Risks of Accidents with Electric Vehicles

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Source: YouTube - A Tesla suddenly burst into flames in Shanghai
Risks of Accidents with Electric Vehicles

1. Test car and crash setup
2. Safety during accident & rescue of passengers
3. Transportation & storage of accident cars
4. Firefighting
5. Summary
1. Test car and crash setup

Electric cars in accidents
- Risk of electrical contact with high voltage wires
- Risk of short circuit
- Risk of deformations/intrusions on high voltage battery → risk of fire

Where is the high voltage battery located?
- Front end → previously
- Floor assembly → today
- Rear end → hybrid, additional batteries
1. Test car and crash setup

Crash setup
- Side collision
- 50 km/h
- Outdoor

Crash cars
- Renault Fluence ZE (stationary)
  - Driver: HIII 50%
  - Co driver: ES2
- Mercedes Benz A-Class (driven)
  - Driver: HIII 5%
HV car Renault Fluence ZE

- 400 V Li-ion battery behind rear seats
- Battery capacity 22 kWh
- 70 kW electric engine at 11'000 min\(^{-1}\)
- Nozzle on rear back rest to flood the battery in case of fire
- High voltage emergency switch on bottom rear right
- Battery can only be leased
- Spare battery in CH available within 3–6 month!
- The recycling of Li-ion batteries is only in proving stage
2. Safety during accident & rescue of passengers

Questionnaire from occupants:
- Passive safety loss for electric cars?
- Risk of electric shock?
- Risk of fire?

Questionnaire from rescue personnel:
- How can electric cars be detected?
- Is there a possibility to measure the voltage on the car body?
- Where are the cut sectors?
2. Safety during accident & rescue of passengers

Side collision Mercedes Benz A-Class to Renault Fluence ZA

No short cut and no fire on battery
2. Safety during accident & rescue of passengers

Deformations on Renault Fluence ZA:

- B-pillar & left doors
- Side skirts & floor
- C-pillar & rear seat
- Roof
2. Safety during accident & rescue of passengers

Safety for passengers during collision

- Good passive safety level in electric car
- High voltage was shut down – no electric shock
- No leakage of battery
- High voltage components remained attached

Police & rescue personnel

- How to detect electric cars involved in an accident? Number plate? -> safety equipment
- Rescue card on tablet -> e.g. emergency switch
- Confusing situation because ignition remained “on”
2. Safety during accident & rescue of passengers

Information on rescue card, Renault Fluence:

- Cut sectors, location of battery & pyro, ...
2. Safety during accident & rescue of passengers

Rescue

- In some cases the entire roof has to be cut off
2. Safety during accident & rescue of passengers

Answers to questionnaire from occupants:

- Passive safety loss in electric cars → no, they have an equivalent safety level
- Risk of electric shock → during and after an accident highly unlikely
- Risk of fire → highly unlikely, as long as there are no deformations on battery

Example front crash with eRodd from Kyburz:

- LiFe-battery in center tunnel
  - lower energy density
  - lower tendency for thermal runaway
- Frontal impact with 64 km/h
- Cooling with CO2 worked
2. Safety during accident & rescue of passengers

Answers to questionnaire from rescue personnel:

- How can electric cars be detected → charger connection, lettering, no exhaust pipe, … identification on database with number plate in progress

- Is there a possibility to measure the voltage on the car body
  → some measure the potential between rim and road … no safe measure
  → shut down of high voltage in an accident works properly → no measurement need, if airbags deployed

- Where are the cut sectors → rescue card
3. Transportation & storage of accident cars

Questionnaire from breakdown service

- Risk of electric shock?
- Risk of fire during transport?
- Appropriate transport vehicle?
- Risk of fire during storage?
3. Transportation & storage of accident cars

Procedure

- The head of operations releases the accident cars after occupant rescue
- Currently the transport is conducted by a roadside assistance, with the common tow truck
- Safe tow trucks for electric cars are in development (Container)
- Storage with (5 m) distance to other cars
3. Transportation & storage of accident cars

Protective measures

- Protective clothing, with helmet and gloves (1000 V)
- Prove that the car body is free of voltage
- Battery temperature observation, IR-camera

Transportation in Firebox

- Transformed sea container
- Electric isolated floor
- Own extinguishing system with aerosol gas
- There are 2 Fireboxes in Switzerland
- Could also be used as storage box
Transportation in Firebox → for cars a good and safe solution
3. Transportation & storage of accident cars

Answers to questionnaire from personnel:

- **Risk of electric shock**
  - extremely low risk (car identification)
  - high risk if *battery pack was opened*

- **Risk of fire during transport**
  - dangerous, especially in *tunnels*

- **Appropriate transport vehicle**
  - not regulated and usually *not available*

- **Risk of fire during storage**
  - even burned out electric cars can catch fire *week(s) after the accident*
  - separate *fire area* with min. 20 m distance to other cars
4. Firefighting

Questionnaire from fire fighters:

- Where is the battery placed in the car?
- Best extinguishing agent?
- Risk of high voltage?
- Leakage of electrolyte?
- Toxic gas?
- Extinguishing water (environment)
4. Firefighting

Location for fire fighter training:
- Concrete fire plate
- Protected with 15 cm gravel
- Catch basin for extinguishing water

Battery inflammation:
- Additional li-ion batteries in trunk (+20 kWh)
- Inflammation by help of a metal fire
Fire of li-ion battery:

- It was hard to put the battery on fire
- After 2 min the trunk could not be opened by door handle
- Start of fire intervention after 10 min
- Opening of the trunk by means of hydraulic spreader
Li-ion battery on fire:

- **Materials**
  - Anode: graphite
  - Cathode: LiCoO$_2$
  - electrolyte
  → the fire cannot be extinguished

- Up to 7 x higher energy release (with 42 kWh → 294 kWh)

- Hydrofluoric acid may be produced

- Water is split to Hydrogen and Oxygen by high temperature
Fire-control of li-ion battery:

1. Personnel protection
   → accident casualty
   → fire fighter (breathing protection)

2. Water is the only working extinguishing agent
   → cooling
   → prevent that the fire spread to other cells
   → wash out of smoke
   → discharge of cells by water
   → no risk for electric shock over the water jet
Challenge: cells usually are capsuled → difficult access

- This tool does not solve this issue!

### Technische Daten

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<thead>
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<th>Material</th>
<th>rostfreier Stahl</th>
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<tbody>
<tr>
<td>Länge (mit Verlängerungsrohr 500 mm)</td>
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<td>Gewichte</td>
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<td>Gewinde</td>
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</table>

Stainless steel
4. Firefighting

Fire-control of li-ion battery:
- Start of cooling in front
- Proceed backwards to the battery
4. Firefighting

Experiences:

▪ After 15 min the burning cells burned out, fire under control
▪ 7500 liter water were used
▪ 5 min after extinguishing, the cell temperature started to rise again
▪ 4 h later again
▪ The car completely burned out
▪ All electric wires lost their isolation (also on battery)
4. Firefighting

Answers to questionnaire from fire fighters:

- Where is the battery placed in the car → **rescue card**
- Best extinguishing method → lots of **water**
- Risk of high voltage  
  → during extinguishing **no risk**
  → after extinguishing a contact with high voltage wires **is possible**
- Leakage of electrolyte → depending on damage **leakage is possible**
- Toxic gas → high risk, **breathing protection**
- Extinguishing water (environment) → should be **retained**
5. Summary

Electro mobility

- Number of electric cars is growing, but important players are not ready yet
  - Availability of spare batteries not guaranted
  - Disposal facilities are not ready for electric cars
  - Recycling of li-ion batteries still in progress

- Safety
  - Equivalent passive safety for occupants
  - Very low risk for electric shock and fire
5. Summary

Rescue personnel

- It is not easy to detect an electric car involved in an accident
- Most important information on rescue card
- Uncertainty for
  - Safety equipment
  - Extinguishing method
  - Procedures with electric cars mostly not defined
5. Summary

Fire

- If a battery inflamed
  → the car will probably completely burn out
  → leakage of very toxic gases and
  → extinguishing water
  → lots of water helps to control the fire
- After extinguishing
  → risk of electrical shock because of
  → missing isolation
  → the battery can catch fire again
Electric cars are much safer than expected

Thank you for your attention!