GUIDELINE

Last update: September 2024

Components for Systems Using Flammable Refrigerants

1 Purpose

The purpose of this guideline is to provide common interpretation of the demands to and application of components in vapour compression systems using flammable refrigerants within the framework of the RACHP standards in the EU. As flammable refrigerants play a big role in the phase down of HFC refrigerants this guideline will facilitate the design of low GWP systems.

2 Scope

This guideline is valid for the components comprising a vapour compression system - using flammable refrigerants - i.e. valves, heat exchangers, compressors and other mechanical, electronic and electro-mechanical controls. This guideline covers only components for systems to operate in non-hazardous areas i.e. non ATEX areas, see Figure A1. It should be noticed that vapour compression systems serve in a broad variety of applications which may be designed for operation under special conditions. This guideline will only cover the main stationary applications which can be found in the ANNEXES 1-6

3 Definitions

Refrigeration, air conditioning and heat pump systems
combination of interconnected refrigerant-containing parts constituting one closed circuit in which the refrigerant is circulated for the purpose of extracting and delivering heat (i.e. cooling and heating). For simplicity only the term refrigerating system is used as common phrase hereafter.

Self-contained system
complete factory-made system which is in a suitable frame or casing, is fabricated and transported complete or in two or more sections, can contain isolation valves and in which no refrigerant-containing parts are connected on site.
Monoblock systems are considered as compact hermetically sealed self-contained systems but not exactly defined in any regulatory or standard text.

Split system
system consisting of a number of refrigerant piped units that form a separate but interconnected unit, requiring the installation and connection of refrigerant circuit components at the point of use.

Ventilated enclosure
separate enclosure containing a system, or parts thereof, typically used inside a building and as a mean to avoid a flammable atmosphere in the building by control of a ventilation rate.

Sealed system (equivalent to hermetically sealed systems)
refrigerating system in which all refrigerant containing parts are made tight by welding, brazing or a similar permanent connection which may include capped valves and capped service ports that allow proper repair or disposal, and which have a tested leakage rate of less than 3 grams per year under a pressure of at least a quarter of the maximum allowable pressure.

Note 1 to entry: Joints based on mechanical forces which are prevented from improper use by the need of a special tool are considered as a similar permanent connection.

Component
individual functional item of a refrigerating system.

Refrigerant
fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure usually involving changes of the aggregate state of the fluid.

Flammable refrigerant
refrigerant with a flammability classification of Class 2L, Class 2 or Class 3 in accordance with ISO 817.

Lower flammability limit LFL
minimum concentration of refrigerant that is capable of propagating a flame within a homogeneous mixture of refrigerant and air.

Operator
the natural or legal person exercising actual power over the technical functioning of refrigerating systems.

4 Regulatory frames and standards, introduction

Risk analysis is a central element in safety standards, regulations and directives. Safety standards build on a sum of experience and to some extend theoretical risk assessment, even though a specific risk assessment procedure is not a part of those standards. This results in boundaries for operating conditions of refrigerating systems- including service and design.

4.1 EN Safety Standards

Harmonised standards are the preferred way to comply with the EU safety directives, such as the Pressure Equipment Directive 2014/68/EU, the Low Voltage Directive 2014/35/EU, and the Machinery Directive 2006/42/EC. They are however not the only way, as it is allowed for manufactures to replace parts or all of a standard with a risk assessment. There are a number of system safety standards for stationary RACHP systems. These can be grouped by how broad a market segment they cover. The horizontal standard (also known as group safety standard) covers a wide range of products while the vertical standard (also known as product safety standard) only covers a specific product type. See Table 2.

The international standard ISO 5149 is a horizontal system safety standard very similar to the EU standard EN 378. During the last years text pieces have migrated from ISO 5149 to EN 378 and vice versa. Similar, the International IEC 60335 series of standards are comparable to the EN 60355 standards series.

The system safety standards for RACHP equipment sets a number of requirements for systems using flammable refrigerants.

The requirements can be categorized into requirements for:

- Competences of people working with the system.
- Charge size limits to minimize the impact of worst-case leakage incidents.
- Avoiding hot surfaces, to avoid ignition or decomposition of leaked refrigerant.
- Avoiding ignition sources beyond hot surface, to avoid ignition of leaked refrigerant.

Table 1: Maximum surface temperatures

Refrigerant	Auto-ignition temperature (°C)	Maximum system surface temperature in EN standards (°C)	Maximum surface temperature (ex-system) in machine room in EN 378-2:2016 (°C)
R-32	648	548	548
R-170	515	415	415
R-290	470	370	376
R-600a	460	360	368
R-1234yf	405	305	324
R-1234ze(E)	368	268	294
R-1270	455	355	364

The requirements on competences of people are generally regulated by the certification required by the EU F-gas regulation (article 10) and as a delegated act which will be developed in 2024. Article 10 describes that the certification now also involves *relevant* alternatives to fluorinated refrigerants including natural refrigerants. The ATEX "Workplace" Directive also requires a sufficient level of competence when working with flammable substances, so even though the EU F-gas regulation would not cover all flammable substances, there is a legal requirement for personnel to be competent.

The standard EN ISO 22712:2023 describes the competences needed for relevant personnel in the different phases of the lifecycle of the refrigerating equipment, from design and commissioning, to operation, to service and decommissioning, including flammable refrigerants. This standard replaced the EN 13313:2010.

The system safety standards describe a set of rules for refrigerant charge and are only valid within the charge limits they prescribe. The charge limit depends on system architecture, location of the system, who has access to the system and sometimes also the purpose of the system. The charge limits do not set requirements on components. Table 2. gives an overview of the European system safety standards.

Table 2: European and other relevant system safety standards

EN IEC 60335-2-11:2022 + A11:2022	Household and similar electrical appliances – Safety – Particular requirements for tumble dryers	Currently defines rules for up to 150 g of flammable refrigerant. Copies IEC 60335-2-11:2019 with minor modifications related to EU legislation. The general policy is to adopt latest IEC version with minor modifications.
EN IEC 60335-2-24:2022 + A11:2022	Household and similar electrical appliances – Safety – Particular requirements for refrigerating appliances, ice-cream appliances and ice makers	Currently defines rules for up to 150 g of flammable refrigerant. Copies IEC 60335-2-24:2020 with minor modifications related to EU legislation. The general policy is to adopt latest IEC version with minor modifications.
EN 60335-2-40:2003 +A13:2013	Household and similar electrical appliances – Safety – Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers	Charge limits depend on refrigerant type and system architecture. Derived from the 2002 version of IEC 60335-2-40 with amendments. Process is ongoing to update the EN standard based on the IEC 2022 and harmonise it. The current defines rules up to 130×LFL (4940g R290 or 39.8kg of R32), although for most indoor units the rules are only defined up to 26×LFL (988g R290 and 3.4kg R32).
EN 60335-2-75:2004+A12:2010	Household and similar electrical appliances - Safety - Part 2-75: Particular requirements for commercial dispensing appliances and vending machines	Uses other standards limits for refrigeration system for example EN IEC 60335-2-24 or EN IEC 60335-2-89
EN IEC 60335-2-89:2022+A11:2022	Household and similar electrical appliances – Safety – Particular requirements for commercial refrigerating	The harmonised EN standard is based on the IEC 60335-2-89:2019 and amendment A11 from 2022 with minor modifications related to EU legislation. Currently defines rules up to 13×LFL (494g R290) for A3 and 1.2 kg for A2L

	appliances and ice makers with an incorporated or remote refrigerant condensing unit or compressor	
EN 378:2016	Refrigerating systems and heat pumps — Safety and environmental requirements	Charge limits depend on system architecture, location of the system, who has access to the system and the purpose of the system.
EN 50570:2013+A1:2018	Household and similar electrical appliances – Safety – Particular requirements for commercial electric tumble dryers	Currently allows 150 g of flammable refrigerant.
ISO 20854:2019	Thermal containers – Safety standard for refrigerating systems using flammable refrigerants – Requirements for design and operation	The standard describes how to do risk assessment of refrigerated cargo containers. It does not prescribe specific limits to refrigerant charge amount, and most requirements are related to what needs to be considered in the risk assessment. No EN version is planned.
EN 17893:2024	Thermal Road Vehicles – Safety Standard for temperature-controlled systems using flammable refrigerants for the transport of goods – Requirements and risk analysis process	The standard describes how to do risk assessment of refrigerated cargo vehicles. It does not prescribe specific limits to refrigerant charge amount, and most requirements are related to what needs to be considered in the risk assessment.
IEC 60335-2-118:2021	Household and similar electrical appliances – Safety – Particular requirements for professional ice-cream makers	Requirements for professional ice-cream makers with non-flammable refrigerants. No EN version is published. Requirements for flammable refrigerants are expected to be included in next revision based on IEC 60335-2-89:2019.

European system safety standards generally regulate hot surfaces separately from other ignition sources. In the EN standards the requirement is that surfaces in the system which may come into contact with leaked refrigerant has to be 100 K below the auto-ignition temperature of the flammable refrigerant (EN 378-2, EN IEC 60335-2-11, EN IEC 60335-2-24, EN 60335-2-40, EN IEC 60335-2-89). This is tougher than the requirements of ATEX, which would only require surfaces to be below the auto-ignition temperature. The maximum surface temperatures for selected refrigerants are given in Table 1. In practice there are very few components which can become hot enough for this requirement to be relevant.

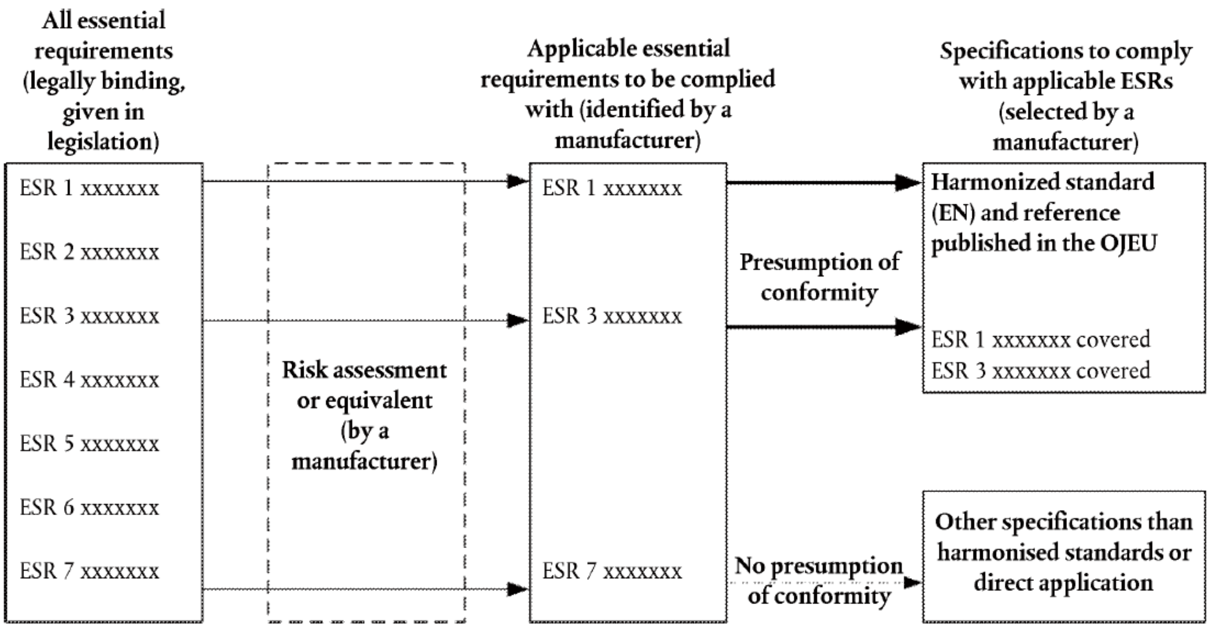
4.2 Risk assessment options

In the EU legislative system, product safety starts with a risk assessment, identifying the relevant risks and the relevant essential health and safety requirements (ESRs) in the safety legislation.

Following a harmonised standard gives the manufacturer a right to presume conformity with the ESRs that the standard is harmonised towards. A harmonised standard normally covers all the ESRs relevant for a given product type within a specific safety directive or regulation, which is why it is common to refer to harmonised standards as being harmonised with a given safety directive or regulation.

Although harmonised EN standards are the preferred way of complying with ESRs, it is also possible to follow “other specifications than harmonised standards”, see Figure 1. This approach is normally called the risk assessment approach, not to be confused with the risk assessment identifying risks and relevant ESRs.

Doing a detailed risk assessment on all safety aspects from scratch infers a risk of overlooking potential risks, and therefore the approach is usually limited to a single aspect of an application. Often the risk assessment is based on complying with a non-harmonised standard, i.e. a risk assessment showing that this non-harmonised standard is appropriate for addressing the risks in the application or for a particular product. An example could be following the latest IEC 60335-2-40, even before it gets adopted in the EU as EN IEC 60335-2-40 and gets harmonised.



(ESR means Essential Requirements)

Figure 1: EU legislative system for products according to the EU Blue Guide

Most refrigeration equipment falls under the scope of the Machinery Directive MD 2006/42/EC, being replaced by the Machinery Regulation EU 2023/1230. Under this directive / regulation, refrigeration equipment and systems, specifically those using flammable refrigerants, must undergo a fire and explosion risk assessment to ensure safety.

The harmonized standards EN 378-2, EN IEC 60335-2-89 and EN 60335-2-40 with the machinery directive 2006/42/EC, provide specific requirements to render the equipment safe. These standards are going to be harmonized with the new Machinery Regulation EU 2023/1230.

5 Demands on components

Standards are not by default aligned, harmonised or well written. This can create confusion in the market and the result may be an overreaction to the demands for components. One example could be a system builder who cannot make a clear interpretation of requirements for ignition sources in a standard. It may then result in a requirement of a 'safe' but unnecessary high specification which often is the ATEX certification. This is of course not a viable way to proceed.

A qualified component for a flammable refrigerant complies with relevant 'non-flammable' requirements and further:
(1) Possible higher PED classification
(2) Ensured lowest surface temperatures below prescribed ignition temperature if relevant
(3) Ensured by design or installation specification that it is a non-ignition source

Systems with flammable refrigerants can use components qualified for the specific flammable refrigerant. Component manufacturers must specify application ranges and specific approvals like e.g. ATEX. Though, the manufacturer of the system is responsible for designing a safe system, and systems must be designed, installed and serviced according to the demands in the safety standards and the local regulations.

5.1 EN Standards

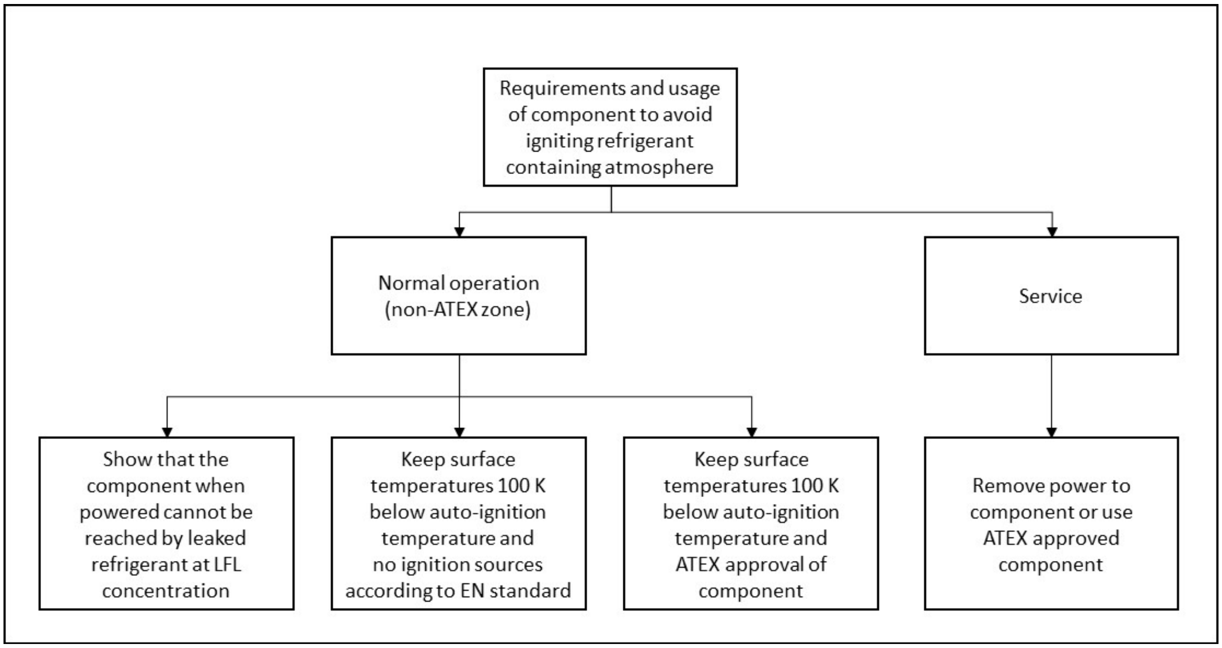


Figure 2: Requirements for components to avoid ignition of refrigerant containing atmosphere

European system safety standards set requirements on avoiding ignition of leaked refrigerant. The requirements in the system safety standards which are specifically relevant for components for flammable refrigerants, are the requirements on maximum temperatures of hot surfaces and the requirements to avoid ignition sources.

To summarise, there are 3 different approaches in the EN standards to avoid ignition of leaked refrigerant, see Figure 2.

European system safety standards set a maximum allowed surface temperature of components when they are used for flammable atmosphere, see Table 2. for the specific temperatures. Most components are not able to approach these temperatures, but for electrical heaters special precautions may be needed to limit the maximum temperature or ensure that leaked refrigerant cannot reach the hot surface.

The requirement to avoid other ignition sources than hot surfaces only apply to components which are reputed to create arcs and sparks (electronic or electro-mechanical components) and are placed where they can be reached by leaked refrigerant. The standards have specific test procedures to determine where this is.

It is possible to introduce mitigating measures e.g. place electronic controllers in a box or similar, so it cannot be reached by the leaked refrigerant. Again, it is the responsibility of the system manufacturer to ensure that the electronic controller is placed where the component manufacturer specifies.

In case components in a refrigerating system are placed where they can be reached by leaked refrigerant according to the test in the relevant system safety standard, it is required to prove that the component does not have ignition sources. As mentioned above the system safety standards generally refer to specific selected clauses of EN IEC 60079-15, a standard harmonised with ATEX,

When European system safety standards set requirements to avoid other ignition sources, they are going beyond the requirements of ATEX. System safety standards assume a larger potentially flammable gas cloud than ATEX does and accordingly have strict location and occupancy demands. It means also they have less requirements for proving that a system has no ignition sources (other than hot surfaces). For instance EN IEC 60335-2-89 refers to clauses from EN IEC 60079-15:2019, however not all as it excludes and modifies some clauses. There are three aspects where the system safety standards are more relaxed than ATEX:

- The disconnection of plugs on components is generally not considered to be normal operation in system safety standards.
- The required resistance to impact is lower than required by ATEX as most components are considered to be protected from impacts
- Components generally do not need to be IP54 if they are protected by an enclosure. (For ATEX approval IP54 is one of the mandatory requirements).

5.2 Requirements from the ATEX and PED directives

Only equipment and components which need to remain powered during a service situation, i.e. emergency lighting, alarms, gas detectors and the emergency ventilation in machinery rooms, need to be approved for use in ATEX zone 2. For the ventilation only the components in the leak affected air-stream need to be approved. See also Annex 1

> Under ATEX a rule of thumb is that leaks happening less than once per year are too infrequent to justify defining an ATEX zone, and when a leak occurs the ATEX standard EN IEC 60079-10-1 will usually assume the hole has a size of no more than 0,1 mm^2 (for a DN50 pipe). By contrast the frequency of large leaks in refrigerating systems is much less than once per year, and the system safety standards typically assume the hole is large enough to leak the whole refrigerant charge in 4 minutes.

It is however common practice for component manufactures to use ATEX approval of those components to prove that there are no ignition sources. This approval is going beyond the requirements of the safety standards, but can be a pragmatic solution for some products, for instance pressure and temperature switches.

The PED directive (see Annex 8) will categorise the component depending on pressure, size and fluid type. Depending on the category different demands on design and material certification have to apply.

5.3 Risk assessment option

The timing of adaption of standards like IEC versus EN standards makes it reasonable to apply the latest and often most progressive IEC standard even before the standard is harmonised in the EU.

Here it is especially worth mentioning that recent changes to IEC standards for A2L refrigerants and draft EN standards can be applied to components and systems, even though these standards are not yet available as harmonised EN standards. For example, to prove that a component cannot ignite A2L refrigerants or allowing higher maximum surface temperatures.

Though, to use these not yet harmonised standards it is necessary to do a risk assessment to show that the requirements adopted are appropriate for the specific component or application.

6 Requirements on components used as a mitigation measure

Mitigating components ensure that flammable atmospheres are detected and mitigated before reaching LFL levels in occupied space or machine rooms. By ensuring these mitigation measures flammable atmospheres are prevented. Components that can function as mitigation instruments are typically:

- Shut-off valves referenced from IEC 60335-2-40.
- Gas detectors referenced from IEC 60335-2-40, EN 378, and ISO 5149.

- Ventilation fans and circulation air flow fans.

The specific demands for mitigating components are rarely different to other components, see again Figure 2. However, IEC 60335-2-40 is considering having special seat leakage demands for safety shut-off valves for sectioning or partitioning systems.

7 Bibliography

Non-binding guide to good practice for implementing the European Parliament and Council Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres, Directorate-General for Employment, Social Affairs and Inclusion (European Commission), 2005, ISBN: 92-894-8721-6.

ATEX “Workplace” directive, Directive 1999/92/EC of the European Parliament and of the council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

ATEX “Equipment” directive, Directive 2014/34/EU of the European Parliament and of the council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast)

Machinery Directive, Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on the machinery, and amending Directive 95/16/EC

Machinery Regulation (EU) 2023/1230 of the European Parliament and of the Council of 14 June 2023 on machinery replaces Machinery Directive 2006/42/EC

Pressure Equipment Directive, Directive 2014/68/EU 15 May 2014 of the European Parliament and the council of 15 May 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment

Low Voltage Directive, Directive 2014/35/EU of the European Parliament and of the council of 26 February 2014

F-Gas regulation: Regulation (EU) 2024/573 of the European Parliament and of the Council of 7 February 2024 on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014

EN 60079-2:2015 Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p" (IEC 60079-2:2014)

EN IEC 60079-10-1:2021 Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres (IEC 60079-10-1:2020)

EN IEC 60079-15:2019 Explosive atmospheres - Part 15: Equipment protection by type of protection "n" (IEC 60079-15:2017)

EN 1127-1:2019 Explosive atmospheres - Explosion prevention and protection, Basic concepts and methodology

EN 378-1:2016, EN 378-2:2016, EN 378-3:2016, EN 378-4:2016, Refrigeration Systems and Heat Pumps – Safety and Environmental Requirements.

EN 50570:2018, Household and similar electrical appliances – Safety – Particular requirements for commercial electric tumble dryers

EN IEC 60335-2-11:2022, Household and similar electrical appliances – Safety – Part 2-11: Particular requirements for tumble dryers

EN IEC 60335-2-24:2010, Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers

EN 60335-2-40:2013, Household and similar electrical appliances – Safety – Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers

EN 60335-2-75:2010 Household and similar electrical appliances - Safety - Part 2-75: Particular requirements for commercial dispensing appliances and vending machines

EN IEC 60335-2-89:2022, Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor

IEC 60335-2-11:2019, Household and similar electrical appliances – Safety – Part 2-11: Particular requirements for tumble dryers

IEC 60335-2-24:2020, Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers

IEC 60335-2-89:2019, Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor

IEC 60335-2-40:2022, Household and similar electrical appliances – Safety – Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers

IEC 60335-2-118:2021, Household and similar electrical appliances – Safety – Part 2-118: Particular requirements for professional ice-cream makers

ISO 20854:2019, Thermal containers — Safety standard for refrigerating systems using flammable refrigerants — Requirements for design and operation

ISO 22712:2023, Refrigerating systems and heat pumps — Competence of personnel

ANNEX 1: Example of a R290 Chiller

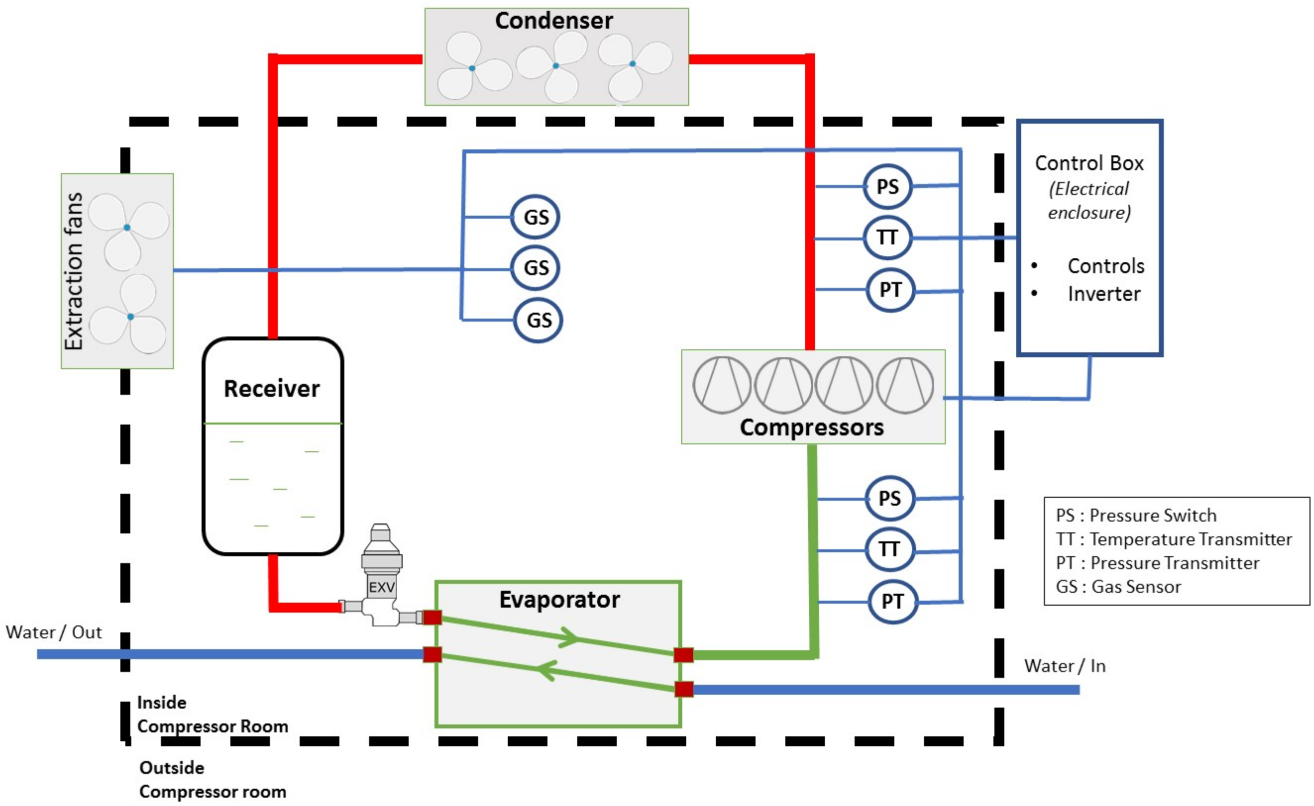


Figure A1

The above Figure A1 shows a typical R290 chiller layout, and this annex briefly explains the design choices of components for a specific chiller regarding avoiding ignition of leaked refrigerant.

The purely mechanical components are not considered to be potential ignition sources, but to be sure they have been checked against the potential ignition sources listed in Annex K of EN 378-2:2016.

The electrical components can be proved not to be ignition sources in various ways, but in this specific case the choice has been: (see also Figure 2)

Show that the component cannot be reached by leaked refrigerant	**No ignition sources according to EN standard**	**ATEX approval of component**
Controls	EXV	Pressure switch
Inverters	PT & TT transmitters**	PT & TT transmitters **
	Compressors	Gas sensor
	Crankcase heater for compressors	

** P and T-transmitters often are selected with ATEX approval as this may be the most favourable commercial decision. In principle transmitters are not recognised as ignition sources.

The choice of placing controls and inverters outside the refrigerating system compartment was made partly to allow easy access by technicians and partly to avoid the risk of igniting refrigerant. Had the inverter been mounted on the compressor, then the inverter could have been approved by applying a risk assessment e.g. IEC 60335-2-40, be ATEX approved or being placed in a pressurised ventilated enclosure EN 60079-2.

ANNEX 2: Example of a split and multi split AC including reversible system

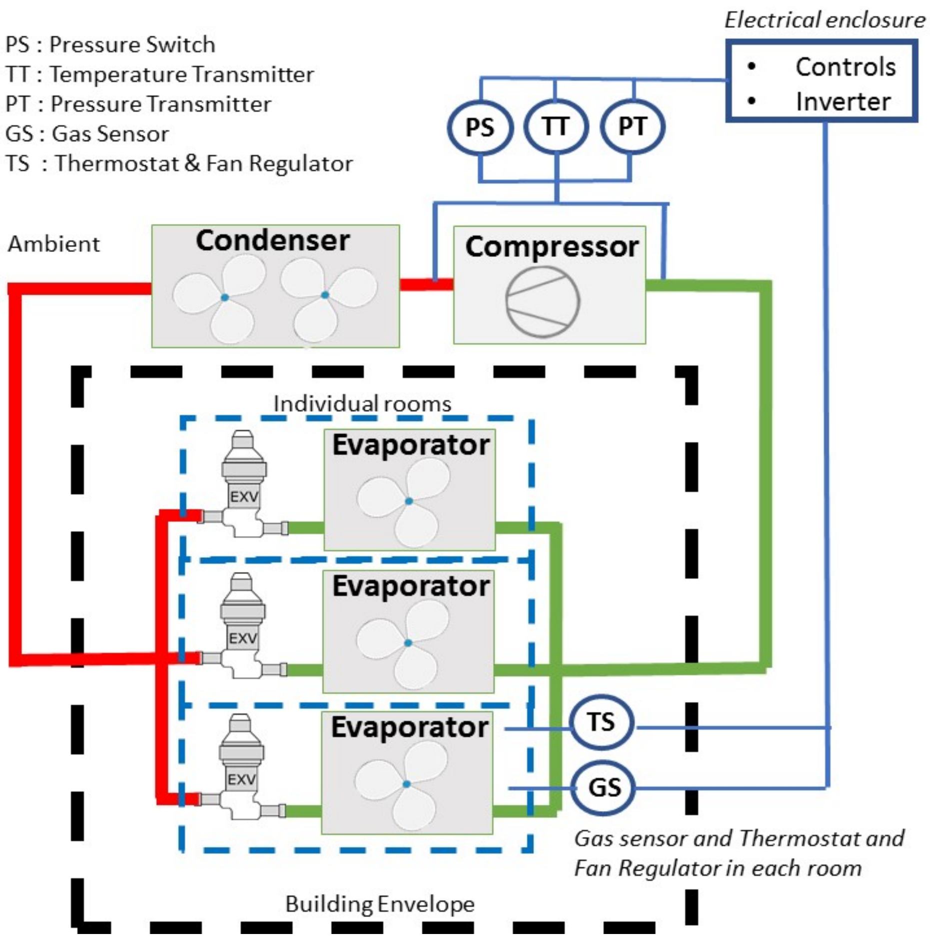


Figure A2

The above Figure A2 shows a typical multi-split AC layout, and this annex briefly explains the design choices of components for a specific system regarding avoiding ignition of leaked refrigerant. Demands on the system design and the installation (room size and placing of the evaporator) will ensure that components just follow the diagram in Figure 2.
The purely mechanical components are not considered to be potential ignition sources, but to be sure they have been checked against the potential ignition sources listed in Annex K of EN 378-2:2016.
The electrical components can be proved not to be ignition sources in various ways, but in this specific case the choice has been: (see also Figure 2).

Show that the component cannot be reached by leaked refrigerant	**No ignition sources according to EN standard**	**ATEX approval of component**
Controls	EXV	Pressure switch
Inverters	PT & TT transmitters**	PT & TT transmitters**
	Compressors	Gas sensor
	Crankcase heater for compressors	

** P and T-transmitters often are selected with ATEX approval as this may be the most favourable commercial decision. In principle transmitters are not recognised as ignition sources.

The choice of placing controls and inverters outside the building envelope was made partly to allow easy access by technicians and partly to avoid the risk of igniting refrigerant. Had the inverter been mounted on the compressor and the refrigerant been a flammable refrigerant, then the inverter would probably have been approved by applying a risk assessment and e.g. IEC 60335-2-40.

ANNEX 3: Example of a self-contained commercial refrigeration appliance

Description of typical self-contained commercial refrigeration appliance (factory charged and sealed)

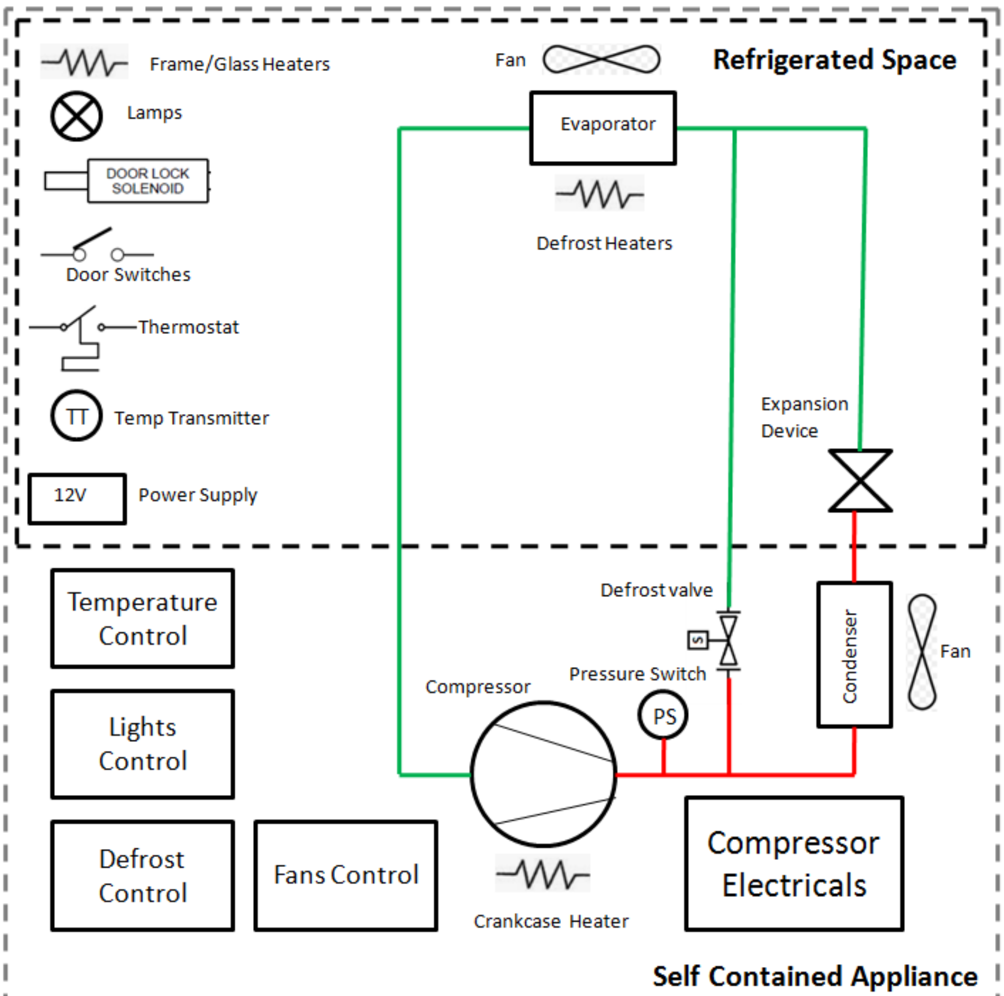


Figure A3

A self-contained appliance is designed to work alone and so should be equipped with all the control and security system needed. In such appliances, distinct types of evaporation systems can be used. One defined as a protected system, with an indirect exchange. And the one studied in this document with a direct exchange, which can be judged as the most critical.

The self-contained appliances, both household or commercial, are covered by relevant product safety standards as mentioned before in this document. The three main ones are: EN 60335-2-24 covering household appliances, EN 60335-2-89 that covers commercial applications (including those with a remote condensing unit), and IEC 60335-2-118 that covers professional ice-cream makers. Other similar standards like EN 60335-2-11 (tumble driers) and EN 60335-2-75 (dispensing appliances and vending machines) are using e.g. EN 60335-2-24 for the refrigerating systems.

All standards (EN IEC 60335-2-11, -2-24, -2-75, and -2-89) require the appliance to be designed to avoid any fire or explosion hazard in event of refrigerant leakage from the cooling system. Components must be placed where concentration of leaked refrigerant cannot reach the flammability limit, or they may not be ignition sources.

ANNEX 4: Example of a remote condensing unit in commercial refrigeration

The Figure A4 shows a typical condensing unit (remote system) used in refrigeration which could be connected to a refrigerated cold room or display cabinets in a supermarket.

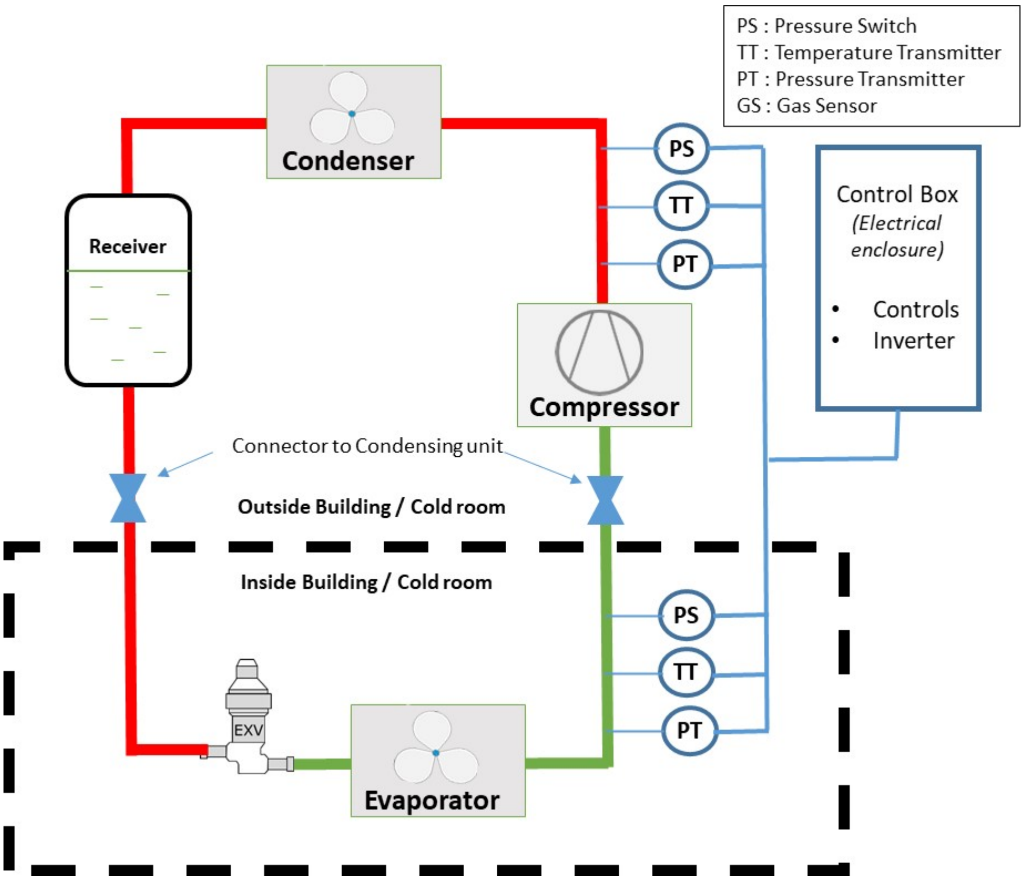


Figure A4

Refrigerating systems using remote condensing units having a charge below or equal to 150g of flammable refrigerant fall under the scope of the standard EN IEC 6335-2-89:2022. Above this limit, EN378 is the applicable standard. This standard sets the charge limit as a function of the LFL, the location, the accessibility, and the indoor space area where the unit is installed. In this case a safety risk analysis shall be elaborated for the complete unit, which includes the evaporator unit.

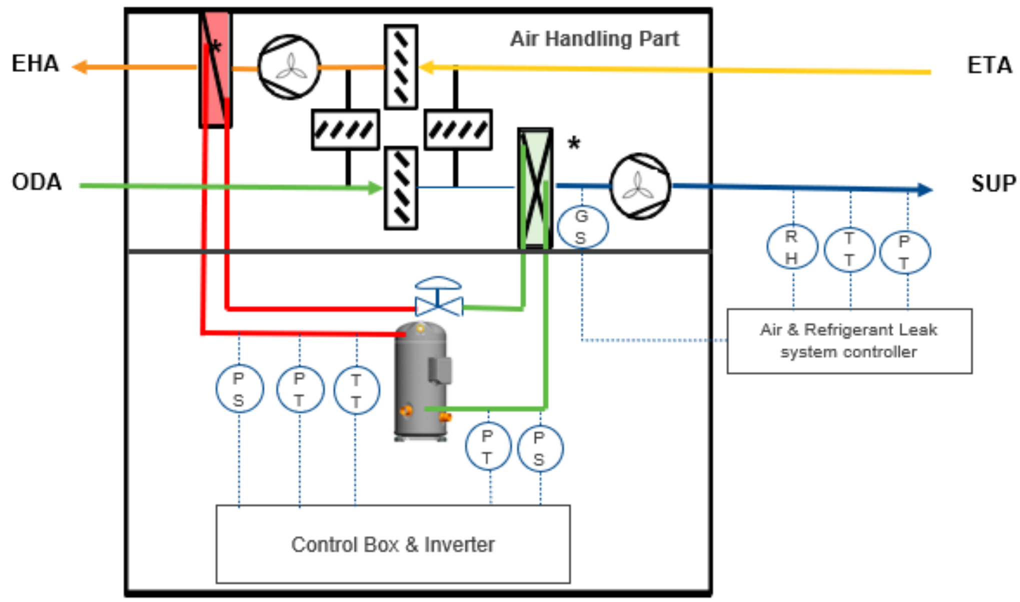
The condensing unit shall be designed to avoid any fire or explosion hazards in the event of refrigerant leakage. This can be accomplished for example by reducing the probability of the leakage using only hermetically sealed joints and ensure that components just follow the diagram in Figure 2.

Show that the component cannot be reached by leaked refrigerant	No ignition sources according to EN standard	ATEX approval of component
Controller	PT & TT transmitters**	PT & TT transmitters**
	Compressors	Pressure switch
	Crankcase heater for compressors	Gas sensor

** P and T-transmitters often are selected with ATEX approval as this may be the most favourable commercial decision. In principle transmitters are not recognised as ignition sources.

Alternatively, the electrical components mounted inside the controller shall be assessed against the risk of ignition of the refrigerant leakage, e.g. by using a restricted breathing enclosure as in EN IEC 60079-15.

ANNEX 5: Example of a rooftop ducted equipment



ODA: Outdoor air entering the unit
SUP: Supply Air
ETA: Extract air leaving the heated/cooled area
EHA: Exhaust air (leaving the air handling unit to the outdoor)

Figure A5

The above Figure A5 shows a typical rooftop heat pump and/or rooftop air conditioner with 2/3/4 damper.
In case of using A2L refrigerants, the unit falls under ducted systems and it is covered by IEC 60335-2-40:2022. The requirement for the charge limits, room size, leak detector and fan operation modes are covered by the standard. The harmonised standard EN 60335-2-40 is under revision for alignment with IEC 60335-2-40:2022. See the section 5.4 for the risk assessment.
In case of using flammable refrigerants, the rooftop unit although installed outdoor is classified as indoor. This is because in case of evaporators leaks, the refrigerant flows into the occupied space. The charge of R290 per refrigerating circuit is limited to 988 g for equipment falling under the scope of IEC 60335-2-40:2022.
The appliance shall be designed to avoid any fire or explosion hazard in event of refrigerant leakage from the cooling system. Components must be placed where concentration of leaked refrigerant cannot reach the flammability limit, or they may not be ignition sources according to the EN standards as referenced in Table 2.
Similarly, the control box and the inverter shall be positioned in an area where concentration of leaked refrigerant cannot reach the flammability limit or must be designed to protect the components source of ignition from an explosive atmosphere using for example the protection methods set in EN 60079-2.

ANNEX 6 : Example of a ventilated enclosure

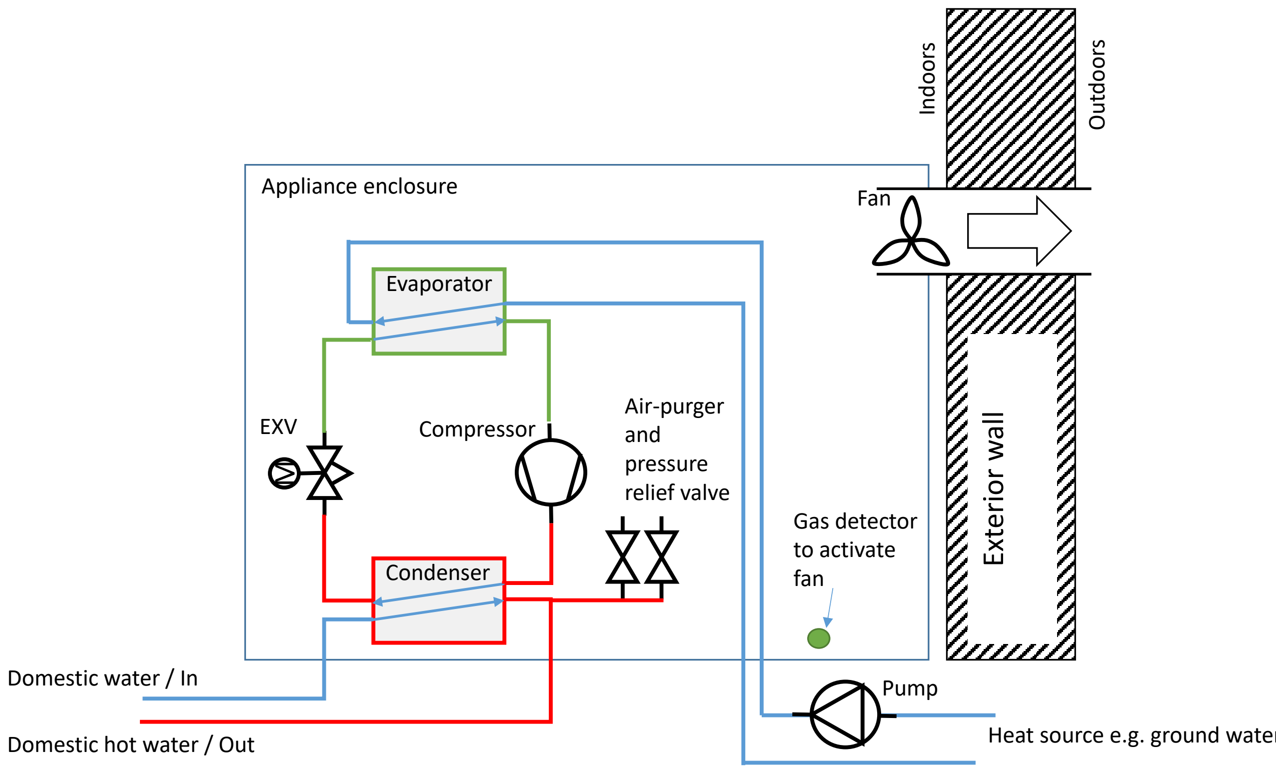


Figure A6

The above Figure A6 shows a typical ventilated enclosure heat pump system. The heat pump is typically an air-to-water or water-to-water heat pump using flammable refrigerants placed inside an enclosure.

The purpose of the enclosure is to ensure safety in case of a refrigerant leak, and the volume inside the enclosure is ventilated to the outdoors, either continuously or triggered by a refrigerant leak detector. This mitigation measure is covered by the harmonised standards EN 60335-2-40 and EN 378-2, as well as by ISO 5149-2.

To ensure safety, the enclosure needs to be ventilated with a fan to the outdoors. The fan has to be strong enough to create an under-pressure of 20 Pa and strong enough to create an airflow to remove the leaked refrigerant to avoid overpressure in the enclosure (with a safety factor of 4).

Inside the enclosure, including the position of the fan, ignition sources are not allowed since a leak can lead to a flammable atmosphere. The electrical components can be evaluated as not having ignition sources or ATEX approved components can be chosen. The requirements for ATEX approved components do include protection against impact and rain, aspects which are not relevant inside an indoor enclosure.

If there is a risk of leakage to the indoors through the refrigerant to water heat exchanger, then this leakage path needs to be prevented. For instance by a double walled heat exchanger, or by an air-refrigerant separator on the water side combined with a pressure safety valve, the air-refrigerant separator and pressure safety valve venting inside the enclosure to ensure that the leak gets carried outdoors by the airflow.

ANNEX 7: Clarification on ATEX Directives

There are two EU ATEX directives:

- ATEX “Workplace” Directive 1999/92/EC covers worker safety when working where there is a risk of an explosive atmosphere.
- ATEX “Equipment” Directive 2014/34/EU covers equipment for use in a flammable atmosphere.

The ATEX “Workplace” Directive is implemented through national legislation and in general close to the “Non-binding guide to good practice for implementing Directive 1999/92/EC "ATEX" (explosive atmospheres)”. This national legislation is relevant when servicing systems with a flammable refrigerant, as mistakes in the procedures can lead to a flammable atmosphere. Note that ATEX considers all flammable refrigerants as explosive i.e. no difference between A2L and A3 refrigerants.

The “Equipment” Directive is a more traditional product safety directive, which sets minimum requirements for equipment which is to be used in an ATEX zone. ATEX considers three zones for gasses (0, 1, 2):

- Zone 0 is a place in which an explosive atmosphere is present continuously or for long periods or frequently;
- Zone 1 is a place in which an explosive atmosphere is likely to occur in normal operation occasionally;
- Zone 2 is a place in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

It is obvious that most refrigerating systems are not installed in an ATEX zone. In case a system with components in the scope of this guideline is installed in an ATEX zone e.g. a petro-chemical plant, then the system builder has to ensure an ATEX approval of the system. Such a system can also contain several non-ATEX approved components while other ‘critical’ components may then be required certified, see Figure A7.

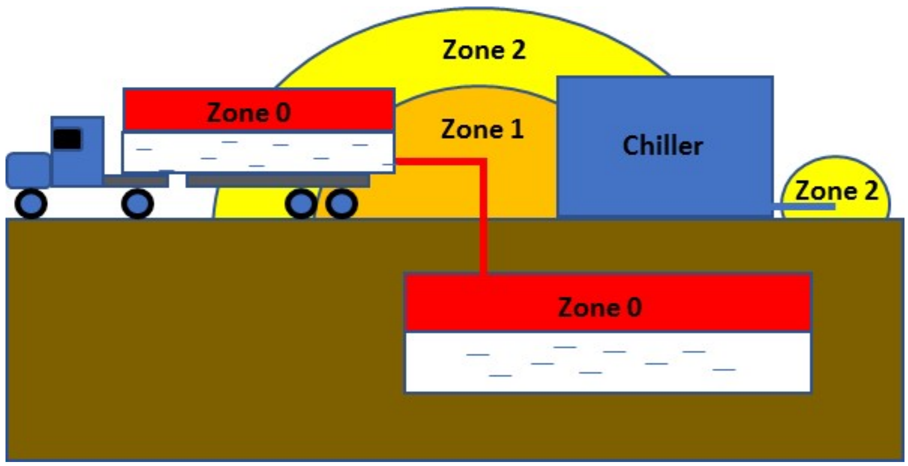


Figure A7: Zone classification according to ATEX.

In general refrigerating systems are tight, and the joints used between refrigerant containing parts can be of ”enhanced tightness” as defined in EN 1127-1:2019. ***This means that joints and components are not considered to give rise to a flammable atmosphere, and therefore not give rise to an ATEX zone, and therefore refrigerating systems do not lead to ATEX zones.***

In machinery rooms the use of gas detectors enforces the concept of “enhanced tightness” as it monitors the joints for tightness. If a leak is detected, it is detected at a level of no more than 25% LFL, where all components with ignition sources are shut down according to the safety standards.

There are two notable exceptions where an ATEX zone is defined:

1. *When a system manufacturer defines a part of the installation as an ATEX zone due to requirements from the installation site.* The system manufacturer and the installer are required to ensure that all components in this zone have the appropriate approval. Safety standards mandate that the discharge pipe of safety valves of refrigerating systems is lead to a safe place. Some system manufacturers chose to define this safe place as an ATEX zone 2. However, it is not a normal procedure to place any components in this area.

2. *When servicing the system there is a risk of a flammable atmosphere. T*his situation normally leads the service personnel to define an ATEX zone 2. When this is done, service equipment and other systems that are to remain powered need to be approved for ATEX zone 2. The prime examples are emergency lighting, alarms, gas sensors and emergency ventilation in machinery rooms. Sound praxis for all service situations is that service personnel should also use portable gas sensors, and these need to be approved for ATEX zone 2.

In other cases, the system safety standards use concepts very close to that of ATEX, and even sometimes refers to clauses in standards which are harmonised with ATEX.

For instance the safety standards require that all components which remain powered in a machinery room after a leak is detected are to be without ignition sources. One way of ensuring this is to have them approved for ATEX zone 2, but another option is to comply with specific clauses of EN IEC 60079-15 which is harmonised with the ATEX equipment standard. In practice these components are the emergency lighting, alarms, gas detectors and normally the emergency ventilation, because they need to remain powered for safety reasons. Incidentally these are the same components which need to remain powered during a service situation and include the components that enforce the durably technically tight concept.

ANNEX 8: The Pressure Equipment Directive (PED)

The Pressure Equipment Directive (PED) sets requirements for the verification of the pressure strength of components depending on the PED category, which is a function of the size, the maximum allowable pressure of the component, and the PED fluid group of the refrigerant. The higher the PED category, the higher the expected risk, and the higher the requirements for verification of design and production of components. The directive has 5 categories: sound engineering, I, II, III and IV. Sound engineering covers a level below category I, and is also known as “a4p3” or article 4 paragraph 3.

The requirements for verification of the pressure strength depends directly on the PED category. Figure A2 shows how the PED category is assigned for PED fluid group 1 and 2 for components which are more like piping than like vessels.

In general, it is advantageous to use a4p3 (article 4 paragraph 3) “sound engineering practices” for ensuring component pressure strength as an alternative to the more rigorous requirements of PED category I, II, III, and IV.

Traditional HFC refrigerants are gasses in PED fluid group 2, non-hazardous substances, and most flammable refrigerants are gasses in PED fluid group 1, hazardous substances. There is however an exception, R-1234ze(E) is in PED fluid group 2 despite the safety classification A2L. The reason for this exception is that the flammability test behind the PED fluid group classification is done at 20 °C, while the flammability test behind the A2L safety classification is done at 60 °C. R1234ze(E) is not flammable at 20 °C, but it is flammable at 60 °C.

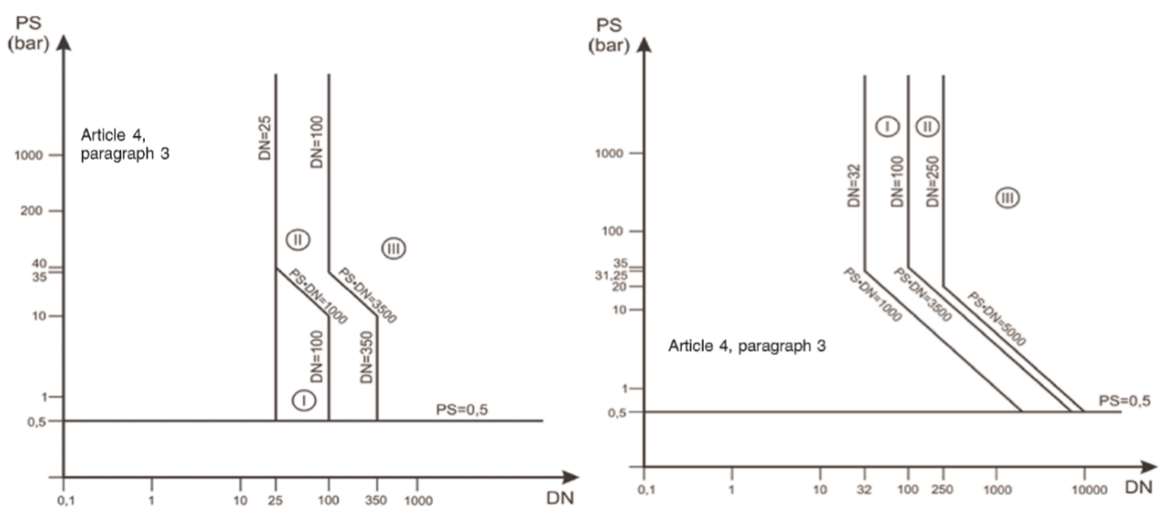


Figure A8: PED Categories for pipe-like components for fluid group 1 i.e. most flammable refrigerants (left) and fluid group 2 i.e. traditional HFC refrigerants and CO_2 (right)

There are three rules of thumb which are useful for a quick estimate of the impact of switching from non-flammable to flammable refrigerant:

- For flammable refrigerants and pipe-like components the use of a4p3 is only allowed up to DN25, while for non-flammable refrigerants a4p3 can be used up to DN32, and sometimes higher.
- For flammable refrigerants and vessel-like components (incl. hermetic compressors) the use of a4p3 is only allowed up to volume (litres) times pressure (bar) equal to 25, while for non-flammable refrigerants the limit is 50.
- For vessels the PED category is generally increased by 1,

Safety valves are always PED category IV, regardless of the size of the component, and the pressure and flammability of the refrigerant.

Revision Index

Revision	Change	Date
A	Initial issue	
B	Final approval	
C	1. Review	December 2019
D	2. Review	April 2023
E	3. Review	September 2024

Further *ASERCOM* Statements and Guidelines:

- **Hydrocarbon Refrigerants in Refrigerating Systems**
- **Carbon Dioxide (CO2) in Refrigeration and Air-Conditioning Systems (RAC)**
- **Containment of Refrigerant Compressors**
- **Electromagnetic Compatibility Directive 2014/30/EC**
- **Energy Efficiency Rating**
- **Recommended liquid line filter dryers and moisture indicators for refrigeration and air conditioning systems with HFCs refrigerants and POE lubricants**
- **Machinery Directive 2006/42/EC**
- **Pressure Equipment Directive 2014/68/EU**
- **Capacity Rating of Thermostatic Expansion Valves**
- **R22 Phase-Out**
- **Recommendations for using frequency Inverters with positive displacement Refrigerant Compressors**
- ***ASERCOM* guidelines for the design of multiple compressor racks using frequency inverters**
- **Refrigerant Glide and Effect on Performances Declaration**
- ***ASERCOM* cyber-security guideline for connected HVAC/R equipment**

For more information, please refer to *ASERCOM*`s website www.asercom.og

About *ASERCOM*

ASERCOM, the Association of European Refrigeration Component Manufacturers, is the platform for addressing scientific and technical challenges, promoting standards for performance and safety, encouraging better environmental protection, and supporting the refrigeration and air conditioning industry and its customers. Further information is available at: www.asercom.org