STUDY ON CURRENT SITUATION OF HFC-32 REFRIGERANT TECHNOLOGY AND APPLICATIONIN ASEAN COUNTRIES

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Abstract:

HFCs usage in HVAC industry is rapidly increasing as a result of the phaseout of ozone-depleting substances (ODS) and growing global demand for air conditioning units. However due to high global warming potential, it is also scheduled to gradual phasedown in order to allow for early transition in sectors where alternatives can be applied, and gives more time and incentive for innovation to deploy alternatives in other areas. HFC-32 is one of those alternatives being promoted at present due to its low GWP. However since HFC-32 is classified as mild flammable refrigerant, class A2L according to ASHRAE Standard 34, and is normally unstable in atmosphere, it is necessary to study on the safe use of this refrigerant in order to relax some regulations imposed on the flammable refrigerant. This paper reviews the current status on the overall evaluation of technical obstruction in using HFC-32. The current situation of HFC-32 enforcement in ASEAN Countries such as Thailand, Indonesia and Malaysiais also presented. It comes to the question that HFC-32 is the final answer to the global warming problem or not and when this refrigerant is going to be last long for usage before being replaced by the new one. This is the question that is still left without the answer.

Key Words:

Refrigerant, ODP, GWP, HCFC, HFC-32

1.0 INTRODUCTION

The problem about ozone layer depletion and global warming has become the main concern since 1985. It has been proved scientifically that man-made chemicals are mostly responsible for this problem. In 1987 the ‘Montreal Protocol on substances that deplete the Ozone Layer’ was negotiated and signed by 24 countries and the EU in order to reduce the use of CFC’s, halons and other man-made ozone depletion substances. Further amendment on the protocol was done in 1997. It was known as “Kyoto Protocol” which was aimed to curb all greenhouse gases. Even through greenhouse gas emissions which come out from fossil fuel are the main source for global warming, but substances with contain large global warming potential such as Fluorocarbon refrigerants used in refrigerators and air conditioning units should not be ignored. Most refrigerants in used today are classified as greenhouse gases hence their production must be phase out. For example, the production of Hydro chlorofluorocarbon (HCFCs) was forced to phase out in the next 20 years due to their high global warming potential. Therefore refrigerants with low global warming potential are being sourced and studied as replacement refrigerants for HCFCs. However the problem about low GWP refrigerants is that they are not very stable in atmosphere and thus are sometimes flammable.

At present HFC-410A and HFC-407C arecurrently used as replacement refrigerants for HCFC-22 due to their zero ozone depletion. However both of them contain high global warming potential and hence have to be finally replaced. There are two alternative refrigerants being proposed for replacing these two refrigerants. One is HFC-32, strongly proposed by Japan and China, and the other is HFC-1234yf, proposed by European countries. HFC-1234yf is currently used in the car market but was announced to be unsafe by Daimler-Benz, a German automobile manufacturer, in August 2012. HFC-32 is just first used in the room air conditioning unit by Daikin, a Japanese air conditioning manufacturer, in November 2012. Having a much lower GWP than HFC-410A, HFC-32 is expected to have less effect on global warming and unlike other Hydrocarbon refrigerants which are recommended by research institutes and non-government organizations of several countries, HFC-32 isfree from serious accidents, such as flashing and explosion, when it is leaked. However, even though HFC-32 could help reducing the overall environmental impact due to its low GWPbut in term of energy performance it should not be much less than that of HFC-410A. Moreover compatibility and safety on the use of HFC-32 should have priority in designing air conditioning components to work with.

2.0 OVERALL EVALUATIONON THE USE OF HFC-32 REFRIGERANT

There are several studies and researches about the overall evaluation on the use of HFC-32 as a refrigerant. The followings are someof those studies.

Atharva Barve and Lorenzo Cremaschi (2012) had performed an experiment of the drop-in energy performance and capacities of refrigerants HFC-32 in a HFC-410A heat pump split system for ducted HVAC in residential applications. Experiments were conducted for cooling and heating modes of the unit and the outdoor temperature was varied from 17°F (-8°C) to 115°F (46°C). They concluded that for refrigerant drop-in application, HFC-32 has comparable heating and cooling capacities as those for HFC-410A and also similar COPs. The discharge pressures and discharge temperatures were higher than those for HFC-410A, especially for moderate to extreme high temperature conditions. Too high discharge temperature and pressure of HFC-32 in extreme high temperature conditions was a concern for the safe operation of the unit and might be a concern for the compressor lifetime cycle.

Hung Pham, RajanRajendran (2012) investigated the drop-insystem performance difference between HFC-32 and HFC-410A on a 3 ton scroll compressor heat pump designed for HFC-410A with thermostatic expansion valve (TXV) for cooling and heating modes by only adjusting the TXV or optimizing systemcharge. The result was 3-4% capacity gain and 1-1.5% EER reduction from drop-in system test. The changes in Te (evaporating temperature) over Tc (condensing temperature) ratio also indicated higher capacity for HFC-32 compared with HFC-410A. However higher heat load on the condenser is expected due to this higher capacity. This implies that the Te/Tc envelope limits for HFC-32 would be less than HFC-410A for the same maximum allowable discharge temperature limit which is currently about 300^{o}F. Therefore modifying compressor in order to reduce the impact of compression heat is required for compressor to be used with HFC-32. Their test also revealed that the change in suction line superheat would also penalize A/C system performance slightly due to higher suction line superheat with HFC-32.

B. Hadya, P. Usha Sri and Suresh Akella (2012) studied on the possibility of using HFC-32 in a vapor compression refrigerationsystem and compared theoretically with HCFC-22. The overall evaluation in term of energy efficiency, safety and economics aspects is studied for favorable performance for lower capacity air conditioning systems, 1 TR of refrigeration capacity. The coefficient of performance for HFC-32 is closely matches for higher condensing temperature. HFC-32 pressure ratio is 25% more when compare with that for HCFC-22. This indicates for bigger size of compressor than that using HCFC-22 for the same refrigeration machine. It also requires for more robust condenser. The study showed that HFC-32 requires very high power (HP) per ton of refrigeration due to pressure ratio is high.

WeihuaGuo, GaofengJi, Honghong Zhan, Dan Wang (2012) studied on the HFC-32 scroll compressor development for air conditioning applications in China. They evaluated the scroll compressor performance and reliability impact by using HFC-32 refrigerant for air conditioning (residential and commercial system) and compared with different popular refrigerants used in China, for example, HFC-410A & HCFC-22. Their study indicated that scroll compressor performance could be improved by using enhance vapor injection (EVI) technology.This technology provides 7~9% efficiency gain at rated heating condition, while providing comparable efficiency at rated cooling condition, comparing to non-injection technology. EVI technology also enhanced the ability to controlled discharge temperature since the HFC-32 compressor has higher compressor discharge temperature compared to other refrigerants.Scroll compressor performance can also improve through scroll element optimization such as lower suction superheat at scroll suction inlet and scroll wrap in order to take care of higher HFC-32 running temperature. HFC-32 scroll set has to be designed at a higher build-in volume ratio in order to reduce the recompression heat and lower discharge temperature under high compression ratio conditions. The concern on the reliability of scroll compressor using HFC-32 was also studied. It was found that HFC-32 requires a new lubricant due to a miscibility issue. A new POE (Polyolester) oil B was developed and passed all the bench tests and compressor reliability tests for use with HFC-32 compressor.

Takeshi Okido, KatsuyaTakigawa, Masanori Saito (2012) studied on the development of refrigeration oil for use with HFC-32. They found out that the current refrigeration oils for use with HFC-410A such as POE (Polyolester) and PVE (Polyvinylether) oils have insufficient miscibility with HFC-32. Therefore the oil tends to stay in the evaporator and not return to the compressor. This can cause a decline in system performance, and the oil return problem may lead to poor lubrication in the compressor. They tested POE oils with modified molecular structures and were able to develop new POE oils that showed outstanding miscibility with HFC-32. They also looked at the inferior lubricity of POE oils since EP additives do not adsorb well on slidingsurfaces and thus anti-wear performance is lacking. To overcome this problem, they developed a new assistant (additive) thatpromotes the adsorption of EP additives and found that it greatly improved the anti-wear performance of POE oils.

3.0 CURRENT SITUATION ON THE USE OF REFRIGERANT HFC-32 INASEAN COUNTRIES

THAILAND

To comply with the Montreal Protocol, Royal Thai Government by Department of Industrial Work (DIW) established the following measures and procedures:

1. Control ODSs as Hazardous Substance Schedule 3 under the Hazardous Substance ActB.E. 2535.

2. Support the use of alternatives to ODSs through taxation measure.

3. Coordinate with international agencies in transferring alternative technologies to Thailand's industrial sector.

4. Establish projects for requesting the financial and technical assistance from the Multilateral Fund through international agencies i.e. the World Bank, UNEP and forward this assistance to enterprises in each industry for converting their equipment as well as for setting up training, seminar and public awareness, etc.

5. Coordinate with international agencies and organizations on the implementation of the Multilateral Fund obligations with the strong focus on the country's benefits as major concerns.

6. Disseminate ODS related information to people through media and public relations.

7. Set up ODS Phase out guidelines for industrial sectors such as those regarding the support of the use of refrigerant storage and recovery in Mobile Air Conditioning (MAC) shops to minimize the release of ODS to the ozone layer, etc.

According to the announcement of DIWabout the guideline for importing HCFC for use in Thailand in the year 2012 stated that importing of HCFC-22 will be controlled during year 2013-2014 and is limited to the amount of 927 ODP ton. From year 2015-2019, it is limited to 834 ODP ton and further reduced to 602 ODP during year 2020-2024. In the final period during year 2025-2029 the imported amount of HCFC-22 is limited to 301 ODP ton and after 2030 no HCFC-22 amount is allowed to be imported to the country. However the department still reserves the right for any further change to the announcement.

As HCFC-22 is going to be controlled by the announcement of DIW, it clearly affects the growth of air conditioning industry in Thailand because other alternative refrigerants such as HFC-410A are 300 times more expensive than that of HCFC-22. Moreover the amount of imported HFC-410A as an alternative to HCFC-22 is also forced to reduce within 5-10 years with the same reason. Apart from that the conversion plan to HFC-410A in Thailand supported by the World Bank was rejected by the Multilateral Fund 64th Executive Committee Meeting (July, 2011). Therefore the conversion to HFC-32 was proposed and accepted at the 68th Executive Committee Meeting as an alternative low-GWP refrigerant with higher efficiency than HFC-410A. Under this resolution, DIW received the financial aid in the amount of 25.5 million dollars from United Nation and Japan for helping air conditioning manufacturers to convert the use of HFC-22 in air conditioning unit to HFC-32. At present there are 13 air conditioning manufacturers joined in this project and 10 more from related industries such as refrigerator foam injection industry that show its interest to join in the project as well. The project is intended to improve the testing equipment, refrigerant charging equipment, charge pumps, and gas leak detectors, and to ensure the safety of manufacturing and storage facilities. The project does not provide help in term of money but rather help by supplying machines and equipment to the factory in order to support the manufacturing of air conditioning unit that uses HFC-32. The main reason why DIW decides to choose HFC-32 as a refrigerant replacement of HFC-22 instead of using HFC-410A is because of its low global warming potential. It is expected that 4 years from now, all Thai air conditioning manufacturers will start producing air conditioning unit that uses HFC-32 and importing HFC-32 to the country. This may result in cost increasing but it is expected to just 5-10% increase. However due to the concern of flammability of this HFC-32, the size of air conditioning unit expected to produce is lower than 24,000 BTUH.

In the meantimeThai Industrial Standard Institute is now on the process of drafting industrial standard for household refrigerator, commercial refrigerator and air conditioning unit on safety requirement that involved with flammable refrigerants. The standards mostly follow IEC 60335-2-24:2010 Household and similar electrical appliances-Safety-Part.2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers, IEC 60335-2-89:2010 Household and similar electrical appliances-Safety-Part.2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor and IEC 60335-2-40:2012

Household and similar electrical appliances-Safety-Part.2-40: Particular requirements for electrical heat pumps, air conditioners and dehumidifiers. These standards will open door for using flammable refrigerants in the electrical appliances for both domestic and imported electrical appliances.

However, according to MinisterialRegulation No. 33 issued by the Department of Public Works and Town & Country Planning, usage of easily flammable refrigerants in air conditioning system for large building is prohibited. The regulation does not provide any definition of easily flammable refrigerant. Therefore any refrigerants which are considered to be flammable are restricted to be used at present according to this regulation.

INDONESIA

The Government of Indonesia made a decision to adopt HFC-32 as an alternative to HCFC-22 for the following sub-sectors.

1. Factory-manufactured refrigeration units for small and medium sized walk-in cold rooms for replacing 2.92 ODP tonnes.

2. The light commercial air conditioning sub-sector in which at present there are only four Indonesian owned manufacturers and consumes 9.30 ODP tonnes.

3. The room — air conditioner (or residential air conditioning) sub-sector in which there is only one manufacturer in Indonesia and caters about 22% of the market for air-conditioners, while the remaining 78% of the market is served by imports of air-conditioners. This sub-sector consumes about 32.30 ODP tones.

The Government also plans to promote the use of HFC-32 with the support from the United Nations Development Program (UNDP) for refrigerant conversion. UNDP will provide the financial support of 12.7 million dollars for the conversion expense in the first period (2013—2015), with the fields of freezing and refrigeration to account for more than two-thirds. According to the Government's plan, the Indonesian Government has set out a policy to phase out HCFC-22 in refrigeration and air conditioning equipment by 2015 which means that Indonesia will complete the conversion to HFC-32 by 2015. For this reason, the following regulatory measures are planned. For example, the import and local production of refrigeration and air conditioning equipment that uses HCFC-22 will be prohibited from 2015. Moreover to facilitate the plan, the Indonesian Government asked Japan for technical cooperation on the grounds that Japanese manufacturers occupy a large share of the Indonesian market. In response to this request, the Ministry of Economy, Trade and Industry (METI) of Japan set up a conversion project in collaboration with such manufacturers as Daikin, Panasonic, Fujitsu General, Toshiba and Hitachi.

The Indonesian Government would also work closely with the industry to ensure appropriate regulations, standards and infrastructure for managing the safe use of this HFC-32 throughout the product lifecycle. The proposed regulations could include restricting import of products/substances with high GWP.

MALAYSIA

The Government of Malaysia is expected to completely phase out the consumption of Hydrochlorofluorocarbons (HCFCs) by 2030. A national HCFCs Phase-Out Management Plan (HPMP) has set up and outlines the overall framework and strategies of implementation to achieve the objective of the plan. The plan details actions to be taken to phase out the use of HCFCs in all sectors, namely in refrigeration, air conditioning, foams, solvents and fire-fighting. To develop the HPMP, the Executive Committee (EXCOM) of the Multilateral Fund for the Implementation of Montreal Protocol had approved a sum of US$173,750 (RM632,420) for the Malaysian Government through the UNDP. The Government also plans to freeze the production and consumption of HCFCs from Jan 1, 2013 to achieve a 10 percent gas reduction by 2015 with zero consumption in CFCs by 2010.

Even though the RAC manufacturing sector is the largest manufacturing sector in Malaysia in consuming HCFC-22 (2,245 mt in 2009), this sector is not being addressed in stage I of the HPMP given that alternative technologies suited to SMEs manufacturing RAC equipment are not fully commercialized and it would take 3 to 4 years to stabilize a technology to ensure cost-effectiveness and market acceptance. The Government of Malaysia views it necessary to provide technical assistance to locally manufacturing companies to ensure that they are adequately supported in managing HCFC and non-HCFC technologies.

4.0 CONCLUSIONS

Based on the fact that HCFC phase out in developing countries has started, ie. freeze in 2013, 10% reductions from 2015 and 35% reductions from 2020 until zero usage in 2030 along with major concern on global warming problem, it is very important to study the use of HFC-32 as a future alternative refrigerant for HCFC-22 and HFC-410A in order to provide basic information as well as safety and risk assessment.However if we look back on the replacement of refrigerants in the past started from CFC-11, CFC-12 to HFC-134A and HCFC-123 or HCFC-22 to HFC-410A or HFC-407C, most of the investment cost is about the hardware, ie., chiller or compressor replacement. Now with the new refrigerant, HFC-32, which is flammable, not only the investment cost on the hardware is needed according to many studies but also peopleware is needed as well for training and certifying technicians in order to qualify for using HFC-32. To perform this activity, training centers or authorized offices must be established. The question is that it is economically worth or not if this new refrigerant is not used long enough since its GWP is not zero. This is the question that is left without answer at present. Moreover, the increase of GWP comes not only from refrigeration and air conditioning industry but also from other industries. Therefore when it comes to a point that GWP not sufficiently reduced due to significant expansion of refrigeration and air conditioning industry and other industries, there might be more severe regulation to force the change of HFC-32 and replace with new refrigerants that contains zero GWP. This certainly means that new regulations and procedures have to be enforcedbecause refrigerants with zero GWP is mostly easily flammable, ie., hydrocarbon refrigerant, and hence a reinvestment on training, certifying and hardware replacement has to be redone. Therefore it is very important to have a clear picture at present about which direction that we should go for the refrigerant in the future and promptly taking any action in order not to confuse consumers as the industry is doing now.

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