Concentration of Propane in case of Leakage under different Variables

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About us

• German NGO working on
  • energy efficiency and climate change
  • Nature conservation
  • Cycle economy
  • Air quality
  • Clean transportation
  • Entitled to sue

• Based in Berlin and at Lake Constance
• 80 staff members
Why are we interested in natural refrigerants?

- The refrigeration and air conditioning sectors are responsible for about 7% of global greenhouse gas (GHG) emission today, equivalent to 3.7 Gt of CO2eq per year (2014) going up to 8.1 Gt CO2eq (2030).

- Natural refrigerants offer potential regarding lower direct emission (leakage/GWP) and to lower indirect emission (better energy efficiency) compared to HFC.

- Barrier: Limitation of charge in standards restrict the use of hydrocarbons

(Sources: Green Cooling Initiative, CCAC)
How to promote natural refrigerants

• Increase Green public procurement
• Ensure ambitious legislation
• Provide economic incentives for a faster market penetration (e.g. Financial instruments)
• Open standards for hydrocarbons
• Set labelling and minimum energy performance standards
Standards concerning refrigerants

- ISO 5149: 2003 – Mechanical refrigerating systems used for cooling and heating – Safety requirements
- IEC 60335-2-89: 2007 – Specification for safety of household and similar electrical appliances. Safety. Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor
Preparing the setting
Example of a test set up

- Behind unit, floor
- Behind unit, 1 m
- 0.5 m from unit, floor
- Near corner, floor
- 0.5 m from unit, floor
- 1.0 m from unit, floor
- Room centre, floor
- Room centre, 1 m
- Opposite side from unit, floor
- Far corner, floor
- 0.5 m from unit, floor

[Image of test set up]
A: Cabinets

Top-mounted condensing unit (">1m") → no airflow required

Evaporator (typically about 1 m above floor level) → no airflow required

Floor-mounted condensing unit ("<1m") → with airflow

Cabinet A: 3.75 m multi-deck, top-mounted condensing unit, with doors (tested also with doors open)

Cabinet B: 2.5 m multi-deck, floor-mounted condensing unit, no doors

Note: cabinets always loaded (most pessimistic case)
<table>
<thead>
<tr>
<th>What did we measure?</th>
<th>What did we observe?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Released mass</td>
<td>Greater mass $\rightarrow$ higher C</td>
</tr>
<tr>
<td>Release mass flow rate</td>
<td>Greater mass flow $\rightarrow$ higher C</td>
</tr>
<tr>
<td>Condenser airflow</td>
<td>Greatly reduces C</td>
</tr>
<tr>
<td>Evaporator airflow</td>
<td>Sign. reduces C for evap leaks</td>
</tr>
<tr>
<td>Cabinet doors</td>
<td>Closed doors gives lower C</td>
</tr>
<tr>
<td>Kick-plates</td>
<td>Slightly increase C</td>
</tr>
<tr>
<td>Condensing unit cover</td>
<td>No cover marginally reduces C</td>
</tr>
<tr>
<td>Roof stand/panel</td>
<td>With slightly increases C</td>
</tr>
<tr>
<td>Condenser return bends vs housing</td>
<td>Substantial reduction in C with free jet</td>
</tr>
<tr>
<td>Positioning within room</td>
<td>Other positions have negligible effect on C</td>
</tr>
</tbody>
</table>
150 gram more dangerous than one kilogram?

10 m² room, floor-mounted cond, 150 g (6 g/m³, 16% LFL), 60 g/min ➔ no fans

Should this be the “maximum permissible concentration” since experience indicates it is not a high risk situation?

40 m² room, top-mounted condenser, 1000 g (10 g/m³, 26% LFL), 60 g/min ➔ no fans

No critical concentrations with 1 kg charge and HUGE hole in the pipe
# Effect of Airflow

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Concentration [% LFL]</th>
<th>Time [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m² room, floor-mounted condenser, 150 g (6 g/m³, 16% LFL), 60 g/min</td>
<td>0 m³/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 m² room, floor-mounted condenser, 150 g (6 g/m³, 16% LFL), 60 g/min</td>
<td>580 m³/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 m² room, floor-mounted, 500 g (10 g/m³, 26% LFL), 60 g/min</td>
<td>580 m³/h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Graphs showing concentration vs. time for different airflow rates and room sizes.](image)
B: Tests on Air Conditioner

Examined certain variables
✓ Real unit vs diffuser
✓ Leak position within unit
✓ Use of louvre (wall unit)
✓ Release mass
✓ Release mass flow rate
✓ Indoor unit airflow
✓ Positioning within room
Leak mass flow rate – how big is a leak hole
Leak mass flow rate (window unit)

20 m², window unit, 1.0 m, 300 g (6 g/m³, 16% LFL), RH return bend

60 g/min

30 g/min
Leak mass flow rate (wall unit)

40 m², wall unit, 1.8 m, 750 g (8 g/m³, 20% LFL), LHRB

30 g/min

120 g/min
Unit airflow leads to near-homogenous mixing of propane concentrations far below the lower explosion limit!
Unit airflow (window unit)

20 m² room, window unit, 1.0 m, 550 m³/h, louvre (at 1.3 m) directed horizontally, 60 g/min

400 g (8 g/m³, 21% LFL)

1000 g (20 g/m³, 53% LFL)
Unit airflow (wall unit)

40 m², wall unit, 1.8 m, 550 m³/h, louvre directed horizontal, 60 g/min

750 g (8 g/m³, 20% LFL)

1250 g (13 g/m³, 33% LFL)
Unit type (wall vs window unit) – no airflow

20 m², 1.8 m, 60 g/min, 400 g (8 g/m³, 20% LFL)
Conclusions – Next steps

• Finalization and publication of full report
• Further research on size of typical hole in the pipe / average mass flow
• We tested with worst case scenarios – in most cases didn’t reach the LEL
• Normal mode with fans brings no critical situations irrespective of the charge
• Higher charges can be installed safely with respective safety measures
• Further safety measures should be: strong pipes, guaranteed airflow, “point of leakage” as high as possible to mix with the air ➔ see top mounted condenser cabinet
• Safety measures should take into account our results and additional findings and support constructive debate
Thank you!

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