REPORT OF NATURAL GAS SAFETY INSPECTION REPORT #11-211

OPERATOR: Knoxville Utilities Board – Knoxville, Tennessee
PERSON(S) CONTACTED: Ms. Brooke Sinclair, Manager of Safety and Technical Services

INTRODUCTION

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

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

> (a) Any person who violates any provision of §§ 65-28-104--65-28-111, or of any regulation issued under such sections, is subject to a civil penalty not to exceed ten thousand dollars ($10,000) for each such violation for each day that such violation persists, except that the maximum civil penalty shall not exceed five hundred thousand dollars ($500,000) for any continuing series of violations.
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> (b) Any civil penalty may be compromised by the authority. In determining the amount of such penalty, or the amount agreed upon in compromise, the appropriateness of such penalty to the size of the business of the person charged, the gravity of the violation, and the good faith of the person charged in attempting to achieve compliance, after notification of a violation, shall be considered. The amount of such penalty, when finally determined, or the amount agreed upon in compromise, shall be paid within thirty (30) days after the determination to the authority, to be used for the purposes of §§ 65-28-104--65-28-111; and, if not paid within such time, may be recovered in a civil action brought by the authority in the chancery court of any county in which a violation exists.

The natural gas pipeline accident described in this report occurred in Knox County, Tennessee in the early hours of December 9, 2009. The accident resulted in one fatality and injuries to two individuals requiring their hospitalization. It involved gas service provided by Knoxville Utilities Board (KUB), a distributor of natural gas that is a "gas public utility" as defined in Tenn. Code Ann. § 65-28-104(4) and as such is subject to the TRA's enforcement authority.

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

There is no dispute that KUB lacked appropriate documentation concerning the installation of the natural gas service line at 9140 Grey Pointe Drive and that this is a violation of rule 49 CFR 192.517. The GPSD did not, however, find any MFSS violations that contributed to the accident. Moreover, the corrective actions already taken by KUB and the additional actions prescribed by the GPSD will reduce the likelihood of any recurrence of this kind of accident.

SYNOPSIS

At approximately 3:00 a.m. EST on December 9, 2009, leaking natural gas ignited at 9140 Grey Pointe Drive in Knoxville, Tennessee (*See* Attachment 1). The resulting explosion destroyed a three-story brick house. One occupant of the house, Nicholas Krzeski, was killed. Two other occupants, his parents Stephen and Sue Krzeski, were injured and hospitalized. The resulting pattern of debris extended approximately 200 feet. Multiple areas of fire were observed at the site, including a fire in the northeast corner of the property fueled by an uncontrolled release of natural gas. The estimated property damage to the residence at 9140 Grey Pointe Drive and adjacent properties was in excess of $1,000,000. The estimated damage to KUB's facilities was $55,000 (*See* Attachments 2 and 3).

At 3:14 a.m., KUB received an E911 call reporting an explosion and house fire at 9117 Hailes Abbey Lane, which runs parallel to Grey Pointe Drive. KUB dispatched a first responder to that address at 3:21 a.m. Rural Metro Fire Department officers already on the scene reported smelling natural gas in the area. KUB operated valves to stop natural gas flow in the area where the explosion was reported, cutting off gas service to forty-three residential customers. Upon learning that the explosion had actually taken place on Grey Pointe Drive, KUB shut off gas flow to eleven additional residential customers, including homes on Grey Pointe Drive (*See* Attachment 3, pg. 2).

At approximately 4:45 a.m., Chris Spencer, Business Management Analyst for KUB, notified Clifton Phillips, TRA Gas Pipeline Safety Engineer, of the explosion. Mr. Phillips instructed KUB to notify the USDOT in accordance with 49 C.F.R. § 191.5. KUB filed an incident report with the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the USDOT (*See* Attachment 1).

INVESTIGATIONS BY KUB, THE GPSD, AND THE KNOX COUNTY SHERIFF'S DEPARTMENT

On the day of the accident, KUB condemned the natural gas main in front of the explosion site in order to restore service to fifty-one customers. KUB excavated and capped the condemned section. After re-pressurizing the distribution lines, KUB conducted bar hole testing along the natural gas service line of 9140 Grey Pointe Drive and the natural gas main in front of 9134, 9140, and 9146 Grey Pointe Drive. All bar hole readings taken with a recently calibrated combustible gas indicator were at 0% of the lower explosive limit (LEL) of a gas-in-air mixture, with the exception of two readings. The first reading was 10% of the LEL above the service tee at 9146 Grey Pointe Drive and the second reading was 5% LEL approximately three feet west of the service tee. These bar hole test locations were approximately 110 feet away from the mechanical tapping tee location (*See* Attachment 3, pg. 2).

KUB also checked odorant levels at five nearby locations using properly calibrated equipment and reported readings within regulatory limits at all five. KUB restored natural gas service to all affected customers with the exception of addresses 9134, 9140, and 9146 Grey Pointe Drive, which remained condemned (*See* Attachment 3, pg. 2). Following the main re-pressurization and customer reinstatement, KUB conducted bar holing and a walking leak survey to all service lines and mains serving the fifty-one customers. All readings from this leak survey were 0% of the LEL. On the following morning, bar hole testing by KUB's leak survey contractor began as soon as access to the explosion site was available. All bar hole readings were 0% of the LEL at the water, natural gas, and electric service lines to 9140 Grey Pointe Drive (*See* Attachment 5).

Larry Borum, Chief of the GPSD, and Mr. Phillips arrived at KUB's offices in Knoxville, Tennessee at approximately 10:30 a.m. that day. Mr. Spencer and Brooke Sinclair, Manager of Safety and Technical Services for KUB, gave them a detailed report of KUB's actions and investigation. Mr. Borum and Mr. Phillips visited the accident site and photographed the debris and markings showing the location of underground utility facilities in the area. They saw burned areas on the ground near the gas pipeline service tap for address 9140 and heard from several people that a natural gas fire had occurred at that location.

Mr. Borum and Mr. Phillips returned to KUB's office to review operation and maintenance records for the facilities involved. KUB produced construction records for the main in front of address 9140 but could not locate the original service card for that address (although a service card for the installation at 9146 Grey Pointe Drive, installed the same day and by the same contractor in 1999, was available). KUB later obtained an affidavit from the owner of the company that installed both service lines stating that it was "the custom and practice of the company and its work crews to test installed service lines with air to 100 psi for at least 15 minutes" at the time of installation, and he believed with confidence that the work crew installing the service line at 9140 had followed that practice (*See* Attachment 4).

On December 10, 2009, KUB met with the Knox County Sheriff's Department's (KCSD) Fire Investigation Unit, headed by lead investigator Mike Dalton, to begin collecting evidence at the accident site. KUB uncovered the natural gas service line to address 9140. Material excavated

from around the line appeared to be normal with no desiccation that would indicate a long-term natural gas leak. The soils appeared to be uniform, high in clay content, and saturated. While excavating the service tee, KUB discovered a copper water service line approximately seven inches above the natural gas service line. Before it was removed, the water service line was observed to have a longitudinal break on the underside. Water, probably from this broken line, was evacuated from the main along Grey Pointe Drive to facilitate pressure testing of the natural gas main. The natural gas main serving 9134, 9140, and 9146 Grey Pointe Drive was air pressure tested on site as a single unit. The unit did not pass, as was expected given the natural gas leak and fire found at the northeast corner of the property the night of the accident. (*See* Attachment 3, pg. 2). Further pressure testing the following day helped isolate the source of the leak (see below).

On December 11, 2009, Mr. Phillips, accompanied by Tom Woosley, GPSD Gas Pipeline Safety Engineer/Trainer, returned to the site to monitor KUB's investigation. KUB exposed the electrical service line, the water service line, and the crushed stone envelope over the sanitary sewer lateral where these utilities crossed the natural gas main. This allowed KUB to determine the approximate vertical location of each buried utility (*See* Attachments 5 and 6). At the street right-of-way, all services except for sewer were located above the natural gas main. Where the water line and sewer lateral entered the home was lower in elevation than the natural gas main, and the electrical conduit was approximately 2' above the natural gas main. In addition to their relative depth in the soil, the lines were all separated horizontally. The natural gas and electric service lines ran from the street into the northeast side of the house, and the water and sewer service lines ran from the street into the front northwest corner of the house. (*See* Attachment 6).

KUB segmented the disconnected length of main into three sections, each consisting of a short section of main and a service line. KUB pressure tested each section by back-feeding air through the service lines to mitigate interference from excess flow valves (EFVs).

The two neighboring sections passed the pressure tests, but the section of main and service line that had served address 9140 did not. It was observed that air from the pressure test was being released between the upper half of the service tee fitting and the top of the natural gas main. Further examination revealed that two of the four nylon bolts clamping the tee to the main were broken, although KUB could not determine whether the bolts broke before or because of the explosion. KUB preserved this section of main for further testing (*See* Attachment 3, pg. 3 and Attachments 7 and 8).

As this section was being removed, it was noted that the service tee's cutter and saddle assembly was not holding the tee in position. With the KCSD's approval and with GPSD engineers present, KUB collected the meter, the regulator, the riser, the service line, and the service tee, along with approximately twenty feet of the main. An evidence tag was affixed, a chain of custody was completed for each item, and the items were taken to a KUB facility for secure storage (*See* Attachment 3, pg. 3).

KUB's records showed that natural gas service to address 9140 was installed in June 1999. Leakage surveys were performed along Grey Pointe Drive in 2000 and 2005; no leaks were

found at address 9140. A search found no leak calls for that address or adjacent properties. There was no record of a service call other than for initial service and meter installation in 1999 and conversion to automated meter reading on July 14, 2009. KUB's review of Tennessee 811 records found no indications of recent excavation activities near the natural gas main and service connection at the accident site (*See* Attachment 3, pg. 3).

The follow-up and final incident report from KUB concluded that:

> KUB experienced a fitting failure at the service tee connection, which was approximately fifty feet from the Krzeski structure. KUB verified odorant levels were within regulated limits and verified records to ensure no reports of natural gas odor prior to the explosion. In addition, the soil located around utilities leading to and penetrating the structure was compacted and consisted of high clay content. As the result of KUB's investigation, KUB cannot determine if the natural gas incident (i.e. the uncontrolled release of natural gas at the northeast corner of 9140 Grey Point Drive) preceded the explosion or resulted from the explosion. Attached is our final Incident Report indicating the KUB investigation is complete and the apparent cause of the natural gas incident is unknown.

(*See* Attachments 9 and 10).

THIRD PARTY TESTING

KUB sent the removed section of main, including the service tee, to Engineering Systems, Inc. (ESI) for examination. X-rays of the service tee taken by ESI showed the cutter assembly was not penetrating the main. The materials noted consisted of one-half inch PE 2406 Plexico polyethylene pipe, two inch PE 2406 Plexico polyethylene pipe, and a Perfection Permalock Tee, Tapping Medium Density Polyethylene Pipe (MDPE) two inches by one-half inch IPS Mechanical. ESI's report, dated May 25, 2010, states that "it is not possible to determine whether the broken bolts on the back side of the Perfection Corp. Permalock® tapping tee were broken prior to the explosion of December 9, 2009 or as a result of that event" (*See* Attachment 11, pg. 4). Additional testing by Test America determined that air space samples taken at the accident site on January 14, 2010 by APR Consultants showed no presence of the components of natural or sewer gas (*See* Attachment 12).

GPSD INVESTIGATION AND ANALYSIS

GPSD reviewed KUB records to determine whether an unacceptable level of risk existed at the time of the accident. GPSD focused on anomalies identified during site observations, briefings by KUB, and reports issued by KUB, KCSD, and consultants. The anomalies identified at the site include the discovery of broken bolts on the bolt-on saddle service tee and the detection of leaks by pressure testing the service line. This particular tee connected natural gas service to the residence at address 9140 and was located a short distance from the water service and sewer lines leading to the basement of the residence where the explosion occurred.

Bolt-on Saddle Service Tee Configuration

Between 1997 and 2001, KUB purchased and private contractors installed approximately 1,875 bolt-on saddle service tees (the type used here is also called a mechanical tapping tee) manufactured by Perfection Corporation under the brand name Perfection Permalock® tapping tees. The tapping tee consists of an upper half and a lower half that fit together around the main. Four nylon bolts, when tightened, cause the halves to fasten around the outer surface of the main. A rubber o-ring located at the base of the tee tower on the upper half is compressed between the outer surface of the main and the base of the tee tower, forming a seal between the exterior of the main and the interior of the tee tower. In addition to the bolt assembly, there is a cutting mechanism which, when locked into place, also serves to secure the mechanical tapping tee to the main. Since this fitting has a double locking feature as noted by the manufacturer, either the bolts or the cutter must be properly in place, and preferably both, to avoid a leak.

Testing of the Affected Bolt-on Saddle Service Tapping Tee

The bolts that broke at address 9140 were positioned on the house side of the main away from the tee outlet. ESI could not determine whether the bolts broke before or because of the explosion. As discussed later in this report, GPSD believes that the discovery of broken or missing bolts on fittings of this type during leak repairs prior to the explosion and the discovery of broken or missing bolts on fittings which were removed by KUB after the explosion support GPSD's conclusion that it is likely that the bolts at address 9140 broke before the explosion. It was also noted that x-rays of the fitting revealed that the cutting assembly had not penetrated the main, indicating that the tee was not properly installed. Failure of the bolts coupled with the improper installation of the cutting assembly could have led to the uncontrolled release of pressurized natural gas at the tee.

The GPSD's Review of Leak Data and Reports

The GPSD reviewed available leak report and repair data for bolt-on saddle service tees installed in KUB's system, including KUB Bureau of Gas leak reports, field activity forms, and field order forms from 2000 through 2009, as well as information from leak surveys in 2002 and 2008. Leak call reports from between 2000 and 2009 record 158 gas leaks associated with tees of this type.

KUB conducted periodic leak surveys on its entire distribution system to comply with the MFSS. In 2002, the periodic survey of 20% of KUB's system found 3 leaks on mechanical tapping tees, which were repaired. The last periodic survey prior to the accident was performed in 2005; this survey included the location where the explosion occurred and reported no leaks at that location.

According to KUB, in 2008, KUB reviewed its leak report forms and noted comments from construction employees who reported on the condition of the saddle tees where leaks occurred. Thirty-seven comments, or approximately 23.49% of the total of 158, indicated that the tees appeared to have broken, loosened, were missing bolts or showed other construction or material

defects.[1] After reviewing these comments and interviewing the employees, KUB followed up by conducting a targeted leak survey of approximately twenty-two miles of gas main and 1,925 service tees in subdivisions where KUB believed that bolt-on saddle service tees had been installed. This targeted survey identified one grade 3 leak on a bolt-on saddle service tee, and the tee was replaced. Following the survey, KUB concluded that no further actions were necessary. As discussed in last section of this report, KUB did not report these comments from construction employees or the utility's response to the GPSD.

In its annual reports to PHMSA, KUB included leaks on mechanical tapping tees under the category "Leaks on Services," which includes both below-ground and above-ground leaks of all material types. As part of its investigation of the explosion, the GPSD requested that KUB provide a breakdown of service line leaks to better analyze the mechanical tapping tee failures in relation to other failures on service lines. The following table shows the annual totals for all leaks on services, comparable leaks on services (excluding leaks resulting from Excavation, Corrosion or Equipment cause codes), and the total number of mechanical tapping tee leaks for the years 2000 through 2009. The table also shows the percentage of mechanical tapping tee leaks as compared to the total leaks on services and as compared to the comparable leaks on services for the same time frame.

[1] Comments include, for example: "bolt on saddle broken off main," "bolt on saddle blown off 2" main," "bolt on saddle that had blown ½ way off," "bolt on saddle had blown off," "found 2" x ½" bolt on saddle blown off main" and "bolt on saddle came off 2" plas. main." Other reports listed "construction defect" or "material failure" as the cause of the leak. Based upon these comments, KUB conducted interviews with the employees for further clarification. Crew members indicated that bolts were broken and/or the tee could be dislodged from the main.

Leaks	Year										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Leaks on Services	962	983	762	945	1003	658	999	1192	968	856	9328
Comparable Leaks on Services*	367	469	292	508	516	179	422	377	397	456	3983
Mechanical Tapping Tee Leaks	7	17	23	16	20	18	16	15	15	15	162
Mechanical Tapping Tee Leaks - % of Leaks on Services	0.7%	1.7%	3.0%	1.7%	2.0%	2.7%	1.6%	1.3%	1.5%	1.8%	1.7%
Mechanical Tapping Tee Leaks - % of Comparable Leaks on Services*	1.9%	3.6%	7.9%	3.1%	3.9%	10.1%	3.8%	4.0%	3.8%	3.3%	4.1%

*Note - Below-ground leaks include leaks in the following PHMSA Cause Codes: Other Outside Force, Operations, Materials or Welds, Natural Forces, Other. The PHMSA cause codes for Excavation, Corrosion and Equipment were excluded from this number.

As shown in the table, a total of 162 tees of this manufacture were replaced because of leaks between 2000 and the date of the explosion. Those 162 mechanical tapping tees represent approximately 1.7% of the total of 9,328 reported leaks on services, and 4.1% of below-ground leaks (excluding Excavation, Corrosion or Equipment cause codes). The 162 mechanical tapping tees represent 8.6% of the approximately 1,875 Perfection Permalock® mechanical tapping tees installed in KUB's distribution system beginning in 1997.

The next part of the GPSD's investigation focused on reports completed during the tee replacement program initiated by KUB after the accident. The forms for these reports included a drawing of a bolt-on saddle service tee so that the user could note any missing or broken bolts, cap status, and cutter position. The GPSD reviewed 543 of these reports and found that 220 indicated broken or missing bolts or improper cutter position. Based on these numbers, approximately 40.5% of the bolt-on saddle service tees showed an abnormal operating condition when exposed. When excavation is to take place within the specified tolerance zone, an excavator exercises such reasonable care as may be necessary for the protection of any underground facility as it is exposed. The KUB Fitting Replacement Report, Section 2, included an item ('Hand Dig') for checking when this method of excavation was employed during exposure of underground facilities. Hand digging is an excavation method practiced in the effort to protect an underground facility during exposure by excavation. The reports indicate that personnel performing the covered task of excavation were using appropriate techniques to avoid damage to the bolt-on saddle service tees and natural gas piping as they were exposing for replacement. GPSD believes that the information in the reports tends to support GPSD's conclusion that the likely cause of the explosion was a leak in the bolt-on saddle tee located at

address 9140 and that the leak was caused by the broken bolts and/or improper position of the cutting assembly.

On March 26, 2008, PHMSA issued Advisory Bulletin ADB-08-02 concerning safety issues associated with mechanical couplings used in natural gas distribution systems. ADB-08-02 includes the following summary:

> Recent events concerning failures of mechanical couplings and related appurtenances have raised concerns about safety in natural gas distribution systems. This notice updates information provided in Advisory Bulletin ADB-86-02 and advises owners and operators of gas pipelines to consider the potential failure modes for mechanical couplings used for joining and pressure sealing two pipes together. **Failures can occur when there is inadequate restraint for the potential stresses on the two pipes, when the couplings are incorrectly installed or supported, or when the coupling components such as elastomers degrade over time. In addition, inadequate leak surveys which fail to identify leaks requiring immediate repair can lead to more serious incidents.** This notice urges operators to review their procedures for using mechanical couplings and ensure coupling design, installation procedures, leak survey procedures, and personnel qualifications meet Federal requirements. Operators should work with Federal and State pipeline safety representatives, manufacturers, and industry partners to determine how best to resolve potential issues in their respective state or region. Documented repair or replacement programs may prove beneficial to all stakeholders involved.

GPSD CONCLUSIONS

Likely Cause of Explosion

Although KCSD's fire investigation report lists the cause of the explosion and fire as undetermined, the report further states that "the most likely cause of the destruction at this location is from natural gas traveling most likely underground along the water line into the basement..." (*See* Attachment 13). Based on direct observation, photographs, reports, leak and repair records, and operator responses immediately following the accident and during subsequent investigations, the GSPD concurs with this assessment, although there is no certainty as to which utility line was actually followed by the migrating natural gas.

A pressure test of the detached segment of service line and main revealed a leak between the outer surface of the main and the top half of the tee. Natural gas migrating from this leak likely entered the house through a utility penetration of the basement wall or floor, reached the LEL, and came into contact with an ignition source.

KUB personnel observed that the soil surrounding the affected service line "appeared to be uniform, high in clay content, and saturated." GPSD inspectors observed that the soil was highly compacted and difficult to dig by hand. These observations strongly suggest that the leaking

natural gas was not absorbed into the soil but rather was forced into the pathway created by the envelope or void surrounding another utility line.

Natural gas leaking below the ground would be expected to follow the path of least resistance, which much of the time would be upward through the soil since gas is lighter than air. Impervious surfaces, such as asphalt or concrete pavement, can prevent gas from venting to the air and redirect it along another path below the surface. This kind of migration can happen in soils that are frozen or wet, but it can also happen in other soils with characteristics that tend to redirect the flow of gas. The pathway of migrating natural gas can also be affected by the pressure and volume of the escaping natural gas.

In an advisory bulletin describing a propane gas incident, the Research and Special Programs Administration (RSPA) of the USDOT reached a similar conclusion about the effect of highly compacted soils. In ADB-02-05, released on September 9, 2002, RSPA states: "Wet or frozen soils can effectively cap an area of leaking gas and cause gas that had been venting through the soil into the air to be redirected along underground utility lines or through loosely compacted soils into structures, especially basements." While this bulletin describes a propane gas incident and propane gas tends to sink, not rise like natural gas, the incident demonstrates that wet or frozen soil conditions, such as those observed at the accident site, can redirect gas along an underground utility line. This can occur whether the gas is propane or natural gas.

In this case, one possible pathway was the sewer service line; it was enveloped in crushed stone for a portion, or perhaps all, of the length of the service to the house, which forms many void spaces through which gas can migrate. Another possible pathway was the water line, which penetrated the basement wall of the house through a polyvinylchloride (PVC) sleeve or casing pipe. The annular space between the carrier pipe and the PVC casing pipe was a possible path for migrating gas to travel through the basement wall.

It is likely, therefore, that the soil above the utility service lines acted as a cap and forced most of the escaping gas to migrate along the sewer line or the water line. As the gas continued to flow, it migrated along the path of least resistance to and through a wall or slab penetration and into the basement. Once the concentration of gas in air reached the LEL (4 to 5%), an undetermined ignition source caused the gas to explode and start the fire.

The results of KUB's bar hole leak surveys might seem to weigh against a definite conclusion pointing to a leaking tee at address 9140, since residual gas was detected, not at that location, but along the main in front of address 9146. Further analysis, however, shows that the conclusion remains sound.

The surveys detected a reading of 10% of the LEL at the gas main in front of address 9146 and of 5% at the next location, just southwest and at a greater distance from address 9140 (*See* Attachment 5). All other readings at locations northeast and southwest of these two were 0% of the LEL. It might appear, therefore, that there was a leak on either the main line or the service line in the immediate area where the residuals were found.

However, based on the successful pressure test of the main and service line for address 9146, it is not likely that the residual gas came from a leak in the immediate area where residuals were found. The gas must have reached this area from a leak on a part of the main or service line other than the section removed from address 9146. The most likely source was the leaking tee for address 9140, from which the residual gas migrated along a path not detected by the bar hole leak survey, most likely into the crushed stone envelope surrounding the sewer line at the point where the gas main line crossed the sewer line to address 9140. Attachment 5 shows the likely migration path within the crushed stone envelope along the sewer service line to address 9140, from that point along the sewer main and the sewer service line to the envelope at address 9146, and from that point to where the residuals were found.

In the absence of additional testing data showing the migration path of the residual gas to those locations, the fact that residual gas was found only in front of address 9146, therefore, does not alter the GPSD's conclusion that gas migrating through a space created by an intersecting utility line entered the basement of the residence at address 9140 and ignited. Nor does it alter the GPSD's conclusion that the gas escaped because a broken bolt-on saddle service tee connecting the gas main and the service line to address 9140 had caused the connection to fail.

KUB Actions Immediately Following the Accident

KUB responded appropriately to the accident. KUB took appropriate steps to make the area safe to protect life and property, including dispatching a first responder at first notification from E911, closing valves to stop the flow of natural gas, conducting leak surveys to identify any migration of natural gas below ground, and verifying odorant levels. KUB duly notified the GPSD of the accident and submitted an incident report to PHMSA (*See* Attachment 1). KUB also conducted a bar hole leak survey, pipe pressure testing, air space testing, and materials testing with assistance from an outside laboratory.

Subsequent KUB Actions

Three months after the incident (in March, 2010), KUB initiated a pilot project to locate, expose, and replace mechanical tapping tees in its distribution system. By July 2010, a full-scale replacement program was underway. In order to find and replace the approximately 1,875 mechanical tapping tees KUB had purchased between 1997 and 2001 (when these fittings were being installed on the system), KUB had to excavate approximately 12,000 service connections. KUB puts direct costs for the replacement project at approximately $4,000,000, but this figure does not include salary and benefits for KUB employees assigned to the project. According to Ms. Sinclair, KUB completed the replacement program by July 1, 2011 and, to the best of the company's knowledge, no mechanical tapping tees remain in service in its distribution system. Regardless of the cause of the explosion, the mechanical fitting failed at some point. KUB's decision following the accident to remove all mechanical tapping tees from its distribution system as quickly as possible was in the best interest of public safety.

RESPONSE AND CONCLUSIONS OF KUB

Based on the analysis described above, GPSD has reached certain conclusions about the likely cause of the explosion. KUB does not agree with these conclusions and has submitted a response including its own analysis and conclusions, which follows below. It should be noted that while GPSD and KUB disagree on the likely cause of the explosion, the decision of the GPSD to require changes in KUB's reporting requirements, as described in the final section of this report, is not based on any conclusion about the cause of the accident.

KUB's Response Concerning the Likely Cause of the Explosion

Although KCSD's fire investigation report lists the cause of the explosion and fire as undetermined, the report further states that "the most possible cause of the destruction at this location is from natural gas traveling most likely underground along the water service line into the basement and into the room listed as Utility or mechanical room and finding an ignition source."

However, the results of KUB's bar hole leak surveys weigh against this conclusion, as there was no residual natural gas detected in bar hole surveys at 9140 Grey Pointe Drive, as would have been expected had this been the path of the natural gas into the structure.

Additionally, the conclusion that natural gas would have migrated down the water service line, or any other utility line connecting to the house, instead of up through the soil, is inconsistent with the known properties of natural gas, *i.e.*, natural gas is lighter than air, and its path of least resistance will generally be up, not down. There were several other ground penetrations for lighting, a water meter, a pad-mounted transformer, and an irrigation system that would have more easily served as outlets for a leaking natural gas service line.

Although the water service line was located slightly above the natural gas main at the street, they are separated horizontally, and ultimately the water service line does descend to a lower depth than the natural gas service line as it penetrates the house. If leaking natural gas were somehow prevented from migrating upward through the soil, it could find a preferential path along a water service line given the right conditions. However, those conditions did not exist in this case. The water service line was found to be encased in tightly packed clay soil, with no sleeving or rock bedding to serve as a preferential pathway for natural gas. That makes it an unlikely route for natural gas to enter the home.

Although the sewer lateral was bedded in crushed stone (at least at the street – this line was not excavated all the way to the house), it was four feet beneath the natural gas main, including a two foot layer of tightly packed clay soil. In order for the sewer lateral to serve as the preferential pathway, the natural gas would have had to migrate approximately 50' along the natural gas main; it would have had to pass through the tightly packed clay soil, and the sewer lateral would need to be bedded in rock all the way to the house, which is not a typical construction practice in this area. There were no scorch or burn marks identified on the sewer lateral, which would have also been expected had it served as the pathway for the natural gas into the house.

Another factor is the distance between the natural gas main and the house itself. For any of these utility lines to serve as the pathway for natural gas into the house, the conditions discussed above would have to be in place all the way from the source of the leak to the house, forcing the natural gas down and through the soil. The chances that this would happen over the approximately 50 feet from the main to the house, without the natural gas migrating to an easier path to the atmosphere, seems unlikely. It is important to note that in addition to the movement of natural gas along to the natural gas main to the west, any escaping natural gas would migrate to the east as well if conditions did not allow for migration up through the top soil and out to the ground surface.

Furthermore, the fact that first responders identified a natural gas leak on fire at the corner of the property near the mechanical tapping tee demonstrates that the natural gas did in fact have a preferential path upward through the soil profile, and not downward through the soil. Although a path along a utility line into the structure is a possible theory, KUB submits that the GPSD's attempts to support that theory with the evidence available have been inconclusive. In summary, KUB concurs with the KCSD's assessment that the ultimate cause of the December 9, 2009 fire and explosion remains "undetermined".

KUB's Response Concerning Reporting Failures of Bolt-On Saddle Tees

With regard to GPSD's statement about the significance of any missing or broken bolts on mechanical tees discovered during pre-explosion repairs or post-explosion removal efforts, KUB believes the agency has not considered the very low percentage of actual leaks found, the effect of likely damage during the removal process itself, or the results of the only scientifically conducted third party testing which was carried out in 2010 by ESI on behalf of KUB. Further, any consideration of remedial actions taken by KUB would not be allowed in litigation proceedings and is inappropriate here.

Regarding the 2007 leak reports, KUB feels that its interviews with the employees involved, the leak survey targeted to identify leaks on mechanical tapping tees, and the fact that only one leak was found supports the conclusion that no further action was warranted at that time. As for the broken bolts found on tapping tees during the replacement program, it is important to recognize that excavating down to and around these saddles was necessary in order to remove them and that none of the mechanical tapping tees removed by KUB as part of the replacement program were leaking prior to being uncovered as part of that project.

The inclusion of Advisory Bulletin ADB-08-02 by GPSD in their report is puzzling since it is focused on mechanical couplings that do not include the mechanical tapping tee at issue in this incident. Accordingly, KUB does not believe this Bulletin is relevant to this report.

Finally, GPSD asserts that by not providing detailed descriptions of failures of these mechanical tapping tees "at the time," KUB in effect deprived GPSD of the opportunity for independent review and assessment that could have been used to assist other pipeline operations in identifying and mitigating risks in their system associated with such devices. KUB would simply note that such information has now been known by the agency for a significant period of time and that to date GPSD has not taken any action with the utilities under their supervision prohibiting

mechanical tapping tees which are (in the words of the agency) "... still commonly used by other gas distribution entities in Tennessee."

VIOLATION AND CORRECTIVE ACTIONS

KUB does not dispute that KUB was in violation of 49 C.F.R. § 192.517 in that:

> KUB did not have appropriate documentation that the natural gas service line installed at 9140 Grey Pointe Drive was properly inspected and pressure tested at the time of installation.

For this violation, GPSD proposes a civil penalty of $20,000. This amount takes into consideration KUB's remedial actions in replacing all mechanical tapping tees at an approximate cost of more than $4,000,000, and KUB's compliance with the following steps which are designed to insure that, from this time forward, KUB will report to the GPSD information about an apparent pattern of equipment failures which may assist the GPSD in determining whether further action is appropriate.

Reporting on Failures of Bolt-On Saddle Tees

Rule 49 C.F.R. § 192.617 states:

> Each operator shall establish procedures for analyzing accidents and failures, including the selection of samples of the failed facility or equipment for laboratory examinations, where appropriate, for the purpose of determining the causes of the failure and minimizing the possibility of a recurrence.

There is no express requirement in § 192.617 that KUB notify the GPSD of an equipment failure including any potential pattern of similar failures. Although KUB submits that the utility took substantial and appropriate steps on its own to investigate the information received from contractors about these failures, it is the opinion of GPSD that KUB should have shared this information with the GPSD at the time. However, given KUB's internal investigation and follow-up after reviewing the comments about prior failures, the GPSD finds no violation of § 192.617.

While mechanical tapping tees are no longer being used by KUB, it should be emphasized that they are still commonly used by other gas distribution entities in Tennessee. Had the detailed descriptions of failures of these mechanical tapping tees as described in comments from KUB construction personnel been provided to the GPSD at the time, the GPSD would have had the opportunity to offer an independent review and assessment that could have been used by the GPSD in assisting KUB or other pipeline operators in identifying and mitigating risks in their systems. In the future, KUB should put measures in place to ensure more timely and detailed communication with the GPSD on matters of this nature. Since the explosion, additional Distribution Integrity Management Program (DIMP) regulations have been promulgated formalizing these requirements. Therefore, in compliance with the amended DIMP requirements

within § 192.1007 (a-c), KUB is directed to develop written procedures requiring the consideration of reasonably available information gained from past design, operations and maintenance (O&M activities, field surveys, One-Call information, excavation damage, and etc.) to identify and characterize primary threats. For those primary threats characterized as "system-wide", KUB must amend their procedures to provide more timely and detailed communication with the GPSD. Failure to follow this procedure(s) in the future would be considered a violation of § 192.617.

Additional Corrective Actions

In compliance with the amended DIMP requirements within § 192.1007 (a-c) and as summarized above, KUB is directed to provide additional detail including, but not limited to, the following:

- Identify the position(s) of the individual(s) who will be responsible for insuring that all of the following requirements are met;
- Identify specific records and other sources of information that will be reviewed in complying with § 192.617 and § 192.1007 (a-c);
- Identify the position(s) of the individual(s) responsible for review of each record and/or other source of information;
- Identify the manner in which KUB will use the information obtained from each source;
- Prepare and submit to the GPSD a plan for developing the aforementioned procedures and providing the information regarding the procedures no later than 180 days from the TRA Director's approval of this report.
- Review existing Operator Qualification training modules related to the installation and inspection of mechanical fittings currently installed by KUB. Update modules as necessary to ensure proper installation, use of tools and equipment, and inspection.
- Work with the GPSD to develop and implement a training program, at KUB's expense, to share KUB's knowledge and experience gained from replacing mechanical fittings and KUB's process for the selection and supervision of private contractors.

ATTACHMENT 1

NOTICE: This report is required by 49 CFR Part 191. Failure to report can result in a civil penalty not to exceed $100,000 for each violation for each day the violation continues up to a maximum of $1,000,000 for any related series of violations as provided in 49 USC 60122. Form Approved OMB No. 2137-0522

U.S. Department of Transportation
Research and Special Programs Administration

INCIDENT REPORT - GAS DISTRIBUTION SYSTEM

[redacted]

Important: *Please read the separate instructions for completing this form before you begin. They clarify the information requested and provide specific examples. If you do not have a copy of the instructions, you can obtain one from the Office Of Pipeline Safety Web Page at .*

Check: [x] Original Report [ ] Supplemental Report [ ] Final Report

1. Operator Name and Address

a. Operator's 5-digit Identification Number 10310

b. If Operator does not own the pipeline, enter Owner's 5-digit Identification Number

c. Name of Operator KNOXVILLE UTILITIES BOARD

d. Operator street address 4505 MIDDLEBROOK PIKE

e. Operator address KNOXVILLE KNOX TN 37921
City, County or Parish, State and Zip Code

2. Time and date of the incident
0315 hr. 12/09/2009 month day year

3. Incident Location
a. 9140 GREY POINTE DRIVE
Street or nearest street or road
b. KNOXVILLE KNOX
City and County or Parish
c. TN 37922
State and Zip Code
d. Latitude: 3587737 Longitude: -8405654
(If not available, see instructions for how to provide specific location)
e. Class location description
○ Class 1 ○ Class 2 ○ Class 3 ● Class 4
f. Incident on Federal Land ○ Yes ● No

4. Type of leak or rupture
○ Leak ○ Pinhole ○ Connection Failure *(complete sec. F5)*
○ Puncture, diameter or cross section *(inches)* ____
○ *Rupture (if applicable):*
○ Circumferential - Separation
○ Longitudinal
- Tear/ Crack, length *(inches)* ____
- Propagation Length, total, both sides *(feet)* ____
○ N/A
● Other: UNDETERMINED - SEE ATTACHMENT

5. Consequences *(check and complete all that apply)*
a. [ ] Fatality Total number of people: 0
Employees: 0 *General Public:* 0
Non-employee Contractors: 0
b. [ ] Injury requiring inpatient hospitalization
Total number of people: 0
Employees: 0 *General Public:* 0
Non-employee Contractors: 0
c. [x] *Property damage/ loss (estimated)* Total $ 55000
Gas loss $ 5000 Operator damage $ 50000
Public private property damage $ 0
d. [x] Gas ignited ○ Explosion ● No Explosion
e. [ ] Gas did not ignite ○ Explosion ○ No Explosion
f. [x] Evacuation *(general public only)* 8 people
Evacuation Reason:
○ Unknown
● Emergency worker or public official ordered, precautionary
○ Threat to the public
○ Company policy

6. Elapsed time until area was made safe:
1 hr. 20 min.

7. Telephone Report
925621 NRC Report Number 12/09/2009 month day year

8. a. Estimated pressure at point and time of incident:
55 *PSIG*
b. Max. allowable operating pressure *(MAOP):* 60 *PSIG*
c. MAOP established by:
● Test Pressure 100 psig
○ 49 CFR § 192. 619 (a)(3)

CHRISTIAN M. SPENCER
(type or print) Preparer's Name and Title
8655582827
Area Code and Telephone Number

Preparer's E-mail Address
8655582484
Area Code and Facsimile Number

Authorized Signature (type or print) Name and Title Date Area Code and Telephone Number

1. Incident occurred on
○ Main ○ Meter Set
○ Service Line ● Other: SERVICE TEE
○ Pressure Limiting and Regulating Facility

2. Failure occurred on
○ Body of pipe ○ Pipe Seam
○ Joint ● Component
○ Other: _____

3. Material involved *(pipe, fitting, or other component)*
○ Steel
○ Cast /Wrought Iron
● Polyethelene Plastic (complete all items that apply in a-c)
○ Other Plastic (complete all items that apply in a-c)
Plastic failure was: ☐ a.ductile ☐ b.brittle ☐ c.joint failure
○ Other material: _____

4. Year the pipe or component which failed was installed: 1999

1. Nominal pipe size *(NPS)* _____ in.
2. Wall thickness _____ in.
3. Specification _____ SMYS
4. Seam type _____
5. Valve type _____
6. Pipe or valve manufactured by _____ in year

1. Area of Incident
○ Under pavement
● Under ground
○ Inside under building
○ In open ditch
○ Above ground
○ Under water
○ Other: _____

2. Depth of cover: 60 inches

Important: There are 25 numbered causes in this section. Check the box to the left of the primary cause of the incident. Check one circle in each of the supplemental items to the right of or below the cause you indicate. See the instructions for this form for guidance.

F1 – CORROSION

If either F1 (1) External Corrosion, or F1 (2) Internal Corrosion is checked, complete all subparts a – e.

1. ○ External Corrosion

a. Pipe Coating
○ Bare
○ Coated
○ Unknown

b. Visual Examination
○ Localized Pitting
○ General Corrosion
○ Other: _____

c. Cause of Corrosion
○ Galvanic ○ Stray Current
○ Improper Cathodic Protection
○ Microbiological
○ Other: _____

d. Was corroded part of pipeline considered to be under cathodic protection prior to discovering incident?
○ No ○ Yes ○ Unknown Year Protection Started:

2. ○ Internal Corrosion

e. Was pipe previously damaged in the area of corrosion?
○ No ○ Yes ○ Unknown How long prior to incident: _____ *years* _____ *months*

F2 – NATURAL FORCES

3. ○ Earth Movement ⇒ ○ Earthquake ○ Subsidence ○ Landslide ○ Other: _____
4. ○ Lightning
5. ○ Heavy Rains Floods ⇒ ○ Washouts ○ Flotation ○ Mudslide ○ Scouring ○ Other: _____
6. ○ Temperature ⇒ ○ Thermal stress ○ Frost heave ○ Frozen components ○ Other: _____
7. ○ High Winds

F3 – EXCAVATION

8. ○ Operator Excavation Damage *(including their contractors)* / Not Third Party

9. ○ Third Party Excavation Damage *(complete a-d)*

a. Excavator group
○ General Public ○ Government ○ Excavator other than Operator subcontractor

b. Type: ○ Road Work ○ Pipeline ○ Water ○ Electric ○ Sewer ○ Phone/ Cable Fiber ○ Landowner ○ Railroad
○ Building Construction ○ Other: _____

c. Did operator get prior notification of excavation activity?
○ No ○ Yes: Date received:
Notification received from: ○ One Call System ○ Excavator ○ General Contractor ○ Landowner

d. Was pipeline marked?
○ No ○ Yes *(If Yes, check applicable items i – iv)*
i. Temporary markings: ○ Flags ○ Stakes ○ Paint
ii. Permanent markings: ○ Yes ○ No
iii. Marks were *(check one)* ○ Accurate ○ Not Accurate
iv. Were marks made within required time? ○ Yes ○ No

F4 – OTHER OUTSIDE FORCE DAMAGE

10. ○ Fire/Explosion as primary cause of failure ⇒ Fire Explosion cause: ○ Man made ○ Natural *Describe in Part G*
11. ○ Car, truck or other vehicle not relating to excavation activity damaging pipe
12. ○ Rupture of Previously Damaged Pipe
13. ○ Vandalism

F5 – MATERIAL OR WELDS

Material

14. ○ Body of Pipe ⇒ ○ Dent ○ Gouge ○ Wrinkle Bend ○ Arc Burn ○ Other: _____

15. ◙ Component ⇒ ○ Valve ○ Fitting ○ Vessel ○ Extruded Outlet ○ Other: _____

16. ○ Joint ⇒ ○ Gasket ○ O-Ring ○ Threads ○ Fusion ○ Other: _____

Weld

17. ○ Butt ⇒ ○ Pipe ○ Fabrication ○ Other: _____

18. ○ Fillet ⇒ ○ Branch ○ Hot Tap ○ Fitting ○ Repair Sleeve ○ Other: _____

19. ○ Pipe Seam ⇒ ○ LF ERW ○ HF ERW ○ DSAW ○ SAW ○ Seamless ○ Spiral ○ Flash Weld ○ Other: _____

Complete a-f if you indicate any cause in part F5.

a. Type of failure:
Construction Defect ⇒ ○ Poor Workmanship ○ Procedure not followed ○ Poor Construction Procedures
Material Defect

b. Was failure due to pipe damage sustained in transportation to the construction or fabrication site? ○ Yes ○ No

c. Was part which leaked pressure tested before incident occurred? ○ Yes, *complete d-f, if known* ○ No

d. Date of test: *//*

e. Time held at test pressure: _____ hr.

f. Estimated test pressure at point of incident: _____ *PSIG*

F6 – EQUIPMENT OR OPERATIONS

20. ○ Malfunction of Control /Relief Equipment ⇒ ○ Valve ○ Instrumentation ○ Pressure Regulator ○ Other: _____

21. ○ Threads Stripped, Broken Pipe Coupling ⇒ ○ Nipples ○ Valve Threads ○ Mechanical Couplings ○ Other: _____

22. ○ Leaking Seals

23. ○ Incorrect Operation

a. Type: ○ Inadequate Procedures ○ Inadequate Safety Practices ○ Failure to Follow Procedures ○ Other: _____

b. Number of employees involved in incident who failed post-incident drug test: _____ Alcohol test:

c. Was person involved in incident qualified per OQ rule? ○ Yes ○ No d. Hours on duty for person involved:

F7 – OTHER

24. ○ Miscellaneous, *describe:* _____

25. ● Unknown

○ Investigation Complete ● Still Under Investigation *(submit a supplemental report when investigation is complete)*

PART H – NARRATIVE DESCRIPTION OF THE INCIDENT *(Attach additional sheets as necessary)*

SEE ATTACHED.


ATTACHMENT 2

ATTACHMENT 3

Knoxville Utilities Board

January 8, 2010

Mr. Larry Borum
Chief – Gas Pipeline Safety Division
Tennessee Regulatory Authority
460 James Robertson Parkway
Nashville, Tennessee 37243-0505

Dear Mr. Borum:

At approximately 3:00 am on December 9, 2009, a single family structure was destroyed by an explosion of unknown origin at 9140 Grey Pointe Drive in west Knox County, Tennessee 37922, herein referred to as the explosion site. The cause of the explosion is still under investigation. As a result of the explosion, there was one fatality and two injuries requiring hospitalization. At this time, it has not been determined whether or not the natural gas incident on Knoxville Utilities Board's (KUB) natural gas distribution system (described in the following paragraph) preceded the explosion or resulted from the explosion.

REPORTABLE INCIDENT: In response to notification by E911, KUB dispatched personnel to the scene. Upon arrival, it was observed that the structure was destroyed; multiple areas within and around the structure foundation were on fire. In addition, an uncontrolled release of natural gas was afire at the northeast corner of 9140 Grey Pointe Drive, approximately fifty feet from the structure. In the opinion of KUB, the natural gas incident was significant as defined by *49 Code of Federal Regulations Part 191* because the cause of the explosion remains undetermined. In compliance with its requirements and those of the Tennessee Regulatory Authority (TRA), KUB is submitting the following preliminary natural gas incident report. All times are represented in Eastern Standard Time (EST).

DESCRIPTION OF EXPLOSION: The three-story brick structure at 9140 Grey Pointe Drive was destroyed by an explosion creating a debris pattern that extended approximately 200 feet and was comprised of small pieces of material from the structure. Multiple areas of fire were observed at the explosion site including within the residential structure footprint. In addition to the explosion, a natural gas incident (i.e., an isolated fire) was observed above the natural gas distribution line near the northeast corner of 9140 Grey Pointe Drive.

The estimated property damage to KUB facilities as a result of the natural gas incident is approximately $55,000. The estimated property damage to the structure at 9140 Grey Pointe Drive and adjacent properties as a result of the explosion are in excess of $1,000,000.

EMERGENCY ACTION TAKEN: On Wednesday, December 9, 2009, KUB received a call from E911 at 3:14 am reporting an explosion and house fire at 9117 Hailes Abbey Lane. The weather was 40 degrees Fahrenheit and clear. KUB confirmed natural gas service was in the area and dispatched a first responder to the address in Whittington Creek Subdivision at 3:21 am. Rural/Metro (RM) was on the scene when KUB's first

responder arrived at 3:45 am to check in at RM's command center. RM reported there was a smell of natural gas in the area and asked KUB to close valves to isolate the natural gas system from the explosion site. KUB was directed to shut off natural gas to Hailes Abby Lane, and KUB's first responder immediately proceeded to operate valves to stop natural gas flow affecting 43 residential customers. By this time, KUB received additional information that the actual explosion had taken place on Grey Pointe Drive, one street north of Hailes Abby Lane. KUB immediately operated natural gas valves shutting off natural gas to 11 additional residential customers including 9140 Grey Pointe Drive. KUB operated a total of three natural gas system valves discontinuing natural gas service at 4:35 am. Another first responder and a construction repair crew joined KUB's initial first responder on site at 5:11 am.

Upon approval by KCSD, and with TRA presence on site, KUB performed bar holing (i.e., creating a small opening in the ground to sample the subsurface of the soil for combustible gas) and a walking leak survey of the natural gas main located along Grey Pointe Drive using a combustible gas indicator (CGI). All readings were 0% of the lower explosive level (LEL) with the exception of two. At the service line connection of 9146 Grey Pointe Drive, a low level of combustible gas was detected (i.e., 5% and 10% of the LEL). These bar hole test locations were approximately 110 feet away from the natural gas incident location. See enclosed sketch for bar hole test locations and readings. The CGI had been recently calibrated (August 28, 2009). In addition, KUB checked for proper odorant levels within the system at five nearby locations. Odorant levels were within regulated limits at all five locations.

Natural gas service was interrupted to fifty-four residential customers in the area of the natural gas incident. Fifty-one customers were interrupted for approximately 15 hours as emergency personnel managed the explosion site and perimeter. Immediately following the re-pressurization of the natural gas distribution lines, KUB directed a leak survey contractor to conduct bar holing and a walking leak survey to all service lines and main serving the fifty-one customers. All readings from this leak survey were 0% of the LEL. Once accessible, KUB condemned the natural gas main on each side of the explosion site in order to restore natural gas service to the fifty-one customers. The condemned main was excavated and capped, and service was restored to all but 9134, 9140 and 9146 Grey Pointe Drive. Subsequently, new natural gas services were installed to 9134 and 9146 Grey Pointe Drive on December 21, 2009.

INVESTIGATIVE ACTIONS TAKEN: At 7:00 am on Thursday, December 10, 2009, KUB met with Knox County Sheriff's Department (KCSD) to begin the collection of information and evidence at the explosion site. Bar hole testing by KUB's leak survey contractor began as soon as access to the explosion site was available. All bar hole readings were 0% of the LEL at the water, natural gas, and electric service lines to 9140 Grey Pointe Drive. See enclosed sketch for bar hole test locations and readings.

KUB determined system-operating pressures to be 55 pounds per square inch gauge (psig). The natural gas distribution system serving 9134, 9140 and 9146 Grey Pointe Drive was air pressure tested on site as a single unit. The unit did not pass.

The natural gas service line at 9140 Grey Pointe Drive was uncovered. The excavated material appeared to be normal with no desiccation that would indicate a long-term natural gas leak. The soils appeared to be uniform, high in clay content, and saturated. During the excavation of the service tee, a copper water service line was discovered approximately seven inches above the natural gas service line. Before the water line was

moved from the excavation area, it was noted to have a longitudinal break on the underside.

KUB secured the natural gas meter and regulator from 9140 Grey Pointe Drive, which had been damaged by the explosion and fire. An evidence tag was affixed and a chain of custody was completed for each, and the items were taken to a KUB facility for secure storage. KUB reviewed evidence collection procedures with the KCSD, who approved KUB chain of custody forms and tags.

On Friday, December 11, 2009, KUB met again with KCSD and TRA to continue evidence collection. A section of the natural gas main and the service lines for 9134, 9140, and 9146 Grey Pointe Drive were isolated by segmenting the lines and then were air tested independently. Water, probably from the broken water service line, was evacuated from the main along Grey Pointe Drive to facilitate pressure testing. The segmented main and service lines for 9134 and 9146 Grey Pointe Drive each passed air testing. The section of segmented main and service line serving 9140 Grey Pointe Drive did not pass. It was observed that air from the pressure test was being released between the upper half of the Perfection Permalock Tee fitting and the top of the natural gas main at 9140 Grey Pointe Drive. Upon further examination, it was observed that two of the four nylon bolts clamping the tee to the natural gas main were broken. At this time, it has not been determined whether or not the broken bolts preceded the explosion or resulted from the explosion. As this section of the natural gas main and service tee were being removed, it was noted that the service tee's cutter and saddle assembly were not holding the service tee in position. Later x-rays of the service tee performed by KCSD showed the cutter assembly was not penetrating the main at the time of x-ray. The materials noted consist of ½-inch PE 2406 Plexico polyethylene pipe, 2 inch PE 2406 Plexico polyethylene pipe, and a Perfection Permalock Tee, Tapping Medium Density Polyethylene Pipe (MDPE) 2 x 1/2 IPS Mechanical.

With the approval of the KCSD and in the presence of the TRA, the meter, regulator, riser, service line, and service tee with approximately twenty feet of natural gas main were collected by KUB. An evidence tag was affixed, a chain of custody was completed for each, and the items were taken to a KUB facility for secure storage.

KUB received notification from Hanover Insurance Company ("Hanover"), the home owners' insurer, on the afternoon of December 11, 2009, that once the explosion site is turned over to Hanover, all future site inspections must be coordinated and conducted at a mutually agreeable time under the supervision of Hanover's attorneys. That turnover of the site occurred at approximately 5:00 pm on December 11 when KCSD left the site. For this reason, KUB's incident investigation has had to be conducted within these parameters and restrictions and has progressed more slowly than may have otherwise been the case. This is not intended to be a criticism of Hanover, but merely an indication of some of the operational factors encountered by KUB in its ongoing investigation.

RECORDS REVIEW: In addition to the collection of evidence, KUB reviewed records associated with 9140 Grey Pointe Drive. KUB determined that the service line was installed in June 1999. KUB performed leak surveys along Grey Pointe Drive in 2000 and 2005 as part of its scheduled area leakage survey program. The 2000 survey was conducted nine months after the natural gas service line was installed to 9140 Grey Pointe Drive. No leak was found at 9140 Grey Pointe Drive during these surveys. KUB also checked records of reported natural gas leak calls and found no natural gas leaks on record for 9140 Grey Pointe Drive and the adjacent properties. KUB has searched its

customer records and found no customer records of a service call to 9140 Grey Pointe Drive by anyone for any reason other than for the initial service and meter installation in 1999 and the conversion of the meter to an automated meter reading on July 14, 2009. KUB also reviewed recent excavation activities via Tennessee One Call records. KUB found no indication of recent excavation activities near the natural gas main and service connection at the explosion site.

DESCRIPTION OF REPAIR: In order to restore natural gas service to fifty-one customers, KUB condemned the natural gas main and services to 9134, 9140, and 9146 Grey Pointe Drive on December 9, 2009. New mains and service lines were later installed on December 21, 2009, to 9134 and 9146 Grey Pointe Drive, restoring utility service. The main and service line at 9140 Grey Pointe Drive were not reinstalled.

CURRENT STATUS: This incident is still under investigation. A supplemental report will be submitted with further information following further on site investigation, which is being coordinated with Hanover's attorneys per the December 11 Hanover letter.

If you have any questions or need additional information, please contact me at (865) 558-2746.

Sincerely,

Brooke A. Sinclair

Brooke A. Sinclair
Manager, Safety and Technical Services

BAS:CMS

Enclosures

c/encs: File – Safety and Technical Services

ATTACHMENT 4

AFFIDAVIT

State of Tennessee
County of Knox

I, Rod King, was the Vice President of Operations for King Energy and Construction, Inc. (KEC), which was an independent contractor for Knoxville Utilities Board (KUB) in the installation of natural gas services, and KEC installed, in the summer of 1998, approximately 50 feet of ¾" polyethylene natural gas service line at 9160 Grey Pointe Dr., Knoxville, Tennessee. Although I was not personally present during the installation of the natural gas service line, it was always the custom and practice of KEC and its employees to test installed natural gas service lines with 100 psi of air for at least 15 minutes, as required by KUB natural gas service line specifications, and correct any leaks or failures that might be observed. I therefore am certain that the KEC crew on this particular installation followed KEC's custom and practice.

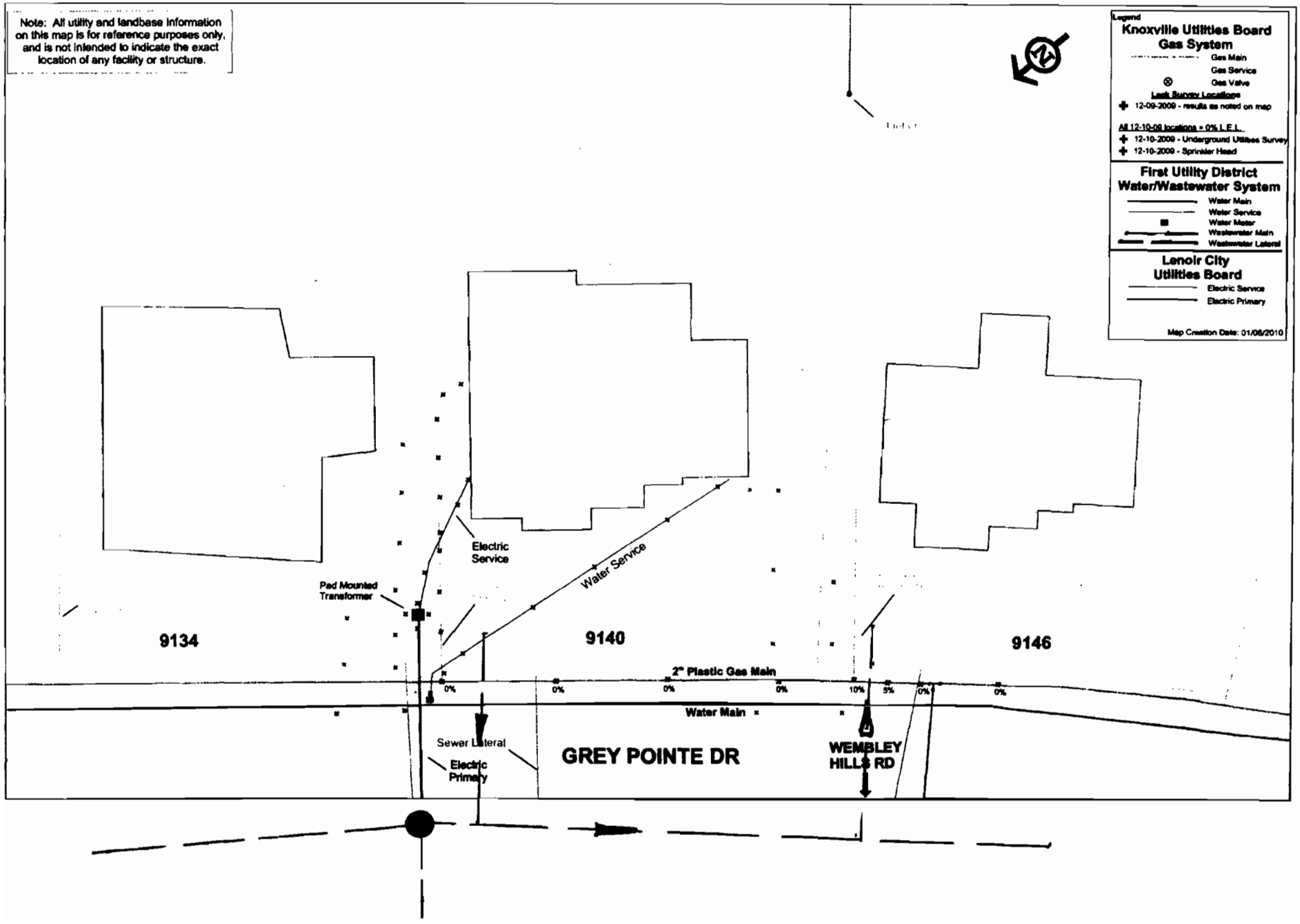
I, Rod King, being duly sworn according to law, deposes and says that the facts set forth above are true and correct to the best of my knowledge, information, and belief.

Sworn before me this [illegible] of July, 2018

Notary

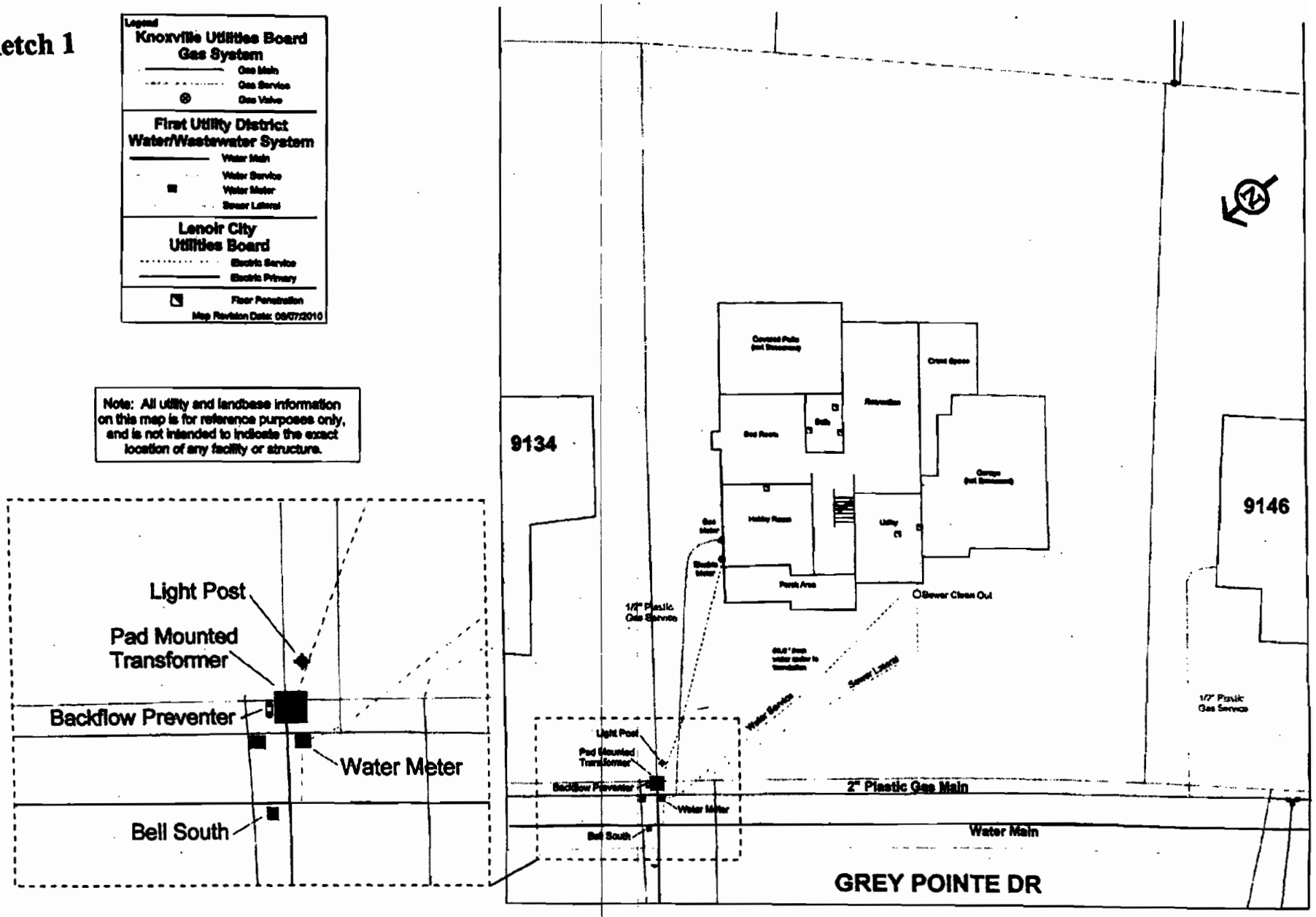
Notary Expires

Attachment 5



ATTACHMENT 6

Sketch 1



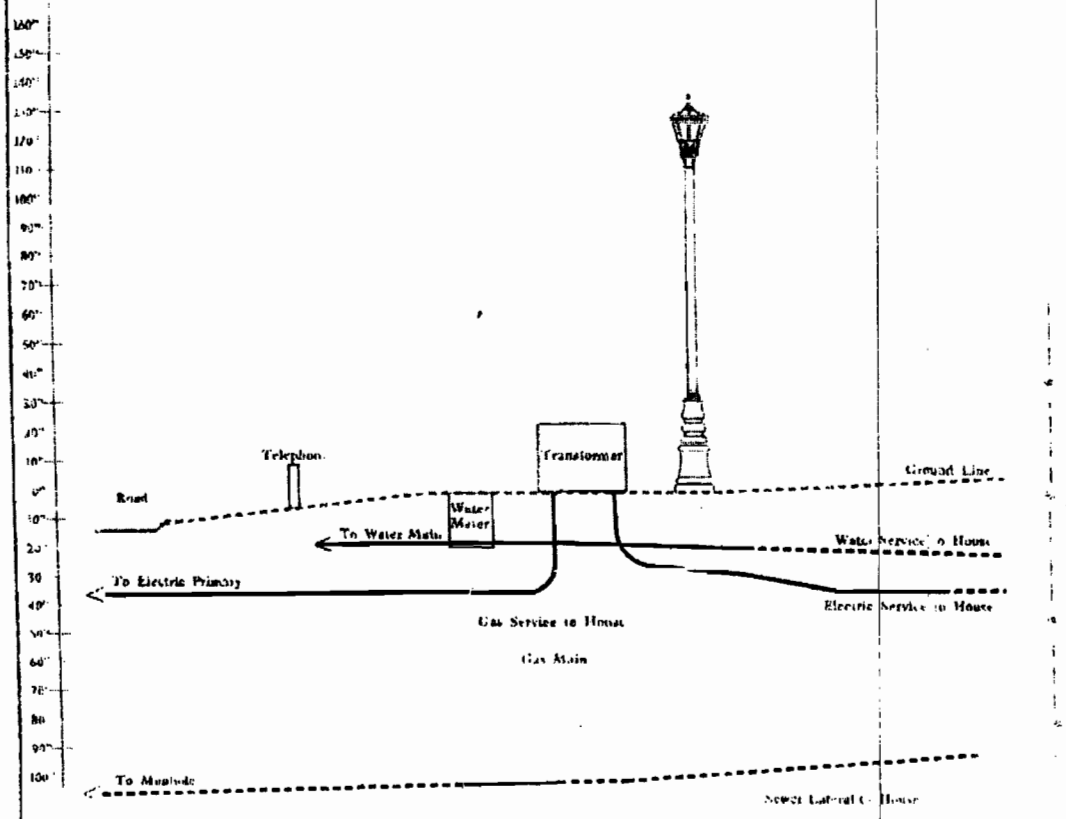
Sketch 2

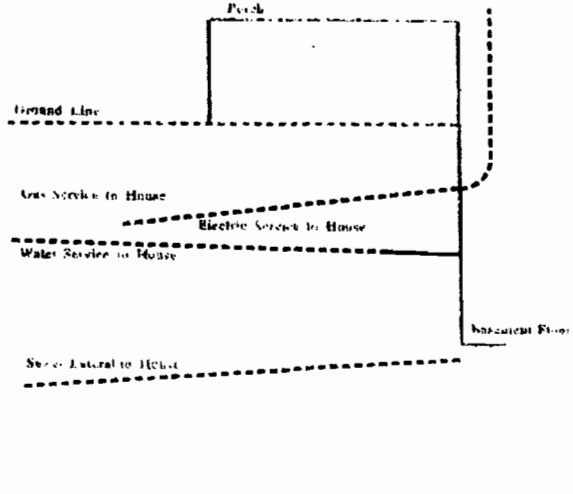
Illustration Perspective

[redacted]

Front of House

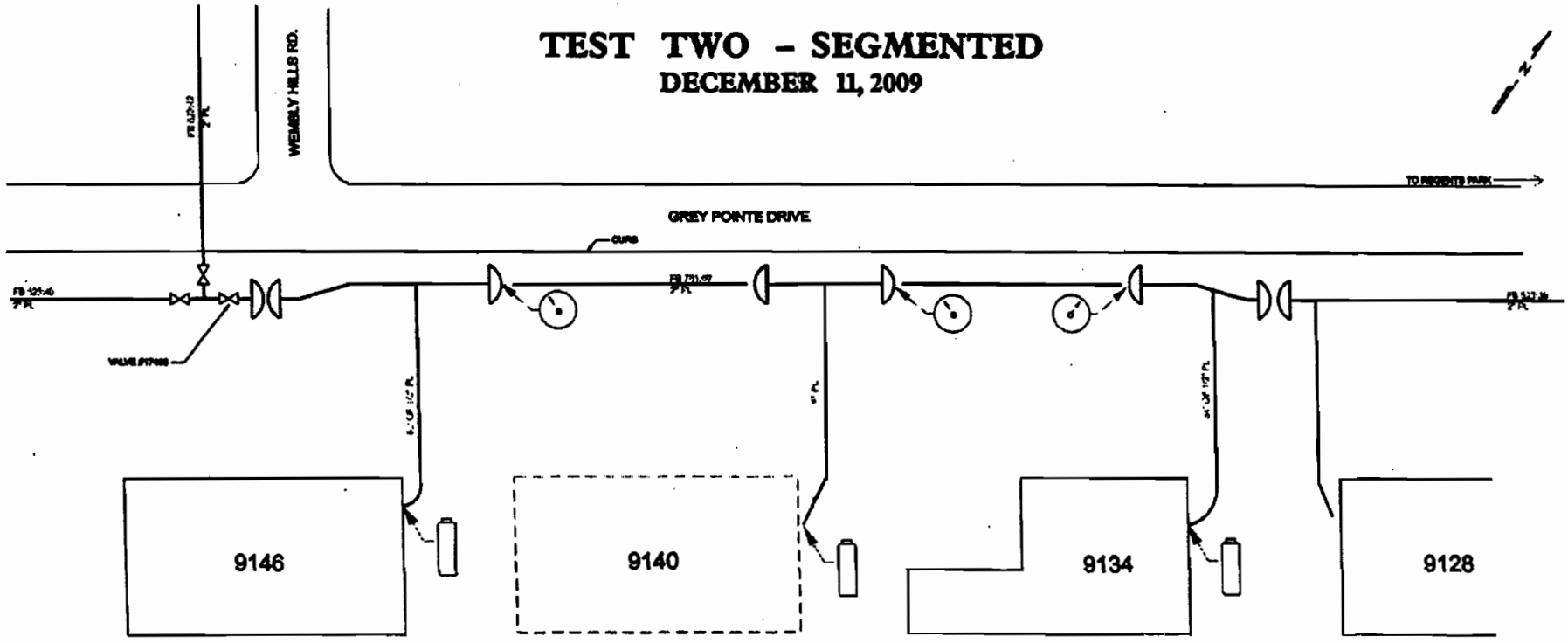
NOTE:
All perspectives shown on this illustration were derived from field measurements where available, and should be considered approximate.





ATTACHMENT 7

TEST TWO – SEGMENTED
DECEMBER 11, 2009



REV.: 0 W.F.P.:	EST.:	W.O.:
DWN.: TECH SERVICES	APPV.:	DATE: 010910
DESC.: 2" SUBSEQUENT GAS MAIN/SERVICE TEST		CHK.:

Knoxville Utilities Board

GREY POINTE DRIVE
WHITTINGTON CREEK SUBDIVISION
- GAS FACILITY PRESSURE TEST

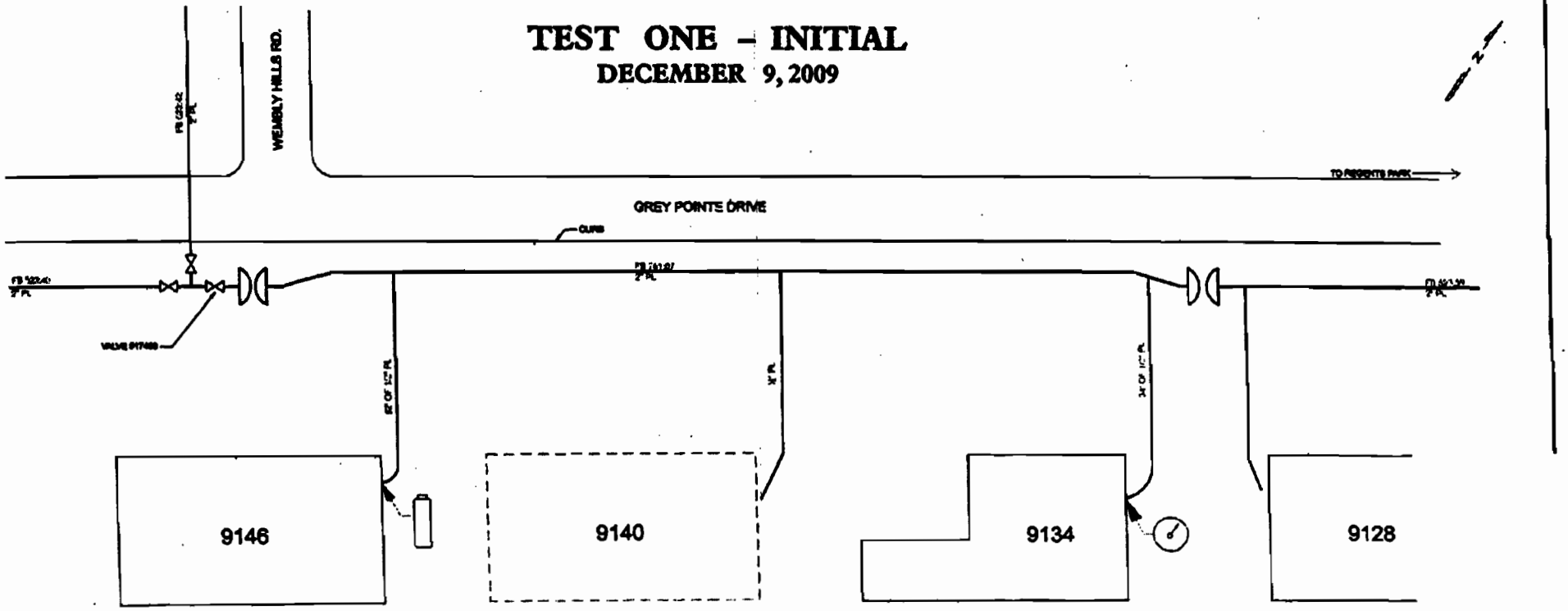
KUB

SHEET 2 OF 2

B– 2

ATTACHMENT 8

TEST ONE – INITIAL
DECEMBER 9, 2009



REV.: 0 W.F.P.#:	EST.:	W.O.:
DWN.: TECH SERVICES	APPV.:	DATE: 01/09/10
DESC.: 2" INITIAL GAS MAIN/SERVICE TEST		CHK.:

Knoxville Utilities Board

GREY POINTE DRIVE
WHITTINGTON CREEK SUBDIVISION
GAS FACILITY PRESSURE TEST

KUB

SHEET 1 OF 2

B– 1

Knoxville Utilities Board

ATTACHMENT 9

June 8, 2010

Mr. Larry Borum
Chief – Gas Pipeline Safety Division
Tennessee Regulatory Authority
460 James Robertson Parkway
Nashville, TN 37243-0505

Re: Gas Incident dated December 9, 2009

Dear Mr. Borum:

This letter is the follow up and final report to the preliminary report dated January 8, 2010 provided by the Knoxville Utilities Board (KUB) for the natural gas incident occurring on December 9, 2009 at 9140 Grey Point Drive in Knoxville, Tennessee.

BACKGROUND: Per the letter dated January 8, 2010, an explosion of unknown origin occurred at 9140 Grey Pointe Drive destroying a single-family structure resulting in one fatality and two injured occupants requiring hospitalization on December 9, 2009 (i.e., explosion site). In addition, upon arrival of responders, an uncontrolled release of natural gas was afire at the northeast corner of 9140 Grey Pointe Drive approximately fifty feet from the structure. This gas release event constitutes a gas incident as defined by 49 Code of Federal Regulations, Part 191, and requires that KUB conduct an investigation. KUB's investigation of the incident focuses on potential public safety issues related to operation of the natural gas distribution system. The cause of the house explosion and fire are under investigation by other parties. On December 9-11, 2009, the Knox County Sheriff's Department conducted an initial site investigation with KUB. During this initial investigation and in the presence of Tennessee Regulatory Authority (TRA), potential pathways for natural gas to migrate into the residential structure were evaluated. No apparent pathway for natural gas was observed from the service tee to the residential structure. As mentioned in the January 8, 2010 letter, at the request of the Sheriff's Department the meter, regulator, riser, service line, and service tee with approximately twenty feet of natural gas main were collected and stored by KUB. As noted, the Perfection Permalock Tee cutter and saddle assembly were not holding the service tee in position and two of the four bolts were broken. KUB conducted leak surveys to ensure that offsite piping was not damaged as a result of the explosion and verified odorant levels were within regulated limits. During this investigation, it was unable to be determined whether or not the broken bolts preceded the explosion or resulted from the explosion.

SUBSEQUENT INVESTIGATIVE ACTIONS TAKEN: Following the initial site investigation, KUB was present for a subsequent investigation at 9140 Grey Pointe Drive led by Hanover Insurance Company ("Hanover") from January 12-14, 2010. Representatives from TRA were on site during the majority of the investigation along with

other interested parties, including utility providers, gas appliance manufacturers and legal representatives.

During this investigation, Hanover excavated the debris from the basement via six grids and collected all major appliances and other items by request, including a fireplace for evidence and/or possible additional examination. On January 13, 2010, Hanover requested assistance from First Utility District (FUD) to use a camera to locate the wastewater manhole near the rear of the residential structure and determine if a wastewater lateral from 9140 Grey Pointe Drive entered the manhole. After completion of the camera work, FUD reported 9140 Grey Pointe Drive does not have a wastewater lateral enter that manhole. KUB was requested to excavate the gas, water and wastewater utility lines along Grey Pointe Drive to obtain measurements. In all cases where the soil was uncovered (i.e., at the water service line penetration to the residential structure, the gas main, water main, and wastewater lateral), the soil appeared to be normal with no desiccation that would indicate a long-term natural gas leak. The soil appeared to be uniform and high in clay content. In addition, KUB conducted "pot holing" along the gas main on Grey Point Drive in front of the Krzeski residence and found no natural gas present.

On January 14, 2010, KUB obtained hand measurements to determine approximate elevations and locations of utilities to create the attached sketch. Hanover and others collected samples of soil from around the water service line at the point of penetration of the basement wall, which appeared to be compacted, high clay content soil. The soil was extremely difficult to hand dig as noted by TRA during the collection. Further, air space samples were taken by APR Consultants in two locations in the basement floor including the floor penetration for the toilet and a vent at the west basement wall. A laboratory blank sample was taken at the north end of the property away from the basement.

THIRD PARTY TESTING: On January 14, 2010, air space samples were taken by APR Consultants. The data from these samples were determined to have no presence of the components of natural or sewer gas. Please see the attached schematic and air space sampling report for further information. On May 4, 2010, the service tee was disassembled and inspected by Engineering Systems Inc. (ESI) to try to determine when in time the bolts broke. According to the ESI report dated May 25, 2010, "it is not possible to determine whether the broken bolts on the back side of the Perfection Corp. Permalock® tapping tee were broken prior to the explosion of December 9, 2009 or as a result of that event."

ADDITIONAL INFORMATION: Although KUB did not conduct any interviews during this investigation, the homeowners, Mr. and Ms. Krzeski, were on site on January 14 and 15, 2010. While on site, the homeowners reported no odor of natural gas was noted prior to the explosion.

CONCLUSION: KUB experienced a fitting failure at the service tee connection, which was approximately fifty feet from the Krzeski structure. KUB verified odorant levels were within regulated limits and verified records to ensure no reports of natural gas odor prior to the explosion. In addition, the soil located around utilities leading to and penetrating the

structure was compacted and consisted of high clay content. As the result of KUB's investigation, KUB cannot determine if the natural gas incident (i.e. the uncontrolled release of natural gas at the northeast corner of 9140 Grey Point Drive) preceded the explosion or resulted from the explosion. Attached is our final Incident Report indicating the KUB investigation is complete and the apparent cause of the natural gas incident is unknown.

If you have any questions or need additional information, please contact me at (865) 558-2746.

Sincerely,

Brooke A. Sinclair
Manager, Safety and Technical Services

BAS:CMS

Enclosures

c/encs: File – Safety and Technical Services

ATTACHMENT 10

NOTICE: This report is required by 49 CFR Part 191. Failure to report can result in a civil penalty not to exceed $100,000 for each violation for each day the violation continues up to a maximum of $1,000,000 for any related series of violations as provided in 49 USC 60122. Form Approved OMB No. 2137-0522

U.S. Department of Transportation
Research and Special Programs Administration

INCIDENT REPORT - GAS DISTRIBUTION SYSTEM

Report Date Jun 06,2016
No. [illegible] (DOT Use Only)

INSTRUCTIONS

Important: *Please read the separate instructions for completing this form before you begin. They clarify the information requested and provide specific examples. If you do not have a copy of the instructions, you can obtain one from the Office Of Pipeline Safety Web Page at .*

PART A - GENERAL REPORT INFORMATION Check: [x] Original Report [ ] Supplemental Report [x] Final Report

1. Operator Name and Address

a. Operator's 5-digit Identification Number 10310

b. If Operator does not own the pipeline, enter Owner's 5-digit Identification Number

c. Name of Operator KNOXVILLE UTILITIES BOARD

d. Operator street address 4505 MIDDLEBROOK PIKE

e. Operator address KNOXVILLE KNOX TN 37921
City, County or Parish, State and Zip Code

2. Time and date of the incident
0315 hr. 12/09/2009 month day year

3. Incident Location

a. 9140 GREY POINTE DRIVE
Street or nearest street or road

b. KNOXVILLE KNOX
City and County or Parish

c. TN 37922
State and Zip Code

d. Latitude: 3587737 Longitude: -8405654
(If not available, see instructions for how to provide specific location)

e. Class location description
○ Class 1 ○ Class 2 ○ Class 3 ● Class 4

f. Incident on Federal Land ○ Yes ● No

4. Type of leak or rupture

○ Leak ○ Pinhole ○ Connection Failure *(complete sec. F5)*

○ Puncture, diameter or cross section *(inches)* ____

○ Rupture (if applicable):
○ Circumferential - Separation
○ Longitudinal
- Tear/ Crack, length *(inches)* ____
- Propagation Length, total, both sides *(feet)* ____

○ N/ A
● Other: SEE ATTACHMENTS

5. Consequences *(check and complete all that apply)*

a. [ ] Fatality Total number of people: 0
Employees: 0 *General Public:* 0
Non-employee Contractors: 0

b. [ ] Injury requiring inpatient hospitalization
Total number of people: 0
Employees: 0 *General Public:* 0
Non-employee Contractors: 0

c. [x] Property damage/ loss *(estimated)* Total $ 55000
Gas loss $ 5000 Operator damage $ 50000
Public private property damage $ 0

d. [x] Gas ignited ○ Explosion ● No Explosion

e. [ ] Gas did not ignite ○ Explosion ○ No Explosion

f. [x] Evacuation *(general public only)* 8 people
Evacuation Reason:
○ Unknown
● Emergency worker or public official ordered, precautionary
○ Threat to the public
○ Company policy

6. Elapsed time until area was made safe:
1 hr. 20 min.

7. Telephone Report
925621 NRC Report Number 12/09/2009 month day year

8. a. Estimated pressure at point and time of incident:
55 *PSIG*

b. Max. allowable operating pressure *(MAOP)*: 60 *PSIG*

c. MAOP established by:
● Test Pressure 100 psig
○ 49 CFR § 192. 619 (a)(3)

PART B - PREPARER AND AUTHORIZED SIGNATURE

CHRISTIAN M. SPENCER
(type or print) Preparer's Name and Title

8655582827
Area Code and Telephone Number

CHRIS.SPENCER@KUB.ORG
Preparer's E-mail Address

8655582484
Area Code and Facsimile Number

Authorized Signature (type or print) Name and Title Date Area Code and Telephone Number

PART C – ORIGIN OF THE INCIDENT

1. Incident occurred on
   - ○ Main
   - ○ Meter Set
   - ○ Service Line
   - ● Other: SERVICE TEE
   - ○ Pressure Limiting and Regulating Facility
2. Failure occurred on
   - ○ Body of pipe
   - ○ Pipe Seam
   - ○ Joint
   - ● Component
   - ○ Other: _____
3. Material involved *(pipe, fitting, or other component)*
   - ○ Steel
   - ○ Cast /Wrought Iron
   - ● Polyethelene Plastic (complete all items that apply in a-c)
   - ○ Other Plastic (complete all items that apply in a-c)
     Plastic failure was: ☐ a.ductile ☐ b.brittle ☐ c.joint failure
   - ○ Other material: _____
4. Year the pipe or component which failed was installed: 1999

PART D – MATERIAL SPECIFICATION (if applicable)

1. Nominal pipe size *(NPS)* _____ in.
2. Wall thickness _____ in.
3. Specification _____ SMYS
4. Seam type _____
5. Valve type _____
6. Pipe or valve manufactured by _____ in year

PART E – ENVIRONMENT

1. Area of incident
   - ○ Under pavement
   - ● Under ground
   - ○ Inside under building
   - ○ In open ditch
   - ○ Above ground
   - ○ Under water
   - ○ Other: _____
2. Depth of cover: _____ inches

PART F – PRIMARY CAUSE OF INCIDENT

Important: There are 25 numbered causes in this section. Check the box to the left of the primary cause of the incident. Check one circle in each of the supplemental items to the right of or below the cause you indicate. See the instructions for this form for guidance.

F1 – CORROSION

If either F1 (1) External Corrosion, or F1 (2) Internal Corrosion is checked, complete all subparts a – e.

1. ○ External Corrosion

a. Pipe Coating
- ○ Bare
- ○ Coated
- ○ Unknown

b. Visual Examination
- ○ Localized Pitting
- ○ General Corrosion
- ○ Other: _____

c. Cause of Corrosion
- ○ Galvanic
- ○ Stray Current
- ○ Improper Cathodic Protection
- ○ Microbiological
- ○ Other: _____

d. Was corroded part of pipeline considered to be under cathodic protection prior to discovering incident?
○ No ○ Yes ○ Unknown Year Protection Started:

2. ○ Internal Corrosion

e. Was pipe previously damaged in the area of corrosion?
○ No ○ Yes ○ Unknown How long prior to incident: _____ *years* _____ *months*

F2 – NATURAL FORCES

3. ○ Earth Movement ⇒ ○ Earthquake ○ Subsidence ○ Landslide ○ Other: _____
4. ○ Lightning
5. ○ Heavy Rains Floods ⇒ ○ Washouts ○ Flotation ○ Mudslide ○ Scouring ○ Other: _____
6. ○ Temperature ⇒ ○ Thermal stress ○ Frost heave ○ Frozen components ○ Other: _____
7. ○ High Winds

F3 – EXCAVATION

8. ○ Operator Excavation Damage *(including their contractors)*/ Not Third Party

9. ○ Third Party Excavation Damage *(complete a-d)*

a. Excavator group
○ General Public ○ Government ○ Excavator other than Operator subcontractor

b. Type: ○ Road Work ○ Pipeline ○ Water ○ Electric ○ Sewer ○ Phone/ Cable Fiber ○ Landowner ○ Railroad
○ Building Construction ○ Other: _____

c. Did operator get prior notification of excavation activity?
○ No ○ Yes: Date received:
Notification received from: ○ One Call System ○ Excavator ○ General Contractor ○ Landowner

d. Was pipeline marked?
○ No ○ Yes *(If Yes, check applicable items i – iv)*
- i. Temporary markings: ○ Flags ○ Stakes ○ Paint
- ii. Permanent markings: ○ Yes ○ No
- iii. Marks were *(check one)* ○ Accurate ○ Not Accurate
- iv. Were marks made within required time? ○ Yes ○ No

F4 – OTHER OUTSIDE FORCE DAMAGE

10. ○ Fire/Explosion as primary cause of failure ⇒ Fire Explosion cause: ○ Man made ○ Natural *Describe in Part G*
11. ○ Car, truck or other vehicle not relating to excavation activity damaging pipe
12. ○ Rupture of Previously Damaged Pipe
13. ○ Vandalism

F5 – MATERIAL OR WELDS

Material

14. ○ Body of Pipe ⇒ ○ Dent ○ Gouge ○ Wrinkle Bend ○ Arc Burn ○ Other: _____

15. ◉ Component ⇒ ○ Valve ○ Fitting ○ Vessel ○ Extruded Outlet ○ Other: _____

16. ○ Joint ⇒ ○ Gasket ○ O-Ring ○ Threads ○ Fusion ○ Other: _____

Weld

17. ○ Butt ⇒ ○ Pipe ○ Fabrication ○ Other: _____

18. ○ Fillet ⇒ ○ Branch ○ Hot Tap ○ Fitting ○ Repair Sleeve ○ Other: _____

19. ○ Pipe Seam ⇒ ○ LF ERW ○ HF ERW ○ DSAW ○ SAW ○ Seamless ○ Spiral ○ Flash Weld ○ Other: _____

*Complete a-f if you indicate **any** cause in part F5.*

a. Type of failure:
Construction Defect ⇒ ○ Poor Workmanship ○ Procedure not followed ○ Poor Construction Procedures
Material Defect

b. Was failure due to pipe damage sustained in transportation to the construction or fabrication site? ○ Yes ○ No

c. Was part which leaked pressure tested before incident occurred? ○ Yes, *complete d-f, if known* ○ No

d. Date of test: //

e. Time held at test pressure: _____ hr.

f. Estimated test pressure at point of incident: _____ *PSIG*

F6 – EQUIPMENT OR OPERATIONS

20. ○ Malfunction of Control /Relief Equipment ⇒ ○ Valve ○ Instrumentation ○ Pressure Regulator ○ Other: _____

21. ○ Threads Stripped, Broken Pipe Coupling ⇒ ○ Nipples ○ Valve Threads ○ Mechanical Couplings ○ Other: _____

22. ○ Leaking Seals

23. ○ Incorrect Operation

a. Type: ○ Inadequate Procedures ○ Inadequate Safety Practices ○ Failure to Follow Procedures ○ Other: _____

b. Number of employees involved in incident who failed post-incident drug test: _____ Alcohol test:

c. Was person involved in incident qualified per OQ rule? ○ Yes ○ No d. Hours on duty for person involved:

F7 – OTHER

24. ○ Miscellaneous, *describe:* _____

25. ◉ Unknown
◉ Investigation Complete ○ Still Under Investigation *(submit a supplemental report when investigation is complete)*

PART G – NARRATIVE DESCRIPTION OF EVENTS CONTRIBUTING TO THE INCIDENT *(Attach additional sheets as necessary)*

SEE ATTACHED.

ATTACHMENT 11

3851 Exchange Avenue
Aurora, Illinois 60504

Engineering Systems Inc.

Phone: (630) 851-4566
Fax: (630) 851-4870
esi-website.com

HODGES, DOUGHTY & CARSON TAPPING TEE EVALUATION TESTING REPORT

ESI File No.: 31034A

Report Submitted to:
MR. HIRAM TIPTON
and
MR. MICHAEL HAYNES
HODGES, DOUGHTY & CARSON PLLC
P.O. BOX 869
617 MAIN STREET
KNOXVILLE, TN 37902

Report Submitted by:

Donald E. Duvall — 5/25/10

Donald E. Duvall, Ph.D, P.E. — **Date**
Senior Managing Consultant
P.E. Lic. Expires: November 30, 2011

DONALD E. DUVALL
062-050452
LICENSED PROFESSIONAL ENGINEER
STATE OF ILLINOIS

and:

Dale B. Edwards /sig — 5/25/10

Dale B. Edwards, P.E. — **Date**
Senior Consultant
P.E. Lic. Expires: November 30, 2011

INTRODUCTION

Engineering Systems Inc. (ESI) was retained by Hodges, Doughty & Carson, PLLC to consult with them on a natural gas distribution piping assembly removed from service in Knoxville, TN. The assembly was comprised of a Perfection Permalock® tapping tee installed on a 2" IPS medium density polyethylene gas main. It had been installed at 9140 Grey Pointe Drive, Knoxville, TN. It was removed from service after an explosion and gas incident at that location occurred on December 9, 2009.

BACKGROUND

The Perfection Corporation Permalock ® tapping tee is a device that is mechanically attached to a polyethylene gas main for the purpose of establishing a new gas service line off of an existing (usually pressurized) gas main. The tee is injection molded of polyethylene pressure pipe resin compounds. It is attached to the gas main by a two piece, full-encirclement base that bolts together around the main. Four bolts secure the two halves of the base together; two located on each side of the main. According to the manufacturer's specifications, the bolts are produced from a glass-filled nylon compound and are sold with the tee fitting by Perfection. When the subject assembly was excavated after the incident, it was discovered that the two bolts positioned on the side of the main opposite the tee outlet were broken. The focus of this investigation was to attempt to determine when in time these bolts broke.

LABORATORY TESTING

A protocol was developed for evaluation of the tapping tee assembly. This protocol is attached as Appendix 1 to this report. It was divided into two groups of tests. The first was directed at developing information to answer the question of when the bolts broke; prior to or as a consequence of the explosion at 9140 Grey Pointe Drive. The second group of tests was directed at additional evaluation of the materials of construction of the gas main and tapping tee.

Photograph 1 shows the complete specimen that, at the direction of the Knox County Sherriff's Department, was removed from 9140 Grey Pointe Drive and stored by the Knoxville Utilities Board (KUB). A few days prior to the testing described herein, the excess lengths of polyethylene pipe were cut off (per the protocol) by KUB and the specimen pictured in Photograph 2 was shipped to ESI's office in Norcross, GA. It was held there in secure storage until the testing commenced.

The first group of tests was carried out on the morning of May 4, 2010. The tapping tee assembly on the gas main was first examined by real-time x-ray fluoroscopy at Applied Technical Services (ATS), Marietta, GA. Photograph 2 shows the test specimen that was x-rayed. It was placed in various orientations in the x-ray machine, pictured in Photograph 3, and moved around within the sample chamber to provide different views

of the specimen. Periodic photographs were taken of the images on the screen of the x-ray instrument. Two x-ray photographs were taken as well, and prints of those are attached as Appendix 2 to this report. The original x-ray films were retained by ESI.

After the x-ray examination, the specimen was taken back to ESI for the rest of the Group 1 tests in the protocol. A number of observations were made in the early stages of the examination at ESI. One observation was that the hole cut in the pipe during installation of the tee on the main and the rubber gasket around that hole that provides a seal between the gas main and the tee base was rotated out of position by approximately 90 degrees (Photograph 4). This observation confirmed an earlier one made when the box was first opened at ATS, that the hole in the pipe wall could not be seen beneath the tapping tee chimney where it was cut during tee installation. It is believed that the hole and gasket were not in this position when the pipe and fitting assembly was in service.

The two broken bolts fell easily out of their locations in the tapping tee base when the assembly was turned upside down during washing. After cleaning, it was observed that each bolt had a mold cavity number at the bottom of the hexagonal shaped recess in each bolt head. The cavity number of each bolt was written in the tee base with a marker next to the hole in which each was inserted when in service (Photograph 5).

The fracture surfaces of the two broken bolts were examined in a stereo-optical microscope to look for features which would indicate when the bolts were broken. The fracture surface of the Cavity #1 bolt is shown in Photograph 6 and that of the Cavity #4 bolt is shown in Photograph 7. In neither case were there any discernable features which could be utilized to determine whether the bolts broke suddenly as a result of the explosion or prior to the explosion.

A variety of information was molded into the surfaces of the tapping tee and its matching base. This information was recorded but is not reproduced here since it has no bearing on the question of when the tapping tee bolts broke. The pipe was manufactured in May 1998 by Plexco which was, in around 2000, merged with Phillips Driscopipe to form Performance Pipe.

The dimensional measurements taken per Group 1, Step 5 of the protocol were performed and are presented in the table below. Measurements were made on one length of pipe that was cut off near the tapping tee saddle during removal of the tapping tee from the pipe. It was marked during disassembly as Piece B, and the measurements were taken on the "B" end. This location is shown in Photograph 8. Since the gas main pipe was originally all one piece off of a long coil of such pipe, only one set of measurements was made. The pipe print line was utilized as the "12 o'clock" reference position. Wall thickness measurements were made at eight approximately equally spaced locations around the pipe circumference. Four outside diameter measurements were made with a digital caliper, spanning the 12-6 o'clock position, the 1:30-7:30 position, the 3:00-9:00 position and the 4:30-10:30 position. No rounding device was available for use on the pipe, so the outside diameters were determined "as is".

Location	Outside Diameter (in.)	Wall Thickness (in.)
12 o'clock	2.379	0.226
1:30 (45° rotation from 12)	2.406	0.226
3:00 (90° rotation from 12)	2.391	0.225
4:30 (135° rotation)	2.378	0.224
6:00 (180° rotation)		0.225
7:30 (225° rotation)		0.224
9:00 (270° rotation)		0.223
10:30 (315° rotation)		0.223

When the tapping tee was uncapped and the cutter removed, the threaded sleeve came out with the cutter.

DISCUSSION

This examination was performed according to the protocol for the Group 1 tests, as appropriate. Because of a lack of discernable fracture surface features on the two broken bolts, it was not possible to determine whether the bolts broke prior to the explosion at 9140 Grey Pointe Drive, or as a result of the explosion. Objects produced from highly glass-filled plastics like the material from which these bolts were manufactured often do not show useful fracture surface features when broken, so this was not an unexpected result. However, until the bolts could be examined in a laboratory environment, one could not know for certain whether there would be features that might permit such a determination. Both bolts broke in the roots of the threads, which is a natural location of stress concentration in a loaded bolt. The bolts would have broken in a thread root regardless of when or why they broke.

The pipe wall thicknesses measured here complied with the requirements of ASTM D2513, "Standard Specification for Thermoplastic Pipe, Tubing and Fittings." Because the results of any of the Group 2 tests in the protocol would not provide information that would enable a determination of when the bolts were broken, none of those tests were performed. All of the pieces of the specimen tested on May 4 have been shipped back to KUB for continued secure storage.

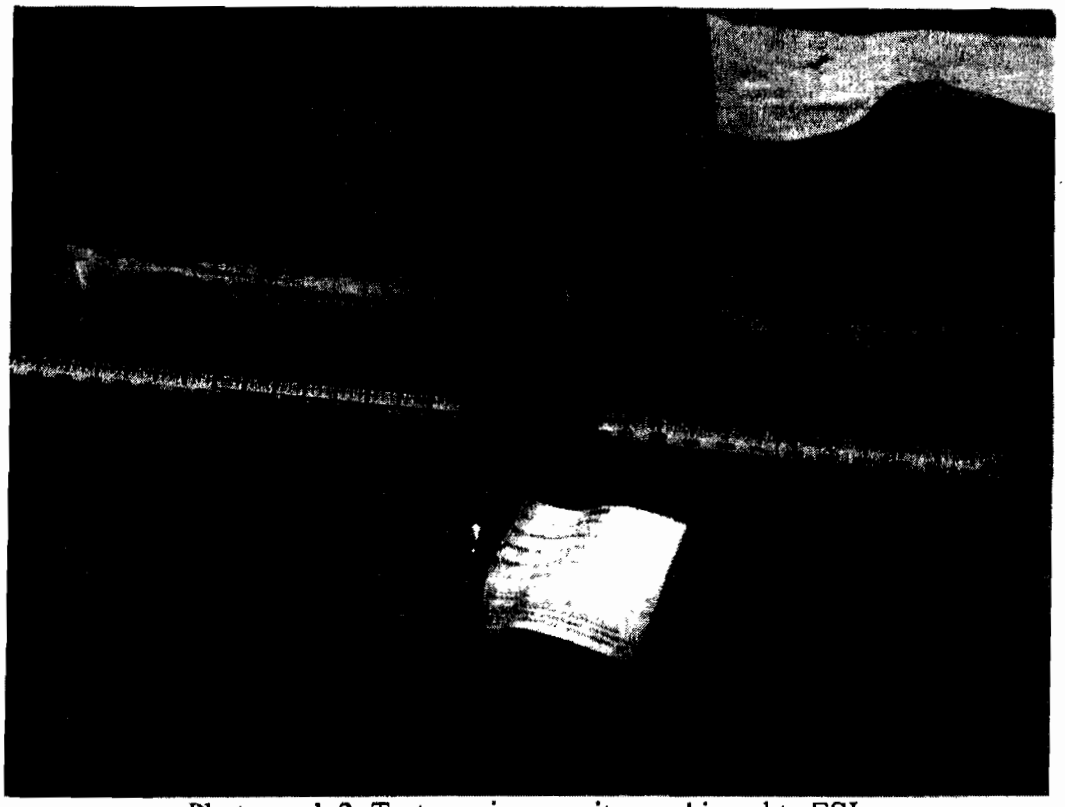
CONCLUSIONS

Based upon the work performed above, the following conclusions are offered to a reasonable degree of scientific and engineering certainty.

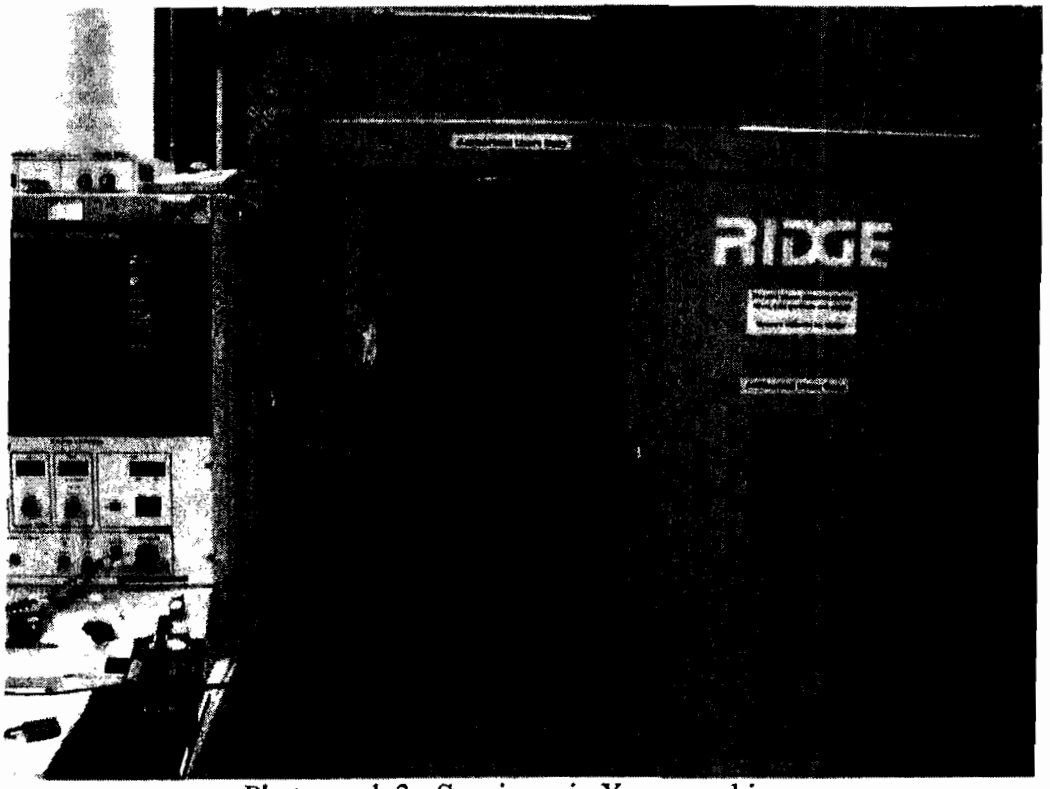
1. It is not possible to determine whether the broken bolts on the back side of the Perfection Corp. Permalock® tapping tee were broken prior to the explosion of December 9, 2009 or as a result of that event.

2. The 2" IPS SDR 11 pipe that was the gas main in this installation had a wall thickness that complied with the requirements of ASTM D2513.

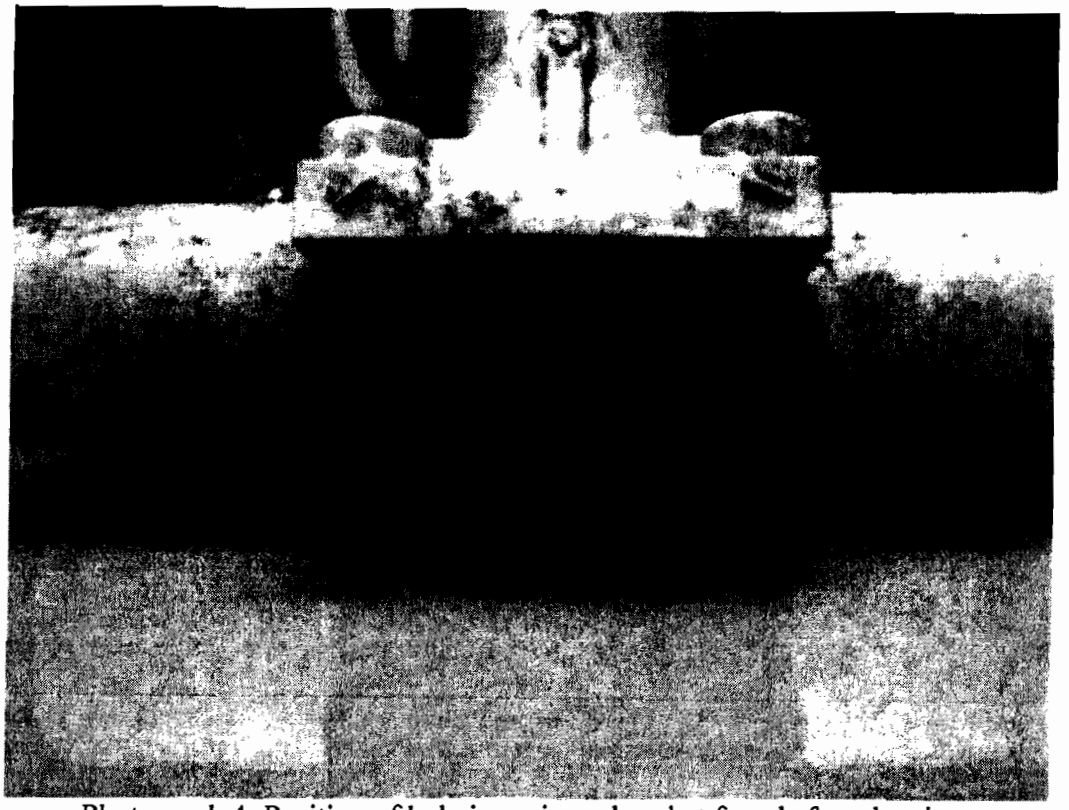
Photograph 1: Pipe and tapping tee assembly after removal from site.



Photograph 2: Test specimen as it was shipped to ESI.

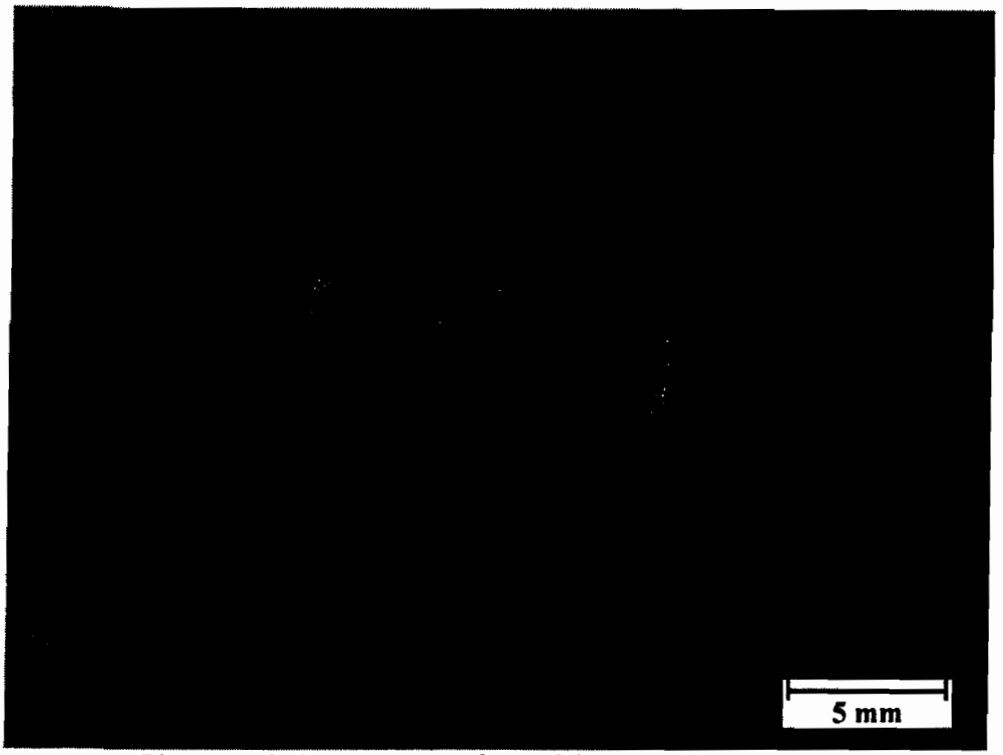


Photograph 3: Specimen in X-ray machine.



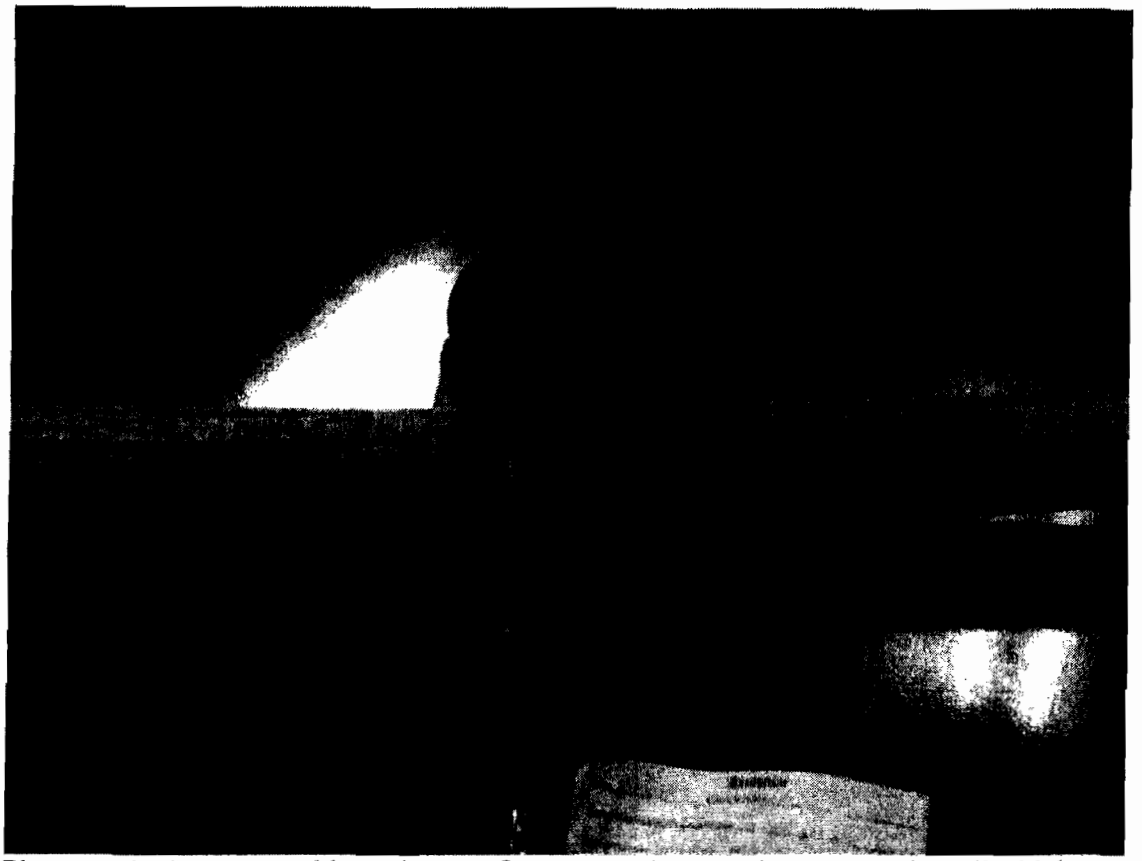
Photograph 4: Position of hole in main and gasket found after cleaning.

Photograph 5: Base of tapping tee with bolt cavity numbers written in.



Photograph 6: Fracture surface of Cavity #1 broken bolt.

Photograph 7: Fracture surface of Cavity #4 broken bolt.



Photograph 8: Assembly prior to further cutting. Diameter and wall thickness measurements made at location of right-most letter "B" in the photo.

Appendix 1

3851 Exchange Avenue
Aurora, Illinois 60504

Engineering Systems Inc.

Phone: (630) 851-4566
Fax: (630) 851-4870
esi-website.com

April 15, 2010

Via E-mail

Mr. Michael Haynes
Mr. Hiram Tipton
Hodges Doughty & Carson
617 Main Street
Knoxville, TN 37901

Re: Testing of Perfection Permalock Tapping Tee Assembly

Gentlemen:
The first stage of testing of the Perfection Permalock tapping tee assembly from the KUB gas distribution system will be carried out on Tuesday, May 4, 2010. The test protocol is presented below. It consists of two groups of activities. The first group, except for the x-ray examination, will be carried out at ESI's Norcross, GA office, where we have a large high bay area that will easily accommodate a large, multi-party inspection. All of the activities in the first group are nondestructive, except for #7. The second group will involve activities that will require a minimal amount of destructive sampling of some of the components. The second group of tests may be performed at a later date, depending upon the results of the Group 1 tests.

The x-ray work will be performed at Applied Technical Services, Inc., 1049 Triad Court, Marietta, GA. It will begin at 8 am on May 4. Once the x-ray work is completed, the sample will be transported to Engineering Systems, Inc., 6190 Regency Parkway, Suite 316, Norcross, GA for the remainder of the Group 1 testing.

For ease of handling and transport, the polyethylene main to which the tapping tee is currently attached will be cut once on either side of the tapping tee. The cuts will be made at a distance of 12 inches from each side of the tapping tee base. The cuts should be made with a plastic pipe cutter in such a way as to minimize any alteration of the tapping tee assembly by the cutting process. The service line that is still attached to the tapping tee outlet will be cut at a distance of 3 – 5 inches from where it connects to the excess flow valve attached to the tapping tee outlet. These cuts will be made by KUB

personnel prior to the sample being sent to ESI in Norcross.

Pressure testing of this assembly has already been performed, prior to the pipe and tapping tee assembly being removed from the ground.

Group 1

1. X-ray examination of the components performed in a laboratory environment. This should be done before any cleaning or disassembly of the components is performed. This work will be performed at ATS.
2. Visual examination and photographic documentation of all as received components.
3. Washing of dirt from the pipe and fitting. This will be done by water spray only; no rubbing or abrasion will be used at this time to dislodge dirt adhering to the pipe and fitting assembly.
4. Visual examination and photographic documentation of the cleaned assembly. Examination of interesting features with a stereo optical microscope if possible.
5. Dimensional measurements of pipe and fitting as appropriate.
6. Removal of the fractured bolts without removing the tapping tee from the main. The bolts will be set aside for microscopic examination of fracture surfaces. If the fractured bolts cannot be removed without removing the tapping tee from the main, then Step 7 below will be executed before the bolts are set aside for fracture surface examination. The fracture surfaces will be examined both with a stereo optical microscope and with ESI's scanning electron microscope (SEM). The SEM can be operated in a low vacuum mode that may permit imaging of the fracture surfaces without the need to apply a conductive coating to them.
7. Procedure for removal of the tapping tee from the main.

A. Cut excess main 3 – 4 inches from either side of the tapping tee. Photographs will be taken of the inside of the main prior to complete disassembly. If an excess flow valve coupling is attached to the tee outlet, cut the service line 3 – 5 inches from the end of the coupling.
B. Remove the tapping tee cap.
C. Remove the cutter body using a 5/16" allen wrench.
D. If the threaded sleeve is engaged with the cutter body, proceed to step F. If the threaded sleeve is visible in the bottom of the tower and is engaged in the main, proceed to step E.
E. Using a #8 easy out, remove the threaded sleeve from the tower/main.
F. If the bolts are retaining the tee to the main, remove them with a 5/16" allen wrench. Note: the bolts may fracture depending on the condition of the exposed threads (the visible threads projecting through the base). If complete preservation of the bolts is required, the polyethylene base could be milled to suitably weaken a segment of the female threads, which would then allow the bolts to be removed without fracture.

Group 2

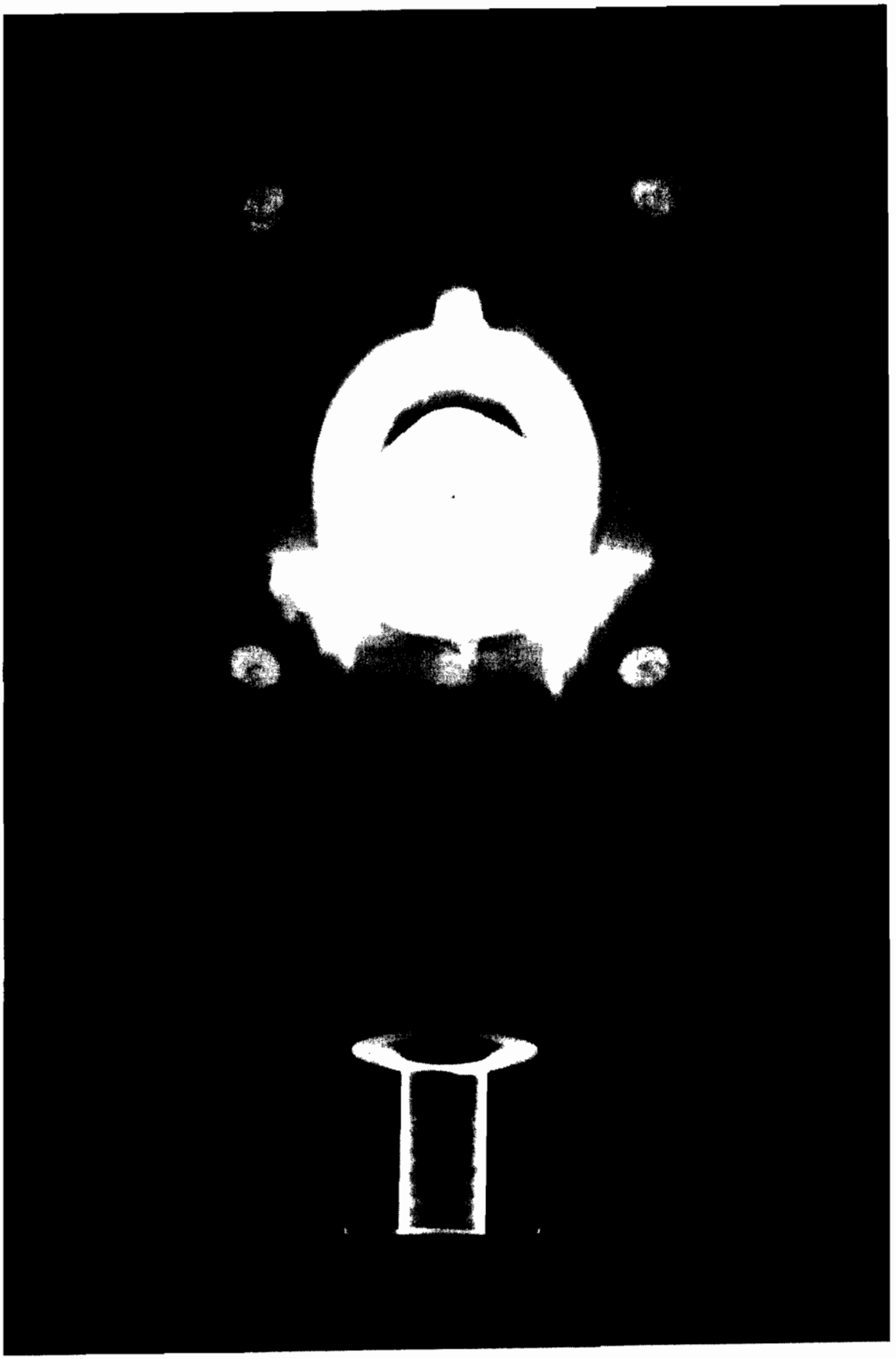
1. Fourier transform infrared (FTIR) spectroscopy can be performed to verify that the tapping tee was manufactured from a polyethylene material. Similarly, the polymer matrix of the GFRP bolts can be verified as being a nylon material. This work can be performed at ESI but will require shaving of a small quantity of material from both the bolts and the tapping tee body.
2. Verification of the specific type of nylon polymer and the glass content of the bolts will require thermal analysis. Differential scanning calorimetry (DSC) will be required to determine the melting temperature of the bolt material, which is necessary to distinguish between the different types of nylon polymers that are used in GRFP nylon products. Thermogravimetric analysis (TGA) will need to be performed to measure the glass content of the nylon compound.
3. If it is desired to verify the type of rubber material used in the o-ring seal of the tapping tee, this can be performed by pyrolysis of the rubber and FTIR on the pyrolyzate. This can also be done at ESI.
4. If it is desirable to verify the curing of the rubber o-ring, it will likely be necessary to perform solvent absorption and swelling of the subject o-ring as well as of an exemplar o-ring compounded and cured to the proper extent.

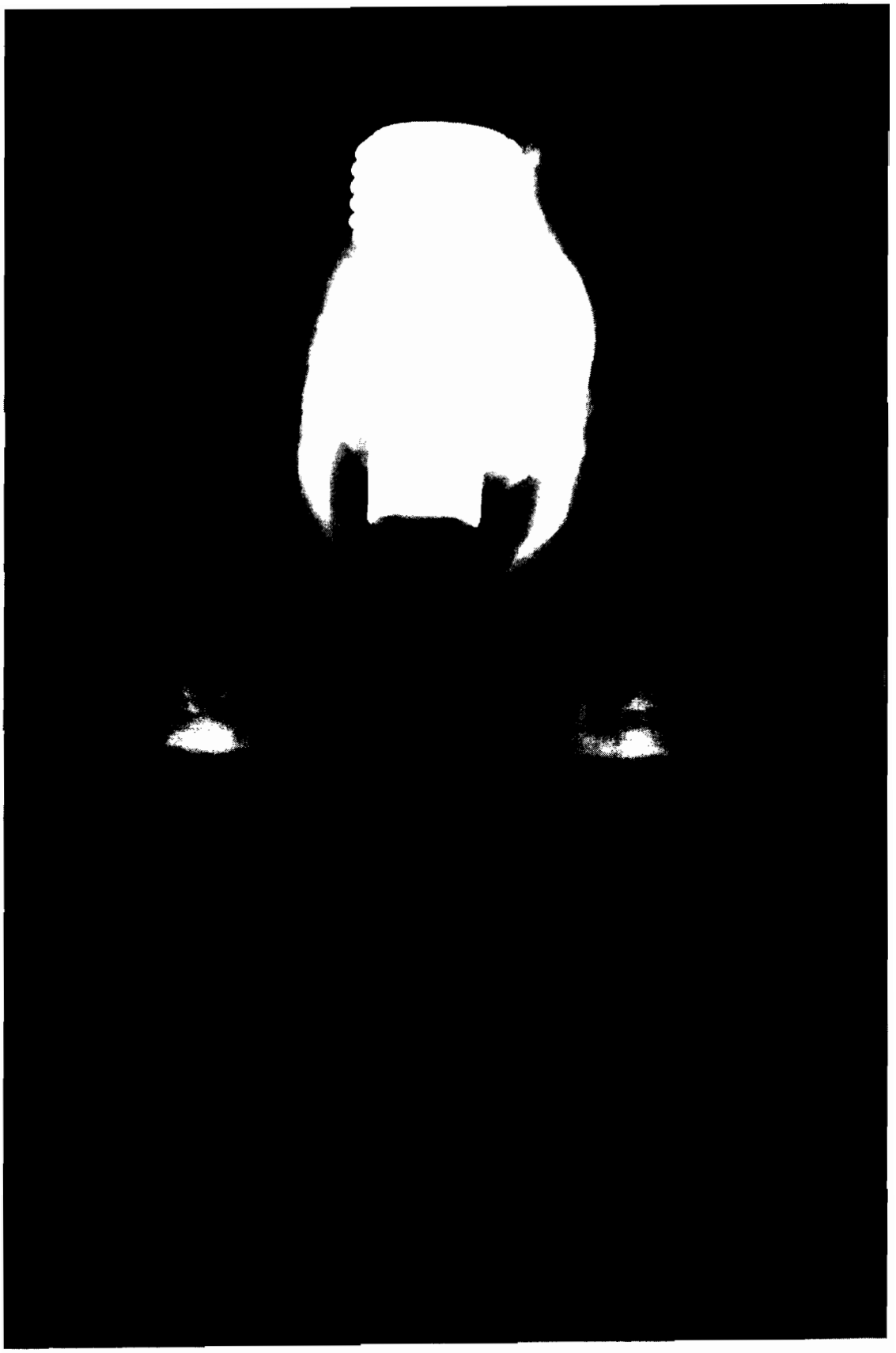
Any questions about the Group 1 testing can be directed either to me or to Dr. Michael Hayes at ESI in Norcross. Dr. Hayes telephone number is 678-990-3280, extension 6002.

Very truly yours,

Donald E. Duvall. Ph.D., P.E.
Senior Managing Consultant

Appendix 2





TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

ATTACHMENT 12

3585 Cadillac Avenue, Suite A Costa Mesa, CA 92626 * 714-258-8610 * Fax 714-258-0921

February 16, 2010

LABORATORY REPORT

Client:
APR Consultants Dickinson
302 Ivy Lane
Dickinson, TX 77539
Attn: Sammy Russo

Work Order:	LTB0049
Project Name:	Air sampling
Project Number:	9140 Grey Pointe Dr.
Date Received:	02/05/10

TestAmerica Los Angeles certifies that the test results provided in this report meet all NELAC requirements for parameters for which accreditation is required or available. Any exceptions to NELAC requirements are noted in the Corrective Action Report. NELAC Certification Number for TestAmerica Los Angeles is E87652. The test results listed within this Laboratory Report pertain only to the samples tested at TestAmerica Los Angeles, unless otherwise indicated. This Laboratory Report is confidential and is intended for the sole use of TestAmerica and its client. This report shall not be reproduced, except in full, without written permission from TestAmerica.

The Chain of Custody, 1 page, is included and is an integral part of this report. This entire report was reviewed and approved for release.

If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 714-258-8610.

Approved By:

Marisol Tabirara
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
3565 Cadillac Avenue, Suite A Costa Mesa, CA 92626 * 714-258-8610 * Fax 714-258-0921

APR Consultants Dickinson	Work Order:	LTB0049	Received:	02/05/10 10:15
302 Ivy Lane			Reported:	02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling		
Sammy Russo	Project Number:	9140 Grey Pointe Dr.		

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION	MATRIX	CONTAINER TYPE
13A	LTB0049-01	01/14/10 14:20	Air	Passivated Canister
13B	LTB0049-02	01/14/10 15:15	Air	Passivated Canister
13C	LTB0049-03	01/14/10 15:33	Air	Passivated Canister

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
3585 Cadillac Avenue, Suite A Costa Mesa, CA 92626 * 714-258-8610 * Fax 714-258-0921

APR Consultants Dickinson	Work Order:	LTB0049	Received: 02/05/10 10:15
302 Ivy Lane			Reported: 02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling	
Sammy Russo	Project Number:	9140 Grey Pointe Dr.	

ANALYTICAL REPORT

Analyte	Result	Data Qualifiers	Units	RL	Dilution	Date Analyzed	Instrument	Analyst	QC Batch
Sample ID: LTB0049-01 (13A - Air)							**Sampled: 01/14/10 14:20**		
ASTM D1945 - Natural Gas									
n-Butane	ND		%(v/v)	0.0000061	1.5	02/08/10 20:53	GC7	td	10B0049
Carbon dioxide	0.039		%(v/v)	0.015	1.5	02/08/10 20:53	GC7	td	10B0049
Carbon monoxide	ND		%(v/v)	0.0015	1.5	02/08/10 20:53	GC7	td	10B0049
C3	ND		%(v/v)	0.0000061	1.5	02/08/10 20:53	GC7	td	10B0049
C6	ND		%(v/v)	0.000015	1.5	02/08/10 20:53	GC7	td	10B0049
C7	0.000080		%(v/v)	0.000015	1.5	02/08/10 20:53	GC7	td	10B0049
C8+	ND		%(v/v)	0.000015	1.5	02/08/10 20:53	GC7	td	10B0049
Ethane	ND		%(v/v)	0.00076	1.5	02/08/10 20:53	GC7	td	10B0049
Hydrogen	ND		%(v/v)	0.030	1.5	02/08/10 20:53	GC7	td	10B0049
Isobutane	ND		%(v/v)	0.0000061	1.5	02/08/10 20:53	GC7	td	10B0049
Isopentane	ND		%(v/v)	0.0000061	1.5	02/08/10 20:53	GC7	td	10B0049
Methane	ND		%(v/v)	0.00030	1.5	02/08/10 20:53	GC7	td	10B0049
Nitrogen	76		%(v/v)	1.5	1.5	02/08/10 20:53	GC7	td	10B0049
Oxygen	23		%(v/v)	0.30	1.5	02/08/10 20:53	GC7	td	10B0049
n-Pentane	ND		%(v/v)	0.0000061	1.5	02/08/10 20:53	GC7	td	10B0049

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APR Consultants Dickinson	Work Order:	LTB0049	Received: 02/05/10 10:15
302 Ivy Lane			Reported: 02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling	
Sammy Russo	Project Number:	9140 Grey Pointe Dr.	

ANALYTICAL REPORT

Analyte	Result	Data Qualifiers	Units	RL	Dilution	Date Analyzed	Instrument	Analyst	QC Batch
Sample ID: LTB0049-02 (13B - Air)							**Sampled: 01/14/10 15:15**		
ASTM D1945 - Natural Gas									
n-Butane	ND		%(v/v)	0.0000059	1.5	02/08/10 21:10	GC7	td	10B0049
Carbon dioxide	0.843		%(v/v)	0.015	1.5	02/08/10 21:10	GC7	td	10B0049
Carbon monoxide	ND		%(v/v)	0.0015	1.5	02/08/10 21:10	GC7	td	10B0049
C3	ND		%(v/v)	0.0000059	1.5	02/08/10 21:10	GC7	td	10B0049
C6	ND		%(v/v)	0.000015	1.5	02/08/10 21:10	GC7	td	10B0049
C7	ND		%(v/v)	0.000015	1.5	02/08/10 21:10	GC7	td	10B0049
C8+	ND		%(v/v)	0.000015	1.5	02/08/10 21:10	GC7	td	10B0049
Ethane	ND		%(v/v)	0.00074	1.5	02/08/10 21:10	GC7	td	10B0049
Hydrogen	ND		%(v/v)	0.030	1.5	02/08/10 21:10	GC7	td	10B0049
Isobutane	ND		%(v/v)	0.0000059	1.5	02/08/10 21:10	GC7	td	10B0049
Isopentane	ND		%(v/v)	0.0000059	1.5	02/08/10 21:10	GC7	td	10B0049
Methane	ND		%(v/v)	0.00030	1.5	02/08/10 21:10	GC7	td	10B0049
Nitrogen	76		%(v/v)	1.5	1.5	02/08/10 21:10	GC7	td	10B0049
Oxygen	24		%(v/v)	0.30	1.5	02/08/10 21:10	GC7	td	10B0049
n-Pentane	ND		%(v/v)	0.0000059	1.5	02/08/10 21:10	GC7	td	10B0049

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APR Consultants Dickinson	Work Order:	LTB0049	Received: 02/05/10 10:15
302 Ivy Lane			Reported: 02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling	
Sammy Russo	Project Number:	9140 Grey Pointe Dr.	

ANALYTICAL REPORT

Analyte	Result	Data Qualifiers	Units	RL	Dilution	Date Analyzed	Instrument	Analyst	QC Batch
Sample ID: LTB0049-03 (13C - Air)							**Sampled: 01/14/10 15:33**		
ASTM D1945 - Natural Gas									
n-Butane	ND		%(v/v)	0.0000062	1.5	02/08/10 21:26	GC7	td	10B0049
Carbon dioxide	0.065		%(v/v)	0.015	1.5	02/08/10 21:26	GC7	td	10B0049
Carbon monoxide	ND		%(v/v)	0.0015	1.5	02/08/10 21:26	GC7	td	10B0049
C3	ND		%(v/v)	0.0000062	1.5	02/08/10 21:26	GC7	td	10B0049
C6	ND		%(v/v)	0.000015	1.5	02/08/10 21:26	GC7	td	10B0049
C7	ND		%(v/v)	0.000015	1.5	02/08/10 21:26	GC7	td	10B0049
C8+	ND		%(v/v)	0.000015	1.5	02/08/10 21:26	GC7	td	10B0049
Ethane	ND		%(v/v)	0.00077	1.5	02/08/10 21:26	GC7	td	10B0049
Hydrogen	ND		%(v/v)	0.031	1.5	02/08/10 21:26	GC7	td	10B0049
Isobutane	ND		%(v/v)	0.0000062	1.5	02/08/10 21:26	GC7	td	10B0049
Isopentane	ND		%(v/v)	0.0000062	1.5	02/08/10 21:26	GC7	td	10B0049
Methane	ND		%(v/v)	0.00031	1.5	02/08/10 21:26	GC7	td	10B0049
Nitrogen	77		%(v/v)	1.5	1.5	02/08/10 21:26	GC7	td	10B0049
Oxygen	22		%(v/v)	0.31	1.5	02/08/10 21:26	GC7	td	10B0049
n-Pentane	ND		%(v/v)	0.0000062	1.5	02/08/10 21:26	GC7	td	10B0049

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
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APR Consultants Dickinson	Work Order:	LTB0049	Received: 02/05/10 10:15
302 Ivy Lane			Reported: 02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling	
Sammy Russo	Project Number:	9140 Grey Pointe Dr.	

PROJECT QUALITY CONTROL DATA

Blank

Analyte	Result	Data Qualifier	Units	RL	Dilution	Date Analyzed	Instrument	Analyst	QC Batch
Sample ID: 10B0049-BLK1 (Blank - Air)									
ASTM D1945 - Natural Gas									
n-Butane	ND		%(v/v)	0.0000040	1.00	02/09/10 22:04	GC7	td	10B0049
Carbon dioxide	ND		%(v/v)	0.010	1.00	02/08/10 13:32	GC7	td	10B0049
Carbon monoxide	ND		%(v/v)	0.0010	1.00	02/08/10 13:32	GC7	td	10B0049
C3	ND		%(v/v)	0.0000040	1.00	02/09/10 22:04	GC7	td	10B0049
C6	ND		%(v/v)	0.000010	1.00	02/09/10 22:04	GC7	td	10B0049
C7	ND		%(v/v)	0.000010	1.00	02/09/10 22:04	GC7	td	10B0049
C8+	ND		%(v/v)	0.000010	1.00	02/09/10 22:04	GC7	td	10B0049
Ethane	ND		%(v/v)	0.00050	1.00	02/08/10 13:32	GC7	td	10B0049
Hydrogen	ND		%(v/v)	0.020	1.00	02/08/10 14:38	GC7	td	10B0049
Isobutane	ND		%(v/v)	0.0000040	1.00	02/09/10 22:04	GC7	td	10B0049
Isopentane	ND		%(v/v)	0.0000040	1.00	02/09/10 22:04	GC7	td	10B0049
Methane	ND		%(v/v)	0.00020	1.00	02/08/10 13:32	GC7	td	10B0049
Nitrogen	ND		%(v/v)	1.0	1.00	02/08/10 13:32	GC7	td	10B0049
Oxygen	ND		%(v/v)	0.20	1.00	02/08/10 13:32	GC7	td	10B0049
n-Pentane	ND		%(v/v)	0.0000040	1.00	02/09/10 22:04	GC7	td	10B0049

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
3585 Cadillac Avenue, Suite A Costa Mesa, CA 92626 * 714-258-8610 * Fax 714-258-0921

APR Consultants Dickinson	Work Order:	LTB0049	Received: 02/05/10 10:15
302 Ivy Lane			Reported: 02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling	
Sammy Russo	Project Number:	9140 Grey Pointe Dr.	

PROJECT QUALITY CONTROL DATA

LCS

Analyte	Result	Data Qualifiers	Units	RL	Dilution	Spike Conc	% Rec	Target Range	Instrument	Date Analyzed	QC Batch
Sample ID: 10B0049-BS1 (LCS - Air)											
ASTM D1945 - Natural Gas											
n-Butane	0.000317		%(v/v)	0.0000040	1.00	0.000277	115%	70 - 130	GC7	02/09/10 21:11	10B0049
Carbon dioxide	0.554		%(v/v)	0.010	1.00	0.499	111%	75 - 125	GC7	02/08/10 12:21	10B0049
Carbon monoxide	0.0238		%(v/v)	0.0010	1.00	0.0228	105%	70 - 130	GC7	02/08/10 12:21	10B0049
C3	0.000407		%(v/v)	0.0000040	1.00	0.000374	109%	70 - 130	GC7	02/09/10 21:11	10B0049
C6	0.000215		%(v/v)	0.000010	1.00	0.000187	115%	70 - 130	GC7	02/09/10 21:11	10B0049
C7	0.000171		%(v/v)	0.000010	1.00	0.000157	109%	70 - 130	GC7	02/09/10 21:11	10B0049
Ethane	0.0272		%(v/v)	0.00050	1.00	0.0250	109%	70 - 130	GC7	02/08/10 12:21	10B0049
Methane	0.0271		%(v/v)	0.00020	1.00	0.0250	108%	75 - 135	GC7	02/08/10 12:21	10B0049
Nitrogen	12.9		%(v/v)	1.0	1.00	11.0	118%	70 - 130	GC7	02/08/10 12:21	10B0049
Oxygen	2.79		%(v/v)	0.20	1.00	2.49	112%	70 - 130	GC7	02/08/10 12:21	10B0049
n-Pentane	0.000255		%(v/v)	0.0000040	1.00	0.000227	112%	80 - 140	GC7	02/09/10 21:11	10B0049

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
3585 Cadillac Avenue, Suite A Costa Mesa, CA 92626 * 714-258-8610 * Fax 714-258-0921

APR Consultants Dickinson	Work Order:	LTB0049	Received: 02/05/10 10:15
302 Ivy Lane			Reported: 02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling	
Sammy Russo	Project Number:	9140 Grey Pointe Dr.	

PROJECT QUALITY CONTROL DATA

LCS Dup

Analyte	Result	Data Qualifiers	Units	RL	Dilution	Spike Conc	% Rec	Target Range	RPD	Limit	Date Analyzed	QC Batch
Sample ID: 10B0049-BSD1 (LCS Dup - Air)												
ASTM D1945 - Natural Gas												
n-Butane	0.000304		%(v/v)	0.0000040	1.00	0.000277	110%	70 - 130	4	30	02/09/10 21:35	10B0049
Carbon dioxide	0.561		%(v/v)	0.010	1.00	0.499	113%	75 - 125	1	20	02/08/10 12:38	10B0049
Carbon monoxide	0.0240		%(v/v)	0.0010	1.00	0.0228	106%	70 - 130	0.7	30	02/08/10 12:38	10B0049
C3	0.000398		%(v/v)	0.0000040	1.00	0.000374	107%	70 - 130	2	30	02/09/10 21:35	10B0049
C6	0.000209		%(v/v)	0.000010	1.00	0.000187	112%	70 - 130	3	30	02/09/10 21:35	10B0049
C7	0.000165		%(v/v)	0.000010	1.00	0.000157	105%	70 - 130	4	30	02/09/10 21:35	10B0049
Ethane	0.0273		%(v/v)	0.00050	1.00	0.0250	109%	70 - 130	0.4	30	02/08/10 12:38	10B0049
Methane	0.0272		%(v/v)	0.00020	1.00	0.0250	109%	75 - 135	0.4	20	02/08/10 12:38	10B0049
Nitrogen	12.9		%(v/v)	1.0	1.00	11.0	118%	70 - 130	0.05	30	02/08/10 12:38	10B0049
Oxygen	2.79		%(v/v)	0.20	1.00	2.49	112%	70 - 130	0.02	30	02/08/10 12:38	10B0049
n-Pentane	0.000249		%(v/v)	0.0000040	1.00	0.000227	110%	80 - 140	2	20	02/09/10 21:35	10B0049

TestAmerica
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APR Consultants Dickinson	Work Order:	LTB0049	Received:	02/05/10 10:15
302 Ivy Lane			Reported:	02/16/10 12:07
Dickinson, TX 77539	Project:	Air sampling		
Sammy Russo	Project Number:	9140 Grey Pointe Dr.		

DATA QUALIFIERS AND DEFINITIONS

ND	Not detected at the reporting limit (or method detection limit if shown)

TAL Knoxville
5815 Middlebrook Pike
Knoxville, TN 37921
phone 865-291-3000 fax 865-584-4315

Canister Samples Chain of Custody Record

TestAmerica assumes no liability with respect to the collection and shipment of these samples.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

LTB0049

Client Contact Information	Project Manager: Sammy Russo	Sampled By: Sammy Russo	1 of 1 COCs
Company: APR Consultants	Phone:		
Address: 302 Ivy Lane	Site Contact:		
City/State/Zip: Dickenson, TX 77539	TAL Contact:		
Phone: 281-337-6700			
FAX: 281-337-8585			
Project Name:	Analysis Turnaround Time		
Site/location: 9140 Grey Point Dr	Standard (Specify)		
PO #	Rush (Specify)		

Sample Identification	Sample Date(s)	Time Start	Time Stop	Canister Vacuum in Field, "Hg (Start)	Canister Vacuum in Field, "Hg (Stop)	Flow Controller ID	Canister ID	TO-15	TO-14A	EPA 3C	EPA 25C	ASTM D-1946	Other (Please specify in notes section)	Indoor Air	Ambient Air	Soil Gas	Landfill Gas	Other (Please specify in notes section)
13A	1-14-10	1420	1423	-28.9	slow bleed		2981											X
13B	1-14-10	1515	1518	-29.2	Ambient Pressure		12489											X
13C	1-14-10	1533	1536	-29.2	↓		12647											X

Sampled by: Sammy Russo

Temperature (Fahrenheit)	Interior	Ambient
Start		
Stop		

Pressure (inches of Hg)	Interior	Ambient
Start		
Stop		

1 BOX RELD AMBIENT
HAND DELIVERED
CUSTODY SEALS INTACT
3 CANS, 0 FLOWS TO 1/29/10

Sammy Russo

Special Instructions/QC Requirements & Comments:
Contact APR - Sammy Russo @ 281-337-6700 for analysis requirements

* TEST - ASTM D1945 PER CLIENT 2/3/10 MDT

Canisters Shipped by:	Date/Time:	Canisters Received by: Alli Smith 1/21/10 9:37
Samples Relinquished by: Sammy Russo	Date/Time: 1-14-10 4:00pm	Received by: Brooke A Smithers
Relinquished by: Debbie Hallet	Date/Time: 1/29/10 9:10am	Received by: Mike A Rose 1/29/10 9:32

LTB0049

Relinquished by: Alli Smith 2/4/10 8:25 Am Rec'd Terri Grant 10:15 2/5/10

TestAmerica

CANISTER FIELD DATA RECORD

CLIENT: TA-KNOX.

CANISTER SERIAL #: KX-2981

DATE CLEANED: _____

CLIENT SAMPLE #: _____

SITE LOCATION: _____

VFR ID: _____

Duration of comp.: _____ Hrs. / mins.

Flow setting: _____ ml/min

Initials: _____

READING	TIME	Vac. (inches Hg) Or PRESS. (psig)	DATE	INITIALS
INITIAL VACUUM CHECK				
INITIAL FIELD VACUUM				
FINAL FIELD READING				

LABORATORY CANISTER PRESSURIZATION			
INITIAL VACUUM (Inches Hg (PSIA) circle unit used))	14.69	2/6/10	JG
.FINAL PRESSURE (PSIA)	22.34	2/6/10	JG

Pressurization Gas: N_2

COMMENTS:

COMPOSITE TIME (HOURS)	FLOW RATE RANGE (ml/min)
15 Min.	316 – 333
30 Min.	158 – 166.7
1	79.2 – 83.3
2	39.6 – 41.7
4	19.8 – 20.8
6	13.2 – 13.9
8	9.9 – 10.4
10	7.92 – 8.3
12	6.6 – 6.9
24	3.5 – 4.0

2

TestAmerica

CANISTER FIELD DATA RECORD

2

CLIENT: TA - KNOX.

CANISTER SERIAL #: KX - 12489

DATE CLEANED: _____

CLIENT SAMPLE #: _____

SITE LOCATION: _____

VFR ID: _____

Duration of comp. : _____ Hrs. / mins.

Flow setting: _____ ml/min

Initials: _____

READING	TIME	Vac. (inches Hg) Or PRESS. (psig)	DATE	INITIALS
INITIAL VACUUM CHECK	[redacted]			
INITIAL FIELD VACUUM				
FINAL FIELD READING				

LABORATORY CANISTER PRESSURIZATION			
INITIAL VACUUM (Inches Hg/ PSIA) (circle unit used))	14.68	2/6/10	
FINAL PRESSURE (PSIA)	21.80	2/6/10	

Pressurization Gas: N_2

COMMENTS:

COMPOSITE TIME (HOURS)	FLOW RATE RANGE (ml/min)
15 Min.	316 – 333
30 Min.	158 – 166.7
1	79.2 – 83.3
2	39.6 – 41.7
4	19.8 – 20.8
6	13.2 – 13.9
8	9.9 – 10.4
10	7.92 – 8.3
12	6.6 – 6.9
24	3.5 – 4.0

3

TestAmerica

CANISTER FIELD DATA RECORD

CLIENT: TA-KNOX.

CANISTER SERIAL #: KX-12647

DATE CLEANED: _____

CLIENT SAMPLE #: _____

SITE LOCATION: _____

VFR ID: _____

Duration of comp. : _____ Hrs. / mins.

Flow setting: _____ ml/min

Initials: _____

READING	TIME	Vac. (inches Hg) Or PRESS. (psig)	DATE	INITIALS
INITIAL VACUUM CHECK				
INITIAL FIELD VACUUM				
FINAL FIELD READING				

LABORATORY CANISTER PRESSURIZATION			
INITIAL VACUUM (Inches Hg / PSIA) (circle unit used))	14.54	2/6/10	JK
.FINAL PRESSURE (PSIA)	22.39	2/6/10	JK

Pressurization Gas: N_2

COMMENTS:

COMPOSITE TIME (HOURS)	FLOW RATE RANGE (ml/min)
15 Min.	316 – 333
30 Min.	158 – 166.7
1	79.2 – 83.3
2	39.6 – 41.7
4	19.8 – 20.8
6	13.2 – 13.9
8	9.9 – 10.4
10	7.92 – 8.3
12	6.6 – 6.9
24	3.5 – 4.0

ATTACHMENT 13

Knox County

Fire Investigation Unit

OFFICIAL FIRE INVESTIGATION REPORT

400 Main Ave, City/County Building • Room 585 • Knoxville, TN 37902 • 865-215-4660 • fax 865-215-4669

Report Number: 0912090721

Incident Address: 9140 Grey Pointe Drive
Responding Fire Department: RMFD Engine 217
Fire Classification: Fire / Undetermined
Est. Damage: $1,000,000.00

Date/Time: 12-9-2009 1:13 AM Wednesday
Notification Time: 0113 **Arrival Time:** 0120
Primary Property Use: Residential
Investigation Status: Investigation Closed

Stephen J. Krzeski	
9140 Grey Pointe Drive	
Knoxville, TN 37922	
865-690-0051	
04-22-1962, W/M	
Insurance Company: Hanover Insurance	

Findings of Investigation

On December 9, 2009, Rural Metro Fire Department, Engine Company 217, 216, 210, and B271 were dispatched to the area of Hailes Abbey Lane in the Whittington Creek Subdivision in West Knox County, for the report of an explosion at a residence. Upon arrival of the engine company found heavy fire involvement and destruction of a multi-story, wood frame residence of over 4000 square feet. They called for additional units to respond to the area of Grey Pointe Drive and upon arrival at that location found the entire structure on the ground. The fire department started search and rescue and attempting to extinguish the fire. During the search and rescue the owner and his wife was found at the rear of the structure where they had been moved by neighbors to a safe area. They were triaged and then transported to UT Medical Center for treatment. The firefighters were advised that the son was most probably in the basement of the structure in his bedroom. This area was well involved with fire at that time, making entry impossible and unsafe.

Member of the Knox County Fire Investigation Unit responded and the following is the facts as found by reporting investigators.

Arrival on the scene:

The entire structure was on the ground and on fire inside the remaining walls of the basement. There was also fire burning on the ground in the area of the front yard to the left of the structure. The path of the fire on the ground was approximately 9 to 10 yards wide left to right and in a line approximately the location of the gas main running parallel to the roadway and the gas service line to the meter on the left side of the residence. All fires outside of the structure had been extinguished upon reporting investigators arrival. There was a large debris field around the structure and extensive damage to the adjoining structures.

Survey of the scene:

Across the front, brick debris was out to the curb and wood debris was scatted towards the front of the house located at 1834 Wembley Hills, the glass for the left garage door was broken out, and small debris were scatter throughout the yard, most were small in size. Insulation was found as far away as 4 houses down Wembley Hills Drive. The roadway was littered with a large amount of glass and small splintered wood parts of the structure. The debris field was at a 45 degree angle left and right of the front of the victim residence. Approximately dispersal distance of the debris was approximately 100 feet.

To the left the debris along Grey Pointe was minimal with only small wood pieces that were whole, not splintered. Some personal effects were found in the yards across the roadway. No large intact pieces were found anywhere to the left of the effected structure.

To the left at 9134 Grey Pointe the driveway was littered with wood debris that was mostly whole. The east side of the effected structure was collapsed into the driveway and yard with the brick having crashed into the side of the residence at 9134 Grey Pointe Drive. The bulk of this brick was the northeast wall and chimney for the fireplace. The brick had fell after folding at the second floor joint, there was two layers of bricks in the area. The wooden structure members found in this area was large full pieces that were heavily charred. The remains of the roof deck was charred underneath but unburned above. Walking further towards the back yard along the property line the larger pieces of the structure were intact but shoved out of the area of the structure by several yards. The columns for the rear deck and the structure were at about a 30 degree angle from the structure footprint. Two of the columns had crushed the metal fence along northeast property line.

The largest pile of debris was at the rear of the house and from observations it looks like the corner was blown out and then laid flat into the yard. The pile of debris was approximately 15 feet deep. The roof deck and all of the connecting structural members were intact. Everything in the area structural wise was laid out at a 30 degree angle from the center line of the structure.

The rear section of the structure was the area of heaviest splintering of structural components. And this was the area of the furthest debris from the structure. This debris was the most damaged from the blast. The window frames for the master bedroom windows were on the ground and intact, the left arch was broken and the continuation was blown approximately 10 more feet out into the yard. A large amount of splintered wood parts were through the yard and into the trees. A large amount of interior finishes were found in the yard in this area as well. There was little to no fire damaged wood in the area of the back center yard. Only lightweight structural components were found in this area and structural components found closer to the structural footprint was burned; it appears this was from the radiant heat of the resulting fires. To the right side the structure was blown out at the same angle as the left side and pan caked out into the yard and down the hill behind the garage and driveway. This side also showed more thermal damage than the left side. The brick and block for the foundation in this area was more shattered and shoved out than the left side. The brick veneer wall for the rear was laid out into the yard and in a general wall configuration. To the right side of the

structure the wall was blown out and then laid down. The brick veneer wall was across the driveway and up against the structure at 9144 Grey Pointe. Garage doors were also against that residence and the windows to 9144 Grey Pointe had been broken out on the 9140 Grey Pointe side. There was more structural damage to the 9144 Grey Pointe structure than the 9134 Grey Pointe residence. The vehicles and appliances in the garage area were in place and were damaged by fire, but not the explosion effects of the incident, but the rather from the crushing effects of the collapse.

The front of the structure was blown into the front yard, and was intact to a point and then laid down onto the front lawn. The front brick veneer wall looks to have fallen down and was completely whole for the most part. There was less explosion force damage to the structure here than in the other areas of the residence. The front porch was undamaged from the blast and the brick veneer wall is separated at the porch floor.

Examination of the interior of the foundation from the front side is as follows in a counter clockwise rotation; the concrete block wall from the northwest (right corner) along the front had fallen down into the basement, this area on the blueprints indicate it is the mechanical room. The dirt wall of the front yard is exposed in this area. The concrete block wall at the front porch area is still intact but showing the force of the blast with a modest amount of separation of the brick and block at the top of the basement wall. The left basement wall of the structure is intact up to about three courses of block from the top. The wall descends toward the rear of the structure along the grade of the adjacent ground of the side yard. This is followed until the wall reaches what was the back yard. The entire rear wall of the structure is burned to the sole plate along the rear wall with most damage being in the center of the rear wall at the location of the ground level exit out of the basement. The right wall for a space listed as crawlspace on the plans is pushed to the right into the crawlspace area. The wall going up to the floor of the garage is intact similar to that of the front porch wall.

Search for Victim and Recovery of the body:

After the fires were out and the scene could be entered and examined, a search for the victim was started. This search included the Knox County Fire Investigation Unit, Knoxville Rescue Squad, and the Rural Metro Fire Department (RMFD). Knoxville Utility Board (KUB) offered the use of a track hoe to assist in moving debris for further investigation. This examination was started from the rear of the structure and worked through the backyard to the area to where the rear of the structure was at ground level in the area of the room denoted on the plans as the "Recreation Room". The debris was lifted and moved slowly so as to be examined by Investigator Lampkin and Dalton for fire damage and for anything related to the investigation and significant to the explosion. The KUB provided track hoe worked in conjunction with investigators. The debris was approximately 2 to 5 foot deep in this area. The debris was layered as it was examined and the layers were in the proper position. The items found on the top of the debris field were that of the upper stories. The area that investigators were working towards was the basement bedroom of the son, Nick Krseski, this room being in the northeast corner of the structure. As the removal of debris was made the basement bath room was found and the then the outer wall to the bedroom. It was in this area that the remains of the victim were found in the center of the bedroom.

Examination and recovery of the victim:

The remains of Nick Krzeski were found in an area close to the center of the bedroom and to the left of the bed, when viewed from the back yard. Upon documenting the body's location it was found that there was an office type chair that the body was seated upon. Observations of the body found that the torso and head were compacted down into itself. And the legs were out towards the front of the structure. The University of Tennessee, Forensic Anthropology Department responded and assisted in the recovery of the body. After recovery the body was transported to the Knox County Forensic Center and Medical Examiner Darinka Mileusnic-Polchan for examination. During the recovery it was found that the torso and heads area was charred and crushed, the extremities were more consumed and the bones being reduced to calicined material.

Examination of the scene for Origin:

The examination of the fire/explosion scene was started on Thursday, December 10th by the Knox County Fire Investigation Unit, and ATF-CFI Special Agent Dennis Kennamer. The pattern of the debris was from the front center of the structure out the back of the structure with a lesser amount to the front side of the structure. This examination of the debris field indicated to this investigator that the area of blast was in the lower levels of the structure and out the rear of the structure towards Hailes Abbey Lane. The debris found in the rear of the structure support this as it is heaviest to the left as viewed from Grey Pointe Drive. The debris distribution in the rear of the structure also shows that the debris is in the proper order with the roof down to the second floor and the rear wall on the bottom. The small parts of the debris found in the back yard was splintered and blown approximately 200 feet or more towards Hailes Abbey Lane. The front debris from the brick veneer wall was shoved out towards the street and fell from the top out after being shoved approximately 10 feet towards the street. The lighter studs from the walls were splintered and blown across the yard and the street. Parts that fell in the yard seemed to show more fire damage, this was from the fire that burned in the basement and radiated into the yard. The large parts that were blown across the street were not charred and showed more evidence of splintering. The front door was the largest piece found across the street in the front yard of 1834 Wembley Hills. The heaviest burning was to the structural components that fell into the basement. There were no clear burn patterns as seen in normal non-explosion scenes.

The area of the structure that indicated the most damage and most probably the area closest to the area of ignition was the concrete block wall from the front left corner of the structure towards the front porch. The dynamics of the explosion would be forced out the rear of the structure with this being the center of the force. This area is described later as the most probable entry of the escaping gas into the structure.

Determination of Cause:

The cause of the fire and explosion is undetermined; the most possible cause of the destruction at this location is from natural gas traveling most likely underground along the water line into the basement and into the room listed as Utility or mechanical room and finding an ignition source.

The sources of ignition that were examined and eliminated:

Smoking – The occupant of the residence were asleep at the time of the explosion and did not smoke, this would eliminate this as a potential cause.

Electrical Failure – The residents had reported no problems with the electrical system prior to the incident. The system was examined and did not show any indicators of failure that could be considered a cause for the explosion or fire. This cause was hampered by the fact of the major destruction that occurred.

Lightning – The area had been subjected to heavy rain and winds in the hours prior to the incident but there was no reports from witnesses that a direct hit from lightning had taken place.

Cooking – The residents were asleep at the time of the explosion and fire. They had not been in the kitchen cooking or using any of the cooking appliances.

Open flames – the residents advised that to their knowledge there was no candles or other open flames in use at the time. The furnaces and water heater are on demand pilots according to information gathered by investigators.

Intentionally set fire – There are no indicators found to show that the fire was intentionally set to cause the event.

It was determined that the gas appliances in the structure would have had to leaked for a significant amount of time and been discovered by residents before reaching the level to have caused this type of explosion. The mechanical room housed the two gas fired furnaces for the basement and main level of the residences, a third unit was located in the attic at the rear of the structure.

The basement mechanical room is the location the water line entered the structure. The water line would have been the most common avenue for the escaping gas to have migrated or conduit from the gas main at the street into the structure and filled the mechanical room where it could be ignited by the furnace. Examination of the furnace in the center of the room showed indicators that the combustion chamber was bent outward. The significances of this fact are unknown to reporting investigator other than not being found in the second unit. Other ignition sources found in the basement did not appear to have contributed to the cause as determined at this time. Nothing was found to indicate the fire and explosion was intentional.

The first material ignited would have been the ignitable vapors of the natural gas.

The ignition source and the reason the gas escaped its pipeline and finding its way into the structure is not known at this time.

Further investigation is being done forensically and will be amendments to this report.

Investigator Name: Mike Dalton