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ARE THE PRODUCT SAFETY STANDARDS READY TO ALLOW IMPLEMENTATION OF UPDATED F-GAS REGULATIONS FOR COMMERCIAL REFRIGERATION?

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ABSTRACT

Updated European F-Gas regulation, as well as similar legislation in other regions, in place to mitigate climate change, are going to limit further the usage of high GWP refrigerants in the next few years in the majority of categories of refrigeration and air conditioning applications. Except CO2 most of known alternatives with low GWP, are flammable in some extent. In recent years, intense activity on existing safety standards update took place and the other updates are still in progress. This paper will summarize the present status of international and regional product standards for commercial refrigeration and describe gaps still to be covered for full implementation of the new F-Gas regulation.

Keywords: Hydrocarbons, A2L, Charge Limit, Safety

1. INTRODUCTION

The European Union, with adoption of revised F-Gas regulation, made another important step towards reduction of CO2 emissions due to human activities in order to preserve our planet for future generations and can be as an example to the other regions that can follow similar path in the next future.

Revised F-gas regulation (EU 2024/573) mandates a complete phase out of the consumption of fluorinated greenhouse refrigerants in the member countries by 2050 as well as progressive bans for the use of fluorinated refrigerants in most of heating and cooling equipment. Final regulation has been published in the Official Journal of the EU and is legally enforceable from March 11 2024.

Adopted regulation will speed up the uptake of alternatives to fluorinated gases – such as 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 be only considered as a transitory solution. With 2050 ban of all fluorinated greenhouse refrigerants their use will be reducing progressively also because of potential PFAS restrictions presently in preparation by European Chemicals Agency (ECHA).

Hydrocarbons are excellent refrigerants. Their use is reducing both direct and indirect emissions. They are cheap and easily available. Manufacturers of residential and commercial refrigeration equipment for many years have been actively working on developing and promoting products using natural refrigerants. Apart from isobutane (R600a) used in all residential appliances in Europe since many years, propane (R290) is already dominating the light commercial plug-in segment as a natural alternative to high GWP gases like R134a and R404A.

For larger commercial systems transition to flammable refrigerants is more problematic considering the system charge level. Because of safety concerns use of carbon dioxide as refrigerant is one of possible solutions. In fact systems with CO2 are already having a strong presence is European supermarkets applications and they can offer also an integrated solutions including space and water heating. Another feasible option for larger systems is to use secondary fluid loop that allows to keep flammable refrigerant containing parts out of occupied space. For medium size stores multiple circuit option with lower charge per system is used.

2. EU FGAS REGULATION

The European Union's updated regulation on fluorinated greenhouse gases, EU 2024/573, introduces significant changes aimed at reducing emissions 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 fluorinated 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 price for HFC quota allocation is set at 3 euro per each ton of CO2 equivalent.

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 of new commercial refrigeration equipment. This rule is particularly relevant for supermarkets 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 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 (Annex I) to other unsaturated fluorocarbons (those of Section 1 of Annex II).

- Self-contained refrigerating appliances using fluorinated greenhouse gases with GWP>150 are prohibited from 1st Jan 2025. There is no ban for fluorinated gas with GWP <150, as voted by European Parliament, however the HCs are already dominating this refrigeration segment in Europe. The tendency is to adopt HCs in systems up to 2-3 KW.

- Other refrigerating equipment (except self-contained appliances and chillers): 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 (already started) 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 where fluorinated gases with GWP>150 are prohibited from 1st January 2027 and are totally prohibited from 1st Jan 2032. For chillers over 12 kW, fluorinated gas with GWP>750 are prohibited from 1st Jan 2027.

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 ton of CO2 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 will be prohibited unless the gases are reclaimed or recycled but only until 2030.

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 flammables 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.
With the exception of CO2, all known alternatives with low GWP mandated by the recent EU F-Gas regulation, are flammable to some extent. Are the EN product standard ready to deal with risks associated with flammable refrigerants and cover all types of commercial applications?

3. SAFETY STANDARDS

Despite the progress in regulatory frameworks, there are significant challenges and safety considerations associated with the use of flammable refrigerants. The main regulatory frameworks that address the safety standards for flammable refrigerants in the EU include the general standard EN 378 and EN 60335 series products standards.

The logic behind any safety standard for systems with flammable refrigerants is to prevent leakage in the first place, and combine this with mitigation measures to ensure that in case of a leak, it will not lead to a significant risk. The most efficient measure is to limit the charge of flammable refrigerant. Charge optimization is not required in EN standards, it is however an important mitigation measure. Note that the charge limits in safety standards are per refrigeration circuit as it is highly unlikely that more than one circuit will leak at the same time.

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. There are a number of system safety standards for stationary refrigerating systems. The horizontal standard (also known as group safety standard) covers a wide range of products while the vertical standard (also known as product safety standard) only covers a specific product type. Table 1 gives an overview of the harmonized European system safety standards for refrigeration.

Table 1: Most relevant European harmonized safety standards for refrigeration

EN 378-2:2016	Refrigerating systems and heat pumps — Safety and environmental requirements Part 2: Design, construction, testing, marking and documentation
EN 60335-2-11:2022	Household and similar electrical appliances – Safety – Part 2: Particular requirements for tumble dryers
EN 60335-2-24:2022	Household and similar electrical appliances – Safety – Part 2: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers
EN 60335-2-40:2013	Household and similar electrical appliances – Safety – Part 2: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers
EN 60335-2-89:2022	Household and similar electrical appliances – Safety – Part 2: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor
EN 50570:2018	Household and similar electrical appliances – Safety – Particular requirements for commercial electric tumble dryers
EN 61010-2-011:2021	Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-011: Particular requirements for refrigerating equipment
EN 60335-1:2021	Household and similar electrical appliances – Safety – Part 1: General requirements

It is important for the equipment manufacturers to use a «product standard» because the risks assessment is integrated in the fulfillment of the standards requirements (it means that during the risk assessment the standard can be used to fulfill the essential health and safety requirements). In particular, the risk connected to the use of flammable refrigerants is covered by specific requirements and it means that an additional risk assessment is not required. As each Part 2, standards of 60335 series has to be used in conjunction with Part 1 – EN 60335-1 *Household and similar electrical appliances – Safety – Part 1: General requirements*.

4. EN IEC 60335-2-89:2022

In 2019, the International Electrotechnical Commission (IEC) revised its safety standard IEC 60335-2-89 with its edition 3, increasing the charge limit for flammable refrigerants in self-contained commercial refrigeration appliances, but EU manufacturers did not use it because of the liability issues when adopting a not harmonised standard. In fact IEC standard is a voluntary international recommendation, but not legally binding.

In 2022 European version **EN IEC 60335-2-89** based on IEC standard was published and more recently in 2023, the standard was included into the list of harmonized standards with Machine Directive therefore legally applicable as a base of product conformity assessment. Thanks to the new EN standard there is no need to conduct a self-assessment when using higher charges of flammable refrigerants.

Standard scope covers most of commercial plug-in appliances: This part 2 of IEC 60335 specifies safety requirements for electrically operated commercial refrigerating appliances and ice-makers that have an incorporated motor-compressor. Examples of appliances that are within the scope of this standard are:

- refrigerated display and storage cabinets;
- refrigerated trolley cabinets;

- service counters and self-service counters;
- blast chillers and blast freezers;
- commercial ice-makers.

But is not applicable to:

- split systems with flammable refrigerant charge above 150 g;
- commercial ice-cream appliances;
- cold temperature rooms;
- multiple refrigerated chambers with a remote motor-compressor.

Present edition of the standard introduced a new limit for the maximum refrigerant charge with flammable refrigerant. For each circuit it is now allowed the maximum charge up to 13 times LFL, but more than 1.2kg. Flammable refrigerant are those of safety class A2L, A2 and A3 according to ISO 817 classification

For systems above 150g limit, several additional requirements are present, here are some of them:

- any refrigeration circuit with charge above 150 g shall be hermetically sealed,
- all refrigerant-containing parts shall be protected and not accessible,
- the appliance has to be constructed in a manner to not cause excessive vibration or resonance,
- the appliance shall be marked with the minimum room area in which the appliance is permitted to be installed.
- any refrigerating circuit shall be constructed such that a leak of refrigerant shall not result in a persistent flammable refrigerant concentration surrounding the appliance verified by passing the test of Annex CC.

This list is not exhaustive, please check published standard for complete information.

The main strategy to minimize the risk of a flammable cloud around the appliance is to create the adequate air flow. It has to be present when appliance is energized even if compressor is off. Different strategies to assure air flow are possible and it is up to the appliance manufacturer to find the optimal configuration to prevent flammable refrigerant concentration. Annex CC leak test has to be passed to comply with the standard. Annex CC is defining the leak rates in function of refrigerant used and sets the compliance criteria.

5. ON GOING STANDARDS UPDATE

5.1. IEC 60335-2-89

IEC SC61C working group WG4 is presently completing final proposal for the new edition of the standard. New edition of -89 standard supposes to cover more types of refrigeration systems not considered by present standard by adding them to the standard scope and by definition of relative requirements.

Scope extension will cover prefabricated cold rooms, packaged refrigerating systems intended for use in cold rooms and partial unit for assembly as a single appliance (split systems).

Other important changes are included into present proposal like: removal of the 1.2 kg threshold of maximum charge for flammable refrigerants, update of Annex CC measurement procedure and its compliance criteria, mandatory marking of maximum allowable pressure (PS). New requirements for partial units with flammable refrigerants are part of the proposal.

The WG4 proposal is introducing the concept of releasable charge and relative method to quantify it. By adding safety shut-off valves to the system, it can be divided into separate sections, therefore limiting the amount of refrigerant which can leak indoors. Activation of shut-off valves can be done for example with use of sensors.

Publication of this new edition of the IEC 60335-2-89 is planned for 2025, but European version of it can take many more years due to suspension of parallel vote by CEN-CENELEC standardization bodies.

5.2. IEC 60335-2-118

New 2nd edition of the standard prepared by SC61C/MT7 is ready for the first vote. It will include provisions for use of flammable refrigerants in professional ice cream makers that in the first edition have not been covered. It is based on the third edition of IEC 60335-2-89. Unfortunately this standard was not released in EN version yet and the timing is unknown.

6. CONCLUSIONS

The updates in EU 2024/573 represent a significant shift for the commercial refrigeration sector in Europe. Manufacturers and users of refrigeration equipment must adapt to the evolving regulatory landscape by investing in new technologies and training staff. The move towards low-GWP refrigerants will likely stimulate innovation in refrigeration technologies, potentially increasing initial costs but offering long-term benefits through reduced environmental impact and compliance with global climate objectives.

European safety standards for the use of flammable refrigerants in commercial refrigeration are governed by a complex framework that reflects the region's commitment to environmental sustainability and safety. The shift towards flammable refrigerants is largely driven by the need to reduce the environmental impact of traditional hydrofluorocarbons, which are potent greenhouse gases. Flammable refrigerants, such as hydrocarbons (HCs), offer very low global warming potential (GWP) and are thus considered eco-friendly. Unsaturated hydrofluorocarbons even if having a low GWP cannot be considered a green alternative because most of them are so called "forever chemicals" (PFAS).

Existing European product safety standards are not yet covering all types of large production volumes commercial applications for use with flammable refrigerants, like cold rooms, ice cream machines or split systems, therefore use of horizontal group standard and/or not harmonized product standars using risk assessment approach is recommended.

Overall, the changes introduced by EU 2024/573 are essential steps towards a more sustainable and environmentally responsible refrigeration industry in Europe. They are designed not only to meet international climate goals but also to set a global benchmark in the management and use of refrigerants.

The European Union continues to evolve its regulatory standards to balance the dual objectives of environmental sustainability and safety. Future revisions to safety standards are likely to focus on expanding the safe use of flammable refrigerants through technological advances and enhanced safety protocols. Meanwhile, industry stakeholders, including manufacturers, businesses, and regulatory bodies, are actively engaged in discussions and research to further refine these standards.

In conclusion, the European approach to integrating flammable refrigerants into commercial refrigeration systems is a cautious yet progressive one, emphasizing both environmental benefits and rigorous safety measures to manage the inherent risks associated with these substances. This transition is reflective of a broader global trend towards sustainability in refrigeration practices, with the EU often leading in regulatory innovation and safety.

NOMENCLATURE

GWP - Global Warming Potential

LFL - Lower Flammability Limit

IEC - International Electro-technical Commission

CEN - European Committee for Standardization

CENELEC - European Committee for Electro-technical Standardization

PFAS - Per- and Polyfluoroalkyl Substances

ECHA – European Chemicals Agency

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