

Incident Summary #II-1289464-2021 (#25109) (FINAL)

SUPPORTING INFORMATION	Incident Date	November 20, 2021		
	Location	Prince George		
	Regulated industry sector	Boilers, PV & refrigeration - Refrigeration system		
	Impact	Qty injuries	0	
		Injury	Injury description	N/A
			Injury rating	None
	Damage	Damage description	A boiler wall tube section was damaged and repaired.	
		Damage rating	Minor	
	Incident rating	Minor		
Incident overview	A leak was identified in the lower furnace of a recovery boiler. The tube leak discharged water and steam directly above the smelt bed. The potential for a smelt water explosion was created. An emergency shut down of the recovery boiler was employed.			
INVESTIGATION CONCLUSIONS	Site, system and components	<p>This industrial site utilizes the KRAFT Pulp manufacturing process. The recovery boiler is a high-pressure steam boiler which is heated by the combustion of black liquor within the furnace. The intense heat in the boiler furnace fuses the inorganic elements of black liquor (mainly sodium carbonate and sodium sulphide) to form what is known as smelt. A significant hazard in the operation of a recovery boilers is a potential smelt-water reaction, an explosion can happen if water is mixed with the high temperature smelt. This incident resulted in water/steam being discharge directly over the smelt bed.</p> <p>The boiler was constructed in 1986. The furnace walls are constructed of SA178 seamless carbon steel tubes with a metal spray coating to protect them from corrosion.</p> <p>Air is introduced near the bottom of the furnace through openings in the tube wall, these primary air ports are formed by offsetting one tube in front of an adjacent one. The offset creates a small cavity where one tube tucks behind another, this cavity is covered up by seal welding a small "crotch plate" to the tubes. The furnace area of the boiler is exposed to high temperatures, thermal cycling, and mechanical stresses. Thermal and/or mechanical fatigue cracks in primary airport crotch/fill plates are known to occur and are an inspection and monitoring item for owners of recovery boilers.</p>		
	Failure scenario(s)	As result of thermal stresses, a crack developed in a boiler primary air port crotch plate and traveled into the boiler tube causing it to leak. Damage mechanisms such as thermal and mechanical fatigue cracking can occur in components known to be affected by thermal and/or mechanical cycling. Air port crotch plates may experience thermal cycling and localized heat flux which could contribute to cracking.		

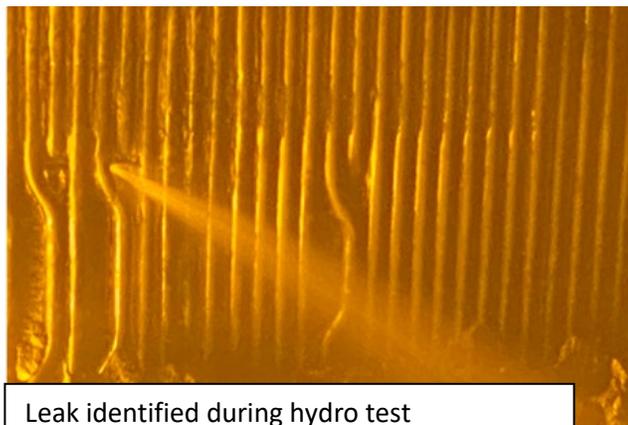
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<p>Facts and evidence</p>	<p>The recovery boiler tube leak was located at a primary airport crotch plate on the rear wall, approximately 3ft above the floor tubes. The boiler tube leak was on the hot side of the tube. Upon initial inspection a crack perpendicular to the tube wall was identified to have traversed from the crotch plate, across the attachment weld and propagated into the tube.</p> <p>The leaking section of tube and was removed. The tube section was sent for examination by an independent material testing and analysis laboratory. The failure analysis report identified findings which included:</p> <ul style="list-style-type: none"> • thick scale deposit of iron and copper oxides was found inside the tube adjacent to the leak • metallographic examination showed evidence of thermal degradation on the fire side of the tube indicating that the tube was exposed to temperature above 750 F for an extended period. • the thermal spray coating was spalled from roughly half the tube surface and the carbon steel showed corrosion thinning <p>Tube scaling can cause elevated metal temperatures as it impedes heat transfer to the boiler water. The adjacent primary air port was also observed to be blinded over which may have resulted in air conditions that contribute to thermal cycling.</p> <p>The boiler crotch plates were inspected 15 months prior for cracks, actions were taken to repair or prevent growth of cracks in proximity of a tube or crotch plate fillet weld. Damage mechanisms such as thermal and mechanical fatigue cracking can occur in components known to be affected by thermal and/or mechanical cycling. Fatigue crack damage has a time aspect to it, the more cycles increase the probability of initiation. Rates of fatigue crack growth typically vary over time. Cracks may be found by examination but cannot be 'inspected out' since they may initiate any time after examination of the part.</p>
<p>Causes and contributing factors</p>	<p>It is highly likely that the tube failure occurred because of a thermal fatigue crack that traveled across the attachment weld and into the tube. Heavy Scale inside tube contributed to the failure by causing elevated metal temperatures.</p>

© Photos courtesy of equipment owner



Typical Port opening and "crotch" plate



Leak identified during hydro test



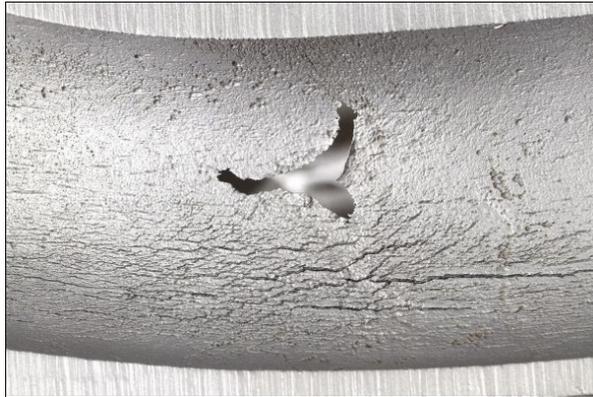
Leak with crotch plate removed



Crotch plate intact



Boiler tube after indication was ground out.
The crack was through wall.



Failure location after cleaning.