System Drop-in Test of R-404A and R-410A with Alternate Refrigerants L40, N40b, and L41a in a Commercial Automatic Automatic Ice Maker

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Presentation Outline

1. Overview of Automatic Commercial Ice Machine
   - Refrigeration system and cycle
   - Performance requirements
2. Test Plan Objectives
   - Refrigerant selection criteria
   - Test conditions
   - Equipment
3. Test Results
   - Drop-in (R-404A)
   - Soft Optimized (R-410A)
4. Conclusions
Refrigeration System Schematic

Freeze Cycle

Harvest Cycle
Cool Vapor Defrost System Schematic

Harvest Cycle Refrigerant Flows

- Accumulator
- HPCV
- Evaporator
- Harvest Valve
- Receiver
- Check Valve
Quasi-Steady State Batch Process
Performance Factors

- Refrigeration system capacity over SST range from 20 F to 0 F at SCT of 105 F
- Refrigeration system COP during freeze cycle
- Heat flux rate (mass flow x enthalpy) during hot gas defrost cycle
- Evaporator superheat (target of 0) over entire freeze cycle
- Harvest cycle performance at low condensing temperature conditions (35 F for IMH, -20 for outdoor condenser)
- Freeze cycle performance at high condensing temperature conditions (110 F for IMH, 120 for outdoor condenser)
LGWP Refrigerant Candidate Selection

**Drop-in candidates for R-404A (baseline)**
- One A1 with medium glide and one A2L with higher glide
- Range of GWP reduction vs. baseline

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Refrigerant</th>
<th>Composition</th>
<th>(Mass%)</th>
<th>Classification</th>
<th>GWP_{100}</th>
</tr>
</thead>
<tbody>
<tr>
<td>R404A</td>
<td>N40b</td>
<td>R-32/R-125/R-134a/R-1234yf</td>
<td>(25/25/20/30)</td>
<td>A1*</td>
<td>1331</td>
</tr>
<tr>
<td></td>
<td>L40</td>
<td>R-32/R-152a/R-1234yf/R-1234ze(E)</td>
<td>(40/10/20/30)</td>
<td>A2L*</td>
<td>285</td>
</tr>
</tbody>
</table>

**Soft Optimization Option**
- Modify ice machine for R-410A
- Select lower GWP option with temperature glide

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</tr>
</thead>
<tbody>
<tr>
<td>R410A</td>
<td>L41a</td>
<td>R-32/R-1234yf/R-1234ze(E)</td>
<td>(73/15/12)</td>
<td>A2L*</td>
<td>494</td>
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</tbody>
</table>
Test Conditions and Equipment

Test Conditions

- ASHRAE/ANSI Standard 29 for MOT
- AHRI Standard 810 for ice machine performance
- Additional low temperature (40 F for IMH, -20 F for remote) and high temperature (110 F for IMH and 120 F for remote) to evaluate operating range

Equipment Selection

- 1400 lb/day air cooled Ice Making Head (complete refrigeration system in indoor cabinet, no accumulator)
- 1000 lb/day remote condensing unit with CVD (compressor and condenser in outdoor section, receiver in indoor)
- Both units use TXV for expansion device
- For soft-optimize test units, condenser tube size and circuit sized for R-410A, and TXV and hot gas solenoid replaced with R-410 components
Drop-in (R-404A) Results

Commercial Ice Machine Test Results at AHRI Standard 810 Rating Condition (T_amb/T_water 90/70 °F)

Relative Performance to R-404A

- L-40
- N-40b

Capacity vs. Energy Consumption

Self-contained system

Split system
Soft-Optimized (R-410A) Results

Commercial Ice Machine Test Results at AHRI Standard
810 Rating Condition (T_amb/T_water 90/70 °F)

- Relative Performance to R-410A
- Capacity
- Energy Consumption

L-41a

Self-contained system
Split system
Off Rating Point Results – 1400 lb IMH

1400 lb/day IMH Ambient Range Performance

Relative Capacity to 90/70 Baseline (%)

-5 -4 -3 -2 -1 0 1 2 3

N-40b L-40

- 40 F air/50 F water
- 70 F air/50 F water
- 110 F air/90 F water
Off Rating Point Results – 1000 lb Remote

1000 lb/day Remote Ambient Range Performance

Relative Capacity to 90/70 Baseline (%)

-20 F air/50 F water
70 F air/50 F water
110 F air/90 F water

N-40b  L-40
Conclusions

- N-40b results were closer to the R-404A baseline performance than L-40 for drop-in tests with both system configurations.

- L-40 capacity and energy efficiency was slightly improved over R-404A for the 1400 lb/day IMH test, but in the split system, had lower capacity and energy efficiency when compared to R-404A.

- L-41 capacity and energy efficiency was slightly improved over R-410A for the 1400 lb/day IMH test, but in the split system, had lower capacity and energy efficiency when compared to R-410A.

- Further investigation is required to determine the different performance trends for the LGWP candidates in the two different system configurations.
Questions?

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