# 2014 smart fortwo ED

## Advanced Vehicle Testing – Baseline Vehicle Testing Results

### VEHICLE SPECIFICATIONS[1]

**Vehicle Features**
VIN: WMEE39AAEK732457
Class: Sub-Compact
Seatbelt Positions: 2
Type: BEV
CARB[2]: Type II ZEV
EPA Fuel Economy: 122 MPGe (City)/93 MPGe (Highway)/107 MPGe (Combined)

**Electric Motor**
Type: Permanent Magnet AC Synchronous
Maximum Power: 55 kW
Maximum Torque: 130 Nm
Max. Motor Speed: 14,000 rpm
Cooling: Active –Liquid Cooling

**Battery**
Manufacturer: Deutsche ACCUmotive
Type: Lithium-ion
Cathode /Anode Material: $LiMn_2O_4$/Hard Carbon
Number of Cells: 279
Cell Configuration: 3 Parallel, 93 Series
Nominal Cell Voltage: 3.7 V
Nominal System Voltage: 344.1 V
Rated Pack Capacity: 52 Ah
Rated Pack Energy: 17.6 kWh
Weight of Pack: 191 kg
Pack-Level Specific Energy: 92.0 Wh/kg
Pack-Level Energy Density: 123 Wh/L
Pack Location: Underneath foot well
Cooling: Active – Liquid-Cooled

**Transmission**
Type: Single Speed
Final Drive Ratio: 9.922

**Weights**
Design Curb Weight: 2,119 lb
Delivered Curb Weight: 1,990 lb
Distribution F/R: 51%/49%
GVWR: 2,535 lb
GAWR F/R: 1,113 lb /1,455 lb
Maximum Payload: 416 lb

**Dimensions**
Wheelbase: 73.5 in
Track F/R: 50.5 in/54.5 in
Length/Width: 106.1 in/61.4 in
Height: 60.7 in

**Tires**
Manufacturer: Kumho
Model: Solus kh 16
Size: P155/55R15
Pressure F/R: 44 psi/44 psi
Spare Installed: N/A - Tire sealant and inflator

NOTES:
1. Vehicle specifications were supplied by the manufacturer, measured, or derived from a literature review.
2. The vehicle was classified as a Type II ZEV by the California Air Resources Board (CARB). The range on consecutive UDDS cycles is over 100 miles (and less than 200 miles), but the vehicle does not meet the charging requirements for the Type III classification.

## PERFORMANCE STATISTICS[1]

### TRACK TESTING[2]

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

Measured Time: 11.0 s

Performance Goal: ≤13.5 s

Peak DC Power from Battery: 65.2 kW

**Maximum Speed**

At ¼ Mile: 74.3 mph

Maximum Speed[4]: 77.7 mph

Performance Goal: ≥90 mph at 1-mile mark

**Braking from 60-0 mph at 100% SOC[5]**

Measured Time: 3.7 s

Distance: 153 ft

Peak DC Power into Battery: 23.1 kW

**Braking from 60-0 mph at 50% SOC[5]**

Measured Time: 3.7 s

Distance: 140 ft

Peak DC Power into Battery: 22.0 kW

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

Measured Time: 26.8 s

Distance: 1,334 ft

Peak DC Power into Battery: 11.5 kW

Total DC Energy into Battery: 29.0 Wh

### DYNAMOMETER TESTING[7]

**Cycle Results[8]**

| | 72 °F | 20 °F | 95 °F + 850 W/m$^2$ |
|---|---|---|---|
| UDDS (Cold Start) | 191.6 Wh/mi | 422.7 Wh/mi | 345.1 Wh/mi |
| UDDS | 182.0 Wh/mi | 355.1 Wh/mi | 321.9 Wh/mi |
| HWFET | 223.6 Wh/mi | 311.6 Wh/mi | 269.3 Wh/mi |
| US06 | 291.5 Wh/mi | 377.5 Wh/mi | 345.7 Wh/mi |
| SC03 | | | 327.3 Wh/mi |

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

| | | | | |
|---|---|---|---|---|
| 10 mph | 158.6 Wh/mi | | 50 mph | 231.9 Wh/mi |
| 20 mph | 144.4 Wh/mi | | 60 mph | 271.0 Wh/mi |
| 30 mph | 163.2 Wh/mi | | 70 mph | 318.0 Wh/mi |
| 40 mph | 192.2 Wh/mi | | 77 mph | 356.4 Wh/mi |

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

| | 0% Grade | 3% Grade | 6% Grade |
|---|---|---|---|
| 35-55 mph | 4.4 s | 5.1 s | 6.0 s |
| 55-65 mph | 3.5 s | 4.2 s | 5.8 s |
| 35-70 mph | 9.6 s | 11.8 s | 15.6 s |
| 55-Max mph | 9.8 s (77.2 mph) | 12.6 s (76.9 mph) | 19.5 s (76.5 mph) |
| Maximum Speed at 25% Grade from Stop: 42.3 mph | | | |

NOTES:

1. Performance numbers based on "Normal" vehicle mode. Performance numbers are averages from multiple tests unless otherwise indicated. Performance numbers are averages from multiple tests. Electricity values are AC values unless otherwise indicated.
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), for a test weight of 2,314 lb, distributed in a manner similar to the original curb loading of the vehicle. Track testing took place between November 11 and November 13, 2014 with a beginning vehicle odometer reading of 4,090 miles. The ambient temperatures ranged from 66 °F to 78 °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 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 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: 24.3530 lb, B: 0.4997 lb/mph, and C: 0.01544 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. The conversion for Wh/mi to miles-per-gallon-of-gasoline-equivalent (MPGe) is to divide 33,700 Wh/gallon-of-gasoline-equivalent by the Wh/mi value.
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. The vehicle could not achieve 80 mph, so the duration of the passing maneuvers from 55 mph were taken until the vehicle could no longer accelerate to a higher speed. The speeds in the parentheses are the top speeds achieved.

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 speed (kW): | 9.1 | 17.3 | 23.8 |
| **(A)** DC energy out of battery at set speed (kWh)[5,7,9]: | 16.9 | 16.5 | 15.4 |
| **(A+)** Total DC energy out of battery (kWh)[5,7,9]: | 17.2 | 16.9 | 16.0 |
| Battery capacity discharge at set speed (Ah): | 49.6 | 48.8 | 46.4 |
| **(B)** Range at set speed (mi)[6,8,10]: | 85.2 | 57.7 | 45.3 |
| **(C)** Post-test charge AC energy from EVSE @ 240 V to onboard charger (kWh)[11]: | 19.2 | 19.3 | 19.2 |
| **(D)** Post-test charge DC energy into battery from onboard charger (kWh): | 16.1 | 16.2 | 16.1 |
| Post-test charge duration (HH:MM): | 06:05 | 05:59 | 06:03 |
| AC electricity consumption rate (Wh/mi)[12]: | 236 | 340 | 406 |
| DC electricity consumption rate (Wh/mi)[13]: | 198 | 285 | 340 |
| **(D/C)** On-Board Charger Efficiency[14]: | 84% | 84% | 84% |
| **(A+/C)** Overall Trip Efficiency[15]: | 90% | 88% | 83% |

NOTES (cont'd on next page):

1. See Note 3 and Note 4 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 the vehicle is no longer capable of maintaining a speed that is 2 mph lower than the set speed. Battery temperature data were not collected for this vehicle.
2. During the 45 mph range test, the average ambient temperature was 23 °C. During the post-test charge, the average ambient temperature was 20 °C.
3. During the 60 mph range test, the average ambient temperature was 18 °C. During the post-test charge, the average ambient temperature was 21 °C.
4. During the 70 mph range test, the average ambient temperature was 25 °C. During the post-test charge, the average ambient temperature was 26 °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, 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 0.26 kWh while the post-test drive required 0.04 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 (17.2 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 0.94 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 1.30 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 (87.5 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 60 mph was completed, 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 0.46 kWh while the post-test drive returned 0.02 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 (16.9 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 1.19 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 0.67 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 (59.6 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, 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 0.47 kWh while the post-test drive required 0.17 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 (16.0 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 1.73 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 1.09 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 (60.4 miles). However, the energy consumption values consider only the distance traveled during the test itself, or value **(B)**.
11. The EVSE data were not available from the unit and the average on-board charger (OBC) AC/DC conversion value from the subsequent dynamometer testing was used instead.
12. 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 speed.
13. The DC electricity consumption rate is calculated by dividing the DC energy from the battery as the set speed **(A)** by the range at the set speed **(B)**.
14. OBC Efficiency is normally calculated by dividing the DC energy from the on-board charger into the battery **(D)** by the AC energy from the EVSE **(C)**. Because these data were not available, the average OBC AC/DC efficiency value from the subsequent dynamometer testing was used instead.
15. Overall Vehicle Efficiency is calculated by dividing the DC energy out of the battery **(A+)** by the AC energy from the EVSE **(C)**. The value is based on the calculated average OBC AC/DC efficiency value.

**As a production vehicle, this vehicle is assumed to meet all Federal Motor Vehicle Safety Standards (FMVSS) for Battery Electric Vehicles.**

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