

## Incident Summary #II-947637-2019 (#16026) (FINAL)

<b>SUPPORTING INFORMATION</b>	Incident Date	November 27, 2019
	Location	Princeton
	Regulated industry sector	Gas - Propane system
	Qty injuries	0
	Injury description	NA
	Injury rating	None
	Damage description	An explosion inside the drum of a soil reclamation extractor caused the combustion air blower and burner to become severely damaged and detached from the extractor. A 48" diameter metal elbow for the exhaust ducting was blown off. The transfer ducting to the cyclone was damaged beyond repair.
	Damage rating	Major
<b>INVESTIGATION CONCLUSIONS</b>	Incident rating	Major
	Incident overview	An explosion occurred in a propane fueled dryer for an industrial thermal soil remediation plant while ignition of the main burner was being attempted.
	Site, system and components	<p>The thermal soil remediation plant was installed in 2009 and utilizes a propane fueled counter flow dryer which evaporates moisture and oil from contaminated soil. The soil is raised to between 5000°F to 10,000°F (2600°C to 5380°C) to allow for remediation of hydrocarbons. The released hydrocarbons are then sent to the oxidizer. The oxidizer has a burner that burns off the hydrocarbons before the heated air is released to the atmosphere. The clean soil is then removed from the dryer on a conveyor system.</p> <p>The system uses a combustion-air fan to supply air for the burner and a large fan that draws the heated air through the system and exhausts it out the stack. Airflow through the system is regulated by fan speeds and mechanically actuated dampers which receive signals from the control panel.</p> <p>A purge of the system is required prior to igniting of the main dryer burner to ensure any residual combustible gases are exhausted from the flue passages. The purge is required to provide a total of four air changes through the system to ensure it is sufficiently purged and it is safe to ignite the main burner. During the purge, both the combustion-air and exhaust fans operate and the combustion air and exhaust dampers both drive to the fully open positions to allow maximum airflow for a set amount of time to achieve the four air changes. After the purge is complete the fan speeds and dampers move to a low fire start position which is calibrated to allow for safe ignition of the burner at a low input.</p>
Failure scenario(s)		
		<p>On the day of the incident the plant experienced an overtemperature condition in the oxidizer while operating. The plant operator shut down the system for a restart to alleviate the problem. The contaminated soil was removed from the dryer to prevent the soil from producing combustible fumes in the drum. The operator initiated a purge to clear any combustible gasses from the system which lasted two minutes. After multiple failed attempts, the oxidizer burner lit, and the oxidizer was warmed up for approximately 15 minutes. A first attempt was made to ignite the main dryer burner.</p>

## Incident Summary #II-947637-2019 (#16026) (FINAL)

	<p>The pilot light ignited but the dryer burner failed to ignite after a 10 second trial for ignition period. This allowed approximately 1.6 million btu's of liquid propane to enter the dryer drum. The operator then attempted to ignite the main burner a second time. The pilot light ignited but the main burner failed after another 10 second trial for ignition. This allowed more unburnt propane to enter the dryer drum.</p> <p>The plant had components that were not operating correctly or were damaged. The combustion air damper arm was not engaged with the damper shaft and the correct amount of air was not being drawn into the system. The dryer burner nozzle was partially plugged, and its primary air diffuser was broken on one side. This caused the burner to be intermittent to start and operate on low fire. The main gas valve train shut off valves were scored on the sealing surfaces and were leaking gas when they were closed.</p> <p>The partially plugged and broken burner combined with the incorrect operation of the combustion air damper caused multiple failed ignition attempts and did not allow enough air to pass through the system to purge it of all of the combustible gases. After the dryer burner failed to ignite the second time the combustible gases were ignited by the oxidizer burner causing an explosion.</p>
Facts and evidence	<p><b>Plant operator statement</b></p> <ul style="list-style-type: none"> <li>• The dryer burner was shut down due to overtemperature of the oxidizer.</li> <li>• The baghouse was purged for two minutes.</li> <li>• The oxidizer burner lit only after multiple failed attempts.</li> <li>• After ignition, the oxidizer was warmed up for 15 minutes.</li> <li>• An attempt was made to light the dryer burner, but the ignition failed.</li> <li>• The system was re-purged, and the dryer burner attempted to light a second time.</li> <li>• The control showed a flame ignition failure after the second attempt then the dryer exploded.</li> <li>• The crossover pipe from the cyclone to the oxidizer flew off and crashed into the tower roof.</li> <li>• Electricians and the millwrights had adjusted the control arm on the combustion air damper on several occasions because of slippage.</li> </ul> <p><b>Industrial gas contractor statement</b></p> <ul style="list-style-type: none"> <li>• The plant had been having numerous problems with starting and keeping the system running in the weeks prior to the incident.</li> <li>• A 10 second trial for ignition on the main burner would allow approximately 1.6 million btu's of liquid propane into the dryer drum.</li> </ul> <p><b>Site observation</b></p> <ul style="list-style-type: none"> <li>• There is no proving switch to ensure that the combustion air damper is wide open during the pre-purge cycle.</li> <li>• The primary burner nozzle was partially plugged, and the primary air diffuser was broken on one side.</li> <li>• There were several Main Flame Ignition fault codes in the burner management system logs.</li> <li>• The main gas safety shutoff valves showed definite scoring marks on the sealing section of the ball valves.</li> <li>• The combustion air damper actuator arm was off of the damper shaft and showed evidence of slippage and alterations to the damper shaft in attempts to prevent the slippage.</li> </ul>

## Incident Summary #II-947637-2019 (#16026) (FINAL)

	<p><b>Testing</b></p> <ul style="list-style-type: none"> <li>• A 1psi pressure test was performed on the shut off valves and significant leakage found while in the closed position.</li> <li>• The combustion air damper shaft was rotated and found to be very difficult to move.</li> <li>• The actuator arm was reinstalled on the combustion air damper shaft and slippage was observed between the arm and the shaft while attempting to operate the damper with the actuator indicating the combustion air damper was not operating correctly.</li> </ul> <p><b>Documents</b></p> <p><b>Service record</b></p> <ul style="list-style-type: none"> <li>• June 17, 2019, an industrial gas contractor technician found the combustion air switches were not working due to fine dust clogging the switch and made a recommendation to replace the air switches with current sensing switches. The recommendation was not acted on and the original switches that were found to be not functioning were still in place at the time of the incident.</li> </ul> <p><b>Operation &amp; maintenance book</b></p> <ul style="list-style-type: none"> <li>• The main burner has a 10 second trial for ignition stage before the main gas safety shutoff valves close.</li> </ul> <p><b>Purge time calculations</b></p> <ul style="list-style-type: none"> <li>• Purge time calculations were completed by the manufacturer of the dryer system prior to the plant being repaired and put back into operation.</li> <li>• The purge calculations required 5.1 minutes of purge time and a new purge timer was set at 6 minutes which is 3 times the length of the original set purge time when the incident occurred.</li> </ul> <p><b>Video</b></p> <ul style="list-style-type: none"> <li>• A dust cloud shown in the video before the incident indicates that there was a positive air flow condition in the primary drum.</li> <li>• The explosion started in the oxidizer section then traveled to the main dryer unit.</li> </ul>
<b>Causes and contributing factors</b>	<p>It is highly likely that continued operation of the plant without proper repair of the combustion air damper operation allowed for failed ignition attempts and inadequate purging of the system. This allowed gas to accumulate inside the dryer drum causing an explosion.</p> <p>The damaged burner ring, leaking gas train shut off valves, failure to upgrade the non-functioning combustion air switches and inadequate purge time of two minutes likely were contributing factors to the explosion.</p>

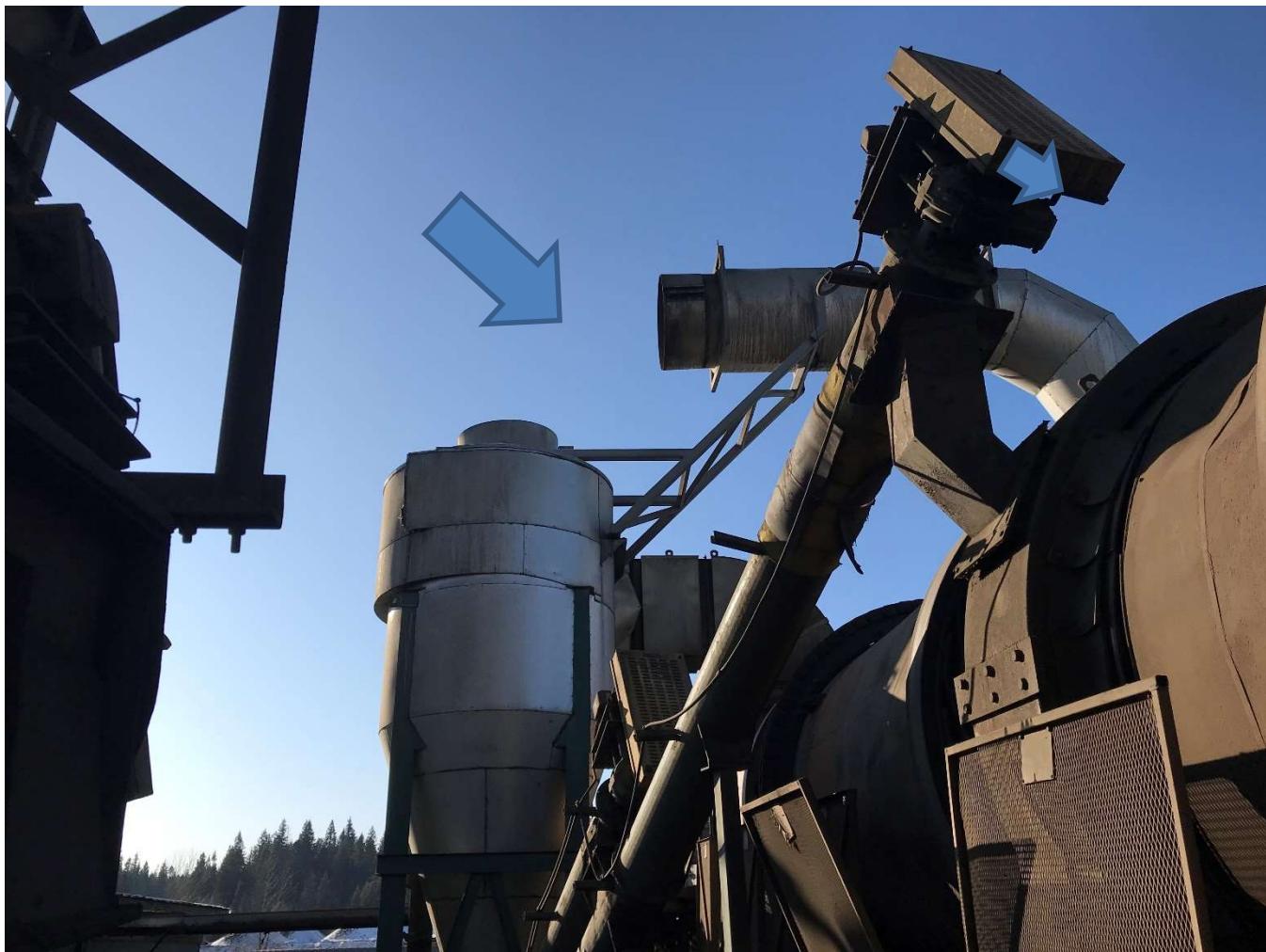


Image 1 – Showing missing 48" ducting exhaust elbow that blew off from the explosion



Image 2 – Combustion air damper shaft showing missing actuator arm and markings indicating arm slippage



Image 3 – Detached combustion air damper actuator arm



Image 4 – Burner after removal showing breakage and gap between the outer shell and the rim of the air diffuser (Blue arrow). This can disrupt the combustion air flow and allow air to leak out the side. This can contribute to an unstable air fuel ratio at the point of ignition from the pilot light causing intermittent burner ignition and unstable operation.