Guideline II: Safety regulations and standards for manufacturers and operators of refrigeration, air conditioning and heat pump (RACHP) equipment in the Ukraine

In the framework of the project

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Contents

List of figures

List of tables

List of boxes

List of Abbreviations

ASR	Technische Regeln für Arbeitsstätten (Technical rules on workplaces)
BAuA	Bundesanstalt für Arbeitschutz (Federal Institute for Occupational Safety and Health)
BMAS	Bundesministerium für Arbeit und Soziales (Federal Ministry of Labour and Social Affairs)
ATEX	ATmosphères EXplosibles
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CO_2	Carbon Dioxide
DIN	Deutsches Institut für Normung (German Institution for Standardisation)
EEA	European Economic Area
ETSI	European Telecommunications Standards Institute
GHG	Greenhouse Gases
GMBI	Gemeinsames Minsterialblatt (Joint Ministerial Gazette)
GWP	Global Warming Potential
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefins
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LVD	Low Voltage Directive
MD	Machinery Directive
MP	Montreal Protocol
NH_3	Ammonia
ODP	Ozone-Depleting Potential
ODS	Ozone-Depleting Substances
OHS	Occupational Health and Safety
PED	Pressure Equipment Directive
RACHP	Refrigeration, Air Conditioning and Heat Pump
PU RAU	Public Union "Refrigerating Association of Ukraine"
TEWI	Total Equivalent Warming Impact
TRBS	Technische Regeln Betriebssicherheit (technical standards on operational or occupational safety)

1 Introduction

While refrigeration, air conditioning, and heat pump (RACHP) appliances provide a critical level of comfort, they are also a major contributor to greenhouse gas (GHG) emissions. The GHG emissions of RACHP equipment are related to their fossil fuel-based energy consumptions and the release of refrigerants with a high global warming potential (GWP).

International political agreements like the Paris Agreement and the Montreal Protocol and its Kigali Amendment direct the way for a transformational change of the RACHP sector towards the use of climate friendly, low GWP refrigerants.

Climate friendly alternatives such as natural refrigerants - hydrocarbons, ammonia and carbon dioxide – are less expensive than synthetic refrigerants and possess advantageous thermodynamic properties, but exhibit a range of specific properties such as flammability, toxicity and high working pressures which can limit their applicability and require special practices or approaches.

Therefore, equipment that operates with such refrigerants require a different approach in terms of design, installation, servicing and operation which places a higher emphasis on safety.

It is the Ukrainian's responsibility to establish appropriate national legal measures to comply with their commitments under such international agreements. Safety regulations are an important prerequisite for the application of these alternative refrigerants and provide guidance for the safe use of RACHP equipment for manufacturers and operators. At the same time international safety standards had been developed over time to allow the wider, but safe use of low GWP refrigerants. Several international and European standards cover different safety aspects, such as product safety, safety of installation sites, or safe working practices.

This paper gives an overview on the most relevant safety regulations and standards and their implementation in the Ukraine and provides recommendations on the adoption of most recent international and European regulations and standards to ensure safety in the RACHP sector. Recommendations are provided to use the latest versions of the safety standards and to develop regulations which are not unnecessarily restrictive and allow the wider, but safe use of low GWP refrigerants.

This guideline is part of a series of **three consecutive** guidelines **prepared** for Ukrainian decision makers to promote climate friendly and energy efficient RACHP appliances in the country:

Guideline I: The regulatory framework for climate friendly and energy efficient alternatives in the refrigeration, air conditioning and heat pump (RACHP) sector in the Ukraine

Guideline II: Safety regulations and standards for manufacturers and operators of refrigeration, air conditioning and heat pump (RACHP) equipment in the Ukraine

Guideline III: Training, qualification and certification for the introduction of climate-friendly cooling and heating technologies in Ukraine

2 Purpose of this guideline

This guideline is intended to provide a comprehensive overview of regulations and standards relevant to the use of flammable refrigerants internationally and particularly in Europe and guide stakeholders in the Ukrainian RACHP industry (manufacturers and operators) in the process of preparing for the adoption of the most relevant regulations and standards that are likely to be implemented in the Ukraine in order to comply with its international climate/ozone agreements and its intentions to work towards its accession to the European Union.
This guideline is aimed at technical associations, companies, operators and manufacturers of RACHP equipment as well as educational institutions and provides basic technical information on climate friendly alternatives to fluorinated gases (f-gases) and the most relevant European regulations and international safety standards that address the particular requirements of RACHP equipment containing such alternative refrigerants. Thus, the guideline includes information on:

- Safety specifics of alternative low GWP refrigerant applications
- European regulations on (RACHP) equipment manufacturing and operation, including a reference to the corresponding German transposition in order to show how the regulation can be implemented in national law
- Relevant international and European safety standards for RACHP equipment
- Standard development processes and its peculiarities
- Recommendations on ensuring safety of RACHP appliances operating with natural refrigerants in the Ukraine.

3 Special characteristics of natural refrigerants

In compliance with the implementation of the Montreal Protocol, countries have been phasing out Chlorofluorocarbons (CFCs) as ozone depleting substances and opening the market for hydrofluorocarbons (HFC)s. Today HFCs are the dominant refrigerants at the market. They have a low ozone depletion potential (ODP), but a significant impact on the climate.

Low global warming potential (GWP)[1] alternatives to HFCs comprise natural refrigerants such as hydrocarbons (HCs), ammonia (NH_3) and carbon dioxide (CO_2) as well as hydrofluorolefins (HFO)s. Their advantages and disadvantages are outlined in Table 1.

Table 1: Low GWP refrigerants: pro's and con's

Refrigerant	Pro's	Con's
Ammonia, NH_3 (R-717)	Natural refrigerant, GWP = 0, zero ODP, low costs, widely available, high energy efficiency, high cooling capacity	Higher toxicity, low flammability (B2L)
Hydrocarbons (propane: R-290, isobutane: R-600a, propylene: R-1270)	Natural refrigerant, not toxic, GWP<3, zero ODP, low costs, widely available, high energy efficiency, high cooling capacity	Higher flammability (A3)
Carbon-dioxide CO_2 (R-744)	Natural refrigerant, not toxic, not flammable (A1), GWP=1, zero ODP, low costs, widely available, high energy efficiency, high cooling capacity	Higher operating pressure, reduced efficiency at ambient >31°C
Hydrofluoroolefins (HFO) (R-1234yf, R-1234ze)	GWP<10, zero ODP, similar energy efficiency and cooling capacity to HFCs	Chemical, expensive, environment and health unfriendly by-products (TFA[2] & HF), lower flammability (A2L)

Source: Own compilation

[1] GWP is expressed as the ratio of the amount of heat trapped by a certain mass of the gas in question to the amount trapped by a similar mass of CO_2.

[2] trifluoroacetic acid

The safety characteristics of refrigerants are defined by international and regional standards such as ISO 817:2014[3] and classified according to their flammability (in classes '1', '2', '2L' and '3') and toxicity (using the letters 'A' and 'B') as illustrated in Figure 1. According to this categorisation a refrigerant of class 1 (e.g. CO_2) is considered as non-flammable, while a refrigerant of category 2L (NH_3 and HFOs) shows a "lower flammability" with a low flame speed. A refrigerant of category 3 (e.g. propane) is characterised by a higher flammability.

Figure 1: Refrigerants – Designation and safety classification

	Lower Toxicity	Higher Toxicity
No flame propagtion ("non flammble")	A1	B1
Lower flammability	A2L	B2L
Flammable	A2	B2
Higher flammibility	A3	B3

Source. ISO 817

Natural refrigerants have historically been used in many RACHP applications, particularly in refrigeration, for many decades before the introduction of fluorocarbons. They all have in common that they have no or little impact on the climate, but they also suffer some disadvantages. Their characteristics are more precisely described in the following sections, where key natural refrigerant types, hydrocarbons, carbon dioxide and ammonia are described with their main properties, including their GWP, safety aspects and thermodynamic properties.

3.1 Hydrocarbons

The most frequently (or commonly) used hydrocarbon refrigerants in the RACHP sector are isobutane (R-600a) and propane (R-290). They have several advantageous characteristics, including the following:

- less expensive than synthetic refrigerants,
- a GWP of <3 and zero ODP,
- non-toxic,
- fulfill most of the specifications required for refrigerants,
- relatively high energy efficiency

However, they are classified as A3 highly flammable refrigerants. Hence, specific precautions and system requirements shall be followed when designing equipment containing HC gases, especially for larger charges. The required charge amounts for a refrigeration system operated with HCs are, however, significantly lower than for those designed for HFCs. Today, hydrocarbons are already prevalent in European and Asian household refrigerators and commercial stand-alone cabinets. Current plug-in refrigeration units with refrigerant charges below 150 gr may achieve refrigeration capacities up to approximately 1,000 Watt.

[3] ISO 817:2014 provides a system for assigning a safety classification to refrigerants based on toxicity and flammability data and provides a means of determining the refrigerant concentration limit.

3.2 Carbon dioxide

Carbon dioxide (CO_2), R-744, is an adequate substitute to HFCs for industrial refrigeration, heat pumps, commercial refrigeration, chillers and cold rooms. CO_2 shows some very favorable properties, including the following:

- colorless, odorless, non-toxic and heavier than air,
- non-flammable,
- much higher volumetric efficiency than that of traditional refrigerants allowing system designs and components with smaller volumes
- high energy efficiency (small pressure drops lead to significantly smaller heat losses)

CO_2, however, operates at higher pressures than other refrigerants requiring special design and stronger materials. R-744 display cabinets are available, but with a slow market uptake. In supermarkets (retail refrigeration) CO_2 containing systems are increasing slowly. They are currently under discussion for mobile ACs[4].

3.3 Ammonia

Ammonia (NH_3), R-717, has been the standard refrigerant for industrial refrigeration systems for more than 125 years. It is globally used in the food and beverage and other processing industries. Ammonia refrigeration systems are characterized by

- the lowest GWP (zero) of all refrigerants and
- higher energy efficiency than systems operated with HFCs.

Ammonia is commonly applied in larger capacity applications such as cascade systems (e.g. with CO_2), chillers, industrial applications, low temperature applications, cold rooms, etc. Ammonia, however, is classified as B2L refrigerant due to its toxicity and low flammability, but its pungent odor has a high warning effect.
In conclusion, natural refrigerants such as hydrocarbons, carbon dioxide and ammonia show some favorable characteristics over high GWP refrigerants. With regards to their relatively higher flammability (due for hydrocarbons), enhanced safety requirements have to be taken into account during manufacturing, operation and maintenance of RACHP equipment. Such requirements have been addressed in a number of regulations and standards that will be presented in Chapter 4 and 5, exemplary for the European Union and Germany.

4 **Eu**ropean regulatory framework on (RACHP) equipment and operation

Standards are in most cases voluntary documents that set out specifications and procedures that aim to ensure products, services, and systems are safe. Even though their application may not be mandatory,

standards provide strong guidance and can lead to the presumption of conformity to corresponding regulations when applied. Importantly, manufacturers, operators, etc. can use standards to demonstrate that their products comply with relevant legislation. In some cases, laws and regulations may even make compliance with standards compulsory.
Several directives at EU level have been established to ensure both, safety for RACHP products or equipment, as well as for the application of these products. The directives find their transpositions in national regulations for EU member states or have equivalences outside of the EU.
In principal, there are two main approaches or types of regulations with an impact on RACHP equipment:

> The product safety approach leads to regulations on product safety. The underlying idea is to create a framework for free trading of goods across boarders: As the main requirement products placed on the market need to be safe. Even if responsibilities for several parties are defined in these regulations, they have very strong influence on the work of **manufacturers.**

[4] Alvin Jose, Alvin (2019): Policy Trends for natural refrigerant in Asia Pacific.

- The occupational health and safety (OHS) approach is focussed on the improvement of safety and health of people at work. The requirements in these frameworks are primarily addressing the responsibility of the **employer** (sometimes also the operator).

For both approaches the major tool is the risk assessment or risk evaluation. When using low GWP refrigerants, both parties (manufacturers and employers/operators) must pay attention to the different or increased safety demands for working with these refrigerants when compared to the existing (environmental harmful) ones.

In the following sections the most important EU directives on product safety and OHS are briefly presented, with a reference to the harmonised standards and their transposition in Germany (as one possible example of national implementation[5]). The table in **Annex I** provides an overview table of the relevant EU regulations.

4.1 Regulations on product safety in the EU

The **framework for the marketing of products** is set out in **Directive 768/2008/EC[6].** This directive sets the scene for different actors in the supply chain for the free trading of goods. Applying the "CE-mark" should demonstrate that the economic operator is acting in accordance with all applicable regulations. The CE marking indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area (EEA). The key instrument for applying the CE-mark is the conformity assessment procedure which includes a risk assessment. Different applicable modules could lead to a presumption of conformity, ranging from simple self-assessment procedures as principally harmless products are involved up to third party involvement from notified bodies on a regular basis.

The "Blue Guide" from the EU describes in detail the current approach from the EU on regulations and standards on products[7].

Amongst several specific directives in this context some are of special relevance for RACHP equipment. For reference only these are briefly introduced in the following sub-chapters with their implementation in German laws and their relevant standards – one could choose other references from other countries as well, in principal the set ups are quite similar.

4.1.1 2001/95/EC[8] General Product Safety Directive

According to the scope of the directive, the purpose of this directive is to ensure that products placed on the market are safe, which is principal quite general and leaves room for interpretation or requires more specific special directives or regulations, which is indeed the case. Some of them are described below, some of them have in common that they distinguish between the use of flammable and non-flammable substances, which has an impact on the use of many alternative refrigerants with low GWP.
The German implementation of the directive (constituting one possible example for national implementation) is the Product Safety Act: "Produktsicherheitsgesetz" (ProdSG). It sets in force the above-mentioned directive on free marketing of products as well as several specific product directives which are introduced below. It also introduces the term "überwachungsbedürftge Anlagen" which means equipment that requires mandatory inspection – plants and equipment using flammable substances are automatically in this range. Under the directive environmental harmful high GWP but less flammable A1-refrigerants have fewer barriers to be used compared to alternative low GWP refrigerants in the higher

[5] In general, the national implementation in the EU member states is very similar. But there are deviations, for example the Swedish regulation on the machine regulation is much more differentiated than in other countries.

[6] 768/2008/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582109929241&uri=CELEX:32008D0768

[7] 2016/C 272/01 Commission Notice — The 'Blue Guide' on the implementation of EU products rules 2016

[8] 2001/95/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582038715913&uri=CELEX:32001L0095

flammability classes A2L- and A3.

4.1.2 2006/42/EC[9] Machinery Directive (MD)

The scope of the directive is machinery of all kind – with some exemptions. A machine under this directive as defined as an assembly of part, which includes a drive system (other than human or animal powered). A RACHP system with a compressor falls always under this directive – with the exemption of household appliances / applications or for (domestic) human comfort. As a result of that, heat pumps for heating private homes are covered by the low voltage directive (see below) whereas heat pumps for the heating of commercial stores etc. are covered by the machine directive. This fact even leads to slightly different requirements for the equipment, depending on the sector in which it is used (For example "machines" under the MD have to be equipped with an emergency stop - the "same" for domestic use doesn't).

A harmonised standard is developed by a recognised European Standards Organisation: European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC), or the European Telecommunications Standards Institute (ETSI). Manufacturers and other economic operators using harmonised standards can declare conformity to EU legislation on product safety. The standard must be published in the Official Journal of the European Union. The actual reference list (12.2019) is 176 pages long and contains several hundred of applicable standards. Out if these only a handful are of specific relevance for RACHP equipment (see also Chapter 5).

The MD differentiates between three standard categories:

- Type A standards specify basic concepts, terminology and design principles applicable to all categories of machinery, also called generic standards e.g. EN 12100. Applying an A-type standard does not lead to full presumption of conformity.
- Type B standards deal with specific aspects of machinery safety or specific types of safeguards that can be used across a wide range of categories of machinery, or horizontal standards

  e.g. EN 378. B-type standards can lead to presumption of conformity, they require a strong link to the manufacturers risk assessment.

- Type C standards provide specifications for a given category of machinery, referred to as vertical standards, like EN 60335. Application of the specifications of a C-type standard on the basis of the manufacturer's risk assessment confers a presumption of conformity.

The "Guide to application of the Machinery Directive"[10] gives a comprehensive description on how to use and implement the directive.
The MD has been transposed into German law as the 9th directive of the German Product Safety Act (9. ProdSV "Maschinenverordnung" – machinery directive). In Poland or Sweden, on the contrary, the implementation in national law included the adoption of several different regulations (laws and ordinances).

4.1.3 2014/35/EU[11] Low Voltage Directive (LVD)

The scope of the directive is electrical equipment using a voltage between 50 and 1,000 V AC (alternating current) and between 75 and 1,500 V DC (direct current). Since the origin of the machine directive is coming from the safe use of mechanical machines acting and moving and the LVDs initial purpose was the safety when using electricity, they nowadays overlap. Due to this reason the "Guide to the application of the Machinery Directive"[12] contains parts dealing specifically with this issue.

[9] 2006/42/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582038666552&uri=CELEX:32006L0042

[10] Guide to application of the Machinery Directive - http://ec.europa.eu/growth/sectors/mechanical-engineering/machinery

[11] 2014/35/EU https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582038612561&uri=CELEX:32014L0035

[12] Guide to application of the Machinery Directive - http://ec.europa.eu/growth/sectors/mechanical-engineering/machinery

The transposition into German law (as one possible example for national implementation) is realised with the 1st directive of the Product Safety Act (1. ProdSV "Verordnung über elektrische Betriebsmittel" – directive on electrical equipment).

4.1.4 2014/68/EU[13] Pressure Equipment Directive (PED)

The scope of the directive is the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure of more than 0.5 bar.

The directive classifies pressure equipment in two groups based on the fluids used in the equipment. Group one covers "harmful" substances, that means they are either toxic, explosive, corrosive or – flammable. Group two are all other substances. The requirements for equipment using group 1 fluids are generally more stringent than for group 2.

Next to the fluid properties, the potential risk is evaluated by the size of the equipment – expressed by the volume of components or equipment or the diameter of tubes and the maximum operating pressure. Depending on the fluid group, the pressure and size (volume or diameter), the directives requires different conformity assessment procedures which are getting stricter the higher the potential risk.

The harmonised standards for the PED comprise a bunch of standards dealing with design and requirements for special pressure equipment for refrigerating systems and heat pumps like piping, vessels, valves, safety switches etc. The standard EN ISO 13585:2012[14] describes the requirements for the qualification of brazers on refrigerating equipment.

PED has been transposed into German law as the 14th directive of the German Product Safety Act (14. ProdSV "Druckgeräteverordnung" – directive on pressure equipment), to cite one possibility of national implementation.

4.1.5 2014/34/EU[15] ATEX- product directive

ATEX is the abbreviation of the French word ATmosphères EXplosibles it covers products for the intended use in explosive atmospheres. That indicates that the original idea for this directive was focussed on products for the use within e.g. chemical plants, refinery or gas stations etc. Products are categorised according to their suitability for safe use in different harmful atmospheres. The "use" includes maintenance and service activities in which temporary flammable zones may occur. One can argue that RACHP equipment with non-intended use in explosive atmospheres falls under this directive because in case of intended maintenance it can create explosive atmosphere when using flammable refrigerants.
The ATEX product directive has an equivalent in the occupational health and safety (OHS) group of directives (see Chapter 4.2), thus leading to an unofficial designation of ATEX 95 (or 114 according to the Lisbon-Treaty) for product safety and ATEX 137 for OHS according to the respective article in the European Treaty on establishing the EU).
The harmonised standards include several important standards, which also apply for RACHP systems like the generic standard EN 1127[16] on explosion prevention or the group of EN 60079[17] standards on equipment for explosive atmospheres. The concept of flammable zones is described in EN60079.
The transposition into German law is realised with the 11th directive of the German Product Safety Act (11. ProdSV "Explosionsschutzprodukteverordnung").

[13] 2014/68/EU https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582038552658&uri=CELEX:32014L0068

[14] EN ISO 13585:2012 Brazing — Qualification test of brazers and brazing operators

[15] 2014/34/EU https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582038450609&uri=CELEX:32014L0034

[16] EN 1127-1:2011 Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology

[17] EN 60079-0:2012 Explosive atmospheres — Part 0: Equipment — General requirements IEC 60079-0:2011 (Modified) + IS1:2013, EN 60079-0:2012/A11:2013, EN 60079-ff

4.2 Regulations on occupational health and safety (OHS) in the EU

The **framework directive 89/391/EEC**[18] **"Safety and health of workers at work"** sets the scene for a bunch of individual directives addressing specific topics (see below) on improving the safe working conditions for workers at work. It sets out the general principles to be followed by the employer, including the avoidance of risk, evaluation of risk, mitigation measures, process implementation for avoiding risks, and the information and training of workers. It also lays out requirements for the individual directives. Since directive 89/391/EEC only covers workers employed by an employer, the directives 91/393/EC[19] and 2008/104/EC[20] extends the scope to temporary staff.

The transposition to national legislation includes several individual laws. In Germany, for example, the main regulation is the law on the safety of workers at work (ASchG "Arbeitsschutzgesetz"). This law connects the directive(s) on (general) product safety with regulations on occupational health and safety (see below) since it is using classifications from the product directive to classify and assess risks.

4.2.1 89/654/EEC[21] workplace safety directive

The first individual directive (89/654/EEC) on the above-mentioned general directive lays down minimum requirements for safety and health at the workplace and imposes ggeneral obligations for the employer such as traffic routes to emergency exits, technical maintenance of the workplace and of the equipment and devices, and the maintenance of safety equipment and devices intended to prevent or eliminate hazards.

The German workplace safety directive (ArbStättV – "Arbeitsstättenverordnung") sets in force the European directive. It explicitly requires (by law) the employer to perform a risk assessment on potential risks for workers at their workplaces. It also introduces special standards – technical rules on workplaces (ASR – "Technische Regeln für Arbeitsstätten"), which are published in the Joint Ministerial Gazette of the ministries (GMBl[22] –"Gemeinsames Minsterialblatt). The technical rules on workplaces (ASRs) are developed by working groups of the Federal Institute for Occupational Safety and Health ("Bundesanstalt für Arbeitschutz" - BAuA) in co-operation with scientific experts and different stakeholders (social insurance, employers, unions etc.). The BAuA is a federal organization under control of the Federal Ministry of Labour and Social Affairs that is in charge of OHS (BMAS "Bundesministerium für Arbeit und Soziales). The ASRs concretize the requirements from the directive and should represent the actual technical state of the art. Applying these standards would lead to the presumption of conformity to the directive. The ASR V3[23] describes the process of the risk assessment for the employer.

4.2.2 89/655/EEC[24] work equipment directive

Work equipment is the scope of the second individual directive for workplace safety. It follows very much the structure of the directive above (e-g. requiring additional specific strictly technical standards as needed). Work equipment are tool and machines but also technical equipment that can potentially harm the worker (e.g. air conditioners or refrigeration equipment) It also introduces the concept of danger zones for workers which is getting of interest when using RACHP equipment with flammable refrigerants and the risk that these are released to the working environment.

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18 89/391/EEC https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31989L0391&from=EN

19 91/393/EEC https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31991L0383

20 2008/104/EC https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32008L0104&from=LV

21 89/654/EEC https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31989L0654&from=EN

22 GMBl Homepage: https://www.gmbl-online.de/

23 ASR V3 : Risk Assessment: https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/ASR/pdf/ASR-V3.pdf?__blob=publicationFile&v=3

24 89/655/EEC https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582039660990&uri=CELEX:31989L0655

The German transposition (as one example for national implementation) is the BetrSichV – "Betriebssicherheitsverordnung". It is also linked to the product safety directive and introduces technical rules for concretization and guidance. These standards are called TRBS - "Technische Regeln Betriebssicherheit" ((technical standards on operational (or occupational) safety)). They are also developed by the BAuA. The TRBS generate a comprehensive and complex framework on operational safety: some standards are generic (the 1000 series) – like the TRBS 1111 "Risk assessment", some are horizontal (the 2000- series), looking at types of risks (e. q. explosive atmospheres) and other standards are vertical (the 3000 series) on risks from specific equipment or tasks.
The group of TRBS 2152 provides concrete guidance for working under potentially explosive atmosphere.

4.2.3 1999/92/EC[25] ATEX OHS directive

The OHS ATEX directive is the 15th individual directive to the framework directive on workplace safety. The main requirement for the employer is to create an explosion protection document, identifying, risks, hazardous places and mitigation measures and information of workers on the risks. It introduces categories on hazardous places (different flammable zones). These definitions are taken up in product standards like EN 60079. This directive also creates a direct link to the product ATEX directive.

Whereas some countries have a specific regulatory transposition for the product OHS ATEX directive ((like Austria where an ATEX (product) directive and a VEXAT[26] (OHS) exist), in Germany the OHS directive is linked to the structure of the work equipment directive and the TRBS ((technical standards on operational (or occupational) safety)) as described above.

Besides these regulations there are other European regulations that contain safety requirements for RAHCP equipment, such as regulation **(EU) No 517/2014** of the European Parliament and of the Council **on fluorinated greenhouse gases**. Due to the complexity of this regulation and because it also sets a number of other, rather environmentally related rules, it is dealt with **in more detail in Guideline I.**

Following a description of the most important safety regulations for RAHCP equipment and its application in the European Union, Chapter 5 provides an overview of relevant safety standards, their scope and impact for equipment using flammable refrigerants.

5 International and European standards on RACHP equipment

The associated risks caused by the flammable and toxic properties of alternative refrigerants require suitable safety standards that go along with the phase down of HFCs in countries.
Standards are developed by experts in technical committees and working groups. They are voluntary instruments and can be adapted and/or incorporated into national legislation, but otherwise have no legal standing (except in contract law). In most cases there is no obligation by law to use standards, nevertheless applying the standards allows a presumption of conformity to several laws and regulations.
In the RACHP sector, safety standards are an important tool to ensure a safe use of the equipment. They include prescriptive or performance-based safety requirements, giving guidance to engineers and technicians regarding the design, installation, marking, maintenance, etc.
Since the standard development process is usually lengthier than the actual technical developments, standards can become obsolete and a hindrance for the uptake of new technologies, such as RACHP equipment containing flammable refrigerants.
There are two international standards organisations that publish relevant safety standards for the RACHP sector: the International Standardisation Organisation (ISO) and the International Electrotechnical Commission (IEC).

[25] 1999/92/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582040043797&uri=CELEX:31999L0092

[26] Verordnung explosionsfähige Atmosphären (VEXAT): https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20003475 (19.02.2020)

At regional (e.g. European) level there are equivalent organisations, such as the European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardization (CENELEC), which often elaborate the international standards, adopting it to the regional context, covering the same or very similar scope and requirements.

5.1 Safety standards for RACHP equipment

There are two main types of standards that apply specifically to RACHP systems[27].

- **Group Standards** (also referred to as generic or horizontal standards) and
- **Product Standards** (or vertical standards).

The table below gives an overview of relevant standards in the RACHP sector and the product sectors they refer to. All these standards have their legal basis in the Machinery Directive 2006/42/EC (see **Chapter 4.1.2**).

Table 2: Overview of the most relevant product and group standards in the RAC sector

Sector	Vertical/Product standards			Group/Horizontal standards
	IEC 60335-2-24	IEC 60335-2-40	IEC 60335-2-89	ISO 5149-1, -2, -3, -4
	EN 60335-2-24	EN 60335-2-40	EN 60335-2-89	EN 378-1, -2, -3, -4
Domestic refrigeration	×			×
Commercial refrigeration			×	×
Industrial systems				×
Transport refrigeration				×
Air-conditioners & Heat pumps		×		×
Sanitary hot water heat pumps		×		×
Dehumidifiers		×		×

Source: GIZ (2018)[28]

Vertical standards only cover specific types of equipment within a product sector or sub-sector of the RACHP market, e.g. domestic refrigerators. Horizontal standards on the contrary provide rules that can be applied to most parts of the RACHP market and include more generic and overarching requirements based of common characteristics and practices of any RACHP equipment, installations and technician activities.

Sometimes the boundaries between vertical and horizontal standards are not rigid and designers, manufacturers, installers and contractors must decide which is the most appropriate standard for their situation[29]. Sometimes it may be a combination of those within different sections of the horizontal and the vertical standards. In some other cases, however, it is defined in the standard which standard(s) have precedence (e.g. EN378 stipulates that the requirements in EN 60335-2-89 primarily apply)

Annex II provides a brief description of the scope and the status of the above presented standards.

[27] According to ISO/IEC Guide 51, Safety aspects – Guidelines for their inclusion in standards: https://www.iso.org/standard/53940.html

[28] GIZ (2018): International Safety Standards in Air Conditioning, Refrigeration & Heat Pump. https://www.giz.de/de/downloads/giz_2018_Safety_Standards.pdf

[29] Provided that a particular standard has not been mandated by national legislation.

RACHP safety standards address a wide range of hazards associated with RACHP systems and equipment. Aspects related to refrigerant safety constitute one important part of these hazards that are considered in the design, construction and handling requirements of the standards. The following table provides a summary of those topics covered by RACHP safety standards that are affected by refrigerant choice. It should be used for reference on the highest maximum values only, under specific circumstances, these values might be smaller.

Table 3: Important topics to be addressed by RACHP safety standards

Category	**IEC 60335-2-24** **EN 60335-2-24**	**IEC 60335-2-89** **EN 60335-2-89**	**IEC 60335-2-40** **EN 60335-2-40**	**ISO 5149-1, -2, -3, -4** **EN 378-1, -2, -3, -4**
Scope	Domestic refrigerators, freezers and ice makers	Plug-in commercial appliances and cabinets with a condensing unit and single compressor	Factory made whole air conditioners, heat pumps, dehumidifiers and partial units	All commercial and industrial refrigeration, air conditioning and heat pump systems
Limits on refrigerant charge amount.	150 g flammable refrigerant. No limits for R-744. R-717 is out of scope.	500 g A3 flammable refrigerant. 1,200 g A2L/A2 flammable refrigerants No limits for R-744. R-717 is out of scope.	Approx. 1 kg of HC in a direct system inside (depending upon room size) and 5 kg outside or special enclosure. No limits for R-744. R-717 is out of scope.	1 kg, 1.5 kg, 5 kg, 10 kg, 25 kg of HC and no limit, depending upon type of system and/or room size. No limits for R-744 or limited by room size. No limits of R-717 if located outside or in machinery room.
Marking	Requires flammability or high-pressure warning symbols, as appropriate.			
Strength pressure	Specifies pressure tests for systems and components (where applicable).			
Electrical equipment	Specifies design, construction and test requirements.			Refers to appropriate standards.
Sources of ignition	Describes what to consider and how to avoid a potential source of ignition, including a test method option (applies to all these standards except ISO 5149).			
Information & instructions	Details concerning the installation, use, service, maintenance, and disposal of the equipment so that users, operators and technicians are aware of how to handle flammability hazards.			
System tightness	Systems generally must be constructed as “sealed” or “hermetically sealed” systems if they are to use flammable refrigerants indoors (e.g., no or limited number of reusable mechanical connections or fittings).			
Pressure limiting/ relief devices	The need for additional devices to limit or relieve excess pressure may apply to smaller systems if flammable refrigerants are used.			
Secondary/ indirect systems	Additional components for secondary or indirect circuits (such as those using water or brine) are required to vent a leak that has occurred from the evaporator into the secondary circuit if the primary refrigerant circuit exceeds a certain charge size.			
Gas sensors	n/a		Gas sensors may be mandated to initiate mitigation measures such as ventilation, alarms, terminating electrical supplies, etc. These may be applicable to systems using flammable refrigerants in machinery rooms or even for systems in occupied spaces.	
Construction of machinery rooms or ventilated enclosure	n/a		Machinery rooms or special enclosures may have certain requirements if flammable refrigerants are used, such as number and opening of doors, fire resistance of walls, tightness and minimum airflow rates, etc.	

Source: GIZ (2018)[30]Table 3

[30] GIZ (2018): International Safety Standards in Air Conditioning, Refrigeration & Heat Pump. https://www.giz.de/de/downloads/giz_2018_Safety_Standards.pdf

It becomes clear that the refrigerant type has an impact on various design and construction aspects of the refrigeration system. For instance, systems must be constructed as "sealed" or "hermetically sealed" systems if they use flammable refrigerants, sources of ignition should be avoided, gas sensors or emergency ventilation may be mandated and some additional tests (such as leak tests or pressure tests) may be required. These requirements may affect the cost of systems and convenience for manufacturers and installers. Refrigerant charge size limits, however, constitute the most important requirement within safety standards in terms of viability for application of natural refrigerants, particularly for HCs.

With regards to carbon dioxide, R-744, that operates at higher pressures than other refrigerants the standards provide rules stipulating thicker materials, higher pressure rating for pipes and components, additional use of pressure relief devices and/or pressure limiting devices, and higher competencies for workers involved in construction of components and assemblies. For ammonia (R-717) stricter limits on the quantity of refrigerant in occupied spaces and limited use in more densely populated areas is required.

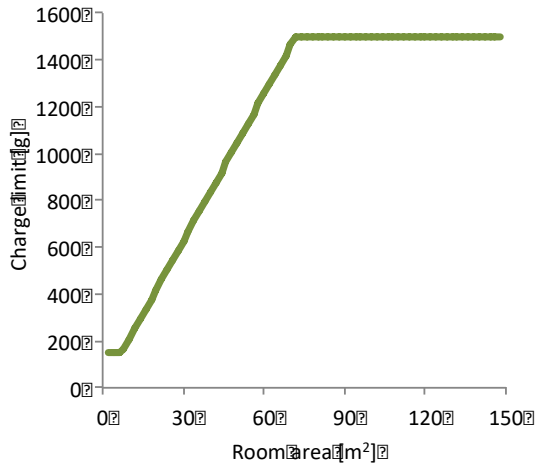
The biggest challenge for flammable refrigerants is to optimize their charge sizes in a way that energy efficiency and safety is compromised within acceptable levels. Tests provided evidence that there is a relationship between refrigerant charge and cooling capacity and the energy efficiency of a RACHP appliance.

Current safety standards imply two types of constraints for refrigerant charge amounts:

- the maximum charge being an overall cap according to the application and location of the system, and
- an allowable charge as a function of room size and in some cases the installation height of the equipment.

In Figure 2 it is visualised that for propane "R-290" if the mass of the refrigerant is more than 150 g in the system the allowable charge is a function of the room size. The maximum allowable charge is limited to 1500 g, after which increasing the size of room does not permit more R290.

Figure 2: Example relationship between room size and refrigerant charge limits



Source: GIZ (2018)[31]

[31] GIZ (2018): International Safety Standards in Air Conditioning, Refrigeration & Heat Pump. https://www.giz.de/de/downloads/giz_2018_Safety_Standards.pdf

The maximum charge, however, does generally not pose a barrier and is nevertheless a broadly arbitrary value assigned to ensure the amounts used do not extend to uncontrolled quantities.

In addition to the RACHP safety standards identified above, there is a range of other safety standards, applicable to RACHP equipment, addressing the following items **(guideline 3 contains a more in-depth description of EN 13313 on the competence of personnel):**

- General safety of compressors and pumps (e.g., IEC 60225-2-34, EN 809, IEC 60204-1, EN 1012, EN 12693)
- Pressure safety of system vessels and components (e.g., ISO 4126, EN 1736, EN 12178, EN 12263, EN 12284, EN 13136, EN 13445, EN 14276)
- Tightness of components and connections (e.g., ISO 14903, EN 16084)
- Competence of personnel (e.g., EN 13313)
- Electromagnetic compatibility (e.g., EN 61000-series)
- General safety of machinery (e.g., ISO 12100, EN ISO 13849-1)
- Risk assessment of equipment using flammable gases (e.g., EN 1127-1)
- Safety characteristics of refrigerants (e.g., ISO 817, IEC 60079-20-1)
- Gas detection (EN 14624, IEC 60079-29-series, EN 50402)
- Classification of hazardous areas (e.g., EN 60079-10-1)
- Electrical equipment for use in potentially flammable areas (e.g., IEC 60079-0, IEC 60079-1, IEC 60079-2, IEC 60079-5, IEC 60079-6, IEC 60079-7, IEC 60079-11, IEC 60079-13, IEC 60079-14, IEC 60079-15, IEC 60079-17, IEC 60079-18, IEC 60079-19, IEC 60079-25, IEC 60079-26, IEC 60079-32, IEC 60079-33)

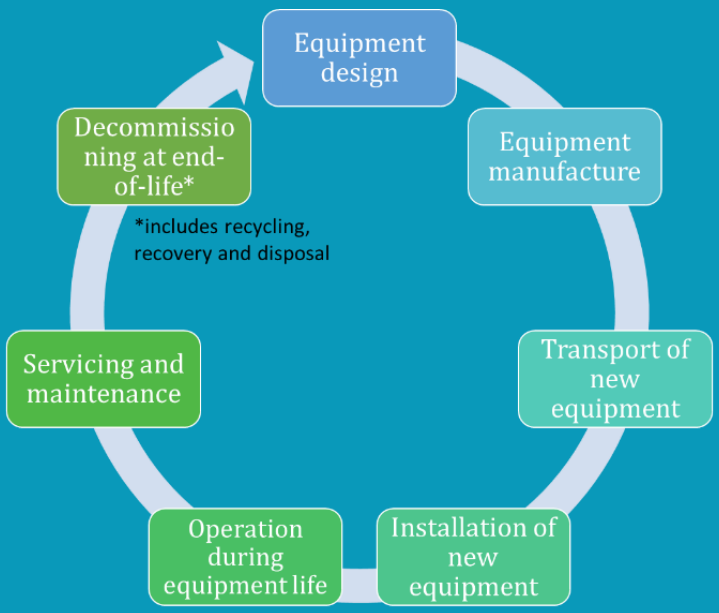
A complete list of relevant standards can be found in **Annex III.**

It must be noted that in many countries, there are other safety related regulations that cover RACHP equipment and may take precedence over specific RAHCP safety standards. Sometimes their requirements are more stringent than those in the safety standards. Such examples may include regulations which cover flammable gases in manufacturing and process environments, transportation of dangerous goods, or workers involved with the handling of flammable substances.

Box 1: Standards along the product lifecycle

Safety issues such as flammability need to be considered at different circumstances along the RACHP equipment lifecycle. The following picture illustrates the different stages in a typical RACHP product lifecycle:

Figure 3: Typical RACHP product lifecycle



Source: own compilation

Since safety problems related to a specific product can vary throughout the lifecycle, different safety standards may be applied at different lifecycle stages: For instance, when a flammable refrigerant is used, the risks during normal operation could be very low, because the probability is very low that there will be a leak in an area with a source of ignition. During site installation, maintenance or decommissioning at end-of-life, however, a technician might be using tools (constituting ignition sources), which could ignite any remaining refrigerant that has leaked out of the equipment and impose a hazard. [32]

That is why standards for the training of designers, installers and maintenance technicians are pivotal, besides the product standards. For example, European Standard EN 13313 "Refrigerating systems and heat pumps – Competence of personnel" comprises a comprehensive set of guidelines about the training competencies for different personnel working on RACHP systems at different stages of the product lifecycle. This standard applies to all types of refrigerants.[33]

[32] UNEP 2017; Safety standards relevant to Refrigeration, Air-Conditioning and Heat Pump equipment. http://conf.montreal-protocol.org/meeting/workshops/safety-and-standards/presession/briefingnotes/safety_standards_relevant_to_refrigeration_ac_and_heat_pump_equipment.pdf

[33] For more information on that standard, please refer to UBA (2020): Guideline on training, qualification and certification for the introduction of climate-friendly cooling and heating technologies in Ukraine

5.2 Adoption of standards at national level

(International) RACHP safety standards are not automatically legally binding for companies and its personnel. They are only mandatory when the government establishes certain laws or regulations that specifically require compliance with these standards.

Countries have some flexibility regarding the design and implementation of standards. They can either adopt international (ISO/IEC) and/or regional standards as a "copy and paste" of such standards or adopt the international standards with national modifications or deviations, for example where requirements of the international standard conflicts with national legislation. In addition, some countries have their own nationally developed RACHP safety standards, which may be similar or substantially different from the international standards in terms of technical requirements and/or structure and approach. Due to the increasing number of internationalisation of companies, there is, however, a preference amongst various stakeholders to harmonize requirements within RACHP safety standards.[34]

Most countries have a **national standardisation body (NSB)** that are members of the international standardisation organisations (ISO or IEC). International standards are usually developed and reviewed by groups of experts in technical committees (TC)s. Thus, the international standardisation bodies host a great number of TCs on various topics. Their experts are put forward by the organisation's national members (the NSBs). Countries can take part in the TC as participating or observing members. For example:

- ISO's Sub-Committee on "safety and environmental requirements for refrigerating systems", called "ISO/TC 86/SC 1, constantly works on the elaboration of standard ISO 5149-1:2014 "Refrigerating systems and heat pumps — Safety and environmental requirements". The Committee consists of 22 participating and 19 observing members. The Ukraine is currently not represented.[35]
- At IEC, the standard committee "SC 61C" works on the safety of refrigeration appliances for household and commercial use (where the Ukraine is an observer country)[36], while the committee "SC 61D" deals with appliances for air-conditioning for household and similar purposes (where the Ukraine is also an observer country-member).[37]
- The "CEN/TC 182 - Refrigerating systems, safety and environmental requirements" published EN 378-1/2/3/4 (among others). The Ukraine as a Companion Standardization Body (CSB) to CEN can participate in this TC as an observer country.[38]

The NSB is usually responsible for the preparation of a guideline on development, maintenance and layout of the national and adopted international standards, following the requirements and general principles of the international or regional standardisation bodies.

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[34] UNEP 2014: international standards in refrigeration and air-conditioning. http://www.unep.fr/ozonaction/information/mmcfiles/7679-e-International_Standards_in_RAC.pdf

[35] https://www.iso.org/committee/50362.html

[36] One of its products is standard 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.

[37] One of its products is standard IEC 60335-2-40:2018 "Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers". More information on IEC: https://www.iec.ch/dyn/www/f?p=103:6:0##ref=menu

[38] https://standards.cen.eu/dyn/www/f?p=204:22:0::::FSP_ORG_ID,FSP_LANG_ID:6163,25&cs=16740DC95B2641740FB9EC299304D30DE

Prior to adoption of an international/ regional standard or its implementation into national regulation a comprehensive national open and transparent consultation process is usually held in order to ensure an appropriate consideration of each stakeholders' needs and the national context so that it will not duplicate or be in conflict with any existing regulations. This also requires a transparent process of monitoring and evaluation.[39]

Box 2: German Institute for Standardisation (DIN)

The German Institute for Standardization (Deutsches Institut für Normung e.V., DIN) is a non-profit association, consisting of representatives from industry, associations, public authorities, commerce, the trades and research organizations.

On behalf of the German Federal Government, DIN is the acknowledged national standards body that represents German interests in European and international standards organizations. The staff at DIN coordinates the standardization process at national level and is responsible for organizing German participation in standards work at European and international level. Besides the core work of the Institute it also organises several standards information exchange fora for practitioners. The portal on air conditioning and ventilation technology, that DIN e.V. provides in cooperation with the Buildings-Climate Association (FGK) gives a constantly updated overview of the standardization activities in the field of air conditioning and ventilation technology on national (DIN), European (CEN) and international (ISO) level, compiling information on the respective working groups (TCs), published standards and draft standards, ongoing projects and contact persons. The exchange fora also serve to motivate German experts/practitioners to participate in these standardization activities.[40]

Accreditation bodies are required to ensure that the national, regional or international standards are correctly applied by institutions that provide certification, testing, inspection and calibration services.
National RACHP associations are technical bodies and contact points for companies and technicians. They provide input to the NSBs and support the implementation and compliance with standards, for instance, by explaining the relevant standards to their members. RACHP associations often also provide training and certification for technicians.
There are a number of barriers to the development and adoption of standards in general. Countries might not have the necessary technical resources and expertise with associated financial commitment in order to participate in international standardisation organisations. In some countries, bureaucracy may hinder the standardisation process, especially where incorporation into the national legislation is concerned. Also, the lack of formal connections with international/regional standardisation bodies, and/or a lack of cooperation with the relevant national institutions can exacerbate the process. Moreover, the prices for standards mentioned earlier range from around 100 to approximately 400 EUR, which can pose a challenge particularly if the relevant national institutions are not in place.[41]
Another barrier can be the technical language and general design of standards, which might be difficult to understand, especially by small companies and individuals that make up the 'informal sector' of servicing technicians in many developing countries and are often responsible for installation and servicing of refrigeration and air-conditioning equipment. That is why simple guidance and support to explain the relevant standards and how they need to be implemented is required. For larger established enterprises implementation and compliance with standards might be easier, particularly if the company was involved in the development or adoption of the standard or the prior consultation process.

[39] UNEP 2014: international standards in refrigeration and air-conditioning. http://www.unep.fr/ozonaction/information/mmcfiles/7679-e-International_Standards_in_RAC.pdf

[40] https://www.din.de/en/about-standards

[41] UNEP 2014: international standards in refrigeration and air-Conditioning. http://www.unep.fr/ozonaction/information/mmcfiles/7679-e-International_Standards_in_RAC.pdf

6 Standards and regulations for RACHP equipment in the Ukraine

The Law of Ukraine "On Standardization" from 2015 created the preconditions for the alignment of national standardization system with international and European standards and rules, as well as implementation of the Association Agreement between the Ukraine and the European Union, in particular with regard to the implementation of required administrative and institutional reforms.
According to chapter 1 article 11 of the Law, the Ministry of Economic Development and Trade established the NSB, which started its activity on 03.01.2015[42], performed by the State Enterprise "Ukrainian Scientific Research and Training Center for Standardization, Certification and Quality Problems" (SE UkrNDNC). SE UkrNDNC is the leading standardization organization in the Ukraine recognized at national, international and European levels. It represents the interests of Ukraine in ISO, IEC as a full member and is a companion standardization body to CEN and CENELEC. SE UkrNDNC`s name is currently changed to SE Ukrainian Agency of Standardization (UAS). The UAS acts a non-government body; the draft national standards shall not be agreed with government bodies; no rules guiding development of standards and technical regulations for enterprises shall be set up; mandatory application of national standards shall be abolished.[43]
There is a Ukrainian translation for the most relevant international RACHP standards (see Table 4).
Still, the awareness and the information level among the industry participants in the Ukraine remains very low. There is a need to increase the industry understanding of the applicability of the standards in practice.

Table 4: European and Ukrainian RACHP standards (not officially confirmed)

International standard & scope	Ukrainian translation	Scope of Ukrainian standard
IEC 60335-2-40 'Particular requirements for electrical heat pumps, air conditioners and dehumidifiers' Air conditioners, heat pumps, water heating heat pumps, dehumidifiers, chillers (Electric heat pumps, sanitary hot water heat pumps, air conditioners, supplementary heaters, and dehumidifiers incorporating motor-compressors and hydronic fan coil units)	DSTU EN 60335-2-40:2014[44]	Apply analogue and analogue electricity. Bakery-free. Part 2-40. Electric heat pumps, air conditioners and hair dryers.
IEC 60335-2-89 'Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor'	DSTU EN 60335-2-89:2016[45] (EN 60335-2-89:2010; A1:2016; A2:2017, IDT; IES 60335-2-89:2010, IDT; A1:2012; A2:2015, MOD)	Seems to apply analogue. No baking. Part 2-89. Additional options to the industrial refrigeration
EN 378 'Refrigeration systems and heat pumps' Part 1: Basic requirements, definitions, classification and selection criteria Part 2: Design, construction, testing, marking and documentation Part 3: Installation site and personal protection Part 4: Operation, maintenance, repair and recovery All stationary or mobile refrigerating/ air conditioning systems except for vehicle air conditioning systems, including secondary cooling or heating systems and their components. The scope is similar to ISO 5149.	DSTU EN 378-1:2014[46] DSTU EN 378-2:2017 (EN 378-2:2016, IDT) DSTU EN 378-3:2005 DSTU EN 378-4:2014	Seems to apply analogue Refrigerators and heat pumps. - Part 1: Basics of applications, classification and selection criteria
IEC 60335-2-24:2010 Household and similar electrical appliances 'Particular requirements for refrigerating appliances, ice-cream appliances and ice makers'	DSTU IEC 60335-2-24-2001[47]	Seems to apply analogue

[42] http://uas.org.ua/en/zagalni-vidomosti-pro-dp-ukrndnts/(19.02.2020)
[43] http://www.ier.com.ua/files//Projects/2012/presentation_12_6_14_ENG.pdf (19.02.2020)
[44] https://www.ukrainelaws.com/p-345381-dstu-en-60335-2-402014.aspx (19.02.2020)
[45] https://www.ukrainelaws.com/p-360194-dstu-en-60335-2-89-2016.aspx (19.02.2020)
[46] https://www.ukrainelaws.com/p-345028-dstu-en-378-12014.aspx (19.02.2020)
[47] https://www.ukrainelaws.com/p-39016-dstu-iec-60335-2-24-2001.aspx (19.02.2020)

With regards to the regulatory framework in Ukraine, it must be noted that the country is obliged (in the framework of the Association Agreement[48] between the European Union and its member states and Ukraine) to harmonize at least part of its existing national legislation to hundreds of EU regulations from many branches of law. For example, Article 56 of the Agreement stipulates that Ukraine shall take the necessary measures in order to gradually achieve conformity with EU technical regulations and EU standardization, metrology, accreditation, conformity assessment procedures and the market surveillance system, and undertakes to follow the principles and practices laid down in relevant EU Decisions and Regulations, in particular Decision No 768/2008/EC on a common framework for the marketing of products or the Product Safety Directive (2001/95/EC).

Over the previous years, Ukrainian government has been in an ongoing process to develop legislative acts compliant with the EU legislation, including those regulations presented in Chapter 4. For instance, in line with EU legal acts, Ukraine has approximated their technical regulations for safety of low voltage electric equipment and for safety of machinery and mechanisms.

7 Summary and recommendations

International climate regimes such as the Paris Agreement and the Montreal Protocol's Kigali Amendment - that Ukraine is part of - oblige their signatories to phase down harmful high GWP refrigerants within a stipulated timeframe (for further specifications see Guideline 1 on environmental regulations for RACHP equipment).

Climate friendly natural refrigerants like hydrocarbons, ammonia and carbon dioxide show very favourable properties and can be used alternatively. Their application in RACHP equipment, however, requires specific safety precautions. This is especially due for hydrocarbons that are classified as "A3" highly flammable refrigerants.

In Europe, several technical regulations have been issued to ensure safety of (RACHP) equipment, its manufacturing, operation and maintenance. This guideline provides a brief description of the most relevant regulations in the European Union, including:

1) regulations that address the **safety of products** – primarily providing requirements for manufacturers:
    - Framework directive 768/2008/EC for the marketing of products
    - 2001/95/EC General Product Safety Directive
    - 2006/42/EC Machinery Directive
    - 2014/35/EU Low Voltage Directive
    - 2014/68/EU Pressure Equipment Directive
    - 2014/34/EU ATEX- product directive
2) regulations that address the **occupational health and safety of people at work**, putting responsibility on the employer (sometimes also the operator):
    - Framework directive 89/391/EEC on safety and health of workers at work
    - 89/654/EEC workplace safety directive
    - 89/655/EEC work equipment directive
    - 1999/92/EC ATEX OHS directive

In the course of Ukraine's European integration process and the gradual approximation of Ukrainian legislation to EU rules, norms, and standards, it is recommended to pay attention to the regulations listed

[48] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:22014A0529(01)&from=EN (19.02.2020)

and its specific requirements for product safety and OHS for workers at work. An in-depth comparative analysis of European and Ukrainian legislation should be carried out with the aim to establish analogue rules and safety measures in Ukraine.

In general, the national implementation in the EU member states is very similar. But there are deviations, for example, the Swedish regulation on machinery is much more differentiated than in other countries. In order to align its own legislation with EU regulation, it is recommended that Ukraine carries out an analysis of the various national implementations of the EU directives and uses the legislation that is closest and most suitable to its legislation and specific country's circumstances as a blueprint or guideline.

Besides these regulations there are several international and European product and horizontal safety standards in place that apply for RACHP equipment. These standards are relevant for the application of low GWP but flammable refrigerants. Manufacturers and operators of RACHP equipment can demonstrate their conformity with the EU legislation when they comply with the corresponding standards. Similarly, it would be important for the Ukraine to implement the relevant product and horizontal safety standards, which allow the safe use of low GWP but flammable refrigerants. These principles should be considered when developing the above-mentioned regulations in the Ukraine and the corresponding safety standards for refrigerants.

Safety standards for RACHP equipment include prescriptive or performance-based safety requirements, giving guidance to engineers and technicians regarding the design, installation, marking, maintenance, etc.

The most relevant international and European standards for RACHP equipment include the following:

- Group/horizontal standards: ISO 5149-1, -2, -3, -4 and EN 378-1, -2, -3, -4, and
- Vertical/Product standards:
    - Domestic refrigeration: IEC 60335-2-24, EN 60335-2-24
    - Commercial refrigeration: IEC 60335-2-89, EN 60335-2-89
    - Air-conditioners, heat pumps, sanitary hot water heat pumps, and dehumidifiers: IEC 60335-2-40, EN 60335-2-40.

They address a wide range of hazards associated with RACHP systems and equipment. Aspects related to refrigerant safety constitute one important part of these hazards that are considered in the design, construction and handling requirements of the standards. The refrigerant type has an impact on various design and construction aspects of the refrigeration system. For instance, the refrigerant charge size for RACHP systems is restricted according to the application and location of the system and the room size - if they contain flammable refrigerants. Moreover, the equipment must be constructed as "sealed" or "hermetically sealed", sources of ignition should be avoided, gas sensors or emergency ventilation may be mandated and some additional tests (such as leak tests or pressure tests) may be required.

Countries have some flexibility regarding the design and implementation of standards. They can either adopt international (ISO/IEC) and/or regional standards as a "copy and paste" or adopt the international standards with national modifications or deviations, for example where requirements of the international standard conflicts with national legislation. The adoption of the safety standards in the Ukraine should allow the safe use flammable low GWP refrigerants as it has been recognized by the latest revision of the

IEC product standard IEC 60335-2-89:2019 allowing an increased amount of A3 refrigerants for commercial refrigeration applications and, in a similar way, the intended revision of IEC 60335-2-40 with an increased amount of A3 refrigerants for ACs and HEAT pumps.

Currently the application and the legal status (incorporation in regulations) of the horizontal and vertical safety standards for RACHP appliances is unclear. The Ukrainian NSB, the SE Ukrainian Agency of Standardization (UAS) should provide further clarifications on these matters to the industry. In order to promote their outreach, certification, and inspection, it could be advisable to strengthen the role of

national accreditation bodies and RACHP associations. They could be put in charge to raise awareness towards these standards, provide explanations and support their implementation and ensure that the standards are correctly applied.
Besides this short list of standards there are other safety standards, applicable to RACHP equipment, addressing very particular items such as the competence of technicians, safety characteristics of refrigerants, safety of compressors and pumps, and electrical equipment in potentially flammable areas (see Annex III for the full compilation of RACHP related standards). It is recommended to carry out a precise comparison between those international standards listed and Ukrainian standards, as a basis for further decisions on the alignment of Ukrainian standards and the potential translation and adoption of international standards.
A national consultation process with relevant national and international experts may be required to ensure the national context is carefully evaluated in reference to existing standards and that the requirements of all relevant stakeholders are taken into consideration. The RACHP associations and the National Ozone Unit as a focal point for the Montreal Protocol could ensure that the UAS is aware of the appropriate requirements in the context of the HCFC and HFC phase-out plans (see Guideline 1). The timing of the development or adoption of standards is very important to ensure it is synchronized with other related or interconnected standards and is appropriate for the national context.
Provided that resources are available, the UAS could also strengthen its collaboration and involvement with the Technical Committees of the international and regional standardization organizations, including:

- ISO/TC 86/SC 1, which is working on ISO 5149-1:2014;
- IEC "SC 61C" that works on the safety of refrigeration appliances for household and commercial use;
- IEC "SC 61D" that deals with appliances for air-conditioning for household and similar purposes; or
- CEN/TC 182 who published EN 378-1/2/3/4 (among others).

The Ukraine is already an observer country to some of these TCs.

Annex I: EU directives related to RAHCP equipment and implementation in Germany

Number	89/391/EEC	89/654/EEC	89/655/EEC	1999/92/EC	2001/95/EC	2006/42/EC	2014/35/EU	2014/68/EU	2014/34/EU
Short	WSD	WPSD	WESD		GPSD	MD	LVD	PED	ATEX
About	Workers Safety	Work Place Safety	Work Equipment Safety	ATEX - Workers Safety-Occupational Health and Safety	General product safety	Machine Directive	Low Voltage Directive	Pressure Equipment Directive	
refers to		89/391/EEC	89/391/EEC	89/691/EEC 15th Individual Directive					
Harmonised Standard					2017/C 267/03	2018/C 092/01	2018_C326_02	2014/C 313/02	2018/C 209/01
thereof relevant to business					NONE	EN ISO 12100; EN378-2; EN 60335-1; EN 60335-2-40	EN 60335-1, EN 60335-2-40	EN 378, (EN 1057), EN 12178, EN12263, EN12284, EN 12735, EN 13134, EN13547, EN 13585, EN 14276	EN 1127-1, EN13160, EN 60079
Further Reading	https://osha.europa.eu/de			Non-binding guide to good practice for implementing the Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres					
Germany		Verordnung über Arbeitsstätten vom 12 August 2004 Official publication: Bundesgesetzblatt Teil 1 (BGB 1); Number: 2004/44; of 24/08/2004; Page: 02179-02189	Betriebssicherheitsverordnung BetrSIchV, Früher (amtl. Verweis):Verordnung über Sicherheit &Gesundheits-schutz bei der Benutzung von Arbeitsmitteln bei der Arbeit (Arbeitsmittel-benutzungs-verordn AMBV) 11/03/1997, Official public:Bundesgesetzblatt pt 1;11/03/1997; Page:450	Verordnung zur Rechtsvereinfach-ung im Bereich der Sicherheit und des Gesundheits-schutzes bei der Bereitstellung von Arbeitsmitteln und deren Benutzung bei der Arbeit, der Sicherheit beim Betrieb überwachungs-bedürftiger Anlagen und der Organisation des betrieblichen Arbeitsschutzes 27/9/2002. Official publication: BGBl Part 1, n°70 of 2/10/2002, Page: 3777	Gesetz zur Neuordnung der Sicherheit von technischen Arbeitsmitteln und Verbraucher-produkten 06/01/2004 Official publication: BGBl. part 1 n° 1 of 09/01/2004; Page: 2	Verordnung zur Änderung von Verordnungen nach §3 des Geräte- und Produktsicherheitsgesetzes; Official publication: Bundesgesetzblatt Part 1 (BGB 1); n° 25; of 18/06/2008; Page: 01060-01066	Erste Verordnung zum Produktsicher-heitsgesetz (Verordnung über elektrische Betriebsmittel – 1. ProdSV) Official publication: Bundesgesetzblatt Part 1 (BGB 1); n° 13; of 31/03/2016; Page: 00502-00508	Vierzehnte Verordnung zum Produktsicher-heitsgesetz (Druckgeräte-verordnung – 14. ProdSV) Official publication: Bundesgesetzblatt Part 1 (BGB 1); n° 18; of: 18/05/2015; Page: 00692-00699	Elfte Verordnung Produktsicher-heitsgesetz (Explosionsschutzproduktever-ordnung – 11. ProdSV)Official public: Bundesgesetzblatt Part 1 (BGB 1); n° 2; of 15/01/2016; page: 00039-00046

Annex II: Relevant product standards for RACHP systems

IEC 60335-2-24:2010 'Particular requirements for refrigerating appliances, ice-cream appliances and ice makers'

Scope	**Domestic refrigerators, freezers and ice makers**
	Refrigerating appliances for household and similar use; ice-makers incorporating a motor-compressor and ice-makers intended to be used in frozen food storage compartments; refrigerating appliances and ice-makers for use in camping, touring caravans and boats for leisure purposes, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances and 24 V DC for appliances when battery operated. These appliances may be operated from the mains, from a separate battery or operated either from the mains or from a separate battery. The safety of ice-cream appliances intended for household use, their rated voltage being not more than 250 V for single phase appliances and 480 V for other appliances. Compression-type appliances for household and similar use, which use flammable refrigerants.
Status	The latest version of IEC 60335-2-24 is the amended consolidated version IEC 60335-2-24:2010+AMD1:2012+AMD2:2017, published in 2017. In addition, IEC 60335-2-24:2010/AMD2:2017/ISH1:2018 Interpretation sheet 1 - Amendment 2 - Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers has been published in 2019.

IEC 60335-2-40 'Particular requirements for electrical heat pumps, air conditioners and dehumidifiers'

Scope	**Air conditioners, heat pumps, water heating heat pumps, dehumidifiers, chillers**
	Electric heat pumps, sanitary hot water heat pumps, air conditioners, supplementary heaters, and dehumidifiers incorporating motor-compressors and hydronic fan coil units
Status	The latest version of IEC 60335-2-40 is the version IEC 60335-2-40:2018, published in 2018. IEC/TC 61/SC 61D/WG 9 'Addition of coverage for A2L refrigerants' began work in 2011, to develop additional requirements for A2L refrigerants. The Final Draft International Standard (FDIS) version was launched for vote in October 2017 and is expected to be published in early 2018. IEC/TC 61/SC 61D/WG 16 'Address A2 and A3 refrigerants' began work in September 2015 to address charge sizes and mitigation measures, such as increasing the allowable charge size using improved system tightness, minimum airflow and determining the maximum releasable charge. The IEC/TC 61/SC 61CD/WG 16 proposals are in preparatory stage and expected to be published in 2019-2022. IEC/TC 61/SC 61D/WG17: References to 60079 series – review the FDIS of 60079-15 and identify which changes are necessary for 2-40 and prepare a DC. Review the 60079 related comments on 61D/348/CDV that are deferred to the next revision IEC/TC 61/SC 61D/WG18: Altitude considerations for refrigerants

IEC 60335-2-89 'Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor'

Scope	**Plug-in commercial appliances and cabinets with a condensing unit and single compressor**
	Electrically operated commercial refrigerating appliances that have an incorporated compressor or that are supplied in two units for assembly as a single appliance in accordance with the manufacturer's instructions (split system)
Status	The latest published version of IEC 60335-2-89 is the IEC 60335-2-89:2019, published in June 2019. It introduces several modifications, most prominently the increase of the allowable charge limit for A3 refrigerants from 150 g to approximately 500g (depending on the type of fluid) and an increase in the maximum charge limit of A2L and A2 refrigerants to 1.2kg per circuit. It further includes improved system tightness measures and a surrounding concentration test with leak simulation. The previous version IEC 60355-2-89:2010+AMD1:2012+AMD2:2015 introduced requirements for transcritical systems and an 'enhanced flexing test', and aligned content with the updated version of IEC 60335-1.

EN 378 'Refrigeration systems and heat pumps'

Scope	**All stationary or mobile refrigerating/ air conditioning systems except for vehicle air conditioning systems, including secondary cooling or heating systems and their components. The scope is similar to ISO 5149.**
	The standard covers the safety of persons and property, provides guidance for the protection of the environment and establishes procedures for the operation, maintenance and repair of refrigerating systems and the recovery of refrigerants. It described topics such as the design, construction, testing, marking and documentation; the installation site and personal protection and operation, maintenance, repair and recovery.
Status	The standard consists of four parts: The latest published versions are: • EN 378-1:2016 Refrigerating systems and heat pumps - Safety and environmental requirements - Part 1: Basic requirements, definitions, classification and selection criteria • EN 378-2:2016 Refrigerating systems and heat pumps - Safety and environmental requirements - Part 2: Design, construction, testing, marking and documentation • EN 378-3:2016 Refrigerating systems and heat pumps - Safety and environmental requirements - Part 3: Installation site and personal protection • EN 378-4:2016+A1:2019 Refrigerating systems and heat pumps - Safety and environmental requirements - Part 4: Operation, maintenance, repair and recovery EN378-1/2/3:2016 include requirements for A2L refrigerants as an update from the previous version. CEN/TC 182/WG 6 is reviewing the standard and there is a focus on developing modifications to cover a variety of different measures to help HCs become more widely applicable. These include improved system measures, such as protection against mechanical impacts, airflow requirements able to prevent the formation of flammable mixtures and improved charge limits for A3 refrigerants below ground. CEN/TC 182/WG 12 is responding to the request of the EU to implement improved charge size for hydrocarbons.

ISO 5149 'Refrigerating systems and heat pumps'

Scope	**All stationary or mobile refrigerating/ air conditioning systems except for vehicle air conditioning systems, including secondary cooling or heating systems and their components. The scope is similar to EN 378.**
	The standard specifies the requirements for the safety of persons and property, provides guidance for the protection of the environment, and establishes procedures for the operation, maintenance, and repair of refrigerating systems and the recovery of refrigerants.
Status	The standard also consists of four parts: • ISO 5149-1:2014 Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Definitions, classification and selection criteria (ISO 5149-1:2014/Amd 1:2015 has been published in 2015 and ISO 5149-1:2014/DAmd 2 is currently under development) • ISO 5149-2:2014 Refrigerating systems and heat pumps — Safety and environmental requirements — Part 2: Design, construction, testing, marking and documentation (ISO 5149-2:2014/DAmd 1 is currently under development) • ISO 5149-3:2014 Refrigerating systems and heat pumps — Safety and environmental requirements — Part 3: Installation site (ISO 5149-3:2014/DAmd 1 is currently under development) • ISO 5149-4:2014 Refrigerating systems and heat pumps — Safety and environmental requirements — Part 4: Operation, maintenance, repair and recovery (currently under review) ISO/TC 86/SC 1/WG 1 is considering a variety of additional requirements to enable larger allowable charges of flammable refrigerants.

Annex III: Additional standards relevant to the RACHP sector

The following standards are of higher priority:

- Tightness of components and connections
  - ISO 14903/ EN 16084:2011, Refrigerating systems and heat pumps — Qualification of tightness of components and joints
- Competence of personnel
  - EN 13313:2010, Refrigerating systems and heat pumps — Competence of personnel
- Risk assessment of equipment using flammable gases
  - EN 1127-1:2011: Explosive atmospheres. Explosion prevention and protection. Basic concepts and methodology.
- Classification of hazardous areas
  - EN 60079-10-1, Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres
- Electrical equipment for use in potentially flammable areas
  - IEC 60079-0:2011, Explosive atmospheres – Part 0: Equipment - General requirements

The following standards are of interest:

- General safety of compressors and pumps
  - EN 60335-2-34:2013, Household and similar electrical appliances — Safety — Part 2-34: Particular requirements for motor-compressors (IEC 60335-2-34:2012)
  - EN 809, Pumps and pump units for liquids — Common safety requirements
  - IEC 60204-1, Safety of machinery — Electrical equipment of machines — Part 1: General requirements
  - EN 1012-3, Compressors and vacuum pumps — Safety requirements — Part 3: Process compressors
  - EN 12693:2008, Refrigerating systems and heat pumps — Safety and environmental requirements —Positive displacement refrigerant compressors
- Addressing pressure safety of system vessels and components
  - EN 1736:2008, Refrigerating systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements, design and installation
  - ISO 4126-1, Safety devices for protection against excessive pressure — Part 1: Safety valves
  - ISO 4126-2, Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices
  - EN 12178:2003, Refrigerating systems and heat pumps — Liquid level indicating devices — Requirements, testing and marking
  - EN 12263:1998, Refrigerating systems and heat pumps — Safety switching devices for limiting the pressure — Requirements and tests
  - EN 12284:2003, Refrigerating systems and heat pumps — Valves — Requirements, testing and marking
  - EN 13136:2013, Refrigerating systems and heat pumps — Pressure relief devices and their associated piping — Methods for calculation
  - EN 13445-1:2014, Unfired pressure vessels — Part 1: General
  - EN 13445-2:2014, Unfired pressure vessels — Part 2: Materia
  - EN 13445-4:2014, Unfired pressure vessels — Part 4: Fabrication
  - EN 13445-5:2014, Unfired pressure vessels — Part 5: Inspection and testing
  - EN 13445-6:2014, Unfired pressure vessels — Part 6: Requirements for the design and fabrication of pressure vessels and pressure parts constructed from spheroidal graphite cast iron
  - EN 13445-8:2014, Unfired pressure vessels — Part 8: Additional requirements for pressure vessels of aluminium and aluminium alloys

  - EN 14276-1:2006+A1:2011, Pressure equipment for refrigerating systems and heat pumps — Part 1: Vessels — General requirements
  - EN 14276-2:2007+A1:2011, Pressure equipment for refrigerating systems and heat pumps — Part 2: Piping — General requirements
- Electromagnetic compatibility
  - EN 61000-6-1:2007, Electromagnetic compatibility (EMC) — Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1:2005)
  - EN 61000-6-2:2005, Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments (IEC 61000-6-2:2005)
  - EN 61000-6-3:2007, Electromagnetic compatibility (EMC)— Part6-3: Generic standards— Emission standard for residential, commercial and light-industrial environments (IEC 61000-6-3:2006)
  - EN 61000-6-4:2007, Electromagnetic compatibility (EMC)— Part6-4: Generic standards— Emission standard for industrial environments (IEC 61000-6-4:2006)
- General safety of machinery
  - EN ISO 12100:2010, Safety of machinery — General principles for design — Risk assessment and risk reduction (ISO 12100:2010)
  - EN ISO 13849-1:2015, Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2015)
- Safety characteristics of refrigerants (e.g.,
  - ISO 817:2014, Refrigerants — Designation and safety classification
  - IEC 60079-20-1)
- Gas detection
  - EN 14624, Performance of portable leak detectors and of room monitors for halogenated refrigerants
  - IEC 60079-29-1:2016, Explosive atmospheres – Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases
  - IEC 60079-29-2:2015, Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen
  - IEC 60079-29-3:2014, Explosive atmospheres – Part 29-3: Gas detectors - Guidance on functional safety of fixed gas detection systems
  - IEC 60079-29-4:2009, Explosive atmospheres – Part 29-4: Gas detectors - Performance requirements of open path detectors for flammable gases
  - EN 50402: 2005+A1: 2008 Electrical apparatus for the detection and measurement of combustible or toxic gases or vapours or of oxygen. Requirements on the functional safety of fixed gas detection systems
- Electrical equipment for use in potentially flammable areas
  - IEC 60079-1:2014, Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"
  - IEC 60079-2:2014, Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p"
  - IEC 60079-5:2015, Explosive atmospheres – Part 5: Equipment protection by powder filling "q"
  - IEC 60079-6:2015, Explosive atmospheres – Part 6: Equipment protection by liquid immersion "o"
  - IEC 60079-7:2015, Explosive atmospheres – Part 7: Equipment protection by increased safety "e"
  - IEC 60079-11:2011, Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"
  - IEC 60079-13:2010, Explosive atmospheres – Part 13: Equipment protection by pressurized room "p"
  - IEC 60079-14:2013, Explosive atmospheres – Part 14: Electrical installations design, selection and erection

- IEC 60079-15:2010, Explosive atmospheres – Part 15: Equipment protection by type of protection "n"
- IEC 60079-17:2013, Explosive atmospheres – Part 17: Electrical installations inspection and maintenance
- IEC 60079-18:2014, Explosive atmospheres – Part 18: Equipment protection by encapsulation “m”
- IEC 60079-19:2010+AMD1:2015 Explosive atmospheres – Part 19: Equipment repair, overhaul and reclamation
- IEC 60079-25:2010, Explosive atmospheres – Part 25: Intrinsically safe electrical systems
- IEC 60079-26:2014, Explosive atmospheres – Part 26: Equipment with Equipment Protection Level (EPL) Ga
- IEC 60079-32:2015, Explosive atmospheres – Part 32: Electrostatics hazards
- IEC 60079-33:2012, Explosive atmospheres – Part 33: Equipment protection by special protection 's'