

Incident Summary #II-1637869-2023 (#41677) (FINAL)

SUPPORTING INFORMATION	Incident Date	November 20, 2023	
	Location	Vancouver	
	Regulated industry sector	Gas - Natural gas system	
	Impact Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Damage	Damage description	Dislodgement of a boiler vent stack and the emission of exhaust gas containing carbon monoxide into an indoor space.
		Damage rating	Minor
Incident rating	Minor		
Incident overview	A boiler serving a commercial space experienced a combustion event that dislodged the boiler vent. The appliance continued to operate with the vent dislodged allowing products of combustion to exhaust into the mechanical room.		
INVESTIGATION CONCLUSIONS	Site, system and components	<p>Two gas-fired hydronic boilers located in a roof-top mechanical room provide building heat and domestic hot water. The hydronic boilers incorporate a system of pumps, valves and fittings that distributes hot water to the building heat emitters which, in turn, modulate the building temperature.</p> <p>A gas-fired boiler ignites natural gas to create heat within a combustion chamber, which transfers the heat to water through a heat exchanger. The products of combustion exit the boiler through a vent that is routed to the outside where the products of combustion are safely emitted. The boiler vent is constructed of S636 stainless steel. Venting sections are joined with silicone gaskets and gear clamps. The Fulton is a direct-vent boiler, in which both the air for combustion and the exhaust vent are piped directly to the outdoors.</p> <p>The boiler room has a 5psi gas supply that is regulated down to 14" WC (1/2PSI) via two-line pressure regulators. The boiler requires a maximum gas inlet pressure of 14" WC.</p> <p>The Fulton Pulse boiler incorporates a unique combustion design utilizing a pulse combustion principal. Gas and air are drawn into the boiler combustion chamber and ignited by an electronic spark. Between 60 and 70 pulses of the air/gas mixture are ignited per second, producing a rapid burning pressurized pulse. The turbulence of the pulse combustion increases heat transfer to the heat exchanger.</p> <p>The boiler gas supply is controlled by the gas valve train which incorporates the following components:</p> <ul style="list-style-type: none"> A) Appliance regulator - Regulates the gas pressure from an inlet pressure of 14" water column (WC) to an outlet pressure of 3.9" WC. B) Two safety shut off valves (SSOV) - Stop the flow of gas when the boiler is not firing or experiences a safety failure. 	

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	<p>C) Modulating gas valve - Modulates the flow of gas to the combustion chamber for different firing rates (low to high fire).</p> <p>D) High gas pressure switch - Shuts the boiler down if the gas pressure exceeds the setpoint. The high gas pressure switch has an adjustable setpoint from 3-21" WC. At the time of the incident the switch was adjusted to a setpoint of 7" WC.</p> <p>E) Low gas pressure switch - Shuts the boiler down if the gas pressure falls below the setpoint.</p> <p>The boiler incorporates a direct-spark ignition where the main burner is ignited without the use of a pilot burner. With this ignition strategy, a volume of gas is ignited at once inside the combustion chamber. Prior to ignition, the modulating gas valve modulates to a low fire position so that the minimum amount of gas necessary for ignition is allowed into the combustion chamber. Under normal operating conditions the measured gas pressure entering the combustion chamber during ignition is 2.5-3" WC. This is controlled by the modulating valve and the setpoint of the appliance regulator.</p>
<p>Failure scenario(s)</p>	<p>The appliance regulator on the boiler valve train had failed so that it no longer reduced the gas pressure to the required 3.9" WC. As a result, the measured gas pressure downstream of the appliance regulator was equal to the inlet pressure of 14" WC.</p> <p>During ignition, the gas pressure exceeded the maximum allowable manifold pressure, allowing significantly more gas into the combustion chamber than would be permitted under normal operating conditions. The accumulation of gas inside the boiler combustion chamber resulted in a hard light-off in which the combustion chamber over pressurized, creating a positive pressure in the boiler vent. A section of vent became dislodged because of the over pressure.</p> <p>After ignition, the boiler continued to run with a dislodged vent, allowing products of combustion to enter the building mechanical room which condensed on the ceiling.</p> <p>The following day the property manager performed a daily check on the mechanical room and found the mechanical room ceiling covered in condensation from the flue gas.</p> <p>No CO alarms were installed in the mechanical room to alert staff of elevated CO levels.</p>

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<p style="text-align: center;">Facts and evidence</p>	<p>Statement from building manager:</p> <p>During a daily mechanical room inspection, the building manager noticed a large volume of water spread throughout the boiler room ceiling. Assuming it was a water leak he called a plumbing technician to inspect for leaks. The technician identified that the boiler vent had become dislodged and was emitting exhaust gases into the mechanical room, which condensed on the boiler room ceiling.</p> <p>Statement from gas technician:</p> <p>An annual maintenance was performed on the boiler prior to the incident in August of 2023 and the following maintenance items were serviced:</p> <p>Maintenance items checked during service:</p> <ul style="list-style-type: none"> • flapper gaskets replaced (both gas and air). • Replaced ignition spark plug and flame sensing rod. • Combustion analysis with OEM specifications. • Test all limits and safeties. • Check gas pressures, manifold and inlet. <p>After the incident technician inspected the following components of the boiler and all were found to be functioning properly:</p> <ul style="list-style-type: none"> • Flame rod. • Spark plug. • Combustion values withing manufacturer's specifications. • Pre and post purge time. • Obstructions in venting and combustion air. • High Gas Pressure switch. • Low gas Pressure switch. • Inlet gas pressure. <p>The boiler appliance regulator item was inspected by the technician and found to be faulty:</p> <ul style="list-style-type: none"> • The appliance regulator's downstream pressure was tested in multiple locations. The downstream pressure was 14"WC, the same as the inlet pressure. Any attempt to adjust the regulator resulted in the same pressure reading (14"WC), indicating a failed regulator. • The technician installed a new appliance regulator and was able to adjust the regulator to the required manifold pressure of 3.5"WC. • After installing the new appliance regulator, the technician cycled the boiler numerous times and found no ignition delay and no indications of faulty operation.
<p style="text-align: center;">Causes and contributing factors</p>	<p>It is probable that the failed appliance regulator allowed an excessive amount of gas into the boiler combustion chamber, resulting in a hard light off that was significant enough to dislodge the boiler vent. The boiler continued to run, exhausting flue gas directly into the mechanical room.</p> <p>A lack of CO detectors prevented an early warning of elevated CO.</p>



Image 1 - Fulton Boiler.



Image 2 - Boiler Vent.



Image 3 - Boiler Valve Train Components.