The Future of Refrigerants: Where Do We Go From Here?

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Global Leader of Refrigerant Strategy
Trane, Thermo King, Hussman
Options For HVAC Refrigerants

**Fluorocarbons**

- **Ozone Depleters (Montreal Protocol)**
  - **Class 1** High ODP CFC’s
    - R-11
    - R-12
    - R113
    - R-500
  - **Class 2** Low ODP HCFC’s
    - R-22
    - R-123

- **Non- Ozone Depleters (Kyoto Protocol)**
  - **Higher GWP**
    - R-134a
    - R-410A
    - R-407C
  - **Lower GWP**
    - R-32
    - R-152a

**“Natural” Refrigerants**

- Propane
- Butane
- CO₂
- Ammonia

*Ingersoll Rand 2010 ©*
Montreal Protocol Signed

- All CFC production Stopped (R-11, R-12) in developed countries

Kyoto Protocol Signed

- No new R-22 for service
- No new equipment with R-123 in developed countries
- No CFC’s for developing countries

- No new R-123 for service in developed countries, no HCFC’s in new equipment in developing countries

- No HCFC production in developing countries

1990

- Continued use of recycled CFC’s

No new equipment with R-22

- Continued use of recycled R-22
- Continued use of recycled R-123

2000

- Continued use of recycled R-22, R-123 for developing countries

2010

- No automotive use of R-134a in Europe

2020

- No new equipment with R-22

2030

- Continued use of recycled R-123

2040

- Continued use of recycled R-22

2050

Today

Note: Included in the use of “recycled” refrigerants is also the use of stockpiled supplies of the refrigerant produced before the phase out date. In addition, there is no restriction on the importation of recycled and recovered supplies of refrigerants.
Heating Piping Air Conditioning

REFRIGERANTS: The Future In The Balance
Kyoto Protocol
Greenhouse Gas Coverage

- **Six (6) Gases**
  - Carbon Dioxide -- CO$_2$
  - Methane -- CH$_4$
  - Nitrous Oxide -- N$_2$O
  - Hydrofluorocarbons -- HFCs
  - Perfluorocarbons -- PFCs
  - Sulfur hexafluoride -- SF$_6$

- **Base Period**
  - 1990 for CO$_2$, CH$_4$, and N$_2$O
  - 1990 or 1995 for HFCs, PFCs, and SF$_6$
European HFC Restrictions

- **Denmark**
  - General HFC ban in 2006
  - HFC ban on HVAC equipment in 2007, except if the factory refrigerant charge is <10kg for cooling applications or <50 kg for heat pump applications

- **Austria**
  - HFC ban on HVAC equipment, appliances and cars in 2008, except if factory charge is <20kg of refrigerant

- **Switzerland**
  - Domestic Refrigeration HFC Ban - 2003
  - Air Conditioners HFC Ban - 2005
  - Mobile Air Conditioning HFC Ban – 2008

- **F-Gases Directive on car air conditioning**
  - No new vehicles containing F-gases, with a GWP greater than 150, in 2011
  - Prohibit sale of vehicles containing F-gases, with a GWP greater than 150, in 2017
HFOs
New, Low Global Warming Potential Refrigerants

By J. Steven Brown, Ph.D., P.E., Member ASHRAE

and R-1234yf. R-152a, if used, would likely be implemented in an indirect system (secondary loop) because of...
Country GHG Cap & Trade Legislation

- **Japan**
  - GHG emissions reduction target of 60-80% by 2050
  - Will start trial cap & trade program fall of 2009
  - Govt pressure on GHGs, including HFCs, against industries desires

- **New Zealand Cap & Trade (Legislation in process)**
  - Six gases including HFCs
  - All sectors

- **Australia Cap & Trade (Legislation in process)**
  - Five gases
  - Separate HFC regulation (25% below 2000 levels by 2020)
  - HFC regulations begin in 2011

- **European Union (27 countries) - 2008**
  - CO2 only cap and trade, utilities & large industrials
  - HFCs under regulatory pressure
Ways in Which HFC’s Could be Phased Out/Down

- Climate Change Regulation (Kyoto Protocol)
- Montreal Protocol Modification
- US Cap and Trade Regulation
- Direct Implementation from US EPA
Balance of Environmental Issues

- Minimal Ozone Depletion (ODP)
- Minimal Global Warming potential (GWP)
- Best delivered efficiency (part and full load)
- Short atmospheric life
- Lowest possible leakage rate
Environmental Impact of Refrigerants

Ozone Depletion Potential (ODP)

- CFC-11: 1.0
- CFC-12: 0.9
- HCFC-22: 0.8
- HCFC-123: 0.7
- HFC-134a: 0.6
- HFC-410A: 0.5
- HFC-407C: 0.4
- HFC-245fa: 0.3

Global Warming Potential (GWP)

- CFC-11: 1.0
- CFC-12: 0.9
- HCFC-22: 0.8
- HCFC-123: 0.7
- HFC-134a: 0.6
- HFC-410A: 0.5
- HFC-407C: 0.4
- HFC-245fa: 0.3

Energy Efficiency (COP)

- CFC-11: 6.8
- CFC-12: 6.6
- HCFC-22: 6.4
- HCFC-123: 6.2
- HFC-134a: 6.0
- HFC-410A: 5.8
- HFC-407C: 5.6
- HFC-245fa: 5.4

Atmospheric Life (years)

- CFC-11: 20 years
- CFC-12: 35 years
- HCFC-22: 50 years
- HCFC-123: 55 years
- HFC-134a: 60 years
- HFC-410A: 65 years
- HFC-407C: 70 years
- HFC-245fa: 75 years
ODP versus GWP

CFC-11
12
113
114
115
HCFC-22
123
124
141b
142b
HFC-32
125
134a
143a
152a
227ea
236fa
245fa

ODP (relative to R-11)  GWP (relative to CO₂)

Chiller Operating Pressure

- Condenser (100°F)
- Off Line (72°F)
- Evaporator (38°F)

<table>
<thead>
<tr>
<th>Chiller Type</th>
<th>Operating Pressure (psig)</th>
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<tbody>
<tr>
<td>R-11</td>
<td>310.0</td>
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<tr>
<td>R-123</td>
<td>270.0</td>
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<tr>
<td>R-12</td>
<td>230.0</td>
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<td>R-134a</td>
<td>190.0</td>
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<td>150.0</td>
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<tr>
<td>R-410A</td>
<td>110.0</td>
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What Is Important Over the Life of a Chiller?

- Cost of Energy (94.5%)
- First Cost of Chiller (5.18%)
- Cost of Initial Charge Of Refrigerant (0.25%)
- Refrigerant Added Over 30 years (0.04%)
The Future

Emissions

Energy Efficiency

Focusing on Emissions and Efficiency is fundamental to doing what’s right
Summary

- All fluorocarbon refrigerants in use today are under legislative jeopardy
- The balanced approach to refrigerant selection is the best way to protect the environment
  - Ozone Depletion
  - Global Warming
  - Energy Efficiency
  - Short atmospheric life
  - Low pressure (low tendency for leakage)
- Chiller selection should focus on:
  - High Energy Efficiency
  - Minimal leakage rates
  - Superior technical design
Questions?