A2L: Mildly Flammable Refrigerants
From a Danfoss Perspective
Content

- Environmental Impact
- Refrigerant Trends
- Low GWP HFC and A2L
- The Refrigerants
- Safety Standards and regulations for A2L
- Danfoss Policy
Challenges

Environmental Impact

Challenges
- Lacking energy resources
- Global warming

Demand for welfare

Growing population
Growing need: food, water & medicine

Sustainable solutions
Affordable solutions

Sustainability limit

Time

Growing population
Growing need: food, water & medicine

Lacking energy resources
Global warming

Demand for welfare
- The Climate benefits of the Montreal Protocol may be offset by increases in HFCs
- There are options available to minimise the climate influence of HFCs

(UNEP nov. 2011)
TEWI = Direct emission + Indirect emission
TEWI: Total Equivalent Warming Impact

Reduction of TEWI is the most important measure to fight global warming.

Note – different types of applications have different composition of TEWI
Refrigerant status and trends
F-gas regulation review

The first official draft will be published in November-December.
Montreal– Phase-down/out schedules & proposals

China takes it very seriously!
This has sparked interest in **R32**
Low GWP HFCs and Flammability

HFCs with Low GWP tends to be less stable than traditional high GWP HFCs:
- Falls apart quickly in the atmosphere -> reason for low GWP
- Stable inside the system inside the system
- Tend to be flammable, but less than the hydrocarbons.
- Most are categorized as A2L

For HFCs, lower GWP tends to be related to higher flammability, but it is not a universal rule.
A2L: “Mild” Flammability definition

Safety standards divides refrigerants by:
- Toxicity (A or B) and
- Flammability (1, 2L, 2, or 3).

A: Low Toxicity
- Permissible exposure limit > 400 ppm
- Risk of accidents related to toxicity is low

2L: Mildly flammable
- Flammable!
- Requires more than 100 g/m³ to burn (typically 300 g)
- Heat of combustion less than 19,000 kJ/kg
- Burning velocity less than 10 cm/s
- Effect of ignition is not so large, and typically difficult to ignite

<table>
<thead>
<tr>
<th>Toxicity</th>
<th>Flammability</th>
<th>A1: CFC, HCFC, most HFCs</th>
<th>B1: Seldom used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Non flammable</td>
<td>A2L: Most Low GWP HFC</td>
<td>B2L: Ammonia</td>
<td></td>
</tr>
<tr>
<td>2L: Mildly flammable</td>
<td>A2: R152a</td>
<td>B2: Seldom used</td>
<td></td>
</tr>
<tr>
<td>2: Lower flammability</td>
<td>A3: HCs</td>
<td>B3: No refrigerants</td>
<td></td>
</tr>
<tr>
<td>3: Higher flammability</td>
<td>A3: HCs</td>
<td>B3: No refrigerants</td>
<td></td>
</tr>
</tbody>
</table>
R32, mildly flammable for A/C and HP

- R32 (gwp=675) is a substitute for R410A (gwp 2100)
- Mildly flammable! Take into account!
- Slightly higher Pressure than R410A (2-3 bars)
- Higher volumetric capacity
  - More compact system
- Higher efficiency rate
- Allowed in EU, India and many other places. China and US (limited appl.) will allow during 2013.

Danfoss will have a large program for R32 in 2013 ready for China, and CE and ATEX approved for EU.

China HPMP plan:

<table>
<thead>
<tr>
<th>Application</th>
<th>Alternative Refrigerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor condensing unit</td>
<td>NH₃, R134a, CO₂, R410A, R32</td>
</tr>
<tr>
<td>Small sized chiller (Heat pump)</td>
<td>R410A, R134a, R32</td>
</tr>
<tr>
<td>Industrial &amp; commercial chiller (Heat pump)</td>
<td>R410A, R134a, R32</td>
</tr>
<tr>
<td>Medium sized</td>
<td>R410A, R134a, R32</td>
</tr>
<tr>
<td>Large sized</td>
<td>R134a, R410A</td>
</tr>
<tr>
<td>Heat pump water heater</td>
<td>R134a, R410A, CO₂, R32</td>
</tr>
<tr>
<td>Unitary air-conditioner</td>
<td>R410A, R32</td>
</tr>
<tr>
<td>Multi-connected air-conditioner (Heat pump)</td>
<td>R410A, R32</td>
</tr>
<tr>
<td>Freezer and cold storage</td>
<td>NH₃, R134a, R404A, CO₂, R410A</td>
</tr>
<tr>
<td>Train Air-conditioner</td>
<td>R410A, R32</td>
</tr>
</tbody>
</table>
R1234yf for Automotive

R1234yf was the first HFO on the market:

- GWP is 4

- A mildly flammable refrigerant with properties similar to R134a.

- Used in automotive, but some resent debate whether it is too flammable

- For commercial applications it is primarily expected to be used in blends
R1234ze(E) Especially for Chillers

- GWP is 7

- A mildly flammable refrigerant with properties similar to R134a.

- The currently most difficult A2L to ignite

- Primarily interesting for Chillers with high cooling capacity

- **Danfoss Turbocor compressor available**
A2L in EU follows rules for A2 (so far)

A2L refrigerants still classified as A2 in EU:

- A2L has not been introduced in the European safety standards EN378 and IEC60335.

- A2L will be introduced in the next versions of the safety standards. EN378 draft 2013, official probably 2015.
The maximum charge for a given room size is determined by:

\[ m_{\text{max}} = 2.5 \times \text{LFL}^{\frac{5}{4}} \times h_0 \times A^{\frac{1}{2}} \]

There are some details in IEC60335 specific to household applications, which are not in EN378.
Charge limits for non-“human comfort:"

<table>
<thead>
<tr>
<th>EN378 simplified</th>
<th>Occupancy for system with A2 refrigerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>I (occupied)</td>
</tr>
<tr>
<td>a</td>
<td>m</td>
</tr>
<tr>
<td>b</td>
<td>10kg</td>
</tr>
<tr>
<td>c</td>
<td>&gt; 1 person per 10 m²</td>
</tr>
<tr>
<td></td>
<td>&lt; 1 person per 10 m²</td>
</tr>
</tbody>
</table>

a = general occupancy  
b = supervised occupancy  
c = authorized occupancy  
* = independent of room size

<table>
<thead>
<tr>
<th>m₂</th>
<th>m₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>R32</td>
<td>11.7 kg</td>
</tr>
<tr>
<td>R1234yf</td>
<td>11.0 kg</td>
</tr>
<tr>
<td>R1234ze</td>
<td>11.5 kg</td>
</tr>
</tbody>
</table>

The introduction of A2L category in next version of EN378 is expected to increase most limits by 50%
PED: EU Pressure Equipment directive

- Traditional refrigerants are PED fluid group II
- A2L refrigerants are generally PED fluid group I
- For pipes and vessels this may require 3rd party approval

R32 is in PED Group I
R410A is in PED Group II
A2L and ignition sources

If the system leaks there is a high probability that a local flammable atmosphere will form around the components.

- It is therefore a good idea to avoid that components have ignition sources.

- In EU (EN378 safety standard) it is even a requirement that no ignition sources are present where leaked refrigerant may flow or stagnate.

All Danfoss components for A2L can be used in ATEX zone 2, meaning that they do not have ignition sources.
Be Aware of Local Regulations!

Local regulations, especially in southern EU limits where flammable refrigerants may be used...
Why use Danfoss products for flammables?

- More than 20 years of experience with flammable refrigerants.

- All Danfoss products for flammable refrigerants are complying with PED fluid group 1 for flammable substances.
  - This is a clear legal requirement!

- All Danfoss products for flammable refrigerants are complying with ATEX zone 2.
  - This supports the requirement in the EU safety standard EN378: No ignition sources shall be present where leaked refrigerant may flow or stagnate.

- Long term strategy for expanding the product program for flammables, ensuring a good partnership in the turbulent years to come!
Danfoss Policy

Danfoss encourages the further development and use of low-GWP refrigerants to help slow – and ultimately reverse – the process of global warming while helping to ensure continued global wellbeing and economic development along with the future viability of our industry.

- We will enable our customers to achieve these refrigerant goals while continuing to enhance the energy efficiency of refrigeration and air-conditioning equipment.
- Danfoss will proactively develop products for low-GWP refrigerants, both natural and synthetic, to fulfil customers’ needs for practical and safe solutions without compromising energy efficiency.
- Danfoss will lead and be recognized in the development of natural refrigerant solutions.
- Danfoss supports the establishment of a global regimen through the Montreal Protocol to phase down emissions of high-GWP refrigerants ... to provide for long-term production of very small quantities of HFCs for critical needs.
- R32 more products
- PED
- Wrap-up not a separate slide