EV Technology and Standards

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EV Technology

The Qualifiers:

• Technically accurate but broadly generalized
• The focus is on EV technology
  • Why? Many variants operate as pure EVs
• Nissan Leaf is used for explanation
  • Why? It’s the most common EV on the road
• The technology is advancing...quickly!
EV Technology

• Operates almost identically to a conventional auto...or does it?
  ➢ Drives similarly, it’s quiet!
  ➢ Where do I fill up?
  ➢ What’s Eco Mode?
  ➢ What’s the temperature outside?
EV Technology

• Mechanically much simpler...or is it?
  ➢ Basic EV has no radiator or transmission
  ➢ Hybrids significantly more complex
  ➢ Chevy Volt in a class by itself
  ➢ Tesla also in a class by itself
• Significant environmental and health benefits

➢ Huge reductions in GHG, particulate matter, noise and heat generation

➢ Batteries can have a second life and are classified as non-hazardous waste

➢ Benefits magnified in the urban environment
EV Technology Benefits

- Cost ~ $1.00/gallon to fuel
Vehicle Comparison

Battery Electric (BEV)

*Nissan Leaf*

Grid charged batteries range ~110 miles, no gas powered engine, batteries and electric motor only

Plug-In Hybrid Electric Vehicle (PHEV)

*Ford C-Max Energi*

Grid charged batteries range ~20 miles, gas powered engine works alone or in tandem with electric motor

Extended Range Electric Vehicle (EREV)

*Chevy Volt*

Grid charged batteries range of ~53 miles, small gas powered generator charges batteries to extend range

Hybrid (HV)

*Toyota Prius*

No grid charged battery range, gas powered engine charges batteries and works alone or in tandem with electric motor
EV Charging Components
Ev Charging Components, EVSE

Electric Vehicle Service Equipment (EVSE)

- Connected to an electric power source
- Provides AC or DC power
- EVSE communicates with EV to regulate power
- Power output is important
EV Battery Systems

**Traction Battery Systems**

- Traction are usually Lithium-ion, like laptops
- AKA, Rechargeable Energy Storage Systems (RESS)
- Traction batteries power electric drive motors
- Conventional 12-volt battery for aux systems
- Nickel-Metal Hydride has been used in hybrids

Photo: Nissan
EV Battery Systems

Traction Battery Sizes and Mileage Range

Larger battery = more range...and weight = less range

- Nissan Leaf, 30 kWh (~110 mile range*)
- Ford C-Max, 7.6 kWh (~20 mile range)
- Chevy Volt, 18.4 kWh (~53 mile range*)
- Toyota Prius, 1.3 kWh (works tandem with ICE)
- Tesla, 85 kWh (~265 mile range)

* Photo: Nissan 2016 model*
Onboard Charger

- Communicates with EVSE during charging
- Converts EVSE AC to DC to charge batteries
- Bypassed with DCFC, direct DC to the batteries
- Regulates power during Level 1, 2 charging
- Typically 3.3 kW or 6.6 kW per hour
**EV Inlet**

- Connects EV to EVSE
- Interface between EVSE and onboard charger
- Can be SAE J1772 or CHAdeMO, or both

Photo: Wardsauto.com
EVSE (Charger) Connector

- Connects EVSE to EV
- 1772 and CHAdeMO meet all safety standards
- Very similar in operation
- Choice based on a variety of technical needs
- Can be used for both Level 2 and DCFC
- There are other international standards (IEC)
**EVSE Connectors**

**CHAdEMO**
- Developed by Japanese auto manufacturers
- Standard for Nissan, Mitsubishi and others
- CHAdEMO is most widely deployed

**SAE J1772 Combo T2**
- Develop by SAE International
- Standard, for Chevy, Ford, BMW and others
- 100 kW rating versus 62.5 for CHAdEMO
EV Motors

- Variations between vehicles is significant
- Considerations for efficiency, performance, size
- Leaf uses Permanent Magnet AC (107 hp)
- Tesla uses AC induction (360 hp)
**EV Drivetrains**

- **Series** Hybrid Electric Vehicle
  - Two power sources
  - Single path to power the wheels

- **Parallel** Hybrid Electric Vehicle
  - Two power sources
  - Two parallel paths to power the wheels

Drawings: MIT
• **Drive Mode**
  - Electric motor operating normally
  - Consuming battery power

• **Generator Mode**
  - Electric motor operates in reverse to provide “engine braking”
  - Converts the electric motor into a generator to recharge batteries
EV Related Standards

IEC EN 62660-1&2
IEC EN 61982-2&3
Testing for Lithium-ion cells

IEC 61851 PEV Conductive Charging System

SAE J1766
EV/PHEV Crash Integrity Testing

SAE J2578
Fuel Cell Vehicle Safety

SAE J2464
Electric Vehicle Battery Abuse Testing

SAE J2029
EV/HEV Battery Safety Standard

ISO 23773
Fuel Cell Vehicle Safety

FMVSS 305
Electric Powered Vehicles; Electrolyte Spillage and Electrical Shock Protection

SAE J1772™
PEV Conductive Charge Coupler

SAE J12380
Vibration Testing of Electric Vehicle Batteries

ISO 6469
EV Safety

IEC 62196
Industrial plugs and socket outlets

EV / PHEV Safety Standards

Electric Vehicle Safety Technical Symposium

Robert Galyen, SAE International
EV Related Standards

Vehicle Design and Systems

• American National Standards Institute (ANSI) coordinates EV standards development by:
  • Society of Automotive Engineers (SAE), National Highway Traffic Safety Administration (NHTSA) and others
SAE EV Standards

Intertek Applies EV SAE Standards

On Board Battery Charger
SAE J2894 (Power Quality)

Charging Inlet
SAE J1772

Charging Station (EVSE)
SAE J2293

Hybrid Battery Safety
SAE J2929
Abuse
SAE J2464

Vehicle pictured is used for illustrative purposes only - no further claims are made or intended.

www.intertek.com
National Electrical Code (NEC)

- NEC Article 625, wiring and equipment external to the EV connecting it to a supply of electricity. (AKA, the charger...AKA, EVSE)

- Article 625 requires NRTL certification of the EVSE
EV Related Standards

• The Occupational Health and Safety Administration (OSHA) and Nationally Recognized Testing Laboratories (NRTL)
  • OSHA requires NRTL certification for many products, electronic equipment is the largest category
  • Underwriters Laboratories (UL) and Intertek Testing Services (ITSNA)
• International Organization for Standardization (ISO)
• International Electrotechnical Commission (IEC)
UL EV Standards

Intertek Applies EV UL Safety Standards

- Battery Charger (on/off board)
  - UL 2202
- Charging Inlet
  - UL 2251
- Hybrid Battery
  - UL Subject 2580
- Charging Station (EVSE)
  - UL Subject 2594
  - Personnel Protection Circuitry
  - UL 2231-1 and UL 2231-2
- Charging Plug
  - UL 2251

Vehicle pictured is used for illustrative purposes only - no further claims are made or intended.

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Vehicle Crash Safety Standards

• National Highway Traffic Safety Administration (NHTSA)
  • Oversees safety performance standards for motor vehicles and motor vehicle equipment
  • NHTSA is legislatively mandated, manufacturers must comply
  • EVs routinely receive the highest crash safety ratings, Tesla among the best ever

• EV Accident Recovery
  • EV traction battery is a sealed system that undergoes rigorous testing
  • Well insulated system with crash and short-circuit auto-shutoff
  • Traction battery systems routinely exceed 350 volts
  • First Responders need special training to understand the technology and safety systems
**Additional Standards**

- **Americans with Disabilities Act (ADA)**
  - Charging stations must accommodate access
  - Public access and commercial facilities
  - U.S. Americans with Disabilities Act—28 CFR Part 36 (ADA)
  - 2003 International Building Code
  - 2009 ANSI A117.1

- **Signage**
  - Particularly important for EV owners
  - Provides specific information on local regulations and ordinances
  - Federal Highway Administration (FHWA) defines standards
  - FHWA—Manual on Uniform Traffic Control Devices (MUTCD)
  - 2009 ANSI A117.1
Automated and Connected Vehicles

• Automated Vehicles (AV)
  • NHTSA definition: “...are those in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input.”
  • Five levels of automation: ranges are Level 0, No automation; Level 3, Limited Self-driving; Level 4, Full Self-Driving

• Connected Vehicles (CV)
  • Connected vehicle technologies enable safe, interoperable networked wireless communications among vehicles (V2V), the infrastructure (V2I), and travelers’ personal communication devices (V2X)
  • Reduce highway crashes; assess the performance of the transportation system; provide accurate information to travelers; reduce unnecessary stops, delays, and emissions

• Transportation planning
  • MAP-21 requires state DOTs and regional MPOs to have a multimodal transportation plan with a minimum 20-year time horizon
  • These cars will be here well before 2035 so we better get busy
For Future Reference

• Electric Vehicle Charging Technologies Analysis and Standards—Doug Kettles
  

• Electric Vehicle Transportation Center—EVTC
  
  http://evtc.fsec.ucf.edu/

• ANSI, Progress Report, Standardization Roadmap For Electric Vehicles, Version 2.0—ANSI
  

• Alternative Fuels Data Center—AFDC
  
  http://www.afdc.energy.gov/

• Clean Cities
  
  http://www1.eere.energy.gov/cleancities/

• A Guide to the Lessons Learned From the Clean Cities Community Electric Vehicle Readiness Projects—Clean Cities
  
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