# TB04: Flammable refrigerants in air conditioning and heat pump systems

## 1 Overview

The GB F-Gas Regulations are currently under review and a stakeholder consultation is expected before the end of the year from DEFRA. The EU updated their regulations in March 2024 and this brought in some important placing on the market bans which will have an effect on the UK market, regardless of whether or not the UK follows suit with similar restrictions to sales.

The EU has dictated that split system air conditioning and heat pump systems with a duty of less than a 12kW must utilise refrigerants with a GWP (global warming potential) of less than 150 from 1st January 2027, and larger systems with a duty of 12kW or more must utilise refrigerants with a GWP of less than 750 from 1st January 2029. As a general rule of thumb, lowering the GWP levels tends to introduce safety aspects to the refrigerant in use. One or more of the following issues are common: ***flammability, toxicity, very high pressure***.

UK Government, in its F-Gas assessment report issued December 2022, acknowledged that the phase down, or de facto phase out of certain refrigerants based on their GWP levels, would be challenging for the UK market to meet, but it is anticipated that the GB Regulations will largely follow a similar path to that of the new EU regulations - so it can be expected that we will see similar restrictions to sales of systems with medium or low GWP refrigerants in many types of system from 2026 onwards. Regardless of our own GB Regulations, manufacturers will not be manufacturing and supplying as many systems with medium or low GWP refrigerants going forward because they tend to build systems suitable for the whole European market.

## 2 Safety categories classification

**ASHRAE classifications**

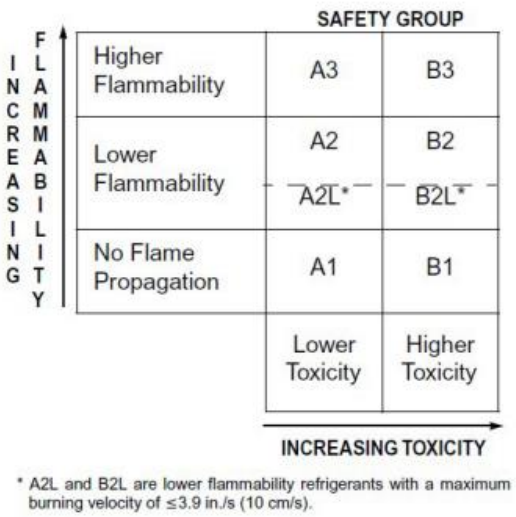
The internationally accepted designation of safety categories for all refrigerants is based on **A** or **B** for toxicity level and **1, 2L, 2** or **3** for flammability levels from ASHRAE Standard 34.

Those refrigerants categorised “A” are non-toxic, or of lower toxicity;

whereas refrigerants categorised “B” are considered to be toxic.

Flammability levels increase in line with the designated number.

- Safety Group Classifications




* A2L and B2L are lower flammability refrigerants with a maximum burning velocity of ≤3.9 in./s (10 cm/s).

Some examples of common refrigerants:

R410A and R744 ($CO_2$) are classified as A1 refrigerants as they are non-toxic and non-flammable[1].

R32 is classified as an A2L refrigerant as it is non-toxic but of lower flammability[2].

R717 (ammonia) is classified as a B2L refrigerant as it is very toxic but of lower flammability.

R290 (propane) is classified as an A3 refrigerant as it is non-toxic but highly flammable.

Different refrigerants will have benefits and drawbacks when compared with others. For example, R290 when compared with R410A in smaller duty split system air conditioning and heat pump systems has a very low GWP of 3[3], it has high heat transfer performance, and operates with lower pressure ratios which tends to lead to lower leakage rates, but the highly flammable refrigerant does have safety considerations that were not relevant with R410A.

## 3 Safe working practices

Technicians and engineers working with flammable refrigerants should have training in the specific handling requirements of them. Courses can range from a basic overview of working with flammable refrigerants, to the more in-depth City & Guilds Hydrocarbons qualification C&G6187-21.

When handling highly flammable refrigerants there is a generally accepted principle of having no ignition source within 3m of the refrigerant cylinder. To determine allowable proximity of potential ignition sources to installed systems you must risk assess the system to account for:

Total refrigerant charge volume, likelihood of leakage, rate of leakage, other mitigating factors such as exposure to wind which may dissipate any refrigerant leak before the leak reaches the lower flammability level (LFL).

For example, if an R290 system is leaking then the leaked refrigerant will not become potentially flammable until the concentration reaches the LFL of 0.038kg/$m^3$ or approximately 2.1% by volume. A tiny leak of a few grams a day in a split system outdoor unit, for example, would likely never reach the LFL and therefore not be a fire hazard. A larger leak of the entire refrigerant charge by catastrophic pipe or component failure, however, may present the risk of rapidly reaching the LFL and stay below the upper flammability level (UFL) of approximately 9.5% by volume rendering the risk of ignition to be high.

## 4 System location

Attention should be given to the location of hydrocarbon systems in particular, that units are not installed adjacent to opening doors or windows which could result in leaking refrigerant migrating directly into the building.

They should also not be located adjacent to drain gulleys or air vent bricks in building foundations due to the heavier than air nature of the refrigerants which, in the event of leakage, could see the refrigerant drawn into the foundations or drainage system and become very dangerous.

Manufacturer's installation guidelines should always be strictly adhered to.

[1] Although these refrigerants are classed as non-toxic, they are heavier than air and will readily displace air in a room where leaking refrigerant is present. Asphyxia by air being displaced is a very real hazard which must be accounted for in any risk assessment you carry out.

[2] Lower flammability refrigerants have a burning velocity (flame propagation rate) less than or equal to 10 cm per second if ignited.

[3] IPCC 4th Assessment Report used by the F-Gas Regulations as the benchmark for comparing GWP levels.

## 5 SAFETY STANDARD BS EN 378

Applying the safety standard BS EN 378 to determine maximum refrigerant charge allowable can be complicated – there really isn't an easy answer – but with care and planning it is possible to ensure the installations you design or work on are safe for you, your clients, and the public.

The maximum allowable charge for any refrigerant, set out in EN378[4], is dependent on:

- The size of the room the system is in, or where the pipework may pass through where there are joins in the pipework;
- Location classification of the room under consideration;
- Access category for personnel to the area under consideration;
- What the room itself is used for.

The maximum allowable charge based on flammability is calculated as being the greater of[5]:

1) The charge limit determined by Table C.2 in Annex C of BS EN 378-1-2016;
2) $m_1$ x 1.5 for systems using refrigerants with flammability class 2L;
3) $m_1$ for systems using refrigerants with flammability class 2 or 3;
4) 150g for sealed refrigerating systems.

Note that the charge limits in table C are capped based on the LFL of the refrigerant which can be found in Annex E of BS EN 378-1-2016.

**Calculation for determining maximum allowable charge of an A2L refrigerant in an air conditioning or heat pump system used for human comfort:**

Where the refrigerant charge when using an A2L refrigerant in an air conditioning or heat pump system used for human comfort is greater than m1 x 1.5, the maximum charge shall be in accordance with the following equation:

$$m_{max} – 2.5 \times LFL^{5/4} \times ho \times A^{1/2}$$

where:

- $m_{max}$ is the maximum allowable charge in kg
- m is the refrigerant charge in the system in kg
- $A_{min}$ is the required minimum room area in m2
- A is the room area in m2
- LFL is the lower flammable limit in kg/$m^3$, taken from Annex E
- $h_o$ is the height factor of the appliance:
    - 0.6 for floor mounted;
    - 1.8 for wall mounted;
    - 1 for window mounted;
    - 2.2 for ceiling mounted

**NOTE:** For air conditioning and heat pump systems where the above calculations do not provide a solution for required refrigerant charge it may be possible to use IEC 60335-2-40 to increase the maximum allowable charge and still comply with industry safety standards. Refer to manufacturers' instructions at all times.

[4] BS EN 378-1-2016

[5] $M_1$ = 4 $m^3$ x LFL. This multiplier is based on a charge of 150g of R290.