ELECTRIC, AND HYBRID ELECTRIC

General Motors Hy-Wire

•Applied to all types of vehicles

•Applied by every automotive manufacturer, and small specialty companies as well.

•Ford is predicting by 2010 that ½ of their fleet will be hybrid capable.

•Not new.

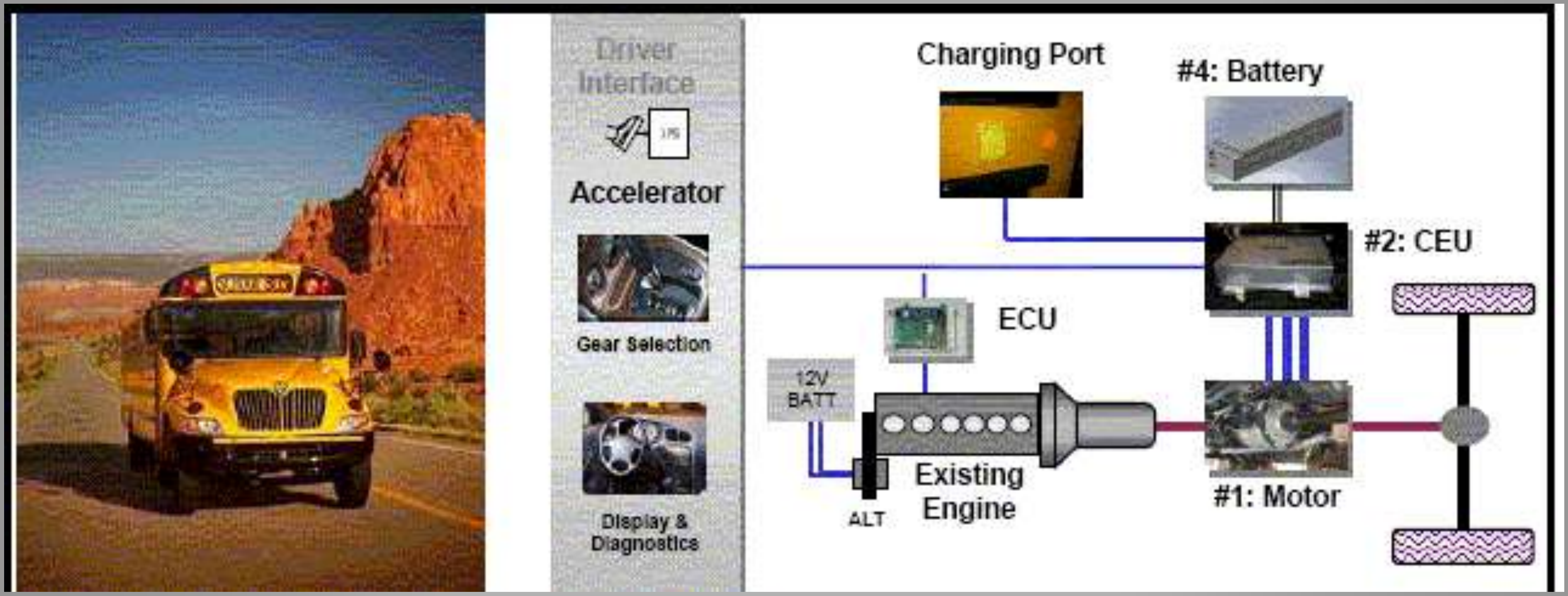

Chevrolet Volt

Plug-in Hybrid using an Electric Motor, and a 1.0L Engine driving a generator to obtain 150 mpg. Will travel up to 50 miles on the battery alone! (350 miles on battery and tank of gas.)

Other companies working on PHEV SUV capable of 100 mpg and 40 miles on all-electric mode.

Pure Electric

Pure Electric


Driver Interface
Accelerator
Gear Selection
Display & Diagnostics
Charging Port
#4: Battery
#2: CEU
ECU
12V BATT
ALT
Existing Engine
#1: Motor

From hybrid designs that can run on diesel and/or battery, then battery only to operate a 'boom' (for example) to a pure electric medium duty truck that can operate up to 100 miles

Ann Arbor Transportation Authority (and other agencies) have hybrid electric busses.

Tesla Motors, Inc.

Top speed 130 mph

Manufacturer based out of San Carlos, CA, but building a $47+ million R&D facility in Rochester Hills, MI

100 cars at $100,000 are already sold!

Series Gasoline/Electric Hybrid

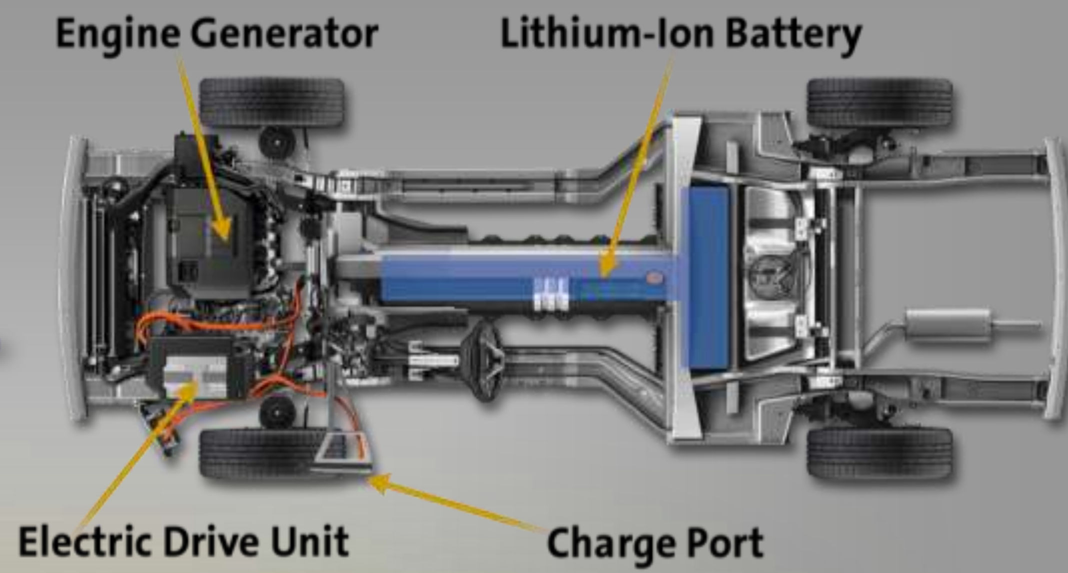
Parallel Gasoline/Electric Hybrid

Series Gasoline/Electric for FWD, and Parallel Electric for RWD (4WD)

Honda Accord, Civic, Insight, Toyota Camry, Prius, Highlander, Estima, Lexus LX400h, LS600h, Ford Escape, Mercury Mariner, GMC Pick-up, Chevrolet Pick-up, Tahoe, Saturn Vue, BMW X3…

MAJOR COMPONENTS

- **Charger**
- **Traction/Propulsion Battery (Multiple cells wired in series to store DC power)**
- **Controller (Supplies current to motors in either DC or AC form – up to 900 VDC and/or 1000 VAC!)**
- **Electric Traction/Propulsion Motor**
- **Hybrid Electric vehicles also have a conventional IC engine**


Engine Generator
Lithium-Ion Battery
Electric Drive Unit
Charge Port

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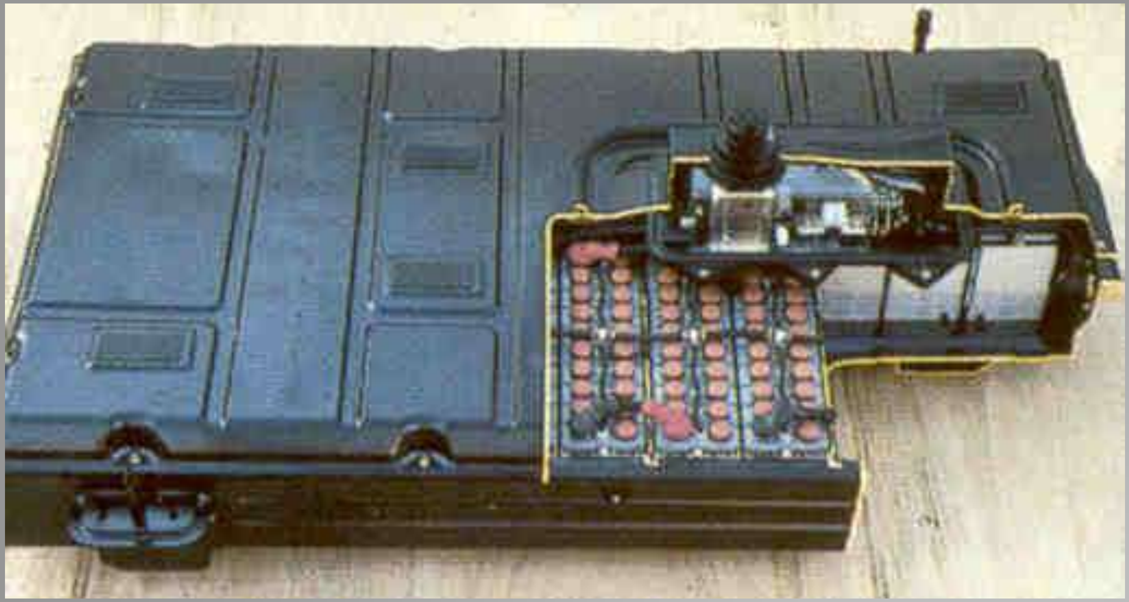
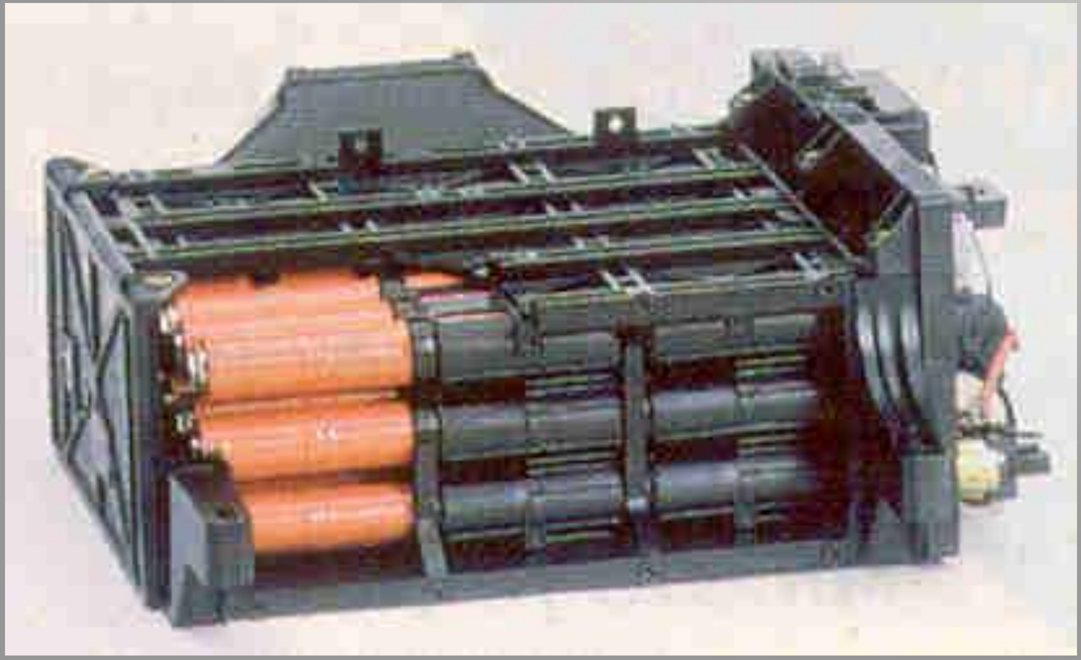


Ranges over 650 volts, with ability to flow over 400 Amps.

In addition to the traditional 12 V battery.



Lead Acid,

Lithium Ion,

Nickel Metal Hydride,

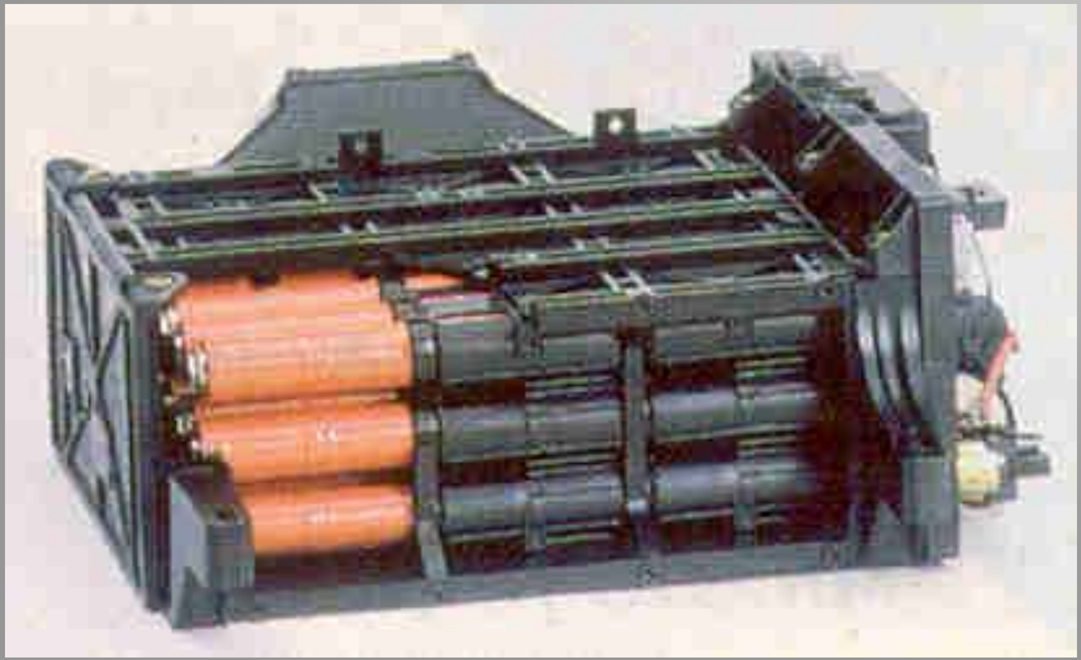
Nickel Cadmium,

Sodium borohydride

- Some are acid, and some are alkaline.

The electrolyte in a NiMH battery is a gray paste-like substance with a pH of 13.5.

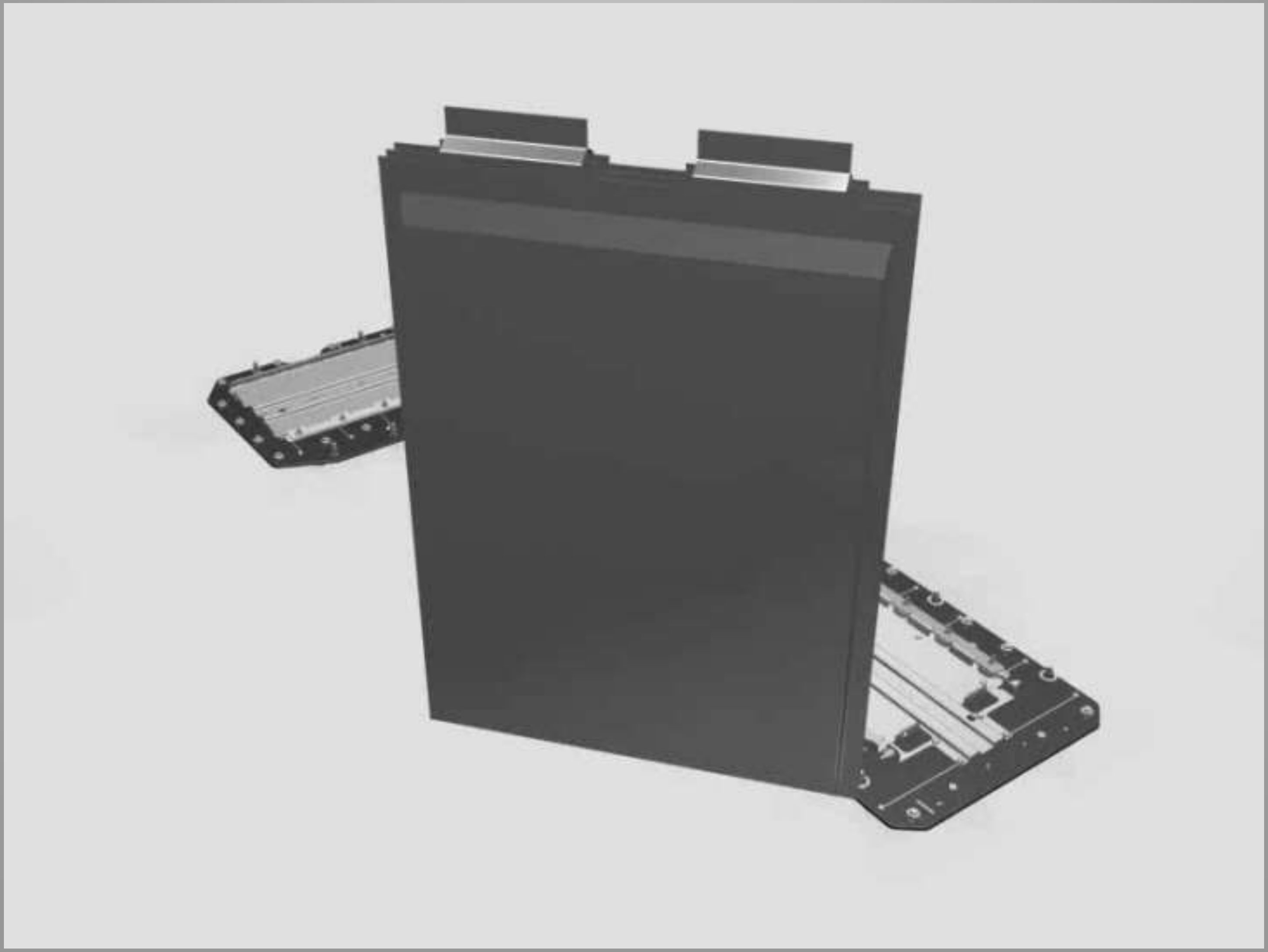
A ‘base’.



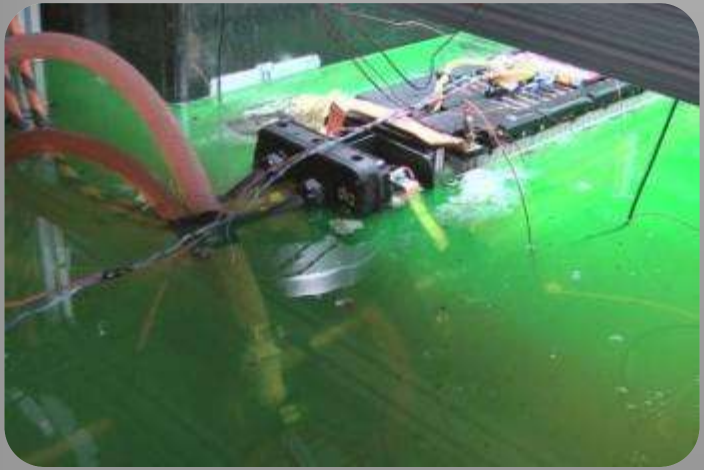
Ranges over 650 volts, with ability to flow over 400 Amps.

Nickel Metal Hydride

Volt Battery/Vehicle Integration: Details



Battery Abuse Testing



- Charge / Discharge
- Vibration
- Nail Penetration
- Cold Conditions
- Hot Conditions
- Short Circuit
- Humidity
- Fire
- Crush
- Water Immersion

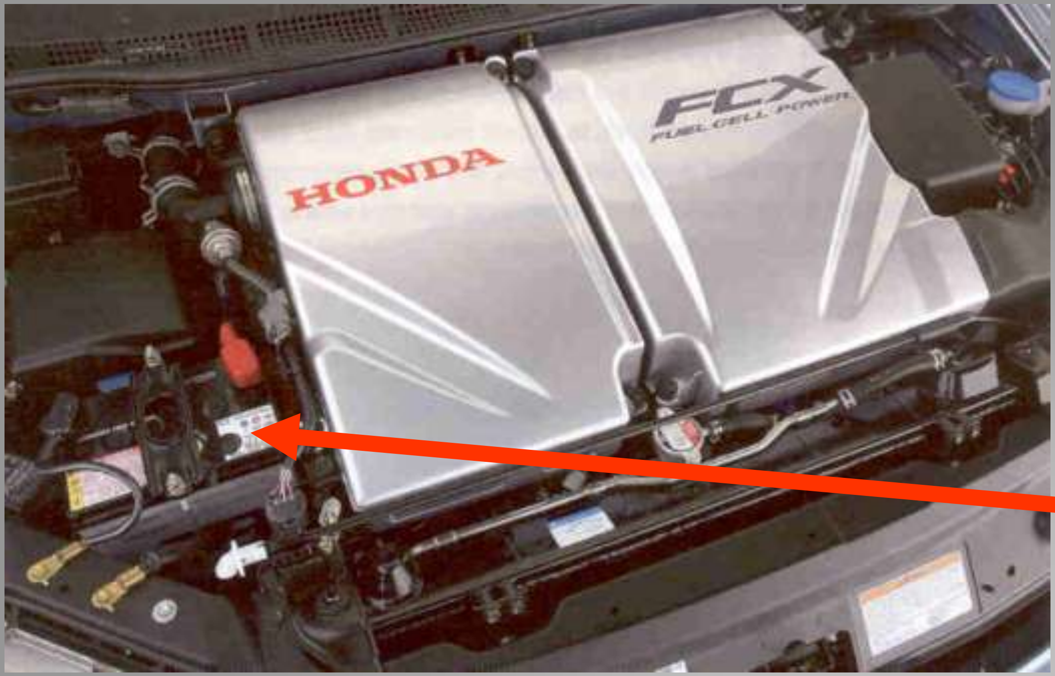
Some recharge by plugging into a charging station.

(Westland apartment complex, Meijer in Warren, Allen Park, and Holland, Schoolcraft College, GVSU…)

Others (most) use a 'regenerative braking system' and/or generator system within the drive train.

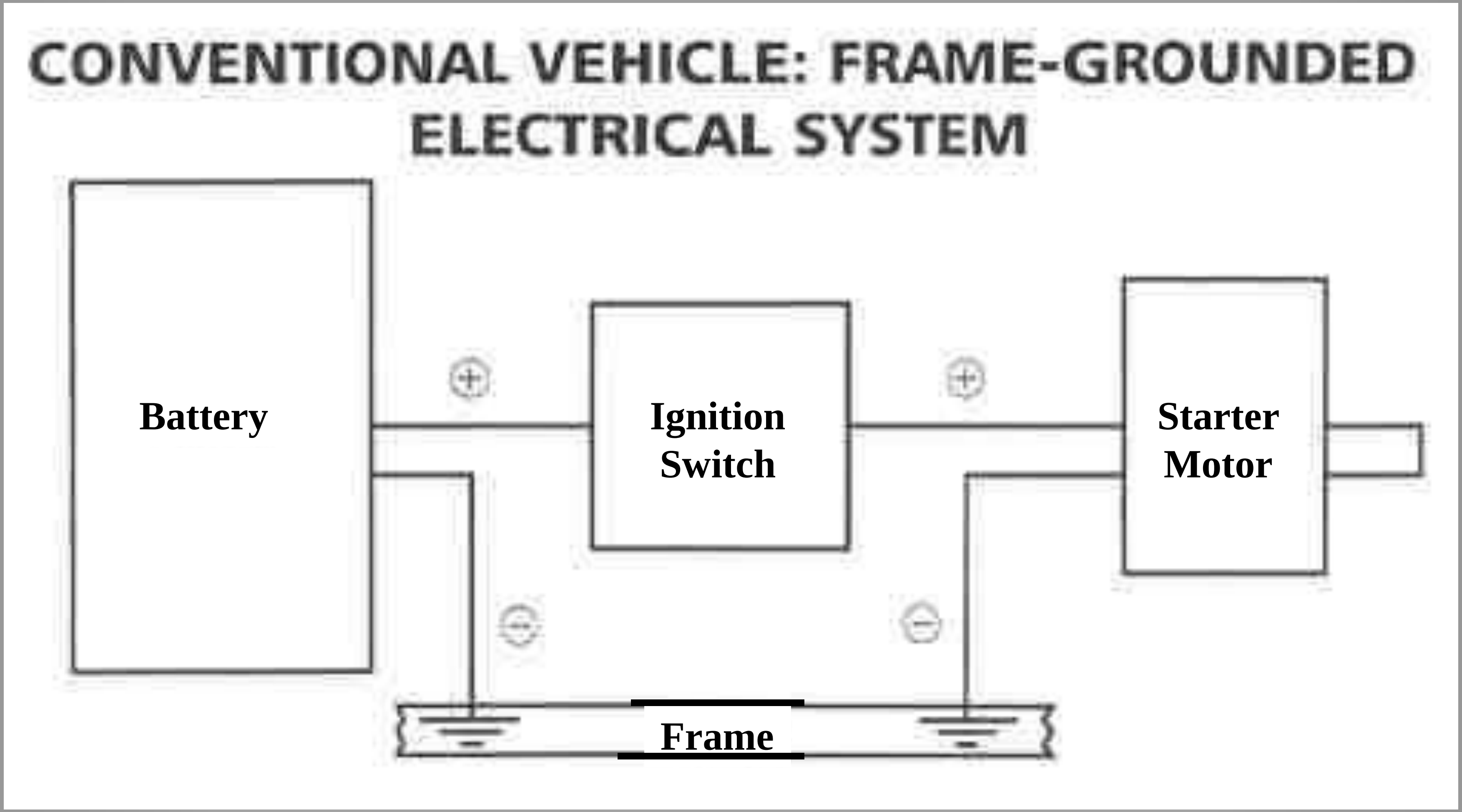
Controller for Electric Vehicle

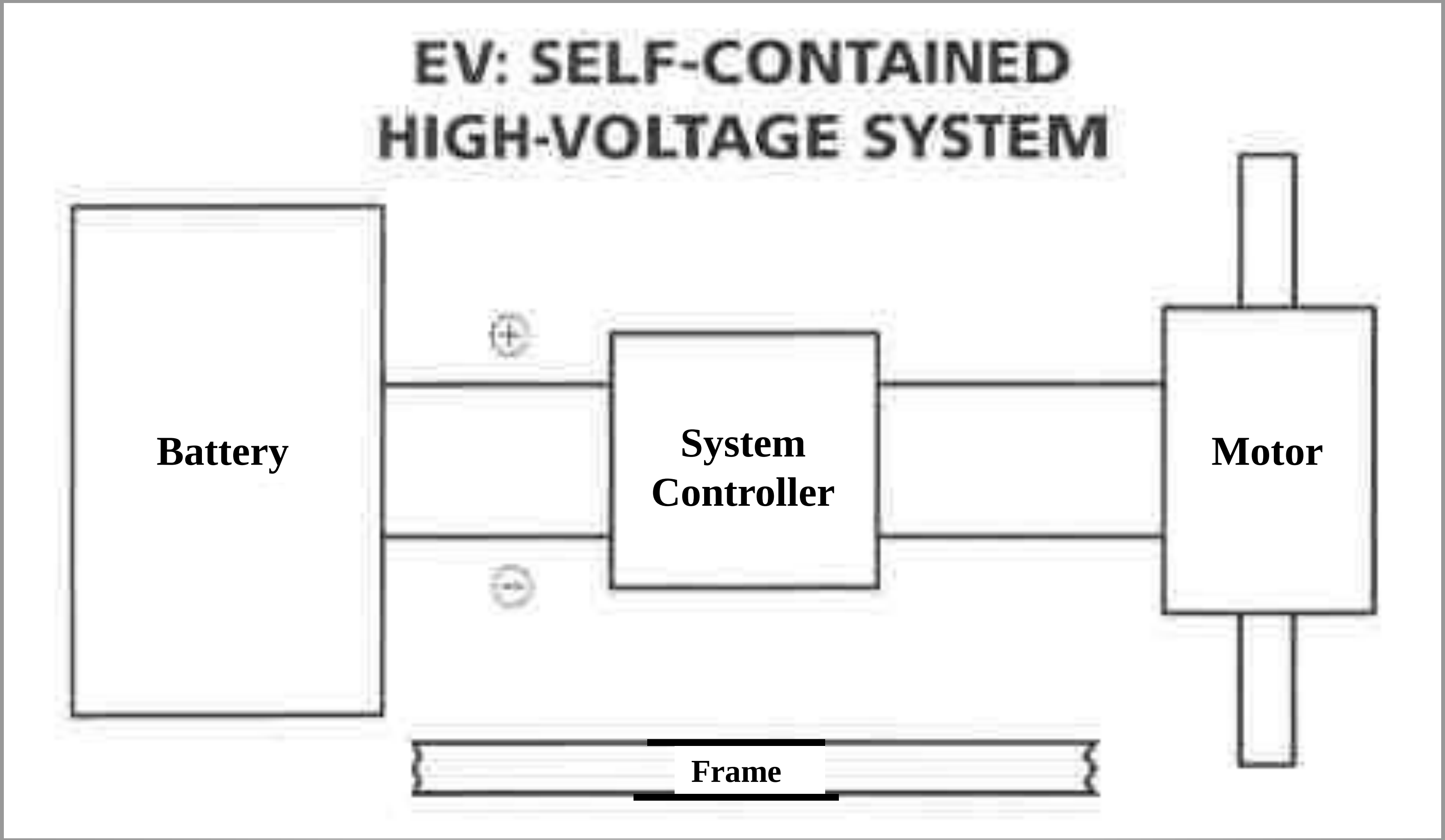
Utilizes/Requires a separate cooling system dedicated to the high voltage components.



Controller for Gasoline / Electric Hybrid Vehicle

Note the 12 volt battery


CONVENTIONAL VEHICLE: FRAME-GROUNDED
ELECTRICAL SYSTEM
Battery
Ignition
Switch
Starter
Motor
Frame



Potential for electrical shock is ‘minimized.

High Voltage System is isolated from the frame, and "contained" when:

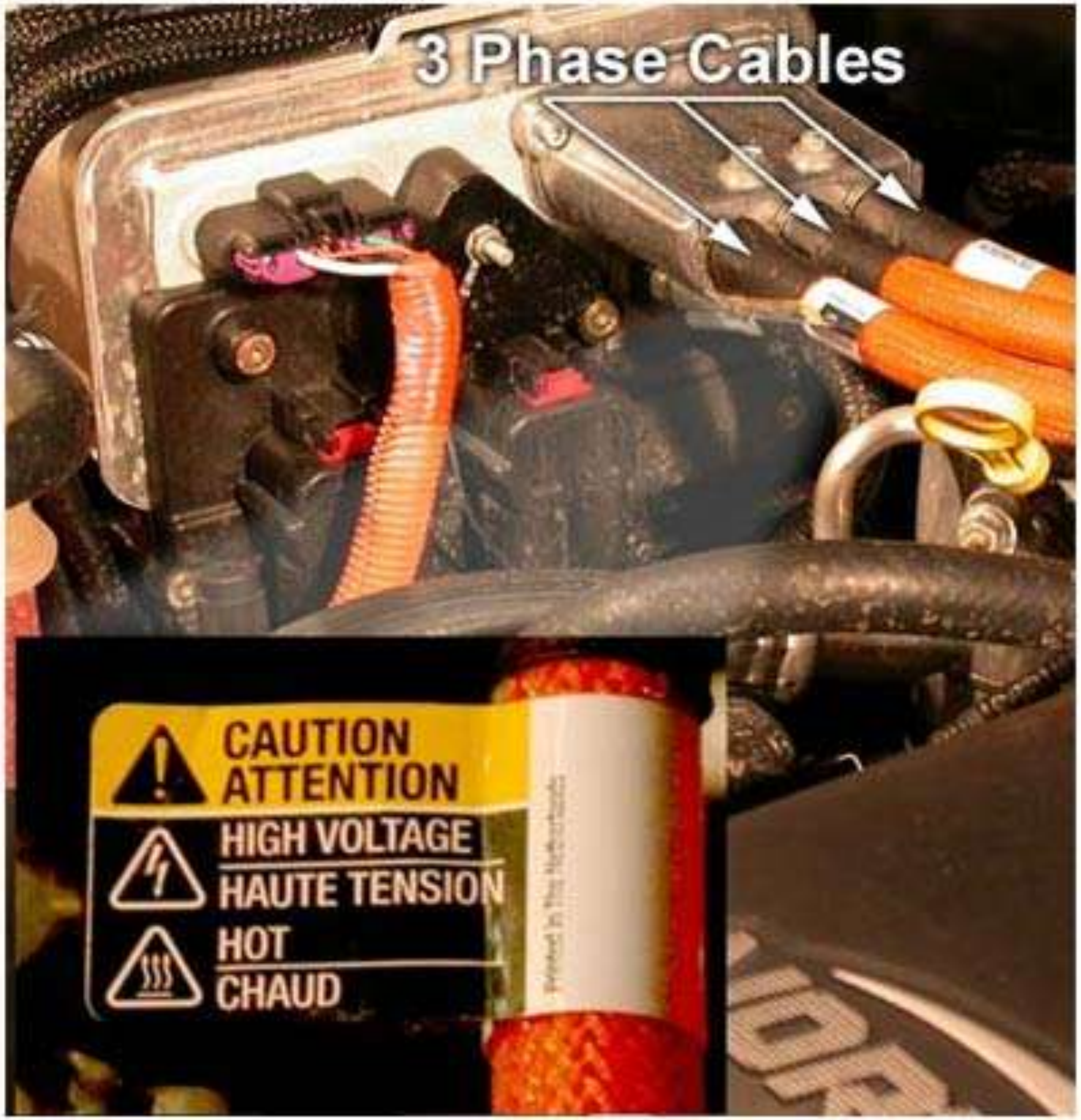
- **The vehicle is off,**
- **High voltage disconnect is off,**
- **The 12V battery is disconnected,**
- **Crash/inertia switches are triggered**
- **Interlock wiring is interupted, or**
- **GFI- type breaker is tripped.**

May also use high temperature (140 deg F) disconnect, and/or high amp fuse.

High voltage cable with outer shield and grounding system for protection.

High voltage cables carrying DC or 3-phase AC are marked/wrapped <u>orange or yellow.</u>


VORTEC



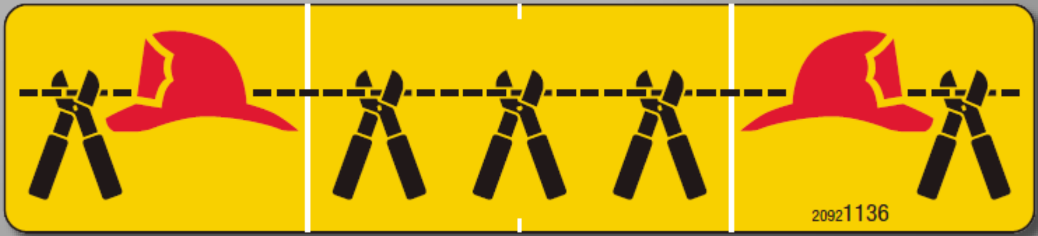
3 Phase Cables

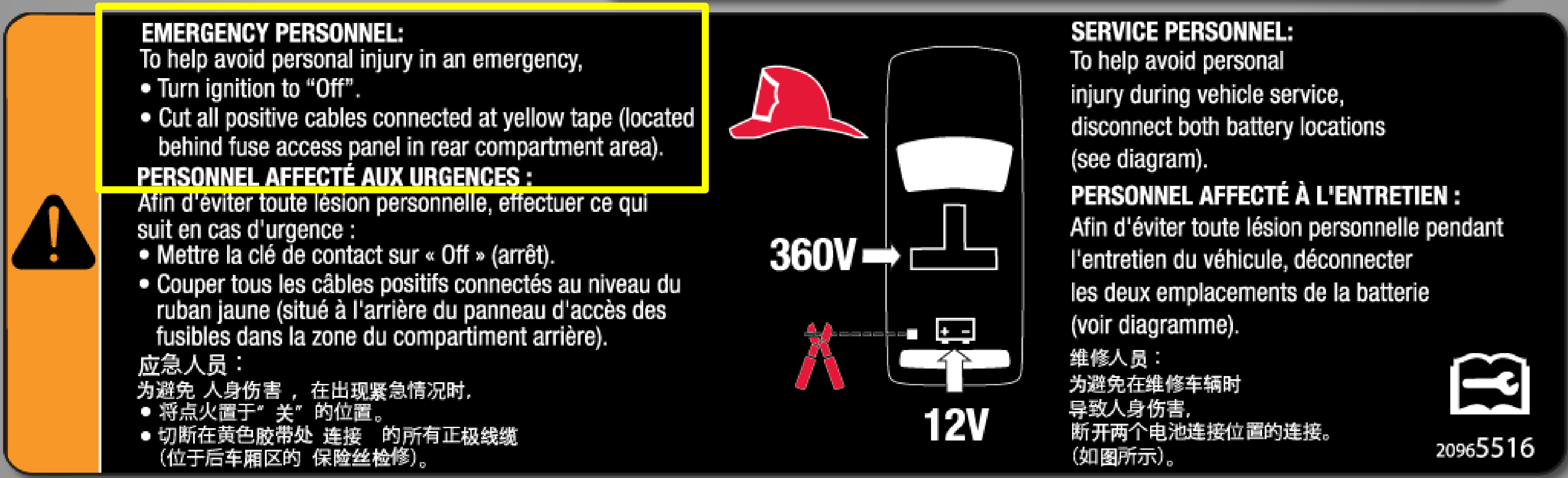
Caution: To reduce the risk of severe shock and burns, always treat the 3 phase cable and connectors as if the voltage is present.

Orange cables contain over 60VDC

Vehicle Labeling Strategy

– **Danger & Warning**
– **Color Coding**
– **High Voltage Disconnect**



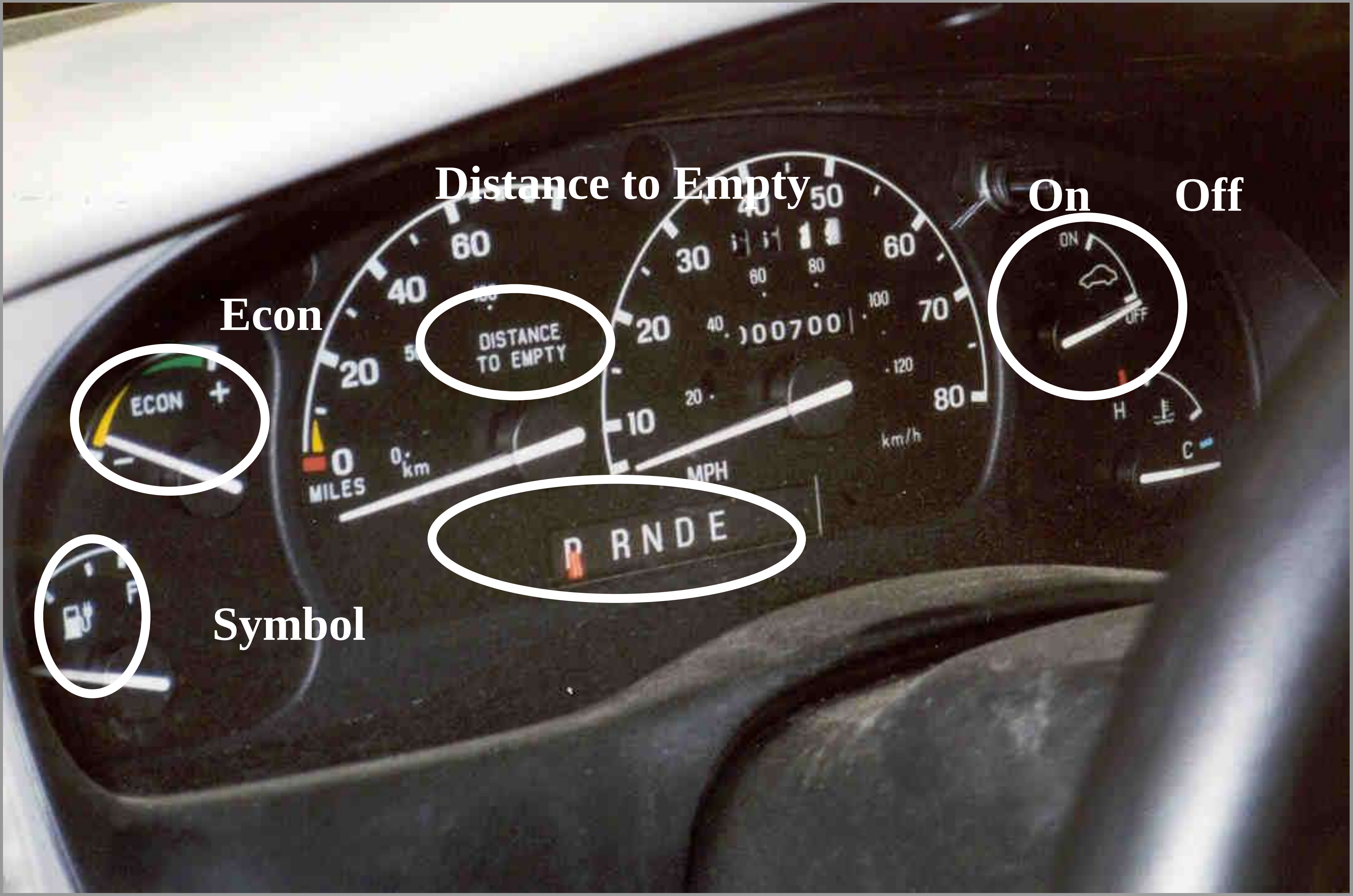


Blue cables contain over 30VDC but less than 60VDC

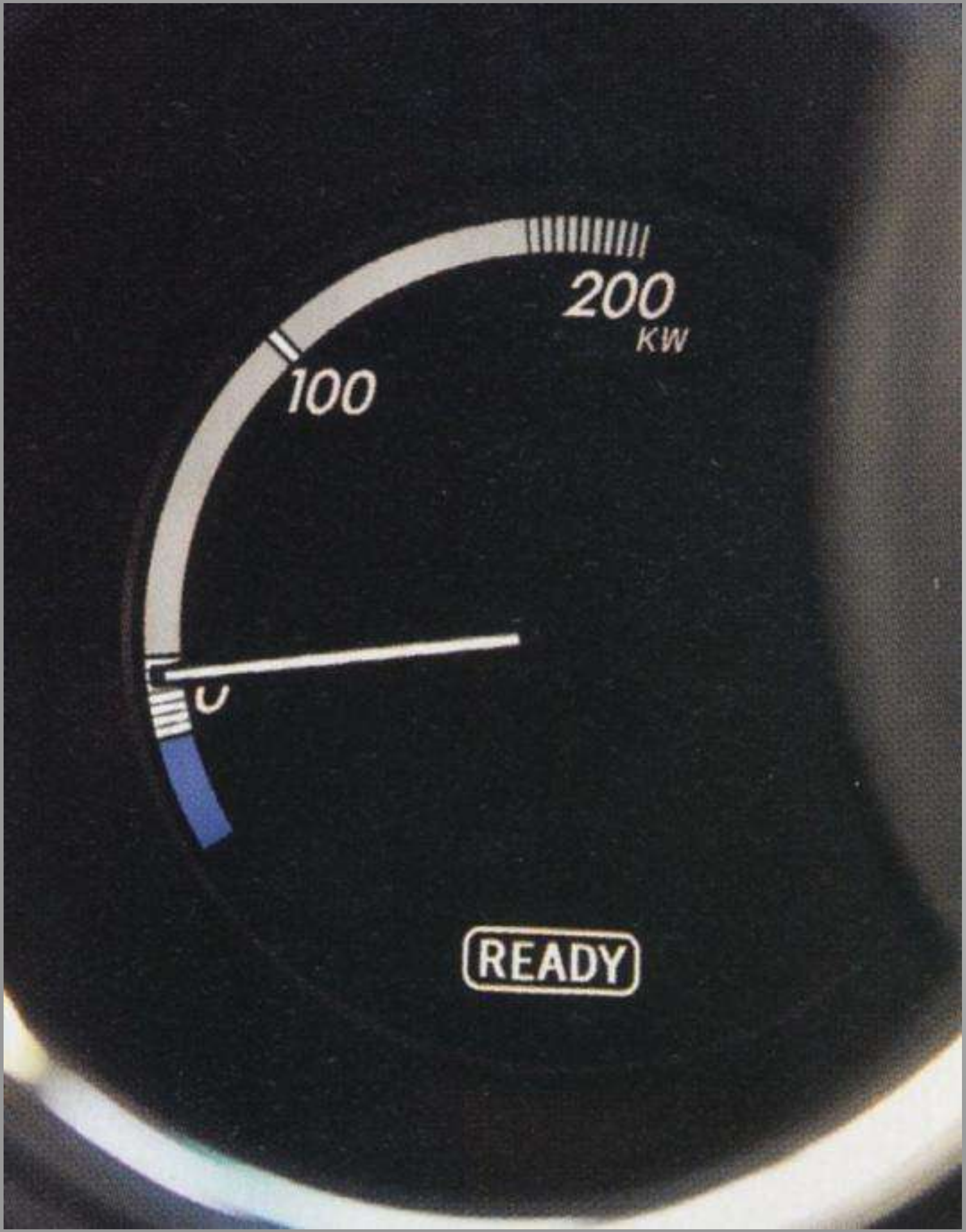
Logos

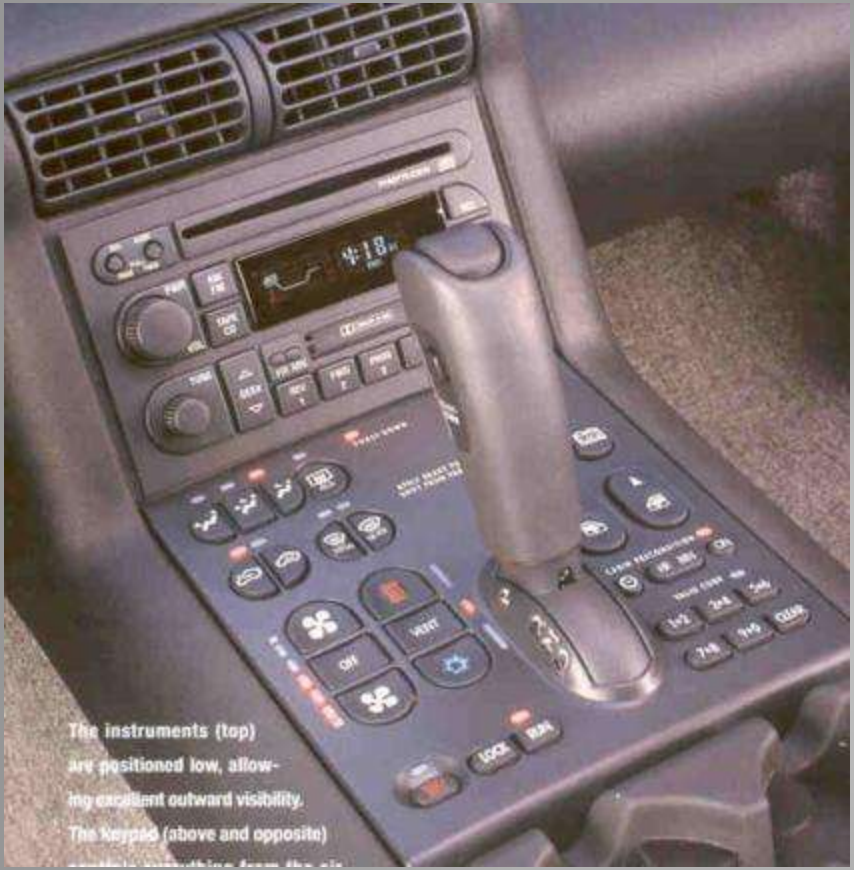
IDENTIFY


70% of incidents
What is it?



Instrument Panel Indicators


200
KW
100
0
READY



Instrument Panel Indicators

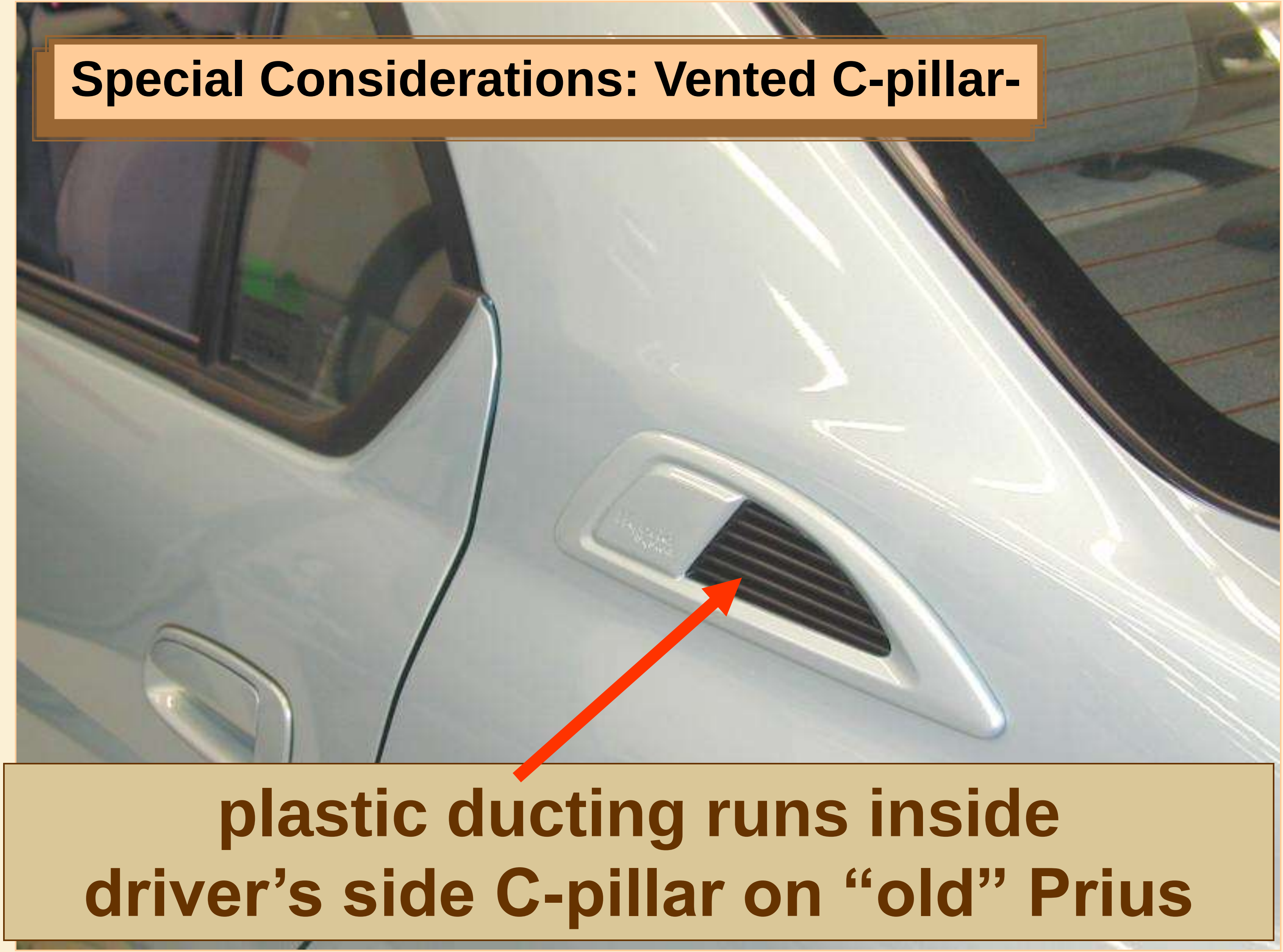
Instrument Panel Indicators

1st push: Accessory,

2nd: ON,

3rd: OFF

Special Considerations: Vented C-pillar-



plastic ducting runs inside driver’s side C-pillar on “old” Prius

Automatic Engine Start-Stop

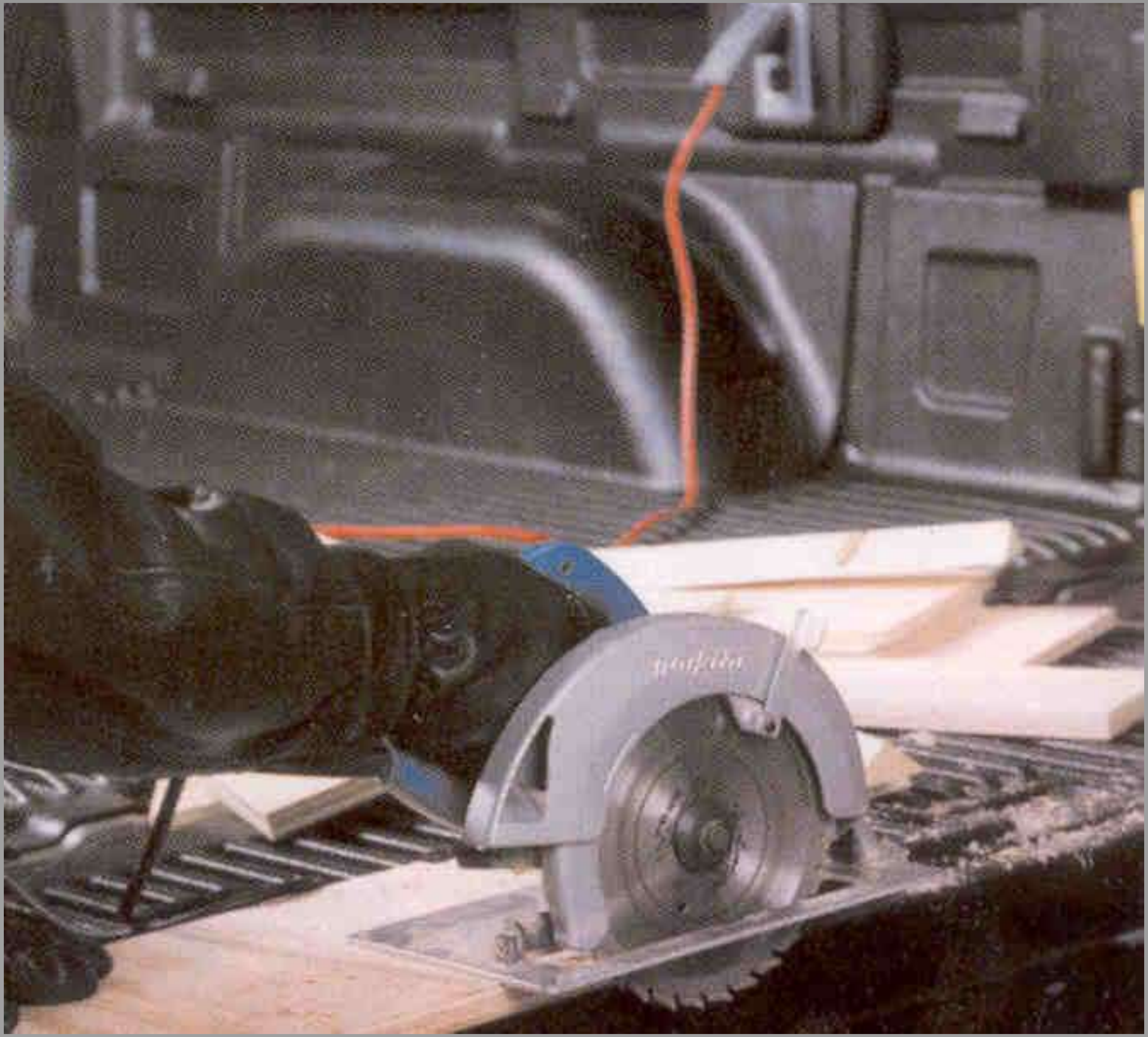
This feature improves fuel economy and reduces vehicle carbon dioxide emissions by shutting the engine off:

- During coasting, when the vehicle is traveling below 15 mph
- During braking
- While in Drive with the vehicle stopped
- While in Park

Mild and Full Hybrid Models Use This Feature

Vehicle "appears" to be OFF except for one 'ready' light which will be illuminated

The "ready" light is an important piece of the puzzle



110VAC and 220VAC output – up to 2400 watts!

For the most part, alternative fuel vehicles are very safe. However, as with anything in life, are there some things that you just should not do…like smashing a can of WD40 with a rake?

Electric and Hybrid Rescue/Response

What are some appropriate steps to take when responding to and arriving at the scene of an accident involving an electric, or hybrid electric vehicle?

First Responder Field Scenarios

Vehicle on Fire

NO increased risk to first responders

Vehicle in Water

NO increased risk of shock hazard

At a Minimum:

- Remove the ignition key.
- Disconnect the 12 volt battery.

OR

- Disconnect the 12 volt battery.
- Remove the high voltage fuse in the engine compartment fuse box (or all of the fuses in the engine compartment fuse boxes).

Electric, Electric Hybrid, and Fuel Cell Rescue/Response

- **ID as an AFV (Markings, Battery Pack, Controller, Instrument Cluster, Gauges, Driver...)**

- **Do not approach from the front, or from the rear.**

Electric and Hybrid Rescue/Response

- **ID as an AFV (Markings, Battery Pack, Controller, Instrument Cluster, Gauges, Driver...)**
- **Assume 'on' and approach safely (sides)**
- **Isolate the area**
- **Check for Release/Damage around Battery Pack**
- **Chock Wheels**

Electric and Hybrid Rescue/Response (cont.)

- **Set Brake.**
- **Engage “Park”.**
- **Reposition seats, lower windows, tilt/telescope wheel, open door locks.**
- **Turn vehicle off – silently on! (Typical when coasting, braking, stopped in ‘drive,’ and in ‘park.’)**
- **Verify the car is off – lights out!**

•**Remove the key(s) from the area.**

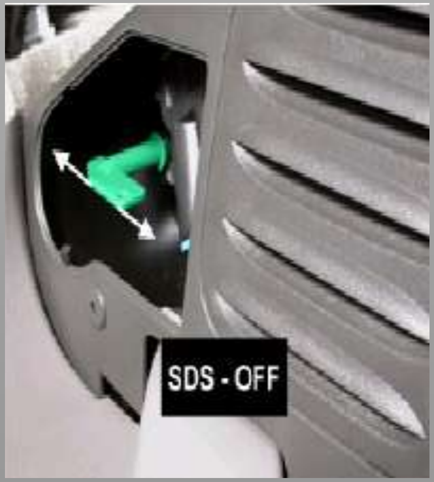
- **Disconnect the 12 volt battery.**

Electric and Hybrid Rescue/Response (cont.)

- **Utilize research information such as Emergency Response Guides, Holmatro Vehicle Safety Systems book, or the Moditech Software.**

Electric and Hybrid Rescue/Response (cont.)

- **Turn off/Disconnect High Voltage Battery Service Disconnect Device.**



Exposed electrical components, wires, and HV batteries present potential high voltage shock hazards.

Honda Insight in the rear near the battery pack

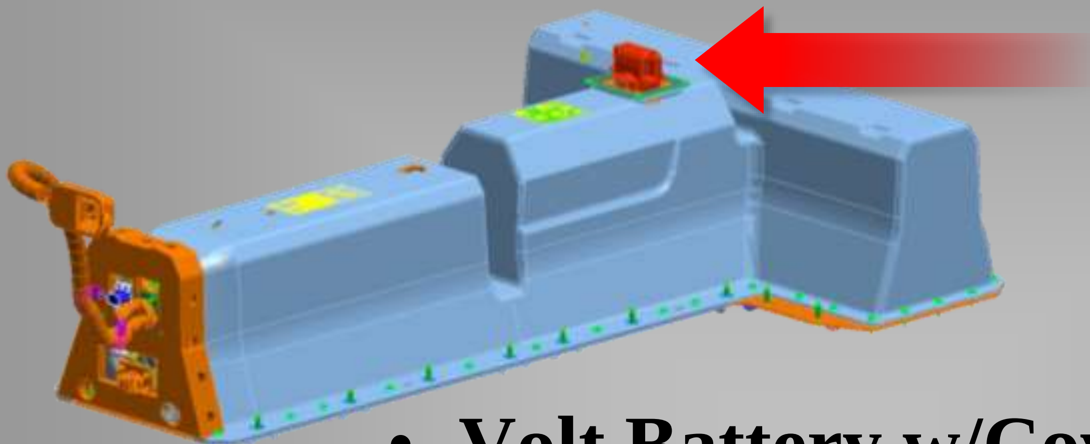
Honda Civic is behind the rear seat back, behind a bolted-on panel.

Note the location of the battery pack: eliminates “tunneling” as an easy option for extrication.

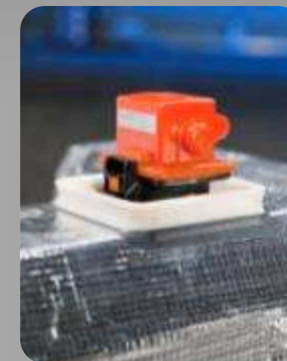
Toyota Prius is accessed through the trunk

Toyota and Lexus SUVs, the battery is under the rear seat. The disconnect is accessed through a plate on the side of the seat base in the driver side rear door area

Ford/Mercury is in floor of the rear storage area, under the carpet

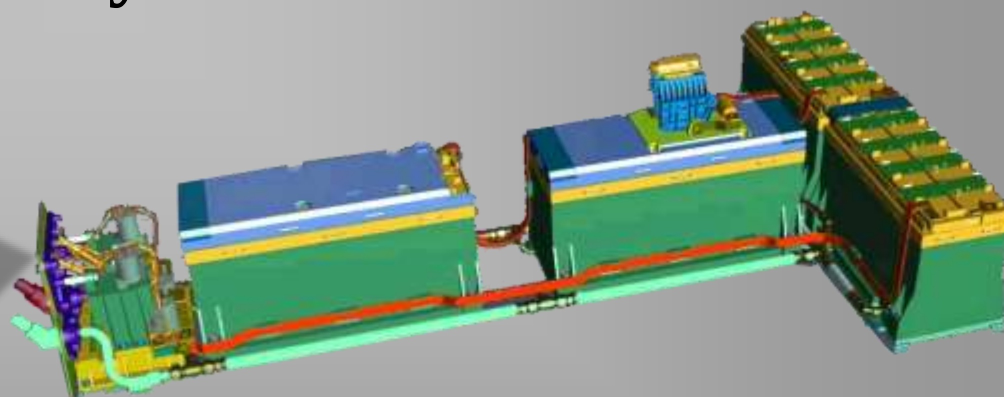


Manual
Service
Disconnect



- **Volt Battery w/Cover**

Electrical
Interface
to Vehicle
(Battery Disconnect Unit)



Volt Battery w/o Cover

[redacted]

Electric and Hybrid Rescue/Response (cont.)

- Option to remove the “high voltage” fuse in the engine compartment fuse box (or all the fuses in the engine compartment fuse boxes…)
- Verify car is off!

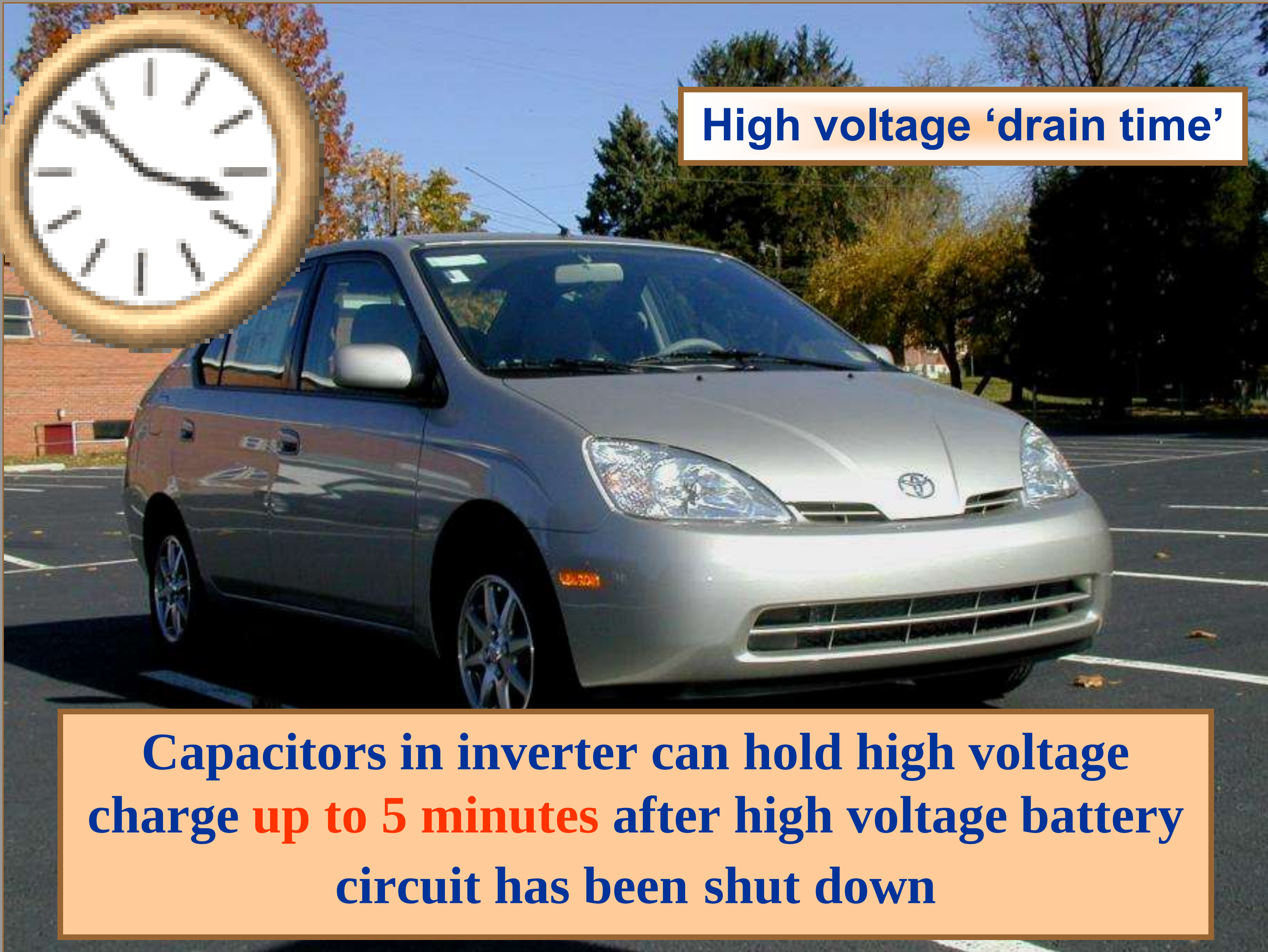
Electric, and Hybrid Electric Rescue/Response (cont)

- “<u>Really try to avoid</u>” **cutting into, or opening, or cribbing to any High Voltage Cable or Component.** **(Battery Pack, Controller, Motors...**

Electric and Hybrid Rescue/Response (cont.)

If the battery pack is opened, and components are exposed, and they are still creating electricity, and you have to reach ‘near’ the exposed parts, then Class 0 electrical PPE would be appropriate to minimize the potential for electrocution or arc flash to your body.

High voltage ‘drain time’



Capacitors in inverter can hold high voltage charge up to 5 minutes after high voltage battery circuit has been shut down

Electric and Hybrid Electric Rescue/Response (cont)

- Cutting through any orange high voltage cable is a LAST resort – and only if done one at a time.
- If electrolyte is released/leaking, dilute with lots of water.
- Venting, or off-gassing high voltage battery vapors are potentially toxic and flammable.
- Do not push or tow a hybrid vehicle with the drive wheels on the ground.

Electric and Hybrid Electric Fire Response

- Prevent the fire. (sparks, etc)
- If you detect leaking fluids, sparks, smoke, flames, increased temperature, gurgling or bubbling sounds from the HV battery compartment, assume there is a battery fire and ventilate the passenger area (open doors and roll down windows).
- Be alert as there is a potential for delayed fire with damaged lithium-ion batteries.

Electric and Hybrid Electric Fire Response (cont)

- **Follow "Rescue" response steps**
- **Turn off power to charger, or disconnect cable to charger if charging.**

Electric and Hybrid Electric Fire Response (cont)

- **The interior of the battery will begin to ‘deteriorate’ at approx 160 deg F, … which will lead to a ‘thermal event’.**


MAR 24 2004
1:49:20 PM


MAR 24 2004
1:49:20 PM

Electric and Hybrid Electric Fire Response (cont)

- **If fire is persistent (re-ignites), consider that battery pack may be involved. (*Command decision*...<u>let burn</u> or extinguish … LOTS of water or class D extinguisher … Offensive … or Defensive …)**

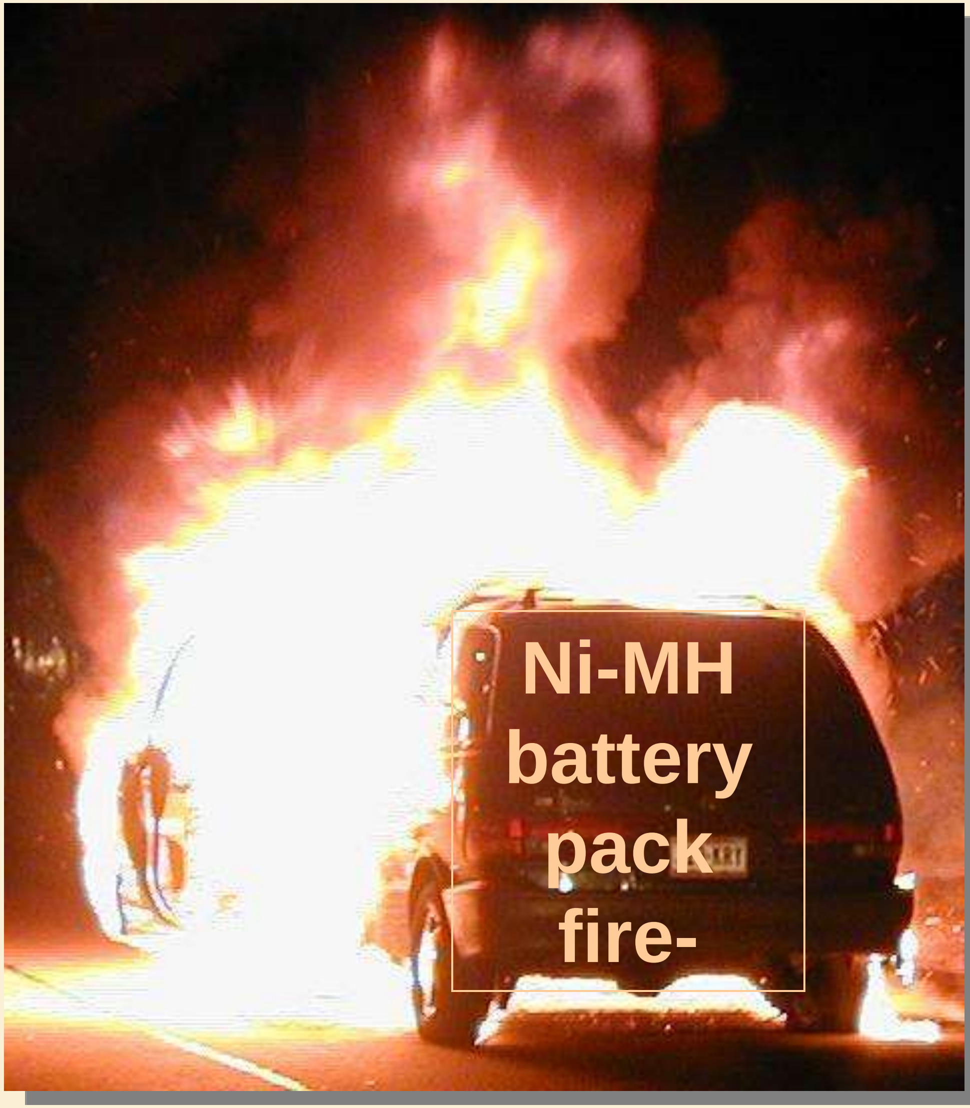
Responders are advised that virtually all fires involving Ni-MH batteries can be controlled if overwhelmed with water

water application will cool vehicle…

control spread of fire…

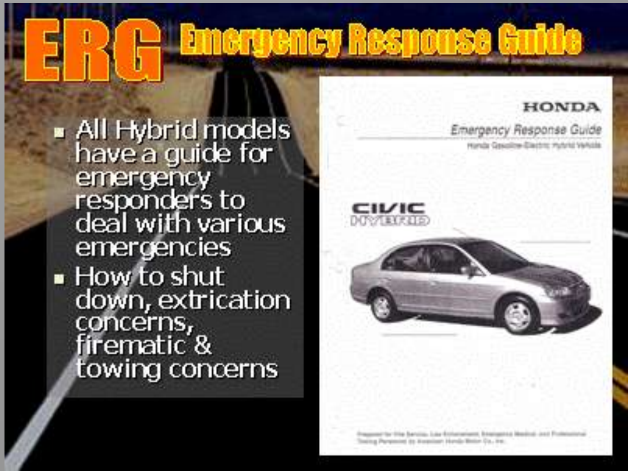
and

cool adjacent battery cells



Electric and Hybrid Electric Fire Response (cont)

- **Because by-products are toxic, move unprotected personnel upwind and uphill (and away from moving traffic).**
- **Anticipate other common vehicle fire hazards.**
- **Refer to MSDS and ERG guides**
- **Use normal extinguishing methods … including SCBA**
- **Do not breach HV battery cover**



Electric and Hybrid Rescue/Response Key Points

- ✓Be cautious and avoid all high voltage components.
- ✓Turn the ignition switch off.
- ✓Disconnect the 12V battery.
- ✓Turn off the High Voltage Service Disconnect Switch.
- ✓Remove the High Voltage Fuse from the Engine Compartment Fuse Box

HYDROGEN

Gaseous and Liquid Storage

Very Similar to CNG and LPG

As of December 2006 there were at least 4 Hydrogen fueling stations in Southeastern Michigan.

Gaseous and Liquid Storage

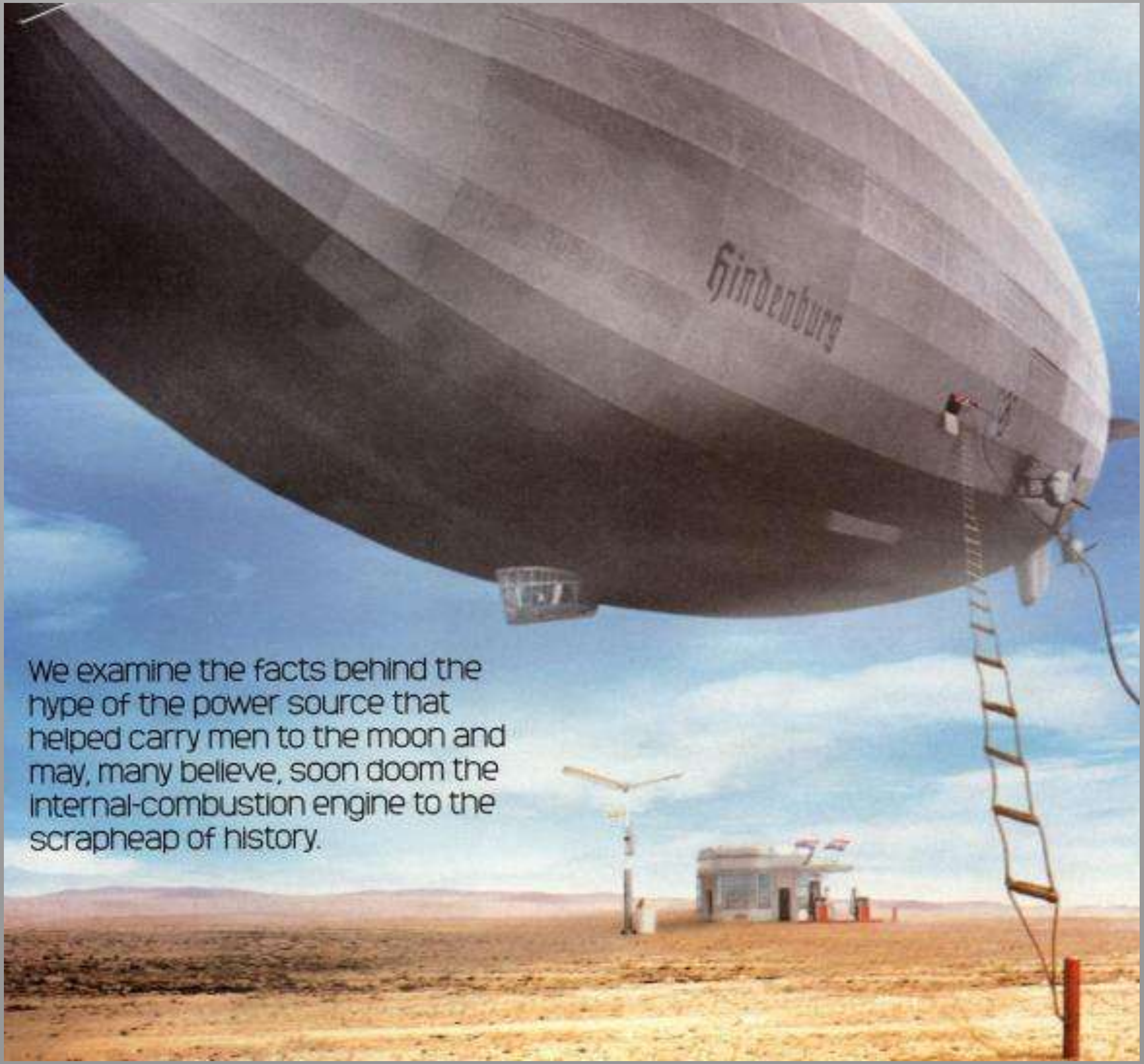
Very Similar to CNG and LPG

There are multiple hydrogen fueling stations in Southeastern Michigan.

Seen as one of the most influential changes in vehicle technology that will develop in the next 10 years.

Iceland, as one example, has been using hydrogen powered vehicles since 2003

Hydrogen vs. Gasoline



HYDROGEN ELECTRIC
RACING FEDERATION

"Race on Sunday, Sell on Monday!"

H-500 in Indianapolis in May 2009


Scientific Research


PROTOTYPE

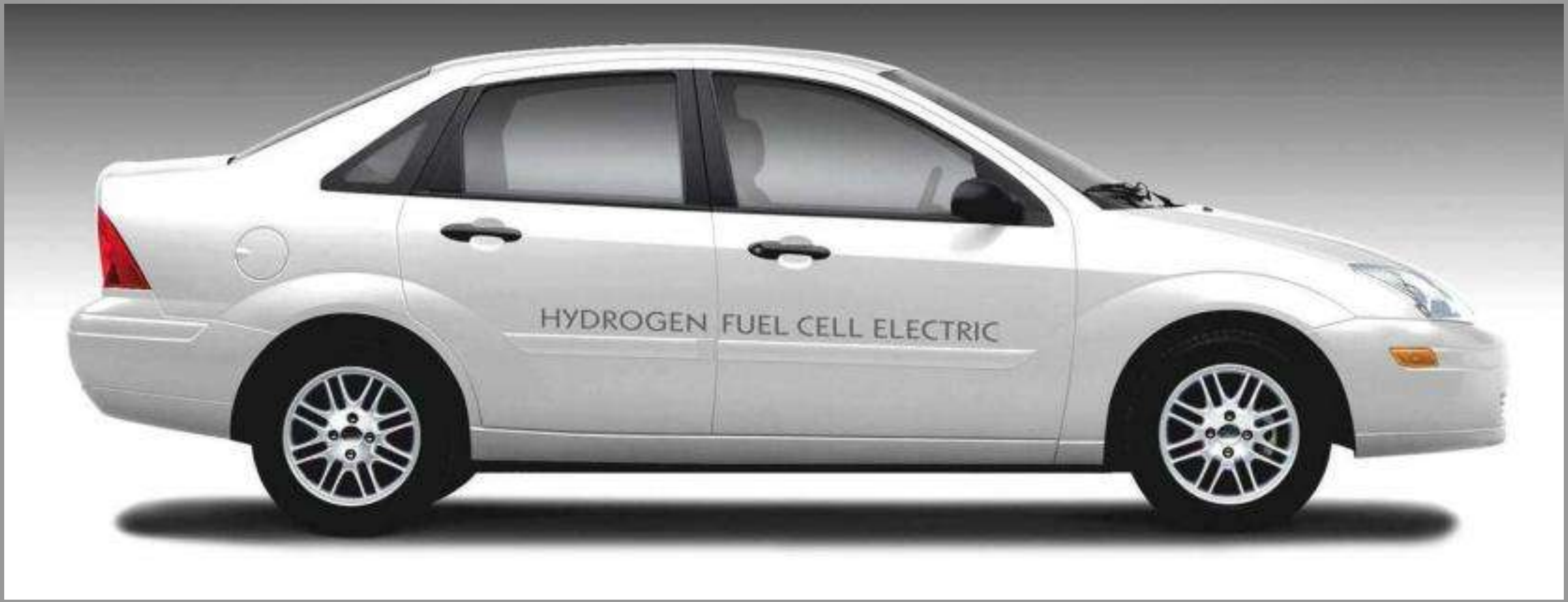
Dual Hydrogen/Gasoline BMW 760i

6L V-12, top speed of 143 mph, 400 mile range

16.3 gal. gas tank, and 17.6 lb. liquid hydrogen tank @ -253*C

Unveiled in November 2006 in L.A. and available in April 2007

FUEL CELL



Ford Focus,
E450 Van,
BMW, Toyota,
Mazda, Busses

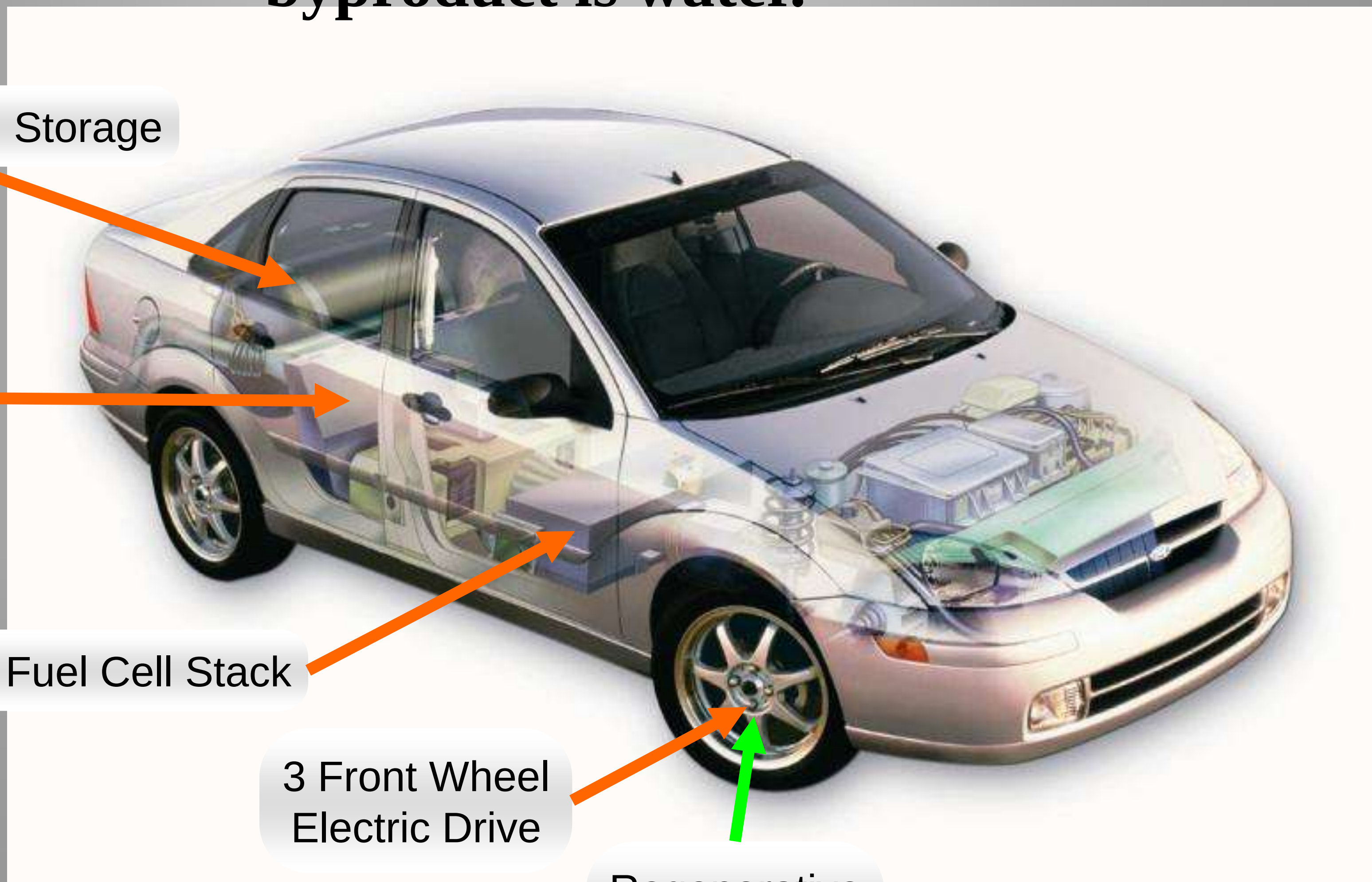
Fuel Cell Electric – Either from Hydrogen or Reforming other Fuels

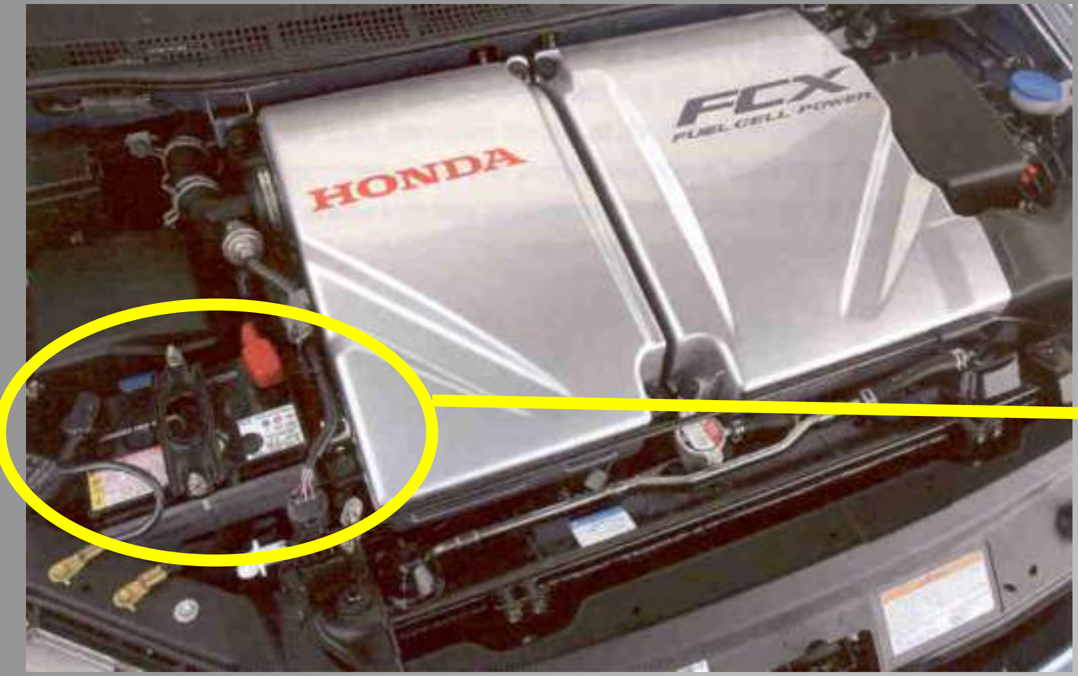
Honda FCX Clarity unveiled in LA in 2007, to be leased in California in the summer of 2008 for around $600/month.

GM is building 100 Equinox FCs as part of a test program in New York, Los Angeles, and Washington.

What is a Fuel Cell Vehicle?

Fuel Cell converts hydrogen to electricity – the byproduct is water.





Controller for Fuel Cell Vehicle

Conventional 12 volt battery

Typical High Voltage Battery Pack

1-4 tanks; carbon fiber wrapped

Hydrogen vs. Gasoline Vapors

Gaseous, 14x lighter than air, colorless, odorless	Volatile liquid, vapors sink, colorless, distinctive odor
Flammable range 4% – 75% concentration in air	Flammable range 1.4% – 7.6% concentration in air
Disperses rapidly away from leak source	Puddles around leak creating flammable vapor concentration
Auto-ignition temperature ~960 ° F	Auto-ignition temperature ~815° F
Burns colorless, or pale-blue	Burns with a bright flame

Hydrogen Safety

Hydrogen Safety Video

IDENTIFY


HYDROGEN
FUEL CELL


HYDROGEN
FUEL CELL


Compressed
Hydrogen

Instrument Panel Indicators


FUELCELL


60
70
MPH
80
90
100
110
120
km/h
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
kW x 10
0
1
2
3
4

Fuel Cell Rescue/Response

What are some appropriate steps to take when responding to and arriving at the scene of an accident involving a fuel cell powered vehicle?

Its really just an electric vehicle with an extra twist.

Fuel Cell Rescue/Response

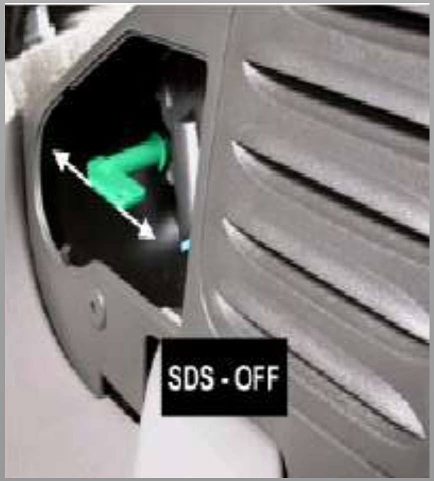
- **ID as an AFV (Markings, Battery Pack, Controller, Instrument Cluster, Gauges, Driver...)**
- **Assume ‘on’ and approach safely (sides)**
- **Isolate the area**
- **Check for Leaks/Damage around Battery Pack**
- **Chock Wheels**
- **Set Brake**
- **Engage “Park”**

Fuel Cell Rescue/Response (cont.)

- **Reposition seats, lower windows, tilt/telescope wheel, open door locks**
- **Turn vehicle off – silently on!** **(Typical when coasting, braking, stopped in ‘drive,’ and in ‘park.’)**
- **Remove key from area**
- **Disconnect 12V battery**
- **Verify power/lights are off**

Fuel Cell Rescue/Response (cont.)

- **Turn off/Disconnect High Voltage Battery Service Disconnect Device**



Fuel Cell Rescue/Response (cont.)

- **Turn gas cylinders off.**
- **Crib, but not to any fuel or high voltage system component or line**
- **Do not cut any part of the fuel system**
- **If electrolyte is leaking, dilute with lots of water.**

Fuel Cell Rescue/Response (cont.)

- **Never touch, cut, or open any high voltage cable or component (Battery Pack, Cables, Controller, Motors…)**

•Do not push or tow a hybrid with its drive wheels on the ground.

Fuel Cell Rescue/Response (cont.)

- **“Introduction to Hydrogen Safety for First Responders” on-line training program at www.hydrogen.energy.gov/firstresponders**

Fuel Cell Fire Response

- **Prevent the fire. (sparks, etc)**
- **Follow “Rescue” response steps**
- **Anticipate other common vehicle fire hazards.**
- **Refer to MSDS and ERG guides**
- **Use normal extinguishing methods**

Fuel Cell Fire Response

- **Do not extinguish hydrogen flame**
- **Keep clear of PRD vent location (approx 230 deg F)**
- **Do not breach HV battery cover**
- **If fire is persistent, consider that battery pack may be involved. (*Command decision*...burn or extinguish…water or class D extinguisher…)**

Detect H_2 Release

- **H2 Fire Detection**
  - Thermal (or UV) Detectors
  - Long Handle Broom (only as last resort)

- **H2 Leak Detection**
  - Frost around PRD vent
  - Loud hissing sound
  - Thermal Conductivity Sensor
  - Catalytic Combustion Sensor
  - Electrochemical Sensor

…a LOT of information.

Questions?

ACTIVITY 2:
HANDS-ON REVIEW

ACTIVITY 3:
TABLE-TOP DISCUSSIONS

Car vs. Building involving a 'typical' hybrid electric vehicle?
Size up?
Shut Down?
Patient Access?


Standard Federal
Drive-up ATM


Small Groups

Scenario #1

Call: Odor investigation – Hydrogen Gas

Time: 1:30 Tuesday Afternoon.

Response: District Engine

You are dispatched to the City Hall Parking Garage. Upon arrival you are met by the caller who takes you to the area where they believe the leak is. They state they smell hydrogen gas, and believe it is coming from a parked vehicle.

You can see the vehicle has a logo painted on it that reads, "Hydrogen Fuel Cell Powered," and there is a logo on the rear that reads, "Compressed Hydrogen."

You smell an odor very similar to an over-heated electrical motor. The odor seems to be strongest inside the unlocked vehicle.

Scenario #3

Call: Assist PD at a Property damage accident in a parking lot of a grocery store in your first response area.

Time: 17:30 Friday afternoon.

Response: District Engine or Ladder Co.

When you arrive at this call you find that a Toyota Prius was hit in the side by a moving van with very significant intrusion. There were no injuries as the car was unoccupied, but there is gray paste that was appeared to be spattered near the rear seat from between the cushions. The driver was retrieving the child safety seat and toys from the rear seat area when they tried picking up the paste. They began yelling about the stuff "burning", and hurting their hands.

Scenario #4

Call: Truck on Fire next to an office building.

Time: 10:15 Saturday Morning.

Response: Two fire trucks

You are dispatched to this location for a truck fire. When you arrive you find a late model Ford Ranger, with the interior approximately 50% involved. The windows have broken out, and the fire has vented out the windows.

The owner, Mr. Granger, tells you that the truck is electric powered, and that it was charging when he noticed the fire.

The building is an exposure but not in danger, as of yet anyway.

Scenario #6

Call: Assist PD at a Property damage accident in a parking lot of a grocery store in your first response area.

Time: 17:30 Friday afternoon.

Response: District Engine or Ladder Co.

When you arrive at this call you find that a Mercury Mariner was hit hard in the side, near the rear, by a moving van with very significant intrusion. There are no injuries but there is gray paste spattered from the bottom of the SUV, near the rear of the vehicle. A tow truck driver was cleaning up the scattered car parts and glass fragments when he smeared some of the paste on his hand. He began yelling about the stuff "burning", and hurting his hands.


RESCUE