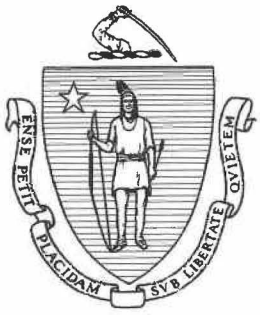

The Commonwealth of Massachusetts

DEPARTMENT OF PUBLIC UTILITIES

INCIDENT REPORT

3 Hancock Avenue, Lexington, Massachusetts
November 9, 2005

PIPELINE ENGINEERING AND SAFETY DIVISION

Accident File

Location: Lexington, Massachusetts

Date of Accident: November 9, 2005

Gas Company: KeySpan Energy Delivery New England

Estimated Property Damage: Over $394,000 *

Injuries: Two

Report Issued - June 2007

* Estimated by KeySpan Energy Delivery, New England

TABLE OF CONTENTS

I. INTRODUCTION

A. Scope of this Investigation

The Massachusetts Department of Public Utilities, formerly known as the Department of Telecommunications and Energy ("Department"), Division of Pipeline Engineering and Safety ("Division"), pursuant to G.L. c. 164, § 105A and a Federal Certification Agreement as provided for in 49 U.S.C.§ 60105, has investigated a natural gas ("gas") release at 3 Hancock Avenue, Lexington, that occurred on November 9, 2005 ("incident").[1] The incident contributed to an explosion, fire and over $394,000 in property damage to the dwelling, as estimated by KeySpan Energy Delivery, New England ("KeySpan") (Exh. 1).[2] There were two injuries as a result of the explosion and fire (Exh. 2). The pipeline involved was owned and operated by KeySpan.

As part of the Department's annual certification process by the United States Department of Transportation ("U.S. DOT"), the Department must report to the US DOT

> each accident or incident . . . involving a fatality, personal injury requiring hospitalization, or property damage or loss of more than an amount the Secretary

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1 Incident means any of the following events:
(1) An event that involves a release of gas from a pipeline or liquefied natural gas or gas from an LNG facility and,
  (i) A death, or personal injury necessitating in-patient hospitalization; or
  (ii) Estimated property damage, including cost of gas lost, of the operator or others, or both, of $50,000 or more.
(2) An event that results in an emergency shutdown of an LNG facility.
(3) An event that is significant in the judgment of the operator, even though it did not meet the criteria of paragraphs (1) or (2)." 49 C.F.R. Part 191,§ 191.3.

2 As a result of a merger completed in 2007, KeySpan is part of the National Grid utility system.

> establishes... and any other accident the [Department] considers significant, and a summary of the investigation by the [Department] of the cause and circumstances surrounding the accident or incident.
> 49 U.S.C. § 60105(c).

The purpose of this report is to inform the U.S. DOT as to the circumstances surrounding, and as to the cause of the incident.

The Department has established procedures for determining the nature and extent of violations of codes and regulations pertaining to safety of pipeline facilities and the transportation of gas, including but not limited to, 220 C.M.R. §§ 101.00 through 113.00. See 220 C.M.R. § 69.00 et seq. The Division also enforces the U.S. DOT safety standards for gas pipeline systems as set forth in 49 C.F.R. Part 192 ("Part 192"). G.L. c. 164, § 105A.

B. Overview of Incident

On November 9, 2005, at 11:19 a.m., the Lexington Fire Department ("Fire Department") received an alarm for an explosion and fire at 3 Hancock Avenue (Exh. 2). The fire department was at the scene immediately after the gas explosion. At 11:35 a.m., KeySpan was notified of the incident by the fire department and requested at the scene. A KeySpan crew working at the intersection of Hancock Street and Coolidge Street, Lexington, also responded to the scene. Additional KeySpan personnel arrived at the scene at 12:23 p.m., and the gas was shut off at 1:09 p.m.

At approximately 12:00 p.m.,[3] KeySpan notified the Division of the explosion and fire (Exh. 3). KeySpan reported that a portion of the distribution system in Lexington had been over pressurized. Three Division investigators arrived at the scene at about 1:20 p.m.

The Division's investigation finds that KeySpan inadvertently connected a two pounds per square inch gauge("psig")[4] high pressure[5] main to a 60 psig high pressure main while in the process of performing a main connection. This allowed natural gas from the 60 psig system to enter the lower pressure two psig system, resulting in an over-pressurization of the two psig system including the natural gas service line[6] feeding 3 Hancock Avenue.

A metallurgical analysis of the service piping concluded that the over-pressurization event caused the service line feeding 3 Hancock Avenue to blow out at a corroded section of inside service line piping, releasing gas into the basement of the house. The gas explosion was

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3 In a letter to all operators; the Director of the Division has requested that operators inform the Department of any incident promptly, but no more than two hours after the incident.

4 Pounds per square inch gauge refers to the pressure expressed in pounds exerted on one square inch of surface area. The designation "gauge," indicates the readings are already adjusted to ignore the surrounding atmospheric pressure, which is 14.7 psi at sea level. If psig gauge were not connected to any pressure source, it would read zero even thought it is actually sensing 14.7 psi at sea level.

5 A high pressure system is a system in which the pressure in the main is higher than the pressure provided to the customer. Part 192, § 192.3.

6 A distribution line that transports gas from a common source of supply to an individual customer, to two adjacent or adjoining residential or small commercial customers, or to multiple residential or small commercial customers served through a meter header or manifold. A service line ends at the outlet of the meter or at the connection to a customer's piping, whichever is further downstream , or at the connection to customer piping if there is not meter.

caused by the ignition of an accumulation of natural gas in the basement of 3 Hancock Avenue (Exh.2). There were multiple ignition sources in the basement, including a water heater pilot and a furnace burner. It could not be determined which source triggered the explosion and subsequent fire (id.). KeySpan reported eleven additional locations where there were leaks on inside company-owned piping (Exh. 4).

II. THE DIVISION INVESTIGATION

A. Description of the Site

Hancock Avenue is located in a residential area of Lexington. The area consists of mostly single family houses. The structure at 3 Hancock Avenue was a two-story wood frame house with a basement. The house was constructed in 1865. The furnace and hot water heater were located in the front portion of the basement (Exh. 5).

The gas meter and service regulator[7] were also located inside the house near the front foundation wall. The gas service line entered the house below ground, through the front foundation wall (Exh. 6). The 1.25-inch diameter service line was installed on May 26, 1919. Massachusetts Materials Research Inc. ("MMR") has analyzed it and determined that the service line was made of carbon steel pipe. The gas main[8] under Hancock Avenue was four-

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7 A service regulator is a valve which reduces the pressure in the service line from the pressure in the main to the pressure provided to the customer.

8 A main is a distribution line that serves as a common source supply for more than one service line. Part 192, § 192.3.

inch cast iron pipe, installed in 1911 (Exh. 7). The maximum allowable operating pressure ("MAOP")[9] of the main and service at the time of the incident was two psig.

B. Description of the Scene

1. The Homeowners

At the time of the explosion, there were two people at 3 Hancock Avenue. The son of the homeowner stated that he was in a bedroom on the second floor of the house when he heard a loud hiss. He went outside to get his mother to investigate the noise. His mother said that she could not hear any noise outside but could smell gas. They both went back into the house. The homeowner opened the basement door and turned on the light. She stated that she took a few steps into the basement. At that time her son made her go back outside. He stated that at no time could they smell gas inside of the house (Exh. 2). The lack of an odor may have been caused bya wall separating the basement.

The son retrieved his cell phone prior to leaving the house. He stated that five minutes had passed between the time he heard the hissing sound and when he called 911. Approximately a minute later the house exploded (Exh. 2).

2. The Scene

On November 9, 2005 at approximately 1:20 p.m., three Division investigators arrived at 3 Hancock Avenue to investigate the incident. Representatives from KeySpan, Lexington Police and Fire Departments, and the State Fire Marshall's Office were at the scene.

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[9] Maximum Allowable Operating Pressure (MAOP) means the maximum pressure at which a pipeline or segment of a pipeline may be operated. Part 192 § 192.621.

The house had been completely destroyed by the explosion and ensuing fire (Exh. 8). The house had collapsed into the basement. The adjacent two car garage was partially destroyed. Debris had been blown into the street and throughout the yard (Exh. 9).

The service regulator and meter had been severed from the service line near the inside foundation wall (Exh. 10). KeySpan shut the main down near the intersection of Hancock Street and Hancock Avenue (Exh. 5, at 4). KeySpan shut off the gas by inserting a stop off bag into the four-inch cast iron main. The pressure at this time was approximately 1.25 psig.

The Division's investigators requested that KeySpan pressure test the portion of the service line from the main to a point outside the foundation wall. The pressure test did not include the section of KeySpan's service line that passed through the foundation wall, the interior piping, the service regulator and the meter. The service line was pressure tested to 34.2 inches water column[10] ("in.wc.") for 15 minutes, at the end of the pressure test the pressure was 30.3 in.wc. The service line was then pressure tested at 50.0 in.wc. for 15 minutes, at the end of the pressure test the pressure was 44.9 in.wc. The Division investigators observed slight leakage on the test equipment. The Division considers this leakage to be insignificant.

After the completion of the pressure tests, the investigators exposed the remaining portion of service line that passed through the foundation wall. The pipe section was photographed and taken into custody by the Lexington Fire Department. The inside piping, the regulator, and the meter were also taken into custody by the fire department.

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10 "Inches water column" is a measurement of pressure with 27.71 inches of water column equal to one psig.

C. KeySpan Energy Delivery New England - Records

1. Service to 3 Hancock Avenue

KeySpan last entered the house on May 21, 1996, to replace the meter (Exh. 11). KeySpan provided no record of a leakage survey or a corrosion inspection being performed at that time. KeySpan could not gain access to the house on July 23, 2004 (Exh. 12). KeySpan provided no other records of entry to the house after 1996. State law requires that meters be replaced every seven years. G.L. c. 164, s. 115A.

2. Leakage Survey and Repair Records

The main and services underlying Hancock Avenue were leak surveyed on August 18, 2005 (Exh. 13). The service line was surveyed up to the exterior building wall. No leaks were discovered (id).

KeySpan has no records of any leak surveys performed on the company owned interior piping. KeySpan has no records of any maintenance or replacement work being performed on the main for one year prior to the incident (Exh. 7). There is also no record of any leaks on the service line or any maintenance performed on customer owned piping or appliances (Exh. 14).

Federal pipeline safety regulation Part 192, § 192.3 states that a service line ends at the outlet of the customer meter or at the connection to a customer's piping, whichever is further downstream, or at the connection to customer piping if there is no meter. Federal pipeline safety regulation, Part 192, § 192.723: Distribution systems: Leakage surveys, requires leakage surveys to be conducted of services and mains at three or five year intervals, if they

are located outside of business districts.[11] In KeySpan's O&M procedure LSUR-5020 Walking Surveys states that at least once each three years all services outside the business district shall be leakage surveyed by walking each buried service line (Exh. 20). The survey is conducted by walking along the route of the pipeline or in the area between the main and the building. The procedure does not address leakage survey of interior service piping. KeySpan's procedures only address the portion of the service line up to the foundation wall. KeySpan does not have any record of performing a leak survey of the company piping inside 3 Hancock Avenue (Exh. 19).

Based on this information, KeySpan had inadequate operating and maintenance procedures to address leakage surveys. Therefore, KeySpan's procedures do not comply with federal pipeline safety regulations. Part 192, §§ 192.3; 192.723.

3. Leakage Surveys on Hancock Avenue After the Incident

Immediately after the incident, KeySpan conducted leakage surveys of the houses on Hancock Avenue. Records indicate that the surveys were conducted inside houses that were

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[11] (a) Each operator of a distribution system shall conduct periodic leakage surveys in accordance with this section.
(b) The type and scope of the leakage control program must be determined by the nature of the operations and the local conditions, but it must meet the following minimum requirements:
(1) A leakage survey with leak detector equipment must be conducted in business districts, including tests of the atmosphere in gas, electric, telephone, sewer, and water system manholes, at cracks in pavement and sidewalks, and at other locations providing an opportunity for finding gas leaks, at intervals not exceeding 15 months, but at least once each calendar year.
(2) A leakage survey with leak detector equipment must be conducted outside business districts as frequently as necessary, but at least once every 5 calendar years at intervals not exceeding 63 months . . . . Part 192, § 192.723.

accessible (Exh. 15). The results of the leakage surveys were negative. There is no record of the four-inch cast iron main being surveyed immediately after the incident, because it was shutdown.

4. Operating Pressure on Hancock Avenue

The MAOP of the main and service on Hancock Avenue is two psig. Shortly after the incident the main was shut down. The pressure in the main at that time was 1.25 psig.

KeySpan used their records to estimate the maximum pressure reached in the two psig system. The estimate was based on the pressure drop at the surrounding regulator stations that supply the 60 psig system. KeySpan estimated the maximum pressure throughout the two psig distribution system to be 56 psig (Exh.16). The maximum pressure at 3 Hancock Avenue was 50.3 psig.

The federal pipeline safety regulation Part 192, § 192.621: Maximum allowable operating pressure: High-pressure distribution systems,[12] requires that the MAOP not be exceeded. The Division is also investigating the over-pressurization incident itself. The Division will issue a separate report on the results of that investigation.

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[12] (a) No person may operate a segment of a high pressure distribution system at a pressure that exceeds the lowest of the following pressures, as applicable...

(5) The pressure determined by the operator to be the maximum safe pressure after considering the history of the segment, particularly known corrosion and the actual operating pressures.

(b) No person may operate a segment of pipeline to which paragraph (a) (5) of this section applies, unless over-pressure protective devices are installed on the segment in a manner that will prevent the maximum allowable operating pressure from being exceeded, in accordance with § 192.195. Part 192 § 192.621

5. Odor Testing

The state regulation, 220 C.M.R. § 101.06(20), requires operators to odorize gas in their distribution systems. Gas must be "readily perceptible to the normal or average olfactory senses of a person coming from fresh uncontaminated air into a closed room containing 0.15 percent gas and air." The state regulation, 220 C.M.R. § 101.06(20)(a), requires operators to conduct periodic sampling of odorant concentrations throughout their system.

KeySpan conducts odorant sampling throughout its system on a monthly basis. On November 9, 2005, several odor level tests were conducted in Lexington after the explosion (Exh.17). The results of the tests are as follows:

1. 7-9 Harrington Street @ 1:15 p.m. - Odor level 0.08 percent gas and air

2. 55 Coolidge Avenue @ 2:15 p.m. - Odor level 0.07-0.09 percent gas and air

The odor detectability levels of gas in air ranged from 0.070 percent to 0.09 percent gas in air, indicating that the odorant levels were within the limit prescribed in the state regulation. The odorant levels also met the federal pipeline safety requirement, contained in Part 192, § 192.625, which requires that gas be odorized so that it can be detected at a level of one percent gas in air.

6. Corrosion Control Procedures and Records

Federal pipeline safety regulation, Part 192, § 192.481: Atmospheric corrosion control: Monitoring,[13] requires atmospheric corrosion inspections of aboveground piping every three

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[13] (a) Each operator must inspect each pipeline or portion of a pipeline that is exposed to the atmosphere for evidence of atmospheric corrosion; as follows: Onshore, At least once every 3 calendar years, but at intervals not exceeding 39 months.
(b) During inspections the operator must give particular attention to pipe at soil-to-air
(continued...)

years. KeySpan's Operating and Maintenance manual ("O&M") addresses the inspection of exposed pipe in procedure CORR 5101: Atmospheric Corrosion Program (Exh. 18). The procedure states that inspections must be performed once every three years to determine if atmospheric corrosion exists. Further, it states that the Corrosion Control Section shall be responsible to inspect "all outside service piping installations to the outlet of the meter (id. at 3)." The procedure does not address atmospheric corrosion inspection of interior service piping. Part 192, § 192.3 (definition of "service line"). KeySpan stated that it does not have any record of corrosion monitoring of interior company piping at 3 Hancock Avenue, Lexington (Exh. 19). KeySpan's procedures require atmospheric corrosion inspection of only the "outside service piping installations (Exh. 18, at 3)."

Based on this information, KeySpan had inadequate operating and maintenance procedures to address atmospheric corrosion monitoring. Therefore, KeySpan's procedures do not comply with federal pipeline safety regulations. Part 192, §§ 192.3; 192.481.

D. Failure Analysis of Pipe Sections

Massachusetts Materials Research, Inc. ("MMR") conducted a failure analysis of the interior piping and fittings from 3 Hancock Avenue.[14] The pipe was recovered by the Lexington Fire Department and stored at their facility. After the piping and fittings were released to the Division, they were taken to MMR for metallurgical testing. The piping and

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[13](...continued)
interfaces, under thermal insulation . . . . Part 192, § 192.481

[14] Copies of the MMR report can be obtained by contacting: Veda-Anne Ulcickas, Massachusetts Material Research, Inc., P.O. Box 810, Century Drive, West Boylston, MA 01583.

fittings consisted partly of sections of high pressure piping and a valve, which was located upstream of the regulator. The low pressure piping from the regulator to the meter inlet, the regulator and regulator vent pipe, and the meter were also part of the evidence sent to MMR. The purpose of the testing was to document the condition of the interior facilities and to attempt to determine the cause of the incident.

MMR performed debris analysis, leak testing, radiographic examination, microscopic examination, fracture surface conditions and chemical analysis. Their analysis and testing found:

1. The fractured end was corroded to a knife-edged appearance and the corrosion appeared to be from the outer surface to the inner surface.

2. On-site photographs taken after the incident during the dismantling of the foundation to excavate this pipe revealed that the fracture surface was visible at the cellar wall.

3. Examination of the fracture origin region revealed extensive corrosion at the knife-edged region rimming the blown-out section.

4. The inlet pipe examination revealed that the metal at the fracture origin had been completely consumed by corrosion products by the time of the incident.

Based on the analysis, MMR concluded the following:

> This incident was caused by the over-pressure event on the two psig gas main resulting in a blown out section of corroded inlet pipe on the service line to 3 Hancock Avenue. The corroded region of pipe surrounding the missing blown-out material revealed regions where the pipe wall was corroded through. This indicates that portions of the pipe retaining pressure consisted solely of corrosion products. The corroded portion of pipe was visible to inspection outside the inner foundation wall surface in the cellar of 3 Hancock Avenue.
>
> Pipe material and corrosion product analysis indicated a high phosphorous Type 1008 or similar carbon steel with mechanical properties consistent with the material and its metallurgical condition. The corrosion product leachable pH

was 7.4, which indicates a slightly basic environment. The higher phosphorous content and basic environment would both act to retard corrosion of this pipe.

The cupric meter shutoff valve was constructed of leaded brass and possessed a secondary fracture caused by the incident.

The inlet pipe dimensions correspond to Standard Schedule 40 pipe. The nominal corrosion rate for the time period covering the 1919 installation date to the 2005 incident rate was 0.0016-inch per year. Corrosion was caused by a phenomenon known as barrier effect.

MMR discussed the possible cause for the condition of the service piping.

In general, the mild indoor environment of this service was not detrimental to the majority of the exposed pipe. However, even in mild environments, transition zones can be ideal locations for corrosion. A transition zone can be defined as a change in piping material, a wall penetration region, a change in insulation status (i.e. insulated to non-insulated pipe run), etc. These are regions where slight differences in the local environment can create electropotential anomalies that lead to corrosion. In this specific case, the rocks of the foundation were a boundary between the soil they contacted on one side of the wall and air of the cellar room they defined. Temperature differentials, especially in the summertime, likely caused the rocks to sweat. This would expose the portion of pipe emerging from the foundation to a wetter environment (from actual drips and/or higher local humidity) than the rest of the exposed length. Over time, this can lead to localized general corrosion like that on this incident inlet pipe, despite the lack of aggressive elements and the corrosion retarding effects of higher phosphorous and basis pH. This phenomenon is called the "barrier effect."

While piping lengths within walls are not visible to visual inspection, this corroded region was, based upon scene photographs. Since it is possible that loose, flaky corrosion product could hide severe wall wastage from a cursory visual pipe inspection, the possibility of adding touch to inspection programs should be investigated.

III. FINDINGS AND CONCLUSIONS

A. Findings

1. A four-inch cast iron main was laid under Hancock Avenue Lexington in 1911.

2. A 1.25 - inch steel service line to 3 Hancock Avenue was installed in 1919.
3. The MAOP of the main and the service on Hancock Avenue was two psig.
4. On November 9, 2005, KeySpan allowed natural gas from its 60 psig system to enter the two psig system servicing, among other places in Lexington, 3 Hancock Avenue.
5. KeySpan estimated the maximum pressure at 3 Hancock Avenue to be 50.3 psig.
6. A metallurgical analysis of the KeySpan service piping at 3 Hancock Ave concluded that the over-pressure event resulted in a blown out section of the service line to 3 Hancock Avenue.
7. Natural gas escaped from the blown out section of the service line at 3 Hancock Avenue, accumulated in the basement, and ignited.
8. Possible ignition sources in the basement included a water heater and furnace; however, the exact source of ignition could not be determined.
9. Two residents were in the area of the house at the time of the explosion.
10. Both residents were taken to the hospital with minor injuries and released.
11. KeySpan's last entry into 3 Hancock Avenue was to replace the meter on May 21, 1996.
12. On August 18, 2005, KeySpan conducted a leakage survey of the main and outside service piping of 3 Hancock Avenue, but did not find any leaks.
13. KeySpan has no record of conducting a leakage survey of its interior service piping at 3 Hancock Avenue.
14. KeySpan has no record of monitoring corrosion of its interior service piping at 3 Hancock Avenue.
15. KeySpan has no record of any maintenance or replacement work being performed on the main on Hancock Avenue one year prior to the incident.
16. KeySpan has no record of any leaks on the service line, or any maintenance performed on customer owned piping or appliances at 3 Hancock Avenue.
17. KeySpan conducted a leakage survey immediately after the incident of the houses that were accessible on Hancock Avenue and found no leaks.
18. KeySpan does not have a record of the leakage survey of the main on Hancock Avenue after the incident, because it was shutdown.
19. KeySpan met the odorization requirements of state and federal pipeline safety regulations.
20. KeySpan's Operating and Maintenance Procedures require atmospheric corrosion monitoring of company piping be conducted on outside service lines.

21. KeySpan's Operating and Maintenance Procedures require leak surveys be conducted by walking along the route of the company piping or in the area between the main and the building.

B. Conclusions

1. The analysis in the MMR report was based upon substantial evidence and the report's conclusions are reasonable.
2. The cause of the incident was natural gas released from the blown out section of service pipe into 3 Hancock Avenue, the exact ignition source can not be determined.
3. KeySpan's corrosion monitoring procedures do not provide that it monitor corrosion up to "the outlet of the customer meter," should that meter (and service line) be located inside a customer's premises. 49 C.F.R. Part 192, § 192.3.
4. KeySpan's leakage survey O&M procedures do not provide for a leakage survey of interior service piping "to the outlet of the service meter" because the procedures only address that portion of KeySpan service line up to the foundation wall. Part 192, § 192.3.

IV. KEYSPAN ACTIONS

On February 11, 2008, pursuant to G.L. c. 164, § 105A and 220 C.M.R. §§ 69.00 et seq., the Department concluded an enforcement action with KeySpan. KeySpan Energy Delivery, New England, D.P.U. 05-PL-17. KeySpan agreed to amend its O&M procedures to establish a program that requires corrosion monitoring and leak surveys of KeySpan inside service piping, consistent with the frequency requirements established in federal and state regulations.