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Hybrid-electric road vehicles — Exhaust emissions and fuel consumption measurements —

Part 2: Externally chargeable vehicles

Véhicules routiers électriques hybrides — Mesurages des émissions à l'échappement et de la consommation de carburant —

Partie 2: Véhicules rechargeables par des moyens externes

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 23274-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

This first edition of ISO 23274-2, together with ISO 23274-1, cancels and replaces ISO 23274:2007, which has been technically revised.

ISO 23274 consists of the following parts, under the general title *Hybrid-electric road vehicles — Exhaust emissions and fuel consumption measurements*:

— *Part 1: Non-externally chargeable vehicles*

— *Part 2: Externally chargeable vehicles*

Hybrid-electric road vehicles — Exhaust emissions and fuel consumption measurements —

Part 2: Externally chargeable vehicles

1 Scope

This part of ISO 23274 specifies a chassis dynamometer test procedure to determine the end of CD (charge-depleting) state and consumed electric energy during CD state.

The identification of the end of CD state is an important step for procedures to determine exhaust emissions and fuel consumption. Final determination of exhaust emissions and fuel consumption is not included in this part of ISO 23274.

This part of ISO 23274 applies to vehicles with the following characteristics.

— The vehicles are hybrid-electric road vehicles (HEV) with an internal combustion engine (ICE) and the on-board rechargeable energy storage system (RESS) for vehicle propulsion which is supplied by electric energy from the stationary external power source.

— A CD state, in which the electric energy in RESS from the stationary external power source is consumed, is followed by a CS (charge-sustaining) state in which the fuel energy is consumed sustaining the electric energy of the RESS.

— Only batteries are assumed as the RESS of a vehicle.

— The RESS is not charged while driving unless by regenerative braking and/or by generating by ICE.

NOTE 1 Trolleybuses and solar powered vehicles are not included in the scope.

— The vehicle is classified as a passenger car or light duty truck, as defined in each regional annex.

— Only liquid fuels (for example, gasoline and diesel fuel) are used.

NOTE 2 In the case of vehicles with ICE using other fuel [for example, compressed natural gas (CNG), hydrogen (H_2)], this part of ISO 23274 can apply except the measurement of consumed fuel; otherwise the measurement method for those using the corresponding fuel can apply.

2 Normative references

The following referenced documents are indispensable for the application 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 23274-1, *Hybrid-electric road vehicles — Exhaust emissions and fuel consumption measurements — Part 1: Non-externally chargeable vehicles*

3 Terms and definitions

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

3.1
applicable driving test
ADT
single driving test schedule which is specified for each region

EXAMPLE Chassis dynamometer test cycle for light-duty vehicles in Japan (JC08), New European Driving Cycle (NEDC), Urban Dynamometer Driving Schedule (UDDS)

3.2
charge balance of RESS
change of charge in battery during fuel consumption measurement

NOTE Normally expressed in ampere hours (Ah).

3.3
charge-depleting state
CD state
operating mode of a HEV with ICE in which the vehicle runs by consuming mainly the electric energy from the stationary external power source or along with the fuel energy simultaneously or sequentially until CS state

3.4
charge-sustaining state
CS state
operating mode where the HEV runs by consuming the fuel energy while sustaining the electric energy of the RESS

3.5
energy balance of RESS
ΔE_{RESS}
change of battery energy state during an applicable driving test

NOTE 1 Normally expressed in watt hours (Wh).

NOTE 2 For practical use, the energy balance of RESS is approximated by multiplying the charge balance of battery in ampere hours (Ah) by the nominal voltage in volts (V). Nominal voltage is defined in 9.4.2 of ISO 12405-1:2011.

3.6
externally chargeable HEV
HEV with a rechargeable energy storage system (RESS) that is intended to be charged from an external electric energy source

NOTE 1 External charge for the purpose of conditioning of the RESS is not included.

NOTE 2 Externally chargeable HEVs are widely known as plug-in HEVs (PHEVs).

3.7
hybrid-electric vehicle
HEV
vehicle with both a rechargeable energy storage system (RESS) and a fuelled power source for propulsion

EXAMPLE Internal combustion engine or fuel cell systems are typical types of fuelled power sources.

3.8
non-externally chargeable HEV
HEV with a rechargeable energy storage system (RESS) that is not intended to be charged from an external electric energy source

3.9
rated capacity
supplier's specification of the total number of ampere hours that can be withdrawn from a fully charged battery pack or system for a specified set of test conditions such as discharge rate, temperature, discharge cut-off voltage, etc.

3.10
rechargeable energy storage system
RESS
system that stores energy for delivery of electric power and which is rechargeable

EXAMPLE batteries or capacitors

3.11
regenerative braking
braking with conversion of kinetic energy into electric energy for charging the RESS

3.12
state of charge
SOC
available capacity in a battery pack or system

NOTE Expressed as a percentage of rated capacity.

4 Symbols and abbreviated terms

A/C	air-conditioning
ABS	antilock braking system
ADT	applicable driving test
BMD	bag mini-diluter
CD	charge-depleting
CFR	Code of Federal Regulations
CLA	chemiluminescent assay
CNG	compressed natural gas
CO	carbon oxide
CS	charge-sustaining
CVS	constant volume sampler, constant volume sampling
E	energy
ECE	Economic Commission for Europe
E_{CF}	energy of consumed fuel
EPA	Environmental Protection Agency
E_{RESS}	energy of RESS
F	consumed fuel
FC	fuel consumption

FCT	full charge test
FEC	full environmental chamber
FID	flame ionization detector
FTP	Federal Test Procedure
H_2	hydrogen
HC	hydrocarbon
HEV	hybrid-electric vehicle
HFEDS	Highway Fuel Economy Driving Schedule
HFID	heated flame ionization detector
ICE	internal combustion engine
ISO	International Organization for Standardization
JC08	chassis dynamometer test cycle for light-duty vehicles in Japan
NDIR	non dispersive infrared
NDUVR	non dispersive ultraviolet resonance absorption
NEDC	New European Driving Cycle
NOx	nitrogen oxide
RESS	rechargeable energy storage system
SAE	Society of Automotive Engineers, Inc.
SC03	Speed Correction Driving Schedule
SOC	state of charge
TCS	traction control system
THC	total hydrocarbons
UDDS	Urban Dynamometer Driving Schedule
UN	United Nations
US-06	Supplemental FTP
ρ	density

5 Test conditions and instrumentation

5.1 Test conditions

For test conditions, ISO 23274-1 applies.

5.2 Test instrumentation

Test instrumentation shall have accuracy levels shown in Table 1, unless specified differently in Annex A, B or C.

Table 1 — Accuracy of measured values

Item	Unit	Accuracy of measurement
Time	s	± 0,1 s
Distance	m	± 0,1 %
Temperature	°C	± 1 °C
Speed	km/h	± 1 %
Mass	kg	± 0,5 %
Current	A	± 0,5 %
Electric energy	Wh	± 0,5 %

5.3 Charging of the RESS

5.3.1 Application of a normal charge

5.3.1.1 Normal charging procedure

The charging of the RESS shall be carried out at an ambient temperature of (25 ± 5) °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.

5.3.1.2 End-of-charge criteria

The end-of-charge criteria shall correspond to a charging time of 12 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. After charging, the vehicle shall not be conductively connected to the stationary external power source unless otherwise specified by the manufacturer.

5.3.1.3 Fully charged RESS

A RESS is fully charged when charged according to the normal charging procedure (see 5.3.1.1) and the end-of-charge criteria (see 5.3.1.2).

5.3.2 Charging the RESS and measuring energy

The vehicle shall be physically reconnected to the stationary external power source within 2 h following completion of the appropriate test sequence unless otherwise specified by the regional standards or regulations.

The RESS shall then be fully charged in accordance with the normal charging procedure (see 5.3.1.1).

The energy, *E*, in a.c. Wh, delivered from the stationary external power source, as well as the charging time duration, shall be measured. The energy-measuring equipment shall be placed between the stationary external a.c. power source and the vehicle power inlet.

6 Test procedure

6.1 General

This clause specifies how to determine the end of CD state and consumed electric energy during CD state. In this part of ISO 23274, applicable driving tests during CS state are only used to determine the end of CD state.

In general, the results for the CS state in this part of ISO 23274 are not consistent with regulatory requirements and should not be used for that purpose. See ISO 23274-1 to determine the exhaust emissions and fuel consumption for the CS state. If only the CS state applies, then only testing in accordance with ISO 23274-1 is necessary.

The appropriate regional procedure to measure exhaust emission and fuel consumption shall be selected (see Annexes A, B and C for example). The test sequence and the single test steps of the test procedure to determine the end of CD state are described below.

6.2 Test sequence

6.2.1 General

This test procedure consists of the following steps.

a) Perform vehicle preconditioning; (see 6.2.2).

b) Perform vehicle soak (see 6.2.3).

c) Perform initial charge of RESS to full (see 5.3.1.1).

d) Move the vehicle to the test room (see 6.2.4).

e) Run an applicable driving test and measure exhaust emissions, charge balance and fuel consumption (see 6.2.5).

f) Determine if the end of CD state is reached (see 6.3.2 or 6.3.3).

If the end of CD state is identified, then go to g). If not, the procedure from e) shall be repeated.

g) Fully charge the RESS and measure a.c. electric energy (see 5.3.2).

6.2.2 Vehicle preconditioning

Vehicle preconditioning shall be carried out in accordance with the corresponding annex of regional test procedure, if necessary.

If necessary, SOC may be pre-adjusted by charging or discharging, to obtain suitable energy balance of RESS between the beginning and the end of test.

6.2.3 Vehicle soak

The vehicle shall be soaked in accordance with the appropriate regional procedure (see Annexes A, B and C for example).

6.2.4 Vehicle movement to the test room

When the vehicle is brought into the test room, and moved during the test if necessary, it shall be pushed or towed (neither driven or regeneratively recharged.). The test vehicle shall be set on the chassis dynamometer after the chassis dynamometer has warmed up just before the test. The vehicle shall not be activated during soak until right before starting the test.

6.2.5 Measurement in each applicable driving test

Energy balance of RESS, consumed fuel and exhaust emissions shall be measured in each applicable driving test. The conditions of the vehicle during the applicable driving test shall follow the appropriate regional test procedure (see Annexes A, B and C for example).

6.2.6 Electric energy measurement

The RESS shall be fully charged in accordance with the procedure described in 5.3.1.

After completing the applicable driving tests (see 6.3), the RESS shall be fully charged as specified by vehicle manufacturers. The charging shall be started within 2 h after completion of the test in accordance with 5.3.

For the determination of the end of CD state (case 2) according to 6.3.3, the electric energy of the RESS before charging may be adjusted to the mean value of the electric energy during CS state.

6.3 Determination of the end of CD state and the beginning of CS state

6.3.1 General

The energy balance of the RESS during CS state varies depending on the design of a HEV system and its operation. Therefore this part of ISO 23274 specifies two cases for the determination of the transition point between CD and CS state. Case 1 and case 2 depend on the characteristics in the CS state as described in Figure 1 and Figure 2 and defined in 5.3.2 and 5.3.3. One of these cases shall apply unless the regional Annexes A through C contain specific direction. Case 1 is applicable to most HEVs. If case 1 is not applicable, case 2 shall apply.

CD state does not exist unless the nominal energy of the RESS is 2 % or more of energy of consumed fuel in an applicable driving test. See Annexes A, B and C for the measurement of consumed fuel.

6.3.2 Determination of the end of CD state (case 1)

Case 1 applies when the energy balance of the RESS during each applicable driving test in CS state is varying within a specified small range (see Figure 1). For case 1, one or more applicable driving tests shall be carried out. The vehicle is in CS state when the energy balance of the RESS during each driving test is varying within the specified range.

The applicable driving test where CD state ends shall be determined by performing applicable driving tests as follows.

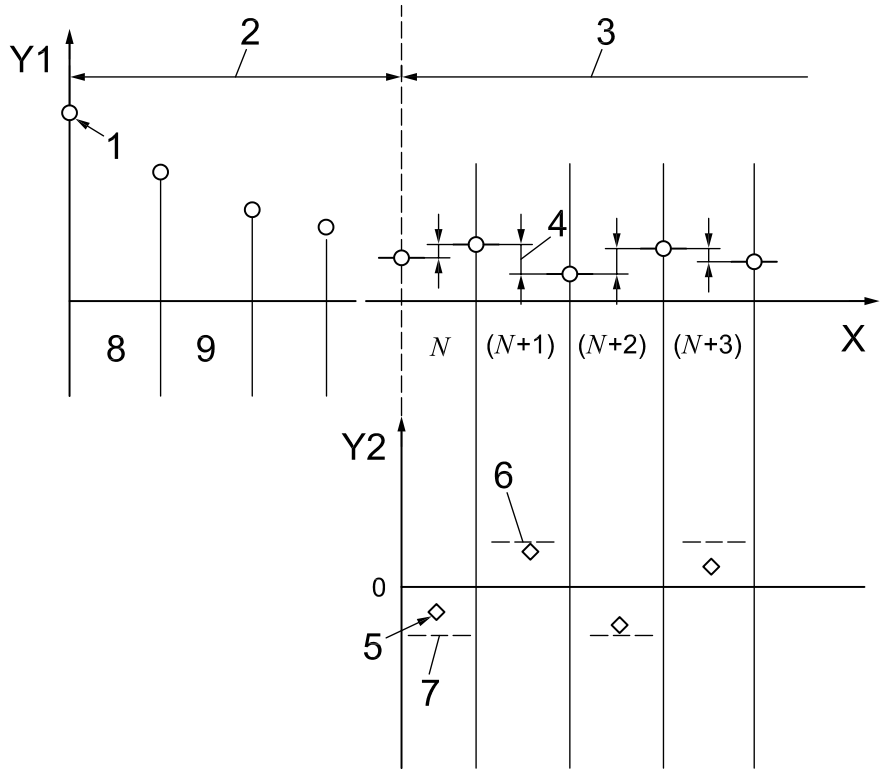
— The energy balance of RESS (ΔE_{RESS}, Wh) between the start and the end of each applicable driving test shall be calculated.

— Applicable driving tests shall continuously be carried out until each ΔE_{RESS} is determined to be stable within $\pm(0{,}01 \times E_{\mathrm{CF}})$ in Wh, E_{CF} is the energy of consumed fuel of applicable driving test (converted to Wh using lower heating value).

— One or more consecutive applicable driving test(s) are necessary to know whether the vehicle is in CS state.

— The applicable driving test where CD state ends is the one before the first applicable driving test where CS state starts.

NOTE See Annex D for the procedure.



Key

1	full charge	8	first test
2	CD state	9	second test
3	CS state	N	test number
4	ΔE_{RESS}	X	time sequence
5	ΔE_{RESS} of Nth test	Y1	electric energy of the RESS (Wh)
6	$+0{,}01 \times E_{CF}$ of $(N+1)$th test	Y2	ΔE_{RESS} (Wh)
7	$-0{,}01 \times E_{CF}$ of Nth test		

Figure 1 — Determination of transition point of CD and CS state (case 1)

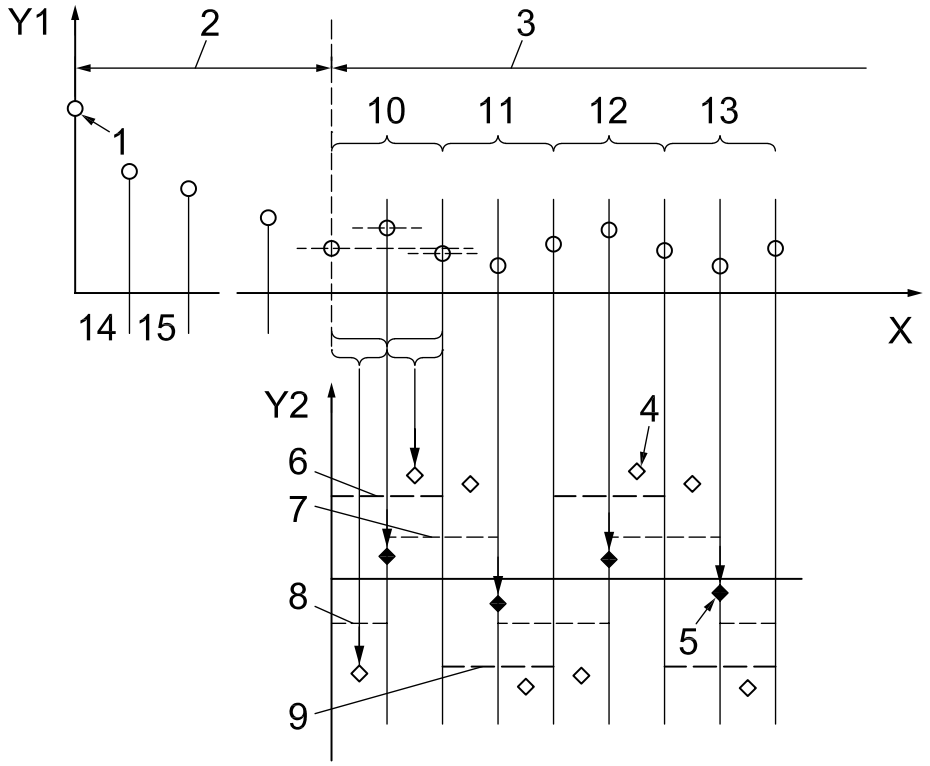
6.3.3 Determination of the end of CD state (case 2)

Case 2 applies when the energy balance of the RESS during a set of applicable driving tests in CS state is varying within a specified small range(see Figure 2).

The applicable driving test where CD state ends is given by specifying the first set of applicable driving tests in CS state as follows.

A series of applicable driving tests supposed to be in CS state shall be divided into sets. A set consists of consecutive applicable driving tests. The number of applicable driving tests in a set should be minimum. When the energy balance at the start of the first driving test and the end of the last test in the set is determined to be stable within ± 1 % of the consumed fuel of one(P = 1 in Annex D) or more (P > 1 in Annex D) consecutive set(s), the vehicle shall be determined as being in CS state. The applicable driving test where CD state ends is the first applicable driving test of the first set of applicable driving tests in the series where CS state starts.

NOTE See Annex D for the procedure to determine the minimum number of ADTs in a set.



Key

1	full charge	10	first set
2	CD state	11	second set
3	CS state	12	third set
4	ΔE_{RESS} of a single test	13	fourth set
5	ΔE_{RESS} of a set	14	first test
6	$+0{,}01 \times E_{CF}$ of first set	15	second test
7	$+0{,}01 \times E_{CF}$	X	time sequence
8	$-0{,}01 \times E_{CF}$	Y1	electric energy of the RESS (Wh)
9	$-0{,}01 \times E_{CF}$ of second set	Y2	ΔE_{RESS} (Wh)

Figure 2 — Determination of transition of CD and CS state (case 2)

7 Additional data evaluation of results

Determination of CD state shall be documented. By determination of CD state in accordance with Clause 6, the following results can be obtained:

— the number of applicable driving test(s) until CD state ends;

— electric energy consumed in the CD state as measured in accordance with 5.3.2.

NOTE Exhaust emissions and fuel consumption representing CD state depend on regional regulations.

Annex A
(informative)

Test procedure in Japan

A.1 General

This Annex describes the typical procedures and related conditions in Japan to measure the exhaust emissions and fuel consumption of the passenger cars and light duty trucks defined in Japan regulations.

Japan Regulations are written as Announcement that Prescribes Details of Safety Regulations for Road Vehicles (MLIT Announcement No. 619, 2002 Attachment 42), TRIAS 5-9-2009 and TRIAS 60-4-2009.

A.2 Test

A.2.1 Test facility

A.2.1.1 Chassis dynamometer

The equivalent inertia mass of the chassis dynamometer shall be set to the standard value of equivalent inertia mass specified in the right column of Table A.1 according to the relative test vehicle mass (vehicle curb mass plus 110 kg) specified in the left column of the table. Furthermore, if the standard value of the equivalent inertia mass in the right column of the table cannot be set, it is permissible to set the equivalent inertia mass within a range between the said standard value and the said standard value plus10 %.

A.2.2 Applicable driving test (ADT)

The test vehicle shall run the applicable driving test (ADT). In Japan, JC08-mode driving schedule [0 s to 1 204 s] specified in Japan Regulations is applicable (See Figure A.1).

A.2.3 Test vehicle mass

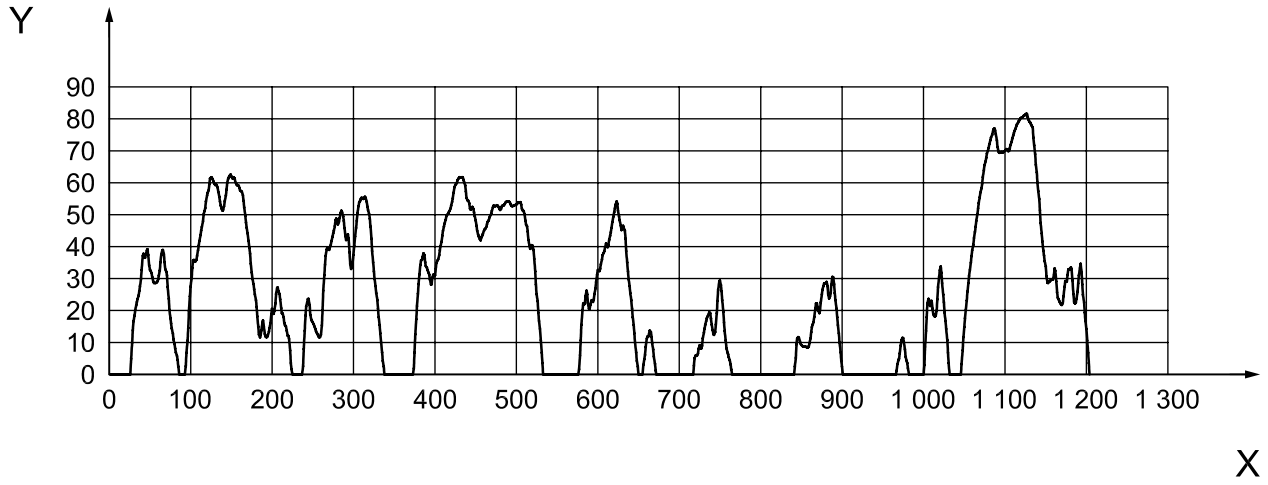
Test vehicle mass at measuring running resistance and at measuring exhaust emissions on the chassis dynamometer shall be vehicle curb mass plus 110 kg.

A.3 Test procedure

Preconditioning shall be performed by running an ADT on the chassis dynamometer after given road load setting. Then, the test procedure until electric energy measurement in 5.2.5 shall be carried out according to the test flow in Figure A.2.

Table A.1 — Test vehicle mass and standard value of equivalent inertia mass

Test vehicle mass kg	**Standard value of equivalent inertia mass** kg
~480	455
481~540	510
541~595	570
596~650	625
651~710	680
711~765	740
766~850	800
851~965	910
966~1 080	1 020
1 081~1 190	1 130
1 191~1 305	1 250
1 306~1 420	1 360
1 421~1 530	1 470
1 531~1 640	1 590
1 641~1 760	1 700
1 761~1 870	1 810
1 871~1 980	1 930
1 981~2 100	2 040
2 101~2 210	2 150
2 211~2 380	2 270
2 381~2 625	2 500
2 626~2 875	2 750
2 876~3 250	3 000
3 251~3 750	3 500
Continued in increments of 500 kg	Continued in increments of 500 kg



Key
X time (s)
Y speed (km/h)

Figure A.1 — JC08-mode driving schedule

A.4 Calculation of exhaust emissions and fuel consumption

A.4.1 Exhaust emissions

Each exhaust emission component in the sample gas shall be calculated by each ADT.

A.4.2 Fuel consumption

By using each exhaust emission component in the sample gas of each ADT, fuel consumption (km/l) shall be calculated according to the carbon balance method as in the following equations.

A.4.2.1 In case of gasoline

$$FC_{(i)} = \frac{866 \times \rho_f}{0{,}429 \times m_{CO} + 0{,}866 \times m_{THC} + 0{,}273 \times m_{CO2}} \quad \text{(A.1)}$$

where

$FC_{(i)}$	is fuel consumption of i-th ADT	km/l
ρ_f	is fuel density	g/cm^3
m_{CO}	is CO emission mass	g/km
m_{THC}	is THC emission mass	g/km
m_{CO2}	is CO_2 emission mass	g/km

A.4.2.2 In case of diesel oil

$$FC_{(i)} = \frac{862 \times \rho_f}{0{,}429 \times m_{CO} + 0{,}862 \times m_{THC} + 0{,}273 \times m_{CO2}} \quad \text{(A.2)}$$

A.4.3 Calculation of fuel consumption

Based on the fuel consumption calculated in A.4.2, consumed fuel (l) in each ADT shall be calculated.

$$F_{(i)} = \frac{8{,}172}{FC_{(i)}} \tag{A.3}$$

where

$F_{(i)}$ is consumed fuel of *i*-th ADT l

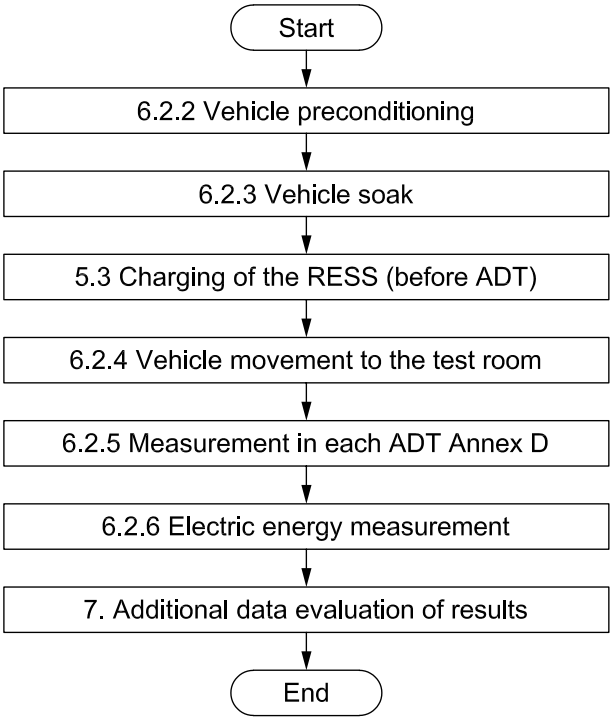


Figure A.2 — Test flow

Annex B
(informative)

Test procedure in Europe

B.1 Overview

The test procedure prescribed in this Annex is based on UN ECE Regulation R 101 (Emission of carbon dioxide, fuel and electric energy consumption, range), as amended to be applied to Hybrid Electric vehicles, and on UN ECE Regulation 83 (Emissions of pollutants).

NOTE The following documents of both Regulations have been considered in this Annex:

— R 101: E/ECE/324 Rev.2/Add.100/Rev.2;

— R 83: E/ECE/324 Rev.1/Add.82/Rev.3.

At further amendments of R 101 and R 83, this part of ISO 23274 and especially Annex B will have to be reviewed.

The measurements of the exhaust emissions (CO, NOx, HC particulates) and of CO_2 emission and fuel consumption are performed by applying the Type I Test in R 83.

The description given in the following clauses contain only the essentials to understand the procedure. For details reference is made to the relevant clauses in both UN ECE Regulations.

B.2 Scope

Based on the legal requirements in Europe this Annex specifies the measurement procedures for the determination of the exhaust and carbon dioxide emission and the fuel consumption of externally chargeable HEV of categories M1 and N1 with a maximum permissible total mass (according to ISO 1176) of 3 500 kg. As fuels for the ICE, only gasoline and diesel fuel are considered.

B.3 Test

B.3.1 Test equipment

B.3.1.1 Chassis dynamometer

Features, accuracy, load and inertia setting, calibration and other steps to prepare the chassis dynamometer to be used are prescribed in R 83, Annex 4, Clauses 4.1, 5.1 and 5.2 and in Appendices 2 and 3 of Annex 4. The adjustment of the inertia simulators to the vehicle's translatory inertias shall be according to Table B.1, given in R 83, Annex 4, Clause 5.1.

B.3.2 Exhaust gas sampling system

The system that shall be used is the constant volume sampler (CVS) system. Details are given in R 83, Annex 4, Clause 4.2 and 4.4 and in Appendix 5 of Annex 4.

B.3.3 Analytical equipment

Emitted gases shall be analysed with the following instruments:

— non dispersive infrared (NDIR) absorption type analysers for CO and CO_2 determination;

— for HC determination, flame ionization (FID) type analysers for spark ignition engines and heated flame ionization (HFID) type analysers for compression ignition engines;

— chemiluminescent (CLA) or non-dispersive ultraviolet resonance absorption (NDUVR) analysers for NOx determination.

Particulates shall be gravimetrically determined of the particulates collected with two series mounted filters.

Details on applying, calibration, accuracy requirements are prescribed in R 83, Annex 4, Clause 4.3 and 4.5 (for gases used for calibration) and in Appendix 6 of Annex 4.

Table B.1 — Equivalent inertia of dynamometer related to the reference mass of the vehicle

Reference mass of the vehicle, m_v kg	**Equivalent inertia**, I kg
$m_v \leq 480$	455
$480 < m_v \leq 540$	510
$540 < m_v \leq 595$	570
$595 < m_v \leq 650$	625
$650 < m_v \leq 710$	680
$710 < m_v \leq 765$	740
$765 < m_v \leq 850$	800
$850 < m_v \leq 965$	910
$965 < m_v \leq 1\,080$	1 020
$1\,080 < m_v \leq 1\,190$	1 130
$1\,190 < m_v \leq 1\,305$	1 250
$1\,305 < m_v \leq 1\,420$	1 360
$1\,420 < m_v \leq 1\,530$	1 470
$1\,530 < m_v \leq 1\,640$	1 590
$1\,640 < m_v \leq 1\,760$	1 700
$1\,760 < m_v \leq 1\,870$	1 810
$1\,870 < m_v \leq 1\,980$	1 930
$1\,980 < m_v \leq 2\,100$	2 040
$2\,100 < m_v \leq 2\,210$	2 150
$2\,210 < m_v \leq 2\,380$	2 270
$2\,380 < m_v \leq 2\,610$	2 270
$2\,610 < m_v$	2 270

B.4 Test vehicle

B.4.1 General

The test vehicle shall be in running order, as determined by the manufacturer, with all the equipment, as provided as standard.

B.4.2 Test mass

The mass of the vehicle under test (in R 83 called "reference mass", see Clause 2.2) shall be the "unladen mass" plus a uniform figure of 100 kg. The "unladen mass" (see R 83, Clause 2.2.1) is the mass of the vehicle in running order, without load and persons, but with the fuel tank 90 % full.

B.4.3 Tyres

The tests shall be performed with all tyres in respect to their width provided as standard by the vehicle manufacturer. Optionally the prescription of R 83 (see Annex 4, Appendix 3, Clause 4.1.2) may be applied, i.e. only the widest of the standard widths or the widest minus one (in case of more than three standard widths) shall be chosen.

The tyre pressure shall be according to the vehicle manufacturer's specification, but may be increased by up to 50 % when the test is done on a two-roller dynamometer (R 83, Annex 4, 5.3.2).

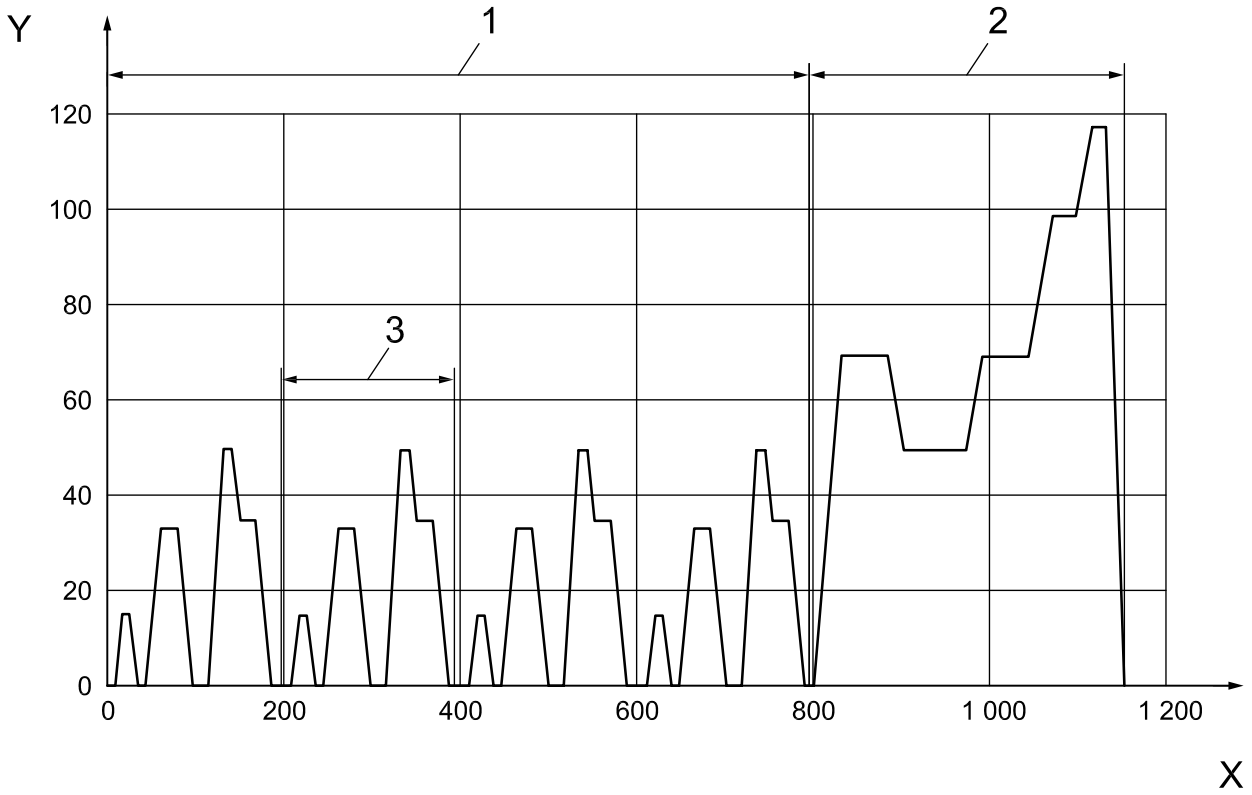
B.4.4 Test fuels

Details on the test fuels (in R 83 called reference fuels) are given in Annex 10 and Annex 10a of R 83.

B.4.5 Test cycle

The test cycle prescribed for the Type I Test (verifying exhaust emissions, see also B.5.2) is in detail described in Appendix 1 of Annex 4 of R 83 including allowable tolerances.

The test cycle is made up of one Part One (urban) cycle consisting of four elementary urban cycles, and one Part Two (extra urban) cycle, as roughly illustrated in Figure B.1 and described in Table 2.



Key

X time, s
Y vehicle speed, km/h
1 Part 1 (urban) cycle
2 Part 2 (extra urban) cycle
3 elementary urban cycle

Figure B.1 — Test cycle

Table B.2 — General information on test cycle

Parameter	Urban cycle	Extra urban cycle
Average speed	19 km/h	62,6 km/h
Maximum speed	50 km/h	120 km/h
Effective running time	4 × 195 s = 780 s (13 min)	400 s (6 min 40 s)
Theoretical distance	4 × 1 013 km = 4 052 km	6 955 km

B.5 Test procedure

B.5.1 Preconditioning of vehicle

Besides the vehicle stabilization over at least 3 000 km (see 4.1.3.1 of this standard) R 101, Annex 8, Clause 5.2 requires two consecutive full test cycles (see B.4) as preconditioning. Upon request of the manufacturer, one Part One and two Part Two cycles may be applied for positive ignition engines.

(In R 83, Annex 4, Clause 5.3.1, three consecutive extra urban cycles are prescribed for the particulate determination of compression ignition engines.)

B.5.2 Conditioning of the vehicles

After the preconditioning according to B.5.1, the vehicles shall be kept in a room with a relative constant temperature between 20 °C and 30 °C for at least 6 h, until the engine oil and coolant temperatures are within ± 2 °C of the room temperature. For details see R 83, Annex 4, Clause 5.3.

B.5.3 Performance of the test

One complete test cycle according to B.4 shall be run with the test equipment as in B.2, the test vehicle as in B.3 after the preconditioning and conditioning as in B.5.1 and B.5.2. The following requirements shall be met during the test. General descriptions of the test including the number of tests are given in 5.3 of R 83.

B.5.3.1 Special conditions

Temperature shall be between 20 °C and 30 °C, the absolute humidity between 5.5 g H_2O/kg dry air and 12.2 g H_2O/kg dry air. For details, see R 83, Annex 4, Clause 6.1.1.

For details on air blown over the vehicle under test, see Clause 6.1.3 of R 83, Annex 4.

B.5.3.2 Performing the different steps of the test cycle

The test shall be performed according to the prescriptions of the vehicle manufacturer, starting with the activation of the propulsion system and followed by the procedure to meet the allowed tolerances of the test cycle.

B.5.3.3 Sampling and analysis

As for ICE vehicles, the CO_2 emission and the fuel consumption shall be determined separately for the urban and the extra urban cycle (see Clause 5.1.1 of Annex 5 of R 101). Therefore sampling and analysis has to be performed separately, although this is not required for the determination of the exhaust emissions (CO. HC, NOx and particulates) according to R 83.

Details on sampling and analysis are given in R 83, Annex 4, Clause 7.1 and 7.2.

B.6 Calculation of the exhaust emission and fuel consumption

B.6.1 Exhaust gas, CO_2 and particulate emission

The mass and volume calculation of the emitted pollutants and their correction to standard conditions (273,2 K and 101,33 kPa) and the determination of the no-humidity-correction-factor for NOx shall be performed according to Clause 8 and Appendix 8 of Annex 4 of R 83.

The results shall be expressed in grams per kilometre (g/km).

B.6.2 Fuel consumption

The calculation of the fuel consumption shall be done as prescribed in R 101, Annex 6, Clause 1.4. In case that the fuels used differ from those (reference fuels) to which the formulas refer, correction factors may be applied, which is also described in Clause 1.4.

The result shall be expressed in litres per 100 km (l/100 km).

Annex C
(informative)

Test procedure in North America

C.1 General

This Annex describes the test procedure recommended for use in the United States, and other countries that embrace the use of SAE (Society of Automotive Engineers, Inc.) methods, for measuring fuel consumption and range of fuel cell and hybrid fuel cell electric vehicles fuelled by compressed gaseous hydrogen. Specifically, SAE Recommended Practice J1711, issued JUN2010, is the governing document and citations throughout this Annex are with reference to this issue date.

C.2 Scope

This US Annex of ISO 23274-2 prescribes the uniform chassis dynamometer test procedures for externally chargeable hybrid electric vehicles designed to be driven on public roads. Low speed vehicles are not included. Also not included in the scope are vehicles that will always deplete while driving on the prescribed driving cycles. Instructions are given for measuring and calculating the charge-depleting fuel consumption and electric energy consumption for five test cycles:

— the “city” fuel consumption test using the Urban Dynamometer Driving Schedule (UDDS);

— the “highway” fuel consumption test using the Highway Fuel Economy Driving Schedule (HFEDS);

— the Supplemental FTP (US-06);

— the Speed Correction drive cycle (SC03);

— the Cold UDDS.

C.3 Test equipment

C.3.1 Chassis dynamometer

Use of an electric 48-inch single roll chassis dynamometer, or equivalent, is required for fuel cell vehicle and hybrid fuel cell electric vehicle testing. All factors concerning the dynamometer, specifically its capability requirements, configuration, calibration, warm-up, and settings, are presented in the sub-paragraphs to paragraph 4.5 of SAE J2572, and which give further reference to other specific requirements as contained in 40 CFR Part 86.135-90 (i). The determination of the dynamometer load coefficients shall be as specified in SAE J2264.

C.3.2 Exhaust gas sampling system and analytical equipment

The constant volume sampler and exhaust gas analytical equipment shall conform to that specified in 40 CFR Part 86.

C.4 Test vehicle

C.4.1 Vehicle stabilization

Prior to testing, the test vehicle shall be stabilized as specified in 40 CFR Part 86.098-26, which includes vehicle mileage accumulation either to a manufacturer-determined distance or to 2 000 miles (per 40 CFR Part 86.1831-01c) over the Durability Driving Schedule (defined in Appendix IV of Part 86). Vehicles for which regular, external charging is recommended shall have their RESS recharged to full charge at least once between each refilling of consumable fuel. However, charging frequency for the RESS shall not be greater than is anticipated during normal vehicle use.

C.4.2 Vehicle appendages

Vehicles shall be tested with normal appendages (mirrors, bumpers, etc.). Certain items (e.g. hub caps) may be removed where necessary for safety on the dynamometer. If an off-board fuel source is used for the test, the test vehicle may include a connector to receive the fuel from that source.

C.4.3 Tyres

Manufacturer's recommended tyres shall be used.

C.4.4 Tyre pressure

For dynamometer testing, tyre pressures should be set at the beginning of the test according to the manufacturer's recommended values. These same tyre pressure values should also be used to establish the dynamometer road-load coefficients (see Section 4.1.3.7) and shall not exceed levels necessary for safe operation.

C.4.5 Tyre conditioning

Tyres shall be conditioned as recommended by the vehicle manufacturer. They shall have accumulated a minimum of 100 km (62 miles) and have at least 50 % of the original usable tread depth remaining.

C.4.6 Lubricants

The vehicle lubricants normally specified by the manufacturer shall be used.

C.4.7 Regenerative braking

If the vehicle has regenerative braking, the regenerative braking system shall be enabled for all dynamometer testing (with the exception of preparatory testing such as Dynamometer Load Coefficient Determination as described in Section 4.1.3.6). Depending upon how the regenerative braking is blended with the foundation (friction) braking system, the most accurate way to account for the effect of regenerative braking is to test the vehicle on a four-wheel drive electric dynamometer. However, it has been shown that the contribution of regenerative braking in many modern hybrid vehicle designs results in nearly the exact outcome on either a two-wheel drive dynamometer or four-wheel drive dynamometer. Manufacturers must declare if testing the vehicle on a two-wheel drive dynamometer may significantly change the contributions of regenerative braking on the final results.

C.4.8 Traction control

If the vehicle is equipped with an Antilock Braking System (ABS) or a Traction Control System (TCS) and is tested on a two-wheel dynamometer, the vehicle's ABS or TCS may inadvertently interpret the non-movement of the set of wheels that are off the dynamometer as a malfunctioning system. If so, then modifications to the ABS or TCS shall be made to achieve normal operation of the remaining vehicle systems, including the electric motor assist, engine start-stop, and regenerative braking system.

C.4.9 Vehicle preparation

The vehicle shall be prepared for testing as specified in 40 CFR Part 86-131-00. This includes provisions for the installation of fittings for draining fuel and a throttle position sensing signal to control dynamometer dynamic inertia weight adjustments when applicable.

C.4.10 RESS stabilization

The RESS shall have been stabilized with the vehicle, as defined in C.4.1 or by equivalent conditioning. In the event that a stabilization cycle different from the one specified in C.4.1 is used, it is the vehicle manufacturer's responsibility to establish that the cycle used is equivalent in its ability to stabilize the RESS.

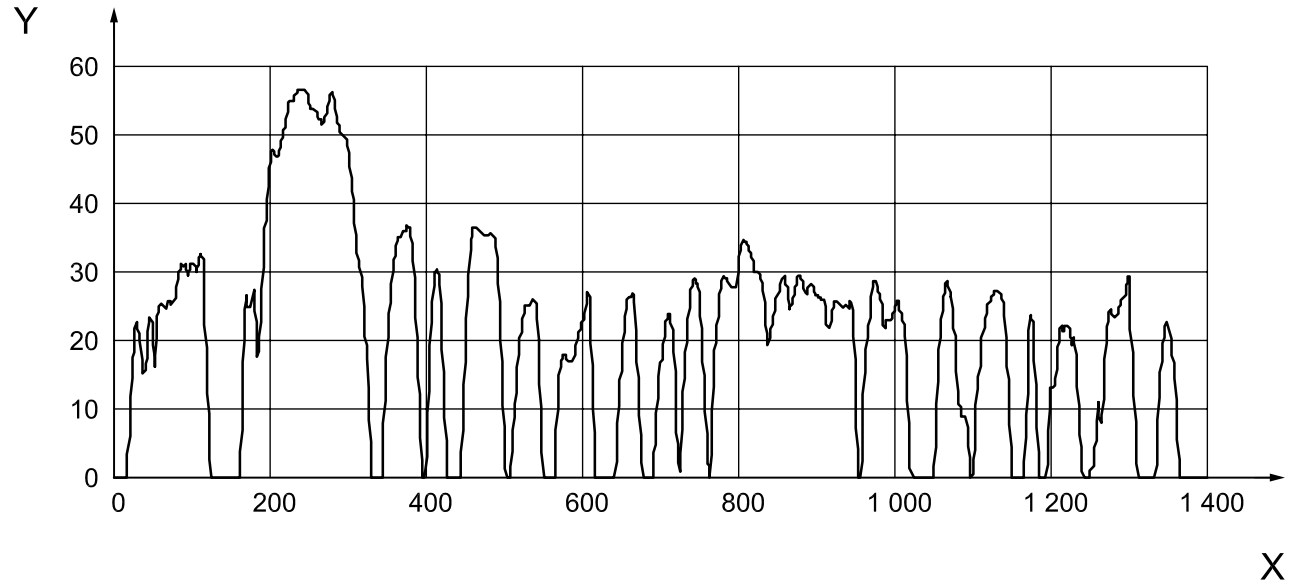
C.5 Test driving schedules

C.5.1 General

The driving schedules to be used for vehicle testing provided by the United States Environmental Protection Agency (EPA) are the Urban Dynamometer Driving Schedule (UDDS) and the Highway Fuel Economy Driving Schedule (HFEDS), the Supplemental FTP Cycle (UD06), and the Speed Correction Driving Schedule (SC03).

C.5.2 Urban Dynamometer Driving Schedule (UDDS)

The driving cycle used for the city fuel economy test, illustrated in Figure 1, represents US city driving and consists of a series of non-repetitive idle, acceleration, cruise, and deceleration modes of various time sequences throughout an interval of 1 372 s, as detailed in the EPA Urban Dynamometer Driving Schedule (UDDS).



Key

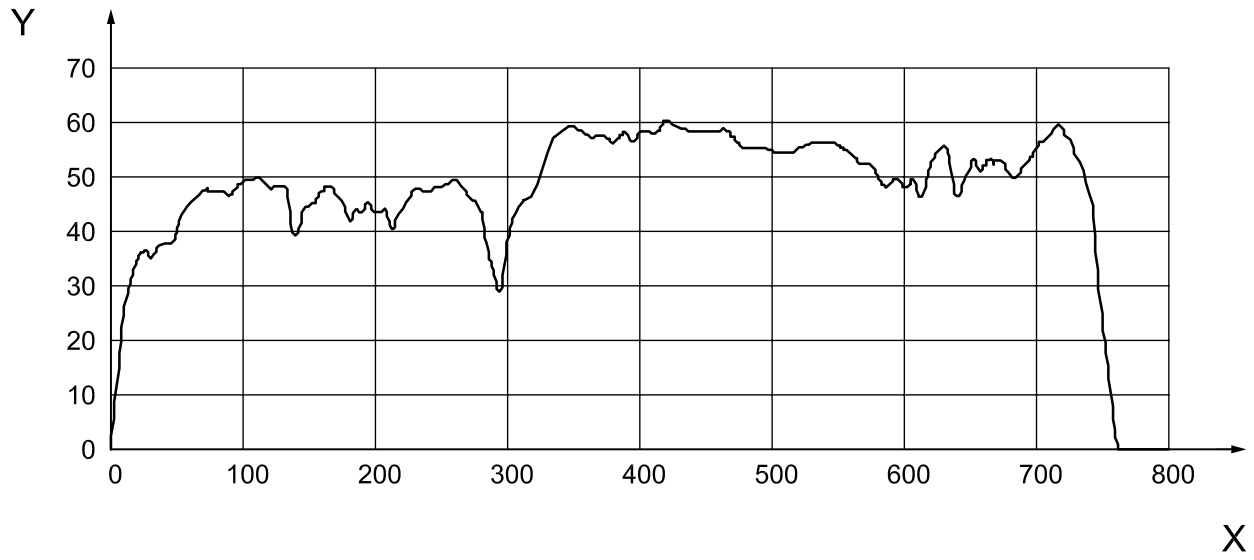
X test time, s

Y vehicle speed, mph

Figure C.1 — EPA Urban Dynamometer Driving Schedule
Duration: 1 369 s; distance: 7,45 miles; average speed: 19,59 mph

C.5.3 Highway Fuel Economy Test Driving Schedule (HFEDS)

The driving cycle used for the highway fuel economy test, illustrated in Figure 2, represents US highway driving and consists of a series of non-repetitive acceleration, cruise, and deceleration modes of various time sequences throughout an interval of 765 s, as detailed in the EPA Highway Fuel Economy Driving Schedule (HFEDS).



Key

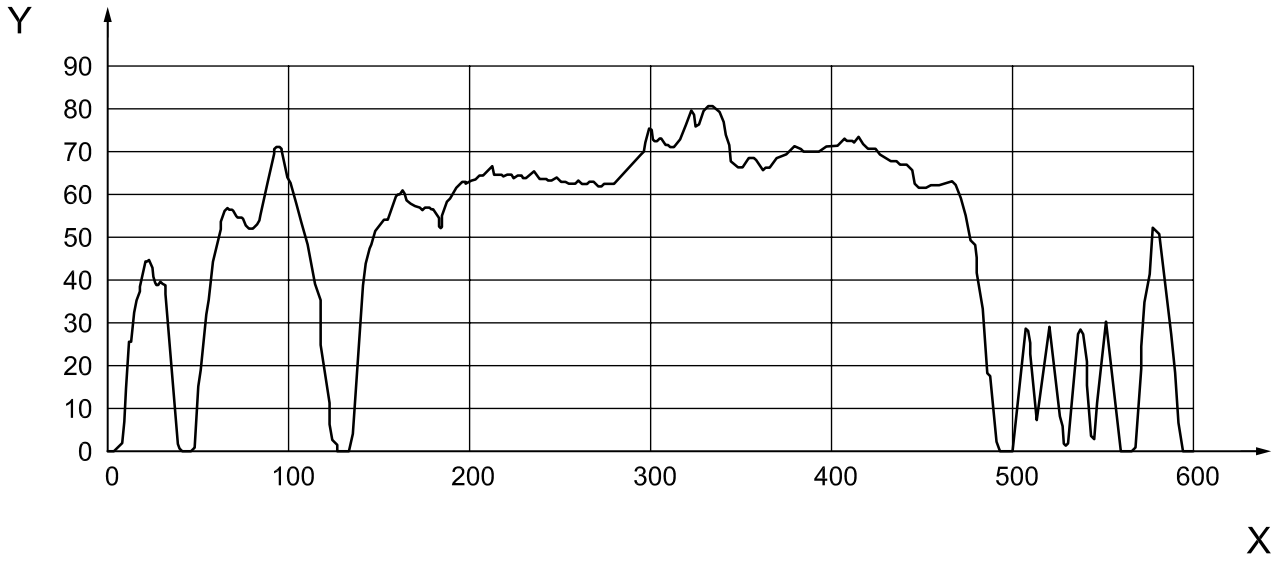
X test time, s

Y vehicle speed, mph

Figure C.2 — EPA Highway Fuel Economy Test Driving Schedule Duration: 765 s; distance: 10,26 miles; average speed: 48,3 mph

C.5.4 Supplemental FTP, or US06 Schedule

The driving cycle used for the US06 test, illustrated in Figure 3, represents more aggressive US city and highway driving and consists of a series of non-repetitive acceleration, cruise, and deceleration modes of various time sequences throughout an interval of 596 s.



Key

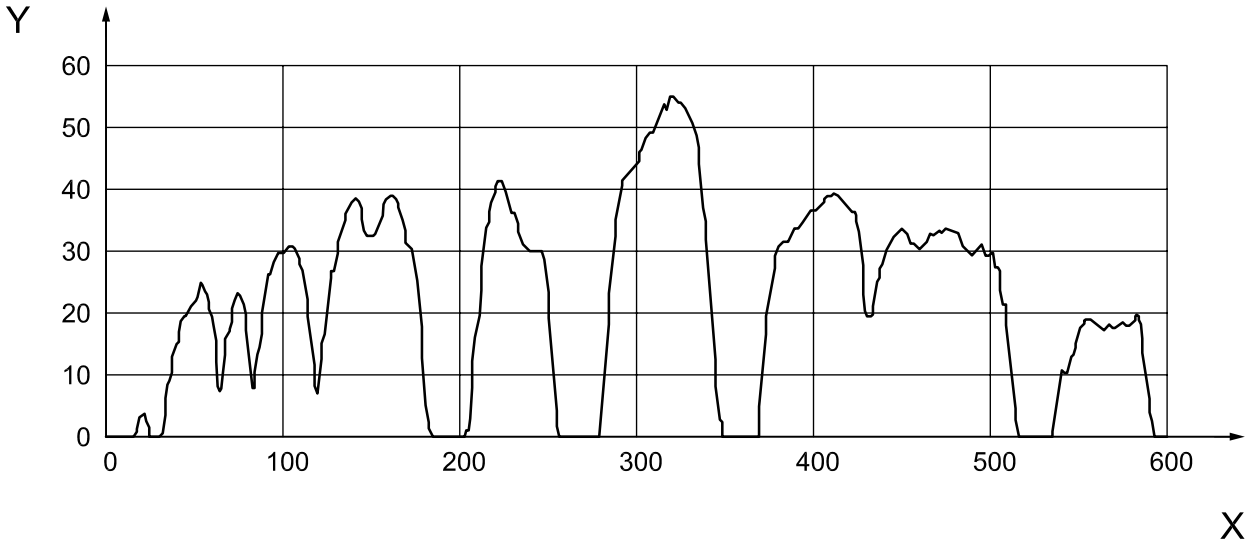
X test time, s

Y vehicle speed, mph

Figure C.3 — US06 or Supplemental FTP Driving Schedule
Sample period: 596 s; distance: 8,01 miles; average speed: 48,37 mph

C.5.5 Speed Correction Driving Schedule (SC03)

The driving cycle used for the highway fuel economy test, illustrated in Figure 2, represents US city driving and consists of a series of non-repetitive acceleration, cruise, and deceleration modes of various time sequences throughout an interval of 596 s.



Key

X test time, s

Y vehicle speed, mph

Figure C.4 — US03 or Speed Correction Driving Schedule
Sample period: 596 s; distance: 3,58 miles; average speed: 21,44 mph

C.6 Test procedures

C.6.1 Test conditions

Adequate test site capabilities for safe venting and cooling of batteries, containment of flywheels, protection from exposure to high voltage, or any other necessary safety precaution shall be provided during testing and external charging. The conditions in C.4.1 through C.4.9 shall also apply to all tests defined in this document. For other test conditions not specifically addressed in this document, the test conditions specified in 40 CFR Part 86 shall apply, where appropriate.

C.6.2 Vehicle test weight

The vehicle shall be tested at the weight specified in 40 CFR Part 86, which includes definitions for loaded vehicle weight [curb weight plus 136,1 kg (300 lb)] and adjusted loaded vehicle weight (curb weight plus one-half vehicle payload).

Table C.1 — Test vehicle weight and equivalent inertia weight

Loaded vehicle weight lb	Equivalent test weight lb		Loaded vehicle weight lb	Equivalent test weight lb
Up to 1 062	1 000		3 438 to 3 562	3 500
1 063 to 1 187	1 125		3 563 to 3 687	3 625
1 188 to 1 312	1 250		3 688 to 3 812	3 750
1 313 to 1 437	1 375		3 813 to 3 937	3 875
1 438 to 1 562	1 500		3 938 to 4 125	4 000
1 563 to 1 687	1 625		4 126 to 4 375	4 250
1 688 to 1 812	1 750		4 376 to 4 625	4 500
1 813 to 1 937	1 875		4 626 to 4 875	4 750
1 938 to 2 062	2 000		4 876 to 5 125	5 000
2 063 to 2 187	2 125		5 126 to 5 375	5 250
2 188 to 2 312	2 250		5 376 to 5 750	5 500
2 313 to 2 437	2 375		5 751 to 6 250	6 000
2 438 to 2 562	2 500		6 251 to 6 750	6 500
2 563 to 2 687	2 625		6 751 to 7 250	7 000
2 688 to 2 812	2 750		7 251 to 7 750	7 500
2 813 to 2 937	2 875		7 751 to 8 250	8 000
2 938 to 3 062	3 000		8 251 to 8 750	8 500
3 063 to 3 187	3 125		8 751 to 9 250	9 000
3 188 to 3 312	3 250		9 251 to 9 750	9 500
3 313 to 3 437	3 375		9 751 to 10 000	10 000

C.6.3 Gear shifting

During testing, the vehicle's transmission shall be operated as specified in 40 CFR Part 86.128, which includes the requirement to follow in-use shifting patterns for manual-transmission vehicles.

C.6.4 Dynamometer capabilities

Dynamometers used in testing HEVs shall have the capabilities specified in 40 CFR Part 86.108-00, which include the capability of dynamically controlling inertia load during the US06 Test Procedure.

C.6.5 Dynamometer configurations

Dynamometers used in testing HEVs shall be configured as specified in 40 CFR Part 86-108-00 (b)(2), which is a 48-inch, single-roll, electric, chassis dynamometer. If the HEV has a four-wheel drive design, it shall be tested on a four-wheel-drive dynamometer. Otherwise, four-wheel-drive vehicles may be tested in a two-wheel-drive mode of operation, per 40 CFR Part 86.135-90(i).

C.6.6 Dynamometer calibration

The dynamometer shall be calibrated as specified in 40 CFR Part 86-118-00.

C.6.7 Dynamometer augmented braking

The augmented braking feature on the dynamometer (if any) should be turned off while performing HEV or PHEV testing, because it interferes with the proper functioning of the regenerative braking on such vehicles and may adversely impact the benefit of regenerative braking in hybrid testing.

C.6.8 Dynamometer warm-up

If the dynamometer has not been operated during the 2-h period immediately preceding usage, it shall be warmed up using a non-test vehicle, as recommended by the dynamometer manufacturer or as specified in 40 CFR Part 86-135-00 (f).

C.6.9 Dynamometer load coefficient determination

The dynamometer coefficients that simulate road-load forces shall be determined as specified in SAE J2263 and SAE J2264 with the following provisions:

a) Vehicles equipped with regenerative braking systems that are actuated only by the brake pedal shall require no special actions for coastdown testing on both the test track and dynamometer.

b) Vehicles equipped with regenerative braking systems that are activated at least in part when the brake pedal is not depressed shall have regenerative braking disabled during the deceleration portion of coastdown testing on both the test track and dynamometer, preferably through the use of a “neutral” gear with no active regenerative braking or through temporary software changes in the vehicle’s control system. Mechanical changes to the vehicle to deactivate regenerative braking (such as completely removing the drive shaft) are discouraged. However, if this practice becomes necessary as a last resort, every safety precaution shall be taken during vehicle operation, and the same mechanical modifications shall occur on both the test track and dynamometer. Methods to accelerate a vehicle without a drive shaft on both the test track and the dynamometer shall be determined by the manufacturer.

If the vehicle does not have a mechanical neutral, the manufacturer shall prescribe procedures and calculation methods for coastdown and road-load determination that correctly account for the possibly significant amount (possibly 5 % or more of the vehicle mass) of rotating inertia not present in more conventional vehicles.

C.6.10 Practice runs

Practice runs over the prescribed driving schedules are encouraged to allow time for the test driver to practice following the driving schedules and to feel comfortable with the vehicle’s operation.

C.6.11 Testing to end of CD state

Test cycles are repeated until the CS state is found according to the calculations explained in Annex D. Let the stability criteria, $P = 1$.

C.6.12 Dynamometer test procedures

C.6.12.1 UDDS test procedure

The following specifics relate to using this procedure for the UDDS test.

a) Vehicle Preconditioning — The vehicle shall be preconditioned in the driver-selected operating mode in which it will be tested and at a CS SOC level. The preconditioning is subject to the requirements of 40 CFR Part 86.132, which includes fuel tank drain-and-fill, driving over the UDDS, and a 12-h to 36-h vehicle soak.

b) RESS Charging/Vehicle Soak — After preconditioning and while the vehicle is soaking (68 °F to 86 °F, as specified in 40 CFR Part 86.132), the RESS shall be brought to Full Charge.

c) Test Site Conditions — The ambient temperature levels encountered by the test vehicle shall be no less than 20 °C (68 °F) and no more than 30 °C (86 °F). During dynamometer driving, all vehicle accessories shall be turned off, and a fixed-speed cooling fan shall direct cooling air to the vehicle, as specified in 40 CFR Part 86.135-94.

d) Intra-Test Pauses — Between the UDDS cycles, the vehicle should soak for (10 ± 1) min with the key switch in the "off" position, the hood closed, test cell fan(s) off, the brake pedal not depressed, and the RESS not recharged from an external electric energy source. The SOC instrumentation should not be turned off or reset to zero during the intra-test pauses. In the case of ampere-hour meter measurement, the integration should remain active throughout the entire FCT until it is concluded. It is preferred that the pauses be consistently (10 ± 1) min. However, it is acknowledged that many test facilities do not have the software and or hardware to do so without longer pauses at some time after two to four cycles for data collection or test setup. In this case, a duration window of 10 min to 30 min shall be allowed during intra-test pauses. Good engineering judgment should be applied in arranging these test pauses, thus causing the least disruption in the test procedure. It is strongly preferred that the majority of soak periods remain as close to the 10-min recommendation as possible. During all soak periods, the key switch must be in the "off" position, the hood must be closed, the test cell fan(s) must be off, the brake pedal not depressed, and the RESS not recharged from an external energy source.

e) Measurements and Emissions Sampling — Exhaust emissions and the actual distance travelled by the dynamometer roll surface shall be measured during each of the UDDS cycles. Although two sample bag sets are used consecutively during a UDDS for conventional vehicles (Bag 1 and Bag 2), it is necessary in the FCT to use only one sample bag set during each UDDS and, therefore, to conduct the FCT in a test site designed for that capability.

C.6.12.2 HFEDS test procedure

The following specifics relate to using this procedure for the HFEDS test.

a) Vehicle Preconditioning — The preconditioning is subject to the requirements of 40 CFR Part 86.132. The consumable fuel shall be drained and the tank refilled unless 1) the vehicle underwent a previous CST (in any driving schedule) within the last 72 h in CS mode, and 2) the vehicle has since remained under ambient laboratory conditions. A preconditioning cycle(s) consisting of one or more UDDS, HFEDS, or US06 cycles run in CS mode shall be run within 36 h before the FCT. The vehicle shall be at a CS SOC level before charging.

b) RESS Charging/Vehicle Soak — After preconditioning and while the vehicle is soaking (68 °F to 86 °F, as specified in 40 CFR Part 86.132), the RESS shall be brought to Full Charge.

c) Test Site Conditions — The ambient temperature levels encountered by the test vehicle shall be no less than 20 °C (68 °F) and no more than 30 °C (86 °F). During dynamometer driving, all vehicle accessories shall be turned off, and a fixed-speed cooling fan shall direct cooling air to the vehicle, as specified in 40 CFR Part 86.135-94.

d) Intra-Test Pauses — The vehicle should be driven over as many HFEDS cycles in CD mode, separated by a 15-s key-on idle rest (without pauses), as the facility capabilities allow. If test pauses are required to stop testing and reinitialize the test system, then these pauses shall be less than 30 min in length. It is strongly preferred that the majority of intra-test pauses be key-on 15-s idle periods. If possible, four (4) HFEDSs should be run in a row, separated by 0- to 30-min key-off soak periods. Many (but not all) emissions laboratories can run four cycles on either CVS or BMD sampling systems. The 0- to 30-min range for the soak period is chosen based on the capability of the laboratories to read, evacuate, and purge the four bags and to initialize a new test. Good engineering judgment will be applied in arranging these test pauses, thus causing the least disruption in the test procedure. During all test pauses, the vehicle shall be at zero speed, the key switch must be in the "off" position, the hood must be closed, the test cell fan(s) must be off, the brake pedal not depressed, and the RESS not recharged from an external energy source. The SOC instrumentation should not be turned off or reset to zero during the intra-test pauses. In the case of the ampere-hour meter measurement, the integration should remain active throughout the entire FCT until it is concluded.

e) Measurements and Emissions Sampling — Exhaust emissions and the actual distance travelled by the dynamometer roll surface shall be measured during each of the HFEDSs.

C.6.12.3 US06 test procedure

The following specifics relate to using this procedure for the US06 test.

a) Vehicle Preconditioning — The preconditioning is subject to the requirements of 40 CFR Part 86.159-00. The consumable fuel shall be drained and the tank refilled unless 1) the vehicle underwent a previous CST (in any driving schedule) within the last 72 h in CS mode, and 2) the vehicle has since remained under ambient laboratory conditions. A preconditioning cycle(s) consisting of one or more UDDS, HFEDS, or US06 cycles run in CS mode shall be run within 36 h before the FCT. The vehicle shall be at a CS SOC level before charging.

b) RESS Charging/Vehicle Soak — After preconditioning and while the vehicle is soaking (68 °F to 86 °F, as specified in 40 CFR Part 86.132), the RESS shall be brought to Full Charge.

c) Test Site Conditions — The ambient temperature levels encountered by the test vehicle shall be no less than 20 °C (68 °F) and no more than 30 °C (86 °F). During dynamometer driving, all vehicle accessories shall be turned off, and a fixed-speed cooling fan shall direct cooling air to the vehicle, as specified in 40 CFR Part 86.159-00 (b)(9). Dynamometer load reduction for low-powered vehicles may be used in accordance with 40 CFR Part 86.108-00(b)(2)(ii).

d) Intra-Test Pauses — The vehicle should be driven over as many US06 cycles in CD mode, separated by a 1-min to 2-min (90 s) key-on idle rest (without pauses), as the facility capabilities allow. If test pauses are required to stop testing and reinitialize the test system, then these pauses shall be less than 30 min in length. It is strongly preferred that the majority of intra-test pauses be key-on 90-s idle periods. If possible, four US06 cycles should be run in a row, separated by 0- to 30-min key-off soak periods. Many (but not all) emissions laboratories can run four cycles on either CVS or BMD sampling systems. The 0- to 30-min range for the soak period is chosen based on the capability of the laboratories to read, evacuate, and purge the four bags and to initialize a new test. Good engineering judgment will be applied in arranging these test pauses, thus causing the least disruption in the test procedure. During all test pauses, the vehicle shall be at zero speed, the key switch must be in the "off" position, the hood must be closed, the test cell fan(s) must be off, the brake pedal not depressed, and the RESS not recharged from an external energy source.

e) Measurements and Emissions Sampling — Exhaust emissions and the actual distance travelled by the dynamometer roll surface shall be measured during each of the US06 cycles.

C.6.12.4 SC03 test procedure

The following specifics relate to using this procedure for the SC03 test.

a) Vehicle Preconditioning — The preconditioning is subject to the requirements of 40 CFR Part 86.132. The consumable fuel shall be drained, the tank refilled, and a preconditioning cycle shall be run

unless 1) the vehicle underwent a previous CST (in any driving schedule) within the last 72 h in CS mode, and 2) the vehicle has since remained under ambient laboratory conditions. A preconditioning cycle(s) consisting of one or more UDDS, HFEDS, or US06 cycles run in CS mode at normal ambient conditions (68 °F to 86 °F) shall be run within 36 h before the FCT. The vehicle shall be at a CS SOC level before charging.

b) RESS Charging/Vehicle Soak — After preconditioning and while the vehicle is soaking (68 °F to 86 °F, as specified in 40 CFR Part 86.132), the RESS shall be brought to Full Charge.

c) Test Site Conditions — The entire test is to be conducted either in an full environmental chamber (FEC) (as specified in 40 CFR Part 86.161) or under test conditions that simulate testing in an FEC (as specified in 40 CFR Part 86.162). For testing in an FEC, the following ambient test conditions shall be provided: 35 °C (95 °F) air temperature, 100 grains of water per pound of dry air, a solar heat load intensity of 850 W/m^2, and vehicle cooling air flow proportional to vehicle speed.

d) A/C Operation — For FEC testing, all vehicle windows shall be closed, and the vehicle air-conditioning system shall operate as specified in 40 CFR Part 86.160-00 (c)(6). For testing under conditions that simulate testing in an FEC, the conditions as specified in 40 CFR Part 86.162-00 shall apply. For vehicles with manual climate control settings, after the second SC03 cycle is completed, the fan speed can be set to minimum in order to avoid cooling the cabin beyond normal driver comfort levels.

e) Intra-Test Pauses — Between the SC03 cycles, the vehicle should soak for (10 ± 1) min with the key switch in the “off” position, the hood closed, the test cell fan(s) off, the brake pedal not depressed, and the RESS not recharged from an external electric energy source. It is preferred that the pauses be consistently (10 ± 1) min. However, it is acknowledged that many test facilities do not have the software and or hardware to do so without longer pauses at some time after two to four cycles for data collection or test setup. In this case, a duration window of 10 min to 30 min shall be allowed during intra-test pauses. Good engineering judgment will be applied in arranging these test pauses, thus causing the least disruption in the test procedure. It is strongly preferred that the majority of soak periods remain as close to the 10-min recommendation as possible. During all soak periods, the key switch must be in the “off” position, the hood must be closed, the test cell fan(s) must be off, the brake pedal not depressed, and the RESS not recharged from an external energy source.

f) Measurements and Emissions Sampling — Exhaust emissions and the actual distance travelled by the dynamometer roll surface shall be measured during all SC03 cycles.

C.6.12.5 Cold UDDS test procedure

The following specifics relate to using this procedure for the Cold UDDS test.

a) Vehicle Preconditioning — The vehicle shall be preconditioned in the driver-selected operating mode in which it will be tested. The fuel specifications are subject to the requirements of 40 CFR Part 86.213, with a Reid vapour pressure (RVP) of 11,5 ± 0,3. The preconditioning is subject to the requirements of 40 CFR Part 86.232, which includes fuel tank drain-and-fill and driving over the UDDS, starting at a temperature of (20 ± 3) °F [(–7 ± 1,7) °C]. The ambient temperature shall average (20 ± 5) °F, and it shall not be less than 10 °F (–14 °C) nor more than 30 °F (–1 °C) during the preconditioning. Humidity should be set low enough to prevent condensation on the dynamometer rolls. A 12- to 36-h vehicle soak follows the preconditioning at the same ambient conditions mentioned above.

b) RESS Charging/Vehicle Soak — After preconditioning and while the vehicle is soaking at (20 ± 3) °F [(–7 ± 1,7) °C], the RESS shall be brought to Full Charge.

c) Test Site Conditions — The ambient temperature levels encountered at the start of the test shall be at (20 ± 3) °F [(–7 ± 1,7) °C]. The average temperature during the test must be (20 ± 5) °F [(–7 ± 2,8) °C]. The maximum excursions must be between 10 °F minimum and 30 °F maximum. Maximum excursions lasting up to 3 min must not exceed 15 °F minimum and 25 °F maximum. During dynamometer driving, all vehicle accessories shall be turned off, and a fixed-speed cooling fan shall direct cooling air to the vehicle, as specified in 40 CFR Part 86.135-94.

d) Heater/Defroster — At the start of the test, manually controlled climate control systems will have the air flow directed to the windshield for optimal defrosting, the air flow source set to outside air (not recirculation), the fan speed set to "off" or "low", and the air temperature set to the hottest setting. At the second idle of the test (approximately 2 min into the test, allowing the engine to accumulate some heat), the fan speed will be set to maximum. At the sixth idle of the test, at approximately 505 s into the test (corresponds with the end of Bag 1 and the start of Bag 2 of the Cold FTP), the fan speed setting will be reduced to the lowest possible setting to maintain air flow, and the temperature setting will remain at the hottest setting. These settings will be held for the remainder of the test, including the two bags following the 10-min soak period. For automatic climate control systems, the manufacturer can manually override the system and use the provisions specified for manual systems, or the system selector will be set to heater or defroster mode and the temperature will be set to 72 °F for the duration of the test. For vehicles with multiple-zone climate control systems (e.g. front and rear temperature/fan controls and/or separate driver/passenger temperature/fan controls), the same fan and temperature settings should be set and maintained for all the zones for both manual and automatic interior climate control systems.

e) Intra-Test Pauses — Between the UDDS cycles, the vehicle should soak for (10 ± 1) min with the key switch in the "off" position, the hood closed, the test cell fan(s) off, the brake pedal not depressed, and the RESS not recharged from an external electric energy source. It is preferred that the pauses be consistently (10 ± 1) min. However, it is acknowledged that many test facilities do not have the software and or hardware to do so without longer pauses at some time after sets of two to four cycles for data collection or test setup. In this case, a duration window of 10 min to 30 min shall be allowed during intra-test pauses. Good engineering judgment will be applied in arranging these test pauses, thus causing the least disruption in the test procedure. It is strongly preferred that the majority of soak periods remain as close to the 10-min recommendation as possible. During all soak periods, the key switch must be in the "off" position, the hood must be closed, the test cell fan(s) must be off, the brake pedal not depressed, and the RESS not recharged from an external energy source.

C.7 Calculation of exhaust emissions and fuel consumption

C.7.1 Emissions calculations

The specifications for emissions measurement equipment can be found in 40 CFR Part 1065 Engine Testing Procedures. The methods for calculating emissions per unit distance for each test cycle shall be those found in 40 CFR Part 86.144-94.

C.7.2 Fuel economy calculations

The methods for fuel economy for each test cycle from the collected emissions shall be found in 40 CFR Part 600.113-08.

Annex D
(informative)

Procedure for determining the beginning of CS state

D.1 General

This procedure systematically determines the minimum number of applicable driving tests in a set in order to identify the beginning of CS state in 6.3 even if case 1 or case 2 is unknown prior to measurement.

D.2 Procedure

D.2.1 Basic procedure

1) Let k = 1 and m = 1. Based on the result (j = 1) of the first applicable driving test (ADT), calculate A and B and determine if $A \leq$ (less than or equal to)B.

If yes, this is (1) in Table D.1 and then move to 2).

If no, move to 3).

$$A = \left| \sum_{i=1+(j-k\times m)}^{j-k\times(m-1)} \Delta E_{\mathrm{RESS}(i)} \right| \tag{D.1}$$

$$B = 0{,}01 \times \sum_{i=1+(j-k\times m)}^{j-k\times(m-1)} E_{\mathrm{CF}(i)} \tag{D.2}$$

where

j is the total number of ADTs;

k is the number of ADTs in a set;

m is the number of ADTs(when case 1, k = 1) or of sets (when case 2, k > 1) consecutively satisfying $A \leq B$.

2) If P = 1, the fuel and electric consumption in the first ADT are output and the test ends.

P is the value of m satisfying the criterion in order to complete the procedure.

NOTE If a user needs more stability, increase P.

3) Let j increase one by one and conduct the j-th ADT. Let k = 1 and m = 1. Calculate A and B and determine if $A \leq B$ in case 1. This is (2) in Table D.1.

4) If $m < P$ when comparing P with m, increase m stepwise by one and retrospectively determine if the number of ADTs satisfying consecutively $A \leq B$. This is (3) in Table D.1.

5) If $m < P$ when j is increased at less than k times m, determine that the result cannot satisfy the conditions of CS in case 1.

6) Next, add 1 to k and let k = 2 and m = 1. Calculate A and B by a set consisting of two ADTs and determine if $A \leq B$ in case 2. This is (4) in Table D.1.

7) Next, let *j* increase one by one and conduct the *j*-th ADT. Let *j* increase until *k* is more than *j*. Calculate *A* and *B* and determine if $A \leq B$ in each *j*-th test in case 2. Unless $m < P$, the set of *k* ADTs cannot be determined as in CS state. Return to 3).

8) Henceforth, by the same procedure, continue measuring, calculating and determining in a ADT(s) until $m = P$. Then document *j*, *k*, and *m* and end the test.

The {(1+[$j - k \times m$)}th ADT is determined as the beginning of CS state.

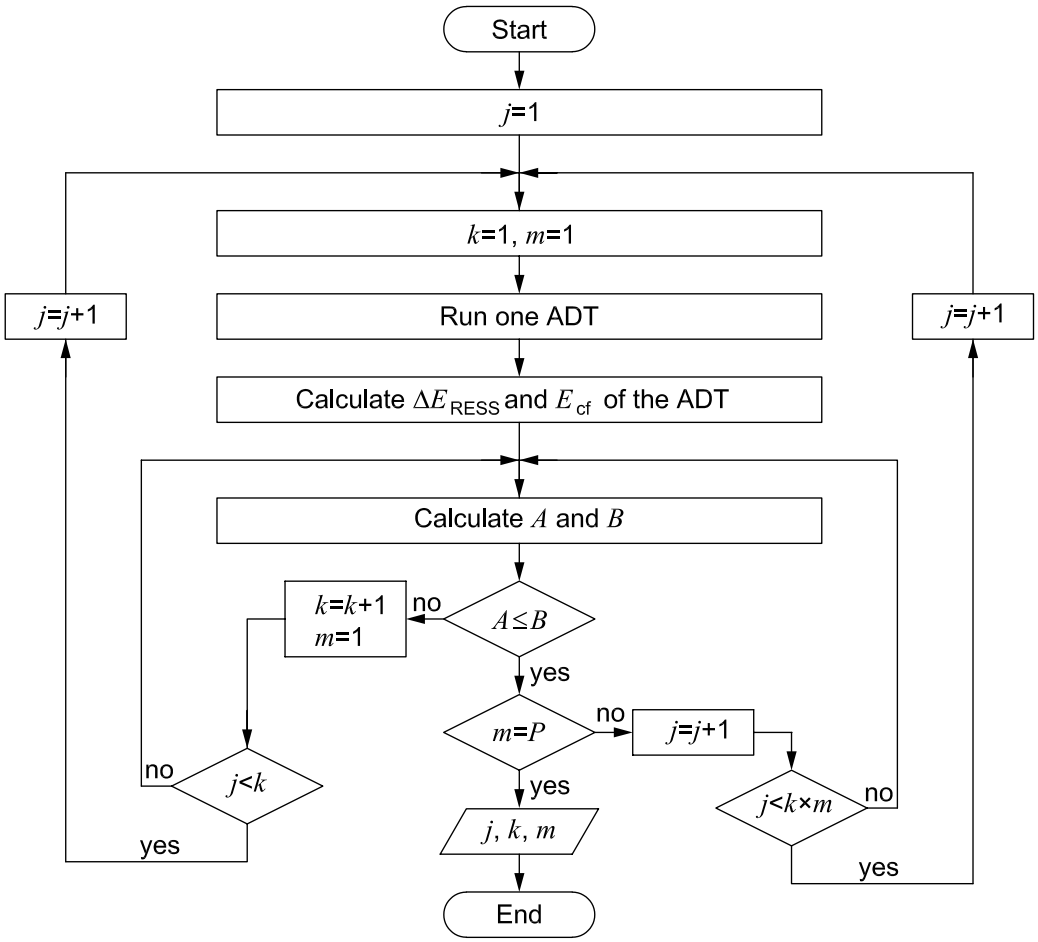


Figure D.1 — Flowchart of determining the beginning of CS state (basic procedure)

Table D.1 — Sample results by calculating in line with the flowchart

j	*k*	*m*	$1 + j - k \times m$	$j - k \times (m - 1)$	**Remark**
1	1	1	1	1	(1)
2	1	1	2	2	(2)
2	1	2	1	1	(3)
2	2	1	1	2	(4)
3	1	1	3	3	
3	1	2	2	2	
3	1	3	1	1	
3	2	1	2	3	
3	3	1	1	3	
4	1	1	4	4	

Table D.1 *(continued)*

j	k	m	$1 + j - k \times m$	$j - k \times (m - 1)$	**Remark**
4	2	1	3	4	
4	2	2	1	2	
4	3	1	2	4	
4	4	1	1	4	
5	1	1	5	5	
5	1	2	4	4	
5	1	3	3	3	
5	1	4	2	2	
5	1	5	1	1	
5	2	1	4	5	
5	2	2	2	3	
5	3	1	3	5	
5	4	1	2	5	
5	5	1	1	5	
…	…	…	…	…	
…	…	…	…	…	

D.2.2 Example

As a particular condition, this D.2.2 describes the condition of $P = 1$.

$j - (k + 1)$ is the ADT where CS state begins.

$j - k$ is the ADT where CD state ends.

$$A = \left| \sum_{i=j-(k+1)}^{j} " E_{\mathrm{RESS}(i)} \right| \tag{D.3}$$

$$B = 0{,}01 \times \sum_{i=j-(k+1)}^{j} E_{\mathrm{CF}(i)} \tag{D.4}$$

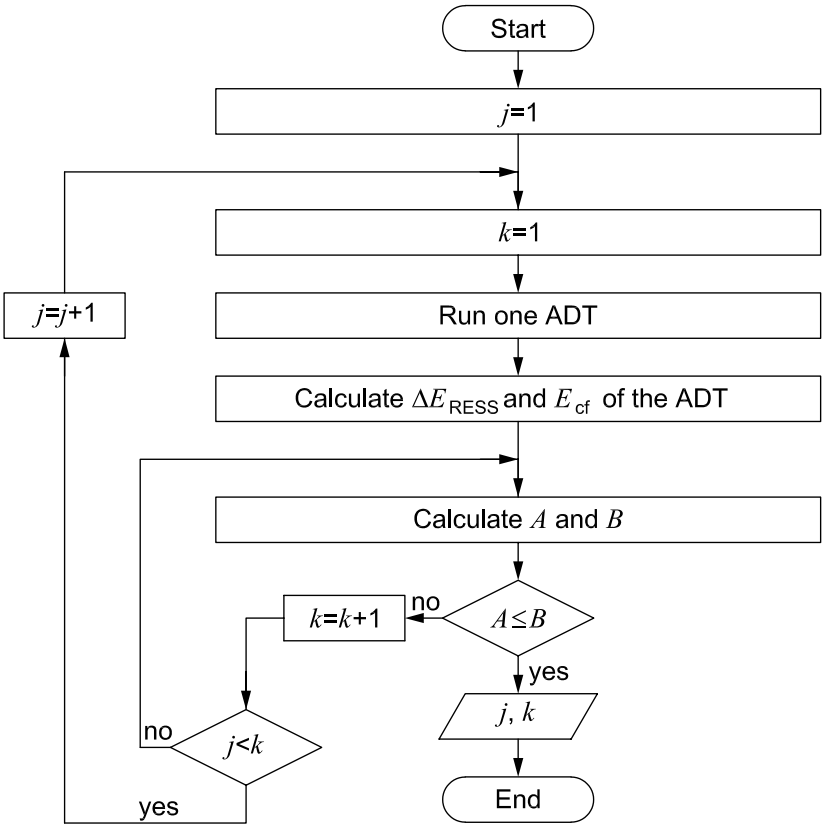


Figure D.2 — Flowchart of determining the beginning of CS state (example)

Bibliography

[1] ISO 12405-1: 2011, *Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems — Part 1: High-power applications*

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