

# 【Proposal】 JAMA Position Test Boundary condition @23deg.C C/D<sub>(constant temp.)</sub> vs. cold Test track for HDV Battery Deterioration

JAMA Battery Deterioration MTG

28 Feb. 2024

# Results : CD@Room Temp.23°C(constant temperature)

RESS	48kWh	Room Temp.:23°C	Test date	Discharge						RTE			Charge							
				Voltage	Capacity	Energy	Duration	C/Temp.	warning	Round Trip			Voltage	Charge	Capacity	Energy	Duration	C/Temp.		
	Method			Stop+5sec	Ah	kWh	SEC	ST->End	Error	Ah	Efficiency	kWh	Stop+0sec	PWR	Ah	kWh	SEC	ST->End		
	n				PW	PW	<12,600		Empty					kW	PW	PW	<12,600			
1a C/3	1	Constant speed On-Board_Constant	2023/11/14	271.67	98.52	35.912	8,439	26->29		1.005	0.956	0.956	390.01	DC48	89.808	34.025	10,594	31->36		
				246.70	2.385	0.607	373	30->30	•					395.79	AC3	10.609	4.173	6,788	35->34	
					101	37	8,812								100.417	38.198	17,382			
	2	Constant speed On-Board_Constant	2023/11/17	276.66	99.12	36.13	8,109	25->29		0.984	0.953		0.953	396.92	AC3	102.634	38.427	56,674	30->28	
				253.41	1.86	0.49	389	30->30	•					-	-	-	-	-	-	
					100.98	36.62	8,498													
3	Constant speed On-Board_Constant	2023/11/21	273.60	100.58	36.69	8,066	26->29		1.020	0.959		0.959	390.06	DC100	89.556	34.432	3,925	31->39		
			244.94	2.3	0.579	353	29->30	•					395.47	AC3	11.314	4.449	6,101	39->37		
				102.88	37.269	8,419									100.87	38.881	10,026			
1b	1	JE05 On-Board_JE05	2023/11/13	268.97	101.02	36.615	17,508	23->29		1.018	0.962	0.962	391.25	DC48	91.31	34.677	10,298	30->35		
				246.30	2.211	0.56	375	30->30	•					396.54	AC3	10.06	3.966	5,865	35->34	
					103.231	37.175	17,883										101.37	38.643	16,163	
1c	1	On-Board	2023/11/16	248.81	103.1	37.623	15,110	26->29	•	1.007	0.966	0.966	390.86	DC48	91.62	34.722	9,273	30->35		
				-	-	-	-	-	-					396.42	AC3	10.74	4.231	6,331	35->34	
														102.36	38.953	15,604				
	2	On-Board	2023/11/20	245.60	102.32	37.25	15,064	22->28	•	0.988	0.962		0.962	396.68	AC3	103.61	38.705	52,529	29->27	
				247.03	103.18	37.706	15,530	24->29	•	1.001	0.948		0.948	391.05	DC100	91.96	35.415	3,897	29->38	
					-	-	-	-	-	-					396.51	AC3	11.07	4.364	6,463	38->36
															103.03	39.779	10,360			
2 C/3	1	Bidi	2023/11/09	266.95	100.355	36.47	10,163	21->27		0.999	0.971		0.971	397.60	AC3	100.411	37.566	55,498	27->26->28	
				266.85	98.171	35.746	12,736	25->29		0.970	0.943		0.943	396.97	AC3	101.186	37.899	55,685	29->28	
					267.10	100.7323	36.645	9,165	22->26		0.994	0.931		0.931	391.32	DC100	88.9961	34.3258	2,962	29->38
	3	On-Board_Bidi	2023/11/24	242.64	1.444	0.362	253	28->28	•					396.66	AC3	13.82287	5.43908	8,123	38->36	
								102.1768	37.00749	9,418							102.819	39.76488	11,085	
										0.999	0.955	0.961	0.946	0.957					+8	
										0.015	0.012	0.005	0.014	0.012					13:00=17:00	
										1.00±0.05	1C	2C	0.05C						Precon : Overnight Soak	

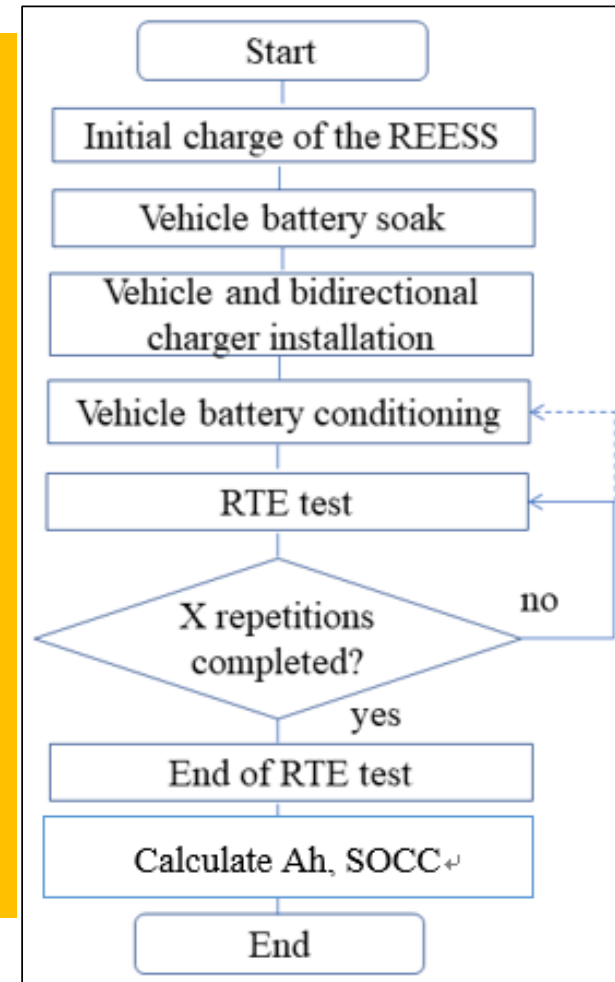
## <Result>

- Each Discharge/Charge time within 3.5 hours(12,600s) : Discharge\_0.33C-rate, Charge\_2.0C-rate
- Full Charge/Empty Discharge criteria : The on-board criteria in BMS to automatically stop charging/discharging to prevent damage to the RESS due to over-charging/over-discharging
- Test sequence : Charge<Pre con>→overnight→Discharge<Cell max. temp+3°C⇒+7°C>→30min.→Charge→End
- Repetition of RTE test completed criterion :  $\leq 1.000 \pm 0.050$ <Ah> or OEM's  $\pm 0.050$ <kWh>

# Consideration & Position (Method2)

## <JAMA Position> method2 Boundary condition of test sequence

- Battery deterioration measurement index: **Ah [or kWh]**  
High-voltage areas are insulated to prevent electric shock;  
voltage measurement is not possible with ISC.
- Environmental temperature: **18~30 degree C**
- MPR <Degradation level> : **Ah≒kWh**
- Test time : **within 3.5 hours**  
<Discharge\_0.33C-rate, Charge\_2.0C-rate>
- Full Charge/Empty Discharge criteria : **Threshold value at which the BMS** is set within the BMS to automatically stop charging/discharging to prevent RESS damage due to overcharge/overdischarge
- Test sequence : **Charge**<Pre con>→**overnight**  
→**Discharge**<Cell max. temp =<R.T.+3 degree C>  
→**30min.**→**Charge**→End
- Repetition of RTE test completed criterion :  **$1.000 \pm 0.050 @Ah$**   
**[OEM Declaration value  $\pm 0.050@kWh$ ]**



**Confidential**

# Results : Test Track @ Cold location

Conducting RTE tests for discharging and charging by method in two test tracks by cold location , and measured the following items.

- UBC[Ah] and UBE[kWh]
- Test time
- Cell temperature transition

The test vehicle did not have a battery temperature control function.

RESS	48kWh		Test date	Amb.temp deg.C	Discharge								Amb.temp deg.C	RTE		Charge								Amb.temp deg.C
	Method	n			Start-1s	Voltage End+0s	Voltage End+5s	Capacity	Energy	Duration	C/Temp.	warning		Round Trip Efficiency	Start-1s	Voltage End+0s	Capacity	Energy	Duration	C/Temp.	Amb.temp deg.C			
								Ah	kWh	SEC	Δ°C	ST->End						Cut-off	Ah	kWh		Ah	kWh	
1a	1	Const. speed(TT_A)	6-Dec	6.7	394.3	265.3	268.9	102.64	37.35	8,495	5	20->17->22	-	1.046	1.012	283.7	396.0	AC3	99.96	37.40	55,860	10	20->10->11	10.2
		On-Board_C/SPD	10.7	283.9	229.8	3.7	1.90	0.48	241	0	22	-	-	-	-	-	-	-	-	-	-	-	-	
	2	Const. speed(TT_A)	8-Dec	0.1	392.3	342.7	344.8	90.38	33.10	7,182	6	4->10	-	1.007	0.942	285.3	391.9	DC50	92.28	35.40	6,570	8	12->20	3
		On-Board_C/SPD	1.7	344.6	247.9	3.8	12.29	3.84	1,718	2	10->12	-	2.2	391.6	397.1	AC3	9.68	3.83	5,894	2	19->17	-0.3		
	3	Const. speed(TT_B)	13-Dec	-2.2	390.3	332.3	334.8	93.17	33.91	7,627	8	0->8	-	1.069	1.018	293.6	396.6	AC3	95.67	35.87	53,044	6	7->1	-4.4
		On-Board_C/SPD		0.2	339.3	231.9	3.7	9.11	2.59	1,018	0	9	-	0.5	-	-	-	-	-	-	-	-	-	
4	Const. speed(TT_B)	14-Dec	-2.3	391.5	326.2	327.2	92.46	33.62	7,537	7	1->8	-	0.979	0.915	295.7	391.7	DC50	90.04	34.62	6,389	8	8->16	-1.3	
	On-Board_C/SPD		-1.1	330.0	276.5	3.7	5.62	1.72	876	1	8->9	-	-0.5	391.0	397.0	AC3	10.11	3.99	6,175	3	16->13	-2.4		
5	Const. speed(TT_A)	18-Dec	-5.5	389.6	336.4	339.7	89.01	32.21	7,404	7	-3->4	-	1.074	1.021	291.0	396.2	AC3	100.16	38.62	12,564	7	3->4	-12.1	
	On-Board_C/SPD		-5.2	344.0	248.6	3.6	10.96	3.39	1,821	2	4->6	-	-5.3	-	-	-	-	-	-	-	-	-		
6	Const. speed(TT_B)	20-Dec	-6.3	392.0	334.3	340.6	92.06	33.51	7,978	8	-2->6	-	1.005	0.935	283.8	391.7	DC50	91.06	34.97	6,449	8	8->16->15	-2.8	
	On-Board_C/SPD		-1.2	343.3	231.0	3.7	10.23	3.13	1,435	2	6->8	-	-1	390.8	397.0	AC3	10.72	4.23	6,594	2	15->13	-3.8		
1	On-Board	7-Dec	11.4	390.7	253.8	3.7	101.69	37.19	15,280	4	11->15	-	0.992	0.945	280.1	391.9	DC50	92.41	35.34	5,553	8	15->23	8.8	
			-	-	-	-	-	-	-	-	-	-	-	391.4	397.2	AC3	10.12	4.00	5,966	2	23->21	6.2		
2	On-Board	11-Dec	-0.7	395.4	252.3	3.7	101.95	36.93	14,710	7	0->7	-	1.050	1.017	269.4	396.8	AC3	97.09	36.31	52,608	5	8->3	-3.2	
			-	-	-	-	-	-	-	-	-	-	0.988	0.932	276.3	391.9	DC50	92.26	35.41	6,637	8	7->16->15	-1	

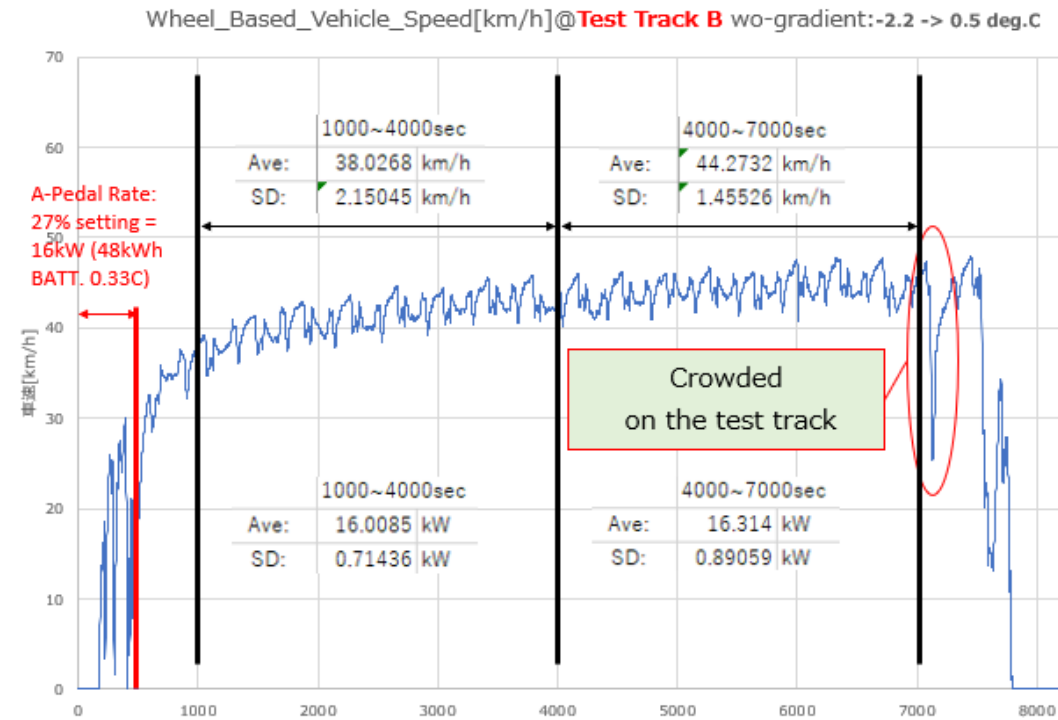
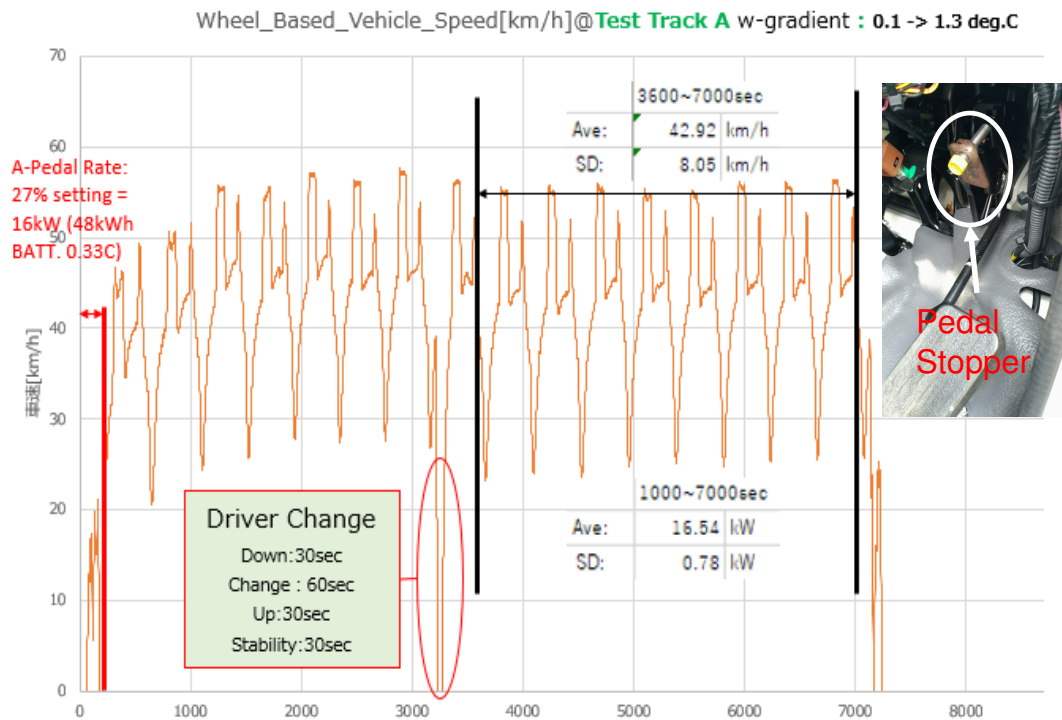
<Result>

- "Ah" of AC charging at low cell temperatures is decline. (see to □)
- Discharge Ah deviation at low cell temperature: Ave\_ **101.2Ah**, SD\_ **2.0Ah** <2.0%>. CD:101.6Ah,1.1Ah<1.0%>
- RTE Ah[%]: Ave\_ **102.22**, SD\_ **4.0** . CD:99.9, 1.5

**Confidential**

# Results: Comparison HDV Test Track A vs. B

- HDV OEMs own some Test Tracks with a gradient, so comparison was made around 0deg.C at the same A-pedal opening
- Test Track-A has 1 hour for driver changeover



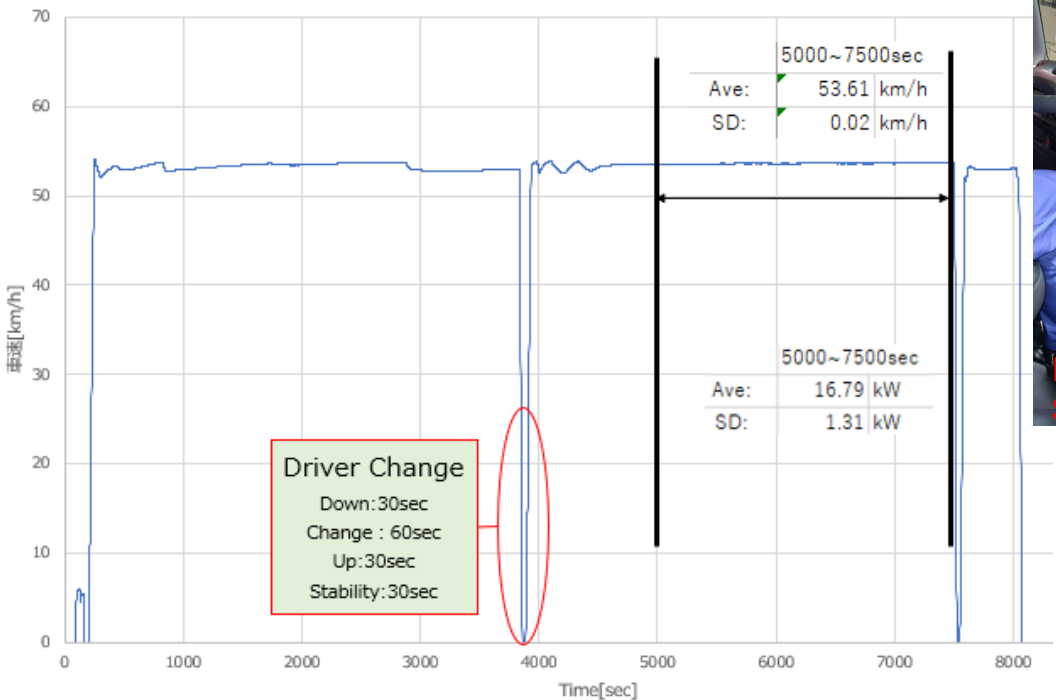
## <Result>

- Target C-rate:  $C/3 \pm 20\%$   $\langle 16 \pm 3.2 \text{ kW} \rangle$  :  $16.5 \pm 2.3 (=3 \times 0.78)$  ,  $16.3 \pm 2.7 (=3 \times 0.89)$
- Target Speed deviation:  $\pm 2.0 \text{ km/h}$  :  $8.0 \text{ km/h}$  ,  $2.1 \sim 1.5 \text{ km/h}$
- Warm-up time varies depending on temperature.

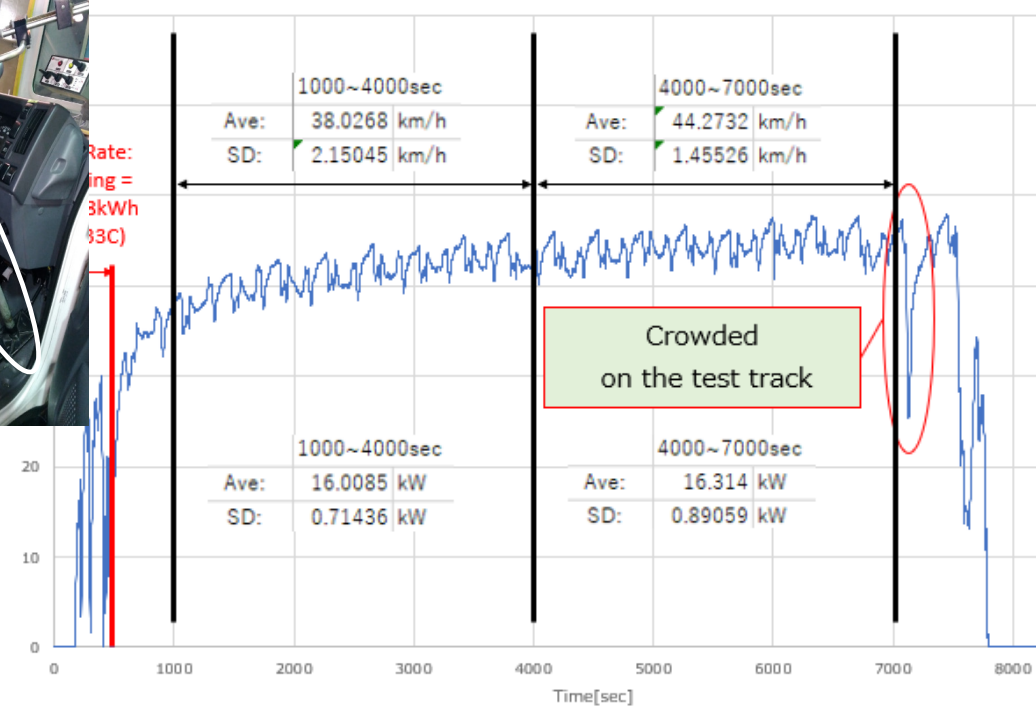
# Results: Comparison CD vs. HDV Test Track B

- HVAC, etc. are non-operational in the chassis dyno. test.
- C/D has 1 hour for driver changeover.

Vehicle\_Speed[km/h]@CD : 23 deg.C



Wheel\_Based\_Vehicle\_Speed[km/h]@Test Track B wo-gradient:-2.2 -> 0.5 deg.C



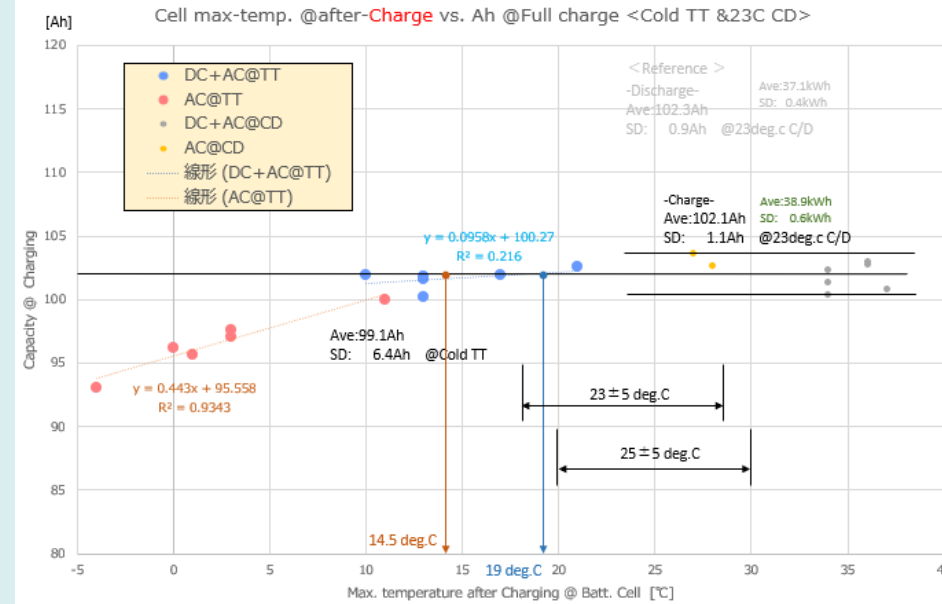
## <Result>

- Target C-rate:  $C/3 \pm 20\%$   $\langle 16 \pm 3.2 \text{ kW} \rangle$  :  $16.8 \pm 3.9 (=3 * 1.3)$  on chassis dyno. test..
- Speed deviation: 0.02 km/h on chassis dyno. test.

# Consideration & Position (Method1a)

## <Consideration>

- Environmental temperature:
  - Both discharging and charging seem to affect the Ah/kWh measurement value.
  - In particular, low-power AC charging seems to have a large impact.
  
- Battery output:
  - 1) Output operation is done using the Acc-pedal opening fixed method (our own).  
 Target:  $0.33\text{C-rate}(16.0\text{kW}) + 20\%(3.2\text{kW}) < 0.43\text{C-rate}(20.6\text{kW})$   
 This target seems possible to satisfy.
    - With the method used in C/D, the target C-rate was not achieved due to insufficient fixation.  
 Target:  $16 \pm 3.2 \text{ kW} < 16.8 \pm 3.9\text{kW}$
  - 2) Priorities
    - Consideration that priority should be given to battery outlet output rather than vehicle speed. If the vehicle speed is fixed, changes **in running resistance due to gradients, air, rolling, etc.** will be added, which will increase the deviation of the battery outlet output and make it impossible to achieve the target C-rate.



The vehicle with the above data does not have a battery cell temperature control function.

# Consideration & Position (Method1a)

## <Consideration (cont.)>

### ➤ Driver change:

If you prepare multiple drivers and use this test vehicle, it is possible to decelerate for 30s ⇒ change for 60s ⇒ accelerate for 30s ⇒ stabilize for 30s (Dr. change can be made within 10 minutes.)

## <Conclusion> Method 1a Test boundary condition

### > Ambient temperature

**The battery temperature during normal operation and the maximum allowable deviation need to be agreed upon between OEMs."**

### > C-rate control

The specific value of  $0.33 \pm 20\%$  is the battery threshold of the vehicle tested this time.

The maximum allowable C-rate depends on the specifications of the battery used by each company.

**Each company should set the maximum C-rate that will not cause damage to the customer's battery, and set the average C and allowable tolerance rate accordingly.**

**"C-rate limitations according to manufacturer recommendation".**

### ➤ Driver change:

**Multiple drivers, change and return to main measurement within 5 minutes (maximum 10 minutes).**



Thank you