A Transition to Sustainable Heat Pumps – a Position Paper from the Scientific Community

Introduction

We, as members of the scientific community have been assisting the European heat pump industry with their product improvements for almost three decades. At this point we would like to comment on the ongoing debate on the technical feasibilities and changes that would occur when using R290/propane as refrigerant in heat pumps.

History

First, it should be stated that propane and other hydrocarbons have been used as refrigerants for more than 100 years. These fluids are by no means new as refrigerants. During the last 30 years, hydrocarbons (isobutane) have been used in Europe as the standard refrigerant in millions of household refrigerators as well as in some heat pumps and AC-equipment. Thus, many years of experience using hydrocarbons as refrigerants already exists.

Efficiency

The favorable thermodynamic and transport properties of propane and other hydrocarbons make them very well suited as refrigerants. Based on the properties, they can be expected to provide low pressure drops and a system efficiency as high, or even higher, than synthetic alternatives. Their superiority is not only theoretically proven but is also supported by system efficiency comparisons carried out by using thousands of product data for systems from almost the entire EU market, which use either propane or other refrigerants.

Safety

It is well known that propane and other hydrocarbons are highly flammable, and of course, this needs to be considered carefully when designing systems. The use of natural gas (e.g., LNG as fuel in cars), which is common and accepted almost all over the world, involves similar risks. Hydrocarbons used in heat pumps, however, are contained in hermetic systems. International safety standards are already in place and are constantly being improved. New standards will most probably allow a wider use of hydrocarbon refrigerants, as more detailed safety precautions are being developed. An important factor for increasing safety, or broadening the use of hydrocarbons to larger systems, is to reduce the refrigerant charge per kW heating capacity in heat pumps. This is an area which has been neglected by the industry up to now since the amount of charge is not an important factor when using non-flammable fluids. Recent research and development have shown that efficient systems can be operated with about 10 g of propane per kW, as compared to about 100 g of propane per kW required with typical designs.

Availability of components

A recent survey has shown that several hundred designs of hydrocarbon heat pumps from about 48 different manufacturers are commercially available in Europe. These numbers clearly show that the components required for producing such heat pumps are available on the market. All of the basic research and development work to optimize the design of heat exchangers as well as compressors using low-GWP refrigerant has been done in the past 15 years. This has led to widely available components and design rules for scaling up capacities.

Time required to re-design

Many manufacturers in Europe are already working on new heat pump designs with propane as refrigerant. Going from non-flammable synthetic refrigerants to flammable hydrocarbons requires careful consideration of the safety, both at the production sites and for the products. A similar transition was made about 30 years ago, when the whole refrigerator industry switched from using R12 to isobutane in a time frame of 3-5 years. Based on this background, a transition time to propane for outdoor installations of 3-5 years and for indoor heat pump of 3-8 years seems to be realistic, depending on the different applications and capacity ranges.

Market transition started

For air-to-water heat pumps the transition has started, since most European heat pump manufacturers have shifted their focus to propane for new products. Six out of the top ten heat pump models in the requests for funding in Germany in 2022 (all air-to-water) were charged with propane. Other product groups will follow this transition and the dynamics of its demonstrated path.

Conclusions

In conclusion, we support the intention of the review of the F-Gas regulation. The use of natural refrigerants leads to an overall sustainable operation of heat pumps. It is a clear decision for environmental protection but also provides the industry with a long-term reliable perspective, allowing the focus to lie on further optimization rather than on adopting systems to new refrigerants every few years.

Although the refrigerant change to propane for air-to-water outdoor heat pumps is unstoppable, the change to propane for indoor heat pumps is still challenging and will probably require more than three years, due to complex safety regulations and building requirements. Therefore, we argue for the early announcement of clear and ambitious fade-out dates of synthetic refrigerants, taking different development time spans for different product classes (indoor/ outdoor/ monobloc/ split/ multi-split/VRF) and application areas (residential/commercial/industrial) into account. Any development of new products should clearly focus on natural refrigerants.

The sustainability of this recent market transition should be supported by defining high, but transparent and easy applicable, product safety requirements, simplified and more harmonized building codes and safety requirements for logistics and mass production processes, including those applicable to production sites.

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