Ontario Recreation Facilities Association

Building Community Since 1947

Technical Safety BC – Investigation Report Ammonia Release – Fernie Memorial Arena, October 17, 2017

ORFA Commentary on Ontario-related Legislation, Regulations, and Registered Refrigeration Plant Operational Best Practices

VERSION 1.0

ISSUE DATE: AUGUST 2018

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INCIDENT OVERVIEW

On October 16, 2017, the curling brine chiller at the Fernie Memorial Arena, BC was put back into operation after a seasonal shutdown. During the shutdown and seasonal maintenance, ammonia had been detected in the curling brine system, indicating that the curling brine chiller was leaking.

At 3:53 a.m. on October 17, 2017, an ammonia alarm in the arena's mechanical room was triggered and the system was shut down. Between 9:15 a.m. and 9:38 a.m., rising pressure contained within the curling brine system led to the separation of a pipe coupling in the mechanical room. Upon separation of the coupling, an estimated 9 lb. of ammonia was rapidly released into the room followed by additional ammonia from the system. The atmosphere in the mechanical room may have reached or exceeded concentrations of 20,000 parts per million (ppm) of ammonia.

Ammonia odour was reported from nearby areas of the community between 9:40 a.m. and 1:20 p.m.. At 12:50 p.m., an electrician discovered a worker in the mechanical room, called 911, removed the person, and performed CPR until the arrival of the fire department.

A total of three people were found deceased in the mechanical room: the director of leisure services, the refrigeration operator, and a refrigeration mechanic.

Responders opened the emergency discharge valve and pressed the emergency stop for the ammonia system located on the exterior wall of the arena at 1:50 p.m.. Opening the discharge valve resulted in an estimated initial release of 55 lb. of ammonia into the atmosphere with approximately 632 lb. of ammonia from the system being slowly released during the subsequent days.

Due to the three fatalities, the ammonia release and the unknown amount of ammonia remaining in the arena on the day of the incident, the City of Fernie issued a local state of emergency and evacuated approximately 55 homes and 95 residents from the surrounding area. The evacuation order remained until October 22, 2017 and the local state of emergency remained in effect until October 24, 2017.

The Ontario Recreation Facilities Association Inc. (ORFA) has reviewed the investigation report produced by Technical Safety British Columbia (the safety authority and governing body for pressure vessels and operating engineers in BC), and offers the following comparative as it relates to Ontario related legislation, regulations, and registered refrigeration plant operational best practices.

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2	*Technical Safety BC*	Counter-part in Ontario: Technical Standards and Safety Authority (TSSA)
2	*Safety Standards Act*	Equivalent in Ontario: Operating Engineers Regulation (OER)
2	*Incidents involving products or work subject to the Act are required to be reported in accordance with Section 36 of the Act.*	OER 47. The user shall notify the chief officer, by telephone or other direct means, as soon as is practicable of any accident, injury or death, but no more than eight hours after the accident, injury or death, as the case may be, and shall within 48 hours after the accident, injury or death, send the chief officer a written report of the occurrence where, (a) a person is seriously injured or killed from any cause; or (b) an accident occurs involving property damage.
2	*The role of Technical Safety BC with respect to the investigation of incidents is to understand relationships between incidents, equipment and work that are subject to the*	The same investigative relationships occur with TSSA: • Fire departments/Office of the Fire Marshal • Electrical Safety Authority

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	Act. It is our aim to learn from these investigations what happened to inform efforts to prevent the recurrence of similar incidents. Often, these investigations are conducted in cooperation with other agencies including fire departments, WorkSafeBC, law enforcement officials, and the Coroners Service.	• Ministry of Environment, Conservation and Parks • Ministry of Labour • Law enforcement officials, and • Office of the Chief Coroner
5	*In October 2010, seven years prior to the incident, the City of Fernie received a recommendation from their maintenance contractor to replace the curling system brine chiller due to its age. Analysis of evidence gathered during the investigation identified a series of key decisions during this seven- year period that contributed to the incident.* *Potential influences of these decisions were identified, including:* *A. facility management and organizational priorities;* *B. failure to include safety risk criteria from aging infrastructure risk assessment;* *C. operational management structure;* *D. employee capacity and turnover;* *E. incomplete maintenance planning; and* *F. an industry practice of run-to-failure or run-past-failure for brine chillers.*	Each of the items outlined in 5 A to F have been identified as Ontario industry issues by the ORFA over the past 20-years. The ORFA has created a series of resources to assist members of the importance to address each contributing factor. Refer to: ORFA Guidelines and Best Practices The ORFA Guidelines and Best Practices have also been blended into the following training courses: Basic Arena Refrigeration, Advanced Refrigeration Facility Operator, Recreation Facility Environmental Systems and Legal Awareness I: Supervising in a Recreation Environment. Further, the opportunity to apply for the ORFA Certified Arena Refrigeration Plant Technician (CARPT) professional designation is provided to those individuals with the required skills and knowledge.
6	*The City of Fernie initially scheduled funding to replace the curling brine chiller for 2013. This funding was deferred to 2014 and then deleted from further financial planning. At the end of the 2016/2017 operating season, an ammonia leak was detected in the curling system, indicating a potential failure of the chiller. A decision was made to monitor the leaking chiller in the summer of 2017, followed by a decision to put the leaking chiller back into operation on October 16, 2017. Available evidence did not indicate that there was an awareness of any safety risk associated with the continued operation of the chiller by any parties involved.*	The ORFA reminds members of the importance of asset management and the tracking of life expectancy of equipment. The Occupational Health and Safety Act (OHSA) gives a worker the right to refuse work that he or she believes is unsafe to himself/ herself or another worker. The Act sets out a specific procedure that must be followed in any work refusal. It is important that workers, employers, supervisors, members of joint health and safety committees (JHSCs) and health and safety representatives understand the procedure for a lawful work refusal.
6	*In addition to analysis of the cause, the investigation also evaluated the role of the ammonia detection, ventilation and discharge*	The ORFA recommends that all members evaluate current refrigeration plant room ammonia detection,

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	systems following the ammonia release. This analysis determined the ventilation system could not have prevented the large concentration of ammonia within the room, and that it may have contributed to the spread of ammonia to other areas of the arena. It was also determined that the deployment and configuration of the emergency discharge system introduced risk while not reducing the amount of ammonia released into the mechanical room.	ventilation and discharge systems and bring equipment up to current standards. Refer to: Canadian Standards Association B52-13 Mechanical Refrigeration Code. The 11th edition of CSA B52 provides minimum requirements for the design, construction, installation, inspection, and maintenance of mechanical refrigeration systems.
7	*The scope of activity undertaken during the investigation included:* *• documentation of the scene;* *• examination of log books, manuals and procedures;* *• integrity inspections, tests and analyses of refrigeration system equipment;* *• operational tests of the ammonia detection and ventilation systems;* *• laboratory analyses of the curling brine chiller, brine system pipe couplings and valves;* *• analysis and simulation of ammonia release and dispersion;* *• interviews of current and past City of Fernie employees and maintenance contractors;* *• examination of email correspondence relating to the Fernie Memorial Arena;* *• examination of budget and financial management between 2010 and the incident date;* *• examination of strategic planning materials related to the arena and asset management;* *• examination of arena work, inspections and service orders between 2010 and the incident date;* *• evaluation of the organizational structure, turnover and management incentives at the City of Fernie;* *• examination of industry asset management planning materials;* *• evaluation of qualifications and training materials for refrigeration industry workers;*	The ORFA continues to promote the practical and legal importance of quality record keeping and log book practice. Refer to ORFA log book order form The ORFA reminds owners and chief operators that all testing requirements identified in the list MUST be coordinated by the plant owner, or operator, as they are not automatically scheduled by the plant service provider. OER 45. (3) A refrigeration installation referred to in subsection (1) that is located in a machinery room, as defined by CAN/CSA-B52, shall be equipped with a gas detector system that will activate the alarm system required by clause (2) (a) and start a mechanical ventilation system if there is a leak of refrigerant causing the airborne concentration of refrigerant to rise above the level value as defined by CAN/CSA-B52. O. Reg. 219/01, s. 45 (3). The ORFA offers two specific tools to assist plant owner/operators with managing the plant room: • Safety Activities For Effective Refrigeration (SAFER); and • Recreation Facilities Asset Management (RFAM)

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	• benchmarking of maintenance practices and industry behaviours at other arenas and service providers.	The ORFA will offer support to TSSA in gathering up to date benchmarking information for our sector.
8	*The potential for corrosion in this type of system results from the chemical reactions between the calcium chloride brine solution and the carbon steel welded tubes. Brine systems of this type are also subject to periodic air ingress that can promote corrosion. Removal of this trapped air from the system is part of regular operation and maintenance. Evidence indicates that a corrosion inhibitor (brinehib) was being added periodically to the brine solution to slow the corrosion process within the system.*	Refer to ORFA Resource: The Importance of Ongoing Monitoring of Secondary Refrigerant Health
15	*Once the brine system coupling separated and relieved the internal pressure, the ammonia in solution and any ammonia in the brine pipe quickly expanded, projecting the contents of the brine pipe outward from the pipe opening. The ammonia quickly vapourized and expanded to fill the mechanical room reaching estimated concentrations exceeding 20,000 ppm.*	The ORFA reminds members of the need to include the dangers of vapourizing ammonia in their in-house plant training manuals.
17	*Technical Safety BC's investigation sought to gain insight into the operational context in which the incident occurred. Correspondence and administration records were examined from the City of Fernie and maintenance contractors and interviews were conducted with key personnel relating to the management of the equipment that failed.*	Key to this point is the need to have all internal staff, managers, and other stakeholders trained to the same level of competency and knowledge base.
17	*Evidence identified a number of potential influences for these decisions. These influences include organizational and departmental priorities, employee turnover, organizational design, ineffective communications, and a lack of hazard awareness associated with leaking chillers and aging equipment.*	The ORFA has been warning that these same types of influences exist in many Ontario refrigeration plant rooms today. The ORFA continues to provide support to and advocate for reduction in these shortcomings.
18	*In 2013, the replacement of the chiller was deferred to 2014 as shown in the 2013-2017 Five-Year Financial Plan deliberation. In 2014, the reference to the curling chiller replacement disappeared from five-year*	The ORFA reminds plant operators of the importance of continually being proactive in the awareness of the condition of their work environment. Frontline staff have the same "Right to Know" as senior management staff of

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	financial/capital spending plans and subsequent years' capital spending plans. The chiller replacement was no longer a budgeted activity, however it remained as an item in various management documents following 2014, including the City's 2014-2018 Corporate Strategic Plan, 2016 Business Plan, and management capital planning worksheet for 2017. In addition, five quotes were requested by the City for chiller replacement between January 2015 and August 2017. Evidence identifies that the chiller replacement deferral from 2013 to 2014 was likely influenced by other priorities for the refrigeration system.	the condition and planned maintenance of the refrigeration plant room.
19	*According to the organizational chart for the City of Fernie and the job description for the director of leisure services, the director was responsible for a wide array of duties which included: leisure services delivery and planning; facility equipment and infrastructure management and planning; and human resources management and planning for the Leisure Services Department.*	The ORFA has recognized the same potential issues within many Ontario refrigeration plant rooms. A recommendation was therefore introduced to encourage every Ontario refrigeration plant room to have a Certified Arena Refrigeration Plant Technician (CARPT) for the purpose to assist managers who may not be directly involved in the day to day operations. Further, the CARPT designation holders would have a working knowledge of the refrigeration plant and work directly with service providers, as well as, assist in training other staff.
20	*A robust maintenance program typically involves a variety of strategies that includes knowledge of wear out or equipment end-of-life.*	Refer to ORFA Resource: Developing a Comprehensive Registered Refrigeration Maintenance Plan
27	*Insufficient equipment emergency procedures and training may have contributed to the decision to isolate the chiller and brine system on the morning of the incident.*	This once again supports the ORFA recommendation that every Ontario refrigeration plant room to have a Certified Arena Refrigeration Plant Technician (CARPT) to assist managers who may not be directly involved in the day to day operations. Further, the CARPT designation holders would have a working knowledge of the refrigeration plant and work directly with service providers, as well as, assist in training other staff.
28	*Ammonia odours were reported in the community close to the time of the incident and firefighters reported measuring 400 ppm of ammonia within the arena lobby during their response. As part of the investigative scope and mandate, Technical Safety BC examined technical systems in place at the Fernie Memorial Arena that are intended to minimize the impact after a release has occurred. In particular,*	Refer to ORFA Resource: Recreation Facility Emergency Planning

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	Technical Safety BC's investigation examined the condition of the alarm and ventilation systems to determine if they contributed to the ammonia concentrations experienced within the mechanical room or the community. In addition, the investigation analyzed the configuration and impact of the emergency discharge system deployed in response to the incident.	
30	*The fan belt on the large fan was discovered to be cracked and in poor condition. When operating, the fan belt was observed to be slipping, resulting in a reduced average fan speed. The reduced ventilation system capacity was measured as being 75% of that required during a leak/ rupture scenario.* *Inspection of the vestibule doors identified a gap under the door between the mechanical room and vestibule. The door between the vestibule and the arena public space did not incorporate a seal at the bottom. The gaps and sealing under the vestibule doors provided a possible leakage path for ammonia from the mechanical room into the arena lobby inconsistent with the B-52 Mechanical Refrigeration Code definition for tight fitting doors.*	The ORFA recommends that members add these items to current operational and maintenance manuals if not already in place.
34 – 41	*Technical Safety BC concludes that 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.* *Technical Safety BC concludes that the incident was caused by a decision to*	Although this report is directed to BC arena refrigeration plant operators, the Fernie Investigation Report outcomes will be included in all future ORFA training materials and resources. Further, ORFA recommends that refrigeration plant owners and/or operators ensure that the Fernie Investigation Report outcomes are included in all internal refrigeration plant operations and maintenance manuals.

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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.*

After examination of the detection, alarm, ventilation and discharge systems, Technical Safety BC concludes the following:

- *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.*

Recommendation 2 to Arena Owners:
Implement a refrigeration system maintenance program that addresses:

- *Wear-out / End-of-Life - utilizes an established maintenance end-of-life strategy;*
- *Resources - organizational resource commitment for significant maintenance activity;*

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• Approval & Accountability - program is approved and monitored by the owner, separate from the responsible manager.

Recommendation 3 to Training Providers:
Add brine testing, analysis and interpretation to the training and qualifications of refrigeration operators, refrigeration mechanics and 4th class power engineers.

Recommendation 4 to Arena Owners:
Provide refrigeration system, maintenance program and worker qualification/skill awareness training to all employees and representatives responsible or involved with approving arena maintenance related activities or expenses.

Recommendation 5 to Training Providers (Refrigeration Operators, Refrigeration Mechanics and 4th Class Power Engineers): *Improve training related to maintenance strategies and maintenance program awareness dealing with component wear-out and condition assessment so that graduates can effectively participate with a comprehensive program.*

Recommendation 7 to Training Providers (Refrigeration Operators and Mechanics): *Develop and implement generically applicable emergency situational guidance that can be taught and posted within mechanical rooms.*
Examples of simple 'SAFE PRACTICE' instructions for consideration:
• DO NOT operate equipment that is suspected to be failed/leaking.
• DO NOT isolate liquid refrigerant within suspected failed/leaking equipment.
• DO NOT isolate secondary coolant systems without pressure relief.

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Recommendation 8 to Refrigeration Maintenance Contractors: *Implement procedures for employees interacting with owners and operators to clearly disclose and refer items that are a cause for concern to refrigeration professionals with the necessary training to provide advice. Maintenance contractors are reminded of their obligation to report hazards that are not known to be addressed by the owner.*

Recommendation 12 to Arena Owners: *Conduct an assessment and test of ventilation systems to evaluate effective internal ventilation of the mechanical room and external discharge in a manner that minimizes risk of exposure.*

Recommendation 16 - to Arena Owners: *Inspect all emergency discharge piping and confirm that routing does not enter any spaces that present a risk to public safety.*

Recommendation 17 - to Training Providers: *Review and amend guidance relating to the operation of an emergency discharge system such that specific scenarios where the benefits outweigh the risks are clearly identified and the necessary information to perform an emergency risk assessment is identified.*

Recommendation 18 – to Local Governments, Arena Owners, and Technical Safety BC: *Make publicly available the following information associated with management and oversight of regulated refrigeration systems at public assembly facilities (such as arenas):*
• refrigeration system maintenance programs for regulated equipment;
• related capital budgeting plans for supporting maintenance programs;
• assessment and audit criteria;
• results of assessments and audits;
• independent recommendations relating to the condition of equipment, including

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	recommendations from maintenance contractors for repair or replacement; and, *• any other information relevant to the assessment, audits and overall safety of the technical equipment and its management programs.*	

Conclusion

The death of three workers at the Fernie Arena in October of 2017 has resulted in a sad legacy of hard lessons, the resolve of which is to do better moving forward to ensure such a tragedy never happens again.

The ORFA has long maintained, and valued, the professional, efficient and competent operation of recreation facilities within the province. The Association will continue to support its members, and continue to strive to produce industry-leading education, value-added services, and quality products to assist in protecting arena workers in Ontario.