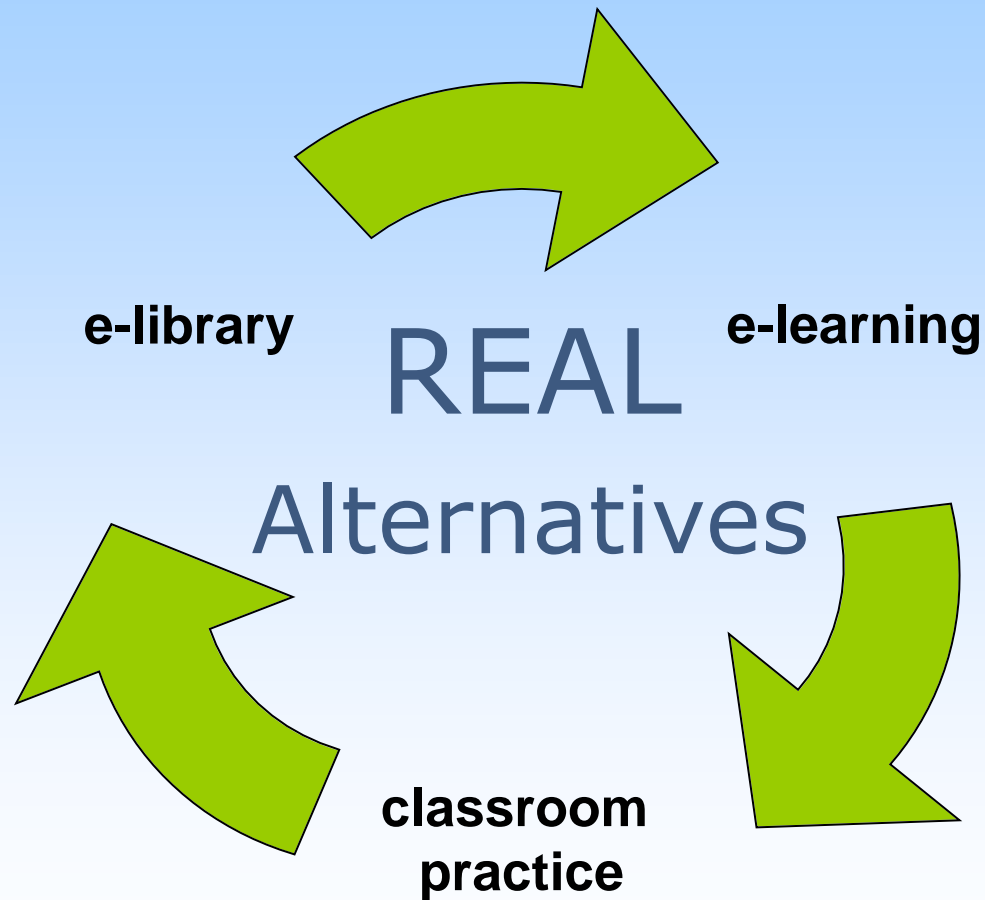


# Refrigerant Emissions and Leakage-blended learning for alternative refrigerants in new equipment

safety, efficiency, reliability and containment



# Refrigerant Emissions and Leakage-blended learning for alternative refrigerants in new equipment

Developed as part of a collaborative Leonardo da Vinci European project 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)

# 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 - INDIPENDENT

Associazione Tecnici del Freddo, Italy



Institute of Refrigeration, UK



London South Bank University, UK



Foundation for the Protection of the Ozone Layer, Poland



European Association for Refrigeration, Air Conditioning and Heat Pumps (AREA)



Limburg Catholic University College, Belgium



Informationszentrum für Kälte- Klima- und Energietechnik, Germany



With the co-operation of the International Institute of Refrigeration



[www.realalternatives.eu](http://www.realalternatives.eu)



# The 2 year work programme started Oct 2013 - ending next Oct 2015

## STEPS

1 - Research to clarify training needs and opportunities	LSBU
2 - Review of existing resources	LSBU
3 - Developing training booklets, e-learning pages, library	KHLim
4 - Piloting, testing and translation	ATF
5 - Measuring impact, evaluating and adjusting	IKKE
6 - On going dissemination and stakeholder engagement	AREA / IOR
7 - Project Management	IOR
8 – Explore sustainability options post funding	PROZON
Launch of free resources and training schemes in English, Polish, German, Dutch and Italian	Spring 2015

# Conclusions - industry needs

- ➡ 104 responses from major stakeholders to define industry needs
- ➡ 63 individuals from 12 European countries took part in the pilot test

- Need for improved skills – especially for CO2 and HFO/low flammable refrigerants
- Retraining to address safety, reliability and leakage
- Assessed and certificated classroom based training, with supporting on line technical information



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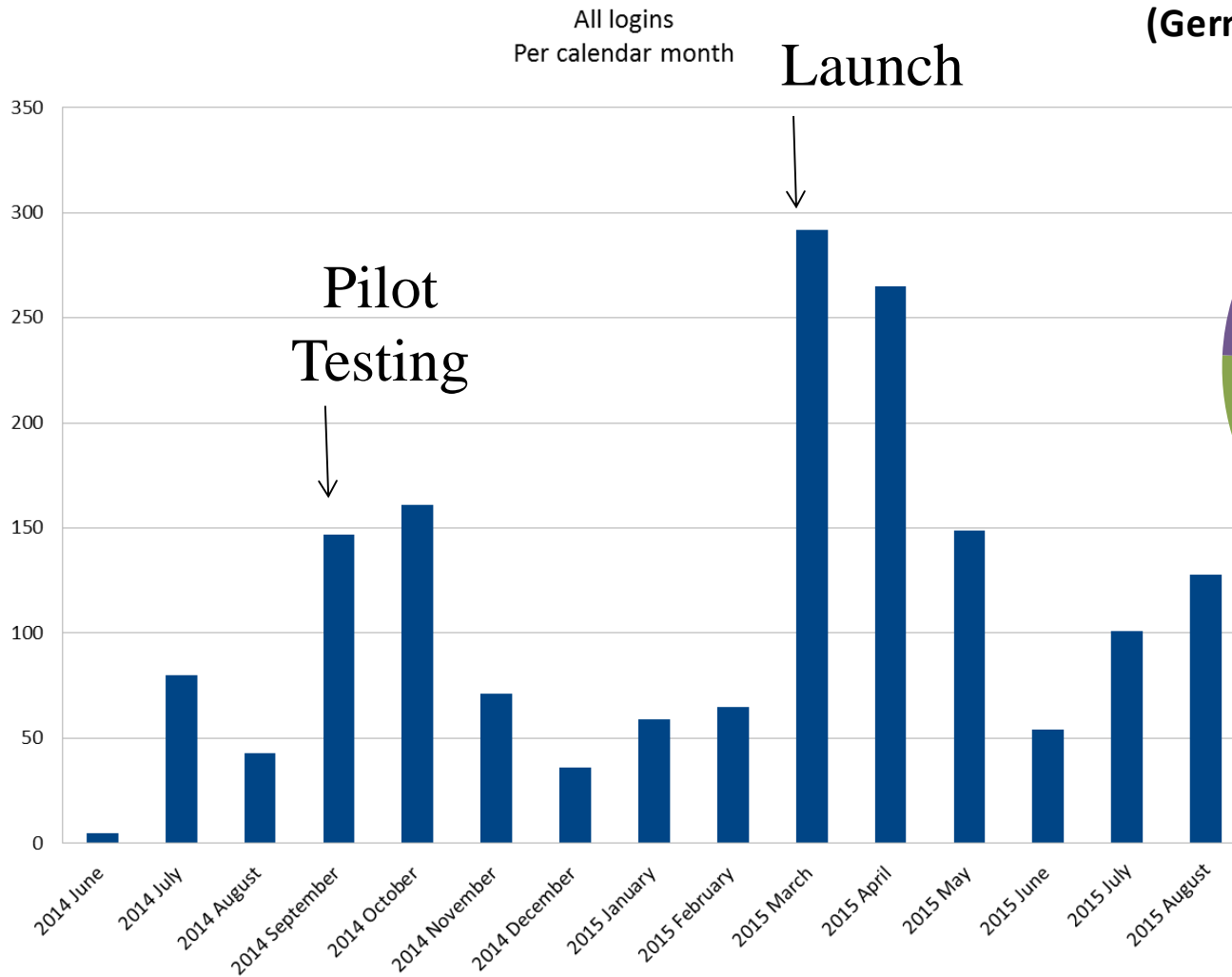


# REAL Alternatives blended learning resources:

- flexible learning programmes and schemes for use by individuals, companies or training providers.
- multi-lingual website
- e-learning & booklets study materials in Dutch, English, French, German, Italian, Polish
- searchable e-library (over 100 free documents) of resources users can add to and can also rate
- tracking spreadsheets, report formats and other tools
- standard on-line tests and controlled assessment papers in classroom with optional certification
- stakeholders contribute materials and resources
- opportunities for more translations, training programmes etc

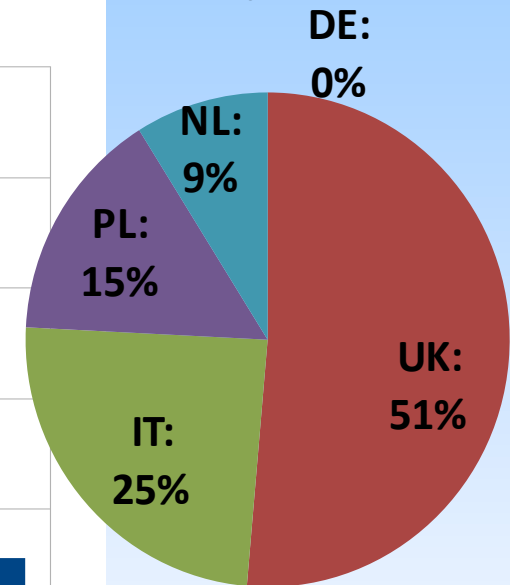


# Numbers – Elearning Login



## DIVIDED BY LANGUAGE

(German too early for consistent data)



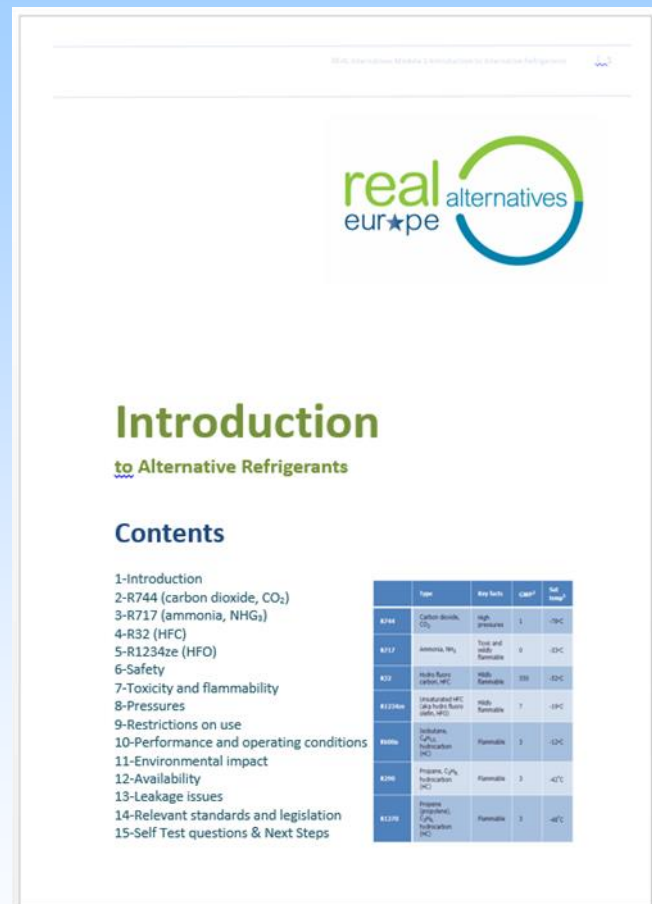
549 have registered to use the website and download library/download booklets



# Learning materials in 8 modules

## Real Alternatives Europe programme modules:

1. Introduction to Alternative Refrigerants - safety, efficiency, reliability and good practice
2. System design using alternative refrigerants
3. Containment and leak detection of alternative refrigerants
4. Maintenance and repair of alternative refrigerant systems
5. Retrofitting existing systems with low GWP alternatives
6. Checklist of legal obligations
7. Measuring the financial and environmental impact of leakage
8. Tools and guidance for conducting site surveys



# Multi language e-learning with free registration (English, French, German, Italian, Polish, Dutch)

Real Alternatives Europe - English / Learning paths / Module 1 - Introduction to Alternative Refrigerants / Preview

Course home

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48%

Module 1 - Introduction to Alternative Refrigerants

Introduction

Aim ✓

Basic Properties ✓

Application ✓

Refrigerants

R744 ✓

R717 ✓

R32 ✓

R1234ze ✓

R290 R1270 R600a ✓

R717 (Ammonia, NH<sub>3</sub>)

Properties

R717 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/m<sup>3</sup>, so it is evident at levels much lower than those which are hazardous (the ATEL / ODL is 350 mg/m<sup>3</sup>). It is the only commonly used refrigerant which is lighter than air which means that dispersion of any leaked refrigerant takes place quickly.

R717 also operates with very high discharge temperatures. Single stage compression can therefore normally be used above -100C evaporating temperature. Below this, two stage compression with interstage cooling is required.

The high toxicity limits the application of R717 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 R717 is the primary refrigerant.

Ammonia corrodes copper so steel pipe 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 on the capital cost of an ammonia installation.

See also:

- Institute of Refrigeration Safety Code Ammonia

Campus Startpagina | Mijn cursussen | Mijn agenda | Mijn vooruitgang | Sociaal netwerk

Real Alternatives Europe - Nederlands

Miriam Rodway

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

Gelieve eerst de 'Vakbeschrijving' te lezen voor u begint.  
Begin met de e-learningmodules die u vindt onder 'Leerpad'.  
U kan een test afleggen onder 'Oefeningen'.  
Bedankt voor uw deelname aan deze piloot-test.

Vakbeschrijving | Leerpad | Oefeningen | Notities

Deze cursus

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16%

Module 3 - Omsluiting en lekdetectie bij alternatieve koelmiddelen

Inleiding ✓

Lekdichtheid installatie

Belangrijke factoren ✓

Ligging van leken ✓

Vaak voorkomende lekpunten

Schraderventielen ✓

Parasakselingen

R744 PRV

R717 Systemen

Lekdetectiemethoden

Methoden

Vissel en Gear

Effectieve Lekdetectie

Schraderventielen

De inspanningen in het kader van het consorciële UK Real Zero-project hebben ertoe geleid tot de ontwikkeling van de schraderventiel. Het project heeft ook manieren naar voren gebracht om de lekken te voorkomen. Alle details vindt u in het document dat onderaan in de kijker staat. Het is van essentieel belang dat op al deze punten een lektest wordt uitgevoerd.

Dankzij de inspanningen tijdens het project zijn drie belangrijke zones geïdentificeerd en werd de nodige ervaring met alternatieve koelmiddelen opgedaan. De zones (hieronder beschreven) vertonen het meeste potentieel voor grote verbeteringen.

Schraderventielen

Bij de keuze voor de ventielbekermen moet men er zich van vergewissen dat ze geschikt zijn voor het koelmiddel en het diacyclo, net als voor het druk- en het temperatuurbereik waarin de systemen worden gebruikt. Verschillende systemen en koelmiddelen kunnen verschillende types schraderventielen vereisen.

De kern moet worden verwijderd voor de schraderventiel in het systeem wordt geïsoleerd. Zodra de behuizing afgevoerd is, moet men de kern opnieuw monteren. De kern moet vervolgens met het juiste aanhaalmoment worden vastgezet.

Het ventiel moet worden afgedekt. De dop die daarvoor het vaakst wordt gebruikt, is voorzien van een dichtung die afbreekt en lekt wanneer ze heet wordt. Een zeshoekige moer, die met behulp van een moerleedat zorgvuldig kan worden vastgezet, is in dit geval een betere oplossing. De moer moet zo worden geïsoleerd dat ze het schraderventiel niet indrukt wanneer ze wordt aangespannen.

Meer info:

- Real Skills Europe Guide to 13 Common Leak Points

# Each module offers downloadable Learning Booklets (PDF)

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## Introduction to Alternative Refrigerants

### Contents

- 1-Introduction
- 2-R744 (carbon dioxide, CO<sub>2</sub>)
- 3-R717 (ammonia, NHG<sub>3</sub>)
- 4-R32 (HFC)
- 5-R1234ze (HFO)
- 6-Safety
- 7-Toxicity and flammability
- 8-Pressures
- 9-Restrictions on use
- 10-Performance and operating conditions
- 11-Environmental impact
- 12-Availability
- 13-Leakage issues
- 14-Relevant standards and legislation
- 15-Self Test questions & Next Steps

	Type	Key facts	Cap <sup>1</sup>	Std Temp <sup>2</sup>
R744	Carbon dioxide, CO <sub>2</sub>	High pressure	1	-78°C
R717	Ammonia, NH <sub>3</sub>	Toxic and mildly flammable	0	-33°C
R32	Hydro fluorocarbon, HFC	Highly flammable	550	-52°C
R1234ze	Unsubstituted HFO (aka Hydro fluorocarbon, HFO)	Mildly flammable	7	-19°C
R600a	Isobutane, C <sub>4</sub> H <sub>10</sub> , hydrocarbon, HC	Flammable	3	-12°C
R290	Propane, C <sub>3</sub> H <sub>8</sub> , hydrocarbon, HC	Flammable	3	-42°C
R1270	Propene (propylene), C <sub>3</sub> H <sub>6</sub> , hydrocarbon, HC	Flammable	3	-48°C

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## Design Differences For Alternative Refrigerants

### Contents

- 1-Minimising leakage potential
- 2-R744 (Carbon dioxide)
- 3-R717 (Ammonia)
- 4-R32
- 5-R1234ze
- 6-R600a (Iso. butane)
- 7-R290 and R1270 (i-Propene and Propene)
- 8-Appendix 1, Design Process for Flammable Refrigerant Systems
- 9-Self Test Questions

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## Containment & Leak Detection to Alternative Refrigerants

### Contents

- 1-Refrigerant containment
- 2-Common leaks
- 3-Leak detection methods
- 4-Effective leak
- 5-Containment pressure testing
- 6-Leak test regime
- 7-Flare leak detection
- 8-Indirect leak detection

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## Financial, environmental, safety & reliability Alternative Refrigerants & Leakage

### Contents

- 1-General
- 2-Environmental impact
- 3-Financial cost
- 4-Safety issues
- 5-Making a case for reducing leakage

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## Legislation & Standards For Alternative Refrigerants

### Contents

- 1-General
- 2-Fluorinated Gases
- 3-Flammable Refrigerants

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## Maintenance & Repair of Alternative Refrigerant Systems

### Contents

- 1-Hazards of Refrigerant
- 2-Flammable refrigerant acids
- 3-R744 (Carbon Dioxide)
- 4-R717 (Ammonia)
- 5-Self Test questions & Next Steps

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## Site Surveys & Advice on Alternative Refrigerants & Leakage

### Contents

- 1-Introduction to site surveys
- 2-Site survey procedure
- 3-Identifying opportunities for leak reduction
- 4-Reporting on leak reduction strategies

# Register at the project Website and searchable e-library

The screenshot shows the REAL Alternatives website home page. The header includes the logo and navigation links: EVENTS, HOME, PARTNERS, E-LIBRARY, LEARNING PLATFORM, NEWS, LOGIN. A search bar contains the term "hydrocarbon" with filters for language and topic. The main content area features a "Welcome to the REAL Alternatives e-library" message, a description of the resource, and a "Register HERE to use the full library" link. A sidebar on the left contains navigation options like "STAKEHOLDERS", "EVENTS", "ABOUT US", "CONTACT US", "FIND OUT MORE ABOUT OUR PROGRAMME PARTNERS", and "REGISTER HERE FOR THE LATEST NEWS AND UPDATES".

This screenshot displays the search results for "hydrocarbon". The page features a central banner for the "E-LIBRARY" with a laptop image and the text "Search our database of information". Below the banner are sections for "EVENTS" (Partner Meeting to Prepare for Pilot Testing), "NEWS" (E-Library Swells with 90 Documents), and a "Tweets" section with a tweet from Star Refrigeration. A "LEARNING PLATFORM" section is also visible. The footer lists co-funding partners: Lifelong Learning Programme, IOR, IKKE, ARES, and others.

The search results list three documents from the British Refrigeration Association:

- Servicing hydrocarbon in a retail environment** (UK flag) - Practical guide to handling flammable refrigerants in retail service environ...
- BRA Guide to Flammable Refrigerants** (UK flag) - An introduction to flammable refrigerants and signpost where more detailed information can be obtained if necessary. (5 stars)
- Service of hydrocarbon refrigerant equipment in a retail environment** (UK flag) - Useful practical guide to hydrocarbon safety. (5 stars)
- Servicing equipment containing Hydrocarbons in a retail environment** (UK flag) - (5 stars)

# Promoting the use of Alternatives at international meetings and events

**Tweets**

Show Media

Follow

REALAlternatives @REAL\_Alts\_EU  
eurammon have added 10 new documents on ammonia to library at realalternatives.eu

REALAlternatives @REAL\_Alts\_EU  
100 case studies featured in FIA report

Tweet to @REAL\_Alts\_EU

REALAlternatives @REAL\_Alts\_EU - Oct 14  
**Blended learning for alternative refrigerants @Chillventa 2014**



REAL Alternatives refrigeration learning Community

100 Likes

Reach a new milestone

REAL Alternatives refrigeration learning  
27 February at 11:58

Learning goes live in Polish on 3rd March and English on 19th March. Find out more at [www.realalternatives.eu](http://www.realalternatives.eu)

REAL Alternatives refrigeration learning added a new photo on 27 February at 11:58

fridgehub

REAL Alternatives announce date for webinar

EUROPE: Following the successful piloting and testing announced that the English language version of the REAL Alternatives Blended learning program will launch on 19th March with a free webinar introduction.

The REAL Alternatives project, led by a consortium of educational institutions and bodies from Italy, Germany, Poland and Belgium is designed to improve knowledge of alternatives to high refrigerants, and includes e-learning modules, supplemented with learning booklets, interactive and an e-library of user-generated industry information about alternative refrigerants.

The webinar starts at 2pm and closes at 5.15pm. It will feature the following presentations from industry representatives:

- The evolution of approaches to Refrigerant Emissions and Leakage reduction, from Graeme Holdment**
  - The link between efficiency, cost and leakage
  - Good practice in design and maintenance of systems
  - Why Alternative refrigerants?
  - The Blended learning approach (material, library, e-learning and classroom)
- Legislative drivers and limitations for moving to alternative refrigerants, Ray Gluckman**
  - The impact of the F-Gas Regulations
  - Challenges for the future of refrigeration use
  - The wider international context
- REAL Alternatives: safety, efficiency, containment and training, Jane Gertshore**
  - What is an alternative refrigerant and why are they different?
  - Design choices for minimising environmental impact
  - Delivering improved knowledge and understanding for technicians

The presentations will be followed by a demonstration of REAL Alternatives e-learning, library and training booklets and a Q&A session.



[www.realalternatives.eu](http://www.realalternatives.eu)



# Thanks also to our stakeholders, who helped during the project

**we are proud to have among our stakeholders  
European Commission DG Clima & UNEP OzonAction**

## Stakeholders

A wide variety of stakeholders representing all partner countries as well as EU and International agencies are contributing to this project. Stakeholders are involved in sharing resources, commenting and piloting draft materials, and disseminating information about the programme. Some of our current stakeholders are shown below:

Please contact us if you wish to become a REAL Alternatives stakeholder - [go to contact form](#)

We are proud to have among our stakeholders **the European Commission DG Clima & UNEP Ozone Action** as well as the following companies:

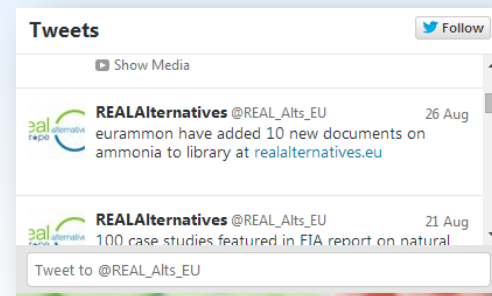


[www.realalternatives.eu](http://www.realalternatives.eu)



# How you can get involved

- become a stakeholder
- add technical material to the e-library now
- **sign up technicians for the FREE e-learning courses launched in MARCH 2015**
- register to deliver classroom training courses using these materials as an employer or training provider
- register for updates at the website, follow us on twitter
- translate in other languages
- spread the word...





## Module 1 - Introduction to Alternative Refrigerants

### Introduction

Introduction ✓

Basic Properties ✓

Application ✓

### Refrigerants

R744 ✓

R290 R1270 R600a ✓

R32 ✓

R1234ze ✓

R717 ✓

### Safety

Classification ✓

Flammability ✓

Toxicity ✓

Higher Pressures ✓

### Restriction on use

Maximum Charge Size ✓

Direct Expansion Systems ✓

Indirect Systems ✓

Comfort cooling/heating ✓

### Examples

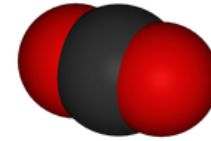
Eg.1 - Non Comfort ✓



## R744 (Carbon Dioxide, CO<sub>2</sub>) WP = 1

### 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 effect the application of R744.



CO<sub>2</sub> molecule

### Usage

R744 is used in the following system types:

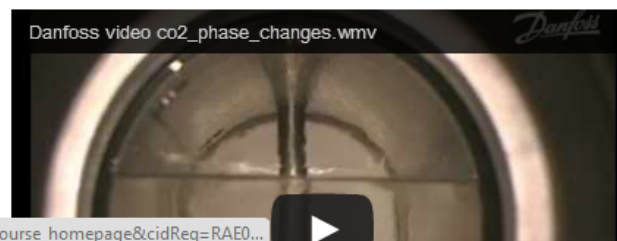
- Pumped secondary – where R744 is the secondary fluid cooled by a primary system. R744 is a volatile secondary which, coupled with the high capacity and density, reduces the required pump power compared to other secondary fluids such as glycol.
- Cascade – where the heat rejected by the condensing R744 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 g. The high stage system can be R744 (see below), or it can be HFC, HC, HFO or R717.
- 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 g). The high side pressure is typically 90 bar g when transcritical.

Currently (2014) R744 has been used in several thousand retail systems and in industrial systems in Europe. It is starting to be used in heat pumps and in integral systems. Some examples of R744 are shown below:



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

This video gives an introduction to carbon dioxide properties when used in refrigeration







## Module 1 - Introduction to Alternative Refrigerants

### Introduction

- Introduction ✓
- Basic Properties ✓
- Application ✓

### Refrigerants

- R744 ✓
- R290 R1270 R600a ✓
- R32 ✓
- R1234ze ✓
- R717 ✓

### Safety

- Classification ✓
- Flammability ✓
- Toxicity ✓
- Higher Pressures ✓

### Restriction on use

- Maximum Charge Size ✓
- Direct Expansion Systems ✓
- Indirect Systems ✓
- Comfort cooling/heating ✓

### Examples

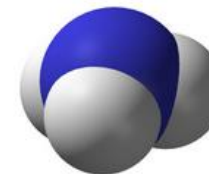
- Eg.1 - Non Comfort ✓

## R717 (Ammonia, NH<sub>3</sub>) GWP = 0

### Properties

R717 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 3mg/m<sup>3</sup> so it is evident at levels much lower than those which are hazardous (the ATEL / OD L is 350 mg/m<sup>3</sup>). It is the only commonly used refrigerant which is lighter than air which means that dispersion of any leaked refrigerant takes place quickly.



NH<sub>3</sub> molecule

R717 also operates with very high discharge temperatures. Single stage compression can therefore normally be used above -10°C evaporating temperature. Below this, two stage compression with interstage cooling is required.

The high toxicity limits the application of R717 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 R717 is the primary refrigerant.

Some examples of Ammonia packaged systems are shown below:



Ammonia corrodes copper so steel pipe 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 on the capital cost of an ammonia installation.

The video below shows an example of an adsorption ammonia system used in a building services application



Course home

real alternatives  
our type

32%

### Module 4 - Guidance on the Maintenance and Repair for Alternative Refrigerant Systems

- Introduction ✓
- Hazards ✓
- Service Procedures
- Flammable Refrigerants**
- Safety ✓
- Equipment ✓
- Leak Testing
- Recovery and Evacuation ✓
- Brazing
- Charging and Replacement
- R744**
- Safety ✓
- Equipment
- Leak Detection
- Disposal
- Evacuation and Charging
- Isolating Replacing
- R717**

## The safe working environment and PPE

### 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

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.



Figure 1, suitable ventilation fan

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.



Figure 2, flammable gas detectors

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 CO<sub>2</sub> type.



Figure 3 (left), dry powder fire extinguisher  
Figure 4 (right), CO<sub>2</sub> fire extinguisher



# Real Alternatives to comply to 517/14 Article 10 Training and Certification

8. Member States shall ensure that all natural persons holding certificates under certification programmes provided for in paragraphs 1 and 7 have access to information regarding each of the following:

(a) technologies referred to point (e) of paragraph 3

9. Member States shall ensure the availability of training for natural persons who wish to update their knowledge in relation to the matters referred to in paragraph 3



[www.realalternatives.eu](http://www.realalternatives.eu)



- **Melting glaciers**
- **Rising seas**
- **Increasing temperatures**

**For our environment, one of the solution is  
→ Competence**

**THANK YOU!**

**Email: [buoni@centrogalileo.it](mailto:buoni@centrogalileo.it)**

**Marco Buoni**

*VicePresident, AREA Air Conditioning & Refrigeration European contractors' Association ([www.area-eur.be](http://www.area-eur.be))  
Secretary General Italian Association of Refrigeration Technician, ATF ([www.associazioneATF.org](http://www.associazioneATF.org))*



[www.realalternatives.eu](http://www.realalternatives.eu)





**THANK YOU!**

**Email: [buoni@centrogalileo.it](mailto:buoni@centrogalileo.it)**

## **Marco Buoni**

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[www.realalternatives.eu](http://www.realalternatives.eu)





**THANK YOU!**

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