Overview of fire risks related to electric vehicles in garages

Vincent Mans
European Fire Safety Week
Nov, 19th 2020
FIRE SAFETY IN E-MOBILITY ON THE MOVE...

- continuous growing EV market
- pushed by green horizon political objectives
- understood and demanded by the society !!!
### Table: Fire Incidence in E-Vehicles

<table>
<thead>
<tr>
<th></th>
<th>parked and/or charging</th>
<th>driven</th>
<th>post crash</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fire incidence (a)</strong></td>
<td>60%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Fire incidence (b)</strong></td>
<td>52%</td>
<td>26%</td>
<td>22%</td>
</tr>
</tbody>
</table>

**References:**

(a) A review on battery fires in electric vehicles. 2018
Fire Technology 56, P. Sun, H. Niu, R. Bisschop, X. Huang,

(b) Fire Safety LIB in road vehicles/ RISE report 2019/51
R. Bisschop, O. Willstrand, F. Amon, M. Rosengren
THE FUTURE

(a) Houston's Tranquility Park Garage with GRIDbot charging stations [173], and (b) hund new EVs parked in a public area in Wuhan, China, showing a high fire risk [155].
Regulated by MS and based on the Construction Eurocodes

- 90-120 min REI for >100m²
- 120-180 min REI for robotic parking
- Class B s1 d0 for reaction to fire – walls,..
- Cca-s1b,d1,a1 EN 50399 – Cables

Ventilation requirements > 100 m²

Factors: **fire load**, geometry, evacuation.
No fuel, but 400 l containing organic electrolytes....

A Zotye M300 EV having its batteries replaced
### Table 7: Flammability data for the electrolyte solvent in LIB cells and data for conventional automotive fuels for comparison.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ethyl Acetate (EA) [37] [38]</td>
<td>77</td>
<td>427</td>
<td>-3</td>
<td>2.2 / 9</td>
</tr>
<tr>
<td>Dimethyl Carbonate (DMC) [37] [38]</td>
<td>91</td>
<td>458</td>
<td>16</td>
<td>4.22 / 12.87</td>
</tr>
<tr>
<td>Ethyl Methyl Carbonate (EMC) [37] [38]</td>
<td>110</td>
<td>440</td>
<td>24</td>
<td>-/-</td>
</tr>
<tr>
<td>Diethyl Carbonate (DEC) [37] [38]</td>
<td>126</td>
<td>445</td>
<td>25</td>
<td>1.4 / 14.3</td>
</tr>
<tr>
<td>Ethylene Carbonate (EC) [37] [38]</td>
<td>248</td>
<td>465</td>
<td>143</td>
<td>3.6 / 16.1</td>
</tr>
<tr>
<td>Propylene Carbonate (PC) [37] [38]</td>
<td>242</td>
<td>455</td>
<td>132</td>
<td>1.8 / 14.3</td>
</tr>
<tr>
<td>Gasoline [39]</td>
<td>30 to 210</td>
<td>&gt;350</td>
<td>&lt; -40</td>
<td>1.4 / 7.6</td>
</tr>
<tr>
<td>Diesel [40]</td>
<td>&gt;180</td>
<td>240</td>
<td>&gt;61.5</td>
<td>0.7 / 5</td>
</tr>
</tbody>
</table>
HRR HIGHER IN EV FOR SAME RANGE

(c) Fire heat release of burning vehicle fuel

Fire heat release, $Q_h$ (GJ)

EV Battery

Gasoline for ICEV

Range (km)

ICEV VEHICLES SIMILAR HRR THAN EV IN REAL TESTS

*Figure 20.* Evolution of HRR versus time for test vehicles which were suspended over a propane burner of 2 MW: (a) three different pure battery EVs, and (b) a small PHEV and a large PHEV compared with the gas tank and internal combustion engine (ICE) vehicles [91].

Standards specific for e-Mobility:

IEC 62196 Type 2 official EU connector

IEC 62196-1  Glow wire test

For garages:

Reaction to fire > Cca-s1b,d1,a1. EN 50575
VENTILATION IN GARAGES

Actual situation:

Actual Regulations intended for opacity (evacuation) EN 1366-1

**Toxic fumes not considered**

*What is coming with e-mobility:*

More and toxic smoke

Higher fire risk
### Table 6. List of toxic gas emissions from full-scale EV fire tests [95].

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Weight</th>
<th>Battery or fuel capacity</th>
<th>Total CO (kg)</th>
<th>Total HF (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown BEV</td>
<td>1122</td>
<td>16.5 kWh</td>
<td>10.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Unknown ICEV</td>
<td>1128</td>
<td>Full tank of Diesel</td>
<td>12.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Unknown BEV</td>
<td>1501</td>
<td>23.5 kWh</td>
<td>11.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Unknown ICEV</td>
<td>1404</td>
<td>Full tank of Diesel</td>
<td>15.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Toxic gases from fire in electric vehicles

The aim of the project is to raise the level of knowledge regarding toxic gases generated by fire in electric vehicles and to investigate how this affects fire fighting operations.

The project results are expected to create a basis for relevant risk assessment. The results are also expected to be used in other areas such as

Summary
PROJECT NAME
E-TOX
STATUS
Active
RISE ROLE IN PROJECT
Coordinator
PROJECT START
2019-10-01
DURATION
1 year

Pinfa is part of: cefic
LIGHT WEIGHT MATERIALS IN EV

Increased number of polymeric pieces in EV

Contribute to the total fire load

Reinforced polymers (carbon, glass fibres,..)
- toxic fumes
- nano particles/fibres
TO CONCLUDE....

EV fires in **closed areas, like garages**, is the worst and most probable fire scenario.

Reaction/Resistance to fire of all elements in garages is **quite well regulated** although a slightly higher fire load for EV may suggest a future revision.

Smoke emission is the issue. **Mainly for toxicity**

Need for ventilation designs **beyond actual standards**

Need for more research regarding **extinguishing systems**

Need for more research regarding **firemen exposure**
THANKS

Vincent Mans
BACK UP

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FIRE IN ALL VEHICLES IS AN OLD CONCERN

Number of 1998-2015 vehicle fire incidents in Sweden, intentional burning

Source: Swedish Civil Contingencies Agency statistics database. [1]
To perform simulations and analysis of test results and realistic fire scenarios, for example what concentrations can be expected at different positions in a parking garage with certain geometry and ventilation.
Fires in EV

60% parked/ charging
20% driven
20% post crash

WHERE ARE THE FIRE RISKS IN E-MOBILITY?

Batteries
AC/DC electric systems
Chargers
Weight reduction