AGENDA
CITY OF CREVE COEUR
FACILITIES TASK FORCE
CITY OF CREVE COEUR, MISSOURI
MARCH 6, 2023
10:00 AM

CALL TO ORDER

ROLL CALL

APPROVAL OF MINUTES

1. **Approval of January 9, 2023 Facilities Task Force Meeting Minutes**

BUSINESS FROM STAFF

2. **Dielmann Recreation Center Structural Evaluation**
   Summary: A structural evaluation of the facility was conducted to identify any structural deficiencies before considering moving forward with the R-22 switchover project.
3. **B32 Final Ice Arena Refrigerant Change Feasibility Study**
   Summary: The report has been updated to provide the task force with current construction costs to switchover the R-22 refrigerant to Ammonia.

NEXT MEETING DATE

ADJOURNMENT

Posted by: ______________________

Date/Time posted: ______________________

If you need special accommodations to attend a meeting, services may be arranged by contacting the Office of the City Administrator in advance.

MINUTES
CITY OF CREVE COEUR
FACILITIES TASK FORCE
CITY OF CREVE COEUR, MISSOURI
JANUARY 9, 2023
10:30 AM

CALL TO ORDER

A regular meeting of the Facilities Task Force of the City of Creve Coeur was called to order by Chair, City Council Member Joseph Martinich at the City Council Chamber, 300 North New Ballas Rd, City of Creve Coeur Government Center, Creve Coeur, MO 63141 on Monday, January 9, 2023 at 10:30 AM.

ROLL CALL

Mayor Robert Hoffman
Chair, City Council Member Joseph Martinich
Vice- Chair, City Council Member Tim Carney
Member Marjorie Richter
Member Richard Darrow- Via Zoom
Member Barry Glantz Member-
ViMember Richard Kutta

Staff Present: City Administrator Mark Perkins, Director of Public Works Jim Heines, Director of Recreation Jason Valvero, Building Maintenance Technician Jeremy Miller, and City Clerk Kellie Henke.

Others Present: Scott Ward of B32 Engineering Group, Michael Chiodini of Chiodini Architects, and Kevin Griesemer of G&W Engineering.

APPROVAL OF MINUTES

1. **Approval of November 7, 2022 Facilities Task Force Meeting Minutes**

RESULT: **APPROVED (UNANIMOUS)**
MOVER: Marjorie Richter
SECONDER: Tim Carney
AYES: Carney, Martinich, Hoffman, Richter, Darrow, Glantz, Kutta

The vote on the motion being 7 ayes and 0 nays, motion carried.

DISCUSSION ITEMS

2. **B32 Kick-off Meeting**

Scott Ward of B32 Engineering Group provided an overview of the Ice Arena

Refrigerant Change Feasibility Study created November 4, 2021 and revised on April 5, 2022. Discussion included Refrigeration System Improvement and Replacement options and the advantages and disadvantages of each. Four options were identified for improving the refrigeration system.

Option 1: Maintain the existing R-22 refrigeration system and make selected improvements. No discussion took place as the consensus of the Task Force was to not proceed with this option.

Option 2: New indirect, HFC/HFO synthetic-based refrigeration system. Mr. Ward stated a synthetic-based refrigerant is estimated to be 10-15% less energy efficient than the existing R-22 system and approximately 30-40% less efficient than an ammonia-based system. Synthetic refrigerants may be faced with future restrictions with high global warming potential.

Option 3: New indirect, ammonia-based refrigeration system. Mr. Ward stated an ammonia-based system is a common system that offers longevity of industrial grade equipment and refrigerant (30+ years). Ammonia is a pure refrigerant, which results in a much greater level of efficiency than synthetic refrigerants. Most refrigeration systems installed in the St. Louis area over the last decade have been ammonia-based systems. Mr. Ward stated a low-charge ammonia system could be designed. However, this type of system is newer, requires more control and maintenance, and may be a little less efficient. The Task Force consensus is to not proceed with a low charge ammonia system. Members and staff expressed concern about the operational issues and ice-quality issues associated with a low-charge system.

Option 4: New indirect, CO2-based refrigeration system. Mr. Perkins stated it is concerning that there is a limited number of contractors familiar with this type of system.

Mr. Kutta stated the ice rink floor could be replaced concurrently with the refrigerant system to minimize down time for the ice arena. City Administrator Mark Perkins asked Mr. Ward for his opinion on the status of the ice rink floor, to which, Mr. Ward stated there were no aging signs that warranted the need for replacement at this time; the estimated cost for replacement of the ice rink floor is approximately $1,000,000 minimum. It is expected that ice floor will need to be replaced within the next 5 to 10 years.

Mayor Hoffman asked what are the health risks of an ammonia-based system, to which Mr. Ward stated each type of refrigerant comes with its own health risks. Mr. Ward recommended installing a vestibule on the inside of the existing refrigeration, to house life safety equipment so that it can be monitored prior to entering the ammonia room; a second eyewash-shower system is required outside the refrigeration room. The vestibule would provide a safe space for anyone entering the room to stop and monitor any potential hazards (like an ammonia leak) before entering the room through the gas monitoring system or window in the door. It also provides another barrier between the ammonia system and anyone that might be outside the refrigeration room.

Mr. Ward stated next steps include updating the Feasibility Study with additional detail regarding the HVAC and Safety systems and verifying the dimensions of the current refrigeration room. Mr. Ward stated the cost estimates provided in July of 2022 are still valid.

The Task Force consensus is to proceed with an ammonia-based system.

3. Government Center Building Needs Assessment Report- Final

Mr. Perkins reminded the Task Force of the cost estimates provided in the Feasiblity Study and stated it would not be practical for the City to finance a new Government Center at this time. Mr. Perkins stated that multiple revenue sources could be used but a general obligation bond issue will be necessary. In the interim, the City will focus on short-term improvements, including smaller maintenance projects. Director of Public Works Heines provided an overview of the smaller maintenance projects.

The Task Force consensus is to not proceed with a schematic level design for a new building at this time.

Mr. Heines provided an update of the roof replacement for the Government Center, Ice Arena and the Public Works Facility and stated discussions are still being held with the insurance company.

NEXT MEETING DATE

The next Facilities Task Force meeting, tentatively, will take place on Monday, March 6, 2023 at 10:00 AM.

MINUTES
CITY OF CREVE COEUR
FACILITIES TASK FORCE
CITY OF CREVE COEUR, MISSOURI
JANUARY 9, 2023
10:30 AM

ADJOURNMENT

The meeting adjourned at 11:51 AM.

THE POWERHOUSE AT UNION STATION ● 401 S. 18TH ST., STE. 400 ● SAINT LOUIS, MISSOURI 63103-2296

Dielmann Recreation Center
11400 Olde Cabin Road
Creve Coeur, MO
Structural Evaluation

Report Prepared for:
Jason Valvero
Director of Recreation
11400 Olde Cabin Road
Creve Coeur, MO 63141

Horner & Shifrin Project Number
2300700

Date: January 21, 2023

Executive Summary

Horner & Shifrin was retained by the City of Creve Coeur to provide a structural engineering evaluation of the Dielmann Recreation Center to determine if the structure has any structural deficiencies or required structural updates. The existing mechanical system for the ice rink is being upgraded and the city is interested in making any necessary structural repairs to the building as part of the upgrade work. The location, aerial view, and elevation views are provided in Figures 1 through 3 below.

The following observations and conclusions were made by Chad Brenton, PE.

Overall Comments

- The structure is in good condition for its age and use. There were no major structural issues noticed at the time of inspection that require repairs.

- A few minor structural issues were noticed, and repairs have been recommended with estimated costs. See the "Estimated Repair Costs" and "Conclusion & Recommendations" sections.

- The minor structural issues are as follows:

    - Multiple issues with the roof gutters and drainage system were noticed. They are not considered a structural issue, but their repairs will only help the performance of the roof and improve the longevity of the building structure.

    - A crack has developed in a concrete header beam for a maintenance door located on the northeast wall of the ice rink space. This header beam is not in the critical load path for the building structure; however, it does support the wall above the door. Sealing and monitoring the crack will help stop the issue from developing further.

    - The ceiling in the basement garage is in poor condition. The damaged drywall ceiling itself is not a part of the structural system and not considered a structural issue. However, they help to protect the underside of the floor above. Repairing and waterproofing the ceiling will ensure the floor system does not get compromised.

- A few maintenance and building system issues were noticed as well. While not a part of the structural system. Their repairs will only help promote the longevity and safe use of the building. Estimated repairs have been recommended with estimated costs. See the "Estimated Repair Costs" and "Conclusion & Recommendations" sections.

- Additionally, it's been mentioned that the basement has been prone to flooding events. Given this history and since the basement garage door remains open during regular business, it is recommended to investigate possible site improvements that could help with draining water away from the basement. Keeping moisture out of the garage will help the ceiling remain intact.

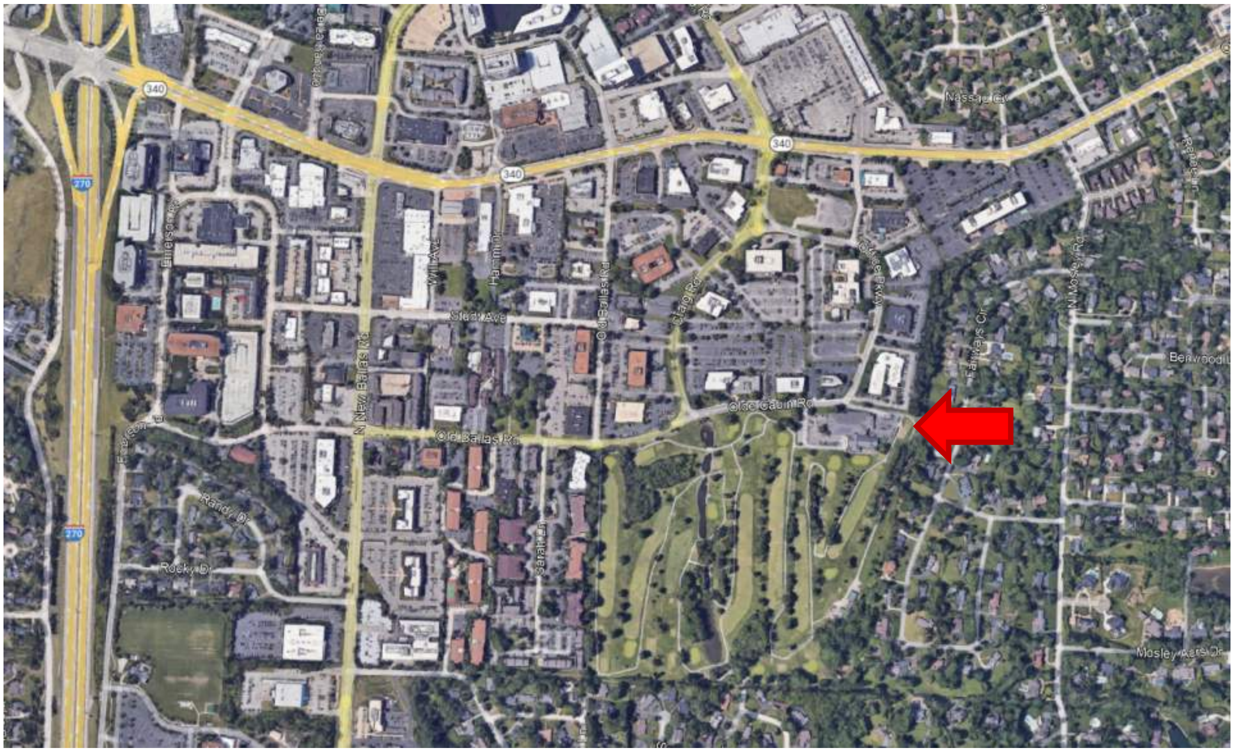


Figure 1 – Aerial View

Figure 2 – Southwest (Front) Elevation

Figure 3 – South Elevation

Estimated Repair Costs

Table 1 below represents the total estimated repair costs to the City of Creve Coeur. These estimations were done from an engineer's perspective using available construction cost data. Exact repair costs may differ depending on construction schedule, available materials, and labor cost. Repairs are not required at this time but recommended for consideration. See the "Conclusions and Recommendations" section for detailed explanations.

Table 1: Estimated Repair Costs

Description	Figure references	Total Repair Cost ($)
Minor Structural Issues		
Selective Gutter Repairs	5, 10, 11, 13, 14, 15	$10,000
Concrete Header Beam Repair	19	$100
Basement Ceiling Repairs	25, 26, 27 28	$2,500
Total		$12,600
Building System Issues		
Tuckpointing Exterior Joints and Cracks	9, 12, 18	$900
Repair or Drainage Channel	6, 7, 8	$1,500
Railing Repairs	16	$50
Soffit Replacement	17	$50
Plumber Consultant	29	$100
Mechanical Consultant	31	$100
Electrical Consultant	32	$100
Total		$2,800
Grand Total		$15,400

Scope of Work

The scope of the investigation includes completing a visual inspection of the building to determine the structural integrity or issues of concern for the use and operation of the structure. An engineer's cost estimate is to be provided for any required structural repairs and or recommendations.

Materials or other testing and removal of existing finishes to expose hidden conditions are excluded from the scope of work. Additionally, evaluation of the adequacy of existing mechanical, electrical, plumbing, and fire protection systems is outside this scope of work. Any visible concerns with these systems that were noticed during the inspection were noted for your consideration.

This report summarizes the findings of the investigation.

Building Description

The description & associated information is provided below:

Table 2: Building Description

Approx. Building Square footage	37,000 sq. ft.	Current Occupancy:	Group A-3/A-4 Ice Rink & Golf Club House Facility
Foundation Footprint	1 Story building w/ basement level	Year of Original Construction:	1970's
Foundation Type	Concrete Slab (unknown depth)	Foundation Type:	Concrete Slab (unknown depth)
Roof Geometry	Hip Roof with Shingles	Flooring:	Structural Concrete Slab
Vertical Load Systems	(Club House) Light-Frame Wood Construction	Lateral Load System	(Club House) Light-Frame Wood Shear & Bearing Walls
	(Ice Rink) Stack Bond Masonry & Mass Timber Roof Truss		(Ice Rink) Ordinary Reinforced Masonry Shear and Bearing Walls

Site Inspection

The inspection was completed on Friday, January 6, 2023 at 9:00 am. Jason Valvero was on site to help provide access to all parts of the building. The inspection began outside the front entrance (Southwest corner) and continued clockwise around the exterior. The inspection then continued to the inside starting with the office and lobby. Next the ice rink space was inspected, then the Golf club house & meeting rooms, followed by the basement garage. Additional maintenance rooms were inspected at the end when access was provided. A final cursory walk was conducted around the property to check for any relevant issues to the structure itself.

The following observations were made:

<u>Exterior Observations</u>

- Figure 4 – Mortar Joint Damage: Eroded mortar joint at base of walls.
- Figure 5 – Gutter Damage: Large quantities of rain, snow and ice tend to accumulate in roof valleys like this.
- Figure 6-8 – Blocked Roof Drainage & Collection. Black corrugated drain line ends slightly downhill from drainage channel. The drainage channel was full of sediment and drained to a low point in the parking lot.
- Figure 9 – Foundation Joint Separation. Joint filler material missing or eroded.
- Figure 10 & 11 – Damaged Gutter Sections (Southwest corner of ice rink space). The gutter is damaged and separated from the roof. May be full of debris.
- Figure 12 – Vertical Masonry Joint Crack. Typical temperature and shrinkage cracks but not a structural issue.
- Figure 13 – Damaged Gutter Section (Southwest corner of ice rink space). The gutter is damaged and separated from the roof. May be full of debris.
- Figure 14 – Gutter Separation. Downspout has separated from the Gutter Drop (North wall of ice rink space).
- Figure 15 – Gutter Damage. Water staining to the exterior façade is visible indicating that the gutter may not be draining properly. It could be incorrectly slopped or clogged (Northeast corner in mechanical space).
- Figure 16 – Loose Railing Section. The railing, when pushed against would move horizontally and may pose a safety issue.
- Figure 17 – Missing soffit. Located at the Southwest corner of the Golf club house section.

Figure 4 – Mortar Joint Damage

Figure 5 – Gutter Damage Above Offices

Figure 6 – Downspout Collection South wall of Ice Rink

Figure 7 – Sediment Filled Drainage Channel

Figure 8 – Downspout Collection South wall of Ice Rink

Figure 9 – Foundation Joint Seperation

Figure 10 – Damaged Gutter Sections

Figure 11 – Damaged Gutter Sections

Figure 12 – Vertical Masonry Joint Crack

Figure 13 – Damaged Gutter Sections

Figure 14 – Gutter Seperation (North Side of ice Rink)

Figure 15 – Damaged Gutter Sections

Figure 16 – Loose Railing Section

Figure 17 – Missing Soffit

Interior Observations

- Figure 18 – Lintel Joint Crack. The masonry joint has separated between the blocks holding the steel lintel for the doorway to the ice rink space. This does not appear to be a structural issue but may have developed due to temperature differences between the lobby and the ice rink.
- Figure 19 – Concrete Header Beam Crack. A crack has developed on the right side of an exterior maintenance door. Northeast corner.
- Figure 20 – Mass Timber Roof Beam. Evidence of previous repair and reinforcement. Beams seem stable and no visible structural issues apparent at the time.
- Figure 21 – Mechanical Area Above Bathrooms (Northeast corner). No structural issues noticed above the public spaces.
- Figure 22 & 23 – Crack in Masonry Block. Block is not part of the critical load path of the structure and is not considered a structural issue.
- Figure 24 – Vertical Hairline crack in concrete basement wall. No evidence of water intrusion and is not considered a structural issue.
- Figure 25 – 28 – Falling/Molding Ceiling drywall. Drywall and drywall tape are separated due to high moisture content in garage and lack of water proofing. The molding sections appear to be damaged from a recent pipe burst event.
- Figure 29 – Detached Pipe. Pipe appears to run to daylight. Possibly above the roof.
- Figure 30 – Vertical Hairline crack in concrete basement wall under stairs. No evidence of water intrusion and is not considered a structural issue.
- Figure 31 – Mechanical duct cover. May pose a mechanical issue. Consult a mechanical contractor.

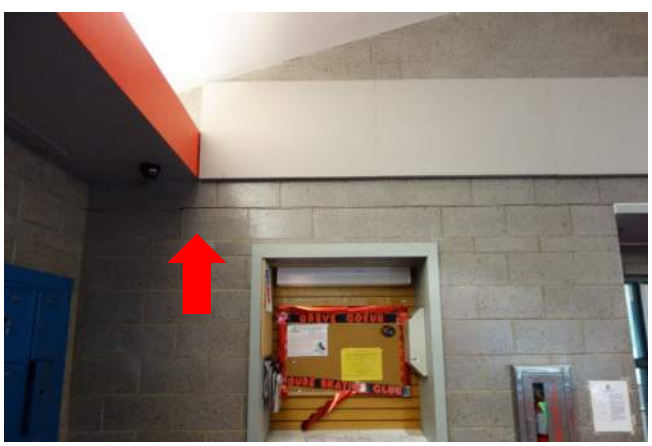


Figure 18 – Lintel Joint Cracks

Figure 19 – Concrete Header Beam Crack

Figure 20 – Mass Timber Roof Beam

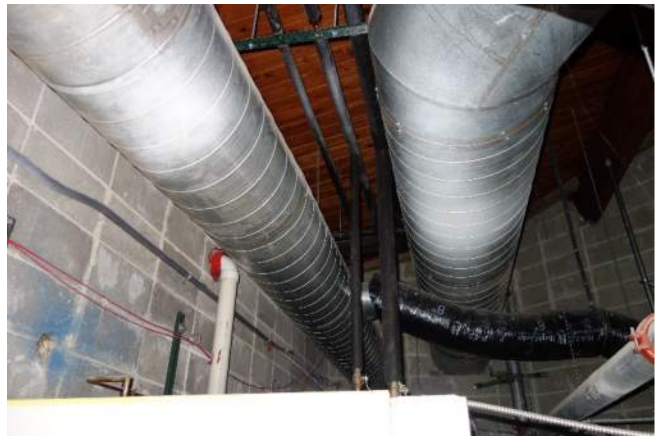


Figure 21 – Mechanical Area above Bathrooms

Figure 22 – Crack in Masonry Block

Figure 23 – Crack in Masonry Block

Figure 24 – Vertical Hairline Crack

Figure 25 – Falling Ceiling Drywall

Figure 26 – Rust under Ceiling Drywall

Figure 27 – Falling Ceiling Drywall

Figure 28 – Molding Ceiling Drywall

Figure 29 – Detached Pipe

Figure 30 – Vertical Hairline Crack

Figure 31 – Mechanical Duct Cover

Additional Property Observations

- Figure 32 – Missing Cover Plate to Light Pole. Exposed wires accessible to the public pose a safety issue that could result in electrical shock.

Figure 32 – Missing Cover Plate to Light Pole

Conclusions and Recommendations

Based on the inspection and review of available material, Horner & Shifrin has reached the following opinions with a reasonable degree of engineering certainty. Conclusions and opinions offered are based upon the information available to Horner & Shifrin at the time of this report. They may be subject to revision after the date of publication as additional information becomes available.

Conclusion on the condition of the structure

The structure is in good condition for its age and use. While not all aspects of the structural systems were visible, evidence from the exterior and interior proves to be sufficient to conclude that there are no major structural issues that warrant required repairs at this time.

However, A few minor structural issues and building system issues were noticed. Even though they are not required, it is advised to consider the following Recommended Repairs to help promote the longevity and safe use of the building.

It was also mentioned by Jason Valvero, that the basement has been prone to flooding events. Given this history and since the basement garage door remains open during regular business, it is recommended to investigate possible site drainage improvements that could help with draining water away from the basement. Keeping moisture out of the garage will help the drywall ceiling remain dry and intact.

Minor Structural Issues & Recommended Repairs

- Repair and replace damaged gutters and downspouts. This will help make sure rainwater is diverted sufficiently away from the structure (See figure 5, 10, 11, 13, 14, 15).
- Seal the concrete header beam crack (see figure 19) with an epoxy injected sealant. After the repair, if the crack grows larger, or interferes with the opening of the door, remove, and replace the header beam with a new, engineered, reinforced-concrete, header beam.
- The ceiling in the basement garage is in poor condition (see figures 25-28). While not a part of the structural system and not considered a structural issue, they help to protect the underside of the floor above. Repairing and waterproofing the ceiling will ensure the structural floor system does not get compromised. Repair as follows:
    - Replace water damaged and loose drywall boards on ceiling.
    - Sand/grind off any rust that has developed on the floor support beams and any steel under the removed drywall boards. Repaint exposed metal with a rust preventive paint.
    - Re-tape and re-mud cracked joints between drywall sections.
    - Prime the full surface area of the drywall ceiling with an exterior grade waterproof primer.

Building System Issues & Recommended Repair:

The following are also not required repairs but would be considered good building maintenance & management practice:

- Tuckpoint eroded joints and or seals around the base of the building exterior (see figure 4). Preferably any damaged joints from grade to 1' above grade. Any expansion/construction joints (see figure 9) should be sealed with a waterproof, exterior grade, caulking. This will help make sure rain and snow cannot penetrate the building envelope and damage the structure.
- Tuckpoint vertical masonry joint cracks larger than 0.3mm. on the exterior. And the masonry joint cracks around the lintel beam on both sides (see figure 12 & 18) Repairing would mitigate any potential source for moisture that could harm the structure long term.
- Clean out the drainage channel along the south wall of the ice rink space, near the front door (see figure 6-8). Extend the drainage channel or a French drain down the parking lot to ensure rainwater can positively drain away from the structure (see dashed line in figure 8). Currently it would seem rainwater would be pooling at the base of the existing drainage channel. This could pose a safety hazard for pedestrians.
- Repair loose railing section by repacking the connection to concrete with new non-shrink grout (see figure 16).
- Replace missing soffit to ensure a properly sealed roof structure (see figure 17).
- Consult a Plummer about reattaching the vertical pipe in the garage (See figure 29).
- Consult a Mechanical Contractor about the loose cover or the mechanical duct (see Figure 31).
- Consult an Electrical Contractor about installing a new cover over the opening in the Light Pole (see Figure 32).

End of Inspection Report

Ice Arena Refrigerant Change Feasibility Study

The Deilmann Recreation Complex

For:

City of Creve Coeur
300 N New Ballas Road
Creve Coeur, MO 63141

November 4, 2021
Revision 1:
April 5, 2022
Revision 2:
February 16, 2023

Submitted by:
Scott A. Ward, P.E.
B32 Engineering Group, Inc.
2211 O'Neil Road
Hudson, WI 54016
651.256.3090

File No. 900.16.270

ICE ARENA REFRIGERANT CHANGE FEASIBILITY STUDY
CREVE COEUR, MISSOURI
11.4.21; Rev 1: 4.5.22; Rev 2: 2.16.23

B32° Engineering Group

1.0 TABLE OF CONTENTS

2.0 BACKGROUND AND PURPOSE

The Creve Coeur Ice Arena is located in the Deilmann Recreation Complex at 11400 Olde Cabin Road in Creve Coeur, Missouri. The Creve Coeur Ice Arena has a long tradition of ice hockey, ice skating, and curling. The highest level of play at this facility is high school practices. High School games are not played at this facility due to the limited seating. As part of a continued effort: to improve operation and efficiency at the facility; to plan for future improvements to the ice system; and to continue to provide high quality ice for its user groups; the City of Creve Coeur has commissioned this study to evaluate the options for replacing the R-22 refrigerant in the existing 18-year-old indirect R-22-based ice system, or replacing the entire refrigeration system, along with other improvements. R-22 refrigerant was phased out of importation to and production in the U.S. in 2010 due to its high ozone depleting potential (ODP). In the past 6 months or so the price of R-22 refrigerant has risen substantially and is expected to keep rising as supplies have become very limited and purchases restricted to small quantities.

B32 Engineering Group, Inc. visited the site, with Chiodini Architects, on September 23, 2021. The ice sheet was in place during the site visit. B32 Engineering Group, Inc. has reviewed the Murphy report dated February 15, 2021, agree with its findings and reference it throughout this report.

The facility was built in 2003 and currently operates in the ice mode year-round.

3.0 ICE SYSTEM REVIEW

3.1 Description of Existing Ice System

The existing ice system includes a refrigeration system, a concrete ice rink floor system and a dasher board system. The existing refrigeration system is an indirect R-22-based/glycol refrigeration system and was installed in 2003. Since 2003 the following major improvements to the refrigeration system were completed:

1. 2008 – Compressor 3 remanufactured or rebuilt.
2. 2008 – New evaporative condenser.
3. 2008 - Added heat to the snow melt pit.
4. 2019 - Compressor 1 remanufactured or rebuilt.
5. 2017 – Compressor 2 remanufactured or rebuilt.
6. 2017 – Subfloor or underfloor circulation pump.
7. 2021 – Installed new fins in existing evaporative condenser. The city will finish installing interior fins in 2021.

The existing refrigeration includes: three Carlyle reciprocating compressors Model 5H120-A219 with capacity of approximately 20 tons each at a 0-degree saturated suction temperature providing a total capacity for the refrigeration system of approximately 120 tons; flooded-type plate and frame chiller system with two plate and frame chillers and one surge drum; rink floor pumps, one evaporative condenser, a control system and a waste heat recovery system. The existing system is considered a "skid package" system where the majority of the components are built and delivered on a single steel frame or "skid".



Photos 1 & 2 – Existing refrigeration system

There is a waste heat recovery system that serves the subfloor heating system under the rink floor and the snowmelt pit in the resurfacer room. This system essentially provides free heat from the refrigeration system. The subfloor heating system is reportedly in good working order and there are no concerns with frost building up under the ice rink floor. The snowmelt pit heating system is reportedly performing well.


Photo 3 – Existing evaporative condenser


Photo 4 – Existing snow melt pit and coil

The existing concrete ice rink floor was installed with the original building in 2003 and extended to NHL standard size of 200' x 85' in 2008. The fluid in the subfloor heating system is glycol. The concrete is reported to be uneven which leads to uneven ice thickness and possibly increased energy use and ice quality concerns. In 2003-04 the subfloor header piping system under score keeper's box was replaced. In 2008 the size of the rink floor was extended to the NHL standard size of 200'x85'.

Photo 5 – Overall ice rink floor

Photo 6 – Bleacher seating in ice arena

The existing refrigeration room is approximately 550 square feet which is adequate in size to house a new refrigeration system. See the conceptual ice system layout at the end of the report. There is only one access door out of this room, and it opens directly to the exterior of the building. The existing life safety systems in the refrigeration room include a gas monitoring system and mechanical ventilation and are reportedly in good - working order. B32 Engineering Group did not test or witness the operation of any life safety systems.

The existing dasher board system was installed in 2003 (18 years old) and is reaching its typical life expectancy of 20-25 years. Some improvements to the existing system were completed and include the replacement of the white poly facing and the modification of the boxes and doors to meet the requirements of the Americans with Disabilities Act (ADA) in 2008. The manufacturer of the dasher board system is not known. The system appears to be in fair condition and no other concerns have been reported.

Photo 7 – Existing dasher board system

Photo 8 – Existing dasher board system – Scorer's box

4.0 ICE SYSTEM IMPROVEMENT AND REPLACEMENT OPTIONS

4.1 General

The existing 18-year-old ice system (refrigeration system, ice rink floor and dasher board systems) is nearing its expected useful and safe life of 25 years. Some improvements have been made to the refrigeration system, as outlined above.

The scope of this study did not include evaluating the existing ice rink floor or dasher board system. Murphy performed thermal imaging on the ice rink floor in 2021 and found no large differences in temperature concluding there are likely no leaks in the piping system.

The existing refrigeration room is large enough to accommodate any of the recommended refrigeration system improvement and replacement options outlined in the next section. The conceptual ice system layout, included at the end of this report, shows the layout for Option 3 – stick built ammonia system. This drawing also shows a new access door and vestibule between the refrigeration room and the resurfacer room. The additional access will provide a more convenient access for the facility staff to enter the refrigeration room and provides another layer of protection or isolation between the refrigeration room and the resurfacer room if the ammonia option is selected. The cost estimate includes these improvements and other code required improvements to the refrigeration room each of the recommended options outlined below.

4.2 The Future of Refrigerants

When discussing ice system options, refrigerants are now the key element to consider when determining what type of refrigeration system is the best fit for your ice rink facility. So, it is necessary to understand how refrigerants impact refrigeration equipment and system options. First, let's start with a little history. R-22 has been the most popular refrigerant used in ice rink applications in recent history. With the signing of the Montreal Protocol in 1987, the United States Environmental Protection Agency (EPA) implemented the final rule of Section 604 of the Clean Air Act in July 1992, limiting the production and consumption of a set of chemicals known to deplete the stratospheric ozone layer as measured by their ozone depleting potential (ODP). R-22, which also has a high global warming potential (GWP), was one of these targeted chemicals and as of 2020, is no longer manufactured or imported in the U.S and can no longer be installed in new refrigeration systems. However, R-22 can be used in existing systems until the supply runs out.

In 2016 the Kigali Amendment was applied to the Montreal Protocol focusing on the phasedown of production and consumption of HFCs to reduce greenhouse gas emissions driving down the global warming potential (GWP) of refrigerants. More than 90 countries ratified this amendment in 2019 including Canada but excluding the U.S. as of February 2020. The U.S EPA made certain HFC refrigerants unacceptable for us in the Significant New Alternatives Policy (SNAP) Rules 20 (2016) and 21 (2017). However, the U.S. courts partially vacated these rules, and the industry is awaiting the EPA rewrite expected in 2020. Despite this, states may choose to adopt and set their own timeline for implementation of the SNAP rules . Some of the refrigerants that are currently used in ice skating facilities and are on the phasedown list include: R-134A R-404A, R- 407B, R-407C, and R-507A.

California is one of the states leading the way to lower GWP refrigerants. The California Air Resources Board (CARB) Activity adopted the SNAP Rules 20 and 21 in September 2018 and approved a limit the GWP of refrigerants used in ice rinks to < 750, following the lead of other Countries such as Canada and Europe. This would eliminate R-134a which has a global warming potential of 1410 (meaning the release of one gram of R134a would have the same global warming effect as releasing 1410 grams of carbon dioxide). In late 2020 California passed legislation reducing the GWP even lower to < 150, eliminating most synthetic refrigerants. California is part of a "Climate Alliance" that approximately 22 other states participate in, which have adopted HFC transition dates.

Currently, the ice rink industry is caught in a transition period for refrigerants as new environmental regulations are implemented. Careful consideration and evaluation of the current refrigerant options should be made. The replacement refrigerants for HCFC refrigerants (e.g., R-22, etc.) and HFC refrigerants (e.g., R-507, R407C, R-134a, etc.) are fairly new with a limited history and performance data in this application. Some of those new refrigerants are R-448A, R-449A, and R513A. R-513 is a new blended synthetic refrigerant that is supported by the National Hockey League as a sustainable, non-ozone depleting, lower global warming potential (GWP) alternative refrigerant. Its GWP is 613 and its ASHRAE Safety Classification is A1 which is lower toxicity and no flame propagation.

Large global companies, such as Coca Cola, are leading the charge to ban HFCs and use natural refrigerants such as CO2, hydrocarbons and ammonia. Since 2004, more than thirty ice skating facilities in Europe have switched over to using CO2 as the secondary refrigerant with ammonia as the primary. The first CO2-based ice system in North America, and the first *direct* CO2-based system in the world, opened in 2011 in Quebec, Canada with a second rink opening in Montreal in 2012. The U.S. now has eight ice rink facilities that use CO2. B32 Engineering Group, Inc. was the leader in this application designing the first CO2 based ice rink system in the U.S. in 2016 and has since designed five more.

4.3 Refrigeration System Improvement and Replacement Options

Four main options were identified for improving or replacing the existing refrigeration system at this facility. Additional information such as common terms or definitions, financial programs, cost estimates, etc. can be found at the end of this report. Where applicable, this report references the Murphy report dated February 15, 2021, for additional information and to provide a contractor's perspective to the improvements and cost estimates. The following options will be discussed in this section:

- Option 1: Maintain existing R-22 refrigeration system. Make selected improvements.
- Option 2: New indirect, HFC/HFO synthetic-based refrigeration system.
- Option 3: New indirect, ammonia-based refrigeration system. See conceptual layout in report.
- Option 4: New indirect, CO2-based refrigeration system.

The estimated energy efficiency stated below for each refrigeration system replacement option is given to provide a rough order of magnitude only and may not be specific to this facility. The efficiency of each system can vary greatly depending on the facility type, programming, building construction, operations, weather, length of season, etc.

Cost estimates include construction cost, design, legal, financial and administration costs, and design and construction contingencies for proposed improvements. Cost estimates are based on similar work performed in ice rink facilities from 2018-2021 and recent bid results. Costs will vary depending on the time of year the projects are bid, the economic climate and the size and scope of the project. In general, costs are rising due to the number of ice rink renovation projects, cost of materials, COVID restrictions, etc.

4.3.1 Option 1: Maintain existing R-22 refrigeration system. Make selected improvements

Description: The City may elect to continue to operate the existing indirect R-22-based refrigeration system with selected improvements with the goal of replacing the system in the very near future.

Advantages:

- Lower near-term costs.
- Avoid disruption to user groups, ice schedule and revenue from construction activities.
- Allow a little more time for the new refrigerants and technology to develop. Extending the use of the existing refrigeration systems for a while longer will allow newer ice system technology, such the use of CO2 refrigerant or new synthetic replacement refrigerants, to develop allowing manufacturing costs to decrease, and service companies to gain more experience.

Disadvantages:

- On-going maintenance and equipment costs.
- Risk disruption to schedule and loss of ice as equipment and systems become less dependable.
- Risk of catastrophic leak or failure in system and high cost of repairs and refrigerant replacement.

- Increased environmental concerns with increasing risk of refrigerant release, etc.
- Future availability and higher cost of refrigerant. In the last 6 months or so R-22 refrigerant supplies have decreased substantially increasing the cost to record levels (approximately $23/pound per Murphy and expected to rise significantly higher by the end of the year) and limiting the purchase of R-22 to 30-90 pounds per purchase. The existing system has an estimated charge of over 1,000 pounds of R-22 per Murphy's report.

Recommendation: Unfortunately, at this time there is no "drop-in" or replacement refrigerant for R-22 refrigerant in a flooded type of refrigeration system like the existing system. The traditional pure synthetic refrigerants like R-507 and R-134a will most likely start to be phased out as soon as 2024 based on their high global warming potential (GWP). In addition, these refrigerants substantially decrease the capacity of the refrigeration system by 50% or more as shown in the Murphy report dated February 15, 2021. New blended synthetic refrigerants such as R-513, R-448A, R-449A, etc. would have the same issues and potentially reduce the capacity of the system even further. In addition, these new refrigerants are blends of multiple refrigerants vs pure refrigerants like R-22, R-134a etc. which would likely cause additional operational issues in a flooded-type refrigeration system. Simply replacing the refrigerant in the system is not a recommended option at this time.

Since the trend toward higher cost and lower availability for R-22 refrigerant is not expected to change any time in the foreseeable future, and there are no proven refrigerant replacements for R-22 in a flooded refrigeration system or without substantially reducing capacity, we recommend the City start budgeting and planning for a full replacement of the refrigeration system. If the City elects to continue to operate the existing system, we recommend that only the improvements or repairs that required to maintain the system in a safe working condition and to improve the monitoring of the refrigerant charge and system for leaks, etc. be performed. We recommend the following improvements, etc.

- Budget for 500 pounds of refrigerant replacement and store if possible. If a surplus of R-22 refrigerant is not purchased and stored, one smaller leak in the system could force the facility to shut down until additional R-22 could be purchased. This will likely result in the loss of the ice sheet and cancellation of programming. ***This is the first time in 20 plus years that the ice rink industry has faced this type of limitation and potential for substantial impacts to the operation of the facility.***

Cost Estimate of items above: $18,000

- Recoat condenser steel support system as recommended in Murphy report.
- Continued monitoring and testing:
  - Monitor the condition of all systems for life and safety concerns.
  - Monitor for refrigerant leaks in the system.
  - Monitor and test all fluids in the system twice a year.
  - Monitor the condition of the ice rink floor and surrounding perimeter concrete and walls. Document all cracking, heaving, movement, etc.
  - Monitor glycol temperatures from the subfloor heating system to assure the system is operating properly.
- Continue to perform the required maintenance on the equipment and systems.

Cost Estimate of items above: Typical maintenance.

4.3.2 Option 2: New indirect, HFC/HFO-synthetic based system (R-513, etc.)

Description: Replace the existing R-22-based indirect refrigeration system with a new R-513-based refrigeration system, or similar type refrigerant, located inside the existing refrigeration room with a water fluid cooler. The equipment used in this type of system is more commercial grade quality and may include direct expansion chillers (vs flooded), blended HFC or HFO refrigerant, semi-hermetic compressors (vs open drive) and pumps. B32 can provide a conceptual drawing of this system if desired.

Photo 9 - Example of a Carrier or Trane package systems

Advantages:

- Lower capital cost.
- Potentially less space required.
- Lower refrigerant charge.
- Potential to be converted to another synthetic refrigerant type as synthetic refrigerants are phased out in the future. R-513 is a new blended synthetic refrigerant by Opteon that is supported by the National Hockey League as a sustainable, non-ozone depleting, lower global warming potential (GWP) alternative refrigerant. Its GWP is 613 and its ASHRAE Safety Classification is A1 which is lower toxicity and no flame propagation. See the Future of Refrigerants section of this report for additional information.

Disadvantages:

- Lower quality of materials and equipment compared to the existing system. For example, the compressors would likely be replaced when they fail and not re-built, refrigerant piping is copper in place of steel, etc.
- Lower life expectancy (approx. 20 years vs. 30+ years for an ammonia industrial grade system).
- Lower efficiency than industrial grade system. Estimated to be 10-15% less energy efficient than the existing R-22 indirect system.
- Uses synthetic (HFO) refrigerant. Future regulations are uncertain regarding synthetic refrigerants.
- Less waste heat available to recover and use from system.
- Equipment arrangement (e.g., skid package) makes maintenance more difficult.

Cost Estimate: $1,688,000

Cost of Preventative Maintenance. All of the refrigeration system options have similar preventative maintenance requirements and costs. The main difference in maintenance cost is the type of compressors. All options can use screw or reciprocating compressors. The existing R-22 refrigeration system uses reciprocating compressors and would have the highest maintenance costs. Option 2 typical uses screw compressors and could save approximately $7,000 per year in top end maintenance on the reciprocating compressors.

Recommendation: This is a good option if the budget cannot support a natural refrigerant and these systems are currently being used in other ice rink facilities including some NHL facilities.

4.3.3 Option 3: New indirect, ammonia-based system

Description: Replace the existing R-22-based indirect refrigeration system with a new ammonia-based refrigeration system in existing refrigeration room. See figure at the end of this report for conceptual location and equipment layout.

Photo 10 - Example of a stick-built industrial grade, flooded ammonia-based system

Advantages:

- Best available proven technology for this application.
- Proven performance and dependability.
- Maximum operational efficiency. Estimate to be 20% to 25% more efficient than existing R-22 system.
- Sustainability. Ammonia is a naturally occurring refrigerant.
- Longevity of industrial grade equipment and refrigerant (30+ years). Synthetic refrigerants may be faced with future restrictions with high global warming potentials. Ammonia is also a pure refrigerant.
- Lower cost refrigerant ($2 per pounds vs. $15 to $28 per pound for synthetics)
- Availability of equipment and parts.
- Refrigerant charge will be less than the existing R-22 system. Could also explore the option of a low charge ammonia system reducing the charge to under 500 pounds.

Disadvantages:

- Requires more space. Typically, an ammonia system will require more space for the equipment because of the industrial grade equipment that is used in these systems and the systems are typically built on-site and are not a package type system.
- Recommend installing a vestibule on the inside of the existing refrigeration, as shown on the figure at the end of the report, to house life safety equipment so that it can be monitored prior to entering the ammonia room. All types of refrigeration systems require certain life safety systems like a gas monitoring system and one eyewash-shower station inside the mechanical room and an emergency ventilation switch and refrigeration stop button on the outside of the refrigeration room. For ammonia, a second eyewash-shower system is required outside the refrigeration room. The only way to provide this second system and prevent it from freezing is to construct a vestibule or install in the resurfacer room. The vestibule itself is not required by code. However, it does offer a few additional safety advantages. It provides a safe space for anyone entering the room to stop and monitor any potential hazards (like an ammonia leak) before entering the room through the gas monitoring system or window in the door. It also provides another barrier between the ammonia system and anyone that might be outside the refrigeration room. The risk of an ammonia leak is no greater than any other type of refrigerant and all refrigerants are dangerous. The amount of the ammonia that would be less than the existing R-22 system and the overall charge is much less than the large industrial facilities, so fire and explosion are much less of a concern, if at all. Ammonia refrigerant has been used in ice rink applications since they started building the facilities and is now more common than ever.
- Potentially more training required for operators of the refrigeration system. All refrigerants are dangerous and should be approached with caution and operating staff should be trained. Even though additional training is not required by code to operate an ammonia system, it is recommended that the operating staff take training courses specifically for ammonia refrigeration including both the operation and safety of the system. It has been B32's experience that most ice arena facilities that use ammonia refrigeration use an outside service company that has experience with ammonia for repairs and even some routine maintenance and system checks.
- Potentially greater health/safety hazards in comparison to synthetic refrigerants.
- Reporting requirements. There may be additional annual reports that are required depending on the volume of ammonia that will be in the system. The US EPA has been more aggressive at requiring additional reporting for ice rinks (mainly on the east coast) that operate with more than 500 pounds of ammonia. The proposed system could require as much as 900 pounds. If a low charge ammonia system was used that quantity could be much less, maybe even less than 500 pounds. The reporting for any facility that has less than 10,000 pounds is fairly straightforward. The cost estimates are based on a typical ammonia system.
- Higher capital costs.

Cost Estimate: $1,954,000

Cost of Preventative Maintenance. All of the refrigeration system options have similar preventative maintenance requirements and costs. The main difference in maintenance cost is the type of compressors. All options can use screw or reciprocating compressors. The existing R-22 refrigeration system uses reciprocating compressors and *would have the highest maintenance costs. Option 3 has historical used reciprocating compressor but in the past 5 years more screw compressors have been used. The use of screw compressors could save approximately $7,000 per year in top end maintenance on the reciprocating compressors.*

Recommendations: This option should be strongly considered because of its increased efficiency and use of natural refrigerants as well as the ever-changing phase-out of synthetic or artificial refrigerants. However, the City should be mindful of the potentially greater health hazard over synthetic or artificial refrigerants such as R-513, etc. Although all refrigerants are hazardous. It would be prudent to start discussions of the replacement options with the fire marshal, the City's insurance carrier, and other interested parties to educate them on all aspects of ammonia refrigerant.

4.3.4 Options 4: New indirect carbon dioxide (CO2)-based system

Description: Replace the existing R-134a-based refrigeration system with a new CO2-based indirect refrigeration system located inside the refrigeration room and using an air-cooled gas cooler system. The use of CO2 refrigerant may likely be the next substantial "innovation" in the ice rink industry. This option is based on a multiple semi-hermetic compressor system of approximately 200-ton, plate and shell chiller, pumps, etc. operating at leaving glycol temperatures of 10°F and entering glycol temperatures of 13°F. It's likely that this option will fit in the existing refrigeration. B32 can provide a conceptual drawing of this system to confirm. See the Future of Refrigerants section in this report for additional information on CO2 and the use of CO2 in ice rink facilities.

Photo 11 - Example of an Indirect CO2 Chiller Package

Advantages:

- Higher efficiency. CO2 <u>indirect</u> is estimated to be approximately 5% less efficient than an ammonia system.
- Potentially higher heat recovery temperatures.
- Potentially less space required than an industrial grade system.
- Uses an air-cooled gas cooler system which is shorter in height than the water fluid cooler proposed in Options 2 and 3.

Disadvantages:

- Higher equipment costs due to limited availability.
- Fewer contractors familiar with technology.
- Proprietary control systems used with this technology.
- Efficiency drops off in warmer temperatures.
- Additional safety devices and systems may be required.
- There is a U.S. patent on some or all of this technology as it applies to ice rinks and therefore manufacturers may be limited.

Cost Estimate: $2,092,000

Cost of Preventative Maintenance. All of the refrigeration system options have similar preventative maintenance requirements and costs. The main difference in maintenance cost is the type of compressors. All options can use screw or reciprocating compressors. The existing R-22 refrigeration system uses reciprocating compressors and would have the highest maintenance costs. Option 4 typically uses semi-hermetic reciprocating compressors which are typically not rebuilt but rather discarded and replaced when a failure occurs.

Recommendations: It is recommended that a CO2 refrigerant-based indirect refrigeration system be considered. If the City is interested in pursuing the use of CO2 refrigerant, we encourage a site visit to at least one facility that is currently using this type of system, along with in-depth discussion with the facility's management and operation personnel and manufacturer's representatives. B32 Engineering Group has extensive experience with CO2 refrigerant applications in ice rink facilities.

It is also recommended that a more in-depth study of CO2 system options and code requirements be performed during a pre-design or preliminary design phase for this project to determine the feasibility of a CO2 ice system in this facility.

5.0 PROJECT SCHEDULE

The improvements should be planned well in advance of the desired construction time so equipment and materials can be ordered and delivered to the site. Minimizing disruption to the facility's busy schedules and user groups will be a key element to the success of this project.

A very general, typical schedule for similar ice rink type projects is as follows:

Design Phase:	June-September (3-4 months)
Bidding:	October-November (October is the ideal bidding time for this type of work)
Order Materials:	November – March
Construction:	March – October (we estimate construction on this project to take 3-4 months)

If construction is started later and the new refrigeration system is not operational by October, a temporary chiller could be used until the new refrigeration system is complete. The cost of a temporary chiller system is approximately $23,000 per month plus utilities. These costs are not included in the cost estimate.

B32 Engineering Group, Inc. has extensive experience in working closely with clients to evaluate and identify renovation and improvement solutions for existing ice systems. We understand the City will use the information in this report to determine the scope of the refrigeration system replacement project. Once the project scope and funding sources have been identified, we will work closely with the City to develop a detailed project schedule.

6.0 SUPPLEMENTAL INFORMATION

6.1 General Definitions

Included in this section are definitions for the basic terminology used throughout this report.

Ice System: A term that collectively refers to the refrigeration system, ice rink floor system, waste heat recovery system and dasher board system. This is the type of system that is currently installed in this facility.

Direct System: A *direct* refrigeration system circulates the primary refrigerant (e.g., R-22) directly through the ice rink floor. There is no secondary solution or refrigerant. These types of systems were very common in the 1970's and early 1980's. Today, indirect refrigeration systems, where glycol solutions are circulated in the rink floor, are more common due to costs and environmental concerns with large quantities of refrigerant required to operate the system.

Indirect-type System (existing system at the Hockey Center): In an *indirect* system the primary refrigerant (e.g., R-22, ammonia, etc.) stays in the refrigeration room. Heat is removed from the ice rink floor through a secondary refrigerant or glycol solution that is circulated in the floor. The heat exchange between the glycol solution and the primary refrigerant takes place in the refrigeration room.

HCFC: Hydrochlorofluorocarbon (e.g., R-22, etc.) – synthetic refrigerant with less ozone depleting than CFCs (e.g., R-12, etc.) but deplete natural resources and contribute to global warming. These are phased out by the Montreal Protocol.

HFC: Hydrofluorocarbon (e.g., R404A, R407C, R-507, etc.) – synthetic refrigerant that deplete natural resources and contribute to global warming. Many have a high global warming potential (GWP) and are now to being phased out of production.

HFO: Hydrofluro-Olefins (e.g., R513A, 1234YF, etc.) – a new class of synthetic refrigerant that have a much lower global warming potential (GWP) than HCFCs or HFCs. These new refrigerants are blends of several refrigerants and are not pure refrigerants as many of the HCFCs and HFCs are.

u-HFC: Unsaturated Hydrofluorocarbons - Low GWP HFCs that produce dangerous hydrogen fluoride when they burn and transform to trifluoro-acetic acid in the atmosphere. These are generally patented and much costlier.

Natural Refrigerants: Naturally occurring refrigerants such as ammonia (R-717), carbon dioxide (CO2) and hydrocarbons.

6.2 Financial Assistance Programs.

There are several financial programs that have traditionally been used on ice rink renovation projects. The local utility companies should be consulted to determine what programs are available and apply to this project(s). They may include:

1. Engineering Assistance Study Program. Some utilities offer this program. The purpose of this program is to provide the City with the necessary business case justification to implement energy-saving opportunities. This evaluation report can be expanded to identify energy conservation opportunities, energy modeling, etc. to meet the programs requirements. Some utilities will reimburse their users up to 75% of the cost of this study. One example where the user would benefit from this additional energy analysis is in selecting a refrigerant (ammonia, CO2, etc.) or refrigeration system to replacing the existing synthetic (R-22, etc.) refrigerant or system. It is typically required that the program be pre-approved by the utility prior to starting any work on the study.
2. Rebate Programs. Rebate programs are often available through utilities for many energy improvement measures that can be performed such as lighting replacement, motor replacement, installation of variable frequency drives, improving insulation systems, etc. Custom rebate programs are also available and may apply to the refrigeration system replacement depending on the type of system selected. The utilities should be contacted to identify possible rebates prior to starting any improvement project relating to energy savings. Some rebates require preapproval prior to purchasing and installation.

END

Opinion of Probable Project Costs - Refrigerant Change Feasibility Study
Deilmann Recreation Complex, Creve Coeur MO
Creve Coeur, MO
B32 File No. 900.21.437

Date: 11.4.21 SAW
Revised: 7.26.22 SAW
Revised: 2.07.23 PAF

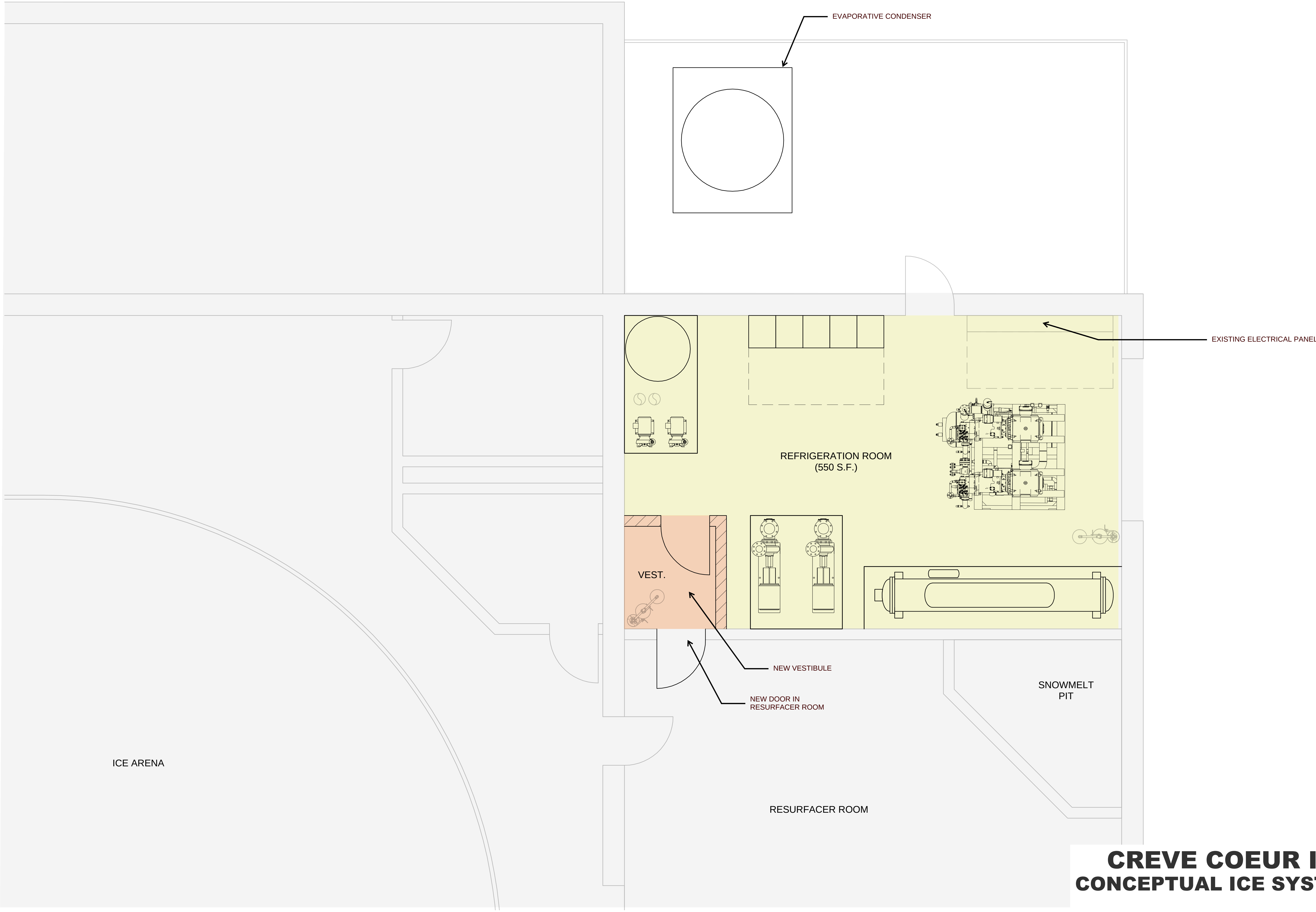
Costs include: escalation, general conditions, ice rink contractors profit, insurance, bonds

Item	Cost Estimate[1]		
	Option 2	Option 3	Option 4
Refrigerant type	R-513	Ammonia	CO2
Grade of system	Commercial	Industrial	Mix
Demolition of existing refrigeration system and condenser	$28,000	$28,000	$28,000
Misc. HVAC demolition	$7,000	$7,000	$7,000
Misc. Electrical demolition	$7,000	$7,000	$7,000
Remove and dispose of existing glycol and flush existing rink floor, transmission mains and refrigeration system (option to test and reuse)	$25,000	$25,000	$25,000
New 120 ton refrigeration system (includes new motor control center or panels, condenser , pumps, glycol, refrigerant, etc.)	$925,000	$1,100,000	$1,216,000
New glycol solution	$60,000	$60,000	$60,000
Preheat for resurfacer water	Not available	Not included	Not included
Reuse existing snowmelt pit	$0	$0	$0
Concrete equipment pads	$4,500	$4,500	$4,500
Rework existing condenser supports	$8,000	$8,000	$8,000
New electric service if required	$37,000	$0	$37,000
Eyewash and shower stations (1 for synthetic and CO2 and 2 for ammonia)	$15,000	$27,000	$15,000
New ventilation system in refrigeration room	$50,000	$65,000	$50,000
Misc. plumbing in refrigeration room (water lines, move or add drains, etc.)	$20,995	$20,995	$20,995
Misc. electrical in refrigeration room (receptacles, panels, lights, etc.)	$30,000	$30,000	$30,000
Replace existing single exterior door	$13,000	$13,000	$13,000
New vestibule and door into resurfacer room (vestibule for ammonia only)	$22,000	$57,000	$22,000
Misc. sitework improvements around existing refrigeration room	$0	$0	$0
New screen wall (ammonia and R513) or modify existing for CO2 option	$0	$0	$15,000
Paint interior of existing refrigeration room	$4,500	$4,500	$4,500
Subtotal of estimated construction costs	$1,256,995	$1,456,995	$1,562,995
Estimate, design and constr. Contingency (20%)[1]	$251,399	$291,399	$312,599
Total estimated construction costs	$1,508,394	$1,748,394	$1,875,594
Engineering, legal, financial and administrative (20%)[1]	$301,679	$349,679	$375,119
Total estimated project costs (2024)	**$1,810,073**	**$2,098,073**	**$2,250,713**
Expected useful life - refrigeration system (yrs.)	15-20	30+	25
Adjusted Costs for 2025[2]	$1,954,879	$2,265,919	$2,430,770

Footnotes:

1. See cost estimate narrative in report.
2. Applied escalation costs of **8%** per year.

B32° Engineering Group



CREVE COEUR ICE ARENA
CONCEPTUAL ICE SYSTEM LAYOUT
11/1/2021