Safety with Flammable Refrigerants

By Björn Palm

In previous columns we have described developments regarding the **upcoming revision of the F-gas Regulation** and the **proposal to ban all PFAS refrigerants**. Together, if approved, these new regulations would mean that **none of the synthetic refrigerants currently in use could be sold within a few years**.

One of the few synthetic exceptions, which **is not classified as PFAS (according to the current definition) and does not have a GWP above 150**, is **R152a**. This refrigerant resembles **R134a (or R12)** and was already proposed **30 years ago when R12 was phased out**. We have not heard any recent proposals to relaunch this refrigerant. Like **R32 and the HFOs**, **R152a is flammable**. We may have reason to return to this refrigerant in a future column.

The new regulations will therefore mean that we will primarily have to rely on **natural refrigerants**, namely **hydrocarbons, ammonia, and carbon dioxide**. We can expect that a large part of the market currently dominated by **HFC/HFO refrigerants** will be replaced by **hydrocarbons such as propane, propene, and isobutane**.

Those who have visited the major trade fairs recently can confirm that **many suppliers already offer components and systems using hydrocarbons**. Danfoss recently announced that it is **expanding its range of compressors designed for propane**.

Several manufacturers now offer **air-to-water heat pumps using propane**, often designed for **outdoor installation**. **Ground-source heat pumps using propane** are currently commercially available from only **one or a few manufacturers**. These systems must be installed **indoors**, and to comply with current regulations without complications, the **refrigerant charge must not exceed 150 g**. At least one manufacturer, the Spanish company **EcoForest**, offers a **6 kW ground-source heat pump** that meets this requirement.

Increasing Focus on Safety

Safety issues related to **flammable refrigerants** have naturally received increasing attention as their use expands.

Is it possible to make **larger propane heat pumps sufficiently safe**?
And if so, **how should the regulatory framework be designed?**

There are many proposed technical solutions, including:

- **Sectioning of the refrigerant circuit** with fast-closing valves so that only part of the refrigerant charge is released in case of pipe rupture.
- **Sealed enclosures with forced ventilation to outdoor air**, using **explosion-proof (Ex-rated) fans**.

- **Sealed enclosures with oxygen-free environments**.
- **Mixing of air and refrigerant during leakage** to prevent high concentrations at floor level.
- **Minimizing refrigerant charge** through the use of compact heat exchangers and compressors, shorter piping systems, and lubricants that do not dissolve refrigerant.

Research at KTH

At **KTH**, we have for some time been running a research project aimed at investigating **how systems using flammable refrigerants can be made safer**. The project is part of an **international collaboration within the IEA Heat Pump Technology (HPT) programme**.

In addition to technical solutions such as those mentioned above, we will also investigate **what happens to the refrigerant during a leak**, i.e. what **concentration levels can be expected at different locations during leakage**.

The intention is to study this through **computer simulations**, combined with **experimental testing** to validate the simulation models.

We also plan to investigate **how leaks should best be detected**:

- Where should detectors be placed?
- Which detector types are sufficiently reliable yet inexpensive enough to be integrated into heat pumps?
- Do detectors need to be tested regularly?

Another area within the project is **risk assessment related to different technical solutions**. In many other industries, this is an obvious and essential tool used to determine which technical solutions should be approved.

We only need to think of **the aviation industry** or **autonomous vehicles**. A closer example may be the **oil and refinery industry**, where large quantities of flammable substances are handled safely under well-defined regulatory frameworks.

For **flammable refrigerants to be widely adopted**, clear rules are needed regarding **system design and handling procedures**. Our hope is that this project will contribute to the **development of such regulatory frameworks**.

In addition, we must ensure that **technical personnel are properly trained** to handle these systems safely during **installation, maintenance, and disposal**. New **training initiatives** will therefore be necessary.

We do not believe that the work of refrigeration technicians will become more difficult with flammable refrigerants, but **it will become more important to know exactly what one is doing**. Anyone who has received proper training will feel confident in their work—even when the refrigerant is flammable.

Future Applications

In the future, we will likely see **more large heat pumps installed in district heating systems**. With increasing amounts of **wind power**, electricity will be inexpensive much of the time, while **competition for bioenergy** will likely make wood chips and pellets more expensive.

We believe that even **large heat pump systems** will be able to use **hydrocarbon refrigerants**. However, this represents a **significantly greater challenge than ground-source heat pumps**.

If you already have **experience working with flammable refrigerants**, we would be very interested in hearing from you. We welcome your **experiences and any suggestions for technical solutions**.

Older refrigerant columns can be found on our website:

https://www.energy.kth.se/applied-thermodynamics/publications