Incident Summary #II-1504227-2023 (#31354) (FINAL)

SUPPORTING INFORMATION	Incident Date		January 29, 2023
	Location		White Rock
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	0
		Injury description	None
		Injury rating	None
	Impact – Damage	Damage description	Products of combustion including carbon monoxide (CO) were exhausted to an interior space. The boilers heat exchanger became plugged and exhausted levels of (CO) into the interior space.
		Damage rating	Minor
	Incident rating		Minor
	Incident overview		A boiler used to heat a single-family rental home had a plugged heat exchanger and a by-passed safety switch which allowed flue gas containing carbon monoxide (CO) to enter the home.
INVESTIGATION CONCLUSIONS	Site, system and components		**Site and System** • The single-family dwelling rental premises utilizes one boiler for heating water that circulates through a piping system containing pumps and zone valves. The hot water gets circulated to radiators through the home and provides heating. • The heating system includes the boiler and its natural draft venting system where flue gases rise through natural convection up a vertical venting system safely to the outdoors. **The Gas Safety Regulation** • The Gas Safety Regulation under the Safety Standards Act, identifies legal requirements in BC and outlines duties of owners of rental premises concerning gas appliances. **The Gas Safety Regulation requires the owner of rental premises to** • Post a notice, of a permanent nature, respecting the safe operation of an appliance, on the premises in a conspicuous location where it can be seen by any person using the appliance. • Ensure that appliances on the rental premises are maintained in a safe condition and maintain accurate records of maintenance and servicing performed on the gas system on the rental premises. **Boiler components** • The boiler has a rapid thermal drop-out safety sensor which has a thermal sensor wired in series with the safety control circuit of the boiler. Upon an over heating condition of the heat exchanger, the sensor will shut off the flow of natural gas to the burner of the boiler. • The proper installation of the rapid thermal drop-out sensor is a critical factor in ensuring the safe operation of the boiler.

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	• The boiler has a flame rollout safety sensor which has a thermal sensor wired in series with the safety control circuit of the boiler. This sensor is located at the front of the unit where the burner is located. Upon a flame rollout condition, the sensor will shut off the flow of natural gas to the burner of the boiler. • On a call for heat from thermostat(s), the boiler fires and heats the water in the boiler through heat transfer across the heat exchanger of the boiler for the heating systems in the home. • If the boiler is operating correctly and the heat exchanger is maintained at an approved temperature, the boiler will continue operating until the thermostat(s) are satisfied to the desired temperature in the home. • Under normal operation, the products of combustion from a boiler are exhausted to the exterior of the building through the heat exchanger and vent system. **Soot** • A black powdery or flakey substance consisting largely of amorphous carbon, produced by the incomplete burning of an organic matter or natural gas. **Flame rollout** • Flame rollout is a hazardous condition where the venting of flue products through the heat exchanger is not taking place causing the flame and flue products to escape the front of the unit where the burner is located. **Carbon monoxide** • Carbon monoxide is a colourless, odourless, tasteless gas that is toxic to humans and animals **(Chart 1 - 2)** • Exposure to carbon monoxide interferes with the body's ability to absorb oxygen, which can result in serious illness or death. • Symptoms of carbon monoxide poisoning can present similar to flu symptoms: headaches, nausea, dizziness, or vomiting. • For more information on carbon monoxide, visit **Carbon Monoxide Safety Tips**.
Failure scenario(s)	The boiler **(Photo 1)** was installed and in use for many years with no evidence of proper maintenance. The boiler's burners and flame started running in a state of incomplete combustion and as a result the heat exchanger became excessively plugged with soot. Over time, the boiler became so plugged that the flue products were unable to effectively vent through the heat exchanger of the boiler and into the venting system. This condition caused the over heating of the heat exchanger that would have tripped the thermal drop-out safety sensor. The rapid thermal drop-out sensor was removed and by-passed **(Photo 2)**, this created a condition for the boiler to continue operating in an unsafe condition. This caused the flue products containing carbon monoxide to roll out the front of the unit and spill into the home **(Photo 3)**. The carbon monoxide detector in the home **(Photo 4)** eventually sounded alarming the occupants. The boiler eventually shut off through the flame rollout switch.

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Facts and evidence	**Statement from the property manager of the home.** • The property manger was unable to provide evidence of accurate records confirming any maintenance performed on the regulated gas equipment in the home. **Statement of the gas fitter attending site due to the boiler shutting off.** • They diagnosed the boiler and noted the rapid thermal drop-out sensor was found removed and by-passed. • They found excessive signs of flame rollout and burnt wiring on the front of the boiler. • Due to the as found conditions, they disconnected and capped the boiler from the gas supply and reported it to Technical Safety BC. **Statement of the gas fitter who attended site to repair the boiler and place it back into service.** • They found the heat exchanger was excessively plugged with soot. As a result of this condition, they were required to take the boiler apart and clean the heat exchanger. • They found that the rapid thermal drop-out sensor was removed and by-passed. • They needed to order a new rapid thermal drop out sensor and re-wire it, following manufacturers specifications. **Statement from the occupants of the rental premises.** • **January 29th, 2023, 09:00.** - An occupant in the home could smell an unfamiliar odor in the home. The occupant went to look at the boiler and found it had yellow looking flames coming out the front of the unit. • **January 29th, 2023, 11:00.** - The carbon monoxide detector went off in the downstairs of the home adjacent to the boiler room. Moments later the boiler stopped working. **As found conditions of the boiler on site by the Safety Officer.** • The boiler was found with evidence of flame rollout coming out the front of the boiler (**Photo 3**). • The rapid thermal drop-out sensor was found laying on the floor beside the boiler (**Photo 2**).
Causes and contributing factors	It is very likely that due to the boiler having insufficient servicing, this caused the heat exchanger for the boiler to become plugged over time. During the boilers operation with a plugged heat exchanger and removed/by-passed thermal drop-out sensor, this condition likely caused carbon monoxide to enter the living space of the home.

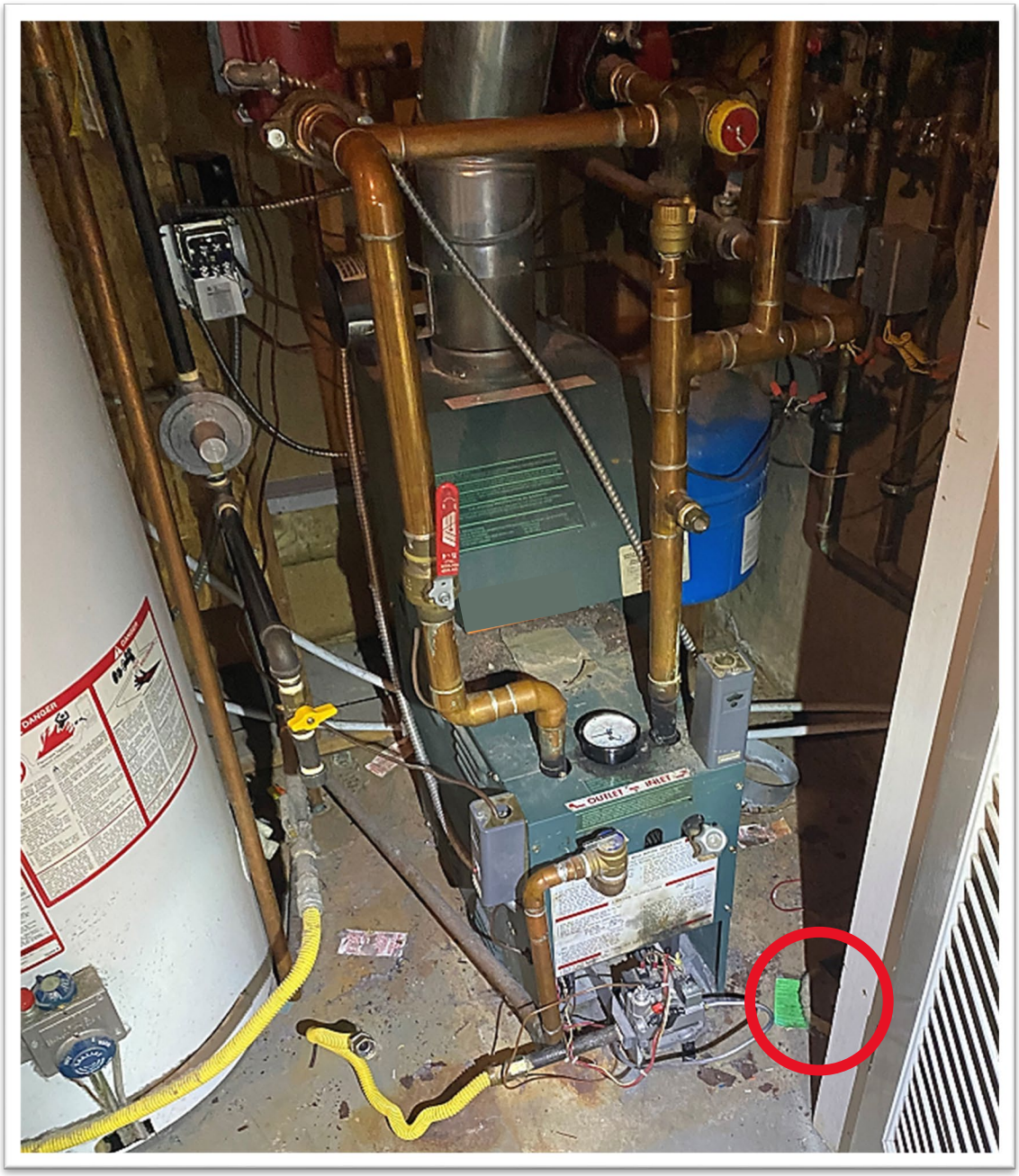

Photo 1 [*Taken by Safety Officer*] - The boiler disconnected from the gas supply. **RED** – refer to Photo 2

Photo 2 - The rapid thermal drop-out sensor was found laying on the floor beside the boiler.

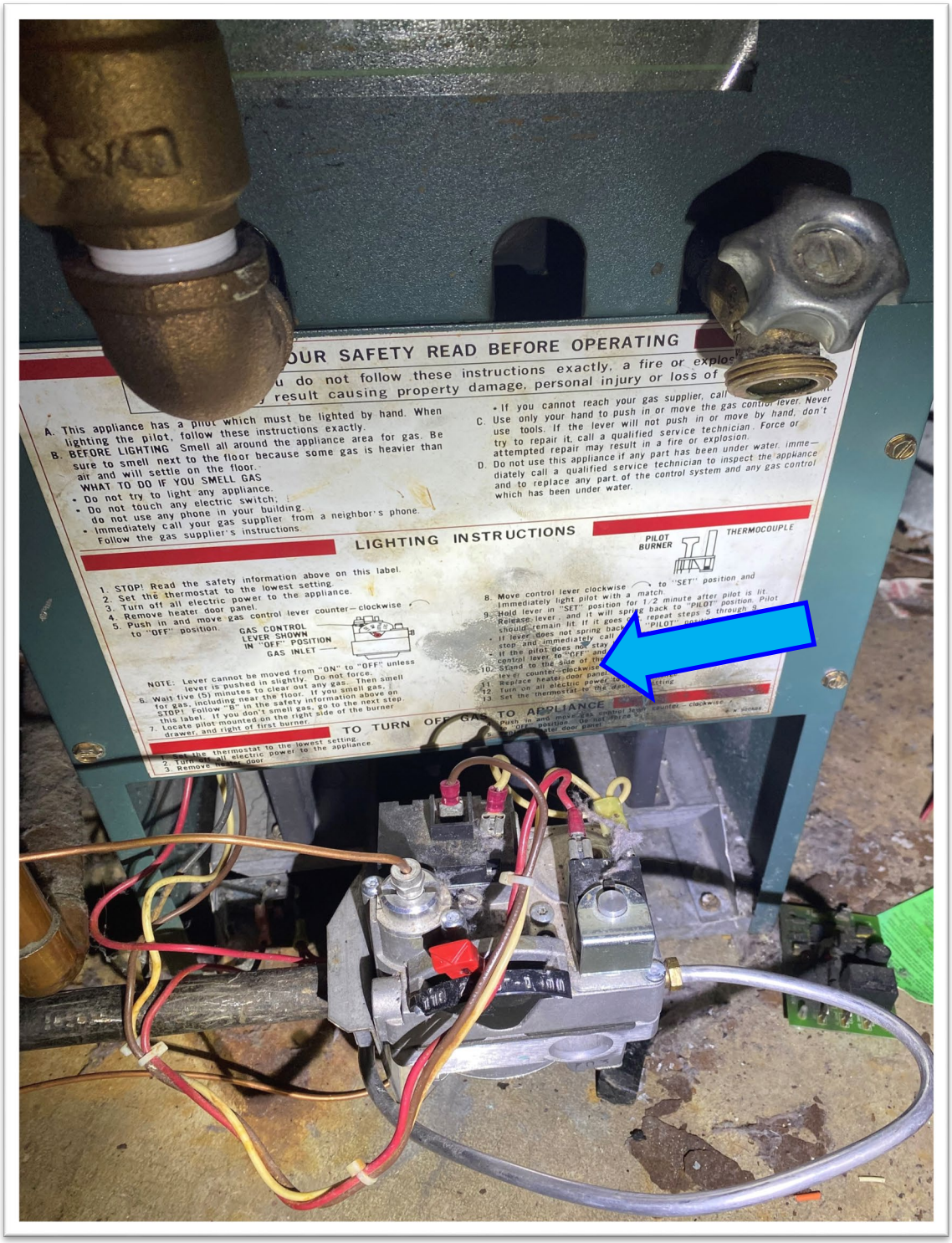

Photo 3 – The front of the boiler (**BLUE**) showing evidence of flame roll out.

Properties of Carbon Monoxide

Colourless	Cannot be seen.
Tasteless	Cannot be detected through the sense of taste.
Odourless	Cannot be detected by sense of smell, However, CO can also be accompanied by aldehydes. Aldehydes' odour can somewhat resemble vinegar, which can be detected by the sense of smell, and may also result in a metallic taste in the mouth.
Non-irritating	Carbon Monoxide will not cause irritation. However, aldehydes usually present with higher levels of CO will irritate the eyes, nose, and mucous membranes.
Specific gravity	Slightly lighter than air (Sg 0.975). It may, but not always collect near the ceiling, and mixes freely with air.
Flammable (explosive) limits	CO is flammable between concentrations of 12.5% to 74% when mixed with air. Its ignition temperature is 609°C (1128°F).
Toxic	Can cause death if enough is absorbed into the bloodstream.

Chart 1 - Properties of Carbon Monoxide – From Technical Safety BC's "Carbon Monoxide Handbook"

*Concentrations (*ppm)*	*Observations and Health Effects*
1 to 3	Normal.
25	Occupational exposure limit averaged over 8 hour period.
30 to 60	Exercise tolerance reduced.
100	15-minute short-term exposure limit (STEL).
60 to 150	Frontal headache. Shortness of breath on exertion.
150 to 300	Throbbing headache, dizziness, nausea, and impaired manual dexterity.
300 to 650	Severe headache; nausea and vomiting; confusion and collapse.
700 to 1000	Coma and convulsions.
1200	Immediately dangerous to life and health (IDLH).
1000 to 2000	Heart and lungs depressed. Fatal if not treated.
Above 2000	Rapidly fatal.

*1 ppm = 1 part of gas per million parts air by volume

Chart 2 - Carbon Monoxide concentrations and health effects – From Technical Safety BC's "Carbon Monoxide Handbook"

Photo 4 – Carbon monoxide properties and health effects.