Refrigerants with Low Global Warming Potential

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With the ratification of the Montreal protocol in 1987, chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants, such as R11, R12, R22, and R123, have been or will soon be phased out due to their high ozone depleting potential (ODP). Subsequently, the HVAC&R industry turned to hydrofluorocarbon (HFC) refrigerants as substitutes. Due to their zero ODP, HFC refrigerants have gained widespread use since the 1990s in refrigeration, air-conditioning, and heat pump applications, with commonly used HFC refrigerants, including R134a, R410A, R404A, and R407C, among others.

Regulations and concern for the environment is driving research to identify effective refrigerant alternatives with low global warming potential (GWP).

However, many HFC refrigerants have relatively high global warming potentials. The global warming potential (GWP) is a measure of the potency of a greenhouse gas relative to carbon dioxide (where carbon dioxide, by definition, has a GWP value of 1). The HFC refrigerants commonly in use today have GWP values that are thousands of times larger than that of carbon dioxide.

Thus, environmental concerns are driving regulations and the HVAC&R industry towards lower GWP alternatives to HFC refrigerants currently in use. Existing lower GWP refrigerant alternatives include, but are not limited to, hydrocarbons, such as propane (R290) and isobutane (R600a), as well as carbon dioxide (R744), ammonia (R717), and R32. Note that with the exception of carbon dioxide, all of these existing alternatives are either mildly flammable

(ASHRAE safety classification 2L for ammonia and R32) or have higher flammability (ASHRAE safety classification 3 for propane and isobutane). In addition to existing alternatives, new lower GWP refrigerant alternatives are currently being developed by refrigerant manufacturers, including hydrofluoro-olefin (HFO) and unsaturated hydrochlorofluorocarbon (HCFO) refrigerants. These next-generation refrigerants and their blends are typically either non-flammable (ASHRAE safety classification 1) or have lower flammability (ASHRAE safety classification A2L).

In an effort to determine the impact of new lower GWP alternative refrigerants on systems, the industry and various research organizations have been investigating the performance of these refrigerants in HVAC&R systems and components. Ideally, alternative lower GWP refrigerants should provide the same, or better, energy performance as current refrigerants, with reduced environmental impact.

One such effort is the Low GWP Alternative Refrigerants Evaluation Program (Low-GWP AREP), led by the Air-Conditioning, Heating and Refrigeration Institute. The program consists of compressor calorimeter testing, system drop-in testing, soft-optimized system testing, and heat transfer testing. Numerous equipment manufacturers, national laboratories, and academic institutions have performed equipment testing with refrigerants supplied by major refrigerant manufacturers. The results from testing show that, in general, the new alternative refrigerants (many of which are mildly flammable) exhibit similar efficiency and capacity as compared to currently used HFC refrigerants. With minor modifications to system design, it is anticipated that new equipment making use of these new refrigerant alternatives will achieve increased performance.

It should be stressed that GWP is not and should not be the only metric to evaluate a refrigerant's environmental impact. The impact should be evaluated accounting for both the direct emission of refrigerants that escape from HVAC&R products and the indirect emission of CO2 from the electricity consumed by HVAC&R products over their lifetime. This is called Life Cycle Climate Performance (LCCP). The lower the LCCP is, the less the environmental impact. A low GWP value is only an indication of low impact from direct emission in theory. The product efficiency directly affects the indirect emission. Generally speaking, the direct emission is only a small fraction of the overall LCCP, with indirect emissions accounting for the majority of the overall impact. Therefore, it is very important that lower GWP refrigerants must have performance comparable to or higher than the HFCs currently in use.

Opportunities for using new lower GWP refrigerant alternatives exist both in new and existing equipment. New equipment can be designed for optimal energy performance using new alternative refrigerants, while incorporating the additional safety features necessary to use A2L and A3 refrigerants. Current regulations allow for use of A2L and A3 refrigerants in small hermetically sealed systems, such as those in self-contained display merchandisers and window air conditioners.

Existing equipment can be retrofit with a new lower GWP alternative provided the alternative has similar properties to the refrigerant being replaced, minimizing system modifications. Such refrigerant retrofits are attractive for reducing environmental impact of systems with large refrigerant charge, such as centralized commercial refrigeration. Since existing systems using

HFC refrigerants are not specifically designed to use flammable refrigerants, retrofit is limited to A1 alternatives. Retrofitting with A2L or A3 refrigerants is not permitted.

Timely and cost-effective implementation of flammable refrigerants will be impeded without proper revision of relevant safety codes and standards. While demand for the flammable refrigerants is increasing, current codes and standards adoption processes are relatively slow. In an effort to revise relevant safety codes and standards in a timely manner, joint collaboration between the Air-Conditioning, Heating and Refrigeration Institute (AHRI); American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE); California Air Resources Board; and the U.S. Department of Energy has been initiated.

Research efforts underway or planned include: Benchmarking Risk by Real Life Leaks and Ignitions Testing / Investigation of Hot Surface Ignition Temperature (HSIT) for A2L Refrigerants / Leak Detection of A2L Refrigerants in HVAC&R Equipment / Flammable Refrigerants Post-Ignition Simulations and Risk Assessment Update / Guidelines for Flammable Refrigerant Handling, Transporting, Storing, and Equipment Servicing, Installation, and Dismantling / Servicing and Installing Equipment using Flammable Refrigerants / Assessment of Field-made Mechanical Joints / Investigate the proper basis for setting charge limits of A2L, A2, and A3 refrigerants for various types of products / and Modeling tools for flammability evaluation of low-GWP refrigerant blends.

These projects are being completed under an accelerated timeline so that the results may be included in updates to relevant codes and standards, including ASHRAE Standard 15 and the International Code Council (ICC) International Mechanical Code. It is anticipated that the results of these various projects will be available late in 2017. Significant efforts are being made to accelerate implementation of A2L and A3 alternative refrigerants. It is hoped these efforts will impact the market within the next several years.