PEMS Performance in Specific Environmental Conditions for IRDE with High and Varying Altitudes and Temperature

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Difficulties, Concerns for Reliable Testing at IRDE

- Compare to European RDE, there are some difficulties for IRDE.

Invalid Trip

Heavy Traffic

- Number of Start-stop

Speed Bump

- Urban – Rural

Vehicle Emission

Dust

- Frequent maintenance

Road Condition

- Vibration

Equipment Reliability

High Temperature

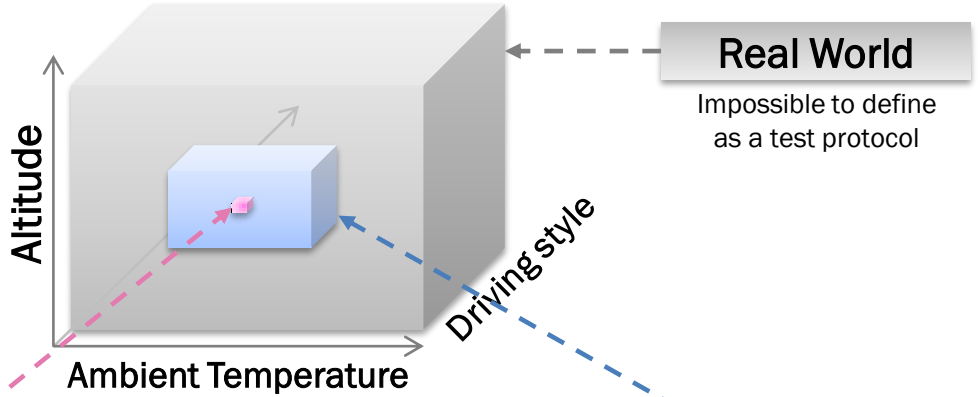
- Changing analyzer reading during the test

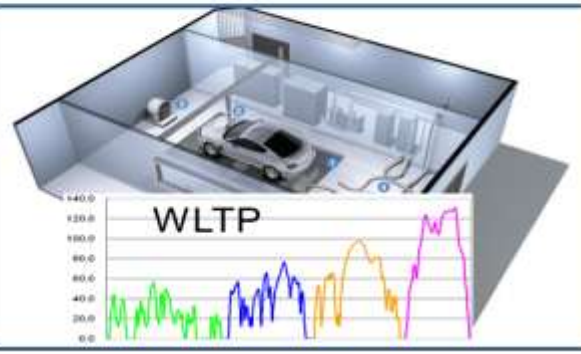
Varied Altitude

- Changing analyzer reading during the test

Background: RDE Overview

- RDE (Real Driving Emissions) by definition is performed under a wide range of conditions.



	Lab test	RDE test
Time : Altitude : Temp. :	WLTP: 30min, FTP75: 40min Static pressure 23±5 degC	90 ～ 120 min Normal : ～ 700m Extend: 700～1300m Normal : 0 ～ 30 degC Extend: -7～0, 30～35 degC
Driving pattern		 Urban 0-60 km/h 34±10% (>29%) Average 15-40km/h etc. Rural 60-90km/h 33±10% Motorway 90-145 km/h 33±10 % Min 110km/h 5min above100km/h

Boundary Limit are Different per Region

- Boundary limit is applied to the topography and climate for each region..
  - High altitude in 2,400 m is required in China.
  - High temperature in 45degC is required in India.

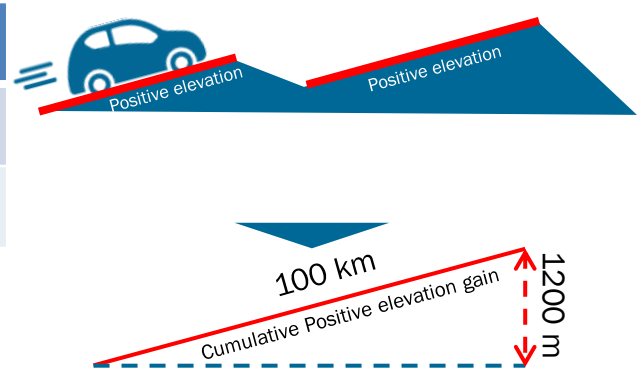
		EU	Japan	China	India
Regulation		EURO 6d	Att. 119	GB 6	AIS-137
Altitude	Moderate	≤ 700 m	≤ 700 m	< 700 m	≤ 700 m
	Extended	≤ 1,300 m	≤ 1,000 m	< 1,300 m < 2,400 m	≤ 1,300 m
Temperature	Moderate	0~30degC	0~35degC	0~30degC	10~40degC
	Extended	-7~0 30~35degC	-2~0degC 35~38degC	-7~0degC 30~35degC	40~45degC

- Measurement technique for PEMS toward high altitude and temperature are required.

Changing Elevation During the Test

- Varying altitude happens during RDE tests in mountainous regions or areas where the distance from sea level to mountain is short.
  - Total accumulated altitude rise is regulated as 1,200 m per 100 km as CPE (Cumulative Positive Elevation gain).

	EU	Japan	China	India
Regulation	EURO 6d	Att. 119	GB 6	AIS 137
CPE	≤ 1,200 m/100 km			



- Measurement technique for PEMS toward the measurement at varying altitude is required.

Hot Condition and Significant Temperature Gap During IRDE

Components	CO, NOx, PN
Test Duration	90 to 120 min.
Trip requirement	Altitude Normal:～700m Extend： 700~1300m
	Temperature Normal:0～40℃ Extend： -7～0℃, 40～45℃

PEMS Validation at 23degC

Urban 15	Rural	Motorway
- 45 km/h	45 - 65 km/h	65 km/h -
29% - 44%	33%±10	33%±10
		100km/h - ≧ 5min

- Trip requirement depends on vehicle categories .
  - Some categories will not adopt motorway.
- Urban, Rural, Motorway：Each distance should be at least 16km

※Source: Draft for RDE, D0, published on January 2019

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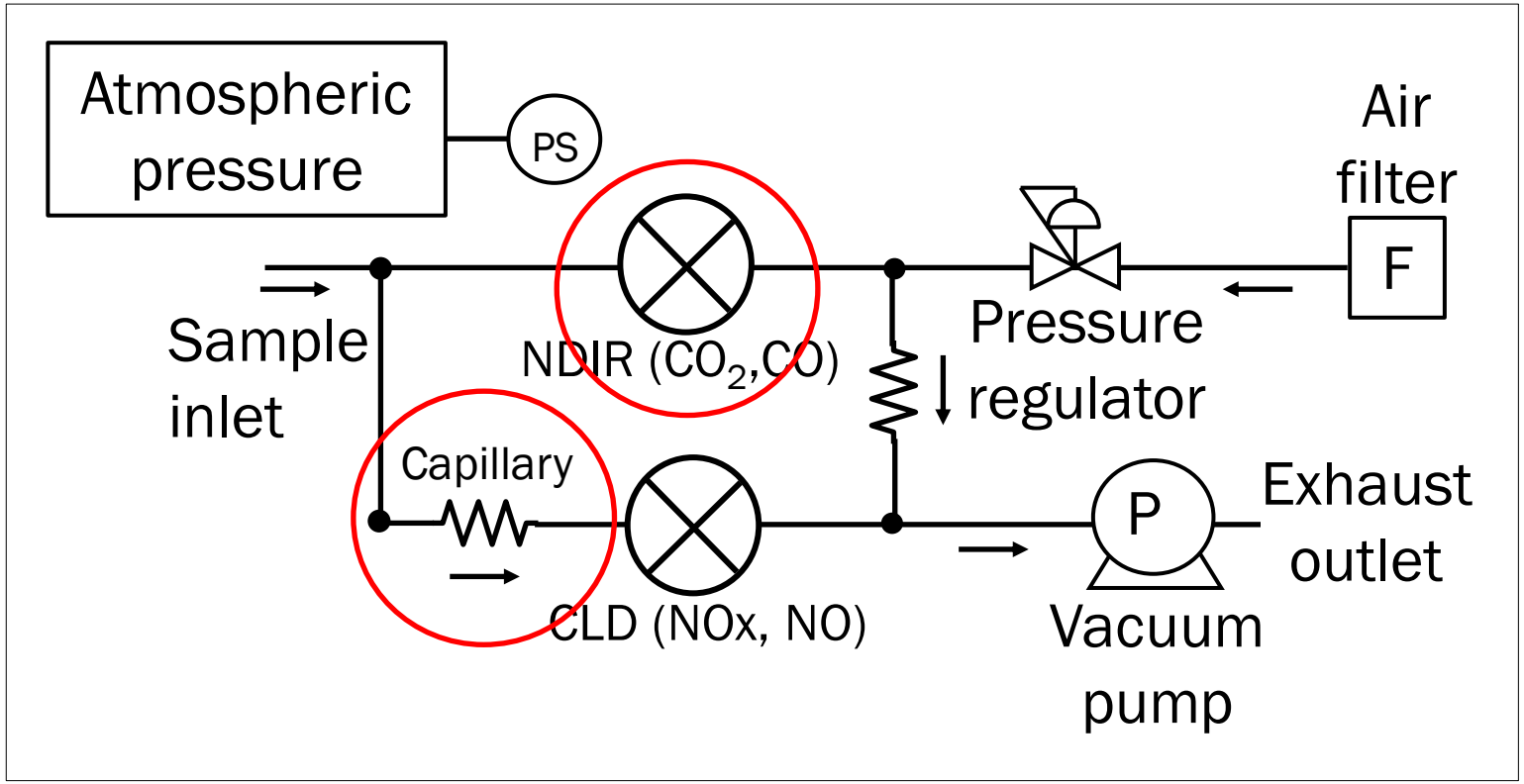
PEMS Need to be Considered Altitude Changes

■ Pressure controlling of Conventional system

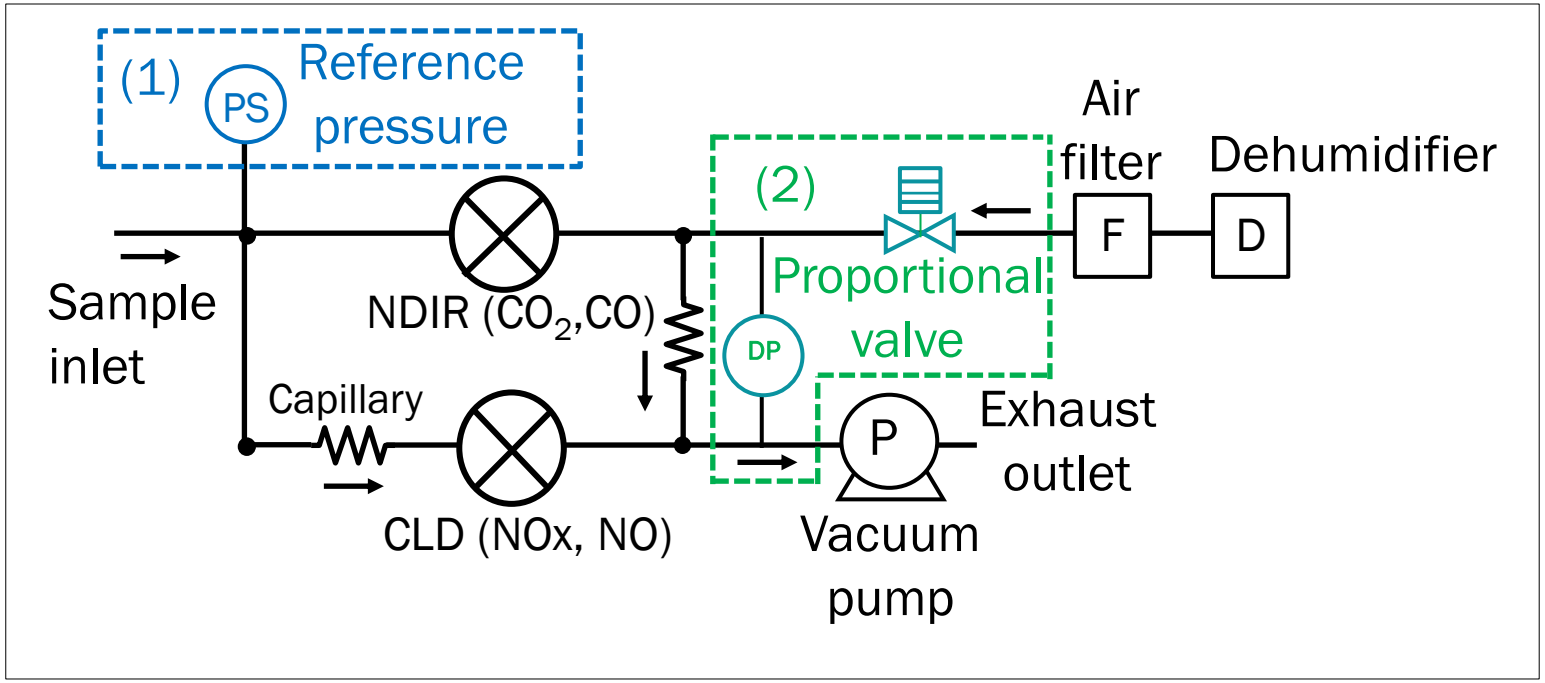


■ Point to consider the analytical reliability.

- Inside NDIR gas cell pressure changes from sea level to smaller than barometric pressure.
- CLD method NOx analyzer sensitivity is relative to the pressure before and after capillaries.

Countermeasure for the elevation change.

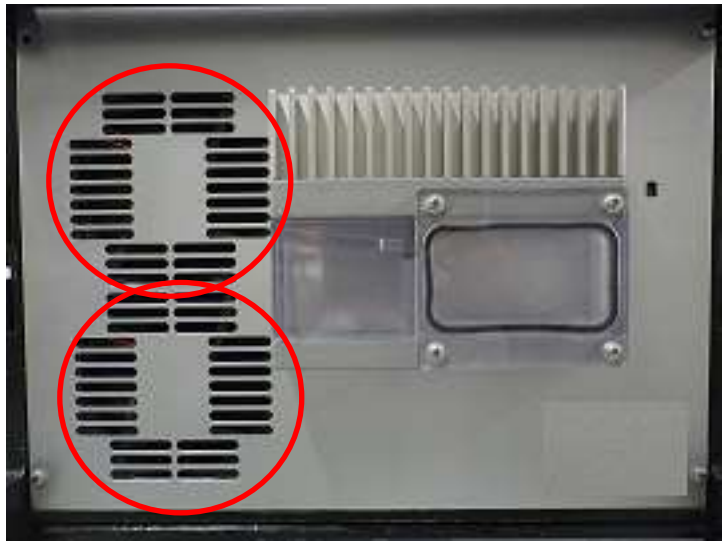
- Techniques to be reliable PEMS for elevation change.



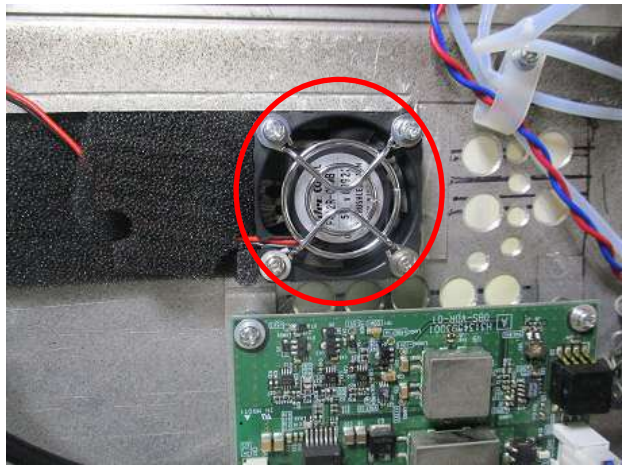
- Techniques
  - Inline pressure sensor implements a precise pressure compensation by sensing pressure close to the sample inlet point.
  - Proportional valve with differential pressure sensor implements the precise pressure controlling toward stable sample flow rate by maintaining a certain differential pressure across the capillary.
  - Dehumidifier eliminates ambient humidity effect, especially for CLD because of O_3 source.

Gaseous PEMS Analyzer Countermeasure for Heat

- Countermeasure point for 45 degC
  Swipe any high temperature condensation inside analyzer by re-design of ventilation system
- Solution example

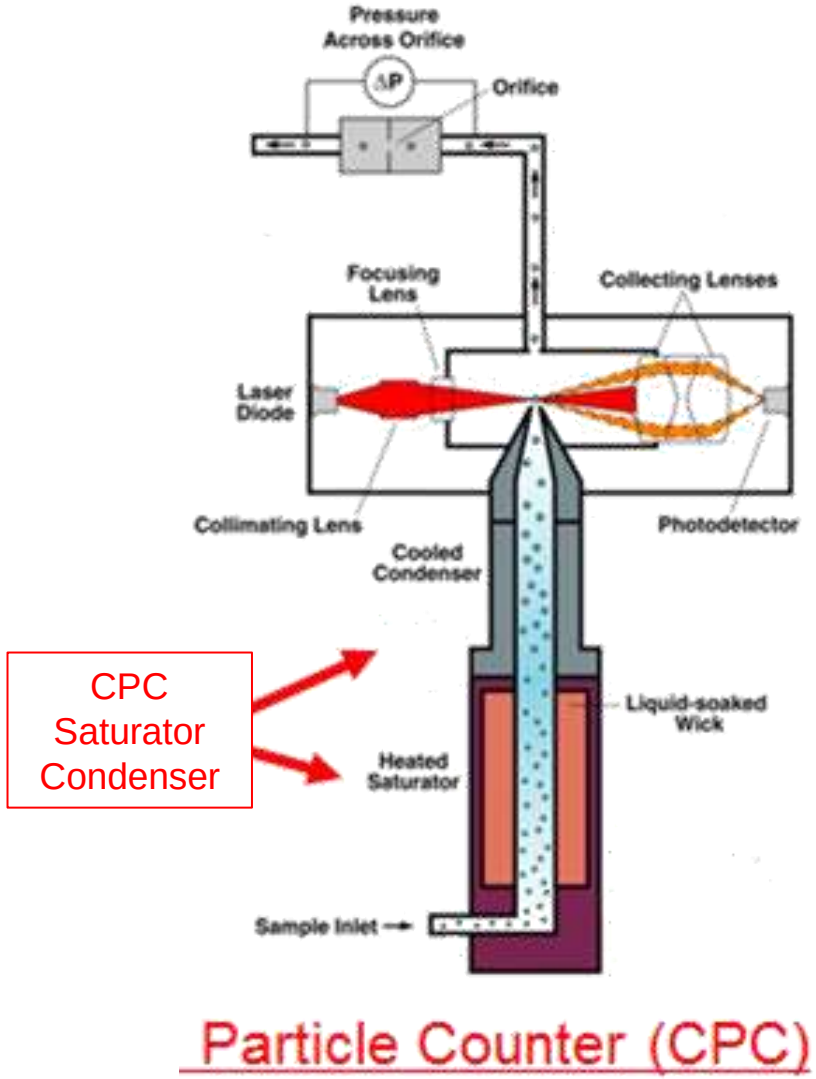


Reinforcement of
wind velocity for FAN

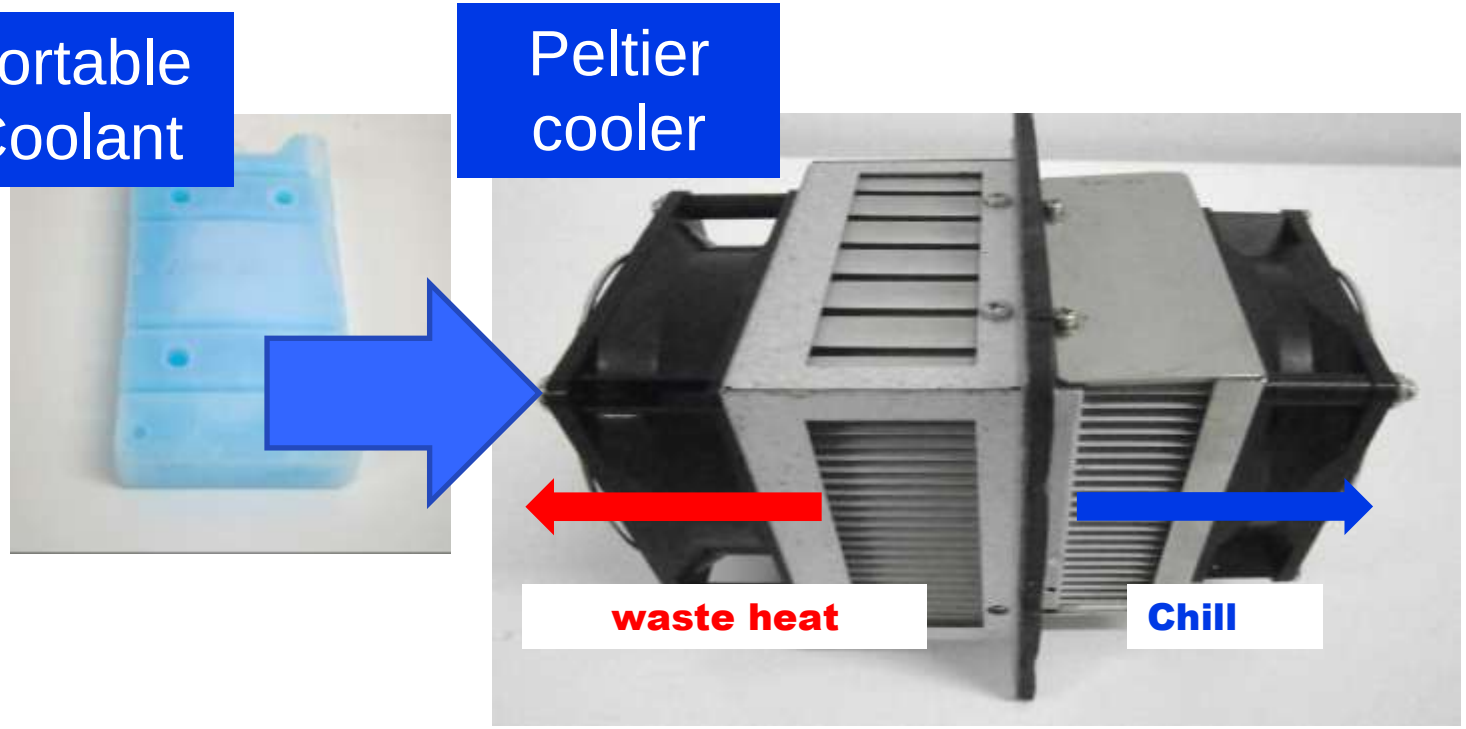


Add FAN inside

Cooling Analytical Equipment for PN Measurement



- Countermeasure point for 45 degC but detector is controlled at 21 and 30degC for Condenser and Saturator.
- Keep stable temperature inside PEMS even big delta T between PEMS validation and 45degC environment condition.
- Solution tried two different method.



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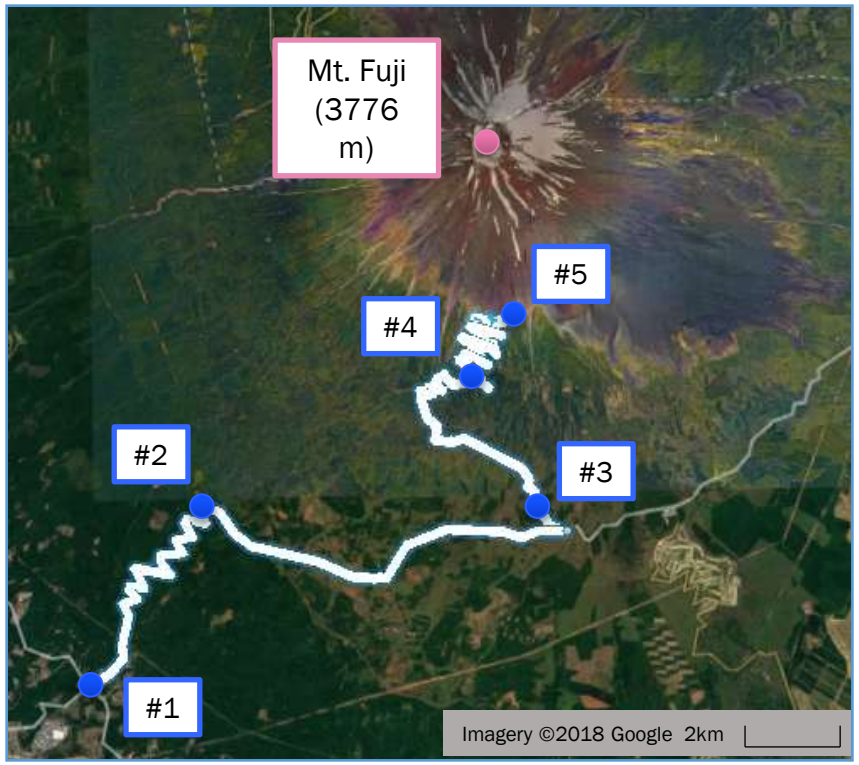
Elevation Change Test Data on Mt. Fuji

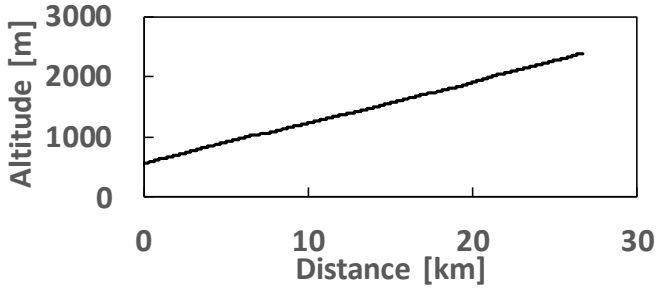
Route on Mt. Fuji



Altitude of each point

Point [#]	Altitude [m]
1	510
2	1,000
3	1,450
4	2,000
5	2,380

Altitude change on the route



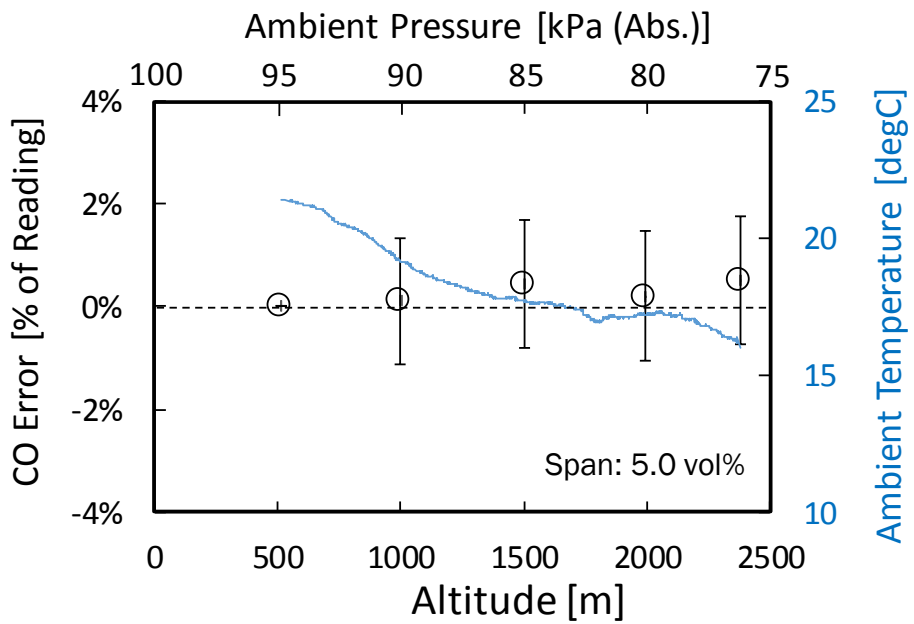
- Linear altitude change
- No downslope
- Light traffic & No traffic signals

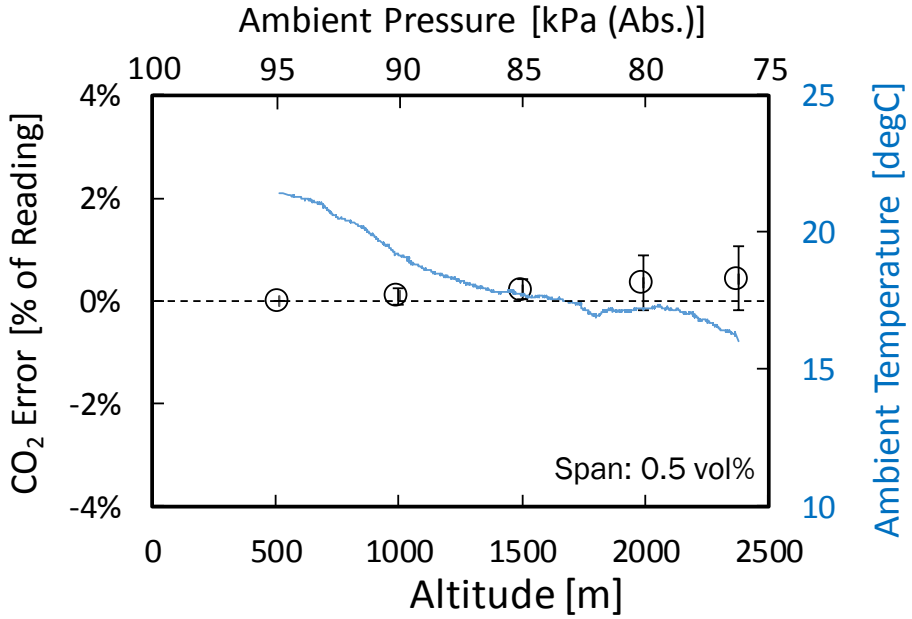
Altitude change on the test exceeds CPE requirement

- Check PEMS performance on extreme altitude changing condition.

CO / CO2 Analyzer Sensitivity Change on Mt. Fuji

CO_2 and CO results of advanced system on Mt. Fuji

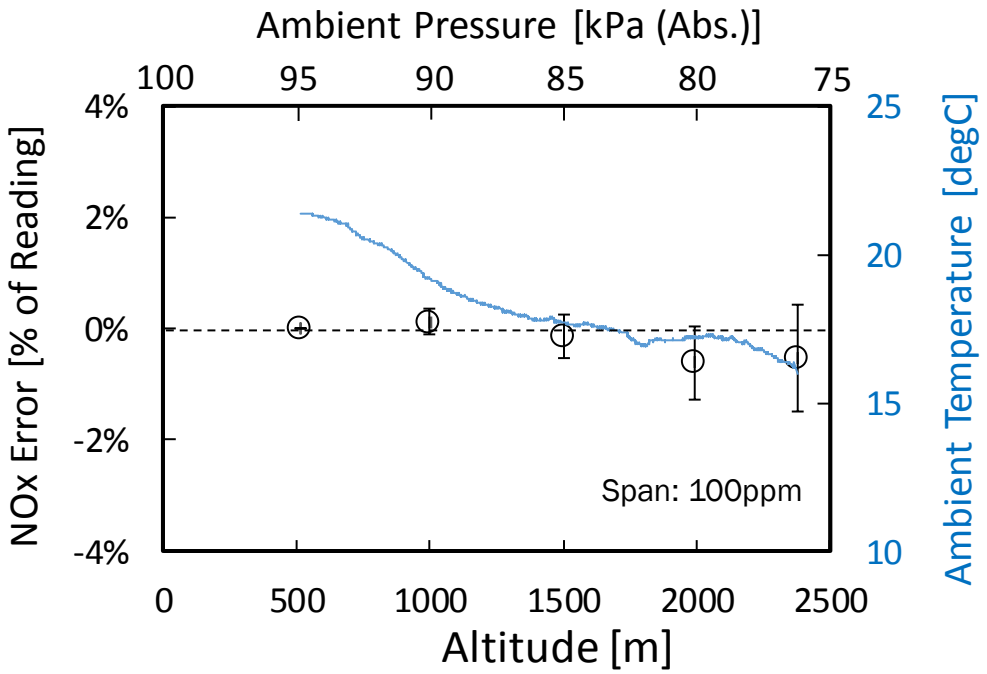


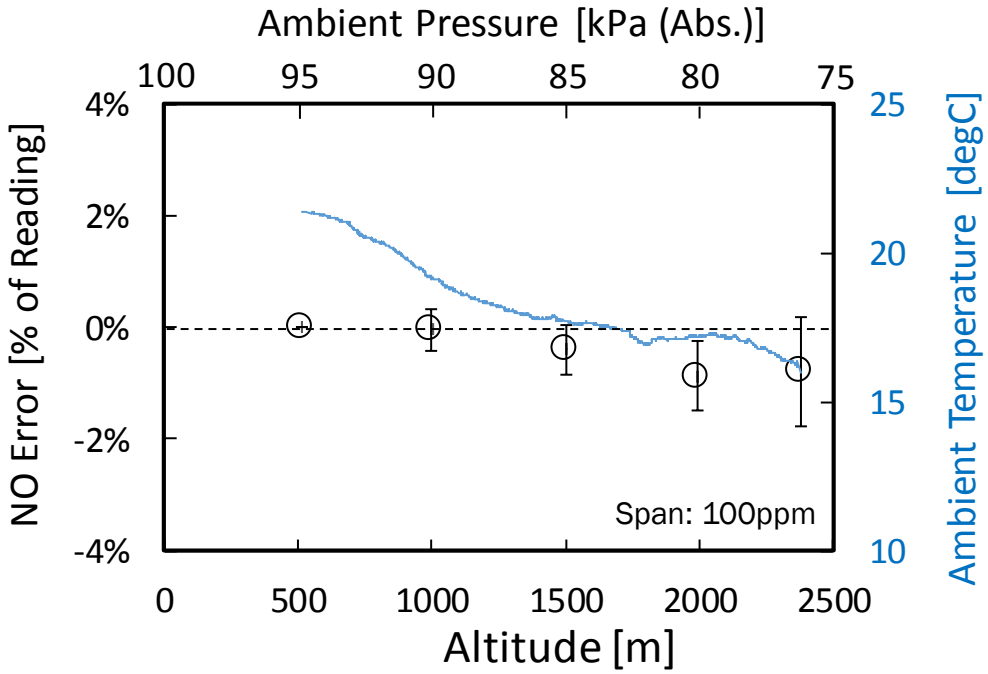


- Similar performance to the altitude simulation chamber.
  - Pressure controlling system worked properly at high altitude.
  - CO has slightly higher deviation than CO_2. CO is sensitive to temperature change due to low S/N at lower pressure (10x lower Span than CO_2)
  - ✓ Measured value error: within 1.0%
  - ✓ Standard deviation (2σ): less than 2.0%

NOx / NO Sensitivity Change on Mt. Fuji

NOx and NO results on Mt. Fuji



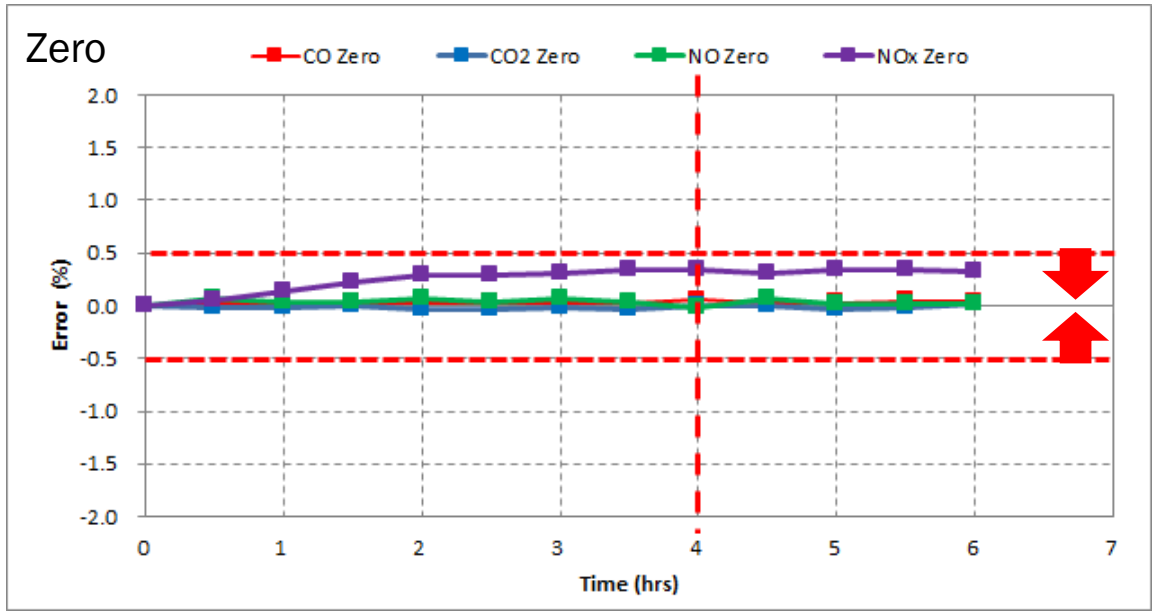


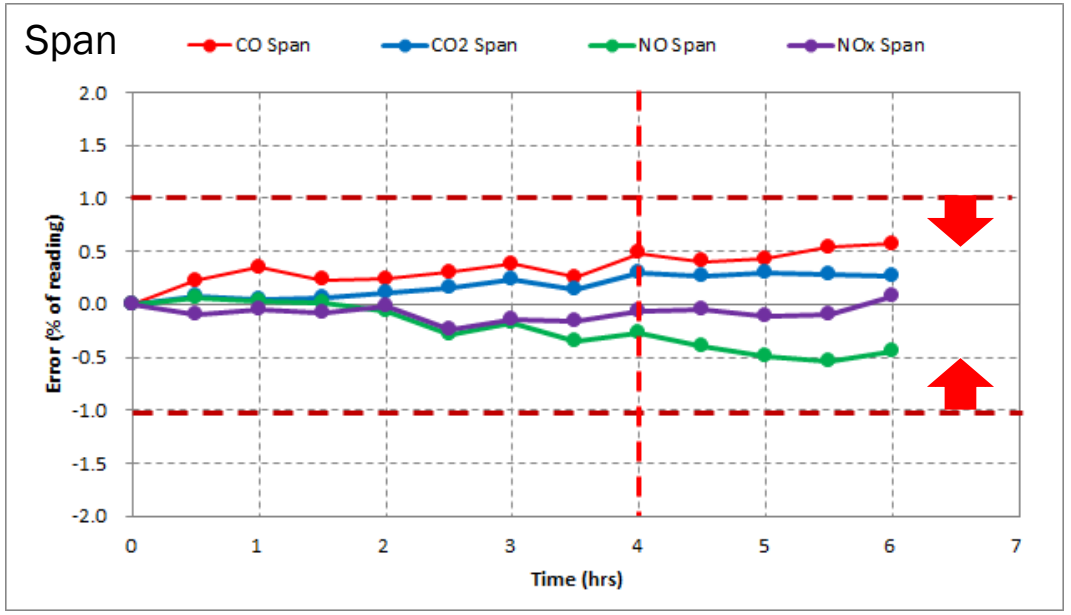
- Similar performance to the altitude simulation chamber.
  - Pressure controlling system worked properly at high altitude.
  - NOx and NO are sensitive to pressure change because of measurement principle.
  - ✓ Measured value error: within 1.0%
  - ✓ Standard deviation (2σ): less than 2.0%

Gaseous Component Measuring Stability at 45degC

- Result example (under evaluation currently)
- Condition : Room temperature 45 degC

  Concentration: CO; 0.5 vol%, CO_2; 5 vol%, NO/NO_X; 100 ppm

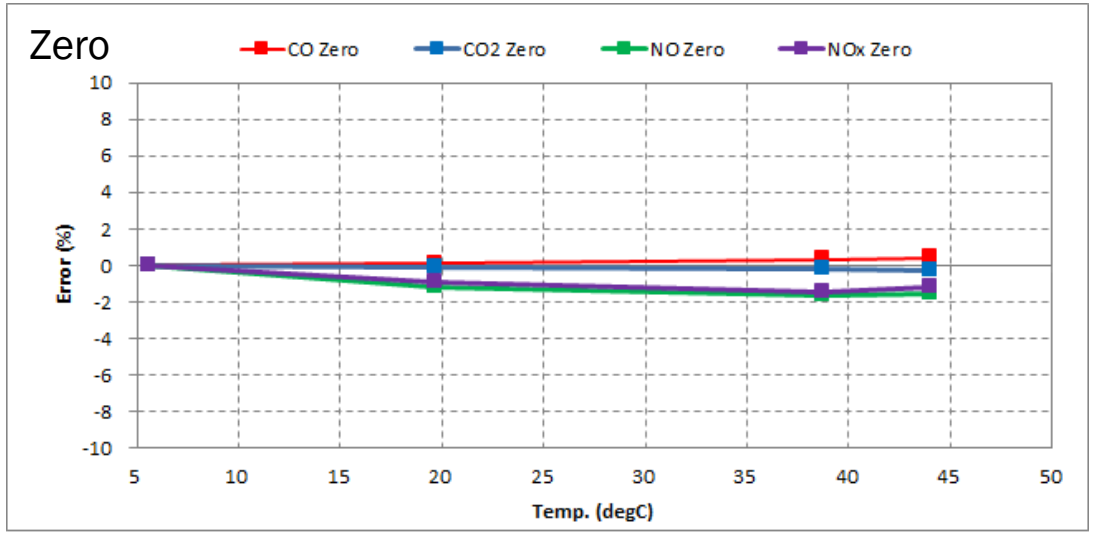


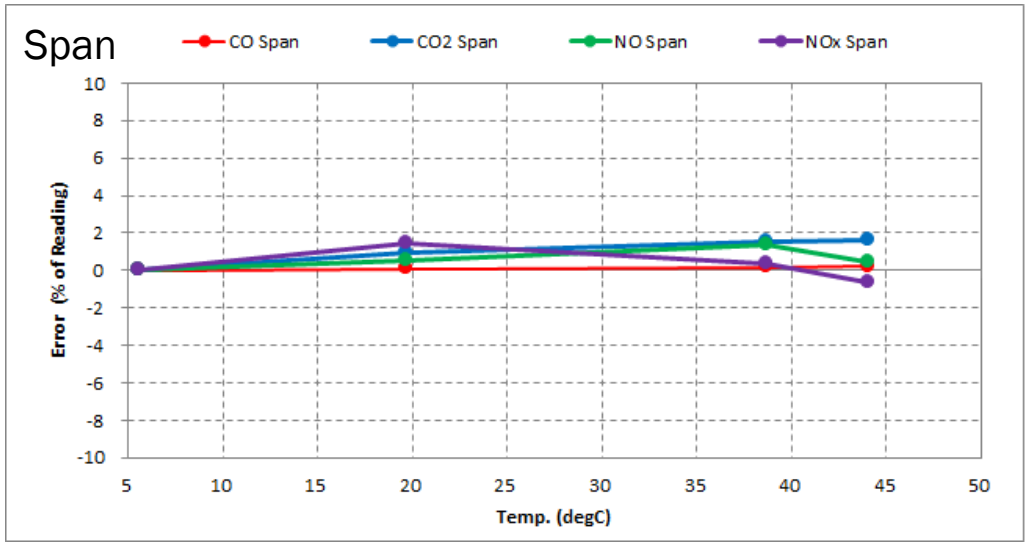


Drift result @ 45 degC

Gaseous Component Sensitivity Change from Low to High Temperature.

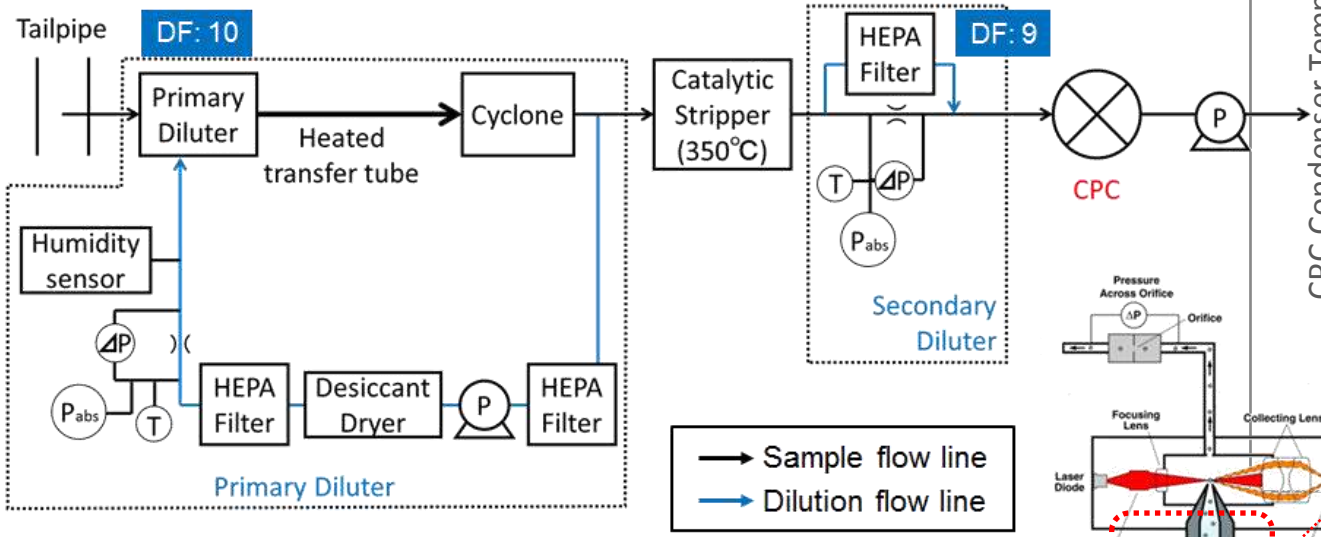
- Result example (under evaluation currently)
- Condition : Room temperature 5 (start) to 45 (goal) degC
  Concentration: CO; 0.5 vol%, CO_2; 5 vol%, NO/NO_X; 100 ppm
  There is a temperature Compensation for NO and NO_X

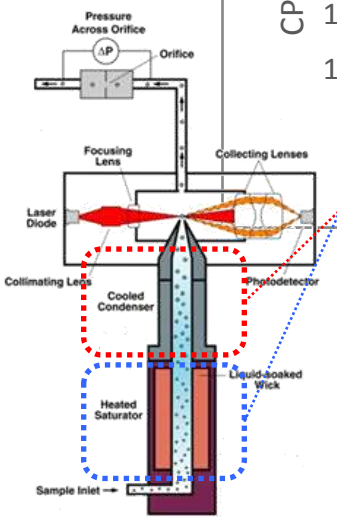




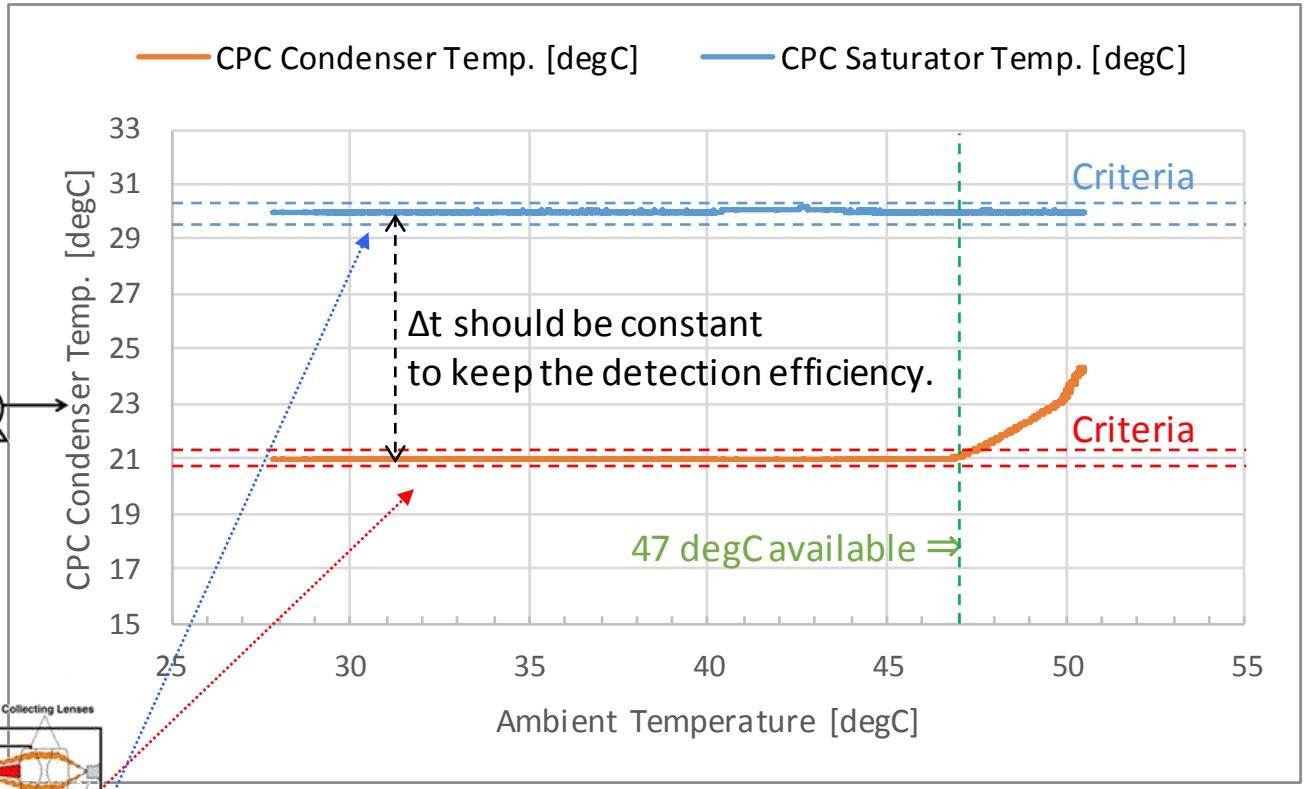
PN Detector Stability under Temperature Change

- Up to 47degC showing stable temperature





Condensation Particle Counter (CPC)



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Summary: IRDE Reliable Testing Possibility

- There are significant difficulties in order to be a reliable RDE test in India comparing to the European test by environment, traffic, road condition and so on.
- Especially the altitude and high temperature are significant different occasion in India. Especially, drift test in the specific RDE procedure between PEMS validation in laboratory and end of test may have extreme condition changes.
- To comply under the specific environmental condition, the technique of cooling analyzer and pressure control or compensation could have reliable result less than 2% analyzer sensitivity changes for gaseous and PN.
- By using these techniques, it can have reliable result even under specific condition of Indian RDE.

HORIBA

Thank you for your attention.

Thank you

감사합니다

Cảm ơn

ありがとうございました

Dziękuję

धन्यवाद

Grazie

Merci

谢谢

நன்ற

ขอบคุณครับ

Obrigado

Σας ευχαριστούμε

شُكْرا

Tack ska ni ha

Большое спасибо

Danke

Gracias