

EV/Hybrid Systems

MDOT Safety Training
October 17, 2023

Objectives

1. Discuss battery principles
2. Explain thermal runaway and stranded energy
3. Explain Electric Vehicle and Hybrid Electric Vehicle components
4. Explore the dangers of high voltage and proximity key systems
5. Illustrate ways to identify vehicles involved in scenes
6. Explain how to immobilize and disable vehicles
7. Discuss the characteristics of Electric Vehicle accidents and fires
8. Provide resources and tools needed to safely control scenes

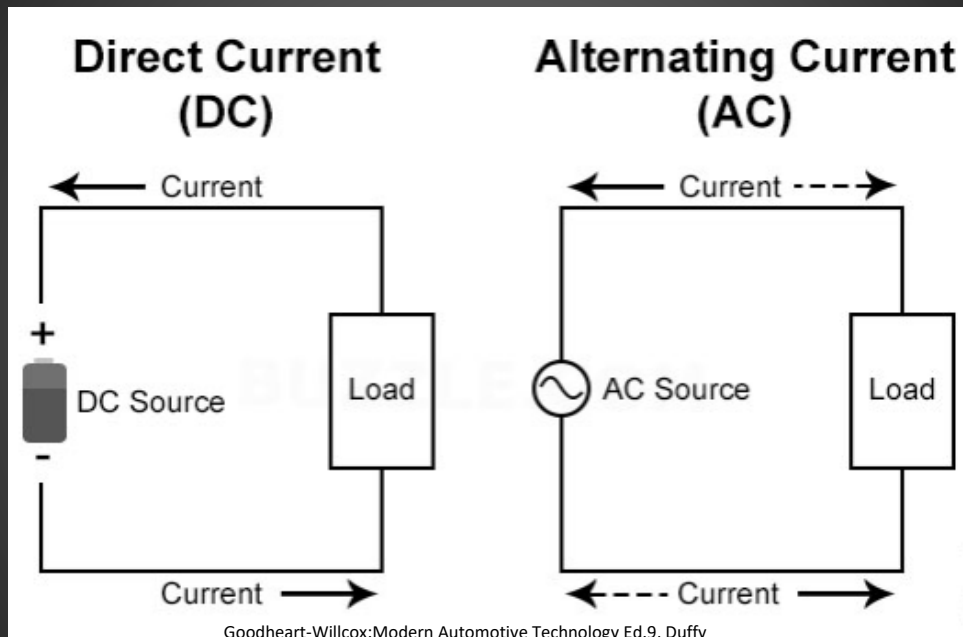
Basic Background Knowledge

AC Voltage: Alternating current, flows positive and negative.

- Produced by magnetic field rotation through wire
- Ex. Outlets in residential/buildings utilizing earth ground
- Will flow through human body if contact “hot” while touching ground

DC Voltage: Direct Current, flows one way

- Produced by battery
- Ex. Mobile powered devices such as phones and flashlights
- Must complete positive to negative path with body to receive shock



Basic Background Knowledge

ICE: Internal Combustion Engine

EV: Electric Vehicle propelled by only electric motors

HEV: Hybrid Electric Vehicle propelled by electric motors and ICE

PHEV: Plug-in Hybrid Electric Vehicle

CNG Vehicle: Vehicle propelled by Compressed Natural Gas

LNG Vehicle: Vehicle propelled by Liquid Natural Gas

LPG Vehicle: Vehicle propelled by Liquid Propane Gas

Battery Types

Nickel Metal Hydride (NiMH)

- Toyota still uses
- Contain small liquid solution (Gel)



Lithium Ion

- Surpassed NiMH for usage in 2020
- Cylindrical, Pouch, Prismatic
- Solid state or liquid Li-Ion (Gel)

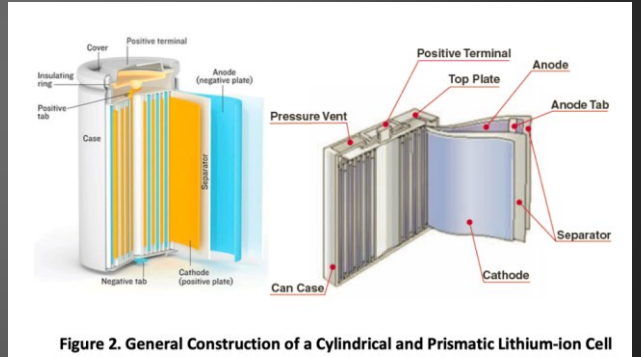
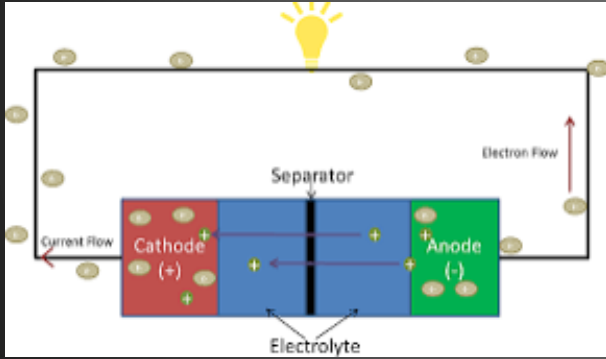


Forms

- Pouch, Cylindrical, Prismatic

Battery Design

Anode, Cathode, Separator



Uses

Most modern rechargeable devices

- Phones
- Smart Watches
- Toothbrushes
- Scooters, Bikes
- Hoverboards
- Cars
- Busses



autoweek.com



nypost.com

Thermal Runaway

Damaged separator, Overcharge/Rapid charge, Non-certified batteries

- Causes internal overheating
- Leads to propagation
- Off gassing toxic gas
 - Tesla Term- “Cherry Bubble Gum”
- Flammable
- Explosive

Pouch Battery



Electric Scooter



EV Fire Rates



Stranded Energy



Stranded Energy

Compromised batteries can enter runaway phase for weeks (Chevy Volt Reignited 3 weeks after test)

Packs are sealed

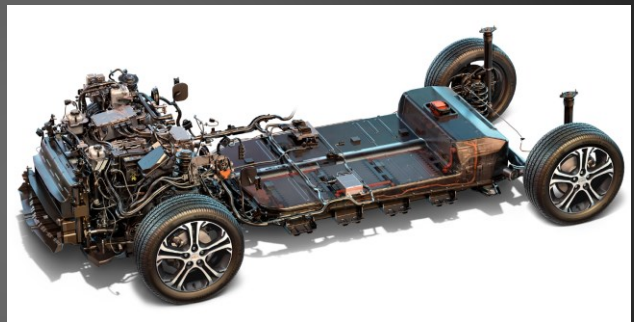
- Submerging doesn't work
- "Rosenbauer" Nozzle



EV Main Components

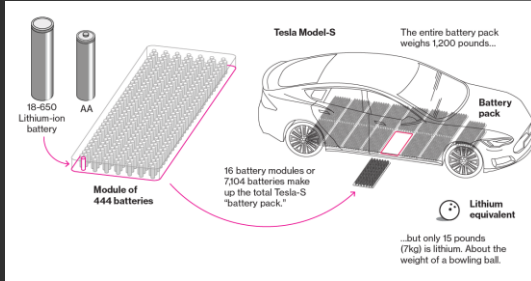
- Inverters: Convert DC to AC to be used by motors
- Converters: Increase or Decrease voltage (AC or DC)
- High Voltage battery: Can be 100-800V Li-Ion
- Low voltage battery: 12V lead acid
- Emergency Disconnect: Used to Disable HV system
- High Voltage disconnect: Used for vehicle service not disabling
- 12v control relay: 12v relay located in HV battery that controls HV
- Charging Port
- High Voltage Cables
- Key fob/card- Proximity Keys

Chevy Bolt/Volt Battery and Motor



GMcenterlearning.com

Tesla Lithium Ion Batteries



Teslabattech.com

*Battery packs maybe cooled with coolant which can leak out when damaged. Often mistaken for acid leaking.

Batteries account for 40% of vehicle cost 2016



Ford Lightning Battery



insideevs.com



Proximity systems

- [Toyota ERG](#)
- “Ready” “Run” light
- Key Fob/Proximity key
 - Active up to 16ft
 - Can start ICE on HEV
 - Activates 12v electric system- airbags, pretensioners
- Auto start/stop
 - Brake pedal release



toyotalearning.com

Identify

Limited grille openings

Badging

Charge Port



GMcenterlearning.com, Ford/EV/training.com



Fuel Cell Identifying

CNG: Blue Diamond right rear



LNG: Blue Diamond right rear



LPG: Black Diamond right rear



NFPA: Altfuel imagery

CNG and LPG



Fuel Cells

CNG: 3,600 psi and lighter than air

LNG: 120 psi, vapors are lighter than air, cryogenic state

LPG: 200 psi, heavier than air

Basic Scene Response

1. Identify

- Communicate to departments or dispatch
 - What is involved, systems affected, vehicle state, compromised areas

2. Immobilize

- Approach from 45 degrees
- Chock vehicle wheels
- Briefly attempt to locate proximity key

3. Disable with ERG and Relocation

- [Tesla ERG](#)



Unique Hazards

- Both 12v battery and DC to DC converter should be consider power supply to 12v relay.
 - Regenerative systems can store energy in capacitors for over 10-15 minutes after disablement
 - HV fuses designed to rupture during short or collision
 - Disabling 12v system disables HV, airbags, pretensioners, ect.
 - HV battery still energized
 - Disabling ignition and disconnecting 12v battery will disable 12v system and converter
 - Removing HV from fuse box secondary disablement method
- *Cutting 12v cable is not complete disablement

Disabling the High Voltage System

- Use ERG to locate 12v disconnect and HV cut loop/Plug



Retrieved from: <https://www.tesla.com/firstresponders>

Retrieved from: <https://www.tesla.com/firstresponders>

Scene

Fires

1. Establish 80-100 ft safety zone
2. Control Traffic
3. Fire Blanket to relocate
4. Run off may require HazMat

Accidents

1. Determine battery state
2. Establish safe zone
3. Thermal Image for heat and monitor
4. Compromised battery systems may require HazMat
5. Submerged will “Micro Bubble”

[Fire Blanket](#)



Hazards of accidents

- If the high voltage battery receives damage, it can release toxic vapors including sulfuric acid, oxides of carbon, nickel, aluminum, lithium, copper, and cobalt. volatile phosphorus pentafluoride may form at temperatures above 230° Fahrenheit.
 - Full PPE including SCBA recommended
 - Use fog streams and PPV fans to redirect these vapors if necessary
- Vehicles can still move if “run” system is active and proximity key is near

Hazards of accidents

- Lithium-ion Battery
 - The HV is comprised of lithium-ion cells, which are considered dry cell batteries and if damage may leak a small amount of clear battery fluid
- Components of the electric motors are liquid cooled with a glycol-based, blue-colored fluid, which may leak out if these components are damaged
- Front carrier on the rear wheel drive Tesla Model S is magnesium



ERG Sources

- <https://www.nfpa.org/Training-and-Events/By-topic/Alternative-Fuel-Vehicle-Safety-Training/Emergency-Response-Guides>
- All Manufactures

Apps

- EVR- EV Rescue-Electric Vehicles
- Euro Rescue
- ANCAP Rescue
- moditech

EV & AFV ERG's & TRAINING App / Internet Links

EURO RESCUE



MODITECH



ANCAP RESCUE



NFPA ERG's



NFPA EV & AFV Training

<https://www.nfpa.org/EV>



Summary

- Critical to obtain identification of vehicle ASAP
- Damage to HV systems may not be visible immediately
- Damaged batteries can lead to thermal runaway and stranded energy
- Active “run” systems can cause vehicle movement
- Immobilize and disable systems as soon as possible
- Communication between dispatch, law, fire, ems, towing
- Utilize ERG's

References

- Archer, Brock. (2016). Tesla EV safety training video. *Advanced Extrication*. Retrieved from: <http://advancedextrication.com/2013/03/tesla-ev-safety-training-video/>.
- International Energy Agency. (2016). Global EV outlook 2016: Beyond one million electric cars. *International Energy Agency Publications, 2016*. Retrieved from https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf.
- Nanalyze. (2017). How many electric cars are there in the USA? *Nanalyze*. Retrieved from <http://www.nanalyze.com/2017/03/electric-cars-usa>.
- [National Fire Protection Agency]. (2014, Dec 9). *Tactical considerations for extinguishing fires in hybrid and electric vehicles* [Video File]. Retrieved from: https://youtu.be/mtCk3srID_w.
- Tesla Motors Inc. (2009). *Roadster: Emergency Response Guide*. Palo Alto, CA: Tesla. Retrieved from: <https://www.tesla.com/firstresponders>.
- Tesla Motors Inc. (2013). *Model S 2013: Emergency Response Guide*. Palo Alto, CA: Tesla. Retrieved from: <https://www.tesla.com/firstresponders>.
- Tesla Motors Inc. (2014). *Model S 2014: Emergency Response Guide*. Palo Alto, CA: Tesla. Retrieved from: <https://www.tesla.com/firstresponders>.
- Tesla Motors Inc. (2015). *Model S 2014-2015 AWD Dual Motor: Emergency Response Guide*. Palo Alto, CA: Tesla. Retrieved from: <https://www.tesla.com/firstresponders>.
- Tesla Motors Inc. (2016). *Model S 2016: Emergency Response Guide*. Palo Alto, CA: Tesla. Retrieved from: <https://www.tesla.com/firstresponders>.
- Tesla Motors Inc. (2016). *Model X 2016: Emergency Response Guide*. Palo Alto, CA: Tesla. Retrieved from: <https://www.tesla.com/firstresponders>.
- <https://www.samsungsdi.com/column/technology/detail/56462.html?listType=gallery>
rosenbaueramerica.com

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