The Brooklyn Park Community Activity Center. Source: Stevens Engineers

APPLICATION OF CLIMATE-FRIENDLY ICE RINK TECHNOLOGIES: BROOKLYN PARK COMMUNITY ACTIVITY CENTER

Name of Facility:
Brooklyn Park Community Activity Center (CAC)

Location:
5600 85th Avenue North
Brooklyn Park, MN 55443

Type of Facility:
Community multi-sheet rink
Rink area = 50,800 ft^2

Technology/Refrigerant Used:
Indirect ammonia/calcium chloride system

FACILITY OVERVIEW

The Brooklyn Park Community Activity Center (CAC) is a recreational facility located in Brooklyn Park, Minnesota, that is operated by the city. The facility is home to two regulation-size ice arenas that provide 6,700 hours of indoor ice time to approximately 100,000 patrons each year. The facility also hosts a gymnasium, racquetball courts, banquet rooms, walking track, outdoor skate park, and an on-site fishing pond.

PROJECT BACKGROUND

The original arena was constructed in 1983 and the second arena in 1997 with two 85' x 200' ice sheets that were served by separate refrigeration systems. Rink 1 used a direct[1] R-22 Holmsten refrigeration system and

[1] A direct refrigeration system circulates the primary refrigerant directly through the ice rink floor.

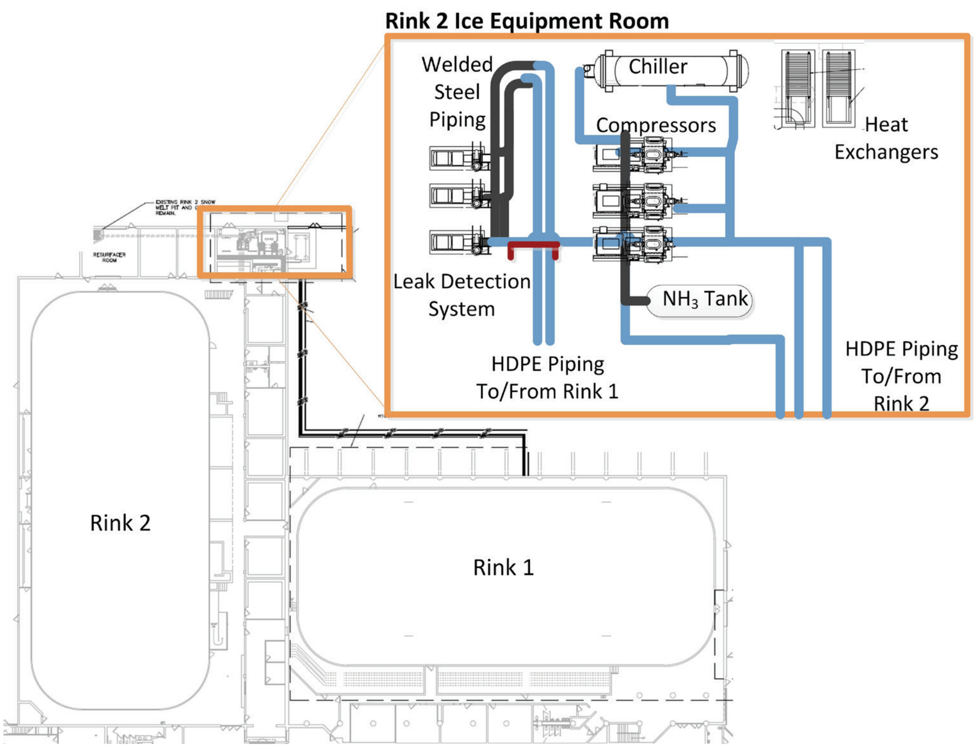
Rink 2 used an indirect[2] ammonia (NH_3)/glycol system. The direct R-22 system consisted of two eight-cylinder reciprocating compressors, a low-pressure receiver, two pumper drums, an evaporative condenser, and a waste heat recovery system. The total heat extraction capacity of this system was approximately 136 tons (1,632,000 BTUs/hour). After 27 years of operation, the aging direct R-22 system began experiencing issues such as corrosion in the vessels and rink floor piping; three major leak events in the ice rink floor necessitated either significant repairs or replacement of the system.

In 2009, the City of Brooklyn Park began working with Stevens Engineers to design an indirect ammonia (NH_3)/calcium chloride ($CaCl_2$) system to replace both rink refrigeration systems. Brooklyn Park selected the design for the following reasons:

- The city already had experience using indirect systems in Rink 2;
- The NH_3/$CaCl_2$ system does not need to circulate refrigerant through the spectator seating area; and
- The system reduces the rink's environmental impacts.

Brooklyn Park city officials elected to use NH_3 as the primary refrigerant in the new system because of its favorable environmental characteristics and high energy efficiency. In comparison to R-22, which has a Global Warming Potential (GWP) of 1,810[3] and an Ozone Depleting Potential (ODP) of 0.055,[4] NH_3 has zero GWP and ODP.[5] Brooklyn Park selected $CaCl_2$ as the secondary refrigerant in the new system because of its observed higher efficiency compared to glycol mixtures.

The modification of the ice arena's refrigeration system was part of a larger energy efficiency retrofit project that used stimulus money from the federal government's Energy Efficiency and Conservation Block to improve citywide energy efficiency.



Schematic of the CAC's current NH_3/$CaCl_2$ refrigeration system. The NH_3/$CaCl_2$ system is housed in the equipment room for Rink 2. Source: Stevens Engineers

[2] An indirect refrigeration system uses two refrigerants. A primary refrigerant stays confined in the ice equipment room and a secondary refrigerant is circulated in the rink floor.

[3] Intergovernmental Panel on Climate Change (IPCC). 2007. Working Group I to the Fourth Assessment Report of the IPCC (AR4). Available at: www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

[4] U.S. EPA. 2014. GWPs and ODPs of Some Ozone-Depleting Substances and Alternatives. Available at: www.epa.gov/ozone/snap/subsgwps.html

[5] Ibid.

SYSTEM DESCRIPTION

The new indirect $NH_3/CaCl_2$ system has a refrigeration charge size of 387 pounds of NH_3, which replaces the 6,000 pounds of R-22 and 1,200 pounds of NH_3 used in the previous systems. Brooklyn Park expanded the ice equipment room for Rink 2 to accommodate the $NH_3/CaCl_2$ system. The renovated equipment room now houses three compressors on concrete pads, an above-ground NH_3 containment tank, a chiller, a leak detection system, heat exchangers, and a combination of welded steel and high-density polyethylene piping. Each rink floor has approximately 10 miles of 1-inch piping.

Other Sustainability Measures

In conjunction with replacing the rinks' refrigeration systems, three other cutting-edge modifications to the facility were made:

1) Replaced the energy- and water-intensive cooling towers used to cool the refrigeration system with a well connection to the city's raw water system.
2) Used the city's raw water as a geothermal coolant to reduce the refrigeration system's energy use. The connection from the well provides water at 49˚F, which allows the compressors to operate at temperatures lower than the minimum temperatures listed in the manufacturer's specifications. The lower operating temperature requires half the electricity and produces double the capacity of a typical system.
3) Balanced the heating and cooling loads through an advanced control system, which makes use of warm and cold outdoor air when temperatures are advantageous to the system. The design allows heating systems to utilize waste heat in the facility from dehumidification, rink heat, snow melting, resurfacing, and subfloor heating.

The CAC's current $NH_3/CaCl_2$ refrigeration system. The new indirect $NH_3/CaCl_2$ system has a refrigeration charge size of 700 pounds of NH_3. Source: Stevens Engineers

SYSTEM PERFORMANCE AND COSTS

The Brooklyn Park CAC ice rink is now considered one of the most energy efficient ice rinks in the United States, and possibly the world. The new system requires half the energy of the previous systems to perform at the same capacity. The unique heat design and incorporation of the heat pump system allows the recovery and reuse of 95 percent of the waste heat that is generated from the refrigeration system. When compared to an indirect R-507 system, the two-sheet ammonia-based system is at least 15 to 20 percent more energy efficient. The Brooklyn Park CAC ice rink is also achieving additional energy efficiency gains due to the integration of the geothermal exchange system. The system uses advanced controls to lower the condensing temperature from a typical 96˚F for NH_3 to approximately 52–57˚F, resulting in increased operational efficiency. Overall, the city's energy efficiency retrofit project is reducingits annual electric and natural gas consumption by 317,000 kWh and 11.1 million ft^3, respectively. The city's overall energy efficiency retrofit project is reducing emissions by more than 1.7 million pounds of CO_2 equivalent annually, which is equivalent to taking more than 160 cars off the road every year.[6] The ice arena upgrades account for nearly 30 percent of the project's total carbon reductions.

The indirect $NH_3/CaCl_2$ system has experienced no refrigeration leaks to date. Furthermore, by selecting $NH_3/CaCl_2$ instead of hydrofluorocarbon (HFC) refrigerants, like R-507, additional greenhouse gas emissions are avoided.

A breakdown of the costs associated with the ice rink renovation is as follows:

- **Installation costs.** The overhaul of the two ice rinks cost $4.5 million, which the City of Brooklyn Park funded with grants, Heritage Infrastructure Funds, bonds sales, and utility energy savings rebates. Installation costs for indirect ammonia ice systems are typically 3.5 percent more than R-22 or HFC systems, since the systems usually require additional building renovation costs to address ammonia's toxicity and mild flammability (e.g., a fire-rated room, vestibule on the entrance door to contain potential ammonia leaks, or exterior entrance).
- **Operation and maintenance costs.** Maintenance costs are somewhat lower for an industrial-grade ammonia system than a similar system using R-22 or HFC-based refrigerant because of the smaller equipment and increased efficiency in its operation. Maintenance costs include compressor oil changes, gasket replacements, and inspections, among other activities.
- **Costs savings.** The citywide efforts to improve energy efficiency are saving the city more than $250,000 per year in utility and other operational costs; the ice rink renovations are contributing approximately 25 percent to these cost savings. The citywide efforts to improve energy efficiency, which include the ice rink renovations, have an estimated payback period of just over 12 years.

CHALLENGES AND LESSONS LEARNED

The conversion to a new ice rink was a major undertaking, and with it, the Brooklyn Park CAC faced a number of construction-related obstacles, including finding sufficient space for the new systems, routing piping through the existing building, and working around day-to-day services and operations during renovation.

The Brooklyn Park CAC also had to overcome a challenge related to using the system's waste heat for other building applications, since as a result of improvements to the energy consumption of the refrigeration system, the waste heat given off by the cooling plant became insufficient to continue to use as a source for many of the heating needs of the building. Introducing new heat pumps not only satisfied the hot water temperatures required by the facility but it also significantly reduced operation costs over time.

Other ice arenas have since been upgraded with similar designs using similar advanced control technology and climate-friendly refrigerants. The geothermal connection may be a viable option for some facilities, if local governments can access raw or finished water mains at a low cost. The controls and balancing of the system is applicable to any ice arena in any community.

The CAC's previous R-22 refrigeration system.
Source: Stevens Engineers

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[6] See EPA's Greenhouse Gas Equivalencies Calculator, available at: www.epa.gov/cleanenergy/energy-resources/calculator.html.