WHY PROMOTE NATURAL REFRIGERANTS IN AC&R APPLICATIONS? & THEIR CURRENT GLOBAL APPLICATIONS

By
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Chairman AAR standards committee
15th April 2021

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Natural Refrigerants
(Zero ODP & Ultra-low GWP Refrigerants)

- Ammonia NH_3 (R-717)
- Carbon Dioxide CO_2 (R-744)
- Air (R-729)
- Water H_2O (R-718)
- Sulphur dioxide SO_2(R764)
- Hydrocarbons (HC-290-Propane, HC-600a-Isobutane and R-1270 Propylene & others

2

What is the need for use of Natural refrigerants ?

Reasons

1. No Global warming
2. Refrigerants known to mankind since the life came to earth
3. Offer no regret solution
4. Environmentally safe solutions

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CURRENT SITUATION-GLOBAL WARMING

1. Air conditioning and refrigeration industry consumes more than 40 % of total world production of energy.

2. 40% of Building Power consumed by comfort- Air Conditioning

Ref.: ASHRAE Journal September-2014

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TWO TYPES OF GLOBAL WARMINGS BY HVAC&R

1. .Direct Global warming due to leakage of Refrigerants- Depends on type of Refrigerant and quantity of refrigerant charge in the system

2.. Indirect GWP from equivalent CO2 emission due to energy consumption over the life time(TEWI)It is important to note that 90% GWP contribution in HVAC&R comes from energy consumption & every kWh of extra power contributes nearly 0.8kg of CO2

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Various conference leading to acceptance of use of natural refrigerants

1. MONTREAL PROTOCOL-SEPTEMBER 1987-CFC PHASEOUT SCHEDULE

2. KYOTO PROTOCOL-11TH DECEMBER 1997-REDUCE EMISSION GASES CAUSING GLOBAL WARMING

3.KIGALI AGREEMENT-25TH OCTOBER 2016-PHASE OUT HFC -HIGH GLOBAL WARMING REFRIGERANTS

4. EPA SNAP RULE-OCTOBER 2016-PHASE OUT R134A,R404A, ETC.-HIGH GLOBAL WARMING REFRIGERANTS

5. PARIS AGREEMENT-NOVEMBER 2016-HFC PHASE DOWN IN 30 YEARS

6.KATOWISE POLAND(COP24)-DECEMBER 2018-LIMIT TEMPERATURE RISE BELOW 2^0C

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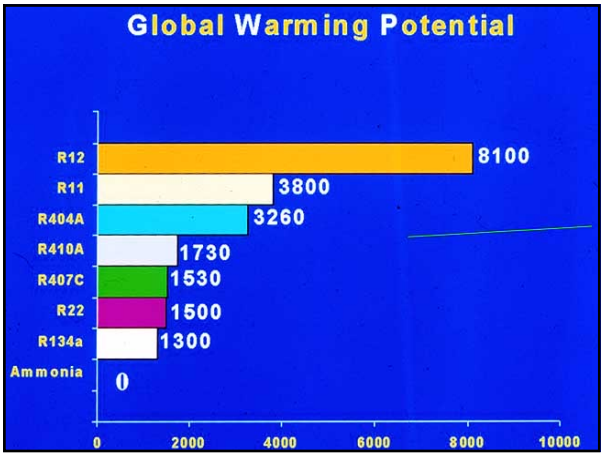

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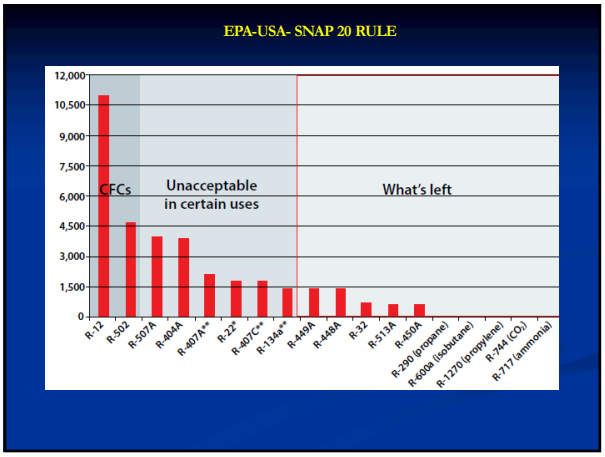

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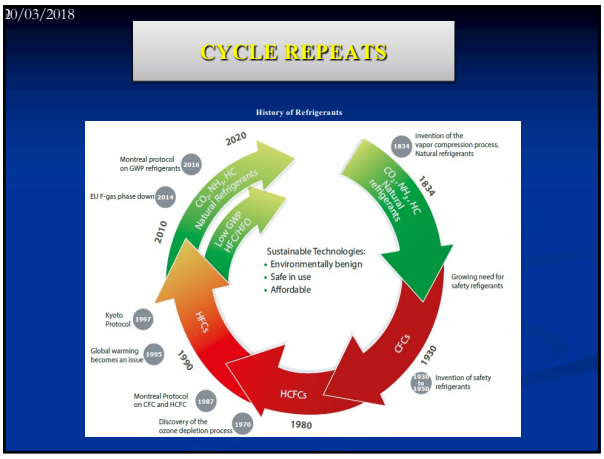

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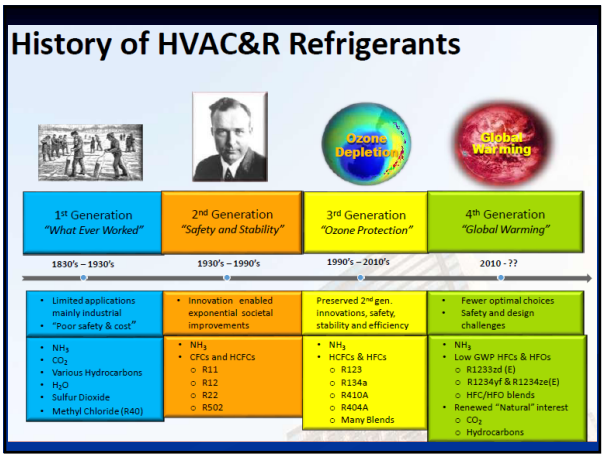

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ASHRAE POSITION DOCUMENT ON AMMONIA AS A REFRIGERANT
Approved by ASHRAE Board of Directors July 2, 2014

1.Ammonia has been continuously used as a refrigerant since the initial practical use of the vapor-compression refrigeration cycle was developed.
2.It has remained the main refrigerant used in industrial refrigeration systems because of its superior thermodynamic properties and low cost.
3. Restrictions on CFC, HCFC and many HFC refrigerants have re-focused attention on ammonia to emerge as one of the widely used refrigerants that, when released to the atmosphere, does not contribute to ozone depletion and global warming.
4. ASHRAE considers that the continued use of ammonia is necessary for food preservation and air conditioning.
5. ASHRAE promotes a variety of programs such as a dedicated chapter in the Refrigeration Handbook and several current and former research projects to preserve the economic benefits of ammonia refrigeration while providing for the management of risks.

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ASHRAE JOURNAL February 2017- Page22

"Changing rules around the use of high global warming potential (GWP) refrigerants have been one of the hottest topics in the HVAC&R industry in the last few years.

Following the phase out of ozone-depleting refrigerants starting in the 1990s, the U.S. EPA, acting under the Significant New Alternatives Policy (SNAP) program, has recently changed the status of certain high GWP refrigerants. In the next several years, refrigerants such as R-404A, R-507A, R-134a, and others will be prohibited for use in some types of new or retrofit commercial refrigeration installations"

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Comparison of Various Refrigerants

ASHRAE Fundamentals 2013 Table 8-29.8

Refrigerants 29.9

Table 9 Comparative Refrigerant Performance per Ton of Refrigeration

No.	Refrigerant Chemical Name or Composition (% by mass)	Evaporator Pressure, psia	Condenser Pressure, psia	Compression Ratio	Net Refrigerating Effect, Btu/lb	Refrigerant Circulated, lb/min	Liquid Circulated, gal/min	Specific Volume of Suction Gas, ft³/lb	Compressor Displacement, gal/min	Power Consumption, hp	Coefficient of Performance	Compressor Discharge Temp., °F
170	Ethane	233.2	672.8	2.88	69.5	0.81	0.35	0.541	3.27	0.489	2.7	121.73
744	Carbon dioxide	326.9	1041.4	3.19	57.3	0.51	0.10	0.269	1.03	0.257	2.69	157.73
1270	Propylene	51.9	189.1	3.64	123.0	0.46	0.11	2.081	7.12	0.295	4.5	107.33
290	Propane	41.5	155.9	3.76	119.5	0.47	0.12	2.502	8.73	0.292	4.5	96.53
502	R-22/115 (48.8/51.2)	49.7	190.3	3.83	45.6	1.25	0.13	0.814	7.59	0.306	4.38	100.13
507A	R-125/143a (50/50)	55.0	211.6	3.85	47.4	1.20	0.14	0.814	7.31	0.321	4.18	94.73
404A	R-125/143a/134a (44/52/4)	52.9	206.0	3.89	49.1	1.16	0.14	0.860	7.45	0.318	4.21	96.53
410A	R-32/125 (50/50)	69.3	271.5	3.92	72.2	0.77	0.09	0.873	5.04	0.298	4.41	123.53
125	Pentafluoroethane	58.5	226.4	3.87	36.7	1.51	0.16	0.631	7.12	0.327	3.99	87.53
22	Chlorodifluoromethane	42.8	172.2	4.02	69.9	0.81	0.08	1.248	7.58	0.287	4.66	127.13
12	Dichlorodifluoromethane	26.3	107.5	4.09	50.3	1.12	0.10	1.479	12.43	0.284	4.7	100.13
500	R-12/152a (73.8/26.2)	31.0	127.1	4.09	60.1	0.94	0.10	1.504	10.54	0.284	4.66	105.53
407C	R-32/125/134a (23/25/52)	41.8	182.7	4.38	70.2	0.81	0.09	1.289	7.80	0.298	4.5	118.13
600a	Isobutane*	12.8	58.5	4.58	113.5	0.50	0.11	6.524	24.30	0.288	4.62	85.73
134a	Tetrafluoroethane	23.6	111.2	4.71	63.6	0.89	0.09	1.945	12.90	0.290	4.6	98.33
124	Chlorotetrafluoroethane*	12.8	64.3	5.03	50.7	1.11	0.10	2.741	22.81	0.287	4.62	85.73
717	Ammonia	34.1	168.5	4.94	474.3	0.12	0.02	8.197	7.34	0.282	4.76	209.93
600	Butane*	8.1	41.0	5.05	125.6	0.47	0.10	10.325	36.04	0.292	4.74	85.73
11	Trichlorofluoromethane	2.9	18.1	6.25	67.0	0.84	0.07	12.317	77.52	0.264	5.02	109.13
123	Dichlorotrifluoroethane	2.3	15.8	6.81	61.2	0.93	0.08	14.279	99.21	0.274	4.9	91.13
113	Trichlorotrifluoroethane*	1.0	7.8	7.71	52.7	1.04	0.08	26.940	209.02	0.268	4.81	85.73

*Superheat required.

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WHY AMMONIA?

Ammonia C.O.P. (Efficiency)Comparison with other refrigerants for various applications

Refrigerant	For positive Temperature cold rooms- $+40^0C/2^0C$	For secondary fluids operation $+40^0C/-5^0C$	For low temperature cold rooms- $+40^0C/-25^0C$	Blast freezers/IQF $+40^0C/-40^0C$
Ammonia-R717	6.20	4.965	2.91	2.06
R410A	5.43	4.80	2.50	1.75
R134a	5.88	4.67	2.70	1.88
R404A	5.18	4.07	2.26	1.52
R22	5.93	4.74	2.79	1.98

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AMMONIA REFRIGERATION SAFETY STANDARD

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HERMETIC AMMONIA SCROLL COMPRESSOR

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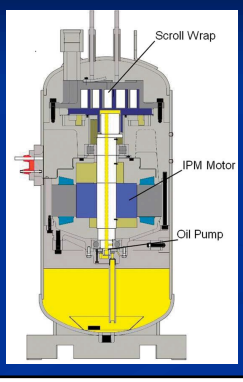
HERMETIC AMMONIA SCROLL COMPRESSOR



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Semi Hermetic Ammonia Compressor with encapsulated copper winding motor

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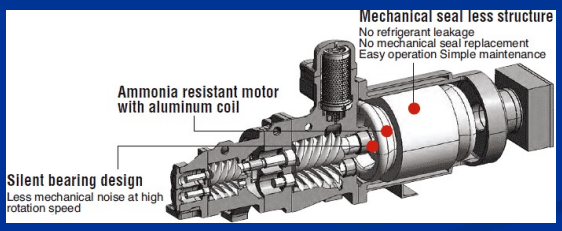
AMMONIA SEMI HERMETIC SCREW COMPRESSORS-KOBELCO-MYCOM



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CO_2 COMPRESSOR

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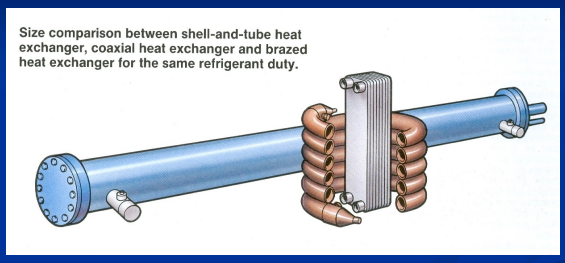

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EVAPORATORS

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SHELL & PLATE HEAT EXCHANGER

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Aluminum Coolers

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New Technology for use of encapsulated copper winding motors for Ammonia

A new electromotor technology is being developed now, using encapsulated copper windings or aluminium windings for semi-hermetic ammonia compressor. A hermetic scroll compressorfor ammonia small refrigerating systems is announced and first small chilling units are sold on the market. The DX evaporators require miscible oil with ammonia; new compressor oil types are developed.

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What is Low Charge Ammonia System

Low charge systems are defined as systems having no more than 1.3kg/kW

Low charge factory made packaged refrigeration systems of less than 0.3kg/ton(3.517kW) are available using shell and plate heat exchangers. Use of High side float eliminates use of H.P. receiver.

Systems with as low as 0.06kg/kW charge are also available for some applications

Ref: ISHRAE JOURNAL JAN-March 2017-Star Refrigeration UK-R. Lamb

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Low Ammonia Charge Systems-0.33kg/TR

Andy Pearson-IIAR presentation

Optimum charge systems have become very common, and the generally accepted benchmark is to achieve a specific charge of about 1.3kg/kW(0.8Lb/Ton).

As an example, a project at Walwyn Garden city in England involved such a standard. The system was designed to be quite large, with cooling capcity of 7500kW(2160TR), and was to use plate evaporators and condensers.

The job specifications stipulated that the charge was to be less than 250kg per chiller.

The eventual solution developed was to use three water chillers, each 2500kW(720TR) in capcity, and each requiring 238 kg(524Lbs) of ammonia upon commissioning.(0.0952kg/kW)-(0.739lb/Ton)

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D-X -Low Charge Ammonia Systems-Advantages

1. Reducing the risk to workers & products associated with Ammonia leaks
2. Reducing Regulatory obligations
3. Can be used up to lowest -7^{0}C temperature but used mostly for positive temperature
4. For freezer applications not suitable due to poor performance of evaporator
5. Colmac USA has patented the systems

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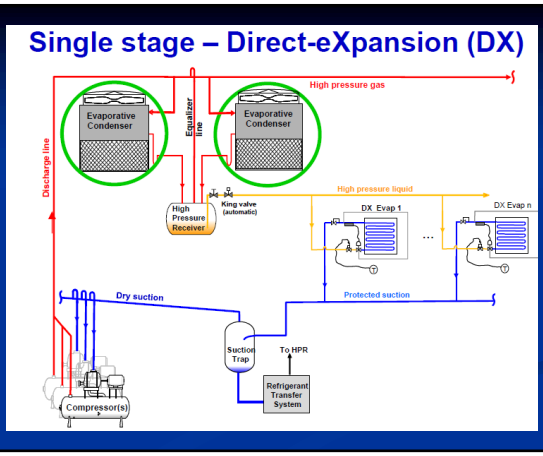
Single stage – Direct-eXpansion (DX)



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RECENT TRENDS-AMMONIA PAKAGE SYSTEMS

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PACKAGE CHILLER
PHE –Chiller/condenser L.P. Package

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SABROE PACKAGED AMMONIA CHILLER

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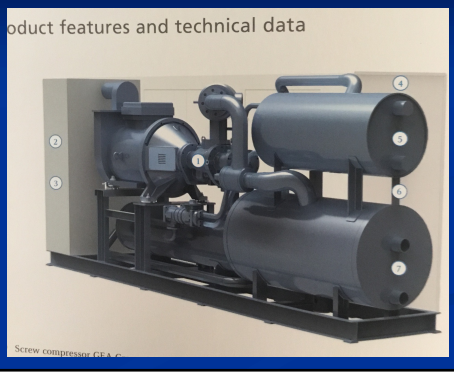
SABROE AMMONIA PACKAGED CHILLER



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PACKAGE AMMONIA CHILLER WITH HERMATIC SCROLL COMPRESSOR-MYCOM-JAPAN

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AIR COOLED AMMONIA PACKAGE CHILLER-Azane by Star Refrigeration UK-784kW-200kg (0.86kg/Ton)refrigerant charge

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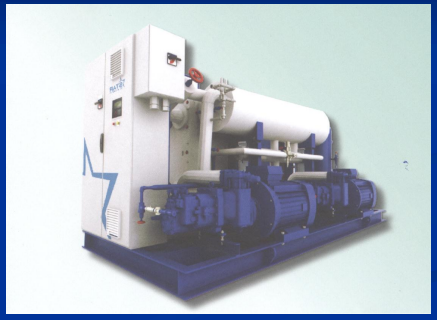
WATER COOLED PACKAGE CHILLER-SCREW COMPRESSORS & PHE CONDENSER/COOLER-856 kW-86 kg

0.1kg/kW≤ 0.353kg/TR



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WATER CHILLER USING RECIPROCATING COMPRESSOR & ENCLOSED SHELL - PLATE CONDENSER/COOLER

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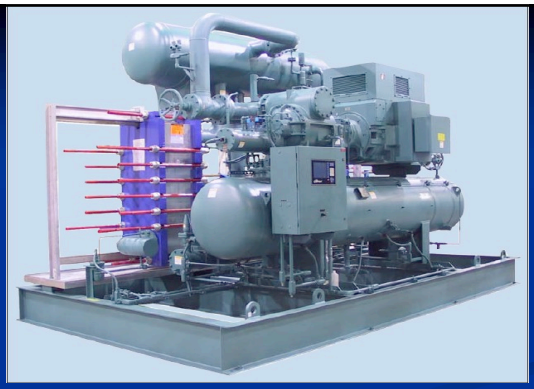

A duel Purpose Chiller for Food Processing Plant and and comfort Air conditioning

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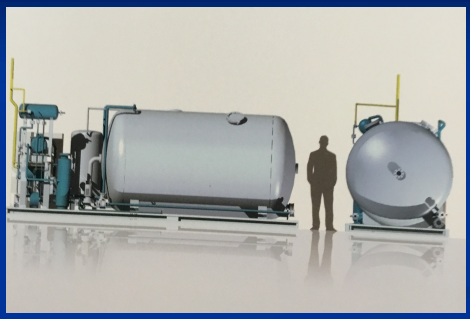
ZUDEK ITALY AMMONIA PACKAGE CHILLER



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Package Ammonia Chiller Installed on roof top

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Package Ammonia Chiller installed on Roof Top

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PACKAGE CHILLER ON ROOF TOP

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PACKAGE CHILLER ON ROOF TOP

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AMMONIA AIR CONDITIONING APPLICATIONS

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ASHRAE Journal –May 99-page14

William McCloskey, Executive vice President of Baltimore Air Coil said "IIAR & its members must dedicate themselves to countering the negative perception about ammonia, not with the industry peers but with general public. This includes the faulty perception that city code prohibits use of ammonia in installations in metropolitan areas".

He sited an example that in several cities including Chicago which has restrictive codes, more than 140 urban ammonia installations are operating.

The air conditioning installations using ammonia include McCormick Place & W.W. Grainger office building. The 40 storey Blue Cross Blue Shield building that also has ammonia chillers for air conditioning.

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USE OF AMMONIA REFRIGERANT IN COMFORT AIR CONDITIONING

1. Oslo Air Port -Norway
2. Heathrow Terminal -5 -4x6.6MW
3. Singapore Changi-Air Port
4. Stuttgart Airport Terminal 3-2300kW Grasso
5. Copenhagen Airport
6. Dusseldorf Airport
7. Zurich Airport
8. Christchurch Airport-New Zealand
9. KWN Greenpeace Headquarters office building-Vienna
10. Berlin Ostbanhof train station-Grasso system for three storey building complex

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USE OF AMMONIA REFRIGERANT IN COMFORT AIR CONDITIONING

11. Telephone Exchange- Copenhagen
12. Roche Headquarters office Building-in London -930 kW- Star Refrigeration
13. Sabb-Linkoping-Sweeden-4 ammonia chiller of 2 megawatt
14. Mulligan Letter sorting center-Switzerland-Jonson Controls
15. Ozeaneum in Stralsund-Jonson controls-500kW A/C
16. DX systems with soluble oils in large Halls Process Plants
17. Thermal storage systems for Malls, Cinema Halls
18. Space Shuttles
19. Hanover Trade Fair Building -3.5MW
20. Homerton University Hospital- 2x 0.5MW

Ref: Euromon issue-Refrigerants by nature-2012

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Oslo Airport Air conditioning system

An air conditioning installation with ammonia at Oslo Airport, Norway which was commissioned in October 1998.
Total refrigeration capacity - 6300kW
Electrical Motors - 1720kW
(5 x 280) + (2 x 160)
Refrigerant charge (ammonia) 2500kgs
Plant uses Ammonia refrigerant in indirect cooling chilled water system, using 5 number reciprocating 16 cylinder compressors in one area & 2 number reciprocating compressors of 8 cylinders in another area.
This is one of the largest and most advanced airport having a capacity to handle 16 to 18 million passengers / year with 64 check in counters and handling 80 aircrafts per hour. The total operational building area is 18,000sq.mtr and commercial area 2.7 sq.km. The total area is 13 sq.km.

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HVAC Plant Room at Oslo Airpoprt, Norway

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HEATHROW LONDON T-5 AIR CONDITIONING PLANT

To make the vast Terminal 5 virtually independent from the use of ozone-depleting and high global warming HCFCs and HFCs, all heating and cooling is done by a dedicated energy centre providing continuous supply of hot and chilled water for heating and air-conditioning respectively. All chillers operate with the non-ozone depleting and non global warming refrigerant ammonia (R717). The natural substance was selected by the airport authority because it was recognised as a future proof solution offering excellent efficiency. A thorough risk analysis and safety review removed last concerns regarding the system design and the installation's safety and confirmed that ammonia would not pose any greater risk to the public or the airport staff than any other conventional large chiller solution. In fact, large ammonia chillers had been already used before in more densely populated applications without any safety compromises.

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One of The Four package Ammonia Chillers being installed at Heathrow Airport

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Stuttgart Air port-2300kW capacity installed by Grasso Nederland

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Grasso installs an ammonia system for Terminal 3, using two liquid chilling packages totalling to 2300kW capcity. The iceban system is designed to work alongwith already installed refrigeration circuits to get maximum efficiency also in low load conditions.

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A public building in hannover

Has been air conditioned using three air cooled 700kW system each usign 150kg of ammonia refrigerant.

- New design (PHEs and spray type shell & tube evaporator)
- Better efficiency (>30%) than HFC134a
- Less charge (0.02 to 0.5 kg/kW) for dry and flooded evaporation
- Higher discharge pressure (up to 40 bar) for heat pump
- Safety level increased significantly towards "zero leak"

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Ammonia for Air Conditioning and Commercial Refrigeration

Migros supermarket in Zurich ammonia system is used for both space air conditioning as well as for refrigerated display cabinets.

- Ammonia A/C with central plants
- Ammonia display freezer cabinets
- Independent circuits
- Secondary refrigerants used-Srini Mega food park in India

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AMMONIA GLYCOL SYSTEM

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ASHRAE HVAC&R INDUSTRY NEWS

Semi-Hermetic Ammonia System Heats, Cools Dutch Business, Apartment Complex

EINDHOVEN, The Netherlands—An ammonia heat pump has been installed to heat and cool 40,000 m² of apartments and business premises in the Netherlands. The re-modeled office complex, a former factory for conglomerate Philips, will use the 800 kW ammonia heat pump system fitted with two twin screw compressors for space heating during the winter and air conditioning during the summer. One of the compressors is redundant in case the system fails. An ammonia heat pump was selected to heat and cool the building complex due to its high-efficiency, zero global warming potential and zero ozone-depleting potential, said the developer.-
18th October 2018

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The complete Ammonia Chiller package including electric starter panel and all wiring at the P&T building, Copenhagen.

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Jhonson controls uses ammnia system to air condition 5000 sq.m of of office area using Four ammonia water chilling units each of 2MW capacity

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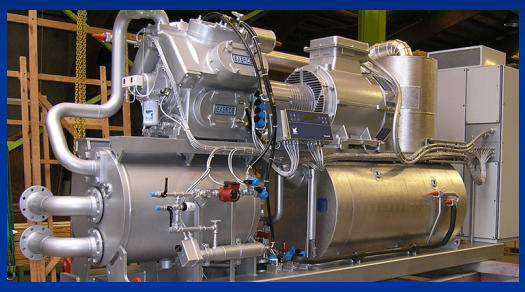
Logan City Council south of Brisbane -Australia



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Logan City Council south of Brisbane -Australia

Converted the old fashioned existing air cooled R22 based air conditioning system to a new water cooled NH_3 based system.

Not only did this new system reduce Logan City Council's annual energy consumption by around 50%; it also eliminated any commercial and environmental risks associated with future releases of chemical refrigerants.

The new water chillers have a combined capacity of 1200 kW.
They are state of the art with built-in speed control, desuperheaters for heat recovery, less than 25 kg NH_3 charge per unit and computerized control and monitoring systems.
The new NH_3 based system replaced two existing R22 based plants. The performance of the new system has exceeded expectations to such an extent that the chilled water supply temperature set point to the various air handling units had to be increased during commissioning. This, of course, improves energy efficiency further.
The new water chillers feature an IPLV of close to 10; a vast improvement on the old R22 system with a coefficient of performance (COP) of around 2.8

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Star Refrigeration Roof Top Units using Low charge Ammonia systems Roche Headquarters -Germany

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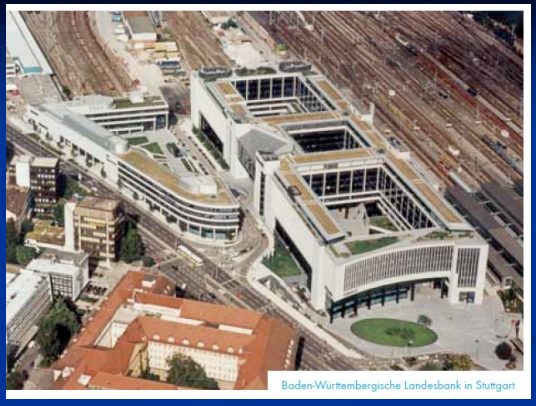

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Yasushi Sasaki, Mayekawa at ATOM America 2017-Sandigo California

One project using ammonia for residential district heating in an area with total of 700 households had experienced very high -COP compared to traditional HFC refrigerants. The COP was 5.35 compared to 3.57 delivered by traditional HFC systems, overall it was 156% more efficient.
Similarly, Mike Kallas of U.S. low charge package solutions manufacturer Azane Inc. -Part of Scottish firm Star Refrigeration indicated that based on analysis,we estimate that 70% of all buildings would use ammonia roof top packages for office and retail buildings.
A similar system has been provided for department store for air conditioning with 213lbs. Of ammonia refrigerant providing chilled water at 45.0^0.F and with air cooled condenser. Also at Napoleon, OH and a bakery in Portland with 450lbs of ammonia charge.

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The spectacular new museum with it huge sea water acquariumx, having water of 2.6 million litres, offers visitors spectacular journey through the underwater world.
The refrigeration system needed for cooling the water for acuariums and for air conditioning the building is provided by refrigeration plant of 900kW capacity divided in to 400kW for aquarium and 500kW for air conditioning the building. The cold water is supplied at 6 deg C and returned at 12 deg c.Jhonson controls did the designing of refrigeration system using single stage ammnia flooded design evaporators.Two Sabroe reciprocating compressors were utilized.

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US Seafoods to replace R22 with ammonia-ammonia21 News

U.S. Seafoods of Seattle will install Ammonia freezer equipment after being found guilty of violating the Clean Air Act by releasing ozone-depleting refrigerant R22 from two of its fish processing vessels in Alaska. Environmental Protection Agency (EPA) investigators discovered that in 2012 the freezers ..(ASHRAE NEWS Letter –November 2017)

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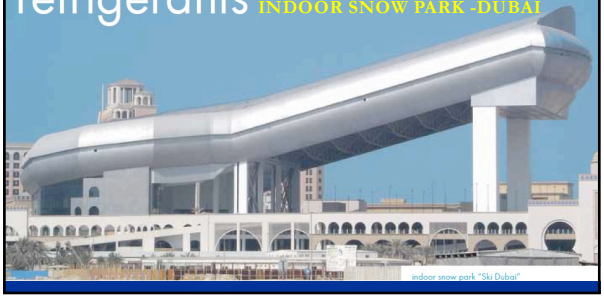
Winter sports fun all year round, thanks to natural refrigerants

INDOOR SNOW PARK -DUBAI



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CARBON DIOXIDE AS REFRIGERANT

LATEST TRENDS

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CARBON DIOXIDE AS REFRIGERANT

Crititcal Temperature	30.98 Deg C	73.77 bar a
Triple Point	-56.55 Deg C	5.1796 bar a
	45 Deg C	100 bar a
→	40Deg C	91.48 bar a
	0 Deg c	34.85 bar a
	-20 Deg C	19.696 bar a
	-40 Deg C	10.04 bar a
	-78.5 Deg C	Atmospheric Pr.

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CARBON DIOXIDE AS REFRIGERANT

ADVANTAGES AS REFRIGERANT

1. Low GWP/No ODP
2. Natural Refrigerant
3. Non Toxic/Non Flammable
4. High Density-Hence smaller system
5. Small Compressor Size-Nearly 6 to 8 Times smaller
6. Smaller Piping-Less insulation
7. High Heat transfer Coefficients
8. Smaller Condensers/Evaporators
9. Low Pressure losses
10. High Efficiency in Sub Critical Cascade Applications
11. Positive Pressures in Low Temperature Applications
12. Low Cost compared to any other refrigerant

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CARBON DIOXIDE AS REFRIGERANT

DISADVANTAGES AS REFRIGERANT

1. High Discharge Pressures
2. Very Low Critical Temperature- +31.8 deg C
3. Limited Flexibility in Applications
4. Cascade Coolers are More expensive
5. Heavier than Air-Suffocation in Higher Concentrations
6. 400 PPM in Atmosphere-Less than 800 PPM allowed –EN 13779-5000 PPM Max Work place concentration
7. Odourless-Detectors are required
8. Solid Phase above atmospheric Pressure-Safety Valves , drains open to atmosphere
9. Liquid to Gas expansion ratio is very high
10. Liquid Traps & also Gas Traps must be avoided
11. Liquid line leakage Most Dangerous- -78.5 Deg C Temperature
12. Moisture Less than 5 PPM-Not soluble in Refrigerant
13. Only Gas Charging-Liquid Charging Vacuum-Thermal Shock

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CARBON DIOXIDE AS REFRIGERANT

APPLICATIONS IN INDIA

SUB CRITICAL SYSTEMS-CASCADE

1. High Stage R134a, or R404A
2. Low stage Carbon Dioxide

OR

1. High Stage Ammonia
2. Low stage carbon Dioxide

3.OR

4. Secondary Coolant as brine in super markets

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CO_2 in Domestic Application

Coca Cola Company uses both R134a and CO_2 for its 550-litre Refrigerators, with the result that systems operating with CO_2 consume 20 to 30% less energy. The application is in supercritical range i.e. condensing temperatures are above 31.2^{0}C

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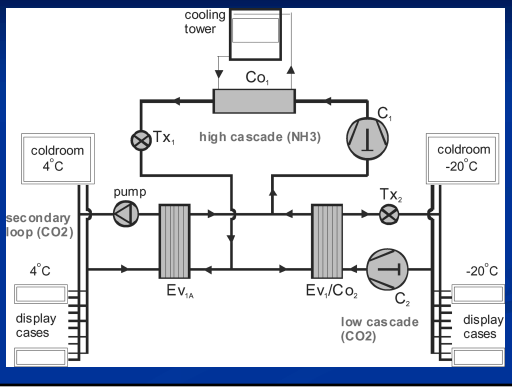
Cascade Ammonia CO2 system for super Markets



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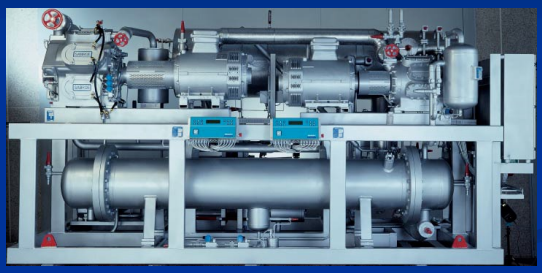
CO2 Ammonia Cascade



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AMMONIA-CO_2 USED AS BRINE SYSTEM –FRUIT STORAGE-HOLLAND

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CO_2 Bus Air Conditioning

CO_2 A/C installation: August 1996
Operation hours: 1700

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HYDROCARBONS AS REFRIGERANTS

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Typical applications for hydrocarbons are:

- .Domestic refrigerators and freezers
- •Bottle coolers
- •Ice cream freezers and commercial freezers
- •Commercial refrigerators
- •Beer coolers
- •Beverage dispensers
- •Dehumidifiers
- •Heat pumps
- •Supermarket refrigeration (in combination with secondary cooling or as a high temperature stage in a cascade CO_2 system)
- •Small air conditioners

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Most Important Hydrocarbons as Refrigerants

	Formula	Refrigerant	Boiling Point-^{0}C	Critical Temperature-^{0}C
N-butane	C_4H_{10}	R600	-0.5	152
Iso-butane	C_4H_{10}	R600a	-12	135
propane	C_3H_8	R290	-42	96.6
propylene	C_3H_8	R1270	-47.7	91
ethane	C_2H_6	R170	-88.7	91
Ethylene	C_2H_4	R1150	-103.8	9.5

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Hydrocarbons As Refrigerant As Replacement

HFC	HC alternative	Applications
R134a	R600a	Household appliances
R134a	R290/600a mixtures	Commercial applications
R404A,R507A	R290,R1270 & their mixtures	Industrial plants-Petrochemicals
R407C	R290,R1270	Air conditioning and heat pump systems
R410A	R1270/170 mixtures	Deviations due to refrigerating capacity & pressure levels
R23,R14	R170,R1150	Low temperature cascades
R227ea	R600a	High temperature applications

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Hydrocarbon as refrigerant

1. Butane has been used in more than 300 million Domestic Refrigerators and now finding use in smaller commercial systems.

2. Propane in central air conditioning systems report 10 to 30% energy savings and with minimum changes can be used in current installations using R22 refrigerant

3. Unilever uses propane in 360 liters ice cream freezers and compared to R404A reports on an average 9% power savings over R404A

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Hydrocarbons as refrigerant

Butane is very successful in more than 300 million domestic refrigerators currently being used.
Pepsi has compared the results and indicate that small drink chillers with 150g refrigerant consumes 27% less energy than those using R134a refrigerant

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1. With the support from international organizations, China has converted 18 room Air conditioner making plants to R290 which has a capcity of 45,00,000 units per year

2. They have also 3three no compressor production lines to produce 54,00,000 unit per year

3. Up to August 2019, 1,60,000 units have been installed as room Air conditioners

4. Godrej has introduced 6,00,000 units in the Indian market

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R-290 PROPANE A.C.-CHINA-(More than 3, million)

85

Energy-Efficient Propane (HC-290) Based Room Air Conditioners by Godrej & Boyce

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PROPANE FOR AIR CONDITINING

Germany-The Municipal corporation has installed unit using propane for cooling the servers and for air conditioning.

The system is of 20kW capacity using 2.5 kg of propane(R290).

The system is working since 2011.- Eurammon

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PROPANE FOR HEATING/AIR CONDITINING-2x250kW

For shopping center in Mythen center AG-Switzerland uses propane for heating and air conditioning.

The units are designed to work round the clock having high COP and EER by means of high performance-frequency controlled compressors. The system per unit uses 15kg of refrigerant

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PROPANE CO_2 CASCADE

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API 619 Propane Refrigeration Package
Caim Energy, Rajadthan

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PROPANE PACKAGE FOR PETROCHEMICAL REFINERY

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White Paint That Could Reduce Need for AC

Purdue University engineers have created radiative cooling white paint that can keep surfaces up to 18°F (10°C) cooler than their ambient surroundings. According to the researchers, the paint would replace the need for air conditioning by absorbing almost no solar energy and sending heat away from the building and into deep space. Compared with commercial white paint, Purdue's paint maintains a lower temperature under direct sunlight and reflects more ultraviolet rays, according to the researchers.-29-10-2020 ASHRAE news

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THANK YOU
Questions?

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