Missouri Public Service Commission

Gas Incident Report

Missouri Gas Energy
Case No. GS-2007-0381

Blue Springs, Missouri
January 8, 2007

Energy Department ... Utility Operations Division
July 2007… Jefferson City, Missouri

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SYNOPSIS

At approximately 1:42 p.m., Central Standard Time (CST, all times in this report are Central Standard Time) on Monday, January 8, 2007, a natural gas explosion and flash fire occurred in a vacant single family residence located at 1706 SW Smith Street in Blue Springs, Missouri. Approximately 20 neighboring homes were occupied at the time of the explosion and these occupants were evacuated, however no injuries were reported.

Missouri Gas Energy (MGE or Company) provides natural gas service in Blue Springs, Missouri. Natural gas was supplied to 1706 SW Smith Street by a 2-inch diameter, coated and cathodically protected steel natural gas main installed parallel to and along the west side of 18th Street and was operating at approximately 10 pounds per square inch gauge (psig) at the time of the explosion and flash fire. On September 1, 1969, this 2-inch in-service diameter coated and cathodically protected steel main replaced a 2-inch diameter unprotected bare steel natural gas main, which was abandoned and still in-place parallel to and along the west side of 18th Street.

On January 8, 2007, natural gas was inadvertently introduced into the 2-inch abandoned natural gas main during construction work by Infrasource (Contractor), a construction contractor hired by MGE. On January 8, 2007, Infrasource workers were in the process of replacing gas lines at the intersection of 18th and Walnut Streets when they mistakenly connected a newly installed and in-service 2-inch polyethylene (PE) natural gas line to the abandoned 2-inch main along 18th Street, introducing natural gas into the abandoned main. The natural gas escaped through the open ends of the abandoned main and migrated through the soil and rock into the sewer main. The natural gas eventually entered the structure at 1706 SW Smith Street through improperly installed sewer drain piping located in the basement of the structure. The migrating natural gas accumulated within the structure and was ignited by an undetermined source.

The probable cause of the connection of the new 2-inch PE in-service natural gas line to the abandoned 2-inch natural gas line was the failure of MGE and Infrasource to follow MGE's established procedures for properly locating and identifying the correct line to connect to.

As a result of its investigation, the Staff determined that sufficient evidence exists to conclude MGE violated Missouri Public Service Commission pipeline safety regulation 4 CSR 240-40.030(12)(C)1., regarding following the procedures in its Gas Construction Standards Manual and that MGE's failure to follow its Gas Construction Standards Manual procedures contributed to the explosion.

As a result of Staff's investigation, this report contains eight (8) recommendations regarding MGE.

CONCLUSIONS

1. The probable cause of the incident was the ignition of natural gas that accumulated in the basement of 1706 SW Smith Street. The natural gas originated from an abandoned natural gas main along 18th Street. The natural gas escaped from the open ends of the abandoned line, migrated through the ground and into the sewer system. Once in the sewer system, the natural gas entered into 1706 SW Smith Street through improperly installed sewer piping in the basement, accumulated, and was ignited. The probable source of ignition was not determined, but could have been one of several natural gas appliances in the basement with standing pilots.

2. The probable cause for the locating and marking of the abandoned line was the failure of the locating contractor to access the abandoned pipeline maps available to them in MGE's computer mapping system. Also contributing to the identification of the wrong line was MGE's failure to provide maps of the abandoned pipeline to Infrasource. The correct in-service line probably would have been identified if MGE would have provided maps to Infrasource showing both the abandoned line and the in-service line, and their relationship to each other.

3. The probable cause for the introduction of natural gas into the abandoned line was the failure of Infrasource to follow MGE's construction standards which require use of pressure gauges to identify in-service lines to ensure connection to the correct main. If Infrasource had known the line was not pressurized (and likely not in service) they would not have made the connection to the abandoned line, and the explosion would not have occurred.

4. After the explosion, MGE implemented procedures to ensure that construction project packets include maps and information regarding abandoned pipelines. MGE also implemented procedures to ensure that, before tie-ins are completed, pressure gauges are to be used to confirm the operation of the line being tied to. MGE also held training and discussions at all of its offices covering proper leak investigation methods, including checking sewer manholes.

5. MGE's and Infrasource's actions during connection to the abandoned line did not adhere to MGE's procedures outlined in its Gas Construction Standards Manual.

MGE is responsible for Infrasource's actions due to MoPSC Regulation 4 CSR 240-40.030(12)(B)3., which states: "each operator shall be responsible for ensuring that all work completed by its consultants and contractors complies with this rule." By Infrasource not verifying that they had connected to the correct line MGE violated, MoPSC Regulation 4 CSR 240-40.030(12)(C)1., which states in part "each operator shall prepare and follow for each pipeline, a manual of written procedures for conducting operations and maintenance activities and emergency response."

6. The Staff believes the violation of the Missouri Public Service Commission Regulation identified in Conclusion 5 contributed to the explosion. As a result of the Staff's investigation, the report contains eight (8) recommendations regarding MGE.

RECOMMENDATIONS

1. The Staff recommends MGE ensures its contract locator examines the abandoned pipeline maps available to them for any locate request. This may require MGE to modify existing training or provide additional training to the contract locator personnel so they are aware of the importance of this task.

2. The Staff recommends MGE should include the same abandonment maps in the project information it gives to contractors performing work on construction projects. MGE has already started to implement this recommendation.

3. The Staff recommends MGE conduct training with its contract inspectors on MGE's computer mapping system. This would include training on how the contract inspectors can access maps of abandoned pipelines in the areas of the projects they are responsible for.

4. The Staff recommends MGE conduct additional leak investigation training for its personnel to emphasize the importance of checking sewer manholes when they are located in the area of leak investigation. MGE has already conducted this training in all of its operating offices.

5. The Staff recommends MGE use pressure gauges to verify the correct line is being connected to, as required by its construction standards. MGE needs to ensure that any contractor working for it receives proper training concerning the importance of this procedure. MGE may need to provide further detail in its operating procedures to describe how this process should be done. MGE has already started to implement this recommendation.

6. The Staff recommends MGE have a contract inspector on-site for any critical procedure during a construction project being performed by a contractor. This would especially include any pipeline connection.

7. The Staff recommends MGE file a response to these recommendations in Case Number GS-2007-0381 within thirty (30) days of the filing of this Report.

8. The Staff recommends the Office of General Counsel file a complaint with the Commission regarding the violation noted in this Gas Incident Report.

FACTS

NOTE: Except for the information gathered during the on-site investigation and/or interviews, the information used to compile this portion of the report was obtained in record and/or statement form.

The Incident

At approximately 1:42 p.m., (CST) on Monday, January 8, 2007, a natural gas explosion and flash fire occurred in a vacant single family residence at 1706 SW Smith Street in Blue Springs, Missouri.

Personal Injuries

The involved residence was vacant at the time of the explosion and flash fire. There were no injuries reported.

Property Damage

The residential structure located at 1706 SW Smith Street received minor damage as a result of the explosion and flash fire (See Appendix B-2, Photographs 1 & 2). There were no personal contents in the structure. The Central Jackson Fire Protection District estimated the damage to the building at $5,000.

Site Description

The involved structure is located at the southeast corner of the intersection of Smith Street and 18th Street, and is located in the central part of Blue Springs, Missouri, just west of the downtown business district (See Appendix A-1, Figure 1). The structure faced north to Smith Street. The natural gas service line traversed east from the main on 18th Street to the natural gas meter located approximately in the middle of the structure. The area immediately surrounding 1706 SW Smith Street is a residential area consisting primarily of single-family residences.

The involved structure was a two (2) bedroom, single-level wood frame house with clapboard siding. There was a small basement under the center portion of the house and crawl spaces under other portions of the house extending north and south from the top of the basement walls.

Meteorological Data and Conditions

The weather reporting station located at Kansas City International Airport, in Kansas City, Missouri, approximately 30 miles northwest of 1706 SW Smith Street, recorded a high temperature of 54 degrees Fahrenheit (ºF), a low of temperature of 22º F and a mean temperature of 38º F on January 8, 2007. Precipitation measured for the month of January, up to and including January 8, was 0.1 inches. There was no precipitation on January 8. The wind averaged 13 miles per hour generally from a westerly direction.

Natural Gas System

Natural gas in the Blue Springs, Missouri area is provided by Missouri Gas Energy, a division of Southern Union Company. At the time of the explosion and flash fire, 1706 SW Smith Street was supplied natural gas by a 2-inch diameter, coated and cathodically protected steel main located parallel to and 2 feet east of the west pavement edge of 18th Street. An abandoned[1] 2-inch diameter, bare and unprotected steel natural gas main was located parallel to and 1 foot west of the west pavement edge of 18th Street (See Appendix A-2, Figure 2). The abandoned 2-inch diameter, bare steel natural gas main along 18th Street had been replaced with the 2-inch diameter, coated and protected steel main on September 1, 1969.

At the time of the explosion and flash fire, the 2-inch diameter, coated and protected steel main and service line serving 1706 SW Smith Street were operating at a pressure of approximately 10 pounds per square inch gauge (psig). The established maximum allowable operating pressure (MAOP)[2] of the coated and protected natural gas main was 10 psig.

The natural gas service line for 1706 SW Smith Street was a ½-inch diameter polyethylene pipe that was installed by MGE on April 9, 1999. The service line extended from the main to the natural gas meter located approximately in the middle of the house (See Appendix B-1, Photograph 2).

[1] An abandoned pipeline is one that is still underground but has been separated from its source of gas, purged of all natural gas and permanently removed from service

[2] MoPSC regulation 4 CSR 240-40.030(1)(B)16., defines the “maximum allowable operating pressure (MAOP)” as the maximum pressure at which a pipeline or segment of a pipeline may be operated.

MGE's Protected Bare Steel Main Replacement Program, and the Walnut Street and 18th Street Protected Bare Steel Replacement Project

MGE is required to replace at least five (5) miles of protected bare steel main per year under Case No. GO-2002-50. The 3-inch and 2-inch diameter protected bare steel main in the 1800 block of Walnut Street, and specifically, at the intersection of Walnut Street and 18th Street, were included in the Company's on-going replacement program. However, none of the protected bare steel mains within a two-block radius of 1706 SW Smith Street have currently been identified as having justification to be replaced, using the replacement criteria in Case No. GO-2002-50. Even though the mains did not meet the replacement criteria, the Company decided to go ahead and replace this particular area of protected bare steel main because of some leaks and the location of these leaks. The protected bare steel pipe replacement on Walnut Street, and part of 18th Street was part of a larger replacement project consisting of protected bare steel mains and service lines in the surrounding area.

MGE contracted with Infrasource to replace/abandon existing protected bare steel natural gas main and any unprotected bare steel service lines with the polyethylene (PE) natural gas mains and service lines.

Main and Service Line History

The original 2-inch diameter unprotected bare steel main, along the west side of 18th Street between Walnut Street and Smith Street, was replaced with 2-inch diameter coated and cathodically protected steel piping on September 1, 1969. The original 2-inch diameter bare steel main was abandoned in-place. The original 1¼-inch diameter unprotected bare steel service line for 1706 SW Smith Street was replaced with ½-inch diameter PE piping on April 9, 1999.

Company/Contractor Actions and Observations

On the morning of the explosion, Infrasource prepared to make a connection between the newly installed 2-inch PE pipeline under Walnut Street and the existing 2-inch coated steel pipeline on 18th Street. Infrasource had previously called Missouri One Call to request that underground facilities in the area be located. SM&P, a contract locator for MGE, had located and marked the gas lines in the area with yellow paint. Infrasource did not have copies of the maps of abandoned natural gas pipelines in the

area of excavation. The contract locator had access to MGE's computer mapping system, which includes maps of abandoned pipelines. However, they did not access the abandoned pipeline maps for this locate.

An Infrasource employee was hand digging in the area of the connection on 18th Street to expose and avoid hitting a telephone cable. In the process he uncovered a 2-inch bare steel pipeline. There had been previous inconsistencies in the plans they were given for the project, so the Infrasource project foreman then contacted the MGE contract inspector to confirm whether this was the pipe to which they were suppose to connect. They asked for service card information for the two residences close by, 1707 and 1801 Walnut Street, and asked MGE if this was the only pipeline that ran down 18th Street. The MGE contract inspector obtained the service cards and stated that he believed that it was the only pipeline on 18th Street. The service card for 1707 Walnut indicated that is was connected to a 2-inch bare steel natural gas main on 18th Street. The service card for 1801 Walnut indicated that it was connected to a 2-inch coated steel natural gas main on 18th Street. The Infrasource crew thought the bare pipeline might be the correct line, and took a cathodic protection reading. They obtained a -0.89 volt reading, which is above the minimum amount of protection required by Missouri Regulations[3].

On January 8, 2007, shortly before noon, personnel from Infrasource completed a three-way tap[4] between an abandoned 2-inch main on 18th Street and a 2-inch PE main that went under Walnut Street and connected to the new 4-inch PE main (See Appendix A-2, Figure 2). They did not realize they had incorrectly identified and connected to the abandoned 2-inch main on 18th Street instead of the in-service 2-inch steel main. MGE personnel were not on-site at the time the tap was made. The Infrasource personnel then left for their lunch break.

At approximately 12:30 pm an MGE contract inspector arrived at the scene and noticed the smell of natural gas in the air. He spoke with the Infrasource crew that was on-site and they proceeded to try to find the source of the odor. They started to dig a hole at the connection point between the 2-inch PE natural gas main on 18th Street and the 4-inch PE natural gas main on Walnut Street, thinking that this might be the source of the natural gas odor.

[3] MoPSC regulation 4 CSR 240-40.030(9)(H) & Appendix D requires a negative (cathodic) polarized voltage of at least -0.85 volt, with reference to a saturated copper-copper sulfate anode.

[4] A three-way tapping tee is used to make connections between mains without shutting down gas flow.

At 12:49 pm MGE received a call from the public reporting an odor of natural gas in the air on Walnut St. between 15th Street and 20th Street (See Appendix A-2, Figure 2). An MGE serviceman was dispatched to the area, and arrived at 12:57 pm. He initially started to use his Flame Ionization (FI) leak detection instrument. However, it seemed to be indicating leaks at numerous locations. So, he began making a series of bar-holes[5] on Walnut Street. He started at 15th Street and worked his way east. However, after he was part way between 16th and 17th street he noticed the Infrasource crew working closer to 18th Street. He stopped bar testing and went to speak with the Infrasource personnel. After speaking with the Infrasource crew he came to the conclusion that the gas in the air was from a purging operation.[6]

At approximately 1:42 p.m., MGE and Infrasource personnel witnessed an explosion and flash fire at 1706 SW Smith Street. The Infrasource crew extinguished the curtains that were on fire in the house. The MGE serviceman on the scene contacted dispatch to report the incident and request police, fire, and Company assistance. The serviceman turned off and removed the meter to the house. He then began checking for natural gas in the sewer manholes in the street (See Appendix A-2, Figure 2). There were high levels of natural gas found in the sewer (readings up to 85% gas-in-air) near 1706 SW Smith Street.

Meanwhile the Infrasource crew resumed digging, and found natural gas escaping from an open ended 2-inch bare steel pipe. They capped that line and realized they had connected to an abandoned line on 18th Street. They squeezed off the 2-inch PE natural gas main on 18th Street, which stopped the flow of natural gas into the abandoned pipeline.

During this time, the police and fire departments arrived and evacuated the area between 17th Street and 19th Street and from Walnut Street to Main Street (See Appendix A-2, Figure 2). Company crews also turned natural gas off to approximately thirty residences in the area.

[5] Bar-holes are small diameter holes made in the ground by a steel rod to facilitate sampling of the subsurface atmosphere for natural gas with a combustible gas indicator.

[6] Purging of newly installed natural gas pipelines is a process by which natural is gas introduced into one end of the pipeline to expel air from the pipeline before its ready for service.

Once the natural gas readings in the sewers went to zero and it was determined that the area was again safe, residents were allowed to return to their homes. Company crews then began the process of turning natural gas back on to the homes that had to be turned off.

The next day the Infrasource crew exposed the 2-inch coated steel main, and started the process of making the correct connection. On the morning of January 10, 2007, with Company and Staff personnel onsite, Infrasource completed the correct connection from the 4" PE main on Walnut Street to the 2-inch coated steel main on 18th Street.

Company's Actions to Meet MoPSC Reporting Requirements

MGE completed the Missouri Public Service Commission incident reporting requirements as follows:

1. The initial telephone notification of a possible natural gas incident was made to the Staff at 2:35 p.m. on January 8, 2007.

2. The explosion did not meet the Missouri Reporting Requirements in that there were no deaths, no personal injuries, and estimated property damage was less than $10,000.

3. Even though the explosion did not meet the Missouri Reporting Requirements, in the Commission's rules, the Staff believes there were three issues that need to be addressed in a formal report. These issues include: Following Operations and Maintenance Procedures; Proper Locating Procedures; and Proper Leak Investigation Procedures.

Commission Staff Actions and Investigation

Notification of Staff by the Company

The Missouri Public Commission's Energy Department - Safety/Engineering Staff (Staff) was notified directly by MGE at 2:35 p.m. on January 8, 2007. Several Staff members were in Kansas City at the time of the incident conducting an annual safety inspection of MGE's Central Region's operations and immediately proceeded to the incident site.

Incident Site Investigation

Two members of the Staff arrived at the incident site at approximately 3:30 p.m. on January 8, 2007. Staff spoke with several MGE supervisors who described the events that had occurred and the actions taken up to that point. The Staff observed actions that were continuing to occur, such as leak investigations and service restorations. Staff also observed that Infrasource crews remained on-site and were performing various construction and backfilling activities along Walnut Street between 17th and 19th Streets. The Staff proceeded with an examination of the excavations and work being performed by the contractor at the intersection of Walnut and 18th Streets.

Observations of Contractor Excavations

The Staff initially observed an excavation at the northwest corner of Walnut and 18th Streets. This excavation had been made by Infrasource to expose a portion of an existing 2-inch diameter steel natural gas line for the purpose of connecting in new PE natural gas piping from new construction on Walnut Street (See Appendix B-1, Photograph 1). The Staff observed a 2-inch diameter bare steel pipeline traversing through the excavation and into the north and south side of the excavation. Staff noted that a 2-inch 3-way tapping tee was connected to the top of the bare steel piping. A 2-inch diameter coated steel and plastic transition fitting[7] was connected to the outlet of the tapping tee and a PE cap was connected to the outlet of the transition fitting. The Staff also noted that a 2-inch diameter PE pipe extended into the excavation from the south and was capped near the outlet of the capped transition fitting. Staff proceeded to take a cathodic protection reading on the bare steel piping in the excavation and obtained a reading of -0.89 volts.

The Staff then observed an excavation on the south side of Walnut Street where 18th Street intersects Walnut Street. This excavation had initially been started by the contractor to expose the connection point of the 2-inch PE natural gas main on 18th Street to the 4-inch PE natural gas main on Walnut Street, thinking this might be the source of the natural gas odor in the area. However, this connection was not found, but instead a 2-inch diameter bare steel pipeline was exposed. The Staff observed approximately 12 inches of this 2-inch bare steel piping with a cap on the end exiting from the north side of the excavation (See Appendix B-1, Photograph 2).

[7] A fitting with steel on one end and plastic on the other end, which allows a plastic piping system to be connected to a steel piping system.

Exterior Observations of 1706 SW Smith Street

After completing an examination of the excavations and work performed by Infrasource at Walnut and 18th Streets, the Staff proceeded with an exterior and interior investigation of the structure at 1706 SW Smith Street (See Appendix B-2, Photograph 1) in order to ascertain evidence of an explosion, possible points of entry of the natural gas, and possible ignition sources. The only evidence of explosion damage was on the west side of the structure. Sliding glass doors had been separated from the structure and displaced onto the west side of the wooden deck. Guttering on the west side of the structure had been separated from the fascia and displaced onto the yard (Appendix B-2, Photograph 2).

Interior Observations of 1706 SW Smith Street

Upon entering the main level of 1706 SW Smith Street through the opening caused by the displaced sliding doors that led into the living area of the structure, Staff saw no apparent evidence of explosion or fire damage. Adjacent to and south of the living area, there was a kitchen. Scorching and melting was evident on the curtains and venetian blinds on the west kitchen window and on the top half of louvered doors that separated the kitchen area from a stairway that led into the basement. Also, at the top of the stairway, there was a door that led onto a covered breezeway between the main structure and an unattached garage. The top inside of this door and the ceiling above the door had sustained moderate scorching and burn damage (See Appendix B-3, Photograph 1). There was no other evidence of explosion or fire damage within the main level of the structure. The Staff then went to the basement.

In the basement area, Staff observed a concentration of burn damage and scorching in the north and northeast area of the basement. The basement walls in this area were poured concrete, and exhibited varying degrees of scorching and soot accumulation. The scorching and soot accumulation continued upward from the basement floor, along the east wall, and up into the ceiling of the basement. This scorching and soot accumulation was concentrated in an area around and above sewer piping in the basement floor (See Appendix B-3, Photograph 2). This sewer piping consisted of a coffee can, plastic lid, and small diameter polyvinyl chloride (PVC) drain pipe located over a drain in the basement floor. The plastic lid and PVC piping were burned and melted. Also, located in the basement were a natural gas space heater, water heater, and floor furnace. All of which were found with their controls in the “ON” position.

MGE and the contractor planned to locate and expose the 2-inch diameter coated and protected steel natural gas main on 18th Street the next morning and make the connection to the 2-inch PE natural gas main on 18th Street. Knowing this information and due to darkness, the Staff delayed further investigation until the next morning and left the incident site at approximately 6:00 p.m. on January 8, 2007.

Upon arrival the next morning, the Staff observed that the excavation at the northwest corner of Walnut and 18th Streets, containing the 2-inch abandoned natural gas main and original tapping tee, had been enlarged to the east thereby exposing the in-service 2-inch in-service natural gas main (See Appendix B-4, Photograph 1). The 2-inch in-service main was approximately three feet east of the 2-inch abandoned main. Staff remained at the site expecting the contractor to make the connection between the 2-inch in-service natural gas main and the 2-inch PE natural gas main on 18th Street. However, the contractor decided to make the connection the next day. With this information, Staff departed the site to return the next day.

Upon arrival the next morning, January 10, 2007, the Staff observed the contractor connect the existing 2-inch in-service natural gas main on 18th Street and connect the new 2-inch PE natural gas main, also along 18th Street (See Appendix B-4, Photograph 2). The contractor verified the 2-inch coated steel main as the correct line to connect to by installing pressure gauges and monitoring natural gas pressure in the main

MGE's Operations and Maintenance Standards and Personnel Training

Company's Gas Construction Standards

MGE's Gas Construction Standards Manual includes procedures to follow when making branch connections, tie-ins, tees, and tapping. These procedures are to be followed by any contractor working on the Company's natural gas facilities. Among the procedures stipulated in the manual are: ensure correct line has been identified, and confirm system operation with the use of pressure gauges.

Personnel Training

MGE has a written training program for its employees.[8] This program covers such topics as: (1) Abnormal Operating Conditions (AOC) – Failure to Follow Procedures; (2) AOC – Report of Gas Odor; (3) AOC – Flammable Gas Atmosphere; (4) Leak Investigation - Outside; (5) Accidental Release of Gas; (6) Recognizing Emergency Conditions; and, (7) Properties of Natural Gas.

Participants of MGE's training program review the program's topics and take a written test or hands-on evaluation after the reviews. All MGE employees at or responding to this incident were current on their required training and qualifications.

Contractor Personnel Training

The contractor also has a written training program for its employees (See footnote 9 on this page). This program includes training covering topics such as: (1) characteristics/hazards of natural gas; (2) recognizing emergency conditions; (3) accidental release of gas; (4) job site protection; (5) abnormal operating conditions overview; (6) general requirements for connections to main piping; (7) inactive pipelines, except service lines; and, (8) tapping and stopping. Employees review the program's topics and take a written test or hands-on evaluation after the review.

The records provided by the contractor indicated that the contractor's employees, who were involved in the incident, had been adequately trained and qualified. This training and qualification included the performance of the tasks that were required to follow MGE's Standards for performing branch connections, tie-ins, tees, and tapping.

[8] MoPSC regulation 4 CSR 240-40.030(12)(D)1., requires that no operator may permit an individual (operators themselves, independent contractors and subcontractors, and employees of these contractors) to perform on a pipeline system an operation, maintenance or emergency-response function regulated by this rule unless that individual has been trained and successfully completed a test to demonstrate possession of the knowledge and skills under the training rule.

ANALYSIS

Factors that Led to the Incorrect Identification of the In-Service Natural Gas Main

Prior to installing the new 2-inch PE natural gas piping across Walnut Street and connecting it to the in-service 2-inch natural gas main on 18th Street, Infrasource had previously called Missouri One Call to request that underground facilities in the area be located. Particularly, the employees requested the in-service 2-inch natural gas main be located and marked at the intersection of Walnut and 18th Streets and continuing north on 18th Street for 100 feet. MGE's locating contractor located and marked, with yellow paint, above the location they thought was the in-service 2-inch natural gas main on 18th Street in the vicinity of the planned connection of this main to the new 2-inch PE natural gas main on 18th Street. However, the yellow locating marks were above the location of the abandoned 2-inch natural gas main instead of the in-service 2-inch natural gas main. Infrasource then based its initial excavation on those incorrect locating marks. If the contract locater had accessed, or Infrasource had been given, maps of the abandoned natural gas main in addition to maps of the in-service natural gas main, both would have known that there were two lines in close proximity (one in-service and one abandoned) making it more likely that the correct (in-service) natural gas main would have been located, excavated and exposed.

Since MGE did not provide the abandonment maps, neither the Infrasource nor the MGE's contract inspector knew that there was more than one natural gas line on 18th Street. The conflicting information they gathered from the service cards also added to the confusion, with one service card showing the main on 18th Street being bare and the other as being coated.

The Infrasource crew did check the cathodic protection level on the abandoned steel pipeline and obtained a reading that indicated that it was protected from corrosion above the minimum level for an in-service pipeline. Staff could not determine why the abandoned 2-inch bare steel line met the minimum criteria for a cathodically protected pipeline. MGE records indicated that this line was never under cathodic protection.

Inadvertent Connection and Introduction of Natural Gas Into Abandoned Line

Prior to introducing natural gas into the newly installed 2-inch PE natural gas main and tapping through the 3-way fitting into the 2-inch abandoned natural gas main,

Infrasource did not verify that this 2-inch main was the correct line to connect to. Infrasource should have placed a pressure gauge on the 3-way fitting as required by MGE's construction standards. If Infrasource had done so, the lack of a reading on the pressure gauge would have alerted Infrasource that the 2-inch abandoned line was not pressurized and probably not in service. That should have caused Infrasource to check further before connecting the newly installed 2-inch PE natural gas main to an abandoned pipe and probably would have resulted in natural gas not being released into the abandoned main.

Natural Gas Escape and Migration

Once the connection was completed on the abandoned line on 18th Street, natural gas flowed from the 10 psig main through the abandoned line. The natural gas would then have escaped from the open ends of the abandoned line. The escaping natural gas likely traveled toward the sewer main, taking the path of least resistance through the soil. Staff was unable to determine the exact point of entry of the natural gas into the sewer main.

Once the natural gas entered into the sewer main, there would be little resistance to migration of the natural gas. The amount of time between when natural gas began to flow into the abandoned line and the explosion indicates that the rate of natural gas build-up in the sewer system was rather rapid and conversely dissipated quickly after the explosion, and after Company crews stopped the flow of natural gas into the abandoned line.

Immediately after the explosion, numerous leak tests conducted by MGE servicemen in and around the incident site, including sanitary sewer manholes in the area, indicated the presence of natural gas in the sewer system. MGE obtained an 85% mixture of gas-in-air reading in a sewer manhole located in the intersection of 18th and Smith Streets.

Natural Gas Entrance and Ignition

Natural gas present in the sanitary sewer system probably entered the structure at 1706 SW Smith Street through the sewer lateral serving the dwelling. Once in the sewer lateral to the structure, the natural gas probably entered the structure through improperly installed sewer drain piping in the basement floor.

Once the natural gas accumulated in the structure to an explosive mixture, it could have been ignited by one of several natural gas appliances in the structure. Available ignition sources in the structure included a natural gas floor furnace, water heater, and space heater located in the basement. They all had standing pilots.

Structural Damage

As noted in the **Commission Staff Actions and Investigation,** the sliding glass doors on the west side of the structure were separated from the structure and displaced onto the west side of a wooden deck. This was the only evidence of structural damage to the structure by the explosion. There was some fire and heat damage located in the kitchen, top of the basement stairs and in the basement. However, the fire and heat damage was generally concentrated on wood surfaces, curtains, and concrete. The limited explosion damage coupled with the evidence of very little fire and heat damage indicate there was a small amount of natural gas in the structure before it was ignited. The ignition probably occurred when the mixture of natural gas and air was near the lower explosive limit (LEL) of the natural gas[9], producing little structural damage. This is because the inefficient burning of the natural gas produces low velocity pressure waves and lower maximum pressures. This would also have allowed for a slow rise in the rate of pressure build-up during the explosion and produced a pushing or bulging type of damage. This is evident by the fact that the sliding glass doors were just dislodged and displaced a short distance and no other structural damage was evident. In addition, explosions of mixtures near the LEL do not tend to produce large quantities of post-explosion fire, as nearly all of the fuel is consumed. There was very little fire and heat damage observed in the structure as noted above.

Company Leak Investigation

The MGE serviceman responding to the leak call from the public at this location stopped his investigation shortly after speaking with the Infrasource crew. He had made the incorrect assumption that all of the gas in the air was due to a purging operation by the Infrasource. During his leak investigation, the MGE serviceman did not check any of the sewer manholes in the area being investigated. Staff cannot determine if this would have prevented the explosion, but further investigation would have led to the discovery of natural gas in the sewer system. With the knowledge that natural gas was present in

[9] The lower explosive limit is the least amount of gas in an air mixture that will burn. This mixture for natural gas is approximately 4.5% gas-in-air.

the sewer system, there could have been a quicker evacuation of the public in the area and manhole lids could have been removed, allowing the natural gas to begin venting out of the sewer system and into the atmosphere.

New Company Procedures and Work Practices

MGE has already implemented procedures to ensure that construction and locate project packets include abandonment maps and information. MGE also has held training and discussions all of its operating offices covering proper leak investigation methods, including checking sewer manholes.

APPENDIX A
(Figures)

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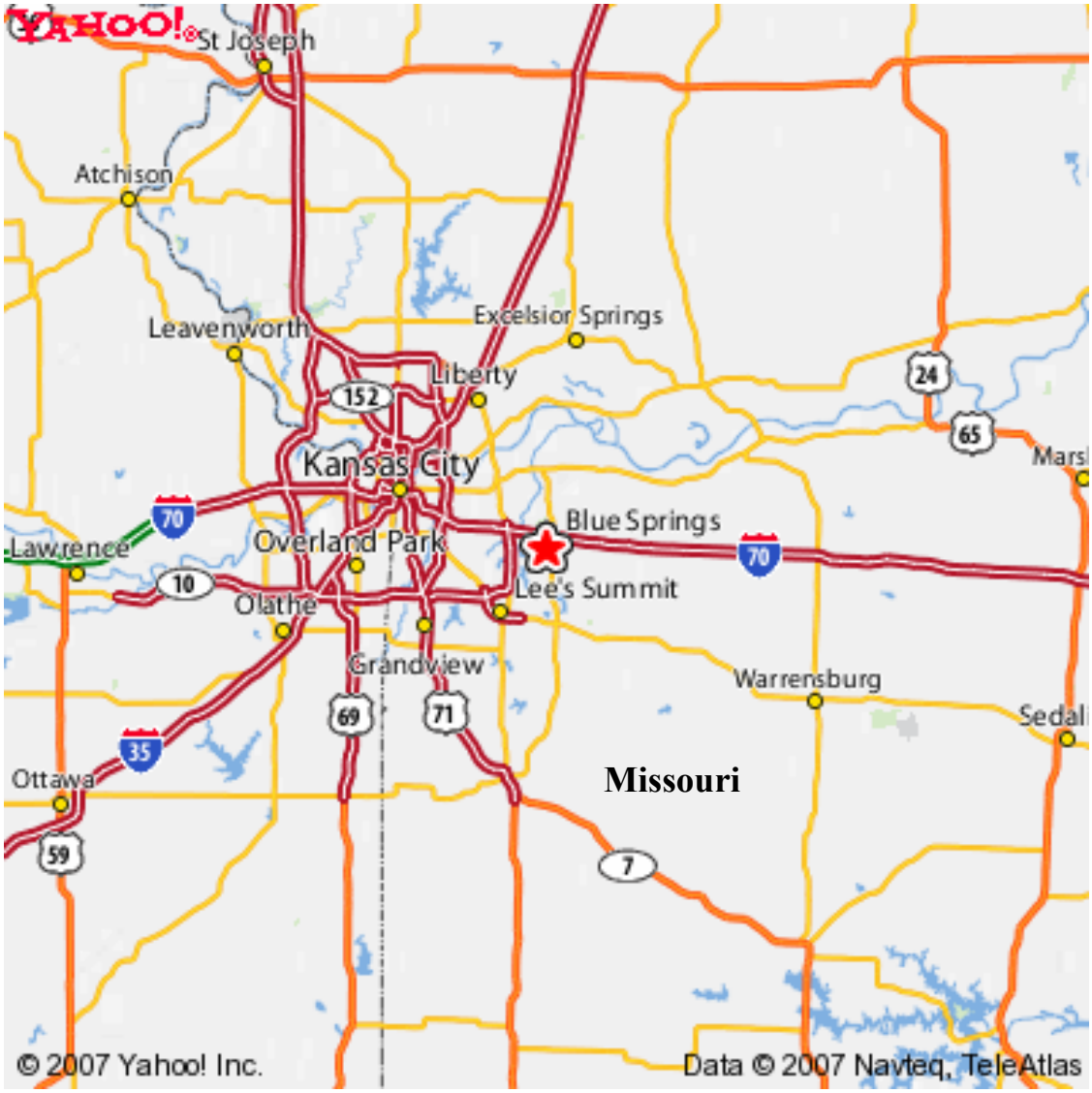
(Not to Scale)



(**Note:** Map drawing provided courtesy of Yahoo Maps ®)

Figure 1
Overall Map View of Blue Springs, Missouri
Appendix A-1

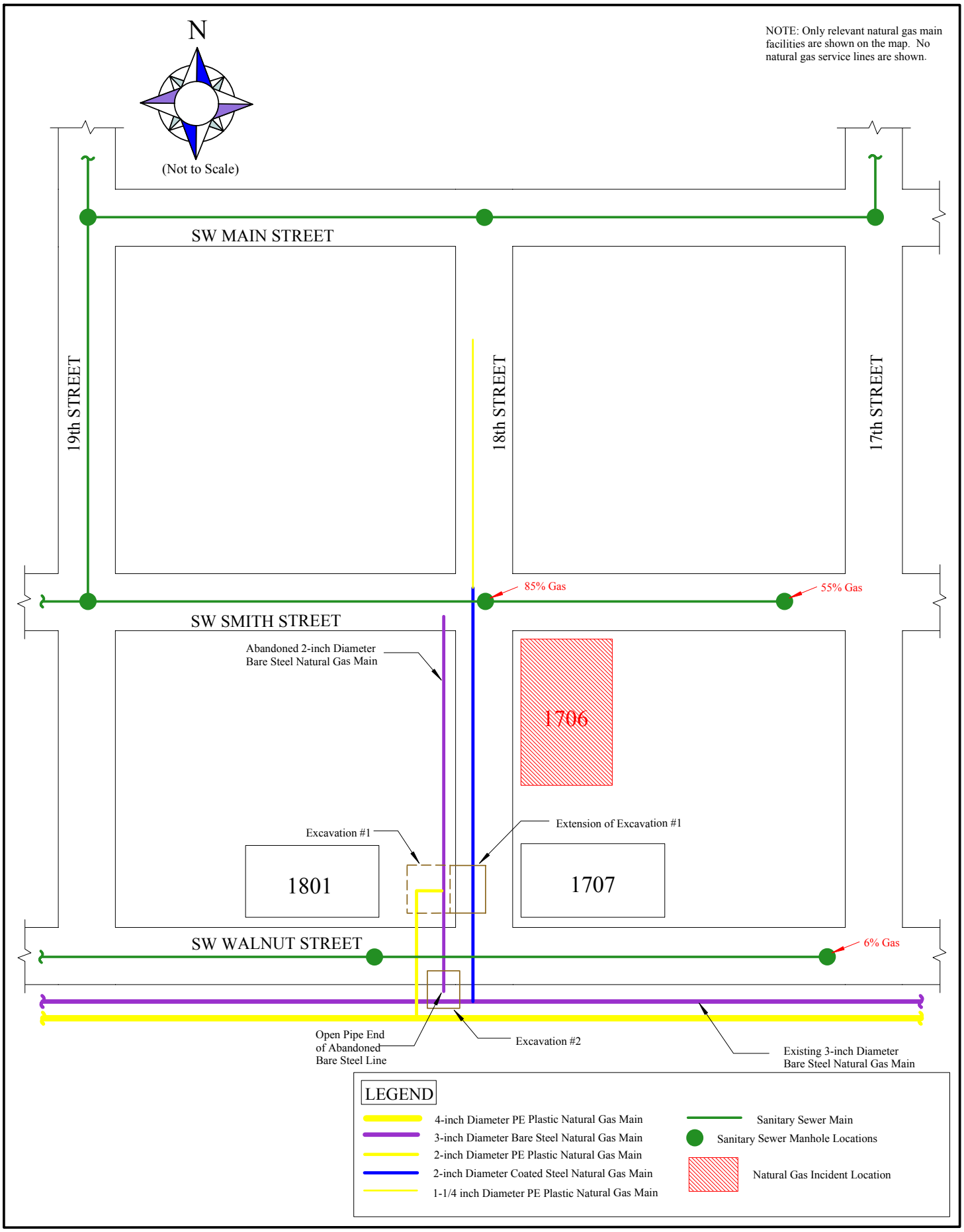


Figure 2
Plan View of 1706 Smith Street-Incident Location
Appendix A-2

APPENDIX B
(Photographs)

Photograph 1
Incorrectly tapped 2-inch abandoned natural gas main

Photograph 2
Capped 2-inch abandoned natural gas main

Photograph 1
1706 SW Smith Street

Photograph 2
Damage to the entrance of 1706 SW Smith Street

Photograph 1
Ceiling of stairwell leading to the basement of 1706 SW Smith Street

Photograph 2
Improperly installed sewer drain pipe and fire damage in the basement of 1706 SW Smith Street

Photograph 1
Pipe to the left is the in-service natural gas main (Yellow Arrow)
Pipe to the right is the abandoned natural gas main with the incorrect tap (Red Arrow)

Photograph 2
Final correct tie-in connection to 2-inch in-service main on 18th Street