LG&E
a PPL company

Linda C. Bridwell
Executive Director
Kentucky Public Service Commission
211 Sower Boulevard
Frankfort, Kentucky 40601-8294

Louisville Gas and Electric Company
State Regulation and Rates
220 West Main Street
P.O. Box 32010
Louisville, Kentucky 40232
www.lge-ku.com

Rick E. Lovekamp
Manager Regulatory Strategy/Policy
T 502-627-3780
rick.lovekamp@lge-ku.com

January 29, 2021

RE: ***Louisville Gas and Electric Company Alleged Failure to Comply with KRS 278.495, 807 KAR 5:022, and 49 C.F.R. Part 192***
Case No. 2017-00119

Dear Ms. Bridwell:

In accordance with the Kentucky Public Service Commission's Order of March 16, 2018, Ordering Paragraph No. 4 in Case No. 2017-00119, please find Louisville Gas and Electric Company's ("LGE") 2020 Annual Report on the implementation of LG&E's Action Plan. This report will serve as the third annual report for the years 2018 – 2022.

The original will be filed with the Commission within 30 days of the lifting of the state of emergency.

Should you have any questions regarding the enclosed, please contact me at your convenience.

Sincerely,

Rick E. Lovekamp

Rick E. Lovekamp

Louisville Gas and Electric Company
2020 Annual Report
Case No. 2017-00119

In accordance with the Kentucky Public Service Commission's Order of March 16, 2018 in Case No. 2017-00119, Louisville Gas and Electric Company ("LG&E") submit the third annual report for the years 2018–2022. The annual report provides a status on the implementation of LG&E's Action Plan and the number of bolted-style coupling systems removed in 2020 from distribution lines having an operating pressure in excess of 60 psig along with observations of the removed couplings.

LG&E developed the Action Plan in collaboration with Daniel Ersoy of the Gas Technology Institute ("GTI"). The Action Plan focused on the removal of couplers in the LG&E transmission and high-pressure distribution systems, prohibited use of couplers going forward except in very limited circumstances and only in lower-pressure environments, and to improve the training and communication efforts to minimize the chances of coupler separations. The Action Plan items align with Section 3 of the GTI Report that was submitted in Case No. 2017-00119 as an attachment to Commission Staff's Second Request for Information.

LG&E had completed all action items in the Action Plan submitted in the 2018 annual report with the exception of one item which continues to remain open and in progress.

GTI Report Section 3, Part F: Continuous Process Improvement and Leading Indicators

Action 1: Continuous process improvement and leading indicators, including incorporating findings into Distribution Integrity Management Program ("DIMP").

Action Taken: The Gas Distribution and Information Technology teams have launched an initiative to implement a new risk analysis software to consider the suggested, among other, risk factors associated with the distribution system. As risk identification is improved, analysis will allow a better ranking of infrastructure to be utilized by the DIMP team members to initiate improvements.

Status: In Progress – The procurement process is in its final stages with the new risk software scheduled to be operational in the spring of 2021.

The couplings retired from LG&E's distribution system include the following listed. In accordance with the Action Plan Section 3, Part E, a program was implemented for the opportunistic bolted style coupling removal or encapsulation (for systems > 3 psig) in October 2017. In accordance with the Kentucky Public Service Commission's Order to the Louisville Gas and Electric Company on March 16, 2018 for Case No. 2017-00119, the Louisville Gas and Electric Company ("LGE") hereby notifies the Commission that the following eight mechanical couplings were removed from service from LG&E's high-pressure gas distribution system in 2020. The five couplings were physically removed from the ground while three couplings were retired in place by terminating the pipeline in an upstream and / or downstream location. None of the eight couplings were removed from service due to a failure in the coupling or a leak.

Distribution Couplings removed from the ground:

1) 1609 Poplar Level Road – A 4-inch bolted style mechanical coupling installed in 1961 was removed from service on 7/7/2020 and removed from the ground on 7/7/2020 for inspection of defects. The lab analysis is attached as in Exhibit A.

2) 1609 Poplar Level Road – A 4-inch bolted style mechanical coupling installed in 1961 was removed from service on 7/7/2020 and a portion of it removed from the ground 7/7/2020 for inspection of defects. The lab analysis is attached as in Exhibit B. Due to operational feasibility during the third-party damage repair a portion of the coupling was abandoned in place.

3) 796 Eastern Parkway – An 8-inch bolted style mechanical coupling installed in 1956 was removed from service on 7/28/2020 and removed from the ground on 7/28/2020 for inspection of defects. The lab analysis is attached as in Exhibit C.

4) 4th & Main Street – A 4-inch bolted style mechanical coupling installed in 1987 was removed from service on 5/4/2020 and removed from the ground on 5/4/2020 for inspection of defects. The lab analysis is attached as in Exhibit D.

5) River Road and Witherspoon Road – A 16-inch bolted style mechanical coupling was removed from service on 12/16/2020 and removed from the ground on 12/16/2020 for inspection of defects. The lab analysis is in process and will be submitted as a supplemental report.

Distribution Couplings retired in place:

1) 11th & Dumesnil St – Two 4-inch mechanical couplings installed in 1983 were removed from service and abandoned in place on 6/16/2020.

2) 11th & Jefferson St. – A 4-inch mechanical couplings installed in 1957 was removed from service and abandoned in place on 5/28/2020.

IMR TEST LABS
A Curtiss-Wright Business Unit
www.imrlouisville.com

4510 Robards Lane
Louisville, KY 40218
T: 1.502.810.9007 | **F**: 1.502.810.0380

LG&E - Kentucky Utilities
6900 Enterprise Drive
Louisville, KY 40214

November 30, 2020

Attention: Chad Augustine

Exhibit A

Report No. 202002565

Metallurgical Evaluation of a 4" Coupling and Associated Hardware

Location: 1609 Poplar Level Rd.

DESCRIPTION AND PURPOSE

A natural gas pipe section including a coupling was submitted for metallurgical evaluation. The section was a 4" pipe with a Dresser Style 39 Insulating Coupling. Two joint harnesses were also affixed to the pipe section. Copies of the installation information for the coupling and harnesses were provided for this investigation. It was reported that the coupling had been installed in the field at 1609 Poplar Level Rd. on March 10, 1961. The pipe section was subsequently excavated after substantial service duration without failure. It was requested that the general dimensions, weld quality, corrosion condition and mechanical properties of the coupling components be determined as directed.

RESULTS

The submitted pipe section with the coupling is shown in Figures 1 through 4. Two lugs of the joint harnesses had been fillet welded to both pipe segments. Two rods and associated nuts had been affixed through the welded lugs to apply compression to the coupled joint. The coupling consisted of a steel coupling with an interior nonmetallic gasket / sleeve. Prior to receipt, the ends of the pipe segment were labelled as Ends A and B, as shown in Figures 1 through 4. The top and bottom of the coupling section were also marked. Lugs A1 and A2 were welded to Pipe A, and Lugs B1 and B2 were welded to Pipe B. The rod between Lugs A1 and B1 was identified as Rod 1. The remaining lugs were identified in a corresponding fashion.

Figure 1. Photograph of the top of the submitted coupling sample.

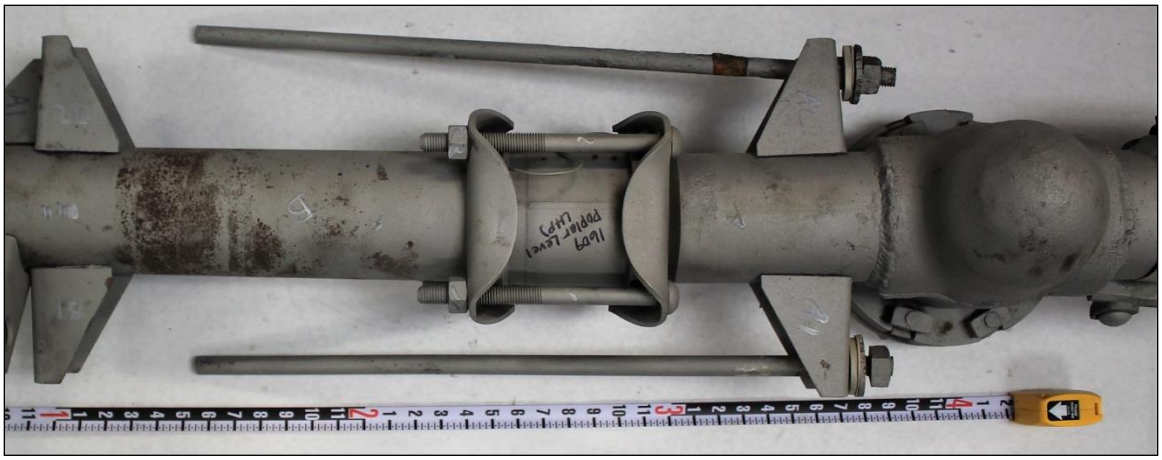


Figure 2. Photograph of the bottom of the submitted sample.

SECTION 1- DIMENSIONAL MEASUREMENT

The two sets of harness lugs were positioned around the pipe. The relative orientations of the harness lugs were measured by photographing the assembly from the ends and applying a protractor overlay for angle measurement. The obtained measurements are shown in Figures 3 and 4 with the data summarized in Table 1. The depth of insertion of the pipe segments into the coupling was also measured and the dimensions are provided in Table 2. No requirements were provided for these characteristics.

TABLE 1 – LUG SPACING DIMENSIONAL MEASUREMENTS

Component	Angle	Deviation from 180°	Image
Rod A1 / Rod A2	190°	10°	Figure 3
Rod B1 / Rod B2	185°	5°	Figure 4

TABLE 2 – PIPE COUPLING DIMENSIONAL MEASUREMENTS

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A	3.5”	0.25” (Original sample length – 40”)
Pipe B	3”	

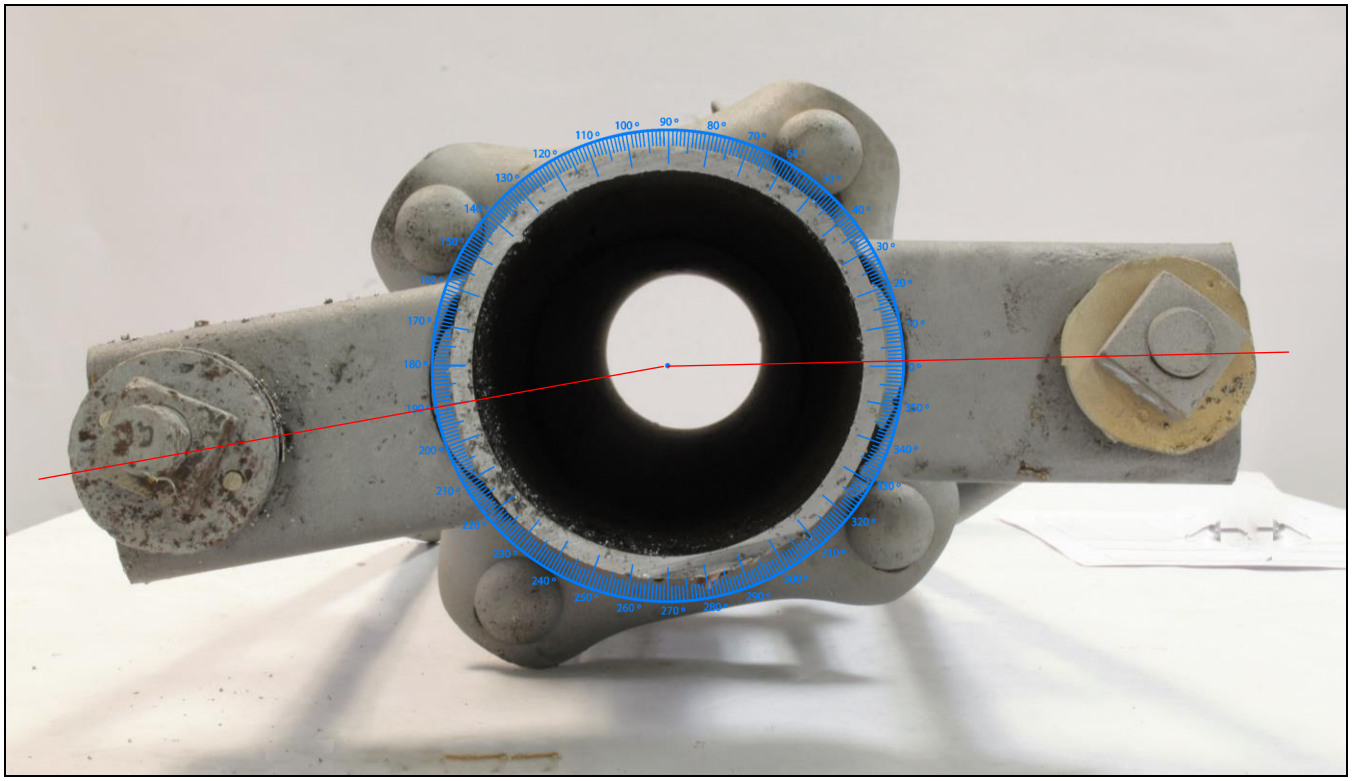


Figure 3. End facing image of the sample at End A with a superimposed protractor.

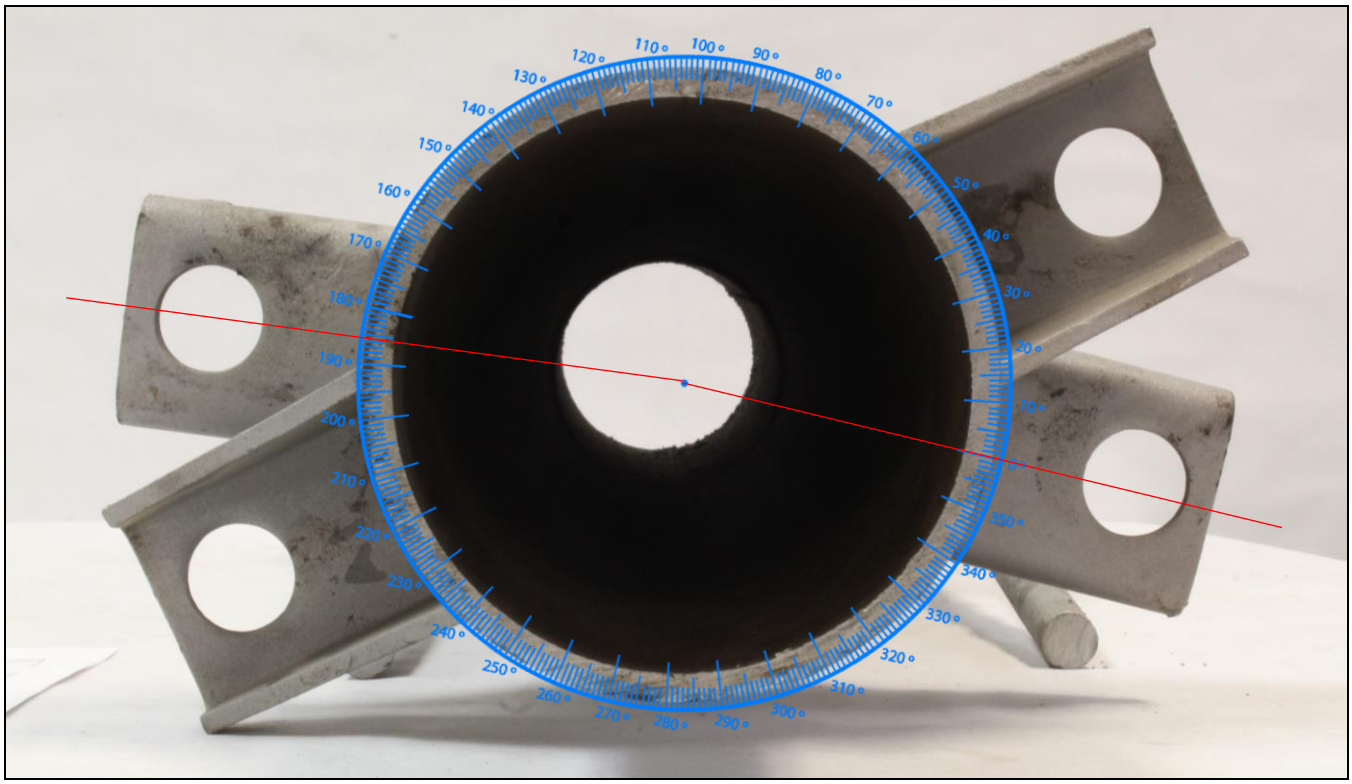


Figure 4. End facing image of the sample at End B with a superimposed protractor.

SECTION 2- VISUAL OBSERVATIONS

The lug attachment welds were regions of interest on the pipe coupling sample. Each lug contained four fillet weld locations; exterior top, exterior bottom, interior top, and interior bottom. Each weld that was present was inspected visually using a flashlight and magnifying lens. It was indicated that welding was performed in accordance with API 1104. General weld inspection was performed initially, followed by visual inspection by an outside NDE company. For comparison purposes, the welds were rated as substantial fusion, partial fusion, and minimal fusion. The summarized weld fusion and corrosion observations are provided in Table 3. Representative weld regions are shown in Figures 5 through 10. The welds contained localized weld discontinuities including undercut, porosity, arc burn and spatter. No cracking in the welds or base metal heat affected zones (HAZ) was visually identified. Some superficial corrosion of the coupling and associated hardware was observed, but no significant material loss had occurred.

The coupling and harness rods were also inspected for corrosion alteration. No significant corrosion was identified. The observations for the rods and bolts are provided in Table 4. No corrosion cracking was evident. The rods were not necked down or stretched.

The elastomeric components of the coupling consisted of a pipe separator, insulating sleeve, and two gaskets. Inspection revealed that they appeared to be intact and not degraded.

TABLE 3 – LUG WELD VISUAL EXAMINATION RESULTS

Component	Location	Weld	Observations
Lug A1	Exterior	Top	Substantial Fusion
		Bottom	Minimal Fusion
	Interior	Top	Minimal Fusion
		Bottom	Substantial Fusion
Lug A2	Exterior	Top	Substantial Fusion
		Bottom	Minimal Fusion
	Interior	Top	Minimal Fusion
		Bottom	Substantial Fusion
Lug B1	Exterior	Top	Substantial Fusion
		Bottom	Minimal Fusion
	Interior	Top	Minimal Fusion
		Bottom	Substantial Fusion
Lug B2	Exterior	Top	Substantial Fusion
		Bottom	Minimal Fusion
	Interior	Top	Minimal Fusion
		Bottom	Substantial Fusion

TABLE 4 – FASTENER VISUAL EXAMINATION RESULTS

Component	Observations
Rod 1	Bent but not stretched, no substantial corrosion pitting, rotated freely
Rod 2	Not bent or stretched, substantial corrosion pitting observed, rotated freely
Bolt 1	Not bent or stretched, no substantial corrosion pitting
Bolt 2	Not bent or stretched, no substantial corrosion pitting
Bolt 3	Not bent or stretched, no substantial corrosion pitting
Bolt 4	Not bent or stretched, no substantial corrosion pitting

Figure 5. Image of the Lug A2 exterior top weld which exhibited substantial fusion except for some arc burn, porosity, undercut, and spatter.

Figure 6. Image of the Lug A2 exterior bottom weld which exhibited no fusion.

Figure 7. Image of the Lug B2 exterior top weld which exhibited substantial fusion except for some arc burn, spatter, porosity and undercut.

Figure 8. Image of the Lug B2 exterior top weld which exhibited no fusion.

Figure 9. Image of the Lug B1 interior bottom weld which exhibited substantial fusion except for some porosity and spatter.

Figure 10. Image of the remainders of an additional piece, which had been welded then cut off, present on Side A of the assembly.

SECTION 3- TORQUE TESTING- FOR INFORMATION ONLY

Torque testing was performed on the nuts of the rods and bolts on the pipe coupling sample. A calibrated torque wrench was used to determine breakaway torque on each fastener. The breakaway torque measurements are summarized in Table 5. Rod fasteners did not have a specified torque requirement. The four coupling bolts exhibited torque values ranging from 25 to 45 ft.-lbs. All torque values were below the Dresser Style 38 coupling installation torque recommendation of 75 ft.-lbs. minimum for 5/8" fasteners.

TABLE 5 – FASTENER TORQUE MEASUREMENT

Component	Breakaway Torque	Observations
Rod 1	0 ft.-lbs.	Rotated Freely
Rod 2	0 ft.-lbs.	Rotated Freely
Bolt 1	30 ft.-lbs.	Did not satisfy the recommended torque
Bolt 2	25 ft.-lbs.	Did not satisfy the recommended torque
Bolt 3	45 ft.-lbs.	Did not satisfy the recommended torque
Bolt 4	45 ft.-lbs.	Did not satisfy the recommended torque

SECTION 4- TENSILE TESTING, ASTM A370-17A

Tensile testing was performed on round specimens that were removed from the two harness rods and the four coupling bolts. The tensile properties of the fasteners were measured and the results are summarized in Table 6. No mechanical property requirements were provided for the fasteners.

TABLE 6 – FASTENER TENSION TEST RESULTS

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %③	Reduction in Area, %
Rod 1①	72.5	43.2	38	65
Rod 2①	78.0	43.0	33	57
Bolt 1①	82.5	61.5	36	78
Bolt 2①	86.0	50.5	31	57
Bolt 3①	94.5	45.2	26	44
Bolt 4①②	94.5	45.1	26	43

① Specimen Dimensions; Diameter 0.25" with gage length of 1.00"
② Interrupted Test
③ Percent elongation was measured using elongation-after-fracture measurements

SECTION 5- ROCKWELL HARDNESS, ASTM E18-17

Small sections of the four lugs were excised for hardness testing. Rockwell hardness testing was performed on sectioned segments of the lugs after the removal of surface roughness by sanding. The obtained results are provided in Table 7 and are suggestive of a moderate strength level. No requirements were provided for comparison.

TABLE 7 – LUG HARDNESS TEST RESULTS – ROCKWELL B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug A1	70	70	71	69	70
Lug A2	70	69	69	71	70
Lug B1	65	65	64	64	65
Lug B2	70	69	70	70	70

SECTION 6- NONDESTRUCTIVE EXAMINATION

The two separated ends of the disassembled coupling were sent to a third party NDE laboratory for inspection. Visual, magnetic particle and liquid dye penetrant inspection were performed on the lug attachment welds. Inspection was performed in accordance with the acceptance criteria of API 1104 “Welding of Pipelines and Related Facilities”. The inspection results are provided as Appendix A. Two representative welds are shown in Figures 11 and 12 with the dye penetrant test media remaining.

Figure 11. Image of the Lug A1 exterior top welds after dye penetrant media had been used during inspection.

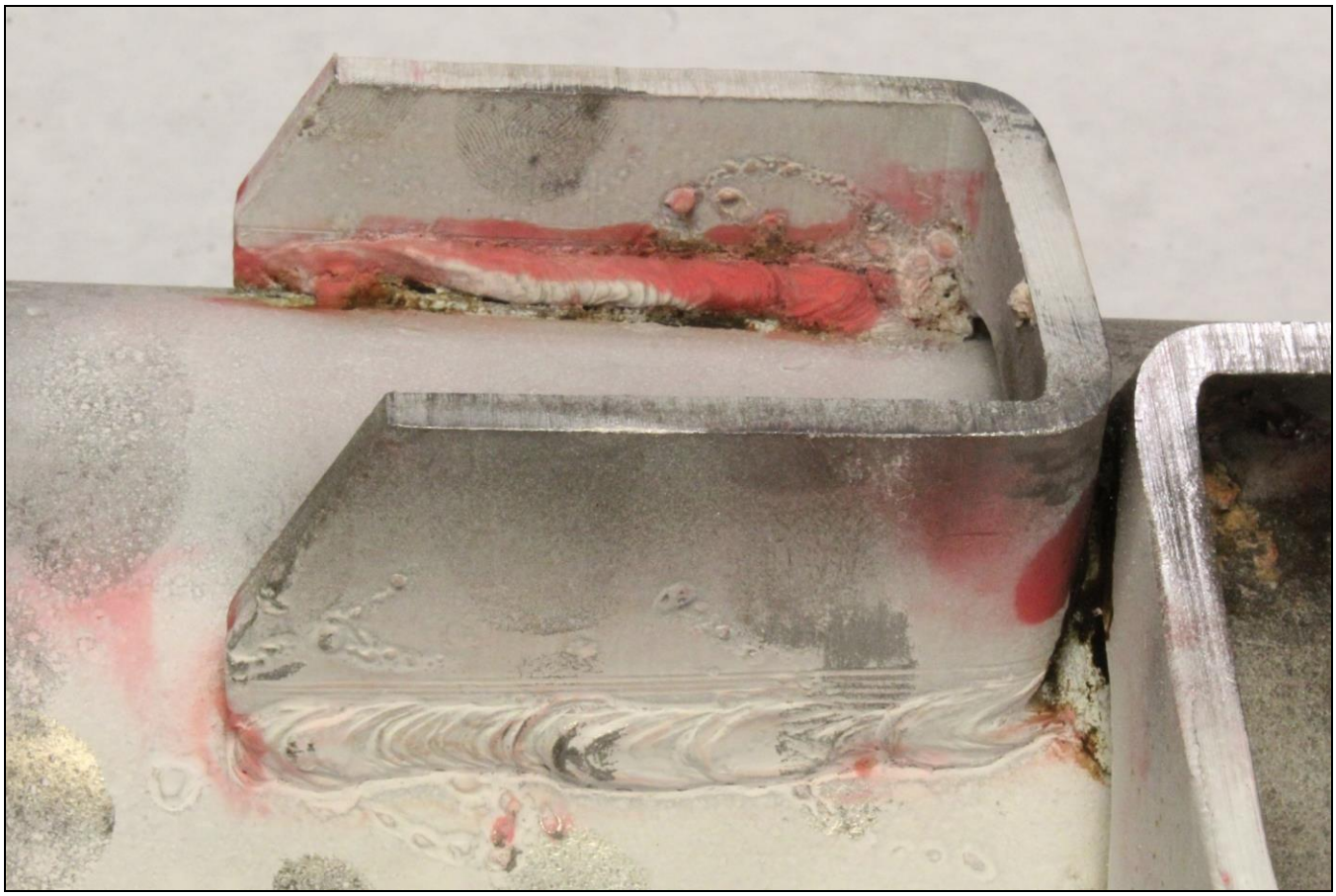


Figure 12. Image of the Lug B1 exterior top welds after dye penetrant media had been used during inspection.

A2LA ACCREDITED
Testing Cert # 1140.03 & 1140.04

Nadcap Administered by PRI ACCREDITED Materials Testing Laboratory

Respectfully submitted

Brian Kelly
Failure Analyst

Concurrence

Phillip Swartzentruber, Ph.D., E.I.T.
Chemistry Department Manager
Failure Analyst

APPENDIX A – LIQUID DYE PENETRANT / VISUAL INSPECTION RECORD

MISTRAS

Liquid Penetrant Examination Report

195 Clarksville Road | Princeton Junction, NJ 08550 | P: (609) 716-4000; F: (609) 716-4145 www.mistrasgroup.com

Client:	IMR TEST LABS	Date:	11/17/2020	Page:	1 of 1
Address:	4510 ROBERTS LANE	Job Number:			
	LOUISVILLE KT40218	Purchase Order:	6670FA		
Contact:		Reference Number:	202002565		
Location:	MGI LAB	Part No/Description:	TOP		

Code/Specification	Procedure	Acceptance Criteria
ASME SEC V,ART 6	100-PT-001 REV20	API 1104

Type and Method

☐ Fluorescent:	☐ Water Wash [Method A]	☒ Red Visible Dye:	☐ Water Wash [Method A]
[Type I]	☒ Solvent Removable [Method C]	[Type II]	☒ Solvent Removable [Method C]
	☐ Post Emulsified: ☐ Hydrophilic [D] ☐ Lipophilic [B]		☐ Post Emulsified [Method B]
Sensitivity Level:	☐ ½ ☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ N/A	☐ Other: N/A	

	Manufacturer	Type	Batch Number(s)	Application Method	Process Time (minutes)	
					Pre-clean Dry Time:	15 MIN
Cleaner:	SPOT CHECK	SKC-S	18G14K	SPRAY/CLOTH	Penetrant Dwell Time:	10 MIN
Penetrant:	SPOT CHECK	SKL-SP2	17L02K	BRUSH	Emulsifier Time:	N/A
Developer:	SPOT CHECK	SKD-S2	17J05K	SPRAY	Developer Time:	10 MIN
Emulsifier:	N/A	N/A	N/A	N/A	Post Clean Method:	N/A

Developer Form: ☐ a. Dry Powder ☐ b. Water Soluble ☐ c. Water Suspended ☒ d. Nonaqueous Wet ☐ e. Specific Application

Penetrant Removal Method & Dry Time	Black Light (Model and S/N)	White Light Source
DAMP CLOTH/10MIN	N/A	L.E.D

☒ Original ☐ Repair	Material & Thickness	Test Temperature
	C/S (VARIOUS)	72 F

Surface Condition
☒ As Welded ☐ As Ground ☐ As Cast ☐ Rough Machined ☐ Final Machined ☐ Meets Code Requirements

Test Results	Quantity Inspected: 4	Quantity Accepted: 0	Quantity Rejected: 4

WELD "A"
A-1- REJECTED FOR POROSITY AND UNDERCUT
A-2- REJECTED FOR SURFACE POROSITY AND UNDERCUT

WELD "B"
B-1- REJECTED FOR UNDERCUT AND CRACK
B-2- REJECTED FOR UNDERCUT AND POROSITY

Technician Name, Level & Date	Customer (if applicable):	Reviewed By (if applicable):
DANIEL WEICK LEVEL II		

Certification of Inspection, Liquid Penetrant [Basic Report Form] 100-PTFORM-002 | Rev 1

Bolt-Style Coupling (pressures > 3 psig)

This form will be completed when LG&E or LG&E contractors expose a bolt-style coupling in a system where the pressure is > 3 psig (medium and high pressure distribution and transmission) and the coupling will be backfilled. The purpose of the form is to provide Operations, Engineering and Gas Regulatory personnel with information about the bolt style coupling installation.

Part A- Discovery of Coupling

Precautions:

1. Stop excavation upon discovering the bolt-style coupling in the excavation
2. Set-up a perimeter around the excavation to keep the public away from the excavation

General Information:

1. Contact Employee for the bolt style coupling found: **Lee Perry (for discovery), Bo Taylor (removal)**
2. Date of exposure: **3/23/2020**
3. Location: **1609 Poplar Level Rd. Louisville, KY 40217**
4. Size of coupling (based on pipe size if not exposed enough to determine): **4"**
5. Type of soil (circle one): Sandy Clay Gravel Topsoil Other (take picture and describe)
6. Soil Density test: □ Type A □Type B □Type C
7. Status: □ Removed □Abandoned in place □Backfilled- left in service
8. Discovered How?: □ Leak on Coupler □Other Maintenance Excavation □Facility Replacement
   □Facility Retirement □Other_____

Pictures:

1. Take at least two pictures of the coupling. The pictures should be from different angles (additional pictures can be taken).
2. Email pictures to supervisor. Ensure pictures are attached to this form:

Sketch: Provide a sketch showing the coupling orientation (vertical/horizontal), nearby branches, pipe, valves and fittings, other utilities or structures, etc.

Leak Survey:

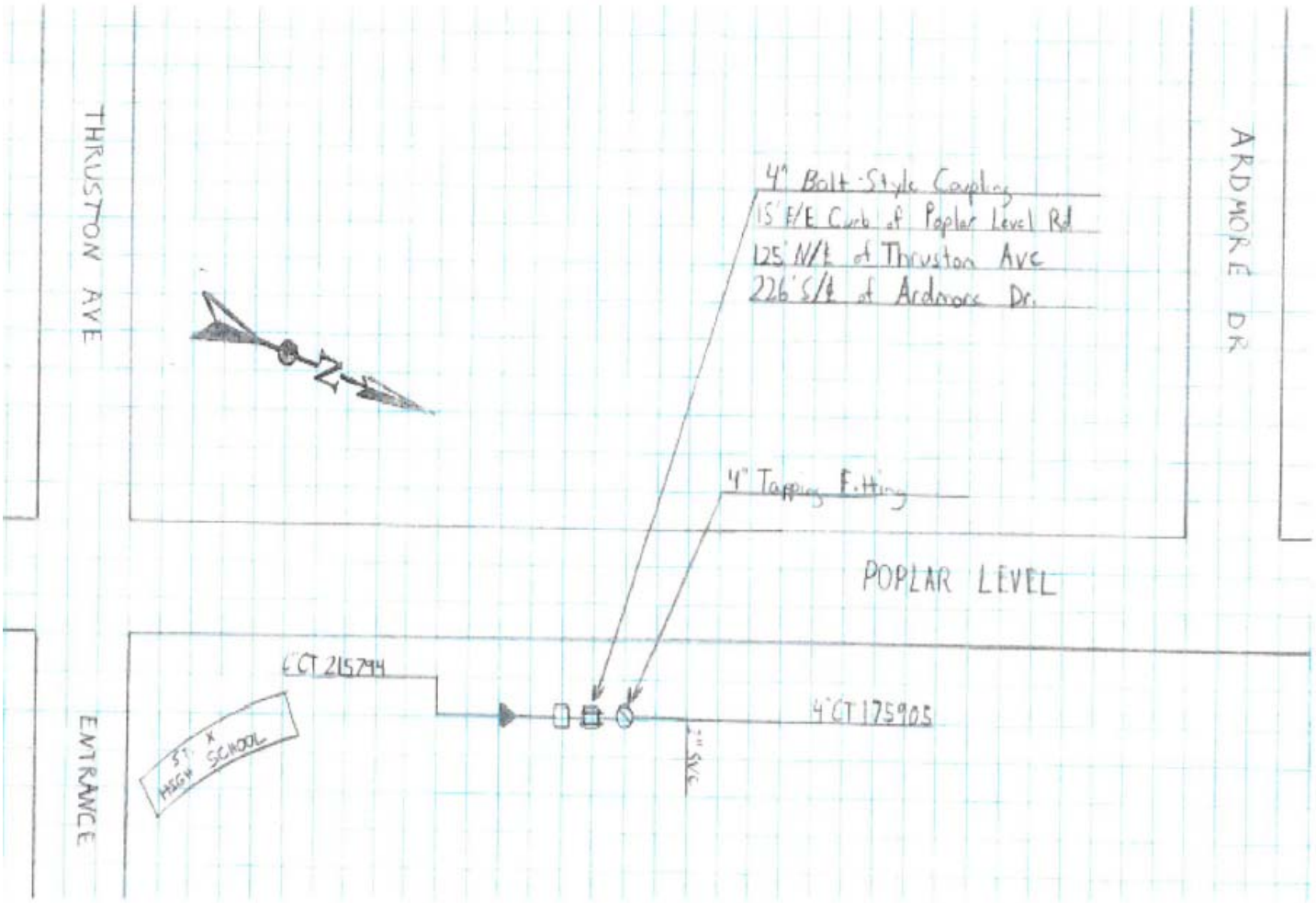
1. Use an instrument designed to detect natural gas to check for the presence of natural gas after backfilling the excavation. Include readings in the above sketch in relation to the coupling. If the contact employee is not leak survey qualified they should contact:
   a. Their supervisor to call Gas Regulatory to complete the survey after the excavation is backfilled. Call [redacted]
   b. If Gas Regulatory is not available contact Gas Dispatch to have the survey assigned to a Gas Trouble Technician.

Leak Survey completed at time of backfill (circle one) yes no not applicable

Include completed form in the main report and email a scanned copy of the completed form (back and front) to the Distribution Integrity Management (DIM) group.

Field Pictures

Sketch


THRUSTON AVE
ARDMORE DR
4" Bolt-Style Coupling
15' E/E Curb of Poplar Level Rd
125' N/E of Thruston Ave
226' S/E of Ardmore Dr.
4" Tapping Fitting
POPLAR LEVEL
6" CT 215794
4" CT 175905
2" SVC
5' x 5' HSGW
SCHOOL
ENTRANCE

Safety Briefing

Date: 10/8/2020

Employee Name	Employee ID
Craig Meade	[redacted]
Sarah Nicholson	[redacted]

	Hazards Identified
	Sharp edges on cut pipe ends. Wear gloves when handling.
	Pinch points on couplings. Wear gloves when handling.
	Some couplings samples are heavy. Use a partner to assist with moving. Use proper lifting techniques. Wear hard toes shoes.
	Debris may on samples. Wear eye protection.
	Tripping hazards on floor. Keep area clean and free of tripping hazards

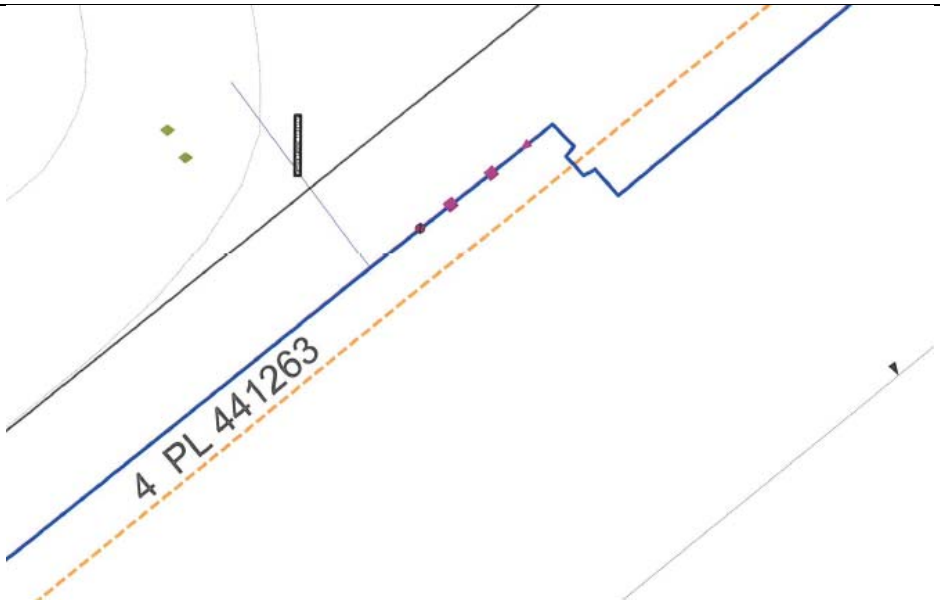
	PPE Required
	Hard toed shoes
	Safety glasses
	Gloves (leather preferred)

Part B- Coupling Information

General Information			Tracking #: 2020-010
PO Number 1070637	Expense Org 004610	Project 158276	Task COUPLER
Address/Location 1609 Poplar Level Rd. Louisville, KY 40217			
Size 4”	Material STL	Coating CT	MAOP 99 PSIG
Main/Service Number 175905	Soil Type (from Part A) Clay	Manufacturer DRESSER	Model
Pipe Connection:	Steel to Steel	Steel to Plastic	Plastic to Plastic

Historical Information	
Installation Date 03/10/1961	Document Source Quest
Installation Company N/A	Document Source
Foreman N/A	Document Source
Welder N/A	Document Source

GIS Information
Sys Id (of Coupler) 11334699
Screen Capture



Pictures (Label the following parts before taking pictures.)

Figure 1 Coupler Top View

Figure 2 Coupler Body

Figure 3 Pipe A

Figure 4 Pipe B

Part C- Visual Inspection of Coupling

Visual Inspection Performed by: Craig Meade & Sarah Nicholson Date: 10/8/2020

Table 1- Component Quantities

Number of Bolts on Coupler Body	4
Number of Reinforcement Rods	2
Number of Lugs	4

Table 2- Corrosion

	Pipe A	Pipe B	Coupler Body	Bolts	Rods	Lugs	Nuts
General External Corrosion Present?	YES	YES	NO	NO	YES	NO	YES
Localized Corrosion Present?	NO	NO	NO	NO	YES	NO	YES
Pit Depths	NO	NO	NO	NO	NO	NO	NO
Internal Corrosion?	NO	NO					

Table 3- Coupler Body

Bolt	Washer Present	Nut present?
1	NO	YES
2	NO	YES
3	NO	YES
4	NO	YES
5		
6		

Table 4- Reinforcement Rods

Rod	Length (in.)	Diameter (in.)	Washer present at head of bolt?	Washer present at end of bolt?	Nut Present? Type?	Type of rod?
1	25 ½"	0.74"	YES	N/A	SQUARE	NON-THREADED
2	26 ½"	0.75"	YES	N/A	SQUARE	NON-THREADED
3						
4						

Type of Lug

(Please indicate the shape of the lug by circling one below. If the lug shape is different than any preset shape below, sketch the shape.)

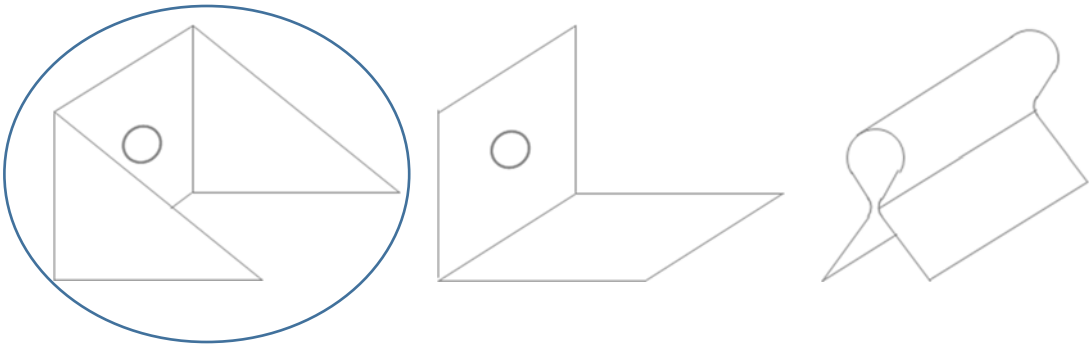


Table 5- Lugs (Measurements)

Pipe Side	Lug Number	Thickness (in.)	Circumference (in)	
			Distance to next lug, clockwise	Distance to next lug, counter-clockwise
A	1	0.24"	4.875	3.75
A	2	0.23"	3.75	4.875
A	3			
B	1	0.23"	4.75	4.25
B	2	0.25"	4.25	4.75
B	3			

Table 6- Lugs (Observations)

Lug	Lug	Assembly sets aligned?	Deformed?	Deflected? (angle of)
A1	B1	YES	NO	NO
A2	B2	YES	NO	NO
A3	B3			

Table 7- Lugs (Weld Quality)

Pipe Side	Lug Number	Any part detached from pipe?	Welded on all sides of exterior? If no, describe	Are welds on exterior continuous? If no, describe	Welded on all sides of interior? If no, describe	Are welds on interior continuous? If no, describe
A	1	NO	NO (1 EXT. WELD)	YES	NO (1 INT. WELD)	YES
A	2	NO	NO (1 EXT. WELD)	YES	NO (1 INT. WELD)	YES
A	3					
B	1	NO	NO (1 EXT. WELD)	YES	NO (1 INT. WELD)	YES
B	2	NO	NO (1 EXT. WELD)	YES	NO (1 INT. WELD)	YES
B	3					

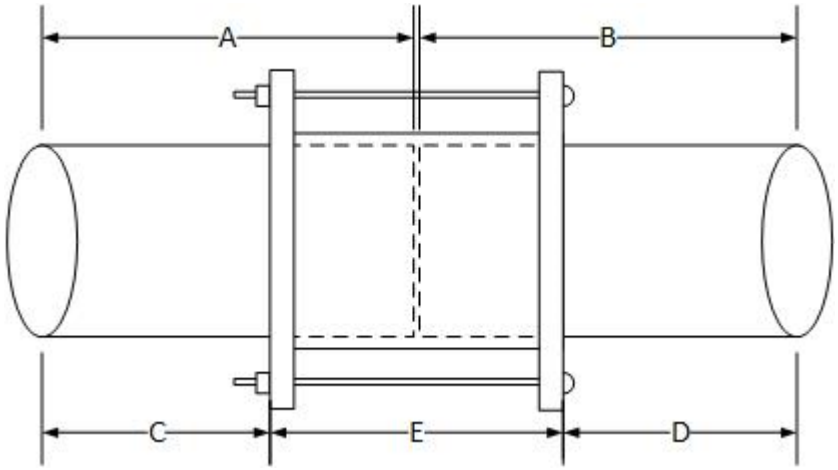


Table 8- Stab Depth

	A	B	C	D	Stab Depth (A-C) or (B-D)
Pipe Side A	44 ½"		41"		3 ½"
Pipe Side B		30 ½"		26 ½"	4"
	Sum of stab depths (should be closely equal to measurement E)				7 ½"
	Coupler Length (E)				6 ½"
	Difference				1"

Additional Comments and General Observations

HP coupler – external laboratory analysis required.

Part D- Analysis of Coupling

The section is designed to be a template for the lab performing analysis of the couplers. The lab may draft a report as a separate document, but the tables below should be used within the report. The tables may be transferred to the report. Rows may be added to any table to accommodate for additional components, but should additional columns be needed for data purposes, please contact LG&E. It is **not** the intention for the table(s) to be completed in duplicate if a separate document is created.

Section 1- Dimensional Measurement

[Insert results summary here]

Table #- Lug Spacing Dimensional Measurements

Compound	Angle	Deviation from 180°	Image
Rod ##/Rod ##			
Rod ##/Rod ##			

Table # – Pipe Coupling Dimensional Measurements

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A		
Pipe B		

[Insert associated pictures and figures here]

Section 2- Visual Observations

[Insert results summary here]

Table # – Lug Weld Visual Examination Results

Component	Location	Weld	Observations
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	

TABLE # – Fastener Visual Examination Results

Component	Observations
Rod #	
Rod #	
Bolt #	
Bolt #	
Bolt #	
Bolt #	

[Insert associated pictures and figures here]

Section 3- Torque Testing- for information only

[Insert results summary here]

TABLE # – Fastener Torque Measurement

Component	Breakaway Torque	Observations
Rod #		
Rod #		
Bolt #		
Bolt #		
Bolt #		
Bolt #		

[Insert associated pictures and figures here]

Section 4- Tensile Testing, ASTM A370-17a

[Insert results summary here]

Table # – Fastener Tension Test Results

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %	Reduction in Area, %
Rod #				
Rod #				
Bolt #				
Bolt #				
Bolt #				
Bolt #				

[Insert associated pictures and figures here]

Section 5- Rockwell and Superficial Hardness, ASTM E18-17

[Insert results summary here]

TABLE # – Lug Hardness Test Results – Rockwell B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug ##					
Lug ##					
Lug ##					
Lug ##					

[Insert associated pictures and figures here]

Section 6- Mag Particle/Dye Penetrant Test

[Insert results summary here]

[Insert results table here]

[Insert associated pictures and figures here]

IMR TEST LABS
A Curtiss-Wright Business Unit
www.imrlouisville.com

4510 Robards Lane
Louisville, KY 40218
T: 1.502.810.9007 | **F**: 1.502.810.0380

LG&E - Kentucky Utilities
6900 Enterprise Drive
Louisville, KY 40214

November 30, 2020

Attention: Chad Augustine

Exhibit B

Report No. 202002566

Metallurgical Evaluation of a 4" Half-Coupling

Location: 1609 Poplar Level Rd.

DESCRIPTION AND PURPOSE

A natural gas pipe section including a coupling was submitted for metallurgical evaluation. The section was a 4" pipe with a Dresser Style 39 Insulating Coupling. Two joint harnesses were also affixed to the pipe section. Copies of the installation information for the coupling and harnesses were provided for this investigation. It was reported that the coupling had been installed in the field at 1609 Poplar Level Rd. on March 10, 1961. The pipe section was subsequently excavated after substantial service duration without failure. It was requested that the general dimensions, weld quality, corrosion condition and mechanical properties of the coupling components be determined as directed.

RESULTS

The submitted pipe section with the coupling is shown in Figures 1 through 3. Two lugs of the joint harnesses had been fillet welded to the pipe segment. No rods or associated nuts were provided. Only one end of the coupling was submitted. Prior to receipt, the end of the pipe segment was labelled as End A, as shown in Figures 1 through 3. The top and bottom of the coupling section were also marked. Lugs A1 and A2 were welded to Pipe A.

Figure 1. Photograph of the top of the submitted coupling sample.

Figure 2. Photograph of the bottom of the submitted sample.

SECTION 1 - DIMENSIONAL MEASUREMENT

The two harness lugs were positioned around the pipe. The relative orientations of the harness lugs were measured by photographing the assembly from the ends and applying a protractor overlay for angle measurement. The obtained measurements are shown in Figure 3 with the data summarized in Table 1. No requirements were provided for these characteristics.

TABLE 1 – LUG SPACING DIMENSIONAL MEASUREMENTS

Component	Angle	Deviation from 180°	Image
Rod A1 / Rod A2	178°	2°	Figure 3

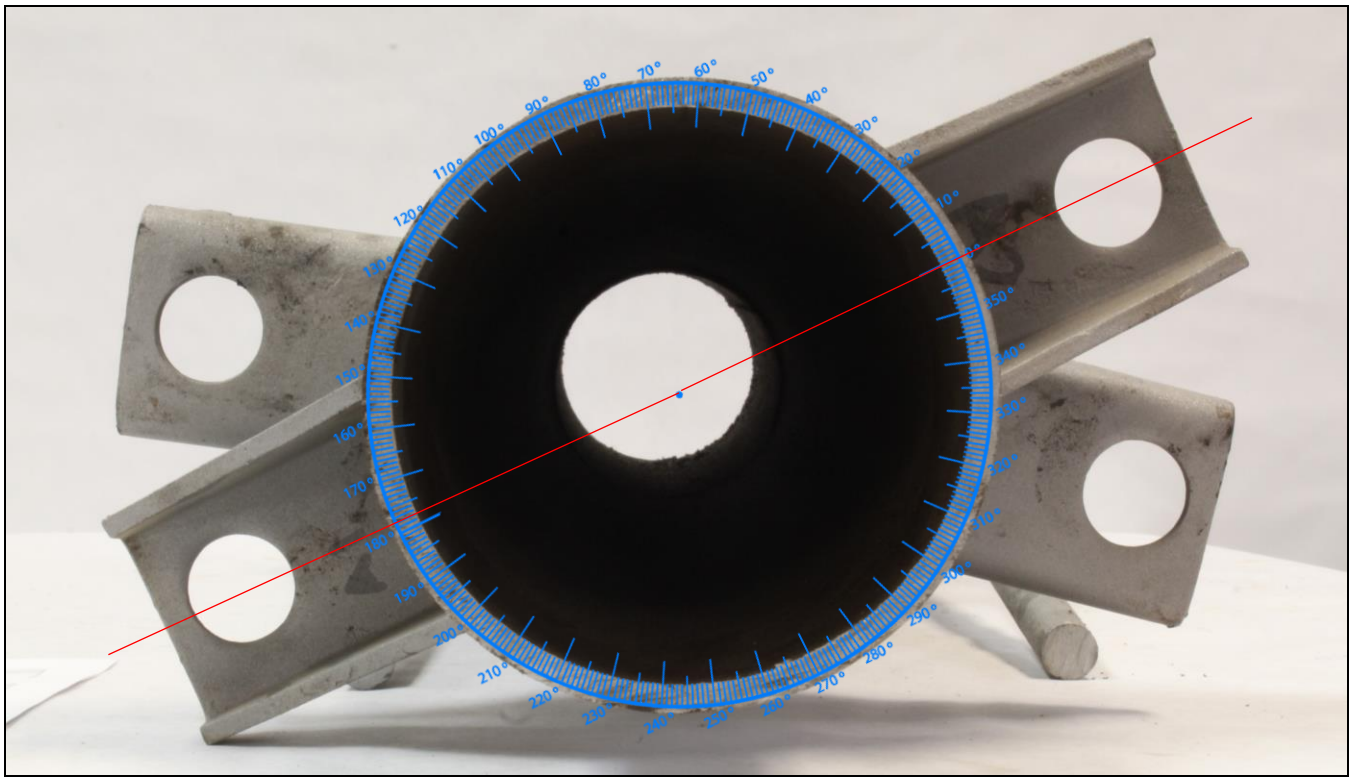


Figure 3. End facing image of the sample at End A with a superimposed protractor.

SECTION 2 - VISUAL OBSERVATIONS

The lug attachment welds were regions of interest on the pipe coupling sample. Each lug contained four fillet weld locations; exterior top, exterior bottom, interior top, and interior bottom. Each weld that was present was inspected visually using a flashlight and magnifying lens. It was indicated that welding was performed in accordance with API 1104. General weld inspection was performed initially, followed by visual inspection by an outside NDE company. For comparison purposes, the welds were rated as substantial fusion, partial fusion, and minimal fusion. The summarized weld fusion and corrosion observations are provided in Table 2. Representative weld regions are shown in Figures 4 through 7. The welds contained localized weld discontinuities including undercut, porosity, arc burn and spatter. No cracking in the welds or base metal heat affected zones (HAZ) was visually identified. Some superficial corrosion of the coupling and associated hardware was observed, but no significant material loss had occurred.

TABLE 2 – LUG WELD VISUAL EXAMINATION RESULTS

Component	Location	Weld	Observations
Lug A1	Exterior	Top	Substantial Fusion
		Bottom	No Fusion
	Interior	Top	Substantial Fusion
		Bottom	Substantial Fusion
Lug A2	Exterior	Top	Substantial Fusion
		Bottom	No Fusion
	Interior	Top	Substantial Fusion
		Bottom	Partial Fusion

Figure 4. Image of the Lug A1 exterior top weld which exhibited substantial fusion except for some arc burn, porosity, undercut, and spatter.

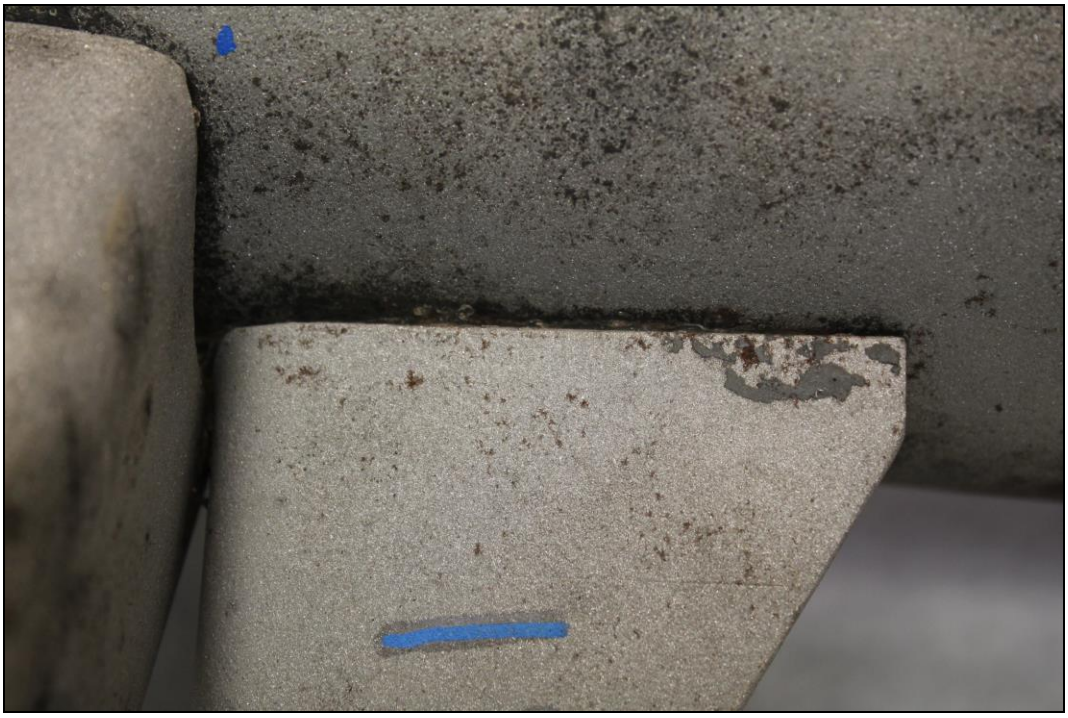


Figure 5. Image of the Lug A1 exterior bottom weld which exhibited no fusion.

Figure 6. Image of the Lug A2 exterior top weld which exhibited substantial fusion except for some arc burn, and undercut.

Figure 7. Image of the Lug A2 interior bottom weld which exhibited substantial fusion except for some arc burn and spatter.

SECTION 3 - ROCKWELL HARDNESS, ASTM E18-17

Small sections of the two lugs were excised for hardness testing. Rockwell hardness testing was performed on sectioned segments of the lugs after the removal of surface roughness by sanding. The obtained results are provided in Table 3 and are suggestive of a moderate strength level. No requirements were provided for comparison.

TABLE 3 – LUG HARDNESS TEST RESULTS – ROCKWELL B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug A1	64	67	66	65	66
Lug A2	58	58	61	60	59

SECTION 4 - NONDESTRUCTIVE EXAMINATION

The end of the disassembled coupling was sent to a third party NDE laboratory for inspection. Visual and liquid dye penetrant inspection were performed on the lug attachment welds. Inspection was performed in accordance with the acceptance criteria of API 1104 “Welding of Pipelines and Related Facilities”. The inspection results are provided as Appendix A. Two representative welds are shown in Figures 8 and 9 with the dye penetrant test media remaining.

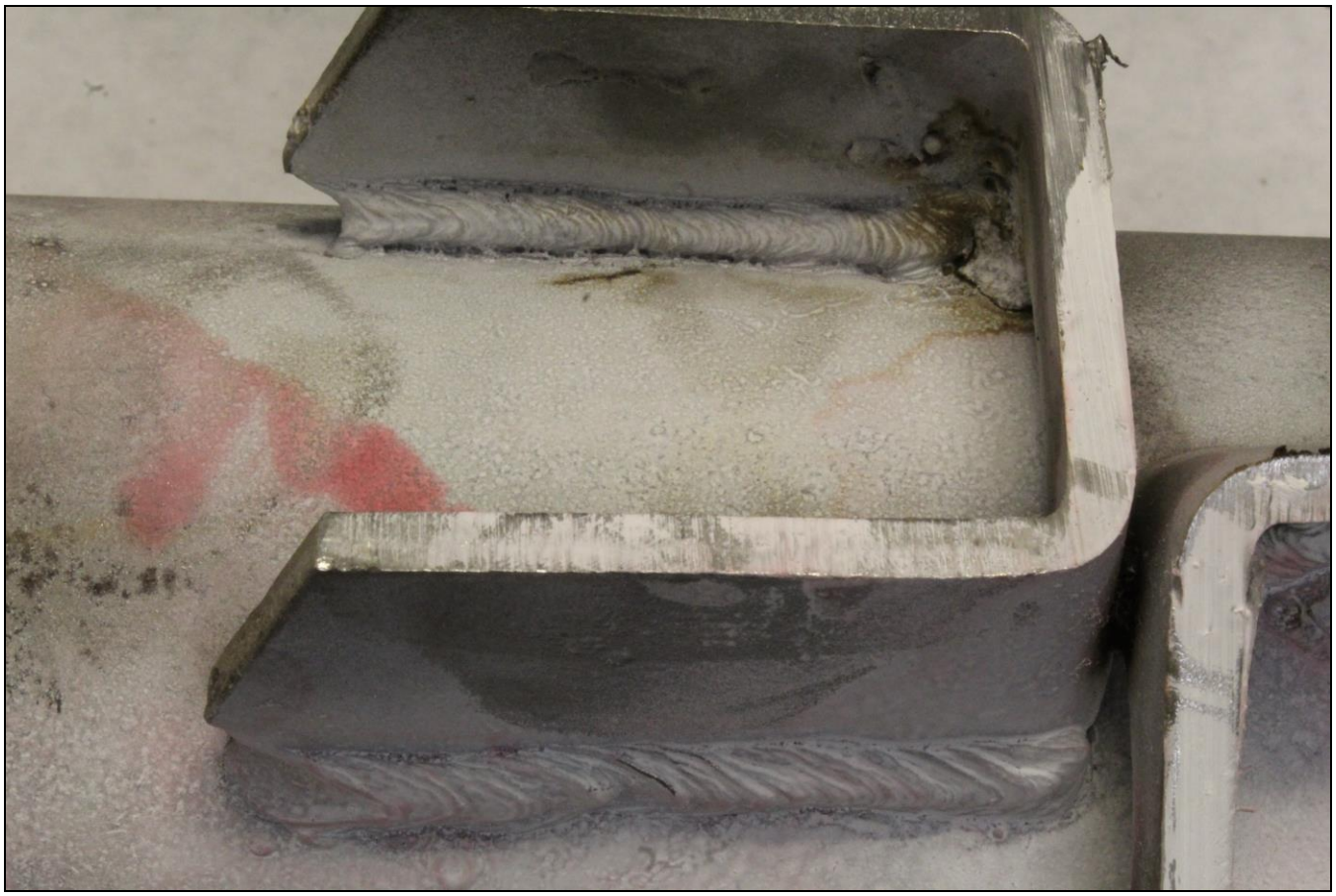


Figure 8. Image of the Lug A2 exterior top welds after dye penetrant media had been used during inspection.

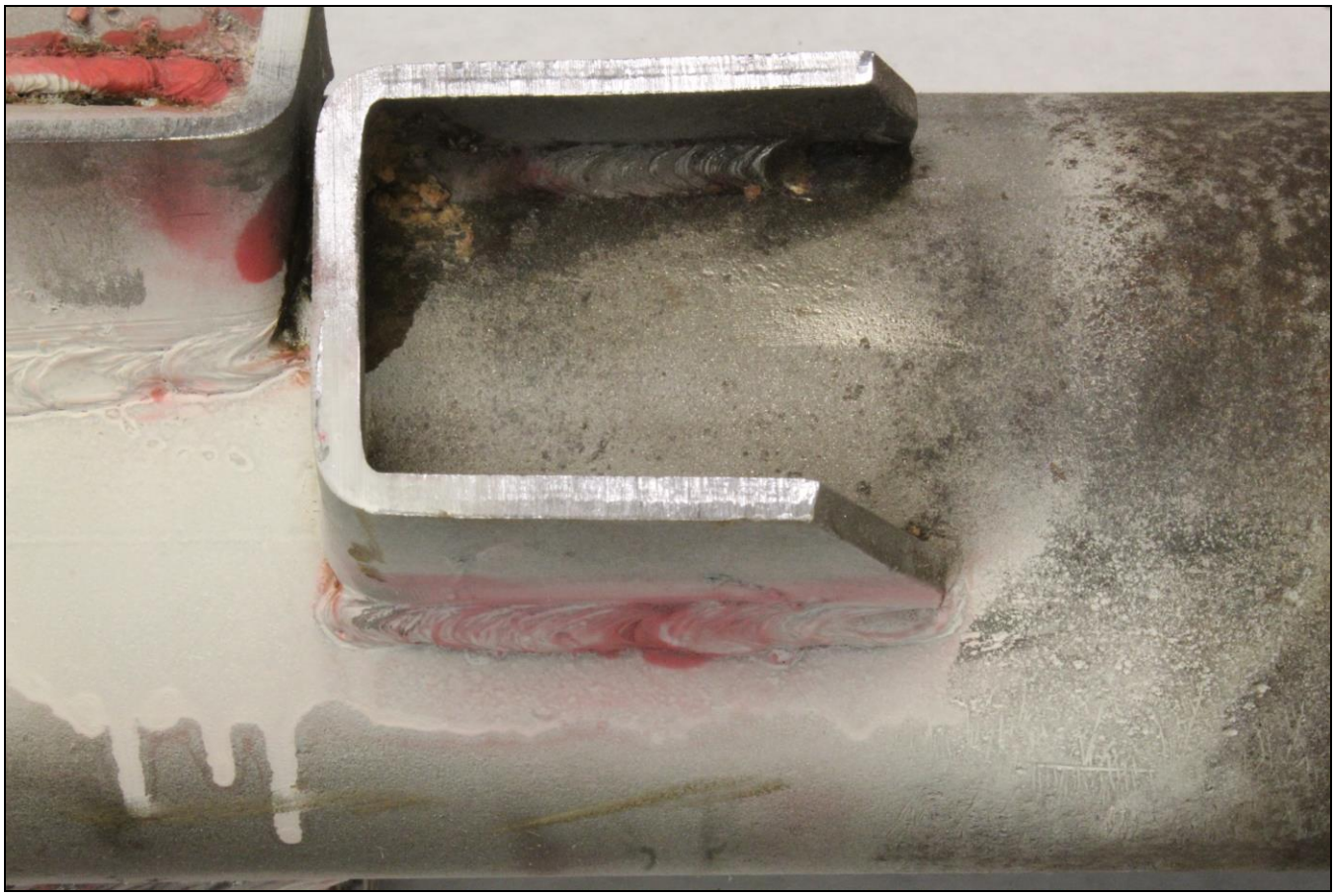


Figure 9. Image of the Lug B2 exterior top welds after dye penetrant media had been used during inspection.

Respectfully submitted

Brian Kelly
Failure Analyst

Concurrence

Phillip Swartzentruber, Ph.D., E.I.T.
Chemistry Department Manager
Failure Analyst

APPENDIX A – LIQUID DYE PENETRANT / VISUAL INSPECTION RECORD

MISTRAS

Liquid Penetrant Examination Report

195 Clarksville Road | Princeton Junction, NJ 08550 | P: (609) 716-4000; F: (609) 716-4145 www.mistrasgroup.com

Client:	IMR TEST LABS	Date:	11/17/2020 Page: 1 of 1
Address:	4510 ROBERTS LANE	Job Number:	
	LOUISVILLE KT40218	Purchase Order:	6671FA
Contact:		Reference Number:	202002566
Location:	MGI LAB	Part No/Description:	N/A

Code/Specification	Procedure	Acceptance Criteria
ASME SEC V,ART 6	100-PT-001 REV20	API 1104

Type and Method

☐ Fluorescent: [Type I] ☐ Water Wash [Method A] ☒ Solvent Removable [Method C] ☐ Post Emulsified: ☐ Hydrophilic [D] ☐ Lipophilic [B]

☒ Red Visible Dye: [Type II] ☐ Water Wash [Method A] ☒ Solvent Removable [Method C] ☐ Post Emulsified [Method B]

Sensitivity Level: ☐ ½ ☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ N/A ☐ Other: N/A

	Manufacturer	Type	Batch Number(s)	Application Method	Process Time (minutes)	
					Pre-clean Dry Time:	15 MIN
Cleaner:	SPOT CHECK	SKC-S	18G14K	SPRAY/CLOTH	Penetrant Dwell Time:	10 MIN
Penetrant:	SPOT CHECK	SKL-SP2	17L02K	BRUSH	Emulsifier Time:	N/A
Developer:	SPOT CHECK	SKD-S2	17J05K	SPRAY	Developer Time:	10 MIN
Emulsifier:	N/A	N/A	N/A	N/A	Post Clean Method:	N/A

Developer Form: ☐ a. Dry Powder ☐ b. Water Soluble ☐ c. Water Suspended ☒ d. Nonaqueous Wet ☐ e. Specific Application

Penetrant Removal Method & Dry Time	Black Light (Model and S/N)	White Light Source
DAMP CLOTH/10MIN	N/A	L.E.D

☒ Original ☐ Repair	Material & Thickness	Test Temperature
	C/S (VARIOUS)	72 F

Surface Condition

☒ As Welded ☐ As Ground ☐ As Cast ☐ Rough Machined ☐ Final Machined ☐ Meets Code Requirements

Test Results	Quantity Inspected: 2	Quantity Accepted: 0	Quantity Rejected: 2

WELD "A"
A-1- REJECTED FOR UNDERCUT AND LACK OF PENATRATION
A-2- REJECTED FOR UNDERCUT AND LACK OF PENATRATION

Technician Name, Level & Date	Customer (if applicable):	Reviewed By (if applicable):
DANIEL WEICK LEVEL II		

Bolt-Style Coupling (pressures > 3 psig)

This form will be completed when LG&E or LG&E contractors expose a bolt-style coupling in a system where the pressure is > 3 psig (medium and high pressure distribution and transmission) and the coupling will be backfilled. The purpose of the form is to provide Operations, Engineering and Gas Regulatory personnel with information about the bolt style coupling installation.

Part A- Discovery of Coupling

Precautions:

1. Stop excavation upon discovering the bolt-style coupling in the excavation
2. Set-up a perimeter around the excavation to keep the public away from the excavation

General Information:

1. Contact Employee for the bolt style coupling found: **Lee Perry (discovery) Bo Taylor (removal)**
2. Date of exposure: **3/23/2020**
3. Location: **1609 Poplar Level Rd. Louisville, KY 40217**
4. Size of coupling (based on pipe size if not exposed enough to determine): 4”
5. Type of soil (circle one): Sandy Clay Gravel Topsoil Other (take picture and describe)
6. Soil Density test: □ Type A □Type B □Type C
7. Status: □ Removed □Abandoned in place □Backfilled- left in service
8. Discovered How?: □ Leak on Coupler □Other Maintenance Excavation □Facility Replacement
   □Facility Retirement □Other_____

Pictures:

1. Take at least two pictures of the coupling. The pictures should be from different angles (additional pictures can be taken).
2. Email pictures to supervisor. Ensure pictures are attached to this form:

Sketch: Provide a sketch showing the coupling orientation (vertical/horizontal), nearby branches, pipe, valves and fittings, other utilities or structures, etc.

Leak Survey:

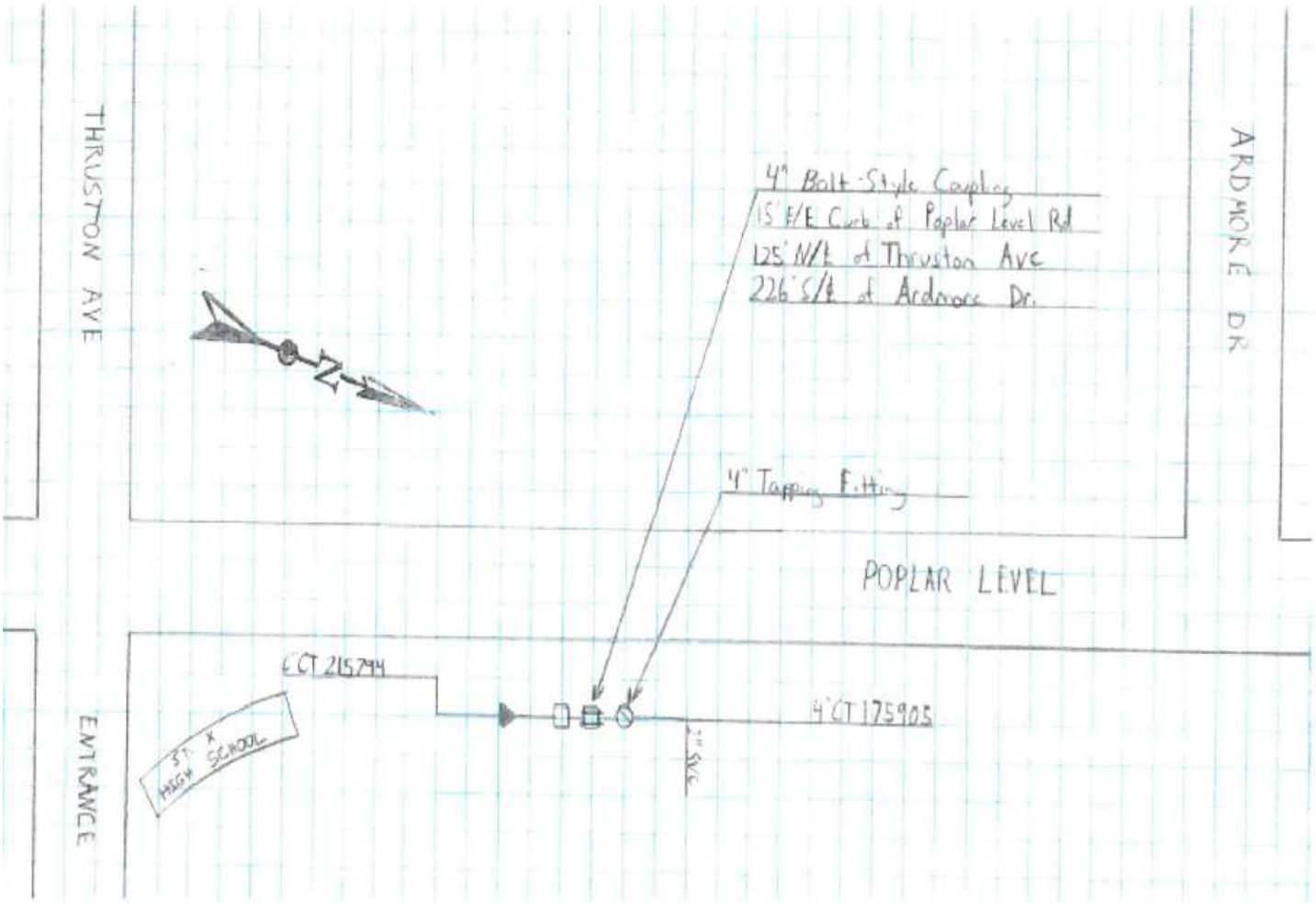
1. Use an instrument designed to detect natural gas to check for the presence of natural gas after backfilling the excavation. Include readings in the above sketch in relation to the coupling. If the contact employee is not leak survey qualified they should contact:
   a. Their supervisor to call Gas Regulatory to complete the survey after the excavation is backfilled. Call [redacted]
   b. If Gas Regulatory is not available contact Gas Dispatch to have the survey assigned to a Gas Trouble Technician.

Leak Survey completed at time of backfill (circle one) yes no not applicable

Include completed form in the main report and email a scanned copy of the completed form (back and front) to the Distribution Integrity Management (DIM) group

Field Pictures

Sketch


THRUSTON AVE
ARDMORE DR
4" Bolt-Style Coupling
15' E/E Curb of Poplar Level Rd
125' N/E of Thruston Ave
226' S/E of Ardmore Dr.
4" Tapping Fitting
POPLAR LEVEL
6" CT 215794
4" CT 175905
5' x HIGH SCHOOL
ENTRANCE
2" SVC

Safety Briefing

Date: 10/22/2020

Employee Name	Employee ID
Erin Holton	[redacted]
Sarah Nicholson	[redacted]

	Hazards Identified
	Sharp edges on cut pipe ends. Wear gloves when handling.
	Pinch points on couplings. Wear gloves when handling.
	Some couplings samples are heavy. Use a partner to assist with moving. Use proper lifting techniques. Wear hard toes shoes.
	Debris may on samples. Wear eye protection.
	Tripping hazards on floor. Keep area clean and free of tripping hazards

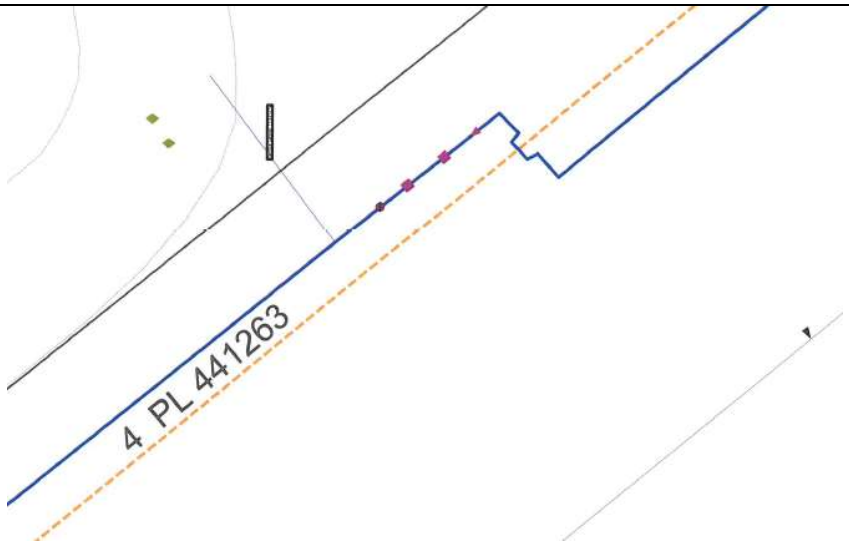
	PPE Required
	Hard toed shoes
	Safety glasses
	Gloves (leather preferred)

Part B- Coupling Information

General Information			Tracking #: 2020-011
PO Number 1070637	Expense Org 004610	Project 158276	Task COUPLER
Address/Location 1609 Poplar Level Rd. Louisville, KY 40217			
Size 4”	Material STL	Coating CT	MAOP 99 PSIG
Main/Service Number 175905	Soil Type (from Part A) Clay	Manufacturer DRESSER	Model
Pipe Connection:	Steel to Steel	Steel to Plastic	Plastic to Plastic

Historical Information	
Installation Date 03/10/1961	Document Source Quest
Installation Company N/A	Document Source
Foreman N/A	Document Source
Welder N/A	Document Source

GIS Information
Sys Id (of Coupler) 73263284
Screen Capture



Pictures (Label the following parts before taking pictures.)

Figure 1 Top View

Figure 2 Side View

Figure 3 Lug A1

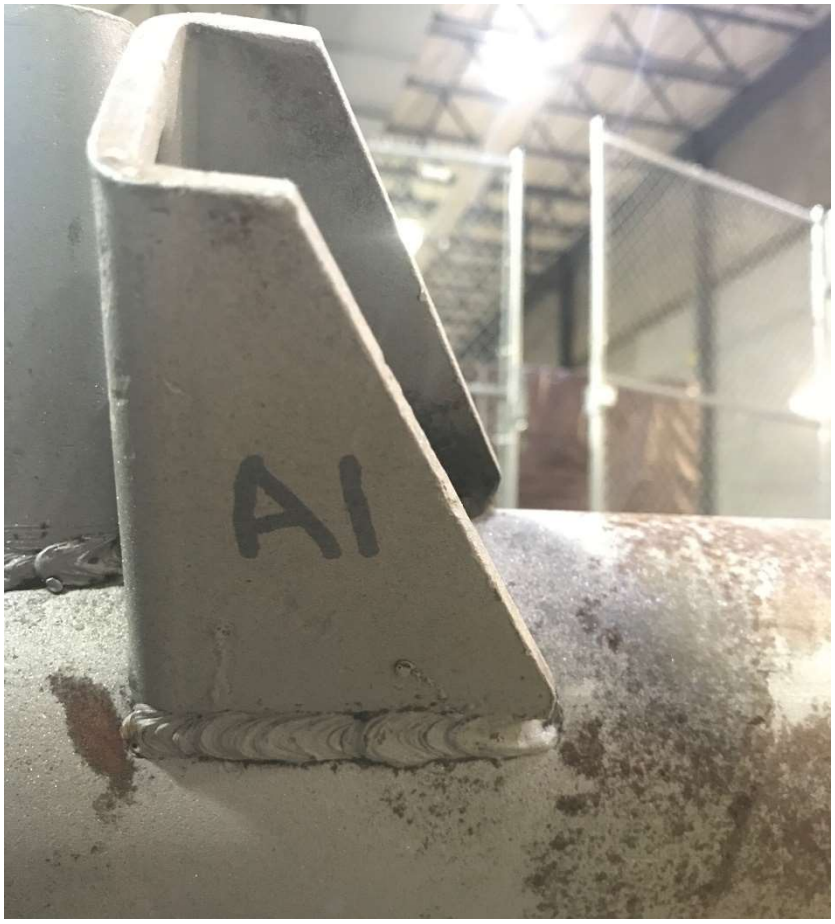


Figure 4 Lug A1 (bottom)

Figure 5 Lug A1 (interior)

Figure 6 Lug A2

Figure 7 Lug A2 (bottom)

Figure 8 Lug A2 (interior)

Part C- Visual Inspection of Coupling

Visual Inspection Performed by: Erin Holton Date: 10/22/2020

Table 1- Component Quantities

Number of Bolts on Coupler Body	N/A
Number of Reinforcement Rods	N/A
Number of Lugs	2

Table 2- Corrosion

	Pipe A	Pipe B	Coupler Body	Bolts	Rods	Lugs	Nuts
General External Corrosion Present?		YES				NO	
Localized Corrosion Present?		NO				NO	
Pit Depths		NO				NO	
Internal Corrosion?		NO					

Table 3- Coupler Body

Bolt	Washer Present	Nut present?
1		
2		
3		
4		
5		
6		

Table 4- Reinforcement Rods

Rod	Length (in.)	Diameter (in.)	Washer present at head of bolt?	Washer present at end of bolt?	Nut Present? Type?	Type of rod?
1						
2						
3						
4						

Type of Lug

(Please indicate the shape of the lug by circling one below. If the lug shape is different than any preset shape below, sketch the shape.)

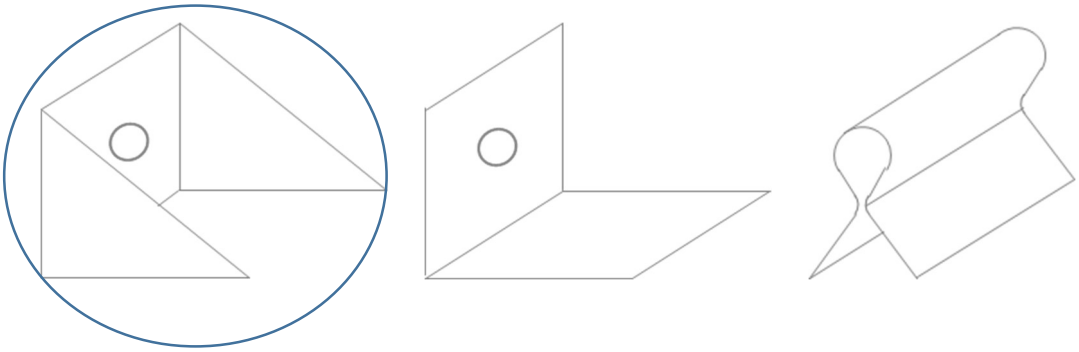


Table 5- Lugs (Measurements)

Pipe Side	Lug Number	Thickness (in.)	Circumference (in)	
			Distance to next lug, clockwise	Distance to next lug, counter-clockwise
A	1	0.22”	4.25	4.75
A	2	0.22”	4.75	4.25
A	3			
B	1			
B	2			
B	3			

Table 6- Lugs (Observations)

Lug	Lug	Assembly sets aligned?	Deformed?	Deflected? (angle of)
A1	B1			
A2	B2			
A3	B3			

Table 7- Lugs (Weld Quality)

Pipe Side	Lug Number	Any part detached from pipe?	Welded on all sides of exterior? If no, describe	Are welds on exterior continuous? If no, describe	Welded on all sides of interior? If no, describe	Are welds on interior continuous? If no, describe
A	1	NO	NO (1 EXT. WELD)	YES	NO (1 INT. WELD)	YES
A	2	No	NO (1 EXT. WELD)	YES	NO (1 INT. WELD)	YES
A	3					
B	1					
B	2					
B	3					

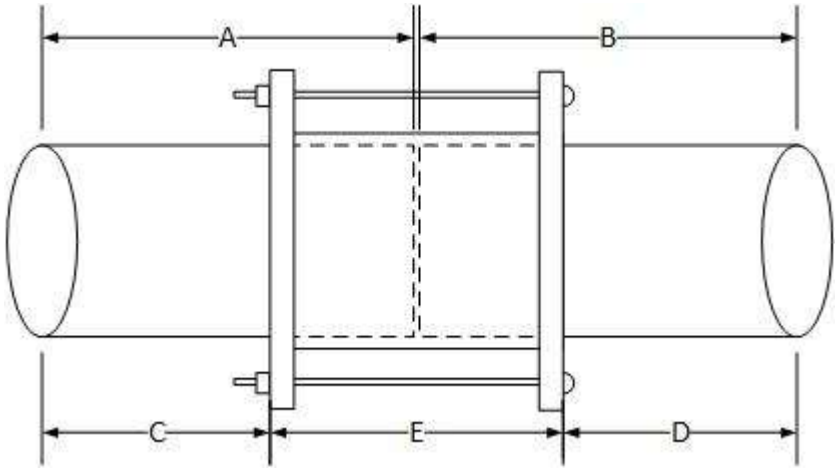


Table 8- Stab Depth

	A	B	C	D	Stab Depth (A-C) or (B-D)
Pipe Side A					0
Pipe Side B					0
	Sum of stab depths (should be closely equal to measurement E)				0
	Coupler Length (E)				
	Difference				

Additional Comments and General Observations

Only lugs present on Coupler 2020-011. Remaining pieces of coupler assembly abandoned in place. Need external analysis on lugs only.

Part D- Analysis of Coupling

The section is designed to be a template for the lab performing analysis of the couplers. The lab may draft a report as a separate document, but the tables below should be used within the report. The tables may be transferred to the report. Rows may be added to any table to accommodate for additional components, but should additional columns be needed for data purposes, please contact LG&E. It is **not** the intention for the table(s) to be completed in duplicate if a separate document is created.

Section 1- Dimensional Measurement

[Insert results summary here]

Table #- Lug Spacing Dimensional Measurements

Compound	Angle	Deviation from 180°	Image
Rod ##/Rod ##			
Rod ##/Rod ##			

Table # – Pipe Coupling Dimensional Measurements

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A		
Pipe B		

[Insert associated pictures and figures here]

Section 2- Visual Observations

[Insert results summary here]

Table # – Lug Weld Visual Examination Results

Component	Location	Weld	Observations
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	

TABLE # – Fastener Visual Examination Results

Component	Observations
Rod #	
Rod #	
Bolt #	
Bolt #	
Bolt #	
Bolt #	

[Insert associated pictures and figures here]

Section 3- Torque Testing- for information only

[Insert results summary here]

TABLE # – Fastener Torque Measurement

Component	Breakaway Torque	Observations
Rod #		
Rod #		
Bolt #		
Bolt #		
Bolt #		
Bolt #		

[Insert associated pictures and figures here]

Section 4- Tensile Testing, ASTM A370-17a

[Insert results summary here]

Table # – Fastener Tension Test Results

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %	Reduction in Area, %
Rod #				
Rod #				
Bolt #				
Bolt #				
Bolt #				
Bolt #				

[Insert associated pictures and figures here]

Section 5- Rockwell and Superficial Hardness, ASTM E18-17

[Insert results summary here]

TABLE # – Lug Hardness Test Results – Rockwell B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug ##					
Lug ##					
Lug ##					
Lug ##					

[Insert associated pictures and figures here]

Section 6- Mag Particle/Dye Penetrant Test

[Insert results summary here]

[Insert results table here]

[Insert associated pictures and figures here]

IMR TEST LABS
A Curtiss-Wright Business Unit
www.imrlouisville.com

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Louisville, KY 40218
T: 1.502.810.9007 | **F**: 1.502.810.0380

LG&E - Kentucky Utilities
6900 Enterprise Drive
Louisville, KY 40214

November 30, 2020

Attention: Sarah Nicholson

Exhibit C

Report No. 202002563

Metallurgical Evaluation of an 8" Coupling and Associated Hardware

Location: 796 Eastern Parkway

DESCRIPTION AND PURPOSE

A natural gas pipe section including a coupling was submitted for metallurgical evaluation. The section was an 8” pipe with a Dresser Style 39 Insulating Coupling. Three joint harnesses were also affixed to the pipe section. Copies of the installation information for the coupling and harnesses were provided for this investigation. It was reported that the coupling had been installed in the field at 796 Eastern Parkway on April 13, 1956. The pipe section was subsequently excavated after substantial service duration without failure. It was requested that the general dimensions, weld quality, corrosion condition and mechanical properties of the coupling components be determined as directed.

RESULTS

The submitted pipe section with the coupling is shown in Figures 1 through 4. Three lugs of the joint harnesses had been fillet welded to both pipe segments. Three rods and associated nuts had been affixed through the welded lugs to apply compression to the coupled joint. The coupling consisted of a steel coupling with an interior nonmetallic gasket / sleeve. Prior to receipt, the ends of the pipe segment were labelled as Ends A and B, as shown in Figures 1 through 4. The top and bottom of the coupling section were also marked. Lugs A1, A3 and A5 were welded to Pipe A, and Lugs B1, B3 and B5 were welded to Pipe B. The rod between Lugs A1 and B1 was identified as Rod 1. The remaining lugs were identified in a corresponding fashion.

Atypical for the couplings, three of the coupling holes accommodated the rods with standard bolts through the remaining three coupling holes.

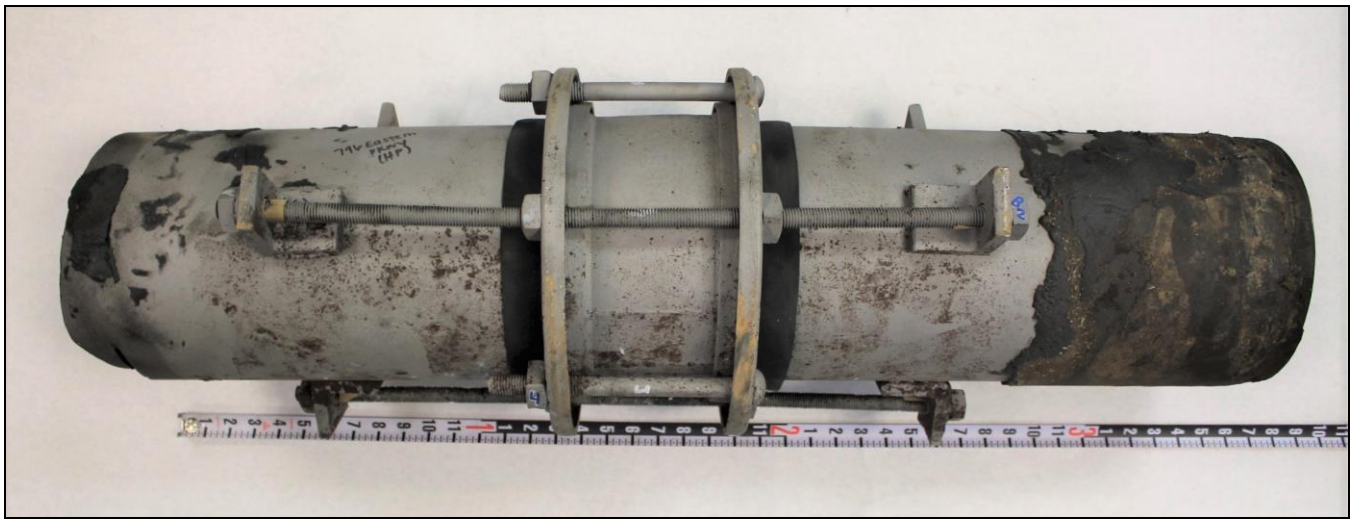


Figure 1. Photograph of the top of the submitted coupling sample.

Figure 2. Photograph of the bottom of the submitted sample.

SECTION 1- DIMENSIONAL MEASUREMENT

The three sets of harness lugs were positioned around the pipe. The relative orientations of the harness lugs were measured by photographing the assembly from the ends and applying a protractor overlay for angle measurement. The obtained measurements are shown in Figures 3 and 4 with the data summarized in Table 1. The depth of insertion of the pipe segments into the coupling was also measured and the dimensions are provided in Table 2. No requirements were provided for these characteristics.

TABLE 1 – LUG SPACING DIMENSIONAL MEASUREMENTS

Component	Angle	Deviation from 120°	Image
Rod A1 / Rod A3	119°	0°	Figure 3
Rod A3 / Rod A5	129°	9°	Figure 3
Rod B1 / Rod B3	121°	1°	Figure 4
Rod B3 / Rod B5	117°	3°	Figure 4

TABLE 2 – PIPE COUPLING DIMENSIONAL MEASUREMENTS

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A	3”	1/2” (Original sample length – 39”)
Pipe B	3”	

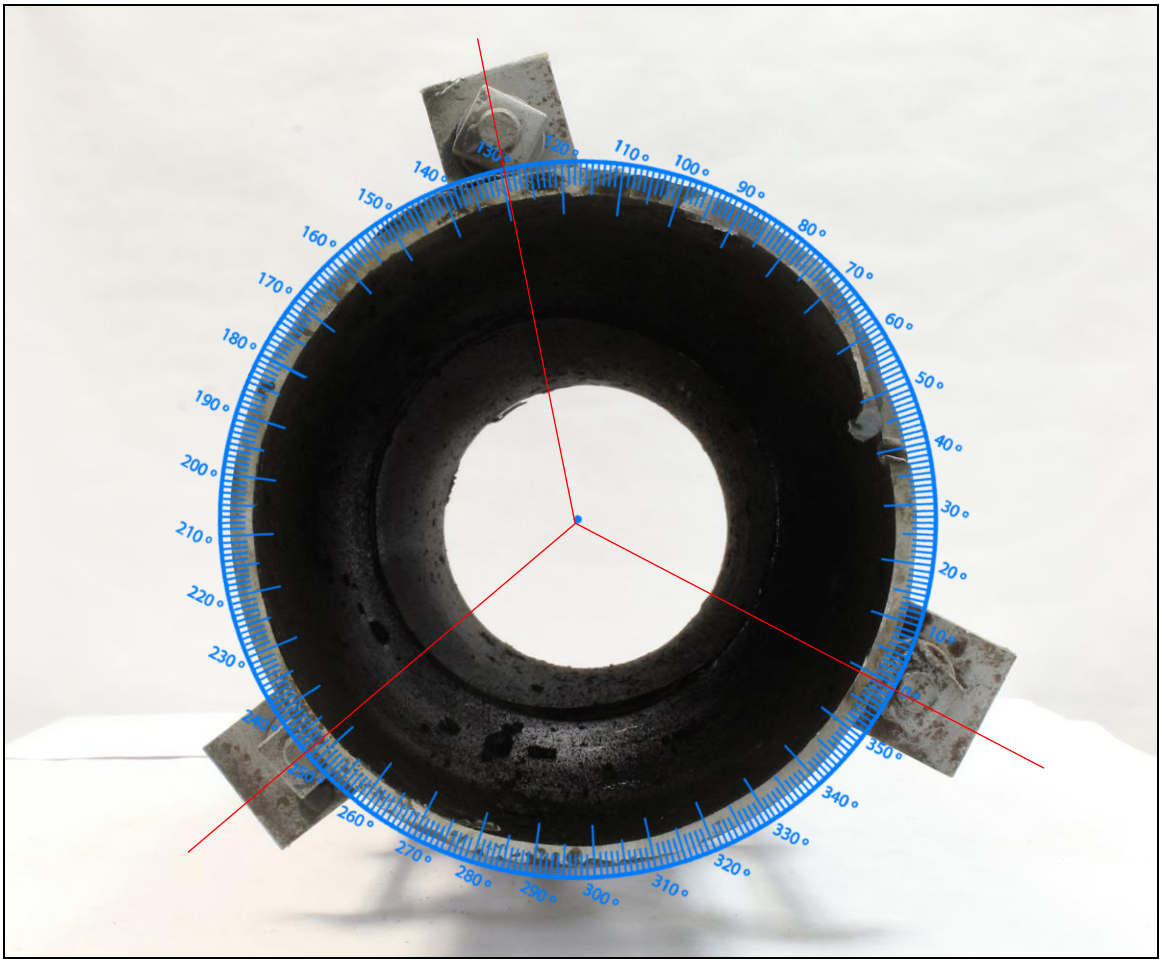


Figure 3. End facing image of the sample at End A with a superimposed protractor.

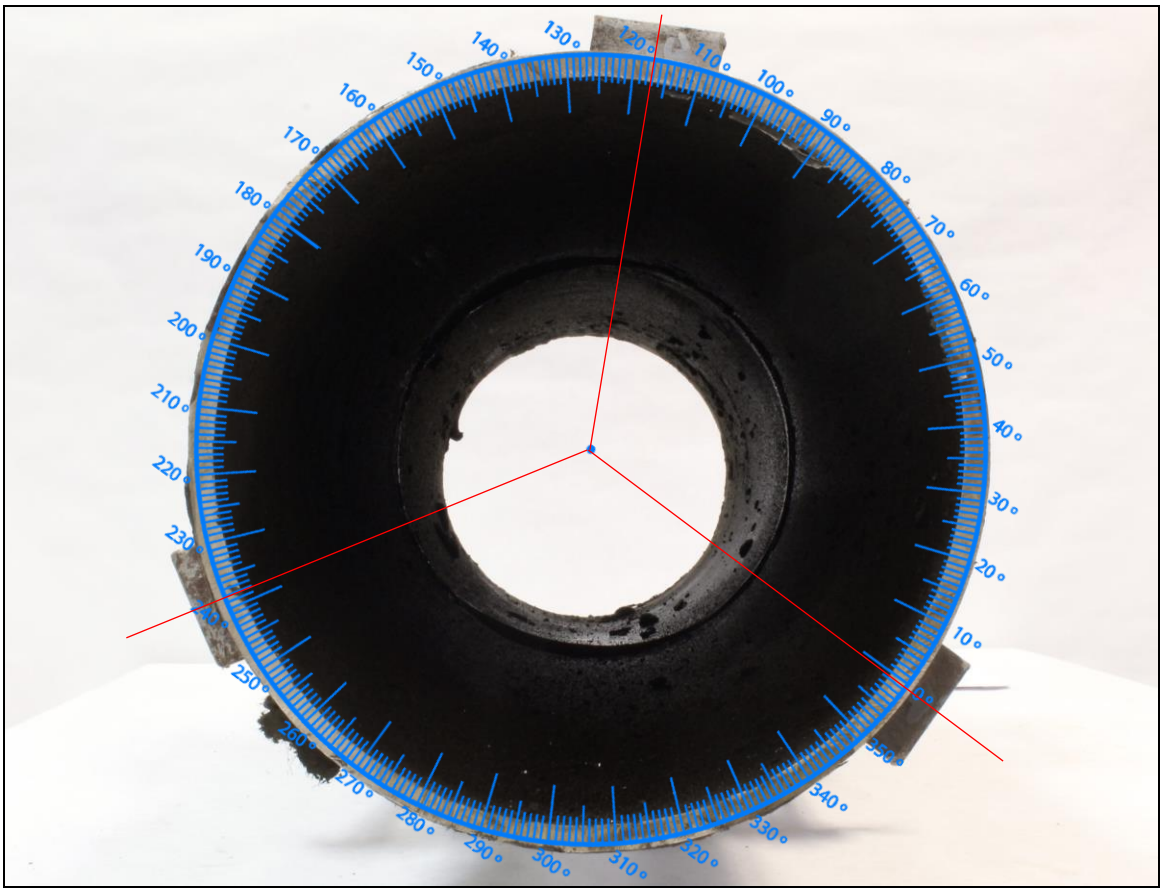


Figure 4. End facing image of the sample at End B with a superimposed protractor.

SECTION 2- VISUAL OBSERVATIONS

The lug attachment welds were regions of interest on the pipe coupling sample. Each lug contained two fillet weld locations; exterior top and exterior bottom. Each weld that was present was inspected visually using a flashlight and magnifying lens. It was indicated that welding was performed in accordance with API 1104. General weld inspection was performed initially, followed by visual inspection by an outside NDE company. For comparison purposes, the welds were rated as substantial fusion, partial fusion, and minimal fusion. The summarized weld fusion and corrosion observations are provided in Table 3. Representative weld regions are shown in Figures 5 through 12. The welds contained localized weld discontinuities including undercut, porosity, and spatter. No cracking in the welds or base metal heat affected zones (HAZ) was visually identified. Some superficial corrosion of the coupling and associated hardware was observed, as well as several areas of significant material loss.

The coupling and harness rods were also inspected for corrosion alteration. Several areas of significant corrosion were identified. The observations for the rods and bolts are provided in Table 4. No corrosion cracking was evident. The rods were not necked down or stretched.

The elastomeric components of the coupling consisted of a pipe separator, insulating sleeve, and two gaskets. Inspection revealed that they appeared to be intact and not degraded.

TABLE 3 – LUG WELD VISUAL EXAMINATION RESULTS

Component	Location	Weld	Observations
Lug A1	Exterior	Top	Substantial fusion
		Bottom	No Weld
Lug A3	Exterior	Top	Substantial fusion
		Bottom	No Weld
Lug A5	Exterior	Top	Substantial fusion
		Bottom	No Weld
Lug B1	Exterior	Top	Substantial fusion
		Bottom	Substantial fusion
Lug B3	Exterior	Top	Substantial fusion
		Bottom	Partial fusion
Lug B5	Exterior	Top	Substantial fusion
		Bottom	Minimal fusion

TABLE 4 – FASTENER VISUAL EXAMINATION RESULTS

Component	Observations
Rod 1	Not bent or stretched, no substantial corrosion pitting
Rod 3	Bent, Substantial corrosion observed
Rod 5	Not bent or stretched, no substantial corrosion pitting
Bolt 2	Not bent or stretched, no substantial corrosion pitting
Bolt 4	Not bent or stretched, Substantial corrosion observed
Bolt 6	Bent but not stretched, no substantial corrosion pitting

Figure 5. Image of the Lug A1 exterior top weld which exhibited substantial fusion except for some arc burn and undercut.

Figure 6. Image of the Lug A3 exterior top weld which exhibited substantial fusion except for some spatter and undercut.

Figure 7. Image of the Lug A5 exterior bottom weld which exhibited no fusion.

Figure 8. Image of the Lug B1 exterior top weld which exhibited substantial fusion except for some arc burn, spatter, porosity and undercut.

Figure 9. Image of the Lug B3 exterior top weld which exhibited substantial fusion except for some arc burn, porosity, spatter and undercut.

Figure 10. Image of the Lug B5 exterior bottom weld which exhibited minimal fusion.

Figure 11. Image of the Bolt A4 fastener assembly which exhibited corrosion and pitting.

Figure 12. Image of the pipe exterior wall surface which exhibited substantial pitting damage.

SECTION 3- TORQUE TESTING- FOR INFORMATION ONLY

Torque testing was performed on the nuts of the rods and bolts on the pipe coupling sample. A calibrated torque wrench was used to determine breakaway torque on each fastener. The breakaway torque measurements are summarized in Table 5. Rod fasteners did not have a specified torque requirement. The designation “Inner” signifies the rod nut at the coupling face. The six coupling bolts exhibited torque values ranging from 35 to 110 ft.-lbs. Bolt 2 and Rod 1 and 3 Outer torque values were below the Dresser Style 39 coupling installation torque recommendation of 75 ft.-lbs. minimum for 5/8” fasteners.

TABLE 5 – FASTENER TORQUE MEASUREMENT

Component	Breakaway Torque	Observations
Rod 1 Inner	80 ft.-lbs.	Satisfied the recommended torque
Rod 1 Outer	35 ft.-lbs.	Did not satisfy the recommended torque
Rod 3 Inner	75 ft.-lbs.	Satisfied the recommended torque
Rod 3 Outer	Rotates Freely	Did not satisfy the recommended torque
Rod 5 Inner	80 ft.-lbs.	Satisfied the recommended torque
Rod 5 Outer	80 ft.-lbs.	Satisfied the recommended torque
Bolt 2	55 ft.-lbs.	Did not satisfy the recommended torque
Bolt 4	80 ft.-lbs.	Satisfied the recommended torque
Bolt 6	110 ft.-lbs.	Satisfied the recommended torque

SECTION 4- TENSILE TESTING, ASTM A370-17A

Tensile testing was performed on round specimens that were removed from the three harness rods and the three coupling bolts. The tensile mechanical properties of the fasteners were measured and the results are summarized in Table 6. No mechanical property requirements were provided for the fasteners.

TABLE 6 – FASTENER TENSION TEST RESULTS

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %②	Reduction in Area, %
Rod 1①	137	120	22	64
Rod 3①	136	120	23	62
Rod 5①	138	120	24	65
Bolt 2①③	75.5	37.8	33	53
Bolt 4①	74.0	40.8	35	60
Bolt 6①	72.5	41.1	36	62

① Specimen Dimensions; Diameter 0.25” with gage length of 1.00”
② Percent elongation was measured using elongation-after-fracture measurements
③ Interrupted Test

SECTION 5- ROCKWELL HARDNESS, ASTM E18-20

Small sections of the six lugs were excised for hardness testing. Rockwell hardness testing was performed on sectioned segments of the lugs after the removal of surface roughness by sanding. The obtained results are provided in Table 7 and are suggestive of a moderate strength level. No requirements were provided for comparison.

TABLE 7 – LUG HARDNESS TEST RESULTS – ROCKWELL B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug A1	72	78	74	68	73
Lug A3	63	63	76	76	70
Lug A5	66	70	73	67	69
Lug B1	64	72	74	74	71
Lug B3	65	69	70	70	68
Lug B5	65	69	70	69	68

SECTION 6- NONDESTRUCTIVE EXAMINATION

The two separated ends of the disassembled coupling were sent to a third party NDE laboratory for inspection. Visual and liquid dye penetrant inspections were performed on the lug attachment welds. Inspection was performed in accordance with the acceptance criteria of API 1104 “Welding of Pipelines and Related Facilities”. The inspection results are provided as Appendix A. Two representative welds are shown in Figures 13 and 14 with the dye penetrant test media remaining.

Figure 13. Image of the Lug B5 exterior bottom welds after dye penetrant media had been used during inspection.

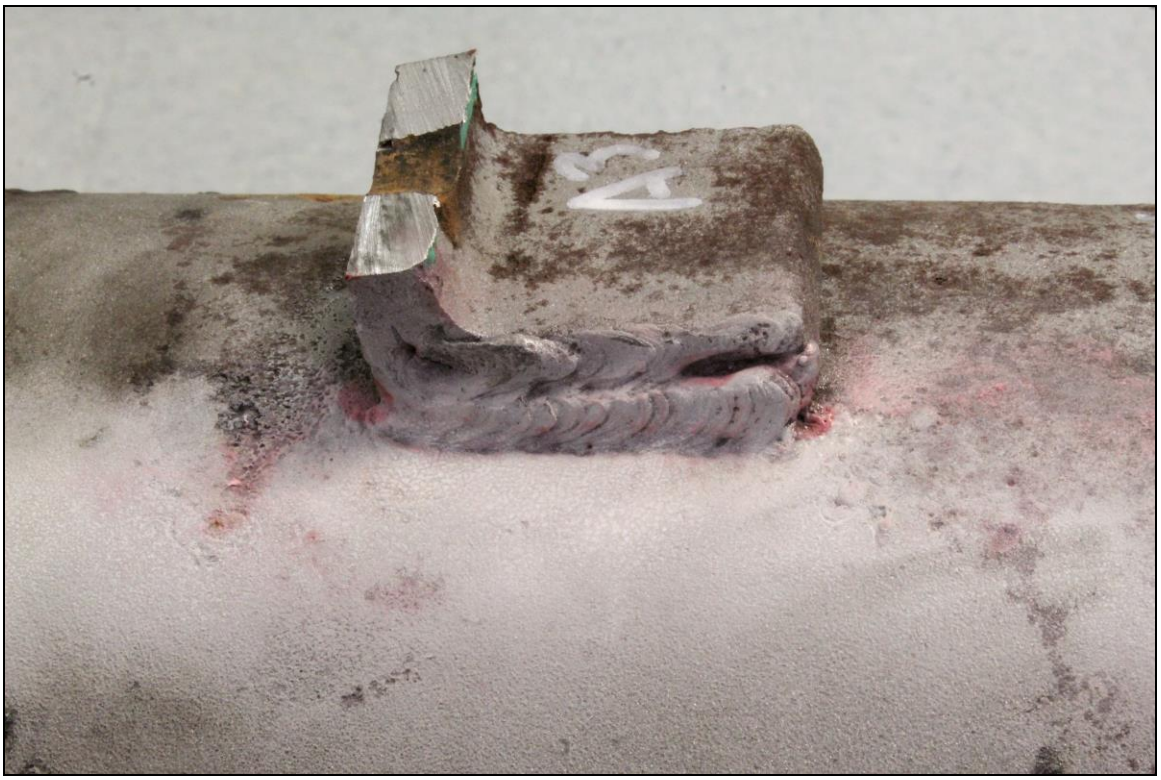


Figure 14. Image of the Lug A3 exterior top welds after dye penetrant media had been used during inspection.

Respectfully submitted

Brian Kelly
Failure Analyst

Concurrence

Phillip Swartzentruber, Ph.D., E.I.T.
Chemistry Department Manager
Failure Analyst

APPENDIX A – LIQUID DYE PENETRANT / VISUAL INSPECTION RECORD

MISTRAS

Liquid Penetrant Examination Report

195 Clarksville Road | Princeton Junction, NJ 08550 | P: (609) 716-4000; F: (609) 716-4145 www.mistrasgroup.com

Client:	IMR TEST LABS	Date:	11/17/2020 Page: 1 of 1
Address:	4510 ROBERTS LANE	Job Number:	
	LOUISVILLE KT40218	Purchase Order:	6668FA
Contact:		Reference Number:	202002563
Location:	MGI LAB	Part No/Description:	A&B

Code/Specification	Procedure	Acceptance Criteria
ASME SEC V,ART 6	100-PT-001 REV20	API 1104

Type and Method

☐ Fluorescent: [Type I]	☐ Water Wash [Method A]	☒ Red Visible Dye: [Type II]	☐ Water Wash [Method A]
	☒ Solvent Removable [Method C]		☒ Solvent Removable [Method C]
	☐ Post Emulsified: ☐ Hydrophilic [D] ☐ Lipophilic [B]		☐ Post Emulsified [Method B]
Sensitivity Level:	☐ ½ ☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ N/A	☐ Other: N/A	

	Manufacturer	Type	Batch Number(s)	Application Method	Process Time (minutes)	
					Pre-clean Dry Time:	15 MIN
Cleaner:	SPOT CHECK	SKC-S	18G14K	SPRAY/CLOTH	Penetrant Dwell Time:	10 MIN
Penetrant:	SPOT CHECK	SKL-SP2	17L02K	BRUSH	Emulsifier Time:	N/A
Developer:	SPOT CHECK	SKD-S2	17J05K	SPRAY	Developer Time:	10 MIN
Emulsifier:	N/A	N/A	N/A	N/A	Post Clean Method:	N/A

Developer Form: ☐ a. Dry Powder ☐ b. Water Soluble ☐ c. Water Suspended ☒ d. Nonaqueous Wet ☐ e. Specific Application

Penetrant Removal Method & Dry Time	Black Light (Model and S/N)	White Light Source
DAMP CLOTH/10MIN	N/A	L.E.D

☒ Original ☐ Repair	Material & Thickness	Test Temperature
	C/S (VARIOUS)	72 F

Surface Condition
☒ As Welded ☐ As Ground ☐ As Cast ☐ Rough Machined ☐ Final Machined ☐ Meets Code Requirements

Test Results	Quantity Inspected: 6	Quantity Accepted: 0	Quantity Rejected: 6

PART "A"
A-1- REJECTED FOR PIN HOLE POROSITY AND UNDERCUT
A-2- REJECTED FOR PIN HOLE POROSITY AND UNDERCUT
A-3- REJECTED FOR COLD LAP, SURFACE AND PIN HOLE POROSITY

PART "B"
B-1- REJECTED FOR UNDERCUT, PIN HOLE AND SURFACE POROSITY, LACK OF FILL
B-2- REJECTED FOR LACK OF FILL , SURFACE AND PIN HOLE POROSITY
B-3- REJECTED FOR LACK OF FILL AND UNDERCUT

Technician Name, Level & Date	Customer (if applicable):	Reviewed By (if applicable):
DANIEL WEICK LEVEL II		

Certification of Inspection, Liquid Penetrant [Basic Report Form] 100-PTFORM-002 | Rev 1

Bolt-Style Coupling (pressures > 3 psig)

This form will be completed when LG&E or LG&E contractors expose a bolt-style coupling in a system where the pressure is > 3 psig (medium and high pressure distribution and transmission) and the coupling will be backfilled. The purpose of the form is to provide Operations, Engineering and Gas Regulatory personnel with information about the bolt style coupling installation.

Part A- Discovery of Coupling

Precautions:

1. Stop excavation upon discovering the bolt-style coupling in the excavation
2. Set-up a perimeter around the excavation to keep the public away from the excavation

General Information:

1. Contact Employee for the bolt style coupling found: **Bo Taylor**
2. Date of exposure: **7/28/2020**
3. Location: **796 Eastern Pkwy. Louisville, KY 40217**
4. Size of coupling (based on pipe size if not exposed enough to determine): 8”
5. Type of soil (circle one): Sandy Clay Gravel Topsoil Other (take picture and describe)
6. Soil Density test: □ Type A □Type B □Type C
7. Status: □ Removed □Abandoned in place □Backfilled- left in service
8. Discovered How?: □ Leak on Coupler □Other Maintenance Excavation □Facility Replacement
   □Facility Retirement □Other_____

Pictures:

1. Take at least two pictures of the coupling. The pictures should be from different angles (additional pictures can be taken).
2. Email pictures to supervisor. Ensure pictures are attached to this form:

Sketch: Provide a sketch showing the coupling orientation (vertical/horizontal), nearby branches, pipe, valves and fittings, other utilities or structures, etc.

Leak Survey:

1. Use an instrument designed to detect natural gas to check for the presence of natural gas after backfilling the excavation. Include readings in the above sketch in relation to the coupling. If the contact employee is not leak survey qualified they should contact:
   a. Their supervisor to call Gas Regulatory to complete the survey after the excavation is backfilled. Call [redacted]
   b. If Gas Regulatory is not available contact Gas Dispatch to have the survey assigned to a Gas Trouble Technician.

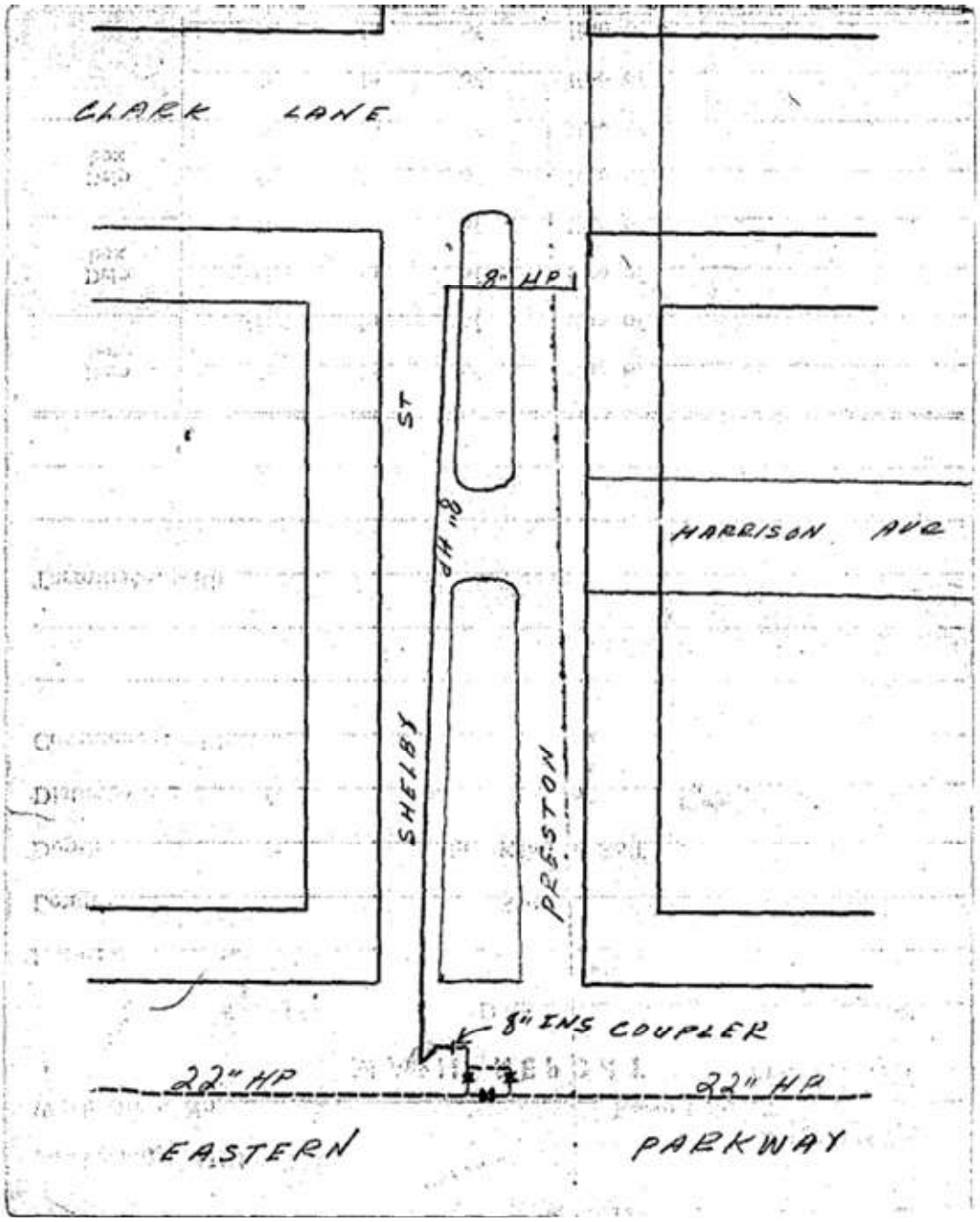
Leak Survey completed at time of backfill (circle one) yes no not applicable

Include completed form in the main report and email a scanned copy of the completed form (back and front) to the Distribution Integrity Management (DIM) group.

Field Pictures

[Pictures not provided by field]

Sketch


CLARK LANE
8" HP
ST
HARRISON AVE
SHELBY
PRESTON
8" INS COUPLER
22" HP
22" HP
EASTERN
PARKWAY

Safety Briefing

Date: 10/14/2020

Employee Name	Employee ID
Craig Meade	[redacted]
Sarah Nicholson	[redacted]

	Hazards Identified
	Sharp edges on cut pipe ends. Wear gloves when handling.
	Pinch points on couplings. Wear gloves when handling.
	Some couplings samples are heavy. Use a partner to assist with moving. Use proper lifting techniques. Wear hard toes shoes.
	Debris may on samples. Wear eye protection.
	Tripping hazards on floor. Keep area clean and free of tripping hazards

	PPE Required
	Hard toed shoes
	Safety glasses
	Gloves (leather preferred)

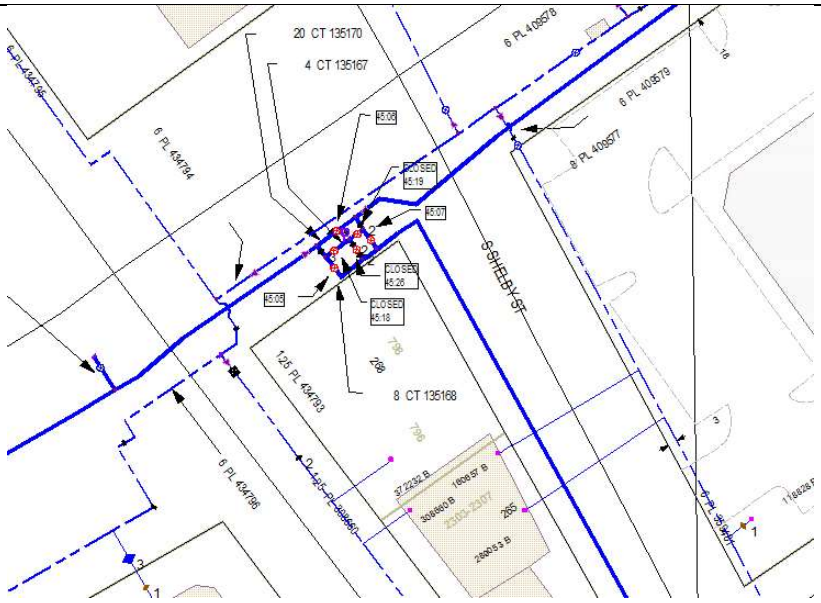
Part B- Coupling Information

General Information			Tracking #: 2020-020
PO Number	Expense Org	Project	Task
1070637	004610	158276	COUPLER
Address/Location			
796 Eastern Pkwy. Louisville, KY 40217 (Eastern Pkwy @ Shelby St.)			
Size	Material	Coating	MAOP
8”	STL	CT	99 PSIG
Main/Service Number	Soil Type (from Part A)	Manufacturer	Model
137295	Clay	DRESSER	

Pipe Connection:	Steel to Steel	Steel to Plastic	Plastic to Plastic

Historical Information	
Installation Date	Document Source
4/13/1956	Quest
Installation Company	Document Source
N/A	
Foreman	Document Source
C U Young	Quest
Welder	Document Source
N/A	

GIS Information
Sys Id (of Coupler)
11239007
Screen Capture



Pictures (Label the following parts before taking pictures.)

Figure 1 Top View

Figure 2 Coupler Body

Figure 3 Bottom View

Figure 4 Pipe A, Lug A1

Figure 5 Pipe A, Lug A2 and A3

Figure 6 Pipe B, Lug B1

Figure 7 Pipe B, Lug B2 and B3

Figure 8 Pipe A Pits

Figure 9 Coupler Pits 2-5

Figure 10 Coupler Pits 1

Figure 11 Pipe B Pits

Part C- Visual Inspection of Coupling

Visual Inspection Performed by: Sarah Nicholson and Craig Meade Date: 10/14/2020

Table 1- Component Quantities

Number of Bolts on Coupler Body	4
Number of Reinforcement Rods	3
Number of Lugs	6

Table 2- Corrosion

	Pipe A	Pipe B	Coupler Body	Bolts	Rods	Lugs	Nuts
General External Corrosion Present?	YES	YES	YES	YES	YES	YES	NO
Localized Corrosion Present?	YES	YES	YES	YES	YES	YES	NO
Pit Depths	YES	YES	YES	NO	YES	NO	NO
Internal Corrosion?	NO	NO					

Table 3- Coupler Body

Bolt	Washer Present	Nut present?
1	NO	YES
2	NO	YES
3	NO	YES
4	NO	YES
5		
6		

Table 4- Reinforcement Rods

Rod	Length (in.)	Diameter (in.)	Washer present at head of bolt?	Washer present at end of bolt?	Nut Present? Type?	Type of rod?
1	22 ½"	0.59"	YES	YES	SQUARE	THREADED
2	24 ½"	0.57"	YES	YES	SQUARE	THREADED
3	24 ½"	0.60"	YES	YES	SQUARE	THREADED
4						

Type of Lug

(Please indicate the shape of the lug by circling one below. If the lug shape is different than any preset shape below, sketch the shape.)

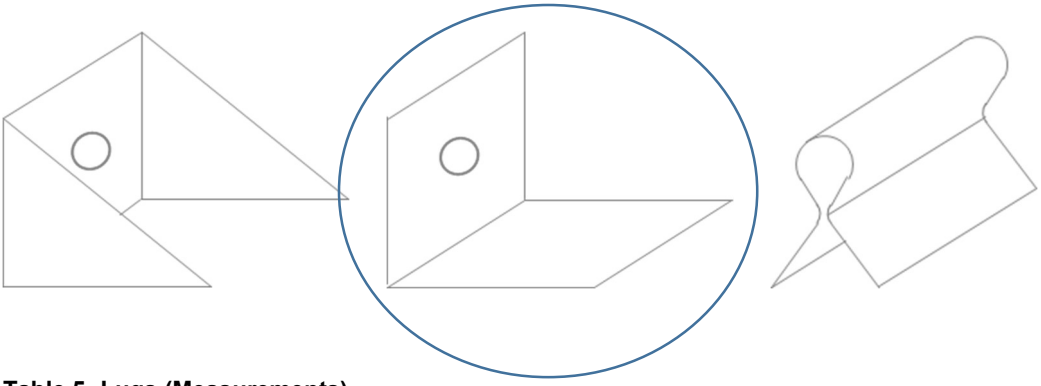


Table 5- Lugs (Measurements)

Pipe Side	Lug Number	Thickness (in.)	Circumference (in)	
			Distance to next lug, clockwise	Distance to next lug, counter-clockwise
A	1	0.50"	7.25	6.875
A	2	0.50"	7.5	7.5
A	3	0.48"	7	7.5
B	1	0.48"	7.25	7
B	2	0.48"	7	7.25
B	3	0.47"	7.125	7.125

Table 6- Lugs (Observations)

Lug	Lug	Assembly sets aligned?	Deformed?	Deflected? (angle of)
A1	B1	YES	NO	NO
A2	B2	YES	NO	NO
A3	B3	NO	NO	NO

Table 7- Lugs (Weld Quality)

Pipe Side	Lug Number	Any part detached from pipe?	Welded on all sides of exterior? If no, describe	Are welds on exterior continuous? If no, describe	Welded on all sides of interior? If no, describe	Are welds on interior continuous? If no, describe
A	1	NO	NO (1 EXT. WELD)	YES	NO	NO
A	2	NO	NO (1 EXT. WELD)	YES	NO	NO
A	3	NO	NO (1 EXT. WELD)	YES	NO	NO
B	1	NO	NO (2 EXT. WELDS)	NO	NO	NO
B	2	NO	NO (1 EXT. WELD)	NO	NO	NO
B	3	NO	NO (2 EXT. WELDS)	NO	NO	NO

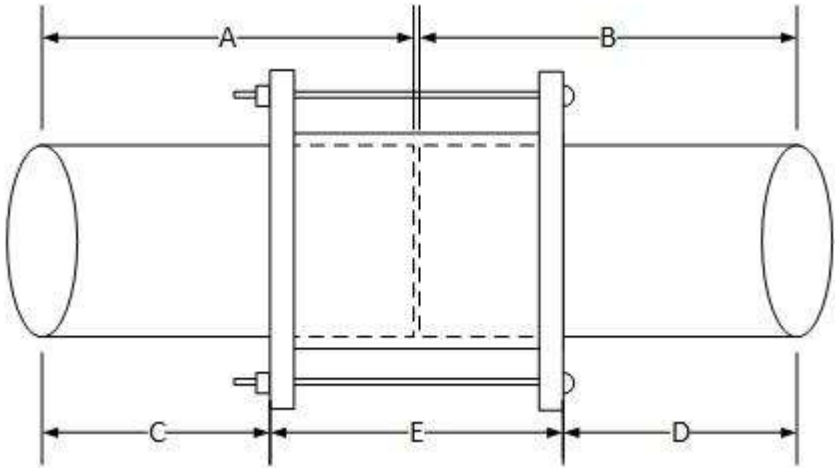


Table 8- Stab Depth

	A	B	C	D	Stab Depth (A-C) or (B-D)
Pipe Side A	18 ¾”		15 ¼”		3 ½”
Pipe Side B		21 ½”		18”	3 ½”
	Sum of stab depths (should be closely equal to measurement E)				7”
	Coupler Length (E)				6 ½”
	Difference				½”

Additional Comments and General Observations

HP coupler; IMR inspection required.

Pit	Depth (in)
A1	0.130
A2	0.105
A3	0.080
A4	0.085
A5	0.110
A6	0.170
A7	0.150
A8	0.175
A9	0.135
A10	0.130
B1	0.075
C1	0.075
C2	0.053
C3	0.055
C4	0.067
C5	0.047

*C#=coupler, pit number

*Note: hand pit depth gauge was used

Part D- Analysis of Coupling

The section is designed to be a template for the lab performing analysis of the couplers. The lab may draft a report as a separate document, but the tables below should be used within the report. The tables may be transferred to the report. Rows may be added to any table to accommodate for additional components, but should additional columns be needed for data purposes, please contact LG&E. It is **not** the intention for the table(s) to be completed in duplicate if a separate document is created.

Section 1- Dimensional Measurement

[Insert results summary here]

Table #- Lug Spacing Dimensional Measurements

Compound	Angle	Deviation from 180°	Image
Rod ##/Rod ##			
Rod ##/Rod ##			

Table # – Pipe Coupling Dimensional Measurements

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A		
Pipe B		

[Insert associated pictures and figures here]

Section 2- Visual Observations

[Insert results summary here]

Table # – Lug Weld Visual Examination Results

Component	Location	Weld	Observations
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	

TABLE # – Fastener Visual Examination Results

Component	Observations
Rod #	
Rod #	
Bolt #	
Bolt #	
Bolt #	
Bolt #	

[Insert associated pictures and figures here]

Section 3- Torque Testing- for information only

[Insert results summary here]

TABLE # – Fastener Torque Measurement

Component	Breakaway Torque	Observations
Rod #		
Rod #		
Bolt #		
Bolt #		
Bolt #		
Bolt #		

[Insert associated pictures and figures here]

Section 4- Tensile Testing, ASTM A370-17a

[Insert results summary here]

Table # – Fastener Tension Test Results

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %	Reduction in Area, %
Rod #				
Rod #				
Bolt #				
Bolt #				
Bolt #				
Bolt #				

[Insert associated pictures and figures here]

Section 5- Rockwell and Superficial Hardness, ASTM E18-17

[Insert results summary here]

TABLE # – Lug Hardness Test Results – Rockwell B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug ##					
Lug ##					
Lug ##					
Lug ##					

[Insert associated pictures and figures here]

Section 6- Mag Particle/Dye Penetrant Test

[Insert results summary here]

[Insert results table here]

[Insert associated pictures and figures here]

IMR TEST LABS
A Curtiss-Wright Business Unit
www.imrlouisville.com

4510 Robards Lane
Louisville, KY 40218
T: 1.502.810.9007 | **F**: 1.502.810.0380

LG&E - Kentucky Utilities
6900 Enterprise Drive
Louisville, KY 40214

November 30, 2020

Attention: Chad Augustine

Exhibit D

Report No. 202002564

Metallurgical Evaluation of a 4" Coupling and Associated Hardware

Location: 4th and Main St.

DESCRIPTION AND PURPOSE

A natural gas pipe section including a coupling was submitted for metallurgical evaluation. The section was a 4" pipe with a Dresser Style 39 Insulating Coupling. Two joint harnesses were also affixed to the pipe section. Copies of the installation information for the coupling and harnesses were provided for this investigation. It was reported that the coupling had been installed in the field at 4th and Main St. on May 7, 1987. The pipe section was subsequently excavated after substantial service duration without failure. It was requested that the general dimensions, weld quality, corrosion condition and mechanical properties of the coupling components be determined as directed.

RESULTS

The submitted pipe section with the coupling is shown in Figures 1 through 4. Two lugs of the joint harnesses had been fillet welded to both pipe segments. Two rods and associated nuts had been affixed through the welded lugs to apply compression to the coupled joint. The coupling consisted of a steel coupling with an interior nonmetallic gasket / sleeve. Prior to receipt, the ends of the pipe segment were labelled as Ends A and B, as shown in Figures 1 through 4. The top and bottom of the coupling section were also marked. Lugs A1 and A2 were welded to Pipe A, and Lugs B1and B2 were welded to Pipe B. The rod between Lugs A1 and B1 was identified as Rod 1. The remaining lugs were identified in a corresponding fashion. Several secondary welds without lugs were evident.

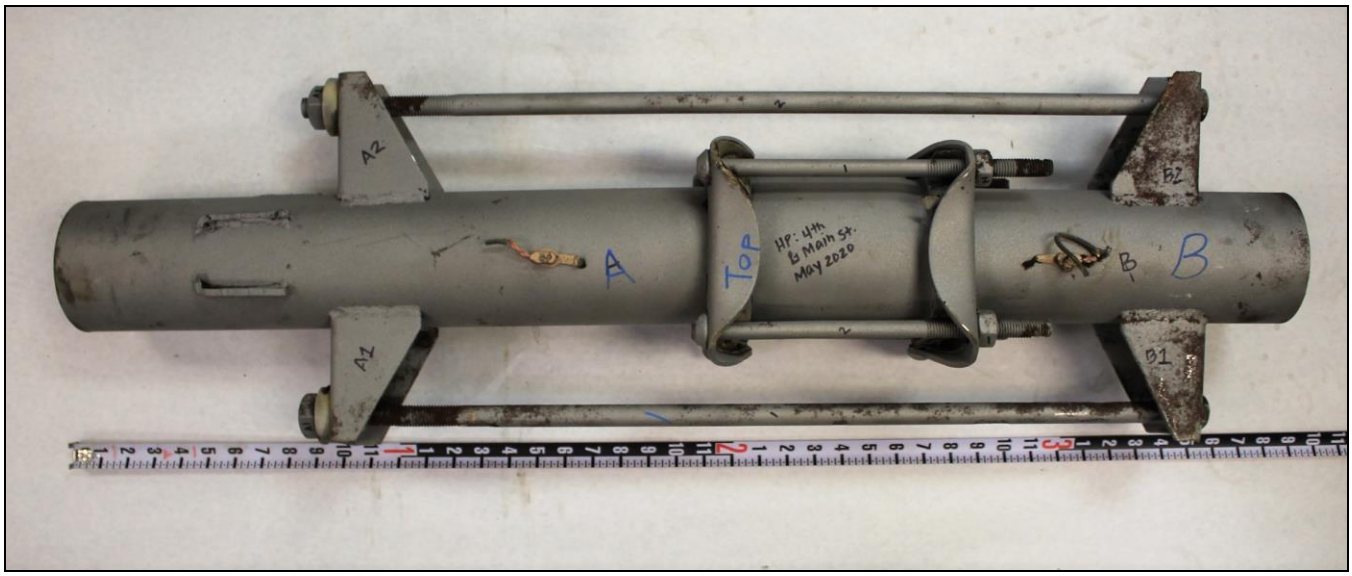


Figure 1. Photograph of the top of the submitted coupling sample.

Figure 2. Photograph of the bottom of the submitted sample.

SECTION 1- DIMENSIONAL MEASUREMENT

The two sets of harness lugs were positioned around the pipe. The relative orientations of the harness lugs were measured by photographing the assembly from the ends and applying a protractor overlay for angle measurement. The obtained measurements are shown in Figures 3 and 4 with the data summarized in Table 1. The depth of insertion of the pipe segments into the coupling was also measured and the dimensions are provided in Table 2. No requirements were provided for these characteristics.

TABLE 1 – LUG SPACING DIMENSIONAL MEASUREMENTS

Component	Angle	Deviation from 180°	Image
Rod A1 / Rod A2	165°	15°	Figure 3
Rod B1 / Rod B2	173°	7°	Figure 4

TABLE 2 – PIPE COUPLING DIMENSIONAL MEASUREMENTS

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A	2.75”	1/2” (Original sample length – 41.5”)
Pipe B	4.5	

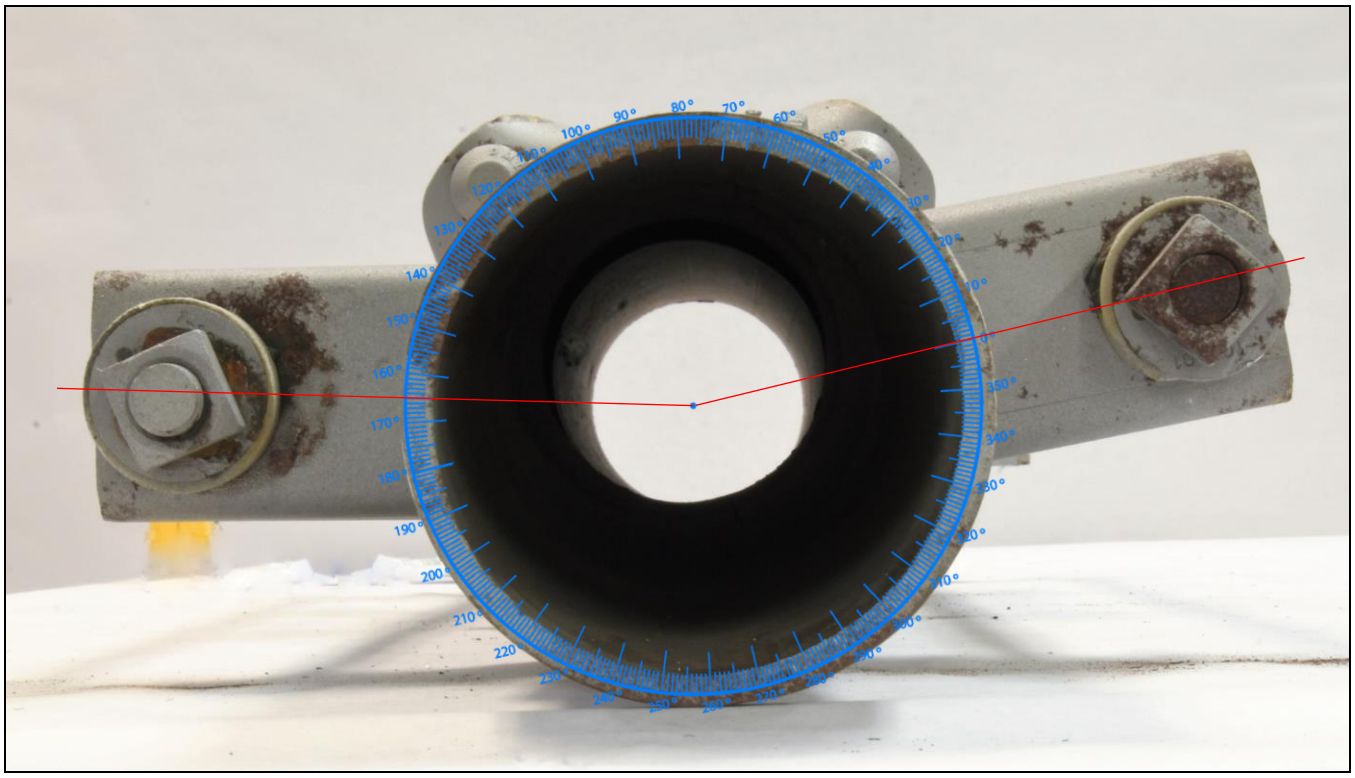


Figure 3. End facing image of the sample at End A with a superimposed protractor.

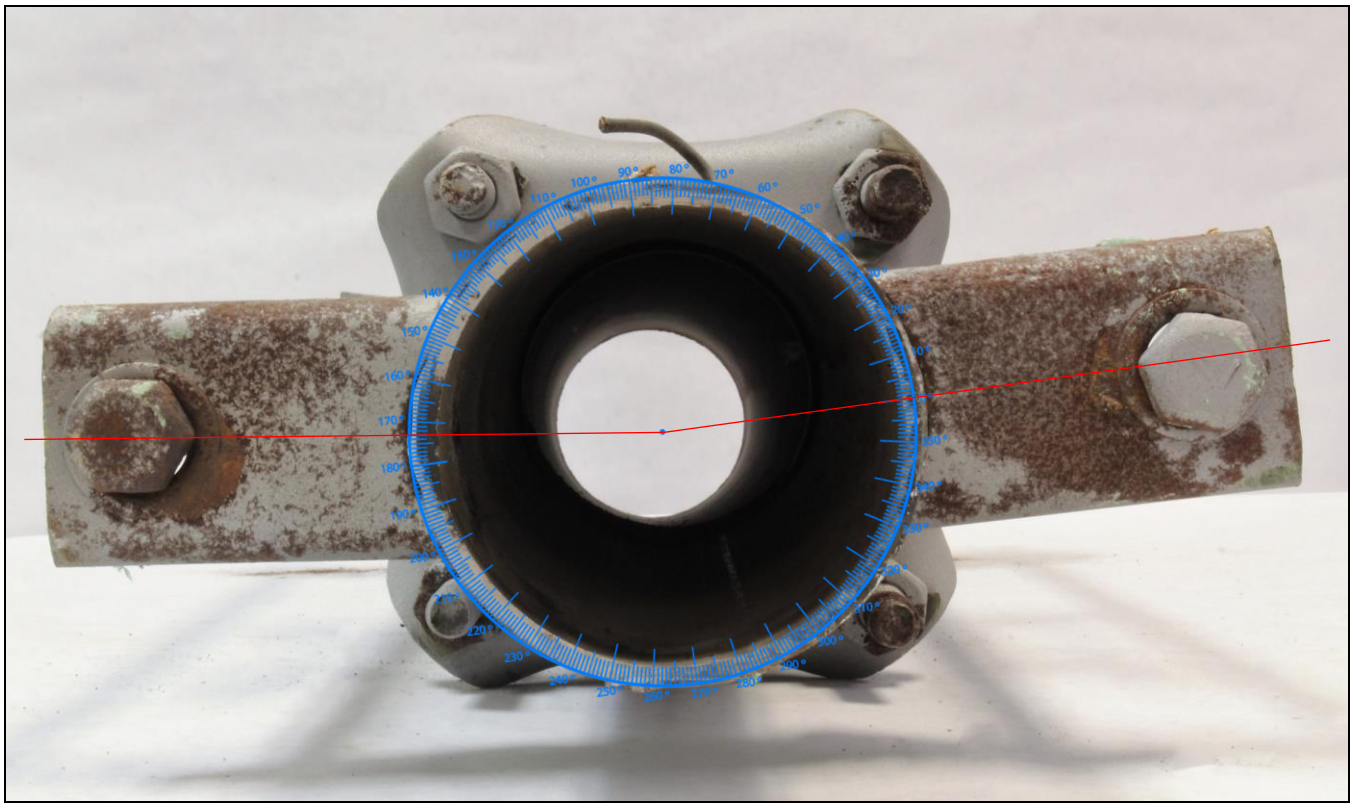


Figure 4. End facing image of the sample at End B with a superimposed protractor.

SECTION 2- VISUAL OBSERVATIONS

The lug attachment welds were regions of interest on the pipe coupling sample. Each lug contained four fillet weld locations; exterior top, exterior bottom, interior top, and interior bottom. Each weld that was present was inspected visually using a flashlight and magnifying lens. It was indicated that welding was performed in accordance with API 1104. General weld inspection was performed initially, followed by visual inspection by an outside NDE company. For comparison purposes, the welds were rated as substantial fusion, partial fusion, and minimal fusion. The summarized weld fusion and corrosion observations are provided in Table 3. Representative weld regions are shown in Figures 5 through 10. The welds contained localized weld discontinuities including undercut, porosity, and spatter. No cracking in the welds or base metal heat affected zones (HAZ) was visually identified. Some superficial corrosion of the coupling and associated hardware was observed, but no significant material loss had occurred.

The coupling and harness rods were also inspected for corrosion alteration. Several regions of corrosion were identified on the coupling rods. The observations for the rods and bolts are provided in Table 4. No corrosion cracking was evident. The rods were not necked down or stretched.

The elastomeric components of the coupling consisted of a pipe separator, insulating sleeve, and two gaskets. Inspection revealed that they appeared to be intact and not degraded.

TABLE 3 – LUG WELD VISUAL EXAMINATION RESULTS

Component	Location	Weld	Observations
Lug A1	Exterior	Top	Substantial Fusion
		Bottom	Substantial Fusion
	Interior	Top	Substantial Fusion
		Bottom	Substantial Fusion
Lug A2	Exterior	Top	Substantial Fusion
		Bottom	Substantial Fusion
	Interior	Top	Substantial Fusion
		Bottom	Partial Fusion
Lug B1	Exterior	Top	Substantial Fusion
		Bottom	Substantial Fusion
	Interior	Top	Substantial Fusion
		Bottom	Substantial Fusion
Lug B2	Exterior	Top	Substantial Fusion
		Bottom	Substantial Fusion
	Interior	Top	Substantial Fusion
		Bottom	Substantial Fusion

TABLE 4 – FASTENER VISUAL EXAMINATION RESULTS

Component	Observations
Rod 1	Not bent or stretched, Substantial corrosion observed
Rod 2	Not bent or stretched, No substantial corrosion pitting, Rotated freely
Bolt 1	Not bent or stretched, no substantial corrosion pitting
Bolt 2	Not bent or stretched, no substantial corrosion pitting
Bolt 3	Not bent or stretched, no substantial corrosion pitting
Bolt 4	Not bent or stretched, no substantial corrosion pitting

Figure 5. Image of the Lug A1 exterior top weld which exhibited substantial fusion except for some porosity and spatter.

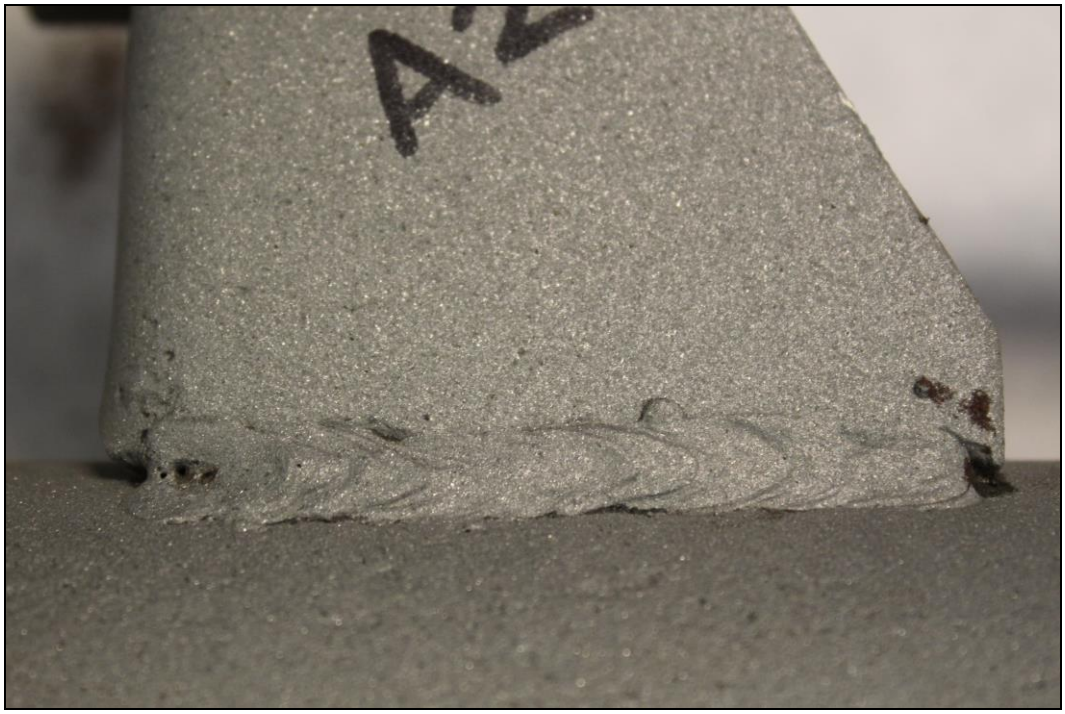


Figure 6. Image of the Lug A2 exterior top weld which exhibited substantial fusion except for some porosity.

Figure 7. Image of the Lug B2 exterior top weld which exhibited substantial fusion except for some undercut, and porosity. Pitting corrosion damage was observed.

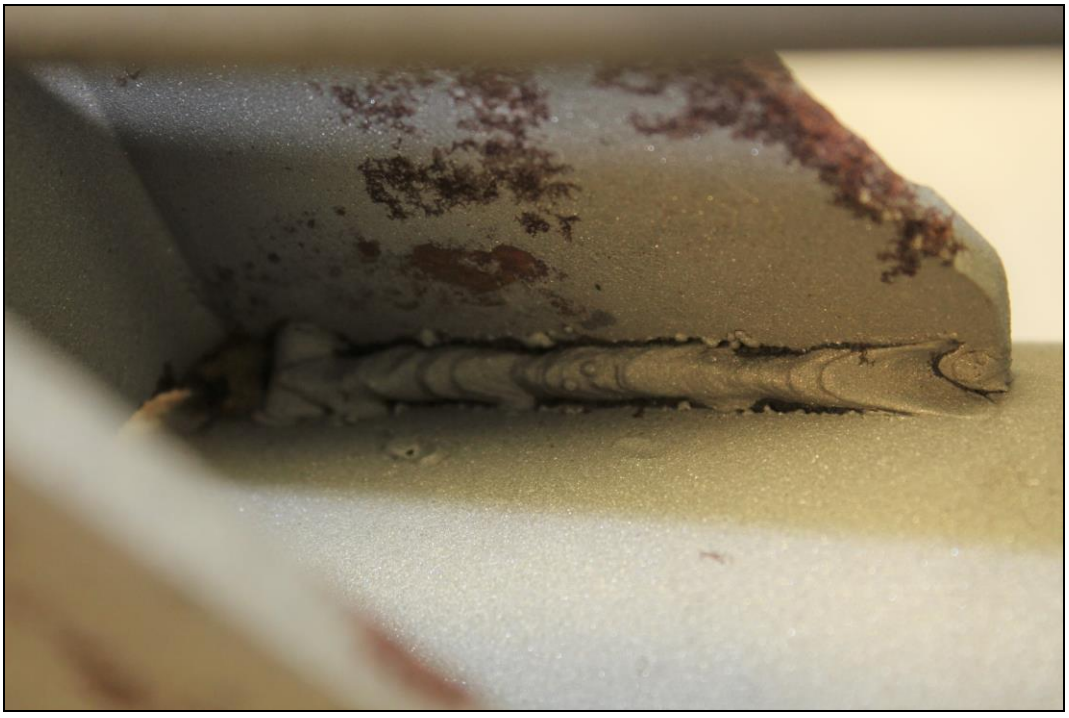


Figure 8. Image of the Lug B2 interior bottom weld which exhibited substantial fusion except for some arc burn, spatter, porosity and undercut.

Figure 9. Image of the Lug A1 fastener assembly which exhibited substantial corrosion.

Figure 10. Image of the remainders of additional lugs, which had been welded then cut off, present on Side A of the assembly.

SECTION 3- TORQUE TESTING- FOR INFORMATION ONLY

Torque testing was performed on the nuts of the rods and bolts on the pipe coupling sample. A calibrated torque wrench was used to determine breakaway torque on each fastener. The breakaway torque measurements are summarized in Table 5. Rod fasteners did not have a specified torque requirement. The four coupling bolts exhibited torque values ranging from 20 to 45 ft.-lbs. All bolt and rod torque values were below the Dresser Style 39 coupling installation torque recommendation of 75 ft.-lbs. minimum for 5/8" fasteners.

TABLE 5 – FASTENER TORQUE MEASUREMENT

Component	Breakaway Torque	Observations
Rod 1	Rotates Freely	Did not satisfy the recommended torque
Rod 2	Rotates Freely	Did not satisfy the recommended torque
Bolt 1	30 ft.-lbs.	Did not satisfy the recommended torque
Bolt 2	20 ft.-lbs.	Did not satisfy the recommended torque
Bolt 3	45 ft.-lbs.	Did not satisfy the recommended torque
Bolt 4	40 ft.-lbs.	Did not satisfy the recommended torque

SECTION 4- TENSILE TESTING, ASTM A370-17A

Tensile testing was performed on round specimens that were removed from the two harness rods and the three coupling bolts. The tensile mechanical properties of the fasteners were measured and the results are summarized in Table 6. No mechanical property requirements were provided for the fasteners.

TABLE 6 – FASTENER TENSION TEST RESULTS

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %②	Reduction in Area, %
Rod 1①	110	60.5	24	47
Rod 2①	101	57.0	26	52
Bolt 1①	90.0	54.0	30	57
Bolt 2①	82.0	56.5	37	77
Bolt 3①	82.0	62.0	36	78
Bolt 4①	82.5	58.0	38	77

① Specimen Dimensions; Diameter 0.25” with gage length of 1.00”
② Percent elongation was measured using elongation-after-fracture measurements

SECTION 5- ROCKWELL HARDNESS, ASTM E18-17

Small sections of the four lugs were excised for hardness testing. Rockwell hardness testing was performed on sectioned segments of the lugs after the removal of surface roughness by sanding. The obtained results are provided in Table 7 and are suggestive of a moderate strength level. No requirements were provided for comparison.

TABLE 7 – LUG HARDNESS TEST RESULTS – ROCKWELL B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug A1	60	60	61	59	60
Lug A2	65	66	66	65	66
Lug B1	60	61	62	61	61
Lug B2	59	61	60	61	60

SECTION 6- NONDESTRUCTIVE EXAMINATION

The two separated ends of the disassembled coupling were sent to a third party NDE laboratory for inspection. Visual, magnetic particle and liquid dye penetrant inspection were performed on the lug attachment welds. Inspection was performed in accordance with the acceptance criteria of API 1104 "Welding of Pipelines and Related Facilities". The inspection results are provided as Appendix A. Two representative welds are shown in Figures 11 and 12 with the dye penetrant test media remaining.

Figure 11. Image of the Lug A2 welds after dye penetrant media had been used during inspection.

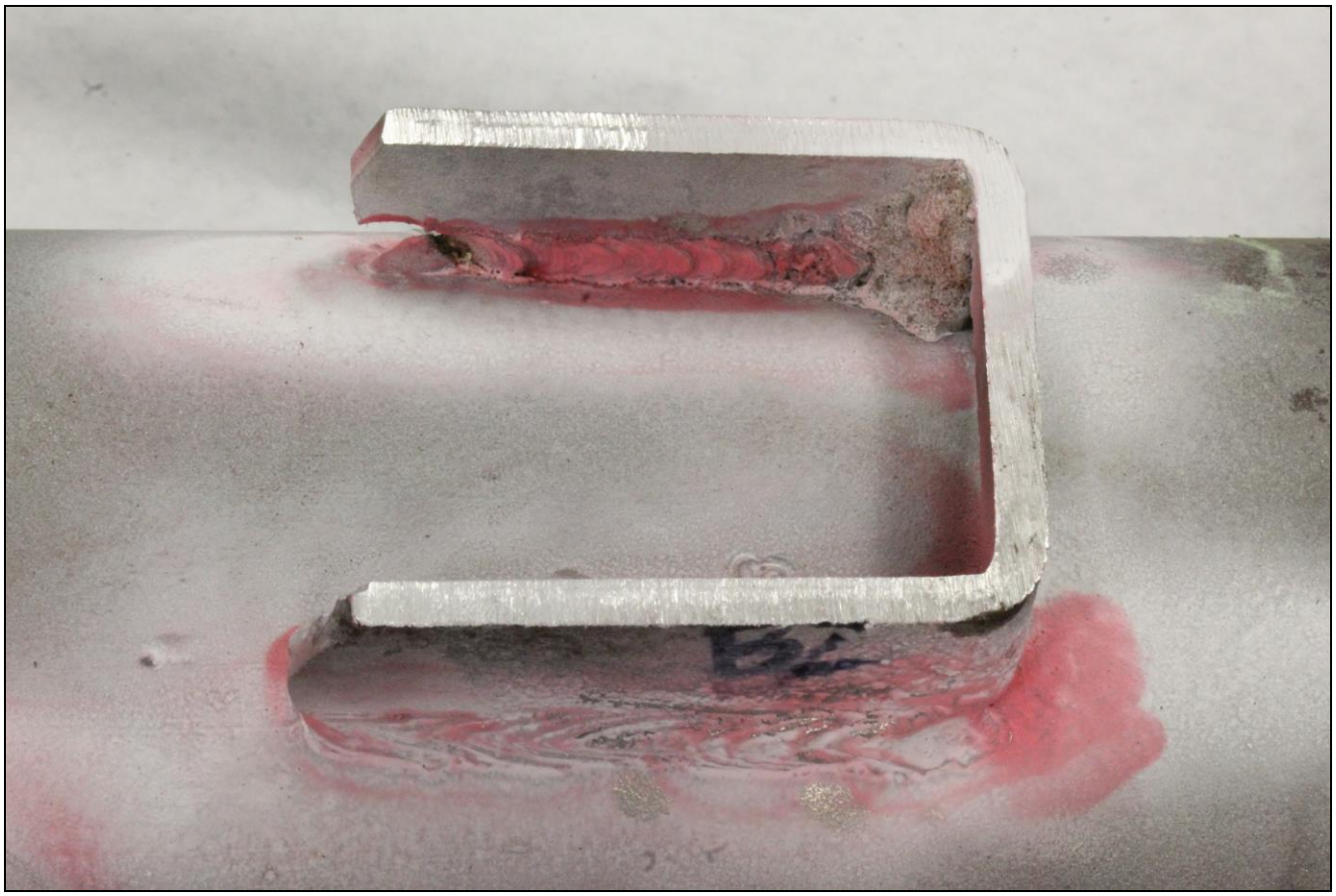


Figure 12. Image of the Lug B2 welds after dye penetrant media had been used during inspection.

Respectfully submitted

Brian Kelly
Failure Analyst

Concurrence

Phillip Swartzentruber, Ph.D., E.I.T.
Chemistry Department Manager
Failure Analyst

APPENDIX A – LIQUID DYE PENETRANT / VISUAL INSPECTION RECORD

MISTRAS

Liquid Penetrant Examination Report

195 Clarksville Road | Princeton Junction, NJ 08550 | P: (609) 716-4000; F: (609) 716-4145 www.mistrasgroup.com

Client:	IMR TEST LABS	Date:	11/17/2020	Page:	1 of 1
Address:	4510 ROBERTS LANE	Job Number:			
	LOUISVILLE KT40218	Purchase Order:	6669FA		
Contact:		Reference Number:	202002564		
Location:	MGI LAB	Part No/Description:	BOTTOM		

Code/Specification	Procedure	Acceptance Criteria
ASME SEC V,ART 6	100-PT-001 REV20	API 1104

Type and Method

☐ Fluorescent: [Type I] ☐ Water Wash [Method A] ☒ Solvent Removable [Method C] ☐ Post Emulsified: ☐ Hydrophilic [D] ☐ Lipophilic [B]

☒ Red Visible Dye: [Type II] ☐ Water Wash [Method A] ☒ Solvent Removable [Method C] ☐ Post Emulsified [Method B]

Sensitivity Level: ☐ ½ ☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ N/A ☐ Other: N/A

	Manufacturer	Type	Batch Number(s)	Application Method	Process Time (minutes)	
					Pre-clean Dry Time:	15 MIN
Cleaner:	SPOT CHECK	SKC-S	18G14K	SPRAY/CLOTH	Penetrant Dwell Time:	10 MIN
Penetrant:	SPOT CHECK	SKL-SP2	17L02K	BRUSH	Emulsifier Time:	N/A
Developer:	SPOT CHECK	SKD-S2	17J05K	SPRAY	Developer Time:	10 MIN
Emulsifier:	N/A	N/A	N/A	N/A	Post Clean Method:	N/A

Developer Form: ☐ a. Dry Powder ☐ b. Water Soluble ☐ c. Water Suspended ☒ d. Nonaqueous Wet ☐ e. Specific Application

Penetrant Removal Method & Dry Time	Black Light (Model and S/N)	White Light Source
DAMP CLOTH/10MIN	N/A	L.E.D

☒ Original ☐ Repair	Material & Thickness	Test Temperature
	C/S (VARIOUS)	72 F

Surface Condition

☒ As Welded ☐ As Ground ☐ As Cast ☐ Rough Machined ☐ Final Machined ☐ Meets Code Requirements

Test Results	Quantity Inspected: 4	Quantity Accepted: 0	Quantity Rejected: 4

WELD "A"
A-1- REJECTED FOR POROSITY
A-2- REJECTED FOR POROSITY AND LACK OF FILL

WELD "B"
B-1- REJECTED FOR POROSITY AND UNDERCUT
B-2- REJECTED FOR POROSITY AND UNDERCUT

Technician Name, Level & Date	Customer (if applicable):	Reviewed By (if applicable):
DANIEL WEICK LEVEL II		

Certification of Inspection, Liquid Penetrant [Basic Report Form] 100-PTFORM-002 | Rev 1

Bolt-Style Coupling (pressures > 3 psig)

This form will be completed when LG&E or LG&E contractors expose a bolt-style coupling in a system where the pressure is > 3 psig (medium and high pressure distribution and transmission) and the coupling will be backfilled. The purpose of the form is to provide Operations, Engineering and Gas Regulatory personnel with information about the bolt style coupling installation.

Part A- Discovery of Coupling

Precautions:

1. Stop excavation upon discovering the bolt-style coupling in the excavation
2. Set-up a perimeter around the excavation to keep the public away from the excavation

General Information:

1. Contact Employee for the bolt style coupling found: **Tom Hebbeler**
2. Date of exposure: **5/4/2020**
3. Location: **4th & Main St.**
4. Size of coupling (based on pipe size if not exposed enough to determine): 4”
5. Type of soil (circle one): Sandy Clay Gravel Topsoil Other (take picture and describe)
6. Soil Density test: □ Type A □Type B □Type C
7. Status: □ Removed □Abandoned in place □Backfilled- left in service
8. Discovered How?: □ Leak on Coupler □Other Maintenance Excavation □Facility Replacement □Facility Retirement □Other_____

Pictures:

1. Take at least two pictures of the coupling. The pictures should be from different angles (additional pictures can be taken).
2. Email pictures to supervisor. Ensure pictures are attached to this form:

Sketch: Provide a sketch showing the coupling orientation (vertical/horizontal), nearby branches, pipe, valves and fittings, other utilities or structures, etc.

Leak Survey:

1. Use an instrument designed to detect natural gas to check for the presence of natural gas after backfilling the excavation. Include readings in the above sketch in relation to the coupling. If the contact employee is not leak survey qualified they should contact:
   a. Their supervisor to call Gas Regulatory to complete the survey after the excavation is backfilled. Call [redacted]
   b. If Gas Regulatory is not available contact Gas Dispatch to have the survey assigned to a Gas Trouble Technician.

Leak Survey completed at time of backfill (circle one) yes no not applicable

Include completed form in the main report and email a scanned copy of the completed form (back and front) to the Distribution Integrity Management (DIM) group.

Field Pictures

[Field pictures were not provided]

Sketch

[No sketch provided]

Safety Briefing

Date: 09/24/2020

Employee Name	Employee ID
Sarah Nicholson	[redacted]

	Hazards Identified
	Sharp edges on cut pipe ends. Wear gloves when handling.
	Pinch points on couplings. Wear gloves when handling.
	Some couplings samples are heavy. Use a partner to assist with moving. Use proper lifting techniques. Wear hard toes shoes.
	Debris may on samples. Wear eye protection.
	Tripping hazards on floor. Keep area clean and free of tripping hazards

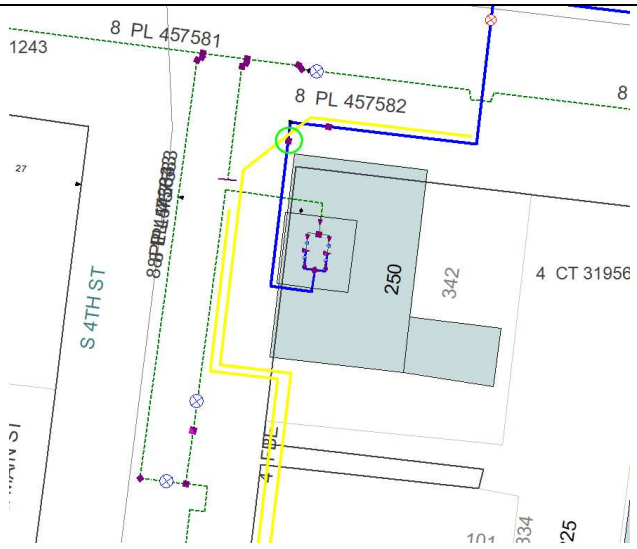
	PPE Required
	Hard toed shoes
	Safety glasses
	Gloves (leather preferred)

Part B- Coupling Information

General Information			Tracking #: 2020-023
PO Number 1070637	Expense Org 004610	Project 158276	Task COUPLER
Address/Location 4th & Main St. Louisville, KY			
Size 4”	Material STL	Coating CT	MAOP 99 PSIG
Main/Service Number 319567	Soil Type (from Part A)	Manufacturer Dresser	Model
Pipe Connection:	Steel to Steel	Steel to Plastic	Plastic to Plastic

Historical Information	
Installation Date 5/7/1987	Document Source SmallWorld
Installation Company Southern	Document Source Quest
Foreman Campville	Document Source Quest
Welder Paul Harvard	Document Source Quest

GIS Information
Sys Id (of Coupler) 73263356
Screen Capture



Pictures (Label the following parts before taking pictures.)

Figure 1 Pipe Side A

Figure 2 Pipe Side B

Figure 3 Bolt Pipe A

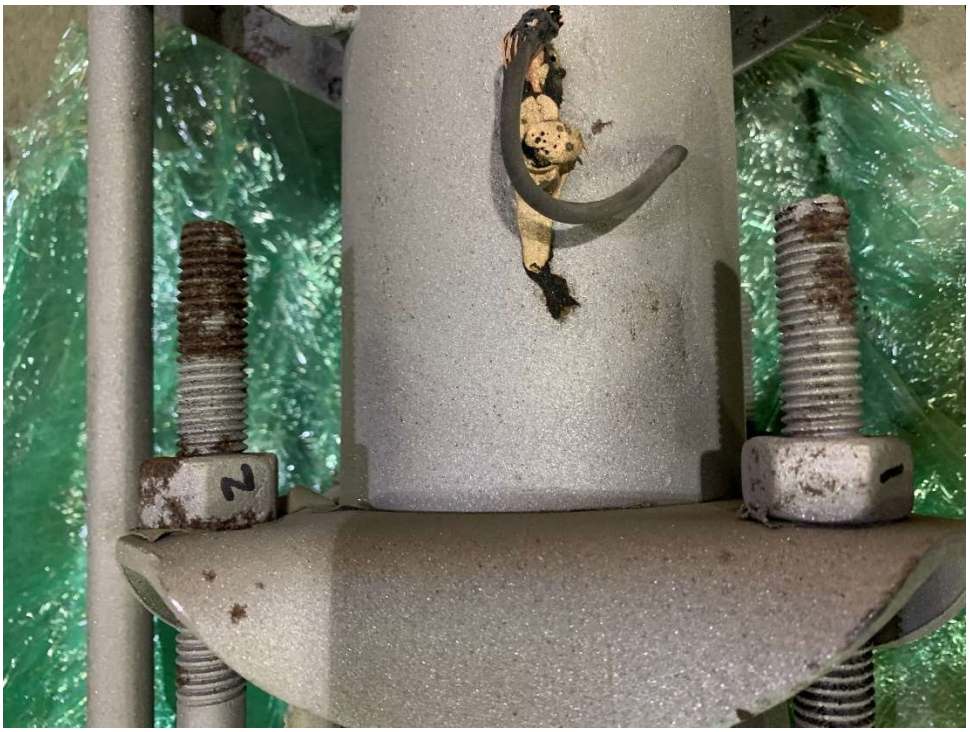


Figure 4 Nuts (Coupler Body) Pipe A

Figure 5 Lugs Pipe B

Figure 6 Reinforcement Rods

Figure 7 Coupler [Top View]

Figure 8 Close up of Lug Backend

Part C- Visual Inspection of Coupling

Visual Inspection Performed by: Sarah A. Nicholson Date: 9/24/2020

Table 1- Component Quantities

Number of Bolts on Coupler Body	4
Number of Reinforcement Rods	2
Number of Lugs	4

Table 2- Corrosion

	Pipe A	Pipe B	Coupler Body	Bolts	Rods	Lugs	Nuts
General External Corrosion Present?	NO	YES	NO	YES	YES	YES	YES
Localized Corrosion Present?	NO	YES	NO	NO	YES	YES	NO
Pit Depths	NO	NO	NO	NO	NO	NO	NO
Internal Corrosion?	NO	NO					

Table 3- Coupler Body

Bolt	Washer Present	Nut present?
1	NO	YES
2	NO	YES
3	NO	YES
4	NO	YES
5		
6		

Table 4- Reinforcement Rods

Rod	Length (in.)	Diameter (in.)	Washer present at head of bolt?	Washer present at end of bolt?	Nut Present? Type?	Type of rod?
1	30 ½"	0.74"	YES	YES	SQUARE & HEXAGONAL	KIT PROVIDED
2	30 ½"	0.73"	YES	YES	SQUARE & HEXAGONAL	KIT PROVIDED
3						
4						

Type of Lug

(Please indicate the shape of the lug by circling one below. If the lug shape is different than any preset shape below, sketch the shape.)

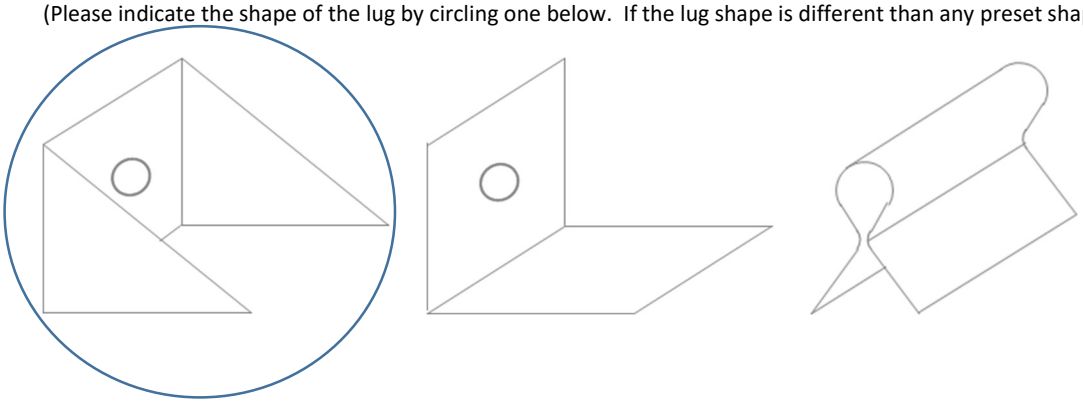


Table 5- Lugs (Measurements)

Pipe Side	Lug Number	Thickness (in.)	Circumference (in)	
			Distance to next lug, clockwise	Distance to next lug, counter-clockwise
A	1	0.22"	5	4.5
A	2	0.27"	4.5	5
A	3			
B	1	0.21"	4.5	4.625
B	2	0.20"	4.625	5
B	3			

Table 6- Lugs (Observations)

Lug	Lug	Assembly sets aligned?	Deformed?	Deflected? (angle of)
A1	B1	NO	NO	SLIGHTLY
A2	B2	YES	NO	NO
A3	B3			

Table 7- Lugs (Weld Quality)

Pipe Side	Lug Number	Any part detached from pipe?	Welded on all sides of exterior? If no, describe	Are welds on exterior continuous? If no, describe	Welded on all sides of interior? If no, describe	Are welds on interior continuous? If no, describe
A	1	NO	NO (2 EXT. WELDS)	YES	NO (2 INT. WELDS)	YES
A	2	NO	NO (2 EXT. WELDS)	YES	NO (2 INT. WELDS)	YES
A	3					
B	1	NO	NO (2 EXT. WELDS)	YES	NO (2 INT. WELDS)	YES
B	2	NO	NO (2 EXT. WELDS)	YES	NO (2 INT. WELDS)	YES
B	3					

NOTE: Back side of each lug detached from pipe

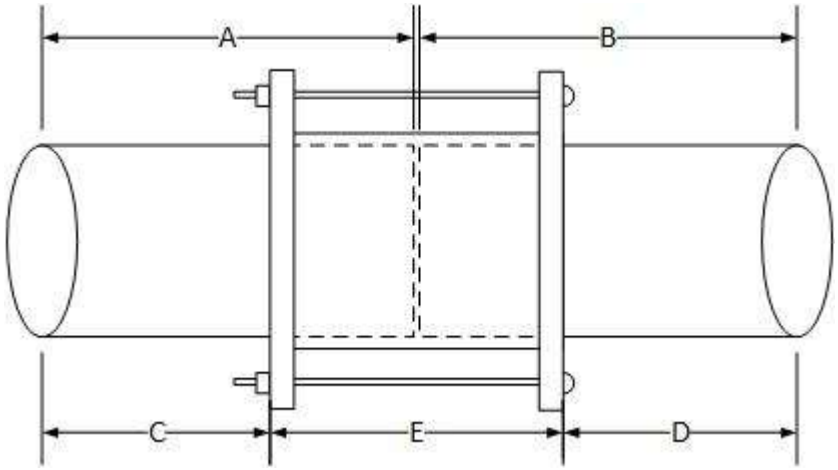


Table 8- Stab Depth

	A	B	C	D	Stab Depth (A-C) or (B-D)
Pipe Side A	25.875		21.5		4.375
Pipe Side B		15.875		11.5	4.375
	Sum of stab depths (should be closely equal to measurement E)				8.75
	Coupler Length (E)				8.25
	Difference				0.5

Additional Comments and General Observations

HP coupler – requires further analysis from IMR.

Part D- Analysis of Coupling

The section is designed to be a template for the lab performing analysis of the couplers. The lab may draft a report as a separate document, but the tables below should be used within the report. The tables may be transferred to the report. Rows may be added to any table to accommodate for additional components, but should additional columns be needed for data purposes, please contact LG&E. It is **not** the intention for the table(s) to be completed in duplicate if a separate document is created.

Section 1- Dimensional Measurement

[Insert results summary here]

Table #- Lug Spacing Dimensional Measurements

Compound	Angle	Deviation from 180°	Image
Rod ##/Rod ##			
Rod ##/Rod ##			

Table # – Pipe Coupling Dimensional Measurements

Component	Depth of Pipe into Coupling	Gap Between Pipes in Coupling
Pipe A		
Pipe B		

[Insert associated pictures and figures here]

Section 2- Visual Observations

[Insert results summary here]

Table # – Lug Weld Visual Examination Results

Component	Location	Weld	Observations
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	
Lug ##	Exterior	Top	
		Bottom	
	Interior	Top	
		Bottom	

TABLE # – Fastener Visual Examination Results

Component	Observations
Rod #	
Rod #	
Bolt #	
Bolt #	
Bolt #	
Bolt #	

[Insert associated pictures and figures here]

Section 3- Torque Testing- for information only

[Insert results summary here]

TABLE # – Fastener Torque Measurement

Component	Breakaway Torque	Observations
Rod #		
Rod #		
Bolt #		
Bolt #		
Bolt #		
Bolt #		

[Insert associated pictures and figures here]

Section 4- Tensile Testing, ASTM A370-17a

[Insert results summary here]

Table # – Fastener Tension Test Results

Component	Ultimate Tensile Strength, ksi	0.2% Offset Yield Strength, ksi	Elongation, %	Reduction in Area, %
Rod #				
Rod #				
Bolt #				
Bolt #				
Bolt #				
Bolt #				

[Insert associated pictures and figures here]

Section 5- Rockwell and Superficial Hardness, ASTM E18-17

[Insert results summary here]

TABLE # – Lug Hardness Test Results – Rockwell B – HRBW

Results	Reading 1	Reading 2	Reading 3	Reading 4	Average
Lug ##					
Lug ##					
Lug ##					
Lug ##					

[Insert associated pictures and figures here]

Section 6- Mag Particle/Dye Penetrant Test

[Insert results summary here]

[Insert results table here]

[Insert associated pictures and figures here]