

Drive trace indexes for the electrified vehicles

<discussion paper>

WLTP/SG-EV

29 AUG 2017

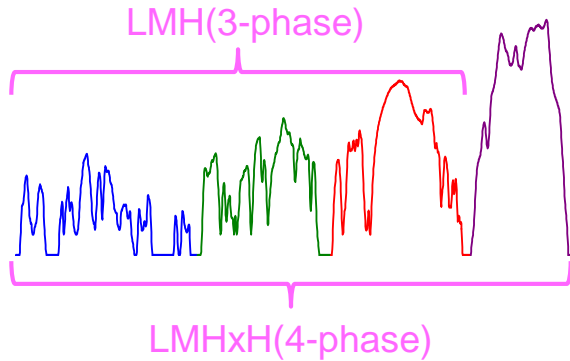
Japan

Need to clarify how to calculate the drive trace indexes for the electrified vehicles

1. Drive trace indexes for ICEVs
2. Drive trace indexes for PEVs
 - Consecutive cycle test
 - Shortened test
3. Drive trace indexes for OVC-HEVs
 - Charge depleting (CD) test
 - Charge sustaining (CS) test
4. Drive trace indexes for the range extender type vehicles

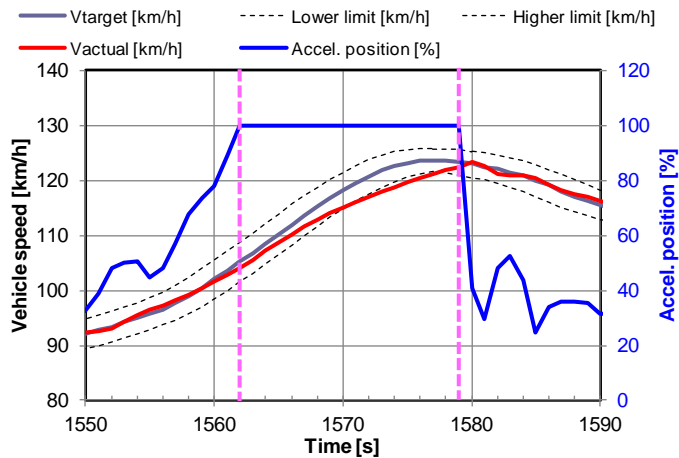
1. Drive trace indexes for the ICE vehicles

① Calculation portion



- Calculate DTIs for LMH(3-phase) and LMHxH(4-phase)

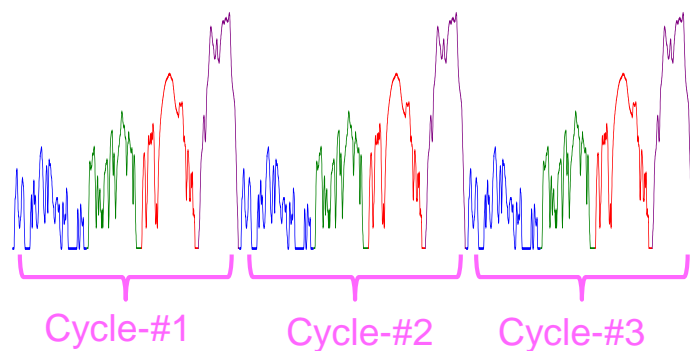
② In the case that the accelerator control is fully activated



- [Annex 7, 7.1.] The prescribed speed (value) shall be used instead of the actual vehicle speed(value) for drive trace index calculations.

2.1. Drive trace indexes for PEV consecutive cycle test

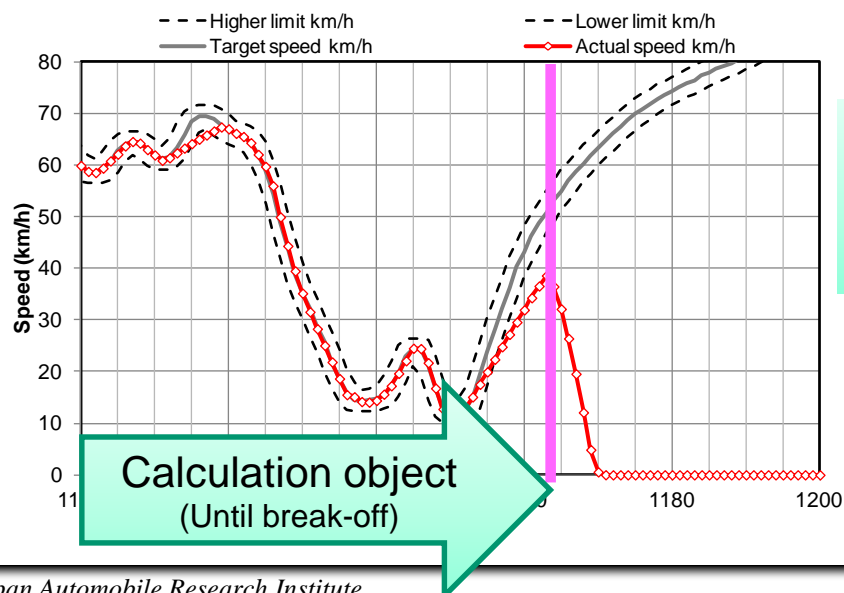
③ Calculation portion for consecutive cycle test



- Calculate DTIs in each cycle
- 3-phase and 4-phase respectively

Cycle	IWR	RMSSE	ER/DR/EER/ASCR
1	X.XX	X.XX	...
2	X.XX	X.XX
3	X.XX	X.XX	...

④ Calculation portion at the cycle reached break-off

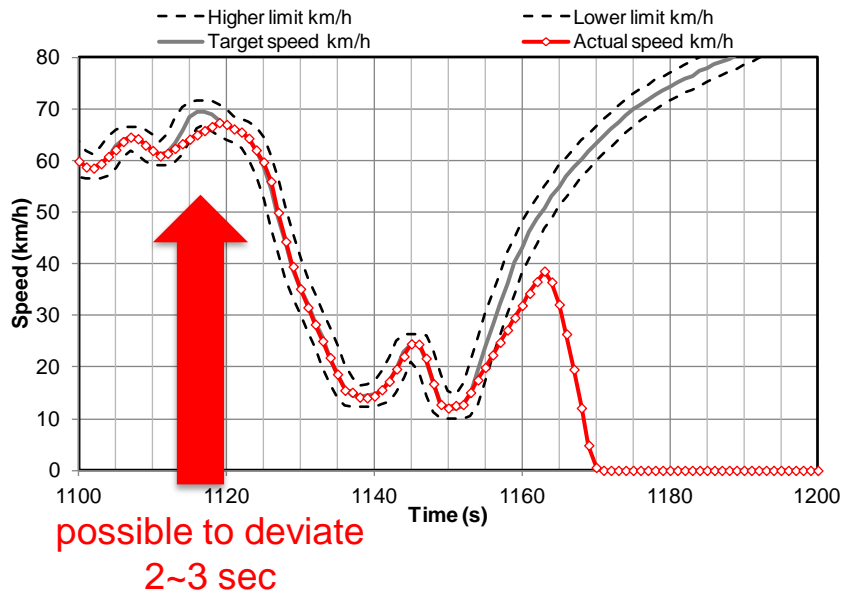


- Calculate until the break-off point. The rule of Annex 7-7.1. will be applied until this point.

Continued

2.1. Drive trace indexes for PEV consecutive cycle test

⑤ Deviation of 2~3 seconds



- It is possible to deviate for 2~3 seconds when a remaining battery level is low.
- Do NOT accept intentional smooth driving. However if the accelerator control is fully activated, the deviation of 2~3 s may be allowed. Then this portion will be applied the rule described in the paragraph 7.1. of Annex 7.

<Necessity condition>

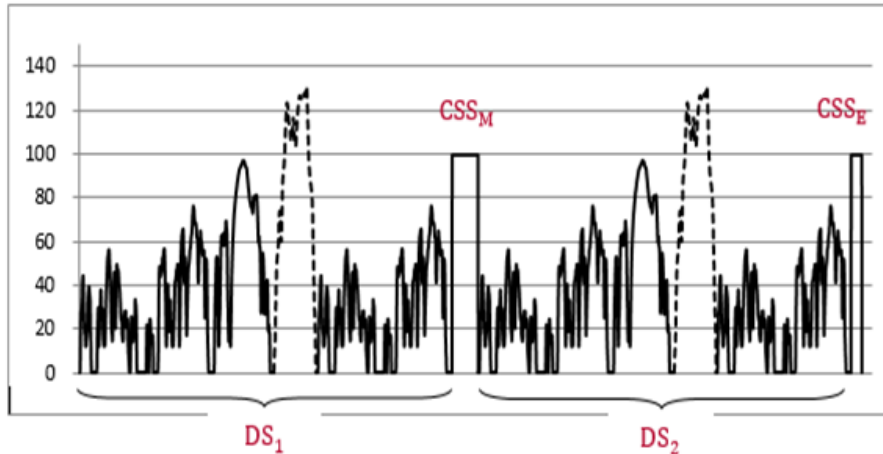
Follow the Annex 8, Appendix 6

- Selected appropriate driver-selectable mode
- Selected appropriate driving cycle
- Applied appropriate cycle modification

2.2. Drive trace indexes for PEV shortened test

⑥ Calculation portion for shortened test

Shortened test procedure



- For the shortened test, the drive trace index should be calculated during the two dynamic segments (DS_1 and DS_2) respectively.
- It is not necessary to calculate during the constant speed segments (CSS_M and CSS_E) because the driving style in CSS doesn't influence the test results.

Drive trace index for DS1

Driving index	Low	Middle	High	Ex-High	Low	Middle	City1	City2	Total
Energy rating [ER]	0.606	-0.023	0.878	0.206	0.400	0.460	0.216	0.437	0.408
Distance rating [DR]	0.318	0.008	-0.014	-0.103	0.082	-0.002	0.130	0.037	0.010
Energy Economy Rating [EER]	0.286	-0.031	0.884	0.309	0.317	0.459	0.086	0.404	0.396
Absolute speed change rating [ASCR]	0.748	0.197	1.267	0.261	0.443	0.715	0.482	0.574	0.617
Root Mean squared Error [RMSSE]	0.302	0.306	0.275	0.271	0.295	0.312	0.303	0.302	0.295
Inertia Work Rating [IWR]	0.797	0.116	1.142	0.198	0.369	0.775	0.391	0.611	0.559

Drive trace index for DS2

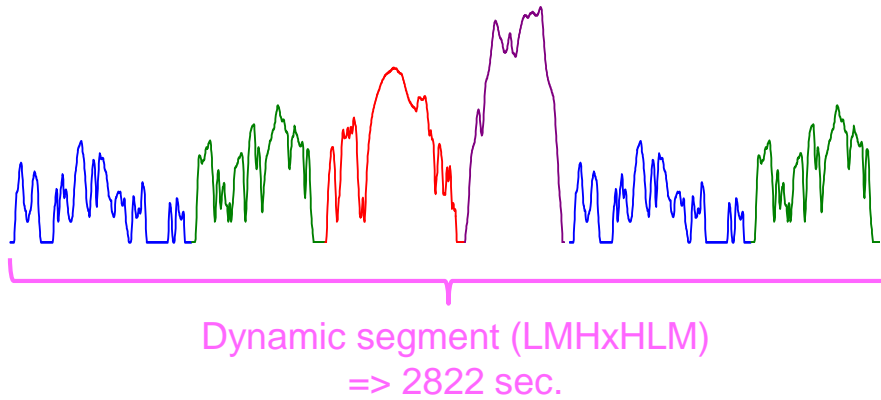
Driving index	Low	Middle	High	Ex-High	Low	Middle	City1	City2	Total
Energy rating [ER]	1.101	0.298	0.551	0.278	0.607	0.148	0.604	0.323	0.430
Distance rating [DR]	0.141	-0.032	0.020	-0.064	0.194	0.031	0.036	0.095	0.021
Energy Economy Rating [EER]	0.950	0.329	0.528	0.342	0.411	0.117	0.564	0.227	0.408
Absolute speed change rating [ASCR]	0.951	0.552	0.742	0.867	0.717	0.119	0.758	0.428	0.643
Root Mean squared Error [RMSSE]	0.267	0.312	0.284	0.256	0.315	0.361	0.287	0.336	0.302
Inertia Work Rating [IWR]	1.001	0.857	0.665	1.141	0.845	0.232	0.915	0.480	0.781

Reference

Continued

2.2. Drive trace indexes for PEV shortened test

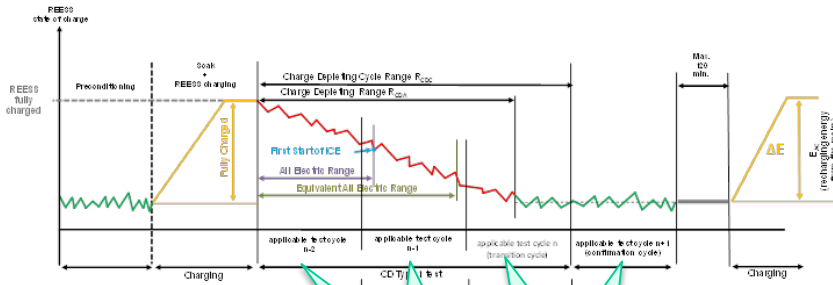
⑦ Number of deviations



- The duration of the dynamic segment is 2822 sec . It is longer than that of WLTC 4 phase.
- Speed tolerance:
 - 4 phase 1800 s => 10 times deviation are allowed = $1/180$ s
 - => 3 phase 1477 s => 8 times
 - => Dynamic segment 2822 s => 16 times

3.1. Drive trace index for OVC-HEV CD tests

⑧ Calculation portion

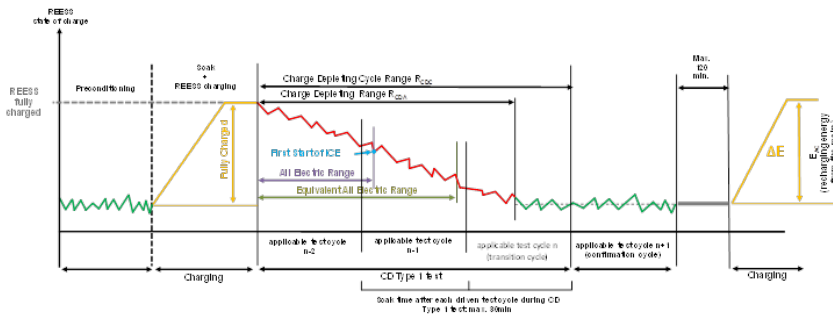


Calculate DTIs respectively

- Calculate DTIs in each cycle

Cycle	IWR	RMSSE	ER/DR/EER/ASCR
1	X.XX	X.XX	...
2	X.XX	X.XX
...
n+1	X.XX	X.XX	...

⑨ Speed trace tolerances

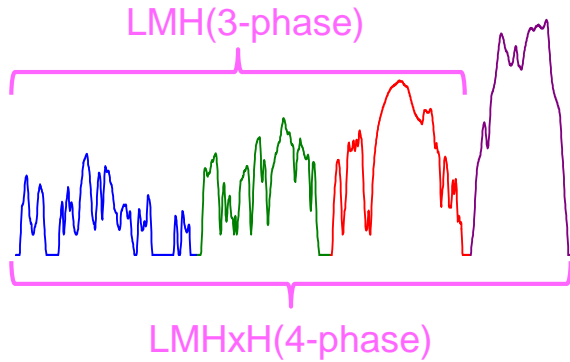


Calculate DTIs respectively

- Follow the paragraph 2.6.8.3 of Annex 6 (There shall be no more than 10 deviations within 1 sec. per each cycle.)

3.2. Drive trace index for OVC-HEV CS tests

⑩ Calculation portion



- Calculate DTIs for LMH(3-phase) or LMHxH(4-phase)

4. Drive trace index for the range extender type vehicles

⑪ Range extender type vehicles

Example



Item	Power (kW)
Electric motor	125
Engine (Generator)	28

- Drivability may be different between CS test and CD test ??

=> Apply the rule described in the paragraph 7.1. of Annex 7

<Necessity condition>

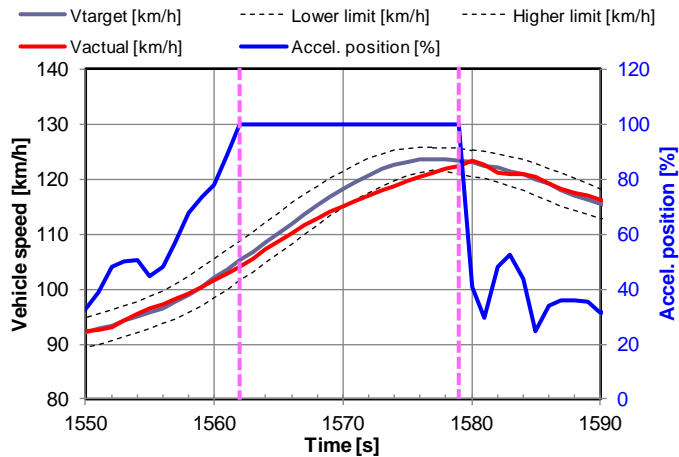
Follow the Annex 8, Appendix 6

- Selected appropriate driver-selectable mode
- Selected appropriate driving cycle
- Applied appropriate cycle modification

Need to discuss on the applicable test cycle (Classification / Cycle modification) for such vehicles.

5. Others

⑫ the accelerator control



- How to check/ensure the accelerator control is fully activated?

=> CAN data or Appropriate sensor
(Potentiometer, Rotary encoder, etc)

=> Accelerator position > 95%?

Discussion points on the DTIs for the electrified vehicles

#	Items	Concerns	Solutions
1	ICEVs	Which part should be calculated the DTIs?	Calculate DTIs for LMH(3-phase) and LMHxH(4-phase) respectively
2	ICEVs	In the case that the accelerator control is fully activated, How to deal with such portion?	(Annex 7, 7.1.) The prescribed speed (value) shall be used instead of the actual vehicle speed(value) for drive trace index calculations
3	PEVs	When the consecutive cycle test procedure is used, which part should be calculated the DTIs?	Calculate DTIs in each cycle
4	PEVs	When the consecutive cycle test procedure is used, how to calculate the DTIs of the cycle that the break-off criterion is reached.	Calculate until the break-off point. The rule of Annex 7-7.1. will be applied until this point.
5	PEVs	It is possible to deviate for 2~3 seconds when a remaining battery level is low. - Break-off: 4 sec or more - Speed tolerance: less than 1 sec on any one occasion	Do NOT accept intentional smooth driving. However if the accelerator control is fully activated, the deviation of 2~3 s may be allowed. Then this portion will be applied the rule described in the paragraph 7.1. of Annex 7. <Necessity condition> Follow the Annex 8, Appendix 6 -Selected appropriate driver-selectable mode -Selected appropriate driving cycle -Applied appropriate cycle modification
6	PEVs	When the shortened test is used, which part should be calculated the DTIs?	Calculate DTI only Dynamic segments.

Continued

Discussion points on the DTIs for the electrified vehicles

#	Items	Concerns	Solutions
7	PEVs	The duration of the dynamic segment is 2822 sec . It is longer than that of WLTC 4 phase. The deviation times should be increased.	4 phase 1800 s=> 10 times deviation are allowed => once per 180 s =>3 phase 1477 s => 8 times =>Dynamic segment 2822 s => 16 times
8	OVC-HEVs (CD test)	Which part should be calculated the DTI?	Calculate DTIs in each cycle
9	OVC-HEVs (CD test)	Speed trace tolerances	Follow the paragraph 2.6.8.3 of Annex 6 (There shall be no more than 10 deviations within 1 sec. per each cycle.)
10	OVC-HEVs (CS test)	Which part should be calculated the DTI?	Calculate DTIs for LMH(3-phase) or LMHxH(4-phase) respectively
11	Range extender type	Driveability may be different between CS tests and CD tests.	Apply the rule described in the paragraph 7.1. of Annex 7. <Necessity condition> Follow the Annex 8, Appendix 6 -Selected appropriate driver-selectable mode -Selected appropriate driving cycle -Applied appropriate cycle modification => Need to discuss on the applicable test cycle (Classification / Cycle modification) for such vehicles.
12	Accelerator control	How to check/ensure the accelerator control is fully activated?	CAN data or Appropriate sensor (Potentiometer, Rotary encoder, etc)

(Ref.) Associated sentence

Annex 6, 2.6.4.4. Accelerations

The vehicle shall be operated with the appropriate accelerator control movement necessary to accurately follow the speed trace. The vehicle shall be operated smoothly, following representative shift speeds and procedures. For manual transmissions, the accelerator controller shall be released during each shift and the shift shall be accomplished in minimum time. If the vehicle cannot follow the speed trace, it shall be operated at maximum available power until the vehicle speed reaches the respective target speed again.

Annex 6, 2.6.8.3. Speed trace tolerances

Vehicles that cannot attain the acceleration and maximum speed values required in the applicable WLTC shall be operated with the accelerator control fully activated until they once again reach the required speed trace. Speed trace violations under these circumstances shall not void a test. Deviations from the driving cycle shall be recorded.

The tolerances shall not be shown to the driver:

- (a) Upper limit: 2.0 km/h higher than the highest point of the trace within ± 1.0 second of the given point in time;
- (b) Lower limit: 2.0 km/h lower than the lowest point of the trace within ± 1.0 second of the given time.

Speed tolerances greater than those prescribed shall be accepted provided the tolerances are never exceeded for more than 1 second on any one occasion.

There shall be no more than ten such deviations per test cycle.

Annex 8, 3.1.1.2.

If the vehicle cannot follow the applicable test cycle within the speed trace tolerances according to paragraph 2.6.8.3. of Annex 6, the accelerator control shall, unless stated otherwise, be fully activated until the required speed trace is reached again.

Annex 8, 3.4.4.1.1. Speed trace and breaks(Consecutive cycle Type 1 test procedure)

The test shall be performed by driving consecutive applicable test cycles until the break-off criterion according to paragraph 3.4.4.1.3. of this annex is reached.

Breaks for the driver and/or operator are permitted only between test cycles and with a maximum total break time of 10 minutes. During the break, the powertrain shall be switched off.

Annex 8, 3.4.4.1.3. Break-off criterion(Consecutive cycle Type 1 test procedure)

The break-off criterion is reached when the vehicle exceeds the prescribed speed trace tolerance as specified in paragraph 2.6.8.3. of Annex 6 for 4 consecutive seconds or more. The accelerator control shall be deactivated. The vehicle shall be braked to standstill within 60 seconds.

Annex 8, 3.4.4.2.1. Speed trace(Shortened Type 1 test procedure)

The shortened Type 1 test procedure consists of two dynamic segments (DS_1 and DS_2) combined with two constant speed segments (CSS_M and CSS_E) as shown in Figure A8/2.

The dynamic segments DS_1 and DS_2 are used to calculate the energy consumption of the phase considered, the applicable WLTP city cycle and the applicable WLTP test cycle. The constant speed segments CSS_M and CSS_E are intended to reduce test duration by depleting the REESS more rapidly than the consecutive cycle Type 1 test procedure.

Annex 8, 3.4.4.2.3. Break-off criterion(Shortened Type 1 test procedure)

The break-off criterion is reached when the vehicle exceeds the prescribed driving tolerance as specified in paragraph 2.6.8.3. of Annex 6 for 4 consecutive seconds or more in the second constant speed segment CSS_E. The accelerator control shall be deactivated. The vehicle shall be braked to a standstill within 60 seconds.

Annex 8, 4.4.2. Pure electric range for PEVs

The ranges determined in this paragraph shall only be calculated if the vehicle was able to follow the applicable WLTP test cycle within the speed trace tolerances according to paragraph 2.6.8.3. of Annex 6 during the entire considered period.

Annex 8 - Appendix 6 , 1.1.

The manufacturer shall select the driver-selectable mode for the Type 1 test procedure according to paragraphs 2. to 4. inclusive of this appendix which enables the vehicle to follow the considered test cycle within the speed trace tolerances according to paragraph 2.6.8.3. of Annex 6. This shall apply to all vehicle systems with driver-selectable modes including those not solely specific to the transmission.

Annex 7. 7. Drive trace indices

7.1. General requirement

The prescribed speed between time points in Tables A1/1 to A1/12 shall be determined by a linear interpolation method at a frequency of 10 Hz.

In the case that the accelerator control is fully activated, the prescribed speed shall be used instead of the actual vehicle speed for drive trace index calculations during such periods of operation.

7.2. Calculation of drive trace indices

The following indices shall be calculated according to SAE J2951(Revised JAN2014):

- (a) ER : Energy Rating
- (b) DR : Distance Rating
- (c) EER : Energy Economy Rating
- (d) ASCR : Absolute Speed Change Rating
- (e) IWR : Inertial Work Rating
- (f) RMSSE : Root Mean Squared Speed Error

(Ref.) Applicable test procedure

The applicable test procedure is selected according to the estimated PER and the vehicle classification(max speed)

Table A8/3

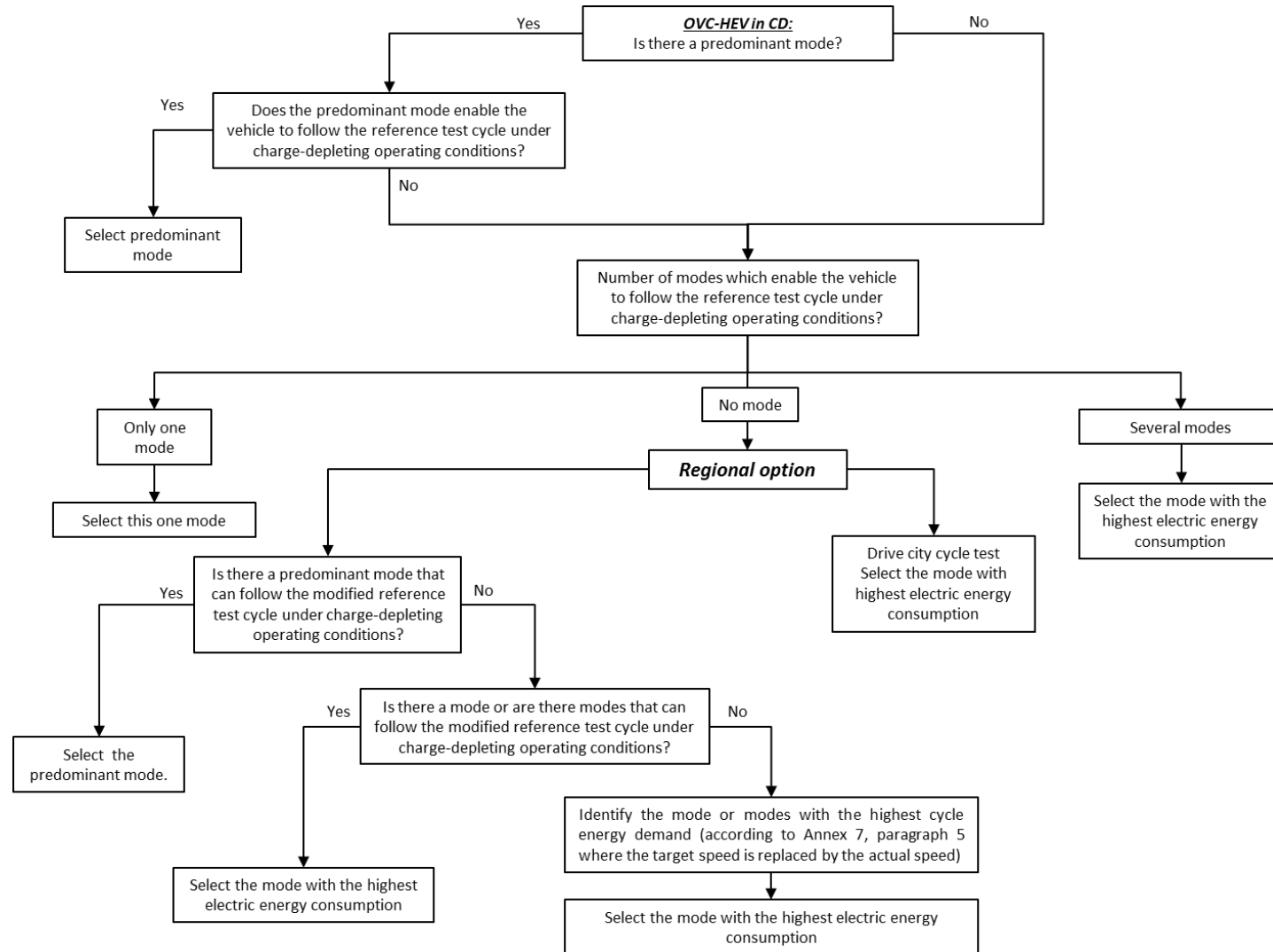
Procedures to determine pure electric range and electric energy consumption

<i>Applicable test cycle</i>	<i>The estimated PER is...</i>	<i>Applicable test procedure</i>
Test cycle according to paragraph 1.4.2.1. of this annex including the extra high phase.	...less than the length of 3 applicable WLTP test cycles.	Consecutive cycle Type 1 test procedure (according to paragraph 3.4.4.1. of this annex).
	... equal to or greater than the length of 3 applicable WLTP test cycles.	Shortened Type 1 test procedure (according to paragraph 3.4.4.2. of this annex).
Test cycle according to paragraph 1.4.2.1. of this annex excluding the extra high phase.	...less than the length of 4 applicable WLTP test cycles.	Consecutive cycle Type 1 test procedure (according to paragraph 3.4.4.1. of this annex).
	...equal to or greater than the length of 4 applicable WLTP test cycles.	Shortened Type 1 test procedure (according to paragraph 3.4.4.2. of this annex).
City cycle according to paragraph 1.4.2.2. of this annex.	...not available over the applicable WLTP test cycle.	Consecutive cycle Type 1 test procedure (according to paragraph 3.4.4.1. of this annex).

(Ref.) Selection of driver-selectable modes for CD test

Figure A8.App6/1

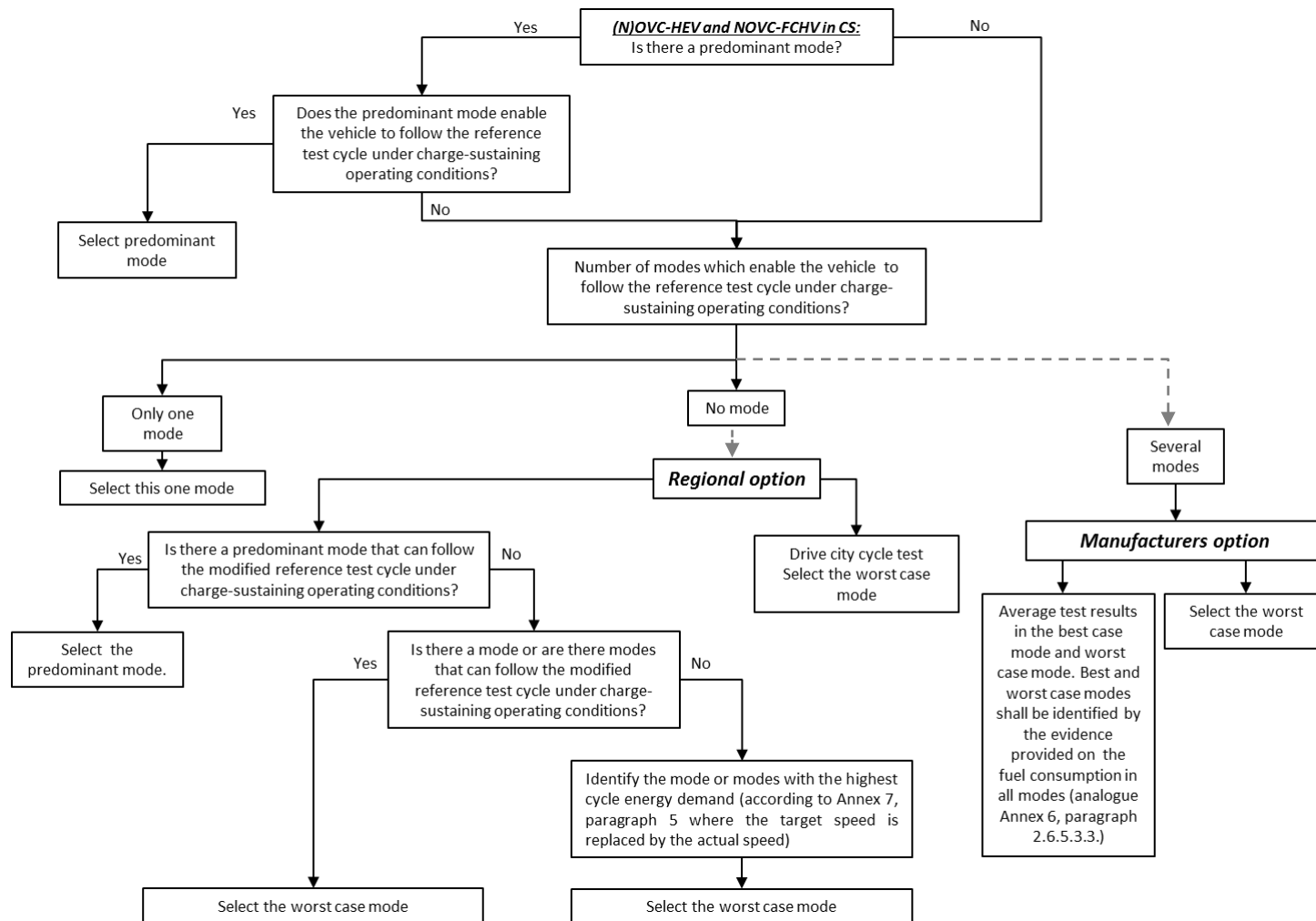
Selection of driver-selectable mode for OVC-HEVs under charge-depleting operating condition



(Ref.) Selection of driver-selectable modes for CS test

Figure A8.App6/2

Selection of a driver-selectable mode for OVC-HEVs, NOVC-HEVs and NOVC-FCHVs under charge-sustaining operating condition



(Ref.) Selection of driver-selectable modes for PEVs

Figure A8.App6/3
Selection of the driver-selectable mode for PEVs

