FIRE INVESTIGATION FOR HYBRID
and
HYDROGEN-FUELED VEHICLES

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Introduction

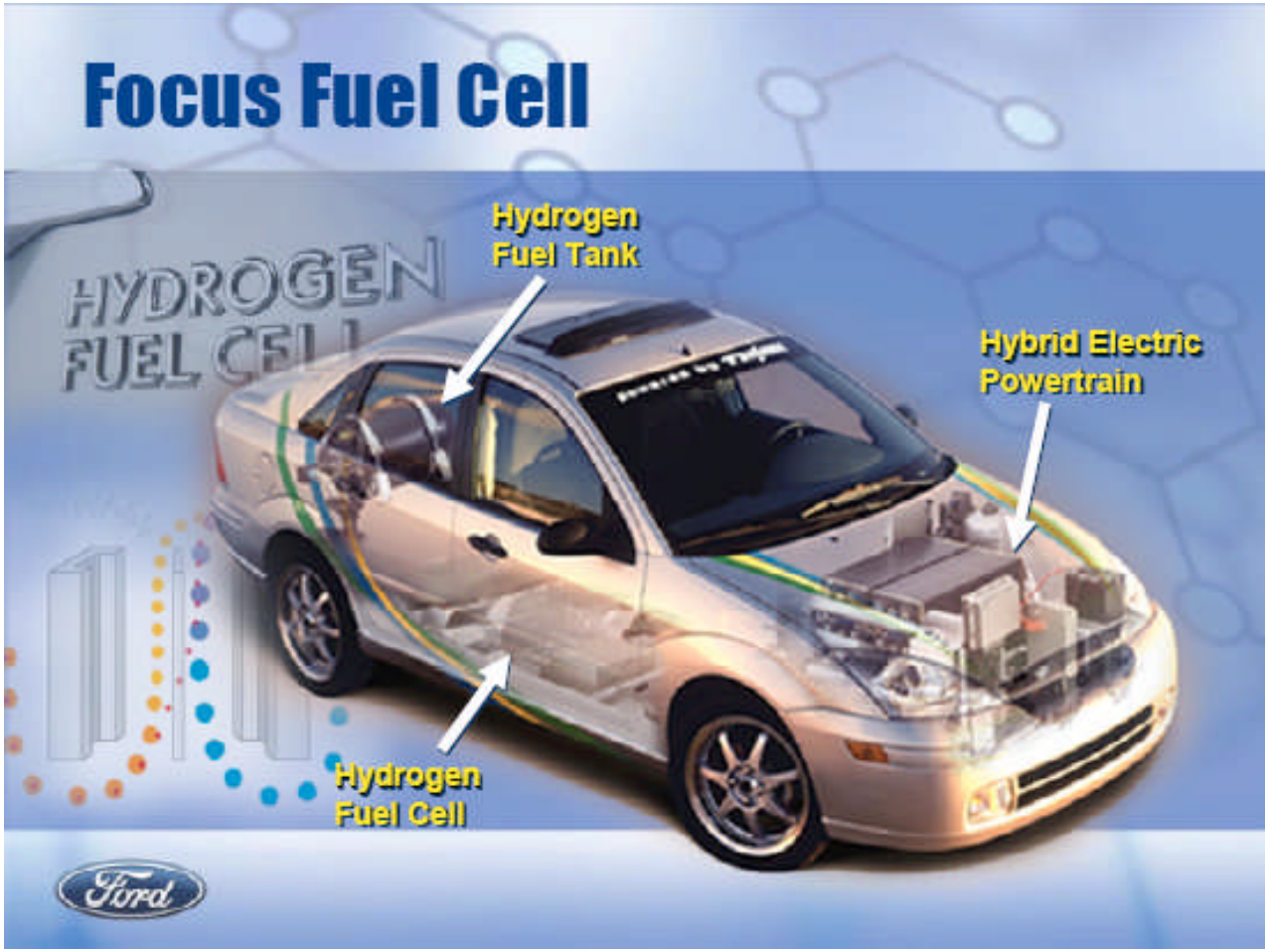
- Hybrid and Hydrogen vehicles are being introduced
  - 200,000 hybrid vehicles on the road in US
  - 500 H2 vehicles worldwide
- Special fire investigation techniques required
  - High voltages (up to 600 volts)
  - Battery and ultracapacitor energy storage
  - Flammable hydrogen

Introduction (Continued)

- NFPA 921 “Guide for Fire and Explosion Investigation” is being updated
- Chapter 25 covers vehicle fires
- Authors’ personal ideas are presented here
- Any changes will be a result of a formal NFPA process
- NFPA 921 update will be published in 2008

Ford Escape Hybrid

Ford Focus Fuel Cell Vehicle



Vehicle Investigation Safety

- Hybrid Vehicle Investigation Safety
  - Assume high voltage energized
  - Learn about high-voltage system
  - Manual battery disconnect
  - Check with voltmeter
  - Use extra caution when examining battery pack
  - Can move without warning if energized and enabled

Vehicle Investigation Safety

- Hydrogen-Fueled Vehicle Investigation Safety
  - Hydrogen may be venting – wait until finished
  - Tank or fuel system damage – can have delayed burst
  - Safely vent hydrogen
    - Low ignition energy
    - Buoyant and rapidly diffuses
    - Leaks in confined spaces most dangerous
  - Most H_2 fuel cell vehicles will also be hybrids

Electric Motors

- Hybrids and fuel cell vehicles have electric traction drive
  - One or more motors
  - Inverter and other power electronics
  - Variable frequency AC or DC
    - Up to 600 Volts

Hybrid Vehicle Description

- Both Internal Combustion Engine and electric motor(s)
- Also have 14-volt system for auxiliary loads
- High voltage battery or ultracapacitor
- Other loads may go to high voltage
  - Power steering
  - Air conditioning
- Two wire system – orange wires
  - Does not use chassis return for high voltage
- Automatic disconnect for high-voltage
- May have fuse or circuit breaker

Hydrogen-Fueled Vehicle Description

- Hydrogen storage
  - High pressure gas most common now
    - 5,000 to 10,000 psi
  - Cryogenic liquid hydrogen
  - Hydride – intermediate pressure – ca 1500 psi
- Protected by Pressure Relief Devices
  - Thermally actuated to protect tanks from fire
  - Pressure actuated

Hydrogen-Fueled Vehicle Description (Continued)

- Pressure regulators – one or more
- Fill line with check valve(s)
- Isolation valve – normally closed
- Vent lines and fuel cell exhaust
- Hydrogen sensors – maybe
- Study the manufacturer’s manuals and emergency response guide

Hybrid Vehicle Investigation

- Same as conventional vehicle, except
- High-voltage system potential fire cause
- Study protective strategies used by manufacturer
- Determine if disconnect and/or fuse is open
- Check for prior damage or modifications to high voltage system

Hydrogen Vehicle Investigation

- Was H_2 involved in fire?
  - First fuel burned, or
  - Involved later in fire
- Were tanks damaged by fire or crash?
- Did the tanks leak or burst and release their contents?
- Were any high or intermediate pressure piping or components damaged?

Hydrogen Vehicle Investigation (Continued)

- Did any of the pressure relief devices vent?
- Did any hydrogen sensor detect a leak? Alarm?
- Were any fuel system components repaired, modified or damaged prior to fire?
- Many fuel cell vehicles will also be hybrids
  - Follow investigation advice for hybrids

Conclusions

- Hybrid vehicles are now being mass produced
- Hydrogen vehicles are being aggressively developed
- There are new investigation methods needed for these vehicles
- There are new fire ignition and propagation possibilities