Westfalen

Information for practitioners 5

Refrigerant selection guidelines.

An overview of the refrigerants of the future.

Helping you choose the right refrigerant.

You can rely on our expertise

Selecting the right refrigerant is not easy. Each has advantages and disadvantages which must be expertly weighed. In future it will also be necessary to assess a refrigerant's suitability for the intended application before using it.

In light of new regulations there is a need to replace refrigerants - even in existing systems– with new substances that are more environmentally friendly.

Here at Westfalen we have many years' experience working with refrigerants and are more than willing to help you to plan this or to switch over the refrigerants in your system.

Selecting the right refrigerant

Refrigerant is the driving force behind a cooling system. As it circulates it is evaporated, compressed, condensed and allowed to expand.

Heat is transferred by the refrigerant evaporating at low pressure in the part to be cooled, this heat being released to the outside when the refrigerant is compressed and condensed above ambient temperature.

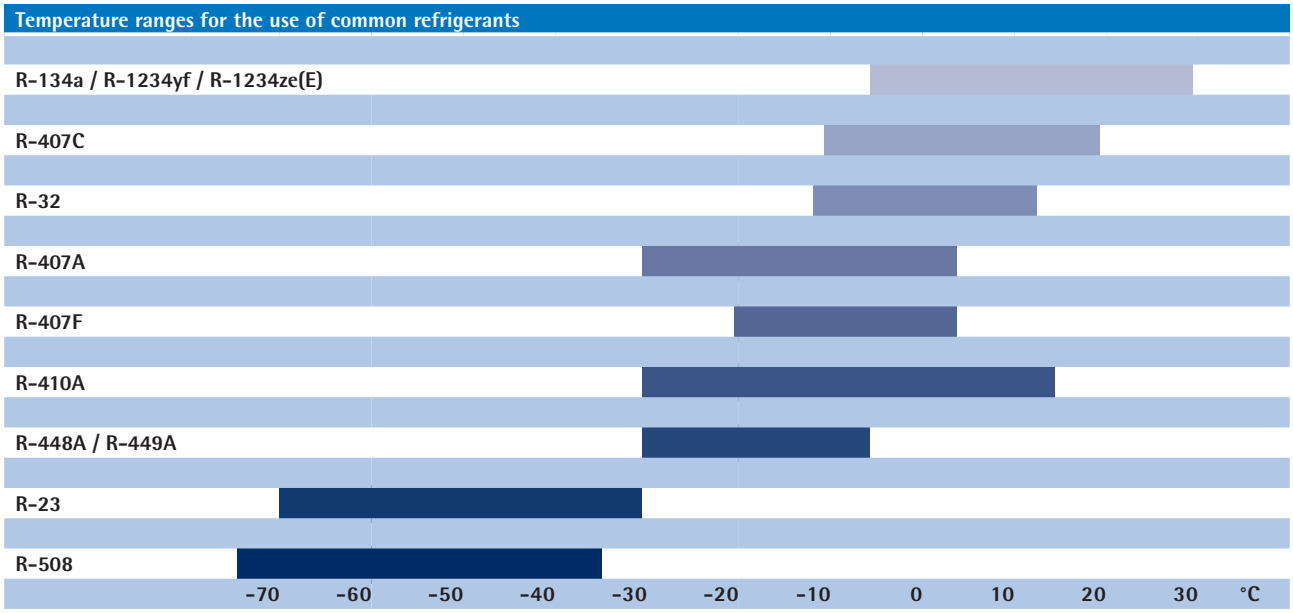
Choosing the right refrigerant has a significant impact on a refrigeration system's effectiveness, construction cost and energy consumption. A range of legislation and regulations need to be taken into account to ensure the refrigerant you select is also the best choice long-term. These guidelines will provide valuable support in selecting the right refrigerant.

The perfect refrigerant

In truth, there is no such thing as the perfect refrigerant for every application. The areas of application are simply too varied. Nevertheless modern refrigerants and some longer established ones can meet the most challenging requirements. For almost every area of application exists a practical solution that is intelligent, economical and environmentally friendly. Refrigerants should not be flammable, poisonous or corrosive and in addition should possess the following basic properties.

- Should mix well with oil
- Thermal and chemical stability
- High cooling and warming capacity for low energy input
- Good pressure ratio
- Low compression temperature
- Good price-performance ratio
- Compatible with materials commonly used in refrigeration technology

Environmental impact is also particularly important. Over the past few years, various national and international legislation, directives and regulations have already initiated an extensive change process that is having a significant impact on product selection and usage. The use of refrigerants with Ozone Depletion Potential (ODP) has been banned. Other refrigerants that significantly contribute to the Earth's greenhouse effect when released into the atmosphere are being tightly regulated and some taken off the market entirely.



Application ranges based on room temperature. The products listed are the most widely used refrigerants in commercial refrigeration technology - but this is by no means an exhaustive list.

System suitability: measurement bases

Selecting the right refrigerant depends on the intended usage and type of system.

The measurement bases for specific evaluation include:

- Suitability for the required temperature range
- Appropriate thermodynamic properties such as boiling point and specific heat capacity
- Suitable pressures
- Compatibility with machinery and other materials used
- Availability of suitable machine oil
- Availability of suitable connection technology
- High efficiency
- Sustainable compliance with applicable legislation and directives (lowest possible risk)

Cooling, air conditioning and heat pump systems have long service lives, often lasting many decades. Over this time the choice of refrigerant greatly influences energy consumption and a highly efficient refrigerant will yield considerable cost savings.

The potentially higher initial investment very quickly pays for itself. It is also worth taking into account the environmental aspects and associated legislative requirements. Selecting your refrigerant with sustainability in mind means you will avoid costly retrofits and legislative pitfalls.

Temperature ranges

Refrigerants need to be suitable for different temperature ranges depending on their application. The resulting evaporation temperature produces different evaporating pressures, which should not be below atmospheric pressure during system operation.

Even the smallest leak may allow air and moisture to enter the refrigeration circuit. As a general rule, the lower the evaporation pressure, the lower the volumetric refrigeration capacity. The compressor should therefore be correctly sized to achieve the required refrigeration capacity.

Low evaporation pressure, however, also means low condensing pressure. This increases the safety of the system and reduces the level of pressure protection required, which in turn allows the use of thinner-walled pipes and vessels, reduces the risk of leaks and potentially permits a lower classification in terms of pressure equipment directives and operational safety.

Big changes in the future refrigerant market.

Reduction in permitted CO_2 equivalents

Finding the right refrigerant for each application has been significantly impacted by new European regulations, notably (EU) 517/2014.

The main focus of this regulation is the gradual reduction of permitted CO_2 equivalents [in the form of fluorinated greenhouses gases (HFC)] up to the year 2030.

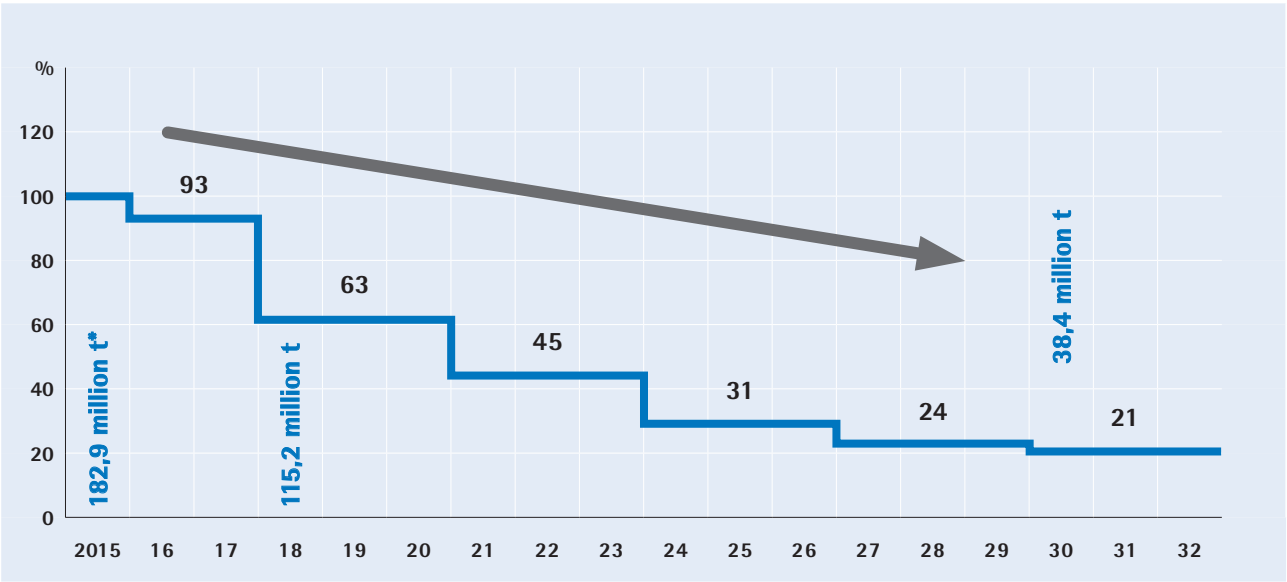
As shown in the equation:
CO_2 equivalent in tonnes = mass HFC x GWP*

(*GWP = Global Warming Potential = direct impact on the greenhouse effect when released into the atmosphere)

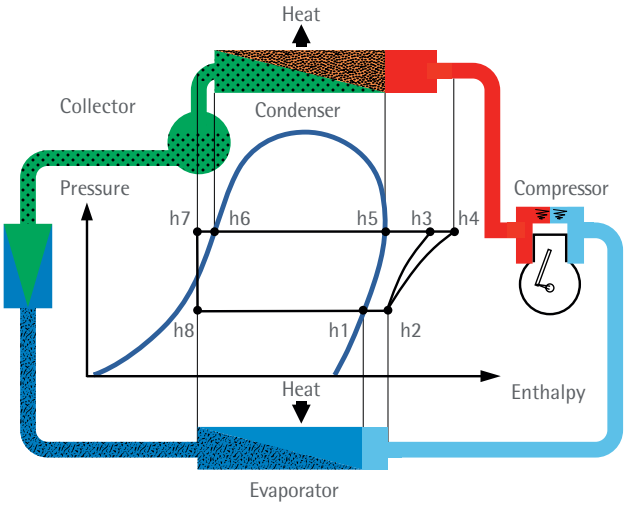
The refrigerant sector has two options: to reduce either the quantity of HFC refrigerant or the GWP of the refrigerants used.

Reductions in HFC refrigerants can be achieved with intelligent technical solutions, such as compact and permanently sealed systems, or by using refrigerants that do not act as HFCs in the equation, such as natural refrigerants or hydrofluoroolefin (HFO).

Manufacturers in the sector are offering various solutions for reducing GWP values. Replacing the refrigerant in existing systems should remain an option.



Reduction of permitted CO_2 equivalents in the form of fluorinated greenhouses gases (HFC).
*source: Cornelius Rhein, EU Commission

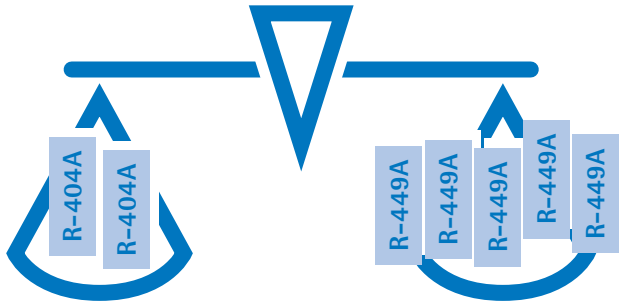


Example of a refrigeration circuit.

Falling GWP values: existing refrigerants replaced appropriately

The diagram shows a comparison of quantities having the same CO_2 equivalent.

CO_2 equivalent = mass · GWP



$70t\ CO_2 = \mathbf{18\,kg \cdot 3.9}\ \frac{t}{kg}$ $70t\ CO_2 = \mathbf{50\,kg \cdot 1.4}\ \frac{t}{kg}$

18 kg of refrigerant R-404A "weighs" the same as e.g. 50 kg R-448A or R-449A in CO_2 equivalents.

If 18 kg of R-448A or R-449A was used instead of R-404A, there would be a reduction of:

$$\mathbf{18\,kg \cdot 1.4}\ \frac{t}{kg} = 25.2t\ CO_2$$

This corresponds to a CO_2 equivalent reduction of 64%.

mbv stands for maximum burning velocity, the maximum propagation speed of the flame of a burning mixture of refrigerant and air.

Increase in flammability in future refrigerants

The recognisable problem for the future is this: falling GWP values mean increased flammability of individual refrigerants. For specialist refrigeration businesses this means that the flammability risks in using certain refrigerants in many applications and various installation conditions will need to be increased in tenders, offers, operating manuals etc.

There is currently a lot of momentum in the development and introduction of new synthetic refrigerants. However, this is not increasing clarity. The following information is oriented toward refrigerants that have been used in the past and in part toward those in use today and - above all - their priority applications.

Replacement of a refrigerant in an existing system is, however, limited to one having the same safety classification. Approval of compressor and component manufacturers should be checked prior to use.

High flammability	A3	B3
Low flammability	A2	B2
mbv ≤ 10 cm/s	**A2L**	**B2L**
Not flammable	A1	B1
	Low toxicity	High toxicity

Classification of refrigerants in terms of safety.

Overview of the most important refrigerants.

For use in deep-freeze systems

Refrigerant	GWP	Safety classification	Notes
R-404A	3,922	A1	Rapid replacement required
R-507	3,985	A1	Rapid replacement required
R-407A	2,107	A1	3 substance refrigerant blend with a pronounced temperature glide and significantly higher discharge temperature than R-404A / R-507
R-407F	1,825	A1	Manufacturer's designation: Performax® LT, otherwise as R-407A
R-448A	1,387	A1	Manufacturer's designation: Solstice® N40; 5 substance refrigerant blend, pronounced temperature glide, significantly higher discharge temperature than R-404A / R-507
R-449A	1,397	A1	Manufacturer's designation: Opteon™ XP40; 4 substance refrigerant blend, pronounced temperature glide, significantly higher discharge temperature than R-404A / R-507
R-452A	2,140	A1	Manufacturer's designation: Opteon™ XP44; 3 substance refrigerant blend, temperature glide, discharge temperature similar to R-404A / R-507; not recommended for stationary refrigeration systems due to its high GWP value particularly suited to refrigerated vehicles
R-454A	239	A2L	Manufacturer's designation: Opteon™ XL40, 2 substance refrigerant blend, pronounced temperature glide, significantly higher discharge temperature than R-404A / R-507
R-454C	148	A2L	Manufacturer's designation: Opteon™ XL20 (like R-454A)
R-455A	148	A2L	Manufacturer's designation: Solstice® L40X, 3 substance refrigeration blend with 3% CO_2

For use in plus cooling systems

Refrigerant	GWP	Safety classification	Notes
R-134a	1,430	A1	Medium-term replacement required. Cannot be used in new car air conditioning systems in the EU from 2017
R-450A	603	A1	Manufacturer's designation: Solstice® N13, 2 substance refrigerant blend, near-azeotropic, somewhat lower refrigeration capacity than R-134a
R-513A	631	A1	Manufacturer's designation: Opteon™ XP10, 2 substance refrigerant blend, azeotropic, similar refrigeration capacity to R-134a
R-1234yf	4*	A2L	Priority replacement for R-134a in automotive air conditioning systems. Can be used in stationary refrigeration technology, similar refrigeration capacity to R-134a
R-1234ze(E)	7*	A2L	Manufacturer's designation: Solstice® 1234ze(E), significantly lower refrigeration capacity than R-134a, defined as not flammable on safety data sheet; well suited to screw and turbo compressors

*GWP not recognised as part of the reduction in accordance with regulation (EU) 517/2014.

For use in air conditioning systems and heat pumps

Refrigerant	GWP	Safety classification	Notes
R-410A	2,088	A1	Replacement required, alternative with safety classification A1 not available
R-32	675	A2L	Already a component of many refrigeration blends; very high discharge temperature; highly efficient; favoured by leading manufacturers of heat pumps and low-powered air conditioning split systems
R-407C	1,774	A1	Developed as a replacement for R-22; almost completely superseded in this usage by R-410A; 3 substance refrigerant blend, pronounced temperature glide
R-447A	583	A2L	Manufacturer's designation: Solstice® L41, 3 substance refrigerant blend, pronounced temperature glide
R-454B	460	A2L	Manufacturer's designation: Opteon™ XL41, 2 substance refrigerant blend, small temperature glide

Use our consultancy services!
Do you have more questions about the use of refrigerants or other products and their areas of application? Just ask – our refrigerant experts will be only too happy to help!

More information at
westfalen.com

For use in low temperature cascade systems

Refrigerant	GWP	Safety classification	Notes
R-23	14,800	A1	Due to extremely high GWP values long-term availability is doubtful
R-170	6	A3	Hydrocarbon ethane; replacement for R-23 in small units
R-508A	13,214	A1	Like R-23; 2 substance refrigerant blend
R-508B	13,396	A1	Like R-508A
R-1150	4	A3	Hydrocarbon ethylene (ethene); higher working pressure than R-170

Hydrocarbons

Refrigerant	GWP	Safety classification	Notes
R-290	3	A3	Propane; very good thermodynamic properties, comparable with R-22; low discharge temperature; used in low-power systems and cold water or cold brine systems
R-600a	3	A3	Isobutane; widely used in domestic refrigeration; highly efficient but low volumetric refrigeration capacity
R-1270	2	A3	Propylene (Propene); like R-290 but with a higher working pressure, therefore more suitable for deep freeze applications

Inorganic natural refrigerants

Refrigerant	GWP	Safety classification	Notes
R-717	0	B2L	Ammonia (NH_3); has been successfully used in industrial refrigeration technology for over 150 years; high specific evaporation energy; high capacity for low refrigerant mass flow; very high discharge temperature; not compatible with copper or copper alloys, therefore can only be used with open design compressors
R-744	1	A1	Carbon dioxide (CO_2); increasingly important due to the regulation of fluorinated refrigerants; unfavourable triple point and high pressures; very large volumetric refrigeration capacity and good heat transfer properties; used in food retailing in cascade or transcritical systems

	R-23	R-32	R-116	R-125	R-134a	R-143a	R-1234yf	R-1234ze	R-744
R-404A				44 %	4 %	52 %			
R-407A		20 %		40 %	40 %				
R-407C		23 %		25 %	52 %				
R-407F		30 %		30 %	40 %				
R-447A		68 %		3.50 %				28.50 %	
R-448A		26 %		26 %	21 %		20 %	7 %	
R-449A		24.30 %		24.70 %	25.70 %		25.30 %		
R-450A					42 %			58 %	
R-452A		11 %		59 %			30 %		
R-454A		35 %					65 %		
R-454B		68.90 %					31.10 %		
R-454C		21.50 %					78.50 %		
R-455A		21.50 %					75.50 %		3 %
R-507				50 %		50 %			
R-508A	39 %		61 %						
R-508B	46 %		54 %						
R-513A					44 %		56 %		

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