System Drop-in Test of R-410A Alternative Refrigerants
And
High Ambient Testing of R-410A and DR-55
in a Lennox 5 Ton Rooftop AC Unit

AHRI AREP Phase II Low-GWP Conference
Session III
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Presentation Outline

• Goal of This Test Program
• Description of Base Unit Tested
• Results of Standard Cooling Tests
• Results of Limited High Ambient Testing
• Conclusions
Test Program Goal

Several New Alternative Refrigerant Blends Became Available After AREP Phase I

<table>
<thead>
<tr>
<th>Refrigerant Name</th>
<th>ASHRAE Designation</th>
<th>GWP (AR4)</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>R-32</td>
</tr>
<tr>
<td>R-410A</td>
<td>R-410A</td>
<td>2088</td>
<td>50.0%</td>
</tr>
<tr>
<td>ARM-71A</td>
<td>&lt; 500</td>
<td>50% to 80%</td>
<td>10% to 40%</td>
</tr>
<tr>
<td>DR-5A</td>
<td>R-454B</td>
<td>466</td>
<td>68.9%</td>
</tr>
<tr>
<td>HPR2A</td>
<td>~ 600</td>
<td>76.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>L-41-2</td>
<td>R-447A</td>
<td>572</td>
<td>68.0%</td>
</tr>
<tr>
<td>R-32</td>
<td>R-32</td>
<td>675</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Compare the HFO blends’ drop-in performance against: R-32 & R-410A
Base R-410A Unit Information

Unit Under Test: 5 Ton, 12.7 EER, R-410A Single Package AC Unit (SP-A)

AHRI Ratings:
Cooling Capacity (Btuh): 60,000
EER Rating: 12.7

Specifications of Baseline System:
Indoor: ECM Direct Drive Blower Motor, Indoor Coil: 3/8” tubes, 10 circuits
Outdoor: Scroll Comp., PSC Fan Motor, Outdoor Coil 3/8” tubes, 6 circuits
R-410A Refrigerant Charge Quantity: 14.8 lbs. / 3MAF-POE Oil
Refrigerant Flow Control: TXV (adjustable stem added)
Nominal Air Flow: Indoor 1759 CFM, Outdoor 4800 CFM
LGH060H4ESP – 5 Ton Unit
Testing Protocol and Interpretation of Results

Procedures

- The compressor was “run-in” at the start of the test program
- No oil changes were made during testing
- The expansion valve was fitted with an adjustable stem
- Unit charged to match the s-cool* (14F) and s-heat (13F) of baseline at “B”
- At the end, the unit was re-tested with R-410A

*Note: TXV instability prevented charging R-32 to more than 7F subcooling. A TXV developed for R-32 would improve performance.
Testing Protocol and Interpretation of Results

Interpretation

For “drop-in” testing, the capacity and efficiency are not directly comparable between refrigerants when their suction vapor densities are different. When the suction vapor density is lower, the refrigerant mass flow rate will be lower. This will tend to reduce capacity and possibly increase the efficiency of the system.
Cooling Capacity (BTUH)
Cooling Test Results

Capacity Relative to R-410A

- R-410A (begin)
- ARM-71A
- L-41-2
- HPR2A
- DR-5A
- R-32
- R-410A (end)

Temp (°F)

80 90 100 110 120 130
Cooling Test Results:

EER Relative to R-410A

- R-410A (begin)
- ARM-71A
- L-41-2
- HPR2A
- DR-5A
- R-32
- R-410A (end)

Graph showing EER relative to R-410A across different temperatures.
Compressor Discharge Temperature (During 125F Outdoor Ambient Test)

- R-410A (begin)
- ARM-71A
- L-41-2
- HPR2A
- DR-5A
- R-32
- DR-55
- R-410A (end)

The chart shows the compressor discharge temperature in degrees Fahrenheit for different refrigerants and models during a 125F outdoor ambient test. The data is depicted with bars of different colors representing each refrigerant type.
High Ambient Testing

Late in the AREP Phase II program a request came in to test at these additional high outdoor ambient test points:

<table>
<thead>
<tr>
<th>Indoor db/wb</th>
<th>Outdoor db</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>F</td>
</tr>
<tr>
<td>29/19</td>
<td>84/66</td>
</tr>
<tr>
<td>46</td>
<td>115</td>
</tr>
<tr>
<td>29/19</td>
<td>84/66</td>
</tr>
<tr>
<td>52</td>
<td>125.6</td>
</tr>
<tr>
<td>29/19</td>
<td>84/66</td>
</tr>
<tr>
<td>55</td>
<td>131</td>
</tr>
</tbody>
</table>

DR-55 was under test at the time so the following additional results were obtained.
High Ambient Testing

Charging at “B” Test Condition:

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Superheat (F)</th>
<th>Subcooling (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-410A</td>
<td>14.0</td>
<td>14.2</td>
</tr>
<tr>
<td>DR-55</td>
<td>14.4</td>
<td>10.4*</td>
</tr>
</tbody>
</table>

*Note: Experienced TXV instability, even with adjustment of stem, and this prevented charging with DR-55 to more than 10.4F subcooling. This is an example of a compromise made when doing “drop-in” testing.
High Ambient Testing

Capacity vs. Outdoor Temperature

- R-410A
- DR-55
- DR-55 (84/66)

BTUH vs. F
High Ambient Testing

EER vs. Outdoor Temperature

- **R-410A**
- **DR-55**
- **DR-55 (84/66)**

Temperature (°F) vs. EER

90 100 110 120 130 140

6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00
Conclusions

• These alternates can serve as R-410A substitutes, with optimization
• All are ASHRAE A2L category and applying them is being studied
• It was clear that there is room for optimization:
  – TXV bulb charge
  – TXV port size
  – Refrigerant charge quantity
  – Compressor displacement
• All of the alternates have compressor discharge temperatures higher than R-410A and R-32 compressor discharge temp. above 250F at 125F test point. (250F is usually considered a safe upper limit for POE oil)
• At 131F test point, DR-55 was slightly more efficient than R-410A
• These performance comparisons are not the last word…
Questions?

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