Validation2 test results

prepared by Japan (JARI)

14th DHC & 11th DTP group
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Joint Research Centre, Ispra, Italy

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    6. Temperature in test cell

1. Purpose

Validation 2 test program was developed by VTF to resolve and/or to close the varieties of open issues for global test regulation (gtr). JARI supported this program from the view points of the following items using 4 vehicles.

- CO_2 Compensation by Vehicle test mass
- Repeatability
- Forced cool down
- RCB measurement of low voltage battery
- Temperature in soak room
- Temperature in test cell
- Temperature in dilution tunnel

2. Test vehicle

Vehicle No.	A	B	C	D
Vehicle category	PC	PC	LDCV	LDCV
Class	M	H	M	H
Fuel type	Petrol	Diesel	Petrol	Petrol
Engine capacity (cc)	1,597	3,200	1,496	1,998
Max. rated power (kW)	80	140	80	98
Unladen mass (kg)	1,325	2,230	1,030	1,650
Technically permissible maximum laden mass (LM)	1,910	3,110	1,900	3,200
Mass including all optional equipment for the heaviest vehicle (OMH)	1,385	2,360	1,280	1,780
Power to mass ratio (KW/t) (Unladen mass basis)	60.4	62.8	77.7	59.4
Test mass – lightest (kg)	1,489	-	1,312	2,212
Test mass – Medium (kg)	1,519	-	-	2,277
Test mass – heaviest (kg)	1,549	2,578	1,562	2,342
After treatment	TWC	OC, DPF, LNT	TWC	TWC, AI
Emission standard	JP2005, 75% decrease	JP2009	JP2005 75% decrease	JP2005, 50% decrease
Maximum speed (km/h)	150	160	160	145
Transmission	4AT	5AT	4AT	4AT

3. Test matrix

Vehicle	Type	Fuel	Class*	Test cycle	Test mass	Rolling resistance***	Air drag	Condition	Soak	# of test
A	PC	Petrol	M	WLTC v5	Lightest	Best	Best	Cold-Hot	Natural	1
						Worst-L	Worst			1
					Mid	Worst-M				1
					Heaviest	Worst-H				1
								Cold	Forced	1
B		Diesel	H	WLTC v5	Heaviest	Worst-H	Worst	Cold-Hot	Natural	(3×2)+1**
								Cold	Forced	1
C	LDCV	Petrol	M	WLTC v5	Lightest	Worst-L	Best	Cold-Hot	Natural	1
					Heaviest	Worst-H	Worst			4
								Cold	Forced	1
D			H	WLTC v5	Lightest	Best	Best	Cold-Hot	Natural	1
						Worst-L	Best	Hot	-	1
							Worst	Cold-Hot	Natural	1
					Mid	Worst-M				1
					Heaviest	Worst-H				1
								Cold	Forced	1

(*) Class: L : P to M <[30-35] kW/t, M : L=< P to M < 70 kW/t, H : 70 =< P to M

(**) L-M-H-xH: 3 times, L-M-H: 3 times, Each phase(L/M/H/ExH): 1 time in Hot condition for PM sampling

(***) Rolling resistance: $\mu_{r\_i} * TM_j$ i: Best / Worst, j: Lightest / Mid. / Heaviest

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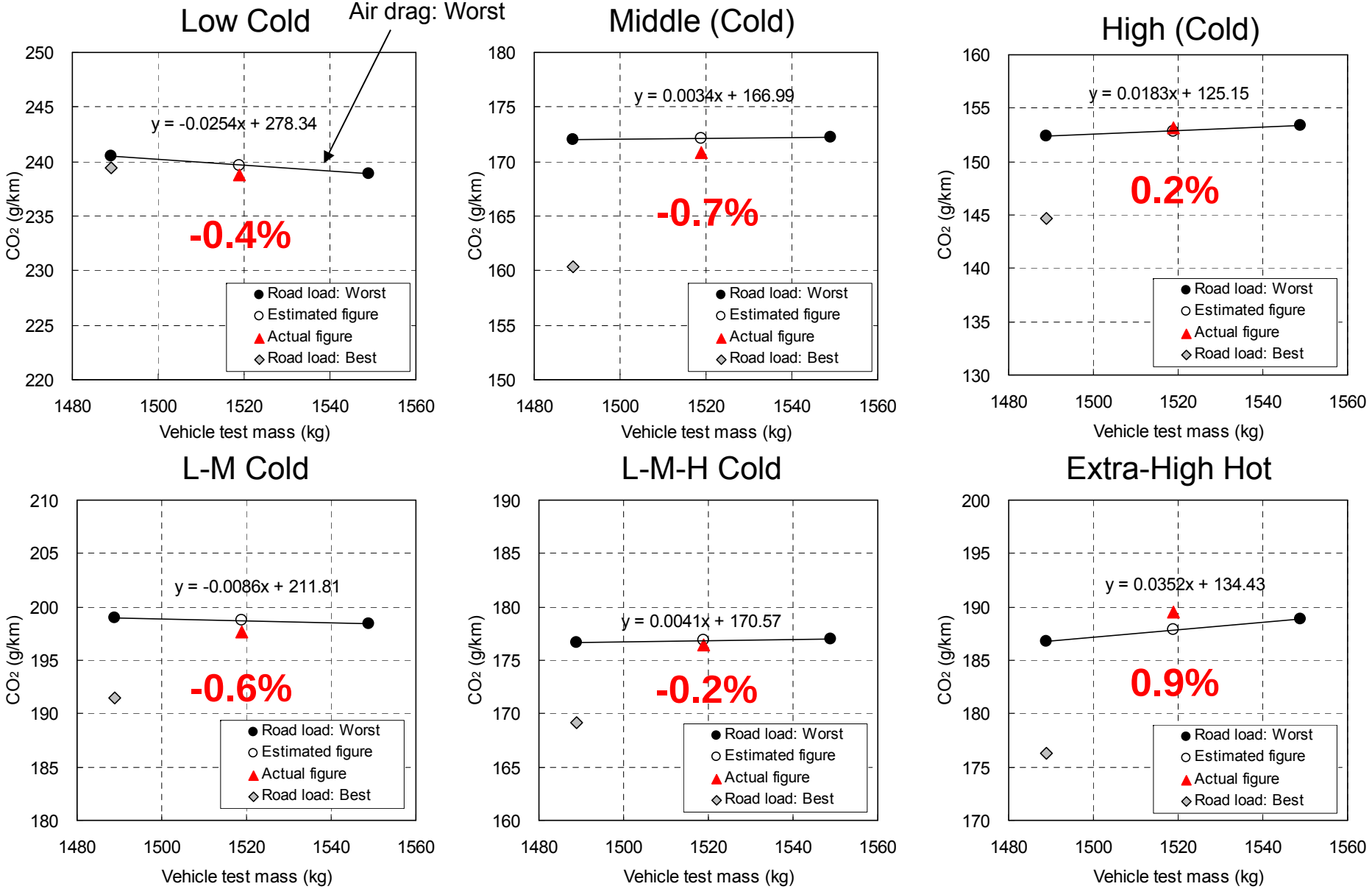
CO_2 compensation by vehicle test mass – Vehicle A

Rolling resistance: $\mu_{r\_worst} * TM_j$

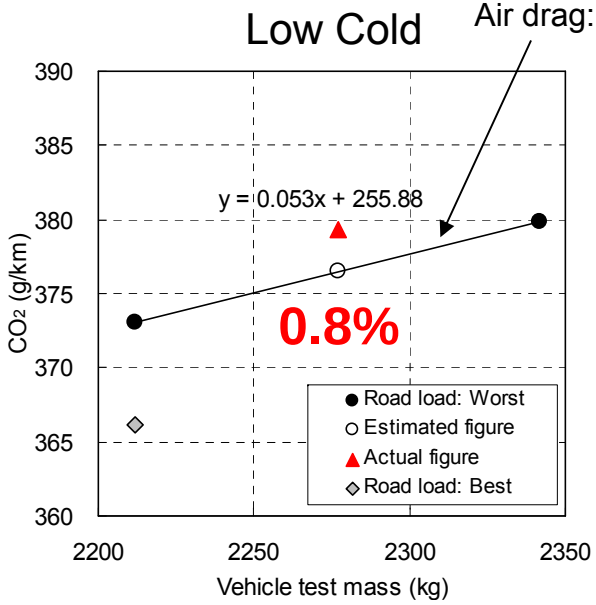
Air drag: Worst

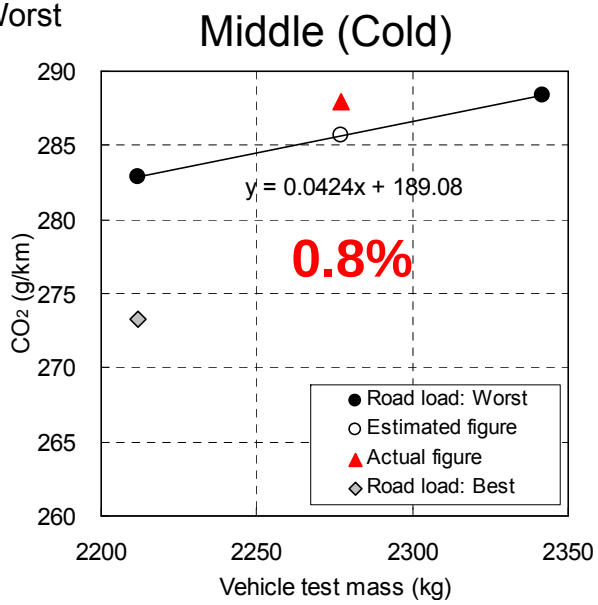


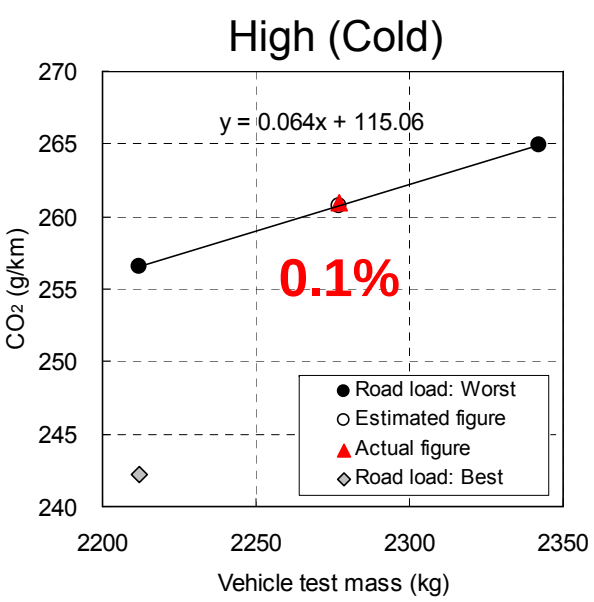
CO_2 compensation by vehicle test mass – Vehicle D

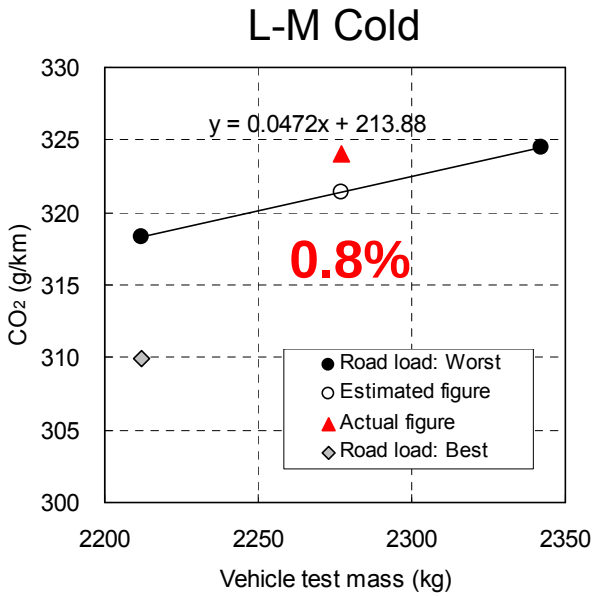
Rolling resistance: $\mu_{r\_worst} * TM_j$

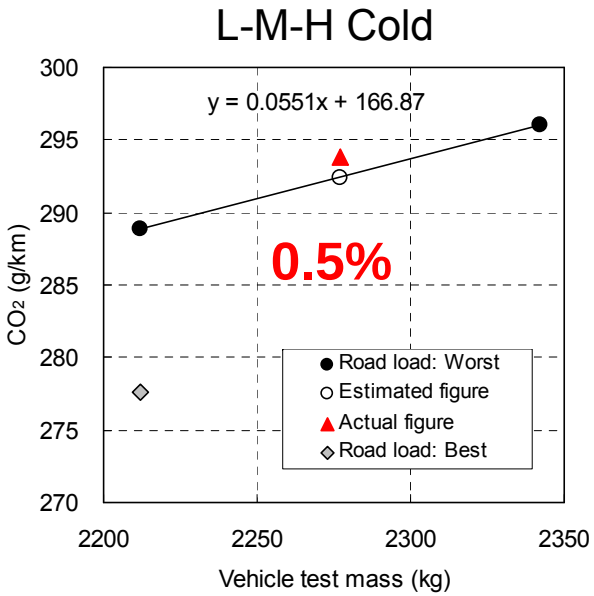
Air drag: Worst

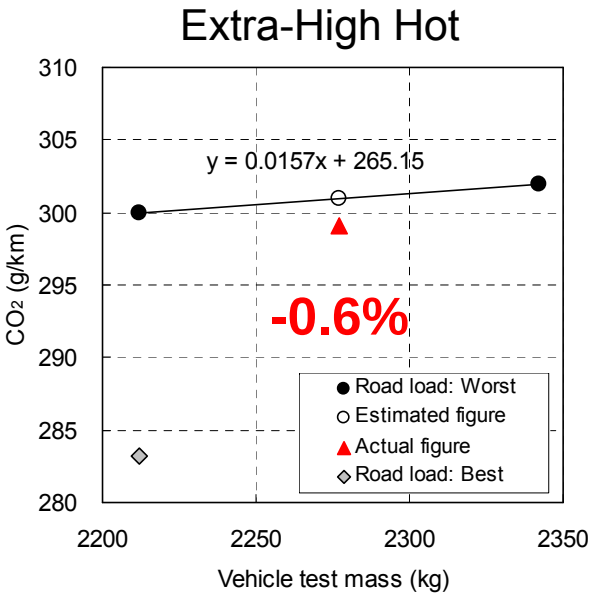












Observation

- No significant difference was observed between the estimated CO_2 value and the actual CO_2 value on intermediate test mass when applying the worst road load condition.

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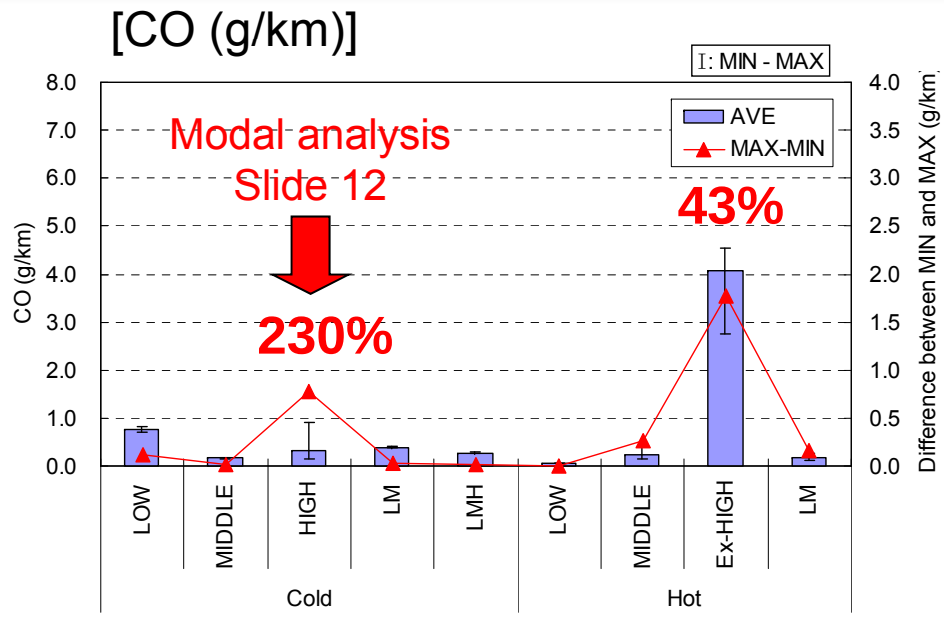
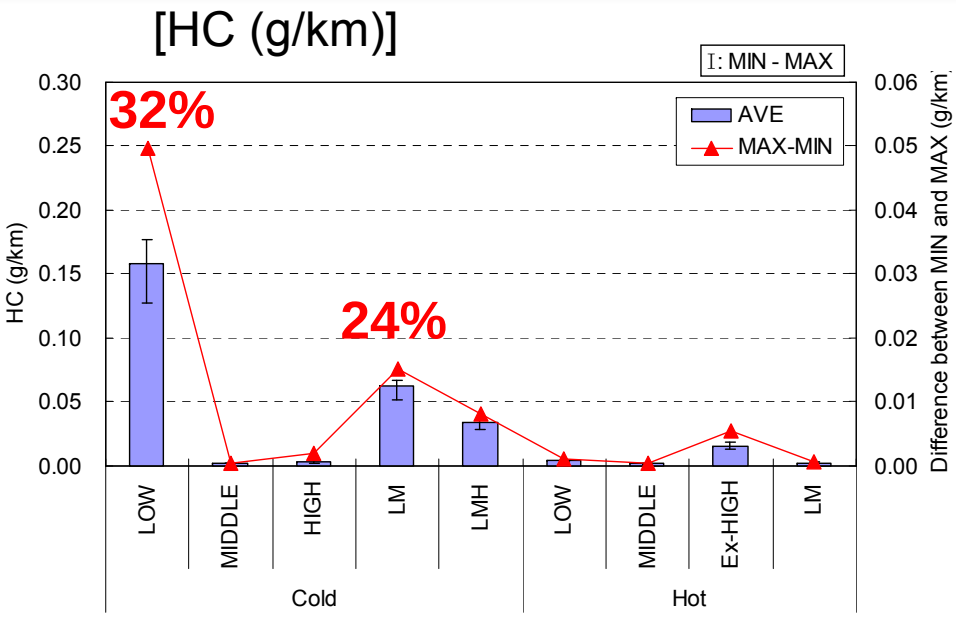
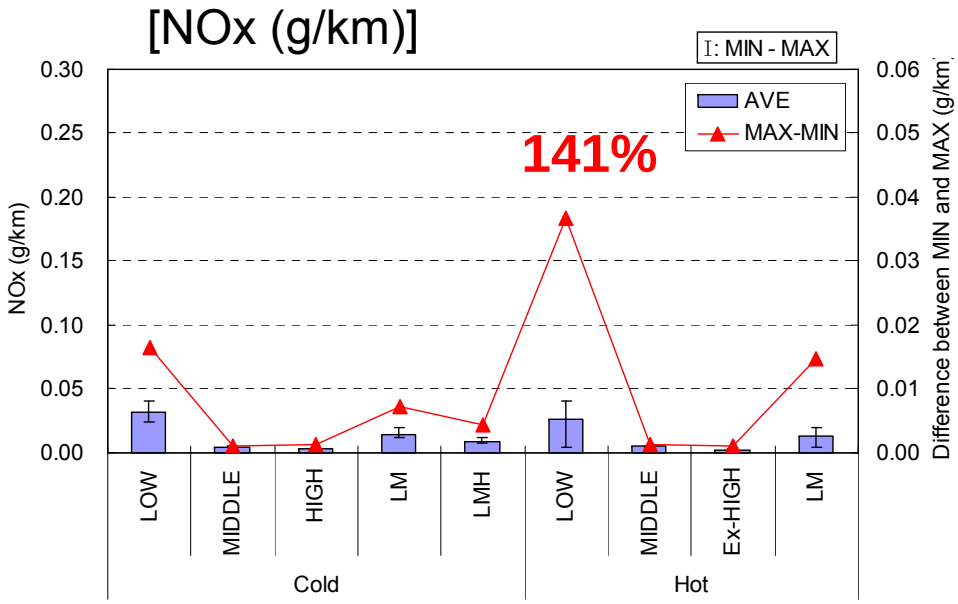
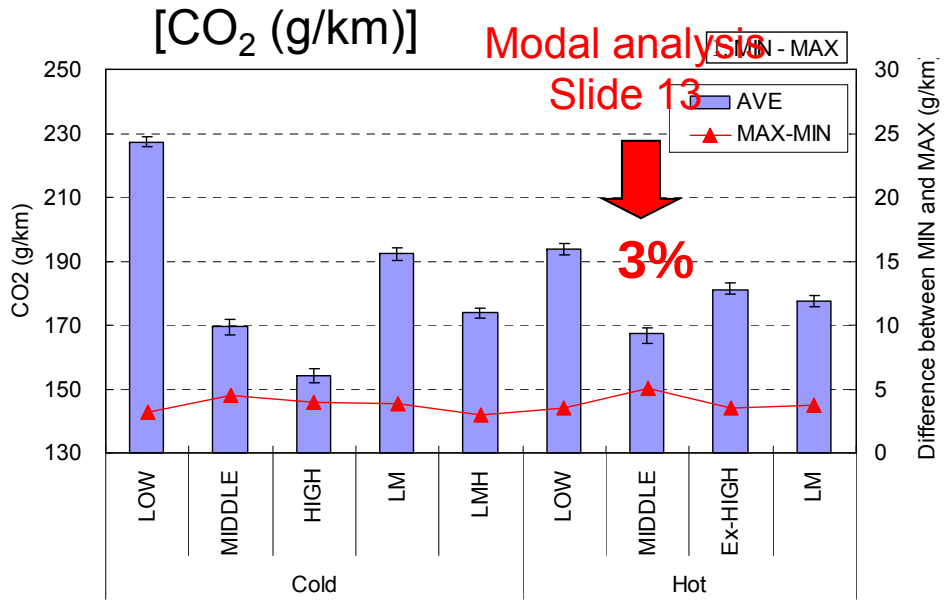
Repeatability – Vehicle C

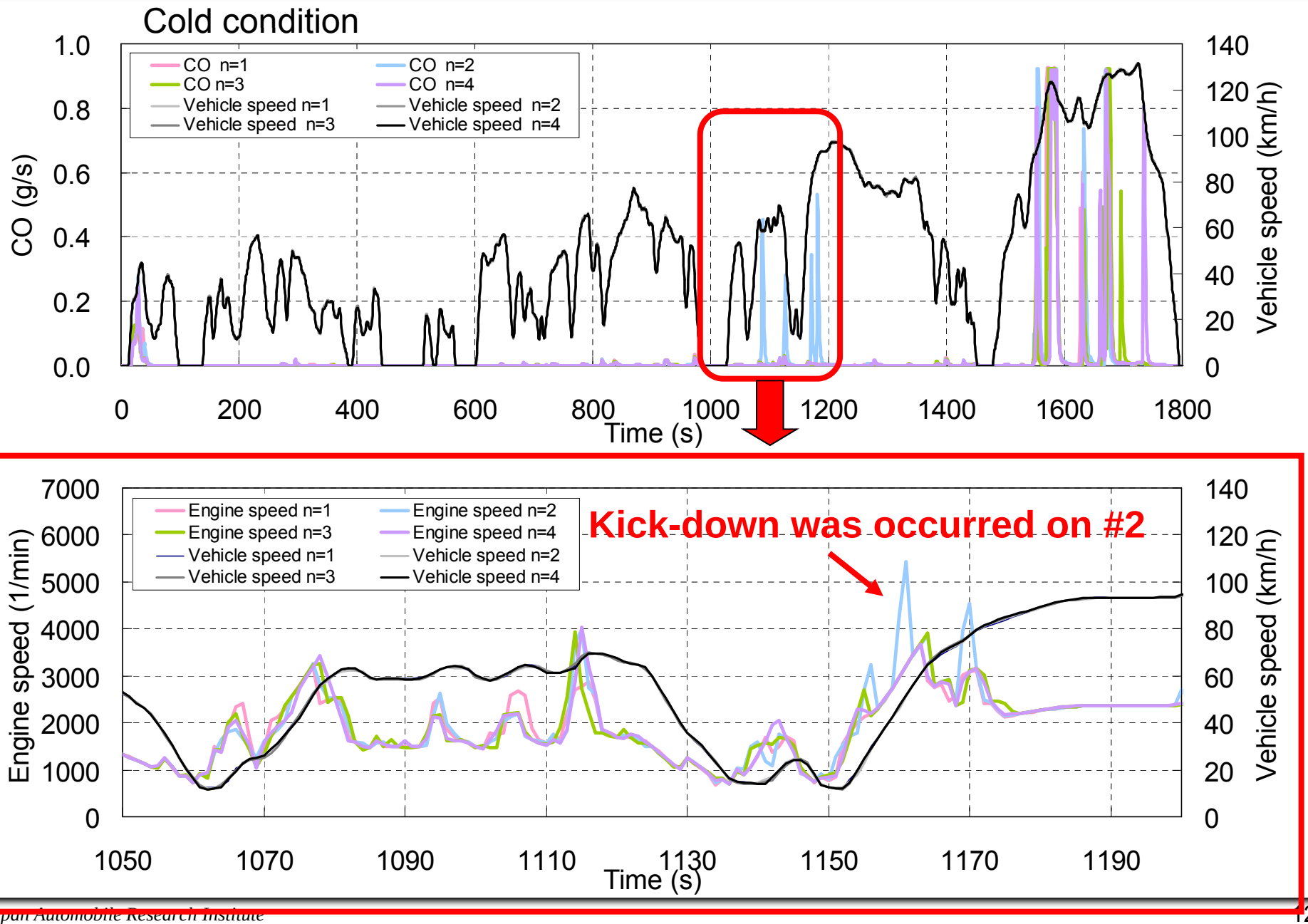




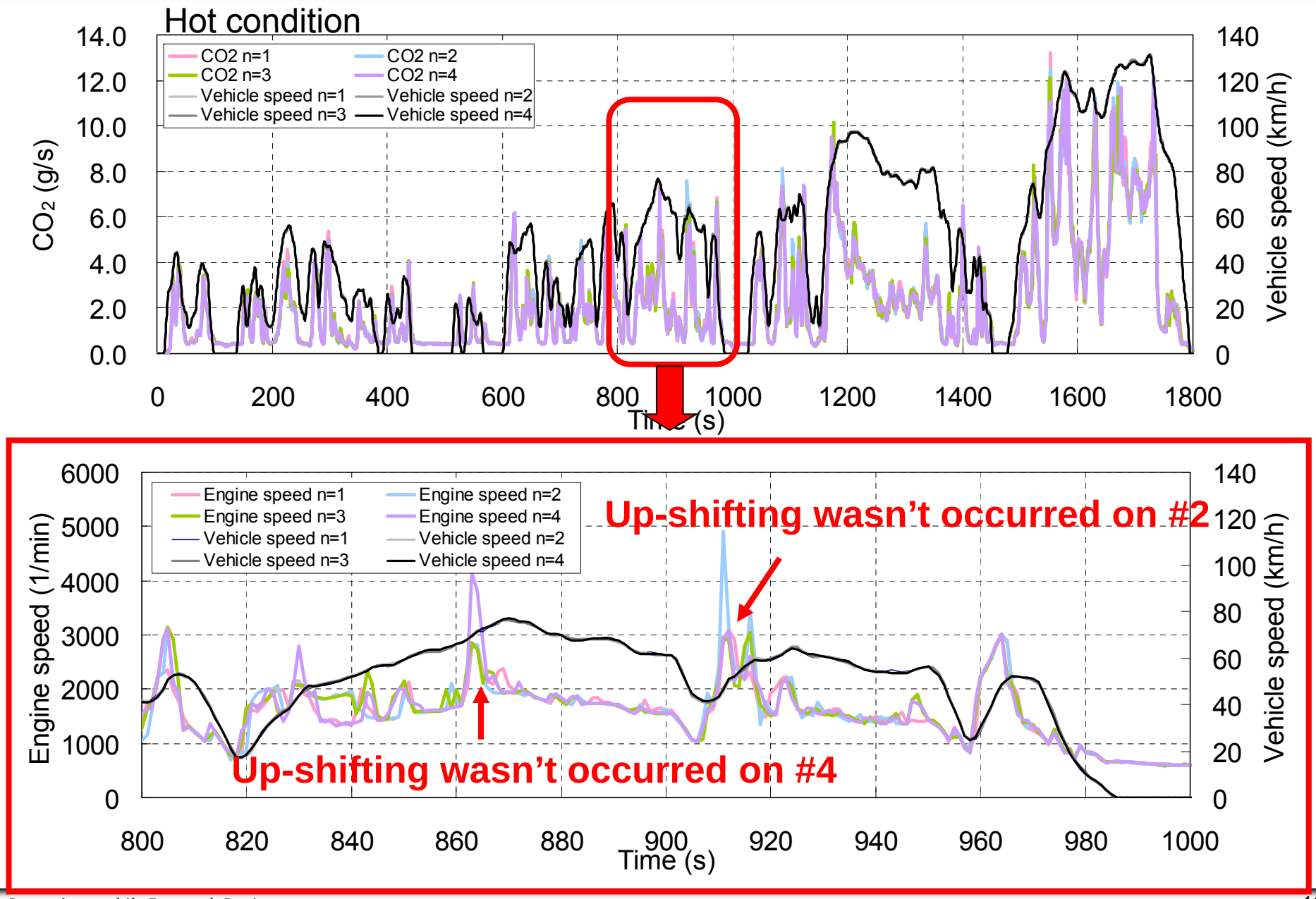




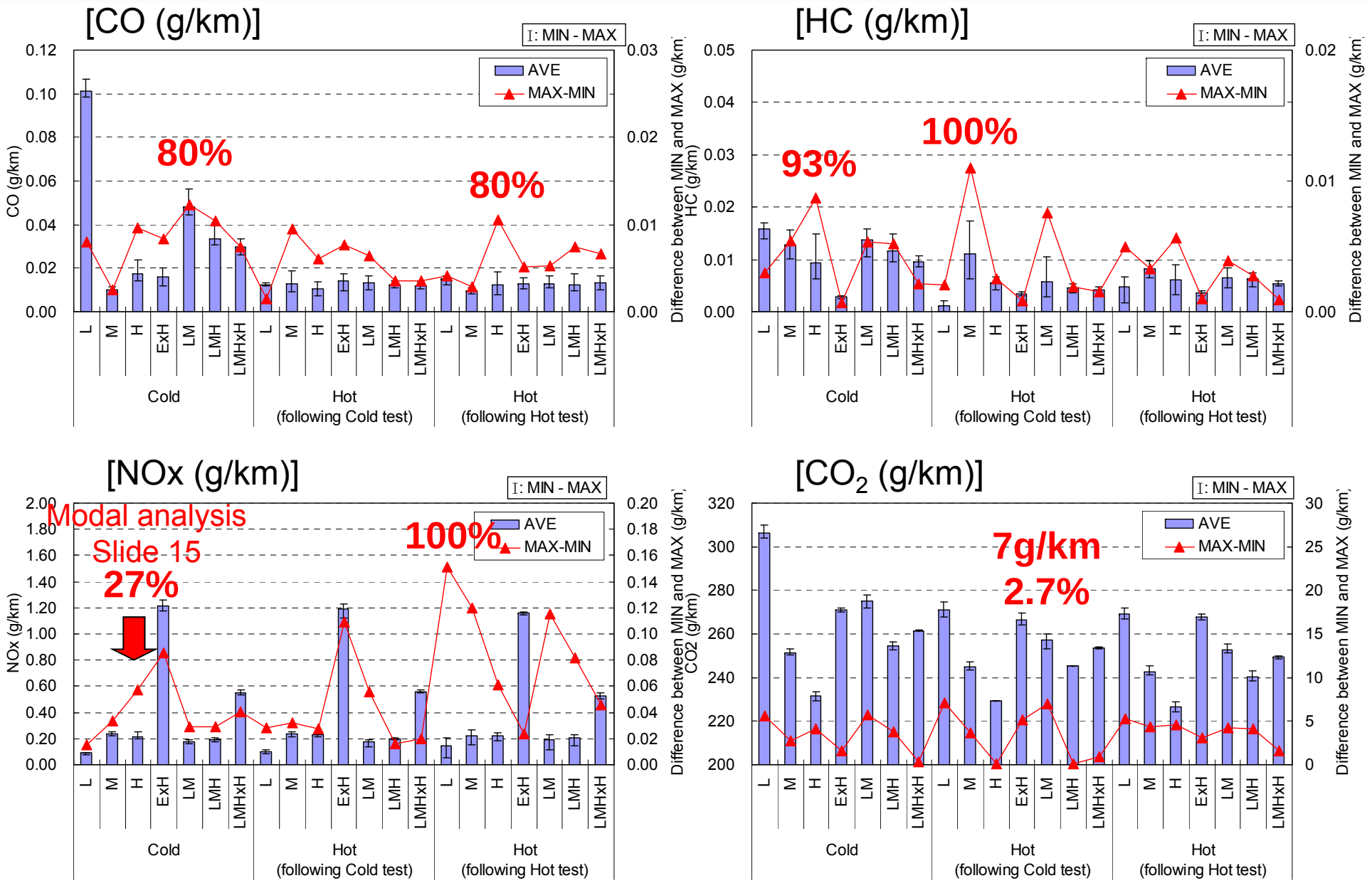
Repeatability of CO – Vehicle C



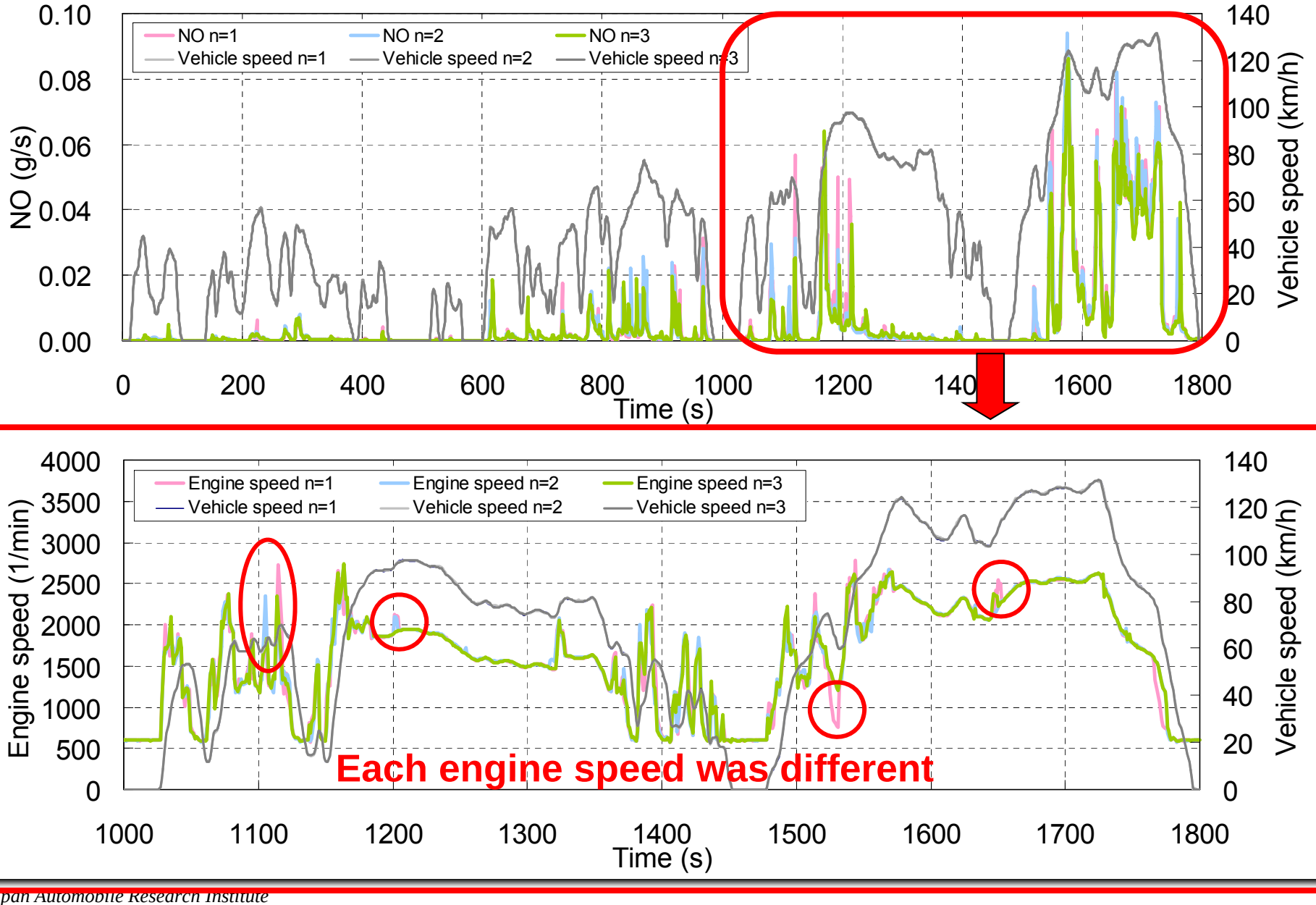
Repeatability of CO_2 – Vehicle C



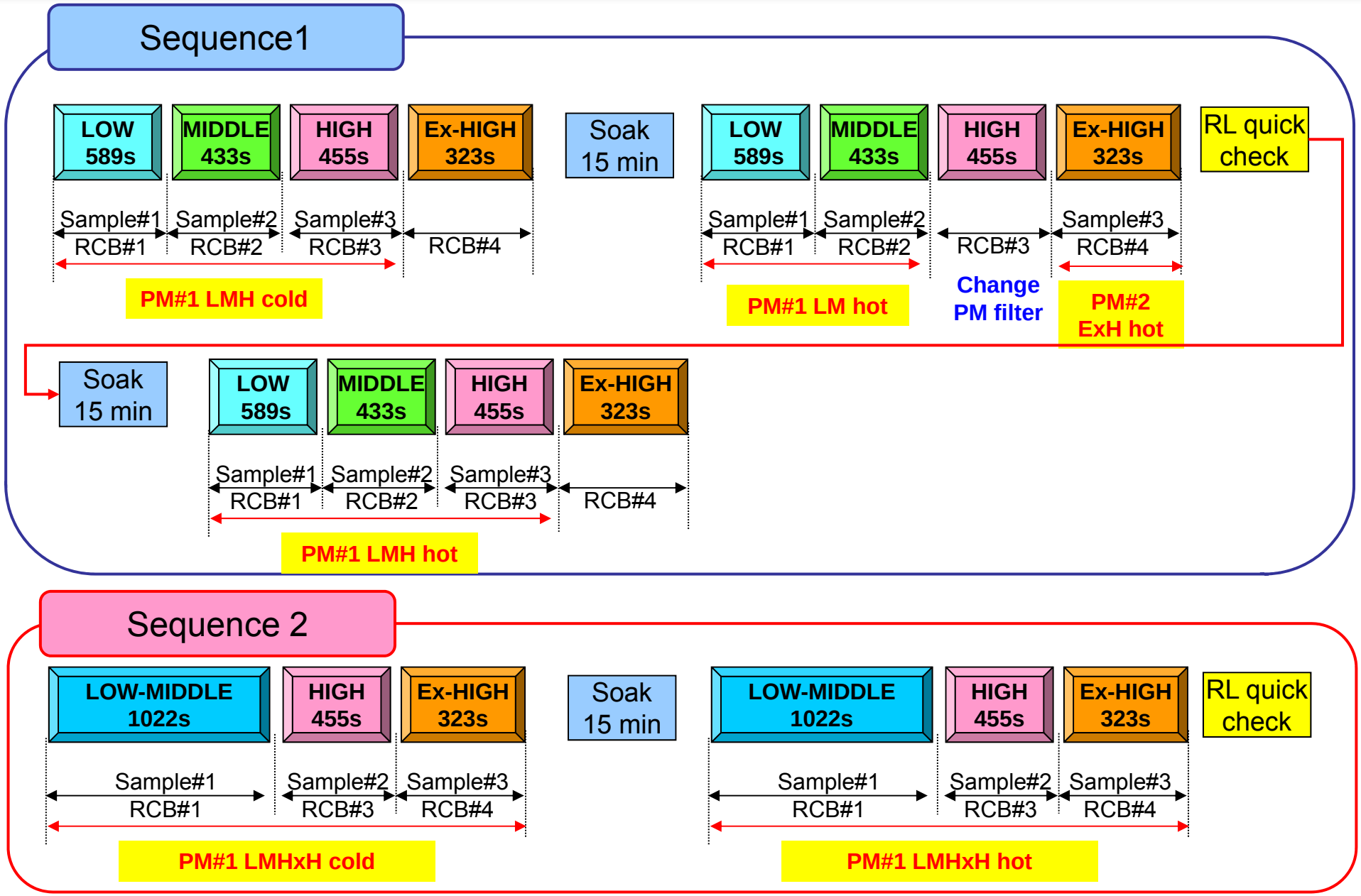
Repeatability – Vehicle B (Diesel)



Repeatability of NO – Vehicle B (Diesel)

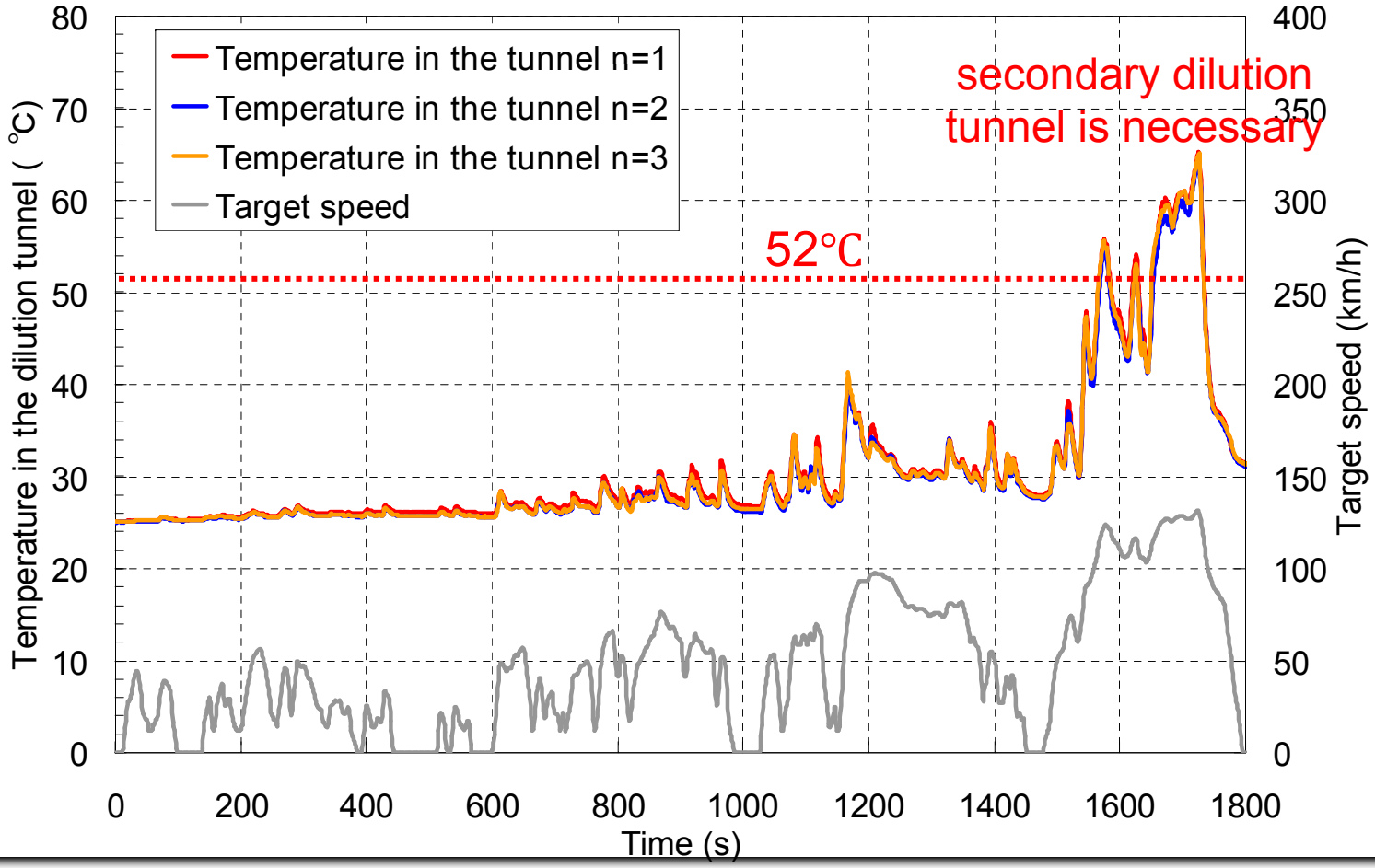


PM sampling for Labs Equipped with 3 Bags & 2 PM samplers

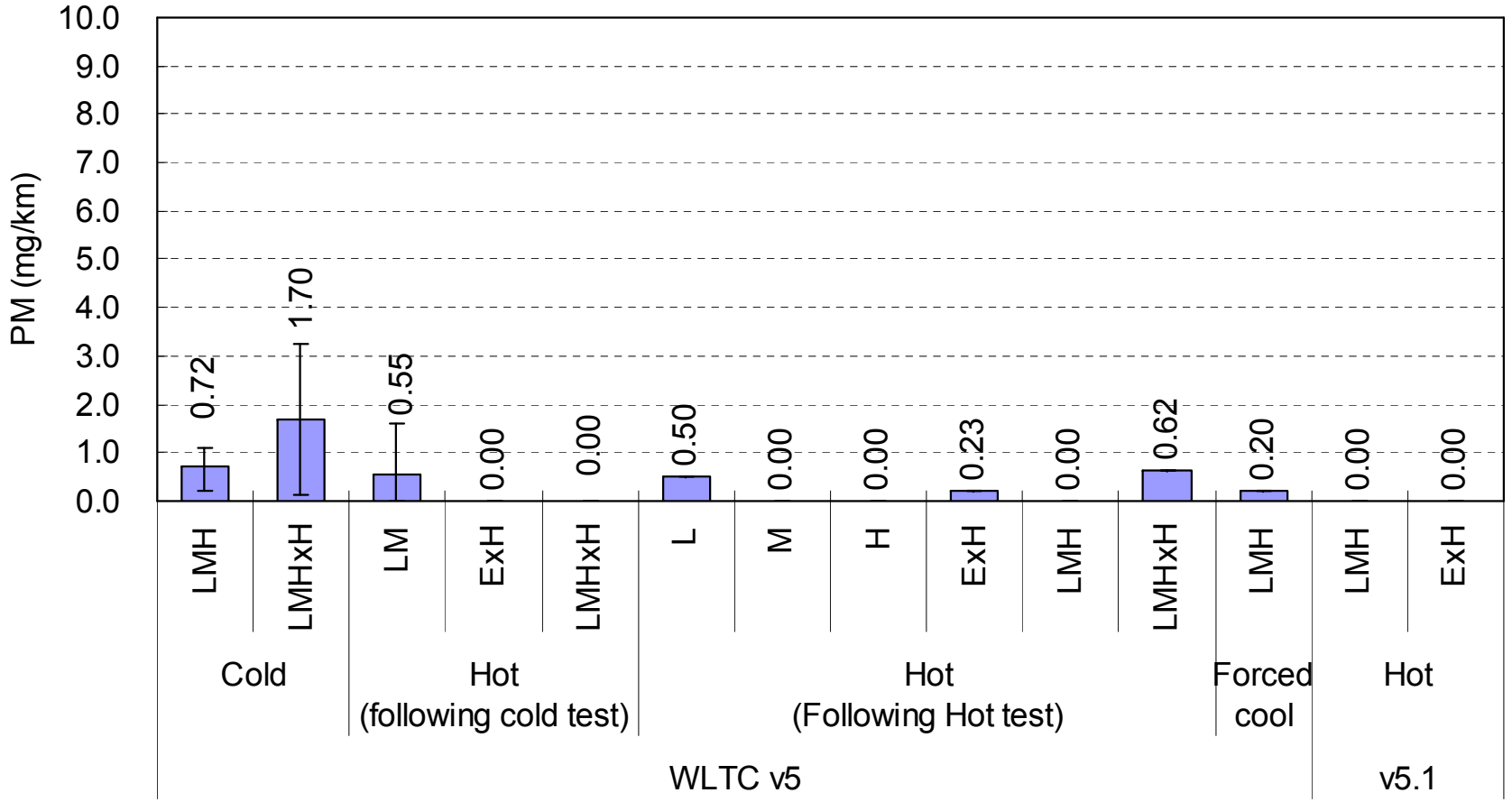


Dilution tunnel temperature

	CVS (m^3/min)	DF		MAX of Tunnel Temp. (℃)
		Bag	MIN of Modal	
LOW	30	59	10.7	26.9
MIDDLE	30	37	6.2	31.8
HIGH	30	29	6.5	41.4
Extra-HIGH	30	16	6.1	65.2



Ref.) Particle Matter



Observation

- Vehicles with automatic transmission have a tendency of test-to-test variability for CO_2 emission. This is due to aggressive test cycle makes kick-down timings and up-shifting timings different.
  - The CO_2 emission was varied by approximately 7 g/km in 6 repeated tests on vehicle B.
- The temperature in dilution tunnel exceeds 52 degrees C during Extra-high phase. This requires some actions, such as secondary dilution tunnel, reconsideration of mode construction and so on.

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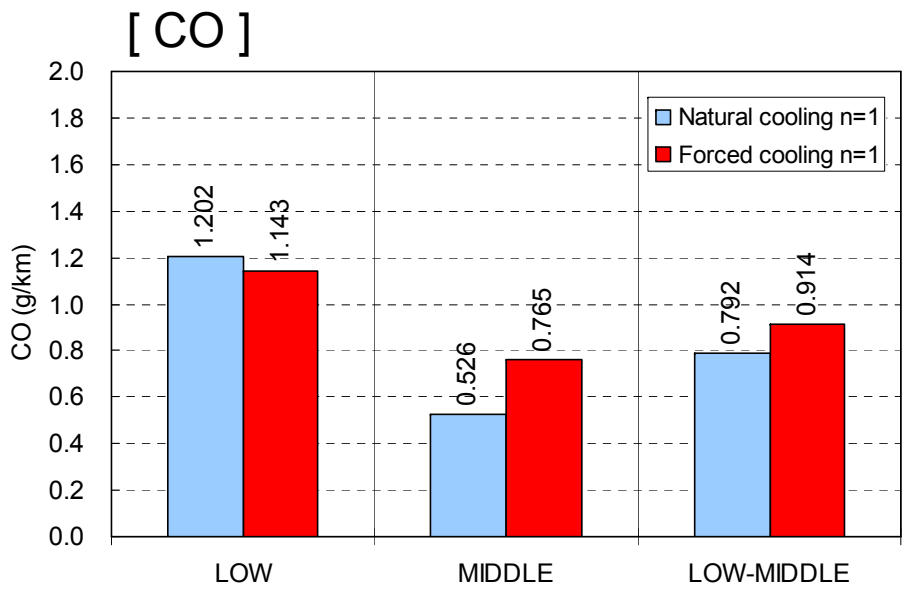
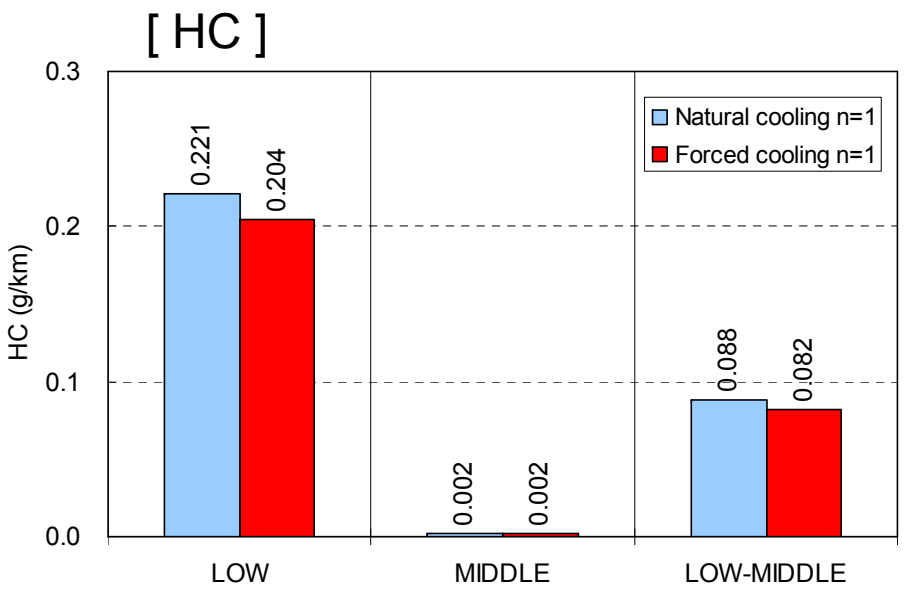
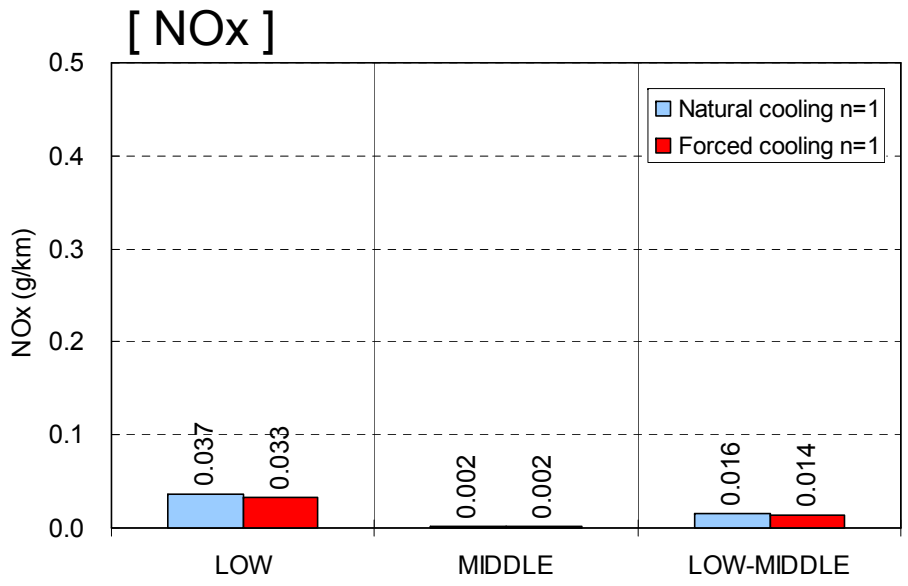
Evaluation of Forced cooling

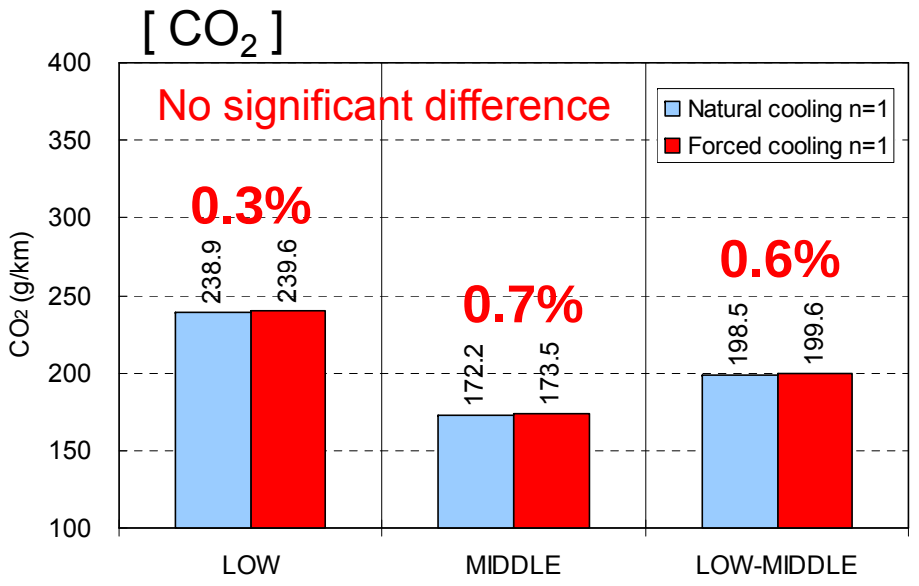
- The method for Forced cooling
  - Forced cooling for 5 hours by using engine cooling fan and Soak for 1 hour to be stabilized
  - Measured points
    - Coolant temperature: inside of the radiator cap or reservoir tank.
    - Engine oil temperature: at the point of the oil level gauge.
  - Test was started after the coolant and engine oil temperature are within 25 +/- 2K.

Forced cool down – Vehicle A

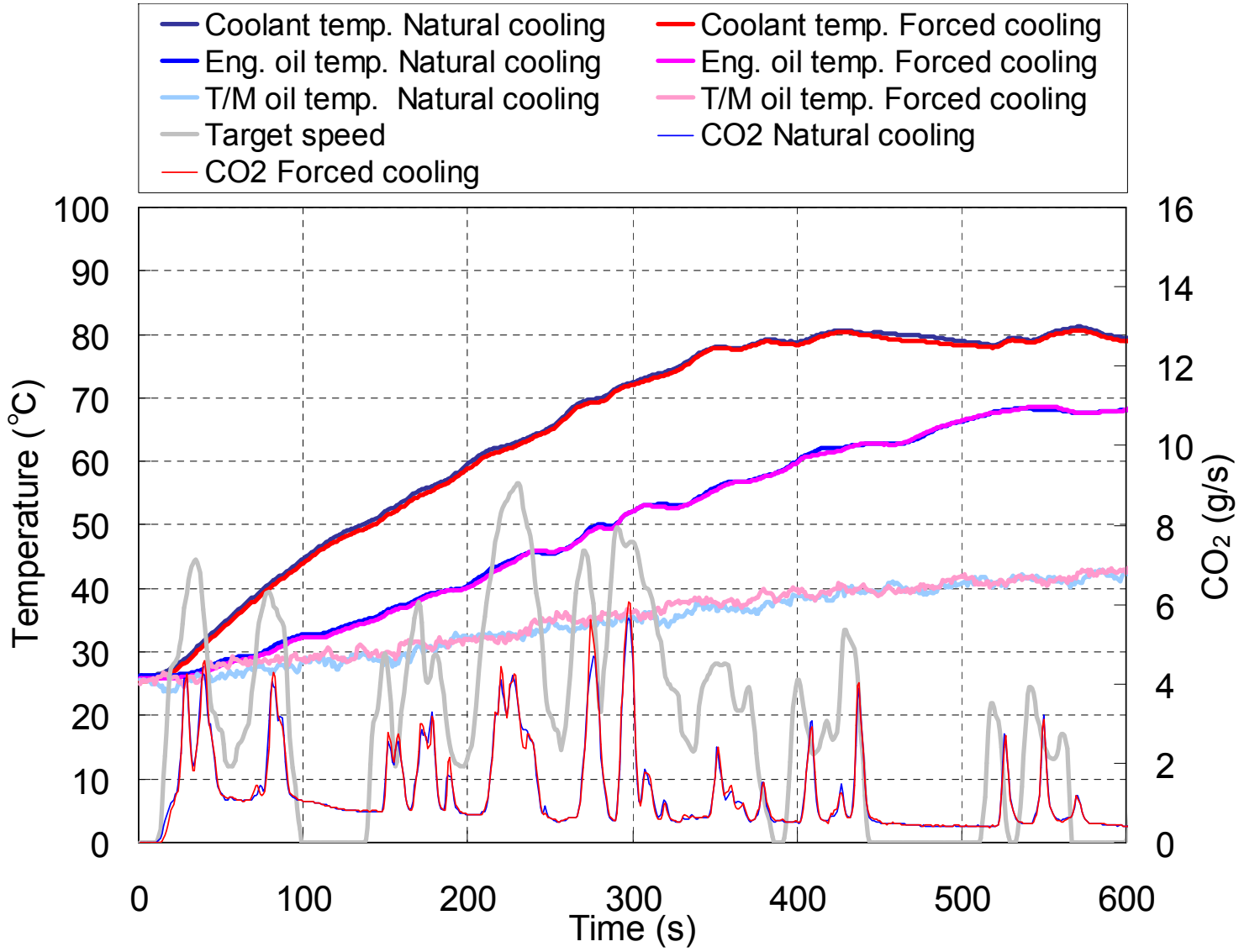






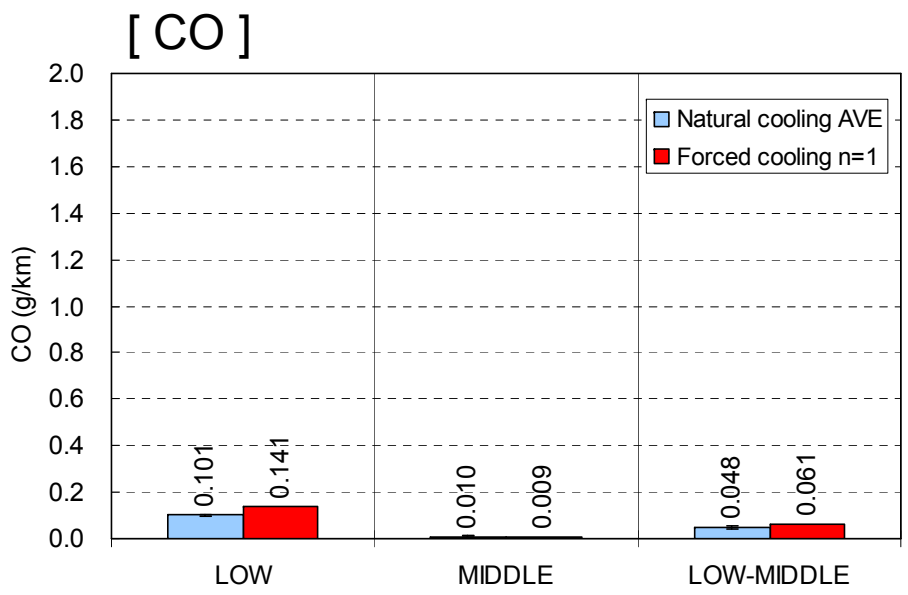


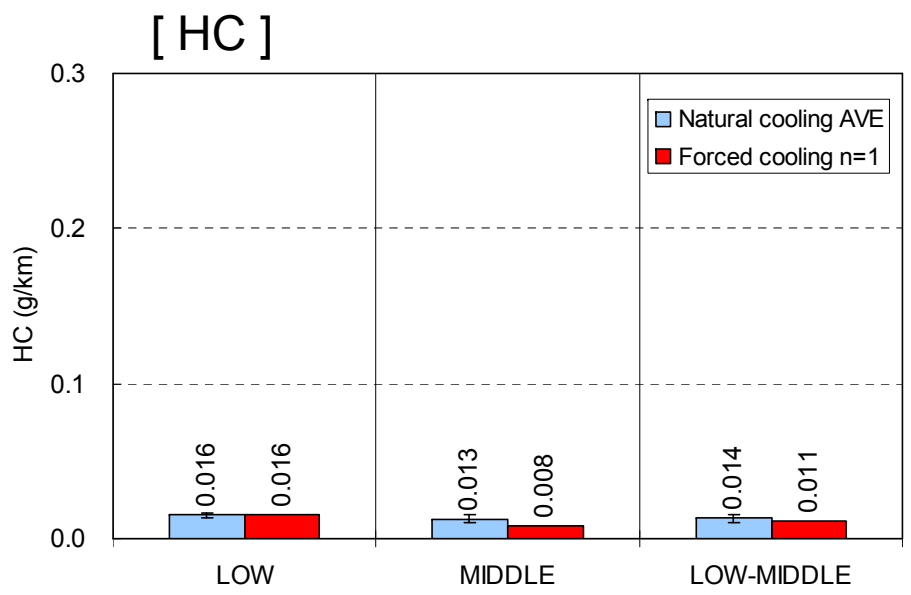
Forced cool down – Vehicle A

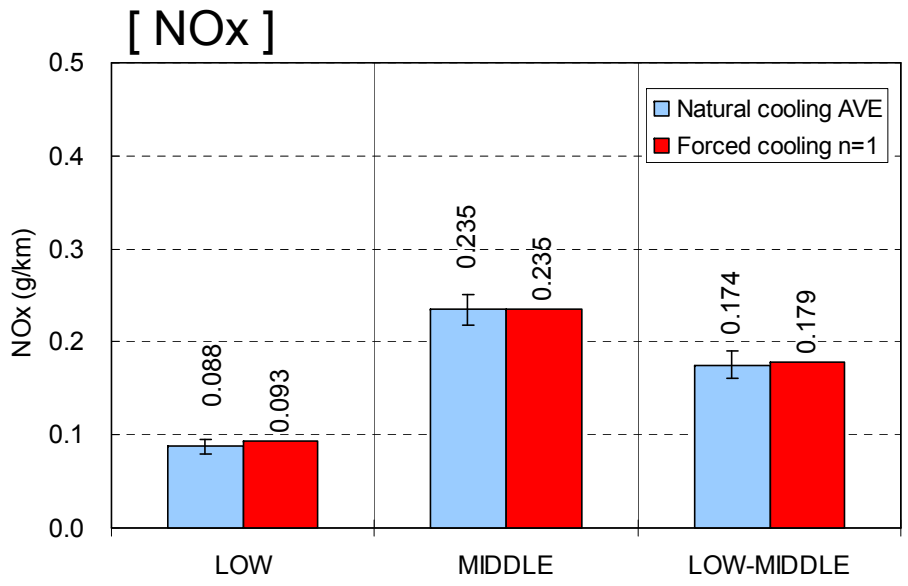


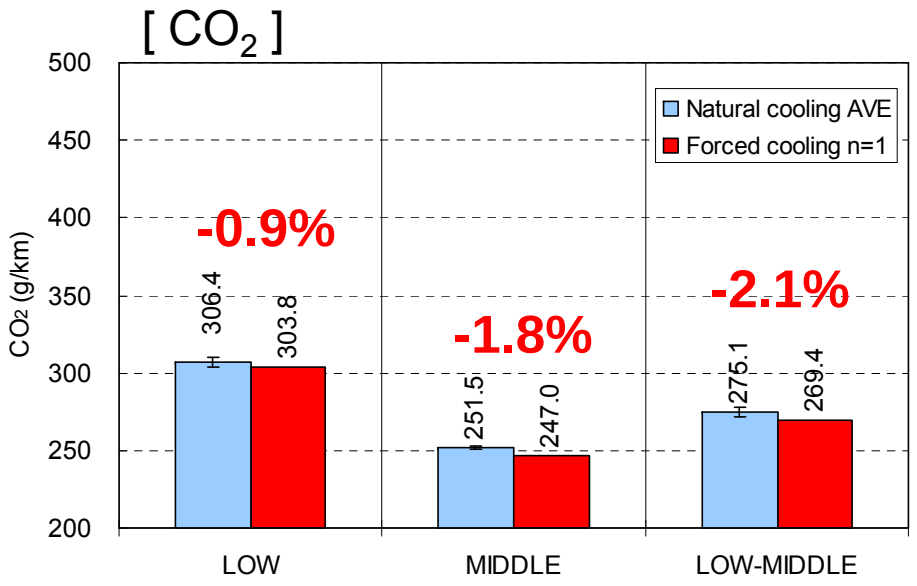
No significant difference was observed

Forced cool down – Vehicle B

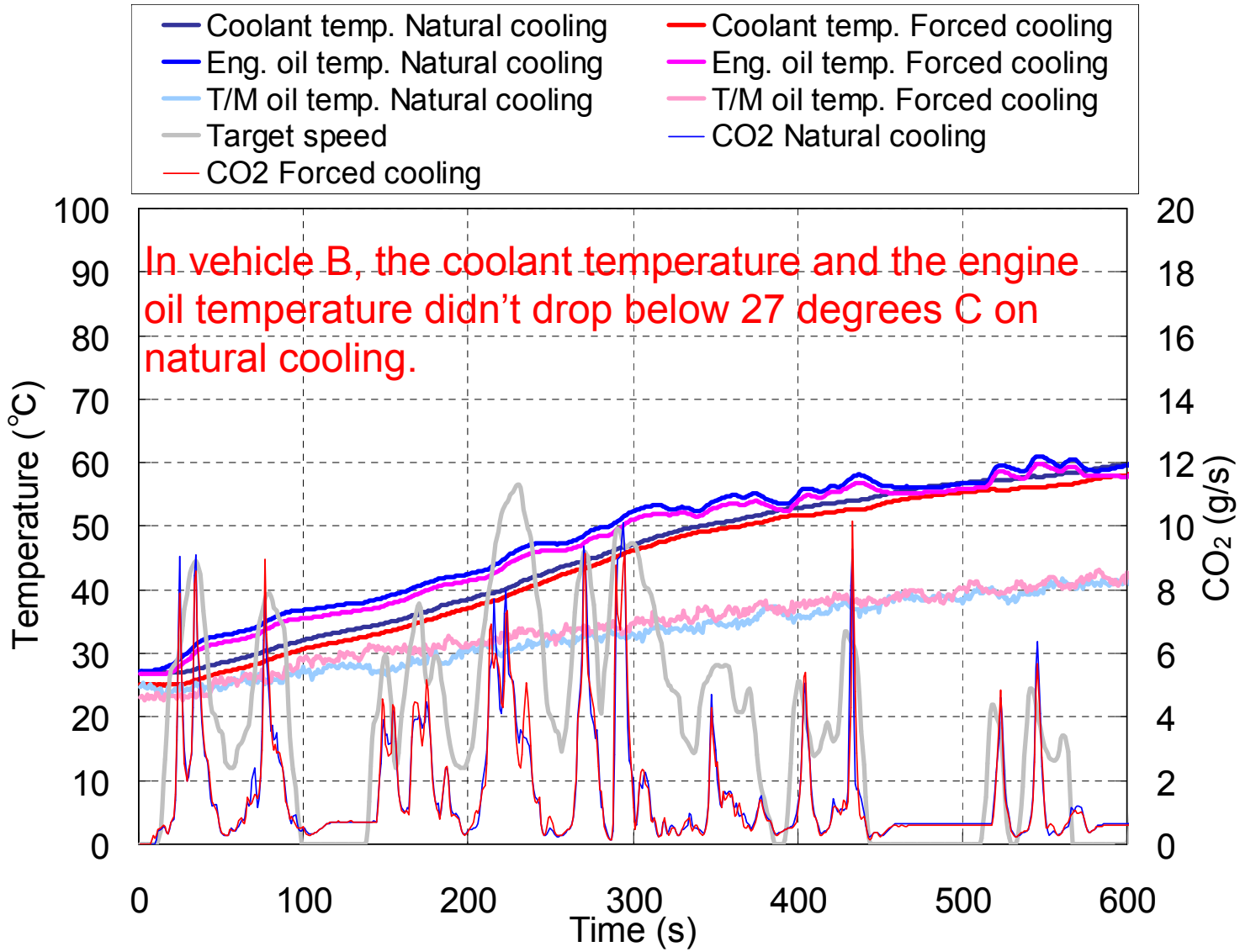




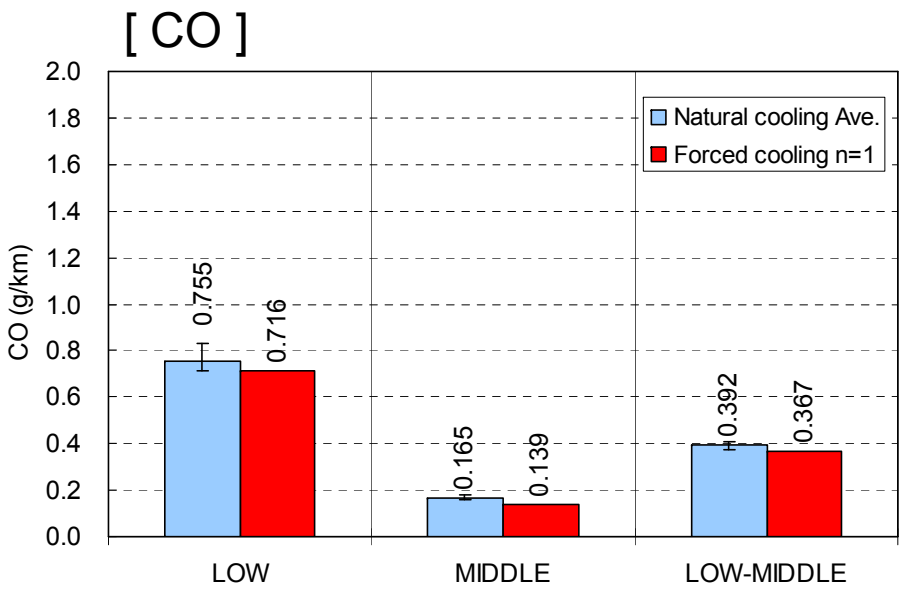


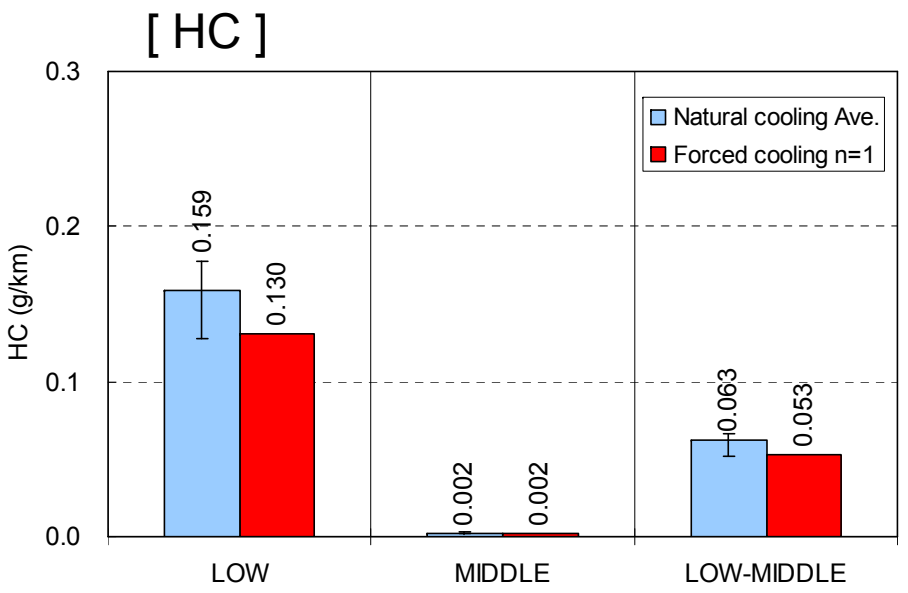


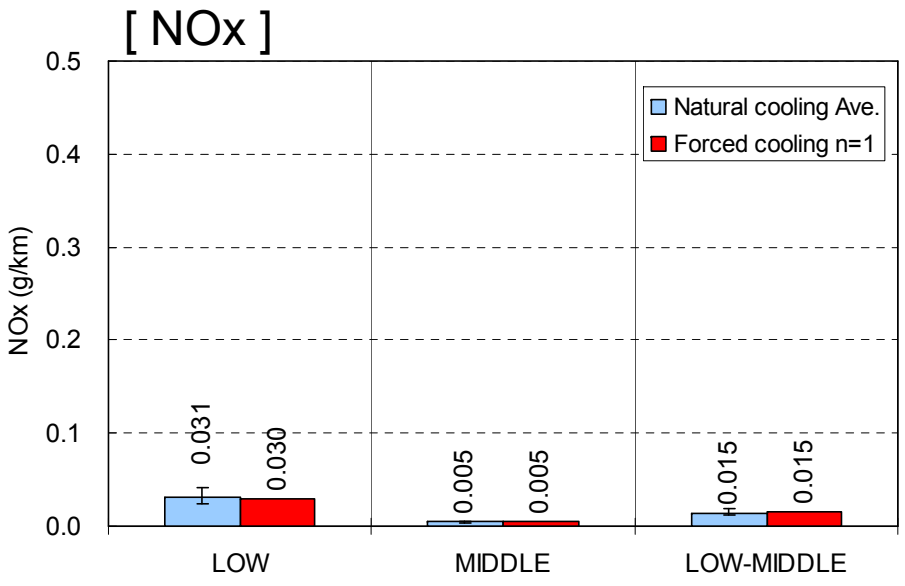
Forced cool down – Vehicle B

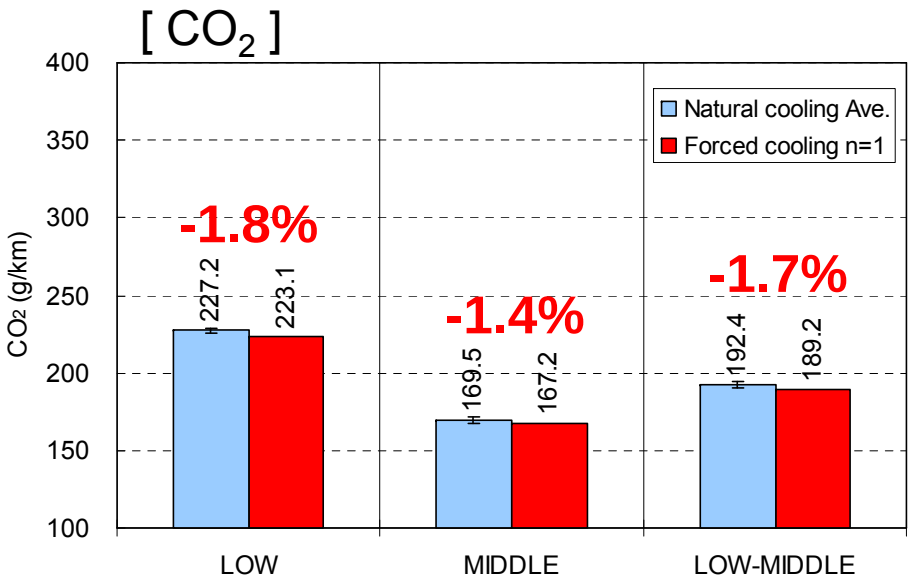


Forced cool down – Vehicle C

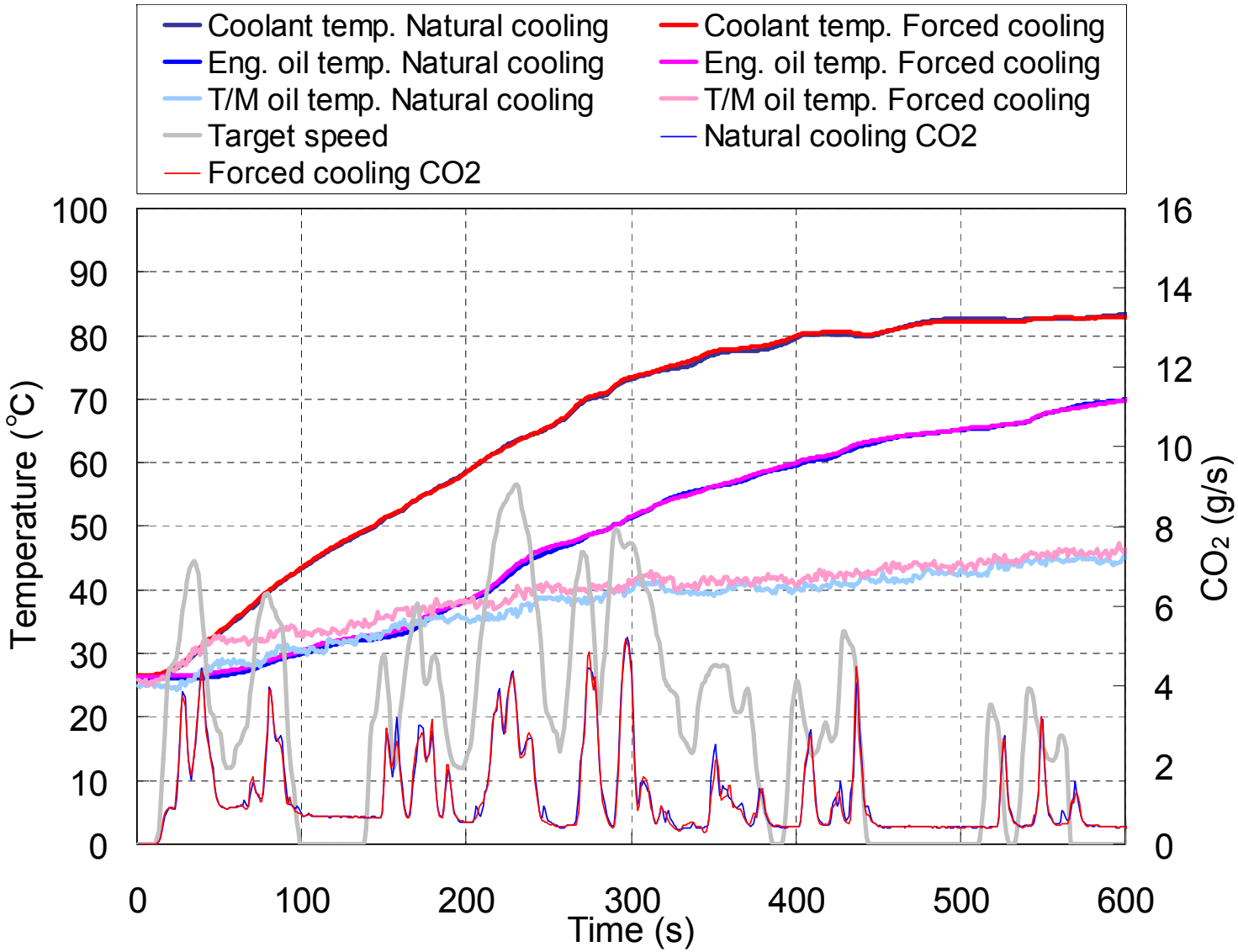






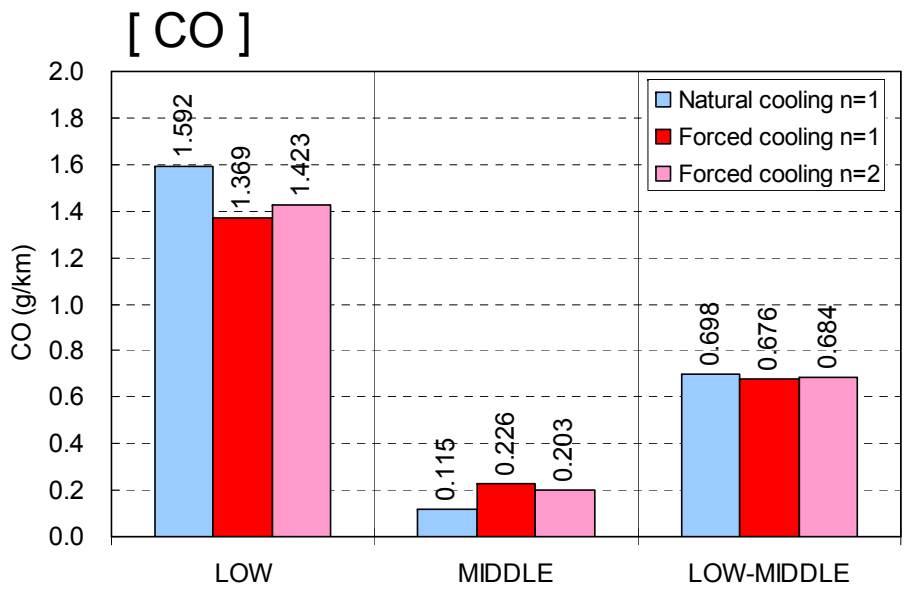


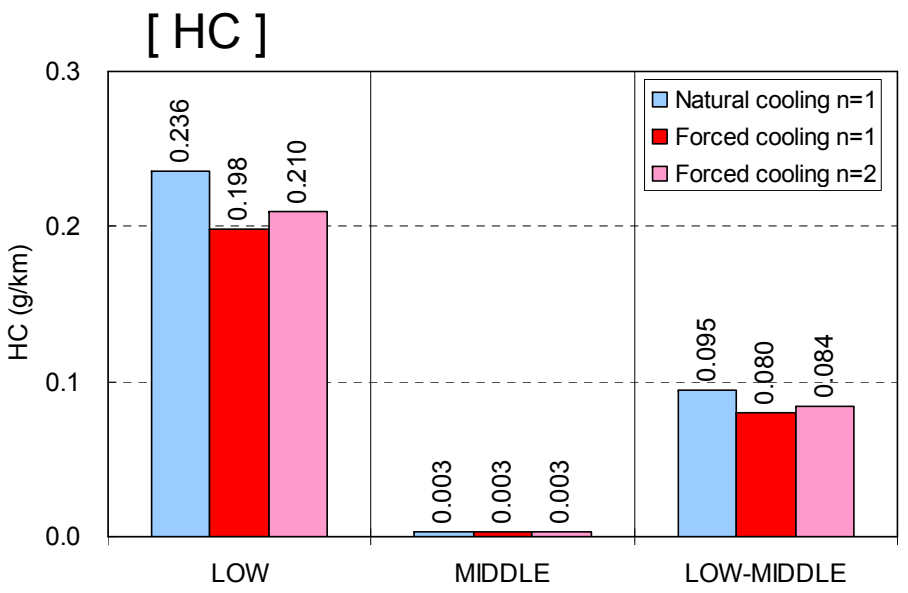
Forced cool down – Vehicle C

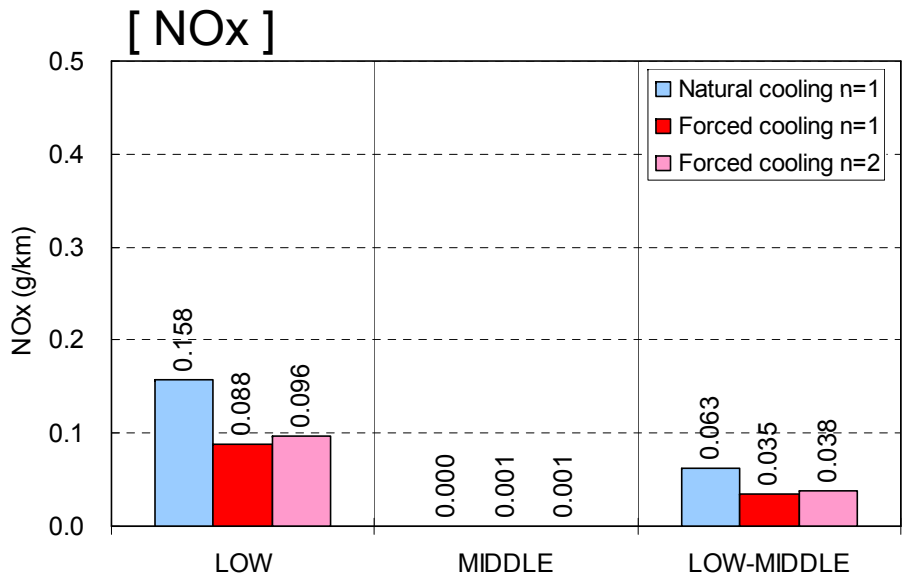


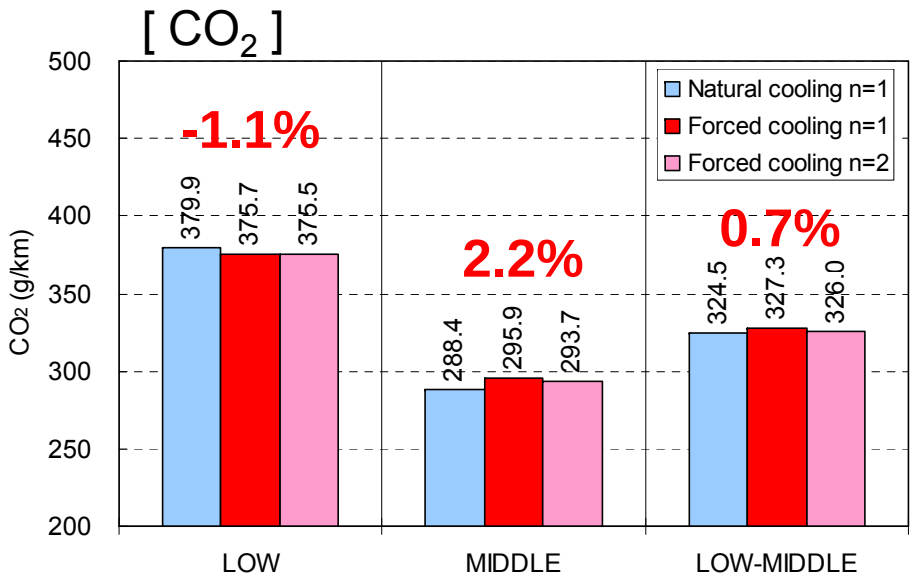
No significant difference was observed

Forced cool down – Vehicle D

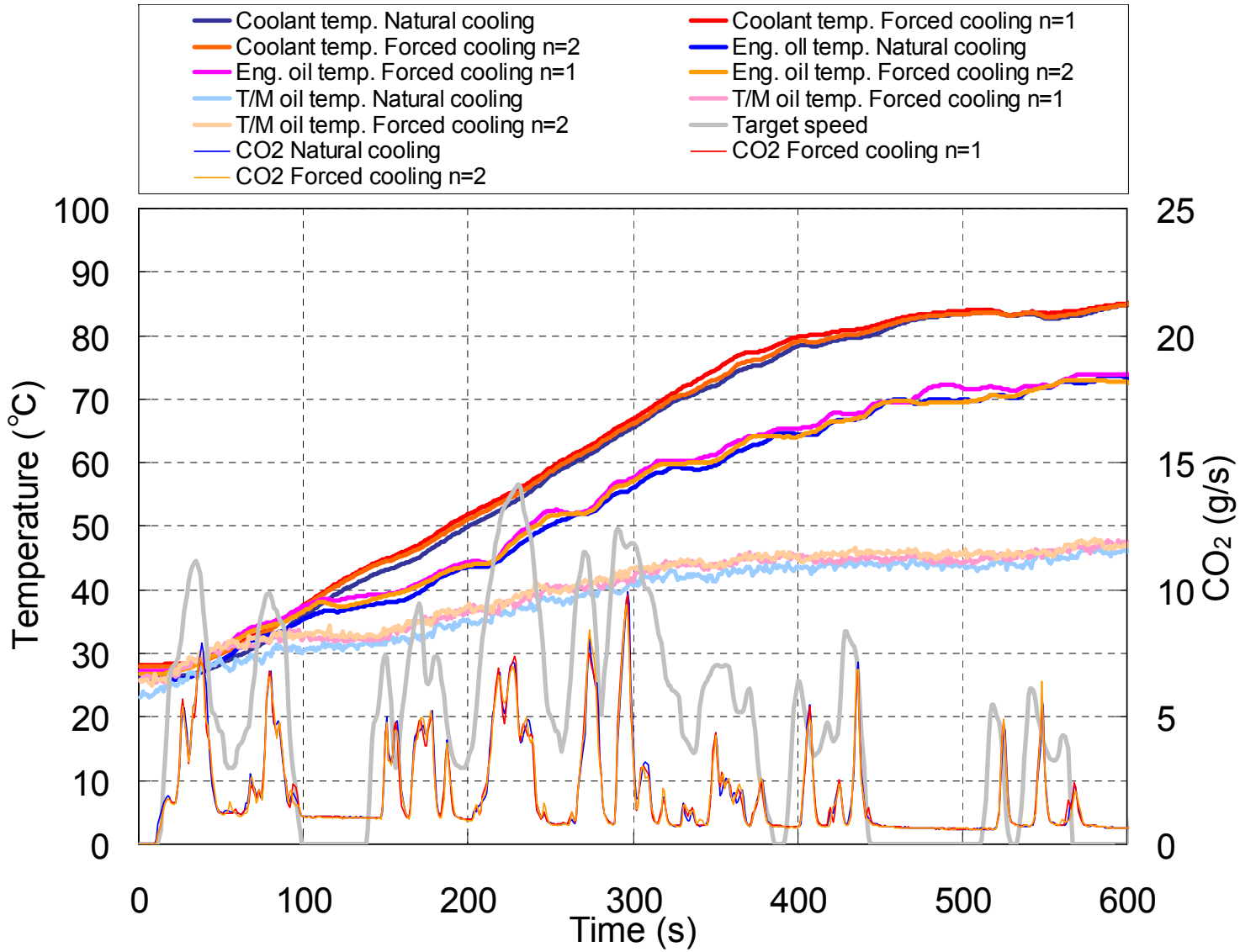








Forced cool down – Vehicle D



No significant difference was observed

Observation

- Although the repeatability/variability of the forced cooling has not evaluated, it was expected that there is no significant difference between the normal cooling and the forced cooling in regards with all emissions.
- In some cases, the coolant temperature and the engine oil temperature don't drop below 27 degrees C within [Approx. 16] hour normal soaking.

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Net Energy Change (NEC) Tolerances

- SAE J1711, 3.8 Net Energy Change (NEC) Tolerances

  For purposes of the document, an objective has been set to be able to measure a value for fuel consumption that is within ±3% of the vehicle's true, representative fuel consumption, on any given CST (the Charge-Sustaining Test). Analysis and test experience suggests that this goal can be met by limiting the change in RESS stored electrical energy over the test cycle to ±1% of the total fuel energy consumed over the same cycle.

$$\bullet\ NECtolerance: \left|\frac{NetEnergyChange}{TotalFuelEnergy}\right| \le 1\%$$

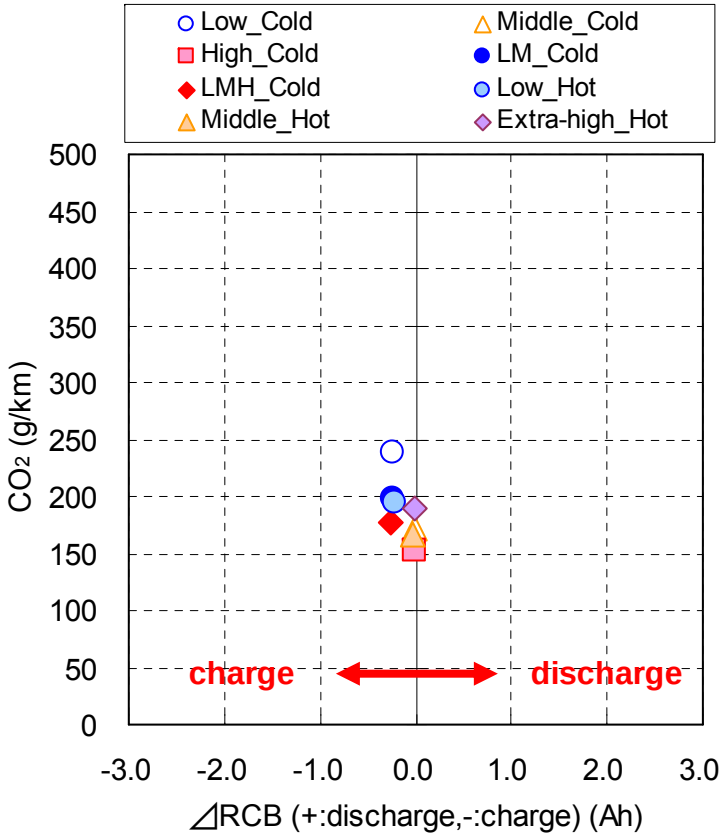
$$\bullet\ NetEnergyChange = \left[(A\cdot h)_{final} - (A\cdot h)_{initial}\right]\cdot V_{system}$$

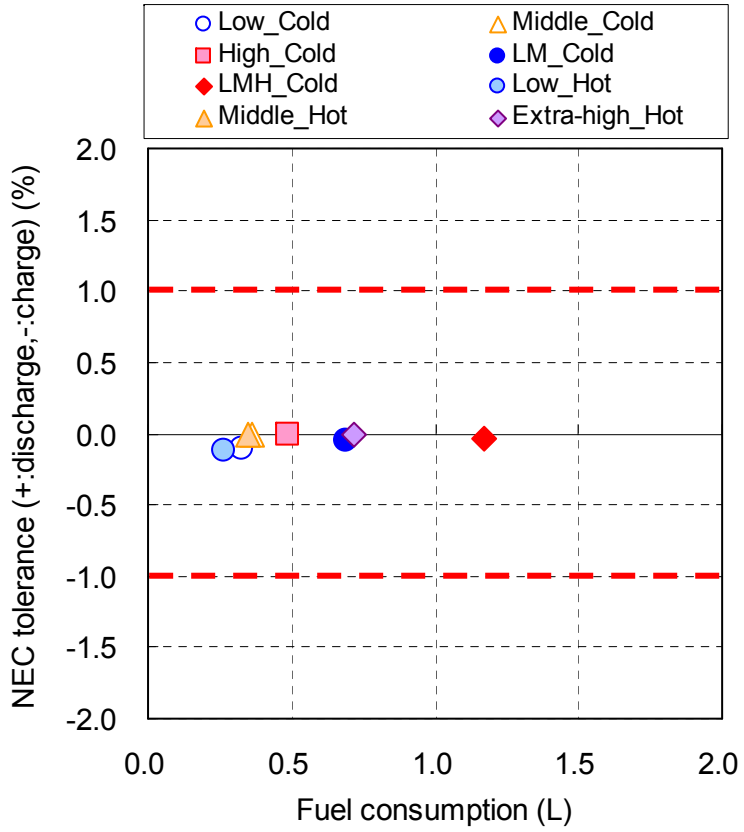
$$\bullet\ TotalFuelEnergy = NHV_{fuel}\cdot m_{fuel}$$

$$\bullet\ -\frac{NHV_{fuel}\cdot m_{fuel}}{V_{system}\cdot K_1}\times 0.01 \le NEC \le \frac{NHV_{fuel}\cdot m_{fuel}}{V_{system}\cdot K_1}\times 0.01$$

NEC tolerance – Vehicle A

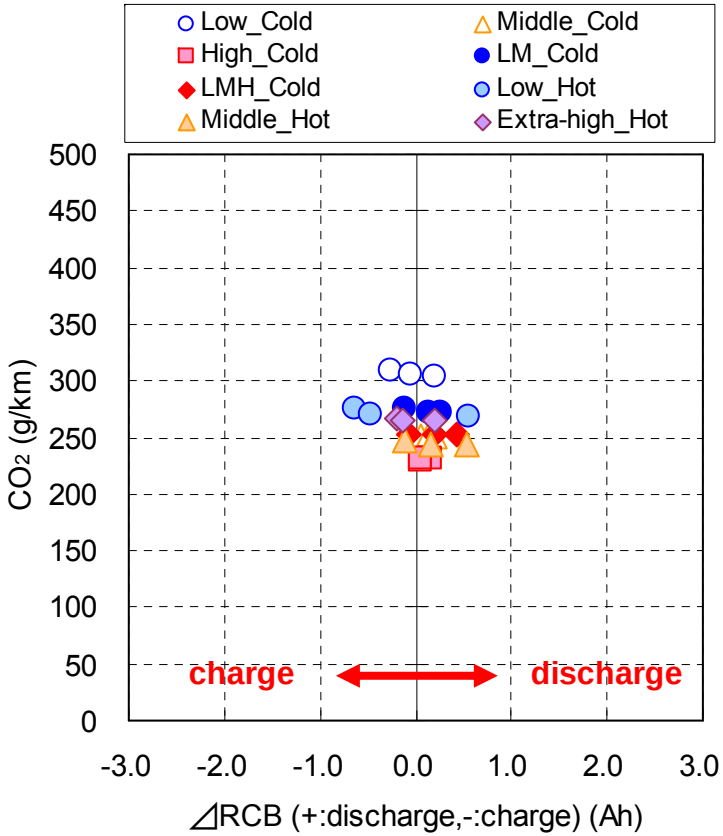
Vehicle A
Test mass: Heaviest
Road load: Worst

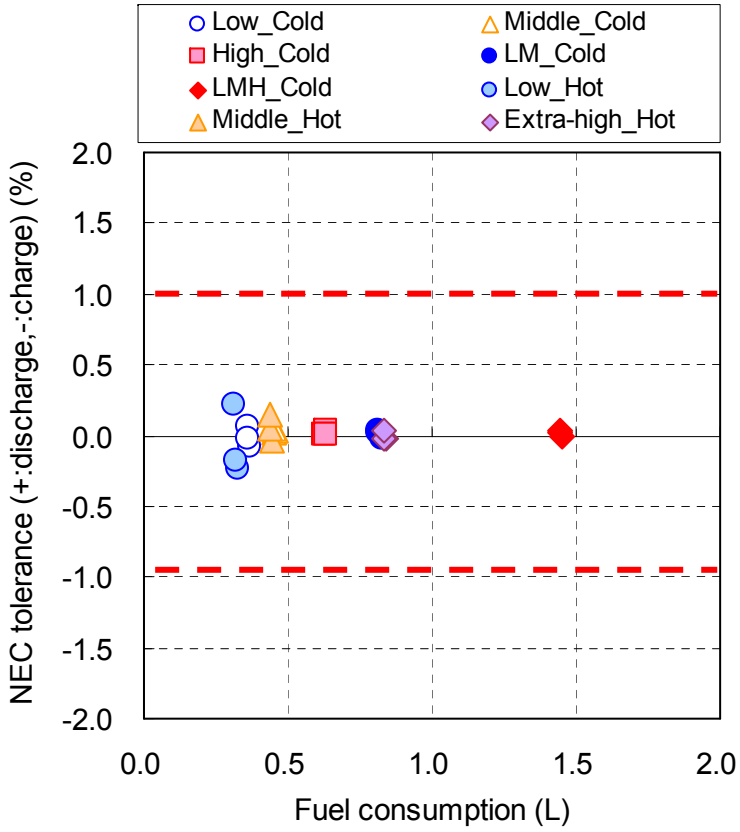




NEC tolerance – Vehicle B

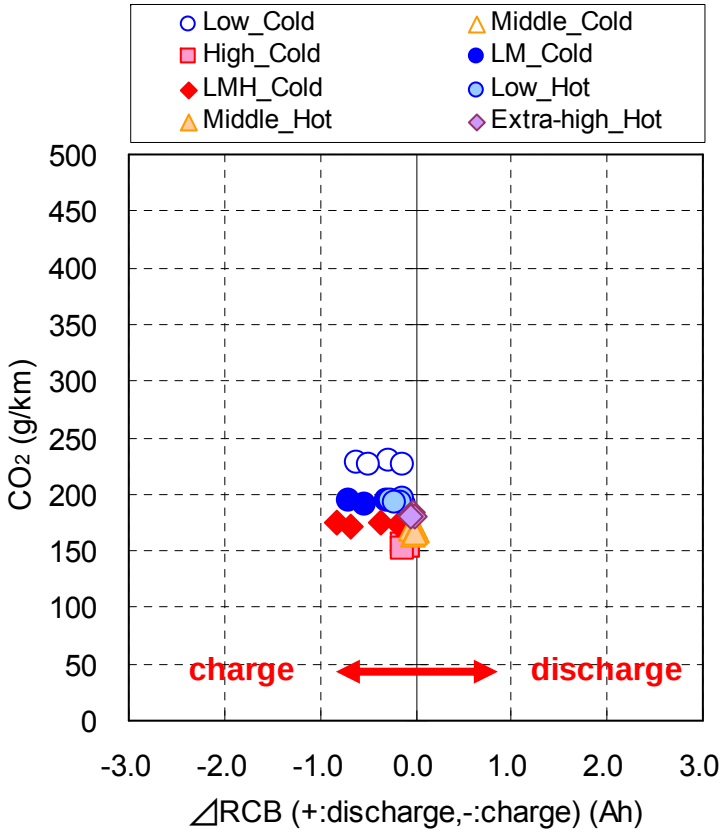
Vehicle B
Test mass: Heaviest
Road load: Worst

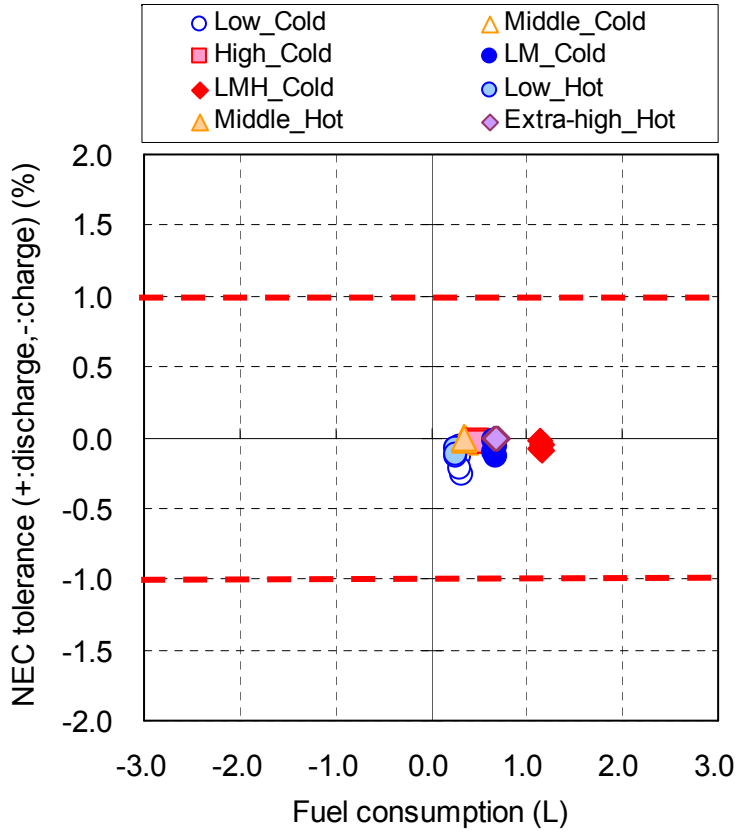




NEC tolerance – Vehicle C

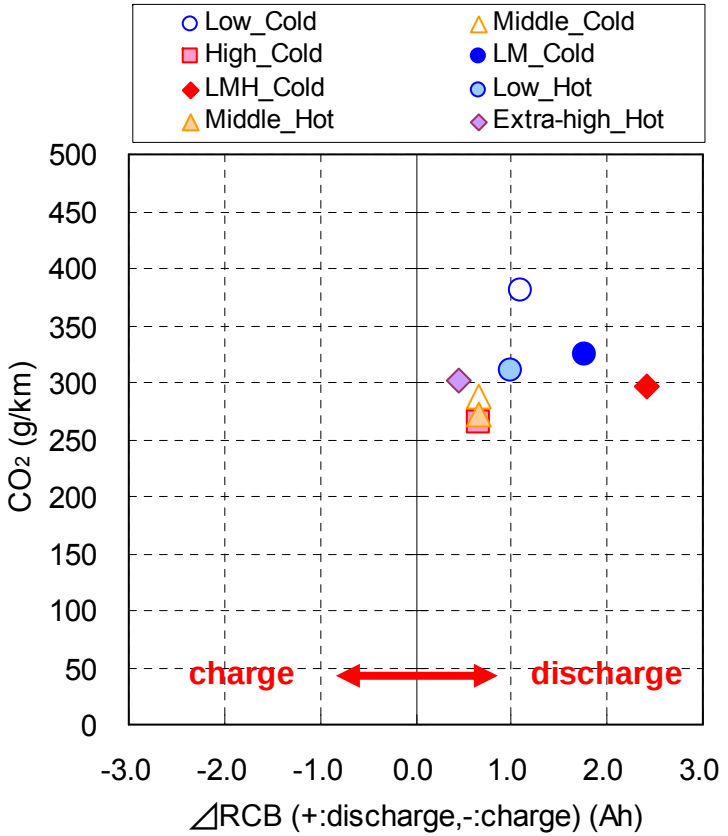
Vehicle C
Test mass: Heaviest
Road load: Worst

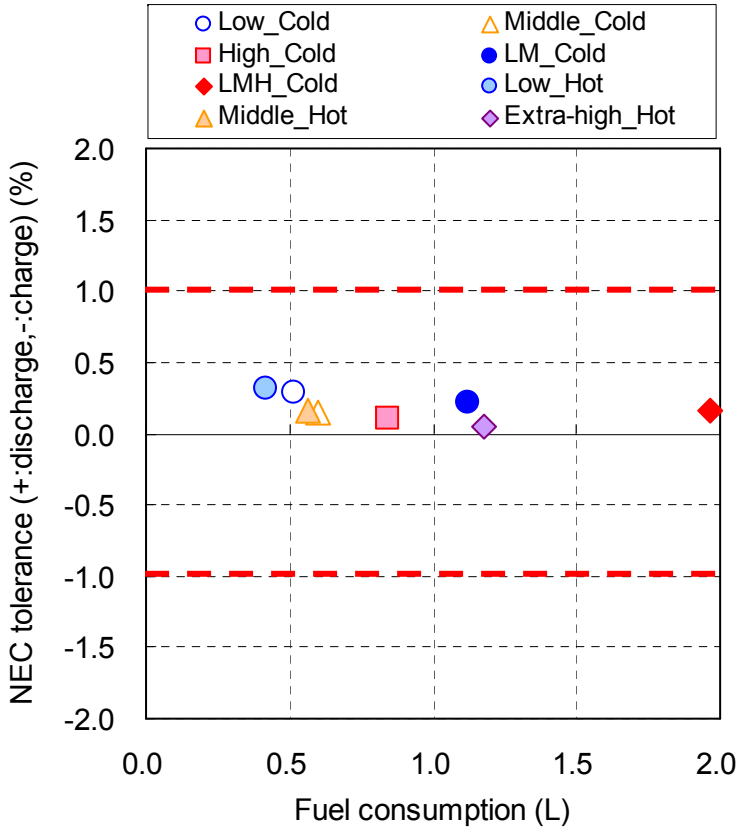




NEC tolerance – Vehicle D

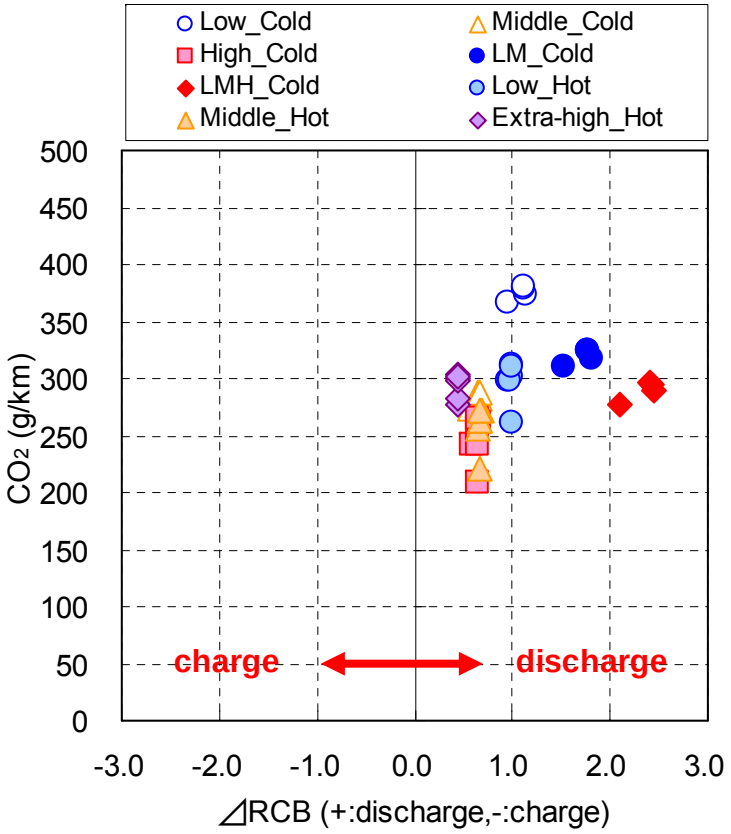
Vehicle D
Test mass: Heaviest
Road load: Worst

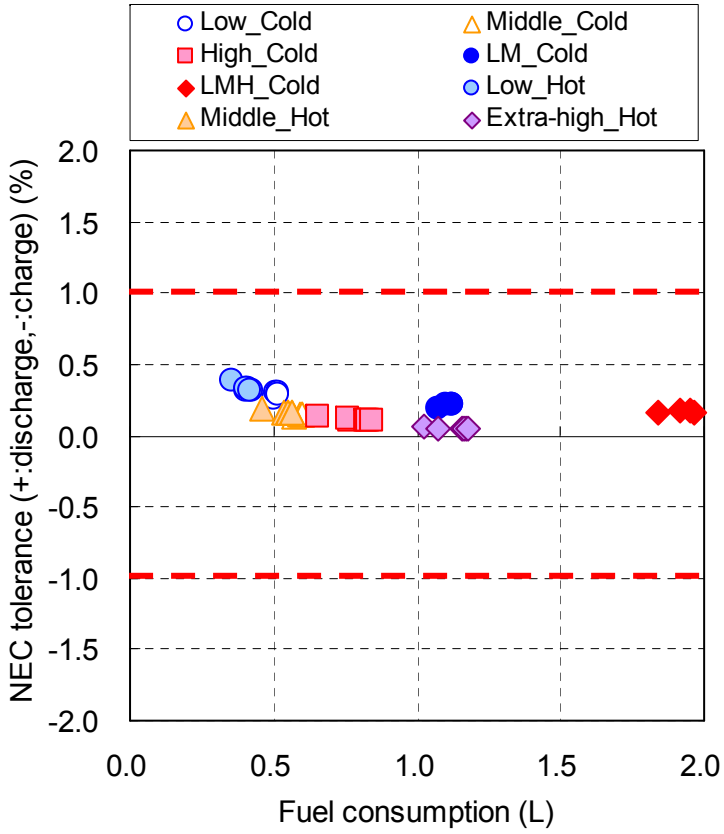




NEC tolerance – Vehicle D

Vehicle D
Test mass: Lightest, Middle, Heaviest
Road load: Best, Worst





Observation

- Each NEC tolerance (total 38 tests) is within 1% of total fuel energy.

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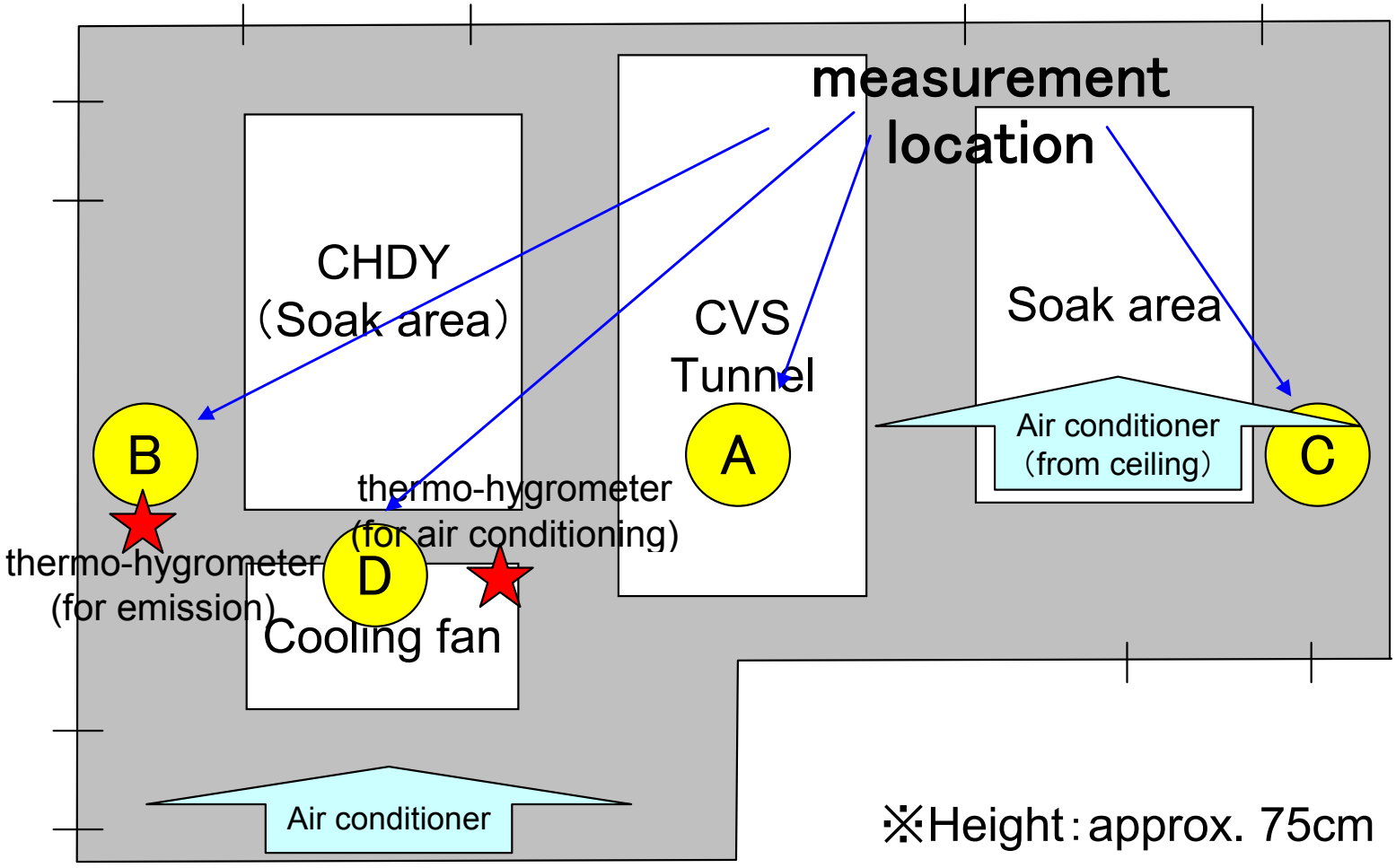
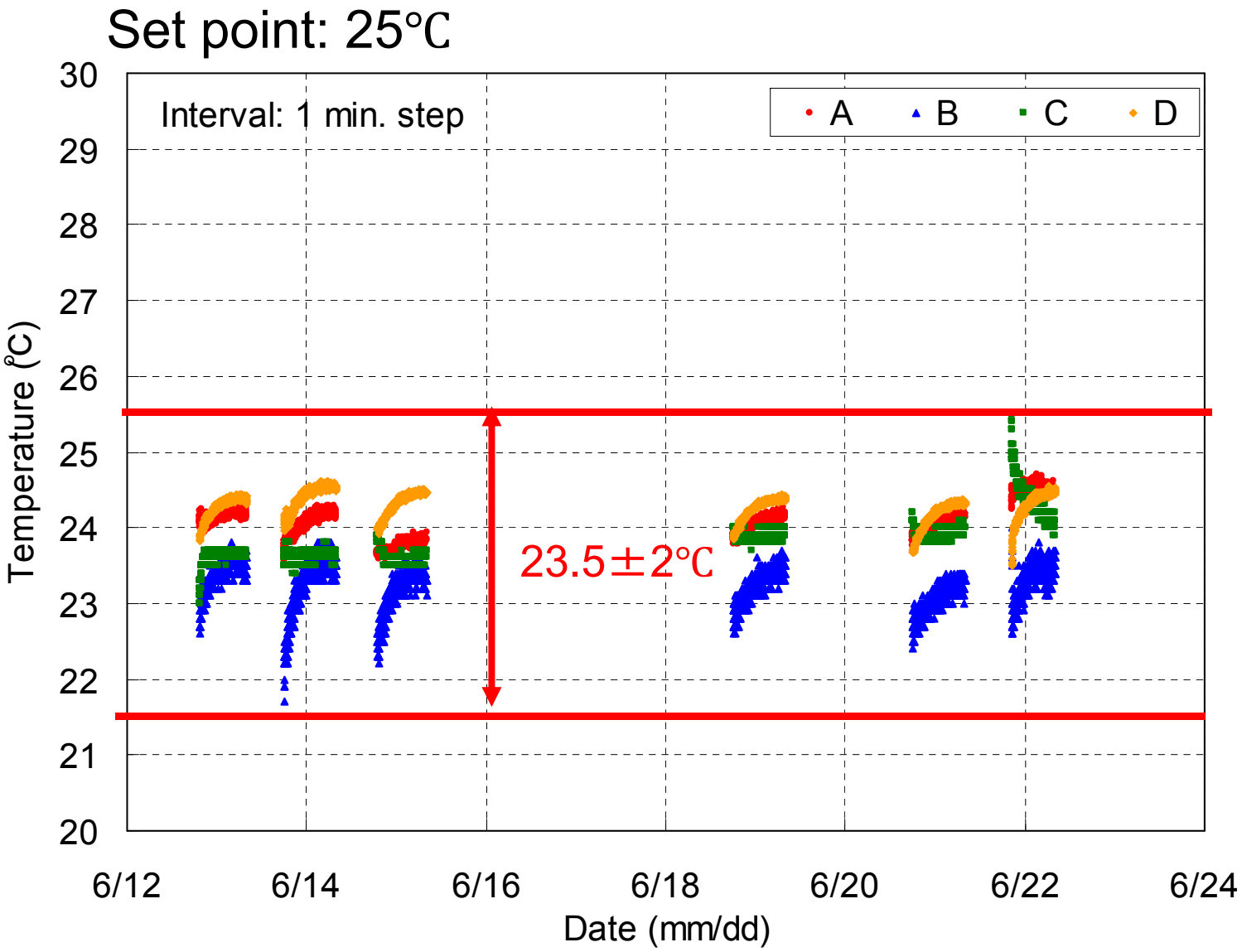
1. Purpose
2. Test vehicle
3. Test matrix
4. Test result
    1. CO_2 compensation by vehicle test mass
    2. Repeatability
    3. Forced cool down
    4. RCB measurement
    5. Temperature in soak room
    6. Temperature in the test cell

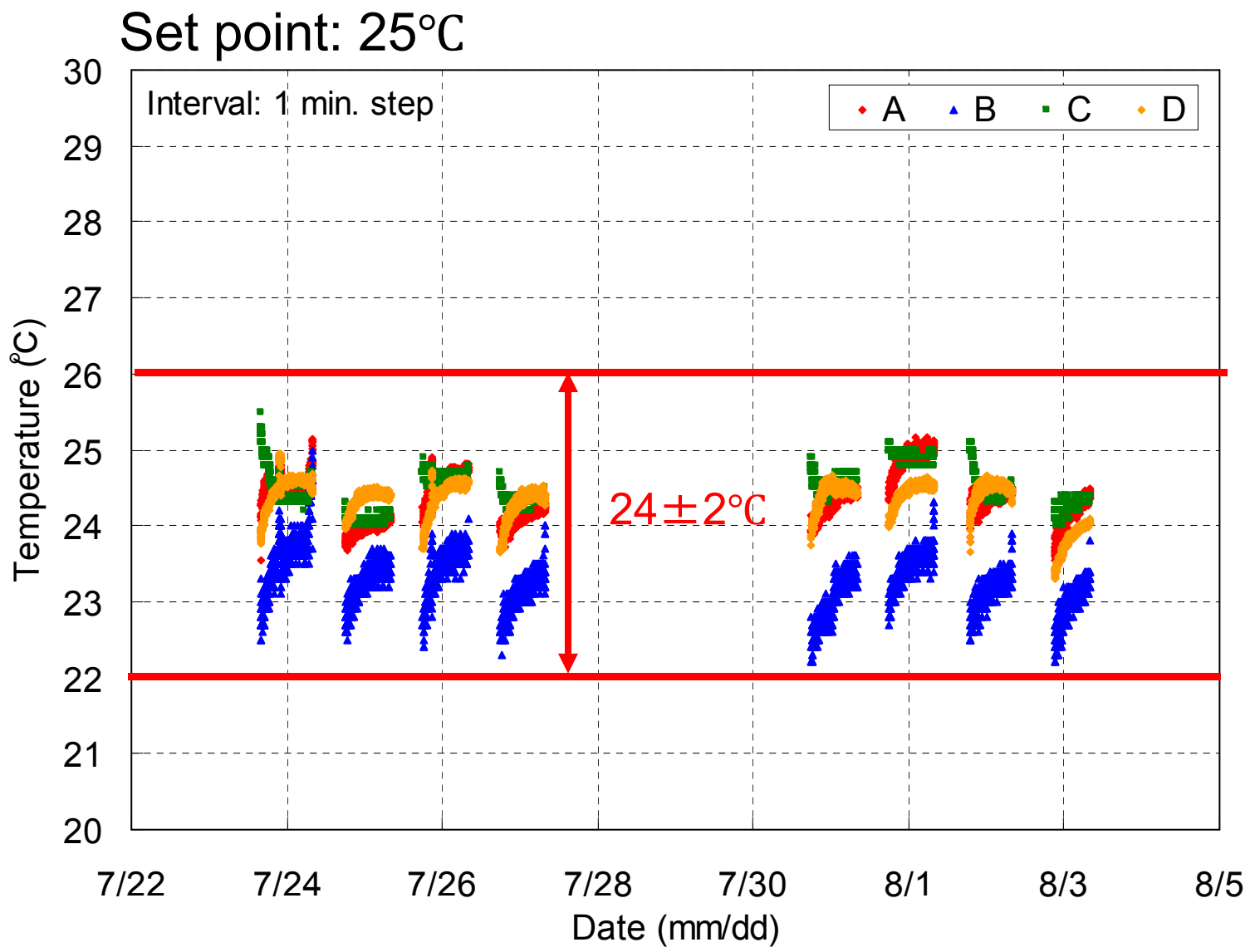
Soak room and test room



Temperature in soak room – 1st term



Temperature in soak room – 2nd term



Observation

- Soak room in JARI are well controlled within +/- 2 degrees C.

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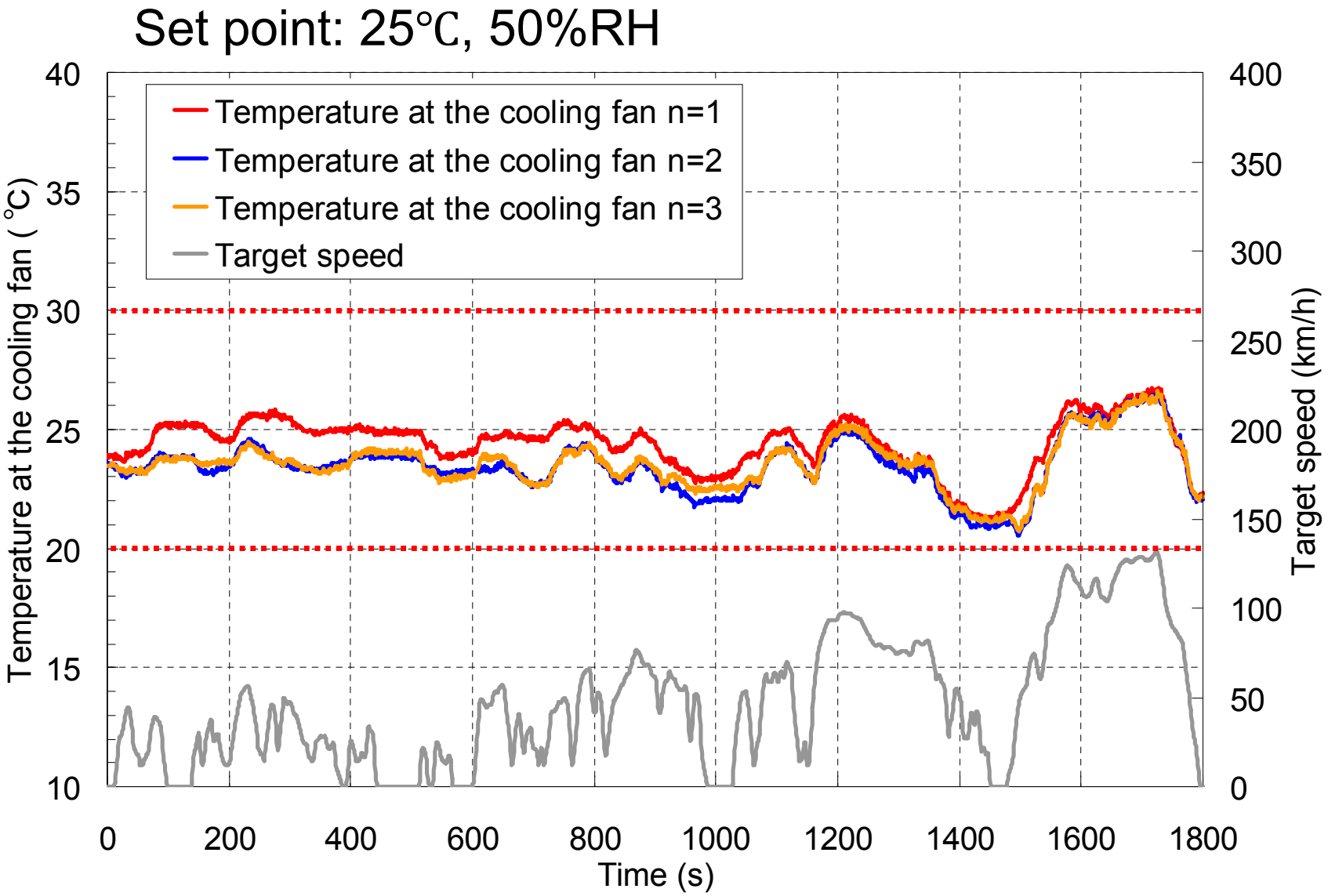
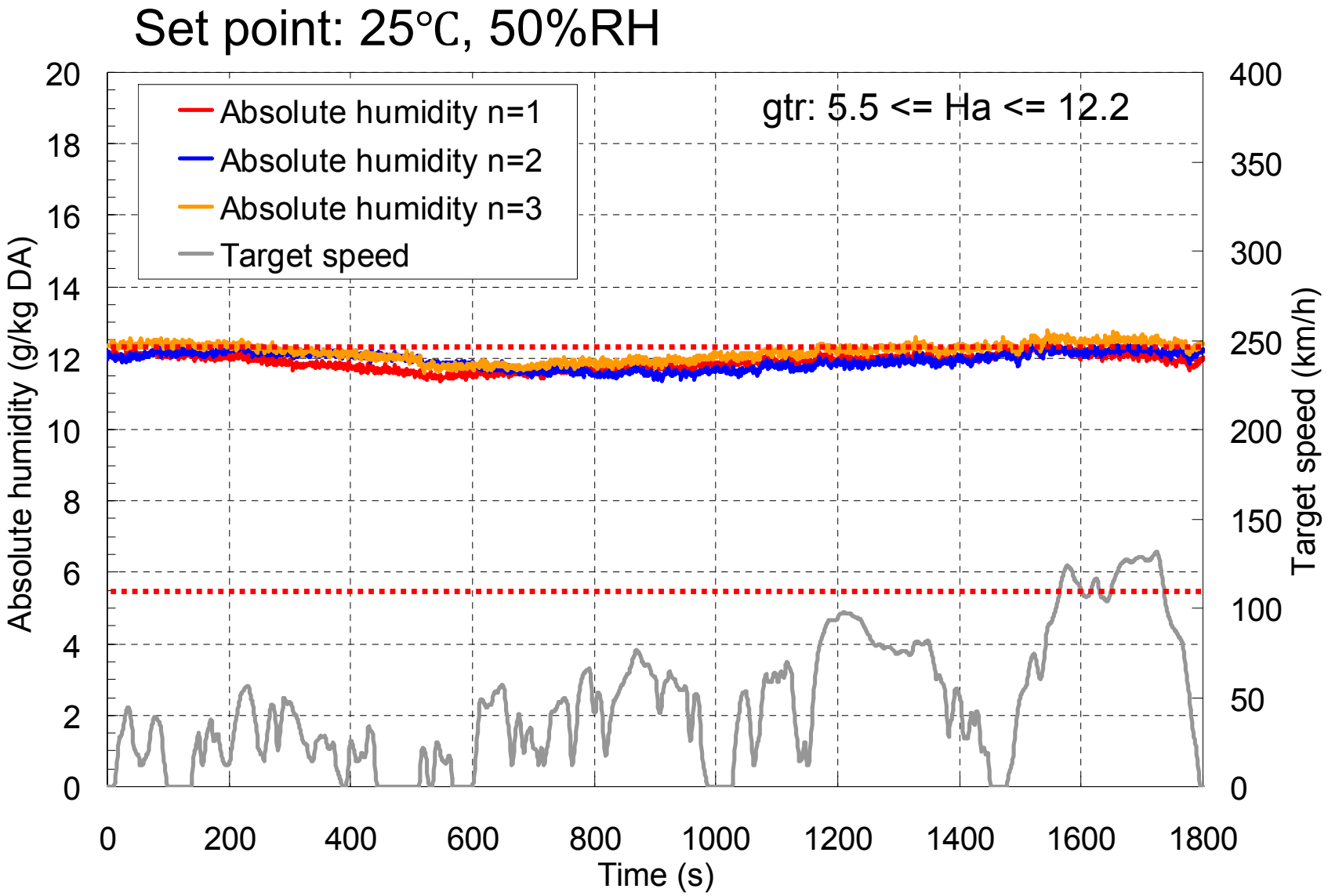
    5. Temperature in the soak room
    6. Temperature in test cell

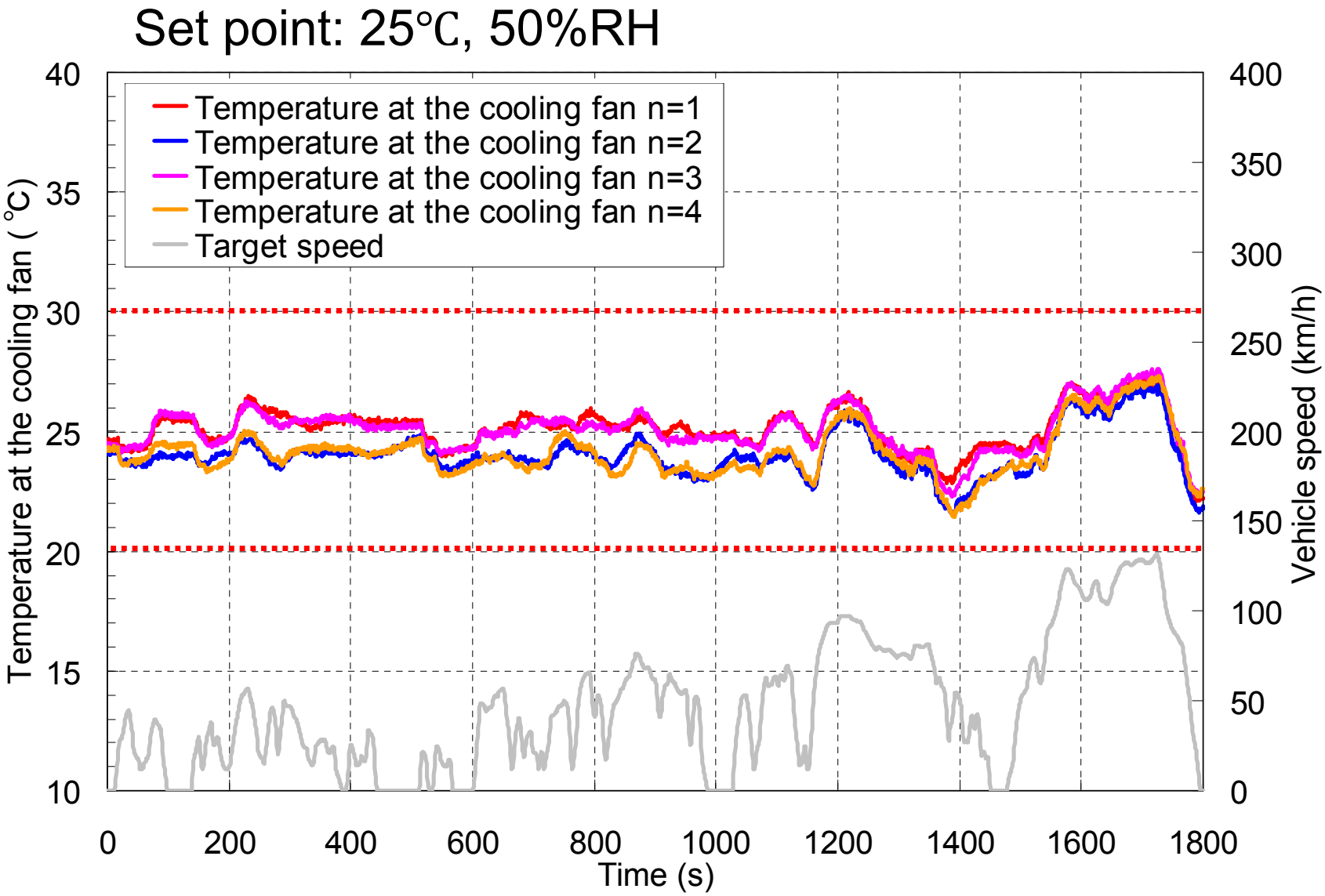
Temperature in test cell – Vehicle B



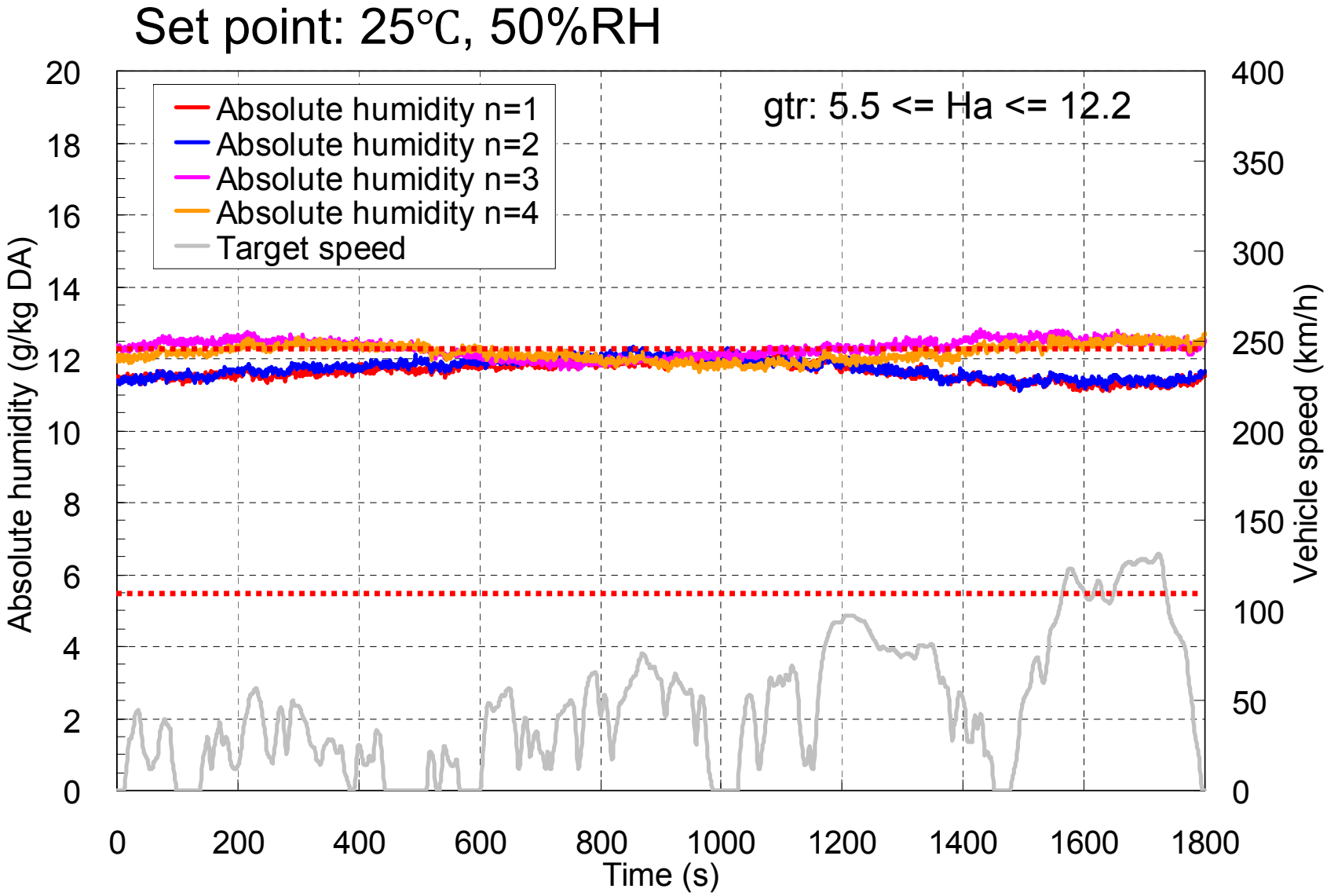
Absolute humidity in test cell – Vehicle B



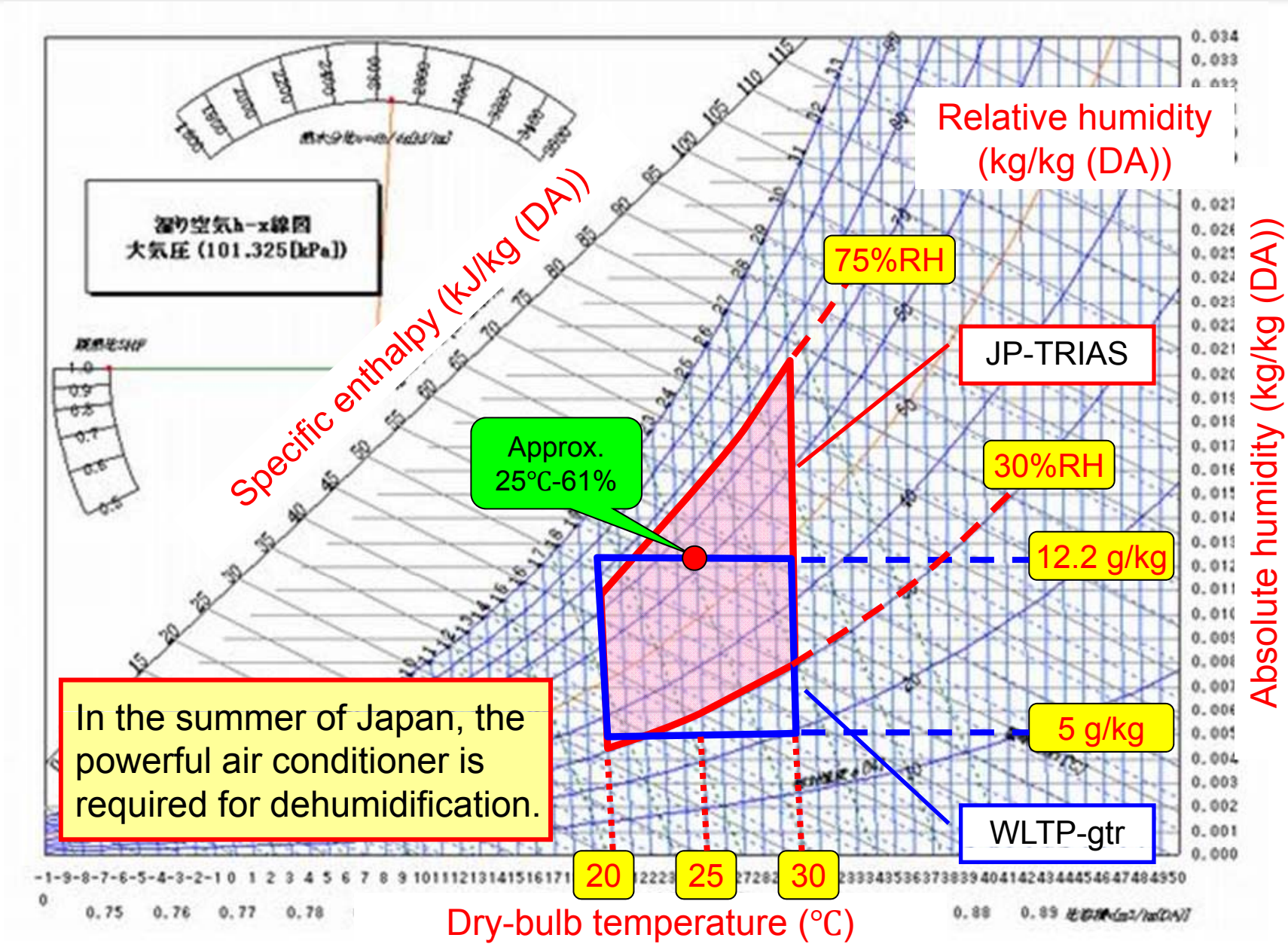
Temperature in test cell – Vehicle C



Absolute humidity in test cell – Vehicle C



Ref.) Comparison of test cell condition on h-x curve



Observation

- It might be hard for all laboratories to keep test cell temperature within 25 +/- 2 degrees C during whole WLTC driving.
- It is one of ideas to set temperature tolerance within 25 +/- 2 degrees C for specific phase(s).