Incident Summary #II-1263238-2021 (#24277) (FINAL)

SUPPORTING INFORMATION	Incident Date		October 1, 2021
	Location		Burnaby
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Impact – Damage	Damage description	Release of carbon monoxide (CO) into occupied spaces
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		A hot water boiler in a rooftop mechanical room was emitting high levels of CO in the flue gas out to the rooftop. The nearby rooftop air handler fan pulled the CO into the building setting off alarms.
INVESTIGATION CONCLUSIONS	Site, system, and components		• The building is a 26-story high rise building of concrete construction. • The mechanical room is on the rooftop and separated from the interior space of the building. • The mechanical room has air intake grills where outside air enters the space for the combustion of fuel burning appliances. • There are three gas fired boilers in the mechanical room that provide hot water for the building. • The boilers exhaust products of combustion to the outside through cylindrical metal vents with fans to increase the airflow. • Complete combustion for such a boiler is where the ideal fuel to air ratio results in a typically solid blue flame from the burner. The chemical by-products of this ideal process are carbon dioxide (CO^2) and water (H^2O). This type of combustion is most efficient and results in less carbon and CO in the exhaust. • Conversely, incomplete combustion from an improper fuel to air ratio can result in a wavy yellow flame from the burner, accumulations of black carbon soot in the exhaust path, and increased emissions of CO. • Another by-product of incomplete combustion are organic compounds know as aldehydes. While CO is odorless, aldehydes have a sharp penetrating odor. The odor of aldehydes differs from odorants added to natural gas for detection. Aldehydes, much like CO, are toxic to humans and animals. • The three boilers at this site have a shared gas regulator valve intended to maintain a setpoint outlet gas pressure through varying operating loads. • Each boiler has a gas valve intended to start and stop the flow of gas to the burner and control the manifold gas pressure to the boiler's burner for proper combustion. • Standing alone on the rooftop is the air handling unit (AHU) that is used for hallway pressurization in the building. The AHU fan has a 15,200 cubic feet per minute (cfm) capacity. It also has a gas fired heater to normalize the inbound air temperature and humidity levels. The AHU exhausts its products of combustion to the outside through a side vent.

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Failure scenario(s)	Boiler 2, one of the three rooftop boilers, had a gas valve that was experiencing fluctuating highs and lows of gas manifold pressure. The gas pressure outside of the boilers specified range led to improper combustion and the emission of elevated levels of CO and black carbon soot buildup in the boiler and in the exhaust venting system. The nearby air handling unit likely drew in the products of combustion from boiler 2 into the building until it triggered CO detectors including one in an apartment. The CO was also likely drawn back into the boiler room through the air intake openings for the mechanical room.
Facts and evidence	Utility technician statements • The technician was dispatched to the site due to reports from the fire department of multiple units indicating an alarm status from the fire alarm system. • They reported that once on site, they were advised that the fire department had evacuated the building due to multiple CO alarms throughout the building. • As soon as the technician went on the open rooftop through the stairwell vestibule, they could smell the aldehydes (products of combustion) very strongly. • The wind was static, not blowing hard really when they attended after the incident. • The exhaust vent for the AO Smith Boiler #2 had a reading taken with over 500PPM CO. • The air handler unit's exhaust was tested for CO and levels of 150PPM were recorded. • The technician suspected that the CO was being sucked in by the nearby air handler and distributed throughout the building. • The two other boilers exhausts were found to have lower CO levels between 20-40 PPM. • There are gas pressure monitoring systems available for boilers like this, where if the gas pressure gets too high it will shut off the boiler. This type of system was not in place for this boiler. Gas contractor statements • During troubleshooting the flue gas a gas analysis test was performed for boiler 2 and measurements of 700 PPM CO were taken at the power venter, while boilers 1 and 3 had minimal levels of CO in their flue gases. • Boiler 2 was found to have thick black carbon soot all around the copper coils of its heat exchanger as well as in the venting. Boilers 1 and 3 did not have the same carbon buildup. • After cleaning the boiler of the carbon soot, a flue gas analysis test was performed, and the CO levels did not reduce. • The valve for the boiler is required to be set to provide a manifold gas pressure of 3.5 inches of water column (WC). • The gas valve for boiler 2 was measured with a manometer and levels intermittently fluctuating below 3.5 WC and as high as 4.6 inches WC during testing over a period of one hour. • The gas valve for boiler 1 was tested for comparison to boiler 2 with no fluctuations in gas pressure noted. • The gas fitter stated that with the higher gas pressure there may have been a need for additional intake air. • The air intake for all fuel burning appliances in the rooftop mechanical room was calculated to be a minimum requirement of 333 inches squared, while the actual available intake was 300 inches squared (90 %).

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	• The regulator for the three boilers was set at 7-inch water column and the lock up pressure test was at 10 inch water column. This was not deemed to be a factor inthe CO carbon buildup. • The power venter for boiler 2 was found to be working after the incident. • All three boilers had quarterly maintenance visits. • The gas fitter determined during troubleshooting that the MUA had no cracks in its heat exchanger and was not a likely source of CO as such. Emergency personnel CO measurements: • 290 PPM in the boiler room. • 500 PPM from the boiler 2 exhaust. • Levels ranging from 2-100 PPM in the lobbies and dwellings.
Causes and contributing factors	The likely cause of the hazardous CO levels in the flue gas of boiler 2 was a faulty gas valve that led to improper combustion. The CO likely accumulated on the rooftop and was drawn in through the AHU into the building as well as through the air intakes into the mechanical room.

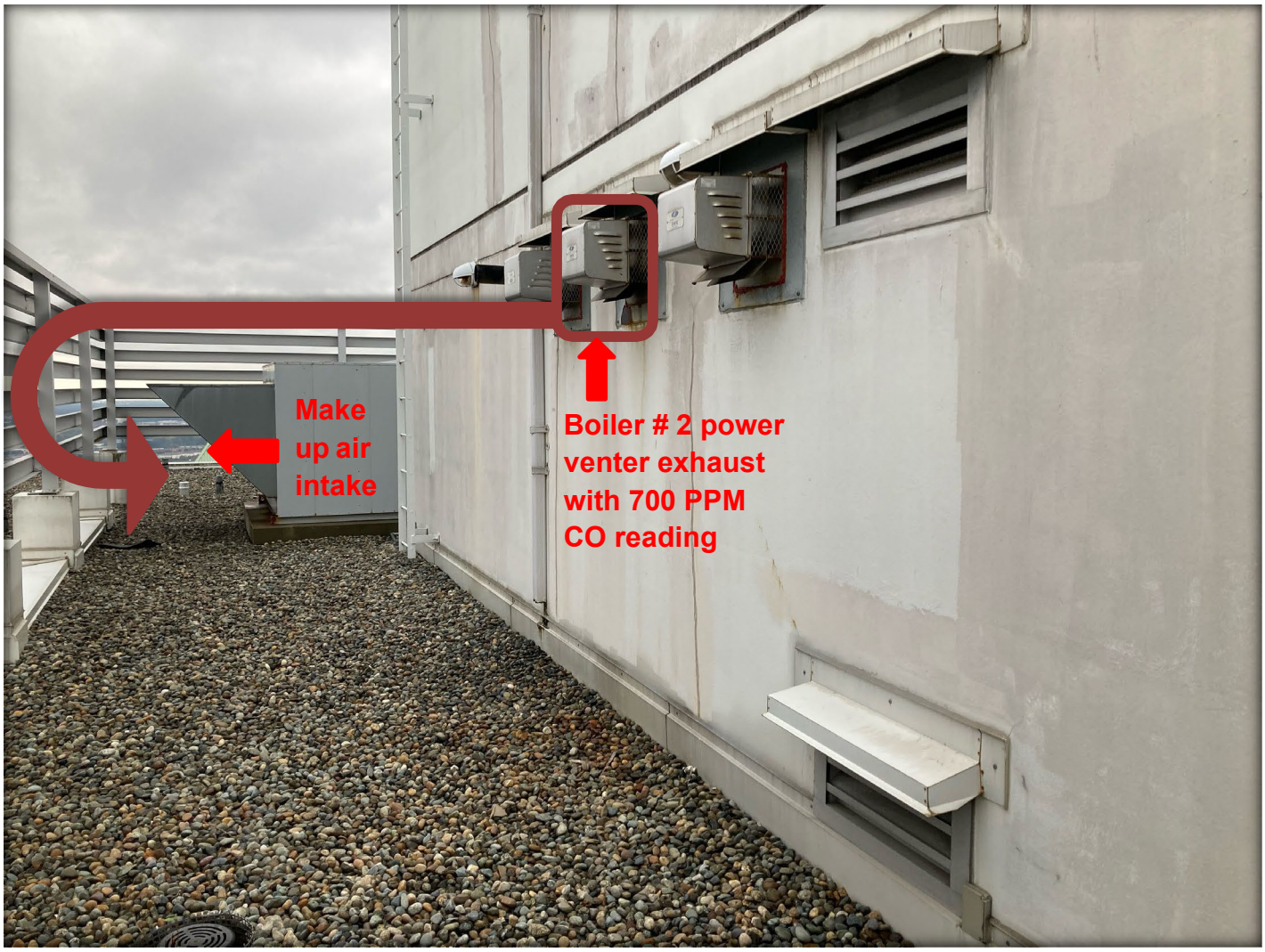

Image 1 – Likely path of travel for exhaust from boiler # 2 power venter to make up air intake. Boiler # 2 power venter exhaust measured at 700 PPM CO.

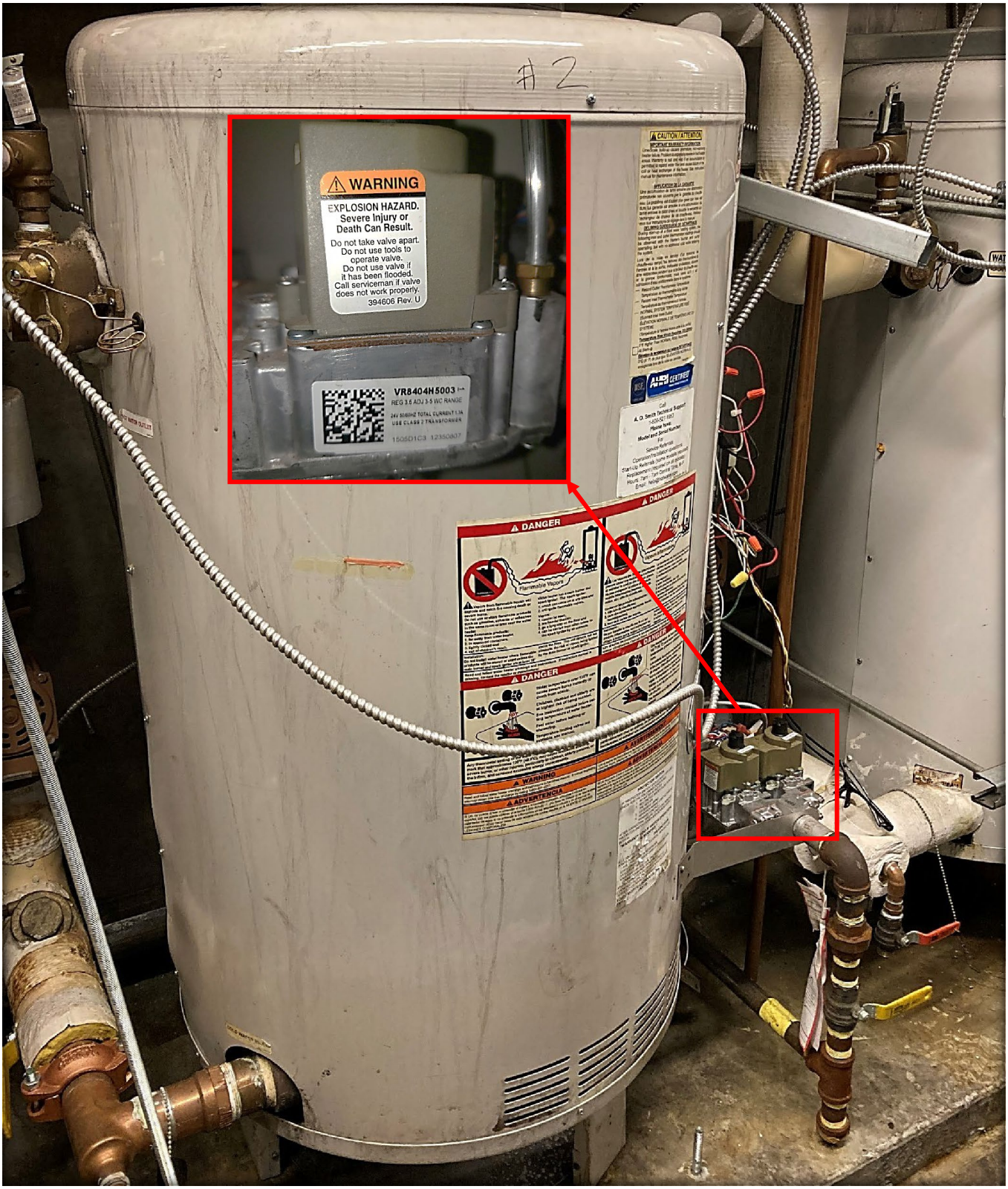

Image 2 – Boiler 2 gas valve (small red square) with side view of gas valve (large red square).