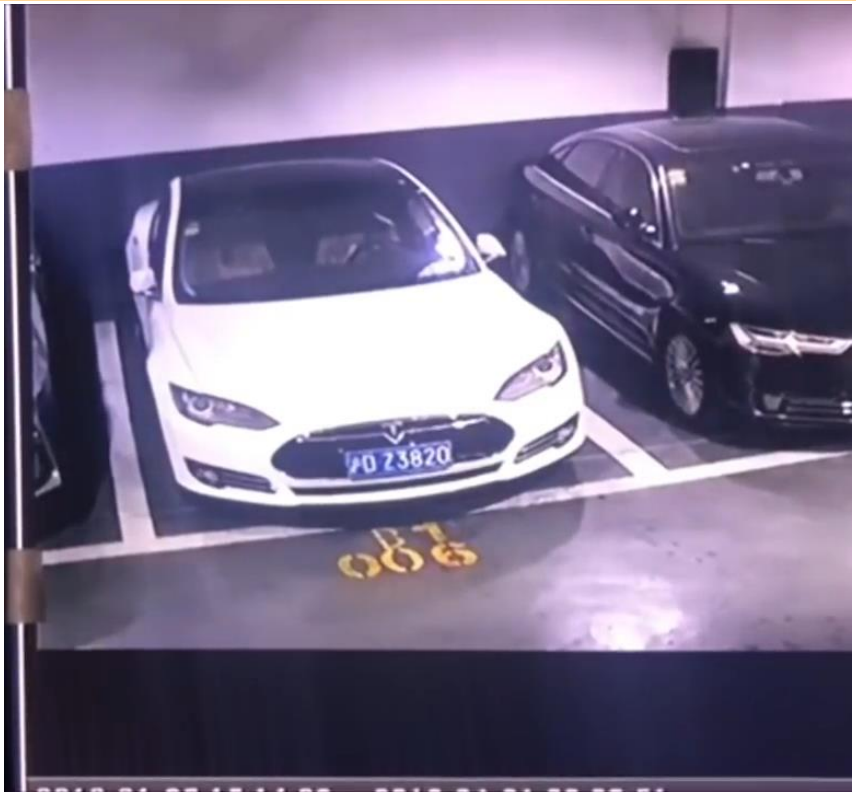
Berner
Fachhochschule

Risks of Accidents with Electric Vehicles

Raphael Murri

BFH & DTC Dynamic Test Center AG

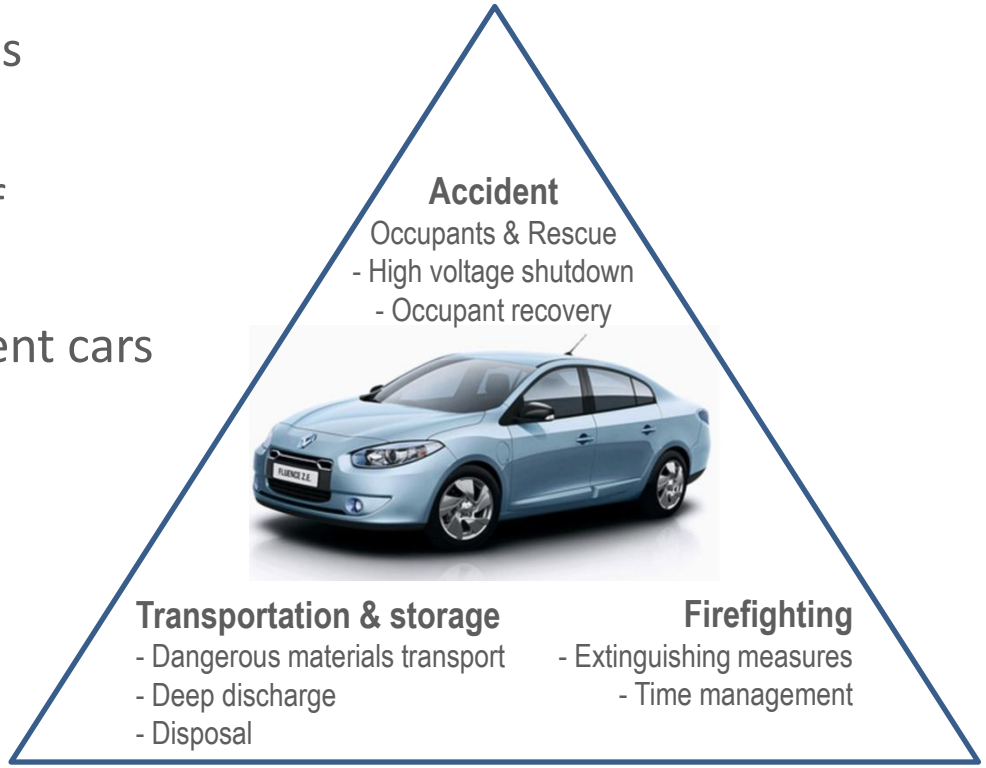


Source: YouTube - A Tesla suddenly burst into flames in Shanghai

Content

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

Renault ZOE

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%

1. Test car and crash setup

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:

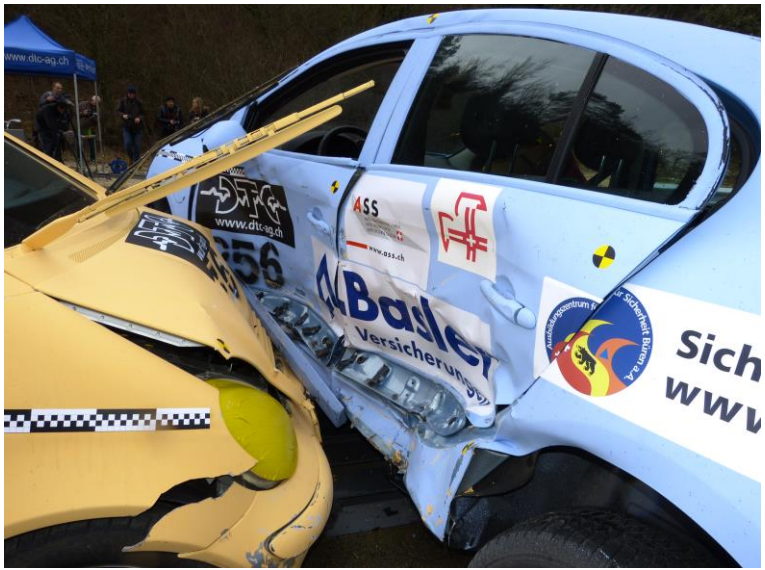
- Passive safety loss for electric cars?
- Risk of electric shock?
- Risk of fire?

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

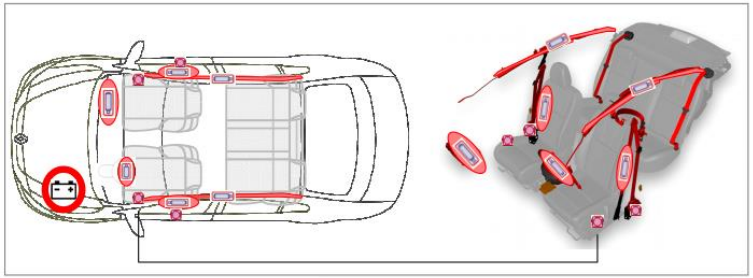
- How to detect electric cars involved in an accident? Number plate? -> safety equipment
- Rescue card on tablet -> e.g. emergency switch
- Confusing situation because ignition remained “on”

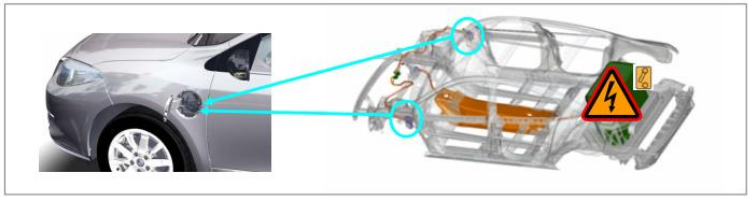
2. Safety during accident & rescue of passengers

Information on rescue card, Renault Fluence:

- Cut sectors, location of battery & pyro, …

	Haupt-Energie	Stop & Start	Hybrid
Diesel			
Benzin			
Elektro	Lithium-Ionen		





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 eRod 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

3. Transportation & storage of accident cars

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

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:

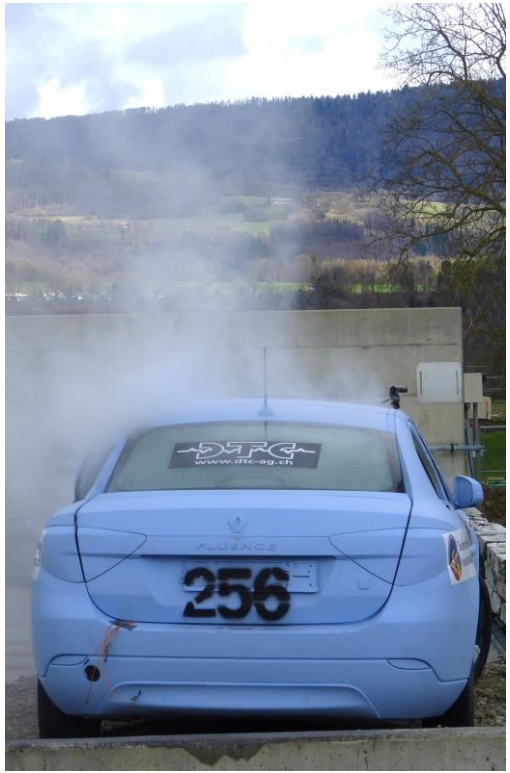
- Concrete fire plate
- Protected with 15 cm gravel
- Catch basin for extinguishing water

Battery inflammation:

- Additional li-ion batteries in trunk (+20 kWh)
- Inflammation by help of a metal fire

Fire of li-ion battery:

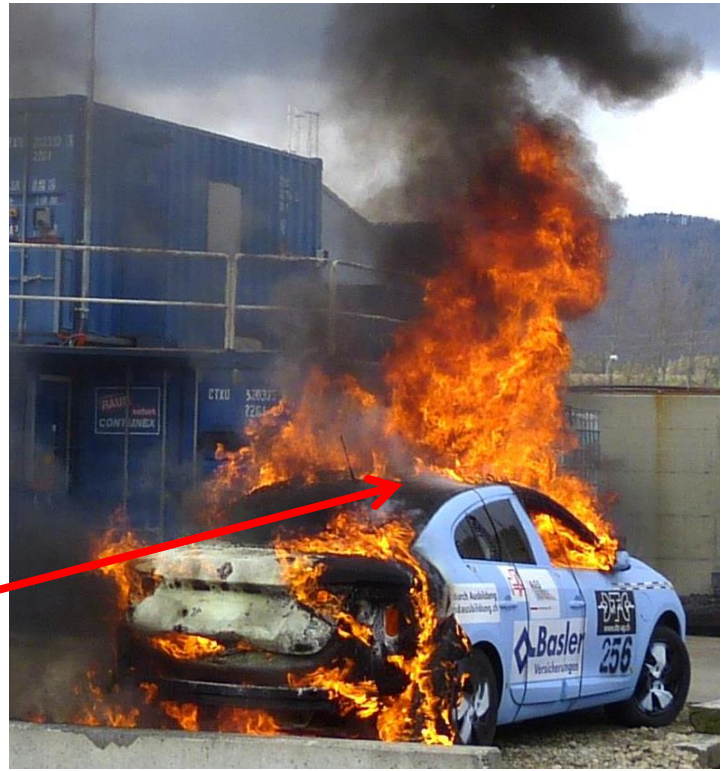
- It was hard to put the battery on fire
- After 2 min the trunk could not be opened by door handle
- Start of fire intervention after 10 min
- Opening of the trunk by means of hydraulic spreader



Li-ion battery on fire:

- Materials
  - Anode: graphite
  - Cathode: $LiCoO_2$
  - electrolyte

  $\rightarrow$ the fire cannot be extinguished
- Up to 7 x higher energy release (with 42 kWh $\rightarrow$ 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

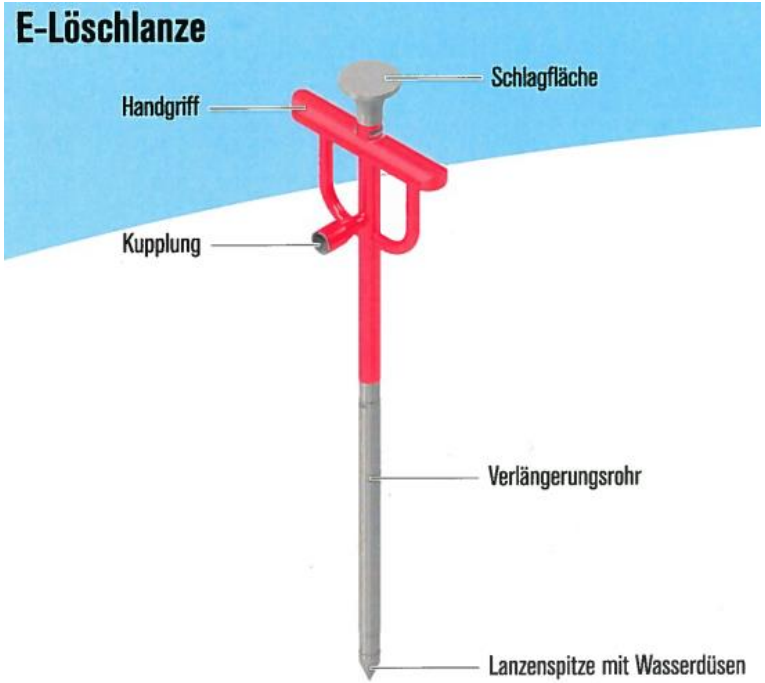
Challenge: cells usually are capsuled → difficult access

- This tool does not solve this issue !

Technische Daten

Material	rostfreier Stahl
Länge (mit Verlängerungsrohr 500 mm)	1.105 mm
Gewichte	
■ E-Löschlanze komplett (Griff, Verlängerung 500 mm, Spitze)	7.915 g
■ E-Löschlanze ohne Verlängerung	6.890 g
■ Lanzenspitze	210 g
■ Verlängerungsrohr 500 mm	820 g
■ Verlängerungsrohr 1.000 mm	1.910 g
Kupplung Storz	
■ Baugröße	DIN 25/D
■ Gewinde	1"

Stainless steel



Fire-control of li-ion battery:

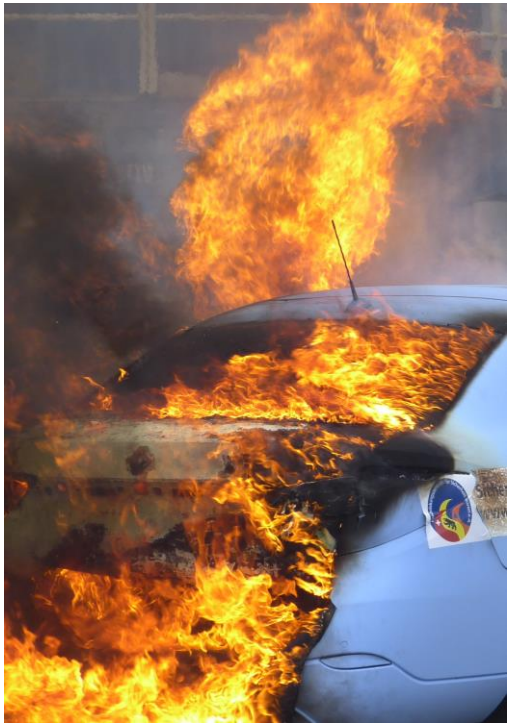
- Start of cooling in front
- Proceed backwards to the battery

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)

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!