In-vehicle Battery Durability GTR Annex 3 Part A Test Procedure and Performance Parameter

1st UBE Break Out Group Web-Meeting Summary

Elena Paffumi

July 2021

Summary:

6.3.2.   Verification procedure

(…)

The measured SOCR and measured SOCE values shall be determined by dividing the measured values for range and usable battery energy by the certified values for range and usable battery energy, respectively, determined as described in Annex 3 to this GTR, expressed in %.

$$SOCE_{measured} = \frac{UBE_{measured}}{UBE_{certified}} * 100$$

$$SOCR_{measured} = \frac{Range_{measured}}{Range_{certified}} * 100$$

Summary: main open points

- How to define the $UBE_{certified}$ for both PEV and OVC-HEV
- With or without declaration, i.e. amendments of in-placed regulations or not
- Certified UBE values defined by applying an AF; to be defined both for PEV and OVC-HEV
- Defined a $UBE_{measured}$ and $EAER_{measured}$ $EAER_{certified}$ for OVC-HEV
- Verifying the proposal for the interpolation family and group of vehicles concepts
- How to address all regional regulations

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Summary: <u>Preliminary</u> discussion outcomes

➤ Option 1 without declaration seems the favourable option

➤ Give provisions on how to calculate $UBE_{certified}$, $UBE_{measured}$, EAER, etc. in the durability GTR based on the GTR15; the different regional regulations might refer to the definitions and apply the method according to their procedures

➤ $UBE_{certified}$ values defined by applying an AF based on range:

- AF_{PER} for PEV - very probable
- AF for OVC-HEV seems be different between EU (AF_{EAER}) and JPN (AF_{EC}) but still discussion needed for the exact definition and equation to be used for EAER or EC

➤ $UBE_{measured}$ values for PEV and OVC-HEV based on GTR15 procedure

➤ $SOCR_{measured}$ OVC-HEV EAER given definition to be checked

➤ Maximum certified calculated UBE among V_H, V_M, V_L seems the best approach, i.e., worst for durability

➤ Rounding of measured values as discussed

➤ Discussion still open on how to define the parameters in the durability GTR: to refer to GTR15 post-processing tables and equations or to define the complete text in the durability GTR

Some extra slides prepared for the break out group discussion as background
Another set of slides was also presented and discussed

Summary: with/without declaration

		Certified and measured values proposal	pro	drawback	comment
certified	Option 1 without declaration	➤ To define a certified UBE for PEV and OVC-HEV in the durability GTR by applying an AF based on range and/or energy consumption ➤ To define/specify the AF_{range} for PEV CCT and STP ➤ To define/specify the AF for OVC-HEV ➤ To defined a certified EAER in the durability GTR for OVC-HEV	No need to amend regulations	-No declared values -To define parameters or give provisions in the new GTR for different regulations i.e. GTR15, UN-R-101 …	-To check family concept -AF: worst for durability, or vehicle H etc.
	Option 2 with declaration	➤ Adding declaration and definition of UBE for PEVs and OVC-HEVs ➤ Adding declaration and definition of EAER for OVC-HEV	Certified values available	Amendment of regulations required	
measured	Option 1 and Option 2	➤ To define a measured UBE for PEV and OVC-HEV in the durability GTR i.e. based on GTR15 … ➤ To defined a measured EAER for OVC-HEV in the durability GTR			-To be defined in the durability GTR

Web-Meeting, July, 2021

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PEV Option 1 without declaration

The usable battery energy and pure electric range shall be calculated according to GTR#15 Amd#6 Annex 8 paragraph 4.4.2.1.1. in case of the shortened Type 1 test procedure or paragraph 4.4.2.2.1. in case of the consecutive cycle Type 1 test procedure **modifying** the following stepwise procedure

parameters	Shorten Test Procedure	Consecutive Cycle Procedure
$UBE_{measured}$	Table A8/11 Step no.1	Table A8/10 Step no.1
	~~$UBE_{measured}$ shall be rounded according to paragraph 7. of UN GTR#15 to the nearest whole number.~~	~~$UBE_{measured}$ shall be rounded according to paragraph 7. of UN GTR#15 to the nearest whole number.~~
$UBE_{certified}$	Table A8/11 Step no.6 **Averaging of tests for $UBE_{STP,ave}$, then alignment of $UBE_{STP,ave}$ by applying AF_{PER}** In the case that the interpolation method is not applied, $UBE_{CCP,ave}$ shall be rounded according to paragraph 7. to the nearest whole number. **Table A8/11 Step no.9 Select the maximum $UBE_{STP,ave}$ and final rounding to the nearest whole number according to paragraph 7.**	Table A8/10 Step no.7 **Averaging of tests for $UBE_{CCP,ave}$, then alignment of $UBE_{CCP,ave}$ by applying AF_{PER}** In the case that the interpolation method is not applied, $UBE_{CCP,ave}$ shall be rounded according to paragraph 7. to the nearest whole number. **Table A8/10 Step no.10 Select the maximum $UBE_{CCP,ave}$ and final rounding to the nearest whole number according to paragraph 7.**
$Range_{measured}$	Table A8/11 Step no.6 or 9 **No rounding**	Table A8/10 Step no.7 or 10 **No rounding**
$Range_{certified}$	Table A8/11 Step no.6 or 9	Table A8/10 Step no.7 or 10

$$AF_{PER} = \frac{PER_{WLTP,decl}}{PER_{WLTP,avg}}$$

JPN
under the study
depend on unit
or require at least three(3) significant number ?

JPN_49MTG
no rounding for measured UBE

JPN
same as above

JPN_49MTG
Wh unit : whole number
kWh unit : at least three (3) significant

JPN
same as above

JPN_49MTG
Wh unit : whole number
kWh unit : at least three (3) significant

JPN
same as above

JPN_49MTG
Wh unit : whole number
kWh unit : at least three (3) significant number

JPN
nearest whole number seems to be OK

JPN_49MTG

2.1.1. Measured UBE values for PEVs

Parameters	Explanation
$UBE_{measured}$	UBE determined by the test procedure used for certification.

2.1.2. Certified UBE values for PEVs

Parameters	Explanation
$UBE_{certified}$	UBE certified is the adjusted usable battery energy (UBE) of the vehicle measured at the point of certification. The adjustment shall be done as follows: $$UBE_{certified} = UBE_{measured@cert} * AF_{UBE,PEV}$$ where: $UBE_{measured@cert}$ is the $UBE_{measured}$ at the point of certification and: $$AF_{UBE,PEV} = \frac{Range_{certified}}{Range_{measured@cert}}$$ where:
$Range_{certified}$	is the manufacturer range declaration for the vehicle measured at the point of certification
$Range_{measured@Cert}$	is the $Range_{measured}$ at the point of certification

	In case of an interpolation family concept, the adjustment shall be done by using the values of vehicle H of the interpolation family. In case of test group concept, the adjustment shall be done by using the values of the test group representative. In case of a self-certification, the manufacturer shall provide $UBE_{certified}$ and give evidence how the value has been determined.

2.2. Range for PEVs

2.2.1. Measured Range values for PEVs

Parameters	Explanation
$Range_{measured}$	Electric range determined by the test procedure used for certification.

2.2.2. Certified Range values

Parameters	Explanation
$Range_{certified}$	Certified range is a manufacturer declaration for range at certification.

MaN_0904
OPTION 1 (without UBE declaration in certification)

MaN_0104
For a single vehicle, situation is clear.
For vehicles which are member of an interpolation family or member of a test group, guidance required
→ for all these cases themselves, battery will be identical
→ UBE certified can be applied to all vehicles in this family

MaN_0104
One adjustment factor
→ for single vehicle → clear
→ for families or test groups: guidance below

MaN_0104
This value is being provided in the certifcation to TAA.
The declaration need to be identical → Must

MaN_0104
This value is being provided in the certifcation to TAA to prove that declaration is confirmed → Must

MaN_0104
Following cases need to be evaluated in Phase 2:
- What shall be done in case of a family but no interpolation?
- This means: no individual values would be available!
- What is the solution for Phase 1?

MaN_0104
This value is being provided in the certifcation to TAA.
→ official value (will be used here)

PEV Option 2 with declaration

2.1. UBE for PEVs

2.1.1. Measured UBE values for PEVs

Parameters	Explanation
$UBE_{measured}$	UBE determined by the test procedure used for certification.

2.1.2. Certified UBE values for PEVs

Parameters	Explanation
$UBE_{certfied}$	Certified UBE is a manufacturer declaration for UBE at certification. In case of an interpolation family concept and in case of test group concept, there should be only one declaration for the interpolation family and the test group concept.

2.2. Range for PEVs

2.2.1. Measured Range values for PEVs

Parameters	Explanation
$Range_{measured}$	Electric range determined by the test procedure used for certification.

2.2.2. Certified Range values

Parameters	Explanation
$Range_{certified}$	Certified range is a manufacturer declaration for range at certification.

MaN_0904
OPTION 2 (with UBE declaration in certification)

MaN_0104
For a single vehicle, situation is clear.

For vehicles which are member of an interpolation family or member of a test group, guidance required
→ for all these cases themselves, battery will be identical
→ UBE certified can be applied to all vehicles in this family

MaN_0104
The declared UBE value shall be used in the calculation of the certification test results
→ e.g. amendment of GTR15 required

MaN_0104
Following cases need to be evaluated in Phase 2:
- What shall be done in case of a family but no interpolation?
- This means: no individual values would be available!
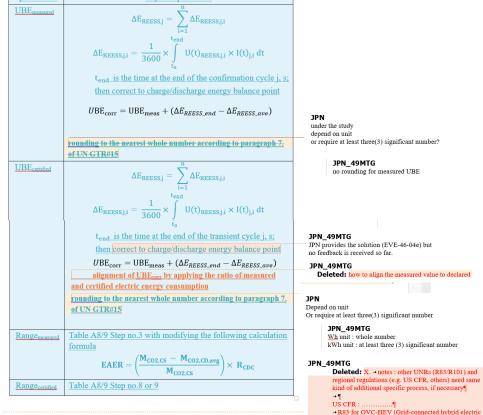- What is the solution for Phase 1?

MaN_0104
This value is being provided in the certifcation to TAA.
→ official value (will be used here)

European Commission

OVC-HEV Option 1 without declaration

The usable battery energy and shall be calculated according to GTR#15 Amd#6 Annex 8 paragraph 4.3. and the equivalent all-electric range shall be calculated according to GTR#15 Amd#6 Annex 8 paragraph 4.4.4.1. modifying the following stepwise procedure

parameters	stepwise procedure
$UBE_{measured}$	$\Delta E_{REESS,j} = \sum_{i=1}^{n} \Delta E_{REESS,j,i}$ $\Delta E_{REESS,j,i} = \frac{1}{3600} \times \int_{t_0}^{t_{end}} U(t)_{REESS,j,i} \times I(t)_{j,i} \, dt$ t_{end} is the time at the end of the confirmation cycle j, s; then correct to charge/discharge energy balance point $UBE_{corr} = UBE_{meas} + (\Delta E_{REESS\_end} - \Delta E_{REESS\_ave})$ ~~rounding to the nearest whole number according to paragraph 7. of UN GTR#15~~
$UBE_{certified}$	$\Delta E_{REESS,j} = \sum_{i=1}^{n} \Delta E_{REESS,j,i}$ $\Delta E_{REESS,j,i} = \frac{1}{3600} \times \int_{t_0}^{t_{end}} U(t)_{REESS,j,i} \times I(t)_{j,i} \, dt$ t_{end} is the time at the end of the transient cycle j, s; then correct to charge/discharge energy balance point $UBE_{corr} = UBE_{meas} + (\Delta E_{REESS\_end} - \Delta E_{REESS\_ave})$ alignment of UBE_{corr} by applying the ratio of measured and certified electric energy consumption rounding to the nearest whole number according to paragraph 7. of UN GTR#15
$Range_{measured}$	Table A8/9 Step no.3 with modifying the following calculation formula $EAER = \left(\frac{M_{CO2,CS} - M_{CO2,CD,avg}}{M_{CO2,CS}}\right) \times R_{CDC}$
$Range_{certified}$	Table A8/9 Step no.8 or 9

JPN
under the study
depend on unit
or require at least three(3) significant number?

JPN_49MTG
no rounding for measured UBE

JPN_49MTG
JPN provides the solution (EVE-46-04e) but no feedback is received so far.

JPN_49MTG
Deleted: how to align the measured value to declared

JPN
Depend on unit
Or require at least three(3) significant number

JPN_49MTG
Wh unit : whole number
kWh unit : at least three (3) significant number

JPN_49MTG
Deleted: X. → notes : other UNRs (R83/R101) and regional regulations (e.g. US CFR, others) need same kind of additional specific process, if necessary¶
→¶
US CFR : …………..¶
→R83 for OVC-HEV (Grid-connected hybrid electric vehicle) : ……………¶
→R101 for PEV (BEV) : …………………¶
→ others :

$$AF_{EC} = \frac{EC_{WLTP,decl}}{EC_{WLTP,avg}} \quad or \quad AF_{EAER}$$

3.1. OVC-HEV performance parameters for Case 1

3.1.1. UBE for OVC-HEVs (Case 1)

3.1.1.1. Measured UBE values for OVC-HEVs (Case 1)

Parameters	Explanation
$UBE_{measured}$	UBE determined by the test procedure used for certification The value is calculated as follows: $UBE_{measured} = \sum_{i=1}^{n} \Delta E_{REESS,i}$ where: $UBE_{measured}$ is the measured electric energy change of all batteries, Wh; $\Delta E_{REESS,i}$ is the measured electric energy change of battery i, Wh; i is the index number of the considered battery; n is the total number of batteries; and: $\Delta E_{REESS,i} = \frac{1}{3600} \times \int_{t_0}^{t_{end}} U(t)_{REESS,i} \times I(t)_{REESS,i} \, dt$ where: $U(t)_{REESS,i}$ is the voltage of battery i, V; $I(t)_{REESS,i}$ is the electric current of battery i, A; t_0 is the time at the beginning of the charge-depleting test or full-charge test, s; t_{end} is the time at the end of the confirmation cycle of the charge-depleting test or the charge-balanced cycle of the full-charge-test, s.

3.1.1.2. Certified UBE values for OVC-HEVs (Case 1)

Parameters	Explanation
$UBE_{certified}$	UBE certified is the adjusted usable battery energy (UBE) of the vehicle measured at the point of certification. The adjustment shall be done as follows: $UBE_{certified} = UBE_{measured@cert} * AF_{UBE,OVC-HEV}$ where: $UBE_{measured@cert}$ is the $UBE_{measured}$ at the point of certification and: $AF_{UBE,OVC-HEV} = \frac{Range_{measured@cert}}{Range_{certified}}$ where: $Range_{certified}$ is the manufacturer range declaration for the vehicle measured at the point of certification $Range_{measured@cert}$ is the measured range at the point of certification In case of an interpolation family concept, the adjustment shall be done by using the values of vehicle H of the interpolation family. In case of test group concept, the adjustment shall be done by using the values of the test group representative. In case of a self-certification, the manufacturer shall provide $UBE_{certified}$ and give evidence how the value has been determined.

3.1.2. Range for OVC-HEVs (Case 1)

3.1.2.1. Measured Range values for OVC-HEVs (Case 1)

Parameters	Explanation
$Range_{measured}$	Electric range determined by the test procedure used for certification. The value is calculated as follows: $EAER_{measured} = \left(\frac{M_{CO2,CS} - M_{CO2,CD/FCT,avg}}{M_{CO2,CS}}\right) \times R_{CDC}$ where: <table><tr><td>$EAER_{measured}$</td><td>is the measured equivalent all-electric range, km:</td></tr><tr><td>$M_{CO2,CS}$</td><td>is the measured CO₂ mass emission of the charge-sustaining (Type 1) test, g/km;</td></tr><tr><td>$M_{CO2,CD/FCT,avg}$</td><td>is the measured arithmetic average CO₂ mass emission of the charge-depleting (Type 1) test or full-charge-test, g/km;</td></tr><tr><td>R_{CDC}</td><td>is the measured length of the charge-depleting test or full-charge test, km;</td></tr></table>

3.1.2.2. Certified Range values for OVC-HEVs (Case 1)

Parameters	Explanation
$Range_{certified}$	Certified range is a manufacturer declaration for range at certification.

MaN_0104
Following cases need to be evaluated in Phase 2:
- What shall be done in case of a family but no interpolation?
- This means: no individual values would be available!
- What is the solution for Phase 1?

MaN_0104
As EAER is no declared range value in type approval, the explanation need to be more detailed here.

MaN_0904
OPTION 1 (without UBE declaration in certification)

MaN_0104
For a single vehicle, situation is clear.

For vehicles which are member of an interpolation family or member of a test group, guidance required
→ for all these cases themselves, battery will be identical
→ UBE certified can be applied to all vehicles in this family

MaN_0104
One adjustment factor
→ for single vehicle → clear
→ for families or test groups: guidance below

MaN_0104
This value is being provided in the certification to TAA.
→ official value (will be used here)

MaN_0405
EAER declaration required → TO DO

MaN_0104
This value is being provided in the certifcation to TAA to prove that declaration is confirmed → Must

3.2. OVC-HEV performance parameters for Case 2

OVC-HEV Option 2 with declaration

3.1. OVC-HEV performance parameters for Case 1

3.1.1. UBE for OVC-HEVs (Case 1)

3.1.1.1. Measured UBE values for OVC-HEVs (Case 1)

Parameters	Explanation
$UBE_{measured}$	UBE determined by the test procedure used for certification. The value is calculated as follows: $$UBE_{measured} = \sum_{i=1}^{n} \Delta E_{REESS,i}$$ where:
	$UBE_{measured}$ is the measured electric energy change of all batteries, Wh;
	$\Delta E_{REESS,i}$ is the measured electric energy change of battery i, Wh;
	i is the index number of the considered battery;
	n is the total number of batteries;
	and: $$\Delta E_{REESS,i} = \frac{1}{3600} \times \int_{t_0}^{t_{end}} U(t)_{REESS,i} \times I(t)_{REESS,i} \, dt$$ where:
	$U(t)_{REESS,i}$ is the voltage of battery i, V;
	$I(t)_{REESS,i}$ is the electric current of battery i, A;
	t_0 is the time at the beginning of the charge-depleting test or full-charge test, s;
	t_{end} is the time at the end of the confirmation cycle of the charge-depleting test or the charge-balanced cycle of the full-charge-test, s.

MaN_0104
Requirement: Determination scheme for UBE need to be added to certification test procedure.

3.1.1.2. Certified UBE values for OVC-HEVs (Case 1)

Parameters	Explanation
$UBE_{certified}$	Certified UBE is a manufacturer declaration for UBE at certification. In case of an interpolation family concept and in case of test group concept, there should be only one declaration for the interpolation family and the test group concept.

MaN_0904
OPTION 2 (with UBE declaration in certification)

MaN_0104
For a single vehicle, situation is clear.

For vehicles which are member of an interpolation family or member of a test group, guidance required
→ for all these cases themselves, battery will be identical
→ UBE certified can be applied to all vehicles in this family

MaN_0104
The declared UBE value shall be used in the calculation of the certification test results → e.g. amendment of GTR15 required

3.1.2. Range for OVC-HEVs (Case 1)

3.1.2.1. Measured Range values for OVC-HEVs (Case 1)

Parameters	Explanation
$Range_{measured}$	Electric range determined by the test procedure used for certification. The value is calculated as follows: $$EAER_{measured} = \left(\frac{M_{CO2,CS} - M_{CO2,CD/FCT,avg}}{M_{CO2,CS}} \right) \times R_{CDC}$$ where:
$EAER_{measured}$	is the measured equivalent all-electric range, km:
$M_{CO2,CS}$	is the measured CO_2 mass emission of the charge-sustaining (Type 1) test, g/km;
$M_{CO2,CD/FCT,avg}$	is the measured arithmetic average CO_2 mass emission of the charge-depleting (Type 1) test or full-charge-test, g/km;
R_{CDC}	is the measured length of the charge-depleting test or full-charge test, km;

3.1.2.2. Certified Range values for OVC-HEVs (Case 1)

Parameters	Explanation
$Range_{certified}$	Certified range is a manufacturer declaration for range at certification.

MaN_0104
Following cases need to be evaluated in Phase 2:
- What shall be done in case of a family but no interpolation?
- This means: no individual values would be available!
- What is the solution for Phase 1?

MaN_0104
As EAER is no declared range value in type approval, the explanation need to be more detailed here.

MaN_0104
This value is being provided in the certifcation to TAA.
→ official value (will be used here)

3.2.   OVC-HEV performance parameters for Case 2

Thank you for the attention

Q&A

Contacts Info:
EC DG JRC DIR-C Energy, Transport and Climate, Sustainable Transport Unit
elena.paffumi@ec.europa.eu

European Commission