

Selecting the right refrigerant for your commercial applications

EU F-Gas regulation is forcing many refrigeration system manufacturers, installers, and specifiers to switch to alternative refrigerants with reduced Global Warming Potential levels for commercial applications. This article can help you assess alternative flammable and non-flammable refrigerants and make an informed choice.

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As the F-Gas regulation impacts refrigerant price and availability, those in charge of designing, installing or operating cold rooms and other commercial refrigeration solutions in Europe are left with several critical questions they must answer:

- What is the impact on our operations?
- What is the best replacement for my current refrigerants?
- Which solutions will best suit our applications over the long term?

The key regulations impacting commercial refrigeration applications

In 1989, the Montreal protocol came into effect. The first phase-down legislation of its kind, it forced companies to avoid using substances that would deplete the ozone layer and to phase out HFC such as R22. The Montreal protocol proved to be a success, with the ozone layer now slowly recovering. And since then, several other phase-down regulations have been brought in to combat substances with a high Global Warming Potential (GWP).

We have the Kigali amendment to the Montreal Protocol, which is set to come into force at the beginning of 2019. But more pressing for commercial refrigeration application HVAC-R professionals to comply with is the EU's recent F-Gas regulation, which has been in force across the European Union since 2015. The F-Gas consists of three main elements:

1. Service on already installed equipment with a GWP over 2500

From 2020 onwards, only recycled refrigerants can be used for servicing. From 2030 onwards, no service is allowed outside these exceptions:

- When the refrigerant charge is less than 40 tonnes CO₂ eq. (or 10.2kg for R404A)
- When temperatures are below -50°C
- When military equipment is involved

2. A ban on the use of F-Gases in many types of equipment

Different refrigeration equipment will have GWP limits placed on the refrigerants

installers and manufacturers can use with them. Rolling out in phases until 2025, these restrictions apply to both domestic refrigerators and freezers, through to commercial refrigeration and air conditioning solutions.

3. A phase down of HFC refrigerants in the market

As part of its push to reduce the impacts of global warming, F-Gas calls for a phase down of CO₂ equivalent tons of all new refrigerants placed on the market.

During 2017, the regulation called for a 7% reduction in equivalent tons of CO₂. By end of 2018, it requires a 37% reduction.

Ban on new equipment:	Conditions/ GWP limit	From: 1 st of January	Main consequences
Commercial Refrigerators and Freezers, hermetically sealed (Ban 11). E.g.: Commercial fridges & freezers in restaurants, clip-on cold rooms, vending machines, etc.	≥ 2500	2020	Ban R404A/507. Alternatives e.g. R448A, R449A, R134a, R450A, R513A, HFO and HC (R290)
	≥ 150	2022	Ban R448A, R449A, R134a, R450A, R513A, R134a. Alternatives: HFO and HC (R290)
Stationary refrigeration equipment for temperatures above +50°C (Ban 12). E.g.: Remote condensing unit cold rooms, milk cooling tanks, etc.	≥ 2500	2020	Ban R404A/507. Alternatives e.g. R448A, R449A, R134a, R450A, R513A, HFO, HC (R290), CO ₂
Multipack centralised refr. systems for commercial use with capacity ≥ 40kW	≥ 150 and ≥ 1500 for prim.circ. of cascades	2022	Bans traditional HFC, except R134a in cascades. Alternatives: HFO, HC, CO ₂

Table 1: F-Gas schedule & GWP limitations by equipment type

What are the alternative options?

Between the changes to servicing and the stringent requirements for CO₂ reduction required by F-Gas, it's clear that many common refrigerants today cannot be used in cold rooms and other self-contained commercial refrigeration applications over the long term.

However, selecting an alternative to current high-GWP refrigerants can be a challenge. In the following sections, we will give advice on alternatives to popular non-flammable refrigerants and offer additional models with flammable refrigerants that can guide commercial refrigeration equipment installers and OEMs make the right choice.

A1 class, non-flammable suitable alternatives to R404A and R134a

In Europe, because of its high GWP, R404A will soon be unsuitable for many applications as a part of the F-Gas regulation. Same restrictions will apply to the R134a in self-contained units from 2022.

As we see the market today, the main non-flammable replacements are:

Suitable replacements for R404A/507

R448A, R449A, R449B, R452A, R407A/F/H

Suitable replacements for R134a

R513A, R450A

Note: in stationary equipment (ban 12) R134a is still an acceptable refrigerant.

To retrofit R404A/R507, R134a systems, using new A1 refrigerants with lower GWP, eliminates the need to double-check requirements that come with flammable refrigerants. However, there are still some points of attention the HVAC-R professionals need to investigate (see box to the right).

A2L/A3 classes, flammable options for longer term choice

For those choosing a long-term solution, more sustainable alternatives to R404A/R134a are needed.

However, there is an inverse correlation between a refrigerant's GWP and its flammability. Many ultra-low GWP refrigerants also have a higher flammability classification than R404A—potentially requiring a different approach to system design and installation.

For those that will consider a flammable refrigerant to comply with F-Gas, propane, or R290 (A3 class), can be a strong replacement for R404A. With a GWP of just 3, R290 is compliant with both current and upcoming F-Gas rules—across all

equipment types. R600a (iso-butane) is already widely used as R134a replacement in small hermetic systems.

A2L refrigerants – so-called mildly flammable refrigerants – like R454A, R454C or R1234yf or R455A can be interesting low GWP alternatives to R404A and R134a.

That said, if you have specific needs and requirements from your refrigerant, you may need to investigate other flammable refrigerant options.



Points of attention for non-flammable refrigerants

- Your existing tools (vacuum pumps, hoses, etc.) can most probably be used.
- Be aware of charge limits even for non-flammable refrigerants due to new EN 378:2016.

Charge is limited if:

- Any part of the refrigeration system is indoor
- General access to the unit (e.g. condensing unit for cabinet in a butchery)
- No emergency exit in the room (e.g. a normal cold room)
- Room is underground

How to calculate charge limit:

Toxicity limit of refrigerant
 $x \text{ room volume} = \text{max charge}$

Example: R449A in a cold room

Toxicity limit: 0,357 kg/m³
 (values in Annex of EN 378:2016)
 Room volume: 3 x 4 x 2,5m = 30 m³
 Max charge: 0,357 kg/m³ x 30 m³
 = 10,7 kg



Points of attention for flammable refrigerants

- Check whether your tools (vacuum pump, hoses, etc.) can be used with flammable refrigerants.
- Be aware of the risks due to flammability when working with these refrigerants

Risks could be:

- During soldering: make sure there is no remaining refrigerant in the system.
- In case of potential leaks: avoid ignition sources (light switch)

In case of retrofit:

- Check compatibility of components for the new refrigerant: compressor, valves, switches, pipes, heat exchangers etc.
- Check whether other electrical components need to be changed. e.g.:
 - Can the fans be used with flammable refrigerants?
 - Is the electrical installation ok for flammable refrigerants?

Understanding flammability classifications

All refrigerants are given a classification code consisting of a letter and a number. For example, R290 is a class A3 refrigerant.



The letter represents the toxicity of the refrigerant, with "A" being a low toxicity substance and "B" being a higher toxicity substance.



The number represents the flammability of the refrigerant, with "1" being non-flammable, "2" being mildly flammable, and "3" being highly flammable. "2L" is an additional classification referring to refrigerants that are mildly flammable, but with a burning velocity of max 10 cm/s.

ASHRAE Standard 34: 2010

	Safety group	
Higher flammability	A3	B3
Lower flammability	A2 / A2L*	B2 / B2L*
No flame propagation	A1	B1
	Lower toxicity	Higher toxicity

* A2L and B2L are lower flammability refrigerants with a maximum burning velocity of ≤ 10 cm/s (3.9 in./s).

Refrigerant charge limitations in EN 378:2016

When considering an alternative refrigerant, F-Gas is not the only regulation you need to keep in mind. The European Committee for Standard's EN 378:2016 (or worldwide ISO 5149/2014) safety standard will also influence your

potential refrigerant options based on the location of your equipment. Also, for the safety of household or commercial refrigeration appliances with integrated or remote compressor or condensing unit such as bottle coolers, vending machines, etc, then the IEC 60335-2 series standard is applied.

Focusing on the EN 378, then the main part of the standard we need to consider is the charge limitations it puts in place, as these can be quite stringent based on the location of equipment, access to it, refrigerant used, and its application. Based on these factors, you may have to consider different refrigerants or equipment and system designs to reduce charge.

Calculating charge limits

To calculate the charge limit for your system, you'll first need to identify certain characteristics and classifications for your chosen refrigerant and equipment:

Step 1. Find which access category applies to your equipment

There are three access categories based on where your equipment is installed:

Step 2. Find which location classification applies

There are four location classes based on where particular refrigeration components operate:

- Class I: all refrigerating-containing parts and systems are in the occupied space
- Class II: compressors and pressure vessels are in a machinery room or in open air
- Class III: All refrigerant-containing parts are in an EN 378-3 compliant machinery room or in open air

- Class IV: All refrigerant-containing parts are in an EN 378-2 and EN 378-3 compliant ventilated enclosure

Step 3. Find which refrigerant classification applies

As explained in the chapter above: Understanding flammability classifications, all refrigerants have a classification that identifies their toxicity and flammability.

To work out the maximum charge limit, you will need to know the classification of the refrigerant you'll be using, as well as its Acute Toxicity Exposure Limit (ATEL) and Lower Flammability Level (LFL).

Once you've found this information, you can begin calculating charge limits based on toxicity and flammability limits.

Step 4. Calculating toxicity limits

For non-human comfort applications:

- Class A₁ refrigerants typically have no charge limits
- Class B₁ refrigerants have toxicity limits for each individual refrigerant outlined in the EN 378 standard

	Code A	Code B	Code C
Category	General access	Supervised access	Authorized access
Characteristics	Buildings that house sleeping facilities, places where movement is restricted, or a location where anyone may enter without knowledge of necessary safety information.	Buildings where only authorized personnel with full knowledge of safety precautions may enter.	Businesses and office spaces, laboratories, and manufacturing plants.
Example	Hospitals, courts or prisons, theatres, supermarkets, schools, university halls, public transport, hotels, dwellings, and restaurants.	Businesses and office spaces, laboratories, and manufacturing plants.	Staff-restricted areas in supermarkets, food and beverage manufacturers, refineries, chemical plants, dairies, and abattoirs.

Step 5. Calculating flammability limits

Different calculations apply for each refrigerant flammability classification. The examples of calculations to the right are all based on equipment being used for commercial applications.

EN 378 : 2016 Charge limitations for flammable refrigerant A2L	Compr & vessel indoors	Refrig equipment indoors Compr & vessel outdoors	Machinery room or open air	Ventilated enclosure
General access e.g. schools, hotel, hospitals, theaters	20% x LFL x room volume but not more than 1,5 x 26m ³ x LFL		No limit	Max 1,5 x 130m³ x LFL Max 56,4 kg R454C 59,4 kg R1234yf 59,9 kg R32 100,6 kg R455A
Supervised access e.g. professional offices, general manufacturing sites	Not more than 11,3 kg R454C 11,3 kg R1234yf 12,0 kg R32 20,1 kg R455A	20% x LFL x room volume but not more than 25 kg		
Authorised access e.g. production of chemicals, food, ... Refineries, non-public areas in supermarkets				

EN 378 : 2016 Charge limitations for flammable refrigerant A3	Compr & vessel indoors	Refrig equipment indoors Compr & vessel outdoors	Machinery room or open air	Ventilated enclosure
General access e.g. schools, hotel, hospitals, theaters	Only sealed systems. 20% x LFL x room volume Below ground : not more than 1 kg Above ground : not more than 1,5 kg		5 kg	Max 130m³ x LFL Max 5 kg R290 5 kg R1270 10,3 kg R610A 10,9 kg R430A
Supervised access e.g. professional offices, general manufacturing sites	20% x LFL x room volume Below ground : not more than 1 kg Above ground : not more than 2,5 kg		10 kg	
Authorised access e.g. production of chemicals, food, ... Refineries, non-public areas in supermarkets	20% x LFL x room volume Below ground : not more than 1 kg Above ground not more than 10 kg		No limit Above ground not more than 25 kg	

Find the right components for your new refrigerants

Once you've understood different refrigerant classifications and calculated charge limits for your installations, you should begin to have a better idea of which low-GWP refrigerants will be best suited to your requirements.

However, you'll then need to consider which components will be compatible with your new potential alternative refrigerants.

Danfoss' Coolselector® 2 can help streamline component selection

With a rundown of every Danfoss product and its compatibility with different refrigerants, it can quickly help you understand your product choices.

It can also help you automatically calculate refrigerant influence on compressor capacity, and understand component parameters including cooling capacity, evaporation, and condensation temperature.



Download Coolselector® 2 at
coolselector.danfoss.com

Explore your refrigerant options

To learn more about alternative refrigerant options and how you can simplify F-Gas compliance, watch our webinar on picking the right refrigerants and components for your cold room and self-contained units.

Watch the webinar at
refrigerants.danfoss.com