BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of an Investigation into Natural Gas Incidents in Unionville and Milan, Missouri, on Systems Operated by West Central Energy.	)))	Case No. GS-2005-0246

STAFF'S REPORT

COMES NOW Staff of the Public Service Commission of Missouri, and respectfully submits as follows:

1. On January 5, 2005, there were natural gas incidents in Unionville and Milan, Missouri. West Central Energy operates both systems under contract with the municipalities. No injuries resulted from the incidents, but there was some property damage.

2. The Commission opened this case on Staff's motion by its Order dated February 3, 2005. In its Order, the Commission directed Staff to file its investigation report by June 3, 2005. The Commission granted Staff's motion for an extension until June 17, 2005, to file its report.

3. Staff has completed its investigation. Its Report, including its recommendations, is attached hereto as Gas Incident Report.

WHERFORE, the Staff asks the Commission to accept its Report, and direct West Central Energy, for the Cities of Milan and Unionville, Missouri, to file its response by July 18, 2005.

Respectfully submitted,

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General Counsel

/s/ Thomas R. Schwarz, Jr.

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Certificate of Service

I hereby certify that copies of the foregoing have been mailed, hand-delivered, transmitted by facsimile or emailed to all counsel of record this 17th day of June 2005.

/s/ Thomas R. Schwarz, Jr.

Missouri Public Service Commission

Gas Incident Report

West Central Energy
Case No. GS-2005-0246

Unionville, Missouri
January 5, 2005

Milan, Missouri
January 5, 2005

Gas Safety/Engineering Section … Energy Department ... Utility Operations Division
June 2005… Jefferson City, Missouri

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SYNOPSIS

At approximately 12:25 a.m., Central Standard Time (**CST, all times in this report are Central Standard Time**) on Wednesday, January 5, 2005, a natural gas ignition and explosion occurred in Unionville, Missouri at a residence located at 1328 Main Street. On this same date, but at approximately 3:10 a.m., a separate natural gas ignition and subsequent fire occurred in Milan, Missouri at a residence located at 715 E. 4th Street. No injuries or fatalities were reported for either incident. The two natural gas ignition events are contained in one Incident Report since both resulted from the same adverse weather conditions.

West Central Energy (WCE) operates the following natural gas distribution systems in Missouri: Unionville and Milan; Green City, Liberal, Mercer, and South Lineville. WCE does not own the individual natural gas systems in Unionville and Milan, the municipal gas systems are owned by the cities. The residential structures involved in the incidents were both supplied natural gas through a coated ½-inch diameter steel service line that was operating at 50 pounds per square inch gauge (psig) at the time of the natural gas ignition and explosion.

The Missouri Public Service Commission's Energy Department - Gas Safety/Engineering Staff (Staff) has determined that the probable cause of the incident in both Unionville and Milan was the over-pressurization of natural gas appliances due to a service regulator malfunction. The combination of adverse weather conditions and water dripping from the roof overhangs onto the bodies of the service regulators caused ice to accumulate on vital pressure-relieving components. Unable to vent, both service regulators failed in an "open"[1] position causing the outlet pressure (downstream from the service regulator) to increase to unsafe appliance delivery pressures. The resulting over-pressurization of the downstream fuel line piping caused natural gas to be released from the appliance control knob assemblies of both natural gas water heaters.

During the course of its investigation into this incident, the Staff did not discover any violations of the Missouri Public Service Commission (Commission or MoPSC) pipeline safety regulations that may have contributed to the incident.

The Gas Incident Report contains five recommendations to WCE as a result of Staff's investigation of both natural gas incidents.

[1] When a regulator has failed in an "open" position, the valve disc can no longer provide a tight seal with the inlet orifice assembly so gas from a high-pressure source of supply (service line) is allowed to flow through the regulator to the meter and customer-owned fuel line.

CONCLUSIONS

1. West Central Energy (WCE) operates the natural gas systems for the following municipal utilities in Missouri: Unionville and Milan; Green City, Liberal, Mercer, and South Lineville.

2. At approximately 12:25 a.m., on Wednesday, January 5, 2005, a natural gas ignition and explosion occurred in Unionville, Missouri at a residence located at 1328 Main Street. On this same date, but at approximately 3:10 a.m., a separate natural gas ignition and subsequent fire occurred in Milan, Missouri at a residence located at 715 E. 4th Street.

3. The natural gas explosion that occurred at 1328 Main Street in Unionville caused structural damage to the west side of the residence and an interior wall was also damaged as a direct result. Numerous single pane glass windows were also dislodged from the building. One occupant was inside the residence at the time of the explosion, but no injuries were reported.

4. The natural gas ignition and subsequent fire that occurred at 715 E. 4th Street in Milan caused extensive fire and smoke damage to the bathroom area of the residential structure. One occupant was inside the residence at the time of the natural gas ignition and subsequent fire, but no injuries were reported.

5. The probable cause of the natural gas explosion at 1328 Main Street and the natural gas fire at 715 E. 4th Street was the over-pressurization of natural gas water heaters due to a malfunction of both service regulators.

6. The probable cause of the service regulator malfunctions in both Unionville and Milan was adverse weather conditions, combined with roof overhangs without gutters located directly above the natural gas meter sets. This allowed water to drip directly from the roof overhangs onto the service regulator bodies below. This combination caused ice to cover and seal vital service regulator breather/relief vents while the regulators were operating in an "open" position. Both the breather vent check valve and the internal relief valve for each service regulator were functioning, but the excess gas pressure could not be vented because the breather vents for both regulators were sealed with ice. When the appliance demand for natural gas decreased, both regulators remained in an "open" position and continued to supply an excessive flow of natural gas, causing the over-pressurization.

7. The over-pressurization eventually caused the downstream appliance controls for both water heaters to malfunction and vent a portion of the natural gas through the top and sides of the gas control knob assemblies. This gas over-pressurization likely increased the flame height of the standing pilot flame. If the thermostat had required the water in the tank to be heated at the time of over-pressurization, the flame from the main gas burner would have also increased in intensity.

8. The potential ignition source(s) for both natural gas incidents would have included either the standing pilot flame, or the main burner flame from the natural gas water heaters.

9. The point of fire origin for 715 E. 4th Street in Milan was the natural gas water heater located in the southwest corner of the bathroom area.

10. The Milan Fire Department did not alert WCE to the fact that the house fire at 715 E. 4th Street may have been natural gas related until Friday, January 7, 2005, two (2) days after the incident.

11. The weather conditions also affected seven (7) other natural gas meter set locations in Milan, Mercer, and Unionville, Missouri during the period of January 4-6, 2005, but caused gas service outages. The service regulators at these locations failed in a "closed" position when their breather vents became blocked with ice when no appreciable gas load (other than pilot lights) was required by downstream appliances.

12. WCE conducted a walking survey of all natural gas meter sets in the towns of Unionville, Milan, Green City, Mercer, Liberal, and South Lineville in a timely and expedited manner to identify other meter sets that might accumulate ice on service regulator equipment. Once potential problem locations were identified, temporary regulator covers were installed by WCE until the manufactured regulator vent shields arrived. As of February 11, 2005, WCE had installed a total of 90 manufactured regulator vent shields in the towns it serves.

13. As a result of both natural gas incidents, WCE has developed procedures for identifying locations throughout their gas distribution systems that may accumulate ice on service regulator equipment. WCE will implement these procedures during annual patrols and when establishing or reinstating gas service to customers. Both the annual patrols and service orders for gas turn-ons are considered to be part of an ongoing monitoring program.

14. The Staff's investigation revealed no violations of Commission pipeline safety regulations that contributed to the incidents, but five (5) recommendations were made to WCE.

RECOMMENDATIONS

1. The Staff recommends that WCE conduct its annual monitoring of meter set locations that might be susceptible to ice build-up on service regulating equipment during early fall of each year when possible.

2. The Staff recommends that WCE review its current annual liaison program with emergency responders in an effort to improve the overall level of communication. The liaison must reinforce the idea of having the emergency responders contact WCE personnel whenever a house fire, or other emergency, is involved so the gas facilities can be safely secured and gas personnel can verify if natural gas was involved, or not.

3. The Staff recommends that WCE review its current public education program to determine what additional information could be included to educate customers on how to identify and report ice build-ups on natural gas meter sets. One of the required semi-annual mailings to the customers, preferably the fall mailing, could include this additional information.

4. The Staff recommends that WCE submit a copy of the proposed additional information, as discussed in Recommendation 3 above, within 30 days of the filing of this Incident Report.

5. The Staff recommends that WCE be directed to file a response regarding each of the above recommendations within 30 days of the filing of this 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 Incidents

At approximately 12:25 a.m., Central Standard Time (CST, all times in this report are Central Standard Time) on Wednesday, January 5, 2005, a natural gas ignition and subsequent explosion occurred at 1328 Main Street in Unionville, Missouri. On this same date, but at approximately 3:10 a.m., a different natural gas ignition and subsequent fire occurred at a residence located at 715 E. 4th Street in Milan, Missouri. Both of the natural gas ignition events are contained in one Incident Report since both resulted from the same adverse weather conditions and involved gas systems operated by WCE.

Personal Injuries

No injuries or fatalities were reported for either natural gas incidents that occurred in Unionville or Milan, Missouri.

Property Damages

The residential structure located at 1328 Main Street in Unionville received structural related damage in which a portion of the west wall was separated and displaced in an area that was north of the basement (see **Appendix A-2**, **Photographs 3** and **4**). One of the interior walls between the living room and the north bedroom also received damage as it was separated from the west wall and floor area. The property damage was estimated to be $35,000, which included the cost of leveling the structure and rebuilding a similar residence.

The residence located at 715 E. 4th Street in Milan received extensive fire and smoke damage to the bathroom area of the residential structure (see **Appendix B-1**, **Photograph 2**). No displacement of the foundation or any wall structures was observed for this residence. The property damage amount based on the repair cost was estimated to be $5,800 by the owner of the residence.

Site Descriptions

The City of Unionville is located in Putnam County at the junction of Hwy. 5 and Hwy. 136, approximately 8 miles south of the Iowa/Missouri state line. The building at 1328 Main Street in Unionville is located within the City's business district and was formerly a church that had been renovated for residential living space. The residence is situated on the northeast corner of the intersection of 14th Street and Main Street. Various internal additions were constructed within the northern section of the building during this renovation process. Another section was added to the east side of the building and a covered wooden porch was installed along the west side of the residence. The structure had a metal roof and a concrete block foundation. The exterior walls were covered with concrete stucco over a wood frame assembly. A partial basement was located near the center of the structure. The remainder of the structure contained a crawl space.

The City of Milan is located in Sullivan County at the junction of Hwy. 5 and Hwy. 6, approximately 23 miles south of Unionville, Missouri. The residence at 715 E. 4th Street is located on the northwest corner of the intersection of S. Pearl Street and 4th Street. The residential structure had wood frame construction with a concrete block foundation. The exterior covering for the walls consisted of 12" Masonite lap siding and most of the structure was covered with a metal roof. The north side of the residence contained a mud room addition with a walkout and the roof for this section consisted of asphalt shingles. The residence is located outside of the primary business district area of Milan.

Weather Data and Conditions

The Weather Underground, Inc. website reported the following conditions for the weather reporting station located at the Kirksville Airport, approximately 30 miles east of Milan, Missouri. On January 5, 2005, a high temperature of 30.0 degrees Fahrenheit (ºF) was recorded with a low temperature of 19.0º F, with 0.27 inches of precipitation occurring for that day. The total amount of precipitation recorded in the form of fog, drizzle, and rain combined for the period of January 1 through January 5, 2005, was 1.83 inches. The average low temperature reported for this same period was 27.8º F.

See **Appendix E**, on page 1, within the **Witness Interviews**-Unionville Light & Power Employee section of this Incident Report for a discussion of the power outages that were caused by the ice storms in early January 2005.

Natural Gas Systems

West Central Energy[2] (WCE) operates the natural gas distribution systems in Unionville and Milan, Missouri. WCE does not own the individual natural gas systems in Unionville and Milan, the municipal gas systems are owned by the cities. WCE does operate, maintain, and provide consulting services for these natural gas systems under a contract with each City. Both residential locations in Unionville and Milan were supplied natural gas through ½-inch diameter coated steel service lines. The natural gas main that served 1328 Main Street in Unionville consisted of 1-inch diameter coated steel installed along the north side of Main Street. In Milan, a 1-inch diameter coated steel natural gas main was located in an alley that was to the north of 715 E. 4th Street.

The established maximum allowable operating pressure[3] (MAOP) for Unionville is 60 pounds per square inch gauge (psig), while the MAOP for the natural gas system in Milan is 58 psig. The operating pressure of the natural gas systems for both Unionville and Milan were approximately 50 psig at the time of both incidents.

The service regulator involved in each incident was a ¾-inch Fisher S-254 that had 1/8-inch orifice assembly installed. Both service regulators contained breather vent check valves and internal relief valve mechanisms that were designed to vent to the atmosphere. A single vent opening (breather vent) was provided for both relief valves to relieve excess pressure from the top side of the regulator diaphragm. The breather vent allows air to be expelled from or drawn into the regulator when the diaphragm moves, which is necessary for proper operation. (A schematic of the Fisher S-254 regulator can be found within **Appendix C**, on page 2, **Figure 1- Sectional View of a Fisher S-254 Service Regulator**.)

[2] Effective May 1, 2005, West Central Energy has adopted the name of Utility Safety & Design, Inc. However, the name "West Central Energy or WCE" will be used throughout this Gas Incident Report.

[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.

Previous West Central Energy Actions

Odorization Records

WCE conducts monthly odorant concentration tests[4] at various locations throughout the natural gas systems of both Unionville and Milan to verify the level of odorant to assure that consumers and the public are able to smell any leaking natural gas. A review of odorant intensity test readings for the 6 months prior to both incidents indicated that the natural gas was adequately odorized, and was readily detectable at an average concentration of 0.30 percent (%) gas-in-air[5] for Unionville, and 0.49% gas-in-air for Milan.

An odorant intensity reading of 0.60% gas-in-air was taken by WCE personnel on January 4, 2005 at 1717 Main Street in Unionville, Missouri, just prior to the incident. An odorant intensity reading of 0.40% gas-in-air was obtained by WCE along N. Broadway on December 6, 2004 for the town of Milan.

WCE's Past Liaison with Emergency Responders

City of Unionville

As part of WCE's liaison[6] program with emergency responders, certain natural gas emergency response procedures and communications are discussed between the various City departments and WCE. The most recent meeting, prior to the incident, included emergency response officials and was conducted on October 8, 2004. This meeting included various personnel from the 911 Dispatch Office; the Sheriff's Office Dispatcher, and the Unionville Fire Chief. All attendees were given a copy of WCE's emergency phone numbers for contact purposes.

[4] MoPSC regulation 4 CSR 240-40.030(12)(P)6., requires at least monthly odor intensity tests of the natural gas to assure the proper concentration has been achieved.

[5] 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.

[6] MoPSC regulation 4 CSR 240-40.030(12)(J)3., requires that each gas operator establish and maintain liaison with appropriate fire, police and other public officials to learn the responsibilities and resources of each organization that may respond to a pipeline emergency. As well as, acquainting the officials with the operator's ability in responding to a gas pipeline emergency; identifying the types of gas pipeline emergencies of which the operator notifies the officials, and plan how the operator and officials can engage in mutual assistance to minimize hazards to life or property.

WCE's Past Liaison with Emergency Responders (continued)

City of Milan

On March 31, 2004, WCE met with certain representatives from both Milan-City and Rural Fire Departments along with the Sullivan County Sheriff's Department. The Milan Fire Chief was given a copy of WCE's emergency phone numbers at this liaison meeting.

WCE Notifications, Actions, and Observations

Initial WCE Notification and Response-1328 Main Street in Unionville, MO

A WCE serviceman was initially contacted by the Putnam County Sheriff's Dispatcher at 12:25 a.m. on January 5, 2005, to perform a gas shut off for 1414 Washington Street due to a fire. As the WCE serviceman was in route (12:37 a.m.) to this location, he observed fire department vehicles parked about a block south of 1414 Washington Street, at 1328 Main Street.

As the WCE serviceman approached the residence at 1328 Main Street, (12:40 a.m.) he observed that the natural gas meter set[7] was completely covered with ice and the service riser valve had been shut off (see **Appendix A-5**, **Photograph 9**). The WCE serviceman attempted to knock most of the ice off of the top portion of the meter set and then spoke with one of the responding Unionville Fire Department personnel who indicated that an explosion had occurred. The serviceman then went inside the doorway along the west side of the building and, no gas odor or fire was observed but smoke was present. The serviceman then proceeded to perform combustible gas indicator (CGI)[8] readings with bar holes[9] near the natural gas meter set and another bar hole about 10 feet south of the meter set. All bar hole readings indicated 0% gas-in-air readings. An additional aboveground check was made near the door entrance along the west side and no gas reading was observed.

At approximately 1:00 a.m., the WCE serviceman traveled to the company office to contact the Vice President and then returned to 1328 Main Street to continue his leak investigation. The

[7] A natural gas meter set consists of both a meter assembly that registers the usage of natural gas and a service regulator that regulates and controls the delivery pressure of gas to the customer's downstream fuel line piping and appliances.

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

[9] 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 (CGI).

Vice President and WCE serviceman conducted extensive CGI investigations for leaks in the vicinity of 1320, 1328, and 1402 Main Street. A sewer clean out on the north side of 1328 Main Street was also checked for gas. All readings taken were 0% gas-in-air.

A thick covering of ice initially made the sewer manhole along 14th Street (located 30 feet west of the northwest corner of 1328 Main Street) inaccessible; however, some time later a second WCE serviceman assisted with removing the manhole cover and a reading was taken. No gas reading was obtained inside the sanitary sewer along 14th Street.

The Vice President and the second WCE serviceman took a CGI reading in the basement by placing the CGI probe into a crawl-through basement access opening. A 0% gas-in-air reading was obtained by WCE personnel. The Vice President and the second WCE serviceman then entered the basement through a crawl-through opening which was located along the west side of the building to examine the gas piping and any natural gas appliances. A natural gas water heater and a disconnected natural gas furnace were observed, but no odor of natural gas was detected and all gas piping appeared to have no open ends, or other damage.

At approximately 2:00 a.m. on January 5, 2005, all three WCE employees left the scene, and contacted the MoPSC 24-Hour Answering Service[10] at approximately 2:05 a.m. in order to report the possible natural gas incident.

At approximately 2:20 a.m. on the same day, the Vice President and the second WCE serviceman returned to 1328 Main Street. Another CGI reading was taken at the same sewer manhole location and the sewer clean out for 1328 Main Street. Once again, no gas readings were observed in either location. Since WCE did not observe any natural gas readings, or migration of gas, the serviceman locked the meter valve for 1328 Main Street and WCE personnel returned home.

On January 6, 2005 at 8:30 a.m., the Vice President returned to 1328 Main Street to take pictures and to obtain a natural gas meter reading.

[10] During weekends and off-time working hours, the Missouri natural gas operators have access to a 24-hour answering service for initial notification purposes of a potential natural gas incident. The MoPSC 24-hour answering service then contacts a Safety/Engineering Staff member and forwards the information regarding a potential natural gas incident, as well as, providing Company contact information.

Initial WCE Notification and Response-715 E. 4th Street in Milan, MO

On January 5, 2005 at approximately 3:10 a.m., the Milan 911 Dispatch Office received a call from a resident reporting a house fire at 715 E. 4th Street, in Milan, Missouri. The Milan Fire Department arrived at the house at approximately 3:26 a.m. and shut off the gas service riser valve at approximately 3:30 a.m. The Milan 911 Dispatch Office then contacted the after-hours WCE answering service at 3:57 a.m. to leave a message that there had been a house fire in Milan at 715 E. 4th Street. Afterwards, the Putnam County Sheriff's Dispatch contacted a WCE serviceman at approximately 4:00 a.m. to report the house fire in Milan. The WCE serviceman learned that the gas had been shut off.

At 4:15 a.m., the same WCE serviceman left a message for the Manager of WCE in Unionville. The message indicated that there had been a house fire in Milan, and that the gas had been shut off. The WCE serviceman then contacted the Milan Fire Chief at approximately 4:56 a.m. on January 5, 2005 to confirm that the gas had been shut off. At that time the Fire Chief did not mention that natural gas was somehow involved in the fire.

The Manager of WCE in Unionville received the voice mail message from the serviceman at approximately 6:30 a.m. The local telephone service for Unionville was out of service due to power outages and ice-related damages. The Manager then contacted the WCE serviceman at approximately 7:00 a.m. to get details on the house fire in Milan. The WCE serviceman indicated that the Sheriff's dispatcher had relayed to him that there was a house fire that had been extinguished and that the gas service had been shut off. There was no more information (as part of WCE's routine annual emergency department training, the company informs the responders to shut off utilities and then report it so that the services can be secured).

At approximately 12:00 p.m., the Manager made a trip to Milan to check on some regulator stations and to stop by 715 E. 4th Street. The Manager during this time verified that all of the regulator stations in Milan were operating correctly, and then drove to 715 E. 4th Street to check for external damage. He observed that the house was locked, but had no signs of external damage and the gas service valve had been shut off. He also observed that the top of the regulator body was covered by a layer of ice. The Manager then placed his finger beneath the breather vent screen to see if any ice had accumulated, but did not feel any ice covering the vent screen area (breather vent) of the regulator. The Manager then locked the service valve off.

Afterwards, the Manager contacted some City Hall personnel in Milan to inquire about the nature of the fire, and was told that they did not know of any particulars other than the occupant had to move out due to the smoke damage.

On January 7, 2005, the WCE serviceman contacted the Manager of WCE to discuss information that he had received late that afternoon while working at the home of one of the firemen that worked for the Milan Fire Department. The fireman had stated that the fire at 715 E. 4th Street was initially in the bathroom at the water heater and then at the furnace. The fireman also stated that it looked to be gas related. This was the first time that anyone had mentioned that the fire may have involved a gas problem.

The Manager arrived at 715 E. 4th Street in Milan at approximately 11:00 a.m. on January 8, 2005 and conducted bar hole checks with a CGI over the natural gas service line and the main that was in the alley north of the residence. Additional gas leak checks were made in the crawl space beneath 715 E. 4th Street, as well as, the sewer cleanout. No gas readings were indicated during any of the leak checks. The Manager then checked the condition of the service regulator at the meter set and discovered that the body of the service regulator had a heavier coating of ice than on January 5, 2005 (see **Appendix B-4**, **Photograph 7**). Upon further observations, the Manager discovered that the service regulator vent screen (breather vent) was fully iced over on the outer surface. Ice was also hanging from the vent screen and in contact with the top of the meter casing. The Manager then proceeded to go into the unlocked house. The Manager observed that most of the contents in the house had been removed and a smoke line was visible in the living room and the top area of the door to the bathroom was scorched. The Manager then entered the bathroom area and observed heavy fire damage on and around the natural gas water heater. The Manager then proceeded to check the natural gas furnace and observed signs of fire damage to the burner area.

At approximately 11:10 a.m. on January 8, the Manager contacted the Vice President of WCE to give an update and to request his presence. The Manager showed the Vice President the fire damage that he had observed. The Vice President contacted the Commission's Assistant Manager of Gas Safety/Engineering at approximately 11:30 a.m. and left a voice mail message. The voice mail message notified the Staff that a reportable natural gas incident was likely involved in the house fire at 715 E. 4th Street, in Milan on January 5, 2005.

WCE Service Outage History Caused by Icing of Service Regulators

On January 4, 2005 the Company experienced two natural gas service outages in Mercer, Missouri that were related to icing of the service regulators. Both of the meter sets were located along the north side of the structures and no gutter system was installed.

On January 5, 2005, a natural gas outage occurred at 490 North State Street in Milan, Missouri. The natural gas meter set was located on the north side of the residence beneath a gable end (no gutter at gable ends).

In Unionville, a total of 3 service outages were reported on January 5, 2005 and an additional outage was reported on January 6, 2005. All four of these locations had a natural gas meter set installed along the north side of the residences and no gutter system was installed.

Post-Incident Actions Taken by WCE

On January 6, 2005, WCE personnel conducted a walk through visual survey of all natural gas meter sets in the following Missouri gas systems of Unionville, Milan, Green City, Mercer, South Lineville, and Liberal, looking for potential regulator freeze-off situations. Between the service orders of regulators that had frozen off and the visual survey, the Company found 12 meter set locations that were directly located under the drip line of a roof. These 12 locations were temporarily fixed by covering the natural gas service regulators with plastic milk jugs. Also during this visual survey, WCE found (in the judgment of the service personnel) several (78) meter set locations that were deemed as potential problem areas. It was decided by the WCE Vice President and the Assistant District Manager to cover all of the 78 natural gas meter sets to minimize a possible reoccurrence.

WCE has since purchased manufactured regulator vent shields that are specifically designed to provide a larger vent area for the Fisher S-254 residential service regulators (this type of service regulator was installed at the two incident locations discussed in this Incident Report). As of February 11, 2005, WCE had installed 90 regulator vent shields throughout all of their operating areas in Missouri.

In response to both natural gas incidents, the following policies and procedures were implemented within WCE's Operating and Maintenance Plan, under Section 2.1 PATROLLING, paragraph 2.11 A) Once annually, not to exceed 15 months, during the regular meter reading

cycle or at the time of a complete leak survey, a patrol of the distribution system will be made to report any activities or conditions that might affect the safety and operations of the system. This would include, but not be limited to, the meter set's physical condition and placement in relationship to the building's openings and roof edge drip line. Any conditions found that need to be corrected will be done, as soon as, possible. These corrections would include, but not be limited to, moving the meter set or the installation of a proper regulator vent shield or piping.

Likewise, Section 3.3-INITIAL CUSTOMER TURN-ON AND REINSTATEMENT OF DISTRIBUTION AND SERVICE LINES, PARAGRAPH 3.35 was revised to indicate the following change of procedure within WCE's Operating and Maintenance Plan:

3.35 When a new service is turned on, the following procedures will be followed, and documented.

A) The service person will do a visual inspection of the meter set. This will include, but not be limited to, the physical condition and placement in relationship to the building's openings and roof edge drip line. Any condition found that needs to be corrected will be done before service is turned on. The corrections would include, but not be limited to, the moving of the meter set or the installation of a proper regulator vent shield or piping.

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 for the residential structure at 1328 Main Street in Unionville, Missouri was made to the MoPSC 24-hour answering service at 2:05 a.m. on Wednesday, January 5, 2005. A Staff member was later contacted by the answering service at approximately 2:10 a.m. that same day.

2. A telephone notification of a possible natural gas incident for the residence located at 715 E. 4th Street in Milan, Missouri was first made to the Assistant Manager of Gas Safety/Engineering by leaving a voice mail message at approximately 11:30 a.m. on Saturday, January 8, 2005. The MoPSC 24-hour answering service was also notified at approximately 11:35 a.m. that same day. The 24-hour PSC answering service then contacted a PSC Staff member at home on January 8, 2005, at approximately 11:45 a.m.

MoPSC Staff Investigations

Natural Gas Incident-1328 Main Street in Unionville, MO

At the direction of the Assistant Manager - Gas Safety/Engineering, two members of the Commission's Energy Department - Safety/Engineering Staff attempted to travel to the incident site in Unionville on January 5, 2005, but due to hazardous traveling conditions the Staff was not able to reach Unionville. On January 6, 2005, the Staff arrived at the incident site located at 1328 Main Street in Unionville at approximately 10:45 a.m.

Upon arrival, the Staff met with both the Vice President and the Manager of WCE. During this time, the Vice President gave a description of the leak investigation actions they had taken and what their findings were. They indicated to the Staff that numerous bar hole checks using a CGI were made along the natural gas service lines and the main along the north side of Main Street. These bar hole checks included all natural gas facilities serving 1402 Main Street (first house to the west of 1328 Main Street), 1328 Main Street (incident site), and 1320 Main Street (first house to the east of 1328 Main Street). WCE personnel also indicated that several bar holes were made around the perimeter of 1328 Main Street, as well as, a sewer cleanout on the north side of this structure. An additional CGI gas reading was taken inside a sanitary sewer along 14th Street (14th Street runs north and south along the west side of 1328 Main Street) after the manhole cover had been successfully removed. All of the CGI gas readings taken by WCE personnel in these locations were 0.0% gas-in-air. In addition, WCE personnel indicated that CGI readings were taken inside the residence near the entrance to the living room area and also in the basement. No gas readings were detected in either location.

During this conversation, the Vice President of WCE indicated that the City of Unionville had been experiencing power outages due to the freezing rain conditions and the accumulation of ice on overhead power lines. The Staff and WCE personnel then observed the condition of the natural gas meter set serving 1328 Main Street. A significant build-up of ice was present on both the body of the natural gas service regulator and meter. While observing the natural gas regulator, a layer of solid ice could be felt covering the underneath side of the breather vent screen assembly (see **Appendix A-1**, **Photograph 2**). Also, a portion of a roof overhang from a wooden porch was located directly above the natural gas meter set on the west side of the residence. Numerous icicles were hanging from the edge of this roof line and no guttering system had been installed to carry the water away from the roof to a downspout (see **Appendix A-2**, **Photograph 3**). The Staff also observed that the natural gas service riser valve was in the "off" position.

Exterior Observations of 1328 Main Street

When the Staff arrived at 1328 Main Street, a significant amount of ice was covering overhead power lines, phone lines, street signs, street lights, and trees (see **Appendix A-1**, **Photograph 1**). Approximately 6 inches of snow was on the ground.

The residence at 1328 Main Street appeared to have been a church at one time that had been remodeled and converted for a family residence. Only the northwest corner of the building and a portion of the west wall near the basement entrance showed exterior damage to the structure. The exterior damage along the west wall was located between the door to the porch on the west side and the northwest corner of the structure and just above the concrete block foundation. The west wall in this area was pushed outwards and cracked in several locations (see **Appendix A-2**, **Photograph 4**).

The largest portion of the structure consisted of a former church sanctuary that had eight tall windows (four windows each on the east and west sides), and another window just above the south entrance to this building. The top portion of the windows in the main church sanctuary consisted of single pane glass that appeared to have been displaced outwards. Also, a section of the top window above the south entrance also appeared to have been displaced outward. The Staff also observed that a basement access cover along the west side of the building was laying in the yard near a sidewalk and appeared to have been displaced from the basement location (see **Appendix A-2**, **Photograph 3**).

Additional sections of living quarters appeared to have been added to the main church sanctuary portion of the building along the north and east sides. An attached wooden porch was also added along the west side of the building that had an extended walkway/handicap accessible ramp (see **Appendix A-3**, **Photograph 5**). Metal roofing had been installed for both the residential structure and the attached wooden porch area. No guttering system for water drainage purposes was installed for either the structure or the wooden porch area.

The natural gas service regulator serving the residence of 1328 Main Street consisted of a ¾-inch Fisher S-254 that had a 1/8-inch diameter orifice. As previously mentioned, the attached breather vent screen for both the internal relief valve and breather vent check valve of this regulator was completely covered with ice even though it was facing in a downward direction (see **Appendix A-1**, **Photograph 2**).

Interior Observations of 1328 Main Street

Most of the rooms and walls were intact except for the living room area and a bedroom to the north of the living room. The northwest corner of the living room wall appeared to have been separated from the west wall near the bottom. A drop suspended ceiling was installed throughout most of the structure except for the main sanctuary area. It appeared that the original ceiling was approximately 12 feet tall in most locations, but had been reduced to about 9 feet with the drop suspended ceiling. Several ceiling panels for the drop ceiling had been displaced from their original location.

The largest room in the residence was located on the south side where the main church sanctuary had been converted to a large combination dining and living room area with a kitchen. Other than the top portions of tall windows that had been displaced outward from this main sanctuary area, and a section of window above the south entrance, very little damage was observed in the main sanctuary. A section of wooden flooring between the main sanctuary area and the entrance into the living room had separated. The section of flooring for the living room was displaced upward approximately three inches above the floor level for the main sanctuary.

No fire damage was observed within the main level of the residence except for some plastic bottles, paper products, and cleaning supplies that were in a plastic tub located in a cabinet beneath the kitchen sink and garbage disposal, just east of the living room area. The plastic tub was partially melted and most of the contents inside had been singed and burned (see **Appendix A-4**, **Photograph 8**). The only other indication of fire damage was located in the basement area that was accessible along the west side of the structure.

The basement interior measured 22.5 feet (east to west direction) by 9.5 feet. The basement walls were approximately 7 feet tall. A natural gas water heater, and a disconnected natural gas furnace, were located in the basement. From the basement, the Staff observed a large crawl space area adjacent to this location, but beneath the wooden flooring that extended to the north, south, and east sides of the structure. A brick wall supported the floor joists and the main level flooring south of the south wall of the basement. The brick wall appeared to have been the original north wall of the church.

Slight fire damage was observed on the natural gas water heater exterior just above, and to the right of the appliance control. The operating instructions label for the water heater was also singed and burned just above the appliance control assembly (see **Appendix A-3**, **Photograph**

6). The Staff also observed that one of the PVC[11] water lines that ran from the water heater to beneath the kitchen sink (east of living room area) appeared to have been exposed to some high temperature as the surface of the plastic pipe was discolored. This discoloration was especially evident where a larger diameter PVC conduit was used to encase the smaller diameter PVC water line (see **Appendix A-4**, **Photograph 7**). In addition to these fire damages, the Staff also observed some type of paper products that had been partially consumed by fire located near the southeast corner of the basement.

The main level of the residence had a fairly new natural gas furnace that was located north of the living room, a gas range in the main kitchen area to the east of the living room and, another gas range in the south kitchen area inside the main sanctuary. There was an older style natural gas furnace in the basement area, but the gas piping to this unit had been disconnected.

After completing sketches and taking photographs of the incident site, the Staff went to the Unionville office to review records pertaining to the incident investigation, odorant intensity readings, prior leakage surveys, order of initial responding personnel, etc. The Staff left the incident site at approximately 3:50 p.m. on January 6, 2005.

Leak Testing of Fuel Line Piping and Water Heater Appliance Control

On January 6, 2005 at approximately 1:45 p.m., the supply valves to all natural gas appliances were shut off and the meter and outlet piping were disconnected from the service regulator. A pressure test fitting was installed on the regulator outlet and then an Inches of Water Column (IWC) gauge was attached. The locking mechanism on the service riser valve was then removed and the service riser valve was turned slowly to the open position so natural gas at the main operating pressure of approximately 50 psig entered the body of the service regulator. The needle of the IWC gauge immediately deflected to the highest pressure reading available which was 35 IWC (about 1 ¼ psig). At the time of this test, no pounds per square inch gauge was available to take a more accurate pressure reading. See the section entitled **Additional Regulator Testing** within **Appendix D** for simulated failure testing of a service regulator under controlled conditions.

After removing the ice that was blocking the breather vent area of the regulator, WCE personnel verified that the set pressure of the regulator was 7.5 IWC and the lock-up pressure was 8 IWC at approximately 1:51 p.m. Afterwards, the Staff and WCE personnel performed a series of

[11] Polyvinyl chloride (PVC) is defined as a common thermoplastic resin, used in a wide variety of manufactured products, including but not limited to piping, rain gear, garden hoses, phonograph records, and floor tiles.

different pressure tests with air to test for any gas fitting or fuel line piping leaks, as well as, testing the downstream appliance control assembly for the water heater in the basement. Prior to any leak testing, the supply inlet valves for all natural gas appliances were shut off to avoid damaging any attached appliance controls or regulators.

Several attempts were made to leak test the customer's fuel line piping with approximately 5 psig of air. Leaks were detected at inlet supply valves to the furnace on the main level and the kitchen range east of the living room area. In an attempt to eliminate the leaks, WCE personnel removed the inlet supply valves for these appliances and the open pipe ends were plugged.

At 2:43 p.m., that same day, an air test at 30 psig was applied to the customer's fuel line piping. During this air test, a leaking 1" to ¾" pipe reducer joint on the gas fuel line piping was found. The leak was located beneath the crawl space along the east side and above the east wall of the basement. Other than the previous described leaks, no other leaks were observed during the 30 psig air test.

For purposes of testing the gas controls on the water heater, a 15 psig air test was applied to the fuel line piping and the appliance control for the water heater. The gas control knob on the water heater was then turned to the "ON" position and the main burner expelled both the air and residual gas in the supply line. The inlet valve to the water heater in the basement was then shut-off and a 50 psig (operating pressure at time of incident) air test was applied to the gas fuel line piping at approximately 3:20 p.m. With the gas control knob set to the "PILOT" position, the inlet valve to the water heater was slowly turned back on and no leak at the control valve assembly (including the appliance control) was observed. The pilot lighting button was then pushed inward while on the "PILOT" setting (pilot lighting position) and the thermocouple[12] was heated with a cigarette lighter for approximately a minute. During this 50 psig air test, the pressure was being applied to the control valve that was now in an "open" position for supplying gas just to the pilot. No noticeable air leaks were detected during this test.

A final air test at 50 psig was conducted after the gas control knob was moved to the "ON" position. During this air test, the gas control knob unseated and popped-up (located on top of the appliance control) which allowed air to leak around the sides and near the top of the appliance control. The air leak appeared to start at a high rate and slowed quickly even though the air pressure was still available. After these checks the test fittings were removed and the open ends were plugged and the meter set was locked.

[12] A thermocouple is a bi-metallic device which creates a small electrical charge when heated at one end.

Natural Gas Incident-715 E. 4th Street in Milan, MO

At the direction of the Assistant Manager - Gas Safety/Engineering, three members of the Commission's Energy Department - Safety/Engineering Staff met with the Manager of WCE and arrived at the incident site located at 715 E. 4th Street in Milan at approximately 10:00 a.m. on January 12, 2005. The actual natural gas incident occurred on January 5, 2005, but the delay in notification and response was attributed to WCE not being informed that the house fire at this address may have involved natural gas, until several days after the occurrence.

Upon arriving at the residence, the Staff discussed WCE's previous leak investigation findings. On January 8, 2005, the Manager had conducted a leak investigation over the service line for 715 E. 4th Street and the natural gas main. Gas leak checks were also made beneath the crawl space for 715 E. 4th Street and the sewer cleanout. No gas readings were indicated during any of these checks. The Staff then proceeded to make visual observations of the outside of the residence.

Exterior Observations of 715 E. 4th Street

No structural damage was observed on the exterior portion of the building and no evidence of fire damage could be seen from the outside. All of the outer walls were intact and appeared to be undisturbed. The roofing material of the residence consisted primarily of metal, except for a small mud room on the north end that had roofing shingles. No type of guttering system was attached to any portion of the roof or the mud room, which had a roof overhang just above the natural gas meter set (see **Appendix B-1**, **Photograph 1**).

The Staff then examined the natural gas meter set. This contained a ¾-inch Fisher S-254 service regulator that had an internal relief valve (IRV) and a breather vent check valve assembly. While observing the natural gas regulator, the Staff checked underneath the breather vent screen to see if any ice build-up had occurred. No ice build-up was detected on either the breather vent screen or the service regulator body.

Interior Observations of 715 E. 4th Street

The most severe fire damage was observed in the bathroom area which was located in the northeast corner of the residence. In this room, a natural gas water heater was located near the southwest corner. The appliance control for this unit was severely damaged so that no testing could be performed. Most of the burning and fire damage was located behind and to the east of the water

heater. There was a well defined v-pattern burn[13] along the south wall and the south door which extended from approximately the height level of the appliance control to the ceiling above. Heavy alligator charring[14] was present on the external surface of the south bathroom door. This charring was located both southeast and slightly above the height level of the appliance control for the water heater (see **Appendix B-1**, **Photograph 2**). During these observations, WCE personnel used a flashlight and a mirror to inspect the firebox beneath the natural gas water heater. Both burning and scorching marks were visible inside the firebox (see **Appendix B-3**, **Photograph 5**).

Scorching and burn marks were also visible on the water heater exterior and a smoke line was present along the east wall in the bathroom area near the shower. A large portion of the shower curtain in this bathroom area had been consumed by the fire and the remaining portion was scorched and black (see **Appendix B-2**, **Photograph 4**).

Slight fire and smoke damage was observed on the exterior surface of the northwest door that leads to the kitchen area. Smoke damage was also observed on the south door between the dining room and bathroom. The damage to the dining room (located south of the bathroom area) was limited to smoke damage in which the walls and ceiling area had been discolored and stained. From the dining room, heavier smoke and heat related damage was observed on the top exterior portion of the south door to the bathroom area (see **Appendix B-2**, **Photograph 3**).

A natural gas furnace was located along the west side of the residence and fire damage was observed on the furnace vent cover and inside the furnace around the main burners (see **Appendix B-3**, **Photograph 6**). The pilot serving this furnace had an appliance regulator, but no regulator was observed for the main burners. No other fire damage was observed in the room that contained the natural gas furnace. The room containing the gas furnace was located a considerable distance west of the bathroom area and was adjacent to the dining room.

The natural gas range in the kitchen had been removed by the owner before the Staff arrived to investigate the incident, but no indications of fire damage were observed in the vicinity of where the gas range had been located. The natural gas appliances in the residence at the time of this investigation included a water heater in the bathroom and a furnace that was located some distance away along the west side of the home.

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[13] The v-pattern burn is a description of the up and out burning pattern of fire as it travels up and away from the point of origin. This produces a "V" pattern, hence its name.

[14] Alligator charring is defined as charring of wood, characterized by relatively wide and smooth blisters, separated by deep grooves or cracks between blisters. Char consists of a carbonaceous material that has been burned and has a blackened appearance.

The Staff left the incident site at approximately 11:30 a.m. on January 12, 2005 and plans were made with WCE personnel to conduct several telephone interviews with emergency response personnel that responded to the fire at 715 E. 4th Street. Some of these plans included traveling to the Milan City Hall to contact the Milan Fire Chief.

Testing of the Residential Service Regulator

In order to safely test the natural gas service regulator, the outlet piping connection downstream from the regulator was taken apart while the service line riser valve was in the closed position. An IWC pressure gauge was then attached to the outlet of the service regulator and then gas at a pressure of approximately 50 psig (operating pressure at time of incident) was slowly introduced at the inlet of the service regulator.

The regulator set pressure was determined to be 7.5 IWC and the lock-up pressure was found to be 8 IWC. For comparison purposes, the set pressure and lock-up of this regulator was repeated three more times and each time yielded the same result.

After testing the service regulator, the Staff and WCE personnel performed an odorant intensity check at the outlet of the regulator serving 715 E. 4th Street. A readily detectable odorant reading of 0.25% gas-in-air was obtained by both the Staff and the Manager of WCE.

Other Staff Investigations and Actions

Missouri Natural Gas Operators Letter

To bring the commonalities of both natural gas incidents to the attention of all Missouri gas operators, the Staff made a mailing to all Missouri Natural Gas Operators. The purpose of the letter was to remind the operators to be aware of possible situations that might lead to ice build-up on pressure regulating and relieving equipment during the winter months. In the letter, the Staff asked that each operator discuss and review this possible safety issue with all Service Department and Meter Reader personnel who would typically see the natural gas meter set installations.

If they discovered any potential problems, the operators were asked to evaluate the location of the meter set and to determine the best course of action, including moving the meter set or placing some type of shielding assembly around the meter set or regulator. The Staff will mail this letter in late fall of each year to serve as a reminder.

ANALYSIS

Icy Weather Conditions

The Staff was not able to travel to the incident site at 1328 Main Street in Unionville on January 5, 2005 due to ice and snow covered highways. Upon arriving to the incident site in Unionville on the morning of January 6, 2005 a significant amount of ice was observed covering overhead power lines, telephone lines, street signs, trees, and bushes (see **Appendix A-1**, **Photographs 1** and **2**), as well as, the natural gas meter set and breather vent assembly at 1328 Main Street.

Ice Accumulation on the Service Regulators

Accumulation of ice on aboveground objects occurs only under certain weather conditions when the ambient air temperature is typically less than or equal to 32º F for an extended period of time. When the Staff arrived at 715 E. 4th Street in Milan on January 12, 2005, no ice build-up was found on the underneath side of the regulator breather vent. However, WCE personnel did observe ice blocking this same breather vent on January 8, 2005.

The amount of total precipitation during the period of January 1, 2005 through and including January 5, 2005 for the Kirksville area was reported to be 1.83 inches with an average low temperature of 27.8º F. The combination of freezing rain and light drizzle conditions that occurred prior to, during, and after both incidents were conducive to ice accumulations. As previously discussed in the **MoPSC Staff Investigations** section on page 15, a layer of ice was present on the underneath side of the breather vent screen for the service regulator at 1328 Main Street in Unionville on January 6, 2005 when the Staff conducted its investigation. Also on different occasions, WCE personnel observed that the breather vents for both service regulators, (both 1328 Main Street and 715 E. 4th Street) were covered with ice (see **Appendix A-5**, **Photograph 9** and **Appendix B-4**, **Photograph 7**).

The amount of ice accumulation was significantly enhanced by water runoff from the roof overhangs that were directly above both natural gas meter sets. The roof overhangs of both structures did not have a gutter system installed to channel water away to downspouts.

Service Regulator Failures

There are basically two types of failure categories that a residential service regulator can experience if certain conditions exist. A service regulator can either fail in an "open" or a "closed" position. If a regulator failed in an "open" position, the valve disc is no longer providing a tight seal with the inlet orifice assembly permitting gas from a high-pressure source of supply to enter the main chamber of the regulator. When a regulator experiences a "wide-open" failure, the separation distance between the seat of the valve disc assembly and the orifice is at a maximum which allows gas at the distribution main operating pressure to enter the main chamber of the regulator. Under normal circumstances, both the pop-up relief disc (internal relief valve) and the breather vent check valve would vent any excess gas (greater than the set pressure of regulator) that exists above the main diaphragm during an "open" or "wide-open" failure. The excess gas created by either failure scenario would then be vented from the topside of the main diaphragm through the attached breather vent. This action is both essential and necessary to prevent the outlet pressure (customer side) from rising above the set pressure of a service regulator. See **Appendix C-Basic Regulator Operation** for a detailed discussion on the operational characteristics of a service regulator under normal operating conditions.

When a regulator fails in a "closed" position, the seat of the valve disc is in direct contact with the regulator orifice, and a tight seal prevents gas from escaping between the inlet orifice side and the valve seat. If the regulator remains in a "closed" position for an extended period of time, the remaining gas in the downstream fuel line piping will eventually be consumed by natural gas appliances that are operating. When the gas has been utilized by the appliances, the gas pilot lights will typically be extinguished causing a noticeable gas service outage. Under normal circumstances, when the outlet pressure drops below the set pressure of the regulator the main diaphragm is forced downward (by the spring) as air is drawn through the breather vent. If the breather vent is blocked, no air is drawn within the top chamber and the main diaphragm is restrained from downward movement that would allow the valve disc to unseat from the orifice.

During the period of January 4-6, 2005, a total of seven natural gas related "outages" in Missouri occurred in the towns of Mercer, Milan, and Unionville (see the section entitled **WCE Service Outage History Caused by Icing of Service Regulators** on page 13 for further details). All of these gas "outages" were caused when the service regulators failed in a "closed" position (excluding the flow required for gas pilots, no significant gas load was required from any downstream gas appliances) and the breather vents became blocked with ice simultaneously. All of these outage locations either did not have a gutter system installed, or were located at a gable end of a residence. Conversely, both of the service regulators involved in this Incident Report

were operating in an "open" position supplying gas to one or more downstream appliances when the breather vents became iced over.

The design of the Fisher S-254 service regulators involved in this incident require the breather vents to be open to the atmosphere at all times. Whenever the breather vent becomes plugged or sealed, the service regulator no longer functions properly. If the vent becomes sealed with the regulator in the "open" position, the regulator is unable to shut-off when the gas demand ceases because air cannot be expelled from the top chamber (above the main diaphragm), which also restricts the necessary upward movement of the diaphragm. Instead of closing, the regulator remains in an "open" position and the outlet pressure begins to increase. As the outlet pressure rises to the setting (set point) of both the pop-up disc and the breather vent check valve springs, the relief valves open to vent the excess gas to the atmosphere. In this case the natural gas is vented through the outlet passageways of both the internal relief and breather vent check valves, except for the port that exits the breather vent area which is sealed. Pressure on the top chamber eventually increases to the outlet pressure. Now the spring force plus the outlet pressure pushes down on the diaphragm. With the outlet pressure equalized on both sides of the diaphragm, the full force of the regulator spring pushes downward with no resistance until the regulator is in the "wide-open" position. This phenomenon causes the outlet pressure to surge towards the inlet pressure. With ice sealing the breather vents, the outlet pressure would increase and approach the inlet pressure until the ice is removed from the vent screen area, allowing the regulator to return to normal operation. The outlet pressure increase would also be limited by the escape of natural gas from damaged appliance controls, as well as, leaking shut-off valves and pipe fittings, or reducers. The breather vent for the service regulator at 1328 Main Street in Unionville remained blocked with ice during the period of January 5-6, 2005.

Basic Operation of a Natural Gas Water Heater

The primary purpose of a water heater is to regulate and maintain the desired temperature for the hot water supply that is used within a household. The water heaters involved in both of the incidents had standing gas pilot lights. Beneath the water tank, a standing gas pilot is located next to the main gas burner. Both the pilot and the main gas burner are located inside of a combustion chamber. Normally, the flame from the gas pilot burns continuously and the heat of this flame is transmitted to a thermocouple. Whenever the standing pilot is extinguished, the thermocouple senses the drop in temperature and a signal is sent to the appliance control so that the control valve for the pilot supply and main burner are closed. This action is necessary to prevent natural gas from escaping the pilot and main burner areas when the pilot is not operating.

The standing pilot is used to ignite the main gas burner when the water in the tank needs to be heated. A thermostat is typically located inside of the water tank which monitors the water temperature. When the temperature of the water in the tank falls below the chosen thermostat setting, the thermostat senses this change and a signal is sent to the appliance control. The appliance control then opens a control valve to supply gas to the main burner.

During the over-pressurization of the gas fuel line piping, the closest natural gas appliances to the outlet of the service regulator would have been subjected to the greatest pressures. For both natural gas incidents, the water heaters were the closest operating gas appliances. Since the standing pilots were operating at the time of both incidents, the control valve would have been in an open position to serve at least the pilots. Based upon the air test of 50 psig that was applied to the water heater appliance control (see **Leak Testing of Fuel Line Piping and Water Heater Appliance Control** on pages 18-19 for details), it is very likely that the gas over-pressurization caused the control knob to unseat and pop-up while the high-pressure gas was supplying both the standing pilot and the main gas burner. The lifting of the control knob would then function as a relief device as gas was escaping from the sides and near the top of the appliance control. If a sufficient amount of gas was vented from the control knob, it is possible that the flame height and intensity of the standing pilot was increased and may have had a torch-like appearance. Likewise, the flame height and intensity of the flames from the main gas burner would also have been affected by the over-pressurization if the thermostat was requiring the main burner to operate. Both natural gas water heaters appeared to have burn damage. The natural gas water heater in Unionville had scorching marks near the top of the access panel and above and to the right of the appliance control. Most of the burn damage to the water heater in Milan was directly above the appliance control, but some scorching was noted just above the drainage outlet (see **Appendix A-3**, **Photograph 6** and **Appendix B-1**, **Photograph 2**). The fire box for the water heater in Milan also had evidence of burning underneath the tank bottom.

Natural Gas Pressure Surge and the Resulting Damages

The outlet (delivery) pressure of the service regulator would increase towards the inlet pressure, as long as, the breather vents remained blocked. The exact amount of over-pressurization in the downstream fuel line piping for both natural gas incident locations was not determined, but would likely be affected by any leaking or damaged appliance controls and regulators, as well as, leaking pipe fittings and shut-off valves to appliances. Based upon the failure testing of the Fisher S-252 service regulator that was similar to the Fisher S-254 (see **Appendix D-Additional Regulator Testing** for detailed information), the amount of over-pressurization involved in both natural gas incidents could have "theoretically" been in the range of 26 psig to 48 psig depending upon which natural gas appliances were operating and the amount of escaping gas.

This over-pressurization would have an adverse effect on downstream natural gas appliance controls and appliance regulators. On January 6, 2005 an air test of 50 psig was applied to the water heater appliance control for 1328 Main Street in Unionville (see **Leak Testing of Fuel Line Piping and Water Heater Appliance Control** on pages 18-19). The result of this test indicated that the appliance control began to leak around the sides and top area of the control knob.

If the flame from the standing gas pilot continued to operate during the over-pressurization, the pilot would have essentially become a "torch" that could have scorched the underside of the water heater tank and provided an ignition source for the escaping gas. It was not determined if the main gas burner for either water heater was operating at the time of the over-pressurization, but if the main burner was operating it could have also provided an additional source of ignition.

Due to the extent of fire damage to the water heater appliance control for 715 E. 4th Street in Milan, no air leakage tests were performed. The natural gas furnace located inside a room along the west side of this residence was also damaged by fire. Most of the burn damage from the fire appeared to have come from inside the furnace unit and from the main burner box area. Both Milan Fire Department personnel and the tenant of 715 E. 4th Street indicated that the fire had originated from the bathroom area before flames were observed coming outside of the main burner box of the natural gas furnace (see **Appendix E-Witness Interviews** section that pertains to both the Milan Fire Department personnel and the tenant of 715 E. 4th Street).

Natural Gas Escape

Once the regulator breather vent assemblies became blocked with ice while both regulators were operating in an "open" position, the outlet pressures would have increased to unsafe levels that approached the inlet pressure of 50 psig. This over-pressurization caused the downstream appliance controls for both natural gas water heaters to eventually malfunction and to vent a portion of the natural gas through the top and sides of the control knob assemblies. The malfunction of the water heater appliance controls would have likely occurred with the control valves in an "open" position so that high-pressure gas was allowed to enter both the pilot and main burner supply lines. The over-pressurization also caused the natural gas furnace for 715 E. 4th Street in Milan to malfunction and to emit flames out of the main burner box area. Natural gas would have escaped from both water heater control knob assemblies and any leaking valve cores in gas shut-offs, leaking pipe fittings or components, and any damaged appliance regulators for gas pilots or main burner assemblies.

Natural Gas Entrance, Accumulation and Ignition

Natural Gas Incident-1328 Main Street in Unionville, MO

Natural gas is lighter than air (natural gas has a specific gravity of 0.6 while air has a specific gravity of 1.0) so it tends to migrate or travel upwards and follow the path of least resistance. Once natural gas began to vent from the sides and top area of the control knob for the water heater appliance control in the basement area, the natural gas would have accumulated beneath the crawl space area and would have entered into any available openings, or cracks, in the wooden flooring, as well as, the concrete block foundation. The percentage of gas-in-air by volume would be less in magnitude near the basement floor level and would tend to increase as the gas traveled upwards towards the crawl space and ceiling area (in this case the wooden flooring above). A solid brick wall, that was located just south of the south wall of the basement, would have prevented most of the gas from entering the crawl space behind this wall. So the majority of the gas would have accumulated beneath the crawl space areas to the west, north, and east. A portion of the escaping natural gas could have also entered a PVC conduit that was used to encase a PVC water line from the water heater. Both the PVC conduit and the PVC water line traversed east beneath the crawl space and then terminated beneath the kitchen sink that was located east of the living room area.

Natural gas has an explosive range that is between approximately 4.5% to 14.5% gas-in-air by volume. A large volume of an optimum mixture of natural gas and air (approximately 10% gas-in-air) would, when ignited, produce a violent explosion splintering wood members and hurling debris great distances over a large area. Since most of the walls were intact except for the northwest corner of the living room and the adjoining west wall, and very little burn damage was observed, it would appear that the gas-in-air mixture at the source of ignition in the basement was either at, or slightly above the 4.5% gas-in-air volume. This type of gas explosion is considered to be a "low-order explosion"[15].

The discoloration of the PVC water line and the PVC conduit in the basement (see **Appendix A-4**, **Photograph 7**), were likely caused by exposure to high temperatures when the gas was ignited. Assuming that a portion of the escaping gas had entered the annular space between the PVC conduit and the PVC water line, this gas-in-air mixture could have also ignited at the time of the explosion. The resultant flash fire within this annular space could have damaged any flammable materials beneath the kitchen sink since the PVC conduit had terminated at this location.

The low-order explosion was responsible for the damage to the northwest corner of the living room and the west wall that adjoined this section. It is also likely that the explosion displaced the basement access cover and caused the separation and lifting of the flooring between the living room and the main sanctuary. This section of flooring was just north of a brick wall that was located in the basement area. It is probable that the explosion raised this section of flooring and also displaced some of the drop ceiling panels in the living room, knocked over items within the main sanctuary to the south, and displaced the top portion of the single-pane glass windows (total of 8) that were also located in the sanctuary.

The only available ignition sources in the basement area were the standing pilot for the natural gas water heater and possibly the flame from the main gas burner if the thermostat had already required the water in the tank to be heated. The standing pilot would have been operating at the time of the gas over-pressurization. Natural gas appliances and electrical sources on the main level were not considered as potential ignition sources since no indications of their involvement were present.

[15] A low-order explosion involves a slow rate of pressure rise or low force explosion characterized by a pushing or dislodging effect upon the confining structure or container and short missile distances as defined by NFPA 921-Guide for Fire and Explosion Investigations (1992 Edition).

Natural Gas Incident-715 E. 4th Street in Milan, MO

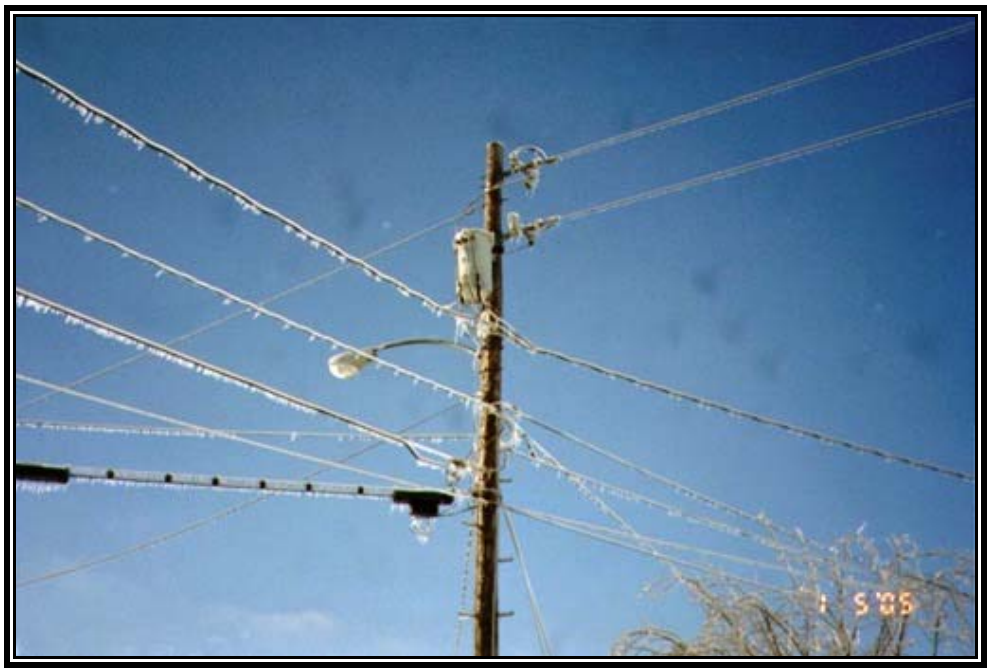
As previously discussed, the most significant burn damage was located near the natural gas water heater in the southwest corner of the bathroom area. A very prominent v-pattern burn was observed along the south wall and directly behind the water heater that extended from approximately the height of the appliance control to the ceiling above. Alligator charring of the south door was present just southeast of the appliance control (see **Appendix B-1**, **Photograph 2**). This type of charring is typically associated with very deep char burns because of the amount of time that the flammable material (wood door in this case) was exposed to fire.

Since no evidence of explosion damage was observed, it is very likely that the venting gas was ignited before the gas accumulated to an explosive level in the bathroom area (gas-in-air mixture below 4.5% near the ignition source). Once the venting gas was ignited, it is probable that this high-pressure gas coming out of the gas control knob on top of the appliance control behaved as a "torch" and ignited other nearby combustible materials in the bathroom. It is possible that the "torch" also made direct contact with the south bathroom door in the area where the alligator charring was observed. The magnitude of gas over-pressurization downstream of the water heater would have been reduced as the gas was venting from the control knob, but was significant enough to cause flames to roll out of the furnace's main burners.

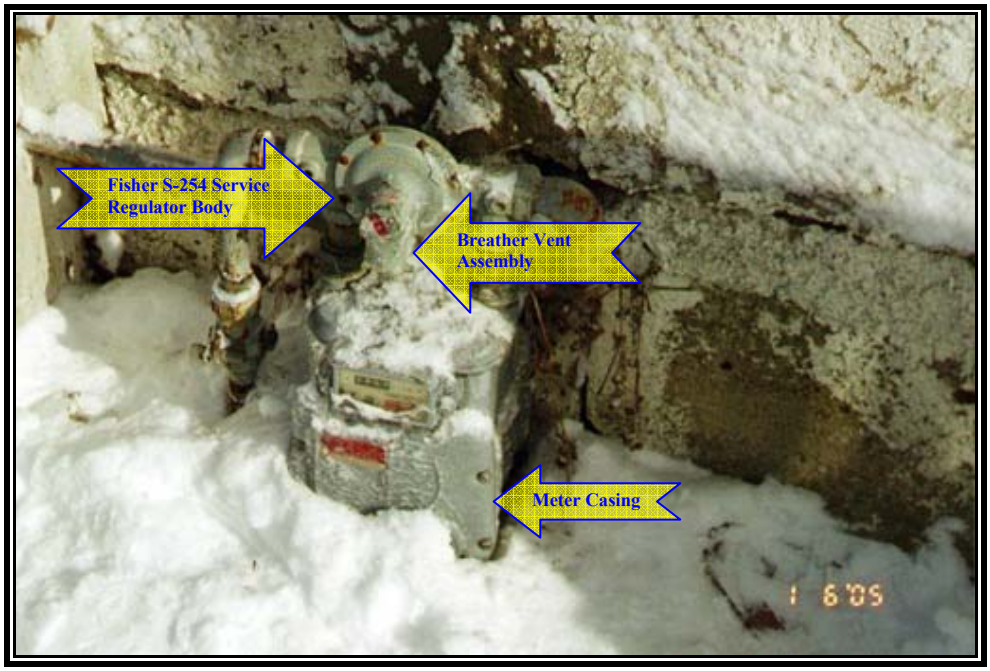
The only available ignition source in the bathroom area was the natural gas water heater. The standing gas pilot would have been operating at the time of the gas over-pressurization. If the thermostat had required the water in the tank to be heated, the flame from the main gas burner would have provided an additional source of ignition. The natural gas furnace was not considered as a possible ignition source because the malfunction of this appliance was secondary to the water heater.

APPENDIX A

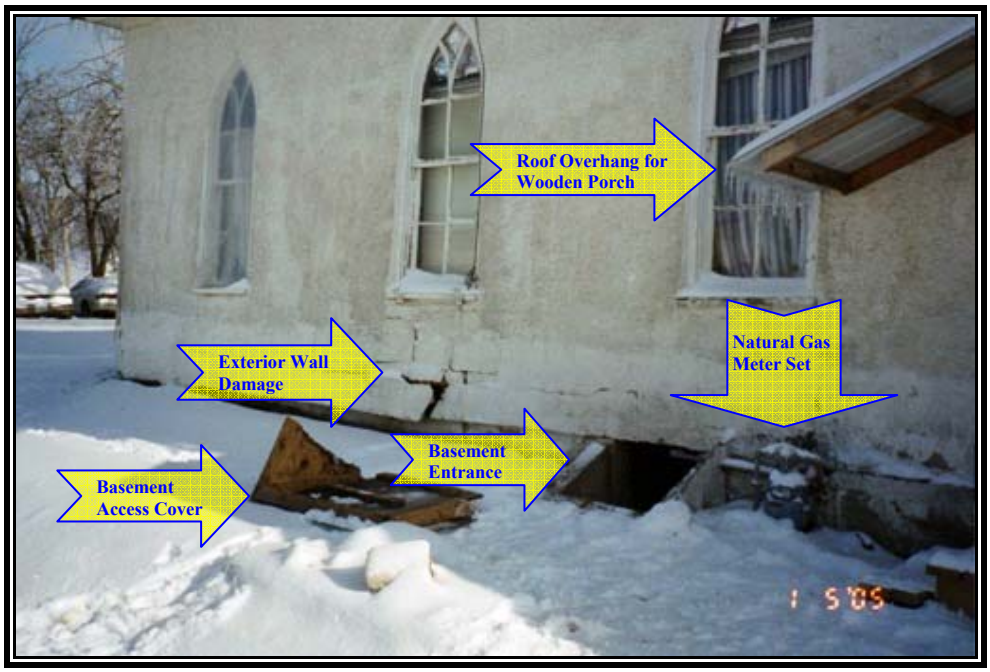
(Unionville-Photographs)



Photograph 1 View looking at the electric and telephone lines in Unionville that were covered with a heavy layer of ice. This power pole is located at the northwest corner of the intersection of Main Street and 14th Street. Observe the ice that had formed on the tree in the lower right-hand portion of this photograph. The date displayed in the lower right-hand corner should be "1 6 '05" (January 6, 2005).



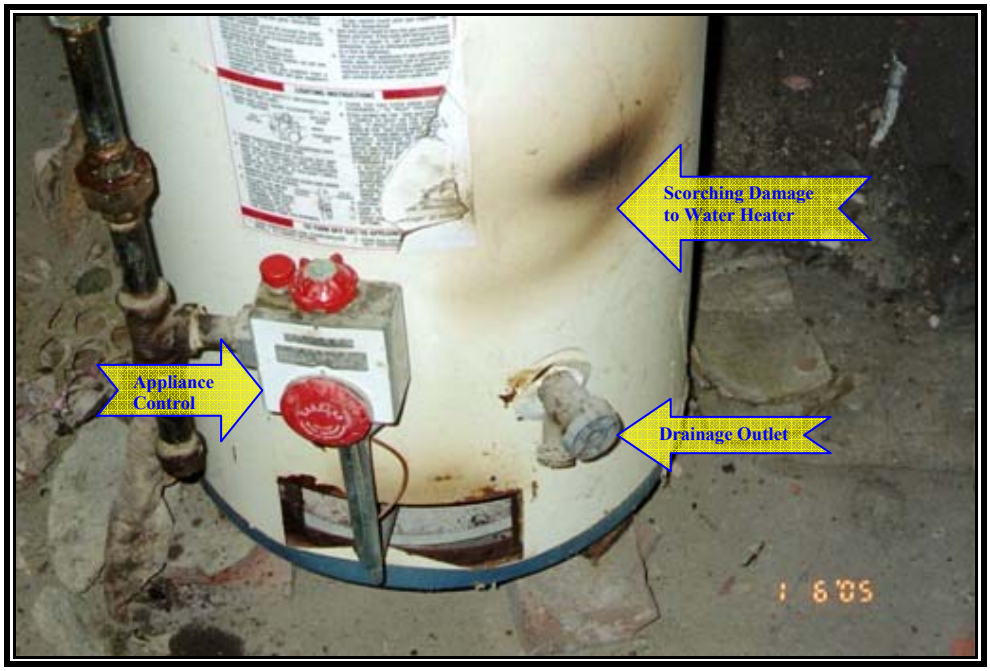
Photograph 2 View of the natural gas meter set that served 1328 Main Street in Unionville. Observe the ice build-up on the outside of the meter casing, as well as, the underneath side of the breather vent assembly where the breather vent check valve is housed.



Photograph 3 Looking at the west wall of 1328 Main Street. Observe the icicles that were hanging down from the roof overhang that was built for the wooden porch. No guttering system was installed for any portion of the roof line overhangs. The natural gas meter set was located directly beneath the roof overhang of a wooden porch. The date shown in the lower right-hand corner of this photograph should be "1 6 '05" (January 6, 2005).

Photograph 4 Close-up view of the damage to the exterior west wall. Note how the wall was buckled and displaced outwards from the foundation. The greatest damage to the west wall was observed from approximately the basement entrance to the northwest corner of the building. The basement access cover was placed over the entrance just prior to taking this photograph.

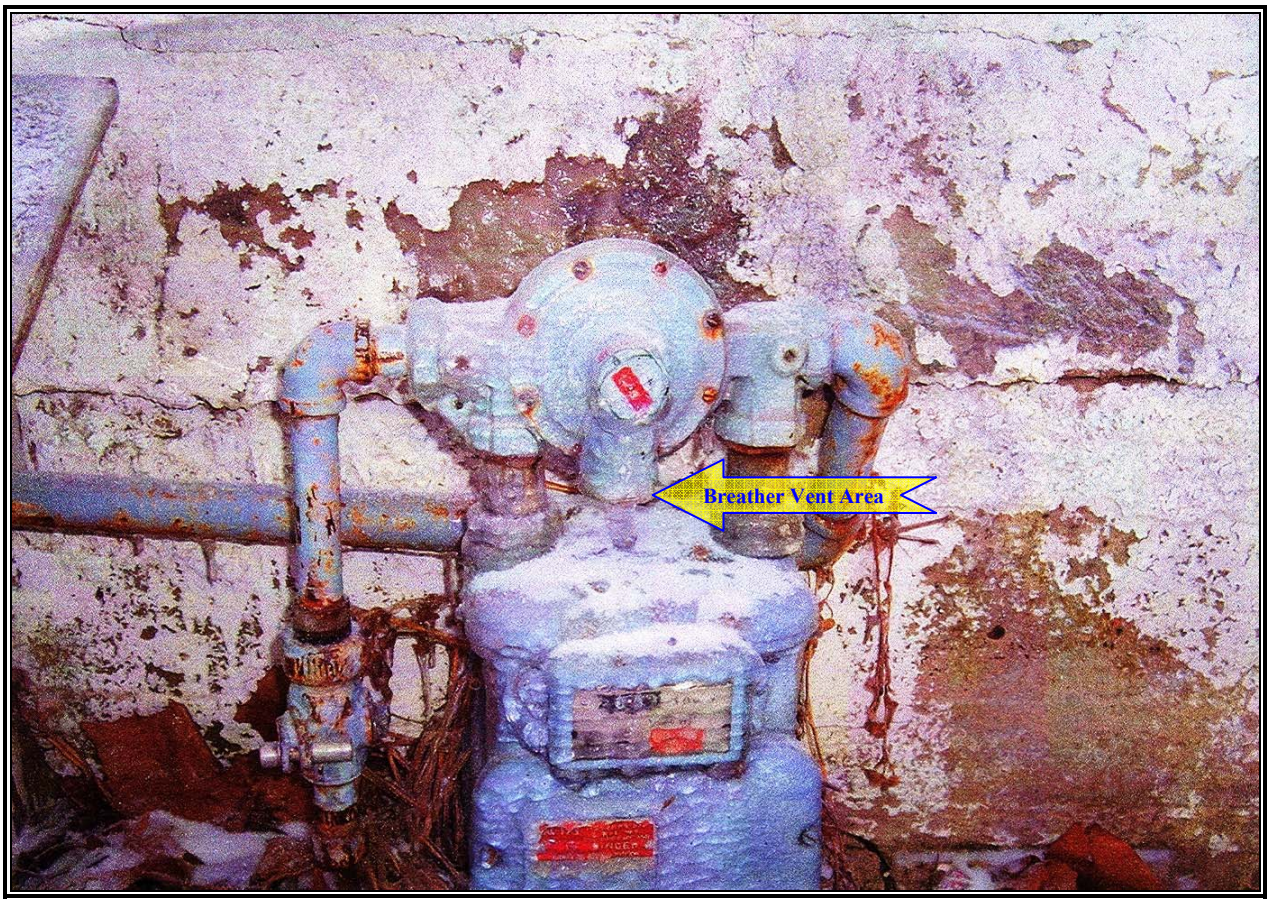
Photograph 5 This view is looking to the northeast at the west side of 1328 Main Street. The street seen in this photograph is 14th Street which runs north and south. The entire roof structure consisted of a metal roof. Note how the roof overhang from the main sanctuary portion of the residence drained onto the below roof for the wooden porch area.



Photograph 6 View of the natural gas water heater that was located near the southeast corner of the basement. The appliance control was physically intact and did not appear to have been damaged. Observe the slight burn mark on the water heater just above and to the right of the drainage outlet, as well as, the light burn mark that was just above the access panel. The "Operating Instructions Label" (just above the appliance control) was singed and slightly burned.

Photograph 7 View of the PVC water line that traversed east from the outlet side (hot) of the water heater to the kitchen sink that was also located east of the living room. The larger diameter PVC pipe was used as a conduit to protect the water line. Observe the light brown discoloration of the PVC water line as it entered into the PVC conduit.

Photograph 8 Looking at the area beneath the kitchen sink. A light blue plastic tub can be seen covered by newspapers (to the right of the P-trap). The kitchen cleaning items on the floor were inside of the light blue plastic tub, but were later removed by fire department personnel in order to extinguish the fire. This was the only indication of fire damage on the main level. The gas range can be seen to the left of the kitchen sink.

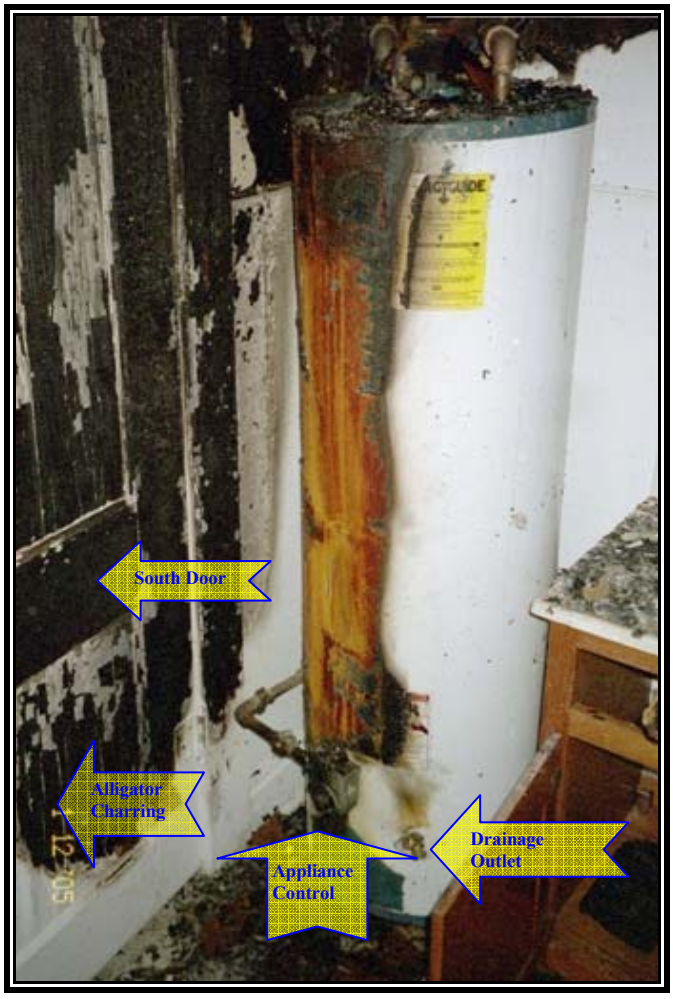


Photograph 9 Close-up view of the natural gas meter set for 1328 Main Street in Unionville. This picture was taken by WCE personnel on January 5, 2005 during their initial response to the incident site. Observe the icicle that hangs from the breather vent area of the regulator and connects to the top of the meter. A layer of ice surrounds most of the regulator body and meter casing.

APPENDIX B

(Milan-Photographs)

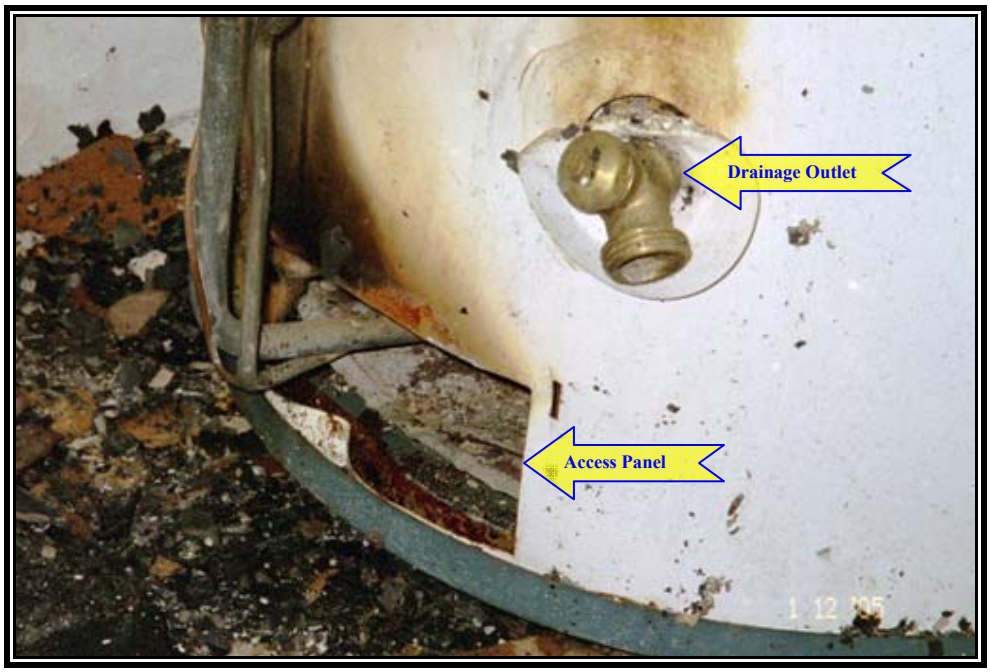
Photograph 1 Looking south at the north side of 715 E. 4th Street. The natural gas meter set is located on the east wall of the mud room. Observe the roof overhang in relation to the location of the natural gas meter set. No guttering system was installed on any portion of the roof.



Photograph 2 View of the southwest corner of the bathroom area where the natural gas water heater was installed. This room had the most severe fire damage. Note the v-pattern burn on the wall between the water heater and the south door. Also observe how the water heater area just above the appliance control was burned. Also note the scorching and discoloration just above the drainage outlet. Alligator charring was observed near the bottom of the south door just southeast of the appliance control.

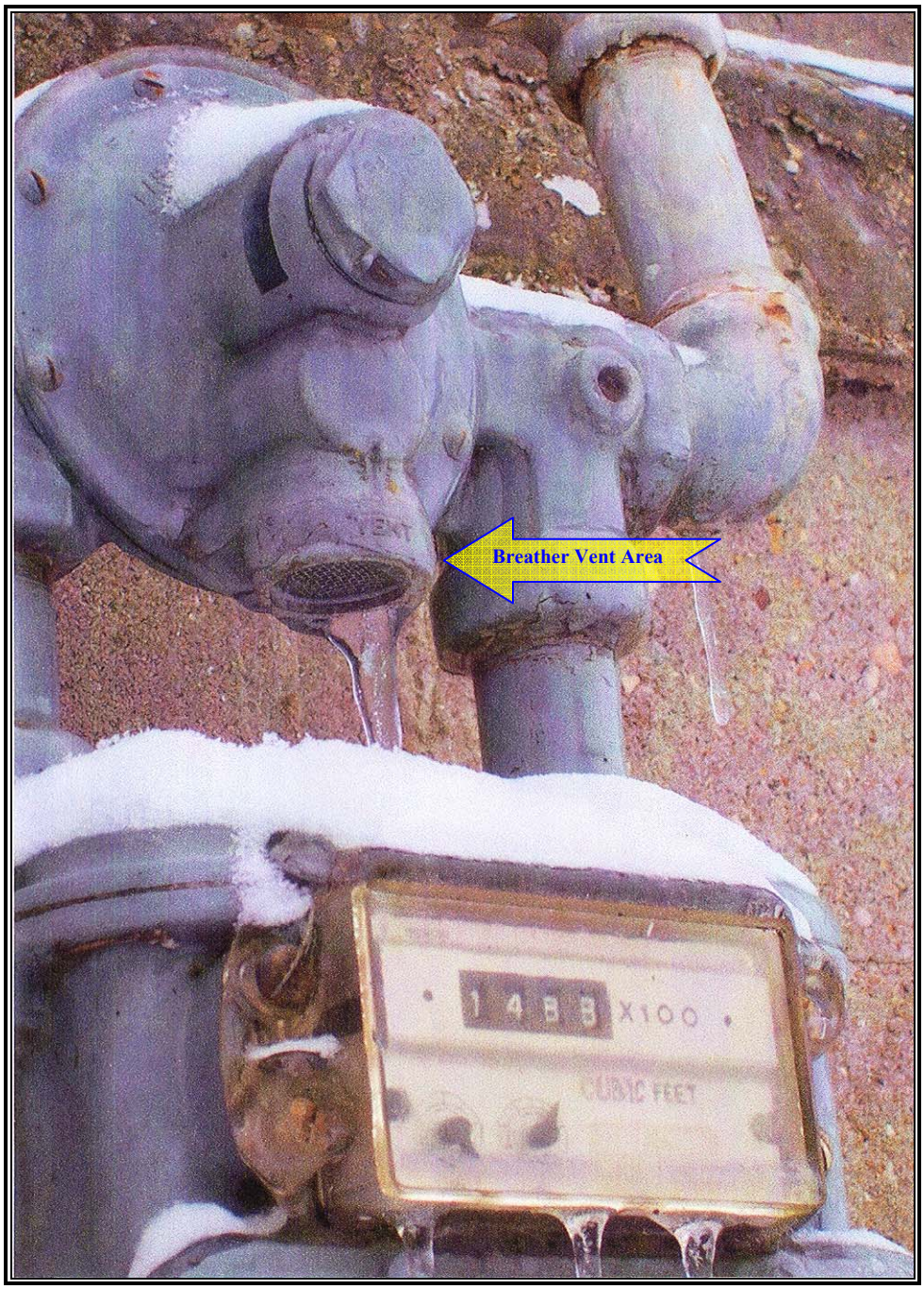
Photograph 3 View looking north (from the dining room) at the south door for the bathroom area. This door was closed at the time of the natural gas incident. The top portion of the door received heat and smoke related damage. The dining room received smoke related damage.

Photograph 4 Looking to the east at the bathroom area that received the most severe fire and smoke related damage in the home. This photograph was taken from the kitchen area of the residence. This west door to the bathroom was also closed at the time of the natural gas incident.



Photograph 5 Looking at the lower portion of the natural gas water heater that was located in the southwest corner of the bathroom area. Indications of scorching and burning were found on the interior portion of the firebox for the water heater. Observe the burn mark that is directly above the access panel and the slight melting and discoloration area near the drainage outlet.

Photograph 6 View of the natural gas furnace that was located in a room along the west side of the residence. This room was located to the west of the dining room area. Note the severe fire damage to the main burner assemblies, as well as, the top and side portions.



Photograph 7 Close-up view of the natural gas meter set for 715 E. 4th Street in Milan. This picture was taken by WCE personnel on January 8, 2005 after learning that the house fire may have involved natural gas. Observe the icicles hanging from the breather vent area of the regulator and the meter index cover. On this date, WCE personnel verified that the regulator vent screen (breather vent) had been iced over and blocked.

APPENDIX C

(Basic Regulator Operation)

Basic Regulator Operation

Under normal operating conditions, a natural gas residential service regulator continuously works to reduce the gas pressure from a distribution service line to a safe working delivery pressure for downstream gas appliances. A residential service regulator is considered to be a single stage regulator that reduces the inlet pressure of the gas source to the desired delivery pressure in one step.

There are three basic operational components for a natural gas service regulator. These components include some type of a loading mechanism (spring), a sensing element (diaphragm), and a control element (valve). These components work together to reduce and regulate gas pressure (see **Figure 1** on the bottom of page 2 within this Appendix).

Under normal conditions, the outlet pressure (delivery pressure to customer) registers on the underside of the main diaphragm, while atmospheric pressure (1 atm = 0 psig) is present in the chamber above the diaphragm. The top chamber is connected to the internal relief valve outlet passageway by a port through the chamber wall. Another passageway exists through the breather vent check valve when it is activated. This passageway ends at the vent to the atmosphere. Assuming the orientation shown by **Figure 1,** the regulator spring is in the top chamber and pushes down against the diaphragm and is balanced by the outlet pressure below the diaphragm. A decrease in downstream pressure allows the diaphragm to drop, forcing the valve lever downward to pull the sealing surface of the valve disc away from the orifice. As the diaphragm is pushed downward, air is drawn into the top chamber from the atmosphere. As the downstream demand is met and downstream pressure increases, the diaphragm moves upward with the valve disc throttling toward the orifice to reduce/stop gas flow. The movement of the main diaphragm controls the position of the valve disc in relation to the orifice opening.

Most residential service regulators are adjusted to deliver a downstream pressure in the range of 7 IWC to 9 IWC. A gas pressure reading of 7 IWC is approximately ¼ psig. Natural gas appliances in homes require a certain volume of gas during their operation. The natural gas appliances place a load/demand on the service regulator when one or more are operating. When no gas appliances are operating, the pressure in the fuel line piping is maintained at the set pressure of the service regulator and minimal flow (for the pilots only) through the meter set occurs. When a natural gas appliance is operating a demand is placed on the service regulator.

Under these conditions, the outlet pressure of the service regulator decreases and the regulator "senses" this decrease in pressure and the operation of the regulator causes a valve to open allowing higher pressure gas to supply the demand at a pressure of 7 to 9 IWC, depending upon the set pressure of the regulator.

As a means of providing over-pressure protection to the customer's fuel line piping and downstream natural gas appliances, most residential service regulators are equipped with some type, or combinations, of relief valves. The Fisher S-254 service regulator is equipped with an emergency pop-up disc relief valve (IRV or internal relief valve) which vents excess gas to the top chamber that normally contains atmospheric air. In addition to this relief valve, the service regulator also has a breather vent check valve that vents excess gas through the breather vent assembly. Both the IRV and breather vent check valve typically have a slightly higher set point value than the set pressure of the service regulator so gas will not vent during normal operation. Both the IRV and breather vent check valve consist of a spring, a valve, and an orifice assembly.

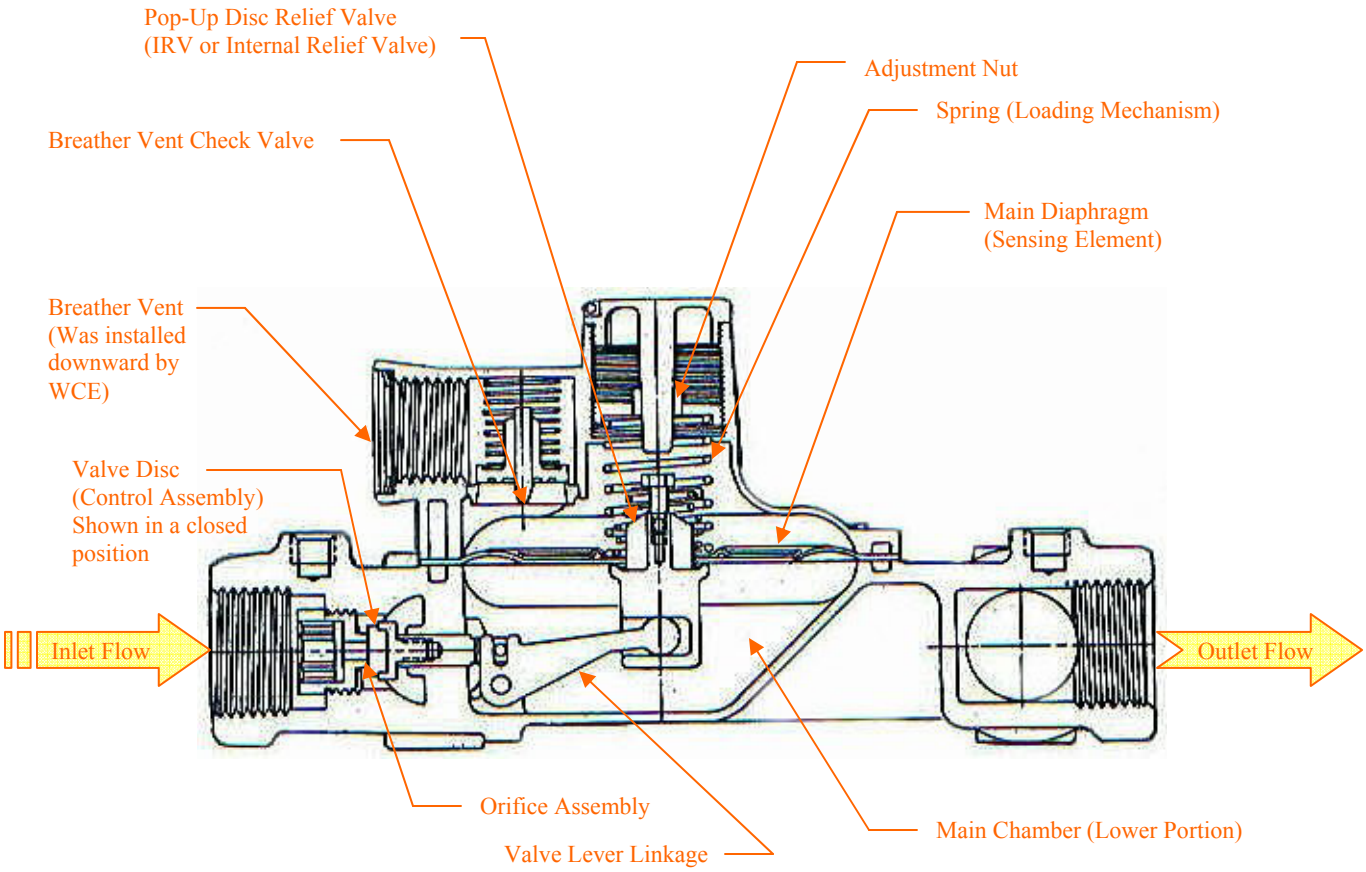


Figure 1- Sectional View of a Fisher S-254 Service Regulator

(Note: Above Staff Drawing is based on the schematic in the Fisher-March 1971 Bulletin:71.1:S250, page 3.)

APPENDIX D

(Additional Regulator Testing)

Additional Regulator Testing

On May 5, 2005 a Staff member traveled to the Unionville-WCE office to conduct further testing on the natural gas service regulator that was removed from 1328 Main Street. Staff met with the Manager of WCE at approximately 9:30 a.m. to discuss the tests. The following tests were conducted in an effort to approximate the regulator failure condition that was believed to have been caused by the accumulation of ice that eventually blocked the breather vent assembly for both the internal relief valve and breather vent check valve mechanisms.

A pressure testing apparatus was connected to simulate a "wide-open" failure condition of the service regulator combined with blocking the breather vent to determine the amount of pressure build-up that would likely be observed downstream in the fuel line piping. An orifice assembly was attached to the pipe end of the apparatus that had been sized for a 75,000 BTU/hr load requirement to approximate both the water heater load of 30,000 BTU/hr and the furnace that was 45,000 BTU/hr. Both of these types of natural gas appliances were inside the residence at 1328 Main Street. The orifice size selection was based on a service regulator set pressure of 7 IWC and assumes that natural gas has approximately 1000 BTU[16] of energy available for each 1 Standard Cubic Foot (SCF) of gas delivered. Based on these assumptions, a #29 drill size was recommended for the orifice size so that a flow rate of 74.45 SCFH[17] (approx. 75 SCFH) could be achieved with a regulator set pressure of 7 IWC. The inside diameter of the orifice assembly was slightly larger than 1/8".

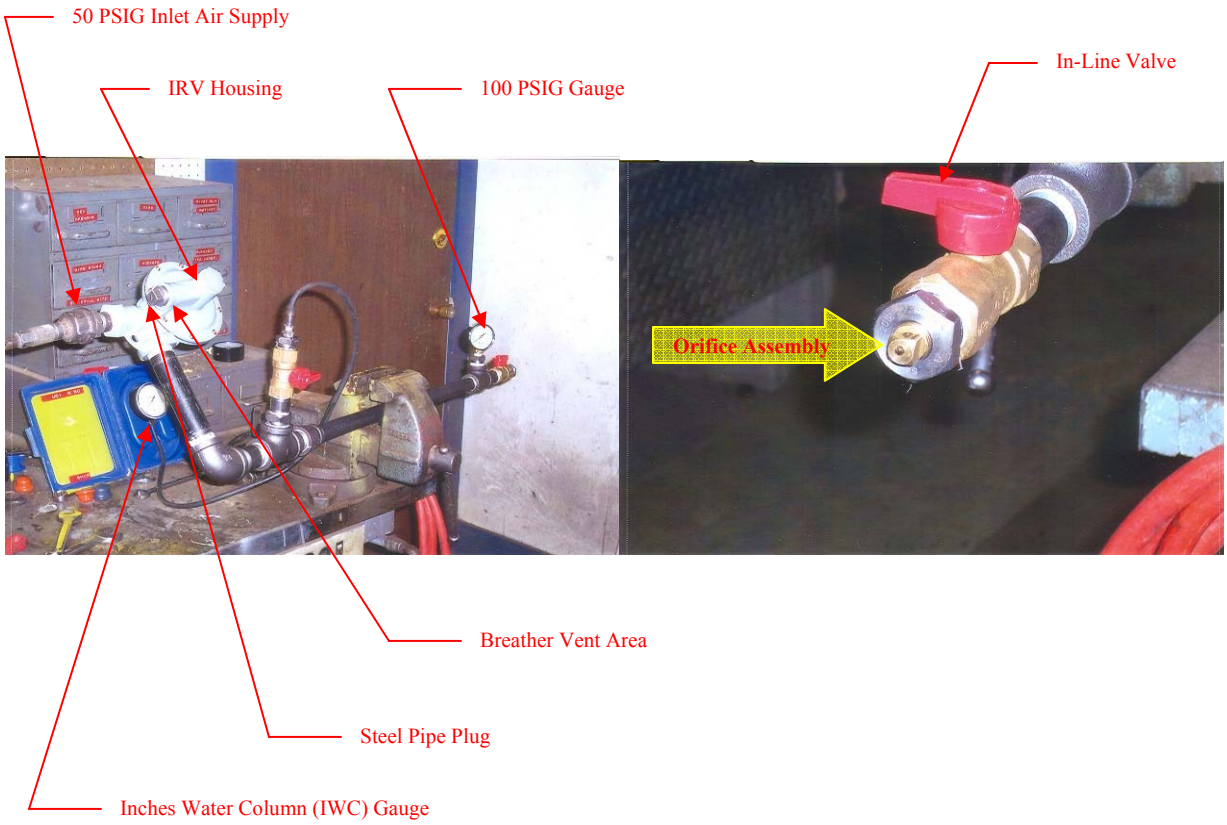
Due to problems involving the removal of the regulator screws around the perimeter of the diaphragm assembly, the Staff was not able to gain access to disconnect the linkage that controls the valve movement and position. A different service regulator (Fisher S-252) was chosen that had similar flow and pressure characteristics as the regulator that was removed from 1328 Main Street.

The valve lever linkage inside the Fisher S-252 regulator was then disconnected so the valve would remain in an open position at all times to simulate a "wide-open" failure. After removing the breather vent screen, a steel plug was inserted to fully block any venting from both the breather vent check valve and the IRV. A compressed air tank that was regulated at a pressure of

[16] A British thermal unit (BTU) is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit. This is the accepted standard for the comparison of heating values of fuels including natural gas.

[17] One (1) SCFH is a volumetric flow rate that is equivalent to 1 standard cubic foot per hour of natural gas.

50 psig was then connected to the inlet side of the regulator body. The two photographs below were taken during the failure testing of the Fisher S-252 service regulator. The photograph on the left shows the breather vent plugged and the photograph on the right is the orifice that was used to simulate the combined load demand of both a natural gas water heater and a furnace.



With the orifice installed at the far pipe end, and open to simulate the water heater and furnace loads, the outlet pressure was determined to be 26 psig. A second test was conducted to simulate the downstream pressure in the steel piping when a device, such as, an appliance control for a water heater or furnace had closed the valve (control valve) to its' main burner assembly. The same testing conditions applied as above except an in-line valve (located upstream of the orifice assembly and downstream from the regulator) was shut-off to simulate a no-flow operating condition (also denoted as lock-up). The downstream pressure in the steel piping between the regulator and the in-line valve was determined to be 48 psig during this test.

APPENDIX E

(Witness Interviews)

Witness Interviews

Unionville Fire Department

The Fire Chief that responded to the fire call at 1328 Main Street indicated that the fires that were observed were so small that both could have been extinguished with a glass of water. One small fire was observed beneath the kitchen sink just east of the living room, and another was observed near the southeast corner of the basement. No other fires were observed.

While extinguishing the fires, no odor of natural gas was detected. The fire department shut off the service line riser valve for the natural gas meter set after the fires were extinguished. The Fire Chief then reported the event to the Unionville 911 Dispatch service and then the fire department notified Unionville Light & Power to have the electricity turned-off at 1328 Main Street.

Unionville Light & Power Employee

An employee of Unionville Light & Power indicated that most of the power outages occurred on January 5, 2005 between the hours of 5 p.m. to 6 p.m. and were attributed to the accumulation of ice on electrical power lines. The majority of the Unionville customers had their power restored between the hours of 2 a.m. to 3 a.m. on January 6, 2005. Isolated power outages still occurred on January 6, 2005 until about 4:00 p.m. later that day.

Milan Fire Department

The Fire Chief was the first to arrive at 715 E. 4th Street on January 5, 2005 and then the Vice Chief arrived shortly afterwards. When they arrived they observed that the bathroom area along the southwest corner of this room was on fire. While they were fighting the fire in the bathroom area near a natural gas water heater, they heard a loud "whoosh" of air followed by a loud "popping" sound. Afterwards, they noticed that the natural gas furnace along the west portion of the structure had caught fire and flames were coming out of the main burner box area.

After extinguishing the fire in the bathroom area they went to the area where the furnace was shooting flames out of the main burner location and extinguished this fire. At no time did the fire department personnel smell natural gas in the air when they were responding to and fighting

both fires. The gas was turned off at the meter set after the natural gas related fires had been extinguished.

Tenant of 715 E. 4th Street in Milan

The tenant of 715 E. 4th Street was awakened by the smell of smoke and the sound of the fire at approximately 3:10 a.m. on January 5, 2005. After awakening, the tenant did smell the odor of natural gas while the fire was occurring. However, the smell of natural gas was not detected before the tenant had retired for the evening. The tenant indicated that the fire had originated from the bathroom area before the furnace had caught on fire.