Proposals of PEV test procedures for Type VI

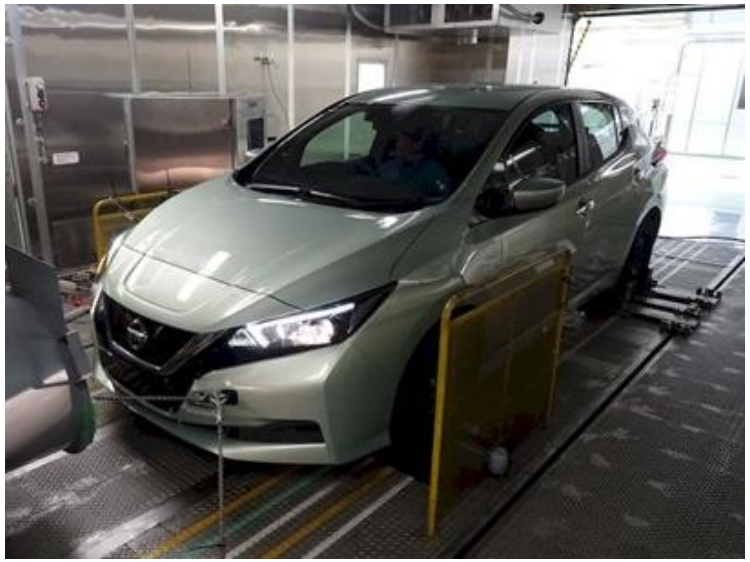
Prepared by Japan

Background and Purpose

- **Low temperature (Type VI) test procedure for PEVs need to be finalized by March 2020.**
- **Evaluate the influence of key parameter such as test cycles, discharge environment, charge environment, soak/charge time, pre-heating and so on under the low temperature condition**

Tested vehicle

Vehicle type	Vehicle mass (kg)	Motor Power (kW)	Battery type, capacity (kWh)	A/C type Compressor Heater
PEV	1,530	Rated 85 Max 110	Lithium-ion 40	Auto A/C Electric compressor PTC heater

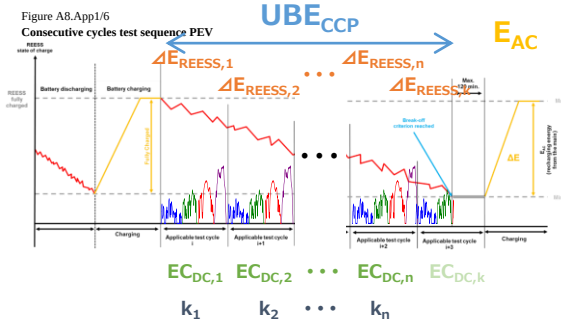


Key Points need to be evaluated

		Type VI (-7degC)	Type I (23degC)	
		Points need to be evaluated and/or considered	CCP	STP
Key parameters	Test Cycle	Same scenario as Type I can be applied or not	Depends on estimated PER	
			4P : <3 cycles 3P : <4 cycles	4P : ≧ 3 cycles 3P : ≧ 4 cycles
	EC_{DC}	Evaluate the equivalency of the possible test cycles	-	-
	E_{AC}	How to evaluate the battery heating function during charge and soaking events, if available	No need to consider the battery heating function	
	UBE	Evaluate the possibility to use same UBE derived during Type I and the equivalency of the possible test cycles	-	-
	k factor	Evaluate the timing when EC_{DC} becomes stable and reflect to calculation formula, if necessary	EC_{DC} becomes stable after the completion of first cycle at latest	

Possible Test Cycles

Consecutive cycle TP (CCP)



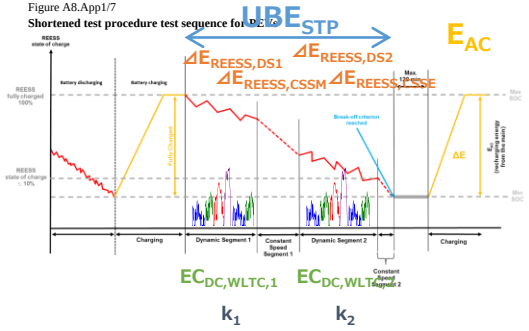
$$EC_{WLTC} = \frac{E_{AC}}{PER_{WLTC}} \qquad PER_{WLTC} = \frac{UBE_{CCP}}{EC_{DC,CCP}}$$

$$EC_{DC,CCP} = \sum_{j=1}^{n_{WLTC}} EC_{DC,WLTC,j} \times k_{WLTC,j}$$

$$k_{WLTC,1} = \frac{\Delta E_{REESS,WLTC,1}}{UBE_{CCP}} \qquad k_{WLTC,j} = \frac{1 - k_{WLTC,1}}{n_{WLTC} - 1}$$

$$UBE_{CCP} = \sum_{j=1}^{k} \Delta E_{REESS,j}$$

Shortened TP (STP)



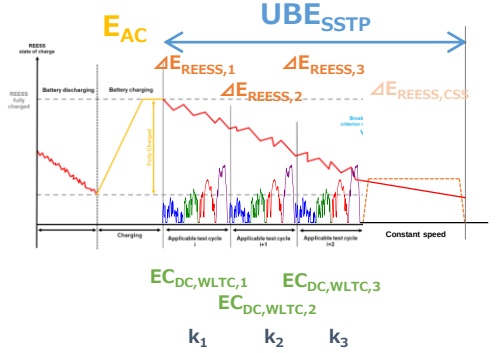
$$EC_{WLTC} = \frac{E_{AC}}{PER_{WLTC}} \qquad PER_{WLTC} = \frac{UBE_{STP}}{EC_{DC,STP}}$$

$$EC_{DC,STP} = \sum_{j=1}^{2} EC_{DC,WLTC,j} \times k_{WLTC,j}$$

$$k_{WLTC,1} = \frac{\Delta E_{REESS,WLTC,1}}{UBE_{STP}} \qquad k_{WLTC,2} = 1 - k_{WLTC,1}$$

$$UBE_{STP} = \Delta E_{REESS,DS1} + \Delta E_{REESS,DS2} + \Delta E_{REESS,CSSM} + \Delta E_{REESS,CSSE}$$

Shortened STP (SSTP)



$$EC_{WLTC} = \frac{E_{AC}}{PER_{WLTC}} \qquad PER_{WLTC} = \frac{UBE_{SSTP}}{EC_{DC,SSTP}}$$

$$EC_{DC,WLTC} = \sum_{j=1}^{3} EC_{DC,WLTC,j} \times k_{WLTC,j}$$

$$k_{WLTC,1} = \frac{E_{DC,WLTC,1}}{UBE_{SSTP}} \qquad k_{WLTC,2} = \frac{E_{DC,WLTC,2}}{UBE_{SSTP}}$$

$$k_{WLTC,3} = 1 - k_1 - k_2$$

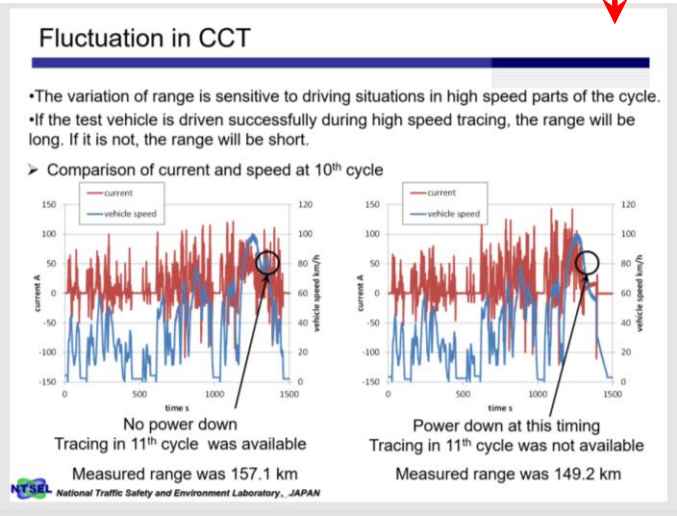
$$UBE_{SSTP} = \Delta E_{REESS,1} + \Delta E_{REESS,2} + \Delta E_{REESS,3} + \Delta E_{REESS,CSS}$$

current Type I

Proposal

Test Cycles Evaluation

	(potential) Critical Concerns		UBE family	Final Judgement
	PER<3 cycles	PER ≧ 3 cycles		
CCP	NONE	**Break-off point is sensitive**	NONE	**× (PER ≧ 3 cycles)**
STP	-	Transient conditions may not able to evaluated	DS may not be enough long	×
S･STP	NONE	NONE	NONE	◎



<in case of the tested vehicle>

transient EC_{DC} | stable EC_{DC}

	1st cycle				2nd cycle				3rd cycle				
CCP	L	M	H	exH	L	M	H	exH	L	M	H	exH	
STP	DS_1						CSS_M	DS_2					CSS_E
	L	M	H	exH	L	M		L	M	H	exH	L	M
(ref) Type I	L	M	H	exH	L	M							

In case that EC_{DC} is not stable due to vehicle/battery warm-up condition and heater operation, DS may not be enough long for correct evaluation.

WLTP-SG-EV-05-10_Japan Shorten test procedure.ppt

SUMMARYs

		CCP -7degC	STP -7degC	SSTP -7degC	Type I*
Key Parameters	Estimated PER	Apply same scenario as Type I, but need to accept the different test procedure between Type I and VI in case		**Cover both CCP and STP (no criteria is necessary anymore)**	YES
	EC_{DC}	218 Wh/km	216 Wh/km	219 Wh/km	
		✓ **CCP and SSTP are identical**			
	E_{AC}	✓ **E_{AC} shall be measured before "cold start testing" to evaluate the consumed energy for battery heating (SG EV agreement)** ✓ **To obtain robust E_{AC},** **(1) battery temperature before charge start shall be well maintained** **(2) interval between charge completion and cold start test shall be well specified**			YES *1
	UBE	34.4 kWh	34.8 kWh (37.1 kWh @ Type I)	34.1 kWh	
		✓ **Not able to apply UBE derived during Type I (SG EV agreement)** ✓ **CCP and SSTP are identical**			YES *2
	k factor	EC_{DC} becomes stable after end of 2 cycles (4 phases cycle) $261@1^{st} \rightarrow 214@2^{nd} \rightarrow 209@3^{rd} \rightarrow 208@4^{th} \rightarrow 207@5^{th} \rightarrow 207@6^{th}$ (Wh/km)			
		Need to modify the calculation formula	**may be "no solution"**	✓ **At least 3 cycles need to be tested, then apply unique factor to each cycle**	YES *3

*) possibility to apply also Type I (later stage)
*1 : battery temperature control is not factor to be considered
*2 : definition of UBE family needs further discussion
*3 : apply same concept, but calculation formula may be modified

CONCLUSIONs

- **Japan proposes the S·STP with specifically defined soak and charge operation**
- **UBE family definition* needs further discussion considering the balance between required accuracy and testing burden**

  *) Japan proposes “battery capacity” as a discussion starter

- **S·STP is best candidate for also Type I, but final decision should be made at later stage**