Incident Summary #II-1271688-2021 (#24671) (FINAL)

SUPPORTING INFORMATION	Incident Date		October 19, 2021
	Location		Coquitlam
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	1
		Injury description	1 open house visitor reportedly fainted.
		Injury rating	Moderate
	Impact – Damage	Damage description	Products of combustion including significant levels of carbon monoxide (CO) were exhausted into the residence. The vent system was disengaged from the boiler. The boiler ignitor experienced distortion from heat.
		Damage rating	Minor
	Incident rating		Moderate
	Incident overview		Delayed ignition detonations resulted in the exhaust vent being blown off the top of the wall mounted condensing boiler with products of combustion including CO exhausting into the dwelling. One person reportedly fainted from exposure to CO while attending an open house.
INVESTIGATION CONCLUSIONS	Site, system and components		**Site and system** • The house utilizes a wall mounted condensing natural gas hydronic boiler manufactured by IBC Technologies for water heating (Image 1). • The heating system includes the boiler, vent system, water tank, pumps, zone valves, thermostats and numerous plastic tubing loops built into the floor to provide heat. **Boiler components** • 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 (Image 2 & 3). • 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, then circulating pumps move the water through the heating loops that heat the rooms throughout the residence. • Under normal operation, the products of combustion from a boiler are exhausted to the exterior of the dwelling through approved venting. **Boiler ignition sequence** • 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.

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	• 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. **Vent system** • The CentroTherm Innoflue vent system is rated to a maximum vent pressure of 20 inches of water column. • The exhaust vent system consists of 2-inch polypropylene (PP) rigid vent pipes, gaskets, retaining clips, fittings and accessories tested under UL-1738 and ULC-S636 standards. • When the vent system is used with appliances that have 3-inch exhaust vent connections, the vent manufacturer has a specific 3-inch gasketed appliance adapter component and a 3-inch to 2-inch gasketed reducer component to be used along with the associated 3-inch and 2-inch retaining clips. • The vent system is tested and approved for use only with the manufacturers specific vent components and is not for use with glue. • The vent manufacturer strongly recommends the use of the manufacturer's supplied clam shell style supports. In instances where the manufacturer's supports are not suitable, field supplied supports that are of clam shell design and have a minimum threaded rod diameter of 5/16" (8mm) are permissible. • The manufacturer's installation guide specifies to space vent support brackets no more than 39 inches (1m) apart for horizontal sections and 78 inches (2m) apart for vertical sections. The guide also states to use additional support brackets at directional changes such as elbows or tee sections as needed. **Carbon monoxide** • 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)	The boiler was manufactured in 2020 and issued with a single prong ignitor that had residual stress in the metal offset bend (Image 2). During operation, the arc gap between the ignitor prong and the metal burner mesh increased beyond the manufacturer's recommended gap distance from release of the residual stress in the ignitor during exposure to heat. On multiple occasions, the boiler was not initially igniting the natural gas as indicated by multiple major ignition trials exceeded errors (Image 5) in the boiler controller. This delayed ignition led to a build up of unburnt gas and explosive detonations when ignition would finally occur. The vent system used two separate reducers that were incompatible with the PP vent pipe, and glue to connect the reducers to the PP vent, which is incompatible with PP vent pipe. The vent system was originally installed with a 2-inch PP vent glued into a 2x3-inch acrylonitrile butadiene styrene (ABS) reducer. After the vent was dislodged on October 19th, 2021, the ABS reducer was exchanged for a CPVC (chlorinated polyvinyl chloride) reducer. Upon arrival for testing in September 2022, the CPVC reducer was also found to be dislodged.

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	The vent system was dislodged in both cases from the force of the boiler's delayed ignition detonations (Image 6) releasing products of combustion, including CO, into the residence.
Facts and evidence	**Site findings** • The ignitor gap was approximately 6-7mm, which is above the maximum recommended gap setting of 4.5 mm. • The boiler error log had 4 failed ignition major errors before the Oct 19th 2021 incident between Aug 31, 2021 to October 16, 2021. • The 3 inches to 2-inch (ABS) reducing fitting (bushing) from original installation was found disconnected from the boiler exhaust entrance fitting after the Oct 19, 2021 incident. • A 3 inch to 2-inch CPVC reducing fitting installed as a post incident replacement for the previous reducing fitting was found disengaged from the boiler exhaust connector prior to the September 15, 2022 testing. • The boiler exhaust connector has a sealing gasket for CPVC (3.5"/88.9mm outside diameter) venting systems. • There is an adhesive residue ring below the sealing where the original ABS reducer was seated indicating a seal was made (Image 7). • The boiler has a label indicating the year built as 2020. **Testing findings by independent gas fitter September 15, 2022.** [Additional information on the testing findings in the square brackets] **Boiler findings** • #1 alarm, dated 2021/08/31, through #5 alarm in fault log dated 2021/10/29 07:20:29, all for max ignition trials exceeded. [These errors are indicative of the boiler not initially igniting the natural gas during ignition sequences which is associated with delayed ignition detonations] delayed ignition. • #6 Alarm, dated 2021/10/29 14:13:46, through #8 Alarm in fault log dated 2021/11/03, all for Fan Pressure minor alarm. NOTE these all occurred while boiler is running and firing. [This may be indicative of condensate backup overfill]. • Boiler set to natural gas and 0-4500 Ft altitude, [suitable for the site's fuel type and location]. • Burner in fair condition, gasket in good condition, burner mesh in good condition. • Line voltage measured at 119.2V. [This indicates power quality was not an issue at time of testing]. Wiring and electrical connections [for the ignitor] inspected and in good condition. • Condensate drain connection showing leakage, both inside the boiler and outside showing signs of acidic venting condensate corroding boiler housing. • Heat exchanger in poor condition, visible debris in combustion chamber, with the appearance of coffee grinds. [This likely indicates condensate overflow and debris from corrosion] **Vent system findings** (*in place during Sept 2022 testing)* • 2" CentroTherm [PP – polypropylene] estimated at 40 feet, glued to a system 636 CPVC 3"x2" bushing [reducer] at unit. Boiler venting joins 2 incompatible materials, using a glue on a product (PP), not intended to be glued. **Gas findings**

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- Inlet gas pressure 8.0”WC static, 7.6”WC at high fire. [In line with the product nameplate requirements for gas pressure].
- Inlet gas pressure remains well above minimum inlet pressure on high fire. [This indicates that low gas pressure was unlikely a factor to any delayed ignition].
- [Regulator] Lock up pressure 13”WC, does not creep up. [This indicates lock up pressure was unlikely to have contributed to delayed ignitions].
- Satisfactory pressure and regulator operation indicate no debris in gas line.
- No supply line problems, pressures within range, no apparent restriction.
- Fuel pressure regulator set and operating correctly.
- Gas valve operating properly.
- Manometer measurement of flue gas pressure saw a repeated increase to 0.13” WC [inches water column] at time of ignition. [this is below the maximum venting system pressure rating of 20 inches water column]

General findings

- Video footage of venting filling the room with over 50 PPM setting off CO handheld device and combustion analyzer, confirmed with two instruments. Measurements taken with ventilation for safety, concentrations would be higher without cross flow ventilation.
- Flue gas analysis completed [with measurements of the gases in typical ranges].
- Moisture in room, on door jam, and reported by homeowner has been an issue since day of installation.

Utility gas technician attended the dwelling Oct 19, 2021 and found a significant amount of carbon monoxide coming from the boiler room and shut off the gas. They identified that the venting was not secured to the boiler and red-tagged the boiler.

Neighbors stated the CO detectors in the home involved with incident had alerted on multiple occasions.

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

Boiler manufacturer representative communications

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- This boiler was issued with a single pronged ignitor of the Kanthal APM [advanced power metallurgy].
- The manufacturer does not have any commissioning or other technical support cases recorded for this unit.

Boiler manufacturer technical support statements

- The coffee grind debris in the bottom of the combustion chamber is likely from an overflowing condensate trap [which was full Sept 15, 2022]. The condensate drain may be clogged.
- The condensate could rise in the chamber and contribute to ignition trials error as well as fan high pressure errors. [This can be associated with increase in pressure and moisture in the chamber, both errors were found in this boiler's error code history]
- The single prong ignitor is good for 4-5 years normally, but sometimes can cause issues, so they recommend changing to a dual prong ignitor.
- There is no switch that would prevent the boiler from operating if the vent was dislodged.

Boiler product guidance material

- The manufacturer's installation and operation manual specify a spark gap setting of between 3.2 minimum and 4.7mm maximum.
- 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.

Vent system representative communications

- Mixing and matching of vent materials are not allowed per UL Listing. [Such as in the case of PP mixed with ABS or CPVC reducers and their glued connections].
- The ISAAL0303 appliance adaptor with a reducer from 2-inch to 3-inch ISRD0302 are required part(s) to transition a 2-inch Innoflue Centrotherm single wall exhaust vent to engage with this boiler that accepts 3-inch schedule 40 pipe.
- Every joint [of a Centrotherm Innoflue venting system] is male to female and sealed by way of a gasket on the female side. These are further reinforced by the connector rings (IANS03 or 02).

Vent installation guide

- Use of Centrotherm supplied supports [example: clam shell style part # IASCM02] is strongly recommended. In instances where Centrotherm supports are not suitable, field supplied supports that are of clam shell design and have a minimum threaded rod diameter of 5/16 inch (8mm) are permissible.

Installing gas contractor statements

- The boiler had a single prong ignitor originally that was never changed by this contractor.

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	• The venting system was supported with U shape 2-hole steel clamps secured to ceiling joists every 4 feet and above the boiler. • They stated they are familiar with commissioning of this type of boiler and there were no errors during the commissioning. • The manufacturer was not involved with commissioning the boiler at this site. • There was lots of dust from construction, mudding, and sanding during the start up stage for the boiler but there were no errors. • They stated having recommended to the owner yearly maintenance for the boiler and an additional initial 6-month maintenance given the construction dust. They were reportedly never called back for maintenance. **Homeowner statements** • An occupant fainted while in the residence for an open house and multiple open house customers reported smelling gas in the residence. • The painter working prior to the incident had complained of smells of gas in the house. • The CO detectors alarmed multiple times prior to the incident. • Water was on the basement floor coming from the boiler room prior to the incident. • The boiler had been run during construction to dry the drywall mud. • The homeowner stated that the boiler hadn't had any maintenance by a gas fitter. • The owner, using a ladder for access above the boiler, viewed the left vent pipe (exhaust vent) completely disconnected and halfway overlapping the entry hole on top of the boiler after the Oct 19, 2021 incident.
Causes and contributing factors	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 incorrectly connected venting configurations. Condensate backup overfill may have contributed to the delayed ignition. The use of reducer fittings incompatible with and glued to the polypropylene venting may have contributed to the vent system disengaging from the boiler during delayed ignition detonations. From related investigations of the same line of boilers, it was found that the pressure from a delayed ignition detonation was sufficient to dislodge properly installed venting systems.

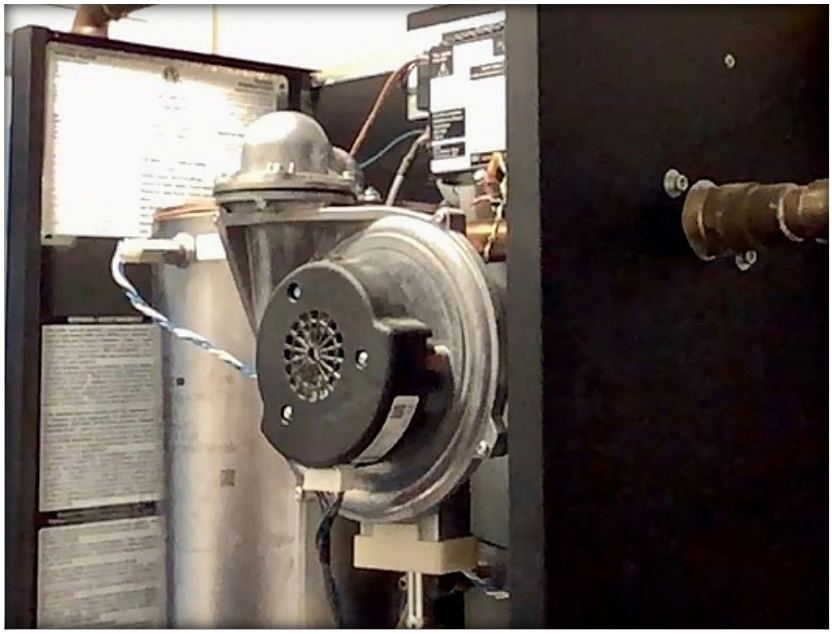

Image 1 – IBC condensing boiler with stainless steel cover off.

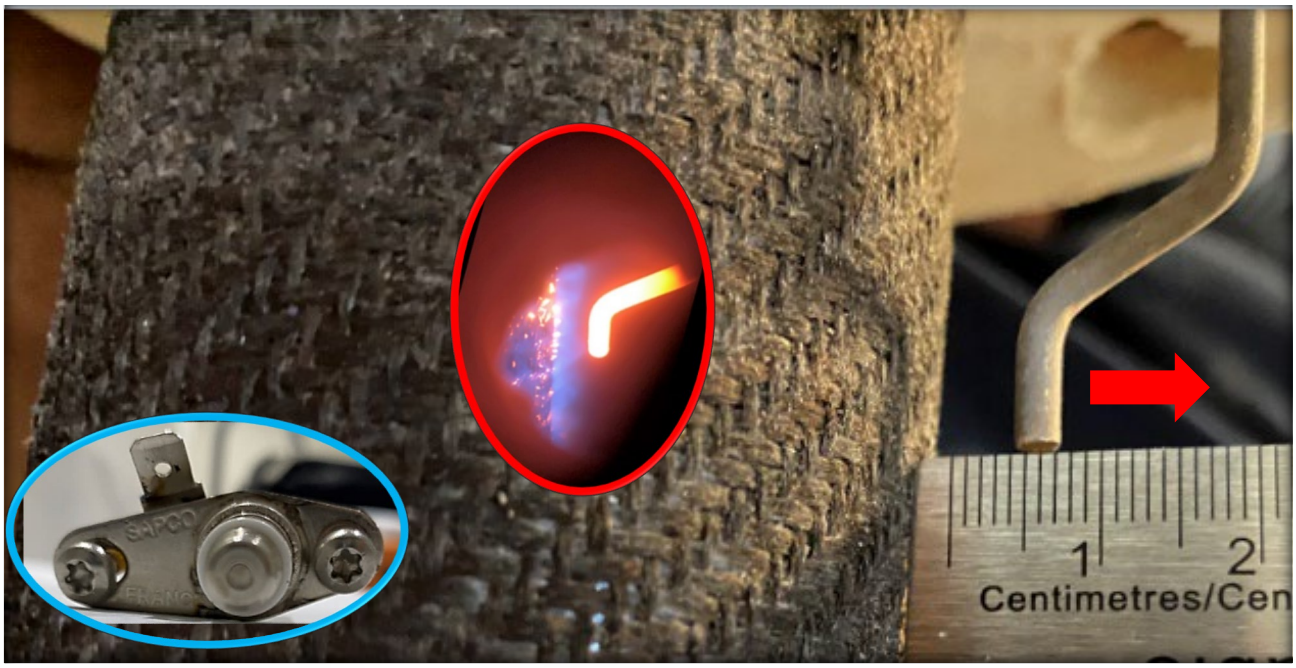

Image 2 - Single prong ignitor and gap distance shown (approximately 6-7mm), arrow indicating direction of rod distortion away from mesh. Note the manufacturer's manual specifies a spark gap setting of between 3.2 and 4.7mm. Red oval picture shows the ignitor during high temperatures after ignition. Blue oval picture shows the ignitor attachment plate and manufacturer details.

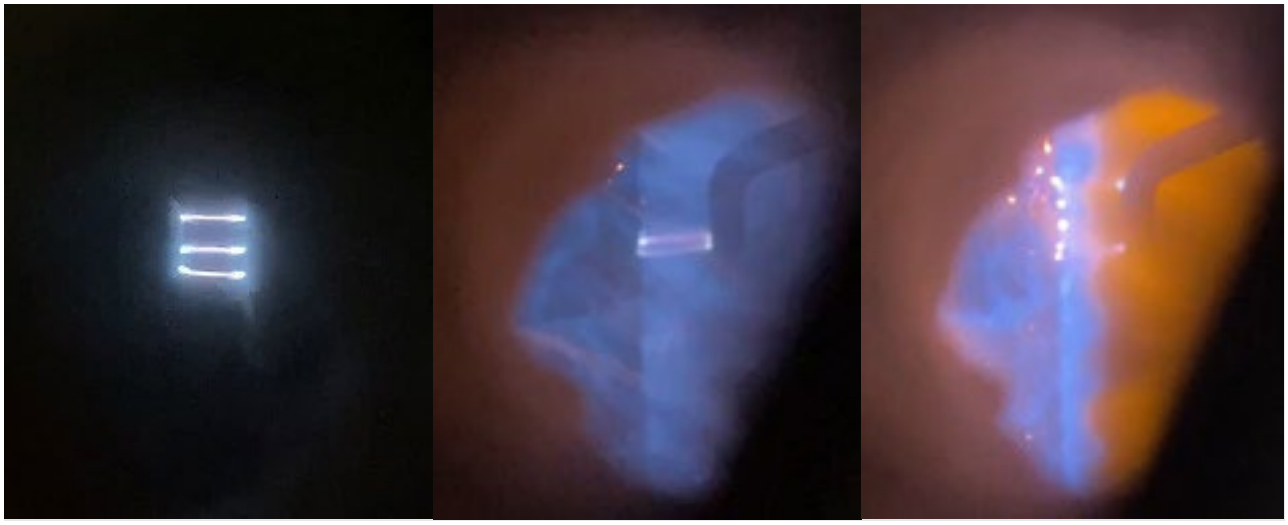

Image 3 - Single prong ignitor arcing to the burner mesh during a 4 second ignition trial during testing.

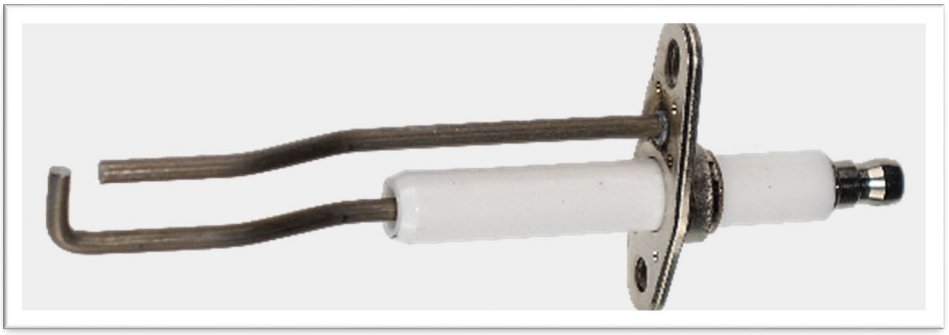

Image 4 - Dual prong type ignitor (P111B) indicated to replace the discontinued single prong ignitor (P-340) in the boiler manufacturers January 2021 product change.

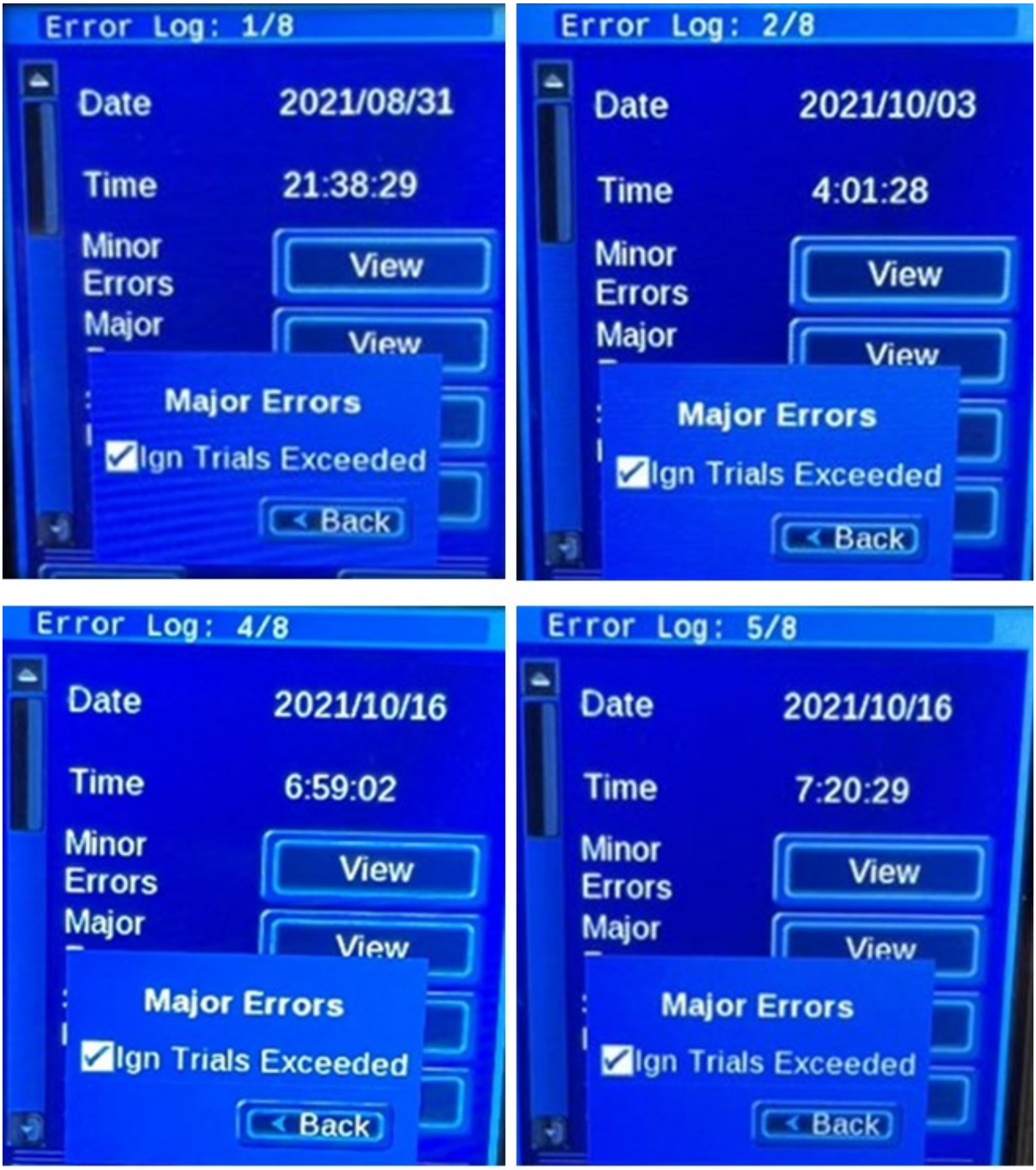

Image 5 - Major ignition trials exceeded errors (4 times) leading up to incident.

Image 6 - The PP vent dislodged from the black ABS reducing fitting on October 19, 2021.

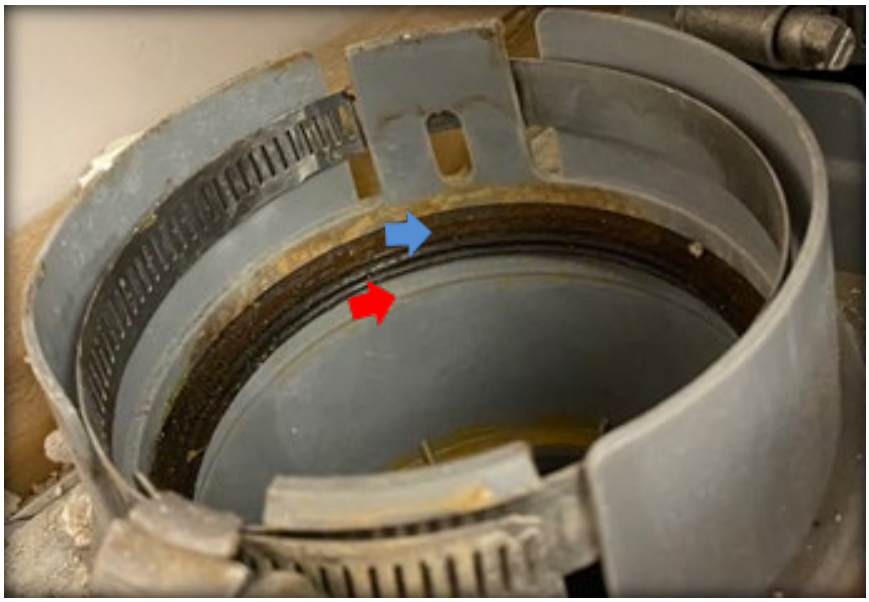

Image 7 – The exhaust vent entrance on the top of the boiler. The gasket (blue arrow) is for sealing around 88.9mm diameter vents. There is a ring from adhesive where the original ABS adapter was seated (red arrow).

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

Properties of Carbon Monoxide

Colourless	Cannot be seen.
Tasteless	Cannot be detected through the sense of taste.
Odourless	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.
Non-irritating	Carbon Monoxide will not cause irritation. However, aldehydes usually present with higher levels of CO will irritate the eyes, nose, and mucous membranes.
Specific gravity	Slightly lighter than air (Sg 0.975). It may, but not always collect near the ceiling, and mixes freely with air.
Flammable (explosive) limits	CO is flammable between concentrations of 12.5% to 74% when mixed with air. Its ignition temperature is 609ºC (1128ºF).
Toxic	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
1 to 3	Normal.
25	Occupational exposure limit averaged over 8 hour period.
30 to 60	Exercise tolerance reduced.
100	15-minute short-term exposure limit (STEL).
60 to 150	Frontal headache. Shortness of breath on exertion.
150 to 300	Throbbing headache, dizziness, nausea, and impaired manual dexterity.
300 to 650	Severe headache; nausea and vomiting; confusion and collapse.
700 to 1000	Coma and convulsions.
1200	Immediately dangerous to life and health (IDLH).
1000 to 2000	Heart and lungs depressed. Fatal if not treated.
Above 2000	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"