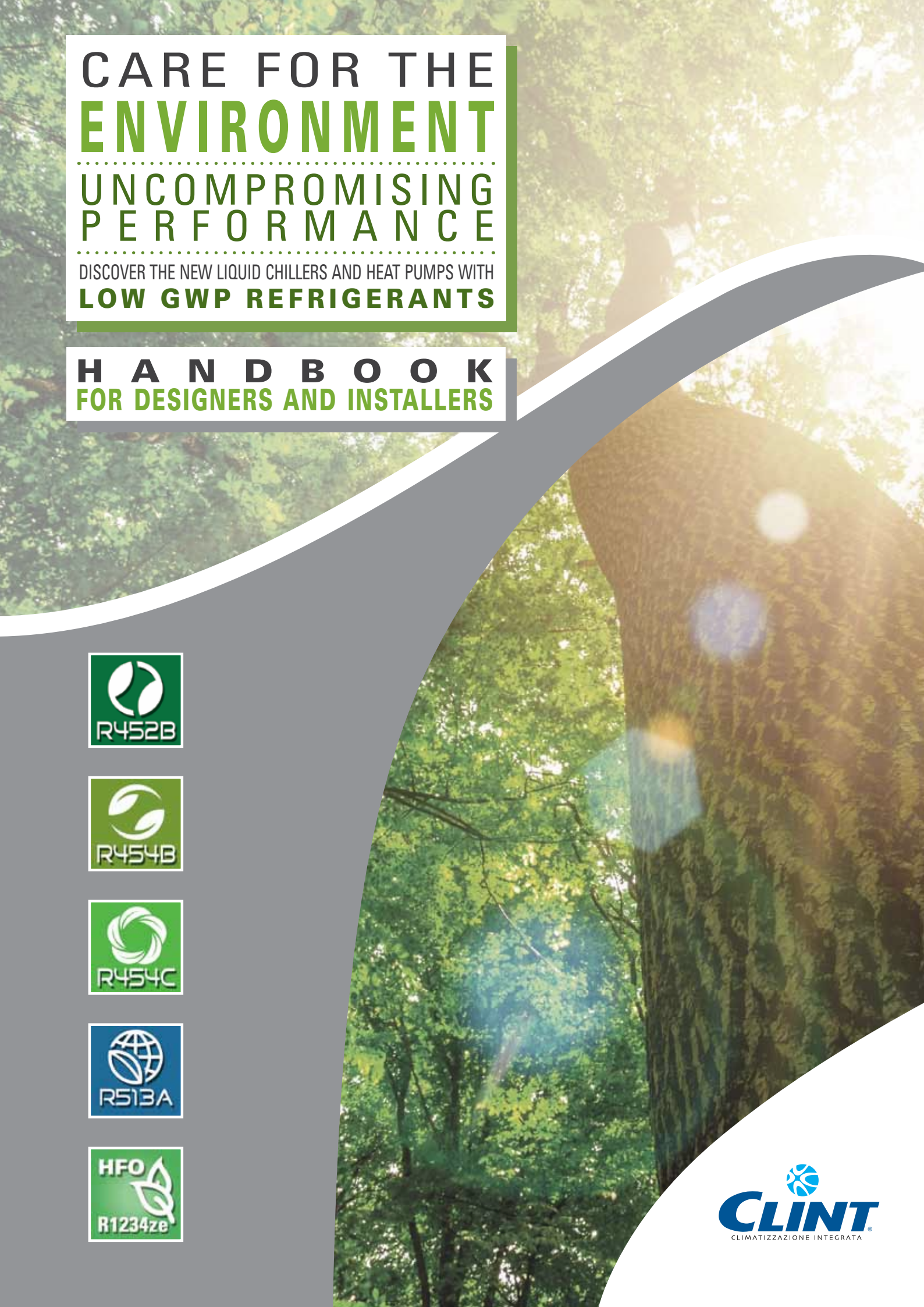
CARE FOR THE ENVIRONMENT

UNCOMPROMISING PERFORMANCE

DISCOVER THE NEW LIQUID CHILLERS AND HEAT PUMPS WITH
LOW GWP REFRIGERANTS

HANDBOOK
FOR DESIGNERS AND INSTALLERS



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LAWS, REGULATIONS AND MARKET 1

WHY ARE ALTERNATIVES TO THE REFRIGERANTS CURRENTLY USED BEING SOUGHT?

GLOBAL WARMING is a climate phenomenon that is affecting our planet and which, if not properly countered, will produce increasingly dramatic consequences on the whole ecosystem. The causes of the rise in temperatures lie in the increase of **greenhouse gases** in the atmosphere, caused by the harmful emissions related to human activity.
Global warming exerts its influence by causing glaciers to melt, subtropical deserts to widen and the increase in sea levels, as well as intensifying extreme weather events such as cyclones, floods, droughts, heat waves and cold snaps.
The scientific consensus on the dramatic effects of global warming has convinced many nations, companies and individuals to take measures to try and limit this phenomenon. The **European Union** is leading these measures through the **Low Carbon Road-Map 2050**, a plan aimed at reducing, by 2050, the Greenhouse Gas (GHG) emissions by 80% compared to 1990 levels.

The Low Carbon Road-Map 2050 also involves the **HVAC (Heating, Ventilation, Air Conditioning) sector**, requiring us to act on two factors:

- Reduction of the DIRECT IMPACT, linked to the release into the atmosphere of refrigerating gases that contribute to the greenhouse effect (F-GAS Directive).
- Reduction of the INDIRECT IMPACT, that is the consumption of primary air linked to equipment operation (EcoDesign Directive).

WHAT ARE GWP AND ODP?

Global Warming Potential (GWP) is the measure of how much a single gas molecule negatively contributes to the increase of the greenhouse effect, and is parameterised with respect to CO_2, which has been assigned value 1. Therefore, the greater the GWP of a refrigerant, the greater the damage it potentially produces on Global Warming.

The ***Ozone Depletion Potential (ODP)*** is the measure of how must a single gas molecule negatively contributes to the thinning of the Ozone layer. The most harmful refrigerants, of the CFC and HCFC category, were banned from the market a few years ago and all allowed refrigerants currently have a 0 ODP value.

These are the GWP_{100AR4} and GWP_{100AR5} values of the most commonly used fluids in the HVAC sector.

			HFC HydroFluoroCarbons			Blend of HFC-HFO				HFO IdroFluoroOlefine	
REFRIGERANT		**CO_2**	R410A	R134a	R32	R452B	R454B	R454C	R513A	R1234ze	R1234yf
GWP_{100AR4}	kg CO_2EQ	**1**	2.088	1.430	675	698	466	148	631	7	4
GWP_{100AR5}	kg CO_2EQ	**1**	1.924	1.300	677	676	467	146	573	<1	<1

GWP_{100AR4} = Global Warming Potential calculated over a period of 100 years according to the 4th Assessment Report (2007) of the IPCC Institute.
GWP_{100AR5} = Global Warming Potential calculated over a period of 100 years according to the 5th Assessment Report (2014) of the IPCC Institute.

1

WHAT IS THE HFC PHASE DOWN SCHEME?

In order to oblige Member States to reduce the use of refrigerant gases that are most damaging to the environment, the EU has set – with the F-GAS Directive entered into force on 1 January 2015 – the maximum amount of HFC gases (HydroFluoroCarbons) and therefore of equivalent CO_2 that can be placed on the market for the product categories of various sectors, including HVAC and Refrigeration. The purpose of the ***Phase Down Scheme*** is to reduce the amounts of harmful HFC gases over the 2015-2030 period and promote the use of low GWP refrigerants (HFO categories and HFO/HFC blends).

The Phase Down Scheme also introduced in the EU the ***HFC refrigerant quota system***, i.e. a mechanism for allocating limited amounts of HFC gases to manufacturers and importers of gas, quotas that can also be marketed among players.

ARE R410A AND R134a GOING TO BE BANNED IN THE HVAC SECTOR?

There are no plans to outright ban these refrigerants, but a revision of the F-Gas regulation is underway to rapidly accelerate the phase-down of all high-GWP refrigerants in favour of natural or GWP<150 refrigerants. The aim is to have a new law in place as from 2024.

ARE SANCTIONS OR TAXES ON THE USE OF HIGH GWP REFRIGERANTS PLANNED IN EUROPE?

To-date, several countries of the old continent have implemented so-called *"Carbon Taxes"*. For example, in Switzerland and Denmark it is mandatory to use only HFO or low GWP refrigerants in medium-large HVAC systems; in Norway there is an extremely high tax for every kg of imported high GWP refrigerant: equal to € 183 per kg of R410A, € 111 per kg of R134a. This means that, for example, installing a 500 kW unit with Scroll compressors and R410A refrigerant, which on average has a 100 kg charge of refrigerant, will cost € 18,300 more just in taxes.

 SWITZERLAND	IT IS MANDATORY to use HFO in large installations exceeding 400 kW. High GWP refrigerants are ONLY allowed in systems below 80 kW. Restrictions in 80 to 400 kW systems depend on the type of installation.
 DENMARK	In installations larger than 250 kW it is MANDATORY to use low GWP gas such as propane-ammonia-CO_2-HFO. In systems up to 250 kW the use of traditional high GWP refrigerants is allowed but a restriction is applied: the units must contain a maximum of 10 kg of refrigerant per circuit.
 NORWAY	Specific tax on imports of high GWP refrigerants, with an amount proportional to the GWP: ≈ 183€ per kg of R410A ≈ 111€ per kg of R134a
 SPAIN	Specific taxation: ≈ € 20 per tonne of CO_2 equivalent.

1

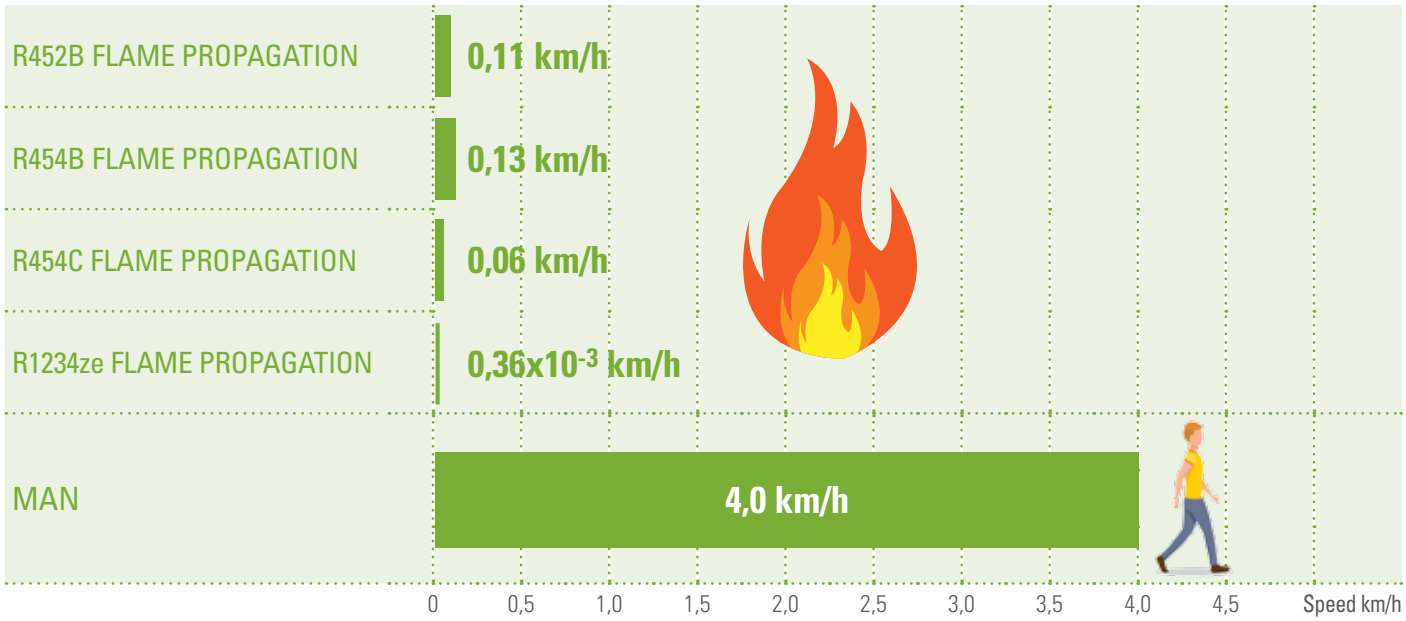
HOW ARE REFRIGERANTS CLASSIFIED?

According to ASHRAE and ISO 817:2014, refrigerants are classified according to two fundamental safety parameters i.e. toxicity and flammability.

TOXICITY	FLAMMABILITY			EXAMPLES
A NON TOXIC	**A1**	NON FLAMMABLE	No propagation of flame in the air	R134a, R410A, **R513A**
	A2L	LOW FLAMMABILITY	Flammable at combustion rate lower than 10 cm/s (0,36 km/h)	**R452B**, **R454B**, **R454C**, **HFO-R1234ze**, R32
	A2	MODERATE FLAMMABILITY	Flammable at combustion rate exceeding 10 cm/s (0,36 km/h)	R152A
	A3	HIGH FLAMMABILITY	Explosive	R441A, R443A, R290 (propane)
B TOXIC	**B1**	NON FLAMMABLE	No propagation of flame in the air	R245fa, R514A
	B2L	LOW FLAMMABILITY	Flammable at combustion rate lower than 10 cm/s (0,36 km/h)	NH_3 (ammonia)
	B2	MODERATE FLAMMABILITY	Flammable at combustion rate exceeding 10 cm/s (0,36 km/h)	---
	B3	HIGH FLAMMABILITY	Explosive	---

WHAT DOES A2L MEAN?

A2L is a subclass of flammable fluids defined as "Low Flammability" in ASHRAE 34 that includes refrigerants that are only flammable at certain temperatures and concentrations and have a flame propagation rate lower than 10 cm/s (0,36 km/h). Therefore, their dangerousness is extremely low. By way of example, considering that a man walks on average at a speed of 4 km/h, while R452B spreads at a rate of 0,11 km/h, R454B at 0,13 km/h, R454C at 0,06 km/h and R1234ze at $0{,}36x10^{-3}$ km/h, in the event of an accident, evacuation would be guaranteed without harming people.



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WHAT ARE THE REGULATIONS AND LAWS IN FORCE CONCERNING LOW-ENVIRONMENTAL IMPACT REFRIGERANTS?

The current application scenarios, related to low GWP refrigerants, are marked by regulations and laws whose main purpose is to protect the environment by reducing the emissions of greenhouse effect fluorinated gases.
The European Directives and Regulations listed here have been implemented by each Member State by issuing specific national Implementing Decrees.
The regulations that govern these issues are:

EU Regulation 517/2014 on greenhouse effect fluorinated gases.
It introduces the progressive reduction of the amount of HFC placed on the market, called "phase down", through the mechanism of allocation of HFC quotas to each manufacturer/importer.
The link from which to download the Regulation is: https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A32014R0517

UNI EN 378 refrigeration systems and heat pumps – Safety and environmental requirements.
The standard specifies the safety requirements for people and goods, provides a guide for environmental protection and establishes procedures for the operation, maintenance and repair of refrigeration systems and the recovery of refrigerants.
It is divided into 4 parts which deal with the following topics:

Part 1: Basic requirements, definitions, classification and selection criteria.
It specifies the classification and selection criteria applicable to refrigeration systems. These classification and selection criteria are used in parts 2, 3 and 4.

Part 2: Design, construction, test, marking and documentation.
It applies to the design, construction and installation of refrigeration systems, including pipes, components and materials. It also specifies the testing, commissioning, marking and documentation requirements.

Part 3: Installation site and people protection.
It concerns the requirements of the equipment installation places, such as machine rooms, defining the specifications for ventilation, doors, accesses, lighting, alarms and detectors. It also indicates how the operating personnel must be equipped.

Part 4: Running, maintenance, repair and recovery.
It considers the operating instructions and documentation for correctly running and maintaining the system. A significant part deals with the management of refrigerant gas and operations for its recovery, recycling, regeneration, transport, storage and disposal.

IEC EN 60335-2-40:2018 special requirements for electric heat pumps, air conditioners and dehumidifiers.
This standard regulates machines with a refrigerant content ranging from 1 kg to 5 kg and is still under revision. The proposal is to increase the allowed charge of A2L refrigerant, implementing various risk mitigation measures. In its current version, the standard sets very strict requirements on the use of flammable fluids (A2L and higher) as refrigerants.

WHICH SECTOR ASSOCIATIONS ARE ADDRESSING THESE ISSUES?

It is a time of great turmoil for the HVAC sector, in which trade associations are carefully monitoring the legislative/regulatory developments underway regarding the use of new low GWP refrigerants.
Below is a list of the main international associations which are dealing with these issues, representing the technical reference point for operators in the HVAC sector.

Main International Associations:

- ASHRAE "American Society of Heating, Refrigerating and Air-Conditioning" (www.ashrae.org);
- REHVA " Federation of European HVAC Associations" (www.rehva.eu);
- IIR "International Institute of Refrigeration" (www.iifiir.org);
- HPC "Heat Pump Centre" (www.heatpumpingtechnologies.org/about/heat-pump-centre/).

Example of some major National Associations:

- ITALY: AICARR - Associazione Italiana Condizionamento dell'Aria Riscaldamento e Refrigerazione; ASSOCLIMA - Associazione dei Costruttori di Sistemi di Climatizzazione
- GERMANY: VDI-TGA - Fachbereich Technische Gebäudeausrüstung der VDI-Gesellschaft Bauen und Gebäudetechnik
- SPAIN: ATECYR - Asociación Técnica Espanola de Climatización y Refrigeración
- FRANCE: AICVF - Association des Ingénieurs en Climatique, Ventilation et Froid
- SWITZERLAND: SWKI - Société Suisse des Ingénieurs en Technique du Bâtiment
- UNITED KINGDOM: CIBSE - Chartered Institution of Building Services Engineers
- THE NETHERLANDS: TVVL - Dutch Society for Building Services
- BELGIUM: ATIC VZW-ASBL - Association Royale de la Technique du Chauffage, de la Ventilation et de la Climatisation
- DENMARK: DANVAK - Fagligt Netværk for Professionelle Inden for HVAC, Energi og Indeklima
- SWEDEN: SWEDVAC Swedish HVAC Society - Energi- och Miljötekniska Föreningen
- FINLAND: FINVAC - The Finnish Association of HVAC Societies
- NORWAY: NORVAC - Norwegian Society of HVAC Engineers
- HUNGARY: ETE - Építéstudományi Egyesület - Scientific Society for Building
- POLAND: PZITS - Polskie Zrzeszenie Inzynierów i Techników Sanitarnych
- RUSSIA: ABOK - Association of Engineers in Heating, Ventilation, Air-conditioning, Heat Supply & Building Thermal Physics

2 A2L REFRIGERANTS: INSTALLATION AND MAINTENANCE METHODS

ARE SPECIFIC QUALIFICATIONS REQUIRED BY INSTALLERS AND MAINTENANCE TECHNICIANS TO HANDLE A2L REFRIGERANTS?

No, the licenses already held by Operators to handle A1 class refrigerants are also valid for A2L class refrigerants. The Authorised Technical Service Centres must have suitable instruments for the recovery of refrigerant, vacuum and vacuum gauge groups with scales in R452B, R454B, R454C and R1234ze.
Regarding their possible disposal, the ATSCs can contact the Bodies already in charge of recovering gas without limitations with respect to those in force.
G.I. Industrial Holding is responsible for updating and assessing the current operating procedures in order to raise awareness in our field Operators.

The F-GAS Directive regulates the activity of the Operators in the sector that handle all classes of refrigerant gases, therefore A1 and A2L classes. Those carrying out leak inspections (F-Gas > 5 t CO_2EQ), F-Gas recovery, installation, repair, maintenance, assistance or disposal on fixed refrigeration and air conditioning equipment, fixed heat pumps or cold storage rooms of trucks and trailers, are obliged to register with the Register of Dealers, obtain a certificate and, in some cases, communicate the data related to the activities carried out to assure **full traceability of the fluorinated gases on the market**.

Please note that the F-GAS Directive introduces changes concerning the frequency of periodic inspections to be carried out on the units, reducing the frequency of inspections required on units with low GWP refrigerants. The frequency of these inspections differs according to the equivalent amount of CO_2 contained in the equipment.

Equivalent amount of CO_2 = GWP x kg of refrigerant.

Equivalent amount of CO_2 (t)	Inspection frequency						
	If not present leak detection system:					If present leak detection system:	
< 5 t	No inspections					No inspections	
5 ≤ x < 50 t	Every 12 months					Every 24 months	
50 ≤ x < 500 t	Every 6 months					Every 12 months	
≥ 500 t	Every 3 months					Every 6 months	
Equivalent amount of CO_2 (t)	**Amount of refrigerant contained in the unit**						
	R410A	**R452B**	**R454B**	**R454C**	**R134a**	**R513A**	**HFO R1234ze**
< 5 t	up to 2,6 kg	up to 7,4 kg	up to 10,7 kg	up to 34 kg	up to 3,9 kg	up to 8,7 kg	from to 5.000 kg
5 ≤ x < 50 t	from 2,6 to 26 kg	from 7,4 to 74 kg	from 10,7 to 107 kg	from 34 to 342 kg	from 3,9 to 39 kg	from 8,7 to 87 kg	from 5000 to 50.000 kg
50 ≤ x < 500 t	from 26 to 260 kg	from 74 to 740 kg	from 107 to 1.071 kg	from 342 to 3.425 kg	from 39 to 385 kg	from 87 to 873 kg	from 50.000 to 500.000 kg
≥ 500 t	over 260 kg	over 740 kg	over 1.071 kg	over 3.425 kg	over 385 kg	over 873 kg	over 500.000 kg

2

ARE THERE ANY ADDITIONAL PRECAUTIONS TO CONSIDER WHEN INSTALLING UNITS WITH R452B, R454B, R454C AND R1234ze?

As a general principle, Hydronic Systems require safety precautions far lower than Direct Expansion Systems (split and VRF).
This is because Hydronic units are heat-cooling machines for intermediate fluid systems: the refrigerant is contained inside a monoblock unit placed either outdoors (aircooled units) or in appropriate utility compartments (watercooled units) and only water (possibly with the addition of glycol) circulates inside system terminals installed in rooms used by residents. The situation is very different for direct expansion systems (split and VRF) for which, being a two-section system, there is a flow of refrigerant in the pipes directly inside the rooms used by residents.

In light of this premise, it is clear from EN 378-3:2017 that, in the case of **aircooled Hydronic units installed outdoors, no additional precaution is required.**

Also in case of **watercooled Hydronic units installed outdoors, no additional precaution is required.**

Whereas, if **watercooled Hydronic units are installed inside utility compartments**, reference should be made to the general provisions contained in EN 378-3:2017.

IN CASE OF INSTALLATION IN CONFINED SPACES, WHICH ADDITIONAL MEASURES MUST BE CONSIDERED?

Standard EN 378-3:2017 sets forth an analysis of the installation made by an expert in flammability (in accordance with EN 60079-10-1): based on the characteristics of the fluid and type of installation, it is possible to establish the any dangerousness of the area and implement suitable solutions for minimising the risks.

For example, the utility rooms must be appropriately marked and ventilated. For greater safety, the installation of sniffers connected to an alarm system and mechanical ventilation of the room is required.

2

ARE THERE RESTRICTIONS ON THE INTENDED USE FOR UNITS OPERATING WITH A2L FLUIDS?

At the moment the issue is not regulated by any European common guideline. The Designer/Installer must refer the specific National Legislation of the Country of installation.
Only for reference, here we report the guiding rules in force in the Italian State:
The topic is covered in detail by the Italian Ministerial Decree of 3 August 2015 (known as "FIRE PREVENTION CODE").
In recent years, and still ongoing, there has been intense activity on the part of the trade associations with the National Fire Brigade that has led to a revision of the Fire Prevention Code through the issuance of several ministerial decrees.
The Ministerial Decree of 18 October 2019 introduced the possibility of using A2L refrigerants in air-conditioning systems in the same way as A1 classified refrigerants: "In areas of activity where occupants may be exposed to the effects of refrigerant gases, A1 or A2L classified refrigerant gases should be used according to ISO 817 "Refrigerants - Designation and safety classification".
In addition, the Ministerial Decree of 10 March 2020 on "Fire Prevention Provisions for air-conditioning systems included in activities subject to fire prevention controls" allowed

- The use of category A1 or A2L refrigerants;
- The installation, always respecting the safety requirements of the rule of art, of indoor units containing the aforementioned fluids.

Whereas, for existing activities, any reconversion of systems with A2L fluids is considered a relevant modification for the purposes of fire safety and is therefore subject to the procedures envisaged by Article 4 paragraph 7 of the decree of 7 August 2012, if it does not entail an aggravation of the pre-existing safety conditions. In any case, please refer to the specific Ministerial Decrees for the different uses.

ARE THERE ANY PARTICULAR ADDITIONAL PRECAUTIONS FOR TRANSPORTING UNITS OPERATING WITH A2L FLUIDS?

No, for road transport the ADR regulation (road transport of dangerous goods) does not set any particular requirements up to a maximum of 333 kg of refrigerant per truck. A specific assessment must be carried out if the route requires the crossing of a tunnel. The label for identifying the refrigerant category will only have different colour and symbols from the label of A1 refrigerants.

A2L refrigerants do not have different requirements from A1 refrigerants for sea transport as well. Assessments must however be carried out case-by-case, as for A1 refrigerants. For air transport, a specific assessment is required on a case-by-case basis.

ARE THERE PARTICULAR ADDITIONAL PRECAUTIONS FOR STORING THESE UNITS?

As for R410A units, units with R452B, R454B, R454C and R1234ze refrigerant must be stored in well-ventilated premises and with ambient temperature between -20°C and +50°C, in areas not directly exposed to sunlight and with low humidity.

2

ARE THERE LIMITS ON THE MAXIMUM REFRIGERANT CHARGE PER UNIT?

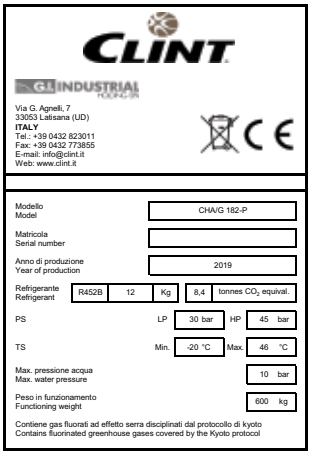
No, for classic installations in engine rooms or outdoors (Class III of EN 378), there are no refrigerant charge limits per unit. Limitations to refrigerant charges are only set forth in direct expansion systems (split and VRF) as they belong to Class II of EN 378 regulation (systems with external compressor and internal device).

IS THERE A SPECIAL PROCEDURE FOR TOPPING UP REFRIGERANT ON THESE UNITS?

There are no additional requirements compared to R410A. R452B must always be topped up in the liquid phase; the same applies to R454B, R454C and R1234ze. An incorrect charge could alter the equipment's operation.
The use of vacuum and charge instruments suitable for A2L category refrigerants is required.
The valves of A2L fluid cylinders are left-handed to differentiate from A1 fluids (right-handed).

HOW ARE THESE REFRIGERANTS GRAPHICALLY IDENTIFIED?

UNIT IDENTIFICATION:
G.I. Industrial Holding labels its units with specific indications to highlight the presence of such A2L Class refrigerants. In addition to a label with the refrigerant's name, specific labels identify the flammability of the gas and its pressure. The serial number plate shows the amount of gas loaded (in kg), the GWP and the overall charge in tons of CO_2 equivalent = refrigerant weight (kg) x GWP/1000. A specific label is affixed on the packaging, identifying the flammability of the refrigerant according to current ADR regulations.



CYLINDER IDENTIFICATION:
Until recently, the American AHRI regulation attributed to each refrigerant gas an identifying colour, used for the cylinders' colour and as background colour for the labels. With the increase in number of gases in Europe, this procedure was discontinued and AHRI itself has proposed to use from 2020 only one light grey colour for the cylinders of all refrigerant gases, and only distinguish between flammable and non flammable refrigerants by the colour of the head.
Since this is a proposal and not a requirement, the various refrigerant manufacturers have the option of whether to colour the cylinder or not but, in any case, all have a common colour of the head to indicate the DANGEROUSNESS of the product: for example, NON flammable refrigerants (A1 category) must have a GREEN head, while FLAMMABLE ones (A3, A2 or A2L) a RED head.

3 R452B, R454B AND R454C: FEATURES AND PERFORMANCES

WHAT ALTERNATIVES TO R410A ARE AVAILABLE ON THE MARKET?

The refrigerants with thermo-fluid-dynamic characteristics most similar to R410a available on the market today are the HFO and HFC mixtures **R452B, R454B, R454C** and the HFC **R32**.

WHAT ARE THE FEATURES AND DIFFERENCES BETWEEN R410A - R452B - R454B - R454C - R32 REFRIGERANTS?

The following table summarises the main features and differences between them.

Refrigerant	**U.M.**	**R410A**	**R452B**	**R454B**	**R454C**	**R32**
Commercial description	-	R410A	Opteon™ XL55 (DR55) Solstice®L41y	Opteon™ XL41 (DR5A)	Opteon™ XL20	R32
Category	-	HFC MIXTURE	HFO/HFC MIXTURE	HFO/HFC MIXTURE	HFO/HFC MIXTURE	HFC
Composition	-	R32 - 50% R125 - 50%	R32 - 67% HFO1234yf - 27% R125 - 7%	R32 - 68,9% HFO1234yf - 31,1%	R32 - 21,5% HFO1234yf - 78,5%	R32
GWP_{100AR4}	kg CO_2EQ	2088	698	466	148	675
GWP_{100AR5}	kg CO_2EQ	1924	676	467	146	677
ODP	-	0	0	0	0	0
Safety class	-	A1	A2L	A2L	A2L	A2L
LFL (Low Flammable Limit)*	Vol %	-	11,9	11,2	7	12,7
UFL (Upper Flammable Limit)**	Vol %	-	23,3	22,0	15,0	33,4
Burning velocity (flame propagation speed)	cm/s	-	3,0	3,7	1,6	6,7
Performance: nominal cooling capacity vs R410A	-	100%	98%	96%	95%	105%
Efficiency: EER vs R410A	-	100%	101%	100%	98%	101%
Glide	K	0,1	1,1	1,3	7,8	0,0
Discharge temperature	°C	78	82	83	76	95

*LFL = Minimum concentration of refrigerant with which the flame can spread inside a homogenous mixture of air and refrigerant.
**UFL = Maximum concentration of refrigerant with which the flame can spread inside a homogenous mixture of air and refrigerant.
GWP_{100AR4} = Global Warming Potential calculated over a period of 100 years according to the 4th Assessment Report (2007) of the IPCC Institute.
GWP_{100AR5} = Global Warming Potential calculated over a period of 100 years according to the 5th Assessment Report (2014) of the IPCC Institute.

3

WHY HAS G.I. INDUSTRIAL HOLDING CHOSEN TO DEVELOP UNITS WITH R452B AND R454B? WHY NOT R32?

G.I. Industrial Holding has chosen to develop units with R452B and R454B because the in-depth research carried out has shown that their features are the most similar to R410A and, unlike R32, compatible immediately with Heat Pump units and Multifunctional units. This allowed us to introduce, **first in the market, an extremely wide range of units with Scroll compressors Cooling Only, Reversible Heat Pumps and Multifunctional 4-pipe units from 50 to 1.220 kW**. The new units in R452B and R454B, developed with our Technological Partners, can operate with the same oil and with a working range similar to the corresponding ranges in R410A.

WHY TWO ALTERNATIVES ARE OFFERED: R452B AND R454B?

G.I. Industrial Holding carried out in-depth researches and tests on both refrigerants, together with its Technological Partners and, as mentioned, their characteristics turned out to be quite similar. The units developed by G.I. Industrial Holding are already technically compatible for operation with both refrigerants: all components, i.e. compressors and coils, are already homologated and validated.
The tests showed that **R452B is the best performing refrigerant** and its glide is lower. In fact, even if its GWP is higher than R454B (676 vs 467), it makes the unit to be best performing and therefore to have a lower energy consumption during its operation: cooling capacity is reduced of only 2% compared to R410A, while with R454B cooling capacity is reduced of 4%; efficiency (EER) is higher (+1% with R452B, while with R454B it is equal to R410A). Therefore, we can state that, thanks to its higher performances, **R452B is the best choice from ecological, energy and economic point of view.**
Furthermore, R452B has a more widespread distribution, making it less subject to price and availability fluctuations. On the contrary, R454B is an excellent solution on projects where the Customer request is specifically focused on GWP minimisation, as for example on Countries where carbon taxes on GWP value are applied.

WHY THE R454C IS PROPOSED FOR HEAT PUMP UNITS FOR HIGH TEMERATURE WATER PRODUCTION?

G.I. Industrial Holding has chosen to use R454C refrigerant for reversible Heat Pumps for high temperature water production (65 °C) because it is a refrigerant with a GWP equal to 146 therefore with a much lower value than the refrigerants R410A and R407C still used for these types of units. Furthermore, from a technical point of view, it allows the realization of a simplified refrigerant circuit not requiring vapor injection to reduce the compressor discharge temperature and allows an optimal operating range both at high and low air temperatures allowing the production of high temperature water both in summer (for domestic hot water production) and in winter.

ARE R452B, R454B AND R454C EASILY AVAILABLE ON THE MARKET? AT WHAT PRICE?

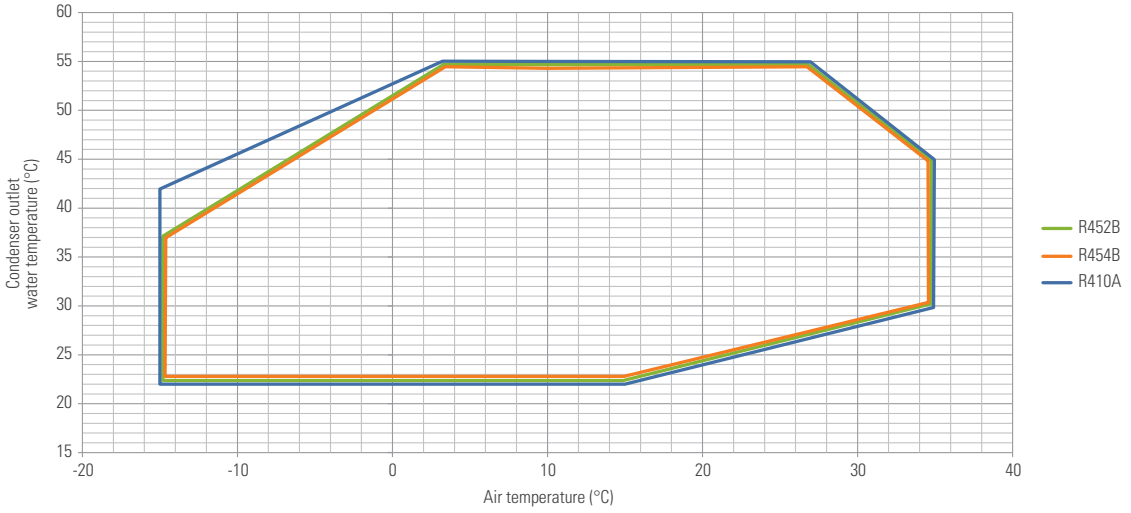
R452B, R454B and R454C are mixtures of R32, R1234yf and R125 refrigerants (the latest is present only on R452B), which are widely used in both the automotive and air conditioning sectors and on industrial refrigeration, are supplied by several Producers and no impaired availability is expected in the medium-long term. We expect that for the future large productions will be maintained and therefore it should be easy to find these blends too, at an adequate cost.

3

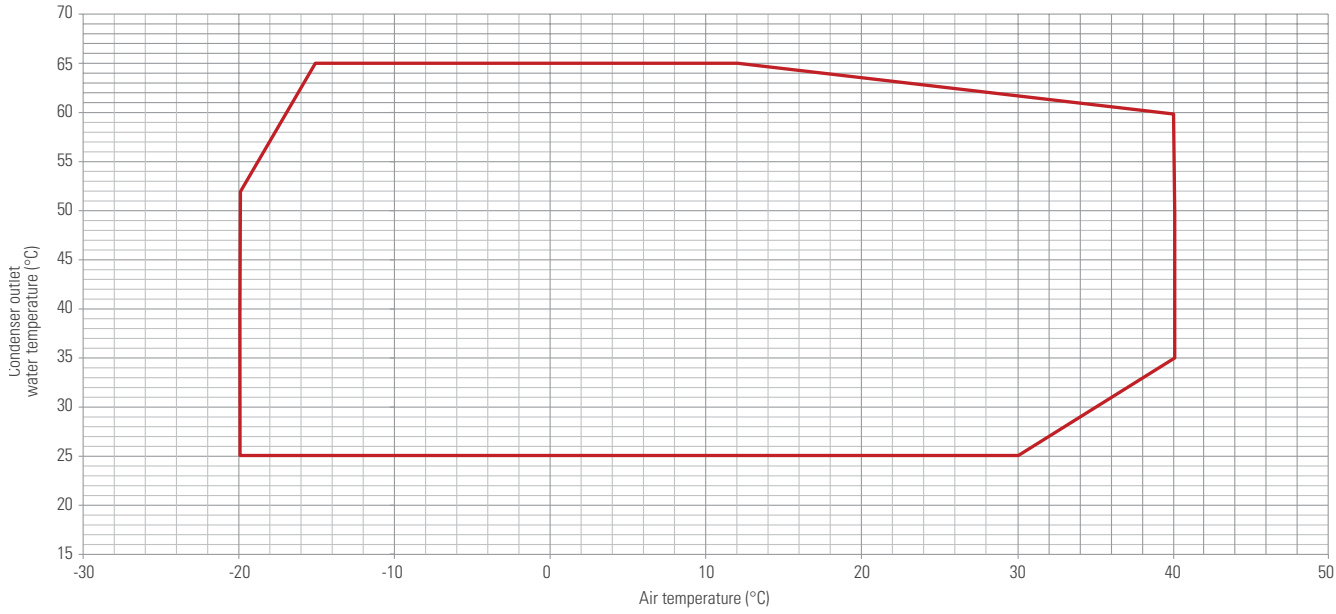
IS THE OPERATING ENVELOPE OF UNITS IN R452B, R454B AND R454C EQUAL TO R410A UNITS?

Yes, the operating range of units in R452B, in R454B and the corresponding units in R410A is wholly similar both in **Cooling only** and in **Reversible Heat Pump** operation. Further below is also reported the operating envelope of heat pump units with R454C refrigerant, which is more extensive.

R410A vs R452B and R454B unit envelope comparison



Envelope of R454C units



3

IS IT POSSIBLE TO REPLACE R410A WITH R452B OR R454B ON AN EXISTING UNIT?

No, the currently installed units do not have qualified components and CE certification in order to safely use group 1 A2L refrigerants, so the replacement on existing units is not authorised.
The new R452B and R454B refrigerants must be loaded by the manufacturer on new units with specifically qualified components to operate with these refrigerants.

ARE R452B AND R454B SUITABLE FOR APPLICATION IN HEAT PUMP UNITS AND FOR MULTIFUNCTIONAL UNITS? AND R454C?

Yes, R452B and R454B refrigerants are available for all of our aircooled and watercooled on/off multi-Scroll ranges **Cooling only, Reversible Heat Pump and Multifunctional 4-pipe unit**. Specific units are also available with Free-Cooling technology.
The R454C refrigerant instead has a specific field of application and is used in dedicated Heat Pumps.

ARE R452B, R454B AND R454C ALSO AVAILABLE ON UNITS WITH INVERTER COMPRESSORS?

Inverter compressors are available on R452B and R454B units only.

WITH COOLING CAPACITY BEING EQUAL, DO WEIGHT AND SIZE DIFFER BETWEEN UNITS IN R452B, R454B AND CORRESPONDING UNITS IN R410A?

No, units in R452B and R454B have similar weight and size to the corresponding units in R410A and the amount of refrigerant charged is the same.

3

WILL THE USE OF R452B, OF R454B OR OF R454C MAKE IT EASIER TO ACHIEVE THE EA C6 CREDIT "ENHANCED REFRIGERANT MANAGEMENT" OF THE LEED® CERTIFICATION?

LEED® (Leadership in Energy & Environmental Design) is a voluntary certification programme that can be applied to any type of building (both retail and residential) based on the entire life cycle of the building: from design to construction up to management.
LEED® promotes a sustainability-focused approach, recognising the performance of buildings in key sectors such as **energy and water saving**, **reduction of CO_2 emissions**, improvement of the environmental quality of interiors, materials and resources used, design and site selection.
LEED® is based on a list of requirements, grouped in 8 categories, some mandatory (called Pre-requisites) and other optional (called Credits), awarded with an assigned score. The sum of credits constitutes the achieved certification level: it ranges from Basic certification level up to Platinum certification level.

Categories

-	Integrative process	1 point
LT	Location and Trasportation	16 points
SS	Sustainable Sites	1 pre-requisite / 10 points
WE	Water Efficiency	3 pre-requisites / 11 points
EA	Energy and Atmosphere	4 pre-requisites / 33 points
MR	Material and Resources	2 pre-requisites / 13 points
EQ	Indoor Environmental Quality	2 pre-requisites / 16 points
IN	Innovation	6 points
RP	Regional Priority	4 points

Score

CERTIFIED
40-49 points

SILVER
50-59 points

GOLD
60-79 points

PLATINUM
80+ points

3

The impact of refrigerants is assessed within the "Energy and Atmosphere" category by ascertaining the *EA C6 Credit "Enhanced Refrigerant Management"* which, if positive, allows **1 Point** to be scored in the design Checklist.
The Credit requires all HVAC systems included in the design to comply with the following equation:

$$LCGWP + LCODP*10^5 \leq 13$$

Where:

LCGWP "Life cycle global warming potential" [kg CO_2/kW Year] = [GWPr * (Lr * Life + Mr) *Rc] / Life

LCODP "Life cycle ozone destruction potential" [kg CFC 11/(kW/Year)] = [ODPr * (Lr * Life + Mr) *Rc] / Life

GWPr "Global warming potential of the refrigerant" (from 0 to 12,000 kg CO_2 / kg of refrigerant)

ODPr "Ozone destruction potential of the refrigerant" (from 0 to 0.2 kg CFC11/ kg di refrigerant)

Lr "Annual refrigerant percentage loss" (2%)

Mr "Life-end refrigerant loss" (10%)

Rc "Specific refrigerant charge" (from 0.065 to 0.65 kg of refrigerant per kW of cooling capacity under AHRI conditions or EUROVENT standard)

Life "Equipment life" (10 years).

As an example, the following is a simulation carried out on a unit working with R410A also available with R452B and R454B refrigerants. Clearly shows that **only the units with R452B and R454B ecological refrigerants allow the LEED® credit to be achieved.**

		CHA/K/AF 906-P	CHA/G/AF 906-P	CHA/L/AF 906-P
Refrigerant		R410A	R452B	R454B
Refrigerant Charge	[kg]	70	70	70
Cooling capacity	[kW]	271	266	260
GWPr		1924	676	467
ODPr		0	0	0
Lr		2%	2%	2%
Mr		10%	10%	10%
Rc		0,26	0,26	0,27
Life		10	10	10
LCGWP	[kg CO_2/kW Year]	14,91	5,34	3,77
LCODP		0	0	0
LCGWP + LCODP		**14,91 >13**	**5,34 <<13**	**3,77 <<13**
RESULT		**NON COMPLIANT**	**COMPLIANT**	**COMPLIANT**

3

DO UNITS IN R452B, R454B AND R454C COMPLY WITH THE ERP REGULATIONS? ARE THEY EUROVENT CERTIFIED?

Yes, as for the corresponding units in R410A, the R452B and R454B ranges also comply with the European ErP regulations for Cooling only, Heat Pump and Multifunctional units.
Also the R454C Heat Pumps units comply with European ErP regulations and all ranges of the Clint catalogue are Eurovent certified.

R513A AND HFO-R1234ZE: FEATURES AND PERFORMANCES 4

FOR UNITS WITH SCREW AND TURBOCOR COMPRESSORS, G.I. INDUSTRIAL HOLDING HAS PRESENTED, FOR SOME TIME, THE LOW GWP R513A REFRIGERANT AS AN ALTERNATIVE TO R134a. WHAT ARE ITS FEATURES AND REQUIRED TECHNICAL MEASURES?

The R513A refrigerant, with GWP equal to 647, is a fluid mixture of HFO and HFC (composed of 44% R134a and 56% HFO-1234yf) in **A1 CLASS**, i.e. non flammable and non toxic. Therefore, it must be **handled exactly like R134a, also in A1 Class: there are no restrictions on its use, transport or installations**.
R513A is compatible with Cooling only, Reversible Heat Pump and Multifunctional 4-pipe applications and is particularly suitable as a replacement of R134a because it has very similar performance and efficiency (cooling capacity -2% and EER -1%) and requires the use of the same lubricating oil.
R513A, easily available on the market at rather low costs, is not suitable for retrofit operations on existing systems, but can be applied by the Manufacturer on new units as the components must be specifically validated.
As for the corresponding units in R134a, the R513A ranges also comply with European ErP regulations (some also ErP 2021) and all have EUROVENT certification.

FOR UNITS WITH SCREW AND TURBOCOR COMPRESSORS, G.I. INDUSTRIAL HOLDING HAS PRESENTED, FOR SOME TIME, THE HFO-R1234ze REFRIGERANT WITH GWP LESS THAN 1. WHAT ARE ITS FEATURES AND REQUIRED TECHNICAL MEASURES?

The HFO-R1234ze refrigerant, with GWP less than 1, is by far the refrigerant with the lowest GWP on the market. G.I. Industrial Holding presented it on specific ranges of watercooled liquid Chillers with Screw and Turbocor compressors. It is not a mixture but a pure fluid.
It is in **A2L CLASS** and, therefore, its handling requires the same precautions as other A2L Class refrigerants described above.
It should be noted, however, that unlike the R452B refrigerant, HFO-R1234ze belongs to 2 PED Group (according to EN378-3:2017) and has even lower flammability levels than R452B. In fact, it only becomes flammable at ambient temperatures above 30°C and at a very limited concentration interval (LFL equal to 7%, UFL equal to 12%).
The HFO-R1234ze refrigerant has a 20% lower performance (cooling capacity) and 1% higher efficiency (EER) compared to R134a. The ranges include watercooled liquid Chillers with Screw and Turbocor compressors specifically designed to operate with such refrigerant, therefore, retrofitting existing systems is not possible. The HFO-R1234ze ranges already comply with European ErP regulations and are EUROVENT certified.

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