## TECHNICAL SAFETY BC
## JURISDICTION AND ROLE

Technical Safety BC oversees the safe installation and operation of technical systems and equipment throughout British Columbia, including of boilers, pressure vessels and refrigeration units.

The role of Technical Safety BC with respect to incident investigation is to understand relationships between incidents, equipment and work that are subject to the *Safety Standards Act*. Technical Safety BC's investigations aim to learn what happened in order to inform efforts to prevent the recurrence of similar incidents.

Technical Safety BC conducted a thorough investigation into the ammonia-release incident at Fernie Memorial Arena on October 17, 2017 to determine cause and provide recommendations to improve refrigeration system safety. Findings and recommendations are included in Technical Safety BC's Investigation Report, released July 25, 2018.

## INVESTIGATION DETAILS

**Investigation timing:** October 2017 – July 2018

**Key items Technical Safety BC reviewed and/or tested:**

- factors that caused and contributed to the ammonia release
- factors that contributed to the impact of the incident following the release
- refrigeration system and components at arena
- organizational and operational decisions that may have contributed to equipment failure
- ammonia detection, alarm, ventilation and discharge systems

## REFRIGERANT HAZARDS

The health and environmental hazards associated with refrigerants such as ammonia are controlled by proper containment, storage and management of the chemicals. Health hazards depend upon the type of exposure, and can range from mild and temporary discomfort to irreversible and serious damage to exposed tissues to death.

## INCIDENT BACKGROUND

The refrigeration system at the Fernie Memorial Arena was typical of many systems in BC. One refrigeration system provided cooling for two coolant systems: one cooled the arena floor, and the other cooled the curling rink floor. The ice floor was cooled by a brine solution (green system in diagram) kept cold by circulating it through a heat exchanger, where liquid refrigerant (blue) chilled the brine solution. The heat exchanger is commonly called a "chiller" and the refrigerant used at the Fernie Memorial Arena was ammonia.

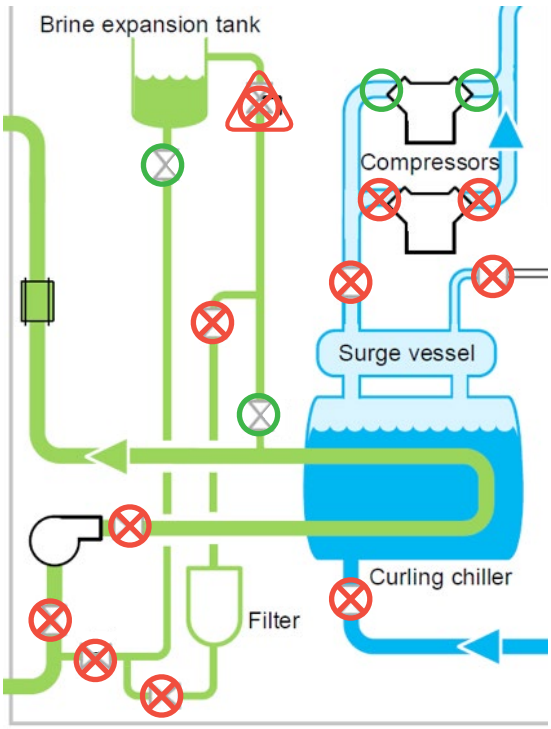


**Diagram:** Valve positions found resulted with liquid ammonia contained in the leaking chiller and no pressure relief in the brine system.

CLOSED  EFFECTIVELY CLOSED  OPEN

## INCIDENT

**April/May 2017:**
During seasonal maintenance, ammonia was detected in the curling brine system, indicating a leak. The Technical Safety BC investigation later found that ammonia had leaked into the brine through a small 2.2mm by 0.2mm hole in a tube within the curling system chiller (* in diagram).

**Summer 2017:**
Curling system remained shut down.

**August 2017:**
Ammonia system and arena brine system started for the upcoming season

**October 16, 2017:**
Curling system returned to operation. Ammonia leaks into brine and releases from the brine into the mechanical room through the brine expansion tanks.

**October 17, 2017, 3:53 a.m.:**
Ammonia alarm in the arena's mechanical room triggered. The brine system and curling chiller are isolated and the refrigeration and brine system shut down (at points marked X). Shut-down configuration isolated liquid ammonia within the chiller and isolated the brine system so that expansion and ventilation of brine was impeded. Ammonia continues to leak into the brine. Ammonia concentration increases in the brine. Brine and chiller temperature rise, leading to elevated pressure within the brine system and chiller.

**…9:15 a.m. – 9:38 a.m.:**
Rising pressure within the brine system eventually exceeds the strength of a pipe joint and a coupling separates within the mechanical room. The coupling's separation suddenly depressurizes the brine system and causes ammonia in the brine and piping to rapidly release into the mechanical room. As ammonia releases, it quickly expands in the room, reaching estimated concentrations above levels that are considered to be rapidly fatal.

**…9:40 a.m. – 1:20 p.m.:**
Ammonia odour reported from nearby areas of the community.

## INCIDENT CONCLUSIONS

1 The equipment failure was caused by a small hole in the curling chiller carbon steel tube resulting from corrosion at a weld seam. Contributing to this failure and the release of ammonia was the:

- chiller age and corrosive potential of the chemicals and materials used;
- presence of tube weld seam fusion defects;
- isolation of the curling brine expansion tank;
- isolation of liquid ammonia within the leaking chiller; and
- unsupported coupling joints on the brine system pipe.

2 The incident was caused by a decision to operate the leaking curling chiller. Contributing to this decision was a failure to replace the aging chiller after it surpassed its recommended operational life-span. The decision and failure to replace the chiller may have been influenced by:

- insufficient hazard awareness relating to leaking chillers and aging equipment;
- omission of component end-of-life strategies from the maintenance plan;
- employee turnover;
- competing organizational and departmental priorities; and
- organizational design of the leisure services department.

3 With the examination of the detection, alarm, ventilation and discharge systems, Technical Safety BC concludes:

- the ventilation system could not have prevented a high concentration of ammonia in the mechanical room;
- fan location and condition contributed to ineffective ventilation after the release;
- fan exhaust location and airflow may have directed ammonia toward building openings;
- mechanical room doors presented a path for ammonia to enter arena public areas; and
- the emergency discharge did not reduce the risk or amount of ammonia leakage into the mechanical room while introducing exposure risk.

## RECOMMENDATIONS

Technical Safety BC has identified 18 recommendations aimed at preventing a similar occurrence. These recommendations seek improvements to:

- owner maintenance programs and organizational design;
- identification of leak hazards and professional disclosure of such hazards;
- training of owners representatives, operators and mechanics;
- secondary coolant system configuration and construction in anticipation of refrigerant leaks; and,
- public transparency and a culture of openness around technical systems.

Additional recommendations are made to improve ventilation system requirements and emergency discharge considerations to reduce the potentially harmful effects following a refrigerant release.

*Technical Safety BC will take a leadership role working with industry and other agencies to advance recommendations and implement safety improvements for ice rink refrigeration systems across British Columbia.*

## ACTIONS PARALLEL TO INVESTIGATION

While the investigation into the incident was ongoing, Technical Safety BC took the following actions:

- Issued a safety order on November 29, 2017 that required owners of ammonia refrigeration plants to test secondary coolants for the presence of ammonia and report the results. All 185 facilities in British Columbia have fulfilled the obligations contained in the safety order and are in compliance.

- Dedicated additional resources to inspect ammonia ice and curling rinks in the province of British Columbia. Technical Safety BC completed physical inspections of 95% of ice rink refrigeration sites prior to July 2018, with the remaining ones to be inspected in the coming weeks.

## FURTHER INFORMATION

Please visit: www.technicalsafetybc.ca