Incident Summary #II-859486-2019 (#12904) (FINAL)

SUPPORTING INFORMATION	Incident Date		May 30, 2019
	Location		North Vancouver
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	None
		Injury description	Not Applicable no injuries
		Injury rating	None
	Impact – Damage	Damage description	Damage to the rear door enclosing the combustion chamber of a large boiler
		Damage rating	Major
	Incident rating		Major
	Incident overview		An explosion occurred within the heat exchanger of a commercial boiler which resulted in significant damage to the rear door, diffuser, and other boiler components, rendering it inoperable.
INVESTIGATION CONCLUSIONS	Site, system and components		Two identical boilers, Boiler number one and two, were used for heating and hot water in a commercial building (Photo 1). The boilers were of the fire tube variety. A fire tube boiler (Diagrams 1 & 2) uses a flame and flue gases to heat water that surrounds the combustion chamber to a desired temperature. The boiler is essentially a heat exchanger where hot gases from a power burner heat a network of tubes that are surrounded by water, transferring the heat into the water. The hot water was used for the purpose of heating and supplying hot water for the building. The flame in this boiler was controlled by a flame safeguard control device. <u>The Power Burner</u> The power burner mixes the fuel gas and fresh air to produce a flame that has a desired length and shape (Photo 3). The combustion blower supplies air to be mixed with the fuel gas so that a flame can be established. The diffuser ensures the air supply and fuel gas are well mixed so that the desired flame can be produced. A combination of gas valves and gas pressure control devices (“gas train”) regulate the desired amount of fuel gas that is needed to sustain the flame. The fuel gas mixture is ignited with a device that produces an electrical spark.
	Failure scenario(s)		Boiler 2 was being started and experienced a large internal explosion. The force of the explosion damaged the rear door, partially separating it from the boiler tank, (Photo 2). The cause of the explosion in boiler 2 was due to issues with the pressure regulator and excessive ignitor gap which resulted in excess unburnt gas to accumulate in the boiler, which ignited when contacting the burner flame.
	Facts and evidence		The following information was determined from interviews with boiler operations and maintenance personnel, document reviews, examination and testing by third party boiler specialist, and external resources.

Incident Summary #II-859486-2019 (#12904) (FINAL)

Maintenance Superintendent

- There are no certified manufactures installation, operating or service manuals filed for boilers 1 or 2.
- Unqualified personnel are working on the gas train of the boilers.
- A third party gas contractor did the annual servicing of the boilers.

Site Plumber (B class Gas Fitter)

- There are no procedures for the operation or servicing of the boilers.
- There is a logbook for the boiler.

Third party gas contractors (A class gas fitter)

- They have conducted work on boiler 2 and that boiler 2 has had flame failure issues.
- Gas pressures to boilers 1 and 2 had a pressure drop which exceeds the code requirements.
- The pilot regulator had failed to properly control gas pressure in boiler 2.
- The pilot for boiler 2 would reduce in size when the main burner opened and further reduce if boiler 1 was operating.
- Witnessed hard lighting on boiler 2 when testing.
- There were issues with the lighting of the pilot due to misalignment of the spark electrode.

Boiler Specialist

Inspect and test results:

- Found that hydraulic liquid from the gas valve of the main burner had leaked
- Gas pressure to boilers 1 and 2 had a pressure drop which exceeds CSA code requirements (CAN/CSA B149.1 -15 6.3.2)
- The pilot regulator had failed and did not regulate the gas pressure of the pilot
- Gas pressure fluctuations in the main burner of Boiler 2 caused delayed ignition resulting in an explosion in the boiler.

Gas Safety Officer

Witnessed testing including:

- Hydraulic residue on top of the main burner gas valve.
- Gas pressure test.
- Testing of the pilot gas valve
- Hard lighting of boiler 2 on several occasions during testing
- Witnessed the spark electrode having to be adjusted to light the pilot correctly

Logbook review

- The boiler logbook had missing entries for maintenance work that had been conducted.
- Work had been carried out by unqualified personnel. For example, alterations made by a worker to the spark electrode who was not qualified to undertake such work.
- Logbooks missing entries from work that had been completed by external gas contractors.
- There were no references in the logbook that any testing had been carried out after any adjustments of the spark electrode.

Incident Summary #II-859486-2019 (#12904) (FINAL)

	Document review • Preventative Maintenance work procedures – No documentation available or logbook entries for routine annual maintenance required on boiler 1 and 2. (no evidence available to confirms that these procedures have been followed) • Invoices – records indicate a history of flame failures where the spark electrode required adjusting. **Discussion** The boiler went through its starting sequence by first lighting the pilot using the spark electrode. The spark electrode had been incorrectly adjusted such that a large spark gap delayed lighting of the pilot gas. The flame safety circuit detected the pilot flame and opened the burner gas valve. As the gas started to flow, gas pressure dropped causing the pilot to reduce in size which delayed lighting of the burner resulting in an excessive amount of unburnt gas to be introduced into the furnace portion of the heat exchanger. When the gas pressure stabilised the pilot flame increased and lit the burner which in turn ignited the unburnt gas in the furnace portion of the heat exchanger causing the explosion. The pilot reducing in size shows that the regulator was trying to regulate the gas pressure. The pressure in the main header fluctuated beyond the amount acceptable by CSA.
Causes and contributing factors	The cause of the explosion in boiler 2 was likely due to a failing pressure regulator, combined with excessive ignitor gap which resulted in excess unburnt gas in the boiler in the presence of a flame. Several factors contributed to the boiler 2 explosion incident: • Incorrect set up and/or testing of gas regulating devices - Testing after the failure found that the gas pressures had not been set correctly as per the CSA standard. • Routine testing not conducted - No evidence that the system was tested to confirm proper function after the spark electrode was adjusted. If periodic testing procedures were conducted as required, the excessive gas pressure fluctuation should have been detected and corrected to avoid a hard lighting condition that led to the explosion. - There were no logbook records or other documentation maintained by the facility to show that routine maintenance protocols had been followed. It was evident that routine maintenance was not performed and/or documented as required by regulation. • Managerial oversite - Lack of operational and maintenance instructions for the safe running of the boiler and lack of certification for the installation. - Lack of operating or maintenance manuals for personnel to reference for the safe operation of the boiler, resulting in incorrect adjustments of boiler components and missed operational testing of boiler components. - Facility management did not ensure that work on the boilers was conducted by qualified individuals. Consequently, unqualified personnel adjusted the boilers gas components. - Hazards associated with hard light-offs were not understood by the operations and/or maintenance personnel.

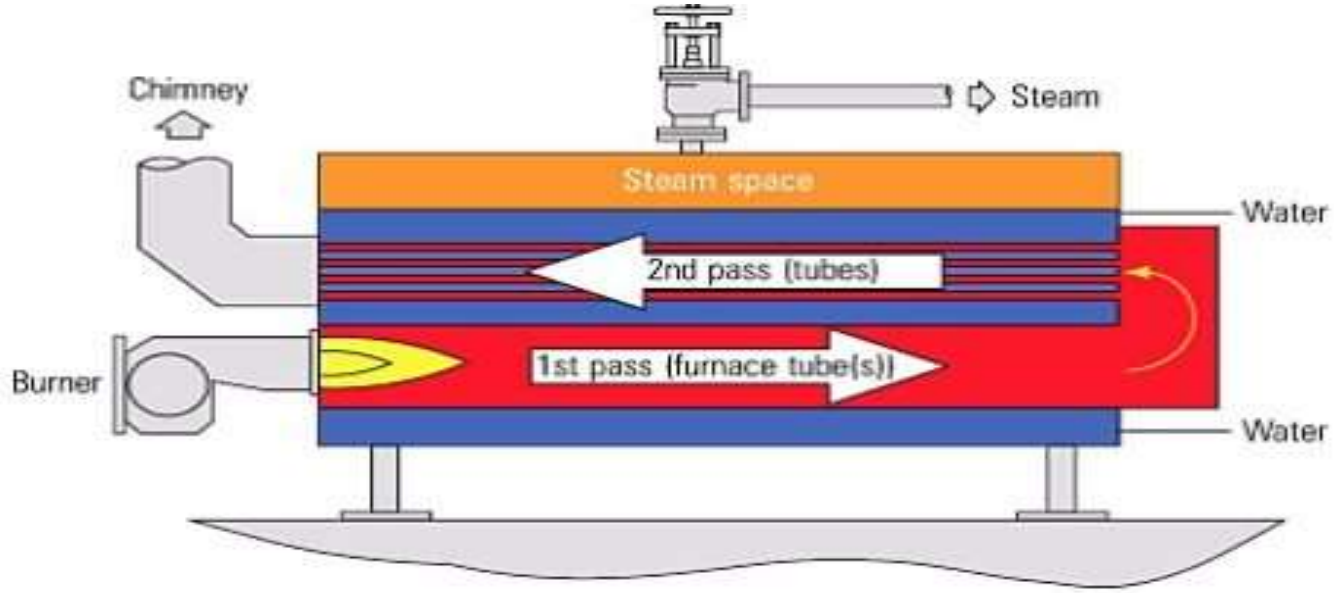

Diagram 1: A fire tube boiler

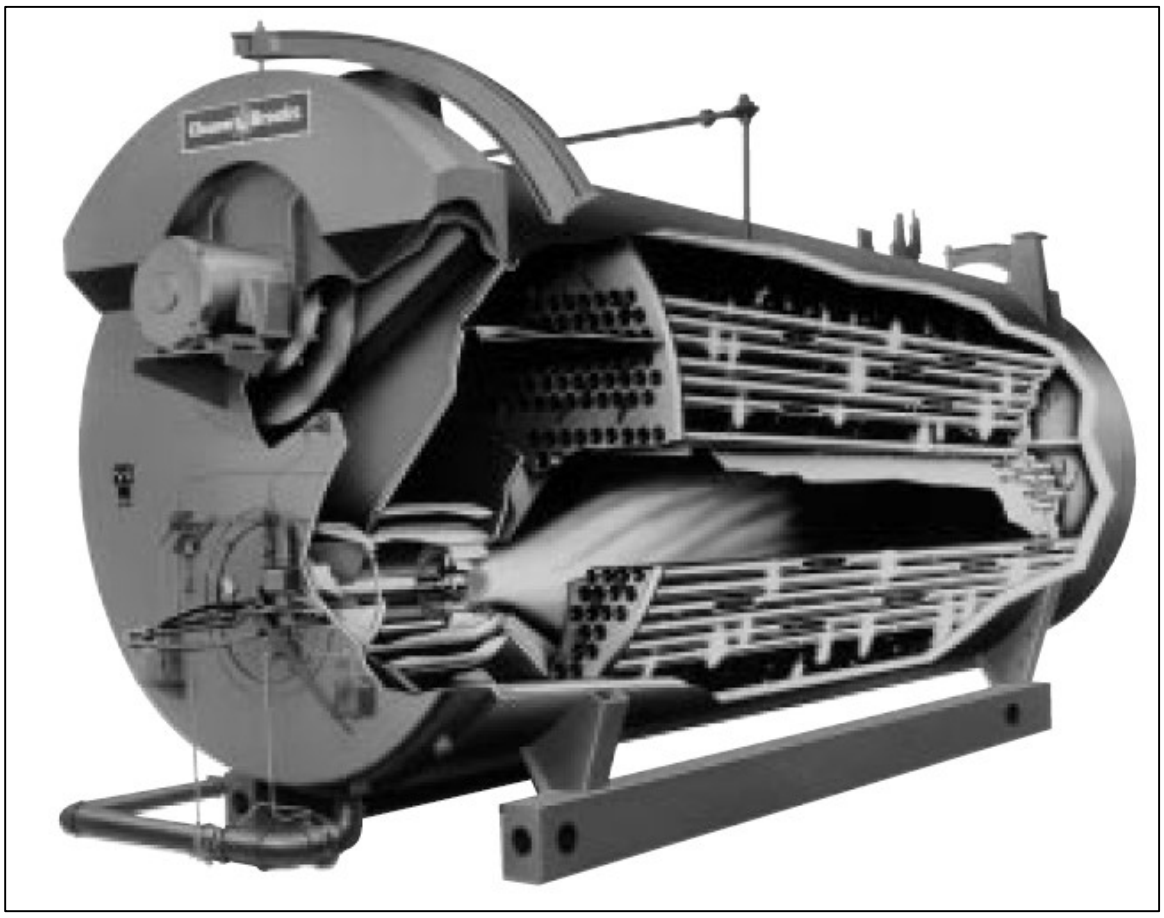

Diagram 2: Cut away view of a typical fire tube boiler (Clever Brooks manual)

Photo 1: Front view boiler 1 (left) and rear view boiler 2 (right).

Photo 2: Boiler 2 front door open with burner removed (left), damaged rear door (right)

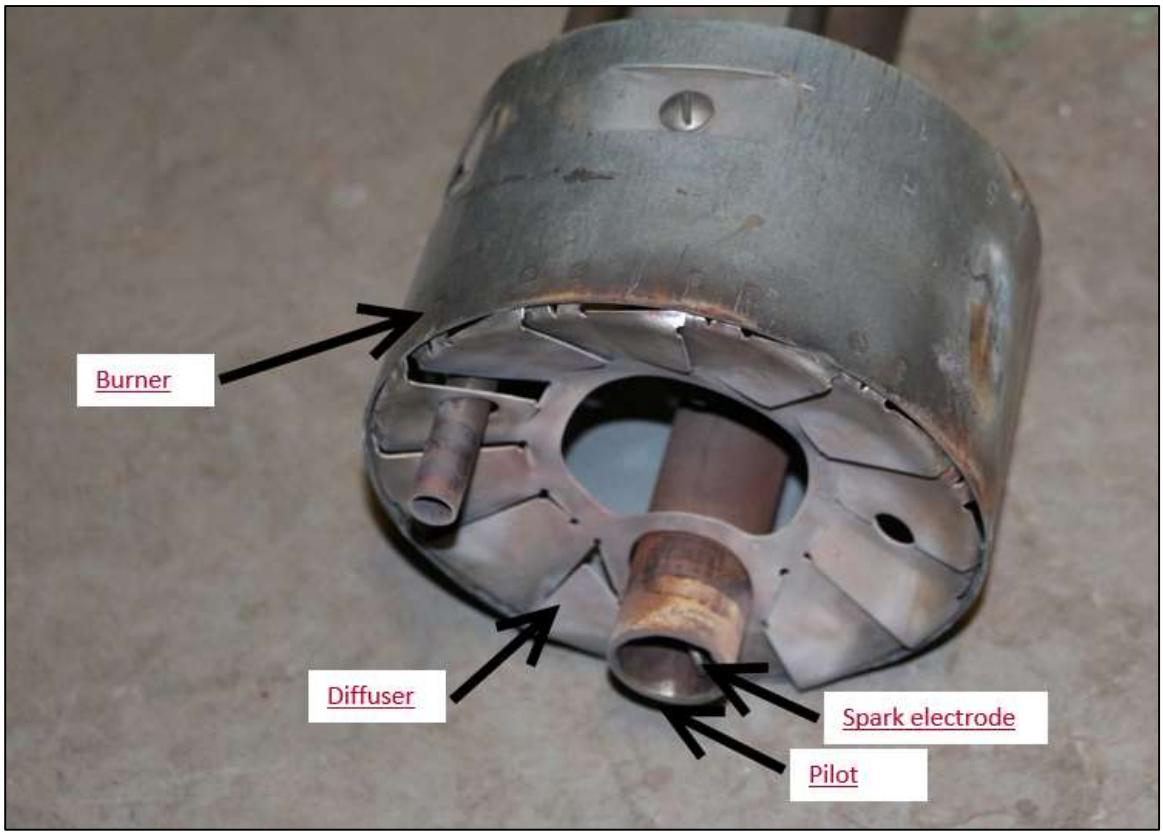

Photo 3: Power burner and its components.

Photo 4: Undamaged power burner (exemplar) compared to damaged power burner. Diffuser deformed due to force of the explosion (fins flattened and pushed in).