

Incident Summary #II-1288074-2021 (#25071) (FINAL)

SUPPORTING INFORMATION	Incident Date		November 18, 2021
	Location		Comox
	Regulated industry sector		Gas - Natural gas system
	Impact Injury	Qty injuries	28
		Injury description	One moderate injury requiring hospitalization and up to 27 additional injuries all ranging from minor to moderate resulting from a natural gas explosion.
		Injury rating	Moderate
	Damage	Damage description	Explosion damage to a military barracks building, including blown out walls, roof, windows and a partially collapsed second story floor.
		Damage rating	Severe
	Incident rating		Severe
Incident overview		An exposed underground gas line was struck by an excavator while installing new perimeter drain around an occupied military barracks building under exterior renovation. The escaping gas from the damaged gas line migrated into the building through building openings and contacted a source of ignition resulting in a large explosion.	
INVESTIGATION CONCLUSIONS	Site, system and components		<p>The building is a two-level multi-unit residence used for housing personnel. The building is structured in the shape of an “H” with individual rooms along the ends and common areas in the connecting middle section (Diagram 1). The design creates areas on the East and West sides surrounded by three two story walls and open on one end. The structure is built on a 4-foot-deep crawl space with passive ventilation openings into the crawl space located around the entire structure. The East side of the building has an attached mechanical room with a double access door facing the outside. The mechanical room houses equipment including a gas fired water heater, hallway pressurization and ventilation air handling unit and air compressors along with electrically operated components such as pumps, switches, and controls.</p> <p>Contractors working at the site are required to review and sign a construction contract that stipulates they and their subcontractors must comply to all provincial and municipal regulations.</p> <p>The building had a natural gas supply from the gas utility. A ¾ inch diameter polyethylene gas line was run underground approximately 40 feet away from a main distribution line to a gas meter located on the East side of the building outside the mechanical room. The supply pressure in the line up to the meter was 80 pounds per square inch (PSI).</p> <p>Medium density polyethylene underground gas line is manufactured yellow which provides increased visibility while exposed and identifies it as containing combustible gas.</p>

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Excavation work in the vicinity of a gas installation is subject to section 39 of the *Gas Safety Regulation*, requiring persons performing excavating work to:

- Request gas service locations from the gas company prior to beginning excavation work.
- Consider a gas installation to lie within a one-meter zone on either side of the location indicated by the gas company.
- Confirm gas line locations by hand digging to expose their exact locations.
- Not excavate in a manner that is damaging or *dangerous* to a gas installation.

Manners of excavation that are considered *dangerous* are not defined in the Regulation.

The CSA Z662 Canadian Standard for Oil and Gas Pipeline Systems states that operating companies (Gas utility) shall communicate company-specific safe work practices and conditions to those who purpose ground disturbance.

The BC Common Ground Alliance best practices, identify a “*Tolerance zone*”, based on the *Gas Safety Regulation*, within one meter on either side of an underground facility, such as a gas line. The guidance from the best practice document is for the ground disturber to “*exercise the necessary care*” within this zone. There is discretion given to the ground disturber who “may wish to consider using” lower risk methods such as hand digging, hydro-excavation or pneumatic hand tools in the tolerance zone.

WorkSafeBC produced a guideline document titled “Prevention of Damage to Buried Facilities in BC”, this document recommends “*The hand exposure zone is a distance 1m either side of the located marks within which an excavation with mechanical equipment must not take place, until the buried facility has been hand exposed and is clearly visible.*” This recommendation is included in the standard for training programs produced by the BC Common Ground Alliance for ground disturbance.

The gas utilities’ guideline for excavation safety around natural gas states that when exposing gas lines, no mechanical equipment can be used within 1 meter of an identified buried gas line, until such time that the gas line has been exposed by hand. Once the line has been exposed there are no rules or guidelines addressing the protection of an exposed gas line or limits for distances away for mechanical excavation.

The emphasis of the regulation and guidelines are focused on prevention of damage through identification and exposure of gas lines and has not been found to directly consider explosion risks prior to an accidental gas release.

Combustible gases have a specific range of fuel-to-air ratios in which ignition can occur called the flammable range. For natural gas the flammable range is commonly identified as between 5-15% of a gas-air mixture. The 5% is the lower flammable limit (LFL) and the 15% is the upper flammable limit (UFL). These terms are also referred to as the lower explosive limit (LEL) and upper explosive limit (UEL) when detecting gas concentrations in an enclosed space. Natural gas concentrations outside of this range are not ignitable. For a natural gas explosion of a structure to take place, the released gas needs to mix with a volume of air to between its LFL and UFL then contact an ignition source. The expansion of gases during combustion will be

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	<p>contained by the structure causing a rapid increase in pressure inside that will force the structure outward.</p>
<p>Failure scenario(s)</p>	<p>A contracting company was hired to install new perimeter drain around the exterior of a military barracks buildings. Prior to the work beginning, the gas utility was contacted, and the underground gas line locations were identified and marked. When the required excavation for the drainpipe approached the area of the underground gas line, the contractor entirely exposed a 15-foot length of the gas line by hand digging backwards from the location of the gas meter. The exposed gas line ran parallel to the location of the required trench before turning and crossing over to the other side and ending away from the location of the trench (Diagram 1). The entire section of the gas line from the gas meter to past the location of the trench was exposed and visible so mechanical digging was not necessary in the vicinity of the line. Once the gas line was exposed it became vulnerable to external damage and had no means of physical protection from accidental contact.</p> <p>The exterior of the building was under renovation with new siding being installed. Due to that renovation work, the double door to the building's mechanical room had been removed and replaced with plywood sheets to secure it during off-work hours. The morning of the incident the plywood had been removed to allow worker access into the mechanical room.</p> <p>No actions were taken prior to the excavation work commencing to anticipate for an accidental gas release or to identify risk factors such as possible gas migration into the building, building occupancy at the time of the work or potential ignition sources in the area.</p> <p>Immediately prior to the gas line strike the excavator was working in the vicinity close to the end of the exposed gas line. There was no spotter directly observing the excavator work at the time. The excavator bucket contacted the gas line where it re-entered the ground severing it completely. The severed gas line was seven feet away from and pointed directly at the center of the mechanical room door opening. Gas began escaping at 80psi pressure in the direction of the mechanical room door opening and in the vicinity of other building openings on an inside corner. For approximately 10-15 minutes gas migrated inside the building, accumulating to an explosive concentration, and contacting a source of ignition creating an explosion. The explosion occurred before the building could be completely evacuated.</p>
<p>Facts and evidence</p>	<p>Interviews were conducted with the excavator operator and the site supervisor employed by the contracting company responsible for the perimeter drain excavation.</p> <p>Excavator operator statements</p> <ul style="list-style-type: none"> • They had completed the same task excavating for perimeter drain on the neighbouring building in the weeks prior and excavated around the underground gas line without incident. • The job was ahead of schedule, and everything had been going well. • Visibility was good and there were no distractions or anything out of the ordinary or out of routine. • The company has discussed the gas line at the site and planned of hand exposing it and staying 1 meter away with the excavator. • They had entirely exposed the gas line 15 feet out from the gas meter by hand and it was entirely visible to them while in the cab of the excavator.

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- They had little perceived risk in working around the exposed gas line. They stated it was only a small $\frac{3}{4}$ " line at low pressure and not a 4-6" high pressure line. Other contractors had mentioned to them that when they had hit gas lines that it was a one in a million chance it would cause a problem.
- They believed they had done everything right. They had discussed the line prior to work, located and hand exposed it and planned to stay one meter away with the excavator.
- They do not know how or why the line was hit.
- The door to the mechanical room had been removed and the mechanical room was wide open and that is where the gas line was hit.
- The first indication the line was hit was the sound. There was a "pop" sound then the sound of air releasing like when you are filling a tire.
- The gas was leaking for between 10-15 minutes before the explosion occurred.

Site Supervisor statements

- They had covered in work preparation meetings that they would not be digging with the machine closer than 1 meter to either side of the gas line.
- The schedule was good and there was plenty of time to complete the work and there wasn't a need to rush.
- The gas line was completely exposed by hand from the gas meter to a meter past the other side of the location of the drain trench.
- The excavator operator was a qualified and talented operator with lots of experience on the machine they were using.
- They were the designated spotter for the excavator operator when working around underground services. After the gas line was exposed the job of the spotter was complete and they were not in the trench spotting for the operator when the line was struck.
- The excavator operator was very aware of the location of the gas line, they had gone over the line after it was exposed. They did not witness the gas line strike but assumed the operator had moved something or put the bucket down and struck the gas line.
- They were following every step of the process correctly then the operator hit the gas line.
- They didn't believe there was any equipment error with the excavator.
- From multiple recent discussions, they were told the risk of ignition of a gas leak is one in a million and it can't ignite. *"It does not light, and it doesn't blow up."* *"Buildings don't blow up, it doesn't happen, ever. Gas lines get hit all over Vancouver Island all the time, multiple times a week ... and nothing ever blows up, ever."*
- They do not understand how the building blew up.

The excavator operator and site supervisors' statements indicate they believed that they were working in a manner that was not dangerous. They did not state an awareness of explosion risks or hazards when asked. And they indicated a limited understanding of gas flammability and explosion mechanics.

Report from the gas utility

- The gas service to the building was a $\frac{3}{4}$ inch diameter polyethylene line operating at 80psi.
- A request for gas location was made through BC One Call by the contractor in April 2021.

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	<ul style="list-style-type: none"> • The gas location package delivered to the contractor from the gas utility included a map showing the gas line location, instruction for safe excavation and some clauses from the <i>Provincial Gas Safety Regulation</i>. • The instruction for safe excavation says to hand dig to expose the gas line before using mechanical equipment then to follow provincial laws and regulation when excavating. • The gas utility received a call at 8:53am reporting the gas leak, at 10:43am the gas leak was stopped by the utility technicians. <p>An independent fire and explosion investigator was hired by Technical Safety BC to examine the scene. A report was produced by the investigator (Appendix A) which stated the following:</p> <ul style="list-style-type: none"> • Debris from the explosion was found up to 106 meters away from the location of the buildings mechanical room. • Natural gas was the only fuel identified capable of producing the damage observed. • The proximity of the gas line break would allow the gas vapors to flow through the passive air openings into the building. • When the air/fuel mixture contacted a competent ignition source, the ignition of the mixture would result in an overpressure inside the structure causing the damage observed. • There were multiple competent ignition sources within the building.
<p>Causes and contributing factors</p>	<p>The explosion was caused by the excavator hitting the exposed gas line.</p> <p>The gas line in the vicinity of the excavation work had been located, identified, and exposed by hand. The hazard of hitting the line with the excavator had been identified by the contractor who developed a plan and communicated to employees to keep mechanical excavation over one meter away from the line.</p> <p>Contributing factors that could be considered dangerous manners of excavation work include:</p> <ul style="list-style-type: none"> • Working in close proximity to an exposed and unprotected gas line with a mechanical excavator. • Working in close proximity to an unprotected gas line without a spotter. • Misunderstanding of explosion risks when working near live gas lines. • Not moderating excavation practices when increased risk of explosion hazards are present such as occupied buildings, building openings and ignition sources.

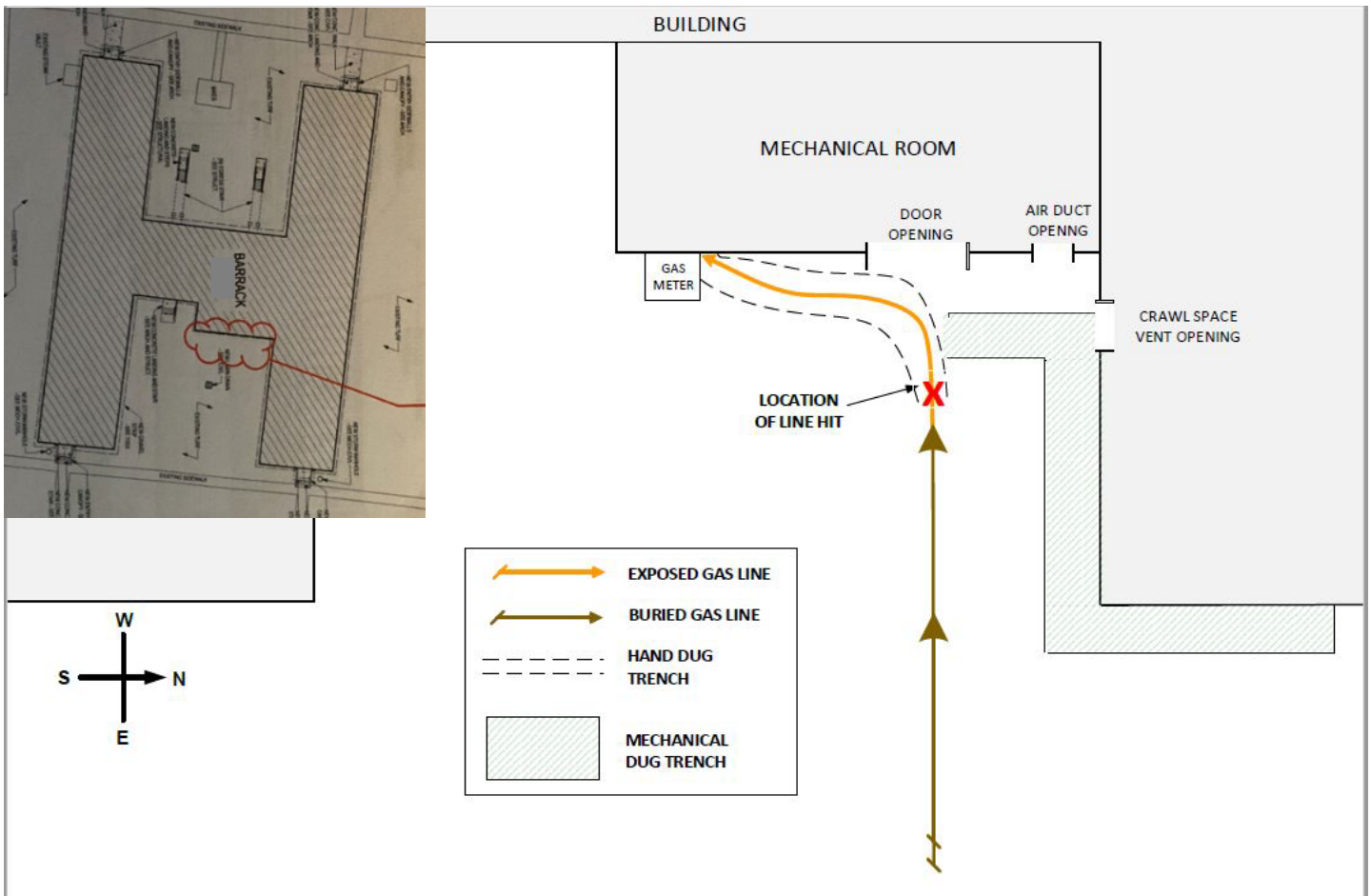


Diagram 1 - Location of gas pipe hit in relation to the building and building openings.



Image 1 – East side of building prior to incident. Red arrow indicates location of gas meter. Blue arrow indicates the mechanical room door opening with door removed. Red oval indicates location of gas pipe strike.

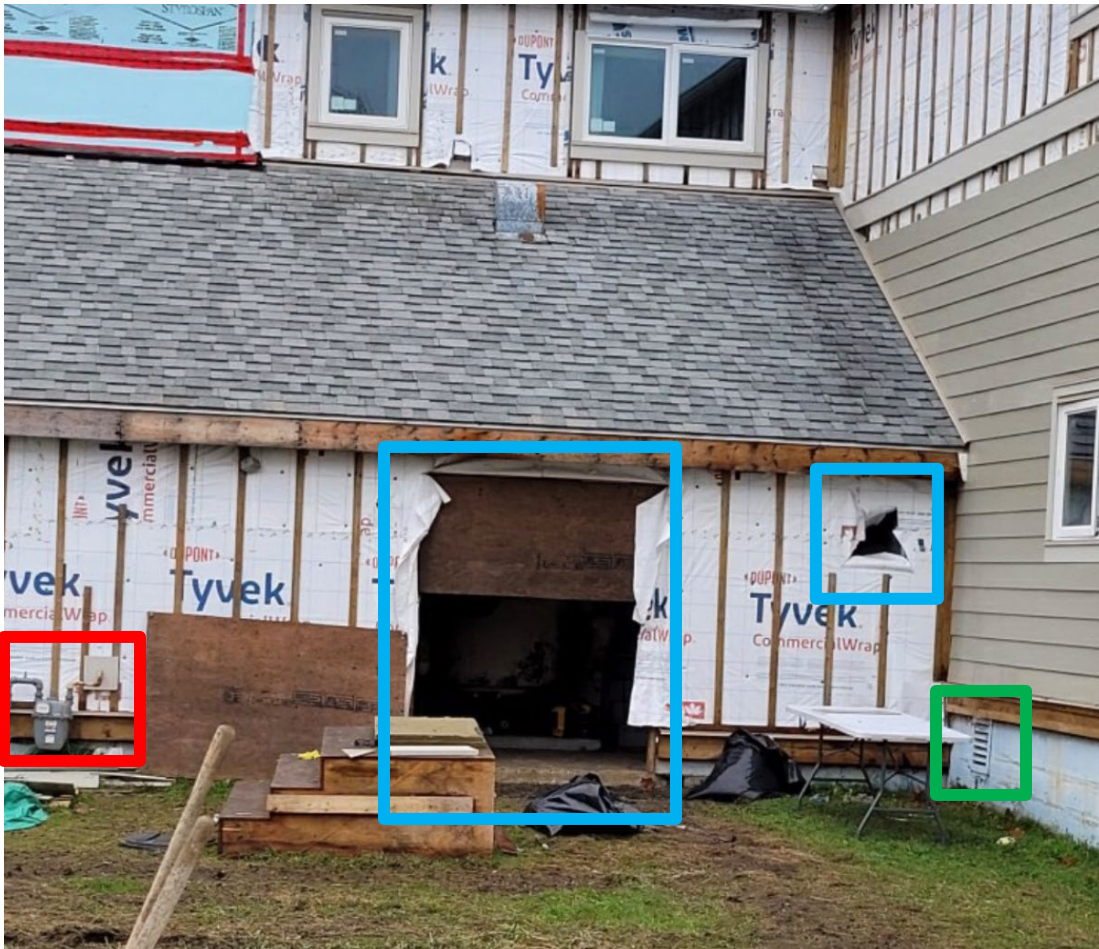


Image 2 – Mechanical room entrance prior to excavation and explosion. Redbox shows location of gas meter, blue boxes show the mechanical room doorway with door removed and an opening for the combustion air duct for the water heater, green box shows passive ventilation into the building crawlspace.



Image 3 – Still shot taken from airport surveillance video showing blast and debris.



Image 4 – East side of building after the incident.



Image 5 – West side of building after the incident.



Image 6 – Mechanical room piping and equipment after the incident.



Image 7 – Excavator damage from the blast and flying debris from the explosion.



Image 8 -Opening to mechanical room with orange paint marking the edges of the doorway that was not installed at the time of the explosion.



Image 9 – The gas pipe laid back in the hand dug trench after the incident. The red arrows indicate the pipe break 7 feet away and centered to the mechanical room doorway opening. The green lines indicate the location of the mechanically dug trench. The yellow arrow indicates the direction of gas flow from the broken pipe towards the mechanical room door opening. The red symbol indicates the location of the gas pipe strike.



Image 10 – Close image of the severed end of gas pipe.



Image 11 – Macro image of gas pipe break from an independent testing laboratory

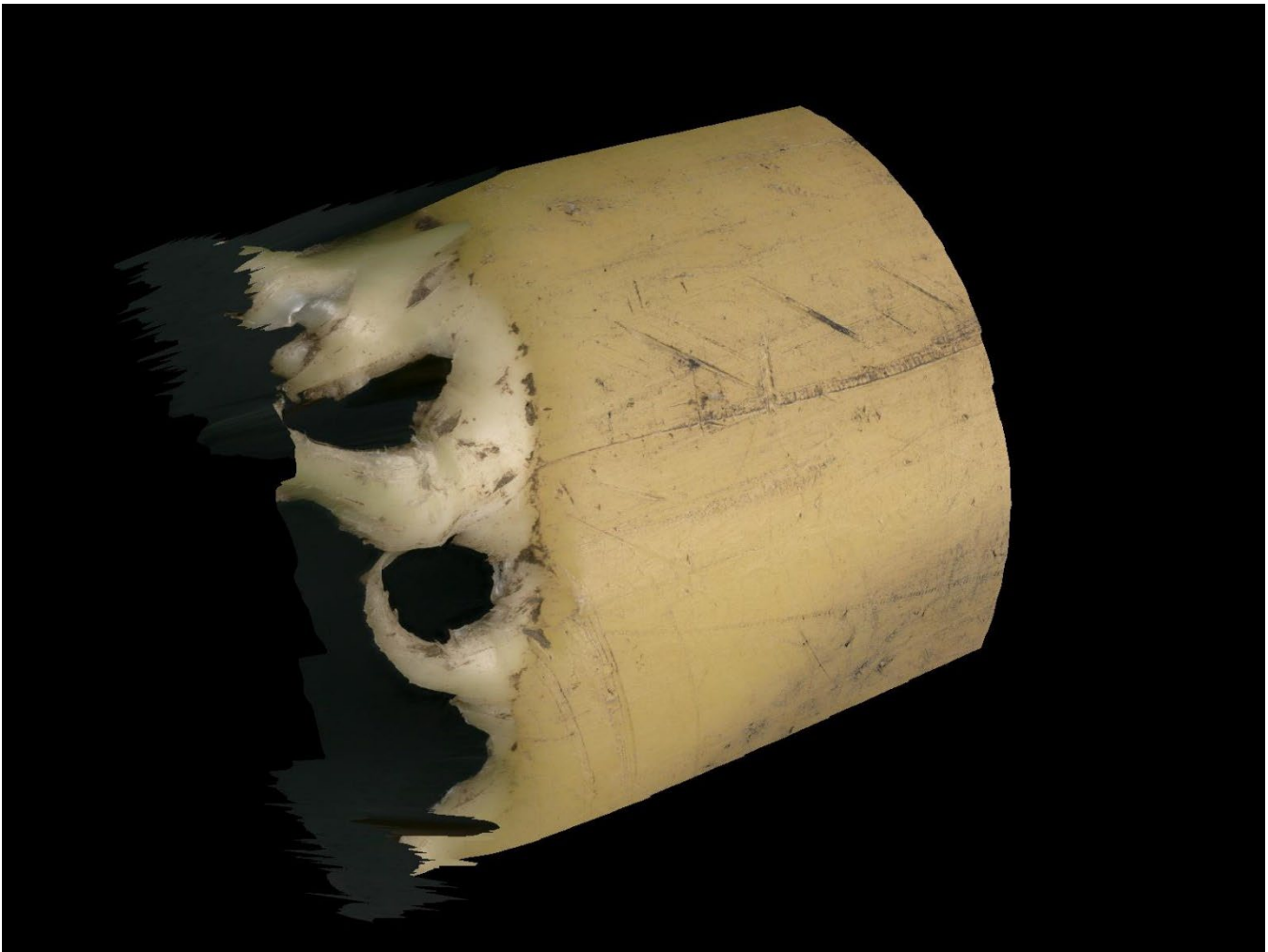


Image 12 – Macro image of gas pipe break from an independent testing laboratory