

Incident Summary #II-1872877-2025 (#56576) (FINAL)

SUPPORTING INFORMATION	Incident Date	February 24, 2025
	Location	Castlegar, BC
	Regulated industry sector	Gas - Natural gas system
	Qty injuries	2
	Impact Injury	Injury description
		One occupant (Tenant 1) was found deceased in the upstairs rental suite. A second occupant (Homeowner) was found in the basement and taken to hospital with severe symptoms of Carbon Monoxide (CO) poisoning but later released.
	Impact Injury	Injury rating
		Fatal
	Damage	Damage description
		The vent piping system for the natural gas furnace separated at an elbow joint inside the home releasing flue gases containing high levels of CO into the home.
INVESTIGATION CONCLUSIONS	Damage rating	
	Moderate	
	Incident rating	
INVESTIGATION CONCLUSIONS	Severe	
	Incident overview	
	A malfunctioning gas furnace located in the lower suite of a two-storey residential home expelled flue gasses containing high levels of CO into the home through a disconnected vent joint. CO built up into the home's living spaces both upstairs and downstairs causing exposure to occupants. The CO exposure caused serious illness to a homeowner who lived in the basement suite and a person (Tenant 1) was found deceased* in an upstairs suite.	
	*Please note that the cause of death (COD) is not determined by Technical Safety BC. The BC Coroners service conducts their own investigation to determine COD.	
	Location:	
	The home is a raised bungalow style with two self-contained living units. The upstairs of the home was occupied by two adult renters and two cats. The basement unit was occupied by one adult, who was also the owner of the residence. The basement contained a natural gas high efficiency furnace and a natural gas conventional hot water tank. These appliances were located inside the basement unit and were generally not accessible to the tenants in the upstairs suite.	
	Installation:	
	The furnace was installed in the residence around 2007 and was the primary heating appliance for the entire home (including an upper and lower suite). It was located within the owner-occupied suite in the lower level of the home in an enclosed space with a flush door on the outside (Image 3) and walls built closely around the sides and rear.	
	The Furnace:	
	The furnace was a 2006 York furnace model PS9B12N060UP11C Serial No W0H6858589 which had no recalls associated with it according to York Intl. (a subsidiary of Johnson Controls USA which purchased York Brand in 2005).	
	Site, system and components	

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General Furnace Function:

A furnace operates by using natural gas to heat air which is then circulated through the home using a system of ducts. Products of combustion (Flue gas) transfer heat but are kept separate from the home heating air with the use of a heat exchanger.

High efficiency furnaces have both a primary heat exchanger and a secondary condensing heat exchanger that can provide heating efficiency above 90%. Once efficiency rises above 90%, moisture containing corrosive properties in the flue gas condenses and collects in the secondary heat exchanger and is drained out of the furnace. The draft inducer fan draws combustion air for the gas burners through a piping system directly from outside. The furnace produces flue gas from the burners which is drawn through the primary and secondary heat exchangers by a draft inducer fan which then pushes the flue gas through the vent piping system where it can dissipate safely outdoors.

Proper air flue ratios are necessary for proper gas combustion. Incorrect air fuel ratios in the burners can result in problems with delayed ignition. A delayed ignition occurs when gas flows for several seconds before the ignition by the hot surface ignitor resulting in a small explosion in the burner chamber that can send pressure waves through the system including the vent. If this occurs within the set trial for ignition period (typically <5 seconds), the furnace will typically continue to run.

Incomplete Combustion:

Incomplete combustion occurs when there's not enough oxygen for the fuel to burn completely. Insufficient oxygen for combustion can result in rapid increases in the production of CO and other chemical compounds.

Aldehydes are additional chemical compounds that form as byproducts of incomplete combustion. While CO is odorless, aldehydes have a distinct, sharp, and often irritating odor.

Carbon Monoxide (CO):

As a natural by-product of combustion in any natural gas burning appliance, the exhaust contains small amounts of CO which is typically carried safely outside by the venting system where it can dissipate. Depending on the quality of combustion, and the air to fuel ratio, the percentage of CO in the exhaust can increase or decrease dramatically. The risk of exposure to CO indoors is greatest in colder months, like in fall and winter. This is because most homes in Canada are heated by fuel burning appliances that operate more frequently as temperatures drop.

CO is produced when you burn any type of fuel, and it can be found both indoors and outdoors. CO can move freely throughout indoor spaces. 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](#)").

Air Filter:

The furnace incorporates an air filter meant to filter out debris and contaminants from heating air. A blocked furnace filter can result in reduced air flow, increasing the load on the blower fan and reducing air flow across the heat exchanger resulting in higher temperatures. A missing or improperly fit air filter can result in debris and contaminants being drawn into the furnace and restricting airflow around the heat exchanger.

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Safeties:

Residential gas furnaces incorporate electrical safety circuits designed to shut the furnace off in the event that unsafe conditions are sensed. The electrical safety circuits have switches which monitor aspects of the furnaces performance and will open the electrical circuit if any of the monitored values go outside the switches set parameters. When the electrical safety circuit is interrupted, the furnace will stop operating.

Three safeties were relevant to this incident:

1) The blower door safety switch

This switch interrupts all power at the unit when the panel covering the blower compartment is removed. Electrical supply to the furnace is dependent upon the panel that covers the blower compartment being in place and properly positioned.

2) Pressure switch

The pressure switch monitors the airflow from the draft inducer blower. The switch de-energized the ignition control module and the gas valve if it senses a blockage of the combustion air piping system, blockage of the vent piping system, failure of the combustion air blower motor or blockage of the condensate drain piping. If insufficient flow through the venting system is sensed during normal operation the switch will open and shut the furnace down.

3) High limit temperature switches

The furnace has two high temperature limit switches. If either of the limit switches sense temperatures above their setpoints the electrical circuit will open, and the furnace will stop operating. The control module will lockout if the limit trips five consecutive times within a single call for heat. The controls will automatically reset and try ignition again after one hour.

Act, Regulation, and Code:

In British Columbia, natural gas burning equipment is a regulated product under the Safety Standards Act (the Act). The equipment, installation, operation, maintenance, repair, and disposal of these appliances are regulated under the Act and associated regulations. In this case, the Safety Standards General Regulation (SSGR) and the Gas Safety Regulation (GSR).

The GSR adopts CSA B149.1-20, the Natural Gas and Propane Installation Code (the Code).

Together, the Act, Regulations, and Code make up the legal framework for installing, operating, and maintaining gas equipment in British Columbia.

Duties of rental property owners in BC with respect to gas systems:

In BC, rental property owners hold a legal responsibility under the Gas Safety Regulation (Section 55) to maintain their gas equipment in “safe condition” and to also maintain accurate record of the maintenance and servicing performed.

Failure scenario(s)

In 2007, a furnace was installed in a residence by a licensed contractor. The home had the top and bottom floors separated as individual suites. At the time of the incident, the owner lived in the lower suite while tenants rented the upstairs. The furnace had an incorrectly sloped vent pipe that did not allow for the venting

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condensate to drain properly but it still operated until 2021 with only minor repairs (if it was not heating), and no regularly scheduled maintenance.

In 2021, there were operational issues with the furnace described as “furnace not working”. A licensed contractor was hired to diagnose the issues. At that time, the licensed contractor sent an apprentice to investigate. The apprentice identified a comprehensive list of concerns with the furnaces operation which included a clogged heat exchanger, venting and gas piping concerns, and the furnace intermittently turning off due to the activation of the high limit safety.

The incorrect venting slope was fixed to allow the condensate to drain properly. The vent connection that was repaired at the back of the furnace had limited accessibility and the pipe was not properly fully inserted into the coupling during repair resulting in a weak but intact connection.

Following the testing, the apprentice technician documented an extensive number of repairs that would be required or, as a recommended alternative, the furnace could be replaced. The furnace was described as being in “rough condition” but the terms “unsafe” or “hazardous” were not used and it was not noted whether the furnace was left operating or not. The repairs and recommendations were documented on the contractor’s service order and given to the homeowner. The contractor did not receive any requests from the homeowner to proceed with any repairs or replacement of the furnace.

From 2021 to 2025, the furnace continued to be used as the primary heating appliance for both the upstairs and downstairs suites. There were no documented repairs or maintenance during this time resulting in further deterioration of the condition of the furnace. The homeowner had several people they knew during this period assess and advise they regarding the furnace and was provided verbal recommendations to replace the furnace each time.

At some point, the bolts holding the inducer fan to the furnace were loosened breaking the seal between the inducer fan and the furnace. This allowed the inducer fan to draw some air from the room instead of drawing it all through the burners. This small change would have two significant impacts on the operation of the furnace:

1. As a portion of the air being pulled by the inducer fan now bypassed the burners, there was insufficient oxygen for combustion at the burners resulting in significantly elevated levels of CO in the flue gas (>400 ppm).
2. The cool air flowing into the inducer fan could have cooled the gasses at the location of the high limit switch and satisfied the pressure sensing safeties resulting in continued operation of the furnace, when otherwise it would have likely shut itself off due to the activation of one or multiple safety mechanisms.

The loose inducer fan likely reduced the likelihood of these safety controls activating and shutting off the furnace intermittently.

The furnace continued to operate in very poor condition, and with the high levels of CO being produced and carried outside through the intact vent pipe until the day of the incident.

On the day of the incident, the landlord described hearing “two big bangs” from the furnace. The owner began to investigate expecting to find broken parts and removed the top cover of the furnace. No broken parts were identified but the top connector was hot and “tacky”. They considered calling a contractor but indicated they “couldn’t get a hold of anybody at 2:30 in my area on a Sunday”. The owner turned the

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	furnace on and off several times and noted that the control board had a “slow green flash” which they interpreted as “there was nothing wrong with it.” The owner indicated they were comfortable allowing it to run, despite knowing that it did need to be replaced, because, in their experience as a commercial electrician, electrical should fail safe (the safeties wouldn’t allow it to run), and felt the furnace would do the same. Unbeknownst to the owner, the bangs heard were likely delayed ignitions which resulted in damage to the venting system. When the pressure from the delayed ignition occurred, the incorrectly assembled joint that was made in 2021 finally failed resulting in the vent becoming disconnected at the back of the furnace which was not easily viewed. The furnace continued to operate and began circulating the high levels of CO from the escaping flue gas throughout the home. As the furnace continued to operate during the cold weather, the CO accumulation increased in the house, eventually reaching >350 ppm in the downstairs suite. Although there were several smoke detectors in the upstairs unit, the home did not have any CO detectors to alert the occupants. Occupants of the home began experiencing severe symptoms of CO poisoning shortly afterwards. The one upstairs tenant who was home passed away. The homeowner was found downstairs by first responders unresponsive, taken to hospital, and eventually recovered.
Facts and evidence	<u>Statements</u> Homeowner: • They had owned home since February 2007, and the furnace was already in place. • At some point, they thought they could see one of the “Fernco” vent connections inside the furnace starting to melt. After that time, they remember that the furnace seemed to start and stop quite frequently, around every ten minutes. • They have rented the upstairs suite to tenants since 2008 and current tenants since 2021. • About two or three years ago the furnace ducts were cleaned. • About two years ago they bought parts and had worked on the furnace themselves. • Outside the door of their suite there is an inducer motor and high-limit switch intended to use in the furnace repairs. • They had been working in Whitehorse in 2021 when the gas contractor, who was called by the tenant, inspected and tested the furnace. • After the contractor left, the furnace was left on as far as they know. • After the contractor visit, they had multiple other people advise them about the furnace and told them to replace it. • They had multiple quotes for the furnace replacement but had not proceeded with any of them prior to the incident. • Around 12:00 pm on Sunday February 23, they remembered hearing two loud bangs coming from the furnace and expected to see parts. • They also remembered smelling a smell that they thought was an electrical type of smell maybe. • They inspected the furnace area after the bangs and found nothing.

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- Then the last thing they remember from that day is falling asleep at around 2PM - 4PM on that Sunday and waking up in the hospital with out any recollection of the incident.

Tenant 2:

- They moved into the suite with their partner in November of 2021.
- Often noticed that when the owner smoked downstairs, cigarette smoke travelled from the living space up through the vents.
- They had noticed the furnace making loud banging, “whoomping”, and clunking noises which seemed to have been getting louder over time during the cold months.
- They communicated with their partner by text messages the evening of February 23rd regarding symptoms their cats were experiencing and smells in the house.
- They had a phone call with their partner who was in the home the night before the incident from 10PM until 3AM and noticed their partner’s voice was unusually low and wavey and dragged a bit.
- They began texting their partner again the morning of the incident around 7AM and did not receive a response.
- Friends went to house and checked on the tenant who didn’t show up to work and found them deceased and noticed a very strong smell of gas.
- After the incident when the house was cleared, an individual noticed that the bed was made, a lunch box was on counter, and tea was made which was the normal morning routing for the other tenant between 3AM and 6AM.

Text Messages between Tenants:

- The night before the incident, the two tenants were exchanging text messages and discussed that their two cats were acting sick, had defecated in the home and where not eating or drinking which they believed may have been from some food they had given them. The house had a “harsh” smell like “gas fumes”, and it may have been from the owner downstairs burning some food. Lastly, they discussed possibly getting some gas testing equipment to test for gas in the home.

First responder:

- Readings over 150ppm CO were measured in the upstairs suite at an open entry door upon arrival.
- >350ppm CO was measured in the area of the furnace in the basement suite.

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Site observations

- No CO detectors were found on premises; however, eight different smoke alarms were found in the upstairs suite.
- The top cover of the furnace was found to be laying on the ground beside the furnace.
- The flue vent behind the furnace was found disconnected, solvent edging showed the pipe had been inserted at an angle and with insufficient depth.
- The flue vent as found was not completely inserted (prior to the incident) when installed at the furnace connection point, allowing it to distort in position and break the connection seal following the downstream vent section failure.
- Flue gas condensate was found forming in a pocket made by the failed vent section causing the induced-draft fan to intermittently surge in pressure.
- The induced-draft fan assembly was found loosely mounted to the furnace with 4 of 5 hold-down screws loosely installed and not making a tight seal.
- The ground wire to the furnace case was disconnected.
- The incident furnace had a “Fasco” A225 Draft Inducer Motor model 7021-11577/CG25061280472.
- The manufacturer confirmed the model number on the motor was likely an original and there were no recalls on the furnace or motor at the time of this report.
- Confirmed by conversations with suppliers that the “06” is the former way the year was captured in the serial number.
- This year matches the year of the furnace which is evidence that this motor is likely original to the furnace.

Gas appliance testing and examination

As part of the investigation, a third party independent certified gas contractor was hired to conduct examination and testing of the gas appliances in the home including the furnace. The furnace was later removed from the home and taken offsite for further disassembly, examination and testing.

Gas hot water heater

- The gas technician performed a combustion analysis of water heater flue gas to measure CO amounts. 3 ppm CO was measured at draft hood which is considered low enough to rule out the hot water heater contributing to the excessive CO amounts found after the incident.

Furnace

- Between 250-560 ppm (parts per million) of CO was measured in the exhaust at the flue outlet.
- The temperature rise across the furnace was measured at 80F which is 10F above the manufactures specified range of 40-70F temperature rise.
- The furnace firing rate when tested found it was in an overfired condition.
- The manifold gas pressure was set 1.0" w.c. higher than the nameplate maximum of 3.5" w.c.
- The furnace flue gas temperature was 143F.
- On a call for heating, the furnace start sequence was normal.
- The burners and combustion area were found in good condition.
- No visual signs of soot or carbon on the burner side of the heat exchanger tubes.
- Standard programmable thermostat located in the hallway of the upstairs rental suite. Programmed schedule not found.
- Integrity of the wiring was fine, and safety devices were not bypassed.

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- During disassembly testing, all safety switches were in the proper positions when heat applied. It is not known if the switches opened at specific and correct temperatures.
- Flue vent pressure switches were functioning.
- Flame sensor was found to be working correctly.
- Service door power switch was bypassed with electrical tape holding the switch down when the cover was removed.

Documents

Service order from 2021 gas contractor callout for “Furnace not working”:

- Furnace was noted to be in “rough condition”.
- Gas pressure was found to be too high (4.4” WC) and was set to the proper level (3.5” WC).
- Vent pipe was found incorrectly sloped away from the furnace and was cut, raised up and reassembled for proper drainage so further furnace testing could be conducted.
- Temperature rise across the furnace was high and it would only run for 30-40 minutes before tripping out on the inducer draft blower limit switch.
- Temperature in the exhaust was measured at over 175F which is higher than the 160F limit switch setting.
- The invoice noted to the owner that the furnace was cycling on high limit and was not reliable. Recommended repair or replacement.
- 4.5 hours of labor was documented plus a material charge for a PVC coupler, glue and primer, strapping and screws.

Furnace installation manual:

- Warning indicates “*Improper installation, adjustment, alteration, service or maintenance can cause injury or property damage.*”
- At the time of installation PVC pipe and fittings were approved for vent piping of the furnace to the outdoors.
- Vent pipe assembly includes cutting, deburring, chamfering, dry fitting, the disassembly and then the use of approved cement and primer per the pipe manufactures instructions to create permanent airtight and watertight sealed joints.

Standard vent pipe assembly practices:

- Pipe should be cut square, deburred, cleaned of dirt, grease and moisture, and dry fit together.
- The proper cement should be applied to both the end of the pipe and the fitting socket.
- While the cement is still wet the pipe should be inserted fully into the socket and twisted ¼ turn.
- The pipe and fitting should be held together for approximately 30 seconds to eliminate push out.
- The joint should be left to set before in can be carefully handled.
- Set time for 2” PVC joints vary between 5-15 minutes depending on outdoor temperature.

Independent lab testing:

The separated PVC vent pipe sections were tested by an independent laboratory and confirmed that the solvent used was correct for PVC piping.

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Causes and contributing factors

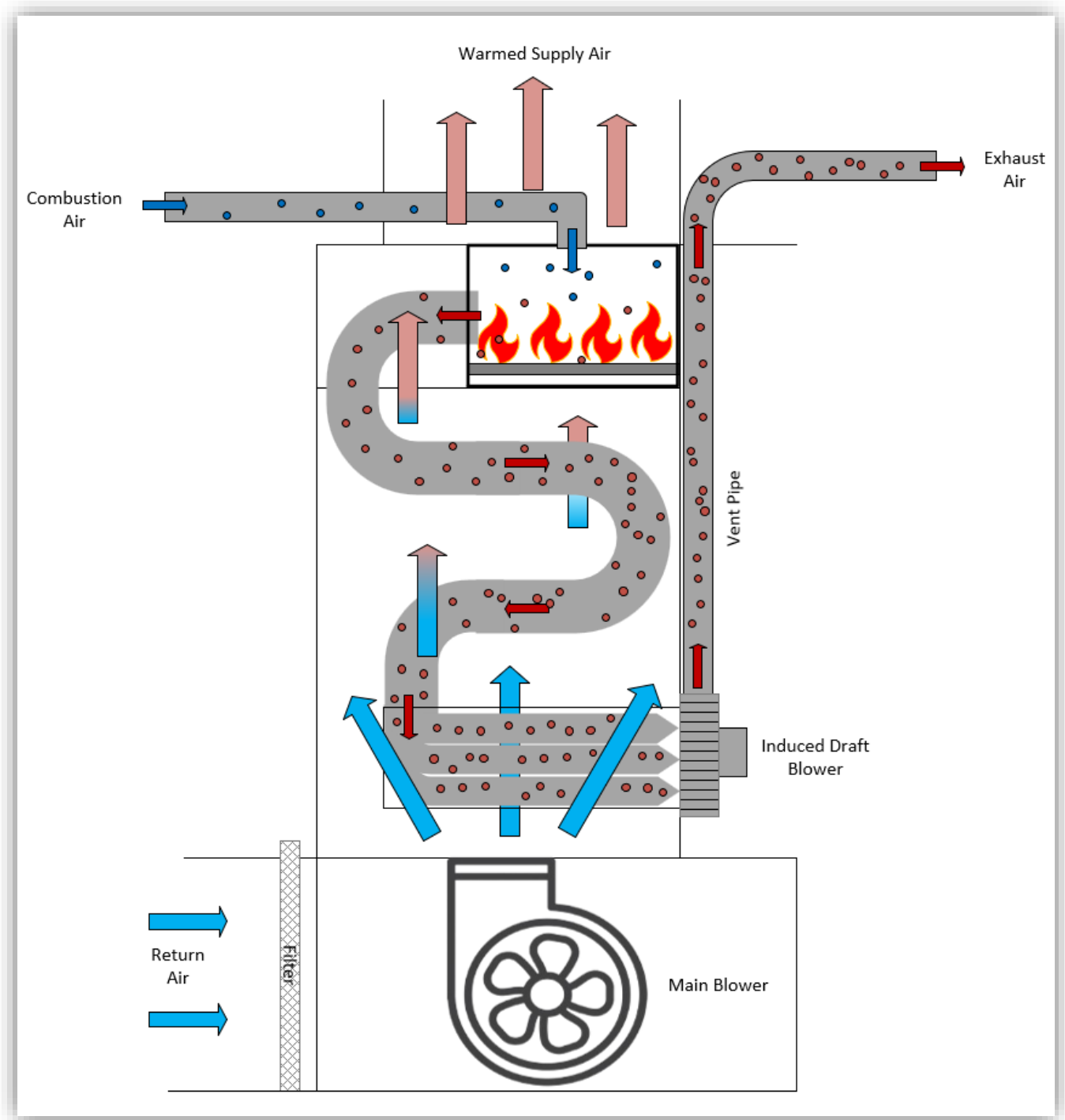
The incident was caused by CO from incomplete combustion of gas in the furnace leaking into the home through a disconnected vent pipe.

Contributing factors include:

- The incorrectly assembled PVC vent pipe joint allowed it to come apart when strained, allowing flue gasses to enter the home.
- The furnace did not receive the required regular maintenance outlined by the manufacturer which led to an extremely dirty air filter and secondary heat exchanger that restricted airflow which would have caused operational issues and was likely related to the reported tripping of the high limit switch.
- No action was taken in response to the licensed gas contractor's recommendations to replace and/or repair the furnace.
- The loose inducer fan housing bolts created insufficient air flow to the gas burner which caused incomplete combustion, the production of high levels of CO in the flue gases, and delayed ignitions. The change in airflow likely also limited the effectiveness of the inducer fan high limit switch.
- There were no CO detectors in the home to alert the occupants of dangerous levels of CO indoors.



Image 1 - Upper level of the two-story home.



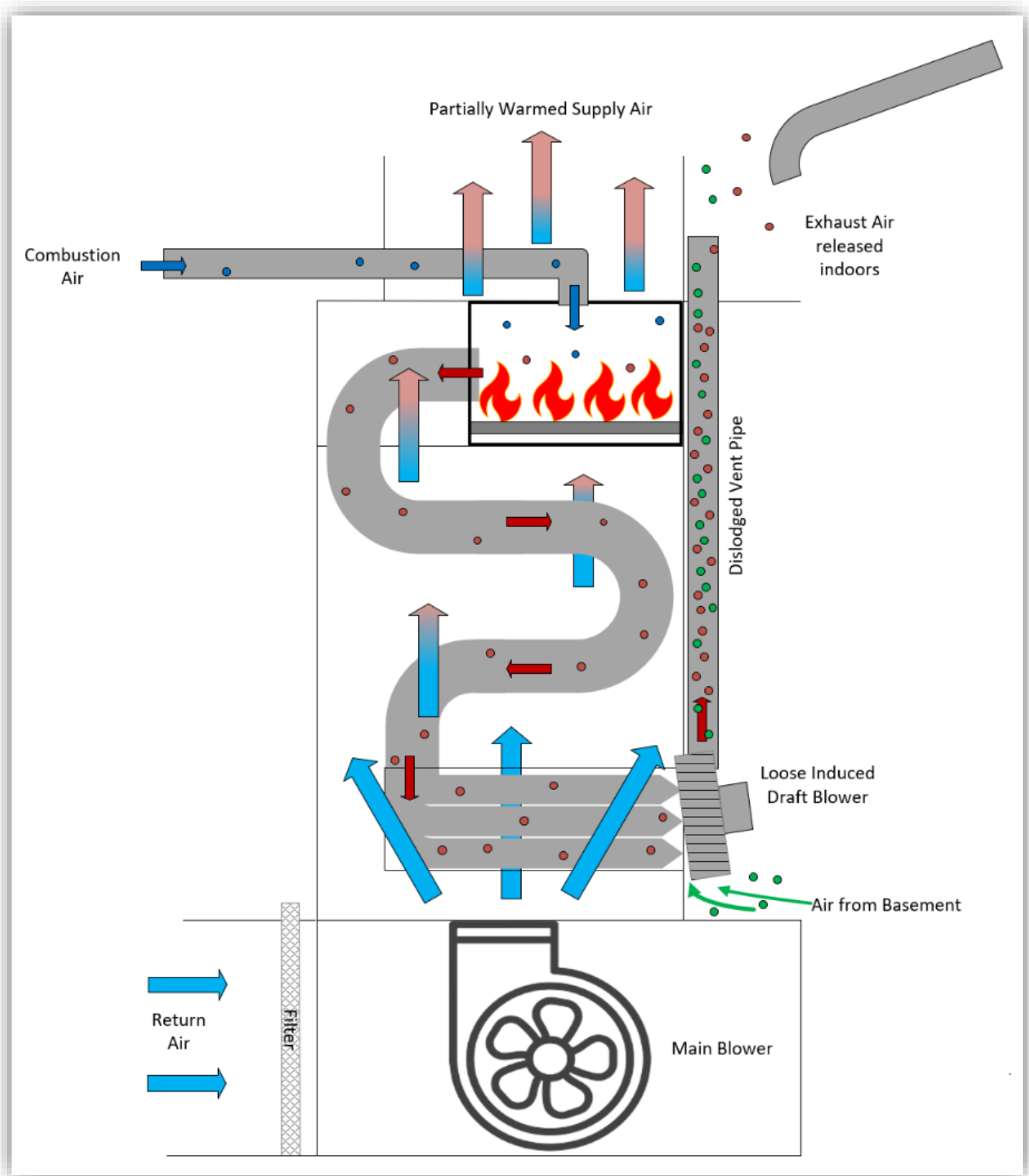


Image 2 – Diagram of typical furnace operation (top) and furnace operation with loose induced blower and detached vent pipe (bottom).



Image 3 – Gas furnace with upper cover removed as found after incident.

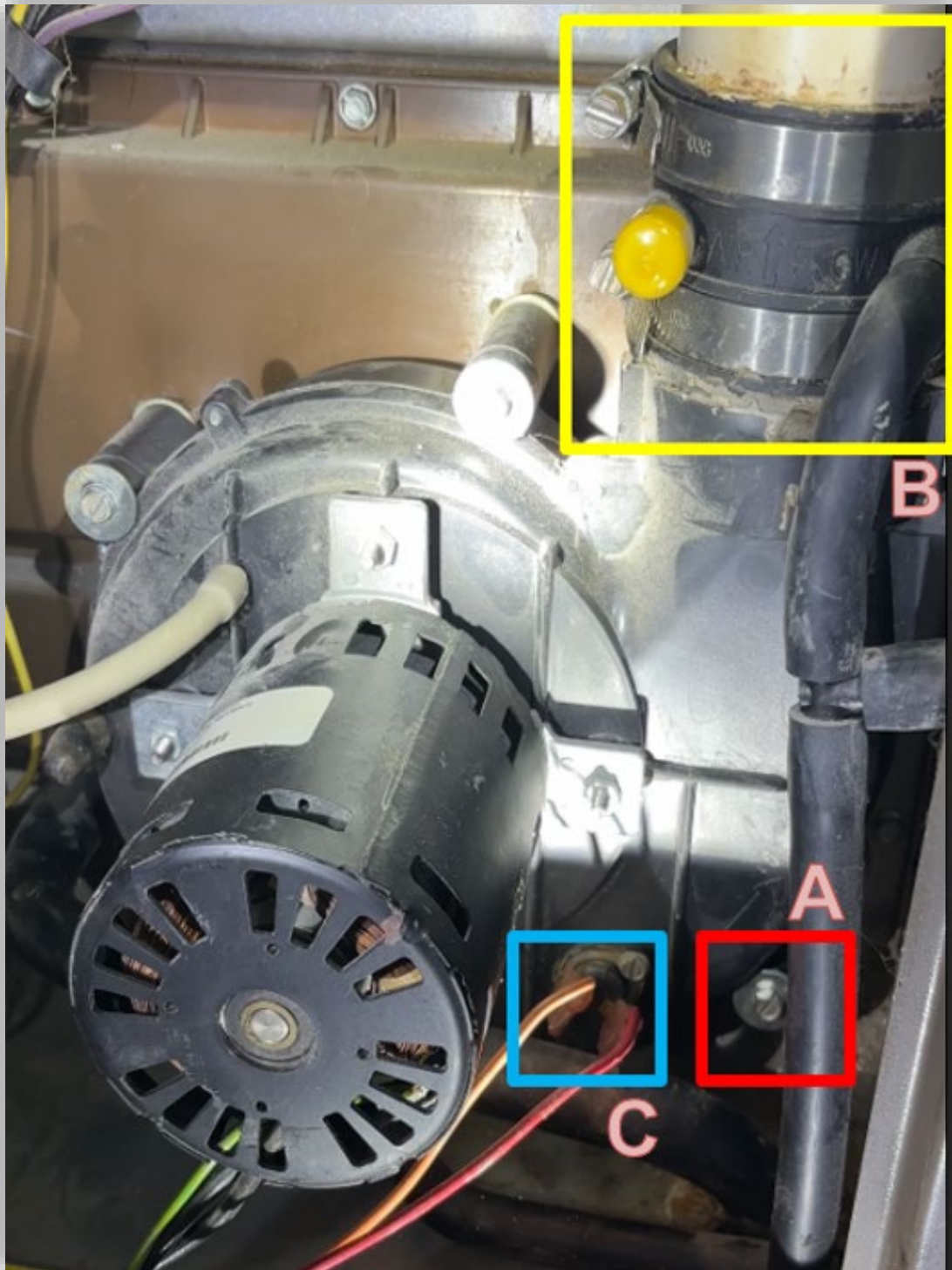


Image 4 – Draft inducer motor showing loose mounting bolts [A] leaking “Fernco” vent pipe coupling [B], and high temperature limit switch [C].



Image 5 – Draft inducer motor connection to furnace showing condensate leakage from improper seal from loose connection.



Image 6 – Disconnected flue vent pipe behind furnace as found after incident.



Image 7 – Disconnected flue vent pipe from other angle.



Image 8 – Dirty secondary heat exchanger found during furnace disassembly.



Image 9 – Furnace air intake (bottom) and vent pipe termination (top) on the outdoor wall of the home.