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Explanatory note on the need for the use of a diverse range of refrigerants in the heat-pump sector

v.2

Introduction

The European Commission is preparing a proposal to revise *REGULATION (EU) No 517/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006* (hereafter, F-gas Regulation). The proposal is expected to be adopted in April 2022 and submitted to the European Parliament and the Council, starting herewith an ordinary legislative procedure.

The European Heat Pump Association (EHPA), representing the heat-pump technologies value chain in Europe (heat pump and component manufacturers, research institutes, universities, testing labs and energy agencies) has expressed the views and suggestions of the industry in its position paper on the F-gas Regulation Review.

Given the **urgency to reduce Europe's energy dependency on fossil fuels in the heating sector** and the undisputed need to quadruple the amount of heat pumps to be installed by 2030 to achieve that purpose, the paper concludes that **any new measure that would limit the availability or the choice of refrigerants (bans, stricter phase-down) to be used by heat pumps in the foreseeable future will slow-down the speed at which heat pumps need to be installed to reach the EU carbon-neutrality targets**.

The paper states that in order to meet the European Green Deal objectives and the new level of ambition brought by the "Fit for 55" package it is crucial that the revised F-gas Regulation supports the required accelerated deployment of heat pumps by 2030, for which purpose *"**The Regulation should support a diversified use of refrigerants**. No heat-pump technology may be hampered, based on its refrigerants contents, to bring its necessary environmental contribution in a safest possible way today."*

This explanatory notes illustrates the reasons why a policy framework which supports the use of a diverse range of refrigerants should be maintained. It covers:

- the diversity in heat-pump applications;
- the diversity in heat-pump technologies;
- the diversity of aspects to be considered for each use case.

1. The diversity in heat-pump applications

Heat pumps fulfil space heating, cooling and hot water production needs across various parts of the society and the economy.

Here is a non-exhaustive list of some heat-pumps applications:

For further information, examples and illustrations, please consult the White paper *"Heat Pumps Integrating technologies to decarbonise heating and cooling"* and www.ehpa.org.

- single homes
- multi-family homes
- multi apartments buildings
- commercial areas offices
- public buildings, including social housing
- hospitals
- schools
- hotels
- large space areas
- industrial processes
- district heating and cooling

2. The diversity in heat-pump technologies

The benefits of heat pumps to the above-mentioned applications come from using a full range of technologies, which all have their specific qualities and variations.

Here is a non-exhaustive list of some heat-pumps technological variations

For further information, examples and illustrations, please consult the White paper *"Heat Pumps Integrating technologies to decarbonise heating and cooling"* and www.ehpa.org.

- Diversity in usages:
  - space heating: human comfort, agriculture, logistics
  - space cooling: human comfort, agriculture, data centers
  - water heating: domestic hot water, swimming pools
  - combi (space and water heating)
  - multi functions (space/water heating + ventilation or space/water heating + air cooling)
  - district heating/cooling
  - industrial processes

- Diversity in main thermal source:
  - Air
  - Water
  - Ground
  - Sewage/grey water
  - Waste heat

- Diversity in auxiliary energy source:
  - Electricity
  - Gas
  - Hybrid solutions

- Diversity in sinks:
  - air
  - water
  - brine

- Diversity in capacities
  - Small (Residential) 2 to 20 kW
  - Light commercial 20 to 200 kW
  - Heavy commercial, industrial > 200 kW

- Diversity in systems design:
  - split systems
  - monobloc (outdoor, indoor)
  - integrated in other systems

- Diversity in compressor types:
  - rotary
  - scroll
  - screw
  - centrifugal

- Diversity in capacity control:
  - fixed
  - staged
  - variable

- Diversity in refrigerants used:
  - HFCs
  - HFOs
  - Blends
  - Non-fluorinated (HC, $C0_2$, NH_3)

Overview of some refrigerants (with chosen characteristics) used in heat pumps (source: *Heat Pumps Integrating technologies to decarbonise heating and cooling* (2018), based on Bitzer refrigerant report 19 (A-501-19)):

NAME	GROUP	FLAMMABILITY	SAFETY CLASS	GWP (AR 4)
R32	HFC	mild	A2L	675
R125	HFC	no	A1	3500
R134A	HFC	no	A1	1430
R152A	HFC	yes	A2	124
R245FA	HFC		B1	1030
R404A	HFC	no	A1	3922
R407C	HFC	no	A1	1774
R410A	HFC	no	A1	2088
R1234YF	HFO	yes	A2L	4
R1234ZE	HFO	yes	A2L	7
R448A	HFO	no	A1	1387
R449A	HFO	no	A1	1397
R290 PROPANE	Hydrocarbon	high	A3	3
R600	Hydrocarbon	high	A3	3
R717	Amonia	no	B2L	0
R744	Carbondioxide	no	A1	1

Note: Other refrigerants should be added to this list, such as R455A (GWP 148).

3. The diversity of aspects to be considered for each use case

The large variety of applications for heat-pumps also comes with additional regulatory and/or health, safety and environmental considerations (HSE) that need to be taken into account before applying the best technological choice to a use case.

<u>Here is a non-exhaustive list of aspects to be considered when chosing the best technological variations:</u>

- installation constraints (limited spaces, longer pipping lengths, access to the heat pump, possibility of ventilation to outdoor, rules for piping)
- technical feasibility, performance
- safety of the product and related rules
- safety of people, installers and workers and related rules
- energy-efficiency requirements (and further improvements potential)
- material efficiency requirements
- reparability (easiness and possibility to replace components)
- cost-effectiveness and total cost of ownership for the end-user
- new building/renovation plans and standards
- ease of installation and qualification of installers
- availability of components (including refrigerants)
- sound levels
- climate conditions
- demand-response requirements
- reusing, recycling, reclaiming of refrigerants
- practices on field from installers linked to their habits, and different in each country[1]
- other national, regional and local requirements, regulations and standards

[1] For instance, in France, the largest EU market for electric heat pumps today (with 267,000 electric heat pumps air to water installed in 2021), about 88% of electric heat pumps air to water installed were split technology.

Conclusion

Many aspects need to be considered when opting for the most suitable heat-pump solution for any given use case (see example in the annex below). Among the diversity of technological solutions in play, refrigerants are just one piece of the puzzle. **A "silo" approach on refrigerants could lower EU's climate ambition level and lead to unintended environmental, social, economic and political consequences for the EU's citizens and businesses.**

The joint existing commitment by industry and policymakers to speed up the deployment of heat pumps by 2030 and beyond requires a flexible regulatory framework regarding the choice of refrigerants (such as the one offered by the current F-gas Regulation). In contrast, **any new measure that would limit the availability and/or the choice of refrigerants (bans, stricter phase-down) to be used by heat pumps would slow-down the speed at which heat pumps need to be installed and put at risk the EU carbon-neutral net zero objectives.**

Allowign the use of a full range of refrigerants will contribute to the implementation of an unprecedented level of EU emissions reduction ambition as already made possible by the F-gas Regulation as it is today and the heat-pump growth as it is expected in the coming years, allowing the EU to **reduce Europe's dependency on fossil fuels in the heating sector**.

Annex – Example of aspects to be considered for best technological choice (including refrigerants)

The example below provided by the German heat pump association (BWP) illustrates the restrictions that may apply when using a refrigerant with a lower GWP. **It shows why the market cannot fully move to monobloc heat pumps using R290.**

It is important to note that beyond limitations for safety reasons, any future restriction with regard to refrigerant used in heat-pumps is de facto slowing-down the much needed deployment of heat-pumps.

Heat Pumps with R290 – Restrictions on Use

Summary and main conclusions

Special attention must be paid to safety requirements due to high flammability. The normative framework is set by EN 378 from Machinery Directive and EN 60335-2-40 from low voltage directive.

In this annex, heat pumps are meant as indirect systems. The explanations given are not valid for direct expansion systems.

The most important charge limits for indoor installation of heat pumps with R290 are:

- up to 150 g without additional requirements - resulting capacity not sufficient
- up to 1 kg (1,5 kg) + requirements to floor space - not enough space available on site
- up to 5 kg + ventilated enclosure or indirect method – high effort and residual risks

Outdoor installation of R290 heat pumps is restricted by:

- charge (and therefore capacity), which has to be sized by the place of the installation
- availability of sufficient outdoor area close to the building
- distance to openings, windowsn, doors, etc. with regards to movement of refrigerant in event of leakage
- for air source: distance to boundary properties regarding sound
- for ground source: availability of heat source.

To sum up:
Outdoor Installation is an option for R290 in many cases, but it will not be possible to set up a heat pump with R290 everywhere in case of boundary conditions like openings (light wells) to the house or difficult installation conditions for monoblocs. Alternatively, A1 or A2L refrigerants (with some degree of flammability) can still be used. For indoor applications with R290 additional safety installations are necessary which highly limits the volume of applications.

Currently EN 378 and EN 60335-2-40 are being revised and will contain more options, however, this will only be applicable from 2025 for EN 378. As such, current restrictions in EN 378 and EN 60335-2-40 are explained in this document.

General

R290 falls under refrigerants category A3, which is less toxic and highly flammable. The density is greater than that of air. Charge limits are defined by EN 378 and EN 60335-2-40 for each individual refrigerant, depending on the conditions on site.

Indoor installation

For indoor installation, following applies beside national or even local installation requirements. Two legal frameworks are relevant for heat pumps in the light of requirements according to refrigerants. These are namely Machinery directive and EN 378 series as well Low Voltage Directive and EN 60335-2-40. The relevance is determined by intended use.

EN 378, based on Machinery Directive, is valid for all refrigeration systems and heat pumps unless a specific product standard applies.

EN 60335-2-40 is a relevant product standard following the Low Voltage Directive and has to be accounted for household appliances. A household appliance is defined by intended use as declared by the manufacturer. Clearly, capacity and size have to meet a “typical” use for domestic purposes, but there are no clear limits set, neither for capacity, for temperature or anything else. The common understanding is the typical operation in self-occupied houses or flats.

EN 378 Series (Machinery Directive)

Refrigerant charge limits are defined by access categories a, b , c and location classes I to IV. A charge of 150g is not subject to any requirements, but the resulting capacity is not sufficient, at least for domestic heating.

The access category for domestic heating will be “a – general” according to the standard. A supervised (b) or even authorized (c) access cannot be assumed in most cases, specifically for the huge amount of heat pumps in private domestic buildings, regardless they are rented or self-occupied.

Location Class I “Heat pump located in occupied space”:

A floor space of 570 m² to 1580m² per kg charge is required, depending on height of installation (0.6 to 1 m.). This will not allow to install a heat pump of sufficient capacity for heating with state-of-the-art technology. A total charge limit of 1,5 kg (1 kg below ground) will additionally restrict the use. In location class I, the upper limit varies, depending on the access category between 1 and 1,5kg. For below ground applications all systems are restricted to maximally 1 kg.

Location Class II "Compressor located in machinery room" (or outdoor, see below):
This location class typically sets charge limits and applies in general to split systems.

Similar charge restrictions as in class I apply, however this Annex does not consider how to handle split installations. In general when considering split installations the risks of handling the refrigerant connections by installers has to be observed carefully.

Location Class III "Heat Pump located in machinery room" (or outdoor, see below): for access category a, an upper charge limit of 5kg applies. However, safety requirements concerning machinery rooms cannot be reliably met in private households. And even if it is possible, charge limit of 5 kg will additionally restrict the use.

Location Class IV "Ventilated enclosure":
Design concept seems to be the most feasible solution. The safety system must be completed on site (suction pipe, fan, flow switch, safety- and alarm system), the safety system requires additional energy for fan operation. Charge limit of 5 kg will restrict the use. Furthermore, there are requirements to keep under-pressure inside the enclosure requiring high air flows which further limits its use in real life.

"Indirect Method":

This method supports the binding/destruction of the refrigerant within the housing and is technically very demanding to implement. Price effects on the product cannot yet be estimated and suitability for series production must be proven.

EN 60335-2-40 (Low Voltage Directive and Machinery Directive)

The standard is relevant for owner-occupied buildings or flats (see above, "Indoor Installation"). Product-specifc standards superpeed generic standards.

According to Low Voltage Directive (LWD) and the harmonized standard EN 60335-2-40, the requirements regarding the available space for A3 refrigerants are identical to those from EN 378-1 in access category "a" and location class I. Contrary to this, the maximum charge is limited to 1 kg.

For outdoor applications, an extension up to 5 kg is possible with additional safety measures as mentioned in the annexes. This is namely a ventilated enclosure, equal to location class IV of EN 378. In most cases, that high limit is not relevant since the resulting capacity exceeds the required load of an owner-occupied building.

In addition, it is important to take into account that ignition sources can occur outside but also inside units, from all electric parts, which means further changes are required to the structure and materials of the units, leading to additional costs compared to A1 or A2L-based equipment.

Outdoor Installation

It must be said in advance, that outdoor installation is no universal heat pump solution: this requires, among others, an appropriate location regarding sound emissions.

Additional requirements to the place of installation are due to the use of R290:
Restrictions to the outdoor installation are covered by both, EN 378 and EN 60335-2-40 in the same way. In EN 378, an outdoor installation for domestic application is located in class III. The charge for access category "a" is limited to 5 kg (about 70kW of heating capacity), which cannot satisfy every usage. Higher charge limits are possible based on risk analyses and/or cascades. But nevertheless, several needs apply to the place of outdoor installation with regards to operational safety.

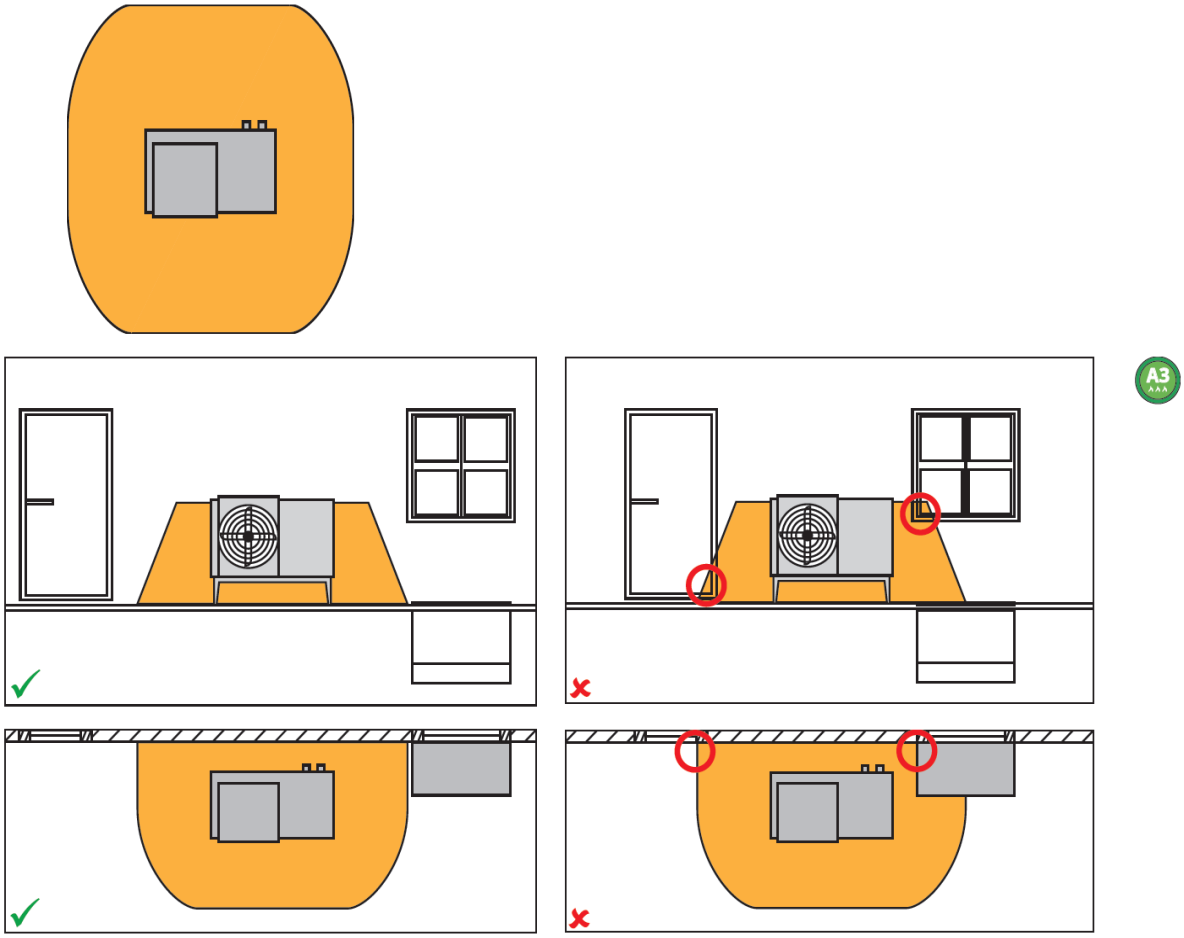
For outdoor installations, EN 378-3 (clause 4.2) sets specific requirements to avoid that refrigerant enters the building.

Since no European Standard is available for outdoor installation, the following might be considered as state of the art for application on site. Besides that, national and local requirements might apply for installation and operation of heat pumps with R290. Specifications from the manufacturers must always be accounted.

Manufacturers define a safety sector including the heat pump and its near surrounding. At least the following shall not occur in this area.

- Building openings
  - Windows
  - Doors
  - Light wells
  - Flat roof windows
  - Air Inlet / Outlet of ventilation systems
  - others
- Pump chamber, inlets in sewers and waste-water shafts, etc.
- footpaths and driveways
- subsidence or depressions of the ground

- boundaries of the property



Sketch: The safety sector is limiting the freedom of choice of the installation location. This limitation will restrict the use. (yellow marking – indicative, distances to be defined by manufacturer)