Case Story

Running hot and cold

CO_2 saves in more ways than one

With an estimated 8,000 ice hockey rinks in the United States and Canada, the small Quebec town of Saint-Gédéon-de-Beauce, 20 miles west of the Maine border, boasts the world's first ice hockey rink that uses 100 percent carbon dioxide (CO_2) refrigeration.

In 2010, the town's 10-year-old R-22 refrigeration system used in the Marcel Dutil Arena was replaced with a system using R-744, more commonly known as CO_2.

"We developed the Eco-2-System to address Quebec's phaseout of HCFCs and provide a natural alternative to ammonia," says Luc Simard, engineer for Compressor Systems Control (CSC), Inc., in Les Côteaux, Québec. "But our goal was to use 100 percent CO_2 in a system that would work in practically any rink in North America."

The Eco-2-System's CO_2 gas-to-liquid heat rejection phase differs from conventional R-22 systems. With R-22, the refrigerant vapor exits the compressor at 270 psig at the highest. This high-pressure superheated vapor enters a condenser, where it is cooled into a high-pressure liquid during the condensation process. Then, the high-pressure liquid goes through an expansion valve and exits as a low-pressure mixture of liquid and vapor. This mixture circulates through a heat exchanger in a primary loop that cools glycol or brine in a secondary loop to freeze the ice. The entire cycle occurs below the critical pressure, which means the refrigerant exists in both vapor and liquid states during the heat rejection process. This is called a "subcritical" refrigeration cycle.

However with the Eco-2-System, the gas remains in a vapor state throughout the entire heat rejection process. Because the vapor remains above the critical pressure point and, therefore, cannot phase change into a liquid during the heat rejection process, it is called a "transcritical" refrigeration cycle.

Simard uses the Danfoss ICMTS valve to regulate the flow of CO_2 in the system. "This valve is absolutely essential to the process," he emphasized. "Without it, the refrigeration cycle doesn't work, and there's no ice."

5%

lower energy costs

using the Eco-2-System compared to a 3.2 COP with leading systems that use a glycol/brine loop.

The Danfoss ICMTS valve enables the transcritical cycle by regulating the phase change from vapor into liquid. After entering a liquid state, the CO_2 is pumped through a network of 1/2-inch-diameter copper tubes embedded four inches apart in the rink's concrete slab. Two inches of concrete was poured on top of the existing slab to hold the new piping. Copper tubes were used to contain the pressurized liquid. The tubes are wrapped in a very thin polyethylene film to prevent any possible interaction with the concrete.

"The entire rink works like a huge freezer," continued Simard. "A small pump circulates the liquid CO_2 through the tubes. The slab functions like an evaporator coil in a food freezer."

The CO_2 is constantly boiling in the tubes. Because boiling always occurs at a constant specific temperature, the temperature of the concrete slab stays a constant 19°F (-7°C). Thanks to the Eco-2-System, when the Zamboni machine resurfaces the ice, the water freezes immediately making the ice drier and smoother.

"Another benefit of the transcritical CO_2 cycle is that it yields a lot of heat that can be reclaimed to make lots of hot water," added Simard. "We use a Danfoss EKC 326a gas cooler control to keep the CO_2 vapor in the transcritical range. Then the vapor is discharged from the gas cooler at 212°F (100°C) into two heat reclaim units to create hot water for showers and space heaters."

Thanks to heat reclaim, last winter the arena did not require any backup heating for hot water, which reduced energy costs. The Eco-2-System's Coefficient of Performance (COP) is 3.35 (11.43 EER equivalent) when operating in continuous heat reclaim mode and 3.56 (12.1 EER) when the outdoor ambient temperature falls below 41°F (5°C). Compared to a 3.2 COP with leading systems that use a glycol/brine loop, the Eco-2-System reduces annual refrigeration costs by nearly 5 percent.

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Luc Simard, engineer for Compressor Systems Control (CSC), Inc.

Overview of the installation

- Installation of the Eco-2-System which uses a "transcritical" refrigeration cycle
- Installation of the ICMTS to regulate the flow of CO_2 in the system

About the ICMTS

- Direct coupled connections
- Connection types are DIN butt weld
- Low temperature steel body
- Low weight and compact design
- Regulating cone ensures optimum regulating accuracy particularly at part load
- Manual opening possible via ICAD or Multi-function tool
- PTFE seat provides excellent valve tightness
- Magnet coupling - real hermetic sealing

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