




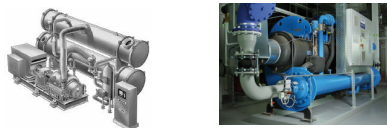


**LATEST UPDATE ON LOW GWP REFRIGERANT
DEVELOPMENT AND IMPLEMENTATION**

10-Apr-2018, Beijing

Honeywell
THE POWER OF **CONNECTED**

Solstice® Low-GWP Refrigerants













| Solstice HFOs | | | | |
|----------------------|-------------------------------------|-------------------------------------|-------------------------------------|---|
| Current Product | Non Flammable | Mildly Flammable (ASHRAE A2L) | Select Application Examples | |
| HFC-134a GWP=1300 | | Solstice yf (R1234yf) GWP < 1 | Mobile A/C, Vending, Refrigerators |  |
| HFC-134a GWP=1300 | | Solstice ze (R1234ze) GWP < 1 | Cascades – Med Temp Refrigerators |  |
| HFC-134a GWP=1300 | | Solstice ze (R1234ze) GWP < 1 | Chillers – Med Pressure |  |
| R-123 GWP= 79 | Solstice zd (R1233zd) GWP = 1 | | Chillers – Centrifugal Low Pressure |  |

Note: All GWP values from the IPCC, “AR5”

Honeywell Confidential - © 2017 by Honeywell International Inc. All rights reserved.

Solstice HFOs for Low and Medium Pressure Applications

Solstice® Refrigerant Blends

| Solstice HFO Blends | | | | |
|----------------------|---|--|------------------------------------|---|
| Current Product | <i>Solstice™ N Series</i> Reduced GWP Option Non Flammable (ASHRAE A1) | <i>Solstice™ L Series</i> Lowest GWP Option Mildly Flammable (ASHRAE A2L) | Select Application Examples | |
| HFC-134a GWP=1300 | N-13 - GWP=547 (R450A) R515A - GWP=387 | | Chillers, Med-temp Refrigeration |    |
| HCFC-22 GWP=1760 | | L-20 - GWP=295 (R444B) | Stationary A/C, Refrigeration |    |
| R-404A GWP=3943 | N-40 - GWP=1273 (R448A) | L-40X - GWP=146 (R455A) | Low-Temp Refrigeration & Transport |    |
| R-410A GWP=1924 | | L-41z - GWP=714 (R447B) L-41y - GWP=675 (R452B) | Stationary A/C Applications |    |

Note: All GWP values from the IPCC, “AR5”

Honeywell Confidential - © 2017 by Honeywell International Inc. All rights reserved.

Solstice HFO Blends for Medium & High Pressure Apps

Solstice Refrigerant for R134a Replacement

| Refrigerant | Formulation | Molar Mass | Cri. Temp. | NBP | GWP* | ASHRAE Class | Capacity | Efficiency |
|------------------------|-----------------------------|------------|------------|-------|------|--------------|----------|------------|
| | | [kg/mol] | [°C] | [°C] | [-] | [-] | % | % |
| R-134a | - | 102.0 | 101.1 | -26.1 | 1300 | A1 | 100% | 100% |
| Solstice ze (R-1234ze) | - | 114.0 | 109.4 | -19.0 | <1 | A2L | 76% | 102% |
| Solstice 515A | 88% R-1234ze 12% R-227ea | 118.7 | 108.2 | -19.3 | 403 | A1 | 76% | 102% |
| Solstice N13 (R-450A) | 42% R-134a 58% R-1234ze | 108.7 | 105.6 | -23.6 | 547 | A1 | 88% | 101% |

* Note: All GWP values from the IPCC, "AR5"; **Condition: Tc=54.4°C, SC=8.3°C, Te=7.2°C, SH=27.8°C;

- **1234ze: GWP=0; ASHRAE A2L (mild flammable)**
 - Similar efficiency relative to R134a. Lower capacity can be addressed during design.
 - Potential applications: high stage of cascade CO2 systems; Screw compressor chillers; Mid-higher temperature heat pump
- **R-515A, "non-flammable ze"**
- **N13: R-134a/1234ze (42/58); GWP=547; ASHRAE A1 (non-flammable)**
 - 60% reduction of GWP. Lower capacity and small glide can be addressed during design.
 - Potential applications: high stage of cascade CO2 systems; Screw compressor chillers; Mid-higher temperature heat pump
 - Non-flammable and could be quick adopted with current R-134a tech platform

Honeywell Confidential - © 2017 by Honeywell International Inc. All rights reserved.

Multi Options to Meet Different Requirement

Solstice Refrigerants for Larger Chillers

Solstice zd

- ASHRAE A1
- Best low pressure alternative
- GWP reduced by 99.9%

Solstice ze

- ASHRAE A2L
- GWP reduced by 99.9%

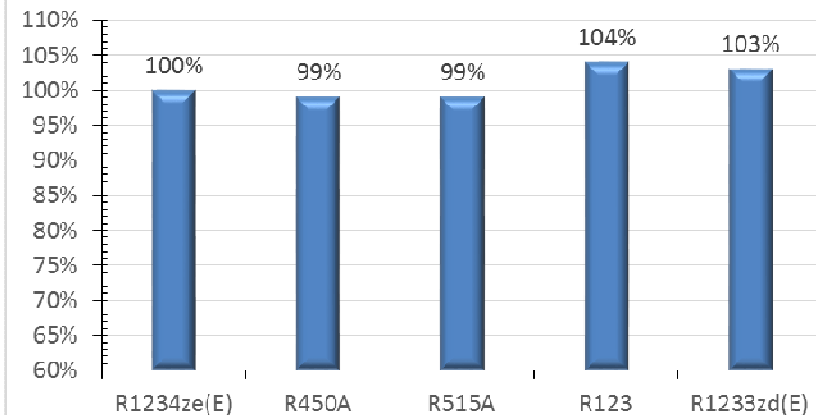
Solstice R515A

- ASHRAE A1
- GWP reduced by ~70%
- Azeotropic mixture → Flooded systems

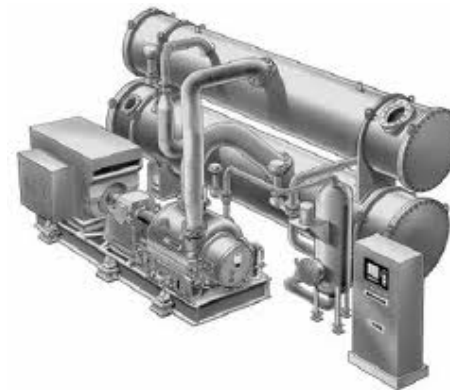
Solstice R450A (N13)

- ASHRAE A1
- GWP reduced by ~60%
- Zeotropic mixture → DX systems

COP Comparison between Solstice and 134a



Condition: $T_{\text{evap}} = 5\text{C}$; $SH = 5\text{C}$; $T_{\text{cond}} = 40$; $\eta_{\text{is}} = 0.8$

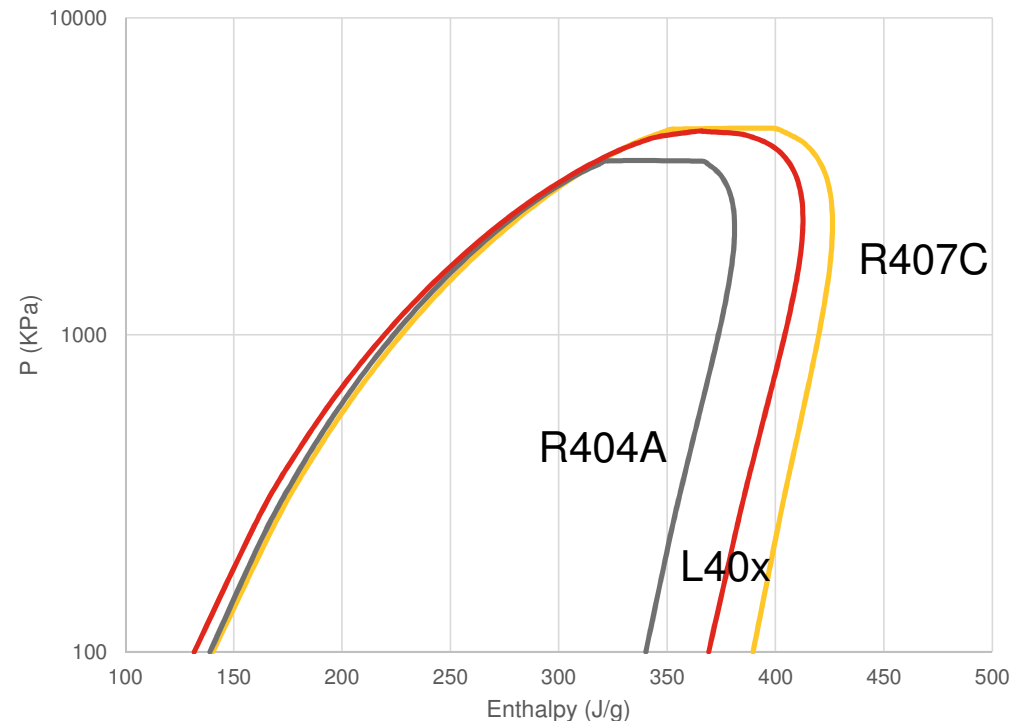


Honeywell Confidential - © 2017 by Honeywell International Inc. All rights reserved.

Global Adopted Solstice zd for Low Pressure Chiller

Requirements of Self-Contained Refrigeration Systems

- GWP<150 (F-Gas mandate from 2022) on hermetically sealed systems
- Discharge temperature:
 - Limited to 135°C at compressor calorimeter conditions.
 - Below 120°C preferred at “System” operating conditions
- Use of suction-Line/Liquid-Line heat exchanger
- Capacity larger than 90% still recoverable with compressor sizing without major impact on heat exchangers.



Honeywell Confidential - © 2017 by Honeywell International Inc. All rights reserved.

Solstice L40x (R-455A), Designed for the Most Critical Requirement

Solstice L40X: A2L, GWP<150 for Tomorrow

GWP<150

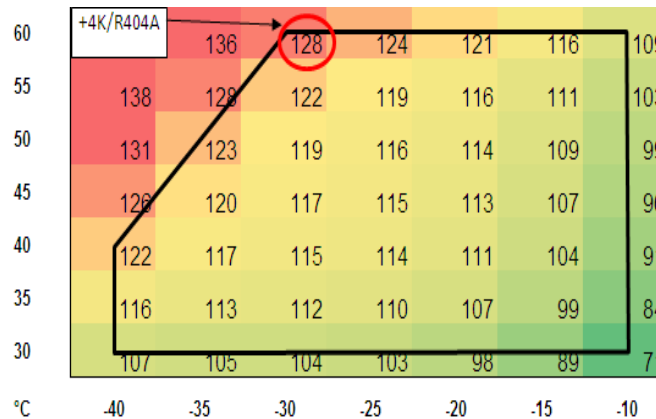
Solstice L40X

| | Solstice® L40X |
|---------------------------------------|----------------------------------|
| Baseline | R-404A (A1, 3922 / 3943) |
| GWP 4 th / 5 th | 148 / 145 |
| Class | A2L |
| Potential app. Use | Self-contained, condensing units |
| Drop-in ⁽¹⁾ Cap. | 4% lower |
| Drop-in ⁽¹⁾ Eff. | 3% to 6 % higher |
| Compressor ⁽²⁾ | Recip, Rotary, Scroll |
| Comments | Same Tdis in LT |
| Status | Developmental |

| Drop-in results (freezer) | | | | | |
|---------------------------|-------------------|--------------------|-------------------|----------------|------|
| | T _{evap} | T _{disch} | T _{cond} | Q ₀ | COP |
| | [°C] | [°C] | [°C] | [%] | [%] |
| R404A | -34.9 | 100 | 33.5 | 100% | 100% |
| L40X | -34.4 | 108 | 36.1 | 96% | 106% |



Calorimeter tests on compressor (Mid/Mid with SH=10K)



Honeywell Confidential - © 2017 by Honeywell International Inc. All rights reserved.

| | -40 | -35 | -30 | -25 | -20 | -15 | -10 |
|----|-----|-----|-----|-----|-----|-----|-----|
| 30 | -1% | 2% | 5% | 7% | 9% | 11% | 12% |
| 35 | -1% | 3% | 6% | 8% | 10% | 11% | 12% |
| 40 | -1% | 3% | 7% | 9% | 11% | 12% | 13% |
| 45 | | 2% | 7% | 10% | 12% | 14% | 15% |
| 50 | | 0% | 6% | 11% | 14% | 15% | 17% |
| 55 | | | 4% | 10% | 15% | 18% | 19% |
| 60 | | | 1% | 9% | 16% | 20% | 23% |

COP vs. R404A

Suitable Properties for Diverse Applications: Refrigeration and Heating

Thanks you for your attention!

More information, pls visit Honeywell booth: E3D31