Commercial, residential and industrial buildings are responsible for about half of the world’s energy consumption and greenhouse gas (GHG) emissions, with HVAC systems playing a significant role in both of these impacts.

### Industry Consensus on HFC Refrigerants

The industry is working through its national associations to engage non-governmental organizations (NGOs) and governments around the world to ensure that the industry continues to move towards next-generation options.

### Refrigerant Regulatory Evolution

The global scrutiny on the GWP of all current-generation refrigerants continues to grow, pushing the industry to next-generation options.

### Regulatory Timeline

A look at the global phase-down schedule established by the Kigali Amendment to the Montreal Protocol, which became official on November 17, 2017 when it received its 20th ratification.

Europe is shown separately as they are leading the global phase down with actions already taken.

More information available at [http://ozone.unep.org/sites/ozone/files/pdfs/FAQs_Kigali_Amendment.pdf](http://ozone.unep.org/sites/ozone/files/pdfs/FAQs_Kigali_Amendment.pdf)

### Key Terms Defined:

- **ODP** – ozone depletion potential – degree to which a substance can deplete the ozone layer; all measurements relative to a similar mass of CFC-11, which is indexed at 1.0.
- **GWP** – global warming potential – degree to which a greenhouse gas (GHG) traps heat in the atmosphere; all measurements relative to a similar mass of carbon dioxide (CO₂), which is indexed at 1.0. The build-up of GHGs can cause climate change.
- **CFCs** – chlorofluorocarbons (e.g. R-11, R-12) – phased out by the Montreal Protocol in 1996 because of their very high ODPs. Significant impact on both ozone depletion and global warming due to the chlorine and fluorine atoms and very long atmospheric lives.
- **HFCs** – hydrofluorocarbons (e.g. R-22, R-134a) – also contain chlorine, but contribute less to ozone depletion and climate change due to shorter atmospheric lives. Still in use globally, but have phase-out dates scheduled under the Montreal Protocol.
- **HFOs** – hydrofluoroolefins (e.g. R-1234yf, R-1234ze) – do not contain chlorine, but they do have high GWPs given their fluorine content. Now being phased down globally under the Kigali Amendment to the Montreal Protocol.

### Refrigerant Management Requirements

Section 608 of the U.S. Clean Air Act – effective January 1, 2017, the requirements are becoming more stringent. The U.S. EPA has indicated they plan to re-visit certain aspects of the 2016 rule which extended refrigerant management requirements to non-exempt substitutes.

The more stringent handling requirements that go into effect starting in 2018 enhance the appeal of leak-tight designs, such as hermetically-sealed.

More information available at [https://www.epa.gov/section608/revised-section-608-refrigerant-management-regulations](https://www.epa.gov/section608/revised-section-608-refrigerant-management-regulations)

### Future Availability

The U.S. EPA allows for continued use of recycled, recovered and stockpiled supplies of all refrigerants indefinitely, regardless of phase out date.

### American Innovation & Manufacturing Act of 2018

A bipartisan bill introduced February 15, 2018 to advance next-generation technologies as alternatives to HFCs. This bill would give the U.S. EPA the authority to phase down HFCs in the U.S., but ratification of Kigali is necessary to fully manage the process.


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**HFO blends** (e.g. R-452B, R-454B, R-513A, R-514A) – blends including an HFO. They feature lower GWPs and, as they receive ASHRAE classification and SNAP approval, are becoming available for use in specific applications.

- Zerotropes (400 series blends) – have components that boil and condense at different temperatures (i.e. have some degree of temperature glide). Lower glide is typically preferred for HVAC applications.
- Azeotropes (500 series blends) – behave like a single component refrigerant during phase change, with virtually no temperature glide.

### Montreal Protocol

An international treaty signed in 1987, originally designed to protect the ozone layer by phasing out the production and consumption of ozone depleting substances. The Kigali Agreement was officially ratified in 2017 as an amendment to the Montreal Protocol, and phases down the global production and consumption of HFCs beginning January 1, 2019. Individual countries must ratify the amendment for it to apply domestically.

### SNAP

The Significant New Alternatives Policy of the U.S. Environmental Protection Agency (EPA) evaluates refrigerants and classifies them as acceptable or unacceptable replacements based on their overall risk to human health and the environment.

- De minimis - lacking significance or importance; too trivial or minor to merit consideration.
Connsiderations When Selecting Refrigerants

Flammability
With the transition to lower-GWP refrigerant options, flammability has emerged as a new variable for consideration, especially in higher operating pressures.
In 2010, a new flammability category was created within ASHRAE 34. Subclass 2L captures refrigerants with a Burning Velocity (BV) less than 10 cm/second and a high Minimum Ignition Energy (MIE), i.e. difficult to ignite and sustain a flame.
The industry continues to debate the application of slightly flammable (2L) refrigerants. Specifically, ASHRAE 34, UL 60335-2-40, and current standards are based.
Trane is committed to offering non-flammable solutions whenever possible, and the lowest possible flammability when slightly flammable solutions are required.

Toxicity
This is, perhaps, one of the most misunderstood properties of refrigerants. Specifically, it is important to distinguish between toxicity and safety; they are not the same. Because refrigerants displace oxygen, the greatest safety risk associated with all refrigerants is exposure leading to asphyxiation. Occupants are significantly less likely to be exposed to unsafe levels of low pressure refrigerants because during a leak – air would leak into the machine rather than being expelled into the space.
ASHRAE 34 classifies a refrigerant’s toxicity based on its operational exposure limit (OEL). OEL refers to the time-weighted average concentration of refrigerant to which “nearly all workers can be repeatedly exposed without adverse effect” over the course of a “normal eight-hour workday and a 40-hour week.”

Lower (A) refrigerants have an OEL ≥ 400 ppm
Lower (B) refrigerants have an OEL < 400 ppm
R-123 has an OEL of 50 ppm. This means you should see no negative effect if you are exposed to 50 ppm of R-123 for 6 hours/day, 40 hours/week. For chiller applications, rarely do mechanical rooms see > 2 ppm, and this exposure typically occurs during servicing for very short periods of time.
To avoid confusion with building code definitions, ASHRAE 34 was updated to indicate toxic, highly toxic or neither as defined in the International Fire Code (IFC), Uniform Fire Code (UFC) and OSHA regulations. None of the refrigerants shown in the table are considered “toxic” or “highly toxic” as defined by the OSHA, UFC or NFPA 1 (National Fire Protection Association) Fire Code.

Refrigerant Choices
This table compares various properties of both current and next-generation refrigerants. The efficiencies and capacity changes shown are based on the theoretical properties of the refrigerant alone, with all design variables held constant for objective comparison.

Environmental Impact by Refrigerant
Below are the theoretical efficiencies of common refrigerants, with all variables held constant for comparison:

Low Pressure Medium Pressure High Pressure

Refrigerant Efficiency (COP)

R-134a
R-1234yf
R-452B
R-454B
R-513A
R-1233zd
R-1234ze
R-22
R-410A
R-452B
R-514A
R-454B

Operating Pressure by Refrigerant
This graphic compares the operating pressures of each refrigerant:

Low Pressure
Medium Pressure
High Pressure

Additional Information About Select Refrigerants

R-452B, R-454B
Two alternatives for R-410A that, when used as a drop-in, deliver similar capacity, about 5% better efficiency and an opportunity to reduce refrigerant charge. Both are classified as A2L, under ASHRAE Standard 34.

R-513A
Non-flammable replacement for R-134a, which has no impact on capacity, near-zero ODP and 55% lower GWP (573 vs. 1300). While the theoretical efficiency drop is about 2%, if used as a drop-in, the actual impact on chiller efficiency has been about 4-6%, depending on application.

R-514A
Non-flammable replacement for R-123 that offers the highest performance of all next-generation options available today with zero ODP and a GWP of 2. While classified as a “B1”, R-514A has a dramatically improved exposure limit (6X higher) compared to R-123, a fluid that has been safely used for 3500,000+ chiller-years of operation over the past 25 years.

R-1233zd
A single molecule non-flammable replacement for R-123, which offers near-zero ODP and an ultra low GWP of 1. Often referred to as “zd”, it is classified as an “A1” refrigerant.

R-1234ze
A single molecule replacement for R-134a, which offers zero ODP and an ultra-low GWP of 1. It is classified as A2L under ASHRAE Standard 34. It is considered non-flammable for handling, manufacturing and design by European pressure equipment directive (PED), resulting in some early use in Europe, but U.S. standards all consider it flammable.

How Do You Protect Your Investment?
Choose the best refrigerant for each application based on a balance of safety (toxicity, flammability, asphyxiation and physical hazards), environmental impacts (lowest GHG emissions) and total cost of ownership (energy efficiency of the entire system).

EcoWise™
The Ingersoll Rand EcoWise™ portfolio of products designed to lower environmental impact with next-generation, low-GWP refrigerants and higher efficiency operation is part of our climate commitment to increase energy efficiency and reduce the GHG emissions related to our operations and products.