F-GAS 2019 REVOLUTION IN REFRIGERATED TRANSPORT

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Introduction

Since 2015, the EU regulation on fluorinated gases n° 517/2014/UE replaced the previous one n° 842/2006/UE. It strongly reinforced the environmental constraints on hydrofluorocarbons (HFC) used in refrigeration machines. HFCs with global warming potential (GWP) over 2 500 kg CO2/kg will be banned for new equipment since 2020 and the total quota of GWP available at European scale already decreased by a 37 % since 2015. In the same time prices of HFC were multiplied by more than 10 for R404A for instance. This evolution will go on for several years in the frame of European F-gas but also of Kigali amendment.

In this context, refrigerated transport, with more than 95 % of its refrigerants load in R404A, should face both evolutions of environmental and economic constraints. As it was already pointed by several authors, refrigerated transport is the refrigeration sector most impacted by these evolutions. Refrigerated transport is also the sector with the lowest number of alternatives either for refrigerants or for cold production.

This article presents the evolution of HFCs in refrigerated transport since 2015 and the tendencies for the next years. It also updates the existing solutions on the market and the ongoing research programs for transport refrigeration units.

Refrigerated transport fleet and refrigeration units

Refrigerated transport fleet

The United Nations Agreement for Refrigerated Transport (ATP) requires conformity certificates for all transport equipment used for international transport of perishable goods. In France all the refrigerated transport equipment should have a certificate of conformity. This certificate includes the insulated body and the refrigeration unit. For the refrigeration unit, the reference and quantity of refrigerant are specified. Since 2002 France has developed an electronic platform DATAFRIG© for the management of these certificates. Cemafroid is in charge of its development and management.

At the end of 2018, DATAFRIG was containing some 350 000 refrigerated transport equipment among which some 113 684 with a valid ATP or national certificate the 31st of December 2018 (see figure 1).

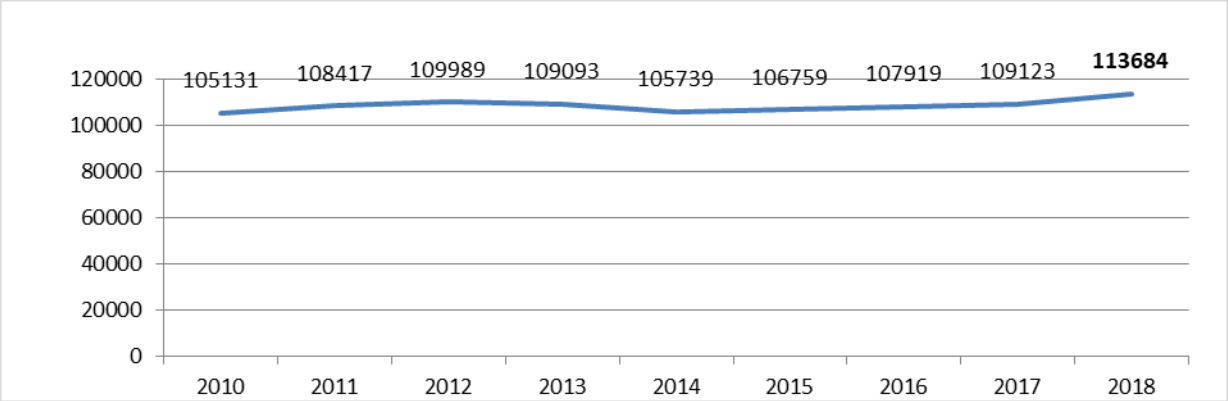

Figure 1 : Number of valid ATP certificates in France the 31st of December of the year.

DATAFRIG© is used to deliver new certificates but also to renew certificates of in service equipment. For each demand of certificate, the F-gazes nature and quantity are updated.

Refrigeration solutions in refrigerated transport

Refrigerated transport mainly uses vapour compression systems either with eutectic tubes or plates or more often with a blown evaporator. The analysis of the refrigerated transport equipment which received a certificate in 2018 in France, given in the graph of figure 2, shows clearly the predominant place of vapour compression systems with more than 96, 6 % of the equipment sold with a refrigerated unit. Most of them were using till 2016 R134a or R404A, a refrigerant condemned at short term in the frame of European F-gas. The current average F-Gas load in transport refrigeration units is of 3, 86 kg/unit but this load depends on the technology of the unit, its refrigeration capacity and installation in the body. These refrigerant loads are quite different for independent and motor driven refrigeration units. If for non-independent units, refrigerant load is about 1,66 kg it is about 6,85 kg for independent unit [2].

Very few solutions appeared on the market. If CO_2 unit were tested on the field, none are commercialised till now. The only alternative commercialised since 2015-2016 are using new HFCs, mainly blends, such as R452A, the most common of them.

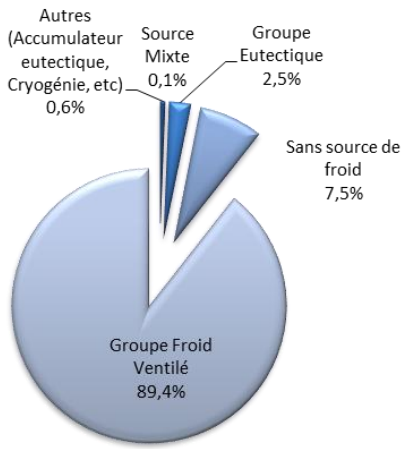

Figure 2: analysis of the refrigerated transport equipment which received a certificate in 2018 in France.

Nevertheless, other solutions have been developed or redeveloped during the last ten years such as CO_2 or N_2 cryogenic refrigeration units by Cryofridge, Thermoking or Air Liquide, or adsorption systems with ammonia by Coldway Technologies. Their market share, even if it is small with less than 1 %, is increasing.

Evolution of F-gases in refrigerated transport since 2010

F-gases in new refrigerated transport equipment

In 2015-2016 appeared on the market new versions of the existing transport refrigeration units with R452A as refrigerant in place of R404A. These units were tested and showed most of the time comparable refrigeration capacities. Analysing the ATP certificates delivered in France these last years we can see the evolution of R452A on the refrigerated transport market. Each year an average of some 16 000 certificates are delivered for new equipment either for French market or for export. As shown in figure 3 from 2010 to 2018 ATP certificates delivered in France each years, increased passing from 14 525 to 19 486.

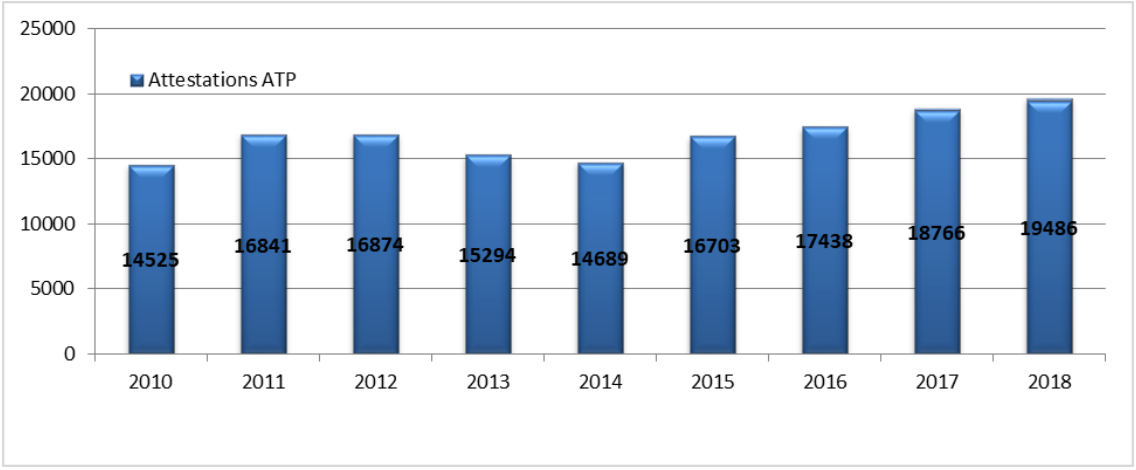

Figure 3 : Number ATP certificates delivered in France each year

The analysis of ATP certificates delivered in 2018 for new equipment indicates the refrigerant gases used from 2010 to 2018 as shown by figures 4 and 5. It shows that the number of equipment loaded with R404A increased till 2016. It appears that the real change occurred in 2018 with 69 % of new refrigerated transport unit loaded with R452A. Nevertheless 17 % were still loaded with R404A in 2018 which is quite important less than two years before the ban of virgin R404A on European market.

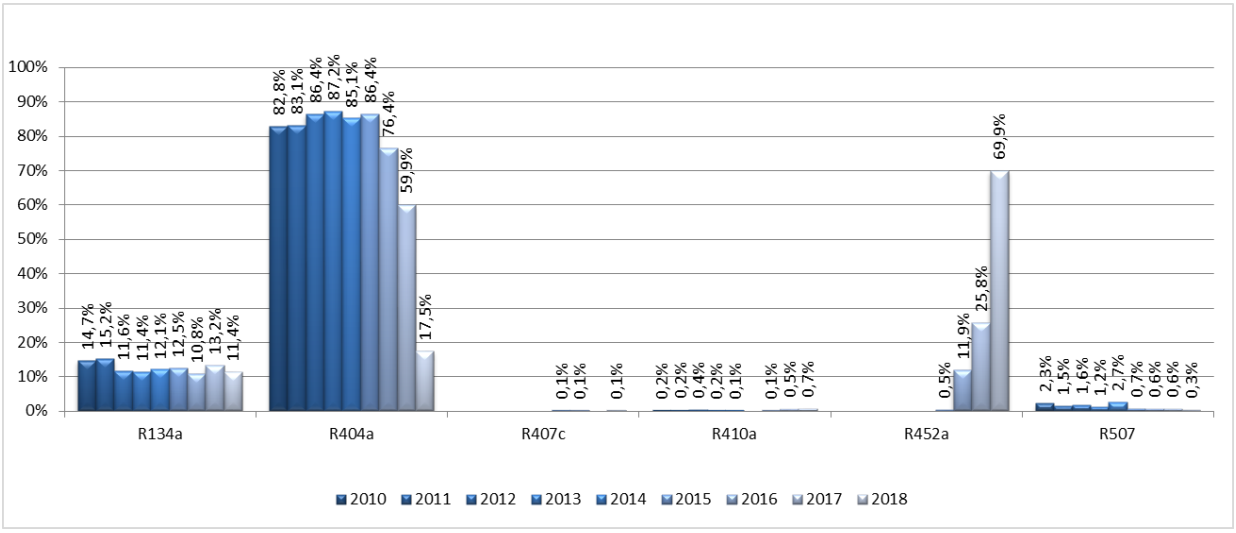

Figure 4 : evolution of F-gases in new transport refrigerated equipment from 2010 to 2018 in number of equipment.

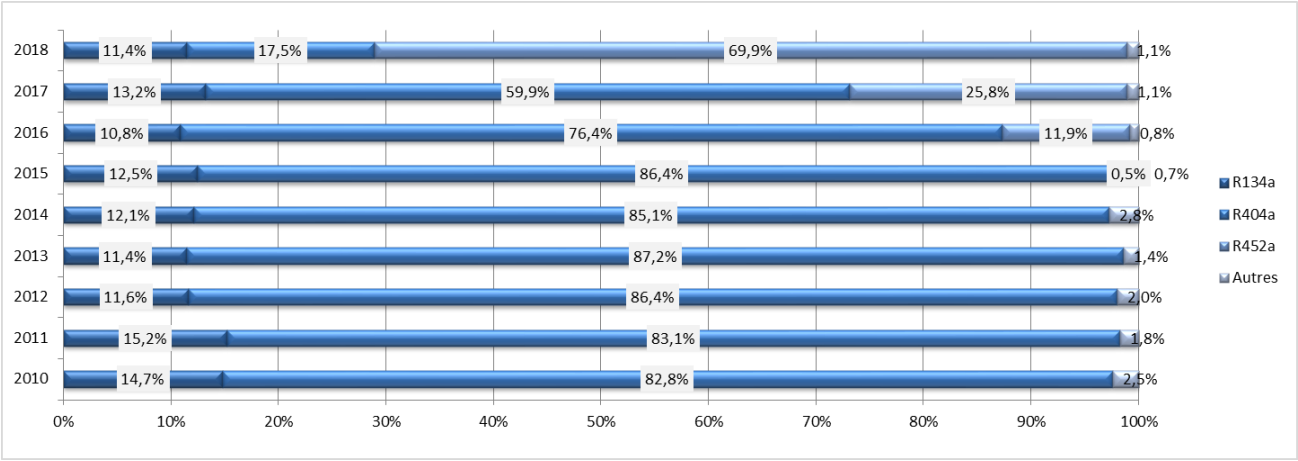

Figure 5 : evolution of F-gases in new transport refrigerated equipment from 2010 to 2018 in number of equipment.

F-gases in in service refrigerated transport equipment

Since 2017, transport refrigeration unit manufacturers also proposed drop-in of R404A in the existing transport refrigeration units. Most of them choose R452A as for new equipment. Nevertheless, other fluids such as R442A or R449 were also proposed. Manufacturers retested their units with this new refrigerant. ATP was updated in order to allow drop in in in service equipment with a renewal of ATP certificate.

The analysis of certificates renewal for in service equipment shows in graphs of figure 6 and 7 that even if the switch has been done for new equipment from R404A to R452A, it is not the case for in service ones. At the end of 2018, 87, 2 % of in service refrigerated transport equipment were still loaded with R404A in France and the evolution between 2017 and 2018 was really low. The market share of R404A increased till 2017 and reached 88,8 % of the fleet this year.

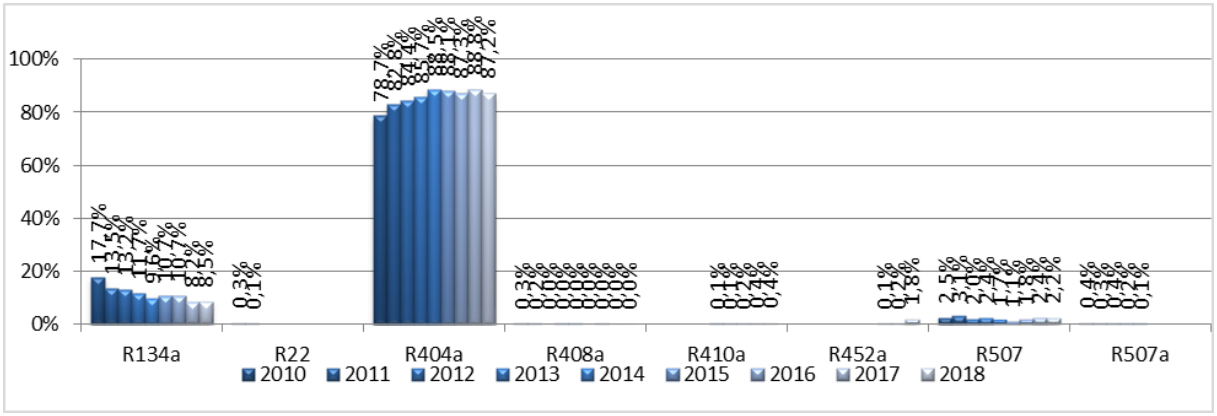

Figure 6 : evolution of F-gases in in service transport refrigerated equipment from 2010 to 2018 in number of equipment.

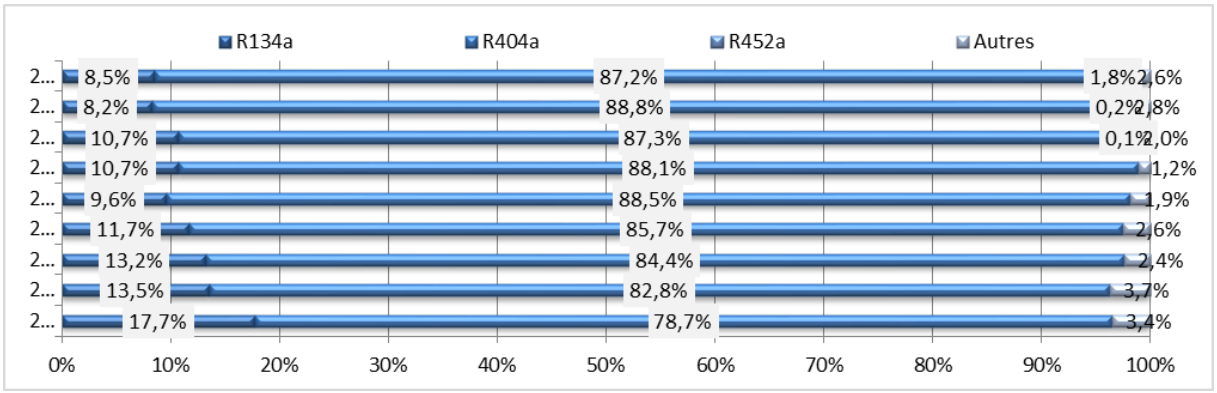

Figure 7 : evolution of F-gases in in service transport refrigerated equipment from 2010 to 2018 in number of equipment.

Possible future evolutions for transport refrigeration

Existing solutions

The new solutions already on the market will certainly go on their development. For the vapour compression systems, machines loaded with R452A will offer a good solution for the next years even if the price of R452A as reached nearly the price of R404A and its availability will also decrease in the next future. It is still the only short term solution for vapour compression systems in refrigerated transport.

The alternatives to vapour compression systems such as cryogenic and adsorption systems, even if they have a very small market share now, will develop in the close future. They offer long term sustainable solutions that will not be impacted by the future regulations or the next steps of existing. If cryogeny is dedicated to quite large transport equipment and mainly semi-trailers and heavy duty transport, solutions such as adsorption are till now more dedicated to small refrigerated transport equipment such as tricycles, vans and light commercial vehicles.

Short and medium term new solutions

At short term, vapour compression systems manufacturers should propose alternatives to R452A and other HFCs blends such as the R448A, R449A, R450A, R407A or R407H (see table 1). Their theoretical performances are comparable to those of R404A in the same operating conditions but each of them has technical characteristics to be evaluated on the ground for their application. Some of these technical characteristics are: the reduction of the refrigerant capacity and the reduction of COP, the temperature glide during compression, the compatibility with oils and lubricating materials, the effects of the change in performance following the losses of the most volatile components and their flammability. The R452A represents the most concrete possibility in the short term to replace the R404A [3]. It is a mixture of HFC and HFO whose compositions is as follow: 30% of R1234yf, 59 % of R125 and 11% of R32. It is a non-flammable fluid belonging to security category A1 of ASHRAE classification and having a GWP value equal to 2141, 45% lower than the GWP of R404 and lower than the fateful threshold of 2500. Others blends have been studied less. A recent study [4], realised for a different application than refrigerated transport pointed out that R407H has a refrigeration capacity 5% lower than R404A but its COP is 8% higher than the COP of R404A and 4% higher than the one of R452A. Using the R407H the compressor delivery temperature would be higher than using R404A but lower than the values for the applications considered in this study.

Natural refrigerants are still in test such as CO_2 with Carrier or hydrocarbons. They still represent a good potential alternative. Hydro-fluoro-oleine, are also tested in a large number of refrigeration applications including transport refrigeration units prototypes. It is predictable that in the near future new fluids will be proposed on the market.

On the same time the other refrigeration technologies will certainly extend their range of applications and improve their performances.

Refrigerant fluid	**T_{critic} (°C)**	**GWP**	**ODP**	**ASHRAE security group**
R404A	72,1	3260	0	A1
R134a	101,1	1300	0	A1
R410A	72,5	1730	0	A1
R452A	74,9	2141	0	A1
R448A	83,7	1387	0	A1
R449A	81,5	1397	0	A1
R450A	105,7	601	0	A1
R407F	82,7	1824	0	A1
R407H	86,5	1495	0	A1

Table 1: characteristics of fluids used in refrigerated transport

Long term solutions

On a longer term, transport refrigeration will strongly change .It should improve its energetic performances but also adapt its energy sources to those of the new vehicles. Fuel cells, fatal energy reuse or new batteries will be new sources of energy for transport refrigeration units. Storage of cold such as in adsorption or refrigerant units will also take a larger place on the market.

Conclusion

Even if new solutions appeared on the market for refrigerated transport during the last years, the evolution is really slow. The change of HFC made mandatory by European regulation only started seriously in 2018 and mainly for new equipment. Even if new techniques and new fluids are already on the market such as R452A or cryogeny and adsorption, it requires time to implement them on a large scale.

The route is still long for transformation of refrigerated transport solutions in regard with the F-gas requirements. The challenge is open and quite exciting for industries.

References

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