# *In-vehicle battery durability e-HDVs*
# *Open Items*

Elena Paffumi, Gian-Luca Patrone
Web Meeting, February 28th-29th, 2024

European Commission

# e-HDVs tests: open questions EVE IWG 68th

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.
- 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 ✓
- Run-in HD-PEV and HD-OVC-HEV: draft in the text ✓
- Break-off criterion: For HD-PEV, speed or power not kept any longer. ✓ For HD-OVC-HEV draft proposal in the text
- Cruise control use: possible to be used ✓
- Verification and qualification of the on-board data (voltage) (OICA proposal): to be discussed
- Steps of the test procedure (schemes and text in the draft GTR): updated schemes and text in the draft
- 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: to be discussed
- MPR and metric: to be discussed

# e-HDVs test open questions: temperature

- Temperature Method 1a and Method 1b, to suggest a range of values?
- Soak, pre-conditioning and charge at 23°C: to add a sentence in case it is not applied?
  - To try to limit the effect of the temperature in the UBE measured in test 1a and 1b:

    - Higher variation in the UBE measurements at cold
    - UBE certified at cold smaller than UBE certified 23°C
    - To be avoided UBE certified at 23°C and UBE ISC at -5°C for instance

      $SOCE = (UBE_{meas})_{-5°C} / (UBE_{cert})_{23°C}$
    - Comparison between different vehicles in the family tested at different temperatures (Part A, Part B) ?

      $(UBE_{meas}/UBE_{cert})23°C$ vs $(UBE_{meas}/UBE_{cert})0°C$

  - Tolerance on the UBE measured?
  - ~~Corrective factor related to temperature?~~
  - ~~To suggest a range of temperature values?~~

# e-HDVs test open questions: temperature ✓?

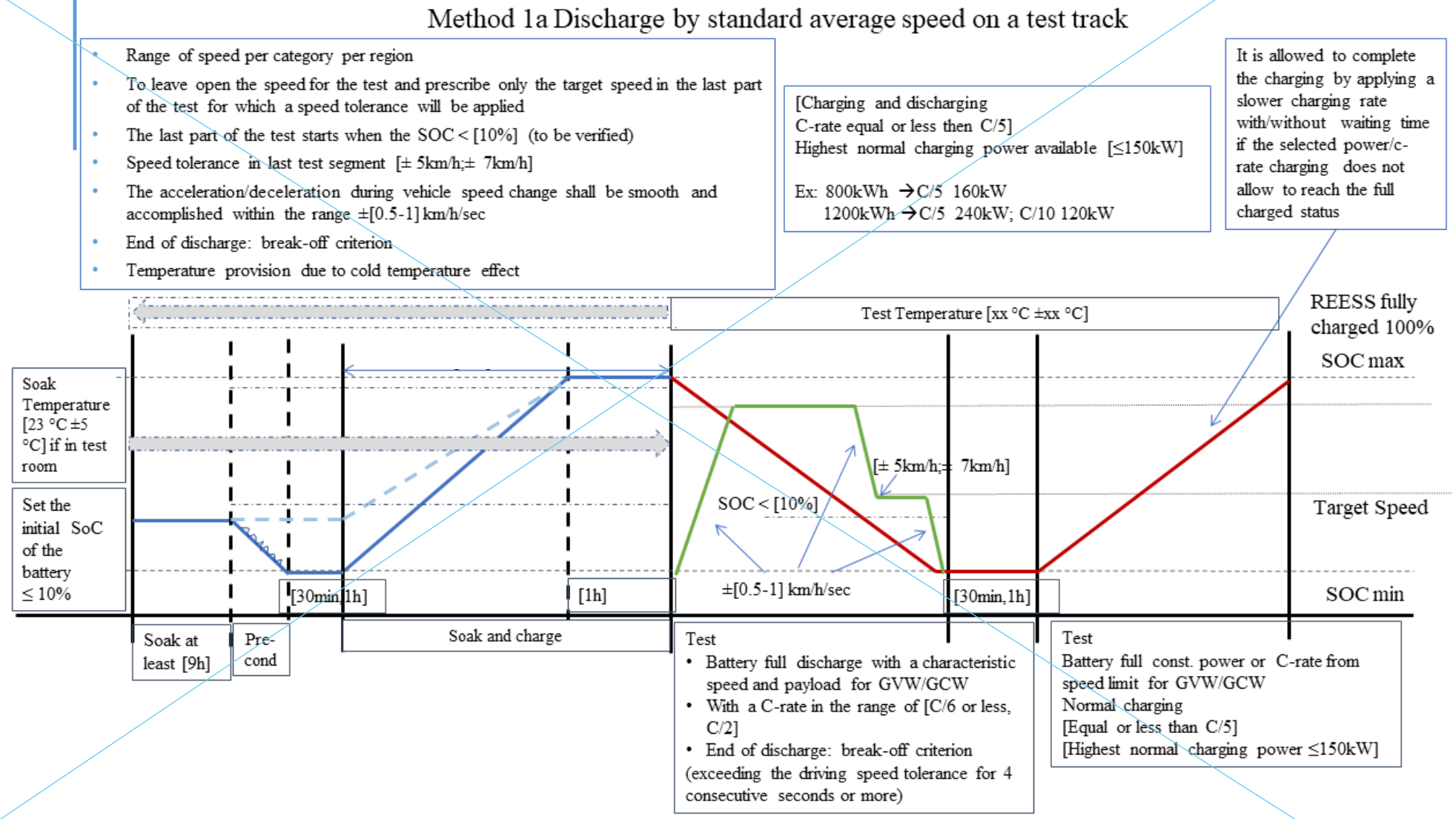
- ~~[The [average] ambient temperature during the test shall be in a given range of values to guarantee the consistency of the UBE measured results at type approval and in-service testing.~~

  ~~The temperature ranges are defined as followed:~~

  - ~~Warm temperature [>30°C]~~
  - ~~Medium temperature [10°C, 25°C ]~~
  - ~~Low temperature [2°C,5°C]~~
  - ~~Cold temperature [<-3°C] (higher variation in the UBE measurements below 0°C; UBE certified smaller than UBE certified 23°C)~~

- from RDE moderate conditions (0 to 35 C) ?
- Pre-warming of the battery in cold environment with measurement of the energy?
- Pre-warming of the battery with an external system
- Active/passive BMS
- ~~In case the soak, pre-conditioning, soak and charge are not carried out in a test room, they shall be performed at the same temperature range of the following test as depicted in Figure A3/2 ?~~

# e-HDV tests open questions: temperature



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

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]

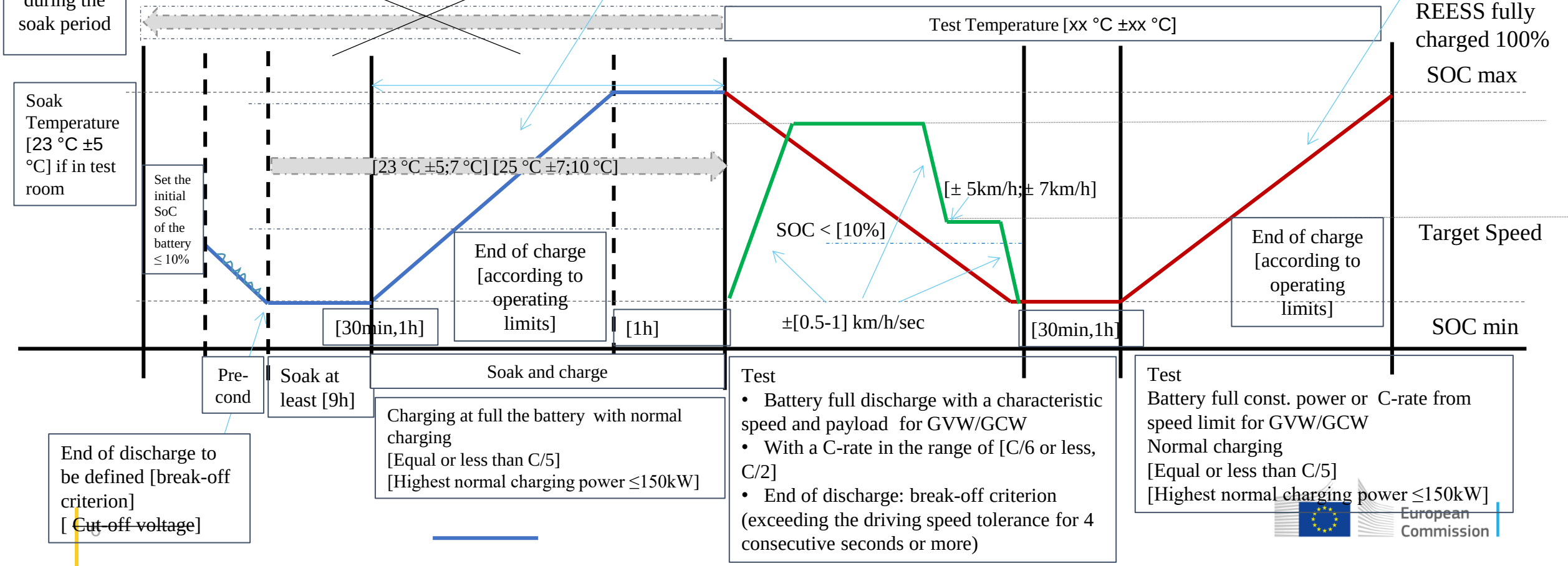
Ex: 800kWh →C/5 160kW
1200kWh →C/5 240kW; C/10 120kW

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

The REESS shall not be charged during the soak period

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

**from RDE moderate conditions (0 to 35 C) ?**




End of discharge to be defined [break-off criterion]
[ ~~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 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]



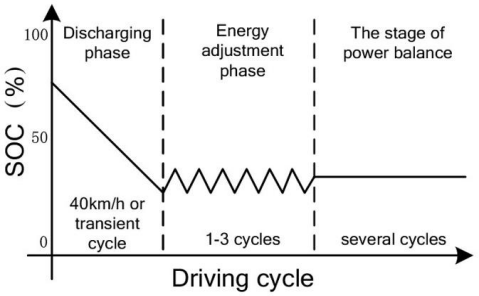
European Commission

# e-HDVs tests open questions: acceleration, road grading/slope ✓

- Road grading/slope, accuracy on UBE to add? Correction factor?
- Effect of the acceleration to the target speed with road grading/slope

# e-HDVs tests open questions: Break-off criterion

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



# e-HDVs tests open questions: Break-off criterion

- Break-off criterion Alternative method:
  - 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.

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

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

    - [the $\left|\Delta E_{REESS,dt}\right|$ 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.]

# e-HDVs tests open questions: Steps of the test procedure ✓

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

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]

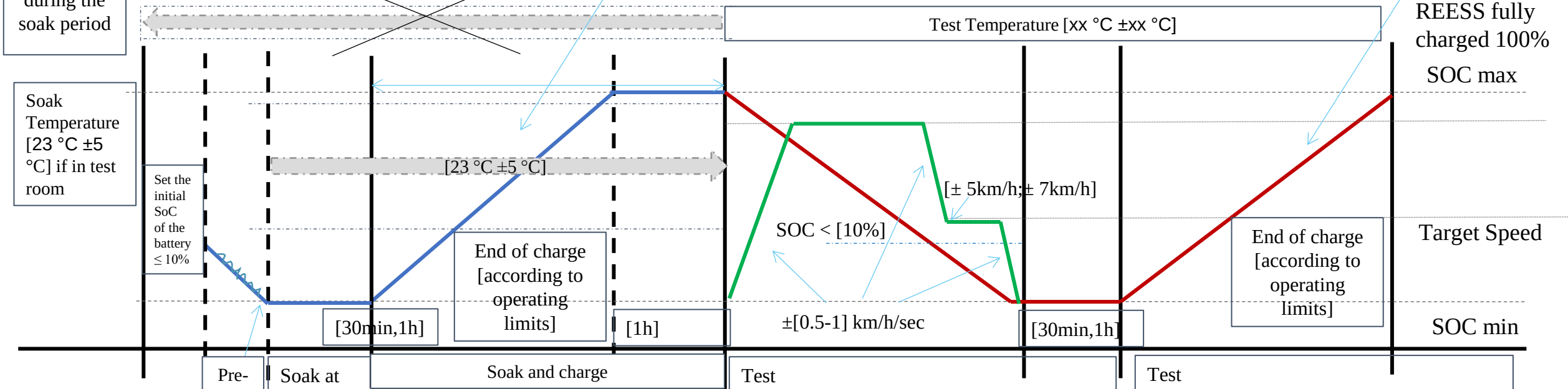
Ex: 800kWh →C/5 160kW
1200kWh →C/5 240kW; C/10 120kW

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

The REESS shall not be charged during the soak period

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

**from RDE moderate conditions (0 to 35 C) ?**




End of discharge to be defined [break-off criterion]
[ ~~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 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]



European Commission

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

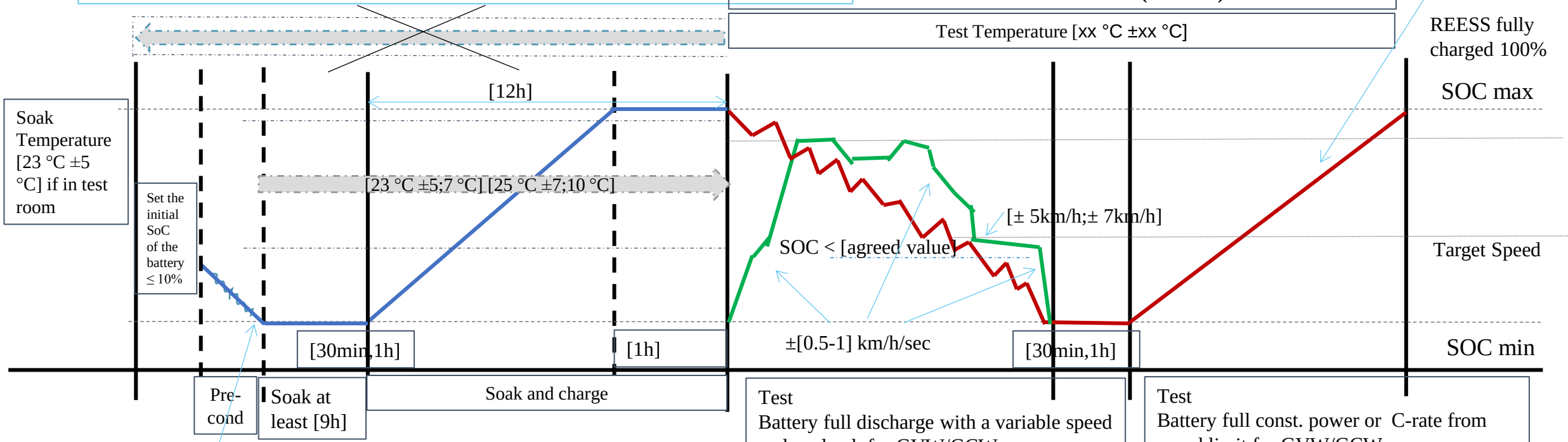
- Range of on-road speed per category per region
- To leave open the speed for the test
- The last part of the test starts with a given SOC level
- Some agreement with local regional authority for SOC minimum level and test
- Same route as type approval or different in accordance with regional authority
- 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) ?**




End of discharge to be defined [break-off criterion]
[ ~~Cut-off voltage~~]

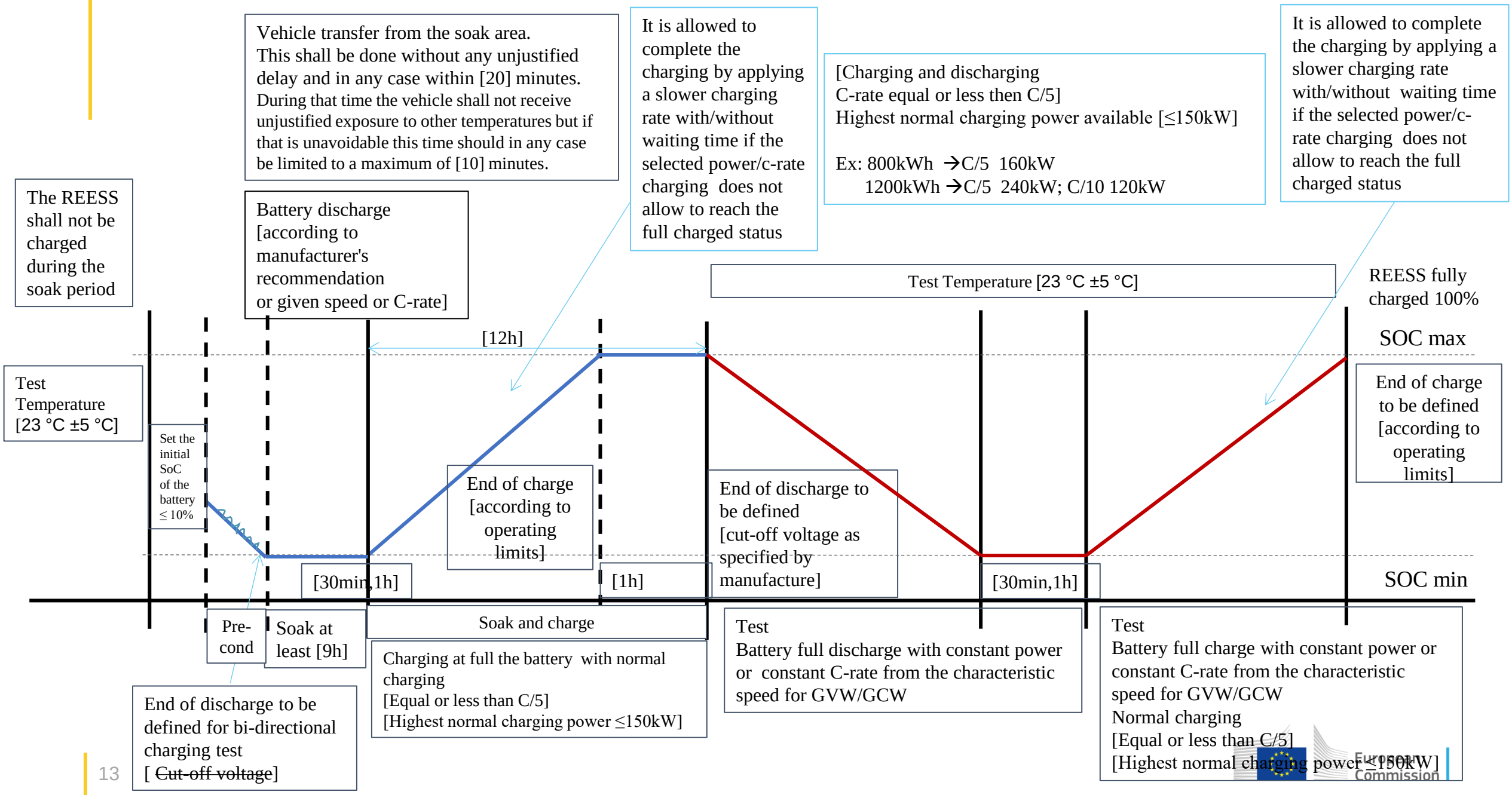
Test
Battery full discharge with a variable speed and payload for GVW/GCW
- With a C-rate in the range of [C/6 or less, C/2]
- End of discharge: break-off criterion (exceeding the driving speed tolerance for 4 consecutive seconds or more)

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]



European Commission

# Method 2 bidirectional charging system available



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

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

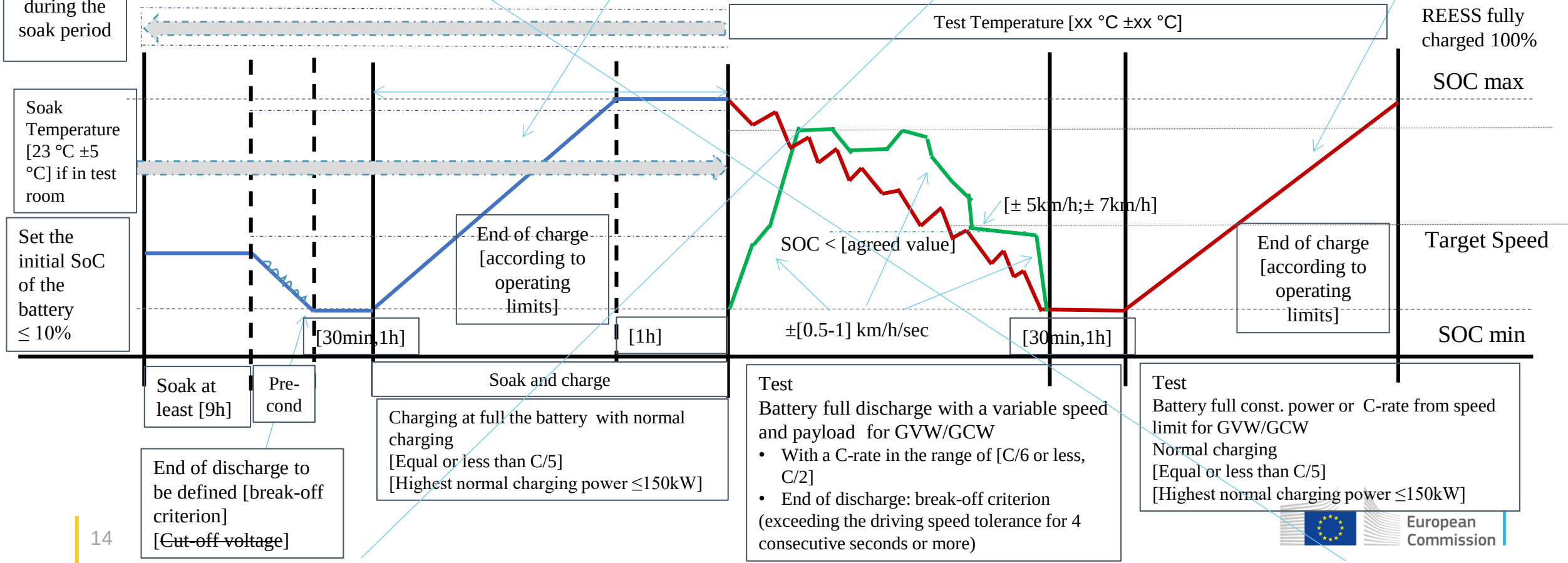
[Charging and discharging
C-rate equal or less then C/5]
Highest normal charging power available [≤150kW]

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

The REESS shall not be charged during the soak period

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




End of discharge to be defined [break-off criterion]
[~~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 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]



European Commission

# Method 2 bidirectional charging system available

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

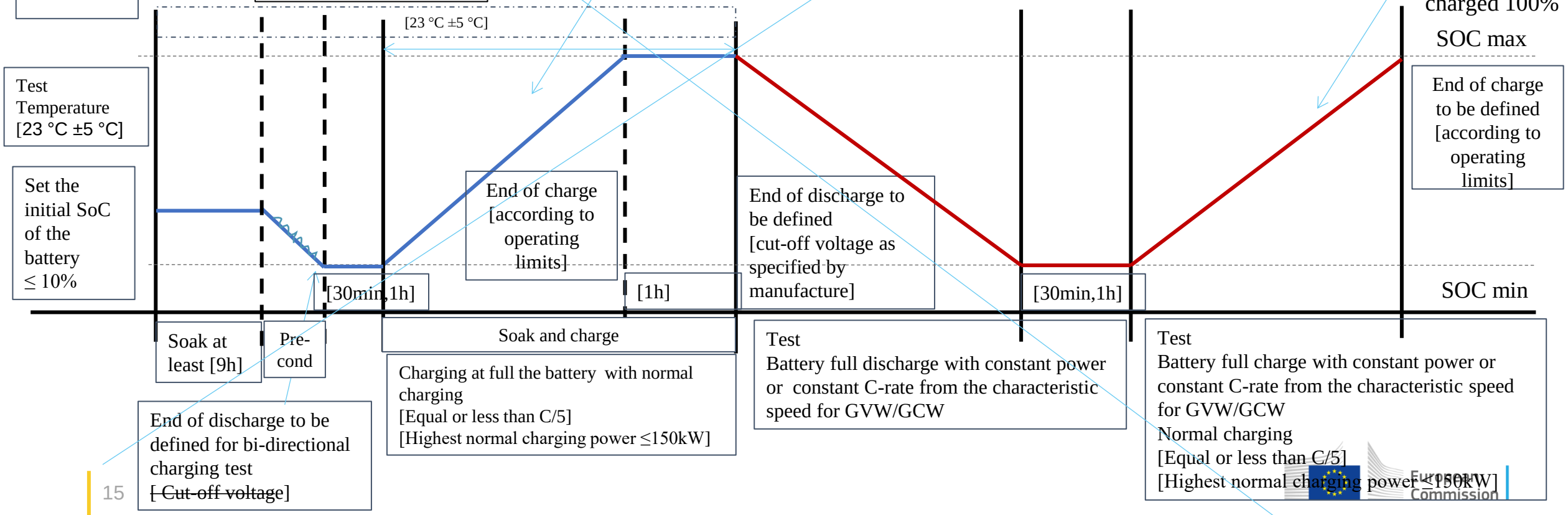
[Charging and discharging
C-rate equal or less then C/5]
Highest normal charging power available [≤150kW]

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

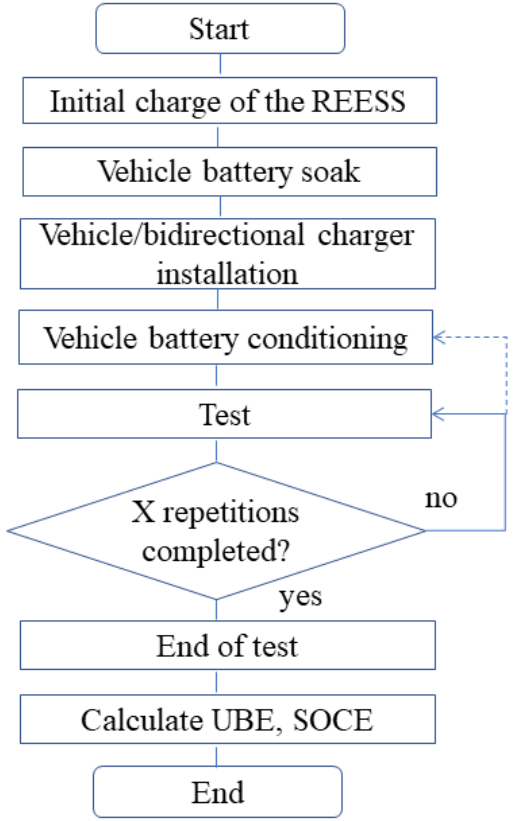
The REESS shall not be charged during the soak period

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



# e-HDVs tests open questions: test repetition

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



# 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 draft text
  - [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].
  - [The on-board measurement data of the voltage can be used during the in-service testing only when the accuracy of on-board measurement data is confirmed during the Type Approval Test and a safe inspection point is made available for the direct measurement verification. →ISC?
  - [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

# e-HDVs tests open questions: Metric and MPR

- To be discussed
- JRC presentation as overview

# 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