Flammability of refrigerants: what are the current industry challenges?

While increasing numbers of low-GWP fluids are being developed, more and more products on the market are classified as flammable. How are these fluids classified? What measurements should be taken into account? What fluid charge can be loaded into equipment? This feature will shed light on the subject, particularly on A2L-classified refrigerants.

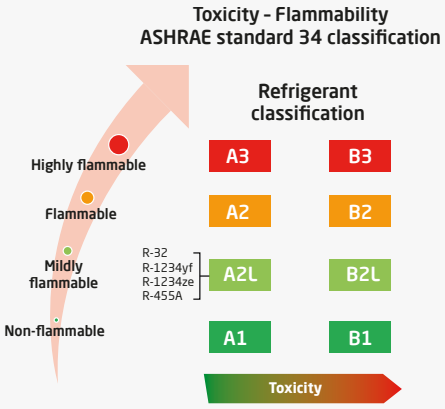
Refrigerants are safety classified according to the ASHRAE 34 standard, using approved test methods to assess their toxicity and flammability.

The classification from the ISO 817 standard is used to identify these categories. The letter indicates the level of toxicity, A= low toxicity refrigerants and, B= the higher toxicity ones, whilst the number indicates the level of flammability, 1= Non-flammable, 2= flammable, 2L= lower flammability and 3= higher flammability.

With the need of F-Gas to move to lower GWP refrigerants, a new group was created some time ago with a classification of A2L with and is being integrated step by step into various standards. This is particularly the case with the latest revision (2016) of the EN378 safety standard about the environment of refrigeration installations and heat pumps, recognising the A2L classification and allows for greater charge sizes than A2 and A3 refrigerants based on the lower flammability limit.

Examples of A2L refrigerants are R-1234yf, R-32, and R-455A. A requirement of an A2L refrigerant is that it has a burning velocity below 10cms/second and they have a restricted flammability area compared to A2 and A3 refrigerants. By combining these various criteria, the final classification is shown in this ASHRAE classification diagram.

ASHRAE classification



A2L fluids: how to use them and for which applications

Under European legislation, very low-GWP fluids must be used for certain applications, both currently and in the future. In order to meet these requirements, producers have thought ahead and developed new HFO molecules in order to achieve a global warming potential of less than 1. But the lower the GWP, the higher the flammability. A compromise therefore had to be found between flammability and GWP in order to meet professionals' needs as effectively as possible and provide solutions that were both environmentally friendly and efficient.

The new A2L fluids can be used for many applications and various different processes – as could HFCs and HCFCs – while at the same time complying with current legislation and recommendations associated with their low levels of flammability. Currently, they must only be used with **new purpose-built equipment** or **with** systems specially designed to operate with these products. Under no circumstances should a system operating with a non-flammable fluid be retrofitted to run on a flammable fluid without carrying out studies or preliminary reclassification and authorisation in order to ensure continued compliance with current regulations.

A few examples of applications:
R-32 is recommended as a replacement for R-410A in new split systems with charges of less than 3kg. R-32 cannot be used as a drop-in replacement for R-410A because the thermodynamic characteristics and its classification as an A2L-category refrigerant requires design changes.

R-1234yf is widely used in car air-conditioning systems for all engine-driven vehicles produced since 1 January 2017.

R-1234ze is now used as a replacement for R-134a in new installations adopted by most chiller manufacturers. Its properties are perfectly suited for high-temperature applications.

- A2L blends containing R-32, R-1234yf or R-1234ze have been developed for other applications and have been certified or are in the process of being approved by equipment manufacturers. R-455A and R-454C in particular are being used, mainly as a replacement for R-404A in commercial cooling systems, as well as in industrial applications. R-452B and R-454B are considered potential alternatives to R-410A.

A2L fluids per application

Applications	Fluid	GWP*	Additional information
Commercial cooling/Industrial refrigeration	R-455A (L40X) R-454C R-1234ze	146 146 <1	Condensing units Built-in units Low-temperature refrigeration CO_2 cascade system
Stationary air-conditioning system	R-452B (L41y) R-454B R-32	675 466 677	
Heat pumps	R-452B (L41y) R-454B R-455A (L40X)	675 466 146	
Chillers	R-1234ze	<1	
Domestic cooling	R-1234yf	<1	Refrigerators
Car air-conditioning	R-1234yf	<1	New vehicle models since 2011

* according to the IPCC 5th assessment report

A2L fluid charges: which reference should be taken into account?

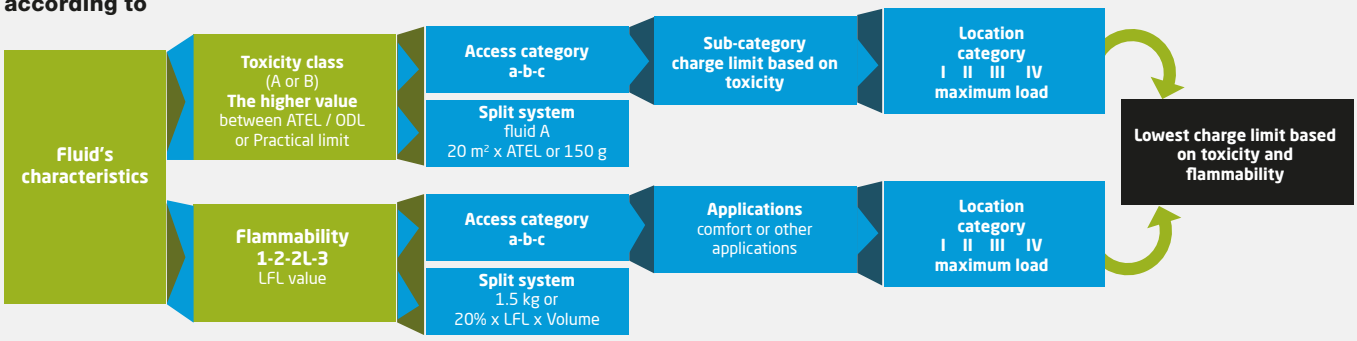
Fluid charges in refrigeration and air-conditioning equipment are governed by international and European standards, as well as local regulations. For equipment manufacturers, for example, the main priority is to ensure compliance with the product's safety standard (for example: the EN 60335-2-24 standard for domestic refrigeration appliances). If the new A2L classification is not incorporated, the second priority is to use the group's safety standard. The reference in use today is the European EN378: 2016 standard. This does not apply to systems designed before the date on which it came into force. It does, however, apply to extensions or alterations carried out on systems after its publication, or in the event of systems being transferred and then used on a different site. It introduces the concept of risk assessment. The EN 378 standard can be used to calculate an installation's maximum charge, taking three criteria into consideration: the characteristics of the refrigerant selected, access category and equipment location.

Calculation method

As per EN378-1 - Annexe C - Requirements for maximum refrigerant charge limits

The charge limit is determined according to

Drawer calculation method:
Several levels of calculation are possible - The higher the value for the two risks (toxicity/ flammability) should be selected – Then the lower of the two values will determine the maximum charge



Examples of how charges are calculated depending on the application according to the EN378 standard

Split system in a 150 m³ building open to the general public (categories a and I)		
Fluid	Limit affected	Charge in kg
R-290 (A3)	Flammability	0.15
R-455A (A2L)	Flammability	2.54
R-1234ze (A2L)	Flammability	1.81
R-600a (A3)	Toxicity	0.17
R-448A (A1)	Toxicity	7.76

For a comfort installation installed on a wall, located in a 50 m³ space for 20 m², used for beds (categories a and I)		
Fluid	Limit affected	Maximum charge in kg
R-290 (A3)	Flammability	0,34
R-455A (A2L)	Flammability	6.9 or 82.5 with 2 security measures
R-32 (A2L)	Flammability	4.6 or 59.9 with 2 security measures
R-452B (A2L)	Flammability	4.66 or 60.5 with 2 security measures
R-410A (A1)	Toxicity	22 or without restriction if 2 security measures

If stricter local regulations exist, they take precedence over EN 378

Maintaining equipment with A2L refrigerant charges

The **relevant training** is mandatory for technicians and personnel. To ensure safety when working on systems in enclosed areas, a few best practices should be adhered to, for example:

- Install safety and ventilation systems that are appropriate for the location and for A2L-category fluids.
- Install a leak-detection system in the working areas.
- In the event of an accidental leak, ventilate the area before entering it. Use breathing equipment, if necessary.

A2L-category fluids must be recovered for compliance with regulations. They must be packaged in special packaging for flammable fluids, and then labelled and identified as such in order to prevent any accidents.

The **maintenance equipment used** will depend on the type of systems concerned. Although certain tools, such as hoses and manifolds (care should be taken to avoid contamination) may be used, tools incorporating electric circuits or motors must be specifically designed for use with A2L-category fluids, and must be in compliance with local regulations (ATEX, for example). Vacuum pumps, recovery machines and leak detectors, for example, must meet specific requirements if they are to be used with A2L-category fluids. Never use equipment designed for A2L-category fluids to handle A3-category flammable fluids.

NB: this presentation does not cover all the details specified in the EN 378 standard and does not guarantee compliance with it.
Non-binding information – Refer to the standards available at www.boutique.afnor.org