R404A – THE END OF AN ERA

1st October 2014

Robert Kebby
Marketing Manager

ACR TODAY
Air Conditioning and Refrigeration for Today's People

Honeywell

Why R-404A?

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- Success of R404A over the last 15 to 20 years
  - Replaced ODP products such as R12 / R502 – & more recently R22
  - Marketed well as a ‘one solution’ replacement
  - Filled a gap – well accepted by manufacturers
  - Cost Effective solution
  - Easy to Apply – A Convenient Replacement!
- Used mainly on Commercial Refrigeration
  - Accounted for around 40% of EU stock (2010) in CO_2 Teq
  - 85% of this was used in Supermarkets where leak rates are highest
  - If nothing changes – grow by a further 6% by 2020
- Why Change?
  - Poor Energy Efficiency (10 to 15% lower)
  - Very High GWP (3922)
  - R404A has a very poor overall environmental impact
  - Regulations - F-Gas 2015 has been designed to reduce the effect our industry has on the Environment

2011

Is it time to stop using R404A?

2012

The end for R404A refrigerant?

2013

New F-Gas regulations put pressure on high GWP refrigerants

2014

R404A – the alternatives

F-Gas – Control of Use

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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

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

Maintenance & Service Bans*

(only those affecting Refrigeration shown here)

Genetron Performax® LT F-Gas Ready Honeywell

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

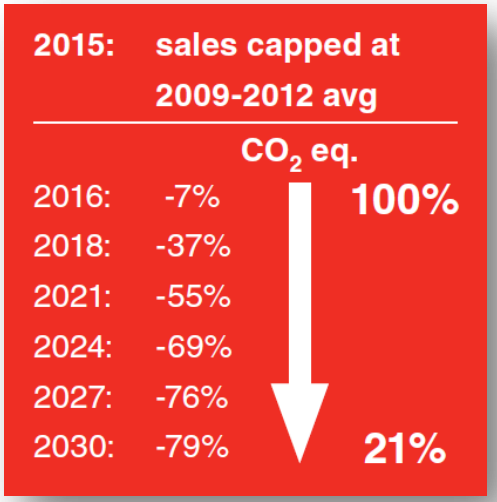
*Note – This document is not a comprehensive collection of all the 2015 F-gas bans

Phase-Down of HFC's will have the Greatest Impact

F-Gas – Phase Down

Honeywell

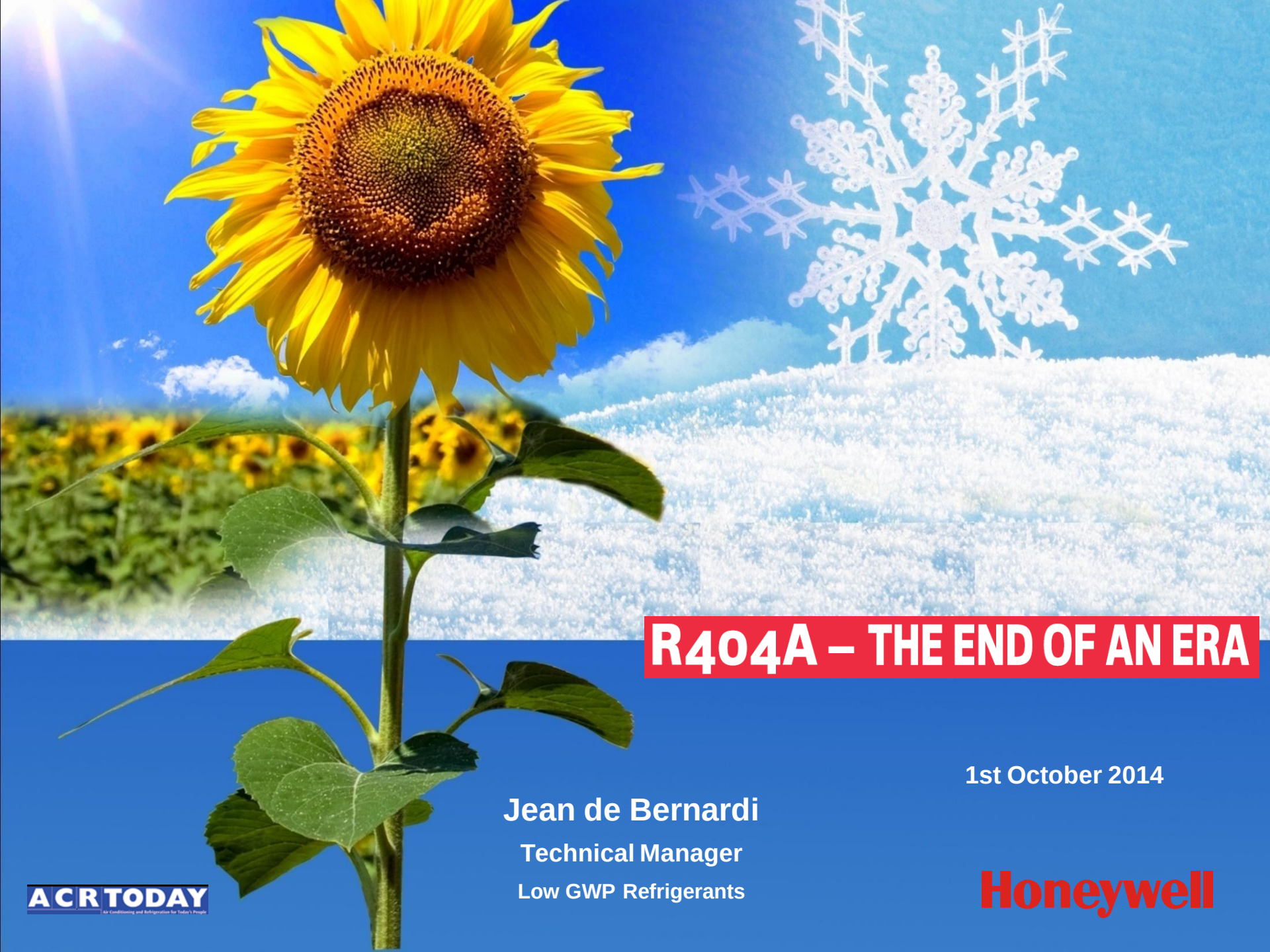
- **Phase Down Mechanism**
  - Main driver for industry to change
  - CO_2 Teq Quota on supply – change dynamics
  - Value /cost will be change from cost per kg (£/kg) to cost per CO_2 Teq (£/ CO_2 Teq)
  - A Major 'step-down' in 2018 – Significant Impact



- **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

F-gas Regulations will Challenge our Industry ➡ Opportunities



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Jean de Bernardi

Technical Manager

Low GWP Refrigerants

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Agenda

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- Comparative Assessment of R404A alternatives in existing systems or new built (15')
- Technical considerations for a successful retrofit or new design (10')
  - Glide
  - Tdischarge
  - Fractionation
- Questions & Answers (10')

Selecting the Right Refrigerant (Cycle Analysis)

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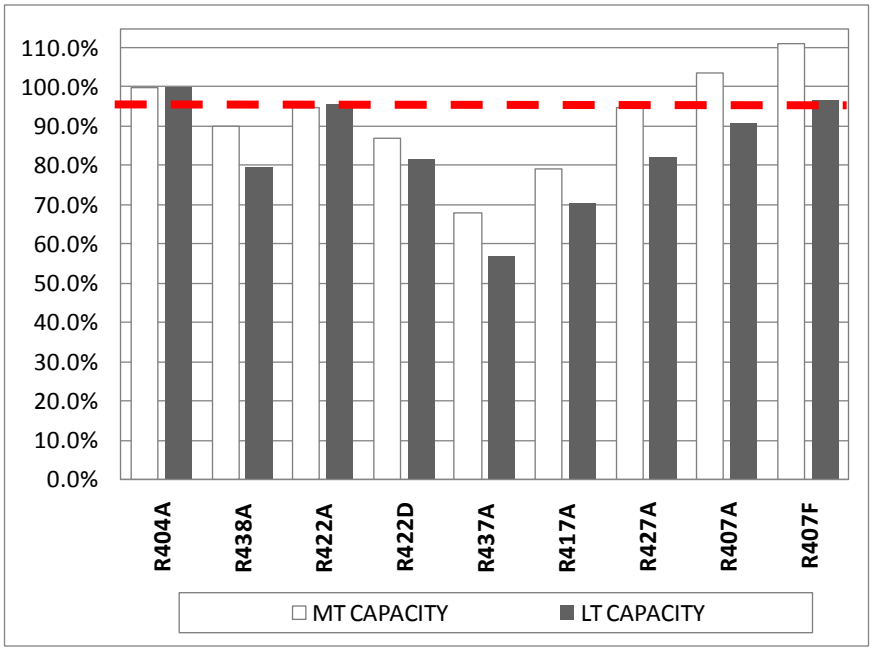
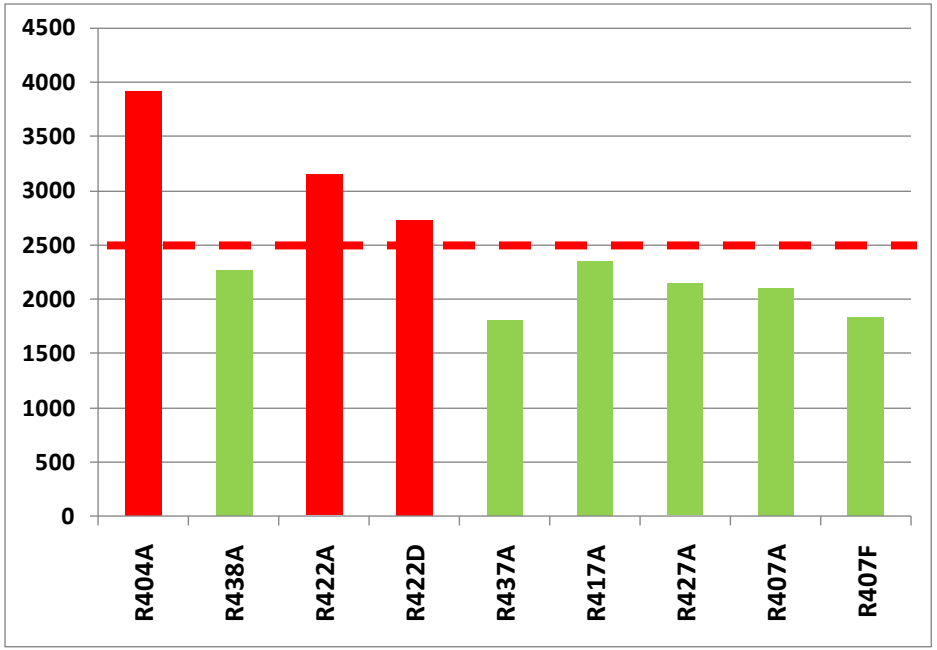
Main commercially available products: 2 selection criteria

Criteria 1: minimum 95% R404 (MT or LT) Capacity



Criteria 2: GWP < 2500



R407F is the best capacity provider with lowest GWP for supermarket applications

R407F (Genetron Performax® LT)

Honeywell

- Developed for use in low and medium-temperature commercial refrigeration applications
- Proven for retro-fit of R-22 and R-404A

- ASHRAE **R-407F**
- **GWP = 1825**
- **A1** ASHRAE safety rating
- EPA SNAP approved
- Reach registered
- 100% Zero ozone depleting

Blend of
R-32 / R-125 / R-134a
30% / 30% / 40%

R407F is the Lowest* GWP HFC for Supermarket Applications

* Commercially Available

Independent Measured Performance Comparison

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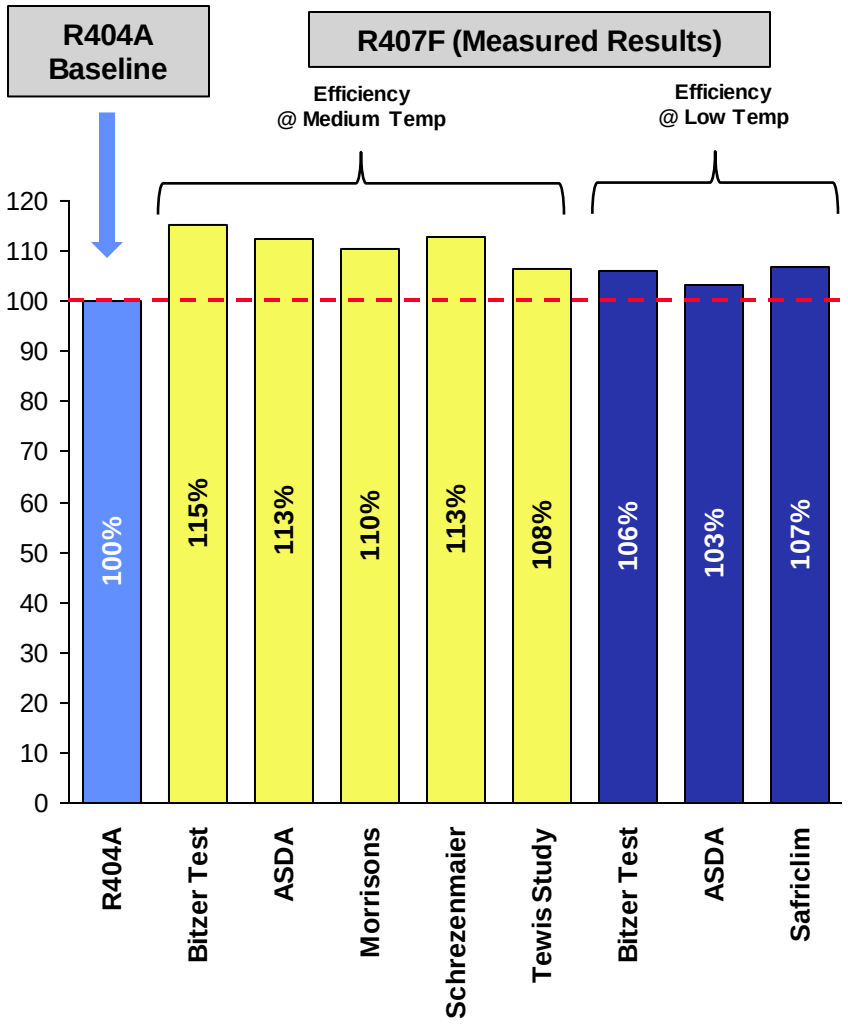


Efficiency comparisons
(Independent verification)

- 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

Full Stores Comparison: ASDA / WALMART

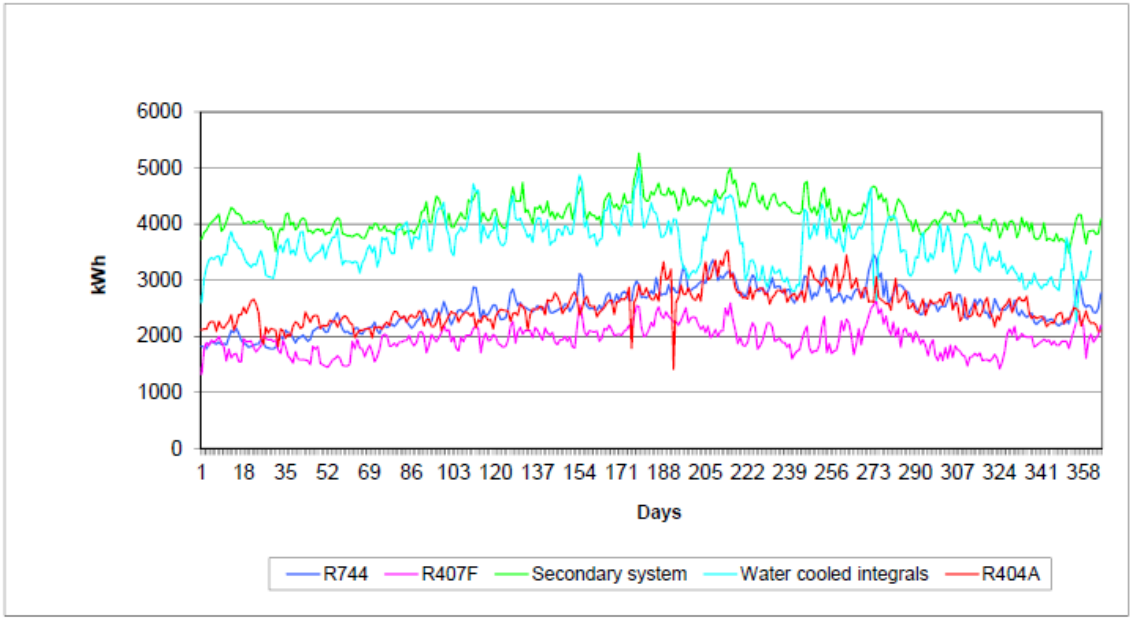


Figure 2 – 2011 Annual energy consumption.

	R407F system	R404A system	R744 system	Secondary system	Water cooled integrals
Total energy consumption in 2011 (kWh)	710,983	919,413	916,831	1,520,700	1,315,531
Life Time TEWI (Tonnes CO2)	6,055	17,669	6,893	11,433	10,027

Figure 1 – Energy consumption and environmental impact summary.

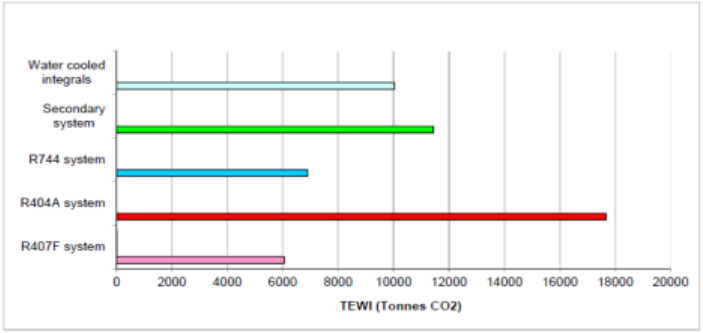


Figure 3 – 2011 Environmental Impact.

*** R404A data from 2005**

**** Ref – www.ior.org.uk *(Evaluation of available Refrigeration Systems in the Retail Sector – by James Bailey & Brian Churchyard, 4th Oct. 2012)***

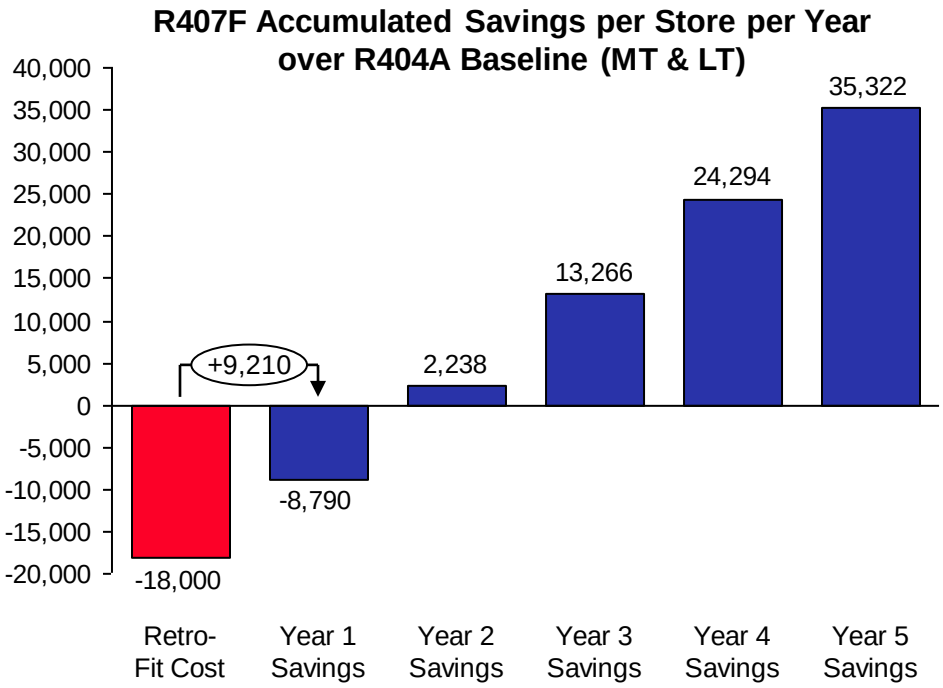
- Lowest Electricity consumption and lowest CO2 emissions for R407F under UK climate.
- Extract from Conclusions *'this paper identifies that irrespective of a retailer's refrigeration strategy it is possible to greatly reduce emissions by retrofitting systems operating on R404A / R22 with Performax® LT'*

R407F: Lowest CO2 Emissions and Best Financial Choice for a Supermarket

Supermarket Store Trials – Savings R407F vs. R404A

Honeywell

Extrapolated from 1 Year trial



Annual Comparison	Usage (kg's)	R407F Savings/kg over R404A (€)	R407F Accumulated Savings over R404A
Year 1	996	9.25	9210
Year 2	130	84.90	20238
Year 3	130	84.90	31266
Year 4	130	84.90	42295
Year 5	130	84.90	53323
Total 5 Years	1516	35.19	53323

- Combination of cost for retro-fit / refrigerant / leaks and energy consumed
- Typical Supermarket Example:
  - Cost of retro-fit pay back inside 2 years
  - Total Estate of 500 stores over 5 years
    - Estimate savings R407F = **€26.6M**
    - Cost to Retro-Fit = **€9M**
    - Estimate net savings = **€17.7M**
- **Direct money saving for new build!**

Leak Rate @ 15%/annum
Cost of Energy @ €0.14/kWh

R407F Provides Very Short Payback or Direct Money Savings

R407F Case Studies

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- Case: Saucisson Storage
- Application: Food Process / Storage
- Location: Macon, France
- Trial: Direct R404A v R407F
- Compressor: GEA Bock
- Contractor: Safriclim
- Result: Energy Benefit of 7%

- Case: Biedronka Stores
- Application: Supermarket
- Location: Warsaw, Poland
- Trial: Retro-Fit R404A with R407F
- Compressor: Bitzer
- Contractor: n/a
- Result: Energy Benefit of 15%

In Summary
In any of the systems tested were not any additional adjustment-all parameters set IE. for R404A refrigerant. It is the turn of ny plus the use of R407F as a wildcard R404A-there is no need for laborious adjustment expansion valves (thermostatic). The results of the research allow for the formulation of the conclusion that using new refrigerants GenetronPerformax LT-R407F, you can add space investment in refrigeration installation to improve its energy efficiency, lower total cost of ownership and causes ić to environmental protection through reducing carbon dioxide emissions

Compressor Qualification – June 2014

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COMPRESSOR APPROVAL for Performax® LT (R407F)

Compressor Manufacturers Update on R407F Qualification

BRANDS	Qualified for use on Performax® LT (R407F)	Included in Selection Software
Copeland Scroll / EMERSON Climate Technologies	Qualified & Released	Yes Current Ver. Select 7.7
Bitzer	Qualified & Released	Yes Currently on-line Version
BOCK COMPRESSORS	Qualified & Released	Yes
Frascold	Qualified & Released	Yes
DORIN	Qualified & Released	Yes
Tecumseh	Medium Temp Qualified. Low Temp excluded	Next Release
Maneurop RECIPROCATING COMPRESSORS	Final Testing - Expect Full approval in Summer 2014	
embraco	Testing - Not qualified for LT Hermetics	Samples Only

4GE-23Y

Op. Frequency: 50 Hz

MT conditions

to = -10°C
tc = 45°C
Δtoh = 10 K
Δtuc = 0 K

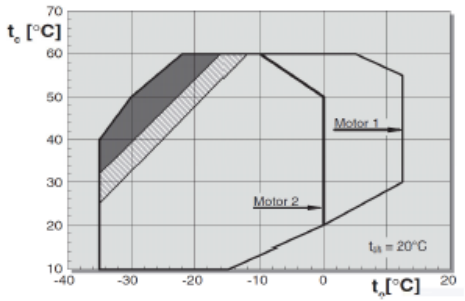
Refrigerant(i)	R404A	R407A	R407F
Evaporator capacity [kW]	41,053	39,281	42,994
Power input [kW]	20,13[illegible]	17,404	18,281
COPo [-]	2,03[illegible]	2,257	2,352
COPo_R(i)/COPo_R404A [%]	100,0%	110,7%	115,4%
Tdisch (°C)	73[illegible]	86.8	90.9

LT conditions

to = -35°C
tc = 40°C
Δtoh = 10 K
Δtuc = 0 K

Refrigerant(i)	R40[illegible]A	R407A	R407F
Evaporator capacity [kW]	12,[illegible]22	9,974	11,218
Power input [kW]	10,[illegible]	8,199	8,671
COPo [-]	1,22[illegible]	1,217	1,294
COPo_R(i)/COPo_R404A [%]	100,0%	99,7%	106,0%
Tdisch (°C)	81.5	115.2	122.5

R407F 4VES-7Y .. 6FE-50Y③,④



t_o Evaporating temperature (°C)
t_{oh} Suction gas temperature (°C)
Δt_{oh} Suction gas superheat (K)
t_c Condensing temperature (°C)
Additional cooling or max. 0°C suction gas temperature
Additional cooling or limited suction gas temperature according to <20 K suction gas superheat

③ Evaporating and condensing temperatures are based on dew point conditions (saturated vapour)

④ Lower evaporating temperatures are possible with CIC® operation.
Selection upon request.

R407F is Qualified in All Major Compressor Brands and Technologies

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Typical Supermarket System / Glide Influence

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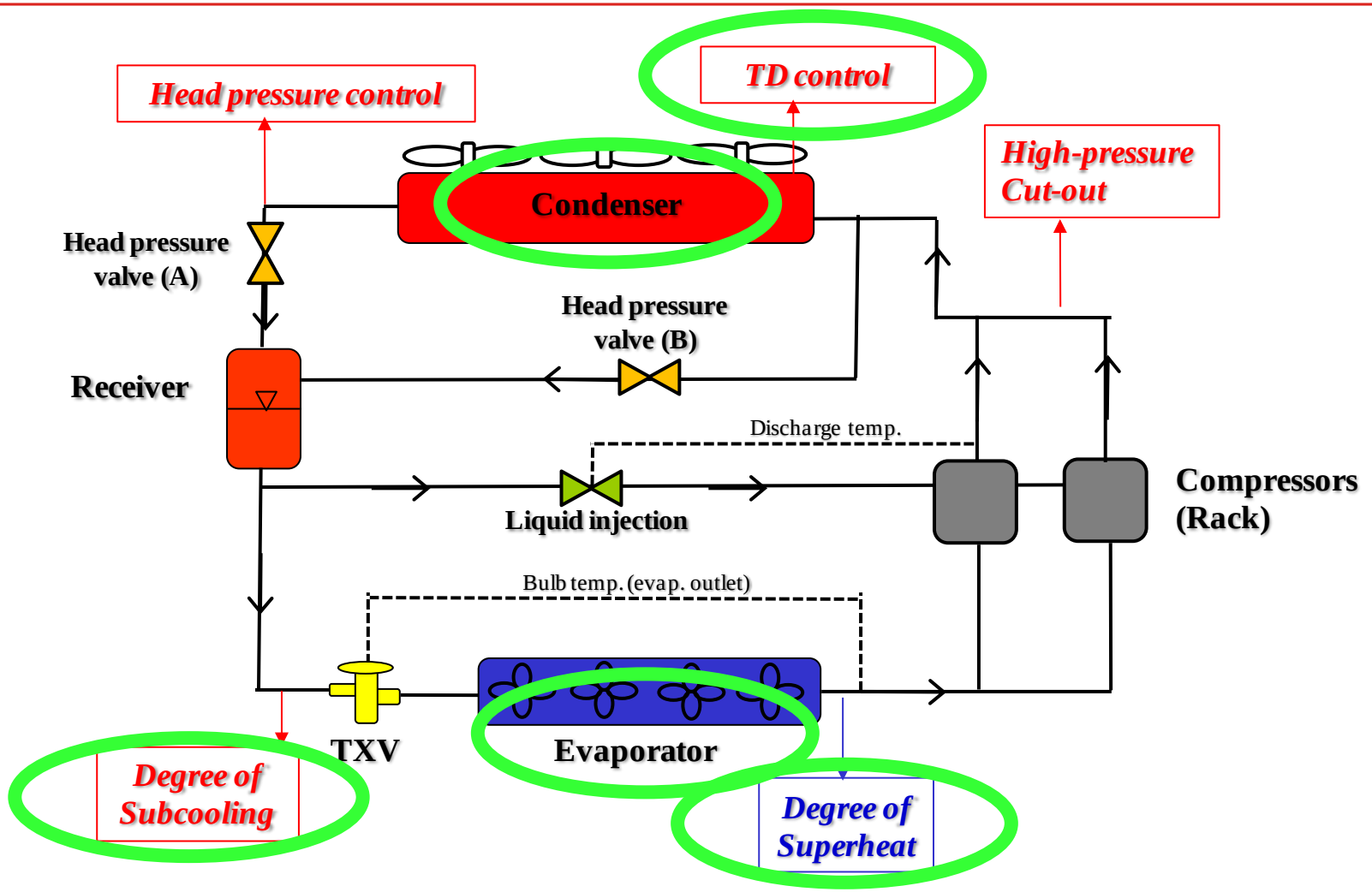

Glide management educational presentation can be found here

Glide Should be Considered for Main System Settings

Compressor Performance: Glide Influence

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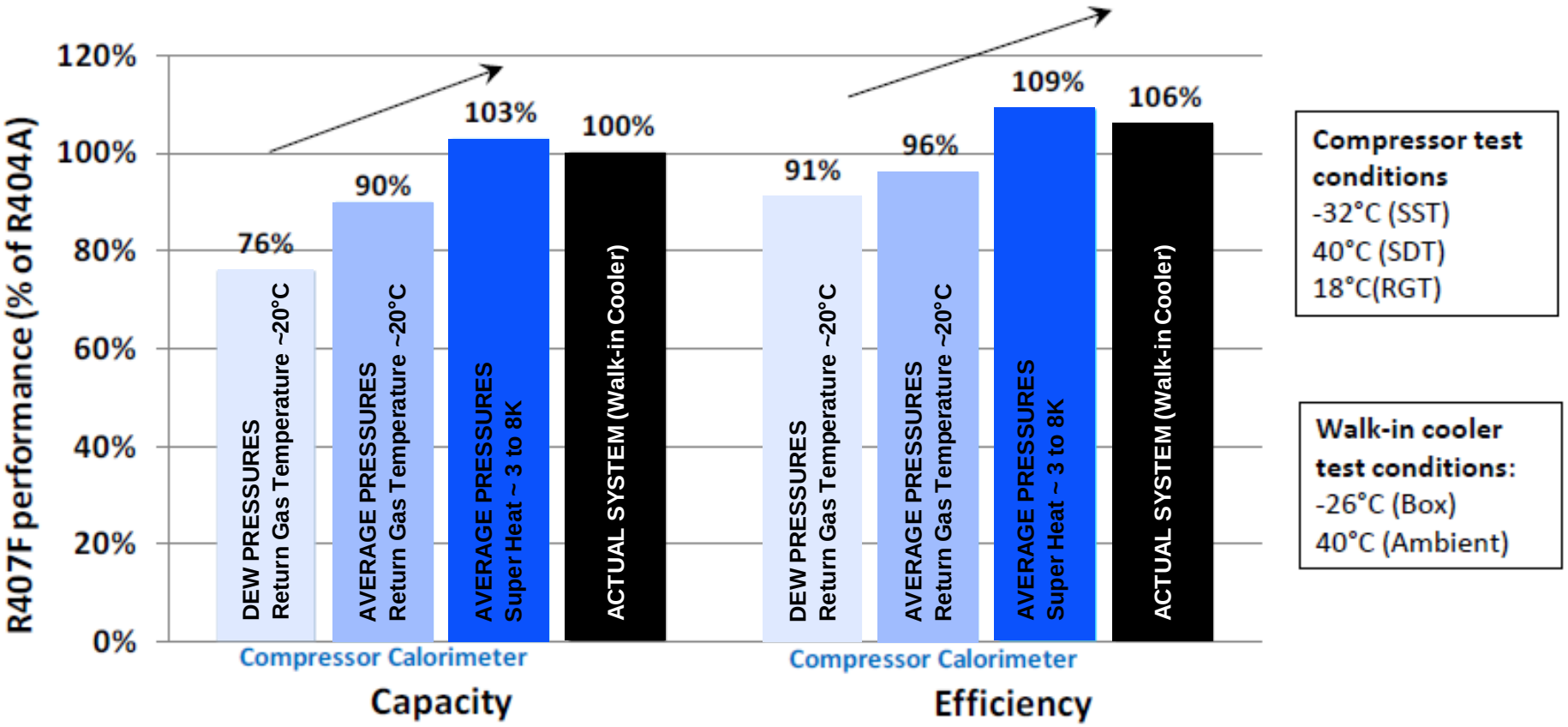

- Selecting Dew pressure is misleading vs. Capacity and COP system results.
- Very high superheat has negative impact on refrigerants cycle.
- Appropriate system settings is a key to Capacity and Electricity consumption.

Average Pressures and Controlled SH are Key Factors

Fractionation: Nominal vs. Circulating Composition

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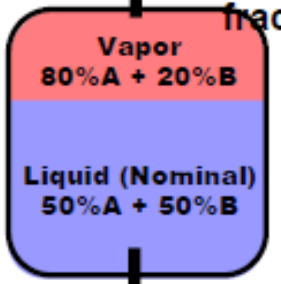
Fractionation is the change in the circulating (system) composition relative to the nominal composition

1) Refrigerant Charging:



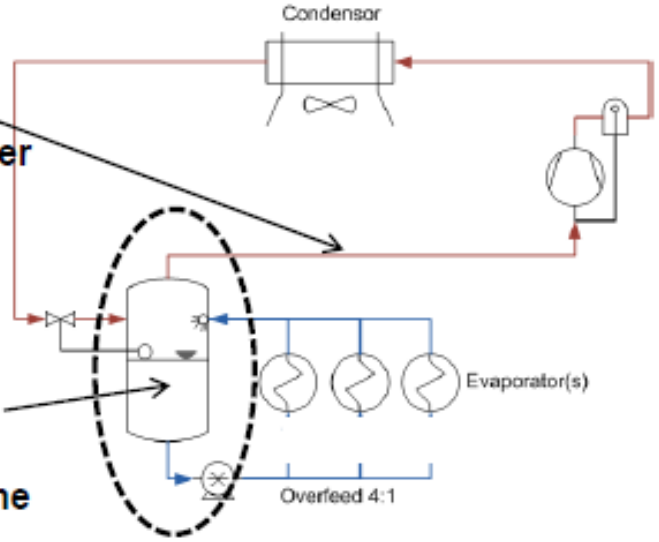
Charge from vapor port will cause fractionation

Blends should always be charged from liquid port

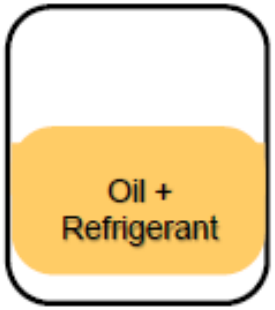
2) Flooded Evaporators:

high-pressure components circulate at higher concentration

Higher concentration of low-pressure components in the accumulator



3) Lubricant:



Blend components may have preferential solubility

4) During Leak Events

Higher pressure components of the blend may leak first, causing change in composition.

Leakage: Several Worst Case Scenario Leaks (30% each)

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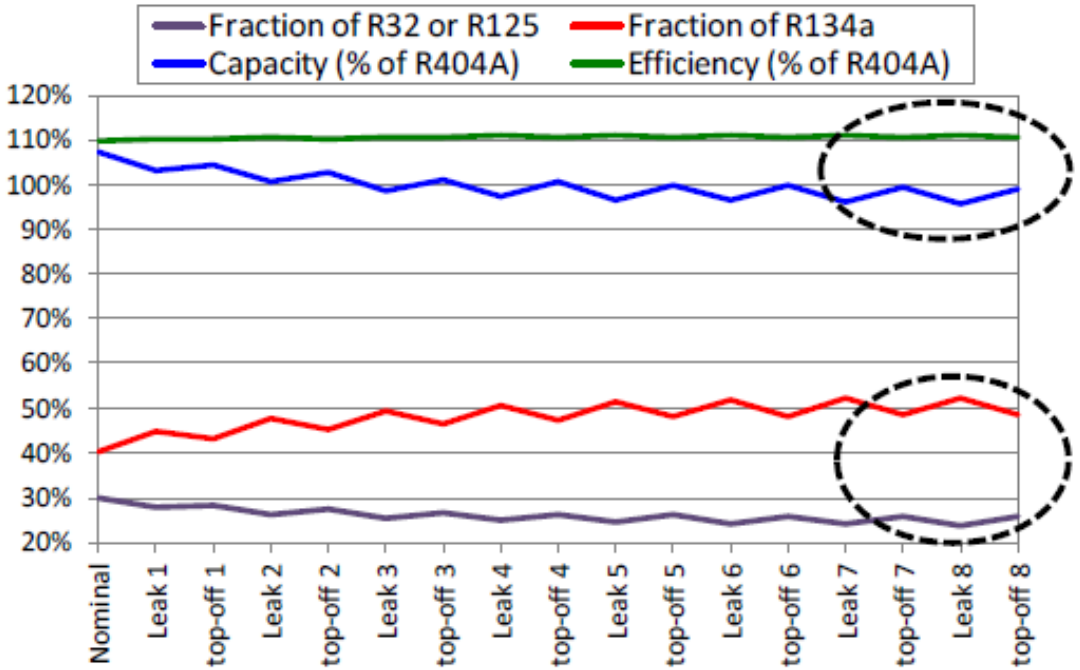

After several leak/top-off events, composition and performance would become stable

1) **Using experimental data we estimated the impact of 8 consecutive "two-phase" (worst case scenario) leaks of 30% of the total charge each, followed by top-offs.**

2) **After the 8th leak/top-off event:**
   - Changes in composition due to leaks would be compensated by the top-offs, so the blend composition would remain stable
   - Capacity would remain nearly unchanged and still a match of R404A
   - Superior efficiency of R407F would be maintained

R407F Maintains High COP and Capacity for Worst Case Leakage

Technical Conclusion

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- When compared to R404A – R407F provides .....
  - Energy Improvements (up to 15%)
  - Carbon Benefits (on GWP -53.5% and TEWI -66%)
  - Capacity Improvements
  - Life Cycle Cost Benefits / Engineer 'Friendly'
  - 'Future proof' complies with F-Gas regulation post 2030 and minimizes HFC taxes where applied
- Simple to retro-fit R404A (glide!)
  - Same Expansion Valves
  - Remove R404A / Evacuate / Change Drier / Liquid Charge with R407F
  - Optimise System / Expansion Valve settings for R407F (Super Heat)
  - Check Operation ..... Save Energy!
- Widely available through a multi-channel distribution network

Genetron Performax® LT F-Gas Ready Honeywell

Performax LT can be used for servicing without end date. R404A will be banned.

Genetron Performax® LT (R407F) – The 'First Choice' Solution

Thank you! Questions?

Honeywell

Honeywell

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