Incident Summary #II-1385649-2022 (#28171) (FINAL)

SUPPORTING INFORMATION	Incident Date		June 2, 2022
	Location		Vancouver BC
	Regulated industry sector		Boilers, PV & refrigeration - Refrigeration system
	Impact – Injury	Qty injuries	13
		Injury description	13 people had some mild exposure to the (Ammonia) NH3 gases eyes and experienced varying eyes and respiratory discomfort.
		Injury rating	Moderate
	Impact – Damage	Damage description	No physical equipment damages, approximately 600 pounds (272 kgs.) of ammonia was released into the atmosphere.
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		One ammonia safety relief valve in the refrigeration system of a community centre ice rink opened and released approximately 600 pounds (272 kgs.) of the ammonia through the vent stack into the atmosphere. The community centre and the neighboring high school were evacuated and 13 people outside the community centre were examined by the emergency medical services personnel and released.
INVESTIGATION CONCLUSIONS	Site, system and components		In this community ice rink, an ammonia refrigeration system is used to cool a calcium chloride solution (Brine) that is then pumped through the ice rink underfloor piping or tubing, this cools the rink ice to a suitable temperature for skating. The ammonia refrigeration system is contained within the machinery room that is separated from the ice rink and only accessed by the authorized facility staff, a secondary refrigerant, (the brine) is cooled to approximately 15 Deg. F (minus 10 Deg. Celsius) in a chiller which is a shell and tube heat exchanger (Image 1). The brine being a non-toxic fluid is circulated (pumped) out of the machinery room through the under- floor piping and cools the water into ice and maintains the ice at a cold temperature. The refrigeration system ammonia is contained within pressure piping and pressure vessels, the pressure vessels are designed to a maximum allowable working pressure and the system pressure is controlled by running the compressor(s) and maintaining a selected ammonia vapour condensation temperature. If the system over-pressurizes by control system malfunction or equipment mis-operation, the system is protected by safety valves on various vessels that will open and discharge ammonia to the atmosphere through a vent discharge stack (Image 7) and reduce the system pressure to a safer pressure. Contractors have been trained in this facility's Standard Operating Procedures (SOP's). The facility staff typically only energize and de-energize the electrical motors and rely on the contractors to ensure that the mechanical system is safe to work on.

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Failure scenario(s)	This ammonia refrigeration system for the ice rink had been shutdown, the full ammonia charge (of 800 pounds, 362.8 kgs) was being stored in the chiller, attached surge vessel and the oil pot. Three days prior to the incident a contractor was doing maintenance on the brine system to install a pH sensor in the brine pump discharge piping upstream of the pump's discharge isolator (Image 4). When the job was finished the contractor had only partially de-isolated the equipment, leaving the brine pump suction valve closed, tagged, and locked off (Image 2 and 3). On the day of the incident the facility staff started the brine pump as part of the Preventative Maintenance (PM) schedule and was unaware that the pump suction valve was still in the closed position. After 4 hours with the pump running, the brine fluid temperature increased to 111 Deg. F (44 Deg. C) this raised the liquid ammonia temperature that was stored in the chiller. The increase in temperature caused an increase in the ammonia systems pressure to thepoint the safety valve on the oil pot (Image 5) opened at 250 pounds per square inch(psi) discharging ammonia into the vent stack and to the outside air (Image 7). The oil pot safety valve was the first and only safety valve to open. The system pressure forced ammonia liquid out of the chiller, through the oil pot connected to it, and into the vent stack. This reduced pressure in the vent stack when the ammonia liquid vaporized as it absorbed heat and changed to a vapor as it moved upward and exited the vent stack. When the cooler ammonia gas mixed with the surrounding air, the ammonia cloud dropped down to the ground level, instead of rising upward as expected on a warm day. The ground level ammonia cloud then entered the machinery room through open louvres of the machinery room ventilation intake. The ammonia leak detectors in the machinery room were activated which started the machinery room exhaust fan that increased the amount of ammonia entering the room through the ventilation intake louvres.

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Facts and evidence	Interview Statements: • The ammonia system was shutdown for the dry floor season, and the ammonia charge is stored in the chiller and surge vessel. • A contractor was doing maintenance on the brine system 3 days before the incident to install a pH sensor in the pump discharge piping before the pump discharge valve. • The contractor was responsible for isolating the equipment they were working on, but only partially de-isolated the equipment, leaving the pump suction valve closed tagged and locked out. • On June 2, the ice facility operator started the brine system, as part of the non-running pump preventative maintenance program. The closed pump suction valve was not noticed when the pumps were started. • The brine pumps ran for approximately 4 hours with no brine flowing in the system. • With the suction valve in the closed position the pump ran with no flow, and the brine fluid temperature rose to 111 Deg. F (44 Deg C). • After the 4 hours the warm brine raised the ammonia liquid stored in the chiller vessel which also raised the ammonia pressure to the relief valve set pressure of 250 psi (1723.7 kPa). • The oil pot safety valve lifted first, the oil pot also connects to the chiller sump and the liquid ammonia was pushed out of the chiller through the open relief valve to the vent stack located above the machinery room by the evaporative condenser. • The stack sensor alarmed and notified the monitoring company that notified the plant staff by phone at 14:06 • The machinery room vestibule monitor was checked, and the vent stack sensor reading was reading 10,000 ppm. • The machinery room sensors were reading 0 ppm, so entry was made. • The oil pot safety valve discharge piping was frosting up, indicating ammonia was flowing to the vent stack. It was noticed that the brine pump was operating but making an unusualsound and was shut down. • An attempt was made to view the vent stack and the windsock but when the east outside door was opened a strong smell of ammonia was observed, and the door immediately closed. • An order to evacuate the community centre was given. • The wind direction at the incident time was blowing from the northwest going to the southeast verified by sight from the northeast side of the community centre. • A warning was communicated to people using the field southeast of the community centre to leave the area. • The ammonia liquid discharging from the safety valve was flashing into a vapour inside the vent discharge piping, during this change from liquid to vapour the temperature drops and the liquid /gas mixture that leaves the top of the vent stack can be denser than the surrounding air and proceeded to drop to the ground instead of rising as would have been expected on a warm day. • The ammonia vapour entered the machinery room through the air intake louvres located at ground level below the discharge vent stack.

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	• This activated the ammonia leak sensors that initiated the room ventilation exhaust fan, this increased the amount of ammonia entering the machinery room by pulling it in through the machinery room air intake louvres. • The machinery room was vacated while the ammonia sensors were readinga high ppm in the room. • Plant staff called The Fire Department & Hazmat crew, who responded with mobile EMS personnel. • The staff proceeded to evacuate the community center • The Killarney High School located adjacent to the community centre was also evacuated. • Once the ammonia charge volume was reduced enough the safety relief valve closed the machinery room was cleared of vapour by the room exhaustsystem • 13 people outside of the community center were looked at by the EMS personnel and released.
Causes and contributing factors	The starting of the brine system with the pump suction valve in the closed position caused the incident by allowed the liquid ammonia contained in the chiller to increase in temperature and pressure causing the safety valve to open and relieve the pressure by releasing the ammonia to the atmosphere. Contributing factors to this incident include: • The contractor responsible for isolating / de-isolating the equipment, did not leave a service report or communicate with the facility operator when they left the facility. • The facility staff assumed the equipment was ready for service. • The operations personnel started the brine pump without making a complete operational assessment prior to running the pump.

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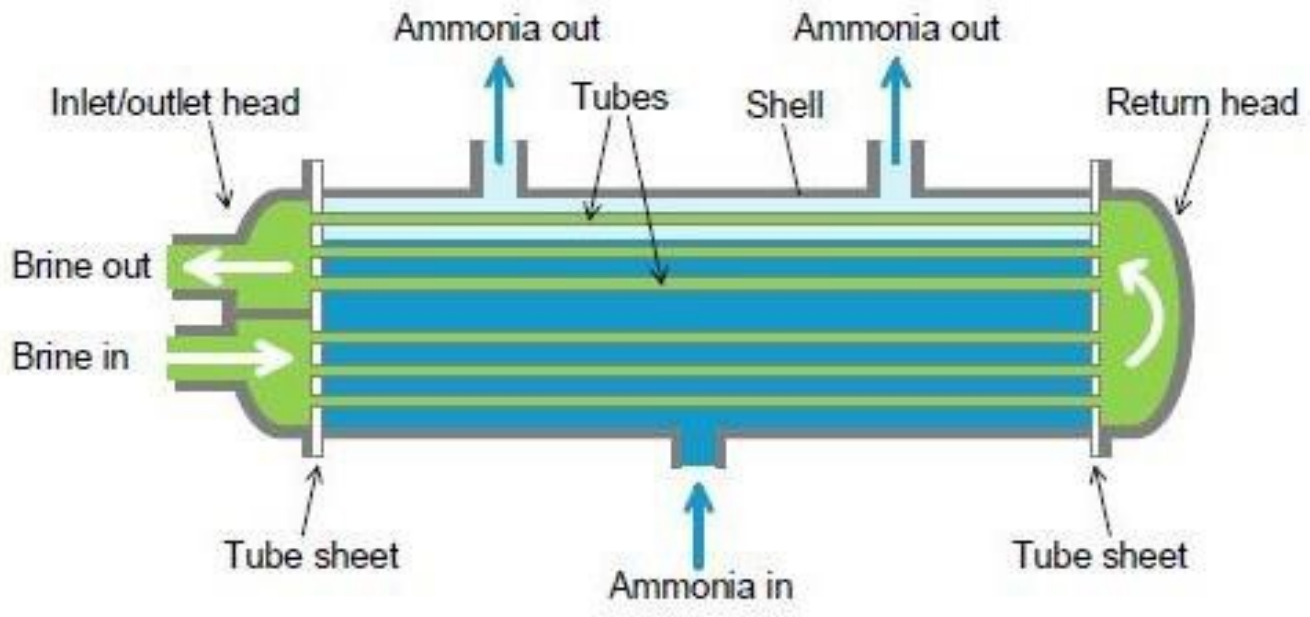

Image 1 – Diagram of typical brine chiller.

Image 2 - Brine pump discharge valve with scissor clip and lock (open position).

Image 3 - Brine pump suction valve with scissor clip and lock, (Closed position) as found after incident.

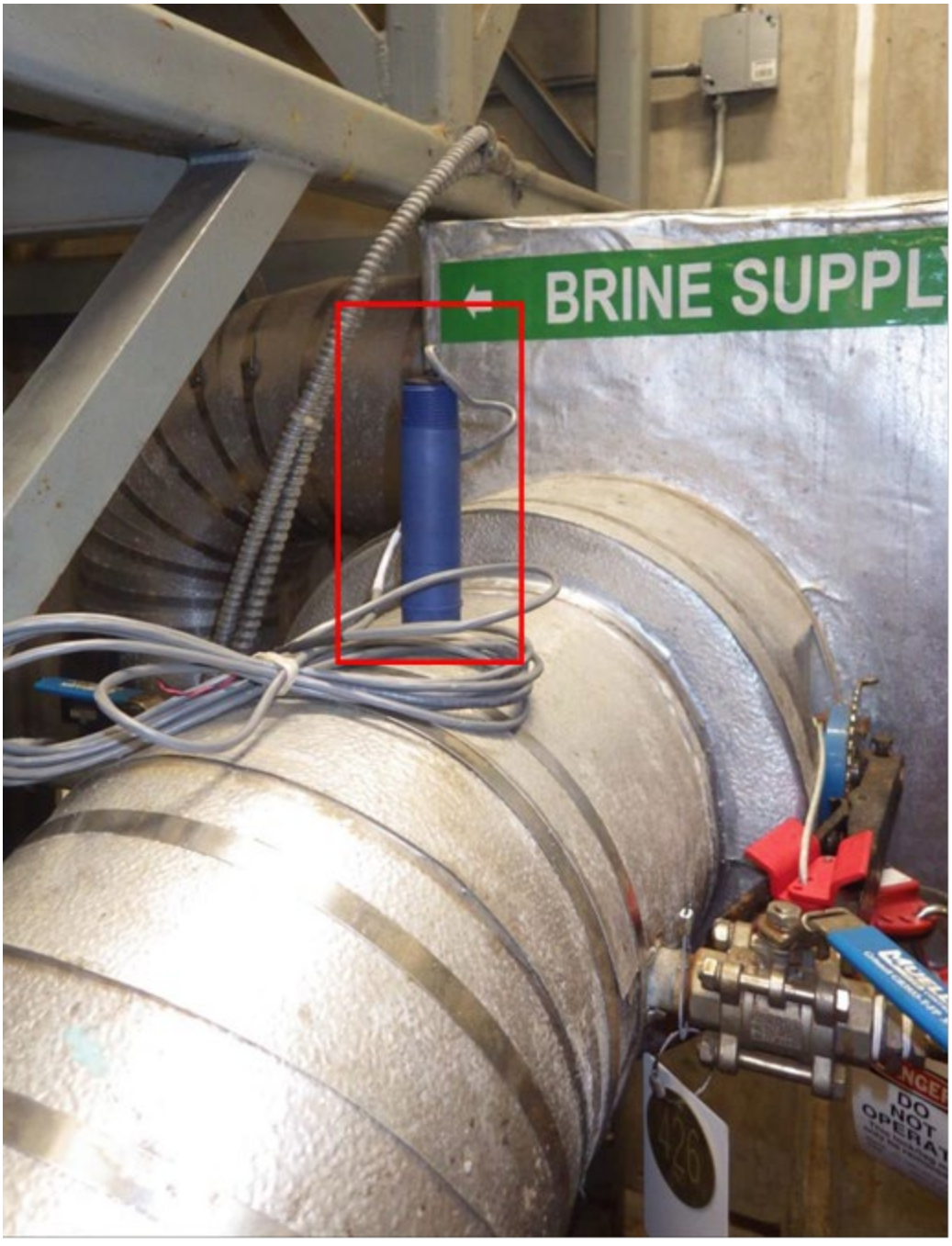

Image 4 – Red box showing newly installed pH sensor in the brine discharge piping.

Image 5 - Oil pot located on the machinery room floor beside the chiller.

Image 6 - Oil pot and the attached safety valve, the one that opened discharging liquid ammonia to the outsidevent stack.

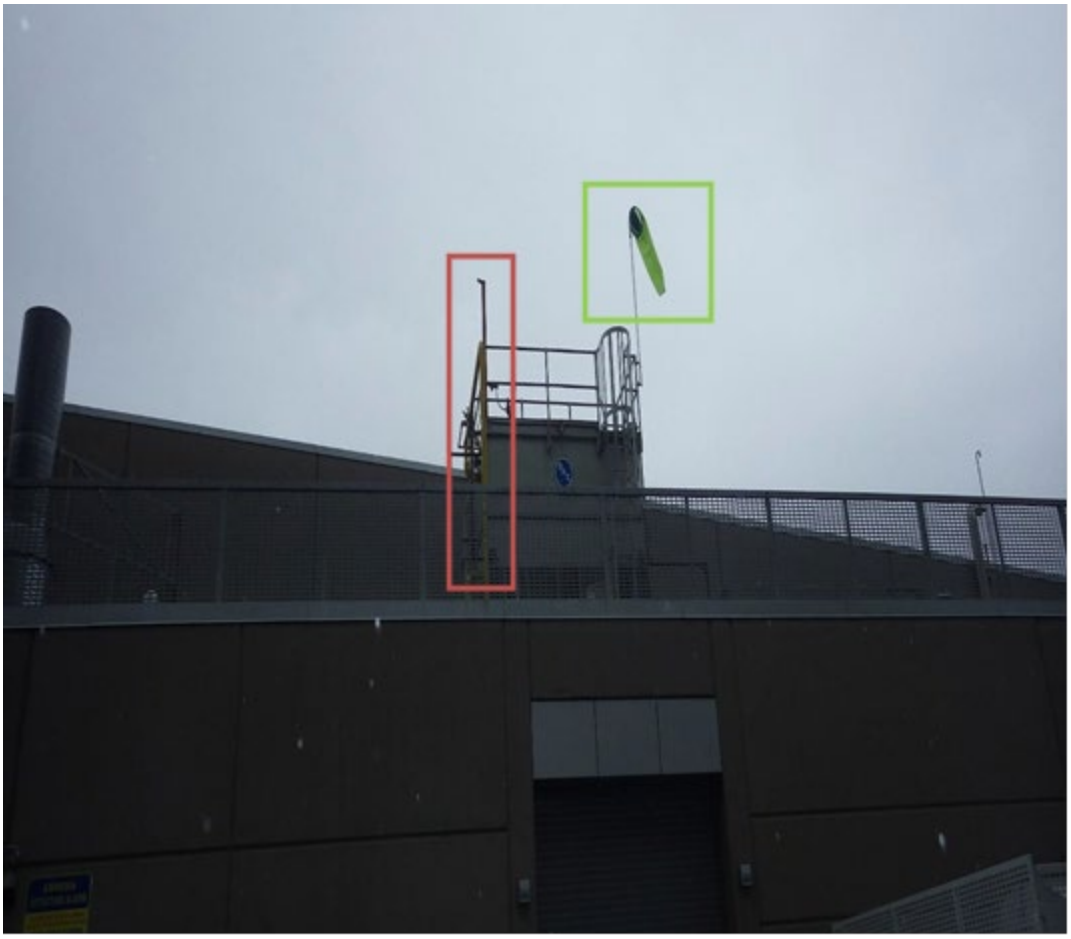

Image 7 - Vent stack and windsock located by the rooftop evaporative condenser. Red box shows theammonia vent stack and the green box shows the windsock.

Image 8 - Red box showing air intake to this machinery room which ammonia entered during the release.