

EU-Commission

JRC Contribution to EVE IWG:

In-vehicle battery durability e-HDVs

Outcomes from the breakout group on C-rate

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Web Meeting, December 6-7, 2023

e-HDVs tests: C-rate discussion

Open points to be discussed

- C-rate, constant or variable, depending on the test method
- C-rate calculation method
- Accuracy, tolerance, boundary conditions, deviation of the UBE measured across the testing methods
- End of discharge criterion, safety provision for on-road tests, requirements
- C-rate calculation based on the nominal battery energy
- C-rate charging , RTE calculation, ...
- ...

e-HDV's tests: C-rate discussion table to be filled in

Type of vehicle	Test procedure	C-rate constant			C-rate variable	Calculation method				End of discharge criterion, safety provision, etc.	Charging C-rate		Deviation across the testing methods	C-rate based on nominal battery energy
		Single C-rate (different for categories)	Multiple C-rate (different for categories)	C-rate equal or less than C/5 and with the highest normal charging power available [≤150kW]	C-rate profile representing the WHVC	WHVC (median, weighted average)	Different mission profiles or driving cycle (median, weighted average)	Characteristic speed for vehicle category and mission profile	C-rate in the range of [C/5,C/3] (from OEMs decl.)		Equal to discharge C-rate	Normal or ultra-fast [>150kW]		
HDV without bidirectional charging	Method 1a									safety provision + on-board discharge				
	Method 1b													
HDV with bidirectional charging	Method 2									Cut-off voltage				

e-HDV's tests: discussion table to be filled in

Type of vehicle	Test procedure	C-rate-constant Constant representative speed		Constant C-rate	Constant representative power	C-rate-variable	Calculation-method Speed or power definition			End of discharge criterion, safety provision, etc.	Charging C-rate/power		Deviation across the testing methods	C-rate based on nominal battery energy
		Single/constant C-rate-speed (different for categories)	Multiple /variable C-rate-speed (different for category)				C-rate equal or less than C/5 and with the highest normal charging power available [≤150kW]	Single/constant power (different for categories)	C-rate-profile representing the WHVC		WHVC (median, weighted average)	Different-mission profiles or driving cycle (median, weighted average)		
HDV without bidirectional charging	Method 1a	<p>Breakout group: With characteristic speed: different speed for regions but same methodology and test procedure</p> <p>JAMA/OICA: constant vehicle speed[km/h] at each GVW/GCW vehicle weight condition based on speed limits It's difficult or impossible for buses or many kind of body application trucks to set up the test vehicle weight with GVW. JAMA-HD thinks unrealistic measuring UBE/UBC in constant speed - Method1a-discharge on ISC. These buses and body application trucks can have a measured UBE/UBE by only the maximum normal charging power - Method1a-charge or the constant discharging power - Method2.</p> <p>Japan*: to delete this</p>	<p>To consider more than one constant speed for Method 1a</p> <p>Japan*: please refer sheet "discharge pattern" final vehicle speed is lowest one</p>						<p>Breakout group: Regional specific speed and payload in agreement with authorities (GVW, GCW)</p> <p>With a C-rate in the range of [C/6 or less, C/2], as check</p> <p>Family definition Part A : to consider adding a provision in Part A family to account for different vehicle configurations and battery size</p> <p>Guideline for the harmonisation of characteristic speed</p> <p>Japan*: Regional specific speed and payload in agreement with authorities (GVW, GCW)</p> <p>With a C-rate in the range of [C/6 or less, C/2], as check</p> <p>Family definition Part A</p> <p>Guideline for the harmonisation of characteristic speed</p>	<p>Breakout group: Cut-off voltage</p> <p>Break –off criterion</p> <p>System cannot maintain power any longer</p> <p>Japan*: Cut-off-voltage Break –off criterion (exceeds the tolerance for 4 consecutive seconds or more)</p> <p>System cannot maintain power any longer</p>	<p>JAMA/OICA: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan*: normal</p> <p>Japan*: to delete this</p>			
	Method 1b		<p>Breakout group: Regional specific speed and payload in agreement with authorities (GVW, GCW)</p> <p>Variable speed but limits could be set</p> <p>Tolerances of the average speed to be discussed</p> <p>Japan* suggests Method1b as optional/to be deleted</p>						<p>Breakout group: Variable speed but limits could be set</p> <p>Tolerances of the average speed to be discussed</p> <p>Japan* suggests Method1b as optional/to be deleted</p>	<p>Breakout group: Cut-off voltage</p> <p>System cannot maintain power any longer</p> <p>Break –off criterion</p> <p>Safety provision + on-board discharge</p> <p>Japan* suggests Method1b as optional/to be deleted</p>				
HDV with bidirectional charging	Method 2		<p>Japan*: allow to apply as a manufacture option if c-rate @ maximum speed is less than V2X upper limit (duplicate at least minimum and maximum speed)</p>	<p>Breakout group: C-rate equal or less than C/5 and with the highest normal charging power available [≤150kW]</p> <p>Japan*: to delete this</p>	<p>Breakout group: With a constant power derived from the most representative operational driving speed for vehicle category and mission profile as method 1a:</p> <p>different around regions</p> <p>but same methodology and test procedure</p> <p>JAMA/OICA: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan*: to delete this</p>				<p>Breakout group: The power shall be derived from the most representative operational driving speed for vehicle category and mission profile as defined in Method 1a</p> <p>JAMA/OICA: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan*: to delete this</p>	<p>Breakout group: Cut-off voltage</p> <p>Percentage voltage drop</p> <p>System cannot maintain power any longer</p> <p>Suggestion to define a new provision for Method 2</p> <p>Japan*: Cut-off-voltage Percentage-voltage drop System cannot maintain power any longer</p> <p>Suggestion to define a new provision for Method 2</p> <p>an indication on a standard on-board instrument panel to stop the vehicle</p>	<p>JAMA/OICA: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan*: why is the recharge needed?</p> <p>Japan*: why is the recharge needed?</p>			

e-HDV's tests: C-rate discussion

- Three testing methods: Method 1a, Method 1b, Method 2
 - **C-rate to be defined** → **suggestion to define a reference speed instead of a C-rate**
- ~~Constant C-rate vs variable C-rate~~ → constant C-rate seems favourable for simplicity of the test procedure to be applied;
- ~~Different proposals on the C-rate calculation or testing methods:~~
 - Method 1a**
 - - a C-rate representative of a range of driving power values from different mission profiles or driving cycle
 - - with a constant C-rate defined as the median C-rate of the cumulative frequency of the C-rate profile equivalent to WHVC
 - - a constant C-rate corresponding to the most representative operational driving speed for vehicle category and mission profile
 - - a constant speed corresponding to the most representative operational driving speed for vehicle category and mission profile
 - - a C-rate in the range of [C/6 or less, C/2]
 - Method 1b**
 - - multiple C-rate calculation based on driving cycle → possibility to set more than one constant speed
 - - Variable C-rate but limits could be set → average speed corresponding to the most representative operational driving speed for vehicle category and mission profile
 - a C-rate in the range of [C/6 or less, C/2]
 - Method 2**
 - - reproduce C-rate profile representing the WHVC with constant C-rate phase in the middle and in the end of discharge pattern to avoid the unstable SOC at the end of measurement
 - - a constant C-rate equal or less than C/5 or C/2.3 (0.2C or 0.43C) and with the highest normal charging power available [$\leq 150\text{kW}$] as defined in paragraph 6.1.1 of this GTR
 - - a power derived from the most representative operational driving speed for vehicle category and mission profile

e-HDVs tests: C-rate discussion

- Three testing methods: Method 1a, Method 1b, Method 2
 - **Additional questions**
 - Same C-rate calculation procedure for all the test methods (1a,1b,2) ? **1a and 2 correlated**
 - Deviation of the UBE measured across methods? Accuracy? Equivalence of testing method 1a, 1b, 2 ? **1a and 2 correlated**
 - End of discharge criterion ?
 - The end of discharge criterion is reached when the cut-off voltage as defined by the manufacturer is reached. →Method 1a,1b, 2. **Suggestion to define a new provision for Method 2**
 - System cannot maintain power any longer →Method 1a,1b,2
 - Break –off criterion →Method 1a,1b
 - Japan*: an indication on a standard on-board instrument panel to stop the vehicle →Method 2
 - Test track and on-road test: safety provision + on-board discharge? Accuracy? Deviation in respect to Method 2 needed? **Still to be discussed**
 - C-rate calculation based on nominal battery capacity. C-rate = power/nominal battery energy **ok**
 - RTE calculation for all methods: charge C-rate equal to discharge C-rate
 - Method 1a: ? Or to long charging time so different provision? →normal charging power <150kW
 - Method 1b: ? Or to long charging time so different provision? →normal charging power <150kW
 - Method 2: a C-rate equal or less than C/5 or C/2.3 (0.2C or 0.43C) and with the highest normal charging power available [≤150kW] as defined in paragraph 6.1.1 of this GTR
 - Constant power [kW] from kW on speed limits or constant C-rate from speed limits

e-HDVs tests: Method 1a

Outcome from breakout group

- Test in Method 1a driving on test track with characteristic constant speeds (regional speed)
 - different speed around regions
 - but same methodology and test procedure
- Regional specific speeds and payload in agreement with authorities (GVW, GCW)
- With a C-rate in the range of $[C/6 \text{ or less, } C/2]$, as check, not to have unwanted battery behaviour
- Family definition: to consider adding a provision in Part A family to account for different vehicle configurations and battery size
- Considering defining a guideline for the harmonisation of the characteristic speed
 - Boundary conditions or information for speed definition
 - Urban, extra-urban, highway, country road, ...
 - Suggested speed range, values to avoid ...
 - To consider more than one constant speed for Method 1a
 - 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 $[\pm 5\text{km/h}; \pm 7\text{km/h}]$
 - The acceleration/deceleration during vehicle speed change shall be smooth and accomplished within the range $\pm[0.5-1] \text{ km/h/sec}$
 - End of discharge: break-off criterion
 - Temperature not prescribed

e-HDVs tests: Method 1b

- **Outcome from breakout group**
 - Test in Method 1b driving on road with characteristic speeds (regional speed)
 - different speed around regions
 - but same methodology and test procedure
 - Regional specific speeds and payload in agreement with authorities (GVW, GCW)
 - With a C-rate in the range of $[C/6 \text{ or less, } C/2]$, as check, not to have unwanted battery behaviour
 - Family definition: to consider adding a provision in Part A family to account for different vehicle configurations and battery size
 - Considering defining a guideline for the harmonisation of the characteristic 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
- Japan* suggests Method1b as optional or delete it
 - Speed tolerance ?
 - Which speed is typically refer to while driving on road?
 - Accuracy of results influencing factors: road grading, power request, driving style ?
 - Post-processing, calculation prescription to correct the influencing factor ?
 - Break-off criterion
 - System cannot maintain power any longer for 4 consecutive seconds or more ?
 - if safety provision on minimum SOC level and on-board discharge to complete the depleting, break-off? an indication on the dashboard of the vehicle ?
 - Temperature not prescribed

e-HDVs tests: Driver breaks

[Breaks for the driver are permitted as prescribed in Table A3/x, but they shall be verified with region local authorities not to violate local legal rules].

Reference to driven km

Table A3/x

Breaks for the driver

Distance driven in constant speed (km)	Maximum total break (min)
Up to 100	10
Up to 150	20
Up to 200	30
Up to 300	60
More than 300	Shall be based on the manufacturer's recommendation

Note: During a break, the powertrain shall be switched off.

Reference to driving time

Table A3/x

Breaks for the driver

Driving time (h)	Maximum total break (min)
every each 1h	10
...
.....	..
More than xx	Shall be based on the manufacturer's recommendation

Note: During a break, the powertrain shall be switched off.

- Having more than one driver is permitted to comply with the short resting time needed to maintain the conditioning of the batteries.

e-HDVs tests: Method 2

- **Outcome from breakout group**
 - Test in Method 2 with a constant power or constant C-rate derived from the most representative operational driving speed for vehicle category and mission profile
 - different around regions
 - but same methodology and test procedure
 - Regional specific speed and payload in agreement with authorities (GVW, GCW)
 - With a C-rate in the range of [C/6 or less, C/2], as check, not to have unwanted battery behaviour
 - Family definition: to consider adding a provision in Part A family to account for different vehicle configurations and battery size
 - Considering defining a guideline for the harmonisation of the test:
 - constant C-rate seems to be the favourable option
 - with a C-rate in the range of [C/6 or less, C/2] and with the highest normal charging power available [$\leq 150\text{kW}$] as defined in paragraph 6.1.1 of this GTR
 - One C-Rate or multiple: corresponding to one speed, at least maximum and minimum speed?
 - End of discharge: Cut-off voltage, Percentage voltage drop, System cannot maintain power any longer (break-off criterion on power: BMS configured to work with a Bi-dir system?), (exceeds the tolerance* for 4 consecutive seconds or more, * : discharge rate @ minimum vehicle speed), an indication on a standard on-board instrument panel to stop the vehicle
 - SOC level not acceptable by CP
 - Temperature $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$

e-HDV's tests: discussion table

Type of vehicle	Test procedure	Test procedure description	Test procedure guideline	soaking/pre-cond/soak and charge/test	acceleration to target speed	deceleration to target speed of the last segment	speed tolerance last segment of the test	speed tolerance and accuracy of test	end of discharge break-off criterion	deceleration to stop the vehicle	driver breaks	cruise control	Charging Normal DC [≤ 150kW]	Temperature	Test repetitions	Road grading	Deviation across the testing methods
HDV without bidirectional charging	Method 1a	<p>Breakout group:</p> <ul style="list-style-type: none"> -Regional specific speed and payload in agreement with authorities (GVW, GCW) but same methodology and test procedure -With a C-rate in the range of [C/6 or less, C/2], as check -Family definition Part A : to consider adding a provision in Part A family to account for different vehicle configurations and battery size <p>JAMA/OICA**:</p> <ul style="list-style-type: none"> -It's difficult or impossible for buses or many kind of body application trucks to set up the test vehicle weight with GVW. JAMA-HD thinks unrealistic measuring UBE/UBC in constant speed - Method1a-discharge on ISC. These buses and body application trucks can have a measured UBE/UBC by only the maximum normal charging power - Method1a-charge or the constant discharging power - Method2. 	<p>Guideline for the harmonisation of characteristic speed:</p> <ul style="list-style-type: none"> -Range of speed per category per region -To leave open the speed for the test and prescribe only the target speed for the last part of the test for which the 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 	<ul style="list-style-type: none"> -Soak: Set the initial SoC of the battery ≤ 10%, Test Temperature [23 °C ±5 °C], Soak at least [9h] -Pre-conditioning: fully discharge of the battery -Soak and charge: Charging at full the battery with normal charging after [30min, 1h] resting time, Test Temperature [23 °C ±5 °C] -The actual test run shall start within a period of 1 hour after the vehicle is disconnected from the grid, otherwise the preconditioning and charge shall be repeated 	<ul style="list-style-type: none"> - The acceleration during vehicle speed change shall be smooth and accomplished within the range ±[XXX] km/h/sec -acceleration ratio -time to reach the target speed - 0.5 -1km/h/sec - verification ? -OICA difficult to control acceleration while driving a vehicle to be verified 	<ul style="list-style-type: none"> - The deceleration during vehicle speed change shall be smooth and accomplished within the range ±[XXX] km/h/sec -deceleration ratio -time to reach the target speed - 0.5 -1km/h/sec - verification ? -OICA difficult to control deceleration while driving a vehicle to be verified 	<ul style="list-style-type: none"> options: <ul style="list-style-type: none"> - ± 5km/h - GTR4 ± 4km/h - influence on SOC level near the break-off - only in the last segment or all the test - 5km/h or 7km/h to be verified 	<ul style="list-style-type: none"> proposal to define a tolerance only in the last segment of the test 	<ul style="list-style-type: none"> Break –off criterion - System cannot maintain power any longer - exceeds the speed tolerance for 4 consecutive seconds or more to be verified 	<ul style="list-style-type: none"> The accelerator control shall be deactivated and the vehicle shall be braked to standstill within 60 seconds. to be verified 	<ul style="list-style-type: none"> [Breaks for the driver are permitted as prescribed in Table A3/x, but they shall be verified with region local authorities not to violate local legal rules]. Breaks versus km Breaks versus driving time to be verified Having more than one driver is permitted to comply with the short resting time needed to maintain the conditioning of the batteries. to be verified 	<ul style="list-style-type: none"> OICA: if cruise control is available, possibility to use it during the test To verify if cruise control can be used in type approval 	<ul style="list-style-type: none"> Normal [≤ 150kW] DC EMC for AC JAMA/OICA**:-constant power[kW] from KW-on speed-limits or constant C-rate from speed-limits If the speed is not specified, it is not possible to replicate it by the power selection The vehicle shall be connected to the mains within 120 minutes after coming to a standstill. to be verified Japan*: to delete charging 	-No limitation	?	?	
	Method 1b	<ul style="list-style-type: none"> -Regional specific speed and payload in agreement with authorities (GVW, GCW) but same methodology and test procedure -With a C-rate in the range of [C/6 or less, C/2], as check -Family definition Part A : to consider adding a provision in Part A family to account for different vehicle configurations and battery size to be verified Japan* suggests Method1b as optional/to be deleted 	<p>Guideline for the harmonisation of characteristic speed:</p> <ul style="list-style-type: none"> -Range of on-road speed per category per region -To leave open the speed for the test and prescribe only the target speed for the last part of the test for which the speed tolerance will be applied? -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 - If same routes is used, different provision on minimum SOC level and test (to be verified) -Speed tolerance? in last test segment ? 	<ul style="list-style-type: none"> -Soak: Set the initial SoC of the battery ≤ 10%, Test Temperature [23 °C ±5 °C], Soak at least [9h] -Pre-conditioning: fully discharge of the battery -Soak and charge: Charging at full the battery with normal charging after [30min, 1h] resting time, Test Temperature [23 °C ±5 °C] -The actual test run shall start within a period of 1 hour after the vehicle is disconnected from the grid, otherwise the preconditioning and charge shall be repeated 	<ul style="list-style-type: none"> The acceleration during vehicle speed change shall be as smooth as possible in relation to traffic conditions and safety of driving? -OICA difficult to control acceleration while driving a vehicle to be verified 	<ul style="list-style-type: none"> not applicable for on-road driving 		<ul style="list-style-type: none"> Speed tolerance ? Accuracy of results influencing factors: road grading, power request, driving style ? Post-processing, calculation prescription to correct the influencing factor?: correction due to power request etc... To be verified 	<ul style="list-style-type: none"> Break –off criterion - System cannot maintain power any longer - for 4 consecutive seconds or more ? - if safety provision on minimum SOC level (regional authority) and on-board discharge to complete the depleting, break-off? an indication on the dashboard of the vehicle ? to be verified 	<ul style="list-style-type: none"> The accelerator control shall be deactivated and the vehicle shall be braked to standstill within 60 seconds. to be verified 	<ul style="list-style-type: none"> [Breaks for the driver are permitted as prescribed in Table A3/x, but they shall be verified with region local authorities not to violate local legal rules]. Breaks versus km Breaks versus driving time to be verified Having more than one driver is permitted to comply with the short resting time needed to maintain the conditioning of the batteries. Buses regional rules for the driver to be verified 	<ul style="list-style-type: none"> OICA: if cruise control is available, possibility to use it during the test To verify if cruise control can be used in type approval 	<ul style="list-style-type: none"> Normal [≤ 150kW] DC EMC for AC JAMA/OICA**:-constant power[kW] from KW-on speed-limits or constant C-rate from speed-limits If the speed is not specified, it is not possible to replicate it by the power selection The vehicle shall be connected to the mains within 120 minutes after coming to a standstill. to be verified Japan*: to delete charging 	-No limitation	?	?	

e-HDV's tests: discussion table

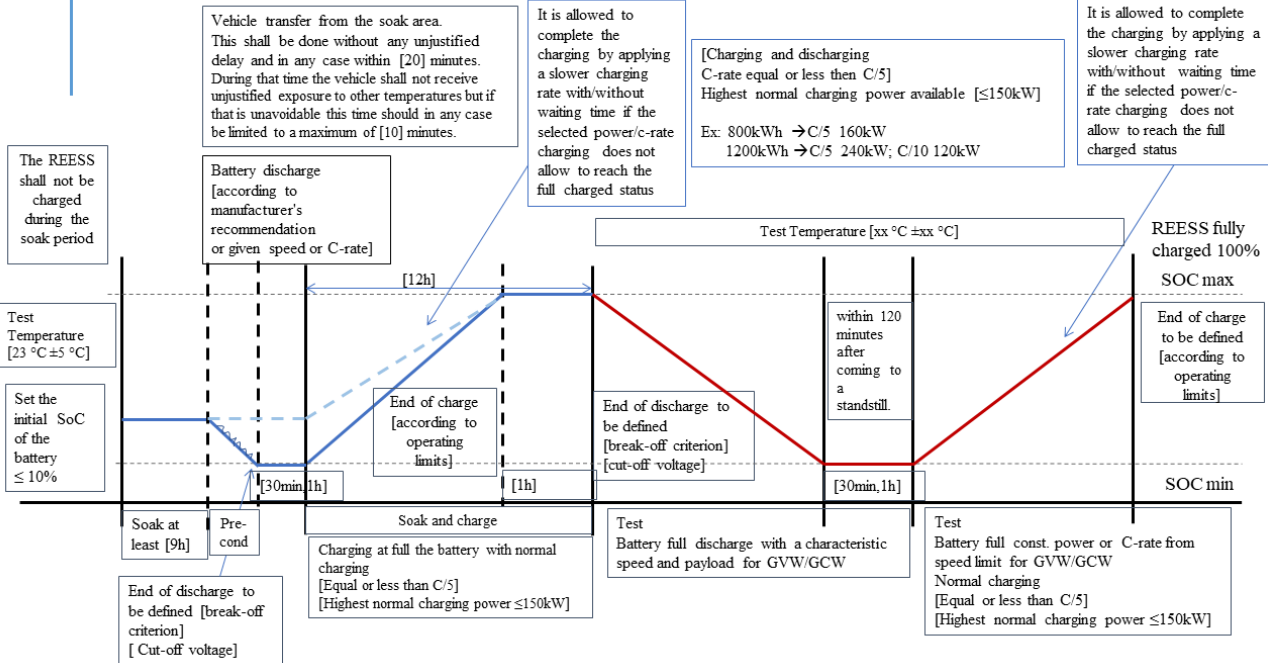
HDV with bidirectional charging	Method 2	Test procedure description	Test procedure guideline	soaking/pre-cond/soak and charge/test	end of discharge break-off criterion	Charging	Temperature	Test repetitions	Deviation across the testing methods
		<p>-With a constant power or constant C-rate derived from the most representative operational driving speed for vehicle category and mission profile:</p> <ul style="list-style-type: none"> - Regional specific speed and payload in agreement with authorities (GVW, GCW) but same methodology and test procedure - With a C-rate in the range of [C/6 or less, C/2], as check, not to have unwanted battery behaviour - Family definition: to consider adding a provision in Part A family to account for different vehicle configurations and battery size <p>JAMA/OICA**: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan* suggests Method2 as optional/to be deleted</p>	<p>Guideline for the harmonisation of characteristic power /c-rate</p> <p>Being now the speed of Method 1a not defined except the last segment, which power/C-rate to be considered?</p> <p>option to be verified:</p> <ul style="list-style-type: none"> -Range of speed per category per region could be considered (see Japan discharge pattern concept) - multiple-speeds, one speed, at least maximum and minimum speed? - with a C-rate in the range of [C/6 or less, C/2] and with the highest normal charging power available [≤150kW] as defined in paragraph 6.1.1 of this GTR - Family definition: to consider adding a provision in Part A family for the maximum normal charging power instead of defining the highest normal charging power available [≤150kW] to be verified <p>JAMA/OICA**: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan*: allow to apply as a manufacture option if c-rate @ maximum speed is less than V2X upper limit (duplicate at least minimum and maximum speed)</p>	<ul style="list-style-type: none"> -Soak: Set the initial SoC of the battery ≤ 10%, Test Temperature [23 °C ±5 °C], Soak at least [9h] -Pre-conditioning: fully discharge of the battery -Soak and charge: Charging at full the battery with normal charging after [30min, 1h] resting time, Test Temperature [23 °C ±5 °C] -The actual test run shall start within a period of 1 hour after the vehicle is disconnected from the grid, otherwise the preconditioning and charge shall be repeated. If the same instrument is used both for charging and discharging the battery of the vehicle, the actual test run shall start within a period of 1 hour after the setting of the bi-directional charging system in the discharging mode]. 	<p>Breakout group: Cut-off voltage</p> <p>Percentage voltage drop</p> <p>System cannot maintain power any longer</p> <p>Suggestion to define a new provision for Method 2</p> <p>break-off criterion on power: BMS configured to work with a Bi-dir system?</p> <p>SOC level not acceptable by CP</p> <p>Japan*: Cut-off voltage</p> <p>Percentage voltage drop</p> <p>System cannot maintain power any longer</p> <p>Suggestion to define a new provision for Method 2</p> <p>an indication on a standard on-board instrument panel to stop the vehicle</p> <p>to be verified</p>	<ul style="list-style-type: none"> -Equal to discharge power/C-rate -Normal DC [≤ 150kW] -The REESS shall be fully charged with a defined [power/C-rate] equal or less than C/5 according to operating limits and the highest normal charging power available [≤150kW] as defined in paragraph 6.1.1 of this GTR <p>JAMA/OICA**: constant power[kW] from KW on speed limits or constant C-rate from speed limits</p> <p>Japan*: why is the recharge needed?</p> <p>[The recharge shall start within 120 minutes after the end of discharge].</p> <p>To be verified</p>	23 °C ±5 °C	?	

e-HDV's tests: open questions

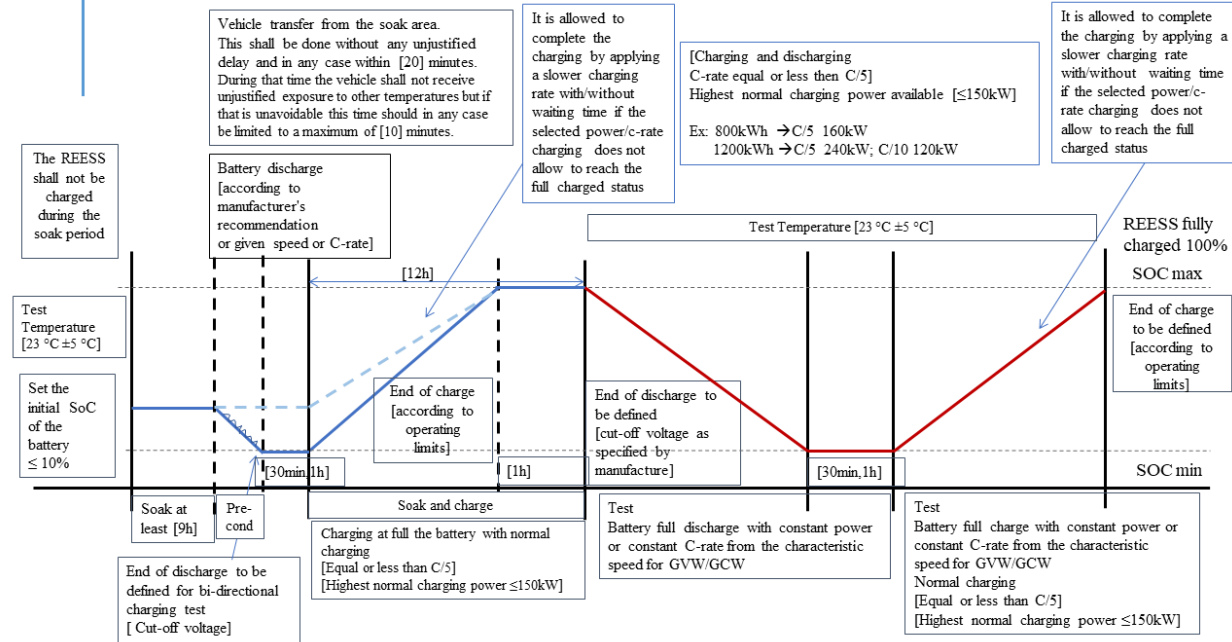
- HD-OVC-HEVs:
 - CD test? vehicle's test operation mode?
 - Break-off criterion for Method 1a and Method 1b ?
 - Energy change correction procedure after break-off ?
- Test repetitions?
- Accuracy? Deviation among the test method?

e-HDV's tests: additional point to be considered is the need of setting a soak, pre-conditioning steps etc.

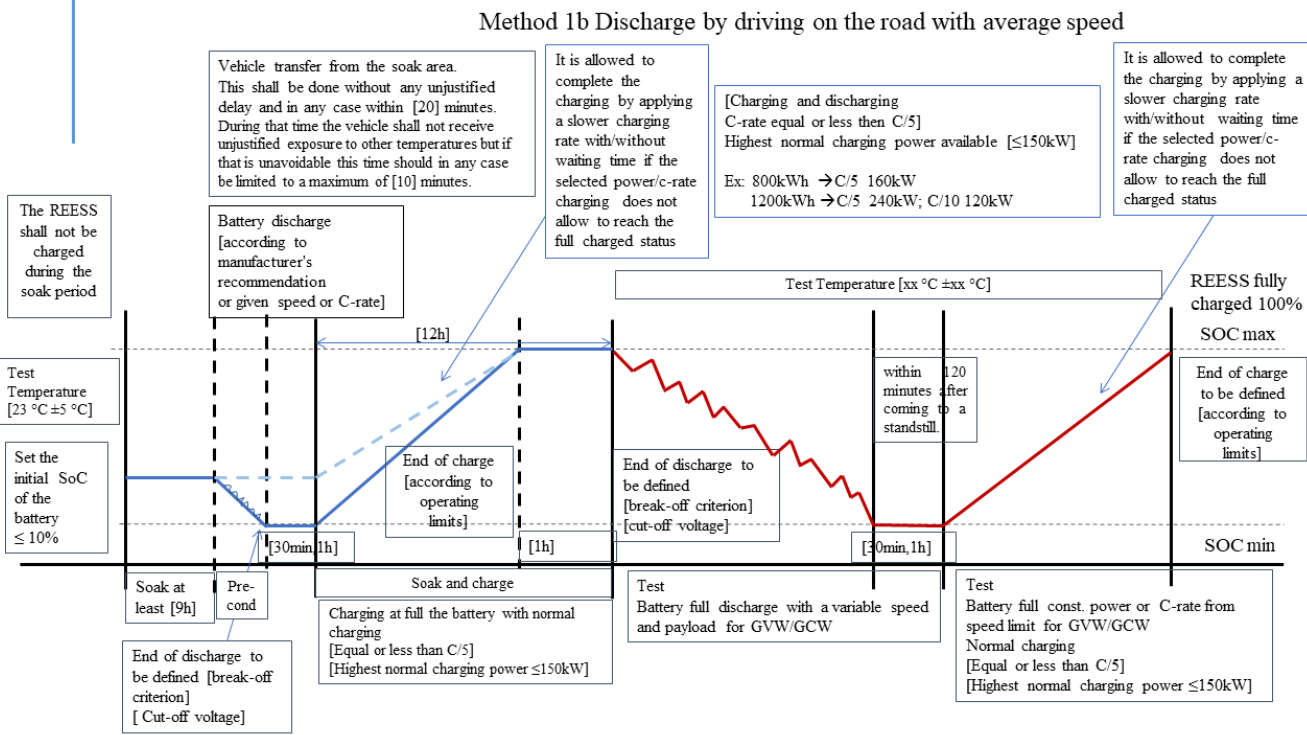
Method 1a Discharge by standard average speed on a test track



Method 2 bidirectional charging system available



e-HDV's tests: additional point to be considered is the need of setting a soak, pre-conditioning steps etc.



Thank you

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e-HDV's tests: Test procedures table

Methods for Checking Battery Durability Monitor for HDV

	HDV with no bidirectional charging		HDV with bidirectional charging
	Method 1a	Method 1b	Method 2
Description	Discharge by standard average speed with tolerances on test track	Discharge by driving on the road with average speed with higher tolerances	Virtual Round Trip Efficiency (VRTE) test
Repeatable	And charge Yes	And charge Partly, if tolerances are set	Charging and discharging in a column Yes
C-rate	Constant (different for categories)	Variable but limits could be set	Constant
RTE	YES	YES	YES
UBE	Yes	Yes, but it depends on the driving	Yes
UBC	Yes	Yes	Yes
comment	tolerances of the average speed to be discussed Proposal from Japan on different constant speeds in the test	tolerances of the average speed to be discussed	
C-rate calculation method	With characteristic speed/limits, different speed for regions but same methodology and test procedure	With characteristic speed/limits, different speed for regions but same methodology and test procedure	With a constant power derived from the most representative operational driving speed for vehicle category and mission profile as method 1a Constant power from kW of characteristic speed/limits or constant C-rate from characteristic speed/limits
Reference section (charge/discharge)	Comment from OICA test data: flexible due to measurement results charge/discharge (RTE to be discussed RTE with tolerance in addition)	Comment from OICA test data: due to measurement results charge event as reference (RTE to be discussed RTE with tolerance in addition)	Comment from OICA: reference charge or discharge and RTE with tolerance in addition
Alternative Method	HDV Dyno testing with similar driving characteristics		
Feasibility	voltage sensor, voltage measurement, under discussion		
discharge vs charge	UBE in discharging		
UBE vs UBC	discharge and charge RTE		