WHITEPAPER

PFAS in refrigerants: What now?

The urgent need for sustainable cleanroom solutions

ABN CLEANROOM TECHNOLOGY

Introduction

In recent years, per- and polyfluoroalkyl substances (PFAS) have come under increased scrutiny due to their harmful effects on both the environment and human health. Initially lauded for their water- and grease-repellent properties, these chemicals—numbering over 4,700—found widespread use in products ranging from coatings and packaging materials to refrigerants.

However, their persistence in the environment, often referred to as “forever chemicals,” has led to global contamination of water, soil, and even food. PFAS in refrigerants raise particular concerns in industries like cleanroom technology, which demands environmentally friendly solutions.

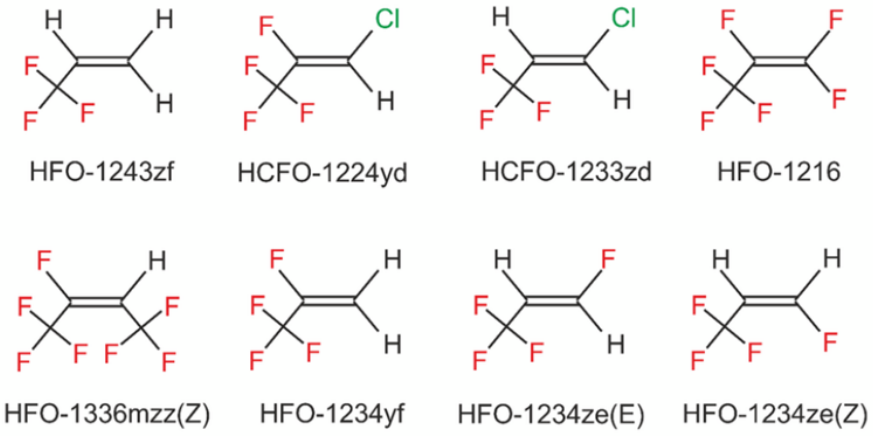
With their harmful characteristics and the difficulty in removing them from the environment, regulations surrounding PFAS have tightened, amplifying the need for PFAS-free alternatives like R32, CO_2, propane, and ammonia (NH_3).

1. Global Warming Potential (GWP) and HFO Refrigerants

Global Warming Potential (GWP) is a key metric for measuring the impact of substances on climate change, comparing their effect to that of carbon dioxide (CO_2) over 100 years. In recent years, Hydrofluoroolefins (HFOs) have emerged as alternative refrigerants due to their low GWP, often significantly lower than traditional Hydrofluorocarbons (HFCs). This makes HFOs attractive for reducing the climate impact of refrigerants.

Despite their advantages in terms of GWP, HFOs have a significant drawback: many contain PFAS or break down into PFAS over time. PFAS are extremely persistent, bioaccumulative, and difficult to degrade, making them harmful to both the environment and public health. This places HFOs in a complex scientific and environmental dilemma. While they help reduce global warming, they contribute to long-lasting chemical pollution.

This complexity raises a fundamental question: Do the climate benefits of HFOs outweigh the long-term risks of PFAS pollution? Innovations in natural refrigerants like CO_2, propane, and ammonia—refrigerants with low GWP and no PFAS-related issues—are increasingly seen as the sustainable path forward, particularly for cleanroom applications where cooling demands are high.



2. Natural alternatives for refrigerants

In response to the environmental challenges posed by HFOs and growing concerns over PFAS, there is increasing interest in natural refrigerants like CO_2 (R-744), propane (R-290), and ammonia (NH_3, R-717). These alternatives not only boast extremely low to zero GWP but are also free from PFAS and do not produce harmful byproducts. They represent a future-proof solution for both commercial and industrial applications, including cleanrooms, where stringent environmental regulations are in place.

For example, CO_2 is considered an excellent refrigerant for low-temperature applications. It is non-toxic and non-flammable. Ammonia, known for its high energy efficiency, has been successfully used in industrial refrigeration for decades. Propane, with its exceptionally low GWP, offers a great balance between environmental friendliness and energy efficiency, though its flammability requires careful management.

The transition to these natural refrigerants is further driven by regulations limiting fluorinated refrigerants. Not only do these alternatives address PFAS-related issues, but they also help companies reduce their environmental footprint while complying with increasingly stringent environmental standards.

3. Balancing the Pros and Cons of PFAS-free refrigerants

At ABN Cleanroom Technology, our vision and responsibility are to actively contribute to a more sustainable future by completely phasing out PFAS-containing refrigerants, including HFOs and blends like R454B. While HFOs have a low GWP, the long-term negative effects of PFAS far outweigh these benefits. We even prefer alternatives like R32, despite its higher GWP, as it is PFAS-free. However, the ultimate solution lies in natural refrigerants like CO_2, propane, and ammonia, which offer a sustainable and eco-friendly cleanroom environment.

When transitioning to PFAS-free refrigerants, it is important to consider both the benefits and the potential drawbacks of the alternatives. Below, we outline some of the most common PFAS-free refrigerants, their challenges, and how ABN Cleanroom Technology manages these drawbacks:

R32 (Difluoromethane)

- **Benefits:** R32 is a highly efficient refrigerant and 100% PFAS-free.
- **Drawbacks:** Although R32 is less harmful to the environment than traditional refrigerants, it still has a relatively high GWP and a certain degree of flammability.
- **Additional consideration:** F-gas regulations aim to eventually phase out all refrigerants with a GWP higher than 1. While it is still possible to install systems with R32 today, there is no guarantee that future repairs or maintenance will be feasible due to evolving regulations and availability.

CO_2 (Carbon Dioxide)

- **Benefits:** CO_2 is a natural refrigerant with an extremely low GWP and is non-toxic.
- **Drawbacks:** The main drawback of CO_2 is the extremely high pressure required for it to work efficiently, which places greater demands on the materials and systems.

- **Our approach:** ABN Cleanroom Technology designs and builds systems specifically tailored to handle the high pressure of CO_2 safely. This includes using high-quality materials, conducting regular pressure tests, and implementing robust safety protocols. Additionally, these systems are always installed in controlled, isolated environments, away from the working areas inside cleanrooms.

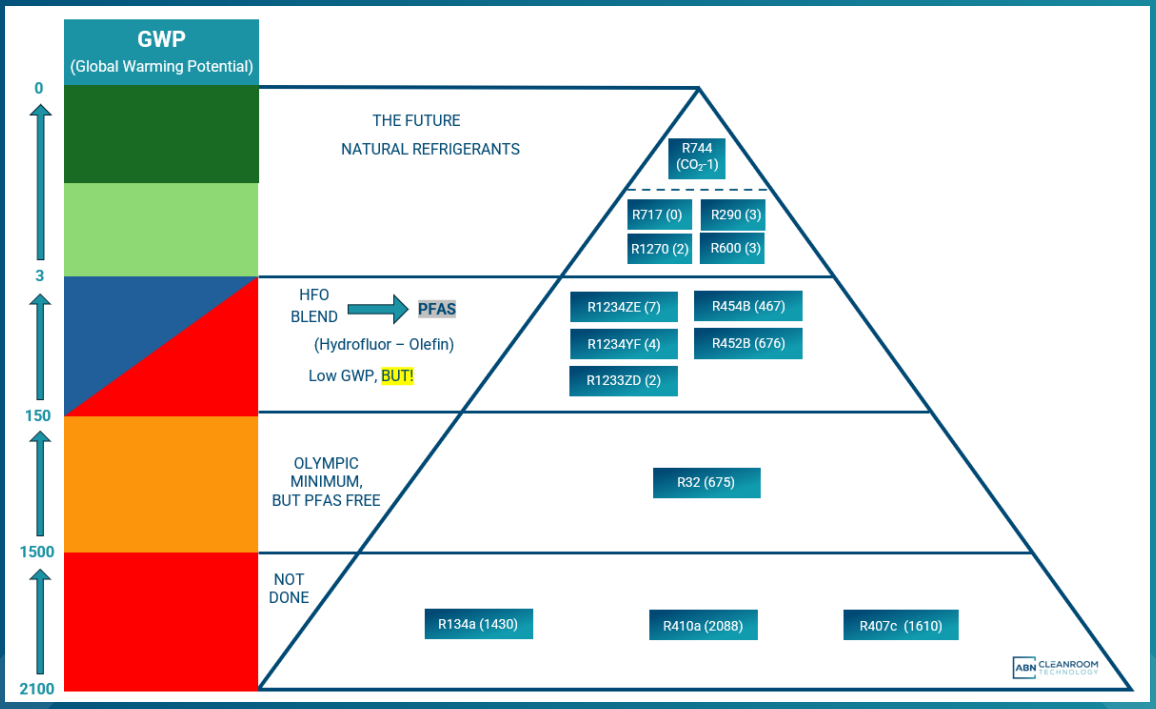
Propane (R290)

- **Benefits:** Propane is an environmentally friendly refrigerant with a low GWP and excellent thermodynamic properties. It can be applied under very strict ATEX regulations, and the propane content per circuit is kept very low (2 to 3 kg per circuit), which is much less than a typical gas cylinder (9 kg) commonly used in and around homes (e.g., BBQs, weed control).
- **Drawbacks:** The main drawback of propane is its explosion risk, as it is a highly flammable gas.
- **Our approach:** Although propane is inherently flammable, it is only used in our systems in safe, outdoor environments, far from the cleanroom itself. Propane chillers are equipped with advanced leak detection and ventilation systems and integrated into the outside environment after a thorough risk assessment. Thanks to our strict safety measures and redundant security systems, the risk of incidents is minimal.

NH_3 (Ammonia)

- **Benefits:** Ammonia is one of the most energy-efficient refrigerants and has no negative impact on the environment.
- **Drawbacks:** Ammonia is toxic and can pose health risks if a leak occurs.
- **Our approach:** At ABN Cleanroom Technology, we have opted not to use ammonia in our refrigeration systems due to its toxicity.

By carefully balancing the benefits and potential drawbacks, ABN Cleanroom Technology remains focused on providing safe, sustainable, and PFAS-free cooling solutions for cleanroom applications.



4. The Future of Refrigeration in Cleanroom Technology

As regulations evolve, it's important to note that even refrigerants like R32 may eventually face restrictions. Under the F-gas regulations, the ultimate goal is to phase out all refrigerants with a GWP greater than 1. While systems with R32 may still be installed today, there is no guarantee that future repairs or maintenance will be possible due to regulatory changes or supply issues.

At ABN Cleanroom Technology, we are committed to staying ahead of these developments, ensuring that our solutions not only meet today's needs but also anticipate tomorrow's challenges. By embracing natural refrigerants and prioritizing safety and sustainability, we aim to lead the cleanroom industry toward a greener, PFAS-free future.

5. Conclusion

The transition away from PFAS-containing refrigerants is both a necessity and an opportunity. While challenges remain, especially in balancing efficiency, safety, and environmental impact, the use of natural refrigerants like CO_2, propane, and ammonia offers a clear path forward. At ABN Cleanroom Technology, we are committed to providing innovative, sustainable cleanroom solutions that meet the highest standards of safety and environmental responsibility.

Want to know more?

Jo Nelissen MSc is the founder and CEO of ABN Cleanroom Technology and holds a Master Degree in Mechanical Engineering & Asset Management. He focuses on innovative concepts in pre-engineered cleanroom design. Furthermore, he specializes in asset management in modular & pre-engineered cleanroom design.

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