

Incident Summary #II-1019057-2020 (#17992) (FINAL)

SUPPORTING INFORMATION	Incident Date	May 30, 2020
	Location	Prince George
	Regulated industry sector	Boilers, PV & refrigeration - Boiler and pressure vessel system
	Impact	Qty injuries
		0
		Injury description
	Damage	NA
		Injury rating
		None
INVESTIGATION CONCLUSIONS	Site, system and components	Damage description
		High solids black liquor piping elbow ruptured and sprayed black liquor onto buildings and equipment.
		Damage rating
	Incident overview	Moderate
		At 12:30 am on May 30 th , 2020, failure of a 6" pressure piping elbow located on top of a storage tank resulted in black liquor being sprayed onto adjacent buildings, equipment and ground within an approximately 50m area. The line from the liquor transfer pump into the top of the tank failed and 74% black liquor solids were released for approximately 20 minutes. A similar failure had occurred on Feb 8, 2020.
		The organic matter in black liquor is made up of water/alkali soluble degradation components from wood. Black liquor is corrosive. High solids black liquor at a temperature of approximately 140°C is transferred from a concentrator vessel to a storage tank via stainless steel piping. The piping material is made from a corrosion resistant material. The flow of black liquor into the storage tank is controlled by a valve located immediately upstream of a 90 degree piping elbow discharging into the storage tank. The system configuration and materials are designed to be suitable for black liquor service.
	Failure scenario(s)	Hot alkaline liquor corrosion and erosion of a stainless steel (SS) schedule 10 6" - 90 degree piping elbow caused thinning of the piping wall. The thinned piping then ruptured and released a flow of black liquor from the top of the storage vessel.
		Inspection of the failed piping elbow found a large hole indicating a complete rupture had occurred. Inspection of the piping wall verified thinning of the metal had occurred at various locations with the worst at the outer radius or sweep of the elbow. Inspection of the thinning determined that the primary damage mechanism was erosion/corrosion. Industry literature (WRC 488 "Damage Mechanisms in the Pulp and Paper Industry") explains that stainless steels and nickel alloys can experience uniform corrosion when exposed to hot, alkaline liquors above certain threshold temperatures. The corrosion mechanism of this type of failure is referred to as "hot alkaline liquor corrosion". Hot alkaline liquor corrosion of stainless alloys occurs when the passive film (ultra-thin film of corrosion product on a metal's surface that acts as a barrier to additional chemical reaction) that normally protects the alloy surface fails due to excessive temperatures. Flow velocities and other physical conditions can disrupt the passive film. The Process Instrumentation Diagram for the High Solids Concentrator (HSC) firing liquor system specifically mentions that the control valve package was located close to the tank inlet to prevent flashing, thus indicating a known potential for increased turbulence. Process changes made in January 2019 contributed to higher process pressure and temperature (increased from 136°C to 146°C) contributing to lower viscosity and more turbulent flow of black liquor. It was stated by a mill employee that the control valve immediately upstream of the failed elbow was noisy, sounding like cavitation (the rapid formation and collapse of vapor pockets in a flowing liquid in regions of very low pressure) was occurring.

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	<p>The elbow had been previously replaced on Feb 8, 2020 when a similar incident had occurred. The original 304 SS elbow was replaced with 316 SS. This material was chosen for the repair because it was readily available and in consideration of operational pressures to get the mill back into operation. Thickness surveys of the heavy black liquor line found acceptable rates of thinning other than at the failed elbow location indicating no systemic corrosion issue with the use of 304 SS. For hot alkaline liquor corrosion, type 316 SS has a poorer performance due to its lower temperature threshold and higher corrosion rate as compared with 304 SS. The intent was that the elbow would be replaced during the next major turnaround (in approximately 2 months) in April 2020 when a permanent engineering solution and repair could be made. Due to the Covid-19 Pandemic, the next major turnaround was delayed to September 2020.</p>
<p>Causes and contributing factors</p>	<p>It is highly likely that erosion/corrosion caused thinning of the pressure piping elbow resulting in a subsequent rupture of the pressure boundary. Incorrect selection of piping metallurgy, adverse flashing conditions within the piping, a change to the black liquor process and a delay in planned maintenance were contributing factors.</p>

Black Liquor release





Heavy Black Liquor line piping on top of Black liquor storage tank



Failed 316 SS Sch 10 6" Elbow