

Figure 5.53 Temperature in different parts at maximum power output (testing vehicle C)

5.3.2 Effect of the SOC at the start of the test

(A) Testing vehicle A

For the examination of how the SOC at the start of the test affects measurements of HEV system power output, two types of SOC were used: full charge and charge within the normal usage range. The full charge was defined as the SOC at which regenerative current stops flowing after the battery has been charged with regenerative current through operations such as turning the accelerator off and braking while the vehicle is driven from the chassis dynamometer. For the normal usage range, under conditions where Δ SOC before and after the test become the same when the vehicle is run in JC08 mode, the value around the middle in the SOC range during the test is defined as the normal usage SOC. With testing vehicle A, according to the data from the scanning tool attached to the OBD connector, the full charge was SOC 80% and the normal usage SOC was 55%.

The effect of different SOC on power output is shown in Figure 5.54. In terms of testing conditions, the vehicle speed was 160 km/hr and the warm-up was done at the constant speed of 60 km/hr for 20 minutes. The facility used for the test was the axle-hub chassis dynamometer. The power output measurements were obtained as the wheel driving power as well as the combined value of the engine power and battery power, which is being proposed to the ISO, and the two were compared.

The wheel driving power was 63.0 kW on average when the SOC at the start of the test was 80%, and 62.7 kW on average when the SOC was 55%; the difference of 0.3 kW was recorded. The effect of the different SOC at the start of the test resulted in a difference of less than 1.0 kW, which leads us to believe that the effect is small. The deviations were -1.5 to 1.0 kW with the 80% SOC and -1.8 to 0.6 kW with the 55% SOC; the variations were moderately large in these results.

When power output was calculated by the method proposed to the ISO, the average value was 72.6 kW with the 80% SOC, and 72.2 kW with the 55% SOC; the difference was 0.4 kW. The effect of the different SOC at the start of the test resulted in a difference of less than 1.0 kW, which leads us to

believe that the effect is small. The deviations were ± 0.2 kW with the 80% SOC and ± 0.0 kW with the 55% SOC; the variations were small.

In terms of differences in power measurements taken at different places, with the 80% SOC, the wheel driving power was 63.0 kW, which was 9.6 kW lower than the 72.6 kW recorded by the method proposed to the ISO, and likewise, with the 55% SOC, it was 9.5 kW lower. This showed that the difference in power output between different measuring points is not affected by the SOC at the start of the test.

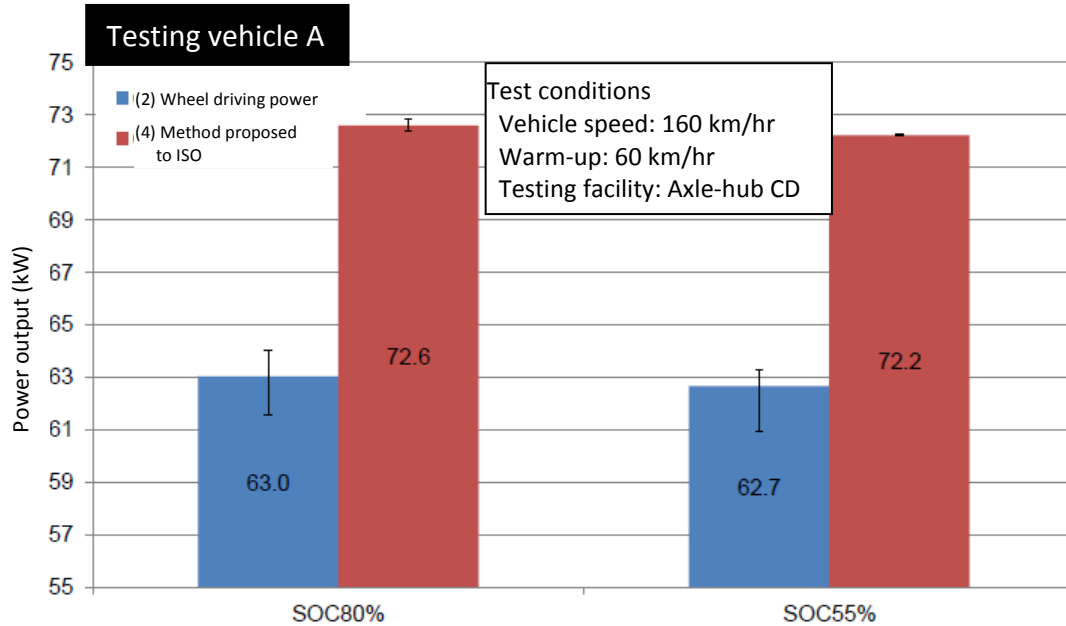


Figure 5.54 Effect of difference in SOC at the start of test on power output (testing vehicle A)

After it was understood that when the SOC is within the range of the full charge to the normal usage SOC, the difference of the SOC at the start of the test had almost no effect on the HEV system power output, effect of the SOC on the HEV system power when the SOC is outside of that range was studied. To obtain an SOC that was lower than the SOC range of normal usage, EV drive at low speed was carried out and the battery was forced to drain. The relationship between the SOC at the start of the test and the power output is shown in Figure 5.55. The x-axis represents SOC at the start of the test and the y-axis represents power output. As for the testing conditions, the vehicle speed was 160 km/hr and warming up was carried out for 20 minutes at the constant speed of 60 km/hr. The facility used for the test was the axle-hub chassis dynamometer. With testing vehicle A, the SOC as low as approximately 55% did not affect the battery power and therefore the HEV system power did not significantly change. When the SOC was around 45%, the battery power was reduced and the HEV system power was also lower. When the SOC was 35%, the battery power was significantly reduced and the HEV system power became close to the engine power. This made it clear that if power output is measured in a test where the SOC at the start of the test is outside of the normal usage range, the resulting measurements of the HEV system power are lower.

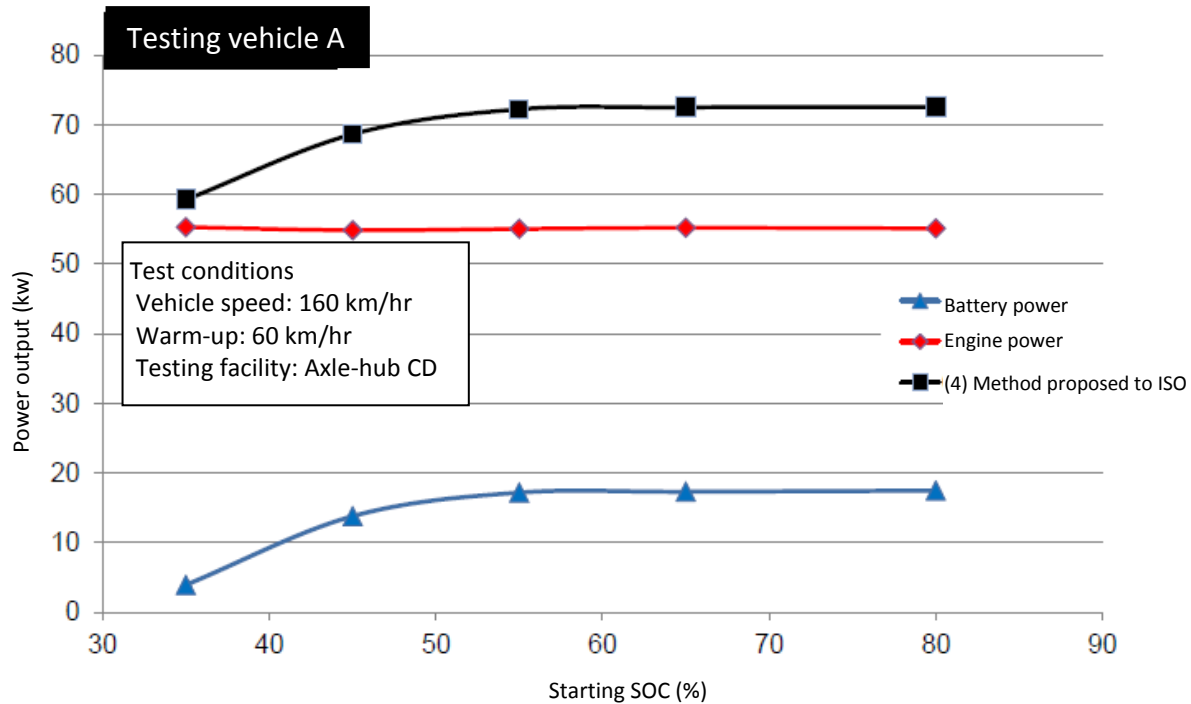


Figure 5.55 Relationship between SOC at the start of the test and power output (testing vehicle A)

(2) Testing vehicle B

With testing vehicle B, data obtained from the scanning tools attached to the OBD connector indicated the full charge SOC as 93% and the normal use SOC as 70%.

The effect of different SOC on power output is shown in Figure 5.56. In terms of testing conditions, the vehicle speed was 68 km/hr in second gear and the warm-up was done at the constant speed of 60 km/hr for 20 minutes. The facility used for the test was the axle-hub chassis dynamometer. The power output measurements were taken as the wheel driving power as well as the combined value of the engine power and battery power, which is being proposed to the ISO, and the two were compared.

The wheel driving power was 84.8 kW on average when the SOC at the start of the test was 93%, and 86.8 kW on average when the SOC was 70%; the difference of 2.0 kW was recorded. The SOC at the start of the test is thought to have certain effect on power output. The deviations were -1.9 to 1.7 kW with the 93% SOC and ± 0.2 kW with the 70% SOC; the variation was moderately large with the 93% SOC.

When power output was calculated by the method proposed to the ISO, the average value was 92.6 kW with the 93% SOC, and 92.4 kW with the 70% SOC, resulting in a 0.2 kW difference. The effect of the different SOC at the start of the test resulted in a difference of less than 1.0 kW, which leads us to believe that the effect is small. The deviations were -0.3 to 0.4 kW with the 93% SOC and -0.4 to 0.5 kW with the 70% SOC; the variations were small.

In terms of differences in power measurements taken at different places, with the 93% SOC, the wheel driving power was 84.8 kW, which was 7.8 kW lower than the 92.6 kW recorded through the method proposed to the ISO, and it was 5.6 kW lower with the 70% SOC. This showed that the SOC at the start of the test affects the difference in power output between different measuring points.

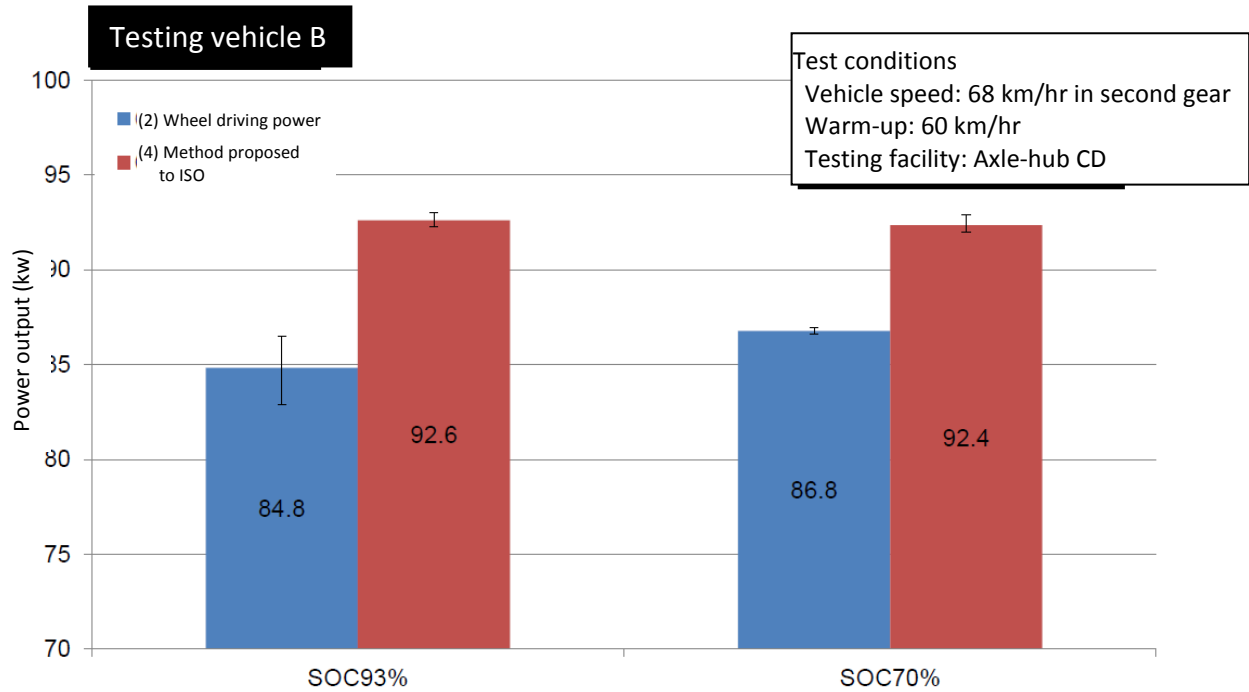


Figure 5.56 Effect of difference in SOC at the start of test on power output (testing vehicle B)

After it was understood that when the SOC is within the range of the full charge to the normal usage SOC, the difference of the SOC at the start of the test has almost no effect on the HEV system power output obtained by the method proposed to the ISO, effect of the SOC on the HEV system power when the SOC is outside of that range was studied. The relationship between the SOC at the start of the test and the power output is shown in Figure 5.57. The x-axis represents SOC at the start of test and the y-axis represents power output. As for the testing conditions, the vehicle speed was 68 km/hr in second gear and the warm-up was carried out for 20 minutes at the constant speed of 60 km/hr. The facility used for the test was the axle-hub chassis dynamometer. With testing vehicle B, because there was no change in battery power within the SOC range that could be tested, the HEV system power did not show any significant changes either.

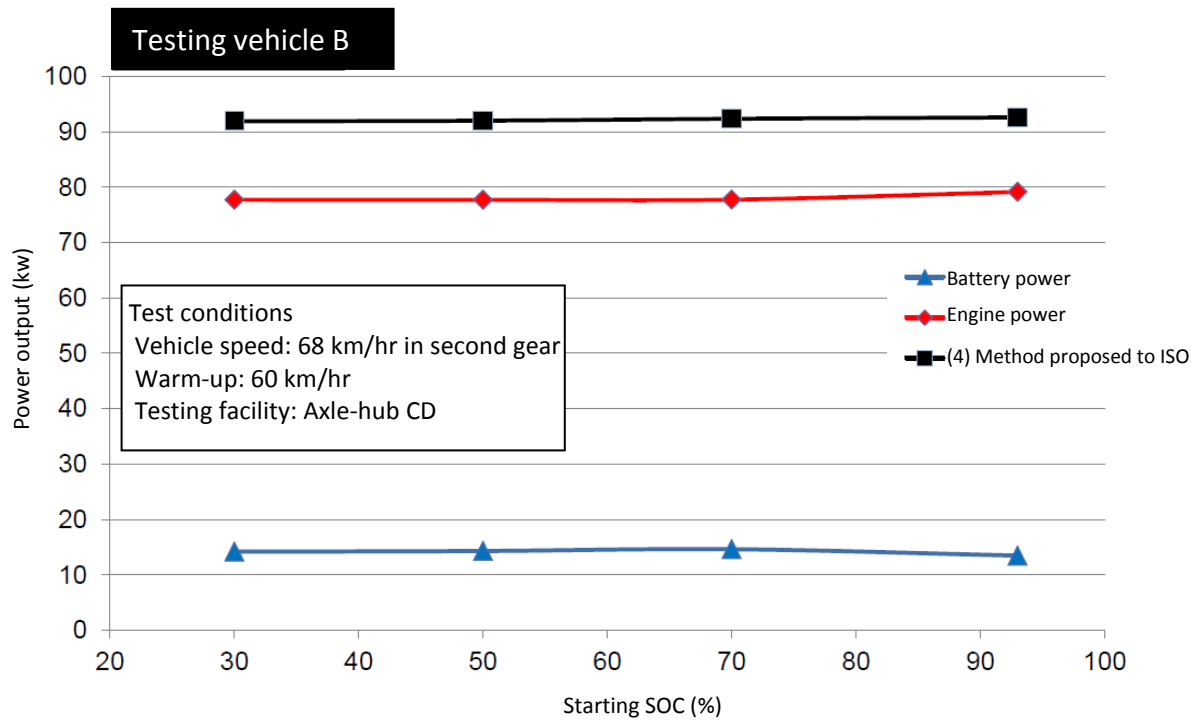


Figure 5.57 Relationship between SOC at the start of the test and power output (testing vehicle B)

(3) Testing vehicle C

With testing vehicle C, data obtained from the scanning tools attached to the OBD connector indicated the SOC when the maximum power was generated within the CD (charge-depleting) range was 90% and the SOC at the beginning of the CS (charge-sustaining) range was 29%.

The effect of different SOC on power output is shown in Figure 5.58. In terms of testing conditions, the vehicle speed was 160 km/hr and the warm-up was done at the constant speed of 60 km/hr for 20 minutes. The facility used for the test was the axle-hub chassis dynamometer. The power output was taken as the wheel driving power as well as the combined value of the engine power and battery power, which is being proposed to the ISO, and the two were compared.

The wheel driving power was 131.6 kW on average when the SOC at the start of the test was 90%, and 134.0 kW on average when the SOC was 29%; a difference of 2.4 kW was recorded. The SOC at the start of the test is thought to have certain effect on power output. The deviations were -0.7 to 0.6 kW with the 90% SOC and -1.6 to 1.2 kW with the 29% SOC; the variation was moderately large with the 29% SOC.

When power output was calculated by the method proposed to the ISO, the average value was 147.3 kW with the 90% SOC, and 145.6 kW with the 29% SOC, resulting in a 1.7 kW difference. The effect of the SOC at the start of the test resulted in a difference larger than 1.0 kW, which leads us to believe that there is a certain effect. The deviations were ± 0.2 kW with the 90% SOC and -0.6 to 0.3 kW with the 29% SOC; the variations were small.

In terms of difference in power measurements taken at different places, with the 90% SOC, the wheel driving power was 131.6 kW, which was 15.7 kW lower than the 147.3 kW recorded through the method

proposed to the ISO, and likewise, it was 11.6 kW lower with the 29% SOC. This showed that the difference in power output between different measuring points is affected by the SOC at the start of the test.

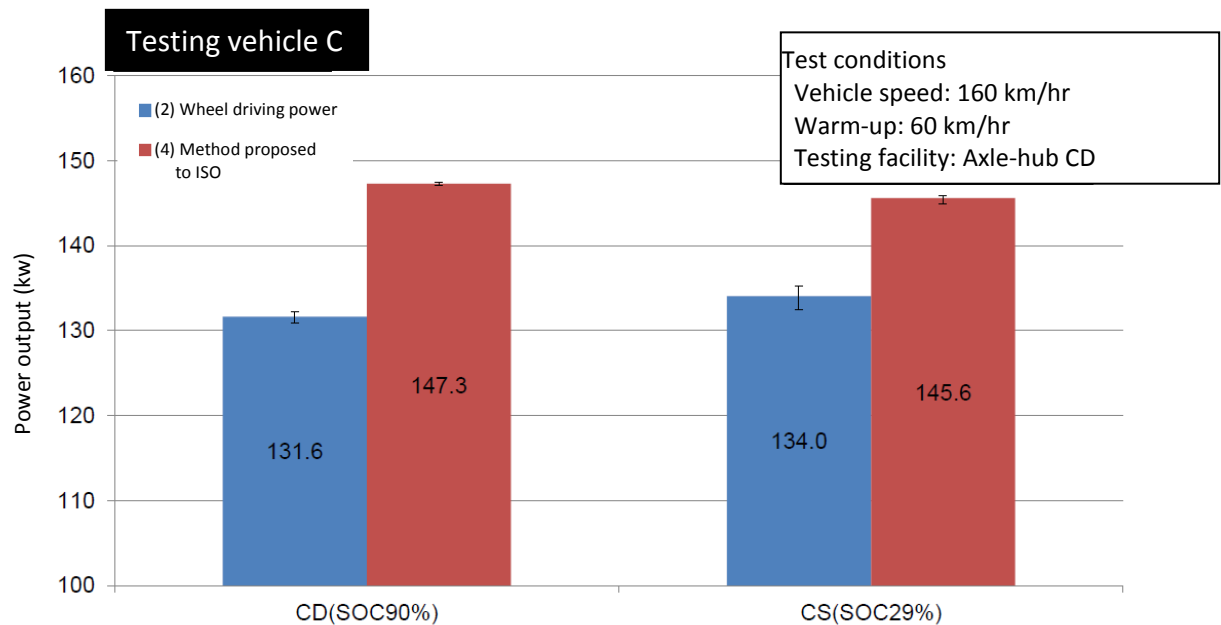


Figure 5.58 Effect of difference in SOC at the start of test on power output (testing vehicle C)

After it was understood that when the SOC is within the range of 90% to 29%, the difference of the SOC at the start of the test has a moderate effect on the HEV system power output, effect of the SOC on the HEV system power when the SOC is outside of that range was studied. The relationship between the SOC at the start of the test and the power output is shown in Figure 5.59. The x-axis represents SOC at the start of the test and the y-axis represents power output. As for the testing conditions, the vehicle speed was 160 km/hr and the warm-up was carried out for 20 minutes at the constant speed of 60 km/hr. The facility used for the test was the axle-hub chassis dynamometer. With testing vehicle C, the power output was approximately 4.0 kW lower with 100% SOC, and, when the SOC was forcibly lowered to 20%, the power output was reduced by approximately 50 kW.

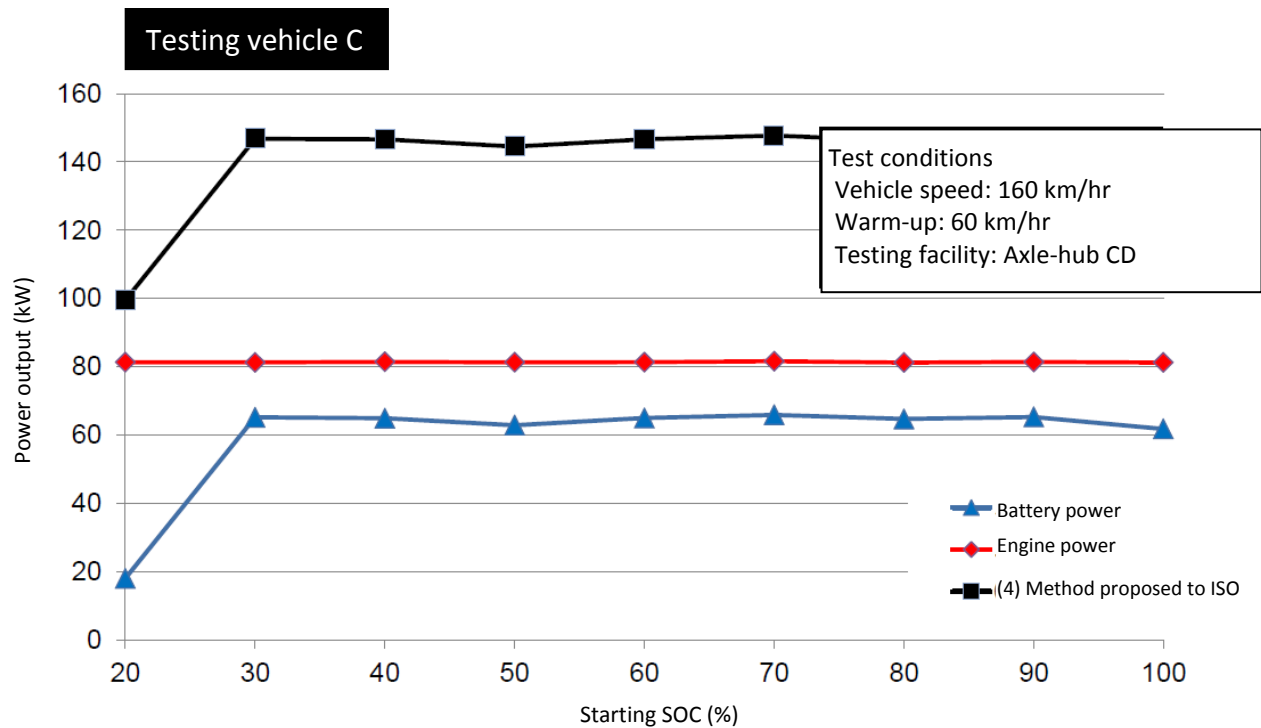


Figure 5.59 Relationship between SOC at the start of the test and power output (testing vehicle C)

5.3.3 Effect of testing speed

(1) Testing vehicle A

For the examination of how the testing speed affects the measurements of HEV system power output, two types of testing methods were studied. The first uses the method proposed to the ISO as a reference, and determines the speed at which the maximum power is generated through multiple tests in each of which a different speed is set by using the speed control of the chassis dynamometer. The other method is one that is being studied by the SAE. In this method, the vehicle is accelerated full throttle on a running resistance-controlled chassis dynamometer, and the speed that generates the maximum power output is determined. The vehicle is tested again at that speed on the speed-controlled chassis dynamometer and the maximum power output is measured.

Results of tests where power output was measured with the speed of the vehicle changed for each test, conducted with the method proposed to the ISO as a reference, are shown in Figure 6.50 and Table 5.13. The x-axis represents the vehicle speed and the y-axis represents power output. In terms of testing conditions, the SOC at the start of the test was 80% and the warm-up was conducted for 20 minutes at the constant speed of 60 km/hr. The facility used for the tests was the axle-hub chassis dynamometer. Power output for comparison was calculated by combining the battery power and the engine power output.

The results show that between 145 and 165 km/hr, the engine power output is mostly steady. Steady engine power output means steady engine rotation speed. This is because testing vehicle A is equipped with a continuously variable transmission and there is no correlation between the vehicle's travelling speed and the engine rpm. It is also shown that the battery power is mostly steady when the vehicle

speed is between 150 and 165 km/hr. The HEV system power output, which is the combined value of battery power and engine power output, is mostly steady between 150 and 165 km/hr without an obvious peak, and it was understood that the maximum power output can be measured within this range.

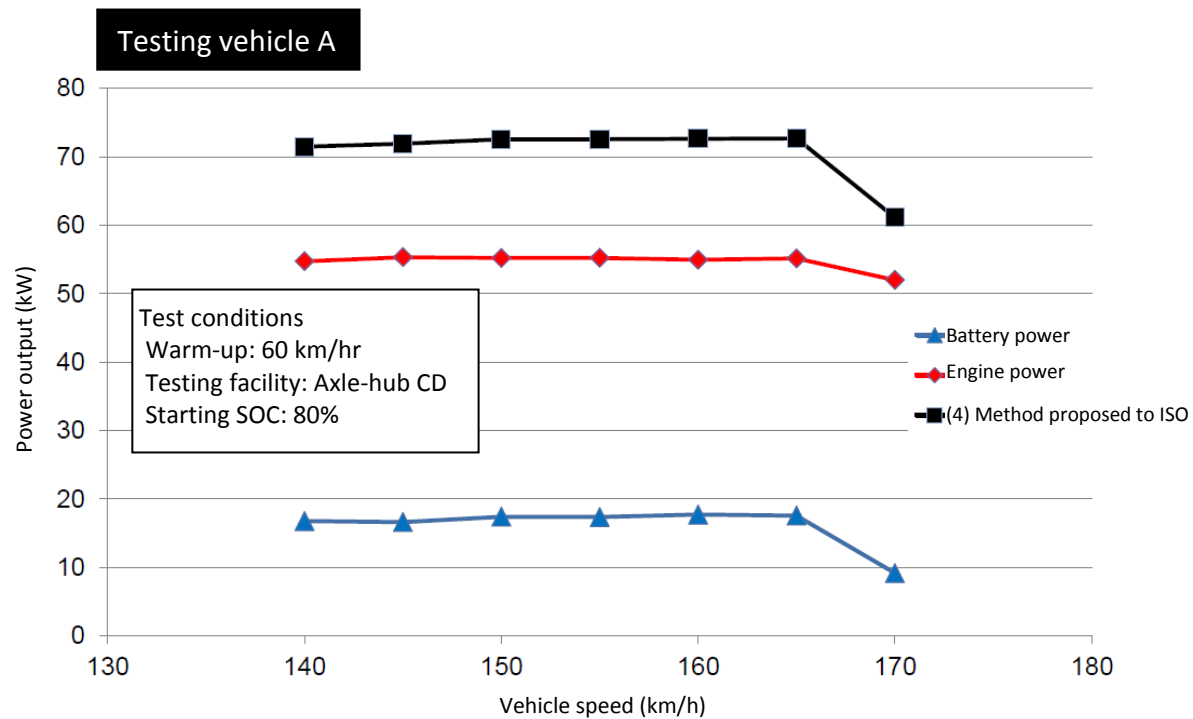


Figure 5.60 Relationship between vehicle speed and power output (testing vehicle A)

Table 5.13 Vehicle speed and power output (testing vehicle A)

Vehicle speed	140 km/hr	145 km/hr	150 km/hr	155 km/hr	160 km/hr	165 km/hr	170 km/hr
Engine power output	54.7 kW	55.3 kW	55.2 kW	55.2 kW	54.9 kW	55.1 kW	52.0 kW
Battery power	16.7 kW	16.6 kW	17.4 kW	17.3 kW	17.7 kW	17.5 kW	9.1 kW
(4) HEV system power output (proposed to the ISO)	71.5 kW	71.9 kW	72.6 kW	72.6 kW	72.6 kW	72.7 kW	61.1 kW

Next, the chassis dynamometer was set on running resistance control as being studied by the SAE, and the changes in power output when the vehicle was accelerated full throttle are shown in Figure 5.61. The x-axis represents vehicle speed and the y-axis represents power output. In terms of testing conditions, the SOC at the start of the test was 80% and the warm-up was conducted for 20 minutes at

the constant speed of 60 km/hr. The facility used for the tests was the axle-hub chassis dynamometer. Considering effects of the battery dying, tests were conducted under three conditions: starting acceleration from 0 km/hr, mid-range acceleration from 100 km/hr and mid-range acceleration from 140 km/hr. Four types of power are shown: engine power, battery power, wheel driving power and the HEV system power output proposed to the ISO (battery power + engine power). The results show that the engine power is not affected by the speed at which the test was started and it is more or less steady from around 80 km/hr. Battery power showed a tendency to temporarily increase right after the start of the test, but it is understood that after the initial period, the starting speed has almost no effect on it. It is observed that the battery power changes gradually in accordance with the vehicle speed. The wheel driving power also showed almost no effect of the test-starting speed and showed an upward trend as the vehicle speed increased. The HEV system power, calculated by combining battery power and engine power, showed a trend similar to that of the wheel driving power, but from 50 to 80 km/hr, it showed a gradual downward trend. After that range, up to approximately 145 km/hr, it showed a gradual upward change, and afterwards, it decreased by a little and then the power output became steady. This result showed variable changes in the wheel driving power and a clear peak of the power output was not detected. On the other hand, the engine power output peaked around 145 km/hr when the vehicle was accelerated from 0 km/hr. An enlarged image of the increasing power output between 130 and 170 km/hr is shown in Figure 5.62. In the mid-range acceleration starting from 100 km/hr, the peak was hard to determine. In the mid-range acceleration from 140 km/hr, a temporary increase was detected and the peak was observed around 140 km/hr. Based on these results, it can be said that 145 km/hr, where clear peaks were observed, is the speed where the maximum power is generated. At this speed, when a test was done with the chassis dynamometer set at the constant speed (i.e. the testing method proposed to the ISO), Table 5.13 indicates 71.9 kW, so this speed is different from results obtained under conditions of the testing method proposed to the ISO. This is because testing vehicle A has a function of increasing power output when the accelerator was released and then stepped on again, and the test using the method proposed to the ISO can include it, while this function cannot be recreated when the vehicle is accelerated full throttle with running resistance control as done in the SAE method.

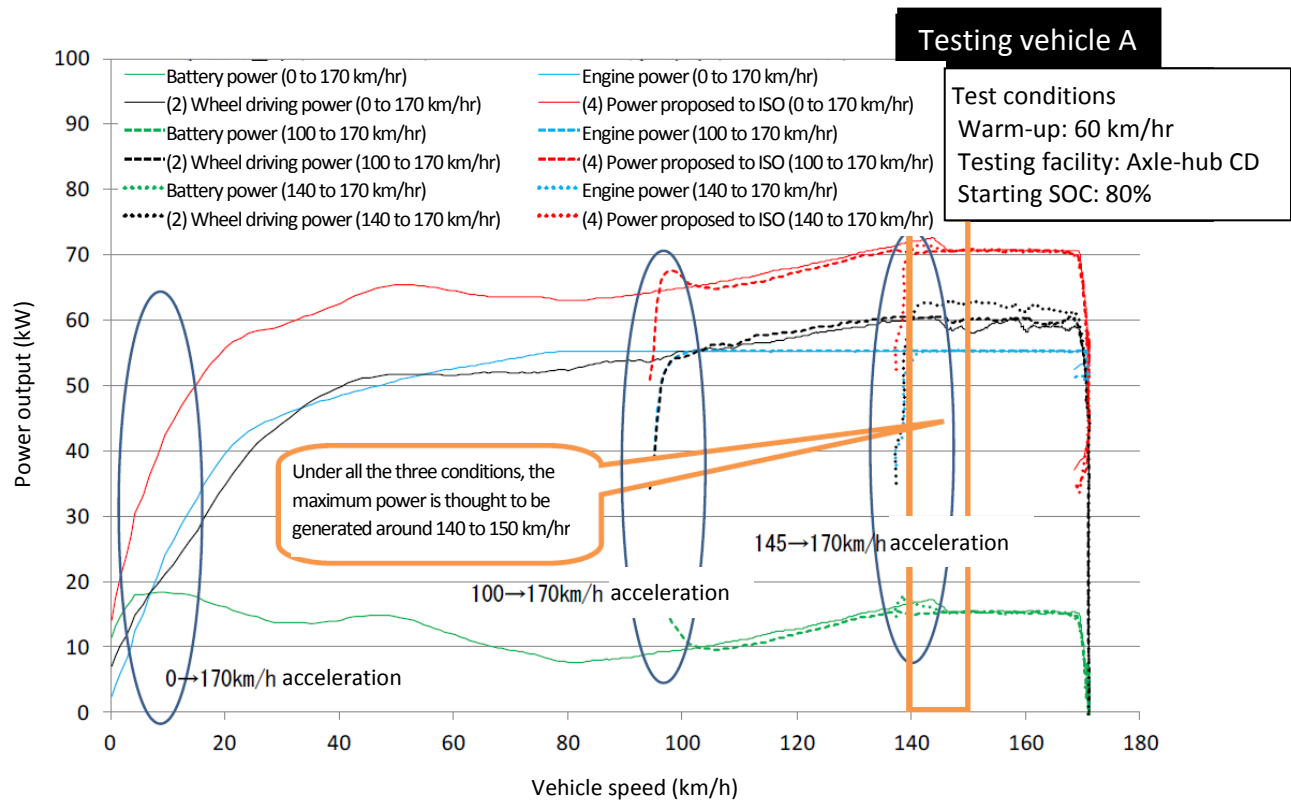


Figure 5.61 Changes in power output when the vehicle was accelerated full throttle on running resistance control (testing vehicle A)

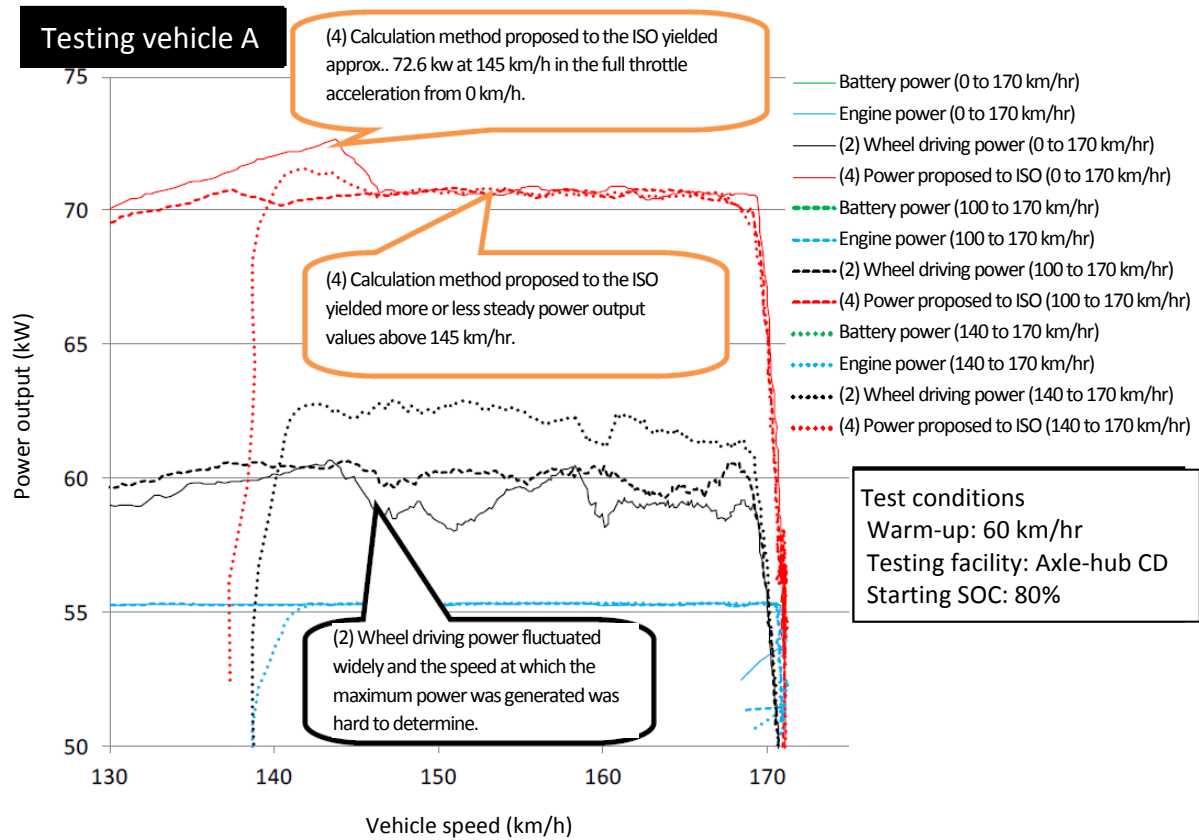


Figure 5.62 Changes in power output when the vehicle was accelerated full throttle on running resistance control (enlarged) (testing vehicle A)

(2) Testing vehicle B

Testing vehicle B is equipped with a stepped automatic transmission and therefore is affected not only by the vehicle speed but also by the gear position. For this reason, the relationship of the power output with the engine rpm and the gear position was examined, and results are shown in Figure 5.63. The x-axis represents engine rpm and the y-axis represents power output. In terms of testing conditions, the SOC at the start of the measurements was 93% and the warm-up was done for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer and the chassis dynamometer were used for the test. Power output was compared in engine power output measurements and in HEV system power output values calculated by the method proposed to the ISO (battery power + engine power output).

It can be observed that around the point where the HEV system power output is the highest, the engine power output shows the characteristics of corresponding to the engine rpm. The HEV system power output, which is calculated by adding the battery power and the engine power output, is more or less steady in the second gear position, but is the highest around 5650 rpm. Above this rpm, the gear was automatically shifted up and measurements in the second gear position could not be taken. In the third gear position, as was the case with the second gear position, the test results show that the power output was more or less steady. The fact that the HEV system power output was steady while the engine power output increased indicates that the battery power decreased as the engine power output increased. In the fourth gear position, the maximum power was generated at 5500 rpm, and above that

rpm, the power output gradually decreased. Regarding effects of different gear positions, it is understood that the second and third gear positions yielded almost the same power, but the fourth gear position resulted in power that was approximately 5.5 kW higher. These results indicate that when a vehicle is equipped with a stepped transmission, gear positions can influence power measurements and therefore tests need to be done for each gear position. Also, while it was originally believed that the maximum HEV system power would be generated at the engine rpm where the engine generates its maximum power, the battery power's peak does not necessarily correspond with that engine rpm.

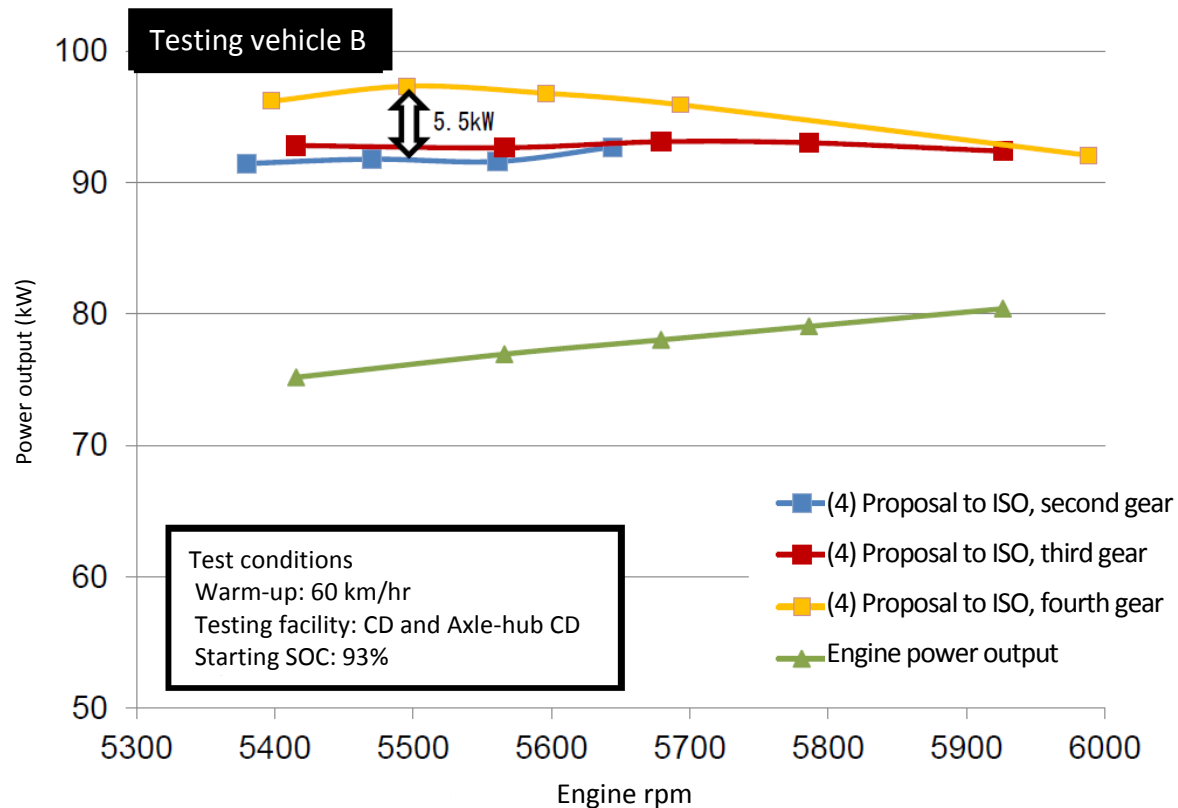


Figure 5.63 Relationship between engine rpm and power output (testing vehicle B)

Next, the chassis dynamometer was set on running resistance control as in the testing method being studied by the SAE, and the changes in power output when the vehicle was accelerated full throttle are shown in Figure 5.64. The x-axis represents vehicle speed and the y-axis represents power output. In terms of testing conditions, the SOC at the start of the test was 93% and the warm-up was carried out for 20 minutes at the constant speed of 60 km/hr. The facility used for the tests was the axle-hub chassis dynamometer. Considering effects of the battery dying, tests were conducted under three conditions: starting acceleration from 0 km/hr, mid-range acceleration from 60 km/hr in the second gear position and mid-range acceleration from 80 km/hr in the third gear position. Four types of power are shown: engine power, battery power, wheel driving power and the HEV system power output proposed to the ISO (battery power + engine power). Because the vehicle is equipped with a stepped automatic transmission, the engine power output changed dramatically at the time of gear shift, and behaved like teeth of a saw relative to the vehicle speed. The battery power was affected little by the difference in the speed at which the test was started and increased gradually as the vehicle speed increased. It was confirmed that the power decreased when the motor shifted, and when the engine rpm is high, the

battery power showed a tendency to be squeezed, the extent of which varied depending on the gear position. The wheel driving power also showed almost no effect of the test-starting speed. The HEV system power calculated by combining battery power and engine power showed similar trends as the wheel driving power, but the peak in the second gear position was detected around 60 km/hr, in the third gear position around 80 km/hr, in the fourth gear position around 115 km/hr and in the fifth gear position around 145 km/hr, indicating that the peak of power output varies depending on the gear position. The results show that the vehicle speed at which the maximum HEV system power was generated was around 112 km/hr. In the testing method of the ISO, the converted vehicle speed at which the maximum power was generated was 115 km/hr, and this means that the difference in the testing speed was 3 km/hr and the power output was different by 0.7 kW between the two testing methods.

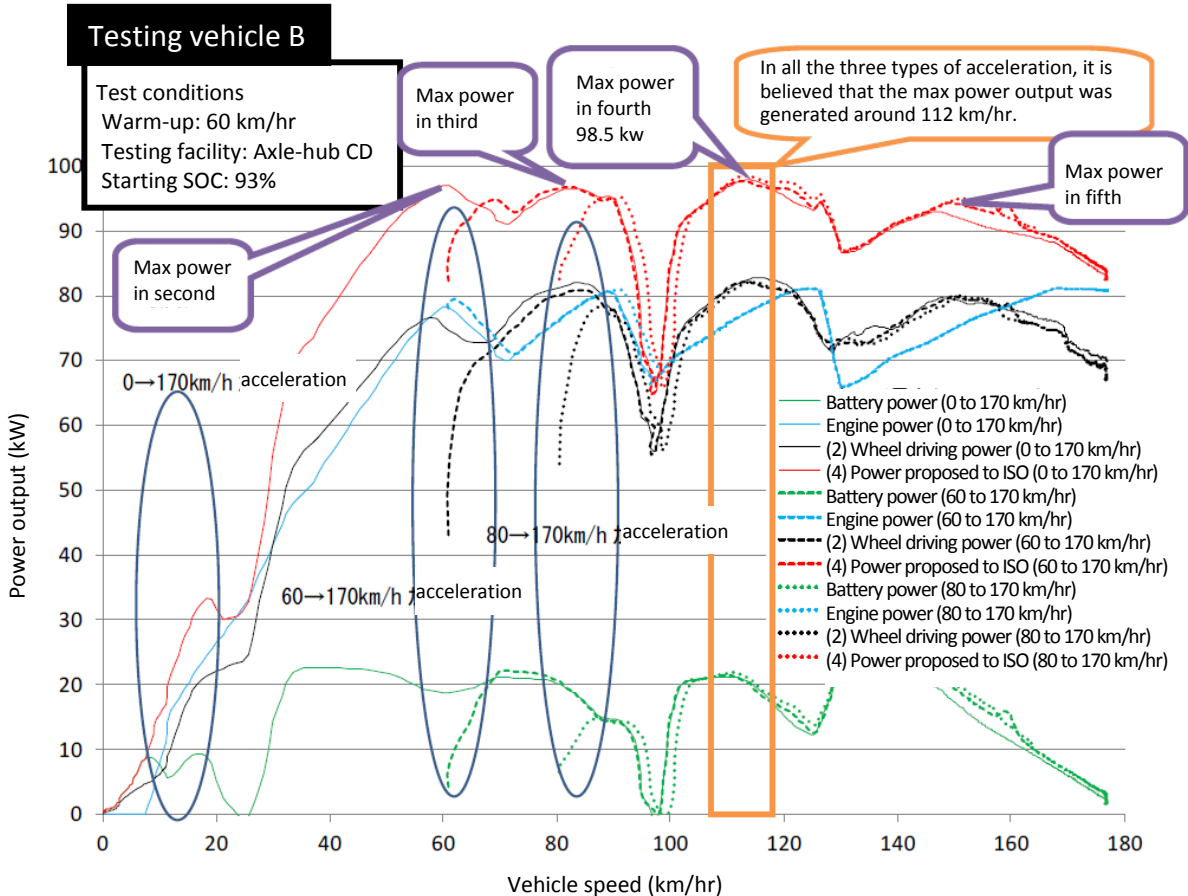


Figure 5.64 Changes in power output when the vehicle was accelerated full throttle on running resistance control (testing vehicle B)

(3) Testing vehicle C

Results of tests where power output was measured with the speed of the vehicle changed for each test are shown in Figure 6.55. The x-axis represents the vehicle speed and the y-axis represents power output. In terms of testing conditions, the SOC at the start of the test was 90% and the warm-up was conducted for 20 minutes at the constant speed of 60 km/hr. The facility used for the tests was the axle-hub chassis dynamometer. Engine power output, battery power and the combined value of these two were used for comparison.

The results show that between 30 and 120 km/hr, the engine power output is mostly steady. Steady engine power output means steady engine rotation speed. This is because in this speed range, testing vehicle C operates as a series vehicle. The battery power was mostly steady when the vehicle speed was between 60 and 120 km/hr. When the vehicle speed exceeds 130 km/hr, the drivetrain switches to the parallel operation and the vehicle speed and the engine rpm show correlation. The combined value of battery power and engine power output (HEV system power output proposed to the ISO) peaked at 160 km/hr, which indicated that this was the vehicle speed at which the maximum power output was generated.

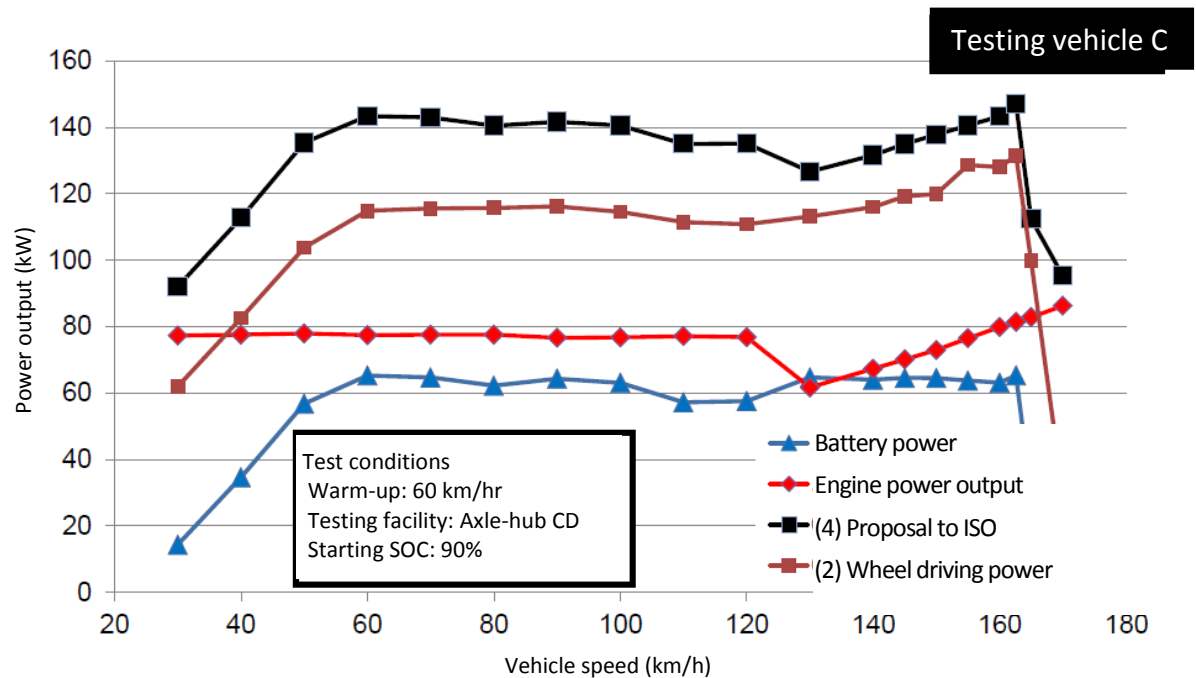


Figure 5.65 Relationship between vehicle speed and power output (testing vehicle C)

Next, the chassis dynamometer was set on running resistance control as the testing method being studied by the SAE, and the changes in power output when the vehicle was accelerated full throttle are shown in Figure 5.66. The x-axis represents vehicle speed and the y-axis represents power output. In terms of testing conditions, the SOC at the start of the test was 90% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The facility used for the tests was the axle-hub chassis dynamometer. Considering effects of the battery dying, tests were conducted under two conditions: starting acceleration from 0 km/hr and mid-range acceleration from 140 km/hr. Four types of power output are shown: engine power, battery power, wheel driving power and the battery power + engine power. The results show that the engine power is mostly steady from around 40 km/hr to 120 km/hr. Beyond 130 km/hr, the engine power output increased as if to correspond to the vehicle speed. The battery power fluctuated from around 40 km/hr to 120 km/hr, but did not appear to correspond to the increase of the vehicle speed. Beyond 140 km/hr, the battery power became steady. The wheel driving power increased beyond 140 km/hr corresponding to the vehicle speed, and reached its peak at 160 km/hr. The combined value of the battery power and the engine power output (HEV system power

output proposed to the ISO) showed a similar trend as the wheel driving power and reached its peak at 160 km/hr. Based on these results, 160 km/hr is considered to be the speed at which the maximum power output is generated. This matches the maximum power-generating speed indicated in Figure 5.65. At this speed, the maximum power output was 147.3 kW when the vehicle was run on the chassis dynamometer at the constant speed, while the maximum power output on the running resistance control mode was 145.2 kW; there was a 2.1 kW difference.

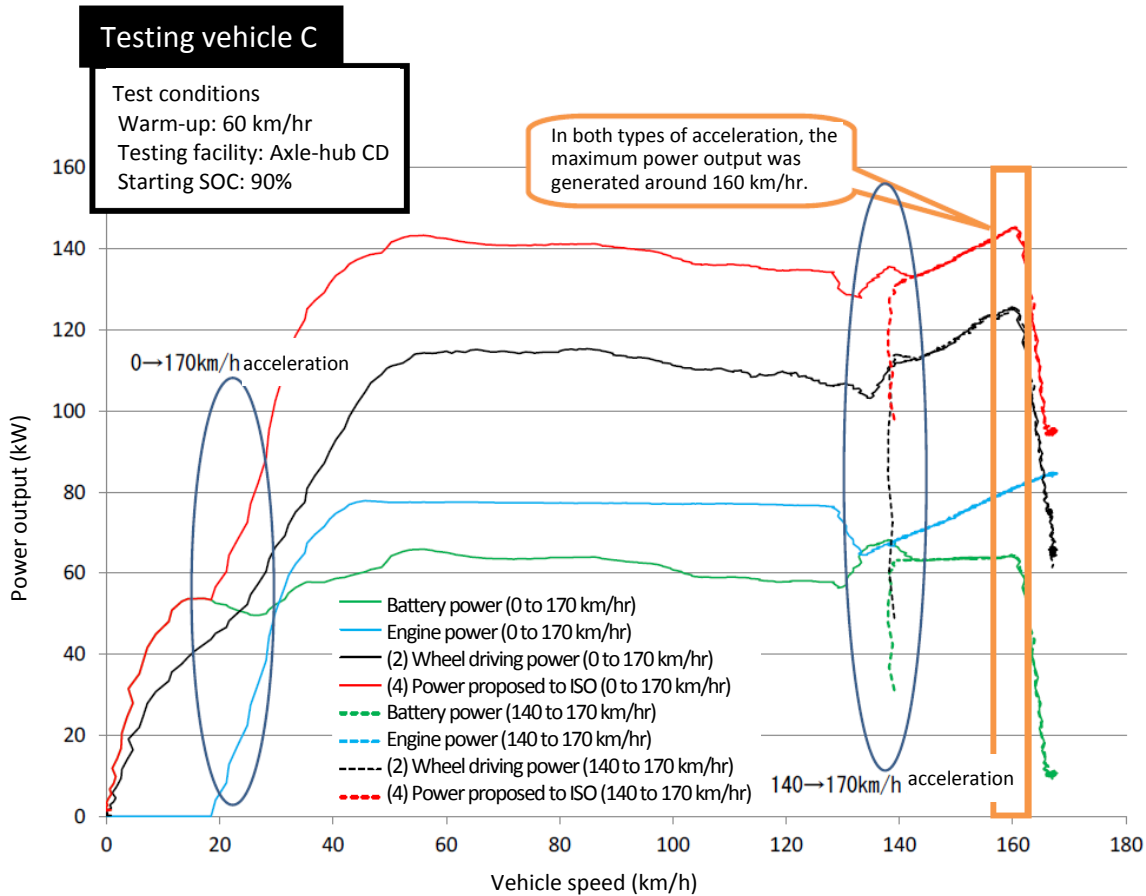


Figure 5.66 Changes in power output when the vehicle was accelerated full throttle on running resistance control (testing vehicle C)

5.3.4 Effect of test repetition

(1) Testing vehicle A

To design a testing method, conditions such as the length of time between tests have to be defined. In the present study, to obtain high replicability, a cooling period was inserted to let batteries etc. cool down after each test, and then vehicles were warmed up again and the following test was started. However, in this way, only approximately one test per hour can be carried out. Considering cases where multiple tests are done at different speeds or where a test is repeated multiple times under the same conditions to confirm replicability, the time required to test this way becomes a heavy burden. In the method currently proposed to the ISO, tests at three or more speed points are required, and therefore it is necessary to conduct a series of four tests or so. For this reason, in order to shorten the time spent for repeated tests, cooling periods were eliminated and tests were conducted in repeated cycles of

warm-up – SOC adjustment – test – warm-up. This method allows approximately two tests per hour. Another concern regarding repeated tests is that power output of driving parts such as the engine, motor and battery might decrease due to their increased temperature. Regarding the engines and motors, considering maximum power output tests such as UN Regulation No. 85, *Power Measurement of Internal combustion Engines and Electric Motors*, the concern is not great because, though the rpm changes, it is believed that full throttle operation is allowed for about five minutes. Therefore, it was assumed that the main concern is the battery temperature. Changes in battery temperature and battery power in four repeated tests are shown in Figure 5.67. The x-axis represents time, the left y-axis represents temperature and the right y-axis represents battery power. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 80% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. The vehicle warm-up was started with the temperature of the battery at 25 °C, and at the end of the warm-up, the temperature at the warmest spot of the battery was approximately 26 °C. The SOC was then adjusted and the temperature was approximately 27 °C after the SOC adjustment. The temperature was approximately 28 °C at the end of the test, rose to approximately 31 °C at the start of the second warm-up, and after the completion of the warm-up, it was approximately 33 °C. At the end of the second test, it was approximately 35 °C and was approximately 40 °C at the beginning of the third warm-up. The temperature continued to go up, but then it went down during the warm-up and it was approximately 35 °C at the beginning of the third test. At the end of the third test, it was approximately 36 °C, and while it went up to around 40 °C at the beginning of the fourth warm-up, it went down again during the warm-up to be approximately 35 °C at the beginning of the fourth test. These results showed that the battery temperature goes up to a certain point but it goes down during the 20 minutes of vehicle warm-up and tests can be conducted with steady starting temperatures at or below 35 °C. Furthermore, because the battery power changed little in these four power output tests, it was understood that tests can be repeated this way without creating problems.

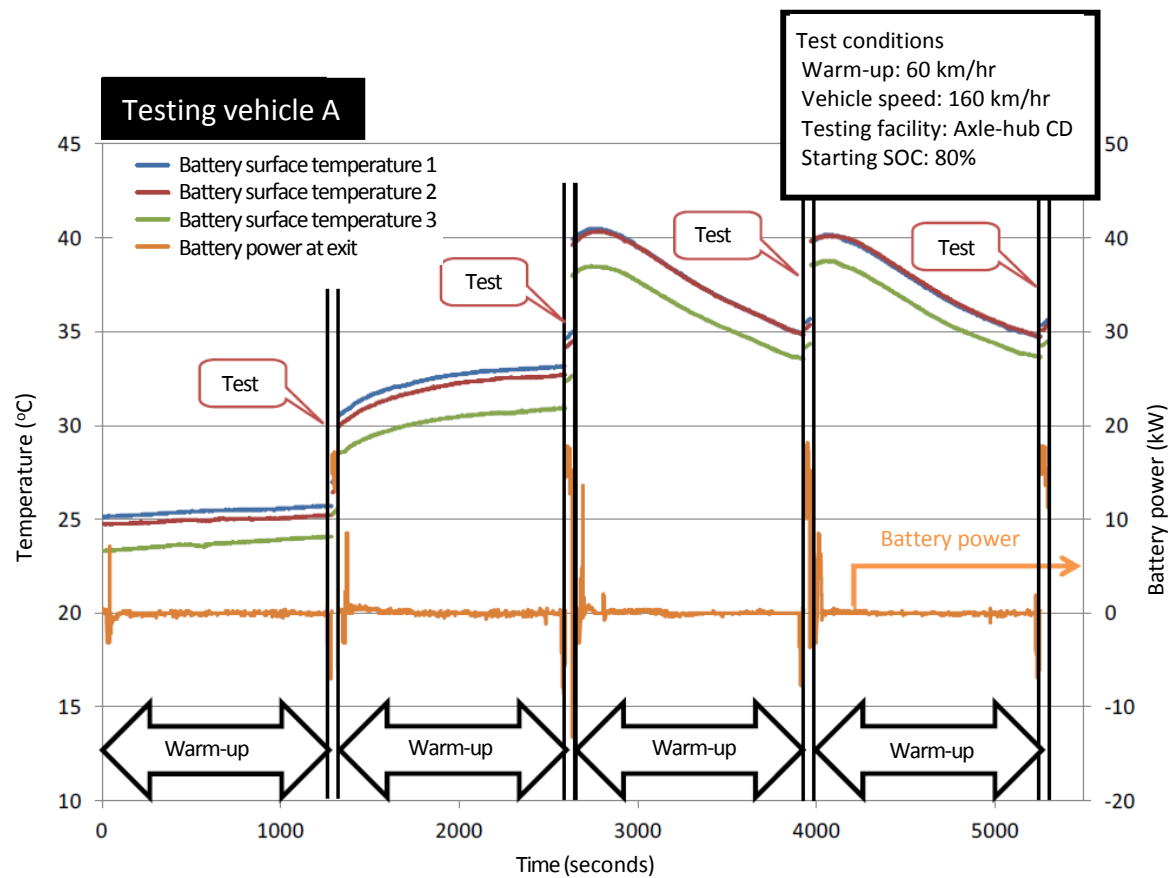


Figure 5.67 Changes in battery temperature and power during a series of four tests including warm-up periods (testing vehicle A)

Next, to further reduce the time required for repeated testing, it was decided to eliminate the 20-minute warm-up periods. After one test was completed, only the SOC adjustment was done and then the next test was conducted. This way allows four tests within approximately 10 minutes. Figure 5.68 shows changes in battery temperature and battery power during four tests repeated without warm-up periods inserted. The x-axis represents time, the left y-axis represents temperature and the right y-axis represents battery power. In terms of testing conditions, the starting SOC was 80% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. For the first test, the vehicle was warmed up for 20 minutes, the SOC was then adjusted and the battery temperature at that time was approximately 31 °C. After the test, the temperature kept going up even during the SOC adjustment and it was approximately 34 °C at the start of the second test. During the third SOC adjustment, the temperature still kept going up and was approximately 38 °C at the start of the third test. During the fourth SOC adjustment, the temperature continued to go up and was approximately 41 °C at the start of the fourth test. At this point, the HEV system power output increased by 1.0 kw, but since the temperature appears to keep going up, depending on the vehicle tested, it is expected that the deviation can be larger.

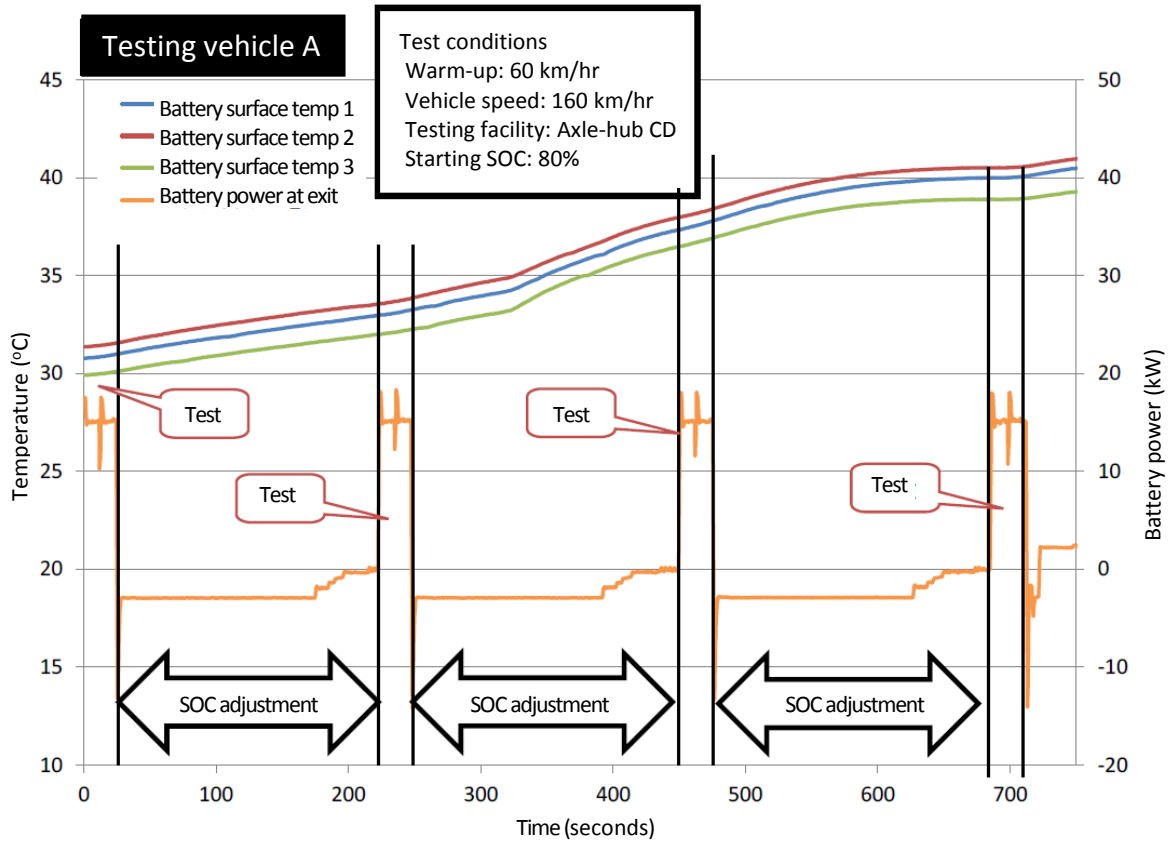


Figure 5.68 Changes in battery temperature and power during a series of four tests without warm-up periods between tests (testing vehicle A)

(2) Testing vehicle B

Changes in battery temperature and battery power in four repeated tests are shown in Figure 5.69. The x-axis represents time, the left y-axis represents temperature and the right y-axis represents battery power. In terms of testing conditions, the vehicle speed was 115 km/hr in the fourth gear position, the starting SOC was 93% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. The vehicle warm-up was started with the temperature of the battery at 25 °C, and at the end of the warm-up, the temperature at the warmest spot was approximately 33 °C. The SOC was then adjusted and the temperature was approximately 34 °C after the SOC adjustment. The temperature was approximately 28 °C at the end of the test and rose to approximately 34 °C at the start of the second warm-up. During the second warm-up, the temperature increased, but then started to go down, and at the completion of the warm-up, it was approximately 35 °C. It was approximately 34 °C at the beginning of the second test. At the start of the third warm-up, the temperature was approximately 35 °C. Though the temperature is higher after a test, it goes down during vehicle warm-up, and at the beginning of the third test, it had gone down to approximately 33 °C. At the end of the third test, it was approximately 34 °C, and it was also approximately 34 °C at the beginning of the fourth warm-up, but it went down again during the warm-up to approximately 33 °C at the beginning of the fourth test. Based on these results, it was understood that the battery temperature goes up to a certain point but it goes down during the 20 minutes of vehicle warm-up and tests can be conducted with steady temperatures at or below 33 °C. Furthermore,

because the battery power changed little in these four power output tests, it was understood that tests can be repeated this way without creating problems.

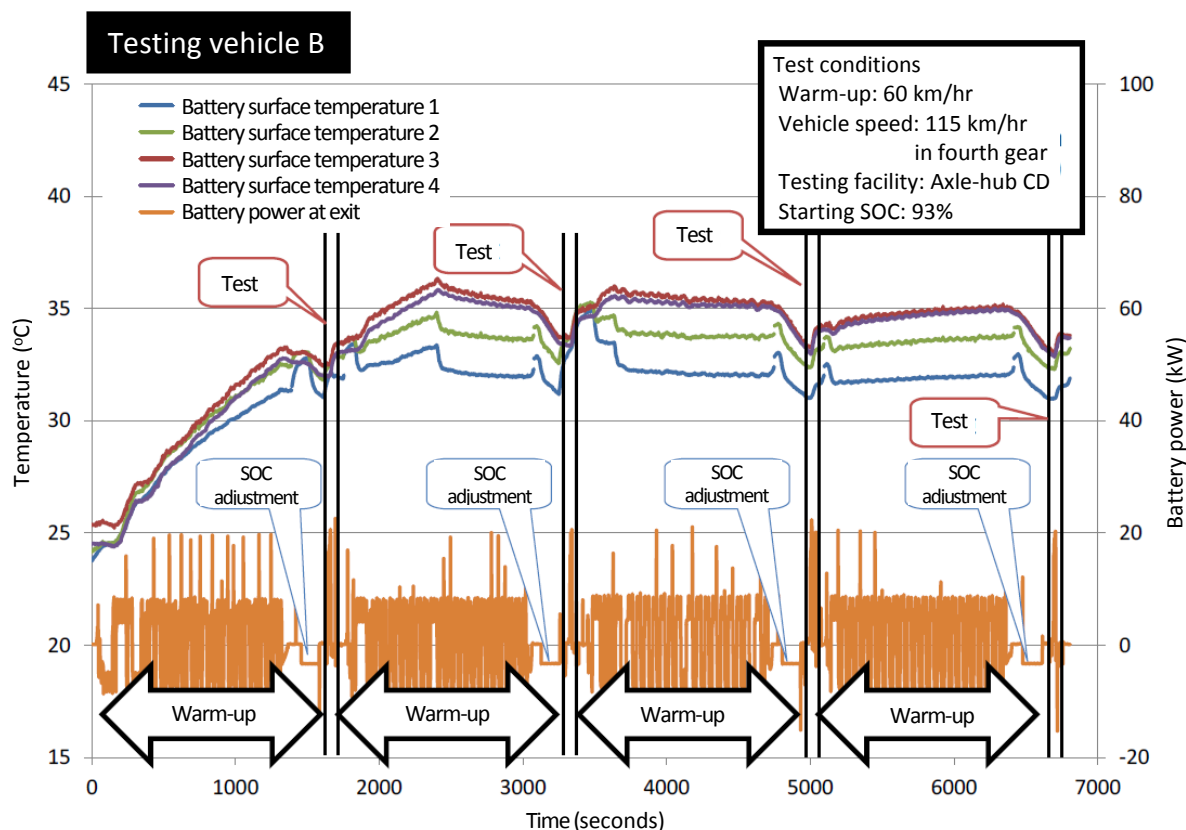


Figure 5.69 Changes in battery temperature and power during a series of four tests including warm-up periods (testing vehicle B)

Next, to further reduce the time required for testing, it was decided to eliminate the 20-minute warm-up periods. After one test was completed, only the SOC adjustment was done and then the next test was conducted right after. This method allows four tests within approximately 10 minutes. Figure 5.70 shows changes in battery temperature and battery power during four tests repeated without warm-up periods inserted. In terms of testing conditions, the vehicle speed was 115 km/hr in the fourth gear position, the starting SOC was 93% and the vehicle was warmed up for 20 minutes at the steady speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. For the first test, the vehicle was warmed up for 20 minutes, the SOC was then adjusted and the battery temperature after the SOC adjustment was approximately 33 °C. After the test, the temperature kept going up even during the SOC adjustment, but then it went down slowly and was approximately 34 °C at the start of the second test. During the third SOC adjustment, the temperature kept increasing and then went down slowly and was approximately 34 °C at the start of the third test. The temperature changed in a similar way during the fourth warm-up and was approximately 35 °C at the start of the fourth test. At this point, the HEV system power output increased by 1.2 kW, but since the temperature appears to generally keep going up, depending on the vehicle tested, it is expected that the deviation can be larger.

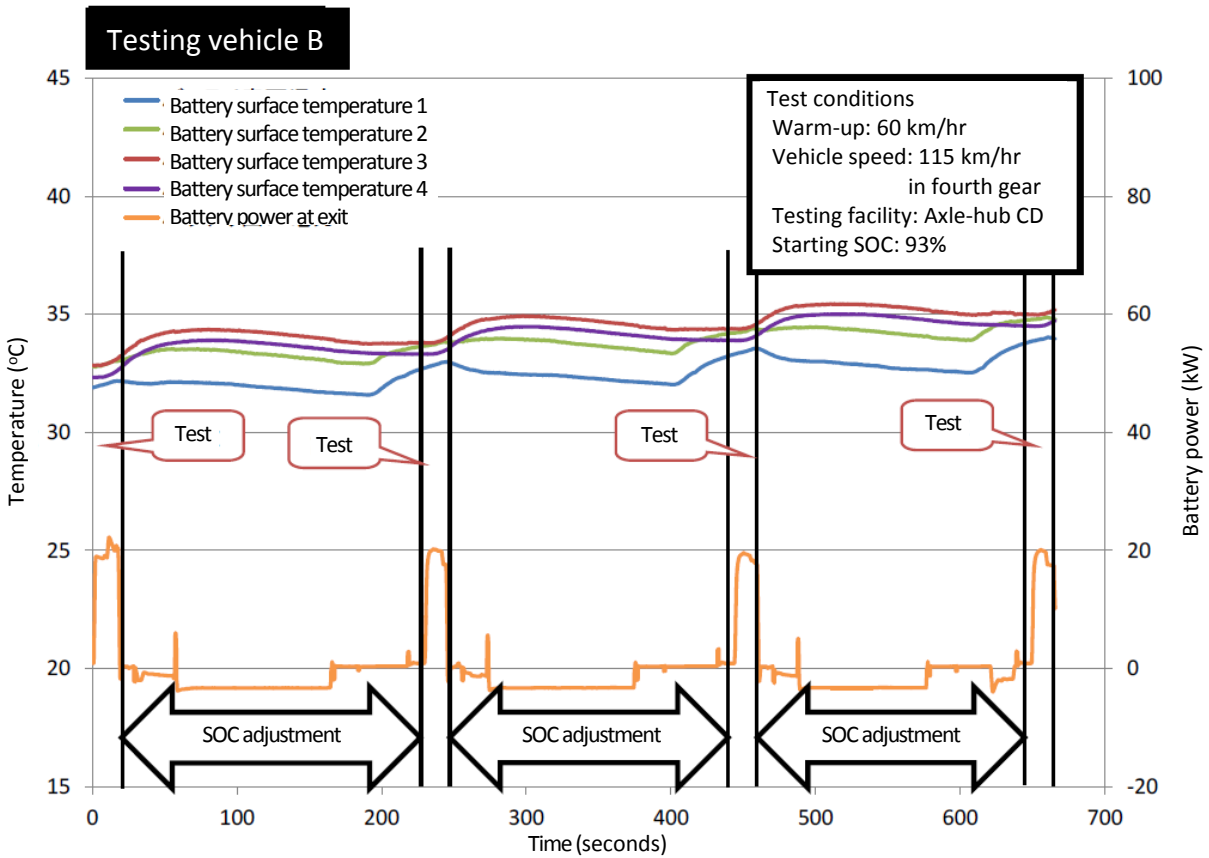


Figure 5.70 Changes in battery temperature and power during a series of four tests without warm-up periods between tests (testing vehicle B)

(3) Testing vehicle C

Changes in battery temperature and battery power during four repeated warm-ups and tests are shown in Figure 5.71. The x-axis represents time, the left y-axis represents temperature and the right y-axis represents battery power. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 90% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. The vehicle warm-up was started with the temperature of the battery at 27 °C, and at the end of the warm-up, the temperature at the warmest spot was approximately 30 °C. The SOC was then adjusted and the temperature was approximately 30 °C after the SOC adjustment. The temperature was also approximately 30 °C at the end of the test and rose to approximately 31 °C at the start of the second warm-up. During the second warm-up, the temperature increased to approximately 33 °C at the end of the warm-up and it was also approximately 33 °C at the start of the second test. At the start of the third warm-up, it was approximately 33 °C. The temperature kept going up after the test and during the warm-up and it was 34 °C at the beginning of the third test. After the third test was completed, the battery cooling device started to operate and the temperature went down to approximately 32 °C. It was approximately 32 °C at the beginning of the fourth warm-up, and went up again to approximately 35 °C at the beginning of the fourth test. Based on these results, it was understood that the battery temperature goes up to a certain point but the battery gets cooled by the battery cooling device and tests can be conducted with steady temperatures at or below 35 °C. Furthermore, because the battery power changed little in these

four power output tests, it was understood that tests can be repeated this way without creating problems.

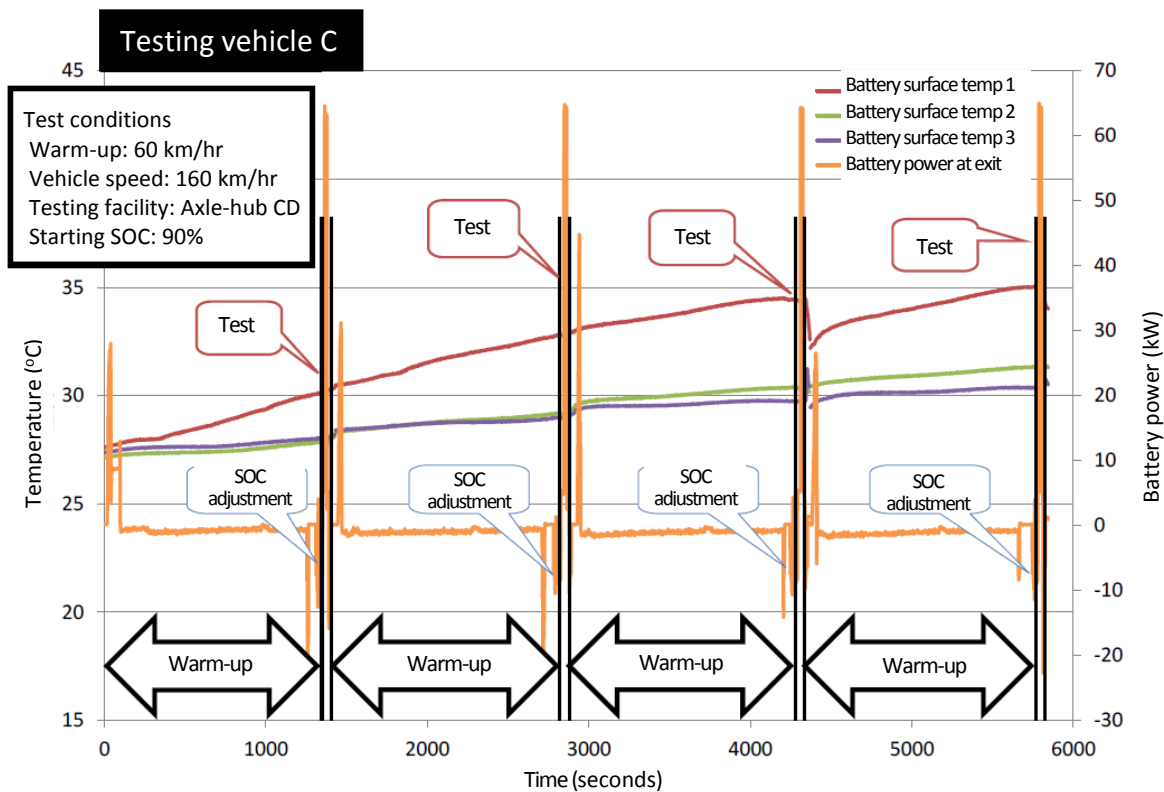


Figure 5.71 Changes in battery temperature and power during a series of four tests including warm-up periods (testing vehicle C)

Next, to further reduce the time required for testing, it was decided to eliminate the 20-minute warm-up periods. After one test was completed, only the SOC adjustment was done and then the next test was conducted right after. This method allows four tests within approximately 10 minutes. Figure 5.72 shows changes in battery temperature and battery power during four tests repeated without warm-up periods inserted. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 90% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. For the first test, the vehicle was warmed up for 20 minutes, the SOC was then adjusted and the battery temperature after the SOC adjustment was approximately 29 °C. After the test, the temperature kept going up even during the SOC adjustment, and it was approximately 30 °C at the start of the second test. During the third SOC adjustment, the temperature kept increasing slowly and was approximately 30 °C at the start of the third test. The temperature changed in the similar way during the fourth SOC adjustment and was approximately 31 °C at the start of the fourth test. At this point, the HEV system power output decreased by 1.9 kW, which is a significant deviation, and for this reason, stable testing this way is difficult.

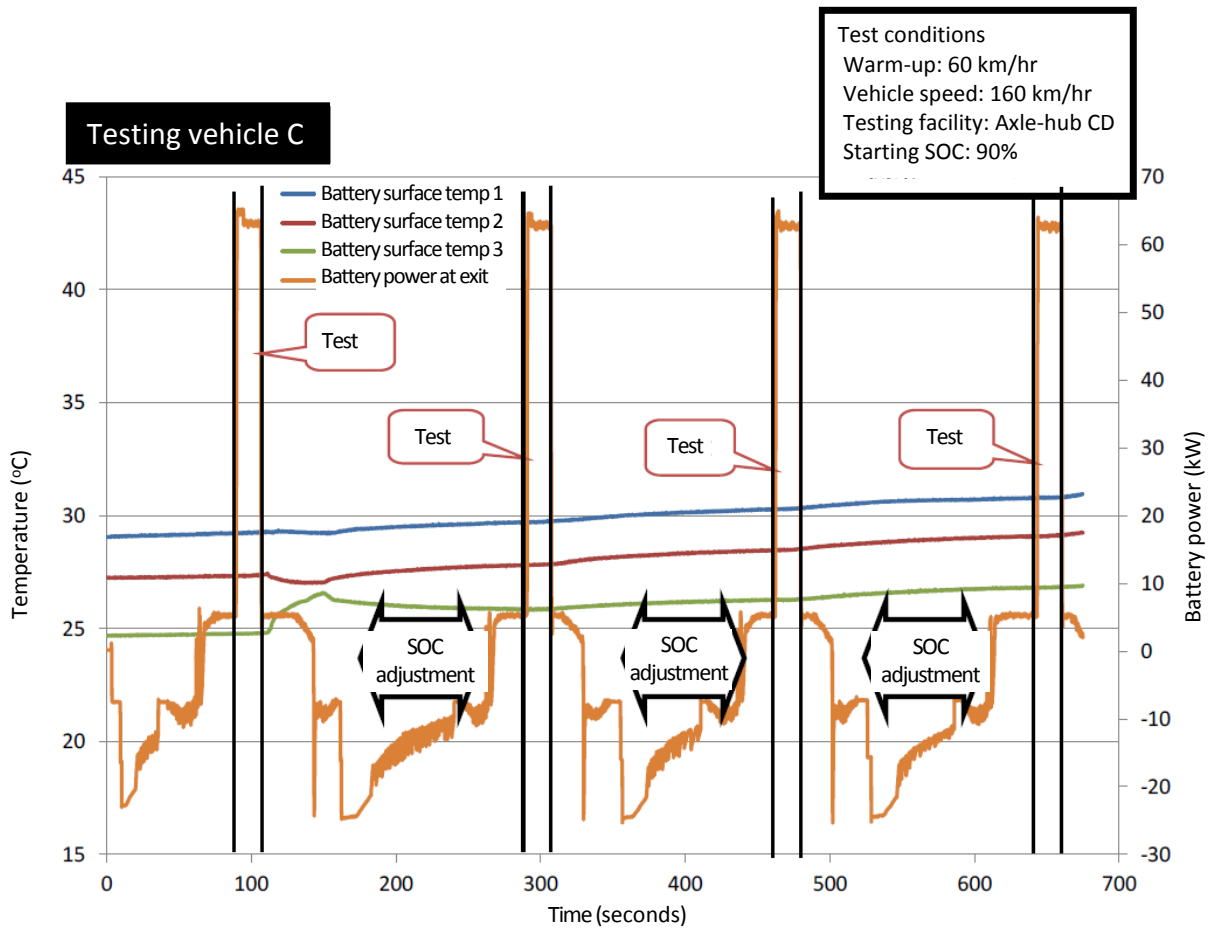


Figure 5.72 Changes in battery temperature and power during a series of four tests without warm-up periods between tests (testing vehicle B)

5.3.5 Effects of duration of power output

(1) Testing vehicle A

When measuring HEV system power output, in addition to test conditions defined above, the duration of power output needs to be studied. If the duration is too short, it is expected that in some cases, calculation of power output values is difficult because of fluctuation of measurements. On the other hand, if the duration is too long, the battery power diminishes and what is measured is the engine power output and not the HEV system power output. For this reason, the test method proposed to the ISO is designed to measure the maximum power output over a short period of time, not the rated power output over a long period of time. A duration of one second is proposed based on market research results, but other durations have been also studied. This study evaluated measurements taken with four levels of durations: one second, two seconds, three seconds and five seconds. Moving averages of time-series data sampled at 10 Hz were calculated for the four levels of periods. Effects of duration of power output on the HEV system power output measurements are shown in Figure 5.73 and Table 5.14. The x-axis represents time, the left y-axis represents engine rpm and the right y-axis represents HEV system power output. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 80% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The chassis dynamometer was used as the testing facility. Because testing vehicle A has the function of temporarily

generating higher power when the accelerator is released and then engaged again, the power output measurements varied significantly depending on duration. When the power output duration was one second, the HEV system power output was 73.5 kW, but over two seconds, it was 72.6 kW, which was 0.9 kW lower. Over three seconds, the power output was 71.9 kW, which was 1.6 kW lower than that measured over one second. Over five seconds, it was 71.3 kW, 2.2 kW lower. It was understood, based on those results, that with vehicles that have the function of temporarily generating higher power output, effects of the length of power output duration on the HEV system power output measurements are significant.



Figure 5.73 Effects of duration of power output on HEV system power output (testing vehicle A)

Table 5.14 Duration of power output and HEV system power output (testing vehicle A)

Power output duration (second) (moving average period)	1	2	3	5
HEV system power output	73.5 kW	72.6 kW	71.9 kW	71.3 kW

Next, Figure 5.74 shows changes of HEV system power output over time when the accelerator was kept at full throttle. The x-axis represents time, the left y-axis represents temperature and power output, and the right y-axis represents battery voltage. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 80% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The chassis dynamometer was used as the testing facility. For this test, the accelerator

was kept at full throttle until the battery ran out. As a result, for about 70 seconds, the HEV system power output could stay at 70 kW. Afterwards, the battery power gradually decreased, and accordingly, the HEV system power went down as well.

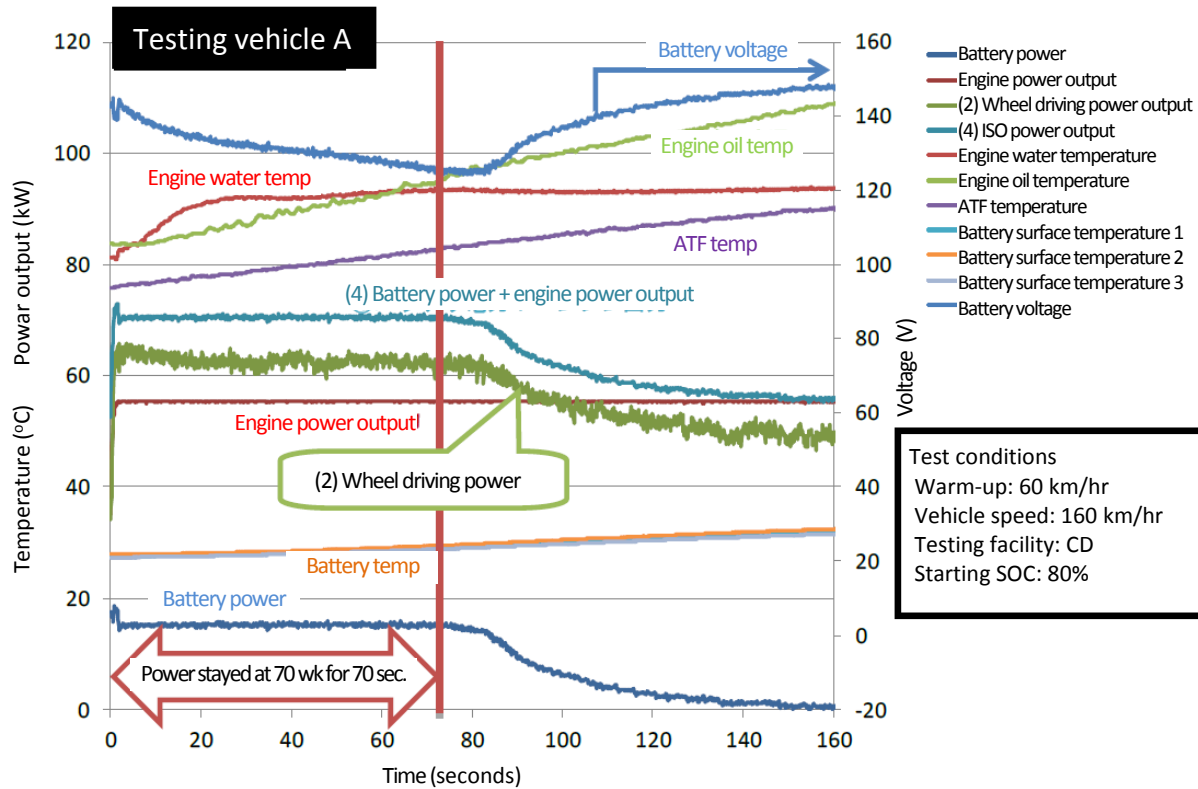


Figure 5.74 Changes of HEV system power output during full throttle (testing vehicle A)

(2) Testing vehicle B

Measurements taken with four levels of durations were evaluated: one second, two seconds, three seconds and five seconds. Moving averages of time-series data sampled at 10 Hz were calculated for the four levels of periods. Effects of duration of power output on the HEV system power output measurements are shown in Figure 5.75 and Table 5.15. The x-axis represents time and the y-axis represents HEV system power output. In terms of testing conditions, the vehicle speed was 115 km/hr in fourth gear, the starting SOC was 93% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. Because testing vehicle B does not have the function of temporarily generating higher power, the power output measurements varied little over different durations. When the power output duration was one second, the HEV system power output was 95.3 kW, and over two seconds, it was 95.3 kW, recording no difference. Over three seconds, the power output was 95.1 kW, which was 0.2 kW lower than that measured over one second. Over five seconds, it was 95.1 kW, 0.2 kW lower. It was understood, based on those results, that with vehicles that do not have the function of temporarily generating higher

power output, there is almost no effect of the length of power output duration on the HEV system power output measurements.

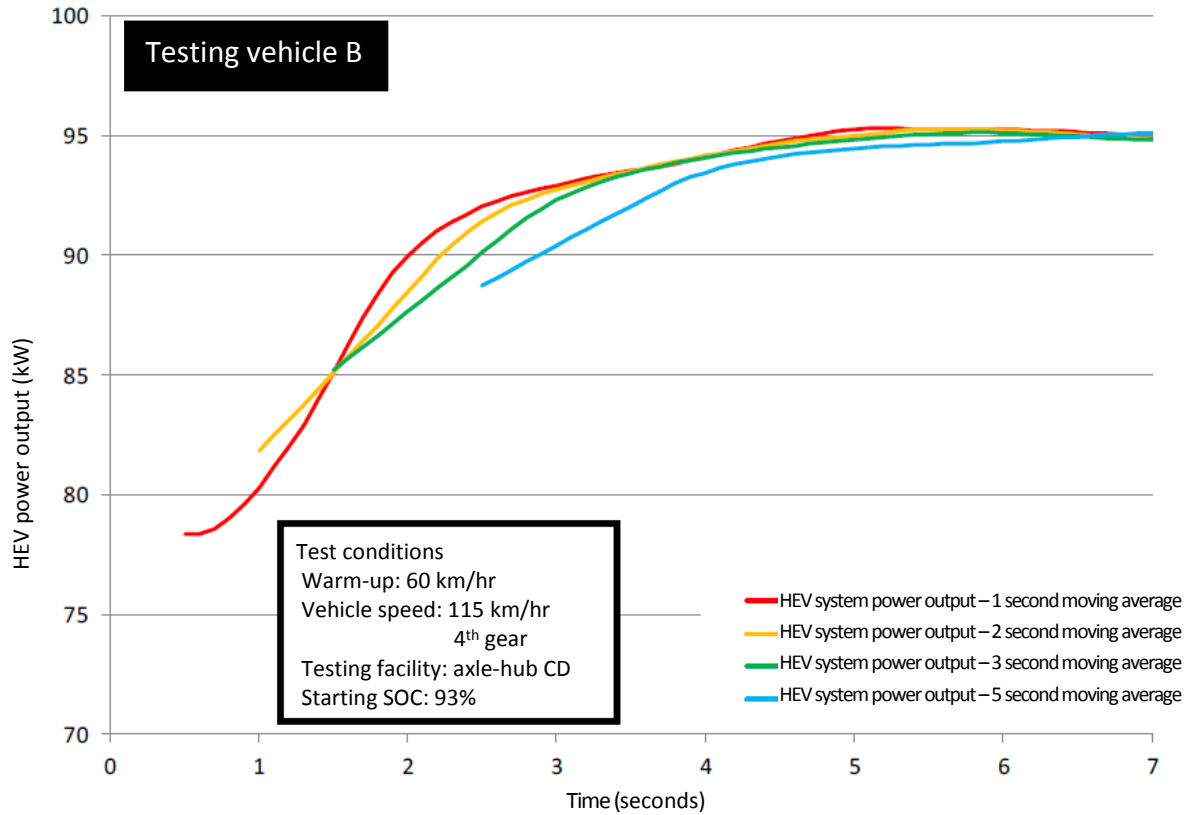


Figure 5.75 Effects of duration of power output on HEV system power output (testing vehicle B)

Table 5.15 Duration of power output and HEV system power output (testing vehicle B)

Power output duration (seconds) (moving average period)	1	2	3	5
HEV system power output	95.5 kW	95.3 kW	95.1 kW	95.1 kW

Next, Figure 5.76 shows changes of HEV system power output over time when the accelerator was kept at full throttle. The x-axis represents time, the left y-axis represents temperature and power output, and the right y-axis represents battery voltage. In terms of testing conditions, the vehicle speed was 115 km/hr in fourth gear, the starting SOC was 93% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. For this test, the accelerator was kept at full throttle until the battery ran out. As a result, for about 55 seconds, the HEV system power output could stay at 90 kW. Afterwards, the battery power gradually decreased, and accordingly, the HEV system power went down as well.

Testing vehicle B

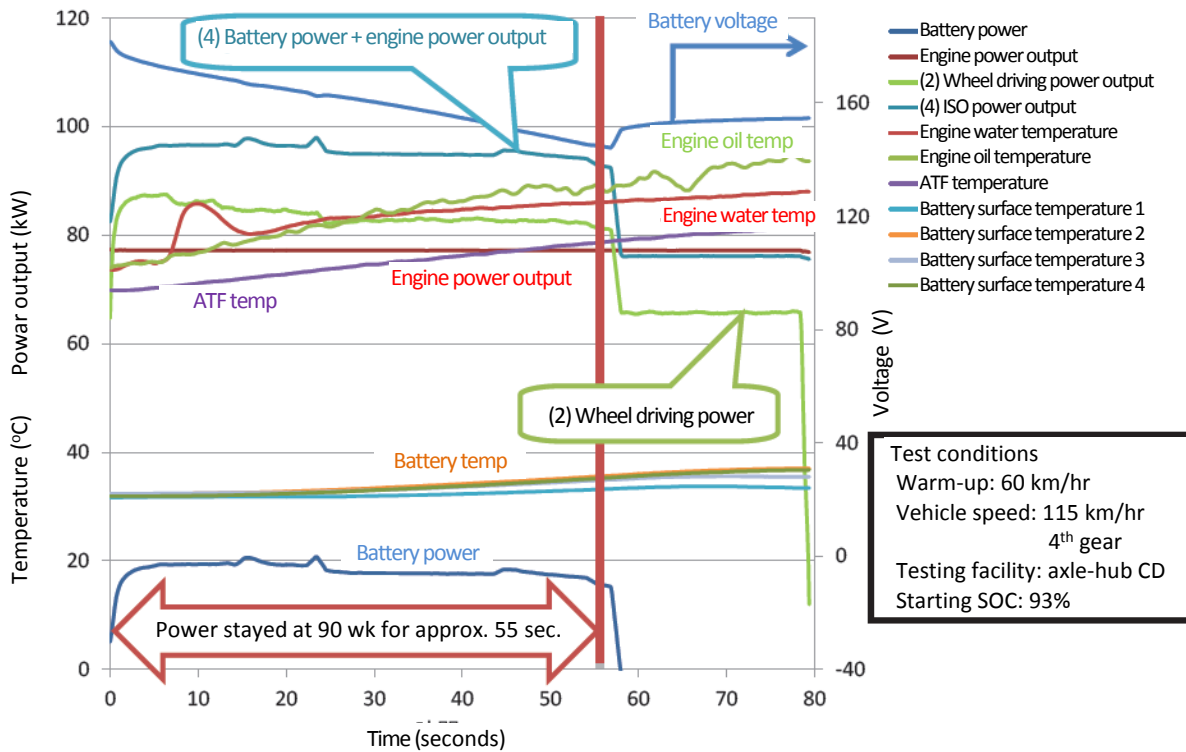


Figure 5.76 Changes of HEV system power output during full throttle (testing vehicle B)

2) Testing vehicle C

Measurements taken with four levels of durations were evaluated: one second, two seconds, three seconds and five seconds. Moving averages of time-series data sampled at 10 Hz were calculated for the four levels of periods. Effects of duration of power output on the HEV system power output measurements are shown in Figure 5.77 and Table 5.16. The x-axis represents time and the y-axis represents HEV system power output. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 90% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. Because testing vehicle C does not have the function of temporarily generating higher power, the power output measurements varied little over different durations. When the power output duration was one second, the HEV system power output was 147.3 kW, 147.4 kW over two seconds, and 147.3 kW over three seconds; there were almost no changes. Over five seconds, it was 147.0 kW, 0.3 kW lower. It was understood, based on those results, that with vehicles that do not have the function of temporarily generating higher power output, there is almost no effect of the length of power output duration on the HEV system power output measurements.

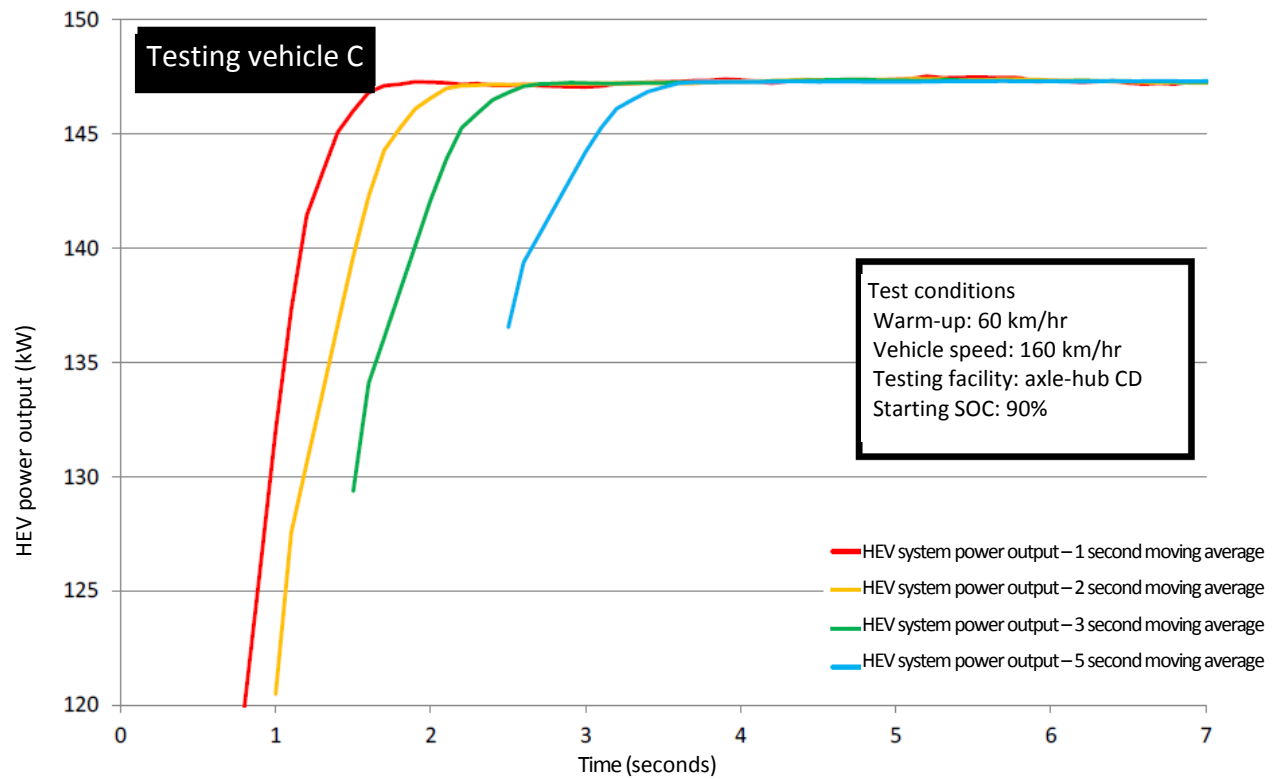


Figure 5.77 Effects of duration of power output on HEV system power output (testing vehicle C)

Table 5.16 Duration of power output and HEV system power output (testing vehicle C)

Power output duration (seconds) (moving average period)	1	2	3	5
HEV system power output	147.3 kW	147.4 kW	147.3kW	147.0 kW

Next, Figure 5.78 shows changes in HEV system power output over time when the accelerator was kept at full throttle. The x-axis represents time, the left y-axis represents temperature and power output, and the right y-axis represents battery voltage. In terms of testing conditions, the vehicle speed was 160 km/hr, the starting SOC was 90% and the vehicle was warmed up for 20 minutes at the constant speed of 60 km/hr. The axle-hub chassis dynamometer was used as the testing facility. For this test, the accelerator was kept at full throttle until the battery ran out. As a result, for about 380 seconds, the HEV system power output could stay at 145 kW. Afterwards, the battery power gradually decreased, and accordingly, the HEV system power went down as well.

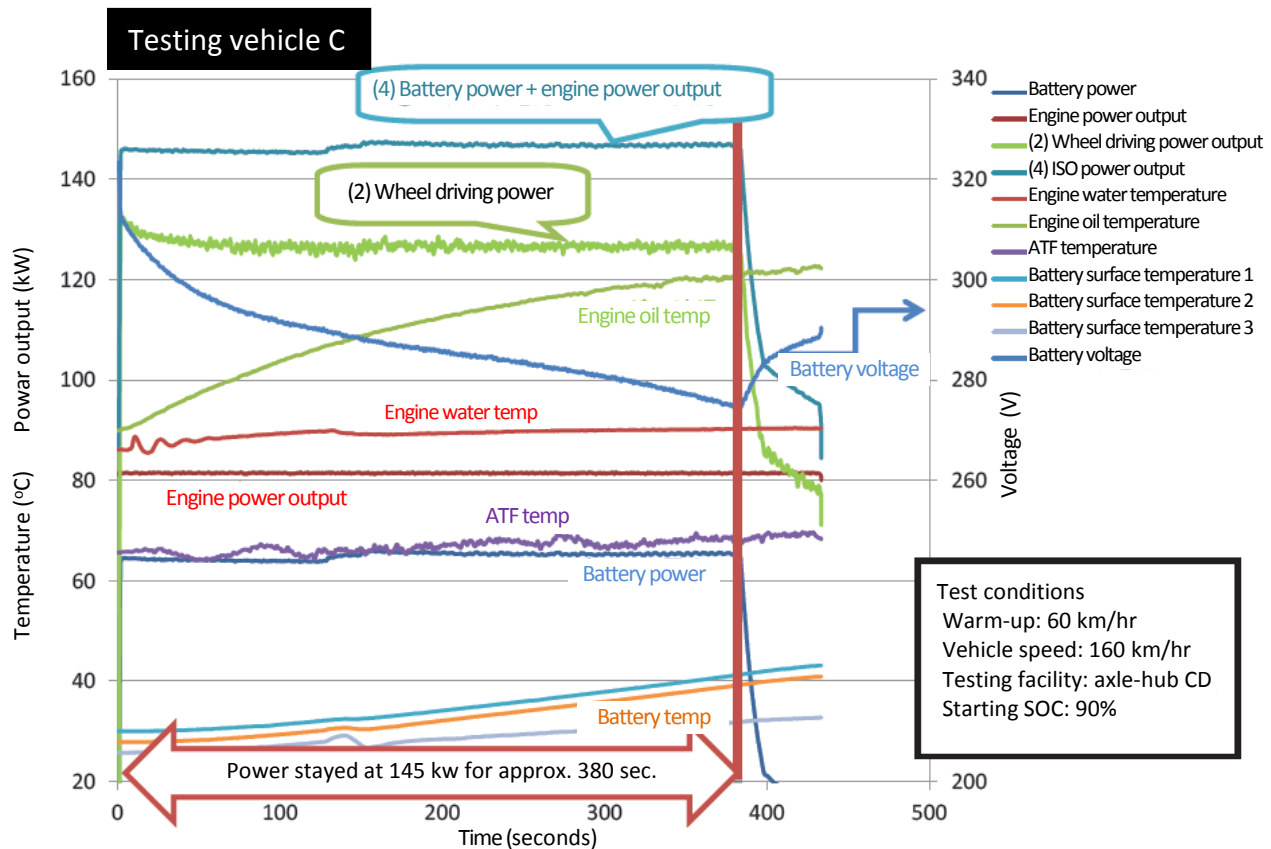


Figure 5.78 Changes of HEV system power output during full throttle (testing vehicle C)

5.3.6 Summary

In developing measuring methods, the possibility of testing conditions affecting HEV systems' power output should be considered. For this reason, testing conditions including warm-up methods, state of charge at the beginning of the test, testing speed, gear position, and power output duration were treated as parameters, and the effect of changes in each of them on HEV system power output is shown in Table 5.17.

Because the maximum deviation was 0.4 kW when vehicles were tested under the same conditions on the chassis dynamometer, this value was used as the baseline to evaluate the effects of differences in parameters.

Using the case where vehicles were warmed up at the constant speed of 60 km per hour as the basis, a cold condition and a JC08 mode warm-up condition were compared. When power output was obtained by adding up engine power output and battery power, which is the method proposed to the ISO, compared with the average values in the cases where vehicles were warmed up at the constant speed of 60 km per hour, the maximum difference was 0.4 kW with vehicle A, 1.4 kW with vehicle B and 1.2 kW with vehicle C, showing that the effect was great with vehicles B and C. Based on this result, it is deemed necessary to specify the warm-up method, and a specification such as "warm up at the constant speed of 60 km per hour for 20 minutes or longer" would be considered appropriate.

To examine the effect of the state of charge (SOC) at the beginning of the test, two values of SOC, i.e. the SOC at the time of maximum power output and the SOC within the regular range of usage, were

used as the SOC at the beginning of the test. The difference in power output between the two SOC was 0.4 kW with vehicle A, 0.2 kW with vehicle B and 1.7 kW with vehicle C, showing that, with some vehicles, this difference can be larger than the deviation under the same conditions. When the SOC at the beginning was very low and outside the range of regular usage, the power output was significantly decreased.

To examine the effect of the speed of the vehicles, two methods were evaluated: the method proposed to ISO in which a different speed level is set in each of multiple tests, and the method that is being considered by the SAE, in which the speed at which the vehicle reaches maximum power output is sought under running resistance control. The testing speed in the SAE method was sometimes different from that of the ISO method, and the SAE method recorded lower power output compared with the ISO method: 0.8 kW lower with vehicle A, 0.7 kW lower with vehicle B and 2.0 kW lower with vehicle C, which were larger differences than deviations under the same conditions. Based on this, it is thought that, while the method that is being considered by the SAE has the advantage of easily yielding the maximum power output speed, it cannot appropriately evaluate vehicles that can increase power output for a short period of time like vehicle A, and that therefore a method in which different speed settings are used in separate tests to determine the maximum power output speed, like the one proposed to the ISO, is more appropriate.

Regarding the effect of the gear position, with vehicle B, the power output was 5.5 kW lower in second gear than in fourth gear, and it became clear that it is necessary to take the gear position into consideration when testing vehicles.

To evaluate the effect of repeating tests, one set of tests was conducted with 20 minutes of warm-up time (at the constant speed of 60 km per hour) between them, and another set was done without warm-up time in between, and the differences between the results of test 1 and test 4 were compared. When the warm-up was inserted between tests, the difference between tests 1 and 4 was 0.5 kW with vehicle A, 1.0 kW with vehicle B, and 0.2 kW with vehicle C; the differences with vehicles A and B were larger than deviations under the same conditions. When tests were repeated without a warm-up in between, the difference between tests 1 and 4 was 1.0 kW with vehicle A, 1.2 kW with vehicle B, and 1.9 kW with vehicle C, which were larger than those in the sets where warm-up was inserted. This indicates that more highly replicable results can be obtained when a warm-up is inserted between tests.

For the examination of the effect of power output duration, moving averages for one second and three seconds were compared. The moving average output for three seconds was lower than that of one second by 1.6 kW with vehicle A and by 0.2 kW with vehicle B, and they were the same with vehicle C. With vehicles B and C, the differences were smaller than deviations recorded under the same conditions, but the difference was large with vehicle A. This is because with vehicles that can increase power output for a short period of time like vehicle A, when the period over which the moving average is taken is longer, the power output goes down from the peak.

These results show that differences in certain conditions can result in differences in power measurements that are larger than deviations in measurements obtained under the same conditions. These conditions include the warm-up method, the method to determine the vehicle's running speed, the gear position, the way the tests are repeated and the duration for which power output is measured. Therefore these conditions have to be specified definitively when tests are conducted.

Table 5.17 Effects of testing conditions on power measurements of HEV

Tested vehicle		A	B	C	Remarks
System		Series-parallel	Parallel	Series-parallel	
Deviation under same conditions		-0.3 – 0.3 kW	-0.3 – 0.4kW	-0.2 – 0.2 kW	Four tests with chassis dynamometer
Effect of testing facilities	Power output calculated with the method proposed to ISO	-0.1 – 0.6 kW	-0.8 – 0.0 kW	-3.5 – 0.0 kW	Difference from power output measured with chassis dynamometer
Effect of warm-up method	Method that warms up batteries faster	JC08 mode	Steady at 60 km/hour	Steady at 60 km/hour	Comparison between steady 60 km/hr and JC08 mode
	Range of power output variation	-0.3 – 0.4 kW	-1.0 – 1.4 kW	-1.2 – 0.6 kW	Difference from power output measured after warm-up steady at 60 km/hr
Effect of SOC at the beginning of the test	Within the range of normal usage	-0.4 kW	-0.2 kW	-1.7 kW*	Difference from power output measured with the SOC of maximum power output
	Low SOC	13.3 kW (SOC: 35%)	-0.7 kW (SOC: 30%)	-47.8 kW (SOC: 20%)	Difference from power output measured with fully charged batteries
Effect of testing speed	Power output calculated through the SAE method	-0.8 kW	-0.7 kW	-2.0 kW	Difference from power output calculated through the method proposed to ISO
	Difference of speed condition calculated through the SAE method	-20 km/hr	-3 km/hr	0 km/hr	Difference from speed condition obtained through the method proposed to ISO

Effect of gear position		Unknown because of the continuously variable transmission	-5.5 kW (2 nd gear)	Unknown because of the continuously variable transmission	Difference from power output in 4 th gear
Effect of repeating tests	Warming up + SOC adjustment + test	+0.5 kW	+1.0 kW	+0.2 kW	Power output in the 4 th test compared with the 1 st test
	SOC adjustment + test	+1.0 kW	+1.2 kW	-1.9 kW	Power output in the 4 th test compared with the 1 st test
Duration of power output	Duration of measurement (3 seconds)	-1.6 kW	-0.2 kW	0.0 kW	Difference from power output measured for one second

* -4.1 kW when the SOC was 100%.

6. Trend research (conducted in 2015)

6.1 . Trend research on HEV system power measuring methods in different countries

At present, as far as available information indicates, it can be said that there is no established testing method (standards or criteria) for HEV system power output of small-sized vehicles. However, since around 2013, different countries (the US's SAE, etc.) have started discussions regarding the standardization of HEV system power output tests, and in 2014, the UN's GTR EVE started a study of testing methods for HEV system power output led by Germany and South Korea.

To respond to those activities, Japan also started a project involving calculation methods for HEV system power output at ISO/TC22/SC37 (electric vehicles; reviewing organization in Japan: JARI).

(1) Activities at UN WP29 GRPE (Pollution et energie working group)

The EVE Informal Working Group under GRPE (hereafter "EVE IWG") is conducting a study of HEV system power led by Germany and South Korea ("EVE" stands for Electric Vehicle Environment).

Cooperation with the E-Lab, which is concurrently working and having discussions in Phase 1b and Phase 2 of WLTP, is hoped for, and as part of the cooperation, it is likely that the issue of HEV system power output will be studied. It is expected to be done for the purpose of downscaling and classification.

(2) Effort at the US SAE

The SAE in the US started discussions on how to develop HEV system power output measuring methods in the summer of 2013 for the purpose of proper presentation in product catalogues (SAE J 2908 Task Force under the SAE HEV & EV Technical Committee. Chair: Michael Duoba, Argonne National Laboratory).

The SAE is of the view that if the power output is ultimately measured at the shaft end (tyre or axle), the total power output measurements can be obtained. While it appears that Chair Duoba is exchanging information with South Korea (KATRI), they are not cooperating for the purpose of standardization. The

SAE has been also studying and testing the power output measurements below in addition to defining system power output:

- Powertrain Power
- Electric Assist DC kW
- Electric-only Drive Power
- Wheel Torque and Power – when engine not fueled
- Regen Rating DC kW

As a result, they are currently proposing three methods and have introduced them at the above-mentioned EVE IWG of the United Nations:

1. Measure the engine power output and the battery power; the same way as ISO20762 (described below)
2. Measure the axle power (engine and output side of the motor and generator)
3. Measure the power output on the axle or wheel using a chassis dynamometer or an axle-hub chassis dynamometer

(3) Activities for establishing international standards

In response to what is being done by the UN and the SAE discussed above, Japan also created a working group (HEV System Power Output WG) in the HEV subcommittee, which is under the JARI FC/EV Standardization Committee, and in 2014, began studying HEV system power output measurement tests. The goal is to create an International Standard, and the working group is aiming to establish testing methods that would allow proper presentation in product catalogues as well as appropriate comparison with power measurements of conventional internal combustion engine vehicles.

System power output measuring methods reviewed include the method to calculate the total power output by adding the engine power output and the motor power output, and the method to measure power output at the axle end using an axle-hub chassis dynamometer or chassis dynamometer, which is the method being considered by the SAE and South Korea. After theoretically comparing those methods, it was determined that, because it is desirable to obtain HEV system power output measurements in a way that corresponds to the power measuring method of conventional internal combustion engine vehicles, the driving conditions that generate the maximum power, which are to be calculated by adding the engine power output and the battery power in a test conducted on a platform at a constant speed, should be identified.

In 2014, with the approval of the Japan Automobile Manufacturers Association, it was decided that the effort for the international standardization should be moved forward, and in March 2015 at the ISO/TC22/SC37/WG2 (Performance of electronic vehicles) international meeting and the SC37 general assembly, it was agreed that a new proposal shall be submitted to the ISO. The new proposal was voted on between April 18 and June 19, 2015, and was adopted. The HEV System Power working group of JARI developed a working draft, and in December 2015, ISO/TC22/SC37/WG2 international meeting started to study technical issues.

6.2 Trends in standardization

A research on trends in standardization related to batteries and charging identified the following developments.

(1) Batteries

LIB cell safety test (IEC62660-3)

- The forced internal short circuit test that Japan proposed was adopted, while potential alternative testing methods proposed by Germany, France and Japan are being reviewed. A careful study of alternative testing methods will continue, with Japan leading the work while taking into consideration effects on consumer-use batteries, etc. South Korean battery manufacturers are also actively participating in the study of alternative testing methods by offering test data, etc.
- China's domestic standard has adopted the nail penetration test. It is necessary to define proper standard tests within the framework of international standardization and encourage China to consider aligning their standard with the international one; however, China has suspended their participation in IEC meetings.

LIB pack safety requirements (ISO 12405-3) and RESS safety specifications (ISO 6469-1)

- With a view to adding thermal runaway testing to ISO 12406-3, Japan and Germany have submitted their own draft testing methods. There is no established standard testing method, discussions are being held, and issues such as compatibility with the EVSgtr are being considered.
- The vibration and impact tests of battery packs have been partially cited in China's domestic standard and have caused problems. For this reason, Germany is proposing relaxation of testing conditions. China has suspended its participation in ISO meetings as well.

(2) Charging systems

DC charging (IEC 61851-23, IEC 61851-24 and IEC 62196-3)

- A first edition was released in 2014 with regulations regarding three systems, including Japan's CHAdeMO (system A). Continued or new studies of items such as conformance tests (proposed by Japan, China and Germany), bidirectional power supply (proposed by Japan), dual chargers (jointly proposed by Japan, Netherlands and Germany) and conversion boxes (proposed by Germany) have started. Overall, countries are working together to move forward with discussions under Japan's lead.
- With electronic vehicles being introduced into the markets of many countries, development and commercialization of dual chargers, conversion boxes, adapters, etc. for the purpose of charging vehicles with different systems have started in western countries. The American company Tesla is using its own system connector and adapter, which are different from specifications of the IEC, and requesting a review of requirements regarding prohibition of the use of an adapter with a vehicle connector in the current IEC standard. Reactions are necessary from the point of view of protecting Japan's systems and promoting wider use of electronic vehicles.
- Germany is proposing a study on connector testing methods in anticipation of high current charging in the future, and Japan will also consider reflecting its domestic study results [on the work of developing international standards].

Charging of light-weight electronic vehicles (IEC 61851-3 series and IEC 62196-4)

- Discussions are being held under the leadership of Switzerland, which aims to establish a German association's standard EnergyBus on public charging of electronic vehicles as an international standard. "Light-weight electronic vehicles" refers to a wide range of vehicles, from bicycles to super-small four-wheeled cars, and overlapping with other standards is an issue. Many challenges exist, including the dogmatic project management by the project leader (Switzerland). Japan is proposing a DC charging system and connector forms for electronic two-wheel vehicles, but partly because they have not been put to commercial applications, their inclusion in the development of the standard is proving difficult. Challenges have to be dealt with to develop proper standards so that wider use of light-weight electronic vehicles in the future will not be hindered.