

In-vehicle battery durability e-HDVs

Open Items

Elena Paffumi, Gian-Luca Patrone
EVE IWG 74th, Tokyo, Japan,
EVE IWG 75TH

September 18th-19th, 2024



e-HDV's tests: open questions EVE IWG 69th

Open points of the draft HDV GTR:

- Proposal to merge Method 1a and Method 1b (OICA proposal EVE IWG 66) : to be discussed; in Japan method 1b is not applicable. If merged, only Method 1a will remain. OICA to verify internally the proposal. To keep both ✓ agreed
- Vehicle selection type approval and for Part A verification (Japan proposal EVE IWG 66): to be discussed
- Driver breaks: km vs time based: time based favourable ✓ JPN: should be confirmed no conflict with RDE ✓ agreed
- Run-in HD-PEV and HD-OVC-HEV: draft in the text ✓ JPN supports draft GTR description ✓ agreed
- Break-off criterion: For HD-PEV, speed or power not kept any longer. ✓ For HD-OVC-HEV draft proposal next slide
- Cruise control use: possible to be used ✓ EU, Japan, US EPA ok to use it ✓ agreed
- Verification and qualification of the on-board data (voltage) (OICA proposal): see next slide (current and voltage) ✓
- Steps of the test procedure (schemes and text in the draft GTR): updated schemes and text in the draft ✓ agreed
- Temperature, road grading/slope, acceleration to the target speed,...Method 1a & 1b: ✓
- Alternative method: draft text added in the GTR
- Test repetitions: Removed ✓ agreed
- MPR and metric: to be discussed

- **EVE IWG 69th: Four items to report to EVE IWG 70th**
 - **Temperature**
 - **Road grading/slope**
 - **Break-off criterion for HD-OVC-HEVs**
 - **Alternative method**

e-HDVs tests: open questions

Open points of the draft HDV GTR:

- Part A family definition ✓ additional revision needed ✓
- Part B family definition ✓ additional revision needed ✓
- Part C family definition placeholder: to be discussed
- Part C Verification of reported virtual distance: to be discussed; updated for both virtual distance concept and En-throughput; to be revised for HDVs scenario
- Part A: Statistical Method for Pass/Fail decision for a sample of vehicle ✓ agreed as it is
- Parameter A statistic to be revised in case due to voltage measurement: data needed
- Revision of the definitions in the draft GTR: to check REESS, Battery,... ✓
- Auxiliary systems are used to complete the battery discharge: break-off criterion Manufacturer should demonstrate the equivalency between the indicate the warning light condition and the 4 seconds rule for this specific case to stop the test. Prove given to TA .
- Selection of testing methods: technology driven (if bidi available or not) or manufacturer option between Method 1a,1b, 2? Alternative method, CP option? Annex 3, Par. 2
- 'small-volume manufacturer', (added the EU reference in definition), Special purpose, off-road and all-wheel-drive vehicles ✓
- Annex 1: dynamic charging technology survey: no exclusion, but monitoring and reporting ✓
- Annex 1: Was the vehicle not charged adequately* for the last month? by driving the vehicle no less than **50 km** ✓
- Vehicle selection
- Annex 2
- ~~Required information paragraph, to be moved to Annex 1? Shall/may or remove the text~~
- Monitored parameters to be kept for monitoring the tests
- Table A3/1 Measurement items and required accuracy
- Break-off The vehicle can be driven to reach the charging spot after the brake to standstill requirement has been met. ~~Two options: increase the 60 seconds, allow to still drive after the brake to standstill~~
- 'The equivalence of the method with Method 1a, 1b and 2 shall be demonstrated to the responsible authority.' ?
- Method 2 steps, name ...

e-HDVs test open questions: temperature ✓



ALTERNATIVE TO CONSIDER

- Pre-conditioning, soak and charge to be carried out in a test room/soak area, [23 °C ±5; ± 7 °C] [25 °C ±7; ± 10 °C] → **25 °C ±5;**
- If test room/soak area not available, not applicable..., allowed to use pre-warming of the battery in cold environment with internal designed functional systems with measurement of the energy

➤ ~~from RDE moderate conditions (0 to 35 C)~~

Japan: to improve practical test execution, propose RDE moderate conditions (0 ~ 35 C). based on technical justification, OK to expand the 5% tolerance in case of outside range from 18 ~ 30C.

PLUS THIS REQUIREMENT ON EXTERNAL SYSTEM

- Not allowed the pre-warming of the battery with an external system, different from a charging station
- Part A verification: A parameter discussion

To provide your views
Pilot test phase in support to revision



- **EVE IWG 69th: Four items to be reported to EVE IWG 70th**
 - **Temperature. To discuss after the pilot phase**
 - **Road grading/slope**
 - **Break-off criterion for HD-OVC-HEVs**
 - **Alternative method**

e-HDV's tests open questions: acceleration, road grading/slope ✓

Japan:

to improve practical test execution, propose to apply same conditions as RDE requirement means that “the cumulative elevation gain” shall be less than 1,200m / 100km

- Road grading/slope, accuracy on UBE to add?
- Effect of the acceleration to the target speed with road grading/slope
- Effect on the last portion of the test: grading, payload, speed, power request ... near the break-off point

EVE IWG 70th
favourable

PROPOSAL TO CONSIDER

- Proposal to apply same conditions as RDE requirement on all the route/test: “the cumulative elevation gain” shall be less than 1,200m / 100km **and be determined according to(RDE Appendix 7b as example, regional regulations, ...).**
- Effect on the last portion of the test: slope at the end of the test to be reported
- No conditions for method 1b as per method 1a

To provide your views
Pilot test phase in support to revision

- **EVE IWG 69th: Four items to be reported to EVE IWG 70th**
 - **Temperature**
 - **Road grading/slope. To discuss after the pilot phase**
 - **Break-off criterion for HD-OVC-HEVs**
 - **Alternative method**

e-HDV's tests open questions:

Break-off criterion

□ Break-off criterion Method 1a, 1b:

- For HD-PEV speed or power not kept any longer ✓ 4 sec rule agreed
- Break-out session 23rd Oct 2024: If the HD-PEV does not experience a decrease of driving speed or a driving power cut due to the vehicle design or the battery cannot be depleted on the road for safety reason, the last part of the test shall be agreed with the local authority.
- For HD-OVC-HEV draft proposal in the next slide
- Proposal on cumulative UBE to be revised to reflect distance driven, operational mode etc.
- ~~If auxiliary systems are used to complete the battery discharge: break-off criterion; the level of warning signal should be equivalent to the 4 seconds criterion,...~~

To provide your views

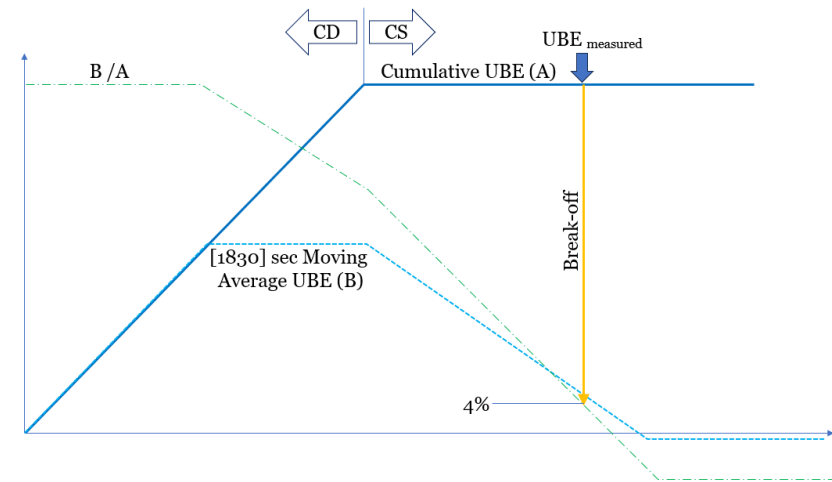


- EVE IWG 69th: Four items to be reported to EVE IWG 70th
 - Temperature
 - Road grading/slope
 - **Break-off criterion for HD-OVC-HEVs. Still open**
 - Alternative method

e-HDV's tests open questions: Break-off criterion

Break-off criterion **Method 1a, 1b:**

- For HD-PEV speed or power not kept any longer ✓ 4 sec rule agreed
- For HD-OVC-HEV draft proposal in the text based on LDV-OVC-HEV



- [In case of HD-OVC-HEVs the pure electric vehicle test operation mode shall be selected. The break-off criterion is reached when ...].

ALTERNATIVE TO CONSIDER

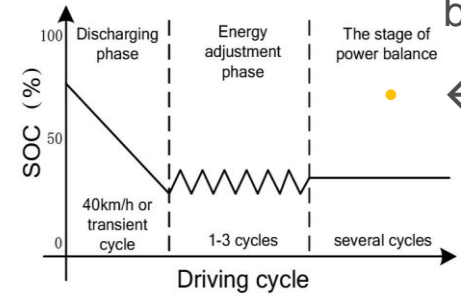
- [the vehicle cannot drive in pure electric mode for [4] consecutive seconds or more without recuperation from the engine operation]
- [the $|\Delta E_{REESS,dt}|$ in the last xx dt of driving is equal to or less than xx per cent of the ~~total nominal energy capacity of the battery~~ **cumulative UBE**. The manufacturer shall provide evidence to the responsible authority after the test that this requirement is fulfilled.]
- [For HD-OVC-HEV, the end of the charge-depleting test is considered to have been reached at the end of the energy adjustment phase when the break-off criteria is reached for the first time in the stage of power balance.]

favourable

← China proposal

Japan: at least 1500sec ?
JE05 : 1830 sec
WLTP 4 : 1800 sec
WLTP 3 : 1477 sec

Japan: 4 per cent of cumulative UBE



e-HDV's tests open questions: Break-off criterion EVE IWG 71st

Japan: at least 1500sec ?
JE05 : 1830 sec
WLTP 4 : 1800 sec
WLTP 3 : 1477 sec

Break-off criterion Method 1a, 1b:

➤ For HD-OVC-HEV draft proposal in the text based on LDV-OVC-HEV

Japan: 4 per cent of cumulative UBE

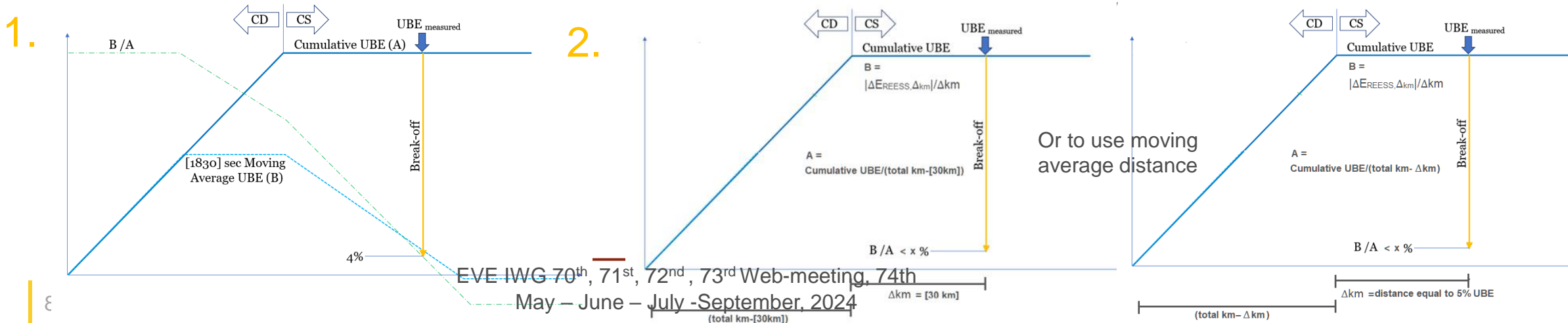
- [In case of HD-OVC-HEVs the pure electric vehicle test operation mode shall be selected. The break-off criterion is reached when ...].

1. [the $|\Delta E_{REESS,dt}|$ in the last xx dt of driving is equal to or less than xx per cent of the cumulative UBE. The manufacturer shall provide evidence to the responsible authority after the test that this requirement is fulfilled.]

30 km ? → Percentage of UBE (5%) instead of km

2-3-5 per cent ?

2. [the $|\Delta E_{REESS,\Delta km}|/\Delta km$ in the last xx km of driving is equal to or less than xx per cent of the cumulative UBE/(total distance travelled - Δkm) (energy consumption before the last Δkm). The manufacturer shall provide evidence to the responsible authority after the test that this requirement is fulfilled.]



e-HDVs tests open questions: Break-off criterion

□ Break-off criterion Alternative method:

- For HD-PEV speed or power not kept any longer ✓ 4 sec rule agreed
- For HD-OVC-HEV draft proposal in the next slide

To provide your views




- EVE IWG 69th: Four items to be reported to EVE IWG 70th
 - Temperature
 - Road grading/slope
 - Break-off criterion for HD-OVC-HEVs. Still open
 - Alternative method

e-HDVs tests open questions: Break-off criterion

□ Break-off criterion Alternative method:


- For HD-PEV speed or power not kept any longer ✓ 4 sec rule agreed
- For HD-OVC-HEV draft proposal in the text based on LDV-OVC-HEV

- 
- [the relative electric energy change, REEC in the last xx dt of driving, as defined in the following equation, is less than [4] or [5] percent.

$$REEC_{dt} = \frac{|\Delta E_{REESS,dt}|}{E_{cycle} \times \frac{1}{3600}}$$

E_{cycle} is the total energy demand E for the whole cycle ...]

same
criterion
as
Method
1a/1b?

- 
- [the $|\Delta E_{REESS,dt}|$ in the last xx dt of driving is equal to or less than xx per cent of the total nominal energy capacity of the battery-cumulative UBE. The manufacturer shall provide evidence to the responsible authority after the test that this requirement is fulfilled.]
 - [the $|\Delta E_{REESS,\Delta km}|/\Delta km$ in the last xx km of driving is equal to or less than xx per cent of the cumulative UBE/(total distance travelled - Δkm) (energy consumption before the last Δkm). The manufacturer shall provide evidence to the responsible authority after the test that this requirement is fulfilled.]
 - To refer to regional regulations for HD-OVC-HEV dyno testing, if available (i.e. REEC)

30 km ? → Percentage of UBE (5%) instead of km

2-3-5 per cent ?

e-HDV's tests open questions: Steps of the test procedure ✓

- Agreed as reported in the following slides ✓
- Soak and charge temperature [25 °C ±5 °C] if in a test room ✓ agreed
- Soak and charge for a minimum of 6 hours and a maximum of 36 hours ✓ agreed
- ~~With a C-rate in the range of [C/6 or less, C/2]~~ to remove this requirement since there is already the requirement on the speed ✓ agreed . **To leave it in Method 2**
- ~~If on-board system are used to complete the REESS depleting due to safety reason (method 1a and 1b), c-rate? (Typically is automatically set). Criterion for stopping the test?~~ ✓ Break out session on 23rd October 2024 decision not to consider this option
- Variability of test methods, the same test method in certification and ISC,..if UBE is declared which is the test to keep in ISC “the same”?
- **“A” parameter revision, based on data**

Method 1a Discharge by standard average speed on a test track

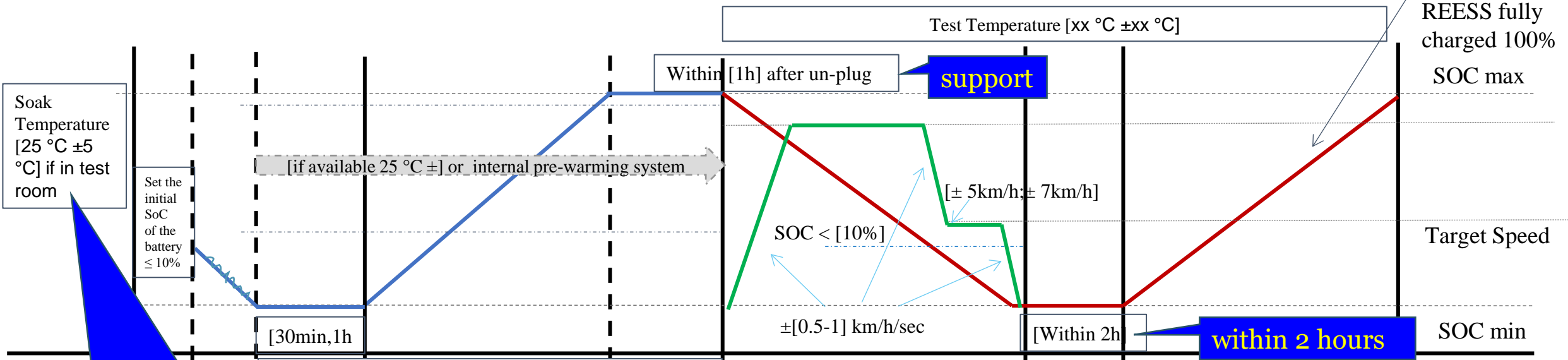
- Range of speed per category per region track
- To leave open the speed for the test and prescribe only the target speed in the last part of the test for which a speed tolerance will be applied
- The last part of the test starts when the SOC < [10%] (to be verified)
- Speed tolerance in last test segment [$\pm 5\text{km/h}; \pm 7\text{km/h}$]
- The acceleration/deceleration during vehicle speed change shall be smooth and accomplished within the range $\pm[0.5-1]$ km/h/sec
- End of discharge: break-off criterion
- Temperature provision due to cold temperature effect

[Charging and discharging
C-rate equal or less than C/5
Highest normal charging power available $\leq 150\text{kW}$

Ex: $800\text{kWh} \rightarrow C/5$ 160kW
 $1200\text{kWh} \rightarrow C/5$ 240kW; C/10 120kW

It is allowed to complete the charging by applying a slower charging rate with/without waiting time if the selected power/c-rate charging does not allow to reach the full charged status

from RDE moderate conditions (0 to 35 C)?



Soak Temperature [$25\text{ }^\circ\text{C} \pm 5\text{ }^\circ\text{C}$] if in test room

Set the initial SoC of the battery $\leq 10\%$

[30min, 1h]

Within [1h] after un-plug

support

REESS fully charged 100% SOC max

Target Speed

SOC min

Pre-charge

Soak and charge for a [minimum of 6 hours and a maximum of 36 hours]

Test

- Battery full discharge with a characteristic speed and payload for GVW/GCW
- With a C-rate in the range of [C/6 or less, C/2]
- End of discharge: break-off criterion (exceeding the driving speed tolerance for 4 consecutive seconds or more)

Test

Battery full const. power or C-rate from speed limit for GVW/GCW
Normal charging [Equal or less than C/5]
Highest normal charging power $\leq 150\text{kW}$

Japan: 23 or $25 \pm 5 = 18 \sim 30\text{ }^\circ\text{C}$ as an option, wider temperature range is acceptable without any correction if manufacture allows.

6 to 36 hours

not able to support



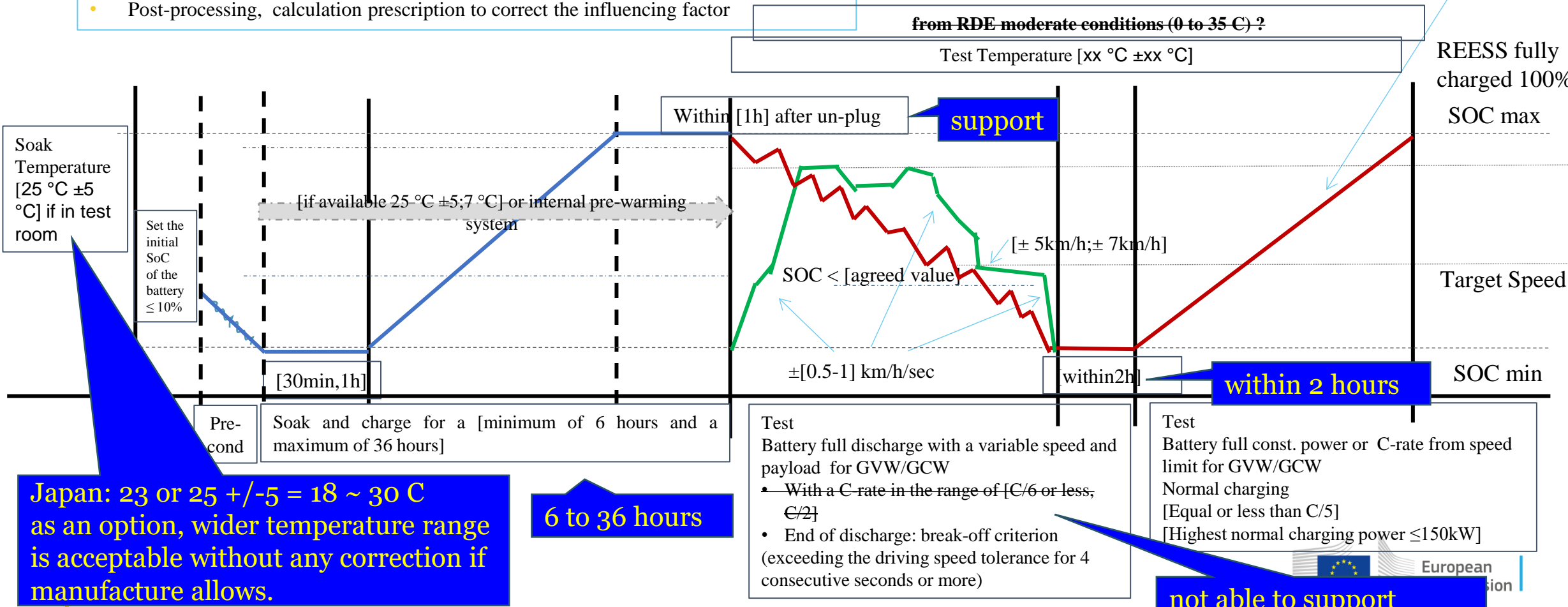
Method 1b Discharge by driving on the road with average speed

- Range of on-road speed per category per region
- To leave open the speed for the test
- The last part of the test starts with a given SOC level
- Some agreement with local regional authority for SOC minimum level and test
- Same route as type approval or different in accordance with regional authority
- If same routes is used, different provision on minimum SOC level and test
- Speed tolerance? in last test segment ?
- The acceleration/deceleration during speed change shall be as smooth as possible in relation to traffic conditions and safety of driving
- Post-processing, calculation prescription to correct the influencing factor

[Charging and discharging
C-rate equal or less than C/5
Highest normal charging power available $\leq 150\text{kW}$

Ex: $800\text{kWh} \rightarrow C/5 \ 160\text{kW}$
 $1200\text{kWh} \rightarrow C/5 \ 240\text{kW}; C/10 \ 120\text{kW}$

It is allowed to complete the charging by applying a slower charging rate with/without waiting time if the selected power/c-rate charging does not allow to reach the full charged status



Method 2 bidirectional charging system available

Japan: 23 or 25 +/- 5 = 18 ~ 30 C as an option, wider temperature range is acceptable without any correction if manufacture allows.

Vehicle transfer from the soak area. This shall be done without any unjustified delay and in any case within [20] minutes. During that time the vehicle shall not receive unjustified exposure to other temperatures but if that is unavoidable this time should in any case be limited to a maximum of [10] minutes.

It is allowed to complete the charging by applying a slower charging rate with/without waiting time if the selected power/c-rate charging does not allow to reach the full charged status

[Charging and discharging C-rate equal or less then C/5]
Highest normal charging power available [$\leq 150\text{kW}$]

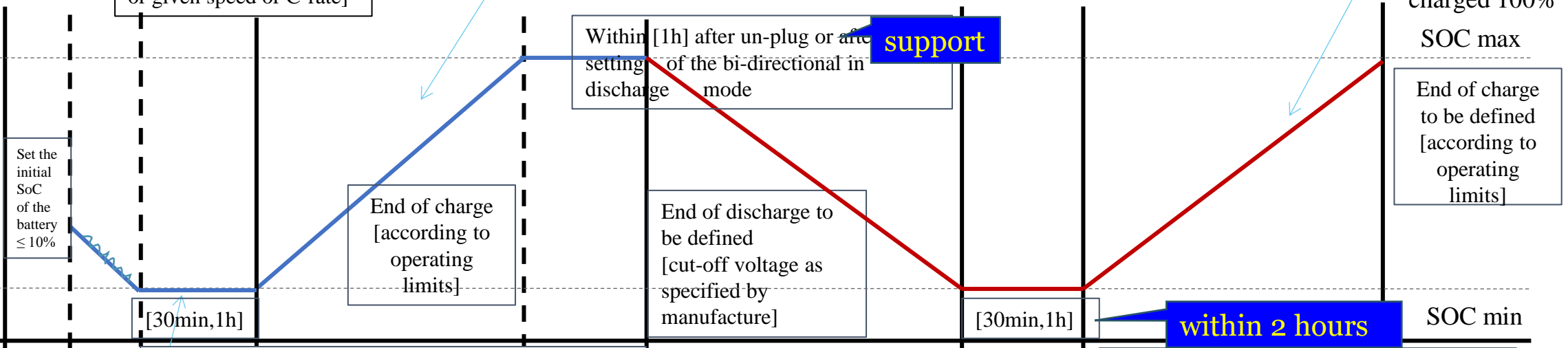
Ex: 800kWh \rightarrow C/5 160kW
1200kWh \rightarrow C/5 240kW; C/10 120kW

It is allowed to complete the charging by applying a slower charging rate with/without waiting time if the selected power/c-rate charging does not allow to reach the full charged status

within 0 ~ 35 C

Test Temperature [23 °C \pm 5 °C]

Test Temperature [23 °C \pm 5 °C]



follow manufacture recommendation

6 to 36 hours

within 2 hours

not able to support

End of discharge to be defined for bi-directional charging test [Cut-off voltage]

Charging at full the battery with normal charging [Equal or less than C/5]
[Highest normal charging power $\leq 150\text{kW}$]

Test Battery full discharge with constant power or constant C-rate from the characteristic speed for GVW/GCW
With a C-rate in the range of [C/6 or less, C/2]

Test Battery full charge with constant power or constant C-rate from the characteristic speed for GVW/GCW
Normal charging [Equal or less than C/5]
[Highest normal charging power $\leq 150\text{kW}$]

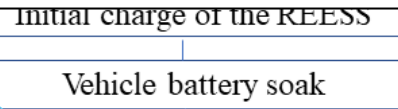
e-HDV's tests open questions: test repetition



- Method 1a
- Method 1b
- Method 2
- Alternative Method

EVE IWG 69th

➤ Decision to remove it agreed ✓



- EVE IWG 70th: OICA proposal to allow repetitions for Method 2
- EVE IWG 71th: OICA agreed to remove repetitions for Method 2 with comment on RTE check

proposal to delete possible scenarios

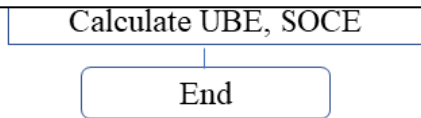
#2
no repetition with the additional tolerance based on ambient temperature

EVE-68-08e
Repetition of RTE test criterion :
1.000±0.050 @Ah

OEM Declaration value±0.050@kWh
for UBE_{certified}

EVE IWG 71th

➤ Agreed ✓



#1
repetition without any additional tolerance
to be handled as a part of statistical analysis process)

e-HDVs tests open questions: REESS voltage measurement ✓

- Verification and qualification of the on-board data (voltage) (OICA proposal)
- Draft text:
- Measurement of the voltage and current
- Possibility to use on-board-data

OK with this

■ [As an alternative to the use of voltage measurement devices, use of on-board measurement data is permissible if the accuracy and frequency of these data is demonstrated to the responsible authority to meet the minimum requirements for accuracy and frequency described in [paragraph 2.2. of this annex]

and frequency

■ [The on-board measurement data is confirmed by direct measurement verification

EVE IWG 69th

➤ Agreed ✓

service testing only when the accuracy of on-board measurement data at the inspection point is made available for the direct

➤ Possibility to use on-board data during ISC but to retain the ability to measure the voltage

■ [External REESS voltage measurement (GTR No. 15)]

- The REESS voltage shall be measured with the equipment and accuracy requirements specified in paragraph x.x. of this annex. To measure the REESS voltage using external measuring equipment, the manufacturers shall support the responsible authority by providing REESS voltage measurement points and safety instructions.

■ [Vehicle on-board REESS voltage data (GTR No. 15)]

- As an alternative to the external REESS voltage measurement specified in paragraph x.x. of this annex, the manufacturer may use the vehicle on-board REESS voltage measurement data. The accuracy of these data shall be demonstrated to the responsible authority.]

e-HDVs tests open questions: **Alternative method**

- Draft text added in the draft HDV GTR to be revised and completed

propose to allow the additional cycle as a CP option.
(please refer “15_13-03-2024-GTR HDV battery durability working draft GTR - v15_JPN.docx”)

- To revise the text and refer as much as possible to regional regulations
- Driver breaks to check
- Proposal to rename it as Method 3
- Phase 1, Phase 2 discussion

To provide your views



- **EVE IWG 69th: Four items to be reported to EVE IWG 70th**
 - **Temperature**
 - **Road grading/slope**
 - **Break-off criterion**
 - **Alternative method**

e-HDVs tests open questions: Metric and MPR

- To be discussed
- JRC presentation as overview
- Japan proposal
- China proposal
- OICA proposal
-

e-HDVs tests open questions: Battery Replacement?

- EVE IWG 70th: to be addressed in the second phase ✓

e-HDVs tests open questions: Vehicle group O trailers and semitrailers ?

- EVE IWG 70th: to be addressed in the second phase ✓

e-HDVs GTR: where are we?

- **Draft HDV GTR text** (open or revised elements are in track changes)
 - Rational under development
 - MPR and metric (including En-throughput and eventual virtual distance discussion if needed)
 - Family concept: Part A, Part B and if needed Part C ✓
 - Vehicle selection type approval and for Part A verification (Japan proposal EVE IWG 66)
 - Part A Statistical method pass/fail decision ✓
 - Part B Pass/Fail Criteria for the battery durability family
 - Part C Verification of reported virtual distance
 - Annex 1 dynamic charging technology (vehicle exclusion from Part A ?)
 - Annex 2 Values to be read from vehicles
 - Annex 3 EVE-68-04e
 - Vehicle speed definition in Method 1a and Method 1b
 - Recording frequency of the measurements: 20Hz during discharge, 0.033Hz during recharge
 - Break-off criterion OVC-HEVs
 - Alternative method draft text
 - Annex 4 (optional) MPR and metrics
- **e-HDVs test procedures:** Open Item List EVE-68-04e, EVE-69-07e
- **MPR and metric:** EVE-68-11e, EVE-69-06e, EVE-69-10e, EVE-69-23e, EVE-72-06e

EVE IWG 70th, 71st, 72nd, 73rd Web-meeting, 74th
May – June – July -September, 2024

Thank you

Contacts Info:

EC DG JRC DIR-C EMC Sustainable, Smart and Safe Mobility Unit
elena.paffumi@ec.europa.eu, gian-luca.patrone@ec.europa.eu



© European Union 2024

Unless otherwise noted the reuse of this presentation is authorised under the [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/) license. For any use or reproduction of elements that are not owned by the EU, permission may need to be sought directly from the respective right holders.