NEW JERSEY DIVISION OF FIRE SAFETY

Firefighter Fatality and Serious Injury Report Series

A Fire Chief and a Police Officer Suffer Burn Injuries In a Natural Gas Explosion

Flemington, New Jersey

Report Issued
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STATE OF NEW JERSEY
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INTRODUCTION

The investigation of this incident was conducted by the New Jersey Division of Fire Safety in conjunction with the New Jersey Department of Labor and the New Jersey Department of Health. This report was prepared in accordance with N.J.S.A. 52:27D – 25d, Duties of the Division. The purpose of these firefighter casualty investigations is to report the causes of serious firefighter injuries or deaths and identify those measures which may be required to prevent the future occurrence of deaths and serious injuries under similar circumstances. In some cases new information may be developed, or old lessons reinforced, in an effort to prevent similar events in the future.

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SUMMARY

On January 22, 2000 the Flemington Fire Department (FFD) responded to a reported odor of natural gas at 32 Church Street in Flemington Borough, NJ. Upon arrival, the Fire Chief and a Flemington Borough Police Officer determined the source of the leak to be located in the basement of the building near the gas meter. While attempting to shut down the flow of gas, the accumulating gas ignited explosively which resulted in burn injuries to both the Fire Chief and the Police Officer.

INVESTIGATION

The Incident

On January 22, 2000 at 1436 hours the Flemington Fire Department (FFD) responded to a report of an odor of gas located at 32 Church Street, Flemington. The main part of the structure was over one-hundred years old with an addition of undetermined age attached. The building was two stories in height and was of wood frame construction built in what is commonly known as “balloon construction” meaning that the supporting structures of the walls span more than one floor with no fire-stopping between floor levels. The building measured 46’ 5” across, by 51’ 2” front to back and was used as a business occupancy. At the time of the incident, the building was being renovated and it was the workmen in the building who first made the notification that there was an odor of gas present. All workers evacuated the structure and none were involved further with the incident.

Upon receipt of the reported odor of gas, the FFD responded with two engines and a tower ladder. Department Chief Charles Smith also responded in a department owned incident command vehicle. Chief Smith arrived on scene at 1439 hours. He positioned his vehicle so as to block traffic at the intersection of Church Street and Main Street which was located approximately Southeast of the building with a bank building between Main Street and the building at 32 Church Street. The area where Chief Smith parked was approximately 150’ from the building. After arriving on scene, Chief Smith walked over to the area of the building at 32 Church Street to try to determine where the odor of gas was coming from. At 1445 hours Patrolman George Becker of the Flemington Police Department arrived on scene at the location where Chief Smith had parked his vehicle. Upon his arrival, Ptl. Becker saw Chief Smith in the vicinity of 32 Church Street and Smith yelled to Becker that he believed the gas was coming from that building. Ptl. Becker then proceeded to Smith’s location on foot. Together they then checked the perimeter of the building to try to ascertain where the gas meter and accompanying shut-off might be. As they arrived at the “D” side of the building, they noted a vent for the gas meter coming out of the side of the building and assumed that the meter was inside the structure. They then entered an adjacent doorway that was unlocked. Just inside the door to the right was a furnace which was vented via a power blower through the exterior wall. Adjacent to the furnace was a trap door that led to stairs to the basement area. After they opened the door, both Becker and Smith descended the stairs. Becker located the gas meter and reported to Smith that there was a shut-off valve. Smith indicated that he was going to go back up to get a wrench to shut it off. As Smith went back up, Becker attempted unsuccessfully to shut off the valve with his bare hand. While his hand was still near the meter, Becker felt what he described as air blowing against his hand. By this time, Chief Smith had reached the doorway where they had entered from and yelled to the assembling fire crews outside for someone to bring him a pipe wrench and a gas detection meter. Witnesses outside the structure reported that only seconds later there was an explosion and Chief Smith was thrown approximately 25-30’ from the building where he landed in the parking lot. Immediately, Captain Steven Kilinski ran to the aid of Chief Smith as did the driver of Engine 49-61, FF Robert Umgelter. Both Kilinski and Umgelter had arrived on scene while Chief Smith and Ptl. Becker were inside

the structure. As Umgelter approached Smith, he heard screams coming from inside the structure. Seeing that Chief Smith was already being cared for by Captain Kilinski, Umgelter ran toward the building in the direction of the screams. At this time Ptl. Becker came out of the doorway where he and Smith had originally entered. Becker's clothes were on fire and he reported that he was trying to protect his face from the flames by covering it with his hands. After he exited the building, he dropped to the ground, which was covered with snow, and began rolling to attempt to extinguish the flames. FF Umgelter, who was joined by FFs Larry Tiger and Matthew Gross, began throwing snow onto Becker to put out the fire. EMS personnel then arrived on scene and took over the treatment of Smith and Becker.

At about this time other firefighters on scene began fighting the fire that had ignited in the structure. Due to the balloon construction of the building, fire spread rapidly from the basement area to the second floor where much of the fire damage occurred. When the fire was finally extinguished, it was determined that the building had sustained heavy damage both from the explosion and the fire and it was noted that the structure was actually moved approximately 2" off its foundation.

Flemington Fire Chief and Police Officer Injuries

Chief Smith and Ptl. Becker both received burn injuries due to the explosion. The injuries were mainly to their faces and hands. Due to his being in the structure at the time of the explosion, Ptl. Becker suffered more serious burns. Both men were airlifted from the scene, Becker to the St. Barnabas Medical Center Burn Unit; Smith to the Lehigh Valley Hospital Burn Unit in Pennsylvania.

Explosion/Fire Cause Investigation

A detective of the NJ State Police Arson Unit investigated the cause of the explosion and subsequent fire. It was learned that the gas leak was caused by a separation of the service line of the building where it connects to the gas main at the street. Due to the ground being frozen and the service line passing under a sidewalk and paved areas, the gas did not leak into the surrounding ground and did not vent to the surface. Instead it entered the protective pipe surrounding the service line and took the path of least resistance by following this pipe into the basement of the structure where it vented. It is suspected that the motor of a power ventilation system for the heating system located on the first floor provided the ignition source for the gas that had accumulated in the building. The resultant fire was triggered by the high heat conditions caused by the explosion and sustained by the abundance of fuel present.

ANALYSIS

Flammable Gas Detection Equipment

Upon the arrival of Chief Smith and Ptl. Becker, the odor of natural gas was detected in the area of 32 Church Street. Other firefighters arriving on scene shortly afterward noted a significant odor of gas a considerable distance from the area of the leak. When the two men identified the suspected source of the leak to be the 32 Church Street building, they decided to enter the building without the benefit of a flammable gas detection device that could have warned them that the gas concentration in the structure was nearing or had reached the explosive range for natural gas. Such a device was available upon arrival of apparatus of the fire department and was in fact being requested when the gas ignited.

Self Contained Breathing Apparatus and Personal Protective Equipment

During the time when Chief Smith and Ptl. Becker were in the hazardous area, inside and in close proximity to the structure where they believed the gas was leaking, neither was wearing appropriate personal protective equipment (PPE) or SCBA. When the natural gas ignited, they suffered burns to their clothes and bodies due to the lack of even the minimal protection that could have been offered by PPE. This failure to utilize protective equipment was the primary physical reason the two men were injured.

Control of Ignition Sources

At this incident, as with any incident involving potentially flammable or explosive atmospheres, control of sources of ignition is vital to prevent ignition of flammable gas. The ultimate result of this incident indicates that identification of potential sources of ignition and efforts to control them were inadequate.

Positioning of Apparatus and Securing of the Scene

Upon arrival at the scene, apparatus was positioned at key locations substantially distant from the immediate hazardous area both to prevent the vehicles from becoming potential sources of ignition and also to prevent unauthorized access to the scene. Department officers and apparatus operators used appropriate judgment in this regard and as a result no additional injuries occurred due to the gas explosion, nor was any apparatus damaged.

Standard Operating Procedures for Operations at Natural Gas Leaks

The FFD did not have a standard operating procedure for operating at the scene of a natural gas leak. A review of the department's standard operating procedures revealed that there were sections that pertained to hazardous materials incidents and incidents involving special hazards. However, these were not specific with regard to all aspects of operations at the incident scene nor did they provide step-by-step guide for dealing with these types of incidents.

LESSONS LEARNED

Physical Properties of Natural Gas

Natural gas is gaseous at any temperature over -161 C (-258 F). Since that is a very cold temperature, natural gas is normally considered to be a gas. Natural gas boils at atmospheric pressure and a temperature of -161 C, exactly like water turns into a gas (steam) at +100 C. Because of this property, natural gas is transmitted and stored as a gas. The volume of natural gas is measured in cubic meters (m3) or cubic feet (cu.ft. or cf); its flow in m3/hr or cu.ft./hr or cfh.

In its pure state, natural gas is odorless, colorless, and tasteless. For safety reasons, however, an odorant called Mercaptan is added, so that any leak can be easily detected because of the typical smell.

The composition of natural gas is never constant. However, Methane is by far the largest component, its presence accounting for about 95% of the total volume. Other components are: Ethane, Propane, Butane, Pentane, Nitrogen, Carbon Dioxide, and traces of other gases. Very small amounts of sulphur compounds are also present. Since methane is the largest component of natural gas, the properties of methane are generally used when comparing the properties of natural gas to other gases.

NATURAL GAS ANALYSIS							
	Constituent						
	Methane CH_4	**Ethane C_2H_5**	**Propane C_3H_8**	**Butane C_4H_{10}**	**Carbon Dioxide CO_2**	**Nitrogen N_2**	**Total**
Volume	**94.8%**	**2.9%**	**.8%**	**.2%**	**.1%**	**1.2%**	**100%**
Specific Gravity (rel. air=1): 0.586							

Methane is a simple hydrocarbon, a substance consisting of carbon and hydrogen. There are many of these compounds, and each has its own number of carbon and hydrogen atoms joined together to form a particular hydrocarbon gas or fuel gas.

Methane is a very light fuel gas. If the number of hydrogen and carbon atoms are increased, we have progressively heavier gases, releasing more heat - therefore more energy - when ignited. For this reason the heat content of butane, for instance, is greater then that of propane, and propane has more energy than methane per unit of volume.

Specific gravity of a gas is defined as the weight of a given volume gas compared to the weight of the same amount of air at the same temperature and pressure, where air weight is taken as reference (= 1).

- Specific gravity of air = 1.00
- Specific gravity of methane = 0.55
- Specific gravity of natural gas = typically 0.60
- Specific gravity of propane = 1.56
- Specific gravity of butane = 2.00

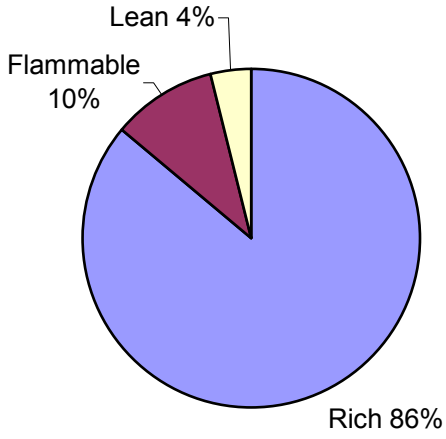
This means that natural gas will rise if escaping, thus dissipating from the site of a leak. This important characteristic makes natural gas safer than most fuels.

Natural gas does not contain any toxic component, therefore there is no health hazard in handling of the fuel. Heavy concentrations, however, can cause drowsiness and eventual suffocation.

The range of flammability for a particular flammable gas is the upper and lower percentage of a gas in an air-fuel mixture within which the mixture can burn or explode. The range of flammability is determined by the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL).

For natural gas, the LEL is 4%, while the UEL is 14%. This means that a natural gas mixture ignites within a range of 25:1 to 7:1 air-to-fuel ratio by volume. By comparison, a propane mixture ignites within a range 2% LEL to 10% UEL.

Flammable Natural Gas to Air Percentage



The energy contents of a gas is the amount of British Thermal Units (Btu) per unit of volume at the same pressure and temperature.

A Btu is the amount of heat required to increase the temperature of one pound of distilled water 1 F at 70 F.

The more carbon and hydrogen atoms in the molecule of a hydrocarbon-based fuel, the higher its energy content. Natural gas has an energy contents of about 1000 Btu per cubic foot at atmospheric pressure. By comparison, propane is 2500 Btu per cubic foot and butane 3200 per cubic foot.

Assessment Flammable Gas Incidents

When sizing-up risks at a natural gas incident, keeping track of times and key events is critical. Flammable gas incidents often start out as vapor releases which may eventually ignite once they come in contact with an ignition source. It is important that the incident commander acquire the following information during the size-up process:

- Time the incident started. Remember, this may not necessarily be the same time the incident was reported.
- The time between when the leak started and the time the emergency responders arrive on scene. This will give an idea as to how much gas has been released.
- Layout of the incident scene. Factors such as exposures, terrain, potential sources of ignition need to be evaluated.
- Water supply requirements and resources.
- The size of the area affected by the vapor release and the probability that the problem will be confined to its present size.
- Factors involving evacuation issues such as population centers, schools, hospitals etc.
- Estimated time of arrival of personnel and equipment from the gas utility.

Use of SCBA and Appropriate PPE

It was noted previously that Chief Smith and Ptlm. Becker entered a hazardous area without first donning personal protective clothing and SCBA.

Supervisors and safety officers have a responsibility to enforce the use of SCBA any time members are in hazardous atmospheres. Further, personnel have a responsibility with regard to their own well being and must be cognizant of the need for SCBA. This use of SCBA is consistent with the requirements of N.J.A.C. 10:100-10 (b) Standards for Firefighters; Respiratory Protection Devices which states:

> *Approved self-contained breathing apparatus with a full facepiece, or with approved helmet or hood configuration, shall be provided to, and worn by, firefighters as follows:*
>
> 1. *While engaged in interior structural firefighting;*
> 2. *While working in confined spaces where toxic products of combustion or an oxygen deficiency may be present.*
> 3. *During emergency situations involving toxic substances; and*
> 4. *During all phases of firefighting and overhaul.*

Additionally, the FFD Standard Operating Procedures require the use of SCBA by all personnel during hazardous materials incidents where it “has been determined to have, or suspected as a contaminated atmosphere as a result of a hazardous material incident having occurred.”

Structural firefighting gear including helmet, protective hood, bunker coat, bunker pants, boots, gloves and PASS device can offer significant protection to the wearer engaged in natural gas firefighting and leak control if the user is fully aware of the hazards being encountered and the limitations of the protective clothing. The FFD Standard Operating Procedures require that “Full protective clothing will be worn at all times by fire department personnel who are actively involved in the fireground operations.”

On-Scene Operations

Once a general size-up of the incident scene is conducted, an adequate water supply must be established in case the flammable gas should ignite inside a structure or fire threatens exposures. Under normal circumstances, a pressure fed natural gas fire, such as that from an outdoor gas main, that is not threatening exposures, should not be extinguished unless it is possible to stop the flow of fuel to the fire. Otherwise, gas can migrate over large areas and find an ignition source.

Personnel should try to eliminate all sources of ignition in the area including motor vehicles, open flames, electrical and heating devices and any other potential points of ignition.

Responders working in teams and appropriately outfitted in PPE and SCBA should evaluate the exterior of the structure, looking especially for gas shut-off valves which they can work to close using non-sparking tools. The team must then evaluate the concentration of the gas in a given building area utilizing a properly calibrated combustible gas indicator. An adequate number of personnel equipped and ready to enter the hazardous area must be standing by in case the entry team encounters problems.

If the gas indicator readings exceed 10% of the lower explosive limit (LEL), the team should immediately withdraw and ventilate the building utilizing positive pressure ventilation. If a mechanical blower is to be used, personnel must ensure that the area where the blower will be positioned is free of vapors within the explosive limits with the combustible gas indicator. A water fog stream can rapidly disperse vapors in most cases. Once the blower can be started, readings of the structure should be taken on a regular basis. Once the level of flammable gas has dropped below 10% of the LEL, the entry team can move inside the structure to control sources of ignition and work to locate and/or isolate the source of the gas leak if the flow of gas was not able to be stopped from the exterior.

If the volume of leaking gas is too great for the department to disperse or presents unreasonable risks to responders, the affected area and an adequate buffer zone should be evacuated in accordance with distances noted in the US DOT Emergency Response Guidebook until such time as the gas utility can shut off the flow of gas to the area.

Safety Officers

Regulations of the Division of Fire Safety N.J.A.C 5:75, Incident Management System mandate the use of a safety officer(s) on all incidents.

The FFD Standard Operating Procedures specify the duties of Safety Officers operating at incident scenes and state that “Safety Officers hold the same authority as Line Officers in enforcing SOPs pertaining to the safety of operations and personnel protection.”

Safety Officers need to observe operations on the fire scene and identify and order the correction of safety hazards to personnel. Major breeches of safety protocols at this incident included the non-use of personal protective clothing and equipment including SCBA. Additionally, entry into the structure without first assessing the concentration of natural gas and/or isolating potential sources of ignition provided a situation where serious injury or even death of personnel was highly probable.

Standard Operating Procedures for Operations at Natural Gas Leaks

As stated previously, the FFD did not have a standard operating procedure for operating at the scene of a natural gas leak.

In areas where natural gas is the primary energy source, fire departments can expect to respond to a considerable number natural gas leaks. Accordingly, departments should develop specific procedures for handling these types of incidents. Once developed and implemented, the department should train on the procedure and utilize it at each incident to ensure a uniform approach to mitigation and personnel safety.

Rather than re-inventing the wheel, so-to-speak, departments should obtain copies of standard operating procedures utilized by other departments and adjust them to fit the specific needs of the department. The local gas utility can also provide a wealth of information and should be included in the development process to ensure uniformity with their procedures.

CONCLUSION

The injuries sustained at this incident can be directly attributed to the insufficient use of full personal protective clothing and equipment including SCBA by those involved. The failure to assess the concentration of natural gas inside the structure before entry was made and failure to isolate or eliminate potential sources of ignition created an unnecessary risk for responders that could have easily resulted in the deaths of two individuals.

Incidents involving hazardous materials, especially materials such as natural gas must never be taken lightly. All possible measures available must be undertaken to safeguard personnel including the development of standard operating procedures well in advance of incidents, the use of appropriate personal protective equipment, and a systematic approach to mitigation of the hazard based upon established procedures.

REFERENCES

- N.J.A.C. 5:75, Incident Management System; NJ Department of Community Affairs, Division of Fire Safety, Trenton, NJ.
- Standard Operating Procedures; Flemington Fire Department; 38 Park Ave.; Flemington, NJ 08822.
- N.J.A.C. 10:100-10 (b) Standards for Firefighters; Respiratory Protection Devices; NJ Department of Labor, Trenton, NJ.
- Technocarb Equipment Ltd.; 30488 Great Northern Ave.; Abbotsford, B.C. Canada V2T 6H4.
- National Propane Gas Association; 1600 Eisenhower Lane; Suite 100; Lisle, Il 60532.
- Investigation Report; NJ State Police; PO Box 7068; West Trenton, NJ 08628.