2013 Ford C-MAX Hybrid

Advanced Vehicle Testing – Baseline Testing Results

VEHICLE SPECIFICATIONS[1]

Vehicle Features

VIN: 1FADP5AU1DL528698
Class: Large Car
Seatbelt Positions: 5
Type: HEV
CARB[2]: BIN 3
EPA Fuel Economy: 45/40/43 mpg (City/Highway/Combined)

Engine

Model: 16 Valve DOHC Duratec with Intake Variable Camshaft Timing (iVCT)
Displacement: 2.0 L
Cycle: Atkinson
Power: 105 kW @ 6,000 rpm
Torque: 174 Nm @ 4,000 rpm
Configuration: Inline 4-Cylinder
Fuel Tank Capacity: 13.5 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
Cell Config.: 76 Series Cells
Nominal Cell Voltage: 3.7 V
Nominal System Voltage: 281.2 V
Rated Pack Capacity: 5.0 Ah
Rated Pack Energy: 1.4 kWh
Weight of Pack: 76 lb
Pack Location: Under Floor of Rear Seat/Trunk
Cooling: Active – Fan Cooled

Motor/Generator 1

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

Motor/Generator 2

Type: PM AC Synchronous
Cooling: Active – Liquid Cooled

Weights

Design Curb Weight: 3,607 lb
Delivered Curb Weight: 3,636 lb
Distribution F/R (%): 62/38
GVWR: 4,641.0 lb
GAWR F/R: 2,414/1,011 lb
Max. Payload: 825 lb

Dimensions

Wheelbase: 104.2 in
Track F/R: 60.5/60.4 in
Length/Width: 173.6 in/72.0 in
Height: 63.9 in
Ground Clearance: 5.67 in

Tires

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

PERFORMANCE STATISTICS[3]

TRACK TESTING[4]

Acceleration 0-60 mph[5]

Measured Time: 9.2 s

Performance Goal: ≤13.5 s

Peak Power from Battery: 39.3 kW

Maximum Speed

At ¼ Mile: 85.6 mph

At 1 Mile[6]: 117.0 mph

Performance Goal: ≥90 mph at 1-mile mark

Braking 60-0 mph[7]

Measured Time: 3.0 s

Distance: 125 ft

Peak Power into Battery: 0.62 kW

Deceleration 60-10 mph[8]

Measured Time: 74.4 s

Distance: 3,240 ft

Peak Power into Battery: 10.0 kW

Total Energy into Battery: 76.1 Wh

DYNAMOMETER TESTING[9]

Cycle Results[10]

	72 °F	20 °F	95 °F + 850 W/m^2
UDDS (Cold Start)	51.3 mpg	28.9 mpg	46.6 mpg
UDDS	60.4 mpg	44.0 mpg	51.9 mpg
HWFET	60.9 mpg	51.7 mpg	59.8 mpg
US06	40.0 mpg	36.7 mpg	37.1 mpg
SC03	--	--	47.5 mpg

Fuel Economy at Steady-State Speed, 0% Grade

15 mph	84.8 mpg		60 mph	50.3 mpg
30 mph	80.1 mpg		75 mph	39.0 mpg
45 mph	68.9 mpg			

Duration of Passing Maneuver at Grade[11]

	0% Grade	3% Grade	6% Grade
35-55 mph	4.6 s	4.6 s	5.5 s
55-65 mph	3.5 s	3.4 s	4.0 s
35-70 mph	8.0 s	8.8 s	10.4 s
55-80 mph	7.4 s	8.6 s	10.8 s
Maximum Speed at 25% Grade from Stop: 22.7 mph (All-electric), 43.5 mph (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 was classified as BIN 3 by the California Air Resources Board (CARB).
3. Performance numbers based on "Normal" vehicle mode. Performance numbers are averages from multiple tests. The vehicle test weight was 3,967 lb.
4. 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 on June 26, 2013 with a beginning vehicle odometer reading of 4,128 miles. The ambient temperatures ranged from 80 ºF to 97 ºF.
5. The acceleration is measured from the point at which the vehicle begins to move. The acceleration and maximum speed results were averaged from six runs. The peak power into the battery value was taken from a single run.
6. The maximum speed was reached before the one-mile mark.
7. Controlled braking on dry surface. Results are averaged from six runs. The peak power into the battery value was taken from a single run.
8. 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. The time and distance results are averaged from six runs.
9. Dynamometer testing occurs after the track testing is complete. Dynamometer testing began on August 23, 2013, with the vehicle odometer reading 4,451 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: 21.75 lb, B: 0.365 lb/mph, and C: 0.01859 lb/mph^2.
10. 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.
11. 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 HEV 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 HEV 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 HEV 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 HEV 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.

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