

## Incident Summary #II-747636-2018 (#8333) (FINAL)

SUPPORTING INFORMATION	Incident Date	August 23, 2018	
	Location	Cranbrook, BC	
	Regulated industry sector	Boilers, PV & refrigeration - Refrigeration system	
	Impact	Qty injuries	0
		Injury description	None
		Injury rating	None
	Damage	Damage description	Cross-contamination between ammonia and brine side of a chiller vessel (tube leak)
		Damage rating	Major
	Incident rating	Major	
Incident overview	Contamination occurred between the ammonia (shell side) and brine (tube side) of the shell and tube brine chiller, Figure 1. The presence of ammonia was detected in the brine by sensory evaluation (smell) while troubleshooting start-up issues. The plant was shut down and emergency actions were taken to remove ammonia from the system.		
INVESTIGATION CONCLUSIONS	Site, system and components	Shell and tube exchanger section of a skating rink refrigeration system. Under normal operation the ammonia and brine systems are separate. Heat is extracted from brine in the tubes and transferred to liquid ammonia on the shell side via tube surfaces within the chiller. Heat extraction is controlled by the operating pressure on the ammonia/shell side of the chiller and the flow rate of the brine within the tubes.	
	Failure scenario(s)	Physical contact occurred between the brine and ammonia. Ammonia migrated into the brine and brine migrated into the ammonia. The migration occurred through a breach in the tube material.	
	Facts and evidence	<p>Summary of facts and findings from analysis of evidence:</p> <ul style="list-style-type: none"> <li>- The chiller was 19 years old at the time of failure.</li> <li>- Brine was used as the secondary coolant.</li> <li>- Hydrostatic testing detected two leaking tubes.</li> <li>- Analysis of the tubes detected areas of incomplete fusion along weld seams and corrosion, Figures 3 - 6. This deficiency could allow fluid transfer through the tube walls allowing brine and ammonia to mix.</li> <li>- A jacket (an article of clothing) was discovered inside the chiller vessel resting against the tube sheet on the inlet side of the first pass chiller, Figure 2. The jacket partially blocked the flow of brine into the chiller, which may have disrupted flow dynamics and pressure differentials between the ammonia and brine during start up.</li> </ul> <p>The chiller was 19 years old at the time of failure. Mechanisms of failure in heat exchangers such as corrosion are cumulative and the risk of failure increases with age. Weld deficiencies such as fusion defects increase the likelihood of failure in the chiller tubes. Incomplete weld fusion creates a crevice where the rate of corrosion can increase and cause premature cracking through the tube wall.</p>	

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### Causes and contributing factors

The presence of weld defects and chiller age likely caused the tube leak failure. It is possible that flow disruption due to the jacket blocking some brine tubes may have created conditions that also increased the rate of corrosion within the chiller.

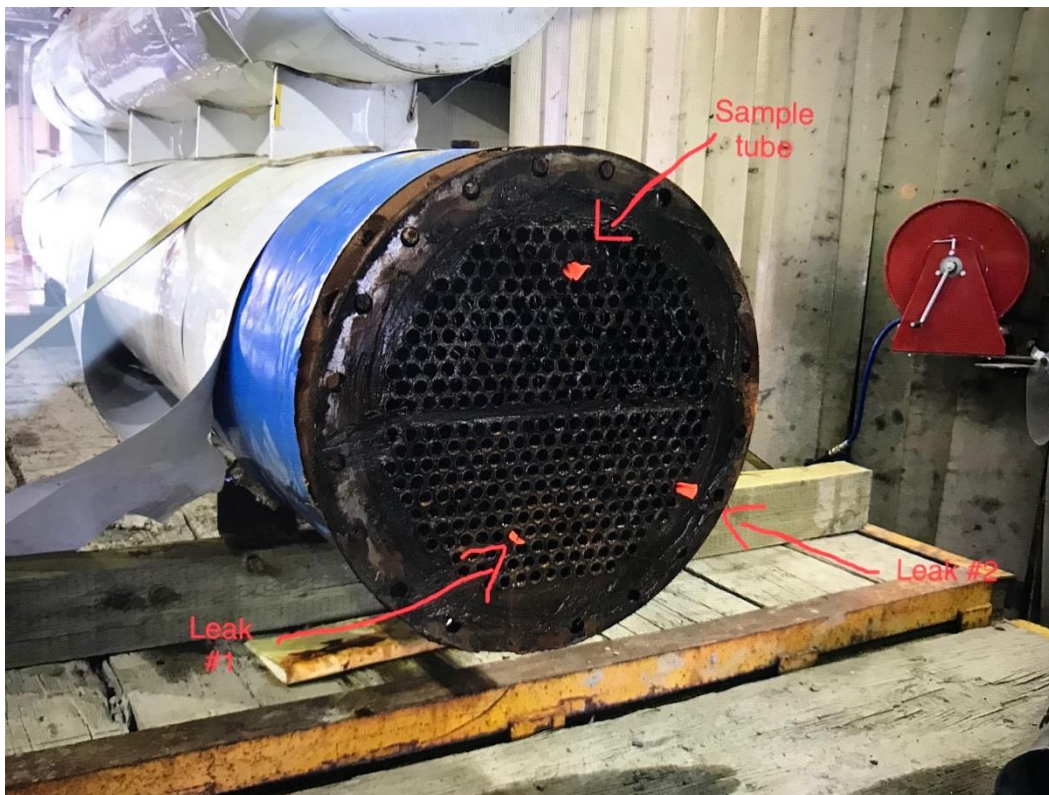


Figure 1: Chiller partially disassembled to examine brine tubes, two tubes found to have leaks.

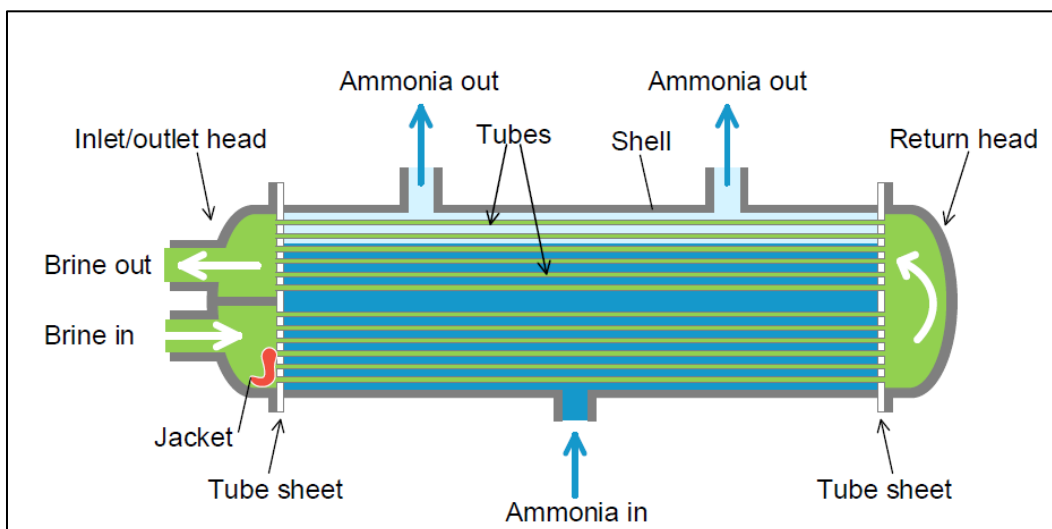


Figure 2: Diagram showing the approximate position of the jacket in the chiller vessel



Figure 3: Tube being removed for analysis

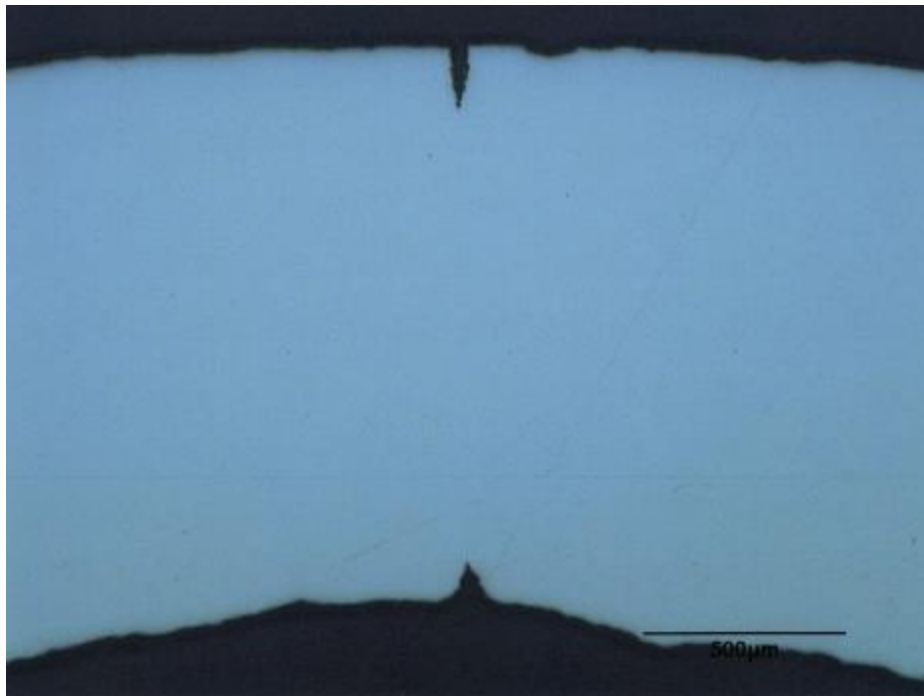


Figure 4: View of tube cross-section showing cracks initiating on the outside and inside wall along weld line.



Figure 5: Cracks along the weld line on the outside wall of the tube.

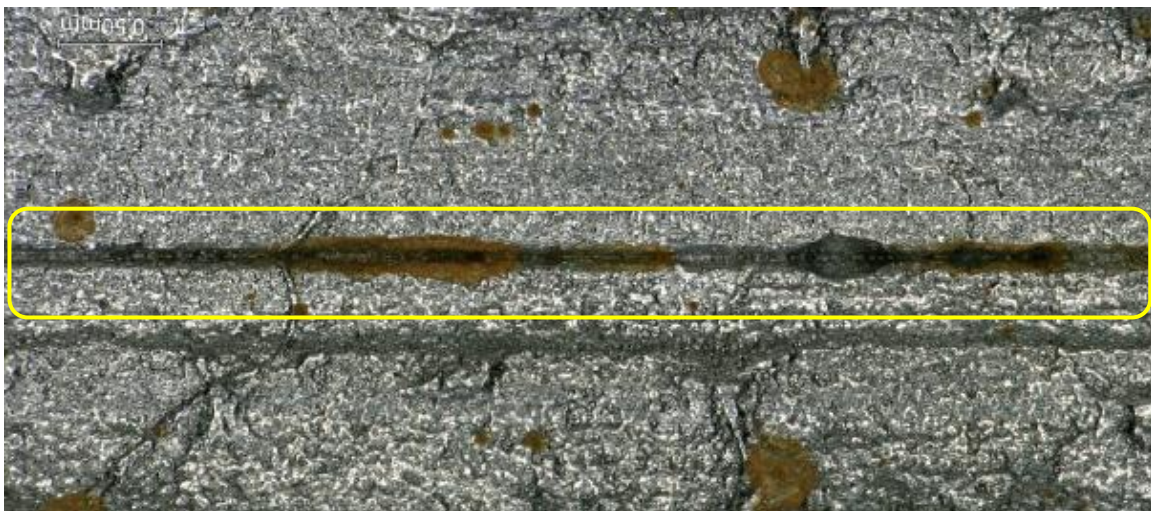


Figure 6: Weld fusion line defect found on the inside wall of the tube.