# Incident Summary #II-1260939-2021 (#24215) (FINAL)

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| SUPPORTING INFORMATION | Incident Date | | September 28, 2021 |
| | Location | | Peace River Region |
| | Regulated industry sector | | Boilers, PV & refrigeration - Boiler and pressure vessel system |
| | Impact – Injury | Qty injuries | 0 |
| | | Injury description | None |
| | | Injury rating | None |
| | Impact – Damage | Damage description | A biomass-fired thermal fluid heater's steel shell buckled and melted away several large sections, it also shifted and permanently deformed its steel helical coil and its steel soot blower piping melted away a large hole. |
| | | Damage rating | Major |
| | Incident rating | | Major |
| | Incident overview | | A biomass-fired thermal fluid heater developed a secondary fire causing damage to the lower portion of its heat exchangers shell, helical coil, refractory, and soot blower piping rendering the heater inoperable. |
| INVESTIGATION CONCLUSIONS | Site, system and components | | This lumber manufacturers biomass-fired thermal fluid heater has five main components, the fuel, the reciprocating step-gate furnace, the helical coil heat exchanger, the soot blower piping, and the induced draft fan.<br><br>The fuel burned in this reciprocating step-gate furnace is known as hogged fuel. Hogged fuel is wood refuse that has been chipped or shredded by a machine known as a hog. Because hogged fuel is often piled up outside on the ground, dirt and sand can end up in the mix. Typically, hogged fuel intended for burning has a moisture level between 45-50% and is burned with an oxygen level between 7-9%. If these values are not monitored or maintained the fire can either snuff out or burn hotter.<br><br>The reciprocating step-gate furnace has three zones or stages of combustion. First there is the drying zone, where the hogged fuel dries as it prepares to ignite. Second is the combustion zone, where the hogged fuel burns releasing flue gases that reach temperatures over 1000 degrees Celsius. The third and final zone is the ash zone where ash is removed from the furnace.<br><br>As flue gases are drawn from the furnace by the induced draft fan, heat, ash, and slag is deposited or transferred to the helical coils in the draft direction change and low velocity areas. A helical coil is a metal tube that has been formed into a spiral shape like a compressed spring. Over time ash and slag will build up and periodically the soot blower piping will release compressed air through small holes to disturb the ash. This allows the draft to draw any loosened ash out of the system. However, this does not eliminate all the ash and slag as some does not detach from surfaces it is stuck to. As ash and slag accumulate at the neck of the heat exchanger it would have needed to be manually removed. |
| | Failure scenario(s) | | Dry hogged fuel contaminated with sand was burned prematurely within the drying zone of the furnace. |

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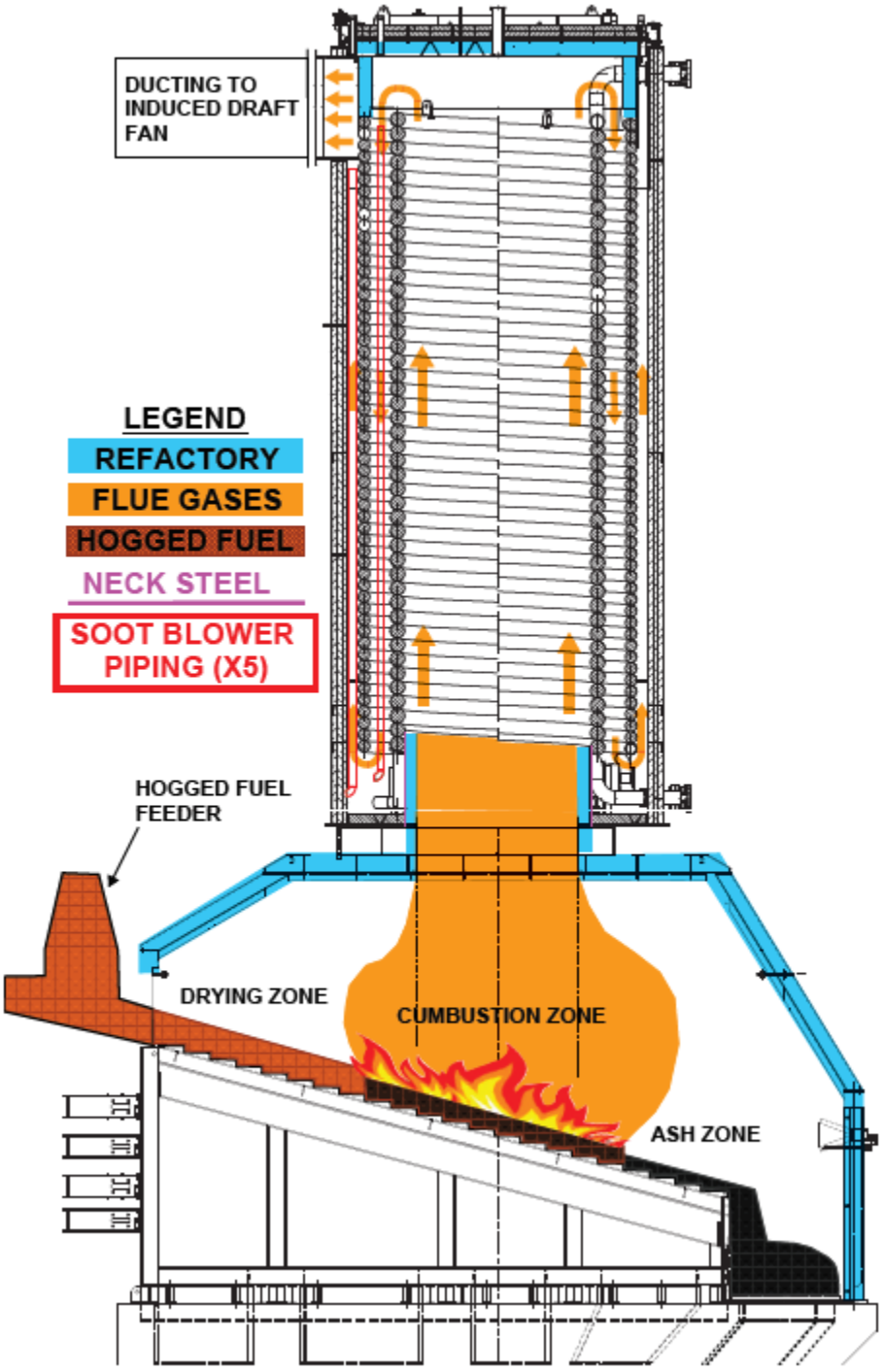
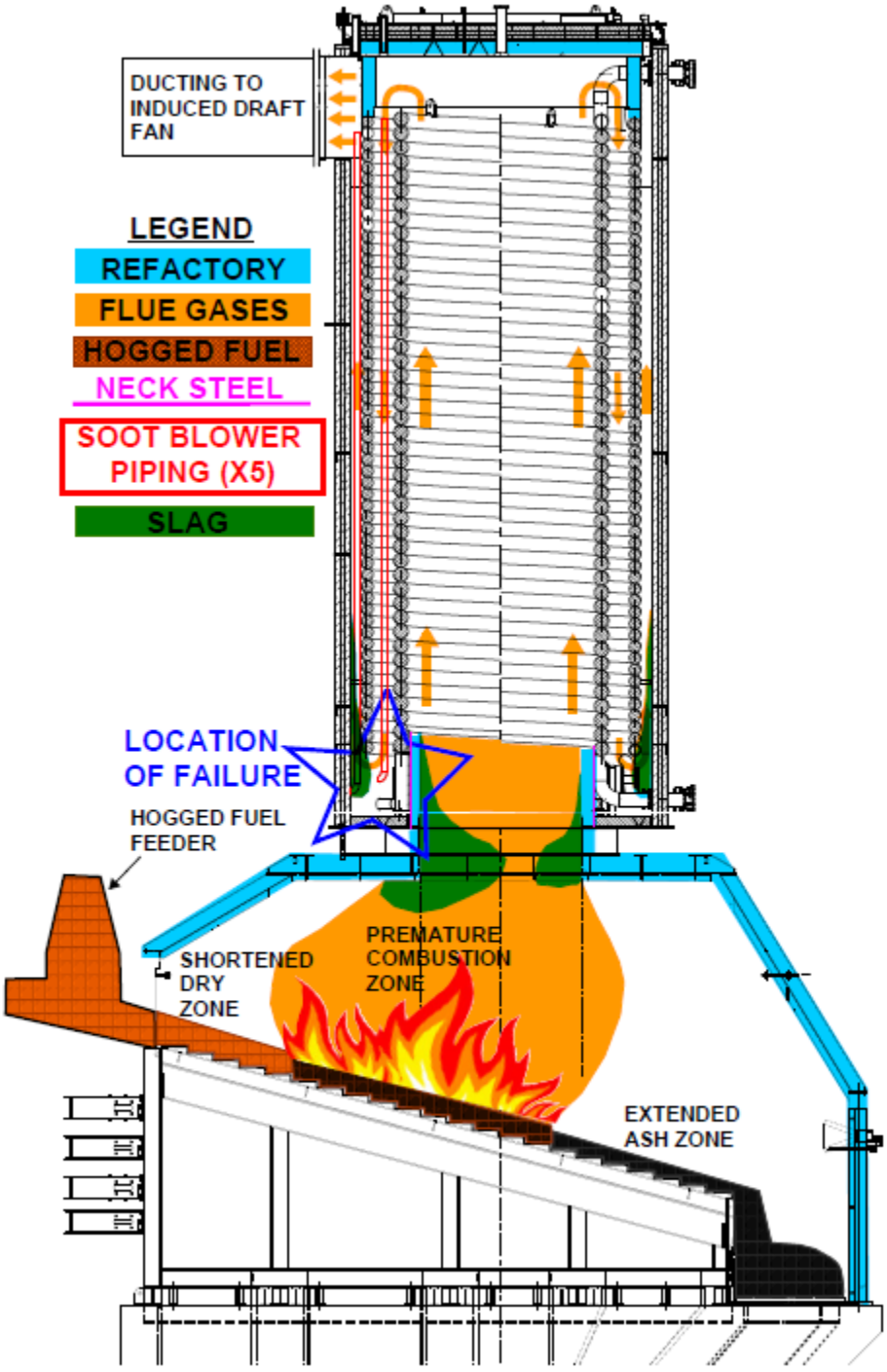
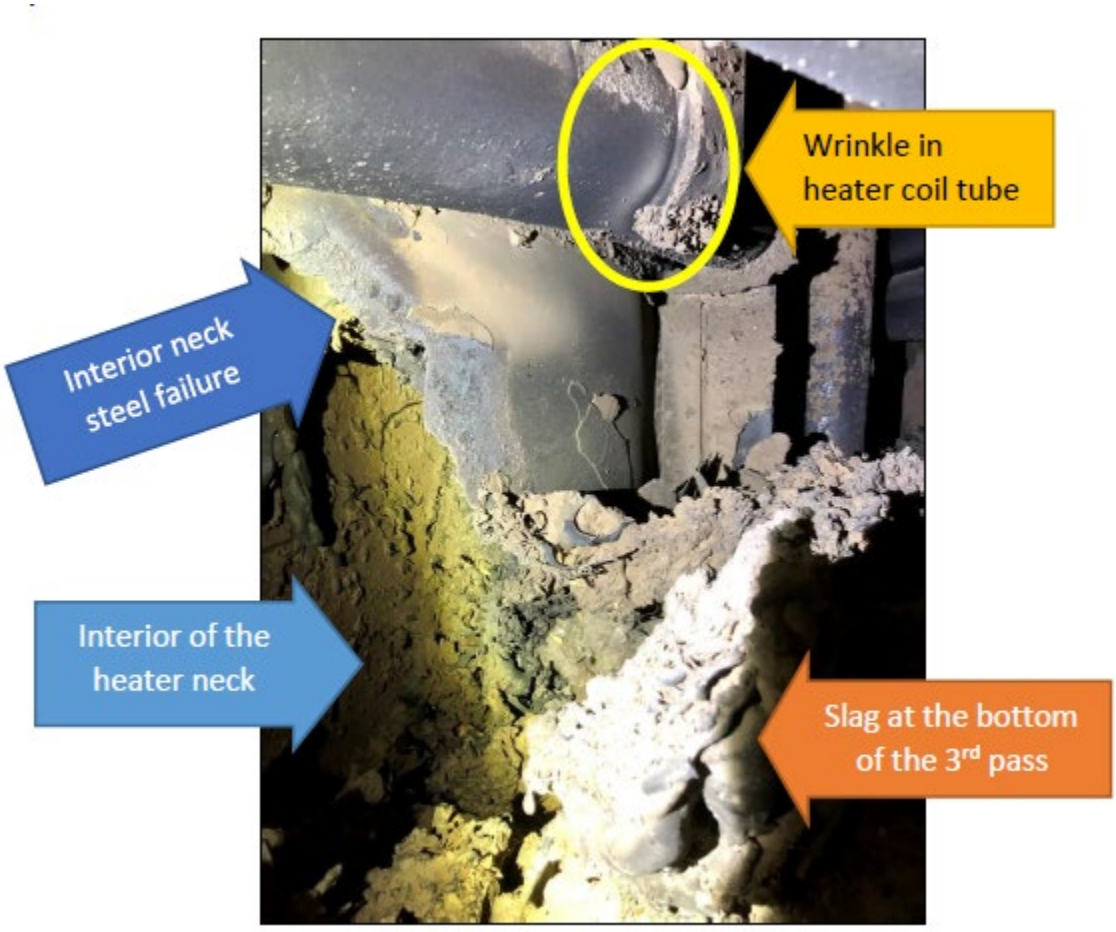
| | The dryness of the hogged fuel increased the rate of combustion and combustion temperature causing vaporization of non-combustible elements and minerals. The vaporized non-combustibles then fused with the ash to form slag at an accelerated rate. Slag, also known as clinker, is a hard glass or rock-like material that is formed in biomass fired furnaces when non-combustibles vaporise and fuse with ash.<br><br>As the slag accumulated and the furnace neck began to choke off the draft and the induced draft fan would have had trouble maintaining the furnace vacuum setpoint. Internally this would create a strong vacuum effect downstream at any choke points and if the shell were already softened due to heat it would begin to collapse inward.<br><br>Eventually the weight of the slag would have pulled refractory away form the interior neck steel. Then the vacuum and the heat of the furnace would have caused the shell to buckle, crack or form small holes. The cracks and holes would have allowed flue gases and outside air to enter the neck of the heat exchanger. When the outside air reached the slag, the slag would have re-ignited starting a secondary fire. Then extreme heat from the secondary fire melted away more of the shell steel, damaged the helical coil and the soot blower piping. |
| Facts and evidence | • Owner reported that they did not investigate fuel stocks on site or imported from off site to determine that moisture level was within 45-50% tolerances.<br><br>• Photographic evidence of excessive amount of slag (clinker) at and around the location of failure.<br><br>• Photographic evidence of the hogged fuel stored on the ground allowing for contamination of the hogged fuel.<br><br>• Owner reported difficulty maintaining sufficient draft even though the induced draft fan was running high. Later it was determined that the insufficient draft was caused by choke point at the furnace neck. Photographic evidence of the neck choked by slag.<br><br>• Owner reported high whistling noise near point of failure prior to failure. This whistling sound was determined to be outside air rushing into the draft. |
| Causes and contributing factors | It is likely that the dryness of the hogged fuel increased the rate of combustion and combustion temperature leading to accelerated production of slag. The accumulation of slag then would have choked off the draft, collapsed the shell, and introduced outside air. Once outside air hit the slag, the slag re-ignited starting a secondary fire and the extreme heat damaged the shells, the helical coil, and soot blower piping. |




**Normal combustion of hogged fuel reciprocating step-gate furnace and path of flue gases through helical coil heat exchanger.**




**Premature combustion of hogged fuel, slag accumulations, and location of failure.**




**Heater neck shell failure, slagging, and deformed coil.**

**Failed shell and hole in soot blower piping.**

**Helical coil neck obstruction.**

**Buckled shell.**

**Slag (clinker) sample and deposit of slag on outer shell.**

**Outer shell steel melted away.**

**Hogged Fuel.**