Missouri Public Service Commission

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February 7, 2001

Mr. Dale Hardy Roberts
Secretary/Chief Regulatory Law Judge
Missouri Public Service Commission
P. O. Box 360
Jefferson City, MO 65102

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Missouri Public
Service Commission

RE: Case No. GS-2001-224

Dear Mr. Roberts:

Enclosed for filing in the above-captioned case are an original and eight (8) conformed copies of a **GAS INCIDENT REPORT.**

This filing has been mailed or hand-delivered this date to all counsel of record.

Thank you for your attention to this matter.

Sincerely yours,

Eric William Anderson
Assistant General Counsel
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EWA:ccl
Enclosure
cc: Counsel of Record

Service List for
Case No. GS-2001-224
February 7, 2001 (ccl)

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Missouri Public Service Commission

Gas Incident Report

Missouri Gas Energy
Case No. GS-2001-224

1426 W. 50th Terrace
Kansas City, Missouri
August 8, 2000

Gas Safety Section ... Gas Department ... Utility Operations Division
February 2001 Jefferson City, Missouri

Missouri Public Service Commission

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SYNOPSIS

At approximately 4:05 p.m., Central Daylight Saving Time (CDST, all times in this report are Central Daylight Saving Time) on Tuesday, August 8, 2000, a natural gas flash fire occurred in an excavation in front of 1426 W. 50th Terrace in Kansas City, Missouri. There was no property damage as a result of the flash fire. Two contract employees for Missouri Gas Energy (MGE or Company) a division of Southern Union Company were working in and near the excavation when the natural gas flash fire occurred. As a result of the flash fire, one of the contract workers received first, second, and third degree burns to his face and arms and was transported to a nearby hospital where he was treated and released. The other contract worker received severe burns to his arms and was transported to the Kansas University Medical Center Burn Unit in Kansas City, Kansas where he remained for nine days for treatment and skin grafts.

MGE provides natural gas service in Kansas City, Missouri. At the time of the flash fire a 4-inch diameter, cast iron main installed parallel to and along the north side of W. 50th Terrace and supplying natural gas to the 1400 block of W. 50th Terrace was in the process of being replaced with a 2-inch diameter, polyethylene (PE) main. The PE main was also installed parallel to and along the north side of W. 50th Terrace. Company records indicated that the 4-inch diameter, cast iron main was operating at 30 inches water column (IWC) (approximately 1.1 pounds per square inch gauge) [psig] at the time of the flash fire.

The Missouri Public Service Commission's Gas Department - Safety/Engineering Staff (Staff) has determined that the probable cause of the incident was the escape of natural gas from the 4-inch diameter, cast iron main located in front of 1426 W. 50th Terrace. The service line tapping tee for 1426 W. 50th Terrace had broken-off from the top of the 4-inch diameter, cast iron main causing an approximate ¾-inch diameter hole in the top of the main.

Natural gas escaped from the hole in the top of the 4-inch diameter, cast iron main, into the atmosphere in and above the excavation, and was ignited by an undetermined source.

The cause of the fractured service line tapping tee was construction work on August 8, 2000, by Gas Distribution Contractors (GDC), a construction contractor for MGE. During August 8, 2000, GDC was in the process of replacing the 4-inch diameter, cast iron main along W. 50th Terrace with 2-inch diameter, PE pipe. At the location of the flash fire, GDC personnel were in the process of disconnecting the existing service line for 1426 W. 50th Terrace from the 4-inch diameter, cast iron main. This was being done in preparation of re-connecting a new PE service line for 1426 W. 50th Terrace to a newly installed 2-inch diameter, PE main. When a GDC

employee applied a wrench to the plug in the top of the tapping tee in preparation for disconnecting the existing service line for 1426 W. 50th Terrace from the 4-inch diameter, cast iron main, the tapping tee broke-off from the top of the main.

During the Staff's investigation of the incident, no probable violations of Missouri Public Service Commission (MoPSC or Commission) pipeline safety regulations were found that could have contributed to the incident.

The Staff is making several recommendations to MGE as a result of this investigation.

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 4:05 p.m., CDST on Tuesday, August 8, 2000, a natural gas flash fire occurred in an excavation in front of 1426 W. 50th Terrace in Kansas City, Missouri.

Personal Injuries

Two GDC workers were working in and near the excavation when the natural gas flash fire occurred. One of the GDC workers received first, second, and third degree burns to his face and arms. He was transported by ambulance to the Kansas University Medical Center in Kansas City, Kansas where he was treated and released. The second GDC worker received burns to his arms that were more severe. He was transported by ambulance to the Kansas University Medical Center Burn Unit in Kansas City, Kansas where he remained nine days for treatment and skin grafting.

Property Damage

There was no property damage as a result of the natural gas flash fire.

Site Description

The excavation in which the natural gas flash fire occurred was located in front of 1426 W. 50th Terrace in Kansas City, Missouri. W. 50th Terrace runs in a direction that is approximately a west/east direction between Wyoming Street and Ward Parkway and is located in the south central part of Kansas City, Missouri just east of the Missouri/Kansas state line (See Appendix A-1, Figure 1). For purposes of this report, all geographical locations will be referenced as if W. 50th Terrace was oriented in a west/east direction. The area immediately surrounding 1426 W. 50th Terrace is a residential area consisting predominately of single-family residences.

The excavation itself was located immediately north of the north curb of W. 50th Terrace (See Appendix A-2, Figure 2). The excavation was approximately five feet long and five feet wide and was approximately 36 to 40 inches in depth. The excavation contained the following: an exposed section of 4-inch diameter, cast iron natural gas main; an exposed section of 2-inch diameter, PE natural gas main; the existing tapping tee and exposed section of 1¼-inch diameter, bare-steel service line to 1426 W. 50th Terrace; and, a new PE tapping saddle and exposed section of new ½-inch diameter, PE service line to 1426 W. 50th Terrace.

Meteorological Data and Conditions

The weather reporting station located at Kansas City International Airport, in Kansas City, Missouri, approximately 30 miles north of 1426 W. 50th Terrace, recorded a high temperature of 96.8 degrees Fahrenheit (°F), a low of temperature of 80.6° F and a mean temperature of 89.2° F on August 8, 2000. During the afternoon of August 8, 2000, the wind averaged approximately 12 miles-per-hour.

Natural Gas System

Natural gas in the Kansas City, Missouri area is provided by Missouri Gas Energy, a division of Southern Union Company. At the time of the flash fire, the 1400 block of W. 50th Terrace was supplied natural gas by a 4-inch diameter, low pressure (LP)[1], cast iron pipe located parallel to and 4 feet north of the north curb line of W. 50th Terrace and a 2-inch diameter PE, intermediate pressure (IP)[2] pipe located parallel to and 5 feet north of the north curb line of W. 50th Terrace (See Appendix A-2, Figure 2). The 4-inch diameter, cast iron main in the 1400 block of W. 50th Terrace had recently been replaced with 2-inch diameter, PE pipe. However, both the 4-inch diameter, cast iron main and the 2-inch diameter, PE main were pressurized with natural gas because not all of the service lines in the 1400 block of W. 50th Terrace had been transferred from the old cast iron natural gas main to the new PE natural gas main. At the time of the flash fire, the 4-inch diameter, cast iron main was operating at a pressure of approximately 30 inches of water column (IWC) (approximately1.1 psig) and the 2-inch diameter, PE main was operating at approximately 55 psig.

[1] The Company defines "low pressure" as operating pressures up to and including 2 psig.

[2] The Company defines "intermediate pressure" as operating pressures between 2 psig and 60 psig.

The maximum allowable operating pressure (MAOP)[3] of the cast iron natural gas main was 2.2 psig and the MAOP of the PE natural gas main is 60 psig.

The natural gas service line to 1426 W. 50th Terrace had been a 1¼-inch diameter, unprotected[4] bare-steel pipe threaded into a 4-inch diameter, cast iron main by a 1¼-inch street tee[5] (See Appendix B-1, Photograph 2). The new natural gas service line to 1426 W. 50th Terrace consists of a ½-inch diameter, PE pipe traversing north from the new 2-inch diameter PE main and terminating at the natural gas meter located at the structure.

MGE's Cast Iron Main and Unprotected Bare-Steel Service Line Replacement Programs

Effective December 15, 1989, the Commission adopted new Pipeline Safety Regulations applicable to corporations, municipal gas systems, and public utilities subject to the Commission's jurisdiction. In subsection (15)(D) of the regulations, the Commission required all operators who have cast iron mains to develop a replacement program and submit it with an explanation to the Commission by May 1, 1990. Under the regulations, the replacement program is to be prioritized to identify and eliminate pipelines in those areas that present the greatest potential for hazard in an expedited manner. On May 1, 1990, MGE filed its initial Proposed Replacement Program (program) for cast iron mains with the Commission. The Company's cast iron replacement program contains a specific priority schedule to eliminate cast iron mains. The Company's cast iron replacement program, and subsequent approval of the program by the Commission, is contained in Case No. GO-91-277.

In subsection (15)(C) of the regulations, the Commission required all operators who have unprotected steel service lines to establish instrument leak detection survey and replacement programs for their unprotected steel service lines. The regulations required the operator to choose one of three replacement options and submit their choice of option or combination of options to the Commission by May 1, 1990. Each option included a requirement for an annual leak survey of unprotected steel service lines and a replacement schedule. The current version of MGE's unprotected steel service line replacement program is contained in Case No. GO-99-302.

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[3] 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.

[4] The service line piping was not protected from corrosion by the application of cathodic protection.

[5] A fitting screwed into the main that has a screwed outlet connection for the attachment of the service line piping. There is a threaded plug in the top of the tee that can be removed to allow access into the fitting to shut off the flow of gas.

The W. 50th Terrace Cast Iron Main and Unprotected Bare-Steel Service Line Replacement Project

The 4-inch diameter, cast iron natural gas main in the 1400 block of W. 50th Terrace and the 1¼-inch diameter, unprotected bare-steel service line for 1426 W. 50th Terrace were included in the Company's on-going replacement program. The cast iron main replacement on W. 50th Terrace was part of a larger replacement project consisting of: the replacement of 90,000 feet of cast iron natural gas main with PE pipe; replacement of the unprotected bare-steel service lines connected to this cast iron main with PE pipe, and; an upgrade from a LP system to an IP system. The newly installed PE pipe has a MAOP of 60 psig and a normal operating pressure of 25 psig. This particular project encompasses an area bounded by Westport Road to the north, State Line Road to the west, Ward Parkway to the south, and Wornall Road and Wyandotte Road to the east. The section of cast iron natural gas main and service lines on W. 50th Terrace were in the replacement program due primarily to the number of leaks in that section of pipe and the potential for further corrosion. This project was contracted to GDC for the installation of new PE natural gas mains and service lines and for the abandonment of existing cast iron natural gas main and unprotected bare-steel service lines.

Previous Company Actions

Main and Service Line History

The Company completed the original 4-inch diameter, cast iron main installation in the 1400 block of W. 50th Terrace on January 26, 1922. The original 1¼-inch diameter, unprotected bare-steel service line for 1426 W. 50th Terrace was installed on January 14, 1959.

Odorization Records

The Company's monthly odorant concentration test conducted at a test point near the incident site on August 3, 2000, five days prior to the incident, indicated that the natural gas was adequately odorized and readily detectable at a concentration of 0.20 percent (%) gas-in-air.[6]

[6] MoPSC regulation 4 CSR 240-40.030(12)(P)1., requires the odorant in natural gas to be readily detectable at a concentration of less than 0.90% gas-in-air, based upon a lower explosive limit at 4.5% gas-in-air.

Company Notification, Actions and Observations

On August 8, 2000, at approximately 4:25 p.m., the Company was notified by the Kansas City Fire Department of a natural gas flash fire at 1426 W. 50th Terrace. The fire department was responding to the flash fire as a result of a 911 emergency call. A GDC worker at the incident site made the call at approximately 4:10 p.m. A Company Superintendent requested a Duty Supervisor to respond to the incident site. MGE's Supervisor in charge of Company contractor inspectors (contract inspector's supervisor) was also requested to respond to the incident site to investigate the circumstances surrounding the flash fire and injuries. In addition, a GDC supervisor responded to the site to perform an investigation on behalf of his company.

MGE's contract inspector's supervisor arrived at the incident site at approximately 4:49 p.m.

Upon arrival at the site, the MGE's contract inspector's supervisor observed that the area had been made safe. The incident area was barricaded to keep unauthorized personnel from entering the site and to provide protection to the public. He observed that the flow of natural gas had been terminated with the use of a rubber expansion stopper.[7] The stopper was inserted into the hole in the top of the main. MGE's contractor inspector's supervisor remained on-site while the remaining GDC workers finished abandoning the old bare-steel service line to 1426 W. 50th Terrace. GDC workers also connected the new PE service line for 1426 W. 50th Terrace to the new 2-inch diameter, PE main. The excavation was backfilled and MGE's contract inspector's supervisor left the site at approximately 6:00 p.m.

On September 12, 2000, MGE's Superintendent of Standards and Training met with the Company's Contract Inspector and the Contract Inspector's immediate supervisor to review the circumstances of the incident, and if the contractor had followed the proper safety procedures. MGE concluded that the contractor properly complied with the Company's Construction Standards and had followed safe work practices.

[7] An expansion stopper is a rubber device inserted into an opening in a natural gas pipeline, that when expanded, fills the annular space between the device and the sides of the pipe opening, effectively terminating the flow of gas.

MoPSC Reporting Requirements

The Missouri Public Service Commission incident reporting requirements were completed as follows:

1. The initial telephone notification of a possible natural gas incident was made to the Staff at 6:05 p.m. on August 8, 2000.

2. The Company made a telephonic notification to the United States Department of Transportation (US-D.O.T.) of a natural gas incident on August 8, 2000. This incident did meet the US-D.O.T. Federal Incident reporting requirements because there was a release of gas from a pipeline that resulted in a personal injury necessitating in-patient hospitalization.

3. US-D.O.T. form RSPA F 7100.1, as completed by the Company, was transmitted to the MoPSC on September 8, 2000. The Staff forwarded the report to the US-D.O.T. on September 11, 2000.

Contractor's Actions and Observations

Immediately after ignition of the natural gas and resulting flash fire, GDC workers extinguished the fire. The fire was extinguished at approximately 4:06 p.m. Immediately after the fire was extinguished, the workers inserted a rubber expansion plug into the hole in the top of the cast iron natural gas main, terminating the flow of natural gas. GDC workers at the site rendered aid to their injured crewmembers and called 911 at approximately 4:10 p.m. Two additional GDC supervisors were contacted and arrived at the incident site at 4:15 p.m. The fire department arrived at 4:20 p.m. Other employees of GDC finished the abandonment of the existing 1¼-inch diameter, unprotected bare-steel service line to 1426 W. 50th Terrace. They connected the new PE service line for 1426 W. 50th Terrace into the new 2-inch diameter, PE main. They completed the abandonment by removing the expansion plug from the hole in the top of the cast iron natural gas main and inserting a 1-inch diameter, threaded brass plug into the hole. The fractured service line tapping tee with two attached 90 degree elbows and an approximate 3 foot attached section of 1¼-inch diameter bare-steel service line piping was removed from the excavation and secured by Company personnel (See Appendix B-1, Photograph 1). The broken-off portion of the tapping tee (pipe threads), which remained in the top of the cast iron main, was also removed and secured by the Company (See Appendix B-2, Photograph 3). After

completion of the abandonment of the old bare-steel natural gas service line and the connection of the new plastic natural gas service line, the excavation was backfilled.

In addition, after the flow of natural gas was terminated, GDC employees made a series of bar holes[8] over the cast iron main from a location just west of 1440 W. 50th Terrace to a location just east of 1424 W. 50th Terrace. Also, bar holes were made over the service lines to 1424, 1426, 1440, 1445, 1429, and 1427 W. 50th Terrace (See Appendix A-2, Figure 2.). GDC employees then used a combustible gas indicator (CGI)[9] to sample the atmosphere in these bar holes for the presence of natural gas. No natural gas was detected during these checks.

On September 12, 2000, a GDC supervisor and GDC's training specialist met with MGE's Superintendent of Standards and Training to review the contractor's training methods and for the contractor to provide the Company with their safety training documentation.

Commission Staff Actions and Investigation

Notification of Staff by the Company

As noted earlier is this report, the Missouri Public Commission's Gas Department - Safety/Engineering Staff (Staff) was notified directly by MGE at 6:05 p.m. on August 8, 2000. Since there was no property damage, the area was made safe, and the excavation had already been backfilled at the time the Staff was notified of the incident, the Staff did not to immediately travel to Kansas City and begin an investigation. The Staff proceeded by scheduling interviews with all of the parties involved, as soon as they were available. One of the GDC worker's interview was delayed until his release from the hospital.

MGE's Operations and Maintenance Standards, Emergency Procedures, and Training

Operations and Maintenance (O&M) Standards

MGE's O&M Standards includes procedures for working in and around excavations where a hazardous atmosphere (excavations where the atmosphere within the excavation contains a

[8] 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.

[9] A CGI is an instrument used to draw a sample of the atmosphere and measure the percentage of natural gas in the sample.

concentration of flammable gas at, or in excess of, 4% gas-in-air) exist or could reasonably be expected to exist.[10] These procedures are to be followed by any contractor performing work on the Company's natural gas facilities.

Included in these procedures is a requirement that, in all excavations where there is a reason to suspect the presence of a flammable gas, the atmospheric environment in and around the excavation must be tested with a CGI before personnel are allowed access. Also, included in these procedures, is a requirement for personnel protective equipment (PPE)[11] to be used anytime that a hazardous atmosphere has been identified.

Emergency Procedures

MGE has written procedures to minimize the hazard resulting from a pipeline emergency, which includes measures to follow for preventing accidental ignition of natural gas.[12] These measures are to be adhered to by any contractor performing work on the Company's natural gas facilities.

These standards describe the proper measures for preventing accidental ignition of natural gas when working on the Company's natural gas distribution system. These standards address work areas that include locations where tie-ins and abandonment's are performed on "live" natural gas facilities.

Personnel Training

MGE has a written training program for its employees.[13] This program includes training for its contract construction inspectors and covers such topics as: (1) abandonment of facilities; (2) accidental release of gas; (3) contract inspector training; (4) how to recognize emergency

[10] MoPSC regulation 4 CSR 240-40.030(12)(C)2.J., requires that operators take adequate precautions in excavated trenches to protect personnel from the hazards of unsafe accumulations of vapor or gas, and making available, when needed at the excavation, emergency rescue equipment.

[11] PPE includes, but not limited to, a fire retardant suit and hood, respiratory protection and rescue equipment.

[12] MoPSC regulation 4 CSR 240-40.030(13)(X), requires that each operator must take steps to minimize the danger of accidental ignition of gas in any area where the presence of gas constitutes a hazard of fire or explosion.

[13] 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.

conditions; (5) possible ignition sources, indoor/outdoor; (6) job site protection; (7) properties of natural gas; (8) natural gas fire fighting; and, (9) disconnection of gas.

Participants of MGE's training program annually review the program's topics and take a written test after the reviews.[14]

The MGE inspector, charged with inspecting the involved contractor crew, last participated in training during March 11-19, 1998. A written test covering each subject was administered to determine the effectiveness of the training. The MGE inspector satisfactorily passed tests covering such subjects as: (1) abandonment of facilities; (2) accidental release of gas: (3) contract inspector training; (4) how to recognize emergency conditions; (5) possible ignition sources, indoor/outdoor; (6) job site protection; (7) properties of natural gas; (8) natural gas firefighting; and, (9) disconnection of gas.

Contractor Personnel Training

The contractor also has a written training program for its employees (See footnote 13 on page 10). This program includes training covering topics such as: (1) characteristics/hazards of natural gas; (2) outdoor ignition sources; (3) recognizing emergency conditions; (4) firefighting techniques; (5) accidental release of gas; (6) job site protection; (7) installing PE service lines; (8) gas incident reporting; and, (9) abandonment of facilities. Employees annually review the program's topics and take a written test after the review (See footnote No. 13 on page 10).

Training records provided by the contractor indicated that the contractor 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 service line replacements, working safely in and around excavations where a hazardous atmosphere exists or could exist, and to properly respond to natural gas emergency conditions (See footnote 14 on this page).

The contractor's training records indicated that the two involved employees had participated in initial training and testing during March of 1997. These records also indicated that the two employees participated in training and retesting during March of 2000. The topics covered

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[14] MoPSC regulation 4 CSR 240-40.030(12)(J)2.B., requires the operator to train the appropriate operating personnel and conduct an annual review to assure that they are knowledgeable of the emergency procedures and verify that the training is effective.

during this training and retesting included: (1) characteristics/hazards of natural gas; (2) outdoor ignition sources; (3) recognizing emergency conditions; (4) firefighting techniques; (5) accidental release of gas; (6) job site protection; (7) installing PE service lines; (8) gas incident reporting; and, (9) abandonment of facilities.

Staff Interviews With the Involved Contractor Workers

On August 10, 2000, at 10:30 a.m., the Staff met with MGE personnel and GDC personnel, including one of the workers involved in the incident. This meeting was held at the MGE offices located at 3420 Broadway in Kansas City, Missouri.

At the time of the incident, the GDC worker was completing the installation of a new PE service line to 1426 W. 50th Terrace and abandoning the old unprotected bare-steel service line to 1426 W. 50th Terrace. The old bare-steel service line would be abandoned at the existing cast iron main. The worker indicated that he was at the top of the excavation and the other worker was in the excavation. The worker in the excavation was getting ready to remove (unscrew) the plug from the top of the existing tapping tee to 1426 W. 50th Terrace. The other worker had a brass hammer, steel chisel, and steel adjustable-wrench. The worker indicated that he thought the other worker was going to remove the rust from the plug's operating nut (Appendix B-1, Photograph 1) and other fittings in preparation for removing the plug. The worker had his back to the excavation, when he saw a fireball. He ran and got a fire extinguisher off a nearby work truck and extinguished the fire. After he extinguished the fire, he noticed that the base of the tapping tee had broken-off from the top of the main leaving a hole in the main. He then inserted a rubber expansion plug in the hole in the main to stop the flow of natural gas from the hole. He rendered aid to the other worker and called an ambulance. Neither worker was wearing any personal protective equipment (PPE). The worker indicated that he thought that electric heat fusion irons, which had been used in the excavation to join PE pipe, were positioned on the ground approximately 3 feet from the excavation. The irons were plugged into an operating portable electric generator. He said that he did not smell the odor of natural gas while working in this excavation. He also indicated that the excavation was checked for the presence of natural gas with a leak detection instrument before beginning the abandonment process and none was detected.

The worker indicated that normally they would clean any rust and debris from fittings prior to working on them and would check for the presence of natural gas. They would also loosen the plug in the top of the tee without fully removing it. After loosening the plug, they intended to put on their PPE before removing the plug because natural gas would be released when the plug

was removed from the top of the tapping tee. This was typically done in preparation for installing a rubber expansion plug in the top of the tee.

It was indicated to the Staff, that when the ambient air temperature is extremely high, MGE contract job inspectors allow the contract workers to remove their PPE after having finished in one excavation and prior to beginning work in the next excavation.

The worker told the Staff that he had received safety training, heat fusion training, gas qualification training, and on-job training, all provided by GDC. He also indicated that he was knowledgeable of MGE's Standards for preventing accidental ignition, working safely in and around excavations where a hazardous atmosphere exists or could exist, and the abandonment of facilities.

On September 11, 2000 at 9:00 a.m., the Staff met with MGE personnel and the other GDC worker involved in the incident. This meeting was also held at the MGE offices located at 3420 Broadway in Kansas City, Missouri.

On the day of the incident, this GDC worker was involved in installing new PE service lines and abandoning old service lines. Just prior to the incident he had installed the new PE service line to 1426 W. 50th Terrace and was preparing to abandon the old unprotected bare-steel service line to 1426 W. 50th Terrace. This was to be the last service line abandonment for this day. He had removed his PPE and intended to loosen the plug in the top of the tapping tee before putting back on his PPE. The worker indicated that the MGE contract job inspector allows them to remove their PPE when it's very hot. He understood that he did not have to wear any PPE, as long as, gas was not blowing and three people were present while he was in the excavation. He indicated that it is normal to just loosen the plug and then fully removing the plug after donning PPE because natural gas is released when the plug is fully removed. He also indicated that the plugs would usually loosen without any trouble. The worker applied torque to the operating nut on the plug with an adjustable-wrench and attempted to loosen the plug when the tapping tee broke-off the top of the main allowing natural gas to escape. He was exiting the excavation when there was an ignition of the escaping natural gas. He thought approximately five seconds had elapsed from the time the tee broke-off of the main until the ignition occurred.

The worker thought that someone at the top of the excavation was manning a fire extinguisher. He also said that prior to beginning the abandonment of the old service line to 1426 W. 50th Terrace, he had smelled the odor of natural gas in the excavation. According to the worker, the

electric heat fusion irons had been removed prior to the incident. He also said that MGE contract job inspectors had frequented the job site the day of the incident.

The worker indicated that he had received on the job training, heat fusion training, safety training, respirator training, and training in the characteristics of natural gas. GDC provided all the training. He also indicated that he was knowledgeable of MGE's Standards, including standards for preventing accidental ignition, working safely in and around excavations where a hazardous atmosphere exists or could exist, and the abandonment of facilities.

Examination of Fractured Tapping Tee, Attached Fittings, and Piping

As noted earlier in this report, the broken tapping tee, attached fittings, a segment of service line piping, and broken-off pipe threads from the base of the tee were removed from the excavation and secured by MGE on August 8, 2000. These fittings and piping were made available to the Staff during the interview on August 10, 2000.

Upon initial examination, the Staff noted that the fittings and piping exhibited general corrosion[15] and pitting of the base metal. The pipe and fittings were covered with hardened clay and corrosion scale (See Appendix B-1, Photographs 1 and 2, and Appendix B-2, Photograph 4). The fracture in the tapping tee was located at the first non-engaged thread in the threaded portion of the base of the tee (See Appendix B-1, Photograph 1 and Appendix B-2, Photograph 4). The Staff also observed that at the point of fracture at the base of the tee, heavy corrosion had thinned the pipe wall appreciably (See Appendix B-1, Photograph 2). An observation of the broken-off pipe threads from the tapping tee also revealed an appreciable amount of pipe wall thinning at the point of fracture due to corrosion (See Appendix B-2, Photograph 3).

The Staff also observed marks and gouges on the operating nut on the top of the plug. This could have resulted from applying torque to the plug with a wrench (See Appendix B-1, Photograph 1).

[15] General Corrosion can be defined as the process of corrosion occurring over most of the surface area of metal in the soil rather than the occurrence of isolated corrosion cells on the metal.

Other Witness Statements

MGE Construction Inspector

The MGE construction inspector's job includes inspecting service line replacements performed by a contractor. The inspector for the replacement project on W. 50th Terrace had three contractor (GDC) crews to oversee the day of the incident, including the GDC crew that was involved in the incident. He had checked these crews on the morning of the incident to ensure that the GDC crews were following MGE's procedures regarding service line replacements and safety. The inspector stated that the GDC crew involved in the incident was working in the 1400 block of W. 50th Terrace, replacing service lines to residences on both sides of the street. He indicated that he had visited this particular crew four times that day. He also indicated that on his final visit of the day with this crew, they were preparing to abandon the old bare steel service line to 1426 W. 50th Terrace. The inspector stated that he had noticed water "bubbling" in the excavation where the abandonment would take place.[16] He then instructed the crew to abandon the old bare-steel service line to 1426 W. 50th Terrace and subsequently left this crew to check on another crew. The inspector left the site prior to the time of the incident.

MGE's Supervisor of Company Contractor Inspectors

The MGE supervisor of Company contract inspectors received a call from an MGE superintendent reporting that a flash fire had occurred at 1426 W. 50th Terrace. He arrived at the site at 4:49 p.m. and noted that GDC personnel were at the site and had barricaded the area off. He observed that two fire extinguishers were taken off the trucks and positioned upwind from the excavation where the flash fire had occurred. The cast iron natural gas main had a rubber expansion stopper inserted into a hole in the top of the main. The supervisor indicated that one of the fire extinguishers had been used and its contents expended. An employee of GDC, at the site, informed the supervisor that another GDC employee was trying to loosen the plug in the top of the old tapping tee on the cast iron natural gas main when the tee broke-off of the main, allowing natural gas to escape. He speculated that as the tee broke-off it must have made a spark that ignited the escaping natural gas. GDC employees at the site told him that one of the injured GDC workers was "fire watching" and extinguished the fire. The two injured GDC workers, who were involved in the incident, had already been transported to the hospital. The supervisor stated that the fire department had left the site and had told GDC not to backfill the excavation until the fire inspector had looked at the site and made his report. The supervisor and remaining GDC workers remained at the site until the fire inspector finished his report. After the fire

[16] The "bubbling" could have been an indication of a small leak on the natural gas piping in the excavation.

inspector was finished, the remaining GDC workers completed the abandonment of the old service line to 1426 W. 50th Terrace and backfilled the excavation. The MGE supervisor left the site at approximately 6:00 p.m.

ANALYSIS

Corrosion of the Unprotected Bare-Steel Tapping Tee and Service Line

The corrosion of the unprotected bare-steel tapping tee and unprotected bare-steel service line is a natural phenomenon. It occurs over time when any bare metal is buried in the soil. At the time of the original service line installation, no corrosion prevention methods were used, or required by pipeline safety regulations, to protect the service line.

Over a period of years, the normal process of corrosion resulted in general corrosion of the tapping tee, fittings, and service line piping. The corrosion caused thinning of the pipe wall at the location of the threaded portion of the tapping tee base. The corrosion process would have occurred over a long period of time. No evidence was discovered to determine that exact length of time that the corrosion existed prior to the fracture of the tapping tee. The amount of metal loss at the point of fracture indicates that the corrosion process was active for an extended period of time.

Because steel is a less noble metal (i.e., lower on the galvanic series) than cast iron, the steel tapping tee would have tended to corrode to "protect" the cast iron main. Since the threaded portion of the tapping tee was in direct contact with the cast iron main, the corrosion would tend to concentrate in this location.

The type of underground corrosion experienced by the unprotected bare steel tapping tee in the soil is known as galvanic corrosion.[17] Normally, a galvanic corrosion cell exists when two different metals are in contact and surrounded by an electrolyte, such as soil. In this case, the corrosion cell consisted of an anode (steel tapping tee and piping), a cathode (cast iron main), an electrolyte (soil), and an electrical conductive path (contact area where the steel tapping tee was threaded into the top of the cast iron main). Since the steel is less noble than cast iron, the steel becomes the anode and will corrode to cathodically protect the cast iron.

One of the best methods to address the phenomenon of corrosion on cast iron and bare steel pipe is with an aggressive replacement program as noted in the **MGE's Cast Iron Main and Unprotected Bare-Steel Service Line Replacement Programs** section of this report. The

[17] The increased corrosiveness of a metal in contact with a different metal that is associated with the flow of electrons through an electrolyte from a less negative metal to a more active metal.

replacement program's intention is to remove potentially corrosive pipe from the system before it becomes hazardous due to corrosion leaks.

Fracture of the Tapping Tee

The fracture of the tapping tee occurred as a result of forces exerted on the plug in the top of the tee. These forces were imposed on the tapping tee when a GDC employee applied torque to the operating nut on the plug with an adjustable-wrench. This external force induced stresses beyond the strength of the remaining steel at the fracture location. The fracture initiated at the first non-engaged pipe thread of the base of the tapping tee.

The nominal wall thickness of the tapping tee base was reduced at the fracture initiation point (first non-engaged pipe thread) due to the depth of the threads in the pipe. The nominal pipe wall thickness of the tapping tee base was reduced even more because of the loss of metal due to the effects of corrosion.

The force exerted by the application of the wrench on the operating nut of the plug in the tapping tee created a twisting moment in which the shear stress exceeded the shear strength of the remaining metal in the corroded pipe threads, causing the failure at the weakest point.

Natural Gas Escape, Migration, and Ignition

After the tapping tee fractured from the top of the main, natural gas would have exited from the hole in the main at a pressure of approximately 1.1 psig. Since natural gas is lighter than air, it would have escaped up into the atmosphere of the open excavation. Since the cast iron main was exposed and the excavation was open, there would have been no resistance to the upward flow of natural gas.

The natural gas accumulated to an explosive mixture[18] and could have been ignited by one of several sources available in and above the excavation. One possible ignition source was the fusion heating irons that were located in close proximity to the excavation and were cycling on and off to maintain a preset temperature. The operating electrical generator, which was also located close to the excavation, could have provided an ignition source. Another possible

[18] The explosive range of natural gas is a mixture of between 4.5% and 14.5% gas-in-air.

ignition source could have been an electrical arc generated at the instant the tapping tee separated from the cast iron main.

Contractor's Work Practices

The practice of loosening the plug in the top of the service line tapping tee before donning PPE was a normal procedure and under normal circumstances should be a completely safe operation. However, in this incident, the corrosion to the pipe threads had weakened the metal to the extent that the torque of the wrench was sufficient to break the tee off of the main. The weakened state of the tapping tee connection to the main probably was not evident to the GDC worker before he attempted to loosen the plug.

The practice of removing PPE after completing one abandonment and before the start of the next abandonment was a normal procedure used by the contractor. MGE contract job inspectors allow this practice, especially when the outside air temperature is extremely high, as it was on the day of the incident. Also, MGE O&M Standards only require PPE to be used when the atmosphere in an excavation contains a concentration of flammable gas at, or in excess of, 4% gas-in-air. GDC workers tested the atmosphere in the excavation with a CGI prior to loosening the plug and gas was not detected. Since natural gas is released when the plug is fully removed from the service tapping tee, the GDC workers do put on their PPE before beginning this process and completing the abandonment. The Staff does believe, however, that if the GDC workers had been wearing their PPE prior to loosening the plug, they probably would have escaped injury.

The Staff believes the fracture of the service line tapping tee was an isolated situation and was unforeseen by the GDC workers. The Staff also believes that the GDC employees properly followed MGE's Standards for service line abandonments and for working in excavations where a hazard exists or could exist. In light of this incident, however, the Staff believes that MGE could, in the future, take precautions to protect personnel anytime there is the potential for a sudden release of gas. These precautions could include, but not be limited to, donning PPE prior to loosening the plug on the tapping tee and removing any potential ignition source from the vicinity of an excavation.

The GDC Worker's Interviews

The interviews with the involved GDC workers revealed several differences in their perception of the events leading up to and after the flash fire. In one instance, the workers disagreed about the location of the fire extinguisher. One worker indicated that the other involved worker was manning a fire extinguisher at the top of the excavation and the other worker indicated that he had to retrieve a fire extinguisher from a nearby truck after the natural gas had ignited. In another instance, the workers disagreed whether the odor of natural gas was detected prior to them working in the excavation. One worker indicated that he smelled the odor of natural gas just prior to beginning to abandon the old bare-steel service line and the other worker did not smell any natural gas. And, the workers disagreed with regard to the location and operation of the electric heating irons. One worker said that the heating irons were situated within 3 feet of the excavation and were plugged into a portable electric generator, and the other worker said that the heating irons had been removed prior to the incident.

The Staff believes that these differences between the two GDC workers are their recollections of the events surrounding the incident. The Staff believes that these differences are normal human behavior and do not have a significant impact on the outcome of the Report.

CONCLUSIONS

1. At approximately 4:05 p.m., CDST, Tuesday, August 8, 2000, a flash fire involving natural gas occurred in an excavation in front of 1426 W. 50th Terrace in Kansas City, Missouri.

2. Two injuries resulted from the flash fire. A contract employee for MGE received first, second and third degree burns to his face and arms. He was transported to a nearby hospital where he was treated and released. A second contract employee for MGE received burns to his arms that were more severe. He was transported to the Kansas University Medical Center Burn Unit in Kansas City, Kansas where he remained nine days for treatment and skin grafts.

3. The probable cause of the incident was the ignition of natural gas that had accumulated in the atmosphere in and above an excavation in front of 1426 W. 50th Terrace. The natural gas originated from a hole in the top of a 4-inch diameter, cast iron natural gas main located in the excavation. The natural gas escaped upward into the atmosphere in and above the excavation and was ignited. The probable source of ignition was not determined, but could have been one of several electrical devices near the excavation or a spark generated when the steel tapping tee fractured and separated from the cast iron natural gas main.

4. The hole in the 4-inch diameter, cast iron natural gas main occurred during construction work on August 8, 2000, by GDC, a contractor hired by MGE. During August 8, 2000, a GDC employee was in the process of abandoning an unprotected bare-steel service line for 1426 W. 50th Terrace in conjunction with MGE's cast iron replacement program. In an attempt to loosen the plug in the top of the tapping tee for 1426 W. 50th Terrace, a GDC employee applied a wrench to the plug. This caused induced stresses in excess of the pipe thread's maximum strength at the location where the tapping tee was threaded into the 4-inch diameter, cast iron natural gas main.

5. Two factors contributed to reduced strength of the pipe at the location of the fracture. One was a reduction of the nominal wall thickness of the tapping tee base due to the depth of the threads in the pipe. Also, the nominal wall thickness of the tapping tee base was further reduced because of metal loss due to galvanic corrosion.

6. The GDC workers properly followed MGE's Standards for the abandonment of facilities and were adhering to safe work practices.

7. The GDC workers were not wearing their PPE at the time of the incident, nor were they required to for the particular operation being performed (loosening the plug in the top of the tapping tee). PPE is required to be worn by the GDC workers when removing the plug in the top of the tapping tee and completing the abandonment because natural gas is released during this process.

8. It is probable that the GDC workers would have escaped injury if they had been wearing their PPE while loosening the plug in the top of the service line tapping tee.

9. The Staff's investigation did not reveal any violations of Missouri Public Service Commission's regulations by MGE that could have contributed to the incident.

RECOMMENDATIONS

1. The Staff recommends that MGE review and revise as necessary its requirements and training on the use of PPE. Especially, to consider requiring personal protective equipment to be used for any type of operation conducted on "live gas" piping where there is a potential for the accidental release of natural gas considering the circumstances of this incident. This review should include replacement projects involving abandonment's and "live" tie-ins.

2. The Staff recommends the practical elimination of all potential ignition sources in and around an excavation where there is a possibility for the accidental release of natural gas.

3. The Staff recommends that MGE file a response to these recommendations in Case No. GS-2001-224 within thirty (30) days of the filing of this Report for review by the Commission.

APPENDIX A
(Figures)

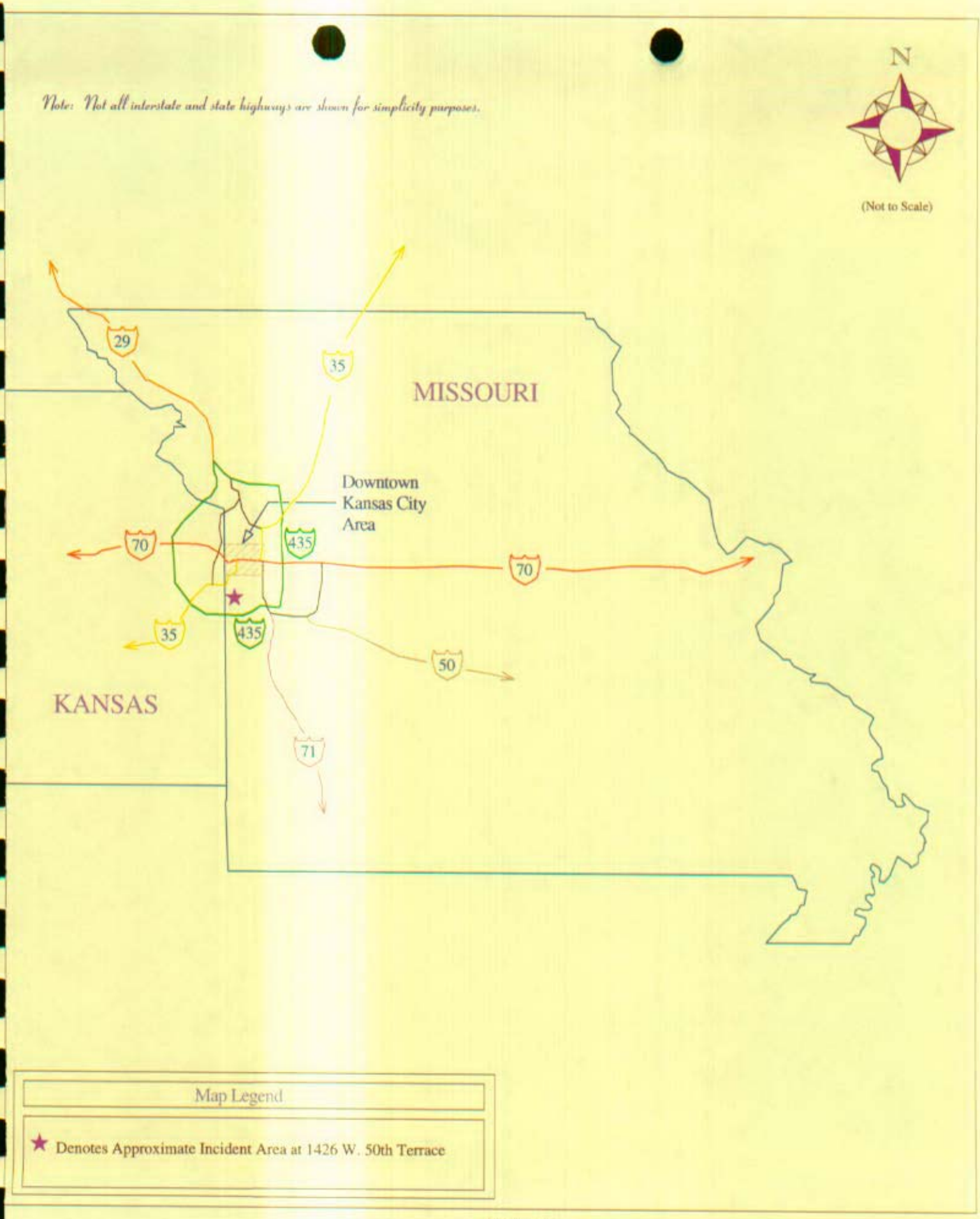


Figure 1
Overall View of 1426 W. 50th Terrace Incident Location
Appendix A-1

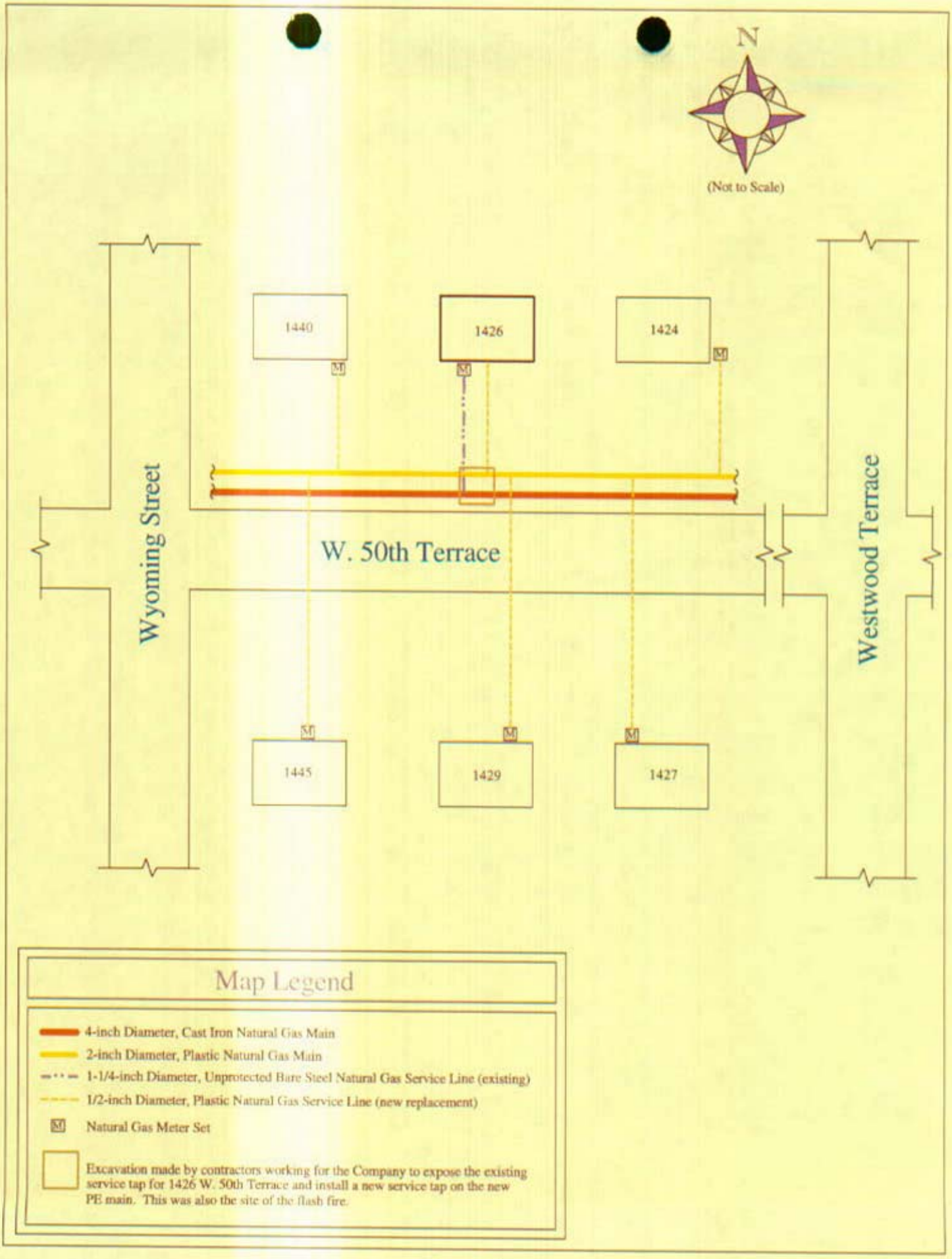
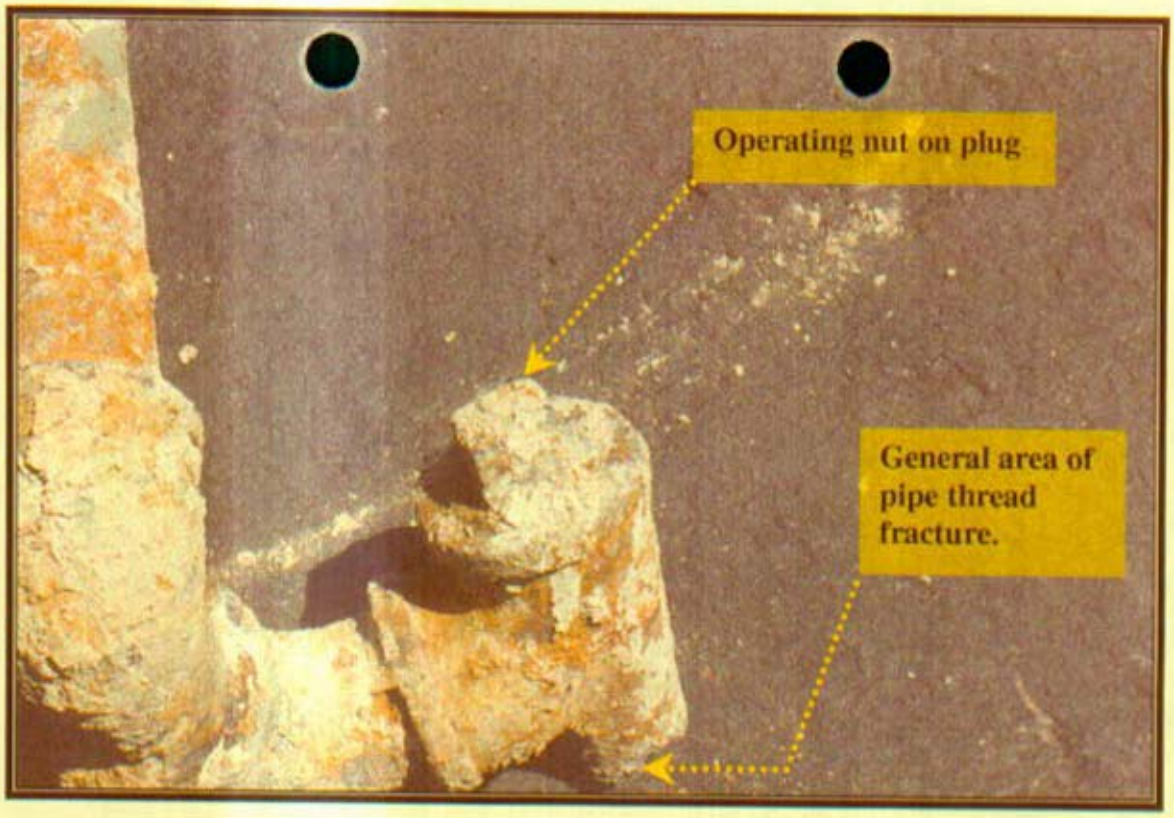


Figure 2
Plan View of 1426 W. 50th Terrace Incident Area
Appendix A-2

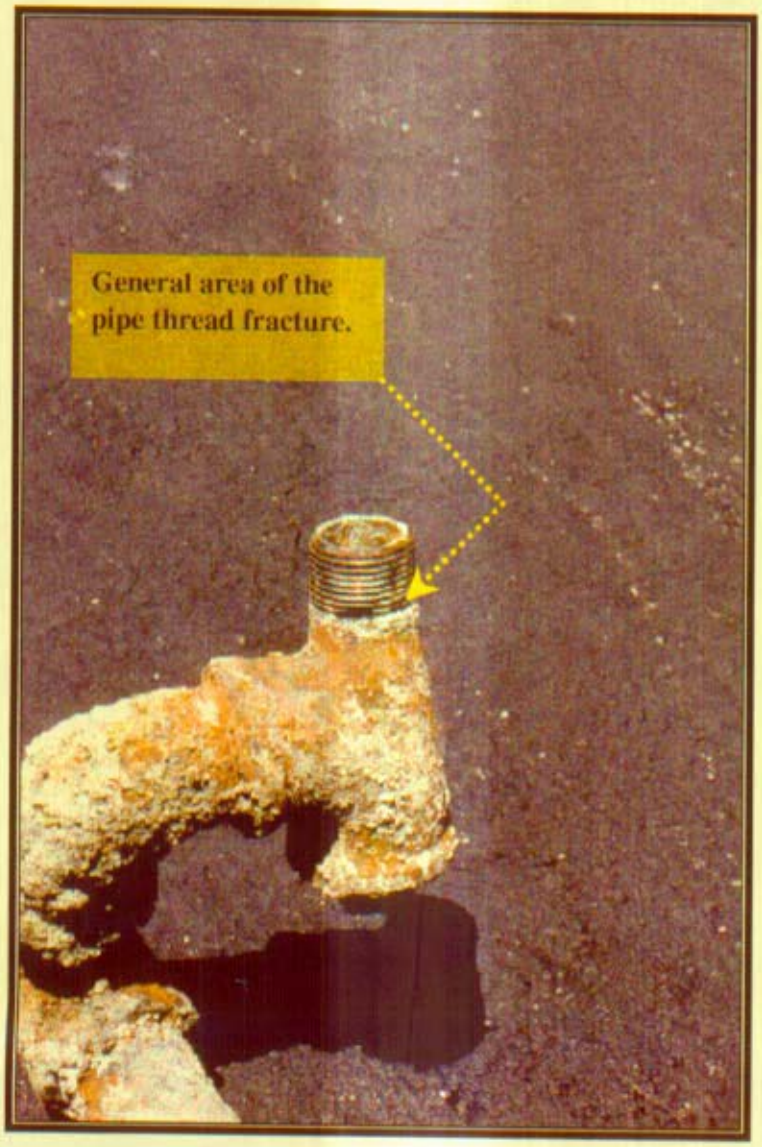
APPENDIX B
(Photographs)



Photograph 1 View of the top side of the tapping tee and attached piping.

Photograph 2 View of the underneath side of the tapping tee base where the pipe threads fractured.

Photograph 3 View of the fractured pipe threads that separated from the bottom of the tapping tee. Note the corrosion on top of the threads.



Photograph 4 View of the tapping tee with the section of fractured pipe threads placed on top of the tapping tee. NOTE: The tapping tee and attached pipe components were actually oriented 180° from the position shown.