TRIAGE

MUNICIPALITY OF CLARINGTON

TRIAGE REPORT FOR
INSPECTION – RINK REFRIGERATION & PAD
NEWCASTLE MEMORIAL ARENA

103 CAROLINE ST. W, NEWCASTLE, ON

SEPTEMBER 23, 2020

VERSION 1.0

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Official Rink Engineering Consultant of the NHL®

REVISION LOG

REVISION DOCUMENTATION

Revision	Date	Description
VER: 1.0	*23-Sep-2020*	*Issued to Client*

APPROVAL

INTRODUCTION

I.B. Storey Inc. has performed a triage inspection for the Newcastle Memorial Arena. A triage report assesses the current state of the facility and provides recommendations for immediate action on safety issues, short-term corrective actions on safety mitigation and performance enhancements, and long-term capital expenditure planning to ensure the longevity of the building. The intent of this inspection is to stabilize immediate issues and secure the ongoing operations for the rink into the future.

This report is divided into two parts in order to provide a complete assessment of the equipment in the building and the current adherence to health and safety codes. Part 1 addresses the age and current integrity of the installed equipment, and part 2 addresses the current adherence to the CSA B52 safety standards. Both sections provide recommended next steps.

Part 1 of this report has been prepared to provide an assessment of the equipment and infrastructure at the Newcastle Memorial Arena in Newcastle, Ontario. I.B. Storey visited the site on August 24, 2020 and reviewed the status of the following equipment and systems:

- Refrigeration plant
- Rink floor, boards and glass
- Rink dehumidification

In addition to an assessment of the age and useful life of the equipment, this part of report will provide an overview of recommended corrective actions in the form of immediate actions, short term corrective actions and long-term capital expense planning to address any noted issues. These recommendations are provided as an action plan to provide guidance for the safe operation of the rink.

Part 2 of the report is a plant safety compliance review and risk mitigation strategy. During the inspection on August 24, 2020 I.B. Storey Inc. reviewed the current plant safety features and compared them to the current safety standard used by the Technical Standards and Safety Authority (TSSA) for refrigeration plants in Ontario, CSA B52-18 Mechanical Refrigeration Code. This section presents a summary of the noted safety issues and recommended corrective actions to bring the refrigeration plant up to the code standards as well as further risk mitigation strategies.

BACKGROUND

The Newcastle Memorial Arena is a single sheet ice rink constructed in 1976. The building operates as an ice rink from October through March, and as a floor venue from April through to September.

Category	Building Details
Year of Construction	1976
Building Use	Seasonal single sheet ice rink; Out of season community floor space
Refrigerant Type	Ammonia
Major Refrigeration Plant Equipment	Compressor x 2 Cold Brine Pump Condenser Pump Evaporative Condenser Shell and Tube Chiller
Dehumidification	Mechanical dehumidifier in rink zone x 2

Part 1 – Integrity Triage

EQUIPMENT ASSESSMENT

I.B. Storey conducted an on-site inspection of the refrigeration plant, dehumidification system and rink floor, boards and glass on August 24, 2020. The following highlights the status of all of the major equipment in these systems with an overview of their current status as of the inspection date.

REFRIGERATION PLANT

Chiller

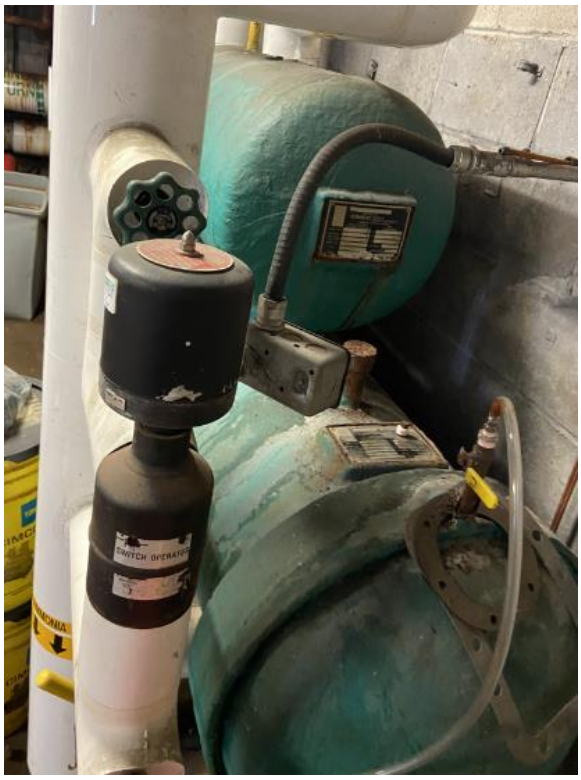


Figure 1: Chiller barrel and vessel.

Category	Information
Model	Cimco Refrigeration Shell and Tube Chiller
Year of Construction	1999
Purpose	Uses ammonia gas in conjunction with compressors and condensers to cool ice rink and maintain ice.
Median Equipment Life	24 years
Current Age	21 years

Observations and Analysis

- The chiller is very near the median end of life, and may be subject to failures in the near future. The chiller and attached surge drum are the primary ammonia storage vessels and given the hazardous nature of ammonia the chiller should not be allowed to operate near the median end of life.
- **Chiller failures are a serious risk to public health and safety because toxic refrigerant may leak. Replacement of the chiller should be considered as soon as possible**[1].
- Documentation on site shows inspection for this equipment was due in March, 2019. This inspection should be completed, or proper documentation should be posted.
- Chiller relief valves need to be replaced by November 21, 2021. **This is a critical safety component.**
- Chiller components show signs of significant rusting on connections where insulation is not present. This indicates significant wear on the metal components, increasing the potential risk of failure.

Figure 2: Signs of rusting on the chiller sight glass ports.

Recommended Actions

Category	Recommended Action
Immediate Actions	• Have a brine analysis performed to check for ammonia contamination in brine as an early sign of chiller failure. • Have chiller and surge drum re-inspected for insurance purposes and to detect potential leaks.

Shot-Term Actions	• Replace chiller relief valves by November 2021.
	• Perform ongoing monitoring of brine to test for potential chiller failure. Additional ongoing monitoring is recommended, including[2]:
	  ○ Check for any increase in volume in the secondary refrigerant (brine) system.
	  ○ Check for any unusual increase in pressure in the secondary refrigerant (brine) system.
	  ○ Test the system heat exchange for leaks during the off season.

Capital Expenditure Planning	• Pursue opportunities to replace the chiller as soon as possible. ○ **This is a significant health and safety risk. Replacing the chiller on its own or as part of a total refrigeration plant upgrade should be prioritized. Given the age of all of the equipment, a full plant replacement is recommended at this time.**

[1] Based on the current condition of the refrigeration plant equipment, a full plant replacement is recommended.
[2] Refer to Technical Safety BC SO-BP-2017-01 "Safety Order: Ammonia refrigeration systems in public occupancies" for detailed recommendations prepared by Technical Safety BC following the tragic and fatal ammonia release accident in Fernie, British Columbia in 2017.

Compressors

Figure 3: Compressor #1

Figure 4: Compressor #2

Category	Compressor 1 Information	Compressor 2 Information
Model	Mycom N6WA	Cimco C5-W04A (Mycom N4WA[3])
Year of Construction	2010	1999[4]
Purpose	The prime mover[5] of the refrigeration system, the two compressors work together to provide cooling to the shell and tube chiller to maintain ice conditions.	
Median Equipment Life	20 years	
Current Age	10 years	21 years

[3] Though this compressor has been rebranded as a Cimco compressor, it is a Mycom compressor manufactured by Mayekawa and rebranded by Cimco Refrigeration.
[4] No data on the current age of this unit was available, however the unit matches with the chiller equipment installed in 1999. It is reasonable to assume that this compressor is as old as the chiller.
[5] Prime mover refers to the hardware powering the refrigeration system, performing the compression on the gaseous ammonia.

Observations and Analysis

- Both compressors look to be aged with some light signs of wear and tear on the outer casing.
- Compressor #1 is verified to be from 2010, making it half way through its expected service life.
- Compressor #1 is due to have reliefs replaced by February, 2024 while compressor #2 is due earlier by September, 2022.
- The motor on compressor #2 failed on start up in 2011, and was replaced at that time.
- Compressors #2 is nearing the end of the typical operating life for this type of equipment, beyond which it will become increasingly more expensive to maintain it.
- Compressor #2 represent a significant safety risk, as it is compressing gaseous ammonia, a toxic, flammable refrigerant. Aging compressors pose a serious hazard to life and health.
- Though having multiple compressors allows for the system to continue operating at a limited capacity with only one compressor, these units are near the end of life and should be replaced. Plan for compressor replacements as soon as possible.

Category	Recommended Action
Immediate Actions	• Maintain routine maintenance procedures.

Shot-Term Actions	• Replace compressor relief valves as needed.
	  ○ February 2024 for Compressor #1.
	  ○ September 2022 for Compressor #2.

Capital Expenditure Planning	• Pursue opportunities to replace the compressors as soon as possible. ○ **Compressors are essential equipment for the refrigeration plant and ice cannot be maintained without them. Additionally, as the prime mover responsible for compressing ammonia mechanical issues with this equipment is a safety hazard. This equipment should be planned for replacement in conjunction with the chiller.**

Pumps

Figure 5: Cold Brine Pump

Category	Information
Model	Armstrong 4030 6x4x10
Year of Construction	2007
Purpose	Circulates cold brine (secondary refrigerant) through the ice rink floor in order to maintain ice.
Median Equipment Life	20 years
Current Age	13 years

Observations and Analysis

- The cold brine (secondary refrigerant) pump is showing signs of corrosion. The use of brine in the system may introduce greater stress on the equipment and reduce the overall service life.
- Brine as a secondary refrigerant requires regular maintenance and monitoring of corrosion inhibitors, and if this maintenance has not been carried out significant corrosion and damage to the pump interior is likely.
- Regular maintenance on the equipment should be maintained.
- The failure of this pump would disable the ice rink until a replacement could be installed.
- Plan for equipment replacement in 5 years. It is recommended that if the compressors and chillers are replaced, the brine pump be replaced as well for overall system longevity.

Figure 6: Condenser Pump

Category	Information
Model	Armstrong 4280 3x2x8
Year of Construction	2001
Purpose	Delivers cooling water to the evaporative condenser to help heat rejection from the refrigeration plant.
Median Equipment Life	20 years
Current Age	19 years

Observations and Analysis

- The condenser pump shows little signs of wear on the outer casing, though any issues with the impeller or interior casing could not be assessed without disassembly.
- Based on the age of the equipment, it should be planned to replace this pump within 1 to 3 years.
- Failure of this pump may limit the ability of the refrigeration plant to operate in high outdoor temperatures during the shoulder seasons, and will increase overall energy consumption and operating costs.

Category	Recommended Action
Immediate Actions	• Maintain routine maintenance procedures.
Shot-Term Actions	
Capital Expenditure Planning	• Plan to replace cold brine pump in 5 years. ○ Brine pump should be replaced at the same time as large refrigeration plant overhaul if pursued. • Plan to replace condenser pump in 1 to 3 years.

Controls

Figure 7: Primary Control Panel

Figure 8: Backup Controls

Category	Primary Controls Information	Backup Controls Information
Model	Black & McDonald Control System	Honeywell T775
Year of Construction	2010[6]	1999[7]
Purpose	The primary control system operates the refrigeration plant as needed based on control sensors, with logic for equipment staging and seasonal adjustments. The backup controls are used when there are issues with the primary controls.	
Median Equipment Life	N/A years	
Current Age	10 years	21 years

Observations and Analysis

- The primary control system is a control system provided by Black & McDonald.
- The backup control unit is an industry standard Honeywell T775. This unit is aged, and the series of controllers was redesigned several years ago to provide more information.
- Control systems have no definitive service life and can be used for long periods of time, however improvements to controls technology provide better energy savings.
- Control sensors should be recalibrated to ensure accuracy for controls.

[6] No data on the current age of this equipment was available, however it is assumed that this control system was installed with the compressor upgrade, as the control system was not provided by the original system installer.
[7] No data on the current age of this equipment was available, however it can be reasonably assumed that this equipment was installed with the chiller in 1999.

Category	Recommended Action
Immediate Actions	• Maintain routine maintenance procedures.
Shot-Term Actions	• Recalibrate all sensors to ensure accuracy in controls.
Capital Expenditure Planning	• Plan to replace the control system when the refrigeration plant is overhauled. ○ **I.B. Storey Inc. recommends open source control systems when upgrading to ensure that the hardware and software can be updated indefinitely to match improvements in control technology and add new features to the plant. This control system should control the entire refrigeration system.** ○ **The existing controller should be integrated into a new overall control system if a control system is pursued before a refrigeration plant replacement.**

ICE RINK FLOOR, BOARDS AND GLASS

Ice Rink Floor

Figure 9: Ice rink floor showing serious signs of wear

Figure 10: Scrapes and divots noted over ice rink floor surface

Category	Information
Construction	Poured concrete over rink piping
Year of Construction	1976[8]
Purpose	The concrete floor and piping used to create the ice surface for the ice rink. Also used for indoor sports and community activities in the off season.
Median Equipment Life	25+ years
Current Age	44 years

[8] No data about the age of the ice rink floor is available at this time. Based on an assessment of the condition of the floor it is reasonable to assume that this floor construction is original to the building.

Observations and Analysis

- Serious wear and tear has been noted over the ice rink surface with signs of patching to deal with issues.
- The cold floor piping uses a clamped design for the piping connections, common in older ice rinks.
    - Header clamps should be checked annually for damage and repaired as needed.
- Cold floor header piping was under repair during the site inspection, showing signs of failure.
- Rink cold floor piping shows signs of rust and decay, and insulation is missing in the header trench which negatively affects performance.
- This floor has reached its end of life and should be replaced as soon as possible.

Figure 11: Clamped ice rink header with missing insulation in trench

Category	Recommended Action
Immediate Actions	• Maintain routine maintenance procedures and check ice rink header clamps annually.
Shot-Term Actions	• Consider a rugged cover to place over the concrete surface during off-season activities to prevent ongoing damage to concrete.
Capital Expenditure Planning	• Plan to replace the ice rink concrete and piping as soon as possible. ○ **I.B. Storey Inc. recommends new ice rink floors be installed with fusion welded HDPE piping to remove the need for ongoing clamp maintenance and provide corrosion resistant piping.**

Boards and Glass

Figure 12: Ice rink boards and glass

Category	Information
Construction	Wooden boards on metal frame
Year of Construction	1976[9]
Purpose	The boards and glass are used to keep play on the ice surface and keep spectators and players safe.
Median Equipment Life	25+ years
Current Age	44 years[9]

Observations and Analysis

- Boards and glass are aging, with serious plexiglass scuffing and board rippling issues.
- Significant corrosion is noted on the metal around the doorways into the rink zone. Cracked and distorted boards can also be seen.
- Upper and front board facings show significant waviness, likely as a result of moisture issues with the wooden components underneath.
- Cracks and splits in the boards were observed at floor level, showing ongoing wear and tear.

Figure 13: Waviness in board facings

[9] No data about the age of the boards and glass are available at this time. Based on an assessment of the boards it is reasonable to assume they are original to the building, with modifications and replacements done over the years as maintenance actions.

- The boards and glass system does not currently have modern safety features like:
    - Soft protective cover over the caprail to prevent player injuries
    - Curved terminations at player entry areas to prevent player collisions with sharp edged glass.
    - While these safety features are not mandatory, they are highly recommended by I.B. Storey Inc. for improved user comfort and safety.

Figure 14: Example photos of curved terminations (left) and soft caprail protections (right).

Category	Recommended Action
Immediate Actions	
Shot-Term Actions	
Capital Expenditure Planning	• Plan to replace the ice rink boards and glass at the same time as the floor replacement, as soon as possible. ○ **I.B. Storey Inc. recommends a modern board system with an aluminum frame to resist metal corrosion and provide flexibility for safety, along with a soft protective plastic piece along the caprail before the glass to prevent player injury and curved terminations for enhanced safety.**

DEHUMIDIFICATION

Figure 15: Mechanical dehumidifier in rink zone

Category	Information
Model	Cimco Humicon Mk VIII
Quantity	2
Year of Construction	13+ years[10]
Purpose	Removes moisture from the air using a compressor to cool the air below dewpoint, before returning the air to the zone.
Median Equipment Life	20 years
Current Age	N/A

[10] The exact age of this unit was not available as the nameplate was not accessible, however these units stopped being manufactured in 2007, making these dehumidifiers at least 13 years old.

Observations and Analysis

- No information on the age of the two dehumidifier units is available and the units were not accessible.
- The units were not in use during the inspection as the rink was out of season, however rusting was observed in the metal structure of the roof showing inadequate dehumidification has been an ongoing issue.

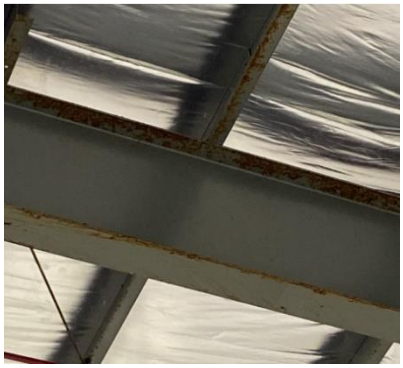


Figure 16: Rusting on ceiling beams

Category	Recommended Action
Immediate Actions	• Inspect the dehumidifiers to ensure that both units are working properly. • Continue regular maintenance on the units.
Shot-Term Actions	
Capital Expenditure Planning	• Plan to replace the dehumidifiers within 5 years. ○ **Consider a central air handling unit with built in dehumidification to provide proper zone conditioning and prevent moisture build ups leading to premature building structural damage and mold growth.** ○ **The new dehumidification units should be integrated into a central control system to ensure ongoing monitoring and humidity control in the rink zone.**

PRIORITIZED ACTION PLAN

The following summarizes the recommended actions in order of priority.

Immediate Actions				
Number	Equipment	Action	Timing	Budget Cost[11]
1	Chiller	Have a brine analysis performed to check for ammonia contamination in brine as an early sign of chiller failure.	Immediately	$500
2	Chiller	Have chiller and surge drum re-inspected.	Immediately	$800
3	Rink Floor	Perform annual inspection of the rink header clamps to look for mechanical failures.	Immediately	$400
Short Term actions				
Number	Equipment	Action	Timing	Budget Cost[11]
1	Rink Floor	Consider a rugged cover to place over the concrete surface during off-season activities to prevent ongoing damage to concrete.	Before spring 2021	$140,000[12]
2	Controls	Recalibrate all sensors to ensure accuracy in controls	Before start up 2021	$4,000
3	Chiller	Perform ongoing monitoring of brine to test for potential chiller failure. Recommended twice per year.	Before start up 2021	$1000 / year
4	Chiller	Replace chiller relief valves by November 2021	November 2021	$2,400
5	Compressor	Replace compressor 2 relief valve by September 2022	September 2022	$400
6	Compressor	Replace compressor 1 relief valve by February 2024	February 2024	$400
Capital Expense Planning				
Number	Equipment	Action	Timing	Budget Cost[11]
1	Refrigeration Plant	Replace the refrigeration plant to address issues with aging equipment approaching end of life.	As soon as possible.	$750,000

[11] AACE Class 5 Concept Screening budget.
[12] This budget cost includes an insulated floor that could be used over the ice surface. More budget friendly options may be available if insulation is not required.

		• The chiller is nearing end of life, as is one of the compressors. • Given the cost of replacing a chiller and compressor relative to the cost of the refrigeration plant, it is recommended that a full plant replacement be considered. • This should include new compressors, chiller, condenser and pumps. • This should include a controls upgrade as part of the overall plant refresh. • The upgrade should include integrated heat recovery, using waste heat from the refrigeration plant to save on heating costs.		
2	Rink Floor, Boards and Glass	Replace the rink floor, boards and glass with new fusion welded piping and an aluminum dasherboard system with advanced safety features. • The existing floor concrete surface is badly damaged and will be in need of overhaul. • The aging cold floor runs the risk of leaking, and brine levels should be closely monitored to determine the risk. It is recommended that the floor piping be replaced with a fusion welded system to prevent maintenance issues with the current clamped headers, while simultaneously pouring a new concrete floor and replacing the boards and glass. Replacing the boards at the same time as the floor will allow anchors to be placed without having to drill into a new or existing floor, potentially causing leaks.	As soon as possible.	$1,050,000
3	Dehumidification	Replace the aging dehumidification units in the rink zone with an alternative. • I.B. Storey recommends a fully integrated air handling unit for the rink zone, to provide adequate dehumidified fresh air with the minimum amount of energy used. • This option can be incorporated with the heat recovery from a new refrigeration plant to further reduce operating costs.	< 5 years	$50,000

Part 2 – Plant Safety Compliance Review and Risk Mitigation Strategy

CSA B52-18 COMPLIANCE REVIEW

The CSA B52 Mechanical Refrigeration Code is the standard adopted by the TSSA for refrigeration regulation in Ontario and is intended to minimize the risk of personal injury by providing minimum requirements for the design, construction, installation, inspection, and maintenance of mechanical refrigeration systems. As these standards are updated regularly, even facilities which were once in compliance may find that their systems have either been grandfathered into "compliance" or age has rendered some, or all, components non-compliant. The following are two lists of non-compliant TSSA issues found during the review of the refrigeration room at the Newcastle Memorial Arena. The first list contains critical items which need to be addressed at the next available opportunity to ensure safety of the community centre users in the case of an emergency and the second list contains other items which need to be taken care of to ensure complete compliance with code. To aid in understanding these deficiencies, clauses associated with deficiencies have been laid out with associated photos and a complete check list of the B52-standard attached as appendices.

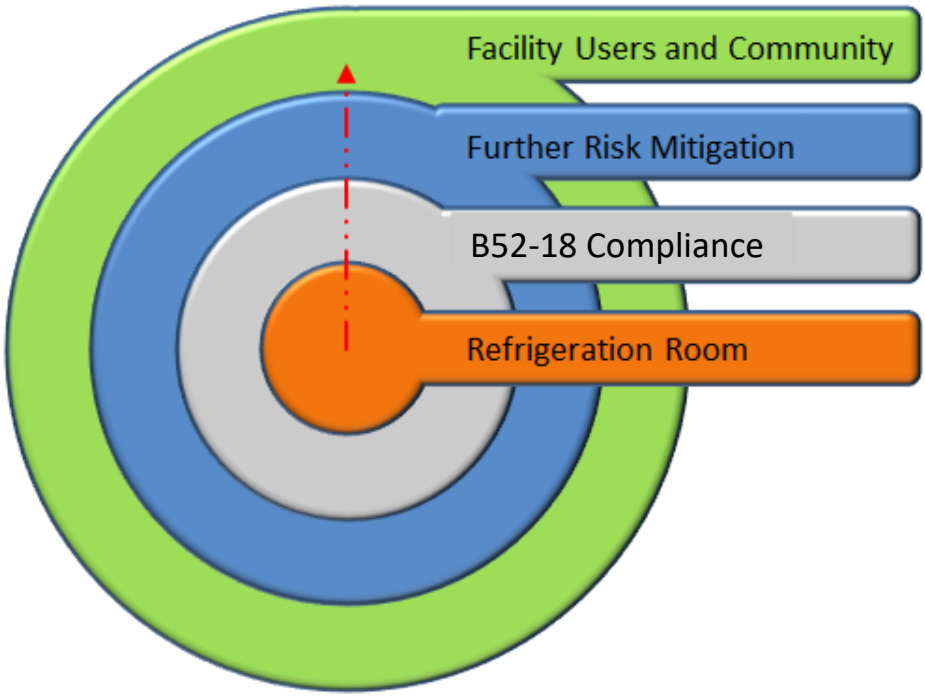
CRITICAL B52-18 NON-COMPLIANT ITEMS		
Section	Description	Notes
6.1.3 b)	Equipment that is not accessible from floor level shall be installed so that it can be safely reached by a permanently installed staircase(s) or ladder(s) with a platform(s) and railings meeting the workplace safety requirements; or by a mobile device(s) for lifting personnel to the equipment.	• Evaporative condenser installed on the roof has no permanently installed staircase or ladder for access.
6.1.3 c)	(c) Roof- and mezzanine-mounted equipment shall be set back 3 m (10 ft) from any edge where a fall hazard exists, except under the conditions specified in Item (d). If the workplace safety requirements of the jurisdiction of installation impose a greater setback, those requirements shall apply.	• Evaporative condenser is installed at the edge of the roof

CRITICAL B52-18 NON-COMPLIANT ITEMS		
Section	Description	Notes
6.1.3 d)	(d) Where roof- and mezzanine-mounted equipment cannot be set back as specified in Item (c), railings and fall-arrest system attachment points shall be provided in accordance with the workplace safety requirements of the jurisdiction of installation.	• No railings or fall-arrest system installed though the equipment is placed next to the edge.
6.2.5.3	Exhaust air from machine room to be located close to area where refrigerant should collect. Make up air shall replace exhaust air. Make up air shall be positioned so that discharged air does not short cycle into make up air. Supply and exhaust serve ONLY machine room.	• Wall exhaust fan is small and airflow was noted to be limited. An air measurement should be contracted to ensure suitable airflow through the emergency exhaust.
6.3 c)	The machinery room envelope, including any vestibule, shall be of tight construction.	• Air gaps are visible at the exit door to the room. • A wooden window frame with aging wood shows clear signs of leakage. • Gaps are visible in the plywood ceiling.
6.3 d)	Walls, floors, and ceiling of constructed of 1-hour fire-resistive construction.	• The ceiling of the room is made of plywood, and is not 1-hour fire resistant • Cold Brine hatch is made of wood and is not 1 hour fire-resistant
6.3 f)	All pipes piercing the interior walls, ceiling, or floor shall be tightly sealed to the walls, ceiling, or floor through which they pass.	• Pipes passing through the ceiling and walls are not sealed properly.
6.3 j)	Detectors working, and in a location where refrigerant would collect. Detector shall start the ventilation fans and actuate alarms.	• The refrigerant detector was reporting an inaccurate level when observed on site.
6.8.2	Refrigerant piping crossing an open space that provides a passageway is at least 7-1/2 ft above the floor.	• Piping is only 7-1/2 ft to the centerline of the piping, not providing the required free clearance.
B.2.9	Emergency valve: glass-fronted box; painted bright red; placed outside where it can't be used by general public. At least 7 ft above ground, unless permitted.	• The emergency valve is less than 7 ft above the ground and could be accessed without a ladder.

OTHER B52-18 NON-COMPLIANT ITEMS		
Section	Description	Notes
5.11.1	Each refrigeration system shall be provided with a permanent sign that is securely attached, readily accessible, and legible, and that indicates the following: (a) name and address of the installer; (b) refrigerant type; (c) lubricant type and amount (d) total weight of refrigerant required for normal operation (e) field test pressures applied; (f) refrigeration capacity at design or nominal conditions; and (g) for prime movers, the rating or full-load current and voltage	• A sign displaying all this information was not located in the mechanical room

RISK MITIGATION ITEMS

While the review of the ammonia plant has revealed several items that are non-compliant with the TSSA refrigeration standards, it is paramount to note that the TSSA standards are only a bare minimum. Ensuring that the mechanical room meets TSSA safety standards is the first step that should fit into an overall plan to mitigate risks associated with providing efficient refrigeration for the facility.

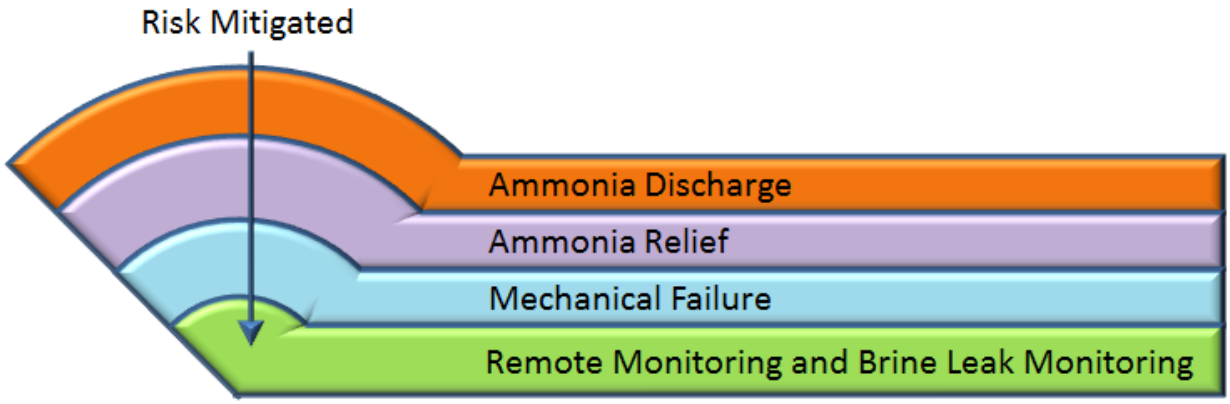


At a minimum, the following should be considered when determining the safety requirements that should be adopted for a refrigeration system:

- Safety to operators of the refrigeration system.
- Safety to users of the facility.
- Safety to public infrastructure (malls, schools, roads, etc.) around the facility.
- Safety to private infrastructure (homes, condos etc.) around the facility.
- Safety to the natural environment around the facility.

Since the initial installation of the refrigeration system in the 1970s and the refurbishment in 1999 (with an additional compressor replacement in 2010), advancements in technology have continued to provide risk mitigating options for ammonia plant installations that would not have been available or feasible in the past.

The review at the Newcastle Memorial Arena has revealed that risk mitigation strategies can be implemented for several aspects of the system as follows, with each measure identified as focusing on health or finance concerns. Risk items are presented in a stacked order, with each risk being prevented by the successful mitigation of all risk items that follow.



Risk Mitigation		
Risk Type	Item	Notes/Actions
	Ammonia Discharge Due to Component failure	• The refrigeration system at the Newcastle Memorial Arena does not have its refrigerant charge posted in the mechanical room as per B52 requirements (see Section 1), but based on the equipment in the plant the approximate refrigerant charge is 600 pounds. • In some cases, ammonia forms denser than air mixtures that roll along the ground, posing a danger to life, environment, and property. • Accidental full discharge is unlikely; however, reduction in charge greatly reduces risk range in a worst-case scenario. • Less charge reduces dispersal speed, providing emergency services with more time to respond. • A low charge plant will require approximately 60% less charge than existing system. • An ultra-low charge plant will require approximately 80% less than existing system. • Switching to an alternate, low-toxicity, environmentally sustainable refrigerant will prevent any hazards to nearby buildings and people.

Risk Mitigation		
Risk Type	Item	Notes/Actions
	Ammonia Relief Due to Component Over-Pressure	• The relief system at the Newcastle Memorial Arena ensures that dangerous pressures do not develop in the refrigeration system, causing component failure. • This relief system releases ammonia gas into the atmosphere when pressure is too high in a refrigeration component. • Adding an indoor relief system as a first relief stage renders discharged ammonia harmless and keeps it from the atmosphere.
	Mechanical Failure Due to Mechanical Age	• Both component failure and over pressure can result from the use of aging equipment. • Preventing component failure mitigates accidental ammonia discharge. • Aged equipment at the Newcastle Memorial Arena includes the chiller, pumps and one of the compressors. At around 20 years old this equipment is nearing the end of its useful life and is recommended for replacement in the coming years. • Only one brine pump is available at the arena. In the event of failure, there is no emergency backup for continued ice operation. • Efficient mechanical design increases equipment life and reduces available failure points.
	Remote Information Monitoring	• Information monitoring provides an operator with a first line of risk mitigation in any system. • Remotely provides information which alerts to operation of the system outside of a preset tolerance. • Knowledge of such operation helps diagnose failing components or dangerous conditions long before they would become obvious.
	Brine Leak Monitoring	• The disposal of brine, which is used as a secondary refrigerant at the facility, is regulated and needs to be carried out properly. • To prevent, or at least, mitigate brine leaks, a brine leak monitoring system should be installed on site.

Full Ammonia Discharge
Immediately Dangerous to Life and Health (IDLH) Range

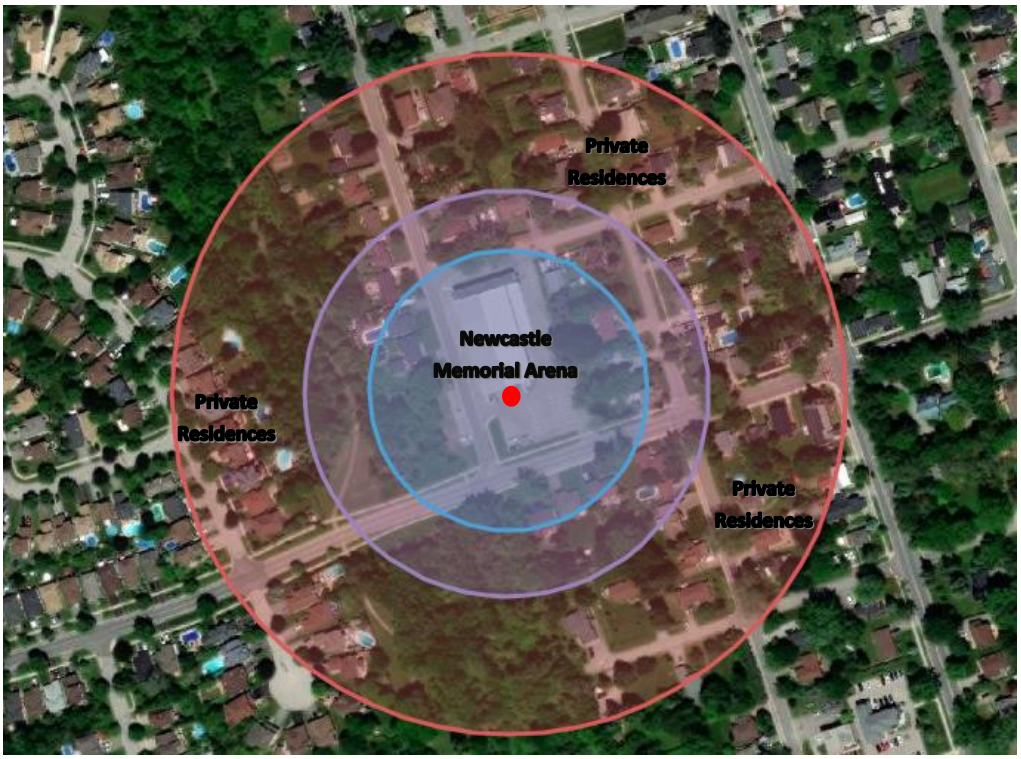


Figure 17: Health and safety danger ranges for visualization and decision-making.

- IDLH range does not factor in wind distribution and refrigerant charges have been estimated as no detailed signage is available. These ranges are presented for visualization and decision-making purposes only.
- The existing refrigeration plant range, shown in red above, covers more than 50 residential properties.
- Low charge plant (60% reduction), shown in purple above, would result in approximately 35 properties being removed from the immediately dangerous to life and health range.
- Ultra-low charge plant (80% reduction), shown in blue above, would limit dispersal to the arena and the nearest 6 residential properties.
- Switching to an alternate, lower toxicity, environmentally sustainable A1 category refrigerant could remove the impact to surrounding buildings entirely and eliminate issues with toxicity and flammability.
- Reduction in the IDLH range provides more time for people to evacuate and emergency teams to arrive, as the charge disperses slower. These ranges must be considered even if on-site ammonia evacuation equipment is used, as the refrigerant is still on site.

CORRECTIVE ACTIONS

The following recommendations have been categorised into compulsory actions required to meet the CSA B52 standards and risk mitigation considerations for implementation as budget allows.

1. **Safety Compliance**
    - Tight fighting of emergency outdoor exit and window from mechanical room.
    - Tight fitting of pipe entrance through ceiling, and tight-fitting brine pipe entrance into the brine trench.
    - Installation of 1-hour fire-resistive tight-fitting trench cover for the brine trench.
    - Relocation of the emergency relief box to be at the required height.
    - Adjustment of refrigerant piping in the mechanical room to provide the required 7-1/2 ft free clearance.
    - Installation of proper system labelling including key details about refrigerant charge and emergency contacts.
    - Installation of railing or fall protection measures for the evaporative condenser.
    - Install new ammonia gas detector or properly calibrate the existing unit.

      Budget Cost: $50,000
2. Risk Mitigation
    - As the age of the refrigeration plant is closing on 20 years, it is advised that new refrigeration plant equipment be investigated in the near future.
        - Based on the close proximity to nearby residential and community properties, it is recommended that a low-toxicity refrigerant be pursued.
        - Converting to a low-toxicity environmentally sustainable refrigerant will not result in operating cost increase.
    - Install indoor ammonia containment for the relief system if ammonia is kept on site.
    - Install, or have on standby, an extra brine pump in case of unexpected failure of the main pump.
    - Install, or have on standby, an extra water pump in case of unexpected failure of the main pump.
    - Install a remote monitoring system for the refrigeration plant.
    - Install brine leak detection system.

      Budget Cost: $750,000[13]

[13] This budget cost is suitable for either the low charge (60% refrigerant reduction) or low-toxicity refrigerant options. Additional costs required for the ultra-low charge (80% refrigerant reduction) option.

CONCLUSIONS AND NEXT STEPS

In order to ensure efficient and safe operation of the plant, it is recommended that the renewal of the refrigeration plant be pursued at the earliest convenience as the most recent TSSA assessment in the room was from December 2008, 12 years ago. Corrective actions not directly related to the installation of a new refrigeration plant should be corrected at the same time. Next steps are outlined as follows:

- Review report to select measures to be implemented.
- Engineering design of selected measures.
- Obtain actionable budget.
- Project facilitation to ensure compliant installation.

Based on the aging life of the refrigeration equipment, it is recommended that a complete renewal of the rink refrigeration system be planned as soon as possible. The ongoing status of the chiller should be closely monitored to ensure public health and safety with regular brine tests to detect ammonia leaks and potential chiller failure.

The current state of the refrigeration system and rink floor will require a significant investment for continued operation. It should be noted that a major building overhaul replacing the rink floor and refrigeration plant can be accomplished for approximately 50 to 60% of the cost of full new construction.

Though it is outside of the scope of this study, several key building upgrades are recommended to be pursued as part of the overhaul. The existing mechanical room shows severe signs of wear and is well below code. This is an additional block structure that was built onto the end of the rink, and it is recommended that as part of the upgrades the entire room be demolished and replaced. This would address the code issues as well as the cracked and sloping floors observed in the refrigeration room.

The building currently has 4 dressing rooms, while 6 dressing rooms is the current standard. It is recommended that two additional dressing rooms be added onto the building as part of any building overhaul.

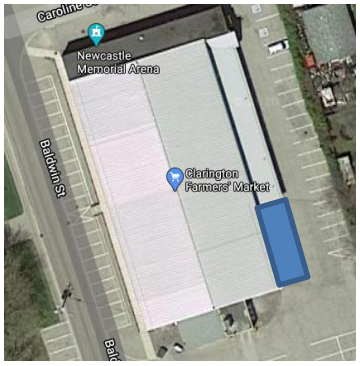


Figure 18: Building overview with recommended dressing room addition in blue.

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APPENDIX A
B52-18 COMPLIANCE PHOTOS

6.1.3 Evaporative condenser installed on the roof has no permanently accessible ladder, is on the edge, and has no railing

6.3 c) Room not tightly sealed – daylight clearly visible through door, aging window frame

6.3 d) Ceiling and trench cover not made of fire-resistant material

6.3 f) Pipes passing through walls and ceiling not properly sealed

6.3 j) Refrigerant detector reporting inaccurate value

B.2.9 Emergency valve less than 7ft above the ground

APPENDIX B
B52-18 COMPLIANCE CHECKLIST

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
4	**SYSTEM CASSIFICATION AND APPLICATION REQUIREMENTS**		
4.6.1	No portion of a refrigeration system shall be installed in or on a public stairway, stair landing, or exit.	✓	
4.6.2	No portion of a refrigeration system shall interfere with free passage through a public hallway or lobby.	✓	
	Refrigeration systems installed in a public hallway or lobby shall be limited to unit systems containing not more than the quantity of a Group A1 refrigerant as specified in Table 1.	N/A	
5	**EQUIPMENT DESIGN AND CONSTRUCTION**		
5.4.3	Copper and its alloys shall not be used in contact with ammonia, except as a component of bronze alloys for bearings or other uses not involving refrigerants.	✓	
5.6.3.1	Low side ammonia separation vessels > 12 in. diameter must have a high liquid level sensing device installed to automatically trip compressors.	✓	
5.9.2.1	All systems containing more than 3 kg (6.6 lb) of refrigerant shall have stop valves installed		
	(a) on each suction inlet of each compressor, compressor unit, or condensing unit;	✓	
	(b) on each discharge outlet of each compressor, compressor unit, or condensing unit, and on each liquid receiver; and	✓	
	(c) on each inlet and outlet connection of a volatile direct system separator/receiver.	N/A	
	Systems containing more than 50 kg (110 lb) of refrigerant shall have stop valves installed at the following locations:		

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
5.9.3.1	(a) on each suction inlet of each compressor, compressor unit, liquid refrigerant pump, or condensing unit;	✓	
	(b) on each discharge outlet of each compressor, compressor unit, liquid refrigerant pump, or condensing unit;	✓	
	(c) on each inlet of each liquid receiver, except for self-contained systems or when the receiver is an integral part of the condenser or condensing unit;	✓	
	(d) on each outlet of each liquid receiver; and	✓	
	(e) on each inlet and outlet of condensers when more than one condenser is used in parallel in the system.	✓	
5.11.1	Each refrigeration system shall be provided with a permanent sign that is securely attached, readily accessible, and legible, and that indicates the following:		No signage provided.
	(a) name and address of installer;	X	
	(b) refrigerant type;	X	
	(c) lubricant type and amount;	X	
	(d) total weight of refrigerant required for normal operation;	X	
	(e) field test pressures applied;	X	
	(f) refrigeration capacity at design or nominal conditions; and	X	
	(g) for prime movers, the rating or full-load current and voltage.	X	
5.11.2	Equipment signs that indicate the following: (a) manufacturer's name; (b) manufacturer's nationally registered trademark; (c) identification number; (d) test pressures; (e) refrigerant type.	✓	

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
5.11.3	For systems containing more than 45 kg (100 lb) of refrigerant, signs that designate the following: (a) the main electrical disconnect switches; (b) any remote control switches; (c) any pressure-limiting devices; (d) each pressure vessel; (e) the main shut-off to each vessel; and (f) the refrigerant piping.	✓	
5.11.5	Systems with movers having capacity exceeding 175 hp, the following information is provided: (a) emergency first responders number; (b) emergency shutdown instructions; (c) Contact info forr for emergency service; (d) Contact info for local authority, and instructions to contact in emergency.	N/A	
6	**INSTALLATION**		
6.1.1	Compressor and Condenser foundations to be structurally sound.		
	(a) Appropriate equipment clearance	✓	
	(b) Equipment that is not accessible from floor level shall be installed so that it can be safely reached by a permanently installed staircase(s) or ladder(s) with a platform(s) and railings meeting the workplace safety requirements; or by a mobile device(s) for lifting personnel to the equipment.	X	Condenser has no permanent ladder.

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
6.1.3	(c) Roof- and mezzanine-mounted equipment shall be set back 3 m (10 ft) from any edge where a fall hazard exists, except under the conditions specified in Item (d). If the workplace safety requirements of the jurisdiction of installation impose a greater setback, those requirements shall apply.	X	Condenser is not set back on the roof.
	(d) Where roof- and mezzanine-mounted equipment cannot be set back as specified in Item (c), railings and fall-arrest system attachment points shall be provided in accordance with the workplace safety requirements of the jurisdiction of installation.	X	No railing is provided on the roof.
6.2.1	Adequately sized machinery room restricted to authorized personnel.	✓	
6.2.2	Machinery room doors open outward and are self-closing and tight fitting. The doors do not open to a public corridor or any room used for assembly.	✓	
6.2.4.3	Combustion equipment can be used, as long as combustion air is ducted from outside OR vapour detector automatically shuts down combustion process	N/A	
6.2.5.1	Machinery rooms to be ventilated to outdoors	✓	
6.2.5.2	Ventilation is provided by one or more power driven fans	✓	
6.2.5.3	Exhaust air from machine room to be located close to area where refrigerant should collect. Make up air shall replace exhaust air. Make up air shall be positioned so that discharged air does not short cycle into make up air. Supply and exhaust serve ONLY machine room.	X	Wall exhaust fan is small and airflow was noted to be limited. An air measurement should be contracted to ensure suitable airflow through the emergency exhaust.

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
6.2.5.4	Fan switches are installed inside and outside of the machinery room. Switches outside the room shall start but not stop fans.	✓	
6.2.5.5.1	Mechanical ventilation sized to exhaust potential accumulation of refrigerant due to leaks or a rupture of the system as specified in the clause.		
6.2.5.5.2	Minimum ventilation required when the refrigeration system is operating or the room is occupied.	✓	
6.3	No flame-producing devices installed.	✓	
	The machinery room has an exit door that opens directly to the outer air. Exits communicating with the building are through a vestibule.	✓	
	The machinery room envelope, including any vestibule, shall be of tight construction.	✓	
	Walls, floors, and ceiling of constructed of 1-hour fire-resistive construction.	X	
	Exterior openings are not to be under any fire escape or any open stairway.	N/A	
	All pipes piercing the interior walls, ceiling, or floor shall be tightly sealed to the walls, ceiling, or floor through which they pass.	X	
	Air ducts passing through shall be of tight construction and have no openings in the refrigeration room.	N/A	
	Remote pilot control of the mechanical equipment immediately outside the machinery room solely for shutting down the equipment in an emergency.	✓	
	Ventilation fans shall have a control switch on a separate circuit and be located immediately outside of the machinery room.	✓	

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
	Detectors working, and in a location where refrigerant would collect. Detector shall start the ventilation fans and actuate alarms.	✗	Refrigerant detector was reading incorrect value.
	Alarm system installed	✓	
6.8.1	Minimize danger of ammonia piping being struck (by falling objects, material handling, e.t.c) from any direction.	✓	
6.8.2	Refrigerant piping crossing an open space that provides a passageway is at least 7-1/2 ft above the floor.	✗	Refrigerant piping is 7-1/2 ft to center line. Not enough clearance
6.8.3	Refrigerant piping shall not obstruct passages, or be installed in a shaft containing moving objects (elevators etc), or in a stairway	✓	
6.10	Emergency discharge system per Annex B		
7	**OVERPRESSURE PROTECTION**		
7.1.2	Pressure vessels (with diameter above 6in) and volume less than 3ft3, that contain liquid refrigeratant and can be isolated need pressure relief valves	✓	
7.2.3.2.1	Pressure relief valves on refrigerant pumps.	N/A	
7.3.1.1	Every refrigeration system shall be protected by a pressure-relief device	✓	
7.3.6.1.2	Emergency discharge > 15 feet above ground, > 25 ft from any door, vent, or window	✓	
7.3.6.1.3	Ammonia relief stack, or dilution tank.	✓	
8	**MAINTENANCE OF SYSTEMS**		
8.4.2	Look for maintenance tags.	✓	
8.4.4.a)	Refrigeration equipment must be clean - no water residue or dirt.	✓	
8.4.5.a)	Check for refrigeration logbooks.	✓	
9	**PRECAUTIONS**		
ANNEX B	**GUIDELINES FOR EMERGENCY DISCHARGE OF REFRIGERANT**		
B.2.7	Emergency discharge line must slope down to receiver.	✓	

CSA B52-18 MECHANICAL REFRIGERATION CODE - CHECKLIST			
SECTION	**DESCRIPTION**	**Status**	**Comments**
B.2.8	An emergency switch to stop the refrigeration equipment shall be provided alongside the emergency valve.	✓	
B.2.9	Emergency valve: glass-fronted box; painted bright red; placed outside where it can't be used by general public. At least 7 ft above ground, unless permitted.	X	Emergency relief valve is less than 7 ft above ground level.