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FOR THE ENVIRONMENT

HFO

Technical Note

1. What type of refrigerants is A2L?

HFO (Hydro-Fluoro-Olefin) refrigerants are refrigerants in pure or mixture form. In pure form, they are fluorinated hydrocarbons with a double carbon bond.
Due to their chemical structure they are substances that are unstable once released into the atmosphere and therefore decompose rapidly. Unlike HFC refrigerants, they therefore do not accumulate in the atmosphere and cause a very low greenhouse effect (GWP). Since they do not contain chlorine, they also do not damage the atmospheric ozone layer. They are therefore considered to be environmentally friendly refrigerants.

These refrigerants (categorized as A2L) offer system manufacturers reliable alternatives that help to minimize system redesign, giving the possibility of higher charge and easier integration of electrical components compared to more flammable hydrocarbon (HC) refrigerants (A3).

Which are the A2L refrigerants?

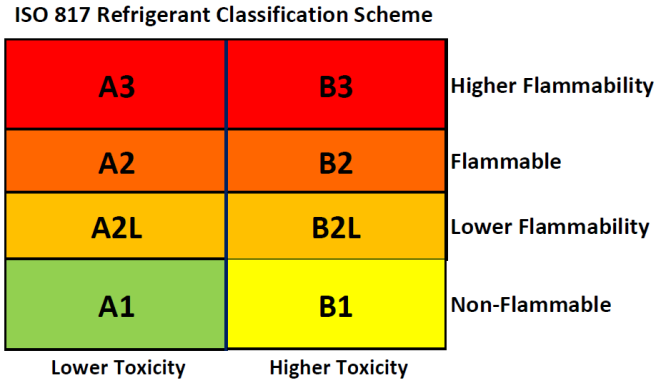
R1234yf	GWP	4
R1234ze	GWP	7
R454C	GWP	148
R454A	GWP	239
R454B	GWP	467
R452B	GWP	698
R455A	GWP	148
R32	GWP	675

1.1 What does A2L mean?

According to ISO817, US ASHRAE 34 and EN378, the classification for refrigerant safety is defined by means of:

The letter indicating the level of toxicity:
-A: refrigerant with low toxicity;
-B: toxic refrigerant

The number indicating the level of flammability:
-1 non flammable;
-2L mildly flammable;
-2 flammable;
-3 highly flammable.



A2L are therefore refrigerants with low toxicity and low flammability.

Main parameters that characterize the degree of flammability of a refrigerant:
the lower and upper flammability limits (LFL) and (UFL)
the burning velocity (BV)
the minimum ignition energy (MIE)
the heat of combustion (HOC)
A requirement common to all flammable refrigerant safety classes (i.e. 2L, 2 and 3) is that flame spread must occur during the test carried out in accordance with ASTM E681, standard method for determining flammability concentration limits of chemicals
All flammable refrigerants, which have a lower flammability (e.g. A2L) or higher flammability (e.g. A3), can spread a flame and therefore have flammability limits. These limits (LFL and UFL) define the minimum and maximum concentrations of a substance in the air capable of spreading a flame. Under the LFL, there's not enough fuel to support a fire. Above the UFL, the concentration is too high and there is not enough oxygen in the air. The lower the LFL value, the greater the risk, since a flammable concentration can be reached more easily by a leak. For A2Ls there is also a limit on the speed of flame spreading which must not exceed 10 cm/sec

1.2 Compliance with new refulation 2024/573

The European Regulation 2024/573 (that substitute the Directive F-Gas 517/2014) introduces further innovations aimed at reducing the use of HFCs compared to the old regulation. From 1 January 2025 and from 1 January 2030 there will be different prohibitions depending on the system use, see below:

Placing on the market prohibitions referred to in Article 11(1)

Products and equipment		Date of prohibition
(1) Non-refillable containers for fluorinated greenhouse gases listed in Annex I, empty, partially or fully filled, used to service, maintain or fill refrigeration, air-conditioning or heat pump equipment, fire protection systems or electrical switchgear, or for use as solvents.		4 July 2007
STATIONARY REFRIGERATION		
(2) Domestic refrigerators and freezers:	(a) that contain HFCs with GWP of 150 or more;	1 January 2015
	(b) that contain fluorinated greenhouse gases, except if required to meet safety requirements at the site of operation.	1 January 2026
(3) Refrigerators and freezers for commercial use (self-contained equipment):	(a) that contain HFCs with GWP of 2 500 or more;	1 January 2020
	(b) that contain HFCs with GWP of 150 or more;	1 January 2022
	(c) that contain other fluorinated greenhouse gases with a GWP of 150 or more.	1 January 2025

(4) Any self-contained refrigeration equipment, except chillers, that contains fluorinated greenhouse gases with a GWP of 150 or more, except if required to meet safety requirements at the site of operation.		1 January 2025
(5) Refrigeration equipment, except chillers and equipment covered in points (4) and (6), that contains, or whose functioning relies upon:	(a) HFCs with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below – 50 °C;	1 January 2020
	(b) fluorinated greenhouse gases with a GWP of 2 500 or more, except equipment intended for application designed to cool products to temperatures below – 50 °C;	1 January 2025
	(c) fluorinated greenhouse gases with a GWP of 150 or more, except if required to meet safety requirements at the site of operation.	1 January 2030
(6) Multipack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or more that contain, or whose functioning relies upon, fluorinated greenhouse gases listed in Annex I with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1 500 may be used.		1 January 2022

STATIONARY CHILLERS		
(7) Chillers that contain, or whose functioning relies upon:	(a) HFCs with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below – 50 °C;	1 January 2020
	(b) fluorinated greenhouse gases with a GWP of 150 GWP or more for chillers up to and including a rated capacity of 12 kW, except if required to meet safety requirements at the site of operation;	1 January 2027
	(c) fluorinated greenhouse gases for chillers up to and including a rated capacity of 12 kW, except if required to meet safety requirements at the site of operation;	1 January 2032
	(d) fluorinated greenhouse gases with a GWP of 750 for chillers above 12 kW, except if required to meet safety requirements at the site of operation.	1 January 2027

STATIONARY AIR-CONDITIONING EQUIPMENT AND STATIONARY HEAT PUMPS			
(8)	Self-contained air-conditioning equipment and heat pumps, except chillers, that:	(a) plug-in room air-conditioning equipment which is moveable between rooms by the end user that contains HFCs with GWP of 150 or more;	1 January 2020
		(b) plug-in room air-conditioning equipment, monoblock air-conditioning equipment, other self-contained air-conditioning equipment and self-contained heat pumps, with a maximum rated capacity of up to and including 12 kW that contain fluorinated greenhouse gases with a GWP of 150 or more, except if required to meet safety requirements. If safety requirements at the site of operation would not allow using fluorinated greenhouse gases with GWP of less than 150, the GWP limit is 750;	1 January 2027
		(c) plug-in room air-conditioning equipment, monoblock air-conditioning equipment, other self-contained air-conditioning equipment and self-contained heat pumps, with a maximum rated capacity of up to and including 12 kW that contain fluorinated greenhouse gases, except if required to meet safety requirements. If safety requirements at the site of operation would not allow using alternatives to fluorinated greenhouse gases, the GWP limit is 750;	1 January 2032
		(d) monoblock and other self-contained air-conditioning equipment and heat pumps, with a maximum rated capacity of more than 12 kW but not exceeding 50 kW that contains fluorinated greenhouse gases with a GWP of 150 or more, except if required to meet safety requirements. If safety requirements at the site of operation would not allow using fluorinated greenhouse gases with GWP of less than 150, the GWP limit is 750;	1 January 2027
		(e) other self-contained air-conditioning equipment and heat pumps that contain fluorinated greenhouse gases with GWP of 150 or more, except if required to meet safety requirements. If safety requirements at the site of operation would not allow using fluorinated greenhouse gases with GWP of less than 150, the GWP limit is 750.	1 January 2030

A2L refrigerants are a good answer to this scenario, for example:
R454C and R455A are long term solutions for several uses, having GWP=148.

1.3 Safety regulations

When the equipment is explicitly included in the regulation, reference is made to this, e.g. EN 60335-2-89 for commercial/industrial refrigeration, EN 60335-2-40 for chillers, heat pumps and fixed air climate control. If the specific regulation for the equipment has not integrated the new A2L classification, it is necessary to use the general reference regulation, in this case EN 378 in its actual releases and its various parts 1-2-3-4, to which reference is made.
Another requirement to be met for the installation is compliance with the PED 2014/68 directive concerning pressure equipment

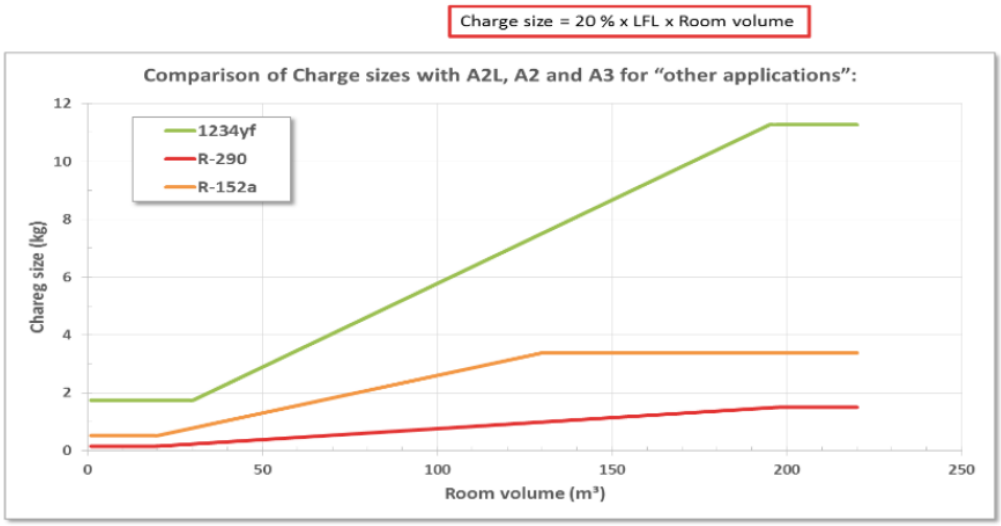
Safety

2.1 General rules

Refrigeration systems using flammable refrigerants must comply with special safety rules, including safety devices and special design for electrical equipment, the introduction of fans to be used in the event of refrigerant leakage to prevent the formation of flammable gas mixtures and avoid the danger of fire.

Maximum concentration limits must be respected, the practical limit for a refrigerant is the highest concentration level in a occupied space, which will not produce harmful effects (e.g. acute) or create a risk of ignition of the refrigerant. It is used to determine the maximum charge for that refrigerant in a specific application.

R1234yf	LFL (kg/m³)	0.289	Pr. lim. (kg/m³)	0.058
R1234ze	LFL (kg/m³)	0.303	Pr. lim. (kg/m³)	0.061
R454C	LFL (kg/m³)	0.293	Pr. lim. (kg/m³)	0.059
R454A	LFL (kg/m³)	0.278	Pr. lim. (kg/m³)	0.056
R454B	LFL (kg/m³)	0.303	Pr. lim. (kg/m³)	0.061
R452B	LFL (kg/m³)	0.31	Pr. lim. (kg/m³)	0.062
R455A	LFL (kg/m³)	0.431	Pr. lim. (kg/m³)	0.086
R32	LFL (kg/m³)	0.307	Pr. lim. (kg/m³)	0.061



In addition, certain general rules must be respected:
- In case of maintenance, when opening pipes use equipment that does not produce sparks or flames;
- The electrical components must be contained in electrical panels in which the refrigerant (in case of leakage) cannot penetrate and be ignited by possible sparkling of the contacts.
- Set the system shutdown sensors below the lower explosive limit;
- Personnel must carry a portable gas detector with them during maintenance or repair;
- Adequate ventilation must always be guaranteed.

2.2 Risk assessment

The risk assessment must be introduced on site to ensure that work is safe. This tool gives information on how to work safely, what risk situations the personnel may face and what information/tools/skills they need.
This assessment follows a few steps:
- Identification of possible risks;
- Risk assessment in terms of hazard and frequency;
- Introduction of the safety system to reduce the risk when this is not negligible;
- Continue with the assessment until the risk is low.

This procedure is specific to each application.
A typical risk assessment scheme is represented in the following picture

	Consequence				
Likelihood	Insignificant	Minor	Moderate	Major	Critical
Rare	LOW Accept the risk Routine management	LOW Accept the risk Routine management	LOW Accept the risk Routine management	MEDIUM Specific responsibility and treatment	HIGH Quarterly senior management review
Unlikely	LOW Accept the risk Routine management	LOW Accept the risk Routine management	MEDIUM Specific responsibility and treatment	MEDIUM Specific responsibility and treatment	HIGH Quarterly senior management review
Possible	LOW Accept the risk Routine management	MEDIUM Specific responsibility and treatment	MEDIUM Specific responsibility and treatment	HIGH Quartely senior management review	HIGH Quarterly senior management review
Likely	MEDIUM Specific responsibility and treatment	MEDIUM Specific responsibility and treatment	HIGH Quarterly senior management review	HIGH Quarterly senior management review	EXTREME Monthly senior management review
Almost certain	MEDIUM Specific responsibility and treatment	MEDIUM Specific responsibility and treatment	HIGH Quarterly senior management review	EXTREME Monthly senior management review	EXTREME Monthly senior management review

2.3 Design, maintenance and rules of intervention

Those handling refrigerants need to be qualified: this is true for every refrigerant, and all the more so for A2Ls because they are more dangerous.

Regulation 2024/573 provides rules regarding the verification of gas leaks/recovery, the maintenance of the equipment register (system log book), the frequency of checks, the purchase of gas, as well as the sale and placing on the market of equipment in addition to the prohibitions already seen above.

EN378 in its four parts specifies the requirements for the system for the various roles, manufacturer, installer, maintenance technician, user.

EN378-1 specifies the classification and selection criteria applicable to refrigeration systems.

Part 2 of the standard is applicable to the design, construction and installation of refrigeration systems including piping, components and materials. It also specifies the requirements for testing, commissioning, marking and documentation.

Part 3 specifies the requirements for equipment installation locations, such as engine rooms, defining specifications for ventilation, doors, access, lighting, alarms and detectors.

Part 4 indicates the operating instructions and documentation for the correct operation and maintenance of the system.

3 How to replace the used refrigerant with A2L type refrigerant

Given that A2L fluids must only be used in new equipment or equipment used in systems specifically designed for operation with these products, under no circumstances may a system operating with a non-flammable fluid be retrofitted with a flammable fluid unless an adequate risk assessment study is carried out beforehand, without prior upgrading and authorization to preserve compliance with current regulations.
R455A and R454C are excellent substitutes for R404A. This replacement is necessary, as said, to upgrade the existing installation.
It is important to point out that the risk assessment must be carried out before the upgrading of the system in order to check its actual feasibility.