Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Low-GWP Alternative Refrigerants Evaluation Program (Low-GWP AREP)

TEST REPORT #27

System Drop-In Test of Refrigerant Blend ARM-70a and DR-5 in An Air to Water Heat Pump

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This report has been made available to the public as part of the author company's participation in the AHRI’s Low-GWP AREP.
List of Tested Refrigerants’ Compositions (Mass%)  

<table>
<thead>
<tr>
<th>ARM-70a</th>
<th>R-32/R-134a/R-1234yf (50/10/40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-5</td>
<td>R-32/R-1234yf (72.5/27.5)</td>
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</table>
1. Introduction:

The present report describes the low GWP blends, ARM-70a and DR5, drop in tests realized in an air to water heat pump. The tested heat pump is sold charged with R-410A blend. Tests are first realized with the heat pump as bought following the AHRI551/591-2011 standard conditions. These tests are considered as reference for the comparison with the drop in tests.

2. Details of Test Setup:

a. Description of System

The tested equipment is an air to water heat pump that has the following characteristics:

- Brand: AERMEC
- Model: ANL020H
- Nominal heating capacity 6.26 kW (@7°C DB air temp. and 75% RH and inlet water temperature of 35°C)
- Baseline refrigerant R-410A
- Refrigerant charge 1500 g

b. Description of Modifications to System

The drop in tests were conducted without any change to the equipment. For each tested low GWP blend, tests are repeated for three different refrigerant charges.

c. Description of Tests Conducted

Tests are conducted following the AHRI 551/591-2011 standard. Heat pump is tested at full capacity for the following conditions:
- TC1: Air DB temperature -8°C, -9°C WB and water inlet/outlet temperature to the heat pump of 35°C/40°C;
- TC2: Air DB temperature 8°C, 6°C WB and water inlet/outlet temperature to the heat pump of 35°C/40°C;
- TC3: Air DB temperature 8°C, 6°C WB and water inlet/outlet temperature to the heat pump of 45°C/50°C;

The experimental set up is presented in the figure 1 below.
It is composed of a climatic chamber simulating the outside ambient conditions and a water loop simulating the heating load.

The climatic chamber has an ultra sound humidifier permitting to control air humidity and a cooling and heating device for controlling temperature. Air temperature is measured at 2 positions in the climatic chamber using PT100 temperature sensors with an accuracy of ±0.05°C and relative humidity is measured with an accuracy of ±1%.

The water loop is equipped with:
- A first cooling section;
- A water capacity of 200 l simulating the thermal inertia of hydronic systems in case of partial load tests;
- A second cooling section needed for high capacity heat pumps;
- And a heating device permitting a fine control of water return temperature to the heat pump.

Inlet and outlet temperatures of water at the condenser of the heat pump are measured using intrusive PT100 sensors with an accuracy of ±0.05°C. Water mass flow rate through the condenser is measured using an electromagnetic mass flow meter with an accuracy of ±1%.

Heating capacity of the heat pump is then derived at full load operation and after reaching the steady state condition. In case of defrost cycles, heat capacity is evaluated only out of the defrost periods as shown in the equation below.

\[
(q_{cd})_{avg} = \frac{1}{\tau_2 - \tau_1} \int_{\tau_1}^{\tau_2} q_{cd} \cdot \delta_t = \frac{1}{\tau_2 - \tau_1} \sum_{i=1}^{n} (q_{cd})_i \cdot \Delta t_i
\]

Where:

\( q \) : heat produced out of the defrost period
\( \tau_1 \) : cycle starting time
\( \tau_2 \): cycle final time
\( \delta_t \): Integration variable
\( \Delta \tau_i \): data acquisition time span
**Low GWP AREP SYSTEM DROP-IN TEST DATA FORM**

### Basic Information

Here we have the results of the three test conditions \{TC1, TC2, TC3\} with the baseline refrigerant

- **Alternative Refrigerant**: R-410a
- **Alternative Lubricant Type and ISO Viscosity**: POE synthetic oil Emkarate RL 32 3MAF
- **Baseline Refrigerant and Lubricant**: R410a - // n/a
- **Nominal Capacity and Type of System**: 5.67 kW cooling / 6.26 kW heating (1.61tons/1.78tons)

### Comparison Data

<table>
<thead>
<tr>
<th></th>
<th>TC1</th>
<th>TC2</th>
<th>TC3</th>
<th>SI Units</th>
<th>TC1</th>
<th>TC2</th>
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<td>1,943</td>
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<td>W</td>
<td>1,631</td>
<td>1,753</td>
<td>2,165</td>
<td>W</td>
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### Air/Water Side Data

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<th>TC1</th>
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<th>SI Units</th>
<th>TC1</th>
<th>TC2</th>
<th>TC3</th>
<th>IP Units</th>
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<td>gal/min</td>
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<td>49.7</td>
<td>C</td>
<td>99.3</td>
<td>104</td>
<td>121</td>
<td>F</td>
</tr>
</tbody>
</table>

1 Total system COP includes the compressor, the fan and pump electrical power input
### Basic Information

Test Condition 1: Heated water Temps: 35.0°C/95.0°F  
Ambient Temps: -8.00°C/17.6°F (db) -8.90°C/16°F (wb)

- **Alternative Refrigerant**: ARM-70a  
- **Alternative Lubricant Type and ISO Viscosity**: POE synthetic oil Emkarate RL 32 3MAF  
- **Baseline Refrigerant and Lubricant**: R-410A - POE synthetic oil Emkarate RL 32 3MAF  
- **Nominal Capacity and Type of System**: 5.67 kW cooling / 6.26 kW heating (1.61tons/1.78tons)

### Comparison Data

<table>
<thead>
<tr>
<th></th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
<th>SI Units</th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
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<tbody>
<tr>
<td><strong>Mode (Heating/Cooling)</strong></td>
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<td></td>
<td></td>
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<tr>
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<td>1.50 Kg</td>
<td>1.65 Kg</td>
<td></td>
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<tr>
<td></td>
<td>35 C</td>
<td>35.4 C</td>
<td>35.1 C</td>
<td>C</td>
<td>95</td>
<td>95.7</td>
<td>95.2 F</td>
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<tr>
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<td>38.7 C</td>
<td>38.4 C</td>
<td>C</td>
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<td><strong>Sensible Capacity</strong></td>
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<td>n/a W</td>
<td>n/a W</td>
<td>n/a W</td>
<td>n/a W</td>
<td>n/a W</td>
<td>n/a W</td>
<td>Btu/hr</td>
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### Air/Water Side Data

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<th>Charge 3</th>
<th>SI Units</th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
<th>IP Units</th>
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<td><strong>Evaporator</strong></td>
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<td><strong>Heat Exchange Fluid</strong></td>
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<td>102</td>
<td>101.1 F</td>
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# Low GWP AREP SYSTEM DROP-IN TEST DATA FORM

## Basic Information

| Test Condition | Test Condition 2: Heated water Temps: 35.0°C/95.0°F
<table>
<thead>
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<th></th>
<th>Ambient Temps: 8.00°C/46.4°F (db) 6.00°C/42.8°F (wb)</th>
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<tbody>
<tr>
<td>Alternative Refrigerant</td>
<td>ARM-70a</td>
</tr>
<tr>
<td>Alternative Lubricant Type and ISO Viscosity</td>
<td>POE synthetic oil Emkarate RL 32 3MAF</td>
</tr>
<tr>
<td>Baseline Refrigerant and Lubricant</td>
<td>R-410A - POE synthetic oil Emkarate RL 32 3MAF</td>
</tr>
<tr>
<td>Nominal Capacity and Type of System</td>
<td>5.67 kW cooling / 6.26 kW heating (1.61tons/1.78tons)</td>
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## Comparison Data

<table>
<thead>
<tr>
<th>Mode (Heating/Cooling)</th>
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<tbody>
<tr>
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</tr>
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### Ambient Temps. Outdoor

<table>
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<tr>
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<td>8.30°C 7.80°C 7.8°C</td>
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<tr>
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<td>6.20°C 5.80°C 5.6°C</td>
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### Ambient Temps. Indoor

<table>
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</tr>
<tr>
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### Heated Water

<table>
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</tr>
<tr>
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### Total Capacity

<table>
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<td>6521 W</td>
<td>22251 Btu/hr</td>
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### Sensible Capacity

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### COP or EER (total)

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### COP or EER (Compressor only)

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## Air/Water Side Data

### Evaporator

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### Inlet Temperature

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### Outlet Temperature

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<td>Heating</td>
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**Low GWP AREP SYSTEM DROP-IN TEST DATA FORM**

**Basic Information**
- Test Condition: Heated water Temps.: 45.0°C/113°F
- Ambient Temps.: 8.00°C/46.4°F (db) 6.00°C/42.8°F (wb)
- Alternative Refrigerant: ARM-70a
- Alternative Lubricant Type and ISO Viscosity: POE synthetic oil Emkarate RL 32 3MAF
- Baseline Refrigerant and Lubricant: R-410A - POE synthetic oil Emkarate RL 32 3MAF
- Make and Model of System: //
- Nominal Capacity and Type of System: 5.67 kW cooling / 6.26 kW heating (1.61tons/1.78tons)

**Comparison Data**

<table>
<thead>
<tr>
<th></th>
<th>Charge 1</th>
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<th>SI Units</th>
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<th>Charge 3</th>
<th>IP Units</th>
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<td>n/a</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
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<td>2.1</td>
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<td>8.23</td>
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</tbody>
</table>

**Air/Water Side Data**

|                                | Charge 1 | Charge 2 | Charge 3 | SI Units | Charge 1 | Charge 2 | Charge 3 | IP Units |
|                                |          |          |          |          |          |          |          |          |
| **Evaporator**                 |          |          |          |          |          |          |          |          |
| **Heat Exchange Fluid**        | air      |          |          |          |          |          |          |          |
| **Flow Rate (gas)**            | 41.7     | m³/min   | 1472     |          |          |          |          |          |
| **Inlet Temperature 1**        | 8.20     | 7.30     | 8.2      | C        | 46.8     | 45.1     | 46.8     | F        |
| **Inlet Temperature 2**        | 7.90     | 7.70     | 8.2      | C        | 46.2     | 45.9     | 46.8     | F        |
| **Condenser**                  |          |          |          |          |          |          |          |          |
| **Heat Exchange Fluid**        | water    |          |          |          |          |          |          |          |
| **Flow Rate (liquid)**         | 980      | L/min    | 259      |          |          |          |          |          |
| **Inlet Temperature**          | 44.9     | 44.7     | 44.8     | C        | 112.8    | 112.5    | 112.6    | F        |
| **Outlet Temperature**         | 49.8     | 49.8     | 49.1     | C        | 122      | 122      | 120.4    | F        |
### Low GWP AREP SYSTEM DROP-IN TEST DATA FORM

#### Basic Information
- **Test Condition 1:** Heated water Temps: 35.0°C/95.0°F
- **Ambient Temps:** -8.0°C/17.6°F (db) -8.9°C/16°F (wb)

#### Alternative Refrigerant
- **DR-5**

#### Alternative Lubricant Type and ISO Viscosity
- POE synthetic oil Emkarate RL 32 3MAF

#### Baseline Refrigerant and Lubricant
- R-410A - POE synthetic oil Emkarate RL 32 3MAF

#### Nominal Capacity and Type of System
- 5.67 kW cooling / 6.26 kW heating (1.61tons/1.78tons)

### Comparison Data

<table>
<thead>
<tr>
<th></th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
<th>SI Units</th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
<th>IP Units</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>1628</td>
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<td>W</td>
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<td><strong>COP or EER (total)</strong></td>
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### Air/Water Side Data

<table>
<thead>
<tr>
<th></th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
<th>SI Units</th>
<th>Charge 1</th>
<th>Charge 2</th>
<th>Charge 3</th>
<th>IP Units</th>
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</thead>
<tbody>
<tr>
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</table>
Low GWP AREP SYSTEM DROP-IN TEST DATA FORM

### Basic Information
- **Test Condition 2**: Heated water Temps: 35.0°C/95.0°F
- **Ambient Temps**: 8.00°C/46.4°F (db) 6.00°C/42.8°F (wb)
- **Alternative Refrigerant**: DR-5
- **Baseline Refrigerant and Lubricant**: R-410A - POE synthetic oil Emkarate RL 32 3MAF
- **Nominal Capacity and Type of System**: 5.67 kW cooling / 6.26 kW heating (1.61tons/1.78tons)

### Comparison Data

<table>
<thead>
<tr>
<th>Mode (Heating/Cooling)</th>
<th>Heating</th>
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<tbody>
<tr>
<td>Compressor Type</td>
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<tr>
<td>Refrigerant Charge</td>
<td>1.40 Kg 1.50 Kg 1.6 Kg</td>
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<td>3.09 lb 3.31 lb 3.52 lb</td>
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# Low GWP AREP SYSTEM DROP-IN TEST DATA FORM

## Basic Information

Test Condition: 3: Heated water Temps.: 45.0°C/113°F
Ambient Temps.: 8.00°C/46.4°F (db) 6.00°C/42.8°F (wb)

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## Comparison Data

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Discussion

Both low GWP blends ARM-70a and DR-5 have shown a higher heating capacity and system COP. Figure 2 compares the heating capacity obtained with R-410A, ARM-70a (3 refrigerant charges) and DR-5 (3 refrigerant charges). DR5 presents the highest heating capacities between the three refrigerants and its optimal charge with regard to the heating capacity is 1.50 kg.

Figure 2 – Heating capacity comparison

Figure 3 compares the system COP obtained in the all the tests performed. Both ARM-70a and DR5 permit to obtain comparable results (10% higher for DR-5 at TC 1, 5% higher for ARM-70a at TC2 2 and equivalent performances for the TC 3).

Figure 3 – System COP comparison