CADDET energy efficiency

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New cooling system in skating rinks saves energy

Energy-saving technology for skating rinks

Summary

When dealing with steel corrosion problems with the brine header pipes in its skating rinks, the City of Montreal has experienced a new concept known as a four-pass brine system with chiller evaporators in series. Utilising this new system resulted in less corrosion of the steel pipes and, as a bonus, energy savings estimated at CAD 8,500 per year. It is suggested that engineers responsible for constructing new skating arenas or replacing existing brine headers in refrigeration systems use this new energy-efficient technology.

Highlights

- **Four-pass system costs less than a two-pass system**
- **Annual energy cost savings of CAD 8,500**
- **Incremental cost for energy-saving measures is zero**

Saint-Donat Arena (1993) showing the PVC brine header and return bends connection 2 two-pass circuits.

Aim of the Project

Montreal owns 25 indoor skating rinks distributed throughout the city. Between 1989 and 1995, recurring steel corrosion problems with the brine header pipes of the cooling system became troublesome. Pipe corrosion has meant replacing brine header systems in six different ice rinks, providing a unique opportunity to modify the design of the system and cut energy consumption. With this methodology corrosion problems in the cooling system of the arenas could be resolved. This new energy-efficient four-pass system produced the same ice quality as the previous two-pass system.

The Principle

By reducing the system brine flow in the refrigeration system of an ice-skating rink, substantial energy savings are possible due to the decrease in required pump-motor power. However, system brine flow can only be reduced significantly if sufficient fluid velocity is maintained in the chiller evaporators and the slab heat exchangers. The design must maintain a good heat-transfer coefficient and avoid laminar flow in the heat exchangers.

The first item changed was the update of the brine specification, leading to a decrease in the specific gravity and, hence, the viscosity of the brine. This permitted a lowered brine flow rate and a reduction in the required pump-motor power.

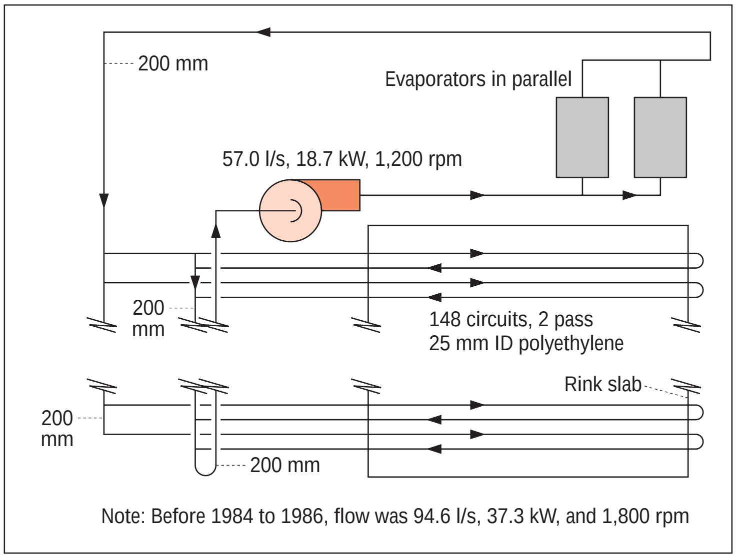

Figure 1: Schematic of two-pass system with evaporators in parallel.

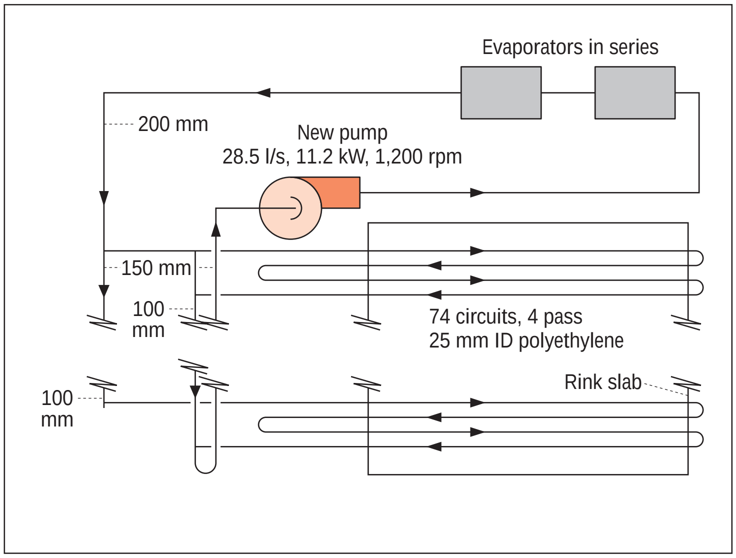

Figure 2: Schematic of four-pass system with evaporators in series.

Next, the two-pass brine distribution system with chiller evaporators connected in parallel was replaced by a four-pass brine distribution system with the evaporators in series. The modification had to be carried out anyway due to serious corrosion problems with the brine header pipes. This permitted an additional reduction of the brine flow rate, allowing the brine pump to operate at even lower motor power than before. The energy consumption savings resulting from this change amount to approx. 15%. The new design has already been tested in five arenas. Table 1 shows the results of three skating rinks.

The Situation

The original two-pass slab system used 296 polyethylene pipes (ID: 25 mm) spaced at intervals of 87.5 mm, as shown in Figure 1. The brine header system was reversed-return, using 200 mm, schedule 40 steel pipes. The chiller evaporators were piped in parallel. The brine was composed of aqueous calcium chloride with a specific gravity of 1.25 at 15.6°C. A single brine pump circulated the brine. The pump, driven by a 37.3 kW, 1,800-rpm motor, possessed a capacity of 94.6 l/s with a head pressure of 296.5 kPa. In most of the installations, two evaporators were piped in parallel, each evaporator using 47.3 l/s. However, in four installations three evaporators were used in this way, each evaporator using 31.5 l/s.

From 1983 to 1986, the city modified all its ice systems to save energy. The original motors (37.3 kW and 1,800 rpm) were rewound to yield motors running at 18.7 kW and 1,200 rpm. The brine flow produced by the pump rotating at 1,200 rpm was nominally 57.0 l/s. Timers were installed in each skating rink and the refrigeration systems (pumps, compressors) were stopped for 6-8 hours at night to save energy during the unoccupied period.

At the end of 1991, budgetary restrictions on city energy consumption led to a search for other possible modifications. By adjusting the brine specification, the installation of a smaller, high-efficiency motor on the brine pump became feasible, allowing reduction of the energy consumption.

The latest modifications of the slab pipe arrangements created a four-pass circuit, as shown in Figure 2, by adding a supplementary return bend to connect two of the two-pass circuits. The original 200 mm brine header system was replaced by a 150 mm header system because brine flow decreased from 57.0 to 28.5 l/s. The header system remained to operate in a reversed-return mode, using 150 mm, schedule 40 steel pipes throughout the system, with the end section using 100 mm, schedule 80 steel pipes. All 148 nipples consist of 25 mm, schedule 80 steel pipes. Schedule 80 PVC tubes can replace the steel pipes. The two (or three) evaporators were piped in series for a flow of 28.5 l/s each. The brine is aqueous calcium chloride with a specific gravity of 1.18 at 15.6°C. The brine is circulated by a single brine pump sized for a brine flow rate of 28.5 l/s and a head pressure of 225.7 kPa, driven by a 11.2 kW high-efficiency motor rotating at 1,200 rpm.

The Organisation

Montreal is the largest city in the province of Quebec, with a population of approximately 1 million. The building service is one of the administrative units of the City of Montreal, and operates a building park of

Table 1: The results of the new four-pass system in three skating rinks.

Skating rink	Heating system	Size of the urban park	Reduction of electrical consumption	Energy cost of operation*
Arena Mont-Royal	electric	small	16.7%	CAD 98,500 ** (1.33 MWh/year)
Arena Saint-Donat	natural gas	medium	14.0%	CAD 89,025 (1.18 MWh/year)
Arena Marcelin-Wilson	natural gas	medium	14.1%	CAD 99,210 (1.27 MWh/year)

* For 8 months.
** Using the kWh rate for 1996.

1.02 million m² which contains 690 municipal buildings. The park has a replacement value of CAD 3,000 million and contains administrative buildings, sports accommodations, activity-, cultural- and community-centres, museums, scientific institutions, and industrial and commercial units.

Economics

The total cost of the modifications implemented between 1992 and 1994 amounted to CAD 77,000 per rink (all amounts include taxes). The energy savings resulting from changing from a two-pass system with evaporators in parallel to a four-pass system with evaporators in series are estimated at CAD 8,500 per year or 8-9% of the annual energy cost per rink. Ice quality remained the same. Since the refrigeration system had to be modified anyway the incremental cost for energy-saving measures can be set to zero. Based on the total replacement costs, the simple payback period is approx. 9 years.

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* IEA: International Energy Agency
OECD: Organisation for Economic Co-operation and Development

IEA

The IEA was established in 1974 within the framework of the OECD to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among the 24 IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology, and research and development (R&D).

This is achieved, in part, through a programme of energy technology and R&D collaboration currently within the framework of 40 Implementing Agreements, containing a total of over 70 separate collaboration projects.

The Scheme

CADDET functions as the IEA Centre for Analysis and Dissemination of Demonstrated Energy Technologies. Currently, the Energy Efficiency programme is active in 15 member countries.

This project can now be repeated in CADDET Energy Efficiency member countries. Parties interested in adopting this process can contact their National Team or CADDET Energy Efficiency.

Demonstrations are a vital link between R&D or pilot studies and the end-use market. Projects are published as a CADDET Energy Efficiency 'Demo' or 'Result' respectively, for ongoing and finalised projects.

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