Incident Summary (5623014)

SUPPORTING INFORMATION	Incident Date			*September 27, 2017*
	Location			*Vancouver, BC*
	Regulated industry sector			*Natural Gas System*
	Impact	Injury	Qty injuries	*0*
			Injury description	*0*
			Injury rating	*none*
		Damage	Damage description	*Collapsed venting system on a natural gas fuelled boiler*
			Damage rating	*Insignificant*
	Incident rating			*Moderate*
	Incident overview			*Components on venting system serving a central heating boiler was found collapsed. The collapse was due to poor combustion leading to a large explosive discharge within the boiler. As the discharge exited through the venting, the negative pressure created from the event collapsed the venting components..*
INVESTIGATION CONCLUSIONS	Site, system and components			*The natural gas fuelled boiler related to this summary is located in a basement mechanical room. The gas supply delivers 5 psi gas pressure to a secondary stage to under .5 psi pressure through a direct acting regulator positioned 48" from inlet port to the unit. The combustion system on this boiler is composed of a flame sensor (flame rod), an ignition device (ignitor), a controlling gas valve, air pressure sensors (to prove combustion air supply), and a vent sensor to monitor adequate exhaust flow (no blockage).All of these safety devices are wired in series to a Burner Management System (BMS), so if any one of them "fails", the circuit is broken and the burner will not operate. The boiler has a sealed combustion chamber that is physically connected to a sealed venting system that exhausts all by-products outside of the building safely.*
	Failure scenario(s)			*Over a period of time, the boiler burner engaged as expected, to provide heat to the hydronic system for the site. However, gas flow exceeded the maximum level allowed by the manufacturer due to an inability of the direct acting regulators installed on the gas piping to supply a controlled amount of gas. As the gas valve on the boiler opened on a call for heat, more gas than expected passed by the valve seats. When the ignitor lit the air\gas mix, the combustion ignition was greater than the engineered safe level, leading to compounding explosive events within the appliance over multiple start-ups. Although the system contained these poor ignition events, they damaged the ignitor and flame rod over time. Consequently, during a call for heat, the gap created from the previous combustion events caused the ignitor to spark only intermittently, not consecutively as designed. This allowed for unignited gasl to stay unlit in the combustion chamber, and as the ignitor sparked, a large explosive event occurred, destroying the flame rod, and passing out through the venting. As it exited, the negative pressure behind the blast collapsed the outer walls of the vent in multiple locations. Due to the collapse, the vent sensors could not verify effective flow, so the BMS shut down the boiler..*
	Facts and evidence			• *Collapsed venting components*

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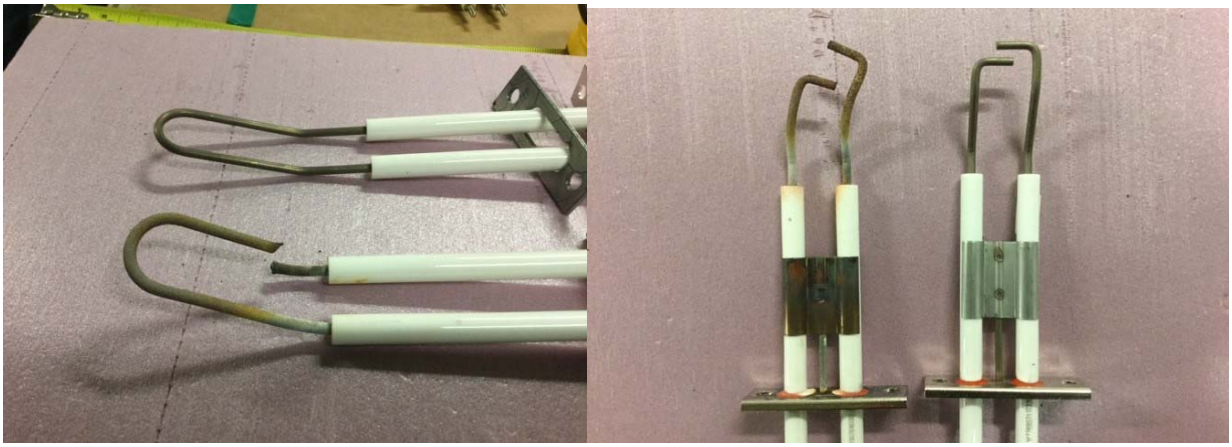
		• *Warped ignitor from the burner with expanded gap from high heat* • *Cracked flame rod due to high heat* • *Fault code on BMS indicated* • *Demonstrated higher than engineered lock up pressure (over twice the maximum allowable) due to the direct acting regulators immediately upstream of the boiler gas inlet*
	Causes and contributing factors	*The regulator immediately upstream of the gas supply inlet of the boiler was not able to modulate gas pressure as required by the boiler burner due to a limited capability to modulate at the same ratio of demand required by the burner. Over time, poor combustion led to a deterioration of the combustion equipment. As these components deteriorated, the combustion characteristics became worse until finally a large explosive event occurred within the unit that collapsed the venting. Routine maintenance from a knowledgeable and qualified technician could have discovered anomalies within the burner as the continuity of the flame rod is measured and trackable on the BMS control display. Regular service on the burner would have shown the ignitor and flame rod were damaged, leading to further tests of the system before the incident would have occurred. Routine pressure tests at annual service would have indicated the higher than allowed pressure during system lock up. According to testimony by the system operator, this boiler was never serviced over the 3 years since it was installed, even though the manufacturer recommends annual servicing.*

Collapsed venting on horizontal run



Warped ignitor and broken flame rod next to a new one for comparison

Lock up pressure test (right hand side) downstream of regulator, upstream of gas inlet to the boiler