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Nidec

Position Paper

Light Commercial Refrigeration

Refrigerants Outlook for Europe

May 2025

Content

Introduction

With the Kigali Amendment to the Montreal Protocol, the global community made another important step towards preserving our planet for future generations by reducing the CO_2 emissions due to human activities. The global phase-down of HFCs in the refrigeration sector represents an important contribution to international climate change mitigation efforts. For many years, Embraco has been actively investing in this direction by developing and promoting hermetic compressors for use with low-atmospheric impact refrigerants on all continents, isobutane (R600a) in household appliances and propane (R290) for light commercial plug-in systems. EU F-gas regulations impose a ban on high global warming potential (GWP) refrigerants in several categories of commercial applications over the years to gradually reduce the direct impact due to HFC refrigerants. Adopted regulation will speed up the uptake of natural refrigerants – in refrigeration, heat pumps and air-conditioning equipment in the European market. Adoption of natural alternatives in the new equipment is quite an urgent task since, with the fluorinated gases, quantities with adopted quotas will not be enough even to service existing equipment. The low GWP synthetic alternatives, like A2L class refrigerants, can only be considered as a transitory solution because of potential PFAS restrictions presently in preparation by the European Chemicals Agency (ECHA). Several transitional alternative synthetic refrigerants have been developed by the chemical industry. Embraco has performed extensive tests to assess the capacity of these alternatives to replace high-GWP refrigerants presently in use. The biggest difficulty was found in trying to replace R404A. This paper will discuss long-term alternatives to replace R404A and R134a with a focus on reliability and performance, as well as the evolution of related safety legislation.

Embraco Policy Statement

- Embraco will encourage the use of low-GWP refrigerants to support global efforts to mitigate climate change.
- Embraco will continue to provide solutions to improve the energy efficiency of refrigeration equipment with low-GWP refrigerants.
- Embraco will support the proactive use of natural refrigerants without compromising appliance safety.
- Embraco will continue to develop products for both natural and synthetic low-GWP refrigerants that exceed present and future energy efficiency standards in order to assure the competitiveness of our products and meet the expectations of the end users.
- Embraco will continue to work with international legislative bodies on the safe use of low-GWP refrigerant options.

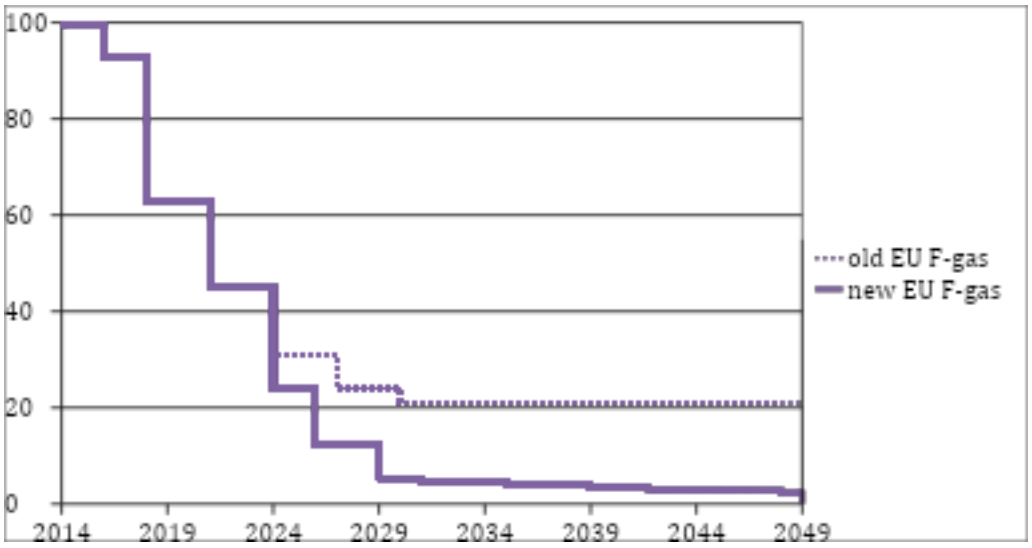
Updated EU F-Gas Regulation

The European Union's updated regulation on fluorinated greenhouse gases, EU 2024/573, introduces significant changes aimed at reducing emissions, including those from the commercial refrigeration sector. This regulation is part of a broader EU strategy to achieve climate neutrality by 2050, in alignment with the European Green Deal. The changes are designed to phase down the use of high global warming potential (GWP) refrigerants, promote alternatives, and enhance leak prevention and repair protocols. Here, we will explore the major updates in the regulation and their implications for the commercial refrigeration industry.

Stricter HFC Phase-Down Schedule

The regulation tightens the existing hydro-fluorocarbons (HFC) phase-down schedule, going even further than the EU's commitment under the Kigali Amendment to the Montreal Protocol. The updated schedule demands a faster reduction in HFC use, with a more ambitious target to lower HFC consumption to about 79% below 2015 levels by 2036 and a complete phase out of the consumption of HFC greenhouse gases in the member countries by 2050. This represents an acceleration compared to previous targets, placing increased pressure on the commercial refrigeration sector to transition to lower GWP alternatives. In addition, the price for HFC quota allocation is set at 3 euros per ton of CO_2 equivalent.

Fig.1 HFC Phase-Down Schedule (EU regulation 2024/573)



Ban on High-GWP Refrigerants

One of the most impactful changes is the introduction of bans on refrigerants with high GWP values in new equipment. Starting from 2025, the use of refrigerants with a GWP of 150 or more will be prohibited in most new commercial refrigeration equipment. This rule is particularly relevant for self-contained and large refrigeration systems, which commonly use HFCs like R-404A and R-507A, both of which have GWP values significantly higher than 150. The regulation aims to push the market towards refrigerants with minimal climate impact, such as hydrocarbons, ammonia, and carbon dioxide, which have much lower GWP values.

Some examples of the new EU deadlines for the use of refrigerant for different commercial refrigeration segments:

- Refrigerators and freezers for commercial use (self-contained equipment) that contain other fluorinated greenhouse gases with a GWP of 150 or more are prohibited from 1st Jan 2025. This is just an extension to already banned HFCs (Annexe I) to other unsaturated fluorocarbons (those of Section 1 of Annexe II).

- Any other self-contained refrigerating appliances using fluorinated greenhouse gases with GWP>150 are prohibited from 1st Jan 2025. There is no ban for fluorinated gases below 150 GWP, however, the HCs are already dominating this refrigeration segment in Europe. The tendency is to adopt HCs in systems up to 2-4 KW.

- Other refrigerating equipment (except self-contained appliances and chillers) like remote and split systems, fluorinated greenhouse gases with GWP>2500 are prohibited from 1st Jan 2025 and with GWP>150 from 1st Jan 2030. This will slow down the migration toward low-GWP options; however, it's an irreversible process that is expected to be concluded in advance of the regulation requirements.

- Chillers with rated capacity up to 12 kW: fluorinated gases with GWP>150 are prohibited from 1st January 2027, and any fluorinated gas is prohibited from 1st January 2032. For chillers over 12 kW, fluorinated gases with GWP>750 are prohibited from 1st Jan 2027.

Existing Systems Maintenance

Enhanced Leak Detection and Reporting Requirements

Updated regulation imposes stricter requirements for leak detection and maintenance of refrigeration equipment. Enhanced leak detection technologies must be installed in systems containing more than 40 tons of CO_2 equivalent of refrigerants. The frequency of inspections will also increase, and operators are required to keep detailed records of any maintenance, servicing, and repairs that could affect refrigerant containment. These measures aim to reduce emissions from leaks, which are a significant source of greenhouse gas emissions in the refrigeration industry.

Recovery, Recycling, and Reclamation

EU 2024/573 emphasizes the importance of recovering, recycling, and reclaiming refrigerants. The regulation specifies more rigorous procedures for the handling of refrigerants at the end of the equipment's life. These procedures are designed to ensure that refrigerants are properly collected and either recycled for reuse in the same type of equipment or reclaimed for use in new equipment, thus minimizing releases into the atmosphere. From 2025, maintenance of equipment for refrigeration using F-gases with high global warming potential is prohibited unless the gases are reclaimed or recycled, but only until 2030. For systems impacted by these service and maintenance bans, there are two options: retrofit with gases with a GWP lower than 2500 or replace them with new equipment that uses a lower GWP refrigerant.

Training and Certification

The regulation extends requirements for training and certification to all personnel handling refrigerants, including those working with high pressures (CO_2) and flammable substitutes like natural refrigerants, which previously might not have required certification. This update ensures that technicians are equipped with the knowledge and skills necessary to work with new technologies and comply with environmental safety standards.

EU F-Gas Regulation Exemptions

EU Commission approved a temporary exemption from compliance with the 150 GWP limit on Jan 1st 2025 for some self-contained types of appliances:

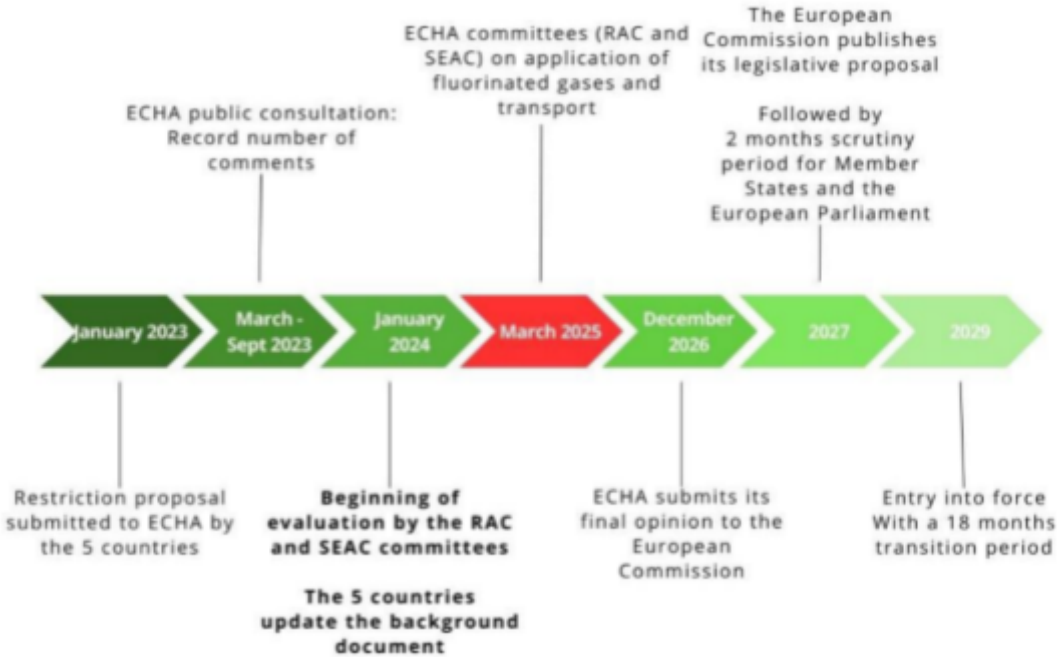
(a) blast cabinets with a full load capacity from 25kg to 100 kg of foodstuff;
(b) artisanal gelato ice cream makers with a cooling capacity higher than 2kW;
(c) ice makers with an ice production capacity from 200 kg to 2000 kg per 24 hours;
(d) trolleys for preserving and regenerating food with rated power input from 1.5 kW to 10.5 kW;
(e) retarder prover cabinets with an absorbed power from 1 kW to 2 kW;
(f) frozen drinks dispensers and cold cream dispensers with a chilled full load capacity greater than 3 litres.

The new deadline for this exemption is June 30, 2026

Any questions on the interpretation of F-gas regulation can be addressed directly through the European Commission (DG Clima) website or to major industry associations (e.g. ASERCOM, EPEE, AREA), and/or by contacting the national authority in charge of EU F-gas regulations.

REACH Regulation Update - PFAS

In 2020, 5 countries, Germany, the Netherlands, Norway, Sweden and Denmark agreed to prepare a joint REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) proposal restricting the use of PFAS. PFAS - Per and Polyfluoroalkyl substances are a complex group of more than 5000 chemicals that have been linked to environmental contamination and negative health effects in humans. Most HFC Refrigerants (A1, A2L) can be affected by the PFAS ban. The aim is to restrict all PFAS in non-essential uses. See below the timing of the REACH Directive update:



EU Safety Standards Update

With the exception of CO_2, all known alternatives with low GWP mandated by the recent EU F-Gas regulation are flammable to some extent.

Harmonized standards are the preferred way to comply with the EU safety directives, such as the EU Pressure Equipment Directive, the EU Low Voltage Directive, and the Machinery Directive, they are however not the only way, as it is allowed for manufactures to replace parts or all of a standard with a risk assessment.

In 2019 global IEC standard used for commercial refrigerating appliances (IEC 60335-2-89) was updated, raising the charge limit for flammable refrigerants: for propane up to approximately 500 g and up to 1,2 kg for A2L safety class flammable refrigerants per one circuit. This makes the transition of light commercial applications to low-GWP refrigerants much easier than with the previous 150 g limit. This new edition of the standard defines a series of specific additional measures needed to allow higher charge levels without increasing risk as set by the previous edition of the standard. The IEC standard is directly applicable in most countries of the world, but in many regions has to be integrated into the local regulatory system. CENELEC TC61 published the EN version of the IEC standard in August 2022. The standard was included in the list of harmonised standards with the EU Machine Directive (MD) in August 2023.

For systems not in the scope of EN 60335-2-89 or other product standards, the general not-harmonized standard EN 378-1 charge limits in function of system configuration, access category and room volume applies and requires case-by-case risk assessment for EU regulatory compliance.

Alternative Refrigerants for Commercial Refrigeration

Embraco offers products for the light commercial refrigeration segment that comply with EU F-gas regulations. This means compressors and condensing units for use with natural and synthetic refrigerants below 150 GWP. Compressors for transition refrigerants (150<GWP<2500) are also available. We recommend, if possible, going directly to the “future-proof” refrigerants, considering the updated EU F-Gas regulation. Every appliance producer has to make a choice: go natural or use one of the new synthetic blends presently available. Table 1 lists the main criteria that should be taken into consideration when making this decision:

Table 1 - Alternative Refrigerant Options

	High GWP HFCs	HCs	Low GWP HFCs
SAFETY CLASS	A1 Not Flammable	A3 Highly Flammable	A2L Slightly Flammable
ENVIRONMENTAL IMPACT	Very High	Ultra Low	Low
REFRIGERANT COST	Ref	Lower	Higher
COMPRESSOR THERMAL REGIME	Ref	Lower	Higher
INVESTMENTS FOR SAFETY	Ref	Yes	Yes
SYSTEM EFFICIENCY	Ref	Much Higher	Same
CHARGE LIMIT FOR SELF-CONTAINED HERMETICALLY SEALED SYSTEMS (IEC/EN)	No	13*LFL	1,2kg

Hydrocarbons

PROPANE (R290)

Embraco offers a full product line of HC compressors as a future-proof solution to meet EU F-gases regulation (up to 38 cc). Propane (R290) is already widely used in several commercial and air conditioning applications. Most of the existing light commercial applications can be designed for the use of HC refrigerants with significant benefits in terms of system efficiency, cost, reliability and acoustic emissions. This is the reason why hydrocarbon compressors are already representing almost 70% of Embraco Nidec sales to European OEMs.

OTHER HYDROCARBONS: ISOBUTANE (R600a)

R600a - isobutane - represents a valid alternative solution for small appliances. It offers benefits in terms of efficiency but has significant limitations in terms of cooling capacity. Due to its low specific cooling capacity, it requires a bigger compressor displacement compared to other refrigerants and consequently, a larger and heavier compressor frame. Isobutane's evaporating temperature range is also limited. The Embraco catalogue features a full range of products for both LBP and HBP applications, including small chest freezers, bottle coolers and wine coolers.

OTHER HYDROCARBONS: PROPYLENE (R1270)

Propylene has very similar properties to propane. Although slightly less efficient, it has the advantage of a higher specific cooling capacity. Therefore, propylene use must be limited to very specific situations. Its use can be approved in ad-hoc solutions for specific situations under the supervision of Embraco technical support.

Next Generation Synthetic Refrigerants

R404A ALTERNATIVES

A series of new mixtures with a GWP below 150 are already available on the European market. All these candidates are mildly flammable and belong to the A2L classification with temperature glide up to 12 K. Tables 2 and 3 list some alternatives to R404A. Embraco is offering compressor models approved for both R454C and R455A for MBP applications. It is important to consider that refrigerants with significant glide have to be treated differently than in the past. A dew point pressure approach for cooling capacity and efficiency cannot be used to define actual system operating conditions; a mid-point approach, instead, should be used for more accurate estimation of product performances. Guidelines on how to define mid-point temperature are stated in standard EN 13215:2016+A1:2020 in Annexe B, where linear and thermodynamic interpolations are described.

Table 2 - Alternative Blends Physical Data

	R 404A	R455A	R454C
TYPE	HFC blend	HFC blend	HFC blend
SAFETY CLASS	A1	A2L	A2L
BOILING TEMP @ 1atm	-47°C	-52°C	-46°C
CRITICAL TEMP	72°C	83°C	82°C
GLIDE @1 bar (ABS)	0,8K	12,4K	8,2K

Table 3 - Embraco Evaluation Summary

	R 404A	R455A	R454C
GWP	3920	148	148
APPLICATION FIELD	L/MBP	L/MBP*	L/MBP*
CAPACITY	Ref	Lower	Lower
EFFICIENCY	Ref	Better	Better
RELIABILITY	Ref	Lower	Lower
LUBRICANT	POE	POE	POE
MOTOR TEMP	Ref	Higher	Higher
DISCHARGE TEMP	Ref	Higher	Higher

*With a limited LBP envelope

R134a ALTERNATIVES

R1234yf can be considered as a low-GWP alternative to replace R134a, and Embraco offers compressor models for this refrigerant in its catalogue, but nowadays its use is limited to very specific applications. R1234ze is not considered a valid alternative to R134a for light commercial systems because of its low specific cooling capacity. Its use would require a completely new product line that, at this stage, does not seem to be a solution for this market segment.

Table 4 - Alternative Blends Physical Data

	R 134a	R1234yf	R1234ze (E)
TYPE	HFC	HFC	HFC
SAFETY CLASS	A1	A2L	A2L
BOILING TEMP @ 1atm	-26°C	-30°C	-19°C
CRITICAL TEMP	101°C	95°C	110°C
GLIDE @1 bar (ABS)	0K	0K	0K

Table 5 - Embraco Evaluation Summary

	R 134a	R1234yf	R1234ze (E)
GWP	1430	Below 1	Below 1
APPLICATION FIELD	L/M/HBP	L/M/HBP	HBP
CAPACITY	Ref	Slightly Lower	Much Lower
EFFICIENCY	Ref	Lower	Lower
RELIABILITY	Ref	Same	NA
LUBRICANT	POE	POE	NA
MOTOR TEMP	Ref	Lower	NA
DISCHARGE TEMP	Ref	Lower	NA

NA – not available

HFC Transitional Solutions

R404A REPLACEMENT

To ease the transition to refrigerants that comply with target final GWP limits, the chemical industry offers several alternatives to existing high-GWP HFC refrigerants. The most notable intermediate refrigerant is HFC blends like R448A, R449A and R452A. They are all in safety class A1 (non-toxic, non-flammable) and are characterized by considerably higher temperature glide than R404A. Their use from 1st of January 2022 is limited only to appliances falling under the definition of refrigerating equipment, except those classified as self-contained or chillers with the present European F-Gas regulation. Refrigerators and freezers for commercial use have to use refrigerants with a GWP below 150.

R134a REPLACEMENT

The only reason to use the below-mentioned R134a alternative blends during the transition period is because of their lower GWP, allowing greater quantities under quota limitations and possible tax reduction in some countries. Both R513A and R450A are approved for specific Embraco series (ECN R513A R450A 2017 and ECN CR/2966/en/18/10) as an alternative refrigerant for Embraco R134a models. Use of R450A and R513A, from 1st of January 2025, is limited only to appliances falling under the definition of refrigerating equipment of the present European F-Gas regulation, except those classified as self-contained or chillers. Refrigerators and freezers for commercial use have to use refrigerants with a GWP below 150.

Warning

Warning Statement about Use of Flammable Refrigerants (A2L, A3) with Embraco Compressors approved for A1 Safety Class Refrigerants (R134a, R404A, etc.).

Embraco is currently producing hermetic compressors for use with A3 and A2L refrigerants to replace high-GWP HFCs. However, it is important to note that:

1. Embraco compressors designed and approved for non-flammable refrigerants (A1 class) cannot be used with any type of flammable refrigerants, including both A3 and A2L class refrigerants.
2. All Embraco products mentioned in the Declaration of Conformity are compliant with all relevant EU directives.
3. For refrigeration systems falling under the scope of the harmonized standard EN IEC 60335-2-89, EU regulations allow the use of flammable refrigerants up to 13 times LFL but no more than 1,2 kg of refrigerant charge for each single refrigeration circuit.
4. Given the above-mentioned charge limitations and considering that all flammable refrigerants require the same design, manufacturing and maintenance precautions, we strongly recommend the use of HC refrigerants wherever technically possible.
5. Embraco offers a full portfolio of compressor models for R290, the refrigerant considered the best option for up to 500 g of charge with R290.
6. Embraco declines any responsibility for compressors used without approved refrigerants and warns that potential reliability issues, such as motor overheating and electrical component malfunction, could occur following the use of unauthorized refrigerants.

Conclusions

Hydrocarbons (isobutane-R600a and propane-R290) represent the best long-term (future-proof) solution for both low and medium pressure light commercial applications.

From 1st of January 2025, any self-contained refrigerating equipment (with few exceptions) in addition to refrigerators and freezers for commercial use must use refrigerants below 150 GWP.

From 1st of January 2030, use of transitional blends (R448A, R449A, R452A, etc) below 2500 GWP will also be banned for remote refrigerating equipment. Until then, R452A can be used with specific Embraco R404A models as well as R448A and R449A within a restricted operating envelope. Refrigerants as R513A and R450A can be used as an alternative to R134a in specific Embraco R134a series. All available alternatives are summarized in Table 10. When using the blends mentioned above outside of the Embraco-approved system conditions, to maintain an Embraco warranty, the final application needs to be validated by the Embraco Technical Support Team on a case-by-case basis.

Table 10 – Summary Table Of Alternative Refrigerants

BANNED REFRIGERANT	TEMPORARY SOLUTION		FUTURE SOLUTION	
	LBP	MBP	LBP	MBP
R404A / R507	R452A	R452A	R290	R290
	R134a	R134a	R455A	R455A
	R407C	R407C	R454C	R454C
	R448A*	R448A*	R1270	R1270
	R449A*	R449A*	R744	R744
	R407A	R407A		
	R407F	R407F		
R134a	R134a	R134a	R1234yf	R1234yf
	R513A	R513A	R600a	R600a
	R450A	R450A	R290	R290

* NE/NT/NJ restricted envelope

- Embraco Approved Refrigerant
- Please contact Technical Support