“Next-Generation Refrigerants for Energy Efficiency and Climate Protection”

5th March’2014
Daikin Air-conditioning India Pvt. Ltd.
Daikin Industries, Ltd is one of leading air conditioner manufactures. Our product range is from residential to commercial air conditioners. Daikin has over 51,000 employees at 207 group companies around the world. Daikin Air-Conditioning India was established in 2000.
Urgent Environment Issues

Ozone depletion

Global Warming

Ozone hole
In developing countries, HCFC22, or R22, is one of main stream refrigerants for air conditioners. R22 must be phased out due to its ODP and converted to substances with zero ODP. When making choice for alternative to R22, various aspects must be taken into account.

HCFC (ex. R22) Phase out Management Plan (HPMP) started in Developing Country

**Screening Factors for the Alternative Refrigerant**

- Energy Resources
- Peak Load
- Affordability
- Natural Resources
- Ozone Protection
- Climate Change
- Safety
- Compact/Light
- Efficient Use
- No/Low Flammable
- Low Toxic
- Regulation
- Patent
- Downsizing
- Market Penetration
- Recycling
- Easy Installation & Maintenance

**HCFC Phase out and change of Refrigerant**

- Lower GWP
- High COP
- Low Emissions
- No/Low Flammable
- Compact/Light
- Easy Installation & Maintenance
- Reduced Charge
- Low Toxic
- Patent
- Downsizing
- Market Penetration
- Recycling
- Energy Resources
- Peak Load
- Affordability
- Natural Resources
- Ozone Protection
- Climate Change
- Safety
- Compact/Light
- Efficient Use
- No/Low Flammable
- Low Toxic
- Regulation
- Patent
- Downsizing
- Market Penetration
- Recycling
- Easy Installation & Maintenance

HCFC Phase out by 2020

Developed Country

Developing Country

Phase out by 2020

Phase out by 2030

Next Generation refrigerants
## Refrigerant Candidates for Stationary ACs

<table>
<thead>
<tr>
<th>Refrigerants</th>
<th>Properties</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_{\text{cond}}$ (MPa)</td>
<td>Vol. Cool. Capacity (vs R22)</td>
<td>Theoretical COP (vs R22)</td>
<td>ODP</td>
<td>GWP (IPCC4th)</td>
<td></td>
</tr>
<tr>
<td>R22</td>
<td>Single</td>
<td>1.73</td>
<td>100</td>
<td>100</td>
<td>0.05</td>
<td>1810</td>
</tr>
<tr>
<td>R407C</td>
<td>Zeotrope</td>
<td>1.86</td>
<td>102</td>
<td>99</td>
<td>0</td>
<td>1770</td>
</tr>
<tr>
<td>HFC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R410A</td>
<td>Azeotrope</td>
<td>2.72</td>
<td>141</td>
<td>92</td>
<td>0</td>
<td>2090</td>
</tr>
<tr>
<td>R32</td>
<td>Single</td>
<td>2.80</td>
<td>160</td>
<td>97</td>
<td>0</td>
<td>675</td>
</tr>
<tr>
<td>R1234yf</td>
<td>Single</td>
<td>1.16</td>
<td>57</td>
<td>90</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>HFO-Mix</td>
<td>Zeotrope</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>0</td>
<td>?</td>
</tr>
<tr>
<td>Non-HFC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R717(NH$_3$)</td>
<td>Single</td>
<td>1.78</td>
<td>116</td>
<td>106</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R290 (Propane)</td>
<td>Single</td>
<td>1.53</td>
<td>83</td>
<td>98</td>
<td>0</td>
<td>&lt;3</td>
</tr>
<tr>
<td>R744 (CO$_2$)</td>
<td>Single</td>
<td>10</td>
<td>243</td>
<td>41</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Candidates for the next generation working fluids**
Diversity of Refrigerant Choice

- There is no one-size-fits-all solution
- All refrigerant are included on the table of refrigerant choice. Choose whatever refrigerant is best suited for each application.
- Daikin is developing R32 split Air-conditioners from residential to light commercial range because R32 is better suited to these applications.
Superior Performance of R32
Total Assessment of Refrigerant

R32 is the most balanced Refrigerant and can reduce GWP by 75%

(※1) LCCP: (Life Cycle Climate Performance)

HFC32 can reduce CO2 eq. emissions by 75%

(※2) Based on IPCC 4th report

(※3) In case that all refrigerant have the performance equivalent to R22
Energy efficiency and Total Emissions

1. SEER Comparison (cooling mode)
   - HPs (Reversible) - 3.5kW-Room AC
   - Efficiency ratio
     - R22
     - R410A
     - R32
   - 0.8  0.9  1.0  1.1

2. Peak power comparison
   - under cooling condition
     - Outside 35°C, room 27°C
     - Power ratio
       - R22
       - R410A
       - R32
       - 0.4  0.8  1.2

3. Total Emissions (LCCP comparison)
   - Total Emissions = (1) Indirect Emissions + (2) Direct Emissions + (3) Emissions During Refrigerant Production
   - LCCP: Life Cycle Climate Potential
     - R22
     - R410A
     - R32
   - (Kg-CO2)

R32 is the best solution for global environment.

(Precondition for Calculation)
*1 Taking low pressure loss into consideration, narrower HEX was used to reduce charge volume.
*2 To improve efficiency, HEX size was increased: Indoor HEX x 1.1 + Path x 2, Outdoor HEX x 1.2, and connecting pipe increased from 3/8=> 5/8
*3 To meet IEC requirements, charge volume was reduced: Indoor HEX x 0.8, Outdoor HEX x 0.5, narrower piping was used.
*4 To improve efficiency: Outdoor unit HEX was increased x 1.1
(HEX= Heat Exchanger)
High Ambient Temperature Performance

Result for High Ambient Conditions – COP Comparison

- R22: +8% @R410A
- R32: +5% @R410A
- R410A

Outdoor temp. (℃) vs Relative COP (vs R22, %)

- 105%
- 100%
- 95%
- 90%
- 85%
- 80%
- 75%
- 70%
- 65%
- 60%
- 55%
- 50%
- 45%
Global warming and Flammability of Refrigerant

Tradeoff relation between Global warming and Flammability
Safety Comparison

Consideration of 2L classification by ASHRAE and ISO.

<table>
<thead>
<tr>
<th>Class</th>
<th>Class 1</th>
<th>Class 2L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Flammable</td>
<td>Slightly flammable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burning Velocity (≤10 cm/s)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Class 2</th>
<th>Class 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2, R410A, R22</td>
<td>R32, R1234yf, Ammonia (higher chronic toxic)</td>
<td>R152a, Propane</td>
</tr>
</tbody>
</table>

The burning velocity (<10cm/s) is too slow to cause horizontal flame propagation nor explosion. Evaluated after long discussion in ASHRAE.

Flammability of 2L refrigerants is very low.
### What is R32?

<table>
<thead>
<tr>
<th>Refrigerants</th>
<th>ODP</th>
<th>GWP (IPCC4)</th>
<th>Flammability (ASHRAE34)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R22</strong></td>
<td>0.055</td>
<td>1810</td>
<td>1</td>
</tr>
<tr>
<td><strong>R32</strong></td>
<td>0</td>
<td>675</td>
<td>2L</td>
</tr>
<tr>
<td><strong>R410A</strong></td>
<td>0</td>
<td>2090</td>
<td>1</td>
</tr>
</tbody>
</table>

**Atoms**

- **Cl**: Good Solubility with Mineral Oil, Ozone Depletion
- **F**: Anti-Combustible, Higher GWP
- **H**: Lower GWP, High Performance, Combustible

**Flammability**

- **R32**: 2L
- **R410A**: 1

**ODP**

- **R22**: 0.055
- **R32**: 0
- **R410A**: 0

**GWP**

- **R22**: 1810
- **R32**: 675
- **R410A**: 2090
A fire accident triggered by flammable refrigerant can only occur when all 3 conditions are met.

1. **Occurrence of Rapid Refrigerant Leakage**
   - Rapid leakage is rare

2. **Mixture with Oxygen**
   - Flammable cloud is small

3. **Contact with Ignition Source**
   - Cannot be ignited from Switch or Cigarette lighter

This report is available on the website of JSRAE (http://www.jsrae.or.jp/info/2012progress_report_j.pdf)
## Main Standards related Refrigerant

**ISO5149 was re-voted (Nov.11, 2013)**

⇒ Received the information from the ISO central office (Jan 13, 2014) that ISO5149-1, 2, 3 are all approved.

<table>
<thead>
<tr>
<th>Field</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td>分野</td>
<td>国際規格</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Refrigerant Classification</th>
<th>ISO817FDIS</th>
<th>-NA- (based on ISO)</th>
<th>ASHRAE 34 UL 2182</th>
</tr>
</thead>
<tbody>
<tr>
<td>冷媒分類</td>
<td>approved(2014)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Usage Restriction for Safety</th>
<th>ISO5149FDIS</th>
<th>EN378</th>
<th>ASHRAE 15 UL 207, UL 250, UL 471, UL 474, UL 484, UL 984, UL 1995, UL 60335-2-40</th>
</tr>
</thead>
<tbody>
<tr>
<td>冷媒の安全使用</td>
<td>Under revision</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The standard of many countries is referring to ISO or has quoted ISO.
- ex. Japan (KHK), China (GB standard), Australia
- Asian countries are also gazing at the trend of Japan, China, etc.

### Voting by the Participate members

<table>
<thead>
<tr>
<th>Part</th>
<th>Content</th>
<th>Voting by the Participate members</th>
<th>Voting by the Participate and Observed members (Only dissenting votes counted)</th>
<th>Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Affirmative votes</td>
<td>Valid votes</td>
<td>% affirmative</td>
</tr>
<tr>
<td>1</td>
<td>Definitions, classification, etc.</td>
<td>15</td>
<td>19</td>
<td>79%&lt;66%</td>
</tr>
<tr>
<td>2</td>
<td>Design, construction, etc.</td>
<td>15</td>
<td>18</td>
<td>83%&gt;66%</td>
</tr>
<tr>
<td>3</td>
<td>Installation, etc.</td>
<td>16</td>
<td>19</td>
<td>84%&gt;66%</td>
</tr>
</tbody>
</table>
Modification in Manufacturing & Service Process
Design Changes for R32 from R22

<table>
<thead>
<tr>
<th>Flammability</th>
<th>Operating Pressure</th>
<th>Discharge Temp.</th>
<th>Refrigeration Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>R32</td>
<td>Safety Standard Refrigerant Charge</td>
<td>Pressure Design Pressure R32: 4.29MPa R410A: 4.15MPa</td>
<td>Control of Suction States</td>
</tr>
<tr>
<td>R410A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **R32** Residential Air-conditioner: Flammable Class 2L
- **R410A** Residential Air-conditioner: Non-Flammable Class 1
- **R22** Residential Air-conditioner: Flammable Class 1

- **Flammability**: R32: Flammable, R410A: Non-Flammable
- **Operating Pressure**: R32: 4.29MPa, R410A: 4.15MPa, R22: 2.9MPa
- **Discharge Temp.**: R32: +10 to +20 degC
- **Refrigerant Charge**: R32: Suniso
- **Service manual**: R32
- **Pressure Design**: Mildly Flammable Class 2L
- **Medium Temp.**: R32: 1.6 times
- **Solubility**: Mineral Oil Suniso
Capacity Building in India

R32 Service Technician Training in India

• Project conducted under Feasibility Study Program for energy efficient home appliances sponsored by METI
• Daikin established a technician training program to expand the Indian servicing network for R32
• 76 sessions were given and 3,600 local installers were trained in this project

Through this project India is developing the necessary expertise to service R32 equipment throughout the country.
## Service Tools Compatibility

<table>
<thead>
<tr>
<th>Tools (*)</th>
<th>R32</th>
<th>R410A</th>
<th>R22</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Gauge manifold</td>
<td>Compatible</td>
<td>Compatible</td>
<td>Compatible</td>
</tr>
<tr>
<td>(2) Charging hose</td>
<td>Compatible</td>
<td>Compatible</td>
<td>Compatible</td>
</tr>
<tr>
<td>(3) Scale</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Pipe bender</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Flare tool</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Torque wrench</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Pipe cutter</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Cylinder adaptor</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) Vacuum pump</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) Refrigerant recovery unit</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(11) Refrigerant recovery cylinder</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) Electric gas leak detector</td>
<td>Compatible</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Progress on Launch of R-32 Air-conditioners
Daikin launched the world’s first air conditioners to use R32 into the Japanese market on November 1, 2012.
“Prime Minister's Award” in The 5th Monodzukuri Nippon Grand Award

Judging process and valued points
Strategy for the new refrigerant R-32 in developing countries
Following the first round of inverter air conditioners, making global-warming friendly R-32 air conditioners a de facto standard, eventually leads to a step-up and strengthening of international competitiveness of Japanese companies. Basic Patent of R32 refrigerant which reduces 75% of global warming effect is opened to expand its use and to improve the environmental standard.

Scene in the award presentation ceremony (Sept. 18th 2013)

<Scene of greeting by Prime Minister Abe>
<Recipients explaining the award-winning work>

<Receiving a prize medal>

The logo comes from the tradition of AMENONUBOKO described in KOJIKI (a record about Ancient Matters) as motif.
# R32 RAC Line-up Expansion

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Premium Model</th>
<th>Basic Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.8kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.6kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0kW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Capacity**

- November, 2012: 4 models
- Today: 53 models

**Full replacement of R410A models**

**Total Sales 1,000,000**
### R-32 RAC Line-up in India

**Capacity**

<table>
<thead>
<tr>
<th>2012-13</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTKV</td>
<td>INVERTER</td>
</tr>
<tr>
<td>FTKM</td>
<td></td>
</tr>
<tr>
<td>FTKP</td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td></td>
</tr>
<tr>
<td>FTC</td>
<td></td>
</tr>
<tr>
<td>FTQ</td>
<td></td>
</tr>
</tbody>
</table>

**Capacity**

- 2.2kW
- 2.5kW
- 3.35kW
- 3.4kW
- 3.5kW
- 4.0kW
- 5.0kW
- 5.2kW
- 6.0kW
- 6.4kW
- 7.1kW

- **2013 - 2 models**
- **Today - 18 models**

- Complete line-up of R32 models launched in Fy14
- Sold over 30,000 units since last year
Daikin launched Commercial air-conditioners using R32 in Japanese market on November 1, 2013.
Daikin is the 1st to launch R32 Air Conditioners. Mitsubishi, Hitachi, and Panasonic are next to follow.
Promotion of R32 Products by different Companies
Thank you for your Attention!!