Incident Summary #II-1659153-2024 (#43298) (FINAL)

SUPPORTING INFORMATION	Incident Date		January 6, 2024
	Location		Maple Ridge
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	8
		Injury description	Individuals experienced carbon monoxide exposure symptoms including, headaches, dizziness, nausea, to varying degrees. Symptoms abated within two hours of vacating the building.
		Injury rating	Minor
	Impact – Damage	Damage description	Flue gas containing dangerous amounts of carbon monoxide (CO) leaked into occupied indoor spaces. Office staff and all the animals were evacuated from the building.
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		A wall-hung condensing boiler exhausted flue gases containing carbon monoxide into the rooftop mechanical room of a non-profit animal shelter. The flue gasses entered the office spaces on the main floor overnight. Staff members who entered Sunday morning began to feel sick and evacuated the premises, along with the animals who resided at the location at the time.
INVESTIGATION CONCLUSIONS	Site, system and components		Building mechanical systems consist of a hot water boiler, an air handling unit, a heat recovery ventilator (HRV), a domestic water heater and a heat pump system. In the original mechanical design, a heat pump was the primary heat source for the building. The boiler was intended to be a secondary source and provide back-up heat when needed. A Lochinvar wall-hung condensing boiler was located in the rooftop mechanical room. Under normal operating conditions, combustion air is supplied to the boiler either piped directly from the outside into the appliance or drawn from inside the mechanical room. The air mixes with the fuel at a ratio that provides optimum combustion, heating the water for the hydronic heating loop, and safely exhausts out of the building through the chimney flue. If the combustion air is supplied from inside the room; the room is required by code have adequate air supply and ventilation to the outside. A condensing boiler incorporates a condensate trap. The purpose of the condensate trap is to collect the condensation and any water vapour produced inside the high efficiency boiler vent system and flue passages in the heating process so it can be removed from the system. The condensate trap is located exterior to the boiler, installed on the condensate drainpipe. Because of the acidic pH levels of condensate, it is piped to a neutralizer tank. The condensate trap is critical to ensuring that the boiler exhaust gasses do not exit through the condensate drain. The trap provides a water seal that effectively prevents vapour from escaping through the drain.

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	The air handling unit (AHU) is located in the mechanical room and draws air from the outdoors and building space. It supplies air to an office area directly below the mechanical room on the second floor and to the first floor. There is a filter rack in the ducting of the AHU upstream of the unit, and a grilled outlet (approx. 6”x8”) that terminates within the mechanical room, supplying fresh air when the AHU is running. There is an HRV that exhausts air from the building to the outside, while tempering supply air. A (4”x4”) grilled inlet located inside the mechanical room exhausts air to the outside through the HRV. The original mechanical design of the building shows the heat pump as the primary source of heat with supply and return piping interconnected with the same hydronic heating system as the boiler. There is a domestic hot water heater in the mechanical room. This system is separate from the heating system. It has no impact on the heating boiler operation.
Failure scenario(s)	The heat pump, which was the designed primary heat source, failed at some point, and the boiler became the primary heat source for the building. The boiler was placed under considerable demand, operating outside of the intent of the original mechanical design. During a winter cold snap, the boiler stopped working and a gas contractor was retained to fix and service the boiler. In the week from December 26 to January 2, technicians had been called to site several times because the boiler was not operating consistently. Technicians spent several days replacing and repairing boiler components including the flame rod sensor, ignitor, and gas valve. The boiler continued to function intermittently. A technician received a “no-heat call” on Friday, January 5, and arrived on site to find the boiler off and the building cold. He changed the gas valve but continued to receive the same error code: “flame failed during ignition.” He consulted with boiler manufacturer tech support, and was instructed to clean the heat exchanger, which he did. By the end of day Friday, January 5, the boiler still had persistent firing issues, was “puffing” and had too much gas pressure. He left the site at 6:30 pm. The next day, two technicians attended the site. They continued to troubleshoot, with the intention of keeping the boiler firing. They discovered that if they removed the condensate trap from the condensate drain, the boiler would run without error. With the threat of impending cold weather, they agreed the most likely way to keep the appliance running overnight was to leave the condensate trap off. They propped the door to the room open for ventilation and left the site. The boiler ran overnight while flue gases containing high levels of CO were escaping through the condensate drain and being expelled into the mechanical room. Flue gas containing high levels of CO was subsequently drawn into the air handling unit from the mechanical room, through a gap in the ducting at the filter rack. The CO was then distributed through the building. As the mechanical room air became increasingly contaminated with flue gases, a high level of CO first entered the office space directly beneath the mechanical room, then the foyer, office, and main work area on the main floor. Because the building was cold, the boiler ran continuously to raise the temperature.

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	Contaminated air from the Mechanical room was drawn into the boiler combustion air intake, which resulted in the boiler producing exponentially higher levels of CO due to a reduction in the available oxygen for combustion. This flue gas recirculation increased the level of CO in the boiler exhaust, the mechanical room, and eventually the office spaces below. This continued overnight and into Sunday morning. The building did not have any alarms to alert staff of elevated CO levels. Staff arrived Sunday morning, and after approximately an hour and a half, began to exhibit symptoms of CO exposure, including headaches, nausea, dizziness, and confusion. Eight staff members in total were affected. The contractor was called in and the staff evacuated to the outdoors their symptoms abated within two hours of being in the fresh air. There were no medical aids. The contractor returned to site with a flue gas analyzer and tested the boiler's flue gas. The technician found that the boiler was producing 4000 parts per million (PPM) of CO. After the boiler was shut down and the building was ventilated for a number of hours a detectible amount of CO was still measured in the occupied spaces and mechanical room.
Facts and evidence	**Technician Statements** • The boiler ran without fault when the condensate trap was removed. • Flue gas exited the boiler drain when the condensate trap was removed. • The mechanical room door was left open to dilute any flue gas that accumulated in the mechanical room. • Aldehydes were identified by odour in the mechanical room when the condensate trap was removed. • The HRV was turned off to prevent air from exhausting out of the mechanical room. • 4000ppm CO was measured in the boiler flue exhaust, a significantly high level of CO and outside the normal operating parameters of the boiler. • The technicians felt obligated to get the boiler running, knowing that the animals would need to be removed from the shelter if the building temperature could not be maintained. • The original building mechanical schematics show the primary heat source in the original design was a heat exchange and recovery system, where the heat pump was the primary source of heat, and the boiler was intended to serve as a back-up source. • According to the facility maintenance manager, the heat pump had been out of commission for more than seven years. • The mechanical schematics indicate that the boiler combustion air was designed to be piped directly to the outside. • A gap of approximately 1.5 cm was observed in the Air Handling Unit filter rack during site examination. The gap in the filter rack provided a passage for gas or vapour from the mechanical room to enter the AHU ducting and then the occupied spaces in the building. The boiler venting system (exhaust flue) through which the spent gases were meant to exit the room, had been modified since the original design installation, and consists of both compliant and non-compliant vent materials. Modifications included: The original 3" combustion pipe appears to have removed, a 4" tee installed on the side, and an additional 3" line routed to the original combustion air termination. This resulted in the boiler drawing its combustion air directly from the boiler room. Under normal operating conditions, the HRV exhausts air from the mechanical room to the outside. Prior to the sequence of events which led to the exposure, the contractor

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	stated that they disconnected the HRV, eliminating the method by which air was being drawn out of the room. The heat pump that was part of the original engineering design was not in use and the boiler was the sole source of heat for the premises. The boiler would have to run for frequent cycles to maintain sufficient building heat during cold weather. Insufficient ventilation from outside, propping the door open, and disconnection of the HRV unit are all factors which could potentially have changed the air pressure in the room, and contributed to the flue gases being drawn into the AHU and entering the building. The weather forecast called for unseasonably low temperatures. There were no maintenance records available at the time of the incident. After the failure of the heat pump, it was not repaired or replaced as per the original engineered design. Disconnecting the HRV eliminated a means of exhausting the gases from the mechanical room. There is no record of an installation permit being obtained, nor was a first certification inspection conducted on the boiler. The boiler did not have an installation permit or an operating permit.
Causes and contributing factors	It is highly likely that the removal of the condensate trap from the boiler resulted in flue gas entering the mechanical room, subsequently being drawn into the building air supply through the filter gap in the air handling unit, resulting in elevated CO levels in the occupied spaces. Contributing factors to the incident include: • The operation of the mechanical system outside of the original design parameters imposed a significant load on the boiler, increasing the requirements for maintenance and potential for failure. • A lack of maintenance records and service history of the mechanical equipment indicates that the boiler may not have been serviced regularly during its lifespan. Lack of service and heavy demand likely contributed to improper function, including high CO and potential heat exchanger restrictions. • The alteration of the boiler venting so that combustion air was taken directly from the mechanical room, impeded the boiler combustion air supply, affecting combustion resulting in elevated CO levels. • The lack of CO detectors installed in the boiler room and occupied spaces prevented an early warning of elevated carbon monoxide levels.

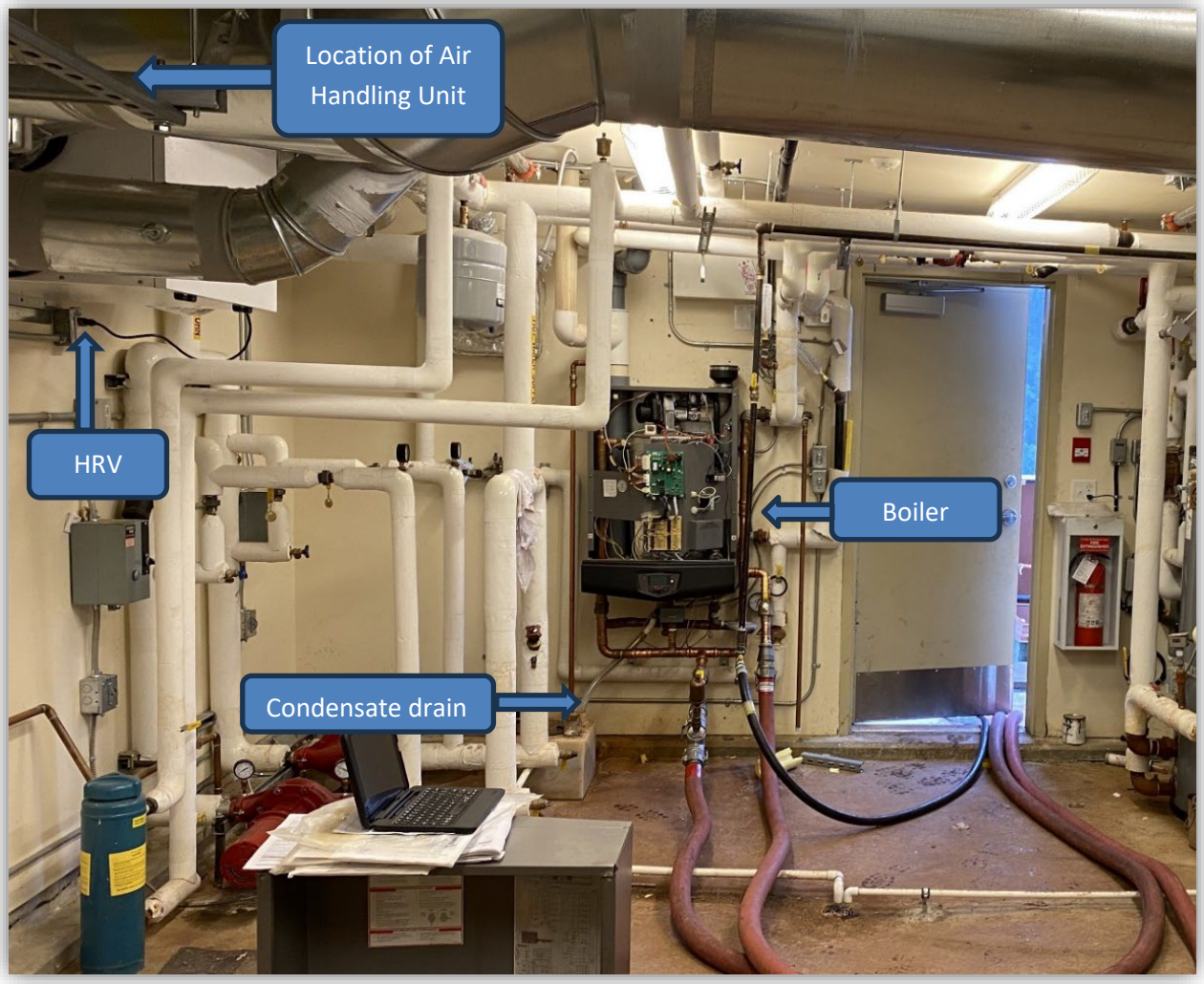

Image 1 – Mechanical room.

Image 2 – Boiler showing left side flue/exhaust piping and right-side showing supply air intake.

Image 3 - Exhaust piping modification that occurred sometime in the life of the appliance.

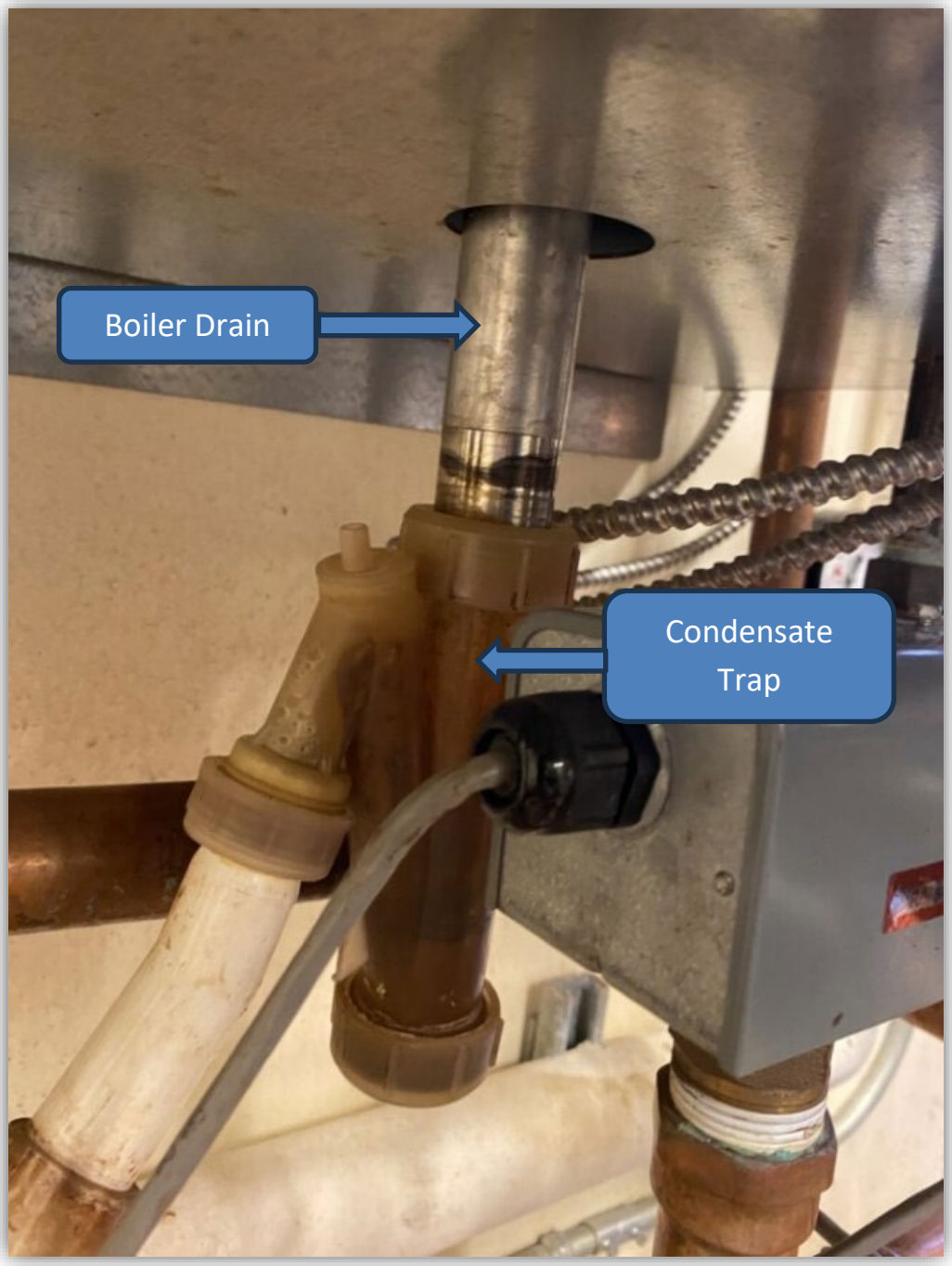

Image 4 – Underside of boiler.

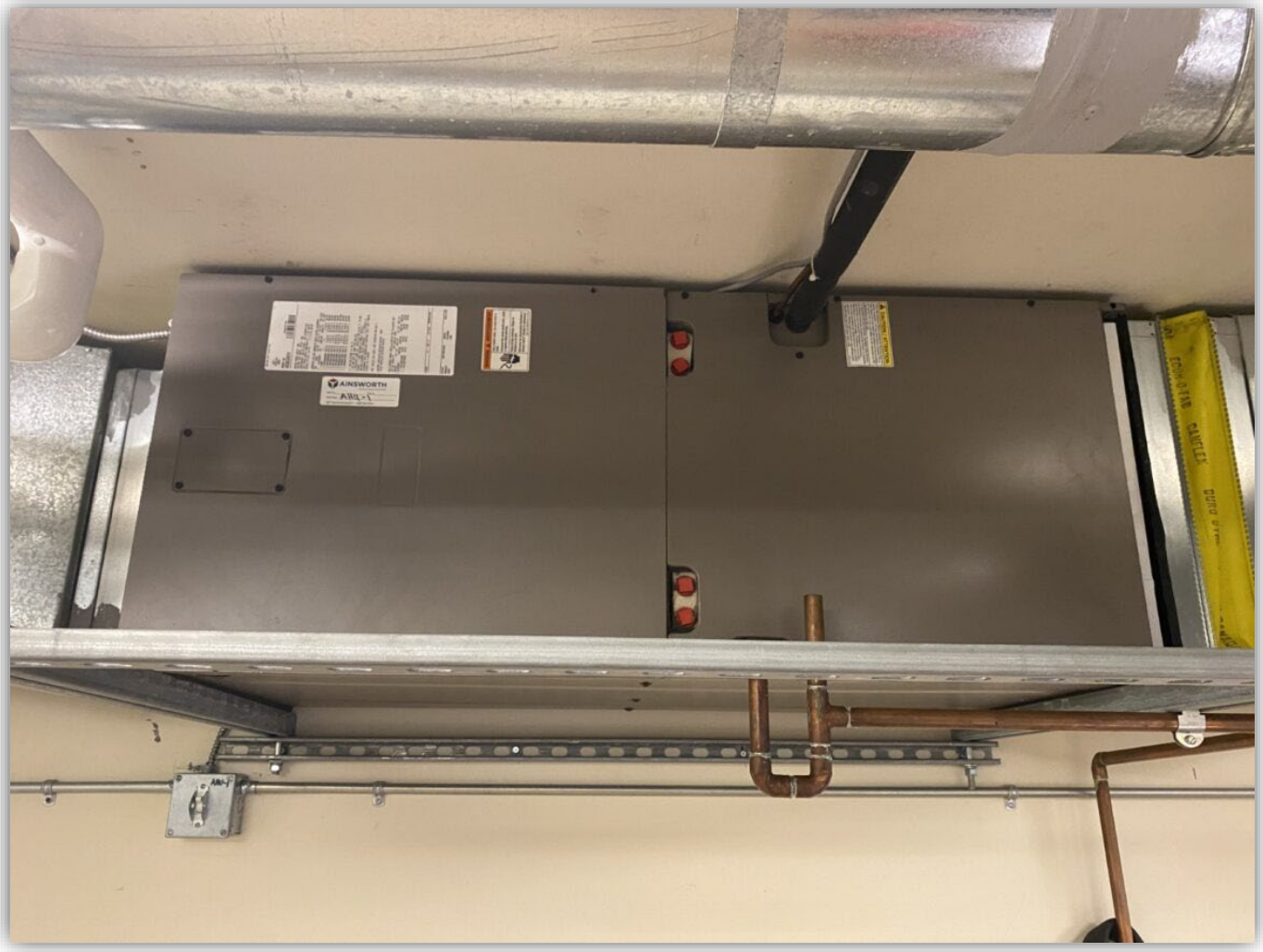

Image 5 – Air handling unit with inlet filter rack on right side.

Image 6 – Unsealed AHU filter rack with arrow showing the gap that drew in the boiler exhaust.

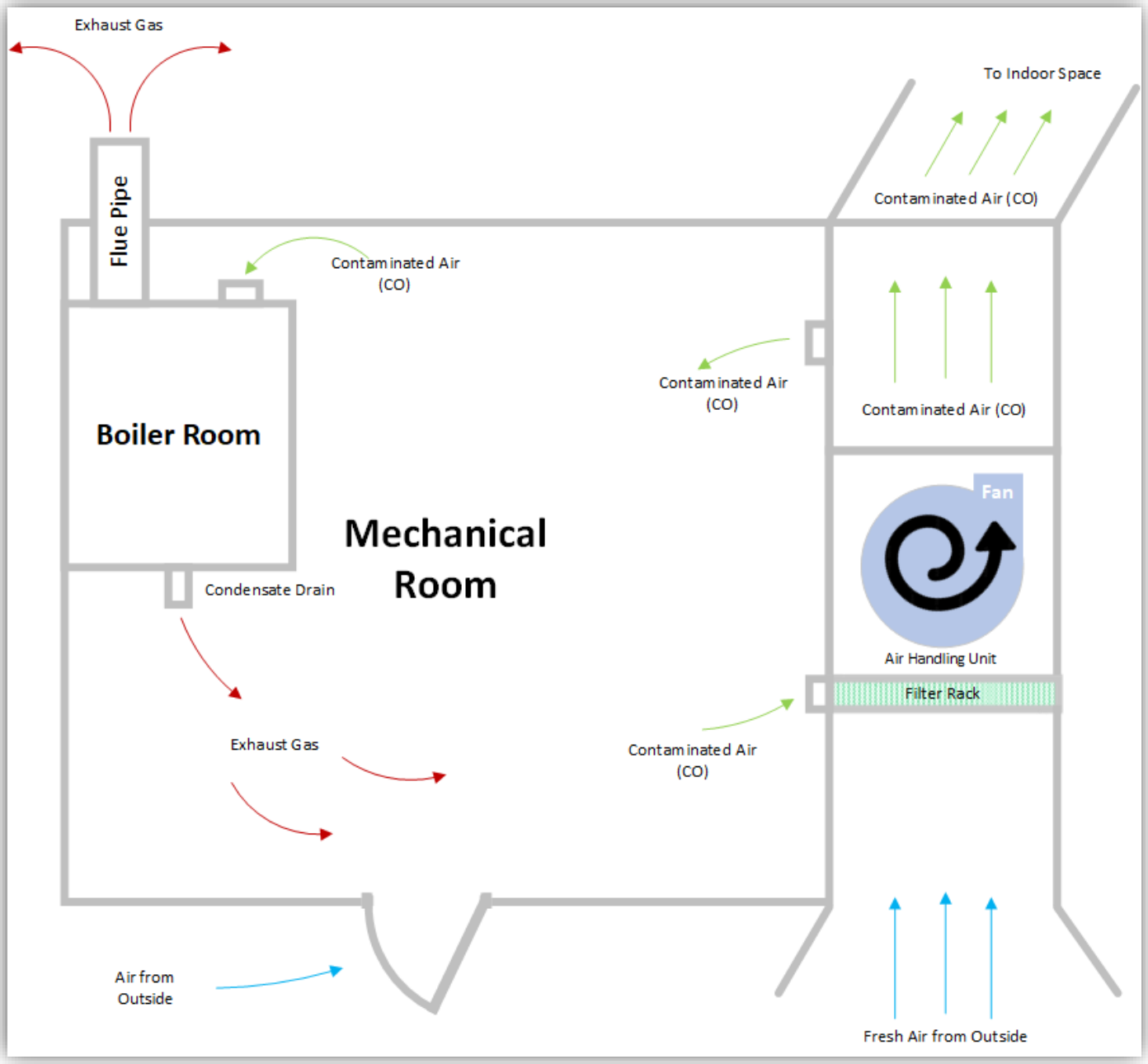

Image 7 – Diagram of mechanical room showing distribution path of CO from boiler into building.