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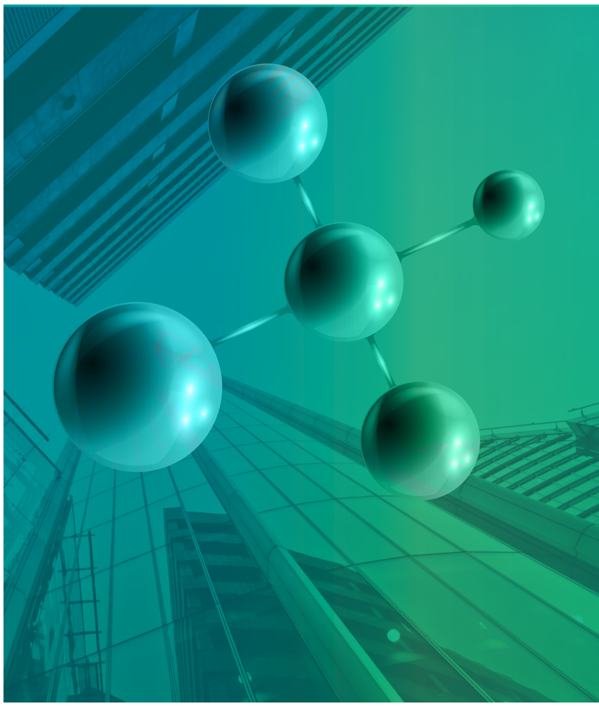
Mitsubishi Electric Guide to BS EN 378: Managing Risk in HVAC Systems with Modern Refrigerants



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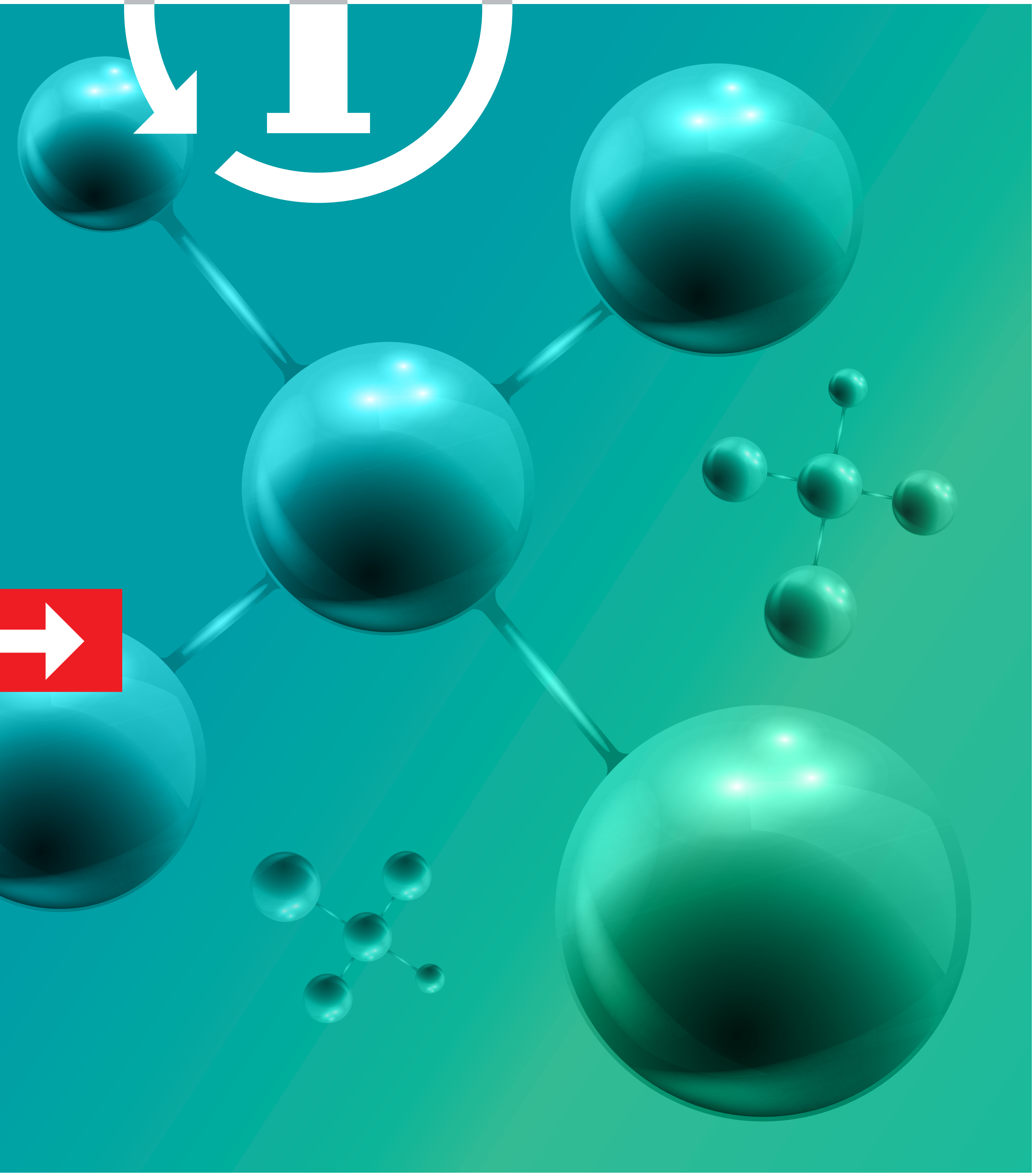


Mitsubishi Electric Guide to BS EN 378: Managing Risk in HVAC Systems with Modern Refrigerants

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today.

This guide accompanies a series of seminars, all of which are CPD certified.

Contents

Introduction

Changing regulations on refrigerants in HVAC systems mean that designers and installers are increasingly looking at products which use refrigerants they may not have used before. The new, low-GWP generation of refrigerants offers many benefits, but it is vital to be aware of the regulations and standards around their use in products and systems.

The aim of this CPD Guide is to consider generic safety standard BS EN 378[1] and related product safety standards such as BS IEC EN 60335[2] that also cover the safe use and application of refrigerant in HVAC systems. It will also touch on how they can help designers, contractors and installers meet the requirements of the HSE's DSEAR[3] *(Dangerous Substances and Explosive Atmospheres Regulations)*.

There is a range of safety standards relevant to refrigerant-using equipment, which has implications for cooling and heating equipment specification, installation and operation. This guide will clarify the differences between standards to help readers make the best choice for their project.

The growing importance of refrigerant choice

Refrigerants are part of a group of chemicals known as fluorinated gases, or F gases. They can cause environmental damage if released into the atmosphere, trapping heat close to the earth's surface and contributing to global warming. Each F gas has a varying level of potential impact, known as its Global Warming Potential (GWP). The higher a refrigerant's GWP number, the more potential harm it can cause.

As a result of these characteristics, the European Union introduced legislation to phase down and remove F gases from the market. These F Gas Regulations have had a significant impact on the HVAC sector, and they will continue to drive change across the refrigerant landscape for the next decade and beyond.

Even though the UK is no longer a member of the EU, the UK government has committed to following the same phase-down route as the EU. Full details of the F Gas Regulation and its application in the UK can be found in the *Mitsubishi Electric CPD Guide to F Gas Regulations and the Future of Refrigerants*[4].

The F Gas Regulations have seen familiar HVAC refrigerants phased down (or out), with new options introduced. This new generation of low-GWP refrigerants offers benefits such as lower embodied carbon and enhanced efficiency, but some are accompanied by requirements for additional risk assessments. This includes a few which are categorised as 'mildly flammable' and 'flammable' (see the table from ASHRAE later in this Guide).

It is, therefore, critical for specifiers and installers to track their decisions about refrigerants in HVAC systems so that they can demonstrate correct risk assessment and potential hazard reduction. There are also other factors to consider when selecting modern HVAC systems for long-term efficient and cost-effective performance for clients.

Refrigerants and risk: considerations for HVAC systems

The UK's changing refrigerant landscape means that consultants and installers must consider several areas of risk when working with HVAC systems.

The principal areas of risk can be categorised as:

Sustainability

Refrigerant choice impacts the embodied carbon footprint of the HVAC system. Using lower GWP refrigerants can help to achieve lower embodied carbon, for example Mitsubishi Electric's R32 VRF system or R32 chillers. It may also be useful to consider technologies that use less refrigerant. One example is Mitsubishi Electric Hybrid VRF, which uses R32 while also requiring less refrigerant in the system overall. In addition, the refrigerant is contained outside of occupied spaces, removing the need for leak detection. An added benefit of this technology is that the medium for carrying cooling and heating is water, which carries no flammability risks.

Energy efficiency

HVAC system energy performance is significantly impacted by the refrigerants used, and this, in turn, will affect the operational carbon of an HVAC system. It is important to select a system that meets energy performance requirements and to understand how certain types of refrigerants affect long-term energy performance. Furthermore, with the increasing focus on whole life carbon, the GWP (global warming potential) of refrigerants can impact the overall carbon footprint of the HVAC system and the building as a whole.

Future proofing buildings

We are seeing an increase in refurbishment applications (often to improve a building's EPC rating), which may involve upgrading the HVAC systems to improve building energy and carbon performance.

With future F-gas phase downs on the horizon, the market has seen significant fluctuations in refrigerant pricing. Generally, as regulations phase down a refrigerant, its price rises for some time. This can impact installation and maintenance costs and should raise questions about the longevity of system installations. As a result, HVAC system upgrades may affect property value or the costs associated with Cat A to Cat B fit-outs, for example.

Flexibility is an increasingly important feature for future buildings. Changing office layouts can require complex air conditioning system re-fits, including changing copper pipe runs to suit different refrigerants. Here, an option such as Hybrid VRF or chillers using low GWP refrigerants such as R32 or R290 can be a useful option, since only the outdoor unit will be changed and indoor pipes carrying water can be re-used. This allows for greater flexibility over the lifetime of a building, including expansion of the system across the building.

Overall, it may be more cost-effective to make an early switch to systems with low GWP refrigerants to address these issues before they become problems and to reduce the likelihood of inflated maintenance costs for building owners.

Safety

As noted previously, lower GWP refrigerants have distinct characteristics, including those that can impact safety in handling and use. For example, Standard BS ISO 817 (*Refrigerants - Designation and safety classification*)[5] provides a system for assigning a safety classification to refrigerants based on toxicity and flammability data.

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)[6] has also developed terms to denote the relative flammability of refrigerants, and these are recognised globally. **The table below indicates the ASHRAE flammability designations of common HVAC refrigerants:**

Refrigerant	GWP	Safety Class: ISO 817; PED (EU)	
R718 (Water)	0	A1	(non-flammable)
R744 (CO_2)	1	A1	(non-flammable)
R290 (Propane)	3	A3	(higher flammability)
R1234yf	4	A2L	(mildly flammable)
R1234ze	7	A2L	(mildly flammable)
R454b	466	A2L	(mildly flammable)
R513A	631	A1	(non-flammable)
R32	675	A2L	(mildly flammable)
R410A	2088	A1	(non-flammable)

It is vital to understand that in the UK, all classes of refrigerant are within the scope of its DSEAR (*Dangerous Substances and Explosive Atmosphere Regulations*) requirements. When DSEAR was introduced in 2002, it only applied to 'flammable' refrigerants classed as A2 and A3. This was later extended to A2L refrigerants (though notably, HSE does not recognise the term 'mildly flammable').

However, the regulation changed in 2015 to include 'gasses under pressure' which means that now all refrigeration, air conditioning and heat pump installations must comply with DSEAR[7]. As a result, the HSE requires that all refrigeration, air conditioning and heat pump installations must undergo a DSEAR risk assessment. HSE notes that DSEAR places these duties on 'employers and the self-employed who are considered employers for the purposes of the Regulations.' They must assess and eliminate or reduce risks from 'dangerous substances'.

The health and safety requirements set out an obligation for the contractor, designer and building owner or manager to provide a safe environment for both the public and employees. This will cover factors such as risk assessment, reduction of risk and safety measures. It also outlines requirements for the provision of emergency equipment, notices and identification, as well as manuals and training. Procedures in the event of an incident are also covered. Any risks identified by an assessment must be eliminated or reduced as far as reasonably practical. Ensuring that you have conducted (and can demonstrate that) all necessary risk assessments and that you have supplied required safety equipment (e.g. leak detection, ventilation, shut-off valves and alarms) correctly is therefore critical.

This Guide will focus on mitigating risks around safety, highlighting important standards that may affect the choice of system and installation approach.

Understanding the Standards around refrigerant choice and application

The origins of standards

To gain a clearer picture of how different standards impact refrigerant and equipment selection and application, it is useful to consider their origins and purpose.

There are two global organisations which publish safety standards:

- The International Standards Organisation (ISO)[8] - publishes generic standards
- The International Electrotechnical Commission (IEC)[9] - publishes product standards

At the European level, there are two further organisations publishing standards:

- The European Committee for Standardisation (CEN)[10] - publishes regional generic standards
- The European Committee for Electrotechnical Standardisation (CENELEC)[11] - publishes regional product standards

The table below illustrates how the generic and product standards flow from the international level to the regions.

		Generic Standard (Horizontal Standards)	Product Standard (Vertical Standards)
International		ISO 5149	IEC 60335-2-24 IEC 60335-2-40 IEC 60335-2-89
Europe		EN 378	EN 60335-2-24 EN 60335-2-40 EN 60335-2-89
UK		BS EN 378	BS EN 60335-2-24 BS EN 60335-2-40 BS EN 60335-2-89
USA		ASHRAE 15	UL 60335-2-24 UL 60335-2-40 UL 60335-2-89
Australia and New Zealand	 	AS/NZS 5149	AS/NZS 60335-2-24 AS/NZS 60335-2-40 AS/NZS 60335-2-89

The European Committees publish standards which cover the same scope and requirements as those published by ISO and IEC, but with a regional focus for Europe. For example, EN standards under CENELEC are generally very similar in content to IEC standards, with some alterations to reflect EU regulations. It is important to note that the UK remains a member of both CEN and CENELEC following its exit from the European Union.

This global and regional approach allows for common standards to be developed by consensus but with regional interpretations. Standards set by CEN and CENELEC are adopted in the UK through the British Standards Institute (BSI)[12].

The designations for standards give an indication of how this adoption has taken place. For instance, BS EN indicates that a European Standard has been adopted directly in the UK. The BSI must publish EN Standards and withdraw conflicting British Standards. For example, BS EN 378 was adopted in 2000, replacing the generic safety British Standard BS 4434 *(Safety aspects in the design, construction and installation of refrigeration appliances and systems)*, which was withdrawn.

A Standard with the designation BS ISO or BS IEC indicates that it has been adopted in the UK from the international Standard with no alterations. BS EN IEC 60335 is an example of this approach.

As a result of this cascade methodology for the development of Standards, it is not uncommon for them to cover common ground. They can be categorised as 'horizontal' or 'vertical' in their coverage. Vertical standards are developed for particular product types, while horizontal standards are broader in scope and include more generic requirements.

These generic requirements are generally based on common practices adopted by the sector and technicians operating in it. Therefore, horizontal standards will account for the extra risk faced by installers or maintenance engineers that may be involved during the design, installation, commissioning, servicing and end-of-life processes.

It is an approach that ensures all operatives are working to the same generic standard, optimising safety. The standards are constantly reviewed in light of industry experience and practice, with feedback taken to technical councils via industry associations and organisations.

It is a general principle that vertical standards should take precedence over horizontal standards. However, it is very important to note that this is not a rigid rule, leaving manufacturers, contractors and installers to make the ultimate decision how to apply relevant safety standards to specific projects. We will consider the implications of this challenge next.

Understanding the Standards around refrigerant choice and application

Selecting and applying standards

When considering the issue of safety in the context of applying refrigerants, there are two important standards which can apply.

The first is BS EN 378 2016 *(Refrigerating systems and heat pumps. Safety and environmental requirements - Design, construction, testing, marking and documentation)*[1].

BS EN 378 is a safety standard that minimises possible hazards to persons, property, and the environment from refrigerating systems and refrigerants. It is a generic or 'horizontal' safety standard comprising codes that cover different product groups.

BS EN 378 safety standard provides guidance and risk assessment advice for businesses that design, construct, install, operate, maintain, and use vapour compression systems for refrigeration, air-conditioning, heat pumps, chillers, and other similar systems. It is published in four parts: BS EN 378-1, BS EN 378-2, BS EN 378-3, BS EN 378-4

The second standard is the BS EN IEC 60335 product safety standard series.

The standard has two parts: BS EN IEC 60335-1 is a product safety standard for electrical appliances used for household and similar purposes. It is therefore considered a 'vertical' standard. It highlights how products should be constructed in accordance with good engineering practice in relation to safety for users.

This part of the standard also provides general testing requirements, markings, classifications, instructions and assurances that the appliances meet the highest safety and efficiency standards.

The standard includes a second part, BS EN IEC 60335-2, which details requirements for over 100 different types of appliances, from dishwashers, toasters, vacuum cleaners, outdoor barbecues and even components such as motor compressors and fans.

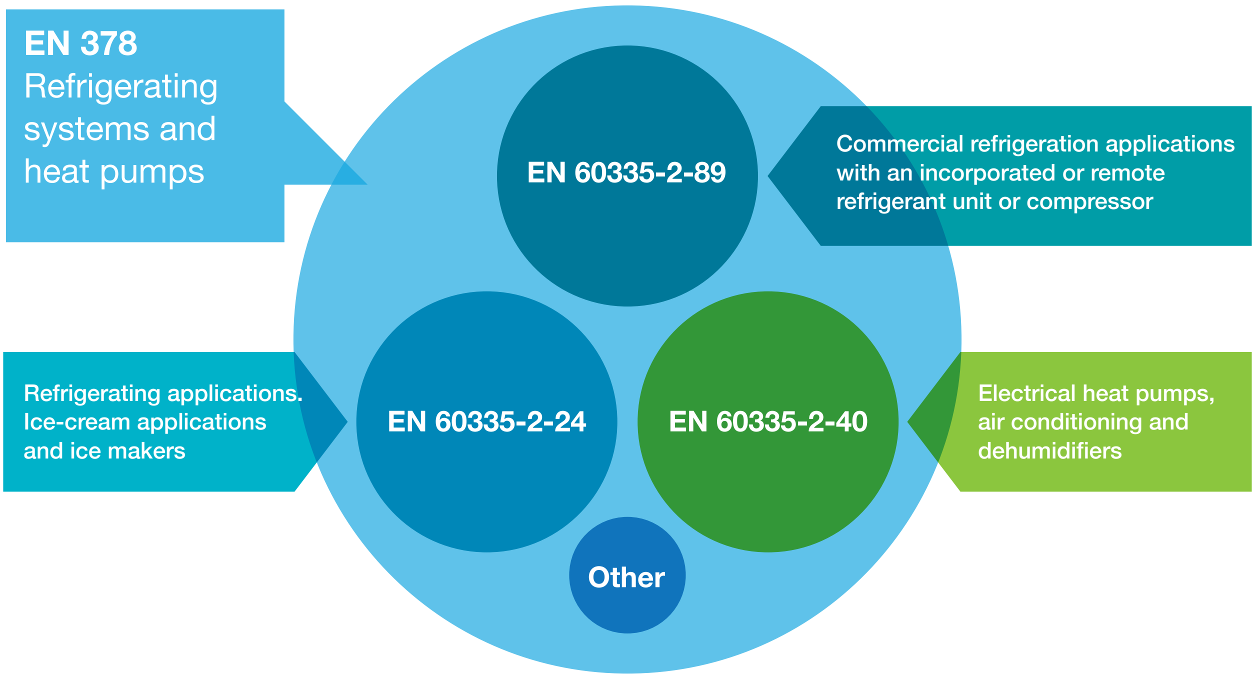
For example, BS EN IEC 60335-2-40 deals with heat pumps, air conditioners and humidifiers. It provides manufacturers with a clear and concise set of guidelines to follow, ensuring that their products are safe, reliable, and efficient. The standard also advises technicians on the installation, maintenance, and repair of these products.

Manufacturers are legally required to construct their products to the relevant part of BS EN IEC 60335-2 to achieve a CE mark (in the case of the UK and Europe) to place equipment on the market. It ensures that the product has predefined triggers to activate safety functions and make active changes to protect users. This protects manufacturers from product liability by ensuring that products include safety elements which activate in the event of catastrophic failure.

In the context of HVAC systems, BS EN IEC 60335-2 has three key sections:

- **BS EN IEC 60335-2-24 Refrigerating appliances**
- **BS EN IEC 60335-2-40 Electrical heat pumps, air conditioning and dehumidifiers**
- **BS EN IEC 60335-2-89 Commercial refrigeration appliances with an incorporated or remote refrigerant unit or compressor**

The diagram below illustrates the relationship between horizontal and vertical standards.



The question for HVAC system designers is which standard to prioritise when specifying safety requirements for a refrigerant-based system under DSEAR. For manufacturers, the answer is that product standards prevail over generic standards.

However, horizontal or generic standards such as BS EN 378 include recommendations that can be applied to most parts of the refrigeration, air-conditioning, chiller and heat pump market. They, therefore, provide more generic and overarching requirements based on the common practices implemented by designers, installers and building owners.

Optimising safety: focus on standards

When considering safety as an area of risk for HVAC installations, it is useful to understand the structure of BS EN 378, as each section provides useful guidance. The standard is split into four main parts, each addressing various aspects of safety.

The table below outlines the main points.

BS EN378-1	BS EN378-2
Part 1: Basic requirements, definitions, classification and selection criteria	**Part 2:** Design, construction, testing, marking and documentation
Defines systems and refrigerants. Advises which formula to use to calculate the practical refrigerant limit of that system based on toxicity and flammability. Points to additional safety requirements if this limit is exceeded. For example, the system may require safety features such as leak detection, alarms, provision of natural or mechanical ventilation, safety shut-off valves. **Product standard EN 60335-2-40, 60335-2-24, 60335-2-89 is mentioned in Part 1.**	Mainly related to the safety of the components used in constructing the system. Covers relevant standards for compressors, heat exchangers, pumps, oil separator, pressure relief devices, valves etc. Covers testing procedures for mechanical and electrical strengths, internal wiring, connection joints, insulation, noise, transportation test etc. This section also covers commissioning, tightness test, vacuum and filling of the system, checking for leaks, marking, information in the manual and logbook requirements. **Product standard EN 60335-2-40, 60335-2-24, 60335-2-89 is also mentioned in Part 2.**

BS EN378-3	BS EN378-4
Part 3: Installation site and personal protection	**Part 4:** Operation, maintenance, repair and recovery
Provides site-specific safety requirements and how to implement them. Electrical Installation. Covers the installation requirements of the refrigeration system, whether positioned in open air (externally to the building) or in a plant room or in an occupied space. Addresses ventilation rates for spaces including at what concentration an alarm or leak detection should trigger, or how a safety shut-off valve should operate. Highlights the need for annual equipment checks and how safety measures must be installed & respond in that space or property. Instruction manual & notices. Maintenance of the site. Visual inspection of the site. Covers the requirement of PPE and first aid during routine or emergencies.	Addresses the installer/end user and their ability to operate the system and its safety mechanisms/processes. Covers system maintenance and repair, including safety requirements during oil or refrigerant changes. Provides procedures to follow during servicing, recovery, reuse and disposal. In service inspection. Guidelines for repairing equipment with flammable refrigerant. Addresses safe handling and storage of refrigerant containers. Training requirements for skilled personnel handling refrigerant based systems.

Optimising safety: focus on standards

BS EN 378 addresses safety at every point of design, installation, commissioning and maintenance - covering the entire lifecycle of a refrigerant-using system for that building or that site. It, therefore, concerns the work of various building engineering professionals, from consulting engineers to installers and commissioning engineers.

The diagram below shows how BS EN 378 applies to various roles and activities:

Part 1, 2, 3 and 4 are intended for different roles

		Part 1	Part 2	Part 3	Part 4
People Interested	Plant / Equipment Designer	●	●		
	Plant / Equipment Manufacturer		●	●	
	Plant / Equipment Installer	●	●	●	
	Service / Maintenance Personnel		●	●	●
	Building / Plant Owner / Operator / Manager	●		●	●
	Building Designer	●		●	
Lifecyle Activity Interested (Activity according to EN 13313, Competence of Personnel)	Design	●	●		
	Pre-assembling		●		
	Installation	●	●	●	
	Putting into operation		●	●	●
	Commissioning		●		●
	Operating			●	●
	In-service inspection		●		●
	Leakage checking		●		●
	General maintenance		●	●	●
	General maintenance		●		●
	Decommissioning				●
	Removing refrigerant				●
	Dismantling				●

It is also important to note that BS EN 378 references other relevant standards within its text, including BS EN IEC 60335. For example, BS EN 378-1 states:

"Product family standards dealing with the safety of refrigerating systems take precedence over horizontal and generic standards covering the same subject."

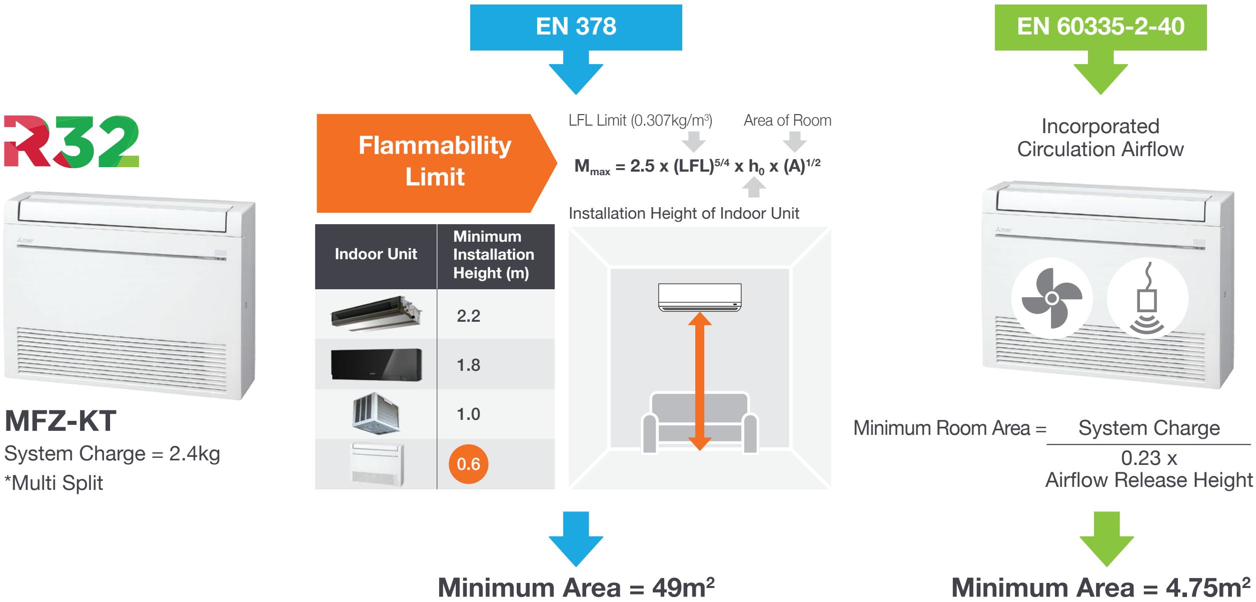
As a result, BS EN IEC 60335 could be applied in relation to charge limits, alternative formulas or types of safety measures that can be considered. BS EN 378-1 notes:

"Where product standards exist for particular types of systems and where these product standards refer to refrigerant quantities limits, such quantities shall overrule the requirements of this standard."

We can use an example with a Mitsubishi Electric product to illustrate the impact of the generic vs product standard application on system design when both treat the issue of leak detection differently.

The diagram below shows the Mitsubishi Electric M Series MFZ-KT indoor floor mounted unit with R32 refrigerant. We can see that if we use BS EN 378 and then BS EN 60335-2-40 to calculate the minimum room area recommendation for safe application, there are different results.

Divergence between standards



Using calculations in **BS EN 378**, if the MFZ-KT unit has a system charge of 2.4 kg (outdoor unit, piping & indoor unit), then as per EN378-1 (Section C.2) the minimum allowable room area is 49m^2. However, if we use the calculations from **BS EN 60335-2-40**, then we can place the unit into a much smaller room of 4.75m^2, making this system more applicable to a wider range of projects.

The product standard (BS EN 60335-2-40) allows for this as its charge limit formula can be used provided the unit has a circulation fan and an inbuilt leak detector. The product standard allows this because, in the event of a leak, the indoor unit should be capable of increasing the fan speed to maximum and triggering an alarm. In this case the remote controller of the unit will display an audible and visual alarm. Please also note as the unit is floor mounted, the inbuilt detector is naturally at a lower level.

However, it is vital to note that the above installation would not comply with BS EN 378 because the alarm on the system does not have an independent power source. This difference in the treatment of leak detection is important for designers and installers to consider.

Optimising safety: focus on standards

Part 1 of BS EN 378 recommends the use of leak detection equipment when a certain charge limit is exceeded. However, Part 3 recommends how to install or implement this leak detection on-site in a specific area of the building, such as an occupied space or machinery room.

The BS EN 378-3 (Part 3) leak detection system installation recommendations are:

- **Locate the detectors where leaking refrigerant can stagnate or concentrate. It should also take into consideration local air patterns from louvres or ventilation systems.**
- **If alarms are employed to warn of a leak, then the power source of the alarm system should be independent of the mechanical ventilation or other refrigerating systems which the alarm system is protecting.**

By contrast, the EN 60335-2-40 leak detection system installation recommendations for manufacturers, provide a choice of three locations for leak detectors:

- **Within the unit**
- **Or 100 mm or less directly below the unit**
- **Or 300 mm above the floor on a wall within the room the unit is installed in.**

Keeping the above in mind, we can look at a particular clause in the product Standard BS EN 60335-2-40:

"An appliance that complies with the text of this standard will not necessarily be considered to comply with the safety principles of the standard if, when examined and tested, it is found to have other features that impair the level of safety covered by these requirements."

This statement indicates that it is the responsibility of the manufacturer and installer to make sure the system is safe enough in all aspects. BS EN 378 provides broader guidance around this topic. BS EN 378-3 (Section 9: Detectors) includes a note on the location of leak detectors. It advises that they:

"Shall be chosen in relation to the refrigerant and they shall be located where the refrigerant leak will concentrate."

In addition, this section points out that the location of the detector should take into account local airflow patterns, including sources of ventilation and "the possibility of mechanical damage or contamination".

As most VRF systems have multiple brazing points and as refrigerant (like R32, R410A or R407c for example) is heavier than air, the safest position for the detectors will be at floor level, since refrigerant leaks are generally associated with field pipes connected externally to the indoor unit (with regards to the power source of the alarm, the product standard has no recommendations). Therefore, responsible manufacturers usually recommend installation of leak detection at 300mm above the floor on a wall within the room where the unit is installed. Refrigerants like Ammonia (R717) that are used in a refrigeration unit are lighter than air, therefore for these applications it would be sensible to put leak detectors at higher levels.

Good practice for Standard selection

Since both the horizontal and vertical standards address issues around safety, this can be a point of confusion, particularly when using A2L refrigerant systems. The decision is becoming more important given the growing emphasis on risk reduction across the construction sector in the wake of the updated Building Regulations and introduction of the Building Safety Act 2022. The Act introduces new responsibilities for safety decisions all along the supply chain.

When considering which recommendations to follow and how to apply them, construction professionals can look to guidance from industry associations, regulations and organisations such as CIBSE, Building Regulations, BREEAM, REFCOM, The Federation of Environmental Trade Associations (FETA) and the Institute of Refrigeration (IoR) among others.

CIBSE[13]

Several CIBSE design guides and codes refer to the use of BS EN 378 as a source for refrigerant design requirements. These include:

- **AM17:** 2022 *Heat Pump Installations for large non-domestic buildings*[14] which recommends use of BS EN 378 throughout, including the comments: "Heat pump installations should comply with BS EN 378-3" and "See BS EN 378 for further information on leak detection."
- **Commissioning Code R:** 2022[15] which states under its Good Practice section that: "Risk assessments should be performed and resulting method statements produced (refer to BS EN 378)."
- **Guide B:** *Heating, ventilating, air conditioning and refrigeration*[16] states in reference to refrigerant leakage that: "The occupier should prepare an emergency procedure to be followed in the event of leakage. BS EN 378 should be consulted for guidance on procedures."
- **Guide B3:** Air conditioning and refrigeration[17] notes that: "The designer has a responsibility to ensure that the design of the refrigeration and heat rejection system as a whole takes into account all the necessary provisions for safe operation and maintenance, as well as the necessary monitoring, warning and automatic protection features to ensure that the system remains safe during normal operation and during times of component failure. Reference should be made to BS EN 378 and in particular to BS EN 378-2 (BSI, 2008b) and BS EN378-3 (BSI 2008 c)."

  Furthermore, B3 points out: "In addition, it is CIBSE policy that the requirements of BS EN 378 (BSI 2008a-d) should be complied with. The Institute of Refrigeration safety codes provide specific guidance on the requirement of BS EN 378."

  And: "Installation process should be aligned with BS EN 378 (2008a-d) and must be carried out by a fully qualified F-gas registered engineer to prevent issues with possible leakage of refrigerant from a system during its operational life." CIBSE Guide B3 also states that in addition to F Gas Regulations and the Environmental Protection Act: "It is CIBSE policy that the requirements of BS EN 378 are complied with as well as (these) statutory regulations."

Optimising safety: focus on standards

Building Regulations: Part F[18]

Part F of the Building Regulations (Ventilation) points to BS EN 378 in its recommended guidance for ventilation for buildings other than offices and car parks (see Table 1.1 in the Regulations).

BREEAM (UK New Construction)[19]

BREEAM UK New Construction refers to BS EN 378 as a requirement for refrigerant-based cooling and heating systems. The '*Pol 01 Impact of refrigerants*' section amounts to three credits and allows designers to calculate the direct effect of life cycle carbon-equivalent emissions (DELC) per kW of cooling and heating capacity.

The aim of this section is to reduce the level of greenhouse gas emissions due to refrigerant leakage during the product's operational lifetime. This section also states it is a prerequisite that all systems with electric compressors must comply with the requirements of BS EN 378 Parts 2 and 3.

REFCOM[20]

F gas certification body REFCOM notes that: "EN 378 contains design information crucial to this (DSEAR) risk assessment and management process and should always be referred to in the planning stage of an A2L installation."

Federation of Environmental Trade Associations (FETA)[21]

FETA states in its guidance note[22]: "By choosing the right refrigerant, equipment and location as dictated by EN 378, the probability of forming a flammable atmosphere can be eliminated, making this assessment (DSEAR) potentially very straightforward as many equipment manufacturers are including data to carry out risk assessments within their technical documentation and installation guidelines."

Institute of Refrigeration (IoR)[23]

The IoR's Safety Code of Practice: *Flammable lower toxicity refrigerant (Groups A2L, A2, A3)*[24] provides guidance for owners, designers, installers and operators of vapour compression refrigerating systems. It applies specifically to refrigerants in groups A2L, A2 and A3, as defined in BS EN378-1-4:2016. It does not apply to refrigerating systems installed in vehicles, ships or aircraft.

The Code notes that the requirements for DSEAR risk assessment by hazard class means that designers and installers must consider the risk of the system "being enveloped in fire or exposed to an external heat source that could cause the system pressure to rise without control leading to explosion".

The Code points out that refrigeration systems designed in accordance with BS EN 378:2016 account for the effect of external heat sources including fire and require suitable levels of protection for the system to remain safe.

Furthermore, the IoR code points out that refrigerant leak detectors: "Shall be calibrated for the specific refrigerant they are intended to detect. Where the refrigerant is heavier than air, sampling points shall be located at floor level. Where the refrigerant is lighter than air, sampling points shall be located at ceiling level." The IoR code further notes that the requirements for refrigerant detectors are laid down in BS EN 378-3:2016

In the Institute of Refrigeration Annual Conference Papers[25] in 2019 it was noted that, when using the BS EN 378 standard, its different parts should not be applied in isolation: "All four parts of the standard must be implemented and used in the design and installation of flammable refrigeration systems."

The publication also pointed out that, for example, Part 1 should not be used to determine maximum refrigerant quantities in isolation. Parts 2 and 3 should also be applied as they provide the system and safety systems design requirements.

It also highlighted: A systematic approach to risk assessing flammable refrigeration systems must be used for risk assessing flammable refrigerants to ensure any refrigeration system inspected has a logical and consistent approach for assessing and dealing with the risks identified. The approach to risk assessment is to prioritise the reduction of the likelihood of a refrigerant release through thorough inspections of the pressure envelope and by analysing the effects of a refrigerant release with regard to explosive, asphyxiation and combustion toxic risks. Further, in the event of a release, it considers if the emergency planning and need awareness are suitable.

In addition, it also cited: "Whilst European standards are not legally binding, they are good practice requirements for safety systems. These good standards can be used to assist in the interpretation of how legislation compliance can be implemented and recognised by the courts."

Conclusions

As the UK moves along the phase-down process for the current range of familiar refrigerants, we will see greater use of A2L or A3 refrigerants. Clients are also driving change as they seek to reduce their organisational carbon footprint and are more likely to be open to discussions about low-GWP refrigerants in HVAC systems.

It is, therefore, essential to be aware of how to assess and minimise risks around the application of these refrigerants and the HVAC systems that use them. Both BS EN IEC 60335 and BS EN 378 provide useful guidance. There does not necessarily have to be an either-or choice of which standard to rely on, but it is critical to have a clear understanding of why decisions are made.

Mitsubishi Electric is dedicated to helping its customers meet the new obligations of our changing refrigerant landscape. We have developed a range of products optimised to work with low-GWP refrigerants, and our equipment meets all required manufacturing standards.

This includes the development of R32 chillers, VRF and Hybrid VRF, which not only uses lower volumes of low-GWP refrigerant, but also removes refrigerant from occupied spaces - removing concerns over leakage and leak detection in those areas of a building. The use of water as a medium for heating and cooling has been applied buildings for centuries. It not only provides a low-carbon approach but is also non-flammable and non-toxic.

However, when considering HVAC system safety during installation and use, our recommendation reflects that of leading industry organisations – to focus on BS EN 378 as a standard that provides a broad approach to managing risk at all stages of installation, system operation, maintenance and end-of-life.

References

1. BS EN 378-1 (with links to sections 2, 3, and 4)

https://knowledge.bsigroup.com/products/refrigerating-systems-and-heat-pumps-safety-and-environmental-requirements-basic-requirements-definitions-classification-and-selection-criteria-1?version=standard

2. BS EN IEC 60335-2

https://knowledge.bsigroup.com/products/household-and-similar-electrical-appliances-safety-particular-requirements-for-room-heaters-5?version=standard&tab=preview

3. Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)

https://www.hse.gov.uk/fireandexplosion/dsear.htm

4. Mitsubishi Electric CPD Guide to F Gas Regulations and the Future of Refrigerants

https://library.mitsubishielectric.co.uk/pdf/book/Issue_78_F_Gas_Regulations_and_the_Future_of_Refrigerants#page-1

5. BS ISO 817 (Refrigerants - Designation and safety classification)

https://knowledge.bsigroup.com/products/refrigerants-designation-and-safety-classification?version=standard

6. ASHRAE Refrigerant Classifications and Safety

https://www.ashrae.org/file%20library/technical%20resources/bookstore/factsheet_ashrae_english_november2022.pdf

7. ACRIB on DSEAR requirements

https://acrib.org.uk/help-and-advice/health-and-safety-risk-management

8. The International Standards Organisation (ISO)

https://www.iso.org/home.html

9. The International Electrotechnical Commission (IEC)

https://www.iec.ch/homepage

10. The European Committee for Standardisation (CEN)

https://www.cencenelec.eu/about-cen/

References

11. The European Committee for Electrotechnical Standardisation (CENELEC)

https://www.cencenelec.eu/about-cenelec/

12. British Standards Institute (BSI)

https://www.bsigroup.com/en-GB/

13. CIBSE

https://www.cibse.org/

14. AM17: 2022 Heat Pump Installations for Large Non-domestic Buildings

https://www.cibse.org/knowledge-research/knowledge-portal/am17-heat-pump-installations-for-large-non-domestic-buildings#:~:text=CIBSE%20AM17%3A%20Heat%20pumps%20for,of%20large%20heat%20pump%20systems

15. Commissioning Code R: 2022

https://www.cibse.org/knowledge-research/knowledge-portal/commissioning-code-refrigerating-systems-2002?id=a0q20000008I7o8AAC

16. Guide B: Heating, Ventilating, Air Conditioning and Refrigeration

https://www.cibse.org/knowledge-research/knowledge-portal/guide-b-set-guides-b0-b4-index-2016

17. Guide B3: Air Conditioning and Refrigeration

https://www.cibse.org/knowledge-research/knowledge-portal/guide-b-set-guides-b0-b4-index-2016

18. Part F of the Building Regulations (Ventilation)

https://www.gov.uk/government/publications/ventilation-approved-document-f

19. BREEAM UK New Construction

https://www.babergh.gov.uk/documents/d/babergh/c20-breeam-non-domestic-buildings-technical-manual-july-2019

20. REFCOM

https://www.refcom.org.uk/

21. Federation of Environmental Trade Associations (FETA)

https://www.feta.co.uk/

22. FETA: An Introduction to A2L Refrigerants and their use in Refrigeration, Air Conditioning and Heat Pump Applications

https://acrib.org.uk/public/downloads/gAuz-/An%20introduction%20to%20A2L%20refrigerants%20May2017.pdf

23. Institute of Refrigeration (IoR)

https://ior.org.uk/

24. IoR Safety Code of Practice 2018 (for flammable lower toxicity refrigerants)

https://ior.org.uk/technical/rachp-publications?state=b&id=149

25. IOR Annual Conference paper delivered by Dr Dermot Cotter MInstR Overview Refrigeration Safety and Risk Assessment for Flammable Refrigerants

A copy of a related presentation by Dr Cotter is available at:
https://ior.org.uk/technical/rachp-publications?id=560&state=b

To receive a CPD seminar on 'Mitsubishi Electric Guide to BS EN 378: Managing Risk in HVAC Systems with Modern Refrigerants', you can call your Mitsubishi Electric Regional Sales Office to arrange an in-house presentation of this information.

If you would like to receive invitations to future CPD events, please email **livingenvironmentalsystems@meuk.mee.com**

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Note: The fuse rating is for guidance only and please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric's air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R290 (GWP:3), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R454C (GWP:148), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

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