INTERNATIONAL STANDARD

ISO 23274-2

Second edition
2021-09

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
ISO 23274-2:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

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

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

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 23274-2:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— deletion of former Annexes A, B and C (regional tests) because their information is obsolete;

— harmonization of terms and definitions with ISO/TR 8713 and ISO 23274-1.

A list of all parts in the ISO 23274 series can be found on the ISO website.

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

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

Part 2: Externally chargeable vehicles

1 Scope

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

The identification of the end of the 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 document.

This document applies to vehicles with the following characteristics.

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

— A CD state, in which the electric energy in the RESS from an external electric power source is consumed, is followed by a charge-sustaining (CS) 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 generative operation driven via the ICE.

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

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 the relevant regional applicable driving test (ADT) standard.

— For the ICE, 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 document can apply except the measurement of consumed fuel; otherwise the measurement method for those using the corresponding fuel can apply.

— The nominal energy of the RESS is at least 2 % of the total energy of consumed fuel over an ADT

2 Normative references

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

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

ISO 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.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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

Note 1 to entry: Chassis dynamometer test schedule for a relevant region is the Worldwide Light-duty Test Cycle (WLTC) or the Urban Dynamometer Driving Schedule (UDDS), for example.

3.2
CD state
charge-depleting state
operating mode of a *hybrid-electric vehicle* (3.5) with ICE in which the vehicle runs by consuming the stored electric energy in the *rechargeable energy storage system (RESS)* (3.7) from an external electric power source or along with the fuel energy simultaneously or sequentially until *charge-sustaining state* (3.3)

3.3
CS state
charge-sustaining state
operating mode where the *hybrid-electric vehicle* (3.5) runs by consuming the fuel energy while sustaining the electric energy of the *rechargeable energy storage system (RESS)* (3.7)

3.4
energy balance of RESS
ΔE_{RESS}
change of *RESS* (3.7) energy state during an *applicable driving test (ADT)* (3.1)

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

Note 2 to entry: For practical use, the energy balance of the RESS is approximated by multiplying the charge balance of the RESS in ampere hours (Ah) with the nominal voltage of the RESS in volts (V).

3.5
HEV
hybrid-electric vehicle
vehicle with both a *rechargeable energy storage system (RESS)* (3.7) and a fuelled power source for propulsion

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

3.6
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 and discharge cut-off voltage

3.7
RESS
rechargeable energy storage system
rechargeable system that stores energy for the delivery of electric energy for the electric drive

EXAMPLE Batteries or capacitors.

3.8
regenerative braking
braking with conversion of kinetic energy into electric energy for charging the *rechargeable energy storage system (RESS)* (3.7)

3.9
SOC
state of charge
available capacity of a *rechargeable energy storage system (RESS)* (3.7) or RESS subsystem expressed as a percentage of *rated capacity* (3.6)

4 Symbols and abbreviated terms

CD	charge-depleting
CNG	compressed natural gas
CS	charge-sustaining
E	energy
E_{CF}	energy of consumed fuel
H_2	hydrogen
ICE	internal combustion engine
UDDS	Urban Dynamometer Driving Schedule
WLTC	Worldwide Light-duty Test Cycle

5 Test conditions and instrumentation

5.1 Test conditions

The test conditions in ISO 23274-1 shall apply.

5.2 Test instrumentation

The test instrumentation shall have the accuracy levels given in Table 1, unless otherwise specified by the relevant regional ADT standard.

Table 1 — Accuracy of measured values

Item	Unit	Accuracy
Time	s	± 0,1 s
Distance	m	± 0,1 %
Temperature	°C	± 1 °C
[a] Accuracy for measured value: ± 0,3 % full scale deflection or ± 1 % of reading, whichever is greater.		

Table 1 *(continued)*

Item	Unit	Accuracy
Speed	km/h	± 1 %
Mass	kg	± 0,5 %
Current	A	± 0,3 % [a]
Electric energy	Wh	± 0,5 %
[a] Accuracy for measured value: ± 0,3 % full scale deflection or ± 1 % of reading, whichever is greater.		

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, a 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 an external electric 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 an external electric power source within 2 h following completion of the appropriate test sequence unless otherwise specified for the relevant region.

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

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

6 Test procedure

6.1 General

This clause specifies how to determine the end of the CD state and the consumed electric energy during CD state. In this document, ADTs during the CS state are only used to determine the end of the CD state.

In general, the results for the CS state in this document are not consistent with ISO 23274-1 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.

There can be regional procedures to measure exhaust emission and fuel consumption. The test sequence and the single test steps of the test procedure to determine the end of the 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 be fully charged (see 5.3.1.1).

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

e) Run an ADT and measure the energy balance of RESS, exhaust emissions and fuel consumption (see 6.2.5).

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

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

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

6.2.2 Vehicle preconditioning

There can be regional ADT standards that state the procedure for vehicle preconditioning. If necessary, the 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

Relevant regional ADT standards can contain information regarding the vehicle soak.

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 nor 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 ADT

The energy balance of RESS, consumed fuel and exhaust emissions shall be measured in each ADT. Regional standards can contain the test procedure regarding the conditions of the vehicle during the ADT.

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 ADTs (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 the 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 the CS state.

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

6.3.1 General

The energy balance of the RESS during the CS state varies depending on the design of an HEV system and its operation. Therefore, this document 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 6.3.2 and 6.3.3. One of these cases shall apply unless a relevant regional ADT contains a specific direction. Case 1 is applicable to most HEVs. If case 1 is not applicable, case 2 shall apply.

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

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

The ADT where the CD state ends shall be determined by performing ADTs as follows.

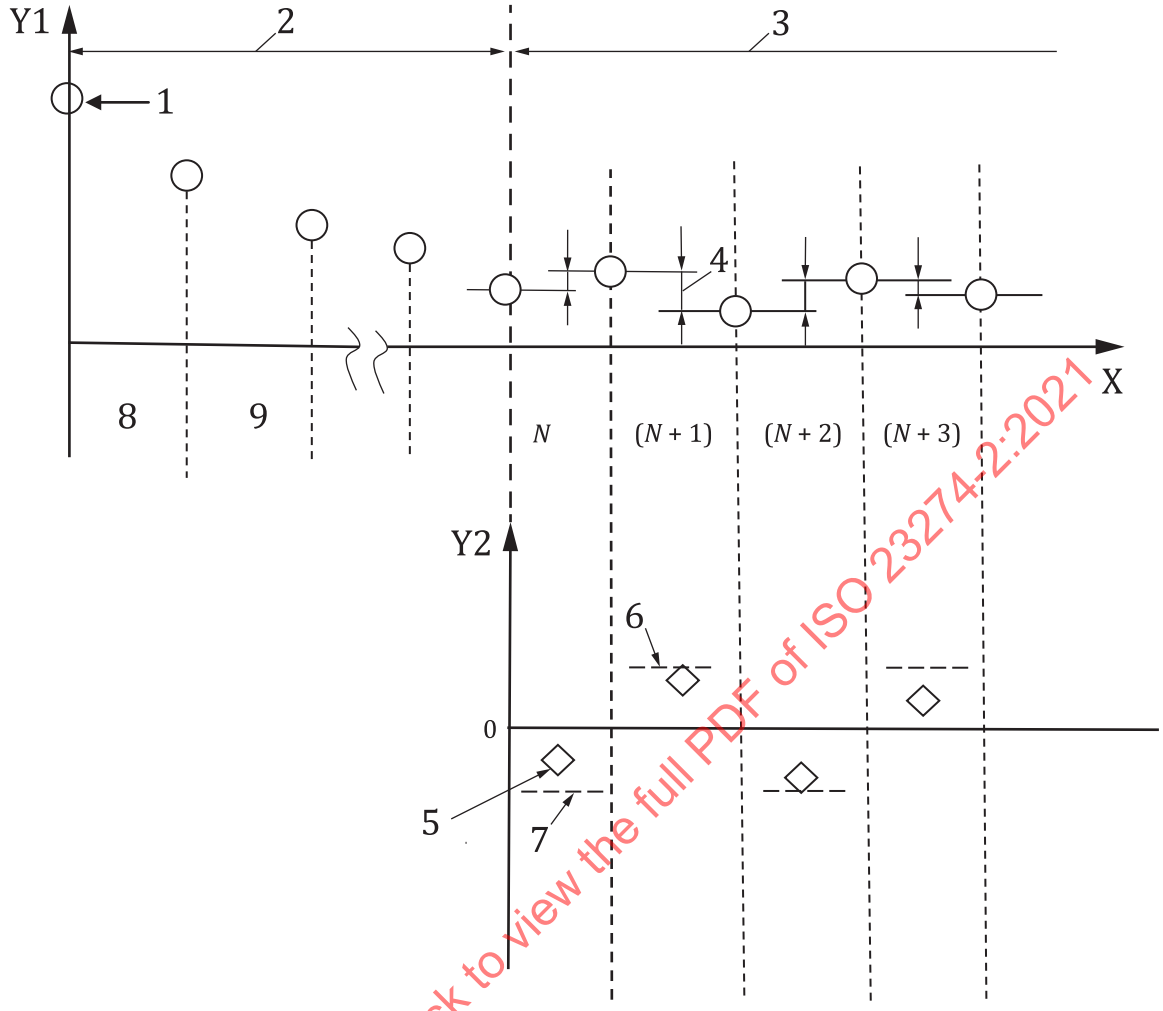
— The energy balance of the RESS (ΔE_{RESS}, Wh) between the start and the end of each ADT shall be calculated.

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

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

— The ADT where the CD state ends is the one before the first ADT at CS state starts.

NOTE See Annex A for information on the procedure to determine the beginning of the CS state.



Key

X	time sequence	6	+0,01 × E_{CF} of $(N+1)^{th}$ ADT
Y1	electric energy	7	−0,01 × E_{CF} of N^{th} ADT
Y2	ΔE_{RESS} (Wh)	8	first ADT
1	fully charged RESS	9	second ADT
2	CD state	N	ADT number
3	CS state		
4	ΔE_{RESS}		
5	ΔE_{RESS} of N^{th} ADT		

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

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

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

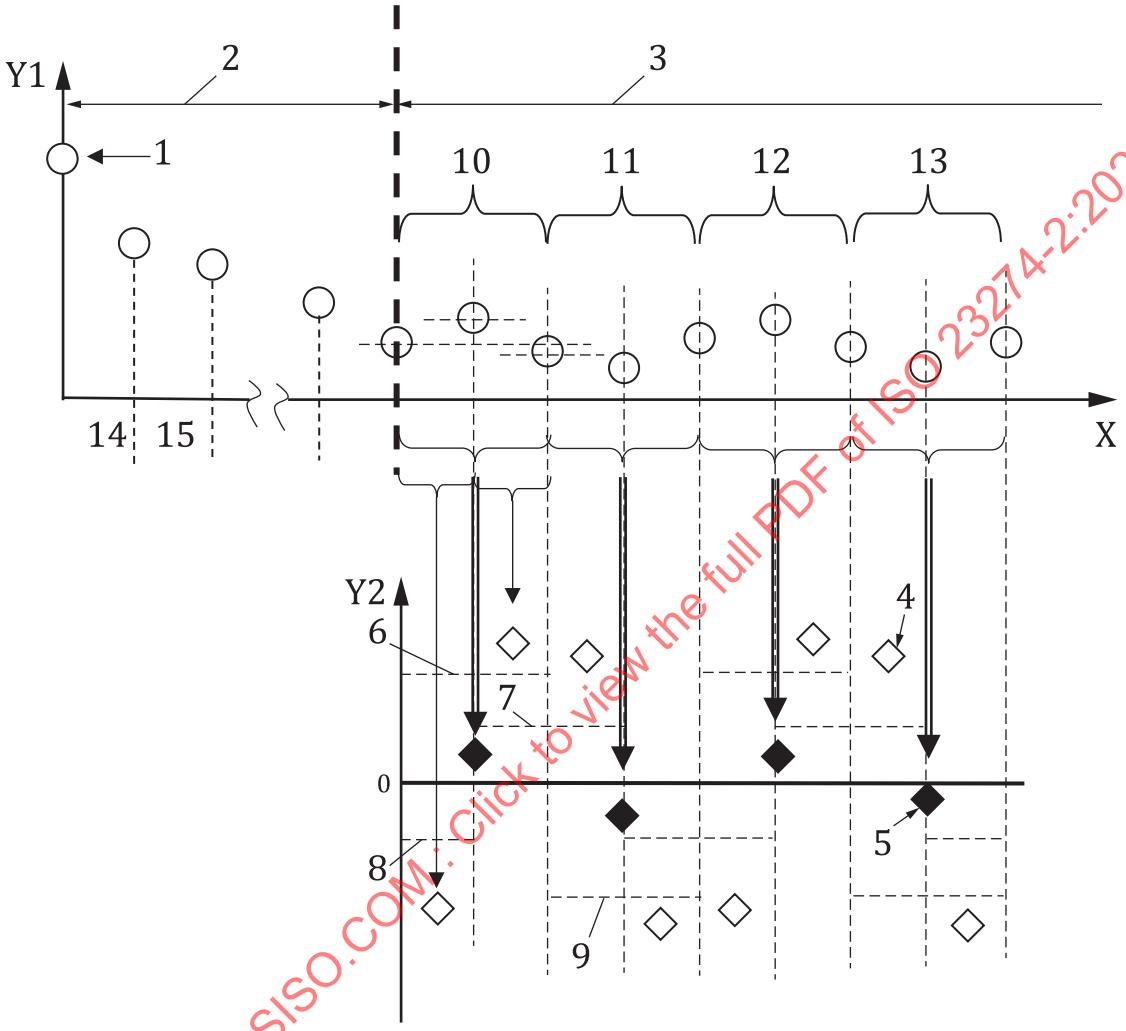
The ADT where the CD state ends is given by specifying the first set of ADTs in CS state as follows.

A series of ADTs supposed to be in CS state shall be divided into sets. A set consists of consecutive ADTs. The number of ADTs in a set should be a minimum. When the energy balance of RESS at the start of the first ADT and the end of the last ADT in the set is determined to be stable within ±1 % of the consumed

fuel of one or more consecutive set(s), the vehicle shall be determined as being in CS state. The ADT where the CD state ends is the one before the first ADT at CS state starts.

NOTE 1 The customer can set the number of times to pass the CS condition in succession. Annex A describes an example of how to set the number of times to pass the condition once (P = 1) and more (P> 1).

NOTE 2 See Annex A for information on the procedure to determine the minimum number of ADTs in a set.



Key

X	time sequence	7	+0,01 × E_{CF} of a single ADT
Y1	electric energy of the RESS (Wh)	8	−0,01 × E_{CF} of a single ADT
Y2	ΔE_{RESS} (Wh)	9	−0,01 × E_{CF} of second set of ADTs
1	fully charged RESS	10	first set of ADTs
2	CD state	11	second set of ADTs
3	CS state	12	third set of ADTs
4	ΔE_{RESS} of a single ADT	13	fourth set of ADTs
5	ΔE_{RESS} of a set of ADTs	14	first ADT
6	+0,01 × E_{CF} of first set of ADTs	15	second ADT

Figure 2 — Determination of transition point from CD to CS state (case 2)

7 Additional data evaluation of results

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

— the number of ADT(s) until the CD state ends;

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

— exhaust emissions and fuel consumption in the CD state as measured based on information on the regional requirements.

Annex A
(informative)

Procedure for determining the beginning of the CS state

A.1 General

This procedure systematically determines the minimum number of ADTs in a set, in order to identify the beginning of the CS state according to 6.3.

The customer defines, if the procedure shall operate under case 1 (see 6.3.2) or case 2 (see 6.3.3) or under an open case condition, where case 1 or case 2 is unknown prior to the operation of the procedure.

The procedure starts with the first ADT cycle. This corresponds with the procedures cycle counter j = 1, set as the start condition for the procedure. The first results for A [see Formula (A.1)] and B [see Formula (A.2)] shall be calculated for this j = 1-st ADT cycle. Every subsequent ADT cycle increments counter j by one ($j = j + 1$).

One or more consecutive ADT cycles are necessary to determine if the vehicle is in CS state.

The procedure also contains the indicators P and CC for the output of the result quality. The customer defines the value for P and thus sets the number for consecutive ADT cycles or sets of ADT cycles and the value for CC and thus sets the number of consecutive ADT cycles in a set, in order to determine the CS mode.

NOTE P = 1; the procedure ends if the first cycle or set of ADT cycles confirms $A \leq B$ [see Formulae (A.1) and (A.2)].

P = 2; the procedure ends if the first two consecutive ADT cycles or sets confirm $A \leq B$.

P = 3; the procedure ends if the first three consecutive ADT cycles or sets confirm $A \leq B$.

CC=0; open case condition. The procedure checks the available cycles and sets of cycles according to definitions given for *P.* Result could be case 1 (*P, k*=1) or case 2 (*P, k*=2 or *P, k*=3, etc.), wherever the CS state is determined first.

CC=1; case 1, *k*=1 condition. The procedure checks cycle by cycle and depending on P consecutive cycles (operates according to the conditions given in 6.3.2).

CC=2; case 2, *k* =2 condition. The procedure checks set by set of two consecutive cycles and depending on P consecutive sets of two consecutive cycles (operates according to the conditions given in 6.3.3).

CC=3; case 2, *k*=3 condition. The procedure checks set by set of three consecutive cycles and depending on P consecutive sets of three consecutive cycles (operates according to the conditions given in 6.3.3).

A.2 Procedure

A.2.1 Basic procedure

The basic procedure to determine the beginning of the CS state is described below and also shown as a flowchart in Figure A.1 and Tables A.1, A.2, A.3 and A.4.

Start:

Step 1) Set j = 1, F_E_{CF} = 0, *P, CC* ;

where

j is the index number of evaluated ADTs in the procedure. Starts with 1, indicates the first ADT cycle;

F_E_{CF} is 0 until the first ADT cycle where $E_{CF} > 0$;

P is the number for consecutive ADT or sets of ADT cycles (set by the customer);

CC is depending on consecutive ADT cycles in a set (set by the customer).

Step 2) Set $k = 1$ and $m = 1$ and go to step 3);

where

k is the number of performed ADTs in a set;

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

Step 3) Evaluate one ADT and go to step 4).

Step 4) Calculate ΔE_{RESS} and E_{CF} and go to step 5).

Step 5) If $E_{CF} > 0$ then go to step 7), otherwise go to step 6).

Step 6) If F_ $E_{CF} = 1$ then go to step 8), otherwise go to step 18).

Step 7) Set F_ $E_{CF} = 1$, and go to step 8).

Step 8) If $CC = 0$ then go to step 11), otherwise go to step 9).

Step 9) Set $k = CC$ and go to step 10).

Step 10) If $j \geq k \times P$ then go to step 11), otherwise go to step 18).

Step 11) Calculate A and B according to Formulae (A.1), (A.2), (A.3) and (A.4) and go to step 12).

$$A = \left| \sum_{i=x}^{y} \Delta E_{RESS(i)} \right| \quad \text{(A.1)}$$

$$B = 0{,}01 \times \sum_{i=x}^{y} E_{CF(i)} \quad \text{(A.2)}$$

$$x = 1 + j - k \times m \quad \text{(A.3)}$$

$$y = j - k \times (m - 1) \quad \text{(A.4)}$$

where

A is the sum of the consumed RESS energy in the relevant ADT cycle(s);

B is 1 % of the sum of the consumed fuel energy in the relevant ADT cycle(s);

x is the lower ADT cycle index number for calculation of A and B;

y is the upper ADT cycle index number for calculation of A and B;

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 $A \leq B$.

Step 12) If $A \leq B$ then go to step 15), otherwise go to step 13).

Step 13) If $CC = 0$ then go to step 14), otherwise go to step 18).

Step 14) Increase k by one and set $m = 1$, and go to step 17).

Step 15) If $m = P$ then go to step 19), otherwise go to step 16).

Step 16) Increase m by one and go to step 17).

Step 17) If $j < k \times P$ then go to step 18) , otherwise go to step 11).

Step 18) $j = j + 1$

Step 19) Document j, k, m, P, CC, CD mode ends at $(j - k \times m)$ and CS mode starts at $(1 + j - k \times m)$. Stop the test.