Fire fighting operations
Electric vehicles

Adam Opel AG

GM Alternative Propulsion Center Europe

Fire fighting operations – electric vehicles
Introductory remarks I

- These documents provide more extensive information on the rescue data sheets for the Opel Ampera/Chevrolet Volt and the Opel HydroGen4/Chevrolet Equinox Fuelcell and should help to promote an understanding of the special operational needs of electric vehicles. In order to gain more profound knowledge, participation in courses on this topic is recommended.
- This complementary and non-binding information in no case replaces solid training in the basic subjects in the area of technical assistance for traffic accidents and fire fighting in line with the corresponding official regulations. Basic knowledge on technical assistance for traffic accidents and about the training contents for fire fighters (FwDV 2/2) and other relevant fire service regulations (FwDV) are required in particular. More extensive training in the area of technical assistance for traffic accidents is an advantage.
- This presentation has been prepared by the Department for Alternative Powertrains at Adam Opel AG in cooperation with the Fire Department of Adam Opel AG, Rüsselsheim plant.

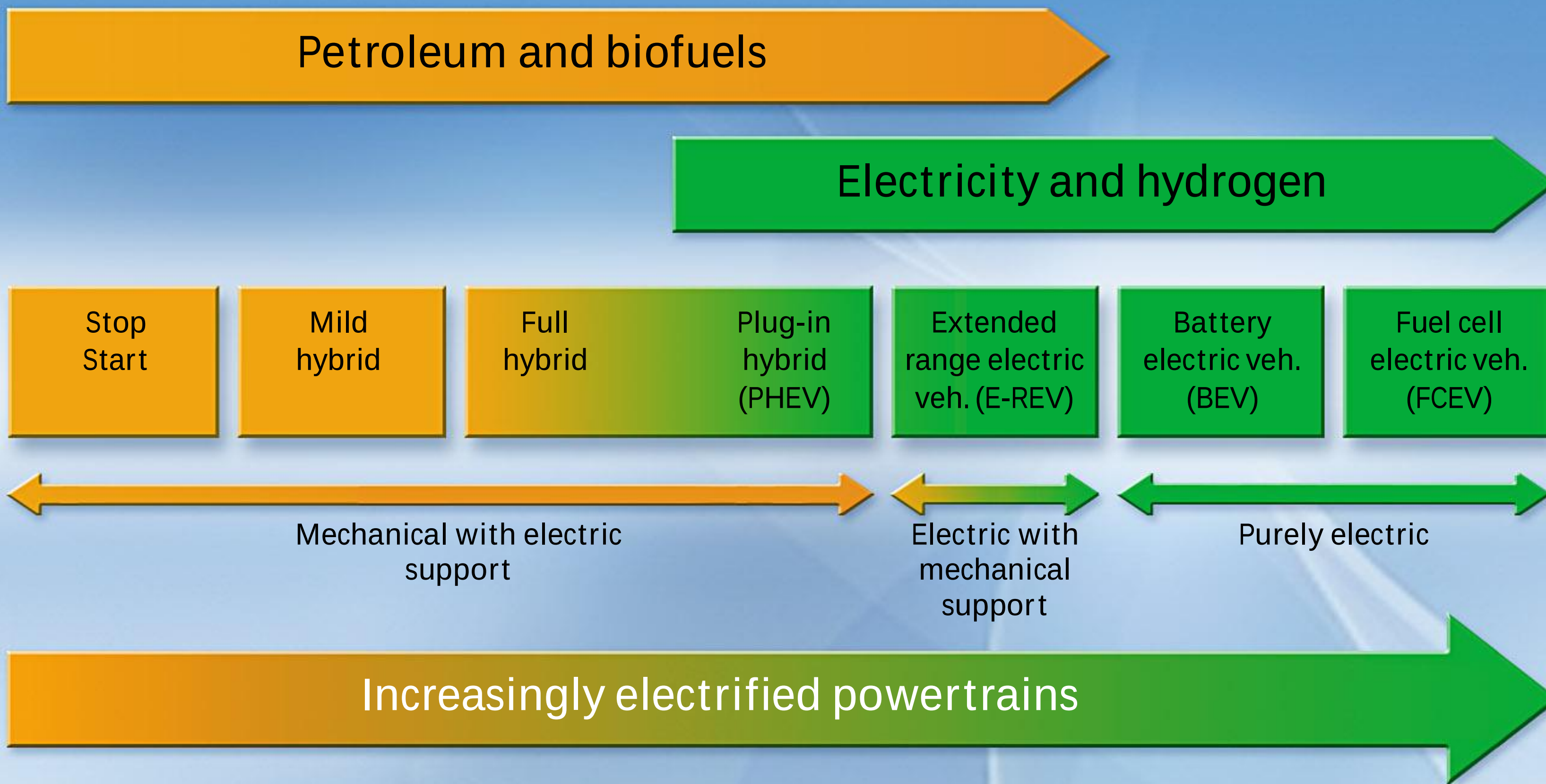
Fire fighting operations – electric vehicles
Introductory remarks II

- The recommendations referred to in this presentation must primarily be seen in the context of achieving the operational goal of the emergency services - i.e. the rescue of human life and fire fighting - and do not represent general rules for dealing with electrically operated vehicles.

Fire fighting operations – electric vehicles
Definitions I

- BEV = Battery Electric Vehicle
  - e.g. Opel RAK-e, Opel MeRegio, Mitsubishi i-MiEV, Peugeot iOn, Daimler A-Class E-Cell
- E-REV = Extended-Range Electric Vehicle
  - e.g. Opel Ampera, Chevrolet Volt
- FCEV = Fuel Cell Electric Vehicle
  - e.g. Opel HydroGen4, Chevrolet Equinox Fuel Cell, Daimler B-Class F-Cell
- HEV = Hybrid Electric Vehicle
  - e.g. Toyota Prius, Mercedes S400, Honda Insight, BMW 7active hybrid, div. Lexus

Vehicle electrification



GM APCE

Paradigm shift:
The cars of the future will run with electric power

Opel RAK e
(BEV)

Opel Ampera
(E-REV)

Opel HydroGen4
(FCEV)

GM APCE

Fire fighting operations – electric vehicles
Definitions II

- The term "low voltage“ : electrical voltages up to 1000 volts
- The term "high voltage": electrical voltages of more than 1000 volts

- Usual voltages in motor vehicles: 12 V (car) and/or 24 V (truck)

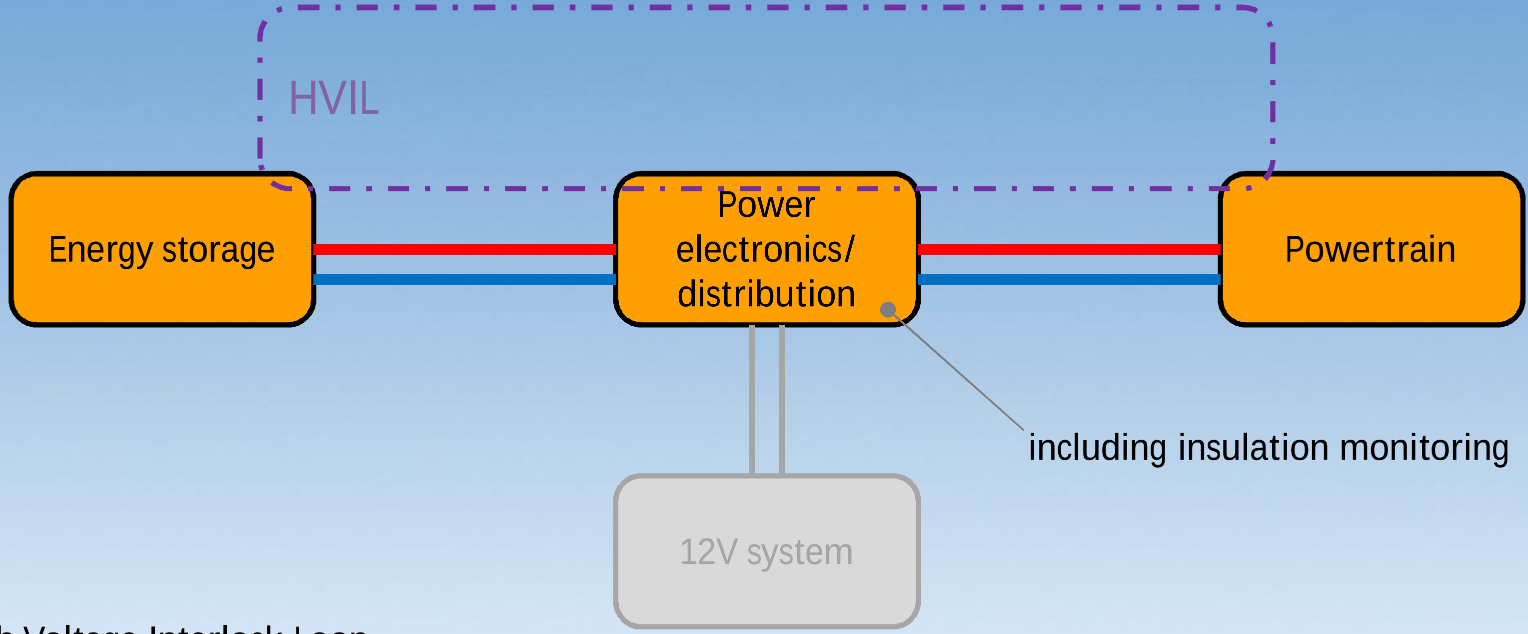
- Electric vehicles:
  - up to max. 650 V (depending on manufacturer)
  - max. 400 V Opel / GM at the present time
  - Standardised connectors allow up to 850V

- The automotive industry uses the term "high voltage" for the powertrain electrics.

Fire fighting operations – electric vehicles
Design features (multi vendor)

- Electric vehicles (EV) usually have two electrical systems
  - 12V electrical system for all usual electrical loads (lights, airbag, ABS, ESP control devices, radio, ...)
  - High-voltage system for the powertrain (depending on the manufacturer up to 650 V)
- Both systems are usually connected via power electronics (Charging the 12V system from the HV system)
- Each system usually has its own energy storage system (12V battery, high voltage battery)

Fire fighting operations – electric vehicles
Principle of the electric architecture of a BEV



HVIL = High Voltage Interlock Loop

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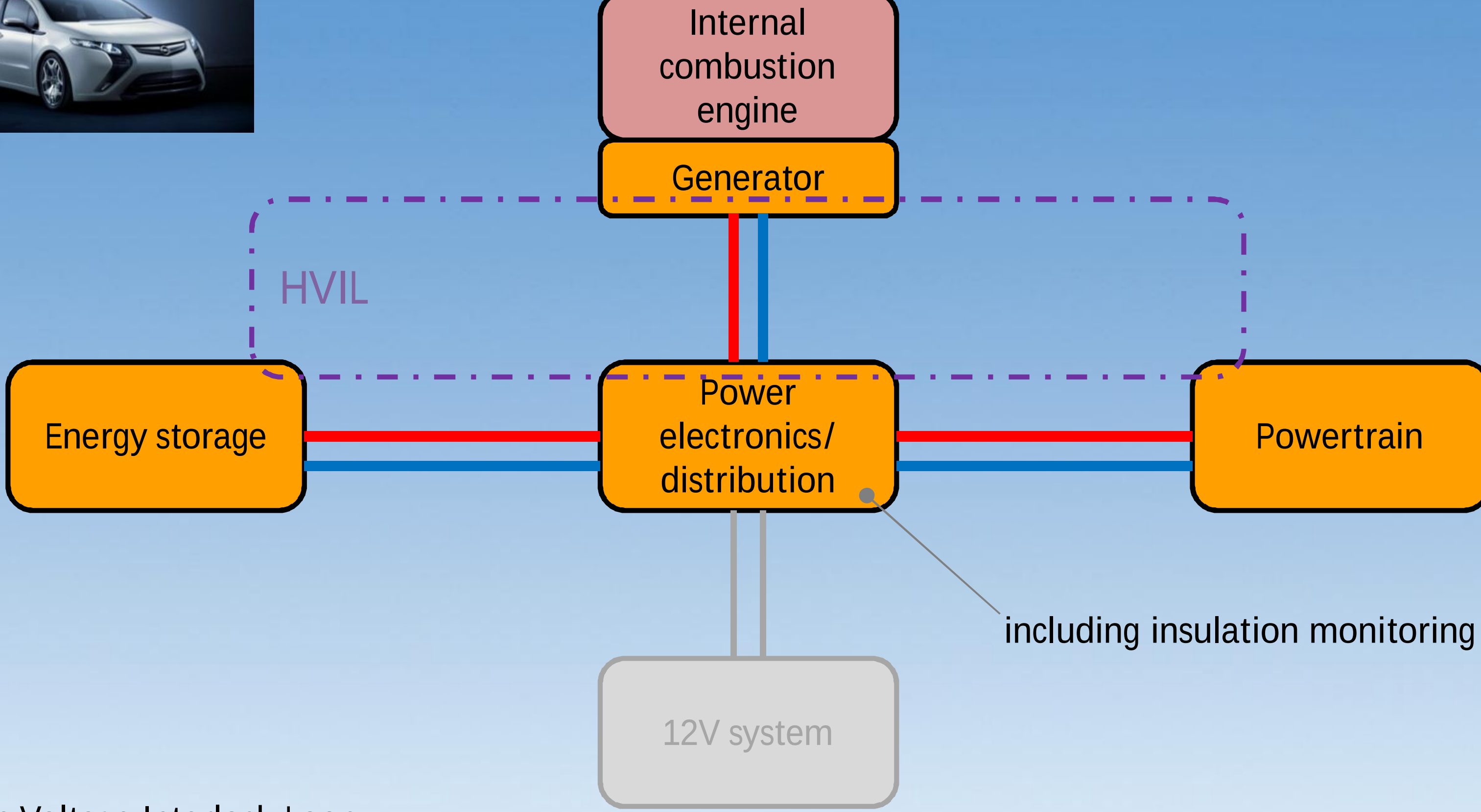
Principle of the electric architecture of an E-REV



HVIL = High Voltage Interlock Loop

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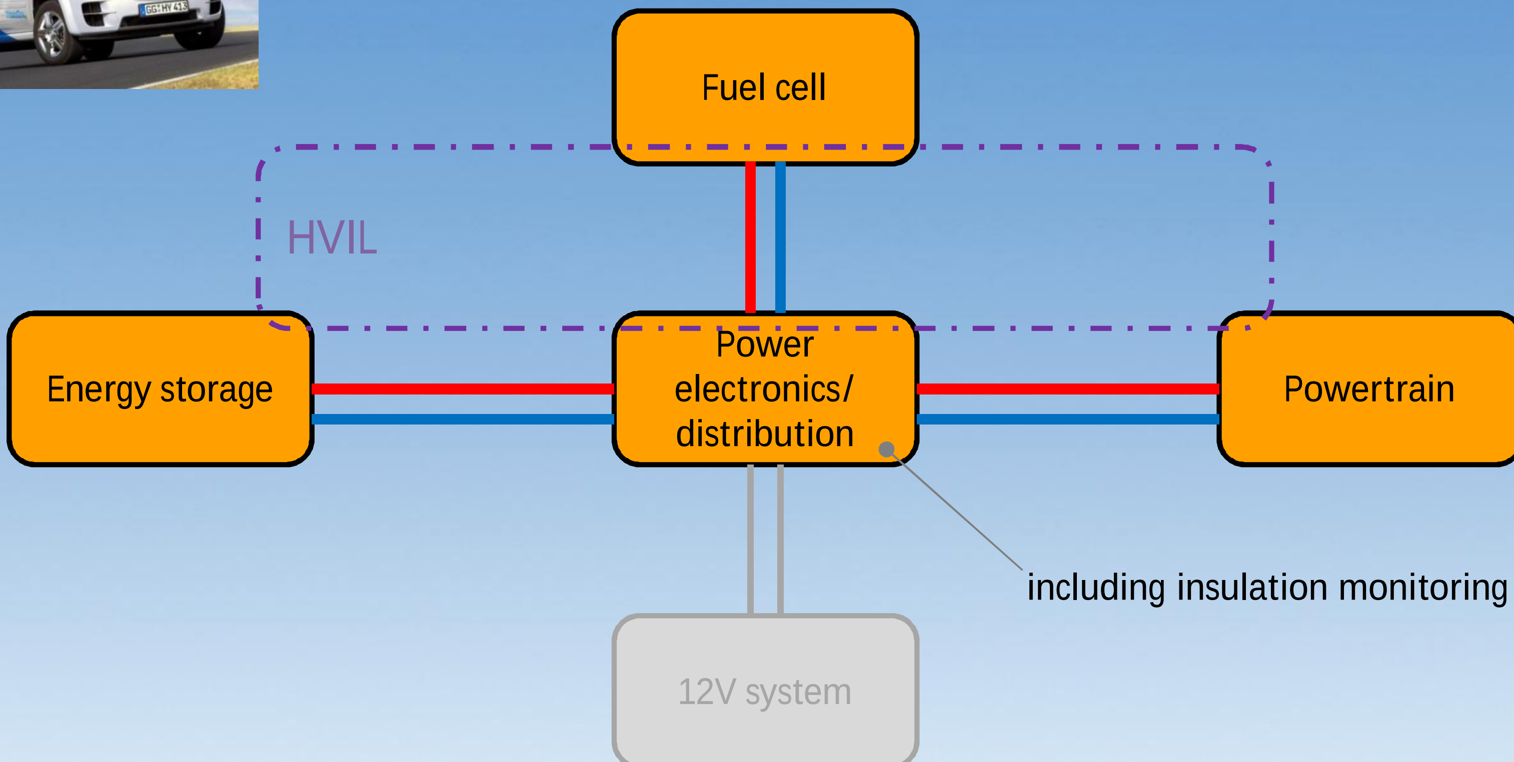
Principle of the electric architecture of a FCEV



HVIL = High Voltage Interlock Loop

Fire fighting operations – electric vehicles
Summary Architectural principles of xEV

- Electric vehicles always have an independent energy storage system, power electronics and an electric machine for the powertrain and energy recovery
- To produce electric energy, an internal combustion engine with an electric machine in generator mode (E-REV) or a fuel cell system (FCEV) can be additionally installed
- Passive and active safety devices are used to monitor the electrical systems

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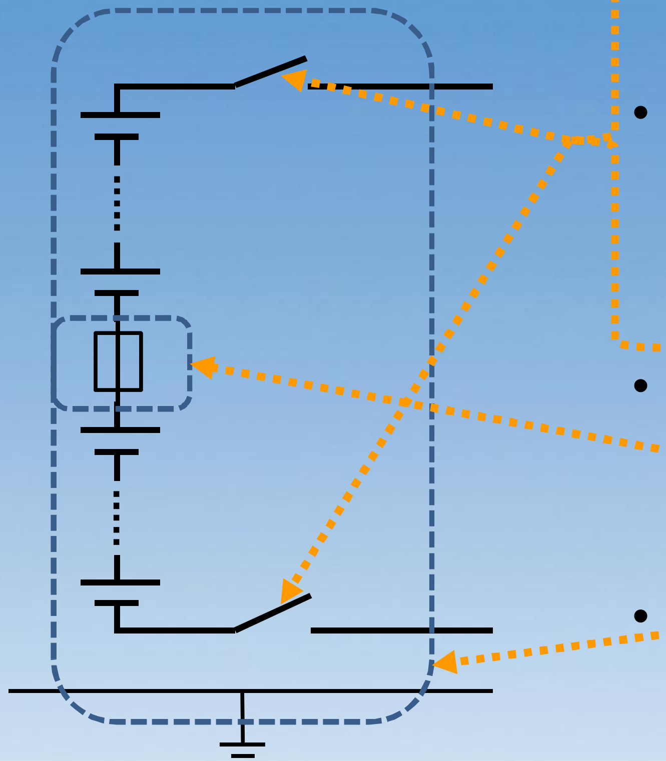
Schematic diagram of the high voltage battery in the Opel Ampera



- Battery switch contacts are controlled by control electronics.
- The switch contacts also open outside of regular operation when airbags are activated, HVIL is interrupted or when the 12V supply is disconnected.
- Manual Service Disconnect (MSD) includes not only load contacts and a high current fuse, but also HVIL control contacts.
- The Ampera high-volt battery is designed in protection class IP67 due to its installation position.

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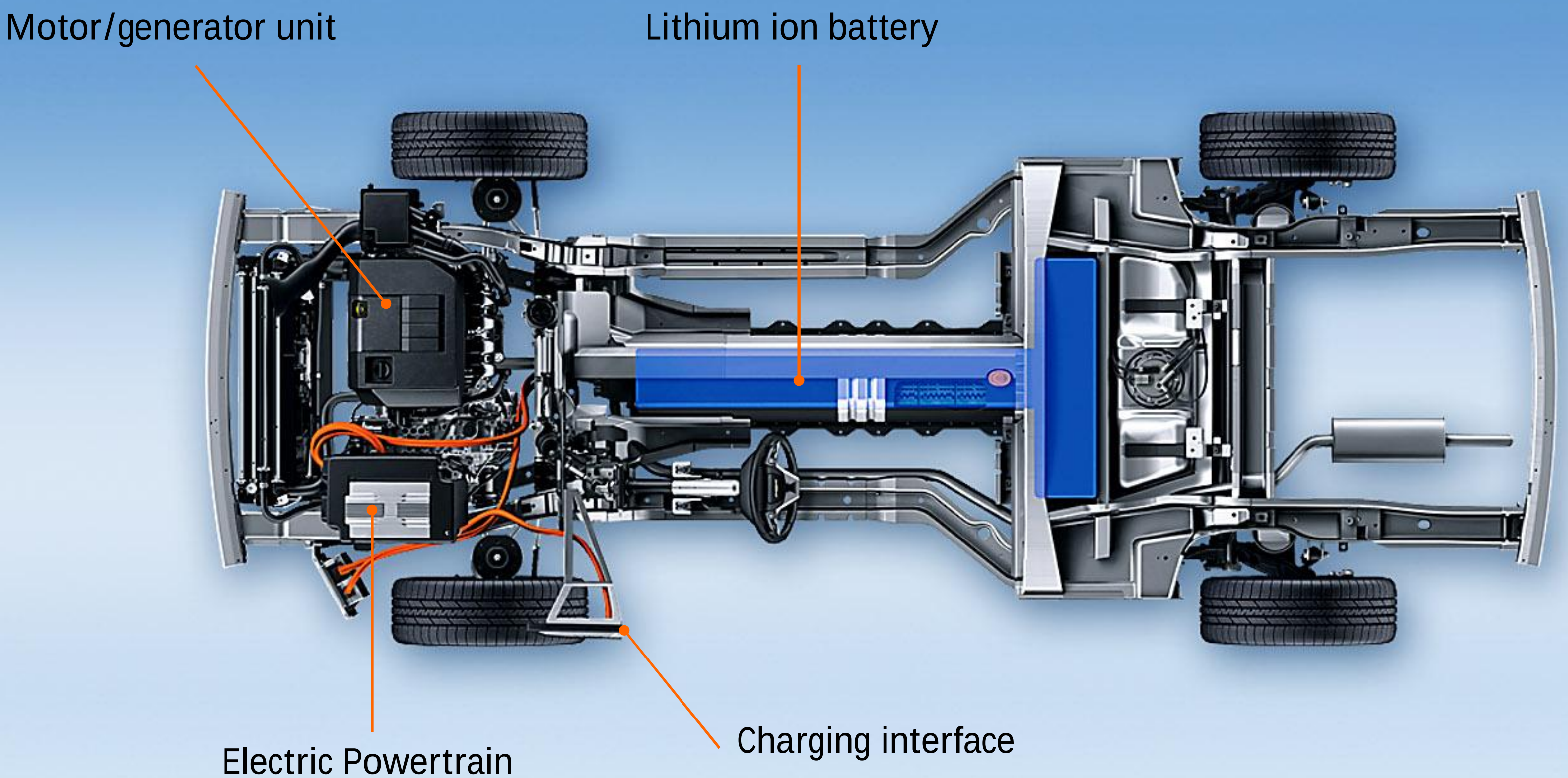
Design features II

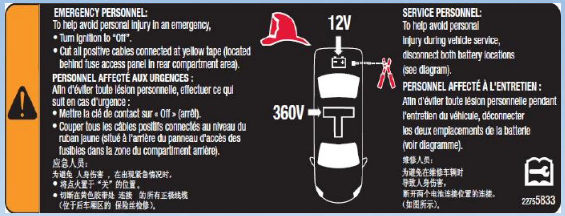


Fire fighting operations – electric vehicles

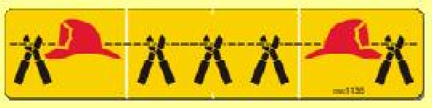
Design features III

- Safety-relevant components are mainly installed in crash-protected zones
  - High-voltage battery
  - High-voltage power electronics
- Orange high-voltage cables (colour is not yet ISO standardised!!)

- In high-voltage systems, forward and return lines are separate HV cables (see 12V system: "+" = cable, "-" = electrical ground potential on vehicle chassis)
- High-voltage components are usually identified by labels such as:



- GM/Opel vehicles are additionally marked with emergency service labels:



Fire fighting operations – electric vehicles
Design features (GM/Opel) I

- High-voltage systems in GM/Opel vehicles are equipped with internal monitoring devices which decommission the system in the case of an error and/or inform the driver of impending errors
  - HVIL (High Voltage Interlock Loop)
  - Insulation monitoring (Ampera: error display; HydroGen4: switch-off)
- Active self-discharge system of the high-voltage system in case of failure/accident
- A danger to passengers and pedestrians is virtually impossible
- If an accident occurs when airbags are activated or a vehicle rollover is detected, the high-voltage system is immediately deactivated

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Scenario "vehicle in the water"

- There is no immediate risk for the rescue workers in the water resulting from a high-voltage battery or a high-voltage system (such as "electric shock") !
  - Physical background: The close proximity of the poles determines the primary current flow
- All high-voltage components that are not installed in the interior of the vehicle are designed with higher degrees of protection (GM/Opel: at least IP67).
- When the entire battery is immersed in water, the possibility of an electrolysis reaction exists, depending on exposure time and immersion depth.
  - Depending on the conductivity of the medium (freshwater, salt water) oxyhydrogen gas can occur with varying intensity.
  - Depending on the state of charge and the salinity, electrolysis lasts from a few hours (sea water with high salt content) to a few days (freshwater).
- If the vehicle is recovered within a short period of time, the risk of oxyhydrogen gas is very low, in the opinion of the participating development departments.

Fire fighting operations – electric vehicles

Operational principles for accident assistance (general)

- In general, there is no significant difference in approach compared to "normal" vehicles:
  - Protect the vehicle from rolling away
  - Make sure the vehicle is in a safe system state
    - Shut the high-voltage system down (charge reduction according to the manufacturer in a few seconds to a few minutes; GM/Opel: a few seconds!)
    - Disconnect the 12V supply (Deactivation of the restraint systems)
    - Resources: Rescue Data Sheet
  - Ensure fire safety (water, foam, powder)
- Closing down the HV system refers to the HV components outside the HV battery; the HV battery itself is still supplied with energy!
- For GM/Opel vehicles, the following applies: When airbags are activated and rollover has been identified, the high-voltage system is automatically shut down!

Fire fighting operations – electric vehicles

Operational principles for accident assistance (high voltage system & battery)

- It is prohibited to cut into a high-voltage battery!
- Avoid cutting/separating orange high voltage cables
- Avoid cutting into other high-voltage components (power electronics)
- Wear extended PPE (face shield, safety glasses, chemical resistant gloves) in the event of a spillage of electrolyte (usually a gel) or of cooling agents
- Bind any leaking electrolyte with conventional binding agents
- After the high-voltage system shuts down, high-voltage batteries can also contain a large amount of energy (sometimes several kWh), depending on the state of the charge! (see fuel tank of a vehicle involved in an accident)

Fire fighting operations – electric vehicles

The myth of battery fire = light metal fire?

- Because of the materials used (e.g. lithium in Li-ion technology) the myth of a risk of light metal fire still prevails.
- In Li-ion batteries, lithium compounds, but not pure lithium or lithium alloys are used.
- The mass fraction of lithium is ~ 1%
- Opel Ampera:
  Lithium content 1,5 kg
  - with a total battery mass of 198 kg
  - and/or cell mass of 112 kg
- Because of the "cell chemistry" and the low level of lithium in the battery mass, light metal fires can be excluded.

Fire fighting operations – electric vehicles

Operational principles for fire fighting

- self-contained breathing apparatus (obligatory)
- Due to the presence of electrical energy, the distances according to DIN VDE 0132 apply to fire fighting measures.
- The distances indicated in DIN VDE 0132 (N-1-5) are valid for CM nozzles at voltages up to 1,000V.
- With respect to the use of fog nozzles, please refer to the general operation principles of HSR in electrical systems.
- Extinguishing agents/procedures: Water spray jet
- No special extinguishing agents are required for fire fighting measures in electric vehicles and/or high-voltage batteries.
- Cool the high-voltage battery after a fire, if possible, with a spray jet (limited accessibility, mostly installed in the floor of the vehicle).

Note: Fire fighting in line with the regulations indicated in DIN VDE 0132, is recommended for safety reasons, as these include both driving operations and the state when loading the HV battery from the public network.

Fire fighting operations – electric vehicles

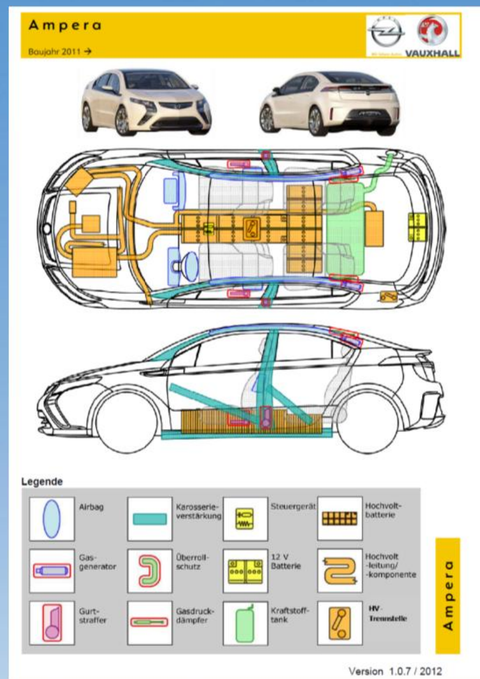
Summary

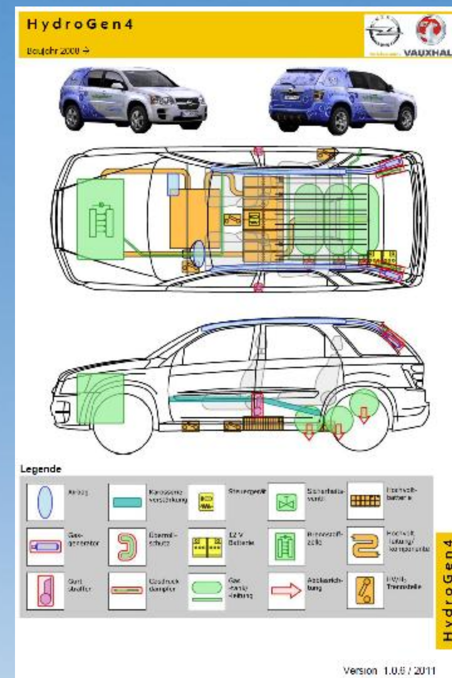
- Operations on electric vehicles do not differ fundamentally from operations on "normal" vehicles
  - ➢ The usual procedures continue to apply
- Putting the vehicle in a safe system state (Resources: Rescue Data Sheet)

<u>New additions include:</u>

- It may be necessary to decommission the high-voltage system
- It is prohibited to cut the high-voltage battery!
- Avoid cutting high-voltage cables/components
- <u>Water spray</u> jet is the preferred extinguishing agent when dealing with electrical systems, use <u>foam</u> preferably for tires and plastic parts
- If possible, cool the high-voltage battery using a water spray jet after a vehicle fire (increased need for extinguishing water)

Rescue Data Sheets





http://www.opel-rescuecard.com

[Opel/ VX Rescue Data Sheets:](http://www.youtube.com/watch?v=_k7jo8zRM1Q)
[http://www.youtube.com/watch ?v=_k7jo8zRM1Q](http://www.youtube.com/watch?v=_k7jo8zRM1Q)


GG EV 61
GM APCE