AMMONIA ICE RINK PLANT REVIEW

FOR

THOROLD COMMUNITY ARENAS

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Thorold, ON
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Report Dated: April 2019
Site Review: January 2019

OVERVIEW

The purpose of this Ammonia Ice Rink Plant Review is to assist the City of Thorold in bringing the existing ammonia system at the Thorold Community Arenas up to the latest code requirements in the Province of Ontario as per both the CSA B52-13 and TSSA Operating Engineers Act 2001 regulations.

The existing system is a built up R717 (ammonia) plant with a total of 119kW (160HP) of prime mover nameplate rating. All major equipment except for the evaporative condenser is located within a machinery room. The complex is comprised of two rink pads, one of which (Frank Doherty Arena) operates year-round while the other (James Whyte Arena) operates from October to April of each year.

The Thorold Community Arenas are classified as per the following according to the current B52-13 Refrigeration Code:
Classification of Occupancy: Public Assembly;
Classification of Refrigeration System: Indirect;
Classification of Leakage Probability: Low;
Classification of Refrigerant: B2 (Ammonia);

The Thorold Community Arenas are also classified as an R12 Refrigeration Plant per the TSSA Operating Engineers Act 2001. This requires the plant to be:
a) registered with the TSSA,
b) to have Guarded Controls,
c) to be Attended 8HR/Day of Operation by a 4th Class/B-Chief, and
d) to maintain a prime mover (compressor) power rating of less than 200HP (149KW) of maximum brake horsepower as determined by its manufacturer name plate data for its normal continuous operation per TSSA O. Reg. 219/01, s. 9 (1).

Each of the above stipulations is currently being met by the facility.

DISCLAIMER

Recommendations made in this report are to the best of CIMCO's understanding of the requirements for the Canadian Standards Association (CSA) and Technical Standards and Safety Authority (TSSA) regulations within the Province of Ontario. CIMCO Refrigeration assumes no liability for errors or omissions in this report. Please be advised that the two governing bodies, CSA and TSSA, are the ultimate authorities on the interpretations of these requirements and as a result they may reference other sections that CIMCO did not specifically highlight.

The City of Thorold should also be aware that there might be other Authorities such as Municipalities, the Fire Chief, etc. that may have additional local requirements that are not addressed in this report.

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Section 1 - AMMONIA PLANT DESCRIPTION/EQUIPMENT INSPECTION

Brief History of Facility

The Thorold Community Arenas is a facility comprised of two ice skating pads. The smaller of the two, James Whyte Arena, was originally constructed in 1936, while the Frank Doherty Arena was added to the existing building in 1974. Over the years, several upgrades have been made to the refrigeration system, including installing new compressors, two new shell and tube chillers, and an evaporative condenser throughout the 1990's. Most recently, the facility replaced the rink floor in the Frank Doherty Arena and added an underfloor heating system in 2017.

Refrigeration System Details:

Existing Refrigeration Equipment:

Note: Observed Operating Conditions based on temperatures and pressures observed and recorded during the CIMCO site visit on January 21, 2019.

Compressor 1 [C-1]: Frank Doherty Arena
Make/Model: MYCOM N6WB Reciprocating Compressor
Design Capacity: 75.4 TR @ 10°F ET/95°F CT, 105.3BHP
Observed Operating Conditions: 80.0 TR @ 10°F ET/86°F CT, 98.4BHP
Motor Details: 575V/3/60, 100HP (75kW), 1780RPM
Installation Date: 1992

Figure 1 - Compressor 1 [C-1]

Compressor 2 [C-2]: James Whyte Arena
Make/Model: MYCOM Cimco C6-W04A Reciprocating Compressor
Design Capacity: 30.6 TR @ 10°F ET/95°F CT, 41.8 BHP
Observed Operating Conditions: 24.8 TR @ 0°F ET/86°F CT, 36.4 BHP
Motor Details: 575V/3/60, 60HP (45kW), 1770 RPM
Installation Date: 1995

Figure 2 - Compressor 2 [C-2]

Chiller 1 [HX-1]: Frank Doherty Arena
Make/Model: CIMCO Shell and Tube Chiller, 2-Pass, 208 Tubes
Design Capacity: 90 TR @ 10°F ET/17°F SST, 850 USGPM
Installation Date: 1998
Vessels: CRN – A2176.45
246290A – 16” O.D. x 16’-0” Long Chiller
246290B – 16” O.D. x 10’-0” Long Surge Drum

Chiller 2 [HX-2]: James Whyte Arena
Make/Model: CIMCO Shell and Tube Chiller, 2-Pass, 286 Tubes
Design Capacity: 69 TR @ 10°F ET/15°F SST, 650USGPM
Installation Date: 1995
Vessels: CRN – F0473.5
206550A – 20” O.D. x 14’-0” Long Chiller
206550B – 20” O.D. x 9’-6” Long Surge Drum

Figure 3 - Chiller 1 [HX-1]

Figure 4 - Chiller 2 [HX-2]

<u>Underfloor Heat Exchanger [HX-3]:</u> Frank Doherty Arena
Make/Model: Alfanova 76L-40L
Capacity: 24 TR @ 50°F IN/57.4°F OUT, 45% Ethylene Glycol
Installation Date: 2017

<u>Cold Floor Pump [P-1] : Frank Doherty Arena</u>
Make/Model: S.A. Armstrong 4030-6X5X10
Operating Conditions: 850 USGpm @ 66ft Head
Motor Details: 575V/3/60, 25HP, 1770RPM
Installation Date: 2017

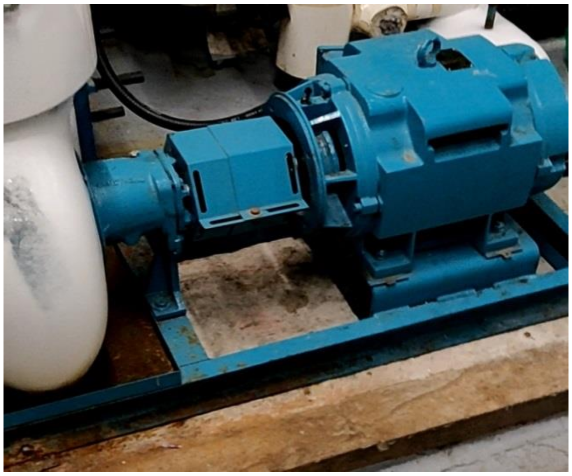


Figure 5 - Cold Floor Pump 1 [P-1]

<u>Cold Floor Pump [P-2]: James Whyte Arena</u>
Make/Model: S.A. Armstrong 4030-6X4X8
Operating Conditions: 650 USGpm @ 50ft Head
Motor Details: 575V/3/60, 15HP, 1760RPM
Installation Date: 2005

Figure 6 - Cold Floor Pump 2 [P-2]

<u>Warm Glycol Pump [WGP-1] : Frank Doherty Arena</u>
Make/Model: S.A. Armstrong 4030-2X2X10
Operating Conditions: 90 USGPM @ 85ft Head
Motor Details: 575V/3/60, 7.5HP, 1770RPM
Installation Date: 2017

Figure 7 - Warm Floor Pump

Ammonia Receiver [SD-1]
Make/Model: 16"OD x 16'LG Vessel
Storage Capacity: 767 lbs NH_3; 90% full by volume @ 90°F
Installation Date: 1959 – Level Column replaced in 2014
Vessel CRN: 4240.5
Note: A visual inspection of the Ammonia Receiver did not reveal any obvious leaks or weak spots, though the age of the vessel is concerning and should be replaced before an incident occurs.

Evaporative Condenser [EC-1]
Make/Model: Evapco LSCA-170
Capacity: 1838 MBH (131 TR) @ 95°F CT/75°WB
Installation Date: 1997
Note: The capacity of this unit is acceptable for running both arenas throughout the winter months, however there may be issues creating ice at the start of the operating season and maintaining the surface temperatures late in the season if outdoor temperatures are above average. Operating both arenas throughout the summer is not a realistic option with this unit as it will require at least an additional 400 MBH of heat rejection capacity.

Figure 8 - Evaporative Condenser [EC-1]

Section 2 - CSA B52-13 MECHANICAL REFRIGERATION CODE

The Canadian Standards Association (CSA) B52-13 standard provides the minimum requirements for the design, construction, installation, inspection, and maintenance of the mechanical refrigeration systems, and is complemented by the practical implementation guidance B52 Handbook, helping to minimize the risk of personal injury. The Code applies to all refrigeration systems installed, whether in new or existing premises, to systems that undergo a substitution of refrigerant, and to parts that are replaced in or added to the system.

NON CODE COMPLIANT ISSUES

CSA B52-13 Section 5 – EQUIPMENT DESIGN AND CONSTRUCTION

5.6 – REFRIGERANT CONTAINING PRESSURE VESSELS

5.6.2.1 – Liquid receivers or parts of a system designed to receive the refrigerant charge during pumpdown shall have sufficient capacity to receive the pumpdown charge without the liquid occupying more than 90% of the volume when the temperature of the refrigerant is 32°C (90°F).

Typically, CIMCO recommends that a single vessel, either the High Pressure Receiver (HPR) or in the case of the Thorold Community Arenas, a surge drum vessel, be of a sufficient size so that the entire ammonia charge of the system can be held by the vessel without exceeding 90% of the total vessel volume per clause 5.6.2.1 above. This is primarily so that the entire system does not need to be evacuated during the event that one of the other vessels (specifically the shell and tube chillers) need to be serviced or replaced.

Currently, the ammonia receiver has a 16" outside diameter and is 16 feet long. This vessel is capable of storing only 765 lbs of ammonia refrigerant at 32°C (90°F) when 90% full.

The estimated total refrigerant charge for this system is 850lbs, which will require that either some of the refrigerant (approx. 85 lbs) be removed from the system during a pumpdown situation, or that volume of ammonia must be stored in the other vessels which are present. While this is not a violation of the code, it is something to consider given the age of the current ammonia receiver.

5.11 – MARKING AND LABELING

5.11.1 – Signs (All Systems)
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 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 mover(s), the rating in kilowatts (hp) or full-load current and voltage.

Typically, a single sign (System Nameplate) will consolidate all of the information required by CSA B52-13 and is mounted on the compressor room exterior door. See standard CIMCO System Nameplate below.

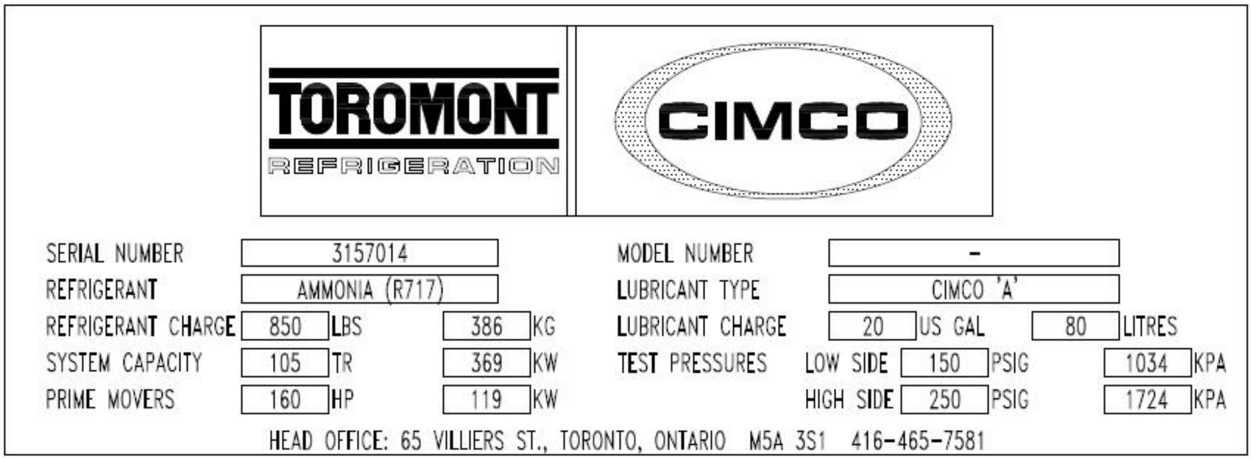


Figure 9 - Standard Cimco System Nameplate

5.11.2 – Nameplates for unit systems, condensing units, compressors, and compressor units
Each unit system and separate condensing unit sold for field assembly in a refrigeration system shall carry a nameplate marked with the manufacturer's name, the nationally registered trademark or tradename, the identification number, the test pressures, and the refrigerant for which it is designed.(…)

The rooftop evaporative condenser does not have a proper manufacturer's nameplate which clearly displays the information required in clause 5.11.2.

5.11.3 – Signs for systems containing more than 45 kg (100 lb) of refrigerant
In addition to meeting the requirements of Clauses 5.11.1 and 5.11.2, systems containing more than 45 kg (100 lb) of refrigerant shall be provided with durable signs and letters not less than 13 mm (1/2") in height designating the following:
a) the main electrical disconnect switch(es);
b) any remote control switch(es);
c) any pressure limiting device(s);
d) each pressure vessel;
e) the main shut-off to each vessel; and
f) the refrigerant piping (indicating whether it is at the high-side or low-side pressure and whether it is normally in the liquid or vapour state).

The following items require additional signage:
- On the MCC – add "Main Electrical Switch"
- At the Emergency Box outside of machinery room – add "Main Electrical Switch" to identify the remote control power shutdown switch
- At the inlet to each vessel – add "Main Shut-Off" tag to the shut-off valve nearest the vessel
- Additional pipe labeling is required to meet 5.11.3(f). CIMCO recommends that the piping be identified with pipe labels as per the International Institute of Ammonia Refrigeration (IIAR) standards. See Figure 10 – Typical Ammonia Pipe Marker.

Figure 10 - Typical Ammonia Pipe Marker

5.11.5(b) – Posting of instructions
It shall be the duty of the owner of a refrigeration system or systems with prime mover(s) having a capacity exceeding 125 kW (175 hp) to place in a conspicuous location and as near as practicable to the refrigerant compressor(s) a card giving directions for operating the system, including precautions to be observed in case of breakdown or leakage, as follows:
a) the telephone number of the appropriate first-response organization for an emergency situation;
b) instructions for shutting down the system in case of emergency;
c) the name, address, and day and night phone numbers for obtaining service;
d) the name, address, and day and night phone numbers of the nearest regulatory authority, and instructions to notify the authority immediately in case of emergency.

Shutdown instructions were not posted in the machinery room, and while items a), c), & d) were present, they were individually displayed. Typically, this information is printed on a single sheet of paper which is either laminated or placed in a glass frame and is mounted in a clear and obvious location near the compressors.

CSA B52-13 Section 6 – INSTALLATION

6.2 – MACHINERY ROOM

6.2.5 – VENTILATION

6.2.5.4 – Fan Switches
Readily accessible independent fan switches shall be installed inside and outside the machinery room. Fan switches located outside the machinery room shall be capable of starting but not stopping the ventilation.

Currently, there are two exhaust fans servicing the machinery room, each with an ON/AUTO switch located outside of the machinery room as per code.

Typically, these switches are mounted together in the vestibule; however, they are currently installed in two separate locations, one in the vestibule and one in the resurfacer room. In the event of an emergency which requires both fans to be manually started, it will be very difficult to safely activate both of the existing fans in a timely manner.

6.2.5.5.1 – Leaks or Ruptures Calculation (Emergency)
The mechanical ventilation required to exhaust a potential accumulation of refrigerant due to leaks or a rupture of the system shall be capable of removing air from the machinery room in the following amounts:
For system refrigerant charges of 7000 kg (15 400 lb) or less:
$Q = 70 \times G^{0.5}$ ($Q = 100 \times G^{0.5}$)

Where

Q = airflow L/s (ft^3/min)
G = mass of refrigerant in kg (lb), in the largest system that is located or partly located in the machinery room

Q = 100 x $850^{0.5}$ = 2915.5 ft^3/min

The emergency capacity of the existing exhaust fans will need to be confirmed by the manufacturer to insure they meet the requirement above.

6.2.5.5.2 – Minimum Ventilation (Continuous & Intermittent Non-Emergency)
Whenever the refrigeration system is operating or whenever the room is occupied, a sufficient part of the mechanical ventilation shall be operated to provide normal volumes equal to the greater of the following:
a) 2.54 L/s/m^2 (0.5 cfm/ft^2) of machinery room area; or
b) the volume required to prevent a maximum temperature rise above ambient greater than 10°C (18°F), based on all of the heat-producing machinery in the room.

a) Refrigeration Room Area: 822.4 ft^2
Min. Continuous Ventilation Required: 411.2 ft^3/min

b) Calculated Intermittent Ventilation Required: 4115 ft^3/min

*Calculation based on total motor horsepower, discharge piping heat gain, and estimated electrical loads.

As in section 6.2.5.5.1, the capacity of the existing exhaust fans needs to be confirmed by the manufacturers to ensure that they are capable of exhausting a minimum of 4115 cfm of air from the machinery room.

Figure 11 - Exhaust Fan 1 & 2

6.2.5.7 – Minimum Temperature
Supplementary heating shall be provided to maintain a minimum machinery room temperature of 5°C (40°F) where damage could result at temperatures below freezing.

This is to protect the equipment, vessels, and piping from freezing during a prolonged or unanticipated plant shutdown. Typically, there is a small space heater (electric, not flame producing; see clause 6.3(a) in CSA B52-13) within the machine room to keep the space above freezing temperatures.

6.3 - CLASS T MACHINERY ROOM

Section 6.3 outlines the special requirements for "Class T" Machinery Rooms which is required for all ammonia refrigeration plants per CSA B52.

6.3(b) – The room shall have at least one exit door that opens directly to the outer air. Other exits communicating with the building shall be permitted, but shall be through a vestibule equipped with approved self-closing, tight fitting fire doors.

There are three existing doorways from the machinery room into adjacent spaces within the Thorold Community Arenas. One to a proper vestibule, one to the Resurfacer Room serving James Whyte Arena, and one to a hallway which also leads to the canteen entrance. Currently, there are two violations of clause 6.3(b) within the arena complex which need to be addressed.

Firstly, there is no door from the machinery room that leads "directly to the outer air." This is a major safety concern, as a worker could be trapped inside with a large amount of ammonia in the event of an emergency.

Figure 12 - Machinery Room North Exit Door

Secondly, the door leading from the refrigeration room into the hallway to canteen does not have a vestibule equipped with approved self-closing, tight fitting fire doors. This space is easily accessible by non-authorized personnel, and it does not display the appropriate signage to warn of any potential dangers associated with a Class T Machinery Room.

An architect and/or structural engineer will need to be consulted to rectify these two accessibility issues in order to become compliant with the CSA B52-13 code.

6.3(d) – The machinery room walls, floor and ceiling shall be of non-combustible construction. Walls, floors, and ceiling separating the machinery room from other occupied spaces shall have a rating of at least one-hour fire resistive construction.

While the ceiling is technically no longer (as of CSA B52-13) required to be one-hour fire rated as there is no occupied space directly above the engine room, CIMCO recommends maintaining this rating as there is an evaporative condenser containing ammonia located on the roof above the machinery room. The existing fire rating of all refrigeration room walls and doors will need to be verified.

6.3(f) – All pipes piercing the interior walls, ceiling, or floor of a Class T Machinery Room shall be tightly sealed to the walls, ceiling or floor through which they pass.

The openings and pipe penetrations shown in the figures below are examples of instances within the machinery room that do not comply with clause 6.3(f) and must be properly sealed as per the CSA B52 Code. In addition to pipe penetrations, clause 6.2.2 states that "… *there shall be no openings that will permit passage of refrigerant to other parts of the building."* The seal around the ducts which penetrate the machinery room walls in Figure 14 below should be checked and confirmed to be of tight construction.

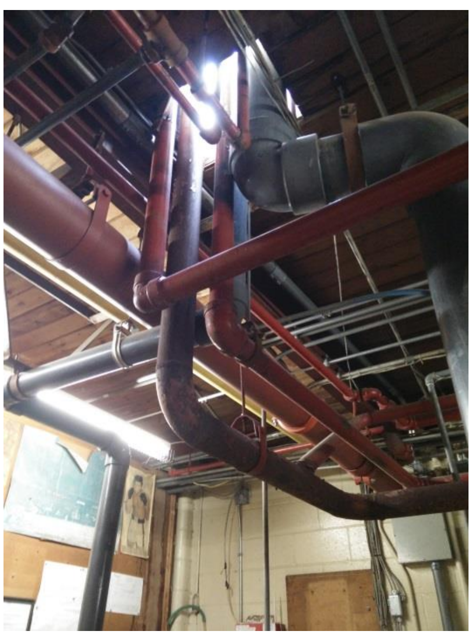
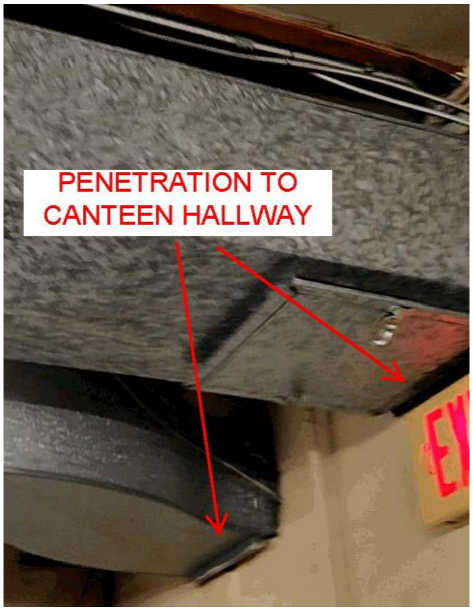


Figure 13 - Machinery Room Roof Openings



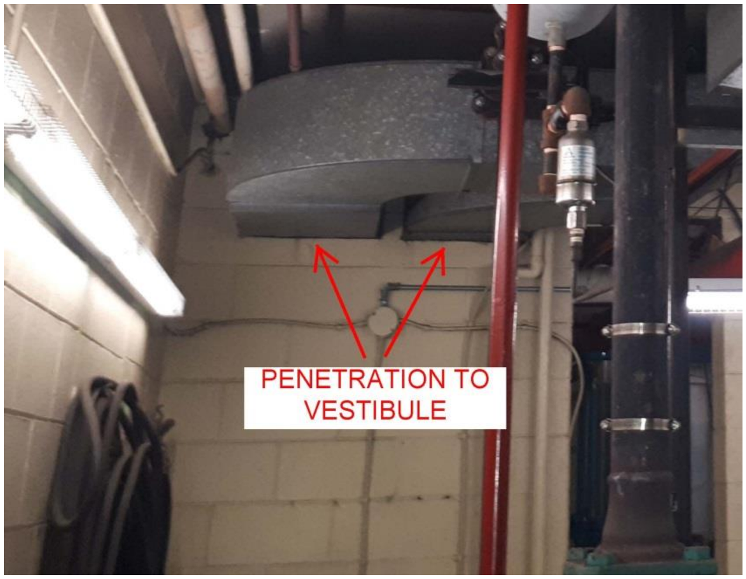


Figure 14 - Machinery Room Duct Penetrations

6.8 – LOCATION OF REFRIGERANT PIPING

6.8.2 – In any building, refrigerant piping crossing an open space that provides a passageway shall be not less than 2.3 m (7-1/2 ft) above the floor unless it is against the ceiling of such a space.

The C-1 dry suction line is only 7' AFF. This is not a major issue, but depending on the scope of the other changes that will be made it may be beneficial to raise this pipe at the same time.

Section 7 – OVERPROTECTION

7.3 – PRESSURE-RELIEF DEVICES

7.3.6 – Discharge or Fusible Plugs and Other Pressure-Relief Devices

7.3.6.3 – The size of the discharge pipe from the fusible plug or other pressure-relief device shall be not less than the size of the fusible plug or other pressure-relief device outlet. If the discharge from more than one plug or relief device is connected into a common header, the size and maximum equivalent length of the discharge header shall be determined by
a) the sum of the rated capacities of all valves discharging into the header; or
b) the sum of the areas of the pipes connecting into the common header.

It has been determined that all of the pressure-relief devices are properly sized for the equipment they are servicing, up to date and well maintained. Currently, there are two separate pressure-relief lines leading to the roof where they can safely discharge refrigerant in the event of an emergency.

One of these lines, which serves only the Underfloor Heat Exchanger [HX-3] (see Section 1) and is correctly sized as 1" steel pipe leading to a 1-1/2" ammonia relief diffuser. This was installed during the floor renovation of the Frank Doherty Arena in 2017.

The other is a common relief header which serves all of the remaining equipment. This common header consists of a 2" steel pipe which tees into a 3" vertical steel pipe above the machinery room roof and topped with an ammonia relief diffuser. Per current CSA B52 relief piping standards, this header should be 3" steel pipe all the way from inside the refrigeration room, through the roof, and to the ammonia diffuser. While it can remain unchanged, any modifications made to the relief system in the future will require this header to be redesigned and replaced.

Section 3 – OTHER RECOMENDATIONS

Eyewash Station

Currently, the only eyewash station in the facility is located in the arena workshop, up two flights of stairs and well away from the machinery room. While it is not explicitly required by CSA B52-13, CIMCO strongly recommends installing an eyewash station inside the machinery room itself as irreversible negative effects of ammonia exposure can occur within 10 seconds if not treated, depending on the quantity of ammonia released. The Immediate Danger to Life and Health (IDLH) concentration for anhydrous ammonia is 300ppm, so contact with even a very small amount of ammonia should be treated as quickly as possible. Typically, the eyewash station is installed in a location that is accessible within 10 seconds of the compressors as this is the most likely location for an emergency ammonia release.

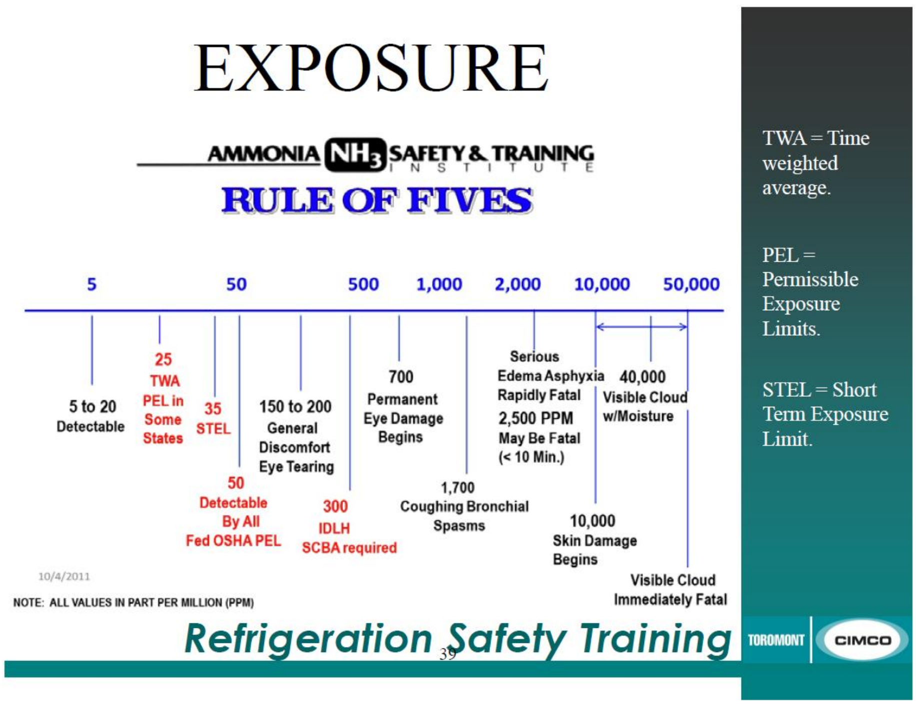


Figure 15 - Ammonia Exposure Levels

Exterior Firebox and Emergency Stop Switch

The exterior enclosures for both the fire relief valves and the emergency stop (E-Stop) switch should be replaced by tightly sealed, outdoor rated cases to protect the internal components from weather, particularly the accumulation of snow. Figure 16 depicts the existing enclosures, and they are not easily accessible in the event of an emergency.

Figure 16 - Existing Firebox & E-Stop Enclosures

Section 4 – SUMMARY & RECOMMENDED PRIORITIES

After analyzing the refrigeration system deficiencies recorded in this report, it is Cimco's recommendation that they be prioritized in the following order based on safety, efficiency, and current best practices with respect to ammonia refrigeration:

1. CSA B52-13, section 6.3(b) – "*at least one exit door that opens directly to the outer air".*
This portion of the code is critical to the safety of anyone performing any work in the machinery room in the event of an ammonia leak. It is currently very difficult to quickly escape the machinery room as a person will need to navigate through the room, up and down multiple sets of steps, and across another space potentially containing large resurfacing equipment. If the person has been exposed to ammonia they may have difficulty seeing or be disoriented and could be unable to safely exit the building. As mentioned before, a structural engineer and/or architect will need to be involved in rectifying this situation.

2. CSA B53-13, section 6.3(b) – "*Other exits communicating with the building shall be permitted, but shall be through a vestibule equipped with approved self-closing, tight fitting fire doors."*
The hallway separating the machinery room and the canteen is too easily accessible for non-authorized personnel. If someone needs to exit the machinery room through this doorway during an emergency, ammonia could be allowed to spread into other occupied spaces within the facility.

3. Exhaust Fan Capacity Verification
As it could not be determined onsite, it should be confirmed that the capacity of the two existing exhaust fans meets or exceeds the required CFM of airflow calculated earlier in this report. If they do not, they should be replaced as soon as possible to ensure proper function if an ammonia release were to occur.

4. Firebox/E-Stop Switch Enclosure Replacement
Shutting down and safely releasing all of the ammonia from the system are two of the first steps for emergency services when responding to an ammonia release. The current firebox and e-stop switch enclosures do not protect their contents well enough from the elements and may cause a delay during emergency response.

5. Eyewash Station Relocation
The only accessible eyewash station is serving both the arena workshop area and the machinery room and is too far from potential ammonia exposure hazard locations. A second eyewash station should be installed within the machinery room to serve this area during an emergency situation.

6. Ammonia Receiver Testing/Replacement
Due to the age of this vessel, consistent inspection and testing will be required until it is replaced.

7. Ammonia Pipe Markers and Machinery Room Signage
There is a significant lack of labels and safety signage throughout the machinery room, this should be brought up to the current standards outlined previously in this report to prevent any avoidable accidents.

8. Relief Piping Replacement

It is common for undersized relief headers to be grandfathered in after code changes are adopted. However, if a part of the relief system which is attached to the existing relief header is modified, the entire relief system will need to be brought up to current CSA B52 sizing standards based on the amount of ammonia which could potentially be discharged at one time.

9. Evaporative Condenser Consideration

While the evaporative condenser does not urgently need to be replaced, it will limit the changes that can be made to the arena operation as it is only capable of rejecting exactly enough heat for the current arena operating conditions. Any future increase to the arena season length (eg. year-round operation of both rinks) will require a new evaporative condenser to be installed.

Please review these comments and recommendations carefully. Any questions or comments can be directed to the author