2013: NATURAL REFRIGERANTS
MARKET GROWTH FOR NORTH AMERICA

CASE STUDIES
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Real-life examples of successfully working technologies are the strongest arguments for spreading innovative solutions, engaging legislators and convincing end-users. From the multitude of existing natural refrigerant-based systems, this section presents a selection of outstanding examples, covering residential, commercial and industrial heating, air-conditioning and refrigeration solutions.

Examples cover North American-based suppliers including: Carnot’s efficient CO₂ transcritical refrigeration technology installation for retailer Sobeys and their NH₃/CO₂ refrigeration system for a food storage warehouse and CO₂ ice rink refrigeration system, (both in Canada); Emerson’s energy saving industrial ammonia heat pump for heat recovery at a food processing plant; the latest Dorin CO₂ transcritical compressors; CIMCO’s CO₂/ammonia brine system for a Canadawide fruit and vegetable distribution center; Alfa Laval’s CO₂ refrigeration systems for retailer S-Market; MYCOM’s CO₂ hot water heat pump at the Somerston Wine Co. and their ammonia/CO₂ chiller at the Carpinteria SUPERVALU store, (both in California); Danfoss and Manitowoc’s collaborative effort to develop hydrocarbon ice machines, and Hill PHOENIX’s CO₂ refrigeration system installation at the Overwaitea Food Group (OFG) Urban Fare Express store in Canada.
INTRODUCTION

For the past several years, Carnot’s services have been retained by Sobeys (a major wholesaler and retailer in Canada) in order to develop an alternative to the conventional refrigeration systems available on the market, which were inefficient, had a high energy consumption, and incurred high maintenance costs.

The goal was to provide a sustainable and reliable solution that would be cost efficient in regards to both initial cost (equipment and installation) and operating cost (energy, maintenance, gas replacement, insurance).

ABOUT THE SYSTEM

An IGA supermarket (part of Sobeys' brand) in the north of Montreal, which opened in April 2011, occupies a total area of 40,866 ft² (3,797 m²). The sales area of 30,488 ft² (2,832 m²) hold 744 ft (227 m) of refrigeration cases (85 MT cases) and 305 ft (93 m) of freezers (40 BT cases). The supermarket also has a heat recovery system and intensive reclaiming of waste heat from the refrigeration units. That recovery system covers almost all the heating needs of the supermarket. A pre-heating water loop is also installed in the supermarket.

Defrosting modes

Because it does not add any heat to the system, the technology that was developed in previous commercial and industrial projects provides the significant benefit of ensuring the stability of display case temperatures, unlike some other systems that may generate high temperatures in display cases. Using our system, we have often observed that the temperature only rises from 4°C (39°F) to 5°C (41°F).

In the low temperature defrost process for refrigerated cases and freezer rooms, Carnot Refrigeration technology uses an electronic expansion valve that expands or contracts in real time to provide exactly the right amount of heat needed by each case to melt the ice.

Low pressure gas is used (about 440 to 500 psig) to defrost the refrigerated cases and the evaporators of the freezer rooms. During the defrost cycle, the same lines are used for the refrigeration cycle. In refrigeration mode, liquid CO₂ is directed to the display...
cases through an oversized line. In defrost mode, the hot gas is directed straight to the display cases using the liquid line.

In summary, the biggest advantage of the hot gas defrost in CO₂ refrigeration systems is the stability and the homogeneity of the temperature levels in display cases, freezer and preparation rooms.

CONCLUSION

Nowadays, transcritical CO₂ refrigeration technology is a proven technology in Canada. The systems installed by Carnot Refrigeration in various supermarkets, are evidence of this. In fact, the GHG emissions are lower than those from a conventional supermarket of the same size. These gains are attributable to the reduction of synthetic refrigerant charges and the decrease of the total energy consumption (-10%). In addition, the heating of the sales area is provided entirely through heat recovery. The interesting thing about the new systems is that CO₂ as refrigerant is used in connection with both medium and low temperature.

After several successful transcritical CO₂ refrigeration system installations in many supermarkets across Canada, the various solutions developed by Carnot are now available for all retailers operating in North America. Carnot also helps the retailers to smoothly introduce this new technology and manages the teams that will be faced with the technology change.
INTRODUCTION

The major task of food processing applications is to ensure the freshness of perishable goods. Storages are used to smooth out peaks and troughs in production, allowing a more continuous supply to customers and helping to maintain the quality of produce.

The warehouse of Courchesne Larose (Michal Inc.) is spread over an area of 100,000 ft² with a 40 ft. height, able to accommodate 2,069,945 kg (4,563,442 lbs) of food per day. It includes 22 ripening rooms for bananas, a main dock with 19 garage doors, and a banana dock with 3 garage doors. The temperature in the rooms varies between 0 and 15°C (32 to 59°F).

Carnot Refrigeration Inc. has designed and manufactured an ideal system for this warehouse. Their NH₃/CO₂ refrigeration system provides a significant advantage because it greatly minimizes environmental impact. Although this system is very new, it should be emphasized that Carnot Refrigeration Inc. has integrated innovative new technologies, for instance the total recovery of the heat rejected by compressors.

ABOUT THE COMPANY

Since 2008, Carnot Refrigeration has been leading the CO₂ market in Canada. The company offers integrated services for the design, manufacturing and installation of high quality and eco-efficient CO₂ systems for supermarkets, industrial applications and ice rinks.

More information at:
www.carnotrefrigeration.com

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ABOUT THE SYSTEM

The major advantages of this technology are summarized as follows:

- Completely eliminates the use of HFCs and / or HCFCs
- Reduces the ammonia quantity drastically without energy penalty
- Reduces piping and insulation size by more than half and the related labour and material cost by 31.5%
- Reduces the use of paraseismic hangers and the structural need to support the pipes
- Ammonia is confined to the mechanical room.
- Provides full heat reclaim (if needed) for space heating or water heating (domestic or process)
**Hot gas defrost**

The hot gas provides a quick and efficient evaporator defrost. Compared to electric defrost, this method has the advantage of zero additional energy expenditure or adding heat in the energy balance of the system.

The hot gas defrost offers the possibility to heat the docks and all other areas of the warehouse as needed, always without additional energy expenditure and no additional mechanical equipment (pumps, loop glycol, heaters, etc.).

**Heat recovery**

The NH₃/CO₂ refrigeration system is designed to recover direct heat from the discharge gases of the CO₂ compressors to fuel recovery coils and to heat the ambient air of offices and warehouse spaces, such as the shipping dock and work shop, which require heat. This option provides recovery capacity (available heat) up to 8 times greater than the use of an intermediate loop glycol.

**TFC – Mode « Free Cooling »**

Using CO₂ by direct expansion in cascade with ammonia, our system employs the TFC mode (free cooling) when the outside temperature is below 8°C. This mode is maintained for 4000 hours in the Montreal area.

During the hours of TFC mode, NH₃ compressors remain completely stopped. These breaks increase the lifetime of the compressors, the lubrication system, and other components of the ammonia loop.

In comparison, for a recirculation loop with CO₂ kept at -8°C, outside temperature must remain below -15°C to allow for the TFC mode. It corresponds to a potential of 250 in the Montreal area. We expect that this system will reduce the total energy (kWh) requirement of the building, compared to a direct NH₃ system.
INTRODUCTION

After having deployed an alternative solution for the supermarket and industrial world, Carnot is now providing a very attractive (cost & safety wise) alternative to ammonia or HFC refrigeration systems used for recreational ice rinks.

ABOUT THE SYSTEM

- Natural and non-toxic refrigerant
- GWP = 1.0 / ODP=0
- No need for fixed machinery mechanics (FMM)
- Does not require any major change in the mechanical room
- Possibility to reuse existing pumps and piping for the brine/glycol closed loop
- Reliable and proven systems
- Very safe, industrial grade product
- Maintains pressure and workload during a prolonged stop
- Increased energy efficiency
- Simple, factory manufactured system
- Compact and lightweight gas cooler
- Replacement parts available from common distributors

ABOUT THE COMPANY

Since 2008, Carnot Refrigeration has been leading the CO₂ market in Canada. The company offers integrated services for the design, manufacturing and installation of high quality and eco-efficient CO₂ systems for supermarkets, industrial applications and ice rinks.

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Description of the CO₂ transcritical refrigeration systems

1- Compressor and Desuperheater
This is the cooling stage in which the pressure is lowered to increase efficiency. We use the direct heat recovery from the CO₂, using stainless steel piping. The heat generated by the refrigerant’s compression is sent to the desuperheater to warm up the hot water closed loop, which feeds the subfloor, the snow pit, etc.

2- Direct heat recovery
The unused heat from the desuperheater is sent to the arena heat recovery units. When the heat recovery is not needed, the refrigerant is sent to the gas cooler (condenser).

3- Domestic hot water exchanger
This is used to preheat domestic hot water.

4- Liquid CO₂ tank
The purpose of this tank is to control the level of the liquid refrigerant, which changes during the use of the system. It also feeds the exchanger with CO₂ / Glycol or brine.

5- Exchanger CO₂ / Glycol or brine
At this stage, the heat transfer fluid is cooled to the preset value to maintain the quality of ice required. The exchanger is specifically designed to be used with CO₂ / Glycol or brine.

6- Glycol/brine circulation pumps
The CO₂OL systems from Carnot Refrigeration have the flexibility to be used with existing circulation pumps, or new ones can be installed to meet customer needs.

7- Distribution system slab and subfloor
As for the circulation pumps, the existing distribution systems for the slab and subfloor can be kept and re-used. To protect the heat transfer fluid closed loop against corrosion and erosion, Carnot’s systems can be equipped with a water treatment.

SUMMARY
In conclusion, the compactness, combined with the simplicity of the CO₂ transcritical solution provided by Carnot Refrigeration allows important savings (capex & opex). The system using CO₂ is the safest solution (for humans and the environment) that is available for recreational ice rinks.
INTRODUCTION

A major food processing plant in Iowa made significant investments in energy conservation. With a focus on energy savings, the plant installed high efficiency boilers and invested in the capture and recover of boiler stack heat. Yet, like many food processing plants, they were paying for electrical energy to remove heat from their refrigerated spaces with an ammonia refrigeration system and rejecting that heat to the atmosphere. Also, they were paying for natural gas to add heat to hot water used for the hygienic cleaning of the plant.

If the rejected heat could be captured and used to provide water heating, substantial energy would be saved. The highest pressures and temperatures in the refrigeration system (compressor discharge gas) provided the best source for heat to be transferred to the sanitation clean-up water. But, as ammonia refrigeration practitioners who have employed “heat reclaim” practices have noted, ammonia at typical condensing pressures, while possessing large quantities of heat energy, condenses at fairly low temperatures [75-95°F (24-35°C)]. The transfer of this energy to city water, through conventional heat exchangers, to create 145-185°F (63-85°C) wash down water, is only effective for limited pre-heating of the cold water supply.

If the refrigeration system compressor discharge gas, at fairly high pressures [180 psig (13.2 atm)] could be fed directly into the suction of a “heat pump” compressor and compressed to even higher pressures (i.e. 450-800 psig (32-55 atm)), condensing this higher pressure ammonia with cold water in a heat exchanger would capture much larger quantities of heat energy than heat reclaim and would elevate the cold water supply from 60°F (15°C) up to the 145°F (63°C) required for wash down.

The requirement of the plant to have the wash down water classified as a potable supply presented another challenge, as local codes prohibit potable water to be in direct heat exchange with ammonia. Using such an ammonia heat pump system would require a secondary loop, thereby lowering the efficiency of heat transfer.

Given the need for sustainable projects to clear the same internal rate of return hurdle as non-sustainable projects, the challenge was to define and justify the project. The project costs would include tapping into the ammonia refrigeration system, adding and installing a custom ammonia heat pump system and employing the electrical energy to operate the high pressure ammonia heat pump system.
ABOUT THE SYSTEM

The ammonia heat pump system delivers hot water at 145°F (62.8°C) using the heat extracted from refrigeration. It features Vilter™ single screw compressors. The inherent high pressure capability of the single screw compressor allows for full acceptance of the highest operating discharge pressure from the host system, even in excess of 180 psig, without the risk of rotor deflection and excessive bearing thrust loads, which can result in accelerated degradation or the loss of efficiency due to over-compression.

With the lower 60°F (15.6°C) incoming cold water temperature during winter, the estimated heating capacity of the heat pump during winter conditions was estimated at 5.738 MMBtuh (1,682 kW), providing 135 GPM (30.7 m³/h) of continuous 145°F (62.8°C) hot water flow. The heat pump was estimated to provide an average year-round heating capacity of 7.013 MMBtuh (2,056 kW), heating 170 GPM (38.6 m³/h) from 62.5°F (16.9°C) to 145°F (62.8°C).

Since its commissioning, the plant heats 170 gallons (644 liters) of water per minute. This hot water is delivered far more efficiently than the water from their natural gas hot water heater. The ammonia heat pump solution has cut heat energy cost by over $250,000 each year and saves fourteen million gallons of water per year because of the reduced load on the evaporative condensers.

By using ammonia, Emerson’s compressor technology solution offers a refrigerant with a good environmental profile (non-ozone depleting and zero global warming impact) that delivers higher temperatures and provides superior performance benefits from its consumed resources, than competing technologies. In addition, the balanced radial and axial force design of the single screw compressor lowers stress on the unit’s bearings, resulting in low operating and maintenance costs, while delivering a performance unachievable with any other type of compressor.

“The heat pump automatically responds to varying operating conditions for the ammonia and hot water. There is very little input needed from the operators. Maintenance requirements are really no different than what is already required for existing compressors, vessels and heat exchangers. Between the boiler stack gas heat recovery and the heat pump, we no longer use the conventional hot water heaters on a daily basis.”

- Infrastructure Program Manager

RESULTS

- Annual operational savings of $267,407
- 14,000,000 gallons (53 million liters) of water saved annually
- Waste heat recovery of 7.0 MMBtuh (2.1 MW)
- 6.51 coefficient of performance (summer)
- 4.23 coefficient of performance (winter)
- Ammonia refrigerant with 0=ODP & 0=GWP
- 15% higher efficiency than comparable technologies
- Design for +20 years service without costly maintenance

Learn more about industrial heat pump systems, featuring Vilter single screw compressors at emersonclimate.com/industrialheatpumps
INTRODUCTION

Carbon dioxide (R744 - CO₂) is nowadays considered one of the most attractive long-term solutions for commercial and industrial refrigeration applications, as well as for hot water heat pumps.

To meet the growing demand for CO₂ technology the Italian compressor specialist has developed a new semi-hermetic reciprocating compressor range and a new semi-hermetic reciprocating compressor model, both for CO₂ transcritical applications.

ABOUT THE SYSTEMS

CD-2S RANGE

The new CD-2S range offers the capability to work with extreme pressure ratios, permitting the use of typical CO₂ low temperature equipment without the need to implement a cascade or a booster arrangement, thus drastically cutting the risk of failure intrinsically present in any booster or cascade application.

The CD-2S range represents the latest, cutting-edge development for transcritical CO₂ compressors. These models can be used in a wide range of applications. They provide several operational benefits:

- The ability to handle large pressure differences produced by typical direct expansion low temperature systems configuration (Tₜₜ = -35°C or -31°F), rejecting the heat directly to the ambient (up to 100 bar discharge pressure), thus providing an intrinsically safer installation. In fact, in a booster system, any failure occurring on the low pressure side will automatically be reflected into the high pressure side, and vice-versa.
- Issues related to stand-still conditions become obsolete, at least regarding compressors, as the compressors have Pₛₛ = 100 bar.
- Increased system efficiency of medium temperature equipment (Tₜₜ = -10°C or 14°F) located in warmer areas by using the sub-cooling effect obtainable through a very simple inter-stage gas heat exchange with a gas cooler outlet. This could clearly boost the installation’s energy efficiency, making CO₂ a viable solution, also for warmer climates (e.g. Southern Europe).

ABOUT THE COMPANY

Dorin entered the field of refrigeration in 1932 with its first open-drive compressor range. The first CO₂ transcritical type was commissioned in 1999. Today, Dorin produces more than 70,000 compressors per year.

More information at:
www.dorin.com

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• Safe operating of a CO₂ heat pump down to extremely low ambient temperatures (T_amb = -25°C or -13°F) with no need for additional electric heaters, thus boosting the equipment’s efficiency.

**Main Characteristics**

• Semi-hermetic reciprocating compressor
• Generous electric motor sizing
• Max. standstill pressure: 100 bar, top figure within competition products
• Displacement (m³/h at 50Hz): 11.6 – 15.1 m³/h
• Cylinders: 4
• Suitable for frequency control regulation, up to 75Hz

**Advantages**

• Room opening for LT applications with single stage compressor with no need for a booster / cascade arrangement: intrinsically safer installation
• Standstill pressure boosted to 100 bar, allowing:
  » No issues during prolonged standstill
  » Safer preservation of goods
  » Extra-robust drive gear for extreme and proven reliability
  » Multi-layer, self lubricating bearing for superb robustness against liquid slugging
  » Silent and smooth operation in any operating condition
  » Wide application envelope to suit all possible applications and systems
• Utmost reliability
• Utmost COP levels

**Main Characteristics**

• Semi-hermetic reciprocating compressor
• Electric motor specifically sized for CO₂ applications
• Max. standstill pressure: 100 bar, top figure within competition products
• Displacement (m³/h at 50Hz): 30.5 m³/h
• Cylinders: 4
• Suitable for frequency control regulation

**Advantages**

• Possibility to reduce the number of compressors in typical rack systems
• Sensible cost reduction for end users
• Standstill pressure boosted to 100 bar, allowing:
  » Prolonged refrigerant containment during long-lasting standstill
  » Safer good preservation
• Extra-robust drive gear for extreme and proven reliability
• Multi-layer self lubricating bearing for superb robustness against liquid slugging
• Silent and smooth operation in any operating condition
• Wide application envelope to suit all possible applications and systems
• Utmost reliability
• Utmost COP levels

**CD5000M**

With its 30.5 m³/h displacement, the new CD5000M is able to work in typical medium-low temperature applications and allow for the consistent decrease of the number of compressors assembled on racks, thus leading to consistent cost reduction for end-users.

CD5000M represents the last extension of the well known and appreciated CD400 range. At the time, the CD400 range already featured the largest CO₂ transcritical model commercially available on the market (namely CD4000H, 26.5 m³/h). With the introduction of CD5000M, DORIN has further strengthened its leading position in the market, allowing its business partners to provide the best solution for end users.
CO₂ / AMMONIA BRINE SYSTEM FOR DISTRIBUTION CENTER

INTRODUCTION

CIMCO’s specialties were fully utilized when it was challenged by Canadawide to design an ammonia/CO₂ system for Canadawide’s growing distribution center. This case study looks at Canadawide’s expansion and its new state of the art refrigeration system, installed at its Montreal warehouse.

Canadawide is a national wholesaler of fruits and vegetables. The company history is as follows:

- 1961 - Green Grocery is founded by Greek immigrant John Pitsikoulis as a grocery store in Montreal, focusing on top quality produce to local clientele
- 1960's - Green Grocery expands to several locations throughout Montreal
- 1979 – First 15,000 sq. ft. warehouse is opened
- 1983 – Name is changed to Canadawide to increase emphasis on the company as a distributor
- 1989 – Retail division is sold to focus on the wholesale division
- 2001 – Canadawide establishes its premises at the Marche Central. This location is refrigerated by R-22.
- 2011 - Canadawide undertakes an expansion of a brand new cold storage.

Original Specification

The original specification was based on a Freon/glycol system. The client’s objectives were to install a system with the following criteria:

- Lowest annual operating costs
- Lowest maintenance costs
- Increased efficiency/heat reclaim
- Employee comfort
- Maintain a timely construction schedule

The cold storage building has a total capacity of 984 kW with the following layout:

- 5,575 m² (60,009 sq. ft.) of refrigerated space
- 8 coolers from -4°C to 5°C (24.8 to 41°F)
- 17 door loading docks
- 8 banana rooms

ABOUT THE COMPANY

Over the years, CIMCO has grown into an international refrigeration leader in the industrial refrigeration food and beverage and cold storage markets. The Canadian Ice Machine Company, now known as CIMCO, was purchased by Toromont Industries Ltd, a publicly traded company, in 1969. Today, CIMCO’s specialties include the full spectrum of engineering, designing, manufacturing, installing, and servicing of industrial, process cooling and recreational refrigeration systems.

More information at: www.cimcorefrigeration.com

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• Dry storage
• Fresh air for the process rooms

Although R-22/Glycol was initially preferred, other approaches, such as direct ammonia, Freon commercial, and ammonia/secondary fluid loop, were considered. However, despite its original preference, Canadawide found that an ammonia/CO₂ brine system would actually align best with their objectives. The contract was awarded to CIMCO in December 2011, with the intent to be operational by April 2012.

ABOUT THE SYSTEM

The designed system uses medium temperature ammonia as the primary refrigerant to cool a single loop of re-circulated CO₂ which feeds the various evaporators.

The mechanical room, located on the second floor, is 6 x 14m (19.7 x 45.9ft) and has a height restriction of 3.9m (12.7ft) under the beams.

To respect the provincial refrigeration code requirements, two 150 kW industrial screw compressors, with ammonia evaporation at -11°C (51.8°F) and ammonia condensation at 35°C (95°F) were selected. In order to increase efficiency, the screws utilize the economizer port to sub-cool the liquid. The heat is rejected via an evaporative cooled condenser located outside, slightly above the mechanical rooms. The condenser was selected with a low-height centrifugal motor, to accommodate the architectural constraints of a 3m (9.8ft) roof height. An internal water sump tank and pump is used because of the rigorous winter conditions in the area. To limit the refrigerant change, the system was designed with a critical charge of ammonia. A high side pressure float is used for the ammonia/CO₂ cascade cooler.

Considering the height limitations, a CIMCO shell and tube one-pass cascade cooler with an increased length was selected, in order to have the minimal diameter size. To keep the efficiency of the system as high as possible, the temperature difference is lower than the average 4.4°C (39.9°F), producing CO₂ at -6.6°C (20.1°F). The CO₂ pump receiver is located directly underneath the heat exchanger and low static head CO₂ pump is utilized. The CO₂ is pumped in the main distribution loop for the entire facility.

Each refrigeration evaporator is equipped with modular valve assemblies. The higher temperature 7°C (44.6°F) rooms use ambient air defrost, while the lower temperature rooms are equipped with electric defrost. Since the entire system is fed via one loop of recirculated CO₂ at -6.6°C (20.1°F), special care had to be taken to minimize the dehydration of the higher temperature rooms with greater operating TD. Special modulating liquid solenoid valves were installed for those applications.

Additionally, the banana room has special requirements to insure quality of the product. Conscious about providing the customer with the best performance and most reliable system, CIMCO installed a plate and frame ammonia/glycol cooler to provide the cooling for the banana room evaporators. This special feature allows the system to operate at a higher temperature, respecting the temperature limit for ensuring the safe preservation of the product.

Safety:

One of the safety concerns associated with CO₂ is the high pressure throughout the system. CIMCO mitigated the safety risks by installing the following safety features:

• High pressure pipe burst: Installed relief valves at critical points for controlled release
• Ammonia system electrical failure: Installed a 3 kW R-404A condensing unit on the CO₂ re-circulator to keep the pressure at the design conditions of 40 bar.

Piping Costs:

CO₂ systems require a higher grade piping due to the higher pressures. Compared to traditional systems, the higher priced piping is offset by smaller diameter size, faster onsite installation, easier layout of the piping route, and less thermal insulation.

Performance:

The complete system has been operating for several months now, and CIMCO is pleased to report that the monthly energy consumption is lower than the original Freon design. More importantly, the room temperature is perfectly maintained, and the humidity level is within the expected levels. The owner had expressed his complete satisfaction, and is planning on using the same design for his phase two expansion.

During the start up procedure, Patrick Ianniciello, the Project Manager, made the following comments:

“In my entire career I have never seen room temperatures going down so fast, this system is operating like crazy, and I would recommend this system over any other I’ve seen.”

CIMCO is pleased to have been the design-build supplier and installer of this innovative and energy efficient ammonia/CO₂ system. This allowed the company to demonstrated that the CIMCO system is a viable alternative, when a direct ammonia system is not the desired option.
INTRODUCTION

At the new S-Market building in Helsinki, Finland, cooling and terminal rooms are full of evaporators labeled and manufactured by Alfa Laval. The company was able to help S-Market become one of the few supermarkets in Finland that use CO2 refrigerant.

“In this very interesting project, our customer, the S-Group, gave us a few prerequisites for the type of cooling equipment they wanted. The most crucial requirement was carbon dioxide, which had to be chosen as the refrigerant,” says Taisto Tolonen, Project Manager at Norpe Finland, the company that installed the supermarket’s cooling system. “The most commonly used refrigerant in Finnish supermarkets is still artificial. The challenge is that it does not meet the upcoming F-gas legislation, which will be enforced in a few years.”

Currently, there are no more than 50 supermarkets in Finland using carbon dioxide as a refrigerant. According to Tolonen, Norpe and Alfa Laval have been cooperating since the 1970s. This latest project started with a visit to Alfa Laval in Italy in December 2011, where the carbon dioxide evaporators are manufactured. “Although carbon dioxide is nature’s own gas, it does not act like traditional, more commonly used refrigerants,” says Hannu Viikilä, Alfa Laval Nordic project owner.

ABOUT THE SYSTEM

S-Market’s cooling system includes an Optigo CC air heat exchanger in the freezer, and Optigo CD coolers in the fish, chicken, ready-food, fruit, and vegetable cold storage rooms. Both models are part of Alfa Laval’s Optigo range of energy-efficient and environmentally friendly air heat exchangers.

There are currently three models available in the range which have been optimized for CO2, and are easy to install, making them ideal for small to medium commercial applications, such as supermarkets, restaurants, and chilled food storage.

Optigo CD

For cooling and freezing rooms, where high activity demands increased airflow, the Optigo CD provides double airflow as well as low air velocity and noise levels. As with the other products in the Alfa Laval’s Optigo product line, the CD model is easy to install, clean and follows HACCP guidelines for food safety.
S-Market’s cooling system consists of one Optigo CD cooler in the fish cold room (0-2°C or 32-35.6°F), chicken cold room (0-2°C or 32-35.6°F), ready-food cold room (3-5°C or 37.4-41°F), fruit and vegetable cold room (6-8°C or 42.8-46.4°F), as well as three coolers in the terminal area (2-4°C or 35.6-39.2°F).

**Optigo CC**

Optigo CC is the perfect single flux choice for larger-volume applications. It has a clever design with a new, highly efficient coil (for reduced refrigerant content) and the same footprint as the previous series. This makes it easy to install and connect, while high-energy efficiency gives low lifecycle costs. An Optigo CC has been installed in S-Market’s freezing room (-20 to -18°C or -4 to -0.4°F).

**RESULT**

“In order to guarantee the highest possible quality of our products, we tested certain units and then created design programs with which to secure exact capacities,” says Hannu Viikilä. Carbon dioxide has good heat exchanging abilities, but its drawback has always been its high pressures. However, Viikilä points to the isolated bunker that Alfa Laval built at its manufacturing site in Alonte, Italy, where long gas coolers can be pressure tested with 172 bar.

“I can proudly say that our clear strength is the ability to combine theory and praxis,” adds Hannu Viikilä. “We are able to show how carbon dioxide reacts at different pressures and our global development team was strongly committed to the correct CO₂ calculation methods.”

Norpe also knows that Alfa Laval has a long reference list concerning challenging refrigeration environments, including supermarkets. “For us as an installer and contractor, it was of great importance to have a reliable and experienced component supplier,” states Lasse Silvan, Project Engineer from Norpe. “We also appreciate the quick service in our native language, as well as high technical know-how on the part of Alfa Laval’s contact persons.”

According to Silvan, the project did not encounter any significant challenges. Supplies came as agreed, and there were no surprises during the pressure and leak tests, which Norpe carried out after installation in November 2012.

**SUMMARY**

Lasse Silvan, Project Engineer, Norpe Finland: “Alfa Laval’s high commitment to new environmentally friendly cooling solutions is admirable. After many years of close co-operation, I can say that they are honestly interested in customers’ needs and are ready to fulfill needs to the smallest detail.”

Hannu Viikilä, Segment Manager, Alfa Laval Nordic: “I appreciate Norpe’s openness to the new and sustainable solutions we can offer. When operating with such a challenging refrigerant like carbon dioxide, it is rewarding that our partner also wants to see our R&D environment with all of its frills.”
INTRODUCTION

Out of concerns over rising energy costs and the commitment to sustainable operations, Somerston Wine Co., producer of Highflyer, Priest Ranch and Somerston wines installed the first ever integrated CO2 refrigerant heat pump heating and cooling system implemented in a winery in North America. The installation is at the state of the art, energy efficient winery, located in a renovated 12,000 sq. ft. (1,115 m²) barn, high in the eastern mountains of Napa Valley, California on Somerston's 1,682 acre (680 ha) ranch. It was designed to be functional, practical, and energy efficient. Somerston's sustainable operations will eventually expand to include a neighboring structure with solar powered lithium batteries, resulting in a winery that is 100% off the grid.

A typical winery would use a natural gas or propane hot water boiler, in addition to an air cooled or water cooled electric chiller for the hot water and chilled glycol systems used for tank fermentation control and barrel room cooling / heating requirements. These separate components cannot recover the heat that is wasted through the air cooled or water cooled condenser of the electric chiller. Furthermore, hot water above 180°F (82°C) is required, which cannot be met using a standard heat pump system.

ABOUT THE COMPANY

MYCOM Mayekawa is a leading provider of energy efficient compressors and thermal systems. Its focus is on developing energy efficient technology for refrigeration, air conditioning, and heating applications.

Mayekawa emphasizes the use of the “Natural Five” refrigerants (water, air, ammonia, CO2 and hydrocarbons), which have the greatest application potential for the next generation of thermal applications and solutions.

More information at: www.mayekawausa.com

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ABOUT THE SYSTEM

The integrated MYCOM ECO Cute CO2 refrigerant heat pump heating and cooling system is comprised of four elements: a MYCOM CO2 refrigerant heat pump, a hybrid adiabatic fluid cooler that replaces the traditional cooling tower, a glycol warming system for tank and barrel room heating, and a high efficiency water cooled glycol chiller for additional tank and barrel room cooling. The components represent cutting-edge technology used only by a handful of companies in the world, and Somerston Wine Co. is the first to integrate the components into a complete system. The CO2 heat pump system operates with zero emissions, as it is all electric, while also achieving a coefficient of performance vastly higher than traditional propane-based hot water boilers and standard refrigerant heat pumps, which requires high temperature hot water. Where a standard propane-based hot water boiler is 80 percent efficient, Somerston’s CO2 heat pump is 360 to 400 percent efficient while performing heating and cooling functions at the same time.
In addition, Somerston’s MYCOM CO₂ refrigerant heat pump can achieve 194°F hot water output temperatures, far outperforming HCFC and HFC refrigerant heat pumps, which only achieve 160°F output at best.

The first component, a MYCOM Eco Cute electric-driven, water source, hot water heat pump, uses CO₂ as a refrigerant for glycol cooling and hot water heating, all in the same unit. It is more efficient than a standard hot water boiler, especially while heating and cooling simultaneously. The heat pump operates using the transcritical refrigeration cycle. By using CO₂ instead of gas fired boilers and HFC refrigerants, Somerston’s system results in a 28% lower carbon footprint overall. This MYCOM CO₂ refrigerant heat pump made its North American debut at the Somerston winery; it is backed with a proven record of performance and effectiveness in Japan and Europe. A large insulated hot water storage tank was also installed for winery peak load requirements.

The second component of Somerston’s system is a hybrid adiabatic fluid cooler, which replaces the traditional cooling tower. While traditional towers require large amounts of water and have high maintenance costs, Somerston’s fluid cooler acts as an air cooler during temperate months and a wet cooler during hotter months. Somerston is the first winery in the USA to utilize this technology.

A larger, high-efficiency electric glycol chiller for harvest cooling loads and a glycol warmer are the final components of the system and are used for tank and barrel room cooling. The MYCOM CO₂ heat pump is used as an integrated component with these other systems to indirectly warm glycol with a special safety plate heat exchanger and directly cool glycol. This results in dramatically lower energy requirements than traditional systems, bringing Somerston’s ideals of a sustainable, environmentally conscious property full circle.

“Somerston’s guiding mission is to operate systemically as a sustainable, efficient, and land-focused project,” says Craig Becker, partner, General Manager, winemaker, and vineyard Manager at Somerston Wine Co. “While plenty of producers build efficiently, they rarely operate efficiently. Every element of the Somerston winery has a purpose, and the energy savings for the integrated CO₂ heating and cooling system will pay for the system’s additional cost within three years.”

RESULTS

Environmental Impact: Using CO₂ as the refrigerant for the heat pump system allows for high hot water temperatures in addition to eliminating the use of HCFC and HFC refrigerants. A 28% overall reduction in greenhouse gas emissions was also achieved.

Safety: The MYCOM heat pump is a closed type system that has a total CO₂ refrigerant charge of 24 lbs, along with safety interlocks to ensure safe and reliable operation.

Costs: The overall cost of using the hybrid components in an integrated system versus a separate gas boiler and glycol chiller system resulted in a 25% premium. The additional costs are expected to be recovered within three years.

Energy Efficiency: By combining the hot water heating system with the glycol cooling system using the MYCOM heat pump unit, a high COP is realized, unlike when using separate systems. The system has been in operation since late 2010 and, when compared to a more traditional system, a 22% energy reduction was achieved. In addition, the MYCOM heat pump can source heat from either the glycol cooling loop for low load conditions or from the higher temperature water cooled condenser of the electric chiller for increased COP and system performance.

SUMMARY

The use of transcritical heat pumps for high temperature hot water heating is a proven technology with very good overall energy efficiency. In addition, the water source version, as described in this case study, has many applications, including Hotels/Resorts, Food Processors, Dairies, Breweries, Manufacturing, and even Building HVAC systems that have a high temperature hot water load and simultaneous cooling load. These types of applications can result in maximum energy savings, while using environmentally friendly equipment.
INTRODUCTION

The phase out of CFC and HCFC refrigerants and the unknown future of their replacement refrigerants have led the supermarket industry to look to alternative, long term, energy efficient solutions. Carbon dioxide (R 744) is rapidly becoming the industry choice for an alternative refrigerant due to its favorable environmental properties (ODP = 0, GWP = 1). Many of these systems are installed using CO₂ as a secondary fluid, circulated through the store to the cases while an HFC refrigerant is still used as the primary refrigerant at the compressor rack.

Another natural choice for refrigerant is ammonia, R717(ODP = 0, GWP = 0). Ammonia has been used since the beginning of mechanical refrigeration due to its efficiency and ease of availability. These applications were typically industrial systems with more than 10,000 lbs of charge. Due to the size of the typical installation, it was not considered as an alternative to synthetic refrigerants in commercial applications. However, new technology in the past ten years has allowed ammonia systems to be designed with significantly lower charges. Low charge systems make it easier to manage the safety of an ammonia system for operators and those who are around the system.

SuperValu approached MYCOM Mayekawa to develop a low charge ammonia/CO₂ chiller that would be part of a CO₂ cascade refrigeration system for an Albertsons test store in Carpinteria, California, which would use 100% natural refrigerants. This collaborative effort would bring the most trusted names in supermarket refrigeration together to show the strength of an all natural refrigerant store, particularly in energy efficiency.

ABOUT THE SYSTEM

MYCOM designed and built the ammonia chiller portion of the refrigeration system for SUPERVALU’s Carpinteria store. The MYCOM unit consisted of the compressors, condensers, and CO₂ heat exchanger that supplied liquid CO₂ to the CO₂ refrigerant skid for distribution to the store.

The design approach for the unit was to develop a skid that was bulletproof and could be used to prove the concept of using ammonia in a supermarket application. Easily available industrial components were used for ease of replacement and familiarity to the service base in the area.
The ammonia unit needed to supply the store with a refrigeration capacity of 860 kbtu/hr (~71TR). This was achieved using a MYCOM M Series reciprocating compressor. The M Series is MYCOM’s next generation reciprocating compressor, specially designed to be used for natural refrigerants with high efficiency. The compressor is coupled to a 125 HP motor with variable frequency drive. The VFD can match load conditions in the store to make sure the system is always operating most efficiently.

Many energy efficiency design elements were included in the skid to reduce energy consumption. The ammonia system uses a flooded plate/shell heat exchanger to condense the CO₂ vapor returning from the store back to a liquid. The flooded design increases efficiency over a direct expansion system, and the plate/shell heat exchanger allows for a narrow temperature (7°F or -14°C TD) difference to raise the suction temperature (13°F or -10°C SST) on the compressor to save energy.

A key design element of the skid was to keep the charge of the unit low so that the risk of an ammonia release was mitigated by the small amount of ammonia in the system. Unlike federal guidelines for systems over 10,000 lbs of ammonia, the State of California’s limit is 500 lbs (227 kg). This makes the amount of ammonia in the system critical. For this unit, even with a flooded design, the charge of the unit during start up was 250 lbs (113 kg).

The safety of the skid was a critical design element since this unit was being placed in a retail location. Ammonia sensors can give early warnings of a release and shut down the compressors to mitigate a release. High powered fans blow the ammonia up and away from the unit in the event of a release. To prevent over pressurization of the unit, pressure can be blown down from high points in the system to the low side. This system attempts to reduce the high pressure points of the system into the low pressure side to prevent the relief valves from lifting. In addition, the base pan of the unit is fully welded to prevent ammonia from spilling onto the roof and into the store in an ammonia loss situation.

Environmental Impact: Using ammonia as a refrigerant eliminates the need for synthetic refrigerants that negatively impact the ozone and have a large greenhouse gas impact. The skid is also designed for energy efficiency and consumes less power than a comparably sized Freon system.

Costs: This unit was designed and constructed as a test system to prove the viability of using ammonia in a supermarket environment. This is not a standard production unit, and it contains a number of elements that increase the cost. There is a fully redundant compressor, motor, and VFD. This not only raises the initial cost of the unit but the life cycle cost as well. Future development will focus on standardizing the skid to further reduce costs.

Energy Efficiency: The strength of ammonia refrigerating systems is their energy efficiency. The combination of the flooded heat exchanger, energy efficient compressor, ammonia as a refrigerant, and water cooled condensing show a preliminary energy advantage of over 30%, compared to a conventional Freon type system. This is an incredible leap forward in efficiency and uses a natural refrigerant to achieve it.

SUMMARY

The collaborative effort to bring ammonia to a supermarket setting, spearheaded by SUPERVALU at their Carpinteria Albertsons store, demonstrates that ammonia is an environmentally friendly, energy efficient alternative to synthetic refrigerants. Preliminary energy savings of using an ammonia/CO₂ system are 30% greater than for conventional systems. This represents a significant increase over previous systems.

While there are still concerns over the safety of using ammonia in supermarkets, the energy values are worthy of serious consideration.
# Energy Efficient Hydrocarbon Ice Machines

## Introduction

For the commercial food service and related industries, which rely daily on large quantities of ice for food displays, safety, preparation, beverages, etc., the ability to reliably and cost efficiently produce ice can have an impact on a business' operation. Between 2005 and 2010, Manitowoc Ice, Inc., the Wisconsin-based manufacturer of commercial ice machines, became interested in taking its product portfolio one step further. It turned to Danfoss with the idea of designing an ice machine that would improve customers’ sustainability efforts by operating on natural refrigerants.

The collaboration with Danfoss led to the development of two new models within Manitowoc’s Indigo Series and two Q-Series under-counter units that are cooled by R290 or propane, which Manitowoc introduced in mid-2011. The use of an environmentally friendly hydrocarbon refrigerant enables Manitowoc to offer customers a product with zero ozone depletion potential (ODP) and low global warming potential (GWP), which also improves energy efficiency and reduces operating costs.

## About the System

Fueled by increasing market interest in environmentally friendly systems and practices, and a goal of preparing the global market for greater hydrocarbon acceptance, the first collaborative project was Manitowoc’s 500-pound ice machine. To convert the ice machine to natural refrigerants, Danfoss replaced a compressor using R-404a, a hydrofluorocarbon (HFC), with a new compressor designed for R290, a hydrocarbon (HC).

Knowing it would also help reduce energy use, Danfoss chose to install one of its SC Series compressors (SC18CNX) for R290, which features a reliable, compact design and a motor with specially-optimized valves and internal motor protection. The SC compressor offers high cooling capacities, low noise levels, and low energy consumption at high ambient temperatures (113°F or 235°C). The SC Series from Secop is part of a large product range designed for R290, which will be continuously extended and improved to provide high energy efficient compressors for natural refrigerants. It can serve both the 115 Volt as well as the 230 Volt markets. In early 2013, Secop will introduce four new models for R290 from the TL and the NL series, with 115 Volt supply.

To further improve the efficiency of the ice machines, Manitowoc installed a specially designed Danfoss TU thermostatic expansion valve, which helps to optimize the charge and regulate the injection of the refrigerant. Manitowoc also replaced the condenser with a new Danfoss microchannel condenser.

## About the Company

Danfoss is a world leader in the research, development, and production of high efficiency electronic and mechanical components and controls for air-conditioning, heating, refrigeration, and motion control systems, as well as for renewable energy technology solutions, such as solar power. Danfoss focuses on combining innovative engineering, energy efficiency, and environmental responsibility. This includes leading the industry in the adoption of natural and lower GWP refrigerants, including ammonia, CO₂, and hydrocarbons.

More information at: www.danfoss.us

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“The decision to offer units operating R290 was primarily driven by some of our large accounts’ internal demand to become more environmentally friendly. We are currently looking at other natural refrigerants like CO₂, but R290 provides the great energy efficiency benefits that our customers are also demanding.”

- Greg Erickson, Field Marketing Manager at Manitowoc Ice, Inc.

### Results & Summary

**Production Capacity:** Typically, replacing R-404a with natural R290 causes production (the volume of ice harvest within each 24-hour period) losses up to 10%. However, by increasing compressor displacement with R290, reducing operating pressure with microchannel heat exchangers, and optimizing component selection, Danfoss and Manitowoc were able to maintain ice production capacity of the R290 systems at the same level as R404a systems, while staying within the 150g charge limit.

**Energy Efficiency:** Although the introduction of hydrocarbon refrigerants was first and foremost intended to create an environmentally friendly system promoting sustainable practices, the lower pressure ratio and discharge temperatures of R290, combined with the high efficiency compressor and components, work together to save 20 to 30% more energy than comparable ice machines. This is a direct benefit to customers, who are also motivated by a reduction in energy costs over time.

**Local & Global Production:** To date, the R290 Indigo Series ice machines are being manufactured for and sold to the European market. However, according to Erickson, Manitowoc is producing the R290 Indigo units at the company’s facilities in Wisconsin and the Q-Series under-counter units in China.

“Because of its readiness for natural refrigerants, we saw the European market as an opportunity to put a stake in the ground and showcase a proven technology. We believe the R290 ice machines will become much more relevant here in the United States over the coming years – and we’ll be prepared with environmentally friendly and energy efficient ice machines when that day comes.”

Deploying these technologies in the USA market will, however, first require tackling a few large hurdles, including the modification of safety standards, which the industry hopes will happen in 2013. Only then can the SNAP approval process for R290 ice machines move forward, and only then can these low GWP, energy efficient hydrocarbon refrigeration systems begin to reshape the market and its environmental impact.

Danfoss received Manitowoc’s 2011 Technology Supplier of the Year award for their critical role in this project.
When Overwaitea Food Group (OFG) chose The Village on False Creek as the location for its newest Urban Fare Express, the bar for sustainability was set high. As a leader in retail sustainability, OFG had already established aggressive goals for green operations in every area of its business, and The Village on False Creek, having earned the highest level of Leadership in Energy and Environmental Design (LEED®) Platinum certification for a neighborhood of its size, was known as one of the most livable and sustainable communities in the world.

OFG is once again setting a benchmark for green retail practices by installing a Hillphoenix Advansor transcritical CO₂ booster refrigeration system in its False Creek store. Urban Fare Express is one of only a handful of HFC (hydrofluorocarbons) - free grocery stores in Canada. This is the first Hillphoenix Advansor transcritical CO₂ booster refrigeration system installed in North America.

OFG began experimenting with CO₂ refrigeration systems in 2010. This followed a long history of commitment to the environment, starting with its first Environmental Stewardship Award nearly 20 years ago.

In addition to its move toward CO₂, many OFG stores feature a variety of smart technologies designed to reduce energy consumption, including:

- High-efficiency lighting with motion sensors in freezer cases
- Energy reduced refrigeration systems
- Energy efficient freezer doors
- High-efficiency, programmable deli and bakery ovens
- Waste-heat recovery systems
- Building automation systems that adjust lighting, heating, and air conditioning as needed

“Recycling, sustainable seafood, reusable bags, energy-efficient stores, and our efforts to be the number one supporter of local products and producers are just some of the ways we show our commitment to sustainability every day.”

- Carmen Churcott, Vice-President, OFG
Hillphoenix Advansor transcritical CO₂ booster system advantages:

- The Advansor transcritical CO₂ booster system utilizes CO₂ as the only refrigerant covering both medium-temp and low-temp loads.
- CO₂ has a high temperature heat of rejection, making it ideal for hot water heat reclamation applications and efficient hot gas defrosting.
- CO₂ systems operate under much higher pressures than conventional HFC-based systems. Many CO₂ systems require steel piping throughout and carry a higher risk of pressure-related system breakdowns. The Advansor system eliminates those concerns by perfecting the use of pressure reducing valves, so that everything inside of the store operates under lower pressure, as it would with an HFC-based system. Contractors can use copper piping and retailers can rest easy knowing that their Advansor system maintains pressures within a range, normally found in traditional DX systems. OFG’s Urban Fare Express has a back-up auxiliary condensing unit on a back-up generator in case of power failure. The smaller condensing unit cools the CO₂ and keeps the pressure low to prevent the loss of CO₂.
- Hillphoenix R&D capabilities ensure that CO₂ technology is a viable option for every merchandising configuration. From walk-ins to custom specialty cases, Advansor technology is available across all Hillphoenix product lines.

Construction of the 23,000 sq. ft (2137m²) Urban Fare Express entailed retrofitting a former Olympic Village structure to accommodate a grocery store and all of its associated systems. One particular challenge included putting the gas cooler in the parking deck. Such a configuration had to include special sound attenuating mufflers and ducts to move hot air outside of the garage building.

**SUMMARY**

HFCs have been the refrigerant of choice in the supermarket industry for decades. However, HFCs are a greenhouse gas and contribute to global warming. Increasingly, food retailers are moving toward more sustainable natural refrigerants including CO₂. It takes 2000-4000 pounds (907-1814 kg) of carbon dioxide to equal the global warming potential of just one pound (0,5 kg) of leaked HFC refrigerant.

“We chose a transcritical CO₂ booster system because it’s 100 percent HFC-free. We’ve seen a number of synthetic refrigerants phased out over the years, and with its high global warming potential, we expect that eventually the current HFC’s will be phased out, too. CO₂ transitions us to a natural refrigerant that we can live with in the future.”

- Ralph Thiel, Director, Store Planning & Construction for Overwaitea Food Group LP

Aside from the green appeal of CO₂, it’s a much cheaper alternative to HFC refrigerants (less than $2 per lb (0,5 kg) compared to $20 per lb (0,5 kg). So why haven’t more retailers made the switch? CO₂ systems are still relatively new to supermarket applications. As companies like OFG demonstrate the advantages of CO₂, industry acceptance will no doubt increase.

“Our company is dedicated to CO₂ in all new stores in urban settings and any location where there is a population base with enough tradesmen to be trained on CO₂ technologies.”

- Ralph Thiel, Director, Store Planning & Construction for Overwaitea Food Group LP
Get in touch with us to learn how we can help you in gathering business intelligence, in getting your climate friendly technology faster to market, and in spreading your message among decision makers.

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