THE F-GAS DIRECTIVE AND THE CONSEQUENT INTRODUCTION ON THE MARKET OF NEW GAS REFRIGERANTS WITH LOW IMPACT: THE IMPLICATIONS ON PRODUCT DEVELOPMENT OF HVAC UNITS.

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The new European Regulation 517/2014 has imposed a drastic reduction in greenhouse gas emissions, with a target of 79% reduction by 2030 compared to the same recorded in the period 2009-2012.

In order to achieve this ambitious target, various initiatives were identified, including a progressive reduction of HFC refrigerant gases, expressed in tons of CO2 equivalent, in the European Union.

This has led to an increased fragmentation of the panorama of gas refrigerants, moving from those that were the two main players until 2017, specifically R410A (high-density refrigerant for applications with scroll compressors) and R134a (low-density refrigerant for applications with screw compressors / centrifugal), to a much more varied scenario.

Specifically, these are the scenarios:

- Short terms: low GWP gas refrigerants (R513A / R454B / R32) allows manufacturers to adapt, rather than redesign, the units thanks to their thermodynamic characteristics;
- Long-terms: nearly zero GWP gas refrigerants (HFO HC), since having GWP values close to zero and therefore the ideal solution, but that imply a substantial redesign and new product development, especially if we consider the applications for which today are used high-density refrigerants.

From this consideration comes the fact that in the current situation there is no better choice than others for HVAC manufacturers (both in direct expansion and conventional hydronic systems), the "driver" is the result of the correct balance between technology / performance / installation limits (in fact, some of the refrigerants are class A2L - slightly flammable) vs. low GWP).

Each HVAC global manufacturer has therefore establish a product development pipeline in order to comply with F-gas regulation but keeping an eye on their global business out of EU, which makes more complex the decision how and where to invest.

Beside the gas refrigerants availability, HVAC manufacturer started feasibility analysis collaborating with both gas refrigerant industry and OEM industry, and it resulted clear that for achieving similar performance as with R410A or R134a, a step in the flammability type of gas refrigerant has to be taken.



Challenge comes on which gas refrigerant to adopt in order to find proper pros/cons balance and according to the different technologies this challenge becomes a massive product development investment.

It has been defined the following, according to global strategy:

- 1. For Hydronic system, using fixed speed scroll compressor, the R454B.
- 2. For Hydronic system, using inverter scroll compressor, the R32.
- 3. For Hydronic system, using fixed speed and inverter screw compressor, the R513A (XP10) and HFO.
- 4. For Hydronic system, using centrifugal compressor, the R513A (XP10) and HFO.

With a specific focus on fixed speed scroll compressor, the selection of R454B came from the following technical considerations, charting out the thermodynamic properties of the R410A and the 2 candidates, we can see that the 3 gasses has similar properties but not all can fit the fixed speed scroll compressor technology. Let see why:

Evaporator enthalpy comparison



Maximum working pressure comparison



Discharge gas temperature comparison



Based on the upon comparison, R454B has been appointed to be the counter answer for replacing R410A.

R454B and compressor availability allow to cover the full line-up from 2-compressor model (<100kW) up to 800kW for multiscroll applications but A2L flammability implies units technical adjustment in the whole chain (from manufacturer to installer) in the following terms:

PRODUCT DESIGN

: in order to ensure that the refrigerant will not be able to flow into any building ventilation fresh air opening, doorway, trap door or similar opening in the event of a leak, the HVAC manufacturer has introduces Safety Pressure Relief Valves both in the refrigerant and water sides.

MANUFACTURING

: Manufacturing production lines and testing chambers must be revised for coping with the risk assessment. Proper brazing license, training and education to workers, proper detection systems must be foreseen for producing unit with R454B.

INSTALLATION

: "Air cooled units must be installed outdoor in the open air (class location III, according to EN 378-1:2016) and respecting the recommendations written in the general manual for installation. Designers and Installers must ensure appropriate ventilation all around the unit to avoid the refrigerant can stagnate and could reach a flammable concentration in case of leak. Furthermore, water circuit shall be designed to **NOT ALLOW** refrigerant releasing into closed areas. The following components are NOT ALLOWED to be installed in indoor spaces:

- Open-type expansion vessels/tanks → Install only hermetic-type.
- Pressure Relief Valves (PRVs) → Install outdoor or connect the outlet to a pipe that relieve outside.
- Automatic Air Vents (AAVs) \rightarrow Cap them after purging the circuit.

SERVICE

: Refrigerant gauges, manometers, vacuum pump and tools are common to R410A but the update of the refrigerant analyser database including R454B refrigerant. Top-up procedure from liquid side can be executed without prior recover of R454B during service activities.

Starting from this point of course, as already said before, beyond the applications involving fixed speed scroll compressors, it is needed to consider the whole world of solutions with variable speed scroll compressors / fixed or variable speed screw compressors / centrifugal compressors ecc.

For this reason the manufacturers, for both direct expansion products and hydronics one, are pushed at least to readapt, or for a long term solution to completely redesign their entire range with the proper refrigerant alternative taking in consideration (like per high density refrigerant applications) the correct balance between advantages and disadvantages.

Concerning what above, here below an assumption of the most probable roadmap for refrigerants phase-out (it is possible to notice how for high density application there is not a long term solution yet, so with a GWP near zero):

DIRECT EXPANSION SYSTEMS

- RESIDENTIAL AND COMMERCIAL $\label{eq:result} R410A \rightarrow R32$
- AIR TO WATER $R410A \rightarrow R32$
- VRF PRODUCTS / HVRF PRODUCTS / VENTILATION $R410A \rightarrow R32$

HYDRONIC SYSTEMS

- FIXED SPEED SCROLL COMPRESSOR $R410A \rightarrow R454B$
- INVERTER SCROLL COMPRESSOR $R410A \rightarrow R32$
- FIXED SPEED AND INVERTER SCREW COMPRESSOR $\ensuremath{\mathsf{R134A}}\xspace \rightarrow \ensuremath{\mathsf{R513A}}\xspace$ and $\ensuremath{\mathsf{HFO}}\xspace$
- CENTRIFUGAL COMPRESSOR **R134A** \rightarrow **R513A** and **HFO**