



HFO REFRIGERANTS FOR CHILLER APPLICATIONS

ISKID CONFERENCE
STEFAN SCHUESSLER

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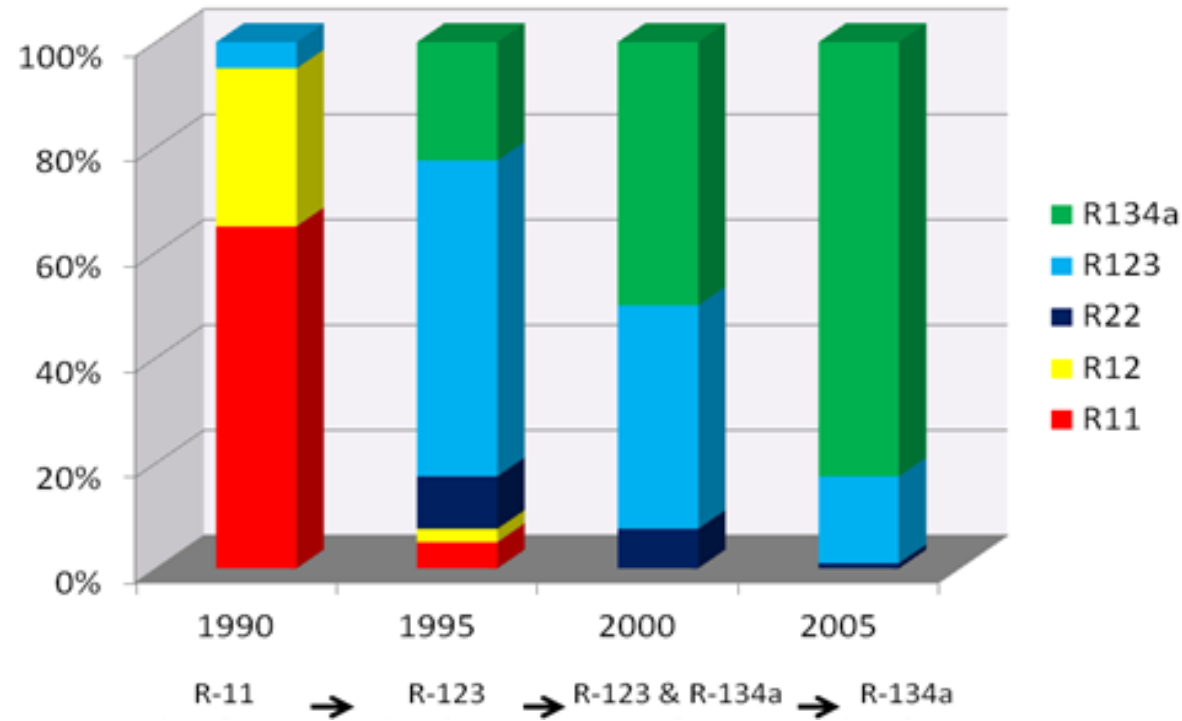
Honeywell

HFO REFRIGERANTS FOR CHILLER APPLICATIONS

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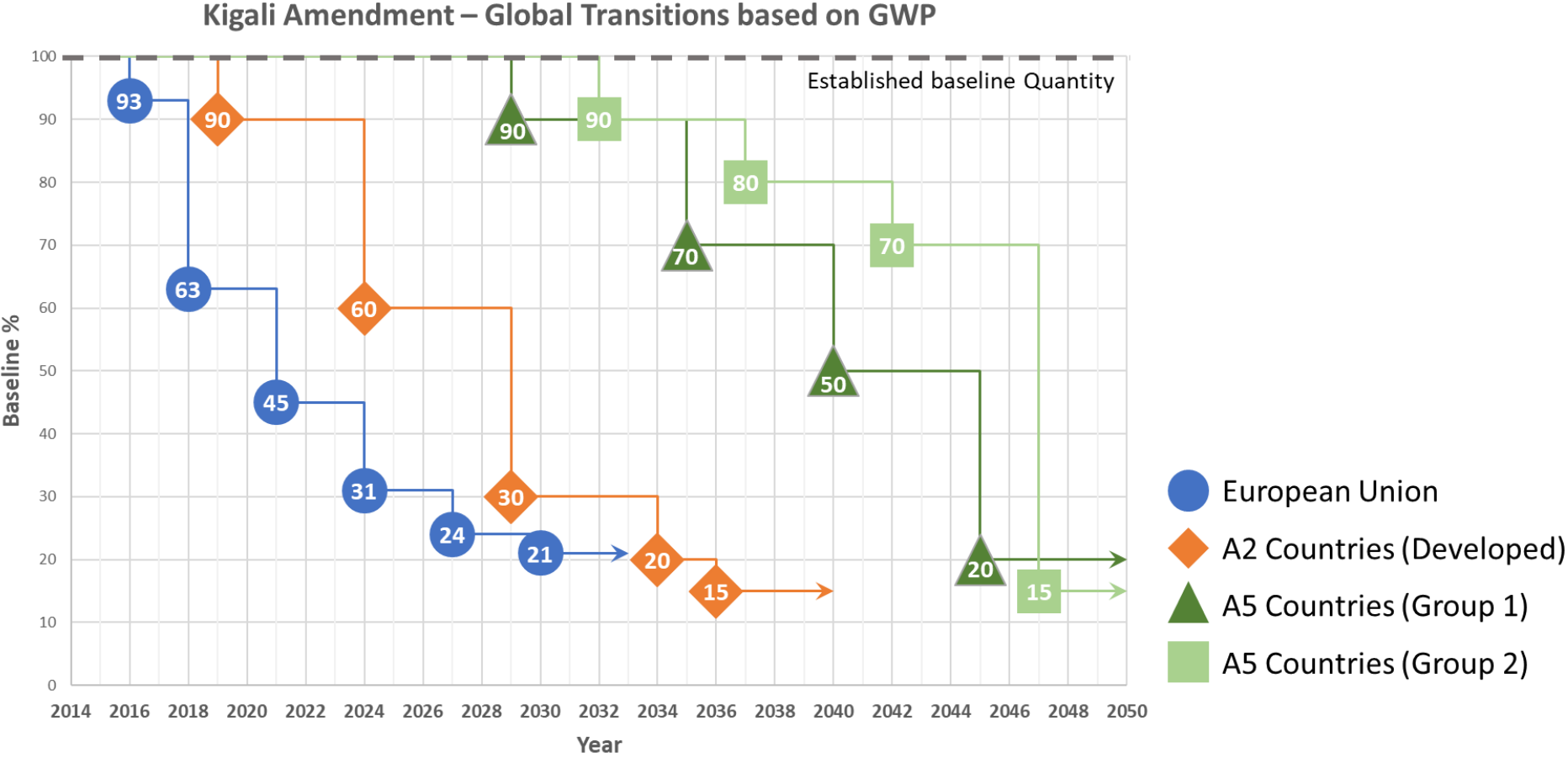
- **Introduction**
- **Regulatory Requirements**
- **Low GWP Chiller Refrigerants**
- **HFO Chiller Applications**
- **Conclusion**

CENTRIFUGAL CHILLER MARKET SHIFT

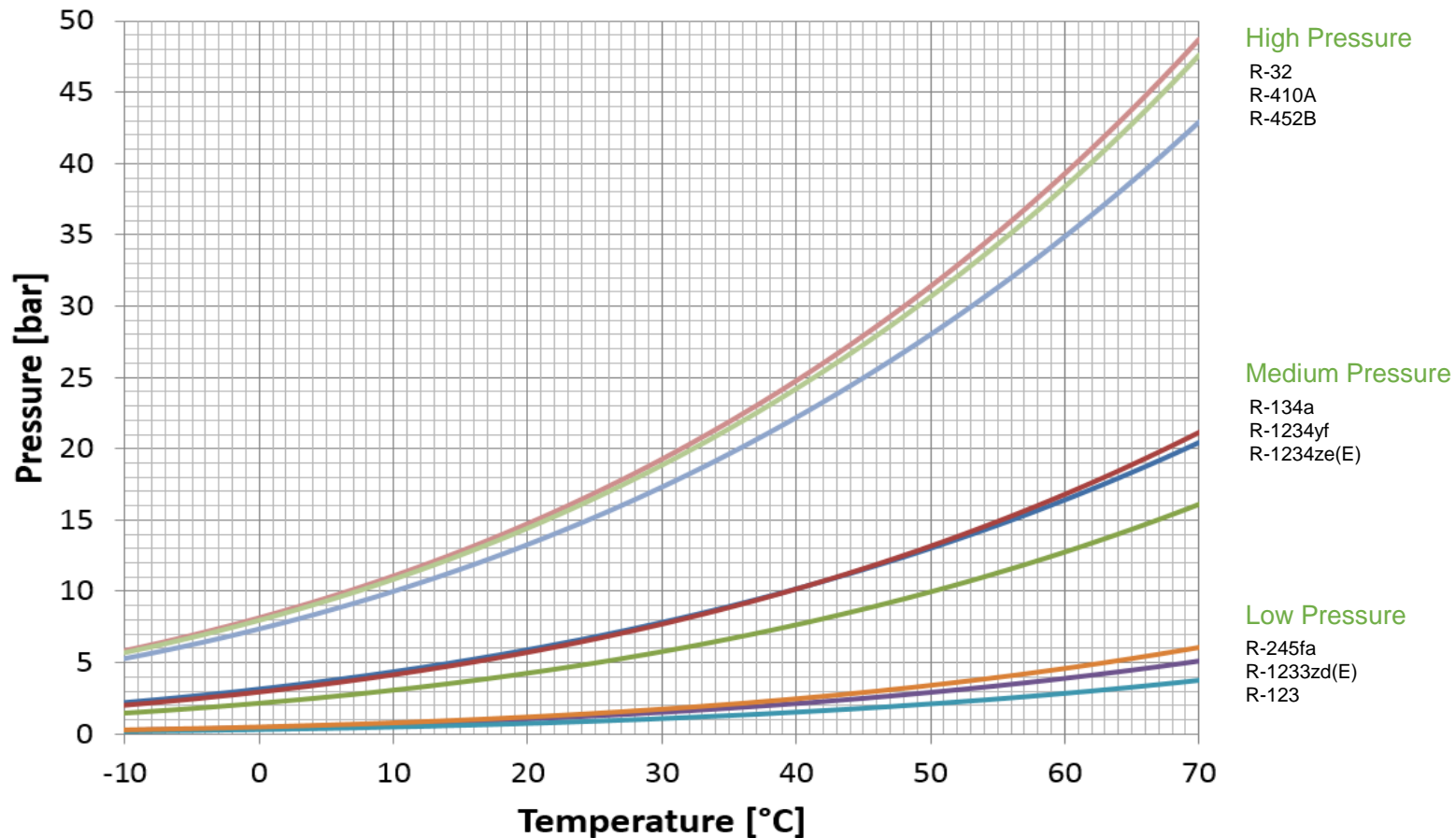


Low GWP solutions required to reduce Direct Impact

KIGALI AMENDMENT



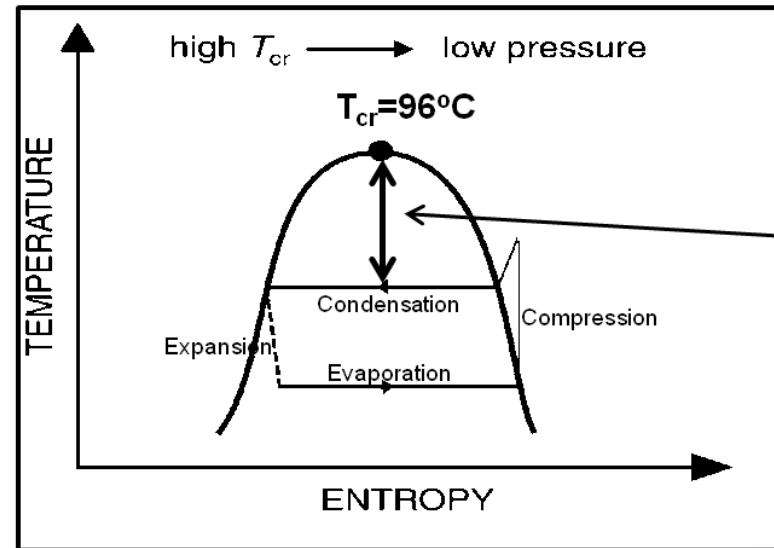
CHILLER WORKING FLUIDS



- Operating pressures are function of refrigerant type used
- Leaks are pressure dependant
- Low pressure fluids are key to “leak-tight” chillers
- R-1234yf and R-1234ze(E) are best-suited to medium pressure chiller applications
- R-1233zd(E) is best-suited for low pressure chiller applications

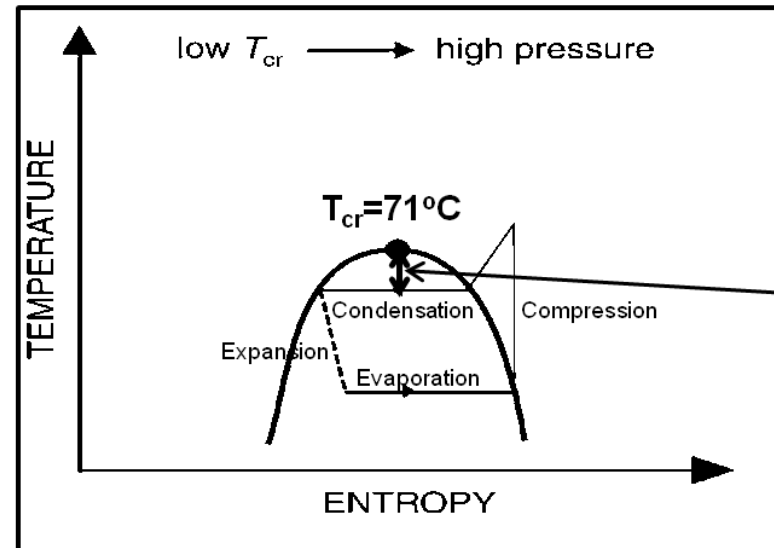
HIGH AMBIENT TEMPERATURE

R22 like



More efficient as cycle operates away from critical temperature

R410A like

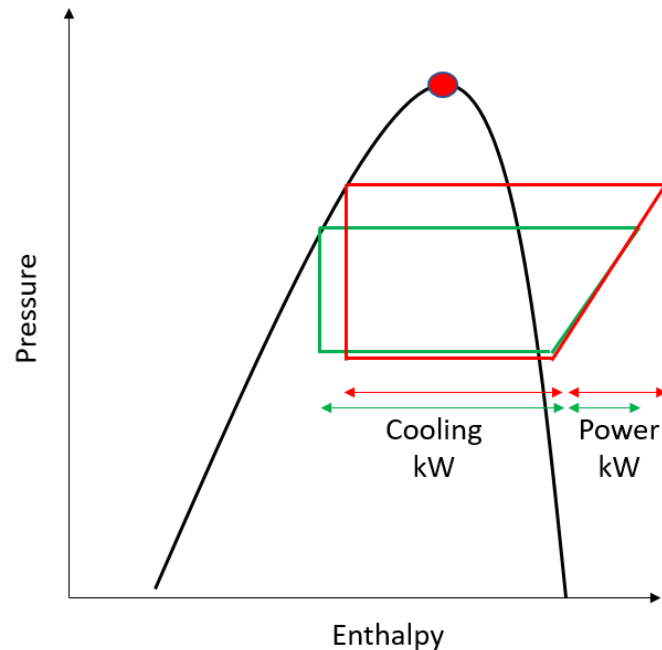


Less efficient as cycle operates close to critical temperature

HIGH AMBIENT TEMPERATURE

Kigali Amendment recognise the difficulties operating at extremely high ambient temperature (HAT)

- ➔ Higher heat loads
- ➔ Heat rejection at high temperature



Refrigerant	Critical Temperature °C
HFO-1233zd	165
R-717	132
HFO-1234ze	110
HFC-134a	101
R-290	96.7
HCFC-22	96.1
HFC-32	78.1
R-410A	71.4
R-744	31

Importance of High Critical temperature

SOLSTICE® N41: R-410A LIKE AND LOWER GWP



SAFETY

- ASHRAE A1 Rating which implies
 - Lower Toxicity
 - Nonflammable



PERFORMANCE

- Capacity >95%
- Energy Efficiency >100%



ENVIRONMENT

- Global warming Potential (GWP) <750
- Ozone Depleting Potential (ODP) ~0

Nonflammable and Lower GWP R-410A Replacement

Similar to R-410A in performance and efficiency but ~65% lower GWP

SOLSTICE® N41: PERFORMANCE

Nonflammable and low toxicity (A1) based on ASHRAE classification

- R-32/R-125/R-131I (49%/11.5%/39.5%)

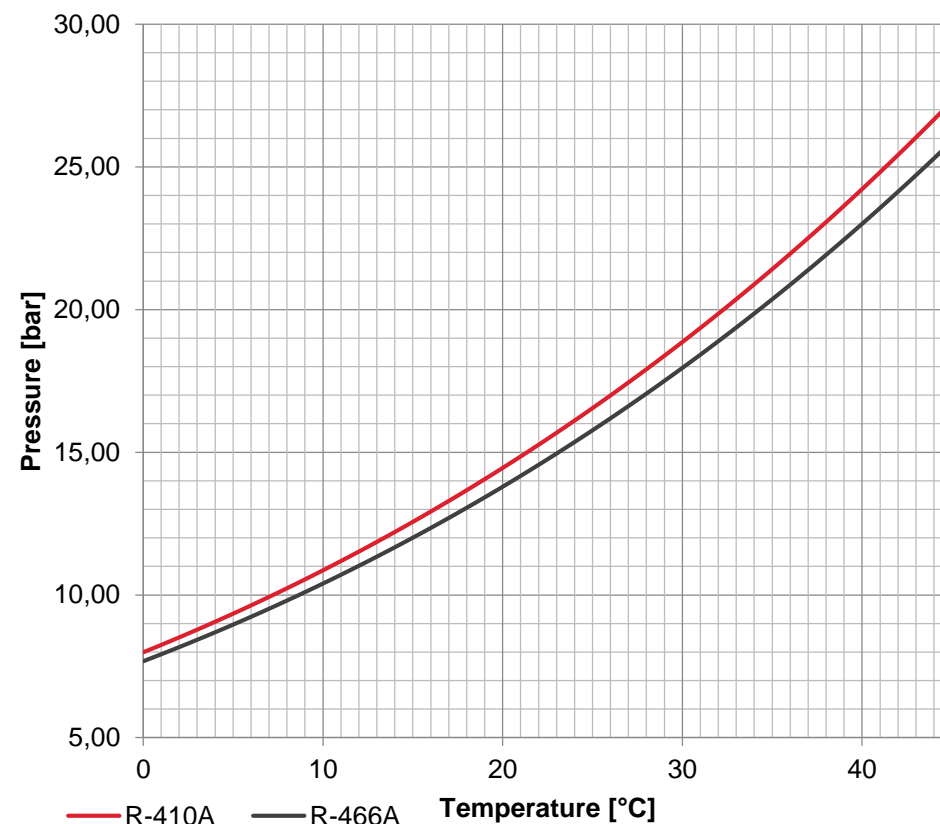
Name	ASHRAE	GWP (AR4)	Capacity Q (AHRI A)	COP (AHRI B)	Flow rate	Diff. T _{disch} (°C)	P _{disch}	Evap. Glide (°C)
R-410A	A1	2088	100%	100%	100%	0	100%	0.1
R-32	A2L	675	105%	100%	70%	+ 17.2	102%	0.0
R-466A*	A1	733	99%	100%	105%	+ 8.0	95%	1.2

*Provisional ASHRAE number

- Closest match to R-410A performance
- Can be used with same size/design of compressor and heat exchangers
- Small evaporator glide shows no significant impact on heating mode (frost formation)

PRESSURE TEMPERATURE RELATIONSHIP

	R-410A		R-466A*	
	Temperature (°C)	Average Pressure (bar)	Temperature (°C)	Average Pressure (bar)
Evaporator Temperature	0	7.99	0	7.68
	2	8.52	2	8.18
	4	9.06	4	8.70
	6	9.64	6	9.24
	8	10.24	8	9.81
	10	10.87	10	10.41
	30	18.86	30	17.96
Condensing Temperature	32	19.86	32	18.90
	34	20.89	34	19.87
	36	21.96	36	20.88
	38	23.07	38	21.92
	40	24.22	40	23.01
	42	25.42	42	24.14
	44	26.66	44	25.30

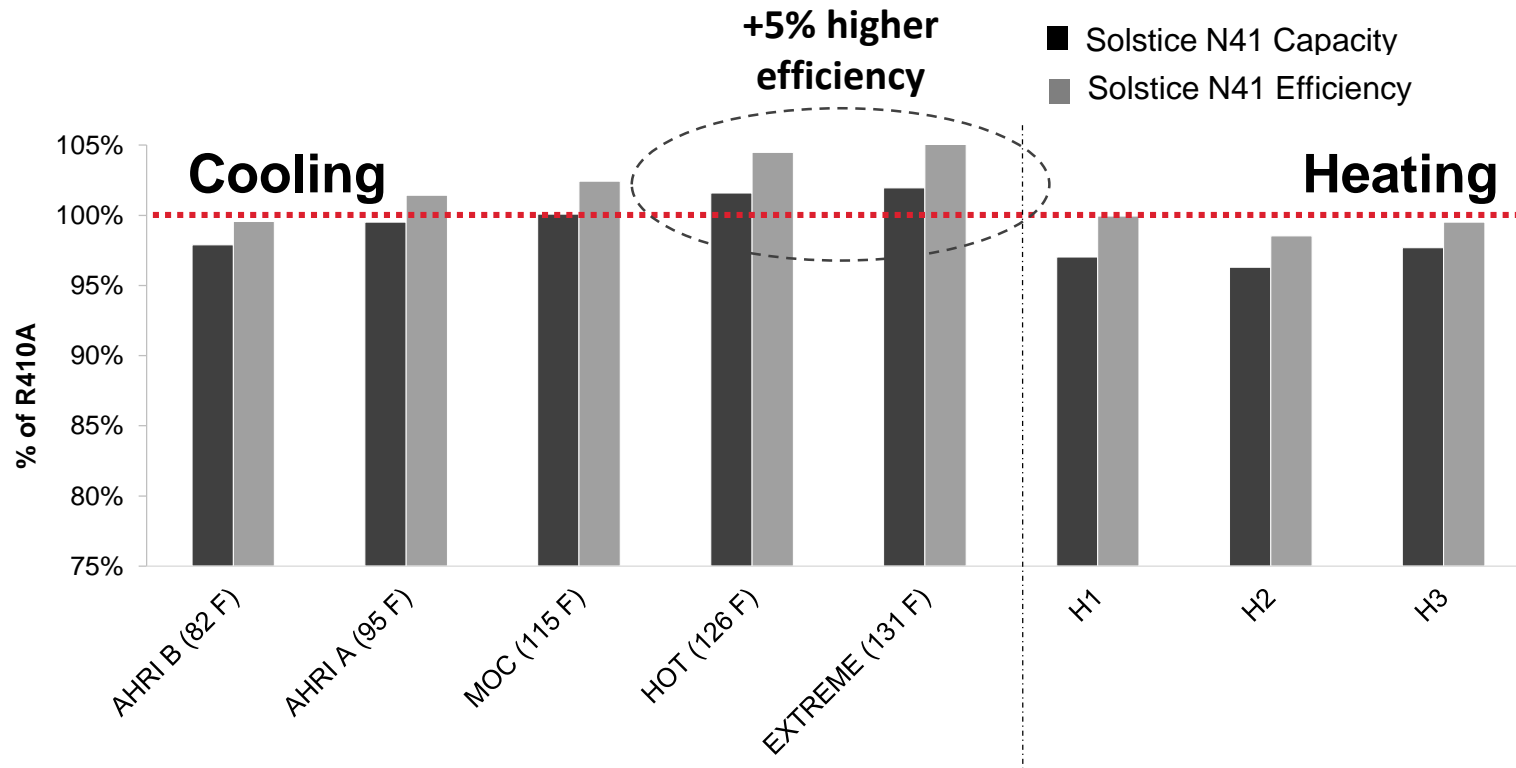


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Solstice® N41 and R-410A have Similar Operating Pressures

EXPERIMENTAL PERFORMANCE EVALUATION

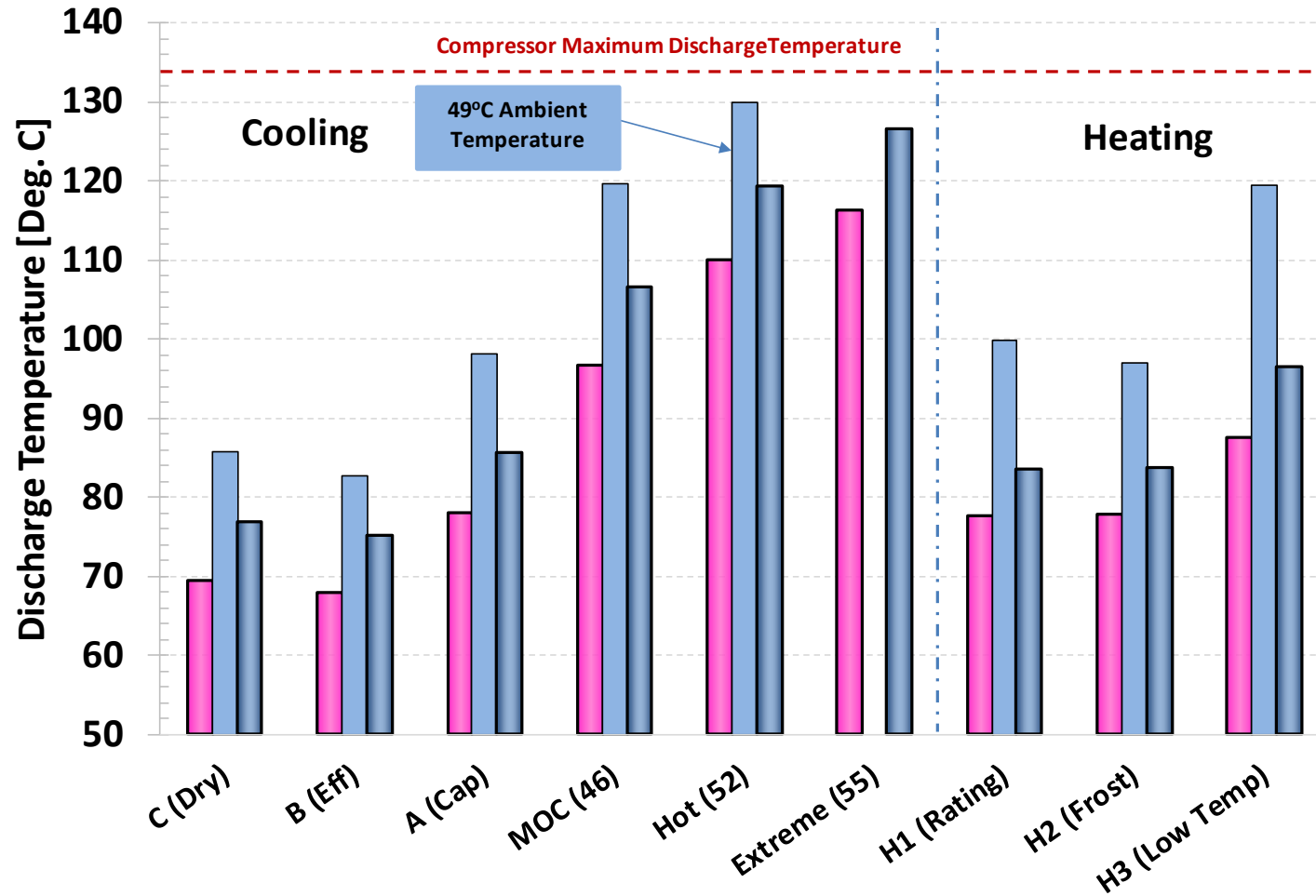
3 Ton, 13 SEER R-410A Heat Pump



- Solstice® N41 (R-466A) matches performance of R-410A at rating conditions, with up to 5% higher efficiency at high ambient
- R-466A can operate at equal or higher efficiency than R-410A without requiring substantial changes

Solstice N41 has higher efficiency than R-410A at high ambient temperature

SOLSTICE® N41: DISCHARGE TEMPERATURE



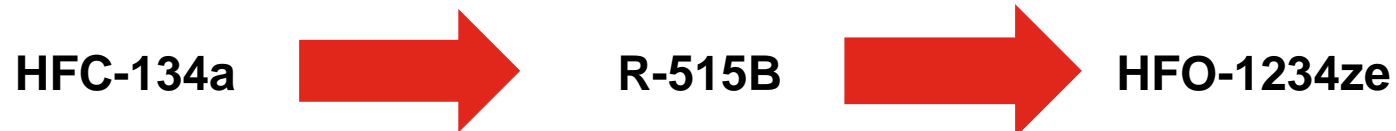
Discharge temperature of R-466A is close to R-410A (significant advantage over R32)

Discharge temperature of Solstice N41 is close to R-410A

SOLSTICE BLEND HDR-137 (R-515B*)

- A new LGWP blend for Heat Pump and Chillers
 - ❑ Blend of 1234ze and 227ea (91.1%/8.9%)
 - ❑ Non flammable with GWP of 293 (AR4) / 299 (AR5), 80% lower than 134a
 - ❑ Azeotropic blend with 0 glide, that simplifies design process
- Exact capacity match to HFO-1234ze, **but Nonflammable**
 - ❑ Since it is nonflammable, no risk mitigation required
 - ❑ Equipment can be designed for both HFO-1234ze and R-515B*
 - ❑ Provides OEM faster / easier roadmap to get to GWP <1, while IEC directives are being revised

	R-515B	R1234ze
GWP	293	<1
Composition	R1234ze/R227ea (91.1%/8.9%)	-
Safety Class	A1	A2L
Evap Glide	0°C	0°C



*provisional ASHREA number

FIRST HFO CHILLER

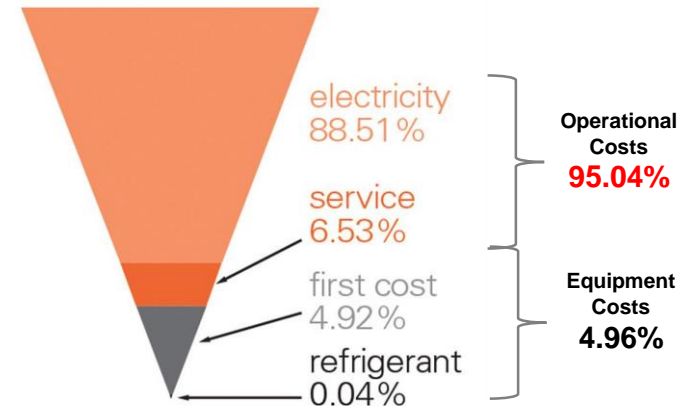


- Developed by Geoclima, an Italian company in 2010
- Using R-1234ze(E) to replace R-134a
- Used for a water loop in a UK supermarket
- In operation since 2011 and no issues reported
- Geoclima reported 3.5% better COP on average vs equivalent R-134a chiller
- More efficient than the HC version used by the same supermarket chain
- Geoclima has optimized HFO based chiller designs, now offering a full range of chillers using R-1234ze

GVAF AIR COOLED CHILLERS R-134A VS R-1234ZE(E)

Model Name	GVAF XP 245 LN	GVAF XPG 245 LN	
Refrigerant	R-134a	R-1234ze	
GWP	1300	<1	
Equivalent MT CO ₂	182 MT CO ₂	<1 MT CO ₂	-99.9%
Cooling Capacity (kW)	878	878	
EER	3.48	3.72	+6.9%
ESEER	5.30	5.65	+6.6%
Power Consumption (kW)	252	236	

Source: www.eurovent-certification.com



Efficiency, an important criteria in chiller selection

CHANNEL TUNNEL APPLICATION



the largest HFO chiller installation of its kind in the world, Trane CenTraVac's using R-1233zd(E) will replace the existing R22 chillers serving the Channel Tunnel.*

- R-1233zd(E) chosen for the renovation of the channel tunnel refrigeration system
- 4 New R-1233zd(E) Chillers replaced R22 old system
- Each chiller providing 14MW cooling load, to maintain tunnel temperature below 25°C
- 33% drop in energy usage – 500.000€ savings in 2017

* <http://www.coolingpost.com/world-news/hfo-chillers-to-cool-the-channel-tunnel/>

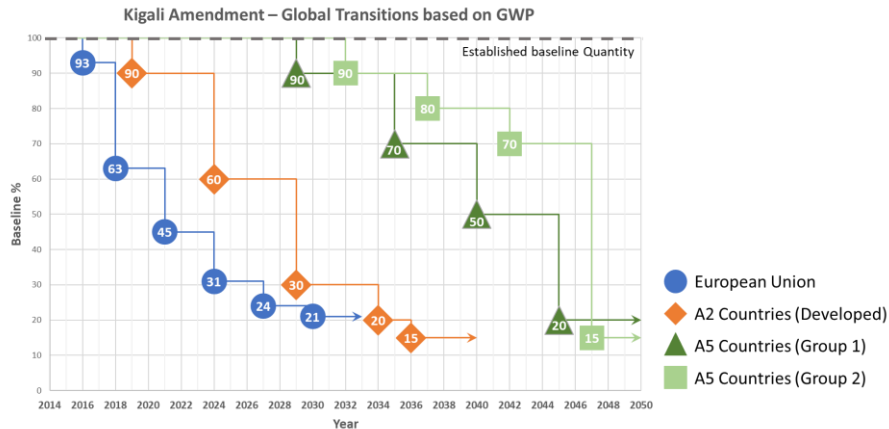
EUROCONTROL APPLICATION



The Quantum 'G' Water cooled chiller

- Eurocontrol's headquarters, flight management and data center facilities in Brussels was equipped lately with a new cooling system based on R-1234ze(E) technology
- Quantum® cooling systems produced by ENGIE Axima are designed with oil-free, magnetic-bearing centrifugal compressors replacing an older R-22 system
- The first results indicate that the cooling system's design helps achieve annual energy savings up to 1,500 MWh and reduce EUROCONTROL's total annual consumption by more than 12 percent, helping EUROCONTROL save up to €150,000 per year on energy costs.

HIGH AMBIENT REGIONS



Although High Growth Regions like Middle East and India are part of article 5 (group 2) countries, meaning according to Kigali agreement, are not concerned immediately with the phase down, and HCFCs are still widely used refrigerants, some manufacturers have shown interest and initiated development of HFO chillers.

These regions are also characterized by high ambient conditions, and therefore it is important not only to provide a low GWP solution but also to demonstrate that the solution works efficiently under the high ambient experienced in the region.

CONCLUSION

- **LGWP molecules have been evaluated in low and medium pressure centrifugal chillers. Comparable performance to existing refrigerants can be achieved in applications investigated to date without significant hardware modification**
- **R-1234ze(E) successfully replacing R-134a in medium pressure chillers**
- **R-1233zd(E) matches R-123 efficiency with higher capacity in low pressure chillers**
- **Majority of chiller manufacturers have adopted these new fluids and the number of field installations is increasing**
- **Honeywell Solstice® Platform ready to meet F-Gas Cap & Phase Down Needs in Europe and Support High Growth Region's**

**THANK
YOU**

Honeywell

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