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

Véhicules routiers électriques hybrides — Mesurages des émissions à l'échappement et de la consomation de carburant — Véhicules non rechargeables par des moyens externes

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

Introduction

Hybrid-electric road vehicle (HEV) design has huge flexibility (in applied components or in operational manners). HEV can be roughly classified by following three characteristics (see also Table 1):

a) external charge capability: externally chargeable/non-externally chargeable;

b) rechargeable energy storage system (RESS): battery/capacitor;

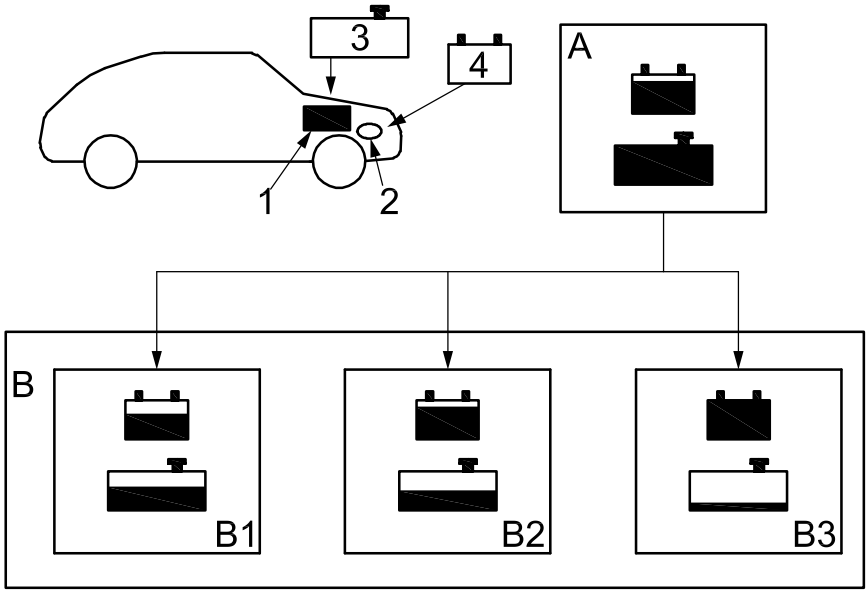
c) driver-selected operating modes: if HEV has no driver-selected operating mode, it has only HEV mode; if HEV has driver-selected operating mode, it has three possibilities [i.e. HEV mode, internal combustion engine vehicle (ICEV) mode and electric vehicle (EV) mode].

Table 1 — Classification of HEV

External charge	Operating mode
Externally chargeable	HEV operating mode
	ICEV operating mode
	EV operating mode
Non-externally chargeable	HEV operating mode
	ICEV operating mode
	EV operating mode

For hybrid-electric vehicles with internal combustion engines (ICE), exhaust emissions and fuel consumption measurements are principally the same as for ICEV. The measured exhaust emissions and fuel consumption, however, cannot be assumed to be the correct ones because the battery state of charge (SOC) of the RESS at the end of the test cycle is not necessarily the same as that at the beginning of the test cycle. In addition, it is not always possible for the SOC of the RESS at the end of test cycle to be equal to that at the beginning of test cycle (see Figure 1).

In this case illustrated in Figure 1, a correction needs to be introduced as described in this International Standard. The linear correction method, as described in Annex D, represents the current state of the art.



Key

1	combustion engine	A	condition before test
2	electric motor	B	condition after test
3	fuel tank	B1	case 1: driven partly by fuel, partly by battery
4	battery	B2	case 2: driven only by fuel
		B3	case 3: driven only by fuel, additional fuel used to charge battery

Figure 1 — Status of energy storage system before and after test

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

1 Scope

This International Standard establishes a uniform chassis dynamometer test procedure for hybrid-electric road vehicles (HEV) with internal combustion engines (ICE) classified as passenger cars and light duty trucks, as defined in each regional annex. This International Standard proposes ways of correcting the measured emissions and fuel consumption of HEV, in order to obtain the correct values when the battery state of charge (SOC) of the rechargeable energy storage system (RESS) does not remain the same between the beginning and the end of test cycle.

This International Standard applies to HEV with ICE of which the nominal energy of the RESS is at least 2 % of the total energy consumption by the vehicle over the test cycle.

This International Standard applies to non-externally chargeable vehicles without an operating mode switch to draw propulsion energy from the following sources of energy:

— consumable fuel, and

— an energy storage battery/capacitor system that is rechargeable only by an on-board engine-generator/ electric motor system.

Consumable fuels covered by this International Standard are limited to petroleum-based liquid fuels (e.g. gasoline and diesel fuel).

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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
battery state of charge
battery SOC
residual capacity of battery available to be discharged, normally expressed as a percentage of full charge

3.2
charge balance of battery
change of charge in battery during test period, normally expressed in Ah

3.3
driver selected operating mode
vehicle propulsion operating mode that the driver can select through on-board switches or other means

3.4
electric vehicle operating mode
EV operating mode
mode of a HEV in which only the RESS is used for vehicle propulsion and possibly auxiliary systems

3.5
energy balance of battery
charge balance of battery multiplied by the nominal voltage, normally expressed in Wh

NOTE This definition is an approximation of the actual energy balance used for practical purpose.

3.6
externally chargeable HEV
plug-in HEV
HEV with RESS that is intended to be recharged for normal operation from an external electric energy source

3.7
hybrid electric vehicle
HEV
vehicle using both a RESS and a fuelled power source for vehicle propulsion

NOTE ICE or fuel cell systems are typical types of fuelled propulsion power sources.

3.8
hybrid-electric vehicle operating mode
HEV operating mode
mode of a HEV with ICE in which both RESS and ICE are used simultaneously or sequentially for vehicle propulsion

NOTE The ICE may also charge the RESS during propulsion or standstill.

3.9
internal combustion engine vehicle operating mode
ICEV operating mode
mode of a HEV with ICE in which only the ICE is used for vehicle propulsion, and in which regenerative braking is excluded

3.10
non-externally chargeable HEV
non plug-in HEV
HEV with RESS that is not intended to be recharged for normal operation from an external electric energy source

NOTE The RESS may be externally charged for infrequent conditioning of the RESS, or other purposes unrelated to vehicle propulsion.

3.11
rechargeable energy storage system
RESS
system that stores energy for delivery of electric energy and which is rechargeable

EXAMPLES Batteries or capacitors.

3.12
regenerative braking
partial recovery of the energy normally dissipated in friction braking, which is returned as electric energy to a RESS

4 Test conditions and instrumentation

4.1 Test conditions

4.1.1 General

Adequate test site capabilities for safe venting and cooling of batteries, protection from exposure to high voltage, or any other necessary safety precaution shall be provided during testing. The conditions in 4.1.2, 4.1.3 and 4.1.4 shall also apply to all tests specified, unless specified differently in Annexes A, B or C.

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 stabilization

Prior to testing, the test vehicle shall be stabilized, including accumulation of vehicle mileage either to a manufacturer-determined distance, or 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.). Certain items on the dynamometer (e.g. hub caps) may be removed for safety, where necessary.

4.1.3.3 Vehicle test mass

The vehicle test mass shall be selected in accordance with Annexes A, B, or C.

4.1.3.4 Tyres

The tyres recommended by the vehicle manufacturer shall be used.

4.1.3.4.1 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) when the tyres are at ambient temperature.

4.1.3.4.2 Tyre conditioning

The tyres shall be conditioned as recommended by the vehicle manufacturer. See Annexes A, B or C for additional requirements for particular regions.

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 correspond to the test procedure mentioned in Annexes A, B and C. However, the shift positions may have been selected and determined previously in accordance with the vehicle characteristics.

4.1.3.7 Regenerative braking

If the vehicle has regenerative braking, the regenerative braking system shall be enabled for all dynamometer testing.

If the vehicle is tested on a single-roll dynamometer and is equipped with systems such as 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 the these systems shall be made to achieve normal operation of the remaining vehicle systems, including the regenerative braking system.

4.1.3.8 RESS stabilization

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

4.1.4 Chassis dynamometer conditions

4.1.4.1 General

HEV should generally be tested on a single-roll chassis dynamometer. HEV 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 roll dynamometer testing may be performed when a modification for single-roll dynamometer testing is not possible for a specific four-wheel driven HEV.

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 2, unless specified differently in Annexes A, B, or C.

Table 2 — Accuracy of measurement test instrumentation

Item	Unit	Accuracy
Time	s	± 0,1 s
Distance	m	± 0,1 %
Temperature	°C	± 1 °C
Speed	km/h	± 1 %
Mass	kg	± 0,5 %
Quantity of electricity	Ah	± 0,5 %
Capacitor voltage	V	± 0,5 % of nominal voltage
Rotating speed	r/min	± 0,5 % of maximum rotating speed

5 Exhaust emissions and fuel consumption tests

5.1 General

The appropriate procedure for a particular region shall be selected from Annexes A, B and C, for Japan, Europe and North America respectively. Details and common procedures for each test mode are described below.

5.2 Test procedure for HEV operating mode

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 suitable energy difference in RESS between the beginning and the end of test.

5.2.2 Vehicle soak

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

5.2.3 Vehicle movement to the test room

The vehicle shall be moved into test room by pushing or towing (never by driving). The test vehicle shall be set on the chassis dynamometer after the chassis dynamometer has warmed up just before the test. The vehicle shall be kept in a cold condition after soak.

5.2.4 Measurement over scheduled driving test

One cycle of the scheduled driving test shall be conducted. Driving distance, energy difference in RESS, consumed fuel and exhaust emissions shall be measured. The conditions of the vehicle during the scheduled driving test shall follow the appropriate regional test procedure in Annexes A, B or C.

5.3 Correction of the test results

5.3.1 General

Correct fuel consumption and exhaust emission shall be obtained from measured exhaust emissions and energy difference of RESS, through the procedure described below. Measurement shall follow the appropriate regional test method shown in Annexes A, B or C.

5.3.2 Allowable limit for RESS energy change

The allowable limit for RESS energy change is defined as follows:

$$| \Delta E_{\text{RESS}} | \leqslant 0{,}01 \times E_{\text{CF}} \tag{1}$$

where

ΔE_{RESS} is the energy change in RESS over the test cycle;

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

Energy change in RESS and maximum allowable energy change in RESS are specified 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 in each scheduled driving test shall be calculated individually in accordance with each regional requirement in Annexes A, B or C.

The basic result shall be calculated and expressed as follows.

$$\text{Exhaust emission (g/km)} = \frac{\text{(weighed mass emission, in grams)}}{\text{(driven distance, in km)}} \tag{2}$$

$$\text{Fuel consumption (l/km)} = \frac{\text{(measured fuel, in litres)}}{\text{(driven distance, in km)}} \tag{3}$$

To adapt regional regulation and rules, details in calculating procedure are specified in Annexes A, B and C.

Annex A
(informative)

Test procedure in Japan

A.1 General principles

A.1.1 General comments on regional information

This annex contains regional information, which supplements the provisions of this International Standard.

A.1.2 General considerations

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

A.2 Accuracy of measurement

A.2.1 The accuracy of determining of road load shall conform to ISO 10521.

A.2.2 The repeatable test result of calibration gas in exhaust emission sampling and analytical systems shall be kept within ± 1 %.

A.2.3 The accuracy of constant volume sampling (CVS) equipment shall be kept within ± 2 %.

A.3 Driving procedure

A.3.1 General

The gear manipulation in each operational condition, specified in Tables A.1 and A.2, shall be performed smoothly and quickly, in accordance with A.3.2 to A.3.4.

A.3.2 Motor vehicles with manual transmission

A.3.2.1 The idling operation refers to a condition in which the accelerator pedal is not depressed, with the transmission gear in neutral.

A.3.2.2 The transmission gear shall be shifted to the low gear positions (or other gear in instances where the “low” gear position should read otherwise in Tables A.1 and A.2) 5 s before the idling operation mode is switched to the acceleration mode.

A.3.2.3 For deceleration, the clutch shall be disengaged at a speed of 10 km/h during the deceleration from 20 km/h to 0 km/h; at a speed of 20 km/h during the deceleration from 40 km/h to 0 km/h (as specified in Tables A.1 and A.2). In the same way, the clutch shall be disengaged at a speed of 30 km/h during the deceleration from 70 km/h to 0 km/h (as specified in Table A.2).

A.3.2.4 In A.3.2.3 above, if the engine speed is under the engine idling speed, the clutch shall be disengaged.