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BS EN378:2016 – Summary of Changes

This Guidance Note explains the role of the BS EN378 "Refrigerating systems and heat pumps - Safety and environmental requirements" safety standard and highlights the most significant changes introduced since the last version was published in 2008.

1. Introduction – role and limitations

BS EN378 is a safety and environmental standard, published by CEN, the European Committee for Standards. It provides guidance for companies who 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, which cover definitions, design (including manufacturing), installation (including commissioning) and operation (including maintenance requirements). In total, the four parts are approximately 180 pages long.

For the refrigeration, air conditioning and heat pump sector BS EN378 provides a means of proving conformity with certain European directives. Part 2 (Design, construction, testing, marking and documentation) is harmonized with Directive 2014/68/EU (The Pressure Equipment Directive also referred to as PED) and with the European Directive 2006/42/EU (The Machinery Directive referred to as MD).

BS EN378 is not, however, a legal requirement in its own right. It is possible to install a system in compliance with all relevant regulations, including PED and MD, without following the requirements of BS EN378. It is not a complete design guide for systems. It gives no presumption of conformity with directive 99/92/EC (The ATEX Workplace directive) or directive 2006/95/EC (The Low Voltage directive). Any system using a "dangerous substance" as defined in the DSEAR (The Dangerous Substances and Explosive Atmospheres Regulation 2002) is required to meet the requirements of those regulations. BS EN378 in full does not provide a presumption of conformity with regard to flammability.

2. What's new in BS EN378:2016

BS EN378 was revised to bring it into alignment with ISO5149 the international safety standard. This included introduction of an additional flammability class, 2L, to the method of charge calculation based on refrigerant classification and the addition of two new alternative methods of charge calculation. Most of this is detailed in Part 1 of the Standard. In Part 2 flowcharts used for determination of protective device requirements have changed. Part 3 includes changes to the requirements for machinery rooms. Changes to Part 4 are less significant. Several informative annexes have been introduced to cover stress corrosion cracking, leak simulation, commissioning and ignition sources (Part 2) and special provisions for handling ammonia vapour during maintenance or decommissioning (Part 4, within the existing Annex C).

3. Changes to Part 1

A "special machinery room" is now called the "separate refrigeration machinery room" in recognition of the fact that the only thing that differentiated it from any other machinery room is that it was used solely for the refrigeration machinery.

The "occupancy category" used to determine allowable charge limits has been changed to "access category" since it is based on consideration of the type of people who are given access to the area in which the equipment is located.

The classification of systems according to location and access is now by Roman numerals for location (eg I, II, III and IV) and lower case letters for access (eg a, b or c). In some cases the terms have not changed but there is a better explanation of the underlying implications. For example Location Class III (all equipment in a machinery

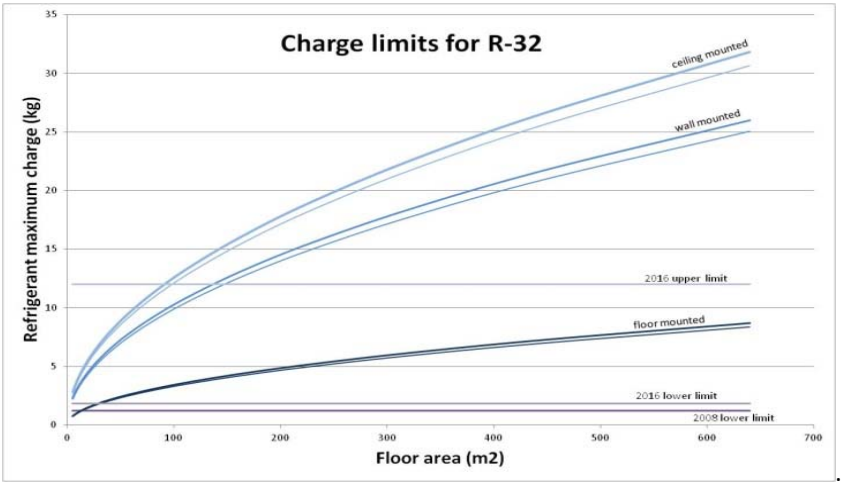
room or the open air) is not incompatible with Access Category a (general access) because a chiller or a condensing unit could be located outdoors in a place which is accessible to the general public.

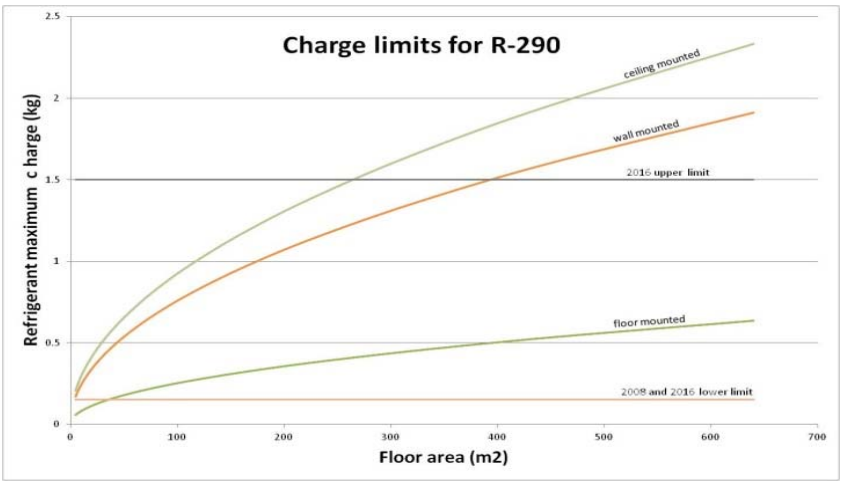
Flammability class 2L and the implications for the design of systems using the new class of low GWP fluorocarbons, often known as HFO refrigerants, has been introduced. However it was already possible to use HFOs in conformity with BS EN378:2008 and although the charge restrictions look different in the new standard the calculation produces the same result; it is only the format of the equation that has changed. For example in BS EN378:2008 part 1 the amount of refrigerant of type A2 permitted in a "human occupied space" for refrigeration was "max. charge = practical limit x room vol. and not exceeding 38 x LFL". For R-1234yf, listed in Annex E as an A2 refrigerant, the LFL is 0.299 kg m^{-3} so the upper limit of charge was 11.36kg. In BS EN378:2016 the amount of refrigerant permitted for a refrigeration application is "20 % x LFL × Room volume and not more than m_2 × 1,5". The factor m_2 is given as 26m^3 × LFL and the LFL listed in Annex E for R-1234yf has been updated to 0.289 kg m^{-3} so the upper limit of charge is 11.27kg. In this case the previous version of the standard not only permitted the use of an HFO, it allowed slightly more of it to be used than the revised standard (about 90 g more, or 0.8%).

Additional calculation methods for systems "for human comfort" have been added. In the 2008 edition there was one additional calculation method which was only used "for human comfort" and applied to all flammable refrigerants. An equation based on empirical studies of leakage is used to calculate the maximum permissible charge (m_{max}), using the LFL, the area of the room (A m^2) and a factor representing the type of installation (h_0 m). The equation is

$$m_{max} = 2{,}5 \times LFL^{5/4} \times h_0 \times A^{1/2}$$

The lower limit has been increased to 6 × LFL for 2L refrigerants (while remaining at 4 × LFL for other flammable refrigerants). More importantly an upper limit of 39 × LFL for 2L and 26 × LFL (or 1.5kg, whichever is greater) for other flammable refrigerants has been introduced. This places a significant cap on the amount of refrigerant that can be used "for human comfort". The effect of the change is shown for R-32 and R-290 in Figures 1a and 1b. The thinner lines are the 2008 result. Note that in 2008 there was no upper limit for this method





Figures 1a and 1b Charge limits for human comfort according to EN 378 Part 1 Annex C.2

The slight changes in the R-32 figures are the result of a small change to the LFL figure and the increase in the lower limit is due to the change from 4 × LFL to 6 × LFL for 2L refrigerants. The R-290 figures have not changed from 2008 to 2016, except that the introduction of the upper cap limits the maximum charge to 1.5 kg. This limit is not in the text of paragraph C.2 but it is implicit in Table C.2 which says "According to C.2 and not more than the greater of m_2 or 1,5 kg". In the case of R-290 m_2 is 0.988 kg so the limit is 1.5 kg.

An additional method of managing risk in occupied spaces under certain circumstances is introduced in clause C.3. The circumstances are quite tightly defined and only apply to A1 and A2L refrigerants where the charge is not more than 150kg, is not more than 195 × LFL (which is 60 kg for R-32), where the system is a "multi-split" system in location class II, where the indoor unit is protected against various types of damage and alternative provisions to ensure safety (such as additional ventilation or safety shut off valves triggered by a refrigerant detector) are provided. This additional method applies to all "refrigerating systems", not only those that are for human comfort. The scope and definitions of the standard make it clear that this also applies to heat pumps. It is less clear, but equally valid to say that it also applies to air-conditioning systems.

There are two approaches shown in clause C.3. If there is a gap under the door of the room in which the indoor unit is fitted then an alternative to the Refrigerant Concentration Limit (RCL) is permitted. This alternative is called "quantity limit with minimum ventilation" (QLMV). In general for A2L refrigerants QLMV is only very slightly higher than RCL, for example for R-32 RCL is 0.061 kg m^{-3} and QLMV is 0.063 kg m^{-3}, so the allowable charge is only 3.3% higher. If additional measures are employed (additional ventilation or safety shut off valves) then a further increase in the limit is permitted. This is termed "quantity limit with additional ventilation" (QLAV), even though it was pointed out during the committee discussion that additional ventilation is not the only measure permitted – the name had stuck, so "QLAV" it is. For R-32 QLAV is based on 50% of LFL and is therefore much higher than RCL (which is based on 20% of LFL), so a calculation value of QLAV of 0.15 kg m^{-3} applies. In general for 2L refrigerants the QLMV values are almost the same as the RCLs and QLAV (with additional safety measures) raises the upper limit on refrigerant charge by a factor of about 2.5

The designer is free to choose for human comfort whether to use equation (1) with a stricter upper limit or to add additional safety measures and use a larger charge.

The other major change in Part 1 is that the tables of refrigerants in Annex E have been updated as far as possible, including the correction of some errors in previous versions. The tables are now aligned with ISO817:2014, but it should be noted that as new blends are developed this list will become quickly out of date and need to be extended. As a result of the corrections and adjustments it is recommended that calculations are always done with the most up to date version of the tables.

4. Changes to Part 2

Changes have been introduced to align with the Pressure Equipment Directive and the Machinery Directive. The flow charts in section 6.2.6.2 have been retained but streamlined. The table of relative pressures (this was Table 3 in the 2008 standard) has been removed and the content is described in paragraph 6.2.6.2, immediately before the flowcharts. Four additional annexes have been added; on stress corrosion cracking, leak simulation test, commissioning procedure and ignition sources. All four new annexes for information only.

5. Changes to Part 3

Changes primarily relate to the introduction of flammability class 2L and the change of name of the "special machinery room". The term "separate refrigeration machinery room" was adopted to reflect the fact that this is a room which only contains refrigeration machinery and other types of machinery are not permitted in the room. Some additional text has been added regarding the installation of equipment in a space which is neither an occupied space nor a machinery room. A typical example, which caused some difficulty in application of the previous wording, is the installation of defrost valve stations in an unoccupied roof void.

For ammonia machinery rooms water sprinkler systems are now permitted only on condition that they cannot be manually over-ridden and they can only be activated by heat.

6. Changes to Part 4

Changes to part 4 are mainly concerned with the addition of procedures for evacuating gas from a system (usually air and water vapour) before charging with refrigerant and for testing halocarbons for moisture.

7. Flammability considerations

As mentioned in the introduction, compliance with all the requirements of BS EN378 does not ensure that the requirements of the Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) are covered. Almost all of the refrigerants in flammability classes 2L, 2 and 3 are included in the definition of dangerous substances in the 2002 regulations because they have a "hazard statement" under the Globally Harmonized System of Classification and Labelling of Chemicals, published by the UN and adopted in the EU by the CLP regulations (EC/1272/2008).

The one exception at present is R-1234ze because while it meets the criteria for classification as flammable in ISO817:2014 it is not considered flammable under the CLP regulation. It is therefore subject to all of the requirements of a 2L fluid in BS EN378, including charge restrictions, but it is not necessary to complete a hazard analysis in line with DSEAR. It is recommended for this anomaly that the hazard analysis should be conducted anyway and stored with the rest of the system design information.

For all other class 2L, 2 and 3 refrigerants the requirements of DSEAR must be followed. This will usually be the completion of a risk assessment and hazard analysis for the plant in question to identify and quantify the risks associated with ignition of the dangerous substance. This assessment needs to be conducted for the whole installation not just the occupied space or the machinery room

8. Conclusions

System design will not fundamentally change with this revision of BS EN378. If systems are to be designed for the use of mildly flammable refrigerants they must follow all of the legal and safety standard requirements associated with flammability. This goes beyond the scope of BS EN378, which is not harmonized with those regulations. It does not mean that all electrical equipment needs to be "flameproof" of the type found in petrochemical plant, but it does mean that if the safety data sheet for the refrigerant has the hazard phrase H220 or H221 then a risk assessment conforming to the requirements of DSEAR must be completed and must cover maintenance and service activity as well as normal operation and standstill. The charge limits in BS EN378 for A2L refrigerants remain quite stringent and it is likely to take several years of experience, risk assessment and further negotiation before these limits can be further relaxed and it is likely that they will never be as generous as those for A1 refrigerants, where the charge limit is based on toxicity, not flammability. Other regulations outside of the scope of BS EN378 must still be applied if companies want to use the new "lower flammability" refrigerants - this does not make their use impossible, but it is an extra layer of complexity to be accommodated.

9. Note on the standard revision process

The text of the revised standard was produced by a Working Group nominated by national standard committees representing CEN member countries (the 28 member states of the European Union, 3 members of the European Free Trade Association (Iceland, Norway and Switzerland), Macedonia and Turkey). The length of time taken to revise BS EN378 is due to the complexity of the topic, the breadth of material covered by the standard and the extensive changes happening in the industry during the change period. A key objective of the task handed from TC182 to WG6 was that the revised version of BS EN378 should as far as possible be aligned with the text of ISO817 and ISO5149, however since it was necessary to retain harmonization with the relevant key European Directives the match cannot be exact. In parallel with the maintenance of BS EN378 the International Standards Organisation (ISO) develops and publishes two standards, ISO817:2014 and ISO5149:2014 (parts 1 to 4). The work programme for the revision of both of these standards and BS EN378:2016 has now commenced.

The IOR is a member of the British Standards Institution and nominates four representatives to the RHE18 Refrigeration Safety Standards Committee. These members also participate in the IOR Technical Committee.

10. Further Guidance

The IOR publishes a set of Safety Codes of Practice which provide guides to the practical interpretation of the standards based on the choice of refrigerant. They are available free to IOR members and can be purchased by non-members: Flammable Lower Toxicity Refrigerants; Non Flammable Lower Toxicity Refrigerants; Ammonia Refrigerant; Carbon Dioxide Refrigerant

The four parts of BS EN378:2016 can be purchased at http://shop.bsigroup.com/Navigate-by/Standards/