INTERIM REPORT:

AHRI LOW-GWP ALTERNATIVE REFRIGERANTS EVALUATION PROGRAM (LOW-GWP AREP)

September 2012

Air-Conditioning, Heating, and Refrigeration Institute
2111 Wilson Blvd., Suite 500,
Arlington, VA 22201-3001

ACKNOWLEDGEMENTS

The AHRI Low-GWP AREP is strongly supported by the HVACR industry. Eighteen industry experts provide technical guidance and oversee the program. Twenty-one entities, internationally and domestically, including air-conditioning and refrigeration equipment manufacturers, universities and national laboratories, are conducting various tests using their own resources, at their own expense. Six chemical producers supply refrigerant samples for testing. AHRI gratefully thanks all of them for contributing their expertise and resources to the program.

Please refer questions or comments on this document to:

Mr. Karim Amrane
Vice President, Regulatory and Research
Air-Conditioning, Heating, and Refrigeration Institute
2111 Wilson Boulevard, Suite 500
Arlington, VA 22201
Phone: (703) 600-0307
Fax: (703) 562-1942

INTRODUCTION

The Air-conditioning, Heating, and Refrigeration Institute (AHRI) Low-GWP Alternative Refrigerants Evaluation Program (Low-GWP AREP) is an industry-wide cooperative research program which is strongly desired by the industry. The program is to provide the industry with a set of performance testing results for different low-GWP alternative refrigerant candidates in a quick and efficient manner.

The Low-GWP AREP is an effort undertaken by AHRI and its member companies. It was launched in March 2011 by action of the Executive Committee of the AHRI. The AHRI Executive Committee oversees the efforts of a Low-GWP AREP Technical Committee, consisting of engineering directors/managers from AHRI member companies. The Technical Committee serves in an advisory role and is responsible for the operations of the program. Entities in the US, Asia, Europe, and South America participate in conducting tests, making the Low-GWP AREP a truly international cooperative effort.

The program will not prioritize these alternatives; rather, it will identify potential refrigerant replacements for high GWP refrigerants, and present performance of these replacements in a consistent and standard manner. This report serves as a summary of the current progress and accomplishments of the Low-GWP AREP program so far.

PROGRAM OBJECTIVES

The objectives of the Low-GWP AREP effort were set forth at the start of the program:

- Identify promising alternatives to high GWP refrigerants for major AHRI product categories;
- Establish testing protocols for evaluating the candidate replacements;
- Conduct tests using the candidate refrigerants; and
- Review and release the information collected and the results of tests.

REALIZATION OF PROGRAM OBJECTIVES AND CURRENT STATUS

<u>Objective 1: Identify Alternatives</u>

The first objective, identifying potential substitutes for high GWP refrigerants, was met. Forty candidates were identified early in the program, including both synthetic and natural refrigerants, among which thirty-eight refrigerants were selected for testing. These refrigerants were chosen by the Technical Committee's vote based on nominations, discussion within the committee, and interest level expressed by the industry.

Neither an upper numerical limit on refrigerants' GWP values nor the safety classifications were limitations to nominating refrigerants, as long as a candidate low-GWP refrigerant has a significant reduction in its GWP relative to the refrigerant it is intended to replace. The program also includes an effort to review existing work related to performance testing of natural refrigerants, and to identify any gaps. The program only accepts test plans on these refrigerants that fill known gaps on comparisons to other alternative refrigerants, since there have been a lot of experimental studies on natural refrigerants, such as R-744. A list of reviewed literature is being developed. All the papers reviewed were related to actual testing, and some included both modeling and testing efforts. The summary will serve as an index to inform the public of what is available, and where to get the information.

The GWP values of these identified candidates and their ASHRAE safety classifications are illustrated in Figure 1. The GWP values may be actual or estimated using 100 year integration time horizon and data from IPCC AR4.

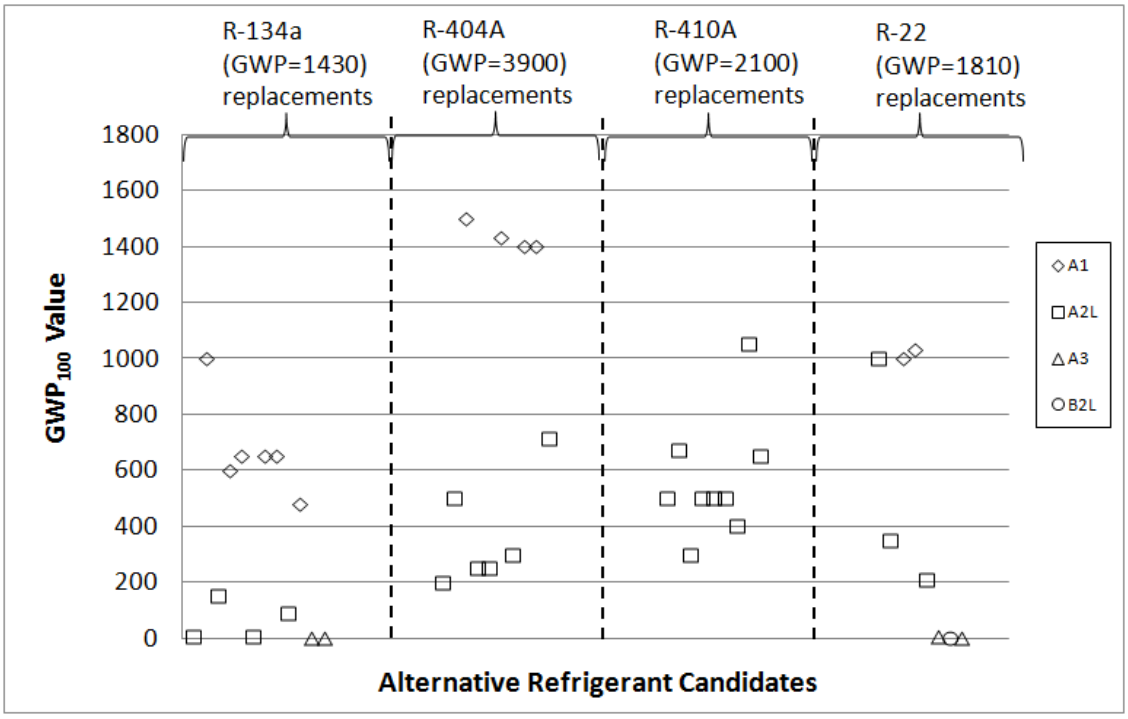

Figure 1: Overview of the candidates' GWP values (GWP values shown are approximate values.)

Objective 2: Establish Testing Protocols

The second objective, to establish a testing program with standardized procedures, was also met. The testing program created under the Low-GWP AREP consisted of compressor calorimeter tests, system drop-in tests, and soft-optimized system tests. Protocols for conducting these types of tests were agreed upon by the Technical Committee with input from other AREP participating companies. These protocols were delineated in the Low-GWP AREP Participants' Handbook, distributed to all program participants.

Objective 3: Conduct Tests

The third objective, to conduct tests, is being realized. Compressor calorimeter, system drop-in, and soft-optimized system tests are being performed. Entities that perform the tests are listed in Appendix A.

Tests are being conducted with 38 refrigerant candidates selected according to individual test entities' interests. These samples were provided by six refrigerant suppliers, listed in Appendix B. The table below summarizes the testing of products and refrigerant candidates.

Table 1: Summary of test matrix

Tests	Number of candidates being tested	Number of products being tested	Product type
Compressor calorimeter	28	35	rotary, scroll, reciprocating
Drop-in	27	30	Air/air heat pump, air/water heat pump, air/air air conditioner, room air conditioner, water/water heat pump, chiller, commercial refrigerator, ice machine, transport AC, transport refrigeration
Soft-optimization	18	19	Air/air heat pump, air/water heat pump, air/air air conditioner, room air conditioner, water/water heat pump, chiller, commercial refrigerator, ice machine, VRF
Note: The numbers and product types in the table are based on approved test plans submitted by testing entities. The actual numbers from testing may vary due to testing entities' schedule changes.			

Testing companies requested one hundred and ten samples in total for testing, among which thirty-nine samples have been tested, and twelve are being tested. The remaining samples will be tested within the next few months.

Objective 4: Publish Results

The results from this program will be available through several channels. It is required that test companies send test results directly to the Technical Committee without refrigerant suppliers' pre-approval. It is expected that all testing will be performed by the end of 2012. Upon acceptance by the Low-GWP AREP Technical Committee, the results will be released to the public at that time. In addition to test results, AHRI will publish the composition(s) of tested refrigerants in November 2012.

All results from testing conducted through the program must be reviewed and approved by the Technical Committee before publication. Testing companies in the program must get the Technical Committee's permission to publish their results outside the program.

Appendix A: List of Testing Entities

US Participants performing tests:

- Carrier Corporation
- Climate Master
- Emerson Climate Technologies
- Follett Corporation
- Goodman Manufacturing
- Hussmann Corporation (contributing the results of tests which were completed prior to the start of the program.)
- Johnson Controls, Inc.
- Lennox Industries Inc
- Manitowoc Ice, Inc.
- McQuay International
- Oak Ridge National Laboratory
- Tecumseh Company Co.
- Thermo King / Ingersoll Rand
- Trane/ Ingersoll Rand
- University of Maryland

International Participants performing tests:

- ARMINES-MINES ParisTech (France)
- Daikin Industries Ltd (Japan)
- Embraco Brazil (Brazil)
- Embraco Slovakia Sro (Slovakia)
- GD Midea Air-conditioning Equipment Co. Ltd (China)
- Shanghai Hitachi Electrical Appliances CO. LTD (China)

Appendix B: List of Refrigerant Suppliers

- Arkema, Inc.
- Daikin Industries Ltd
- E. I. du Pont de Nemours and Company
- Honeywell International, Inc
- Mexichem Fluor, Inc
- National Refrigerants, Inc