COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

LOUISVILLE GAS & ELECTRIC COMPANY	)	
	)	CASE NO. 2017-00119
ALLEGED FAILURE TO COMPLY WITH KRS 278.495, 807 KAR 5:022, AND 49 C.F.R. PART 192	)	

ORDER

Louisville Gas & Electric Company ("LG&E"), a Kentucky corporation which engages in the distribution of natural gas to the public for compensation for light, heat, power, and other uses, is a utility subject to Commission jurisdiction.[1]

KRS 278.495 grants the Commission authority to regulate the safety of natural gas facilities owned or operated by any public utility and to enforce minimum safety standards adopted by the United States Department of Transportation ("USDOT") pursuant to the federal pipeline safety laws, 49 U.S.C. Section 60101, *et seq.*, and amendments thereto. The USDOT adopted minimum safety standards in 49 C.F.R. Part 192. KRS 278.992(1) establishes the penalties for violations of any federal minimum safety standards governing the safety of pipeline facilities.

KRS 278.030 requires every utility to furnish "adequate, efficient and reasonable" service. KRS 278.260 permits the Commission, upon its own motion, to investigate any act or practice of a utility that affects or is related to the service of a utility. KRS

[1] KRS 278.010(3)(b).

278.280(1) further permits the Commission, after conducting such investigation and finding that a practice is unreasonable, unsafe, improper, or inadequate, to determine the reasonable, safe, proper, or adequate practice or methods to be observed and to fix same by Order.

Pursuant to 278.280(2), which directs the Commission to prescribe rules and regulations for the performance of services by utilities, the Commission has promulgated Administrative Regulation 807 KAR 5:006, Section 25, which requires all utilities to adopt and execute a safety program. Here, LG&E has adopted the Gas Operating, Maintenance, and Inspection Procedures ("GOM&I"). Additionally, the Commission has promulgated 807 KAR 5:022, which establishes minimum operation and safety requirements for pipe and components for use in natural gas pipelines.

Commission Staff submitted to the Commission an Incident Investigation Report ("Staff Report") describing an incident that occurred on September 17, 2014, in Prospect, Oldham County, Kentucky, which is attached as an Appendix to this Order. The Staff Report alleges that, on September 17, 2014, at 12889 West Highway 42, Prospect, Oldham County, Kentucky, a mechanical coupling separated on a 12-inch natural gas pipeline, which resulted in a loss of gas that affected 2,400 customers and injuries to two employees of an LG&E contractor.

According to the Staff Report, Southern Pipeline, an LG&E contractor, was reconfiguring one of LG&E's natural gas intrastate transmission pipelines to allow an inline inspection tool to pass internally through the pipeline. On the day of the incident, Southern Pipeline was excavating around several feet of the 12-inch pipeline in a right of way parallel to Highway 42 in Prospect, Kentucky. As a result of the excavation, a mechanical coupling, originally installed on January 5, 1998, was exposed on the pipeline within the excavation site. The excavation work was completed for the day and Southern Pipeline employees were installing barricades at the excavation site when the 12-inch pipeline separated at the mechanical coupling. The coupling separation resulted in a loss of gas, but the gas did not ignite.

The Staff Report states that the force of the coupling separation resulted in flying debris that injured two Southern Pipeline employees. Elvis Posey, Southern Pipeline CDL driver, was admitted to University of Louisville Hospital and treated for a fractured arm. John Schindler, Southern Pipeline laborer, received minor injuries that did not require hospitalization. Two LG&E employees at the incident site, Nicholas Thompson, pipeline inspector, and William Norton, mechanical engineer II, were uninjured. The flying debris caused property damage to the roof of a nearby house and a passing vehicle, but no persons in the nearby house or passing vehicle were injured.

According to the Staff Report, the fire department responded and secured the scene, and then evacuated 24 nearby homes. At 8:20 p.m. on September 17, 2014, the pipeline was fully shut down to allow for repairs, which resulted in loss of gas service to approximately 2,400 customers. By September 20, 2017, service was restored to all customers, with the exception of 32 customers for whom service restoration was further delayed because they had not been home to allow a LG&E technician to perform re-lights.

Based on Commission Staff's investigation of the incident and the information provided by LG&E (Attachment A to the Report), Commission Staff alleges that LG&E

has violated the following provisions of 49 C.F.R. Part 192, 807 KAR 5:022, and LG&E GOM&I:

1. 49 C.F.R. Section 192.605(a); 807 KAR 5:022, Section 13(2)(a) and (b); LG&E GOM&I Table 79.2 and Figure D-8.

> 49 CFR Section 192.605(a) – Procedural Manual for Operations, Maintenance, and Emergencies – General. Each operator shall prepare and follow for each pipeline, a manual of written procedures for conducting operations and maintenance activities and for emergency response.
>
> 807 KAR 5:022, Section 13(2)(a) – Gas Safety and Service – Operations – General Provisions. No person shall operate a segment of pipeline unless it is operated in accordance with this section.
>
> 807 KAR 5:022, Section 13(2)(b) – Gas Safety and Service – Operations – General Provisions. Each operator shall establish a written operating and maintenance plan meeting the requirements of this administrative regulation and keep records necessary to administer the plan.
>
> <u>Finding</u>: LG&E GOM&I Table 79.2 – Number and Size Harness Bolts Required. To restrain a 12-inch 400 PSIG design pressure coupling, the coupling must be installed with seven rods and lugs each with a 3/4-inch diameter or five rods and lugs each with a 7/8-inch diameter. The failed coupling had four rods and lugs with a 3/4-inch diameter.
>
> <u>Finding</u>: LG&E GOM&I Figure D-8 – Typical Harness Installation. Both inside and outside welding surfaces of lugs are to be welded to pipe. The lugs on the failed coupling were welded on one side only.
>
> <u>Finding</u>: LG&E GOM&I Figure D-8 – Typical Harness Installation. A washer should be installed between the lug and nut of the tensioning rod to distribute the load over the lug face. Washers were not installed on both ends of the 12-inch coupling assembly.
>
> <u>Finding</u>: LG&E GOM&I Figure D-8 – Typical Harness Installation. A washer should be installed between the lug and nut of the tensioning rod to distribute the load over the

lug face. No washers were installed on one end of the eight-inch coupling assembly.

2. 49 C.F.R. Section 192.241(a) and (c); 807 KAR 5:022, Section 5(8)(a) and (c)

49 C.F.R. Section 192.241(a) – Inspection and Test of Welds. Visual inspection of welding must be conducted by an individual qualified by appropriate training and experience to ensure that: (1) The welding is performed in accordance with the welding procedure; and (2) The weld is acceptable under paragraph (c) of this section.

807 KAR 5:022, Section 5(8)(a) – Gas Safety and Service – Welding of Steel in Pipelines – Inspection and Test of Welds. Visual inspection of welding shall be conducted to insure that: 1 Welding is performed in accordance with welding procedure; and 2. Weld is acceptable under paragraph (c) of this subsection.

807 KAR 5:022, Section 5(8)(c) – Gas Safety and Service – Welding of Steel in Pipelines – Inspection and Test of Welds. Acceptability of a weld that is nondestructively tested or visually inspected is determined according to the standards in Section 6 of the API Standard 1104.

Finding: The inspection of the welds on lug brackets when the 12-inch coupling was installed on January 5, 1998, did not detect that some welds were not performed in accordance with welding procedure set forth on LG&E GOM&I Figure D-8, which requires both inside and outside welding surfaces of lugs are to be welded to the pipe. Some of the lugs on the 12-inch coupling were welded on only one side.

3. 49 C.F.R. Section 192.619(a)(1); 807 KAR 5:022, Section 13(11)(a)(1); LG&E GOM&I

49 C.F.R. Section 192.619(a)(1) – Maximum Allowable Operating Pressure: Steel or Plastic Pipelines. No person may operate a segment of steel or plastic pipeline at a pressure that exceeds a maximum allowable operating pressure determined under paragraph (c) or (d) of this section, or the lowest of the following: (1) The design pressure of the weakest element in the segment, determined in accordance with subparts C and D of this part.

> 807 KAR 5:022, Section 13(11)(a)(1) – Gas Safety and Service – Operations – Maximum Allowable Operating Pressure: Steel or Plastic Pipelines. Except as provided in paragraph (c) of this subsection, no person shall operate a segment of steel or plastic pipeline at a pressure that exceeds the lowest of the following: (1) Design pressure of the weakest element in the segment, determined in accordance with Sections 3 and 4 of this administrative regulation.
>
> Finding: The 12-inch pipeline was operated at a pressure greater than the pressure rating for a 12-inch coupling and the Maximum Allowable Operating Pressure ("MAOP") of the pipeline. LG&E's 30-Day Report established an MAOP of 400 PSIG for the 12-inch pipeline. LG&E GOM&I, Table 79.2 requires that, to restrain a 12-inch 400 PSIG design pressure coupling, the coupling must be installed with seven rods and lugs each with a 3/4-inch diameter or five rods and lugs each with a 7/8-inch diameter. The restraint system for the failed coupling had four rods and lugs with a 3/4-inch diameter.

Based on its review of the Staff Report and being otherwise sufficiently advised, the Commission finds that *prima facie* evidence exists that LG&E has failed to comply with 49 C.F.R. Part 192. We further find that a formal investigation into the incident that is the subject matter of the Staff Report should be conducted and that this investigation should also examine the adequacy, safety, and reasonableness of LG&E's practices related to the construction, installation, and repair of natural gas facilities.

The Commission, on its own motion, HEREBY ORDERS that:

1. LG&E shall submit to the Commission, within 20 days of the date of this Order, a written response to the allegations contained in the Staff Report.

2. LG&E shall appear on Wednesday, July 12, 2017, at 9:00 a.m., Eastern Daylight Time, in Hearing Room 1 of the Commission's offices at 211 Sower Boulevard in Frankfort, Kentucky, for the purpose of presenting evidence concerning the alleged

violations of 49 C.F.R. Part 192, and of showing cause why it should not be subject to the penalties prescribed in KRS 49 C.F.R. Part 192, for these alleged violations.

3. At the scheduled hearing in this matter, LG&E shall also present evidence on the adequacy, safety, and reasonableness of its practices related to the construction, installation, and repair of natural gas facilities and whether such practices require revision as related to this incident.

4. The July 12, 2017 hearing shall be recorded by digital video recording only.

5. The Staff Report attached as an Appendix to this Order is made a part of the record in this case.

6. Any requests for an informal conference with Commission Staff shall be set forth in writing and filed with the Commission within 20 days of the date of this Order.

By the Commission

ENTERED
MAR 15 2017
KENTUCKY PUBLIC SERVICE COMMISSION

ATTEST:

Talina R. Mathews

Executive Director

APPENDIX

APPENDIX TO AN ORDER OF THE KENTUCKY PUBLIC SERVICE COMMISSION IN CASE NO. 2017-00119 DATED MAR 15 2017

Matthew G. Bevin
Governor

Charles G. Snavely
Secretary
Energy and Environment Cabinet

Commonwealth of Kentucky
Public Service Commission
211 Sower Blvd.
P.O. Box 615
Frankfort, Kentucky 40602-0615
Telephone: (502) 564-3940
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Michael J. Schmitt
Chairman

Robert Cicero
Vice Chairman

Daniel E. Logsdon Jr.
Commissioner

Gas Pipeline Safety Branch Incident Investigation Report -

LG&E Ballardsville Natural Gas Transmission Pipeline

Date of Incident:	September 17, 2014
Location of Incident:	12889 West Hwy 42 Prospect, Oldham County, KY
Name of Operator:	Louisville Gas & Electric Company ("LG&E")
Operator Type:	Intrastate Natural Gas Transmission and Distribution

Investigation Terms and Abbreviations

Kentucky Public Service Commission - **KPSC**
Louisville Gas & Electric Company - **LG&E**
Southern Pipeline Company – **Southern Pipeline**
Gas Technology Institute - **GTI**
Maximum Allowable Operating Pressure - **MAOP**
All pressures referenced are Pounds per Square Inch Gage - **PSIG**.
Gas Operating, Maintenance and Inspection Procedures - **GOM&I**
Title 49 Code of Federal Regulations – **49 CFR**
Kentucky Administrative Regulations - **KAR**
All times referenced in this report will be stated as eastern standard military time.

Incident Description

This incident occurred at 12889 West Hwy 42 Prospect, KY in Oldham County, Kentucky, at approximately 16:51 hours on September 17, 2014. On September 16, 2014, a Southern Pipeline crew, working as a contractor to LG&E, began excavating several feet of natural gas intrastate transmission pipeline in the right of way parallel to Hwy 42 in Prospect, Kentucky. This project included reconfiguring the pipeline to allow for an inline inspection tool to pass internally through the pipe.

A mechanical coupling, originally installed on 1/5/1998 (according to a LG&E Gas Construction and Maintenance Main Work Report dated 1/5/1998 and provided to the KYPSC through an information request) was exposed on the 12-inch pipeline within the excavation site. Southern Pipeline employees had completed the excavation work for the day and were around the excavation site installing barricades when, at approximately 16:51PM the 12-inch pipeline separated at the mechanical coupling. This resulted in a loss of gas with no ignition occurring. The Maximum Allowable Operating Pressure ("MAOP") established by LG&E for that line was 400 pounds per square in gauge ("PSIG"). The pressure at the time of the coupling failure was approximately 250 PSIG. The force of the separation resulted in debris being scattered with sufficient force to damage a passing vehicle (no injuries) and the roof of a nearby house. Two Southern Pipeline employees were injured by flying debris, one was struck in the arm resulting in a fracture and admitted to University of Louisville Hospital, another received only minor injuries with no hospitalization. There were two LG&E employees at the incident site also and they received no injuries. (See Attachment A)

Response to Incident

Fire Department

North Oldham Fire department received the alarm at 16:53 hours and arrived at the scene at 16:56 hours, mutual aid was received by the Harrods Creek Fire Department. The scene was secured and as a precaution 24 homes were evacuated until the flow of gas was shut off at 16:29.
Scene was considered under control at 21:55 hours. The last fire unit cleared from the scene at 22:03 hours.

LG&E

An LG&E employee at the scene promptly called LG&E Gas Control to report the incident, additional LG&E personnel arrived onsite at 17:47. This incident resulted in the loss of gas service to approximately 2,400 customers.
On September 18, crews made sufficient temporary repairs to allow the restoration of customer's service to begin. On September 19, 2014 at 03:35 hours, permanent repairs were completed and the pipeline was restarted. Service was restored to the majority of the affected customers by the end of the day on September 20. Approximately 32 customers were out of town during that period and technicians could not gain access to perform the re-lights.
Final repairs were completed and the scene was restored on September 21, 2014.

KPSC

KPSC staff Joel Grugin was notified to respond to the incident at approximately 17:45 hours September, 17 2014. He arrived on scene at 19:10 hours and stayed onsite until 13:00 hours September 18, 2015.

Investigation

KPSC

This incident was reported to the KYPSC because it met the incident reporting criteria set forth in Federal code CFR PART 191.3 Definitions: Incident (1) (i) (ii) and Kentucky state code 807 KAR5:006 Section 27. Reporting of Accidents, Property Damage, or Loss of Service (1) (a) (b) (c)

The purpose of this investigation is to determine if LG&E was in compliance with Federal and State pipeline safety regulations and subsequently LG&E's own Gas Operating, Maintenance and Inspection Procedures (GOM&I) procedures. The regulations relating to this incident are Title 49 Code of Federal regulations Part 191,192,199 and Kentucky State regulations 807, KAR 5:006, 5:022 and 5:027.

On 8/14/2015 the KY PSC received copies of the LGE GOM&I plans that were in use at the time of the 12 inch coupling installation on January 5, 1998.

LG&E

Pursuant to 49 CFR Part 192.617 Investigation of failures. LG&E obtained the services of Gas Technology Institute "**GTI**" to perform an independent failure analysis of the factors that contributed to the failure of the 12 inch coupling that caused this incident.

Description of Mechanical compression coupling

Most compression couplings are designed to provide a gas tight seal for specified pressure ratings (seat only), but are not designed to resist longitudinal forces which may cause a joint to pull apart, "Pull out" Such force may result from the pressure inside the pipe or from external action such as excavation or ground settlement. In many installation situations it is necessary to restrain the pipe to prevent movement which would cause the compression joint to fail. In this incident restraint was provided by lugs welded to the pipe and threaded tie rods which span the coupling length is the method that was providing this restraint on the failed 12 inch coupling.

GTI Failure Analysis

KPSC has not received from LG&E any contradictions to the findings and conclusions that were found in GTI's failure analysis of this incident. All findings listed in this report are based on the GTI failure analysis, LG&E Incident Report and KYPSC Field Investigation and how they relate to the applicable CFR and KAR codes.

The complete final report of GTI's findings is included in Attachment B of this report. The conclusions stated on page 42 of the report states that a number of factors contributed to the failure of the mechanical coupling / rod & lug restraint system on the Ballardsville transmission line.

GTI believes the most important factors include insufficient amount of lug & harness devices, poor quality of welds on the restraint system "lugs", the use of low yield strength steel in the restraint brackets, the lack of utilizing washers throughout the restraint system, and misalignment in the restraint system.

Findings

- **49 CFR § 192.605(a) and 807 KAR 5:022, Section 13(2)**
  49 CFR § 192.605(a)
  (a) General. Each operator shall prepare and follow for each pipeline, a manual of written procedures for conducting operations and maintenance activities and for emergency response…

  807 KAR 5:022, Section 13(2)
  (2) *General Provisions.*
  (a)No person shall operate a segment of pipeline unless it is operated in accordance with this section.
  (b)Each operator shall establish a written operating and maintenance plan meeting the requirements of this administrative regulation and keep records necessary to administer the plan.

  Finding 1:
  LG&E did not follow the installation instructions of Table 79.2 of their GOM&I plan and install the correct number and size of rods in the installation of the 12 inch coupling on 1/5/1998. Table 79.2 (Attachment B) shows that a 12 inch 400 PSIG design pressure coupling requires 7– 3/4 inch diameter rods and lugs or 5- 7/8 inch diameter rods and lugs to properly restrain it. The failed coupling had 4 -3/4 inch diameter rods and lugs. The thickness of the lugs for this installation as depicted in Figure D-8 (10" pipe and larger) should have had a thickness of .375" was not addressed in the GTI report.

  Finding 2:
  LG&E did not follow the installation instructions of Figure D-8 (Attachment C) of Fittings couplings 1995-03-17 Revision 16 of their GOM& I plan in the installation of the 12 inch coupling on 1/5/1998. Bullet point 2 of the GTI executive summary stated that the lugs were only welded on 1 side of the brackets. The bottom note on Figure D-8 states that "both inside and outside welding surfaces of lugs are to be welded to the pipe". One such photo which shows a lug not welded on the inside can be seen on page 23 figure 25 of the report.

  Finding 3:
  LG&E did not follow the GOM&I plan drawing Figure D-8 (Attachment C) for the installation of the 12 inch coupling on 1/5/1998. The drawing for a plain coupling shows that a washer should be installed between the (lug) bracket and nut of the tensioning rod. Bullet point 4 of the conclusions on page 42 of the GTI report stated that (Washers were not used on both ends to distribute the load over the (lug) bracket face.)

  Finding 4:
  Using the LG&E GO&MI plan drawing D-8 (Attachment C), LG&E did not follow the installation instructions when they installed the 8 inch coupling on the 8 inch pipeline that was installed at an earlier date..
  This drawing depicts the proper installation of a coupling. It shows that washers should be installed between the lug and nut of the tensioning rod.
  Figure 38 on page 37 of the GTI report shows a picture of the rod assembly installed and no washers being present on one end of the installation. Note: While this coupling did not fail it did show signs of distortion of the washer-less side of the coupling

assembly. This documents another instance where an improper installation of a mechanical compression coupling was installed in the LG&E gas system.

- **<u>49 CFR § 192.241 and 807 KAR 5:022, Section 5(8)</u>**

  49 CFR § 192.241

  (a) Visual inspection of welding must be conducted by an individual qualified by appropriate training and experience to ensure that:

  (1) The welding is performed in accordance with the welding procedure; and

  (2) The weld is acceptable under paragraph (c) of this section.

  ...

  (c) The acceptability of a weld that is nondestructively tested or visually inspected is determined according to the standards in section 9 or Appendix A of API Std 1104 (incorporated by reference, see §192.7) Appendix A of API Std 1104 may not be used to accept cracks.

  807 KAR 5:022, Section 5(8)

  (8) Inspection of test welds.

  (a) Visual inspection of welding shall be conducted to insure that:

  1. Welding is performed in accordance with welding procedure; and

  2. Weld is acceptable under paragraph (c) of this subsection.

  ...

  (c) Acceptability of a weld that is nondestructively tested or visually inspected is determined according to the standards in Section 6 of API Standard 1104.

  <u>Finding 5:</u>

  LG&E did not adequately inspect the welds made on the lug brackets as part of the installation of the failed 12 inch coupling installed on 1/5/1998 to detect the quality of the welds and that some were only welded on 1 side.

  The GTI report stated in Conclusions on page 42 bullet point 2 that the weld quality on the lug brackets was poor and that some of the brackets were welded only on 1 side. One such photo which shows a lug bracket not welded on the inside can be seen on page 23 figure 25 of the report.

- **<u>49 CFR § 192.619(a)(1) and 807 KAR 5:022, Section 13(11)(a)(1)</u>**

  49 CFR § 192.619(a) (1)

  (a) No person may operate a segment of steel or plastic pipeline at a pressure that exceeds a maximum allowable operating pressure determined under paragraph (c) or (d) of this section, or the lowest of the following:

  (1) The design pressure of the weakest element in the segment, determined in accordance with subparts C and D of this part...

  807 KAR 5:022, Section 13(11) (a) (1)

  (11) Maximum allowable operating pressure: steel or plastic pipelines.

  (a) Except as provided in paragraph (c) of this subsection, no person shall operate a segment of steel or plastic pipeline at a pressure that exceeds the lowest of the following:

  1. Design pressure of the weakest element in the segment, determined in accordance with Sections 3 and 4 of this administrative regulation.

Finding 6:
LG&E established the MAOP of the line to be 400 psig. (Attachment A).
The 12-inch mechanical coupling was installed with 4-3/4 inch diameter rods. Per Table 79.2 of LG&E's GOM&I Plan (Attachment B), a mechanical coupling with 5-3/4 inch diameter rods would be rated for a maximum pressure of 300 psig. Therefore, the MAOP could not be 400 psig. since the mechanical coupling would be rated for a pressure less than 300 psig. based on its installation.
A review of the pressure records in (Attachment D) provided by LG&E showed that the operating pressure increased on the dates of 5/18/11,10/27/11, 4/9/12, 7/11/13, and 11/20/13 to a pressure that exceeded 300 psig. Therefore, evidence exists that the pipeline has been operated at a pressure greater than the pressure rating of the 12 inch coupling and subsequently the MAOP of the pipeline.

Recommendations

As a result of this incident it has been found that 2 different mechanical compression couplings (the 8 inch and the 12 inch) were not installed per LG&E's GOM&I Plan.
Due to this fact, it is recommended that LG&E evaluate its high pressure distribution / transmission gas system to identify any mechanical couplings for improper installations and take corrective action to address them.
Also all employees who install and inspect welds & couplings should be evaluated to determine that the GOM&I and manufacturers guidelines are followed.

Attachments

Attachment A LG&E Incident Report to Commission and PHMSA Incident Report
Attachment B: GTI Failure Analysis report of the 12 inch coupling failure.
Attachment C: LG&E Gas Operating and Maintenance Inspection Procedures that were in effect at the time the 12 inch coupling was installed on 1/5/1998.
Attachment D: LG&E Pressure records of the Ballardsville pipeline

Investigated By: Joel Grugin, Utility Regulatory & Safety Investigator III

Report By: Joel Grugin 8/11/16

Joel Grugin Date

ATTACHMENT A

LG&E Incident Report to Commission

LG&E PHMSA Incident Report

LG&E KU
PPL companies

RECEIVED

OCT 17 2014

PUBLIC SERVICE
COMMISSION

LG&E and KU Energy, LLC
Corporate Law
220 W. Main Street
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J. Gregory Cornett
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October 17, 2014

Mr. Bill Aitken
Gas Pipeline Safety Branch
Kentucky Public Service Commission
P.O. Box 615
Frankfort, Kentucky 40602

Re: Ballardsville Natural Gas Transmission Pipeline Incident
14-ED-G-026

Dear Mr. Aitken:

I am forwarding the enclosed incident report prepared by Peter Clyde regarding the above referenced incident that occurred on September 17, 2014. This report is being submitted as required by Section 27 of 807 KAR 5:027.

Please return a file stamped copy in the envelope enclosed.

If you need additional information concerning this incident, please contact me at (502) 627-2756 so I can direct your request to the appropriate person.

Sincerely,

J. Gregory Cornett

JGC/kgh

Enclosures

KPSC INVESTIGATION REPORT

LG&E Natural Gas Pipeline Rupture — Type of Report

14-ED-G-026 — Report Number

McBride-Claypool — Investigator

September 17, 2014 — Date of Incident

Peter Clyde — Report prepared by

Location: **12889 West Hwy 42**
Prospect, Oldham County, Kentucky 40059

Case Summary

On September 17, 2014 at approximately 4:51 p.m. Louisville Gas and Electric Company ("LG&E") Gas Control noticed a significant drop in pressure on the Ballardsville Natural Gas Transmission line. At that same time, employee and contractor staff onsite witnessed a mechanical coupling failure.

At approximately 05:09 p.m. LG&E Customer Service received an emergency call from Oldham County Dispatch requesting assistance at the scene of a pipeline incident involving blowing natural gas.

Greg Cornett, Associate General Counsel of LG&E and KU Energy notified the Kentucky Public Service Commission (KPSC), and Jay Warren, Senior Corporate Attorney of LG&E and KU Energy notified the Pipeline Hazardous Material and Safety Administration (PHMSA), both via telephone.

Incident Summary

On September 16, 2014 Southern Pipeline began excavating several feet of natural gas transmission pipe in the right of way parallel to Hwy 42 in Goshen, Kentucky, in order to reconfigure the pipeline to allow for inline inspection.

On September 17, 2014, a mechanical coupling, originally installed on January 5, 1998, was exposed on the 12-inch pipeline within the excavation. Southern Pipeline employees had completed the excavation work for the day when, at approximately 4:51 pm, the pipeline separated from the mechanical coupling. This resulted in a release of gas. The gas did not ignite.

The force of the separation did result in debris being scattered. A passing vehicle and the roof of a nearby house were damaged by the debris.

Two Southern Pipeline employees were injured by flying debris. Elvis Posey, CDL Driver, Southern Pipeline, was struck with a large piece of debris which resulted in a broken arm. Mr. Posey was taken and admitted to University of Louisville Hospital. John Schindler, Laborer, Southern Pipeline received minor injuries but was not hospitalized. LG&E employees Nicholas Thompson, Pipeline Inspector, and William Norton, Mechanical Engineer II, were on site at the time of the incident. William Norton promptly called LG&E Gas Control to report the incident.

Louisville Metro Fire Department responded to the scene and evacuated approximately 24 nearby homes. There were no public injuries as a result of this incident.

At 5:47 p.m., additional personnel responded to the location of the incident. At 8:29 p.m. the pipeline was fully shut down to allow for repairs.

The incident resulted in loss of gas service to approximately 2,400 customers.

On September 18, crews made temporary repairs to the pipeline to allow for restoration of customer's gas service. At 3:35 a.m. on September 19, 2014 the pipeline was restarted.

On September 19 and 20, the majority of customer services were restored. 32 customers remain without service because they have not been home to allow a technician to perform re-lights.

Final pipeline repairs were completed on September 21, 2014.

Witnesses:

William Norton, Mechanical Engineer II
Louisville Gas & Electric Company

Nicholas Thompson, Pipeline Inspector
Louisville Gas & Electric Company

Elvis Posey, CDL Driver – Injured/Hospitalized
Southern Pipeline Construction Company

John Schindler, Laborer – Minor Injuries
Southern Pipeline Construction Company

Tim Higgs, Laborer
Southern Pipeline Construction Company

Larry Waddell, Foreman
Southern Pipeline Construction Company

Contractor Information:

Southern Pipeline Construction Company, Inc.
1272 Old Fern Valley Road
Louisville, KY 40219

DATE OF REPORT: October 17, 2014
END OF REPORT

NOTICE: This report is required by 49 CFR Part 191. Failure to report can result in a civil penalty not to exceed 100,000 for each violation for each day that such violation persists except that the maximum civil penalty shall not exceed $1,000,000 as provided in 49 USC 60122.		OMB NO: 2137-0522 EXPIRATION DATE: 02/28/2014
U.S Department of Transportation Pipeline and Hazardous Materials Safety Administration	Original Report Date:	10/17/2014
	No.	20140107 - 16512 (DOT Use Only)

INCIDENT REPORT - GAS TRANSMISSION AND GATHERING PIPELINE SYSTEMS

INSTRUCTIONS

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

PART A - KEY REPORT INFORMATION

Report Type: *(select all that apply)*	Original:	Supplemental:	Final:
	Yes		
Last Revision Date:			
1. Operator's OPS-issued Operator Identification Number (OPID):	11824		
2. Name of Operator	LOUISVILLE GAS & ELECTRIC CO		
3. Address of Operator:			
3a. Street Address	220 W MAIN ST, PO BOX 32010		
3b. City	LOUISVILLE		
3c. State	Kentucky		
3d. Zip Code:	40202		
4. Local time *(24-hr clock)* and date of the Incident:	09/17/2014 16:51		
5. Location of Incident:			
Latitude:	38.37078		
Longitude:	85.5905		
6. National Response Center Report Number (if applicable):	1095646		
7. Local time *(24-hr clock)* and date of initial telephonic report to the National Response Center (if applicable):	09/17/2014 19:10		
8. Incident resulted from:	Unintentional release of gas		
9. Gas released: (select only one, based on predominant volume released)	Natural Gas		
- Other Gas Released Name:			
10. Estimated volume of commodity released unintentionally - Thousand Cubic Feet (MCF):	7,000.00		
11. Estimated volume of intentional and controlled release/blowdown - Thousand Cubic Feet (MCF)			
12. Estimated volume of accompanying liquid release (Barrels):			
13. Were there fatalities?	No		
- If Yes, specify the number in each category:			
13a. Operator employees			
13b. Contractor employees working for the Operator			
13c. Non-Operator emergency responders			
13d. Workers working on the right-of-way, but NOT associated with this Operator			
13e. General public			
13f. Total fatalities (sum of above)			
14. Were there injuries requiring inpatient hospitalization?	Yes		
- If Yes, specify the number in each category:			
14a. Operator employees	0		
14b. Contractor employees working for the Operator	1		
14c. Non-Operator emergency responders	0		
14d. Workers working on the right-of-way, but NOT associated with this Operator	0		
14e. General public	0		
14f. Total injuries (sum of above)	1		

15. Was the pipeline/facility shut down due to the incident?	Yes
- If No, Explain:	
- If Yes, complete Questions 15a and 15b: *(use local time, 24-hr clock)*	
15a. Local time and date of shutdown	09/17/2014 20:29
15b. Local time pipeline/facility restarted	09/19/2014 03:35
- Still shut down? (* Supplemental Report Required)	
16. Did the gas ignite?	No
17. Did the gas explode?	No
18. Number of general public evacuated:	100
19. Time sequence *(use local time, 24-hour clock)*:	
19a. Local time operator identified incident	09/17/2014 16:51
19b. Local time operator resources arrived on site	09/17/2014 16:51

PART B - ADDITIONAL LOCATION INFORMATION

1. Was the origin of the Incident onshore?	Yes
- Yes (Complete Questions 2-12)	
- No (Complete Questions 13-15)	
If Onshore:	
2. State:	Kentucky
3. Zip Code:	40059
4. City	Prospect
5. County or Parish	Oldham County
6. Operator designated location	Survey Station No.
Specify:	69.872
7. Pipeline/Facility name:	Ballardsville
8. Segment name/ID:	Segment 14.0 (HWY 42)
9. Was Incident on Federal land, other than the Outer Continental Shelf (OCS)?	No
10. Location of Incident :	Pipeline Right-of-way
11. Area of Incident (as found) :	Underground
Specify:	Exposed due to excavation
Other – Describe:	
Depth-of-Cover (in):	48
12. Did Incident occur in a crossing?	No
- If Yes, specify type below:	
- If Bridge crossing –	
Cased/ Uncased:	
- If Railroad crossing –	
Cased/ Uncased/ Bored/drilled	
- If Road crossing –	
Cased/ Uncased/ Bored/drilled	
- If Water crossing –	
Cased/ Uncased	
Name of body of water (If commonly known):	
Approx. water depth (ft) at the point of the Incident:	
Select:	
If Offshore:	
13. Approx. water depth (ft) at the point of the Incident:	
14. Origin of Incident:	
- If "In State waters":	
- State:	
- Area:	
- Block/Tract #:	
- Nearest County/Parish:	
- If "On the Outer Continental Shelf (OCS)":	
- Area:	
- Block #:	
15. Area of Incident:	

PART C - ADDITIONAL FACILITY INFORMATION

1. Is the pipeline or facility: - Interstate - Intrastate	Intrastate
2. Part of system involved in Incident:	Onshore Pipeline, Including Valve Sites
3. Item involved in Incident:	Other
- If Pipe – Specify:	
3a. Nominal diameter of pipe (in):	
3b. Wall thickness (in):	

3c. SMYS (Specified Minimum Yield Strength) of pipe (psi):	
3d. Pipe specification:	
3e. Pipe Seam – Specify:	
- If Other, Describe:	
3f. Pipe manufacturer:	
3g. Year of manufacture:	
3h. Pipeline coating type at point of Incident – Specify:	
- If Other, Describe:	
- If Weld, including heat-affected zone – Specify:	
- If Other, Describe:	
- If Valve – Specify:	
- If Mainline – Specify:	
- If Other, Describe:	
3i. Mainline valve manufacturer:	
3j. Year of manufacture:	
- If Other, Describe:	mechanical coupling
4. Year item involved in Incident was installed:	1998
5. Material involved in Incident:	Carbon Steel
- If Material other than Steel or Plastic – Specify:	
6. Type of Incident involved:	Other
- If Mechanical Puncture – Specify Approx. size:	
Approx. size: in. (in axial) by	
in. (circumferential)	
- If Leak - Select Type:	
- If Other – Describe:	
- If Rupture - Select Orientation:	
- If Other – Describe:	
Approx. size: in. (widest opening):	
by in. (length circumferentially or axially):	
- If Other – Describe:	
	pipe came out of mechanical coupling

PART D - ADDITIONAL CONSEQUENCE INFORMATION

1. Class Location of Incident:	Class 3 Location
2. Did this Incident occur in a High Consequence Area (HCA)?	Yes
- If Yes:	
2a. Specify the Method used to identify the HCA:	Method2
3. What is the PIR (Potential Impact Radius) for the location of this Incident? Feet:	165
4. Were any structures outside the PIR impacted or otherwise damaged due to heat/fire resulting from the Incident?	No
5. Were any structures outside the PIR impacted or otherwise damaged NOT by heat/fire resulting from the Incident?	No
6. Were any of the fatalities or injuries reported for persons located outside the PIR?	No
7. Estimated Property Damage :	
7a. Estimated cost of public and non-Operator private property damage	$ 52,000
7b. Estimated cost of Operator's property damage & repairs	$ 262,000
7c. Estimated cost of Operator's emergency response	$ 60,000
7d. Estimated other costs	$ 950,000
Describe:	restoration/re-light effort
7e. Total estimated property damage (sum of above)	$ 1,324,000
Cost of Gas Released	
7f. Estimated cost of gas released unintentionally	$ 30,709
7g. Estimated cost of gas released during intentional and controlled blowdown	$ 0
7h. Total estimated cost of gas released (sum of 7.f & 7.g above)	$ 30,709

PART E - ADDITIONAL OPERATING INFORMATION

1. Estimated pressure at the point and time of the Incident (psig):	250.00
2. Maximum Allowable Operating Pressure (MAOP) at the point and time of the Incident (psig):	400.00
2.a MAOP established by 49 CFR section:	

-Details:	
3. Describe the pressure on the system or facility relating to the Incident:	Pressure did not exceed MAOP
4. Not including pressure reductions required by PHMSA regulations (such as for repairs and pipe movement), was the system or facility relating to the Incident operating under an established pressure restriction with pressure limits below those normally allowed by the MAOP?	No
- If Yes - *(Complete 4a and 4b below)*	
4a. Did the pressure exceed this established pressure restriction?	
4b. Was this pressure restriction mandated by PHMSA or the State?	
5. Was "Onshore Pipeline, Including Valve Sites" OR "Offshore Pipeline, Including Riser and Riser Bend" selected in PART C, Question 2?	Yes
- If Yes - *(Complete 5a. – 5e. below)*:	
5a. Type of upstream valve used to initially isolate release source:	Manual
5b. Type of downstream valve used to initially isolate release source:	Manual
5c. Length of segment isolated between valves (ft):	35,500
5d. Is the pipeline configured to accommodate internal inspection tools?	No
- If No – Which physical features limit tool accommodation? *(select all that apply)*	
- Changes in line pipe diameter	
- Presence of unsuitable mainline valves	Yes
- Tight or mitered pipe bends	
- Other passage restrictions (i.e. unbarred tee's, projecting instrumentation, etc.)	Yes
- Extra thick pipe wall (applicable only for magnetic flux leakage internal inspection tools)	
- Other	
- If Other, Describe:	
5e. For this pipeline, are there operational factors which significantly complicate the execution of an internal inspection tool run?	No
- If Yes, which operational factors complicate execution? *(select all that apply)*	
- Excessive debris or scale, wax, or other wall build-up	
- Low operating pressure(s)	
- Low flow or absence of flow	
- Incompatible commodity	
- Other	
- If Other, Describe:	
5f. Function of pipeline system:	Transmission Line of Distribution System
6. Was a Supervisory Control and Data Acquisition (SCADA)-based system in place on the pipeline or facility involved in the Incident?	Yes
- If Yes:	
6a. Was it operating at the time of the Incident?	Yes
6b. Was it fully functional at the time of the Incident?	Yes
6c. Did SCADA-based information (such as alarm(s), alert(s), event(s), and/or volume or pack calculations) assist with the detection of the Incident?	Yes
6d. Did SCADA-based information (such as alarm(s), alert(s), event(s), and/or volume calculations) assist with the confirmation of the Incident?	Yes
7. How was the Incident initially identified for the Operator?	Local Operating Personnel, including contractors
- If Other – Describe:	
7a. If "Controller", "Local Operating Personnel, including contractors", "Air Patrol", or "Ground Patrol by Operator or its contractor" is selected in Question 7, specify the following:	Operator employee
8. Was an investigation initiated into whether or not the controller(s) or control room issues were the cause of or a contributing factor to the Incident?	No, the Operator did not find that an investigation of the controller(s) actions or control room issues was necessary due to: (provide an explanation for why the Operator did not investigate)
- If No, the operator did not find that an investigation of the controller(s) actions or control room issues was necessary due to: *(provide an explanation for why the operator did not investigate)*	The Incident was a result of a mechanical coupling failure and not any control room issues.
- If Yes, Describe investigation result(s) *(select all that apply)*:	

- Investigation reviewed work schedule rotations, continuous hours of service (while working for the operator), and other factors associated with fatigue	
- Investigation did NOT review work schedule rotations, continuous hours of service (while working for the Operator) and other factors associated with fatigue	
- Provide an explanation for why not:	
- Investigation identified no control room issues	
- Investigation identified no controller issues	
- Investigation identified incorrect controller action or controller error	
- Investigation identified that fatigue may have affected the controller(s) involved or impacted the involved controller(s) response	
- Investigation identified incorrect procedures	
- Investigation identified incorrect control room equipment operation	
- Investigation identified maintenance activities that affected control room operations, procedures, and/or controller response	
- Investigation identified areas other than those above –	
Describe:	

PART F - DRUG & ALCOHOL TESTING INFORMATION

1. As a result of this incident, were any Operator employees tested under the post-accident drug and alcohol testing requirements of DOT's Drug & Alcohol Testing regulations?	Yes
- If Yes:	
1a. Describe how many were tested:	4
1b. Describe how many failed:	0
2. As a result of this Incident, were any Operator contractor employees tested under the post-accident drug and alcohol testing requirements of DOT's Drug & Alcohol Testing regulations?	Yes
- If Yes:	
2a. Describe how many were tested:	4
2b. Describe how many failed:	0

PART G - APPARENT CAUSE

Select only one box from PART G in the shaded column on the left representing the APPARENT Cause of the Incident, and answer the questions on the right. Describe secondary, contributing, or root causes of the incident in the narrative (PART H).

Apparent Cause:	G6 - Equipment Failure

G1 - Corrosion Failure - *only one sub-cause can be picked from shaded left-hand column*

Corrosion Failure – Sub-cause:	
- If External Corrosion:	
1. Results of visual examination:	
- If Other, Describe:	
2. Type of corrosion: *(select all that apply)*	
- Galvanic	
- Atmospheric	
- Stray Current	
- Microbiological	
- Selective Seam	
- Other	
- If Other – Describe:	
3. The type(s) of corrosion selected in Question 2 is based on the following: *(select all that apply)*	
- Field examination	
- Determined by metallurgical analysis	
- Other	
- If Other – Describe:	
4. Was the failed item buried under the ground?	
- If Yes:	
4a. Was failed item considered to be under cathodic protection at the time of the incident?	
- If Yes, Year protection started:	

4b. Was shielding, tenting, or disbonding of coating evident at the point of the incident?	
4c. Has one or more Cathodic Protection Survey been conducted at the point of the incident?	
If "Yes, CP Annual Survey" – Most recent year conducted:	
If "Yes, Close Interval Survey" – Most recent year conducted	
If "Yes, Other CP Survey" – Most recent year conducted:	
- If No:	
4d. Was the failed item externally coated or painted?	
5. Was there observable damage to the coating or paint in the vicinity of the corrosion?	
- If Internal Corrosion:	
6. Results of visual examination:	
- If Other, Describe:	
7. Cause of corrosion *(select all that apply)*:	
- Corrosive Commodity	
- Water drop-out/Acid	
- Microbiological	
- Erosion	
- Other	
- If Other, Describe:	
8. The cause(s) of corrosion selected in Question 7 is based on the following *(select all that apply)*:	
- Field examination	
- Determined by metallurgical analysis	
- Other	
- If Other, Describe:	
9. Location of corrosion *(select all that apply)*:	
- Low point in pipe	
- Elbow	
- Drop-out	
- Other	
- If Other, Describe:	
10. Was the gas/fluid treated with corrosion inhibitors or biocides?	
11. Was the interior coated or lined with protective coating?	
12. Were cleaning/dewatering pigs (or other operations) routinely utilized?	
13. Were corrosion coupons routinely utilized?	
Complete the following if any Corrosion Failure sub-cause is selected AND the "Item Involved in Incident" (from PART C, Question 3) is Pipe or Weld.	
14. Has one or more internal inspection tool collected data at the point of the incident?	
14a. If Yes, for each tool used, select type of internal inspection tool and indicate most recent year run:	
- Magnetic Flux Leakage Tool	
Most recent year run:	
- Ultrasonic	
Most recent year run:	
- Geometry	
Most recent year run:	
- Caliper	
Most recent year run:	
- Crack	
Most recent year run:	
- Hard Spot	
Most recent year run:	
- Combination Tool	
Most recent year run:	
- Transverse Field/Triaxial	
Most recent year run:	
- Other	
Most recent year run:	
If Other, Describe:	
15. Has one or more hydrotest or other pressure test been conducted since original construction at the point of the incident?	
- If Yes,	
Most recent year tested:	
Test pressure (psig):	
16. Has one or more Direct Assessment been conducted on this segment?	

- If Yes, and an investigative dig was conducted at the point of the Incident:	
Most recent year conducted:	
- If Yes, but the point of the Incident was not identified as a dig site:	
Most recent year conducted:	
17. Has one or more non-destructive examination been conducted at the point of the Incident since January 1, 2002?	
17a. If Yes, for each examination conducted since January 1, 2002, select type of non-destructive examination and indicate most recent year the examination was conducted:	
- Radiography	
Most recent year examined:	
- Guided Wave Ultrasonic	
Most recent year examined:	
- Handheld Ultrasonic Tool	
Most recent year examined:	
- Wet Magnetic Particle Test	
Most recent year examined:	
- Dry Magnetic Particle Test	
Most recent year examined:	
- Other	
Most recent year examined:	
If Other, Describe:	
G2 - Natural Force Damage - *only one sub-cause can be picked from shaded left-handed column*	
Natural Force Damage – Sub-Cause:	
- If Earth Movement, NOT due to Heavy Rains/Floods:	
1. Specify:	
- If Other, Describe:	
- If Heavy Rains/Floods:	
2. Specify:	
- If Other, Describe:	
- If Lightning:	
3. Specify:	
- If Temperature:	
4. Specify:	
- If Other, Describe:	
- If High Winds:	
- If Other Natural Force Damage:	
5. Describe:	
Complete the following if any Natural Force Damage sub-cause is selected.	
6. Were the natural forces causing the Incident generated in conjunction with an extreme weather event?	
6a. If yes, specify: *(select all that apply)*:	
- Hurricane	
- Tropical Storm	
- Tornado	
- Other	
- If Other, Describe:	
G3 - Excavation Damage *only one sub-cause can be picked from shaded left-hand column*	
Excavation Damage – Sub-Cause:	
- If Excavation Damage by Operator (First Party):	
- If Excavation Damage by Operator's Contractor (Second Party):	
- If Excavation Damage by Third Party:	
- If Previous Damage Due to Excavation Activity:	
Complete Questions 1-5 ONLY IF the "Item Involved in Incident" (From Part C, Question 3) is Pipe or Weld.	
1. Has one or more internal inspection tool collected data at the point of the Incident?	
1a. If Yes, for each tool used, select type of internal inspection tool and indicate most recent year run:	
- Magnetic Flux Leakage	
Year:	
- Ultrasonic	

Year:	
- Geometry	
Year:	
- Caliper	
Year:	
- Crack	
Year:	
- Hard Spot	
Year:	
- Combination Tool	
Year:	
- Transverse Field/Triaxial	
Year:	
- Other:	
Year:	
Describe:	
2. Do you have reason to believe that the internal inspection was completed BEFORE the damage was sustained?	
3. Has one or more hydrotest or other pressure test been conducted since original construction at the point of the Incident?	
- If Yes:	
Most recent year tested:	
Test pressure (psig):	
4. Has one or more Direct Assessment been conducted on the pipeline segment?	
- If Yes, and an investigative dig was conducted at the point of the Incident:	
Most recent year conducted:	
- If Yes, but the point of the Incident was not identified as a dig site:	
Most recent year conducted:	
5. Has one or more non-destructive examination been conducted at the point of the Incident since January 1, 2002?	
5a. If Yes, for each examination conducted since January 1, 2002, select type of non-destructive examination and indicate most recent year the examination was conducted:	
- Radiography	
Year:	
- Guided Wave Ultrasonic	
Year:	
- Handheld Ultrasonic Tool	
Year:	
- Wet Magnetic Particle Test	
Year:	
- Dry Magnetic Particle Test	
Year:	
- Other	
Year:	
Describe:	
Complete the following if Excavation Damage by Third Party is selected as the sub-cause.	
6. Did the operator get prior notification of the excavation activity?	
6a. If Yes, Notification received from *(select all that apply)*:	
- One-Call System	
- Excavator	
- Contractor	
- Landowner	
Complete the following mandatory CGA-DIRT Program questions if any Excavation Damage sub-cause is selected.	
7. Do you want PHMSA to upload the following information to CGA-DIRT (www.cga-dirt.com)?	
8. Right-of-Way where event occurred *(select all that apply)*:	
- Public	
- If Public, Specify:	
- Private	
- If Private, Specify:	
- Pipeline Property/Easement	
- Power/Transmission Line	
- Railroad	
- Dedicated Public Utility Easement	
- Federal Land	
- Data not collected	
- Unknown/Other	

9. Type of excavator :	
10. Type of excavation equipment :	
11. Type of work performed :	
12. Was the One-Call Center notified? - Yes - No	
12a. If Yes, specify ticket number:	
12b. If this is a State where more than a single One-Call Center exists, list the name of the One-Call Center notified:	
13. Type of Locator:	
14. Were facility locate marks visible in the area of excavation?	
15. Were facilities marked correctly?	
16. Did the damage cause an interruption in service?	
16a. If Yes, specify duration of the interruption: (hours)	
17. Description of the **CGA-DIRT Root Cause** (*select only the one predominant first level CGA-DIRT Root Cause and then, where available as a choice, then one predominant second level CGA-DIRT Root Cause as well*):	
- Predominant first level CGA-DIRT Root Cause:	
- If One-Call Notification Practices Not Sufficient, Specify:	
- If Locating Practices Not Sufficient, Specify:	
- If Excavation Practices Not Sufficient, Specify:	
- If Other/None of the Above, Explain:	
G4 - Other Outside Force Damage - only one sub-cause can be selected from the shaded left-hand column	
Other Outside Force Damage – Sub-Cause:	
- If Nearby Industrial, Man-made, or Other Fire/Explosion as Primary Cause of Incident:	
- If Damage by Car, Truck, or Other Motorized Vehicle/Equipment NOT Engaged in Excavation:	
1. Vehicle/Equipment operated by:	
- If Damage by Boats, Barges, Drilling Rigs, or Other Maritime Equipment or Vessels Set Adrift or Which Have Otherwise Lost Their Mooring:	
2. Select one or more of the following IF an extreme weather event was a factor:	
- Hurricane	
- Tropical Storm	
- Tornado	
- Heavy Rains/Flood	
- Other	
- If Other, Describe:	
- If Routine or Normal Fishing or Other Maritime Activity NOT Engaged in Excavation:	
- If Electrical Arcing from Other Equipment or Facility:	
- If Previous Mechanical Damage NOT Related to Excavation:	
Complete Questions 3-7 ONLY IF the "Item Involved in Incident" (from PART C, Question 3) is Pipe or Weld.	
3. Has one or more internal inspection tool collected data at the point of the Incident?	
3a. If Yes, for each tool used, select type of internal inspection tool and indicate most recent year run:	
- Magnetic Flux Leakage	
Most recent year run:	
- Ultrasonic	
Most recent year run:	
- Geometry	
Most recent year run:	
- Caliper	
Most recent year run:	
- Crack	
Most recent year run:	
- Hard Spot	
Most recent year run:	
- Combination Tool	
Most recent year run:	
- Transverse Field/Triaxial	
Most recent year run:	
- Other:	
Most recent year run:	
Describe:	
4. Do you have reason to believe that the internal inspection was	

completed BEFORE the damage was sustained?	
5. Has one or more hydrotest or other pressure test been conducted since original construction at the point of the Incident?	
- If Yes:	
Most recent year tested:	
Test pressure (psig):	
6. Has one or more Direct Assessment been conducted on the pipeline segment?	
- If Yes, and an investigative dig was conducted at the point of the Incident :	
Most recent year conducted:	
- If Yes, but the point of the Incident was not identified as a dig site	
Most recent year conducted:	
7. Has one or more non-destructive examination been conducted at the point of the Incident since January 1, 2002?	
7a. If Yes, for each examination conducted since January 1, 2002, select type of non-destructive examination and indicate most recent year the examination was conducted:	
- Radiography	
Most recent year conducted:	
- Guided Wave Ultrasonic	
Most recent year conducted:	
- Handheld Ultrasonic Tool	
Most recent year conducted:	
- Wet Magnetic Particle Test	
Most recent year conducted:	
- Dry Magnetic Particle Test	
Most recent year conducted:	
- Other	
Most recent year conducted:	
Describe:	
If - If Intentional Damage:	
8. Specify:	
- If Other, Describe:	
- If Other Outside Force Damage:	
9. Describe:	

G5 - Material Failure of Pipe or Weld	**Use this section to report material failures ONLY IF the "Item Involved in Incident" (from PART C, Question 3) is "Pipe" or "Weld."**
	Only one sub-cause can be selected from the shaded left-hand column

Material Failure of Pipe or Weld – Sub-Cause:	
1. The sub-case selected below is based on the following *(select all that apply)*:	
- Field Examination	
- Determined by Metallurgical Analysis	
- Other Analysis	
- If "Other Analysis", Describe	
- Sub-cause is Tentative or Suspected; Still Under Investigation *(Supplemental Report required)*	
- If Construction-, Installation- or Fabrication- related:	
2. List contributing factors: *(select all that apply)*	
- If Fatigue or Vibration related:	
Specify:	
- If Other, Describe:	
- Mechanical Stress	
- Other	
- If Other, Describe:	
- If Original Manufacturing-related (NOT girth weld or other welds formed in the field):	
2. List contributing factors: *(select all that apply)*	
- If Fatigue or Vibration related:	
Specify:	
- If Other, Describe:	
- Mechanical Stress	
- Other	
- If Other, Describe:	
- If Environmental Cracking-related:	
3. Specify:	

- If Other, Describe:	
Complete the following if any Material Failure of Pipe or Weld sub-cause is selected.	
4. Additional Factors *(select all that apply)*:	
- Dent	
- Gouge	
- Pipe Bend	
- Arc Burn	
- Crack	
- Lack of Fusion	
- Lamination	
- Buckle	
- Wrinkle	
- Misalignment	
- Burnt Steel	
- Other	
- If Other, Describe:	
5. Has one or more internal inspection tool collected data at the point of the Incident?	
5a. If Yes, for each tool used, select type of internal inspection tool and indicate most recent year run:	
- Magnetic Flux Leakage	
Most recent year run:	
- Ultrasonic	
Most recent year run:	
- Geometry	
Most recent year run:	
- Caliper	
Most recent year run:	
- Crack	
Most recent year run:	
- Hard Spot	
Most recent year run:	
- Combination Tool	
Most recent year run:	
- Transverse Field/Triaxial	
Most recent year run:	
- Other	
Most recent year run:	
Describe:	
6. Has one or more hydrotest or other pressure test been conducted since original construction at the point of the Incident?	
- If Yes	
Most recent year tested:	
Test pressure (psig):	
7. Has one or more Direct Assessment been conducted on the pipeline segment?	
- If Yes, and an investigative dig was conducted at the point of the Incident:	
Most recent year conducted:	
- If Yes, but the point of the Incident was not identified as a dig site:	
Most recent year conducted:	
8. Has one or more non-destructive examination(s) been conducted at the point of the Incident since January 1,2002?	
8a. If Yes, for each examination conducted since January 1, 2002, select type of non-destructive examination and indicate most recent year the examination was conducted:	
- Radiography	
Most recent year conducted:	
- Guided Wave Ultrasonic	
Most recent year conducted:	
- Handheld Ultrasonic Tool	
Most recent year conducted:	
- Wet Magnetic Particle Test	
Most recent year conducted:	
- Dry Magnetic Particle Test	
Most recent year conducted:	
- Other	

Most recent year conducted:	
Describe:	
G6 - Equipment Failure - only one sub-cause can be selected from the shaded left-hand column	
Equipment Failure – Sub-Cause:	Threaded Connection/Coupling Failure
- If Malfunction of Control/Relief Equipment:	
1. Specify:	
- Control Valve	
- Instrumentation	
- SCADA	
- Communications	
- Block Valve	
- Check Valve	
- Relief Valve	
- Power Failure	
- Stopple/Control Fitting	
- Pressure Regulator	
- ESD System Failure	
- Other	
- If Other, Describe:	
- If Compressor or Compressor-related Equipment:	
2. Specify:	
- If Other, Describe:	
- If Threaded Connection/Coupling Failure:	
3. Specify:	Mechanical Coupling
- If Other, Describe:	
- If Non-threaded Connection Failure:	
4. Specify:	
- If Other, Describe:	
- If Defective or Loose Tubing or Fitting:	
- If Failure of Equipment Body (except Compressor), Vessel Plate, or other Material:	
- If Other Equipment Failure:	
5. Describe:	
Complete the following if any Equipment Failure sub-cause is selected.	
6. Additional factors that contributed to the equipment failure *(select all that apply)*	
- Excessive vibration	
- Overpressurization	
- No support or loss of support	
- Manufacturing defect	
- Loss of electricity	
- Improper installation	
- Mismatched items (different manufacturer for tubing and tubing fittings)	
- Dissimilar metals	
- Breakdown of soft goods due to compatibility issues with transported gas/fluid	
- Valve vault or valve can contributed to the release	
- Alarm/status failure	
- Misalignment	
- Thermal stress	
- Other	Yes
- If Other, Describe	root cause analysis under way
G7 – Incorrect Operation - only one sub-cause can be selected from the shaded left-hand column	
Incorrect Operation – Sub-Cause:	
- If Damage by Operator or Operator's Contractor NOT Related to Excavation and NOT due to Motorized Vehicle/Equipment Damage:	
- If Underground Gas Storage, Pressure Vessel, or Cavern Allowed or Caused to Overpressure:	

1. Specify:	
- If Other, Describe:	
- If Valve Left or Placed in Wrong Position, but NOT Resulting in an Overpressure:	
- If Pipeline or Equipment Overpressured:	
- If Equipment Not Installed Properly:	
- If Wrong Equipment Specified or Installed:	
- If Other Incorrect Operation:	
2. Describe:	
Complete the following if any Incorrect Operation sub-cause is selected.	
3. Was this Incident related to: *(select all that apply)*	
- Inadequate procedure	
- No procedure established	
- Failure to follow procedure	
- Other:	
- If Other, Describe:	
4. What category type was the activity that caused the Incident:	
5. Was the task(s) that led to the Incident identified as a covered task in your Operator Qualification Program?	
5a. If Yes, were the individuals performing the task(s) qualified for the task(s)?	

G8 - Other Incident Cause - only one sub-cause can be selected from the shaded left-hand column

Other Incident Cause – Sub-Cause:	
- If Miscellaneous:	
1. Describe:	
- If Unknown:	
2. Specify:	

PART - H NARRATIVE DESCRIPTION OF THE INCIDENT

The pipeline was excavated so modifications could be made to allow passage of in line inspection tools. Within the excavation, a mechanical coupling was exposed. Shortly thereafter, the pipeline separated from the mechanical coupling, which resulted in a release of gas. No ignition or explosion occurred. Repairs were made promptly and the pipeline was returned to service on September 19, 2014.

PART I - PREPARER AND AUTHORIZED SIGNATURE

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ATTACHMENT B

GTI Failure Analysis Report

the Energy to Lead

gti testing laboratories

GTI Project Number: 21745.1.01
Sample Number: 152148

Failure Analysis Investigation of a 12″ Pipe Coupling System

Report Issued:
June 29, 2015

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ACCREDITED
Testing Laboratory
CERT # 2139.01 and 2139.04

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Executive Summary

Table 1. GTI Sample Identification Numbers

GTI Sample ID	Description	Comments	Failure Mode
152148-001	Rod lug bracket #3 D side	Detached from 12" pipe surface	Ductile overload of weld
152148-002	Rod lug bracket #4 D side	Detached from 12" pipe surface	Ductile overload of weld
152148-005	8" Coupling #1 rod lug bracket #2	Partially detached from 8" pipe surface	Ductile overload of weld

Based on the samples provided and the testing and analyses performed, a number of factors contributed to the failure of the mechanical coupling/ rod & lug restraint system on the Ballardsville transmission line on September 7, 2014. GTI believes that the most important factors were, in order of importance:

- The number of rod/lug harness devices installed was too few and below the manufacturer's recommendation of six (6), only four (4) were installed. Per the manufacturer's specification four would have sufficed if they had been the heavy duty ⅞" rod systems rather than the installed ¾" rod light duty systems.
- The weld quality of the detached brackets was poor, with beads applied on only one side, with poor penetration and low weld surface area. Other partially detached brackets were found with weld beads on only one side of their legs.
- The brackets were constructed of very soft, low yield strength Extra Deep Drawing Steel, steel actually designed to yield at a very low stress level. This contributed to the failure in two ways. As the low strength brackets compressed under load, the pipe was no longer constrained by the rod, allowing it to pull out from the coupling. Also the steel under the bolt-heads plastically deformed more easily than a higher-strength steel would have done allowing them pull through the bolt holes. No material specification for the bracket is found in Coupling Systems Inc.'s otherwise comprehensive specifications.
- Washers were not used on both ends to distribute the load over the bracket face.
- The rods and bracket devices were not axially aligned and not uniformly distributed around the pipe. This would have produced a bending moment that could have contributed to bracket detachment.

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Background

On September 16 - 17, 2014 employees of Louisville Gas and Electric and contractor staff from Southern Pipeline were excavating around a 12" natural gas 400 psig MAOP transmission pipe along Highway 42 in Goshen KY in order to reconfigure the pipeline to allow for inline inspection. Excavation work had been completed for the day on September 17 when at 4:51 PM the pipe separated from a mechanical coupling resulting in the release of gas. The pipeline was operating at 250 psig at the time of the incident. The gas release resulted in the injury of two employees, and damage to a nearby home and a passing vehicle. The pipeline had to be shutdown resulting in the loss of service to 2400 customers for 2-4 days.

The samples listed in **Table 2** were provided by the client for analysis.

Table 2. Test Samples Submitted

GTI Sample ID	Description	Comments
152148-001	Bracket #3 Location D (Zorn)	Detached bracket (lug harness) Bracket is severely distorted. Weld contact surfaces corroded, dirty.
151148-002	Bracket #4 Location D (Zorn)	Detached bracket slightly distorted. Weld contact surfaces corroded, dirty
152148-003	12" pipe Location D (Zorn)	Pipe segment that pulled out of coupling. Bracket weld contact surfaces are dirty corroded.
152148-004	Weld bead of bracket #3 location D	Sample of weld bead material, not including substrate
152148-005	Bracket on 8" coupling	Partially detached bracket on one of the two couplings on the 8" pipe

Figure 1. Highway 42 Goshen KY intersection excavation prior to pipe separation

Figure 1 above shows the layout of the pipes prior to the incident. The mechanical coupling that failed can be seen just to the left of the letter *E*. After the incident the pipes involved were moved offsite and photographed by LG&E.

Figure 2. Pipes removed from Goshen Intersection as photographed by LG&E

Figure 3. End segment D-E, pipe was cut by LG&E at D after incident

Figures 2 and **3** above are photographs of the pipes submitted by LG&E after they were removed from the field. Segment D-E was cut from what was originally A-E and henceforth will be referred to as pipe A-D. The uncoated area around the pipe seen at the left at _E_ in **Figure 3** was within the coupling seen at _E_ in **Figure 2**. The 8" pipe seen at the top of **Figure 2**, segment C-B, was not involved in the incident. LG& E submitted it to GTI for inspection and evaluation of the integrity of the couplings.

Throughout this report GTI will conform to the letter codes and bracket numbers as they were labelled by LG&E. Per this scheme the 12:00 pipe orientation is between brackets #1 and #2. In addition to the pipes discussed there were two brackets that had detached from segment D-E that LG&E tagged and shipped to GTI. LG&E provided the information that is included in this background section and their initial observations helped guide GTI's investigation.

Discussion of Analytical Approach and Techniques

The submitted samples were assessed using the test methods shown in **Table 3.**

Table 3. Test Methods Used

Test Method	Revision	Title
GTI PP144 & PP145	2005	GTI Procedures for Failure Analysis
ASTM E3	2011	Standard Guide for Preparation of Metallographic Specimens
ASTM E384	2011e1	Standard Test Method for Knoop and Vickers Hardness of Materials
ASTM E18	2015	Standard Test Methods for Rockwell Hardness of Metallic Materials
ASTM E140***	2012be1	Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
ASTM E1019*	2011	Standard Test Methods for Determination of Carbon Sulfur Nitrogen and Oxygen in Steel by various Combustion and Fusion Techniques
ASTM E415**	2014	Standard Test Method for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry
GTI WI 48***	2014	GTI Procedure for Elemental Analysis of Metal or Other Material Samples by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP)

* performed by an ISO/IEC 17025 accredited sub-contract laboratory and at GTI
** performed by an ISO/IEC 17025 accredited sub-contract laboratory
*** not on GTI's ISO/IEC 17025 Scope of Accreditation

This laboratory maintains A2LA accreditation to ISO/IEC 17025 for specific tests listed in A2LA Certificates 2139-01 and 2139-04 and meets the relevant quality system requirements of ISO 9000:2000.

Test Results

Initial Visual Examination

Upon receipt of the coupling it was inspected to ascertain its type and model number (**Figure 4**). Its appearance did not match that of any picture in the Coupling Systems Inc. catalog.

Figure 4. Failed 12" gas pipe coupling

However, based upon the number and size of the circle bolts, eight of ⅝" dia. X 9", the probable model number is E-1208B5-S. Because of the bolt diameter the coupling is definitely of the "seal-only" type, meaning it is not designed to provide pipe restraint. By design it is to be used only with rod and lug restraint devices (i.e., weld on brackets). Those couplings designed to perform both pipe sealing and pipe restraint, the Maxi-Grip couplings, utilize ¾" dia. bolts. Because the coupling is not designed to prevent pullout, but gas sealing only, little more will be said of the coupling itself.

Examination of Pipe Segment D-E

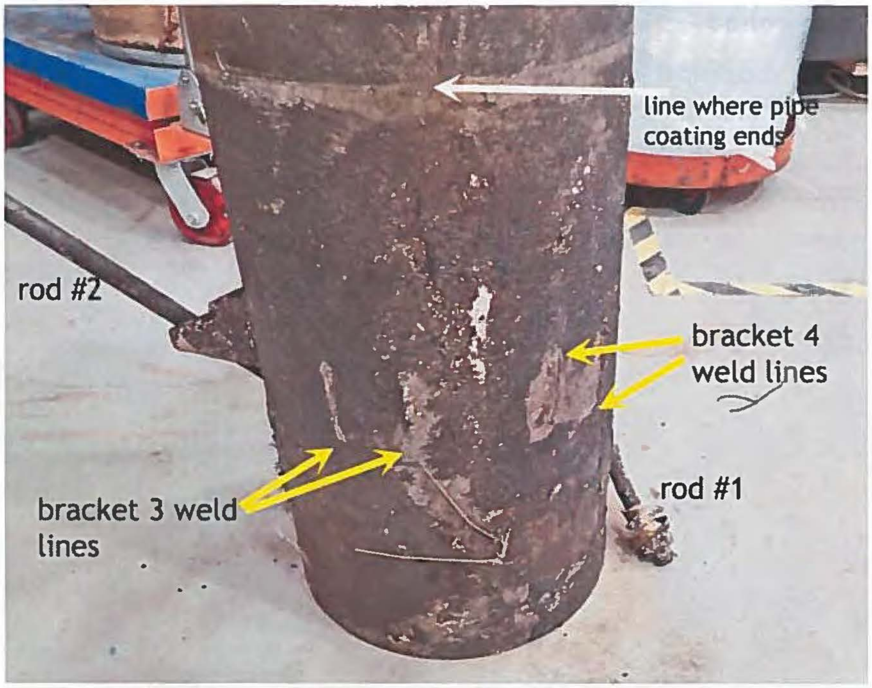

Figure 5. Pipe segment D-E (D side Zorn)

Brackets #3 and #4 had completely detached from the pipe. The welded surface of the pipe was examined and photographed, as shown in **Figures 6** and **7**.

Figure 6. Bracket #3 weld surface on pipe segment D-E

Figure 7. Bracket #4 weld surface on pipe segment D-E

Close examination of the weld fracture surface showed considerable oxidation and dirt where brackets 3 and 4 were attached. Some areas of the pipe had no coating on them, but did not appear to be more corroded or dirty than the fracture surface itself. This suggests that brackets #3 and #4 had broken away long before the September 2014 incident. After inspecting the pipe surfaces, brackets #3 and #4 were examined.

Bracket #3 was severely deformed. It appears that a compression load applied to the top bracket surface overloaded the bracket legs causing them to deform and spread open out (see **Figures 8, 9**, and **10**). Examination of the bracket hole revealed metal flow in the direction of the coupling indicating that the threaded rod must have pulled through the bracket in this direction.

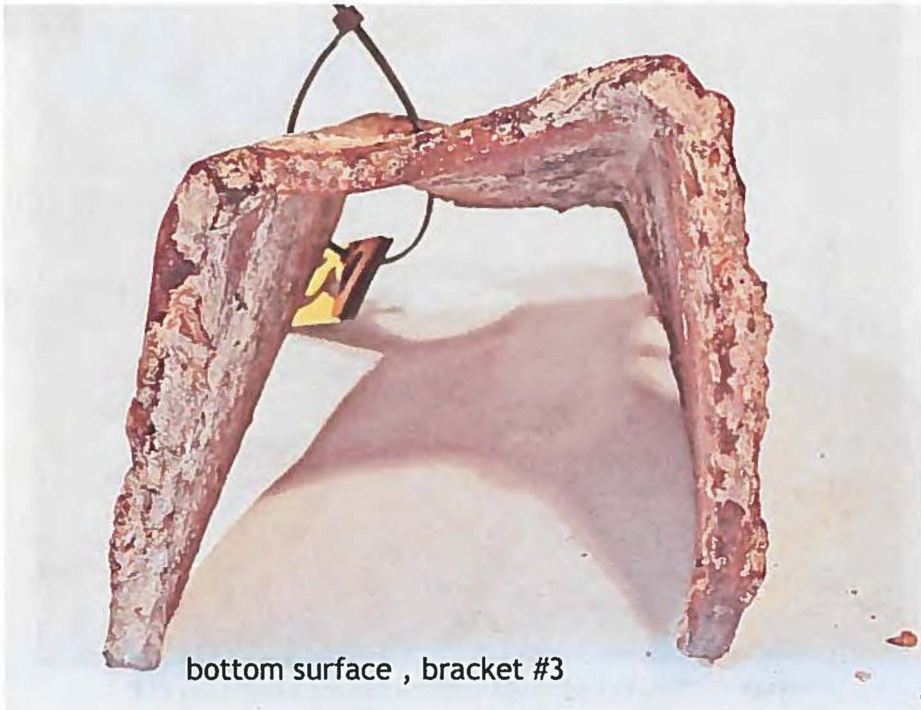

Figure 8. Bracket #3 as-received, 152148-001

Figure 9. D side bracket #3, leg #1 before cleaning

Figure 10. D side bracket #3, leg #2

Figure 11. D side bracket, arrow shows direction of metal flow

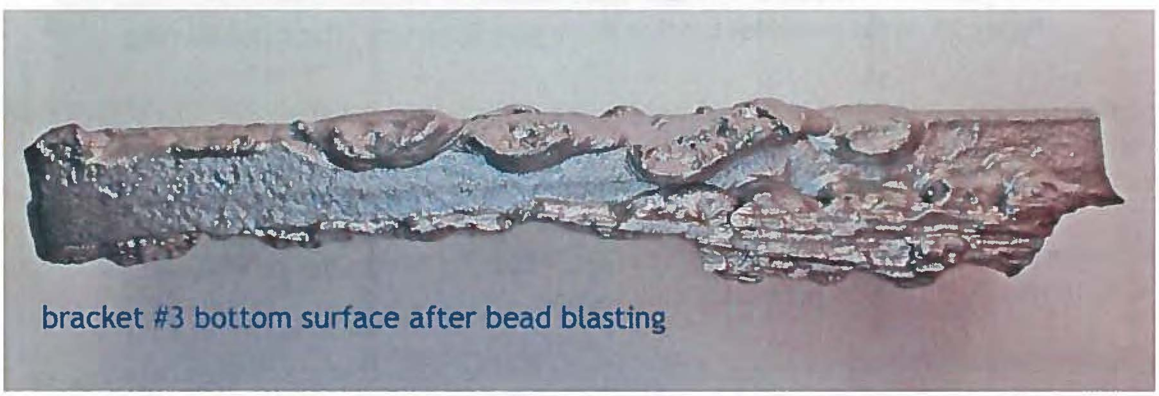

Figure 12. D side bracket #3, leg #2 after glass bead blasting

The mating surface on pipe _D_ was also blasted to remove dirt, corrosion, and coating.

Figure 13 Weld beads for bracket #3 on pipe D surface after bead blasting

The pipe surface where bracket #3 was welded showed a weld bead along only one side of both bracket legs. Weld penetration would have to be described as poor. Two welders at GTI who examined it described it as looking like a stitch or tack weld.

The bottom contact surfaces of the bracket's feet exhibited considerable dirt and corrosion, similar to what was seen on the mating pipe surface.

Bracket#4, shown in **Figure 14** below, differed from bracket #3 in that it exhibited only a minor degree of deformation. It also did not display any fresh fracture surfaces; the entire bottom leg surfaces were dirty and corroded.

Figure 14. Bottom surface of D side bracket #4

Figure 15. Close-up of bracket #4, leg #1

The appearance of the bottom surface of bracket #4 after glass bead blasting is shown in **Figure 16** below.

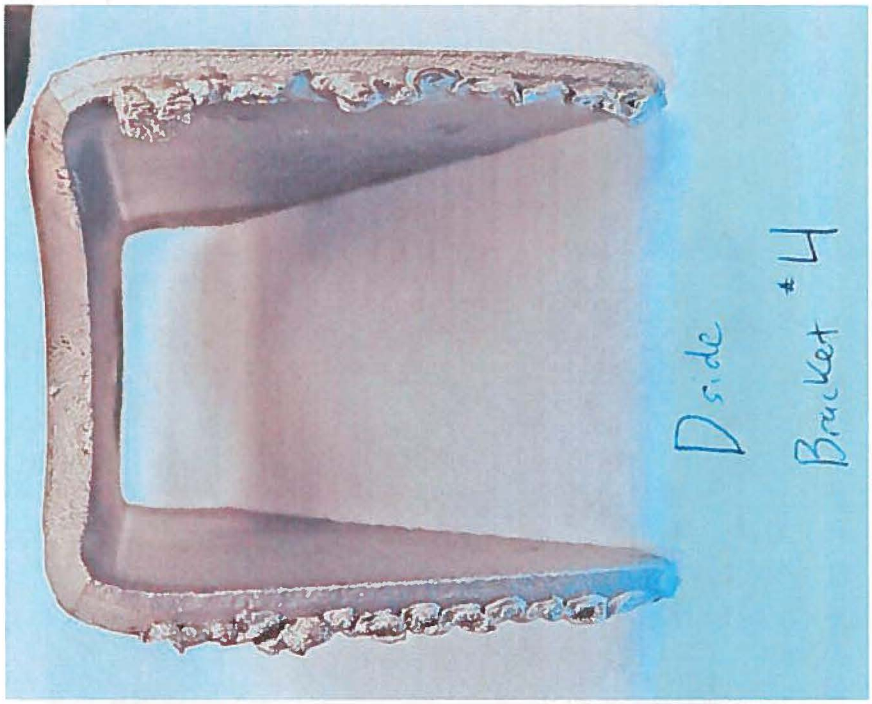

Figure 16. Bracket #4 bottom surface after glass bead blasting

Note that a weld bead is present on only one side of each bracket leg.

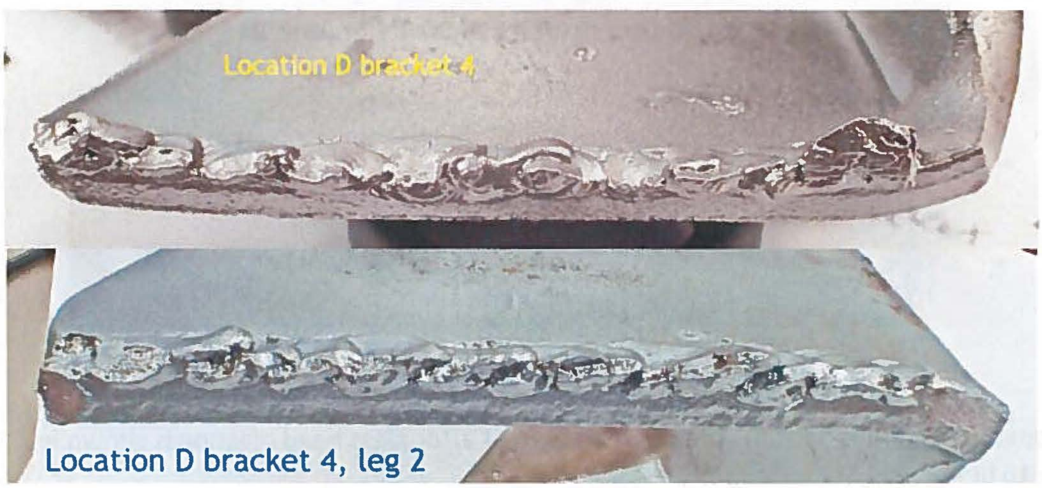

Figure 17. Close-ups of leg bottom surfaces of bracket #4

Fractures of the weld bead can be seen in these two close-up photos (**Figure 17**). They represent probably less than 30% of the bead area; no bond to the pipe was present at some places along the bead even though a lot of weld metal is present. The weld contact area on the pipe was also bead blasted.

(Comparing the pipe contact surfaces to the bracket, note that the pipe surface D4 shows a weld bead present on both sides of the legs but a bead is visible on only one side of each of bracket D4's legs. After careful examination of the mating surfaces we believe that the two detached brackets were misidentified and that what GTI received as #3 was actually #4 and vice versa.) The inside bead of pipe surface D4 does show one large fractured weld spot measuring approximately 0.750" x 0.15". The rest of the bead shown in **Figure 17** makes only narrow contact with the bracket.

Figure 18. Pipe D bracket #4 weld bead on surface

After examination of the brackets and welds on the _D_ segment, the brackets and welds on the Elder Park side were examined (_E_ Side). One bracket, #4 was partially detached.

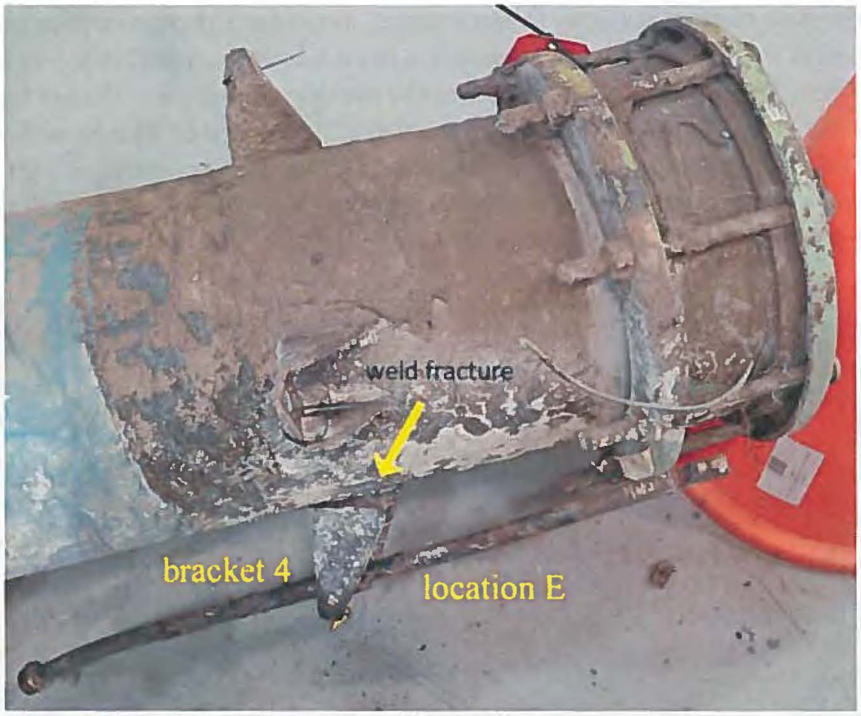

Figure 19. E side Bracket #4 partial detachment

One leg appeared to be almost entirely detached while the other leg seemed to be intact.

Figure 20. E side Bracket #4, close-up of weld fracture (Elder Park Side)

This weld fracture face on the E side differs dramatically from the D side fractures because it appears to be very fresh.

While examining the weld surfaces it was obvious that the brackets were not equidistant around the circumference. The D side (Zorn) pipe diameter was 12.75" or a circumference of 40.035", therefore the center-to-center bracket distances should be approximately 10". The actual measured distances were as follows:

1. bracket #1 to #2, 11.25"
2. bracket #2 to #3, 10.25"
3. bracket #3 to #4, 7.25"
4. bracket #4 to #1, 11.25"

The E side pipe was also measured. Its bracket distances were as follows:

1. bracket #1 to #2, 10.25"
2. bracket #2 to #3, 10.75"
3. bracket #3 to #4, 10.50"
4. bracket #4 to #1, 8.75"

The non-equidistant bracket distances would have produced a bending moment on the lugs rather than axial stress. This is confirmed by the appearance of the D end pipe shown below.

Figure 21. D end of pipe, this end was inserted into coupling

The pipe that was inserted into the coupling was coated after installation. The change in width of the uncoated portion indicates a lack of axial alignment. The width of the uncoated portion varied from 1 $^{11}/_{16}$" to 2 ½".

After the initial examination of the failed brackets was complete, the two pipe sections were sent out for blast cleaning to remove the coating. This was required in order to evaluate the condition of the bracket welds. The photos below document the condition of the brackets on the Elder Park side.

Figure 22. Elder Park side bracket #1

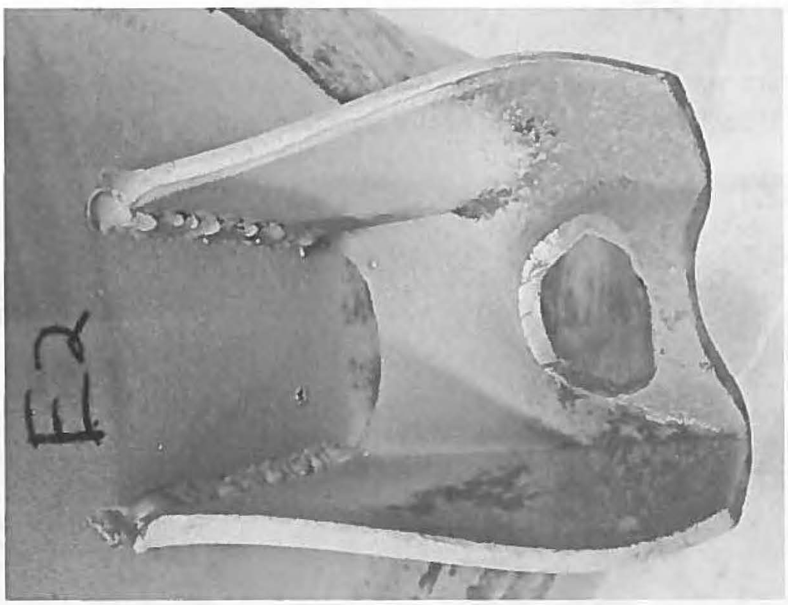

Figure 23. E side bracket #2, severe distortion from compression loading

Figure 24. E side bracket #3 compression overload

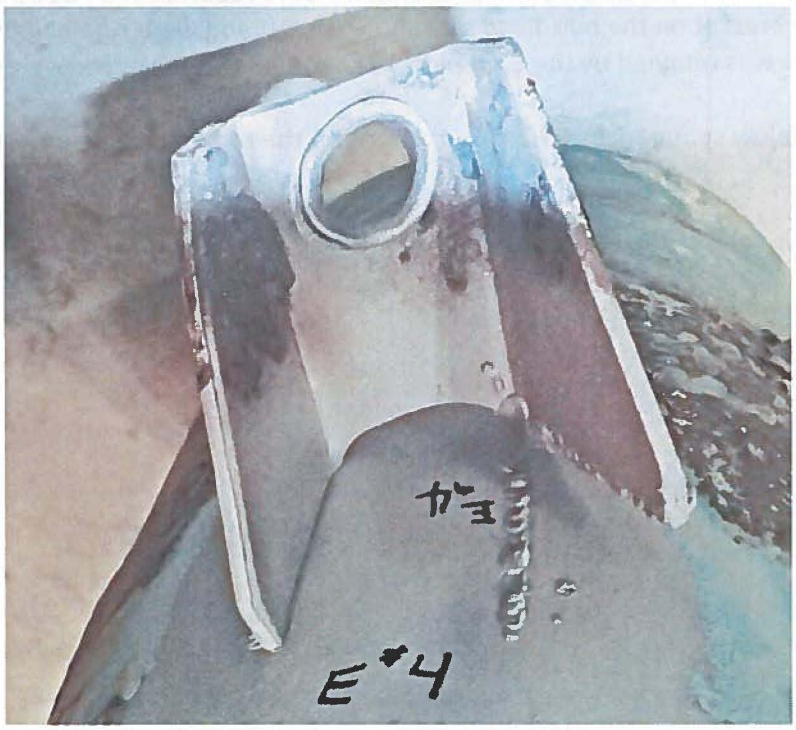

Figure 25. E side bracket #4

A most notable characteristic of the brackets on the _D_ side were the severely deformed and enlarged bracket holes. The threaded rods pulled out of brackets #1 to #3. Rod #4 was still attached to _E_ bracket #4 when GTI received it. It was cut off prior to sending the pipe for blast cleaning. As seen in **Figure 25** bracket #4 appears to have some kind of retaining or reinforcement ring in the bracket hole, this is not seen in the other brackets. Retaining rings may have been present originally on the other brackets, but have pulled out with the rods.

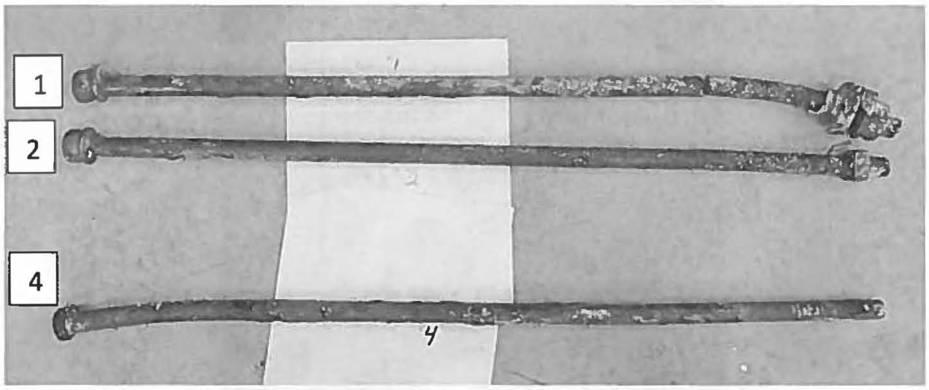

Figure 26. Threaded tensioning rods #1, #2, and #4

GTI received three of the four tensioning rods, as shown above. On the _D_ side the rods were apparently installed with a steel washer and an insulating washer, as seen on the right of rod #1. This is the only rod on which it remained intact. It is not known if the bolt-head sides were installed on the _E_ side with a washer except that none were recovered. Rods #1 and #2 pulled out of the _E_ side bracket on the bolt-head side shown at left and were retained by the _D_ side brackets. Rod #4 was retained by the _E_ side bracket. Rod #3 was never recovered.

Tables 4 and **5** below summarizes GTI's observations on the rod and lug assemblies.

Table 4. Summary of rod and bracket attachment (D side)

		D SIDE (ZORN)	
rod	**bracket**		**bracket attachment & condition**
rod 1 attached D side	Bracket 1		fully attached bracket holes OK
rod 2 attached D side	Bracket 2		fully attached bracket holes OK
rod detached, pulled thru (rod #3 not found)	Bracket 3		completely detached bracket spread, heavy distortion. detached weld surfaces appear dirty , corroded.
rod 4 still within detached bracket 4	Bracket 4		completely detached Minor distortion of bracket, some distortion around hole indicating compression stresses. Detached weld surfaces appear dirty , corroded.

Table 5. Summary of rod and bracket attachment (E side)

		E SIDE (Elder Park)	
rod	bracket		bracket attachment & condition
rod detached,pulled thru	Bracket 1		fully attached
			some distortion of bracket hole
rod detached, pulled thru	Bracket 2		fully attached
			bracket hole enlarged distorted.
			bracket spread distorted
rod detached, pulled thru	Bracket 3		fully attached
(rod #3 not found)			Enlarged distorted bracket hole.
			Bracket spread,distorted
rod 4 attached E side	Bracket 4		One leg fully detached, second leg OK
			Bracket hole enlarged distorted.
			Bracket spread,distorted

The following two tables summarize the condition of the bracket welds.

Table 6. Weld condition D side pipe

	D SIDE (ZORN)
Bracket 1	Weld beads on both sides of both legs
Bracket 2	Weld beads on both sides of both legs
Bracket 3	Weld bead on only one side of both leg. This bead had very low penetration , resembling a tack weld.
Bracket 4	Pipe surface shows pair of beads on both legs, however bracket has bead on only one side of each leg.

Table 7. Weld condition E side pipe

	E SIDE (Elder Park)
Bracket 1	One leg has a weld bead both sides, the other leg has a bead on one side only
Bracket 2	Weld beads on both sides of both legs
Bracket 3	Weld beads on both sides of both legs
Bracket 4	Weld bead on only one side of both legs

Probable Chain of Events Prior to Incident

One pair of brackets and one pair only, #3 is severely deformed on both sides. On the D side bracket #3 is deformed asymmetrically, bent down to one side. It can be surmised that this was due to non-axial loading. On the E side bracket #2 is severely compressed. It is evident that compression overload caused these brackets to yield. As the brackets yielded the rods would no longer be in tension, allowing the pipe to pull out from the coupling. After sufficient pipe movement the more weakly attached brackets D side 3 and 4 then detached. Given the surface appearance of the weld fractures on both mating surfaces of D side brackets #3 and #4, it would appear unlikely that these fractures occurred immediately prior to the incident. It is more likely that the coupling had remained intact because soil conditions had been such as to prevent pipe movement. When excavation occurred it is possible that the removal of soil-overburden created increased stress on the remaining weld connections causing the _E_ side bracket #4 connection to fail (see **Figure 20**). At this point all the stress would have been placed on rods #1 and #2 causing them to pull out from their _E_ side brackets.

Microexamination of the Bracket and Weld

One of the legs of _D_ side bracket #3 was sectioned at a portion of the leg where a bead of typical thickness was present on both sides of the leg.

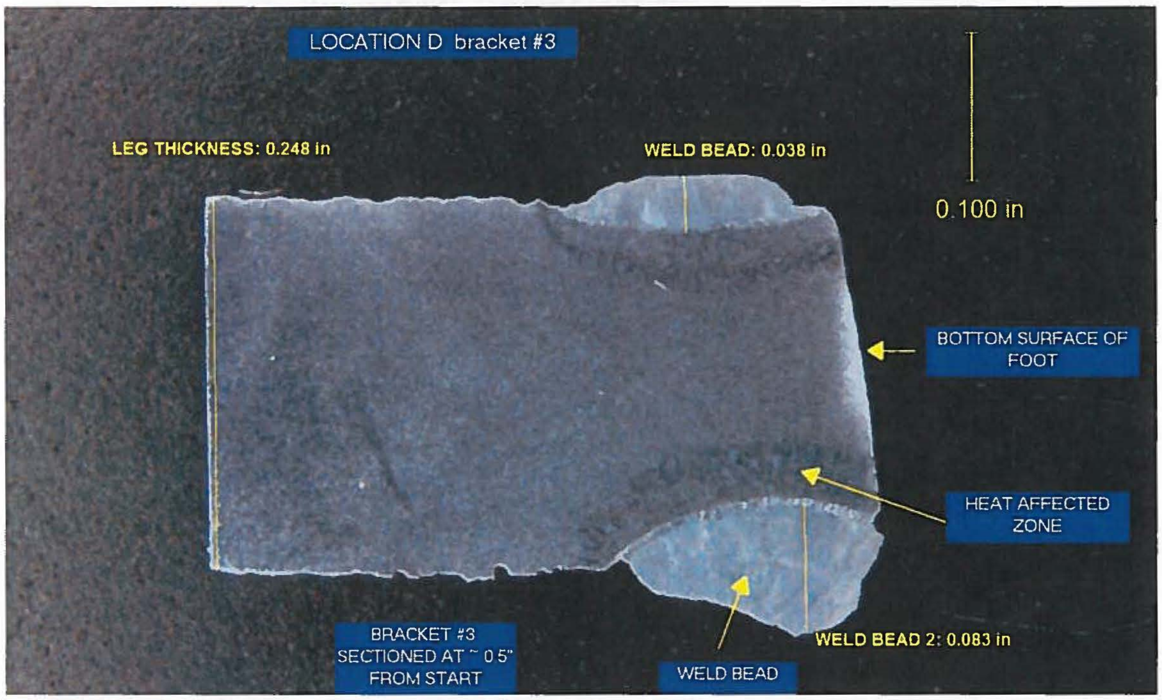

Figure 27. Cross section of bracket #3 leg

As seen in this cross section (**Figure 27**), beads are present along the sides of the bracket, but the bead is not flush with the bottom of the foot and the weld contact area is low.

Figure 28. D side bracket #3 cross section of bottom of leg

Figure 28 shows the microstructure at the bottom of one of the bracket's legs. There is no evidence of melting or incipient fusion. Instead what is visible is grain flow and deformation from a shearing operation when the brackets were blanked out from plates.

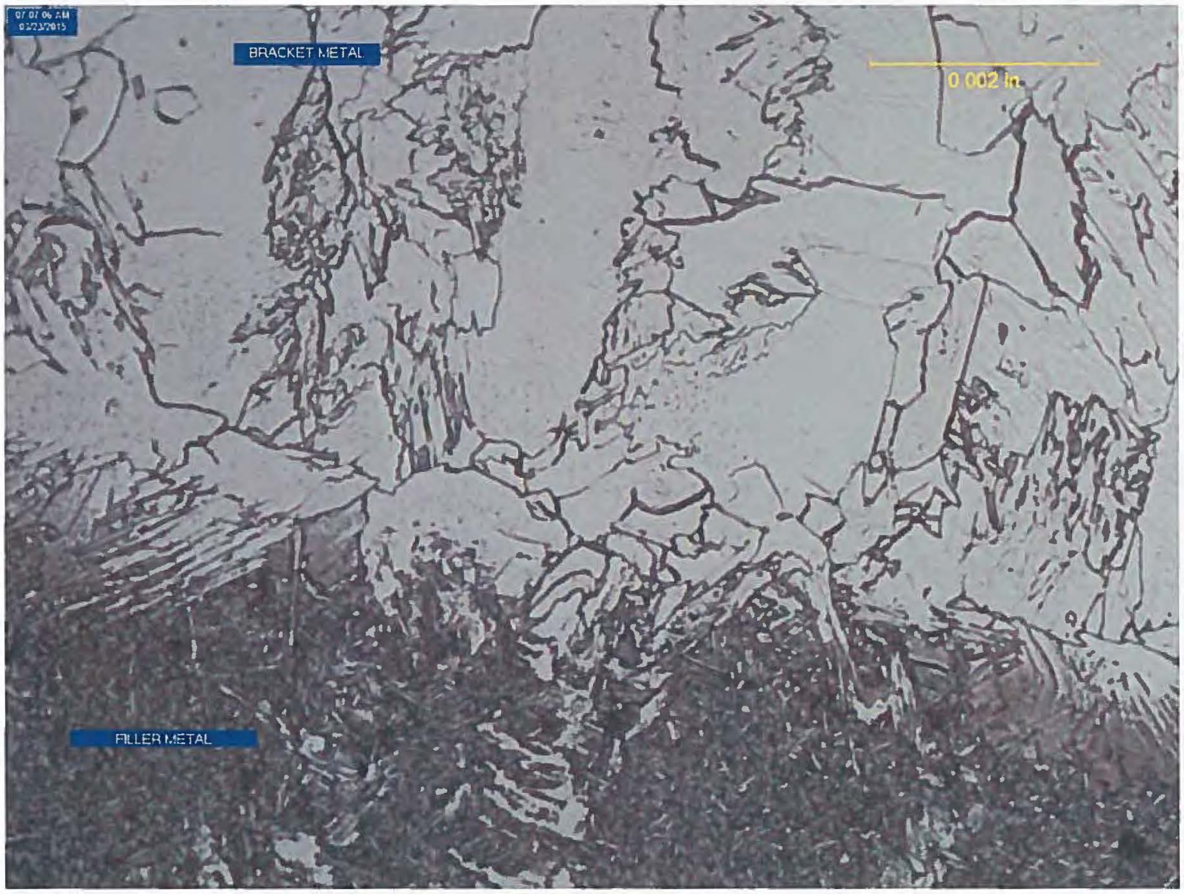

Figure 29. Fusion zone of weld bracket #3, 152148-001

Figure 29 above shows the fusion zone between the bracket metal on top and the darker area on the bottom which is filler rod. The bracket metal near the fusion zone appears to be very low carbon acicular ferrite. The photo below is of the same region at a lower magnification.

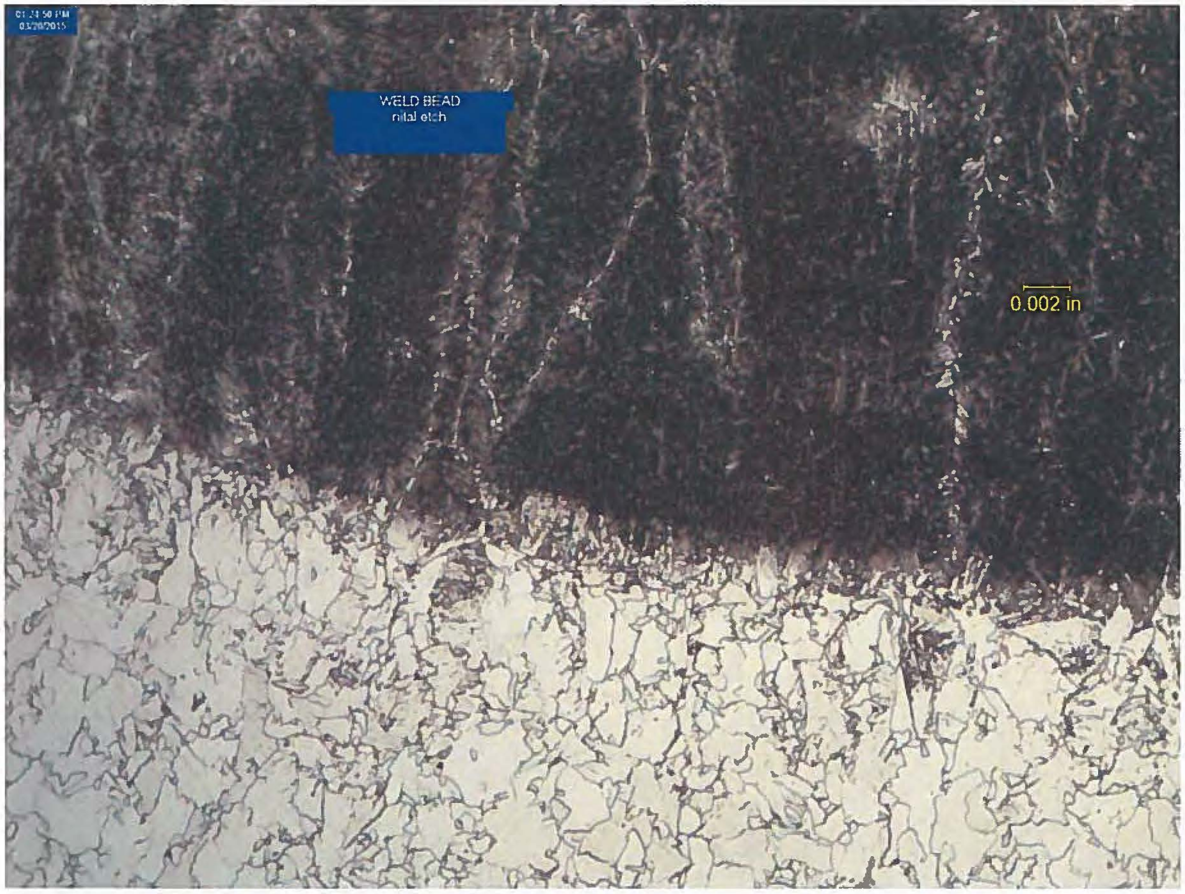

Figure 30. Weld fusion zone nital-etch; filler rod material on top, bracket substrate below

Most unusual is the complete absence of visible carbides in the bracket material. The region of mixture between the filler rod material and substrate is quite low. The structure of the bracket was then examined well away from the weld.

Figure 31. Microstructure of bracket material away from weld

The microstructure seen in **Figure 31** exhibits a complete absence of pearlite (Fe_3C+Fe) or cementite (Fe_3C). This structure is typical for what are termed deep drawing quality steels. Chemistry test results listed in **Table 9** confirm the ultra-low carbon level at 0.008 wt. %. The manganese (Mn) level is also exceptionally low at 0.13%. The titanium level of 0.06% indicates the steel was produced as Interstitial Free (IF) steel, which is steel with no interstitial solute atoms to strengthen the iron lattice. Normal steel making processes cannot go below approximately 0.03% carbon. Deep drawing quality steels are vacuum decarburized to go below 0.01% carbon. Such steels have exceptional formability but very low yield and tensile strengths in the hot-rolled state. By design it is steel produced to have the lowest possible yield strength for maximum drawability and therefore not a typical steel choice for a safety-critical structural application. The CSI catalog provides material specifications for all the parts of their couplings, but none for the bracket. Given that there appears to be no material specification, it is possible that the steel supplier received, from the manufacturer, only a very generic order for "mild steel" (i.e., < 0.25% carbon) and provided this material in good faith. . A check of the surface hardness of the bracket found a HRBW hardness of 43.4 (see **Table 13**). Based on this hardness and the chemistry of the bracket we would estimate a yield strength in the range of 20-25 ksi.

Design Considerations for the Coupling Installation

At the time GTI received the pipes and couplings the diameter of the tensioning rods were measured. All were found to be ¾"x 30". It was not possible to get an accurate measurement of the bracket thickness at that time because of a heavy mastic coating. After blast cleaning the bracket thicknesses were measured and found to be between 0.222" and 0.242". LG&E was able however to provide us with two catalogs produced by the coupling manufacturer Coupling Systems Inc. (CSI). The figure below is reproduced from one of those catalogs. The dimensions of the assemblies used on the Ballardsville line match that of part 13-3A-30 a *light duty* device.

Light Duty — Conductive One End — Insulating Other End

Description	Style Number	Tie Rod & Nut Size	Lug Wall Thickness	Painted Inc. Rod & Nut	Epoxy Coated Inc. Rod & Nut
Insulated with Celcon™ Insulator	13-3A-18	3/4x18	.229	$ 26.09	$ 30.00
Insulated with Celcon™ Insulator	13-3A-24	3/4x24	.229	28.60	32.89
Insulated with Celcon™ Insulator	13-3A-30	3/4x30	.229	31.33	36.03
Insulated with Celcon™ Insulator	13-3A-38	3/4x38	.229	36.53	42.00

Figure 32. Coupling Systems Inc. Rod and Lug Harness Device Part description

Both of the catalogs state that all IPS steel pipe couplings sized 2"-12" are rated for service pressures up to 400 psig, the MAOP of the pipeline in question. One of the catalogs gives no recommendations on the use of rod and lug harness devices, the other catalog which LG&E provided as CSI Coupling Catalog 2 provides a table which is reproduced below.

Number of Assemblies Required for Various Sizes and Pressures
(One Assembly Consists of 2 Lugs and 1 Rod)

Pipe Size	O.D.	AREA	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi	175 psi	200 psi	225 psi	250 psi	275 psi	300 psi
2	2.375" 60.3 mm	4.43 sq. in. .398 sq. m.	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**
4	4.500" 114.3 mm	15.90 sq. in. 1.43 sq. m.	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**
6	6.625" 168.3 mm	34.47 sq. in. 3.10 sq. m.	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**
8	8.625" 219.1 mm	58.43 sq. in. 5.26 sq. m.	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**
12	12.750" 323.8 mm	127.68 sq. in. 11.49 sq. m.	2 **2**	2 **2**	2 **2**	2 **2**	2 **2**	3 **2**	3 **2**	3 **3**	4 **3**	4 **3**	4 **3**	5 **4**
16	16.00" 406.4 mm	201.06 sq. in. 18.10 sq. m.	2 **2**	2 **2**	2 **2**	3 **2**	3 **2**	4 **3**	4 **3**	5 **4**	5 **4**	6 **4**	7 **5**	7 **5**
20	20.00" 508 mm	314.16 sq. in. 28.27 sq. m.	2 **2**	2 **2**	3 **2**	4 **3**	5 **4**	6 **4**	7 **5**	7 **5**	8 **6**	9 **7**	10 **7**	11 **8**
24	24.00" 609.6 mm	452.39 sq. in. 40.72 sq. m.	2 **2**	3 **2**	4 **3**	5 **4**	7 **5**	8 **6**	9 **7**	10 **8**	12 **9**	13 **9**	14 **10**	15 **11**

Note: Light face psi numbers use: .229 Lugs and 3/4" Rods with design loads of 9,060 lbs.
Bold face psi numbers use: .375 Lugs and 7/8" Rods with design loads of 12,850 lbs.

Figure 33. Coupling Systems Inc. Lug and Rod Assembly recommendations

The MAOP of the Ballardsville line is 400 psi, above the maximum pressure rating listed in this table of 300 psi. Therefore, the design loads listed at the bottom of the table will have to be used to determine the recommended number of rod/lug assemblies. Given an area of 127.68 sq. inch for a 12" nominal pipe the maximum load is 127.68 sq. inch x 400 psi = 51,072 lbs. As described in the note of **Figure 33** the maximum design load per rod assembly is 9060 lbs. The minimum number of rod assemblies is therefore $\geq$ 51,072/9,060 or six (6). Only four (4) were installed on this coupling. If the heavy duty rods and lugs had been used then the number of assemblies required would have been > 51,072/12,850 or four (4).

Inspection of the 8" Pipe Assembly

LG&E provided the 8" pipe segment B-C that came off of the 12" pipe. As shown in **Figures 1** and **2** this pipe segment has two pipe coupling devices installed. Per LG&E's request GTI inspected the couplings and rod/lug devices to ascertain their condition. In contrast to the situation on the 12" pipe the number of rod/lug devices used (4), exceeds that recommended using the formula given in **Figure 33** which is 3.

Figure 34. 8" coupling on pipe segment B-C

Due to the large amount of mud on the pipe and the pipe wrap it was not possible to inspect the welds (**Figure 34**). It was possible to see that some of the brackets had begun to yield from compression overloading as shown in **Figure 35**, **Figure 38**, and **Figure 39**.

Figure 35. 8" bracket before blast cleaning. Bracket compression surface has deformed under load.

After the 8" pipe segment was returned from blast cleaning it was inspected again.

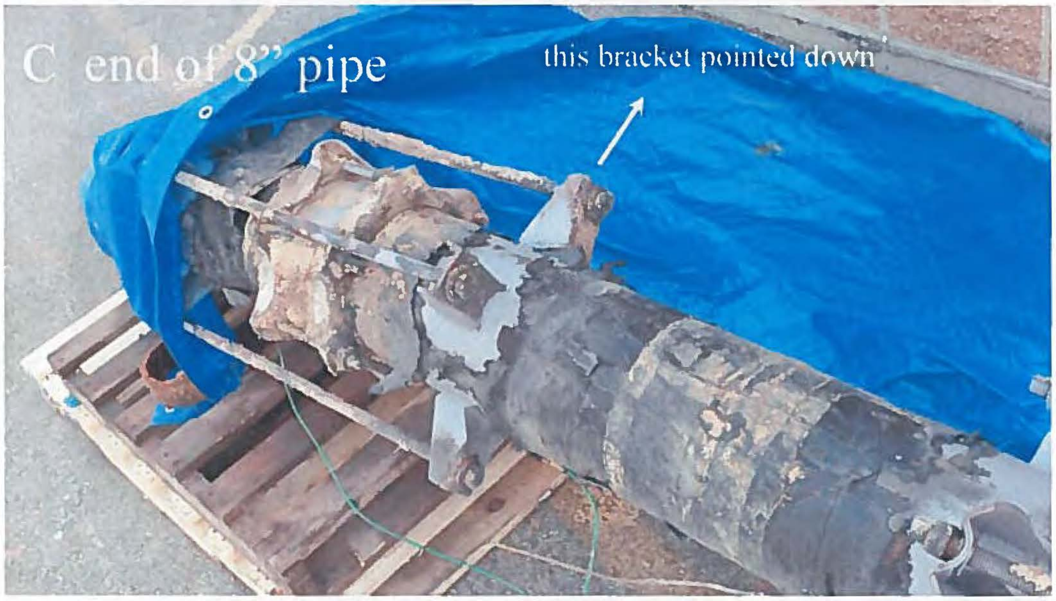

Figure 36. Partial detachment of bracket on 8" pipe

After removal of the pipe wrap it was immediately apparent that one of the rod brackets had partially detached from the pipe (**Figure 36 and 37**). The coupling was on the C end of the pipe, meaning it was the coupling furthest away from the connection to the 12" pipe. Since no detachment had been observed prior to cleaning, the fracture surface was immediately inspected to see if it was fresh.

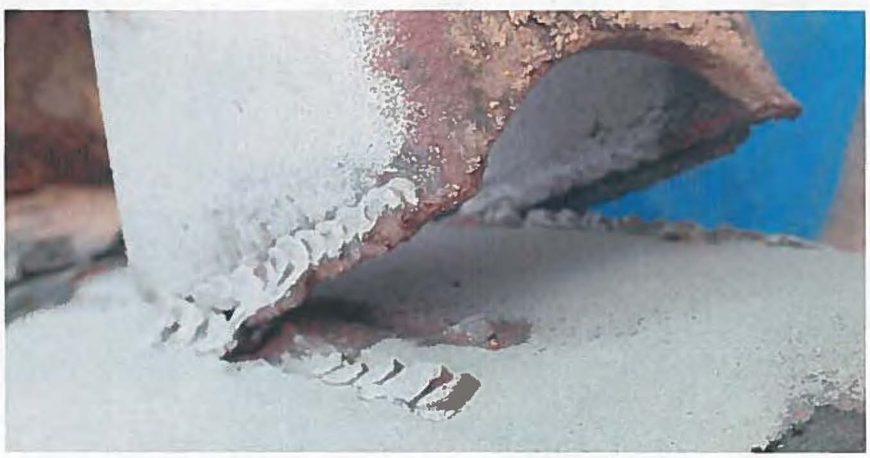

Figure 37. 8" pipe fractured weld bead after cleaning

Fortunately, the weld bead had not been thoroughly cleaned and it was possible to see a significant amount of corrosion on the weld bead. Based on this observation GTI believes that this fracture had existed in the field for some time. Inspection of the weld beads did not reveal any major flaws and all brackets had beads on both the inside and outside of both legs. The amount of contact area however was apparently too small to bear the applied load.

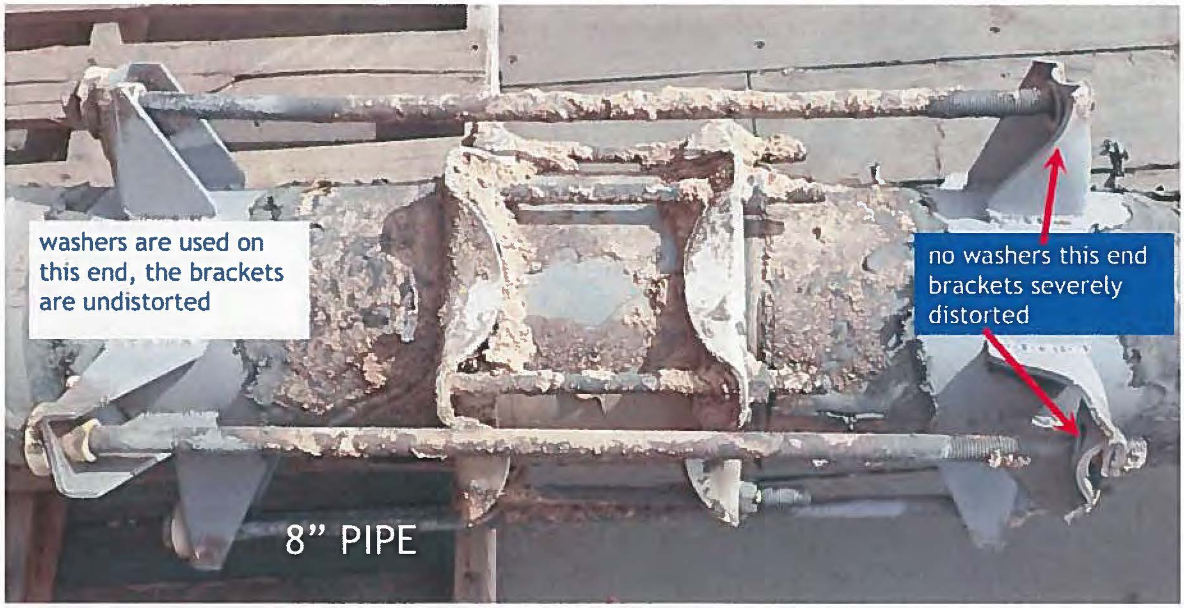

Figure 38. 8" pipe coupling #2 with insulating end

Coupling #1 and Coupling #2 utilized two different rod types. Coupling #1 used a rod that was conductive on both ends, while Coupling #2 used a rod with an insulating washer on one end. The other end on both rod types does not utilize a washer. Instead there appears to be some kind of sleeve insert in the bracket hole. Of the 16 brackets inspected on the 8" pipe, three exhibited medium/heavy distortion from compression overload. In all cases this was on the washer-less side. **Figure 38** shows two of these brackets on the right side. The use of heavy-duty over-sized washers would have spread the load out and might have ameliorated this problem.

Figure 39. Bracket distortion from compression overload. Note absence of washer

The table below summarizes the observations on the 8" pipe.

Table 8. Summary of observations on Ballardsville line 8" pipe couplings

		8" COUPLING #1	
rod	**bracket**	**welds**	**bracket attachment & condition**
Rod 1 OK	Bracket 1 Left	OK	OK
	Bracket 1 Right	OK	OK
Rod 2 is loose	Bracket 2 Left	OK	OK , slight compression distortion
	Bracket 2 Right	FAILED	bracket #2 Right is approximately 2/3 detached along both legs, pulled up and in towards coupling . Mild compression distortion.
Rod 3 is OK	Bracket 3 Left	OK	Bracket #3 Left compressed distorted, no washer
	Bracket 3 Right	OK	OK
Rod 4 is OK	Bracket 4 Left	OK	OK
	Bracket 4 Right	OK	OK
		8" COUPLING #2	
rod	**bracket**		**bracket attachment & condition**
Rod 1 loose	Bracket 1 Left	OK	Bracket 1 Left compressed distorted (washerless)
	Bracket 1 Right	OK	OK
Rod 2 slightly loose	Bracket 2 Left	OK	OK
	Bracket 2 Right	OK	OK
Rod 3 is OK	Bracket 3 Left	OK	OK
	Bracket 3 Right	OK	OK
Rod 4 is taut but bent	Bracket 4 Left	OK	Bracket 4 left severely distorted compressed(washerless)
	Bracket 4 Right	OK	OK

Chemical Analysis

The elemental analyses in **Table 9** and **Table 10** were performed by a GTI approved subcontract laboratory per ASTM E1019 *Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel* and ASTM E415 *Standard Test Method for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry*. The analyses in **Table 11** of the weld bead were performed by GTI's Chemical Research Services Laboratory. Carbon and sulfur content of the weld bead were analyzed per ASTM E1019. Metal elemental analysis was performed on a sample digested using a mixture of nitric and hydrochloric acids. The digested solution was analyzed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) following GTI internal procedure *WI 48 Elemental Analysis of Metal or Other Material Samples by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP).*

Table 9. Steel chemistry, D side Bracket #3, 152148-001

Element	Weight (%)	AISI-SAE C1010 specification Weight (%)
C	0.008	0.08-0.13
Mn	0.13	0.30-0.60
P	0.003	0.030 max
S	0.01	0.050 max
Si	<.01	
Al	0.048	
Cr	0.01	
Ni	<.01	
Mo	<.01	
Cu	0.01	
V	<.01	
Ti	0.06	
Co	<.01	
Cb	<.005	

Table 10. D side pipe (Zorn) steel chemistry

SAMPLE 152148-003 D Side pipe		
Element	Weight (%)	AISI C1021 specification
C	0.22	0.18-0.23
Mn	0.75	0.60-0.90
P	0.004	.030 max
S	0.014	.050 max
Si	0.01	
Al	0.01	
Cr	0.01	
Ni	0.02	
Mo	0.01	
Cu	0.03	
V	<.005	
Ti	<.005	
Co	<.01	
Cb	<.005	

Table 11. Weld bead chemistry of 152148-004 bead removed from D side bracket #3

sample 152148-004 WELD BEAD	
Element	Weight (%)
C	0.192
Mn	0.58
S	0.012
Si	0.05
Al	0.01
Cr	0.02
Ni	0.03
Mo	0.01
Cu	0.07
V	0.03
Ti	0.02
Co	0.01

Material Hardness

Microhardness testing was performed in accordance with ASTM E384 using a Leco microhardness tester. Testing was performed with a Knoop indenter at 500GF and converted to the Rockwell B and C scales per ASTM E140. The test results are provided in **Table 12**.

Table 12. Knoop 500GF microhardness testing of weld and bracket

Lab specimen 152148-001 bracket #3 location D (Zorn)		
LOCATION	Knoop Hardness 500GF	Rockwell hardness converted from HK500 per ASTM E140
Middle of weld bead	260.1	HRC 22
Near surface of weld bead	254.6	HRC 21
Fusion Zone	239.2	HRC 24
.014" below fusion	155	HRB 77
.030" below fusion	107.6	HRB 51

Surface hardness testing was performed in accordance with ASTM E18 using a United Rockwell Hardness Tester. The test results are provided in **Table 13**.

Table 13. Rockwell surface hardness HRBW

Lab specimen 152148-001 bracket #3 location D (Zorn)					
Property	Reading			Average	Std. Dev.
	#1	#2	#3		
Rockwell Hardness, HRBW	43.1	43.7	43.4	**43.4**	0.3

Conclusions

Based on the samples provided and the testing and analyses performed, a number of factors contributed to the failure of the mechanical coupling/ rod & lug restraint system on the Ballardsville transmission line on September 7, 2014. GTI believes that the most important factors were, in order of importance:

- The number of rod/lug harness devices installed was too few and below the manufacturer's recommendation of six (6), only four (4) were installed. Per the manufacturer's specification four would have sufficed if they had been the heavy duty ⅞" rod systems rather than the installed ¾" rod light duty systems.
- The weld quality of the detached brackets was poor, with beads applied on only one side, with poor penetration and low weld surface area. Other partially detached brackets were found with weld beads on only one side of their legs.
- The brackets were constructed of very soft, low yield strength Extra Deep Drawing Steel, steel actually designed to yield at a very low stress level. This contributed to the failure in two ways. As the low strength brackets compressed under load, the pipe was no longer constrained by the rod, allowing it to pull out from the coupling. Also the steel under the bolt-heads plastically deformed more easily than a higher-strength steel would have done allowing them pull through the bolt holes. No material specification for the bracket is found in Coupling Systems Inc.'s otherwise comprehensive specifications.
- Washers were not used on both ends to distribute the load over the bracket face.
- The rods and bracket devices were not axially aligned and not uniformly distributed around the pipe. This would have produced a bending moment that could have contributed to bracket detachment.

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Issued by: Brian Miller
Chief Technologist

Reviewed by: Daniel Ersoy
Executive Director, R&D

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END OF REPORT

ATTACHMENT C

LG&E Gas Operating and Maintenance Inspection Procedures

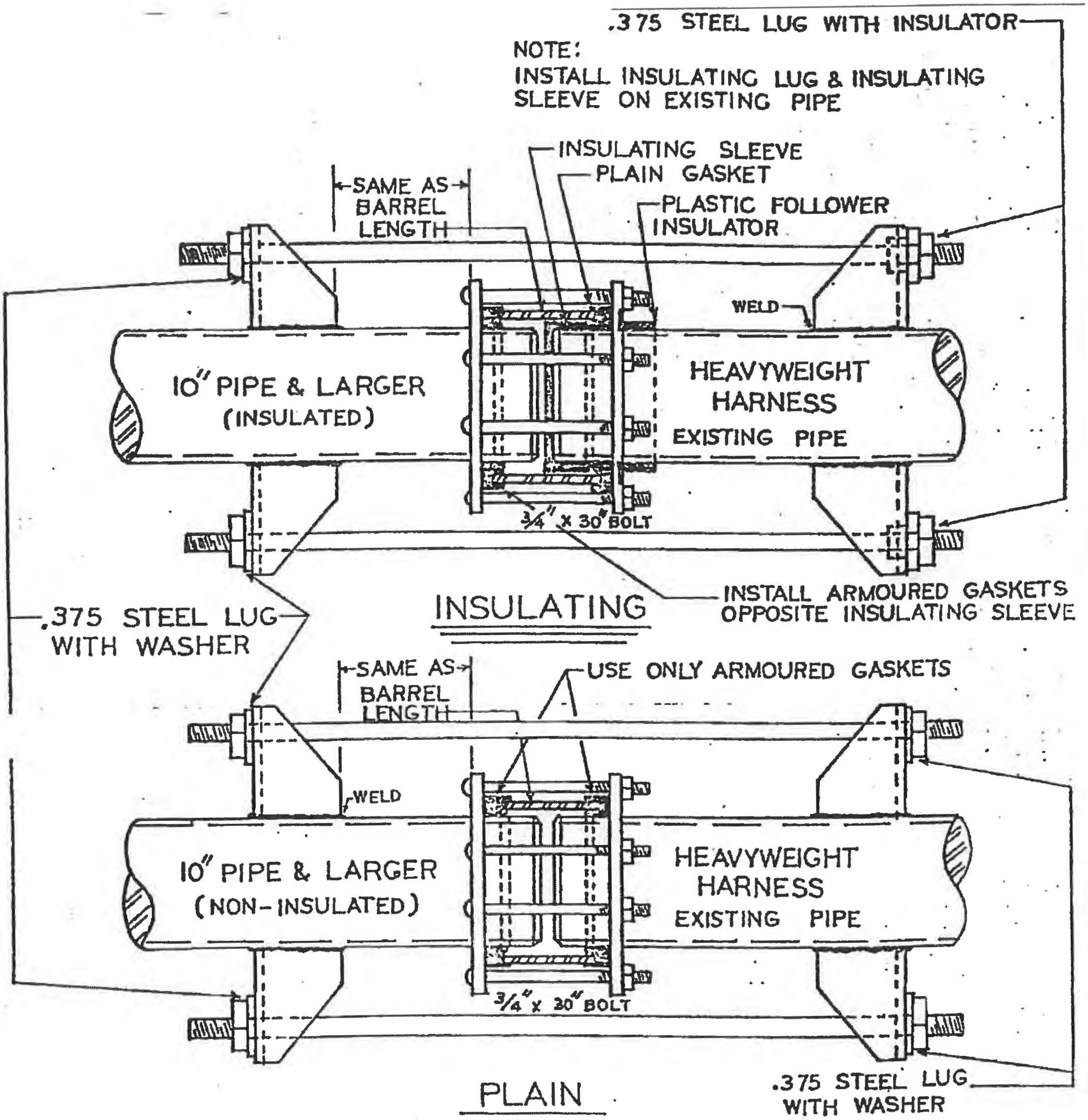
B. Installation

Installation of harnessing shall be in accordance with Table 79.2 and Drawing Number 1319-A.

Table 79.2

NUMBER & SIZE HARNESS BOLTS REQUIRED										
Design Pressure (PSIG)	Nominal Pipe Size & Harness Bolt Size									
	2" thru 6"		8"		12"		16"		20"	
Bolt Size	3/4"	7/8"	3/4"	7/8"	3/4"	7/8"	3/4"	7/8"	3/4"	7/8"
60 or Less	2	2	2	2	2	2	2	2	3	2
175	2	2	2	2	3	2	5	3	7	5
300	2	2	3	2	5	4	8	5	-	8
400	2	2	3	2	7	5	10	7	-	11

NOTE: Harness bolts are to be tightened only to the extent necessary to assure firm contact with lugs.



INSTALL BOND WIRE ON ALL PLAIN COUPLERS

NOTES:

APPLY TWO COATS OF MASTIC TO ALL BARE PARTS

IF AVAILABLE USE PRE-COATED STAB TYPE COUPLERS WHERE POSSIBLE

BOTH INSIDE AND OUTSIDE WELDING SURFACES OF LUGS ARE TO BE WELDED TO PIPE

LOUISVILLE GAS AND ELECTRIC CO.
Louisville, Kentucky

ELECTRIC DIST. ☐ *GAS DEPT.* ☑

TYPICAL HARNESS INSTALLATION

Scale NONE *Date* 3-20-83	FIG. D-8
Drawn by G. DEMKO	
Approved by	

ATTACHMENT D

LG&E Pressure Records

(Attachment contains a printout of Excel Spreadsheet provided by LG&E)

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
5/1/2011 10:00	251.3	256.8
5/2/2011 10:00	251.3	256.8
5/3/2011 10:00	249.9	252.9
5/4/2011 10:00	250.1	252.3
5/5/2011 10:00	250.2	252.0
5/6/2011 10:00	250.2	252.3
5/7/2011 10:00	250.4	252.7
5/8/2011 10:00	250.9	254.5
5/9/2011 10:00	250.5	254.0
5/10/2011 10:00	250.4	253.1
5/11/2011 10:00	250.7	252.7
5/12/2011 10:00	250.7	252.7
5/13/2011 10:00	250.2	252.3
5/14/2011 10:00	250.4	254.6
5/15/2011 10:00	249.8	254.6
5/16/2011 10:00	249.9	252.1
5/17/2011 10:00	250.4	252.3
5/18/2011 10:00	246.2	303.3
5/19/2011 10:00	249.6	252.6
5/20/2011 10:00	250.5	252.4
5/21/2011 10:00	250.7	252.4
5/22/2011 10:00	250.9	252.6
5/23/2011 10:00	250.5	252.4
5/24/2011 10:00	251.0	252.6
5/25/2011 10:00	250.9	256.0
5/26/2011 10:00	251.2	254.6
5/27/2011 10:00	251.2	253.2
5/28/2011 10:00	251.0	253.4
5/29/2011 10:00	251.5	257.1
5/30/2011 10:00	251.5	257.1
5/31/2011 10:00	251.5	257.1
6/1/2011 10:00	251.8	257.5
6/2/2011 10:00	251.8	257.5
6/3/2011 10:00	251.8	257.5
6/4/2011 10:00	255.4	257.9
6/5/2011 10:00	251.0	256.2
6/6/2011 10:00	251.0	256.2
6/7/2011 10:00	251.2	256.2
6/8/2011 10:00	254.3	256.5
6/9/2011 10:00	254.0	255.9
6/10/2011 10:00	253.5	256.7
6/11/2011 10:00	253.7	256.4
6/12/2011 10:00	253.5	256.8
6/13/2011 10:00	250.2	256.8
6/14/2011 10:00	249.9	252.4
6/15/2011 10:00	250.2	252.4
6/16/2011 10:00	250.5	252.9
6/17/2011 10:00	250.9	253.4
6/18/2011 10:00	250.9	253.4
6/19/2011 10:00	250.9	253.4
6/20/2011 10:00	251.2	252.9
6/21/2011 10:00	251.2	252.7
6/22/2011 10:00	251.5	253.1
6/23/2011 10:00	251.5	253.1
6/24/2011 10:00	251.5	253.1
6/25/2011 10:00	250.7	252.4
6/26/2011 10:00	250.7	252.4
6/27/2011 10:00	250.7	252.4
6/28/2011 10:00	250.7	252.6
6/29/2011 10:00	250.9	252.6
6/30/2011 10:00	250.7	252.6
7/1/2011 10:00	250.9	252.4
7/2/2011 10:00	250.7	254.5
7/3/2011 10:00	250.7	254.5
7/4/2011 10:00	250.9	252.6
7/5/2011 10:00	250.7	252.4
7/6/2011 10:00	250.9	252.4

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
9/12/2011 10:00	250.9	255.4
9/13/2011 10:00	251.5	254.0
9/14/2011 10:00	251.5	254.0
9/15/2011 10:00	251.5	254.0
9/16/2011 10:00	251.5	254.0
9/17/2011 10:00	252.4	254.0
9/18/2011 10:00	251.0	254.0
9/19/2011 10:00	251.0	253.1
9/20/2011 10:00	251.0	255.4
9/21/2011 10:00	253.8	265.8
9/22/2011 10:00	251.2	266.9
9/23/2011 10:00	251.2	252.7
9/24/2011 10:00	251.2	254.8
9/25/2011 10:00	252.4	267.5
9/26/2011 10:00	253.2	261.1
9/27/2011 10:00	251.6	253.8
9/28/2011 10:00	251.3	254.5
9/29/2011 10:00	250.7	256.7
9/30/2011 10:00	250.5	252.9
10/1/2011 10:00	250.4	253.2
10/2/2011 10:00	251.2	253.2
10/3/2011 10:00	251.2	253.2
10/4/2011 10:00	251.2	253.2
10/5/2011 10:00	250.5	253.8
10/6/2011 10:00	251.2	254.0
10/7/2011 10:00	251.0	259.0
10/8/2011 10:00	250.7	257.8
10/9/2011 10:00	251.3	257.3
10/10/2011 10:00	251.2	252.9
10/11/2011 10:00	251.2	252.7
10/12/2011 10:00	251.0	257.3
10/13/2011 10:00	252.6	257.1
10/14/2011 10:00	213.2	260.3
10/15/2011 10:00	251.0	253.4
10/16/2011 10:00	251.3	258.6
10/17/2011 10:00	255.4	258.4
10/18/2011 10:00	254.0	259.0
10/19/2011 10:00	250.5	258.9
10/20/2011 10:00	249.9	259.5
10/21/2011 10:00	251.6	256.5
10/22/2011 10:00	249.8	263.4
10/23/2011 10:00	250.9	257.1
10/24/2011 10:00	251.0	253.4
10/25/2011 10:00	250.4	254.2
10/26/2011 10:00	249.6	261.9
10/27/2011 10:00	251.0	301.6
10/28/2011 10:00	118.8	254.6
10/29/2011 10:00	92.3	206.6
10/30/2011 10:00	109.6	241.8
10/31/2011 10:00	106.8	213.7
11/1/2011 10:00	111.3	216.2
11/2/2011 10:00	124.8	253.4
11/3/2011 10:00	124.8	253.4
11/4/2011 10:00	124.8	253.4
11/5/2011 10:00	124.8	253.4
11/6/2011 9:00	124.8	253.4
11/7/2011 9:00	250.5	260.0
11/8/2011 9:00	250.5	260.0
11/9/2011 9:00	253.5	259.2
11/10/2011 9:00	252.3	257.5
11/11/2011 10:00	250.4	257.6
11/12/2011 10:00	250.4	258.9
11/13/2011 10:00	250.4	276.8
11/14/2011 10:00	252.6	273.2
11/15/2011 10:00	249.8	259.3
11/16/2011 10:00	250.2	259.7
11/17/2011 10:00	251.2	255.6

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
1/23/2012 10:00	249.0	258.7
1/24/2012 10:00	251.3	255.1
1/25/2012 10:00	251.3	255.1
1/26/2012 10:00	251.2	257.9
1/27/2012 10:00	250.2	258.1
1/28/2012 10:00	249.3	254.5
1/29/2012 10:00	249.5	252.6
1/30/2012 10:00	250.1	253.1
1/31/2012 10:00	249.9	254.6
2/1/2012 10:00	249.9	254.6
2/2/2012 10:00	249.9	254.6
2/3/2012 10:00	251.0	253.0
2/4/2012 0:00	249.0	253.2
2/5/2012 0:00	249.0	251.6
2/6/2012 0:00	249.0	259.0
2/7/2012 0:00	250.0	257.1
2/8/2012 0:00	251.0	253.8
2/9/2012 0:00	250.0	262.0
2/10/2012 0:00	252.0	257.9
2/11/2012 0:00	257.0	260.4
2/12/2012 0:00	251.0	260.6
2/13/2012 0:00	251.0	262.5
2/14/2012 0:00	251.0	255.3
2/15/2012 0:00	250.0	254.3
2/16/2012 0:00	252.0	253.5
2/17/2012 0:00	250.0	254.8
2/18/2012 0:00	256.0	259.7
2/19/2012 0:00	256.0	259.2
2/20/2012 0:00	250.0	261.7
2/21/2012 0:00	249.0	260.0
2/21/2012 10:00	250.0	252.3
2/22/2012 10:00	250.0	252.4
2/23/2012 10:00	250.0	252.0
2/24/2012 10:00	250.0	256.7
2/25/2012 10:00	250.0	260.1
2/26/2012 10:00	250.0	255.4
2/27/2012 10:00	250.0	259.3
2/28/2012 10:00	252.0	255.9
2/29/2012 10:00	251.0	258.6
3/1/2012 10:00	249.6	252.9
3/2/2012 10:00	249.3	254.8
3/3/2012 10:00	248.8	256.5
3/4/2012 10:00	247.6	259.7
3/5/2012 10:00	249.3	255.9
3/6/2012 10:00	250.1	256.7
3/7/2012 10:00	250.1	253.2
3/8/2012 10:00	249.1	259.5
3/9/2012 10:00	249.9	254.9
3/10/2012 10:00	251.0	253.0
3/11/2012 10:00	250.0	253.0
3/12/2012 10:00	251.0	252.0
3/13/2012 10:00	251.0	252.0
3/14/2012 10:00	251.0	252.0
3/15/2012 10:00	251.0	252.0
3/16/2012 10:00	251.0	252.0
3/17/2012 10:00	251.0	252.0
3/18/2012 10:00	250.0	252.0
3/19/2012 10:00	251.0	252.0
3/20/2012 10:00	251.0	252.0
3/21/2012 10:00	251.0	252.0
3/22/2012 10:00	251.0	252.0
3/23/2012 10:00	251.0	252.0
3/24/2012 10:00	251.0	252.0
3/25/2012 10:00	251.0	252.0
3/26/2012 10:00	251.0	257.0
3/27/2012 10:00	251.0	262.0
3/28/2012 10:00	251.0	252.0

Ballardsville Pipeline Pressure Data
Assembled: **10/19/2015**

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
6/4/2012 10:00	250.2	258.3
6/5/2012 10:00	250.2	256.7
6/6/2012 10:00	250.4	255.3
6/7/2012 10:00	250.2	252.0
6/8/2012 10:00	250.5	260.8
6/9/2012 10:00	250.4	252.3
6/10/2012 10:00	250.4	252.1
6/11/2012 10:00	250.5	252.3
6/12/2012 10:00	250.5	252.6
6/13/2012 10:00	250.5	252.4
6/14/2012 10:00	250.7	252.6
6/15/2012 10:00	250.5	257.8
6/16/2012 10:00	250.7	252.4
6/17/2012 10:00	250.7	252.6
6/18/2012 10:00	250.9	270.6
6/19/2012 10:00	250.9	260.1
6/20/2012 10:00	250.5	257.0
6/21/2012 10:00	250.5	252.4
6/22/2012 10:00	250.7	254.0
6/23/2012 10:00	250.5	252.9
6/24/2012 10:00	249.1	254.2
6/25/2012 10:00	250.4	252.1
6/26/2012 10:00	250.7	252.3
6/27/2012 10:00	250.4	257.6
6/28/2012 10:00	250.5	252.6
6/29/2012 10:00	250.9	257.9
6/30/2012 10:00	251.5	254.0
7/1/2012 10:00	251.6	254.0
7/2/2012 10:00	250.4	253.1
7/3/2012 10:00	250.7	252.4
7/4/2012 10:00	250.5	252.4
7/5/2012 10:00	250.4	252.4
7/6/2012 10:00	250.2	252.0
7/7/2012 10:00	250.1	252.0
7/8/2012 10:00	250.5	252.3
7/9/2012 10:00	250.4	252.1
7/10/2012 10:00	250.4	252.1
7/11/2012 10:00	250.1	252.1
7/12/2012 10:00	250.4	252.4
7/13/2012 10:00	250.2	252.0
7/14/2012 10:00	250.4	252.0
7/15/2012 10:00	250.4	252.0
7/16/2012 10:00	250.2	252.4
7/17/2012 10:00	250.7	252.4
7/18/2012 10:00	250.2	252.3
7/19/2012 10:00	250.2	252.3
7/20/2012 10:00	250.4	257.0
7/21/2012 10:00	250.2	252.0
7/22/2012 10:00	250.1	251.8
7/23/2012 10:00	250.4	257.9
7/24/2012 10:00	250.5	252.1
7/25/2012 10:00	250.2	252.3
7/26/2012 10:00	250.5	252.4
7/27/2012 10:00	250.4	252.1
7/28/2012 10:00	250.4	252.1
7/29/2012 10:00	250.2	252.0
7/30/2012 10:00	250.2	252.4
7/31/2012 10:00	250.1	252.0
8/1/2012 10:00	250.2	251.8
8/2/2012 10:00	250.2	252.1
8/3/2012 10:00	250.4	252.1
8/4/2012 10:00	250.2	252.0
8/5/2012 10:00	250.2	251.8
8/6/2012 10:00	250.2	252.4
8/7/2012 10:00	250.4	254.2
8/8/2012 10:00	250.1	254.9
8/9/2012 10:00	250.5	252.3

Ballardsville Pipeline Pressure Data

Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
10/16/2012 10:00	251.6	258.8
10/17/2012 10:00	251.4	259.4
10/18/2012 10:00	250.9	255.0
10/19/2012 10:00	250.5	254.5
10/20/2012 10:00	250.9	252.7
10/21/2012 10:00	250.6	252.3
10/22/2012 10:00	251.1	252.2
10/23/2012 10:00	251.3	253.6
10/24/2012 10:00	250.9	252.3
10/25/2012 10:00	251.1	252.5
10/26/2012 10:00	251.3	258.0
10/27/2012 10:00	252.2	257.4
10/28/2012 10:00	250.5	260.8
10/29/2012 10:00	250.2	260.8
10/30/2012 10:00	252.8	255.2
10/31/2012 10:00	250.6	260.0
11/1/2012 10:00	252.8	260.5
11/2/2012 10:00	251.4	262.1
11/3/2012 10:00	250.2	257.4
11/4/2012 10:00	251.3	263.2
11/5/2012 10:00	256.0	263.2
11/6/2012 10:00	253.9	263.8
11/7/2012 10:00	253.0	258.3
11/8/2012 10:00	253.4	258.0
11/9/2012 10:00	255.3	258.3
11/10/2012 10:00	256.4	258.6
11/11/2012 10:00	250.8	258.0
11/12/2012 10:00	249.4	260.8
11/13/2012 10:00	253.0	261.6
11/14/2012 10:00	255.8	262.5
11/15/2012 10:00	250.5	260.2
11/16/2012 10:00	250.8	261.1
11/17/2012 10:00	247.2	257.8
11/18/2012 10:00	249.7	261.0
11/19/2012 10:00	249.7	259.4
11/20/2012 10:00	251.3	253.6
11/21/2012 10:00	250.8	259.2
11/22/2012 10:00	251.4	260.2
11/23/2012 10:00	250.8	258.8
11/24/2012 10:00	252.0	259.1
11/25/2012 10:00	252.5	260.0
11/26/2012 10:00	253.6	265.7
11/27/2012 10:00	255.2	283.8
11/28/2012 10:00	255.3	293.5
11/29/2012 10:00	251.4	274.0
11/30/2012 10:00	251.6	253.1
12/1/2012 10:00	250.8	253.1
12/2/2012 10:00	250.8	252.3
12/3/2012 10:00	250.9	253.6
12/4/2012 10:00	251.7	255.6
12/5/2012 10:00	250.5	262.5
12/6/2012 10:00	252.2	257.5
12/7/2012 10:00	252.7	256.0
12/8/2012 10:00	252.3	254.2
12/9/2012 10:00	250.3	262.1
12/10/2012 10:00	248.3	261.4
12/11/2012 10:00	249.8	261.7
12/12/2012 10:00	250.0	261.1
12/13/2012 10:00	250.2	261.4
12/14/2012 10:00	252.8	255.6
12/15/2012 10:00	251.4	258.5
12/16/2012 10:00	251.4	258.3
12/17/2012 10:00	251.4	257.4
12/18/2012 10:00	250.2	259.7
12/19/2012 10:00	250.8	261.4
12/20/2012 10:00	250.0	262.4
12/21/2012 10:00	260.5	263.3

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
2/27/2013 10:00	252.3	260.7
2/28/2013 10:00	253.1	260.7
3/1/2013 10:00	252.6	259.2
3/2/2013 10:00	254.6	260.4
3/3/2013 10:00	253.2	267.6
3/4/2013 10:00	251.0	269.0
3/5/2013 10:00	250.7	260.1
3/6/2013 10:00	252.6	261.8
3/7/2013 10:00	250.9	261.0
3/8/2013 10:00	250.1	259.2
3/9/2013 10:00	249.9	252.1
3/10/2013 10:00	250.4	258.2
3/11/2013 10:00	255.7	261.8
3/12/2013 10:00	252.0	261.0
3/13/2013 10:00	252.4	262.0
3/14/2013 10:00	251.0	257.8
3/15/2013 10:00	251.0	257.0
3/16/2013 10:00	250.5	254.5
3/17/2013 10:00	251.0	256.8
3/18/2013 10:00	251.0	257.6
3/19/2013 10:00	252.1	260.3
3/20/2013 10:00	251.2	258.7
3/21/2013 10:00	254.0	261.7
3/22/2013 10:00	249.6	256.7
3/23/2013 10:00	250.4	253.4
3/24/2013 10:00	251.0	260.9
3/25/2013 10:00	256.7	263.7
3/26/2013 10:00	253.1	262.0
3/27/2013 10:00	252.9	261.8
3/28/2013 10:00	250.1	257.3
3/29/2013 10:00	251.5	259.5
3/30/2013 10:00	252.7	256.2
3/31/2013 10:00	252.1	256.8
4/1/2013 10:00	250.7	262.1
4/2/2013 10:00	251.6	260.7
4/3/2013 10:00	250.2	260.9
4/4/2013 10:00	252.9	261.5
4/5/2013 10:00	249.8	257.8
4/6/2013 10:00	250.7	252.3
4/7/2013 10:00	250.7	252.3
4/8/2013 10:00	250.9	252.3
4/9/2013 10:00	250.7	252.3
4/10/2013 10:00	250.4	252.1
4/11/2013 10:00	251.0	252.4
4/12/2013 10:00	249.3	251.6
4/13/2013 10:00	249.9	252.1
4/14/2013 10:00	250.7	252.4
4/15/2013 10:00	250.9	257.6
4/16/2013 10:00	250.5	257.3
4/17/2013 10:00	250.4	255.2
4/18/2013 10:00	250.4	252.1
4/19/2013 10:00	250.1	258.7
4/20/2013 10:00	251.2	257.3
4/21/2013 10:00	251.3	257.8
4/22/2013 10:00	250.9	253.7
4/23/2013 10:00	251.0	252.3
4/24/2013 10:00	250.4	254.6
4/25/2013 10:00	252.7	261.2
4/26/2013 10:00	252.7	258.2
4/27/2013 10:00	250.7	258.2
4/28/2013 10:00	250.9	252.4
4/29/2013 10:00	250.7	252.3
4/30/2013 10:00	250.5	252.3
5/1/2013 10:00	250.5	252.1
5/2/2013 10:00	250.7	252.3
5/3/2013 10:00	250.9	252.4
5/4/2013 10:00	251.0	252.3

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
7/11/2013 10:00	250.3	300.8
7/12/2013 10:00	251.6	295.0
7/13/2013 10:00	251.3	252.8
7/14/2013 10:00	244.4	255.5
7/15/2013 10:00	248.0	254.4
7/16/2013 10:00	249.8	261.6
7/17/2013 10:00	250.2	264.3
7/18/2013 10:00	250.2	252.7
7/19/2013 10:00	250.0	252.7
7/20/2013 10:00	250.3	251.9
7/21/2013 10:00	250.5	252.0
7/22/2013 10:00	250.5	252.0
7/23/2013 10:00	250.5	252.2
7/24/2013 10:00	250.6	252.2
7/25/2013 10:00	250.6	252.2
7/26/2013 10:00	250.6	252.0
7/27/2013 10:00	250.5	252.2
7/28/2013 10:00	250.5	252.2
7/29/2013 10:00	250.6	252.3
7/30/2013 10:00	250.6	252.2
7/31/2013 10:00	250.5	252.2
8/1/2013 10:00	250.5	252.2
8/2/2013 10:00	250.5	252.8
8/3/2013 10:00	250.3	251.9
8/4/2013 10:00	250.3	252.7
8/5/2013 10:00	250.8	252.3
8/6/2013 10:00	250.6	252.2
8/7/2013 10:00	250.2	255.7
8/8/2013 10:00	250.4	252.0
8/9/2013 10:00	250.4	252.1
8/10/2013 10:00	250.4	252.0
8/11/2013 10:00	250.1	255.6
8/12/2013 10:00	250.9	256.0
8/13/2013 10:00	251.2	255.4
8/14/2013 10:00	250.9	254.9
8/15/2013 10:00	251.3	275.3
8/16/2013 10:00	251.0	252.6
8/17/2013 10:00	250.7	252.6
8/18/2013 10:00	251.0	253.1
8/19/2013 10:00	251.3	253.1
8/20/2013 10:00	251.5	253.1
8/21/2013 10:00	250.9	253.1
8/22/2013 10:00	251.3	253.1
8/23/2013 10:00	250.5	253.4
8/24/2013 10:00	251.8	253.4
8/25/2013 10:00	251.6	253.4
8/26/2013 10:00	250.5	254.5
8/27/2013 10:00	250.5	252.3
8/28/2013 10:00	250.5	252.4
8/29/2013 10:00	250.4	254.0
8/30/2013 10:00	250.7	253.8
8/31/2013 10:00	250.9	252.7
9/1/2013 10:00	251.0	252.7
9/2/2013 10:00	250.7	252.7
9/3/2013 10:00	250.4	259.3
9/4/2013 10:00	250.7	254.2
9/5/2013 10:00	250.4	252.9
9/6/2013 10:00	250.5	253.1
9/7/2013 10:00	250.7	252.9
9/8/2013 10:00	250.9	252.9
9/9/2013 10:00	250.5	252.9
9/10/2013 10:00	250.5	253.2
9/11/2013 10:00	250.5	252.9
9/12/2013 10:00	251.0	252.6
9/13/2013 10:00	250.4	252.6
9/14/2013 10:00	250.2	252.7
9/15/2013 10:00	250.7	252.4

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
11/22/2013 10:00	251.8	258.3
11/23/2013 10:00	253.4	260.4
11/24/2013 10:00	254.3	276.6
11/25/2013 10:00	251.1	294.3
11/26/2013 10:00	254.4	261.0
11/27/2013 10:00	254.1	261.3
11/28/2013 10:00	253.4	261.6
11/29/2013 10:00	251.2	263.6
11/30/2013 10:00	252.3	263.9
12/1/2013 10:00	250.3	258.6
12/2/2013 10:00	252.6	259.9
12/3/2013 10:00	251.1	258.3
12/4/2013 10:00	251.8	253.5
12/5/2013 10:00	251.2	259.3
12/6/2013 10:00	258.1	261.9
12/7/2013 10:00	256.0	261.0
12/8/2013 10:00	248.3	261.0
12/9/2013 10:00	254.0	265.4
12/10/2013 10:00	245.9	291.3
12/11/2013 10:00	254.4	277.5
12/12/2013 10:00	244.3	261.5
12/13/2013 10:00	250.3	260.4
12/14/2013 10:00	248.8	257.9
12/15/2013 10:00	253.8	260.5
12/16/2013 10:00	254.6	259.8
12/17/2013 10:00	256.7	260.7
12/18/2013 10:00	249.2	259.2
12/19/2013 10:00	249.2	252.4
12/20/2013 10:00	250.2	250.6
12/21/2013 10:00	250.2	251.5
12/22/2013 10:00	249.8	258.9
12/23/2013 10:00	248.9	260.1
12/24/2013 10:00	254.7	262.2
12/25/2013 10:00	252.1	263.0
12/26/2013 10:00	249.1	258.1
12/27/2013 10:00	249.8	259.0
12/28/2013 10:00	249.5	255.8
12/29/2013 10:00	249.1	256.9
12/30/2013 10:00	254.3	280.4
12/31/2013 10:00	251.2	264.1
1/1/2014 10:00	247.7	256.3
1/2/2014 10:00	250.8	286.1
1/3/2014 10:00	251.8	284.1
1/4/2014 10:00	250.8	275.1
1/5/2014 10:00	251.4	274.0
1/6/2014 10:00	263.8	289.4
1/7/2014 10:00	255.5	290.8
1/8/2014 10:00	252.9	259.2
1/9/2014 10:00	245.1	261.2
1/10/2014 10:00	248.6	259.6
1/11/2014 10:00	245.3	259.8
1/12/2014 10:00	248.9	253.8
1/13/2014 10:00	252.4	258.3
1/14/2014 10:00	249.4	260.4
1/15/2014 10:00	253.1	276.9
1/16/2014 10:00	253.5	272.6
1/17/2014 10:00	256.1	259.6
1/18/2014 10:00	251.8	260.8
1/19/2014 10:00	245.0	259.9
1/20/2014 10:00	249.2	262.1
1/21/2014 10:00	256.7	278.9
1/22/2014 10:00	247.9	292.6
1/23/2014 10:00	264.2	288.1
1/24/2014 10:00	256.3	284.2
1/25/2014 10:00	257.6	284.5
1/26/2014 10:00	251.1	286.8
1/27/2014 10:00	262.2	295.8

Ballardsville Pipeline Pressure Data
Assembled: 10/19/2015

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
4/5/2014 10:00	249.0	257.1
4/6/2014 10:00	248.5	254.7
4/7/2014 10:00	250.8	259.2
4/8/2014 10:00	249.5	260.6
4/9/2014 10:00	249.2	254.0
4/10/2014 10:00	249.8	252.7
4/11/2014 10:00	249.6	254.5
4/12/2014 10:00	249.9	254.0
4/13/2014 10:00	249.9	251.9
4/14/2014 10:00	250.7	258.6
4/15/2014 10:00	251.0	262.9
4/16/2014 10:00	249.8	262.9
4/17/2014 10:00	249.9	258.5
4/18/2014 10:00	250.1	251.9
4/19/2014 10:00	250.1	251.8
4/20/2014 10:00	250.1	251.9
4/21/2014 10:00	250.4	251.8
4/22/2014 10:00	250.1	253.3
4/23/2014 10:00	250.1	256.0
4/24/2014 10:00	249.8	252.1
4/25/2014 10:00	249.5	253.9
4/26/2014 10:00	249.5	253.7
4/27/2014 10:00	249.8	253.4
4/28/2014 10:00	250.2	251.8
4/29/2014 10:00	250.4	252.1
4/30/2014 10:00	250.4	253.7
5/1/2014 10:00	249.9	251.6
5/2/2014 10:00	249.3	257.6
5/3/2014 10:00	249.3	255.0
5/4/2014 10:00	249.5	252.8
5/5/2014 10:00	249.6	257.3
5/6/2014 10:00	249.6	257.4
5/7/2014 10:00	249.8	254.4
5/8/2014 10:00	249.8	254.0
5/9/2014 10:00	249.6	251.3
5/10/2014 10:00	249.8	251.6
5/11/2014 10:00	249.6	260.2
5/12/2014 10:00	249.5	252.1
5/13/2014 10:00	250.1	252.1
5/14/2014 10:00	250.5	254.7
5/15/2014 10:00	249.5	256.5
5/16/2014 10:00	249.5	251.0
5/17/2014 10:00	249.5	251.1
5/18/2014 10:00	249.5	255.9
5/19/2014 10:00	249.8	252.5
5/20/2014 10:00	249.5	251.6
5/21/2014 10:00	249.8	251.6
5/22/2014 10:00	249.6	251.9
5/23/2014 10:00	249.8	252.1
5/24/2014 10:00	249.6	251.8
5/25/2014 10:00	249.5	252.5
5/26/2014 10:00	250.2	252.2
5/27/2014 10:00	250.4	252.4
5/28/2014 10:00	250.2	252.4
5/29/2014 10:00	250.2	252.4
5/30/2014 10:00	250.4	252.2
5/31/2014 10:00	249.9	252.2
6/1/2014 10:00	249.5	251.6
6/2/2014 10:00	249.8	251.5
6/3/2014 10:00	249.6	251.8
6/4/2014 10:00	216.2	251.8
6/5/2014 10:00	192.0	255.4
6/6/2014 10:00	249.8	251.9
6/7/2014 10:00	249.8	251.5
6/8/2014 10:00	250.4	251.9
6/9/2014 10:00	250.1	251.8
6/10/2014 10:00	249.8	251.9

Ballardsville Pipeline Pressure Data
Assembled: **10/19/2015**

DATE	Pressure Minimum (psig)	Pressure Maximum (psig)
8/17/2014 10:00	87.0	87.0
8/18/2014 10:00	86.0	87.0
8/19/2014 10:00	86.0	88.0
8/20/2014 10:00	86.0	87.0
8/21/2014 10:00	86.0	87.0
8/22/2014 10:00	86.0	87.0
8/23/2014 10:00	87.0	88.0
8/24/2014 10:00	86.0	87.0
8/25/2014 10:00	86.0	87.0
8/26/2014 10:00	86.0	87.0
8/27/2014 10:00	86.0	88.0
8/28/2014 10:00	85.0	88.0
8/29/2014 10:00	87.0	88.0
8/30/2014 10:00	87.0	87.0
8/31/2014 10:00	87.0	88.0
9/1/2014 10:00	86.0	87.0
9/2/2014 10:00	86.0	87.0
9/3/2014 10:00	85.0	87.0
9/4/2014 10:00	86.0	87.0
9/5/2014 10:00	87.0	88.0
9/6/2014 10:00	87.0	88.0
9/7/2014 10:00	86.0	87.0
9/8/2014 10:00	86.0	87.0
9/9/2014 10:00	86.0	87.0
9/10/2014 10:00	86.0	180.2
9/11/2014 10:00	85.7	126.8
9/12/2014 10:00	85.0	164.6
9/13/2014 10:00	104.5	207.2
9/14/2014 10:00	90.2	254.0
9/15/2014 10:00	158.6	256.4
9/16/2014 10:00	133.3	259.2
9/17/2014 10:00	70.3	252.0

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