BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking on the Commission's Own Motion to Adopt New Safety and Reliability Regulations for Natural Gas Transmission and Distribution Pipelines and Related Ratemaking Mechanisms	R.11-02-019 (Filed February 24, 2011)

DECLARATION OF SUMEET SINGH SUPPLEMENTING THE VERIFIED STATEMENT OF PACIFIC GAS AND ELECTRIC COMPANY'S VICE PRESIDENT OF GAS TRANSMISSION MAINTENANCE AND CONSTRUCTION IN RESPONSE TO RULING OF ASSIGNED COMMISSIONER AND ASSIGNED ADMINISTRATIVE LAW JUDGE

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PACIFIC GAS AND ELECTRIC COMPANY

Dated: October 18, 2013

BEFORE THE PUBLIC UTILITIES COMMISSION
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I, SUMEET SINGH, do declare:

1. I am the Senior Director of Integrity Management in Gas Operations for Pacific Gas and Electric Company (PG&E). Prior to that I was the Senior Director of Asset Knowledge Management in Gas Operations for PG&E.

2. I received a B.S. in civil engineering from the University of California, Berkeley, in 2000, and a Masters of Business Administration from the University of California, Los Angeles, in 2008. I have been employed by PG&E for a total of 11 years, spending approximately 9 years in gas operations.

3. I am providing this declaration as a supplement to the Verified Statement of M. Kirk Johnson submitted on August 30, 2013 based on the ongoing analysis of documentation and information on Line 147 conducted by David Harrison, a former PG&E pipeline engineer and now a technical consultant working on our maximum allowable operating pressure (MAOP) validation effort. The ongoing work conducted by Mr. Harrison and his team is discussed in paragraphs 39 through 48 of the Verified Statement. I am also providing copies of recent expert reports from Exponent and from Kiefner and Associates.

4. As discussed in the Verified Statement, in early 2013 Mr. Harrison and his team learned that portions of Segments 108 and 108.7 of Line 147 had been cut out as part of the 2011 hydrostatic testing process. Mr. Harrison was able to confirm from photographs of four sections

of pipe that had been cut out of Line 147 in connection with the strength tests that the long seam for two sections of the pipe was DSAW. Another was seamless, and the fourth was SSAW. Based on this, we updated the MAOP validation documentation for Segments 108 and 108.7 to show the SSAW seam type. Despite the fact that destructive testing confirmed a specified minimum yield strength (SMYS) value of 42,000 psi, we reduced the SMYS value of these segments to 33,000 psi in order to reflect a more conservative SMYS value based on the seam type and installation year.

5. At the time PG&E submitted the Verified Statement, our best available information indicated that while the updated SMYS value did affect the MAOP for the two segments (reduced from 525 psig to 412 psig), these segments were still commensurate with an MAOP of 365 psig. This was based upon, among other things, the conservative SMYS value of 33,000 psi, a wall thickness of 0.3125 inches, and a design factor of 0.5 for a class 3 location.

6. The wall thickness of 0.3125 inches was derived from a 1957 strength test pressure report, the bill of material for performing the hydrostatic testing in 2011, the drawing detail from the 2011 hydrostatic testing that corresponds to the bill of material, and the associated record of material removed form (chain of custody form). A copy of the 1957 strength test pressure report is attached as Exhibit A.

7. Prior to submitting the Verified Statement, we had an "H form" dated December 2, 2011, from a contractor involved with our pressure testing work. The H form was associated with mile point 1.89 that corresponded to segment 107.7 and identified 20 inch diameter pipe with a wall thickness between 0.261 inches and 0.275 inches. It also indicated that the seam type for this pipe was DSAW. A copy of this H form is attached as Exhibit B. Once we confirmed that segment 107.7 pipe was 24 inch diameter pipe and not 20 inch pipe as indicated on the H-form, we discounted this H form due to the inaccuracy and were uncertain of the location due to the incorrect mile point information. We continued to rely on the documentation of 0.3125 inches of wall thickness described in paragraph 6 above for segments 108 and 108.7, although we have also continued to analyze our records for Line 147 and for our entire system.

8. PG&E's review of its records and examination of pipe has been ongoing, and did not end while PG&E was preparing the Verified Statement. We have continued to gather, review and analyze additional information about Line 147. Attached as Exhibit C is a report prepared by PG&E's Applied Technology Services (ATS) Department dated August 29, 2013. ATS performed ultrasonic measurements of the wall thickness of the pipe cutout stored in our Modesto pipe storage yard. This test indicated a pipe wall thickness range of 0.25 inches (from 0.247 inches to 0.258 inches) for pipe believed to be for segment 108, rather than 0.3125 inches as was previously identified on the records. After receipt of this report, we double-checked to confirm that ATS had tested the correct pipe sample, which was confirmed last month.

9. In addition, on August 27, 2013, PG&E received a revised H form from the contractor for the pressure testing work. The revised H form changed the mile point, which now associated it with Segment 108, and also changed the seam type, but did not change its wall thickness measurements. Given the number of changes to the H form, PG&E conducted additional diligence to ensure the correct location and data accuracy by discussing these changes further with our pressure testing team. A copy of this revised H form is attached as Exhibit D. The updated seam type on this form shows A.O. Smith pipe. However, we believe the seam type is actually SSAW, based on a review performed by Michael Rosenfeld of Kiefner and Associates. Both A.O. Smith and SSAW pipe have a joint efficiency factor of 0.8, so this difference in the seam type does not affect the MAOP.

10. Given the updated information from two sources consisting of the ATS report (Exhibit C) and revised H form (Exhibit D), PG&E has applied a conservative representation for the entire length of segments 108 and 108.7 by using a wall thickness of 0.250 inches instead of 0.3125 inches and thus the MAOP for both of these segments would be 330 psig, not 412 psig as described in paragraphs 48 and 49 of the Verified Statement. The MAOP for the entire line remains at 330 psig.

11. On September 13, 2013, I submitted a Declaration supplementing the Verified Statement by submitting reports from Anamet, Inc. concerning the metallurgical evaluation of

the pipe where the leak that was found in October 2012 on Line 147, Segment 109. PG&E also retained Exponent to conduct an analysis to identify why the October 2012 leak on Line 147, Segment 109 was not detected during the hydrotest. Exponent conducted visual, metallographic, fractographic, and chemical analysis of the leak site. Exponent concluded that "[t]he subject leak was caused by cracking that occurred within a location on the pipe body that had been repaired using a weld-metal deposition ('weld repair'). This weld repair was not associated with either a girth or longitudinal seam weld." Moreover, Exponent found "no metallographic or fractographic evidence that any crack growth occurred following the repair weld. Specifically, there was no evidence of progressive crack growth due to fatigue, stress corrosion cracking (SCC) or ductile tearing[.]" The Exponent report is attached as Exhibit E.

12. PG&E also retained Kiefner and Associates to determine whether the hydrostatic pressure tests on Line 147 still established Line 147's fitness for service. Kiefner and Associates conclude that Line 147 is safe to operate. For convenience and clarity, I am quoting the conclusions of Kiefner and Associates in full below:

1. PG&E has substantial knowledge of the type of pipe, construction features, and appurtenances present in Line 147. Data from metallurgical examination of a leak that occurred in 2012 suggests that the affected pipe was reconditioned first-generation A.O. Smith line pipe. Records indicate that such pipe was shipped to the site in 1957, although it is not listed in the PFL, confirming that the database is not perfect.

2. The October 2011 hydrostatic pressure spike test confirmed the fitness for service of the pipeline for its MAOP without doubt. The concept of pressure testing to establish the ability of a pipeline to safely hold pressure at a lower pressure is an accepted practice that is logical and supported by industry experience and research. NTSB and PHMSA have recommended and required, respectively, hydrostatic pressure testing to revalidate pipeline operating pressures. The test was performed to a sufficient margin to assure the integrity of the pipeline well into the future assuming routine maintenance practices such as catholic protection monitoring and damage prevention programs continue to be implemented.

3. A review of data concerning specific pipeline integrity threats provides no evidence that the integrity or fitness for service of Line 147 has degraded in the 2 years since the October 2011 hydrostatic tests were conducted.

In addition, Kiefner and Associates' letter states, "The fact that PG&E may not know all facts about every piece of pipe or component in Line 147 does not cause me particular concern considering that the pipeline in its current condition was successfully pressure tested to a level that supports a maximum allowable operating pressure (MAOP) of 400 psig." A copy of the Kiefner and Associates report is attached as Exhibit F.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct to the best of my knowledge and belief.

Executed this 18th day of October 2013, at San Ramon, California.

SUMEET SINGH, Senior Director
Integrity Management
PACIFIC GAS AND ELECTRIC COMPANY

EXHIBIT A

#75-27
12-20-56 748d

DEPARTMENT OF GAS OPERATIONS

FIELD PRESSURE TEST REPORT
(Per ASA B 31.1.8 - 1955 Code for Pressure Piping, Paragraph 841.4)

Date October 2, 1957

G.M. No. 139349

1. Project Description: Relocate 24" Main 147, Brittan Avenue, San Carlos

2. Pipeline Data:

	Size	Wall Thickness	Steel Specifications
(a) Mainline	20"	0.3125	API 5LX,Gr x 42

(b) Design Operating Pressure, maximum 500 psi

(c) Stress at Max. D.O.P. 16,000 psi; as % of yield 38.1

(d) Location class 3. Type construction C

(e) Test pressure 750 psi; fluid Water Period of test 1 hour

(f) Stress at Test Pressure 24,000 psi; as % of yield 57.2

3. Test Data

(a) Date and time started test 10-21-57 1:20 PM, fluid used Water

(b) Date and time reached test pressure 10-21-57 4:09 PM

(c) Date and time concluded test 10-21-57 5:15 PM, actual test pressure 750 #

(d) Date and time Purging started 10-29-57 10:50 AM concluded 10:55 AM

(e) Date and time Pipeline tied intc System 10-29-57 2:00 PM

(f) Date and time Pipeline Placed in Operation 10-29-57 3:00 PM

(g) Name of PG&E Supervisor conducting test Wm. Mendonsa

(h) Who made test? P. G. & E. Co.

General Construction Department XXX
Division -
Contractor (Indicate Name) -

Instructions:

Retain one copy of this completed test report in Project file. Send one copy each to V.P. in Charge of Gas Operations and to Division Manager concerned.

EXHIBIT B

GE ENERGY
Industrial Solutions

INSPECTION SERVICES
Pipeline Integrity Team
CWA # 2500461774
GEIS Job # LAPI0015

IN-FIELD SERVICES

GEIS Pipeline Integrity Team NDE

Pacific Gas & Electric Company

Hydrostatic Test Dig from October 7, 2011 to November 5, 2011

T43A/B_L147_B _MP-1.89

Documents Contained Within:

H-Form Report T43A/B_L147_B MP-1.89

NDE Reports of T43A/B_L147_B MP-1.89

Photo Report of T43A/B_L147_B MP-1.89

Authors: H. Mayer & J. Hayes

Date: December 2, 2011

Form H: Direct Examination Data Sheet - Page 1 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation:	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.89	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes			Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

Excavation Priority: ☐ Immediate ☐ Scheduled (For ILI - ☐ 1 Year ☐ Other) ☐ Monitor ☐ Effectiveness ☒ Hydro Test

Excavation Reason ☐ ECDA ☐ ILI ☐ Recoat ☐ ICDA ☐ Other NA

If practical, take P/S or CIS reads before excavation: NA

Excavation Details:

U/S Ditch Start GPS Coordinates (Uncorrected Field Measurement)
Northing: 37.4878247306 PDOP: NA
Easting: -122.2701986194 Acc~: NA
Planned Excavation Length (Ft.): NA
Actual Excavation Length (Ft.): 21.0ft

Centerline GPS Coordinates (Uncorrected Field Measurement)
Northing: NA PDOP: NA
Easting: NA Acc~: NA
GPS File Name: Guida 148T4313

D/S Ditch End GPS Coordinates (Uncorrected Field Measurement)
Northing: 37.4878664944 PDOP: NA
Easting: -122.2702163300 Acc~: NA

1.0 Data Before Coating Removal

1.1 Native Soil Type: ☒ Clay ☒ Rock ☒ Sand ☐ Loam ☐ Wet ☐ Other NA
1.1A Backfill Material Found: ☐ Silt ☐ Slurry ☐ Native Depth of Cover (Ft.): 6.00ft
Comments: NA

1.2 Coating Type: ☒ HAA ☐ Somastic ☐ Plastic Tape ☐ Wax Tape ☐ FBE ☐ Powercrete
☐ Bare/None ☐ Coal Tar ☐ Other: NA Comments: NA
Coating Thickness (Inches): 0.250in Number of Layers: 2

1.3 Holiday Testing Performed?: ☐ Yes ☒ No Voltage Used: NA Map Location of Holidays Below.
Device Used: ☐ Coil ☐ Wet Sponge Comments: NA

1.4 Pipe-to-Soil Potentials in Ditch (-mV):

	12:00	3:00	6:00	9:00
US:	-526	-530	-535	-526
DS:	-661	-658	-640	-663

Comments: CP appears to be very low, may be turned off at time of inspection.

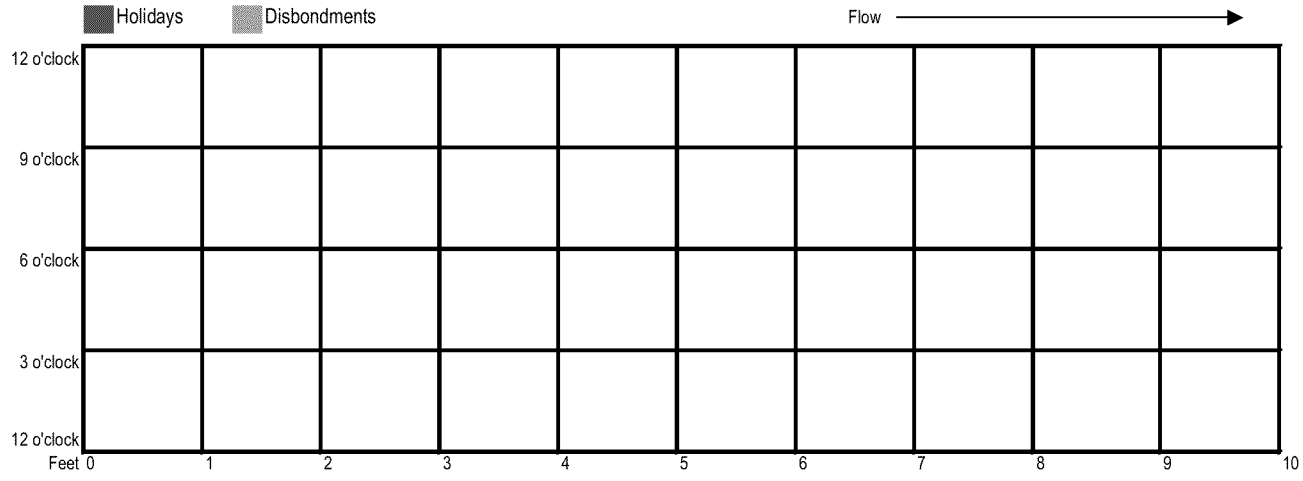
1.5 Soil Resistivity in Ditch (Ω-cm):
Method: ☒ 4-Pin 24469.5 ohm/cm ☐ Soil Box NA
Comments: NA SRM-100 US: N/A DS: N/A

1.6 Soil Sample Location Comments Ditch end (DS) 6:00 position under pipe.

1.7 Ground Water Present?: ☐ Yes ☒ No Sample(s) Collected?: ☐ Yes ☒ No Sample pH: NA
Comments: NA

1.8 Coating Condition: ☒ Good - Adhered to Pipe ☐ Fair - Coating Partially Disbonded or Degraded ☐ Poor - Coating Significantly Disbonded or Missing
Comments: Coating removed & tie in weld areas blasted. Pipe section removed and test pipes installed. Removed pipe section was also assesed and was in good conition except for coating damage from removal and transportation. See comments page 10.

1.9 Map of Coating Degradation*: **Zero Reference Point:** US Exposed Pipe 360 degrees
*Note any calcareous deposit locations



1 CaCO3	- Calcareous deposits containing calcium
2 FeO	- General iron oxide with scale
3 FeCO3	- Calcareous deposits containing iron

Form H: Direct Examination Data Sheet - Page 2 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.89	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

1.10 Photos Taken?*: [X] Yes [ ] No
*See Photo Log for additional information.

1.11 Coating Sample Taken?: [ ] Yes [X] No Location of Sample: NA

1.12 Liquid Underneath Coating?: [ ] Yes [X] No If Yes, pH of Liquid: NA

1.13 Corrosion Product Present?: [ ] Yes [X] No If Yes, Was Sample Taken?: [ ] Yes [X] No
Comments: NA

1.14 Soil pH (Sb Electrode): Upstream: 6.0 Downstream: 7.5 Pipe pH: 6.0

2.0 Data After Coating Removal

2.1 Pipe Temperature (°F): 60.0° F **Measured Pipe Diameter (In.):** 63" = 20.05"

2.2 Weld Seam Type: [X] DSAW [ ] SSAW [ ] ERW [ ] SMLS
[ ] Spiral [ ] Lap [ ] Flash [ ] AO Smith [ ] IF CAN'T DETERMINE, VISUALLY PERFORM MACROETCH & LOCATE

2.3 Girth Weld Coordinates & Identify Type (See Table 5.7.3):
Northing: NA PDOP: NA
Easting: NA Acc~: NA LS Weld Clock Position(s): 8:55
Elevation: NA

2.4 Damage Found:
Corrosion Damage [ ] Yes [X] No Mechanical Damage [ ] Yes [X] No
Other Damage: Non relevant tool marks, no corrosion found greater than 20%

2.5 UT Wall Thickness Measurements:

	US / DS		US / DS		US / DS		US / DS
TDC:	0.270"/0.275"	1 O'clock	0.267"/0.272"	2 O'clock	0.267"/0.271"	3 O'clock	0.265"/0.271"
4 O'clock	0.268"/0.270"	5 O'clock	0.266"/0.271"	6 O'clock	0.268"/0.273"	7 O'clock	0.266"/0.272
8 O'clock	0.269"/0.269"	9 O'clock	0.261"/0.263"	10 O'clock	0.266"/0.264"	11 O'clock	0.269"/0.270"

UT Wall Thickness Grid @ 6:00 is required. Be sure to attach grid to H-Form electronically. See page 6 of 10.

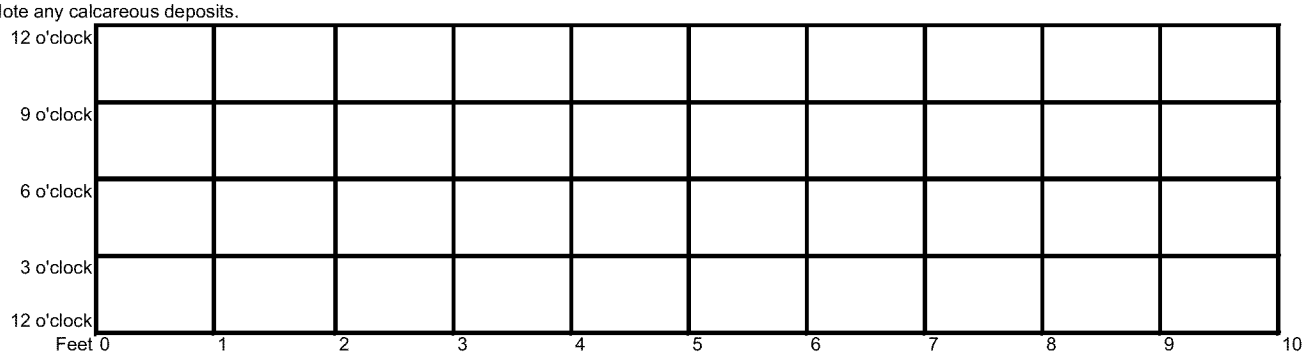
2.6 Wet Fluorescent Mag. Part. Is Required. Comments: 2 linear indications on the removed pipe section. See MT & Photo report.
Were there any linear indications? [X] Yes [ ] No If Yes, attach NDE report electronically as part of the H-Form. Report to include black light and white light photos of indications.

2.7 Take Photos to Document Corrosion and Other Anomalies*
*See Photo Log for additional information.

2.8 Overview Map of Corroded Area*:
*See Pit Depth Measurement Grid for additional Information **Zero Reference Point:** US Exposed Pipe 360 degrees

Flow →

*Note any calcareous deposits.

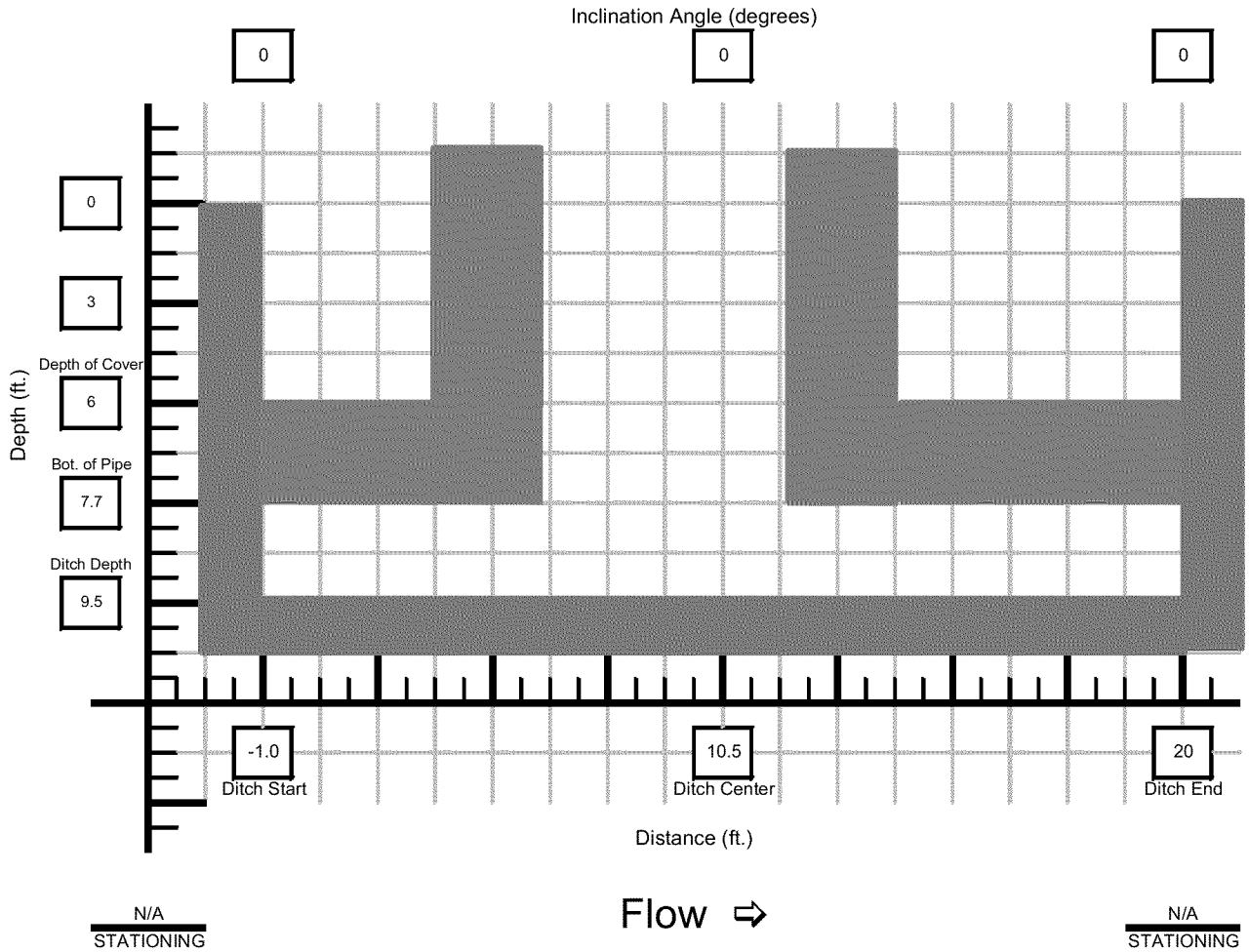


Form H: Direct Examination Data Sheet - Page 3 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.89	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

Excavation Drawing:

At minimum draw pipe elevation profile and indicate stationing of 1) low point and 2) critical inclination angle.
Place an arrow on the drawing indicating direction of gas flow in the region(s). Other labels may also be added (e.g. "to Station").



NOTES: (Record stationing and names of nearby landmarks such as creeks and roads. Provide any additional information that may help in spatially positioning pipe):

**See attached Delorme screen shot on page 11.

Form H: Direct Examination Data Sheet - Page 5 of 10

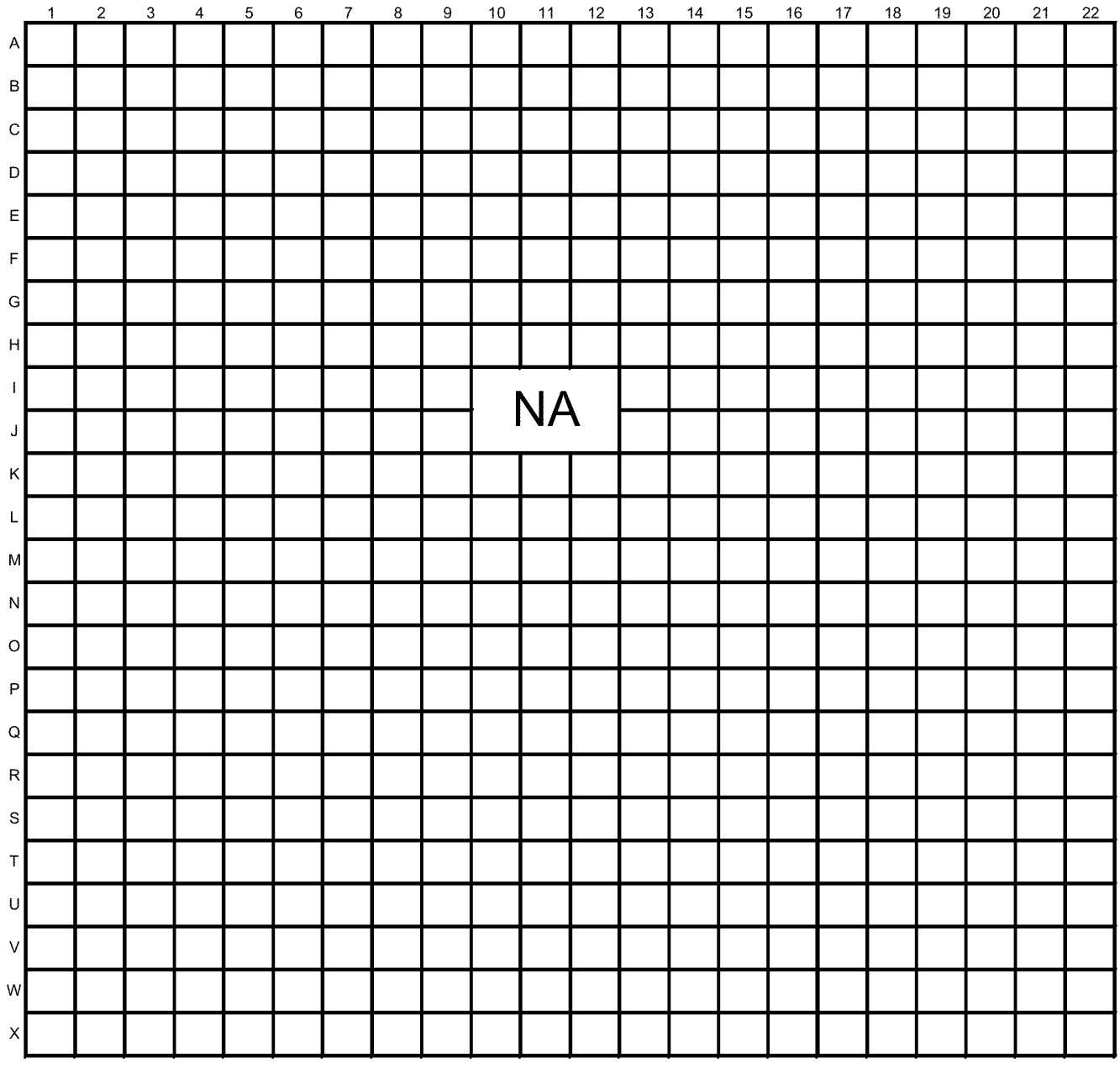
EXTERNAL PIT DEPTH MEASUREMENT GRID SHEETS

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.89	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

.001 - .009
.010 - .099
.100 - .199
.200 - .299
Highest pit reading

Grid Size = _____ Inch x _____ Inch (specify grid size)
Clock Position (specify below)

Anomaly # NA Grid # NA



PIT DEPTH GRID 1 OF 2

Form H: Direct Examination Data Sheet - Page 5 of 10

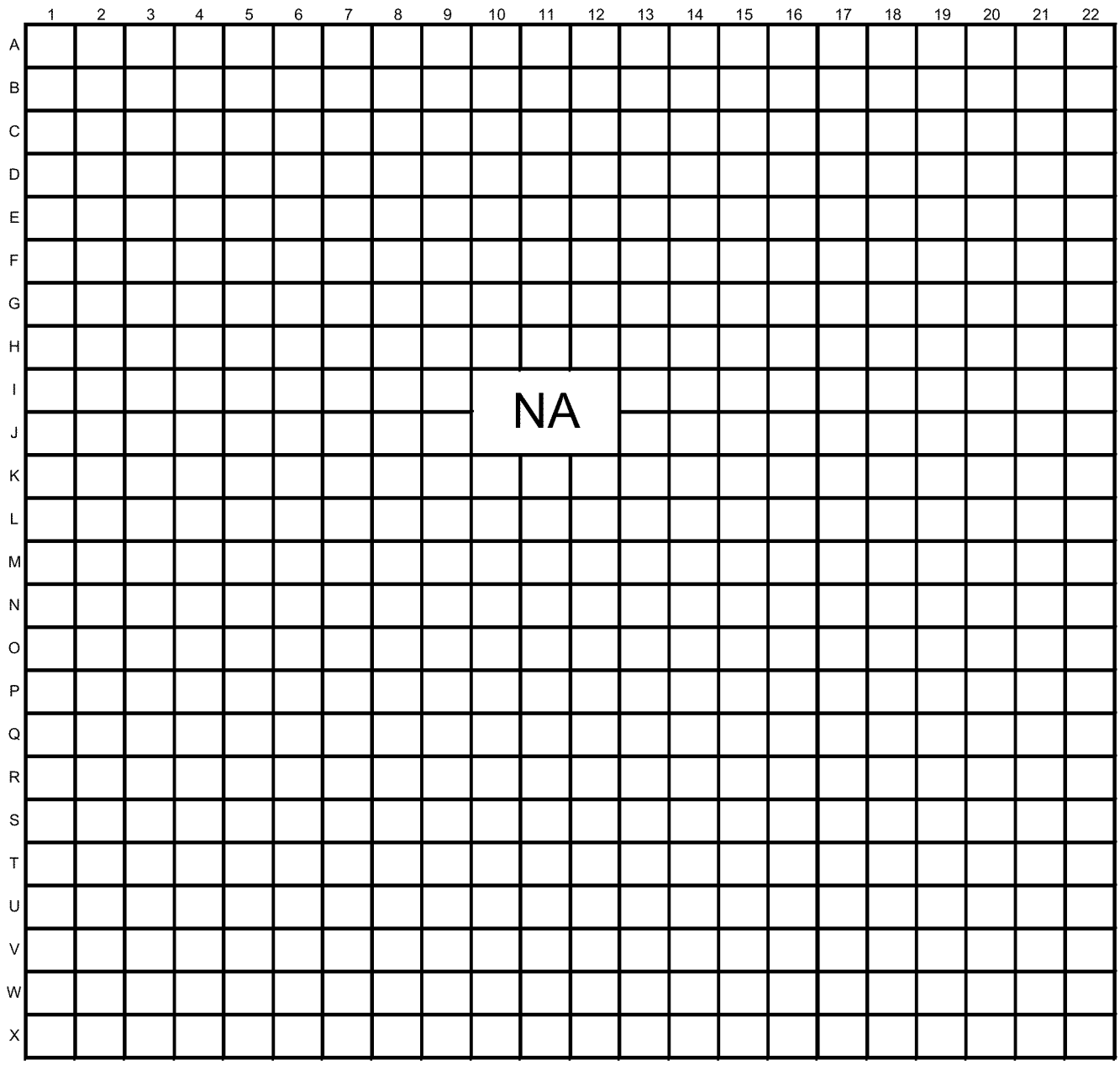
EXTERNAL PIT DEPTH MEASUREMENT GRID SHEETS

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.89	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

.001 - .009
.010 - .099
.100 - .199
.200 - .299
Highest pit reading

Grid Size = _____ Inch x _____ Inch (specify grid size)
Clock Position (specify below)

Anomaly # NA Grid # NA



PIT DEPTH GRID 2 OF 2

Form H: Direct Examination Data Sheet - Page 6 of 10

INTERNAL CORROSION WALL LOSS GRID

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.89	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

Grid Size = 1 Inch x 1 Inch
Clock Position (specify below)
All measurements are in inches.

UT Grid is centered @ 6:00 position on pipe.

	1	2	3	4	5	6	7	8	9	10	11	12
A	0.251"	0.251"	0.249"	0.249"	0.249"	0.249"	0.249"	0.248"	0.248"	0.248"	0.248"	0.248"
B	0.251"	0.254"	0.251"	0.251"	0.249"	0.249"	0.249"	0.249"	0.248"	0.248"	0.248"	0.249"
C	0.253"	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.249"	0.249"	0.248"	0.249"	0.249"
D	0.251"	0.251"	0.251"	0.251"	0.251"	0.249"	0.250"	0.249"	0.249"	0.248"	0.247"	0.249"
E	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.247"	0.248"	0.247"	0.248"
F	0.251"	0.251"	0.251"	0.251"	0.249"	0.249"	0.251"	0.249"	0.249"	0.247"	0.248"	0.249"
G	0.251"	0.251"	0.247"	0.246"	0.249"	0.248"	0.247"	0.247"	0.246"	0.247"	0.248"	0.247"
H	0.248"	0.249"	0.249"	0.249"	0.248"	0.247"	0.247"	0.247"	0.246"	0.246"	0.246"	0.246"
I	0.249"	0.249"	0.249"	0.249"	0.247"	0.246"	0.244"	0.247"	0.244"	0.244"	0.247"	0.246"
J	0.247"	0.247"	0.247"	0.246"	0.246"	0.246"	0.242"	0.244"	0.244"	0.243"	0.244"	0.246"
K	0.247"	0.247"	0.247"	0.246"	0.246"	0.246"	0.244"	0.244"	0.244"	0.244"	0.244"	0.246"
L	0.249"	0.247"	0.247"	0.247"	0.248"	0.248"	0.248"	0.242"	0.244"	0.244"	0.246"	0.244"

INTERNAL CORROSION GRID
1 of 1

COATING DAMAGE

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.89	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

NO.	FEET FROM REFERENCE	O'CLOCK	MAX LENGTH (IN.)	MAX CIRC EXTENT (IN.)
NA	NA	NA	NA	NA

CORROSION LOG

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.89	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

IC or EC	FEET FROM REFERENCE	O'CLOCK	MAX PIT DEPTH (MILS)	MAX LENGTH (IN.)	MAX CIRC EXTENT (IN.)
NA	NA	NA	NA	NA	NA

SB_GT&S_0267298

Form H: Direct Examination Data Sheet - Page 9 of 10

PHOTO LOG

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.89	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

PHOTO NO.	LOCATION	DESCRIPTION	COMMENTS
****See attached photo report.			

Form H: Direct Examination Data Sheet - Page 10 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.89	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

3.0 RECOAT DATA

3.1 Sandblast Media: Sharp Shot 30/60 **Anchor Profile Measurement:** Average: 3.2 mils

3.2 Pipe Recoated With:

☐ Powercrete J ☒ Poly Tape ☐ Bar-Rust 235 ☐ Dev Grip 238 ☐ Dev Tar 247 ☒ Protal 7200 ☐ PE Tape

3.3 For Epoxy Coating Systems, Record Environmental Condition:

Air Temperature: 62.4°F Dew Point: 45.1°F

Pipe Temperature: 67.0°F Relative Humidity: 51.4%

Time of Day: 12:30 pm

3.4 Repair Coating Hardness (If ARC Coating:)

	3:00 -	6:00 -	9:00 -	12:00 -
US	82	79	79	79
DS	79	75	79	81

3.5 Measured Coating Thickness:

	3:00 -	6:00 -	9:00 -	12:00 -
US	33.7	38.7	57.5	27.4
DS	37.3	28.6	39.0	29.3

Holiday Tested?: ☒ Yes ☐ No

Device Used: ☐ Coil ☐ Wet Sponge Voltage Used: UNK Repair All Holidays. YES

3.6 Coupon Test Station Installed?: ☐ Yes ☒ No **ETS Installed?:** ☐ Yes ☒ No

If Yes, Date Installed: NA

Surface Configuration:: ☐ Fink ☐ G-5 Box ☐ Carsonite ☐ Other: NA

3.7 Backfill Material: ☐ Native ☐ Imported Sand ☐ Other: NA

Coating Protections?: ☒ Yes ☐ No

If Yes, Check One: ☐ Rockguard ☐ Tuf-E-Nuf ☐ Conwed ☐ Other: STACguard (transitions only)

3.8 Pipe-to-Soil Readings Over Bell Hole After Backfill: NA

*If specified, a CIS should be done for approximately 100' on either side of the bell hole. Attach data.

Comments: NA

3.9 Attach site sketch of excavation site.

4.0 REPAIR DATA

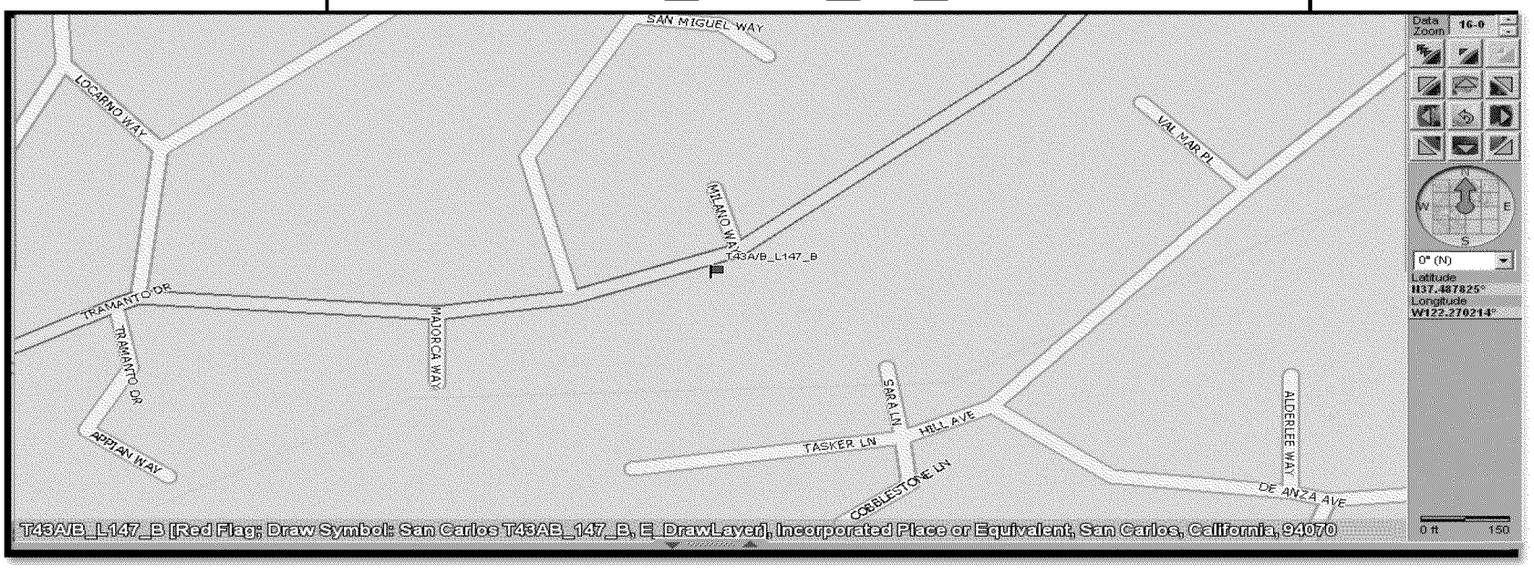
4.1 Repair Made: ☐ Yes ☒ No **4.2 Number of Repair Made:** Replacement "In-Kind configuration"

4.3 Repair Type ☐ Metallic Sleeve ☐ Non Metallic Sleeve ☐ Replace ☐ Can ☐ Filler Metal ☐ Other

4.4 Damage Repaired: ☐ Corrosion ☐ Mechanical ☐ Other

Misc. Comments/Information: T43A had coating removed, area for inspection was blasted from coating up to test pipe tie in weld. About 1 ft of coating was inspected. T43B had coating removed, area for inspection was blasted from coating up to test pipe tie in weld. About 1.5 ft of coating was inspected. Removed pipe section was inspected at the PG&E yard.

T43A/B_L147_B _MP-1.89



GE Energy

INSPECTION & LIFE EXTENSION SERVICES

MAGNETIC PARTICLE EXAMINATION REPORT

☐ Nuclear ☑ Non-Nuclear

To:	From:	Date:
Pacific Gas & Electric Company	H. Mayer/J. Hayes	10/7/2011

Project: **T43A/B_L147_B _MP-1.89**

Purchase Order No:	GEIS Job No:
41497360	LAPI0015

Item

Weld	Structural	Casting	Machinery	Mach. Parts	Pipe	N/A	Other:
☑	☐	☐	☐	☐	☑	☐	N/A

Non-Weld	Plate	Pipe	Bar	Casting	Mach. Parts	N/A	Other:
☑	☐	☑	☐	☐	☐	☐	N/A

Material

Size	Material Thickness	Type of Base Material	Type of Filler Material	Weld
20"	0.250"	Carbon Steel	C/S Smooth	☐ As Welded ☑ N/A

Location	System
70.6 Ft SW of the intersection of Brittan Ave and Milano Way in San Carlos, CA 94070	L-147

Acceptance Standards	Procedure
Customer Specifications	GEIS QCP # 500 Rev 17

Type of Check

Initial	Plate Edge	In Process	Back Gouge	Root Pass	Repair	12 Hour	24 Hour	Final
☑	☐	☐	☐	☐	☐	☐	☐	☑

Type of Inspection

				Other:
☐ Longitudinal	☐ Coil	☐ DC Probe	☑ Continuous	
☑ Wet	☐ Dry	☐ Direct Contact	☑ Residual	
☐ Circular	☐ AC Prod	☑ Yoke	☐ Other	

MT Yoke & Model - Serial No. / Blacklight Model - Serial No.	Surface Preparation Method
Parker DA-400 - S# 18830 / Spectroline BIP - S# 1597251	Abrasive Blasting (Kleen Blast) - NACE 2 Finish
Inspection Medium / Color / Batch No.	**Demagnetization Method / Equipment**
Magnaglo 14A / Flourescent Green / 09M12K	N/A

Reference: Summary ☑ See Attachment

The following areas were requested to be inspected:	Results of Inspection
Bare pipe: -0.40' to 1.35' from original U/S ditch start.	- No relevant indications found @ time of insp.
Bare pipe : 17.4' to 18.45' from original U/S ditch start.	- No relevant indications found @ time of insp.
Removed pipe section.	2 Linear indications were found.
Summary:	
Lin-01: Axial Start=1.60' (From U/S end of pipe), AL=1.58" , CW=0.020" , CLK Position= 4:00	
Lin-02: Axial Start=2.33' (From U/S end of pipe), AL=1.20", CW=0.020", CLK Position= 4:06	
These are on the removed pipe section.	

Indications were on the removed pipe section. Please see attached photo report for additional information.

Copy To:	Requested By:	Reported By (Technician):
Pacific Gas & Electric Company	David Aguiar	H. Mayer/J. Hayes
GE Inspection Services (Los Angeles)	☑ Customer Specifications	NDT supervisor:
	☑ Accept ☐ Reject	Andre J. Filiatrault

GE Energy

Inspection & Life Extension Services

ULTRASONIC EXAMINATION REPORT

☐ Nuclear ☑ Non-Nuclear

To:	From:	Date:
Pacific Gas & Electric Company	H. Mayer & J. Hayes	10/7/2011

Project: **T43A/B_L147_B _MP-1.89**

Purchase Order No:	GEIS Job No:
41497360	LAPI0015

Item

Weld	Structural	Casting	Machinery	Mach. Parts	Pipe	N/A	Other:
☑	☐	☐	☐	☐	☑	☐	

Non-Weld	Plate	Pipe	Bar	Casting	Mach. Parts	N/A	Other
☑	☐	☐	☐	☐	☐	☐	

Material

Size:	No. of Pieces	Type of Base Metal	Type of Filler Material	Weld	
20"	1	Carbon Steel	C/S	☐ Smooth	☑ N/A ☐ As Welded

Location: 70.6 Ft SW of the intersection of Brittan Ave and Milano Way in San Carlos, CA 94070

System: L-147

Acceptance Standards: Customer Specifications

Procedure: QCP-601

Type of Inspection

Soundness	Thickness	Bond
☑	☑	☐

Pulse Echo	Angle-Beam	Other
☑	☐	☐

UT Equipment/Model: USN-60, Serial # 01NLKN, Calibration Date: 10/5/2011, *Calibration Due: 1/5/2012*

Transducer: ☑ Single Crystal ☐ Dual Crystal

Frequency	Size	Angle	Transducer Serial No.:
5 MHz	0.375"	0°	020HFC

Flat	Concave	Convex	Couplant / Batch #
☑	☐	☐	Sonatest Ultragel II / 25-901 07225 AF

Standard	Material	Notch Depth	Serial No.:

Step Wedge ☑ / Tube Wedge ☐	Material	Thickness Range	Serial No.:
	C/S	0.200" - 0.500"	V34693

Reference: Summary ☑ See Attachment

The following areas were requested to be inspected:

12" x 12" (1"x1" grid) at a random 6:00 position on the pipe.
12" lamination scans at cut-line locations.
Thickness readings US & DS inspection areas at the clock positions.

*** Please see attached reports for additional information.*

Results of Inspection:

- No relevant indications @ time of inspection.
- No relevant indications @ time of inspection.
- No relevant indications @ time of inspection.

Copy To:
Pacific Gas & Electric Company
GE Inspection Services (Los Angeles)

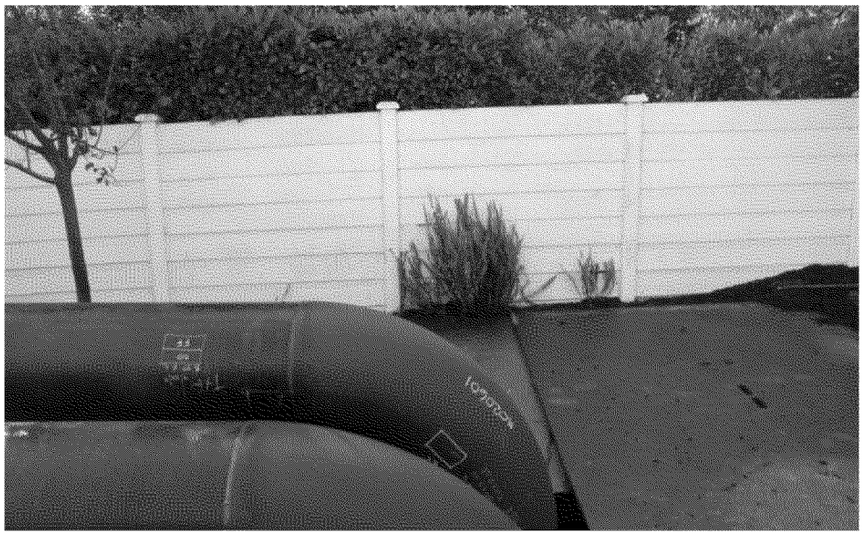
Requested By: David Aguiar

☑ Customer Specifications
☑ Accept ☐ Reject

Reported By (Technician): H. Mayer/J. Hayes

NDT Supervisor: Andre J. Filiatrault

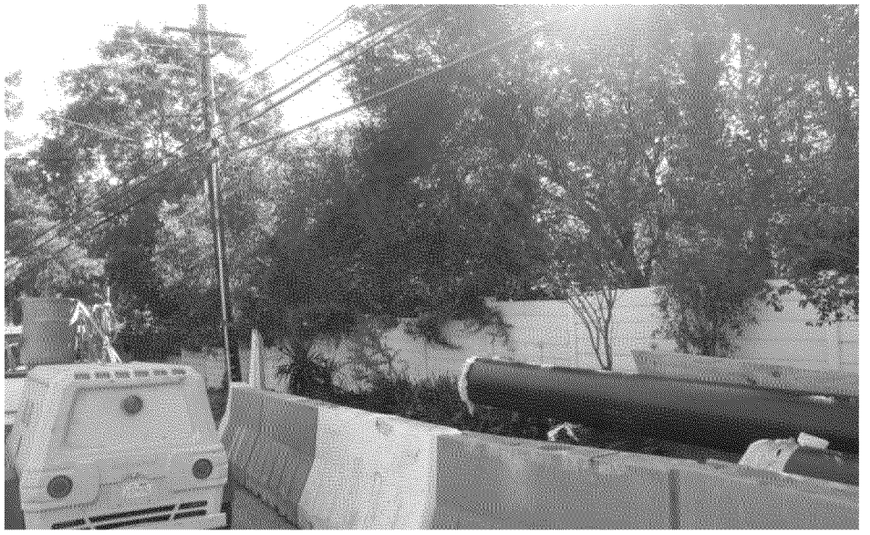
NOTICE:
THIS EXAMINATION REPORT IS A REPORT OF THE RESULTS OF THE NDT PROCEDURE ACTUALLY PERFORMED BY THIS COMPANY IT IS SUBJECT TO THE LIMITATIONS OF THE TESTING SPECIFICATIONS AND PROCEDURES WHICH WERE UTILIZED. BY FURNISHING THIS REPORT, *GE INSPECTION SERVICES* DOES NOT GUARANTEE ANY CONDITION OF THE TESTED SPECIMEN.



Topography looking upstream

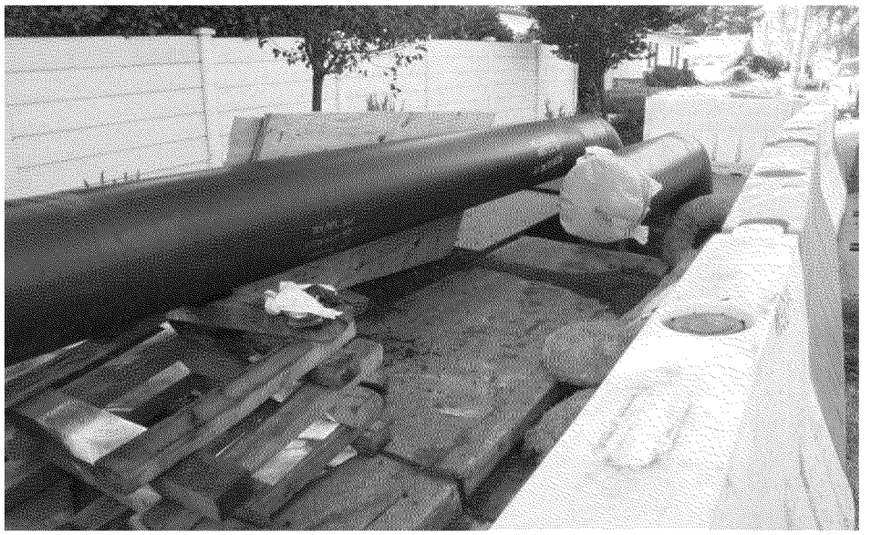
Topography looking downstream

Typical surrounding topography



Typical surrounding topography

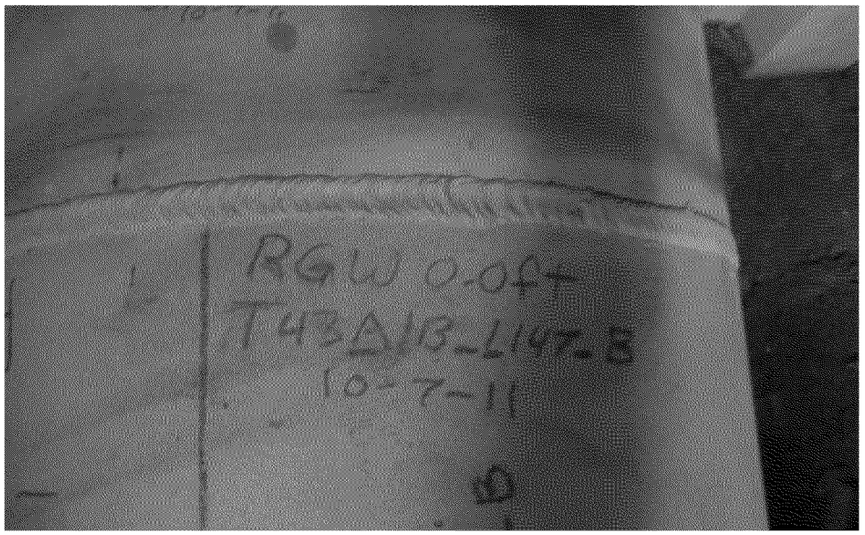
Overview of Dig Site T43A-B_L147_B_MP-1.89



Overview of Dig Site T43A-B_L147_B_MP-1.89

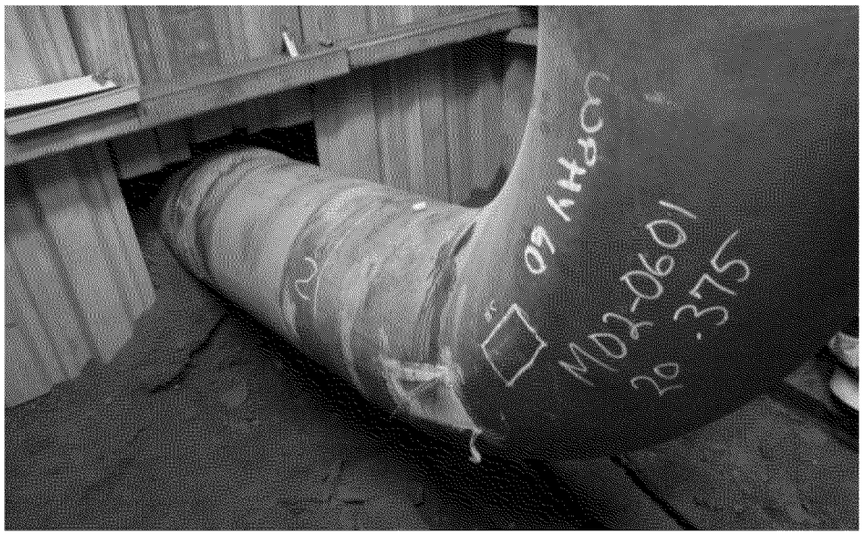
Overview of T43A(US) & T43B(DS) in same excavation.

Closeup of T43A(US) & T43B(DS) in same excavation.



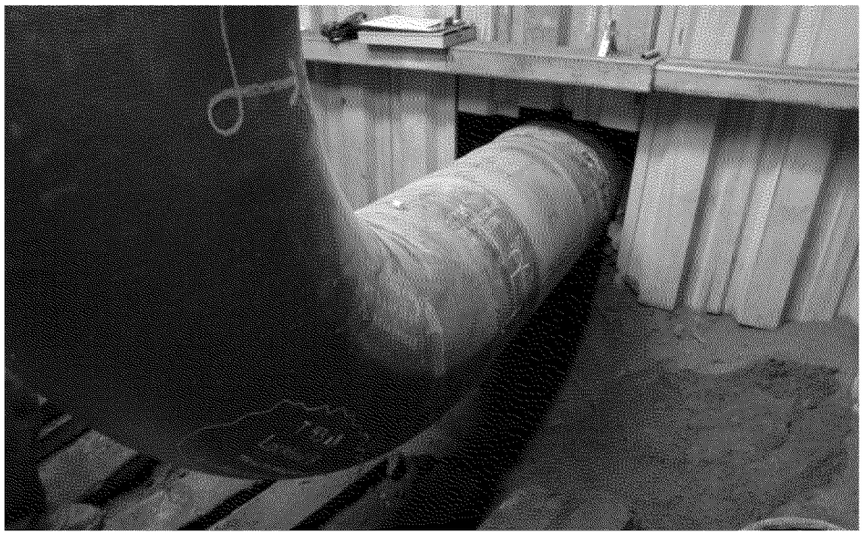
Overview of Reference Girth Weld measurments were taken from.

Overview of coating condition -1ft to 2ft, 3:00 position



Overview of coating condition -1ft to 2ft, 3:00 position

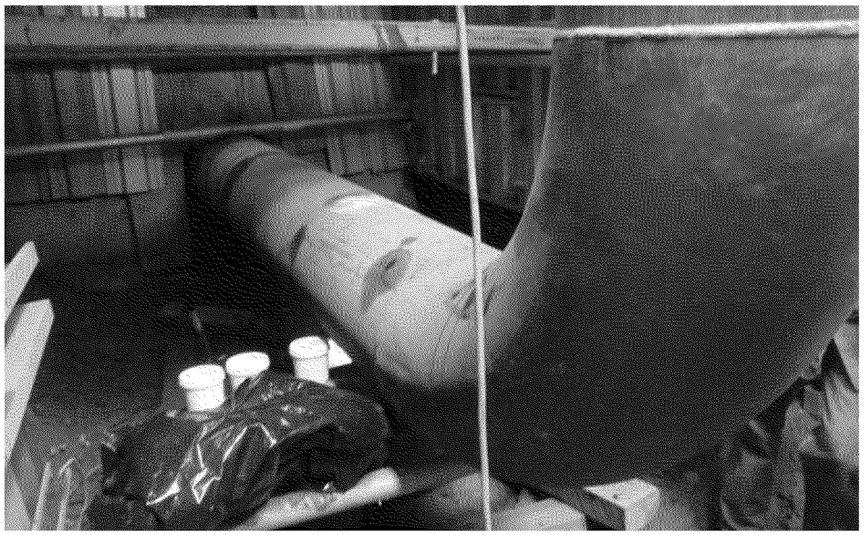
Overview of coating condition -1ft to 2ft, 9:00 position



Overview of coating condition -1ft to 2ft, 9:00 position

Overview of coating condition 17ft to 20ft, 3:00 position

Overview of coating condition 17ft to 20ft, 3:00 position



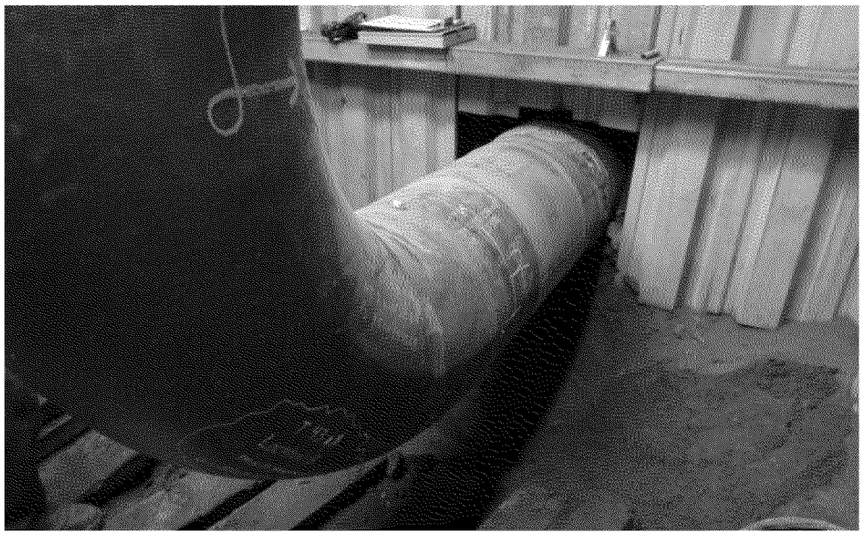
Overview of coating condition 17ft to 20ft, 9:00 position

Overview of coating condition 17ft to 20ft, 9:00 position

Overview of MPI layout -1ft to 2ft, 3:00 position

Overview of MPI layout -1ft to 2ft, 3:00 position

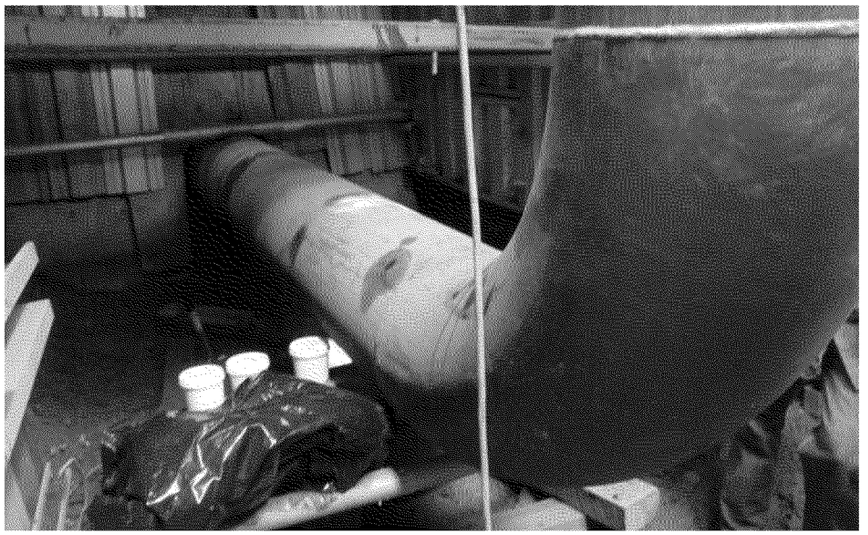
Overview of MPI layout -1ft to 2ft, 9:00 position



Overview of MPI layout -1ft to 2ft, 9:00 position

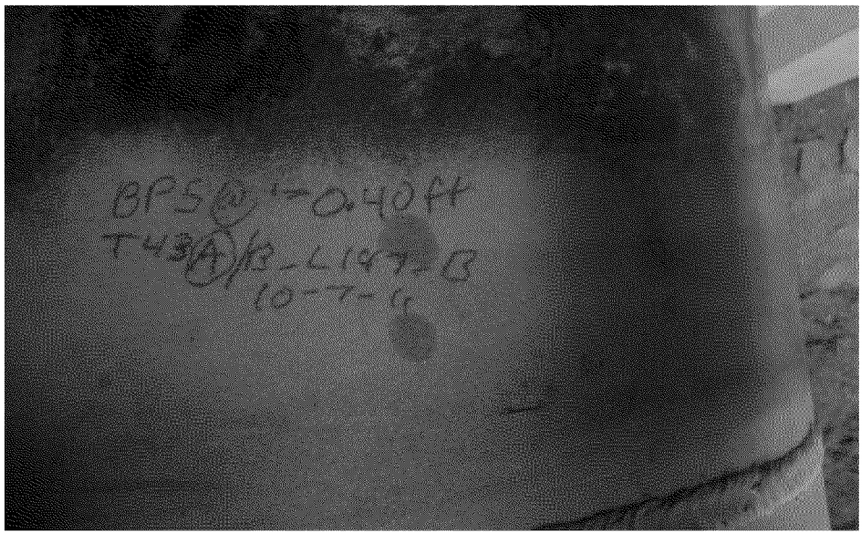
Overview of MPI layout 17ft to 20ft, 3:00 position

Overview of MPI layout 17ft to 20ft, 3:00 position

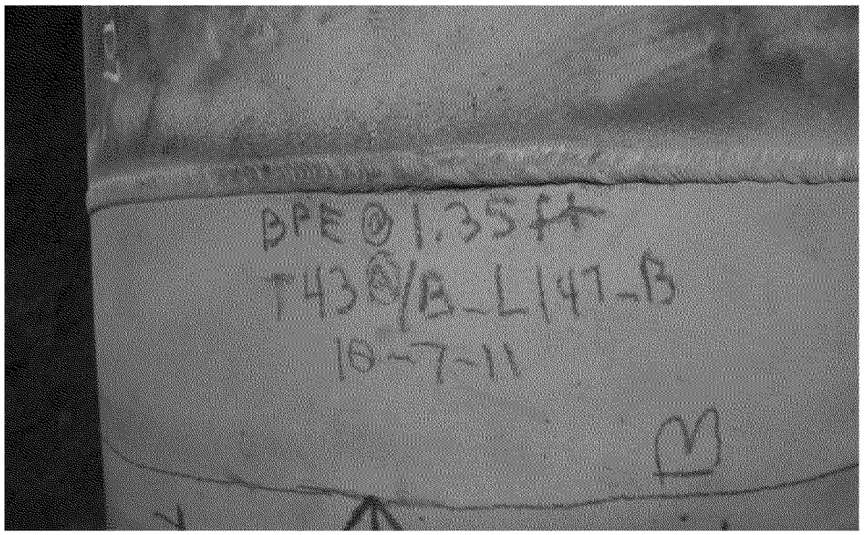


Overview of MPI layout 17ft to 20ft, 9:00 position

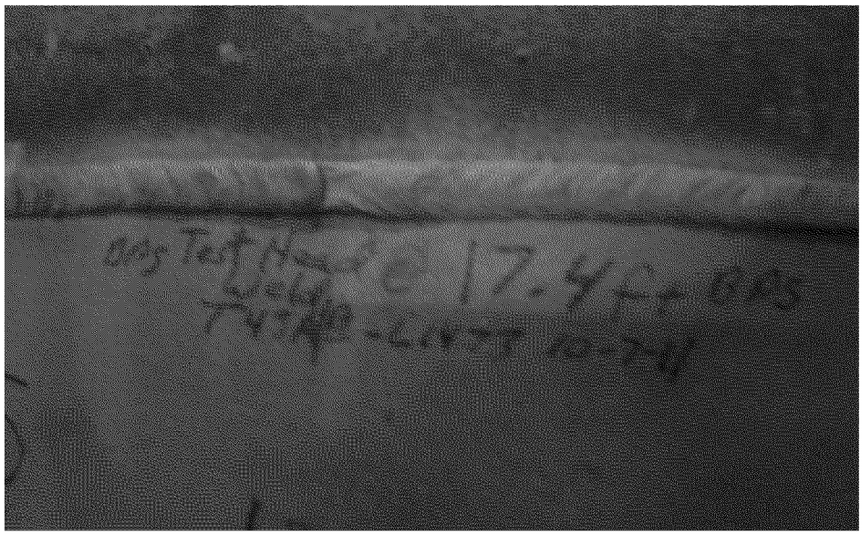
Overview of MPI layout 17ft to 20ft, 9:00 position



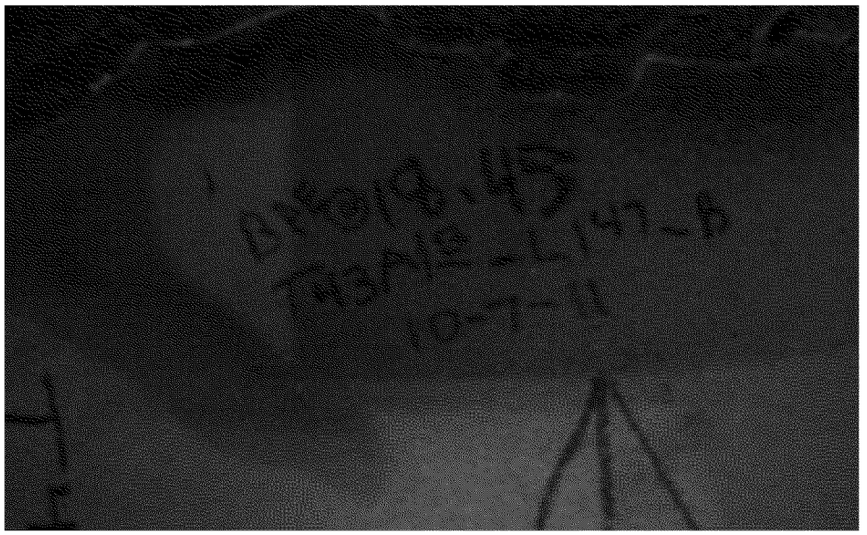
Overview of bare pipe start



Overview of bare pipe end

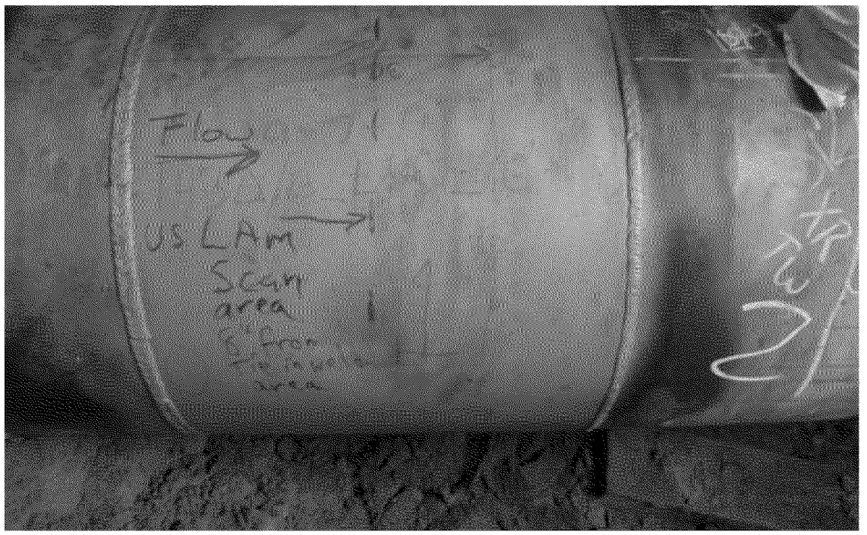


Overview of bare pipe start



Overview of bare pipe end

Overview of feature joint long seam @ 8:55

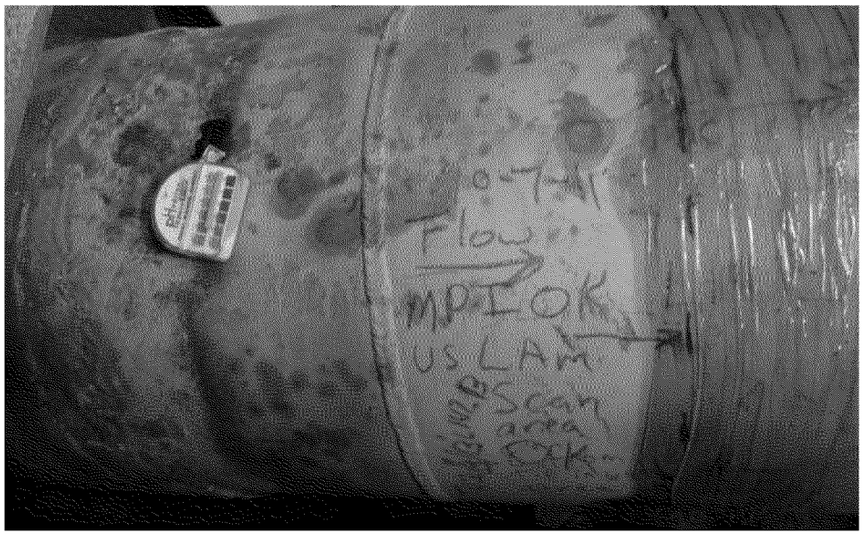


Overview of US lamination scan area.

Overview of DS lamination scan area.

Overview of US MPIOK and Lamination scan OK.

Overview DS of MPIOK and Lamination scan OK.



Overview of pipe Ph.

Closeup of pipe Ph.

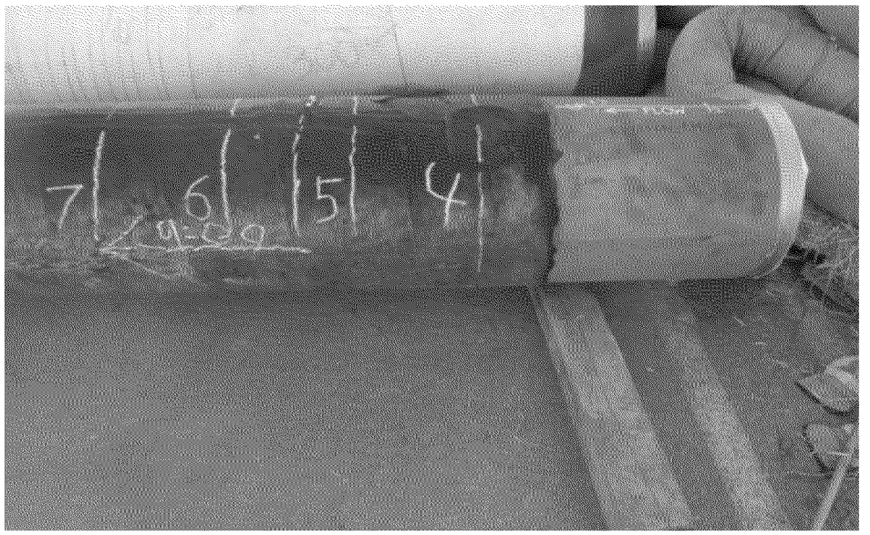
Removed pipe section coating assesment 3:00

Overview of coating condition 3:00 position

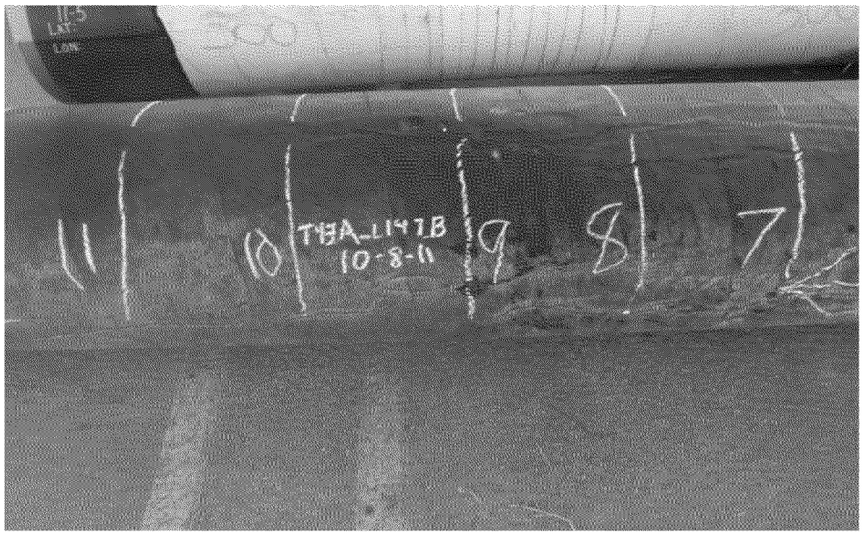
Overview of coating condition 3:00 position

Overview of coating condition 3:00 position

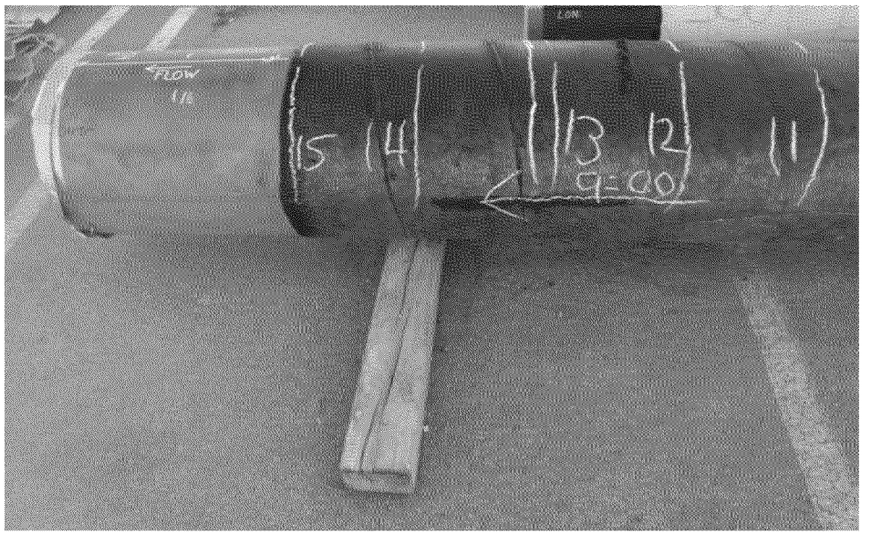
Removed pipe section coating assesment 9:00



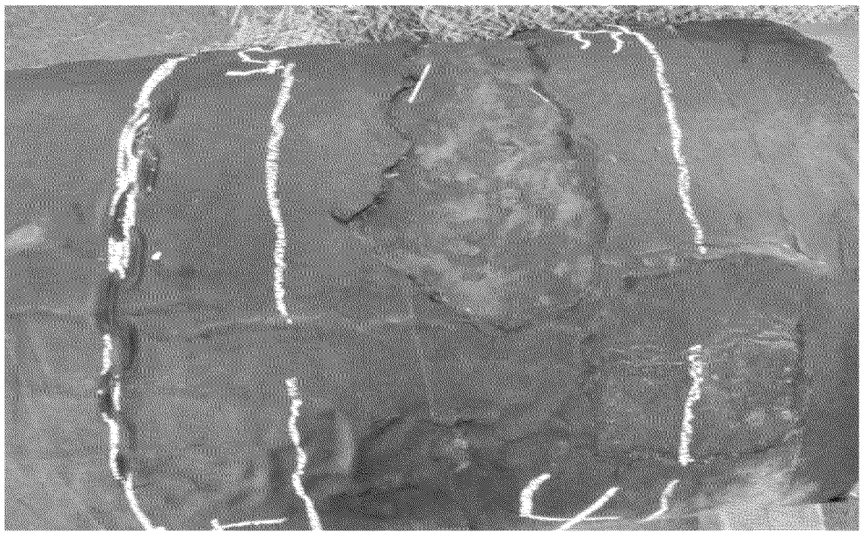
Overview of coating condition 9:00 position



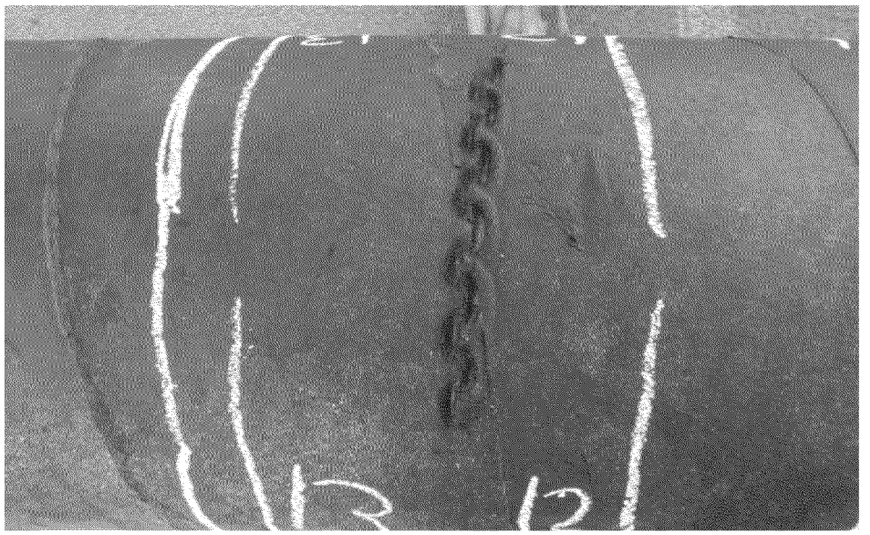
Overview of coating condition 9:00 position



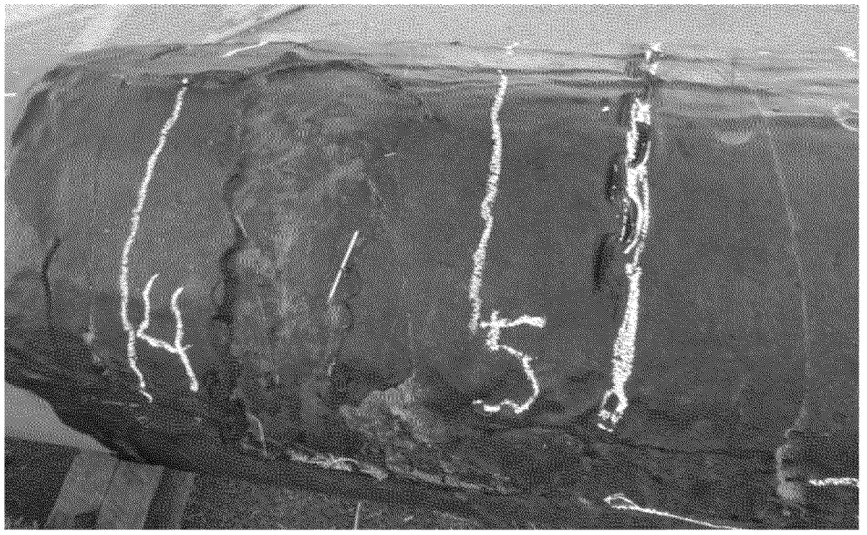
Overview of coating condition 9:00 position



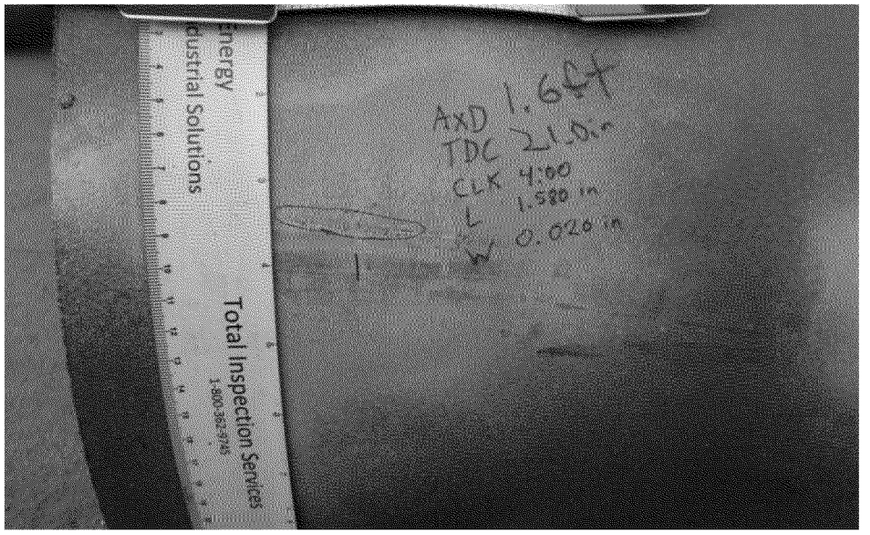
Coating damaged from removal process.



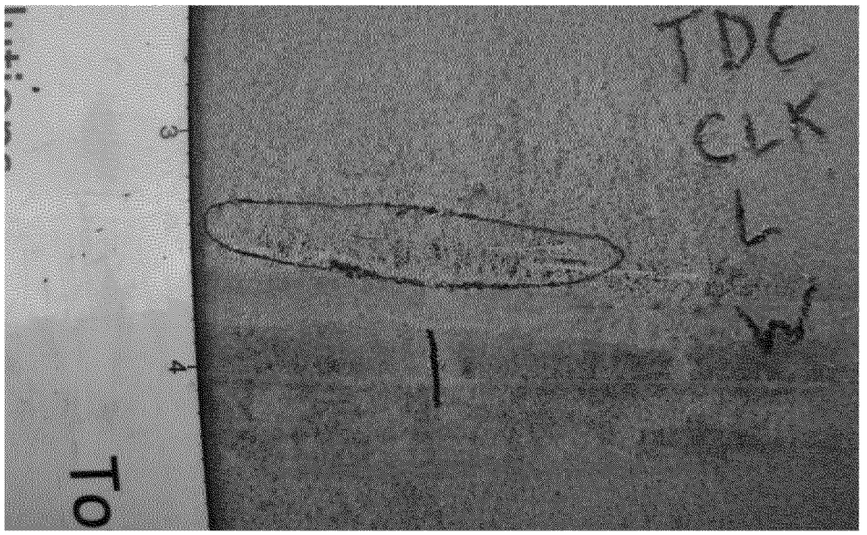
Coating damaged from removal process.



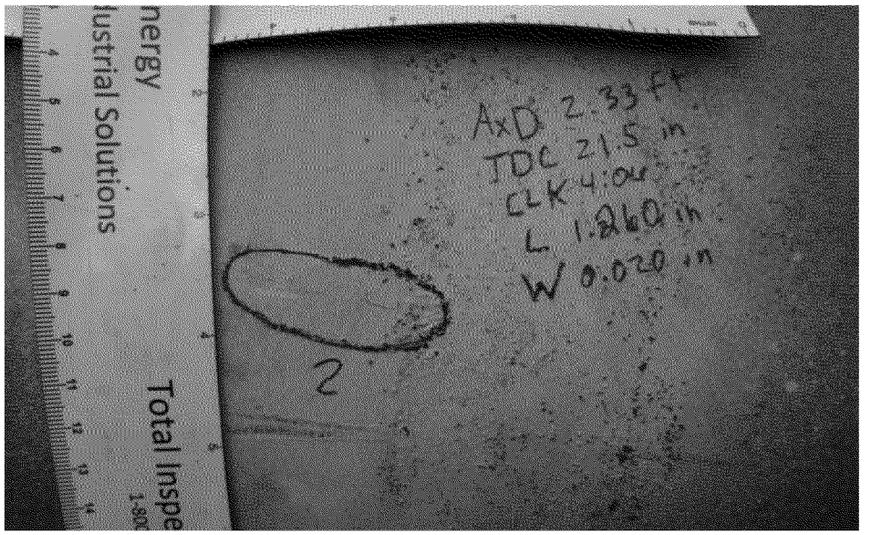
Coating damaged from removal process.



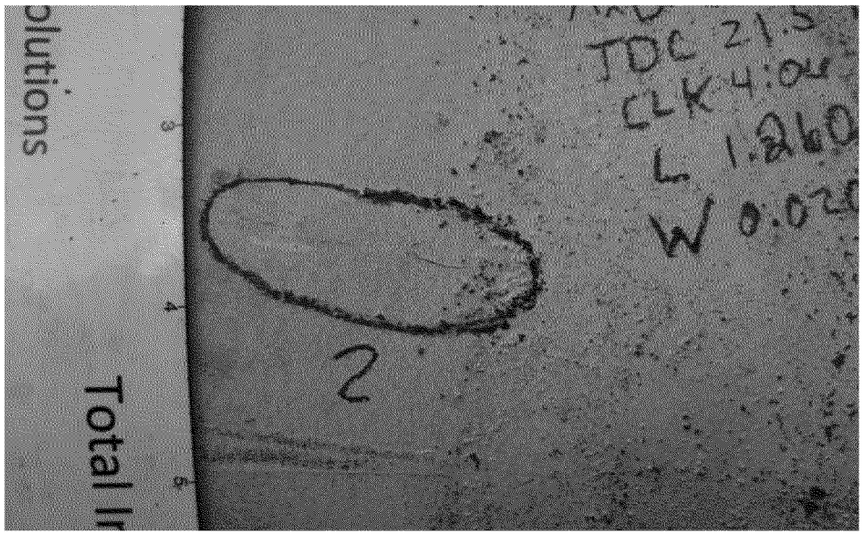
Removed pipe section linear indication-01



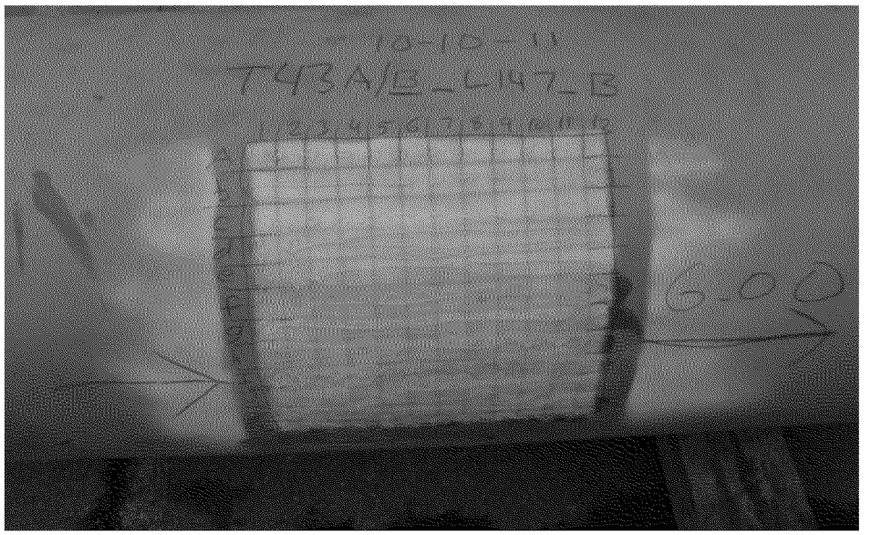
Close up of MT Indications of LIN-01



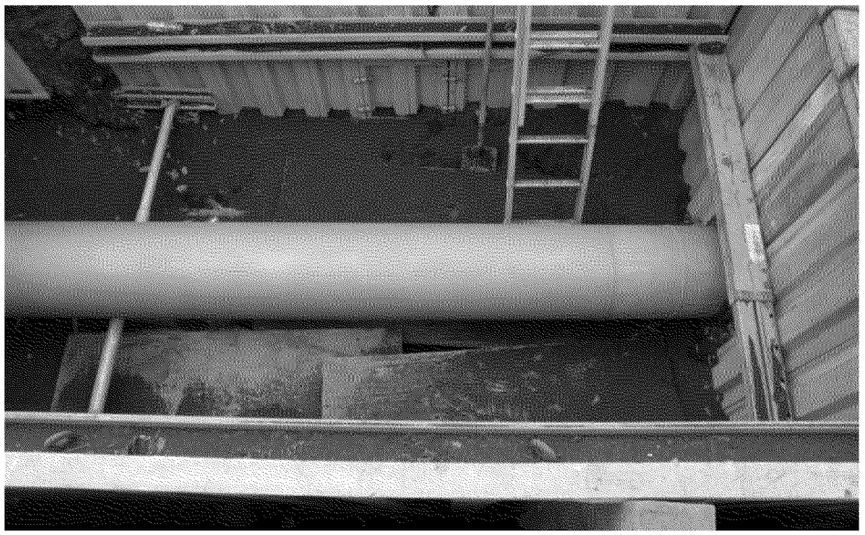
Removed pipe section linear indication-02



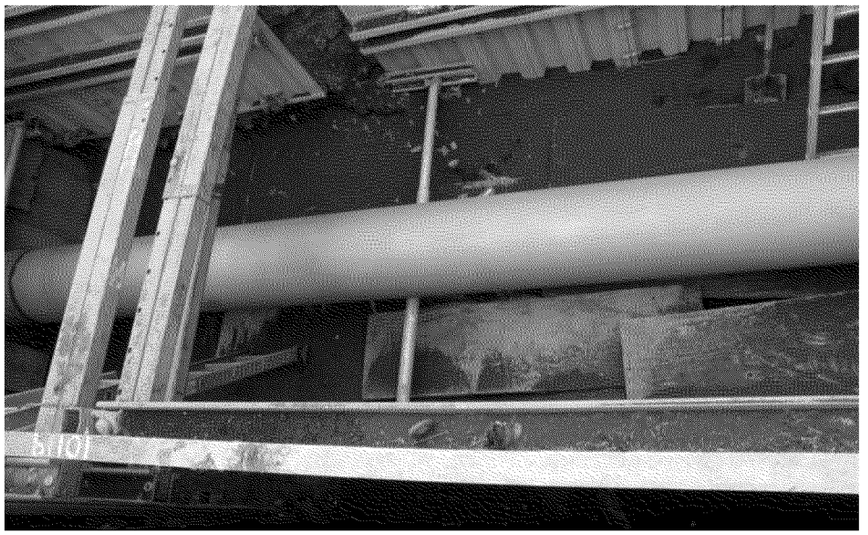
Close up of MT Indications of LIN-02



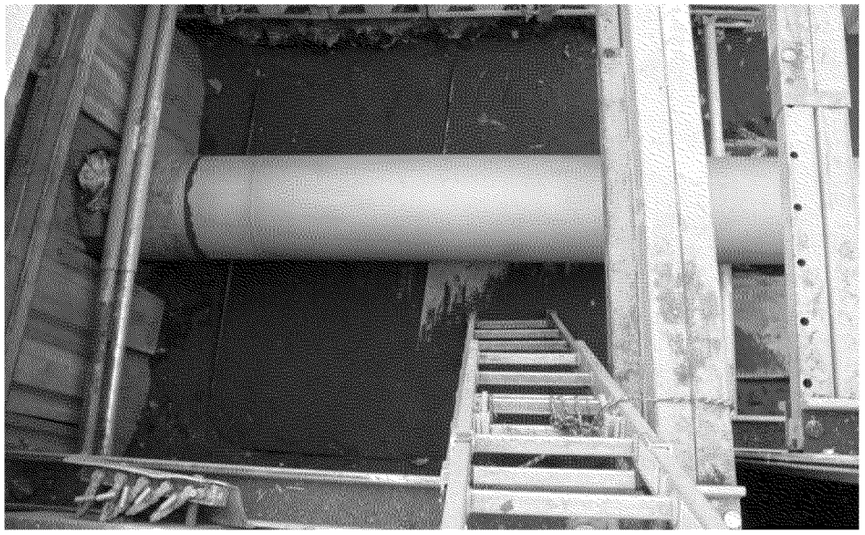
Overview of UT Grid.



Overview of clean blasted inspection area prior to recoat activities



Overview of clean blasted inspection area prior to recoat activities



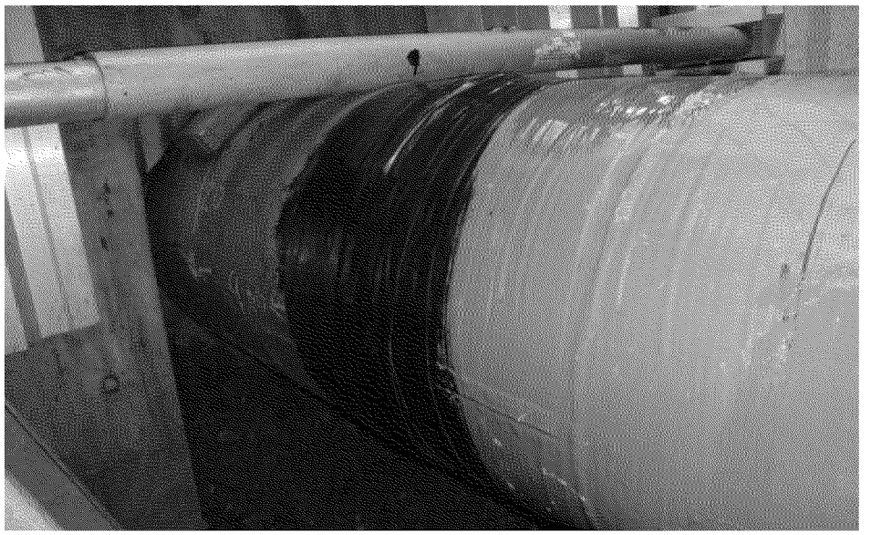
Overview of clean blasted inspection area prior to recoat activities

Overview of final coating condition US 3:00

Overview of final coating condition 3:00

Overview of final coating condition 3:00

Overview of final coating condition 3:00



Overview of final coating condition US 3:00

Overview of completed Slurry

Overview of completed Slurry

Overview of completed Cover looking upstream

Overview of completed Cover looking downstream

EXHIBIT C

Line 147
T-43A, Location B
MP. 1.951
Pipe Spool UT Thickness

Prepared by

Robert de Haas
Sr. Engineering Technician
Welding & NDE Services

Prepared for

Joe Medina
Director
Transmission Process & MAOI

August 29, 2013

Report No.: 413.61-13.327

Pacific Gas and Electric Company
Applied Technology Services
3400 Crow Canyon Road, San Ramon, California 94583

APPLIED TECHNICAL SERVICES

Non Destructive Examination

3400 Crow Canyon Road, San Ramon, CA 94583

Robert de Haas

(925) 866-5849

Cell (209) 480-1063

NONDESTRUCTIVE EXAMINATION DATA

Location and Unit No:	Modesto, Line 147 pipe spool	**Examination Date:**	08/29/2013	**Job**	08607-01K
Client Contact:	Joe Medina	**Examiner(s):**	Robert de Haas		
Manufacturer:	N/A				

INTRODUCTION: At the request of Joe Medina, Director Transmission Process and MAOI, Ultrasonic thickness measurements were taken on a pipe spool, stored in the Modesto pipe storage yard.

COMPONENT EXAMINED: 20" Diameter pipe spool removed from Line 147, (T-43A), MP 1.951.

Pipe spool markings: Line 147
T-43A-11-B, Loc B
Lat. 37.4878247306 / Lon. 122.2701966194

EXAMINATION METHOD: Ultrasonic Thickness Measurements (UTT)
Procedure – ATS-UT-302, Rev 3
Panametrics – EPOCH4, Sn. 21417606
Aerotech Alpha HP - 0.25" diameter, 10 mHz transducer, Sn. G10507
Calibration block – Panametrics 2214E, Sn. 8840
Pipe surface condition – Flash rust

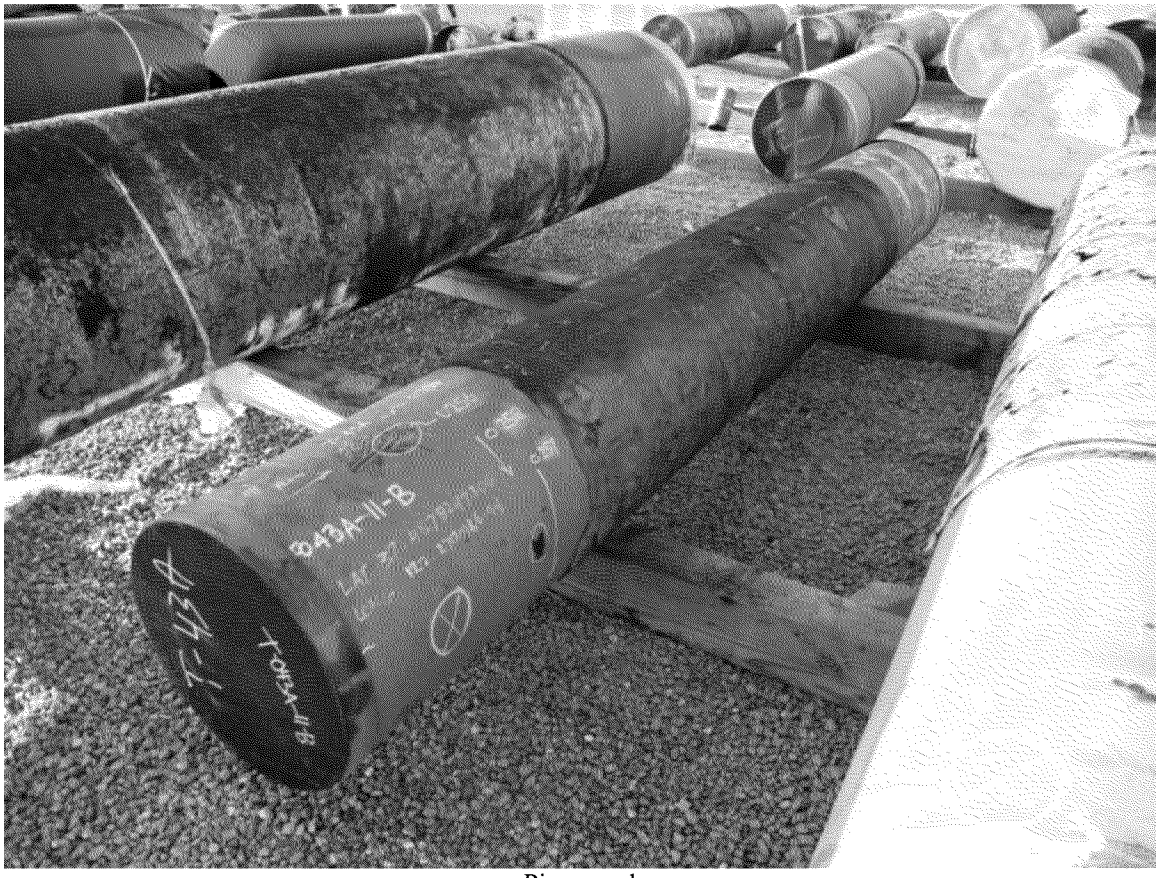
EXAMINATION RESULTS: UT readings showed a pipe wall thickness range of 0.25". Wall thickness readings were taken at four points on the pipe circumference, 90° apart. One additional reading was taken at a polished area where previous pipe grade testing was performed on the upstream end of the spool.

U/S end

Clock position	**12:00**	**03:00**	**06:00**	**09:00**
	0.256"	0.258"	0.257"	0.247"
Polished area	0.256"			

D/S end

Clock position	**12:00**	**03:00**	**06:00**	**09:00**
	0.251"	0.253"	0.254"	0.247"



Pipe spool

Upstream end on spool

Downstream end of spool

EXHIBIT D

GE ENERGY
Industrial Solutions

INSPECTION SERVICES
Pipeline Integrity Team
CWA # 2500461774
GEIS Job # LAPI0015

IN-FIELD SERVICES

GEIS Pipeline Integrity Team NDE

Pacific Gas & Electric Company

Hydrostatic Test Dig from October 7, 2011 to November 5, 2011

T43A/B_L147_B _MP-1.95

Documents Contained Within:

H-Form Report T43A/B_L147_B MP-1.95

NDE Reports of T43A/B_L147_B MP-1.95

Photo Report of T43A/B_L147_B MP-1.95

Authors: H. Mayer & J. Hayes

Date: December 2, 2011

Form H: Direct Examination Data Sheet - Page 1 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation:	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes			Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

Excavation Priority: [ ] Immediate [ ] Scheduled (For ILI - [ ] 1 Year [ ] Other) [ ] Monitor [ ] Effectiveness [X] Hydro Test

Excavation Reason [ ] ECDA [ ] ILI [ ] Recoat [ ] ICDA [ ] Other NA

If practical, take P/S or CIS reads before excavation: NA

Excavation Details:

U/S Ditch Start GPS Coordinates (Uncorrected Field Measurement)
Northing: 37.4878247306 PDOP: NA
Easting: -122.2701986194 Acc~: NA
Planned Excavation Length (Ft.): NA
Actual Excavation Length (Ft.): 21.0ft

Centerline GPS Coordinates (Uncorrected Field Measurement)
Northing: NA PDOP: NA
Easting: NA Acc~: NA
GPS File Name: Guida 148T4313

D/S Ditch End GPS Coordinates (Uncorrected Field Measurement)
Northing: 37.4878664944 PDOP: NA
Easting: -122.2702163300 Acc~: NA

1.0 Data Before Coating Removal

1.1 Native Soil Type: [X] Clay [X] Rock [X] Sand [ ] Loam [ ] Wet [ ] Other NA
1.1A Backfill Material Found: [ ] Silt [ ] Slurry [ ] Native Depth of Cover (Ft.): 6.00ft
Comments: NA

1.2 Coating Type: [X] HAA [ ] Somastic [ ] Plastic Tape [ ] Wax Tape [ ] FBE [ ] Powercrete
[ ] Bare/None [ ] Coal Tar [ ] Other: NA Comments: NA
Coating Thickness (Inches): 0.250in Number of Layers: 2

1.3 Holiday Testing Performed?: [ ] Yes [X] No Voltage Used: NA Map Location of Holidays Below.
Device Used: [ ] Coil [ ] Wet Sponge Comments: NA

1.4 Pipe-to-Soil Potentials in Ditch (-mV):

	12:00	3:00	6:00	9:00
US:	-526	-530	-535	-526
DS:	-661	-658	-640	-663

Comments: CP appears to be very low, may be turned off at time of inspection.

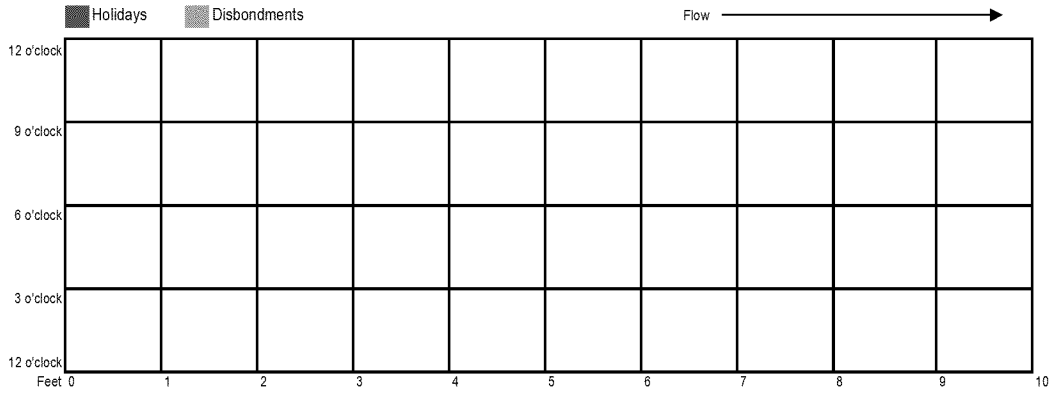
1.5 Soil Resistivity in Ditch (Ω-cm):
Method: [X] 4-Pin 24469.5 ohm/cm [ ] Soil Box NA
Comments: NA SRM-100 US: N/A DS: N/A

1.6 Soil Sample Location Comments: Ditch end (DS) 6:00 position under pipe.

1.7 Ground Water Present?: [ ] Yes [X] No Sample(s) Collected?: [ ] Yes [X] No Sample pH: NA
Comments: NA

1.8 Coating Condition: [X] Good - Adhered to Pipe [ ] Fair - Coating Partially Disbonded or Degraded [ ] Poor - Coating Significantly Disbonded or Missing
Comments: Coating removed & tie in weld areas blasted. Pipe section removed and test pipes installed. Removed pipe section was also assesed and was in good conition except for coating damage from removal and transportation. See comments page 10.

1.9 Map of Coating Degradation*: **Zero Reference Point:** US Exposed Pipe 360 degrees
*Note any calcareous deposit locations



CaCO3	- Calcareous deposits containing calcium
FeO	- General iron oxide with scale
3 FeCO3	- Calcareous deposits containing iron

Form H: Direct Examination Data Sheet - Page 2 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

1.10 Photos Taken?*: [X] Yes [ ] No
*See Photo Log for additional information.

1.11 Coating Sample Taken?: [ ] Yes [X] No Location of Sample: NA

1.12 Liquid Underneath Coating?: [ ] Yes [X] No If Yes, pH of Liquid: NA

1.13 Corrosion Product Present?: [ ] Yes [X] No If Yes, Was Sample Taken?: [ ] Yes [X] No
Comments: NA

1.14 Soil pH (Sb Electrode): Upstream: 6.0 Downstream: 7.5 Pipe pH: 6.0

2.0 Data After Coating Removal

2.1 Pipe Temperature (°F): 60.0° F **Measured Pipe Diameter (In.):** 63" = 20.05"

2.2 Weld Seam Type: [ ] DSAW [ ] SSAW [ ] ERW [ ] SMLS [ ] Spiral [ ] Lap [ ] Flash [X] AO Smith [ ] IF CAN'T DETERMINE, VISUALLY PERFORM MACROETCH & LOCATE

2.3 Girth Weld Coordinates & Identify Type (See Table 5.7.3):
Northing: NA PDOP: NA
Easting: NA Acc~: NA LS Weld Clock Position(s): 8:55
Elevation: NA

2.4 Damage Found:
Corrosion Damage [ ] Yes [X] No Mechanical Damage [ ] Yes [X] No
Other Damage: Non relevant tool marks, no corrosion found greater than 20%

2.5 UT Wall Thickness Measurements:

	US / DS		US / DS		US / DS		US / DS
TDC:	0.270"/0.275"	1 O'clock	0.267"/0.272"	2 O'clock	0.267"/0.271"	3 O'clock	0.265"/0.271"
4 O'clock	0.268"/0.270"	5 O'clock	0.266"/0.271"	6 O'clock	0.268"/0.273"	7 O'clock	0.266"/0.272
8 O'clock	0.269"/0.269"	9 O'clock	0.261"/0.263"	10 O'clock	0.266"/0.264"	11 O'clock	0.269"/0.270"

UT Wall Thickness Grid @ 6:00 is required. Be sure to attach grid to H-Form electronically. See page 6 of 10.

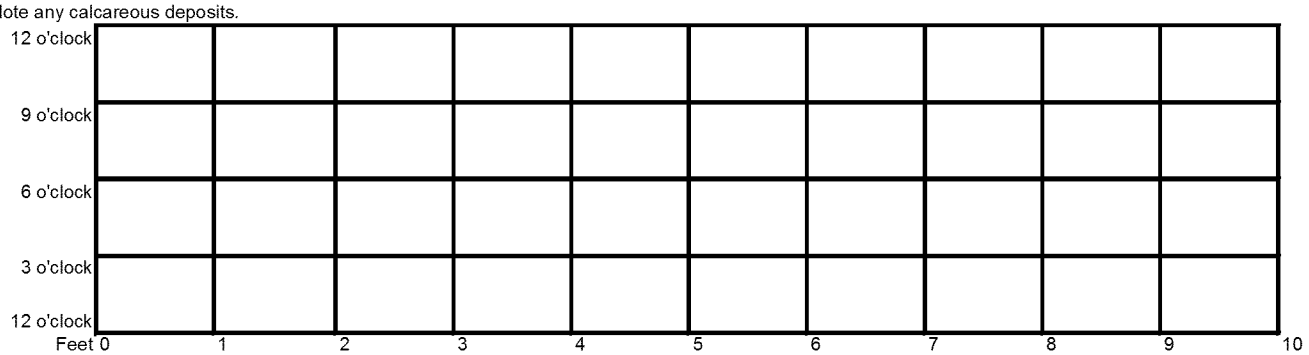
2.6 Wet Fluorescent Mag. Part. Is Required. Comments: 2 linear indications on the removed pipe section. See MT & Photo report.
Were there any linear indications? [X] Yes [ ] No If Yes, attach NDE report electronically as part of the H-Form. Report to include black light and white light photos of indications.

2.7 Take Photos to Document Corrosion and Other Anomalies*
*See Photo Log for additional information.

2.8 Overview Map of Corroded Area*:
*See Pit Depth Measurement Grid for additional Information **Zero Reference Point:** US Exposed Pipe 360 degrees

Flow →

*Note any calcareous deposits.

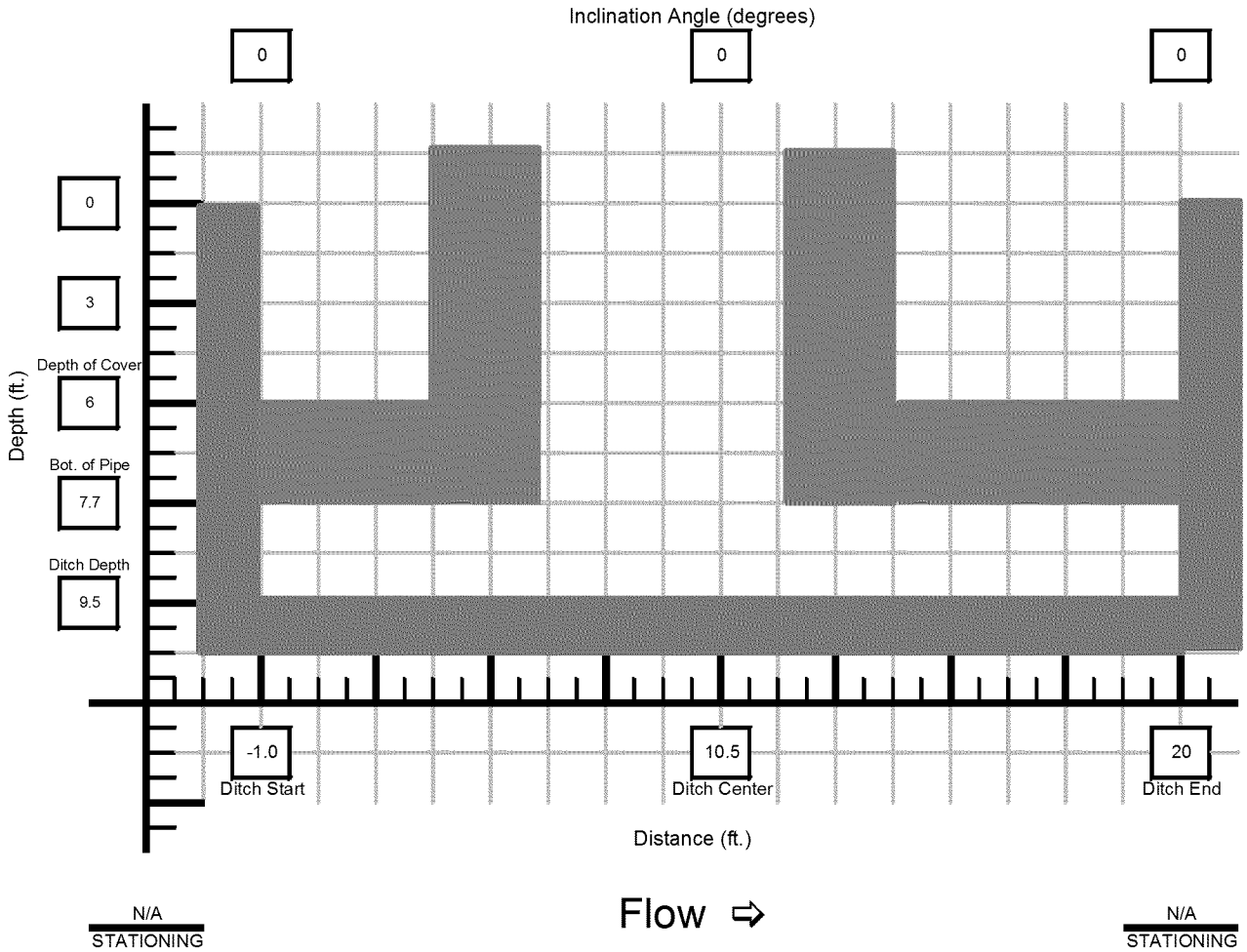


Form H: Direct Examination Data Sheet - Page 3 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

Excavation Drawing:

At minimum draw pipe elevation profile and indicate stationing of 1) low point and 2) critical inclination angle.
Place an arrow on the drawing indicating direction of gas flow in the region(s). Other labels may also be added (e.g. "to Station").



NOTES: (Record stationing and names of nearby landmarks such as creeks and roads. Provide any additional information that may help in spatially positioning pipe):

**See attached Delorme screen shot on page 11.

Form H: Direct Examination Data Sheet - Page 5 of 10

EXTERNAL PIT DEPTH MEASUREMENT GRID SHEETS

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.95	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

.001 - .009
.010 - .099
.100 - .199
.200 - .299
Highest pit reading

Grid Size = _____ Inch x _____ Inch (specify grid size)
Clock Position (specify below)

Anomaly # NA Grid # NA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A																						
B																						
C																						
D																						
E																						
F																						
G																						
H																						
I										NA												
J																						
K																						
L																						
M																						
N																						
O																						
P																						
Q																						
R																						
S																						
T																						
U																						
V																						
W																						
X																						

PIT DEPTH GRID 1 OF 2

Form H: Direct Examination Data Sheet - Page 5 of 10

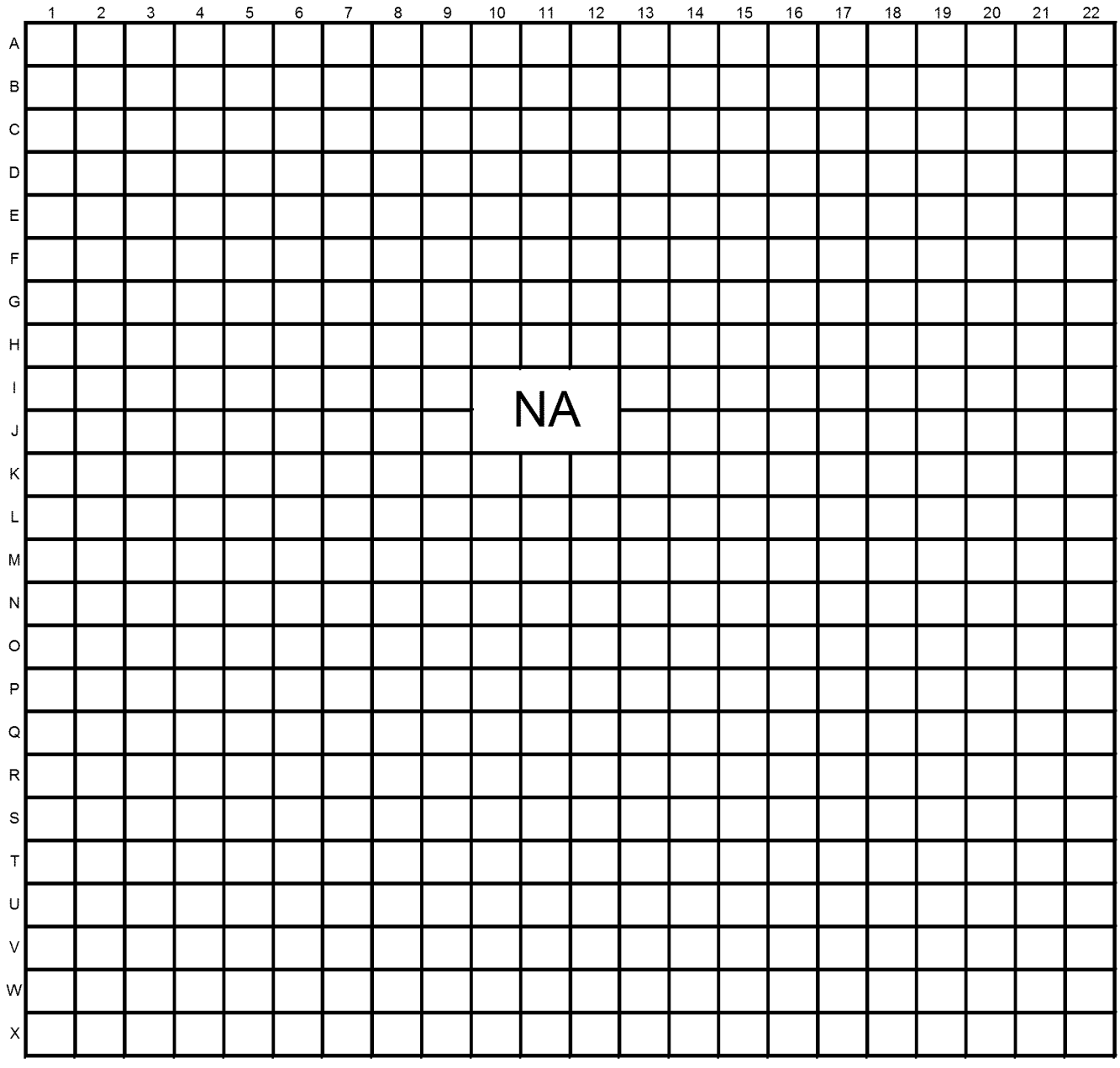
EXTERNAL PIT DEPTH MEASUREMENT GRID SHEETS

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.95	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

.001 - .009
.010 - .099
.100 - .199
.200 - .299
Highest pit reading

Grid Size = _____ Inch x _____ Inch (specify grid size)
Clock Position (specify below)

Anomaly # NA Grid # NA



PIT DEPTH GRID 2 OF 2

Form H: Direct Examination Data Sheet - Page 6 of 10

INTERNAL CORROSION WALL LOSS GRID

DA/ILI		DA		ILI	
Route Number:	L-147	**Site Designation**	T43A/B_B	**ILI Log Distance:**	NA
Date of Excavation:	10/7/2011	**N-Segment:**	NA	**RMP-11 Ref. Section:**	Table 5.6.2
Mile Point:	1.95	**IMA Number:**	NA	**Reference Girth Weld:**	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	**Distance From Girth Weld:**	NA
PG&E Project Manager:	Donovan Fink	**Region Number:**	NA		
Approved By:	Kenji Gailey	**Subregion # (ICDA):**	NA		
Order Number:	41497360	**Stationing:**	NA		

Grid Size = 1 Inch x 1 Inch
Clock Position (specify below)
All measurements are in inches.

UT Grid is centered @ 6:00 position on pipe.

	1	2	3	4	5	6	7	8	9	10	11	12
A	0.251"	0.251"	0.249"	0.249"	0.249"	0.249"	0.249"	0.248"	0.248"	0.248"	0.248"	0.248"
B	0.251"	0.254"	0.251"	0.251"	0.249"	0.249"	0.249"	0.249"	0.248"	0.248"	0.248"	0.249"
C	0.253"	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.249"	0.249"	0.248"	0.249"	0.249"
D	0.251"	0.251"	0.251"	0.251"	0.251"	0.249"	0.250"	0.249"	0.249"	0.248"	0.247"	0.249"
E	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.251"	0.247"	0.248"	0.247"	0.248"
F	0.251"	0.251"	0.251"	0.251"	0.249"	0.249"	0.251"	0.249"	0.249"	0.247"	0.248"	0.249"
G	0.251"	0.251"	0.247"	0.246"	0.249"	0.248"	0.247"	0.247"	0.246"	0.247"	0.248"	0.247"
H	0.248"	0.249"	0.249"	0.249"	0.248"	0.247"	0.247"	0.247"	0.246"	0.246"	0.246"	0.246"
I	0.249"	0.249"	0.249"	0.249"	0.247"	0.246"	0.244"	0.247"	0.244"	0.244"	0.247"	0.246"
J	0.247"	0.247"	0.247"	0.246"	0.246"	0.246"	0.242"	0.244"	0.244"	0.243"	0.244"	0.246"
K	0.247"	0.247"	0.247"	0.246"	0.246"	0.246"	0.244"	0.244"	0.244"	0.244"	0.244"	0.246"
L	0.249"	0.247"	0.247"	0.247"	0.248"	0.248"	0.248"	0.242"	0.244"	0.244"	0.246"	0.244"

INTERNAL CORROSION GRID
1 of 1

Form H: Direct Examination Data Sheet - Page 7 of 10

COATING DAMAGE

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

NO.	FEET FROM REFERENCE	O'CLOCK	MAX LENGTH (IN.)	MAX CIRC EXTENT (IN.)
NA	NA	NA	NA	NA

CORROSION LOG

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

IC or EC	FEET FROM REFERENCE	O'CLOCK	MAX PIT DEPTH (MILS)	MAX LENGTH (IN.)	MAX CIRC EXTENT (IN.)
NA	NA	NA	NA	NA	NA

Form H: Direct Examination Data Sheet - Page 9 of 10

PHOTO LOG

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

PHOTO NO.	LOCATION	DESCRIPTION	COMMENTS
****See attached photo report.			

SB_GT&S_0267335

Form H: Direct Examination Data Sheet - Page 10 of 10

DA/ILI		DA		ILI	
Route Number:	L-147	Site Designation	T43A/B_B	ILI Log Distance:	NA
Date of Excavation:	10/7/2011	N-Segment:	NA	RMP-11 Ref. Section:	Table 5.6.2
Mile Point:	1.95	IMA Number:	NA	Reference Girth Weld:	NA
Examination Performed By:	H. Mayer/J. Hayes		NA	Distance From Girth Weld:	NA
PG&E Project Manager:	Donovan Fink	Region Number:	NA		
Approved By:	Kenji Gailey	Subregion # (ICDA):	NA		
Order Number:	41497360	Stationing:	NA		

3.0 RECOAT DATA

3.1 Sandblast Media: Sharp Shot 30/60 **Anchor Profile Measurement:** Average: 3.2 mils

3.2 Pipe Recoated With:

☐ Powercrete J ☒ Poly Tape ☐ Bar-Rust 235 ☐ Dev Grip 238 ☐ Dev Tar 247 ☒ Protal 7200 ☐ PE Tape

3.3 For Epoxy Coating Systems, Record Environmental Condition:

Air Temperature: 62.4°F Dew Point: 45.1°F
Pipe Temperature: 67.0°F Relative Humidity: 51.4%
Time of Day: 12:30 pm

3.4 Repair Coating Hardness (If ARC Coating:)

	3:00 -	6:00 -	9:00 -	12:00 -
US	82	79	79	79
DS	79	75	79	81

3.5 Measured Coating Thickness:

	3:00 -	6:00 -	9:00 -	12:00 -
US	33.7	38.7	57.5	27.4
DS	37.3	28.6	39.0	29.3

Holiday Tested?: ☒ Yes ☐ No

Device Used: ☐ Coil ☐ Wet Sponge Voltage Used: UNK Repair All Holidays. YES

3.6 Coupon Test Station Installed?: ☐ Yes ☒ No **ETS Installed?:** ☐ Yes ☒ No

If Yes, Date Installed: NA

Surface Configuration:: ☐ Fink ☐ G-5 Box ☐ Carsonite ☐ Other: NA

3.7 Backfill Material: ☐ Native ☐ Imported Sand ☐ Other: NA

Coating Protections?: ☒ Yes ☐ No

If Yes, Check One: ☐ Rockguard ☐ Tuf-E-Nuf ☐ Conwed ☐ Other: STACguard (transitions only)

3.8 Pipe-to-Soil Readings Over Bell Hole After Backfill: NA

*If specified, a CIS should be done for approximately 100' on either side of the bell hole. Attach data.

Comments: NA

3.9 Attach site sketch of excavation site.

4.0 REPAIR DATA

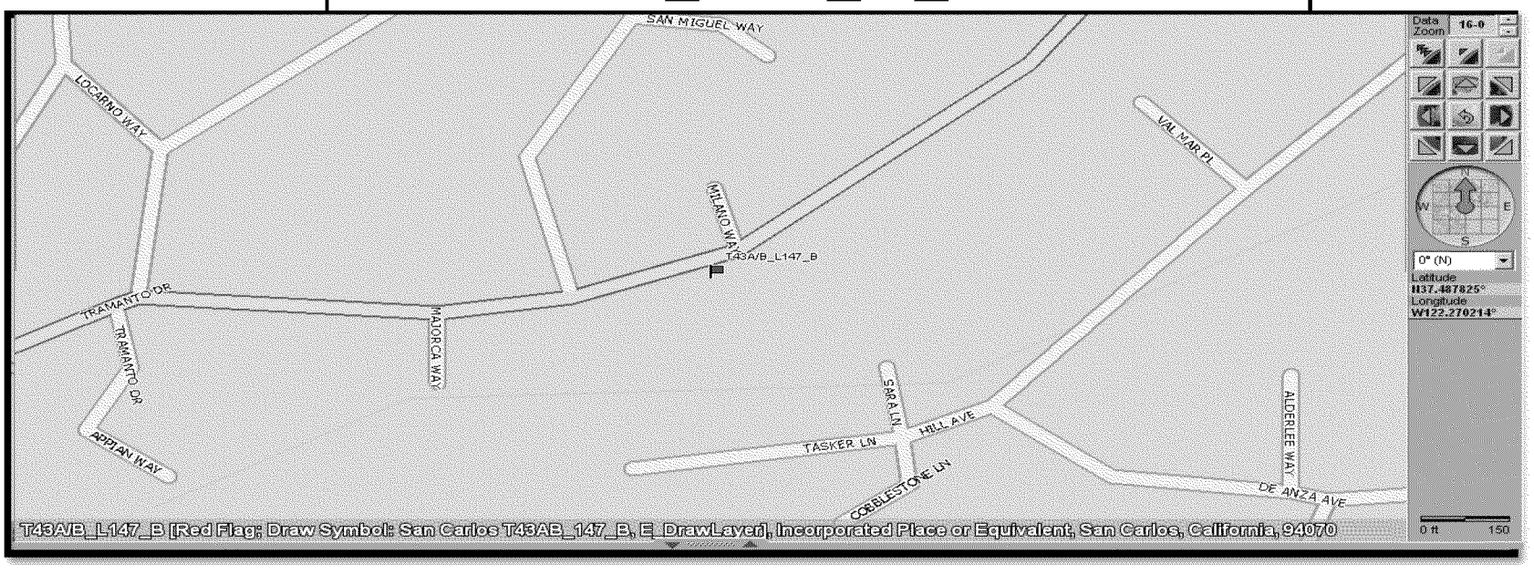
4.1 Repair Made: ☐ Yes ☒ No **4.2 Number of Repair Made:** Replacement "In-Kind configuration"

4.3 Repair Type ☐ Metallic Sleeve ☐ Non Metallic Sleeve ☐ Replace ☐ Can ☐ Filler Metal ☐ Other

4.4 Damage Repaired: ☐ Corrosion ☐ Mechanical ☐ Other

Misc. Comments/Information: T43A had coating removed, area for inspection was blasted from coating up to test pipe tie in weld. About 1 ft of coating was inspected. T43B had coating removed, area for inspection was blasted from coating up to test pipe tie in weld. About 1.5 ft of coating was inspected. Removed pipe section was inspected at the PG&E yard.

T43A/B_L147_B _MP-1.95



GE Energy
INSPECTION & LIFE EXTENSION SERVICES

MAGNETIC PARTICLE EXAMINATION REPORT

☐ Nuclear ☑ Non-Nuclear

To:	From:	Date:
Pacific Gas & Electric Company	H. Mayer/J. Hayes	10/7/2011

Project: **T43A/B_L147_B_MP-1.95**

Purchase Order No:	GEIS Job No:
41497360	LAPI0015

Item

Weld	Structural	Casting	Machinery	Mach. Parts	Pipe	N/A	Other:
☑	☐	☐	☐	☐	☑	☐	N/A

Non-Weld	Plate	Pipe	Bar	Casting	Mach. Parts	N/A	Other:
☑	☐	☑	☐	☐	☐	☐	N/A

Material

Size	Material Thickness	Type of Base Material	Type of Filler Material	Weld
20"	0.250"	Carbon Steel	C/S	☑ N/A ☐ Smooth ☐ As Welded

Location	System
70.6 Ft SW of the intersection of Brittan Ave and Milano Way in San Carlos, CA 94070	L-147

Acceptance Standards	Procedure
Customer Specifications	GEIS QCP # 500 Rev 17

Type of Check

Initial	Plate Edge	In Process	Back Gouge	Root Pass	Repair	12 Hour	24 Hour	Final
☑	☐	☐	☐	☐	☐	☐	☐	☑

Type of Inspection

☐ Longitudinal	☐ Coil	☐ DC Probe	☑ Continuous	Other:
☑ Wet	☐ Dry	☐ Direct Contact	☑ Residual	
☐ Circular	☐ AC Prod	☑ Yoke	☐ Other	

MT Yoke & Model - Serial No. / Blacklight Model - Serial No.	Surface Preparation Method
Parker DA-400 - S# 18830 / Spectroline BIP - S# 1597251	Abrasive Blasting (Kleen Blast) - NACE 2 Finish
Inspection Medium / Color / Batch No.	**Demagnetization Method / Equipment**
Magnaglo 14A / Flourescent Green / 09M12K	N/A

Reference: Summary ☑ See Attachment

The following areas were requested to be inspected:	Results of Inspection
Bare pipe: -0.40' to 1.35' from original U/S ditch start.	- No relevant indications found @ time of insp.
Bare pipe : 17.4' to 18.45' from original U/S ditch start.	- No relevant indications found @ time of insp.
Removed pipe section.	2 Linear indications were found.

Summary:

Lin-01: Axial Start=1.60' (From U/S end of pipe), AL=1.58" , CW=0.020" , CLK Position= 4:00
Lin-02: Axial Start=2.33' (From U/S end of pipe), AL=1.20", CW=0.020", CLK Position= 4:06
These are on the removed pipe section.

Indications were on the removed pipe section. Please see attached photo report for additional information.

Copy To:	Requested By:	Reported By (Technician):
Pacific Gas & Electric Company	David Aguiar	H. Mayer/J. Hayes
GE Inspection Services (Los Angeles)	☑ Customer Specifications ☑ Accept ☐ Reject	NDT supervisor: Andre J. Filiatrault

NOTICE: THIS EXAMINATION REPORT IS A REPORT OF THE RESULTS OF THE NDT PROCEDURE ACTUALLY PERFORMED BY THIS COMPANY IT IS SUBJECT TO THE LIMITATIONS OF THE TESTING SPECIFICATIONS AND PROCEDURES WHICH WERE UTILIZED. BY FURNISHING THIS REPORT, ***GE INSPECTION & LIFE EXTENSION SERVICES*** DOES NOT GUARANTEE ANY CONDITION OF THE TESTED SPECIMEN.

GE Energy

Inspection & Life Extension Services

ULTRASONIC EXAMINATION REPORT

☐ Nuclear ☑ Non-Nuclear

To:	From:	Date:
Pacific Gas & Electric Company	H. Mayer & J. Hayes	10/7/2011

Project: **T43A/B_L147_B_MP-1.95**

Purchase Order No:	GEIS Job No:
41497360	LAPI0015

Item

Weld	Structural	Casting	Machinery	Mach. Parts	Pipe	N/A	Other:
☑	☐	☐	☐	☐	☑	☐	

Non-Weld	Plate	Pipe	Bar	Casting	Mach. Parts	N/A	Other
☑	☐	☐	☐	☐	☐	☐	

Material

Size:	No. of Pieces	Type of Base Metal	Type of Filler Material	Weld
20"	1	Carbon Steel	C/S	☑ N/A ☐ Smooth ☐ As Welded

Location	System
70.6 Ft SW of the intersection of Brittan Ave and Milano Way in San Carlos, CA 94070	L-147

Acceptance Standards	Procedure
Customer Specifications	QCP-601

Type of Inspection

Soundness	Thickness	Bond
☑	☑	☐

Pulse Echo	Angle-Beam	Other
☑	☐	☐

UT Equipment/Model
USN-60
Serial # 01NLKN
Calibration Date:
10/5/2011
Calibration Due: 1/5/2012

Transducer

☑ Single Crystal ☐ Dual Crystal

Frequency	Size	Angle	Transducer Serial No.:
5 MHz	0.375"	0°	020HFC

Flat	Concave	Convex	Couplant / Batch #
☑	☐	☐	Sonatest Ultragel II / 25-901 07225 AF

Standard	Material	Notch Depth	Serial No.:

Step Wedge ☑ / Tube Wedge ☐	Material	Thickness Range	Serial No.:
	C/S	0.200" - 0.500"	V34693

Reference: Summary ☑ See Attachment

The following areas were requested to be inspected:

12" x 12" (1"x1" grid) at a random 6:00 position on the pipe.

12" lamination scans at cut-line locations.

Thickness readings US & DS inspection areas at the clock positions.

*** Please see attached reports for additional information.*

Results of Inspection:

- No relevant indications @ time of inspection.
- No relevant indications @ time of inspection.
- No relevant indications @ time of inspection.

Copy To:
Pacific Gas & Electric Company
GE Inspection Services (Los Angeles)

Requested By: David Aguiar

☑ Customer Specifications

☑ Accept ☐ Reject

Reported By (Technician): H. Mayer/J. Hayes

NDT Supervisor: Andre J. Filiatrault

NOTICE:
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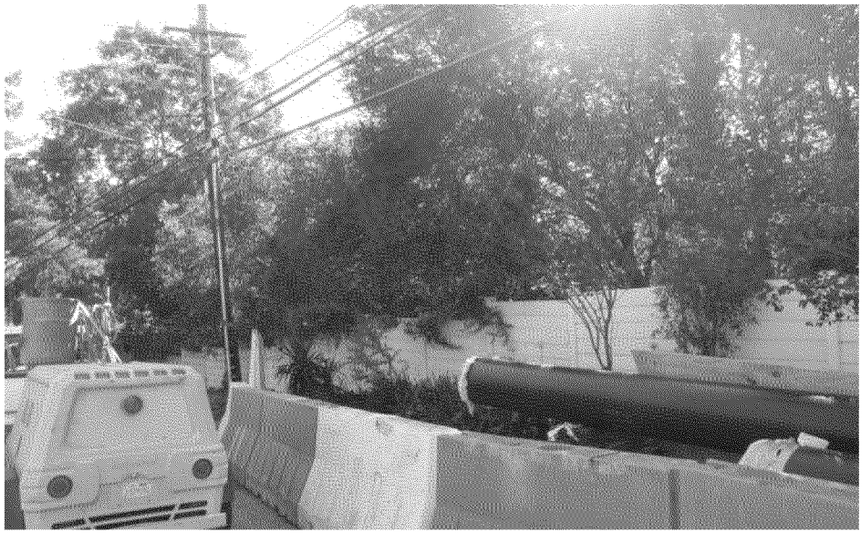
Topography looking upstream

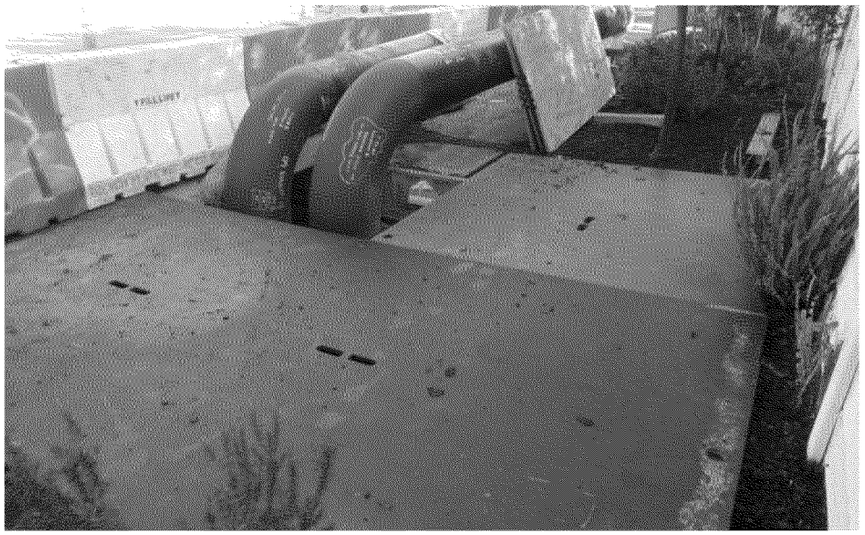
Topography looking downstream

Typical surrounding topography

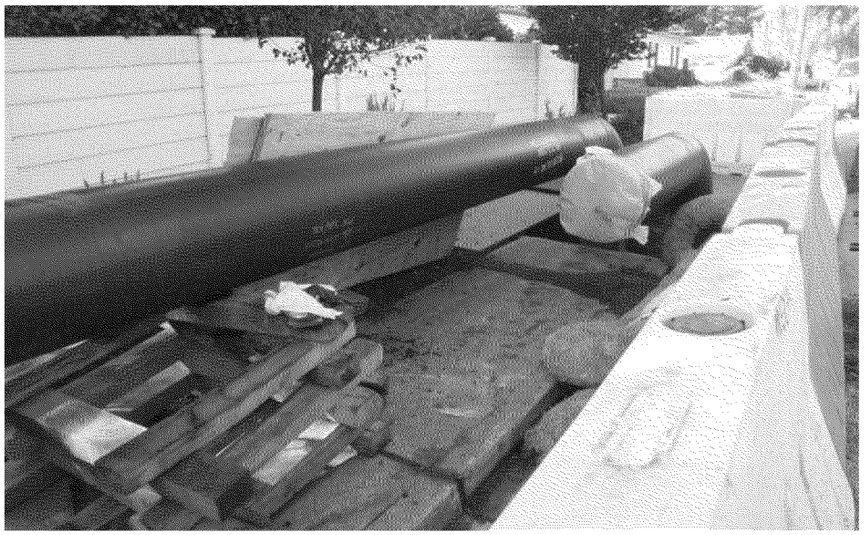


Typical surrounding topography

g



Overview of Dig Site T43A-B_L147_B_MP-1.89

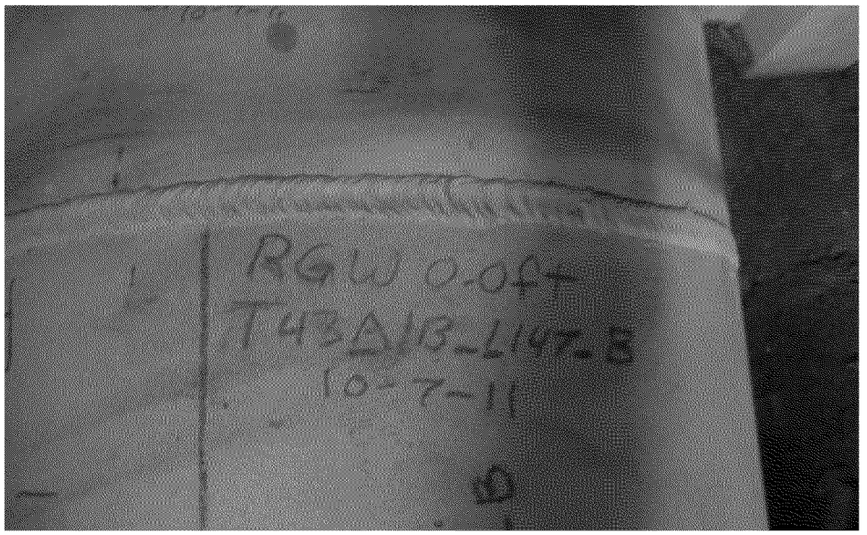


Overview of Dig Site T43A-B_L147_B_MP-1.89

Overview of T43A(US) & T43B(DS) in same excavation.

Closeup of T43A(US) & T43B(DS) in same excavation.

g



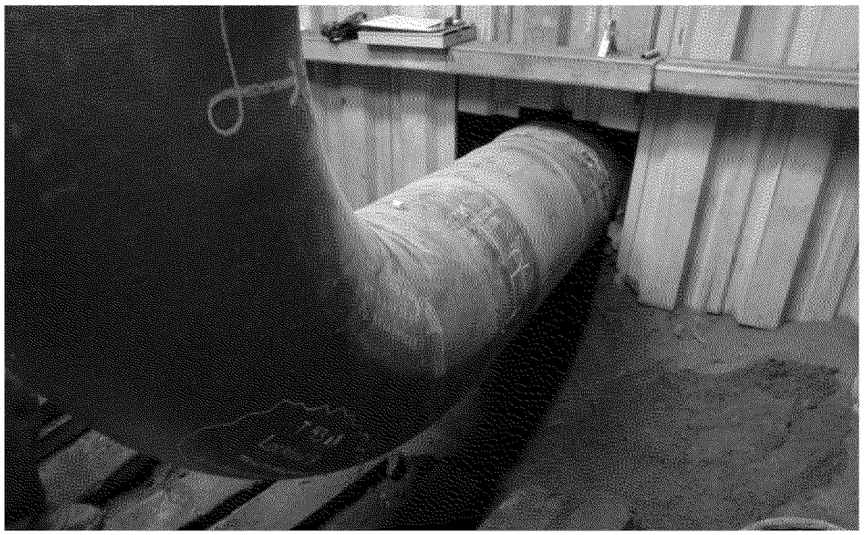
Overview of Reference Girth Weld measurments were taken from.

Overview of coating condition -1ft to 2ft, 3:00 position

Overview of coating condition -1ft to 2ft, 3:00 position

Overview of coating condition -1ft to 2ft, 9:00 position

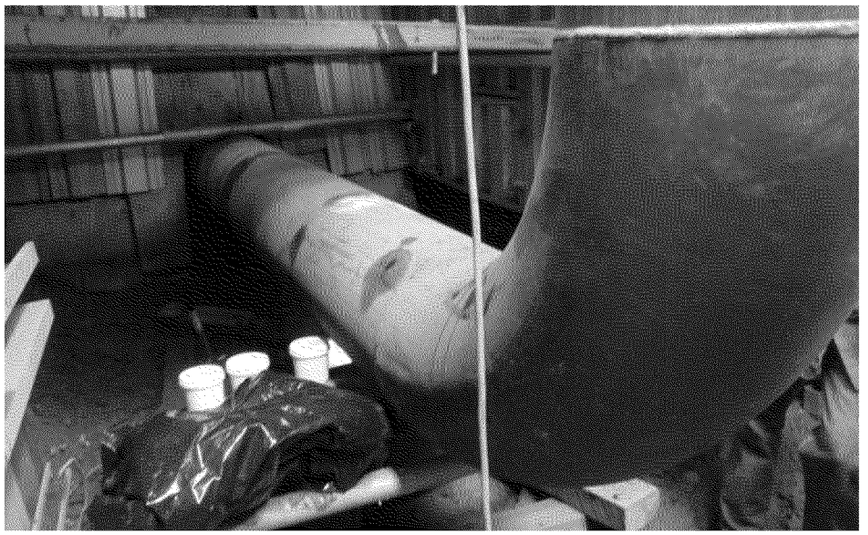
g



Overview of coating condition -1ft to 2ft, 9:00 position

Overview of coating condition 17ft to 20ft, 3:00 position

Overview of coating condition 17ft to 20ft, 3:00 position



Overview of coating condition 17ft to 20ft, 9:00 position

g

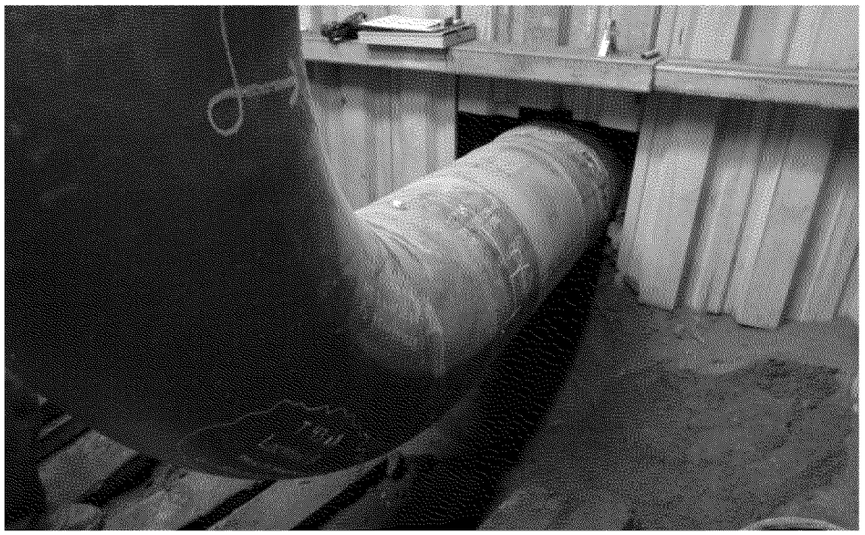
Overview of coating condition 17ft to 20ft, 9:00 position

Overview of MPI layout -1ft to 2ft, 3:00 position

Overview of MPI layout -1ft to 2ft, 3:00 position

Overview of MPI layout -1ft to 2ft, 9:00 position

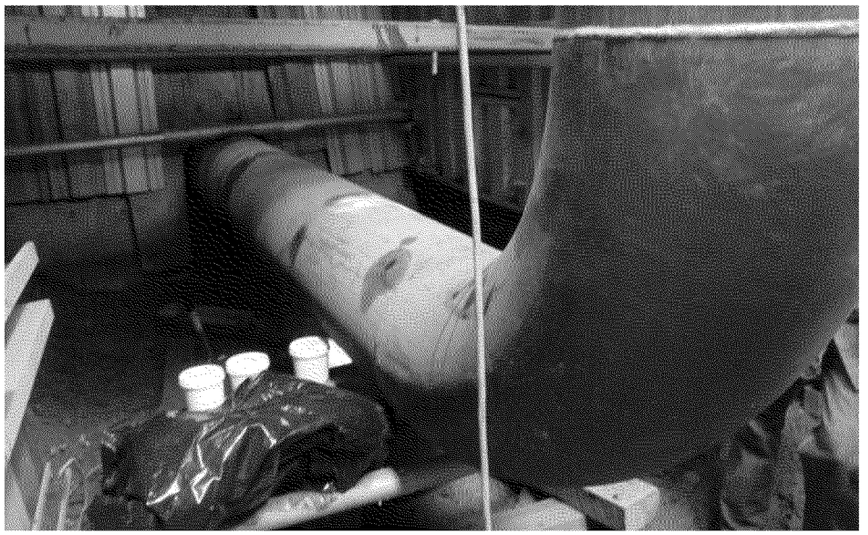
g



Overview of MPI layout -1ft to 2ft, 9:00 position

Overview of MPI layout 17ft to 20ft, 3:00 position

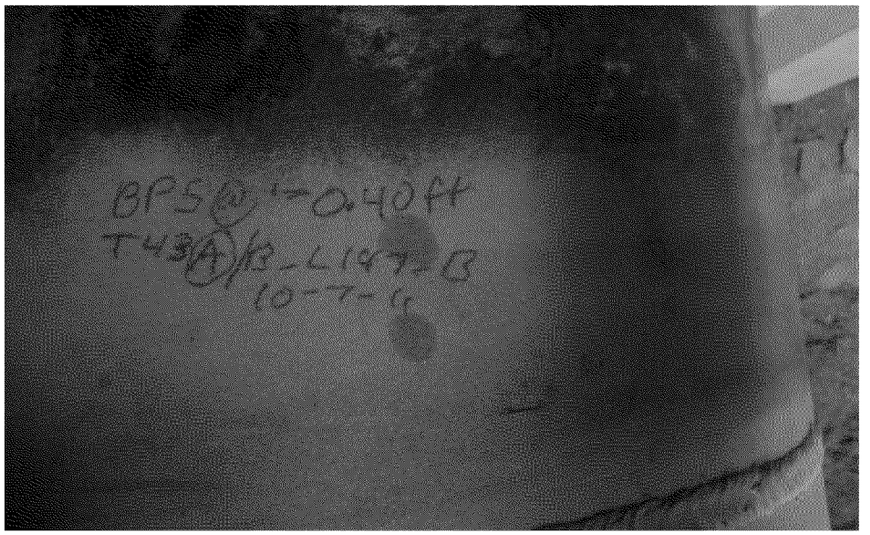
Overview of MPI layout 17ft to 20ft, 3:00 position



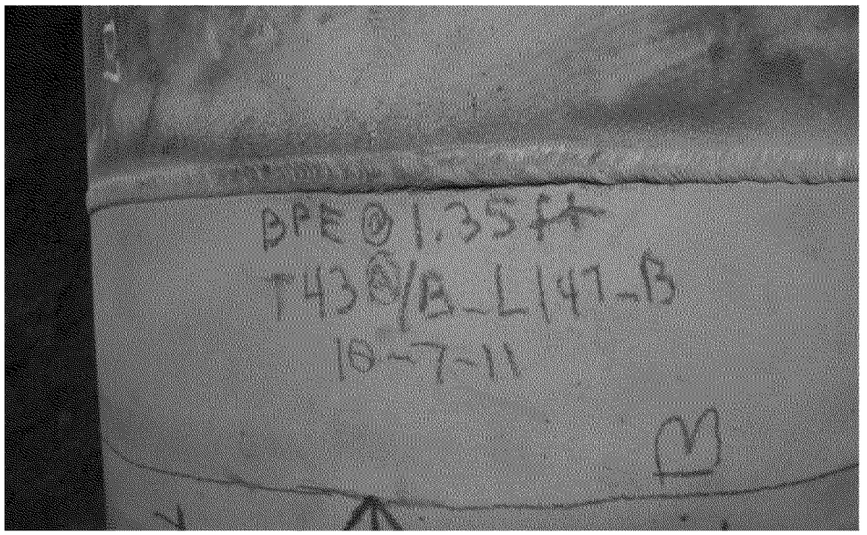
Overview of MPI layout 17ft to 20ft, 9:00 position

g

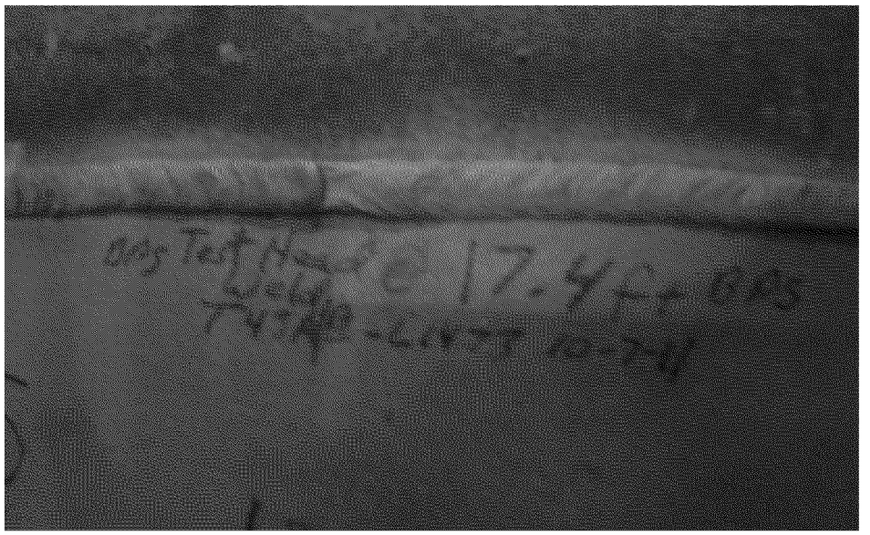
Overview of MPI layout 17ft to 20ft, 9:00 position



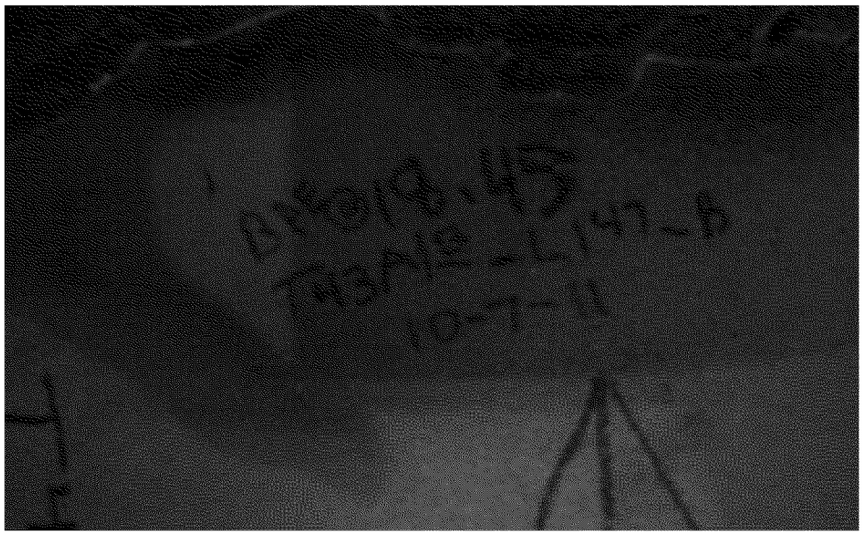
Overview of bare pipe start



Overview of bare pipe end

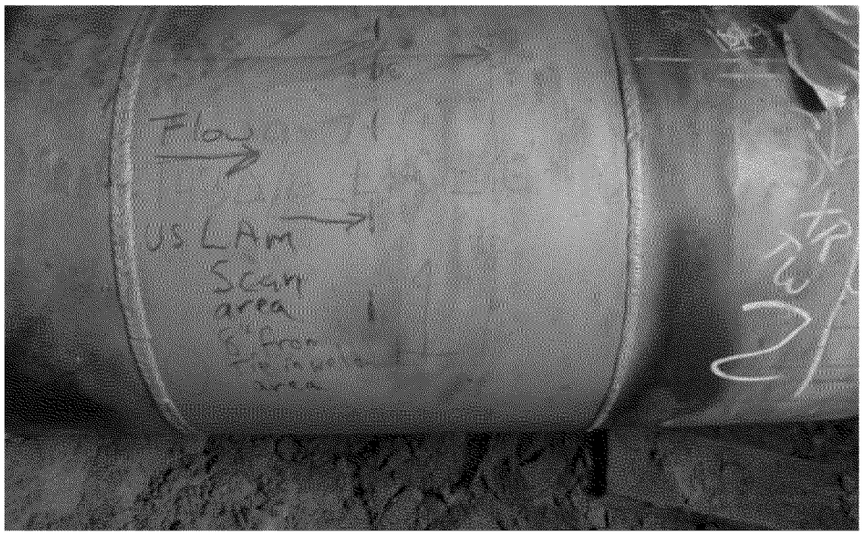


Overview of bare pipe start



Overview of bare pipe end

Overview of feature joint long seam @ 8:55



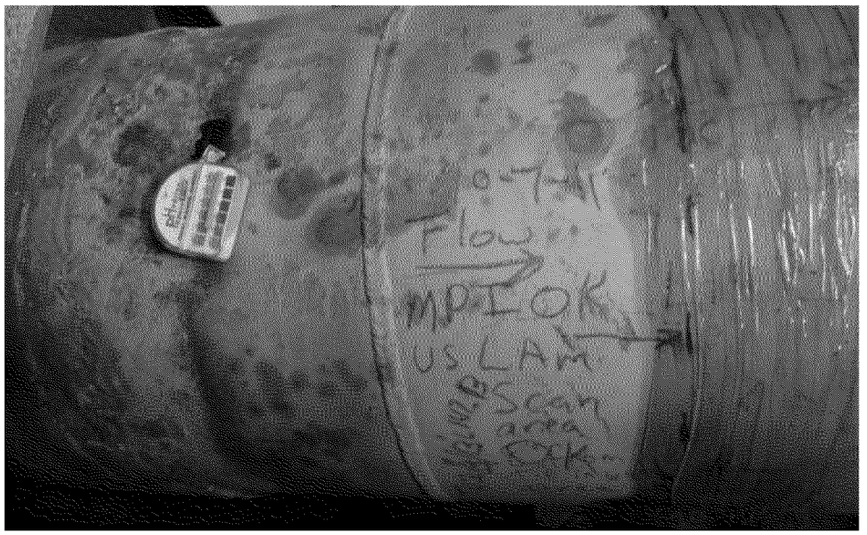
Overview of US lamination scan area.

Overview of DS lamination scan area.

g

Overview of US MPIOK and Lamination scan OK.

Overview DS of MPIOK and Lamination scan OK.



Overview of pipe Ph.

Closeup of pipe Ph.

g

Removed pipe section coating assesment 3:00

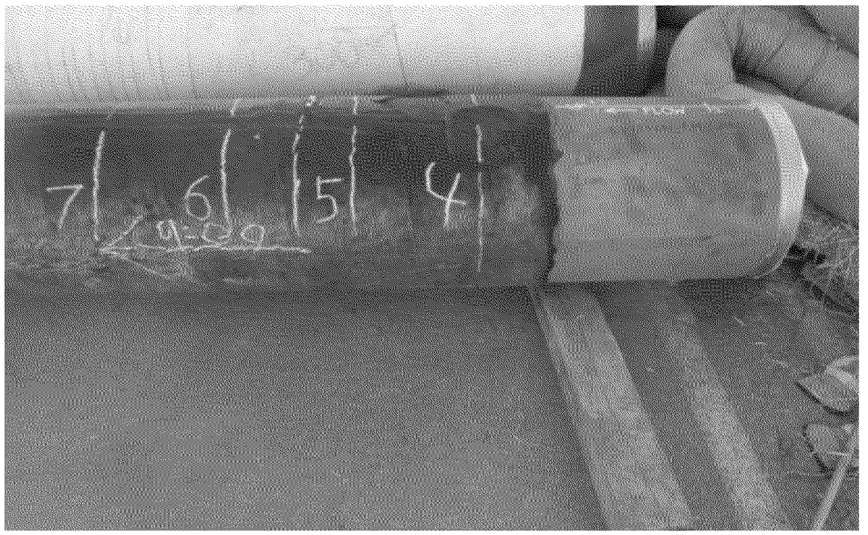
Overview of coating condition 3:00 position

Overview of coating condition 3:00 position

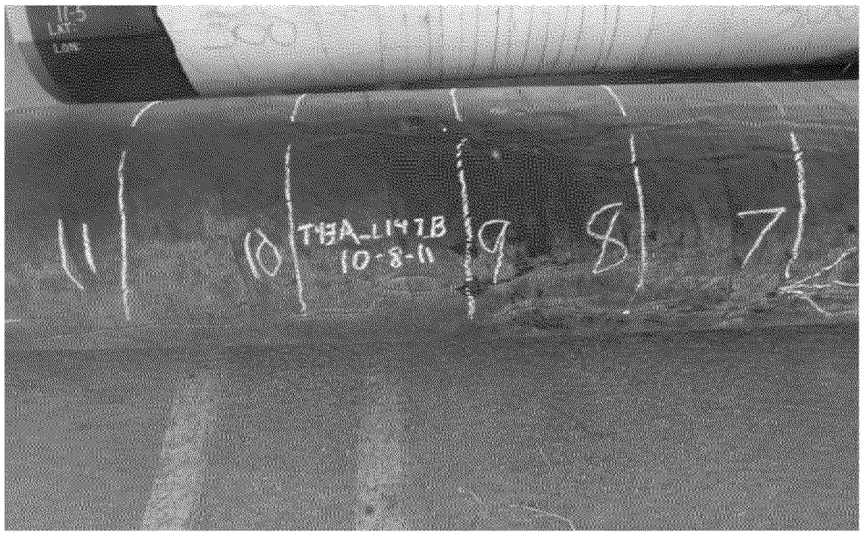
Overview of coating condition 3:00 position

g

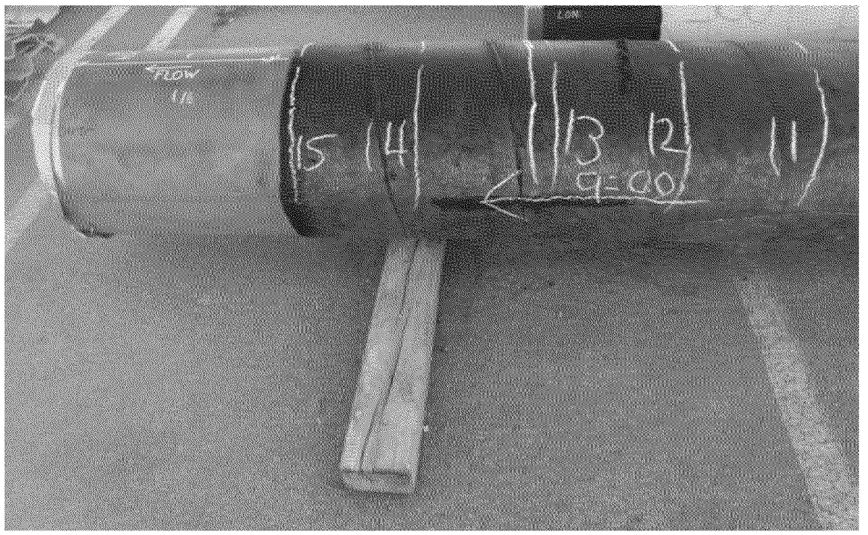
Removed pipe section coating assesment 9:00



Overview of coating condition 9:00 position

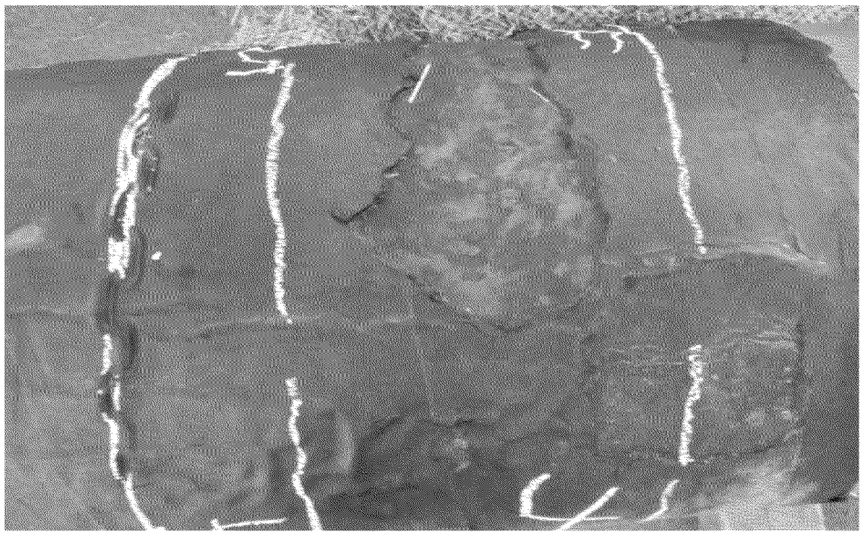


Overview of coating condition 9:00 position

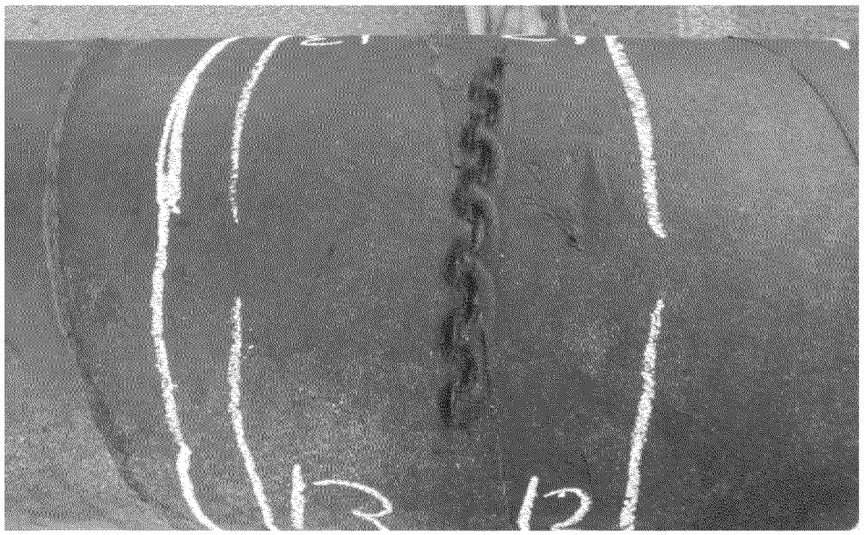


Overview of coating condition 9:00 position

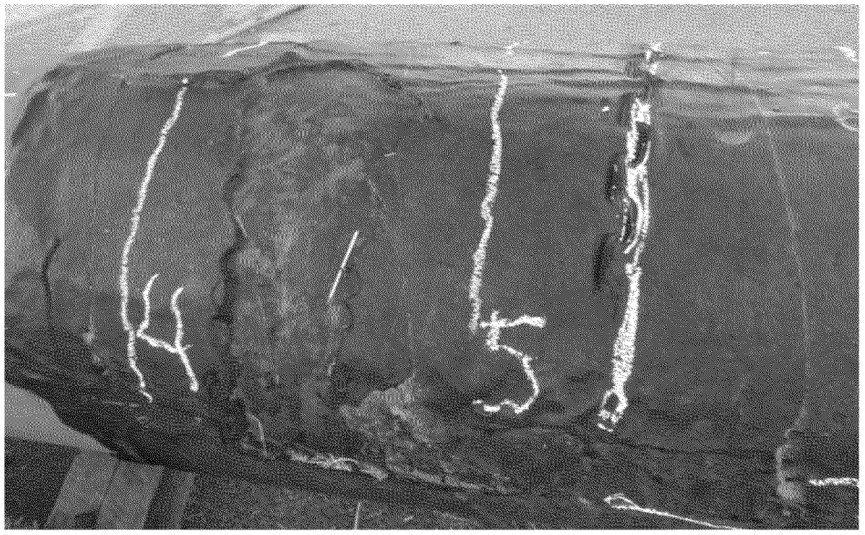
g



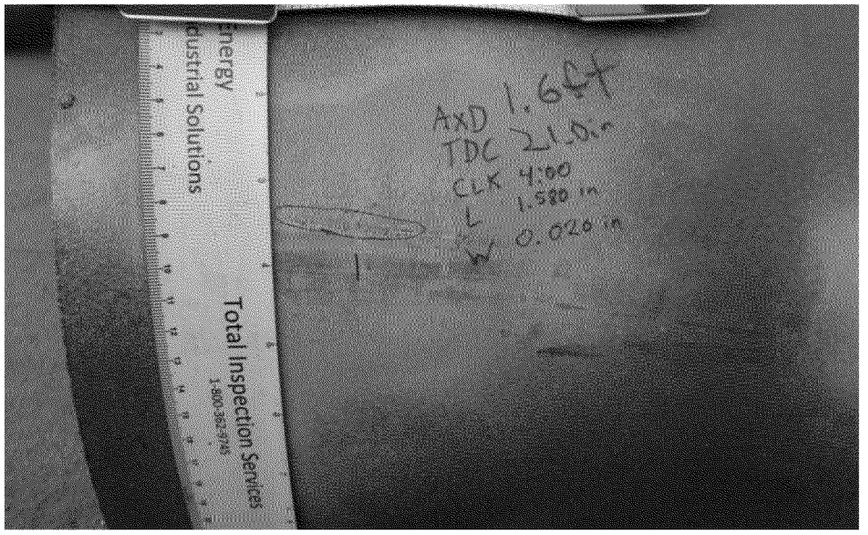
Coating damaged from removal process.



Coating damaged from removal process.

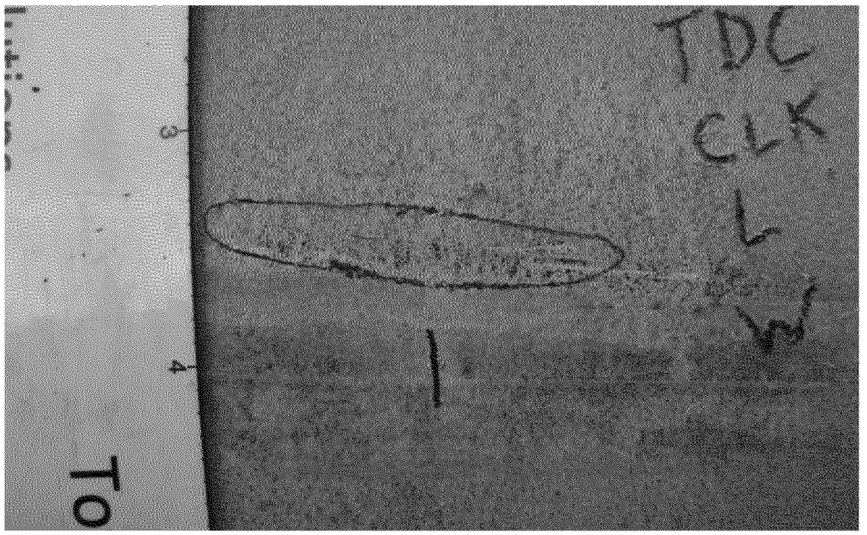


Coating damaged from removal process.

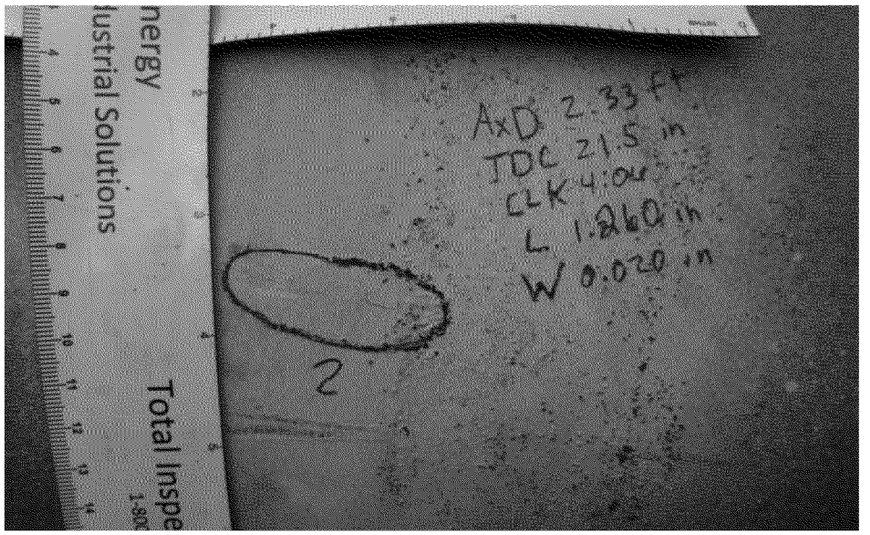


Removed pipe section linear indication-01

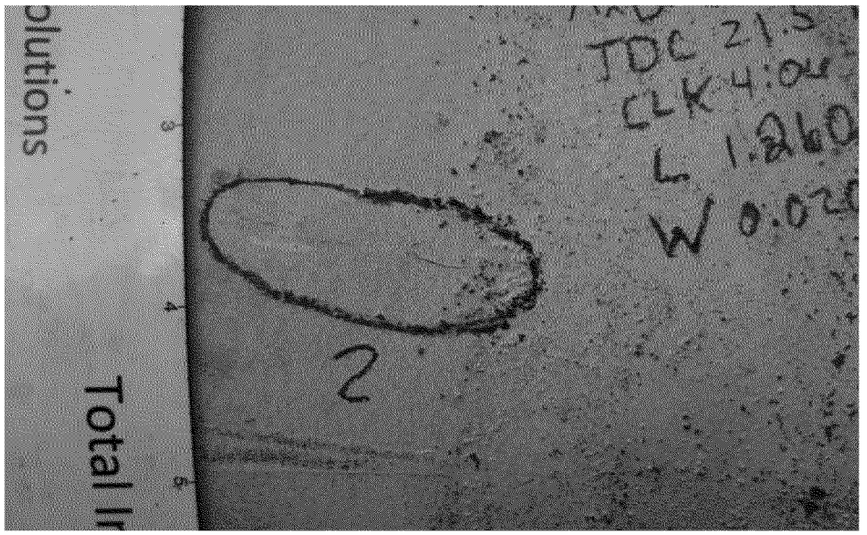
g



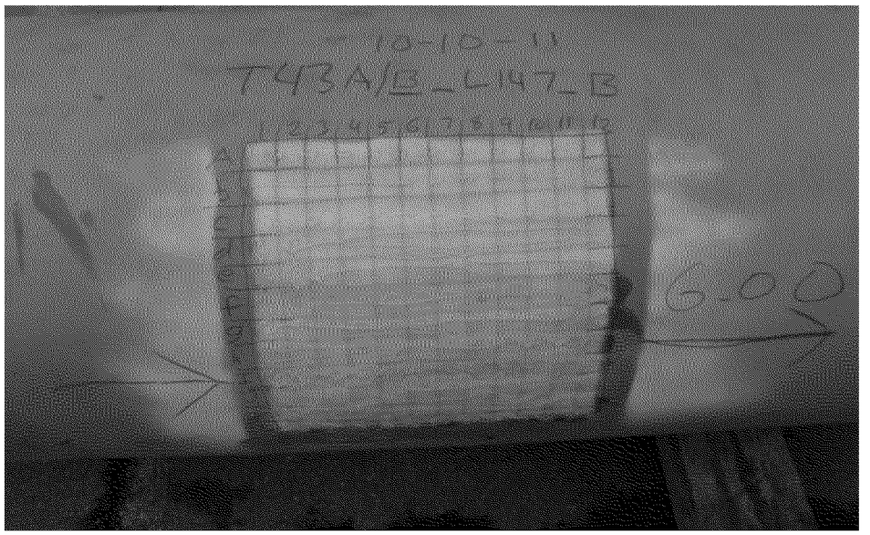
Close up of MT Indications of LIN-01



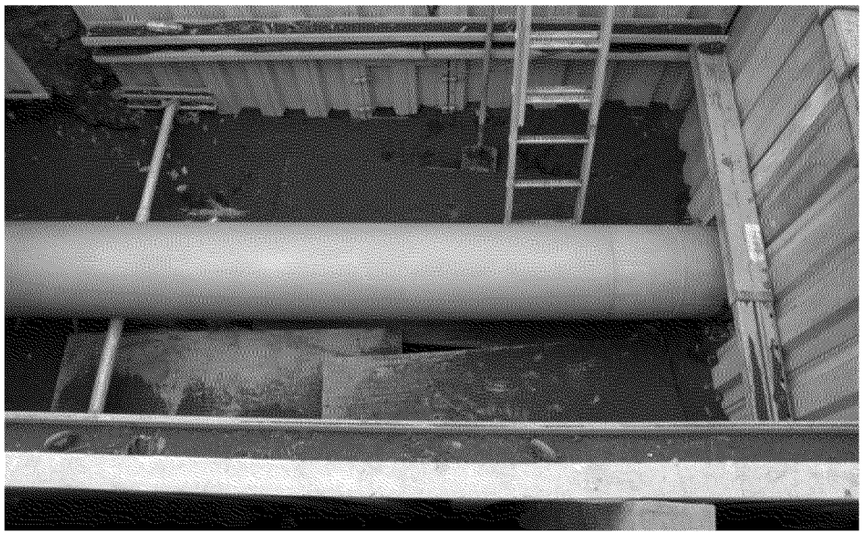
Removed pipe section linear indication-02



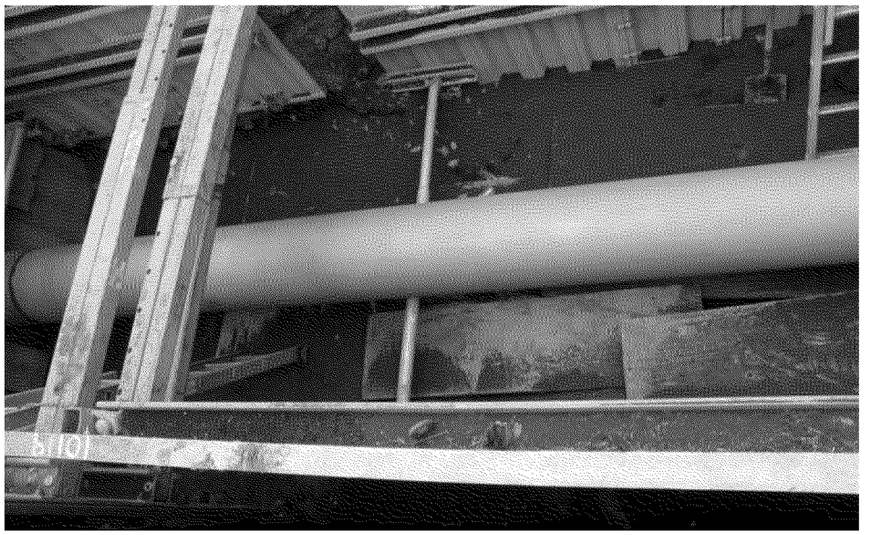
Close up of MT Indications of LIN-02



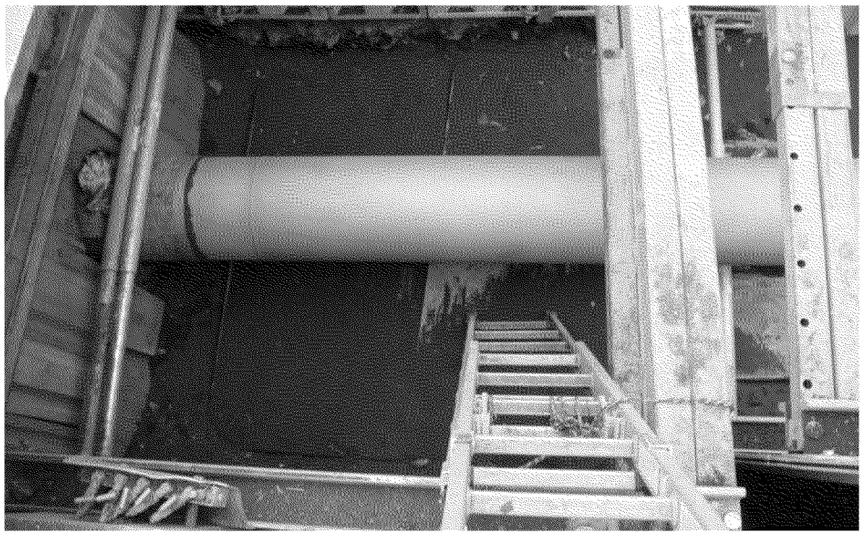
Overview of UT Grid.



Overview of clean blasted inspection area prior to recoat activities



Overview of clean blasted inspection area prior to recoat activities



Overview of clean blasted inspection area prior to recoat activities

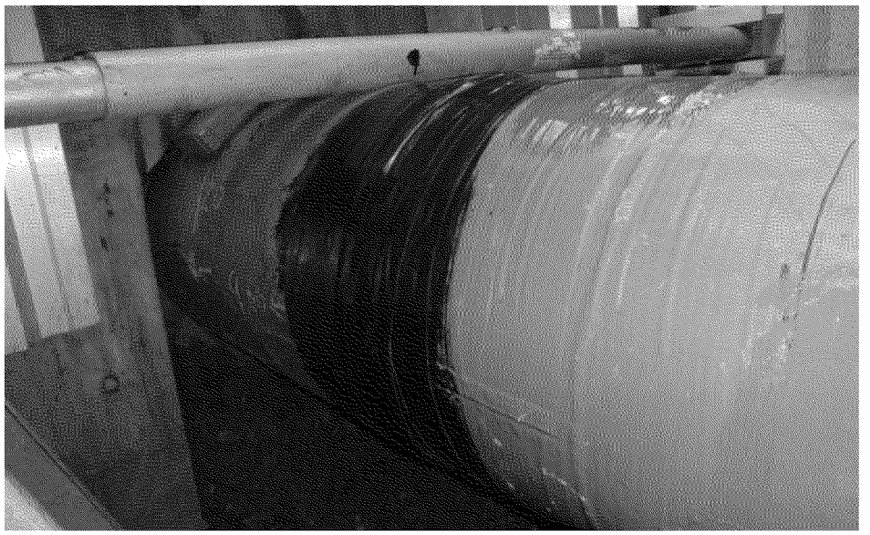
Overview of final coating condition US 3:00

g

Overview of final coating condition 3:00

Overview of final coating condition 3:00

Overview of final coating condition 3:00



Overview of final coating condition US 3:00

g

Overview of completed Slurry

Overview of completed Slurry

Overview of completed Cover looking upstream

Overview of completed Cover looking downstream

g

Overview of completed Cover, 3:00 view

Overview of completed Cover, 9:00 view

g

EXHIBIT E

Failure Analysis Associates

Exponent®

PG&E Line 147 Britton and Rogers Avenue Leak: Metallurgical Analysis

Exponent

PG&E Line 147 Britton and Rogers Avenue Leak: Metallurgical Analysis

Prepared by:

Brad James, Ph.D., P.E., FASM
Exponent Failure Analysis Associates
149 Commonwealth Drive
Menlo Park, CA 94025

October 2013

· Exponent, Inc.

Doc. no. 1306838.000 A0T0 1013 RE15

Contents

Executive Summary

Exponent Failure Analysis Associates (Exponent) has been retained by Pacific Gas and Electric (PG&E) to help determine the cause of the leak identified in Line 147 along Brittan Avenue in San Carlos, California, and why the leak was not detected during a recent hydrostatic test (hydrotest). The subject leak was identified on October 18, 2012, and the hydrotest had been performed approximately one year earlier, on October 24, 2011.

Exponent's metallurgical investigation of the leak followed work conducted by Anamet laboratories. Our work included visual, metallographic, fractographic, and chemical analysis of the leak site. Our analysis largely agreed with the opinions presented by Anamet: the leak occurred within a weld repair section, all cracking occurred during the repair itself, with no metallographic or fractographic evidence that any crack growth occurred following the repair weld. Specifically, there was no evidence of progressive crack growth due to fatigue, stress corrosion cracking (SCC) or ductile tearing from the "pressure reversal" phenomenon occasionally observed during hydrotesting. Significant deposits were observed within the cracks. These deposits were largely iron-oxide based, although high levels of sulfur (likely associated with mercaptan-odorizer present in the natural gas) were identified.

The subject leak was caused by cracking that occurred within a location on the pipe body that had been repaired using weld-metal deposition ("weld repair"). This weld repair was not associated with either a girth or longitudinal seam weld. The cracks associated with the leak within the outer diameter (OD) weld were caused by solidification cracking during the weld repair. Cracks that initiated along the pipe inner diameter (ID), within the heat-affected zone (HAZ) beneath the repair weld were also observed. The HAZ exhibited significant grain coarsening with areas of Widmanstatten ferrite along the prior-austenite grain boundaries. Areas of fracture along the prior-austenite grain boundaries were observed, indicative of the low-toughness associated with severely-coarsened grains, possible segregation of impurity elements (such as sulfur and phosphorus), and high residual stresses from the weld repair. Microhardness testing indicated hardness levels less than 190 HV (approximately 90 on the Rockwell B Scale) within the HAZ. At this low hardness level, hydrogen embrittlement is unlikely to have contributed to the intergranular fracture observed within the HAZ. Like the solidification cracking observed at the pipe outer diameter, these HAZ cracks occurred during or shortly after the weld was made as the metal cooled.

The cracks showed no evidence of propagation over time. The relatively large pressures associated with the hydrotest were insufficient to grow the subject cracks. The subject leak was not detected during hydrotesting. The primary purpose of hydrotesting is to help establish pipeline integrity and find large-scale leaks. The leak path was small, full of oxide, and provided a tortuous path for liquid water to escape.

Background

PG&E Line 147 connects Lines 132 and 101, and extends along a portion of Brittan Avenue in San Carlos, California. The maximum allowable operating pressure (MAOP) of Line 147 documented on the hydrotesting test report was 400 psig.[1] The portion of Line 147 that contained the leak was installed in 1957.[2]

On October 24, 2011, Line 147 was hydrotested between mile posts 1.95 and 3.4.[1] The 8.32-hour-long hydrotest was conducted at a minimum sustained pressure of 607 psig (at the maximum elevation), and included a 30-minute pressure spike to 748 psig (maximum). Thus, the hydrotest was conducted at a pressure in excess of 50-percent greater than the Line 147 MAOP. The hydrotest was certified by RCP Inc.[1] to meet the requirements of the Federal Code of Regulations, Title 49, Part 192, Subpart J for a Class 3 location. The buried pipe segment (7,541 feet) gained 2-degrees F fluid temperature, and the exposed pipe segment (175 feet) lost 3-degrees F over the test period. Given the coefficient of thermal expansion of water, a variation of 1-degree Fahrenheit is equal to 10.14 gallons of water. Thus, a small hydrostatic test leak would have been within the inherent error associated with the test.

On October 13, 2012, approximately one-year after the Line 147 hydrotest, a PG&E gas crew leader observed bubble formations in water associated with an excavation on Brittan Avenue. PG&E testing on October 15, 2012 confirmed the gas leak near the intersection of Brittan Avenue and Rogers Avenue. On November 13, a 6-inch PLIDCO cap was welded over the leak site (50-feet east of Rogers Avenue on Brittan Avenue) at the bottom (6 o'clock position) of the pipe.

Exponent conducted a metallurgical analysis to help determine the cause of the leak and why the leak was not detected during hydrotesting. Our analysis included visual, fractographic, metallographic, and chemical analysis of the leak and associated welds/piping. The results of our investigation are described below.

[1] RCP Inc., Hydrostatic Test Certification, March 15, 2012.

[2] PG&E Leak Repair, Inspection and Gas Quarterly Incident Report (A-Form), 58-12-60279- updated.

Non-Destructive Examination

The portion of Line 147 that contained the subject leak was initially examined by Anamet Inc. (Anamet). As described in their September 6, 2013 report, Anamet conducted leak testing, metallographic analysis, as well as tensile and Charpy V-notch (CVN) testing of the subject pipe. The subject leak and adjacent pipe were transferred from Anamet to Exponent; received by Exponent on September 23, 2013 in the condition shown in Figure 1 and Figure 2.

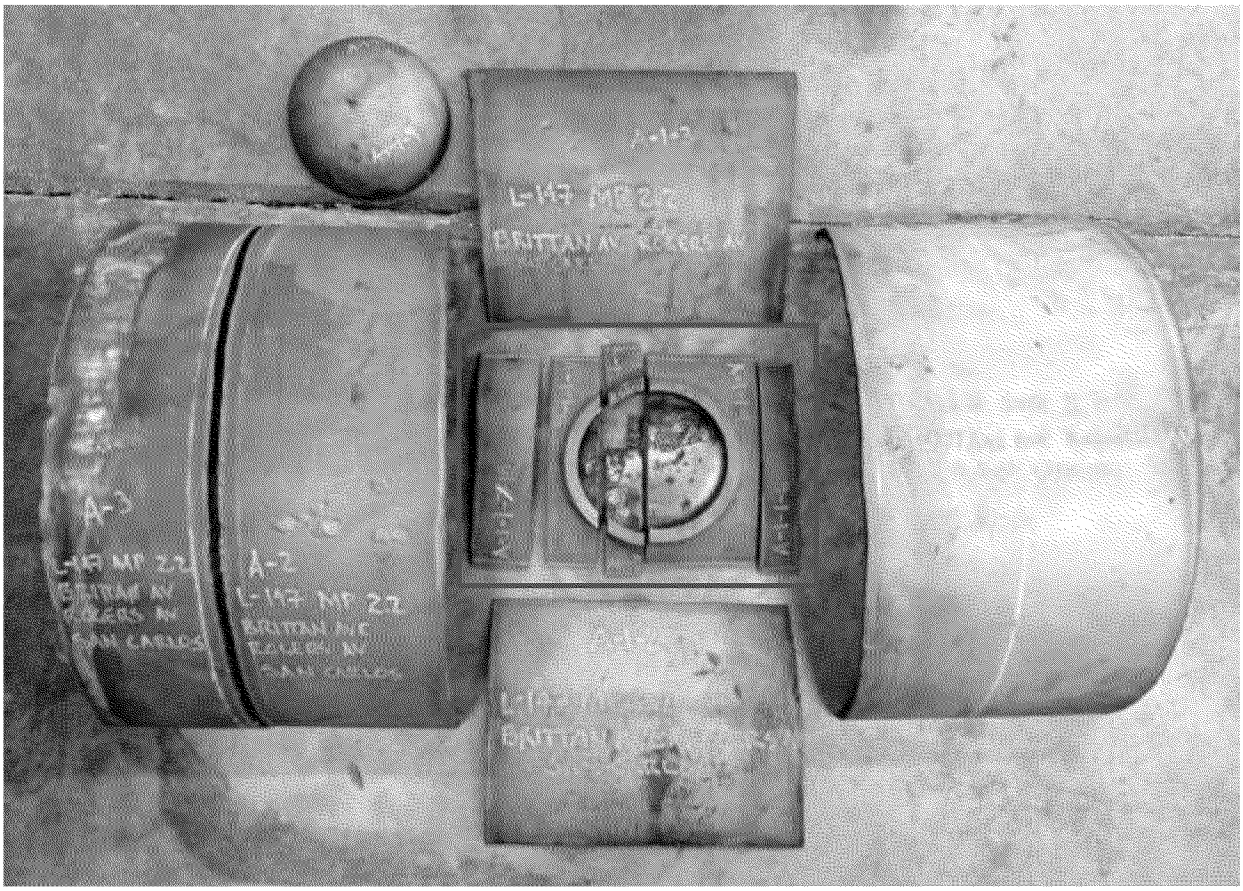


Figure 1. Photograph of the section of L-147 containing the crack and the PLIDCO cap welded over it to stop the gas leak. The red box shows the area magnified in Figure 3. Note the sectioning of the pipe and the yellow markings were made by Anamet.

Figure 2. Photograph of a section of L-147 removed from the section of pipe containing the crack. Note the sectioning of the pipe and the yellow markings were made by Anamet.

The leak site was located in the area in the red box in Figure 1; enlarged in Figure 3. A PLIDCO cap had been welded onto the pipe to stop the leak until the subject pipe section could be removed. Beneath the cap, several weld repairs had been conducted. Anamet had sectioned the approximately 0.4-inch long crack into two pieces, then mounted, polished and etched the parts for analysis. The two metallurgical mounts are shown in Figure 4 as received from Anamet. Exponent retained Anamet's sample ID numbers, which for the metallurgical mounts are A-1-1-8 and A-1-1-7, left and right, respectively in Figure 4. As indicated in Anamet's report, these samples were subjected to serial grinding to evaluate different leak cross-sections. As such, portions of the leak that have been ground-away are no longer available for examination.

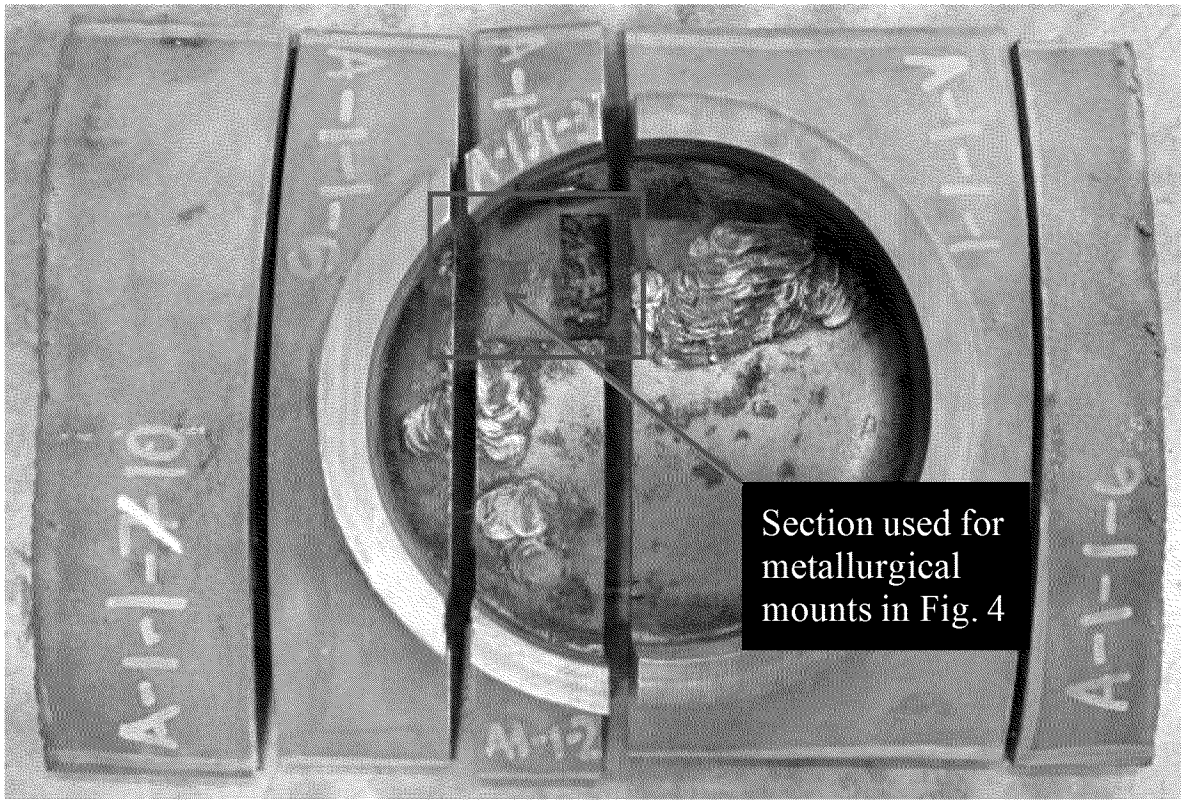


Figure 3. Photograph of the section of L-147 (boxed in red in Figure 1) containing the crack and the PLIDCO cap. Note the sectioning of the pipe and the yellow markings were made by Anamet.

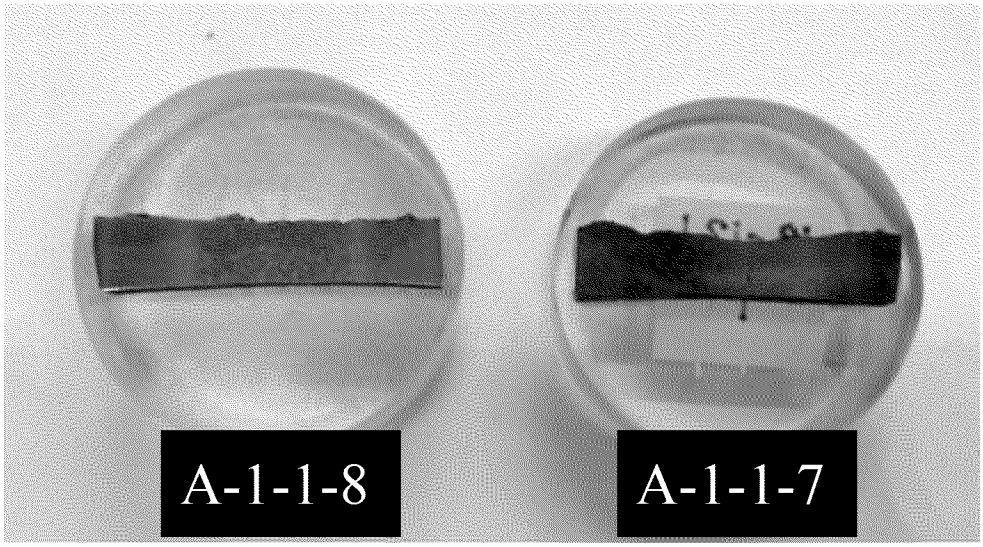


Figure 4. Photograph of the metallurgical mounts of the area containing the crack in L-147 under the PLIDCO cap. Note the metallurgical mounts were made by Anamet: Exponent retained Anamet's sample ID numbers A-1-1-8 (left); A-1-1-7 (right).

Fractographic Examination

Optical Microscopy

Exponent extracted each of leak sections remnants that had been encapsulated by Anamet in metallographic mounts, cooled them in liquid nitrogen, and then fractured them to analyze the leak surfaces. Optical microscope images of the post-fractured leak surfaces are shown in Figure 5 and Figure 6. The dark portions of each sample are the pre-existing crack/leak locations. The brighter-colored areas occurred when Exponent broke the samples open to reveal the leak surface.

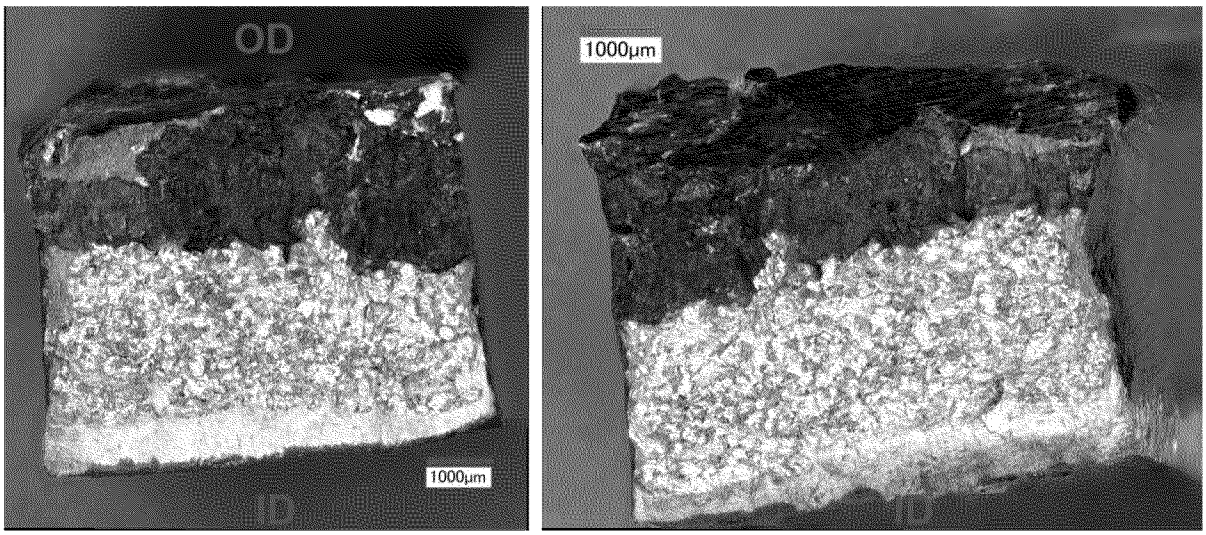


Figure 5. Optical micrographs of the leak surface after opening Anamet's A-1-1-8 metallurgical mount.

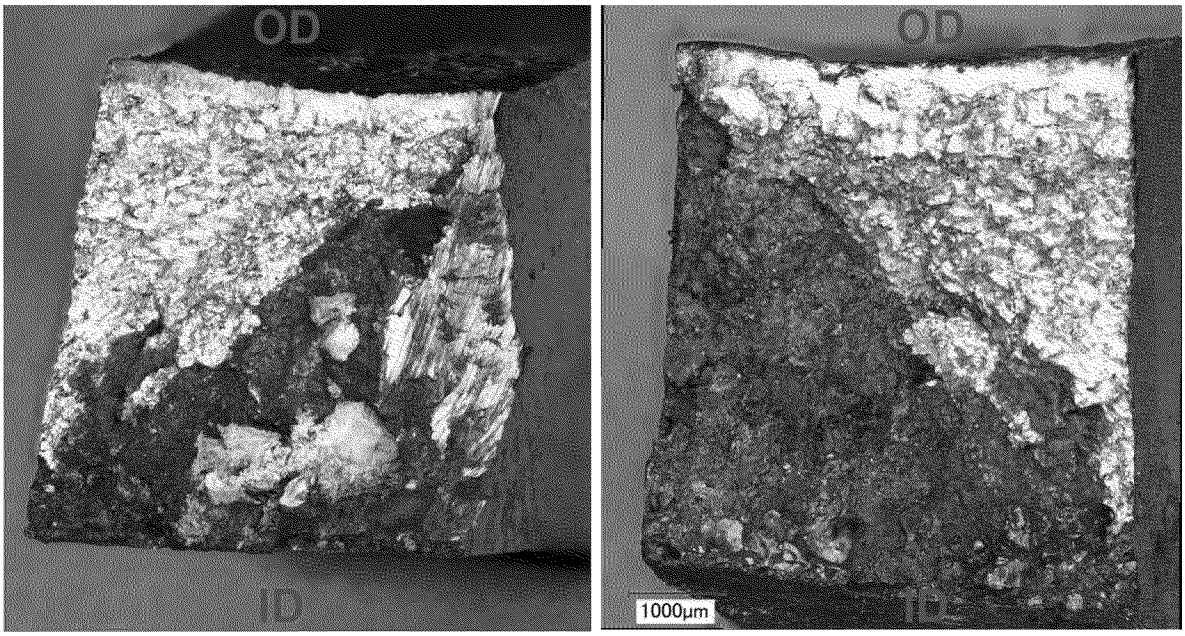


Figure 6. Optical micrographs of the leak surface after opening Anamet's A-1-1-7 metallurgical mount.

As shown in Figure 5, the pre-existing crack in Sample A-1-1-8 only extended from the OD approximately halfway through the pipe wall. The pre-existing crack A-1-1-7 extended from the ID nearly to the OD surface. While neither of these two samples display a clear ID-to-OD leak path, the pre-existing crack in Sample A-1-1-7 extends nearly through the pipe wall thickness. Based on the metallographic images in Anamet's report, as well as fractographic analysis of the remaining broken-open metallographic specimens, it is apparent that the through-wall (ID-to-OD) path for the subject leak was less than the 0.4 inch total length of the cracks.

Scanning Electron Microscopy

The leak surface fracture morphologies were analyzed using SEM/EDS. SEM images of the Sample A-1-1-8 fracture surface are shown in Figure 7. Interdentritic fracture morphology was observed at the pre-existing OD fracture area, consistent with cracking that occurred during cooling of the original weld (known as solidification or "hot cracking"). Solidification cracking occurs when the final solidifying metal cannot support the thermally or mechanically-induced strain from the welding process, and can be caused by poor joint restraint, improper welding parameters, and by interdendritic segregation of steel impurities (such as sulfur). The fracture surface was heavily oxidized, also consistent with solidification cracks in welds.[3] Brittle cleavage fracture morphology was observed on the bottom-half of the fractured Sample A-1-1-8. This cleavage fracture occurred when the sample was cooled in liquid nitrogen and then fractured to allow observation of the leak surfaces. Ductile tearing associated with the intentional fracture of Sample A-1-1-8 was observed at the inner surface. The ductile tearing is

[3] ASM Handbook, Volume 6: Welding, Brazing, and Soldering, ASM International, 2003, pp. 649-651.

caused by a transition from a triaxial stress state to a biaxial stress state when the final ligament breaks, and results in a characteristic ductile "shear-lip" at the final fracture location.

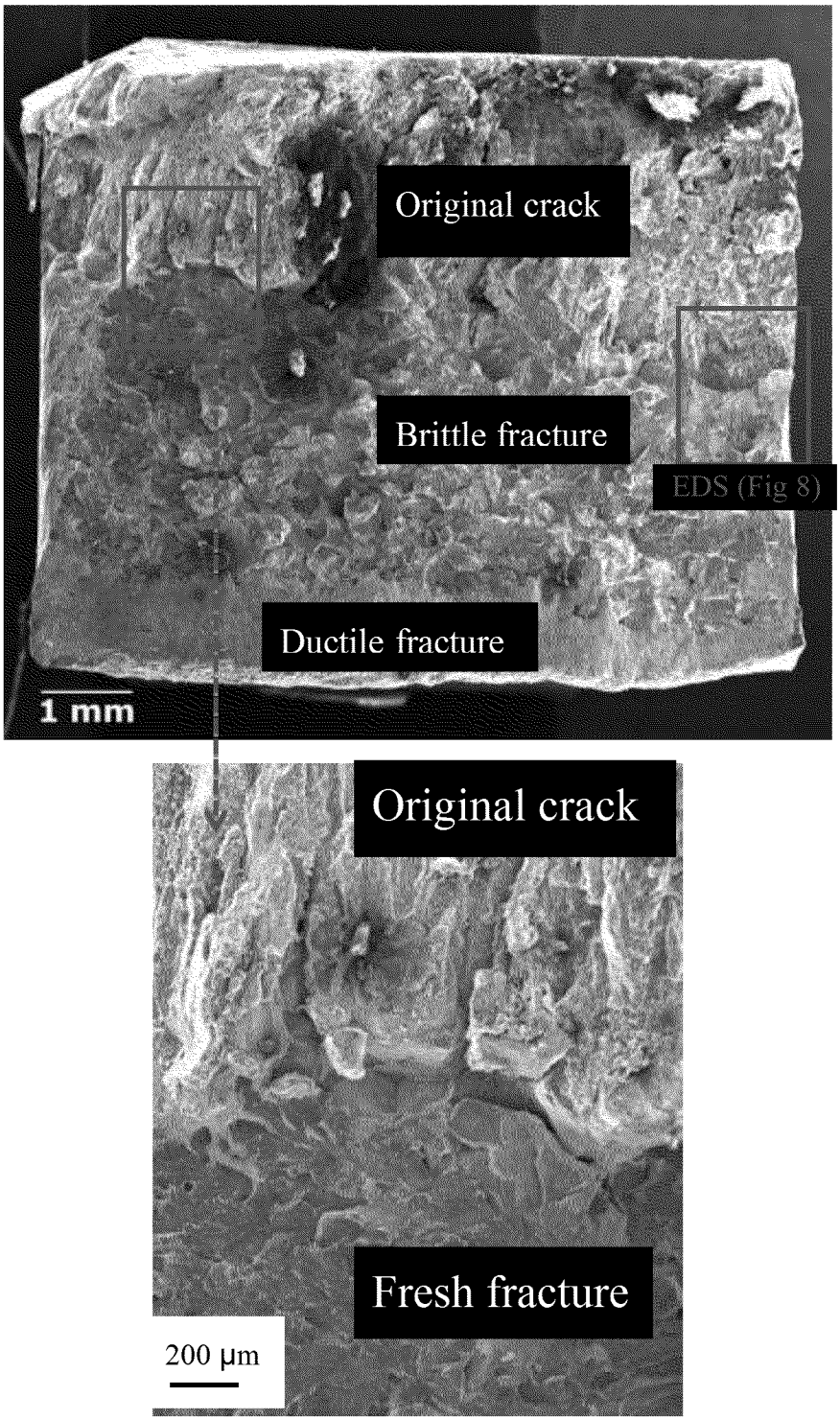


Figure 7. SEM images of Sample A-1-1-8 fracture surface (left side of Figure 5). Top image shows the entire surface with one red box magnified (bottom image) and another red box for the area analyzed with EDS in Figure 8.

The Sample A-1-1-8 fracture surface was examined using EDS, which is highlighted in the red box in top image of Figure 7 and presented in Figure 8. The freshly-induced cleavage fracture surface below shows only the presence of iron and a small amount of carbon. The original crack surface, however, exhibited significantly increased levels of carbon, oxygen and sulfur, consistent with iron oxide (rust) as well as sulfur deposits. The sulfur is most likely from mercaptan-based odorizer added to natural gas to give the characteristic "rotten-egg" smell.

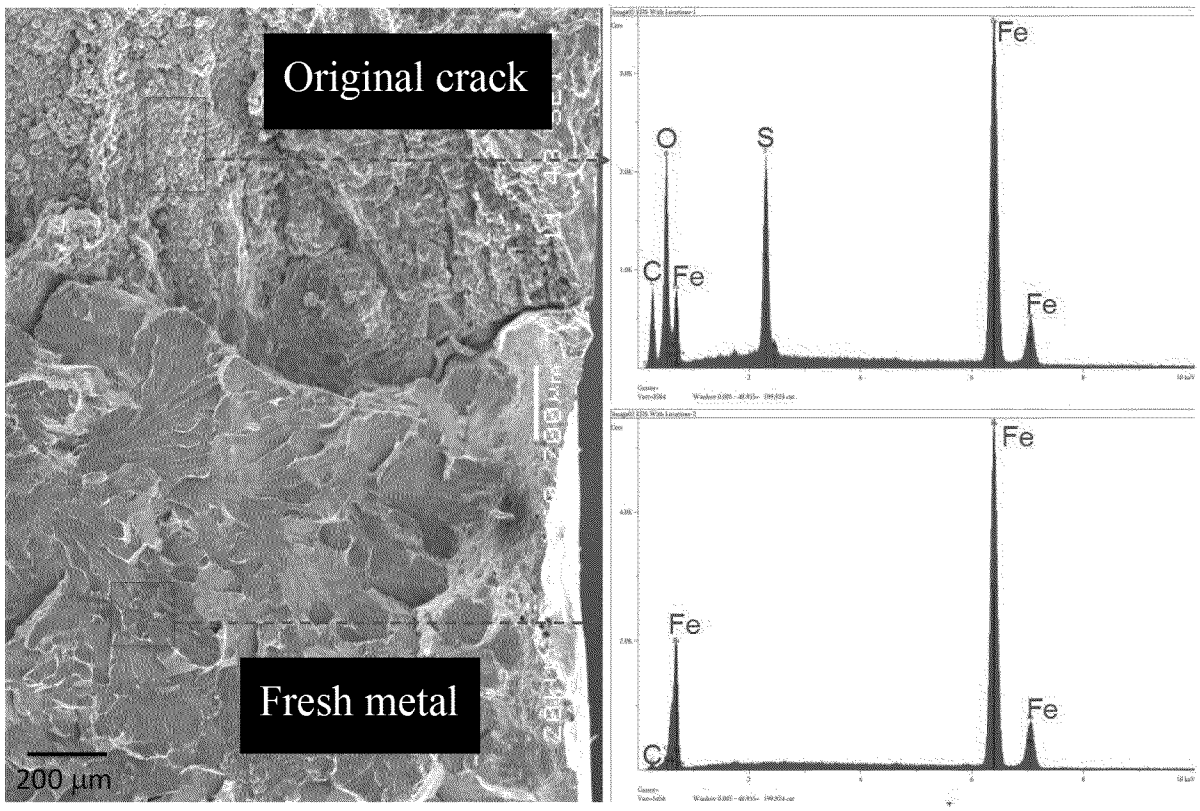


Figure 8. EDS analysis of the area in the red box in the right side of the top image in Figure 7. The lower portion is the freshly cracked surface; the top is the surface of the original crack composed of iron oxide with a large amount of sulfur, likely from the mercaptans added to give scent to the gas.

Similar SEM and EDS examination was performed on the Sample A-1-1-7 fracture surface faces, example images are shown in Figure 9 and Figure 10. The substantial oxide deposits on the original leak surface obscured much of fracture morphology in the original-cracked portion of Sample A-1-1-7, as shown in Figure 9. However, the transition between the original crack surface and the intentional brittle (cleavage) fracture area showed no evidence of progressive growth, also shown in Figure 9.

EDS analysis of the Sample A-1-1-7 fracture surface showed similar findings as exhibited in Sample A-1-1-8. The freshly-exposed brittle fracture surface showed primarily iron with a small amount of carbon, while the original leak surface exhibited significant amounts of carbon, oxygen, and sulfur, as shown in Figure 10.

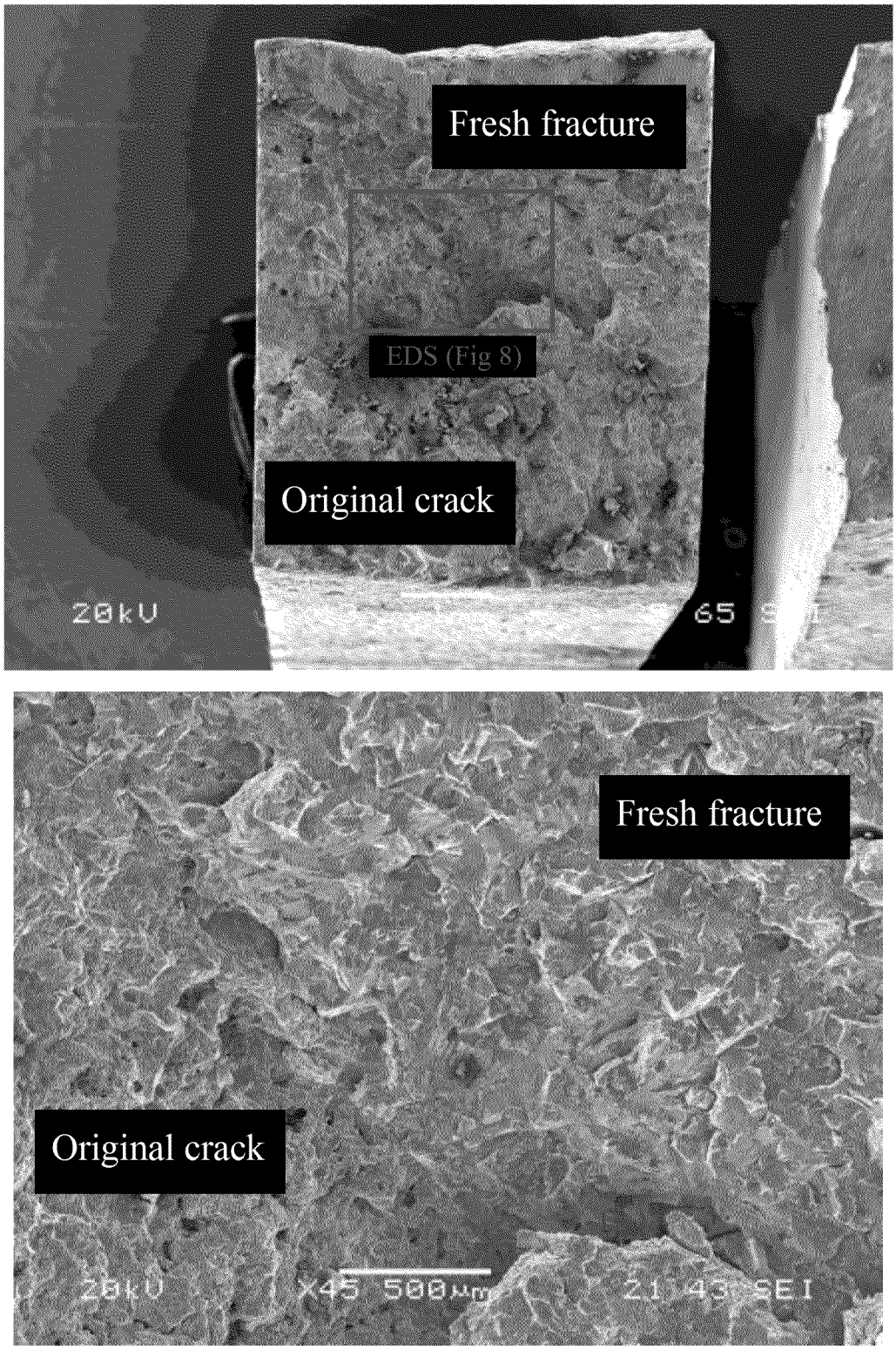


Figure 9. One side of the crack surface in Sample A-1-1-7 (right side of Figure 6). The red box shows the area analyzed with EDS in Figure 10.

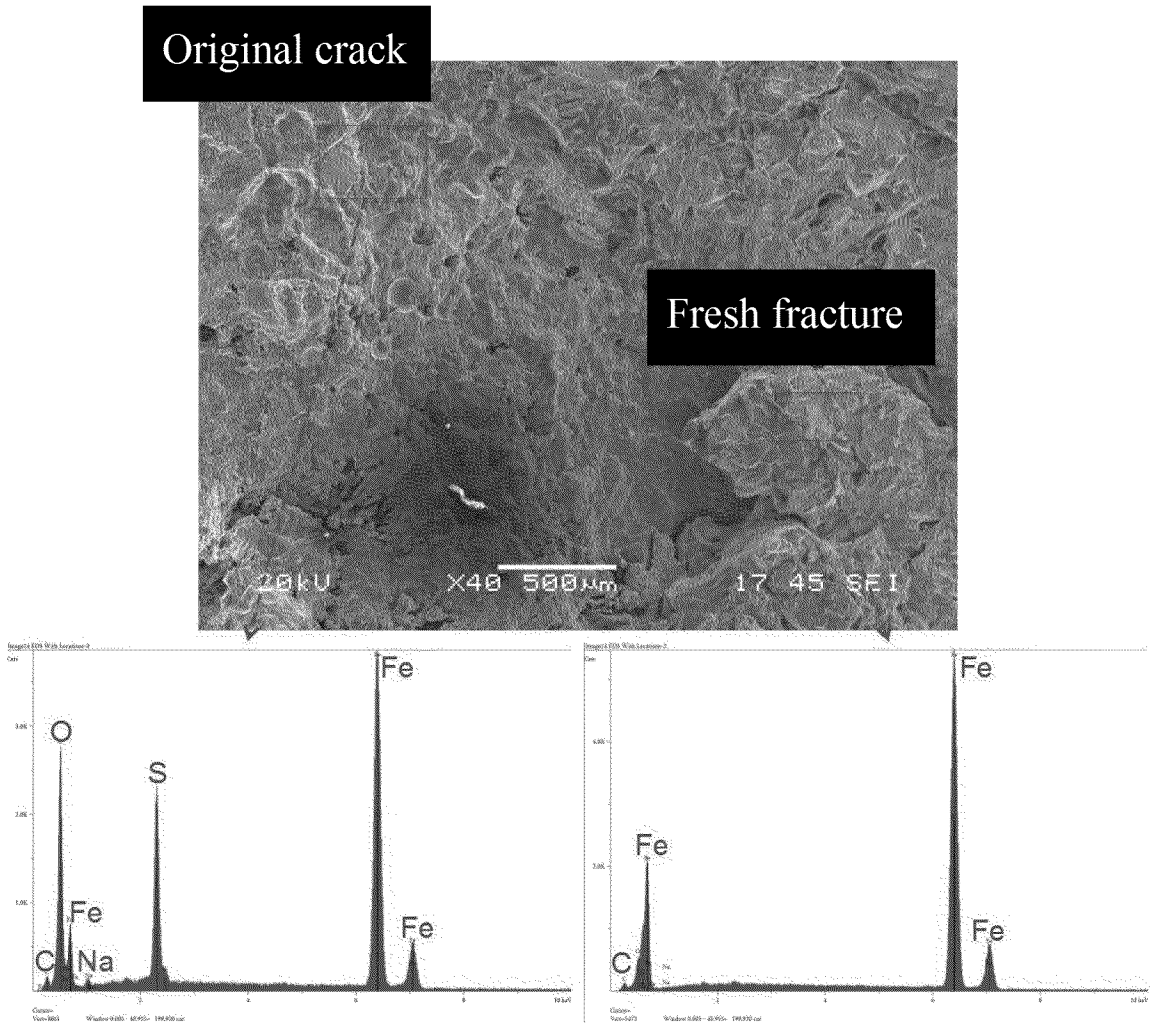


Figure 10. EDS analysis of the area in the red box in the top image in Figure 9. The right side is the freshly cracked surface; the left side is the surface of the original crack composed of iron oxide with significant sulfur.

Metallographic Analysis

Anamet sectioned the subject leak perpendicular to the longitudinal axis of the pipe, and conducted metallographic analyses as described in their September 6, 2013 report. A composite optical image from Anamet's report, shown here as Figure 11, shows that the weld repair contained significant weld porosity and cracks near the center of the weld bead that run parallel to the dendritic structure. There is also evidence of intergranular fracture in the heat-affected zone (HAZ) next to the weld.

Following our fractographic examination, Exponent put the broken halves of the crack back together for further metallographic analysis and microhardness testing, shown in Figure 12 and Figure 13. The samples were re-polished and etched with two-percent nital solution. Like Anamet's analysis, significant porosity and interdendritic cracking were observed within the repair weld. The HAZ below the weld was characterized by grain coarsening with Widmanstatten-morphology pro-eutectoid ferrite, shown in Figure 14. The very large grains within the HAZ and the solidification cracking of the weld pool are both consistent of slow weld speeds with high heat input.

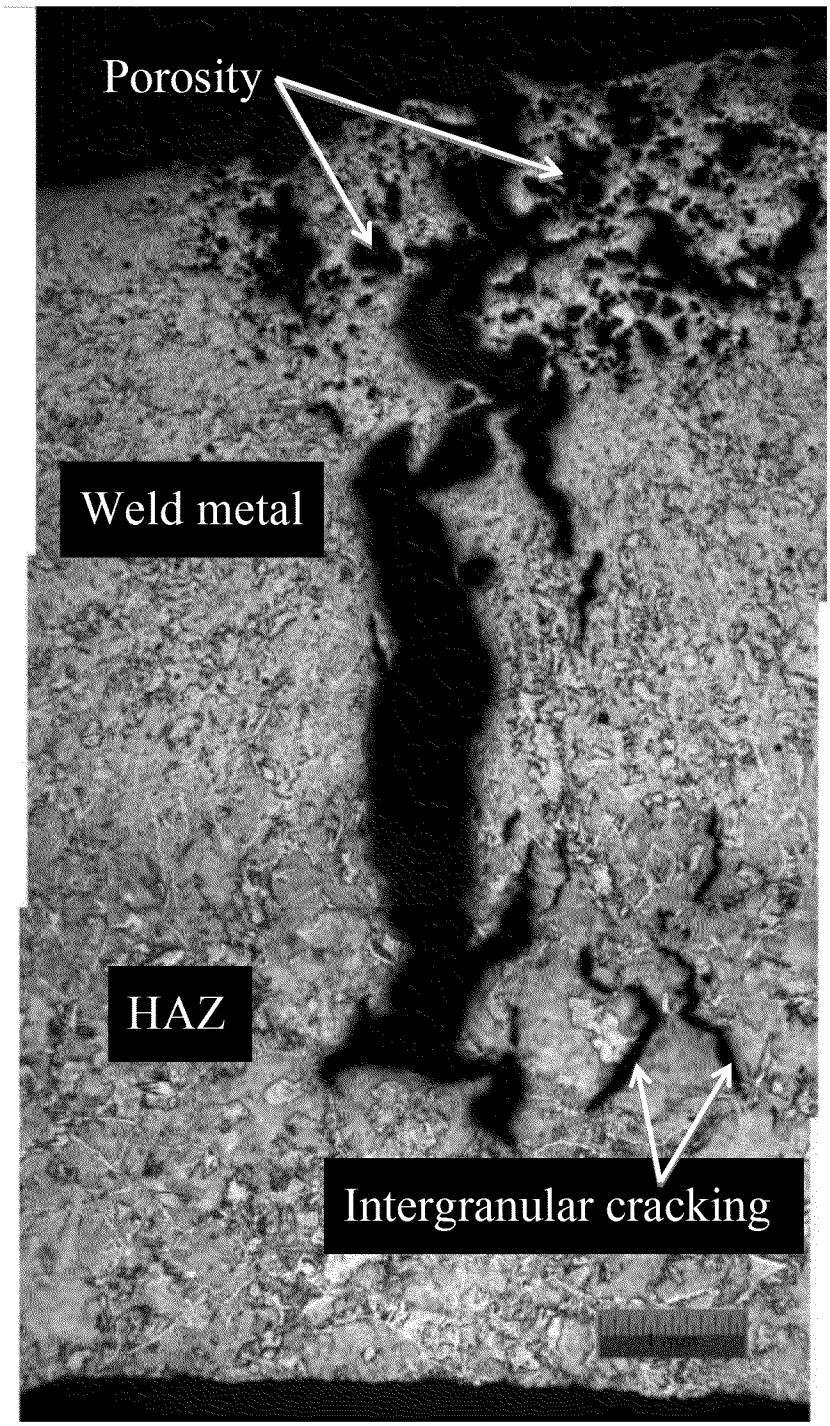


Figure 11. Composite optical micrograph of a metallurgical mount prepared by Anamet. Image reproduced from the September 6, 2013 Anamet report with permission from Anamet.

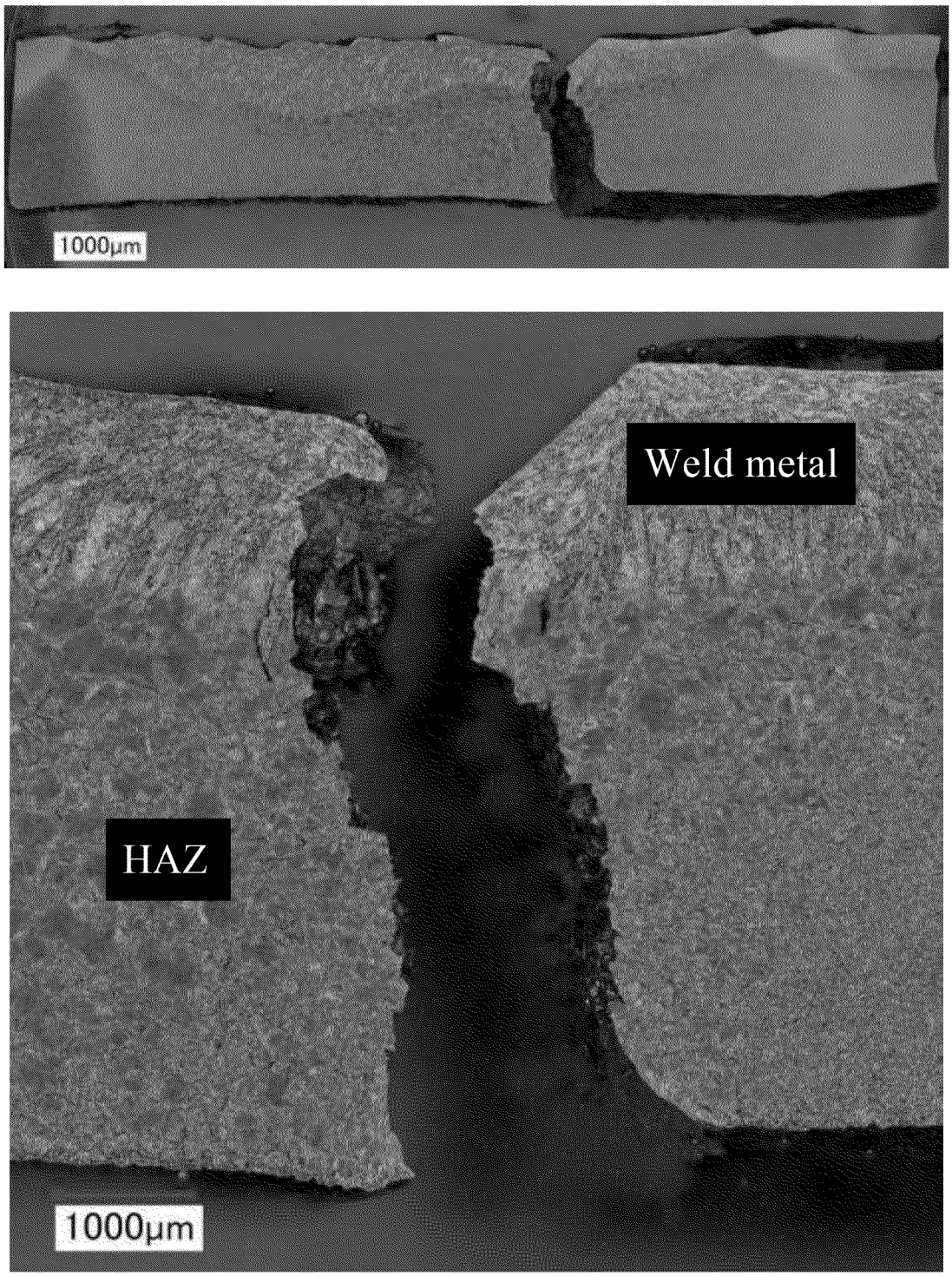


Figure 12. Images of Sample A-1-1-8, re-mounted following fractographic examination.

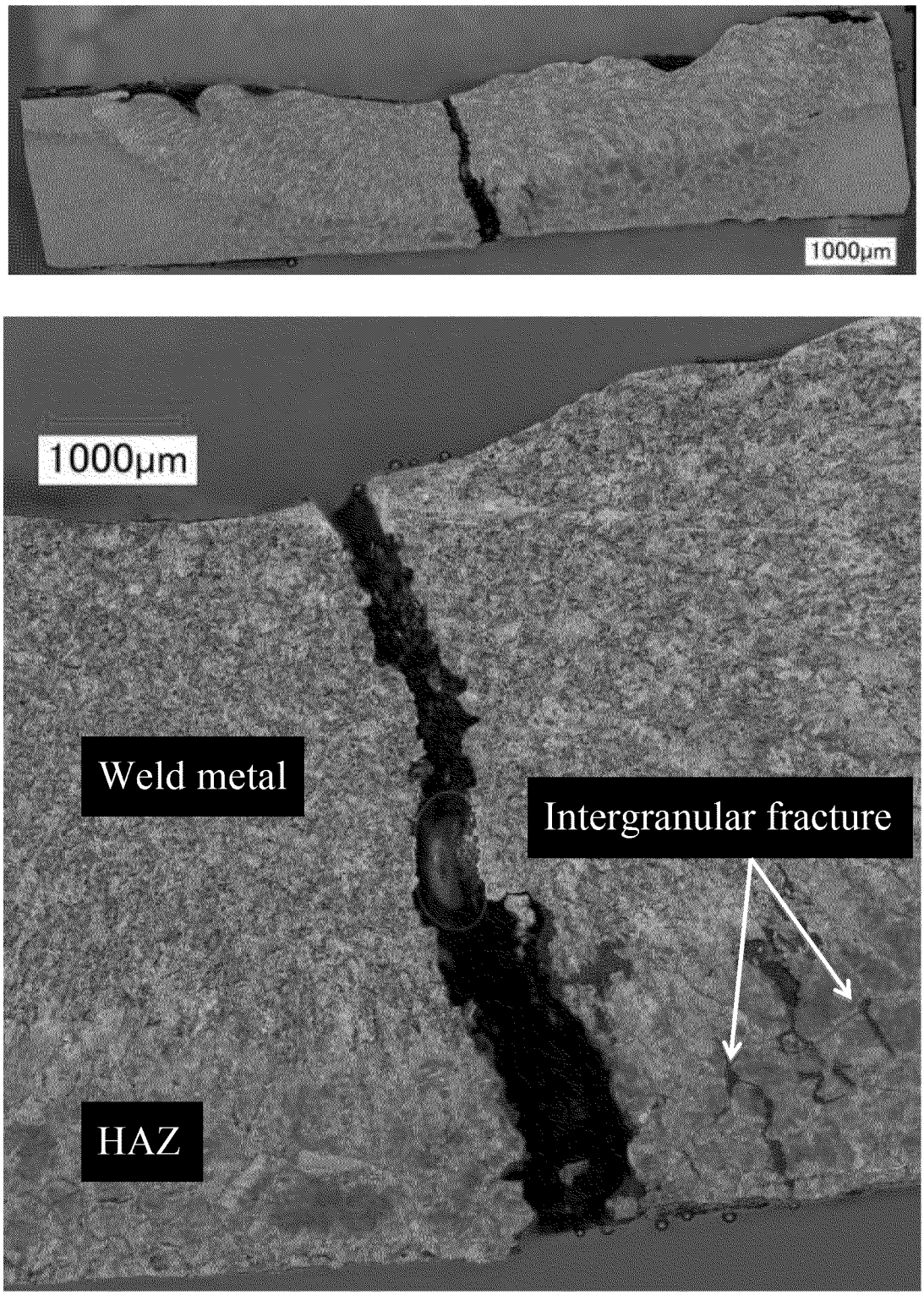


Figure 13. Images of Sample A-1-1-7, remounted following fractographic examination.

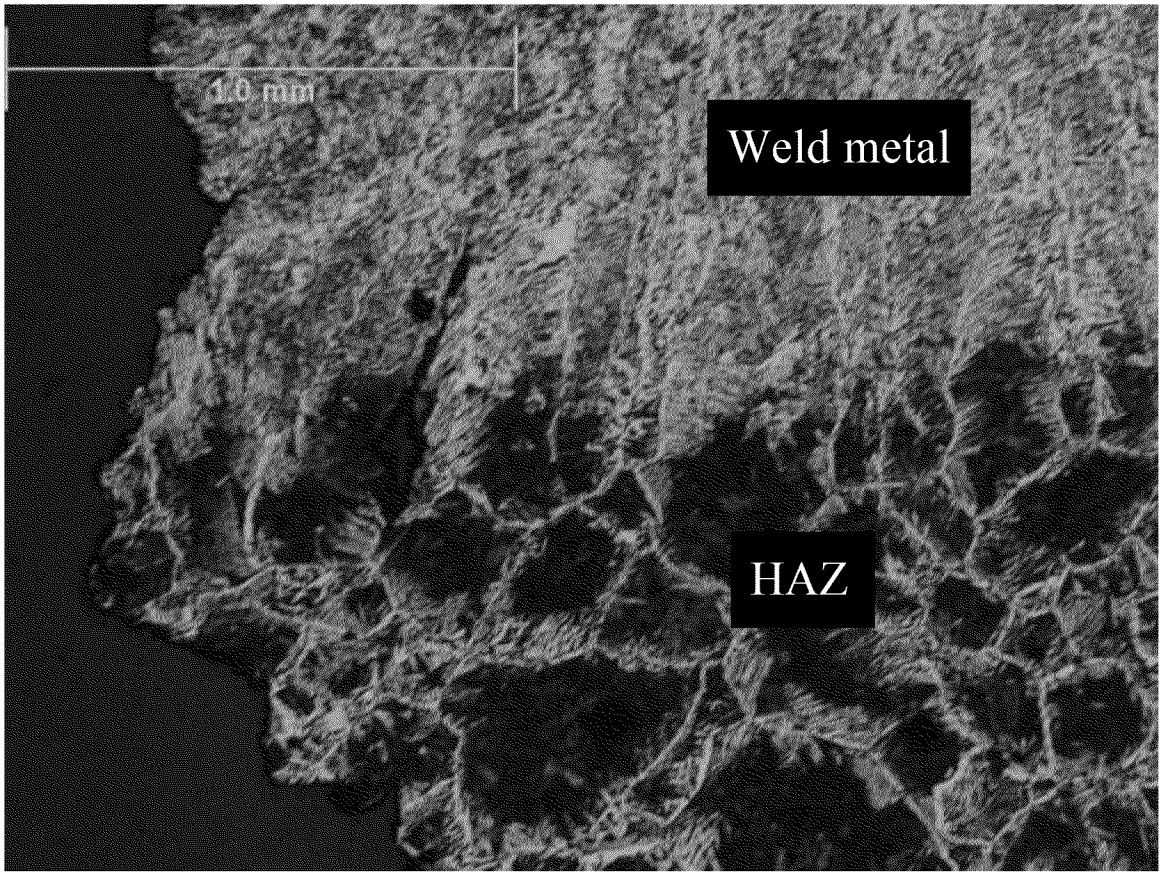


Figure 14. Metallographic image that shows significant grain coarsening beneath the weld in Sample A-1-1-8, with Widmanstatten ferrite at the prior-austenite grain boundaries in the heat-affected zone (HAZ).

Anamet conducted SEM/EDS analysis of the unopened crack in a metallographic mount: originally Figure 20 in their September 6, 2013 report, shown here as Figure 15. Consistent with Exponent's analysis, Anamet determined that the crack was filled with iron oxide and contained appreciable amounts of sulfur.

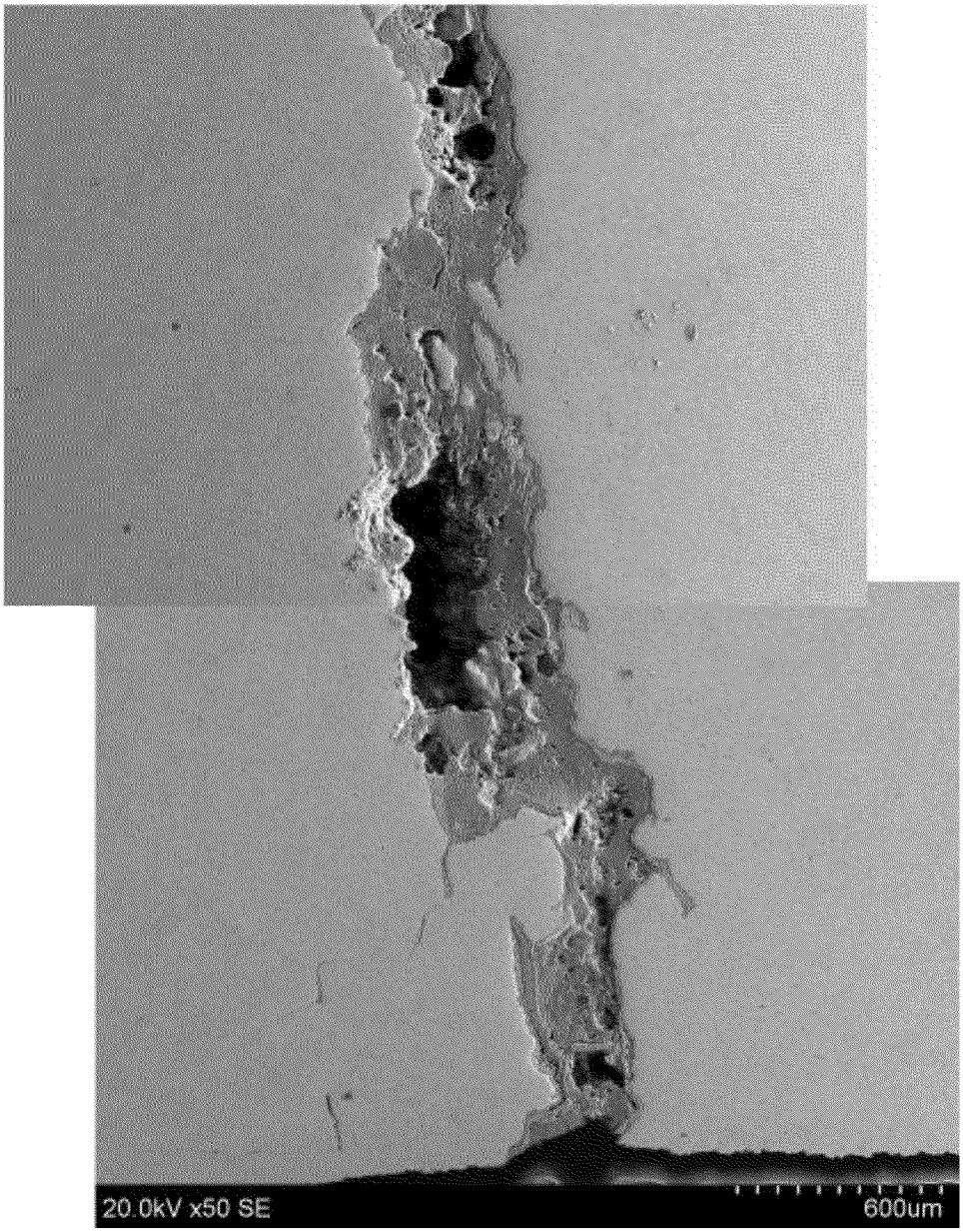


Figure 15. Composite SEM micrograph of the metallographic mount prepared by Anamet. Image reproduced from the September 6, 2013 Anamet report with permission from Anamet.

Vickers microhardness (HV) traverses were conducted over both metallographic mounts to assess hardness in the weld, HAZ, and base metal, shown by red lines in Figure 16. Each microhardness traverse and associated values are shown in Appendix B. Accounting for all testing samples, the base and weld metal exhibited average hardness values between 130-155 HV. The HAZ exhibited slightly higher hardness levels, between 155-190HV. However, it should be noted that the HAZ hardness levels are relatively low, consistent with the significant

grain coarsening observed. For carbon steels, a hardness of over 350HV would be considered excessive, and indicate a possible susceptibility to hydrogen cracking in the HAZ.[4, 5]

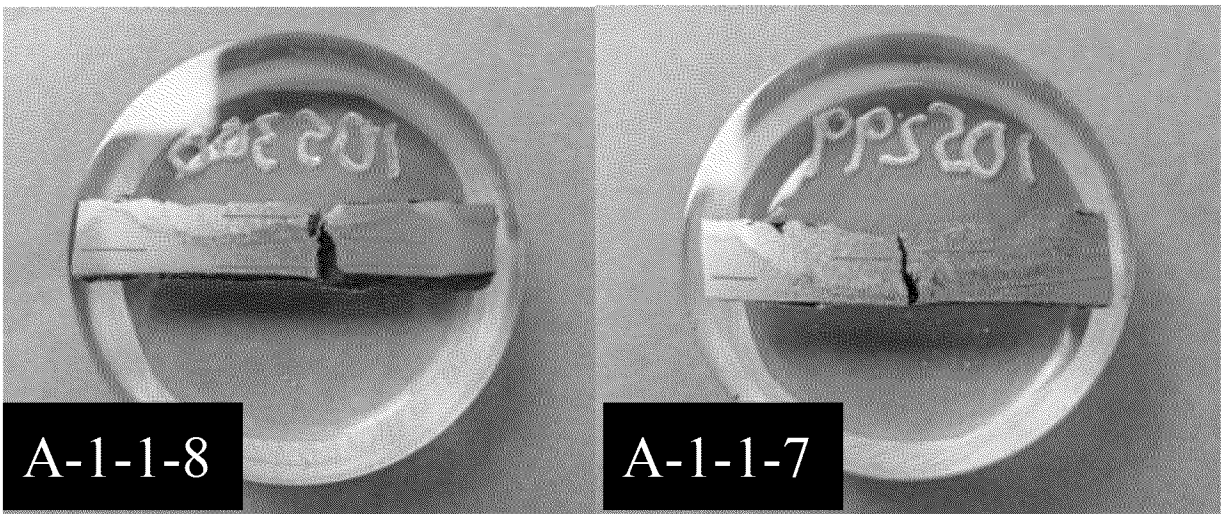


Figure 16. Metallurgical mounts of samples A-1-1-8 and A-1-1-7 made subsequent to opening the crack and examining it via optical microscopy and SEM/EDS. The red lines show where strings of microhardness testing points.

[4] J.F. Lancaster, Metallurgy of Welding, Fourth Edition, 1987, pg. 177.

[5] ASM Metals Handbook, Volume 6, Welding, Brazing and Soldering, pg. 648.

Chemical Analysis

Chemical analyses of the base and weld metal near the leak were performed using direct-current optical-emission spectrometry, shown in Table 1 below. The analysis indicated elemental levels consistent with typical carbon steel. Lower carbon and manganese contents were observed in the weld metal compared to the pipe material, while sulfur and silicon levels were slightly higher.

Table 1 Chemical analysis of the base and weld metal near the crack in L-147.

Element	Base Metal (wt.%)	Weld metal (wt.%)
Fe	Matrix	Matrix
C	0.21	0.15
Mn	0.42	0.33
Cu	0.04	0.03
S	0.02	0.03
P	0.02	0.02
Cr	0.01	0.02
Ni	0.01	0.01
Mo	<0.005	<0.005
V	<0.005	<0.005
B	<0.005	<0.005
Si	<0.005	0.04

The carbon equivalents of the pipe base and weld metal were calculated using the equation:[6]

$$C_{equiv} = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Cu + Ni)}{15}$$

Carbon equivalent is an indicator as to the hardenability of the steel and the propensity for hydrogen-induced cracking. Based on this formula, the carbon equivalent of the base metal was 0.29, while the carbon equivalent of the weld was 0.21. Both these carbon equivalents are relatively low: carbon steels with a carbon equivalent around 0.30 will usually form a pearlite-bainite structure in the HAZ,[7] and are not particularly susceptible to cracking from hydrogen embrittlement.

[6] G. Krauss, Steels: Processing, Structure, and Performance, ASM International, 2005, pg. 407.

[7] J.F. Lancaster, Metallurgy of Welding, Fourth Edition, 1987, pg. 180.

Mechanical Testing

Tensile testing of the base and seam-weld metal was performed on a section of L-147 by Anamet. The results of the testing are given below in Table 2. The base metal exhibited a slightly higher tensile strength than the seam weld, while the seam-weld metal had a slightly higher yield strength.

Table 2. Anamet's transverse tensile testing (ASTM A370-10) of base and seam-weld metal from L-147.

	Base Metal	Seam-Weld Metal
Width of Specimen (in.)	1.508	1.508
Thickness of Specimen (in.)	0.254	0.257
Area (sq. in.)	0.383	0.388
Tensile Strength (psi)	61800	58700
Yield Strength (psi)*	39300	42900
Elongation in 2.0 Gage (%)	41	11
Fracture location	-	weld
Fracture Characteristic	-	Ductile**

* Upper Yield Strength (formerly Y.P.) 0.5% E.U.L.
** Indication observed.

Discussion

Our analysis confirmed that the subject leak in Line 147 occurred at a location in the pipe body that was repaired using weld metal deposition; not associated with a girth or a longitudinal seam weld. The leak was caused by porosity and solidification cracking within the weld metal that occurred during the repair process. Further, significant grain coarsening was observed in portions of the HAZ beneath the OD repair weld, which resulted in areas of intergranular fracture and contributed to the leak. This HAZ cracking also occurred during or shortly after the weld-repair process. HAZ hardness levels were insufficient to result in hydrogen embrittlement.

The cracks associated with the subject Line 147 leak have been present since the time of the weld repair. No fractographic or metallographic evidence of crack propagation (i.e. crack growth) during service or hydrotesting was observed.

Based on our analysis, it is clear that the cracks associated with the subject leak were present during the 2011 Line 147 hydrotest. The 8.32-hour hydrotest was conducted at a minimum of 600 psig, with a half-hour pressure "spike" to a maximum line pressure of 748 psig. No evidence of ductile tearing from the hydrotest was observed on the leak fracture surface. Ductile tearing can result in growth of large anomalies in pipelines during hydrotesting: known as the "pressure reversal" phenomenon. Given that the cracks associated with the leak were relatively short in axial length (less than approximately ½-inch), and relatively blunt (as observed in Anamet metallographic images), the 748-psig hydrotest pressures were insufficient to result in ductile tearing.

The subject leak was not detected during the 2011 hydrotesting. The Code of Federal Regulations Title 49, Part §192.505 indicates that a hydrotest is a strength test for pipelines to be operated at pressures that result in hoop stresses above 30% SMYS. The hydrotest conducted by PG&E on Line 147 was conducted at a minimum of 1.5 times the pipe MAOP, consistent with the federal regulations for a Class 3 location. The eight-hour portion of the hydrotest is intended to catch large-scale leaks. However, small-scale leaks can escape detection; particularly over a long test duration with large temperature changes throughout the day. The subject leak path was small, full of oxide, and provided a tortuous path for liquid water to escape.

Conclusions

- The subject leak discovered in PG&E Line 147 occurred in a weld repair of the pipe body; not associated with either a longitudinal seam or girth weld.

- The cracks associated with the subject leak occurred during the weld repair. Solidification cracking was observed within the weld deposit, while excessive grain growth, associated with high heat input, resulted in decreased toughness and local areas of intergranular fracture within the weld heat-affected zone.

- No evidence of progressive crack growth during service was observed at the leak site. Thus, the subject leak did not grow during service.

- The cracks associated with the subject leak were present during the October 2011 hydrotest. However, the hydrotest did not result in any ductile tearing or crack extension (pressure reversal) at the leak site.

- The leak path was small, full of oxide, and provided a tortuous path that limited the amount of water that could escape during hydrotesting.

Limitations

At the request of PG&E, Exponent has conducted an investigation of a crack that was present in Line-147 and how this was not detected by hydrotesting. Exponent examined the remaining material of the crack (some was destroyed during examination by Anamet Inc.) via optical microscopy and scanning electron microscopy with energy dispersive x-ray spectroscopy. The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use 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 becomes 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 that we have the opportunity to fully address them.

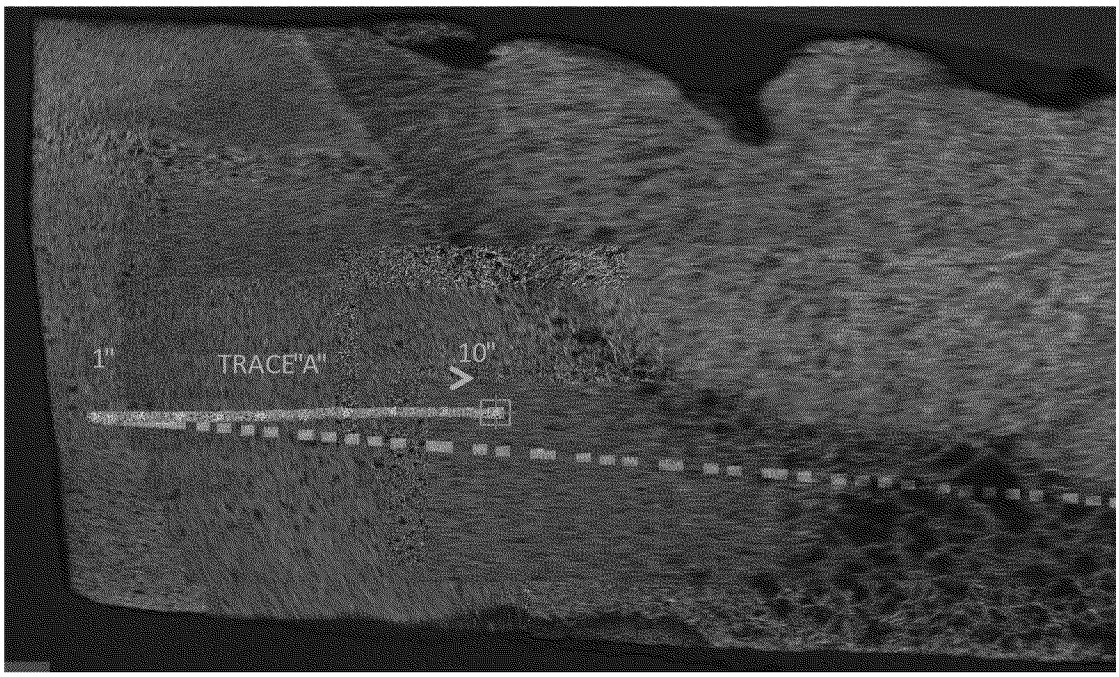
Appendix A

Microhardness Testing

Job Number	Item Number	Comments	Operator
1306838	105299	Kevin Moore	C. Jewett

500 gm

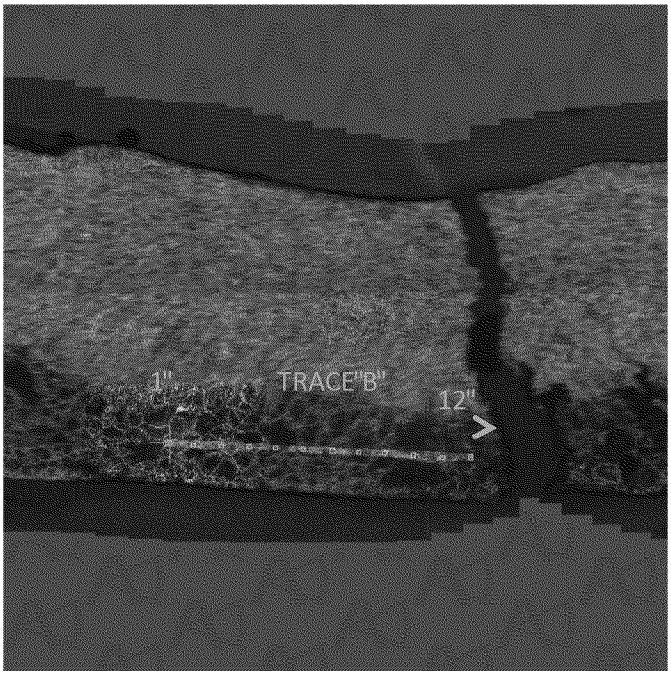
Trace A Loc	Mean Length	Hardness (HV)
1	78.8	149
2	79.3	147
3	80.1	145
4	78.1	152
5	79.4	147
6	82.7	135
7	83.1	134
8	79.5	147
9	78.8	149
10	83.1	134
	Avg:	144
	Max:	152
	Min:	134



Job Number	Item Number	Comments	Operator
1306838	105299	Kevin Moore	C. Jewett

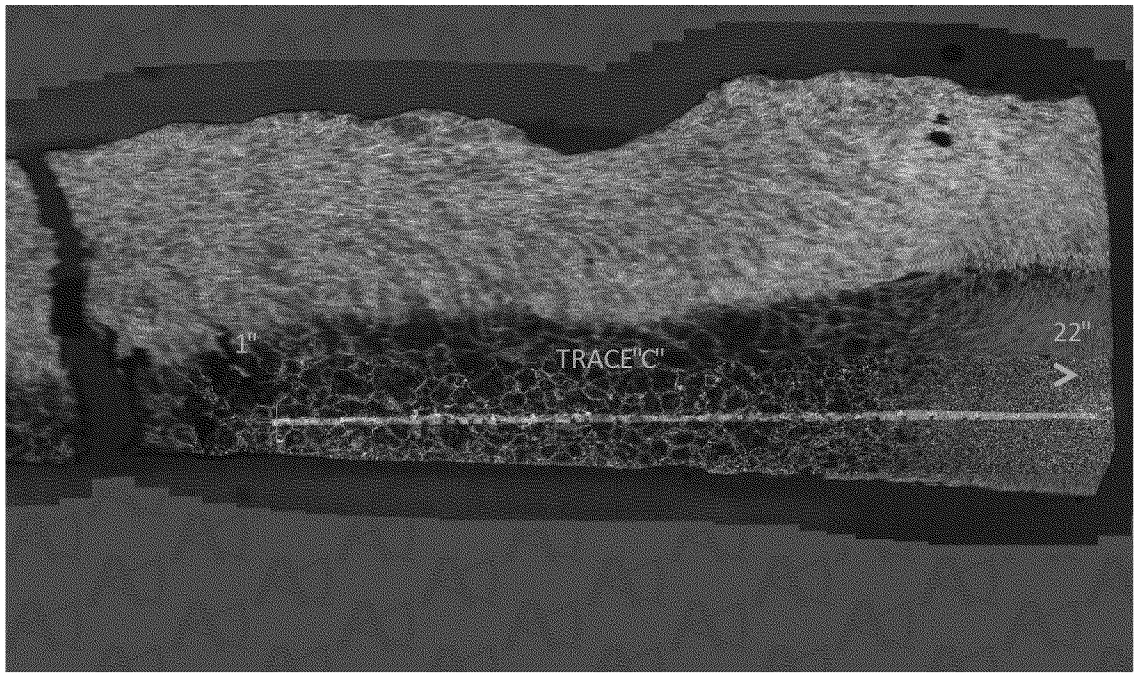
500 gm

Trace B Loc	Mean Length	Hardness (HV)
1	73.1	173
2	73.4	172
3	77.2	156
4	77.9	153
5	72.8	175
6	76.4	159
7	78.7	150
8	70.5	187
9	79.2	148
10	76.6	158
11	75.9	161
12	82.2	137
	Avg:	161
	Max:	187
	Min:	137



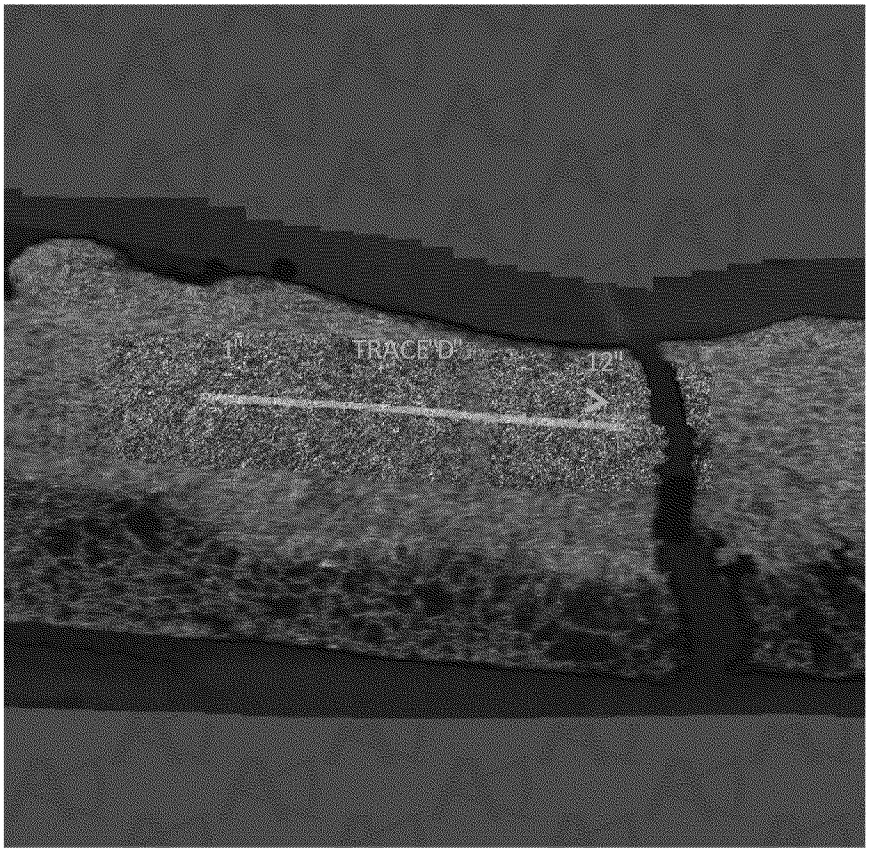
Job Number	Item Number	Comments	Operator
1306838	105299	Kevin Moore	C. Jewett

		500 gm
Trace C Loc	Mean Length	Hardness (HV)
1	69.3	193
2	72.1	178
3	78	152
4	77.1	156
5	73.3	173
6	72.7	175
7	78.6	150
8	69.6	191
9	75.6	162
10	72	179
11	72.6	176
12	75.6	162
13	71.3	183
14	75	165
15	68.4	198
16	74.8	166
17	82.1	137
18	80.9	142
19	80.3	144
20	78.3	151
21	78.5	150
22	80	145
	Avg:	165
	Max:	198
	Min:	137



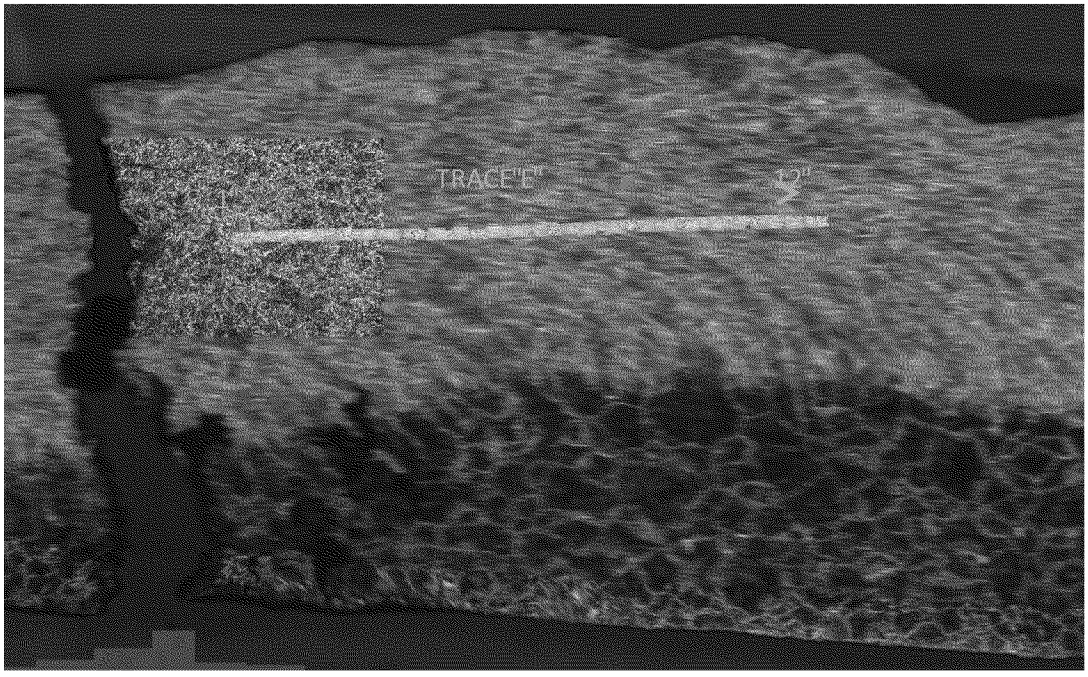
Job Number	Item Number	Comments	Operator
1306838	105299	Kevin Moore	C. Jewett

		500 gm
Mean Length	Mean Length	Hardness (HV)
1	83.4	133
2	76.9	157
3	78.8	149
4	80.6	143
5	79.0	149
6	78.5	151
7	79.6	146
8	79.1	148
9	79.9	145
10	80.1	145
11	77.8	153
12	78.4	151
	Avg:	148
	Max:	157
	Min:	133



Job Number	Item Number	Comments	Operator
1306838	105299	Kevin Moore	C. Jewett

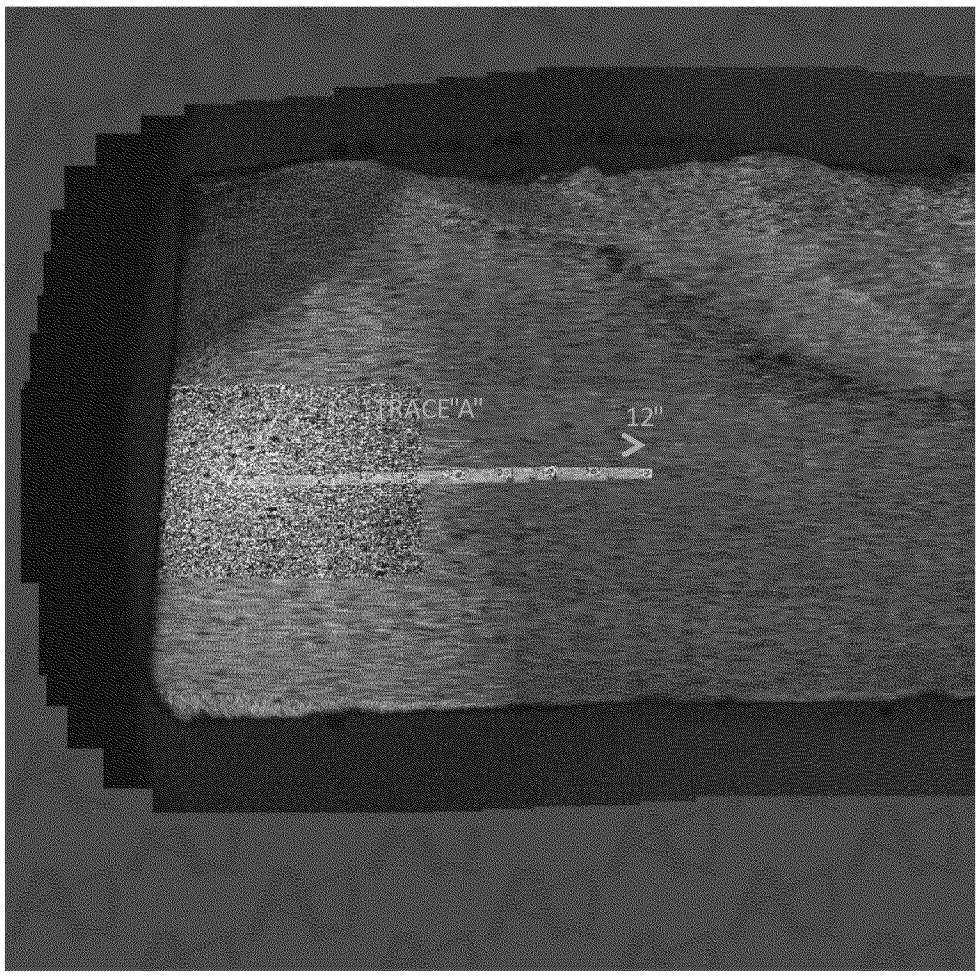
		500 gm
Mean Length	Mean Length	Hardness (HV)
1	77.5	154
2	77.3	155
3	80.7	142
4	79.8	146
5	79.3	147
6	84.5	130
7	77.7	153
8	79.8	146
9	79.3	147
10	82.5	136
	Avg:	146
	Max:	155
	Min:	130



Job Number	Item Number	Comments	Operator
1306838	105300	Kevin Moore	C. Jewett

500 gm

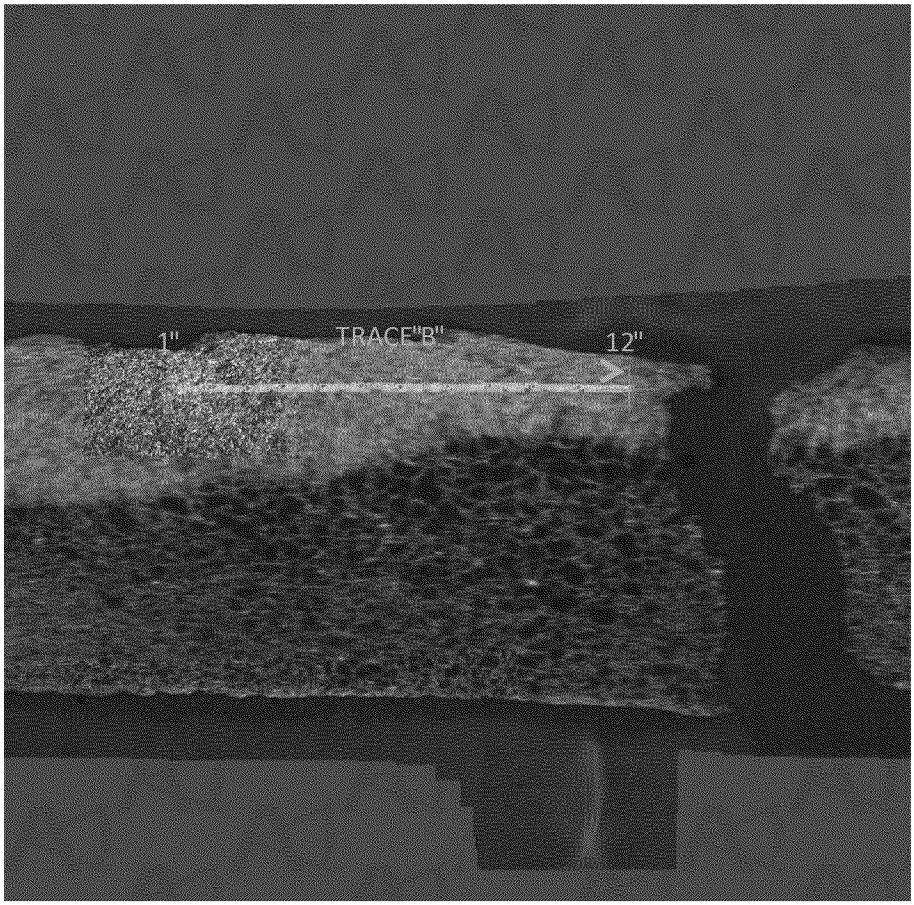
Trace A Loc	Mean Length	Hardness (HV)
1	81.3	140
2	82.9	135
3	85.1	128
4	80.0	145
5	78.2	151
6	81.6	139
7	79.3	147
8	79.0	149
9	80.2	144
10	77.3	155
	Avg:	143
	Max:	155
	Min:	128



Job Number	Item Number	Comments	Operator
1306838	105300	Kevin Moore	C. Jewett

500 gm

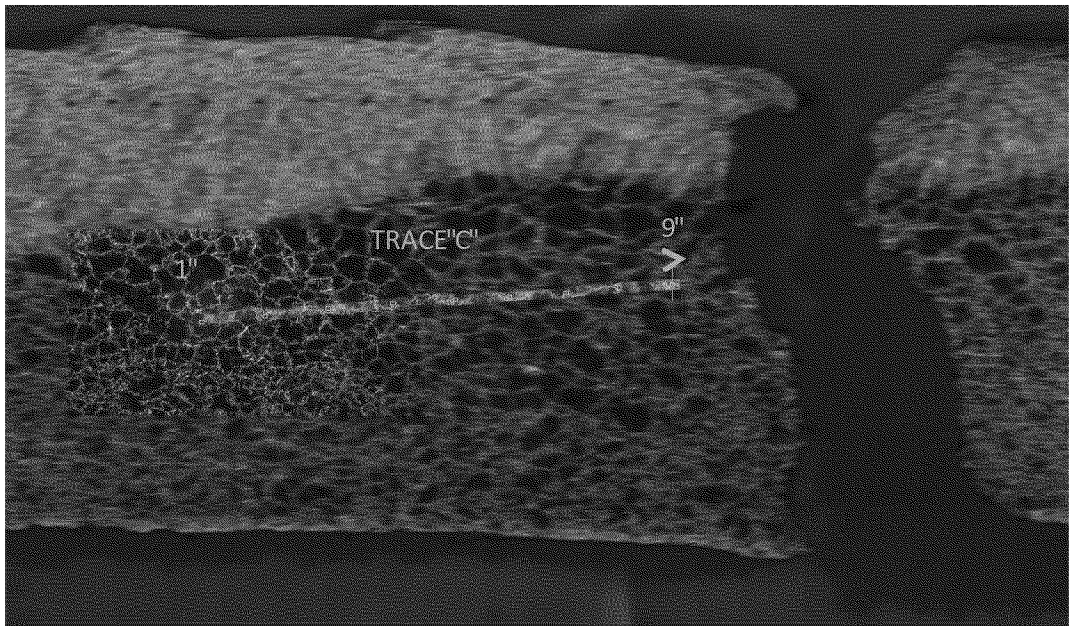
Trace B Loc	Mean Length	Hardness (HV)
1	76.9	157
2	79.2	148
3	79.7	146
4	79.6	146
5	80.1	144
6	79.4	147
7	79.0	149
8	78.2	152
9	79.3	148
10	77.3	155
11	79.6	146
12	69.8	190
	Avg:	152
	Max:	190
	Min:	144



Job Number	Item Number	Comments	Operator
1306838	105300	Kevin Moore	C. Jewett

500 gm

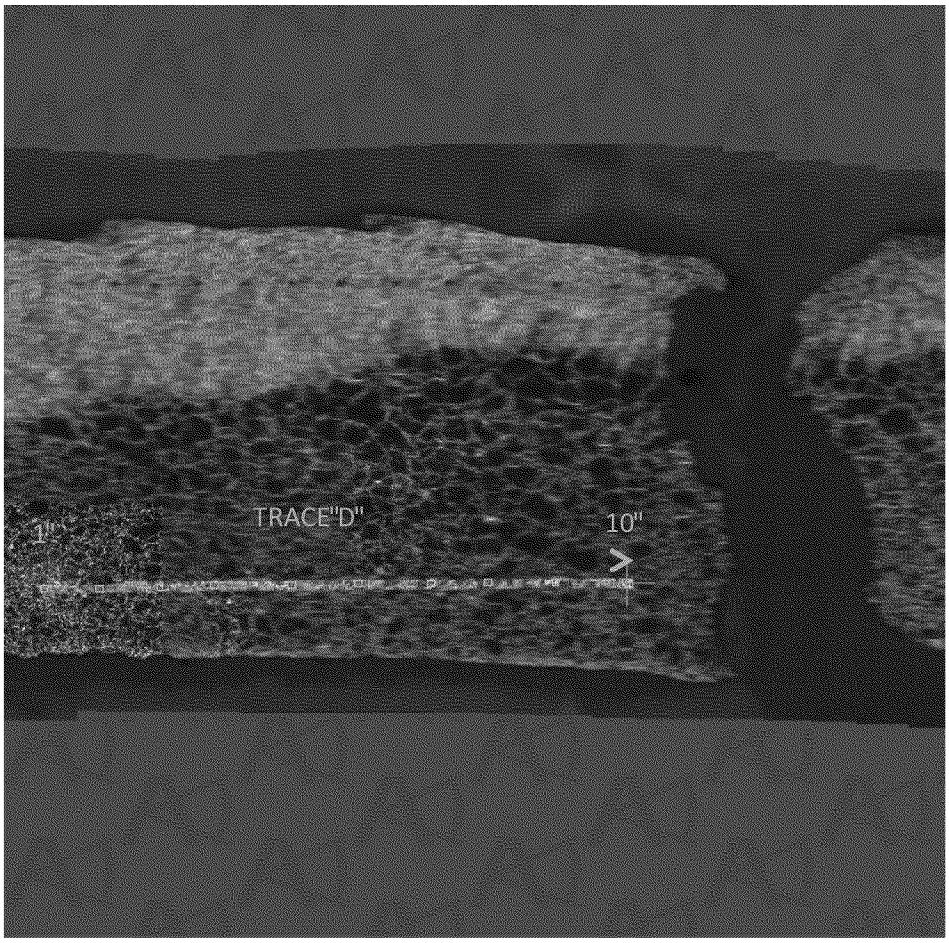
Trace C Loc	Mean Length	Hardness (HV)
1	70.1	189
2	71.2	183
3	73.5	171
4	70.4	187
5	75.8	161
6	75.2	164
7	72.4	177
8	73.1	173
9	71.8	180
Avg:	Avg:	176
Max:	Max:	189
Min:	Min:	161



Job Number	Item Number	Comments	Operator
1306838	105300	Kevin Moore	C. Jewett

500 gm

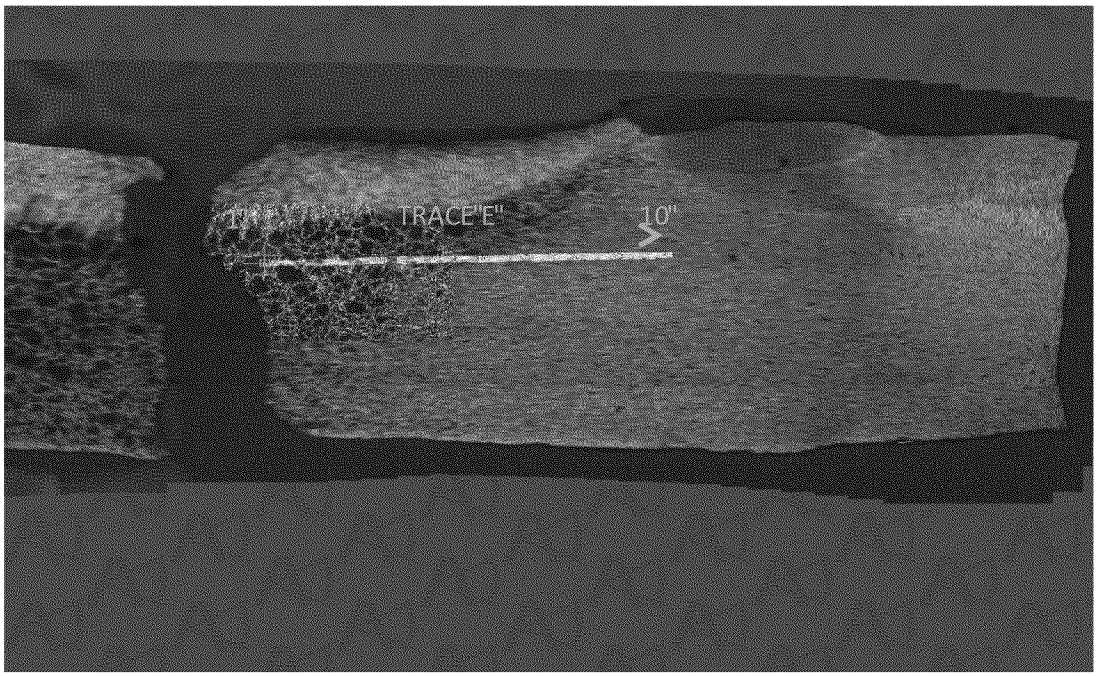
Trace D Loc	Mean Length	Hardness (HV)
1	78.0	152
2	75.0	165
3	75.9	161
4	76.9	157
5	77.8	153
6	78.0	152
7	74.7	166
8	75.4	163
9	76.2	160
10	76.5	158
	Avg:	159
	Max:	166
	Min:	152



Job Number	Item Number	Comments	Operator
1306838	105300	Kevin Moore	C. Jewett

500 gm

Trace E Loc	Mean Length	Hardness (HV)
1	76.8	157
2	76.4	159
3	80.1	145
4	79.0	149
5	78.2	152
6	82.3	137
7	83.1	134
8	85.4	127
9	84.5	130
10	83.4	133
	Avg:	142
	Max:	159
	Min:	127



Job Number	Item Number	Comments	Operator
1306838	105300	Kevin Moore	C. Jewett

500 gm

Trace F Loc	Mean Length	Hardness (HV)
1	70.9	184
2	75.3	164
3	74.6	167
4	75.6	162
5	74.9	165
6	80.1	144
7	81.8	139
8	81.8	139
9	82.7	136
10	84.3	130
	Avg:	153
	Max:	184
	Min:	130