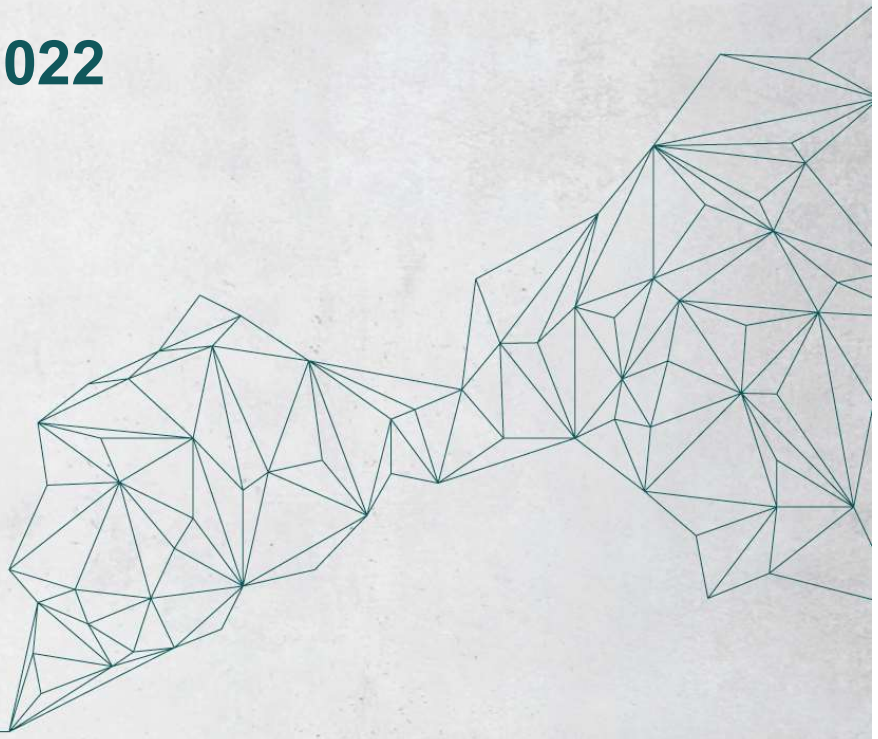
Hall 7A

CHILLVENTA

Chillventa Specialist Forums 2022
Chillventa Fachforen 2022

CONNECTING EXPERTS.



October 2022

A FRESH APPROACH TO COLD STORAGE

WISSAM RACHED
JEAN DE BERNARDI

Honeywell

CONTENTS

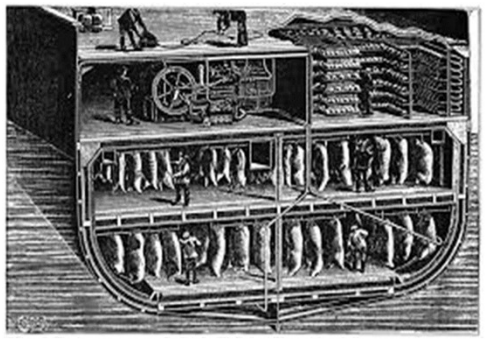
Introduction: Why focusing on Solstice® ze (R-1234ze)?

Solstice® ze is a safe, non-toxic, non-corrosive, energy-efficient and ultra-low GWP refrigerant. For chillers and heat pumps, **Solstice® ze installations deliver the highest Performances (+25% COP)**

INTRODUCTION: WHY SOLSTICE® ZE?

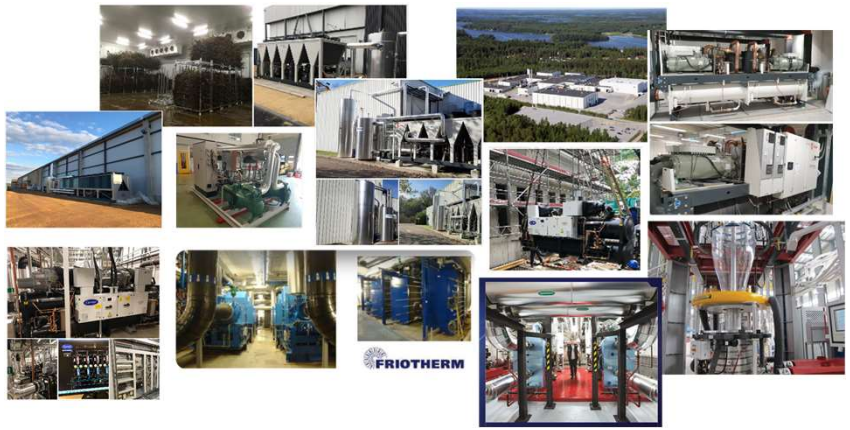
01

1876



« Le Frigorifique », an old sailboat transformed into a steamboat and fitted out by Charles Tellier to be able to preserve, during a transatlantic voyage, thirty tons of meat. With this crossing (Rouen, September 20th - Buenos Aires, 25 December 25th 1876), **Tellier symbolically inaugurated the cold chain**. It was with NH3.

2021



After 145 years of Refrigeration:

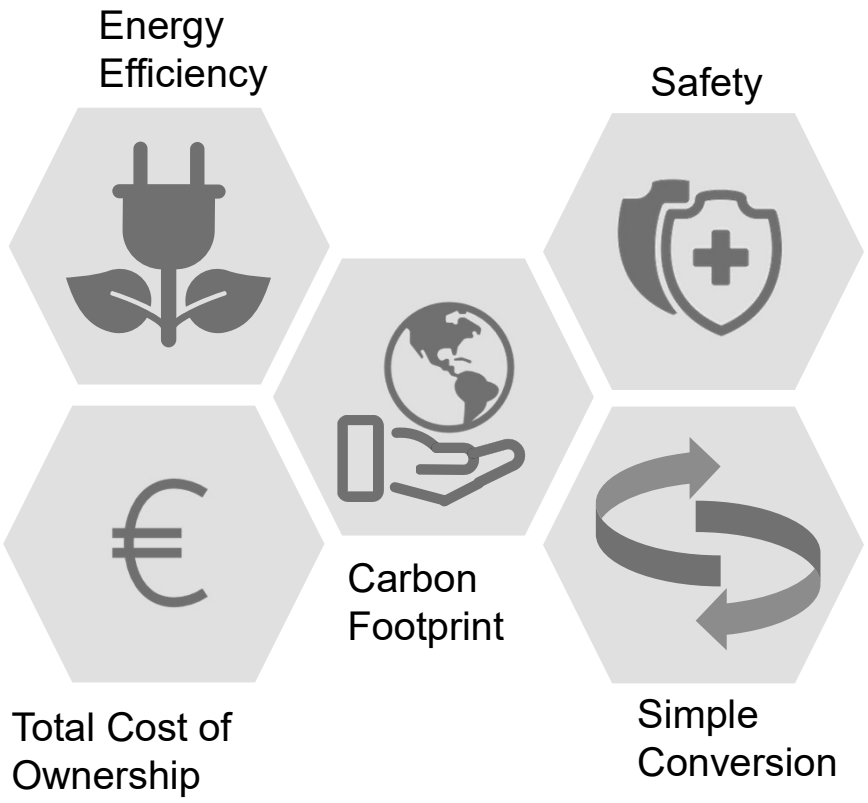
We can see numerous installations switching to R1234ze now, like:

- Medium-pressure chillers to cool large buildings
- High-temperature heat pumps
- District cooling and heating
- Infrastructure projects
- Medium-temperature self-contained refrigeration cabinets
- Process chillers in refrigeration applications
- Organic Rankine Cycle (ORC)

Solstice ze is penetrating the industrial market now

SOLSTICE® ZE: MAIN BENEFITS

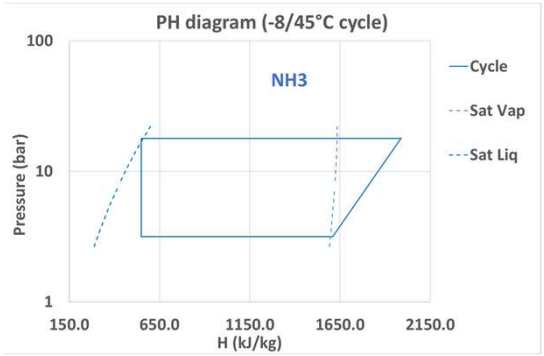
01

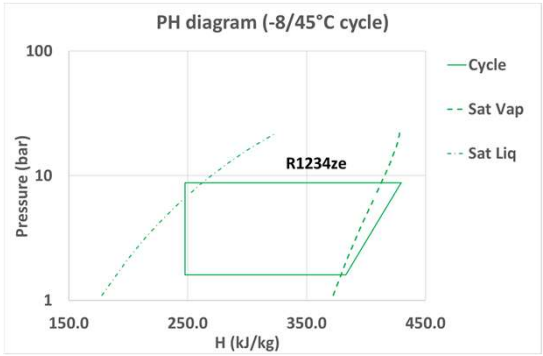


Solstice ze Offers the Best Combination of Properties

INDUSTRIAL REFRIGERATION R1234ZE, NH3

02





	NH3	R1234ze
HP (bar)	17.8	8.7
LP (bar)	3.2	1.6
Suc D (kg/m3)	2.5	8.6
Δh (kJ/kg)	1047	119

Basic cycle (-8 / 45°C)

2°C SC / 5°C SUP / 0.7 μ_isen

- COP (NH3) = 2.8
- COP (R1234ze) = 2.7
- 5 % higher COP for NH3 versus R1234ze

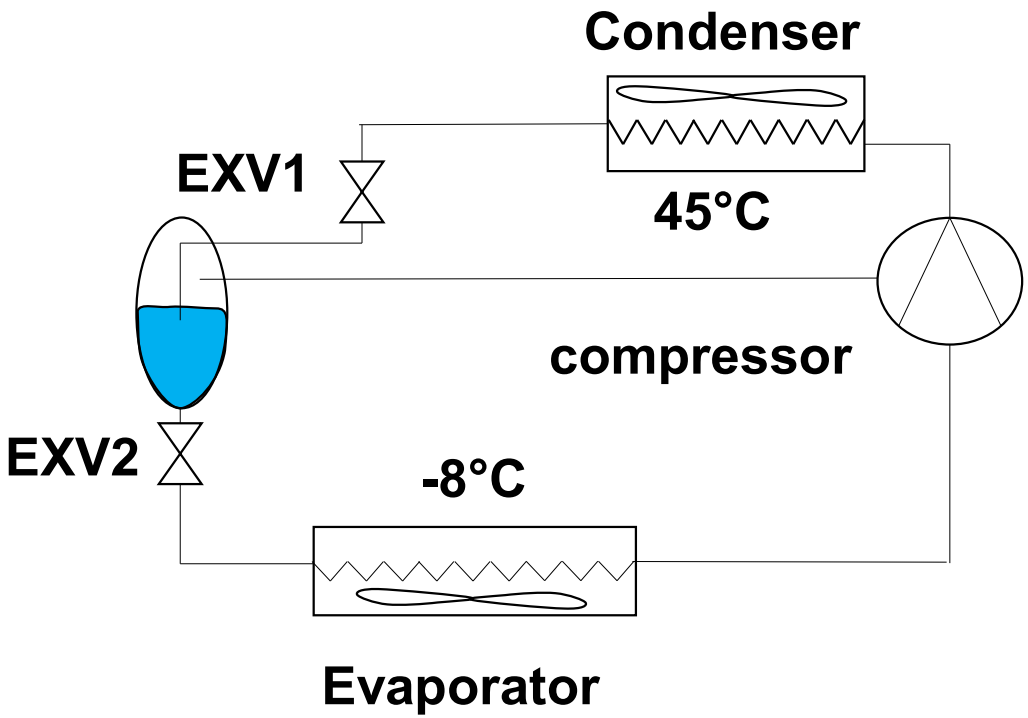
Honeywell simulations based on mentioned assumption

NH3 show better performances in basic cycle calculation (+5%)

ENHANCED CYCLE WITH LIQUID SEPERATOR

Double Expansion with vapor injection

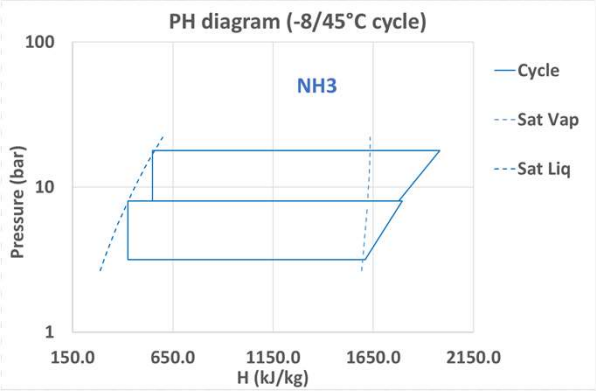
- A vapor liquid separator is installed after the EXV1
- Liquid only inter the EXV2
- Vapor is injected/compressed to the condenser pressure
- Analyses done with variable intermediate pressure

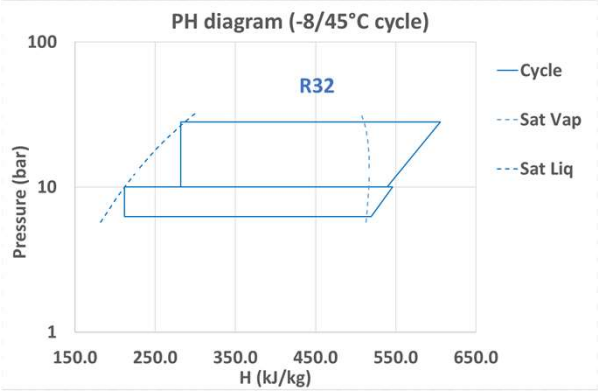


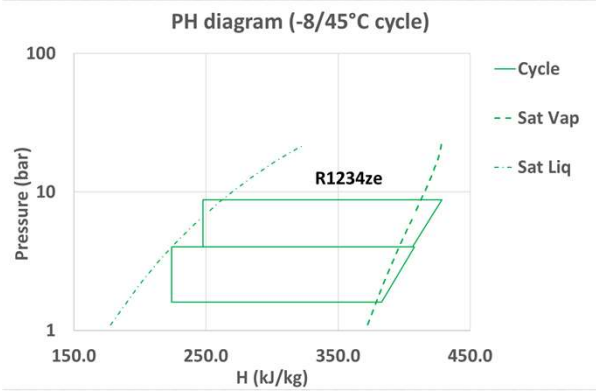
Same cycle with the same conditions is applied on all refrigerants

ENHANCED CYCLE WITH LIQUID SEPERATOR

02







Three refrigerants are selected for performances comparison under the same cycle conditions

Enhanced cycle (-8 / 45°C)

2°C SC / 5°C SUP / 0.7 μ_isen

COP is analyzed versus intermediate pressure

Intermediate Pressure interval

NH3 : 6 to 18 bars

R32 : 10 to 28 bars

R1234ze : 3 to 9 bars

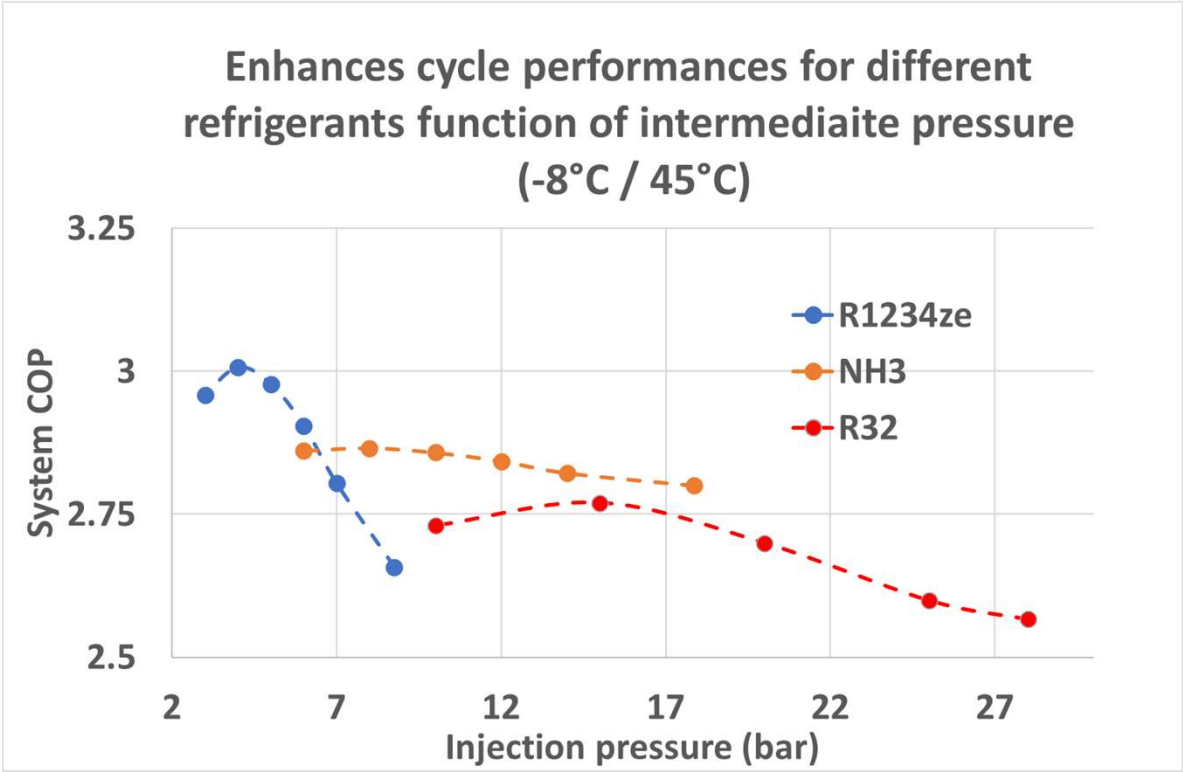
Intermediate pressure is selected to optimize the cycle COP

ENHANCED CYCLE WITH LIQUID SEPERATOR

Impact on the COP

- Enhanced configuration increase the COP of the cycles for all the studied refrigerants
- The increasing COP slope are function of the refrigerants

	COP % increase	COP
R1234ze	+ 13%	3.00
NH3	+ 1%	2.86
R32	+ 8 %	2.77



Honeywell simulations based on mentioned assumption

R1234ze COP is 4.9 % higher than the NH3 COP and 8.3% versus R32

SYSTEM PERFORMANCES MEASUREMENT

Industrial refrigeration

Solstice® ze

NH_3 | R-1234ZE SIDE-BY-SIDE COMPARISON

Measurement campaigns on a NH3 and a R1234ze chillers

Storage under controlled atmosphere

NH_3 Chiller

R-1234ze Chiller

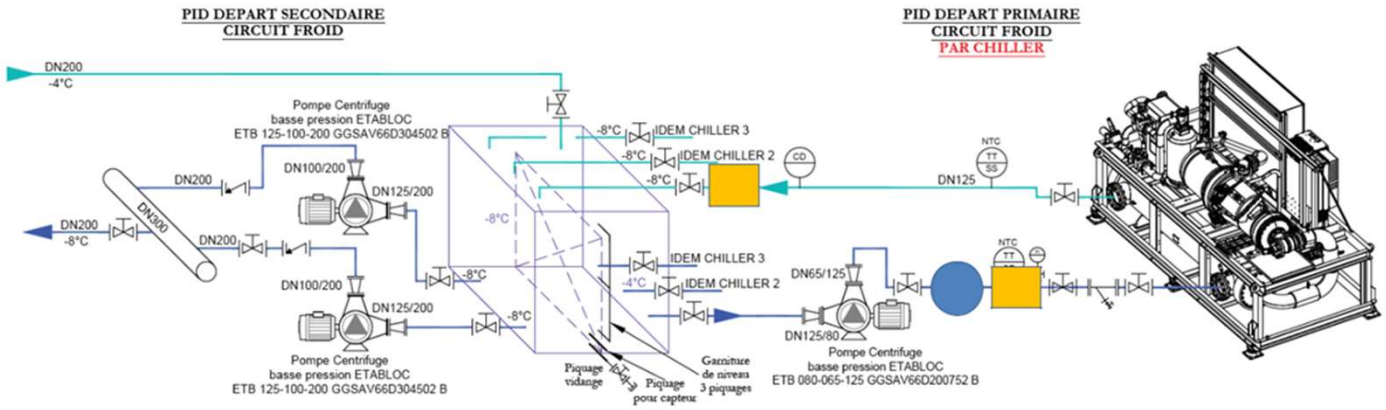
COFRA : Fruits Cooperative of Aiguillon / South-West of France

Chillers were running on the same site under the same conditions

Solstice® ze

03

COMPARISON OF NH3 AND R1234ZE CHILLERS PERFORMANCES



QUERCY REFRIGERATION mandated OPTINERGIE to carry out measurement campaigns on an NH3 chiller and a R1234ze chiller at the COFRA site in Aiguillon (Measurement campaigns was between May and December 2020)

Optinergie Study for Solstice® ze vs NH_3 Chiller at Apple Storage Facility, France

Solstice® ze

03

COMPARISON OF NH3 AND R1234ZE CHILLERS PERFORMANCES

	R1234ze Chiller		NH3 Chiller	
Compressor	✓ Max. power consumption: 301 kW ✓ Variable speed ✓ Brand: BITZER ✓ Series: CSH96113 ✓ Refrigerant: R1234ze		✓ Rated power: 160 kW ✓ Variable speed ✓ Brand: HOWDEN ✓ Refrigerant: R717 (ammonia)	
Condenser	✓ Technology: Air-cooled condensers ✓ Pout = 490 kW ✓ 10 fans of 2.48 kW each ✓ Variable speed ✓ Air flow rate = 269,410 m3/h		✓ Technology: Air-cooled condensers ✓ Pout = 507.6 kW ✓ 12 fans of 2.45 kW each ✓ Variable speed ✓ Air flow rate = 281,520 m3/h	

optinergie

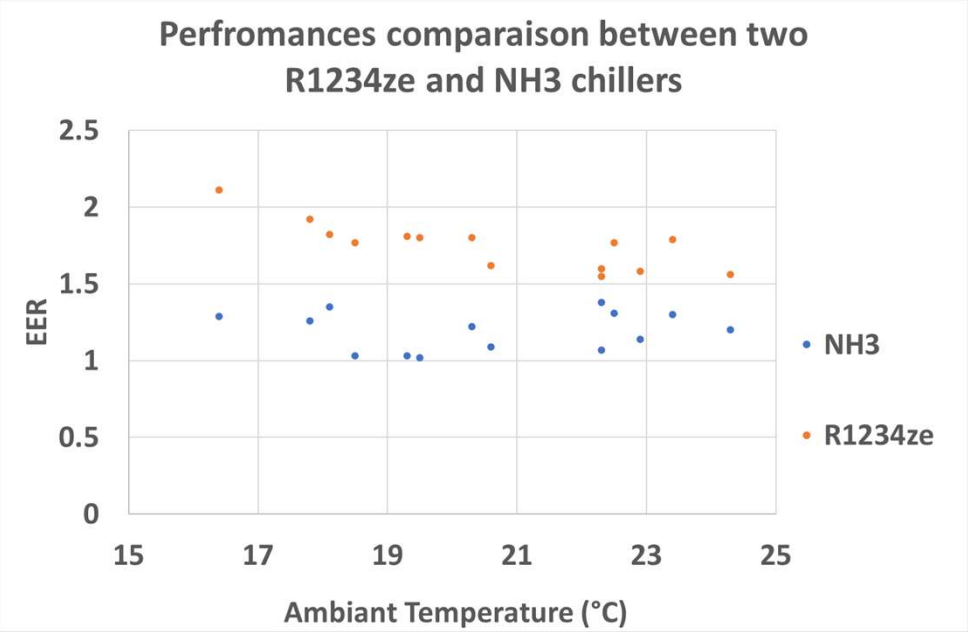
The aim of this mission was to calculate the overall EER (Energy Efficiency Ratio), i.e. the cooling efficiency coefficient for each installation. To do this, the following measurements were carried out for each chiller:

- ✓ **recording of the glycol flow rate**
- ✓ **recording of the inlet and return temperatures on the glycol loop**
- ✓ **electrical consumption of chillers (compressors, condenser, auxiliaries)**

The EER is determined by the ratio between the cooling capacity produced and the electrical energy consumed by the chiller.

The two installation use the same regulation technologies

COMPARISON OF NH3 AND R1234ZE CHILLERS PERFORMANCES



Results are from Optinergie report

The R1234ze chiller performances exceed the NH3 chiller performances

- ✓ R1234ze EER shows higher values versus NH3 EER
- ✓ Calculated medium EER increase is around +25%
- ✓ EER increase allow around ~ € 2M lifetime saving

R1234ze technology shows interesting performance versus NH3

TECHNOLOGIES PERSPECTIVES

Technical perspectives

NH3 challenges

SUSTAINABILITY / TECHNOLOGY

04

Technology evolution will favor R-1234ze not NH_3

Oil-free

- ✓ Cannot be applied to NH_3 when easy to R-1234ze (big stock of COP here)

New Compressor Technologies

- ✓ High-lift oil-free Turbocor will only be applicable to HFO
- ✓ Next Gen screw compressors will only apply to HFO

Thermodynamic Cycle Enhancement

- ✓ Sub-Cooling will benefit R-1234ze more than NH3 (1% COP more per 1K of SC)*
- ✓ 2-stage or economizer will benefit R-1234ze* more

**** CRITICAL TEMPERATURE AND PERFORMANCE OF REFRIGERANTS - APPLICATION TO CHILLERS*** *Paul DE LARMINAT, Johnson Controls Industries, 24th IIR International Congress of Refrigeration– August 16-22, 2015*

Technology Sustainability favors R-1234ze

HAZARDS COMPARISON

Property	Ammonia (NH_3)	Solstice® ze (R-1234ze)
ASHRAE Classification	**B2L**: Highly toxic & Slightly flammable (between 15% and 28% in the air)	**A2L**: Non toxic & Slightly flammable (only above 30°C)
Corrosive / Irritant	**Class E**: Severe burns to skin and human tissues Permanent effects	Non-irritating nor corrosive
Materials compatibility	Attacks copper, zinc and many other metals	Compatible with common metals and alloys
PED Group	**1** (flammable, toxic, oxidizing)	**2** (non-hazardous)
Vapor Density	Lighter than air, but in humid ambiance it can form vapors heavier than air	
Charge Limitations	Building code constraints and charge limitation within populated areas	No charge limit in machine rooms / outside
Other	• Can be a precursor for explosive materials (Listed in the potential risks for terrorist attacks)[1] • Can contribute to eutrophication (algae bloom)	

NH_3 is a Hazardous Chemical (Toxic, Corrosive, Severe Irritant), but Solstice® ze is NOT

1 https://www.health.ny.gov/environmental/emergency/chemical_terrorism/docs/ammonia_general.pdf

NH_3 PHYSICAL PROPERTIES IMPACTING COP

Oil leak,
bottom of glycol HX

- Not miscible with oil
- Needs oil separators
- Even with best oil separator (98% efficient), 2% oil still carry-over in the system
- Oil doesn't return to compressor with liquid (immiscible) but accumulates in cold areas like glycol HX
- Result ➡ Drop in HX coefficient and chiller efficiency

- Highly hygroscopic
- Water penetrates easily when servicing
- Difficult to remove by vacuum pumping
- COP and cooling capacity heavily affected by water content in the circuit
- NH_3 systems require SS pipes rendering bad heat transfer

Oil and Water: Biggest Culprits for Less Efficient NH_3 Systems

04

SOLSTICE® ZE | ENERGY INTELLIGENCE

- R-1234ze is the most energy efficient solution for MT refrigeration processes. Technology developments will even increase this efficiency going forward.
- R-1234ze is safe to use with Copper Std pipes, no reported issues of black dust or any rust related issues.
- R-1234ze does not produce TFA in any measurable amounts and does not break down to produce short chain PFAS that negatively impact the environment and human and animal health
- R-1234ze is a water insoluble, highly volatile, liquefied gas with a boiling point of -19°C. So in case of any catastrophic leakage or spill in water at temperatures of 0°C or above, any liquefied gas will flash vaporize into air. Any remaining dissolved gas will also vaporize with time.
- No other product available today provides the comprehensive range of advantages that R-1234ze offers, including energy efficiency, negligible climate impact, ease of conversion, safety in use and low total cost of ownership

Move over NH_3, It's Time to Meet Solstice® ze

THANK YOU

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CONNECTING EXPERTS.