Low GWP Replacements for Air Conditioning Applications

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Introduction – LGWP Refrigerant Options

Evaluation of LGWP Alternatives for High Ambient Temperatures

Evaluation of LGWP Refrigerants for Hydronic Systems

Evaluation of LGWP replacements for R410A and R407C in positive displacement chillers

Conclusions
Honeywell’s Low GWP Refrigerants
# Ultra-Low GWP Solsticē® Refrigerants

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<th>Examples of Applications</th>
<th>Current Product</th>
<th>Non-Flammable (ASHRAE A1)</th>
<th>Mildly Flammable (ASHRAE A2L)</th>
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<td>MAC, Vending, Refrigerators</td>
<td>HFC-134a</td>
<td></td>
<td>Solsticē yf GWP&lt;1</td>
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<tr>
<td>Chillers, CO₂ Cascade Refrigerators</td>
<td>GWP-1300</td>
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<td>Solsticē ze GWP&lt;1</td>
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<tr>
<td>Centrifugal Chillers</td>
<td>R-123 GWP-79</td>
<td>Solsticē zd GWP=1</td>
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Note: All GWP values use the latest assessment from the ICCP, “AR5”
# Low GWP Solstice® Blends

<table>
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<tr>
<th>Examples of Applications</th>
<th>Current Products</th>
<th>Solstice N Series Reduced GWP Option Non-Flammable (ASHRAE A1)</th>
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<td>N-20-GWP&lt;1000</td>
<td>L-20-GWP&lt;300 (*R-444B)</td>
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<td>Stationary AC Applications</td>
<td>R-410A GWP-1924</td>
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<td>L-41-GWP&lt;600 (*R-447A)</td>
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*Provisional ASHRAE #

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**Solstice® Blends for Medium- and High-Pressure Applications**
LGWP Options for Warm Climates
Testing of R22 Mini-Split (RAC) System

- Strong push towards the phase out R22 in the Middle East countries
- Implementation of stringent efficiency requirements in these regions
- R407C, R410A show a decline in efficiency at high ambient temperatures

- Cooling only system with nominal cooling capacity of 7.0 kW and nominal COP of 3.0
- L20, R407C were evaluated and capillary tube was designed for each refrigerant
- For R407C and L20, the circuitry of heat exchangers were modified to account for the glide and obtain better matching of temperature profiles of the air and the refrigerant

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<th>Test Condition</th>
<th>Cooling Mode</th>
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<tr>
<td></td>
<td>Indoor Ambient</td>
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<tr>
<td></td>
<td>Db</td>
</tr>
<tr>
<td>T1</td>
<td>27</td>
</tr>
<tr>
<td>T3</td>
<td>29</td>
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<tr>
<td>T3 max</td>
<td>32</td>
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</tbody>
</table>

Test conditions (ISO Std. 5151)
L-20: Performance-Mini-Split System

Performance Results

- L20 shows similar capacity and efficiency relative to R22 over range of ambient temperatures observed in warm climates.

- L20 shows 4% to 5% higher efficiency than R407C.

- L20 has 20% lower mass flow than R22 which leads to lower pressure drop in the system and offers potential for further improvement in performance.

- L-20 reduces the direct emissions substantially due to lower GWP (295) and lower charge (85%).

L-20: Lowest GWP, Lower Charge, Excellent Performance
Air-to-Water Heat Pumps (Hydronic Systems)

- These types of heat pumps are used for floor heating or similar applications
- Low ambient temperatures represent a challenge for the performance (capacity, efficiency) and reliability (discharge temperature) of the system
- Most compressor manufacturers have a maximum temperature limit of 130ºC
- Simulations carried out for two types of systems: A typical system with a standard compressor and a system with vapor injected compressor
- Vapor injected systems would typically allow to extend the system operating envelope by improving efficiency and reducing discharge temperature
- Refrigerants considered were R410A as baseline, R32, L-41 and L-20
Performance for a typical system

- Maximum discharge temperature limit for the compressor is about 130°C
- Both, L41 and R32 show about 2% higher efficiency than R410A but with a reduced operating envelope
- L20 shows about 4% higher efficiency compared to R410A across the operating envelope
- L20 has discharge temperature similar to R410A and extends the operating envelope significantly over R32
R32 shows efficiency similar to R410A but still with a significantly reduced operating envelope
L41 shows upto 4% higher efficiency with reliable operation suited to moderately cold climates
L20 has operating envelope identical to R410A with upto 8% higher efficiency

*L-20 matches operating envelope of R410A with improved performance*
Positive Displacement Chillers
Modeling of Chillers

Semi-Theoretical Models: CYCLE-11

Model Characteristics

- Inlet and outlet temperatures of external fluids are imposed
- UA representation of heat exchangers
- Air side heat transfer coefficient assumed to be constant
- Simulation of Real Systems by using calibration with one experimental point
- Accounts for transport properties of working fluids. Good to compare refrigerants

Assumptions

- Capacity 20 ton (70 kW)
- Air temperature 35 °C, Water cooled from 12 °C to 7 °C
- Superheat and subcooling of 5 °C
- Compressor Isentropic and Volumetric efficiency constant
Air Cooled Chillers- R410A Replacement

Drop-In performance shows lower capacity (90%), slightly higher COP (103%) and lower mass flow (69%)

Heat exchangers circuitry modified to increase mass velocity

Shows performance similar to R410A by using a 13% larger compressor displacement
Air Cooled Chillers - R407C Replacement

L20

- Drop-In performance shows similar capacity (99%) and COP (100%) and lower mass flow (80%)
- L20 shows higher efficiency (103%) when heat exchangers circuitry modified to increase mass velocity.
Conclusions

- **Mini Split Air Conditioner for Warm Climates**
  - L20 shows performance similar to R22 especially at high ambient temperatures

- **Air-to-Water Heat Pumps (Hydronic Systems)**
  - L-20 shows higher efficiency with very similar operating envelope compared to R410A
  - With a vapor injected compressor, L20 shows additional efficiency improvement over R410A with an identical operating envelope

- **Air Cooled Positive Displacement Chillers**
  - L41 good option as R410A replacement. Minor system modifications may be required
  - L20 shows similar performance to R407C as drop-in replacement for, and shows improvement in efficiency with minor system modifications

*Further performance and safety evaluations are needed to explore these applications.*
Thank you!!!

Questions?

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