R404A replacements in Commercial refrigeration.

GeneralGas®

Agenda

- F-Gas: business consequences
- Introduction to HFOs and Solstice® family
- R404A replacement:
  - R407F
  - Solstice® N40 (R-448A)
  - HDR110

F-Gas – Control of Use in Commercial Refrigeration

General Gas

New Installation Bans*

(only main bans affecting Refrigeration shown here)

- Domestic refrigerators and freezers using HFC's >150 GWP
- New Commercial Refrigerators / Freezers (hermetically sealed systems) >2500 GWP
- Stationary Refrigeration Equipment requiring HFC >2500 GWP
- Centralised multipack systems >40kW capacity using HFC >150 GWP / except primary circuit (not distributed) of cascade system where <1500 GWP is acceptable
- New Commercial Refrigerators / Freezers (hermetically sealed systems) >150 GWP

2015 → 2016 → 2017 → 2018 → 2019 → 2020 → 2022 → 2025 → 2028 → 2030

- RAC & H/Pump equip. pre-charged with F-gases must be included in a registered Quota system beginning 2017
- Virgin F-gases >2500 GWP for servicing ref equip. With charge size of >40 T CO_2-eq (~10kg R404A)
- Recycled and reclaimed F-gases with >2500 GWP for servicing ref equip with a charge size of >40 T CO_2-eq

Maintenance & Service Bans*

(only those affecting Refrigeration shown here)

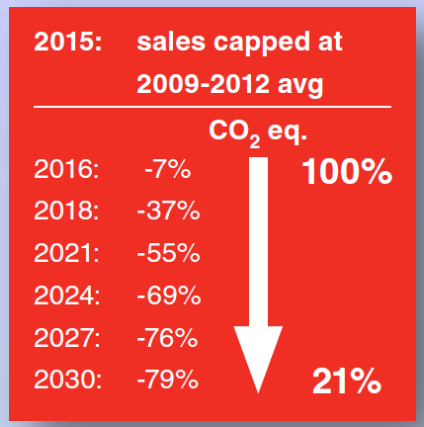
Exemptions include Military equipment and refrigeration applications below -50 Deg C

Genetron Performax® LT F-Gas Ready Honeywell

NOTE: R407F (<1825 GWP) repl. for R404A - can be used for servicing without end date (beyond 2030...)

F-Gas – Phase Down

Phase Down Mechanism



F-gas Regulations will Challenge our Industry Opportunities

- **What is your Strategy for Change?**

  It should include...

  - Refrigerant leak / charge reduction
  - Educate your team and your customers on this change
  - Improve your understanding of the low GWP alternatives to R404A
  - Understand the minor differences in 'how they are applied'

  - Become more comfortable with the differences → glide / flammability / high pressures / different system technologies etc..
  - Refrigerant choice – **STOP using R404A** wherever possible
  - Mindset - Change provides Opportunities for your business

Introduction to Solstice® family

Solstice® HFO molecules Low and medium pressure applications			
	Nonflammable (ASHRAE A1)	*Mildly flammable (ASHRAE A2L)*	*Examples of potential applications*
R-134a GWP=1430	Today	**Solstice® yf** GWP* < 1	Auto A/C, Vending, Refrigerators
		Solstice® ze GWP* < 1	Chillers, CO_2 Cascades Refrigerators
R-123 GWP= 77	**Solstice® zd** GWP* =1		Centrifugal Chillers

Introduction to Solstice® family

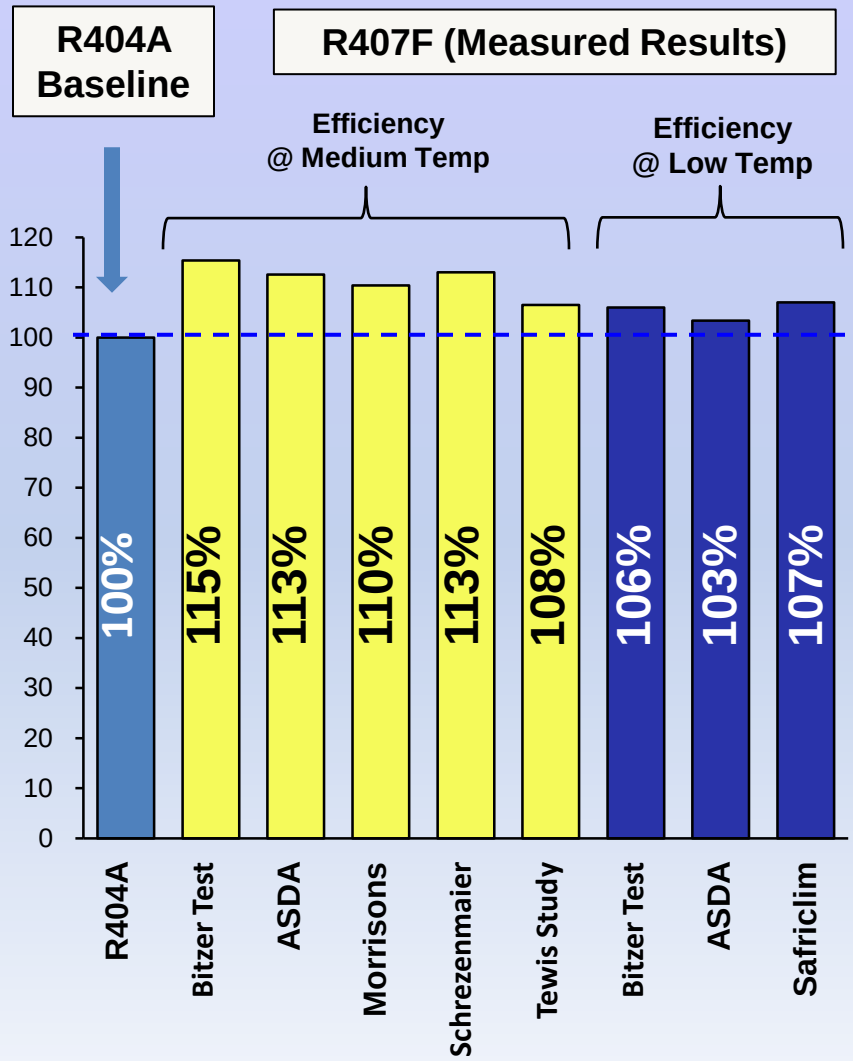
Solstice® Blends			
	Non Flammable (ASHRAE A1)	Mildly Flammable (ASHRAE A2L)	Examples of potential applications
R-134a GWP=1430	**Solstice® N13 (R-450A)** GWP* = 547		Chillers, Med-temp Refrigeration
R-404A GWP=3922	**Solstice® N40 (R-448A)** GWP* = 1273	**Solstice® HDR 110** GWP* < 150	Low-Temp Refrigeration
R-22 GWP=1810	**Solstice® N20** GWP* = 891	**Solstice® L20 (R444B)** GWP* = 295	Stationary A/C, Refrigeration
R-410A GWP=2088		**Solstice® L41 (R-447A)** GWP* = 572	Stationary A/C Applications

*IPPC5

Today

Coming soon

R407F: Independent Measured Performance Comparison



Efficiency comparisons (Independent verification)

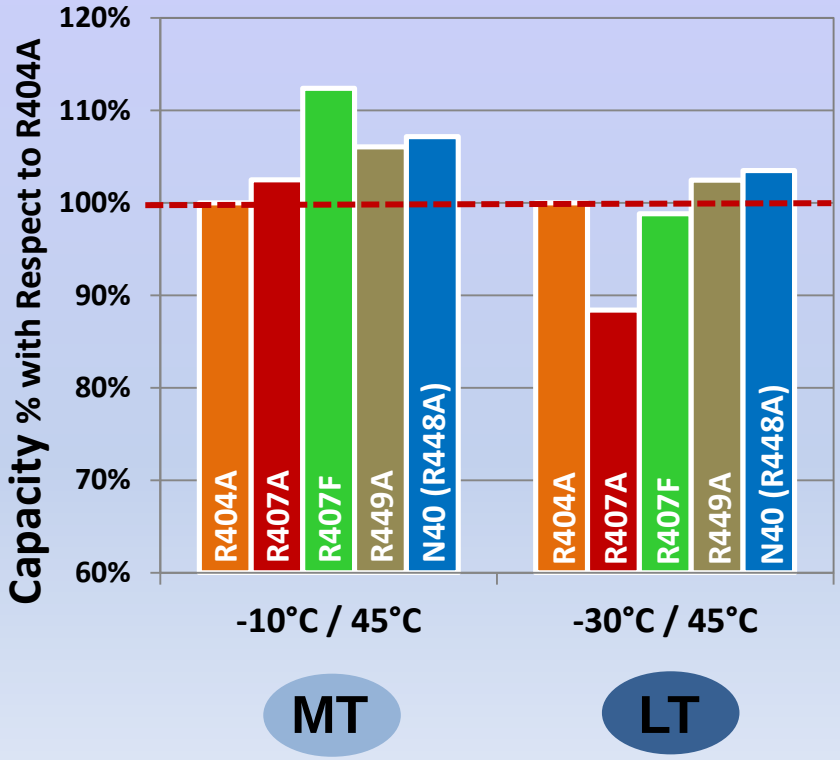
- Important improvements in MT applications ~ 10%
  - Climate / system specific / optimisation during retro-fit
- Still large improvements at LT conditions ~ 6%
- Clear overall improvement in Energy Efficiency shown by R407F

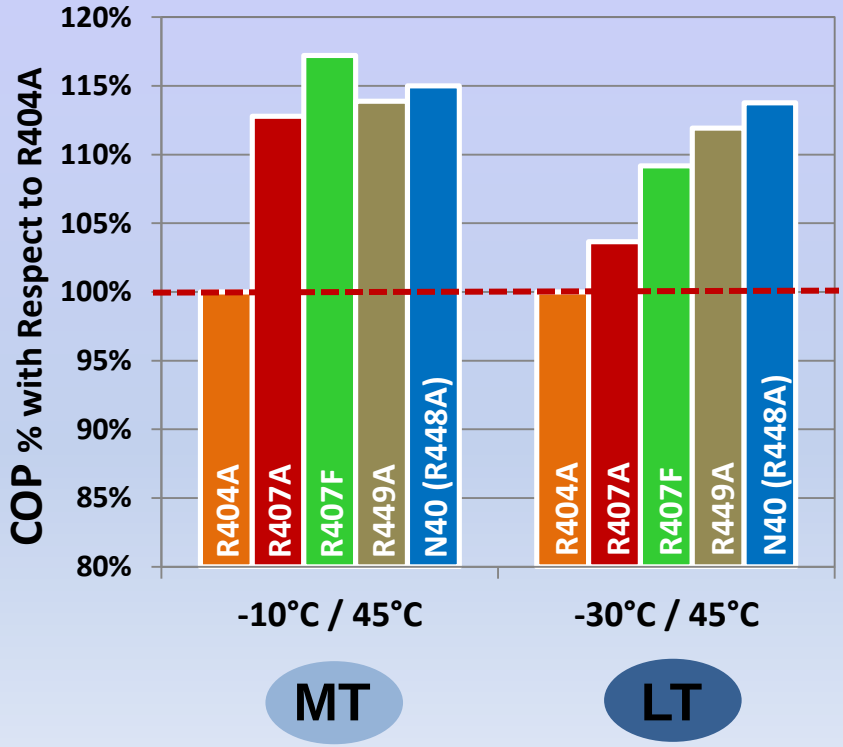
Considerable reduction in operational / running costs

Introducing N40 (R448A): Capacity & COP

BITZER Software: semi-hermetic compressor (4GE-23Y)

Mean Pressures / Suct. Temp = -4°C (LT); 20°C (MT) / Useful Superheat = 5K / Subcooling = 0K





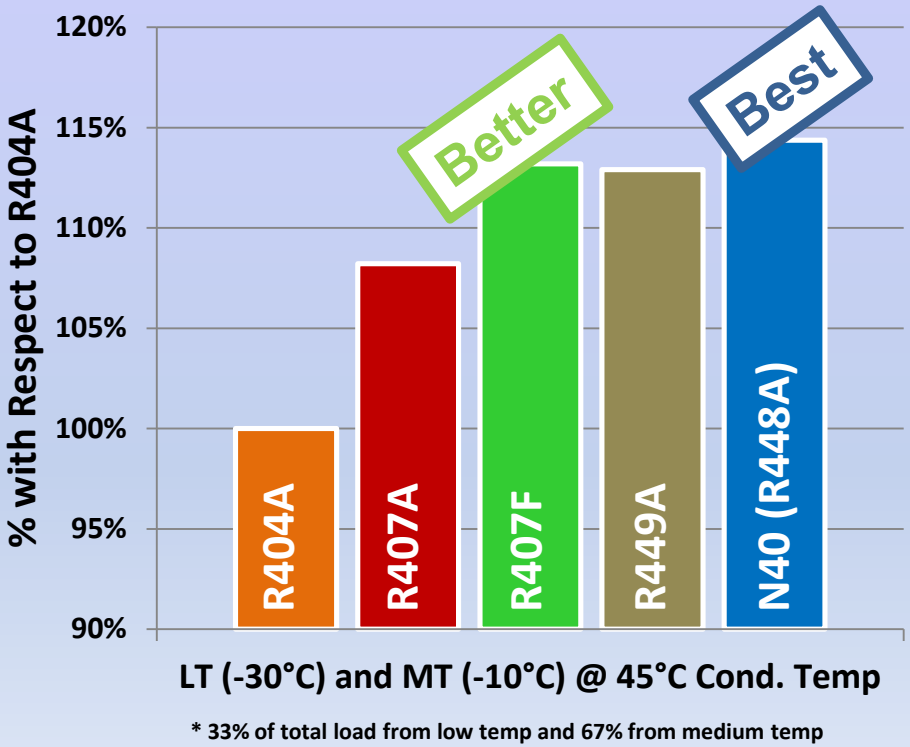
- Under system-like conditions, both R407F and N40 (R448A) provide capacity above 95% of R404A in low and medium temp applications
- Under medium temp system conditions, R407F and N40 (R448A) provide the best efficiency (COP)
- Under low temp system conditions, N40 (R448A) provides the highest COP

Bitzer Performance: Combined LT/MT & $T_{discharge}$

Semi-Hermetic Compressor (4GE-23Y)

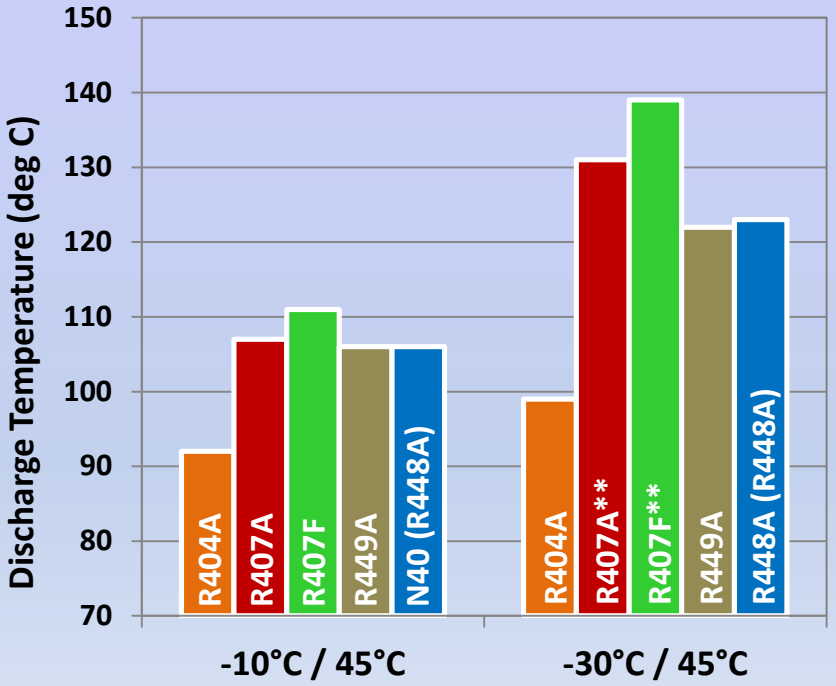
General Gas

Combined* LT and MT Energy Efficiency



* 33% of total load from low temp and 67% from medium temp

Discharge Temperature



**Liquid injection required

MT LT

- R448A (best) and R407F (better) provide the highest combined energy efficiency
- Due to lower discharge temperature, R448A is less likely than R407A or R407F to require liquid injection**

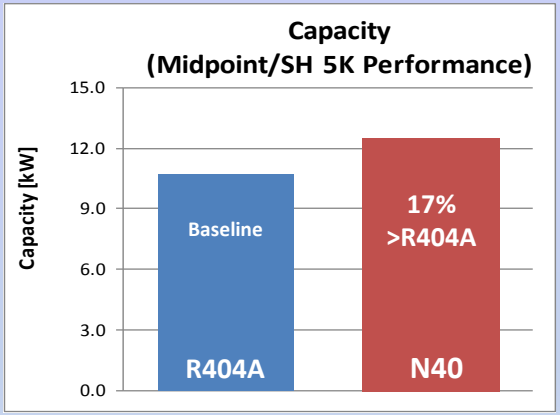
**Requirements will vary depending on the actual operating conditions.

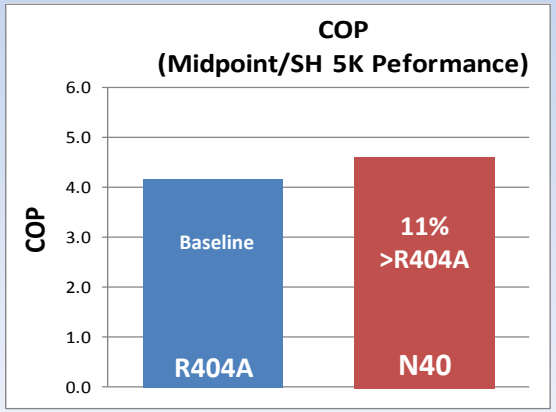
Emerson Performance: Solstice® N40 (R-448A)

- Copeland Liquid and EVI Scroll
- Medium and Low Temperature

***Scroll* System Analysis**

@ -6.7°C / 48.9°C





EMERSON Climate Technologies

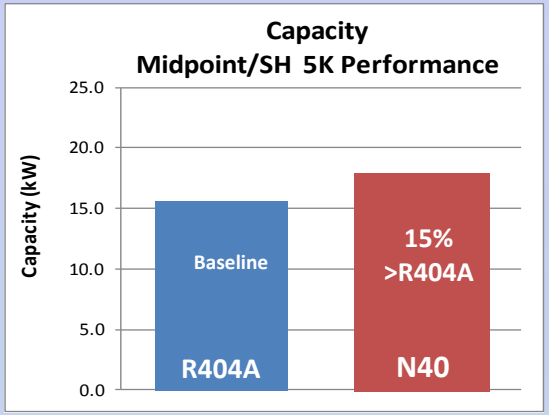
'N40 provides superior Energy Efficiency to that of R-404A with reduced GWP'

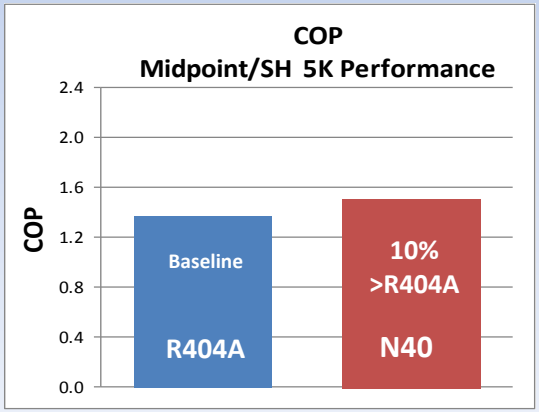
Qualified for Use

- Copeland S/Hermetic Reciprocating
- Medium and Low Temperature

***Semi-Hermetic* System Analysis**

@ -31.6°C / 43.3°C



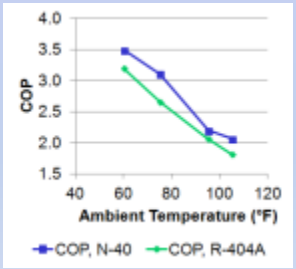


3rd Party evaluations: Solstice® N40 (R-448A)

Oak Ridge National Laboratory (US)

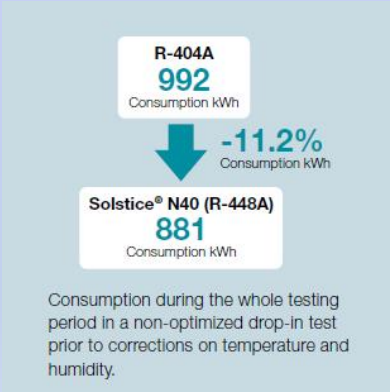
- Supermarket System Evaluation
  - ✓ *Reduced* compressor power by 3.7%
  - ✓ *Increased* refrigeration capacity by 7.5%
  - ✓ *Increased* system COP by 11.6%

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Tewis Smart Systems

- Laboratory Test in Simulated Supermarket set-up vs R-404A



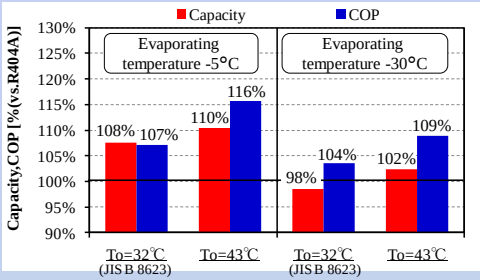
"After this laboratory test, we are convinced that R-448A complements the current portfolio of alternatives for refrigeration systems by providing the lowest GWP, safest, maximum savings refrigerant for optimized characteristics in an R-404A direct retrofit."

Javier Atancia, Tewis Smart Solutions International

3rd Party evaluations: Solstice® N40 (R-448A)

Toshiba Refrigeration (Japan)

- ✓ Condensing Unit Performance trial
  - ✓ Ambient tests at 32º & 43º C to JIS 8623 (std)
  - ✓ N40 showed 4-16%higher COP and excellent match in capacity



'Solstice N40 is well engineered refrigerant to meet requirement as an alternative to R404A'

ASDA (UK)

- Successful >14 months trial store comparison
  - Improved capacity and efficiency vs. R404A
  - Simple retro-fit with minimal system adjustment
  - Discharge Temp close to R404A level (no liq injection required on LT)

Refrigerants roadmap: R-404A

Medium temperature and low temperature stationary refrigeration

Performax LT (R-407F) is preferred option

- Already commercial
- Homologated by most components manufacturers
- Proven experience in commercial, industrial and food service applications over Europe
- Closer cost to R-404A than Solstice N40

Solstice N40 (R-448A) could be interesting if:

- Further GWP reduction is desired
  - Environmental goal
  - Tax country
- Slight improvement of Tdis vs R-407F is required
  - Solstice N40: Tdis still higher than R-404A
  - Solstice N40: Tdis still lower than R-22

BETTER

	Performax LT (R-407F)
Baseline	R-404A (A1, 3922 / 3943)
GWP 4th / 5th	1824 / 1764
Class	A1
Potential app.	MT and LT stationary refrigeration
Use	New/Retrofit
Drop-in (1) Cap.	Similar
Drop-in (1) Eff.	5% to 10% higher
Compressor (2)	Recip, Scroll, Screw
Comments	No TXV change Higher Tdis in LT
Status	Commercial

BEST

	Solstice® N40 (R-448A)
Baseline	R-404A (A1, 3922 / 3943)
GWP 4th / 5th	1386 / 1273
Class	A1
Potential app.	MT and LT stationary refrigeration
Use	New/Retrofit
Drop-in (1) Cap.	Similar
Drop-in (1) Eff.	5% to 10% higher
Compressor (2)	Recip, Scroll, Screw
Comments	No TXV change Good compressor envelope coverage
Status	Available for sampling. Commercial 2015

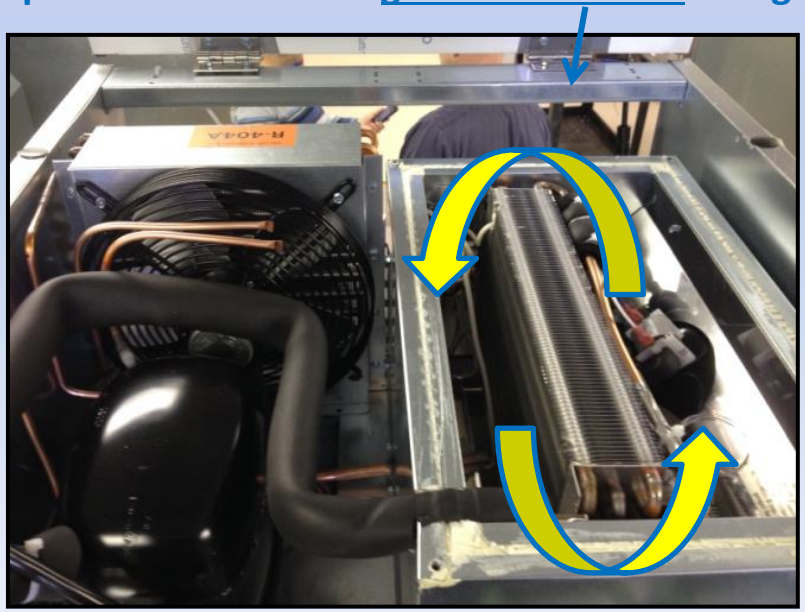
(1) Drop-in test in a non-optimized system

(2) Suitable compressor technology, check with Honeywell technical department for qualified models

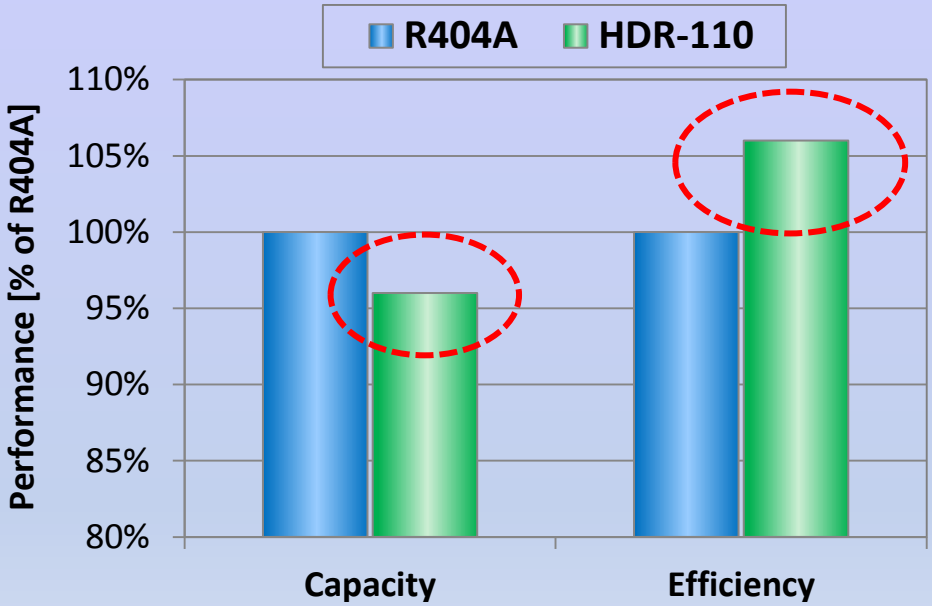
HDR110 (GWP<150): Self-Contained System Evaluation

- **ASHRAE 72 standard test:**
  - 3/4 HP Reach-in R404A Freezer placed in a chamber at 25°C
  - Cabinet volume filed with glycol/water test simulators and frozen food

- **Near drop-in test of HDR-110:**
  - TXV was slightly adjusted to provide appropriate superheat
  - No oil change required. Typical charge optimization carried out
  - **Evaporator position inverted to get counter-flow configuration**



24h Freezer Performance: HDR-110 vs R404A



- Capacity within 5% of R404A
- Efficiency increased by 6%
- Maximum discharge temperature (108°C) within compressor limits

HDR-110 under Evaluation by Major Equipment Manufacturers