Sanhua accepts the challenge of new low-GWP refrigerants

Author: Federico Bisco

Introduction:

A couple of years earlier than expected, 2018 is proving to be a critical year for the entire Refrigeration and Air Conditioning sector. European Regulation 517/2014 provides for a gradual reduction (Phase Down), from 2015, in the use of HFC refrigerants by refrigeration equipment manufacturers. In, this reduction imposed by the legislation must amount to 37% during the current year, while the subsequent steep drop to 45% is to be achieved by 2020. However, we are witnessing a dramatic acceleration of the Phase Down process, in large part due to difficulty in obtaining the most common HFC refrigerants and the consequent sudden and dramatic increase in prices, in accordance with the well-known market rules of supply and demand. This situation is directly controlled by the multinational refrigerant gas producers that have implemented a political and commercial strategy of strong obstruction to the use of widely used refrigerants such as R410a, R134a and R404a. This has effectively forced the entire sector to find and introduce alternative refrigeration fluids.

Alternative low-GWP fluids:

Unfortunately, the full picture on the future of refrigerants is not yet clearly defined; in addition to the more traditional natural gases (hydrocarbons (HC) and R744), new synthetic refrigerants or mixtures have come onto the market that have the common advantage of a low GWP capable of meeting – at least for a few years – the constraints imposed by the European F-Gas directive. However, all the proposed solutions have non-marginal disadvantages or problems that must be evaluated carefully, especially in relation to the application.

GWP Level	Alternatives to R134a	Alternatives to R404a & R22	Alternatives to R410a
	PS approx.: 24 bar	PS approx.: 35 bar	PS approx.: 46 bar
< 4000		R404a (A1; 2) – GWP=3922	
< 2500		R22 (A1; 2) – GWP=1810 R407a (A1; 2) – GWP=2107 R407c (A1; 2) – GWP=1774 R407f (A1; 2) – GWP=1825	R410a (A1; 2) – GWP=2088
< 1500	R134a (A1; 2) – GWP=1430	R452a (A1; 2) – GWP=2140 R448a (A1; 2) – GWP=1270 R449a (A1; 2) – GWP=1280	
< 700	R513a (A1; 2) – GWP=631 R450a (A1; 2) – GWP=605	R454a (A2L; 1) – GWP=238	R32 (A2L; 1) – GWP=675 R452b (A2L; 1) – GWP=676
< 150	R1234ze (A2L; 2) – GWP=7 R1234yf (A2L; 1) – GWP=4 R1270 (A3; 1) – GWP=2 R600a (A3; 1) – GWP=3	R454c (A2L; 1) – GWP=146 R290 (A3; 1) – GWP=3 R744 (A1; 2) – GWP=1 [PS > 60bar]	

Table 1

In order to better clarify the current situation and possible future scenarios, the refrigerant families can be divided into three macro categories that can, in part, be associated with specific applications. Table 1 presents the three categories of synthetic refrigerants in increasing order of maximum working pressures.

Alternative refrigerant fluids to R134a

In addition to having been the refrigerant par excellence of the automotive sector, currently the refrigerant R134a is commonly used in large chillers and heat pumps equipped with screw compressors or centrifugal compressors. The alternative to this refrigerant that is now unanimously regarded as the favourite is the family of HFOs named R1234. This refrigerant occurs in two different types: R1234yf and R1234ze. The first of these has already been adopted massively by the automotive industry and, despite falling in category A2L (mildly flammable), has a volumetric capacity very similar to R134a, thus allowing rapid introduction without the need to increase the size of equipment components. R1234ze, meanwhile, has a lower flammability and shares the same A2L categorisation as its sister fluid, but according to the PED directive (2014/68/EU) falls among the Group 2 fluids. However, this fluid is not experiencing the success of the "yf" variant because its lower vapour density penalises the refrigerating capacity by around 20% when used as a drop-in replacement for a system using R134a. The table identifies other possible fluids as alternatives to the HFOs of the R1234 series, but these have disadvantages of a different kind: the refrigerant mixtures designated R513a and R450a halve the GWP value of R134a, with zero risk of flammability, but represent only a temporary solution and are therefore not taking a decisive hold on the market. The hydrocarbons (R600a and R1270), on the other hand, have a high flammability and, for some commercial applications, a charge limit of less than 150g, which prevent their easy use in multiple applications or in higher-power equipment. Aware of the considerations linked to the fluids presenting themselves as alternatives to R134a, Sanhua has already implemented for some years a process for verifying chemical compatibility with the HFOs and the main mixtures deriving from them. In particular, in relation to the refrigerants of the R1234 series, Sanhua is already able to offer a complete range of mechanical and electromechanical valves that provide full chemical compatibility with these refrigerants and the related oils. The company has also completed an important project for certification of the main electromechanical components for use with hydrocarbons and with refrigerants categorised as mildly flammable (A2L), including R1234yf: the 4-way reversing valves (SHF series), the solenoid valves (MDF, HDF and FDF series) and the electronic expansion valves (DPF series) can now be used by our customers in new-generation equipment.

Alternative refrigerant fluids to R404a

In the refrigeration segment, the refrigerant that has met with the most success in Italy and Europe over the last ten years is unquestionably R404a, while the mixtures of the R407 family have succeeded to a lesser extent. However, the first of these has a GWP of almost 4000 and is therefore the worst enemy of the environment still in circulation. Replacing it is no simple matter, but there are two main viable approaches: the first involves natural fluids, primarily propane (R290), while the second sees the introduction of new mixtures with a GWP certainly lower than that of R404a, but still in the order of 2000. Propane is a hydrocarbon with excellent physical properties; when used in a refrigerator, levels of efficiency comparable to systems using R22 can be easily obtained. However, there remains the exacting problem of its flammability (cat. A3) and the consequent restriction imposed by IEC 60335-2-89 of 150g per individual circuit in commercial applications. This quantity of charge limits the refrigeration power per circuit to approximately 1.5 or 2kW with current technologies, thus restricting its application to small plug-in units installed in supermarkets or small commercial concerns. Sanhua is an important partner for natural refrigerants, particularly propane, and for several years has provided a wide range of certified components for use with flammable refrigerants (valves up to DN 25). Moreover, **Sanhua is the only company in the world capable of integrating these products with micro-channel exchangers (MCHE)**, available in evaporator and

condenser versions. This represents the perfect solution to the need to minimise internal volumes and thus the refrigerant charge. Careful design of the refrigeration circuit, together with the adoption of MCHE technology for both exchangers, has made it possible to reduce the internal volume to 70%. Thanks to this development, while respecting the limit of 150g, some manufacturers are producing prototypes of show cases with refrigeration powers exceeding 2 kW.

However, it should be understood that until there is a drastic revision of standard IEC 60335-2-89, with an expected increase in the imposed limit from the current 150g to 500g, as recently proposed by the International Electrotechnical Committee (IEC/SC 61C), propane will not see widespread use in higher-capacity applications. In the field of commercial refrigeration, we are seeing the introduction of a few mixtures with a GWP of around half that of R404f. This is the case with the mixtures R407a and R407f which are, however, regarded by many as only short-term transitional refrigerants and are already being phased out thanks to the arrival of mixtures such as R452a, which is highly successful in Italy, and R448a/R449a, which appear to be the choice in the rest of Europe. These mixtures have the feature of not being flammable, and it is probably this factor that has attracted most of the refrigeration operators. However, their GWP well in excess of 150 already classes them as transitional refrigerants while we wait to see what might be the real driver of the sector for the near future. There is already talk among insiders of a new family of R454 mixtures, but these fall into the A2L category and therefore partly prompt the same fears that already exist with propane. However, during this phase of uncertainty, Sanhua can support its customers by offering – for its entire portfolio of products – homologation for use with these new refrigerants. We also take pride in having recently updated **the entire range of thermostatic valves (RFKH, RFGB and RFGD series)**, with the introduction of new versions designed specifically for use with the new mixtures mentioned above. Alongside the mechanical thermostats, Sanhua offers a **wide range of electronic expansion valves (DPF and VPF series)** which, as well as **ensuring greater energy efficiency** for the system, allows great flexibility of use. If the valves of the DPF series are used in combination with the **new driver (SEC)** [Figure 1], it is possible – by changing only one parameter in the driver – to select the refrigerant of your system by choosing it from an extensive library pre-installed in the controller. This does away with the need to keep stocks of the dedicated expansion valve for a particular refrigerant because a single product can be easily installed in systems operating with different refrigerants.

Figure 1

The Retail Food sector appears to be increasingly turning towards the use of carbon dioxide (R744), at least at higher latitudes that allow the equipment to achieve greater levels of efficiency. The problem of equipment efficiency is the main critical issue with CO_2, which – due to its physical characteristics (critical point of 33°C) – does not allow a CoP much above 2, even with highly optimised and complex systems. The problem is accentuated in countries with warm climates and electricity production methods still linked to the burning of fossil fuels. Although on the one hand there is a lower possible GWP, on the other hand there is a high consumption of electrical energy, with consequent emission into the atmosphere of CO_2 for its production. This is the case with Italy, where we are seeing a very slow spread of equipment using R744, in contrast to what is happening in the rest of Europe, where these trans-critical systems are driving the sector. Sanhua, a market leader in the Air Conditioning sector, has been active in the refrigeration world for only a few years and works with the same professionalism and attention that it has always applied to air conditioning. In relation to CO_2, Sanhua is already able to offer a **complete range of ball valves for sub-critical applications (CBV series up to 60 bar) and trans-critical applications (CBVT series)** [Figure 2]. In this regard, the company offers an innovative product: a **valve made entirely from AISI304 stainless steel**, with a valve body made from a stainless-steel casting that guarantees **maximum resistance even at working pressures well above 100 bar**. A **Sanhua patent** has also made it possible to create a **bimetallic connection** on joints so that the inner portion of the connections is 99% pure copper for an easy brazing operation with the K65 copper generally used for the piping on R744 equipment.

Figure 2

Alternative refrigerant fluids to R410a

One of the sectors that is certainly experiencing the most difficulty due to this revolution in refrigerants is Air Conditioning. For years, the reference refrigerant for the sector has been R410a, which since January 2017 has suffered – perhaps more than other products – a major inflationary impact: the price has more than tripled. In addition to the already mentioned phenomenon of quotas that restricts availability in Europe, there have been closures of some Chinese plants that produce R125, the fluid that makes up 50% of R410a. Low and medium-power A/C units, probably driven by the choices imposed by a few giants in the Asian sector, have tended towards the use of R32, a well-known fluid for a long time, partly because it too is a constituent component of R410a. Although this refrigerant has a modest GWP content, it also has the characteristic of being mildly flammable (A2L), falls into category 1 according to the PED directive and requires a design pressure of not less than 46 bar. Added to this is the fact that under typical nominal working conditions for an air conditioner, the exhaust temperature at the compressor is rather high and can reach up to 150°C. This factor means that this refrigerant tends to be used only in cooling machines (chillers) and poses numerous critical

issues for all component manufacturers, whether they are producers of compressors or valves. The working pressures (PS) above 40 bar, together with the fact of having a group 1 fluid, make it necessary to certify all valves with DN>25 in category II, a measure that is neither simple nor immediate to implement. Sanhua is already able to confirm the chemical compatibility of the entire current range of products using this refrigerant, and is actively working with the certification bodies to shortly provide the PED certification also needed for larger components with DN>25. At the same time, the company has also worked for the approval of its products using R452b, which is emerging as the solution for heat pumps of medium and high power.

Conclusions:

The refrigeration and A/C market is at an epochal turning point: the new environmentally sensitive regulations and the commercial and economic pressures imposed by the refrigerant producers are accelerating the drop-in of new low-GMP refrigerants or mixtures. Excluding the transitional refrigerants, the trend for all "cold" sectors is towards natural or synthetic refrigerants that are flammable or mildly flammable. This fact obliges all operators in the sector to radically revise the design of the machines and the choice of components, which must be capable of providing maximum compatibility and safety even in the event of leaks or accidents. Similarly, the regulations must be updated to define the new safety standards necessary for using these refrigerants in larger quantities. Sanhua is a company that sees in this change an important opportunity to become a strategic player in the sector and is able, through substantial investment in research, to supply excellent products and state-of-the-art technology.