National Codes, Standards and Legislation of EU Member States with respect to F-Gas alternatives
Project Deliverables 1 and 2

Report for European Commission, DG Clima
CLIMA.C.2/SER/2014/0019r
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1 Introduction

This document provides material for Task 1 of the project for DG Clima on Domestic F-Gas policies. It has been prepared by Ray Gluckman, acting as a sub-contractor to Ricardo Energy & Environment on behalf of DG Clima, in October 2015.

The report is based on the work carried out by Ricardo Energy & Environment and Gluckman Consulting in the period November 2014 to October 2015.

The material in this report addresses the following deliverables required under this contract with DG Clima.

- Deliverable 1 (Task 1.1): Review report - Overview of national codes, standards or legislation of EU Member States with respect to F-Gas alternatives in RAC equipment and foams. This overview is provided in Sections 2.3 to 2.5 of this report.

- Deliverable 2 (Task 1.2): Report - Analysis of Shortcomings (as regards national codes, standards, legislation). The analysis is presented in Sections 2.6 to 2.11 of this report.

- Deliverable 3 (Task 1.3): Draft Mandate for European Standardization Organizations. The draft mandate is provided in a separate document entitled “Draft Mandate”. The contents of the mandate are based on the analysis presented in Sections 2.9 and 2.10 of this report.
Task 1: National codes, standards and legislation on HFC alternatives

2.1 Background to Task 1

The EU F-Gas Regulation, 517/2014 requires a phase-down in the quantities of HFCs that can be placed on the EU market. A series of EU consumption cuts are defined, starting with a 7% cut in 2016 and leading to a 79% cut in 2030.

To meet the phase-down restrictions, users of HFCs must start to use alternative fluids with lower global warming potential (GWP) in new equipment and products that previously used high GWP HFCs. The average GWP of HFCs placed on the market in the F-Gas Regulation baseline period (2009 to 2014) was around 2000\(^1\). By 2030 end users will need to be using fluids with an average GWP below 400.

A number of different low GWP alternatives are available for most of the relevant sectors that use HFCs. However, each alternative has its own particular limitations such as being flammable, being toxic, having poor materials compatibility or requiring higher operating pressures. These issues must be addressed by suitable product design that meets the requirements of safety legislation and industry standards and codes.

A number of standards, codes and legislation at all levels (from European/international to the local level) regulate the safe use of both HFCs and low GWP alternatives in equipment. As the EU F-Gas Regulation drives the use of low GWP equipment it is important that existing standards, codes and legislation do not act as barriers to the uptake of low GWP technologies.

There is a concern that some standards, codes and legislation could act as a barrier as they do not sufficiently exploit the possibility of safely using low GWP alternatives. In this light, Article 11(6) of Regulation 517/2014 mandates the Commission to:

"collect, on the basis of available data from Member States, information on national codes, standards or legislation of Member States with respect to replacement technologies using alternatives to fluorinated greenhouse gases in refrigeration, air-conditioning and heat pump equipment and in foams. The Commission shall publish a synthesis report on the information collected [...] by 1 January 2017."

Task 1 addresses this requirement in the F-Gas Regulation. The scope of Task 1 has been broadened to include:

a) An analysis of EU level standards, codes and legislation that could create barriers to the uptake of low GWP technologies;

b) Development of a draft mandate to European Standards Organisations regarding possible revisions to various EU standards.

The activities in Task 1 address the two largest markets for HFCs:

- Refrigeration, air-conditioning and heat pumps (RACHP)
- Foam blowing

The use of refrigerants and foam blowing agents is controlled by a range of codes, standards and legislation that define safe operating conditions for their use. The types of controls can be split into 3 broad classes:

1. **Mandatory Controls.** Certain controls are mandatory and it would be illegal to use a fluid without adhering to the relevant controls e.g. certain EU Regulations and Directives.

2. **Advisory Controls.** Other controls are “advisory” codes and standards. These are not always mandatory, although it is strongly advised to work within the specified conditions e.g. EN (Euro-Norm) safety codes.

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\(^1\) Based on annual data on EU F-Gas consumption published by the European Environment Agency on behalf of the European Commission
3. **Geographic Controls.** The key controls that affect the use of refrigerants and foam blowing agents are set at EU level and so apply across any geographic region which is part of the EU. This includes mandatory Regulations and Directives and advisory EN codes. Some EU Member States have national or regional legislation that goes further than EU level controls. In particular, this relates to fire regulations that could restrict the use of flammable or mildly flammable refrigerants. Some of the EU level codes are aligned with broader international standards and codes such as ISO standards.

### 2.2 Methodology for Task 1

Task 1 activities were as follows:

- **a) A literature review to identify relevant EU level standards / legislation**
- **b) A survey of all EU Member States to obtain information about national standards / legislation**
- **c) Discussions with experts on standards and on RACHP and foam products**
- **d) Case studies looking in more depth at countries with national standards and at certain EU and international standards / legislation**
- **e) A Consultation Forum with Member State officials and F-Gas stakeholders to discuss the preliminary conclusions of the project**
- **f) A report to summarise all the activities undertaken and the key conclusions.**

### 2.3 EU Level Standards and Legislation

Product and equipment manufacturers, installers and end-users need to comply with a complex range of legislation, codes and standards that apply at EU level to all 28 Member States. Most of the requirements do not directly relate to the use of a particular refrigerant or foam blowing agent, but cover aspects such as general safety legislation for mechanical or electrical safety. Some of the requirements specifically relate to the safe use of refrigerants or foam blowing agents. The most important issues that may act as barriers to the uptake of low GWP alternatives to HFCs include:

- **a) Flammability**
- **b) Toxicity**
- **c) Operation of equipment under pressure.**

There are a number of EU Directives that affect safe use of refrigerants or foam blowing agents. The requirements in these Directives are mandatory. EU Directives are put in place at EU level and then implemented in each Member State through national legislation.

There are also a number of relevant EU codes and standards that set out requirements for safe use of particular types of product or equipment. The key standards are produced by the European Standardisation Bodies CEN and CENELEC. Use of the standards is not mandatory but it is widely accepted that adherence to a relevant EU standard is an important way of showing that the equipment is safe to use.

Table 2.1 summarises the most important safety related legislation and standards that apply at EU level to the selection of RACHP equipment. An analysis of the impact of the Directives and Standards listed in Table 2.1 is presented in Section 2.5 of this report.
Table 2.1: Summary of EU Level Directives and Standards related to RACHP Applications

<table>
<thead>
<tr>
<th>Summary of EU Level Directives</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU Directives</td>
<td></td>
</tr>
<tr>
<td>ATEX 95 (94/9/EC)</td>
<td>ATEX addresses risks related to potentially explosive atmosphere. These Regulations set rules for how flammable refrigerants can be safely used. Directive 14/34/EU replaces 94/9/EC from April 2016.</td>
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<tr>
<td>ATEX 137 (99/92/EC)</td>
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<tr>
<td>LVD 14/35/EU</td>
<td>Low Voltage Directive: rules for use of electrical equipment (50 to 1000 volts).</td>
</tr>
<tr>
<td>GPSD 2001/95/EC</td>
<td>General Product Safety Directive: general safety requirements</td>
</tr>
<tr>
<td>2006/42/EC</td>
<td>Machinery Directive: safety requirements for mechanical machinery</td>
</tr>
<tr>
<td>2010/30/EU</td>
<td>Energy Labelling Directive: requiring efficiency labelling</td>
</tr>
<tr>
<td>TPED 2010/35/EU</td>
<td>Transportable Pressure Equipment Directive (TPED) implementing ADR - the European agreement on the International Carriage of Dangerous Goods</td>
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<table>
<thead>
<tr>
<th>Related Codes and Standards</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td>EU Directives</td>
<td></td>
</tr>
<tr>
<td>EN 378: 2008</td>
<td>Refrigerating systems and heat pumps – safety and environmental requirements. EN 378 provides practical rules to define important parameters such as maximum refrigerant charge. It is harmonised with some of the above EU Regulations. EN 378 is currently under revision. It is likely that a new flammability category (2L, low flammability) will be introduced, to harmonise with international standards including ISO 817.</td>
</tr>
<tr>
<td>IEC EN 60335-2-24</td>
<td>Safety requirements for household and similar electrical appliances</td>
</tr>
<tr>
<td>IEC EN 60335-2-40</td>
<td>Safety requirements for electrical heat pumps, air conditioners, and dehumidifiers</td>
</tr>
<tr>
<td>IEC EN 60335-2-89</td>
<td>Safety requirements for commercial refrigerating appliances</td>
</tr>
<tr>
<td>EN 1127-1</td>
<td>Explosive atmospheres — explosion prevention and protection</td>
</tr>
<tr>
<td>EN 60079</td>
<td>Requirements for electrical systems used in potentially explosive atmospheres</td>
</tr>
<tr>
<td>EN 13463</td>
<td>Non-electrical equipment for use in potentially explosive atmospheres</td>
</tr>
</tbody>
</table>
2.4 Member State Standards and Legislation

Member State Survey

A questionnaire survey was sent to F-Gas Focal Point contacts in all 28 Member States to request information about national level standards and legislation that set requirements that go beyond the EU-level requirements summarised in Table 2.1.

A copy of the questionnaire used in the survey is included in the Project Overview report. The key question related to national standards and legislation was as follows:

*List any national or regional codes, standards and legislation that could restrict the use of refrigerants beyond the requirements in EU Directives and safety standards.*

Due to the specialist nature of the standards requirements we provided the Member State F-Gas Focal Points with two types of support prior to the completion of questionnaires:

a) A webinar was held to explain in detail the background to the standards issue

b) A “Supplementary Questionnaire” was prepared. The Member State F-Gas Focal Points were encouraged to circulate the Supplementary Questionnaire to relevant stakeholders in their Member State, to ensure that experts from the RACHP and foams sectors would be able to contribute to the completion of the main questionnaire.

The response to the Member State survey was very high. Responses were received from 24 out of 28 Member States, an 86% response rate that represents over 95% of the EU population.

The Member States that did not respond to the survey were:

1) Greece,  
2) Hungary  
3) Luxembourg  
4) Slovakia.

Summary of Survey Results

The majority of Member States identified no legislation that goes beyond the EU-level requirements. The headline results from the survey were as follows:

**Foams:** none of the responders highlighted any national codes or legislation that would be a barrier to use of low GWP alternatives in foams

**RACHP:** a significant majority of countries (18 out of 24) said they had no national codes or legislation that would be an extra barrier to use of low GWP alternatives in RACHP

The countries that did highlight standards or legislation that may be of relevance were:

- Austria
- Belgium
- France
- Italy
- Spain
- Sweden

Details of the relevant standards and legislation in these countries is given in Section 2.5, Member State Case Studies. In all cases the barriers to low GWP alternatives related to restrictions on the use of flammable refrigerants. These restrictions could affect the uptake of:

a) Higher flammability refrigerants (hydrocarbons such as propane and iso-butane)

b) Lower flammability refrigerants (HFOs, HFO/HFC blends and HFC-32).

No Member States highlighted any significant national restrictions related to toxic refrigerants (ammonia) or high pressure refrigerants (CO₂).
2.5 Member State Case Studies

As discussed in Section 2.4, the majority of Member States (17 out of 24) do not have any extra legislative barriers. In this section details are provided for the countries that have highlighted relevant barriers or, where relevant, if they have highlighted measures being taken to try and remove such barriers.

**Standards Case Study 1: Italy**

Italy reported a number of Ministerial Decrees that create national barriers related to the use of flammable refrigerants in certain types of public access buildings. These Decrees include:

- D.M. 9/04/1994 (Hotels)
- D.M. 27/07/2010 (Malls)
- D.M. 19/08/1996 (Buildings for Public Shows)
- D.M. 18/09/2012 (Hospitals)
- D.M. 26/08/1992 (Schools)
- D.M. 22/02/2006 (Offices)
- D.M. 16/07/2014 (Kindergartens)
- D.M. 7/07/2014 (Airports)
- D.M. 18/07/2014 (Freight)

The Decrees are all similar in nature and contain similar clauses that affect air-conditioning systems used in the types of building defined in each decree. The rules specifically affect central and localised air-conditioning. They do not apply to refrigeration or heating-only heat pumps.

The requirements for air-conditioning systems are that:

- refrigerants must be non-flammable and non-toxic
- chillers that use ammonia (which has lower flammability) can be used in indirect systems.

The barriers created by these rules mean that:

- split air-conditioning units with flammable refrigerants are not allowed
- chillers with flammable refrigerants are not allowed (unless the refrigerant is ammonia).

These barriers prevent the use of higher flammability refrigerants (such as hydrocarbons) or lower flammability refrigerants (such as HFOs or HFC-32) in the relevant types of public building. This requirement goes well beyond the EU level rules which would allow HCs in chillers and small split air-conditioning and would allow HFOs in chillers and in small / medium sized split air-conditioning.

The rules are not the responsibility of the Environment Ministry – this could make it difficult to get the legislation updated on environmental grounds.

**Standards Case Study 2: Germany**

Germany reported a number of pieces on national / regional legislation that must be considered including:

1. BGR 500, Section 2.35
2. TRBS 2152, part 1, section 3.4.1.

However, discussions with German experts showed that in most situations these are not extra barriers. In general the use of HCs in Germany is less restricted than in EN 378 or in the EN 60335 product standards. Some end users specify that they choose to follow the restrictive EU level standards, so HC use is then still constrained to the EU-level in such circumstances despite the more permissive German framework.

An interesting study was carried out in Germany, regarding the development of a strategy for increased use of hydrocarbon refrigerants². The study was published in December 2014. The study included an investigation of 4 possible HC applications:

² 2014, Heubes, Gschrey and others: Kohlenwasserstoffe sicher als Kältemittel einsetzen - Entwicklung einer Strategie zum vermehrten Einsatz von Kohlenwasserstoff- Kältemitteln als Beitrag zum deutschen Klimaschutzziel unter Berücksichtigung des Energieziels 2050 (Hydrocarbons)
1) split air-conditioning
2) domestic heat pumps
3) refrigerated trucks
4) chillers.

The study included an analysis of product liability issues for Original Equipment Manufacturers (OEMs) and component manufacturers, highlighting the difference between rules in standards and "state-of-the-art" activities that ignore these rules.

The German study identified various important barriers in standards at EU level e.g.

- the formula for calculating maximum charge is restrictive for HCs
- there is no evaluation of leakage quantity / leakage rate – this should be included to increase allowable charge in certain situations
- there is allowance for risk mitigation e.g. ventilation, shut-off valves – this should be included to increase allowable charge in certain situation.

The study also includes an interesting distinction in types of barriers to HCs:

- for split air-conditioning the most important barrier is restrictive standards
- for domestic heat pumps the most important barrier is lack of awareness of HC equipment or a lack of acceptance of HCs by end users.

Some recommendations in the German study include:

1) Green Public Procurement of chillers
2) Changes to standards
3) Review and clarification of product liability laws
4) Set up of an independent and objective consulting centre for hydrocarbon refrigerants.

**Standards Case Study 3: France**

France reported a single Decree that creates national barriers related to the use of flammable refrigerants in certain types of public access buildings.

The Decree of 25 June 1980 is a safety regulation against the risks of fire and panic in public buildings including:

- hotels, restaurants and bars, shops and shopping malls
- hospitals, schools, offices, museums, libraries, conference and entertainment facilities.

Article CH 35 (amended July 2003) affects air-conditioning and creates barriers similar to those in Italy, i.e.:

- split air-conditioning units with flammable refrigerants are not allowed
- chillers with flammable refrigerants are not allowed (unless the refrigerant is ammonia).

The Decree as written appears to address a range of applications beyond just air-conditioning, and includes refrigeration applications. However, experts in France have agreed that it only applies to air-conditioning applications.

The Decree makes several references made to EN 378, but no version is referred to. The Decree was last amended in 2003, so the available version at that time was EN 378:2000. This ambiguity illustrates the importance of harmonisation with the latest versions of EU standards.

**Standards Case Study 4: Belgium**

Belgium reported a number of national or regional rules that create some barriers to the uptake of both HFCs and low GWP alternatives. The situation is Belgium is made more complex by the regional

safely as refrigerants – Development of a strategy for increased use of hydrocarbon refrigerants as a contribution to German climate protection target, taking into account the energy target in 2050)
structure of government (with 3 regions: Flanders, Brussels-Capital and Walloon Region). Some of the relevant rules are at regional level and there are further variations possible at municipal or city level. At local level the Fire Departments may put some restrictions on the use of flammable alternatives. A problem for suppliers of RACHP equipment in Belgium is that these local requirements are not applied in a consistent way across the whole of Belgium. Some RACHP installations may locally require specific environmental authorisations (permis d’environnement). Again this creates problems with consistency across Belgium and the requirement for an authorisation may be perceived as a potential barrier in the consideration of alternatives from the very first steps of a project. Some municipal authorities may impose additional safety restrictions, particularly in relation to flammable alternatives. Experts from Belgium commented that there is a need for transparency and for one single law that covers the refrigeration system requirements. The current system is considered complex, inconsistent and creates unnecessary barriers to low GWP alternatives. Some of the legislation that is relevant includes:

- Flanders: “VLAREM II, Article 5.16.3.3 Koelinstallaties”
- Brussels-Capital Region: legislation contains a small section about natural refrigerants, but there’re no major restrictions mentioned (Belgisch Staatsblad 19.06.2012, p.33383-33391).
- Wallonia: there are 2 important laws covering the use of HFC refrigerants:
  - 12 juillet 2007 - Arrêté du Gouvernement wallon déterminant les conditions intégrales et sectorielles relatives aux installations fixes de production de froid ou de chaleur mettant en œuvre un cycle frigorifique (M.B. 28.09.2007).

**Standards Case Study 5: Spain**

Spain reported their Royal Decree 138/2011, which sets detailed safety standards for refrigeration applications.

The requirements set for higher flammability refrigerants are similar to those in EN 378 except in public access areas where it is only possible to use sealed systems. This creates a barrier to non-sealed systems using higher flammability refrigerants such as hydrocarbons e.g. small split air-conditioning. The requirements for lower flammability refrigerants are quite restrictive when used in public access areas. There is a 2.5 kg charge limit and only sealed systems can be used. This creates a barrier to the use of lower flammability refrigerants such as HFC-32 or HFOs in non-sealed systems e.g. medium and large sized split air-conditioning, condensing units for food retail.

It is useful to note that the Spanish Government has introduced a GWP weighted tax on HFC refrigerants. This adds a significant cost burden to the users of high GWP refrigerants in Spain. For example R-404A has an untaxed price of around €6 per kg. The tax currently applied to R-404A is a further €49.95 per kg. This has proved to be a very powerful driver for Spanish end users to consider lower GWP alternatives.

**Standards Case Study 6: Sweden**

In Sweden there are national level rules set by the Swedish Work Environment Authority. The relevant rules treat all refrigerants as either flammable or non-flammable. This means that all flammable refrigerants are treated as “higher flammability”. There is no distinction made for lower flammability refrigerants.

Hydrocarbons are allowed in appropriate circumstances e.g.

- <0.15 kg in domestic refrigerators
- HC chillers in open air / special machinery rooms

However, when flammable refrigerants are used risk assessment is required – this can be costly / time consuming.
Experts from Sweden would like to see more harmonisation with EU level rules, which would require changes to the current Swedish Work Environment Authority rules.

### 2.6 Impact of EU and National Standards and Legislation

The content of the key EU-level standards and legislation has been assessed from the perspective of the impact on the selection of low GWP refrigerants and foam blowing agents. Discussions have been held with individual experts and feedback has been received and analysed from the Consultation Forum held in September 2015.

The feedback received from Consultation Forum participants was especially helpful as it provided good confirmation of the preliminary conclusions developed during the analysis of standards and legislation. Formal written feedback was received from a number of major European Organisations including:

- AREA
- ASEROCM
- CECED
- ECOS
- EFCTC
- EHI
- EIA
- EPREE
- Eurammon
- GIZ
- JBCE
- JRAIA
- Umweltbundesamt (UBA, Germany)
- Shecco

A copy of all written comments received is included in the Project Overview report. Further feedback was received via short written answers to questions posed to all Consultation Forum participants. Details of the analysis of these responses can be found in the Project Overview report. Based on the analysis carried out and feedback received the impacts are summarised in Sections 2.7 to 2.11.

#### 2.7 R-717 (Ammonia)

The research for this study has not identified any major barriers created by standards or legislation at either EU or national level in relation to the use of ammonia as a refrigerant.

Ammonia is a toxic and lower flammability refrigerant (safety category B2).

Ammonia is widely used for large industrial systems and has some application in water chillers for large building air-conditioning. It has been continuously used in industrial systems for over 100 years, so there is a significant body of expertise available to support the design, installation and maintenance of ammonia systems.

Experts agree that ammonia is a refrigerant to be used with great care and that adherence to the requirements in current safety standards such as EN 378:2008 are an appropriate way forward. The national standards that ban flammable refrigerants (e.g. in France and Italy) all provide exemptions for ammonia. French regulations restrict ammonia charge for building air-conditioning chillers to 150 kg, which is more restrictive than in EU-level standards. However, this is not considered a barrier that will create significant problems for greater market penetration of ammonia systems.

Expert feedback from the Consultation Forum supports the conclusion that no urgent changes are needed to current standards or legislation in relation to ammonia.

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2 Safety categories from EN 378:2008 and ISO 5149
2.8 R-744 (CO2)

The research for this study has not identified any major barriers created by standards or legislation at either EU or national level in relation to the use of CO2 as a refrigerant.

CO2 is a non-toxic and non-flammable refrigerant (safety category A1). A key characteristic of CO2 is a high operating pressure (heat rejection can take place at around 120 bar, compared to around 15 to 20 bar for ammonia, hydrocarbons and fluorocarbon refrigerants). CO2 has a low critical pressure (31°C compared to 132°C for ammonia and 80°C to 100°C for hydrocarbons and fluorocarbons). This means that CO2 systems may need to operate in “ transcritical” mode4 or using cascade designs5.

CO2 was used in the early years of mechanical refrigeration, but was little used between 1950 and 2000 as alternatives such as CFCs and HFCs were considered more cost effective. During the last 15 years CO2 has been re-introduced. The most successful current markets for CO2 are (a) supermarket refrigeration (there are several thousand CO2 systems in EU supermarkets and market growth in other regions) and (b) domestic water heating heat pumps (there are several million small systems in Japan). CO2 is also used in some small hermetically sealed commercial refrigeration systems (e.g. bottle coolers). It is being developed for other markets including mobile air-conditioning, refrigerated transport and small commercial refrigeration systems (condensing units).

CO2 experts have not raised any concerns about legislative / standards issues. There was no national level legislation identified that would affect use of CO2. At EU level, the Pressure Equipment Directive and the current refrigeration safety standard EN 378:2008 provide a suitable framework for the design and operation of safe CO2 systems.

Expert feedback from the Consultation Forum supports the conclusion that no urgent changes are needed to current standards or legislation in relation to CO2.

2.9 Higher flammability refrigerants (hydrocarbons)

The research for this study has identified significant barriers to the uptake of higher flammability refrigerants created by standards or legislation at both EU and national level.

Higher flammability refrigerants include various hydrocarbons (HCs) such as HC-290 (propane), HC-600a (iso-butane), propylene (HC-1270) and various HC blends such as R-441A. The higher flammability category also includes HFC-161. These fluids are easily ignited and are in refrigerant safety category A3 in safety standards such as EN 378 and ISO 5149.

There is currently only limited use of “medium flammability” refrigerants (safety category A2; mainly HFC-152a). These have not been analysed in detail as the usage is very low. The analysis in this section on higher flammability (A3) refrigerants is also generally applicable to A2 refrigerants.

It should be noted that there is likely to be significant use also of other flammable refrigerants such as HFOs and HFC-32, which are categorised as mildly flammable by the ISO 5149 standard. These are analysed separately in Section 2.10.

Prior to 1995, the use of HCs was mainly restricted to specialist refrigeration applications in certain chemical and petrochemical plants that were familiar with handling higher flammability fluids. After the phase out of CFCs in the EU in 1995, HCs were developed for use in domestic refrigerators. HC-600a proved to be a very effective and efficient refrigerant in domestic refrigeration appliances. Most of the EU market for new domestic refrigerators moved to HCs on a voluntary basis in the period 2000 to 2010. HCs have been introduced in other small hermetically sealed equipment in the commercial sector (e.g. for integral retail displays). HCs have also been used for chillers located in machinery rooms or in outdoor locations. Other HC applications include mono-bloc heat pumps and small split air-conditioning.

HC experts and equipment manufacturers agree that these refrigerants must be used with care due to the flammability risk. However, there is disagreement between industry stakeholders about the amount

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4 Transcritical R-744 systems reject heat into the atmosphere using an R-744 condenser / gas cooler. When the ambient temperature is below approximately 20°C, the system operates in a conventional sub-critical mode. In hot weather the system operates with heat rejection above the critical temperature.

5 Cascade systems are designed to avoid operation above the critical temperature of R-744. Heat is rejected via a “cascade refrigeration chiller” which uses a different refrigerant. The chiller is usually located in a special machinery room or on a roof-top. Use of a cascade arrangement keeps the R-744 well below its critical temperature under all ambient temperature conditions – this gives improved efficiency in hot weather.
of refrigerant charge\(^6\) that is safe to use in different applications and with different risk management measures adopted.

### Key Issues

Analysis of legislation and standards shows:

- There is some national legislation that simply bans HCs in certain applications (e.g. in Italy, France and Spain where HCs for air-conditioning applications are banned). This national legislation creates especially severe barriers for HCs in a small number of EU Member States.

- In relation to A3 refrigerant charge, a very conservative (and thus limiting) approach is adopted in refrigeration and air-conditioning safety standard EN 378:2008 and in the proposed revisions to EN 378 that may be agreed in 2016.

- In relation to A3 refrigerant charge, a conservative approach is adopted in the product safety standards IEC EN 60335-2-40 for air-conditioning systems and in IEC EN 60335-2-89 for integral and remote commercial refrigeration appliances.

- There are inconsistencies between some of the above standards e.g. the product standard IEC EN 60335-2-89 restricts the HC charge in hermetically sealed retail display refrigeration units to 0.15 kg whereas EN 378 allows up to 1.5 kg for the same type of equipment.

- There are potential inconsistencies within EN 378:2008 related to the different calculation of maximum HC charge required for human comfort cooling and for “other refrigeration applications”. This allows a larger HC charge for a floor mounted retail refrigeration display than for a floor mounted split air-conditioning unit (see example in table below – 0.95 kg allowed for retail display whereas only 0.18 kg allowed for split air-conditioning).

| Example calculation for HC-290 (propane), Room 5m * 10m * 2.5m |  |
| --- | --- | --- | --- |
| **Evap height** | **Human Comfort** | **Other refrigeration** |
| **Max kg** | 0.6 | 1.1 | 1.8 | 2.2 | 0.33 | 0.53 | 0.65 | 0.95 |

- In the draft EN 378: 2015 the charge size “cap” for A2 and A2L refrigerants is based on a multiplier of the LFL\(^7\) (e.g. 130 x LFL) but for A3 refrigerants it is typically based on a fixed mass (e.g. 1.5 kg). So for A2 and A2L refrigerants there is an advantage in selecting refrigerants with higher LFL, whereas for A3 refrigerants there is no advantage. This is considered by some experts as unreasonable, discriminatory and without justification. There should be a consistent approach for all refrigerants.

- EN 378 (both the 2008 version and the currently proposed revisions) and the EN 60335 product standards are not harmonised with the EU ATEX product Directive 94/9/EC on explosive atmospheres. Standards such as EN 60079-10-1:2009 (Explosive atmospheres. Classification of areas) and EN 1127-1:2011 (Explosive atmospheres. Explosion prevention and protection. Basic concepts and methodology) are harmonised with ATEX, but these are general standards covering a wide range of situations, most of which are not relevant to refrigeration and air-conditioning. Harmonisation of EN 378 and the two EN 60335 product standards with ATEX would ensure that the appropriate requirements for safe use of flammable gases can be applied to refrigeration and air-conditioning applications. It is considered important that this harmonisation includes an appropriate leak detection test in all 3 standards. It may also be appropriate to harmonise EN 13313 (the standard that defines competency requirements for engineers and technicians working with refrigerants) with the ATEX workplace Directive (99/92/EC).

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\(^6\) Refrigerant charge is the quantity of refrigerant contained within a system. For example, a domestic refrigerator might have a charge of 0.1 kg and a large supermarket system might have a charge of 200 kg.

\(^7\) LFL: lower flammability limit
EN 378 is currently being revised, but the terms of reference for the revisions relate mainly to the introduction of a lower flammability category – they do not address higher flammability refrigerants. Several experts expressed the view that it would be possible to introduce further changes to EN 378 that would allow larger HC charges in certain applications. For example, the currently proposed revisions to EN 378 introduce “risk management” procedures that allow larger refrigerant charges, but these are restricted to A1 and A2L refrigerants and provide no benefits to A3 refrigerants such as HCs or to A2 refrigerants such as HFC-152a.

The product standards IEC EN 60335-2-40 and IEC EN 60335-2-89 are also undergoing a review process. As with EN 378, this process is currently concentrating on changes related to lower flammability refrigerants. Further efforts will be required to address higher flammability refrigerants.

**Recommended Changes**

Expert feedback from the Consultation Forum supports the conclusion that changes are required to reduce barriers to the use of HC refrigerants. Particular changes that need consideration include:

a) Removal of national level barriers to flammable refrigerants; national legislation should ideally be no more restrictive than the current and future EU-level standards.

b) Changes that would allow the risk management approach applied to A1 and A2L refrigerants to also be applied to A2 and A3 refrigerants.

c) Changes that would eliminate or reduce the difference between charge calculations for human comfort cooling and for “other” refrigeration applications.

d) Changes that would eliminate or reduce the difference between charge calculations for above and below ground applications.

e) Changes that would provide harmonisation with ATEX Directive 94/9/EC.

f) The changes described in (b) to (e) above should be applied in a consistent way to the 3 most relevant standards i.e. EN 378, IEC EN 60335-2-40 and IEC EN 60335-2-89.

**Barriers**

Various barriers to addressing these issues were identified during this research:

- There are some concerns that the current standards committees lack sufficient HC experts and that the decisions on higher flammability refrigerants could be strongly influenced by organisations whose primary commercial interests are related to lower flammability refrigerants.

- There is a lack of comprehensive data and evidence in the public domain to support changing the current standards. Better laboratory and field data may be required – this could be quite costly and finding appropriate funds could be a barrier.

- It could be important for work on EU level revisions to be carried out in liaison with other international revisions (e.g. under ISO 5149). It is also important that there is coordination within the EU between the CEN and CENELEC standards committees (CEN is responsible for EN 378 and CENELEC is responsible for the EN 60335 product standards).

**Recommended Process**

To help ensure that higher flammability refrigerants can make the maximum contribution to the EU HFC phase down process it is important that the most relevant EU standards are reviewed to allow larger charges of A3 refrigerants where this is safe. Given that the standards making process is a relatively slow one, there is some urgency to start the review process. To overcome some of the barriers described above it might be useful to create a dedicated “EU higher flammability refrigerants standards Working Group” as part of the standard setting process to consider relevant changes.

Such a Working Group should usefully include experts on A3 refrigerants and on the EU standards making process, besides existing members of the relevant technical committees. It would be important that the Working Group Terms of Reference are specifically related to A3 (and possibly A2) refrigerants and that membership should not be biased towards members from organisations with commercial interests in A1 or A2L refrigerants. The Working Group would liaise closely with CEN TC/182 and
CENELEC TC/61 to ensure that the proposed changes would be acceptable to a broad range of relevant stakeholders.

Such a Working Group could:

1. Initially scope out the appropriate changes required to the current standards, using the list (b) to (f) above as a starting point for discussions.
2. Identify existing evidence that is available to support their proposals. They should also consider any extra evidence that is required to support the proposed changes to standards and should identify how such data can be provided and over what timescale.

The scoping work (in Items 1 and 2 above) should be completed 6 months after the Working Group is set up. The Working Group should propose an outline of the proposed changes and a suitable timetable for further work, allowing time for extra evidence collection and analysis if that is required. This work should also take into account any relevant international standards activities that is on-going in relation to higher flammability refrigerants, e.g. changes to ISO 5149 or the IEC versions of the 60335 product standards.

It is important that the process described above should run in parallel to the ongoing progress of the currently proposed revisions to EN 378, in order to gain time. As discussed, these latter revisions do not adequately address higher flammability refrigerants, but will address many issues related to HFOs and blends (see below).

2.10 Lower flammability refrigerants (HFOs, HFO / HFC blends, HFC-32)

The research for this study has identified significant barriers to the uptake of lower flammability refrigerants created by standards or legislation at both EU and national level. Revisions that are currently under review for the three most important refrigeration safety standards (EN 378, IEC EN 60335-2-40 and IEC EN 60335-2-89) go some way to addressing these issues, although there are still barriers at a national level and there may be more scope to further revise the 3 main standards.

Until recently there was very little use of lower flammability refrigerants. Ten years ago, the majority of refrigerants used were either non-flammable (e.g. most HFCs) or higher flammability (e.g. hydrocarbons). The only exception to this was ammonia, which has lower flammability as well as being toxic.

In the last 5 years a number of lower flammability refrigerants have been introduced in response to the need to replace high GWP non-flammable HFCs with low GWP alternatives. There are now a range of lower flammability refrigerants being used or being considered for RACHP applications including:

a) Pure HFOs such as HFO-1234yf and HFO-1234ze
b) Lower GWP pure HFCs, in particular HFC-32
c) A range of new blends that combine HFOs with certain HFCs, such as R-447A, R-454A and R-454B.

All of these refrigerants are flammable but their characteristics are very different to those of higher flammability refrigerants such as HCs. In particular they:

- Are very difficult to ignite – the minimum ignition energy (MIE) is high.
- Burn “gently” with a low burning velocity (BV).
- Have a higher LFL (lower flammability limit) than more flammable fluids.
- Have a low heat of combustion (HoC).

The high LFL combined with high MIE make it much less likely that these refrigerants will ignite than higher flammability refrigerants. The low BV and low HoC makes the consequences of ignition much less severe than for higher flammability refrigerants. The existing EN 378:2008 standard recognises the lower flammability to some extent and already allows larger charges to be used than for higher flammability refrigerants such as hydrocarbons.
Flammability characteristics (such as those described above) are not well understood by many relevant stakeholders (e.g. end users, maintenance contractors, insurance companies etc.). Historically, large parts of the RACHP market avoided the need to fully understand flammability because there were appropriate non-flammable refrigerants available for most applications. The new requirement to phase down the quantity of high GWP HFCs placed on the market in the EU changes this situation. To achieve the EU HFC phase down it will be necessary to use significant quantities of lower flammability refrigerants and it is important that safety standards do not create unnecessary barriers to this objective.

The current EN 378:2008 has 3 flammability categories:

- **Category 1:** non-flammable
  - No flame propagation

- **Category 2:** flammable
  - \( \text{LFL} > 0.1 \text{ kg/m}^3 \) and \( \text{HoC} < 19 \text{ MJ/kg} \)

- **Category 3:** higher flammability
  - \( \text{LFL} < 0.1 \text{ kg/m}^3 \) or \( \text{HoC} > 19 \text{ MJ/kg} \)

At international level there has been recognition of the need to introduce a new lower flammability category into safety legislation. ISO 5149 has introduced a new category as follows:

- **Category 2L:** lower flammability
  - As Category 2 plus \( \text{BV} < 10 \text{ cm/s} \)

The current revisions to EN 378 should introduce the same 2L flammability category and make some provisions for larger charges of 2L refrigerants (compared to the amounts currently allowed under Category 2).

**Key Issues**

Analysis of legislation and standards shows:

- The issue of flammability is highly complex and is not well understood by many stakeholders.
- Some national legislation (e.g. in Italy, France and Spain) bans all flammable refrigerants in certain applications. No distinction is made between different flammability categories.
- The existing EN 378:2008 allows A2L refrigerants to be treated as A2 refrigerants and this already allows the new refrigerants to be used in a range of applications and locations.
- The proposed revisions to EN 378 (which could be finalised by mid-2016) would introduce the A2L category and provide some extra scope for larger A2L refrigerant charges. In particular, a "risk management approach" allows considerably larger charges if designers adopt certain risk management measures such as continuous ventilation or refrigerant shut-off valves triggered by leak detectors.
- Some industry stakeholders believe that there could be further scope to increase the allowed charges of A2L refrigerants than those that will be allowed under the new EN 378.
- It is important that updates to the product standards EN 60335-2-40 and EN 60335-2-89 do not create any extra restrictions compared to the revised EN 378.

**Recommended Changes**

There are fewer barriers to the use of lower flammability refrigerants than there are for higher flammability refrigerants. However, it remains important to ensure that various actions are taken to allow the maximum early transition away from high GWP non-flammable refrigerants. The EU HFC phase down is unlikely to be achieved without significant use of A2L refrigerants.

Particular issues that need consideration include:

a) Removal of national level barriers to lower flammability refrigerants; national legislation should ideally be no more restrictive than the current and future EU-level standards.

b) Early agreement to the currently proposed revisions to EN 378. These revisions go some way to addressing the important issues regarding A2L refrigerants. As discussed in the previous section, the revisions do not address A3 issues. Stakeholders concerned about A3 refrigerants need to be reassured that A3 refrigerants will be addressed urgently.
c) Revisions need to be made to the product standards EN 60335-2-40 and EN 60335-2-89 that reflect the changes proposed in EN 378. There should be consistency between the allowed refrigerant charges in EN 378 and the relevant product standards.

d) After the revised EN 378 has been agreed, CEN TC/182 might be asked (i) whether it is appropriate to begin to consider further revisions for lower flammability refrigerants that would allow higher refrigerant charges in certain applications and (ii) how EN 378 can be modified to provide harmonisation with ATEX Directive 94/9/EC.

Barriers

Barriers to the further development of standards for lower flammability refrigerants include:

- The difficulty of coordinating EU priorities with changes being made at an international level (especially in relation to the product standards EN 60335-2-40 and EN 60335-2-89).
- Whether there is sufficient evidence available to support changes to the way that maximum charges of A2L refrigerants are calculated.

2.11 Member State legislation on use of refrigerants

The Higher Flammability and Lower Flammability Task Forces referred to in Sections 2.9 and 2.10 are unlikely to be the appropriate bodies to address the barriers created in a few Member States through national legislation.

The Commission will need to separately consider how changes to national legislation that affect the use of lower flammability refrigerants can be expedited. In particular this relates to legislation in Belgium, France, Italy, Spain and Sweden.

2.12 Foam blowing agents

The research for this study has not identified any major barriers created by standards or legislation at either EU or national level in relation to the use of low GWP fluids as foam blowing agents.

The HFCs used as blowing agents to make closed cell insulating foam include HFC-134a, HFC-365mfc and HFC-245fa. These are non-flammable fluids with GWPs in the range 790 to 1430.

The foam industry has used low GWP alternatives since the phase out of HCFCs in 2004, mainly because the cost of alternative blowing agents was lower than the HFCs. For polyurethane-type foams there is already widespread use of hydrocarbon blowing agents such as pentane. For extruded polystyrene (XPS) CO₂ is already in use as a blowing agent.

Whilst the majority of foam is already manufactured using these low GWP alternatives, parts of the foam market still use HFCs. The three main reasons for using HFCs are:

- In factories producing small volumes of PU-type foam it is not cost-effective to covert the process to higher flammability HC blowing agents.
- Some products require a very high thermal performance – HFCs may have better performance than either HCs or CO₂.
- Some products require a non-flammable or lower flammability blowing agent.

In response to the HFC phase-down a number of new HFO blowing agents have been developed including HFO-1234ze, HFO-1233zd and HFO-1336mzz. These are all classified as non-flammable fluids for foam blowing applications. These fluids are beginning to enter the foam market for high performance applications.

The main barriers to the introduction of alternative foam blowing agents are:

- The price of alternative blowing agents. Blowing agents represent a significant proportion of the cost of foam raw materials – in a competitive market it is hard to switch to a blowing agent that is significantly more expensive.
- The time and cost related to product development and testing. Many foam products must be tested over long time periods to show stable thermal performance over a long product lifetime.
These barriers are technical and commercial and are quite different to the safety related barriers that apply to the RACHP market. No national or EU-level legislation or standards that could create barriers to the uptake of low GWP foam blowing agents were identified during the research. Expert feedback from the Consultation Forum supports the conclusion that no urgent changes are needed to current standards or legislation in relation to low GWP foam blowing agents.

2.13 Conclusions and recommendations related to standards

National Level Barriers

It has been shown that barriers to the uptake of low GWP alternatives at national or regional level are only of importance in a small number of Member States:

- No Member States reported barriers related to foam blowing agents.
- The majority of Member States (18 out of 24) reported no national barriers related to RACHP.
- Only 4 countries reported having national legislation or regional / municipal rules that are significantly more restrictive than EU level legislation. In all cases this relates to the use of flammable refrigerants. The relevant countries are Belgium, France, Italy, Spain
- 2 further countries (Austria and Sweden) reported some extra barriers, but these are not so significant.

It was agreed by all experts contacted during the study that it would be helpful if all national level legislation or regional rules are made consistent with rules set at an EU level via relevant standards.

EU Level Barriers

At EU level there were no major barriers identified in relation to the use of:

- Low GWP alternatives for foams
- Ammonia for RACHP
- CO₂ for RACHP

Significant barriers were identified in relation to the use of flammable refrigerants. Three important EU standards were identified as being the most important ones for the sector. These are:

a) EN 378, a standard addressing safety and environmental issues in all types of RACHP system.
b) EN 60335-2-40, a product standard for air-conditioning systems
c) EN 60335-2-89, a product standard for integral and remote commercial refrigeration appliances

All of the above standards are currently under revision. A key objective of the revisions is to introduce the lower flammability (2L) safety category and to modify the rules for maximum allowable charge of 2L refrigerants. A revised EN 378 may be finalised by mid-2016. Revisions of the 2 product standards might be complete in 2016, but that is not yet clear.

Getting the revisions of these 3 standards in place as soon as possible is considered a positive step that will reduce some of the current barriers to flammable refrigerants.

However, the findings of this study clearly show that further action is required urgently, especially for higher flammability refrigerants. A potential way forward is described in section 2.9. It is clear however that the standard setting process is largely in the hands of participating industry experts providing the relevant expertise and input to the process, and not in the hands of the policymaker.

The key requirements to be addressed are:

For higher flammability refrigerants:

a) Changes to allow the risk management approach applied to A1 and A2L refrigerants to also be applied to A2 and A3 refrigerants.
b) Changes to eliminate or reduce the difference between charge calculations for human comfort cooling and for “other” refrigeration applications.

c) Changes to eliminate or reduce the difference between charge calculations for above and below ground applications.

d) Changes to provide harmonisation with ATEX Directive 94/9/EC.

For lower flammability refrigerants:

a) Current proposals for revisions of standards will, if accepted in this form in the near future, already enable a wider use of these refrigerants.

b) Further consideration of future revisions could increase the allowable charge of lower flammability refrigerants if it can be shown to be safe to do so.

c) Adoption of changes described above for higher flammability refrigerants in the way that is applicable for lower flammability refrigerants (e.g. eliminate or reduce the difference between charge calculations for human comfort cooling and for “other” refrigeration applications; changes to provide harmonisation with ATEX Directive 94/9/EC)