REVISING IEC 60335-2-40 FOR A2 AND A3 REFRIGERANTS

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Li Tingxun
6th Nov, 2019
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01 Background

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Background

![Graph showing charge mass (Kg) vs. floor area (m²) with data points for h0=1.8m and R290 RAC.]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Evaluated Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Mass</td>
<td>Evaluated</td>
</tr>
<tr>
<td>Charge Amount</td>
<td>Evaluated</td>
</tr>
<tr>
<td>Temperature</td>
<td>Neglected</td>
</tr>
<tr>
<td>Pressure</td>
<td>Neglected</td>
</tr>
<tr>
<td>Interaction with Oil</td>
<td>Neglected</td>
</tr>
<tr>
<td>Velocity</td>
<td>Low velocity</td>
</tr>
<tr>
<td>Rate</td>
<td>Leak takes 4 minutes</td>
</tr>
<tr>
<td>Direction</td>
<td>Downward</td>
</tr>
<tr>
<td>Height</td>
<td>Evaluated</td>
</tr>
<tr>
<td>Location</td>
<td>Middle of the room</td>
</tr>
<tr>
<td>Temperature</td>
<td>Neglected (Used approximately 25°C)</td>
</tr>
<tr>
<td>Pressure</td>
<td>Neglected (Used 1 bar)</td>
</tr>
<tr>
<td>Tightness</td>
<td>Tight room except door gap</td>
</tr>
<tr>
<td>Ventilation</td>
<td>No ventilation except the door gap effect</td>
</tr>
<tr>
<td>Air Flow</td>
<td>None</td>
</tr>
<tr>
<td>Shape</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Obstacles</td>
<td>None</td>
</tr>
</tbody>
</table>

- 5.1th: 10, 17
- 6th: 77, 116

Annexes | Pages
---|---
5.1th | 10
5.1th | 17
6th   | 77
6th   | 116
1. Ignition Source
2. Charge Limit Boundary
3. Charge Limit Additional Formula
4. Mechanical Structure
5. Symbols and Marking
6. Training

- Electrical components
- Air conditioner types (such as VRV)
- Charge mass (Efficiency)
- Tightness
- Marketing
- Service
<table>
<thead>
<tr>
<th></th>
<th>IEC60335-2-40(5.1)</th>
<th>ISO5149</th>
<th>IEC60335-2-40(6.0)</th>
<th>UL 484&lt;sup&gt;9th&lt;/sup&gt;</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2/3)</td>
<td>(2L)</td>
<td>(2L)</td>
<td>(2/3)</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>4 × LFL</td>
<td>6 × LFL</td>
<td>6 × LFL</td>
<td></td>
<td>&lt;M1, no restriction</td>
</tr>
<tr>
<td>M2</td>
<td>26 × LFL</td>
<td>39 × LFL</td>
<td>52 × LFL</td>
<td></td>
<td>M2 &lt; M3, ventilation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 × LFL</td>
<td></td>
</tr>
<tr>
<td>M3</td>
<td>130 × LFL</td>
<td>195 × LFL</td>
<td>260 × LFL</td>
<td></td>
<td>&gt;M3, local regulation</td>
</tr>
</tbody>
</table>

M1 < M2

\[
m_{\text{max}} = 2.5 \times LFL \times h_0 \times A^{1/2} = 0.75 \times LFL \times A \times h_{ra}
\]
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Installation height

Participants
Daniel Kindblad, SE
Bill Hansen, US
Els Baert, BE (Guest)
Mary Koban, US (Guest)
Alberto Aloisi, IT
Hiroshi Yamaguchi, JP
Koji Hatano, JP
Shigeharu Taira, JP
Martin Dieryckx, BE
Brian Rodgers, US (part time)
Byron Horak (part time)
Tingxun Li, CN
Dou Yanwei, CN
Daniel Colbourne, UK

2010
London
Suggest to revise the clause of the installation height
Rejected

2013
Delhi
Propose to revise the clause of the installation height
AHG 12

2013
Stuttgart
China submitted the proposal

2015
Vienna
CD
FDIS approved with no against

2016

Took 6 years to achieve a simple/minor but logical change

Installation height

6.4 Annex GG - Charge limits, ventilation requirements and requirements for secondary circuits

Installation height

The convener reported that SC61D discussed the installation height at its London meeting (notes page 6). SC61D had decided not to change the requirement in the CDV stage.

China Proposal on h for calculation of m可视化 and A可视化

Statement:
Fundamentally we think that the standard should play the role to enable the technology developed and product design. The standard should not support one technology or one product design. However, the proposed language in the meeting WHO, attached in the following, would generate the barriers to number of product development. A standard should have the minimum requirements for safety, and avoid limiting the technology and product development without unnecessarily limiting the product design or application.

The reason to China proposal:

61D/204/RM

CD

Revised

Stuttgart

Vienna

CD

FDIS approved with no against

Took 6 years to achieve a simple/minor but logical change

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Proposed establishment of WG for A2 and A3

- **2014**
  - New York
  - Proposed establishment of WG for A2 and A3
  - UK submitted the proposal
  - WG16 was established
  - Rejected

- **2015**
  - Washington
  - WG9 and AG16 were combined
  - WG9 confirmed the decision of the items are out of scope. When A2 separately.

- **2019**
  - WG9 and AG16 were combined
  - UK submitted the proposal and WG16 was established
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<td>03 Progress</td>
</tr>
</tbody>
</table>
Charge mass

- With airflow circulation
- Enhanced tightness
- Releasable charge mass
Tightness (for charges up to $m_2$)

Normal tightness

Normal tightness without airflow circulation GG.2.1

Normal tightness with airflow circulation GG.2.3

Enhanced tightness

Enhanced tightness without airflow circulation GG.14.2

Enhanced tightness with airflow circulation GG.14.3

Releasable charge

3.156, 3.157, 3.158, 3.159, 22.133, DD.3.1, GG.1.1, Annex QQ

Robustness

7.106, 21.2, 23.102, DD.3.2

Other

5.2, 7.108, 22.115, 22.123, GG.1.3

Leak detection

'ensure that the flammability risk does not exceed that which may be associated with existing charge limits for unventilated “normal tightness” systems'
**Enhanced tightness refrigerating system**

*refrigerating system* in which the indoor units are designed and fabricated to ensure a high level of confidence that large refrigerant leak rates will not occur in normal and abnormal operation

- compressors, pressure relief devices and pressure vessels of the refrigerating system shall be located in locations other than the occupied
- refrigerant distribution assemblies shall meet all applicable requirements of this standard
- refrigerating systems shall use only permanent joints indoors except for site-made or factory made mechanical joints in compliance with ISO 14903
- refrigerant containing parts in indoor units shall be protected from damage in the event of catastrophic failure of moving parts
- pipes in the occupied space in question are installed in such a way that it is protected against accidental damage
- indoor unit shall be tightness tested at the factory with detection equipment with a capability of 3 grams per year
No airflow circulation + Enhanced tightness

\[ m_{max} = F \times LFL \times A \times h_o \]

\( F = 0.2 \times C_{exit}^{-1/2} \) and \( F \leq 0.5 \) such as 0.35
\[ m_{\text{max}} = F \times LFL \times A \times 2.2 \]

\( F \) is a factor not exceeding 0.5. The value shall be the value as used in the equation for calculating \( Q_{\text{min}} \)

\[ Q_{\text{min}} = 3600 \frac{8 \sqrt{A_o}}{240} \left( \frac{m_c}{LFL} \right)^{3/4} \left( \frac{F^{1/4}}{1 - F} \right) \]
$m_{max} = F \times LFL \times A \times 2.2$

$F$ is a factor not exceeding 0.5. The value shall be the value as used in the equation for calculating $Q_{min}$

$$Q_{min} = 3600 \frac{5 Y \sqrt{A_o \dot{m}^{3/4}}}{h_o^{1/8}[LFL(1 - F)]^{5/8}}$$

$$\dot{m}_{leak} = \left(\frac{167}{432}\right) \dot{M}_s \quad \dot{M}_s = 0.61 \sqrt{k \rho_o (p_o - p_{atm}) \left(\frac{2}{k + 1}\right)^{\frac{k+1}{k-1}}}$$
Example comparison of minimum airflow rates for R290 according to 6th edition of IEC 60335-2-40 and the present CD for Enhanced Tightness Refrigeration System (ETRS) with incorporated circulation airflow
Releasable charge

The releasable charge $m_{rl}$ shall be determined in each operating state.

<table>
<thead>
<tr>
<th>Operating mode</th>
<th>Shut-down valves</th>
<th>Sensing method</th>
<th>Mitigation action</th>
<th>Leak hole (mm)</th>
<th>Leak mass (kg)</th>
<th>Leak (% of charge)</th>
<th>Time to $p \rightarrow 0$ bar (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>Open</td>
<td>None</td>
<td>None</td>
<td>1.0</td>
<td>0.67</td>
<td>74%</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.6</td>
<td>0.75</td>
<td>83%</td>
<td>5½</td>
</tr>
<tr>
<td>On</td>
<td>Open</td>
<td>None</td>
<td>None</td>
<td>1.0</td>
<td>0.66</td>
<td>73%</td>
<td>13½</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.5</td>
<td>0.76</td>
<td>84%</td>
<td>3½</td>
</tr>
<tr>
<td>Off</td>
<td>Closed</td>
<td>None</td>
<td>None</td>
<td>1</td>
<td>0.25</td>
<td>28%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.5</td>
<td>0.21</td>
<td>23%</td>
<td>1</td>
</tr>
<tr>
<td>On</td>
<td>Open</td>
<td>IDU Conc</td>
<td>Close valve(s)</td>
<td>1</td>
<td>0.12</td>
<td>13%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.6</td>
<td>0.13</td>
<td>14%</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.5</td>
<td>0.12</td>
<td>13%</td>
<td>½</td>
</tr>
<tr>
<td>Mode</td>
<td>Indoor T (°C)</td>
<td>Outdoor T (°C)</td>
<td>Compressor</td>
<td>Fan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------------</td>
<td>----------------</td>
<td>-------------</td>
<td>-----</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standby</td>
<td>27</td>
<td>35</td>
<td>off</td>
<td>on</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>35</td>
<td>off</td>
<td>off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>Highest</td>
<td>Highest</td>
<td>Highest speed</td>
<td>Highest speed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>Highest</td>
<td>Highest</td>
<td>Highest speed</td>
<td>Highest speed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Leak detection

The fan incorporated to an appliance is continuously operated or operation is initiated by a leak detection system.

- Be activated before the refrigerant concentration reaches 25% of the LFL.
- Response time < 20 seconds (20%-25% LFL).
- Directly to the refrigerant or a representative surrogate gas.
- Confirmation tests:

  - Leak rate (vapor): \( m_r = 7.6 \times h_0 \times \text{LFL (low)} \)
  
  - \( m_r = \frac{1000}{240} m_c \) (high)

- be simulated at the most unfavourable potential leak point.

- the pressure at the inlet to release orifice is not less than 300 kPa (gauge).

- Room area \( A_t \geq \frac{2.4 \times m_r}{\text{LFL} \times h_t} \)
Sensor

- IEC 60079-29-1 shall be applied
- Might not considered ignition sources
- Not depend on the location
- with a tolerance of $\pm 15\%$
- Be selective for environments where non-refrigerant gases are present
- Self-testing
- Be accessible for inspection and replacement
Sensor location

**A2L**

1. Leak → Gas flows to sensor → Conc at sensor → Sensor detect gas → Signal → Fan starts → Min airflow achieved → Floor conc < LFL

**A2/A3**

1. Leak → Gas flows to sensor → Conc at sensor → Sensor detect gas → Signal → Fan starts → Min airflow achieved → Floor conc < LFL

<30S
<20S
WG21 did not reach consensus on the meeting in Shanghai.

Telephone conference calls planned.
THANK FOR YOUR ATTENTION