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HFO-1234yf, New Dawn of Refrigerant Alternatives

R&D for selection of refrigerant alternatives has been a hot issue for the air-conditioning industry for quite a few years. Both the HVAC&R industry and the automobile industry have been searching for the best solutions. According to Directive 2006/40/EC of the European Parliament and of the Council of May 17, 2006 relating to emissions from air-conditioning systems in motor vehicles and amending Council Directive 70/156/EEC, hydrofluorocarbons (HFCs) with a global warming potential (GWP) higher than a 150 level are banned from use in car air conditioning systems. Member states are due to implement the directive from January 2008. Therefore, refrigerant selection for automobiles is now the most urgent problem for 2008.

Automobile ACs now using HFC-134a refrigerant will be banned in EU countries from 2011

At the end of 2007, the German industry association, VDA, chose carbon dioxide (CO_2)as its refrigerant. Germany is the home to Volkswagen, Daimler, and BMW, its decision definitely has a strong impact on other countries.

However, some industry insiders from Germany considered that the time constraints placed on the industry by the EU may hurry the industry into choosing a solution that is not the best for the environment or consumers. Although CO_2 has a GWP as low as 1 and the Ozone depletion potential (ODP) is zero, it has some restrictions with respect to thermo-physical properties. Besides, technical issues regarding the use of CO_2 in mobile air conditioning remain unresolved by the industry, despite years of development. As a result, it can be assumed that CO_2 systems will require more after-sales service and higher warranty costs.

Therefore, CO_2 is probably not an ideal refrigerant for ACs. Many experts also consider that a good refrigerant is not necessarily a natural one. That is why, although the German automobile industry has already decided on CO_2-based solutions, refrigerant-producers DuPont and Honeywell are still developing and commercializing a new refrigerant with low GWP to replace the HFC-134a in mobile air conditioning systems.

At AHR Expo '08, DuPont and Honeywell announced that they have jointly come up with a new refrigerant for mobile air conditioning designed to address concerns about the perceived high GWP of HFC-134a. The refrigerant was identified as HFO-1234yf, meaning it is not an HFC. According to DuPont, the refrigerant is a single component and not a blend. HFO-1234yf has a low GWP of 4 to 6. It is very energy efficient, exhibits low toxicity and is comparable to HFC-134a according to early testing. Evaluations so far indicate that HFO-1234yf will be compatible with existing HFC-134a mobile air conditioning system technology, which enables a smooth, cost-effective industry transition. Other attributes of HFO-1234yf include good cooling performance in hot and moderately hot climates, lower operating pressures than CO_2 systems, greater safety for consumers and service technicians, potentiality to be used in all cars, compatibility with existing technology, and higher reliability and lower warranty costs.

[Continued below]

CO_2 or HFO-1234yf, Which is a Sustainable Refrigerant ?

Honeywell and DuPont recently announced that they have jointly come up with a new refrigerant HFO-1234yf for car air conditioning use. What are the detailed properties of the new refrigerant? Our JARN staff visited to interview Mr. David Diggs, Honeywell's director.

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The 36th Mostra Convegno Expocomfort (MCE) was held on March 11- 15, 2008 at the new Fiera Milano Exhibition Centre in Milan, Italy.

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HFO-1234yf, New Dawn of Refrigerant Alternatives

Full technical data on the new refrigerant candidate was presented by DuPont and Honeywell at the second European Workshop on Mobile Air Conditioning and Auxiliaries held in Torino, Italy in November 2007. Several automotive OEMs also presented the results of their evaluations of HFO-1234yf and identified HFO-1234yf as a promising alternative to HFC-134a.

DuPont and Honeywell are working closely with automotive manufacturers on the development and commercialization of an optimal solution capable of replacing HFC-134a in mobile air conditioning systems globally. Ultimately, the goal is to develop a global low-GWP alternative refrigerant solution that will facilitate a smooth and cost-effective global transition within the industry beginning in 2011 in order to minimize the potential environmental impact of mobile air conditioning in the future.

Researchers in Europe, however, said they still have limited knowledge on the performance of HFO-1234yf. For example, they are not quite clear about the toxicity and the inflammability of the new refrigerant. The good news for DuPont and Honeywell is that European countries other than Germany have not yet announced which refrigerant they will choose in the future.

Different regions have different policies on the new refrigerants. European countries prefer natural refrigerant while the US is busy developing new synthetic refrigerants. Because Europe, the US, and Japan are the 3 most important automobile production bases and markets, Japan's decision will have a significant influence on the global air-conditioning industry. It seems Japan tends to make the same decision as the US and at present this seems to be the most likely scenario. There are indications that some Japanese, even some Korean, automobile makers are evaluating different refrigerant alternatives.

Although the refrigerant selection for automobile air conditioning is urgent at present, Honeywell and DuPont are not limited to this. They also have an extensive R&D effort to identify low GWP refrigerants for stationary ACs and refrigeration applications. If the refrigerant replacement of mobile ACs is successful this year, it will no doubt set up a good example for the refrigerant replacement of room air conditioners (RACs) and commercial ACs.

China produces 70% of the ACs throughout the world. It is very important and urgent for China to select proper refrigerants for its AC&R industry. Although China has not decided what refrigerants it will sanction, it is almost certain that its final decision will be influenced to a great extent by the decision made by Japan, which is very geographically close to China.

Top Interview

CO_2 or HFO-1234yf, Which will be the Winner?

The selection of refrigerant alternatives has been a serious issue for the air-conditioning industry for a long time. In September 2007, German industry association has chosen CO_2 as the refrigerant for automobiles. However, some US companies are still developing and commercializing new refrigerants with low GWP to replace the HFC-134a in mobile air conditioning systems. Honeywell and DuPont recently announced that they have jointly come up with a new refrigerant HFO-1234yf. What are the detailed properties of the new refrigerant? Will the appearance of this new refrigerant bring significant influences on Europe's environmental policy? With all these questions, we visited Mr. David Diggs, global business director for Honeywell's refrigerants business.

Mr. David Diggs, global business director for Honeywell's refrigerants business

JARN (Hereinafter J): First of all, how is the cooperation between Honeywell and DuPont on the research of HFO-1234yf?

Diggs (Hereinafter D): Honeywell and DuPont share resources, investment and technology as part of the agreement. We also are continuing to work closely with the automotive industry to qualify HFO-1234yf.

J: HFO-1234yf was highly appraised at the '2nd International Workshop on Mobile Air Conditioning' held in Italy last November and the ASHRAE meeting on low global warming potential (GWP) refrigerants held at the end of January this year. Could you give our readers more information on this new refrigerant?

D: HFO-1234yf is a low GWP fluorinated gas solution developed by Honeywell and DuPont for mobile air conditioning. It meets new EU GWP requirements and is a near drop-in replacement for HFC-134a. HFO-1234yf offers several advantages over R-744 (CO_2), another HFC-134a replacement being considered. First, HFO-1234yf has a lower overall environmental impact compared to CO_2 due to its higher energy efficiency which results in lower fuel consumption, regardless of what type of climate the car is ultimately used in; second, HFO-1234yf does not require car makers to completely redesign their current air conditioning designs, allowing them to avoid additional cost; third, HFO-1234yf operates at much lower pressures than CO_2, thus eliminating the risks associated with handling an extremely high pressure refrigerant; fourth, because HFO-1234yf is a near 'drop-in' refrigerant, it could possibly be used in the existing fleet of automobiles, leading to faster adoption and hence a more positive environmental impact; the last, there are significant questions as to whether CO_2 can effectively cool the interior of a car in hot climates. HFO-1234yf performs better in all climates than CO_2, providing consumers with a low global warming potential (LGWP) solution that does not sacrifice comfort or reliability.

J: What are the test results of HFO-1234yf? It is said that GWP is 4 and ozone depletion potential (ODP) is 0. Could you give more information on this? Can this new refrigerant achieve the same efficiency level as HFC-134a does if used in the air conditioning system?

D: HFO-1234yf has zero ODP and a GWP of 4. It is different from HFC-134a and all previous fluorocarbon refrigerants in one key respect: atmospheric lifetime. If HFO-1234yf is released to the atmosphere it is rapidly removed (the atmospheric lifetime is 11 days) and the atmospheric degradation products are the same as for HFC-134a.

Among the most important characteristics for an HFC-134a replacement product is its overall environmental impact. LCCP or Life-Cycle Climate Performance takes into account both direct and indirect environmental impact. It characterizes the overall environmental impact of mobile air conditioning (MAC) systems, including the energy used in production of a chemical, the fuel consumption related to its use, and ultimate disposal of the product.

HFO-1234yf has the lowest LCCP compared to R-744 (CO_2) and HFC-134a, regardless of region. These results were presented by the JAMA-JAPIA Consortium at the 2nd European Workshop Mobile Air Conditioning and Auxiliaries Conference in Torino, Italy, last November.

In tests, which included compact and luxury cars, CO_2 performed worse in LCCP across the board. With respect to performance and cooling ability, CO_2 significantly underperformed compared to HFO-1234yf in high ambient temperature conditions.

Samples of HFO-1234yf have been made widely available to OEMs and their suppliers for extensive testing against critical safety, toxicological and environmental criteria. Results of both performance testing and risk assessments have been very favorable, showing very close performance (within 5%) of HFC-134a without the need for any significant changes to the air conditioning system design.

Additionally, based on tests conducted in a variety of climates CO_2 is not nearly as effective at cooling the interior of an automobile as HFO-1234yf. Particularly, in hot climates, in order to reach performance levels close to HFO-1234yf, considerably more engine power is required compared to today's engines used to power HFC-134a systems.

Overall, Honeywell and DuPont's HFO-1234yf solution is as effective as HFC-134a. It offers comparable performance to HFC-134a in warm and hot climates.

J: When will HFO-1234yf be formally registered? In your view, when will this new refrigerant start mass production? And where will be the initial markets of it?

D: We have already begun the registration process in the United States, European Union and Japan. We will base our decision on when to start production of HFO-1234yf based on the needs of the OEMs.

According to the European Union's mobile air conditioning (MAC) directive, new vehicle types introduced in the EU on or after January 1, 2011 must use refrigerants in mobile air conditioning applications with a global warming potential (GWP) below 150. The transition will be completed by 2017.

Honeywell and DuPont will continue to work closely with automotive manufacturers to complete the qualification process for HFO-1234yf, to meet the industry's goals for a smooth and cost-effective global transition in time for the EU's 2011 directive.

J: The development of a new refrigerant usually involves the participation of several related companies. Which car air conditioner companies or chiller makers participated in the co-development of this new refrigerant? Are there any Japanese air conditioner makers? And how do compressor manufacturers respond to this new refrigerant?

D: For more than 2 years, we have been working with the leading OEMs and Tier 1 suppliers globally to evaluate our low GWP alternatives from all regions, including Japanese OEMs and Tier 1 suppliers.

J: Once approved, the new refrigerant will first be used in car air conditioners, right? When will it be used in chillers?

D: The first major use of HFO-1234yf will be in European MAC systems, because of the EU MAC directive. We anticipate that HFO-1234yf will be considered for MAC use in other regions of the world as well. Beyond MAC, we are evaluating the potential for HFO-1234yf in stationary applications. Again, the Honeywell-DuPont solution - HFO-1234yf - enables automakers to meet the new EU regulations globally with minimal disruption to current automobile design and manufacturing methodologies.

J: When are you going to develop a new generation of low GWP refrigerants to replace HFC-407C and HFC-410A?

D: The focus for Honeywell and DuPont is on qualifying a low-GWP refrigerant to replace HFC-134a for mobile air conditioning. In addition to the MAC application we have an extensive R&D effort to identify low GWP refrigerants for stationary AC and refrigeration applications.

J: What is your assessment of the influence of this new refrigerant on China's HVAC&R industry, which is at the transitional period? Do you think China should transfer to HFC-410A first before adopting this new refrigerant?

D: Again, the new Honeywell-DuPont solution - HFO-1234yf - enables automakers to meet the new EU regulations globally with minimal disruption to current automobile design and manufacturing methodologies. HFO-1234yf is designed to closely match the characteristics of HFC-134a while offering a lower GWP. HFC-410A is a higher pressure refrigerant with different characteristics than HFO-1234yf so it is unlikely that HFO-1234yf would be a direct substitute for HFC-410A.

Honeywell invented and patented HFC-410A, which is used by equipment manufacturers as the refrigerant of choice for replacing HCFC-22 in stationary air conditioners and heat pumps.

J: Do you think the appearance of this new refrigerant will bring significant influences on Europe's environmental policy? For example, do you think the new refrigerant will replace CO_2 as the solution for car air conditioners?

D: Fluorocarbons provided refrigeration in the first automobile air conditioning system in 1939 and their reliability and performance has made them the universal choice for mobile air conditioning ever since.

Automakers are seeking the most environmentally-friendly, cost-effective and commercially viable solution globally. Our fluorocarbon solution HFO-1234yf meets EU low-GWP requirements, and we believe it is more reliable than a CO_2 solution in addition to offering superior performance in warm and hot climates.

J: Any more information that you'd like to share with our readers, especially any major initiatives for Honeywell refrigerants in Asia markets?

D: Technical issues regarding the use of CO_2 in car air conditioning remain unresolved by the industry, despite years of development, which include system reliability and durability, high temperature performance, assembly line and charging issues, refrigerant containment and the high cost of the systems. Therefore, it can be assumed that CO_2 systems will require more after-sales service and higher warranty costs compared to HFO-1234yf.

Also, it is important to note again that among the most important characteristics for an HFC-134a replacement product is its overall environmental impact. Other key characteristics are whether the product is safe for consumers and automobile industry employees as well as the ability of the product to effectively cool the interior of a car in all climates, including in China.