# 2013 Ford C-MAX Energi

## Advanced Vehicle Testing – Baseline Testing Results

### VEHICLE SPECIFICATIONS[1]

**Vehicle Features**

VIN: 1FADP5CUXDL530852
Class: Large Car
Seatbelt Positions: 5
Type[2]: Blended PHEV
CARB[3]: TZEV
EPA Fuel Economy: 370 Wh/mi (Charge-Depleting Mode, Combined); 38 mpg (Charge-Sustaining Mode, Combined)

**Engine**

Model: 16 Valve DOHC Duratec with Intake Variable Camshaft Timing (iVCT)
Displacement: 2.0 L
Cycle: Atkinson
Output: 105 kW @ 6,000 rpm
Torque: 174 Nm @ 4,000 rpm
Configuration: Inline 4-Cylinder
Fuel Tank Capacity: 14 US gal
Fuel Type: Regular Unleaded

**Transmission**

HF35 eCVT Hybrid Powersplit

**Battery**

Manufacturer: Panasonic
Type: Lithium-ion (NMC)
Cathode /Anode Material: $LiMn_2O_4$/Hard Carbon
Number of Cells: 84
Cell Configuration: Series
Nominal Cell Voltage: 3.7 V
Nominal System Voltage: 310.8 V
Rated Pack Capacity: 26 Ah
Rated Pack Energy: 7.6 kWh
Weight of Pack: 272 lb
Pack Location: Under Floor in Cargo Area
Cooling: Active – Forced Cabin Air

**Motor/Generator 1**

Type: Permanent Magnet AC Synchronous
Max. Power/Torque: 88 kW/ 240 Nm @ 6000 rpm
Cooling: Active – Liquid Cooled

**Motor/Generator 2**

Type: Permanent Magnet AC Synchronous
Cooling: Active – Liquid Cooled

**Weights**

Design Curb Weight: 3,899 lb
Delivered Curb Weight: 3,882 lb
Distribution F/R (%): 55/45
GVWR: 4,960 lb
GAWR F/R: 2,467/2,493 lb
Max. Payload: 825 lb

**Dimensions**

Wheelbase: 104.3 in
Track F/R: 60.5/60.4 in
Length/Width: 173.6 in/72.0 in
Height: 63.8 in
Ground Clearance: 5.5 in

**Tires**

Manufacturer: Michelin
Model: Energy Saver
Size: P225/50R-17
Pressure F/R: 38/38 psi
Spare Installed: N/A – Tire Sealant and Inflator

## CHARGE-DEPLETING PERFORMANCE STATISTICS[4]

### TRACK TESTING[5]

**Acceleration 0-60 mph[6]**

Measured Time: 8.6 s

Performance Goal: ≤13.5 s

Peak Power from Battery: 50.2 kW

**Maximum Speed**

At ¼ Mile: 87.3 mph

At 1 Mile[7]: 102.4 mph

Performance Goal: ≥90 mph at 1-mile mark

**Braking at 50% SOC from 60-0 mph[8]**

Measured Time: 3.1 s

Distance: 124 ft

Peak Power into Battery: 2.0 kW

**Braking at 100% SOC from 60-0 mph[8]**

Measured Time: 2.5 s

Distance: 118 ft

Peak Power into Battery: 19.1 kW

**Deceleration 60-10 mph[9]**

Measured Time: 73.0 s

Distance: 3,207 ft

Peak Power into Battery: 14.5 kW

Total Energy into Battery: 105.9 Wh

### DYNAMOMETER TESTING[10]

**Cycle Results[11]**

| | 72 °F | 20 °F | 95 °F + 850 W/m$^2$ |
|---|---|---|---|
| UDDS (Cold Start) | 258.0 Wh/mi | 354.3 Wh/mi, 40.6 mpg | 297.6 Wh/mi, 10,417 mpg |
| UDDS | 251.1 Wh/mi | 498.0 Wh/mi 137.6 mpg | 288.2 Wh/mi, 18,893 mpg |
| HWFET | 278.8 Wh/mi | | |
| US06 | 361.7 Wh/mi, 187 mpg | | |

**Energy Consumption at Steady-State Speed, 0% Grade**

| | | | | |
|---|---|---|---|---|
| 10 mph | 145.4 Wh/mi | | 50 mph | 276.4 Wh/mi |
| 20 mph | 146.9 Wh/mi | | 60 mph | 325.8 Wh/mi |
| 30 mph | 194.4 Wh/mi | | 70 mph | 411.6 Wh/mi |
| 40 mph | 223.0 Wh/mi | | 80 mph[12] | 393.9 Wh/mi |

**Duration of Passing Maneuver at Grade[13]**

| | 0% Grade | 3% Grade | 6% Grade |
|---|---|---|---|
| 35-55 mph | 4.6 s | 4.9 s | 5.6 s |
| 55-65 mph | 3.4 s | 3.1 s | 3.7 s |
| 35-70 mph | 7.9 s | 8.5 s | 10.3 s |
| 55-80 mph | 7.7 s | 8.9 s | 10.3 s |
| Maximum Speed at 25% Grade from Stop: 22.4 mph (Engine Off); 52.2 (Engine On) | | | |

NOTES (also from previous page):

1. Vehicle specifications were supplied by the manufacturer, measured, or derived from a literature review.
2. The vehicle classification is "Blended PHEV" because the all-electric operation cannot occur at all speeds and accelerations. In charge-depleting (CD) mode, the engine is used to supplement the electric motor to satisfy speed and acceleration demands in a "blended" manner.
3. The vehicle was classified as a Transitional Zero Emission Vehicle (TZEV) by the California Air Resources Board (CARB).
4. Performance numbers based on "Normal" vehicle mode. Performance numbers are averages from multiple tests.
5. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Track testing took place between July 11 and July 24, 2013 with a beginning vehicle odometer reading of 4,804 miles. The ambient temperatures ranged from 76 °F to 100 °F. No accessories were used except for headlights as required by track regulation.
6. The acceleration is measured from the point at which the vehicle begins to move. The acceleration and maximum speed results were averaged from 12 runs. The peak power value was taken from a single run.
7. The maximum speed was reached before the one-mile mark.
8. Controlled braking on dry surface. Brake testing was performed when the battery was at 50% state of charge (SOC) and also at 100% SOC. The peak power into the battery value was taken from a single run.
9. Coasting in drive on dry surface. Test run data were cut off when the vehicle reached 10 mph, as vehicle creep speeds are typically below this threshold. The peak power into the battery value and total energy into the battery value were both taken from a single (but different) run.
10. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on September 30, 2013, with the vehicle odometer reading 5,645 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 32.1800 lb, B: 0.4714 lb/mph, and C: 0.0168 lb/mph$^2$. All electrical consumption values are given in AC Wh/mi; for the steady-state speed table, a charging efficiency of 80% is assumed since a charge event did not immediately follow.
11. The Cycle Results table presents the fuel economy achieved by the vehicle on five EPA drive cycles at three different ambient temperatures: (1) 72 °F with vehicle climate-control off, (2) 20 °F with vehicle climate-control set to 72°F Auto, and (3) 95 °F with vehicle climate-control set to 72°F Auto. The vehicle is also subjected to 850 W/m$^2$ of solar load at 95 °F to simulate direct sunlight. The drive cycles include a hot start unless otherwise indicated.
12. The engine was on during the 80 mph test.
13. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed, at the specified grade.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document. Values in red indicate that the Performance Goal was not met.

## CONSTANT-SPEED RANGE AND CHARGE TESTING IN CHARGE-DEPLETING MODE[1]

| | 45 mph Test[2] | 60 mph Test[3] | 70 mph Test[4] |
|---|---|---|---|
| Average DC power out of battery at set speed (kW): | 9.0 | 19.1 | 24.8 |
| **(A)** DC energy out of battery at set speed (kWh)[5,7,9]: | 5.3 | 5.2 | 4.9 |
| **(A+)** Total DC energy out of battery (kWh)[5,7,9]: | 5.5 | 5.7 | 5.8 |
| Battery capacity discharge at set speed (Ah): | 17.2 | 16.9 | 16.4 |
| **(B)** Range at set speed (mi)[6,8,10]: | 26.9 | 19.4 | 14.1 |
| **(C)** Post-test charge AC energy from EVSE @ 240 V to onboard charger (kWh): | 7.0 | 7.2 | 7.2 |
| **(D)** Post-test charge DC energy into battery from onboard charger (kWh): | 5.9 | 6.1 | 6.1 |
| Post-test charge duration (HH:MM): | 02:17 | 02:20 | 02:15 |
| AC electricity consumption rate (Wh/mi)[11]: | 249 | 339 | 429 |
| DC electricity consumption rate (Wh/mi)[12]: | 197 | 268 | 347 |
| **(A+/D)** Battery Roundtrip Efficiency[13]: | 94% | 93% | 80% |
| **(D/C)** On-Board Charger Efficiency[14]: | 84% | 85% | 85% |
| **(A+/C)** Overall Trip Efficiency[15]: | 79% | 79% | 81% |

NOTES:

1. See Note 4 and Note 5 on page 2. The vehicle is accelerated to the desired speed and then cruise control is used to maintain the speed. Range is considered reached when either (1) the vehicle transitions from charge-depleting (CD) mode to charge-sustaining (CS) mode or (2) the engine turns on, whichever occurs first.
2. During the 45 mph range test, the maximum battery temperature was 35 °C and the average ambient temperature was 33 °C. During the post-test charge, the maximum battery temperature was 36 °C, and the average ambient temperature was 30 °C.
3. During the 60 mph range test, the maximum battery temperature was 45 °C and the average ambient temperature was 37 °C. During the post-test charge, the maximum battery temperature was 44 °C, and the average ambient temperature was 38 °C.
4. During the 70 mph range test, the maximum battery temperature was 42 °C and the average ambient temperature was 35 °C. During the post-test charge, the maximum battery temperature was 45 °C, and the average ambient temperature was 36 °C.
5. In addition to the energy discharged from the battery during the 45 mph test, energy was discharged during the drive from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 45 mph was completed, the vehicle is in CS mode, but there is still ESS energy throughput during the drive to return the vehicle to the test prep area and the EVSE unit for the post-test charge. The pre-test drive required 0.34 kWh while the post-test drive returned 0.11 kWh, and these energy inputs can be added to the energy consumed during the range test **(A)** to obtain the total output from the battery (5.5 kWh, denoted as **(A+)**) that is used in the calculations discussed in Notes 13-15.
6. In addition to the range measured for the 45 mph test, the pre-test drive required 1.02 miles from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 45 mph was completed, the post-test drive required an additional drive of 0.99 miles to return to the test prep area and the EVSE unit for the post-test charge. These distances can be added to the distance traveled during the range test **(B)** to obtain the total distance traveled (28.9 miles). However, the energy consumption values consider only the distance traveled during the test itself, or value **(B)**.
7. In addition to the energy discharged from the battery during the 60 mph test, energy was discharged during the drive from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 45 mph was completed, the vehicle is in CS mode, but there is still ESS energy throughput during the drive to return the vehicle to the test prep area and the EVSE unit for the post-test charge. The pre-test drive required 0.45 kWh while the post-test drive had no net energy throughput, and these energy inputs can be added to the energy consumed during the range test **(A)** to obtain the total output from the battery (5.7 kWh, denoted as **(A+)**) that is used in the calculations discussed in Notes 13-15.
8. In addition to the range measured for the 60 mph test, the pre-test drive required 1.27 miles from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 60 mph was completed, the post-test drive required an additional drive of 1.04 miles to return to the test prep area and the EVSE unit for the post-test charge. These distances can be added to the distance traveled during the range test **(B)** to obtain the total distance traveled (21.7 miles). However, the energy consumption values consider only the distance traveled during the test itself, or value **(B)**.
9. In addition to the energy discharged from the battery during the 70 mph test, energy was discharged during the drive from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 70 mph was completed, the vehicle is in CS mode, but there is still ESS energy throughput during the drive to return the vehicle to the test prep area and the EVSE unit for the post-test charge. The pre-test drive required 0.61 kWh while the post-test drive returned 0.059 kWh, and these energy inputs can be added to the energy consumed during the range test **(A)** to obtain the total output from the battery (5.8 kWh, denoted as **(A+)**) that is used in the calculations discussed in Notes 13-15.
10. In addition to the range measured for the 70 mph test, the pre-test drive required 1.52 miles from test prep area to point at which vehicle test speed is achieved and maintained. After the range at 70 mph was completed, the post-test drive required an additional drive of 0.95 miles to return to the test prep area and the EVSE unit for the post-test charge. These distances can be added to the distance traveled during the range test **(B)** to obtain the total distance traveled (16.57 miles). However, the energy consumption values consider only the distance traveled during the test itself, or value **(B)**.
11. The AC electricity consumption rate is calculated by dividing the DC electricity consumption rate (in Wh/mi) by the Overall Trip Efficiency for that particular set speed.
12. The DC electricity consumption rate is calculated by dividing the DC energy from the battery at set speed **(A)** by the range at set speed **(B)**.
13. Battery Roundtrip Efficiency is calculated by dividing the DC energy out of the battery **(A+)** by the DC energy from the on-board charger into the battery **(D).**
14. On-Board Charger Efficiency is calculated by dividing the DC energy from the on-board charger into the battery **(D)** by the AC energy from the EVSE **(C).**
15. Overall Trip Efficiency is calculated by dividing the DC energy out of the battery **(A+)** by the AC energy from the EVSE **(C)**.

## CUMULATIVE FUEL ECONOMY DYNAMOMETER PERFORMANCE STATISTICS[1]

| UDDS | | | HWFET | | |
|---|---|---|---|---|---|
| **Miles** | **Cumulative Fuel Economy (mpg)** | **Cumulative Electricity Consumption Rate (AC Wh/mi)** | **Miles** | **Cumulative Fuel Economy (mpg)** | **Cumulative Electricity Consumption Rate (AC Wh/mi)** |
| **5** | N/A[2] | 290.7 | **5** | N/A[2] | 337.9 |
| **10** | N/A[2] | 273.3 | **10** | N/A[2] | 317.8 |
| **15** | N/A[2] | 257.3 | **15** | N/A[2] | 302.0 |
| **20** | N/A[2] | 259.5 | **20** | N/A[2] | 301.3 |
| **25** | N/A[2] | 256.9 | **25**[5] | 891.9 | 283.8 |
| **30**[3] | 529.2 | 242.1 | **30** | 238.3 | 240.5 |
| **35** | 215.9 | 202.7 | **35** | 157.7 | 204.0 |
| **37.3**[4] | 191.5 | 190.4 | **40** | 128.3 | 179.7 |
| | | | **41.0**[6] | 123.4 | 170.8 |

NOTES:

1. See Note 4 on page 2. Values for fuel economy and electricity consumption rate obtained from drive cycle data without accessories and using SAE J1711 methodology. The vehicle is driven on consecutive drive cycles, with fuel economy and electricity consumption rates calculated for each cycle. Where a distance travelled is during a drive cycle, the values have been interpolated.
2. In some cases of blended CD mode, no fuel is used.
3. During the consecutive UDDS cycles, the CD mode ended and the vehicle transitioned to CS mode at 27.16 miles, after 3.6 UDDS cycles (the full UDDS cycle is 7.45 miles long). The Performance Goal is to complete two UDDS cycles or 14.90 miles in charge-depleting mode.
4. The consecutive UDDS testing ended at 37.3 miles, after five consecutive cycles.
5. During the consecutive HWFET cycles, the CD mode ended and the vehicle transitioned to CS mode at 24.03, after 2.3 HWFET cycles (the full HWFET cycle is 10.25 miles long). The Performance Goal is to complete two HWFET cycles or 20.50 miles in charge-depleting mode.
6. The consecutive HWFET testing ended at 41.0 miles, after four consecutive cycles.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

## CHARGE-SUSTAINING PERFORMANCE STATISTICS[1]

### TRACK TESTING[2]

**Acceleration 0-60 mph[3]**

Measured Time: 9.1 s

Performance Goal: ≤13.5 s

Peak Power from Battery: 38.9 kW

**Maximum Speed**

At ¼ Mile: 85.4 mph

Maximum Speed[4]: 105.1 mph

Performance Goal: ≥90 mph at 1-mile mark

**Braking from 60-0 mph[5]**

Measured Time: 3.2 s

Distance: 123 ft

Peak Power into Battery: 12.9 kW

**Deceleration 60-10 mph[6]**

Measured Time: 77.1 s

Distance: 3,495 ft

Peak Power into Battery: 9.9 kW

Total Energy into Battery: 84.2 Wh

### DYNAMOMETER TESTING[7]

**Cycle Results[8]**

| | 72 °F | 20 °F | 95 °F + 850 W/m$^2$ |
|---|---|---|---|
| UDDS (Cold Start) | 49.9 mpg | 24.2 mpg | 44.5 mpg |
| UDDS | 51.2 mpg | 39.8 mpg | 46.7 mpg |
| HWFET | 51.9 mpg | 44.6 mpg | 51.6 mpg |
| US06 | 36.1 mpg | 32.5 mpg | 35.5 mpg |
| SC03 | | | 41.3 mpg |

**Fuel Economy at Steady-State Speed, 0% Grade**

| | | | | |
|---|---|---|---|---|
| 15 mph | 55.1 mpg | | 60 mph | 45.4 mpg |
| 30 mph | 70.8 mpg | | 75 mph | 35.8 mpg |
| 45 mph | 61.7 mpg | | | |

**Duration of Passing Maneuver at Grade[9]**

| | 0% Grade | 3% Grade | 6% Grade |
|---|---|---|---|
| 35-55 mph | 4.8 s | 5.0 s | 5.5 s |
| 55-65 mph | 3.0 s | 3.7 s | 5.9 s |
| 35-70 mph | 8.3 s | 9.3 s | 11.0 s |
| 55-80 mph | 7.9 s | 9.1 s | 14.5 s |
| Maximum Speed at 25% Grade from Stop: 38.2 mph | | | |

NOTES:

1. Performance numbers based on "Normal" vehicle mode. Performance numbers are averages from multiple tests.
2. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Track testing took place between July 11 and July 24, 2013 with the vehicle odometer reading 4,804 miles. The ambient temperatures ranged from 76 °F to 100 °F. No accessories were used except for headlights as required by track regulation.
3. The acceleration is measured from the point at which the vehicle begins to move. The acceleration and maximum speed results were averaged from 12 runs. The peak power value was taken from a single run.
4. The maximum speed was reached before the one-mile mark.
5. Controlled braking on dry surface. The test is not run at a set SOC value in charge-sustaining mode. The peak power into the battery value was taken from a single run.
6. Coasting in drive on dry surface. Test run data were cut off when the vehicle reached 10 mph, as vehicle creep speeds are typically below this threshold. The peak power into the battery value and total energy into the battery value were both taken from a single (but different) run.
7. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on September 30, 2013, with the vehicle odometer reading 5,645 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 32.1800 lb, B: 0.4714 lb/mph, and C: 0.0168 lb/mph$^2$.
8. The Cycle Results table presents the fuel economy achieved by the vehicle on five EPA drive cycles at three different ambient temperatures: (1) 72 °F with vehicle climate-control off, (2) 20 °F with vehicle climate-control set to 72°F Auto, and (3) 95 °F with vehicle climate-control set to 72°F Auto. The vehicle is also subjected to 850 W/m$^2$ of solar load at 95 °F to simulate direct sunlight. The drive cycles include a hot start unless otherwise indicated.
9. The passing maneuver value indicates the amount of time required for the vehicle to transition from the first to the second speed, at the specified grade.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

**This vehicle meets the requirements of PHEV America Vehicle Technical Specification, Revision 1 as follows:**

(1) Vehicles shall comply with Federal Motor Vehicle Safety Standards (FMVSS) applicable on the date of manufacture and such compliance shall be certified by the manufacturer in accordance with 49 CFR 567. Suppliers shall provide a completed copy of Appendix A and Appendix B with their proposal, providing vehicle specifications and the method of compliance with each required section of 49 CFR 571. If certification includes exemption, the exemption number issued by the National Highway Transportation Safety Administration (NHTSA), the date of its publication in the Federal Register and the page number(s) of the Federal Register acknowledging issuance of the exemption shall be provided along with Appendix B. Exemptions for any reason other than non-applicability shall not be allowed.

(2) Suppliers shall supply Material Safety Data Sheets (MSDS) for all unique hazardous materials the vehicle is equipped with, including Energy Storage System (ESS) batteries or capacitors, and auxiliary batteries.

(3) Suppliers shall provide recycling plans for batteries and other vehicle hazardous materials including how the plan has been implemented.

(4) All vehicles shall comply with the Federal Communications Commission (FCC) requirements for unintentional emitted electromagnetic radiation, as identified in 47 CFR 15, Subpart B, "Unintentional Radiators."

(5) Vehicles shall have a minimum payload of at least 400 pounds.

(6) For conversions, Original Equipment Manufacturer (OEM) gross vehicle weight ratings (GVWR) shall not be increased. For conversion vehicles, Suppliers shall specify the OEMs GVWR.

(7) For conversions, OEM gross vehicle axle weight ratings (GAWR) shall not be increased. Suppliers shall provide axle weights for the vehicle as delivered, and at full rated payload.

(8) Tires shall be subject to the following requirements:
- Tires provided with the vehicle shall be the standard tire offered by the plug in hybrid electric vehicle (PHEV) Supplier for the vehicle being proposed.
- Tires shall correspond to the requirements of the placard installed in accordance with 49 CFR 571.109, 110, 119 and 120, as applicable.
- Suppliers shall specify manufacturer, model and size of the standard tire.
- Tires sizes and inflation pressures shall be in accordance with the requirements of the placard.
- At no time shall the tire's inflation pressure exceed the maximum pressure imprinted upon that tire's sidewall.
- The tire shall be operable across the entire operation/load range of that vehicle.
- Replacement tires shall be commercially available to the end user in sufficient quantities to support the purchaser's needs.
- Tires provided as original equipment by the PHEV manufacturer shall not have warranty restrictions in excess of those of the tire's manufacturer, unless the Supplier is the sole warrantor for the tires.
- If the vehicle may be equipped with more than one standard tire, this information shall be provided for each type/manufacturer of each standard tire.

(9) Seating capacity shall be a minimum of 1 driver and 1 passenger. Suppliers shall specify seating capacity (available seat belt positions) for their vehicle. For conversion vehicles, if the vehicle's seating capacity is changed from that specified by the OEM on their FMVSS placard, the seat(s) being added or abandoned shall be modified as required by 49 CFR 571.207, et al, and a new FMVSS placard installed as required by 49 CFR 567, 568 or 571, as applicable.

(10) For conversion vehicles, the OEM passenger space shall not be intruded upon by the ESS or other conversion materials.

(11) The vehicle may utilize a single-speed, multi-speed automatic, manual transmission, or a Continuously Variable Transmission (CVT), and shall have a parking mechanism.

(12) The controller/inverter shall limit the minimum ESS battery discharge voltage to prevent degradation of battery life, and should limit the maximum regeneration voltage to prevent external gassing of the batteries.

(13) Vehicles shall comply with the requirements of 49 CFR 571.105.S5.2.1, or alternatively, 49 CFR 571.105.S5.2.2 for parking mechanisms.

(14) If different, customer available and battery available Department of Energy (DOE) ratings shall both be provided.

(15) Batteries shall comply with the requirements of SAE J1718. Vehicles shall not auto-start the engine to charge the batteries while the vehicle is parked and the key switch is in the OFF position. For vehicles capable of off-vehicle charging (OVC), ESS batteries shall meet the requirements of NEC 625-29 (c) or (d) for charging in enclosed spaces without a vent fan. The vehicle shall be labeled as not requiring ventilation for charging (or have the appropriate classification label from an Underwriters Laboratory (UL)-recognized Testing Laboratory).

(16) For vehicles with ESS system voltages of 48 volts (V) and higher, batteries or capacitors and their enclosures shall be designed and constructed in a manner that complies with 49 CFR571.305. For vehicles with ESS system voltages below 48 volts direct current (VDC), batteries or capacitors, and their enclosures, shall be designed and constructed in accordance with the requirements of SAE J1766. Further, irrespective of ESS system voltage, batteries or capacitors, and electrolyte will not intrude into the passenger compartment during or following FMVSS frontal barrier, rear barrier and side impact collisions, and rollover requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.

(17) Concentrations of explosive gases in the battery box shall not be allowed to exceed 25% of the LEL (Lower Explosive Limit). Suppliers shall describe how battery boxes will be vented, to allow any battery gases to escape safely to atmosphere during and following normal or abnormal charging and operation of the vehicle. Battery gases shall not be allowed to enter the occupant compartment.
Batteries shall comply with the requirements of SAE J1718, and at a minimum shall meet the requirements of NEC 625-29 (c) or (d) for charging in enclosed spaces without a vent fan.

(18) If a Supplier provides a vehicle with parallel battery packs, the Supplier shall provide detailed information on the equipment and charging algorithms required to prevent the parallel strings from becoming unbalanced.

(19) Flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during all modes of operation. Additionally, flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during or following frontal barrier, rear barrier and side impact collisions, and roll-over requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.

(20) For vehicles using fuels other than gasoline, manufacturers shall indicate compliance with appropriate and applicable standards from SAE, NFPA, etc. [e.g., for vehicles using Compressed Natural Gas (CNG) as fuel, manufacturers should indicate compliance with NFPA 52, "CNG Vehicular Fuel Systems Code," as well as 49 CFR 571.303 and 304.].

(21) ESS shall be battery, capacitor, or electromechanical flywheel technology-based as defined in SAE J1711.

(22) Vehicles shall not contain exposed conductors, terminals, contact blocks or devices of any type that create the potential for personnel to be exposed to 60 V or greater (the distinction between low-voltage and high voltage, as specified in SAE J1127, J1128, et al.). Access to any high voltage components shall require the removal of at least one bolt, screw, or latch. Devices considered to be high voltage components shall be

clearly marked as HIGH VOLTAGE. These markings should be installed at any point the voltage can be accessed by the end user. Additionally, cable and wire marking shall consist of orange wire and/or orange sleeving as identified in SAE J1673.

(23) For propulsion power systems with voltages greater than or equal to 48 VDC, the system shall be isolated from the vehicle chassis such that leakage current does not exceed 0.5 MIU.
Charging circuits for ESS battery systems with voltages greater than or equal to 48 VDC shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 5 mA at any time the vehicle is connected to an off-board power supply.

(24) The automatic disconnect for the ESS batteries shall be capable of interrupting maximum rated controller/inverter current. The Supplier shall describe the automatic disconnect provided for the main propulsion batteries.

(25) The vehicle shall be prevented from being driven with the key turned on and the drive selector in the drive or reverse position while the vehicle's charge cord is attached. Additionally, the following interlocks shall be present:
- The controller shall not initially energize to move the vehicle with the gear selector in any position other than "PARK" or "NEUTRAL."
- The start key shall be removable only when the "ignition switch" is in the "OFF" position, with the drive selector in "PARK."
- With a pre-existing accelerator input, the controller shall not energize or excite such that the vehicle can move under its own power from this condition.

(26) If the vehicle is capable of off-board recharging of the ESS, the charger shall be capable of recharging the ESS to a state of full charge from any possible state of discharge in less than 12 hours, at temperatures noted in Section 5.5, as applicable.
The charger shall be fully automatic, determining when "end of charge" conditions are met and transitioning into a mode that maintains the main propulsion battery at a full state of charge while not overcharging it, if continuously left on charge.

(27) If the vehicle is capable of off-board recharging of the ESS, the chargers shall use 120V or 208/240V single-phase 60-Hertz alternating current service, with an input voltage tolerance of 10% of rated voltage. Input current for chargers operating at 208V and 240V shall be compatible with 40-ampere circuit breakers.
Personnel protection systems shall be in accordance with the requirements of UL Standard 2202 and shall be determined based upon ESS system voltages. All personnel protection systems shall meet the requirements specified in the applicable sections of UL2231-1 and 2231-2.

(28) If the vehicle is capable of off-board recharging of the ESS using a 208/240 V charger, chargers shall have a true power factor of .95 or greater and a harmonic distortion rated at 20% (current at rated load).

(29) Regardless of the charger type used, the charger shall conform to the requirements of UL Proposed Standard 2202.

(30) The installation of options shall not relieve Suppliers of meeting other "shall" requirements.

(31) Vehicles shall be accompanied by non-proprietary manuals for parts, service, operation and maintenance, interconnection wiring diagrams and schematics.

(32) Vehicles shall be capable of completing the PHEV America Rough Road Test (ETA-HTP-005) including (1) driving through standing water without damage and without battery to chassis leakage current exceeding 0.5 MIU per UL Standard 2202, and (2) standing for extended periods in extreme temperatures without damage to or failure of the vehicle or its systems. Vehicle shall be capable of completing all HEV America tests without repairs exceeding a cumulative total of 72 hours.

**This information was prepared with the support of the U.S. Department of Energy (DOE) under Award No. DE-EE0005501. However, any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the DOE.**