R290 R&D Report
Haier Air Conditioner

Qingdao Haier Air Conditioner Gen., Corp. Ltd
June 2013
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Development Of The Industry

To Protect the ozone layer

Specific Refrigerant
CFC: R11, R12
(Phase out in 1996)
HCFC: R22, R123
(Phase out in 2020 for developed countries)

Which destruct the ozone layer

The Kyoto protocol (1996)
To Prevent the Earth's Greenhouse Effect

Alternative Refrigerant
HFC: R32, R125, R134a
R404a
R407C=R32+R125+R134a
R410A=R32+R125

With High GWP

Natural Refrigerant
R290, CO2, NH3 etc
No destruction of ozone layer and low greenhouse effect. But there exist safety and performance problems.

Low GWP Refrigerant
HFO1234yf etc
Weak combustible and Micro Toxicity.
Europe is claim to use low GWP Hydrocarbon refrigerant, such as R290.

From Jan.1\textsuperscript{st} 2013, Europe Standard will be classified in two energy admittance criterion as the boundary of GWP = 150. The Product, whose GWP ≤ 150, can get 10% low than the energy access standard.

\textit{(EU) No 206/2012}

(b) From 1 January 2013, air conditioners, except single and double duct air conditioners, shall correspond to minimum energy efficiency and maximum sound power level requirements as indicated in Tables 4 and 5 below, calculated in accordance with Annex II. The requirements on energy efficiency shall take into account the reference design conditions specified in Annex II, Table 3 using the 'Average' heating season where applicable. The requirements on sound power shall relate to the standard rating conditions specified in Annex II, Table 2.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
 & SEER & \textit{SCOP} (Average heating season) \\
\hline
If GWP of refrigerant > 150 & 3.60 & 3.40 \\
\hline
If GWP of refrigerant ≤ 150 & 3.24 & 3.06 \\
\hline
\end{tabular}
\caption{Requirements for minimum energy efficiency}
\end{table}
In order to accelerating elimination of HCFC22, The Ministry of Environmental Protection of China and China Household Electrical Appliance Association worked out HPMP (HCFC22 Elimination Plan) for room air conditioner. And China also encouraging the low GWP Refrigerant development and production.

The new safety standard came into effect on May 1\textsuperscript{st} 2013, which add the flammable refrigerants items, and speed up the usage of R290 process.
Evaluation of R290

1. Conditions Of Use R290

- **Safety**: Non-toxic; Low risk of combustion
- **Environmental**: 0DP=0, GWP≤150
- **Performance**: High efficiency and good social benefits
- **Economic**: Competitive Cost
2、Safety Evaluation

Following tests, which the air conditioner unit using R290, are conducted by Tianjin Fire Controlling Research Institute under The Ministry of Public Security of the People’s Republic of China.

1) Leakage concentration Test

2) Combustion Test

3) Compressor with mixed air Test,

All the above tests to evaluate the possibility and relevant results of fire or explosion accident during the air-conditioner unit operation, installation and maintenance.
Conclusion Of Leakage Concentration Test

It will reach the R290 explosion lowest point during the leakage. Here are the test report from Tianjin Fire Controlling Research Institute.
2) **Conclusion on Combustion Test**

It will combustion and explosion in the very limited space. Here are the Test report by Tianjin Fire Controlling and Research Institute.

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### 4 燃爆实验

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<tr>
<td>5</td>
<td>HFC-161</td>
<td>383g</td>
<td>190s</td>
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<tr>
<td></td>
<td>b=60cm, L_g=42cm, L_w=68cm</td>
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- 测量后立即点火，之后每隔30s点火3次，持续30min
- 是
- 关闭气源时，出现燃烧现象，持续1-2s，见文件

<table>
<thead>
<tr>
<th>6</th>
<th>R3200</th>
<th>382g</th>
<th>192s</th>
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<tr>
<td></td>
<td>b=160cm, L_g=11cm, L_w=65cm</td>
<td></td>
<td></td>
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</tbody>
</table>

- 测量中一直点火
- 关闭气源时，出现燃烧现象，持续1-2s，见文件

<table>
<thead>
<tr>
<th>7</th>
<th>R280</th>
<th>381g</th>
<th>427s</th>
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<tbody>
<tr>
<td></td>
<td>b=160cm, L_g=11cm, L_w=65cm</td>
<td></td>
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</tbody>
</table>

- 测量中一直点火，每隔30s点火一次，持续10min
- 否

<table>
<thead>
<tr>
<th>8</th>
<th>R290</th>
<th>382g</th>
<th>427s</th>
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<tr>
<td></td>
<td>b=50cm, L_g=10cm, L_w=65cm</td>
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</table>

- 测量中一直点火，每隔4min，点火10s，停顿5s，后3min一直点火
- 否

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#### 初步结论：

- 影响浓度分布的最主要因素为泄漏口朝向；
- 制冷剂泄漏后在朝向窄范围内不会超过爆炸下限；
- 如泄漏过程中不能发生燃爆，那么泄漏停止后更难发生燃爆；
- 泄漏后长时间静置，不会在地面形成明显沉降，并形成爆炸混合物；
3) Conclusion of Compressor with mixed air Test,

The Institute have been evaluating the test with below information:

R290 might cause air conditioner fire or explosion, but still with low possibility. So which need to control the product design, production, storage, transportation and installation strictly. And also the worker personal qualification and relevant training is necessary.
3、Performance Test

1）Test result of wall-mounted split unit 12,000BTU: Data contrast of Cooling Operating

With the same system, The Unit with R290 cooling capacity decreased around 2% and power consumption increase about 5% and EER decrease 5% if compare to R22.

Conclusion：The cooling capacity with R290 is lower than the one with R22.
2) Test result of wall-mounted split unit 12,000BTU: Data contrast of Heating Operating

With the same system, The Unit with R290 Heating capacity almost same as R22, but power consumption increase 5% and EER decrease 5%.

Conclusion: The Heating capacity with R290 also lower than the one with R22.
3) Test result of Floor Standing unit 18,000BTU: Data contrast of Cooling and Heating Operating.

With the same system, The floor standing unit with R290 Heating and Cooling capacity, power consumption and EER are almost same. While according to refrigerant charging stipulated in IEC60335, The unit over 5KW can not use R290.
The discharge gas temperature of R290 is apparently lower than R22, which better for overload operation. Under max cooling operation condition, the discharge gas temp of 2HP with R290 is only 80.2 ℃, which lower 15 ℃ than the one with R22.

In the worst working condition (outside temperature over than 53 ℃), the discharge gap temperature just 84.5 ℃ and the unit with R290 still can work normally.
4、Cost Evaluation

1）、Refrigerant Module
① Compressor：12,000BTU will increase 3.5 USD
② Condenser：12,000BTU will decrease 1.4 USD
③ Refrigerant：12,000BTU will decrease 1.6 USD

2）、Electrical Module
① Sensor：new sensor for R290 cost will increase 3.5 USD
② Electrical box：add air-tight and anti-explosion structure，the cost will increase about 2.5 USD.
③ Electrical parts will use high safety standard and anti-explosion material，total cost will increase 2.5USD..

Conclusion: Total 12000BTU FG set cost will increase around 9 USD.
Haier Current R&D Process Of R290

1. Haier R290 Product R&D

① 9,000BTU and 12,000BTU cooling only non-inverter model with R290 refrigerant already finished developed

② 9,000BTU and 12,000BTU Heating non-inverter model with R290 refrigerant already finished developed

③ 9,000BTU and 12,000BTU inverter model is under developing.
Haier Current R&D Process Of R290

2、Production Line and laboratory improvement

① One RAC production line and laboratory in Chongqing manufacturing factory already completed.
② Another two production lines and laboratories have been improving in Jiaozhou manufacturing factory.

3、Product installation and maintenance
Haier already organized to formulate relevant air-conditioner installation and maintenance safety manual, according to our China standard and actual current situation.
Thanks !