A year in new low GWP refrigerants development

One year is not very long time span for most of us, but in refrigeration industry a lot can happen during one year. Today we would like to recall the most important events have happened during this year that affect the industry the most.

At the end of the year 2012 we've been left with more questions than answers regarding the future of fluorinated refrigerants. Let us see if we have got all our questions answered during this year.

How well is the MAC Directive being implemented?

January 01, 2013 was not just a first day of this year, but also the first day when the use of R134a in mobile air conditioning (MAC) systems in new car models become illegal. This is dictated by the European Directive 2006/40/EC (MAC-Directive) which bans the use of fluorinated greenhouse gases (F-gases) with a global warming potential (GWP) higher than 150 in MAC systems. This ban was anticipated years before and many car manufacturers have prepared to it by adopting R1234yf as a refrigerant of a choice for MAC systems.

In the late 2012, Daimler AG – the concern that was among the ones who have implemented R1234yf in some of their new cars – have questioned the safety of R1234yf by presenting their "real-life test scenario" results. These results demonstrated that refrigerant, which is otherwise difficult to ignite under laboratory conditions can be ignited in a hot engine compartment, in contrast to R134a. Daimler reacted to its own finding by discontinuing using R1234yf in its vehicles [1] and recalling 432 potentially affected Mercedes-Benz SL-Class vehicles to replace R-1234yf with R-134a.

The findings opened up debates concerning safety of R1234yf and were used to support the call for a 3-year deadline extension in order to develop CO_2 as an alternative to R134a and R1234yf in MACs [2]. European Commission (EC) have been postponing this deadline from initial date of January 01st, 2011 already 2 times and thus showed no will to extend any exemption on enforcement of MAC Directive, nor introduces new ones [3]. EC additionally pointed out that the Directive does not prescribe any particular refrigerant or MAC system. Instead, there were manufacturers who have opted to use the refrigerant R-1234yf [3].

As there is no legal framework for EC to take any actions against Daimler for not compliance with the requirements of the Directive, it has right to launch infringement proceedings against Member States (MS) not applying the legislation [3]. To avoid such measures, France has temporary introduced a sales freeze on some of Mercedes vehicles this August [4].

Considering a "very uneven picture" of risk assessments performed by different manufacturers, KBA – German Federal Motor Transport Authority – has initiated and coordinated tests on R1234yf safety to come to its own risk assessment [5]. The standard crash tests resulted in that "no adequate proof of a serious hazard in terms of the Product Safety Law occurred for the vehicle types tested here and now available on the market". In these tests a selection of 4 vehicles were subject to a crash tests, which resulted "in two cases, hydrogen fluoride (HF) exposures were determined, and in one case, reproducible flammability were additionally determined, which point to risks with the use of the refrigerant R1234yf" [5] [6].

The report has got a lot of media coverage in articles with often controversial points of view, as for instance “Final KBA report confirms safety risk of R1234yf” [7] and “Refrigerant Denied By Daimler, Considered Safe By Federal Transport Authorities” [8]. On one hand, these results support Daimler’s statement, as R1234yf is concluded to be more dangerous than R134a and the use of R1234yf is thus questionable under the European Union’s efforts to increase road safety. On the other hand, all of the KBA’s tests that were based on the requirements of German product safety law indicated no safety concerns. At any case, now the EC plans to review the crash tests results during a number of meetings with the relevant stakeholders in order to bring the end to the yearlong debate [7].

In fact, R1234yf is not an only refrigerant option to consider in MAC systems. Daimler has decided to rely on CO_2 instead of flammable R1234yf and together with VW and Porsche have announced development of CO_2 technology in MAC systems [9]. They were later supported by BMW and Toyota. Considering that Toyota and VW are in the top list of car manufacturers by volume this means that CO_2 has gained more favor as a refrigerant for MAC systems, compared to R1234yf – the change which was hardly anticipated a year ago (see Figure 1) [10].

Figure 1 - CO_2 outweighs R1234yf (source: Autobild [11])

Is it clear when the new F-Gas Regulation will be released?

Discussions around the future F-Gas Regulation is another topic, which is under discussion through this entire year. The discussions were initiated by the proposal for a regulation of the European Parliament and of the Council on fluorinated greenhouse gases regulation (F-Gas Proposal) [12]. The document proposed much greater measures to mitigate the usage of F-gases compared to the original Regulation 2006/842/EC from 2006, including placing on market prohibitions and phase out schedule.

Later during the year, European Parliament together with the Member States revealed Draft Report on F-Gas Proposal [13], that includes even stricter measures to limit F-gases, like for

instance the ban on stationary refrigeration equipment that contain F-gases from 2020 (see Table 1 for the entire list of proposed placing on market prohibitions).

*Table 1 - **Placing on market prohibition under the amendments of Draft Report on F-Gas Proposal** [13]*

PRODUCT AND EQUIPMENT	DATE OF PROHIBITION
Use of HFC-23 in fire protection systems and fire extinguishers	1 January 2015
Domestic refrigerators and freezers containing HFCs	1 January 2015
Refrigeration equipment that contains fluorinated greenhouse gases with GWP of 2150 or more	1 January 2015
Stationary refrigeration equipment that contain fluorinated greenhouse gases	1 January 2020
Refrigerators and freezers for commercial use (hermetically sealed systems)	January 2015 for HFCs with GWP of 2150 or more 1 January 2018 for all HFCs
Movable room air-conditioning appliances (hermetically sealed) that contain HFCs	1 January 2020
Technical aerosols	1 January 2020
Foams containing fluorinated greenhouse gases	1 January 2015
Stationary air-conditioning equipment that contain fluorinated greenhouse gases	1 January 2020 (1 January 2027 for centrifugal chillers)
Air-conditioning equipment in cargo ships that contain fluorinated greenhouse gases	1 January 2020
Mobile refrigeration equipment except fishing vessels that contain fluorinated greenhouse gases	1 January 2025

There is a hope from the European Parliament side to reach a decision with the Council of Europe in time to make new F-Gas regulations unveiled in 2013 [14]. However, before that, it is needed to reach the consensus on number of questions, where the most points of disagreement are the speed of the proposed HFC phase-down and the recommendation for a series of bans on high-GWP refrigerants and equipment containing them [15]. These bans are one of the key aspects for the Parliament as “from the Parliament’s perspective it is very important to have more clearly defined sectoral bans in order to give very clear market signal to everyone” said F-Gas rapporteur Bas Eickhout.

It is important for EU to reach agreement on ambitious F-Gas Regulation in order to support alternative businesses and enterprises to help them to become frontrunners in the global market and place “at the forefront of huge green technology revolution” [16]. Thus, we might expect F-Gas Regulation to be released within a few coming months.

What about other countries?

While EU is at the forefront of the F-gas mitigation, other countries are addressing this problem as well. In fact, more than one hundred countries have indicated support for including HFC control and phase-down within the Montreal protocol [17], with separate countries being proactive in additional measures. For instance, United States and China agreed to work together to phase down the production and consumption of HFCs [18]. However, the agreements are still needs to be transformed to the actions.

The recent Environmental Investigation Agency (EIA) report argues that a dozen of the largest and most important US supermarket chains and retailers have not taken substantial action to begin phasing out HFCs or reduce the amount of HFC emissions leaking from refrigeration systems. None of the stores surveyed have a clear and comprehensive policy to begin phasing out HFCs, nor have they enacted state of the art maintenance and operation plans to significantly reduce HFC emissions, despite the committed to begin phasing out HFCs starting in 2015. The report points out the attention of US companies that "supermarkets across Europe, Canada, Japan, China, Brazil, South Africa, and throughout the world are using HFC-free refrigerant systems" as the alternatives are available [19].

Do we have refrigerants to meet all the regulations?

Refrigeration industry faces strict regulations regarding the use of the most fluorinated refrigerants. Of course, natural refrigerants are seen to be viable alternatives to high GWP synthetic refrigerants in many applications and can provide refrigeration and/or heating effect at different temperature levels. However, natural refrigerants are often flammable or toxic and not always suitable to be used. Among the synthetic alternatives, few single component low GWP refrigerants are well developed so far. Hence, we would probably need to rely on refrigerant mixtures for most of the applications.

Active development of refrigerant blends is ongoing and six chemical manufacturers provide a number of different refrigerant blends as alternatives to baseline R134a, R404A, R407C and R410A. For instance, significant progress has been reported on development of low GWP refrigerant blends for MAC systems. The blend of 3 refrigerants R445A (formerly known as AC6 and based on 85% R1234ze(E), 9% R134a and 6% CO_2) has been tested and shown similar performance to R-134a at high loads, somewhat less at low loads [20]. Further system performance development obviously is needed and, taking into account that the R445A is a combination of high-pressure refrigerant with the low-pressure refrigerants, this refrigerant, however, brings many questions to the discussion: how the temperature glide, leak detection and refrigerant charge problems will be addressed.

Out of the different fluorinated propene isomers (HFO), not only R1234yf is considered for the future. For example, production range of high performance free cooling chillers using the refrigerant R1234ze(E) has been announced recently [21]. Another HFO – R1234ze(Z) – is given attention as a potential refrigerant for high temperature heat pumps. One of the reasons that these F-gases have strong potential to be used in the future is that they are not defined as "fluorinated greenhouse gases" by the F-Gas Regulation proposal and thus are not subjects for placing on market prohibitions under the proposed regulation (but still needs to be reported regarding the quantities of their use).

This year shown to be as very active on developments in field of low GWP refrigerants. Next year will be not an exception. For instance, recently approved project on low-GWP alternatives promotion for the air conditioning industry in high ambient temperature countries will bring us topics for discussion [22]. Not mentioning that the drama around the MAC Directive and F-Gas regulation is not over yet.

Thank you for following us this year and we hope you will keep in touch during next year as well.

PS

Bibliography

[1] Daimler AG, "New findings concerning the risks of the new R1234yf refrigerant: Mercedes-Benz wishes to continue using the tried-and-tested R134a refrigerant in passenger cars," 25 Sep 2012. [Online]. Available: goo.gl/Zou2V.

[2] Everything R744, "UBA: “Give EU carmakers until end of 2015 to switch to CO2”," 18 Feb 2013. [Online]. Available: r744.com/news/view/3889.

[3] European Comission, "Implementation of Directive 2006/40/EC - Questions and Answers," Feb 2013. [Online]. Available: goo.gl/0nHUs.

[4] Reuters, "Court lifts Mercedes sales ban in blow to France," 27 Aug 2013. [Online]. Available: goo.gl/IQ4K7v. [Accessed 19 11 2013].

[5] KBA, "Press Release no. 25/2013 - Risk assessment of the Kraftfahrt-Bundesamt (KBA, Federal Motor Transport Authority) concerning the use of refrigerant R1234yf in vehicle air conditioning systems (MAC)," 8 Aug 2013. [Online]. Available: goo.gl/TYUFhf. [Accessed 19 Nov 2013].

[6] Kraftfahrt-Bundesamt, "Technischer Bericht. Untersuchungen zur möglichen Entflammbarkeit des Kältemittels R1234yf in Kraftfahrzeugen," TÜV Rheinland Kraftfahrt GmbH, Flensburg, 2013.

[7] Everything R744, "Final KBA report confirms safety risk of R1234yf," 8 Nov 2013. [Online]. Available: r744.com/news/view/4694. [Accessed 19 Nov 2013].

[8] J. Wilkins, "Germany: Refrigerant Denied By Daimler, Considered Safe By Federal Transport Authorities," 13 Nov 2013. [Online]. Available: goo.gl/6BmQ0M. [Accessed 19 Nov 2013].

[9] Everything R744, "Daimler, Audi, BMW, Porsche and VW to develop CO2 MAC systems - Third time lucky?," 07 03 2013. [Online]. Available: r744.com/news/view/3957.

[10] Everything R744, "Balance tipping in favour of CO2 as preferred MAC refrigerant," 8 Oct 2013. [Online]. Available: r744.com/news/view/4605. [Accessed 19 Nov 2013].

[11] Autobild, "CO2 gewinnt an Gewicht," 01 Oct 2013. [Online]. Available: goo.gl/sfrnrC. [Accessed 19 Nov 2013].

[12] Europen Commission, "Proposal for a regulation of the European Parliament and of the council on fluorinated greenhouse gases," 4 November 2012. [Online]. Available: bit.ly/fgasproposal.

[13] European Parliament, "Draft Report on the proposal for a regulation of the European Parliament and of the Council on fluorinated greenhouse gases," 01 March 2013. [Online]. Available:

bit.ly/fgasdraftreport.

[14] A. Gaved, "European Parliament hopeful of F-Gas decision by year-end," 18 Oct 2013. [Online]. Available: goo.gl/hH1veA. [Accessed 11 Nov 2013].

[15] A. Gaved, "Prepare for compromises to bring F-Gas proposals to the market," 31 Oct 2013. [Online]. Available: goo.gl/jd6B5g. [Accessed 11 Nov 2013].

[16] Everything R744, "F-Gas discussions take centre stage at ATMOsphere Europe 2013," 22 Oct 2013. [Online]. Available: r744.com/news/view/4640. [Accessed 11 Nov 2013].

[17] D. Doniger, "108 Countries Support HFC Curbs under Montreal Protocol," 24 Nov 2011. [Online]. Available: goo.gl/w3EPq.

[18] The White House, "United States, China, and Leaders of G-20 Countries Announce Historic Progress Toward a Global Phase Down of HFCs," 06 Sep 2013. [Online]. Available: goo.gl/y8XBqK. [Accessed 19 11 2013].

[19] EIA, "The dirty dozen: how your local supermarket is killing the climate," Environmental Investigation Agency, Washington, D.C., 2013.

[20] SAE International, "Road to low-global-warming refrigerant zigs and zags, but R-1234yf still leads," 31 Oct 2013. [Online]. Available: articles.sae.org/12574/. [Accessed 19 Nov 2013].

[21] J. Milnes, "Airedale claims 'first to market' TurboChill low GWP refrigerant," RAC, 31 Oct 2013. [Online]. Available: goo.gl/0zX5Kn. [Accessed 19 Nov 2013].

[22] United Nations, "2013 Work programme of UNEP," Montreal, 2013.