Chillventa CONGRESS 2022
Heat Pumping Technologies
SOLSTICE® N71 (R-471A) AS A LONG-TERM REFRIGERANT FOR RETAIL SECTOR

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ADDRESSING THE NEEDS OF SUPERMARKET OWNERS

How to address them?

- Safety at a sales area
- Reliability (no failures at high ambient)
- Eco-efficiency analyses (CAPEX, OPEX…)
- Flexibility (remodeling, space constraints…)
- Easy installation and service (skills and components available)
- Low GWP products (F-gas, tax, incentives)
Solstice® N71 is a long-term refrigerant for retail sector

- Honeywell Solstice® N71 (R-471A) is the only low GWP (<150), nonflammable refrigerant that answers needs of the retail sector in terms of performance, safety and Total Cost of Ownership (TCO).
  - Low pressure refrigerant → lower leak rates
  - Offers better efficiency in high ambient conditions
  - No charge size limitations for flammability (A1)
  - Standard service practices and traditional contractor base (vs. CO2)
  - Regulatory compliant with Fgas
  - Handling, storage, and transportation same as low pressure nonflammable refrigerants

<table>
<thead>
<tr>
<th>Property</th>
<th>R-471A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition (by weight)</td>
<td>R-1234ze / R-1336mzzE / R-227ea (78.7 / 17 / 4.3 %)</td>
</tr>
<tr>
<td>GWP</td>
<td>148</td>
</tr>
<tr>
<td>Safety class</td>
<td>ASHRAE A1</td>
</tr>
<tr>
<td>Critical temperature</td>
<td>112 °C</td>
</tr>
<tr>
<td>Glide at 1,013 bar</td>
<td>3.2 K</td>
</tr>
<tr>
<td>Boiling point</td>
<td>-16.9 °C</td>
</tr>
</tbody>
</table>

These are just some of a mosaic of properties that must be considered in selecting a refrigerant.
SOLSTICE® N71 (R-471A)
NEW BUILD

Heat recovery
Case study – Supermarket 1000 m²
CASE STUDY – LONDON UK, SUPERMARKET 1000 M²

### Specification of the partitions

1. **Walls**: concrete δ=150 mm and PU δ=200 mm with λ = 0.018 W/m-K
2. **Ceiling**: compressed mineral wool δ=300 mm with λ = 0.03 W/m-K
3. **Floor**: concrete δ=150 mm and PU δ=150 mm with λ = 0.02 W/m-K
4. **Windows**: 10% of the total floor area, with k = 1.5 W/m²-K

### Heat transfer model through partitions

- **Sandwich partition**
- **Simplified partition**

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**Details on modelling heating needs**
## CASE STUDY – LONDON UK, SUPERMARKET 1000 M²

### Specification of the heat sources

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heat through walls and ceiling can be either loss → or gain ←</td>
</tr>
<tr>
<td>2</td>
<td>Heat through floor is a loss →</td>
</tr>
<tr>
<td>3</td>
<td>Heat through windows can be either a loss → or gain ←</td>
</tr>
<tr>
<td>4</td>
<td>Make-up air for mechanical ventilation can be either a loss → or gain ←</td>
</tr>
<tr>
<td>5</td>
<td>Air infiltration (due to non airtight construction) is always a loss →</td>
</tr>
<tr>
<td>6</td>
<td>Heat absorbed by display cabinets and cold rooms is always a loss →</td>
</tr>
<tr>
<td>7</td>
<td>Heat from people (customers and store staff) is always a gain ←</td>
</tr>
<tr>
<td>8</td>
<td>Heat from lighting is a gain ←</td>
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</table>
| 9 | Convectors provides a gain ←  
|   | Convector supply water temp. is 35°C |

### Details on modelling heating needs

- **Heat through walls and ceiling:** Can be either a loss or gain. 
- **Heat through floor:** A loss. 
- **Heat through windows:** Can be a loss or gain. 
- **Make-up air for mechanical ventilation:** Can be a loss or gain. 
- **Air infiltration:** Always a loss. 
- **Heat absorbed by display cabinets or cold rooms:** Always a loss. 
- **Heat from people (customers and store staff):** Always a gain. 
- **Heat from lighting:** A gain. 
- **Convectors:** A gain. (Supply water temp. is 35°C).
ARCHITECTURE FOR FOOD RETAIL

Medium Temperature Solstice® N71 (R-471A)
- Centralized Rack System
- Traditional rack or distributed system (well-know technologies)
- Uses a non-flammable refrigerant of GWP<150 throughout the sales area
- Expect similar performance to typical R-134A Medium Temp systems

Low Temperature Solstice® L40X (R-455A)
- Condensing units with Solstice® L40X (R-455A)
- Possible use of Solstice® N40 (R-448A) for systems < 40 kW
CASE STUDY – REFRIGERATION SYSTEM

**MT system**
- refrigerant R-471A
- installed cooling capacity 100 kW
- simultaneous factor for actual load on refrigeration system:
  \[ x_{\text{day}} = 95\%, \quad x_{\text{night}} = 70\% \]
- evaporating temperature -7°C
- condensing temperature: bin temperature + 8K, but not less than 15 °C
- superheat at compressor suction 10K

**LT system**
- refrigerant R-455A
- installed cooling capacity 14 kW
- simultaneous factor for actual load on refrigeration system:
  \[ x_{\text{day}} = 95\%, \quad x_{\text{night}} = 70\% \]
- evaporating temperature -32°C
- condensing temperature: bin temperature + 8K, but not less than 15 °C
- superheat at compressor suction 10K

**Systems schematics**
1000 M² SUPERMARKET – R471A / R455A SYSTEM

• **Supermarket data**
  – Installed cooling capacity: 100 kW MT & 14 kW LT
  – Heating needs: 209 818 kWh / water network 35/30°C
  – Hot water needs: 119 866 kWh / inlet water 5°C / outlet 60°C

• **Heat recovery scenario**
  – Cover hot water need first
  – Remaining available heat is used for heating
  – Gas boiler is used to cover the remaining needs
1000 M² SUPERMARKET – R471A / R455A SYSTEM

- Heat recovery potential
  - Refrigeration system produce 100% hot water coverage (119 866 kWh)
  - Refrigeration system cover around 20% of the heating needs (41 000 kWh)
  - Total saving: **161 000 kWh/year** (Gas saving if gas boiler is used instead of heat recovery)

Honeywell Simulation based on previously mentioned assumptions

48% is the reduction in gas consumptions for both heating and hot water
SOLSTICE® N71 (R-471A)

REMODELING

Deep subcooling concept
Remodeling existing store is a challenge

RETAIL SECTOR | EXISTING ASSETS

- Open display cases
- Low evaporating temperature (open display cases)
- Most of Existing stores
- Compressor rack designed for open display cases
- Copper tube network for liquid and suction lines (designed for open display cases)
- High remodeling cost
- High pressure and high leakage rate

Remodeling Goals

- Keep High quality customer experience
- Long Term solution (comply with the F-gas)
- Reduce electricity bill (increase efficiency, heat recovery)
- Lowest remodeling cost (low CAPEX)
SOLSTICE® N71 (R-471A) : REMODELING MT

Properties at -8/45°C

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<td>Suction density (kg/m³)</td>
<td>23.24</td>
<td>8.5</td>
</tr>
<tr>
<td>Enthalpy delta (kJ/kg)</td>
<td>102</td>
<td>117</td>
</tr>
<tr>
<td>Volumetric capacity (kJ/m³)</td>
<td>2370</td>
<td>994</td>
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- Existing R-404A systems cannot be drop-in with R-471A.
- Design and architecture changes will be required when remodeling an existing R-404A system.
DEDICATED MECHANICAL SUBCOOLING SYSTEM (DMSS)

DMSS features:

- DMSS sub cools liquid in the outlet of the liquid receiver of the main system
- DMSS increases cooling capacity of the main system without increasing the mass flow

DMSS boosts system capacity
**BENEFIT OF A DMSS ON A SYSTEM CAPACITY**

- Deep subcooling increases initial cooling capacity up to 64%.

### Properties at -8/45°C

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Increase in a volumetric capacity is proportional to subcooling amount.
DMSS can boost overall system COP

- Subcooling drives performances of a system function of the cooling demand.
- There is an optimum subcooling to get maximum COP.
- COP increase as much as +10 … +30%
### DMSS | CONCLUSIONS AND PERSPECTIVES

<table>
<thead>
<tr>
<th>Existing MT system</th>
<th>Remodeling with N71</th>
<th>Results</th>
</tr>
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<tbody>
<tr>
<td>– R-404A or R-404A-like refrigerant</td>
<td>– install DMSS for capacity increase</td>
<td>– system complaint with the F-gas as a long-term solution</td>
</tr>
<tr>
<td>– -10 to -8°C design evaporating temperature</td>
<td>– use existing compressors rack</td>
<td>– R471A offers elevated efficiency versus existing system</td>
</tr>
<tr>
<td>– Open display cabinets</td>
<td>– install doors on display cabinets (Reduced load, higher evaporating temperature leading to energy savings)</td>
<td>– remodeling cost is 50%* of the cost of a brand-new system.</td>
</tr>
<tr>
<td>– Copper pipe network</td>
<td>– use all the installed copper pipes (-40%* capex)</td>
<td>– Additional opportunity for heat recovery</td>
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*Conducted for specific store in north of France, 180 kW cooling MT refrigeration system

**Solstice® N71 is the best option for remodeling existing systems**
SOLSTICE® N71 (R-471A)

REMODELING

Heat recovery
DMSS for hot water production
DMSS FOR A HOT WATER PRODUCTION

- DMSS increase the cooling capacity, COP and produces hot water

- Example:
  - model based on Bitzer reciprocating compressor for the main system and Copeland scroll compressor for the DMSS system
  - running conditions: -10/44°C, 100kW cooling capacity, water inlet/outlet: 15°C / 60°C

DMSS produces hot water with higher COP than the main system
DMSS acts as a heat pump elevating waste, low grade heat

DMSS FOR A HOT WATER PRODUCTION

- More than 50% cooling capacity increase is achieved using subcooling system
- COP stay higher versus R-404A reference system and achieves 20% increase at 20°C subcooling
- Up to 30kW of free hot water production

Honeywell simulation based on previously mentioned assumptions
THANK YOU

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