Incident Summary #II-1880563-2025 (#56884) (FINAL)

SUPPORTING INFORMATION	Incident Date		March 14, 2025
	Location		Victoria, BC
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	2
		Injury description	It was reported that two occupants of the home woke up disorientated and dizzy. One occupant experienced a loss of consciousness and a seizure while the other occupant also experienced a loss of consciousness and broke their nose and received lacerations to their face from falling over.
		Injury rating	Moderate
	Damage	Damage description	N/A
		Damage rating	None
	Incident rating		Moderate
	Incident overview		A gas furnace in a residential home leaked flue gasses containing carbon monoxide (CO) into a masonry chimney which then migrated into the home exposing the occupants to toxic CO.
INVESTIGATION CONCLUSIONS	Site, system and components		Residential gas furnaces use the heat produced from the combustion of a gas/air mixture to heat a home. The combustion occurs at the entrance to a heat exchanger. The flue gases produced by combustion pass through the inside passages of the heat exchanger and are carried safely to the outdoors through a venting system connected to the furnace. A blower draws air from inside the home and passes it around the outside of the heat exchanger. Heat transfers through the heat exchanger shell to the air on the outside which is then distributed throughout the home through a ducting system to heat the home. High efficiency furnaces incorporate a secondary heat exchanger in addition to the primary heat exchanger. A draft inducer fan first draws the flue products through the primary heat exchanger then through the secondary heat exchanger before forcing them through positive pressure to the outdoors through the venting system. The secondary heat exchanger allows additional heat to transfer to the heating air, reducing the amount of heat lost through the exhaust to the outdoors and increasing the appliances heating efficiency. A by-product of removing more heat from the flue products is the generation of condensation, which accumulates inside the venting system and secondary heat exchanger. High efficiency furnaces are designed to allow the condensate to drain back through the venting and furnace and be piped to a separate drain in the home. The venting system for the furnace in the home was installed in a direct vent configuration which uses two separate pipes. One pipe brings all the fresh air in for combustion from outdoors and the second pipe exhausts all of the flue gasses from combustion safely outdoors. Installation in Canada must conform to the requirements of CAN/CSA B149 code. Vent systems must be composed of pipe, fittings, cements, and primers listed to ULC S636 standard for gas venting systems. The B149 code states that a vent system shall provide effective venting and shall be designed and

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	constructed to remove all flue gases to the outdoors and special venting systems, including S636 PVC systems, shall be installed in accordance with the appliance and vent manufacturers certified installation instructions. S636 PVC vent materials are connected by means of solvent welding with the use of approved primers and cements identified by the manufacturer. Solvent welding involves the use of a solvent cement to create a permanent leak-proof connection by softening the surfaces and allowing the molecules to fuse together. The venting manufacturers certified installation instructions specify that the pipe and fitting socket need to be clean and dry. The appropriate primer (if applicable) and cement need to be applied to the pipe and socket, and the fitting shall be fully assembled and held together for a minimum of 15 seconds to resist buoyancy forces from pushing out the pipe from the fitting. They also specify “solvent weld set times” before a joint can be carefully handled. The set times for 2” PVC are between 5-15 minutes dependant on ambient temperatures. Natural gas requires a minimum amount of air to burn completely. When the minimum amount of air is not present, the result is incomplete combustion. One of the by-products of incomplete combustion is CO. CO is a colourless, odourless, tasteless gas that is toxic to humans and animals. Exposure to CO interferes with the body’s ability to absorb oxygen, which can result in serious illness or death. (For more information on CO check out “CO Safety Tips ”).
Failure scenario(s)	The residential home was originally built with multiple solid fuel wood burning fireplaces for heat which used masonry chimneys to exhaust the smoke and combustion gasses from the home. In 2013, A high efficiency natural gas furnace was installed in the home. The furnace utilized a two-pipe direct vent system to draw all combustion air from outside and vent the flue gasses safely to the outdoors. The two pipes were routed through one of the unused masonry chimney passages that had previously been used for a solid fuel burning fireplace. The pipes running up the chimney were built with two pipe sections connected and solvent welded with coupling fittings. On the flue gas pipe, one half of the coupling was effectively connected to the pipe, but the other end did not connect properly and had likely remained disconnected from the original time of installation. Although the pipe was effectively disconnected, it remained positioned closely above the coupling. The path of the flue gasses and natural convection allowed a portion of the flue gasses to exit out the top of the pipe to the outdoors. The other portion of the flue gasses spilled into the masonry chimney which had a sheet metal cap on the top the two pipes protruded through to help prevent moisture, debris and animals from entering the chimney. At some point in time the basement of the home had been renovated, including the construction of walls built closely around the furnace and electric hot water tank. The furnaces return air duct in that room accommodated two furnace filters to capture debris in the airflow. The filter racks had unsealed openings which allowed the furnace blower to draw air in from the enclosure the furnace and the masonry chimney were in. When the furnace was operating, the negative pressure created in the enclosure had the ability to draw in the spilled combustion gasses containing CO from inside the masonry chimney through small, unsealed openings. The flue gasses would be drawn into the return air ducting and distributed throughout the home through the warm air supply ducts.

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Facts and evidence	<u>Statements</u> Home occupants • The two occupants had been away from the home for the last five weeks and returned on February 24th, 18 days prior to the incident. • One occupant had experienced abnormal headaches days prior to the incident. • Around 2 AM the morning of the incident, one occupant had awoken disoriented and dizzy, collapsed and had a seizure. Suspecting that the furnace may be causing it, the other occupant went out to shut the thermostat off and collapsed in the hallway sustaining an injury to their face from the fall. • They called 911 and they opened some doors and windows and evacuated the house. • First responders arrived and attended to them. • First responders entered the home to perform a safety check, but no CO was measured in the home. • They did not take an ambulance to the hospital but one occupant drove themselves and received treatment and stiches for the facial laceration but no blood testing for CO exposure was conducted. • There were no CO detectors installed in the home at the time of the incident. First responders • They received a call and were dispatched at 3:14 AM and were on route at 3:16 AM. • The firehall is less than four km away from the home's location. • Using monitors, they entered the home and detected normal levels of oxygen and no measurable levels of CO. • All doors and windows were closed, and furnace was operated for approximately five minutes, and the measurements were taken again in the home with no change. • The occupants refused medical care and an ambulance, and one occupant took themselves to the hospital for treatment. Site observations • The furnace flue pipe was observed to be disconnected within the masonry chimney. • Staining was observed leaking from the bottom of the original chimney cleanout opening suggesting moisture had been accumulating in the bottom of the chimney potentially from corrosive furnace condensate within the chimney. • The programmable thermostat controlling the furnace was operating on a schedule which reduced the maintained temperature in the home from 18.5°C to 17°C at 9:30pm and not returning to 18.5°C until 6:00am the next morning. • The outdoor temperature in the area the night and early morning of the incident was recorded as a high of 7°C and a low of 2°C. • Examination of the disconnected flue pipe joint showed that it appeared that there had been a proper type of primer and solvent cement used and that after the pipe was inserted into the coupling that it had disconnected before the solvent was able to properly fuse the two components together.

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	Equipment testing The natural gas furnace, and fireplaces were tested by an independent third-party contractor hired by Technical Safety BC for the purpose of incident investigation. The testing identified the following information: • The furnace was operating with average levels of CO in the flue gas of between 20-40 ppm which would be considered normal for the type of appliance. • CO levels were measured within the chimney space between 20-30 ppm while the furnace was operating. • When the flue pipe was blocked with tape to replicate potential environmental conditions, 20ppm CO was measured leaking from an opening in the masonry chimney into the furnace mechanical room. **The testing found a viable path for CO to enter the home although the testing completed was unable to replicate conditions where CO was measured in occupied areas of the home. Other potential situations or environmental conditions may have led to the possible CO exposure symptoms experienced by the occupants. **
Causes and contributing factors	The disconnected vent pipe inside the masonry chimney allowed flue gases containing CO to enter the home. Contributing factors to the incident include: • The solvent welding of the flue vent pipe not following the manufacturers procedure for assembly and joint set times allowed the connection to separate before it was able to fuse together. • The home not having any CO detectors did not alarm the occupants of the presence of CO in the indoor space.

Image 1 – Exterior of home.

Image 2 – Furnace installed in an enclosed space in the basement of the home. The sliding door is shown open when it typically would be closed.

Image 3 – Wall of enclosure removed showing furnace with vent and air pipes entering masonry chimney.

Image 4 – [A] Furnace air intake pipe, pointing down and [B] vent termination pipe, pointing up. Exiting the top of the masonry chimney.

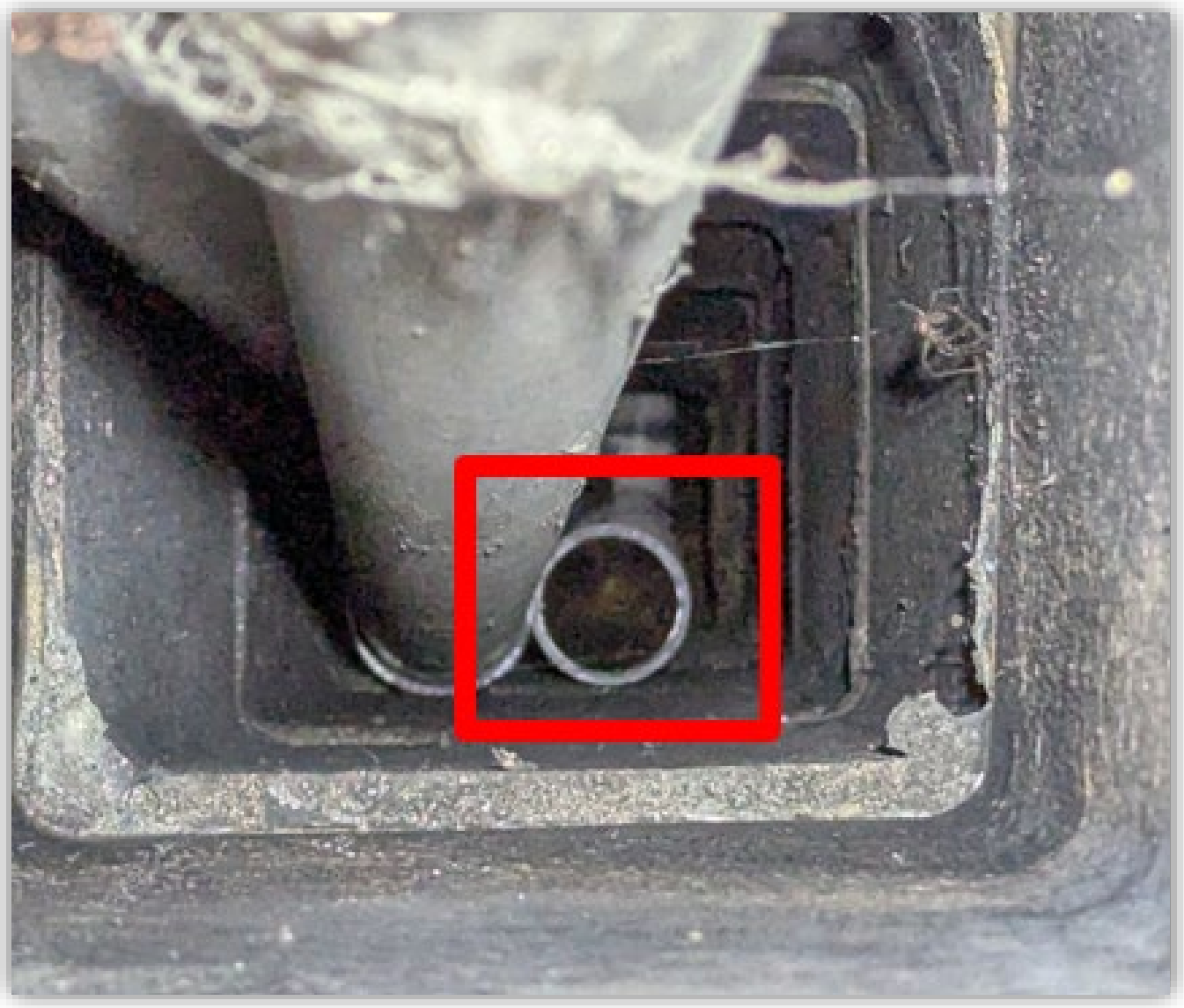

Image 5 – View from top of chimney showing disconnected piping joint.

Image 6 – Alarms installed in home for detecting smoke but not CO.

Image 7 – Furnace air and vent pipes entering masonry chimney with combustion analyser probe for investigation testing. Original metal chimney cleanout door with corrosive staining coming from the bottom.

Image 8 – The opening into masonry chimney that the spilling flue gases were measured entering the home during testing.

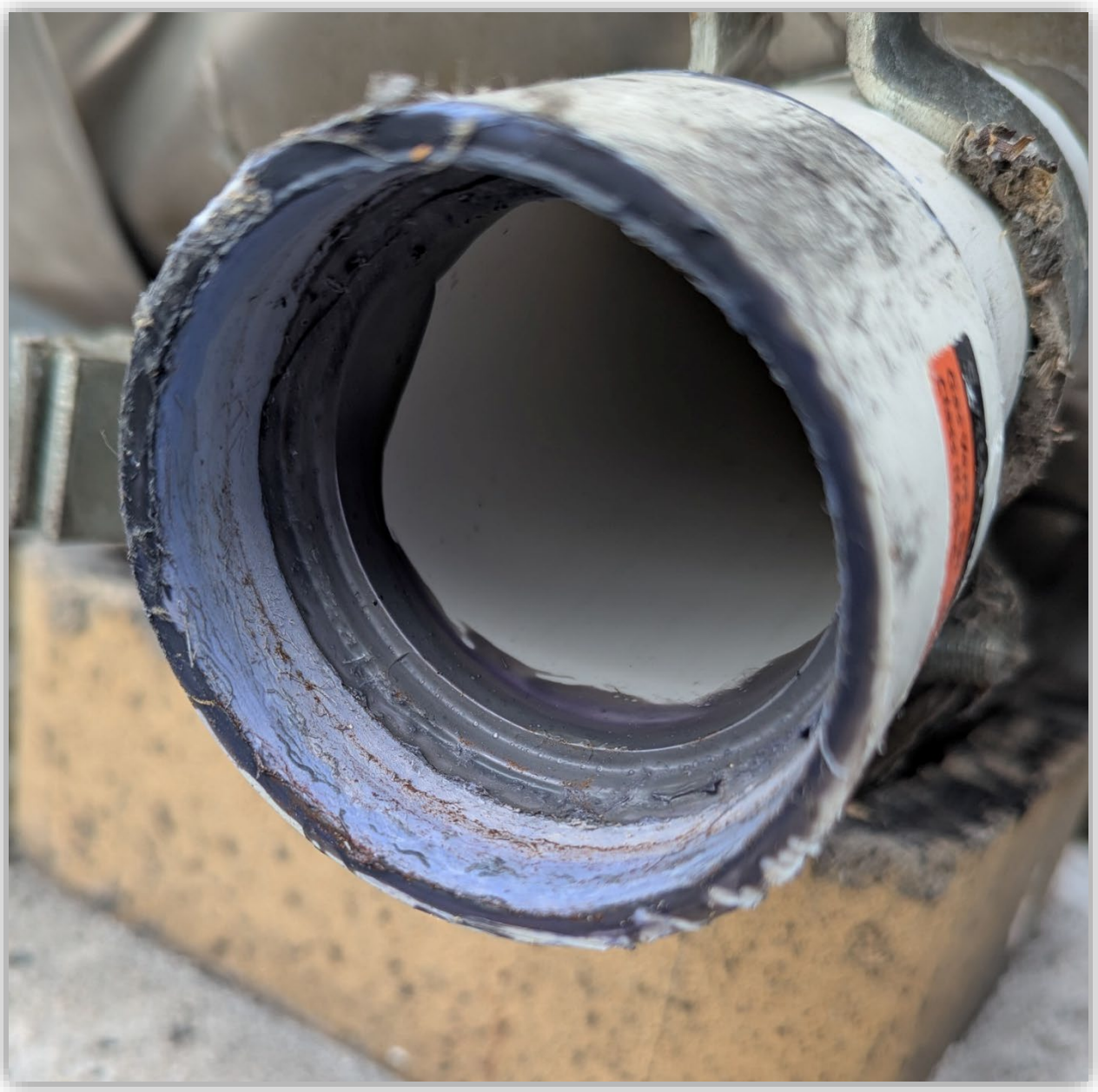

Image 9 – The disconnected flue pipe joint after removal from chimney. Purple primer and grey glue evident around the joint which was fully inserted but never bonded.

Image 10 – Closeup of disconnected flue pipe joint.