INTERNATIONAL STANDARD

**ISO 23274-2**

First edition
2012-08-01

# 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*



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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**
$\Delta E_{RESS}$
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 |
| $\rho$ | 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.

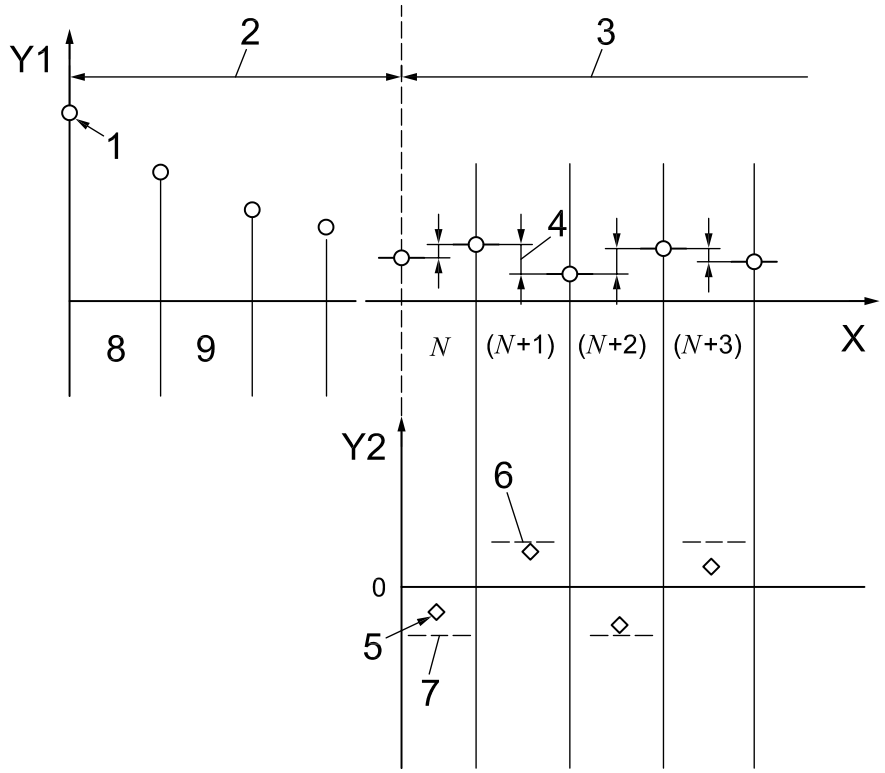
— The energy balance of RESS ($\Delta E_{RESS}$, Wh) between the start and the end of each applicable driving test shall be calculated.

— Applicable driving tests shall continuously be carried out until each $\Delta E_{RESS}$ is determined to be stable within $\pm(0{,}01 \times E_{CF})$ 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 | $\Delta E_{RESS}$ | X | time sequence |
| 5 | $\Delta E_{RESS}$ of $N$th test | Y1 | electric energy of the RESS (Wh) |
| 6 | $+0{,}01 \times E_{CF}$ of $(N+1)$th test | Y2 | $\Delta E_{RESS}$ (Wh) |
| 7 | $-0{,}01 \times E_{CF}$ of $N$th test | | |



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

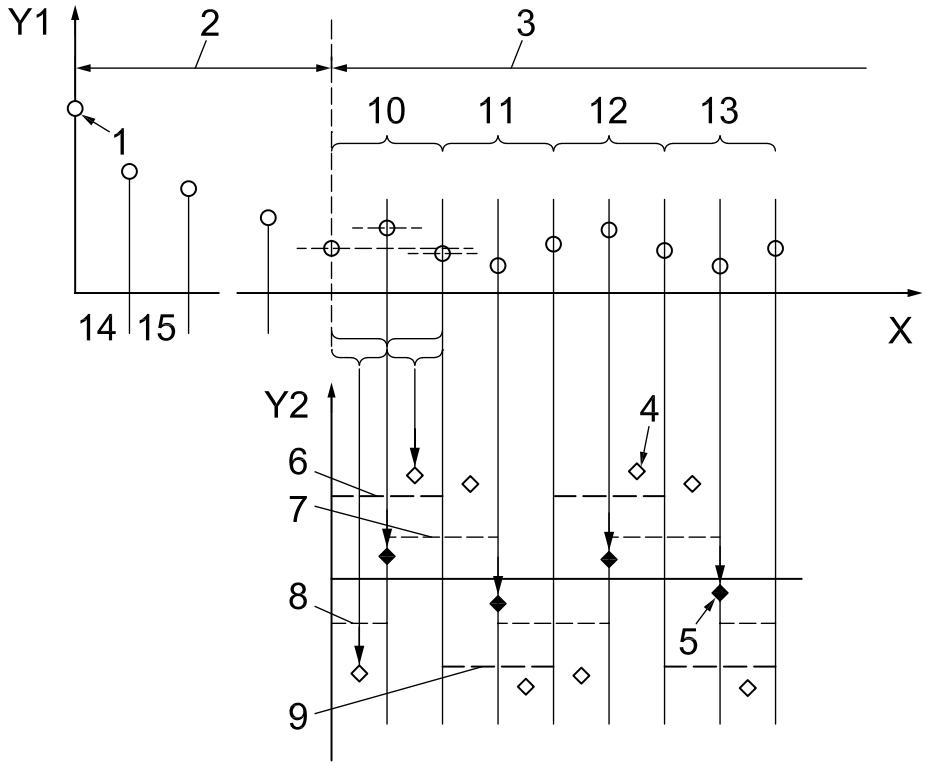
### 6.3.3 Determination of the end of CD state (case 2)

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