Incident Summary #II-1295456-2021 (#25240) (FINAL)

SUPPORTING INFORMATION	Incident Date		November 23, 2021
	Location		Prince George
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Impact – Damage	Damage description	Venting dislodged from boiler allowing products of combustion and condensate to enter the mechanical room.
		Damage rating	Minor
	Incident rating		Minor
	Incident overview		A natural gas fired boiler experiencing explosive detonations from delayed ignition exhausted products of combustion including carbon monoxide (CO) into the mechanical room when the venting system was blown apart from the force of the detonations.
INVESTIGATION CONCLUSIONS	Site, system and components		**Site and system** - The multi unit care home facility utilizes natural gas boilers including two IBC hydronic boilers with sealed venting systems (Cat IV). - The boilers use the combustion of natural gas to heat water which is circulated to heat coils through out the building and is controlled by a direct digital control (DDC) system. **Boiler components** - The boiler ignitor applies an electrical arc to natural gas in the burner. - The produced heat transfers to the water by way of a heat exchanger. This is done at intervals determined by the electronic controls of the boiler based on settings and demand. - The heat exchanger transfers heat to the water system without direct contact. - There are single prong and double prong ignitors that have been provided by the manufacturer for this type of boiler depending on the date of manufacture. - The single prong ignitor operates by creating an electrical arc between the prong and a grounded metal burner mesh. - The double prong ignitor creates an electrical arc between the ignitor's energized prong and the ignitor's grounded prong. - Whether a single or double prong ignitor is utilized, the distance of the gap is a critical factor in ensuring proper ignition. **Boiler venting system** - This boiler's exhaust venting system is required to be sealed at all joints and connections. - The venting consists of polypropylene ducting with gasketed connections and clipped couplings that is supported by metal rod hangers and clamps. - The venting system manufacturer's instructions include requirements for supporting the venting at specified interval distances.

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	Carbon monoxide - CO is a colourless, odourless, tasteless gas that is toxic to humans and animals (Chart 1). - Exposure to CO interferes with the body's ability to absorb oxygen, which can result in serious illness or death. - Symptoms of CO poisoning can present similar to flu symptoms: headaches, nausea, dizziness, or vomiting. - For more information on CO, visit CO Safety Tips.
Failure scenario(s)	The boiler used a single prong ignitor (Image 1) that had residual stress in the metal offset bend. When overheated from the long run cycle occurrences, the arc gap between the ignitor prong and the metal burner mesh would very likely increase beyond the manufacturer's maximum recommended gap distance. On this occasion, the boiler was not initially igniting the natural gas. This delayed ignition led to a build up of unburnt gas and explosive detonations when ignition finally occurred. The venting system separated (Image 2/3) within the interior space from the force of the boiler's detonation. This released products of combustion including moisture and CO into the mechanical room.

Facts and evidence	- Site maintenance worker statements:
	  - While performing a daily mechanical room check, they found exhaust condensate all over the floor and discovered that the boiler venting had segments that had come apart.
	  - The two IBC boilers were installed in 2019 and had yearly pre-winter maintenance by a gas contractor.
	  - The two IBC boilers were the primary boilers and there are other boilers that ran as backup.
	  - They are not aware of there being any CO detectors in the mechanical room.
	- Another site maintenance person stated hearing what sounded like a gun shot from the mechanical room at the time of the incident.
	- Repairing gas fitters' statements and logs:
	  - When attending the site, the IBC boiler B2 was found running and exhausting directly into the room as the venting system was not connected to the boiler. The gas fitter shut off the boiler, exited the room due to concern of CO poisoning, and notified maintenance personnel.
	  - A gun shot type sound was heard when the delayed ignition occurred during troubleshooting.
	  - Upon review of the ignitors through the viewing windows for boilers 1 & 2, the offsets looked similar but the ignitor for boiler 2 was more worn and darker.
	  - The incident had occurred when boiler B2 had delayed ignition and blew the venting system apart.
	  - The boiler (control) board typically allows three errors (ex. delayed ignition) and then shuts off. Once the venting system is blown off, the boiler would continue to run without build up of gas in the sealed chamber or delayed ignition as the boiler exhaust would be free airing.
	  - The pressure switch systems for the boilers monitor for intake and exhaust blockages only and do not monitor for a disengaged venting system.
	  - The basement boiler room was roughly 15-20 feet by 30 feet (450-600 Sq. Ft.) and has a combustion air supply for the space.
	  - Boiler B1/ B2 run constantly at this site with the ignitors directly in the flame.

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	- Boiler B2's digital history log indicated it had an average of 5 ignitions per day and boiler B1 had an average of 4 ignitions per day. - Maintenance log records (Image 4) indicated all boilers on site were serviced on September 28 2021, by a gas fitter. The gas fitter stated this type of maintenance would typically include pulling the ignitors and cleaning them, checking gas pressures, washing the boiler's heat exchanger, cleaning drains, ensuring pressure switch ports are clear, checking electrical connections, and starting up the boiler to run it through a heat cycle. - When the single prong ignitor was replaced with an owner supplied dual prong ignitor during troubleshooting, the delayed ignition stopped occurring. - The November 30th 2021, boiler log book entry indicates that boiler #2 had an internal bang on ignition during troubleshooting (Image 4). - The IBC boilers nameplate bears a manufacturer date of 2018. - The original installing gas fitter stated the two new IBC Boilers were installed incorporating existing venting systems. **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
Causes and contributing factors	The gap between the single prong ignitor and the burner very likely exceeded the maximum recommended gap leading to the delayed ignition inside the boiler burner chamber. The delayed ignition likely caused the boilers venting to become dislodged.

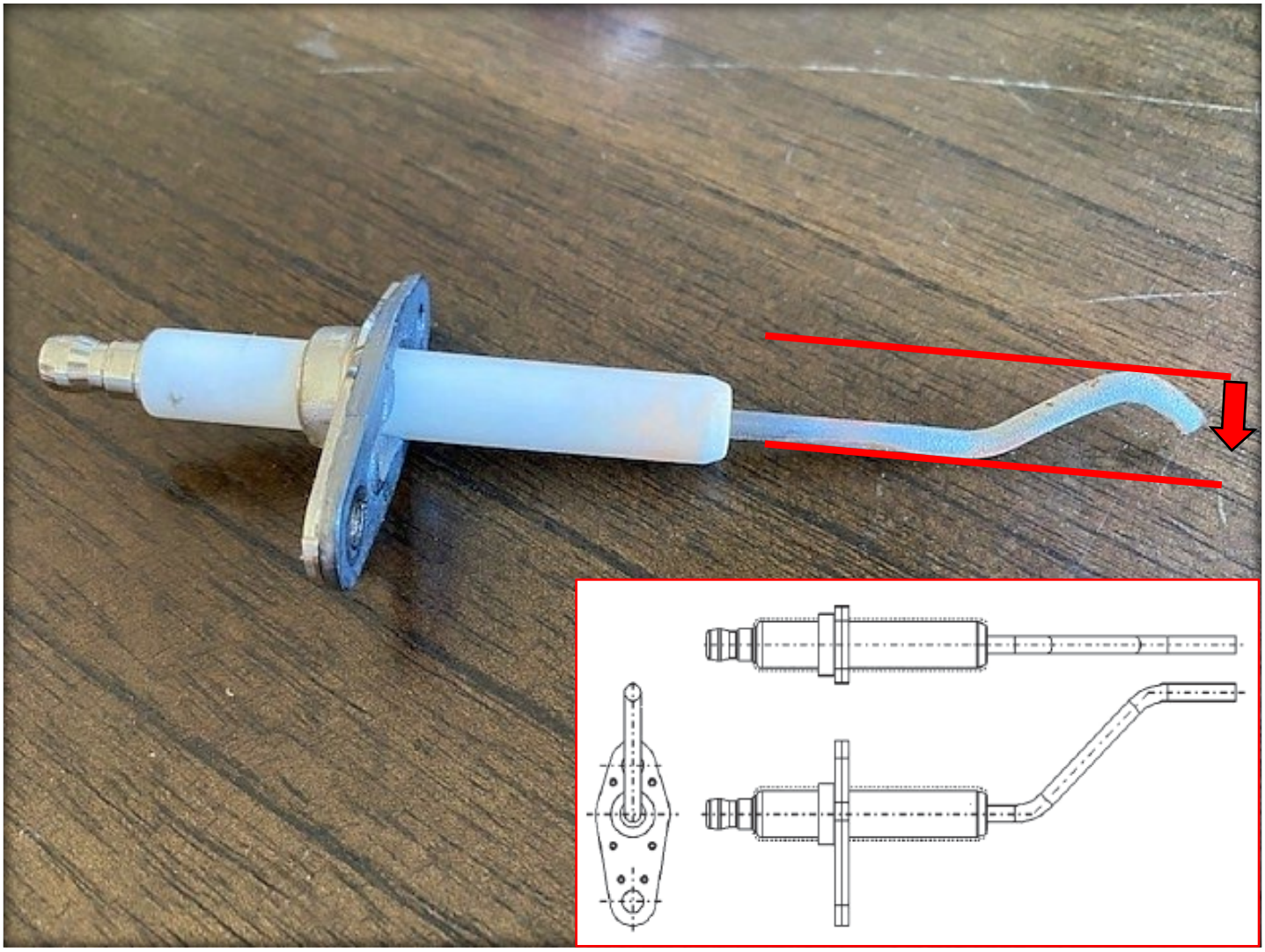

Image 1 – Ignitor removed from the boiler after the incident. Offset bent away from parallel (arrow) compared to as built drawing.

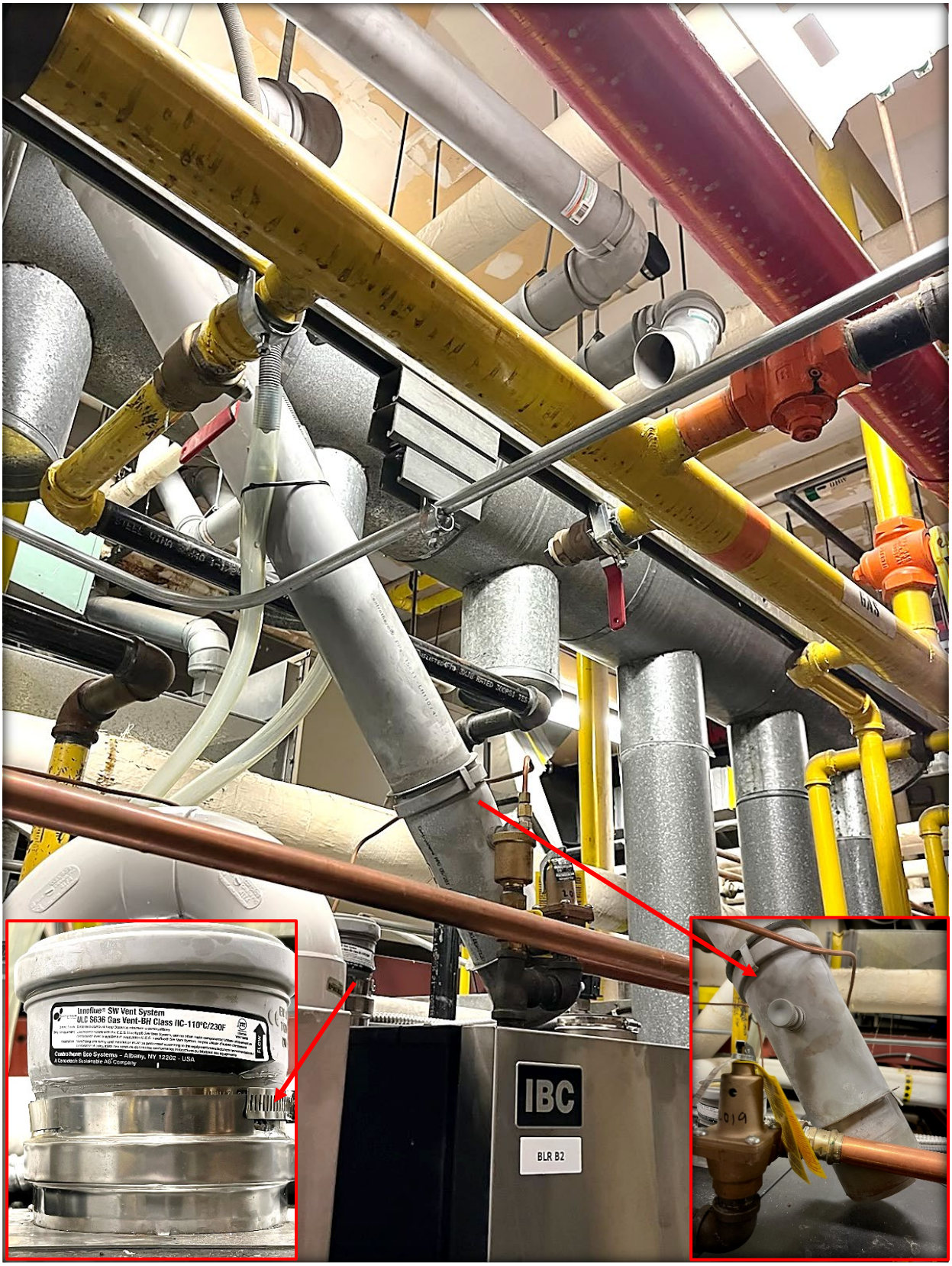

Image 2 – Boiler B2 after the incident with the venting system disengaged and knocked over.

Image 3 – Boiler B2 venting system disengaged (red line) and knocked over (blue line).

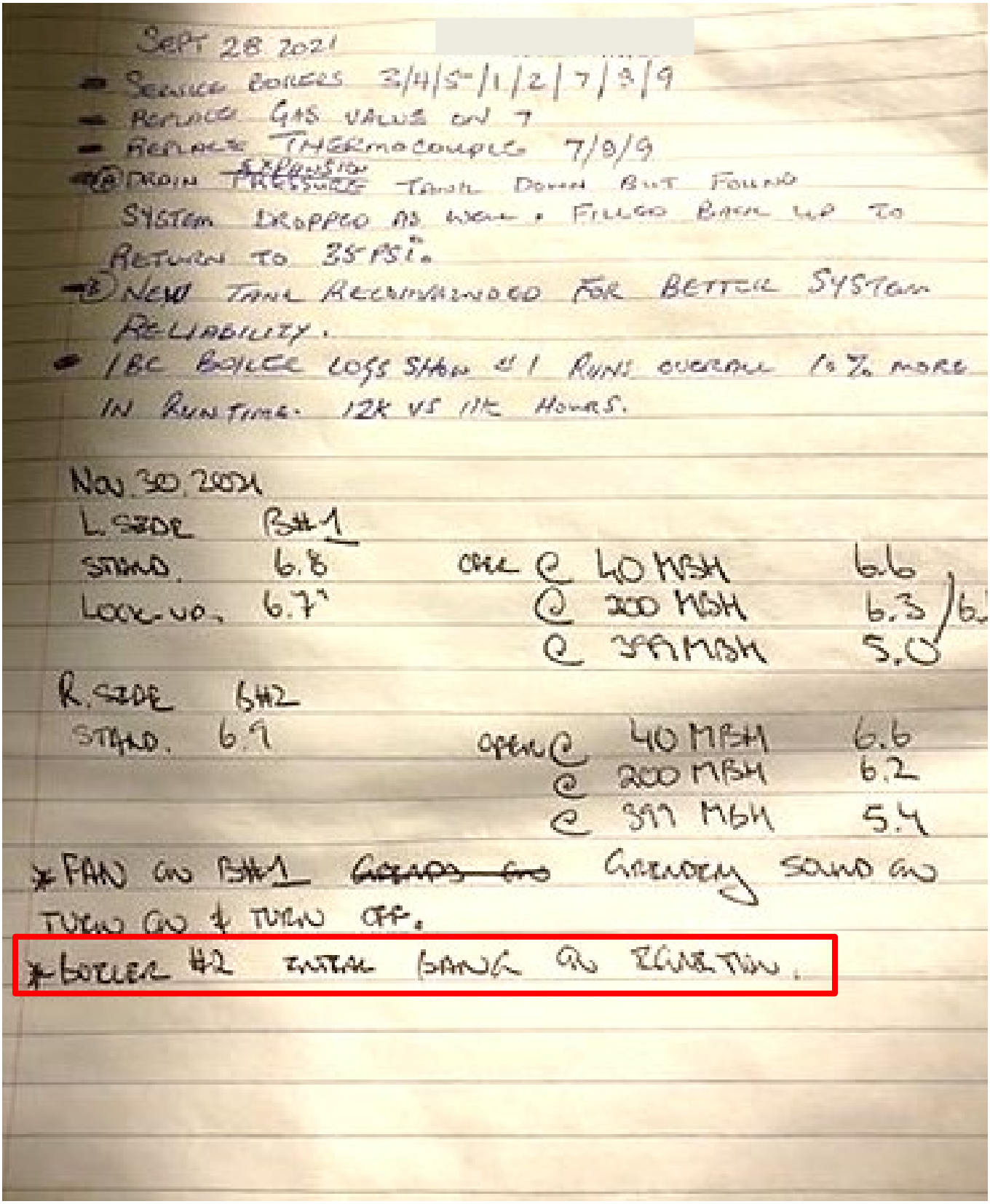

Image 4 - Boiler logbook indicating boiler # 2 had an initial bang on ignition during post incident troubleshooting on Nov 30, 2021.

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"