
**Electric road vehicles — Reference
energy consumption and range — Test
procedures for passenger cars and
light commercial vehicles**

*Véhicules routiers électriques — Consommation d'énergie de
référence et autonomie de référence — Modes opératoires d'essai
pour voitures particulières et véhicules utilitaires légers*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 37, *Electrically propelled vehicles*.

This second edition cancels and replaces the first edition (ISO 8714:2002), which has been technically revised.

The main changes are as follows:

- addition of shortened test;
- deletion of the former Annexes A, B and C (regional tests) because their information is obsolete.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Electric road vehicles — Reference energy consumption and range — Test procedures for passenger cars and light commercial vehicles

1 Scope

This document specifies test procedures for measuring the reference energy consumption and reference range of purely electrically propelled passenger cars and commercial vehicles of a maximum authorized total mass (in accordance with ISO 1176) of 3 500 kg and a maximum speed of 70 km/h or more.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TR 8713, *Electrically propelled road vehicles — Vocabulary*

ISO 8715, *Electric road vehicles — Road operating characteristics*

ISO 10521 (all parts), *Road vehicles — Road load*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

complete electric vehicle kerb mass

mass of the electric vehicle including the rechargeable energy storage system (RESS), without occupants or load, but with combustion heater fuel, cooling liquid, window-washer fluid, lubricating oil, tools and spare wheel, and on-board charger and portable charger or part of it, if provided as standard equipment by the vehicle manufacturer

Note 1 to entry: Adapted from ISO 8715.

3.2

reference energy consumption

quantity of electrical energy from the external AC electric power source needed to recharge the rechargeable energy storage system (RESS), divided by the distance covered or calculated, after the vehicle has been driven through a specified test sequence

Note 1 to entry: The reference energy consumption is usually expressed in watt-hours per kilometre (Wh/km).

3.3

reference range

distance covered by or calculated for an electric vehicle over a designated test sequence on a fully charged rechargeable energy storage system (RESS), to the end of the test sequence as defined by the end-of-test criteria

Note 1 to entry: The reference range is usually expressed in kilometres (km).

3.4

test mass

sum of the *complete electric vehicle kerb mass* (3.1) plus the maximum authorized pay mass (including driver) if it is equal or less than 180 kg; 180 kg, if the maximum authorized pay mass exceeds 180 kg but is less than or equal to 360 kg; half of the maximum authorized pay mass if this pay mass exceeds 360 kg

4 Abbreviated terms

ADT	applicable driving test
CCT	consecutive cycle test
CSS	constant speed segment
RESS	rechargeable energy storage system

5 Test sequence

5.1 General

There are two test methods for measuring the reference energy consumption and reference range of purely electrically propelled vehicles on a chassis dynamometer, the consecutive cycle test (CCT) (see 8.4.3.2) and the shortened test (see 8.4.3.3). The CCT repeats the selected applicable driving test (ADT) cycle (see 5.2) as a test sequence until the end-of-test criterion is reached (see Clause 7). The test sequence of the shortened test consists of a selected number of ADT cycles (see 5.2 and 5.4) followed by a constant speed segment (CSS) (see 5.5). The CSS is performed for discharging the RESS by a higher electrical load than the average ADT cycle load in order to shorten the overall test duration.

The RESS discharging in the shortened test shall be performed by running the vehicle in a CSS or optionally with a constant power discharge via the DC fast charging port (see 5.5).

5.2 Selection of ADT cycle

Select a relevant regional ADT cycle for the definition of the test sequence. The selected ADT cycle applies to either CCT in 8.4.3.2 or shortened test in 8.4.3.3.

The same test sequence shall be used to define energy consumption and range. Every effort shall be made to conduct the tests by following the reference curve within the tolerances given in Clause 6, see Figure 1.

5.3 Deviations in speed trace for vehicles with less maximum speed than the maximum speed of the selected ADT cycle

Vehicles with a maximum speed capability that is less than the maximum speed of the selected ADT cycle shall be operated at fully activated accelerator control when the speed trace cannot be followed.

Speed trace violations according to [Clause 6](#) under these circumstances shall not void a test, if the vehicle speed is higher than 70 km/h. Deviations from the driving cycle shall be recorded.

NOTE If the relevant regional ADT standard, where the selected regional ADT cycle belongs to, includes requirements for a reduced test procedure for vehicles which cannot follow the target speed curve, these requirements for a reduced speed curve are taken into account.

5.4 Selection of the number of ADT cycles for the shortened test

In the shortened test, the selected ADT cycle shall be continued consecutively until an additional cycle after the total range at the cycle end exceeds 40 km to warm-up the relevant drive train components. In the additional ADT cycle test, the energy consumption and range shall be measured under the assumed conditions of a fully warmed-up drive train. The total number of these ADTs, N , is defined as the number of ADTs for the shortened test prior to the CSS.

5.5 Speed determination and procedure for running a CSS

As the second part of the shortened test, a CSS is performed following the required number of ADT cycles as described in [5.4](#). A CSS is also performed in order to discharge the RESS for preconditioning before the normal charging, see [8.4.2](#).

A relevant CSS running speed value for the selected ADT cycle shall be determined by choosing one of the two methods described in [Annex B](#), see [Clauses B.2](#) and [B.3](#). If a shortened test method with a CSS for the selected ADT cycle is available in the relevant regional ADT standard, then this CSS speed value can be used.

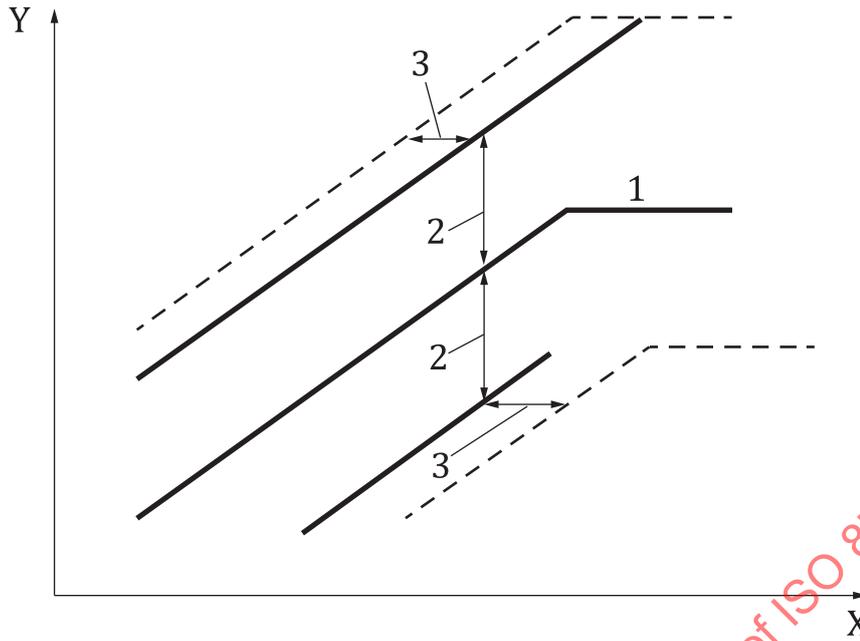
Optionally, the RESS discharging can be performed with a constant power discharge via the DC fast charging port. The determination of the value for power for the RESS discharging and some information necessary for the test are described in [Annex B](#), see [Clause B.4](#).

A CSS shall be run targeting the CSS speed as follows:

The vehicle on the chassis dynamometer shall be accelerated steadily to the specified CSS speed within 60 s. If the CSS speed cannot be reached within 60 s, the accelerator control shall be fully activated until the CSS speed is reached. When the vehicle reached the CSS speed, the speed shall be maintained until the end-of-test criteria according to [Clause 7](#) are satisfied.

6 Tolerances

Tolerances on speed and time in the test sequence shall be as shown in [Figure 1](#).



Key

- X time [s]
- Y speed [km/h]
- 1 reference speed curve
- 2 tolerance of speed, in km/h
- 3 tolerance of time, in seconds [s]

Figure 1 — Reference curve and tolerances

A tolerance on speed of within $\pm 2,0$ km/h and a tolerance on time of within $\pm 1,0$ s shall be geometrically combined at each point as in [Figure 1](#). One deviation of up to 4 s beyond these tolerances is permitted in any drive cycle. This exception shall not be allowed to delay the determination of the end of the test sequence. The total time-out of tolerances shall be mentioned in the test report.

7 End-of-test criteria

The end-of-test criteria are defined as follows.

- a) For vehicles capable of following the speed trace of the selected ADT cycle, the test termination criterion is defined as when the vehicle—due to power limitations—is incapable of maintaining the speed tolerances as defined in [Clause 6](#).
- b) For vehicles with a maximum speed capability that is less than the maximum speed of the selected ADT cycle, it shall be operated at fully activated accelerator control when the speed trace cannot be followed.

If the speed trace is equal or lower than 70 km/h, the test termination criterion is defined as when the vehicle is incapable of maintaining the speed tolerances as defined in [Clause 6](#). If the speed trace is higher than 70 km/h, the test termination criterion is defined as when the vehicle, while operated at fully activated accelerator control is unable to reproduce the best-effort speed versus time relationship established by the vehicle in the first selected ADT cycle. The applicable drive tolerances for the best-effort trace are as defined in [Clause 6](#).

- c) For all vehicles the test termination criterion is defined as when the vehicle is given an indication from the on-board instrumentation to the driver to stop the vehicle, e.g. for safety reasons.

When one of the test termination criteria has occurred, the driver shall immediately apply the brake and the vehicle shall stop within 60 s. At the stop of the vehicle, the test is completed and all measurement activities shall be terminated.

At the shortened test, the DC measurement device additionally shall count the energy values at the test termination point.

NOTE DC measurement is necessary for E_{AC} correction.

8 Measurement of range and energy consumption

8.1 General

The following test method specifies the measurement of the AC electric energy, DC electric energy and the distance, and then the calculation of reference range and reference energy consumption.

8.2 Parameters, units and accuracy of measurements

[Table 1](#) specifies parameters and their units and accuracy of measurements.

Table 1 — Parameters, units and accuracy of measurements

Item	Unit	Accuracy
Time	s	±0,1 s
Distance	m	±0,1 %
Temperature	°C	±1 °C
Speed	km/h	±1 %
Mass	kg	±0,5 %
AC electric energy	Wh	±0,5 %
DC electric energy	Wh	±0,3 % ^a
DC current	A	±0,3 % ^a
DC voltage	V	±0,3 % ^a

^a Any errors in the DC electric energy measurement system shall be less than 1 % of the reading or 0,3 % of the full scale. (Pulsed power electronics measurement needs a wide dynamic range even if it has a small power.)

For the DC energy measurement, wideband meter (power analyser) or wideband ampere-hour meter for pulsed power electronics is required.

The wideband meter (power analyser) is an instrument for processing power and energy in pulsed power electronics by current and voltage inputs. Its bandwidth shall be at least 10 times as high as the switching frequency of the pulsed power electronics, and update period of its outputs shall be 0,05 s or less to get enough time resolution.

Voltage probes and current sensors shall be installed in such a way as to measure voltage at RESS and all current leaving and entering the RESS.

The data of the RESS control unit shall be alternatively applied if the accuracy of the data certifies corresponding accuracy in [Table 1](#).

NOTE If the test vehicle's RESS controller data are not sufficiently accurate, the accuracy of the controller's data are displayed on the data sheet. The accuracy of the resulting specific energy consumption and range can be estimated and are also on the data sheet.

8.3 Test conditions

8.3.1 Vehicle conditions

The test mass shall follow the requirements given in ISO 8715. If the requirement for the test mass is given in the relevant regional ADT standard, then it can be used.

The determination of vehicle road load and the reproduction on the chassis dynamometer shall be in accordance with the ISO 10521 series. The same setting on the chassis dynamometer shall be used throughout the test regardless of CCT or shortened test.

The relevant regional ADT standard can be used if it specifies how to determine the vehicle road load.

The vehicle tyres shall be inflated to the pressure specified by the vehicle manufacturer according to the specifications of the chassis dynamometer when the tyres are at ambient temperature.

The viscosity of oils used for the lubrication of mechanical moving parts shall conform to the specifications of the vehicle manufacturer.

The lighting and light signalling and auxiliary devices shall be off, except those required for testing and usual day-time operation of the vehicle.

All energy-storage systems available for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be in the operating range specified by the vehicle manufacturer.

For the RESS conditioning, the test driver shall follow the procedure recommended by the vehicle manufacturer for keeping the temperature of the RESS in the normal operating range.

The vehicle shall be driven at least 300 km before the test with the RESS that is installed in the test vehicle.

8.3.2 Ambient temperature conditions

Test steps shall be carried out at room temperature between (25 ± 5) °C.

8.4 Test procedure

8.4.1 General

The test procedure consists of the following steps:

- a) charging of the RESS (discharging or charging, preconditioning and normal charging) in accordance with 8.4.2. For shortened test, the energy from the external AC electric power source for charging the RESS ($E_{AC,mes_pre-test}$) can be measured (see 8.4.2.3);
- b) applying the appropriate test sequence (see 5.2), and measuring the range and the DC energy consumption from the RESS, if applicable, and the AC energy from the external AC electric power source for charging the RESS (see 8.4.3);
- c) for CCT, measuring travelled range, the AC energy from the external AC electric power source for charging the RESS after the test and calculation of the reference energy consumption (see 8.4.3.3);
- d) for the shortened test, measuring travelled range, AC energy from the external AC electric power source for charging the RESS after the test, DC energy from the RESS, and calculation of the reference energy consumption and reference range (see 8.4.3.3.2.3).

8.4.2 Charging of the RESS

8.4.2.1 General

Unless otherwise prescribed by the vehicle manufacturer or the RESS manufacturer, the initial charge of the RESS shall be performed as follows.

8.4.2.2 Discharging the RESS

8.4.2.2.1 Setting the remaining RESS level for discharge driving (preconditioning) before full charge

Prior to discharge driving (preconditioning), the remaining state of charge (SOC) of the RESS should be adjusted so that the vehicle can run a distance of up to 50 km at CSS speed. After adjusting the SOC, soak for 9 h or more at the test temperature condition. The soak time can be reduced by agreement between the test institute and customer.

For discharging, a constant power discharge of the RESS via the DC fast charging port can replace running a CSS on a chassis dynamometer (see [Annex B, B.4](#)).

If the SOC level is lower than the requested minimum level, the RESS shall first be charged at least to the requested minimum SOC level before discharging in [8.4.2.2.3](#).

8.4.2.2.2 Vehicle movement

If it is necessary to move the vehicle, push or tow the vehicle so that it does not regenerate or discharge. Exposure to temperatures other than the test environment temperature shall be limited to 30 min.

8.4.2.2.3 Preconditioning (discharge running) for full charge of RESS

Discharging the RESS shall be carried out by driving the vehicle at a constant speed defined by CSS on the chassis dynamometer.

Stop the discharge, if the end-of-test criteria according to [Clause 7](#) are satisfied.

8.4.2.2.4 Application of a normal charge

Soak and charge the vehicle at ambient temperature for 11 h according to [8.4.2.3](#) (normal charging procedure), then start the test within a 1 h period. If charging takes less than 11 h, soaking shall be continued for 11 h. If charging takes more than 11 h, start the test within a 1 h period after charging is completed.

When charging and soaking are completed, push or tow the vehicle onto the chassis dynamometer.

8.4.2.3 Normal charging procedure

8.4.2.3.1 General

The AC energy measurement equipment shall be placed between the external AC electric power source and the vehicle inlet.

The charging of the RESS shall be carried out at an ambient temperature of $(25 \pm 5) ^\circ\text{C}$. The normal charging procedure shall be in accordance with the vehicle manufacturer's specification for normal operation.

For the normal charging procedure all types of special charging shall be excluded, for example, RESS service charging.

The AC energy shall be measured after the test termination.

For the shortened test, the AC energy can be measured optionally after preconditioning if the discharge conditions at the test and for the preconditioning are the same. The measured AC energy values can be used instead of the post-test measurements, see [8.4.3.3.1](#).

8.4.2.3.2 End-of-charge criteria

The end-of-charge criteria shall correspond to a charging time of 11 h except if a clear indication is given to the driver by the standard instrumentation that the RESS is not yet fully charged. In this case, the maximum charging time shall be in accordance with the manufacturer's specification.

8.4.2.3.3 Fully charged RESS

A RESS is fully charged when charged according to the normal charging procedure (see [8.4.2.3.1](#)) and the end-of-charge criteria (see [8.4.2.3.2](#)).

8.4.3 Application of the designated test sequence and calculation for results

8.4.3.1 General

If the test sequence is performed by CCT only, the total range and the AC energy from the external AC energy source for charging the RESS shall be measured after the test.

If the vehicle can run more than N times of the selected ADT cycle (see [5.4](#)), the shortened test according to [8.4.3.3](#) can be the alternative test procedure instead of the CCT.

If the test sequence is performed by the shortened test, measured DC energy ($E_{DC_cycle_n}$) from the RESS and travelled range (d_{cycle_n}) in each n^{th} ADT cycle and in the CSS shall be measured.

NOTE n represents the ADT cycle counter, starting with number 1 up to number N , where the last ADT cycle prior to the CSS is performed.

The total DC energy from the end of initial charge to the end of test (E_{DC}) and to the point where the vehicle stops after end of test (E_{DC_mes}) and the AC energy from the external AC energy source for charging the RESS shall be measured.

Unless otherwise requested by the ADT standard to which the selected ADT cycle belongs to, up to three interruptions of no longer than 15 min in total are permitted between the test sequences, out of respect for human needs. In the CSS of the shortened test, interruptions of up to 10 min per 1 h driving are permitted. During all optional interruption periods, the key or power switch shall be in the "off" position, the hood shall be closed, the test cell fan shall be off, and the brake pedal not depressed.

In the case of the shortened test, interruption during the ADT cycle delays the completion of vehicle warm-up and may cause errors in each calculation result. Therefore, interruptions should be made only during CCS or, if interrupted during an ADT cycle, the interruption time should be minimized.

8.4.3.2 Consecutive cycle test

8.4.3.2.1 Test procedure

The specified test sequence shall start within 1 h after soak and end-of-charge ([8.4.2.3.2](#)).

The test sequence shall continue until the end-of-test criterion is reached (see [Clause 7](#)).

In any case, the total range, d_{ADT} , travelled up to the end of test and to the final stop of the vehicle shall be measured.

The RESS charging according to [8.4.2.3](#) shall start within 1 h after end of test and the AC energy from the external AC energy source for charging the RESS, $E_{AC_mes_post-test}$, shall be measured.

The driving time (in hours and minutes) and the total travelled range (in km) shall be reported.

8.4.3.2.2 Calculation of reference energy consumption, $E_{C,AC}$

The vehicle ADT reference energy consumption, $E_{C,AC}$, shall be calculated according to [Formula \(1\)](#):

$$E_{C,AC} = E_{AC_mes_post-test} / d_{ADT} \quad (1)$$

where

$E_{C,AC}$ is the reference AC energy consumption in Wh/km;

$E_{AC_mes_post-test}$ is the total AC energy measured after the test sequence in Wh;

d_{ADT} is the total performed ADT range in km.

$E_{C,AC}$ is rounded to the nearest whole number.

8.4.3.3 Shortened test

8.4.3.3.1 Test procedure

The specified test sequence shall start within 1 h after soak and end-of-charge ([8.4.2.3.2](#)).

Run the number of ADT cycles selected in [5.4](#) followed by a CSS defined according to [5.5](#) until the end-of-test criteria according to [Clause 7](#).

Consumed DC energy ($E_{DC_cycle_n}$) from the RESS and distance travelled (d_{cycle_n}) in each n^{th} ADT cycle shall be measured.

The total DC energy from the end of initial charge to the end of the test sequence without regenerative energy for final braking (E_{DC}) and the total DC energy from the end of initial charge until the vehicle stops at the end of the test (E_{DC_mes}) shall be measured.

Charge according to [8.4.2.3](#) and measure the energy from the external AC electric power source in watt-hour (Wh).

Optionally, the AC energy can be measured after preconditioning (before the shortened test) if the discharging conditions for the RESS after preconditioning and at the CSS of the shortened test are the same.

Optionally, a constant power discharge of the RESS via the DC fast charging port can replace running a CSS after the ADT cycles (see [Annex B, B.4](#)).

8.4.3.3.2 Calculation of test results

8.4.3.3.2.1 Calculation of specific DC energy consumption of the test

Due to higher mechanical losses of drive train components at low operating temperature (including tyre losses) and low acceptability of regenerative braking, the test starts at higher energy consumption condition at the first ADT cycle. In the next following ADT cycles, the energy consumption decreases toward steady-state condition (completely warmed up condition) in the N^{th} ADT cycle. Measured data can lead to specific DC energy consumption at each ADT cycle.

It will be assumed, that the specific DC energy consumption of the CSS is equal to the specific DC energy consumption of the N^{th} ADT cycle, therefore the total range (d_{ADT_calc}), expressed in kilometres, shall be determined according to [Formula \(2\)](#).

The total range (d_{ADT_calc}) is the sum of each ADT cycle range up to the N^{th} cycle plus the CSS range calculated by dividing the DC energy of the CSS by the specific energy consumption of the N^{th} ADT cycle:

$$d_{ADT_calc} = \sum_{n=1}^N d_{cycle_n} + \frac{E_{DC_CSS}}{E_{DC_cycle_N}} \times d_{cycle_N} \quad (2)$$

where

d_{ADT_calc} is the calculated total range of the shortened test in km;

n is the ADT cycle counter;

N is the number for the last ADT cycle prior to the CSS;

d_{cycle_n} is the range of the n^{th} ADT cycle in km;

E_{DC_CSS} is the DC energy of the CSS in Wh;

$E_{DC_cycle_N}$ is the DC energy of the N^{th} ADT cycle in Wh;

d_{cycle_N} is the range of the N^{th} ADT cycle in km.

8.4.3.3.2.2 Total AC energy (E_{AC}) correction

The correction is done to eliminate from the E_{AC_mes} the effect of the regeneration energy that occurs during braking before the vehicle stops after the test sequence is terminated under the conditions of [Clause 7](#).

$$E_{AC} = E_{AC_mes_post-test} \times (E_{DC} / E_{DC_mes}) \quad (3)$$

where

E_{AC} is the corrected total AC energy in Wh after the test sequence;

$E_{AC_mes_post-test}$ is the AC energy in Wh at end of charging after the test sequence (see [8.4.2.3](#));

$E_{AC_mes_post-test}$ can be replaced by the value $E_{AC_mes_pre-test}$ if the AC energy is measured before the test.

E_{DC} is the total DC energy in Wh from the RESS after the test sequence without regenerative energy for final braking of the vehicle;

E_{DC_mes} is the total DC energy in Wh from the RESS, when the vehicle stops after end of the test.

8.4.3.3.2.3 Reference energy consumption and reference range

$E_{C,AC}$ is the AC reference energy consumption of the shortened test according to [Formula \(4\)](#). d_{ADT_calc} is the calculated total range of the shortened test according to [Formula \(2\)](#):

$$E_{C,AC} = E_{AC} / d_{ADT_calc} \quad (4)$$

where

$E_{C,AC}$ is the reference AC energy consumption in Wh/km;

E_{AC} is the corrected total AC energy in Wh (see [8.4.3.3.2.2](#));

d_{ADT_calc} is the calculated total range for the shortened test in km.

$E_{C,AC}$ is rounded to the nearest whole number.

8.4.4 Test procedure overviews

[Table 2](#) gives an overview on when AC and/or DC energy shall be measured.

Table 2 — AC/DC energy measurement

Measurement	Test method	Consecutive cycle test	Shortened test
DC energy measurement of each ADT cycle		not applicable	applicable
DC energy measurement from start of test to test termination point and to stop of the vehicle		not applicable	applicable
AC energy measurement after the test		applicable	applicable ^a
^a Optionally AC energy can be measured after preconditioning if the RESS conditions after preconditioning and after the test are the same.			

9 Presentation of results

Test results obtained from the measurement of CCT or shortened test shall be reported, see [Annex A](#) for example.

Annex A (informative)

Test results of reference energy consumption and range of test vehicle

A.1 Example of listing test results

Test results are reported as follows:

Date	Test site	Person responsible
Test vehicle:		
Name and model:.....		
Chassis number:.....		
Total mileage:.....		km
Vehicle kerb mass:.....		kg
Vehicle test mass:.....		kg
Equivalent inertia mass (set value):.....		kg
Transmission:.....		

If the vehicle is modified to adjust to the dynamometer in accordance with [8.4](#), detail about the modification should be reported.

Tyre pressure of drive wheels:.....kPa

RESS:

Rated capacity:.....Wh Nominal voltage:.....V

Test results:

ADT:

Start-up time: h min

Test temperature in test room:°C

Relative humidity in test room:.....%

Atmospheric pressure in test room:.....hPa

Driven distance:..... km

CCT E_{AC_mes} :..... Wh
 d_{ADT} :..... km
 $E_{C,AC}$:..... Wh/km

Shortened test E_{AC_mes} :..... Wh
 E_{AC} :..... Wh
 E_{DC_mes} :..... Wh
 E_{DC} :..... Wh
 $E_{C,AC}$:..... Wh/km
 d_{ADT_calc} :..... km

Remarks:

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Annex B (normative)

Determination of CSS speed

B.1 General

The target speed value for the CSS shall be determined alternatively according to [Clause B.2](#) or [B.3](#). If the RESS discharge is performed optionally via the DC fast charging port, the power for the RESS discharge shall be determined according to [Clause B.4](#).

B.2 ADT cycle power method

Using the road load specification value of the test vehicle and the vehicle speed profile data obtained from the ADT cycle data, calculate the profile of traction power generated at the dynamometer roller surface, by the following steps.

Step 1:

With the determined road load coefficients as a result of the road load test, determine the total driving resistance ($F_{RL}(v)$) at a given vehicle speed (v) according to [Formula \(B.1\)](#):

$$F_{RL}(v_i) = f_0 + f_1 \times v_i + f_2 \times v_i^2 \quad (\text{B.1})$$

where

$F_{RL}(v_i)$ is the total driving resistance at the relevant vehicle speed v_i , in N;

v_i is the vehicle speed at the relevant ADT cycle sequence in km/h;

i is the number of order of subsequent speed data of the ADT cycle, starting with 0 at the time at which the ADT cycle starts up to the maximum ADT cycle data sequence at the time at which the ADT cycle ends;

f_0 is the constant term road load coefficient of the test vehicle, in N;

f_1 is the first-order road load coefficient of the test vehicle, in N/(km/h) ;

f_2 is the second-order road load coefficient of the test vehicle, in N/(km/h)².

Step 2:

Calculate the acceleration / deceleration profile of the ADT cycle. The acceleration / deceleration value a at time i , shall be determined according to [Formula \(B.2\)](#):

$$a_i = (v_{i+1} - v_i) / (3,6 \times (t_{i+1} - t_i)) \quad (\text{B.2})$$

where

a_i is the acceleration / deceleration of the vehicle at the relevant number of order of the ADT cycle speed sequence, in m/s²;

- i is the number of order of subsequent speed data of the ADT cycle, starting with 0 at the time at which the ADT cycle starts up to the penultimate ADT cycle data sequence at the time at which the ADT cycle ends;
- v_i is the relevant vehicle speed of the ADT cycle sequence in km/h;
- t_i is the relevant time duration within the ADT cycle data sequence in s, starting at 0 s up to the penultimate cycle duration, typically within a time step of 1 s.

The acceleration value at t_{end} shall be set to 0 in order to avoid empty cells.

Step 3:

The traction power P_i at the relevant ADT cycle data shall be determined according to [Formula \(B.3\)](#):

$$P_i = ((F_{\text{RL}}(v_i) + k_r \times a_i \times m) \times v_i) / 3,6 \quad (\text{B.3})$$

where

- P_i is the power of the roller surface at the relevant ADT cycle sequence, in W;
- i is the number of order of subsequent speed data of the ADT cycle, starting with 0 at the time at which the ADT cycle starts up to the maximum ADT cycle data sequence at the time at which the ADT cycle ends;
- $F_{\text{RL}}(v_i)$ is the total driving resistance at the relevant vehicle speed v_i , in N;
- k_r is a factor for the inertial resistances of the drive train during acceleration. As a default value, 1,03 can be applied.
- a_i is the acceleration / deceleration of the vehicle at the relevant number of order of the ADT cycle speed sequence, in m/s²;
- m is the test mass of the vehicle in kg;
- v_i is the vehicle speed at the relevant ADT cycle sequence in km/h.

Step 4:

Calculate the ADT cycle power (P_{ADT}) as the root mean square (RMS) value of all powers (P_i) of each 1 s sequence as obtained in Step 3, according to [Formula \(B.4\)](#):

$$P_{\text{ADT}} = \sqrt{\frac{\sum_{i=0}^{i_{\text{max}}} P_i^2}{i_{\text{max}}}} \quad (\text{B.4})$$

where

- P_{ADT} is the RMS power for the ADT cycle expressed in W;
- P_i^2 is the square value of P_i in W² according to [Formula \(B.3\)](#);
- i is the number of order of subsequent speed data of the ADT cycle, starting with 0 at the time at which the ADT cycle starts up to the maximum ADT cycle data sequence at the time at which the ADT cycle ends;
- i_{max} is the maximum number of order of subsequent speed data of the ADT cycle.

Step 5: