Failure Investigation Report

Marathon Pipe Line, LLC.

Natural Gasoline Release – Girth Weld Failure

Executive Summary

On September 24, 2022, at approximately 1:50 p.m. Eastern Daylight Time (EDT)[1], Marathon Pipe Line, LLC (Marathon) had a failure involving a girth weld on the RIO 8-inch Products System Pipeline (RIO Pipeline) near Fillmore, Indiana. Pipeline operations continued until the night of September 25, 2022, when Marathon received an odor complaint at 11:02 p.m. from the Putnam County (Indiana) 911 center. Marathon shutdown the RIO Pipeline at 11:13 p.m. and isolated the pipeline with remote block valves on September 26, 2022, at 12:30 a.m.

The failure occurred about one mile southwest of Filmore, Indiana, in a wooded area, approximately 80 feet from Dyer Creek. 595 barrels (bbls) of natural gasoline was released, with 458.2 bbls reaching Dyer Creek and impacting the wildlife in the creek. 62.4 bbls of natural gasoline was recovered. The location is not deemed a High Consequence Area (HCA).

The failure was a pinhole leak and made the actual start time of the release difficult to determine. Based on Marathon's operating records and the review of Computational Pipeline Monitoring (CPM) and Supervisory Control and Data Acquisition (SCADA) data the release occurred on September 24, 2022, at 1:50 p.m. Marathon's Control Center received leak warnings and leak alarms on September 24-25, 2022, but attributed them to measurement issues. They did not suspect a leak or shutdown the pipeline until the odor complaint was received. The RIO Pipeline was shutdown 21 hours and 23 minutes after the failure was approximated to have occurred.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) determined the cause of the pinhole was a girth weld failure from original pipeline construction. A pinhole at the 5:45 position approximately 1/8-inch diameter developed due to poor welding workmanship. The defect was exacerbated by internal corrosion.

1. Operator, Location, Consequences

Lead Investigator	Heather David
Senior Accident Investigator	Gery Bauman
Accident Investigation Director	Chris Ruhl
Date of Report	February 28, 2024
Date of Failure	September 24, 2022
Commodity Released	Natural Gasoline
City, County, and State	Fillmore, Putnam, Indiana
OpID and Operator Name	32147 – Marathon Pipe Line, LLC
Unit # & Unit Name	13923 – RIO Products

[1] All times are reported in Eastern Daylight Time (EDT), unless otherwise noted.

WMS Activity #	22-255928
Milepost / Location	MP 175, 39.655309, -86.762747
Type of Failure	Leak – Material Failure of a Girth Weld – Original Construction Related
Fatalities	None
Injuries	None
Description of Impacted Area	Rural, Wooded Area – Near Dyer Creek
Total Costs	$2,037,984

2. System Description

Marathon operates 7,911 miles of hazardous liquid (HL) pipelines, and 430 PHMSA regulated HL breakout tanks across the United States. Many of these pipelines were installed between 1940 and 1980 and transport crude oil and refined products. The RIO Pipeline is 249 miles long and transports product from Lima, Ohio to Robinson, Illinois. The RIO Pipeline system includes two break out tanks in Robinson, Illinois and six pump stations. Products transported in the RIO Pipeline are isobutane, natural gasoline, diesel, various grades of gasoline, transmix, and normal butane.

The RIO Pipeline is one of two parallel pipelines in the right-of-way (ROW) at the failure location. The Marathon 10-inch Robinson Lima (ROLI) refined product pipeline is on the north side, approximately 25 feet from the RIO Pipeline. The RIO Pipeline is 8-inch nominal diameter, 0.277-inch wall thickness, American Petroleum Institute (API) 5L grade B 35,000 psi yield strength material, seamless pipe constructed in 1945. The pipe was manufactured using the Bessemer steel process, but the manufacturer is unknown. It has a coal tar enamel field-applied coating and an impressed current cathodic protection system.

The RIO Pipeline was hydrostatically tested at 1,935 pounds per square inch gauge (psig) for eight hours on September 29, 2016, in preparation for a flow reversal. From that test, the maximum operating pressure (MOP) of the pipeline was established as 1,520 psig. The MOP is 68% of the specified minimum yield strength (SMYS).

In 2019, Marathon modified the existing pipeline facilities to transport Highly Volatile Liquid through the RIO Pipeline. Two spherical tanks were constructed, and existing pumping units were upgraded in Lima, Ohio. Two bullet tanks were installed for the mainline in Robinson, Illinois.

The failure occurred at mile post (MP) 175, one mile southwest of Fillmore, Indiana. The Speedway RIO pump station is located upstream at MP 142 and the Brazil Pump Station is located downstream at MP 194. The release occurred approximately 80 feet upstream of Dyer Creek and did not have an impact on an HCA. Refer to Appendix A for a site-specific map.

3. Events Leading up to the Failure

The most recent in-line inspection (ILI) on the RIO Pipeline were performed by T.D. Williamson (TDW) and Baker Hughes in 2019 using a traditional magnetic flux leakage (MFL), caliper, inertial measurements unit (IMU), Helical MFL, and ultrasonic thickness crack detection (UTCD) tools. No anomalies were detected at the leak location during the 2019 TDW, nor Baker Hughes inspection surveys. There have been no anomaly digs within 500 feet upstream or downstream of the leak location.

The following timeline of events was established:

- On September 24, 2022, at 6:15 a.m. the RIO Pipeline was shutdown.
- At 11:15 a.m. the RIO Pipeline was restarted.
- At 12:11 p.m. Marathon started Brazil Unit 1 at the downstream Brazil Pump Station.

- At 12:43 p.m. Marathon's Control Center received a CPM Warning Alarm, short period[2]. The Control Center Controller (Controller) attributed the transient alarm to be associated with the Brazil Unit 1 startup. The system automatically cleared the alarm at 1:05 p.m. No operational changes were made.
- At 1:17 p.m. the Control Center received a CPM Warning Alarm, medium period[3]. The Controller attributed the transient alarm to be associated with the Brazil Unit 1 startup. No operational changes were made..

4. Emergency Response

- On September 24, 2022, at approximately 1:50 p.m. the failure occurred.
- At 2:50 p.m. the Control Center received a safety related CPM Leak Alarm, long period[4]. The Controller and the Control Center Specialist (Specialist) believed the transient Leak Alarm was attributed to the Brazil Unit 1 startup along with the elevated leak rates due to temperature tuning[5], specifically with Isobutane in the system. No operational changes were made.
- At 4:07 p.m. the system automatically downgraded the CPM Leak Alarm to a CPM Warning Alarm. The Controller and the Specialist did not make any operational changes.
- On September 25, 2022, at 6:05 p.m. the Specialist coming on shift contacted CPM Support[6] inquiring about the CPM Warning Alarm. The CPM Engineer concluded that trends pointed towards temperature tuning due to most of the leak rate being in volume differential.
- At 6:45 p.m. temperature tuning takes place.
- At 9:33 p.m. the Control Center receives an unexplainable CPM Warning Alarm. As a result, the Control Room attempted to prove meters at Shawnee and Robinson.
- At 11:02 p.m. Putnam County 911 contacted Marathon about an odor complaint near Fillmore, Indiana.
- At 11:13 p.m. Marathon shut down the RIO Pipeline. A check valve at the downstream Brazil Station prevented natural gasoline from flowing back to the leak site.
- At 11:17 p.m. Marathon shutdown the ROLI pipeline, a parallel pipeline within the ROW. No leak signatures were observed on the ROLI pipeline after shutdown, indicating no release.
- At 11:40 p.m. a second notification was received from 911 reporting an updated location, a sheen, and dead animals near the pipeline.
- At 11:47 p.m. Marathon Operations arrived on site to confirm the release based on odor. The leak occurred a MP 175.
- On September 26, 2022, at 12:29 a.m. Marathon's Control Center remotely closed the upstream block valve at MP 173 and remotely closed the downstream block valve at MP 183 at 12:30 a.m.
- At 1:40 a.m. Marathon Operations confirmed the presence of a sheen on the water in Dyer Creek.

[2] Marathon's CPM is calculating a leak rate every second, which is then averaged out using averaging periods. A "short" time averaging period is defined as 5 minutes for pipeline systems.

[3] A "medium" time averaging period is defined as 30 minutes for pipeline systems.

[4] A "long" time averaging period is defined as 2 hours for pipeline systems.

[5] RP1175 defines tuning as a process where the function of the leak detection technique is adjusted for more precise functioning. NOTE Tuning is a way of increasing alarm confidence, decreasing time to detect (or leak volume) and/or adjust the leak detector configuration without adversely affecting the frequency of non-leak alarms.

[6] When CPM support is contacted, the call is directed to a on call CPM Engineer.

- At 1:45 a.m. the first Oil Spill Removal Organization (OSRO) arrived onsite and a second OSRO arrived onsite at 4:30 a.m.
- At 1:52 a.m. Marathon notified the National Response Center (NRC) of the release (NRC Report No. 1348259). Refer to Appendix B for NRC Reports.
- At 4:40 a.m. a slick boom was installed north of East County Road 50 South.
- At 10:50 a.m. the ROLI pipeline was restarted.
- OSRO personnel worked to contain the release and recover natural gasoline. Marathon personnel worked to expose the part of the RIO Pipeline where the release originated.
- At 11:45 p.m. Marathon placed a wood plug in the pinhole, covered the plug with duct tape, and installed a 10-inch PLIDCO Split + Sleeve mechanical bolt-on clamp (PLIDCO Clamp) over the wood plug to stop the release.

5. Summary of Return-to-Service

Marathon replaced the 10-inch PLIDCO Clamp with a 24-inch PLIDCO Clamp and returned the pipeline to service at 6:41 p.m. on September 28, 2022. PHMSA and Marathon agreed that the pipeline will be operated at a pressure not to exceed 90% of the highest experienced pressure at the failure site in the previous 60 days (899.1 psig, a 10% pressure reduction).

On October 27, 2022, Marathon cut out the failed section of pipe including the upstream and downstream welds and sent it to ADV Integrity for metallurgical analysis. Marathon replaced a 101-foot pipe segment with pretested pipe and returned the pipeline to service at 4:30 p.m. on October 27, 2022. The RIO Pipeline continues to operate under the 10% pressure reduction.

Refer to Appendix C for Marathon's Accident Report Submitted on October 21, 2022.

6. Investigation Details

On September 27, 2022, PHMSA's Accident Investigation Division (AID) deployed two Accident Investigators.

Site Observations

On September 27, 2022, AID met with Marathon at the incident command post located at the Fillmore Fire Department and was briefed on the accident and provided historic cathodic protection records. The upstream Brazil Pump Station had been shut down and the pipeline had been isolated with mainline block valves both upstream and downstream of the failure. There was no pressure on the pipeline and all rectifiers were off. The pipeline was operating at 683 psig at the time of the failure. The 60-day average operating pressure was 550 psig and 60-day high operating pressure was 1,000 psig.

The failure location was approximately 80 feet upstream of Dyer Creek. The failure defect was in a girth weld at the 5:45 position. An estimated 458.2 bbls of the natural gasoline reached the creek, where most of the product evaporated. Prior to AID's arrival, Marathon placed a wood plug in the pinhole, covered it with duct tape, and installed a 10-inch PLIDCO clamp over the wood plug to stop the leak (**Figure 1**). Ultrasonic Testing (UT) wall thicknesses measurements of 0.250 inches minimum and 0.282 inches maximum were obtained near the 10-inch repair clamp, in the 0.277-inch wall pipe.

Figure 1. 10-inch PLIDCO Clamp Repair Over the Failure Defect (Looking West) – AID Photograph.

AID interviewed the Marathon Technician who installed the wood plug. The Technician indicated that the leak appeared to be a pinhole in the girth weld at the 5:45 position that resembled corrosion. The Technician observed calcareous deposits and no coating at the location of the pinhole. The Technician hammered a wood plug the size of a pencil into the pinhole and covered the plug with duct tape. The surface of the pipe was then cleaned with a brass wire brush prior to installing the 10-inch PLIDCO clamp. The Technician indicated that there was no visible pitting on the surface of the pipe and the coal tar coating looked good everywhere else.

AID observed the pipeline had field-applied coal tar coating with wrapper, which did not appear disbonded. The Corrosion Technician indicated that both the RIO Pipeline and ROLI Pipeline were protected via impressed current and bonded together approximately 40 miles away at the Staunton Pump Station. A cathodic protection (CP) reading of -1.032 volts was obtained on the RIO Pipeline at the accident site in the bell hole. Marathon indicated that the closest rectifier was off at that time, but other nearby rectifiers were still influencing the CP reading.

A Submar articulated concrete mat, installed in 2007, was located above the pipelines in the creek bed for erosion control. The mat was removed to excavate contaminated soils around the pipeline in the creek bed. The depth of cover at the failure location was 54 inches and there were pipeline markers upstream and downstream of the failure location.

Marathon replaced the 10-inch PLIDCO clamp with a 24-inch PLIDCO clamp as a temporary repair to return the pipeline to service. AID observed that the surface was properly prepared, and the clamp was installed in accordance with the manufacturer's recommendations.

On September 28, 2022, Marathon removed the coal tar coating, sand blasted the downstream pipe joint, and utilized phased array ultrasonic testing to examine for corrosion and weld indications. Ultrasonic testing was performed on the downstream weld to determine any potential metal loss in the weld. AID performed a visual examination of the downstream weld and identified surface porosity in the cap pass and a weld repair containing surface porosity near the 5:45 position. Marathon then removed the coal tar coating and sand blasted the upstream pipe joint. AID visually examined the upstream and downstream girth welds and observed arc burns near the girth weld, surface porosity, and undercut in the girth weld cap pass. No significant external corrosion was observed on the upstream or downstream pipe joints.

AID met with the Environmental Protection Agency (EPA) Region 5 on site representatives who indicated that Marathon's cleanup was effective as most of the product had evaporated and the creek had been cleaned up.

Metallurgical Laboratory Analysis

On October 27, 2022, Marathon cut out the failed section of pipe including the upstream and downstream pipe joints and girth welds. The 24-inch PLIDCO repair clamp remained in place during transportation. The failed pipe was transported in accordance with Marathon's Chain-of-Custody procedures to ADV Integrity in Magnolia, Texas for metallurgical analysis.

On November 8, 2022, AID witnessed the metallurgical analysis. The 24-inch PLIDCO repair clamp was removed to allow visual examination of the leak source. Visual examination of the failed girth weld revealed evidence of a pinhole, arc burns, weld repairs, and external corrosion a few inches upstream from the pinhole (**Figure 2**). The external corrosion appeared to be historic because the coating was intact before removal. There was no visual evidence of calcareous deposits, surface porosity, or undercut associated with the failed girth weld.

Figure 2. External Corrosion at 5:45 Position – AID Photograph.

Ultrasonic wall thickness testing (UT) was performed on the pipe body both upstream and downstream of the failed girth weld. The smallest wall thickness of 0.243 inches (12.27% metal loss) was identified at the 3:30 position upstream of the failed girth weld. Magnetic particle examination was performed on the failed girth weld and no defects were identified.

There was shallow internal corrosion found at the 6:00 position both upstream and downstream of the failed girth weld (**Figure 3**).

Figure 3. Shallow Internal Corrosion at 6:00 Position, Looking Upstream Toward the Failed Girth Weld – AID Photograph.

Marathon provided photographs of the inside of the pipe near the failure location at 5:45 position (Figure 4, on left) and at the smallest wall thickness at the 3:30 position (Figure 4, on right). Shallow internal corrosion was visible both upstream and downstream of the failure location and areas of inadequate penetration were also visible in the root pass of the girth weld.

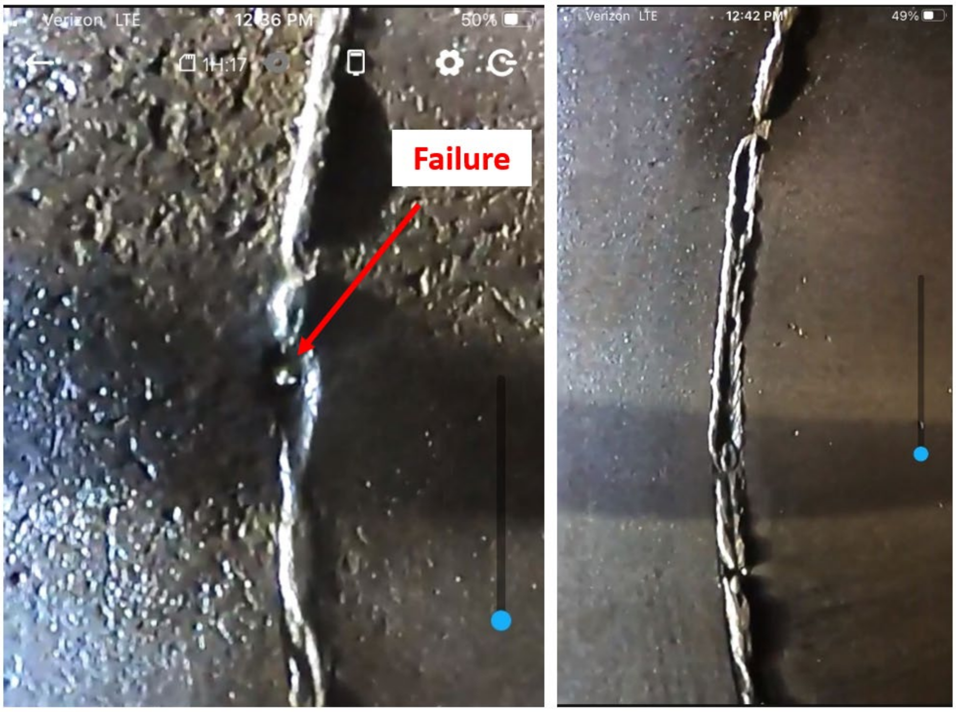

Figure 4. On the Left Photo, at the 5:45 Position There is Root Pass Burn-Through. The Failure Arrow Points Directly at the Wood Plug Still in The Girth Weld Pinhole. On The Right Photo, at the 3:00 Position, There is Incomplete Penetration of the Root Pass – ADV Integrity Photograph.

ADV Integrity's metallurgical analysis (Appendix D) indicated that the leak was identified at a start-stop of the weld cap pass. The internal pipe surface contained a region of minor internal corrosion along the bottom of the pipe, from approximately the 5:00 to 7:00 position. A metallurgical cross section through the identified leak (**Figure 5**) showed the wood plug centered within the weld. The leak's cross section contained areas of irregular metal loss, resembling internal corrosion. It appeared that the leak is associated with a burn-through of the root pass in conjunction with poor welding practices that occurred in the 1945 construction of the pipeline.

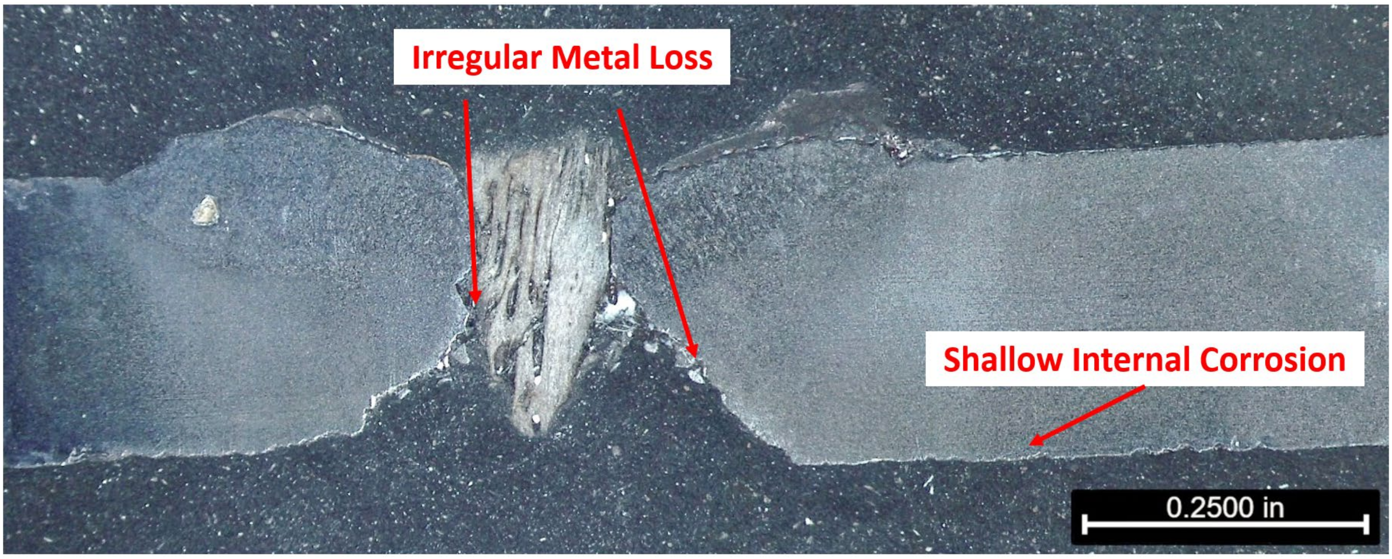

Figure 5. Cross Section Showing Internal Lack of Weld Deposit in the Root, a Concave Weld Cap, and the 1/8-inch Wood Plug – ADV Integrity Photograph.

ADV Integrity also examined the affected weld along the entire circumference and identified several weld imperfections adjacent to the failure location. Weld cap concavity, weld repairs, arc burns, suck back, burn-through, undercut, and incomplete penetration were observed visually. Metallurgical analysis and radiography also identified incomplete fusion, incomplete penetration, underfill, porosity, and internal corrosion. These features are not acceptable when compared to the 20th edition of API 1104; however, there was no industry standard at the time of construction in 1945 that required inspection of girth welds.

ADV Integrity's metallurgical analysis concluded the following:

1. ADV Integrity identified a leak coinciding with the girth weld resulting in an approximately 1/8-inch diameter through-wall hole. The girth weld contained a series of original construction welding features, although no weld flaw was identified within the leak's cross section, it seems possible that an area of undercut, burn-through, or suck back could have been present.
2. The leak coincided with an area of wall loss in the vicinity of the girth weld. Based on this appearance, the observed wall loss was the result of a time dependent mechanism, such as internal corrosion potentially exacerbated by hi-lo present.
3. The pipe material was determined to be consistent with API 5L (1945), Grade B material manufactured using Bessemer steel.

Integrity Assessment

AID reviewed Marathon's integrity assessment program to understand why internal metal loss had not been identified at the failure location by prior ILI's. The weld can challenge ILI tools due to multiple factors including sensor lift off that can occur as the tool passes over the weld. In addition, weld cap reinforcement influences the magnetic signature of the data. Therefore, indications in the weld zone are often challenging to analyze. The approximately 1/8-inch diameter pinhole in the girth weld was not detected by prior ILI's.

The failed section of pipe was being monitored for environmentally assisted cracking and earth movement and was also susceptible to mechanical damage. However, the threats of external corrosion and internal corrosion were not considered active for the failed section of pipe. The prior ILI history detected a significant number of internal features with the deepest remaining internal indications reported as 43% and 45%. Both indications had comments from the ILI vendor that they are manufacturing related and not corrosion related. Across the historic reports, the number of internal metal loss features have remained stable. There have not been changes in the volume or severity of features. The Froude number[7], a leading indicator of internal corrosion susceptibility, is 2.16. This indicates that water is being entrained with the product during operation. Therefore, Marathon has conducted cleaning pig runs twice a year to further reduce the risk of internal corrosion. Based on the stable metal loss counts, Froude number, and cleaning pig operation, the line is considered not active for internal corrosion.

Corrosion

Cathodic protection records indicated that pipe-to-soil "on" readings ranged from -2.67 volts to -1.916 volts over the past 5 years at the nearest test stations located 2 miles upstream and 0.3 miles downstream from the failure location. Marathon indicated that there were no sacrificial anodes connected to the pipe near the leak location at the time of the leak.

A close interval survey performed on February 21, 2020, indicated approximately -2.2 volts on potential and -1.2 volts off potential near the failure location at that time.

A phased array assessment of the upstream and downstream pipe joints performed in the field on September 28, 2022, and September 29, 2022, revealed two internal metal loss indications in the downstream pipe joint located west of the failure. Both indications were located near the 5:45 position 39 feet and 41 feet downstream from the leak location, a few feet from the downstream weld. The two internal metal loss indications had a maximum depth of 23.1% and 28.2% as summarized below in **Table 1.**

Table 1. Phased Array Results from Advanced NDT and Consulting.

Start of Ind	End of Ind	Axial Length	Circ Start	Circ Center	Circ End	Circ Extent	AWT @ Ind	Max Depth	Max Depth	Pipe, Weld, Both?	ID, OD or Mid Wall?	Flaw Type	Grind Length	Prmry NDE Method	Feature I.D. / Item No.	Comments
feet	feet	inch	Clock	Clock	Clock	inches	mils	mils	pct				inches			
39.37	39.45	0.96	5:46	5:55	6:04	0.68	277	64	23.1%	Pipe	ID	Corr	NA	PAUT	NG1	Internal Metal Loss
41.22	41.30	0.96	5:32	5:49	6:06	1.28	277	78	28.2%	Pipe	ID	Corr	NA	PAUT	NG2	Internal Metal Loss

The 2019 ILI inspection report did not report the two internal metal loss features identified by the phased array. Marathon indicated these features were indications of metal loss of less than 10% but the specified depth tolerance of the tool is +/- 15% due to variability of seamless pipe wall thickness.

AID visually examined the downstream pipe joint in the laboratory for any internal metal loss features located 41.22 feet downstream of the failure as previously called out by the phased array on September 28, 2022. AID did not observe any significant internal metal loss at this location. Due to AID's concerns with the phased array accuracy, Marathon cut out and tested the internal metal loss feature to determine the type of feature. This feature was measured at 16.7% metal loss using a pig gauge. AID concluded that the phased array results (**Table 1**) oversized the internal metal loss.

[7] Froude Number is a dimensionless parameter measuring the ratio of the inertia force on an element of fluid to the weight of the fluid element. The Froude Number is the inertial force divided by gravitational force.

Control Center

AID and PHMSA's Central Region reviewed the control room records to understand the sequence of events, alarms, and actions taken by Controllers. The RIO Pipeline is operated from Console 1 of the Findlay, Ohio Control Center.

Marathon's current form of CPM leak detection is a Real Time Transient Model (RTTM) System by Aveva, Simsuite 6.7 version. Marathon started using the Aveva RTTM for the RIO Pipeline in August 2018. The original test records dated February 2018, demonstrated that a CPM Warning Alarm was received at a 10 barrels per hour (bph) leak rate and a CPM Leak Alarm was received at a 90 bph leak rate. CPM models were not initially tested for each pipeline system, therefore initial testing records specific to the RIO Pipeline system do not exist. Point-to-point testing on the RIO Pipeline system was performed in August 2018 to prove data was being passed correctly from SCADA to the CPM System. At that time, the full range of the analog transmitters that could impact the CPM system were not verified. Marathon modified the point-to-point procedure on February 21, 2021, to require full range testing of the analog transmitters. However, at the time of the accident, the initial point-to-point testing did not include this full range requirement.

Marathon's CPM leak warning (CPM Warning) alarm threshold is a default setting currently set at 50% of the CPM Leak Alarm (CPM Leak) threshold for the RIO Pipeline. For this event, the RIO Pipeline averaged a 16.05 bph leak rate prior to the shutdown, which is above the CPM leak warning detection threshold of 11.75 bph, but below the CPM Leak Alarm detection threshold of 23.5 bph based on a 2-hour model. Marathon's Control Center received several CPM Warning Priority 2 alarms and four CPM Leak Priority 1 alarms between September 23, 2022, and September 25, 2022. A control center timeline of events is summarized in **Figure 6**.[8]

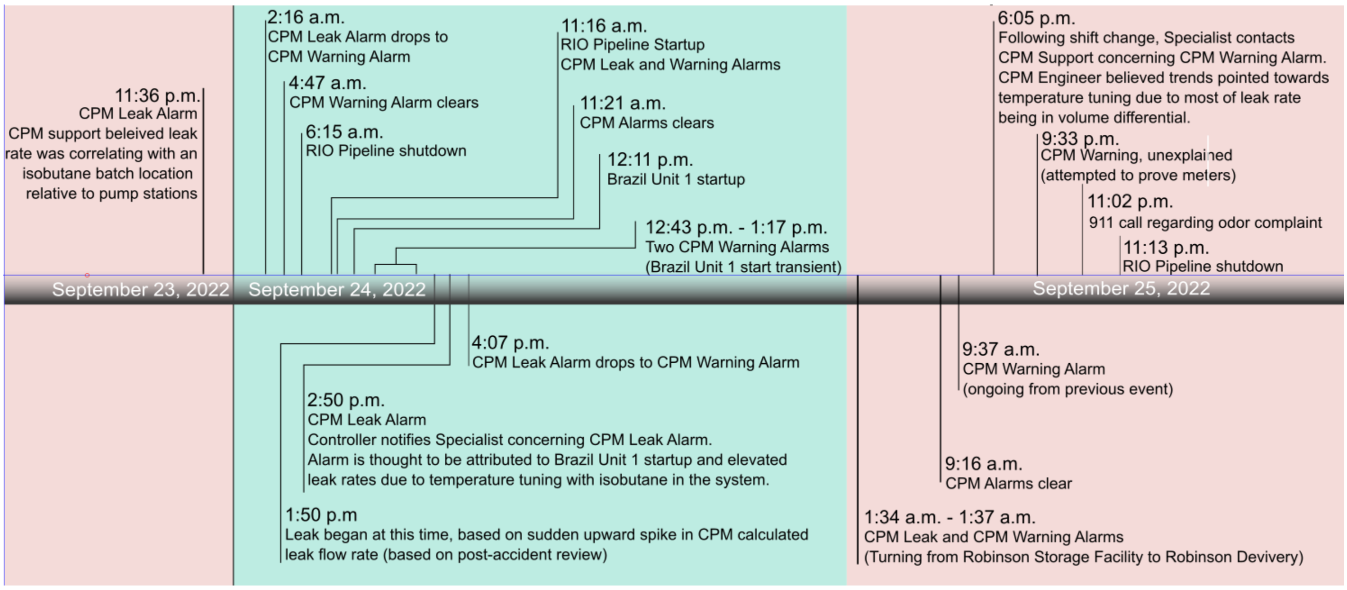

Figure 6. Control Center Timeline of Events.

The CPM Leak Alarm received at 2:50 p.m. on September 24, 2023, remained as a CPM Leak Alarm for a total of 1 hour and 17 minutes before returning to a CPM Warning Alarm. Marathon's control center procedure entitled "CPM Leak" effective September 9, 2020, Step 1 requires the Controller and Specialist to immediately shutdown the system if a leak is suspected. Step 5 requires the Specialist to determine and verify the cause of the CPM Leak Alarm by reviewing meter factors and proving history, event

[8] Refer to Appendix F for a table summarizing the control center response, including alarm response.

history, transmitters including in CPM model, and temperature and gravity profiles. The Specialist can engage the CPM Engineer as needed to assist in determining the cause of the Leak Alarm. Step 5 also requires the Specialist to instruct the Controller to perform normal shutdown of the system and initiate a Stop-Help-Start process if unable to determine the cause of the CPM Leak Alarm within 30 minutes of the alarming or the leak rate does not trend towards zero.

On September 24, 2022, the Controller notified the Specialist concerning the CPM Leak Alarm. The Controller and Specialist attributed the Leak Alarm to the Brazil Unit 1 startup along with the elevated leak rates due to temperature tuning, specifically with isobutane in the system. They also acknowledged that the leak rate was trending down, so they did not contact the CPM Engineer or shut down the pipeline at that time. On September 25, 2022, the Specialist coming onto shift contacted the CPM Support regarding the CPM Warning Alarm. The CPM Engineer attributed the trends pointed towards temperature tuning due to most of leak rate being in volume differential. Marathon acknowledges that the Controller, Specialist, and CPM Engineer initially came to the wrong conclusions, as these alarms were associated with the release of product.

Marathon indicated that the SCADA information was reviewed after the accident and it is determined that the leak began at 1:50 p.m. on September 24, 2022, based on a sudden upward spike in CPM calculated leak flow rate (barrels per hour). Refer to **Figure 7**.

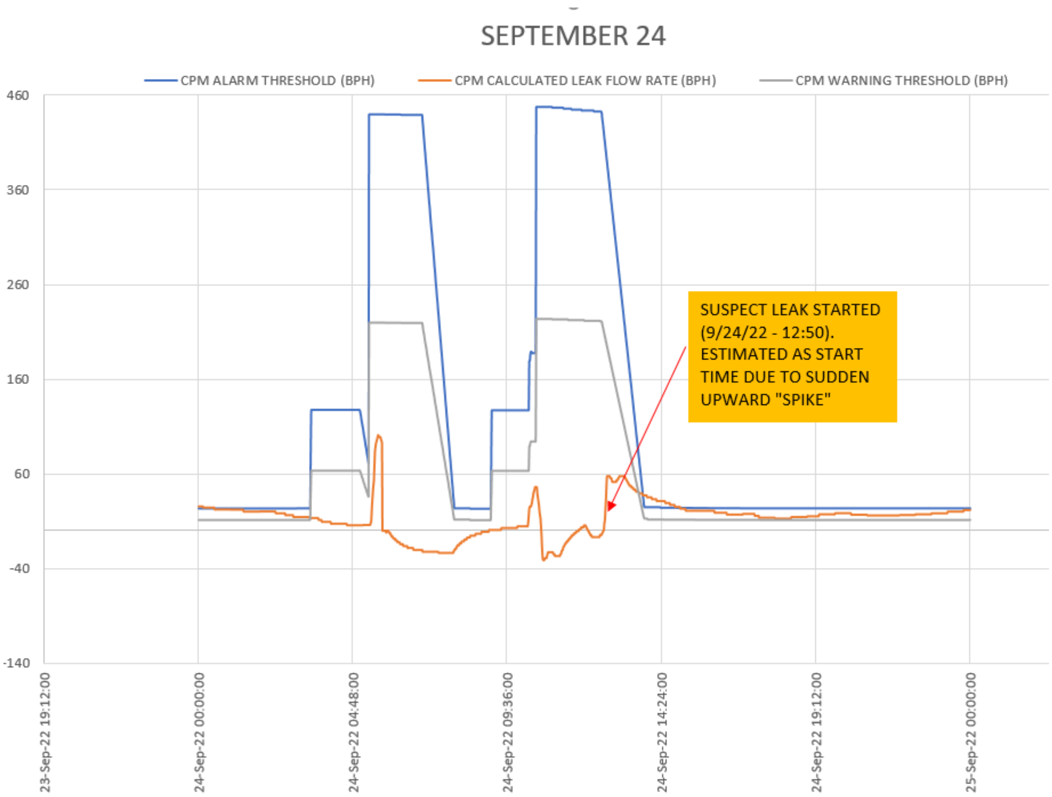

Figure 7. CPM Leak Flow Rate (bph), from Marathon.[9]

To demonstrate if the CPM Warning and CPM Leak Alarms could have been attributed to Brazil Unit 1 startup, Marathon provided a record of all CPM Warnings or CPM Leak Alarms that occurred after a Brazil Unit 1 Startup between September 1, 2021,

[9] Figure 7 is in Central Daylight Time (CDT).

and September 30, 2022. Brazil Unit 1 was started 311 times during that period; as a result of those startups, there were 68 instances (approximately 22%) where a CPM Warning and/or CPM Leak Alarm threshold was reached.

The Console 1 Controller during both day shifts on September 24, 2022, and September 25, 2022, had over four years of experience. There were also three other Controllers who worked on Console 1 during the night shifts on September 24, 2022, and September 25, 2022, who had experience ranging from 4 to 22 years. A Leak Detection Specialist and Trainee also worked on Console 1. Following the accident, Marathon conducted drug and alcohol testing on the Controller and the Trainee. Marathon indicated that no operator qualifications were revoked, retrained, modified, or changed because of this accident.

PHMSA identified the following issues related to the control center:

1. CPM models were not initially tested for each pipeline system, therefore initial testing records specific to the RIO Pipeline do not exist. CPM model defaults are not adjusted per pipeline system or leak segment. Specific procedures that govern initial CPM system testing per pipeline system or that address initial performance tuning of pipeline system do not exist.
2. Marathon's current CPM modeling software version has a known limitation associated with the movement of lighter fluids, such as isobutane. This known limitation has become evident through operating experience, model configuration and performance history, and user group participation. The specific gravity relevant to a batched product is measured through existing instrumentation on the RIO Pipeline system. However, the existing CPM software uses a range for specific gravity. This can impact model reliability, sensitivity, and robustness.
3. Leak warning and Leak Alarms do not include a descriptor that indicates the specific leak detection segment experiencing the warning or alarm. Controllers, Specialists, and the CPM Engineers do not have the leak detection segment identified with the associated Warning Alarm or Leak Alarm, but rather receive this information for the pipeline system.
4. The Controller and Specialist incorrectly attributed the CPM leak indications to be the result of product line makeup, temperature tuning, and starting up Brazil Unit 1. The Controller and Specialist made this incorrect determination based on prior operating history, current pipeline operational status, and other SCADA data and tools available such as trending. Controllers and Specialists do not see all information available to a CPM Engineer. CPM Engineers can determine if a temperature boundary, associated with temperature tuning, has been met. However, this information is not available to Controllers and Specialists.
5. The Controller and Specialist did not contact CPM Support after receiving a CPM Leak Alarm at 2:50 p.m. on September 24, 2022. If the CPM Engineer would have been contacted initially, they may have identified the sudden upward spike in CPM calculated leak flow rate. The Controller and Specialist did not identify the leak flow rate spike.
6. The commodity type is not currently recorded as part of the alarm deficiency tracking or the monthly CPM and other alarm review process. Additionally, the initial data and the documented result of the monthly CPM warning and alarm review does not currently identify the time the model remained in warning or alarm state. This information can impact alarm management effectiveness.
7. CPM Engineers use the alarm and event logs from SCADA, batch tracking information, and the CPM model software to determine what leak detection segment and commodity was involved in the identified CPM leak condition. Therefore, a prompt notification to the CPM Engineer is needed to minimize the time required to reconstruct the conditions associated with the CPM model leak indication.
8. Dynamic alarming is implemented to adjust the CPM Leak Alarm threshold and help eliminate false or nuisance alarms. However, Marathon's current process is not clear as to how adequate adjustments would be made to CPM Leak Alarm thresholds for a specific commodity or pipeline system.
9. Controllers and Specialists are not provided specific training on temperature tuning. Controllers and Specialists cannot view temperature bounding. CPM Engineers currently are the individuals with sufficient access to CPM data to correctly

determine if temperature limitations have been exceeded. CPM Warnings may be too frequent for the existing CPM Engineering staffing levels to adequately address all potential temperature tuning determinations.

Marathon's control center procedure entitled "CPM Warning" effective May 25, 2023, has been revised to require normal shutdown of the system and initiate the Stop-Help-Start process if unable to determine the cause of the CPM Warning Alarm within 4 hours of the alarm ringing in.

Marathon has since implemented a new leak detection analysis tool to assist in data manipulation and analysis, spreading out the 2-hour averaging threshold out to a 36-hour averaging threshold. The new tool looks at historic operation over the previous 10 days. The tool was initially piloted and is now live on the RIO Pipeline system and other similar pipelines that have risk of small leaks that are difficult to detect.

Root Cause Analysis

AID reviewed Marathon's Root Cause Analysis (RCA) report (Appendix E). The RCA findings summary state in part that:

The girth weld contained a series of original construction welding features. The weld defect area and associated wall loss created a void which allowed water to collect thus enabling an environment conducive for internal corrosion. The RIO Pipeline has historically not been a high risk of internal corrosion, which indicates that corrosion would not have been a contributing factor without the causal factor of the girth weld feature.

Corrective Actions

As part of the root cause analysis, Marathon took several corrective actions to reduce the likelihood of reoccurrence. Marathon performed a TDW girth weld analysis on prior ILI data. Indications of potential anomalies were identified at 14 locations. In February of 2023, Marathon conducted integrity digs at each of the locations. A total of 9 digs were completed on the Speedway Station to Staunton Junction segment as summarized in **Table 2**. A total of 5 digs were completed on the Staunton Junction to Robinson segment as summarized in **Table 3**. All the indications were confirmed to have anomalies and were repaired utilizing Type B sleeves.

Table 2. ILI vs. Field - Speedway Station to Staunton Junction Segment, Marathon Provided.

					TDW Girth Weld Analysis				Field Found Data					
Dig No.	Item No.	Weld MAPLID	Distance From Release (mi)	Remediation	Feature	Length (in)	Width (in)	Orientation	Feature	Length (in)	Width (in)	Orientation	Depth (in)	Depth %
1	3362	665329	24.61	B-Sleeve	Manufacturing Ind. @ GW	0.58	0.23	6:30	Lack of Fusion (INT)	0.040	0.250	5:51	0.098	38%
2	3364	665328	24.60	B-Sleeve	Manufacturing Ind. @ GW	0.36	0.08	5:15	Excess Metal (EXT)	0.700	1.400	5:15	0	0%
3	3396	665326	24.58	B-Sleeve	Manufacturing Ind. @ GW	0.36	0.39	5:45	Lack of Fill (Weld Reinforcement) (EXT)	0.500	0.500	5:45	0	0%
4	3398	665325	24.57	B-Sleeve	Manufacturing Ind. @ GW	0.20	0.40	8:45	Lack of Penetration (INT)	0.100	0.410	8:45	0.131	48%
4	3399	665325	24.57	B-Sleeve	Manufacturing Ind. @ GW	0.31	0.36	5:45	Lack of Fill (Weld Reinforcement) (EXT)	0.300	0.300	5:47	0.050	17%
5	3404	665323	24.56	B-Sleeve	Manufacturing Ind. @ GW	0.34	0.21	3:00	ID Lack of Weld	0.200	0.100	2:46	0.185	67%
6	3405	665322	24.55	B-Sleeve	Manufacturing Ind. @ GW	0.44	0.46	5:30	Burn Through / INT ML @ Weld	0.200	0.396	4:55	0.143	56%
7	3410	665321	24.54	B-Sleeve	Manufacturing Ind. @ GW	0.17	0.21	8:30	Lack of Fusion (INT)	0.100	0.328	8:45	0.151	58%
8	3875	665150	23.28	B-Sleeve	Manufacturing Ind. @ GW	0.38	0.07	7:30	Lack of Fusion (INT)	0.040	0.779	7:53	0.210	77%
8	3876	665150	23.28	B-Sleeve	Manufacturing Ind. @ GW	0.21	0.33	9:00	Lack of Fusion (INT)	0.100	0.533	9:07	0.141	88%
8	3877	665150	23.28	B-Sleeve	Manufacturing Ind. @ GW	0.41	0.38	6:45	Burn Through (INT)	0.300	0.533	5:56	0.123	47%
9	3879	665149	23.27	B-Sleeve	Manufacturing Ind. @ GW	0.34	0.38	9:45	Lack of Fusion (INT)	0.086	0.738	9:00	0.256	96%

Table 3. ILI vs. Field - Staunton Junction to Robinson Segment, Marathon Provided.

				TDW Girth Weld Analysis				Field Found Data					
Dig No.	Item No.	Distance From Release on Speedway RIO	Remediation	Feature	Length (in)	Width (in)	Orientation	Feature	Length (in)	Width (in)	Orientation	Depth (in)	Depth %
1	4505	42.33	B-Sleeve	Manufacturing Ind. @ GW	0.61	0.07	6:15	Lack of Penetration	0.30	2.87	5:49	0.175	65%
2	4515	42.37	B-Sleeve	Manufacturing Ind. @ GW	0.43	0.47	6:15	Lack of Penetration and Burn Through	0.30	2.00	6:21	0.111	43%
3	4519	42.38	B-Sleeve	Manufacturing Ind. @ GW	0.33	0.01	7:30	Lack of Penetration	0.10	0.49	7:23	0.129	49%
4	4539	42.40	B-Sleeve	Manufacturing Ind. @ GW	0.50	0.01	5:15	Lack of Penetration and Burn Through	0.17	1.84	4:54	0.085	34%
5	4541	42.41	B-Sleeve	Manufacturing Ind. @ GW	0.45	0.59	6:00	Lack of Fusion	0.20	0.53	5:59	0.155	56%

On December 21, 2022, Marathon conducted an ILI utilizing an ultrasonic circumferential crack detection tool for the RIO Pipeline from the Speedway Station to Staunton segment. A total of 602 manufacturing indications were detected at girth welds, all between 20% and 45% in depth. A total of 3 crack-like circumferential anomalies were detected, all less than 20% in depth. On June 8, 2023, an ILI utilizing an ultrasonic circumferential crack detection tool for all remaining segments of the RIO Pipeline was completed. Marathon has indicated that no 49 CFR Part 195.452(h) conditions exist.

7. Findings and Contributing Factors

PHMSA has determined the cause of the pinhole was a girth weld failure from original pipeline construction. A pinhole at the 5:45 position approximately 1/8-inch diameter developed due to poor welding workmanship. The defect was exacerbated by internal corrosion.

The following factors contributed to the failure:

- Poor welding workmanship in 1945 resulted in a series of original construction welding features such as undercut, burn-through, suck back, inadequate penetration, and porosity.
- The burn-through of the root pass at the 5:45 position allowed water to accumulate and corrode the remaining girth weld metal that was compromised by the start stop in the weld cap.
- The failure location was in a low spot of the pipeline, making it susceptible to internal corrosion.
- The 1/8-inch diameter pinhole in the girth weld was outside the detection capabilities of the prior ILI runs.
- The RIO Pipeline was shutdown 21 hours and 23 minutes after the failure occurred greatly increasing the volume of natural gasoline released.

Appendices

A. Pipeline System Map.

B. NRC Report Nos. 1348259, 1348466.

C. Operator Accident Report – Hazardous Liquid Pipeline Systems No. 20220239.

D. Metallurgical Analysis – Speedway Rio-Staunton 8” Failure Analysis, ADV Integrity, Inc., December 2022.

E. Operator Root Cause Analysis – Investigation Summary, Marathon, February 2023.

F. Operator Control Center Response.

Appendix A. Pipeline System Map.

Figure 7: An ArcGIS-generated Satellite Map with the Site of the Leak Marked by the Red Star (the Insert Map on the Bottom Right Shows the Leak Site Location Within the State of Indiana)

Appendix B.NRC Report Nos. 1348259, 1348466.

NATIONAL RESPONSE CENTER 1-800-424-8802
*** For Public Use ***
Information released to a third party shall comply with any applicable federal and/or state Freedom of Information and Privacy Laws

Incident Report # 1348259

INCIDENT DESCRIPTION

*Report taken by NRC on 26-SEP-22 at 01:52 ET.
Incident Type: PIPELINE
Incident Cause: UNKNOWN
Affected Area: DYER CREEK
Incident occurred on 25-SEP-22 at 11:02 local incident time.
Affected Medium: WATER / DYER CREEK

SUSPECTED RESPONSIBLE PARTY

Organization: MARATHON PIPELINE

FINLEY, OH

Type of Organization: PRIVATE ENTERPRISE

INCIDENT LOCATION
RIO PIPELINE County: PUTNAM
39.655272N -86.762868W
City: FILLMORE State: IN
Latitude: 39° 39' 19" N
Longitude: 086° 45' 46" W

RELEASED MATERIAL(S)
CHRIS Code: GAS Official Material Name: GASOLINE: AUTOMOTIVE (UNLEADED)
Also Known As:
Qty Released: 10 BARREL(S) Qty in Water: 1 BARREL(S)

DESCRIPTION OF INCIDENT
CALLER STATED DUE TO UNKNOWN CAUSES THERE IS A SPILL NATURAL GASOLINE FROM AN EIGHT INCH STEEL BELOW GROUND TRANSMISSION PIPELINE. CALLER STATED THE SPILL HAS CAUSED A SHEEN ON DYER CREEK.

INCIDENT DETAILS
Pipeline Type: TRANSMISSION
DOT Regulated: YES
Pipeline Above/Below Ground: BELOW
Exposed or Under Water: NO
Pipeline Covered: UNKNOWN
---WATER INFORMATION---
Body of Water: DYER CREEK
Tributary of: DEER CREEK
Nearest River Mile Marker:
Water Supply Contaminated: UNKNOWN

IMPACT
Fire Involved: NO Fire Extinguished: UNKNOWN

INJURIES: NO Sent to Hospital: Empl/Crew: Passenger:
FATALITIES: NO Empl/Crew: Passenger: Occupant:
EVACUATIONS:NO Who Evacuated: Radius/Area:

Damages: NO

Closure Type	Description of Closure	Hours Closed	Direction of Closure
Air: NO			
Road: NO	Major Artery:NO		
Waterway:NO			
Track: NO			

Passengers Transferred: NO
Environmental Impact: UNKNOWN
Media Interest: NONE

REMEDIAL ACTIONS
CLEAN UP CREW ENROUTE, INVESTIGATION UNDERWAY.
Release Secured: NO
Release Rate:
Estimated Release Duration:

WEATHER

ADDITIONAL AGENCIES NOTIFIED
Federal:
State/Local: LOCAL EPA
State/Local On Scene: FIRST RESPONDERS (FIRE DEPT)
State Agency Number:

NOTIFICATIONS BY NRC

CENTERS FOR DISEASE CONTROL (GRASP)
26-SEP-22 02:02
ASST COMDT FOR INTELLIGENCE (CG-2) (OFFICE OF INTELLIGENCE PLANS AND POLICY (CG-25))
26-SEP-22 02:02
CG INVESTIGATIVE SVC CHICAGO (CGIS RAO CHICAGO)
26-SEP-22 02:02
CHEM SAFETY AND HAZARD INVEST BOARD (MAIN OFFICE)
26-SEP-22 02:02
DEPT OF HEALTH AND HUMAN SERVICES (SECRETARY OPERATION CENTER (SOC))
26-SEP-22 02:02
DHS CISA (CISA CENTRAL)
26-SEP-22 02:02
MI OFFICE OF INTEL AND ANALYSIS (FIELD OPERATIONS DIVISION)
26-SEP-22 02:02
DOT CRISIS MANAGEMENT CENTER (MAIN OFFICE)
26-SEP-22 02:02
U.S. EPA V (MAIN OFFICE)
26-SEP-22 02:05
U.S. EPA V (OUTSTATION INDIANAPOLIS)
26-SEP-22 02:02
USCG NATIONAL COMMAND CENTER (MAIN OFFICE)
26-SEP-22 02:02
IN STATE DEPT OF HOMELAND SECURITY (SITUATIONAL AWARENESS)
26-SEP-22 02:02
INDIANA STATE DEPARTMENT OF HEALTH (ENVIRONMENTAL PUBLIC HEALTH DIVISION)
26-SEP-22 02:02
NOAA RPTS FOR IN (MAIN OFFICE)
26-SEP-22 02:02
OEPC REGION 5 (MAIN OFFICE)
26-SEP-22 02:02
PIPELINE & HAZMAT SAFETY ADMIN (OFFICE OF PIPELINE SAFETY (AUTO))
26-SEP-22 02:02
PIPELINE & HAZMAT SAFETY ADMIN (HAZARDOUS MATERIAL ACCIDENT INVESTIGATION)
26-SEP-22 02:02
REPORTING PARTY (RP SUBMITTER)
26-SEP-22 02:02
IN DEPT ENV MNGMT (MAIN OFFICE)
26-SEP-22 02:02
IN DEPT ENV MNGMT (COMMUNICATIONS)
26-SEP-22 02:02
USCG DISTRICT 8 (MAIN OFFICE)
26-SEP-22 02:02
US COURTS JUDICIAL SECURITY DIV (FACILITIES AND SECURITY OFFICE (FSO))
26-SEP-22 02:02

ADDITIONAL INFORMATION

*** END INCIDENT REPORT #1348259 ***

Report any problems by calling 1-800-424-8802

PLEASE VISIT OUR WEB SITE AT https://gcc02.safelinks.protection.outlook.com/?url=http%3A%2F%2Fnrc.uscg.mil%2F&data=05%7C02%7Cl.hollingshead.ctr%40dot.gov%7C1098ebbe213644da02c608dc3c83f8e3%7Cc4cd245b44f04395a1aa3848d258f78b%7C0%7C0%7C638451784711980013%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C0%7C%7C%7C&sdata=xyHy%2FdBcfGC0YfQ%2BKSuY3GskbsydOHlXr5BwCVHnL1I%3D&reserved=0

NATIONAL RESPONSE CENTER 1-800-424-8802
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Incident Report # 1348466

INCIDENT DESCRIPTION

*Report taken by NRC on 27-SEP-22 at 20:20 ET.
Incident Type: PIPELINE
Incident Cause: UNKNOWN
Affected Area: DYER CREEK
Incident occurred on 25-SEP-22 at 11:02 local incident time.
Affected Medium: WATER / DYER CREEK

SUSPECTED RESPONSIBLE PARTY

Organization: MARATHON PIPELINE

FINLEY, OH

Type of Organization: PRIVATE ENTERPRISE

INCIDENT LOCATION
SEE LAT AND LONG County: PUTNAM
City: FILLMORE State: IN
Latitude: 39° 39' 19" N
Longitude: 086° 45' 46" W
RIO PIPELINE

RELEASED MATERIAL(S)
CHRIS Code: GCS Official Material Name: GASOLINE: CASINGHEAD
Also Known As: GASOLINE: NATURAL
Qty Released: 595 BARREL(S) Qty in Water: 1 BARREL(S)

DESCRIPTION OF INCIDENT
/// THIS IS A PHMSA 48-HOUR UPDATE TO NRC REPORT # 1348259 ///

THE UPDATE IS AS FOLLOWS: THE CALLER STATED THAT (595) BARRELS OF NATURAL GASOLINE WAS RELEASED DUE TO THIS INCIDENT. THE RELEASE HAS BEEN SECURED AND REPAIRS ARE UNDERWAY.

/// ORIGINAL REPORT BELOW ///

CALLER STATED DUE TO UNKNOWN CAUSES THERE IS A SPILL NATURAL GASOLINE FROM AN EIGHT INCH STEEL BELOW GROUND TRANSMISSION PIPELINE. CALLER STATED THE SPILL HAS CAUSED A SHEEN ON DYER CREEK.

INCIDENT DETAILS

Pipeline Type: TRANSMISSION
DOT Regulated: YES
Pipeline Above/Below Ground: BELOW
Exposed or Under Water: NO
Pipeline Covered: UNKNOWN
---WATER INFORMATION---
Body of Water: DYER CREEK
Tributary of: DYER CREEK
Nearest River Mile Marker:
Water Supply Contaminated: UNKNOWN

IMPACT

Fire Involved: NO Fire Extinguished: UNKNOWN

INJURIES: NO Sent to Hospital: Empl/Crew: Passenger:
FATALITIES: NO Empl/Crew: Passenger: Occupant:
EVACUATIONS:NO Who Evacuated: Radius/Area:

Damages: NO

Closure Type	Description of Closure	Hours Closed	Direction of Closure
Air: NO			
Road: NO		Major Artery:NO	
Waterway:NO			
Track: NO			

Passengers Transferred: NO
Environmental Impact: UNKNOWN
Media Interest: NONE

REMEDIAL ACTIONS

CLEAN UP CREW ENROUTE, INVESTIGATION UNDERWAY.
Release Secured: YES
Release Rate:
Estimated Release Duration:

WEATHER

ADDITIONAL AGENCIES NOTIFIED

Federal:
State/Local: LOCAL EPA
State/Local On Scene: FIRST RESPONDERS (FIRE DEPT)
State Agency Number:

NOTIFICATIONS BY NRC

ATLANTIC STRIKE TEAM (MAIN OFFICE)
27-SEP-22 21:18
CENTERS FOR DISEASE CONTROL (GRASP)
27-SEP-22 20:54
ASST COMDT FOR INTELLIGENCE (CG-2) (OFFICE OF INTELLIGENCE PLANS AND POLICY (CG-25))
27-SEP-22 20:54
CG INVESTIGATIVE SVC CHICAGO (CGIS RAO CHICAGO)
27-SEP-22 20:54
CHEM SAFETY AND HAZARD INVEST BOARD (MAIN OFFICE)
27-SEP-22 20:54
DEPT OF HEALTH AND HUMAN SERVICES (SECRETARY OPERATION CENTER (SOC))
27-SEP-22 20:54
DHS CISA (CISA CENTRAL)
27-SEP-22 20:54
MI OFFICE OF INTEL AND ANALYSIS (FIELD OPERATIONS DIVISION)
27-SEP-22 20:54
DOT CRISIS MANAGEMENT CENTER (MAIN OFFICE)
27-SEP-22 20:54
EPA HQ EMERGENCY OPERATIONS CENTER (MAIN OFFICE (AUTO))
27-SEP-22 20:54
U.S. EPA V (MAIN OFFICE)
27-SEP-22 21:16
U.S. EPA V (OUTSTATION INDIANAPOLIS)
27-SEP-22 20:54
USCG NATIONAL COMMAND CENTER (MAIN OFFICE)
27-SEP-22 20:54
IN STATE DEPT OF HOMELAND SECURITY (SITUATIONAL AWARENESS)
27-SEP-22 20:54
INDIANA STATE DEPARTMENT OF HEALTH (ENVIRONMENTAL PUBLIC HEALTH DIVISION)
27-SEP-22 20:54
NOAA RPTS FOR IN (MAIN OFFICE)
27-SEP-22 20:54
NTSB PIPELINE (MAIN OFFICE)
27-SEP-22 20:54
OEPC REGION 5 (MAIN OFFICE)
27-SEP-22 20:54
PIPELINE & HAZMAT SAFETY ADMIN (OFFICE OF PIPELINE SAFETY (AUTO))
27-SEP-22 20:54
PIPELINE & HAZMAT SAFETY ADMIN (OFFICE OF PIPELINE SAFETY WEEKDAYS (VERBAL))
27-SEP-22 21:16

PIPELINE & HAZMAT SAFETY ADMIN (HAZARDOUS MATERIAL ACCIDENT INVESTIGATION)
27-SEP-22 20:54
REPORTING PARTY (RP SUBMITTER)
27-SEP-22 20:54
SECTOR OHIO VALLEY (COMMAND CENTER)
27-SEP-22 21:19
IN DEPT ENV MNGMT (MAIN OFFICE)
27-SEP-22 20:54
IN DEPT ENV MNGMT (COMMUNICATIONS)
27-SEP-22 20:54
USCG DISTRICT 8 (MAIN OFFICE)
27-SEP-22 20:54
US COURTS JUDICIAL SECURITY DIV (FACILITIES AND SECURITY OFFICE (FSO))
27-SEP-22 20:54

ADDITIONAL INFORMATION

/// THIS IS A PHMSA 48-HOUR UPDATE TO NRC REPORT # 1348259 ///

*** END INCIDENT REPORT #1348466 ***

Report any problems by calling 1-800-424-8802

PLEASE VISIT OUR WEB SITE AT

https://gcc02.safelinks.protection.outlook.com/?url=http%3A%2F%2Fnrc.uscg.mil%2F&data=05%7C02%7Cl.hollingshead.ctr%40dot.gov%7C47de65f93fa14658e9ba08dc3c83de25%7Cc4cd245b44f04395a1aa3848d258f78b%7C0%7C0%7C638451784258249664%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C0%7C%7C%7C&sdata=PrZ%2Fgk%2BxSsxZYcJgVdzvuZLBgZLqTZDgNL9b6F2AFhU%3D&reserved=0

Appendix C.Operator Accident Report – Hazardous Liquid Pipeline Systems No. 20220239.

NOTICE: This report is required by 49 CFR Part 195. Failure to report can result in a civil penalty as provided in 49 USC 60122.		OMB NO: 2137-0047 EXPIRATION DATE: 3/31/2024
U.S Department of Transportation Pipeline and Hazardous Materials Safety Administration	**Original Report Date:**	10/21/2022
	No.	20220239 -37708 ------------------------- (DOT Use Only)

ACCIDENT REPORT - HAZARDOUS LIQUID AND CARBON DIOXIDE PIPELINE SYSTEMS

A federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a current valid OMB Control Number. The OMB Control Number for this information collection is 2137-0047. Public reporting for this collection of information is estimated to be approximately 12 hours per response, including the time for reviewing instructions, gathering the data needed, and completing and reviewing the collection of information. All responses to the collection of information are mandatory. Send comments regarding this burden or any other aspect of this collection of information, including suggestions for reducing the burden to: Information Collection Clearance Officer, PHMSA, Office of Pipeline Safety (PHP-30) 1200 New Jersey Avenue, SE, Washington, D.C. 20590.

INSTRUCTIONS

Important: *Please read the separate instructions for completing this form before you begin. They clarify the information requested and provide specific examples. If you do not have a copy of the instructions, you can obtain one from the PHMSA Pipeline Safety Community Web Page at* http://www.phmsa.dot.gov/pipeline/library/forms .`

PART A - KEY REPORT INFORMATION

	Original:	**Supplemental:**	**Final:**
Report Type: *(select all that apply)*		Yes	Yes

Last Revision Date:	02/14/2023
1. Operator's OPS-issued Operator Identification Number (OPID):	32147
2. Name of Operator	MARATHON PIPE LINE LLC
3. Address of Operator:	
3a. Street Address	539 SOUTH MAIN STREET
3b. City	FINDLAY
3c. State	Ohio
3d. Zip Code	45840
4. Earliest local time *(24-hr clock)* and date an accident reporting criteria was met:	09/25/2022 23:02
4a. Time Zone for local time	Eastern
4b. Daylight Saving in effect?	Yes
5. Location of Accident:	
Latitude / Longitude	39.6553093, -86.76274718
6. Commodity released: *(select only one, based on predominant volume released)*	Refined and/or Petroleum Product (non-HVL) which is a Liquid at Ambient Conditions
- Specify Commodity Subtype:	Other
- If "Other" Subtype, Describe:	Natural Gasoline

- If Biofuel/Alternative Fuel and Commodity Subtype is Ethanol Blend, then % Ethanol Blend:	
- If Biofuel/Alternative Fuel and Commodity Subtype is Biodiesel, then Biodiesel Blend e.g. B2, B20, B100	
7. Estimated volume of commodity released unintentionally (Barrels):	595.00
8. Estimated volume of intentional and/or controlled release/blowdown (Barrels):	
9. Estimated volume of commodity recovered (Barrels):	62.40
10. Were there fatalities?	No
- If Yes, specify the number in each category:	
10a. Operator employees	
10b. Contractor employees working for the Operator	
10c. Non-Operator emergency responders	
10d. Workers working on the right-of-way, but NOT associated with this Operator	
10e. General public	
10f. Total fatalities (sum of above)	0
11. Were there injuries requiring inpatient hospitalization?	No
- If Yes, specify the number in each category:	
11a. Operator employees	
11b. Contractor employees working for the Operator	
11c. Non-Operator emergency responders	
11d. Workers working on the right-of-way, but NOT associated with this Operator	
11e. General public	
11f. Total injuries (sum of above)	0
12. What was the Operator's initial indication of the Failure? *(select only one)*	Notification from Emergency Responder
Other	
12a. If "Controller", "Local Operating Personnel, including contractors", "Air Patrol", or "Ground Patrol by Operator or its contractor" is selected in Question 12, specify the following: (select only one)	
13. Local time Operator identified failure	09/25/2022 23:02
14. formerly C2 Part of system involved in Accident: *(select only one)*	Onshore Pipeline, Including Valve Sites
15. formerly B1 *Auto-populated based on A14* Was the origin of the Accident onshore?	Yes
Yes (Complete Questions B3-B12)	
No *(Complete Questions B13-B15)*	
16. Operational Status at time Operator identified failure:	Normal Operation, includes pauses between batches and during maintenance
17. If Operational Status = Routine Start-Up or Normal Operation, was the pipeline/facility shut down due to the Accident?	Yes

Explain:	
If Yes, complete Questions 17.a and 17.b: *(use local time, 24-hr clock)*	
17a. Local time and date of shutdown	09/25/2022 23:13
17b. Local time pipeline/facility restarted	09/28/2022 18:41
Still shut down*	
18. *If A12 = Notification from Emergency Responder, skip A18.a through A18.c.*	
18a. Did the operator communicate with Local, State, or Federal Emergency Responders about the accident?	
If No, skip 18b. and 18c	
18b. Which party initiated communication about the accident?	
18c. Local time of initial Operator and Local/State/Federal Emergency Responder communication	
19. Local time Operator responders arrived on site	09/25/2022 23:47
20. Local time of confirmed discovery	09/26/2022 01:40
21a. Local time (24-hr clock) and date of initial operator report to the National Response Center :	09/26/2022 01:52
21b. Initial Operator National Response Center Report Number OR	1348259
21c. Additional NRC Report numbers submitted by the operator:	1348466
22. Did the commodity ignite?	No
If Yes, answer 22.a through d:	
22a. Local time of ignition	
22b. How was the fire extinguished?	
specify:	
22c. Estimated volume of commodity consumed by fire (barrels): (must be less than or equal to A7)	
22d. formerly A16. Did the commodity explode?	
23. If 14. is “Onshore Pipeline, Including Valve Sites” OR “Offshore Pipeline, Including Riser and Riser Bend”, answer A23a through f:	
23a. Initial action taken to control flow upstream of failure location	Valve Closure
- If Operational Control	
If Valve Closure, answer A23b and c:	
23b. Local time of valve closure	09/26/2022 00:29
23c. Type of upstream valve used to initially isolate release source:	Remotely Controlled
23d. Initial action taken to control flow downstream of failure location	Valve Closure
- If Operational Control	
If Valve Closure, answer A23.e and f:	
23e. Local time of valve closure	09/26/2022 00:30
23f. Type of downstream valve used to initially isolate release source	Remotely Controlled

24. If A6 = Crude Oil , Refined and/or Petroleum Product (non-HVL) which is a Liquid at Ambient Conditions, or Biofuel / Alternative Fuel (including ethanol blends) AND A15. is Onshore, answer questions A24a and c	
24a. Did the operator notify a "qualified individual" in the Onshore Oil Spill Response Plan?	Yes
If Yes, answer A24b.	
24b. Local time the "qualified individual" was notified.	09/25/2022 23:20
24c. Did the operator activate an Oil Spill Removal Organization (OSRO)?	Yes
If Yes, answer A24d and e:	
24d. Local time operator activated OSRO	09/26/2022 00:00
24e. Local time OSRO arrived on site	09/26/2022 01:45
25. Number of general public evacuated:	0
PART B - ADDITIONAL LOCATION INFORMATION	
1. Pipeline/Facility name:	RIO 8" Products
2. Segment name/ID:	Speedway RIO - Staunton 8"
If Yes, Complete Questions (2-12)	
If No, Complete Questions (13-15)	
- If Onshore:	
3. State:	Indiana
4. Zip Code:	46128
5. City	Not Within a Municipality
6. County or Parish	Putnam
7. Operator-designated location:	Milepost
8. Specify:	175
9. Was this onshore Accident on Federal land?	No
10. Location of Accident:	Pipeline Right-of-way
11. Area of Accident (as found):	Underground
Specify:	Under soil
- If Other, Describe:	
11a. Depth-of-Cover (in):	54
12. Did Accident occur in a crossing?	No
- If Yes, specify type below:	
- If Bridge crossing –	
Cased/ Uncased:	
- If Railroad crossing –	
Cased	
Uncased	
Bored/drilled	
- If Road crossing –	

Cased/ / Bored/drilled	
Uncased	
Bored/drilled	
- If Water crossing –	
Cased/ Uncased	
- Name of body of water, if commonly known:	
- Approx. water depth (ft) at the point of the accident:	
- Select:	
Is this water crossing 100 feet or more in length from high water mark to high water mark?	
- If Offshore:	
13. Approximate water depth (ft) at the point of the Accident:	
14. Origin of Accident:	
- In State waters - Specify:	
- State:	
- Area:	
- Block/Tract #:	
- Nearest County/Parish:	
- On the Outer Continental Shelf (OCS) :	
- Area:	
- Block/Tract #:	
15. Area of Accident:	
PART C - ADDITIONAL FACILITY INFORMATION	
1. Is the pipeline or facility:	Interstate
2. reserved	
3. Item involved in Accident:	Weld, including heat-affected zone
- If Pipe, specify:	
If Pipe Body: Was this a puddle/spot weld?	
3a. Nominal Pipe Size:	8
3b. Wall thickness (in):	.277
3c. SMYS (Specified Minimum Yield Strength) of pipe (psi):	35,000
3d. Pipe specification:	API-5L-Gr. B
3e. Pipe Seam , specify:	Seamless
- If Other, Describe:	
3f. Pipe manufacturer:	Unknown
3g. Pipeline coating type at point of Accident, specify:	Coal Tar
- If Other, Describe:	
3h. Coating field applied?	Yes
- If Weld, including heat-affected zone, specify	Pipe Girth Weld
- If Other, Describe:	

If Pipe Girth Weld is selected, complete items C3a through h above. Are any of the C3b though h values different on either side of the girth weld?	No
If Yes, enter the different value(s) below:	
3i. Wall thickness (in):	
3j. SMYS (Specified Minimum Yield Strength) of pipe (psi):	
3k. Pipe specification:	
Unknown	
3l. Pipe Seam	
- If Other, Describe:	
3m. Pipe manufacturer:	
Unknown	
3n. Pipeline coating type at point of Accident	
- If Other, Describe:	
3o. Coating field applied?	
- If Valve, specify:	
- Valve type	
- If Mainline, Valve Mainline type	
- If Other, Describe:	
3p. Mainline valve manufacturer:	
3q. Type of pump	
- If Other, Describe:	
3r. Type of Service	
- If Other, Describe:	
3s. Tubing material	
3t. Type of tubing	
3u. Specify	
- If Other, Describe:	
3v. Tank Type	
If 3v. = Pressurized:	
3v1. Tank Maximum Operating Pressure	
3v2. What is the set point of the primary pressure relief device on the tank	
3v3. Did the thermal or pressure relief valve activate?	
3v4. Was the MOP of the tank exceeded?	
If 3v = Atmospheric or Low Pressure:	
3v5. Safe-Fill-Level (in feet) at the time of the accident?	
3v6. Was the Safe Fill-Level exceeded?	
3v7. Year of most recent API Std 653 Out-of-Service Inspection	

3v8. API Std 653 In-Service Inspection	
4. Year item involved in Accident was installed:	1945
4a. Year item involved in Accident was manufactured:	1945
5. Material involved in Accident:	Carbon Steel
- If Material other than Carbon Steel, specify:	
6. Type of Accident Involved:	Leak
- If Mechanical Puncture – Specify Approx. size:	
in. (axial) by	
in. (circumferential)	
- If Leak - Select Type:	Pinhole
- If Other, Describe:	
- If Rupture - Select Orientation:	
- If Other, Describe:	
Approx. size: in. (widest opening) by	
in. (length circumferentially or axially)	
- If Other – Describe:	
PART D - ADDITIONAL CONSEQUENCE INFORMATION	
1. Wildlife impact:	Yes
1a. If Yes, specify all that apply:	
- Fish/aquatic	Yes
- Birds	Yes
- Terrestrial	Yes
2. Soil contamination:	Yes
3. Long term impact assessment performed or planned:	Yes
4. Anticipated remediation:	Yes
4a. If Yes, specify all that apply:	
- Surface water	
- Groundwater	
- Soil	Yes
- Vegetation	
- Wildlife	
5. Water contamination:	Yes
5a. If Yes, specify all that apply:	
- Ocean/Seawater	
- Surface	Yes
- Groundwater	
- Drinking water: *(Select one or both)*	
- Private Well	
- Public Water Intake	
5b. Estimated amount released in or reaching water (Barrels):	458.20

5c. Name of body of water, if commonly known:	Dyer Creek
6. At the location of this Accident, had the pipeline segment or facility been identified as one that "could affect" a High Consequence Area (HCA) as determined in the Operator's Integrity Management Program?	No
7. Did the released commodity reach or occur in one or more High Consequence Area (HCA)?	No
7a. If Yes, specify HCA type(s): *(Select all that apply)*	
- Commercially Navigable Waterway:	
Was this HCA identified in the "could affect" determination for this Accident site in the Operator's Integrity Management Program?	
- High Population Area:	
Was this HCA identified in the "could affect" determination for this Accident site in the Operator's Integrity Management Program?	
- Other Populated Area	
Was this HCA identified in the "could affect" determination for this Accident site in the Operator's Integrity Management Program?	
- Unusually Sensitive Area (USA) - Drinking Water	
Was this HCA identified in the "could affect" determination for this Accident site in the Operator's Integrity Management Program?	
- Unusually Sensitive Area (USA) - Ecological	
Was this HCA identified in the "could affect" determination for this Accident site in the Operator's Integrity Management Program?	
8. Estimated cost to Operator – effective 12-2012, changed to "Estimated Property Damage":	
8a. Estimated cost of public and non-Operator private property damage paid/reimbursed by the Operator – effective 12-2012, "paid/reimbursed by the Operator" removed	99,500
8b. Estimated cost of commodity lost	38,484
8c. Estimated cost of Operator's property damage & repairs	80,000
8d. Estimated cost of emergency response	500,000
8e. Estimated cost of environmental remediation	1,320,000
8f. Estimated other costs	0
Describe:	
8g. Total estimated property damage (sum of above)	2,037,984
Injured Persons not included in A11 The number of persons injured, admitted to a hospital, and remaining in the hospital for at least one overnight are reported in A11. ***If a person is included in A11, do not include them in D9.***	
9. Estimated number of persons with injuries requiring treatment in a medical facility but not requiring overnight in-patient hospitalization:	0

If a person is included in D9, do not include them in D10.	
10. Estimated number of persons with injuries requiring treatment by EMTs at the site of accident:	0
Buildings Affected	
11. Number of residential buildings affected (evacuated or required repair):	0
12. Number of business buildings affected (evacuated or required repair):	0
PART E - ADDITIONAL OPERATING INFORMATION	
1. Estimated pressure at the point and time of the Accident (psig):	683.00
If C3. Is Tank/Vessel and C3v. is Atmospheric, do not answer E2. and E3	
2. Maximum Operating Pressure (MOP) at the point and time of the Accident (psig):	1,520.00
2a. Limiting factor establishing MOP (select only one):	SubPart E Pressure Test §195.406(a)(3)
describe:	
2b. Date MOP established	09/29/2016
2c. Was the MOP established in conjunction with a reversal of flow direction?	No
If E2c = Yes, E2d. What is the date of the most recent surge analysis performed at the point of the Accident?	
3. Describe the pressure on the system or facility relating to the Accident (psig):	Pressure did not exceed MOP
4. Was the system or facility relating to the Accident operating under an established pressure restriction with pressure limits below those normally allowed by the MOP?	No
- If Yes, Complete 4.a and 4.b below:	
4a. Did the pressure exceed this established pressure restriction?	
4b. Was this pressure restriction mandated by PHMSA or the State?	
If A14. is “Onshore Pipeline, Including Valve Sites” OR “Offshore Pipeline, Including Riser and Riser Bend”, complete E5 through E7	
5. Answer E5 only when both A23a and A23d are Valve Closure	
Length of segment initially isolated between valves (ft):	47,520
6. Is the pipeline configured to accommodate internal inspection tools?	Yes
- If No, Which physical features limit tool accommodation? (*select all that apply)*	
- Changes in line pipe diameter	
- Presence of unsuitable mainline valves	
- Tight or mitered pipe bends	
- Other passage restrictions (i.e. unbarred tee’s, projecting instrumentation, etc.)	

- Extra thick pipe wall (applicable only for magnetic flux leakage internal inspection tools)	
- Other -	
- If Other, Describe:	
7. For this pipeline, are there operational factors which significantly complicate the execution of an internal inspection tool run?	No
- If Yes, Which operational factors complicate execution? (*select all that apply*)	
- Excessive debris or scale, wax, or other wall buildup	
- Low operating pressure(s)	
- Low flow or absence of flow	
- Incompatible commodity	
- Other -	
- If Other, Describe:	
8. Function of pipeline system:	> 20% SMYS Regulated Transmission
9. Was a Supervisory Control and Data Acquisition (SCADA)-based system in place on the pipeline or facility involved in the Accident?	Yes
If Yes -	
9a. Was it operating at the time of the Accident?	Yes
9b. Was it fully functional at the time of the Accident?	Yes
9c. Did SCADA-based information (such as alarm(s), alert(s), event(s), and/or volume calculations) assist with the detection of the Accident?	No
9d. Did SCADA-based information (such as alarm(s), alert(s), event(s), and/or volume calculations) assist with the confirmation of the Accident?	Yes
10. Was a CPM leak detection system in place on the pipeline or facility involved in the Accident?	Yes
- If Yes:	
10a. Was it operating at the time of the Accident?	Yes
10b. Was it fully functional at the time of the Accident?	Yes
10c. Did CPM leak detection system information (such as alarm(s), alert(s), event(s), and/or volume calculations) assist with the detection of the Accident?	Yes
10d. Did CPM leak detection system information (such as alarm(s), alert(s), event(s), and/or volume calculations) assist with the confirmation of the Accident?	Yes
11. Was an investigation initiated into whether or not the controller(s) or control room issues were the cause of or a contributing factor to the Accident?	No, the Operator did not find that an investigation of the controller(s) actions or control room issues was necessary due to: (provide an explanation for why the Operator did not investigate)

- If No, the Operator did not find that an investigation of the controller(s) actions or control room issues was necessary due to: *(provide an explanation for why the operator did not investigate)*	TapRoot was completed and MPL procedures were followed.
- If Yes, specify investigation result(s): *(select all that apply)*	
- Investigation reviewed work schedule rotations, continuous hours of service (while working for the Operator), and other factors associated with fatigue	
- Investigation did NOT review work schedule rotations, continuous hours of service (while working for the Operator), and other factors associated with fatigue	
Provide an explanation for why not:	
- Investigation identified no control room issues	
- Investigation identified no controller issues	
- Investigation identified incorrect controller action or controller error	
- Investigation identified that fatigue may have affected the controller(s) involved or impacted the involved controller(s) response	
- Investigation identified incorrect procedures	
- Investigation identified incorrect control room equipment operation	
- Investigation identified maintenance activities that affected control room operations, procedures, and/or controller response	
- Investigation identified areas other than those above:	
Describe:	
PART F - DRUG & ALCOHOL TESTING INFORMATION	
1. As a result of this Accident, were any Operator employees tested under the post-accident drug and alcohol testing requirements of DOT's Drug & Alcohol Testing regulations?	Yes
- If Yes:	
1a. Specify how many were tested:	2
1b. Specify how many failed:	0
2. As a result of this Accident, were any Operator contractor employees tested under the post-accident drug and alcohol testing requirements of DOT's Drug & Alcohol Testing regulations?	No
- If Yes:	
2a. Specify how many were tested:	
2b. Specify how many failed:	
PART G – APPARENT CAUSE	
Select only one box from PART G in shaded column on left representing the APPARENT Cause of the Accident, and answer the questions on the right. Describe secondary, contributing or root causes of the Accident in the narrative (PART H).	
Apparent Cause:	G5 - Material Failure of Pipe or Weld

G1 - Corrosion Failure - only one **sub-cause** can be picked from shaded left-hand column	
Corrosion Failure – Sub-Cause:	
- If External Corrosion:	
1. Results of visual examination:	
- If Other, Describe:	
2. Type of corrosion: *(select all that apply)*	
- Galvanic	
- Atmospheric	
- Stray Current	
- Microbiological	
- Selective Seam	
- Other:	
- If Other, Describe:	
2a. If 2 is Stray Current, specify	
2b. Describe the stray current source:	
3. The type(s) of corrosion selected in Question 2 is based on the following: *(select all that apply)*	
- Field examination	
- Determined by metallurgical analysis	
- Other:	
- If Other, Describe:	
4. Was the failed item buried or submerged?	
- If Yes :	
4a. Was failed item considered to be under cathodic protection at the time of the Accident?	
If Yes - Year protection started:	
4b. Was shielding, tenting, or disbonding of coating evident at the point of the Accident?	
4c. Has one or more Cathodic Protection Survey been conducted at the point of the Accident?	
If "Yes, CP Annual Survey" – Most recent year conducted:	
If "Yes, Close Interval Survey" – Most recent year conducted:	
If "Yes, Other CP Survey" – Most recent year conducted:	
Describe other CP survey	
- If No:	
4d. Was the failed item externally coated or painted?	
5. Was there observable damage to the coating or paint in the vicinity of the corrosion?	
- If Internal Corrosion:	
6. Results of visual examination:	
- Other:	
7. Type of corrosion *(select all that apply)*: -	
- Corrosive Commodity	

- Water drop-out/Acid	
- Microbiological	
- Erosion	
- Other:	
- If Other, Describe:	
8. The cause(s) of corrosion selected in Question 7 is based on the following *(select all that apply)*: -	
- Field examination	
- Determined by metallurgical analysis	
- Other:	
- If Other, Describe:	
9. Location of corrosion *(select all that apply)*: -	
- Low point in pipe	
- Elbow	
- Dead-Leg	
- Other:	
- If Other, Describe:	
10. Was the commodity treated with corrosion inhibitors or biocides?	
11. Was the interior coated or lined with protective coating?	
12. Were cleaning/dewatering pigs (or other operations) routinely utilized?	
13. Were corrosion coupons routinely utilized?	
G2 - Natural Force Damage - only one **sub-cause** can be picked from shaded left-handed column	
Natural Force Damage – Sub-Cause:	
- If Earth Movement, NOT due to Heavy Rains/Floods:	
1. Specify:	
- If Other, Describe:	
- If Heavy Rains/Floods:	
2. Specify:	
- If Other, Describe:	
- If Lightning:	
3. Specify:	
- If Temperature:	
4. Specify:	
- If Other, Describe:	
- If Other Natural Force Damage:	
5. Describe:	
Complete the following if any Natural Force Damage sub-cause is selected.	
6. Were the natural forces causing the Accident generated in conjunction with an extreme weather event?	
6a. If Yes, specify: *(select all that apply)*	
- Hurricane	
- Tropical Storm	
- Tornado	

- Other	
- If Other, Describe:	
G3 - Excavation Damage - only one **sub-cause** can be picked from shaded left-hand column	
Excavation Damage – Sub-Cause:	
- If Previous Damage due to Excavation Activity: Complete Questions 1-5 ONLY IF the "Item Involved in Accident" (from PART C, Question 3) is Pipe or Weld.	
Complete the following if Excavation Damage by Third Party is selected as the sub-cause.	
1. Did the operator get prior notification of the excavation activity?	
1a. If Yes, Notification received from: *(select all that apply)* -	
- One-Call System	
- Excavator	
- Contractor	
- Landowner	
1b. Per the primary Accident Investigator results, did State law exempt the excavator from notifying the one-call center?	
If yes, answer 1c through 1e.	
1c. select one of the following:	
Describe	
1d. Exempting authority:	
1e. Exempting criteria:	
Complete the following mandatory CGA-DIRT Program questions if any Excavation Damage sub-cause is selected.	
2. Do you want PHMSA to upload the following information to CGA-DIRT (www.cga-dirt.com)?	
3. Right-of-Way where event occurred: *(select all that apply)* -	
- Public	
- If "Public", Specify:	
- Private	
- If "Private", Specify:	
- Pipeline Property/Easement	
- Power/Transmission Line	
- Railroad	
- Dedicated Public Utility Easement	
- Federal Land	
- Unknown/Other	
4 Was the facility part of a Joint Trench?	
5. Did this event involve a Cross Bore?	
6. Measured Depth from Grade	
Measured depth From Grade	
7. Type of excavator:	
8. Type of excavation equipment:	

9. Type of work performed:	
10. Was the One-Call Center notified?	
If No, skip to question 11	
10a. If Yes, specify ticket number:	
10b. If this is a State where more than a single One-Call Center exists, list the name of the One-Call Center notified:	
10 c. Was work area white lined?	
11. Type of Locator:	
12. Were facility locate marks visible in the area of excavation?	
13. Did the damage cause an interruption in service?	
13a. If Yes, specify duration of the interruption (hours)	
14. Description of the CGA-DIRT Root Cause *(select only the one predominant first level CGA-DIRT Root Cause and then, where available as a choice, the one predominant second level CGA-DIRT Root Cause as well):*	
Root Cause Category	
Root Cause Type	
(comment required)	
G4 - Other Outside Force Damage *- only one **sub-cause** can be selected from the shaded left-hand column*	
Other Outside Force Damage – Sub-Cause:	
- If Damage by Car, Truck, or Other Motorized Vehicle/Equipment NOT Engaged in Excavation:	
1. Vehicle/Equipment operated by:	
If this sub-section is picked, please complete questions 5-11 below	
- If Damage by Boats, Barges, Drilling Rigs, or Other Maritime Equipment or Vessels Set Adrift or Which Have Otherwise Lost Their Mooring:	
2. Select one or more of the following IF an extreme weather event was a factor:	
- Hurricane	
- Tropical Storm	
- Tornado	
- Heavy Rains/Flood	
- Other	
- If Other, Describe:	
- If Previous Mechanical Damage NOT Related to Excavation: Complete Questions 3-7 ONLY IF the "Item Involved in Accident" (from PART C, Question 3) is Pipe or Weld.	
- If Intentional Damage:	
3. Specify:	
- If Other, Describe:	
- If Other Outside Force Damage:	
4. Describe:	
Complete the following if Damage by Car, Truck, or Other Motorized Vehicle/Equipment NOT Engaged in Excavation sub-cause is selected.	
5. Was the driver of the vehicle or equipment issued one or more citations related to the accident?	

If 5 is Yes, what was the nature of the citations (select all that apply)	
5a. Excessive Speed	
5b. Reckless Driving	
5c. Driving Under the Influence	
5e. Other	
If Other, Describe	
6. Was the driver under control of the vehicle at the time of the collision?	
7. Estimated speed of the vehicle at the time of impact (miles per hour)?	
- Unknown	
8. Type of vehicle? (select only one)	
9. Where did the vehicle travel from to hit the pipeline facility? (select only one)	
10. Shortest distance from answer in 9. to the damaged pipeline facility (in feet):	
11. At the time of the accident, were protections installed to protect the damaged pipeline facility from vehicular damage?	
If 11 is Yes, specify type of protection (select all that apply):	
11a. Bollards/Guard Posts	
11b. Barricades – include Jersey barriers and fences in instructions	
11c. Guard Rails	
If Other, Describe	
G5 - Material Failure of Pipe or Weld - only one **sub-cause** can be selected from the shaded left-hand column	
Use this section to report material failures ONLY IF the "Item Involved in Accident" (from PART C, Question 3) is "Pipe" or "Weld."	
Material Failure of Pipe or Weld – Sub-Cause:	Design-, Construction-, Installation-, or Fabrication-related
1. The sub-cause shown above is based on the following: *(select all that apply)*	
- Field Examination	
- Determined by Metallurgical Analysis	Yes
- Other Analysis	
- If "Other Analysis", Describe:	
- Sub-cause is Tentative or Suspected; Still Under Investigation (Supplemental Report required)	
-If Design-, Construction-, Installation- or Fabrication-related	
2. List contributing factors: *(select all that apply)*	
- Fatigue or Vibration-related	
Specify:	
- If Other, Describe:	
- Mechanical Stress:	
- Other	Yes
- If Other, Describe:	Internal Corrosion due to poor welding practice
- If Original Manufacturing-related (NOT girth weld or other welds formed in the field)	

- Fatigue or Vibration-related	
Specify:	
- If Other, Describe:	
- Mechanical Stress:	
- Other	
- If Other, Describe:	
- If Environmental Cracking-related:	
3. Specify:	
- If Other - Describe:	
Complete the following if any Material Failure of Pipe or Weld sub-cause is selected.	
4. Additional factors: (*select all that apply*):	
- Dent	
- Gouge	
- Pipe Bend	
- Arc Burn	
- Crack	
- Lack of Fusion	
- Lamination	
- Buckle	
- Wrinkle	
- Misalignment	
- Burnt Steel	
- Other:	Yes
- If Other, Describe:	Undercut, burnthrough, or suckback as noted in the metallurgical report.
G6 – Equipment Failure - only one **sub-cause** can be selected from the shaded left-hand column	
Equipment Failure – Sub-Cause:	
- If Malfunction of Control/Relief Equipment:	
1. Specify: *(select all that apply)* -	
- Control Valve	
- Instrumentation	
- SCADA	
- Communications	
- Block Valve	
- Check Valve	
- Relief Valve	
- Power Failure	
- Stopple/Control Fitting	
- ESD System Failure	
- Other	
- If Other – Describe:	
- If Pump or Pump-related Equipment:	
2. Specify:	

- If Other – Describe:	
- If Threaded Connection/Coupling Failure:	
3. Specify:	
- If Other – Describe:	
- If Non-threaded Connection Failure:	
4. Specify:	
- If Other – Describe:	
- If Other Equipment Failure:	
5. Describe:	
Complete the following if any Equipment Failure sub-cause is selected.	
6. Additional factors that contributed to the equipment failure: *(select all that apply)*	
- Excessive vibration	
- Overpressurization	
- No support or loss of support	
- Manufacturing defect	
- Loss of electricity	
- Improper installation	
- Improper maintenance	
- Mismatched items (different manufacturer for tubing and tubing fittings)	
- Dissimilar metals	
- Breakdown of soft goods due to compatibility issues with transported commodity	
- Valve vault or valve can contributed to the release	
- Alarm/status failure	
- Misalignment	
- Thermal stress	
- Erosion/Abnormal Wear	
- Other	
- If Other, Describe:	
G7 - Incorrect Operation - only one **sub-cause** can be selected from the shaded left-hand column	
Incorrect Operation – Sub-Cause:	
- If Tank, Vessel, or Sump/Separator Allowed or Caused to Overfill or Overflow	
1. Specify:	
- If Other, Describe:	
- If Other Incorrect Operation	
2. Describe:	
Complete the following if any Incorrect Operation sub-cause is selected.	
3. Was this Accident related to *(select all that apply)*: -	
- Inadequate procedure	
- No procedure established	

- Failure to follow procedure	
- Other:	
- If Other, Describe:	
4. What category type was the activity that caused the Accident?	
5. Was the task(s) that led to the Accident identified as a covered task in your Operator Qualification Program?	
5a. If Yes, were the individuals performing the task(s) qualified for the task(s)?	
G8 - Other Accident Cause - only one **sub-cause** can be selected from the shaded left-hand column	
Other Accident Cause – Sub-Cause:	
- If Miscellaneous:	
1. Describe:	
- If Unknown:	
2. Specify:	
Mandatory comment field:	
PART J – COMPLETED INTEGRITY INSPECTIONS	
Complete the following if the "Item Involved in Accident" (from PART C, Question 3) is Pipe or Weld and the "Cause" (from Part G) is:	
Corrosion (any subCause in Part G1); or	
Previous Damage due to Excavation Activity (subCause in Part G3); or	
Previous Mechanical Damage NOT Related to Excavation (subCause in Part G4); or	
Material Failure of Pipe or Weld (any subCause in Part G5)	
J1. Have internal inspection tools collected data at the point of the Accident?	Yes
J1a. If Yes, for each tool and technology used provide the information below for the most recent and previous tool runs:	
Axial Magnetic Flux Leakage	Yes
Most recent run Year:	2019
Most recent run Propulsion Method (select only one):	Free Swimming
Most recent run Attuned to Detect (select only one):	Metal Loss
Other Describe	
If Metal Loss, specify (select only one):	High Resolution
Other Describe	
Previous run Year:	2012
Previous run Propulsion Method (select only one):	Free Swimming
Previous run Attuned to Detect (select only one):	Metal Loss
Other Describe	
If Metal Loss, specify (select only one):	High Resolution
Other Describe	
Circumferential/Transverse Wave Magnetic Flux Leakage	
Most recent run Year:	
Most recent run Propulsion Method (select only one):	
Most recent run Resolution (select only one):	

Other Describe	
Previous run Year:	
Previous run Propulsion Method (select only one):	
Previous run Resolution (select only one):	
Other Describe	
Ultrasonic	Yes
Most recent run Year:	2012
Most recent run Propulsion Method (select only one):	Free Swimming
Most recent run Attuned (select only one):	Wall Measurement
Other Describe	
Previous run Year:	
Previous run Propulsion Method (select only one):	
Most recent run Attuned to (select only one)	
Other Describe	
If Attuned to Wall Measurement, most recent run Metal Loss Resolution (select only one):	
Other Describe	
Geometry/Deformation	Yes
Most recent run Year:	2019
Most recent run Propulsion Method (select only one):	Free Swimming
Most recent run Resolution (select only one):	High Resolution
Other Describe	
Most recent run Measurement Cups (select only one):	Inside ILI Cups
Previous run Year:	2012
Previous run Propulsion Method (select only one):	Free Swimming
Other Describe	
Previous run Resolution (select only one):	High Resolution
Other Describe	
Previous run Measurement Cups (select only one):	Inside ILI Cups
Electromagnetic Acoustic Transducer (EMAT)	
Most recent run Year:	
Most recent run Propulsion Method (select only one):	
Previous run Year:	
Previous run Propulsion Method (select only one):	
Cathodic Protection Current Measurement (CPCM)	
Most recent run Year:	
Most recent run Propulsion Method (select only one):	
Previous run Year:	
Previous run Propulsion Method (select only one):	
Other, specify tool	
Most recent run Year:	

Most recent run Propulsion Method (select only one):	
Previous run Year:	
Previous run Propulsion Method (select only one):	
Answer J1.b only when the cause i:	
Previous Damage due to Excavation Activity (subCause in Part G3); or	
Previous Mechanical Damage NOT Related to Excavation (subCause in Part G4)	
J1b. Do you have reason to believe that the internal inspection was completed BEFORE the damage was sustained	
J2. Has one or more hydrotest or other pressure test been conducted since original construction at the point of the Accident? (initial post construction pressure test is NOT reported here)	Yes
Most recent year tested:	2016
Test pressure (psig):	1900
J3. Has Direct Assessment been conducted on the pipeline segment?	No
Most recent year conducted:	
Most recent year conducted:	
If J3 is Yes, J3a. For each type, indicate the year of the most recent assessment	
External Corrosion Direct Assessment (ECDA)	
Other, specify type	
J4. Has one or more non-destructive examination been conducted prior to the Accident at the point of the Accident since January 1, 2002?	No
4a. If Yes, for each examination conducted, select type of non-destructive examination and indicate most recent year the examination was conducted:	
Radiography	
Guided Wave Ultrasonic	
Handheld Ultrasonic Tool	
Wet Magnetic Particle Test	
Dry Magnetic Particle Test	
Other	
- If Other, specify type	
PART K – CONTRIBUTING FACTORS	
The Apparent Cause of the accident is contained in Part G. Do not report the Apparent Cause again in this Part K. If Contributing Factors were identified during a root cause analysis, select all that apply below and explain each in the Narrative:	
External Corrosion	
External Corrosion, Galvanic	
External Corrosion, Atmospheric	
External Corrosion, Stray Current Induced	
External Corrosion, Microbiologically Induced	
External Corrosion, Selective Seam	
Internal Corrosion	
Internal Corrosion, Corrosive Commodity	
Internal Corrosion, Water drop-out/Acid	

Internal Corrosion, Microbiological	
Internal Corrosion, Erosion	
Natural Forces	
Earth Movement, NOT due to Heavy Rains/Floods	
Heavy Rains/Floods	
Lightning	
Temperature	
High Winds	
Tree/Vegetation Root	
Excavation Damage	
Excavation Damage by Operator (First Party)	
Excavation Damage by Operator's Contractor (Second Party)	
Excavation Damage by Third Party	
Previous Damage due to Excavation Activity	
Other Outside Force	
Nearby Industrial, Man-made, or Other Fire/Explosion	
Damage by Car, Truck, or Other Motorized Vehicle/Equipment NOT Engaged in Excavation	
Damage by Boats, Barges, Drilling Rigs, or Other Adrift Maritime Equipment	
Routine or Normal Fishing or Other Maritime Activity NOT Engaged in Excavation	
Electrical Arcing from Other Equipment or Facility	
Previous Mechanical Damage NOT Related to Excavation	
Intentional Damage	
Pipe/Weld Failure	
Design-related	
Construction-related	
Installation-related	Yes
Fabrication-related	
Original Manufacturing-related	
Environmental Cracking-related, Stress Corrosion Cracking	
Environmental Cracking-related, Sulfide Stress Cracking	
Environmental Cracking-related, Hydrogen Stress Cracking	
Environmental Cracking-related, Hard Spot	
Equipment Failure	
Malfunction of Control/Relief Equipment	
Pump or Pump-related Equipment	
Threaded Connection/Coupling Failure	
Non-threaded Connection Failure	

Non-threaded Connection Failure	
Defective or Loose Tubing or Fitting	
Failure of Equipment Body (except Compressor), Vessel Plate, or other Material	
Incorrect Operation	
Damage by Operator or Operator's Contractor NOT Excavation and NOT Vehicle/Equipment Damage	
Tank, Vessel, or Sump/Separator Allowed or Caused to Overfill or Overflow	
Valve Left or Placed in Wrong Position, but NOT Resulting in Overpressure	
Pipeline or Equipment Over pressured	
Equipment Not Installed Properly	
Wrong Equipment Specified or Installed	
Inadequate Procedure	
No procedure established	
Failure to follow procedures	

PART H - NARRATIVE DESCRIPTION OF THE ACCIDENT

On 9/25/2022 at 23:02 Eastern Time (local time), Putnam County 911 contacted the Findlay POC about an odor near Fillmore, IN. The RIO8 Products line, running in a steady state, was shut down at 09/25/2022 23:13 Eastern Time and steps were taken to investigate the 911 report. A second call from Putnam County 911 at 09/25/2022 23:40 Eastern Time provide the company with an updated location reporting a sheen on water near the pipeline. Area operations personnel arrive on site at 9/25/2022 23:47 Eastern Time to confirm a release occurred based on smell alone. The upstream block valve at milepost 173 was closed at 00:29 09/26/2022 Eastern Time and the downstream block valve at milepost 183 was closed at 00:30 09/26/2022 Eastern Time.
Company personnel were able to confirm the presence of a sheen on water/creek bank of Dyer Creek at 01:40 Eastern Time on 9/26/2022 and a call was made to the NRC at 01:52 Eastern Time. Due to the properties of the natural gasoline and responding to the release in the middle of the night, it was challenging for responding personnel to distinguish the natural gasoline from water. The natural gasoline does not impart a high contrast sheen to water like other petroleum products. These factors increased the time it took to confirm the presence of natural gasoline on water and contributed to the lower release volume estimate originally reported to the NRC.
The first OSRO onsite at 01:45 Eastern Time and second OSRO onsite at 04:30 Eastern Time on 9/26/2022. Prior to company response equipment being onsite, the local fire department deployed soft, sausage boom on Dyer Creek.
Company personnel deployed to the site contained the release and worked to expose the part of the pipeline were the release originated. Once the release area was exposed and identified, a wood plug was used to stop the release and an 8" PLIDCO clamp was installed around 23:45 on 09/26/2022. After sandblast of the coating from release point to upstream and downstream joints, the company chose to remove the 8" PLIDCO and install a 24" PLIDCO clamp on 09/28/2022. The line was restarted after a static line test and adjusted setpoints to accommodate a 10% derate.
A cut out of the pipe is scheduled for the week of October 24th and metallurgical analysis will be performed the week of November 7th. A supplemental report will be submitted with the results of those activities.
On 12/15/2022 - The Speedway Rio-Staunton 8" failure analysis and metallurgic examination report was received from the vendor. The report concluded that the leak coincided with the girth weld, resulting in an approximately 1/8-inch through-wall hole. The girth weld contained a series of original construction welding features, which could contain an area of undercut, burnthrough, or suckback. The weld defect area and wall loss created an environment conducive for internal corrosion in the weld feature. This line has historically not been a high risk of internal corrosion, which indicates that corrosion would not have been a contributing factor without the causal factor of the girth weld feature.
On 1/9/2023 - Updates were made to Part G and Part K of the report.

PART I - PREPARER AND AUTHORIZED SIGNATURE

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Preparer's Facsimile Number	
Local Contact Name	
Local Contact Email	
Local Contact Phone	

Authorized Signer Name	Aaron Martinez
Authorized Signer Title	Regulatory Compliance Manager
Authorized Signer Telephone Number	2106266343
Authorized Signer Email	awmartinez@marathonpetroleum.com
Date	02/14/2023

Appendix D.Metallurgical Analysis – Speedway Rio-Staunton 8” Failure Analysis, ADV Integrity, Inc., December 2022.

Speedway Rio – Staunton 8” Failure Analysis

Final Report

December 2022

Speedway Rio – Staunton 8" Failure Analysis

Final Report

Prepared for

Marathon Pipe Line, LLC

Findlay, OH

December 2022

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100641-RP01-Rev0-121422

Rev	Date	Description	Prepared	Checked	Reviewed
B	12.09.2022	Issued for Client Review	DBF	---	CBW
0	12.14.2022	Issued for Use	DBF	---	CBW

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ADV INTEGRITY
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Wednesday, December 14, 2022 100641-RP01-Rev0-121422

Jay Burkhart, P.E., *Integrity Engineering*
Marathon Pipe Line, LLC
539 S Main St, Findlay, OH 45840

Jay,

Enclosed is ADV Integrity's report documenting the failure analysis of a leak that occurred on the Speedway Rio to Staunton pipeline segment on the RIO 8" system during a normal operation on September 26, 2022. The failure occurred at Mile Post # 175.94 on the RIO 8" system. The pipeline in question was installed in 1945 using nominal 8-inch OD x 0.277-inch WT, API 5L, Grade B seamless pipe material.

ADV concluded that the leak coinciding with the girth weld resulting in an approximately 1/8-inch diameter through-wall hole. The girth weld contained a series of original construction welding features, although no weld flaw was identified within the leak's cross section, it seems possible that an area of undercut, burnthrough, or suckback could have been present. The leak coincided with an area of wall loss in the vicinity of the girth weld. Based on this appearance, the observed wall loss was the result of a time dependent mechanism, such as internal corrosion potentially exacerbated by hi-lo present. The pipe material was determined to be consistent with API 5L (1945), Grade B material manufactured using Bessemer steel.

Thank you for the opportunity to complete this work and please do not hesitate to contact us with any questions.

Regards,

David Futch, PE | Director, Materials Engineering

ADV Integrity, Inc.
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Texas Registered Engineering Firm F-190

Reviewed by: Cary Windler, PE | Staff Consultant

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION AND BACKGROUND

Marathon Pipe Line, LLC (Marathon) contracted ADV Integrity, Inc. (ADV) to perform a failure analysis of a leak that occurred on the Speedway Rio to Staunton pipeline segment on the RIO 8" system during a normal operation on September 26, 2022. The failure occurred near Fillmore, Indiana at Mile Post # 175.94 on the RIO 8" system (GPS coordinates: 39.65530983, -86.76274718). The leak coincided with girth weld number 662026. Google Earth images of the failure location are shown in Figure 1-1 and Figure 1-2. The leak was stopped using a wooden dowel and then repaired using a PLIDCO clamp upon discovery.

Marathon reported that the pipeline in question was installed in 1945 using nominal 8-inch OD x 0.277-inch WT, API 5L, Grade B seamless pipe material. Marathon reported that the pipeline transports natural gasoline (NGU) at a maximum allowable operating pressure of 1,520 psig.

Marathon requested that ADV determine the likely cause of the leak and document the mechanical properties of the pipe.

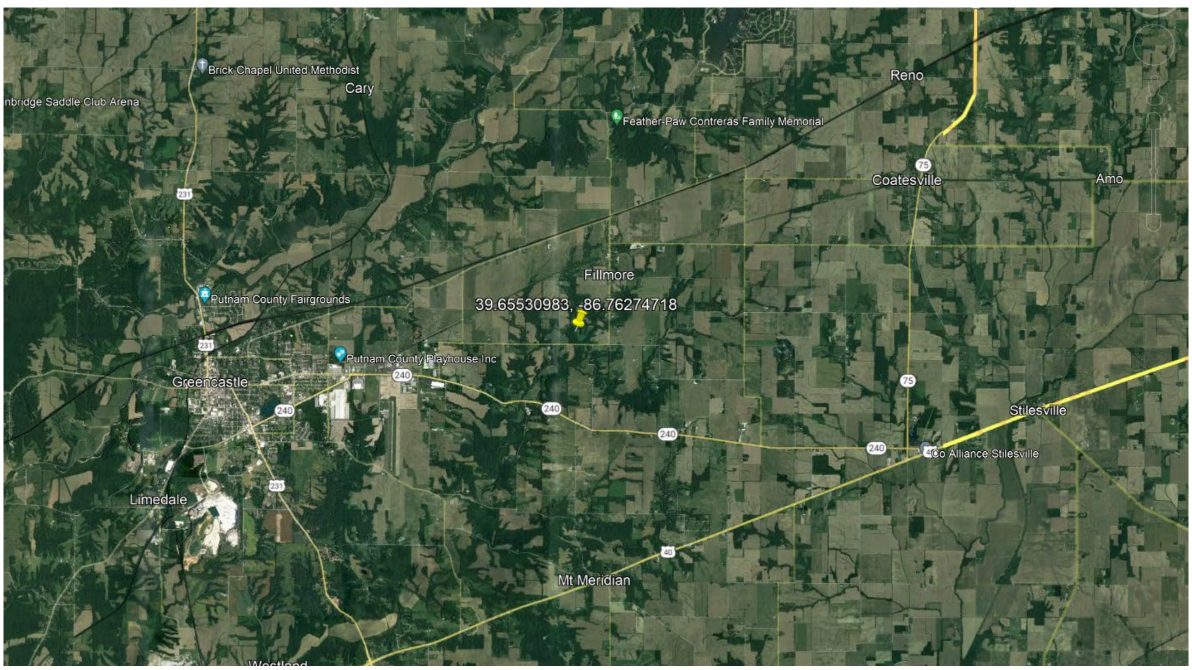


Figure 1-1: Google Earth image of leak location.

Figure 1-2: Google Earth image of leak location.

2.0 VISUAL EXAMINATION

ADV received one pipe sample containing a PLIDCO clamp approximately centered within the sample, shown in Figure 2-1. The PLIDCO clamp, shown in Figure 2-2, was identified as a SPLIT+SLEEVE, Part # SS10824V0 and Serial # 5294902, shown in Figure 2-3. After documenting the pipe dimensions, ADV removed the PLIDCO clamp and documented the torque to remove all 12 nuts. All torque values were between 330 and 520 ft-lbs, as annotated in Figure 2-4.

The external pipe surface was revealed once the PLIDCO was removed. The resulting pipe surface is shown in Figure 2-5. A layer of duct tape was applied over the girth weld, once removed, the leak was identified at approximately the 5:30 o'clock orientation. The wooden plug was identified centered within the weld, shown in Figure 2-6 and Figure 2-7.

ADV collected deposits adjacent to the girth weld (shown in Figure 2-7) and from two areas adjacent to the weld, shown in Figure 2-8 and Figure 2-9. These deposits were set aside for chemical characterization (SEM-EDS and XRD), discussed in Section 7.0.

ADV cleaned the external pipe surface using wire wheels in preparation for straight beam UT to document the wall thickness around the pipe's circumference. The minimum remining wall thickness identified upstream of the weld was 0.243-inch (88% of nominal wall thickness) at the 3:00 o'clock orientation and the minimum remining wall thickness identified upstream of the weld was 0.259-inch (94% of nominal wall thickness) at the 6:30 o'clock orientation.

ADV recorded the dimensions at the upstream and downstream end of the pipe material received. The diameter was measured with a Pi tape and the wall thickness was measured at eight evenly spaced locations around the circumference with a rounded tip micrometer. These results are summarized in Table 2-1 and are consistent with nominal 8-inch OD x 0.277-inch WT pipe.

Table 2-1: Pipe Dimensional Analysis

Location	Outside Diameter (in)	Wall Thickness (in)		
		High	Low	Average
Upstream End	8.66	0.280	0.274	0.277
Downstream End	8.65	0.276	0.252	0.269

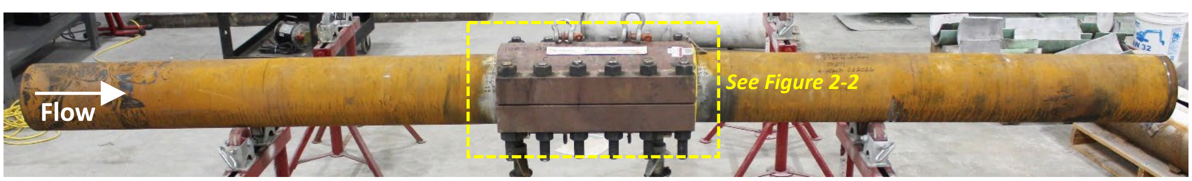


Figure 2-1: Photograph of as-received pipe sample. Ruler is 12 inches long.

Figure 2-2: Photograph of PLIDCO clamp. Ruler is 12 inches long.

Figure 2-3: Photograph of PLIDCO serial information.

Figure 2-4: Photograph of PLIDCO showing torque required to remove each nut (in ft-lbs).

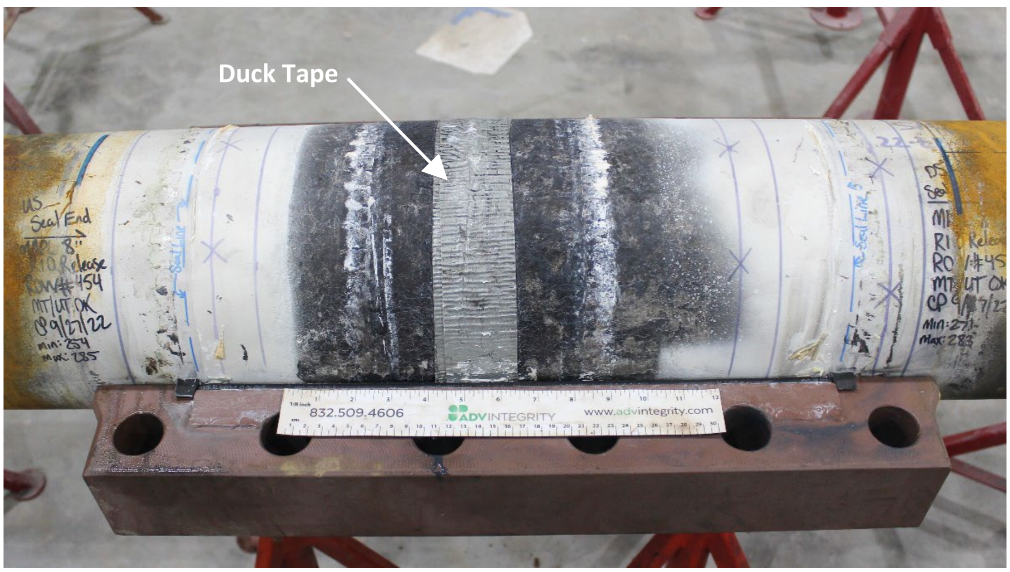


Figure 2-5: Photograph after removing top half of the PLIDCO. Ruler is 12 inches long.

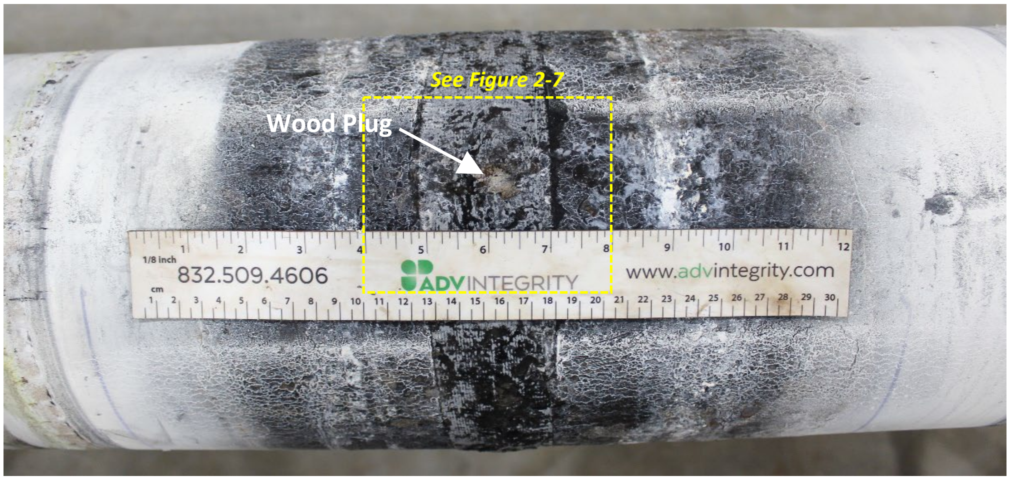


Figure 2-6: Photograph after removing duct tape. Upper numbered scale divisions are inches.

Figure 2-7: Photograph of wood plug present. Numbered scale divisions are inches.

Figure 2-8: Photograph of deposits present along the external pipe surface. Numbered scale divisions are inches.

Figure 2-9: Photograph of deposits present along the external pipe surface. Numbered scale divisions are inches.

3.0 NON-DESTRUCTIVE EXAMINATION

ADV contracted Acuren Inspection, Inc. to perform RT of the girth weld to API 1104. Areas of incomplete fusion, incomplete penetration, underfill, and porosity were identified. These features were outside acceptable workmanship limits within current editions of API 1104, however, construction codes at the time of construction did not require inspection. Images of the RT film are shown in Figure 3-1. The leak was identified in the middle film (view 2-3). The full reader sheet is attached in Appendix A.

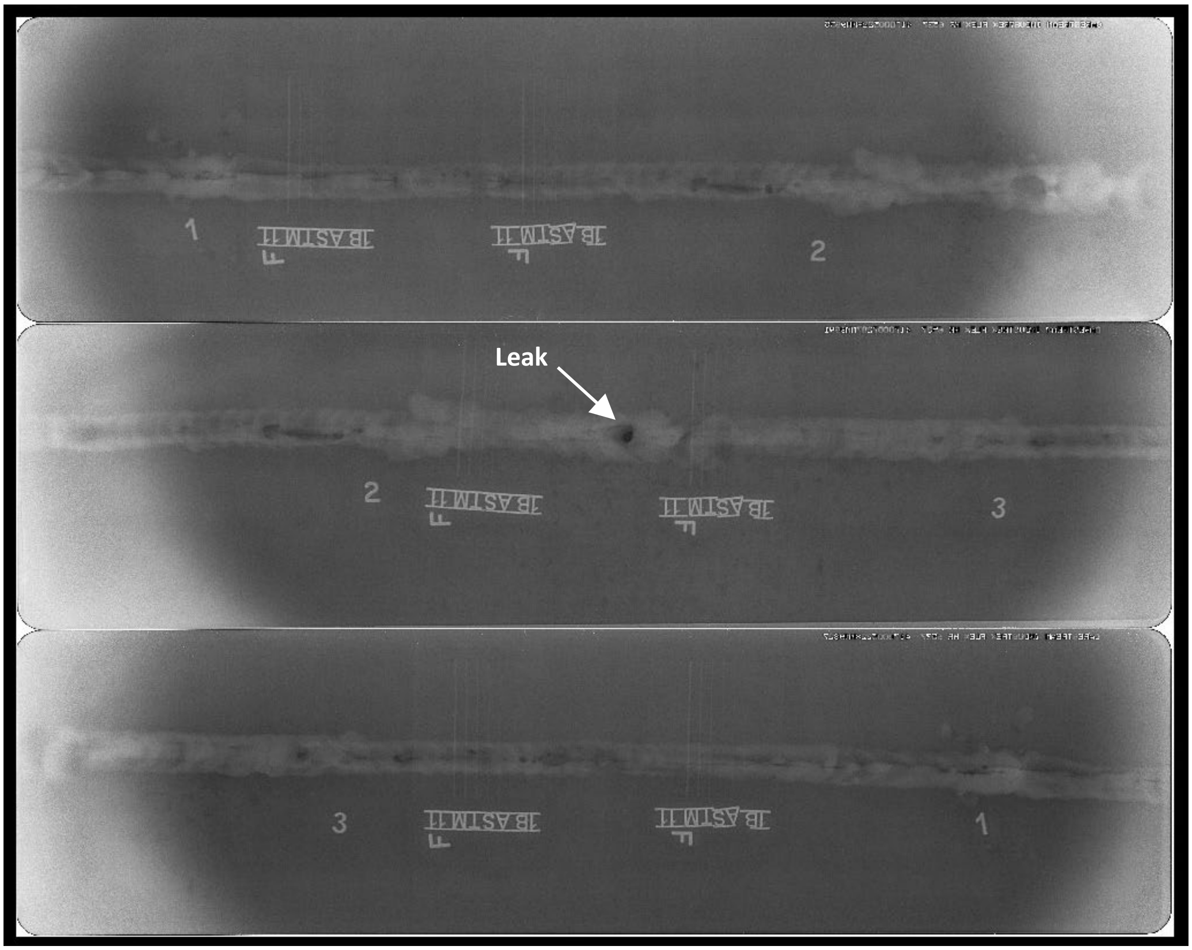


Figure 3-1: RT Images.

4.0 VISUAL EXAMINATION OF GIRTH WELD

ADV saw cut the pipe sample to reveal the internal pipe surface prior to sectioning the leak for metallurgical examination. Photographs of the external and internal weld surface are shown in Figure 4-1, respectively. Images of the external and internal pipe surface in the vicinity of observable features are shown in Figure 4-2 through Figure 4-6. The weld appeared consistent with a SMAW weld. Features identified included:

- External weld cap concavity (such as Figure 4-2)
- External weld repairs (such as Figure 4-3)
- External arc burns (such as Figure 4-2)
- Internal weld suckback and burnthroughs (such as Figure 4-3 and Figure 4-5)
- Internal weld undercut (such as Figure 4-6)
- Internal weld incomplete penetration (such as Figure 4-6)

The leak was identified just adjacent to the external cap tie in between the passes on either side of the pipe. The internal pipe surface contained a region of minor internal corrosion along the bottom of the pipe, approximately 5:00 o'clock to 7:00 o'clock (inch mark 11-17), shown in Figure 4-7. No deposits were collected from the internal pipe surface as there was insufficient present for examination. The external and internal pipe surface around the leak is shown in Figure 4-8. The internal surface contained a teardrop-like area of wall loss at the identified leak.

Figure 4-1: Stitched photographs of external (left) and internal (right) weld surface. Numbered scale divisions are inches.

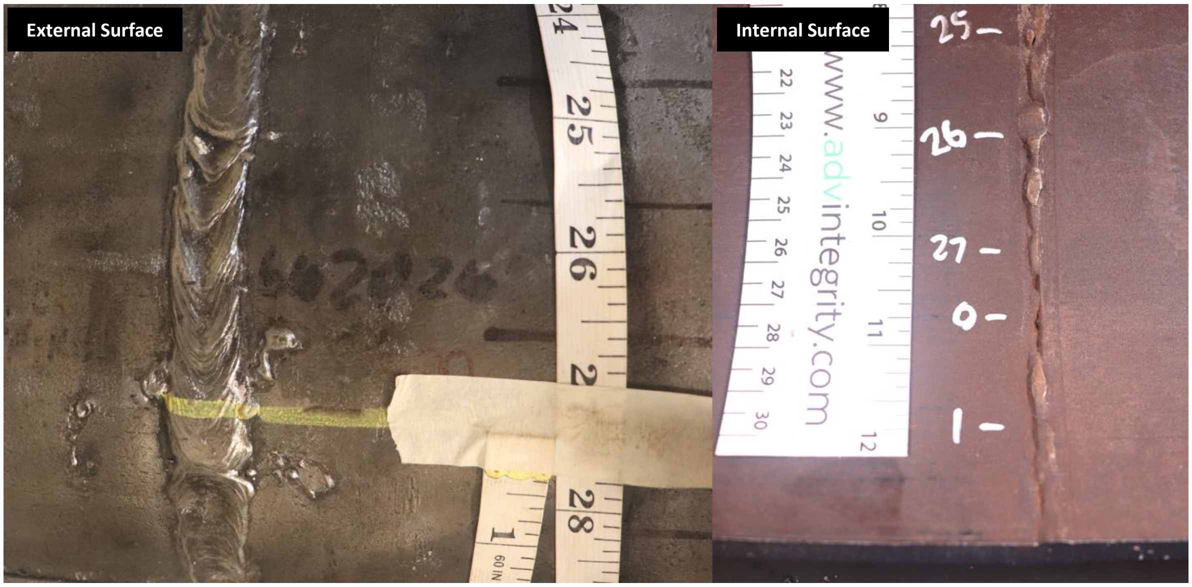


Figure 4-2: Photograph of external (left) and internal (right) weld surface. Numbered scale divisions are inches.

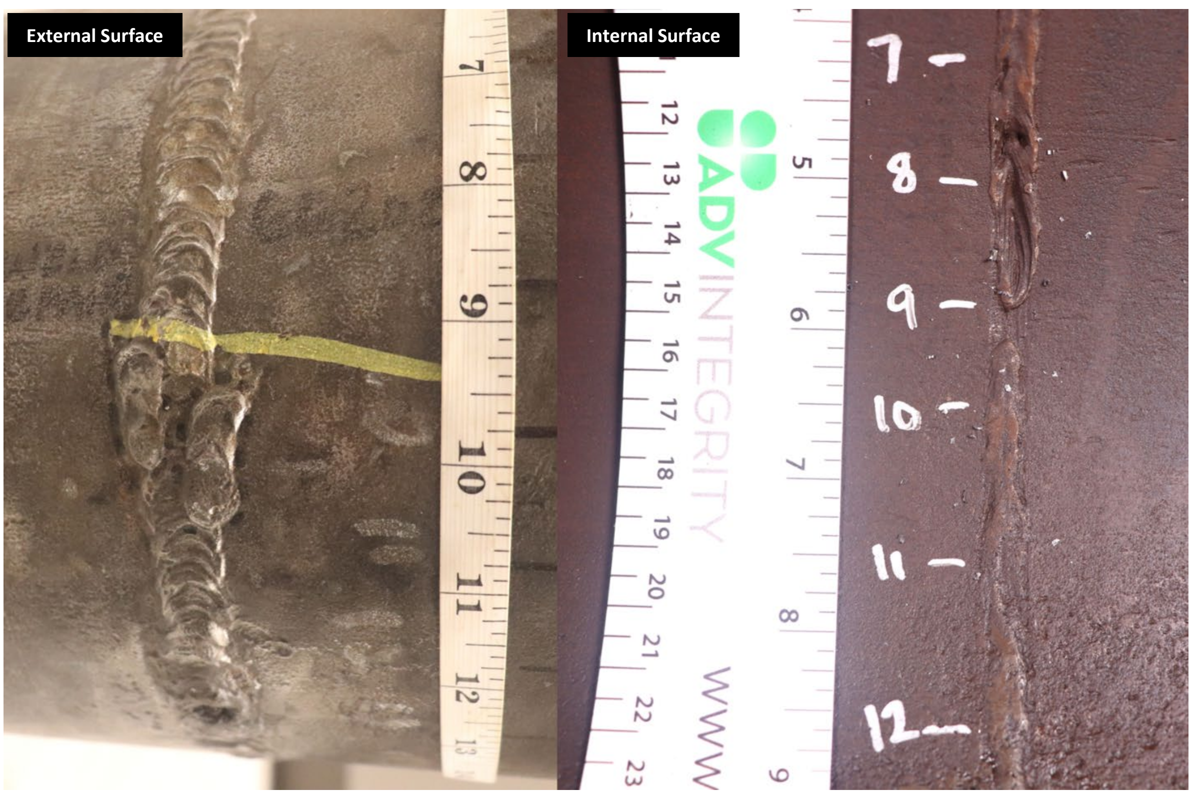


Figure 4-3: Photograph of external (left) and internal (right) weld surface. Numbered scale divisions are inches.

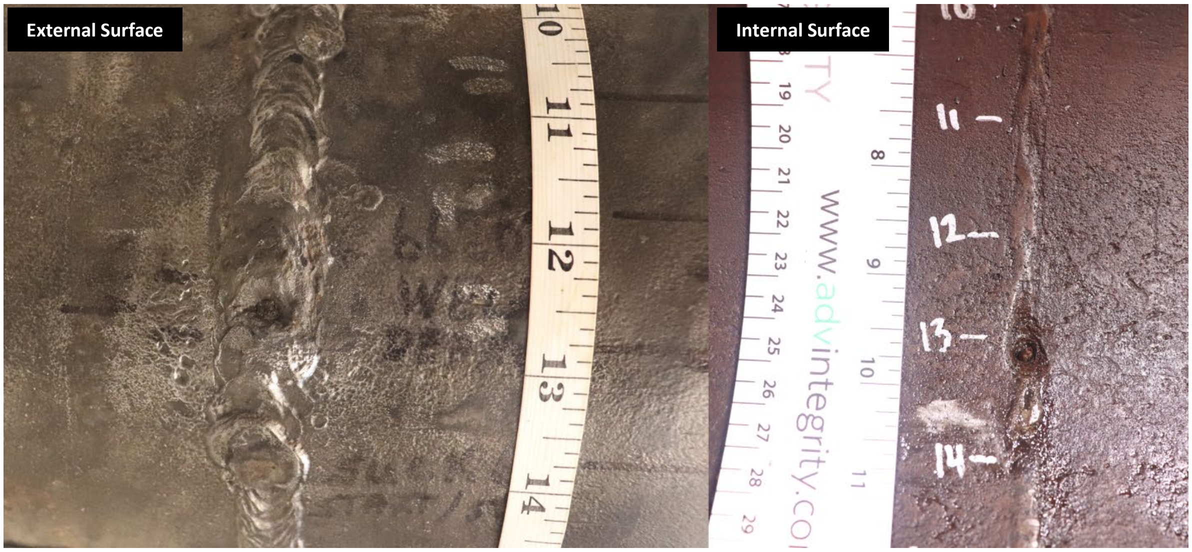


Figure 4-4: Photograph of external (left) and internal (right) weld surface. Numbered scale divisions are inches.

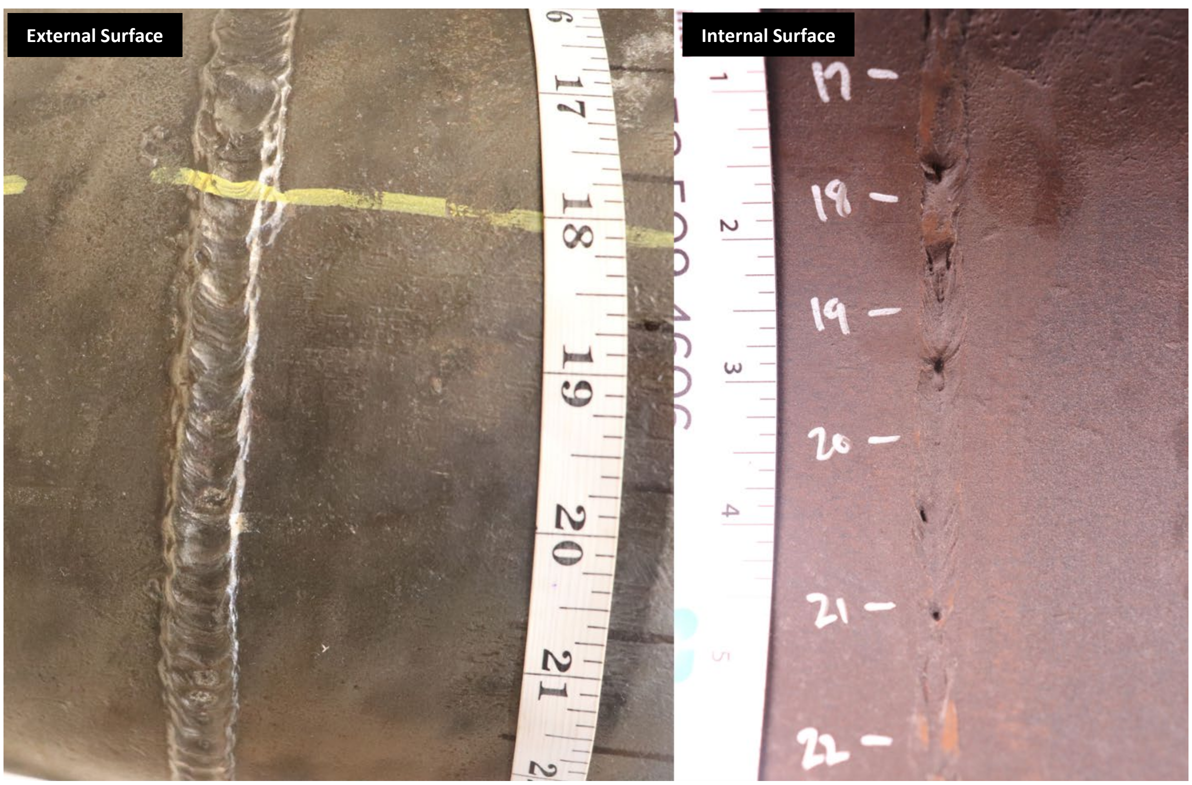


Figure 4-5: Photograph of external (left) and internal (right) weld surface. Numbered scale divisions are inches.

Figure 4-6: Photograph of external (left) and internal (right) weld surface. Numbered scale divisions are inches.

Figure 4-7: Photograph of the internal pipe surface. Upper numbered scale divisions are inches.

Figure 4-8: Photograph of external (left) and internal (right) weld surface at the leak. Major numbered scale divisions are inches.

5.0 METALLURGICAL EXAMINATION

ADV prepared the following metallurgical cross sections to better understand the leak and surrounding girth weld quality. Each of these cross sections are discussed in the subsections below.

- Longitudinal cross section through leak
- Longitudinal cross section through the 7-inch mark (3:00 o'clock orientation)
- Longitudinal cross section through the 10-inch mark (4:30 o'clock orientation)
- Longitudinal cross section through the 14-inch mark (6:15 o'clock orientation)
- Longitudinal cross section through the 23-inch mark (10:15 o'clock orientation)
- Longitudinal cross section through an intact region of the weld adjacent to the leak

5.1 Longitudinal cross section through leak

ADV prepared a metallurgical cross section through the identified leak, shown in Figure 5-1. The wood plug installed in the field is present centered within the weld. The leak's cross section contained areas of irregular wall loss, appearing similar to internal corrosion, shown in Figure 5-2 and Figure 5-3. No girth weld flaws were identified along the leak's cross section, however, those could have been masked during the life of this weld. Other areas of shallow internal corrosion were identified along the internal pipe surface, with a representative area shown in Figure 5-4. Minor hi-lo (0.01-inch) was identified at the leak location.

The base material microstructure appeared consistent with a ferrite-pearlite mixture typical of carbon steel, shown in Figure 5-5.

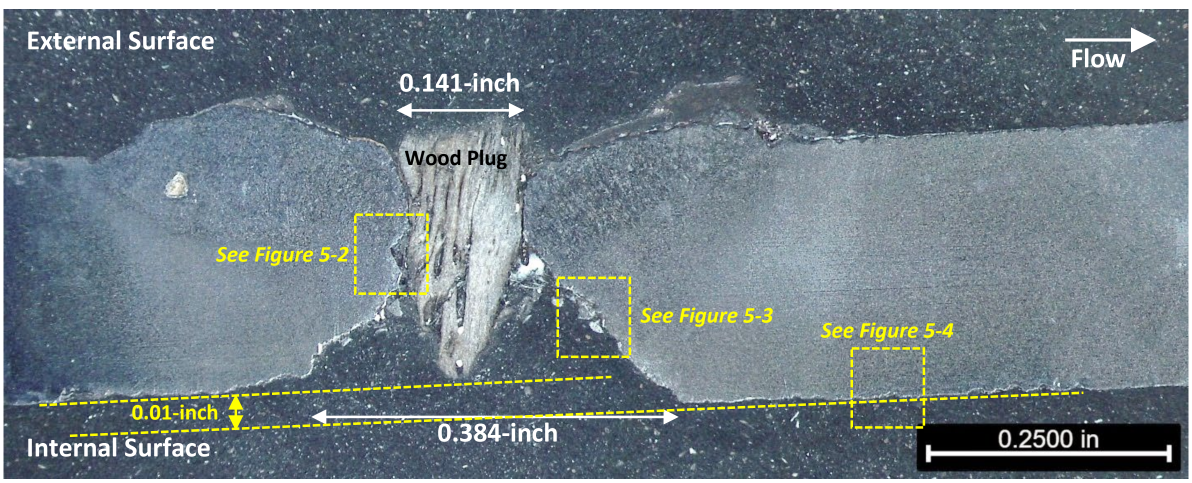


Figure 5-1: Photomicrograph across leak. Etchant is 2% Nital; original magnification is 0.6x.

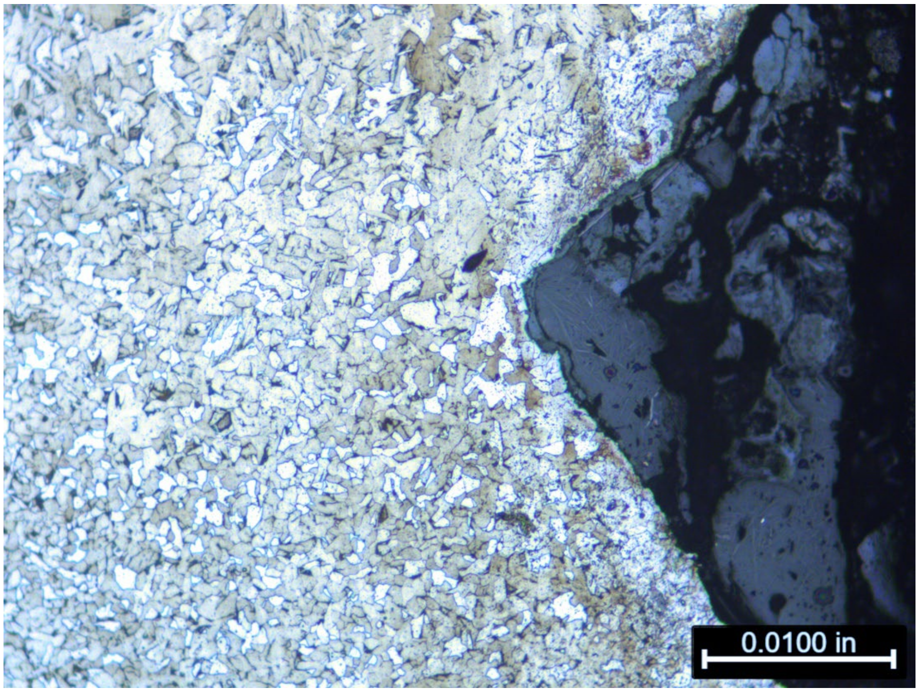


Figure 5-2: Photomicrograph along leak's cross section. Etchant is 2% Nital; original magnification is 100x.

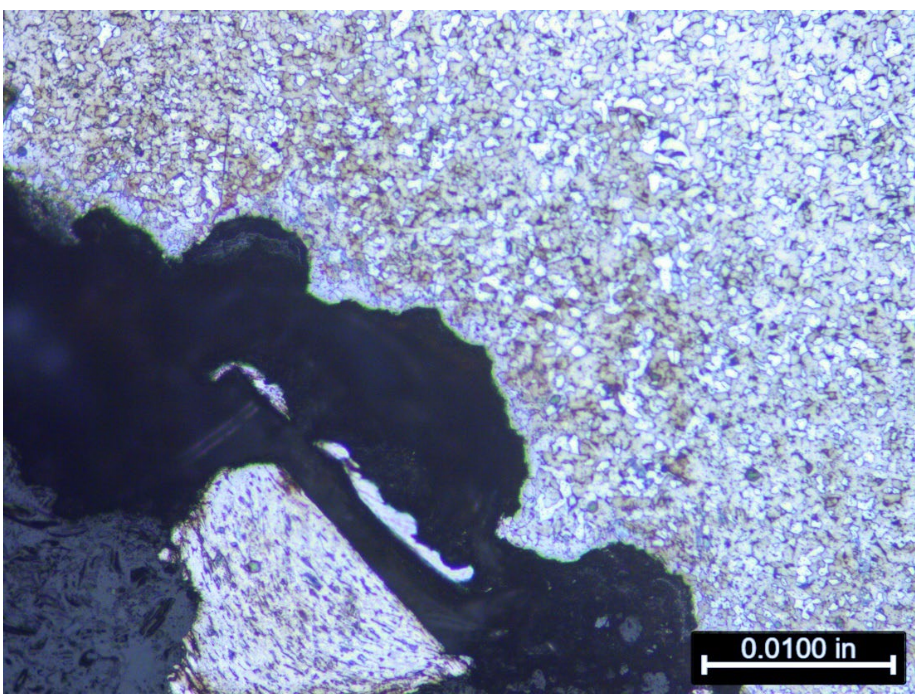


Figure 5-3: Photomicrograph along leak's cross section. Etchant is 2% Nital; original magnification is 100x.

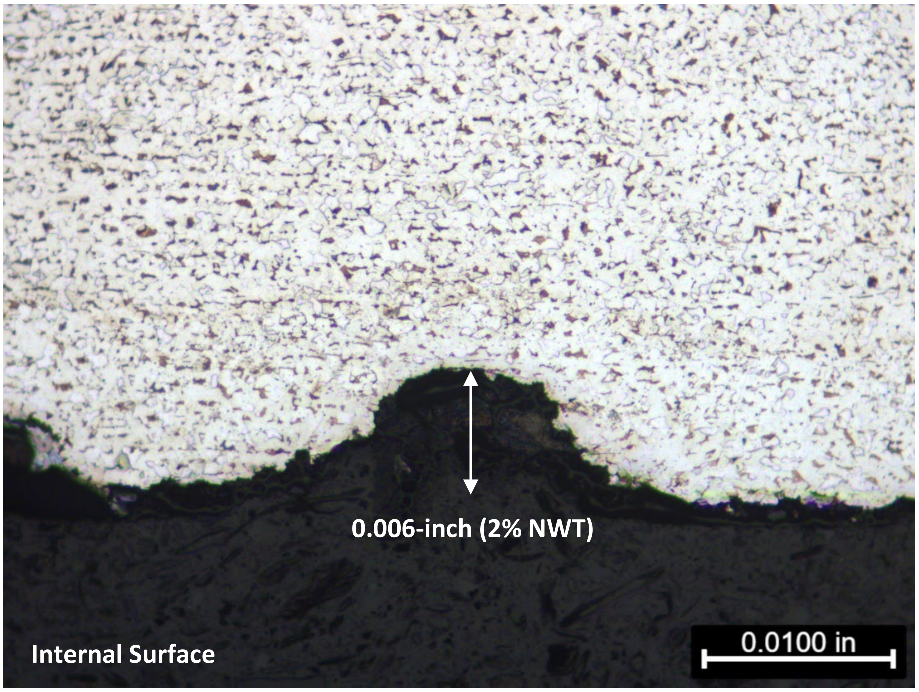


Figure 5-4: Photomicrograph along internal pipe surface adjacent to the leak. Etchant is 2% Nital; original magnification is 100x.

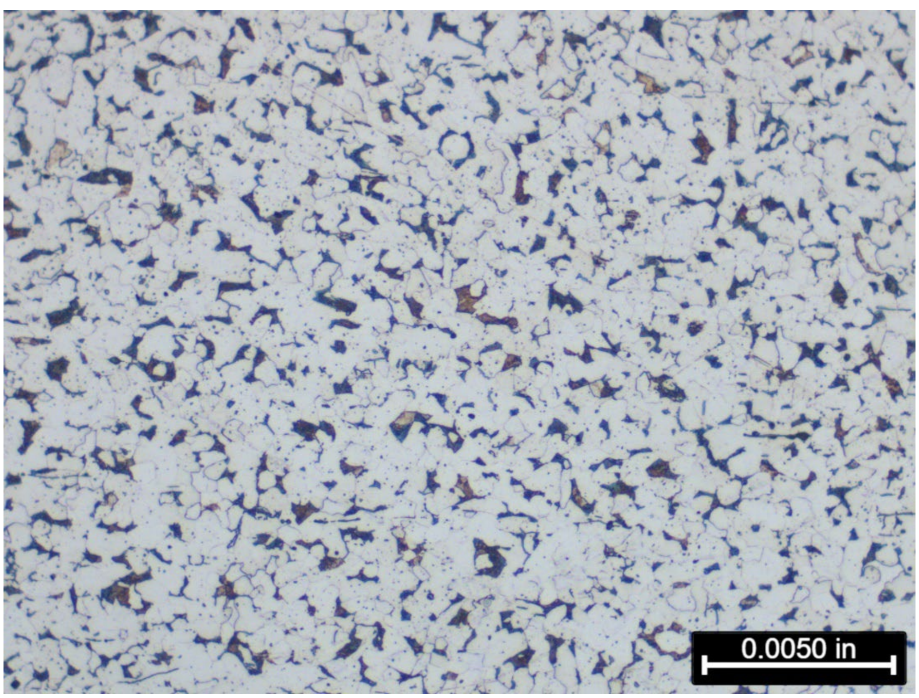


Figure 5-5: Photomicrograph of the base pipe material. Etchant is 2% Nital; original magnification is 200x.

5.2 Longitudinal cross section through the 8-inch mark (3:00 o'clock orientation)

ADV prepared a metallurgical cross section through the 8-inch mark, approximately the 3:00 o'clock orientation, shown in Figure 5-6. The cross section appeared consistent with the visually identified region of suckback. Weld features were identified connecting to the internal pipe surface centered along the root and along the weld toe on one side of the weld, appearing consistent with lack of penetration. These features are shown in Figure 5-7 through Figure 5-9. Minor wall loss along the internal surface was identified, appearing consistent with internal corrosion. A volumetric feature, appearing consistent with porosity, was identified within the weld metal, shown in Figure 5-10.

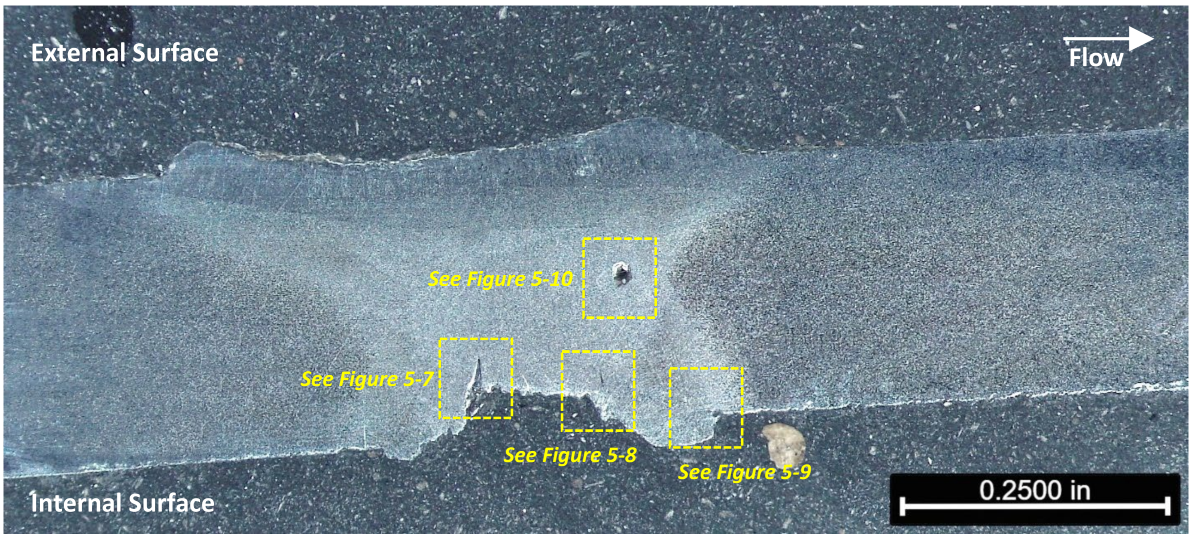


Figure 5-6: Photomicrograph across 8-inch mark. Etchant is 2% Nital; original magnification is 0.6x.

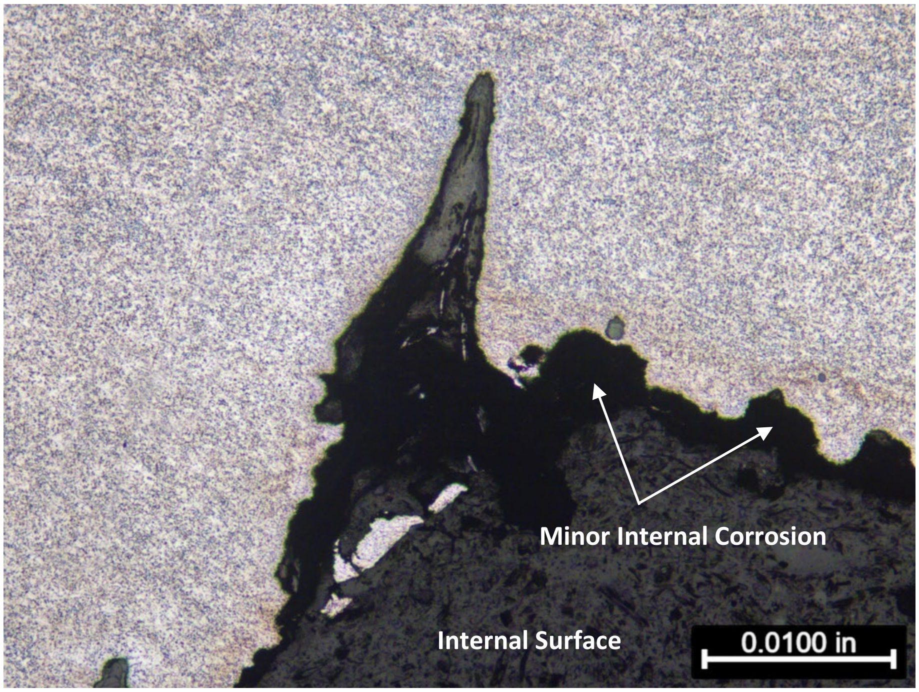


Figure 5-7: Photomicrograph of internal surface connected weld feature. Etchant is 2% Nital; original magnification is 100x.

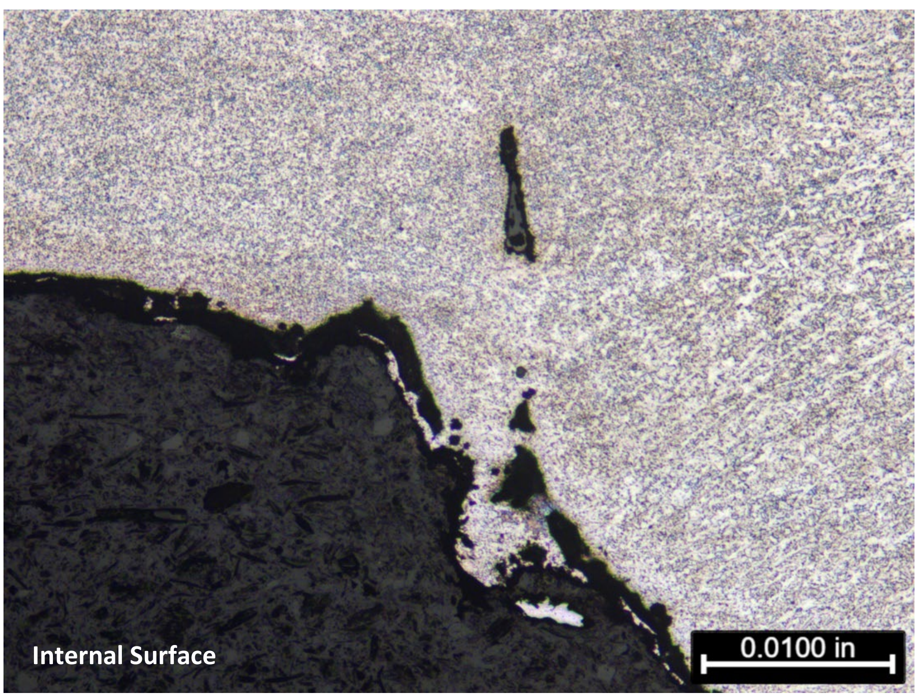


Figure 5-8: Photomicrograph of internal surface connected weld feature. Etchant is 2% Nital; original magnification is 100x.

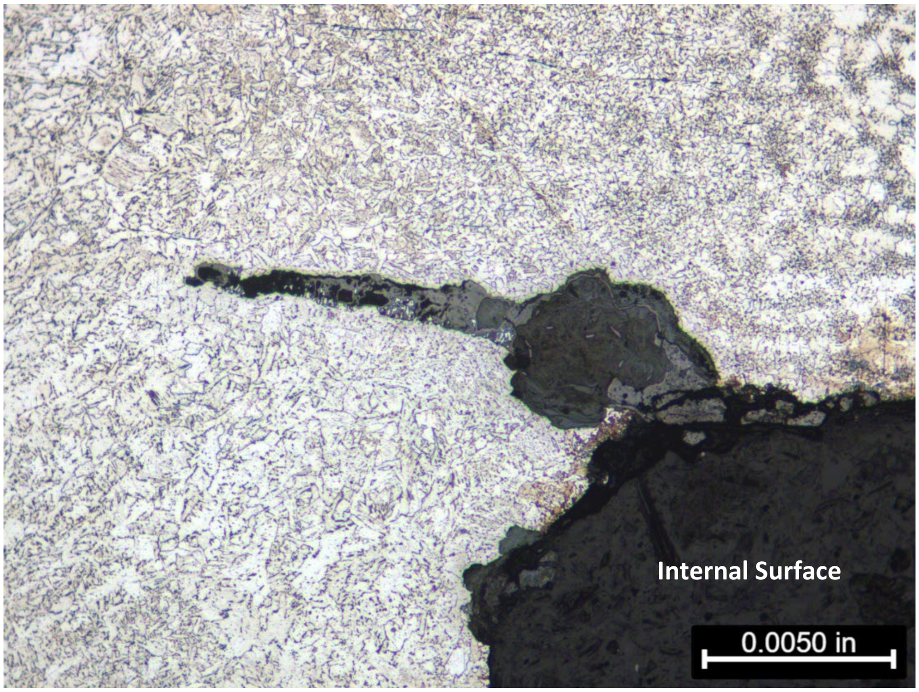


Figure 5-9: Photomicrograph of internal surface connected weld feature. Etchant is 2% Nital; original magnification is 200x.

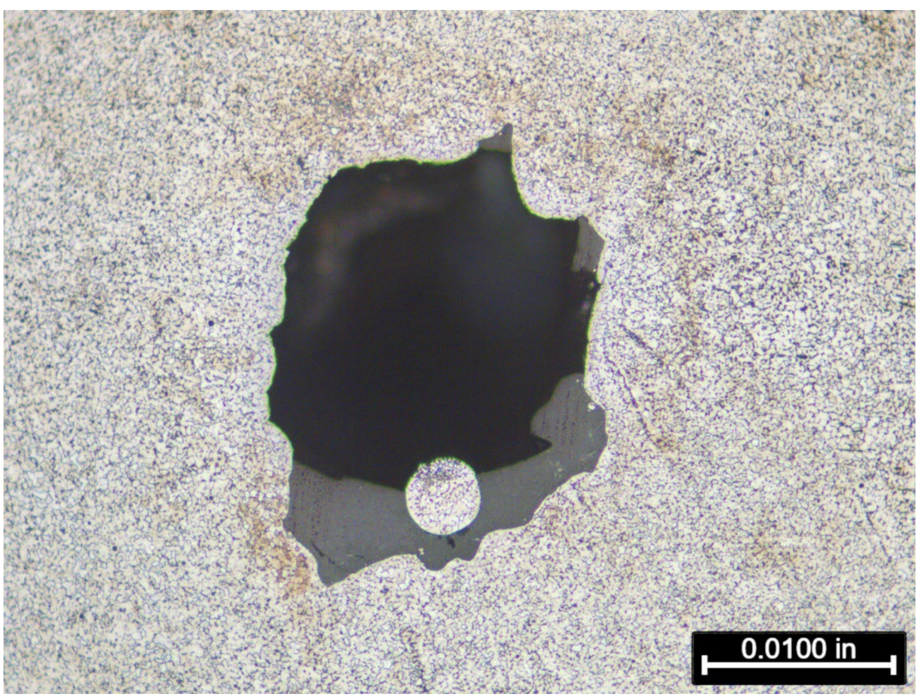


Figure 5-10: Photomicrograph of volumetric feature present within weld metal. Etchant is 2% Nital; original magnification is 100x.

5.3 Longitudinal cross section through the 10-inch mark (4:30 o'clock orientation)

ADV prepared a metallurgical cross section through the 10-inch mark, approximately the 4:30 o'clock orientation, shown in Figure 5-11. The cross section appeared consistent with external surface weld repairs along the cap pass toes. An irregular, rounded internally connected feature was identified along the original root's toe, shown in Figure 5-12. This feature appears consistent with internal undercut, potentially altered via minor internal corrosion. A volumetric feature, appearing consistent with porosity, was identified within the original weld metal, shown in Figure 5-13.

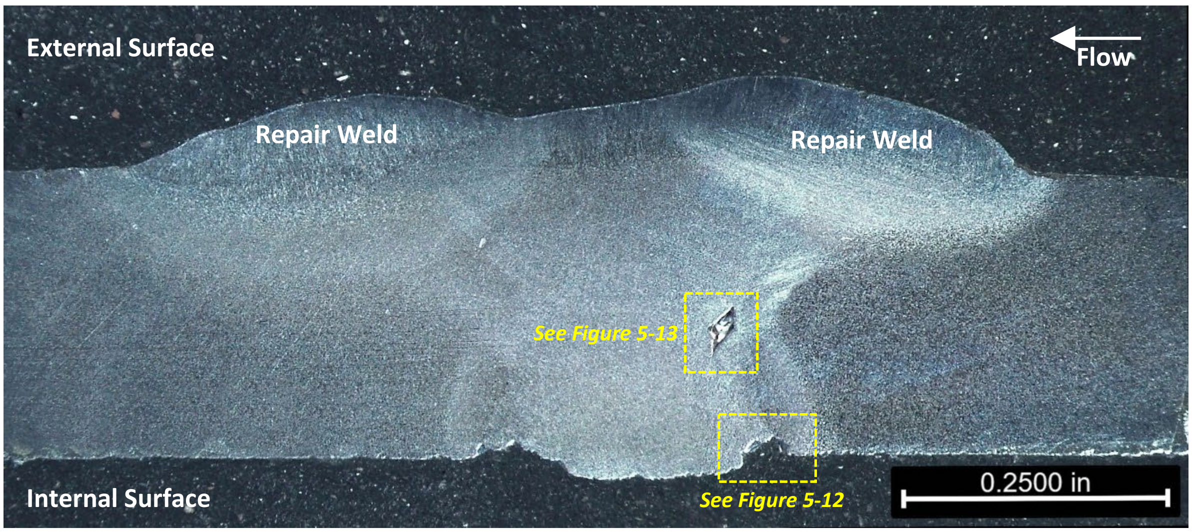


Figure 5-11: Photomicrograph across 10-inch mark. Etchant is 2% Nital; original magnification is 0.6x.

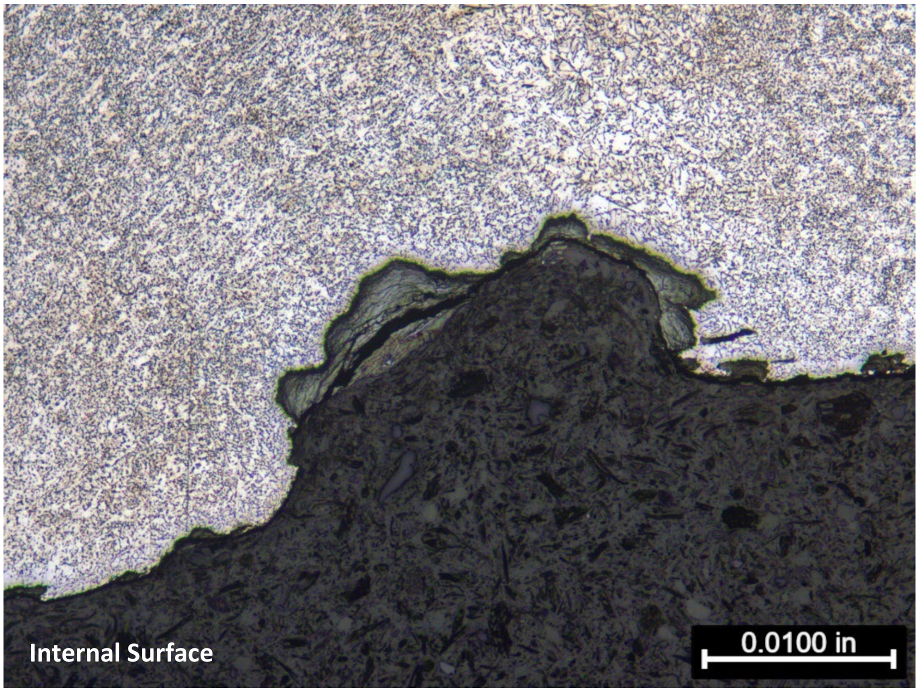


Figure 5-12: Photomicrograph of internal surface connected weld feature. Etchant is 2% Nital; original magnification is 100x.

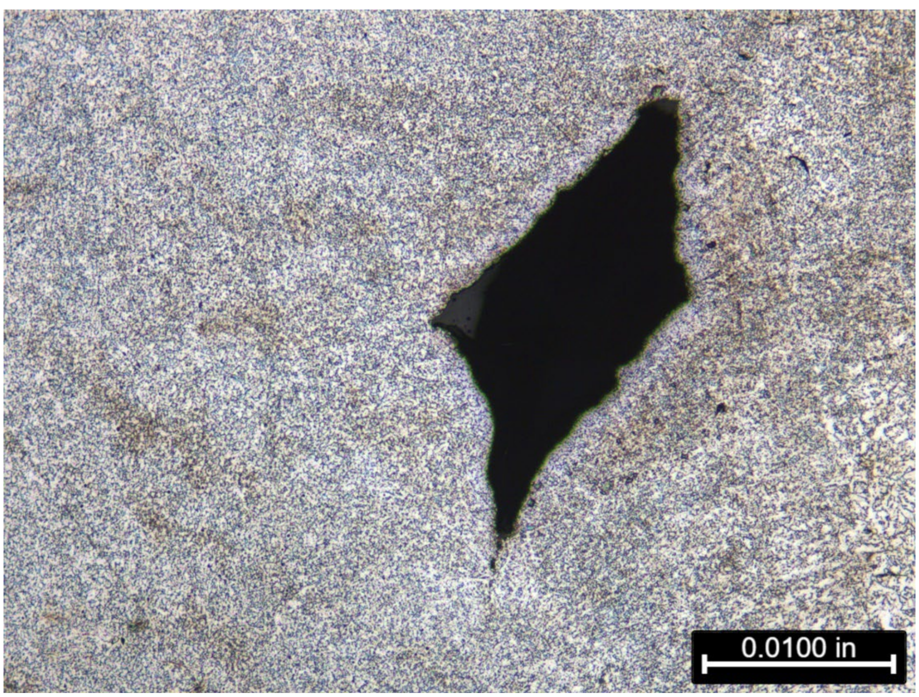


Figure 5-13: Photomicrograph of volumetric feature present within weld metal. Etchant is 2% Nital; original magnification is 100x.

5.4 Longitudinal cross section through the 14-inch mark (6:15 o'clock orientation)

ADV prepared a metallurgical cross section through the 14-inch mark, approximately the 6:15 o'clock orientation, shown in Figure 5-14. The cross section appeared consistent with a concave cap pass. Several irregular, rounded internally connected features were identified along the weld, shown in Figure 5-15. These features appeared consistent with internal corrosion. Two volumetric features was identified within the weld metal, shown in Figure 5-16 and Figure 5-17.

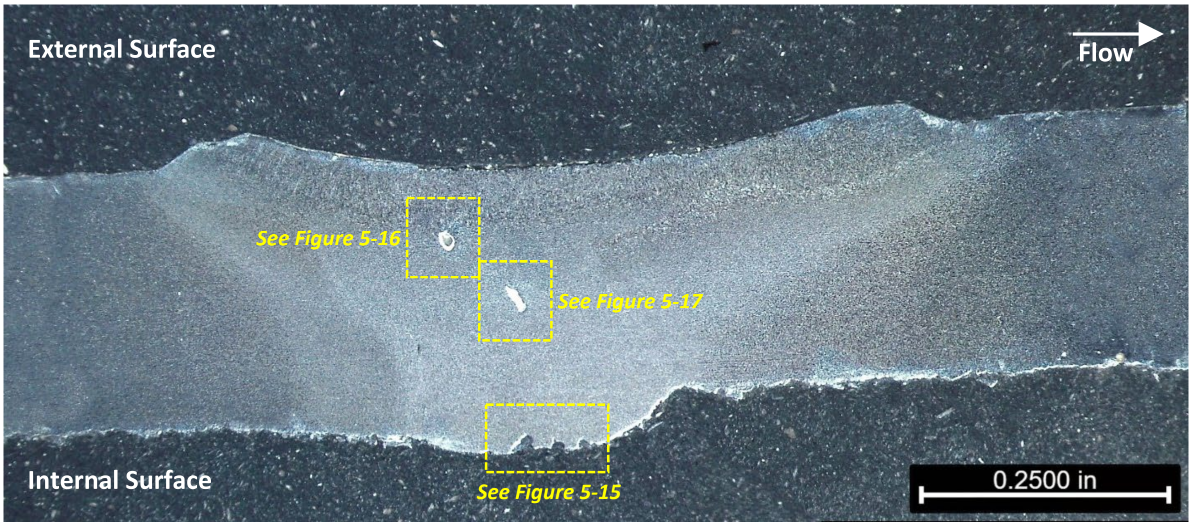


Figure 5-14: Photomicrograph across 14-inch mark. Etchant is 2% Nital; original magnification is 0.6x.

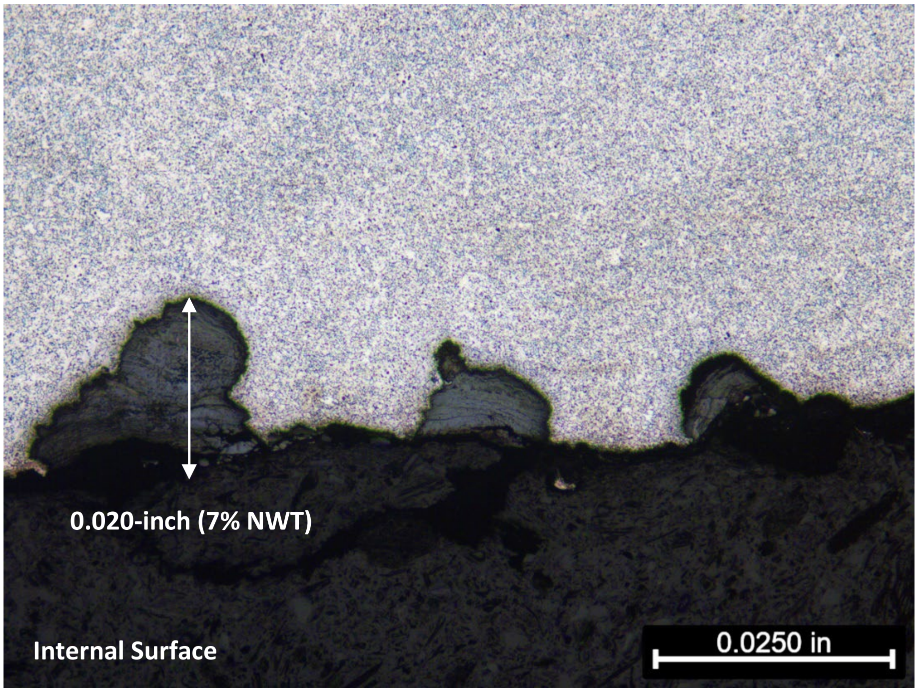


Figure 5-15: Photomicrograph of wall loss present along the internal surface of the weld. Etchant is 2% Nital; original magnification is 50x.

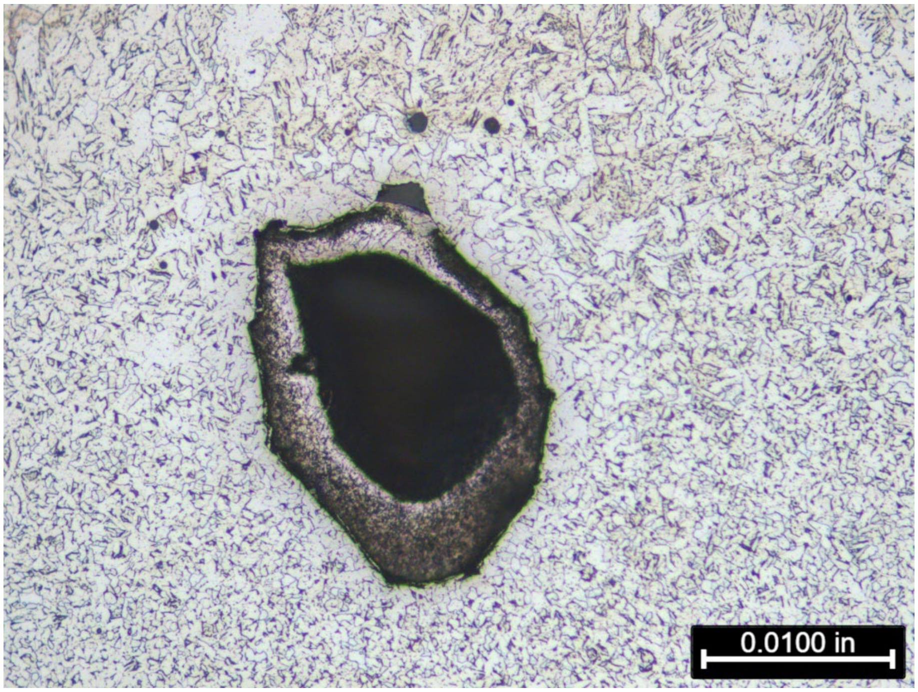


Figure 5-16: Photomicrograph of volumetric feature present within weld metal. Etchant is 2% Nital; original magnification is 100x.

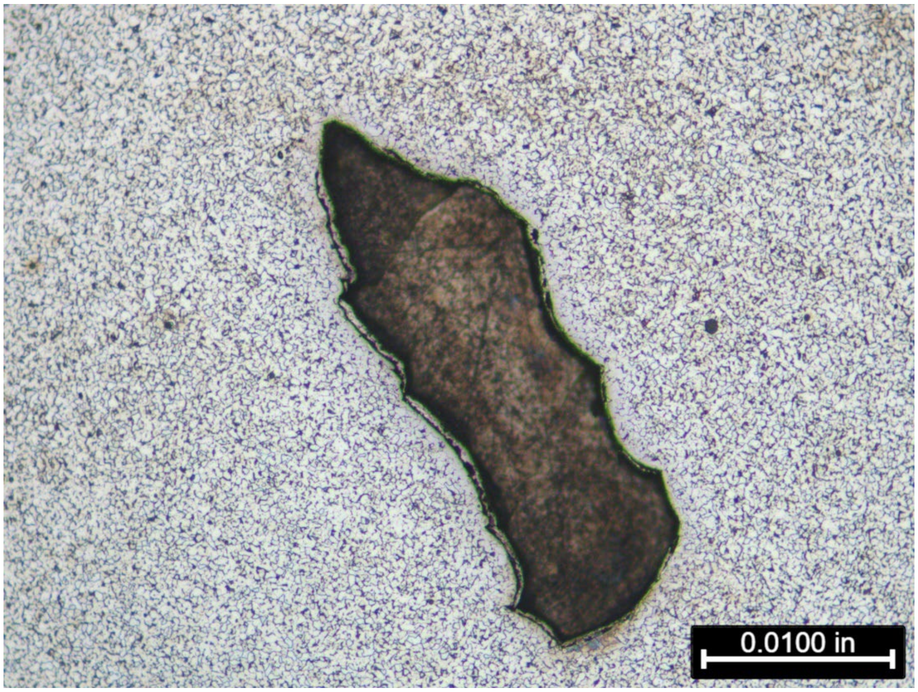


Figure 5-17: Photomicrograph of volumetric feature present within weld metal. Etchant is 2% Nital; original magnification is 100x.

5.5 Longitudinal cross section through the 23-inch mark (10:15 o'clock orientation)

ADV prepared a metallurgical cross section through the 23-inch mark, approximately the 10:15 o'clock orientation, shown in Figure 5-18. An irregular, rounded internally connected feature was identified along the root's toe, shown in Figure 5-19. This feature appears consistent with internal undercut, potentially altered via minor internal corrosion. Weld solidification cracks were identified along the external weld pass, shown in Figure 5-20.

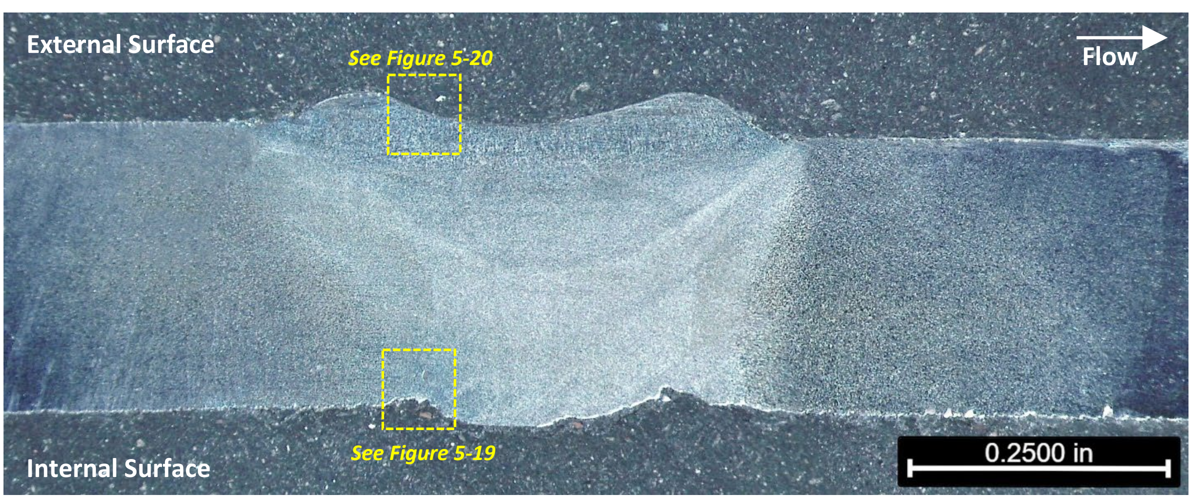


Figure 5-18: Photomicrograph across 23-inch mark. Etchant is 2% Nital; original magnification is 0.6x.

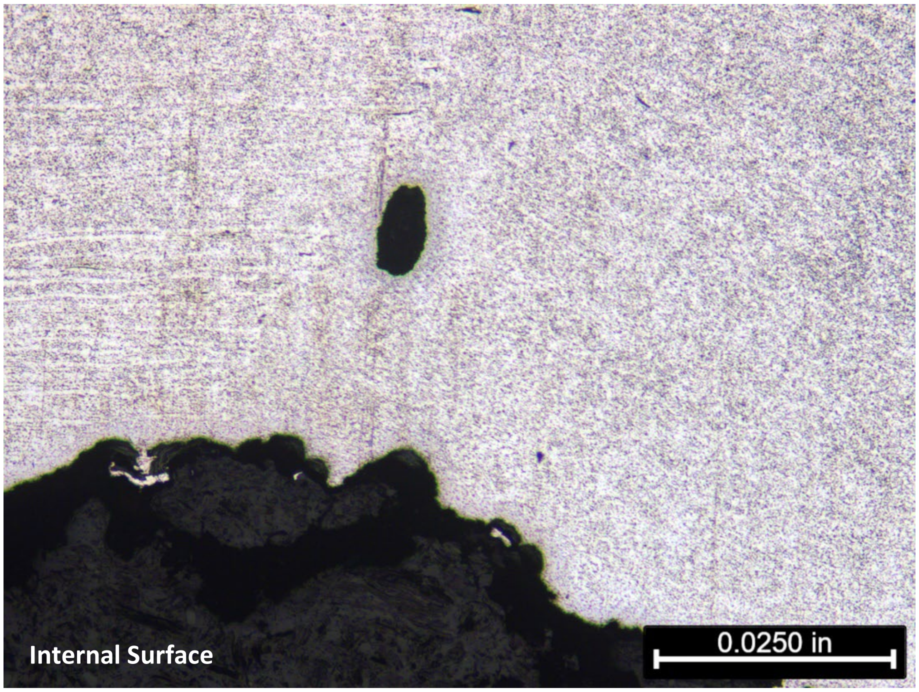


Figure 5-19: Photomicrograph of internal surface connected weld feature. Etchant is 2% Nital; original magnification is 50x.

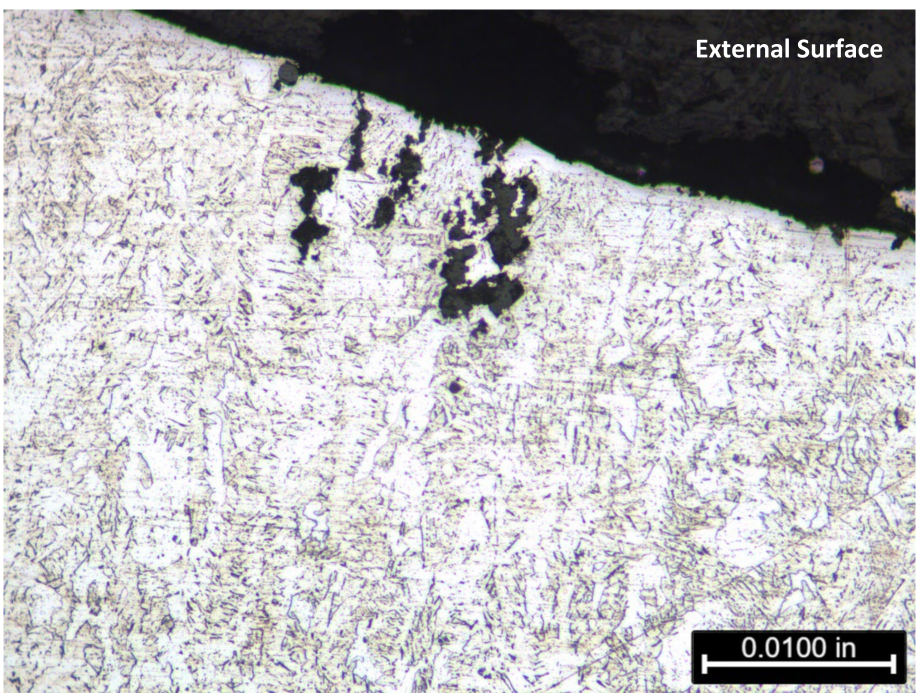


Figure 5-20: Photomicrograph of external surface connected weld feature. Etchant is 2% Nital; original magnification is 100x.

5.6 Longitudinal cross section through an intact region of the weld adjacent to the leak

ADV prepared a metallurgical cross section through an intact portion of the girth weld, shown in Figure 5-21. Two irregular, rounded internally connected feature were identified along the root's toe, with the most significant shown in Figure 5-22. This feature appears consistent with internal undercut, potentially altered via minor internal corrosion. Several irregular, rounded internally connected features were identified along the base pipe adjacent to the girth weld, shown in Figure 5-23. These features appeared consistent with internal corrosion.

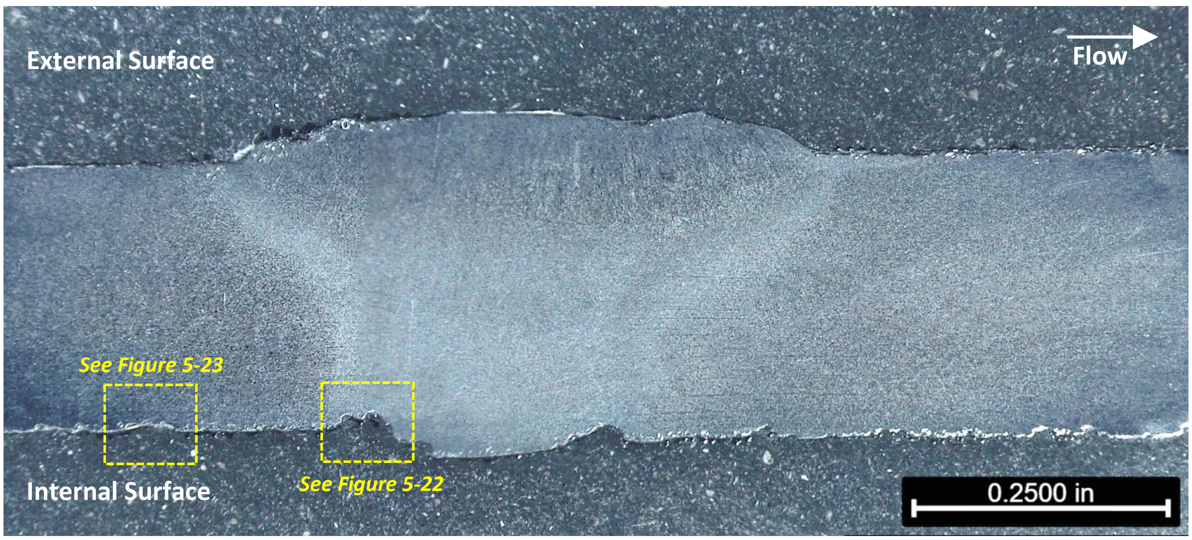


Figure 5-21: Photomicrograph across weld adjacent to leak. Etchant is 2% Nital; original magnification is 0.6x.

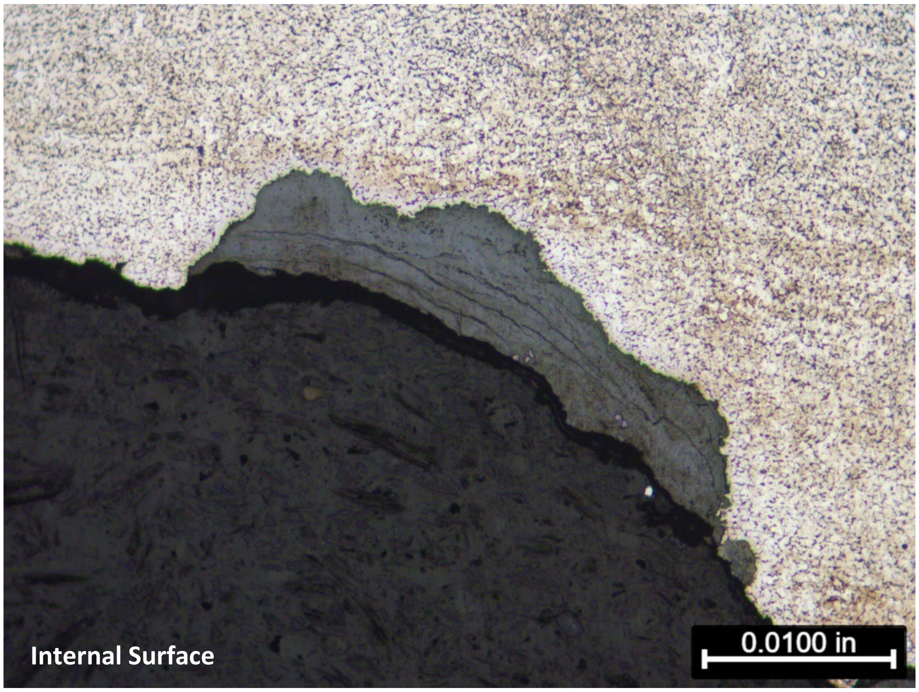


Figure 5-22: Photomicrograph of wall loss present along the internal surface of the weld. Etchant is 2% Nital; original magnification is 100x.

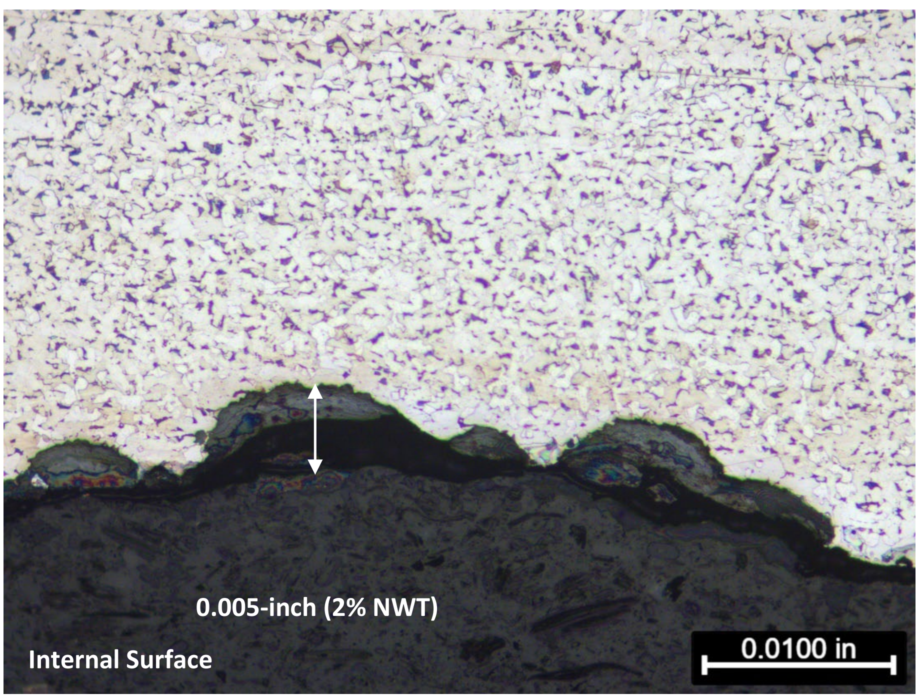


Figure 5-23: Photomicrograph of wall loss present along the internal surface adjacent to the weld. Etchant is 2% Nital; original magnification is 100x.

6.0 HARDNESS TESTING

A full subload Vickers hardness testing (HV0.5) was performed on the metallurgical cross section prepared through the intact girth weld adjacent to the leak, shown in Figure 5-21. A subload map was chosen to investigate the relative strength of the weld compared to the base pipe. These results are consistent with an even-matched girth weld and are summarized in Table 6-1 and Figure 6-1. The full report is attached in Appendix B.

Table 6-1: Hardness Testing Results

Min	Max	Average
132	188	164
Note: All readings are HV0.5.		

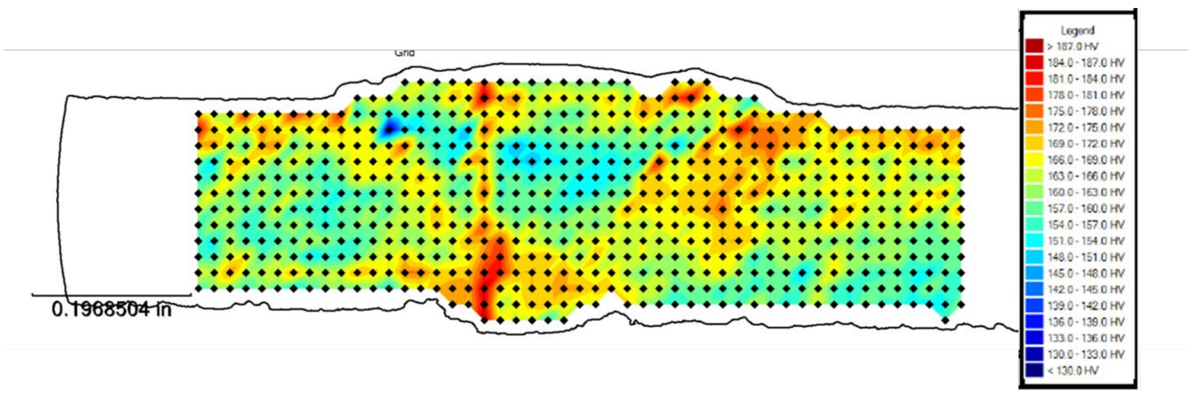


Figure 6-1: Hardness map output.

7.0 ANALYSIS OF CORROSION PRODUCTS

ADV contracted EPI Materials Testing Group (EPI MTG) to perform scanning electron microscopy, coupled with energy dispersive X-ray spectroscopy (SEM-EDS) and X-ray diffraction (XRD) of the corrosion deposits collected from the external pipe surface. These locations include:

- Black deposits adjacent to the leak, shown in Figure 2-7
- Fine white deposits present adjacent to the girth weld, shown in Figure 2-8
- Larger white deposits present adjacent to the girth weld, shown in Figure 2-9

These locations were chosen in an attempt to characterize the presence of cathodic protection at this location. SEM-EDS characterizes the elemental constituents within the deposits, while XRD characterizes the crystalline compounds within the deposits.

First, examination of the black deposits present adjacent to the leak were analyzed. SEM-EDS identified mostly magnesium, silicon, and calcium. XRD identified mostly calcium carbonate. These results are consistent with byproducts of the cathodic protection system, mixed with sand.

Second, examination of the fine white deposits adjacent to the girth weld were analyzed. SEM-EDS identified mostly magnesium, silicon, and calcium. XRD identified compounds including calcium carbonate and those consistent with sand. These results are consistent with byproducts of the cathodic protection system, mixed with sand.

Third, examination of the larger white deposits along the pipe were analyzed. SEM-EDS identified mostly sodium and silicon. XRD identified mostly silicon oxide and sodium chloride. These results were consistent with lime reportedly used at the time of excavation.

All reports are attached in Appendix C.

8.0 MECHANICAL TESTING AND CHEMICAL ANALYSIS

ADV performed a series of mechanical tests to confirm the material properties of the pipe material provided. The mechanical testing was performed by ADV and the chemical analysis was contracted to Bryan Laboratory, Inc. The results for the pipe were compared to the closest API 5L edition from the time of manufacturing: API 5L, 10th Edition (1945).

Chemical analysis of the upstream and downstream (per ASTM A751) and tensile test (per ASTM A370) results, summarized in Table 8-1 and Table 8-2 respectively, are consistent with the requirements of API 5L (1945), Grade B material. The pipe appears to be manufactured using Bessemer steel based on the phosphorus content. The weld metal chemistry was also consistent with a welding consumable utilized on low carbon pipeline steel. Pipe body half-sized Charpy V-notch tests (per ASTM A370) were performed to form a transition curve and results are summarized in Table 8-3 and Figure 8-1.

Table 8-1: Chemical Analysis Results

Element	Composition (%)			
	Upstream Material	Downstream Material	API 5L, Grade B 10th Edition (1945)[1]	Weld Metal
Carbon	0.10	0.10	0.30 (max)	0.10
Manganese	0.41	0.43	0.35-1.50	0.45
Phosphorus	0.070	0.066	0.11 (max)	0.042
Sulfur	0.023	0.022	0.060 (max)	0.022
Silicon	0.22	0.20	---	0.17
Chromium	<0.01	<0.01	---	0.02
Nickel	<0.01	<0.01	---	0.02
Molybdenum	<0.01	<0.01	---	<0.01
Copper	0.01	0.01	---	0.02
Aluminum	0.04	0.05	---	<0.01
Vanadium	<0.01	<0.01	---	<0.01
Titanium	<0.01	<0.01	---	<0.01
Niobium	<0.01	<0.01	---	<0.01
Boron	<0.001	<0.001	---	<0.001
[1] Seamless, Bessemer				

Table 8-2: Tensile Strength Results

Location	Specimen	Yield Strength (psi)	Tensile Strength (psi)	Elongation (%)
Transverse Pipe Body	1	57,300	75,400	29.3
Longitudinal Pipe Body	1	55,300	74,400	25.8
API 5L, Grade B 10th Edition (1945)		35,000 (min)	60,000 (min)	28.3 (min)
Transverse: 1-1/2" wide reduced section, Longitudinal: 1-1/2" wide reduced section, Yield Strength is 0.5% EUL Longitudinal sample performed for information				

Table 8-3: Pipe Body Charpy V-notch Results (half-size specimens)

Location	Specimen	Temperature (°F)	Absorbed Energy (ft-lb)	Approximate Full-Size Equivalent Absorbed Energy (ft-lb)	Percent Shear (%)
Pipe Body	1	-10	0.5	1	0
	2		2	4	0
	3		2	4	0
	Average		**1.5**	**3**	**0**
	1	10	1.5	3	10
	2		2.5	5	10
	3		3.5	7	10
	Average		**2.5**	**5**	**10**
	1	32	5	10	30
	2		5	10	30
	3		4.5	9	30
	Average		**4.8**	**9.7**	**30**
	1	72	12.5	25	60
	2		11	22	60
	3		11	22	60
	Average		**11.5**	**23**	**60**
	1	120	16	32	80
	2		16	32	80
	3		15.5	31	80
	Average		**15.8**	**31.7**	**80**
	1	140	16	32	90
	2		16	32	90
	3		17	34	90
	Average		**16.3**	**32.7**	**90**

Approximate Full-Size Equivalent Absorbed Energy was determined via a thickness ratio correction.

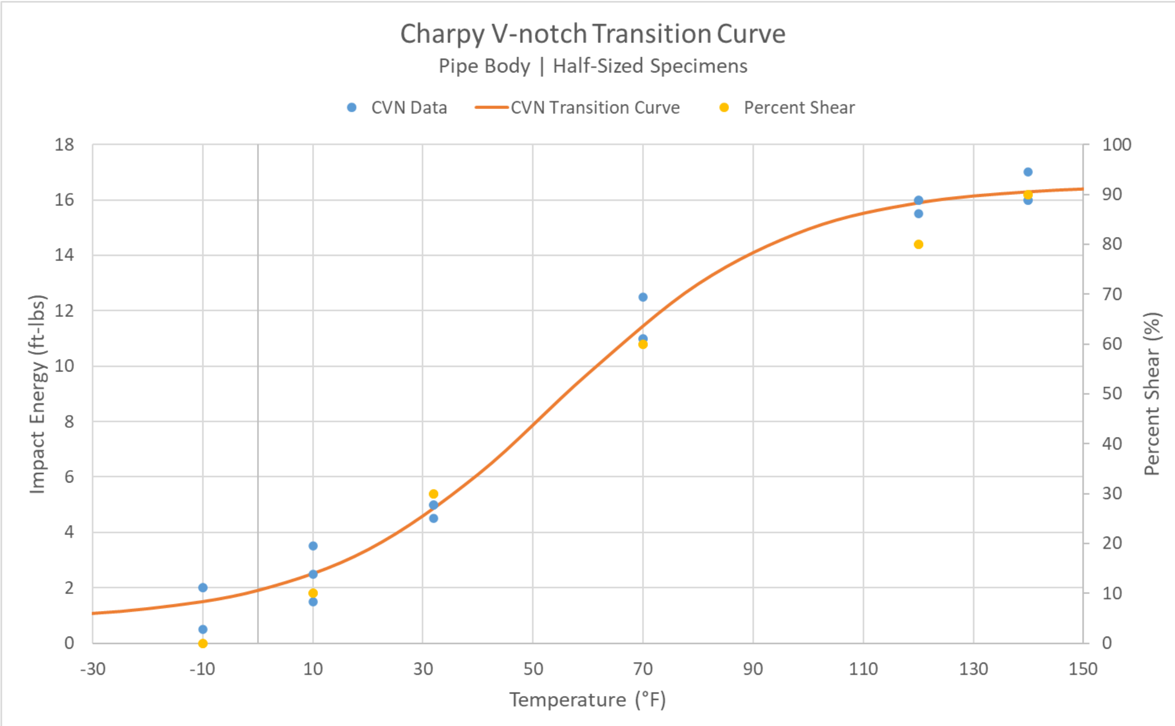


Figure 8-1: Pipe body CVN transition curve.

9.0 DISCUSSION

ADV examined the provided pipe material and identified a leak coinciding with the girth weld resulting in an approximately 1/8-inch diameter through-wall hole. The weld contained a series of original construction welding features, although no weld flaw was identified within the leak's cross section. It seems likely that a weld flaw, such as undercut, burnthrough, or suckback, could have been present, however, may have been masked overtime due to a time dependent mechanism, such as internal corrosion, occurring.

The leak coincided with an area of wall loss in the vicinity of the girth weld. This wall loss extended past the visible heat affected zone, therefore, consumed all of the girth weld root pass present. Based on this appearance, the observed wall loss was the result of a time dependent mechanism, such as internal corrosion. This mechanism could have been exacerbated by an area of minor hi-lo present within the cross section.

10.0 CONCLUSIONS

ADV concluded the following as the result of this examination:

1. ADV identified a leak coinciding with the girth weld resulting in an approximately 1/8-inch diameter through-wall hole. The girth weld contained a series of original construction welding features, although no weld flaw was identified within the leak's cross section, it seems possible that an area of undercut, burnthrough, or suckback could have been present.

2. The leak coincided with an area of wall loss in the vicinity of the girth weld. Based on this appearance, the observed wall loss was the result of a time dependent mechanism, such as internal corrosion potentially exacerbated by hi-lo present.

3. The pipe material was determined to be consistent with API 5L (1945), Grade B material manufactured using Bessemer steel.

APPENDIX A: RT READERSHEET

ACUREN

Acuren Inspection, Inc.
6818 Bourgeois Road
Houston, Texas 77066
Phone: 281.228.0000

www.acuren.com
A Higher Level of Reliability

HOU931304

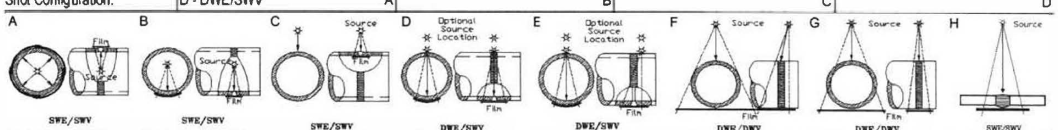
DIGITAL RADIOGRAPHY EXAMINATION REPORT

Page 1 of 1

CUSTOMER: ADV INTERGRITY		ACUREN SERVICE CALL #: 804598	DATE: 11/16/2022
LOCATION/ADDRESS: PO BOX 1449 28246 FM 2920 RD. WALLER, TX 77484		CUSTOMER CONTACT: 832-409-4529	
PART # / DRAWING #: 8" .277WT		CUSTOMER PO #: -	CUSTOMER WO #: 100641
ITEM DESCRIPTION: 8" PIPING		STAGE OF MANUFACTURE: Final	SURFACE CONDITION: As Welded

NDE PROCEDURE	REV.	SPECIFICATION/CODE	REV./EDITION	ACCEPTANCE PROCEDURE / STANDARD:	PARTS INSPECTED:	ACCEPTED:	REJECTED:
CR-ADD-1	15	API 1104	2018	API 1104	1 WELD	0	1

	A	B	C	D
Material and Thickness:	Carbon Steel .277 in.	in.	in.	in.
Diameter: (inches)	8.625	-		
Rein. Thickness: (inches)	0.125	-		
Distance: (inches)	SOD: 8.625 OFD: 0.402	SOD: OFD:	SOD: OFD:	SOD: OFD:
Exposure Time (H:M:S):	35SEC			
IQI Amount / Type / Material:	2 ASTM 1B Mat: SS	Matl:	Matl:	Matl:
IQI Size / Location:	Size: .010 Film	Size:	Size:	Size:
Shim Thickness & Material:	N/A			
Number of Exposures:	3			
Markers: Number or Spacing:	1-2 THRU 3-1			
Focal Spot | µg	0.119 in. 0.0055 µg	in. µg	in. µg	in. µg
Screens: (inches)	Front: N/A Rear: N/A	Front: Rear:	Front: Rear:	Front: Rear:
Image/Media Brand/Type:	Carestream HR			
Shot Configuration:	D - DWE/SWV			



SOURCE:	Ci	kV	ma	DIGITIZING EQUIP. MANUFACTURER / MODEL #:	DIGITIZING EQUIP. SERIAL #:	COMPUTER MONITOR RES.:
☑ Ir ☐ Co ☐ Se ☐ X-Ray	37	-	-	CARESTREAM HPX-1	1441	1920x1080

C - Crack, CP - Cluster Porosity, IP - Insufficient Penetration, EU - External Undercut, S - Surface, **Non Func. Pixel Eval.** Yes ☐ No ☐ N/A ☑
SL - Slag, P - Porosity/Gas Pocket, IF - Insufficient Fusion, IU - Internal Undercut, IPD - IP Due to High/Low, IFD - IF Due to Cold Lap
T - Tungsten, HB - Hollow Bead, EP - Excessive Penetration, IC - Internal Concavity, BT - Burn Through, FA - Film Artifact

Weld/Component	View	Tech.	Pixel Value IQI/Base	Pixel Value Weld	Accept / Reject	Filter Used	Filter Type	Window	Level	List Indications	Welder/Other ID Remarks
662026	1-2	A			Reject	Yes	Flash			IF,P	
	2-3	A			Reject	Yes	Flash			IF,P UNDERFILL	
	3-1	A			Reject	Yes	Flash			IF,IP,P	

☐ Additional Pages | Comments: | Per Diem | Assistant Tech Name (Print):

Imaging Software Version / Revision:	Total # of Welds:	No. on Job:	Travel if Applicable:	Hours Worked:	Total Hours:
RYTHM RT 6.1.59.0	1 PARTS	1	Hours: Miles Total:	to and to	

CLIENT REPRESENTATIVE

Print Name / Signature — Date

The Client Representative who receives this report is responsible for verifying that the acceptance standard listed in the report is correct and promptly notifying Acuren of any issues with this report and/or the work summarized herein. The owner is responsible for the final disposition of all Items inspected.

ACUREN INSPECTOR

TAM HUYNH — 11/16/2022 — II

Print Name / Signature — Date — Inspection Level

PEER REVIEW (IF APPLICABLE):

Print Name / Signature — Date

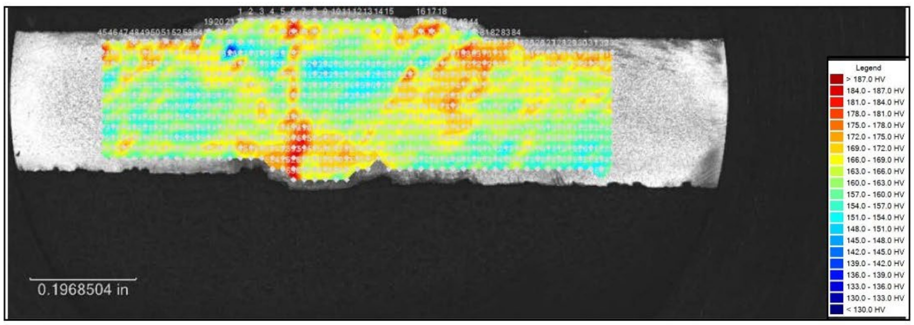
RT-1 Addendum R7 03-18

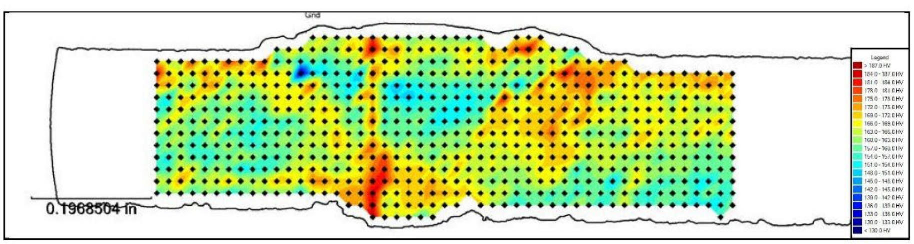
APPENDIX B: HARDNESS TESTING RESULTS

Hardness Map

ADV PN 100641- Intact weld

Date: 12-09-2022
Tester: Admin
Program: Hardness Map



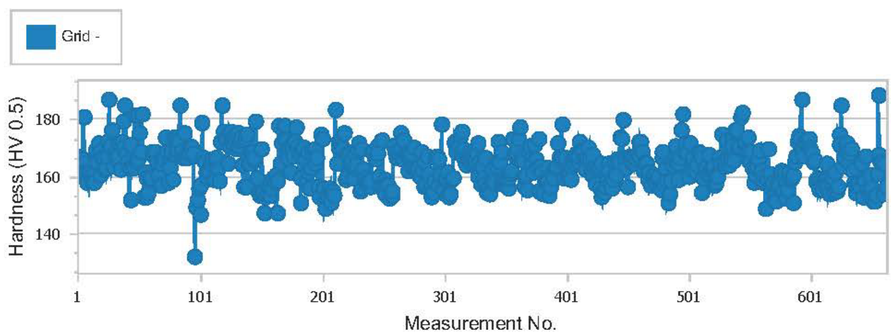


Date: 12-09-2022
Tester: Admin
Program: Hardness Map

Grid

Mean	Minimum	Maximum	Range	Std. deviation
164.0	132.0	188.3	56.4	7.2

Hardness Trace



Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
1	-	160.3 HV 0.5	83.4 HRB	76.9 µm	75.2 µm	
2	-	167.2 HV 0.5	85.5 HRB	75.3 µm	73.7 µm	
3	-	161.6 HV 0.5	83.9 HRB	75.3 µm	76.2 µm	
4	-	165.7 HV 0.5	85.2 HRB	75.6 µm	74.0 µm	
5	-	166.0 HV 0.5	85.2 HRB	74.7 µm	74.8 µm	
6	-	180.5 HV 0.5	89.1 HRB	69.7 µm	73.7 µm	
7	-	164.3 HV 0.5	84.8 HRB	74.3 µm	75.9 µm	
8	-	161.6 HV 0.5	83.9 HRB	75.6 µm	75.9 µm	
9	-	157.6 HV 0.5	82.5 HRB	76.9 µm	76.5 µm	
10	-	161.6 HV 0.5	83.9 HRB	76.2 µm	75.2 µm	
11	-	161.6 HV 0.5	83.9 HRB	76.2 µm	75.2 µm	
12	-	159.6 HV 0.5	83.2 HRB	77.8 µm	74.6 µm	
13	-	160.3 HV 0.5	83.4 HRB	75.9 µm	76.2 µm	
14	-	157.8 HV 0.5	82.6 HRB	77.4 µm	75.9 µm	
15	-	157.6 HV 0.5	82.5 HRB	78.8 µm	74.6 µm	
16	-	168.9 HV 0.5	86.0 HRB	75.6 µm	72.6 µm	
17	-	165.0 HV 0.5	85.0 HRB	75.0 µm	74.9 µm	
18	-	171.5 HV 0.5	86.8 HRB	74.3 µm	72.7 µm	
19	-	160.3 HV 0.5	83.4 HRB	77.2 µm	74.9 µm	
20	-	168.6 HV 0.5	85.9 HRB	75.0 µm	73.3 µm	

Date: 12-09-2022
Tester: Admin
Program: Hardness Map

ADVINTEGRITY

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
21	-	166.4 HV 0.5	85.4 HRB	75.6 µm	73.7 µm	
22	-	166.4 HV 0.5	85.4 HRB	74.7 µm	74.6 µm	
23	-	162.3 HV 0.5	84.1 HRB	77.8 µm	73.3 µm	
24	-	163.0 HV 0.5	84.3 HRB	75.3 µm	75.6 µm	
25	-	172.2 HV 0.5	87.1 HRB	73.7 µm	73.0 µm	
26	-	167.2 HV 0.5	85.5 HRB	74.7 µm	74.3 µm	
27	-	187.1 HV 0.5	90.4 HRB	70.4 µm	70.4 µm	
28	-	170.8 HV 0.5	86.6 HRB	72.8 µm	74.6 µm	
29	-	176.0 HV 0.5	88.0 HRB	71.8 µm	73.3 µm	
30	-	163.6 HV 0.5	84.5 HRB	75.3 µm	75.2 µm	
31	-	167.9 HV 0.5	85.7 HRB	74.0 µm	74.6 µm	
32	-	168.6 HV 0.5	85.9 HRB	73.1 µm	75.2 µm	
33	-	165.7 HV 0.5	85.2 HRB	75.0 µm	74.6 µm	
34	-	167.2 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
35	-	171.5 HV 0.5	86.8 HRB	72.1 µm	74.9 µm	
36	-	162.2 HV 0.5	84.1 HRB	75.3 µm	75.9 µm	
37	-	172.2 HV 0.5	87.1 HRB	73.7 µm	73.0 µm	
38	-	169.9 HV 0.5	86.3 HRB	73.5 µm	74.3 µm	
39	-	179.2 HV 0.5	88.8 HRB	71.5 µm	72.4 µm	
40	-	184.8 HV 0.5	90.0 HRB	70.1 µm	71.6 µm	
41	-	168.2 HV 0.5	85.8 HRB	74.9 µm	73.6 µm	
42	-	164.8 HV 0.5	84.9 HRB	75.6 µm	74.4 µm	
43	-	163.1 HV 0.5	84.4 HRB	75.9 µm	74.8 µm	
44	-	152.0 HV 0.5	80.7 HRB	77.2 µm	79.0 µm	
45	-	170.8 HV 0.5	86.6 HRB	74.6 µm	72.7 µm	
46	-	163.8 HV 0.5	84.6 HRB	74.6 µm	75.9 µm	
47	-	163.0 HV 0.5	84.3 HRB	75.9 µm	74.9 µm	
48	-	181.2 HV 0.5	89.2 HRB	71.8 µm	71.2 µm	
49	-	165.0 HV 0.5	85.0 HRB	74.7 µm	75.2 µm	
50	-	165.7 HV 0.5	85.2 HRB	75.0 µm	74.6 µm	
51	-	181.0 HV 0.5	89.2 HRB	72.6 µm	70.5 µm	
52	-	175.1 HV 0.5	87.8 HRB	73.1 µm	72.5 µm	
53	-	168.6 HV 0.5	85.9 HRB	73.1 µm	75.2 µm	
54	-	181.5 HV 0.5	89.3 HRB	72.5 µm	70.5 µm	
55	-	152.5 HV 0.5	80.8 HRB	78.1 µm	77.8 µm	
56	-	161.4 HV 0.5	83.8 HRB	76.2 µm	75.4 µm	
57	-	152.5 HV 0.5	80.8 HRB	77.5 µm	78.4 µm	
58	-	159.6 HV 0.5	83.2 HRB	77.5 µm	74.9 µm	
59	-	154.4 HV 0.5	81.5 HRB	78.5 µm	76.5 µm	

Date: 12-09-2022
Tester: Admin
Program: Hardness Map

ADVINTEGRITY

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
60	-	158.7 HV 0.5	82.9 HRB	75.7 µm	77.2 µm	
61	-	159.5 HV 0.5	83.2 HRB	76.2 µm	76.2 µm	
62	-	168.6 HV 0.5	85.9 HRB	73.4 µm	74.9 µm	
63	-	167.1 HV 0.5	85.5 HRB	73.7 µm	75.2 µm	
64	-	167.2 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
65	-	168.6 HV 0.5	85.9 HRB	73.1 µm	75.2 µm	
66	-	165.0 HV 0.5	85.0 HRB	74.7 µm	75.2 µm	
67	-	160.3 HV 0.5	83.4 HRB	76.9 µm	75.2 µm	
68	-	157.0 HV 0.5	82.3 HRB	77.9 µm	75.8 µm	
69	-	156.6 HV 0.5	82.2 HRB	76.4 µm	77.5 µm	
70	-	164.3 HV 0.5	84.8 HRB	74.3 µm	75.9 µm	
71	-	166.8 HV 0.5	85.4 HRB	74.7 µm	74.5 µm	
72	-	165.7 HV 0.5	85.2 HRB	75.6 µm	74.0 µm	
73	-	173.8 HV 0.5	87.4 HRB	74.7 µm	71.4 µm	
74	-	168.6 HV 0.5	85.9 HRB	72.8 µm	75.6 µm	
75	-	158.0 HV 0.5	82.7 HRB	77.0 µm	76.2 µm	
76	-	165.0 HV 0.5	85.0 HRB	74.4 µm	75.6 µm	
77	-	163.0 HV 0.5	84.3 HRB	77.2 µm	73.7 µm	
78	-	168.6 HV 0.5	85.9 HRB	74.0 µm	74.3 µm	
79	-	158.9 HV 0.5	83.0 HRB	76.3 µm	76.5 µm	
80	-	173.7 HV 0.5	87.4 HRB	72.8 µm	73.3 µm	
81	-	167.3 HV 0.5	85.6 HRB	74.3 µm	74.6 µm	
82	-	169.2 HV 0.5	86.1 HRB	75.0 µm	73.0 µm	
83	-	173.8 HV 0.5	87.4 HRB	74.3 µm	71.8 µm	
84	-	172.8 HV 0.5	87.2 HRB	72.7 µm	73.8 µm	
85	-	184.8 HV 0.5	90.0 HRB	69.0 µm	72.7 µm	
86	-	168.6 HV 0.5	85.9 HRB	74.3 µm	74.0 µm	
87	-	166.4 HV 0.5	85.4 HRB	75.0 µm	74.3 µm	
88	-	166.2 HV 0.5	85.3 HRB	75.1 µm	74.2 µm	
89	-	175.3 HV 0.5	87.8 HRB	72.8 µm	72.7 µm	
90	-	167.4 HV 0.5	85.6 HRB	74.1 µm	74.7 µm	
91	-	166.4 HV 0.5	85.4 HRB	75.6 µm	73.7 µm	
92	-	168.0 HV 0.5	85.8 HRB	74.5 µm	74.0 µm	
93	-	170.3 HV 0.5	86.4 HRB	73.8 µm	73.8 µm	
94	-	170.0 HV 0.5	86.3 HRB	73.7 µm	74.0 µm	
95	-	167.1 HV 0.5	85.5 HRB	73.3 µm	75.7 µm	
96	-	167.9 HV 0.5	85.7 HRB	73.4 µm	75.2 µm	
97	-	132.0 HV 0.5	73.0 HRB	86.1 µm	81.6 µm	
98	-	149.2 HV 0.5	79.7 HRB	79.5 µm	78.1 µm	

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Tester: Admin
Program: Hardness Map

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
99	-	151.9 HV 0.5	80.6 HRB	78.5 µm	77.8 µm	
100	-	155.7 HV 0.5	81.9 HRB	78.5 µm	75.9 µm	
101	-	157.0 HV 0.5	82.3 HRB	75.9 µm	77.8 µm	
102	-	146.5 HV 0.5	78.8 HRB	79.7 µm	79.4 µm	
103	-	178.5 HV 0.5	88.6 HRB	73.2 µm	70.9 µm	
104	-	166.4 HV 0.5	85.4 HRB	75.3 µm	74.0 µm	
105	-	165.2 HV 0.5	85.0 HRB	74.3 µm	75.6 µm	
106	-	161.2 HV 0.5	83.7 HRB	74.5 µm	77.2 µm	
107	-	159.2 HV 0.5	83.1 HRB	76.2 µm	76.4 µm	
108	-	162.1 HV 0.5	84.0 HRB	75.7 µm	75.6 µm	
109	-	161.6 HV 0.5	83.9 HRB	75.9 µm	75.6 µm	
110	-	164.3 HV 0.5	84.8 HRB	74.3 µm	75.9 µm	
111	-	165.7 HV 0.5	85.2 HRB	75.9 µm	73.7 µm	
112	-	158.9 HV 0.5	83.0 HRB	76.9 µm	75.9 µm	
113	-	165.7 HV 0.5	85.2 HRB	75.3 µm	74.3 µm	
114	-	158.9 HV 0.5	83.0 HRB	76.2 µm	76.5 µm	
115	-	166.4 HV 0.5	85.4 HRB	75.0 µm	74.3 µm	
116	-	162.3 HV 0.5	84.1 HRB	75.9 µm	75.2 µm	
117	-	158.3 HV 0.5	82.8 HRB	75.9 µm	77.2 µm	
118	-	172.1 HV 0.5	87.0 HRB	72.1 µm	74.7 µm	
119	-	184.6 HV 0.5	89.9 HRB	70.0 µm	71.8 µm	
120	-	175.7 HV 0.5	87.9 HRB	72.1 µm	73.2 µm	
121	-	175.6 HV 0.5	87.9 HRB	71.8 µm	73.5 µm	
122	-	173.0 HV 0.5	87.2 HRB	73.1 µm	73.3 µm	
123	-	172.4 HV 0.5	87.1 HRB	73.7 µm	73.0 µm	
124	-	164.2 HV 0.5	84.7 HRB	77.9 µm	72.4 µm	
125	-	170.6 HV 0.5	86.5 HRB	73.7 µm	73.7 µm	
126	-	175.6 HV 0.5	87.9 HRB	73.2 µm	72.1 µm	
127	-	172.5 HV 0.5	87.1 HRB	74.0 µm	72.6 µm	
128	-	172.2 HV 0.5	87.1 HRB	73.4 µm	73.3 µm	
129	-	170.8 HV 0.5	86.6 HRB	73.1 µm	74.3 µm	
130	-	174.5 HV 0.5	87.6 HRB	73.4 µm	72.4 µm	
131	-	169.8 HV 0.5	86.3 HRB	73.7 µm	74.1 µm	
132	-	170.8 HV 0.5	86.6 HRB	74.0 µm	73.3 µm	
133	-	175.2 HV 0.5	87.8 HRB	71.8 µm	73.7 µm	
134	-	172.8 HV 0.5	87.2 HRB	74.3 µm	72.2 µm	
135	-	173.7 HV 0.5	87.4 HRB	74.3 µm	71.8 µm	
136	-	163.9 HV 0.5	84.6 HRB	75.9 µm	74.5 µm	
137	-	156.3 HV 0.5	82.1 HRB	77.5 µm	76.5 µm	

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Tester: Admin
Program: Hardness Map

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
138	-	173.0 HV 0.5	87.2 HRB	72.8 µm	73.7 µm	
139	-	174.6 HV 0.5	87.6 HRB	73.0 µm	72.7 µm	
140	-	156.3 HV 0.5	82.1 HRB	76.9 µm	77.2 µm	
141	-	164.3 HV 0.5	84.8 HRB	75.9 µm	74.3 µm	
142	-	164.3 HV 0.5	84.8 HRB	75.0 µm	75.2 µm	
143	-	168.6 HV 0.5	85.9 HRB	74.7 µm	73.7 µm	
144	-	168.6 HV 0.5	85.9 HRB	74.3 µm	74.0 µm	
145	-	165.2 HV 0.5	85.1 HRB	74.7 µm	75.2 µm	
146	-	166.4 HV 0.5	85.4 HRB	74.3 µm	74.9 µm	
147	-	179.1 HV 0.5	88.8 HRB	71.8 µm	72.1 µm	
148	-	159.6 HV 0.5	83.2 HRB	76.6 µm	75.9 µm	
149	-	154.2 HV 0.5	81.4 HRB	77.9 µm	77.2 µm	
150	-	153.2 HV 0.5	81.1 HRB	78.1 µm	77.5 µm	
151	-	153.5 HV 0.5	81.2 HRB	76.2 µm	79.2 µm	
152	-	169.3 HV 0.5	86.1 HRB	74.3 µm	73.7 µm	
153	-	154.4 HV 0.5	81.5 HRB	76.2 µm	78.7 µm	
154	-	147.3 HV 0.5	79.1 HRB	77.8 µm	80.8 µm	
155	-	152.5 HV 0.5	80.8 HRB	76.6 µm	79.4 µm	
156	-	153.8 HV 0.5	81.3 HRB	78.1 µm	77.2 µm	
157	-	156.5 HV 0.5	82.2 HRB	77.8 µm	76.2 µm	
158	-	157.6 HV 0.5	82.5 HRB	77.2 µm	76.2 µm	
159	-	153.2 HV 0.5	81.1 HRB	76.9 µm	78.7 µm	
160	-	155.7 HV 0.5	81.9 HRB	77.2 µm	77.2 µm	
161	-	159.6 HV 0.5	83.2 HRB	77.5 µm	74.9 µm	
162	-	157.7 HV 0.5	82.6 HRB	75.9 µm	77.4 µm	
163	-	160.3 HV 0.5	83.4 HRB	76.6 µm	75.6 µm	
164	-	147.0 HV 0.5	79.0 HRB	78.5 µm	80.4 µm	
165	-	158.2 HV 0.5	82.7 HRB	77.9 µm	75.2 µm	
166	-	177.6 HV 0.5	88.4 HRB	73.1 µm	71.4 µm	
167	-	164.3 HV 0.5	84.8 HRB	76.2 µm	74.0 µm	
168	-	171.5 HV 0.5	86.8 HRB	73.4 µm	73.7 µm	
169	-	176.0 HV 0.5	88.0 HRB	72.4 µm	72.7 µm	
170	-	177.5 HV 0.5	88.4 HRB	72.6 µm	71.9 µm	
171	-	173.0 HV 0.5	87.2 HRB	72.1 µm	74.3 µm	
172	-	172.5 HV 0.5	87.1 HRB	73.4 µm	73.2 µm	
173	-	166.7 HV 0.5	85.4 HRB	72.9 µm	76.2 µm	
174	-	170.0 HV 0.5	86.3 HRB	73.4 µm	74.3 µm	
175	-	161.6 HV 0.5	83.9 HRB	76.9 µm	74.6 µm	
176	-	170.8 HV 0.5	86.6 HRB	73.4 µm	74.0 µm	

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Program: Hardness Map

ADVINTEGRITY

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
177	-	172.2 HV 0.5	87.1 HRB	73.7 µm	73.0 µm	
178	-	167.2 HV 0.5	85.5 HRB	74.7 µm	74.3 µm	
179	-	172.1 HV 0.5	87.0 HRB	71.5 µm	75.3 µm	
180	-	176.9 HV 0.5	88.2 HRB	73.1 µm	71.6 µm	
181	-	170.8 HV 0.5	86.6 HRB	75.0 µm	72.4 µm	
182	-	167.8 HV 0.5	85.7 HRB	75.0 µm	73.7 µm	
183	-	159.6 HV 0.5	83.2 HRB	75.6 µm	76.8 µm	
184	-	150.5 HV 0.5	80.2 HRB	77.5 µm	79.5 µm	
185	-	169.2 HV 0.5	86.1 HRB	73.1 µm	74.9 µm	
186	-	170.0 HV 0.5	86.3 HRB	74.0 µm	73.7 µm	
187	-	165.8 HV 0.5	85.2 HRB	75.3 µm	74.3 µm	
188	-	158.3 HV 0.5	82.8 HRB	78.2 µm	74.9 µm	
189	-	168.3 HV 0.5	85.8 HRB	76.0 µm	72.5 µm	
190	-	161.6 HV 0.5	83.9 HRB	76.6 µm	74.9 µm	
191	-	155.7 HV 0.5	81.9 HRB	78.5 µm	75.9 µm	
192	-	162.9 HV 0.5	84.3 HRB	73.7 µm	77.2 µm	
193	-	168.9 HV 0.5	86.0 HRB	74.0 µm	74.1 µm	
194	-	166.9 HV 0.5	85.5 HRB	74.2 µm	74.9 µm	
195	-	169.3 HV 0.5	86.1 HRB	73.7 µm	74.3 µm	
196	-	164.4 HV 0.5	84.8 HRB	74.3 µm	75.9 µm	
197	-	166.4 HV 0.5	85.4 HRB	74.7 µm	74.6 µm	
198	-	156.3 HV 0.5	82.1 HRB	76.6 µm	77.5 µm	
199	-	152.5 HV 0.5	80.8 HRB	77.5 µm	78.4 µm	
200	-	174.7 HV 0.5	87.7 HRB	74.1 µm	71.6 µm	
201	-	173.0 HV 0.5	87.2 HRB	72.8 µm	73.7 µm	
202	-	155.7 HV 0.5	81.9 HRB	77.5 µm	76.8 µm	
203	-	151.3 HV 0.5	80.4 HRB	78.5 µm	78.1 µm	
204	-	148.7 HV 0.5	79.6 HRB	79.4 µm	78.5 µm	
205	-	152.5 HV 0.5	80.8 HRB	78.1 µm	77.8 µm	
206	-	152.5 HV 0.5	80.8 HRB	78.5 µm	77.5 µm	
207	-	156.0 HV 0.5	82.0 HRB	77.8 µm	76.4 µm	
208	-	154.1 HV 0.5	81.4 HRB	77.1 µm	78.1 µm	
209	-	150.7 HV 0.5	80.2 HRB	79.1 µm	77.8 µm	
210	-	155.0 HV 0.5	81.7 HRB	77.2 µm	77.5 µm	
211	-	153.2 HV 0.5	81.1 HRB	76.9 µm	78.7 µm	
212	-	183.5 HV 0.5	89.7 HRB	71.7 µm	70.4 µm	
213	-	164.2 HV 0.5	84.7 HRB	75.6 µm	74.7 µm	
214	-	170.0 HV 0.5	86.3 HRB	75.0 µm	72.7 µm	
215	-	172.0 HV 0.5	87.0 HRB	72.8 µm	74.1 µm	

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Program: Hardness Map

ADVINTEGRITY

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
216	-	171.5 HV 0.5	86.8 HRB	72.8 µm	74.3 µm	
217	-	170.8 HV 0.5	86.6 HRB	74.0 µm	73.3 µm	
218	-	169.3 HV 0.5	86.1 HRB	73.1 µm	74.9 µm	
219	-	175.4 HV 0.5	87.8 HRB	72.4 µm	73.0 µm	
220	-	158.6 HV 0.5	82.9 HRB	77.9 µm	75.0 µm	
221	-	159.8 HV 0.5	83.3 HRB	75.3 µm	77.0 µm	
222	-	167.8 HV 0.5	85.7 HRB	73.7 µm	74.9 µm	
223	-	167.7 HV 0.5	85.7 HRB	74.4 µm	74.3 µm	
224	-	164.5 HV 0.5	84.8 HRB	74.9 µm	75.2 µm	
225	-	165.7 HV 0.5	85.2 HRB	76.3 µm	73.3 µm	
226	-	159.2 HV 0.5	83.1 HRB	75.3 µm	77.3 µm	
227	-	167.9 HV 0.5	85.7 HRB	73.7 µm	74.9 µm	
228	-	163.1 HV 0.5	84.4 HRB	76.2 µm	74.5 µm	
229	-	164.1 HV 0.5	84.7 HRB	73.5 µm	76.8 µm	
230	-	169.3 HV 0.5	86.1 HRB	73.4 µm	74.6 µm	
231	-	171.5 HV 0.5	86.8 HRB	74.0 µm	73.0 µm	
232	-	155.0 HV 0.5	81.7 HRB	77.8 µm	76.8 µm	
233	-	155.7 HV 0.5	81.9 HRB	75.9 µm	78.4 µm	
234	-	169.3 HV 0.5	86.1 HRB	73.7 µm	74.3 µm	
235	-	162.3 HV 0.5	84.1 HRB	77.2 µm	74.0 µm	
236	-	159.6 HV 0.5	83.2 HRB	75.6 µm	76.8 µm	
237	-	157.7 HV 0.5	82.6 HRB	77.8 µm	75.5 µm	
238	-	158.3 HV 0.5	82.8 HRB	76.2 µm	76.8 µm	
239	-	156.7 HV 0.5	82.2 HRB	77.3 µm	76.5 µm	
240	-	156.5 HV 0.5	82.2 HRB	77.1 µm	76.8 µm	
241	-	158.3 HV 0.5	82.8 HRB	76.9 µm	76.2 µm	
242	-	168.6 HV 0.5	85.9 HRB	74.7 µm	73.6 µm	
243	-	168.6 HV 0.5	85.9 HRB	75.6 µm	72.7 µm	
244	-	166.4 HV 0.5	85.4 HRB	73.7 µm	75.6 µm	
245	-	166.1 HV 0.5	85.3 HRB	74.7 µm	74.8 µm	
246	-	170.6 HV 0.5	86.5 HRB	73.7 µm	73.7 µm	
247	-	167.9 HV 0.5	85.7 HRB	74.0 µm	74.6 µm	
248	-	160.1 HV 0.5	83.4 HRB	76.6 µm	75.6 µm	
249	-	156.5 HV 0.5	82.2 HRB	77.4 µm	76.5 µm	
250	-	172.4 HV 0.5	87.1 HRB	73.4 µm	73.3 µm	
251	-	156.3 HV 0.5	82.1 HRB	78.1 µm	75.9 µm	
252	-	158.9 HV 0.5	83.0 HRB	76.2 µm	76.5 µm	
253	-	154.0 HV 0.5	81.3 HRB	76.4 µm	78.7 µm	
254	-	157.2 HV 0.5	82.4 HRB	77.4 µm	76.2 µm	

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Tester: Admin
Program: Hardness Map

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
255	-	157.0 HV 0.5	82.3 HRB	77.5 µm	76.2 µm	
256	-	152.4 HV 0.5	80.8 HRB	77.5 µm	78.5 µm	
257	-	153.2 HV 0.5	81.1 HRB	77.3 µm	78.3 µm	
258	-	153.2 HV 0.5	81.1 HRB	77.2 µm	78.4 µm	
259	-	154.9 HV 0.5	81.6 HRB	78.6 µm	76.1 µm	
260	-	170.7 HV 0.5	86.6 HRB	73.1 µm	74.3 µm	
261	-	168.6 HV 0.5	85.9 HRB	74.0 µm	74.3 µm	
262	-	166.4 HV 0.5	85.4 HRB	75.0 µm	74.3 µm	
263	-	167.9 HV 0.5	85.7 HRB	74.0 µm	74.6 µm	
264	-	168.6 HV 0.5	85.9 HRB	74.3 µm	74.0 µm	
265	-	169.3 HV 0.5	86.1 HRB	74.0 µm	74.0 µm	
266	-	175.3 HV 0.5	87.8 HRB	72.4 µm	73.0 µm	
267	-	165.8 HV 0.5	85.2 HRB	74.0 µm	75.5 µm	
268	-	172.5 HV 0.5	87.1 HRB	72.4 µm	74.2 µm	
269	-	167.4 HV 0.5	85.6 HRB	73.3 µm	75.6 µm	
270	-	167.9 HV 0.5	85.7 HRB	74.3 µm	74.3 µm	
271	-	162.2 HV 0.5	84.1 HRB	75.9 µm	75.3 µm	
272	-	168.2 HV 0.5	85.8 HRB	73.1 µm	75.4 µm	
273	-	167.2 HV 0.5	85.5 HRB	74.3 µm	74.6 µm	
274	-	167.9 HV 0.5	85.7 HRB	74.0 µm	74.6 µm	
275	-	162.7 HV 0.5	84.2 HRB	75.4 µm	75.6 µm	
276	-	170.0 HV 0.5	86.3 HRB	72.8 µm	74.9 µm	
277	-	162.3 HV 0.5	84.1 HRB	74.7 µm	76.5 µm	
278	-	162.3 HV 0.5	84.1 HRB	76.9 µm	74.3 µm	
279	-	161.6 HV 0.5	83.9 HRB	75.6 µm	75.9 µm	
280	-	163.0 HV 0.5	84.3 HRB	74.3 µm	76.5 µm	
281	-	159.7 HV 0.5	83.2 HRB	77.2 µm	75.2 µm	
282	-	168.6 HV 0.5	85.9 HRB	73.7 µm	74.6 µm	
283	-	162.1 HV 0.5	84.0 HRB	76.3 µm	74.9 µm	
284	-	156.5 HV 0.5	82.2 HRB	76.6 µm	77.4 µm	
285	-	165.2 HV 0.5	85.1 HRB	75.5 µm	74.3 µm	
286	-	157.0 HV 0.5	82.3 HRB	75.3 µm	78.4 µm	
287	-	167.0 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
288	-	160.9 HV 0.5	83.6 HRB	75.0 µm	76.8 µm	
289	-	155.6 HV 0.5	81.9 HRB	76.3 µm	78.1 µm	
290	-	152.7 HV 0.5	80.9 HRB	78.5 µm	77.4 µm	
291	-	157.0 HV 0.5	82.3 HRB	76.2 µm	77.5 µm	
292	-	154.4 HV 0.5	81.5 HRB	78.5 µm	76.5 µm	
293	-	158.1 HV 0.5	82.7 HRB	75.6 µm	77.5 µm	

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Tester: Admin
Program: Hardness Map

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
294	-	166.4 HV 0.5	85.4 HRB	74.7 µm	74.6 µm	
295	-	167.1 HV 0.5	85.5 HRB	74.0 µm	74.9 µm	
296	-	166.0 HV 0.5	85.3 HRB	74.7 µm	74.7 µm	
297	-	156.7 HV 0.5	82.2 HRB	77.2 µm	76.6 µm	
298	-	160.6 HV 0.5	83.5 HRB	76.1 µm	75.9 µm	
299	-	178.3 HV 0.5	88.6 HRB	71.2 µm	73.0 µm	
300	-	155.5 HV 0.5	81.8 HRB	76.9 µm	77.5 µm	
301	-	158.9 HV 0.5	83.0 HRB	76.6 µm	76.2 µm	
302	-	159.3 HV 0.5	83.1 HRB	76.9 µm	75.7 µm	
303	-	161.6 HV 0.5	83.9 HRB	76.2 µm	75.2 µm	
304	-	153.5 HV 0.5	81.2 HRB	77.4 µm	78.1 µm	
305	-	152.6 HV 0.5	80.9 HRB	76.9 µm	79.0 µm	
306	-	153.8 HV 0.5	81.3 HRB	76.6 µm	78.7 µm	
307	-	158.9 HV 0.5	83.0 HRB	76.6 µm	76.2 µm	
308	-	159.2 HV 0.5	83.1 HRB	76.9 µm	75.8 µm	
309	-	171.5 HV 0.5	86.8 HRB	73.4 µm	73.7 µm	
310	-	172.2 HV 0.5	87.1 HRB	73.1 µm	73.7 µm	
311	-	168.4 HV 0.5	85.9 HRB	73.4 µm	75.0 µm	
312	-	172.2 HV 0.5	87.1 HRB	72.4 µm	74.3 µm	
313	-	170.5 HV 0.5	86.5 HRB	74.2 µm	73.3 µm	
314	-	174.3 HV 0.5	87.6 HRB	72.0 µm	73.9 µm	
315	-	167.3 HV 0.5	85.6 HRB	74.6 µm	74.3 µm	
316	-	175.6 HV 0.5	87.9 HRB	71.0 µm	74.3 µm	
317	-	169.3 HV 0.5	86.1 HRB	73.7 µm	74.3 µm	
318	-	165.7 HV 0.5	85.2 HRB	75.3 µm	74.3 µm	
319	-	163.7 HV 0.5	84.6 HRB	75.3 µm	75.2 µm	
320	-	166.0 HV 0.5	85.3 HRB	73.9 µm	75.6 µm	
321	-	167.9 HV 0.5	85.7 HRB	73.7 µm	74.9 µm	
322	-	164.5 HV 0.5	84.8 HRB	74.3 µm	75.8 µm	
323	-	167.1 HV 0.5	85.5 HRB	72.8 µm	76.2 µm	
324	-	165.7 HV 0.5	85.2 HRB	75.9 µm	73.7 µm	
325	-	165.0 HV 0.5	85.0 HRB	75.3 µm	74.6 µm	
326	-	164.9 HV 0.5	85.0 HRB	74.0 µm	75.9 µm	
327	-	167.9 HV 0.5	85.7 HRB	75.9 µm	72.7 µm	
328	-	171.5 HV 0.5	86.8 HRB	74.0 µm	73.0 µm	
329	-	160.1 HV 0.5	83.4 HRB	75.3 µm	76.9 µm	
330	-	165.0 HV 0.5	85.0 HRB	75.0 µm	74.9 µm	
331	-	157.5 HV 0.5	82.5 HRB	77.6 µm	75.9 µm	
332	-	163.7 HV 0.5	84.6 HRB	75.9 µm	74.6 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
333	-	159.3 HV 0.5	83.1 HRB	75.0 µm	77.6 µm	
334	-	157.1 HV 0.5	82.4 HRB	76.8 µm	76.8 µm	
335	-	166.3 HV 0.5	85.3 HRB	74.4 µm	74.9 µm	
336	-	154.4 HV 0.5	81.5 HRB	75.9 µm	79.1 µm	
337	-	155.7 HV 0.5	81.9 HRB	76.0 µm	78.4 µm	
338	-	153.6 HV 0.5	81.2 HRB	75.6 µm	79.8 µm	
339	-	158.9 HV 0.5	83.0 HRB	76.6 µm	76.2 µm	
340	-	157.6 HV 0.5	82.5 HRB	75.9 µm	77.5 µm	
341	-	162.3 HV 0.5	84.1 HRB	75.6 µm	75.6 µm	
342	-	157.8 HV 0.5	82.6 HRB	76.6 µm	76.8 µm	
343	-	164.3 HV 0.5	84.8 HRB	75.3 µm	74.9 µm	
344	-	163.6 HV 0.5	84.5 HRB	75.6 µm	75.0 µm	
345	-	172.2 HV 0.5	87.1 HRB	73.4 µm	73.3 µm	
346	-	165.0 HV 0.5	85.0 HRB	75.0 µm	74.9 µm	
347	-	157.3 HV 0.5	82.4 HRB	77.1 µm	76.5 µm	
348	-	168.6 HV 0.5	85.9 HRB	74.7 µm	73.7 µm	
349	-	157.8 HV 0.5	82.6 HRB	76.8 µm	76.5 µm	
350	-	157.6 HV 0.5	82.5 HRB	75.9 µm	77.5 µm	
351	-	157.6 HV 0.5	82.5 HRB	75.9 µm	77.5 µm	
352	-	156.3 HV 0.5	82.1 HRB	77.2 µm	76.8 µm	
353	-	155.7 HV 0.5	81.9 HRB	77.2 µm	77.2 µm	
354	-	159.3 HV 0.5	83.1 HRB	75.8 µm	76.8 µm	
355	-	160.9 HV 0.5	83.6 HRB	76.2 µm	75.6 µm	
356	-	161.7 HV 0.5	83.9 HRB	75.9 µm	75.5 µm	
357	-	173.0 HV 0.5	87.2 HRB	72.8 µm	73.7 µm	
358	-	167.6 HV 0.5	85.6 HRB	74.7 µm	74.0 µm	
359	-	168.0 HV 0.5	85.7 HRB	73.4 µm	75.2 µm	
360	-	168.3 HV 0.5	85.8 HRB	73.4 µm	75.0 µm	
361	-	170.0 HV 0.5	86.3 HRB	74.0 µm	73.7 µm	
362	-	173.0 HV 0.5	87.2 HRB	72.1 µm	74.3 µm	
363	-	177.4 HV 0.5	88.3 HRB	72.1 µm	72.5 µm	
364	-	167.0 HV 0.5	85.5 HRB	74.5 µm	74.5 µm	
365	-	165.2 HV 0.5	85.1 HRB	73.0 µm	76.8 µm	
366	-	156.3 HV 0.5	82.1 HRB	78.1 µm	75.9 µm	
367	-	160.1 HV 0.5	83.4 HRB	76.2 µm	76.0 µm	
368	-	160.2 HV 0.5	83.4 HRB	74.0 µm	78.1 µm	
369	-	155.2 HV 0.5	81.7 HRB	78.4 µm	76.2 µm	
370	-	168.6 HV 0.5	85.9 HRB	73.7 µm	74.6 µm	
371	-	170.8 HV 0.5	86.6 HRB	73.7 µm	73.7 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
372	-	165.7 HV 0.5	85.2 HRB	75.0 µm	74.6 µm	
373	-	164.2 HV 0.5	84.7 HRB	74.7 µm	75.6 µm	
374	-	161.6 HV 0.5	83.9 HRB	73.4 µm	78.1 µm	
375	-	171.0 HV 0.5	86.7 HRB	72.0 µm	75.2 µm	
376	-	166.2 HV 0.5	85.3 HRB	74.9 µm	74.5 µm	
377	-	163.0 HV 0.5	84.3 HRB	74.3 µm	76.5 µm	
378	-	173.0 HV 0.5	87.2 HRB	72.4 µm	74.0 µm	
379	-	155.0 HV 0.5	81.7 HRB	76.6 µm	78.1 µm	
380	-	163.2 HV 0.5	84.4 HRB	75.2 µm	75.6 µm	
381	-	161.6 HV 0.5	83.9 HRB	74.7 µm	76.8 µm	
382	-	153.5 HV 0.5	81.2 HRB	77.4 µm	78.0 µm	
383	-	158.1 HV 0.5	82.7 HRB	77.5 µm	75.6 µm	
384	-	158.3 HV 0.5	82.8 HRB	76.9 µm	76.2 µm	
385	-	162.8 HV 0.5	84.3 HRB	74.0 µm	76.9 µm	
386	-	158.3 HV 0.5	82.8 HRB	76.6 µm	76.5 µm	
387	-	153.1 HV 0.5	81.0 HRB	75.3 µm	80.3 µm	
388	-	156.4 HV 0.5	82.1 HRB	77.5 µm	76.5 µm	
389	-	161.1 HV 0.5	83.7 HRB	75.0 µm	76.8 µm	
390	-	159.6 HV 0.5	83.2 HRB	75.6 µm	76.8 µm	
391	-	163.0 HV 0.5	84.3 HRB	75.9 µm	74.9 µm	
392	-	162.9 HV 0.5	84.3 HRB	75.3 µm	75.6 µm	
393	-	163.6 HV 0.5	84.5 HRB	75.6 µm	75.0 µm	
394	-	171.5 HV 0.5	86.8 HRB	73.7 µm	73.3 µm	
395	-	166.4 HV 0.5	85.4 HRB	74.0 µm	75.2 µm	
396	-	165.4 HV 0.5	85.1 HRB	75.3 µm	74.5 µm	
397	-	178.4 HV 0.5	88.6 HRB	72.4 µm	71.8 µm	
398	-	166.4 HV 0.5	85.4 HRB	74.3 µm	74.9 µm	
399	-	159.6 HV 0.5	83.2 HRB	75.9 µm	76.5 µm	
400	-	166.6 HV 0.5	85.4 HRB	74.6 µm	74.6 µm	
401	-	160.3 HV 0.5	83.4 HRB	76.6 µm	75.6 µm	
402	-	161.5 HV 0.5	83.8 HRB	75.8 µm	75.7 µm	
403	-	161.6 HV 0.5	83.9 HRB	75.6 µm	75.9 µm	
404	-	158.9 HV 0.5	83.0 HRB	75.6 µm	77.2 µm	
405	-	163.6 HV 0.5	84.5 HRB	75.0 µm	75.6 µm	
406	-	165.7 HV 0.5	85.2 HRB	75.3 µm	74.3 µm	
407	-	164.3 HV 0.5	84.8 HRB	75.9 µm	74.3 µm	
408	-	166.4 HV 0.5	85.4 HRB	74.7 µm	74.6 µm	
409	-	167.8 HV 0.5	85.7 HRB	75.3 µm	73.3 µm	
410	-	164.9 HV 0.5	85.0 HRB	75.7 µm	74.3 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
411	-	167.2 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
412	-	172.3 HV 0.5	87.1 HRB	73.1 µm	73.6 µm	
413	-	169.1 HV 0.5	86.0 HRB	74.1 µm	74.0 µm	
414	-	168.6 HV 0.5	85.9 HRB	73.4 µm	74.9 µm	
415	-	165.7 HV 0.5	85.2 HRB	74.7 µm	74.9 µm	
416	-	165.7 HV 0.5	85.2 HRB	75.3 µm	74.3 µm	
417	-	162.3 HV 0.5	84.1 HRB	75.0 µm	76.2 µm	
418	-	166.4 HV 0.5	85.4 HRB	73.1 µm	76.2 µm	
419	-	170.0 HV 0.5	86.3 HRB	72.8 µm	74.9 µm	
420	-	166.4 HV 0.5	85.3 HRB	73.7 µm	75.6 µm	
421	-	161.0 HV 0.5	83.7 HRB	74.0 µm	77.7 µm	
422	-	167.3 HV 0.5	85.6 HRB	73.7 µm	75.2 µm	
423	-	161.6 HV 0.5	83.9 HRB	75.6 µm	75.9 µm	
424	-	162.7 HV 0.5	84.2 HRB	75.1 µm	75.9 µm	
425	-	157.6 HV 0.5	82.5 HRB	75.3 µm	78.1 µm	
426	-	162.2 HV 0.5	84.1 HRB	74.7 µm	76.5 µm	
427	-	163.7 HV 0.5	84.6 HRB	76.6 µm	74.0 µm	
428	-	155.9 HV 0.5	82.0 HRB	75.7 µm	78.6 µm	
429	-	152.5 HV 0.5	80.8 HRB	77.5 µm	78.4 µm	
430	-	164.3 HV 0.5	84.8 HRB	74.5 µm	75.7 µm	
431	-	155.0 HV 0.5	81.7 HRB	75.9 µm	78.7 µm	
432	-	154.4 HV 0.5	81.5 HRB	75.9 µm	79.1 µm	
433	-	156.5 HV 0.5	82.2 HRB	78.8 µm	75.2 µm	
434	-	158.1 HV 0.5	82.7 HRB	77.2 µm	76.0 µm	
435	-	164.4 HV 0.5	84.8 HRB	75.6 µm	74.6 µm	
436	-	161.8 HV 0.5	83.9 HRB	76.6 µm	74.8 µm	
437	-	157.3 HV 0.5	82.4 HRB	77.5 µm	76.0 µm	
438	-	155.7 HV 0.5	81.9 HRB	76.9 µm	77.5 µm	
439	-	158.9 HV 0.5	83.0 HRB	76.6 µm	76.2 µm	
440	-	164.8 HV 0.5	84.9 HRB	74.7 µm	75.3 µm	
441	-	161.4 HV 0.5	83.8 HRB	76.3 µm	75.2 µm	
442	-	160.3 HV 0.5	83.4 HRB	76.2 µm	75.9 µm	
443	-	165.7 HV 0.5	85.2 HRB	75.6 µm	74.0 µm	
444	-	165.0 HV 0.5	85.0 HRB	75.3 µm	74.6 µm	
445	-	173.5 HV 0.5	87.4 HRB	73.5 µm	72.7 µm	
446	-	173.0 HV 0.5	87.2 HRB	73.7 µm	72.7 µm	
447	-	179.7 HV 0.5	88.9 HRB	72.2 µm	71.5 µm	
448	-	166.3 HV 0.5	85.3 HRB	74.1 µm	75.2 µm	
449	-	165.2 HV 0.5	85.1 HRB	74.3 µm	75.5 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
450	-	163.0 HV 0.5	84.3 HRB	76.2 µm	74.6 µm	
451	-	156.3 HV 0.5	82.1 HRB	76.9 µm	77.2 µm	
452	-	166.4 HV 0.5	85.4 HRB	74.3 µm	74.9 µm	
453	-	167.1 HV 0.5	85.5 HRB	73.6 µm	75.3 µm	
454	-	167.2 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
455	-	164.3 HV 0.5	84.8 HRB	75.9 µm	74.3 µm	
456	-	166.4 HV 0.5	85.3 HRB	75.6 µm	73.7 µm	
457	-	164.2 HV 0.5	84.7 HRB	75.0 µm	75.2 µm	
458	-	166.0 HV 0.5	85.2 HRB	73.9 µm	75.6 µm	
459	-	167.9 HV 0.5	85.7 HRB	73.7 µm	74.9 µm	
460	-	167.1 HV 0.5	85.5 HRB	74.3 µm	74.6 µm	
461	-	172.0 HV 0.5	87.0 HRB	73.8 µm	73.1 µm	
462	-	172.2 HV 0.5	87.1 HRB	73.1 µm	73.7 µm	
463	-	168.3 HV 0.5	85.8 HRB	73.2 µm	75.2 µm	
464	-	162.1 HV 0.5	84.0 HRB	75.0 µm	76.3 µm	
465	-	165.0 HV 0.5	85.0 HRB	74.3 µm	75.6 µm	
466	-	164.3 HV 0.5	84.8 HRB	74.7 µm	75.6 µm	
467	-	161.4 HV 0.5	83.8 HRB	76.3 µm	75.2 µm	
468	-	159.1 HV 0.5	83.0 HRB	75.7 µm	77.0 µm	
469	-	161.6 HV 0.5	83.9 HRB	75.6 µm	75.9 µm	
470	-	157.0 HV 0.5	82.3 HRB	77.5 µm	76.2 µm	
471	-	159.9 HV 0.5	83.3 HRB	75.5 µm	76.8 µm	
472	-	160.3 HV 0.5	83.4 HRB	75.9 µm	76.2 µm	
473	-	158.3 HV 0.5	82.8 HRB	77.2 µm	75.9 µm	
474	-	157.3 HV 0.5	82.4 HRB	75.9 µm	77.7 µm	
475	-	159.6 HV 0.5	83.2 HRB	76.2 µm	76.2 µm	
476	-	160.0 HV 0.5	83.3 HRB	75.0 µm	77.3 µm	
477	-	155.7 HV 0.5	81.9 HRB	77.2 µm	77.2 µm	
478	-	155.4 HV 0.5	81.8 HRB	75.9 µm	78.6 µm	
479	-	166.5 HV 0.5	85.4 HRB	74.3 µm	74.9 µm	
480	-	168.7 HV 0.5	85.9 HRB	74.0 µm	74.2 µm	
481	-	157.0 HV 0.5	82.3 HRB	76.6 µm	77.2 µm	
482	-	162.7 HV 0.5	84.2 HRB	75.4 µm	75.6 µm	
483	-	158.5 HV 0.5	82.8 HRB	75.8 µm	77.2 µm	
484	-	150.6 HV 0.5	80.2 HRB	75.0 µm	82.0 µm	
485	-	153.8 HV 0.5	81.3 HRB	78.1 µm	77.2 µm	
486	-	153.7 HV 0.5	81.2 HRB	77.4 µm	77.9 µm	
487	-	158.3 HV 0.5	82.8 HRB	76.9 µm	76.2 µm	
488	-	163.9 HV 0.5	84.6 HRB	74.9 µm	75.6 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
489	-	165.7 HV 0.5	85.2 HRB	75.0 µm	74.6 µm	
490	-	170.8 HV 0.5	86.6 HRB	73.4 µm	74.0 µm	
491	-	165.0 HV 0.5	85.0 HRB	75.0 µm	74.9 µm	
492	-	159.0 HV 0.5	83.0 HRB	75.0 µm	77.7 µm	
493	-	164.3 HV 0.5	84.8 HRB	75.6 µm	74.6 µm	
494	-	166.5 HV 0.5	85.4 HRB	75.9 µm	73.3 µm	
495	-	176.0 HV 0.5	88.0 HRB	72.8 µm	72.4 µm	
496	-	181.7 HV 0.5	89.3 HRB	71.7 µm	71.1 µm	
497	-	168.7 HV 0.5	85.9 HRB	74.6 µm	73.7 µm	
498	-	171.0 HV 0.5	86.7 HRB	73.1 µm	74.2 µm	
499	-	171.6 HV 0.5	86.9 HRB	73.7 µm	73.3 µm	
500	-	167.9 HV 0.5	85.7 HRB	74.0 µm	74.6 µm	
501	-	160.0 HV 0.5	83.3 HRB	79.5 µm	72.7 µm	
502	-	171.5 HV 0.5	86.8 HRB	73.7 µm	73.3 µm	
503	-	162.3 HV 0.5	84.1 HRB	74.3 µm	76.8 µm	
504	-	165.0 HV 0.5	85.0 HRB	74.7 µm	75.2 µm	
505	-	166.5 HV 0.5	85.4 HRB	75.0 µm	74.3 µm	
506	-	163.1 HV 0.5	84.4 HRB	75.6 µm	75.2 µm	
507	-	161.6 HV 0.5	83.9 HRB	74.7 µm	76.8 µm	
508	-	163.9 HV 0.5	84.6 HRB	75.0 µm	75.5 µm	
509	-	168.6 HV 0.5	85.9 HRB	75.0 µm	73.3 µm	
510	-	168.1 HV 0.5	85.8 HRB	74.5 µm	74.0 µm	
511	-	166.3 HV 0.5	85.3 HRB	75.4 µm	74.0 µm	
512	-	154.4 HV 0.5	81.5 HRB	75.3 µm	79.7 µm	
513	-	159.5 HV 0.5	83.2 HRB	75.6 µm	76.8 µm	
514	-	163.0 HV 0.5	84.3 HRB	75.3 µm	75.6 µm	
515	-	163.0 HV 0.5	84.3 HRB	76.2 µm	74.6 µm	
516	-	160.6 HV 0.5	83.5 HRB	75.0 µm	77.0 µm	
517	-	167.4 HV 0.5	85.6 HRB	72.6 µm	76.2 µm	
518	-	161.6 HV 0.5	83.9 HRB	75.3 µm	76.2 µm	
519	-	162.4 HV 0.5	84.1 HRB	75.0 µm	76.1 µm	
520	-	163.0 HV 0.5	84.3 HRB	75.0 µm	75.9 µm	
521	-	163.6 HV 0.5	84.5 HRB	74.5 µm	76.1 µm	
522	-	157.0 HV 0.5	82.3 HRB	77.8 µm	75.9 µm	
523	-	160.2 HV 0.5	83.4 HRB	76.2 µm	75.9 µm	
524	-	157.9 HV 0.5	82.6 HRB	75.8 µm	77.5 µm	
525	-	160.0 HV 0.5	83.3 HRB	76.0 µm	76.2 µm	
526	-	166.5 HV 0.5	85.4 HRB	76.2 µm	73.0 µm	
527	-	164.3 HV 0.5	84.8 HRB	75.0 µm	75.2 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
528	-	174.5 HV 0.5	87.6 HRB	72.4 µm	73.3 µm	
529	-	163.6 HV 0.5	84.5 HRB	74.0 µm	76.5 µm	
530	-	163.7 HV 0.5	84.6 HRB	76.2 µm	74.3 µm	
531	-	165.7 HV 0.5	85.2 HRB	73.7 µm	75.9 µm	
532	-	172.6 HV 0.5	87.2 HRB	72.3 µm	74.3 µm	
533	-	165.7 HV 0.5	85.2 HRB	74.3 µm	75.2 µm	
534	-	163.8 HV 0.5	84.6 HRB	75.9 µm	74.6 µm	
535	-	165.7 HV 0.5	85.2 HRB	75.3 µm	74.3 µm	
536	-	173.0 HV 0.5	87.2 HRB	73.4 µm	73.0 µm	
537	-	170.4 HV 0.5	86.5 HRB	74.2 µm	73.3 µm	
538	-	165.6 HV 0.5	85.2 HRB	73.7 µm	75.9 µm	
539	-	176.0 HV 0.5	88.0 HRB	72.8 µm	72.4 µm	
540	-	176.0 HV 0.5	88.0 HRB	72.1 µm	73.0 µm	
541	-	170.1 HV 0.5	86.4 HRB	74.2 µm	73.5 µm	
542	-	170.1 HV 0.5	86.4 HRB	74.2 µm	73.4 µm	
543	-	170.8 HV 0.5	86.6 HRB	74.3 µm	73.0 µm	
544	-	180.7 HV 0.5	89.1 HRB	72.1 µm	71.1 µm	
545	-	182.3 HV 0.5	89.5 HRB	71.2 µm	71.4 µm	
546	-	171.8 HV 0.5	86.9 HRB	72.6 µm	74.3 µm	
547	-	172.2 HV 0.5	87.1 HRB	72.8 µm	74.0 µm	
548	-	168.6 HV 0.5	85.9 HRB	75.0 µm	73.3 µm	
549	-	173.7 HV 0.5	87.4 HRB	72.1 µm	74.0 µm	
550	-	168.4 HV 0.5	85.9 HRB	72.8 µm	75.6 µm	
551	-	165.1 HV 0.5	85.0 HRB	77.2 µm	72.7 µm	
552	-	168.6 HV 0.5	85.9 HRB	74.0 µm	74.3 µm	
553	-	163.0 HV 0.5	84.3 HRB	74.3 µm	76.5 µm	
554	-	157.9 HV 0.5	82.6 HRB	77.1 µm	76.2 µm	
555	-	163.2 HV 0.5	84.4 HRB	74.9 µm	75.9 µm	
556	-	160.3 HV 0.5	83.4 HRB	76.6 µm	75.6 µm	
557	-	163.0 HV 0.5	84.3 HRB	76.9 µm	74.0 µm	
558	-	166.1 HV 0.5	85.3 HRB	75.4 µm	74.0 µm	
559	-	168.9 HV 0.5	86.0 HRB	74.7 µm	73.5 µm	
560	-	161.8 HV 0.5	83.9 HRB	75.3 µm	76.1 µm	
561	-	157.6 HV 0.5	82.5 HRB	76.2 µm	77.2 µm	
562	-	158.1 HV 0.5	82.7 HRB	76.6 µm	76.6 µm	
563	-	160.1 HV 0.5	83.4 HRB	75.9 µm	76.3 µm	
564	-	148.9 HV 0.5	79.6 HRB	75.6 µm	82.2 µm	
565	-	158.9 HV 0.5	83.0 HRB	75.6 µm	77.2 µm	
566	-	169.3 HV 0.5	86.1 HRB	74.4 µm	73.6 µm	

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Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
567	-	160.9 HV 0.5	83.6 HRB	75.0 µm	76.8 µm	
568	-	156.3 HV 0.5	82.1 HRB	76.6 µm	77.5 µm	
569	-	155.7 HV 0.5	81.9 HRB	76.6 µm	77.8 µm	
570	-	157.6 HV 0.5	82.5 HRB	77.8 µm	75.6 µm	
571	-	153.2 HV 0.5	81.1 HRB	77.2 µm	78.4 µm	
572	-	151.1 HV 0.5	80.4 HRB	77.2 µm	79.5 µm	
573	-	157.6 HV 0.5	82.5 HRB	76.6 µm	76.8 µm	
574	-	156.1 HV 0.5	82.0 HRB	76.4 µm	77.8 µm	
575	-	157.0 HV 0.5	82.3 HRB	79.1 µm	74.6 µm	
576	-	160.9 HV 0.5	83.6 HRB	76.6 µm	75.2 µm	
577	-	161.7 HV 0.5	83.9 HRB	75.9 µm	75.5 µm	
578	-	155.0 HV 0.5	81.7 HRB	76.6 µm	78.1 µm	
579	-	161.3 HV 0.5	83.8 HRB	75.6 µm	76.0 µm	
580	-	157.6 HV 0.5	82.5 HRB	76.9 µm	76.5 µm	
581	-	152.4 HV 0.5	80.8 HRB	76.6 µm	79.5 µm	
582	-	155.5 HV 0.5	81.8 HRB	76.2 µm	78.2 µm	
583	-	161.6 HV 0.5	83.9 HRB	76.6 µm	74.9 µm	
584	-	159.0 HV 0.5	83.0 HRB	76.8 µm	75.9 µm	
585	-	159.6 HV 0.5	83.2 HRB	75.3 µm	77.2 µm	
586	-	160.6 HV 0.5	83.5 HRB	76.6 µm	75.4 µm	
587	-	150.8 HV 0.5	80.3 HRB	76.7 µm	80.1 µm	
588	-	165.1 HV 0.5	85.0 HRB	73.7 µm	76.2 µm	
589	-	166.9 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
590	-	172.2 HV 0.5	87.1 HRB	72.1 µm	74.6 µm	
591	-	174.3 HV 0.5	87.6 HRB	72.4 µm	73.4 µm	
592	-	173.0 HV 0.5	87.2 HRB	73.4 µm	73.0 µm	
593	-	186.6 HV 0.5	90.3 HRB	69.9 µm	71.1 µm	
594	-	168.9 HV 0.5	86.0 HRB	74.5 µm	73.7 µm	
595	-	167.2 HV 0.5	85.5 HRB	75.0 µm	74.0 µm	
596	-	172.2 HV 0.5	87.1 HRB	73.4 µm	73.3 µm	
597	-	171.5 HV 0.5	86.8 HRB	74.0 µm	73.0 µm	
598	-	173.0 HV 0.5	87.2 HRB	73.1 µm	73.3 µm	
599	-	173.0 HV 0.5	87.2 HRB	73.4 µm	73.0 µm	
600	-	170.1 HV 0.5	86.4 HRB	73.7 µm	74.0 µm	
601	-	169.2 HV 0.5	86.1 HRB	73.5 µm	74.6 µm	
602	-	167.9 HV 0.5	85.7 HRB	74.7 µm	74.0 µm	
603	-	164.7 HV 0.5	84.9 HRB	75.1 µm	74.9 µm	
604	-	165.7 HV 0.5	85.2 HRB	75.2 µm	74.5 µm	
605	-	157.6 HV 0.5	82.5 HRB	77.5 µm	75.9 µm	

Date: 12-09-2022
Tester: Admin
Program: Hardness Map

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
606	-	158.9 HV 0.5	83.0 HRB	76.6 µm	76.2 µm	
607	-	159.4 HV 0.5	83.1 HRB	75.3 µm	77.2 µm	
608	-	155.5 HV 0.5	81.8 HRB	76.9 µm	77.6 µm	
609	-	158.9 HV 0.5	83.0 HRB	75.9 µm	76.8 µm	
610	-	155.1 HV 0.5	81.7 HRB	77.8 µm	76.8 µm	
611	-	158.3 HV 0.5	82.8 HRB	77.8 µm	75.2 µm	
612	-	158.3 HV 0.5	82.8 HRB	76.2 µm	76.8 µm	
613	-	157.0 HV 0.5	82.3 HRB	75.9 µm	77.8 µm	
614	-	164.4 HV 0.5	84.8 HRB	73.6 µm	76.6 µm	
615	-	156.8 HV 0.5	82.3 HRB	77.0 µm	76.8 µm	
616	-	153.8 HV 0.5	81.3 HRB	79.4 µm	75.9 µm	
617	-	157.6 HV 0.5	82.5 HRB	75.3 µm	78.1 µm	
618	-	159.6 HV 0.5	83.2 HRB	76.9 µm	75.6 µm	
619	-	159.5 HV 0.5	83.2 HRB	75.3 µm	77.2 µm	
620	-	154.4 HV 0.5	81.5 HRB	79.4 µm	75.6 µm	
621	-	161.6 HV 0.5	83.9 HRB	75.3 µm	76.2 µm	
622	-	155.0 HV 0.5	81.7 HRB	77.2 µm	77.5 µm	
623	-	156.3 HV 0.5	82.1 HRB	77.8 µm	76.2 µm	
624	-	174.5 HV 0.5	87.6 HRB	72.8 µm	73.0 µm	
625	-	171.1 HV 0.5	86.7 HRB	72.8 µm	74.5 µm	
626	-	184.9 HV 0.5	90.0 HRB	70.9 µm	70.7 µm	
627	-	163.6 HV 0.5	84.5 HRB	76.3 µm	74.3 µm	
628	-	166.6 HV 0.5	85.4 HRB	73.9 µm	75.2 µm	
629	-	170.8 HV 0.5	86.6 HRB	73.7 µm	73.7 µm	
630	-	171.5 HV 0.5	86.8 HRB	73.1 µm	74.0 µm	
631	-	168.6 HV 0.5	85.9 HRB	73.7 µm	74.6 µm	
632	-	165.1 HV 0.5	85.0 HRB	75.9 µm	74.0 µm	
633	-	167.8 HV 0.5	85.7 HRB	75.7 µm	73.0 µm	
634	-	169.7 HV 0.5	86.2 HRB	74.7 µm	73.2 µm	
635	-	161.7 HV 0.5	83.9 HRB	75.0 µm	76.4 µm	
636	-	157.8 HV 0.5	82.6 HRB	76.6 µm	76.7 µm	
637	-	154.1 HV 0.5	81.4 HRB	77.8 µm	77.4 µm	
638	-	156.8 HV 0.5	82.3 HRB	75.6 µm	78.2 µm	
639	-	157.5 HV 0.5	82.5 HRB	76.6 µm	76.9 µm	
640	-	157.6 HV 0.5	82.5 HRB	75.3 µm	78.1 µm	
641	-	155.8 HV 0.5	81.9 HRB	76.3 µm	78.0 µm	
642	-	164.3 HV 0.5	84.8 HRB	75.3 µm	74.9 µm	
643	-	158.9 HV 0.5	83.0 HRB	75.9 µm	76.8 µm	
644	-	152.6 HV 0.5	80.9 HRB	76.6 µm	79.4 µm	

Date: 12-09-2022
Tester: Admin
Program: Hardness Map

Point	Distance	Hardness	Converted	Diagonal X	Diagonal Y	Comments
645	-	158.3 HV 0.5	82.8 HRB	76.6 µm	76.5 µm	
646	-	166.8 HV 0.5	85.4 HRB	75.4 µm	73.8 µm	
647	-	155.5 HV 0.5	81.8 HRB	76.6 µm	77.8 µm	
648	-	153.8 HV 0.5	81.3 HRB	76.5 µm	78.7 µm	
649	-	160.4 HV 0.5	83.5 HRB	76.8 µm	75.2 µm	
650	-	155.0 HV 0.5	81.7 HRB	77.8 µm	76.8 µm	
651	-	155.6 HV 0.5	81.9 HRB	77.2 µm	77.2 µm	
652	-	151.3 HV 0.5	80.4 HRB	77.5 µm	79.1 µm	
653	-	151.3 HV 0.5	80.4 HRB	78.5 µm	78.1 µm	
654	-	153.1 HV 0.5	81.0 HRB	78.5 µm	77.2 µm	
655	-	160.9 HV 0.5	83.6 HRB	75.6 µm	76.2 µm	
656	-	188.3 HV 0.5	90.7 HRB	71.4 µm	68.9 µm	
657	-	167.5 HV 0.5	85.6 HRB	73.5 µm	75.4 µm	
658	-	165.1 HV 0.5	85.0 HRB	75.0 µm	74.9 µm	
659	-	164.9 HV 0.5	85.0 HRB	75.9 µm	74.0 µm	
660	-	153.7 HV 0.5	81.2 HRB	76.5 µm	78.8 µm	
661	-	164.6 HV 0.5	84.9 HRB	75.4 µm	74.8 µm	
662	-	156.3 HV 0.5	82.1 HRB	76.6 µm	77.5 µm	

APPENDIX C: SEM-EDS AND XRD OF COLLECTED DEPOSITS

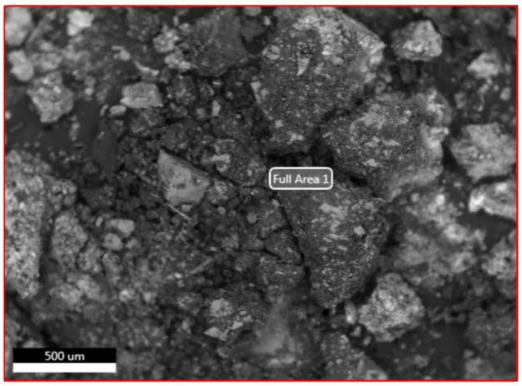
EDAX TEAM

M22-337

Author: EPIMTG
Creation: 11/15/2022 2:02:42 PM

Sample Name: M22-337-03 *Corrosion Deposits*

Area 1



Project: M22-337
Client: ADV Integrity
Contact: David Futch
Payment: PO#2022-1830
Sample ID: M22-337-03
Sample Description: Black powder, ID: Corrosion Deposits Near Wood Plug

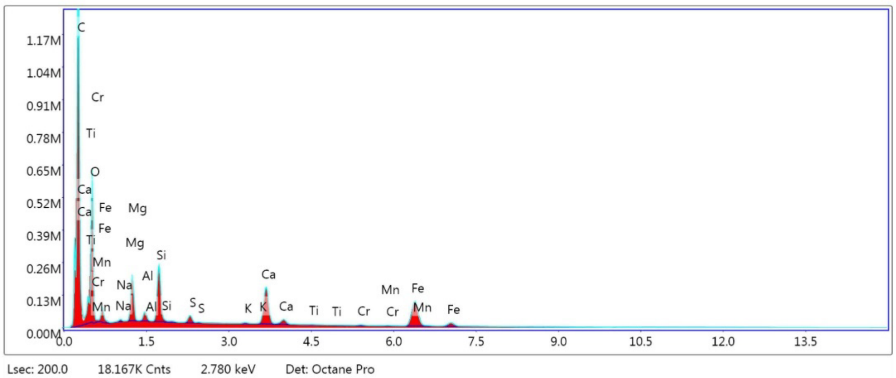
EDAX TEAM

Page 2

Full Area 1

kV: 15	Mag: 50	Takeoff: 34.5	Live Time(s): 200	Amp Time(µs): 0.96	Resolution:(eV) 125.1

Full Area 1 - Det 1



eZAF Smart Quant Results

Element	Weight %	Atomic %	Error %
C K	50.56	66.25	6.89
O K	24.59	24.19	9.15
NaK	0.15	0.10	10.20
MgK	2.46	1.59	5.23
AlK	0.44	0.26	5.14
SiK	2.78	1.56	3.19
S K	0.48	0.24	2.74
K K	0.11	0.04	7.85
CaK	5.15	2.02	1.96
TiK	0.06	0.02	14.04
CrK	0.18	0.05	11.46
MnK	0.13	0.04	13.96
FeK	12.92	3.64	2.63

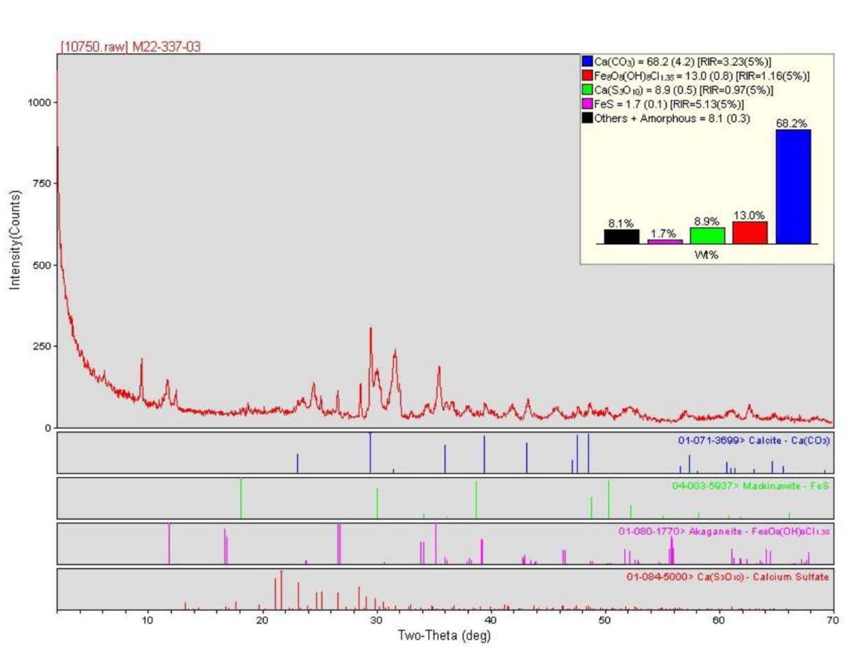
EPI MATERIALS TESTING GROUP
1271 Rayford Bend
Spring, TX 77386
Phone (281) 363-9997
Fax (832) 299-6577
www.epimtg.com

XRD Analysis Report

Client:	ADV Integrity	**EPI MTG Job#:**	M22-337
Contact:	David Futch	**Lab Ref:**	M22-337-03
PO #:	2022-1830	**Date:**	November 22, 2022

Sample I.D.

1. Brownish Red Powder, ID: Corrosion Deposits Near Wood Plug



$Ca(CO_3)$= 68.2%, $Ca(S_3O_{10})$= 8.9%, FeS= 1.7%, $Fe_8O_8(OH)_8Cl_{1.35}$= 13.0%,
Amorphous/Trace Phases= 8.1%

Note: Phase Identification was performed without any knowledge of the sample or its history.
Customer provided information on the sample origin and history could result in a more accurate analysis.

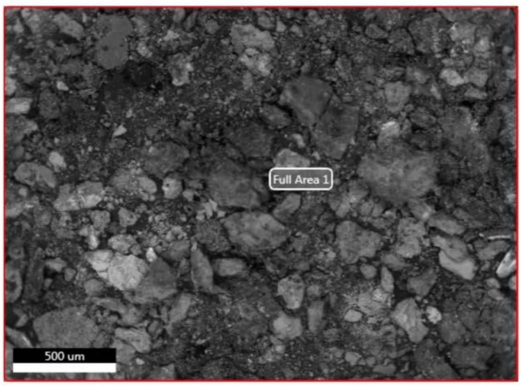
EDAX TEAM

M22-337

Author: EPIMTG
Creation: 11/15/2022 1:51:53 PM

Sample Name: M22-337-02 *Deposits On Pipe*

Area 1



Project: M22-337
Client: ADV Integrity
Contact: David Futch
Payment: PO#2022-1830
Sample ID: M22-337-02
Sample Description: Black Gritty powder, ID: Deposits On Pipe

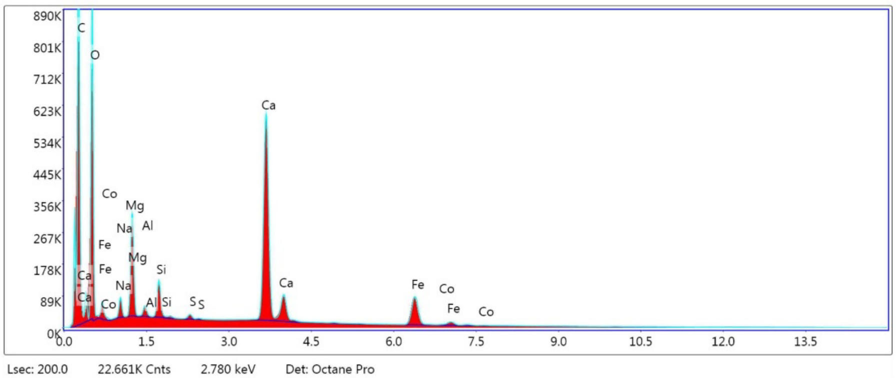
EDAX TEAM

Page 2

Full Area 1

kV: 15	Mag: 50	Takeoff: 34.8	Live Time(s): 200	Amp Time(µs): 0.96	Resolution:(eV) 125.1

Full Area 1 - Det 1



eZAF Smart Quant Results

Element	Weight %	Atomic %	Error %
C K	31.16	46.65	6.95
O K	32.42	36.43	9.18
NaK	1.11	0.86	7.39
MgK	3.92	2.90	5.50
AlK	0.35	0.23	6.10
SiK	1.23	0.79	3.58
S K	0.20	0.11	3.44
CaK	19.72	8.85	1.76
FeK	9.70	3.12	2.59
CoK	0.18	0.06	19.19

EPI MATERIALS TESTING GROUP
1271 Rayford Bend
Spring, TX 77386
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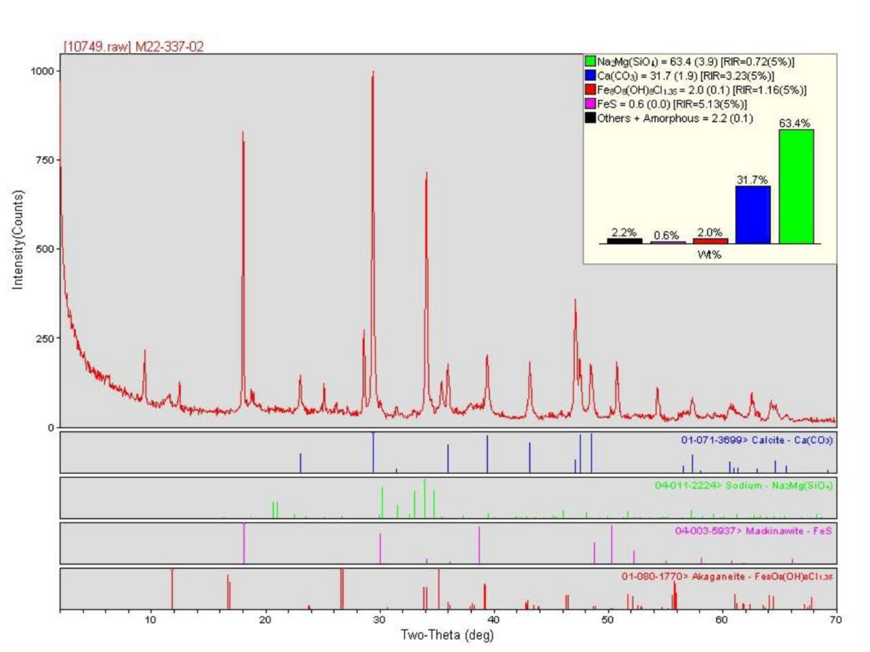
www.epimtg.com

XRD Analysis Report

Client:	ADV Integrity	**EPI MTG Job#:**	M22-337
Contact:	David Futch	**Lab Ref:**	M22-337-02
PO #:	2022-1830	**Date:**	November 22, 2022

Sample I.D.

1. Black Grainy Powder, ID: Deposits on Pipe



$Na_2Mg(SiO_4)$= 63.4%, $Ca(CO_3)$= 31.7%, FeS= 0.6%, $Fe_8O_8(OH)_8Cl_{1.35}$= 2.0%, Amorphous/Trace Phases= 2.2%

Note: Phase Identification was performed without any knowledge of the sample or its history. Customer provided information on the sample origin and history could result in a more accurate analysis.

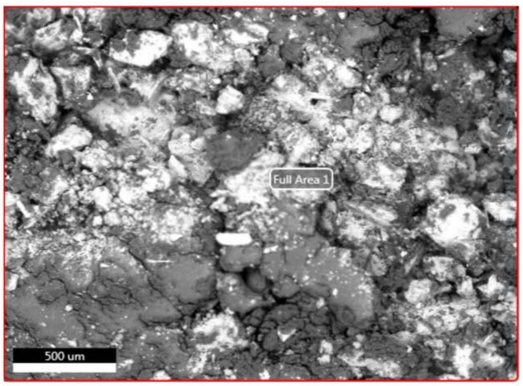
EDAX TEAM *Page 1*

M22-337

Author: EPIMTG
Creation: 11/15/2022 2:16:16 PM

Sample Name: M22-337-01-2nd *White Deposits*

Area 1



Project: M22-337
Client: ADV Integrity
Contact: David Futch
Payment: PO#2022-1830
Sample ID: M22-337-01
Sample Description: White chalky powder, ID: White Deposit

EDAX TEAM

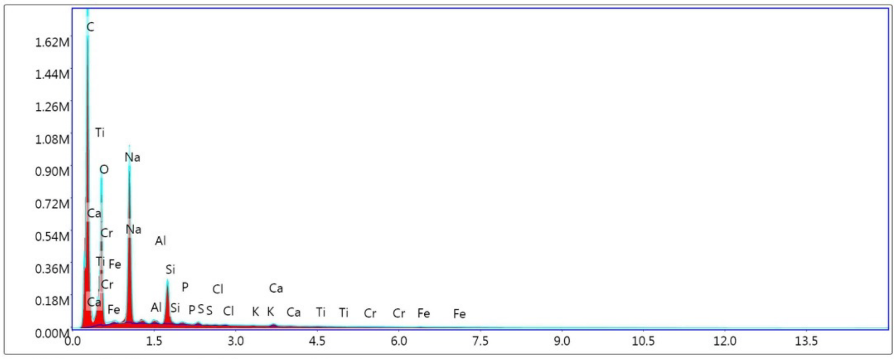
EPI MTG EPI Materials Testing Group

Page 2

Full Area 1

kV: 15	Mag: 50	Takeoff: 34.5	Live Time(s): 200	Amp Time(µs): 0.96	Resolution:(eV) 125.1

Full Area 1 - Det 1



Lsec: 200.0 22.342K Cnts 2.780 keV Det: Octane Pro

eZAF Smart Quant Results

Element	Weight %	Atomic %	Error %
C K	53.19	63.52	6.84
O K	28.92	25.92	8.94
NaK	13.94	8.70	5.55
AlK	0.19	0.10	6.73
SiK	2.66	1.36	3.00
P K	0.11	0.05	11.56
S K	0.21	0.10	3.50
ClK	0.04	0.02	8.47
K K	0.05	0.02	12.93
CaK	0.36	0.13	3.45
TiK	0.07	0.02	12.39
CrK	0.05	0.01	17.65
FeK	0.20	0.05	9.13

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Spring, TX 77386
Phone (281) 363-9997
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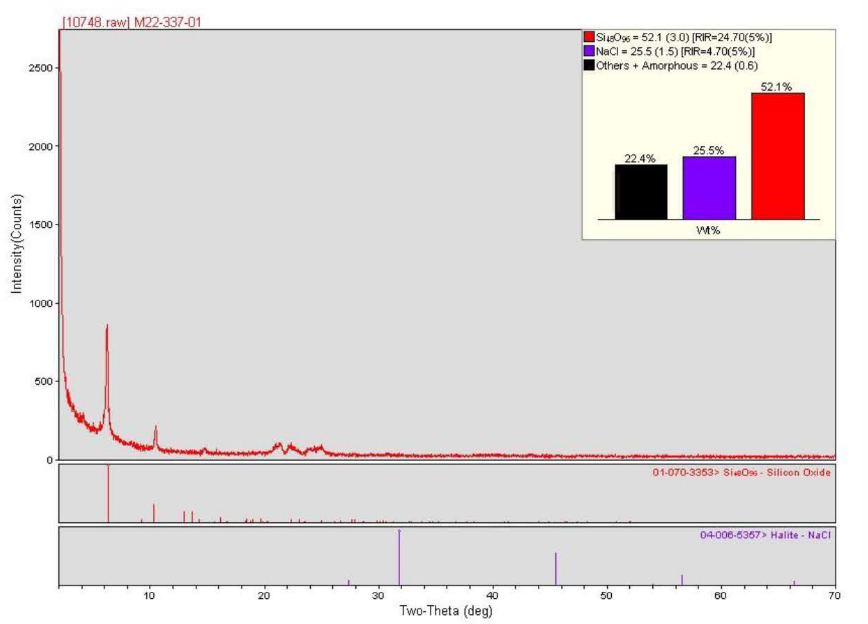
www.epimtg.com

XRD Analysis Report

Client:	ADV Integrity	EPI MTG Job#:	M22-337
Contact:	David Futch	Lab Ref:	M22-337-01
PO #:	2022-1830	Date:	November 22, 2022

Sample I.D.

1. White Chunky Powder, ID: White Deposits



SiO (Silicon Oxide)= 52.1%, NaCl= 25.5%, Amorphous/Trace Phases= 22.4%

Note: Phase Identification was performed without any knowledge of the sample or its history.
Customer provided information on the sample origin and history could result in a more accurate analysis.

Appendix E.Operator Root Cause Analysis – Investigation Summary, Marathon, February 2023.

IR# 351548: Putnam Response			
Incident date	9/25/2022	***Investigation start date***	9/25/2022
PSM Incident?	no	***If Yes, what type?***	NA
Incident category	3	***Investigation reason***	Reportable Release
Pre-incident risk rank	C		

INCIDENT SUMMARY

On 09/25/2022 at 22:02 Central Time, Putnam County 911 contacted the Findlay POC about an odor near Fillmore, IN. The RIO8" Products line, running in steady state, was shut down at 22:13 Central Time and steps were taken to investigate the 911 report. A second call from Putnam County 911 at 22:40 Central Time provided updated location in addition to a report of a sheen on water near the pipeline. Area personnel arrived onsite at 22:47 Central Time to confirm a release based on odor alone thus initiating the emergency response with a Stop-Help-Start. Emergency response activities continued with the upstream block valve at milepost 173 going closed at 23:29 Central Time and the downstream block valve at milepost 183 being closed at 23:30 Central Time.

Company personnel were able to confirm the sheen on Dyer Creek at 00:40 Central Time on 9/26/2022 and emergency response activities continued. The release was contained and a temporary repair via an 8" bolt on sleeve was installed at ~22:45 Central Time on 09/26/2022. Ultimately, it was decided to remove the 8" bolt on sleeve and replace it with a 24" on 09/28/2022. After a successful static test, the pipeline was restarted under a 10% derate at 17:41 Central Time on 09/28/2022

INVESTIGATION AREAS OF FOCUS	FINDINGS SUMMARY
-POC Response	-POC responded in accordance with procedure
-Pipe Failure	- The girth weld contained a series of original construction welding features. The weld defect area and associated wall loss created a void which allowed water to collect thus enabling an environment conducive for internal corrosion. The RIO8" has historically not been a high risk of internal corrosion, which indicates that corrosion would not have been a contributing factor without the causal factor of the girth weld feature.

INVESTIGATION SUMMARY

General Information:

General

- 1945-1989 – RIO8" is operated by a different company
- 1984 – RIO8" ceases to move product
- 1986 – RIO8" is nitrogen purged
- 1989 – Marathon assumes operatorship of RIO8"
- 1989 – RIO8" resumes operation
- 2015 – RIO8" is purged
- 2016 – RIO8" is reversed and reactivated

Prior Hydrotests

- 1945 – commissioning test

INVESTIGATION SUMMARY

- 1974
- 1980
- 1986
- 2016

Past Mainline Incidents

- 1993 – Tile contractor contacted the line resulting in a failure
- 2013 – Power company grounding cable led to a through wall AC fault current failure
- 2017 – Damage to line during a maintenance activity led to a failure
- 2019 – Through wall crack within a gouge caused by mechanical damage during a maintenance activity

Pipe Segment Threat Matrix

- External Corrosion – Not active
- Internal Corrosion – Not Active
- Mechanical Damage – Susceptible
- Long Seam Susceptibility – No
- Selective Seam Weld Corrosion – Non-susceptible
- Environmentally Assisted Cracking – Monitor
- Earth Movement – Monitor

Significant Projects

- 2016 – RIO Reversal
- 2018/2019 – RIO expansion

RIO Leak Alarm Signatures (2 Hour Model)

- Leak warning (CPM Warn) – 11.75 barrels per hour
- Leak alarm (CPM Leak) – 23.5 barrels per hour

Miscellaneous Information Specific to Release Location

- No repair digs have been completed within 500ft upstream or downstream of the release location

Incident Summary:

09/23/2022

- RIO8" receives a CPM Warn alarm at 21:55 Central Time
- RIO8" receives a CPM Leak alarm at 22:36 Central Time
    - CPM support was contacted, and leak rate was correlating with an Isobutane batch location relative to pump stations
    - Isobutane passes Speedway station and the leak rate dropped as anticipated
        - Static test was determined to not be needed with the line conditions acting as anticipated
            - RIO8" model generates many warning alarms due to the varying compressibility of the products (OFI)

09/24/2022

- RIO8" CPM Leak alarm drops to a CPM Warn alarm at 01:16 Central Time
    - Alarm clears at 03:47 Central Time
- Following the schedule, the RIO8" shuts down at 05:15 Central Time
- RIO8" starts up as part of the mega tight line movement at 10:15 Central Time
    - Line was tight prior to startup, showing no abnormal signatures
- RIO8" receives a CPM Leak Alarm at 10:16 Central Time
- RIO8" receives a CPM Warn at 10:16 Central Time
    - Alarms clear at 10:21 Central Time
        - Common to get CPM alarms during startup/shutdown

INVESTIGATION SUMMARY

- RIO8" receives a CPM Warn alarm at 11:43 Central Time
  - Alarm clears at 12:05 Central Time
- RIO8" receives a CPM Warn alarm at 12:17 Central Time
- RIO8" receives a CPM Leak alarm at 13:50 Central Time
- RIO8" CPM Leak alarm drops to a CPM Warn alarm at 15:07 Central Time
  - Issues were thought to be attributed to product line makeup, temperature tuning and a unit starting up at Brazil.

NOTE: After reviewing SCADA information post incident, it is hypothesized the leak began late on 09/24/2022 or early 09/25/2022)

<u>09/25/2022</u>

- RIO8" receives a CPM Leak alarm at 00:34 Central Time
- RIO8" receives a CPM Warn alarm at 00:37 Central Time
  - Alarm clears at 08:16 Central Time
- RIO8" receives a CPM Warn alarm at 08:37 Central Time
- Specialist coming on shift contacts CPM support at 17:05 Central Time inquiring about the CPM Warn alarm
  - Trends pointed towards temperature tuning due to most of the leak rate being in Volume Differential
    - Mainline releases typically show Volume Differential and Flow Differential values
  - Temperature tuning takes place at 17:45 Central Time
- RIO8" CPM Warn alarm clears at 18:18 Central Time
- RIO8" receives a CPM Warn alarm at 20:33 Central Time
- Putnam County Indiana 911 contacts the Findlay POC notifying them of a strong odor at 22:02 Central Time
- Findlay POC shuts down the Robinson-Lima 10" and RIO8"
  - Robinson-Lima 10" and the RIO8" share a ROW in this location
    - Robinson-Lima 10" shutdown at 22:17 Central Time
    - RIO8" shutdown at 22:13 Central Time
      - RIO8" CPM 2hr averaging period averaged 16.05 barrels per hour prior to the shutdown
- Second call into the Findlay POC received from Putnam County Indiana 911 with better location guidance and reports of a sheen at 22:40 Central Time
- MPL Field personnel arrive onsite and confirm a strong Natural Gasoline odor at 22:47 Central Time
- The upstream block valve at milepost 173 was closed at 23:29 Central Time
- The downstream block valve at milepost 182 was closed at 23:30 Central Time

NOTE: Pressure on the RIO8" line segment dropped, indicating a release. No leak signatures were observed on the Robinson-Lima 10" after shutdown

<u>09/26/2022</u>

- The release location was identified by local operations personnel at 00:40 Central Time
  - Emergency response activities continued
- The Robinson-Lima 10" system was restarted at 09:50 Central Time
- Temporary repair via an 8" bolt on sleeve was installed on the RIO8" failure at 22:45 Central Time

<u>09/28/2022</u>

- The 8" bolt on sleeve was removed and replaced with a 24" bolt on sleeve
- RIO8" pipeline system was restarted at 17:41 Central Time

<u>10/27/2022</u>

- Permanent repair of the RIO8" was complete with a straight pipe replacement

INVESTIGATION SUMMARY

- Failed section was sent off to a 3rd party vendor for analysis
  - Failed section included the still intact 24" bolt on sleeve

Integrity Analysis:

- 12/15/2022 – the metallurgic examination report was received from the 3rd party vendor
- Report concluded that the leak coincided with the girth weld, resulting in approximately 1/8" through wall hole
- Girth weld contained a series of original construction welding features, which could contain an area of undercut, burn through, or suck back
- Weld defect area and associated wall loss created a void with allowed water to collect which enabled an environment conducive for internal corrosion.
  - The RIO8" has historically not been a high risk of internal corrosion, which indicates that corrosion would not have been a contributing factor without the causal factor of the girth weld feature. (CF)

Environmental:

- The incident resulted in 595 barrels of natural gasoline being released into the environment with 62.40 barrels being recovered.

CORRECTIVE ACTIONS AND OFI'S

CAUSAL FACTORS/OFI	ROOT CAUSES	CORRECTIVE ACTION	RESPONSIBLE PERSON	LEVEL OF CONTROL
CF1: Girth weld feature created an environment conducive for internal corrosion leading to through wall failure	Equipment Difficulty – Equipment/Parts Defective - Manufacturing	CF1CA1: Pipeline temporary repair with a bolt on sleeve followed by permanent repair of a pipe replacement	(Complete)	Eng
		CF1CA2: Complete dig campaign utilizing TDW girth weld analysis	Dan Seman 3/15/2023	Eng
		CF1CA3: Complete Ultrasonic Circumferential Crack Detection in line inspection tool on the RIO8" system	Dan Seman 7/15/2023	Eng
OFI	OFI	Evaluate POC response procedure for a CPM warning alarm and leak alarm	Kyle Brown 4/30/2023	Admin
OFI	OFI	Evaluate CPM thresholds for the RIO8" system	Jason Dalton 2/28/2023	Eng/Admin
OFI	OFI	Evaluate additional leak detection analysis tools	Ryan Stechschulte 2/28/2023	Eng/Admin
OFI	OFI	Provide correspondence to all MPL FDY POC controllers detailing the incident	Kyle Brown 3/31/2023	Admin

FINAL RISK ASSESSMENT

CONSEQUENCE	FREQUENCY	MPL RANKING	CORPORATE RANKING
Environmental	2-5 years (1-10bbl)	C	NA

Investigation Team	
Jeffrey Busching – MPL Incident Investigation Coordinator Dan Seman – Integrity Analysis Supervisor Nic Roniger – Mainline Integrity Manager Kyle Brown – POC Supervisor Jason Dalton – Hydraulics Manager Ashleigh Carpenter – Corrosion Management Engineer	
Approval/Date	2/10/2023

Appendix F.Operator Control Center Response.

Control Center Response, AID Summary Table

Date Time (EDT)	Alarm State	Shift Report	Marathon's Explanation
9/23/22 10:55 p.m.	CPM WARN	Isobutane between Anderson and Speedway	
9/23/22 11:36 p.m.	CPM LEAK	Isobutane between Anderson and Speedway	CPM support was contacted, and determined the leak rate was correlating with an Isobutane batch location relative to pump stations. Isobutane passes Speedway station and the leak rate dropped as anticipated. A static test was determined to not be needed with the line conditions acting as anticipated. RIO8" model generates many Warning Alarms due to the varying compressibility of the products (OFI).
9/24/22 2:16 a.m.	CPM WARN	Dropped back to "Warning" from Leak Alarm. The 5 min and 30 min leak rates started decreasing around 02:00 a.m., as the product was changing from ISO to NGU at Speedway	Alarm clears at 04:47 a.m.
9/24/22 6:28 a.m.	CPM WARN	System Shutdown Transient Activity	RIO Pipeline shutdown at 6:15 a.m.
9/24/22 11:16 a.m.	CPM LEAK	System Shutdown Transient Activity	RIO Pipeline startup at 11:15 a.m. as part of a mega tight line movement. Line was tight prior to startup, showing no abnormal signatures.
9/24/22 11:16 a.m.	CPM WARN	System Start-up. Delivery location was opened up in preparation for startup, draining barrels into the Robinson Storage Facility	Alarm clears at 11:21 a.m. Common to get CPM alarms during startup/shutdown.
9/24/22 12:43 p.m.	CPM WARN	Brazil Unit 1 Start transient-Warning Alarm-Short Period[1]	Brazil Unit 1 startup at 12:11 p.m. Alarm clears at 1:05 p.m.
9/24/22 1:17 p.m.	CPM WARN	Brazil Unit 1 Start transient-Warning Alarm-Medium Period[2]	

[1] Marathon's CPM is calculating a leak rate every second, which is then averaged out using averaging periods. A "short" time averaging period is defined as 5 minutes for pipeline systems.
[2] A "medium" time averaging period is defined as 30 minutes for pipeline systems.

9/24/22 1:50 p.m.	N/A	N/A	Marathon suspects that the leak started at 1:50 p.m. based on a sudden upward spike in CPM calculated leak flow rate (barrels per hour).
9/24/22 2:50 p.m.	CPM LEAK	Brazil Unit 1 Start transient-Leak Alarm-Long Period[3]	Controller notified Specialist concerning the alarm. The Controller and Specialist determined the Leak Alarm was attributed to the Brazil Unit 1 startup along with the elevated leak rates due to temperature tuning, specifically with Isobutane in the system. They also acknowledged that the leak rate was trending down towards zero. Specialist did not engage the CPM engineer for this alarm because of known temperature tuning issues and the leak rate trending towards zero.
9/24/22 4:07 p.m.	CPM WARN	Brazil Unit 1 Start transient-Returning to "Warning" from "Leak"	Issues were thought to be attributed to product line makeup, temperature tuning, and a unit starting up at Brazil.
9/25/22 1:34 a.m.	CPM LEAK	Turning from Robinson Storage Facility to Robinson Delivery	
9/25/22 1:37 a.m.	CPM WARN	Turning from Robinson Storage Facility to Robinson Delivery	Alarm clears at 9:16 a.m.
9/25/22 9:37 a.m.	CPM WARN	Warning from previous event continued after threshold bump from Control Valve Change returned to baseline	CPM Warn alarm clears at 7:18 p.m.
9/25/22 6:05 p.m.	N/A	N/A	Specialist coming on shift contacts CPM support inquiring about the CPM Warn alarm. Trends pointed towards temperature tuning due to most of the leak rate being in Volume Differential. Mainline releases typically show Volume Differential and Flow Differential values. Temperature tuning takes place at 6:45 p.m.
9/25/22 9:33 p.m.	CPM WARN	Unexplained, attempted to prove meters at Shawnee and Robinson	
9/25/22 11:02 p.m.	N/A	N/A	Putnam County Indiana 911 contacts the Findlay POC notifying them of a strong odor at 11:02 p.m.

[3] A "long" time averaging period is defined as 2 hours for pipeline systems.

			Findlay POC shuts down RIO Pipeline 11:13 p.m. RIO Pipeline CPM 2hr averaging period averaged 16.05 barrels per hour prior to the shutdown.
9/26/22 6:44 a.m.	CPM WARN	Post System Shutdown Alarm	