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# NEW FLAMMABLE REFRIGERANT CHARGE LIMIT IN COMMERCIAL REFRIGERATION

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## ABSTRACT

The Kigali Amendment to the Montreal Protocol, European F-Gas regulation as well as similar legislation in other parts of the planet, in place to mitigate climate change, are going to limit the usage of high GWP refrigerants in the next few years in the majority of categories of commercial refrigeration applications. Except $CO_2$, all known alternatives with low GWP, are flammable in some extent. For the last five years, intense activity on existing safety standards update, took place and many standards update is still in progress. This paper will summarize the present state of international and regional standardization for commercial refrigeration and describe the impact of implemented changes on commercial stand alone cabinets design and testing.

Keywords: Hydrocarbons, A2L, Charge Limit, Safety

## 1. INTRODUCTION

The global community, with the Kigali Amendment to the Montreal Protocol, made another important step towards reduction of $CO_2$ emissions due to human activities, in order to preserve our planet for future generations. The global phase-down of HFCs in the refrigeration sector is representing an important contribution to the international global warming mitigation efforts. Within the wider market context, recent regional and international legislation, and minimum efficiency regulations, most common refrigerants used today in commercial refrigeration will no longer be applicable in many countries.
Manufacturers of both refrigeration equipment and components for many years have been actively working on developing and promoting products for use with low atmospheric impact refrigerants. Apart from isobutane (R600a) in household appliances, significant progress is present also with propane (R290) implementation into light commercial plug-in systems as a natural R404A alternative, as well as the use of carbon dioxide in the supermarket sector. In addition, a series of alternative synthetic refrigerants with reduced Global Warming Potential (GWP) were offered by the chemical industry.
The EU F-Gas regulation imposes a progressive ban of high GWP refrigerants in several categories of commercial applications and at the same time the quota system is considerably limiting the quantities of higher GWP refrigerants on the market. With the exception of $CO_2$, all known alternatives with low GWP, are flammable to some extend. In this paper, focus will be given to the evolution of safety related EU legislation to deal with risks associated with flammable refrigerants.

## 2. BACKGROUND

### EU F-Gas Regulation

European Union with F-Gas Regulation (517/2014) has limited the use of refrigerants with high GWP values. From January 2020 refrigerators and freezers for storage, display or distribution of products in the retail and food service **(commercial use)** industry, equipment classified as hermetically sealed systems that contain HFC refrigerants with a GWP of 2500 or more, are banned (e.g. R404A, R507A). The same applies to the stationary refrigeration equipment, that contains, or that relies upon HFCs with GWP of 2500 or more for its functioning, with the exception of equipment intended for applications designed to cool products to temperatures below -50°C. **From January 1st, 2022** - Refrigerators and freezers for storage, display or distribution of products in retail and food service **(commercial use)** industry, equipment classified as hermetically sealed systems that contain HFC with GWP of 150 or more, are going to be banned (new equipment) (e.g. R134a, R407F, R407C,

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R410A). In case of any questions in this new regulation interpretation, for example: if ice makers should fall under the “refrigerators and freezers” category, or should be considered as “stationary refrigeration equipment”, inquiries can be addressed to major industry associations (eg. ASERCOM, EPEE), or through the European Commission (DG Clima) website or/and contacting the national authorities in charge of EU F-gas regulation.

From January 1, 2020 the use of F-gases with GWP of 2500 or more, in the service or maintenance of refrigeration equipment with gas charge size exceeding 40TCO$_{2equiv}$ (ex. more than 10,2 kg of R404A) was banned, unless when using reclaimed or recycled refrigerants, if available, it is possible to service them until January 1, 2030. For systems impacted by the service & maintenance bans there are two options: retrofit with gases with GWP lower than 2500 or replace them with new equipment that uses lower GWP refrigerant.

EU F-gas regulation (517/2014) defines that the sales and distribution of high GWP gases are controlled with a quota allocation system and is leading to its declining supply and increase of HFC prices. Quantities of HFC gases available for all applications are limited based on GWP value (in 2021, 55% less if compared with 2015 usage - 87MTCO$_{2equiv}$) therefore the industry is forced to switch quickly to low GWP alternatives.

## 3. RELEVANT EU SAFETY STANDARDS

Harmonized EN standards are the preferred way to comply with the EU directives, such as the EU Low Voltage Directive, the Machinery Directive and the EU Pressure Equipment Directive, etc. 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 (Figure 1). The horizontal standards (also known as group or generic safety standard) cover a wide range of products, while the vertical standard (also known as product safety standard) only covers a specific product type. Important to notice that the product family standards dealing with the safety of refrigerating systems takes precedence over horizontal and generic standards covering the same subject.

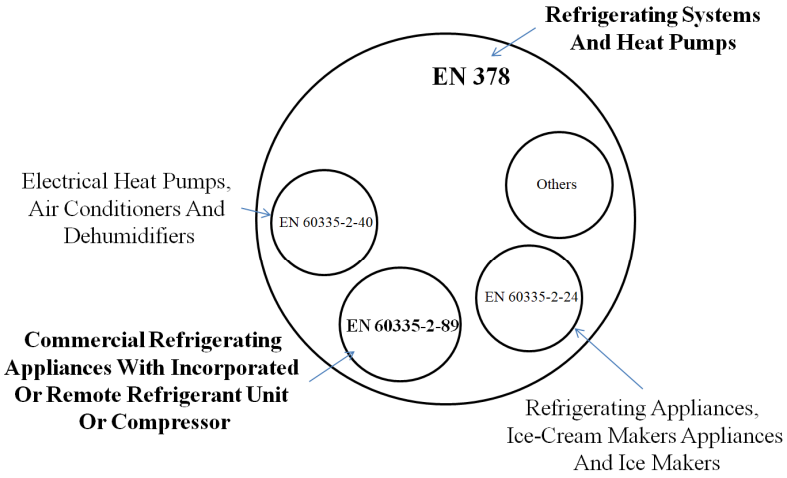


**Fig.1 Relation Between CEN and CENELEC Standards**

The generic or horizontal safety standard for refrigerating systems in EU is the EN 378:

**EN 378 :2016** *Refrigerating systems and heat pumps. Safety and environmental requirements.* European Standard relates to safety and environmental requirements in the design, manufacture, construction, installation, operation, maintenance, repair and disposal of refrigerating systems and appliances regarding local and global environments, includes within its scope piping, components and materials, and additional equipment in direct association with those systems. It also states requirements for testing, commissioning, marking and

documentation. EN 378-1 in particular defines some basic safety requirements for refrigerating systems; such as, limits for refrigerant charge depending on system configuration, its accessibility, the room size, due to the flammability or toxicity of the refrigerant used. EN 378-1 is a generic standard and requires a risk assessment to assure the safety. Examples of charge limitation for direct systems using flammable refrigerants of safety class A2L and A3 in the Figure.2 are based on EN378 Part1. It is important to remind that, when a specific application is covered by the scope of a product (vertical) standard, product standard charge limits are overruling the generic (horizontal) standard charge limitations.

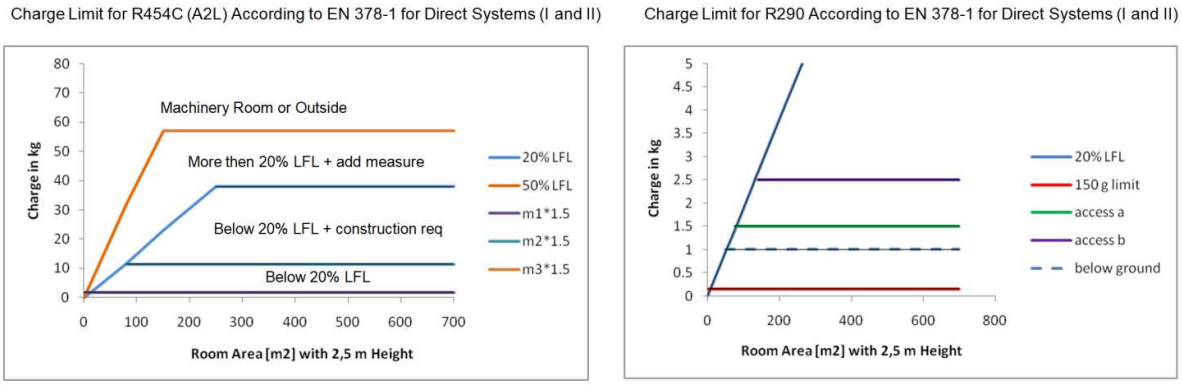


Fig.2 Examples of charge limitation for direct systems according to EN 378-1

The product or vertical standard in EU for commercial refrigeration is EN 60335-2-89:

**EN 60335-2-89:2017** *Household and similar electrical appliances – safety – part 2-89: particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor* specifies safety requirements for electrically-operated commercial refrigerating appliances that have an incorporated compressor or that are supplied in two units for assembly as a single appliance in accordance with the manufacturer's instructions (split system).

This standard is a «product standard» and it means that 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, this standard 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.* The present published EN 60335-2-89/A2:2017 covers only appliances with a charge of less than 150 g of flammable refrigerant in each separate refrigerant circuit and it is based on the old version of IEC 60335-2-89 ed.2. The 150 g constraint on system charge size for flammable refrigerants is considered to be a colossal barrier to essential developments within the sector. CENELEC TC61 is in charge of introduction of the most recent edition of IEC 60335-2-89 standard, that can remove this barrier in the near future.

## 4. NEW EDITION OF IEC 60335-2-89:2019

At the global level, in order to remove above mentioned barrier of 150 g, the International Electrotechnical Commission (IEC), with its subcommittee TC61/SC61C started the update process 6 years ago. According to the decision of the Tokyo Plenary meeting of IEC SC61C on 13 November 2014, a new working group (WG4), was established to discuss the increase of the limit of the charge amount of flammable refrigerants in commercial refrigeration, while keeping the risk at the same level as with the current limit of 150 g, which in more than 20 years in household and light commercial application, showed an excellent safety record.

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As the result of five years of intense activity of WG4 experts, involving major players in the industry from all parts of the world, on June 20, 2019, the new edition 3 of IEC 60335-2-89 was published. The new charge limits and series of additional requirements are defined in the latest standard edition for flammable refrigerants. The maximum refrigerant charge with flammable refrigerant for each circuit was raised to 13*LFL, but not more than 1.2kg. Flammable refrigerants are those of safety class A2L, A2 and A3 according to ISO817 classification. Table 1 shows an example of 2 specific refrigerants' charge limits according to the new standard edition. It is important to remind that, when a specific application is covered by the scope of a product (vertical) standard, product standard charge limits are overruling the generic (horizontal) standard charge limitations.

Table 1 Charge limit calculation examples according to IEC 60335-2-89

| Refrigerant | LFL [kg/m$^3$] | 13*LFL | IEC Approved |
|---|---|---|---|
| **R290 (A3)** | 0.038 | 0.494 kg | **0.494 kg** |
| **R32 (A2L)** | 0.307 | 3.991 kg | **1.2 kg** |

An important change was introduced into the scope of the standard. Commercial ice makers are now part of the scope and they can benefit from the flammable refrigerant charge increase. For systems covered by the standard but with refrigerant charge up to 150g, requirements are remaining the same as in the previous editions. Remote systems with a flammable refrigerant charge above 150g are excluded from the scope,

For systems above 150g up to the new charge limit, several new additional requirements were introduced. Here are some of them: any refrigeration circuit with a charge above 150 g shall be hermetically sealed, all refrigerant-containing parts shall be protected and not be accessible, the appliance shall be constructed in a manner to not cause excessive vibration or resonance and the appliance shall be marked with the minimum room floor area in which the appliance is permitted to be installed (with some exceptions) to prevent refrigerant stagnation in the room in case of a leak.This list is not exhaustive, please check the original standard for complete information.

The main factor to minimize the risk of a flammable cloud around the appliance is the adequate air flow. It has to be present even when the 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 rate as a function of each refrigerant's proprieties and also sets the compliance criteria, where the concentration above 50% for 5 minutes is allowed. Risk level has been analyzed and referenced to the accepted baseline risk of 150 g with the adequate series of tests. Location of sensors to detect refrigerant concentration in air during leak test of Annex CC is shown in Fig. 3. In case of cabinets with doors or drawers, the Annex CC includes door opening test after full charge release inside closed cabinet.

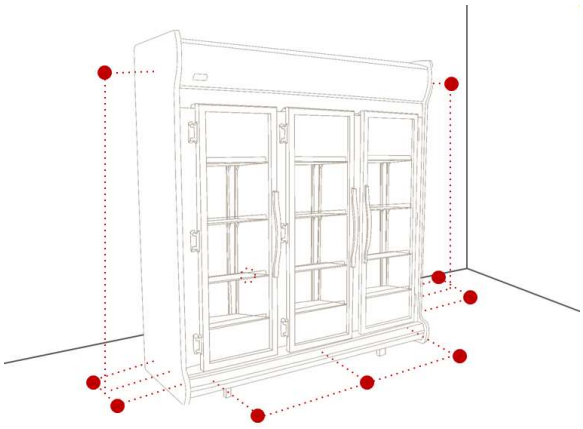

Fig.3 Schematic illustration of testing points in Annex CC

IEC SC61C/WG4 is still working on future amendments of the standard, in particular related to A2L class refrigerants, where new safety studies were published in United States under AHRI sponsorship.

## 5. CONCLUSIONS

Most of the nations have already introduced the new ed.3 of -89 standard inside their standardization system. In New Zealand and Australia, the new edition of AS/NZS 60335.2.89 standard was published in July 2020.
In the USA and Canada, the Working Group 12, under CANENA, is preparing an update of equivalent UL and CSA standards. Several deviations to the original IEC version are expected and the target publication date is by mid 2021. Also Japan, under the Japan Refrigeration and Air Conditioning Industry Association (JRAIA) a Working Group 3 is preparing the Japanese version of IEC 60335-2-89, but the publication date is not yet clear.
In Europe, since the FDIS regarding IEC 60335-2-89 was not submitted for CENELEC parallel voting, CENELEC TC61 is presently working on the conversion of the standard IEC 60335-2-89 into EN version. This standard is intended to become a harmonized standard with EU Machine Directive (MD). Final vote target date is set for March 2021.

## NOMENCLATURE

| | | | |
|---|---|---|---|
| *GWP* | Global Warming Potential | *CENELEC* | European Committee for Electrotechnical Standardization |
| *LFL* | Lower Flammability Limit | | |
| *IEC* | International Electrotechnical Commission | *AHRI* | The Air-Conditioning, Heating, and Refrigeration Institute |
| *CEN* | European Committee for Standardization | | |

## REFERENCES

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