

## **REPORT OF NATURAL GAS SAFETY INSPECTION REPORT #12-217**

**OPERATOR:** Piedmont Natural Gas – Nashville, Tennessee

**PERSON CONTACTED:** Mr. Jim Thweatt, Operations Manager – O&M

### **INTRODUCTION**

The Tennessee Regulatory Authority (TRA), an agency of the State of Tennessee charged with the regulation of investor-owned utility companies, has also been granted express statutory authority to enforce gas pipeline safety standards. The Gas Pipeline Safety Division (GPSD) of the TRA is required, pursuant to 49 U.S.C § 60105(C)(1)(b), Tenn. Code Ann. § 65-28-106, and Tenn. Comp. R. & Regs. 1220-4-5-.47(5) and (6), to report to the Secretary of the United States Department of Transportation (USDOT) concerning all reported gas pipeline accidents or other incidents involving fatality, personal injury requiring hospitalization, property damage or loss of product exceeding amounts established by the Secretary, together with a summary of its investigation of the cause and circumstances surrounding each such accident or other incident.

Pursuant to Tenn. Code Ann. § 65-28-106, the TRA has the authority "to enforce safety standards in the state of Tennessee including the enforcement of federal safety standards as permitted in the Natural Gas Pipeline Safety Act, 49 U.S.C. § 60101 *et seq.*; and to exercise regulatory jurisdiction over the safety of pipeline systems and transportation of gas in accordance with permission granted by the Natural Gas Pipeline Safety Act, 49 U.S.C. § 60101 *et seq.* The TRA's authority to assess penalties for violations of applicable gas pipeline safety standards is set forth in Tenn. Code Ann. § 65-28-108:

(a) Any person who violates any provision of §§ 65-28-104--65-28-111, or of any regulation issued under such sections, is subject to a civil penalty not to exceed ten thousand dollars (\$10,000) for each such violation for each day that such violation persists, except that the maximum civil penalty shall not exceed five hundred thousand dollars (\$500,000) for any continuing series of violations.

(b) Any civil penalty may be compromised by the authority. In determining the amount of such penalty, or the amount agreed upon in compromise, the appropriateness of such penalty to the size of the business of the person charged, the gravity of the violation, and the good faith of the person charged in attempting to achieve compliance, after notification of a violation, shall be considered. The amount of such penalty, when finally determined, or the amount agreed upon in compromise, shall be paid within thirty (30) days after the determination to the authority, to be used for the purposes of §§ 65-28-104--65-28-111; and, if not paid within such time, may be recovered in a civil action brought by the authority in the chancery court of any county in which a violation exists.

The natural gas pipeline accident described in this report occurred in Nashville, Tennessee in the early hours of August 2, 2012. No injuries or fatalities occurred due to this incident; however, property was damaged as a direct result of the incident. It involved a natural gas transmission line operated and maintained by Piedmont Natural Gas (PNG), a transporter and distributor of natural gas that is a "gas public utility" as defined in Tenn. Code Ann. § 65-28-104(4) and as such is subject to the TRA's enforcement authority.

It was the GPSD's responsibility to conduct, with due diligence, an investigation to determine whether any failure on the part of PNG to comply with any requirements of the Minimum Federal Safety Standards (MFSS), 49 C.F.R. §§ 192.1 – 192.1015, contributed to the incident. The GPSD was also responsible for determining whether any measures can be taken to reduce the likelihood of recurrence of such an incident. This is important not only to PNG but also to other operators of transmission lines that may benefit from the findings set forth in this report.

### **SYNOPSIS**

At approximately 12:30 a.m. CST on Thursday, August 2, 2012, a 12-inch diameter steel transmission line (Line M) ruptured near Clarksville Highway (Hwy 41) in the Bordeaux area of Nashville, TN. The sudden release of energy (explosion) resulted in the discharge of earth, rock and other debris from above and around a section of the 12-inch diameter steel transmission line. The discharged material resulted in property damage to a nearby church and a used car business located on the adjacent property. In the initial incident report to the Pipeline and Hazardous Materials Safety Administration (PHMSA), PNG estimated property damage and loss of product to be approximately \$600,000 and \$477,000, respectively.

According to PNG, the Customer Contact Center received customer calls and Gas Control received alarms indicating abnormal operating conditions. First responders were dispatched from the Service Department and the Measurement and Regulation Department. PNG closed valves to stop natural gas flow in the area resulting in temporary loss of service to six (6) customers. Units from the Nashville Fire and Police Departments were on the scene coordinating the evacuations and traffic control.

At approximately 3:30 a.m. CST, Mr. Thweatt, Operations Manager – O&M for PNG, notified Larry Borum, TRA Gas Pipeline Safety Division Chief, of the incident. Mr. Borum arrived on the scene at approximately 4:00 a.m. CST to begin the initial investigation activities.

### **INVESTIGATIONS BY PNG AND THE GPSD**

#### **August 2, 2012**

Upon arrival at the site, Mr. Donnie Whitaker provided the GPSD Chief with an update on the incident to that point in time. The incident site was observed in limited light. Photos were taken of the crater showing the pipe ends and the space where a section of pipe appeared to be missing. Photos were also taken of an unrolled section of pipe laying approximately eighty (80) feet from the crater.

Observations at the site early Thursday morning, August 2, 2012 included the following:

- Earth, rock and debris scattered over a wide area.
- A crater approximately 8 feet deep by 25 feet long by 13 feet wide in a church parking lot.
- Two pipe segments approximately twelve (12) feet in length were exposed in the crater with a space between the ends of the pipe segments.
- Exposed pipe segments appear to be misaligned horizontally and vertically.
- Layered rock visible on sides and bottom of crater.
- 1.25-inch diameter steel service line crossing crater above (Line M).
- Directional drilling equipment near the rupture site.
- Visible damage to church structure and vehicles located on adjacent property.
- Unrolled pipe section located approximately eighty (80) feet from the crater.

Fourteen (14) photos were taken to document observed conditions.

The site was secured by PNG personnel.

### **August 2, 2012**

TRA representatives Larry Borum and Pete Hut, GPSD Engineer conducted a site inspection for additional observation and photos in daylight. It was observed that the segment of pipe downstream (south of) of the missing section included areas that appeared to be devoid of fusion bonded epoxy (FBE) coating, especially from approximately the three o'clock position to the nine o'clock position (looking downstream). Viewing the pipe segments from the top of the crater (not able to see the bottom of pipe), the segment of pipe upstream (north of) the missing section appeared to have bituminous coating still in place and FBE coating appeared to be in place under the bituminous coating.

As part of the PNG transmission integrity management program, a contractor was in the process of accomplishing a horizontal direction drilling (HDD) operation in the immediate vicinity of the incident site. PNG stated that the route of the directional drill was vertically below (deeper than) and at approximately the same horizontal alignment as Line M at the point of rupture. During GPSD inspection visits to the incident site there were no HDD operations in progress.

Ten (10) photos were taken to document observed conditions.

### **August 3, 2012**

The day after the rupture, Larry Borum and Tom Woosley, the GPSD Engineer/Trainer assigned to PNG for the 2012 inspection year, visited the site to determine the status of the PNG incident investigation. PNG personnel were continuing their investigation at the site and were in the process of removing material evidence and establishing chain of custody.

The GPSD representatives witnessed the removal of the two pipe segments from the crater and their placement in protective wrapping prior to loading onto a truck for transport to the testing

laboratory. According to PNG, the material evidence left Nashville on August 6, 2012 and arrived at the testing laboratory on August 7, 2012.

### **August 6, 2012**

Tom Woosley and Annette Ponds, GPSD Engineer visited the PNG office to perform a records review relative to the maintenance and operation of the PNG facilities involved in the incident. The inspection was focused on review of documentation related to the construction and operation and maintenance history of transmission line M. Areas of focus were construction, cathodic protection, leakage history and the transmission integrity management program. Records review detail is as follows:

- **Pipeline Design and Construction:** Extensive records were available for the line since its construction in 1982. Construction drawings consisted of hand sketches to document location of welds, length of pipe joints, approximate cover, location of other structures, location of galvanic anodes, and distances to reference points such as sewer manholes and light poles. Records indicate that the pipeline was constructed of electric resistance welded (ERW), 12.75" OD (outside diameter) by .250" WT (wall thickness), American Petroleum Institute (API) 5L, Grade X42, FBE coated steel pipe. The pipeline was designed and built for service in Class III locations. Design pressure for a pipeline in Class III locations with the recorded specifications would be 875 pounds per square inch gauge (psig). Operator had the original hydrostatic pressure test chart which indicates a 17.5 hour test at approximately 1,290 psig, or approximately 78% of yield strength. This test would allow an MAOP of up to 860 psig. Piedmont had established an MAOP of 730 psig which is well within limits for the class location. Non-destructive testing (NDT) of the pipeline during construction was accomplished by x-ray of all girth welds. X-ray evaluation records that included several girth welds up and downstream of the rupture sight were reviewed and no indications were found.
- **Pipeline Cathodic Protection:** Magnesium anodes were installed during construction of Line M in 1982. The pipeline also received some protective current from the rectifier unit located on Dry Fork Road. Review of cathodic protection surveys over the life of the pipeline showed cathodic protection levels well within operator's criterion and within the criteria found in 49 CFR, Part 192, Appendix D. Rectifier inspection records indicated relatively consistent voltage and current output for the Dry Fork Road rectifier. There appeared to be no periods of inadequate cathodic protection current during the history of this pipeline.
- **Leakage Surveys, Patrolling, and Leak Repairs:** Leakage surveys are on file for the life of the pipeline. The pipeline is surveyed twice annually as required by 49 C.F.R. §192.706 with the most recent survey being conducted on March 15, 2012. This survey was performed under contract with Southern Cross. The results of that survey showed no leaks on the pipeline. Prior surveys indicated no leaks on Line M during its' lifetime. A review of leak repairs over the life of the pipeline found only a grade III leak on the riser of the service to the church building

located near the rupture sight. This service is connected to Line O which runs parallel to Line M. This leak was repaired in August of 2011. The next survey was scheduled to be conducted in October of 2012. Patrolling is conducted in conjunction with the leakage survey with records kept to document completion of the patrol as well as any noted threats to the pipeline. Patrolling records show no excavation activities or other threats to the pipeline in this area.

**Integrity Management Program:** The operator conducted four (4) direct assessment digs on Line M in 2007. These were the result of indications from direct current voltage gradient (DCVG) and close interval (CI) surveys of the pipeline. The only indication near the rupture site was on the opposite side of Clarksville highway, approximately 700 feet away. Coating damage was found but there was no loss of metal requiring reduction in pressure. The only repairs made were to the damaged coating. No significant anomalies have appeared in the rupture area in indirect assessment of the pipeline. There was a minor indication found in a DCVG survey conducted in June of 2012 but investigation found a depleted magnesium anode on Line O that aligned with the indication.

### **Records Review Summary**

**In Service Date:** January 1983

**Pipeline Specifications:** ERW Steel Pipe, 12.75" OD x .250" WT, API5L, Grade X42, FBE coating.

**Class Location:** Class III

**Design Pressure:**  $((2 \times 42,000 \times .250)/12) \times .50 = 875 \text{ psig}$

**Hydro-Test:** 1290 psig (78% Yield Strength) for 17.5 hours, 12/19/82 – 12/20/82

**MAOP:**  $1290/1.5 = 860 \text{ psig}$  allowable, Established at 730 psig (42% SMYS)

**X-Ray:** 100% of welds, no anomalies identified

**Applied Cathodic Protection:** Magnesium anodes + influence of Dry Fork Road Rectifier

**Rectifier Inspections:** Voltage and Current outputs relatively consistent over time

**Corrosion Survey History:** Records available 1983 to present, potentials within acceptable criterion over history of line.

**Leak History:** No leaks on Line M, Grade III leak on funeral home (now church) service riser repaired 8/27/11

**Leak Survey:** Performed twice annually, most recent March 15, 2012, no leaks detected.

**Integrity Management Findings:** Rupture was within HCA, coating damage found and repaired to west of Clarksville Hwy adjacent to school. DCVG minor indication in June 2012 survey in general area of rupture.

### **THIRD PARTY TESTING**

PNG sent the removed segments of Line M along with other material samples to Det Norske Veritas (DNV) at 5777 Frantz Road in Dublin, Ohio, for examination. According to DNV, the evidence samples arrived at their location on August 7, 2012. On October 29, the GPSD began the incident inspection phase focusing on review of the third party testing report completed by DNV. The review was conducted at the PNG offices in the presence of Jim Thweatt.

The DNV report, Final Analysis of 12-inch Line M in Nashville, Tennessee Following In-Service Rupture, included background information on the pipe material, line construction and testing which mirrored information found during the GPSD records review. The DNV report included information as follows:

- Pipe specimens numbered #1, #2, and #3. #1 – upstream (north) segment, #2 – segment separated from pipeline by rupture, #3 – downstream (south) segment.
- No areas of visible corrosion products/scale/deposits were identified on the pipe sections at or away from rupture site.
- Fracture surfaces, deformed areas, dents and gouges present on pipe pieces associated with the rupture.
- Magnetic Particle Inspection (MPI) was performed on outside diameter of pipe surface of all pipe specimens.
- Samples removed from both sides of the main fracture on #2 and from a crack on #1 were removed for fractographic<sup>1</sup> examination.
- Samples contained evidence of pre-existing features on the fracture surface.
- Samples were removed from the matching fracture surfaces at the location on #2 identified as the likely initiation point of the rupture and from the crack on #1 from the location identified as Dent-3. These samples were examined at low and high (scanning electron microscopy, SEM) magnification to identify the fracture origin and document fracture morphology.
- Mechanical testing accomplished on base metal and seam weld.
- Yellow wrap at girth weld 102 missing from bottom half of pipe and edges appeared torn.
- #1 and #3 showed a pattern of linear dents referred to as a “washboard” appearance.
- #1 had three (3) locations of dents – Dent #1, #2 and #3.
- Dent #1 – 6.6 inches wide by 1.15 inches deep.
- Dent #2 – wide flattened area exhibiting sharp linear dents perpendicular to axial direction – 6.5 inches wide by 0.6 inches deep.
- Dent #3 – had 3 inch long transverse crack – 6.0 inches wide by 0.6 inches deep.
- Rupture initiation point – #2 fracture surface morphology consisted of two distinct zones. Near outside diameter (OD) surface a portion of the ruptured pipe wall relatively flat and angled with respect to the surface. Near internal diameter (ID) surface, the remaining wall thickness portion of the rupture was relatively rough and perpendicular to the surface.
- This combination of morphology is consistent with re-rounding cracks originating from the OD surface and with the final fracture toward the ID surface.
- Base metal machine testing – Yield strength 43.3 to 45.7 kips per square inch, ultimate tensile strength 66.5 to 70.3 kips per square inch. Specification for API 5XL Grade X42 42 and 60 kips per square inch, respectively.

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<sup>1</sup> Fractography is a descriptive explanation of a fracture process, usually in metals with specific reference to the use of photographs to study the fracture surface

- CorLAST™ used to estimate burst pressure based on the mechanical properties, nominal pipe dimensions and the actual measured crack for the rupture location. Pressure calculated to burst – 638 psig, actual pressure at time of rupture – 620 psig.

### **Findings Summary**

The DNV report included findings as follows:

- Rupture started at a bottom-side dent located approximately 67 inches from upstream girth weld 102. General appearance of a flattened area with linear dents oriented perpendicular to the pipe axis; forming a “washboard” structure.
- FBE coating missing from bottom side of two damaged pipe segments. Bottom half of tape wrap missing from girth weld 102.
- Colonies of surface breaking axial cracks were identified in the damaged area. These cracks appeared relatively small and extended across the entire length of the bottom-side dent.
- Metallographic cross-sectioning and SEM identify the surface breaking indications as re-rounding cracks characterized as cracks that extend from the OD surface into the wall at an angle of approximately forty-five (45) degrees and advance into the steel with a zigzag path.
- Ejected piece of pipe failed from a fracture that started at the approximate six o’clock orientation.
- Total depth of re-rounding crack with crack extension at the rupture initiation point was 0.203 inches (81% NWT).

### **Discussion and Conclusions**

Results of the investigation indicate that mechanical damage area on the bottom of the pipe was the site of rupture initiation. It is possible that the pipe was dragged over a sharp object during construction resulting in removal of the FBE coating and creating the linear dents perpendicular to the pipe axial direction. The dents were not identified during backfilling operations. The re-rounding cracks may have first formed during denting and flexing back upon pressurization of pipe during the hydrostatic test to 1,290 psig or approximately 78% of specified minimum yield strength. Re-rounding cracks grew deeper, possibly assisted by pressure fluctuations during normal operations.

There was no evidence that the HDD activity was a contributing factor, although this could not be completely ruled out. Drilling fluid may have come through the rocky soil to the rupture area and the drilling caused vibrations in the soil. It is possible that these factors contributed to the final growth of pre-existing crack.

The report also noted that the presence of the 1.25-inch diameter steel distribution line above Line M possibly affected the results of the close interval survey and the direct current voltage gradient survey conducted during transmission integrity management program activities.

## **GPSD INVESTIGATION AND ANALYSIS**

GPSD reviewed PNG records to determine whether an unacceptable level of risk existed at the time of the accident. GPSD focused on anomalies identified during site observations, briefings by PNG, and the report issued by PNG and its consultant.

### **GPSD CONCLUSIONS**

Based on information compiled from field observations, a detailed review of PNG operation and maintenance records associated with transmission line M, operator interviews and the analysis included in the DNV report, Final Analysis of 12-inch Line M in Nashville, Tennessee Following In-Service Rupture, the GPSD offers the following conclusions:

1. The design of Line M is consistent with requirements set forth in 49 C.F.R. Part 192, §§ 101-115.
2. The testing of Line M is consistent with the requirements set forth in 49 C.F.R. Part 192, §192.505.
3. The maximum allowable operating pressure was determined consistent with the requirements set forth in 49 C.F.R. Part 192, §192.619.
4. Records indicate that the pipe included in the incident has been operated and maintained in accordance with 49 C.F.R. Part 192 §§613, 705, 706 and 709.
5. Records indicate that Line M has been evaluated in accordance with transmission integrity management requirements set forth in 49 C.F.R. Part 192, Subpart O.
6. Pre-existing mechanical damage inflicted during construction eventually led to the rupture in the early morning hours of August 2, 2012, in violation of 49 C.F.R. 192.307.”

The GPSD offers that the findings included in the DNV report based on metallurgical testing and analysis are definitive relative to material failure as a result of pre-existing damage to the pipe. Further, it does not appear to be possible to determine the exact cause of the pre-existing damage, but without a scenario implicating that the damage was due to forces occurring after installation was complete, it is highly likely that the damage was inflicted prior to backfilling operations.

### **PNG Actions Immediately Following the Accident**

PNG responded appropriately to the accident. PNG took appropriate steps to make the area safe to protect life and property, including dispatching first responders at first notification. PNG also provided equipment and manpower at a level that was sufficient to control the site and complete cleanup and service restoration as safely and quickly as possible. PNG supervisory control and data acquisition (SCADA) capabilities appeared to perform effectively relative to identification and notification of an abnormal operating condition.



PNG notified the appropriate Federal authority and members of the GPSD.

### **Subsequent PNG Actions**

Subsequent to the incident, PNG initiated and completed actions as follows:

1. PNG filed the Pipeline and Hazardous Materials Safety Administration (PHMSA) incident report (No. 20120087 – 15598) on August 30, 2012.
2. The damaged section of pipe on transmission line M was replaced with 12” outside diameter, 0.375” wall thickness, American Petroleum Institute-5L X-52 steel pipe with an electric resistance welded (ERW) long-seam. All new welds were non-destructively tested by x-ray.
3. An inline caliper inspection tool was run along the entire length of transmission line M and no other areas of concern were identified.
4. Transmission line M hydro-tested to 1,215 pounds per square inch gauge (psig) to establish a MAOP of 810 psig.
5. Transmission line M was internally dried and returned to service August 20, 2012.
6. As part of its integrity management program, PNG is retrofitting its Tennessee transmission lines 8-inch diameter and larger so that in-line tools can be used for inspection. According to PNG, in excess of forty (40) miles of these transmission lines have been retrofitted and internally inspected to date.
7. According to PNG, a caliper tool is now used after construction and before commissioning of new transmission lines to determine if any mechanical damage occurred during construction.

### **VIOLATION AND CORRECTIVE ACTIONS**

**49 CFR §192.307** States that “each length of pipe and each other component must be visually inspected at the site of installation to ensure that it has not sustained any visually determinable damage that could impair its serviceability.” Based on the findings resulting from the Det Norske Veritas (DNV) metallurgical analysis of the ruptured pipe, it is the conclusion of GPSD that PNG failed to ensure that the section of pipe involved in the August 2, 2012 incident had not sustained any visibly determinable damage that could impair its serviceability. Therefore, a violation for failure to comply with the requirements of **49 CFR §192.307** is cited.

For this violation, GPSD proposes a civil penalty of \$15,000. As a result of its investigation, the GPSD has determined that PNG has taken actions to reduce the likelihood of recurrence of such an incident since the construction of transmission line M thirty (30) years ago. This amount takes into consideration PNG’s actions that include an internal inspection and hydro-test of the entire length of Line M in an effort to ensure that similar conditions do not exist in other locations along the line. This amount also takes into consideration PNG’s continued improvement relative to construction quality control and improved PNG operation and maintenance inspection capabilities. Such processes and capabilities should mitigate the risk of future incidents such as the one involving Line M.