

Appendix V: Arena Surveys - Maintenance Programs and Leaking Chillers

Survey of Arena Maintenance Programs

Technical Safety BC reviewed the maintenance programs from a sample of 15 arenas. This review aimed to compare elements of the program presented by the City of Fernie in place at the Fernie Memorial Arena to other similar facilities and equipment.

A review of 15 arena maintenance programs found:

1. 50% of arenas did not have a written maintenance program of any kind.
2. Of the arenas that did possess a written program, 50% of the programs:
 - a. addressed the maintenance requirements detailed in CSA B52-2013 s.8.4
 - b. clearly assigned responsibilities
 - c. scheduled the maintenance activities
3. 73% of arenas were able to produce a service contract with a licensed refrigeration contractor.
4. Owner maintenance programs did not normally plan for equipment service life or replacement. One of fifteen locations had projected service life and had planned for chiller replacement.

The Fernie Memorial Arena possessed a written maintenance program which assigned responsibilities and established service intervals. Fernie Memorial Arena was able to produce a service contract with a licensed refrigeration contractor.

The 15 arena maintenance programs were also reviewed for the following items:

1. Wear-out/Component End-of-life- identification for system and system's components,
2. Resource commitment for end-of-life replacement or condition assessment, and
3. Performance measurement against program objectives.

Table V-1: Arena maintenance program review

Arena	Maintenance Program Criteria		
	Component End of life identification	Resource commitment	Performance measurement
Fernie Memorial Arena	N	N	N
Arena 2	N	N	N
Arena 3	N	N	N
Arena 4	N	N	N
Arena 5	N	N	N
Arena 6	N	N	N
Arena 7	N	N	N
Arena 8	N	N	N
Arena 9	N	N	N
Arena 10	N	N	N
Arena 11	N	N	N
Arena 12	N	N	N
Arena 13	N	N	N
Arena 14	N	N	N
Arena 15	Y	Y	Y
Percent of conformance	6%	6%	6%

Survey of Arenas with Ammonia Detected in Brine

Scope

A survey was taken of 15 ammonia arenas which tested positive for ammonia (NH₃) in the brine. The following questions were asked of the person in charge of the plant:

1. When did they learn of ammonia in the brine?
2. How long have they been operating with ammonia in the brine?
3. What instructions did they seek from their refrigeration contractor?
4. What advice were they provided from their refrigeration contractor?

The survey was conducted at the beginning of 2018, after the Fernie ammonia release incident and after [Safety Order \(SO-BP-2017\)](#) was issued in November 2017 requiring arenas to submit brine testing reports. The intent of the enquiry was to gain an improved understanding of the practices and culture around ammonia in the brine as well as the relationship between the maintenance contractor and the operator.

Summary of Responses

1. When did they learn of ammonia in the brine?

The majority of arenas (11/15) determined the presence of NH₃ in the brine between November 2017 and January 2018. The identification was the result of actions taken to comply with the Ammonia Refrigeration Systems in Public Occupancies Safety Order (SO-BP-2017). Three arenas had identified ammonia between October and November 2017; one had known of the presence since 2014.

2. How long have they been operating with ammonia in the brine?

The majority (11/15) of arenas operated for 1 to 2 months knowing of the presence of NH₃ in the brine. Four arenas were aware of the presence of ammonia in the brine for several months and attributed the concentration to residual amounts present due to previous chiller failure and subsequent replacement.

3. What instructions did they seek from their refrigeration contractor?

Owners consistently sought the services of their licensed refrigeration contractor in order to determine the source of the NH₃ and to identify any potential leak.

4. What advice were they provided from their refrigeration contractor?

Refrigeration contractors consistently recommended performing additional brine tests in order to determine if NH₃ levels were rising or changing. Additional test samples were often sent to different laboratories in order to compare results. Where secondary results were inconclusive, refrigeration contractors advised owners to continue monitoring via periodic testing every 2 to 3 months.

In one instance, 2000 ppm of NH₃ was identified on October 13, 2017, and without direction from the refrigeration contractor, the arena's chief engineer immediately shut down the facility.

In another instance, the chief engineer of the plant followed the refrigeration contractor's advice to continue operating until the seasonal shutdown. The refrigeration contractor firmly stated that the chiller was not leaking. Subsequent inspection determined that the chiller was leaking and the plant was subsequently shut down.

Observations and Findings

1. Refrigeration contractors consistently advised owners to perform additional brine testing in order to verify measured NH₃ concentrations from previous tests and to monitor whether the levels were rising, falling or remaining constant.
2. Owners reported that variations exist in testing methods and reporting practices by laboratories that may lead to different results, notably when NH₃ concentrations were measured near 0 parts per million (ppm).
 - A result near zero ppm usually led to the refrigeration contractor recommending that an additional test be performed.
 - One laboratory used the terminology "LT*50". LT*50 could be interpreted either as a "positive test for ammonia in brine sample", as an "inconclusive result" or as "negligible, if not zero".
3. Ammonia concentrations ranged from 2 ppm to almost 2100 ppm. Ammonia concentrations were also reported as "LT*50".
4. Typically it is the refrigeration contractor who takes the sample, facilitates testing and receives the test report, which is then conveyed to the operator.
5. In the majority of instances, owner/operators relied heavily on the refrigeration contractor's assessment of the equipment and evaluation of the NH₃ indication in the brine samples. The owner is accountable for the safe condition and operation of the equipment but in some instances, deferment to the refrigeration contractor's assessment and recommendations for the equipment was observed.
6. One of the facilities was operated by a contracted company responsible for the operation of many facilities across western Canada. This facility did its own brine testing and did not rely on the refrigeration contractor's service to test its brine. The management of this facility did not rely on the refrigeration contractor's assessment of the situation and took immediate action by closing the facility and addressing the equipment needs, despite the refrigeration contractor's recommendation for continued monitoring and testing.
7. In two instances, the owner and refrigeration contractor decided not to take any further action until the next seasonal shut down of the equipment. Despite NH₃ levels of 2000 ppm with no justifiable rationale provided for its source, the equipment was operated with no further plan to perform inspections to determine the source. Subsequently a Safety Order was issued to compel the plant to take action, starting with shutting down the equipment.

8. In at least 2 instances, a reluctance to attribute ammonia concentrations in the brine to equipment failure was observed. It is likely that the operational issues presented by shutting down the equipment influenced the decisions made by the owner and refrigeration contractor.
9. In general, refrigeration contractors interviewed during this survey expressed that ammonia in the brine was a safety concern if associated with a potential leak. Where there was a justifiable rationale for the NH₃ presence, such as residual presence from previous work, there was no concern about safety.
10. Typically the owner relies on the refrigeration contractor's knowledge and experience in assessing the source of NH₃ in the brine and any subsequent follow up requirements.
11. In 13 of 15 arenas surveyed, the refrigeration contractor or owner's actions verified that the refrigeration equipment was suitable for continued service. In the remaining two cases, it was decided by the owner to continue operating the failed equipment.

Summary

At 11 of 15 arenas, testing for ammonia was initiated by the [Ammonia Refrigeration Systems in Public Occupancies Safety Order](#). The majority of arenas either did not include this type of testing in their maintenance program or relied on the refrigeration contractor to perform the tests. Dependent on the scope of work, the contract with the refrigeration contractor may or may not include brine testing. Owner follow up action to ammonia in the brine was largely reliant on the refrigeration contractor to provide direction. Refrigeration contractors generally advised the owner to perform additional testing and monitoring.

Identification of ammonia in the brine may be an indicator of equipment failure. It is the owner's responsibility to ensure that equipment is maintained and operated safely. The majority of arena maintenance programs did not describe a requirement for testing of ammonia in the brine or for procedures on what to do if ammonia was present in the brine.