Incident Summary #II-1261773-2021 (#24231) (FINAL)

SUPPORTING INFORMATION	Incident Date		September 30, 2021
	Location		Surrey
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Impact – Damage	Damage description	Dangerous concentrations of carbon monoxide (CO) were created and distributed in the hallways of a multi-unit residential tower.
		Damage rating	Major
	Incident rating		Major
	Incident overview		A large air handling unit (AHU) in a 15-story residential tower created conditions in the mechanical room which allowed flue gas, containing high concentrations of CO, to be distributed throughout common hallway areas of the building on two separate occurrences, days apart.
INVESTIGATION CONCLUSIONS	Site, system and components		Natural gas fired hot water boilers are used to provide domestic hot water to the units in the building. The boilers vent their flue gases to the outdoors by means of natural draft vent pipes, which pass through the mechanical room roof. Natural draft vent pipes use an open draft hood (Image 4), which draws air from the room into the vent as the hot gases rise in the pipe. The draft hoods of natural draft appliances need to operate in a neutral pressure environment to avoid back-drafting down the vent pipe, and spilling of the flue gases into the space. Fixed openings are provided in the mechanical room to provide combustion and ventilation air to the gas appliances, and ensure the room remains at a neutral pressure. 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 carbon monoxide (CO). Carbon monoxide is a colourless, odourless, tasteless gas that is toxic to humans and animals. Exposure to carbon monoxide interferes with the body's ability to absorb oxygen, which can result in serious illness or death. (For more information on carbon monoxide checkout "CO Safety Tips") The boilers are installed in a mechanical room on the roof of the 15-story building, (Image 1) along with a 6600 cubic feet per minute (cfm) capacity air handling unit (AHU), used for hallway pressurization in the building. The hallways and common areas of the building are pressurized by the fan through ducting to provide fresh air and limit migration of odours and pollutants from the units and underground parking into the spaces. The AHU operates 24 hours a day and is designed to draw all its intake air from the outdoors through ducting and a large louvered opening in the side

Incident Summary #II-1261773-2021 (#24231) (FINAL)

	of the mechanical room. Filters are installed inside the intake ducting to filter dust and debris from the incoming air (Image5). The filters need to be changed on a regular basis, or as needed to avoid restriction of the air as they become dirty and clogged. The B149.1 Gas installation code states that gas appliances shall not be operated when other equipment, including fans, adversely affect the venting or combustion of the appliance.
Failure scenario(s)	The mechanical room on the rooftop of a 15 story residential tower houses two gas fired boilers, and an air handling unit (AHU) used for ventilation and hallway pressurization. The two boilers were operating with elevated levels of CO in the flue gases up to 1300ppm. The AHU has a metal duct which allows all the intake air to be drawn through a louvered opening in the mechanical room directly from the outdoors. The ducting contains filters, which filter the incoming air from dust and debris. The filters are scheduled to be changed quarterly, and they had become dirty and restrictive since they were last changed three months prior. Extensive plumbing work had taken place in and around the mechanical room during that time, which may have accelerated the rate the filters became dirty. The ducting, metal case, and access doors for the AHU has several unsealed gaps which allowed air to be drawn in from the mechanical room. The restricted filters and unsealed gaps between the filters and the blower, caused the AHU to draw in excessive amounts of air from the mechanical room instead of from outdoors. This created a negative pressure environment in the room and allowed back drafting of the boiler flue vents. The flue gasses containing hazardous levels of CO was drawn into the unsealed openings and through the AHU, which then distributed it into the hallways of the tower through the AHU ducting.
Facts and evidence	Gas utility report • September 27th the gas utility received a call from a tenant on the 15th floor, stating that their CO detector was alarming and had been alarming periodically over the last couple of months. • When the technician got out of the elevator on the 15th floor, they recorded 327 parts per million (ppm) of CO in the ambient air in the hallway. • They went to the mechanical room on the roof and found that the boilers were spilling CO into the mechanical room, which was being sucked into the building by the AHU, so they shut down the boilers. • The mechanical contractor identified dirty air filters in the AHU and planned to change them. • They were called back to the site on September 30th when the Fire department was called to the building and measured 200ppm CO in the ambient air in the hallway on the 15th floor. • The Fire department evacuated the building. Interviews Maintenance contractor company owner • When they perform quarterly preventative maintenance on the appliances, it consists of a visual inspection and testing of basic operating functions and safeties. Only the ambient air in the room is tested for CO with basic CO detectors. Combustion analysis is not performed during basic preventative

Incident Summary #II-1261773-2021 (#24231) (FINAL)

maintenance. If elevated levels of CO are being generated by the appliance, they may not be identified if the appliance is venting correctly.
- Once a year, or as required, they submit a request to the strata management company for a more in-depth disassemble and cleaning of the appliance. If the request is approved, the appliance is disassembled, cleaned, reassembled, and tested including combustion analysis.

Maintenance contractor heating technician
- On September 27th, they attended the site and met with the gas utility technician.
- They tested the draft of the boilers with a smoke test while the AHU was off, and the boilers vented properly.
- When the AHU was turned on, they could physically feel the warm flue gases back drafting into the mechanical roof from the boiler vents.
- They opened the AHU and found the filters were very dirty and restricting the intake airflow.
- The filters were removed, and the mechanical room was tested for spillage of CO, and the AHU and boiler were left operating.
- September 29th, new filters were installed in the AHU and the mechanical room was tested again with a basic CO detector without a digital display and it did not alarm.
- On September 30th, they were called out again for the second occurrence of CO detected in the building.
- Gaps were found in the intake ducting and access doors for the AHU, which allowed air to be drawn in from the mechanical room.
- The Fire Department was on scene and was evacuating the building.
- The boilers and AHU were shut off.
- During on-site testing of the boilers for the investigation, the technician stated that they did not believe that the 1300ppm CO measured in the flue gas was a concern. They stated they thought the appliances would produce this amount in normal operation.

Strata management company
- There is a preventative maintenance program, and a maintenance contract with gas contractors.
- The contractor does quarterly maintenance checks and provides cost estimates for any additional maintenance and repair work.
- The cost estimates are reviewed by the strata council who may provide approvals for the work.
- The building does not have CO detectors in the hallways, and they are now working at having a detection system installed.

Boiler manufacturer
- The flue gas for the boilers should contain less than 200ppm CO when they are operating correctly.

Documents
- Mechanical drawing shows the AHU flow at 6600 cfm.
- Decals on the boilers and AHU show quarterly preventative maintenance had been performed.
- Contractor invoice shows the AHU filters were changed 3 months prior to the incident.

Incident Summary #II-1261773-2021 (#24231) (FINAL)

	Boiler Installation manual • A warning states "*Under no circumstances should the equipment room where the boiler is installed ever be under a negative pressure. Insufficient air supply can interfere with combustion and ventilation of this boiler resulting in unsafe conditions.*" Testing The flue gas of the boilers was tested with the AHU off and the door to the mechanical room open. A smoke test was conducted with the boilers operating, and both boilers were found to be venting correctly. The flue gas of the boilers reached 1300ppm CO withing 30 seconds of operation and maintained that level for the 3-minute duration of the test. Summary With the AHU off and the mechanical room at a neutral pressure, the boilers were producing elevated levels of CO. The technician who had performed maintenance of the boilers did not test the CO levels in the flue gas and did not identify that the levels they were producing were abnormal, and required investigation and repair. The dirty air filters and open gaps in the intake ducting and access doors of the AHU created the negative pressure environment in the mechanical room. With the boilers operating in a negative pressure environment, and the flue gasses not venting properly, it is likely that the back drafting could cause a lack of combustion air at the burners, which would elevate the CO concentration in the flue gas to even higher levels. The AHU drew in the elevated levels of CO from the mechanical room and distributed it through the ducting to common areas and hallways in the building.
Causes and contributing factors	It is highly probable that incorrect maintenance and testing of the gas equipment in the mechanical room caused the incident. The gas equipment being put back into service without proper identification and mitigation of the incorrect operation, likely contributed to the second occurrence of CO entering the indoor spaces. The design of the mechanical room, which incorporates the AHU indoors with the natural draft boilers, likely contributed to the incident by allowing the creation of a negative pressure environment in the mechanical room when the air filters became dirty and drew in and distributed the flue gas containing elevated levels of CO into the indoor spaces.

Image 1 – Mechanical room on roof of tower.

Image 2 – Air intake louver for AHU taking intake air from outside the mechanical room.

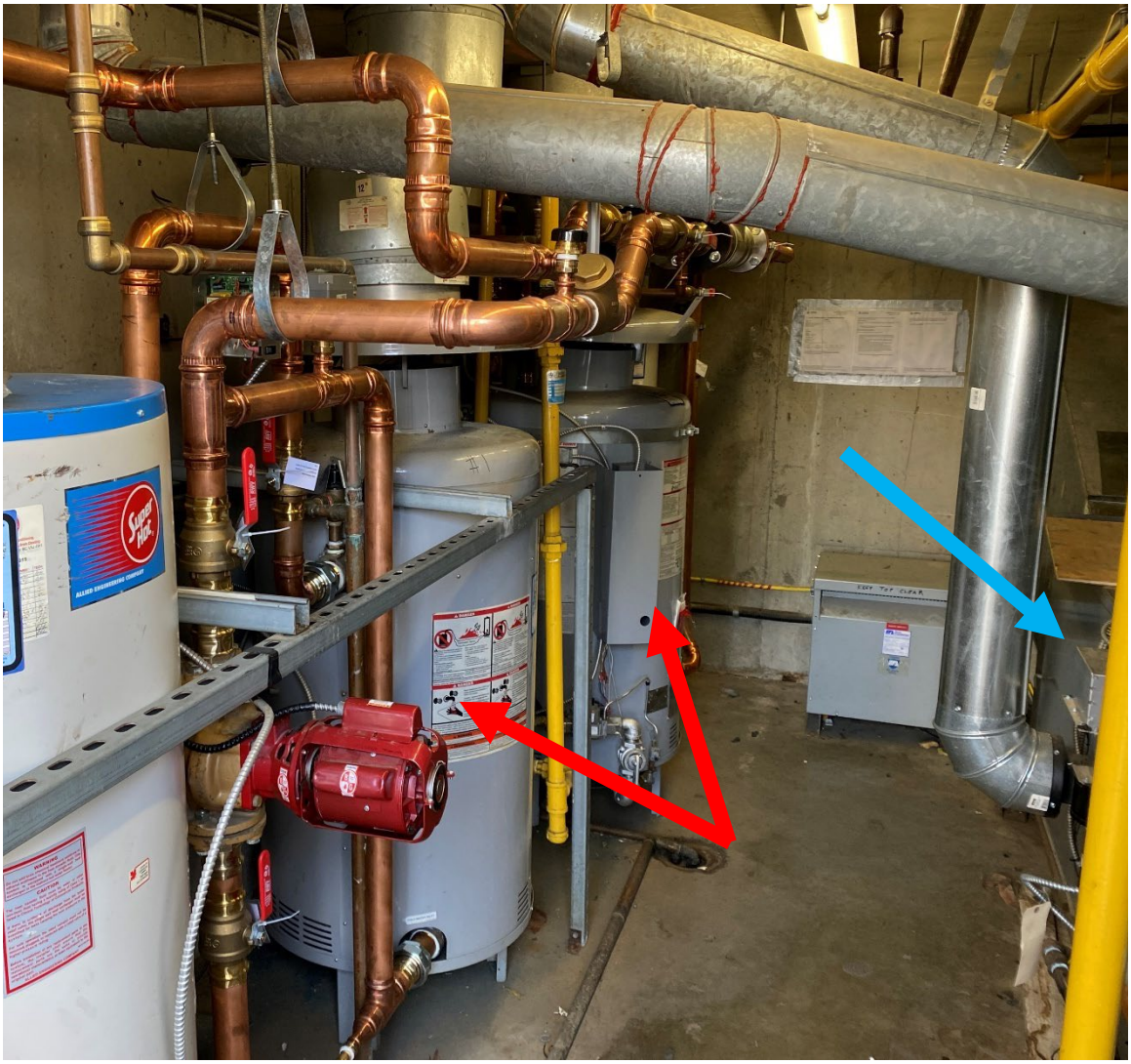

Image 3 – Mechanical room containing the natural draft boilers (red arrows) and the AHU for hallway pressurization (blue arrow).

Image 4 – Gas fired hot water boilers. Draft hoods (red arrows), combustion air opening (blue arrow).

Image 5 – AHU with access door open showing blower and new intake filters installed after the incident.

Image 6 – Gaps around intake air duct connection inside mechanical room between the filters and the blower that were sealed with red silicone after the incident.

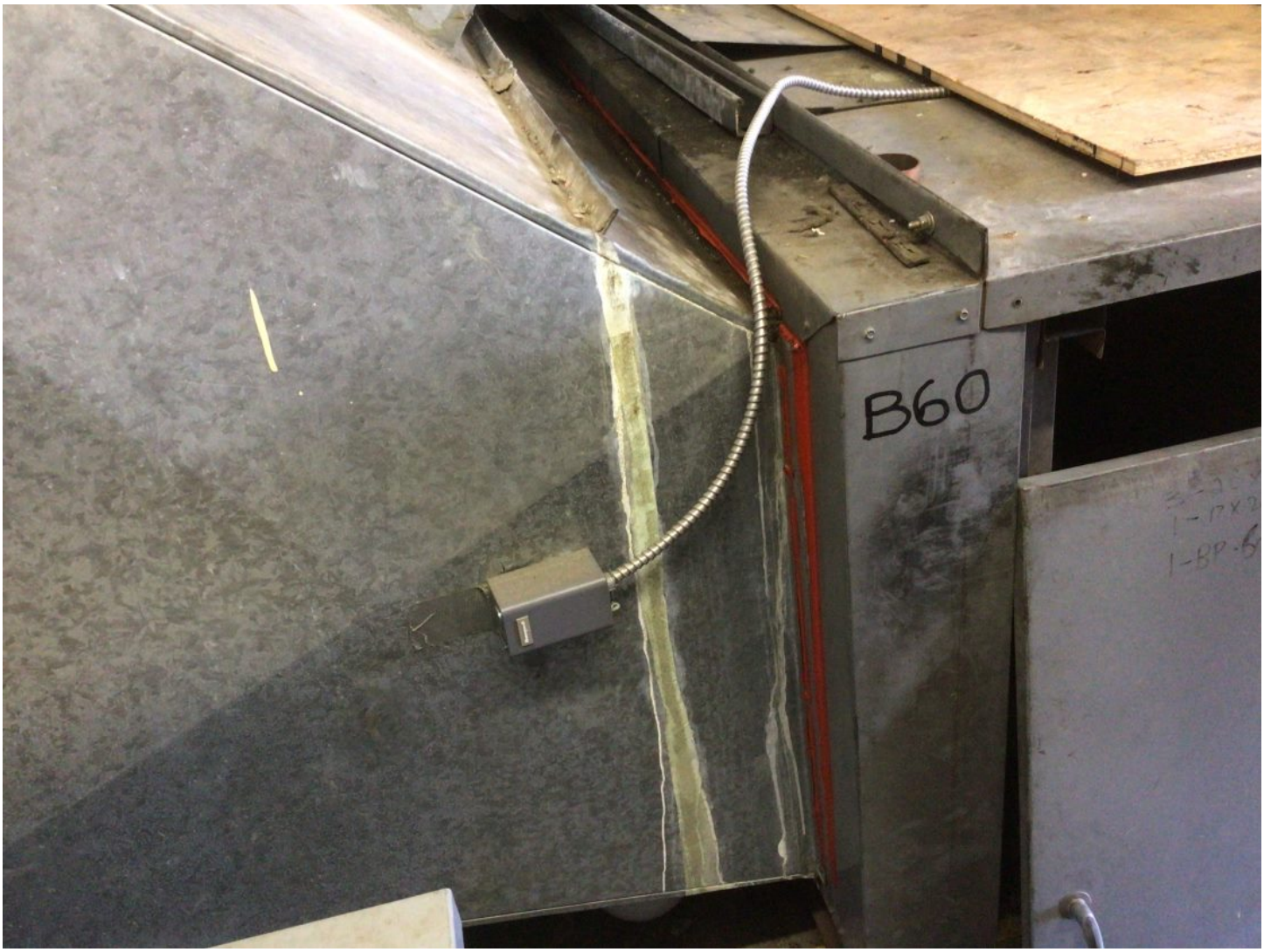

Image 7 - Gaps around intake air duct connection inside mechanical room between the filters and the blower that were sealed with red silicone after the incident.