

Incident Summary #II-1447428-2022 (#30045) (FINAL)

SUPPORTING INFORMATION	Incident Date	October 3, 2022
	Location	Delta
	Regulated industry sector	Gas - Natural gas system
	Impact	Qty injuries
		0
	Injury	Injury description
		None
	Damage	Injury rating
		None
INVESTIGATION CONCLUSIONS	Site, system and components	Damage description
		Products of combustion including carbon monoxide (CO) were exhausted into an interior space. The venting system was disengaged from the boiler. The boiler ignitor experienced distortion from heat.
		Damage rating
		Moderate
		Incident rating
		Moderate
	Incident overview	
	Delayed ignition detonation resulted in the venting being blown off the top of the running IBC boiler with products of combustion including CO exhausting into the boiler room.	
	<p>Site and system</p> <ul style="list-style-type: none"> The multi dwelling residential building utilizes three natural gas hydronic boilers for water heating. The heating system includes the boiler, water tank, and venting system. <p>Boiler components</p> <ul style="list-style-type: none"> The boiler had a single prong ignitor that creates an electrical arc between the prong and a grounded metal burner mesh to ignite natural gas from the burner. The distance of the gap between the ignitor and the burner mesh is a critical factor in ensuring proper ignition. On a call for heat from thermostat(s), the boiler fires and heats the water in the boiler for the heating systems. Under normal operation, the products of combustion from a boiler are exhausted to the exterior of the building through the vent system. <p>Boiler ignition sequence</p> <ul style="list-style-type: none"> The boiler employs an inter-purge ignition trial sequence that is intended to clear any unburnt gas out from the boiler if a burner flame is not sensed in the 4 second ignition attempt. Inter-purge in this case, refers to the boiler's fan operating after a failed ignition trial to remove any remaining combustible gases from the combustion chamber and venting system to allow for a proper combustion sequence on the subsequent ignition trial. The operational and testing requirements for this type of boiler including the multi-try ignition sequence are defined in the ANSI Z21.13-CSA4.9 approval standard. After three failed attempts for burner ignition, the boiler is required to lockout for 1 hour. 	

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	<p>Vent system</p> <ul style="list-style-type: none"> The vent system for the three boilers consists of CPVC (chlorinated polyvinyl chloride) vent pipe, with glued connections between pipe fittings, and metal supporting hangers from threaded rod. The CPVC vent pipe and fittings tested and approved under the ULC-S636 standard. System 636 CPVC vent system manufacturer's requirements include that the venting needs horizontal supports every 5 feet (1.5 meter) and at changes in direction such as 90 degree elbows. The manufacturer requirements include the use of steel strapping that is suitable for use on plastic pipe and the strapping is to be fixed to supporting structure. The manufacturer requirements include that the vent pipe supports are not to be tightly clamped onto the pipe to allow for expansion and contraction. <p>Carbon monoxide</p> <ul style="list-style-type: none"> Carbon monoxide is a colourless, odourless, tasteless gas that is toxic to humans and animals (Chart 1). 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)	<p>The boiler (Image 2) was manufactured and then installed in 2020 and used a single prong ignitor that had residual stress in the metal offset bend. The boiler involved with the incident had been operating with an average of 30 ignition cycles per day as the master of the three boilers and had a history of multiple major ignition trials exceeded errors (Image 6) in the boiler controller. The arc gap between the ignitor prong and the metal burner mesh increased beyond the manufacturer's recommended gap distance (Image 3) from release of the residual stress in the ignitor during exposure to heat. The boiler was not initially igniting the natural gas due to the increased arc gap, which led to a build up of unburnt gas and explosive detonation when delayed ignition would finally occur. The venting system separated from the top of the boiler from the force of the boiler's delayed ignition detonations (Image 1) and products of combustion including CO were released into the boiler room.</p>
Facts and evidence	<p>Site findings</p> <ul style="list-style-type: none"> Boiler #1, that was involved with incident had an ignitor gap that was approximately 6-7mm. This is 1.5-2.5mm over the recommended gap setting of 4.5mm max (Image 3). Boiler #1 had a low water cut off major error on August 26, 2020. Boiler #1 had 7 failed ignition major errors logged in its controller from the winter season of 2020 (Image 6). Boiler #1 was built and installed in 2020. The boiler room has two outdoor air grills approximately 16x16 inches square each. One at floor level and one at ceiling height. The boiler room has an exhaust fan. The supports for boiler # 1's vent were near the first bend and not tight around the vent. This is in line with the venting manufacturers guidelines to allow for expansion and contraction (Image 5).

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Testing findings by independent gas fitter October 11, 2022

[Additional information on the testing findings in the square brackets]

- Found boiler [boiler # 1] in standby on arrival, scrolled through faults/errors found several faults on ignition.
- Shut off the other 2 IBC boilers [boiler 2,3] which forced the #1 boiler to cycle on.
- At this point a Dwyer [brand] manometer was installed to check manifold and inlet pressures [for boiler # 1], manifold pressure appeared to be in spec throughout the firing range, the inlet pressure at low fire was approximately 8" w.c. but fell to 4.9" at full input/firing rate. [The minimum inlet pressure as per the boiler nameplate is 4 inches water column. This drop in inlet pressure is not likely to contribute to delayed ignition].
- The light off was not a smooth light off on one occasion but not to the point of lifting the vent off. [Hard light off such as this is indicative of delayed ignition].
- The burner was removed, and the ignitor inspected, the ignitor gap is greater than manufacturers spec by approximately 1.5 to 2mm. It is also beginning to warp/bend under the stress of prolonged heating (which is normal for these).

Maintenance gas fitter statements

- They had attended the site in July of 2022 for a quarterly maintenance visit, where they cleaned out the combustion chamber with a manufacturer approved product. The inlet gas pressure was checked [and no issue identified]. The ignitor gap was not checked as that was not the contractor's normal practice.
- They attended the site October 3, 2022, for unrelated work and found the IBC boiler #1 running with the vent pipe dislodged from the boiler's exhaust vent connector.
- The clamp that holds the vent in was not loose and had to be loosened before reinstalling it.
- The system was commissioned [by others] in 2021 after a large reno at the building. It [boiler #1] had the original ignitor in it still.

Ignitor product changes

- The boiler manufacturer issued a change to single prong and double prong ignitors that applies to the SL G3 boiler at this site on their website on July 30, 2020, including the following wording:
"During the 2018 heating season, a fraction of IBC's ignitors showed signs of rod distortion. The rod material in the ignitors has since been changed to a Kanthal APM (advanced powder-metallurgical) material to fortify the structure of the ignitor. The improved ignitors sell in the following kits: P-111B for the double-prong offset ignitor and P-340B for the single-prong offset."
Link: [Fortified Ignitors](#)
- The boiler manufacturer identified issues with the original ignitors and issued a discontinuation of P-340 single prong ignitors that applies to the SL G3 boiler at this site as well as other models on their website on January 22, 2021, including the following wording:
"Effective immediately, the P-111B double-prong ignitor (Figure 1) replaces the P-340 single-prong ignitor. The P-111B is the new standard for the SL-series boilers as it combines an improved metallurgic formula for longevity with the convenience of a factory-set spark gap."
Link: [P-111B change](#)

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	<p>Boiler product guidance material</p> <ul style="list-style-type: none"> The manufacturer's installation and operation manual specifies a spark gap setting of between 3.2 minimum and 4.7mm maximum (Image 7). The boiler service manual includes a yearly service maintenance task for a qualified service technician to check the ignition electrode and remove oxidation from the electrode. Replace if necessary. The installation and operation manual includes a maintenance section that does not include any ignitor tasks. The installation and operation or service manuals available online do not include reference to the discontinuation of, or any requirements to replace P-340 single prong ignitors. <p>Installing gas contractor statements</p> <ul style="list-style-type: none"> The boilers were installed and started up in 2020. The ignitors were never changed as the combustion chamber was not opened as the boilers were brand new. The manufacturer helped the gas fitter set the three boilers in a master slave configuration.
<p>Causes and contributing factors</p>	<p>The single prong ignitor issued by the manufacturer with this boiler was unsuitable to maintain the required clearance for ignition. The resulting delayed ignitions very likely dislodged the venting from the boiler's exhaust connector.</p>



Image 1 – Vent for boiler #1 found dislodged from the boiler exhaust connector.



Image 2 – Boiler # 1 with stainless steel cover off.



Image 3 – Boiler #1 single prong ignitor gap at 6.5-7mm from burner mesh.

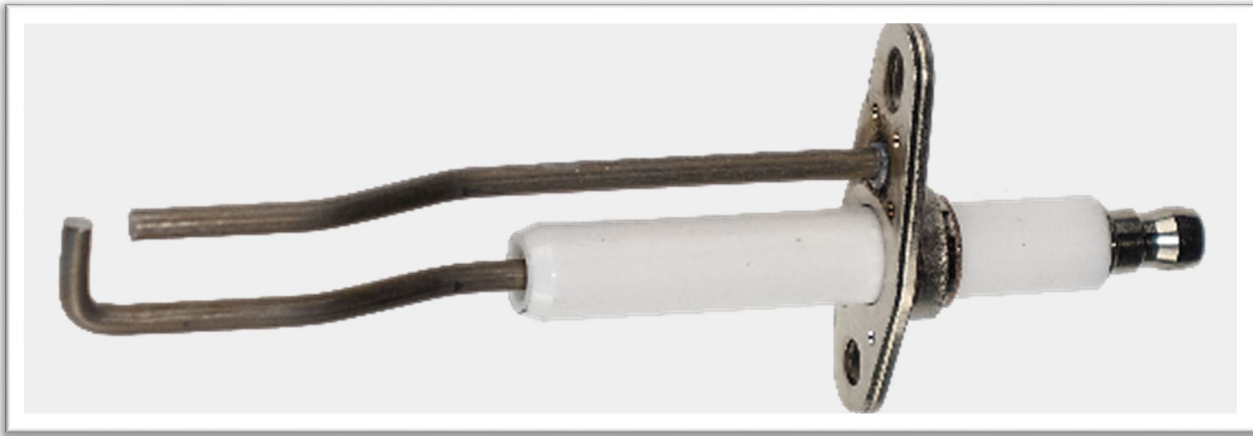


Image 4 - Dual prong type ignitor indicated in boiler manufacturers January 2021 product change.

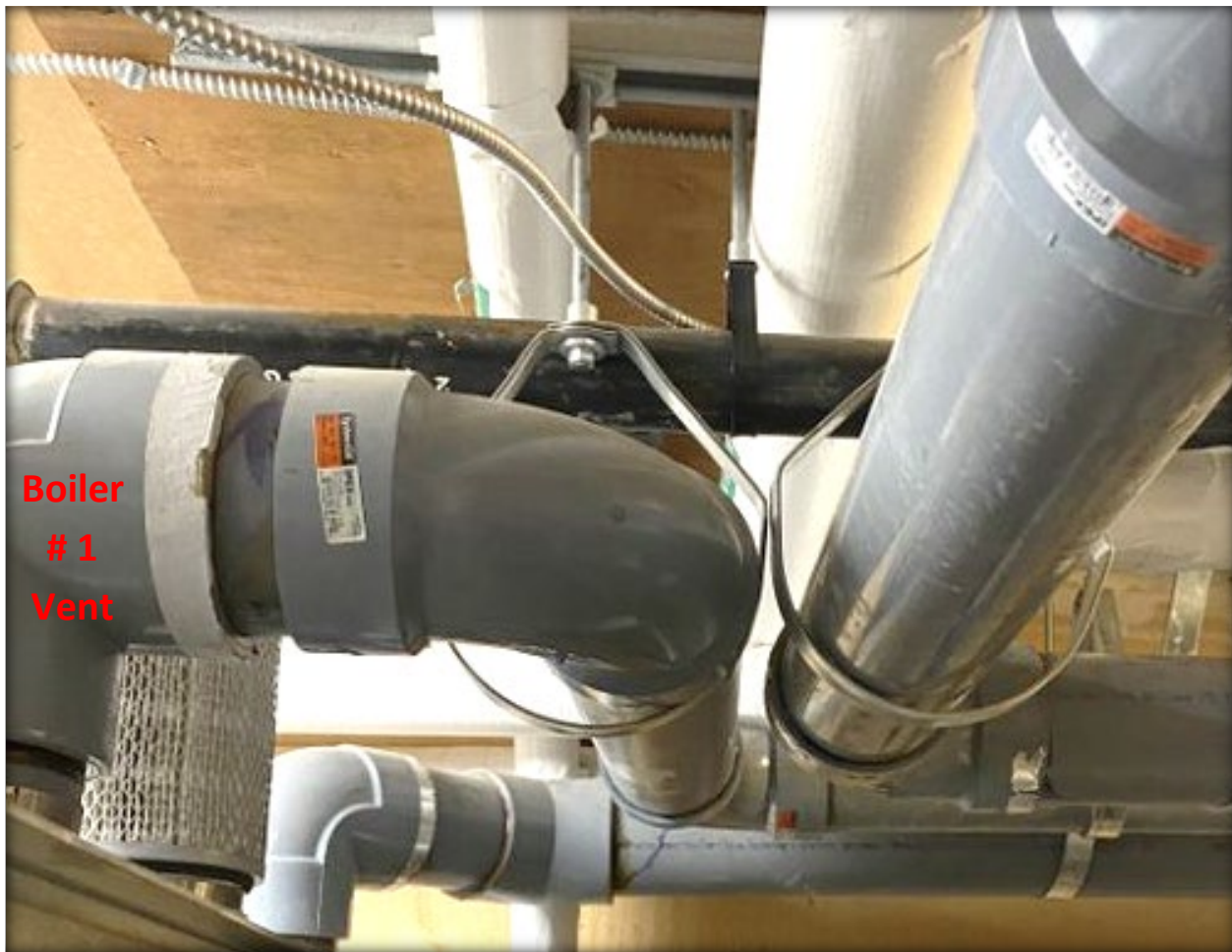


Image 5 – Vent system supports with Boiler # 1.

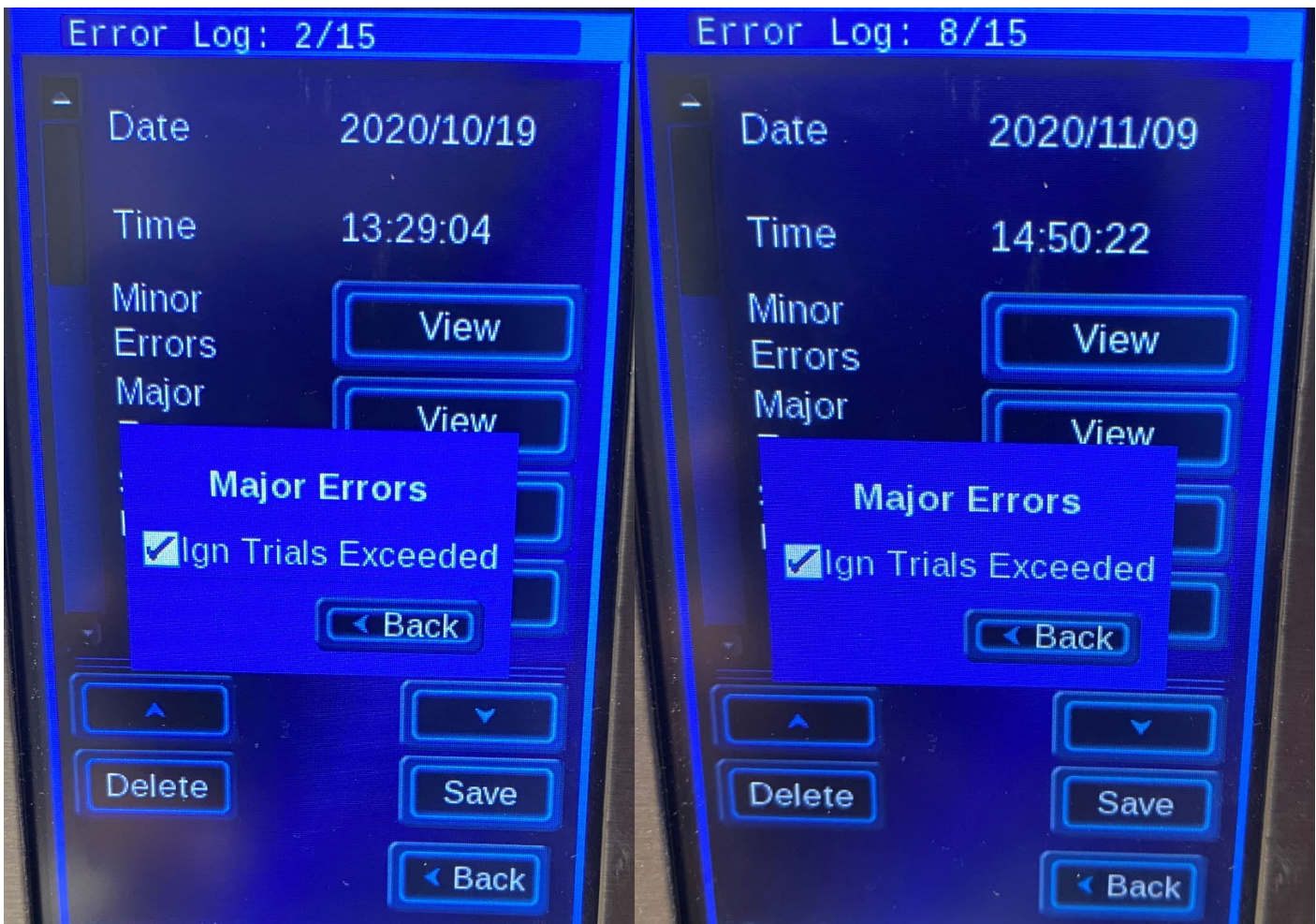


Image 6 - Major ignition trials exceeded errors (2 examples of 7) prior to the incident.

SYMPTOM	DIAGNOSIS	REMEDY
MAXIMUM IGNITION TRIALS ERROR Touchscreen Message: Error – Ignition Failure after 3 tries Boiler has failed to ignite on 3 successive attempts. Boiler in lockout for 1 hour, then repeats 3-try seq. Consult service technician if error recurs.	Gap between igniter probe rods is too large or too small.	Adjust ignitor probe rod gap between 1/8th and 3/16th (3.2-4.7 mm)

Image 7 – Troubleshooting guide (Control module display errors) - Manufacturers installation & operating instructions.

Properties of Carbon Monoxide

<i>Colourless</i>	Cannot be seen.
<i>Tasteless</i>	Cannot be detected through the sense of taste.
<i>Odourless</i>	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.
<i>Non-irritating</i>	Carbon Monoxide will not cause irritation. However, aldehydes usually present with higher levels of CO will irritate the eyes, nose, and mucous membranes.
<i>Specific gravity</i>	Slightly lighter than air (Sg 0.975). It may, but not always collect near the ceiling, and mixes freely with air.
<i>Flammable (explosive) limits</i>	CO is flammable between concentrations of 12.5% to 74% when mixed with air. Its ignition temperature is 609°C (1128°F).
<i>Toxic</i>	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

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