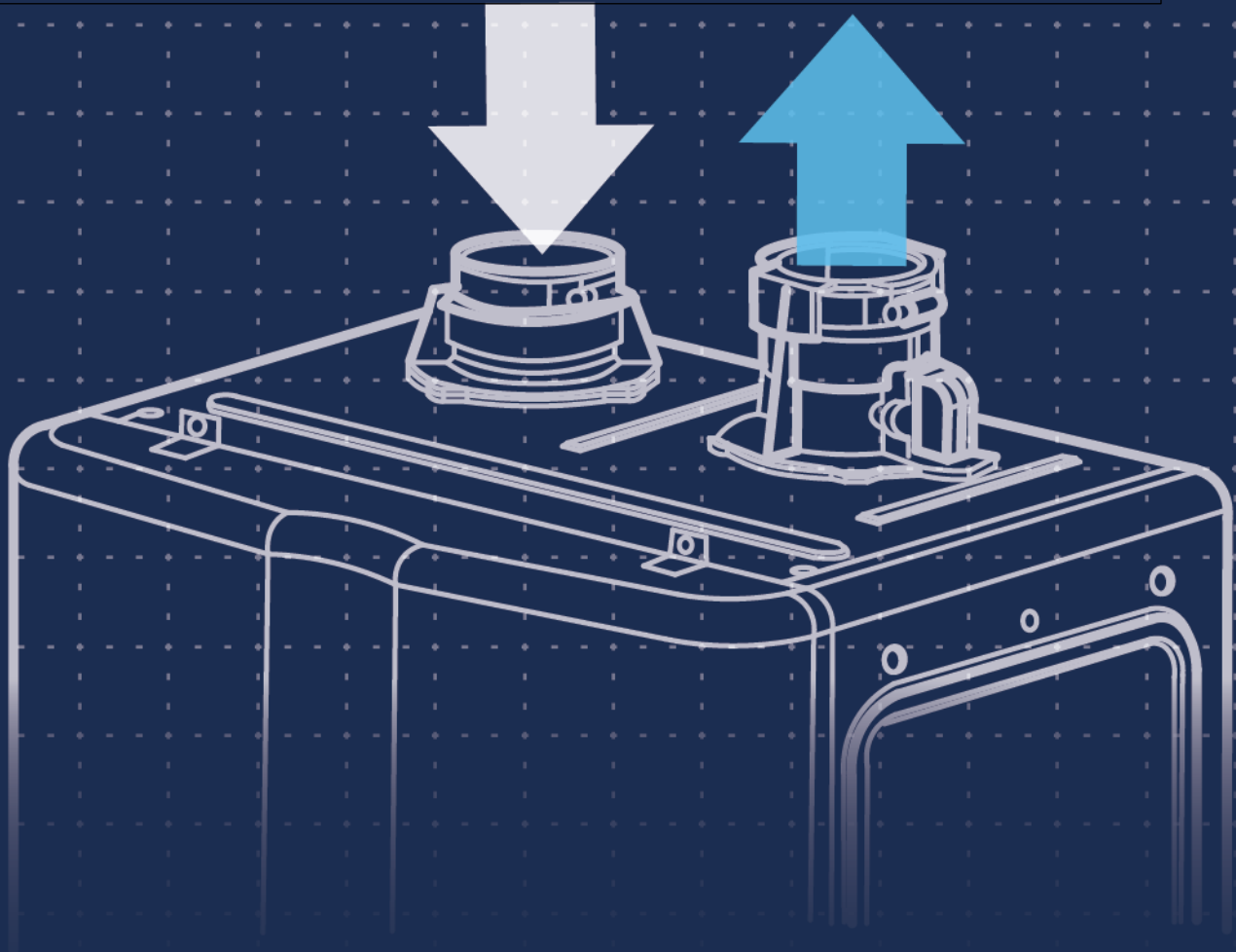


Incident Investigation Report

Carbon Monoxide Release From Boiler Exhaust Venting



Investigation Summary

Background and Trend Identification

At the time of writing this report, carbon monoxide (CO) remains the top identified technical safety risk in British Columbia. As part of our commitment to understanding and mitigating that risk, Technical Safety BC (“TSBC”) investigates incidents, and monitors incident data for emergent trends. Following our investigation of a [2021 incident in Maple Ridge](#) (the “Maple Ridge Incident”), TSBC identified a trend of incidents related to disconnected venting systems related to Category IV, low pressure hot water boilers utilizing direct-spark ignition of the main burners. In total, TSBC investigated 13 separate incidents over a period of several years and was made aware, through communications with other regulators across the country, of similar incidents in other jurisdictions. A system level investigation was undertaken, and this report is being issued pursuant to that investigation to help inform TSBC’s broader prevention initiatives.

Technical Safety BC Jurisdiction and Role

TSBC administers the Safety Standards Act and Gas Safety Regulation, both of which apply to gas systems and equipment in BC, including natural gas boilers and venting systems. Following an incident, TSBC is empowered to investigate to learn from the incident and prevent similar occurrences in the future.

Findings: Systemic Risk Exists Among Certain Category IV Boilers

TSBC’s expanded investigation — including review of other incidents, certification requirements, and directed testing — found that direct ignition boilers, certified to CSA standard 4.9 are at an increased risk of creating carbon monoxide incidents. The boilers allow for delayed ignitions which are capable of damaging the attached venting systems and then continue to operate releasing carbon monoxide indoors. The following factors likely contribute to these incidents:

1. Dedicated delayed ignition testing completed as part of the certification process does not adequately address the potential for venting system damage.
2. Even with proper installation and servicing, delayed ignitions that are capable of damaging or dislodging venting systems can still occur.
3. The boiler designs investigated allowed for continued operation with damaged and dislodged venting systems.
4. Non-cemented joints were more susceptible to failure from delayed ignition, including gasketed venting joints, or boiler/vent adapters.

Recommendations

Recommendations made by TSBC pursuant to this report are included at the end of the report.

Affected Boilers and Operation

Limits of Risk

The investigation found that the affected boilers are Category IV, direct ignition boilers certified to CSA 4.9. No trend or elevated risk has been found to exist among piloted ignition boilers or boilers certified to other standards at this time.

Use and Prevalence

Category IV direct ignition boilers have recently become extremely popular choices in North America due to their versatility. They can be used as standalone units to service buildings such as single family homes, or connected together to service large heating loads in places like condo buildings, schools, or care homes. They are frequently used in new installations and have also become popular choices to replace old models of boilers with larger footprints and less ability to vary heating capacity. The popularity of this style of direct ignition boiler has increased significantly over approximately the last decade.

Operation

When there is a call for heat from the thermostatic controls, direct ignition boilers use an electronic ignition system which supplies arcing voltage from an ignitor rod to ignite a fan-controlled mixture of gas and air released from the main burner. Upon a successful ignition, the boiler transfers heat between the gas combustion and water heating chambers through a heat exchanger. As the gas is burned it creates combustion gases which include moisture and CO. Under normal operation, the boiler fan exhausts the combustion gases from the combustion chamber through a fully enclosed venting system to the exterior of the building where they can dissipate safely.

Venting Systems

Manufacturers generally list approved venting systems for each model of boiler in their certified instructions. Typically, boilers will include some or all of the following: polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), stainless steel (SS), or polypropylene (PP) vent components approved under ULC S636, *Standard for Type BH Gas Venting Systems*. PVC or CPVC venting systems are cemented pipe systems which use a solvent cement that effectively welds the pipe joints together. They are then typically attached to the boiler using a gasketed vent connector and clamp to secure it in place.

The boiler involved in the Maple Ridge incident, as well as several others investigated, were connected to a PP venting system. Unlike cemented venting systems, PP venting is assembled and sealed with gaskets and retaining clips. The pipe is inserted into a fitting with an internal gasket, and mechanical clips are secured to an external ridge on the pipe. All Category IV boiler exhaust venting systems must be sealed at every joint and connection.

Delayed Ignition Detonations

The electronic ignition system is required under the product standard to ignite the gas in less than four seconds after gas reaches the main burner. Delayed ignition events can occur within the four second period when gas entering a combustion chamber is not initially ignited by the electronic ignition system at the beginning of its timed ignition sequence. A delay in main burner ignition allows a volume of a combustible air/gas mixture to accumulate, and when ignition then occurs, the combustion creates a sudden high-pressure condition inside the combustion chamber and flue passages.

Pressure from a delayed ignition can travel through the boiler and exhaust venting system, imparting significant force on the boiler and the attached venting systems. Venting systems are not intended to withstand the pressure spikes associated with delayed ignition events. This can dislodge vents from the appliance and can separate gasketed vent joints. This can potentially

allow continued boiler operation to create serious hazards such as interior moisture causing mould and rot, fire hazards, and toxic CO exposure.

Delayed ignitions can occur due to a wide variety of reasons. Some of the possible causes of ignition issues in boilers:

- Incorrect combustion-air volume.
- Incorrect or fluctuating gas type, supply, pressure, or volume.
- Incorrect ignitor gap or spark location and strength.
- Incorrect electrical connection or supply.
- Dirty/plugged burner mesh.
- Dirty/plugged heat exchanger.

Incorrect appliance installation and maintenance may increase the likelihood of these conditions occurring; however, even diligent adherence to the manufacturer's guidelines cannot eliminate the possibility of delayed ignitions. In interviews, manufacturers indicated that it is not possible to eliminate delayed ignitions from occurring at some point in a boiler's lifecycle. This is partially because many aspects of ignition are reliant upon factors both internal and external to the boiler. To account for this, the product standard incorporates delayed ignition testing intended to validate the boiler's resilience to damage when subject to a delayed ignition.

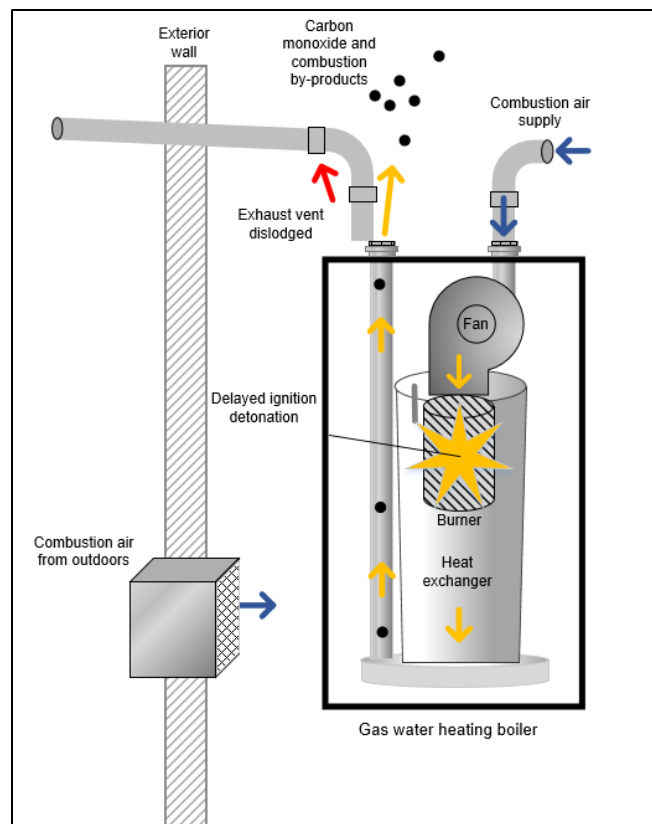


Figure 1 - Boiler delayed ignition damaging attached venting system and continuing to operate spilling flue products including CO into an indoor space.

Carbon Monoxide (CO)

CO is a natural by-product of combustion in any gas-burning appliance. The exhaust contains small amounts of CO, which is typically carried outside by the venting system where it can safely dissipate. Depending on the quality of combustion, and the air to fuel ratio, the percentage of CO in the exhaust can increase or decrease dramatically.

CO is a colourless, odourless, tasteless gas that is toxic to humans and animals. 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 [Carbon Monoxide Safety Tips](#).

Incident Investigation: Maple Ridge Incident

A notable incident occurred in a multi-unit residential building with a common wall-hung condensing boiler located in a central mechanical room used to provide radiant heat for the individual housing units (the "Boiler"). The Boiler was a natural gas-fired Category IV low-pressure hot-water boiler utilizing direct-spark ignition of the main burner. The Boiler was certified by a certification body as conforming to CSA 4.9-14, *Gas-fired low-pressure steam and hot water boilers*.

Relevant facts and evidence, including site observations, interview statements, and documentation related to this investigation were detailed in the original report, which can be found [here](#).

Maple Ridge Incident

On May 23, 2021, the Incident occurred at a multi-dwelling residential building in Maple Ridge, BC (the "**Premises**"). A natural gas fired boiler used for hydronic heating in multiple dwellings experienced delayed ignitions, resulting in damage to the Boiler's attached venting system (the "**Incident**"). The Boiler operated with a damaged venting system, and spilled products of combustion, including toxic CO, into the interior areas of the building. The issue was identified after a gas utility technician responded to a call about a gas odour in the building and notified TSBC.

Investigation

TSBC's investigation revealed that the Boiler had a history of delayed ignitions and the venting system had been damaged multiple times previously. The venting had been previously repaired incorrectly, indicating that delayed ignition occurrences had been an ongoing issue from the time of the Boiler's installation. Escaping products of combustion, including corrosive condensate, moisture, and CO, had infiltrated multiple interior spaces, causing corrosion to electrical distribution equipment, disintegration of the electrical room ceiling drywall, and bowing and splitting of the wood flooring in the dwelling above due to moisture buildup.

Multiple occupants of the Premises reported symptoms of CO exposure, including headaches, nausea, vomiting, loss of focus, and drowsiness at various times over a period of three years. One such occupant sought medical attention for the CO symptoms.

Findings

The Maple Ridge Incident occurred when delayed ignitions damaged the Boiler's attached venting system. The Boiler continued to operate, releasing products of combustion, including CO into indoor areas.

Site observations, interviews, and documents obtained during the [Maple Ridge Incident Investigation](#) showed that the Boiler had a history of delayed ignitions and repeated venting-system damage. The venting had been reattached and the Boiler returned to service, but the underlying hazard persisted. The following factors likely contributed to this incident:

1. The boiler selection for the application was oversized, which resulted in short cycling of the Boiler, increasing the amount of ignition events.
2. Original ignitor selection by the manufacturer contributed to inconsistent ignitor gaps resulting in delayed ignitions.
3. Boiler setup and adjustment with manufacturer technical representatives reduced the delayed ignitions but did not eliminate them.
4. Delayed ignitions had separated the Boiler's polypropylene venting system multiple times during its three years of operation and each time the Boiler would continue to operate, spilling flue products including CO into indoor spaces.

Note: The findings set out in this report have been updated from the original report to reflect information obtained through subsequent investigations and to align them with the broader investigation report.

Expanded Investigation

Following numerous additional notifications beginning in 2020 regarding CO releases from direct ignition boilers into occupied spaces — including schools, residences, and care homes — TSBC expanded its investigation. These incidents were linked to delayed ignition events that caused venting components on wall-mounted boilers to become dislodged. While all incidents involved gas fired Category IV* low pressure hot water boilers utilizing direct-spark ignition of the main burners, they were not limited to a specific boiler manufacturer or certification body.

For more information on those events please see [Appendix A](#) and visit our [incident investigations](#) page.

** Category IV gas appliances operate with a positive vent pressure and a vent gas temperature capable of causing excessive condensate production in the vent.*

Expanded Investigation: Shared Risk Across CSA 4.9-Certified Boilers

While the Maple Ridge Incident involved one boiler installation, it established a site-specific failure sequence: recurring delayed ignitions damaged the attached venting system, the boiler continued to operate, and combustion products entered occupied interior spaces. Based on additional incident notifications involving similar venting failures and CO releases, TSBC expanded its investigation to determine whether that same failure mode represented a broader systemic risk among direct spark ignition boilers certified to CSA 4.9, rather than a hazard limited to one

installation, installer, manufacturer, certification body, contractor, or venting material. The expanded investigation included review of other incidents, examination of certification requirements, and directed testing of venting system performance during delayed ignition events.

Other Incidents Investigated

To date TSBC has investigated 13 other incidents that share the same or similar risks. Other incidents investigated (see [Appendix A](#)) involved gas-fired Category IV low-pressure hot-water boilers incorporating direct-spark ignition of the main burners, tested and certified to the CSA 4.9 standard, and utilizing approved venting systems certified to the ULC S636 standard. These incidents were observed across multiple boiler manufacturers and certification bodies, indicating that the issue is not limited to a particular manufacturer, product line, or certification body. The incidents involve boilers installed in residences, commercial applications, schools and care homes across the province.

CSA Group Standards

CSA Group standards reflect a national consensus of producers and users including manufacturers, consumers, retailers, unions and professional organizations, and governmental agencies. The standards are used widely by industry and commerce and often adopted by municipal, provincial, and federal governments in their regulations, particularly in the fields of health, safety, building and construction, and the environment in order to establish a minimum requirement for quality, safety, and performance.

The CSA 4.9 standard contains a series of tests and requirements for Category IV boilers that must be adhered to. Once a particular model meets the requirements of the standard, the certification agency responsible will authorize the use of a certification mark for that model. That model is then considered authorized to be sold in British Columbia (see Gas Safety Regulation section 31 (1), (a), (i)).

CSA 4.9, *Gas-Fired Low-Pressure Steam and Hot Water Boilers*

This standard applies to newly produced gas-fired low-pressure steam and hot water boilers with gas inlet pressure ratings not exceeding 0.5 psi (3.5 kPa) and input ratings of less than 12,500,000 Btu/h (3 663.389 kW).

The standard states that “The construction of a boiler, whether specifically covered in this Standard or not, shall be in accordance with reasonable concepts of safety, substantiality, and durability. Component parts shall be well-fitted and not show signs of becoming warped, bent, broken, or otherwise damaged during the initial test installation or during any of the tests specified to prevent compliance with this Standard.”

ULC S636, *Standard for Type BH Gas Venting Systems*

This standard identifies requirements that cover the design, construction, and performance of gas venting systems intended for negative or positive pressure venting of gas-fired appliances producing flue gases. The certification covers several different venting types, materials and connection methods.

The scope within the standard notes: “Compliance of a venting system with this standard does not imply that the venting system is acceptable for use on a gas appliance without supplemental

tests in the applicable gas appliance standard resulting in the listing of the appliance for use with the specific type(s) of venting system covered by this standard.”

When asked in an interview, certification bodies indicated that the “supplemental tests” performed were temperature tests of the flue to ensure that temperatures would not exceed those allowed by approved venting systems.

Boiler Testing and Certification

Certification and Testing Context

Delayed ignitions are a known possibility during boiler operation and are specifically tested under the 4.9 standard to assess the boiler’s resilience to damage when subject to a delayed ignition. The testing protocol requires varying delay time intervals of the ignition system up to the maximum specified trial for ignition. To pass the test, each trial must be completed without excessive flame flash-out or damage to the boiler. However, the CSA 4.9 standard does not require assessment of the attached venting system for damage resulting from delayed ignition events, nor is venting system integrity included in the pass/fail criteria. In addition, CSA 4.9 specifies only that the minimum length of venting is acceptable for the delayed ignition test and does not specify the type or configuration of venting for that testing. While the standard requires testing with maximum equivalent venting, no comparable requirement exists for delayed ignition testing.

For comparison, ULC/ORD-C795, Commercial-Industrial Gas Heating Equipment, used for certifying commercial and industrial factory-built gas-fired package boilers, also requires delayed ignition testing. Unlike CSA 4.9, the method of test in ULC/ORD-C795 expressly includes the connected vent system: “delay of ignition shall not result in flashback of flame to the outside of the appliance or any damage to the appliance and the connected vent system”. Damage to the connected venting system is therefore a criterion in ULC/ORD-C795 for passing or failing the test, but it is not included as a pass/fail criterion in CSA 4.9. The language in this document does not apply to the boilers discussed in this report that are certified to the CSA 4.3 standard.

Hazard Notification and Investigation

When a manufacturer becomes aware of incidents involving safety concerns that indicate a certified boiler may pose a hazard or no longer conform to its certification standard, it is expected under certification agreement obligations to promptly notify the applicable certification body (requirement as part of accreditation with the Standards Council of Canada). The certification body may then evaluate the notifications and initiate further investigation.

In several incidents investigated, TSBC was the first to notify the certification body of the incident. When notified, certification bodies would undertake a review of their records to ensure that the model involved in the incident had passed certification and the investigation was closed. Any additional investigation at the site, or manufacturer level was minimal and no additional documentation was provided to TSBC other than certification records.

Directed Delayed Ignition Testing

As part of the expanded investigation, TSBC directed the manufacturer of the boiler involved in the Maple Ridge Incident to conduct additional delayed ignition testing on a new boiler of the same make and model. This testing was used to assess whether the hazard identified in the

incident could also occur under certification-compliant delayed ignition conditions when approved venting materials and maximum equivalent vent lengths were used.

The tests were carried out at the Boiler manufacturer's facility that operates as a satellite facility to complete testing under an agreement with the certification body. The testing protocol followed the specifications outlined in the CSA 4.9 standard using PP venting material attached to the boiler that is approved for use on the boiler by the manufacturer.*

In addition to the minimum requirements in the CSA 4.9 standard, the venting system used in the investigation testing incorporated lengths of pipe and elbows that equated to the manufacturer's longest acceptable equivalent vent length for installation (200 feet). This allowed TSBC to assess whether delayed ignitions that satisfied the certification test method could still damage attached venting systems under installation conditions permitted by the manufacturer.

The testing showed that approved venting attached to a CSA 4.9-certified boiler could experience catastrophic failure during delayed ignition events that remained within the standard's permitted four second ignition timing. At certain intervals, between one and 2.5 seconds of delay, the venting was catastrophically damaged and, in several cases, dislodged from the boiler vent connector.

No further tests exceeding 2.5 seconds of delayed ignition were conducted due to the extent of the damage to the venting system. During the testing, delayed ignitions did not result in any observable damage to the boiler. This result could be interpreted as passing certification since damage to the venting system is not a criterion that has to be assessed according to the standard.

*The venting was installed with sufficient horizontal supports to hold the weight of the venting system as required by the venting manufacturer in their certified instructions. The instructions also indicated to use additional supports "as needed" at changes of directions. There were no supplemental supports included for the tests performed.



Video 1 - Catastrophic venting failure with a 1.0 second ignition delay.

Video 2 - Catastrophic venting failure with a 2.5 second ignition delay.

[Video #1](#) (Click link for video)

[Video #2](#) (Click link for video)

Additional information regarding directed testing performed can be found in [Appendix B](#).

Findings

Systemic Risk:

TSBC's expanded investigation — including review of other incidents, certification requirements, and directed testing — found that direct ignition boilers, certified to CSA standard 4.9 are at an increased risk of creating carbon monoxide incidents. The boilers allow for delayed ignitions which are capable of damaging the attached venting systems, and then continue to operate releasing carbon monoxide indoors.

Contributing Factors:

- 1. Dedicated delayed ignition testing completed as part of the certification process does not adequately address the potential for venting system damage.**

Current delayed ignition testing does not encompass all approved vent styles or consider how length and configuration will affect resilience to delayed ignition events. Testing performed with maximum equivalent length venting, and/or multiple elbows and changes in directions, resulted in significant damage to the venting system even when ignitions occurred within the allowed ignition trial period. In addition, venting damage is not considered in the pass/fail criteria for this test as only boiler damage is called out by the standard.

- 2. Even with proper installation and servicing, delayed ignitions that are capable of damaging or dislodging venting systems can still occur.**

Several manufacturers advised TSBC that delayed ignitions within the trial for ignition period cannot be completely prevented, even with proper installation, maintenance and servicing. The investigation found that when these delayed ignitions occur, in a manner acceptable to the standard (within the trial for ignition period), venting damage often results. In many cases, the boiler will continue to operate, releasing and recirculating CO into interior spaces.

- 3. The boiler designs investigated allowed for continued operation with damaged and dislodged venting systems.**

Although some manufacturers have introduced safeties to prevent operation when certain failures occur (such as a failure at the boiler-to-vent adapter), there are no current requirements for these safeties and many have not. In the incidents investigated, the boilers continued to operate following venting damage from a delayed ignition resulting in the harmful release of CO indoors. The most recent incident, a CO release in North Vancouver resulting in seven hospitalizations, the boiler experienced ignition issues over 75 times before finally igniting. At no point did the boiler lock out in a manner that required a qualified person to investigate and properly address the risk.

- 4. Non-cemented joints were more susceptible to failure from delayed ignition, including gasketed venting joints, or boiler/vent adapters.**

Non-cemented joints used for the transmission of flue gasses can appear in several areas in a boiler system, within the boiler, at the boiler-to-vent adapter, or within the venting system (in the case of polypropylene/steel materials). In all incidents investigated, failures occurred in gasketed or press-fit joints rather than cemented joints (such as those used in CPVC or PVC vent styles). In testing performed using maximum approved lengths of polypropylene venting, multiple failures often occurred, including the complete dislocation of venting components such as elbows, as well as failures at the boiler-to-vent adapter. Investigation found that many certification tests for delayed ignition did not use gasketed style vents, or did not use them at their maximum approved length, despite listing them as an approved venting material in the certified instructions.

Recommendations

Recommendation #1: For owners to promptly service boilers and install CO Alarms

It is recommended that owners and operators of buildings with direct ignition, gas-fired boilers certified to CSA 4.9:

1. Retain a licensed contractor to inspect and service your boiler promptly if it has not been done in accordance with the manufacturer's instructions. The boiler should be reinspected and serviced at least annually to reduce the risk associated with delayed ignitions. Additional information regarding servicing of gas appliances can be found on the [Technical Safety BC website](#).
2. Install CO Alarms in accordance with current building code and manufacturer requirements, and at a minimum, within the boiler mechanical room and in every suite of a multi-unit residential building.

Rationale

TSBC's investigation found that delayed ignitions can damage or dislodge attached venting while the boiler continues to operate, allowing combustion products, including CO, to be released into occupied spaces.

In the Maple Ridge Incident, venting damage occurred repeatedly over time before the cause of delayed ignitions was identified and properly addressed. In many other incidents investigated, regular service was not occurring, resulting in degraded conditions within the boiler that increased the chance of both delayed ignition, and CO exposure. Servicing and repair by a licensed contractor can greatly reduce the chance of a delayed ignition and the potential for it to result in venting damage.

The investigation identified there are many possible causes of delayed ignitions, and the location of venting failures that can result from these delayed ignitions can vary. Although proper servicing and installation does greatly reduce the chances of delayed ignition; it does not fully eliminate the risk. When a delayed ignition does happen, even compliant installations can experience vent damage, and CO release. CO Alarms provide an additional layer of protection that can alert occupants and building operators to hazardous conditions and allow for safe evacuation of the building.

Recommendation #2: For qualified workers to take all necessary steps to reduce the risk of delayed ignitions when working on boilers and vents

It is recommended that licensed gas contractors and certified gas fitters ensure the following when installing, servicing, or repairing any direct ignition boiler certified to CSA 4.9:

1. The proper functioning of all combustion and ignition related functions of the boiler, such that the opportunity for delayed ignition is minimized.
2. The proper support, arrangement, and integrity of venting systems and boiler-to-vent adapters such that the opportunity for damage to venting systems is minimized.

Rationale

TSBC's investigation found that delayed ignitions and associated venting damage can recur over time, and that venting components may be reattached or repaired without the underlying hazard being eliminated. The investigation also identified problems with venting support, proper commissioning of the boiler combustion, or installation of the boiler-to-vent adapter in many of the incidents we examined. Contractors are reminded that proper servicing of a boiler includes the boiler itself, as well as the attached venting system.

Because contractors are typically the parties called to inspect, diagnose, and service these boilers, they are in a key position to identify conditions associated with delayed ignition and venting failure before the boiler is returned to service. Where unsafe conditions remain, the boiler must not be returned to operation. Gas fitters are reminded that units that cannot be returned to safe operation must be prohibited from use and a Safety Officer must be notified.

Recommendation #3: For manufacturers to evaluate and improve boiler design

It is recommended that manufacturers of Category IV direct ignition boilers:

1. Evaluate new and existing designs of Category IV direct spark ignition boilers alongside approved venting materials, adapters, and configurations to determine whether field installed assemblies will safely respond to delayed ignitions.
2. Where necessary, implement appropriate design, control, detection, and/or installation measures for boiler designs to mitigate the risk of continued operation when venting system integrity is compromised.

Rationale

TSBC's investigation found that delayed ignitions are a foreseeable condition over the lifecycle of direct ignition boilers and cannot be fully eliminated through installation, commissioning, or maintenance practices alone. When repeated delayed ignitions occurred in the incidents reviewed, they were capable of damaging or dislodging manufacturer-approved venting systems and boiler-to-vent connections, including non-cemented joints, gasketed connections, and adapters. Following delayed ignition, boilers continue to operate, spilling CO, and other combustion products into indoor spaces resulting in occupant exposure, evacuations and property

damage. In many cases, boilers entered soft lockout conditions from ignition failures, but restarted shortly after, repeating this cycle until eventually, an incident occurred.

Manufacturers are reminded that certification demonstrates compliance with minimum standard requirements; however, manufacturers remain responsible for ensuring their equipment is designed to operate safely, including where necessary, to fail safely. The incidents reviewed indicate an elevated safety risk associated with continued boiler operation after loss of venting integrity that is not adequately mitigated by current product design or incorporated safety features.

Recommendation #4: For the responsible committee to revise applicable certification requirements

It is recommended that the committee responsible for CSA 4.9, gas-fired low-pressure steam and hot water boilers, revise the standard to include design, performance, and certification requirements so that future boiler designs are required to account for the risk of both venting failure, and continued operation following delayed ignition events.

Rationale

Delayed ignition testing being performed as part of certification is not resulting in the desired safety outcome likely intended by the standard. TSBC's investigation and directed testing found that direct ignition boilers certified to CSA 4.9 can experience delayed ignitions that damage or dislodge attached venting while the boiler continues to operate, despite having passed certification requirements. This can allow combustion products, including CO, to be released into occupied spaces.

Testing conducted as part of this investigation found that delayed ignitions at varying intervals within the standard's permitted ignition timing could cause catastrophic venting failure when approved venting was installed at maximum equivalent length.

The current standard requires only minimal venting during delayed ignition testing and does not include attached venting damage as a pass/fail criterion. Further, there were no requirements to monitor for vent damage, or prevent operation of the boiler in the event of vent disconnection, resulting in an unmitigated risk of CO release.

[Appendix A](#) - Other documented boiler vent failures (13 incidents involving four different boiler manufactures, all with dislodged venting systems and up to 443 ppm CO measured in indoor occupied spaces).

Images



Image 1 – (Maple Ridge incident) Wall hung Boiler in the building mechanical room.

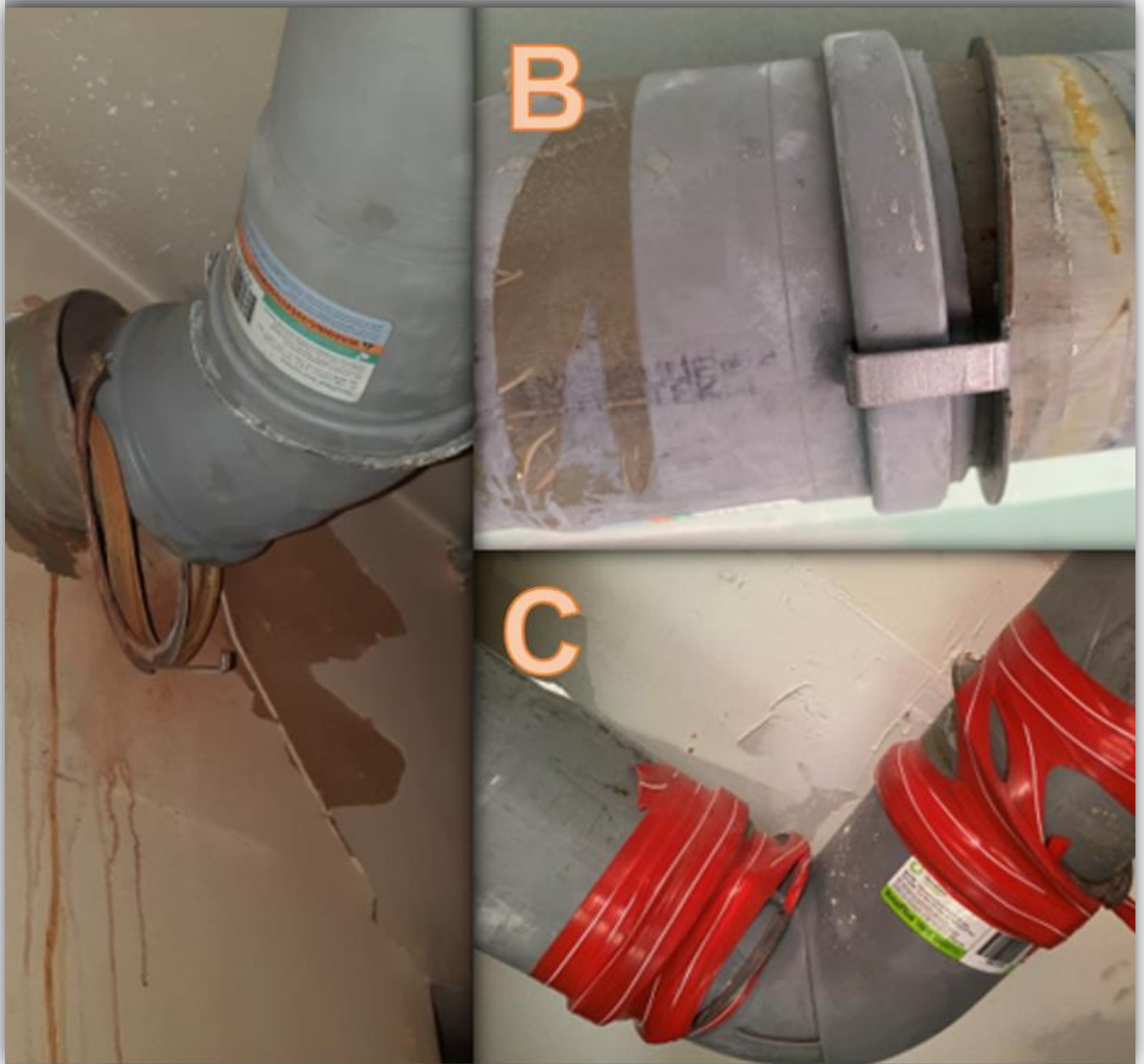


Image 2 – (Maple Ridge incident) Multiple locations of damaged venting showing a dislodged elbow [A], a backed-out connection with an intact retaining ring [B], and a previously repaired elbow with the addition of red tape to help keep the connection together [C]. The red taped connection [C] shows stretching and tearing from a subsequent delayed ignition after its repair.



Image 3 – (Maple Ridge incident) Tenant captured image of a missing vent elbow along with the damaged and mouldy drywall above the electrical meters from the sustained operation of the boiler after a delayed ignition damaged the venting.



Image 4 – Additional incident ([Appendix A](#) - #4) showing dislodged polypropylene venting from delayed ignitions.



Image 5 - Additional incident ([Appendix A](#) - #1) showing CPVC venting dislodged from boiler vent connection from delayed ignitions.



Image 6 - Additional incident ([Appendix A](#) - #5) showing CPVC venting dislodged from boiler vent connection from delayed ignitions.



Image 7 - Additional incident ([Appendix A](#) - #7) showing vent output adapter dislodged from the boiler enclosure from delayed ignitions.



Image 8 - Additional incident ([Appendix A](#) - #7) showing 90-degree polypropylene vent fitting missing from the venting system at the top of the boiler and cracked vent piping from delayed ignitions.



Image 9 - Additional incident ([Appendix A](#) - #7) showing boiler cover blown open from delayed ignitions.



Image 10 - Additional incident ([Appendix A](#) - #7) showing the internal venting output pipe dislodged from the condensate pan from delayed ignitions.



Image 11 - Additional incident ([Appendix A](#) - #9) showing polypropylene venting dislodged from boiler vent connection from delayed ignitions.



Image 12 - Additional incident ([Appendix A](#) - #11) showing 90-degree polypropylene vent fitting separated from the venting system from delayed ignitions.



Image 13 - Additional incident ([Appendix A](#) - #10) showing polypropylene venting dislodged from delayed ignitions.

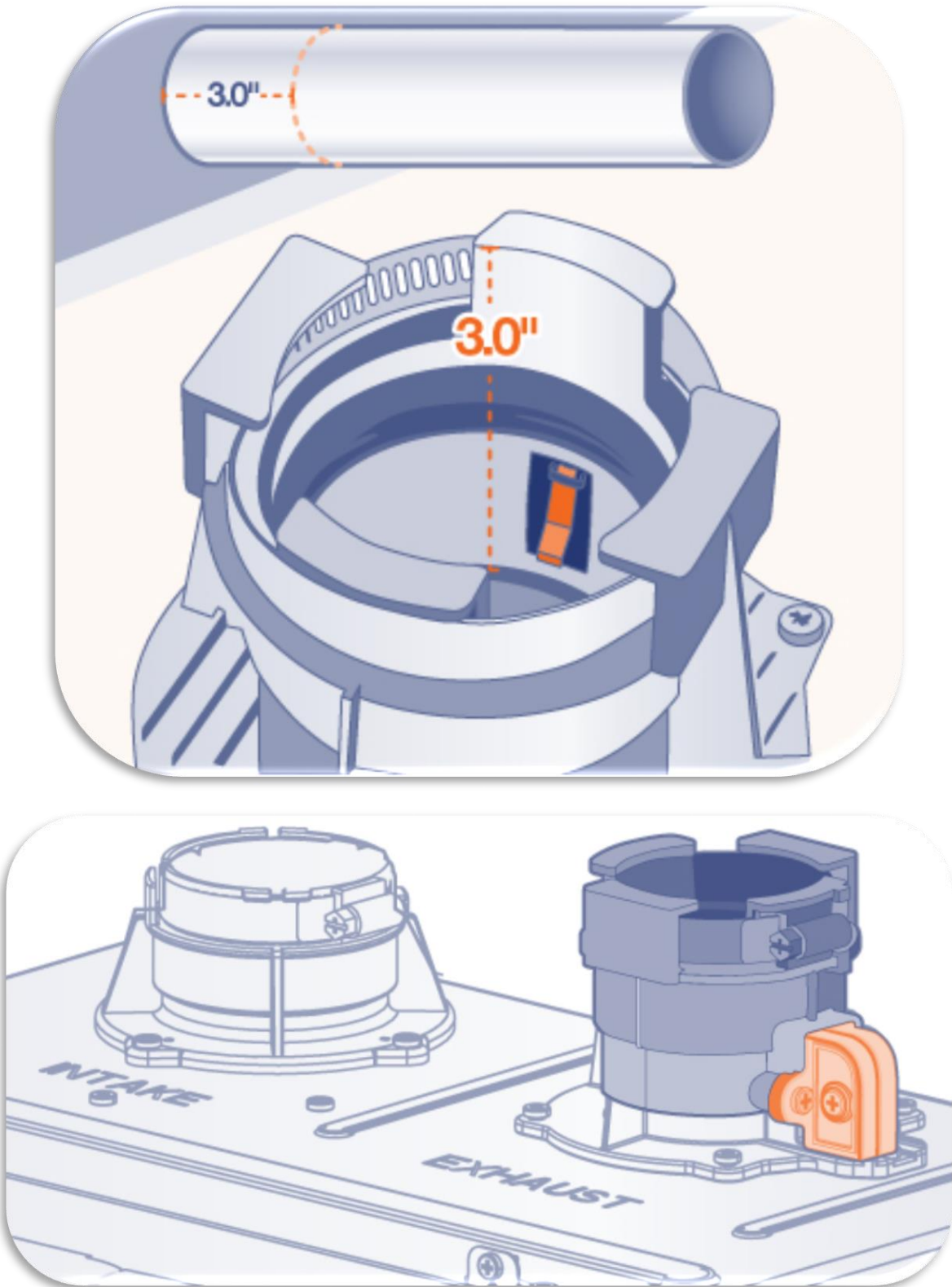


Image 14 – Example of boiler vent installation detector safety switch *(Source: www.navieninc.ca/blog/notice/innovation-by-design-vent-installation-detector).