In-vehicle battery durability e-HDVs
Open Items

Elena Paffumi, Gian-Luca Patrone

EVE IWG 70th , web-meeting,

May 7th-8th , 2024

European Commission

e-HDVs 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: to be discussed
- 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 EVE IWG 69-70th

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 oscillation during 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

- **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 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

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

e-HDVs 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

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

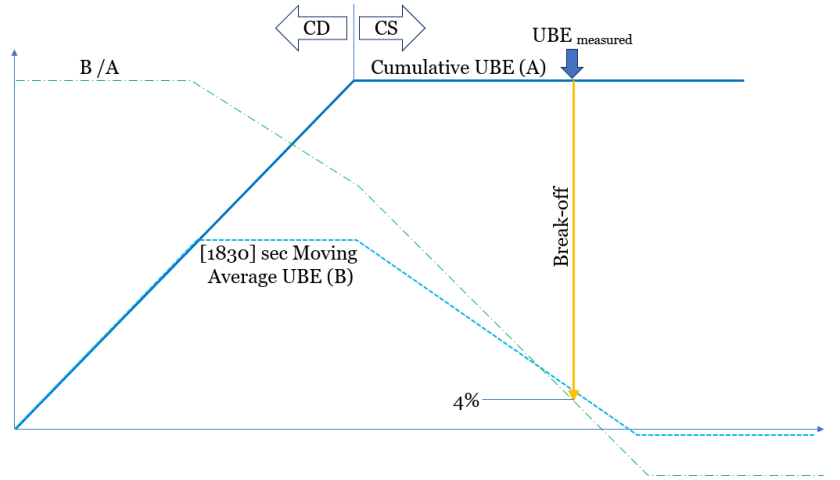
e-HDVs tests open questions: Break-off criterion

- 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 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-HDVs tests open questions: Break-off criterion

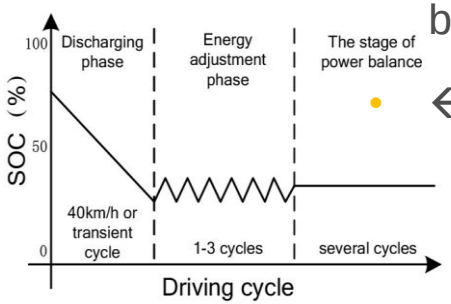


- Break-off criterion **Method 1a, 1b**:
  - For HD-PEV speed or power not kept any longer ✓ 4 sec rule agreed
  - For HD-OVC-HEV draft proposal in the text based on LDV-OVC-HEV
    - [In case of HD-OVC-HEVs the pure electric vehicle test operation mode shall be selected. The break-off criterion is reached when …].

ALTERNATIVE TO CONSIDER

favourable

- [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.]
- ← China proposal



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

Japan: 4 per cent of cumulative UBE

European Commission

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.]
- To refer to regional regulations for HD-OVC-HEV dyno testing, if available (i.e. REEC)

e-HDVs 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?
- 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
- 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 [± 5km/h;± 7km/h]
- The acceleration/deceleration during vehicle speed change shall be smooth and accomplished within the range ±[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 then C/5]
Highest normal charging power available [≤150kW]

Ex: 800kWh →C/5 160kW
1200kWh →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) ?~~

Test Temperature [xx °C ±xx °C]

REESS fully charged 100%

SOC max

Target Speed

SOC min

Soak Temperature [25 °C ±5 °C] if in test room

Set the initial SoC of the battery ≤ 10%

[if available 25 °C ±] or internal pre-warming system

Within [1h] after un-plug

support

[± 5km/h;± 7km/h]

SOC < [10%]

±[0.5-1] km/h/sec

[30min,1h

[Within 2h

within 2 hours

Pre-cond

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

6 to 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 ≤150kW]

not able to support

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

European

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

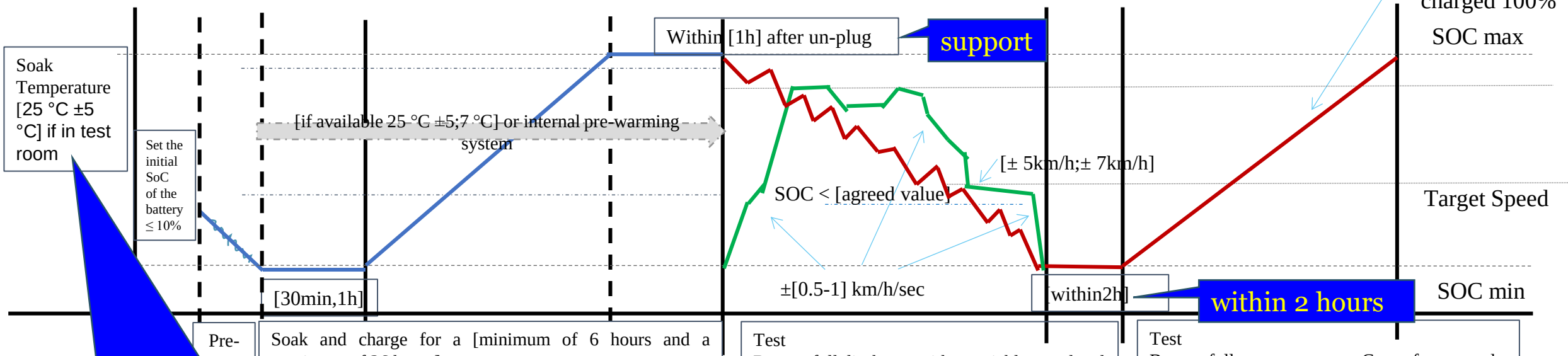
[Charging and discharging
C-rate equal or less then C/5]
Highest normal charging power available [≤150kW]

Ex: 800kWh →C/5 160kW
1200kWh →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) ?~~

Test Temperature [xx °C ±xx °C]



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

6 to 36 hours

Test
Battery full discharge with a variable 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 ≤150kW]

not able to support

European

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 [≤150kW]

Ex: 800kWh →C/5 160kW
1200kWh →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

Battery discharge
[according to manufacturer's recommendation
or given speed or C-rate]

within 0 ~35 C

Test Temperature [23 °C ±5 °C]

REESS fully charged 100%

SOC max

Test Temperature [23 °C ±5 °C]

Within [1h] after un-plug or after setting of the bi-directional in discharge mode

support

End of charge to be defined [according to operating limits]

Set the initial SoC of the battery ≤ 10%

End of charge [according to operating limits]

End of discharge to be defined [cut-off voltage as specified by manufacture]

[30min,1h]

[30min,1h]

within 2 hours

SOC min

Pre-

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

follow manufacture recommendation

6 to 36 hours

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 ≤150kW]

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 ≤150kW]

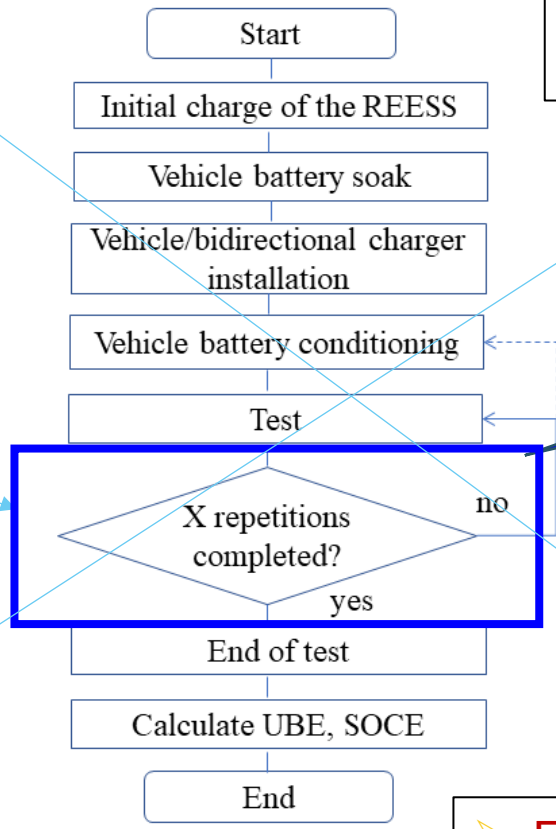
not able to support

e-HDVs tests open questions: test repetition

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

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

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



EVE IWG 69th
- Decision to remove it ✓ agreed

Japan: proposal to delete
Then two possible scenarios

#1
no repetition without any additional tolerance
(can be handled as a part of statistical analysis process)

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

- EVE IWG 70th: OICA proposal to allow repetitions for Method 2
- to be checked by them further, why only Method 2

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 d… service testing only when the accuracy of on-board measurement data is confirme… e inspection point is made available for the direct measurement verification

EVE IWG 69th
- Agreed

- **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
- **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

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 Commission