International Safety Standards in Air Conditioning, Refrigeration & Heat Pump

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→Abstract

In order to achieve the obligations of the Kigali Amendment under the Montreal Protocol, countries must adopt refrigerants with a lower Global warming potential (GWP). Natural refrigerants such as hydrocarbons, carbon dioxide and ammonia are suitable options, but present additional safety hazards compared with conventional HCFC and HFC refrigerants, such that there is a heightened need to introduce appropriate safety standards. Current international safety standards for Air Conditioning, Refrigeration and Heat Pump (ACR&HP) systems pose substantive barriers to the implementation of natural refrigerants, by means of obstructive refrigerant charge size limits.

A positive correlation between refrigerant quantity and cooling capacity is demonstrated for natural refrigerants, such that there is an explicit need to modify international safety standards to allow larger charge sizes. In order to offset the increased flammability risk associated with a greater allowable charge, additional safety measures to mitigate the risk can be introduced to ACR&HP systems. These include improving leak tightness of the system, assuring sufficient airflow, adopting equipment housing design and inclusion of valves.

It is crucial that any changes to existing safety standards or requirements of entirely new safety standards should initially remain voluntary, as requirements are onerous by nature. After a trial period with a voluntary status, standards can subsequently be established as mandatory requirements. Based on experience over the past 20+ years, it is estimated that it will take five to ten years for new or revised standards to be published. Such timelines are inconsistent with the needs of the industry to implement low GWP alternatives in time to comply with obligations under the Montreal Protocol and Kigali Amendment.

This paper has been drafted under the Green Cooling Initiative (GCI), which is financed by the International Climate Initiative (IKI) of the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU).

This paper intends to provide policy makers, standard authorities and private sector representatives with an overview and orientation on international safety standards for ACR&HP systems, in particular addressing developing countries that intend to widen the use of environmentally friendly refrigerants in a safe way. The document identifies what is currently feasible with existing safety standard requirements, and what possibilities exist to ease the barriers and improve safety standards for the future. In particular, the following aspects are addressed:

- The key safety standards applicable to ACR&HP systems;
- How those safety standards can be applied;
- Technical obligations arising from the various safety standards;
- Options and opportunities to improve safety standards internationally and/or nationally.

→Abbreviations

ACR&HP	Air Conditioning, Refrigeration and Heat Pump
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardization
GCI	Green Cooling Initiative
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GWP	Global Warming Potential
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
IEC	International Electrotechnical Commission
ISO	International Standardisation Organisation
LFL	Lower Flammability Limit
UNEP	United Nations Environment Programme

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→ INTRODUCTION

1. Introduction

There is a significant trend towards applying natural refrigerants as low global warming potential (GWP) alternatives to ozone depleting substances (ODSs) and conventional higher GWP hydrofluorocarbons (HFCs). Since the adoption of the Kigali Amendment of the Montreal Protocol on the phase down of HFCs on 15th October, 2016, several countries have already ratified it. The Amendment is expected to enter into force on 1st January 2019.

Low GWP alternative refrigerants include both synthetic and natural refrigerants. The synthetic alternatives typically include certain saturated HFCs, unsaturated HFCs and unsaturated hydrochlorofluorocarbons (HCFCs) and mixtures thereof; whilst these have some attractive characteristics, many exhibit relatively poor thermo-physical properties thus inferring greater investment required to achieve certain system efficiency. Moreover, most unsaturated HFCs and HCFCs have fairly low saturated vapour pressures and therefore require larger system components in order to match cooling or heating capacity of many of the existing refrigerants – the comparatively high cost of these unsaturated fluorocarbons is therefore exaggerated due to greater material costs and a corresponding larger refrigerant charge. These problems can be overcome to a certain extent by mixing with existing HFCs, but in many cases it results in refrigerant blends with undesirably high GWP and/or temperature glide.

Natural refrigerants, including hydrocarbons (HCs), carbon dioxide (R744), and ammonia (R717) have excellent thermo-physical properties compared to fluorinated refrigerants, corresponding to high potential system efficiency as well as being relatively cheap. On the other hand, HCs, R744 and R717 present additional safety hazards compared with conventional HCFC and HFC refrigerants. As such, there is a heightened need to employ safety standards. However, it is recognised that the current international safety standards for refrigeration, air conditioning and heat pump (ACR&HP) applications pose some constraints, mostly in terms of limits on the quantity of refrigerant permitted in systems.

Safety standards have a particular relevance with regard to use and use restrictions for refrigerants in ACR&HP systems. This was identified as one of the main obstacles to the uptake of environmentally friendly refrigerants in a United Nations Environment Programme (UNEP) study on barriers for low GWP alternatives in Article 5 countries (Colbourne, 2010), although equally applies to non-Article 5 too. Reasons for these limitations are largely due to historical dominance of non-flammable, lower toxicity refrigerants, the inertia associated with changing safety standards (and the views of stakeholders), and also the interests of stakeholders with commercial interests in competing technologies.

This document is intended to introduce the topic of international safety standards for ACR&HP systems, in particular addressing developing countries that intend to widen the use of environmentally friendly refrigerants in a safe way. It identifies what is currently feasible with existing safety standard requirements, and which possibilities exist to ease the barriers and improve safety standards for the future. In particular, the following aspects are addressed:

- The key safety standards applicable to ACR&HP systems;
- How those safety standards can be applied;
- Technical obligations arising from the various safety standards;
- Options and opportunities to improve safety standards internationally and/or nationally.

2

→ OVERVIEW AND CHOICE OF RELEVANT ACR&HP SAFETY STANDARDS

2. Overview and choice of relevant ACR&HP safety standards

Within the context of the ACR&HP sector, there are two international standardisation organisations that publish relevant safety standards: the International Standardisation Organisation (ISO) and the International Electrotechnical Commission (IEC). Similarly, at European (regional) level there are equivalent organisations – the European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) – which publish comparable standards that broadly cover the same scope and requirements to those of ISO and IEC.[1]

Table 1 provides a summary of the key international and regional standards and their scope. Those listed are categorised as "vertical" or product standards and as "horizontal" or group standards. Broadly speaking, vertical standards take precedence over horizontal standards, as they are intended to be developed specifically for particular product types and thus have requirements that are more refined for particular cases. Thus, horizontal standards are assumed to cover everything that is not handled by the vertical standards. That is, they include more generic and overarching requirements based on common characteristics and practices of any ACR&HP equipment, installations and technician activities.

However, the boundaries between vertical and horizontal standards are not rigid and ultimately designers, manufacturers, installers and contractors must decide which standard is most appropriate for their respective situation.[2] In many cases, it may be that the most suitable requirements to follow are a combination of those within different sections of the horizontal and vertical standards. Furthermore, requirements within either standard may be deficient in certain measures (perhaps due to their outmoded content), and it may be apparent that improved guidance from elsewhere should take precedence. Indeed, it is inappropriate to regard national or international safety standards as definitive.

Table 1: Scope of different international and regional safety standards for ACR&HP systems

Sector	Vertical (Product Standards)			Horizontal (Group Standards)
	IEC 60335-2-24	IEC 60335-2-40	IEC 60335-2-89	ISO5149-1,-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-to-air air conditioners & heat pumps		×		×
Water heating heat pumps		×		×
Chillers		×		×

1 The Vienna Agreement and Frankfurt Agreement confirm the objective to coordinate CEN and ISO standards development and CENELEC and IEC standards development, respectively. Apart from helping to harmonise international and regional standards, it also minimises repetition of technical work.
2 Provided that a particular standard has not been mandated by national legislation.

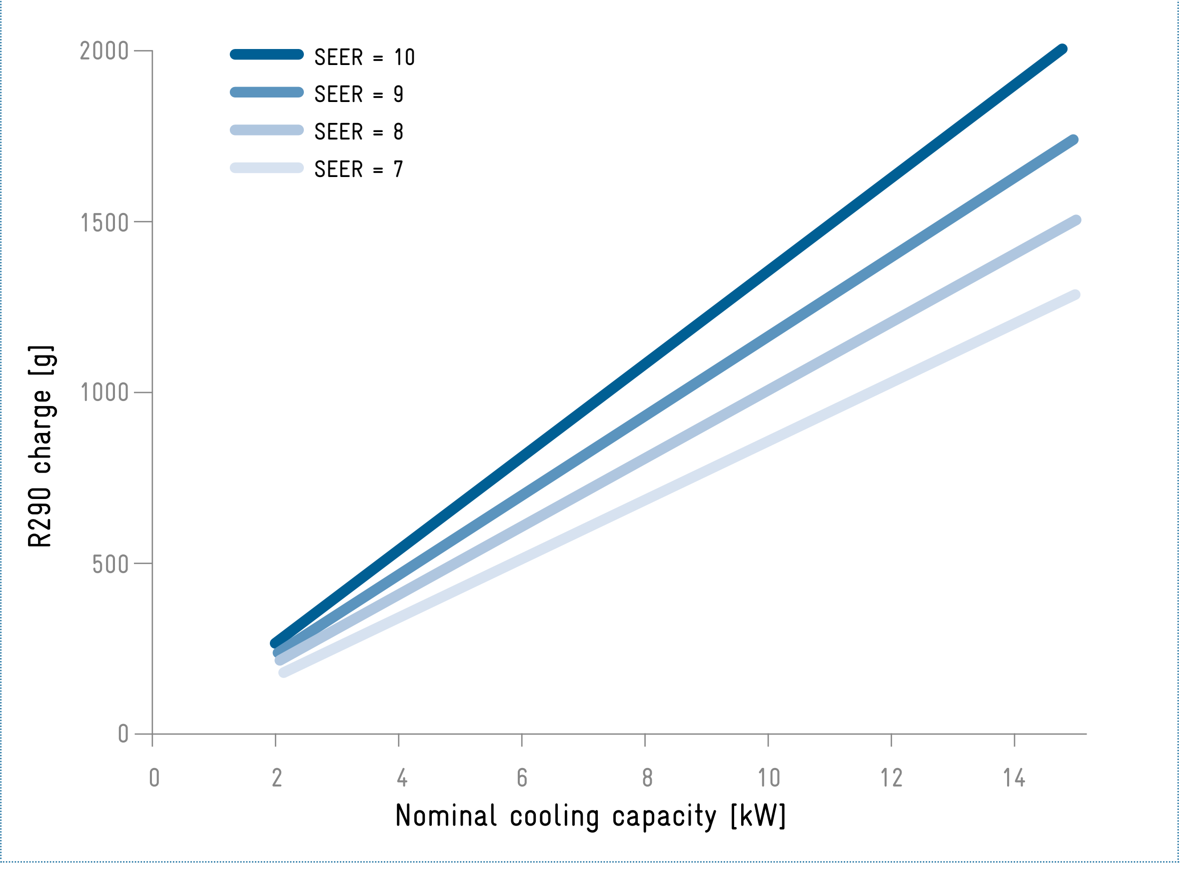
In many cases, countries will adopt the ISO and IEC standards as national standards, which are then essentially a "copy and paste" of the international standards, although it is also common for countries to adopt the international standards but with national modifications. In other countries, safety standards have been developed independent of the international standards, and thus contain requirements that differ substantially.

Although the safety standards listed in Table 1 are specifically applicable to ACR&HP systems, they can seldom be used in isolation. There are a variety of other standards that address safety matters related to equipment, components and methods that may apply generically across different end uses. As such, these types of standards are often invoked by ACR&HP safety standards to address issues such as safety devices, flammability safety, pressure vessels, electrical equipment, controls and so on.

Amongst the numerous types of requirements addressed within the ACR&HP safety standards, the most important aspect to the application of low GWP alternatives is that of refrigerant charge size limits; and this is critical when related to the use of HCs. In particular, charge sizes of systems with flammable refrigerants need to be optimised in order to maintain acceptable safety levels while ensuring high energy efficiency. Figure 1 below provides an illustration of how the cooling capacity of an air conditioner is related to the refrigerant charge for a range of different seasonal efficiencies. The diagram highlights the dependence of system performance and required refrigerant charge. A higher seasonal efficiency requires a higher charge size.

The introduction of energy efficient technologies with low GWP refrigerants requires a suite of technical standards which adequately address both flammability/charge size and energy efficiency.

Figure 1: Example relationship between refrigerant charge and cooling capacity as a function of seasonal efficiency of an air conditioner (SEER) with R290



In addition to the ACR&HP safety standards identified above, there is an array of other safety standards, specific to ACR&HP equipment and also to general concepts that are generally applicable and affect ACR&HP equipment. Both international and regional standards address:

- 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 (e.g. 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)

Many of these standards can influence the ease and cost of operation when applied to ACR&HP systems using low GWP alternatives. Notably, several of the standards may be mandatory or have a legal status that is beyond the particular ACR&HP standards.

3

→ RELATIONSHIP BETWEEN SAFETY STANDARDS AND NATIONAL REGULATIONS

3. Relationship between safety standards and national regulations

The form, significance and status of safety standards differ widely across countries. Consequentially, stakeholders' opinions of the importance of standards are equally as diverse. Globally, the following variations apply:

- **For safety standards, countries**

  – Develop their own safety standards independently;
  – Adopt international (or regional) standards as national standards "as is";
  – Adopt international (or regional) standards as national standards with modifications;
  – Do not have national standards but instead use other countries' standards.

- **Status of safety standards are either**

  – Entirely voluntary;
  – Mandated by national legislation;
  – Deemed as a means of complying with certain legislation;
  – Broadly voluntary except by contractual agreements by two or more entities parties.

- **Compliance with safety standards may be**

  – By self-certification;
  – By a third party certification body only;
  – Overseen by market surveillance systems;
  – Confirmed by at least one governmental institution.

Evidently, it is not straightforward to illustrate typical situations or draw generalisations on how safety standards are treated across most countries.

However, many countries do employ broadly applicable safety regulations that handle generic subjects such as pressure safety, toxicity, electrical safety, flammability and explosion protection, and general safety of machinery and building safety, amongst others. Implications of these also vary: regulations may invoke safety standards to deal with or clarify certain matters, they may effectively rely on safety standards to formulate the safety concept, or in some cases they may directly conflict with safety standards.

Generally product liability is enshrined by applicable health and safety legislation in a given country and so any product placed on the market must comply with such legislation. Infrequently, national legislation may invoke safety standards explicitly, however, in most countries safety standards offer only one interpretation of satisfying the requirements of national legislation. Thus provided that any new safety standard does not conflict with national legislation that governs the use, application and handling of flammable gases it will not in principle lead to product liability issues. Indeed, such legislation generally states that equipment and installations must be "safe" and it is thus left to the user to carry out the requisite risk assessments and to demonstrate a sufficient level of safety has been attained. In fact, the same approach also applies to the use of safety standards; since no standard can comprehensively address each and every single set of circumstances and characteristic of ACR&HP equipment and installations, the manufacturer and installer have an obligation to take account of all the relevant peculiarities that may not be suitably addressed with the standard. Needless to say, this applies to all the different hazards – electrical, pressure, mechanical, toxicity, etc. – that are applicable to the equipment. In carrying out a risk assessment, the stakeholder should seek out the most reliable and relevant empirical data and along with the appropriate tools and techniques to analyse the risk associated with equipment / installation to help gauge whether the proposed design and construction meets some reference safety level. This is irrespective of any requirements specified within the applicable safetystandards.

Concerning possible barriers to trade, the WTO's Technical Barriers to Trade Agreement (TBT) tries to ensure that regulations, standards, testing and certification procedures do not create unnecessary obstacles. Provided that a given country does not publish (a mandatory) safety standard that is more stringent or restrictive than, say, an international standard then a relaxation of charge size limits (that may be offset with appropriate countermeasures) would most likely not conflict with the TET.

4

→ CURRENT REQUIREMENTS FOR SYSTEMS USING FLAMMABLE REFRIGERANTS

4. Current requirements for systems using flammable refrigerants

ACR&HP safety standards address a wide range of hazards associated with ACR&HP systems and equipment. Notably, these safety standards do not only focus on refrigerant charges, but also on many other issues. Aspects related to refrigerant safety represent a proportion of these hazards and the associated design, construction and handling requirements. Table 2 provides a summary of the important topics handled by ACR&HP safety standards that are affected by refrigerant choice.

Table 2: General technical obligations under safety standards for ACR&HP systems

Category	IEC 60335-2-24	IEC 60335-2-89	IEC 60335-2-40	ISO 5149-1, -2, -3, -4
	EN 60335-2-24	EN 60335-2-89	EN 60335-2-40	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 R744 R717 is out of scope	150 g flammable refrigerant No limits for R744 R717 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 R744 R717 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 R744 or limited by room size No limits for R717 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 have to 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.		

Table 2 demonstrates that several design and construction aspects can be affected by refrigerant type. Accordingly, such requirements can potentially influence the cost of systems and convenience for manufacturers and installers. However, refrigerant charge size limits are ultimately the most pivotal requirements within safety standards in terms of viability for application of natural refrigerants. This is particularly the case for HCs. Table 3 summarises the charge size limits for HCs across current safety standards.

Table 3: Refrigerant charge size limits for HCs according to safety standards for ACR&HP systems

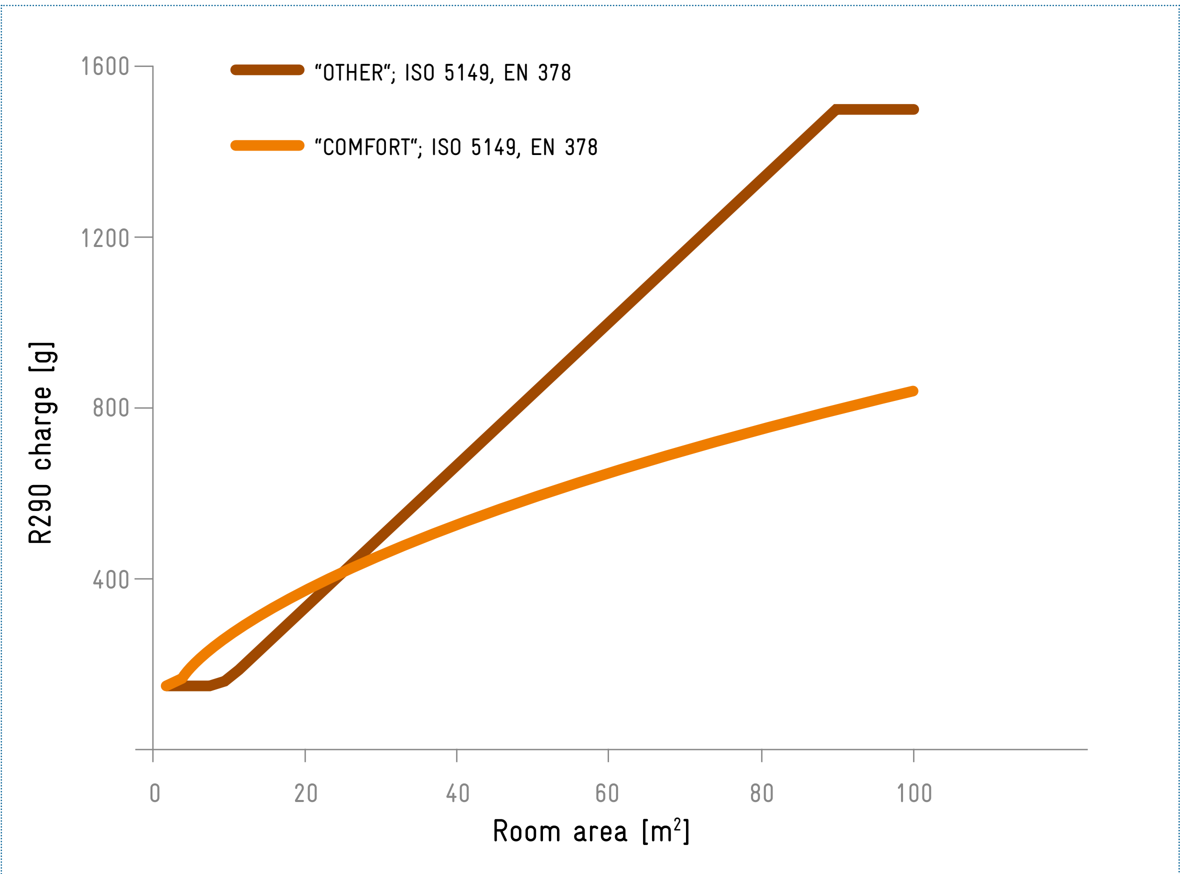
Equipment/ application	Vertical (60335-2-24, -40, -89)		Horizontal (ISO 5149-1, EN 378-1)	
	Maximum charge	Allowable charge	Maximum charge	Allowable charge
Domestic refrigeration	0.15 kg	0.15 kg		
Commercial refrigeration				
• Stand alone	0.15 kg	0.15 kg	1.5 kg	$0.008 \times V_{rm}$
• Condensing units	0.15 kg	0.15 kg	1.5 kg	$0.008 \times V_{rm}$
• Centralised systems			1.5 kg	$0.008 \times V_{rm}$
Transport refrigeration			1.5 kg; 2.5 kg	1.5 kg; 2.5 kg
Large size refrigeration			2.5, 10, 25 kg, no limit	$0.008 \times V_{rm}$
Air conditioner & heat pumps				
• Small self-contained	0.3 kg	$0.01 \times V_{rm}$	0.3 kg	$0.01 \times V_{rm}$
• Mini-split	1 kg	$0.04 \times h \times A_{rm}^{0.5}$	1.5 kg	$0.04 \times h \times A_{rm}^{0.5}$
• Multi-split	1 kg	$0.04 \times h \times A_{rm}^{0.5}$	1.5 kg	$0.04 \times h \times A_{rm}^{0.5}$
• Ducted split	1 kg	$0.04 \times h \times A_{rm}^{0.5}$	1.5 kg	$0.04 \times h \times A_{rm}^{0.5}$
• Ducted commercial	1 kg	$0.04 \times h \times A_{rm}^{0.5}$	1.5 kg	$0.04 \times h \times A_{rm}^{0.5}$
• Hot water heating heat pumps	1 kg, 5 kg	$0.04 \times h \times A_{rm}$	1.5 kg, 5 kg, 10 kg, 25 kg, no limit	$0.04 \times h \times A_{rm}^{0.5}$
• Space heating heat pumps	1 kg, 5 kg	$0.04 \times h \times A_{rm}$	1.5 kg, 5 kg, 10 kg, 25 kg, no limit	$0.04 \times h \times A_{rm}^{0.5}$
Chillers				
• Positive displacement	1 kg, 5 kg	1 kg, 5 kg	1.5 kg, 5 kg, 10 kg, 25 kg, no limit	
• Centrifugal			1.5 kg, 5 kg, 10 kg, 25 kg, no limit	

where: V_{rm} = room volume (in m³); A_{rm} = room area (in m²) and h = unit installation height (in m)

As indicated above, current safety standards tend to rely on two types of constraints for refrigerant charge amounts: (i) the maximum charge being an overall cap according to the application and location of the system, and (ii) an allowable charge as a function of room size and in some cases the installation height of the equipment.

An example is illustrated in Figure 2, based on commercial refrigeration under horizontal standards. With an R290 mass below 150 g, there is no relationship with room size. Above 150 g the allowable charge is a function of room size, until the maximum charge of 1500 g is reached, after which increasing the room size does not permit more R290.

Figure 2: Example of the relationship between room size and refrigerant charge limits (for "comfort" indoor unit install height = 2 m)



The upper maximum charge limits (e.g., 1.5 kg in the above example) are broadly arbitrary values assigned to ensure the quantities used in systems do not extend to uncontrolled quantities. In practice, nevertheless, the upper maximum charge limits prescribed by the current standards seldom create a significant barrier to the selection and application of HCs in most ACR&HP sub-sectors. For instance, the vast majority of single commercial refrigeration cabinets and room air conditioners require less than 1.5 kg of R290 and heat pumps rarely need more than 5 kg. Other than centralised commercial refrigeration systems and large multi-split (e.g., VRF) air conditioning systems where tens of kilograms of HC would be inappropriate, the only applications where the upper maximum charge limits have been found to be problematic are for commercial ducted split and "rooftop" type systems.

Based on the charge size limits indicated in Table 3, and accounting for typical refrigerant needs to achieve a certain cooling capacity at various temperature levels and associated heat loads, an approximation of ACR&HP system capacity ranges is provided in Table 4.

Table 4: Approximate capacity range of different types of applications using HC, R744 or R717

Equipment/application	Approximate maximum capacity with alternative refrigerant (kW)[3]		
	HC (R290, R600a, etc.)	R744*	R717
Domestic refrigeration	No limit	No limit	No limit (sorption type)
Commercial refrigeration			
• Stand-alone equipment	1 to 15	No limit	Not permitted
• Condensing units	5 to 10	No limit	Not permitted
• Centralised systems	2 to 4	No limit	Not permitted
Transport refrigeration	6 to 15	No limit	n/a
Large size refrigeration	60 to no limit	No limit	No limit
Air conditioner & heat pumps			
• Small self-contained	4 to 10	No limit	Not permitted
• Mini-split (non-ducted)	up to 10	No limit	Not permitted
• Multi-split	3 to 6	No limit	Not permitted
• Ducted split	10 to 20	No limit	Not permitted
• Ducted commercial	10 to 20	No limit	Not permitted
• Space/hot water heat pumps (domestic)	10 to 50	No limit	Not permitted
• Heat pumps (commercial)	50 to no limit	No limit	Not permitted
Chillers			
Positive displacement	150 to no limit	No limit	No limit
Centrifugal	25 to no limit	No limit	n/a

** Degradation of capacity and efficiency at moderate to high ambient temperatures must be considered.*

3 The values are based on approximate specific charge sizes per kW of cooling (or heating) for air conditioning, chilled or freezer temperature levels, whether the equipment is located inside or outside, and according to the charge size limits from the cited safety standards.

5

→ RECOMMENDATION ON AMENDED SAFETY STANDARDS FOR NATURAL REFRIGERANTS, SPECIFICALLY HYDROCARBON REFRIGERANTS

5. Recommendation on amended safety standards for natural refrigerants, specifically hydrocarbon refrigerants

The allowable refrigerant charge of HC refrigerants is contentious. In some applications – such as commercial refrigeration – the amount of refrigerant can be constrained due to the size of a shop (e.g., a display cabinet in a convenience store). This can inhibit the applicability of, for example, larger commercial refrigeration in smaller shops. In air conditioning applications where the desired cooling capacity of an air conditioner is strongly influenced by room size, some models may require more refrigerant than is allowed (i.e., to provide the desired cooling capacity for that room size). In order to help resolve such constraints, additional safety mitigation measures can be applied to the ACR&HP systems so as to offset the potentially increased flammability risk ordinarily associated with a greater charge quantity (e.g., per room size). Such mitigation measures include:

- Improving leak tightness of the system, over and above assumed standard practice;
- Adopting equipment housing design to help disperse leaks better than that assumed with conventional housing designs;
- Guaranteeing sufficient airflow rate within the room, to ensure that leaked refrigerant does not stagnate at the floor and its concentration stays below the lower flammability limit (LFL);
- Inclusion of valves or other component to limit the refrigerant amount released in the event of a leak.

The last two measures may be applied in conjunction with some form of leak indication (e.g., gas sensors, ultrasonic detection or system parameters) so they can be activated on demand.

The following provides a practical illustration of how such measures could be applied.

IMPROVED TIGHTNESS

Presently, allowable charge limits are based on the assumption that the refrigerant leaks out instantaneously and at a very fast rate (a "catastrophic" leak). Since a higher leak rate gives the refrigerant less time to dilute in the surrounding air, higher concentrations within the room will develop and in order to avoid those concentrations reaching the lower flammability limit (LFL), the refrigerant mass is constrained accordingly.

Current safety standards do not impose measures to avoid such leaks occurring. Therefore, if such "improved tightness" measures were implemented, the likelihood of "catastrophic" leaks can be effectively disregarded. Accordingly, if a relatively slow leak is assumed, then the refrigerant would more easily dilute with the surrounding air, and a greater amount of released refrigerant can be tolerated until a potentially flammable concentration occurs.

Although quantifying a direct relationship between certain implemented measures and an expected leak rate is not practical, engineering logic and experience helps to provide some approximations. Thus, if all refrigerant-containing parts of the system that are inside the building are engineered so that: (i) within equipment housing, the possibility of damage from external mechanical impact is eliminated, (ii) internal rubbing and fretting of parts are prevented, (iii) configuration of piping is such that potentially deleterious resonances do not occur in piping, and (iv) cracking due to icing or fan damage is prevented, large instantaneous leaks cannot occur.

Research has found that under these circumstances, approximately 2 – 3 times as much refrigerant can be leaked than that prescribed by allowable charge formula (e.g. Table 3) before LFL is likely to be exceeded (e.g., Cleaver et al., 1994; Colbourne and Suen, 2018; Li, 2014; Zhang et al., 2013).

SYSTEMS WITH INTEGRAL AIRFLOW

Allowable charge sizes are based on the assumption that room air is quiescent, such that the only reason why a leak would mix with the air is through the momentum of the released refrigerant itself. Obviously, there is always some (beneficial) airflow occurring in all occupied spaces, but as in some occasions the air flow is negligible, any possible benefit to refrigerant releases has been ignored so far.

However, ACR&HP systems typically use fans to distribute the air that it has cooled or heated away from the equipment, and usually throughout the space it is installed. If this airflow can be guaranteed when needed, it can be accounted for in the dilution of a leaked refrigerant. The presence of forced airflow – either continuously or initiated by some means of leak detection – dramatically improves dilution of a refrigerant release, and thus a much greater quantity of refrigerant can be tolerated before a flammable concentration arises.

Ultimately, if the airflow provided by the fan within the unit that houses refrigerant-containing parts either operates continuously or is initiated by a sensor such as a gas detector, any leaked refrigerant can be mixed almost homogenously within the room. Accordingly, a greater mass of refrigerant for a given room size can be permitted.

CHARGE DETERMINATION BY TEST

Allowable charge size limits with current standards are broadly based on limited measurements of "idealised" releases, i.e., where a refrigerant enters the surroundings under conditions that are essentially unfavourable for mixing with air, thereby leading to higher concentrations and thus requiring a constraint on the amount.

Recent research (e.g. Colbourne and Suen, 2014; 2016) has found that the dimensions and configuration of the housing within which the refrigerant containing parts are located can have a substantial influence on the dilution of the leak. As such, a well-designed housing can help increase the dilution of a leak by up to a factor of five, compared to an "idealised" case. Broadly, a correspondingly greater amount of refrigerant can be released until a flammable concentration is reached. However, the influence is highly complex and the relationship between housing characteristics and resulting refrigerant concentration cannot be approximated easily. Therefore, individual testing may be used.

For a given housing design, leaks may be simulated and the refrigerant concentration at the floor surrounding the unit are measured and (for an assumed leak rate) the acceptable charge of refrigerant may be determined according to the amount that ensures a certain concentration is not exceeded, or exceeded for a specified amount of time.

Note that this approach can be combined with some of the other mitigation measures. For instance, if the system is designed for improved tightness, the release rate of the test can be reduced. Alternatively, if airflow is intended to be continuous, then the test may be carried out with the unit fan operating.

SYSTEM WITH LIMITED RELEASABLE CHARGE

Existing charge size limits assume that the entire "charged" amount of refrigerant leaks out. However, this is not possible as refrigerant remains in the piping and components at atmospheric pressure, and absorbed in compressor oil at the end of a leak. Depending upon the size of system, type of oil, refrigerant, etc., this passive retention of charge can equate to around 3% to 15% of the total charge.

In addition, shut off valves may be employed within a system to actively limit the amount of refrigerant that could be released. System architecture, control functionality, operating conditions, leak location, etc. all have an influence, but approximately 30% to 95% of the nominal charge amount can be actively prevented from being released.

Whether the situation is passive or active, a rigorous test method is necessary to determine the actual amount of refrigerant that can leak out, considering the various operating modes and conditions.

Thus to determine the minimum room size within which the system can be installed, the actual refrigerant amount released from a system – as determined by some standardised test procedure – need be considered.

ADDRESSING POTENTIAL SOURCES OF IGNITION

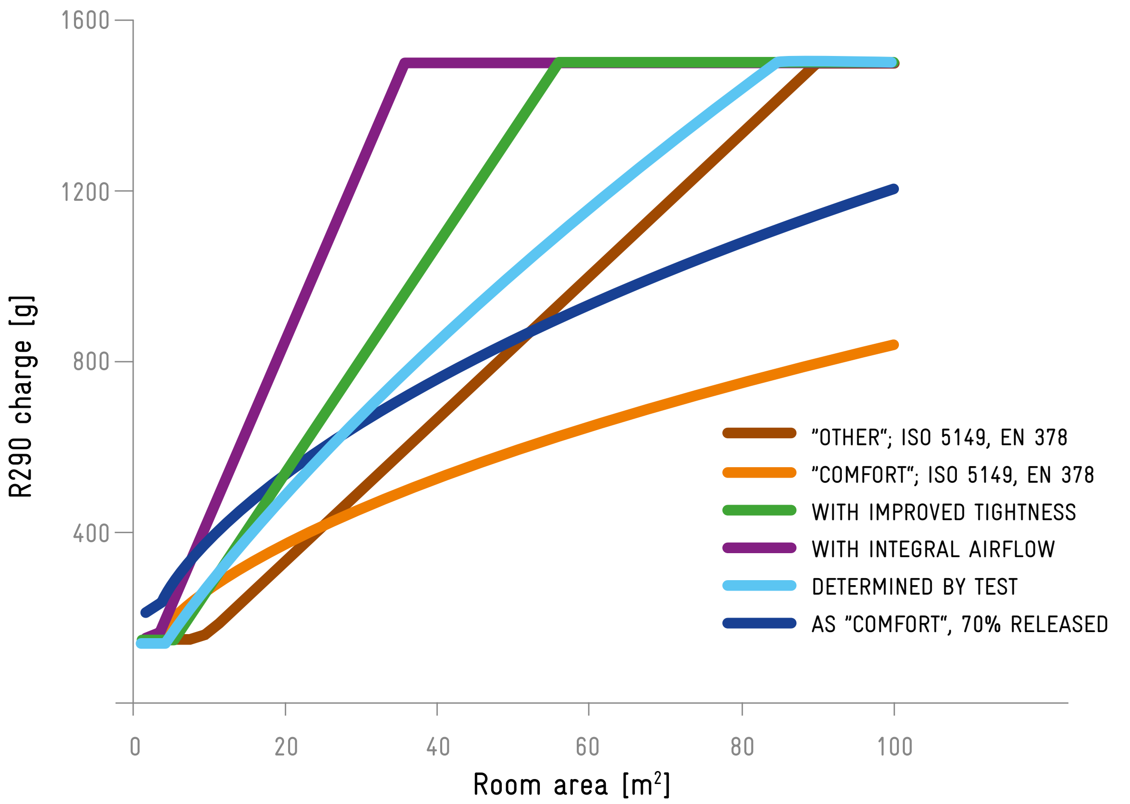
Currently, none of the international safety standards addresses the handling of potential sources of ignition in a way that is consistent with the established standards for protection against ignition of flammable gases. This specifically refers to the IEC / EN 60079-series of standards. ISO 5149 effectively neglects the issue and IEC 6035-2-40 and -89 partially address the issue, but in a manner that is inconsistent with established methodologies. In this respect, revisions are necessary to all three international standards.

The current version of EN 378 includes an approach and a methodology to address the handling of potential sources of ignition, although at present the requirements are incomplete and requires improvement.

OVERVIEW

Figure 3 below compares possibilities based on the above concepts against the existing charge size limits within the current safety standards. Specific limits within the figure are based on certain assumptions used for illustration purposes, and actual constants and factors should be concluded. Nevertheless, from the graph, it can be seen that substantial improvements and flexibility in allowable charge sizes can be achieved through the different approaches described above.

Figure 3: Comparison of different alternative charge size methods and those in current standards for an R290 (propane) system in different room sizes



(Note the "installation height" for air conditioner and improved tightness is 2 m and the curve for "determined by test" is approximated based on tests with an air conditioner indoor unit at 2 m.)

6

→ ADVANCING NATIONAL AND INTERNATIONAL SAFETY STANDARDS

6. Advancing national and international safety standards

As explained previously, in order to achieve national obligations under the Kigali Amendment, it is necessary for ACR&HP systems to use refrigerants with a particularly low GWP. On the other hand, current safety standards pose substantive barriers to the implementation of such refrigerants – primarily HCs – by means of obstructive refrigerant charge size limits. Therefore, there is an explicit need to modify these safety standards so that larger charge sizes are permitted, along with guidance on how to apply them safely.

Presently, all of the critical safety standards IEC / EN 60335-2-89, IEC / EN 60335-2-40, ISO 5149 and EN 378 are being worked on in order to develop revisions and/or amendments. Some of the stakeholders involved are working towards improving charge size limits. In summary:

- For IEC 60335-2-89, WG 4 is working on defining the maximum flammable refrigerant amount for appliances along with measures to maintain the equivalent safety level as for the present 150 g limit;
- For IEC 60335-2-40, WG 16 is addressing improved charge size requirements for A2 and A3 refrigerants based on limiting the amount of refrigerant that can be released in the event of a leak, on effectively dispersing a leak by means of unit airflow and on increasing the allowable charge on condition that the system is constructed with measures to improve leak tightness;
- For ISO 5149, WG 1 is considering a variety of additional requirements to enable larger allowable charges;
- For EN 378, WG 6 is developing modifications to cover a variety of different measures to help HCs become more widely applicable.

Discussions are in progress and new investigations are emerging all the time.

However, those activities are time-consuming and protracted due to established procedures for standards development, as well as to conflicting views with stakeholders involved with competing technologies. Predictions about the publication duration of new requirements range from five to ten years; such timelines are inconsistent with the needs of the industry to implement low GWP refrigerants in time to comply with obligations under the Montreal Protocol and Kigali Amendment.

Therefore, further consideration may be given to mechanisms for interested countries to address such barriers nationally and/or regionally. Since local circumstances vary, the appropriate route for resolving the obstructions may vary slightly. Table 5 provides an indication of the types of interventions necessary, depending on the origin of the national safety standard and its legal status.

Table 5: Interventions for resolving obstructive safety standards

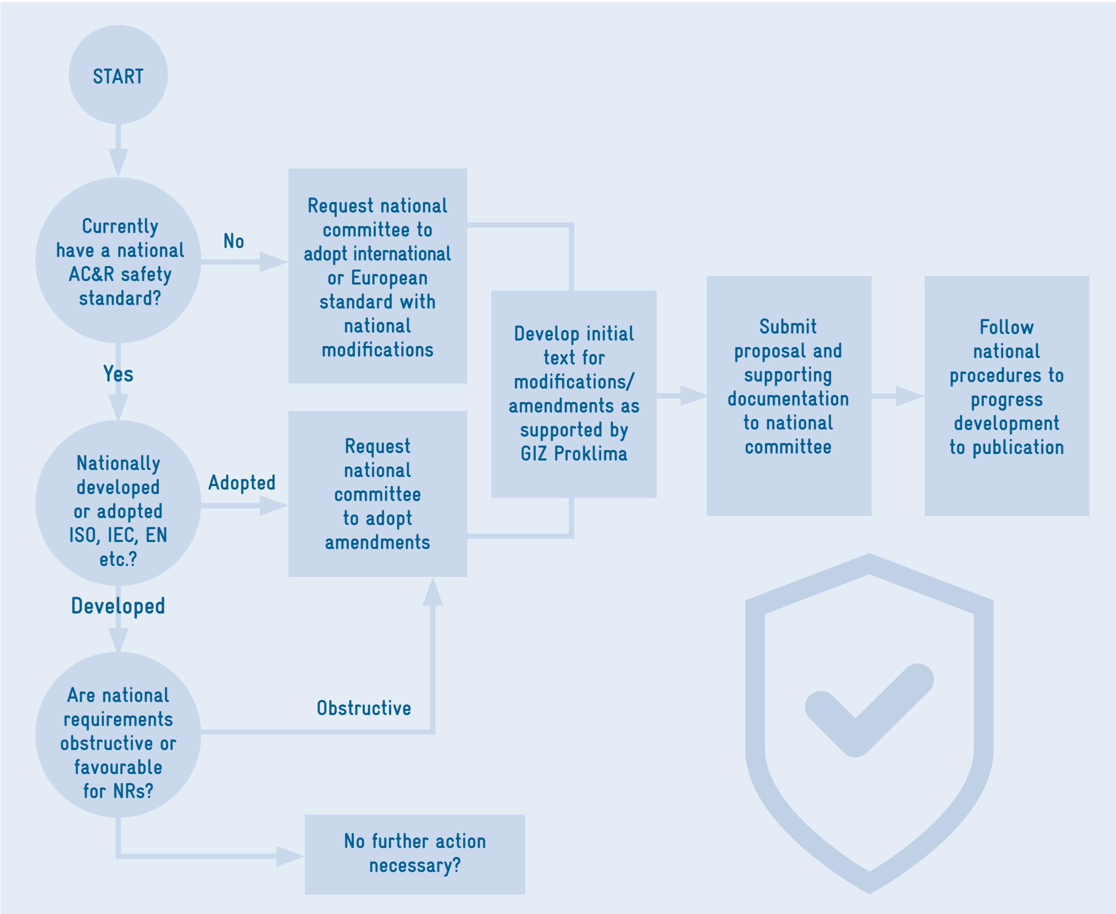
Origin of national safety standard	Status of safety standards		
	Voluntary standard	Standard is mandated by legislation	Standard offers one means of complying with legislation
Own national standard	Modify standard at national level	Modify national standard under consultation with authority responsible for said legislation	Modify national standard with cross-checks against obligations of said legislation
Copy of international standard	Implement national modifications to international version	Modify standard under consultation with authority responsible for said legislation	Modify standard with cross-checks against obligations of said legislation
International standard with national changes	Implement (further) national modifications to international version	Modify standard under consultation with authority responsible for said legislation	Modify standard with cross-checks against obligations of said legislation
None; use other country standard	Adopt other country's standard nationally and apply national modification	n/a	n/a
Do not currently use standard	Adopt other national or international standard and apply national modifications	n/a	n/a

In case the applicable safety standard lacks sufficient requirements necessary for broad use of natural refrigerants, some degree of intervention will be necessary to, for example, introduce requirements consistent with the recommendations in section 5. Where the existing standard is a nationally developed document, a copy of an international standard or one with nationally determined changes, further modifications can and should be made. In cases where there is currently no national standard, an appropriate standard may be adopted and modified accordingly. In the event that a national standard is mandated by national legislation, any modifications should be carried out in consultation with the appropriate national authority to ensure that no conflicts with regulations arise. A similar approach applies where a standard is not mandatory but is recognised as one of several legal options of complying with a national regulation.

In all these circumstances, the necessary steps are affected by the specific safety standards in use.[4] If the existing safety standard is the horizontal standard ISO 5149, then such modifications can be implemented relatively easily. If the standard is EN 378 – or where there is no current standard – then EN 378 together with the modifications indicated in Section 5 can also be implemented without much complication. Conversely, if the vertical standards IEC 60335-2-40 and IEC 60335-2-89 are in use, significant additional work is likely to help align them with the various options identified in Section 5. Ultimately, each country's situation should be addressed on a case-by-case basis. The flow chart in Figure 4 identifies the key decisions and steps to be considered when addressing these issues nationally.

4 If countries have adopted certain standards that contain extensive restrictions such as UL 484 or ASHRAE-15, which pose considerable obstructions to low GWP natural refrigerants, then further work is required to resolve the obstructions.

Figure 4: Flow chart identifying the main decisions and steps for addressing national safety standards



In conclusion, countries mandating safety standards must ensure their internal processes enable them to freely change and alter national standards or national adoptions of international safety standards to suit their national needs and circumstances. This is essential with respect to allowing the wider use of potentially flammable low GWP alternatives in order to meet ambitious improvements in energy efficiency, and lower climate and environmental impact of refrigerants (Munzinger et al., 2016).

In line with any modification to the safety standards, it is also appropriate to address these issues within national legislation. In particular, ensure that:

- National building safety regulations do not conflict with the requirements of modified safety standards;
- Any modifications are consistent with national regulations on pressure, flammability, toxicity, electrical and machinery safety;
- Sufficient knowledge and expertise on the technical subjects addressed therein are readily available for national experts to contemplate.

Critically, any changes to safety standards should at the first stage not be mandatory, since the nature of these requirements tends to be rather onerous. Following an initial trial period of voluntary developed standards, they can subsequently be established as mandatory standards, following refinements and practical trials, etc.

In order to achieve the obligations of the Kigali Amendment under the Montreal Protocol, countries must ensure that safety standards cease to pose barriers to the implementation of natural refrigerants, by means of obstructive refrigerant charge size limits. In order to offset the increased flammability risk associated with a greater allowable charge, additional safety measures to mitigate the risk can be introduced to system design and construction, such as improving leak tightness of the system, assuring sufficient airflow, adopting equipment housing design and inclusion of valves.

7

→ REFERENCES

7 References

Clark, E. and Wagner, S., OzonAction, United Nations Environment Programme (2016) 'The Kigali Amendment to the Montreal Protocol: HFC Phase-down'. [Online]. Available at: http://www.unep.fr/ozonaction/information/mmcfiles/7809-e-Factsheet_Kigali_Amendment_to_MP.pdf

Cleaver, R.P., Marshall, M.R., Linden, P.F. 1994. The build-up of concentration within a single enclosed volume following a release of natural gas. J. Hazardous Materials, Vol. 36 pp. 226-209.

Colbourne D., Suen K. O. Assessment of factors affecting R290 concentrations arising from leaks in room air conditioners. Proc. 13th IIR Gustav Lorentzen Conference on Natural Refrigerants (GL2018). Valencia, Spain, June 2018.

Colbourne D., Suen K. O. R290 concentrations arising from leaks in commercial refrigeration cabinets. Proc. 12th IIR Gustav Lorentzen Conference on Natural Refrigerants (GL2016). Édimbourg, United Kingdom, August 21st-24th 2016.

Colbourne, D., United Nations Environment Programme (2010) 'Barriers to the use of low-GWP refrigerants in developing countries and opportunities to overcome these'. [Online] Available at: http://www.unep.fr/ozonaction/information/mmcfiles/7476-e-Report-low-GWPbarriers.pdf

Colbourne, D; Suen, KO. 2014. Characterisation of a leak of flammable refrigerant within equipment enclosures. Proc. 11th IIR Gustav Lorentzen Conf., Hangzhou.

Li, T. X., 2014a. Indoor leakage test for safety of R-290 split type room air conditioner. Int. J. Refrig., Vol 40, 380–389.

Munzinger, P., Andres, D., Boos, D., Becker, C., Usinger, J., Papst, I., Heubes, J., Oppelt, D. and Röser, F. (2016) Advancing nationally determined contributions (NDCs) through climate-friendly refrigeration and air conditioning - Guidance for policymakers. Available at: https://www.giz.de/expertise/downloads/giz2016-en-proklima-ndcs-through-refrigeration-guidance.pdf

Zhang, W., Yang, Z., Li, J., Ren, C-X., Lv, D., Wang, J., Zhang, X., Wu, W., 2013. Research on the flammability hazards of an air conditioner using refrigerant R-290. Int. J. Refrig., Vol. 36, Issue 5, 1483-1494.

Standards

EN 1012-3, Compressors and vacuum pumps – Safety requirements – Part 3: Process compressors

EN 12178:2003, Refrigerating systems and heat pumps – Liquid level indicating devices – Requirements, testing and marking

EN 12263, Refrigerating systems and heat pumps – Safety switching devices for limiting the pressure – Requirements and tests

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 12693:2008, Refrigerating systems and heat pumps – Safety and environmental requirements

EN 13136:2013, Refrigerating systems and heat pumps – Pressure relief devices and their associated piping – Methods for calculation

EN 13313:2010, Refrigerating systems and heat pumps – Competence of personnel

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 1366-2, Fire resistance tests for service installations – Part 2: Fire dampers

EN 14276-1:2006+A1:2011, Pressure equipment for refrigerating systems and heat pumps – Part 1: Vessels – General requirements

EN 14276-2, Pressure equipment for refrigerating systems and heat pumps – Part 2: Piping – General requirements

EN 14276-2:2007+A1:2011, Pressure equipment for refrigerating systems and heat pumps – Part 2: Piping – General requirements

EN 14624, Performance of portable leak detectors and of room monitors for halogenated refrigerants

EN 1507, Ventilation for buildings – Sheet metal air ducts with rectangular section – Requirements for strength and leakage

EN 16084:2011, Refrigerating systems and heat pumps – Qualification of tightness of components and joints

EN 1736:2008, Refrigerating systems and heat pumps – Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes – Requirements, design and installation

EN 378-1:2016, Refrigerating systems and heat pumps. Safety and environmental requirements. Basic requirements, definitions, classification and selection criteria

EN 378-2:2016, Refrigerating systems and heat pumps. Safety and environmental requirements. Design, construction, testing, marking and documentation

EN 378-3:2016, Refrigerating systems and heat pumps. Safety and environmental requirements. Installation site and personal protection

EN 378-4:2016, Refrigerating systems and heat pumps. Safety and environmental requirements. Operation, maintenance, repair and recovery

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

EN 60079-10-1, Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres

EN 60079-15:2010, Explosive atmospheres – Part 15: Equipment protection by type of protection "n" (IEC 60079-15:2010)

EN 60204-1:2006, Safety of machinery – Electrical equipment of machines – Part 1: General requirements

EN 60335-1:2012, Household and similar electrical appliances – Safety – Part 1: General requirements

EN 60335-2-24:2013, Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers

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

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 60335-2-40:2016, Safety of household and similar electrical appliances – Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers

EN 60335-2-40:2003, Household and similar electrical appliances– Safety– Part 2-40: Pa

EN 60335-2-89:2012, Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor

EN 60335-2-89:2010, 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 60335-2-89:2010)

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) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments (IEC 61000-6-3:2006)

EN 61000-6-4:2007, Electromagnetic compatibility (EMC) – Part 6-4: Generic standards– Emission standard for industrial environments (IEC 61000-6-4:2006)

EN 809, Pumps and pump units for liquids – Common safety requirements

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)

EN ISO 14122-2: Safety of machinery – Permanent means of access to machinery – Part 2: Working platforms and walkways (ISO 14122-2)

EN ISO 4126-1:2013, Safety devices for protection against excessive pressure – Part 1: Safety valves (ISO 4126-1:2013)

EN ISO 4126-2:2003, Safety devices for protection against excessive pressure – Part 2: Bursting disc safety devices (ISO 4126-2:2003)

EN ISO 6708:1995, Pipework components – Definition and selection of DN (nominal size) (ISO 6708:1995)

EN 1861:1998, Refrigerating systems and heat pumps – System flow diagrams and piping and instrument diagrams – Layout and symbols

European Commission (2016) 'REPORT FROM THE COMMISSION on barriers posed by codes, standards and legislation to using climate-friendly technologies in the refrigeration, air conditioning, heat pumps and foam sectors'. [Online]. Available at: http://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/COM-2016-749-F1-EN-MAIN.PDF

European Commission (2017) Pressure Equipment Directive. [Online]. Available at: https://ec.europa.eu/growth/sectors/pressure-gas/pressure-equipment/directive_en

IEC 60079-0:2011, Explosive atmospheres - Part 0: Equipment - General requirements

IEC 60079-1:2014, Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"

IEC 60079-10-1:2015, Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres

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 60079-2:2014, Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure “p”

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 60079-29-1:2016, 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

IEC 60079-32:2015, Explosive atmospheres – Part 32: Electrostatics hazards

IEC 60079-33:2012, Explosive atmospheres – Part 33: Equipment protection by special protection ‘s’

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 60335-2-24: 2013, Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers

IEC 60335-2-40: 2016, Safety of household and similar electrical appliances – Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers

IEC 60335-2-89: 2012, Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor

IEC TS 60079-39:2015 Explosive atmospheres - Part 39: Intrinsically safe systems with electronically controlled spark duration limitation

ISO 12100:2010 Safety of machinery – General principles for design – Risk assessment and risk reduction

ISO 13043: Road vehicles – Refrigerant systems used in mobile air conditioning systems (MAC) – Safety requirements

ISO 13043:2011, Road vehicles – Refrigerant systems used in mobile air conditioning systems (MAC) – Safety requirements

ISO 14903: Refrigerating systems and heat pumps – Qualification of tightness of components and joints IEC 60204-1, Safety of machinery – Electrical equipment of machines – Part 1: General requirements

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

ISO 5149-1: Refrigerating systems and heat pumps – Safety and environmental requirements – Part 1: Definitions, classification and selection criteria

ISO 5149-2: 2014, Refrigerating systems and heat pumps – Safety and environmental requirements – Part 2: Design, construction, testing, marking and documentation

ISO 5149-3: 2014, Refrigerating systems and heat pumps – Safety and environmental requirements – Part 3: Installation site

ISO 5149-4: Refrigerating systems and heat pumps – Safety and environmental requirements – Part 4: Operation, maintenance, repair and recovery

ISO 817: Refrigerants – Designation and safety classification

ISO 817:2014, Refrigerants – Designation and safety classification

Full details of all the standards listed can be found at:

European Committee for Electrotechnical Standardization (CENELEC):
https://www.cenelec.eu/dyn/www/f?p=104:103:0::::FSP_LANG_ID:25

European Committee for Standardization (CEN):
https://standards.cen.eu/dyn/www/f?p=CENWEB:105::RESET

International Electrotechnical Commission (IEC):
http://www.iec.ch/dyn/www/f?p=103:105:0::::FSP_LANG_ID:25

International Organization for Standardization (ISO):
https://www.iso.org/search/x/

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