EPEE Side Event
Achieving the HFC Phase-Down in Europe

12 July 2017
Bangkok
I. Welcome by Juergen Goeller, EPEE Chairman

II. The EPEE Gapometer: Achieving the HFC Phase-Down in Europe by Ray Gluckman, Gluckman Consulting

III. The EN 13313: A tool to define skills and activities & REAL Alternatives 4 LIFE, a blended e-learning programme, by Karsten Beermann, MD IKKE gGmbH

IV. Conclusions by Andrea Voigt, EPEE Director
I. Welcome

By Juergen Goeller
II. The EPEE Gapometer

By Ray Gluckman
EPEE GAPOMETER - Project Objectives

• to develop a Roadmap for meeting EU HFC phase down steps
  – with in-depth understanding of contributions to HFC cuts
    ▪ by market sector and sub-sector
    ▪ by core action

• to monitor progress towards meeting the targets
  – by collecting market intelligence data
  – to identify any gaps between Roadmap and actual activity

• emphasis is on:
  – understanding the challenging cuts in 2018 and 2021
QUANTIFICATION OF REQUIRED ACTIONS FOR PHASE-DOWN
Baseline does not include pre-charged imports—a further 22 MT CO₂ (12%). From 2017, included in quota.

2015: Start point 183 MT CO₂
Based on average EU HFC consumption 2009-2012

2030: Final target 38 MT CO₂
- a cut of 79%
The challenges in 2018 and 2021

- Baseline: 22 MT CO\(_2\) + 183 MT CO\(_2\) = 205 MT CO\(_2\) (44% cut, 90 MT CO\(_2\))
- 2018: 115 MT CO\(_2\)
- 2021: 82 MT CO\(_2\) (60% cut, 123 MT CO\(_2\))
Core Actions to achieve the EPEE Roadmap

1. **Actions for new equipment**
   - use lower GWP alternatives
   - design for less refrigerant charge and low leakage

2. **Actions for existing equipment**
   - leak prevention
   - retrofit with low GWP alternatives

3. **Use of reclaimed refrigerant**
   - recovered from equipment at end-of-life
   - recovered during retrofit of existing equipment
Roadmap: Contributions from Core Actions

Cuts in MT CO$_2$

-90
-36 (40%)
-30 (33%)
-24 (27%)
-20 (16%)

-123
-64 (52%)
-39 (32%)

Baseline
2018
2021

New Equipment
Existing Equipment
Reclaimed Refrigerant
MONITORING OF CORE ACTIONS
Gapometer Market Research Activities

• to test assumptions in Roadmap
  – to highlight any “gaps” between what needs to be achieved and current progress

1. refrigerants used in new equipment
  – surveys of RAC equipment OEMs in 2016 and 2017

2. supermarkets – company policies for:
  – new equipment; leakage reduction; retrofitting of R-404A

3. reclaim / recycling
  – packer fillers
  – RAC contractors
Small split air-conditioning (<3kg) – market survey data

Percentage of R-410A in new small split air-conditioning (<3 kg)

- Roadmap
- 2016 OEM data
Good fit to Roadmap assumptions

Small splits represent 60% of R-410A usage in SAC sub-sectors
This sector includes all DX air-con with >3kg single splits, multi-split, VRF, packaged.

Significant on-going use of R-410A for equipment containing 3 to 12 kg, which represent 60% of R-410A usage in the > 3kg SAC sub-sectors.
Leakage assumptions for 3 market sectors

Supermarkets survey supports Roadmap assumptions
But are the results only from good performers?
Supermarket R-404A Retrofits

- retrofits of R-404A systems helps “kick-start” HFC cuts
  - R-404A: GWP 3922

- slower start to retrofits than assumed in Roadmap
  - but lots of trials being carried out
  - reasonable plans for actions in 2017 to 2020

- early retrofits R-407A (GWP 2107) and R-407F (GWP 1825)
  - recent shift to R-448A and R-449A (GWP 1400)

- good results for ‘quick retrofits’
  - retrofits of R-404A much easier than for R-22
Sources of Refrigerant for Re-use

• from equipment reaching end-of-life
  – mandatory requirement in F-Gas Regulation to recover gas
  – retiring equipment is a significant source of recovered gas

• from equipment being retrofitted
  – key benefit of R-404A retrofits is to ensure that old gas recovery is maximised and the gas is re-used

• what happened to old gas historically?
  – some was illegally vented
  – some was accidentally vented during recovery
  – much was sent for incineration
  – some was re-used
Reused Refrigerant

- reclaimed refrigerant is outside of EU HFC quota
  - hence re-use of old refrigerant can make a useful contribution to phase-down targets
  - Roadmap assumes 24 MT CO$_2$ in 2018: 27% of total cut

<table>
<thead>
<tr>
<th>Year</th>
<th>HFCs re-used</th>
<th>MT CO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tonnes</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>1700</td>
<td>5</td>
</tr>
<tr>
<td>2016</td>
<td>3900</td>
<td>13</td>
</tr>
<tr>
<td>2017</td>
<td>6200</td>
<td>20</td>
</tr>
<tr>
<td>2018</td>
<td>7800</td>
<td>24</td>
</tr>
<tr>
<td>2019</td>
<td>8400</td>
<td>23</td>
</tr>
<tr>
<td>2020</td>
<td>9200</td>
<td>22</td>
</tr>
<tr>
<td>2021</td>
<td>9500</td>
<td>20</td>
</tr>
</tbody>
</table>
KEY MESSAGES
Key Messages (1): Achieving Phase-Down

• 2018 and 2021 targets are very challenging
  – cuts of 44% and 60% from baseline consumption

• Roadmap shows how targets can be achieved via:
  – use of lower GWP gases in new equipment
  – reducing leakage from existing equipment
  – retrofitting R-404A equipment
  – making good re-use of all HFCs available for recovery

• Major risks to end-users if key actions not taken
  – refrigerant prices could jump by factor of >20
  – some high GWP refrigerants could become unavailable
  – quality of installation could suffer if rapid action needed
  – “good EU countries” still exposed to any overall shortages
Key Messages (2): Key Influencers

• required actions / actors are market sector-specific

• some sectors: gas choice for new equipment is key
  – mostly users of high volume products
  – e.g. most air-conditioning sectors; stand-alone commercial refrigeration; transport refrigeration
  – **key influencers:** OEMs and designers / specifiers

• commercial and industrial sectors must address both new and existing equipment
  – **key influencers:** end users and RAC contractors

• need to create good infrastructure for gas re-use
  – **key influencers:** RAC contractors and refrigerant supply chain
Key Messages (3A): New Equipment

• Lower GWP refrigerants are already available for most RAC applications
  – some ultra-low and low GWP options (GWP < 150)
  – some moderate GWP options (GWP 150 to 750)

• BUT uptake of lower GWP options is slower than required

• End users must be strongly encouraged to avoid using high GWP “traditional” HFCs in new equipment

• OEMs / equipment suppliers must make a wide range of lower GWP options available
Key Messages (3B): New Equipment

• Some lower GWP options involve flammable refrigerants
  – training of technicians and development of safety standards are urgent priorities

• Advisors play an important role and must understand the lower GWP options
  – some advisors are not yet fully aware of the needs for:
    – lower GWP refrigerant options
    – alternative configurations (e.g. indirect systems)
  – e.g. building service consultants and RAC contractors
Key Messages (4A): Existing Equipment

• Leakage reduction is important, especially in larger systems
  – supermarkets are a key sector – historically they had high leak rates
• good progress by “best-practice” supermarkets
  – reducing leaks from over 20% per year to well under 10%
• BUT there is a lack of progress in some supermarket companies and some Member States
Key Messages (4B): Existing Equipment

- Retrofit of R-404A systems is a crucial contributor to phase-down targets
  - supermarkets have embraced retrofit in some EU countries
  - BUT greater adoption of retrofits across the EU is urgent to meet 2018 targets
- R-404A (GWP 3922) systems can be retrofitted using refrigerants with GWP around 1400
  - maximising recovery and re-use of R-404A being retrofitted is important
- Industrial users of HFC systems must also consider both leakage and retrofits
  - BUT industrial users are well behind supermarket sector in relation to these issues
Key Messages (5A): Refrigerant Re-Use

• re-use of refrigerant makes an important contribution to HFC phase-down
  – reclaimed HFCs are not accounted for in the HFC phase-down quotas
  – the EPEE Roadmap shows they can provide over 25% of the required cut in 2018

• drivers for recovery and re-use will grow quickly
  – historically there was relatively little HFC re-use as virgin HFCs were low cost
  – higher refrigerant prices and shortages of high GWP gases will encourage re-use
Key Messages (5B): Refrigerant Re-Use

• RAC contractors and end users need to maximise refrigerant recovery
  – at equipment end-of-life and when equipment is being retrofitted
  – this is a legal requirement, BUT some contractors do not comply with current rules

• gas supply chain must provide supporting infrastructure
  – easy access to recovery cylinders
  – easier transport of “waste gas” between countries
  – facilities for reclaim of unmixed and mixed refrigerant

• there is good infrastructure in a few Member States
  – BUT significant work is needed in 2017 and 2018 to maximise refrigerant re-use
Key Messages (6): Outlook for 2018

• 44% cut from baseline starts in 6 months time!

• Gapometer Roadmap shows how the cut can be achieved
  – but it relies on many actions by many different actors

• market research shows significant progress
  – but not enough activity yet
  – recent significant price increases may accelerate action

• without a significant increase in the uptake of the core actions in 2017 and early 2018
  – there could be a severe shortage of some HFC refrigerants in 2018
III. The EN13313 & REAL Alternatives 4 Life

By Karsten Beermann
Revise EN 13313
- CEN / TC 182/WG 4

Dipl.-Ing. Karsten Beermann
convenor

( P.S.: Many Thanks to Hilde Dhont for the support! )
Introduction to EN 13313

Prepared by CEN TC182 WG 4, published November 2010

---

**EUROPEAN STANDARD**

**EN 13313**

**NORME EUROPÉENNE**

**EUROPÄISCHE NORM**

November 2010

ICS 27.080; 27.200

Supersedes EN 13313:2001

English Version

Refrigerating systems and heat pumps - Competence of personnel

Systèmes de réfrigération et pompes à chaleur - Compétence du personnel

Kältanlagen und Wärmepumpen - Sachkunde von Personal

This European Standard was approved by CEN on 16 October 2010.
Why EN 13313?
We need to speak the same language!

- EU certification scheme for HFCs (since 2008) is based on mutual recognition
  - allows technicians to be certified in one country and work in the other EU countries
  - But how to compare the various local schools, assessment and certification bodies? → Requires same definitions & assessment

- Need for training/qualification/certification programmes on non-HFC refrigerants

- A person does not necessarily have to be qualified for all tasks / all types of refrigerants / all types of applications → need to clearly define the scope

Need for a European Standard
What is EN 13313?

1. A tool to define skills & activities

✓ This European standard defines:
  - The activities related to refrigerating (= refrigerant containing) circuits
  - The associated competence profiles required to do those activities

✓ It also establishes procedures for assessing the competence of persons who carry out these activities

✓ The standard can be used for any type of refrigerant
  It is possible to add additional requirements for certain refrigerants/ an example for Ammonia is already given as annex
The standard is **NOT** a training course, evaluation or certification programme

- training schools, legislators, voluntary programmes, in house training programmes **are free to define** which parts of the standard they wish to cover

- Example is given in Annex: the EU F gas certification covers “HFC” gases only, and contains 4 modules/categories of competences

**What is EN 13313?**

2. **NOT** a training course or certification

Scope of training/evaluation/certification scheme can be defined according to the needs.
What is EN 13313?

3. A basis for mutual understanding

✓ The standard allows different training/evaluation/certification programmes to be defined using the same terminology & assessment method

- This facilitates mutual understanding and
  - if necessary - mutual recognition between different training/qualification/certification schemes

- This allows persons to demonstrate for which “modules” they are qualified - not everyone needs to be qualified for all tasks!
13 Activities

- Designing
- Pre-assembling
- Installation
- Putting into operation
- Commissioning
- Operating
- In-service inspection
- Leak checking
- General maintenance
- Circuit maintenance
- Decommissioning
- Removing of refrigerant
- Dismantling

EN13313 does not cover the electrical activities related to a refrigerating system, however an informative example is given in Annex.
4 Competence „levels“

LE : leading edge
FO : fully operational
WK : working knowledge
BA : basic appreciation
2 assessment methods

Theoretical

Practical
### Structure

13 activities

#### Table A.5 — Fluids

<table>
<thead>
<tr>
<th>Fluids</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Pre-assembling</td>
</tr>
<tr>
<td>3.8</td>
<td>3.9</td>
</tr>
</tbody>
</table>

#### Description of tasks, see Clause 3 Terms and definitions

#### Skills to assess

- **Refrigerant behaviour**
  - FO
  - BA
  - WK
  - FO
  - WK
  - WK
  - WK
  - FO
  - WK
  - FO
  - WK
  - FO
  - BA

- **Coolant, secondary loop fluid**
  - FO
  - BA
  - WK
  - BA
  - BA
  - BA
  - BA
  - BA
  - WK
  - BA
  - WK

- **Toxicity**
  - FO
  - WK
  - WK
  - BA
  - BA
  - BA
  - BA
  - BA
  - WK
  - BA
  - WK

- **Flammability**
  - FO
  - BA
  - WK
  - BA
  - BA
  - BA
  - BA
  - BA
  - WK
  - BA
  - BA

- **Fractionation**
  - FO
  - BA
  - WK
  - BA
  - BA
  - BA
  - BA
  - BA
  - WK
  - BA
  - BA

Each cell = level of expertise
- White = theoretical assessment
- Grey = practical assessment
- Black = not applicable

Skills to assess
6 tables

1. Basic thermodynamics
2. Components & tests of refrigerating systems
3. Piping, joints & valves
4. Safety equipment
5. Fluids
6. Communication
Evaluation & certification procedures

General
Persons shall demonstrate a level of competence as defined in the tables, of their theoretical and/or practical ability as necessary for the activity in question.

→ Persons do not need to be qualified for all tasks, but it should be clear for which competences they are qualified and/or certified

Procedures
The evaluation and certification procedures dealing with the competence of persons related to the refrigerating circuit shall be done according to the procedures defined in EN ISO/IEC 17024.
EN 13313 compared to EU F-gas-regulation certificate

Table C.1 — Conversion Table EN 13313 and F-gases regulation

<table>
<thead>
<tr>
<th>EN 13313</th>
<th>Design</th>
<th>Pre-assembling</th>
<th>Installation</th>
<th>Putting into Operation</th>
<th>Commissioning</th>
<th>Operating</th>
<th>In-service Inspection</th>
<th>Leakage checking</th>
<th>General Maintenance</th>
<th>Circuit Maintenance</th>
<th>Decommissioning</th>
<th>Removing Refrigerant</th>
<th>Dismantling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Next steps

• CEN standard → update + CEN/ISO standard
  - Example of required update for EU:
    • EU member states to ensure training programmes for persons recovering F gases from MAC sector
    • EU F-gas-certification & training has to include info on relevant technologies to replace or reduce the use of F-gases and their safe handling

• ISO level standard will allow further international harmonization & comparability of both existing and new training/ qualification/ certification schemes
Revise of EN 13313

- Actual update
- Consider EN 378-2016 and ISO 5149
- Update in consideration F-Gas-VO 517/2014 + 2015/2067
- Additional Informative Annex for flammable refrigerants
- Additional Informative Annex for CO₂
- Influence of energy efficiency
- prEN/ISO 22712 - official procedures
THANK YOU for your attention!

www.i-k-k-e.com
Refrigerant Emissions and Leakage - Blended learning for alternative refrigerants in new equipment

Karsten Beermann
IKKE gGmbH
Refrigerant Emissions and Leakage-blended learning for alternative refrigerants in new equipment

safety, efficiency, reliability and containment

REAL Altertatives

e-library
e-learning

classroom practice

www.realalternatives.eu
Refrigerant Emissions and Leakage-blended learning for alternative refrigerants in new equipment

A European project co-funded by the EU Leonardo Life Long Learning programme to address skills needs in technicians in the refrigeration, air conditioning and heat pump sector in:

- Carbon dioxide
- Ammonia
- Hydrocarbon
- Low Flammables (HFO/R32 etc)

www.realalternatives.eu
Refrigerant Emissions and Leakage-blended learning for alternative refrigerants in new equipment

Addresses safety, efficiency, reliability and containment aspects of service and maintenance.

Critical safety factors associated with alternative refrigerants:

- Higher system pressures
- Flammability
- Toxicity
Consortium of Expert Project Partners

- Associazione Tecnici del Freddo
- Foundation for the Protection of the Ozone Layer
- Institute of Refrigeration
- European Association for Refrigeration, Air Conditioning and Heat Pumps (AREA)
- London South Bank University
- Limburg Catholic University College
- Informationszentrum für Kälte- Klima- und Energietechnik gGmbH

Co-financed by Lifelong Learning Programme

www.realalternatives.eu
Sharing best practice across Europe

Institute of Refrigeration

London South Bank University

Associazione Technici del Freddo, Italy

Limburg Catholic University College

Foundation for the Protection of the Ozone Layer, Poland

Informationszentrum für Kälte- Klima- und Energietechnik gGmbH

Air Conditioning and Refrigeration European Association

www.realalternatives.eu
### The 2 year work programme

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Research to clarify training needs and opportunities</td>
<td>LSBU</td>
</tr>
<tr>
<td>2</td>
<td>Review of existing resources</td>
<td>LSBU</td>
</tr>
<tr>
<td>3</td>
<td>Developing training booklets, e-learning pages, library</td>
<td>KHLim</td>
</tr>
<tr>
<td>4</td>
<td>Piloting, testing and translation</td>
<td>ATF</td>
</tr>
<tr>
<td>5</td>
<td>Measuring impact, evaluating and adjusting</td>
<td>IKKE</td>
</tr>
<tr>
<td>6</td>
<td>On going dissemination and stakeholder engagement</td>
<td>AREA / IOR</td>
</tr>
<tr>
<td>7</td>
<td>Project Management</td>
<td>IOR</td>
</tr>
<tr>
<td>8</td>
<td>– Explore sustainability options post funding</td>
<td>PROZON</td>
</tr>
<tr>
<td></td>
<td>Launch of free resources and training schemes in English, Polish, German, Dutch and Italian</td>
<td>End 2014/Early 2015</td>
</tr>
</tbody>
</table>
Conclusions - industry needs

- clear need for improved skills – especially for Carbon Dioxide and HFO/low flammable refrigerants
- high awareness of retraining to address safety, reliability and leakage
- strong emphasis on assessed and certificated classroom based training, with supporting on line technical information
- high interest levels and commitment by smaller businesses
REAL Alternatives blended learning resources:

- flexible learning programmes for use by individuals, companies or training providers.
- multi-lingual website
- e-learning & study materials in five languages
- searchable e-library of resources users can add to
- tracking spreadsheets, report formats and other tools
- standard online assessments with optional certification
- opportunities for stakeholders to contribute and update the materials and resources

www.realalternatives.eu
## Technical content of materials

<table>
<thead>
<tr>
<th>Real Alternatives Europe programme modules:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction to Alternative Refrigerants - safety, efficiency, reliability and good practice</td>
</tr>
<tr>
<td>2. System design using alternative refrigerants</td>
</tr>
<tr>
<td>3. Containment and leak detection of alternative refrigerants</td>
</tr>
<tr>
<td>4. Maintenance and repair of alternative refrigerant systems</td>
</tr>
<tr>
<td>5. Retrofitting existing systems</td>
</tr>
<tr>
<td>6. Checklist of specific legal obligations</td>
</tr>
<tr>
<td>7. Measuring the financial and environmental impact of leakage</td>
</tr>
<tr>
<td>8. Tools and guidance for conducting site surveys</td>
</tr>
</tbody>
</table>

Co-financed by

[www.realalternatives.eu](http://www.realalternatives.eu)
learning booklets
E-learning

1. The hazards of R32 include:
   - High flammability
   - Mild flammability
   - High toxicity
   - Mild toxicity

R317 (Ammonia, NH₃)

Properties
R317 has a relatively high saturation temperature at atmospheric pressure, is highly toxic, mildly flammable and has a pungent odour.

It can be smelt at concentrations of just 3 mg/m³, so it is evident at levels much lower than those which are hazardous (the ATEL / OCC is 300 mg/m³). It is the only ammonia used refrigerant which is lighter than air which means that dispersion of any leaked refrigerant takes place quickly.

R317 also operates with very high discharge temperatures. Single stage compression can therefore normally be used above -100°C evaporating temperature. Below this, two stage compression with interstage cooling is required.

The high toxicity limits the application of R317 to very low charge systems or industrial systems (i.e., systems in areas which are not accessible by the general public). This typically includes distribution cold stores and food processing plants, usually using secondary systems where R317 is the primary refrigerant.

Ammonia corrodes copper so steel pipes work and open drive compressors are used. It is also immiscible with conventional mineral oils, making oil rectification an additional requirement of the refrigeration systems. The use of steel pipe, open drive compressors and oil rectification impact the capital cost of an ammonia installation.

See also:
- Institute of Refrigeration Safety Code Ammonia

Welkom op de piloot-test van het REAL Alternatives Europe e-learning platform

Gelezen eerst de 'Voorbeschrijving' te lezen voordat u begint.

Begin met de e-learningmodule die u vindt onder 'Leerpad'.

U kan van start gaan onder 'Voorbeschrijving'.

Bedankt voor uw deelname aan deze piloot-test.
Website and e-library available

www.realalternatives.eu
Welcome to the REAL Alternatives Europe e-learning platform pilot

Please read the 'Course description' before you begin.

Start with the e-learning modules you have been invited to test, which can be found under 'Learning Path'.

You can then take the sample Assessment under 'Tests'.

Please remember to complete the Evaluation Survey to feedback your views of the Module content and design at this trial stage.

Thank you for taking part in this trial

Course description
Learning path
Tests
Notebook
REAL Alternatives e-library

Trainers: KHLim-INET Education | Miriam Rodway

Lifelong Learning Programme

www.realalternatives.eu
R744 (Carbon Dioxide, CO₂)

Properties
R744 has high operating pressures, a low critical temperature (31°C) and a high triple point. Its volumetric cooling capacity is between 5 and 8 times that of HFCs, reducing the required compressor displacement and pipe size. Its properties have an effect on how the system is designed and operates, especially in high ambient temperatures. It has a high discharge temperature, necessitating two stage compression for low temperature systems. The document highlighted below has detailed information on how these properties affect the application of R744.

Usage
R744 is used in the following system types:

1. Pumped secondary – where R744 is the secondary fluid cooled by a primary system. R744 is a volatile secondary which, coupled with the high capacity and density, reduces the required pump power compared to other secondary fluids such as glycol.
2. Cascade – where the heat rejected by the condensing R744 is absorbed by the evaporating refrigerant in a separate high stage system. In these systems the R744 operates below the critical point and the high side pressure is generally below 40 bar. The high stage system can be R744 (see below), or it can be HFC, HC, HFO or R717.
3. Transcritical systems – where the R744 heat is rejected to ambient air and at ambient temperatures above approximately 21°C the R744 will be above the critical point (31°C) – i.e. it will be transcritical. The R744 does not condense – it remains a super critical fluid until its pressure is reduced to below the critical pressure (72.8 bar). The high side pressure is typically 90 bar when transcritical.

Currently (2014) R744 has been used in several 1000 retail systems and in industrial systems in Europe. It is starting to be used in heat pumps and in integral systems.

The application of R744 has required additional skills for design engineers and service technicians, and availability of new components.

More information is available in the REAL Alternatives e-library:

- NAReCO2 manual "Natural Refrigerant CO₂"
- Danfoss Application Handbook "Food retail CO₂ refrigeration systems" and "CO₂ for industrial refrigeration"
- Danfoss Application Handbook "Cascade HC/HFC-CO₂ system"
- Danfoss CO₂ Handbook
- Danfoss article "Transcritical refrigeration systems with CO₂"
- Shecco Guide Europe 2013
### Application of Alternative Refrigerants

The table indicates the type of system the refrigerant is most appropriate for – it does not show where these refrigerants are actually being used. The section below gives more information on current applications.

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Central plant</th>
<th>VRV, VRF</th>
<th>Split AC / heat pumps</th>
<th>Chillers</th>
<th>Remote condensing units</th>
<th>Integrals</th>
</tr>
</thead>
<tbody>
<tr>
<td>R744</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R717</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1234ze</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R600a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R290 and R1270</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2, application of alternative refrigerants**

- **Green** – these systems are suitable for the refrigerant type indicated, and the charge size is usually within the limits specified in EN378. Some design changes are required, for example to electrical devices and/or ventilation.

- **Amber** – these systems can and are used with the refrigerant type indicated, but there are restrictions because of the maximum charge or practical limit specified in EN378. Some design changes are required to electrical devices and/or ventilation. In some cases the volumetric capacity of the refrigerant means it is not ideal for the application.

- **Red** – these systems should not be used with the refrigerant type indicated, usually because the charge size exceeds the maximum specified in EN378-1.

**Alternative refrigerants are not suitable to be used in systems which are designed for conventional (non flammable) HFC or HCFC refrigerants.**

A brief introduction to each refrigerant or type of refrigerant is given on the next pages. For more details see the guide “Design differences for alternative refrigerant systems”.

**More information is available in the REAL Alternatives e-library:**

- See REAL Alternatives Guide 2, Design Differences with Alternative Refrigerant Systems
Safety Classification

Safety

All alternative refrigerants covered in this guide have safety issues beyond those of the HFC refrigerants. These include:

- Flammability – mild (HFOs, R32 and R717) and high (HCs);
- Toxicity – low (R744) and high (R717);
- High pressures (R744).

Toxicity and flammability

The safety classifications below are defined in ISO817:2009 and are also used in EN378-1:2008 A2:2012.

Classification

The classifications comprise two parts:

- A or B represents the degree of toxicity;
- 1, 2, 2L or 3 represents the degree of flammability.

The toxicity classification is as follows:

- Class A is lower toxicity (most refrigerants are class A);
- Class B is higher toxicity (R717 is class B).
Flammable Refrigerants

This section covers the safe handling of:

- Hydrocarbons (R600a, R290, R1270);
- R32 (also refer to the section on F Gases);
- R1234ze (also refer to the section on F Gases);
- R717 (also refer to the section on R717).

The safe working environment and PPE

When you work with flammable refrigerants the area must:

- Be well ventilated
- Have no source of ignition within 3 m (a typical safe area when working on flammable refrigerant systems).

If necessary introduce forced ventilation using a suitable fan assembly. This has an Ex rated fan motor and a 5m cable which enables it to be switched on outside the safe work area.

When carrying out invasive work, or if a leak is suspected, check and monitor the work area using an HC detector.

It is important that the detector cannot be zeroed out to background flammable refrigerant levels and alarms at 20% of the lower flammability level.

The photo shows suitable detectors for HCs.

You should also have a fire extinguisher to hand.

This should either be a dry power type with a capacity of at least 2 kg, or an equivalent sized CO₂ type.
NEW: REAL Alternatives 4 LIFE

- Actual Needs report
- Update E-Learning (e.g. EN 378-2016) with additional assessment questions
- New module: “risk & safety”
- Train The Trainer events, practical exercises
- Dissemination world wide on events
- Strong involvement of stakeholders (e.g. IIR + AREA)

- At the end 15 languages

www.realalternatives.eu
THANK YOU!

REAL Alternatives

e-library  e-learning

classroom practice

www.realalternatives.eu
IV. Conclusions

By Andrea Voigt