

REFRIGERANTS SOLUTIONS FOR THE FUTURE

FORANE[®]
REFRIGERANTS

ROUNDTABLE
APRIL 13th. 2017

Yongsong Yang

ARKEMA
INNOVATIVE CHEMISTRY

HFC PHASE DOWN ACTIVITIES SNAPSHOT-GLOBAL

全球HFCs削减行动一览

❖ European Union F-gas 欧盟的含氟气体法案

- Reduction of HFCs quota by **79% by 2030 (CO2-eq)**

❖ MAC directive(2006/40/CE)-Start from 2017, **all new cars in EU** should comply with refrigerants of **GWP<150**

2017年生效的新的汽车空调指令，要求欧盟市场上的新车车用制冷剂**GWP**小于**150**

❖ U.S. EPA SNAP Delisting Final Rule issued in Jul.2015 (SNAP1)

美国环保署关于含氟气体的最终法案

- Ban High GWPs refrigerants for selected applications
- **SNAP 2.0 Final Rule issued December 1, 2016**
 - A/C-Ban R410A/R134a for Chillers from Jan.2024
 - Refrigeration-Ban R404A/407 Series from Jan.2021/2023 by different applications

❖ Japan METI F-gas revised regulation 日本含氟气体修正案

- Ban High GWPs refrigerants for selected applications from 2018 onwards

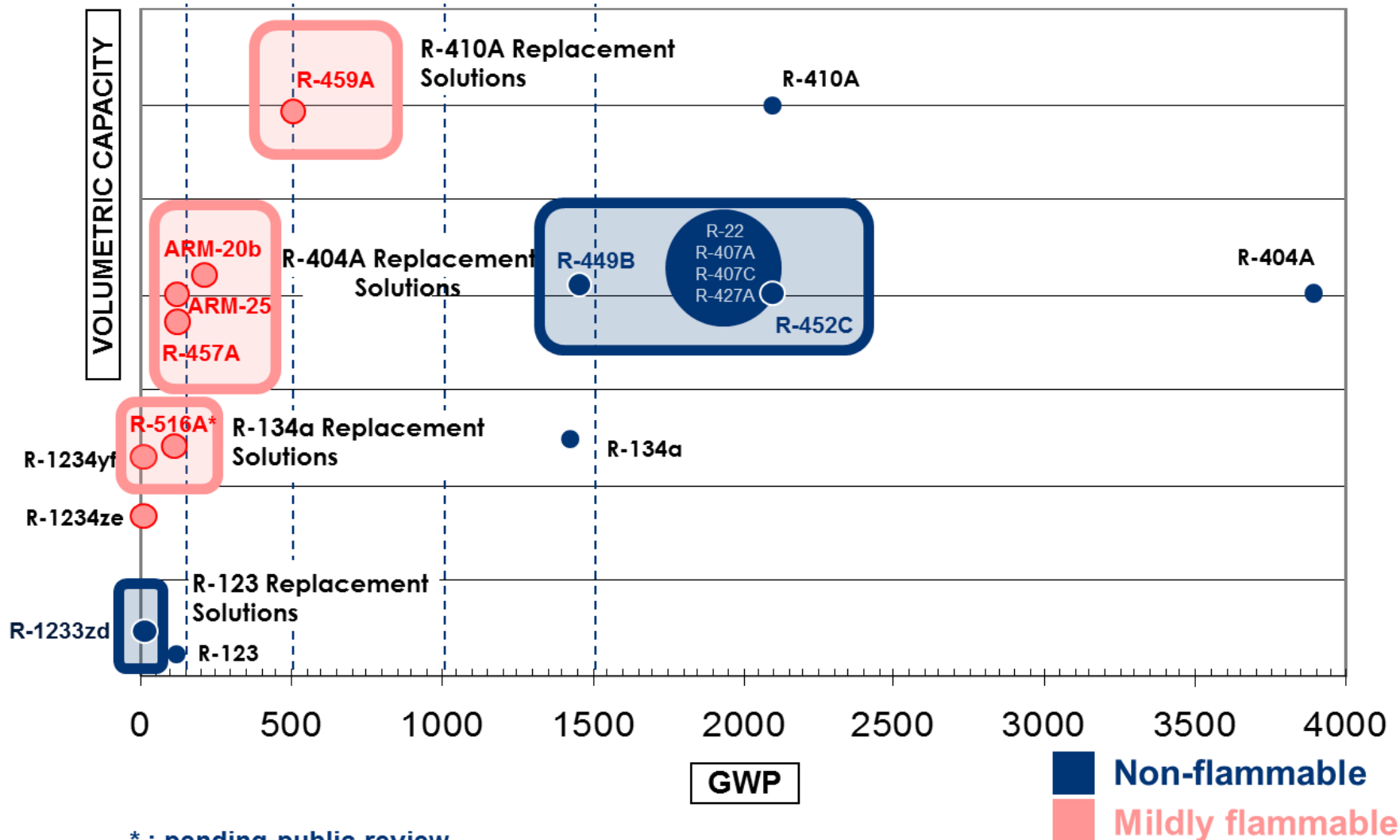
❖ Australia announced to reduce by **85%** of HFCs quota by 2036

澳大利亚宣布到**2036**年削减**85%**HFC配额

Kigali,Rwanda agreement in Oct.2016 showed that the industry is ready to phase down HFCs globally over a period of time sufficient to replace them with low GWP alternatives
2016年10月在基加利签署的修正案表明业界有信心逐步应用低GWP产品淘汰HFCs

ARKEMA'S NEXT GENERATION REFRIGERANTS

阿科玛提供下一代低GWP产品的解决方案



ARKEMA'S SOLUTIONS FOR THE FUTURE IN REFRIGERATION

阿科玛用于冷冻冷藏应用的下一代产品

REFRIGERATION



Hermetically sealed / Stand-alone



Food processing / Cold storage



DX Systems / Multipack centralized



Cascade

R-134a

R-516A



Transportation

R-404A

Drop-in • R-452C

R-404A

Retrofit • R-407A

Drop-in • R-452C

GWP<150 • R-457A / ARM-25

R-22

Retrofit • R-427A

GWP<150 • R-457A

R-134a

R-516A

VERY LOW-GWP REFRIGERANTS FOR REFRIGERATION

极低GWP的用于冷冻冷藏行业的产品

Stand-Alone

Low Temperature



Forane® 404A

Non-Flammable

ODP = 0

GWP = 3943

Centralized DX

Low and Medium Temperature



Forane® 134a

Non-Flammable

ODP = 0

GWP = 1300

Stand-Alone

Medium Temperature



Forane® 457A

Mildly Flammable, A2L

ODP = 0

GWP = 139

Forane® ARM-25

Mildly Flammable, A2L*

ODP = 0

GWP < 150

Forane® 516A

Mildly Flammable, A2L

ODP = 0

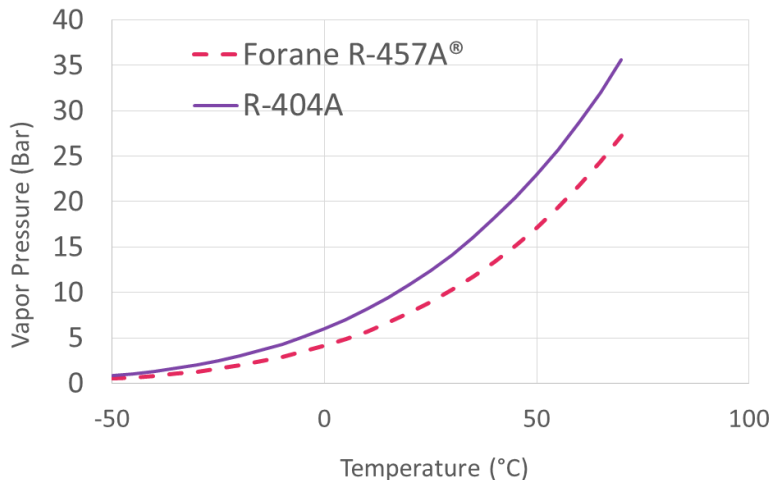
GWP = 131

**Anticipated*

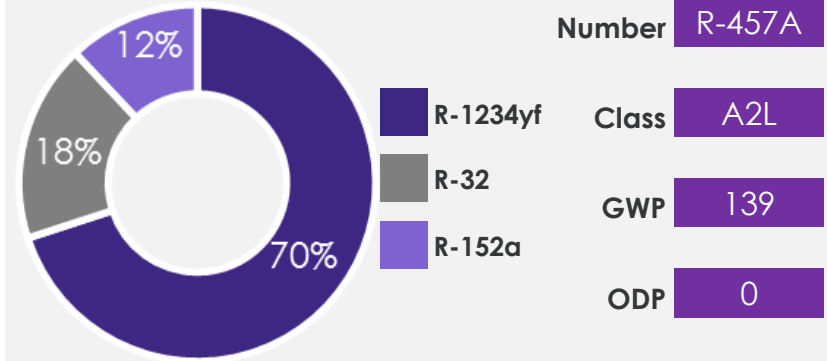
FORANE® 457A (ARM-20A) – R-404A/R-22 REPLACEMENT

FORANE® 457A用于替代R404A/R-22

Property	Value
ASHRAE Class	A2L
GWP100-yr, AR4/AR5	139/139
Molecular mass	87.6 g/mol
Burning Velocity (at nominal)	5.8 cm/s
Bubble point at 101 kPa	-42.9°C
Dew point at 101 kPa	-35.7°C



REFRIGERANT SUMMARY



APPLICATIONS 应用

- ❖ **Stand-alone Refrigeration** 独立式冷冻设备
- ❖ **Supermarket Refrigeration** 超市冷冻
- ❖ **Packaged, RTU** 屋顶机
- ❖ **Split Systems, Unitary** 分体机, 单元机

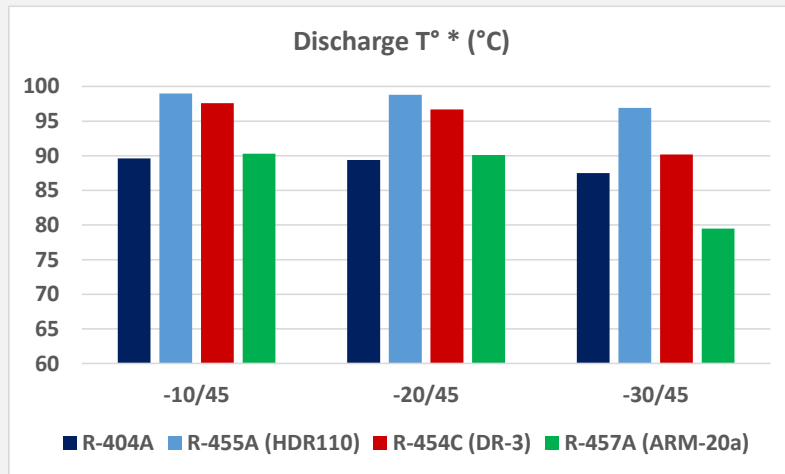
FORANE® 457A (ARM-20A) – R-404A/R-22 REPLACEMENT

FORANE® 457A的相关参数

R-404A Replacement Comparison¹,

对比R-404A

- ✦ Efficiency consistently higher能效高
- ✦ Similar Discharge Temperature排温相近
- ✦ Lower Capacity (15 – 20%)制冷能力衰减



R-22 Replacement Comparison²:

对比R-22

- ✦ Higher Efficiency in RTU at Standard Rating Conditions and High Ambient 标况及高环温工况时能效好
- ✦ Lower Capacity (3 - 10%)制冷能力略低

	AHRI Standard Rating Conditions	
	Outdoor: 35.0°C (95°F) Indoor: 26.7°C (80.0°F)	
	COP	Cooling Capacity, kW _{th}
R-22 (Baseline)	3.04	25.27
L-20A (R-444B)	2.94 (-3.3%)	25.46 (+0.7%)
DR-7 (R-454A)	2.86 (-6.2%)	27.15 (+7.4%)
ARM-20a	3.21 (+5.5%)	24.58 (-2.8%)

1. L.Abbas, *The drive to lower GWP solutions in commercial refrigeration*, Chillventa Forum, October 12th 2016

2. Abdelaziz et al. (2016) ORNL/TM-2016/513, Oak Ridge National Laboratory, Oak Ridge, TN.

-美国橡树岭国家实验室，是美国能源部下属实验室

ARKEMA'S SOLUTIONS FOR THE FUTURE IN A/C

阿科玛用于空调应用的下一代产品

HVAC



Centrifugal chillers

R-123

R-1233zd

R-134a

R-516A



Screw chillers

R-134a

R-516A



Scroll chillers

R-410A

R-459A



Rooftop / Packaged



VRF



Split systems

R-410A

R-459A

R-22

Retrofit • R-427A

GWP 250 • ARM-20b

GWP <150 • ARM-457A

FORANE® 459A (ARM-71A) – R-410A REPLACEMENT

FORANE® 459A用于替代R-410A

❖ Compatible with R-410A Equipment

兼容R-410A设备

- Similar Capacity and Efficiency 能力和能效相近

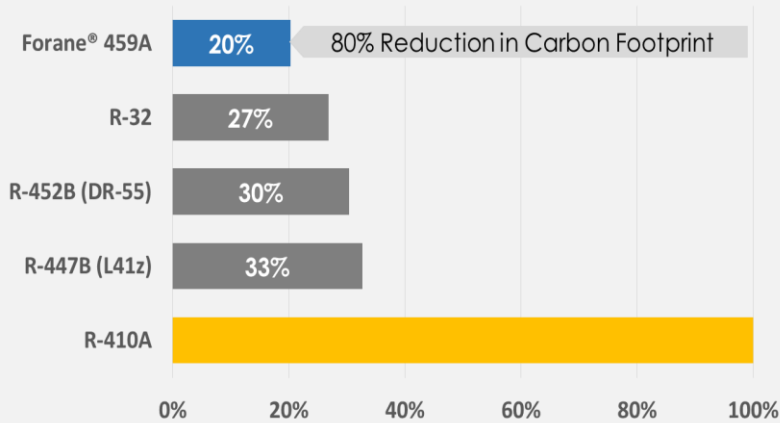
❖ Low Glide (1.5K) 温度滑移小

❖ Limited compressor discharge temperature 排气温升小（与R-410A相比）

❖ Demonstrated more Efficient than 410A¹ 能效比R-410A更高

- At Standard Conditions and High Ambient 标况和高环温工况
- Lowest GWP of Alternatives classified by ASHRAE 最环保
- Lowest Direct Carbon Footprint 排放低

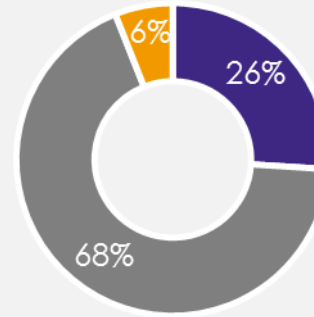
Relative Carbon Footprint of R-410A Alternatives



1. Abdelaziz et al. (2016) ORNL/TM-2016/513, Oak Ridge National Laboratory, Oak Ridge, TN.

-美国橡树岭国家实验室，是美国能源部下属实验室

REFRIGERANT SUMMARY



Number R-459A

R-1234yf

Class A2L

R-32

GWP 461

R-1234ze

ODP 0

APPLICATIONS 适用场合

- ❖ Split Systems, Unitary AC 分体机和单元机
- ❖ Ducted Splits 风管机
- ❖ Packaged, RTU 屋顶机
- ❖ VRF systems 多联机
- ❖ Water-cooled chillers 水冷冷水机组

FORANE® ARM-20B – R-22 REPLACEMENT FOR HVAC & R

FORANE® ARM-20B是全面替代R-22的优选方案

❖ Demonstrated Close Capacity to R-22^{1,2}

系统测试表明制冷能力与R-22相近

- Standard Conditions and High Ambient 标况及高温工况
- Mini-split: CAP within 3% of R-22 分体机测试表明制冷能力与R-22接近
- RTU: CAP of 1 – 10% greater than R-22 屋顶机测试显示其比R-22制冷能力大约1-10%

❖ Efficiency Close to R-22

能效与R-22接近

- About 1 – 12% lower than R-22^{1,2}

❖ As a R-404A Replacement

可作为R-404A的替代产品

- Consistently Higher Efficiency 能效高
- Close Capacity Match to R-404A 制冷能力相当

REFRIGERANT SUMMARY



Number TBD

R-1234yf

Class A2L*

R-32

GWP <250

R-152a

ODP 0

* Anticipated

APPLICATIONS应用场合

- ❖ Packaged, RTU屋顶机
- ❖ Split Systems, Unitary分体机，单元机
- ❖ VRF多联机
- ❖ Stand-alone Refrigeration独立式冷冻设备
- ❖ Supermarket Refrigeration超市冷冻

1. Abdelaziz et al. (2016) ORNL/TM-2016/513, Oak Ridge National Laboratory, Oak Ridge, TN.

2. Abdelaziz et al. (2015) ORNL/TM-2015/536, Oak Ridge National Laboratory, Oak Ridge, TN.

-美国橡树岭国家实验室，是美国能源部下属实验室

❖ FORANE® 516A (ARM-42) – R-134a REPLACEMENT

FORANE® 516A用于替代R-134a

❖ Compatible with 134a Equipment 兼容R-134a设备

- No or Minimal Design Changes

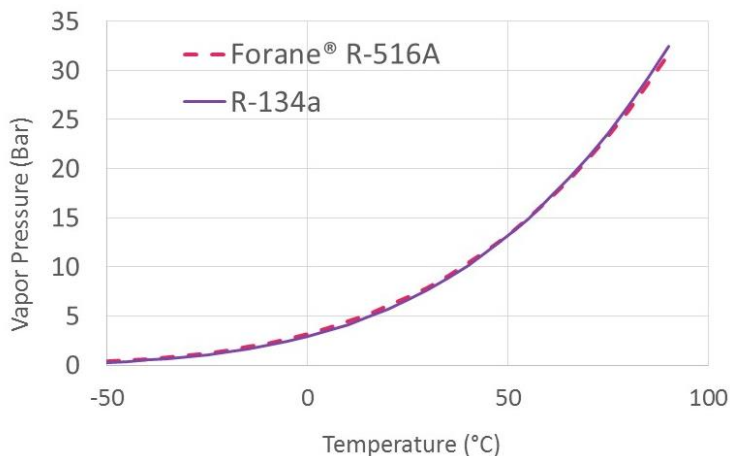
❖ Performance性能

- Full load 满负荷
 - Efficiency close to R-134a (2-3% less)
 - Nearly identical Capacity to R-134a
- Part load 部分负荷
 - Efficiency and Capacity almost identical to R-134a

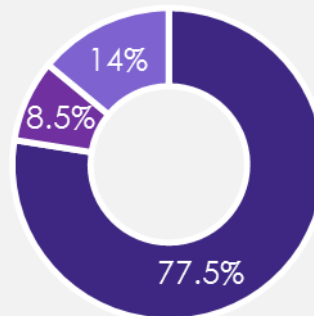
❖ Very-Low GWP (< 150) 极低GWP值

❖ Long term replacement to R-134a

❖ Azeotropic blend 共沸制冷剂



REFRIGERANT SUMMARY



Number R-516A

R-1234yf

Class A2L

R-134a

GWP 131

R-152a

ODP 0

* Anticipated. Submitted to ASHRAE

APPLICATIONS应用场合

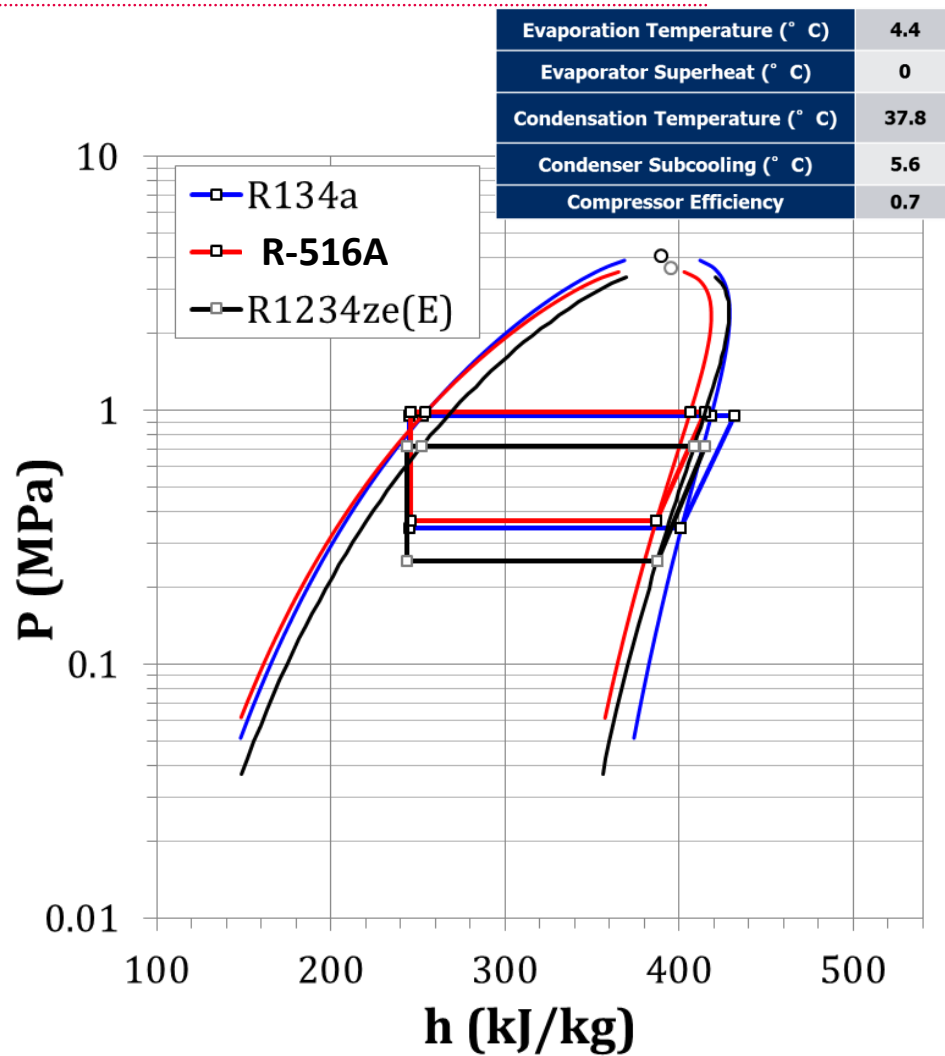
- ❖ Water-cooled Chillers 水冷冷水机组
- ❖ Air-cooled Chillers 风冷冷水机组
- ❖ MT Refrigeration 中温冷冻
- ❖ Stand-alone Refrigeration 独立式
- ❖ Cascade Refrigeration 复叠式冷冻

FORANE® 516A: A CLOSE MATCH TO R-134a

FORANE® 516A的特性与R-134a非常接近

Property	Value
ASHRAE Class (anticipated)	A2L
GWP100-yr, AR4/AR5	142/131
Molecular mass	102.6 g/mol
Burning Velocity (at nominal)	4.75 cm/s
Lower Flammability Limit (LFL) at 23°C	5.0 %v/v
Bubble point at 101 kPa	-29.4°C
Dew point at 101 kPa	-29.4°C

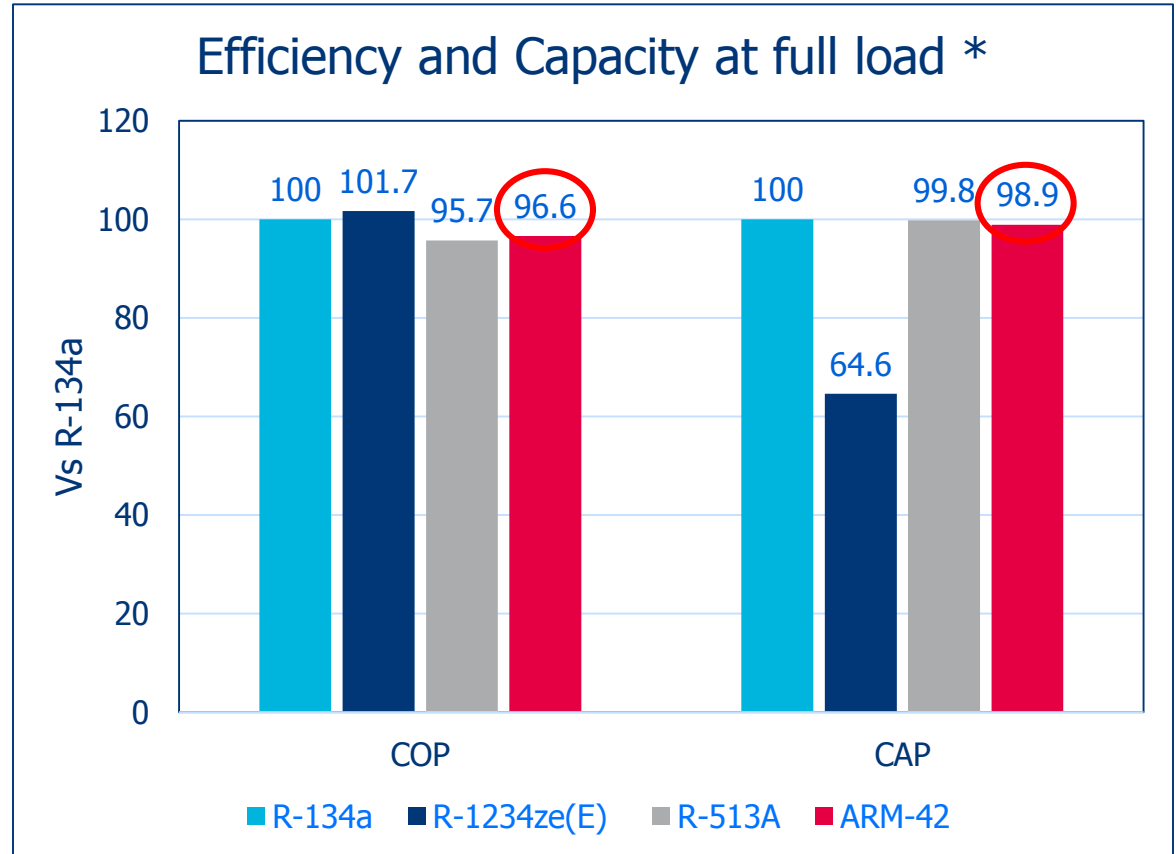
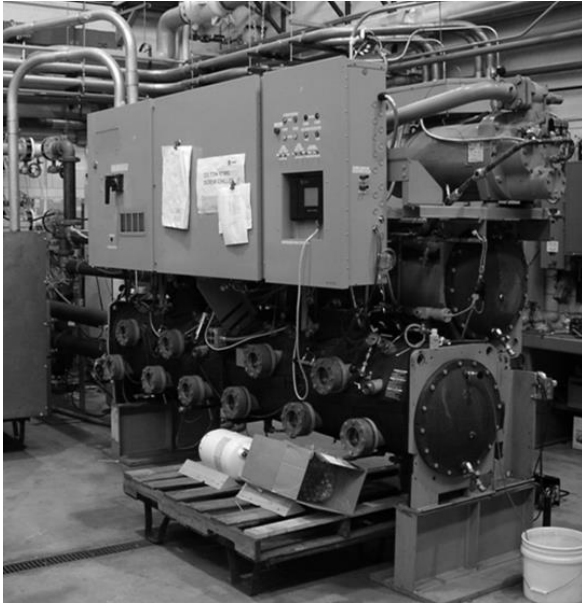
- ✦ **Azeotropic composition** 共沸混合物
- ✦ **Very close match to R-134a properties** 与R-134a特性接近



CHILLER TESTING

冷水机组直接更换制冷剂的测试效果

Water-Cooled Screw Chiller 230 RT nominal - Drop-in tests

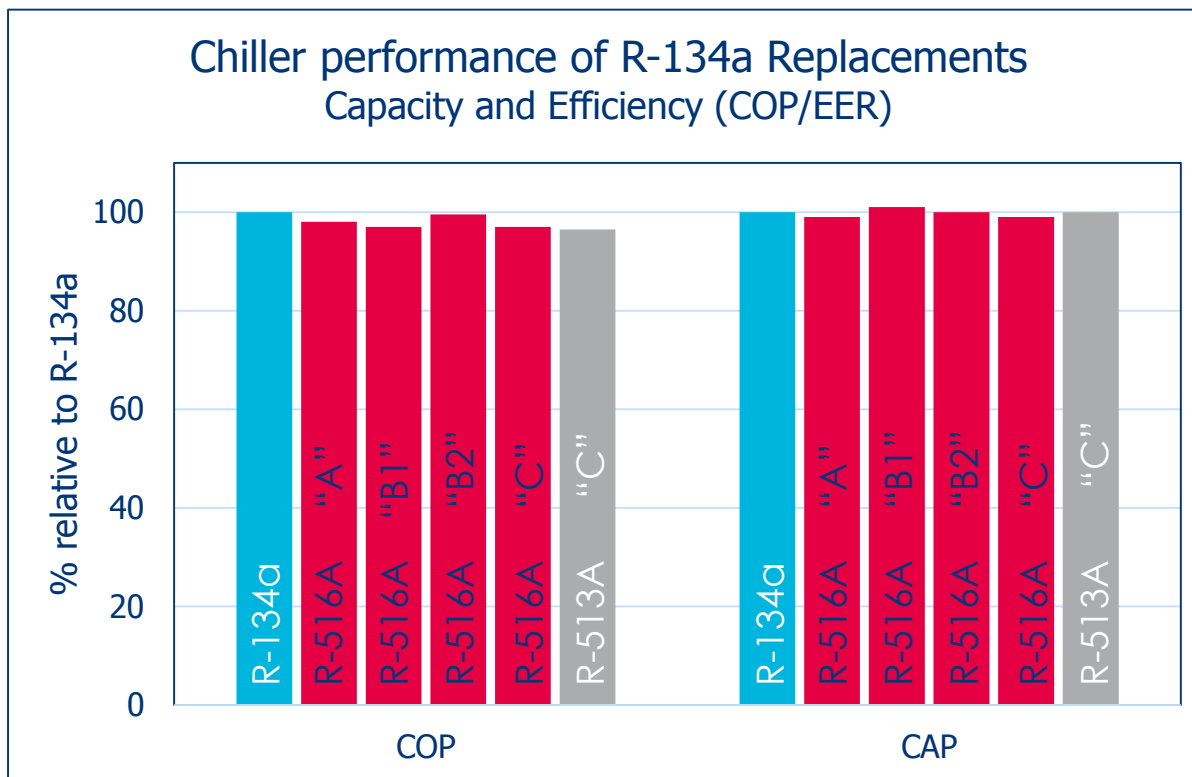


* Schultz K. (2014). Performance of R134a Alternative Lower GWP Refrigerants in a Water-Cooled Screw Chiller, Conference Paper NY-14-C065, ASHRAE Papers CD: 2014 ASHRAE Winter Conference, New York, NY

CHILLER TESTING

冷水机组直接更换制冷剂的测试效果

Air-Cooled Screw Chiller 175 RT nominal - Drop-in tests



A: Cycle calculations

B: Drop-in tests, 175-RT air-cooled, dual-circuit screw chiller, operated with one circuit. ARHI Low-AREP, Report #14

1) Full load, AHRI 550-590 Standard Cond. 2) Part load, 75%. Note: issues with test points 3 & 4 prevented IPLV calculation
Noted by testing company that equal IPLV to R-134a is possible through optimization of controls

C: System drop-in tests, 230-RT water-cooled screw chiller. Full load, AHRI 550-590 Standard Cond. AHRI Low-AREP, Report #7

ARKEMA'S COMMITMENT TO A SUSTAINABLE FUTURE

阿科玛致力于给行业提供可持续发展的制冷剂解决方案

❖ Next generation solutions for all major applications

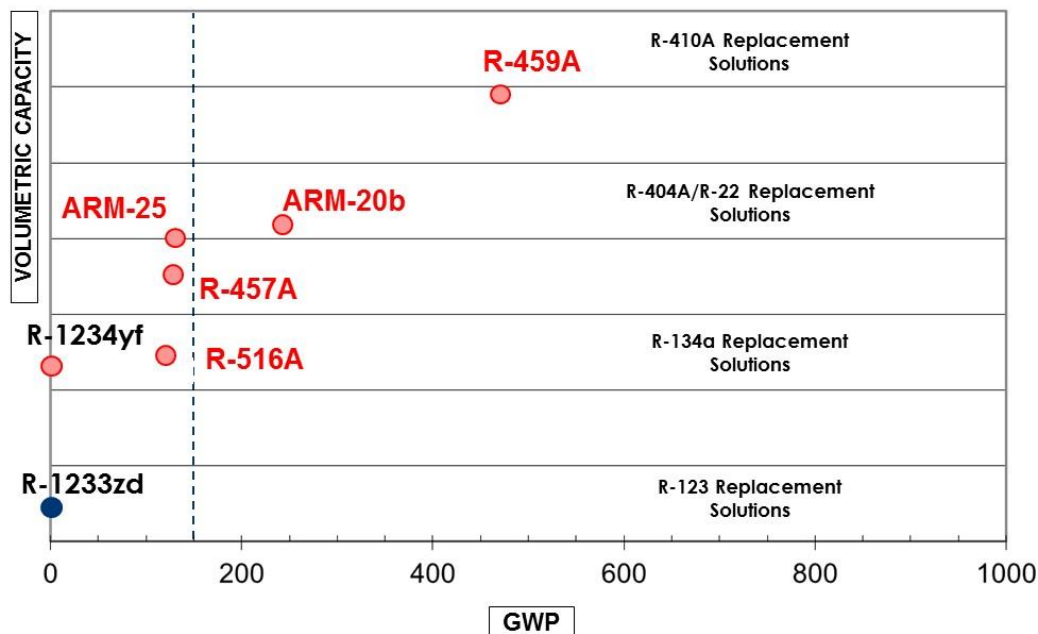
满足不同行业需要的下一代制冷剂方案

- HFO and new generation molecules **HFO**和新物质
- Lower-GWP HFO blends for HVAC-R 低**GWP**的**HFO**混合制冷剂用于空调制冷行业
- Different solutions based on GWP, performance, and flammability 满足**GWP**,性能,可燃性等不同需求的解决方案

❖ Active involvement in industry wide effort to replace current HFCs

积极, 广泛参与行业活动以削减HFCs的应用

- Low GWP AREP First and Second Rounds 美国**AREP**项目第一轮和第二轮
- High Ambient Temperature Testing Initiatives (EGYPRA,PRAHA 2, HAT)高环温使用环境测试项目



QUESTIONS ?



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