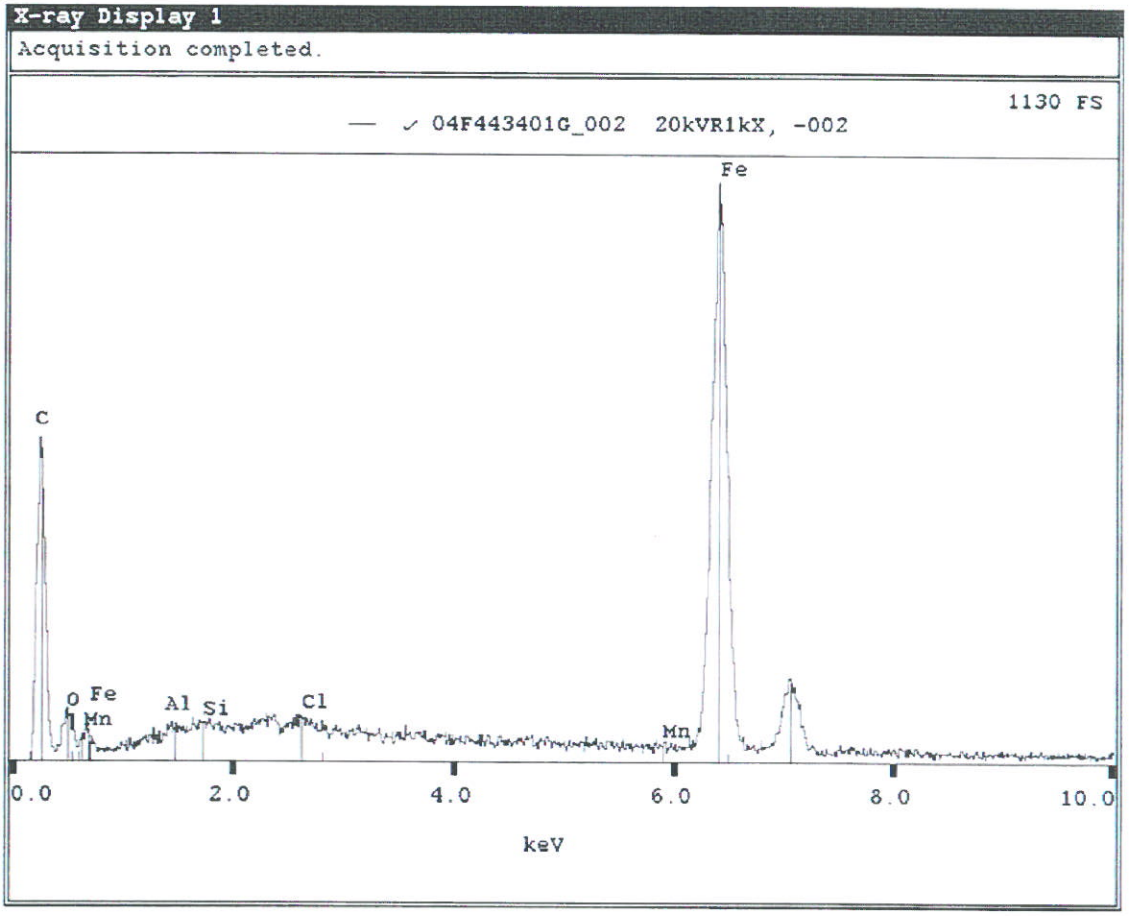


Figure 12. EDS spectra of Mount 10-4B at spot S-002 in photomicrograph 002.

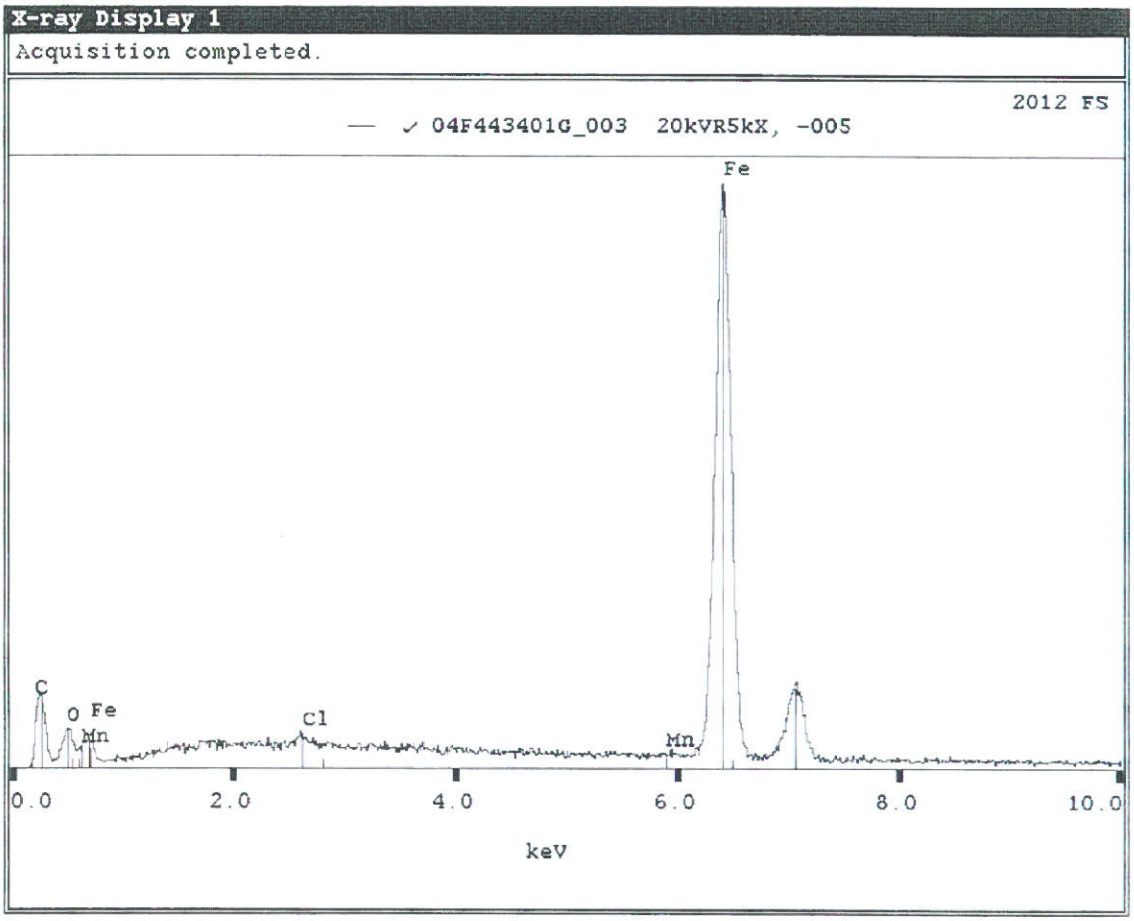


Figure 13. EDS spectra of Mount 10-4B at spot S-003 in photomicrograph 005.

Sample 10-4B

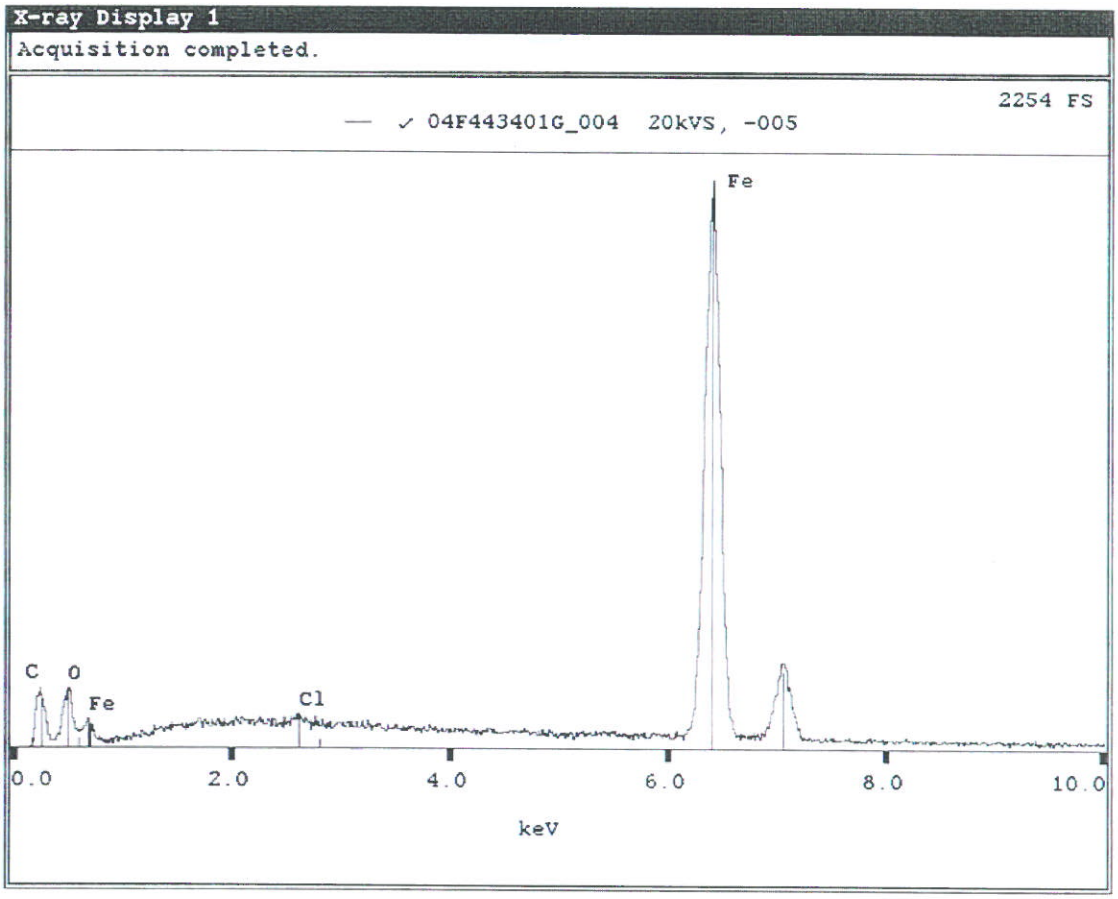


Figure 14. EDS spectra of Mount 10-4B at spot S-004 in photomicrograph 005.

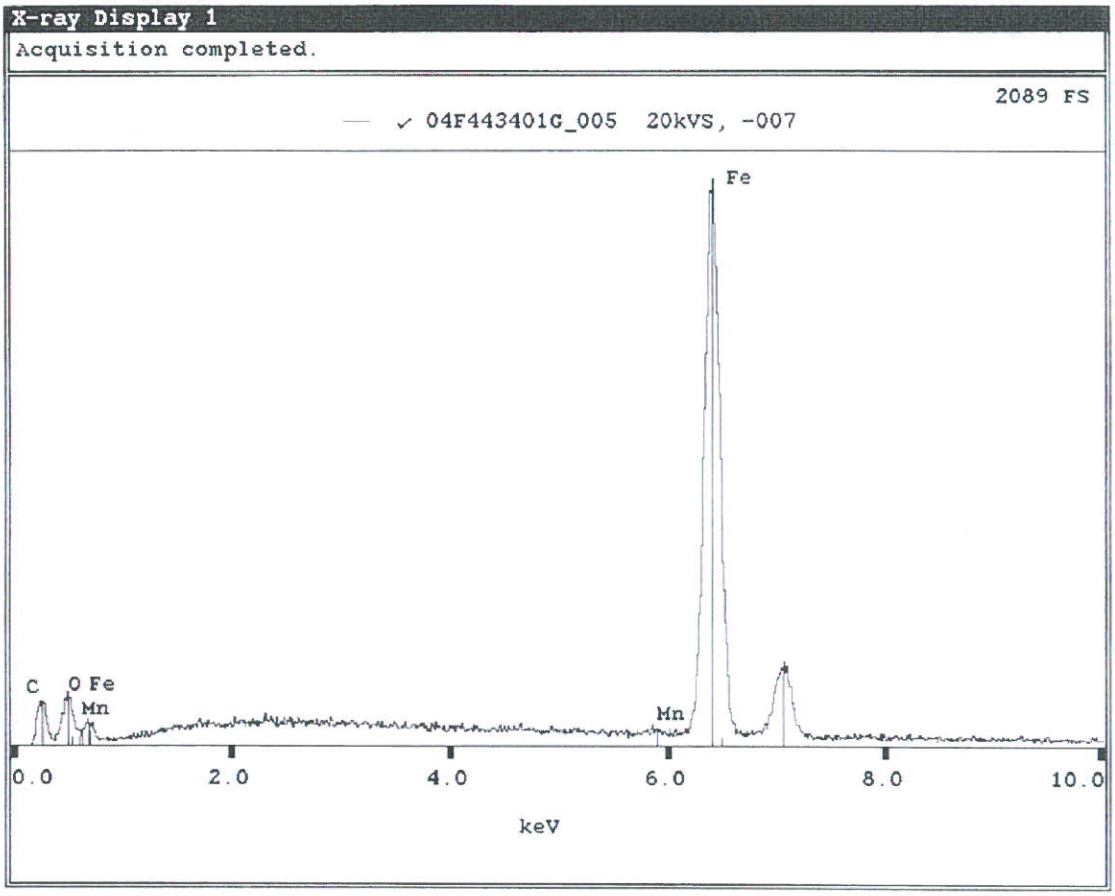


Figure 15. EDS spectra of Mount 10-4B at spot S-005 in photomicrograph 007.

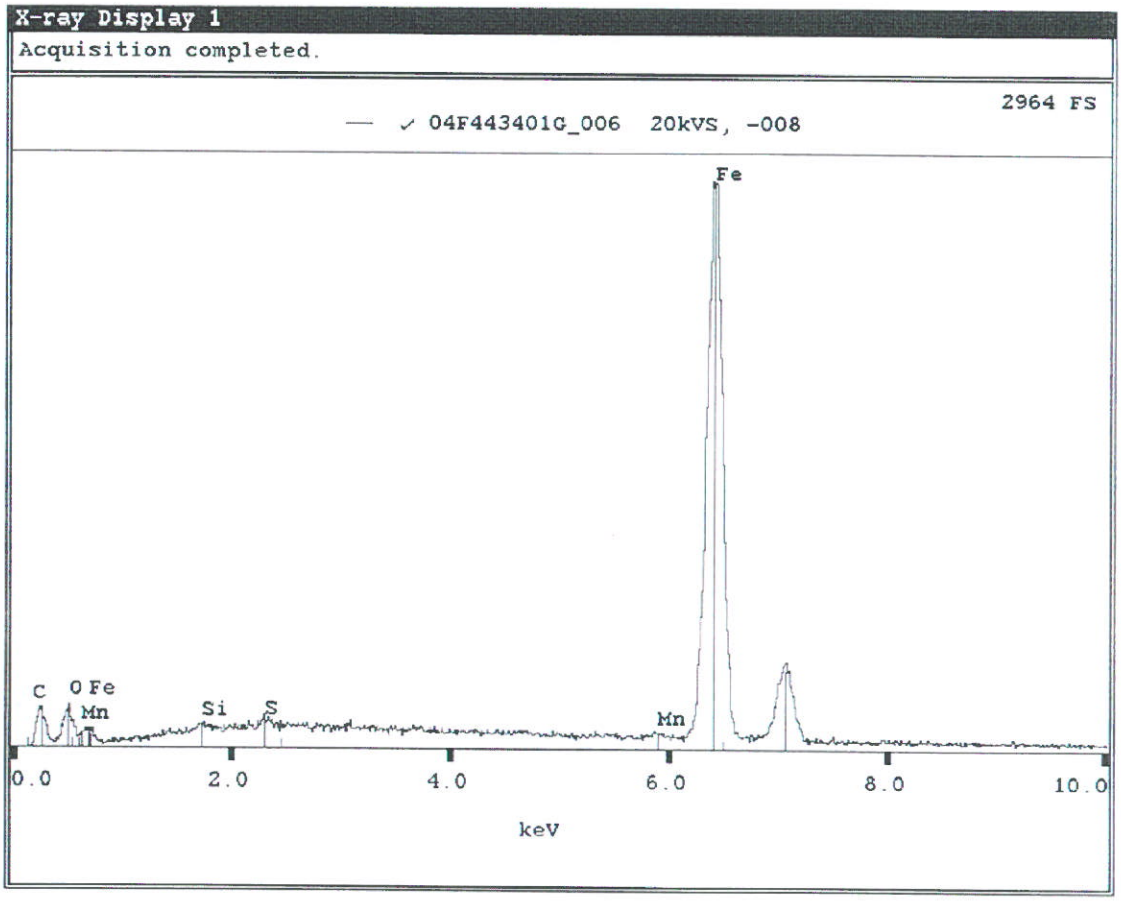


Figure 16. EDS spectra of Mount 10-4B at spot S-006 in photomicrograph 008.

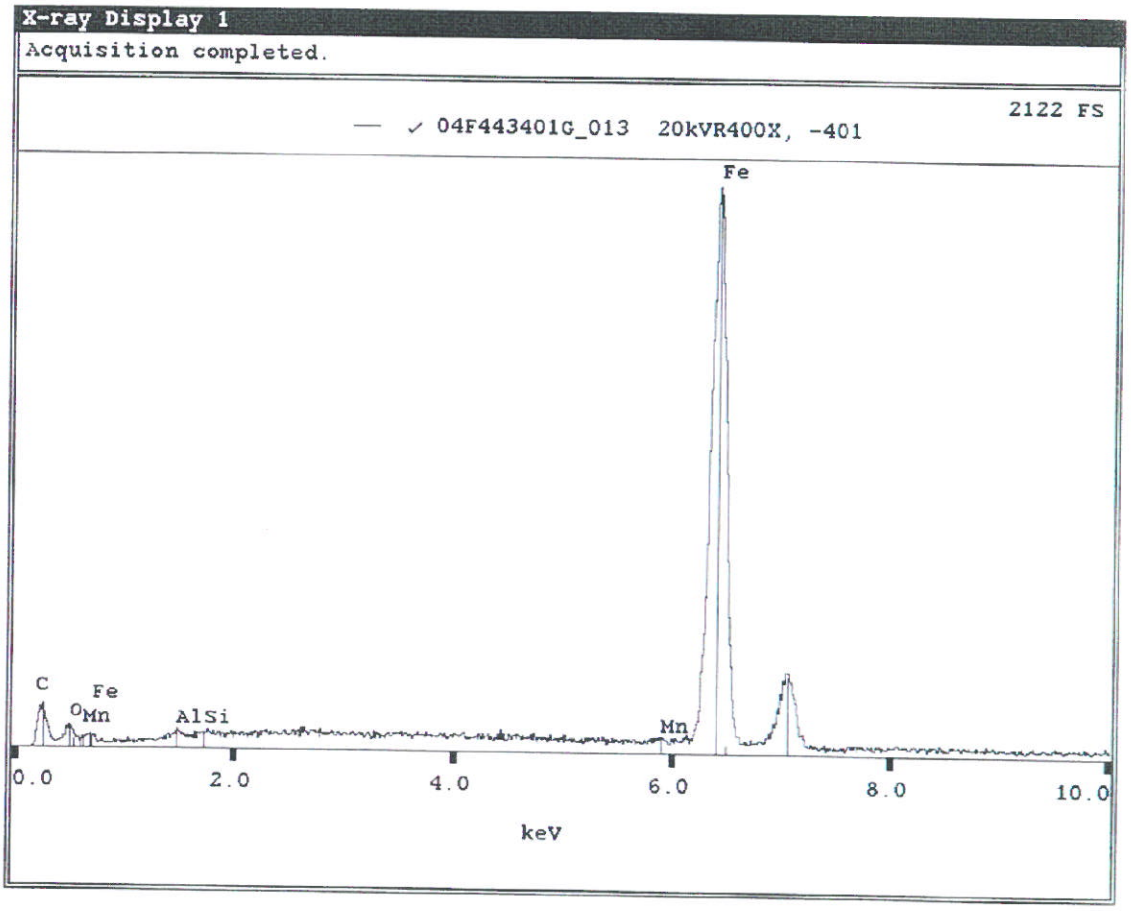


Figure 17. EDS spectra of Surface 10-4C at spot S-013 in photomicrograph 401.

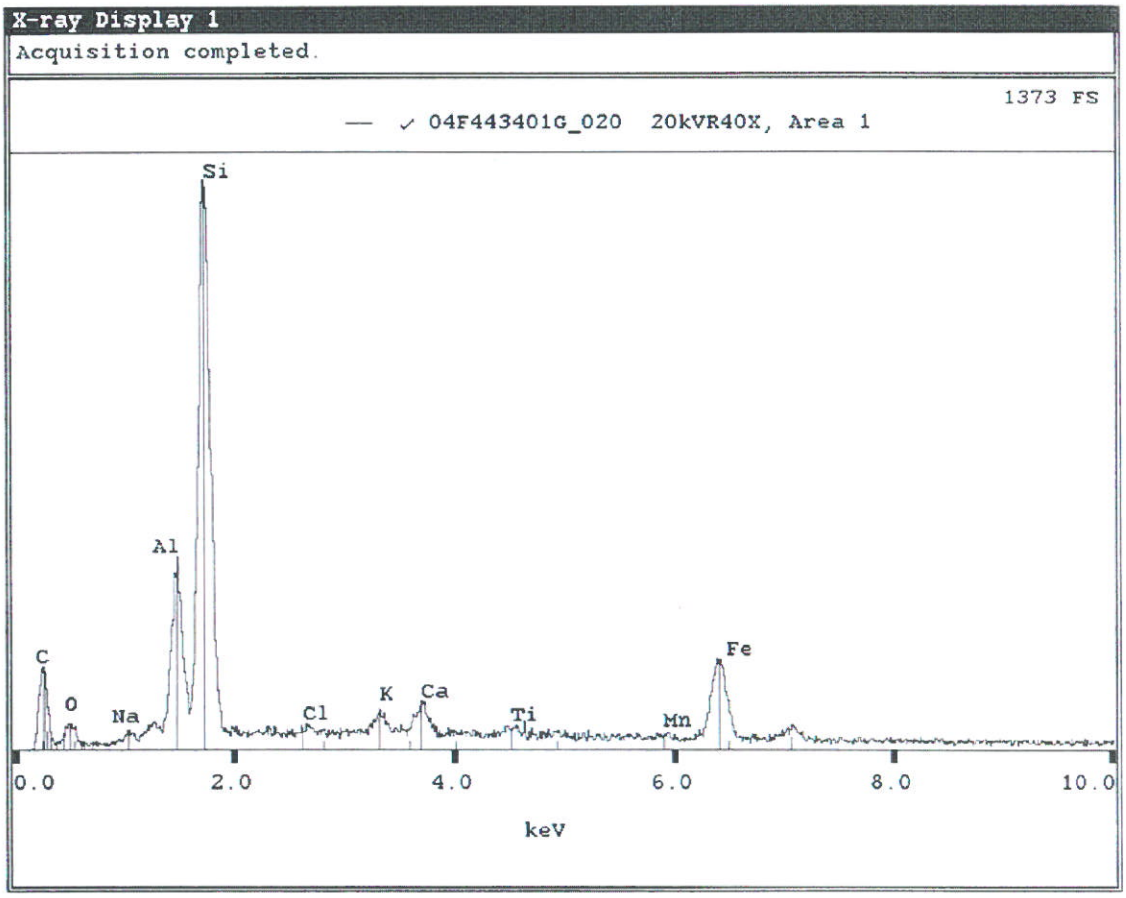


Figure 18. EDS spectra of soil under bottle covering leak area in Segment 10.

Scale Sample B 10, Soil under bottle

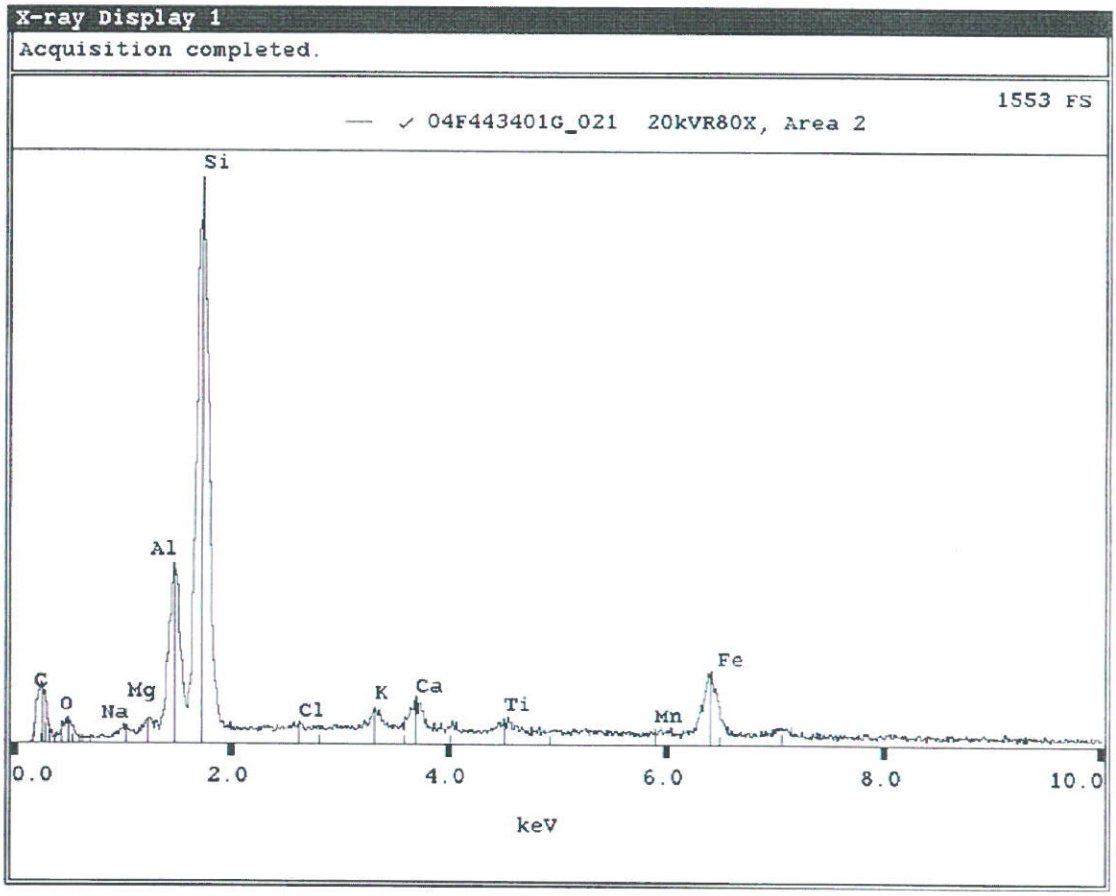


Figure 19. EDS spectra of soil under bottle covering leak area in Segment 10.

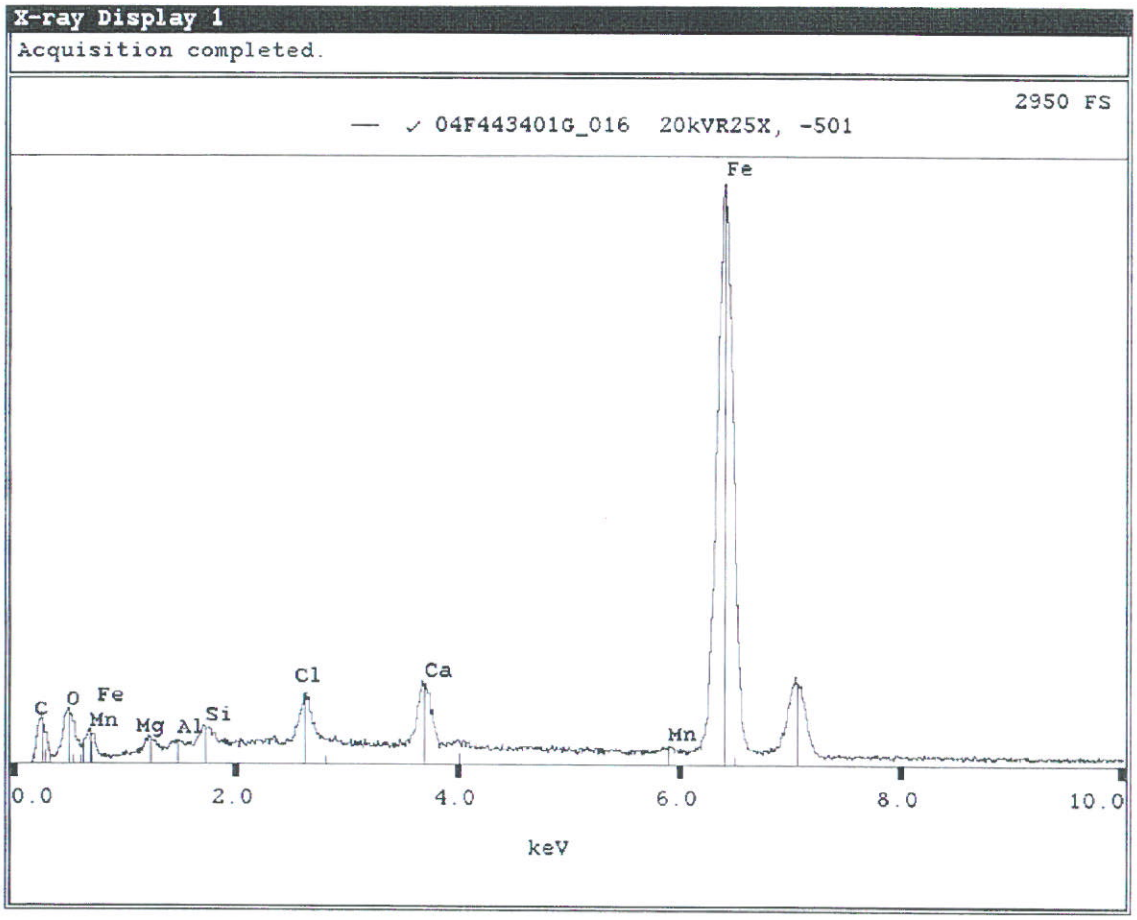


Figure 20. EDS spectra of Surface 10-5B-2 at spot S-016 in photomicrograph 501.

Sample 10-5B-2

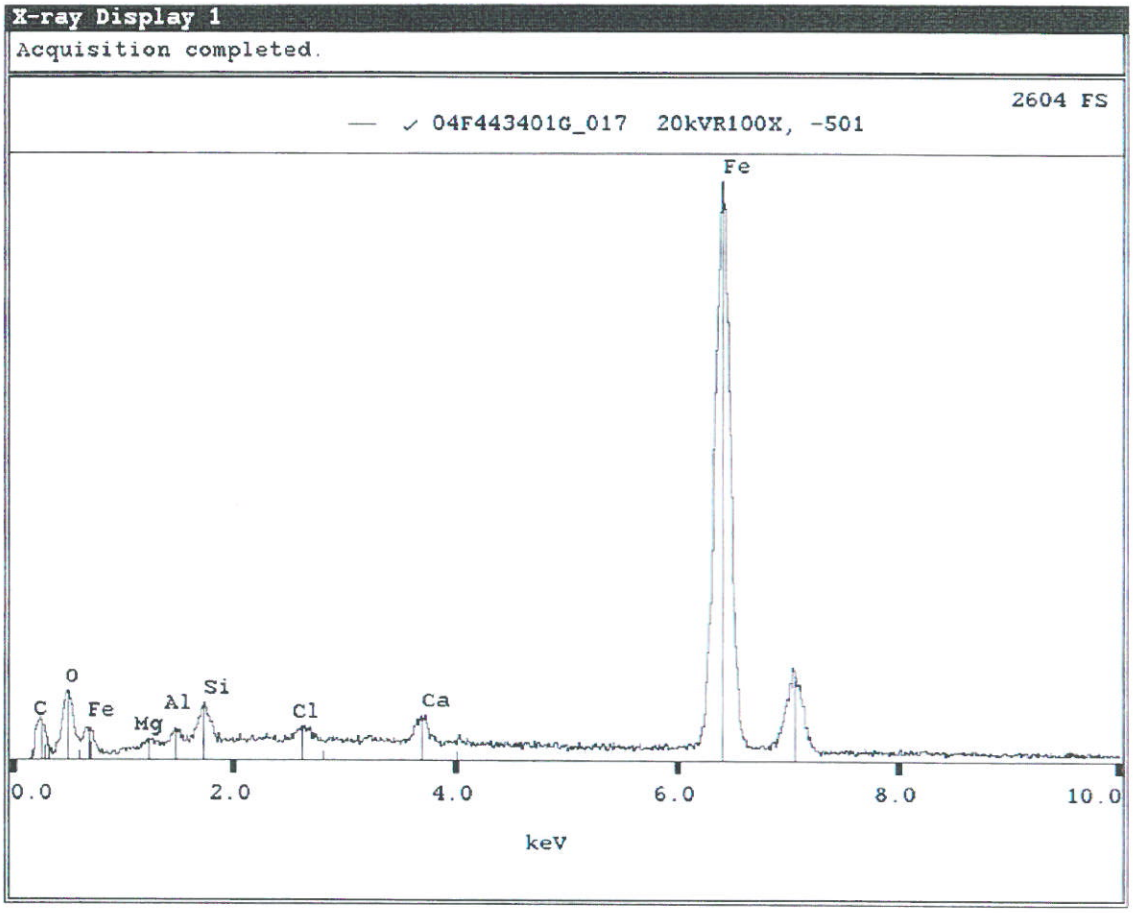


Figure 21. EDS spectra of Surface 10-5B-2 at spot S-017 in photomicrograph 501.

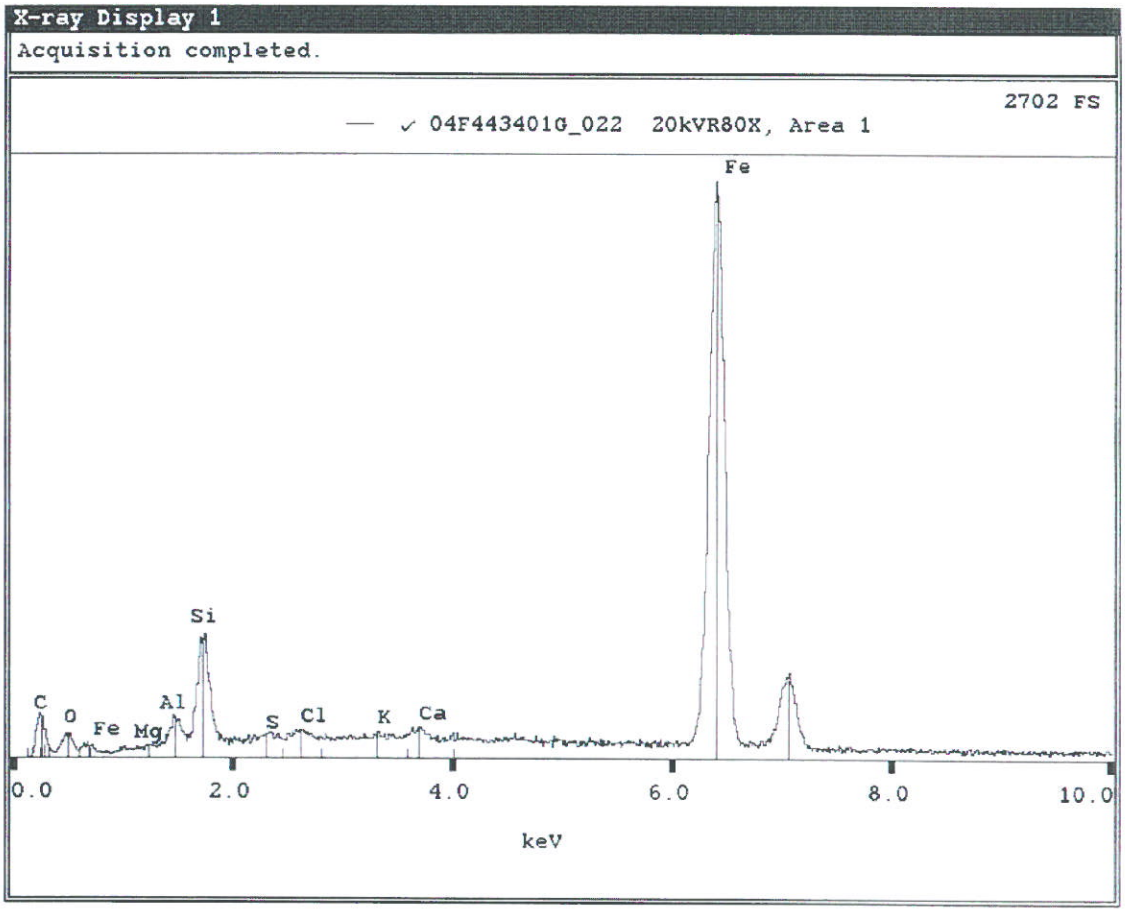


Figure 22. EDS spectra of the OD surface of a nodule from the extrados of the bend in Segment 10.

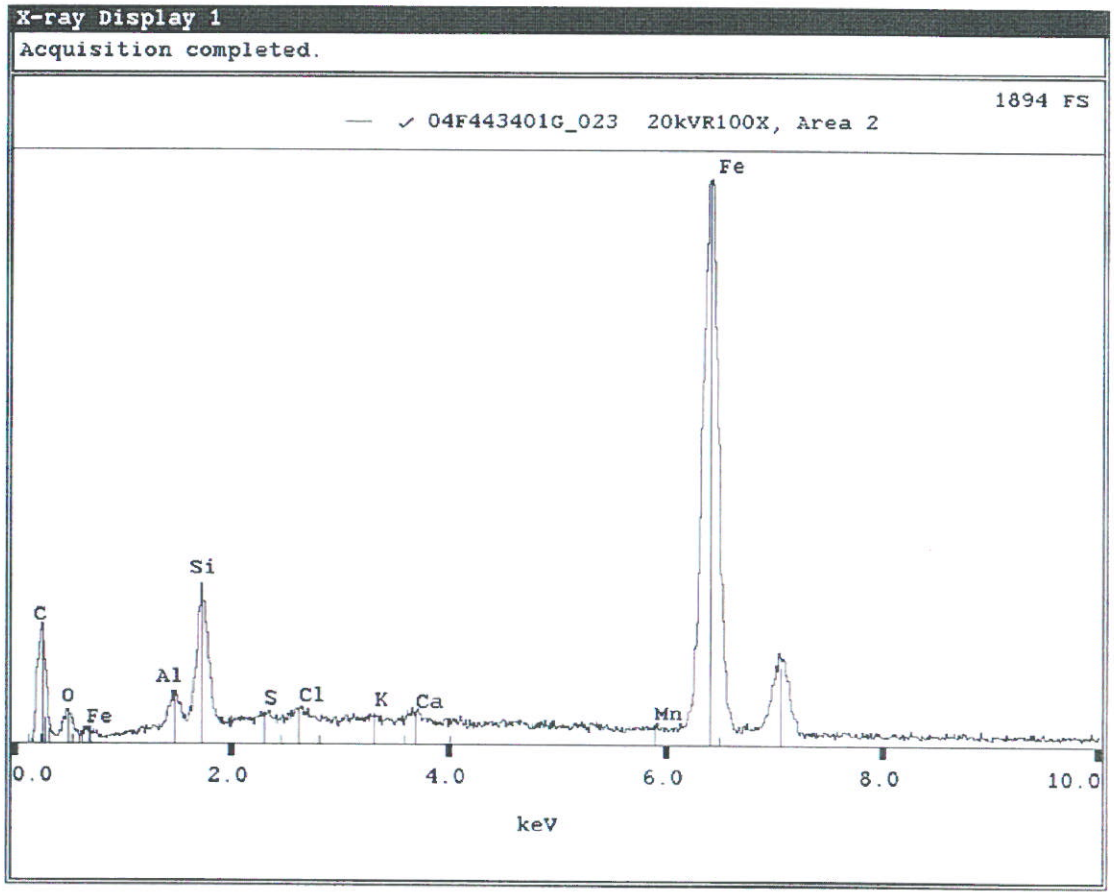


Figure 23. EDS spectra of the OD surface of a nodule from the extrados of the bend in Segment 10.

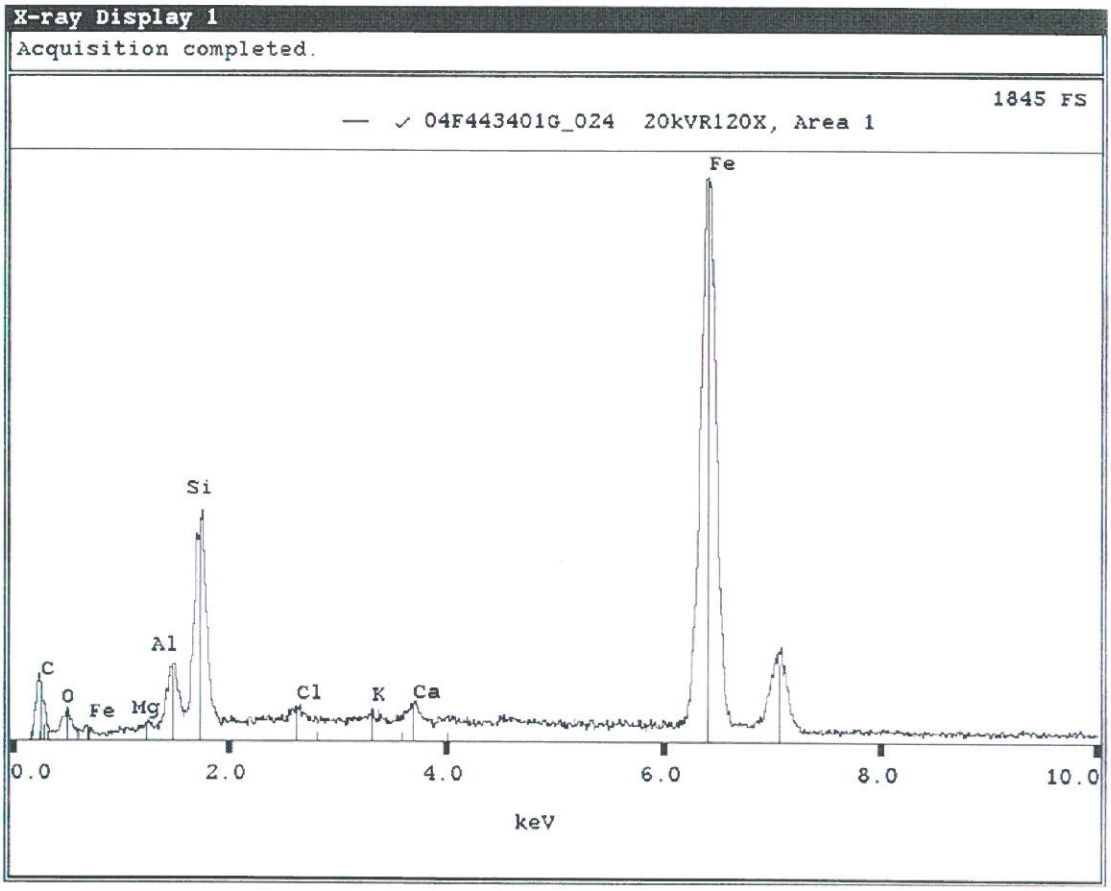


Figure 24. EDS spectra of the ID surface of a nodule from the extrados of the bend in Segment 10.

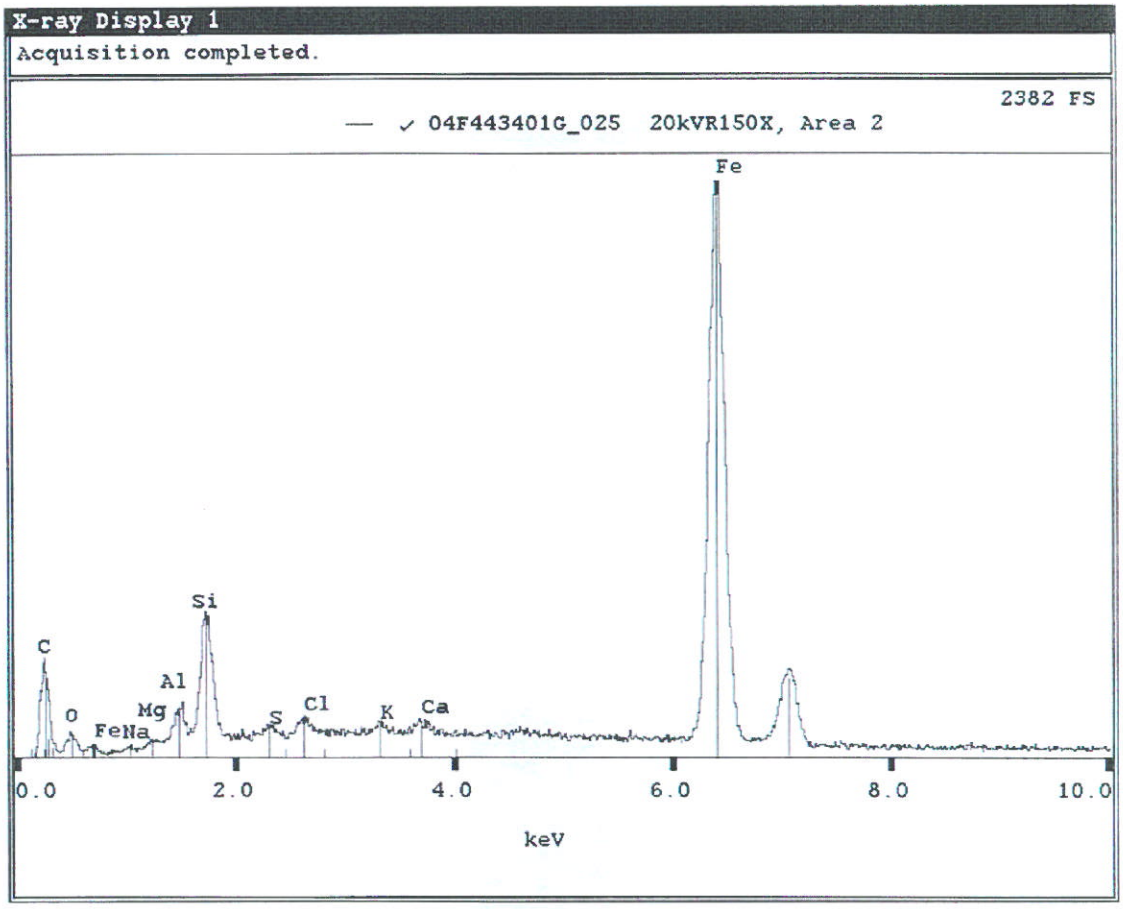


Figure 25. EDS scan of the ID surface of a nodule from the extrados of the bend in Segment 10.

APPENDIX L – UT AND CORROSION PROFILE MEASUREMENTS

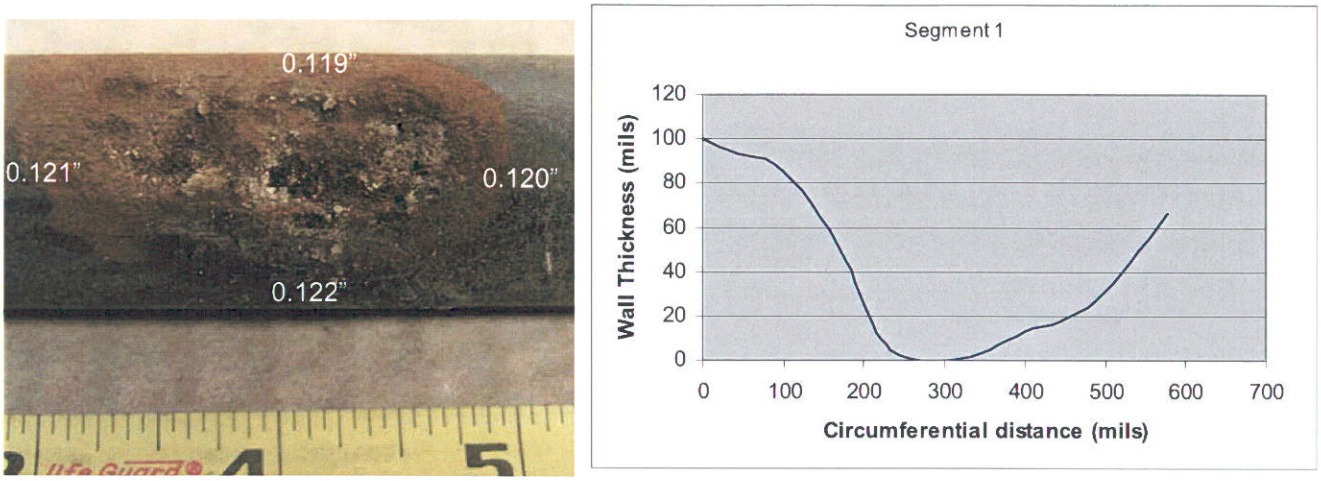


Figure 1. Circumferential profile of the anomaly at the 4-inch location of Segment 1.

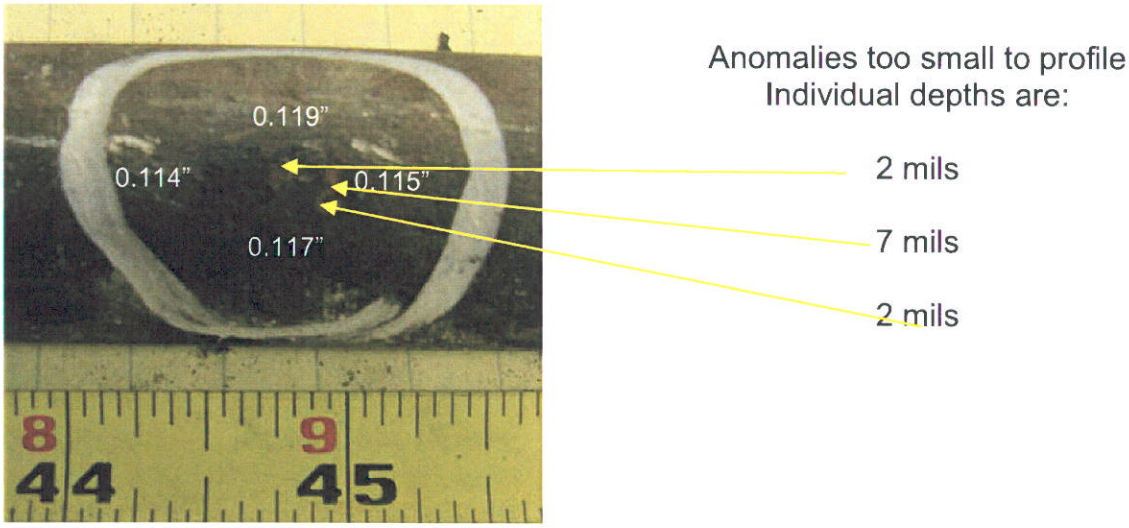
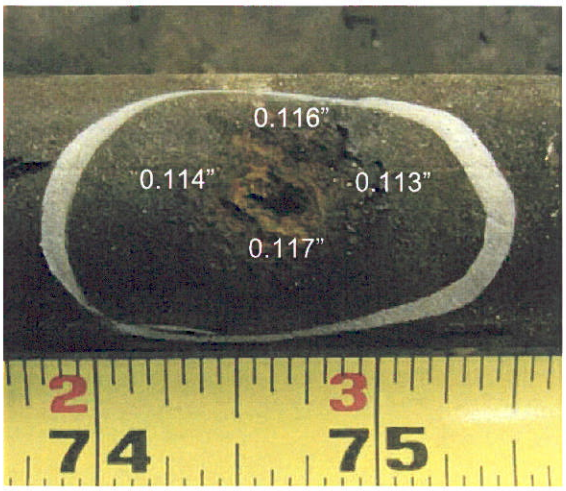


Figure 2. Circumferential profile of three small anomalies at the 45-inch location of Segment 2.



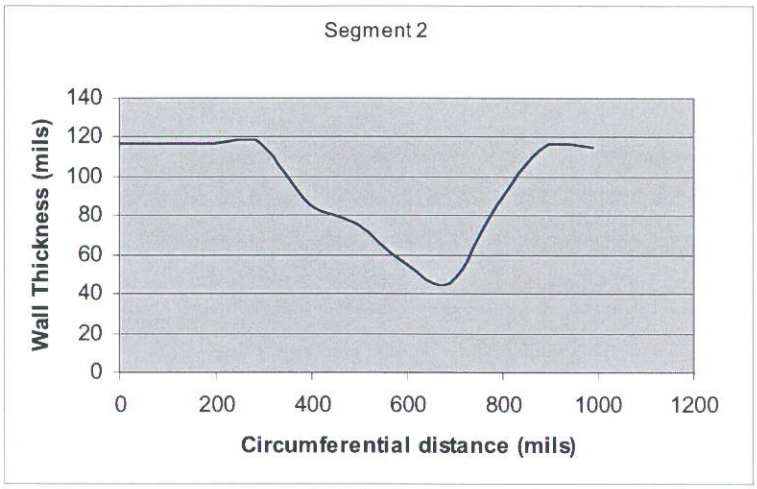


Figure 3. Circumferential profile of the anomaly at the 74.75-inch location of Segment 2.

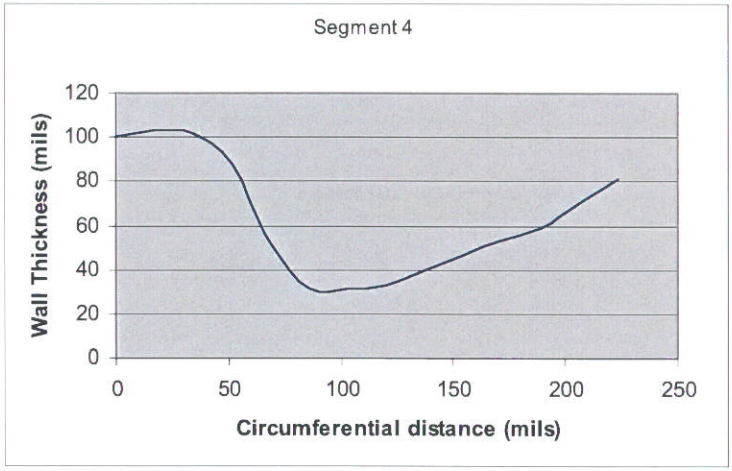
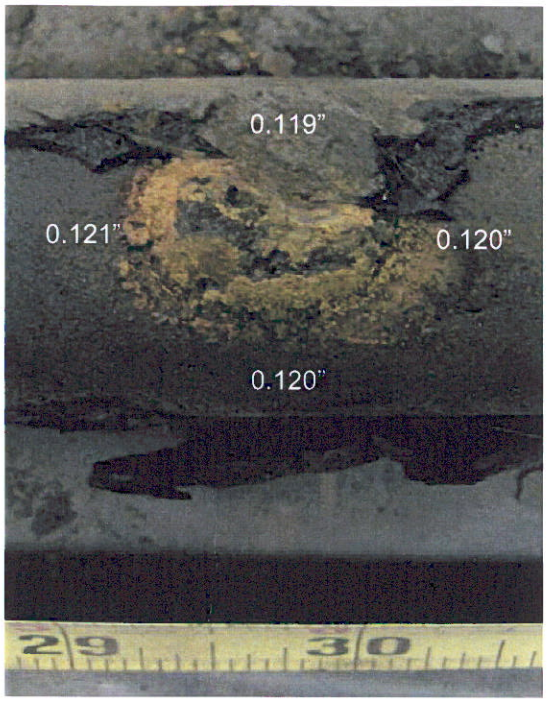


Figure 4. Circumferential profile of the anomaly at the 49.75-inch location of Segment 4.



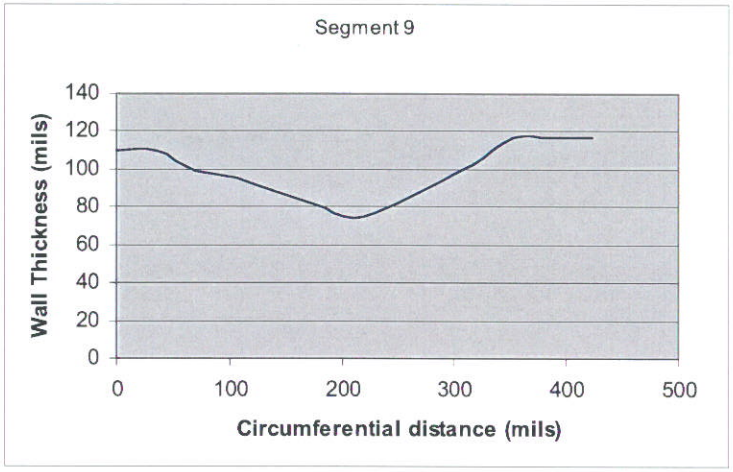


Figure 5. Circumferential profile of the anomaly at the 29.5-inch location of Segment 9.

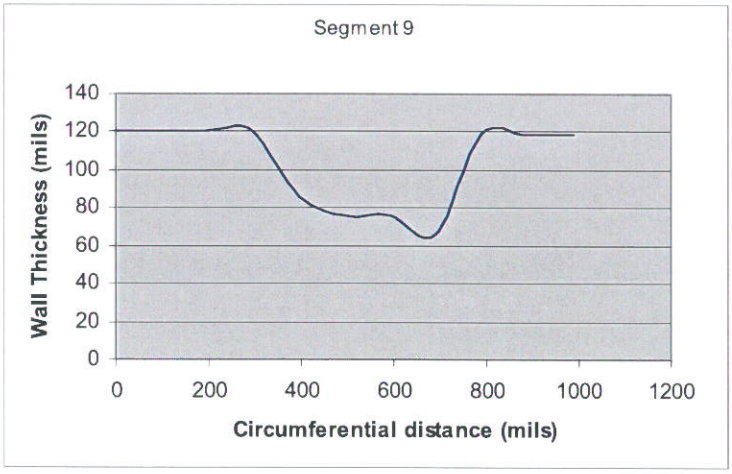


Figure 6. Circumferential profile of the anomaly at the 36-inch location of Segment 9.

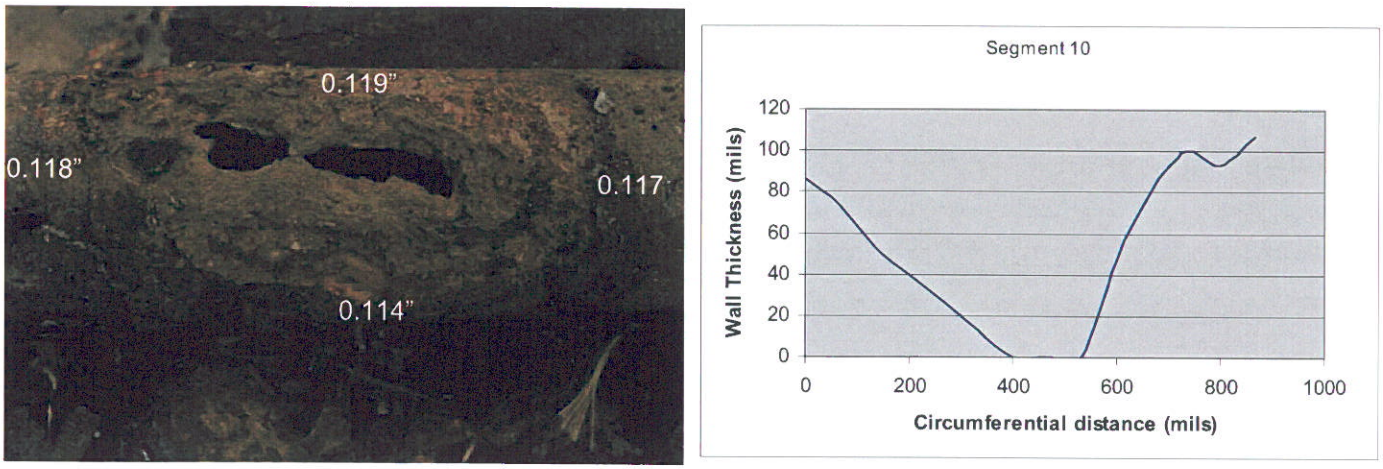


Figure 7. Circumferential profile of the through wall penetration at the 49-inch location of Segment 10.