BS ISO 23274-1:2013

BSI Standards Publication

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

Part 1: Non-externally chargeable vehicles

National foreword

This British Standard is the UK implementation of ISO 23274-1:2013. Together with BS ISO 23274-2:2012, it supersedes BS ISO 23274:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/69, Electric vehicles.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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ISO 23274-1

First edition
2013-01-15

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

Part 1: **Non-externally chargeable vehicles**

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

Partie 1: Véhicules non 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.

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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 23274-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 21, *Electrically propelled road vehicles*.

This first edition, together with ISO 23274-2, 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 1: Non-externally chargeable vehicles

1 Scope

This part of ISO 23274 specifies a chassis dynamometer test procedure to measure the exhaust emissions and the electric energy and fuel consumption for the vehicles.

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

— the vehicle is classified as passenger cars or light duty trucks, as defined in each regional annex;

— the nominal energy of the rechargeable energy storage system (RESS) is at least 2 % of the total energy consumption over an applicable driving test (ADT);

— internal combustion engine (ICE) only using liquid fuels (for example, gasoline and diesel fuel).

NOTE 1 In the case of the vehicles with ICE using other fuel [for example, compressed natural gas (CNG), liquefied petroleum gas (LPG), hydrogen], 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.

This part of ISO 23274 proposes procedures for correcting the measured emissions and fuel consumption of hybrid electric vehicles (HEVs), in order to obtain the values when the battery state of charge (SOC) of the RESS does not remain the same between the beginning and the end of an ADT.

It can also be applied to measurement procedures for exhaust emissions and fuel consumption of externally chargeable HEVs when a vehicle is not externally charged and operated only in the charge sustaining (CS) state, as described in ISO 23274-2.

NOTE 2 For CS state, see ISO 23274-2.

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

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

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 battery
change of charge in battery during fuel consumption measurement

Note 1 to entry: Normally expressed in ampere hours (Ah).

3.3
energy balance of battery
ΔE_{RESS}
change of battery energy state during an applicable driving test

Note 1 to entry: Normally expressed in watt hours (Wh).

Note 2 to entry: 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 ISO 12405-1 or ISO 12405-2.

3.4
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 to entry: External charge for the purpose of conditioning of the RESS is not included.

Note 2 to entry: Externally chargeable HEVs are widely known as plug-in HEVs (PHEVs).

3.5
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.

3.6
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

3.7
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.

3.8
rechargeable energy storage system
RESS
system that stores energy for delivery of electric energy and which is rechargeable

EXAMPLE batteries or capacitors

3.9
regenerative braking
braking with conversion of kinetic energy into electric energy for charging the RESS

3.10
state of charge
SOC
available capacity in a battery pack or system

Note 1 to entry: Expressed as a percentage of rated capacity.

4 Test conditions and instrumentation

4.1 Test conditions

4.1.1 General

For test conditions, 4.1.2 to 4.1.4 apply. Otherwise, the regional standards or regulations (see Annex A, B or C, for example) apply.

4.1.2 Ambient temperature

Tests shall be conducted at ambient temperature of (25 ± 5) °C.

4.1.3 Vehicle conditions

4.1.3.1 Vehicle conditioning

Prior to testing, the test vehicle with RESS shall be stabilized as specified by manufacturers, or the mileage shall be accumulated to above 3 000 km and less than 15 000 km.

4.1.3.2 Vehicle appendages

Vehicles shall be tested with normal appendages (mirrors, bumpers, etc.). When the vehicle is on the dynamometer, certain items (e.g. hub caps) should be removed for reasons of safety, where necessary.

4.1.3.3 Vehicle test mass

The vehicle test mass shall be selected in accordance with the regional standards and/or regulations (see Annex A, B or C, for example).

4.1.3.4 Tyres

4.1.3.4.1 General

The correctly rated tyres as recommended by the vehicle manufacturer shall be used.

4.1.3.4.2 Tyre pressure

The vehicle tyres shall be inflated to the pressure specified by the vehicle manufacturer in accordance with the test chosen (track or chassis dynamometer).

4.1.3.4.3 Tyre conditioning

The tyres shall be conditioned as recommended by the vehicle manufacturer.

4.1.3.5 Lubricants

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

4.1.3.6 Gear shifting

If the vehicle is fitted with a manually shifted gear box, gear shifting positions shall correspond to the regional test procedure (see A, B or C, for example). However, the shift positions should be selected and determined in accordance with the vehicle manufacturer's specification.

4.1.3.7 Regenerative braking

If the vehicle has regenerative braking, the regenerative braking system shall be enabled for all dynamometer testing except where specified in 4.1.4.4 Determining the dynamometer load coefficient.

If the vehicle is tested on a single axle dynamometer and is equipped with systems such as an antilock braking system (ABS) or a traction control system (TCS), those systems may inadvertently interpret the non-movement of the set of wheels that are off the dynamometer as a malfunctioning system. If so, these systems shall be temporarily disabled for adjustment to achieve normal operation of the remaining vehicle systems, including the regenerative braking system.

4.1.3.8 RESS conditioning

The RESS shall be conditioned with the vehicle as specified in 4.1.3.1, or by equivalent conditioning.

4.1.4 Chassis dynamometer conditions

4.1.4.1 General

The vehicle should generally be tested on a single axle chassis dynamometer. A vehicle with four-wheel drive shall be tested by modifying the drive train of the vehicle. When the vehicle is modified, the details shall be explained in the test report.

Double axle chassis dynamometer testing should be performed if a modification for single axle chassis dynamometer testing is not possible for a specific four-wheel drive vehicle.

4.1.4.2 Dynamometer calibration

The dynamometer shall be calibrated in accordance with the specifications indicated in the service manual provided by the dynamometer manufacturers.

4.1.4.3 Dynamometer warm-up

The dynamometer shall be warmed up sufficiently prior to testing.

4.1.4.4 Determining the dynamometer load coefficient

The determination of vehicle road load and the reproduction on a chassis dynamometer shall conform to ISO 10521. 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 coast-down testing on both the test track and dynamometer.

4.2 Test instrumentation

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

Table 1 — Accuracy of measured vehicles

Item	Unit	Accuracy
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 %
Capacitor voltage	V	± 0,5 % of nominal voltage

5 Measurement of exhaust emissions and fuel consumption

5.1 General

The appropriate procedure for a particular region shall be selected from Annex A, B or C, for Japan, Europe or North America, respectively. Common procedures are described below.

5.2 Test procedure

5.2.1 Vehicle preconditioning

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

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

5.2.2 Vehicle soak

The vehicle shall be soaked in accordance with the appropriate regional procedure in Annex A, B or C.

5.2.3 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 nor regenerative 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.

5.2.4 Measurement over ADT

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

5.3 Correction of the test results

5.3.1 General

Measured fuel consumption and exhaust emissions shall be corrected if these test results are influenced by RESS energy balance during the test. However, the correction is not necessary if the RESS energy balance satisfies the conditions in 5.3.2.

5.3.2 Allowable range of RESS energy balance

The correction is not necessary if RESS energy balance is within the following range:

$$\left|\Delta E_{\text{RESS}}\right| \leq 0{,}01 \times E_{\text{CF}} \qquad (1)$$

where

ΔE_{RESS} is the energy change in RESS over the ADT;

E_{CF} is the energy of consumed fuel over the ADT.

Practical methods that apply to battery and capacitor are described in Annex E.

5.3.3 Correction procedure by correction coefficient

The vehicle manufacturer shall deliver the correction coefficient to calculate the fuel consumption and the exhaust emission at $\Delta E_{\text{RESS}} = 0$. The correction coefficient can be obtained in accordance with Annex D. When the measured value is independent of ΔE_{RESS}, a correction is not required.

6 Calculations and expressions

Resultant exhaust emission and fuel consumption for an ADT shall be calculated in accordance with the regional requirement in Annex A, B or C.

Annex A
(informative)

Test procedure in Japan

A.1 General

This Annex describes the procedures and related conditions in Japan (JC08 mode) 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 (Ministry of Land, Infrastructure, Transport and Tourism [MLIT] Announcement No. 619, 2002; Attachment 42)", TRIAS 99-006-01 and TRIAS 31-J042(3) −01.[1)]

A.2 Test

A.2.1 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 plus 10 %.

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

A.3.1 General

Preconditioning shall be performed on the chassis dynamometer after given road load setting. Then, the test procedure shall be carried out according to the test flow in Figure A.2 or A.3.

A.3.2 Cold start JC08 mode (JC08CM)

In the case of a cold start, the test starts immediately after the specified soaking procedure, see A.1. Test flow in Figure A.2 is applicable.

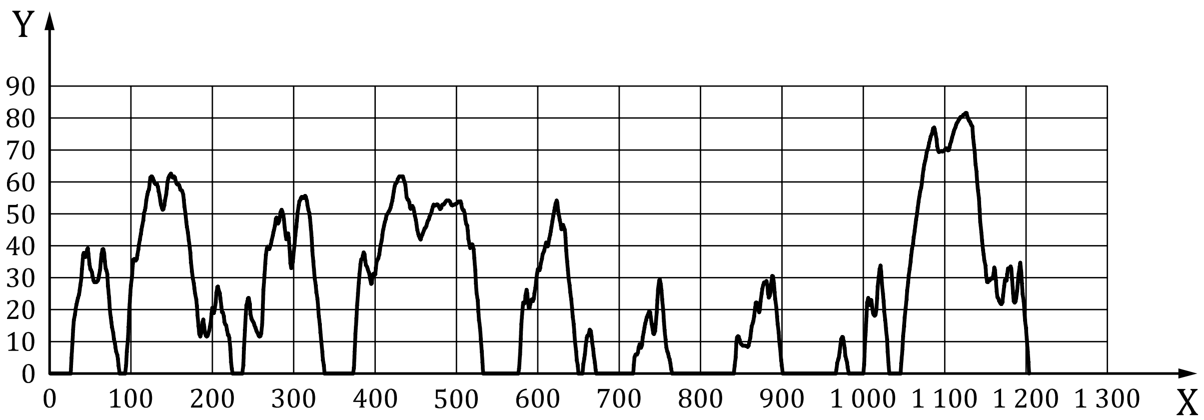
A.3.3 Hot start JC08 mode (JC08HM)

In the case of a hot start, the vehicle is under warmed-up condition. Test flow in Figure A.3 is applicable.

1) TRIAS is available for purchase from the Japan Automobile Standards Internationalization Center (http://www.jasic.org/e/08_publication/bb/20_handbook.htm).

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 – 1080	1 020
1 081 – 1 190	1 130
1 191 – 1 305	1 250
1 306 – 1 420	1 360
1 420 – 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 consumptions

A.4.1 Exhaust emissions

Each exhaust emission component in the sample gas shall be calculated by an ADT (JC08CM or JC08HM).

A.4.2 Fuel consumption

A.4.2.1 General

By using each exhaust emission component in the sample gas of an ADT (JC08CM or JC08HM), fuel consumption (km/l) shall be calculated according to the carbon balance method as in the following equations.

A.4.2.2 In case of gasoline

$$FC_{\mathrm{JC08CM}} \text{ or } FC_{\mathrm{JC08HM}} = \frac{866 \times \rho_{\mathrm{f}}}{0{,}429 \times m_{\mathrm{CO}} + 0{,}866 \times m_{\mathrm{THC}} + 0{,}273 \times m_{\mathrm{CO2}}}$$

where

ρ_{f} is fuel density, g/cm^3;

m_{CO} is CO emission, g/km;

m_{THC} is THC emission, g/km;

m_{CO2} is CO_2 emission, g/km.

A.4.2.3 In case of diesel oil

$$FC_{\mathrm{JC08CM}} \text{ or } FC_{\mathrm{JC08HM}} = \frac{862 \times \rho_{\mathrm{f}}}{0{,}429 \times m_{\mathrm{CO}} + 0{,}862 \times m_{\mathrm{THC}} + 0{,}273 \times m_{\mathrm{CO2}}}$$

A.4.3 Calculation of fuel consumption

Based on the fuel consumption calculated in A.4.2, consumed fuel (l) in each ADT (JC08CM or JC08HM) shall be calculated.

$$F_{\mathrm{JC08CM}} = 8{,}172/FC_{\mathrm{JC08CM}}$$

$$F_{\mathrm{JC08HM}} = 8{,}172/FC_{\mathrm{JC08HM}}$$

where

F_{JC08CM} is consumed fuel of JC08CM, in litres

F_{JC08HM} is consumed fuel of JC08HM, in litres

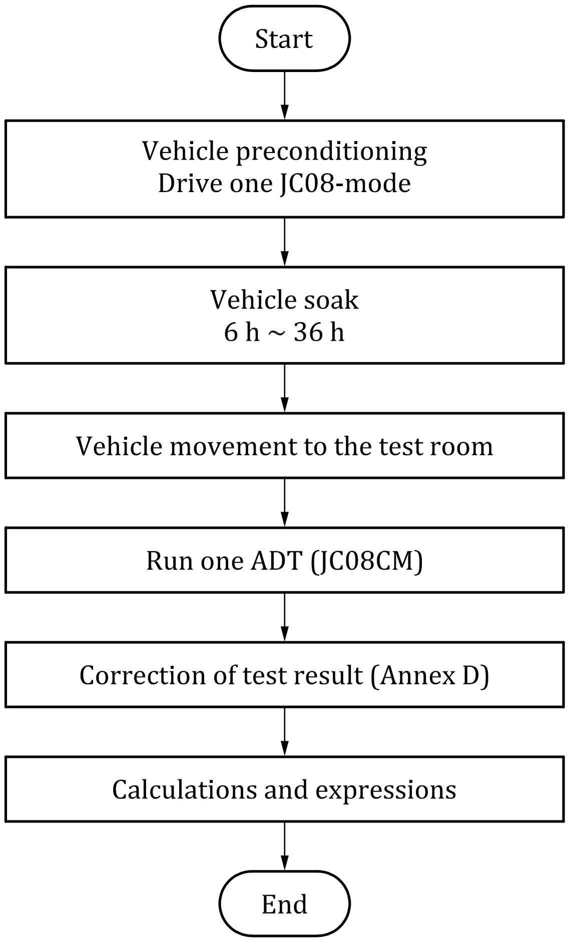


Figure A.2 — JC08CM - Test flow

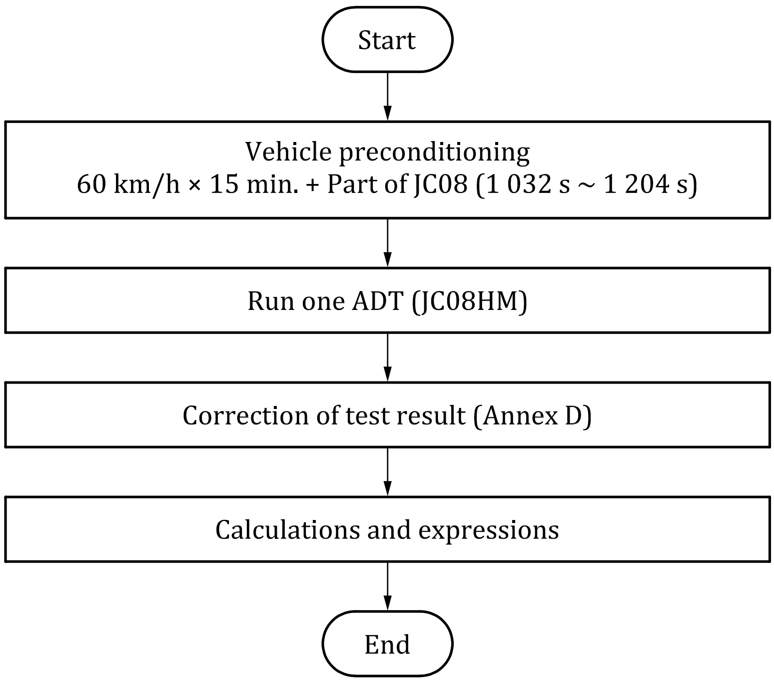


Figure A.3 — JC08HM - Test flow

Annex B
(informative)

Test procedure in Europe

B.1 General principles

B.1.1 General comments on regional information

This annex contains regional information, which supplements the provisions of this part of ISO 23274.

B.1.2 General considerations

The test procedure specified in this annex is based on United Nations Economic Commission for Europe (UNECE) Regulation No. 101, as amended to be applied to hybrid electric vehicles, and on UNECE Regulation No. 83. In UNECE Regulation No. 101, Annex 8, Clause 5, HEV, non-externally chargeable vehicles with HEV mode only are dealt with, but the measurements shall be done as for ICE vehicles, as specified in UNECE Regulation No. 101, Annex 6, with reference to UNECE Regulation No. 83, Annex 4.[2)]

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 UNECE Regulation No. 83. According to the energy change of the RESS during the test, the values measured are corrected using a correction factor as provided by the vehicle manufacturer.

The description given in the following clauses contains only the essentials to understand the procedure. For further details, see the relevant clauses of the two UNECE Regulations, to which reference is made in the text.

B.2 Rationale

Based on the legal requirements in Europe, this Annex specifies the measurement procedures for the determination of the exhaust and the carbon dioxide emission and the fuel consumption of HEV non-externally chargeable and with HEV mode only of categories M_1 and N_1 with a maximum permissible total mass of 3 500 kg (in accordance with ISO 1176). As fuels for the ICE, only gasoline and diesel fuel are considered.

B.3 Test equipment

B.3.1 Chassis dynamometer

Features, accuracy, load and inertia setting, calibration and other steps to prepare the chassis dynamometer to be used are specified in UNECE Regulation No. 83, Annex 4, 4.1, 5.1 and 5.2, and in UNECE Regulation No. 83, Annex 4, Appendixes 2 and 3. The adjustment of the inertia simulators to the vehicle's translatory inertias shall be in accordance with Table B.1 (as specified in UNECE Regulation No. 83, Annex 4, 5.1).

2) The following documents of both Regulations have been considered in this annex:
- UNECE Regulation No. 101: Trans/WP.29/GRPE/2004/2, 30 October 2003 (as amended not yet in force);
- UNECE Regulation No. 83: E/ECE/324 Rev.1/Add.82/Rev.2 E/ECE/Trans/505, 30 October 2001 (in force).

Upon further amendments of UNECE Regulation No. 101 and UNECE Regulation No. 83, this part of ISO 23274, especially this annex, will need to be reviewed.

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.3.2 Exhaust gas sampling system

The system that shall be used is the constant volume sampler (CVS) system. Details of the system, as well as calibration and accuracy, are given in UNECE Regulation No. 83, Annex 4, 4.2 and 4.4, and in UNECE Regulation No. 83, Annex 4, Appendix 5.

B.3.3 Analytical equipment

Emitted gases shall be analysed with the following instruments:

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

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

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

Details on applying, calibration and accuracy requirements are specified in UNECE Regulation No. 83, Annex 4, 4.3 and 4.5 (for gases used for calibration), and in UNECE Regulation No. 83, Annex 4, Appendix 6.

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 (referred to as “reference mass” in UNECE Regulation No. 83, 2.2) shall be the “unloaded mass” plus a uniform figure of 100 kg. The “unloaded mass” (see UNECE Regulation No. 83, 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. Alternatively, the prescription of UNECE Regulation No. 83, Annex 4, Appendix 3, 4.1.2 may be applied, i.e. only the widest of the standard widths or the widest minus one (in the case of more than three standard widths) shall be chosen.

The tyre pressure shall be in accordance with the vehicle manufacturer’s specification, but may be increased by up to 50 % when the test is done on a two roller dynamometer (see UNECE Regulation No. 83, Annex 4, 5.3.2).

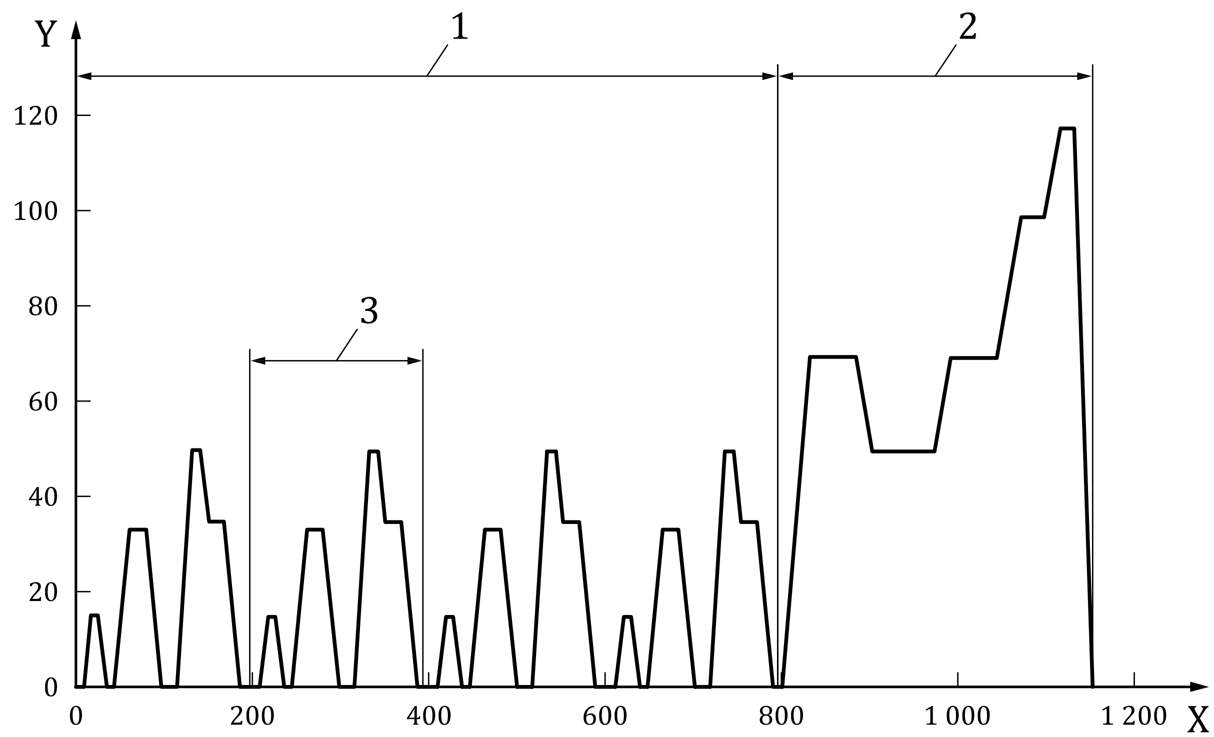
B.4.4 Test fuels

Details on the test fuels (called “reference fuels” in UNECE Regulation No. 83) are given in UNECE Regulation No. 83, Annexes 10 and 10a.

B.4.5 Test cycle

The test cycle specified for the Type I test (verifying exhaust emissions, see also B.5.2) is described in detail in UNECE Regulation No. 83, Annex 4, Appendix 1, 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 B.2.



Key

X time (s)

Y velocity (km/h)

1 Part One (urban) cycle

2 Part Two (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)

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), UNECE Regulation No. 101, Annex 8, 5.2, requires two consecutive full test cycles (see B.4) as preconditioning. At the manufacturer's request, one Part One and two Part Two cycles may be applied for positive ignition engines.

NOTE In UNECE Regulation No. 83, Annex 4, 5.3.1, three consecutive extra urban cycles are specified for the particulate determination of compression ignition engines.

B.5.2 Conditioning of the vehicle

After preconditioning in accordance with 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 UNECE Regulation No. 83, Annex 4, 5.3.).

B.5.3 Performance of the test

B.5.3.1 General

One complete test cycle shall be run in accordance with B.4.5, with the test equipment as in B.3 and the test vehicle as in B.4, after the preconditioning and conditioning as in B.5.1 and B.5.2, and the requirements below shall be met during the test. General descriptions of the test, including the number of tests, are given in UNECE Regulation No. 83, 5.3.

B.5.3.2 Special conditions

The temperature shall be between 20 °C and 30 °C and the absolute humidity between 5,5 g H_2O/kg and 12,2 g H_2O/kg dry air. (For details, see UNECE Regulation No. 83, Annex 4, 6.1.1.).

For details on air blown over the vehicle under test, see UNECE Regulation No. 83, Annex 4, 6.1.3.

B.5.3.3 Performing the different steps of the test cycle

The test shall be performed in accordance with 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.

NOTE The detailed prescriptions for the Type I test in UNECE Regulation No. 83, Annex 4, might not be applicable in many cases to HEV non-externally chargeable and with HEV mode only, e.g. if the vehicle starts driving only using the electric propulsion motor and switches to the ICE at a certain speed.

B.5.3.4 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 cycles (see UNECE Regulation No. 101, Annex 5, 5.1.1). Therefore, sampling and analysis shall be performed separately, although this is not required for the determination of the exhaust emissions (CO, HC, NOx and particulates), in accordance with UNECE Regulation No. 83.

Details on sampling and analysis are given in UNECE Regulation No. 83, Annex 4, 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 in accordance with UNECE Regulation No. 83, Annex 4, Clause 8, and UNECE Regulation No. 83, Annex 4, Appendix 8.

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 specified in UNECE Regulation No. 101, Annex 6, 1.4. If the fuels used differ from the reference fuels to which the formulae refer, correction factors may be applied (see also UNECE Regulation No. 101, Annex 6, 1.4).

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

B.6.3 Correction procedure in relation to the energy change in the RESS during the test

If the energy content of the RESS during the test has been changed (due to participating in the propulsion of the vehicle, or to being charged during regenerative braking or by energy from the ICE), a correction of the results obtained in B.6.1 (in relation to CO_2 emission) and B.6.2 is necessary.

However, in accordance with UNECE Regulation No. 101, Annex 8, 5.3.2, a correction is unnecessary if:

— it can be proved that there is no relation between the energy change of the RESS and the consumption, or

— the energy content of the RESS has increased during the test, or

— a decrease of the energy content of the RESS is smaller than 1 % of the total energy consumption during the test (over one test cycle).

UNECE Regulation No. 101, Annex 8, Appendix 2, explains how the energy change can be determined.

The correction shall be done using correction factors (for CO_2 emission and for fuel consumption) provided by the vehicle manufacturer.

For the determination of the correction factors (for the urban and extra urban test cycle separately) and the correction procedures, 5.3.3 provides the necessary prescriptions. (In R 83, Annex 4, Clause 5.3.1, three consecutive extra urban cycles are prescribed for the particulate determination of compression ignition engines.).

Annex C
(informative)

Test procedure in North America

C.1 General principles

C.1.1 General comments on regional information

This annex contains regional information, which supplements the provisions of this part of ISO 23274.

C.1.2 General considerations

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) methods, for measuring exhaust emissions and fuel economy of hybrid-electric vehicles. Specifically, SAE J1711 is the governing document, and citations throughout this annex refer to this issue.

C.2 Rationale

This annex specifies the uniform chassis dynamometer test procedures for hybrid-electric vehicles (HEVs) that are designed to be driven on public roads. Instructions are given for measuring and calculating the exhaust emissions and fuel economy of HEVs driven on the urban dynamometer driving schedule (UDDS) and the highway fuel economy driving schedule (HFEDS), as well as exhaust emissions determined from the US06 driving schedule (US06) and the SC03 driving schedule (SC03). Other methods may be used provided other corresponding factors are appropriately modified. Selection of the emission constituents to be measured is dependent upon the objectives of the tester. This annex deals only with HEVs that use gasoline or diesel as the consumable fuel, and which have a rechargeable energy storage system (RESS) consisting of batteries that can be recharged only by an on-vehicle device, whereas SAE J1711 covers a broader scope of HEV types.

C.3 Test general information

C.3.1 Driving schedules

The four driving schedules, two for determining exhaust emissions and fuel economy, and two for determining only exhaust emissions, are generally as defined in the Code of Federal Regulations, specifically CFR Title 40.

SAE J1711 delineates specific references to CFR Title 40 for these schedules and related speed tolerances.

C.3.2 Battery state of charge

When the charge-sustaining test method is used (see C.4), SAE J1711 specifies that the change in the RESS stored electrical energy over the test cycle be limited to ±1 % of the total fuel energy consumed over the same cycle, as expressed by Formula (C.1).

$$\left|\frac{\Delta E_{\mathrm{e}}}{E_{\mathrm{f}}}\right| \leq 1\,\% \qquad \text{(C.1)}$$

where

ΔE_e is the change in the RESS stored electrical energy;

E_f is the total fuel energy.

For the case of an HEV equipped with a battery RESS, Formulae (C.2) and (C.3)are used for electrical and fuel energy, respectively, when calculating the maximum and minimum allowed final battery state of charge (SOC) using the detailed equations found in SAE J1711.

$$\Delta E_e = (A_{h,final} - A_{h,initial}) \times V_{system} \tag{C.2}$$

$$E_f = J_{NHV} \times m_{fuel} \tag{C.3}$$

where

$A_{h,final}$ is the stored battery ampere hours for the stated condition at the end;

$A_{h,initial}$ is the stored battery ampere hours for the stated condition at the start;

V_{system} is the battery d.c. nominal system voltage;

J_{NHV} is the net heating value (per consumable fuel analysis), in J/kg;

m_{fuel} is the total mass of fuel consumed over test phase, in kg.

C.4 Test requirements

C.4.1 Vehicle condition

C.4.1.1 General

Prior to initiation of testing and during the testing, the overall condition and configuration of the vehicle shall be as delineated in the paragraphs that follow SAE J1711, all of which are represented below.

C.4.1.2 Vehicle stabilization

Prior to testing, the test vehicle shall be stabilized as specified in CFR Title 40, Part 86.098-26, which includes vehicle mileage accumulation either to a manufacturer-determined distance or to 2 000 miles, over the durability driving schedule (defined in CFR Title 40, Part 86, Appendix IV).

C.4.1.3 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.

C.4.1.4 Vehicle test weight

The vehicle shall be tested at the weight as specified in CFR Title 40, 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).

C.4.1.5 Tyres

The manufacturer’s recommended tyres shall be used. For dynamometer testing, tyre pressures should be set at the beginning of the test at the pressure used to establish the dynamometer road-load coefficients (see C.4.3) and shall not exceed levels necessary for safe operation. Tyres shall be conditioned as recommended by the vehicle manufacturer, have accumulated a minimum of 100 km (62 miles) and have at least 50 % of the original usable tread depth remaining.

C.4.1.6 Lubricants

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

C.4.1.7 Gear shifting

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

C.4.1.8 Regenerative braking

If the vehicle has regenerative braking, the regenerative braking system shall be enabled for all dynamometer testing. An accurate way to account for the effect of regenerative braking is to test the vehicle on a four-wheel drive electric dynamometer. However, a single-axle dynamometer can be used if the regenerative braking system operates in a similar fashion on the drive cycles for both single-axle and double-axle chassis dynamometers. If the vehicle is tested on a two-wheel dynamometer, and is equipped with systems, e.g. an antilock braking system (ABS) or a traction control system (TCS), these systems may inadvertently interpret the non-movement of the set of wheels that are off the dynamometer as a malfunctioning system. If so, modifications to these systems shall be made to achieve normal operation of the remaining vehicle systems, including the regenerative braking system.

C.4.1.9 Vehicle preparation

The vehicle shall be prepared for testing as specified in CFR Title 40, Part 86-131-00, which 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.4.2 Rechargeable energy storage system (RESS) condition

The battery RESS stabilization shall follow the prescription in SAE J1711. RESS failure is discussed in SAE J1711. At the conclusion of the vehicle test, the energy storage capability of the RESS may be verified against the vehicle manufacturer's rating using a current discharge method or a method supplied by the manufacturer.

C.4.3 Dynamometer condition

All factors concerning the dynamometer, specifically its capability requirements, configuration, calibration, warm-up and settings, are presented in the sub-paragraphs to SAE J1711, which give reference to the applicable requirements as contained in CFR Title 40, Part 86. The determination of the dynamometer load coefficients shall be as specified in SAE J2263 and SAE J2264, with provisions specified in SAE J1711 for vehicles equipped with regenerative braking systems that are actuated only by the brake pedal, as well as for vehicles equipped with regenerative braking systems that are activated at least in part when the brake pedal is not depressed.

C.4.4 Instrumentation

As presented in SAE J1711, the equipment referenced in CFR Title 40, Part 86.106 (including exhaust emissions sampling and analysis systems) is required for emissions measurements, where applicable.

All instrumentation shall be NIST (National Institute of Standards and Technology) traceable. Instrument accuracy shall be as specified in CFR Title 40, Part 86, as applicable. The accuracy of instruments for coast down measurements shall be as specified in SAE J2263 and SAE J2264, as applicable.

C.5 Calculation of exhaust emission and fuel consumption

Fuel consumption results are acceptable without corrections if the NEC is within the tolerance specified in C.3.2. However, the fuel consumption may be corrected to a zero change in NEC according to the requirements and methods stated in SAE J1711. Corrections are not made to emissions results.

Once acceptable results are established, in some cases a series of exhaust emissions and fuel economy calculations is necessary to account for cold start and hot start test phases. The driving schedules available for measuring exhaust emissions and fuel economy data are:

— UDDS (urban dynamometer driving schedule), which represents vehicle city driving;

— HFEDS (highway fuel economy driving schedule), which represents vehicle highway driving;

— US06, which represents vehicles driving at high speeds and accelerations;

— SC03, which represents vehicle operation with air conditioning.

UDDS exhaust emission calculation methods (as derived from CFR Title 40, Part 86, Appendix 1) are detailed in SAE J1711.

HFEDS exhaust calculations (CFR Title 40, Part 600, Appendix 1) are detailed in SAE J1711.

US06 exhaust emissions calculations (CFR Title 40, Part 86, Appendix 1) are found in SAE J1711.

SC03 exhaust emissions (CFR Title 40, Part 86) are detailed in SAE J1711.

Cold UDDS exhaust emissions (CFR Title 40, Part 86) are detailed in SAE J1711.

Fuel economy calculations for UDDS, HFEDS, US06, SC03 and Cold UDDS are in SAE J1711.

Annex D
(informative)

Linear correction method using a correction coefficient

D.1 General

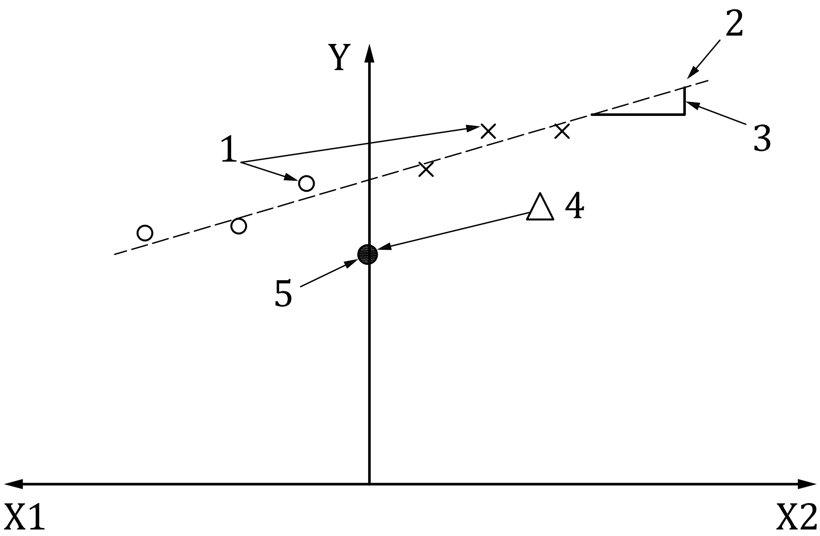
This annex describes the calculation procedure to determine the exhaust emissions and fuel consumption at $\Delta E_{RESS} = 0$. See also Annex F for theory of the linear regression method.

D.2 Method for correcting the exhaust emissions and fuel consumption

D.2.1 Data required for correction coefficient

The exhaust emissions and fuel consumption test shall be repeated several times to determine the correction coefficient defined in D.2.1.1.1. See Figure D.1. The ΔE_{RESS} shall be measured during the test. The SOC and ΔE_{RESS} should be in the normal range specified by the vehicle manufacturer.

NOTE The charge balance may be used instead of energy balance in the case of batteries.



Key

X1 energy balance (Wh), discharge
X2 energy balance (Wh), charge
Y exhaust emissions or consumed fuel (M_E)
1 data
2 pre-measured data for determination of correction coefficient
3 K_{ME}
4 measured value (C_s, $M_{E,s}$)
5 corrected value ($M_{E,c}$) = $M_{E,s} - K_{ME} \times C_s$

Figure D.1 — Example of data collected from ADT

D.2.1.1 Corrections

D.2.1.1.1 Exhaust emission and fuel consumption correction coefficient, K_{ME}.

The fuel consumption correction coefficient, K_{ME}, in l/Wh, for an ADT shall be calculated.

The exhaust emission correction coefficient, K_{ME}, in g/Wh, for each exhaust emission component in exhaust gas such as CO, HC, NOx and CO_2 for an ADT shall be calculated.

The correction coefficients shall be calculated using Formula (D.1):

$$K_{ME} = \frac{n \times \sum C_i M_{E,i} - \sum C_i \times \sum M_{E,i}}{n \times \sum {C_i}^2 - (\sum C_i)^2} \qquad \text{(D.1)}$$

where

$M_{E,i}$ is each exhaust gas component in grams per test or fuel consumption result in an ADT, in litres per test;

C_i is the charge balance at the exhaust gas test and at the fuel consumption test, in watt hours (use the minimum unit);

n is the number of data.

The exhaust emission correction coefficient shall be a four-significant digit figure by rounding the fifth significant digit figure.

D.2.1.1.2 Exhaust emission and fuel consumption at $\Delta E_{RESS} = 0$, M_{EC}

The value of each exhaust emission or fuel consumption, M_{EC}, at $\Delta E_{RESS} = 0$, is derived from Formula (D.2):

$$M_{EC} = M_{E,s} - K_{ME} \times C_S \qquad \text{(D.2)}$$

where

$M_{E,s}$ is each exhaust emission in grams per test or fuel consumption in litres per test;

K_{ME} is the correction coefficient defined in D.2.1.1.1;

C_S is the charge balance of battery, in watt hours (use the minimum unit).

The fuel consumption may also be calculated using the exhaust emission value at $\Delta E_{RESS} = 0$.

Annex E
(informative)

Calculation of allowable range of RESS energy change

E.1 General

The allowable energy change in RESS, expressed by Formula (1) in 5.3.2, may be rewritten as follows, using the net heating value (NHV) of fuel:

$$\left|\Delta E_{\text{RESS}}\right| \leq 0{,}01 \times J_{\text{NHV}} \times m_{\text{fuel}} \times 3\,600 \tag{E.1}$$

where

ΔE_{RESS} is the energy change in RESS over the ADT;

J_{NHV} is the net heating value (per consumable fuel analysis), in J/kg;

m_{fuel} is the total mass of fuel consumed over the ADT, in kg.

For batteries or capacitors, this allowable energy change can be expressed as shown in E.2 and E.3 below.

E.2 Batteries

The energy balance in the battery over the ADT, ΔE_{b}, in Wh, can be calculated from the measured charge balance, ΔQ, and is expressed as follows:

$$\Delta E_{\text{b}} = \Delta Q \times V_{\text{system}} \tag{E.2}$$

where

ΔQ is the charge balance of the battery over the ADT, in Ah;

V_{system} is the nominal system voltage of battery system, in V.

NOTE V_{system} means the same as nominal voltage in 9.4.2 of ISO 12405-1:2011.

For batteries, the equation above may be rewritten as follows:

$$\left|\Delta Q\right| \leq 0{,}01 \times \frac{J_{\text{NHV}} \times m_{\text{fuel}} \times 3\,600}{V_{\text{system}}} \tag{E.3}$$

E.3 Capacitors

The change of energy stored in the capacitor over the ADT, ΔE_{c}, in Wh, is expressed as follows:

$$\Delta E_{\text{c}} = \frac{C}{2} \times \left(V_{\text{final}}^{\;2} - V_{\text{initial}}^{\;2}\right) \times 3\,600 \tag{E.4}$$

where

C is the nominal capacitance of the capacitor, in F;

V_{final} is the terminal voltage of the capacitor at the end of the test, in V;

$V_{initial}$ is the terminal voltage of the capacitor at the beginning of the test, in V.

For capacitors, the equation above may be rewritten as follows:

$$|V_{final}{}^2 - V_{initial}{}^2| \leq 0{,}01 \times \frac{2 \times J_{NHV} \times m_{fuel}}{C} \qquad \text{(E.5)}$$

Annex F
(informative)

Theory for the linear regression method

This annex shows how the linear regression method can theoretically be applied to the correction method for determining the true fuel consumption of HEVs.

The consumed energy of HEVs in HEV operating mode is composed of the fuel energy consumed by the ICE power train system and the electric energy consumed by electric power train system. Assuming that the average efficiency of the ICE power train system in HEV operating mode is equal to that in ICEV operating mode (without electric assist), Formula (F.1) applies:

$$\alpha \times E_{o} = (\alpha \times E_{f}) + (\beta \times \kappa \times E_{e}) \qquad (F.1)$$

where

α is the average efficiency of ICE power train system during the test period;

β is the average efficiency of electric power train system during the test period;

κ is the average efficiency of battery system during the test period;

E_{f} is the consumed energy of fuel in the HEV operating mode during the test period;

E_{e} is the consumed/regenerated energy of electricity in the HEV operating mode during the test period;

E_{o} is the consumed energy of fuel in the ICEV operating mode during the test period.

By applying the additional values listed below, Formula (F.1) can be rewritten as Formula (F.2):

$$\alpha \times \gamma \times U_{o} = (\alpha \times \gamma \times U_{m}) + (\beta \times \kappa \times E_{e}) \qquad (F.2)$$

where

γ is the volume energy density of fuel;

U_{o} is the consumed fuel in the ICEV operating mode during the test period;

U_{m} is the consumed fuel in the HEV operating mode during the test period.

By dividing the consumed values from Formula (F.2) by the distance travelled, L, and introducing the corresponding consumption values listed below, Formula (F.2) can be rewritten as Formula (F.3):

$$\alpha \times \gamma \times F_{o} = (\alpha \times \gamma \times F_{m}) + (\beta \times \kappa \times E_{m}) \qquad (F.3)$$

where

F_{o} is the fuel consumption in the ICEV operating mode in the test period;

F_{m} is the fuel consumption in the HEV operating mode during the test period;

E_m is the electric energy consumption in the HEV operating mode during the test period;

m signifies “measured”.

Therefore, the measured fuel consumption in HEV operating mode, F_m, can be expressed as follows:

$$F_m = F_o - \left[\frac{\beta \times \Delta Q}{\alpha \gamma} E_m \right] \tag{F.4}$$

Electric energy consumption, E_m, can be expressed as follows:

$$E_m \cong V \times \frac{\Delta Q}{L} \tag{F.5}$$

where

V is the system voltage, in V;

ΔQ is the charge balance of the battery during the test period, in Ah;

L is the distance covered in the test period (X).

Formulae (F.4) and (F.5) lead to Formula (F.6):

$$F_m = F_o - \frac{V}{\gamma} \times \frac{\beta \times \kappa}{\alpha} \times \frac{\Delta Q}{L} \tag{F.6}$$

Formula (F.6) shows that the gradient of this equation is in proportion to β/α, namely to the ratio of electric and ICE traction system efficiency. It also shows that the y-axis-crossing value indicates resultant fuel consumption without RESS effect.

In this annex, the polarity of ΔQ is set plus when battery energy is increased (charging) in accordance with battery manners.

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