Refrigeration and Air Conditioning

Next Generation for HCFCs and High GWP HFCs

Chris Bong  MIEAust MAIRAH
MASHRAE
BDM- Energy HVAC Products
VEOLIA- Exclusive Distributor of TRANE (A/NZ)
refrigerant-bearing products that are designed to lower environmental impact with next generation, low global warming potential (GWP) refrigerants and high efficiency operation

- **Trane Sintesis™ air-cooled chiller**
  - R513A: HFO/HFC blend, A1

- **Trane Series E™ CenTraVac chiller**
  - R1233zd(E): HFO, A1

- **Thermo King truck and trailer refrigeration products**
  - R452A: HFO/HFC blend, A1

*Other manufacturers of HFO & Lower GWP products:*
  - R1233zd: MHI.
  - R1234ze: Geoclima, Star, Airedale
  - R513A: Emerson Copeland, Bitzer
Refrigerants Numbering system ASHRAE 34:

- 1\textsuperscript{st} digit on the right is No. Of Fluorine atoms.
- 2\textsuperscript{nd} digit on the right is No. Of Hydrogen atom+1
- 3\textsuperscript{rd} digit on the right is No. Of Carbon atom -1
- 4\textsuperscript{th} digit on the right is No. Of unsaturated Carbon bonds.

- Series 400: Zeotropic blends, different boiling points, glide (5.6\textdegree K - R407C)
- Series 500: Azeotropic compounds, same boiling points, no glide (ie. R513a)
- Series 600: organic compounds
- Series 700: inorganic compounds (ie. R717)
## AS/NZS1677.1:1998 Refrigerant Classification

<table>
<thead>
<tr>
<th></th>
<th>Lower Toxicity</th>
<th>Higher Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Flame Propagation</td>
<td>A1</td>
<td>B1</td>
</tr>
<tr>
<td>Lower Flammability</td>
<td>A2</td>
<td>B2</td>
</tr>
<tr>
<td>Higher Flammability</td>
<td>A3</td>
<td>B3</td>
</tr>
</tbody>
</table>

- Flammability based on Lower Explosive Limit of 0.3 % vol
- Lethal concentration LC50 > 10,000 ppm in short term acute exposures
- Lethal concentration LC50 < 10,000 ppm in short term acute exposures

- Most commonly used refrigerants in Groups A1 such as HFC-134a, HFC-410A, HCFC-123
- A2L and B2L are proposed Lower Flammability Refrigerants
Global Regulatory Pressure

HFC baseline: (2008 - 2010 average)
A2 = HFC + 85% x HCFC
A5 = 90% x HCFC

A2: Australia/NZ, Hong Kong, Japan, Taiwan
A5: China, Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand, Vietnam

HCFC baseline:
A2 = 2.8% x 1989 CFC + 100% x 1989 HCFC
A5 = (2009 HCFC + 2010 HCFC) / 2

EU F-Gas Passed 12/3/2014
Hydrofluoroolefin (HFO) and Hydrocarbon (HC) refrigerants are referred to as fourth-generation refrigerants for the 21st century

- HFO: hydrogen, fluorine and carbon. They are olefins (Double bonds), they have very short atmospheric lifetimes of a few days
- Performance characteristics similar to HFC/HCFC
- Ultra low GWP
- Many HFO has flammability class 2L
Next gen outlook

R-123 (B1) (GWP=77) replacements
R-134a (A1) (GWP=1430) replacements
R-404A (A1) (GWP=3900) replacements
R-410A (A1) (GWP=2100) replacements
R-22 (A1) (GWP=1810) replacements

GWP100 Value

Alternative Refrigerant Candidates

W/C Chillers
Refrigeration
Unitary
Next gen outlook

- R-123 (B1) (COP=1) replacements
- R-134a (A1) (COP=0.94) replacements
- R-404A (A1) (COP=1) replacements
- R-410A (A1) (COP=1) replacements
- R-22 (A1) (COP=1.06) replacements

COP Compared To Baseline Refrigerant

Alternative Refrigerant Candidates

W/C Chillers
Refrigeration
Unitary
### New Low GWP Refrigerants

<table>
<thead>
<tr>
<th></th>
<th>R-123</th>
<th>R-1233zd(E)</th>
<th>R-245fa</th>
<th>R-134a</th>
<th>R-513a</th>
<th>R-1234ze</th>
<th>R-1234yf</th>
<th>R32</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flammability</strong></td>
<td>Non (1)</td>
<td>Non (1)</td>
<td>Non (1)</td>
<td>Non (1)</td>
<td>Non (1)</td>
<td>Slight (2L)</td>
<td>Slight (2L)</td>
<td>2L</td>
</tr>
<tr>
<td><strong>Toxicity</strong></td>
<td>Higher (B)</td>
<td>Lower (A)</td>
<td>Higher (B)</td>
<td>Lower (A)</td>
<td>Lower (A)</td>
<td>Lower (A)</td>
<td>Lower (A)</td>
<td>A</td>
</tr>
<tr>
<td><strong>Fluid Efficiency</strong></td>
<td>9.4 COP</td>
<td>9.3 COP</td>
<td>8.7 COP</td>
<td>8.5 COP</td>
<td>8.3COP</td>
<td>8.5 COP</td>
<td>8.2 COP</td>
<td>8.2 COP</td>
</tr>
<tr>
<td><strong>GWP</strong></td>
<td>79</td>
<td>^1</td>
<td>858</td>
<td>1300</td>
<td>572</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>677</td>
</tr>
<tr>
<td><strong>Atmos Life</strong></td>
<td>475 days</td>
<td>26 days</td>
<td>2,811 Days</td>
<td>4,891 days</td>
<td>2,158 days</td>
<td>14 days</td>
<td>11 days</td>
<td>1,898 days</td>
</tr>
</tbody>
</table>

^Latest GWP value as per Intergovernmental Panel on Climate Change – Fifth Assessment Report (METI document: <5)
Refrigerant operating pressure

2137 KPa
- evaporator (38°F) 3.3 °C
- off line (72°F) 22.2 °C
- condenser (100°F) 37.8 °C

1034 KPa

206 KPa

refrigerant
<table>
<thead>
<tr>
<th>Designated products ※</th>
<th>Present refrigerant (GWP)</th>
<th>Target value (GWP)</th>
<th>Target year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room air-conditioning</td>
<td>R410A(2090) R32(675)</td>
<td>750</td>
<td>2018</td>
</tr>
<tr>
<td>Commercial air-conditioning (for offices and stores)</td>
<td>R410A(2090)</td>
<td>750</td>
<td>2020</td>
</tr>
<tr>
<td>Condensing unit and refrigerating unit (for separate type showcases etc.)</td>
<td>R404A(3920) R410A(2090) R407C(1774) CO₂(1)</td>
<td>1500</td>
<td>2025</td>
</tr>
<tr>
<td>Cold storage warehouse (for more than 50000 m³)</td>
<td>R404A(3920) Ammonia (single digit)</td>
<td>100</td>
<td>2019</td>
</tr>
<tr>
<td>Mobile air-conditioner</td>
<td>R134a(1430)</td>
<td>150</td>
<td>2023</td>
</tr>
<tr>
<td>Urethane foam (for House building materials)</td>
<td>HFC-245fa(1030) HFC-365mfc(795)</td>
<td>100</td>
<td>2020</td>
</tr>
<tr>
<td>Dust blowers</td>
<td>HFC-134a(1430) HFC-152a(124) CO₂(1), DME(1)</td>
<td>10</td>
<td>2019</td>
</tr>
</tbody>
</table>
USA: Proposed HFC Ban

• EPA
  – R134a
    ▪ Aerosol propellants (2016)
    ▪ Motor vehicle AC (model year 2021)
    ▪ Commercial refrigeration (2016)
    ▪ Foam blowing (2017)
  – R404A
    ▪ Commercial refrigeration (2016)

• California
  ▪ Commercial/residential HVAC > 1000 GWP (2020)
  ▪ Refrigerated shipping containers > 150 GWP (2018)
  ▪ Transport refrigerated units > 1000 GWP (2025)
What about Australia

- High GWP HFCs (R410A & R134A) account for >50% of refrigerants used in Australia in 2013.

- Australia is a party to the Montreal Protocol (Ozone Protection and Synthetic Greenhouse Gas Management Act 1989):
  - Support phase down production & consumption of HFC under Montreal Protocol
  - Emission accounting & reporting under the UN Framework Convention on Climate Change (UNFCCC)
  - Promote climate friendly low GWP alternative refrigerants.

- Recent AREMA meeting supported Montreal Protocol on phase down of HFC.
Now, we have choices: What is Best selection for Environment?

1. Low ODP  
   (Ozone Depletion Potential)
2. Low GWP  
   (Global Warming Potential)
3. High operating efficiency
4. Short atmospheric life
5. Low leakage rates

↓Emissions ↑Efficiency is fundamental to doing what’s right for sustainable future
Thank You