

Presented by

Marc-André Lesmerises, PE

**CARNOT**  
REFRIGERATION



- systèmes écoénergétiques -  
- solutions hybrides sur mesure -

CO<sub>2</sub> HFC  
NH<sub>3</sub> GLYCOL



# EXPERIMENTED

Our **mission** is to provide our clients looking for eco-friendly solutions and systems with innovative and reliable custom fit proposals. Here is our experience with CO2 based systems.

- **5 SubCritical CO2 SUPERMARKET**  
(1 700 000 Btu/hr in MT and 300 000btu/hr in LT)
- **23 Transcritical CO2 SUPERMARKET constructed or in construction**  
(1 700 000 Btu/hr in MT and 300 000btu/hr in LT)
- **NH3/CO2 Distribution Centers**  
( 1000KW, 285 TR to 3000KW, 855TR, MT and LT)
- **Several Transcritical applications**  
(smaller scale applications)

# PASSION

**CARNOT**  
REFRIGERATION



- systèmes **écoénergétiques** -  
- solutions hybrides sur mesure -

CO<sub>2</sub>  
NH<sub>3</sub>  
GLYCOL



# RIGOR

**CARNOT**  
REFRIGERATION



- systèmes écoénergétiques -  
- solutions hybrides sur mesure -



# INNOVATION

**CARNOT**  
REFRIGERATION



CO<sub>2</sub>  
NH<sub>3</sub>  
GLYCOL

- systèmes écoénergétiques -
- solutions hybrides sur mesure -



**CARNOT**  
REFRIGERATION



- systèmes **écoénergétiques** -  
- solutions hybrides sur mesure -

# CASE STUDY

Products innovations in the field  
of natural refrigerants

*IGA Ste-Agathe-des-Monts, Québec Canada*



# CASE STUDY *IGA Ste-Agathe-des-Monts*

## ***IGA supermarket in Ste-Agathe-des-Monts***

Opened in April 2011

40 866 ft<sup>2</sup> (3 797 m<sup>2</sup>).

Sales area of 30 488 ft<sup>2</sup> (2 832 m<sup>2</sup>)

744 ft of MT display cases

85 MT display cases

305 ft of LT display cases

40 LT display cases

6 walkin cooler or freezer room

Direct CO<sub>2</sub> heat recovery

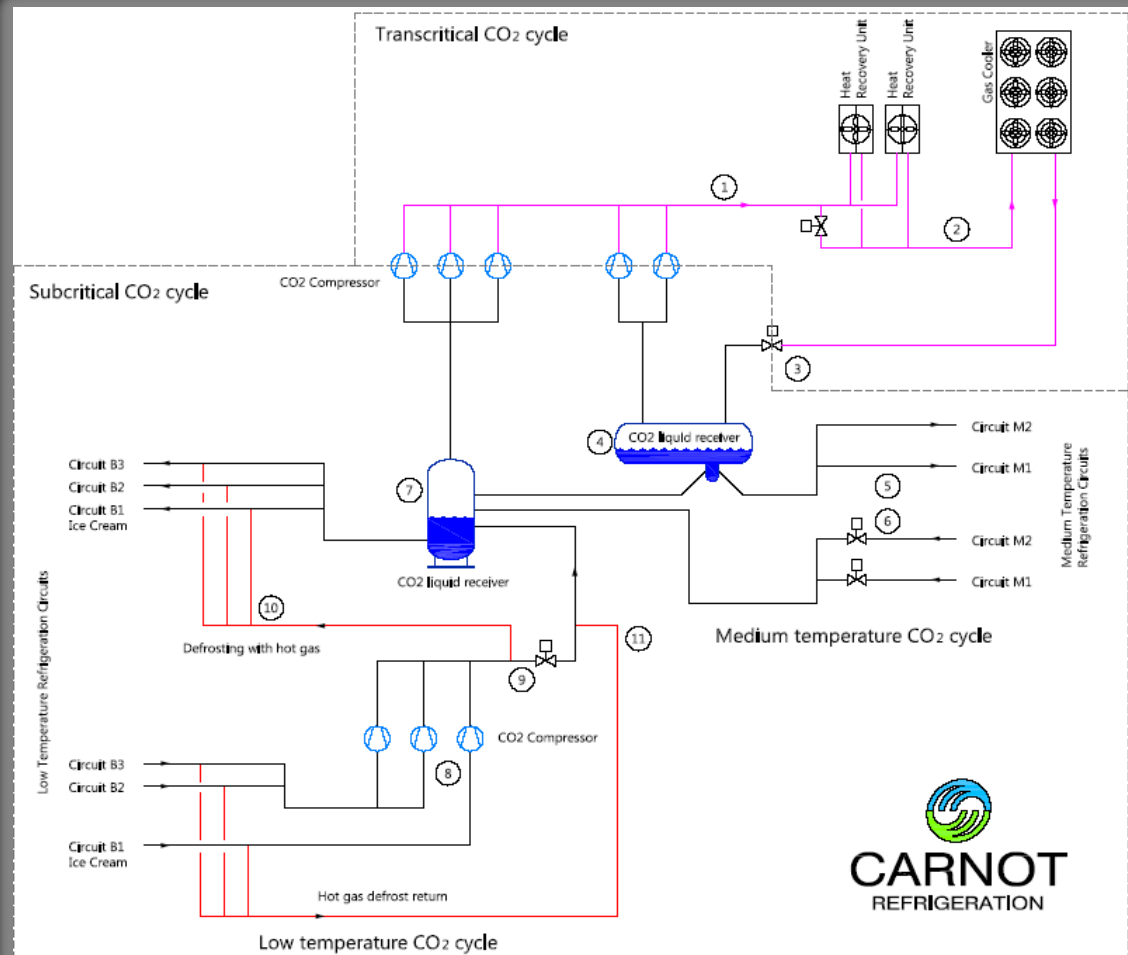


# CASE STUDY *IGA Ste-Agathe-des-Monts*

## SYSTEM DESCRIPTION

The refrigeration system installed at IGA Ste-Agathe-des-Monts is a two stages CO<sub>2</sub> system with two levels of compression and temperature: Low temperature (BT) and medium temperature (MT).

This CO<sub>2</sub> refrigeration system responds to 292 KBtu/hr (86 kW) freezing load for the low temperature stage and 1066 KBtu/hr (312 kW) for refrigerated products. The total load of CO<sub>2</sub> refrigerant is 2 535 lb (1150 kg).



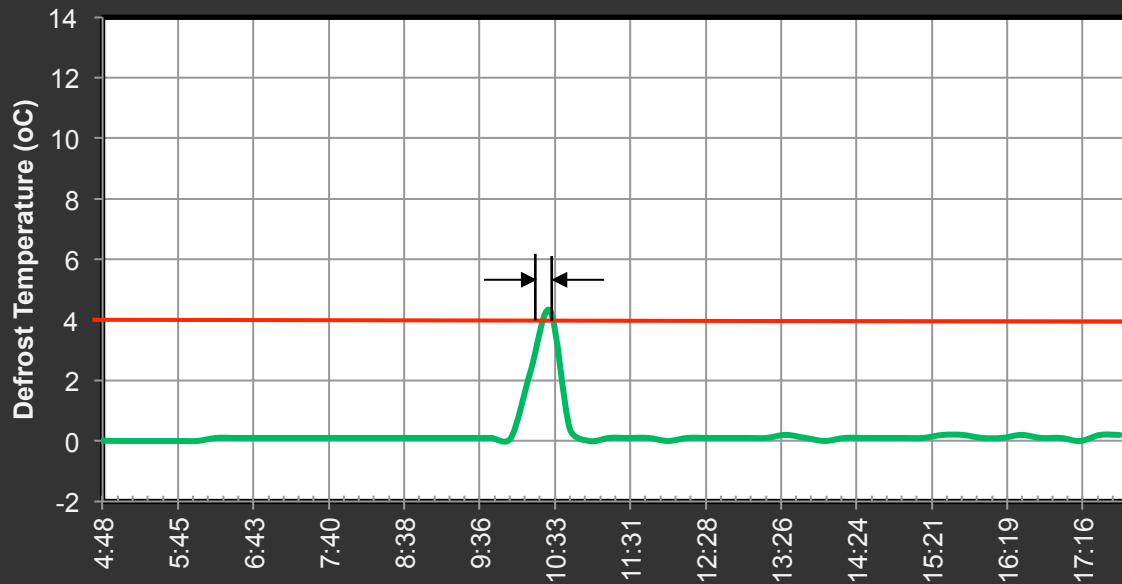


# CASE STUDY *IGA Ste-Agathe-des-Monts*

## DEFROSTING MODES

Defrosting in the medium temperature portion occurs by the increase of the evaporator pressure at a level slightly higher than the freezing point. This method offers the dual benefits of using the heat present in the system to melt the ice, while continuing to cool the display cases. Because it does not add heat to the system, the technology that we have developed in previous commercial and industrial projects, offers the great benefit of ensuring the stability for display cases temperature.

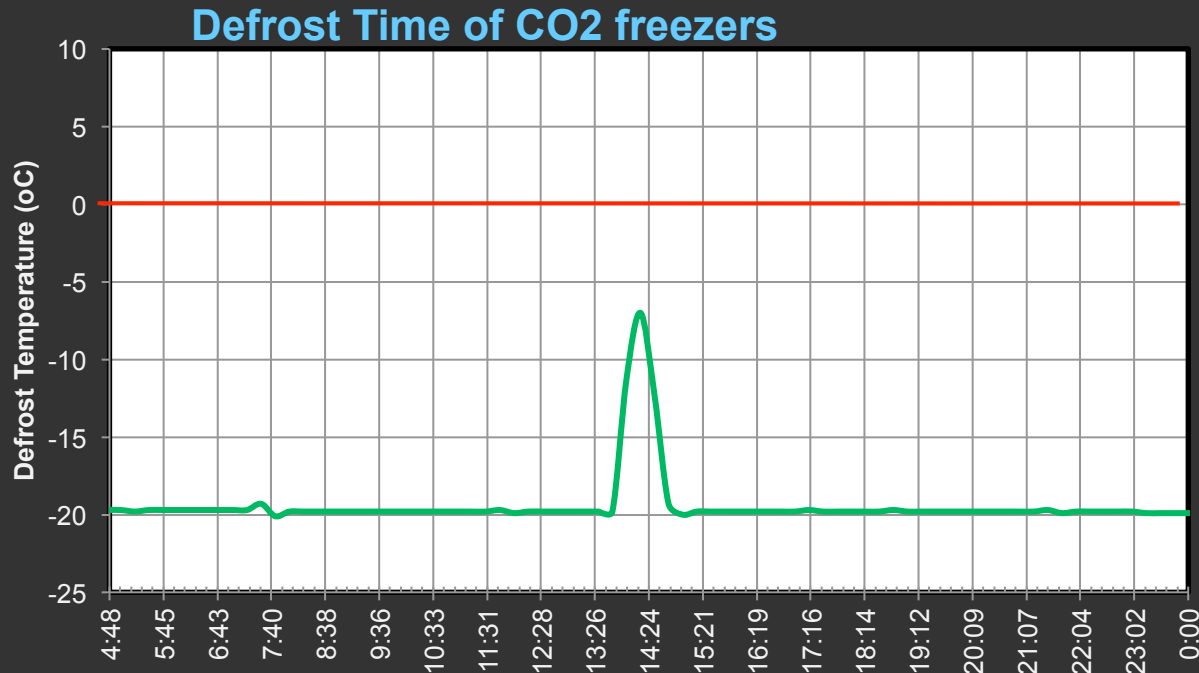
### Defrost time for Medium display cases (CO<sub>2</sub>)



# CASE STUDY *IGA Ste-Agathe-des-Monts*

## DEFROSTING MODES

The graph shows a daily cycle of CO2 Low pressure Hot gas defrost and its associated air discharge temperature for the LT display cases. This graph confirms the benefit of using just the correct refrigerant flow for melt the ice and avoid the frost generation on the product. The product always look perfectly preserved.



# CASE STUDY *IGA Ste-Agathe-des-Monts*

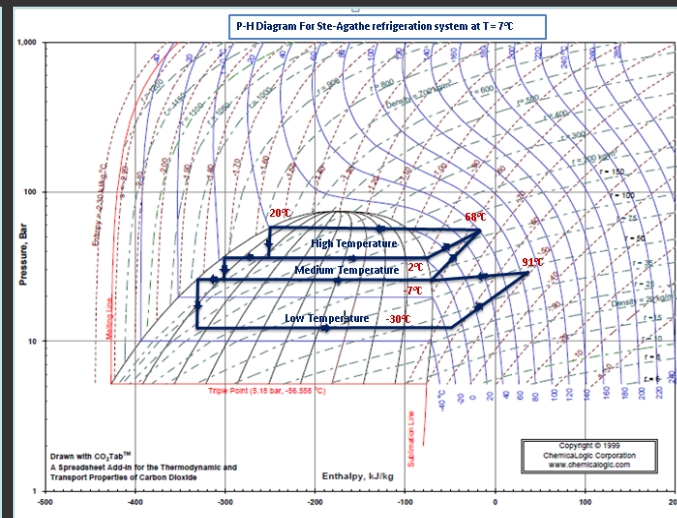
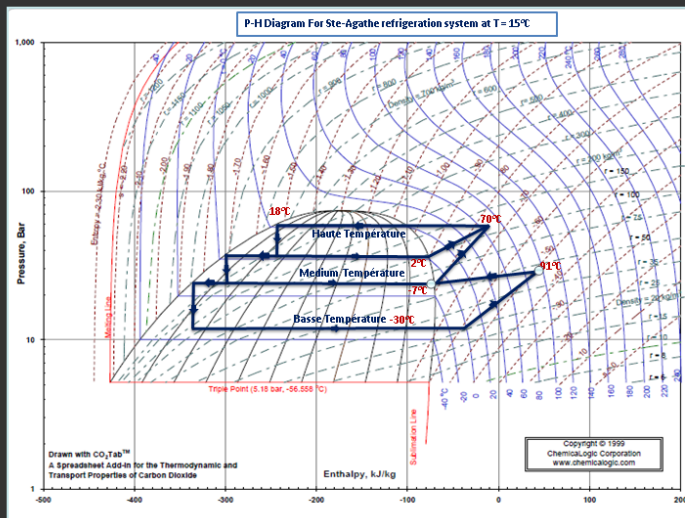
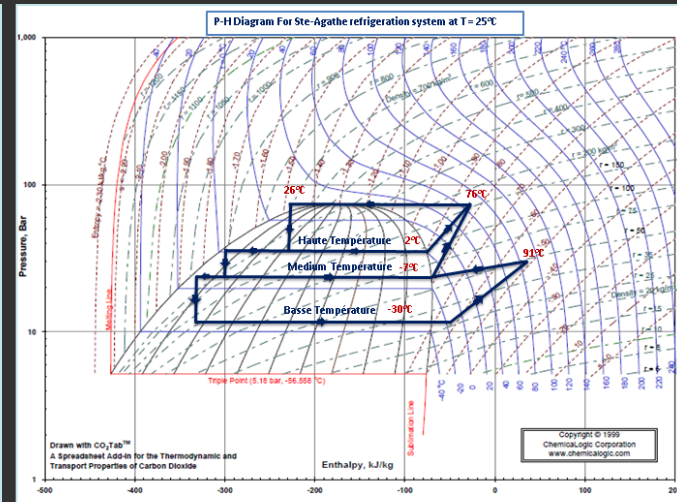
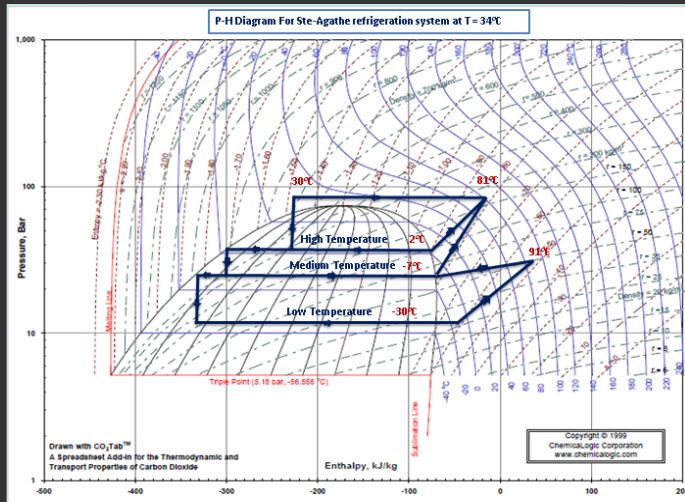
## **P-H DIAGRAM OF THE CO<sub>2</sub> REFRIGERATION SYSTEM**

In the theoretical cycles, the variation of the evaporation and condensation temperature is intimately linked to the variation of the outside temperature. The increase in condensing temperature or decrease in the evaporation temperature generates additional energy consumption by the compressor.

The following figures show the Pressure-Enthalpy diagram of the refrigeration system installed at Ste-Agathe. Each diagram represents the variation of the condensation temperature and pressure as a function of the outside temperature (34, 25, 15, 7, 0, -10 and -14°C).

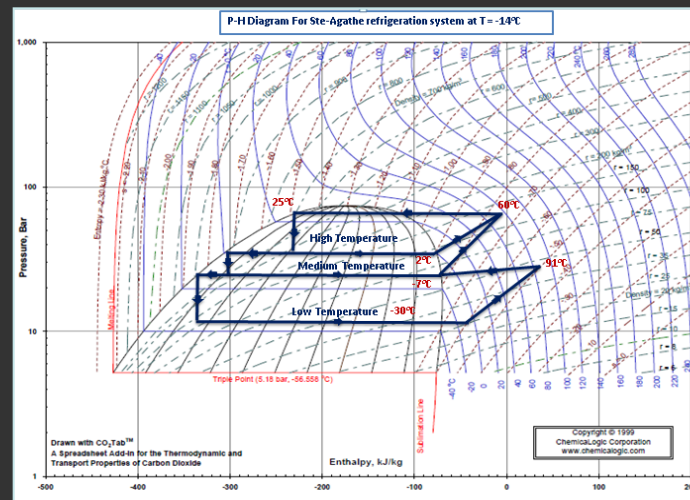
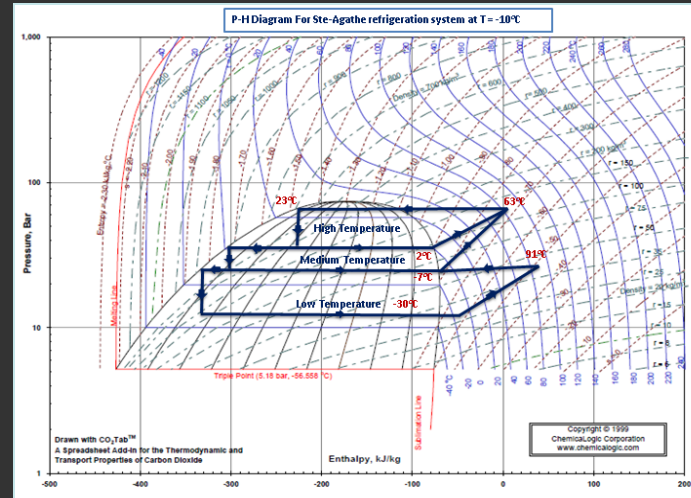
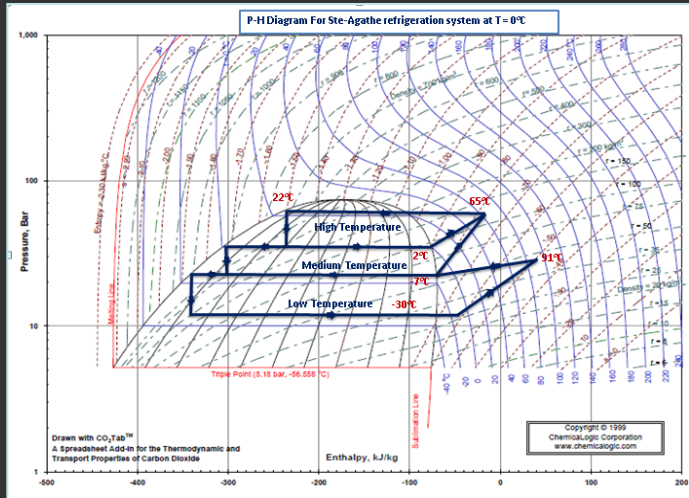
# CASE STUDY *IGA Ste-Agathe-des-Monts*

## P-H DIAGRAM OF THE CO2 REFRIGERATION SYSTEM



# CASE STUDY *IGA Ste-Agathe-des-Monts*

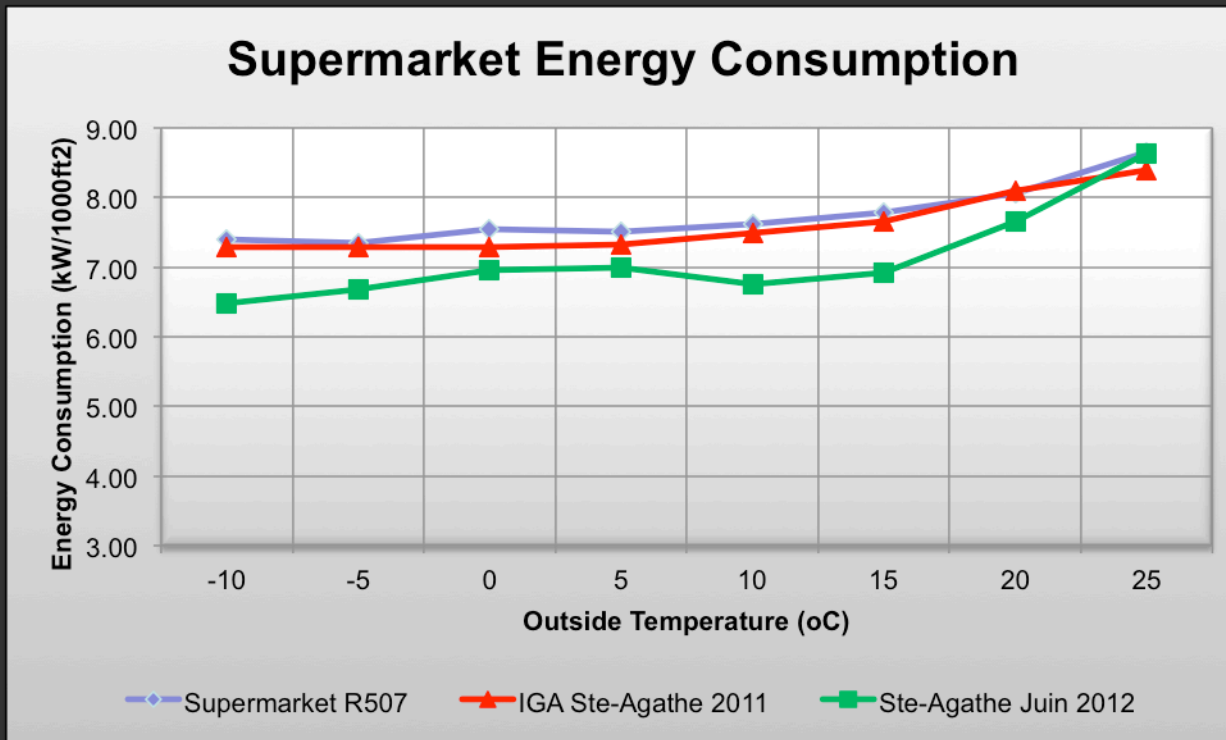
## P-H DIAGRAM OF THE CO2 REFRIGERATION SYSTEM



# CASE STUDY *IGA Ste-Agathe-des-Monts*

## SYSTEM COMPARISON

In order to illustrate the advantages of the CO<sub>2</sub> refrigeration system, the figure below shows a comparison between the energy consumption of two refrigeration systems installed in Quebec. The first one operates with the R507 refrigerant (HFC) and the second, manufactured by Carnot Refrigeration operates with the R744 (CO<sub>2</sub>).



**CARNOT**  
REFRIGERATION



- systèmes **écoénergétiques** -  
- solutions hybrides sur mesure -

# CASE STUDY

Refrigeration system with NH<sub>3</sub> / CO<sub>2</sub>

*Distribution centre Courchesne-Larose (Michal inc.)*



# CASE STUDY *Courchesne-Larose (Michal inc.)*

## Some facts;

The warehouse of Courchesne Larose (Michal inc.) is;  
130,000 ft<sup>2</sup>  
40 ft of height  
4.563.442 #/day (2.069.945 kg/day)  
22 Ripening rooms of bananas (CO<sub>2</sub>) 3  
Avocado ripening room (CO<sub>2</sub>)  
22 Shipping doors  
Temperature between 0 and 15°C.  
512 TR

Carnot Refrigeration has designed, manufactured and installed in a turnkey solution an ideal system for this warehouse.

The refrigeration system with NH<sub>3</sub>/CO<sub>2</sub> has a great advantage on the environment because;

minimizes environmental impacts.

800# of ammonia

4500# of CO<sub>2</sub>





# CASE STUDY *Courchesne-Larose (Michal inc.)*

The major advantages of this technology are summarized as following:

- ✓ Totally eliminate the use of HFC's and / or HCFC's.
- ✓ Reduce the ammonia quantity drastically without energy penalty.
- ✓ Reduce piping and insulation size by more than half and the related labour and material cost by 31,5%.
- ✓ Reduce the use of paraseismic hangers and the structural need to support the pipes
- ✓ Confined the ammonia in the mechanical room.
- ✓ Provide full heat reclaim (if needed) for space heating or water heating (domestic or process)



# CASE STUDY *Courchesne-Larose (Michal inc.)*

## HOT GAS DEFROST

The hot gas provides a quick and efficient defrost evaporators. Compared with 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 NH<sub>3</sub>/CO<sub>2</sub> refrigeration system is designed to recover the heat directly in using the hot gases of CO<sub>2</sub> compressors into the evaporator to heat the ambient air of room where heating is required. This option provides recovery capacity (available heat) up to 8 times greater than the use of an intermediate loop glycol combined with NH<sub>3</sub> systems with floating head pressure. This method of recovery is possible without additional energy expenditure and no additional mechanical equipment (pumps, loop glycol, heaters, etc.).

# CASE STUDY *Courchesne-Larose (Michal inc.)*

## RAIN TFC CYCLE™ – MODE “FREE COOLING”

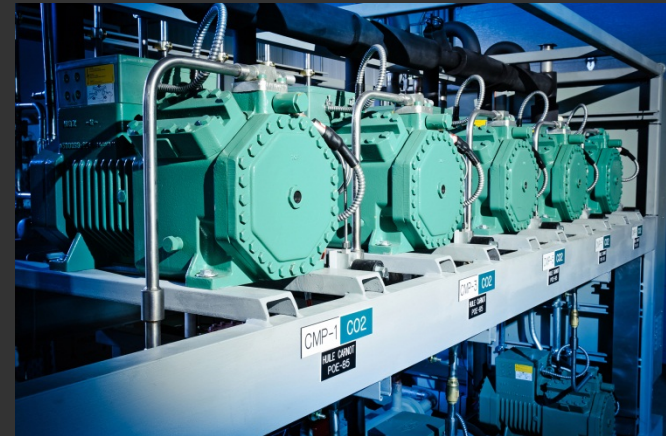
Our system using CO2 by direct expansion in cascade with ammonia keeps TFC mode (free cooling) as long as the outside temperature is below 12°C. This mode is maintained for 5000 hours in the Montreal area. During these hours of TFC mode, the NH3 compressors remain completely stopped. This mode increases the lifetime of the compressors, the lubrication system and other components of the loop of ammonia.





# Carnot Refrigeration System's features

- Highest energy efficiency
  - Direct CO2 heat recovery (no pumps, no heat exchanger).
  - APD in MT and Low temperature Hot gas defrost. No electrical elements, consumption and wiring; (reduction of pull down energy required after defrost)
- Accessible replacement parts thru local wholesalers
- HFC free; phase-out free, low maintenance cost.
- Lowest installation cost of any system
- Light weight and small footprint required for skids and condenser/gas cooler.
- Industrial Quality skids.



# CASE STUDY *IGA Ste-Agathe-des-Monts*

## CONCLUSION

After several successful installations of CO2 refrigeration systems in many supermarkets and distribution center across Canada, the next step for Carnot Refrigeration will involve implementing these innovative technologies in North American supermarkets. A such successful demonstration will provide an energy efficient alternative and a really low GWP and ODP for supermarkets and distribution centers in the future.





**CARNOT**  
REFRIGERATION



- systèmes **écoénergétiques** -  
- solutions hybrides sur mesure -