

Packaged Ammonia Chillers

with Variable
Frequency Drives

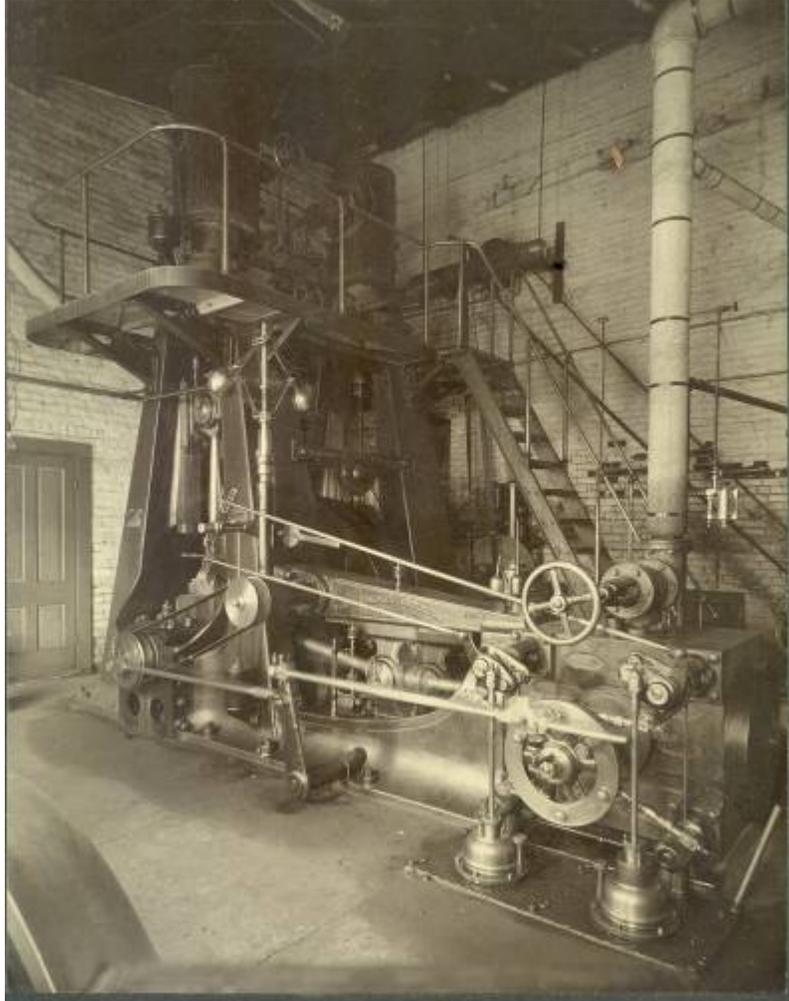
powerPAC[™]

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Director Marketing



Ammonia Refrigeration

Background



Frick ammonia compressor built in 1886. Installed at Gipps Brewery, Peoria, IL. Operated until 1946.

Ammonia as a Refrigerant

Ammonia, The Original Refrigerant:

- Mechanical Refrigeration developed in 1800's
- First practical refrigerating machine using vapor compression developed in 1834
- Basic closed cycle refrigeration system has changed very little since then
- Early refrigerants included ammonia, sulfuric ether, sulfur dioxide, methyl chloride
- Only ammonia secured a lasting role.

Ammonia as a Refrigerant

Ammonia is typically used for:

- Post harvest cooling of fruits & vegetables
- Cooling & freezing of meat, poultry, & fish
- Freezing of ice cream & process foods
- Cooling of beverages, wine & beer
- Refrigeration of dairy products
- Ice manufacturing



Advantages of Ammonia

Ammonia is inexpensive, (mass basis)

- R-717 (NH₃) < \$1 / lb.
- R-22 \$10 / lb.
- R-507 \$12 / lb.
- R-404A \$9 / lb.
- R-134a \$10 / lb.
- Ammonia readily used for agriculture with stable costs
- Costs for all others expected to increase

Advantages of Ammonia

Ammonia leaks are easy to detect/Self alarming

- Pungent odor at levels less than 10 ppm
 - Leaks are detected and fixed before major loss
 - Readily absorbed in water
 - Lighter than air, leaks will rise away from ground
- R-22, R-507, R-404A, & R-134a are odorless
 - Small leaks difficult to detect
 - Major refrigerant loss potential before leak found
 - Heavier than air, displaces oxygen from ground up

Advantages of Ammonia

Ammonia being a natural refrigerant is small part of the solution.....

Ammonia's cycle efficiency is the real answer!

Advantages of Ammonia

Ammonia has better cycle efficiencies

Refrigerant	Net Refrigerant Effect BTU/lb _m	Compressor Displacement cfm	Coefficient of Performance	Efficiency Penalty
507	47.28	3.427	4.18	-13%
404A	48.98	3.494	4.21	-12%
22	70.46	3.573	4.65	-3%
134a	64.51	6.076	4.6	-4%
717	474.20	3.450	4.77	0%

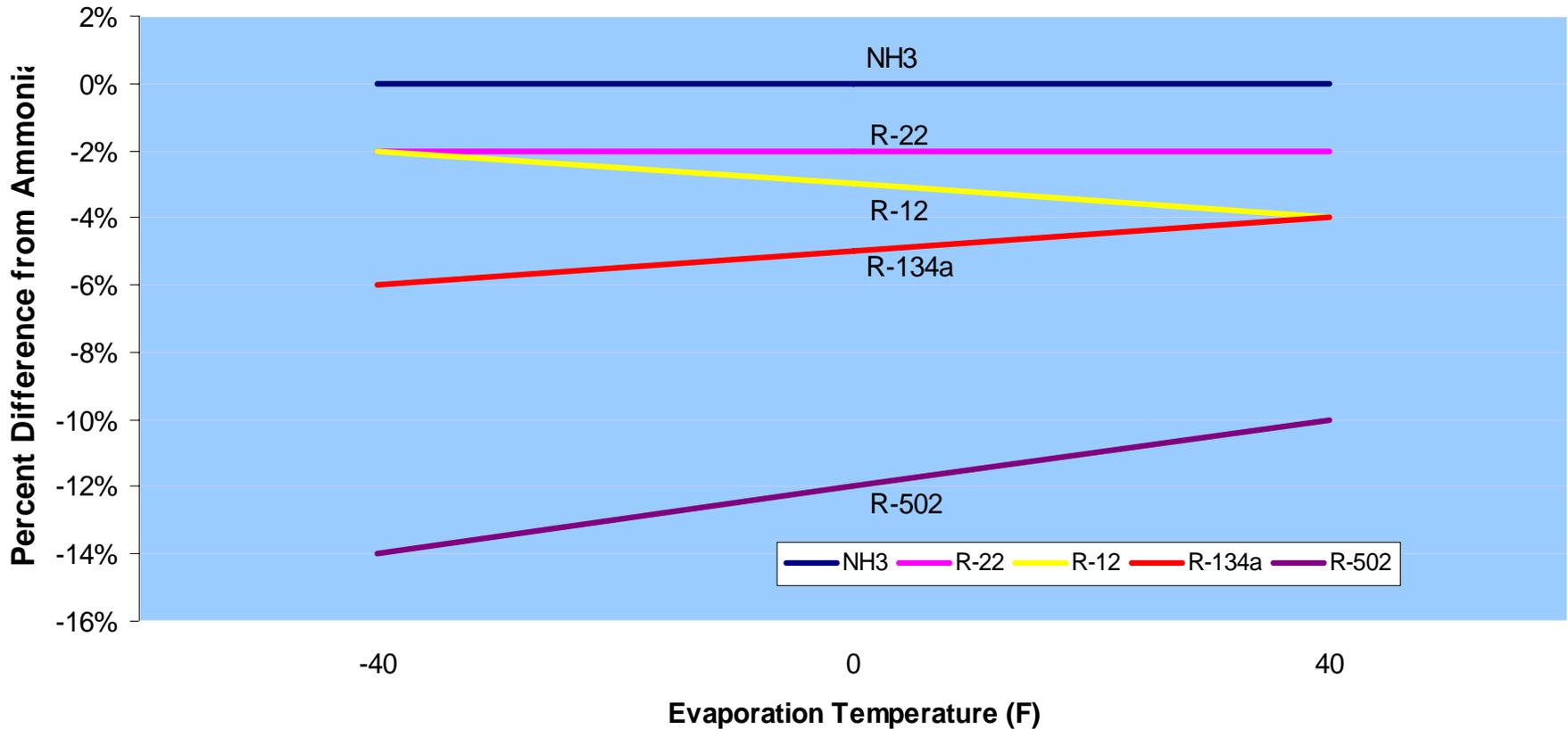
- Result is lower operating costs!

Note ¹: Data based on 5°F evaporative, 86° F condensation, 0°F subcool, and 0°F superheat.

Note ²: The above information was obtained and presented in the 2001 Ashrae Fundamentals Handbook, section 19.8 table 7.

Advantages of Ammonia

Coefficient of Performance for Refrigerants



Disadvantages of Ammonia

Ammonia is not compatible with copper

- Special hermetic motors must be utilized
- Either steel/aluminum piping is required
- Advantages of enhanced heat transfer diminished

Disadvantages of Ammonia

Low concentrations ruled toxic

- Short Term Exposure Limit 35 - 50 ppm
- However self alarming at 5 ppm
- 1500 ppm – instant reaction to flee

Considered flammable

- In narrow range of concentrations of 16-25% by volume of air in presence of open flames

Ammonia Exposure Table

<u>Exposure, ppm</u>	<u>Effects</u>
0-5	Smell hardly detectable.
5-20	Human nose starts to detect.
25	TLV-TWA (Threshold limit value - time weighted average, 8h).
35	STEL (Short term exposure limit - 15 min.)
150-200	Eyes affected to limited extent after about 1 min exposure. Breathing not affected.
500	IDLH (Immediately Dangerous to Life and Health, per NIOSH).
600	Eyes streaming in about 30 s exposure.
700	Tears to eyes in seconds. Still breathable.
1,000	Eyes streamed instantly and vision impaired, but not lost. Breathing intolerable to most participants. Skin irritation to most participants.
1,500	Instant reaction is to get out.

Table 1: Ammonia Exposure: source, *Cooling applications for ammonia refrigeration* by W.F. Stoecker, University of Illinois at Urbana and Atmospheric emissions and control, *Ammonia Plant Safety* by D.P. Wallace.

Disadvantages of Ammonia

Regulations

- OSHA requirement for PSM
- EPA requirements for RMP for systems with over a 10,000 lb R-717 charge
- Permitting in some states, long process
 - California, New Jersey
- Some areas require R-717 safety relief headers be piped to “dump tanks”
 - Added cost to the system

Government Regulations for Ammonia

Under OSHA and USEPA chemical safety programs:

- Facilities with 10,000 lb's or more of ammonia must be registered .
- Synthetic refrigerants not covered.
- Under O.S.H.A. - must have Process Safety Management Program (PSM)
- Under U.S. EPA- must have Risk Management Program (RMP)

Trends Regarding Ammonia Use

European chiller market heavily ammonia based.

- 90% of the chillers produced for the northern European market use R-717
- Currently *few* US Domestic chillers make use of R-717
 - western European multi-national corporations employing their corporate natural refrigerant policy.

Trends Regarding Ammonia Use

The Nestlé Position on Industrial Refrigeration

1 October 2001
Nestec S.A.
Avenue Nestlé 55
1800 Vevey
Switzerland



In line with our environmental policy, Nestlé reiterates its commitment to natural refrigerants.

Nestlé will continue its program, begun in 1986, to phase out our few remaining industrial CFC and HCFC refrigeration systems, replacing them with natural refrigerants ahead of government imposed targets.

Wherever possible, Nestlé will use natural refrigerants in new industrial refrigeration systems. Further, we emphasise our preference for using the combined characteristics of ammonia and carbon dioxide in suitable applications.

Refrigerants in industrial food production

Modern food production, storage and distribution would be impossible without extensive use of refrigeration. Since their first introduction in the mid-1800's, closed circuit refrigeration systems have played a critical role in food manufacturing and in dramatically improving the safe storage and distribution of raw materials and finished products.

As the world's leading food company, the safe, efficient management of industrial refrigeration systems is

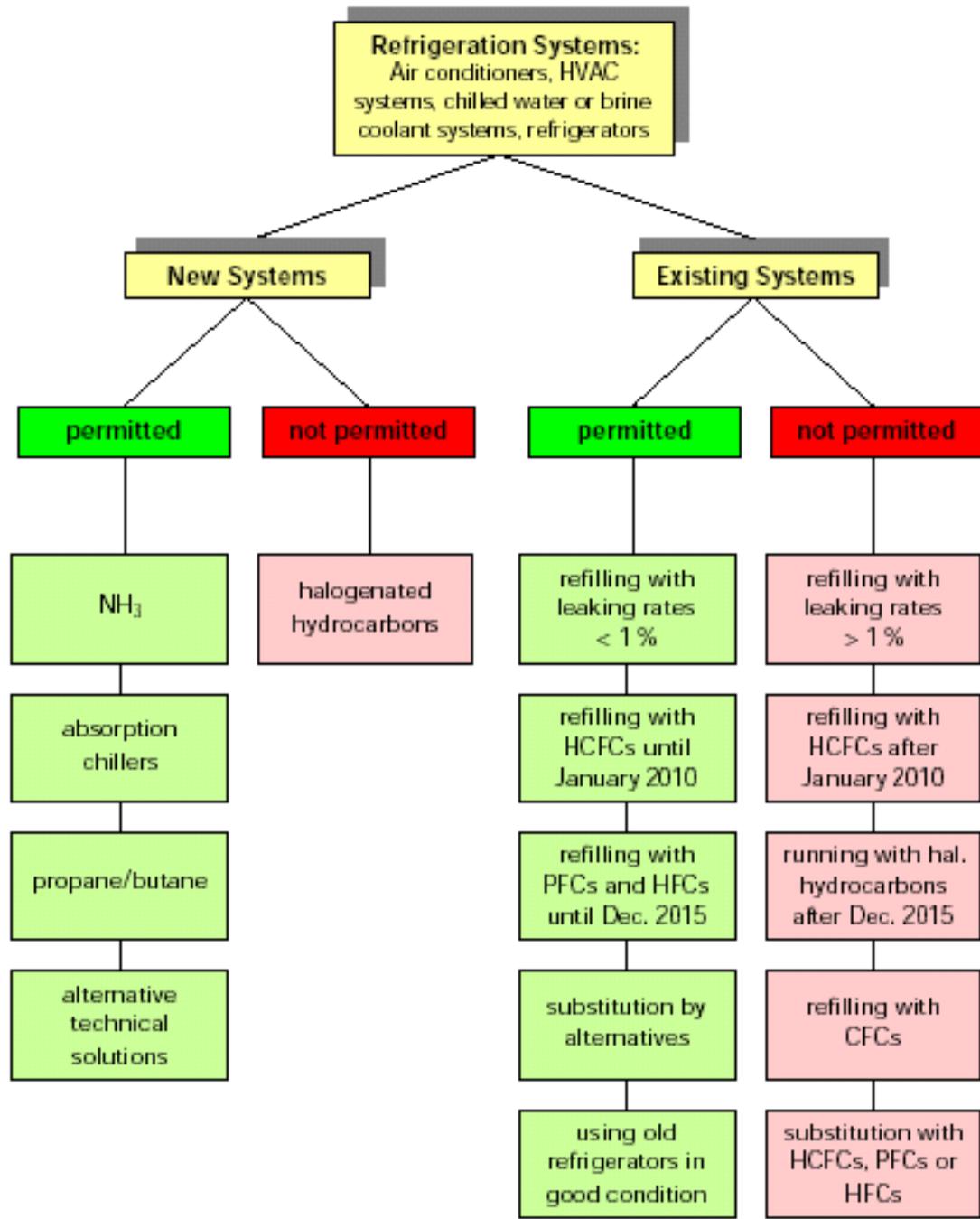
Refrigerants and human safety

The historical move of industry to CFC, HCFC and HFC refrigerants was often motivated by a desire to improve plant safety by avoiding the hazards of some natural refrigerants. Today however, with proper design, construction and operation, a modern industrial system, using selected natural refrigerants can achieve required safety levels.

As with food safety, Nestlé is totally committed to ensuring the safety of our people and our neighbours. Therefore, we design, build and operate our industrial refrigeration systems to ensure that safety is not compromised and continuously seek ways to further improve performance. Where it was necessary, we adopted higher standards than locally demanded.

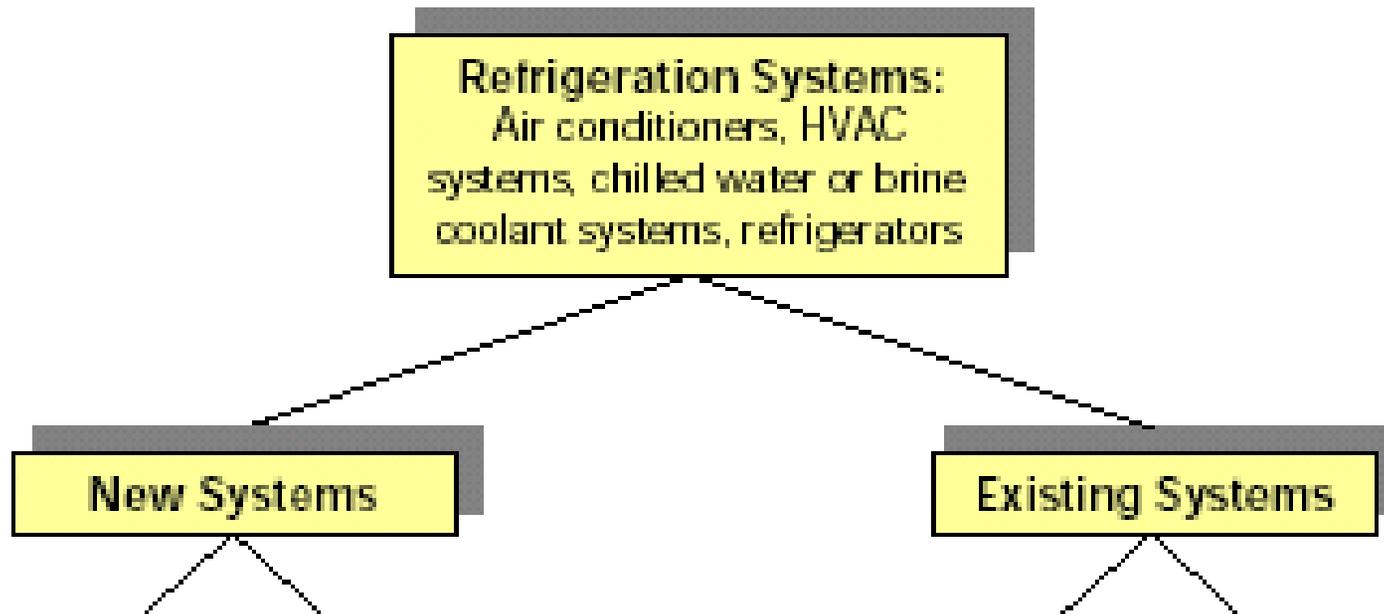
Nestlé and technological developments

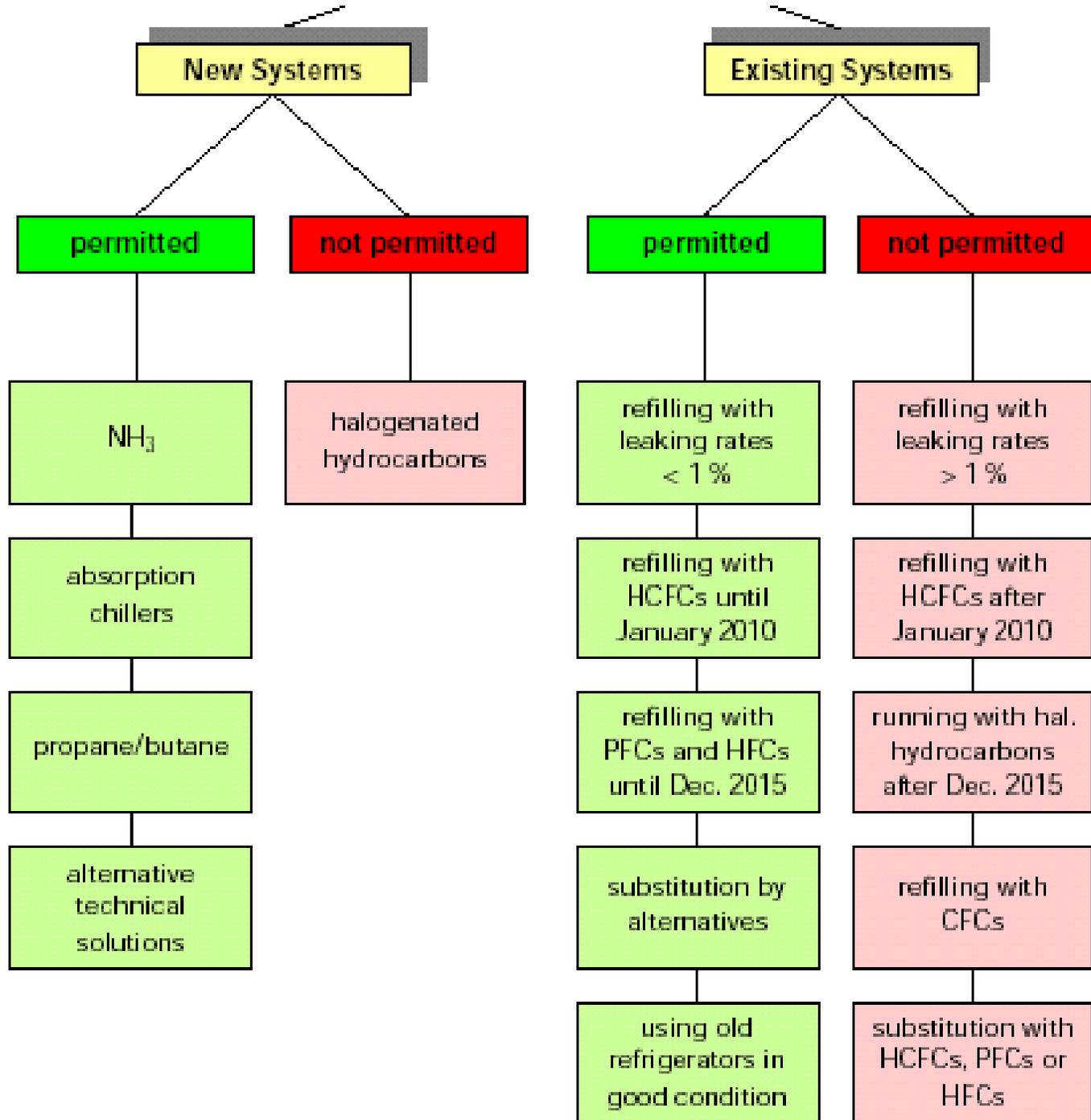
Nestlé engineers have found that, in most food processing applications, ammonia and carbon dioxide together in a cascade refrigeration system can further improve plant safety and efficiency, so meeting environmental and social responsibilities while making good economic sense.

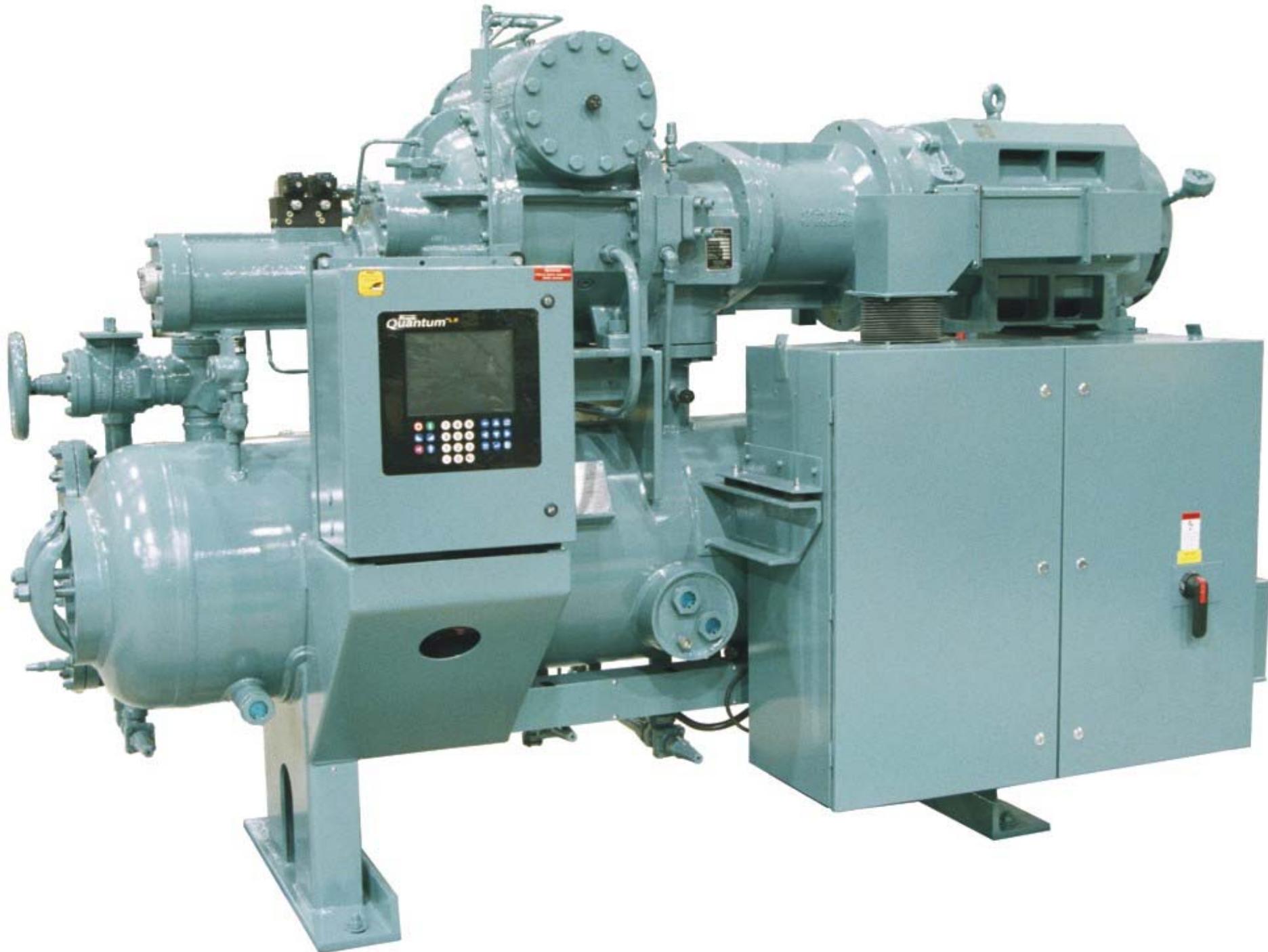


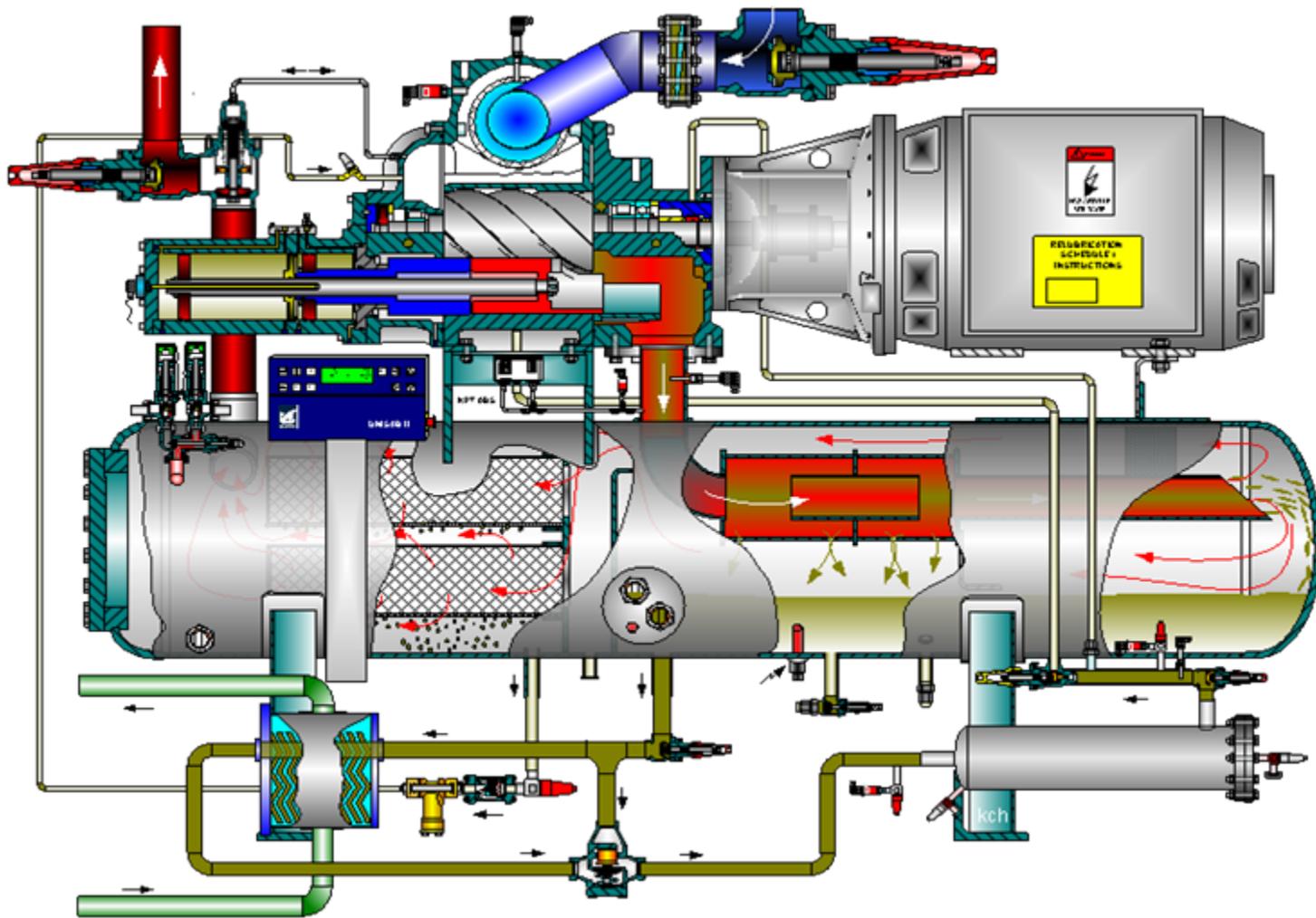
Trends Regarding Ammonia Use

Evaluation Scheme

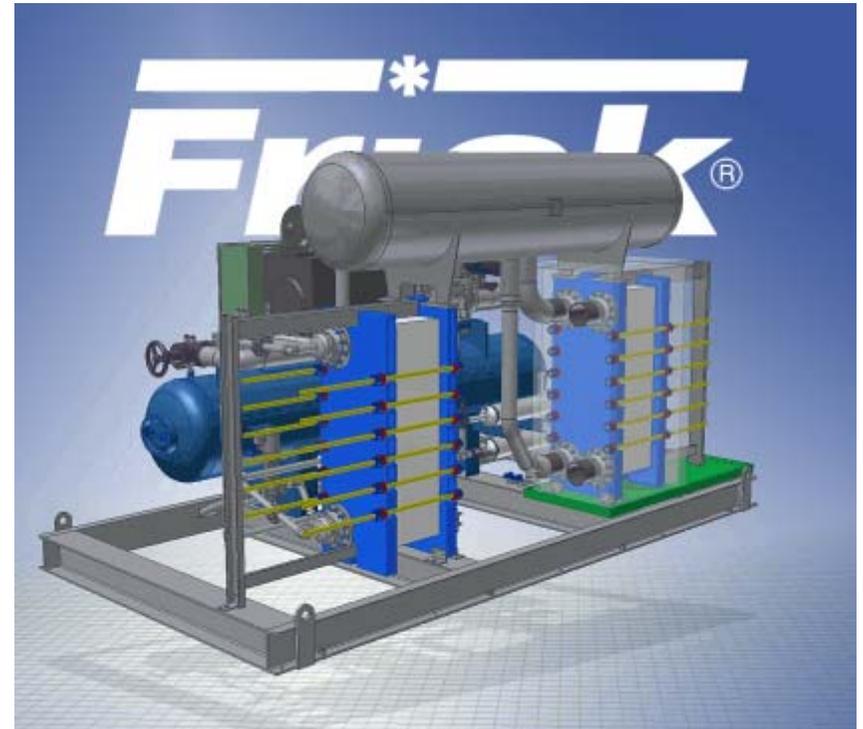








Ammonia Chiller: A chiller that utilizes ammonia as the refrigerant and consists of a compressor package, microprocessor, plate heat exchanger evaporator & condenser, oil cooler, surge drum, all assembled and wired in a factory controlled environment.

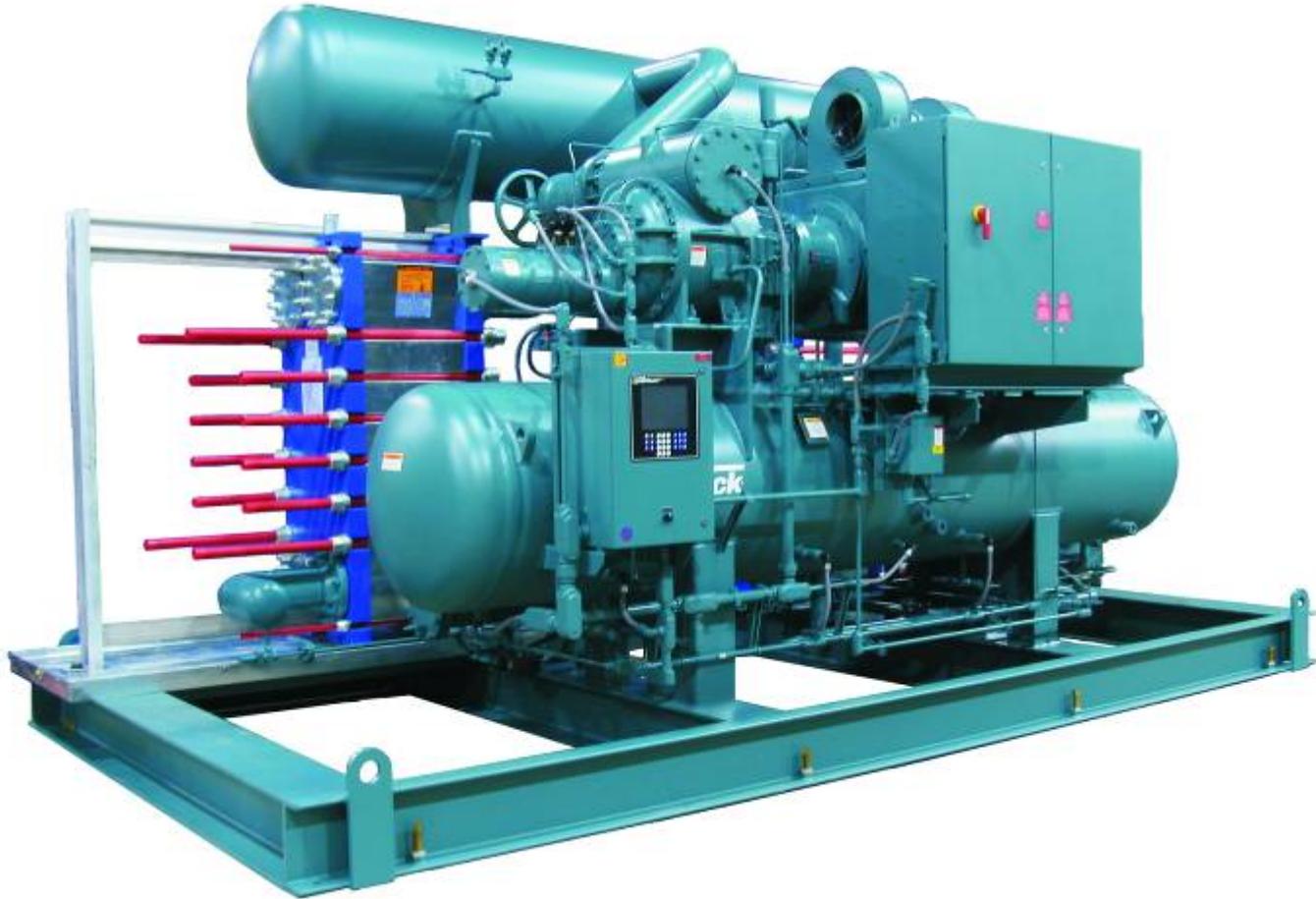


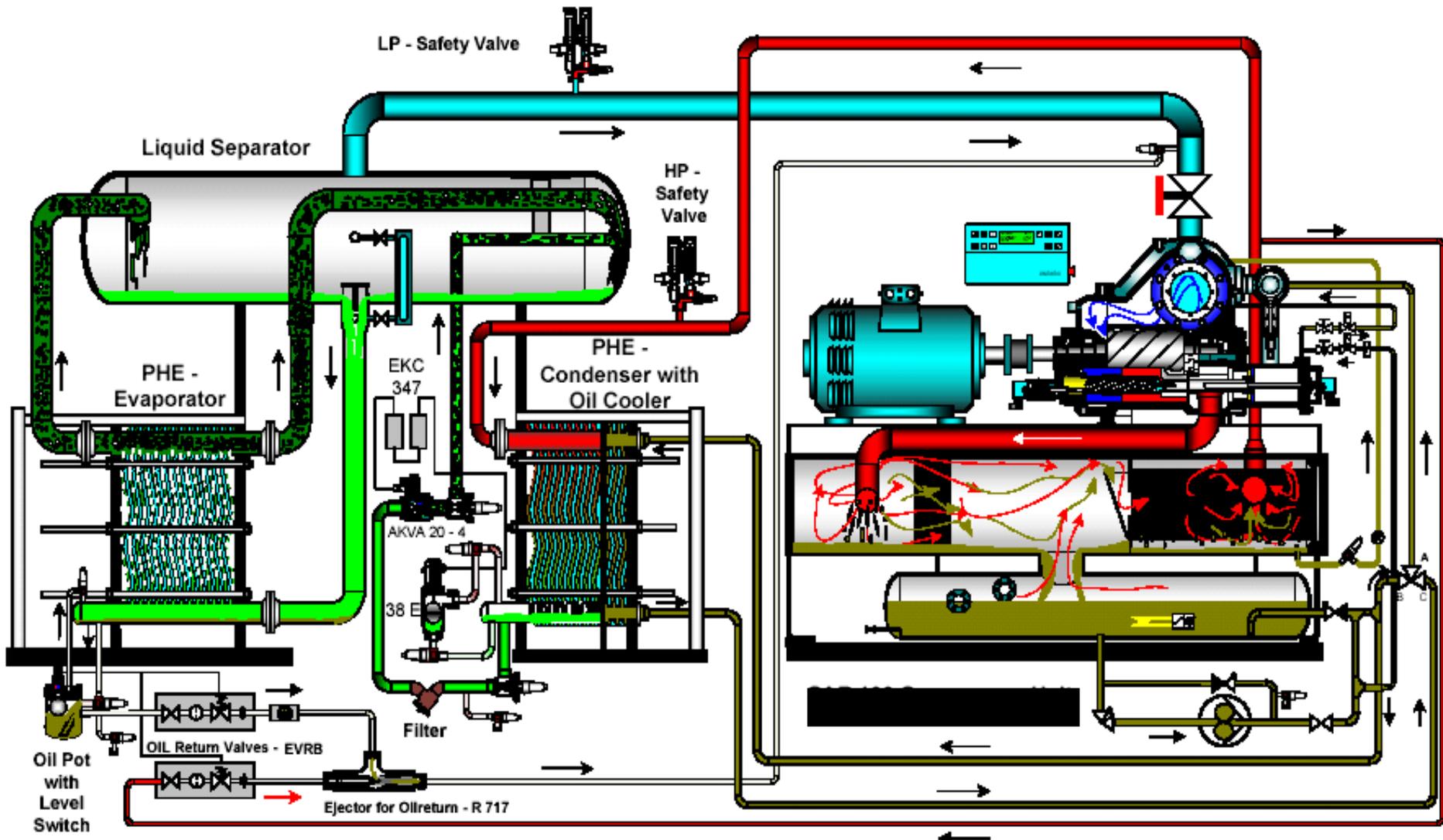
Advantages

- Compact design
- Small ammonia charge
- Evaporator and condenser in stainless steel
- Efficient oil return system
- Less welding
- Complete with control and monitoring system
- Flooded system with ammonia provides an efficient thermal solution while offering ideal operating economics



powerPAC™





Application / Advantages

Processes that require a secondary brine

Flexible capacity expansion with reduced refrigerant charge (Chillers 1 lbs. / ton of refrigeration)

Containment of refrigerant to the chiller package (critical charge)

Factory assembled / factory wired.

Virtual freeze-proof heat exchanger

Application Opportunities

Light Industrial applications:

Utility cooling (i.e. plastic injection mold cooling)

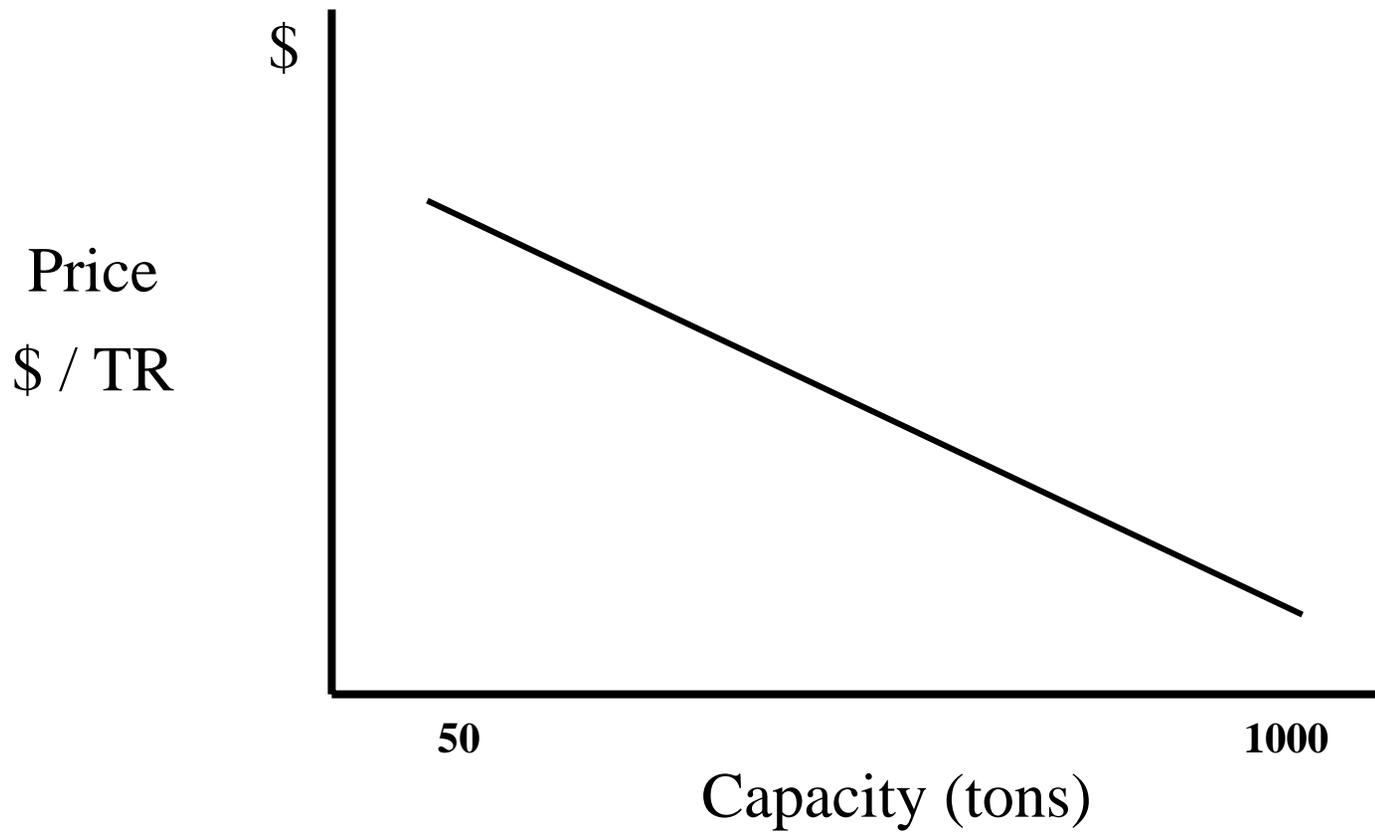
Dairy:

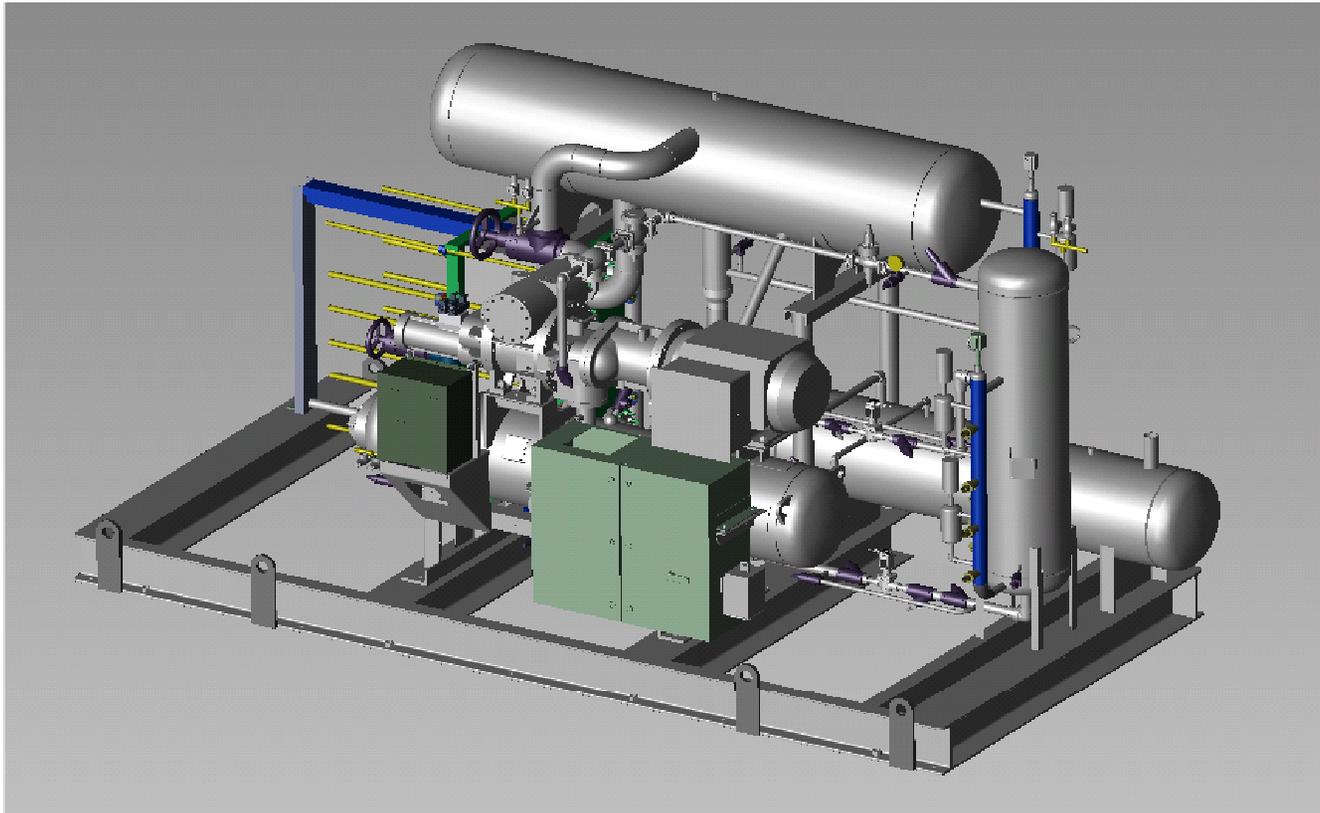
Carbonated Soft Drink:

Bottling lines

HVAC:

Global multinational companies natural refrigerant policy
ban the use of CFC's and HFC's







Heathrow Airport Terminal 5





500 Tons
Cooling Capacity

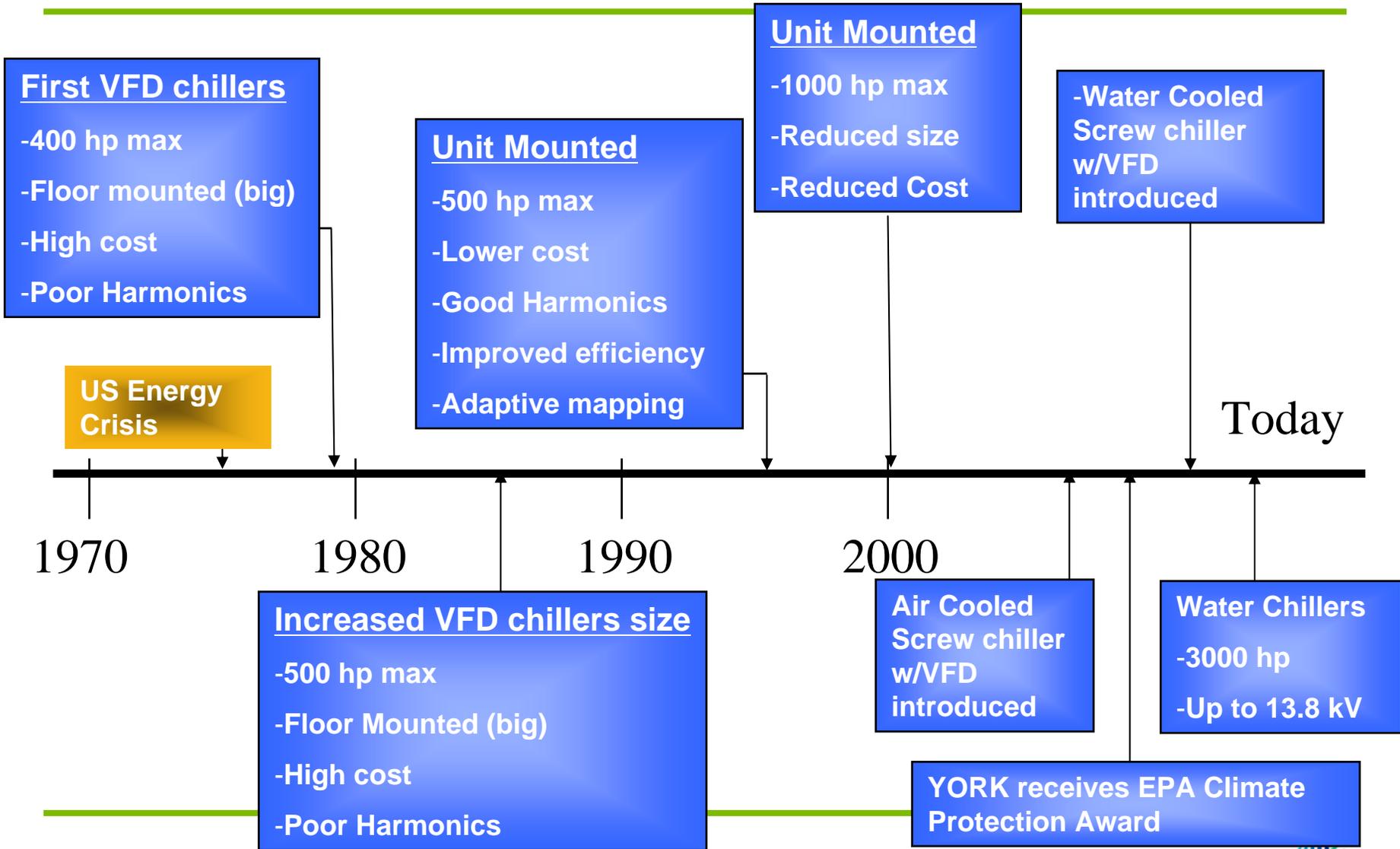




Packaged Mounted Variable Speed Drive



Water Chiller VFD history



2005 EPA Climate Protection Award

Variable Speed Chillers

York Variable Speed Chillers save 400,000 tons of CO₂ emissions annually. That is the equivalent of:

- 78,500 passenger cars not driven for one year

or

- 46,600 homes not powered by electricity for one year.



Ammonia Chiller Installation

Food Processing Plant located in Indiana, USA

- Capacity: 5,800 TR (20,400kW)
 - SST: 30°F (-1.1°C)
 - SCT: 98°F (36.7°C)
- Chillers: 5 @ 1,000TR (3,516kW) 1 Dual PAC 800TR (2,813kW)
 - Each outfitted with packaged mounted, liquid cooled, Variable Speed Drive
- VSD Savings*:
 - 725,000 kW-hr per year
 - 1,243,325 lbs. reduction in greenhouse gas emissions
 - or
 - 564 metric tons reduction in greenhouse gas emissions
 - or
 - 75 equivalent number of single family homes powered in a year with energy savings
 - or
 - 103 equivalent number of cars taken off the road in year with energy savings
 - or
 - 170 tons of carbon equivalent with energy savings



***Source: U.S. EPA**

Chiller Evaluation Method:

IPLV / NPLV

ARI Standard 550 / 590

2003
STANDARD for

PERFORMANCE
RATING OF
WATER -
CHILLING
PACKAGES
USING THE
VAPOR
COMPRESSION
CYCLE

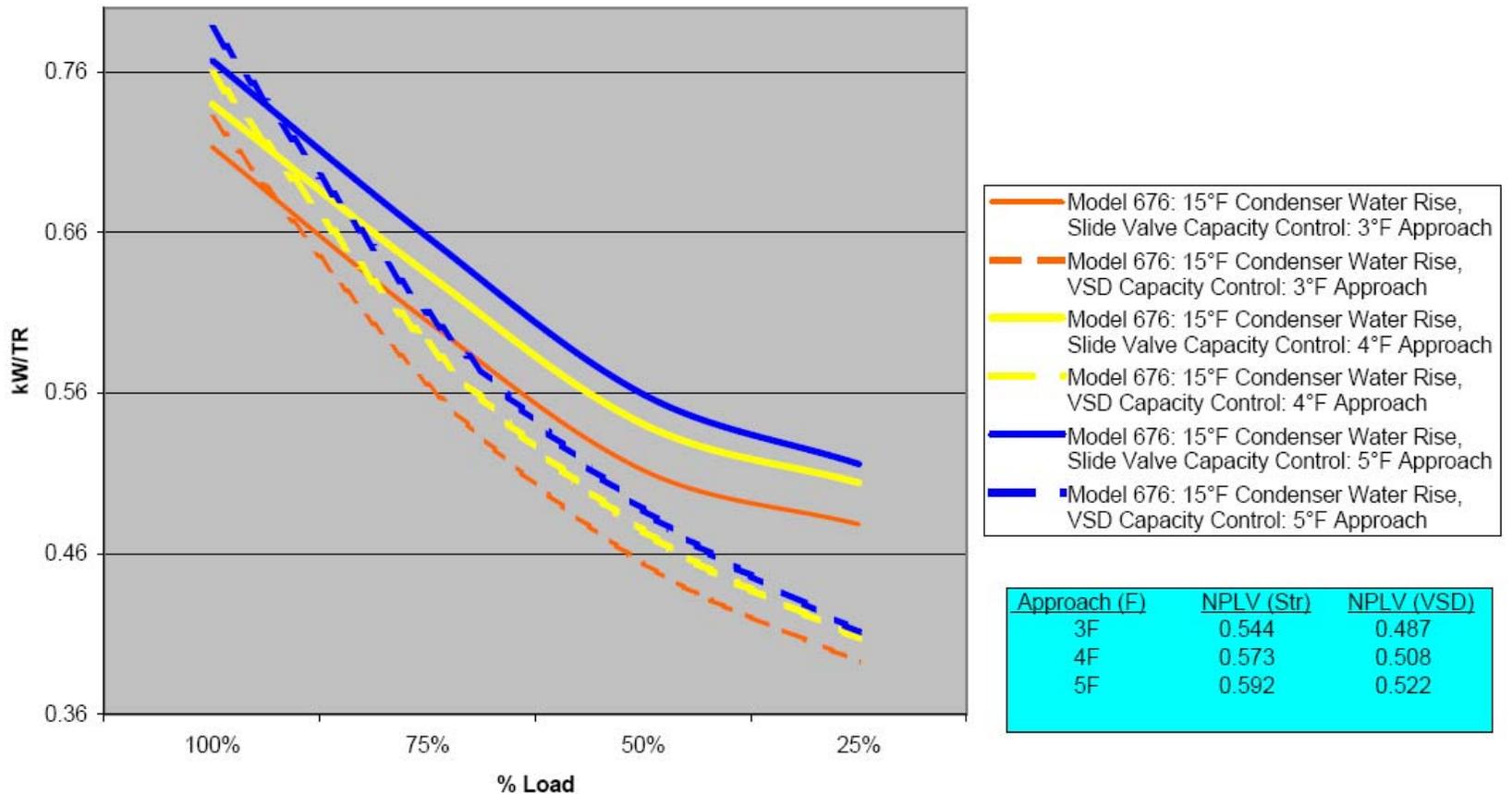


Standard 550/590

4100 N. FAIRFAX DR., SUITE 200 • ARLINGTON, VIRGINIA 22203



Performance vs Capacity Curve Frick Screw Compressor Model 676



Recommendations for Ammonia

- Work with consultants, Design-Build contractors, and manufacturers with a demonstrated record of working with ammonia refrigeration.
- Understand the implications and requirements for the installation location
 - Process Safety Management (PSM)
 - Risk Management Program (RMP)
- Incorporate ammonia safety in your location's safety program
 - www.iiar.org International Institute of Ammonia Refrigeration
 - www.reta.org Refrigerating Engineers & Technicians Association
 - www.eurammon.com European association for Industrial Refrigeration
 - www.iifiir.org/en/
- Visit installations that have ammonia systems operating.

Questions and discussion



Ammonia as a Refrigerant

Ammonia is often used for:

- Turbine Inlet Air Cooling

