

ENGINEERING
TOMORROW

Danfoss

Refrigerant update May 2018

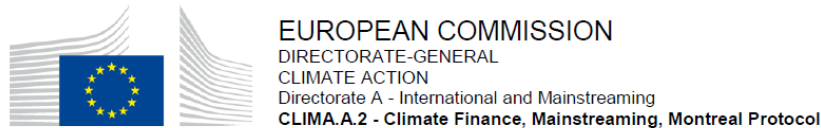
AFAR May 2018, Ibon Vadillo

Let's bring the
refrigerant transition
down to earth

EU F-gas regulation

Impact of phase down – potential price scenario

F-Gas Consultation Forum meeting
Brussels 6. March 2018



3rd Meeting of the Consultation Forum

Extract from MOM :

Abatement prices are ok within the range
of **up to 50 Euro/t CO2e considered reasonable** as regards a fair share
contribution to long-term climate goals.

Price per kg
Based on 50€ / ton CO2

R404A : 195 €

R452A : 107 €

R407H : 75 €

R448/9A : 70 €

R454A : 12 €

R455A : 7 €

R290 : 0,2 €

R410A : 96 €

R452B : 34 €

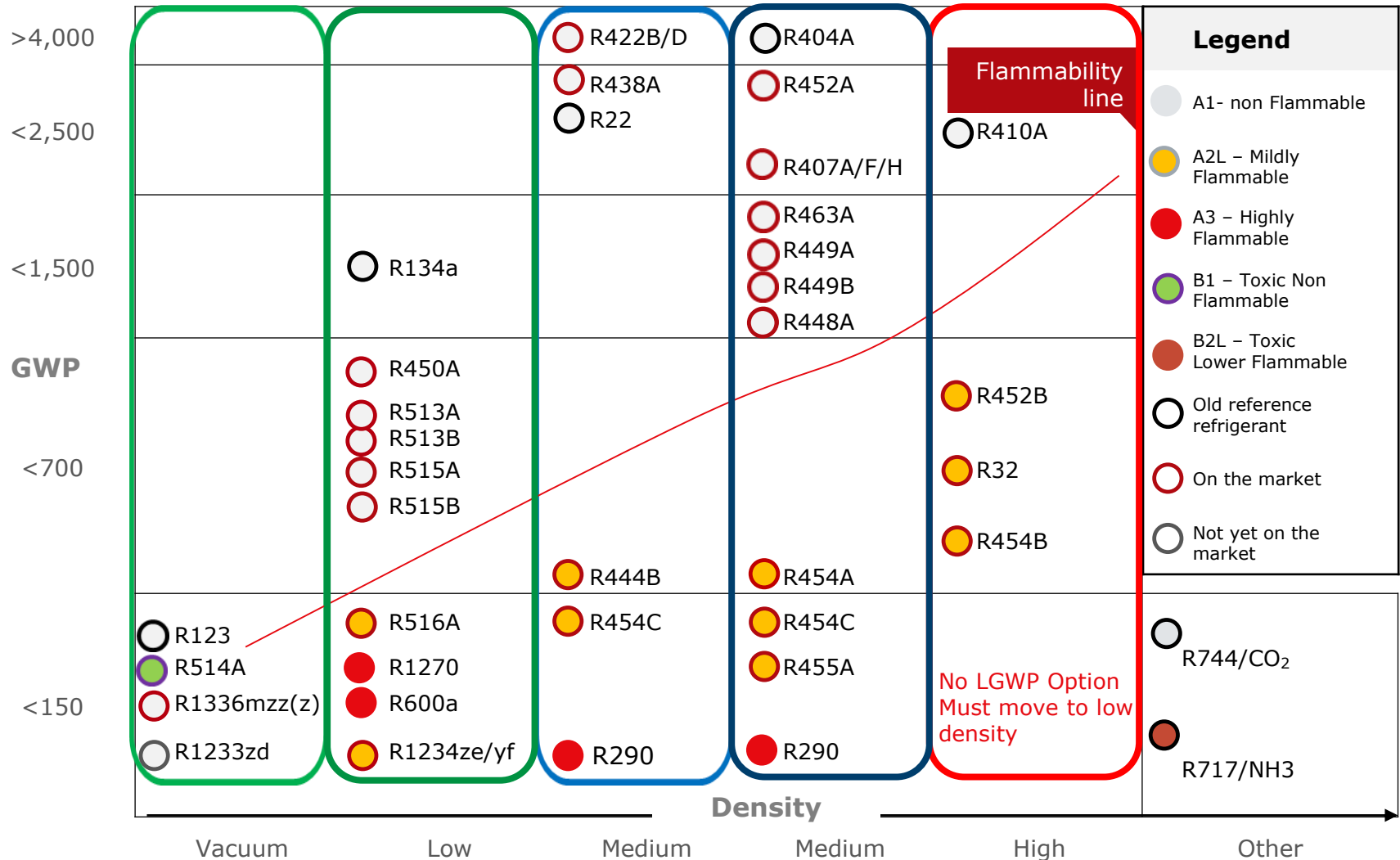
R32 : 34 €

R454B : 23 €

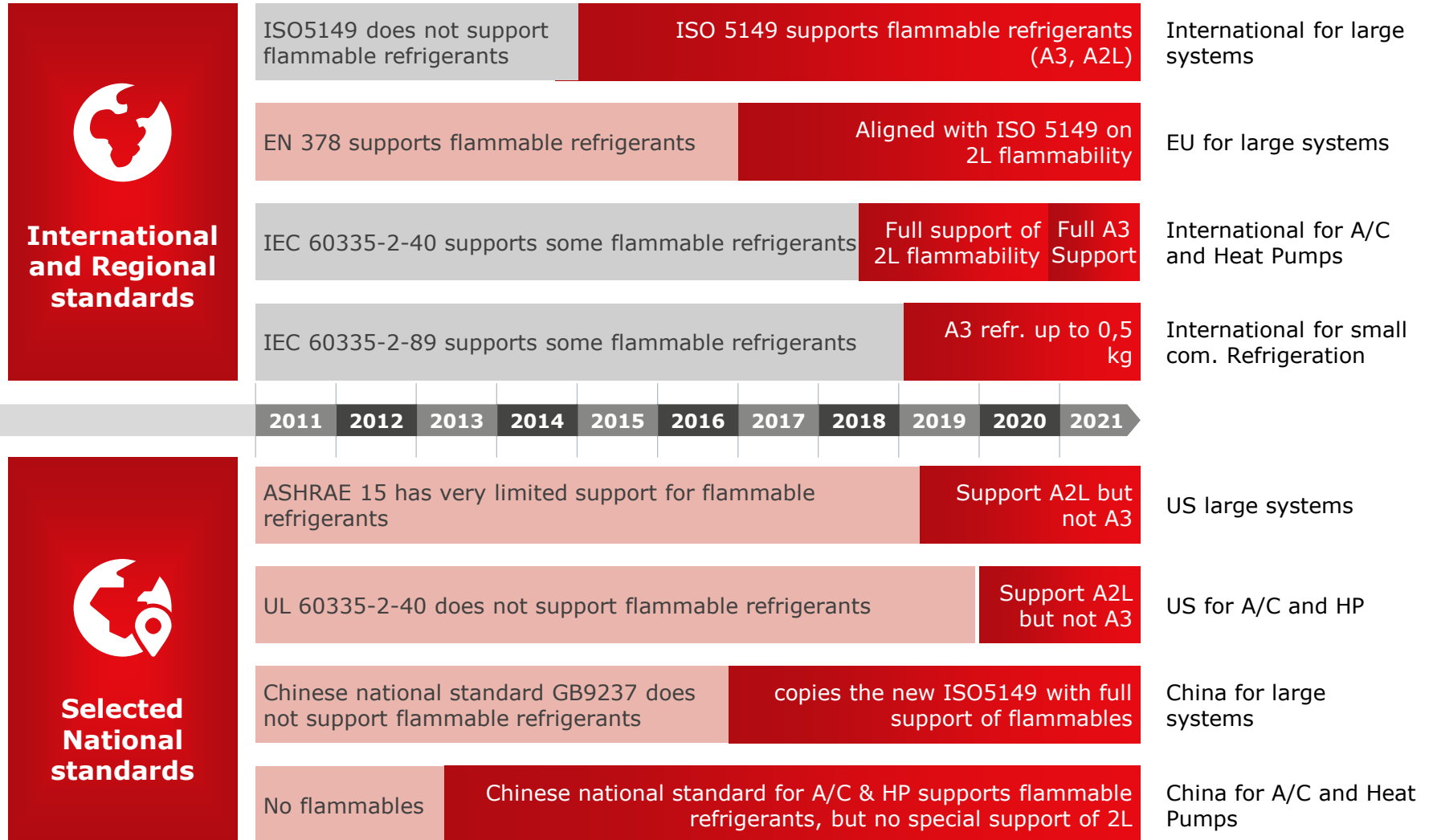
R134a : 65 €

Main refrigerants in Play

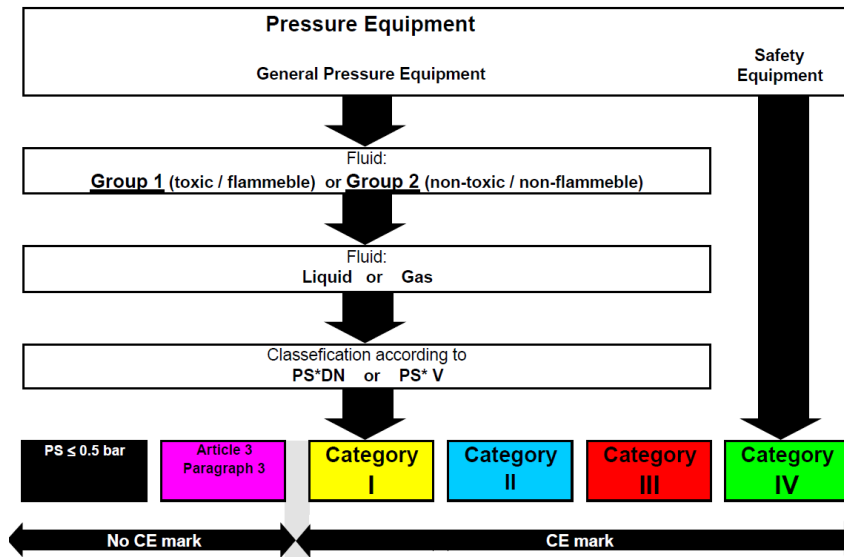
a Picture in Continuous Evolution



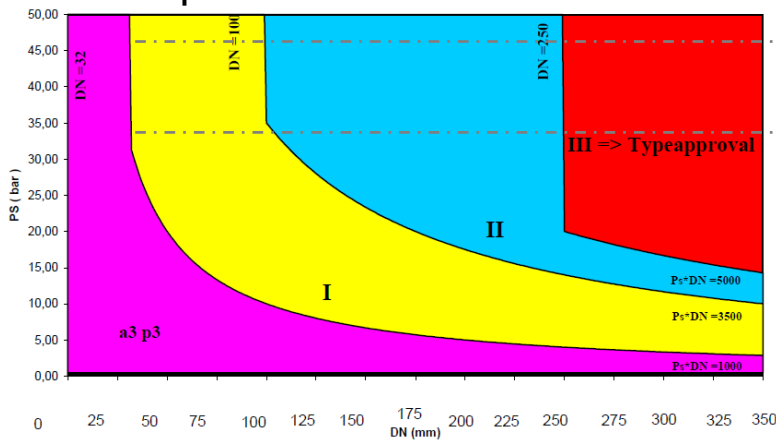
Timely – Safety Standards Development - recognising the **need for flammable refrigerants**



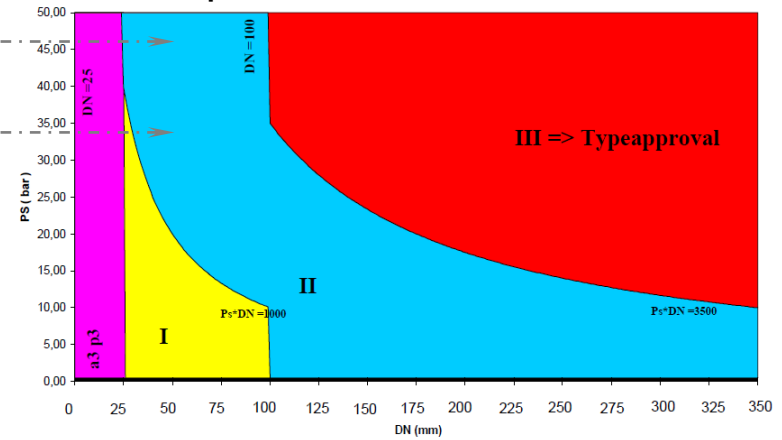
Pressure Equipment Directive



Group 2



Group 1



Refrigerant strategy – Commercial Refrigeration

Applications Industries

Present

Short Term Up to 2022

Long Term 2022-2030



R717
R744

R717
R744

R717
R744

No change expected

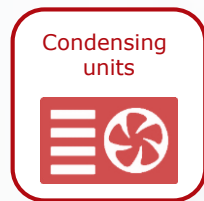


R134a
R407A/R407F
R448A/R449A
R744

R134a
R513A/R450A
R448A/R449A
R744
R290

R744
R290
HFO blends

2020 (service) and 2022 - EU Supermarket 150 GWP



R134a
R404A
R407A/F
R452A
R448A/R449A
R290

R134a
R452A
R513A/R450A
R448A/R449A
R744
R290

R1234yf
R744
R290
R513A/R450A
R455A
HFO blends

EU quotas 2022 - EU: Bans GWP 2500 or less



R134a
R290
R404A
R600a
R744

R134a
R290
R513A
R600a
HFO blends

R290
R600a
R1234yf
HFO blends

Also address plug in units for water loop systems

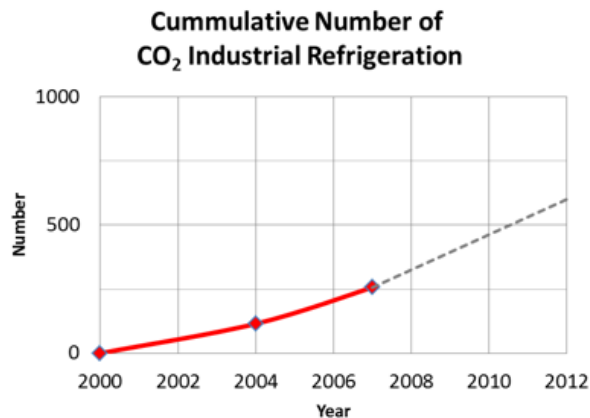
2016 – US SNAP R134a 2020/22 - EU: Bans GWP 2500 and 150

The refrigeration segments are moving to **low GWP** and **natural refrigerants**

Note: Ice machines have their own ruling under SNAP. R404A or R410A have **not** been delisted and will likely continue at least up to 2022

Industrial Refrigeration

- Ammonia more than 100 years of experience
- Safety requirements: Toxicity (NH₃) and flammability (HC)
 - Tightness in Components and systems
 - Charge Reduction: (CO₂ cascades/brine)

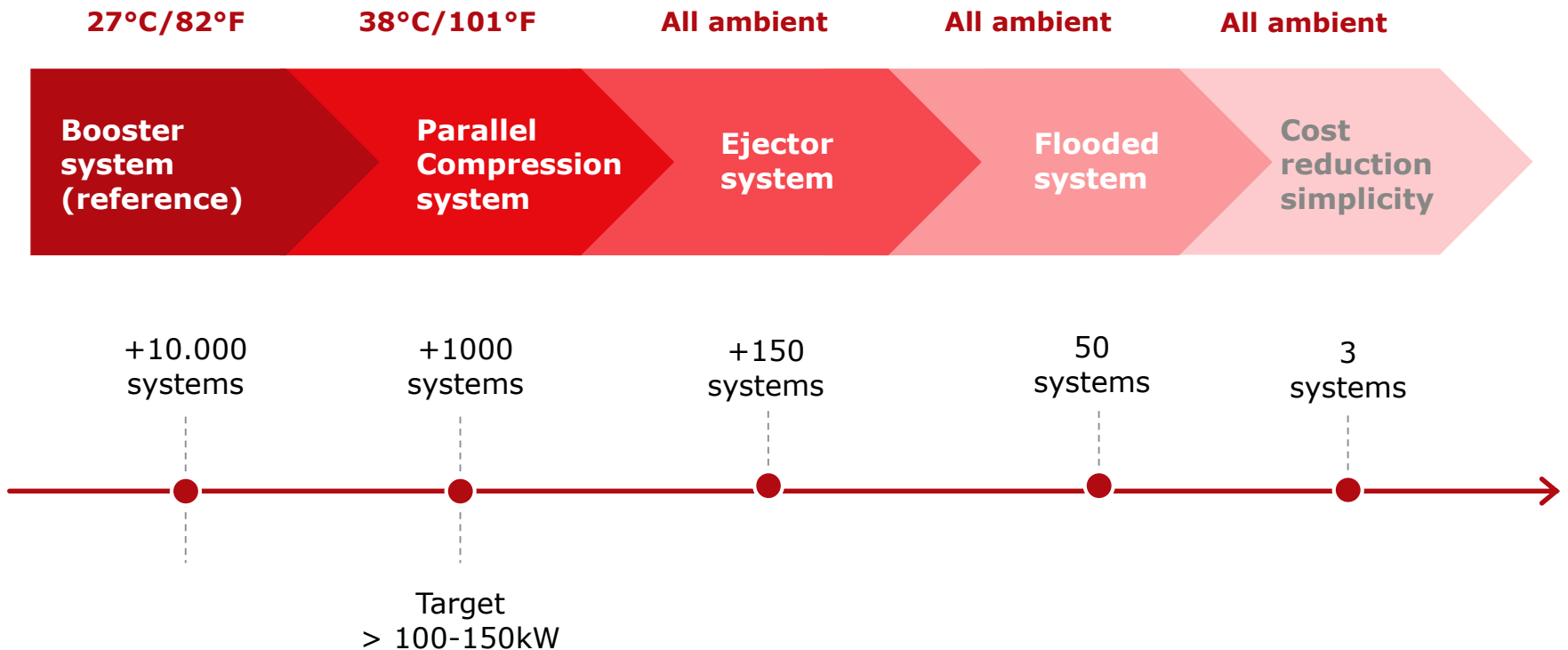


Industrial Refrigeration

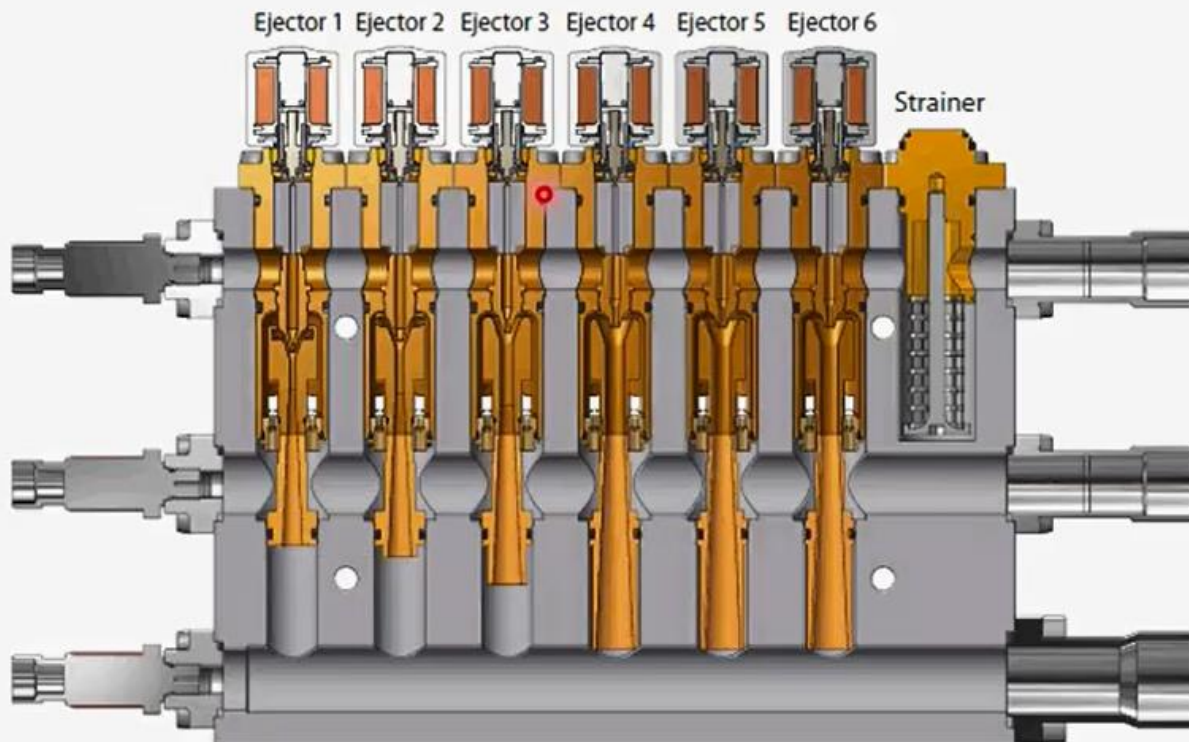
		Industry Drivers (external requirements)					
Application (system type)	Driver (application)	Safety	Global Warming	Energy Saving	Cost	Increased pressure rating	Improved tightness requirements
		Safety requirements toxicity (NH ₃) / flamb. (HC)	"Green Image" Sustainability	Operation cost	First cost of installation		
"Classic" NH₃ installation (pump)							
NH ₃ (high temp.) -> NH ₃ -CO ₂	Reduce NH ₃ charge	●				●	●
NH ₃ (low temp.) -> NH ₃ -CO ₂	Reduce NH ₃ charge / efficiency	●		●		●	●
R22 -> NH ₃ -CO ₂	Eliminate Fgas	●	●			●	●
Glycol system -> CO ₂ pump.	Increase efficiency		●	●		●	●
R22 -> HC	Eliminate Fgas	●	●		●		
"Classic" NH ₃ -> NH ₃ DX	Reduce NH ₃ charge	●					
NH ₃ Heat pumps	Reuse energy		●	●		●	●
CO ₂ Heat pumps	Reuse energy		●	●		●	●
Product requirements		Driver (product)					
Direct welded components	Pressure & tightness					●	●
Increased pressure ratings	Pressure					●	
Increased product safety (e.g. PED)	Safety	●					
Increased use of electronic controls	Efficiency						
Enhanced control systems	Efficiency		●				
Reduce pressure drop	Efficiency		●	●			
Component fast and easy to install	Cost		●	●	●		
Fast and flexible delivery	Cost		●	●	●		

Multipack Centralized, Supermarkets

Technology allows for world wide adoption of CO₂ only systems



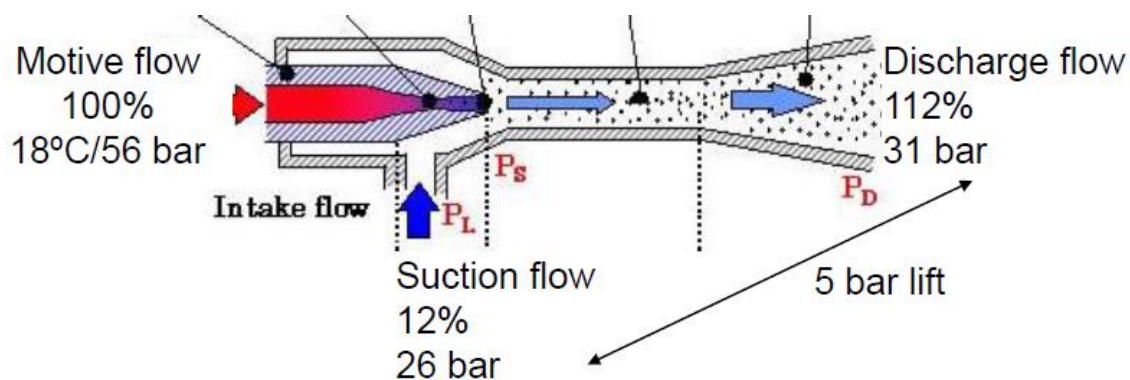
Multi Ejector Block



Type	Code no.	Product name	Ejector 1	Ejector 2	Ejector 3	Ejector 4	Ejector 5	Ejector 6
CTM 6	032F5673	CTM Multi Ejector HP 1875	CTM EHP 125	CTM EHP 250	CTM EHP 500	CTM EHP 1000	Dummy	Dummy
CTM 6	032F5674	CTM Multi Ejector HP 3875	CTM EHP 125	CTM EHP 250	CTM EHP 500	CTM EHP 1000	CTM EHP 1000	CTM EHP 1000

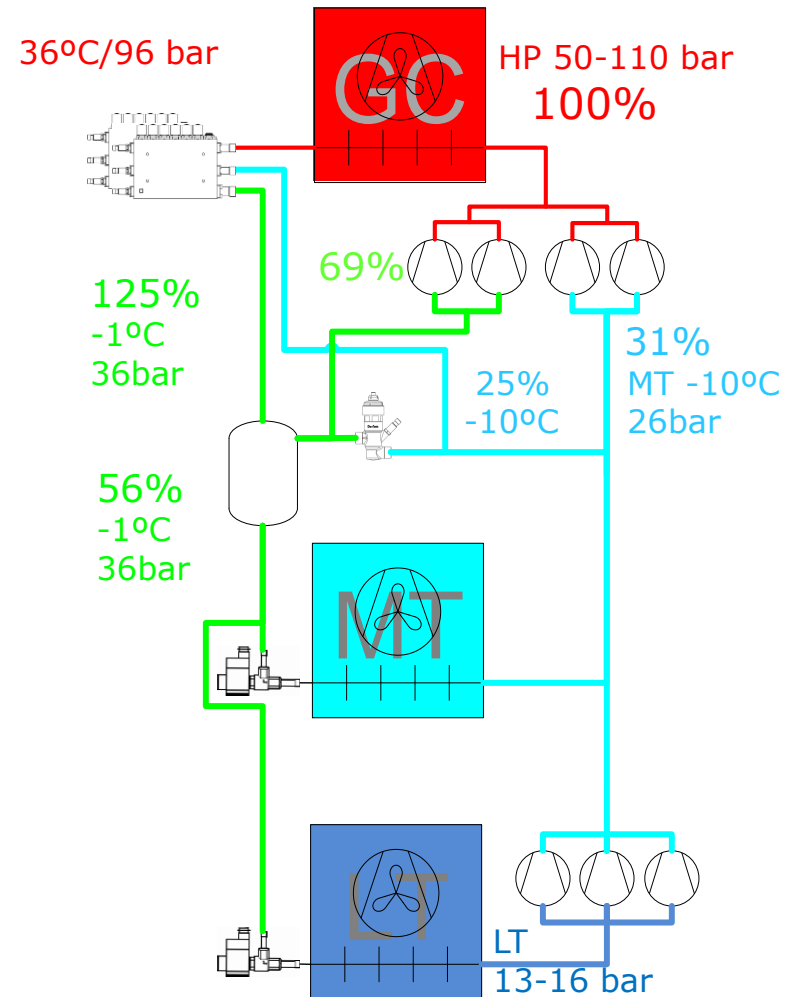
Multi Ejector Block

	High Pressure (HP)	Low Pressure (LP)	Liquid Ejector (LE)
Media on suction side	Primary gas	Primary gas	Primary liquid
CO2 system	Parallel compression	Booster	Booster
Lift/entrainment	6 bar/25% @ 23°C	3 bar/63% @ 23°C	5 bar/17% @ 5°C
	11 bar/25% @ 36 °C	7 bar/50% @ 36°C	5 bar/35% @ 20°C

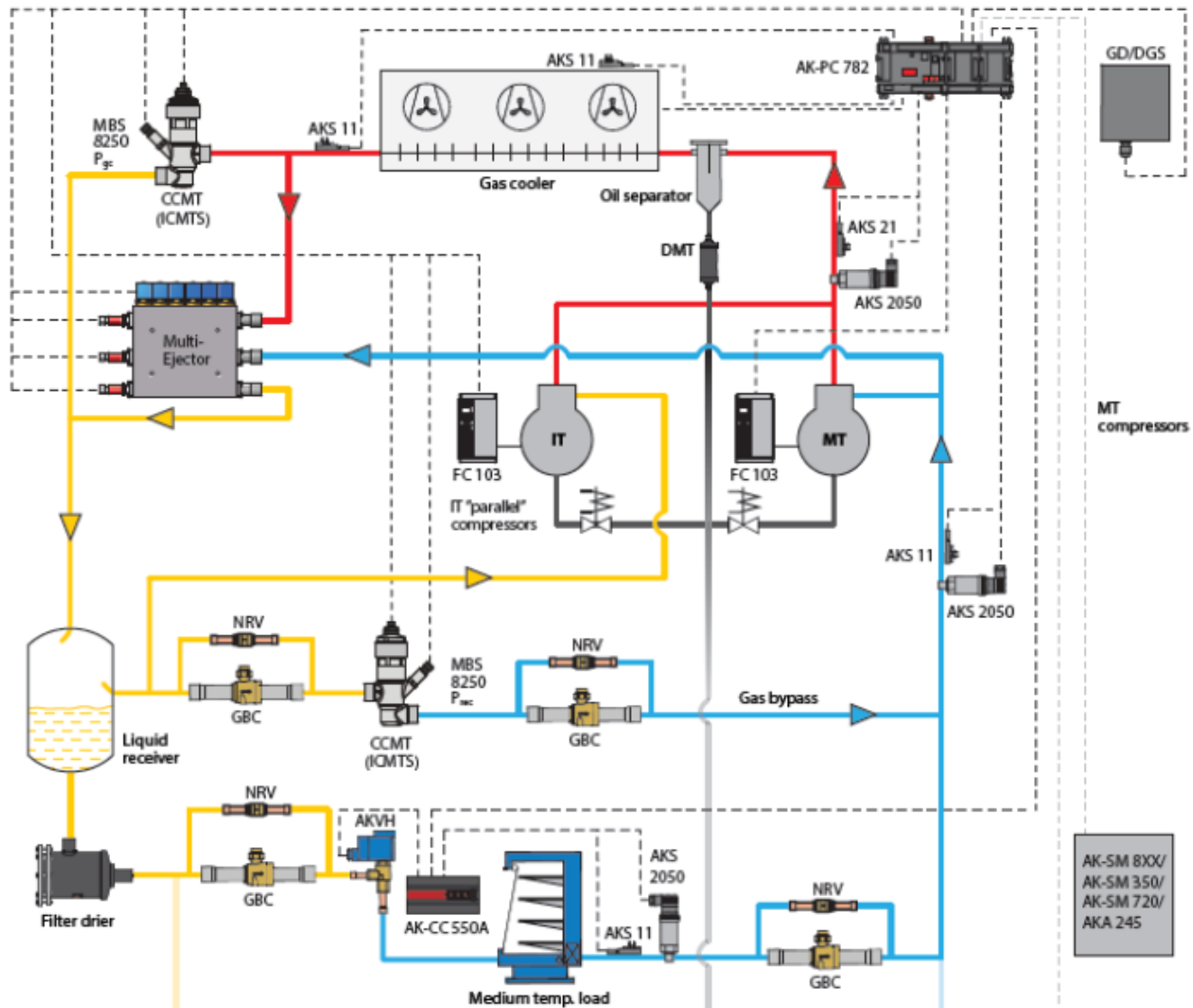


Parallel compression with HP Gas Ejector

- Energy in Warm Climates:
 - Up to -9% vs Paral. Comp.
 - Up to -17% vs Booster
- Swep Volume Saving up to 15-35%
- Target Size from 100-150kW

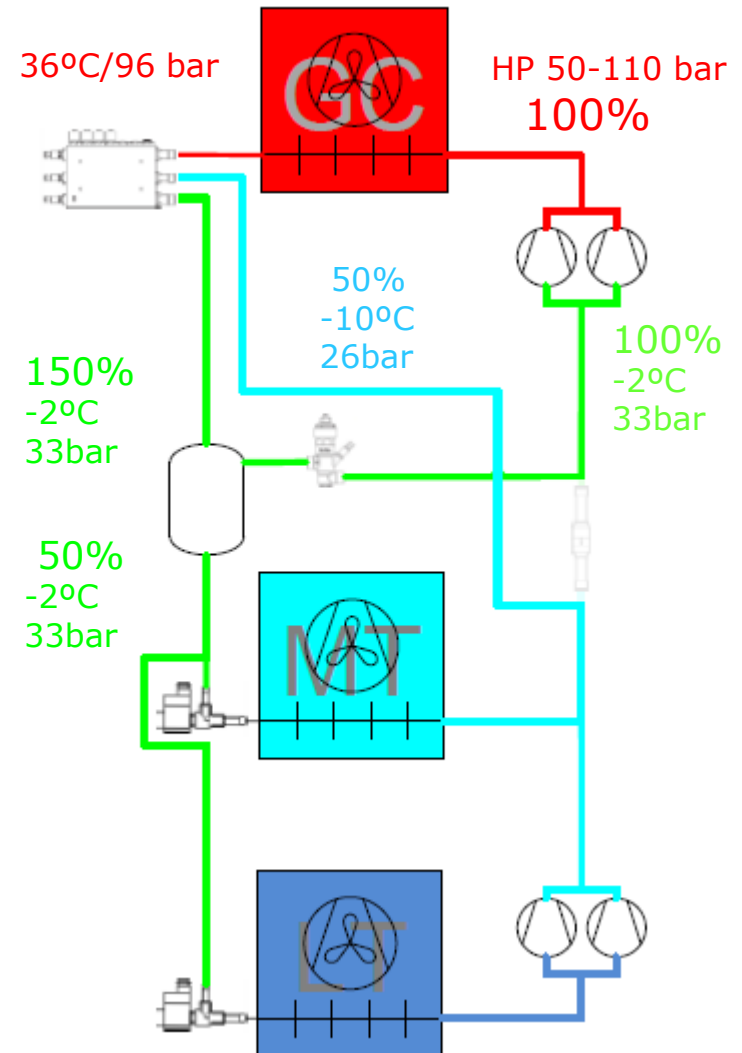


Parallel compression with HP Gas Ejector



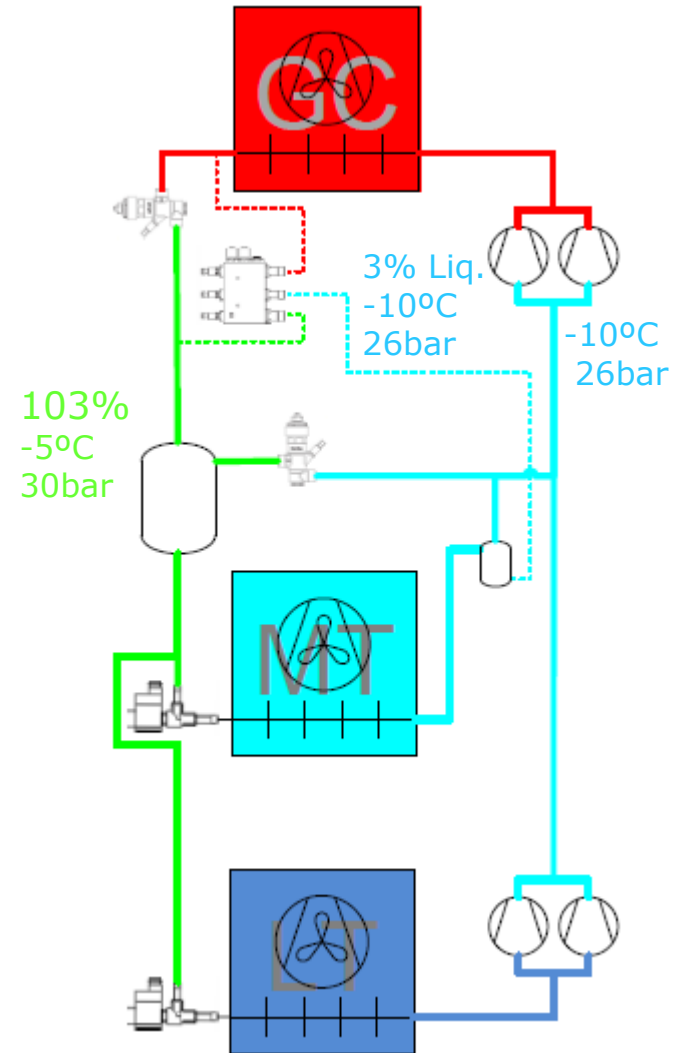
Low Pressure Lift Ejector

- No Paral. Comp.
- Up to -15% vs Booster
- Due to high Suction Pressure MT (7bar higher at 32°C), required swep volumen will be approx. 75% of booster system
- First Cost similar to Booster
- Target 40-150kW



Liquid Ejector

- All systems
- Higher suction Pressure, 1-3K than DX in design point, on average 4-6K higher.
- Swep Volume saving
- Cost can be reduced
- Flooding evaporators managed by case controller (1-5% is returned), if needed DX
- Lift of 5bar even at low high pressures (down to 45bar)
- Target size is more or less all systems



Stationary refrigeration equipment



F-Gas impact:

- > **Phase down** of high GWP refrigerants (i.e. R404A)
- > **Ban 12:** ban of R404A in new equipment:
 - > GWP limit to 2500 from January 2020
 - > Alternative refrigerants: R407A/F, R448/9A, R452A

Danfoss portfolio with alternative ref.	R407A/ R407F	R448A/ R449A	R452A	R290	R134a	R450A	R513A
Fixed speed compressors	✓ MBP recip & scrolls	✓ MBP recip & scrolls ✓ LBP scrolls	✓ LBP recip & scrolls ✓ MBP recip • MBP scrolls	• MBP recip	✓ MBP recip & scrolls	• MBP recip & scrolls	• MBP recip & scrolls
Variable speed compressors	✓ MBP recip & scrolls	✓ MBP scrolls			✓ MBP recip		
Fixed speed fractional compressors		✓ MBP R449A within limits	✓ MBP & LBP within limits	✓ MBP & LBP	✓ MBP		
Variable speed fractional compressors				✓ MBP & LBP	✓ MBP		
Packaged condensing units	✓ MBP fixed and variable speed ranges	✓ MBP fixed speed ranges • MBP variable speed • LBP fixed speed with LI	✓ LBP fixed speed ranges • MBP fixed speed		✓ MBP fixed speed ranges		
Bare condensing units	✓ MBP	✓ MBP	✓ MBP & LBP	✓ LBP • MBP	✓ MBP		
Controls	✓ Thermostatic and electronic expansion valves, solenoid valves (new EVR), sight glasses, ball valves, pressure & temperature regulating valves, water valves, switches, electronic controllers						
Heat Exchangers	✓ Micro-channel, micro-plate heat exchangers						

Available in 2018

Hermetically sealed systems

Boottle cooler, vending machines, clip-on unit for cold rooms



F-Gas impact:

- > **Phase down** of high GWP refrigerants (i.e. R134a and R404A)
- > **Ban 11 in 2 steps:** ban of R404A and R134a in new equipment
 - > In January 2020: GWP <2500
 - > Alternative refrigerants: R450A, R513A
 - > R448A, R449A and R452A are also valid until 2020
 - > In January 2022: GWP <150
 - > Sustainable refrigerant: R290

Danfoss portfolio with alternative refrigerants	R290	R450A	R513A
Fixed speed compressors	• MBP recipis	• MBP recipis & scrolls	• MBP recipis & scrolls
Fixed speed fractional compressors	✓ MBP & LBP	Under evaluation	
Variable speed fractional compressors	✓ MBP & LBP		
Controls	✓ Thermostatic and electronic expansion valves, solenoid valves (new EVR), sight glasses, ball valves, pressure & temperature regulating valves, water valves, switches, electronic controllers		
Heat Exchangers	✓ Micro-channel, micro-plate heat exchangers		

Available in 2017 - Available in 2018

Refrigerant strategy - **Air Conditioning**

Applications Industries

Present

Short Term Up to 2022

Long Term 2022-2030

Centrifugal & Screw Chillers



R134a
R1234ze
R1233zd
R123
R513A
R514A

R134a
R1233zd
R1234ze
R513A
R514A
R515B

R1233zd
R514A
R1234ze
R515B

EU taxes,
quotas
2024 Ban
R134a/SNAP
US

Scroll Chillers



R410A
R407C
R290

R32
R452B
R454B
R410A
R290

R1234ze/yf
R515B
R32
R452B/R454B
R290

EU quotas
2022 F-Gas
revision
2024 Ban
R410A/SNAP
US

Air Handling Units
Rooftops




R410A
R407C

R410A
R32
R452B/R454B
R513A

R515B
R32
R452B/R454B
R1234ze/yf

Heat pumps,
Window units,
Split systems



R410A
R407C
R290
R32

R410A
R32
R452B/R454B
R290

R290
R452B
R454B
R32

2025 Ban -
EU R410A
Self-
contained

VRF



R410A

R410A
R32
R513A

R32
R513A

The air conditioning segments are moving to **low and medium GWP** and **natural refrigerants**

Danfoss R32 & R452B Comparison

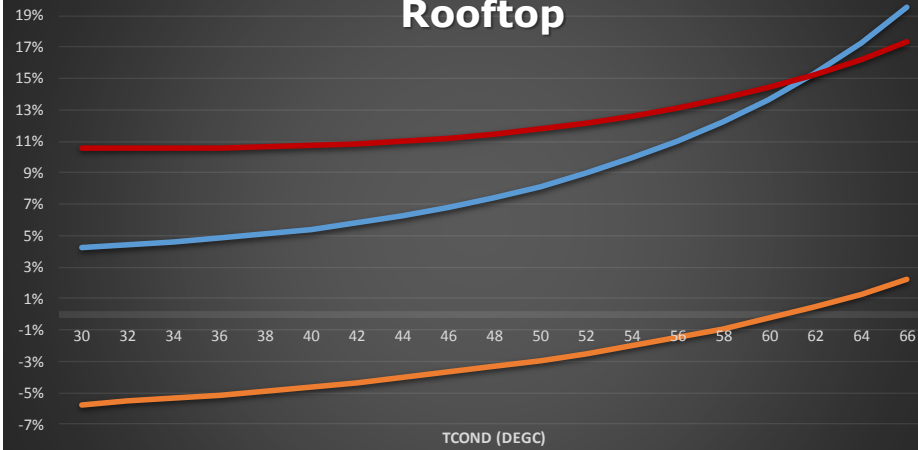
	R410A	R32	R452B
Glide	😊 0.2K	😊 0K	😊 < 2K
DGT	😊 Max 135C (275F)	😞 Up to +35K (+63F)	😞 Up to +10K (+18F)
Max Tk	😊 68C (154.4F)	😞 62C (143.6F)	😊 68C (154.4F)
CP EER ARI 7.2(45)/54.4(130)*	3.24 (11.06)	😊 3.35 (11.43) +3.4%	😊 3.34 (11.40) +3.1%
CP EER PL chiller 4(39)/32(90)*	6.29 (21.45)	😊 6.31 (21.54)	😞 6.28 (21.42)
CP EER FL RTU 9.5(49)/50(122) *	4.13 (14.08)	😊😊 4.21 (14.38) +2.1%	😊😊 4.21 (14.36)
CP EER PL RTU 9.5(49)/34(93) *	7.32 (24.96)	😊😊 7.45(25.41) +1.8%	😊 7.34(25.06)
Qe @ ARI	100%	😊😊 110%	😞 98%
Qe @ Max Tk (62C / 143.6F)	100%	😊😊 115%	😊 100%
System Performance	Due to regulations, DTC/DTE must be reduced	😊 Better HTC, 50% lower pressure drop "liquid side", higher critical temperature	😊 Similar to R32 (since 67% of it) but in lower proportion
Oil	😊 Common and cheap POE	😞 Different POE to solve high solubility & low miscibility at the same time	😊 Same as R410A
Refrigerant Charge	100%	Estimated at 85% w/ opt. design	Estimated at 90%
Safety	😊 A1	😞 A2L	😞 A2L

Compressor Back-2-Back Performance Comparison

R410A-R32-R452B in Compressor Test

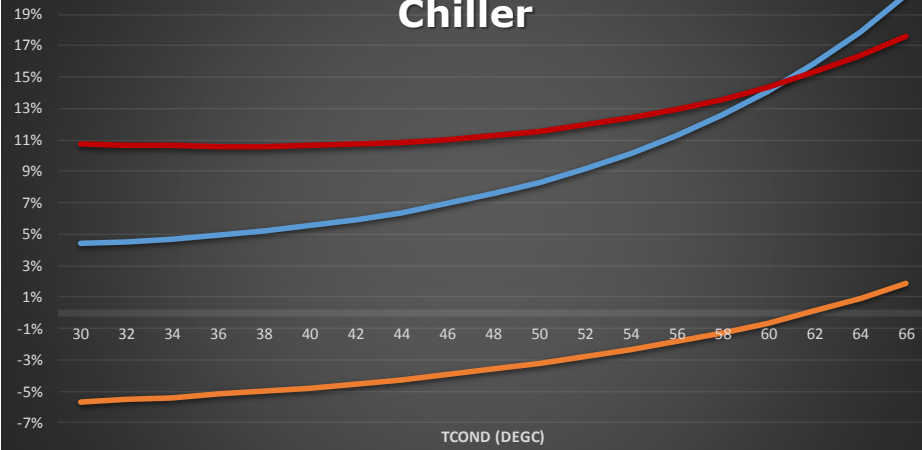
Qe Comparison (Tevap: 9.5C-49F)

Rooftop

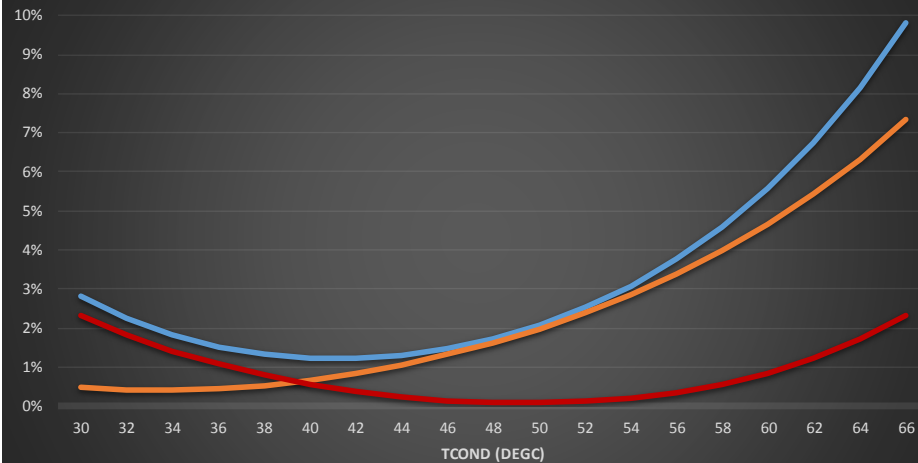


Qe Comparison (Tevap: 4C-39F)

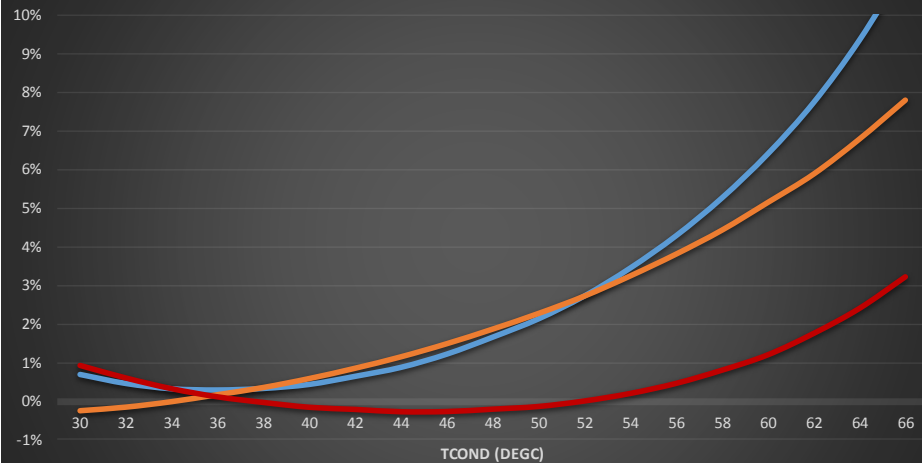
Chiller



EER Comparison (Tevap: 9.5C-49F)



EER Comparison (Tevap: 4C-39F)



— R32/R410A — R452B/R410A — R32/R452B

— R32/R410A — R452B/R410A — R32/R452B



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