



WHY CHOOSE CO₂ CASCADE SYSTEMS

- CO₂ is a green, natural refrigerant (see the GreenPeace article pages 1-4).
- Improved power and efficiency with room temperature below -4° F or -20° C.
Compared to two stage NH₃ systems:
 1. Typical cold storage freezer with a truck dock, 6% to 10% energy saved
 2. Typical -40 F/-40 C, 30% energy saved
 3. Typical -58 F/-50 C, 40% energy saved with quicker freezing time(See attached pages 5-10 for examples)
- Lower installed first cost for a CO₂ cascade system compared to two stage ammonia systems (4% to 15% depending on the size of the system). Smaller engine rooms, smaller wet and dry suction lines and discharge lines (see page 11).
- Reduced ammonia charge (most systems are below 10,000# and require no PSM or RMP). (Page 5 system has 7,900# of ammonia and 70,000# of CO₂, 10-1 ratio.)
- Lower maintenance costs (example: no cooling required on low side compressors, air unit valve stations have five hand valves, one solenoid and one strainer).
- Lower refrigerant cost (CO₂ is about \$0.22 per lb.).
- CO₂ systems are always operating at a positive pressure.
- No ammonia in the food areas.
- CO₂ is non-hazardous and non-flammable.
- Use CO₂ as a brine instead of glycol brine (see page 12).
- The International Institute of Ammonia Refrigeration (IIAR) now has a carbon dioxide (CO₂) refrigeration handbook (see page 13).
- CO₂ literature showing a typical CO₂/R-717 engine room (see page 14).
- Letter from United States Cold Storage who has six (6) CO₂/R-717 cascade systems (see page 15).
- CO₂ job reference list (page 16; tons & degree F and page 17; KWR & degree C).

Natural Refrigerants: The Solutions

Glossary

F-gases: CFCs, HCFCs and HFCs are all part of a family of gases known as F-gases or fluorocarbons. The regulatory control of F-gases is split between the Montreal Protocol and the Kyoto Protocol.

CFCs: Chlorofluorocarbons (and their close cousins HCFCs) are ozone layer depleting substances and are regulated by the Montreal Protocol. These are also strong greenhouse gases but were excluded from the Kyoto Protocol because they were already being regulated.

HFCs: Hydrofluorocarbons are strong greenhouse gases and are regulated by the Kyoto Protocol. HFCs are not ozone-depleting and were developed as replacements for CFCs.

Kyoto Protocol:
A 1997 international treaty to solve global warming by curtailing emissions of greenhouse gases.

Montreal Protocol:
A 1987 international treaty to heal the ozone layer by controlling ozone depleting substances.

Natural Refrigerants:
Common natural refrigerants include isobutane and other hydrocarbons, ammonia, water, air, and carbon dioxide.

GWP: Global Warming Potential is the relative power of a given pollutant to cause global warming over a given timescale, factoring its ability to trap the sun's heat and its atmospheric lifetime. GWPs are measured relative to carbon dioxide, which is given a GWP of 1.

ODP: Ozone Depleting Potential is a factor indicating a substance's relative ozone damaging power.

So what is the solution? What are the alternatives to CFCs, HCFCs and HFCs, the F-gases that are a growing and serious contributor to global warming?

The switch from CFCs and HCFCs to HFCs represents a classic example of industry replacing one harmful chemical with another while protecting the status quo and their market share. All these chemicals contribute to climate change, most with Global Warming Potential (GWP) thousands of times higher than CO₂. By shifting to HCFCs and now HFCs since banning CFCs, we have continued to destroy the ozone layer with HCFCs and harm the climate with both alternatives, and will keep on doing so for the next several decades at least. It has also tarnished the legacy of the Montreal Protocol by creating an enormous and unnecessary problem for the climate. There were natural solutions available (some developed by Greenpeace) when HFCs were originally introduced. Greenpeace believes that these chemicals can and should be replaced with climate-friendly natural refrigerants. This is the only responsible course of action.

What is the history of natural refrigeration technology and Greenpeace's role in developing it?

In the early 1990s, Greenpeace set out to find climate-friendly alternative technologies, convinced that there was a way to avoid HFCs through innovation. The result is the creation of GreenFreeze, which uses hydrocarbons for both the blowing of the insulation foam and the refrigerant and are entirely free of ozone-depleting and global warming chemicals. Greenpeace then commissioned a reluctant manufacturer to build 10 prototypes of the most likely-to-work technology. Greenpeace open-sourced the technology and has received no financial remuneration or royalty for developing the product. Greenpeace then marketed, gathered orders, and pre-sold 70,000 refrigeration units (in three weeks) for an East German manufacturer in order to make the retooling of its factory worthwhile. Since March 15, 1993, when the first GreenFreeze refrigerator rolled off the assembly line, 300 million units have been sold in Europe, Russia, Asia and South America by leading brands including Whirlpool, Bosch, Panasonic, LG, Miele, Electrolux, and Siemens. Greenpeace's achievement was recognized by the United Nations Environment Program in 1997, when GreenFreeze received the prestigious UNEP Ozone Award.

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Natural Refrigerants: The Solutions

What is the current market situation of natural refrigeration technology?

GreenFreeze (hydrocarbon) technology has spread extensively throughout Europe, Japan, Russia and China. It is currently the refrigerant of choice in 300 million household refrigerators worldwide, but it is still illegal to sell or to purchase in the United States and Canada. Greenpeace is currently working to change this situation through a variety of avenues — policy changes, corporate engagement, and, as soon as a manufacturer is ready, market development.

What are natural refrigerants?

Natural refrigerants are naturally occurring, non-synthetic substances that can be used as cooling agents in refrigerators and air conditioners. These substances include hydrocarbons (propane, butane, and cyclopentane), CO₂, ammonia, water and air. (Carbon dioxide....Huh? Yes, CO₂. See the next question.) These are sometimes referred to as 'the Gentle Five', each with a different area of application. Natural refrigerants are ozone layer- and climate-friendly substances. Other refrigeration and cooling techniques include thermo-acoustic and Stirling Cycle, evaporative cooling technologies. An analysis of the myriad of alternative technologies currently available is detailed in this recent Greenpeace report (PDF).

How is CO₂, whose emissions are killing the earth, considered a good natural refrigerant?

The same goes for ammonia — isn't ammonia toxic?

It does seem strange that Greenpeace is arguing for the uptake of carbon dioxide in one area and pushing for its reduction in another. CO₂ has a GWP of 1, and the F-gases currently popular on the market have a GWP in the thousands. Carbon dioxide has no ozone depletion potential (ODP=0) and negligible direct global warming potential when used as a refrigerant in closed cycles. To put it in perspective, while the average car emits 5 tons of

carbon dioxide per year, a CO₂-charged refrigerator or vending machine would emit say 300 grams of CO₂ after its 10-year lifetime. Ammonia has both no ozone depletion potential (ODP = 0) and no global warming potential (GWP=0). It is considered a natural refrigerant because although produced synthetically for refrigeration, it occurs in nature's material cycles. It is a hazardous substance, but is used widely and safely around the world in

large-scale industrial cooling systems such as food processing and building air conditioning.

Natural Refrigerants: The Solutions

What is the Global Warming Potential (GWP) of F-gases and natural refrigerants?

Below is a table that compares the GWP of CFCs and HCFCs to natural (CO2 and hydrocarbon) technology.

Gas	Lifetime (years)	20 year	100 year	500 year
CO2		1	1	1
CFC-11	45	6730	4750	1620
CFC-12	100	11,000	10,900	5,200
HCFC-141b	9.3	2250	725	220
HFC-134a	14	3830	1430	435
Cyclopentane	weeks	<3*	<3*	<3*
Isobutane	weeks	<3*	<3*	<3*
Propane	months	<3*	<3*	<3*

*Note that The 20 year GWP of the common HFC-134a is 3830, more than twice its 100 year GWP, meaning cutting emissions now eliminates an even larger near term threat. Natural refrigerants (in this case, hydrocarbons) are incomparably better for the environment than F-gases, from their low GWPs to their very short atmospheric lifetimes.

Are natural refrigerants cost competitive?

Natural refrigeration technologies also outperform from an economic standpoint. Many natural refrigerants are inexpensive, some less expensive than HFCs. In addition, natural refrigerants often boast the most energy efficient technologies, some up to 40% more energy efficient than HFCs. Depending on the type and size of the system, a company may indeed incur additional expenses upon installing a natural refrigerant system (always the case with a new system), but these costs are offset in the mid- to long-term by reduced costs. Operating costs are lower when using natural refrigerants because of lower leakage related costs, the low cost of maintenance, and most importantly low energy consumption. As governments begin to regulate F-gases more diligently, the inexpensive disposal of natural refrigerants at the end of a refrigerators' lifecycle will become a major financial incentive to switch to cleaner cooling systems.

Many governments and companies believe containment of HFCs will solve the problem. What is Greenpeace's opinion?

If governments and companies had set up a global network to deal with the recapture and safe destruction of all F-gases, they wouldn't be the huge climate problem they are today. Containment policies have been an absolute failure because containment is virtually unenforceable. Leakage rates tend to be much higher than industry claims. And even the data provided by industry points to a catastrophic failure in containment: a chemical industry

Natural Refrigerants: The Solutions

(con't)

website called Alternative Fluorocarbons Environmental Acceptability Study (please link to: www.afeas.org) which compiles and presents F-gas data provided by companies, shows that 81% of the main F-gas currently in use today (HCFC 22) has already been released into the atmosphere. Fifty-nine percent of HFC 134a, the main HFC on the market today, has already been released into the atmosphere.

Containment policies are even more difficult to implement in developing countries because¹ many developing countries lack well-trained personnel who can ensure that fluorine gases will be properly handled, and² adequate disposal facilities are almost non-existent in most developing countries, although this latter point applies to most developed countries as well.

Greenpeace thinks that governments should therefore promote the use of natural refrigerants and endorse phase-out dates for HFCs in refrigeration and air-conditioning. These gases have to be eliminated—not just 'contained'

What is Refrigerants, Naturally!?

In 2004, The Coca-Cola Company, McDonalds, and Unilever, with support from Greenpeace and UNEP (United Nations Environment Program), launched Refrigerants, Naturally! (please link to: <http://refrigerantsnaturally.com>) a multi-stakeholder initiative to develop HFC-free point-of-sale retail vending machines, display cases, beverage coolers, etc. In doing so, Refrigerants, Naturally! became the first corporate alliance with the explicit goal of replacing HFC technology in favor of natural refrigerants. These companies have, over the last years and together with their suppliers, developed and tested multiple innovative HFC-free refrigeration technologies. In 2006, three more companies—Carlsberg, Ikea, and the PepsiCo Company—joined the initiative. The first major US rollouts of HFC-free refrigeration took place on September 29, 2008 when Ben & Jerry's/Unilever installed the

first HFC-free ice cream freezers in the United States. Refrigerants, Naturally! is publicly supported by UNEP and Greenpeace. Refrigerants, Naturally! received the US EPA's Climate Protection Award in 2005. Members of Refrigerants Naturally! call upon other companies to join the initiative to underline the need for sustainable refrigeration solutions. The initiative also helps to send out a strong signal to the supply chain to move HFC-free technologies into widespread use to bring down the cost of changing over to natural refrigerants.

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- i. For instance, ammonia is much less expensive than its HFC counterpart HFC-404A, and hydrocarbons have prices comparable to HFCs.
- ii. For more information, please consult the 2004 report, HFC Containment Has Already Failed by chemist Eric Johnson.

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M&M REFRIGERATION

Celebrating 40 Years
1969-2009

the leader in CO₂ technology



The world's largest CO₂/NH₃ Cascade System consisting of:

- 297,896 square feet of freezer space at -10°F room temperature
- 37,630 square feet of convertible space at -10°F to +35°F room temperature
- 32,325 square feet of rail dock space at +35°F room temperature
- 70,290 square feet of truck dock space at +35°F room temperature
- 438,141 total square feet
- 15,781,185 total cubic feet
- Less than 10,000 pounds of ammonia charge
- Based on kilowatts per cubic foot, the Bethlehem, Pennsylvania plant is the most energy efficient facility operated by U.S. Cold Storage

M&M Refrigeration designs, manufactures, installs and services CO₂ systems, not only for U.S. Cold Storage but also for other blast freezing, processing and cold storage facilities. Contact M&M Refrigeration for further information or for an on-site visit.

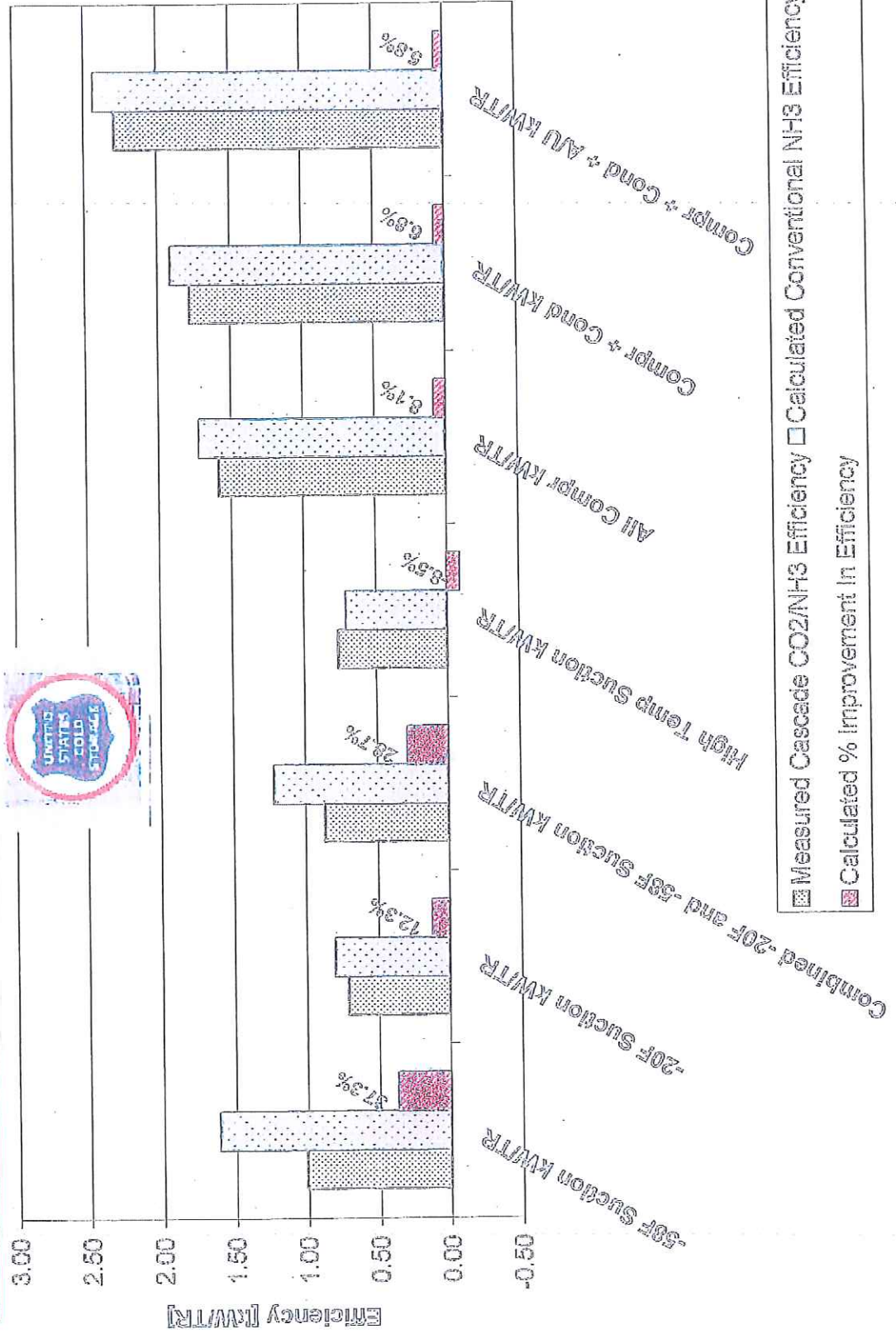
GO GREEN WITH CO₂

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M&M
REFRIGERATION

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Field Monitoring and Evaluation of a Large CO₂/NH₃ Cascade Refrigeration System





Facility A

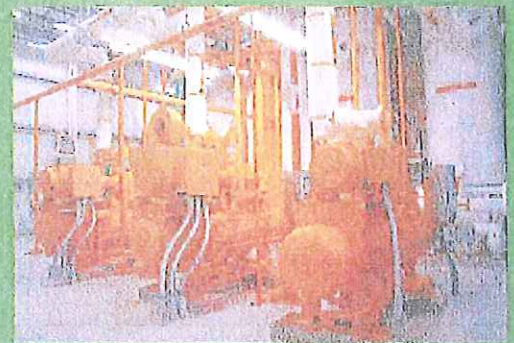
Screw Compressors, Reciprocating Compressors, Thermosyphon oil cooling, CO2 Cascade System, VFD's on Evaporative Condensers, Air Units and Compressors.

Total Building KWH/Sq Ft = 1.30 ←

Facility B

Screw Compressors, Thermosyphon oil cooling, Two-stage Ammonia, VFD's on Evaporative Condensers, Air Units and Compressors.

Total Building KWH/Sq Ft = 1.57



Facility C

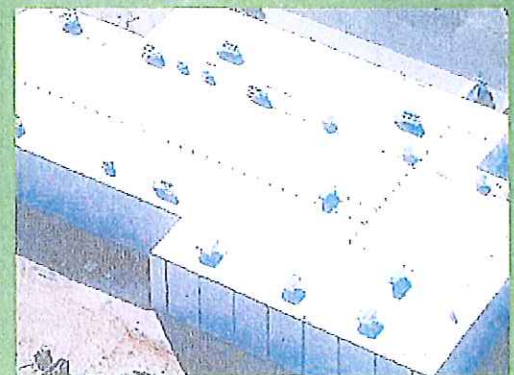
Screw Compressors, Thermosyphon oil cooling, Single Stage R-22, Evaporative Condensing, No Variable Frequency Drives.

Total Building KWH/Sq Ft = 2.12

Facility D

Split System, Freon, Air cooled Condensing, No Variable Frequency Drives.

Total Building KWH/Sq Ft = 2.19



Granville Food Care Facility Keeps Cooler With CO₂ System from Star Refrigeration

It's a lot easier being green at Granville Food Care Ltd in Northern Ireland, thanks to an efficiency-boosting cooling system designed, built and installed by Star Refrigeration at the company's meat freezing and cold storage facility in Dungannon, County Tyrone.



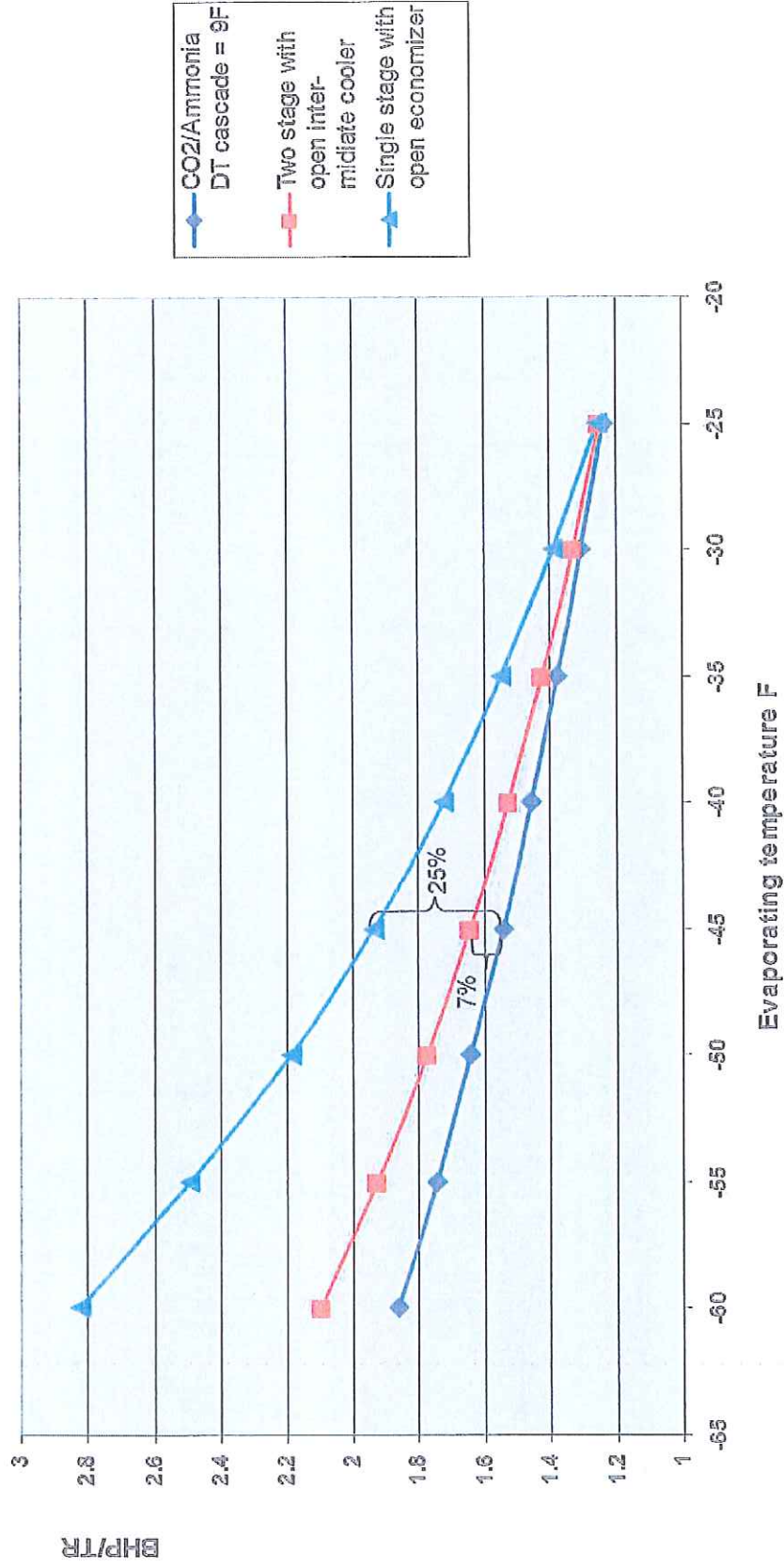
The cascade plant supplies cooling to three cold storage areas and seven blast freezers. Star's refrigeration system is one of the first in Northern Ireland to use CO₂ technology for blast freezing. The Granville plant has a total refrigeration capacity of 1,227kW. The system was designed with sufficient in-built compressor capacity to allow future expansion.

"The ammonia and CO₂ cascade plant has allowed Granville to reduce energy consumption and gain a significant increase in throughput, by improving product freeze times by 23%," said Rob

Lamb, sales director at Star. "It also has a very low ammonia charge. Overall, the new refrigeration plant has enabled the client to expand business without further investment in building infrastructure."

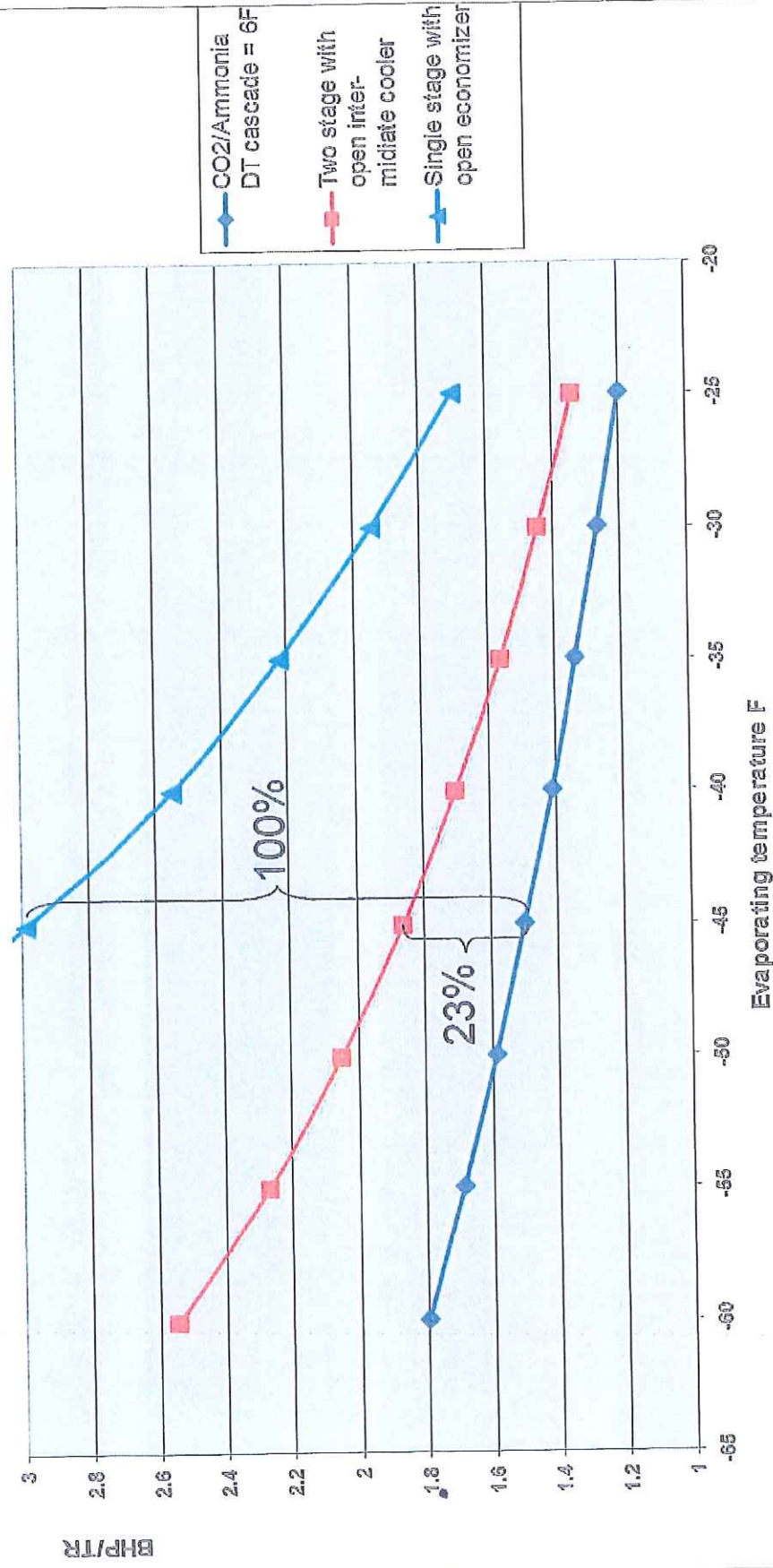
The system was installed in a purpose-built plant room adjacent to the main building. It comprises two low temperature CO₂ compressors and surge drum, supplying liquid CO₂ to coldstores and blast freezers. It also features two ammonia compressors and evaporative condensers, as well as two ammonia to CO₂ cascade heat exchangers.

BHP/TR comparison of CO₂/Ammonia with conventional Ammonia Systems at full load



BACK2BASICS

BHP/TR comparison of CO2/Ammonia with conventional Ammonia Systems at 50% part load



BACK2BASICS

CO₂ as refrigerant

Piping example - 300TR at -40F

Wet suction, 300ft pipe, two 90 bends, one stop valve				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	F	PSI	ft / sec
Ammonia	12"	1.01	0.31	54
CO2	6"	0.96	2.85	23

Dry suction, 100ft pipe, two 90 bends, one stop valve				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	F	PSI	ft / sec
Ammonia	12"	0.29	0.089	68
CO2	6"	0.33	1	39

Liquid, 300ft pipe				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	F	PSI	ft / sec
Ammonia	2½"	1.4	1.4	3.6
CO2	4"	0.3	1.05	3.5

Discharge, 100ft pipe				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	F	PSI	ft / sec
Ammonia	6"	0.21	0.2	79
CO2	4"	0.14	0.9	29

- In general same pipe material and wall thickness as for ammonia
- Copper pipes can be used as well **GO GREEN WITH CO₂**

CHILLERS

CO₂ Chillers Instead of Glycol Chillers at 35 °F

- CO₂ ~ \$1 per gal, Glycol ~ \$8 per gal
- Brine pump HP is 50% less
- Brine pipe size is 400% less
 - 100TR Glycol : (2) 5" pipes
 - 100TR CO₂ : (1) 2" & (1) 3" pipe
- Brine piping insulation costs less
- Air Units are 30% smaller

GO GREEN WITH CO₂



Carbon Dioxide Industrial Refrigeration Handbook



the leader in CO₂ technology



CO₂ Compressors
Screw Compressors
Recip Compressors
Controls
Chiller Packages
Air Units/Condensers
VRT Freezers
Plate Freezers
Ice Machines

Total solutions
through effective
technology

BENEFITS

- Lower operating temperatures with higher production yields
- Up to 33% better efficiency on the low side
- Lower equipment cost
- Lower installation cost
- CO₂ is classified as nontoxic and nonflammable
- No ammonia in working/process/storage areas



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January 5, 2010

Mr. Duffy McConnell, President
M&M Refrigeration, Inc.
412 Railroad Avenue, P.O. Box 449
Federalsburg, MD. 21632

Dear Duffy,

As we begin a new year and the start of another decade I would like to take this opportunity to personally thank you and the entire team at M&M Refrigeration (M&M) for the support provided to United States Cold Storage (USCS) over the past 27 years.

During these past years USCS has experienced considerable growth of our business and refrigerated warehouse capacity growing from approximately 45 million cubic feet in 1983 to over 192 million cubic feet of State-of-the Art refrigerated warehouse capacity today. M&M has contributed largely to the successful expansion program at USCS by providing design assistance, high quality industrial refrigeration equipment and computerized controls to accurately control and monitor these systems.

In 2004 when USCS made the commitment to install our first Cascade Carbon Dioxide (CO_2) and Ammonia (NH_3) Refrigeration System at Bethlehem, Pennsylvania, it could not have been accomplished without the design and installation expertise of M&M Refrigeration. Today the Bethlehem facility is the largest refrigerated warehouse in the world using Cascade Carbon Dioxide (CO_2) and Ammonia (NH_3) as a refrigerant. Moreover, since the initial first phase at Bethlehem in 2004, we have built five (5) other Greenfield locations which utilize Cascade Carbon Dioxide (CO_2) and Ammonia (NH_3) as a refrigerating system—all of which would not have been possible without the assistance and expertise of M&M Refrigeration. Today the cubic capacity at USCS which utilize Cascade Carbon Dioxide (CO_2) and Ammonia (NH_3) as a refrigerant totals over 45 million cubic feet; and, later this year when the expansion at Hazleton, PA is completed our capacity will exceed 50 million cubic feet.

Again, thank you for your support and please pass on our appreciation to everyone at M&M who have contributed to the successful growth of our companies.

Sincerely,

Charles A. Toogood
Vice President Engineering



M&M Refrigeration, Inc.

Reference list of CO2 (R744) installations

6/9/2010

Year	Customer	Application	Low Temperature		Medium Temperature		High Temperature	
			Capacity TR	Temp. degF	Capacity TR	Temp. degF	Capacity TR	Temp. degF
2004	Agger Fish, Brooklyn, NY	Plate Freezers	50	-63				
2005	US Cold Storage Ph1, Bethlehem, PA	Storage			290	-30	165	20
2005	Flint River Services, Savannah, GA	Storage			150	-18	150	27
2006	Lincoln Cold Storage, Lincoln, NE	Plate Freezers	404	-58				
2006	US Cold Storage Ph1, Fresno, CA	Storage/Blast Freezers	220	-58	450	-25	210	20
2006	US Cold Storage Ph2, Bethlehem, PA	Storage			300	-30	155	20
2007	US Cold Storage Ph1, Lake City, FL	Storage			375	-25	125	20
2007	US Cold Storage Ph3, Bethlehem, PA	Storage			300	-30	130	20
2007	Border Cold Storage, Pharr, TX	Storage					320	20
2008	US Cold Storage Ph1, Hazelton, PA	Storage			347	-25	125	20
2008	Unitherm Food Systems, Bristow, OK	Spiral Freezer	25	-60				
2008	Circle Foods, San Diego, CA	Storage/Spiral Freezers	418	-38	60	-10		
2008	US Cold Storage Ph1, Lebanon, IN	Storage			414	-30	145	20
2008	US Cold Storage Ph1, Turlock, CA	Storage			408	-30	143	20
2009	US Cold Storage Ph2, Fresno, CA	Storage/Blast Freezers	54	-58	291	-25	168	20
2010	Frialsa, Mexico City, Mexico	Storage/Blast Freezers			519	-25	26	20
2010	US Cold Storage Ph2, Hazelton, PA	Storage			232	-25	60	20
2010	P.A.T.E, Tepatitlan, Mexico	Blast Freezers			300	-40		
2010	Wegmans Food Markets, Pottsville, PA	Storage					1000	20
2010	Action Block, Homer Alaska	Storage/Blast Freezer			36	-35		



M&M Refrigeration, Inc.

Reference list of CO2 (R744) installations

6/9/2010

Year	Customer	Application	Low Temperature		Medium Temperature		High Temperature	
			Capacity KWR	Temp. degC	Capacity KWR	Temp. degC	Capacity KWR	Temp. degC
2004	Agger Fish, Brooklyn, NY	Plate Freezers	175	-53				
2005	US Cold Storage Ph1, Bethlehem, PA	Storage			1020	-34	580	-7
2005	Flint River Services, Savannah, GA	Storage			530	-28	580	-3
2006	Lincoln Cold Storage, Lincoln, NE	Plate Freezers	1420	-50				
2006	US Cold Storage Ph1, Fresno, CA	Storage/Blast Freezers	770	-50	1580	-32	740	-7
2006	US Cold Storage Ph2, Bethlehem, PA	Storage			1050	-34	540	-7
2007	US Cold Storage Ph1, Lake City, FL	Storage			1320	-32	440	-7
2007	US Cold Storage Ph3, Bethlehem, PA	Storage			1050	-34	460	-7
2007	Border Cold Storage, Pharr, TX	Storage					1120	-7
2008	US Cold Storage Ph1, Hazelton, PA	Storage			1220	-32	440	-7
2008	Unitherm Food Systems, Bristow, OK	Spiral Freezer	90	-51				
2008	Circle Foods, San Diego, CA	Storage/Spiral Freezers	1470	-39	210	-23		
2008	US Cold Storage Ph1, Lebanon, IN	Storage			1450	-34	510	-7
2008	US Cold Storage Ph1, Turlock, CA	Storage			1430	-34	500	-7
2009	US Cold Storage Ph2, Fresno, CA	Storage/Blast Freezers	190	-50	1020	-32	590	-7
2010	Frialsa, Mexico City, Mexico	Storage/Blast Freezers			1880	-32	90	-7
2010	US Cold Storage Ph2, Hazelton, PA	Storage			815	-32	210	-7
2010	P.A.T.E. Tepetitlan, Mexico	Blast Freezers			1050	-40		
2010	Wegmans Food Markets, Pottsville, PA	Storage					3520	-7
2010	Auction Block, Homer Alaska	Storage/Blast Freezers			108	-37		