Incident Summary #II-1097148-2020 (#19770) (FINAL)

SUPPORTING INFORMATION	Incident Date		October 22, 2020
	Location		Prince George, BC
	Regulated industry sector		Boilers, PV & Refrigeration - Boiler and pressure vessel system
	Impact – Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Impact – Damage	Damage description	Cracks propagated through the pressure boundary of two vertical machine mounted air receiver heads.
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		Two newly manufactured vertical machine mounted air receivers used for instrument air processes were installed at a wood treatment facility in November of 2020 by a licensed contractor. During a scheduled maintenance service after 8 months of operation, cracks were located on the top head of each vessel specifically at the head-to-bracket weld fillet welds. The cracking was in similar areas on both vessel heads being at the toe of the weld transverse to the weld start location. The facility Operations Dept. employees safely shutdown the equipment and removed them from service.
INVESTIGATION CONCLUSIONS	Site, system and components		The site is an industrial wood treating facility. As part of the wood treatment process, the site utilizes compressed air to operate valves and instrumentation. The air is compressed by utilizing vertical machine mounted air receivers which are packaged units containing a pressure vessel with a compressor assembly attached to a top bracket welded to the vessel head. Under normal operating conditions, the site utilizes air in cycles as part of the treating process. To help handle the air demand during a treatment cycle, the two new air receivers were introduced to the process. The pressure vessel component is typically constructed in accordance with American Society of Mechanical Engineers (ASME) requirements. Manufacturers who specialize in air receivers will construct many of these vessels in an assembly line process.

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	Corrosion fatigue is a form of fatigue cracking in which cracks develop under the combined effects of cyclic loading and corrosion. Cracking often initiates at a stress concentration such as a pit in the surface. Cracking can initiate at multiple sites and affects all metals and alloys. Crack initiation typically occurs at stress concentration locations such as corrosion pits, notches, surface defects, changes in section, or welds, especially fillet welds.
Failure scenario(s)	The new air receivers were installed by a licensed contractor in site locations indicated by the owner. The flooring was concrete, and no vibration isolation pads were installed under the units as recommended by the manufacturer. The support legs were installed tightly to the concrete floor not allowing room for movement. The facility operates 24 hours hrs/day, 7 days a week. The equipment has a duty cycle of 80%, and it was operating at the high end of its duty cycle limits resulting in many starts/stops on the equipment. Approximately 140-180 cycles per 24-hour period were reported. Because the air receivers operate at a high duty cycle, being installed without vibration isolation pads caused excessive stress at the toe of the fillet welds causing cracks to develop.
Facts and evidence	National Board of Pressure Vessel Inspectors provides an online guide which details common problems with air receivers and states: *“Air receivers with integrally mounted compressors and motors should be installed as recommended by the manufacturer. Since there is usually some vibration produced by a reciprocating-type compressor/motor unit, many manufacturers provide spring-loaded or elastic compound dampers to mount between the floor and the air receiver base. Vibration caused by an integrally mounted compressor/motor unit can cause cracking in the welds attaching the compressor/motor mount to the air receiver or in the welds attaching the base to the bottom of the air receiver. If they occur, the cracks will often "run" or propagate into the vessel material. Vibration damage can also occur where rigid piping is connected to the air receiver.”* A high stress point exists on the equipment at the bracket-to-shell weld configuration which is where the failure happened. A high stress point at the toe of the fillet weld exists in this configuration as indicated in the American Petroleum Institute’s Recommended Practice *API 579, Damage Mechanisms.* The manufacturer’s Operation & Servicing Manual captures installation requirements and recommends that optional vibration isolator pads be installed under the footings, and tanks bolted directly to a concrete floor will not be warranted against cracking. It further mentions that undesirable stress will result if anchor screw/nuts are tightened down completely which can cause cracking.

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	Failure analysis of the two pressure vessels was conducted by an independent laboratory and a report was produced (Appendix A). The analysis found no trace of pre-existing metallurgical or weld defects at the fracture, no evidence of was found to suggest that the fatigue failed initiation was cause by cold or wrong or inappropriate base metal or welding material. The analysis concluded that the fatigue failures of the air receivers was caused by cyclically applied stresses at the start point of the fillet weld toes in the base metal.
Causes and contributing factors	Due to over-tightening of the anchor bolts and the lack of vibration isolation between the foot support and the concrete floor, it is very likely that both failures were due to corrosion fatigue caused by cyclically applied stresses at the weld start location of the fillet weld toe in the base metal. The higher number of cycles per day were a contributing factor.

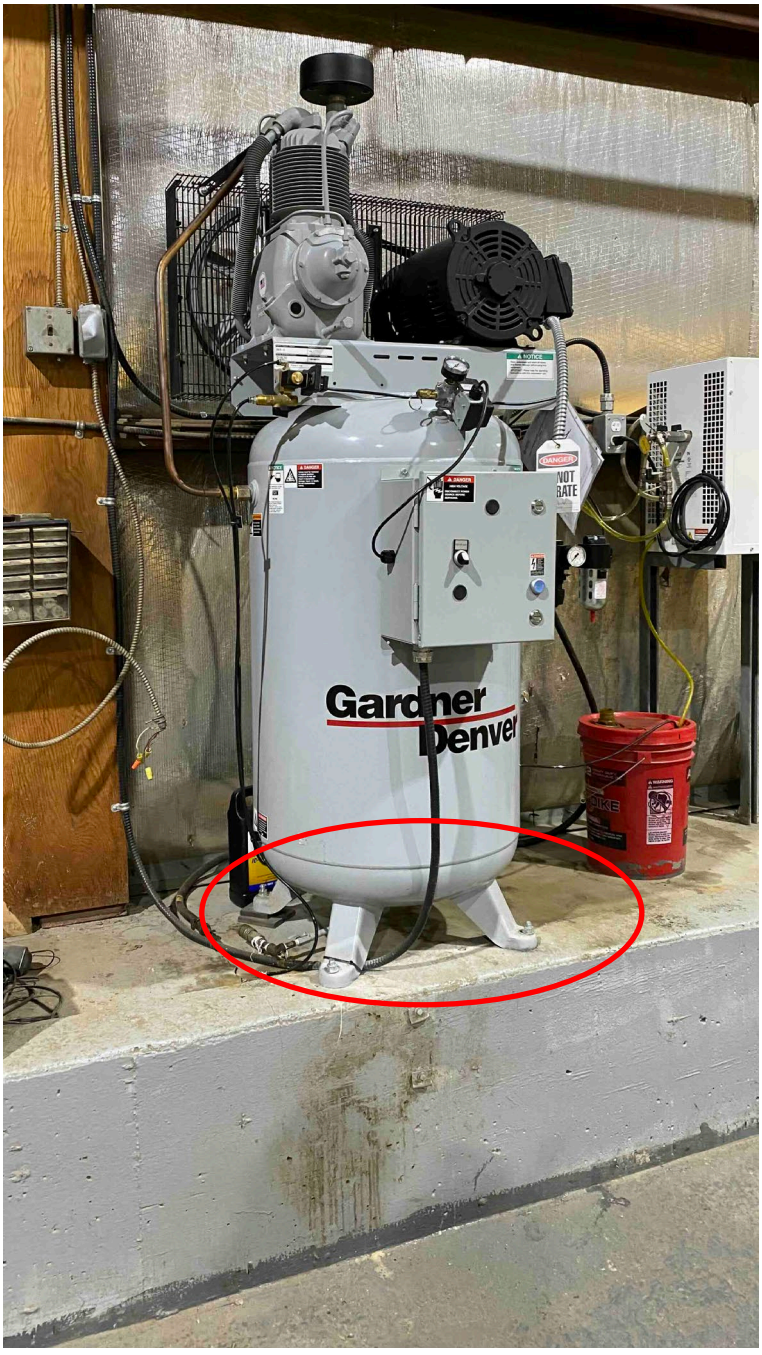

Photo 1

Photo 2

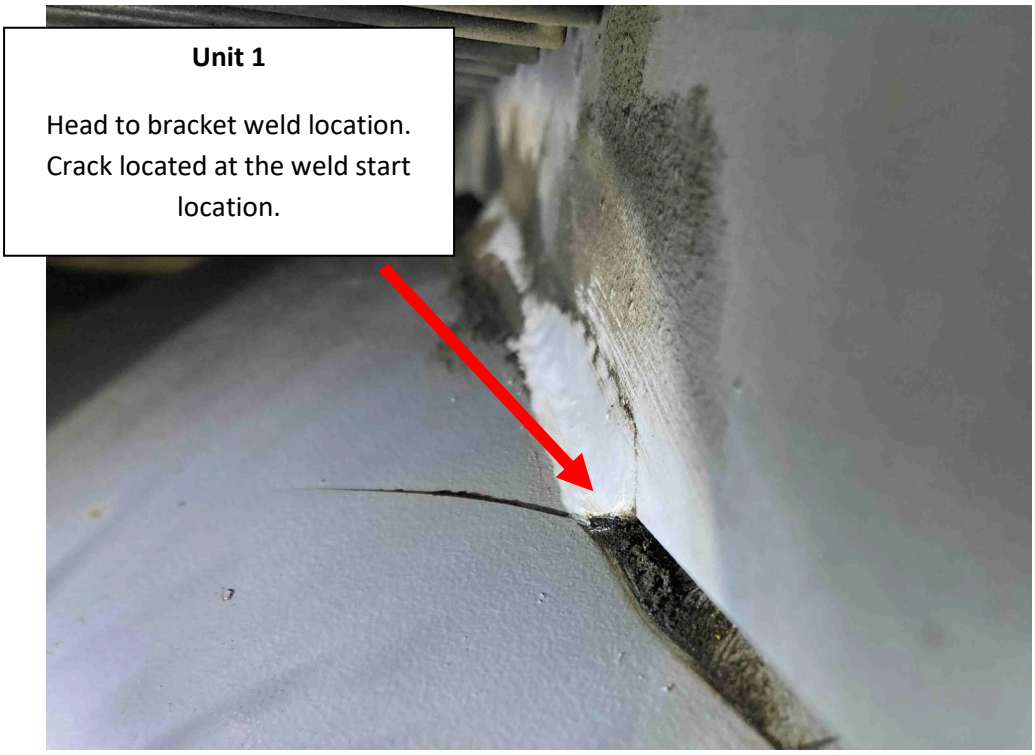

Photo 3: Pressure Vessel Head - Compressor Support Bracket

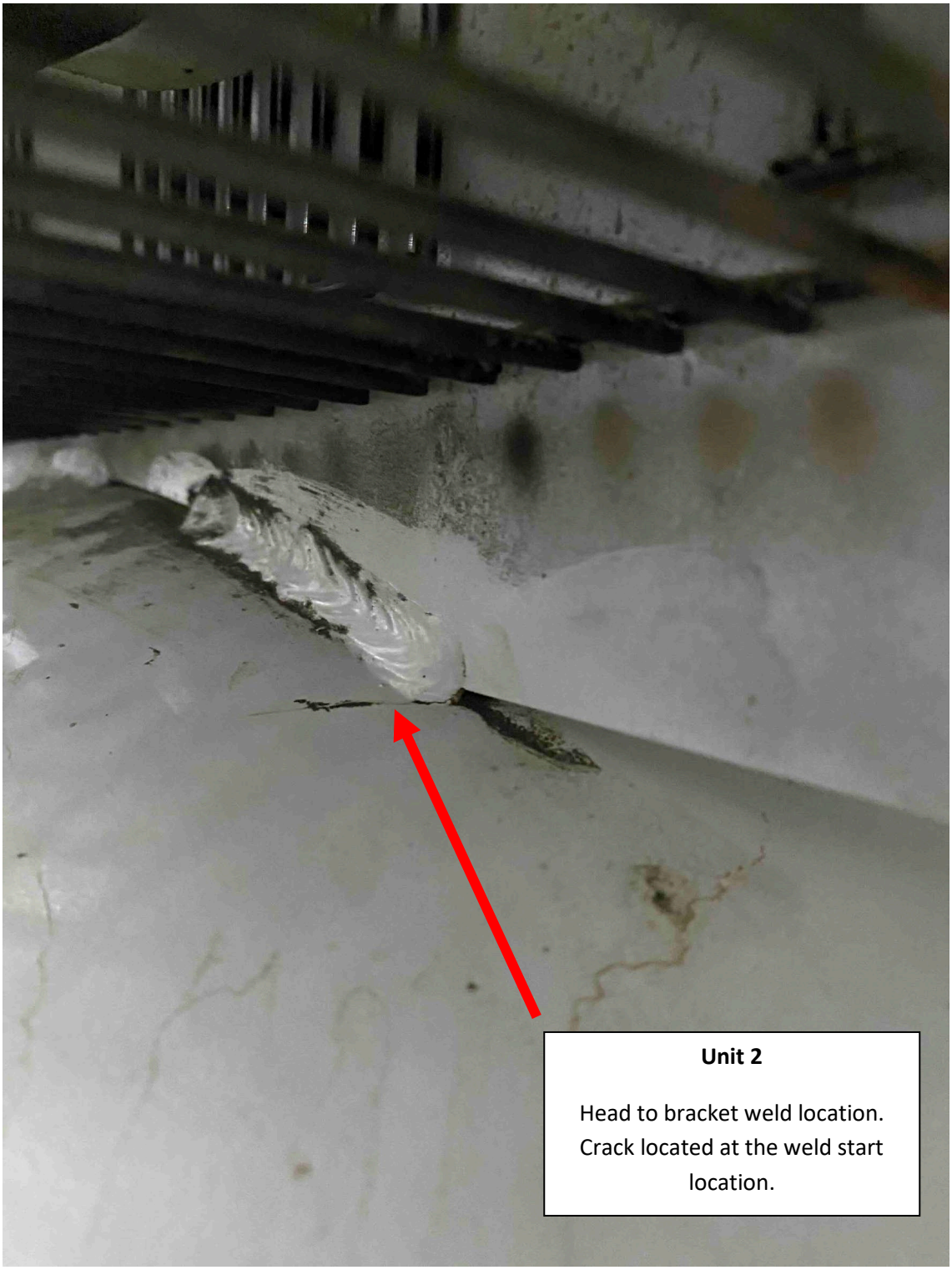

Photo 4: Pressure Vessel Head - Compressor Support Bracket