Advanced Portable Emissions Measurement System for New Measurement Components

~ NH_3, N_2O & SPN_{10} ~

18th March 2022

HORIBA, Ltd., Shun FUKAMI

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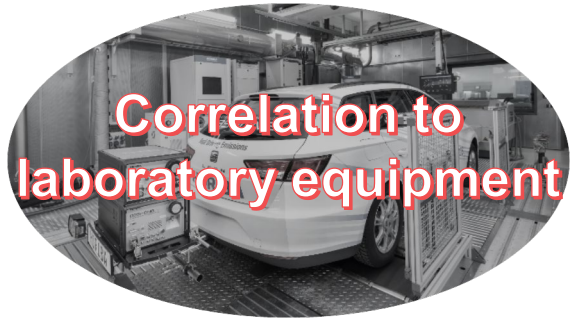
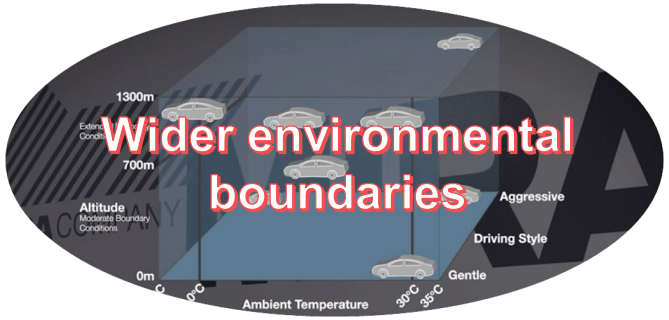
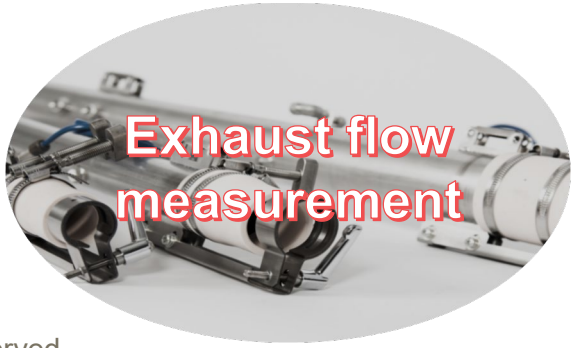
Challenges on RDE







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History of HORIBA PEMS

MEXA-1340AFM

MEXA-1440AFM

Real world monitoring

OBS-2000

HDV in-use tests

(CFR1065, EuroVI)

OBS-ONE
New analyzers

Expanded

RDE regulations

1980s | 2003 | 2005 | 2015 | 2021

OBS-1000

Real world tests

OBS-ONE

RDE regulations in the world

Gas PN PM

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On-board NH_3/N_2O analyzer

■NH_3 & N_2O available

- ✓New developed "IRLAM" technology utilizing QCL-IR
- ✓RDE measurement with high accuracy & compact unit

■Robustness

- ✓High/Low temperature, altitude change
- ✓Vibration/Shock from vehicle

■Flexibility

- ✓Stand alone or Connect with OBS-ONE

What is “IRLAM”?

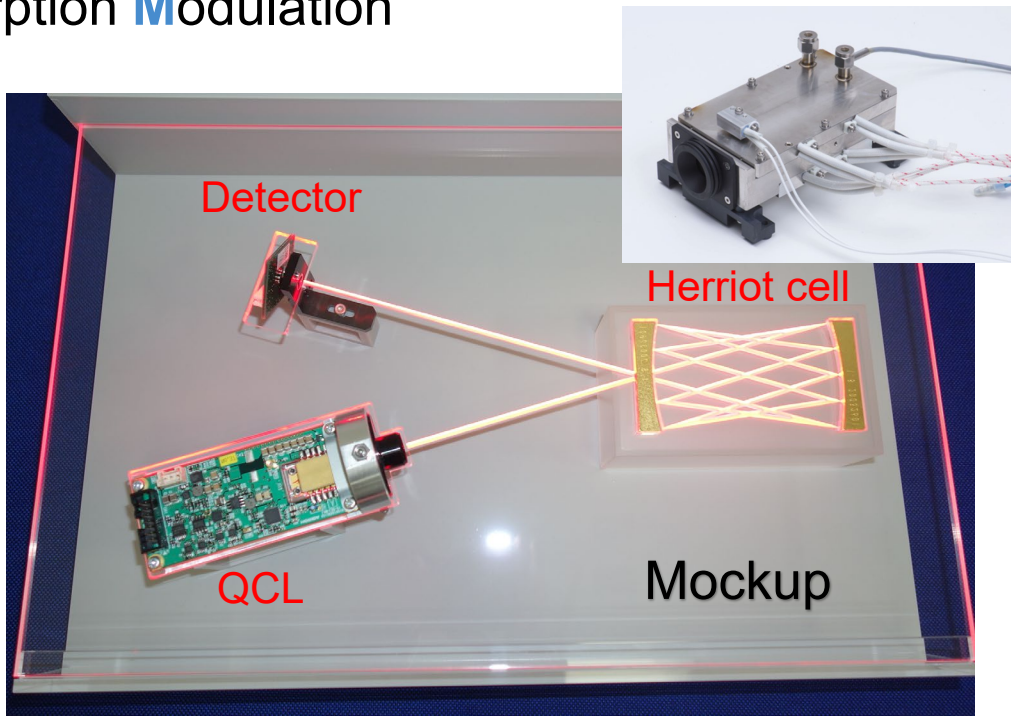
Newly developed gas analysis technology by HORIBA

More info:
https://www.horiba.com/en_en/irlam/

IRLAM by HORIBA

IRLAM : InfraRed Laser Absorption Modulation

- ◆ High accuracy
  - ➢ Infrared absorption utilizing QCL(Quantum Cascade Laser)
  - ✓ Apply a latest technology to PEMS
- ◆ Compact
  - ➢ Small gas cell (Herriot cell)
  - ✓ PEMS optimized hardware design
- ◆ Utility free
  - ➢ Unnecessity of purge gas, liquid nitrogen (LN2)
  - ✓ Unnecessity of mounting gas cylinder in vehicle



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Specification

- Mountable with OBS-ONE
- Front access

	Spec.
Measurement range	NH_3 : 0 - 1500 ppm N_2O : 0 - 1000 ppm
Heating temperature	113 ℃
Sampling flow rate	Approx. 3.3 L/min
Sampling rate	10 Hz
Size (w*d*h)	350mm * 470mm * 255mm
Weight	Approx. 30 kg
Operating condition	Temperature: -10 ~ 45 degC Humidity: Less than 80%RH Altitude: ~ 3000m
Accuracy	+/- 1.0% of full scale or +/- 2.0% of readings whichever is smaller (+/- 0.2% of full scale: below 10% of full scale)
Noise (3σ) zero	NH_3 : ≤ 0.20 ppm N_2O : ≤ 0.15 ppm
Response time $t_{10\text{-}90}$ (Using 6m heated tube)	NH_3 : ≤ 2.5 sec N_2O : ≤ 1.5 sec
Drift (4 hours)	+/- 1.0 % of reading

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Performance

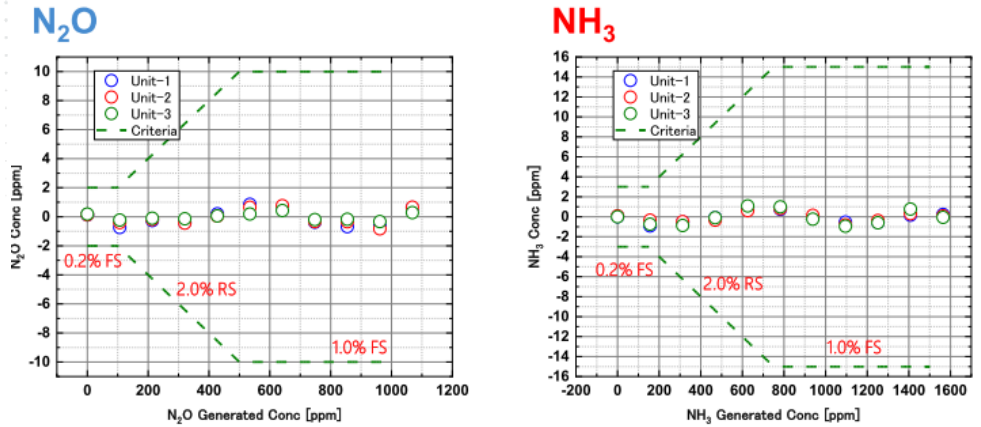
Accuracy & Response time

- Accuracy

+/- 1.0% of full scale or +/- 2.0% of readings whichever is smaller
+/- 0.2% of full scale (at below 10% of full scale)

  - Reference:
    OBS-ONE-GS:
    +/- 0.3% of full scale or +/- 2.0% of readings **whichever is larger**

Higher accuracy at whole range

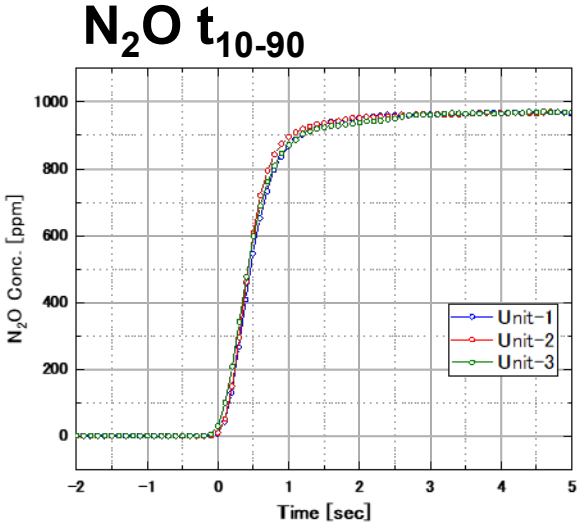


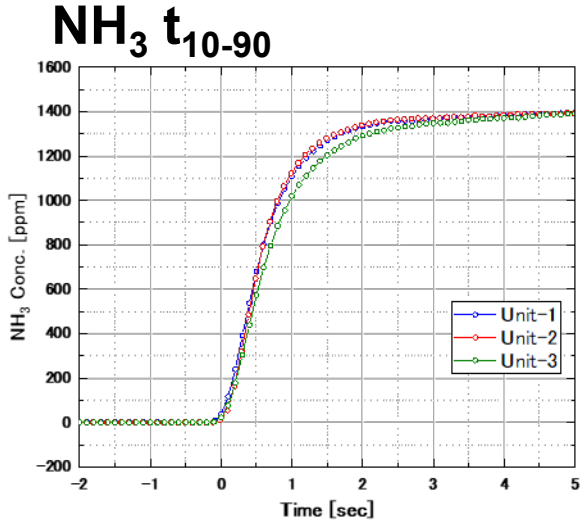
- Response time (Meas. line)

t_{0-10}: 2.5s (N_2O), 3.5s (NH_3)
t_{10-90}: 1.5s (N_2O), 2.5s (NH_3)

at 6m heated tube

Fast response





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Performance

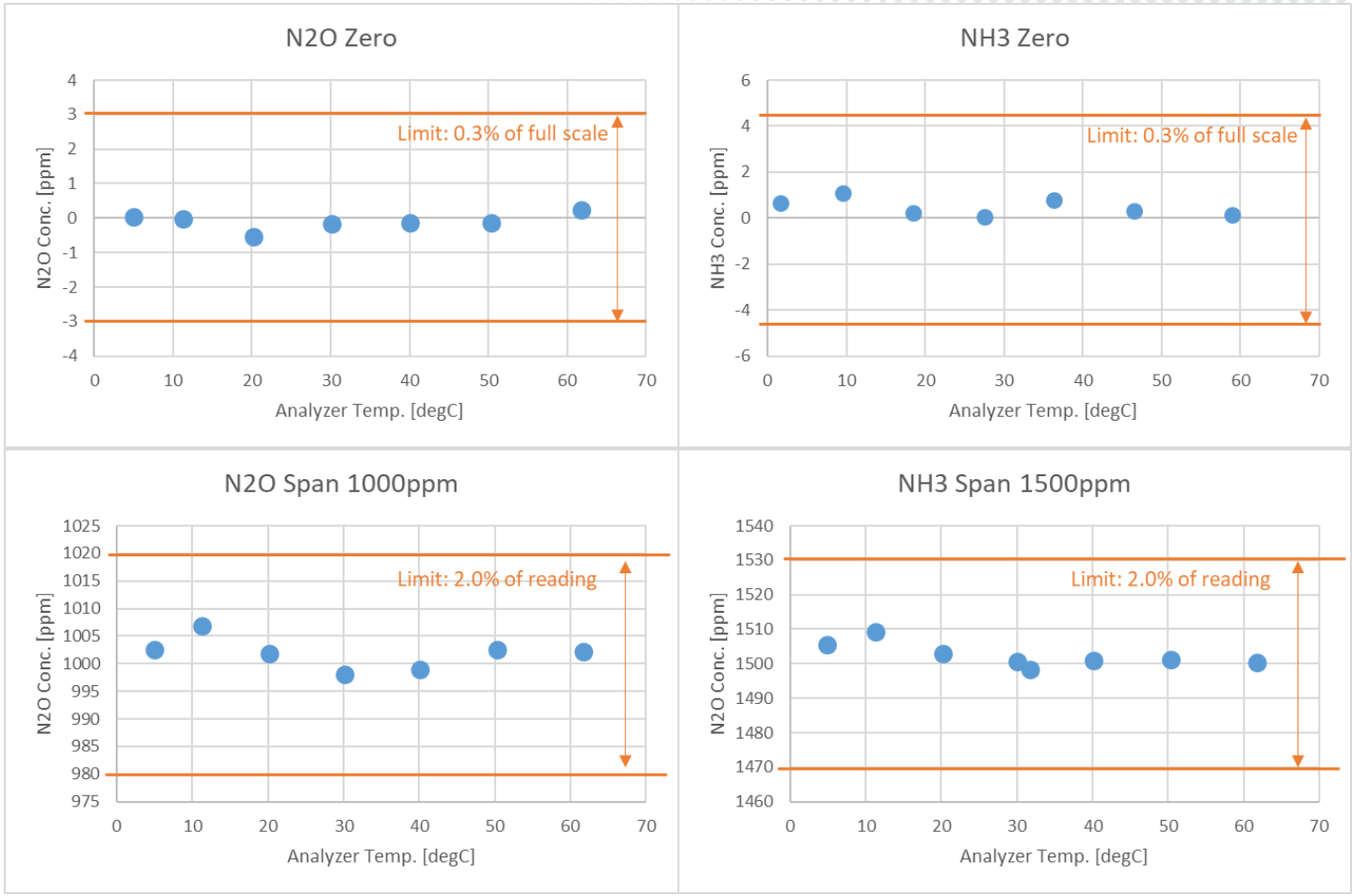
Temperature

- Ambient temperature change

+/- 2.0% of readings or 0.3% of full scale whichever is larger

  - Reference:
    OBS-ONE-GS:
    +/- 2.0% of full scale / 10degC

Stable at “-10 ~ 50 degC”
Zero: ≤ 2ppm, Span: ≤ 10ppm



*X-axis of graph: Temperature inside analyzer
(≒ Ambient temperature + 15 degC)

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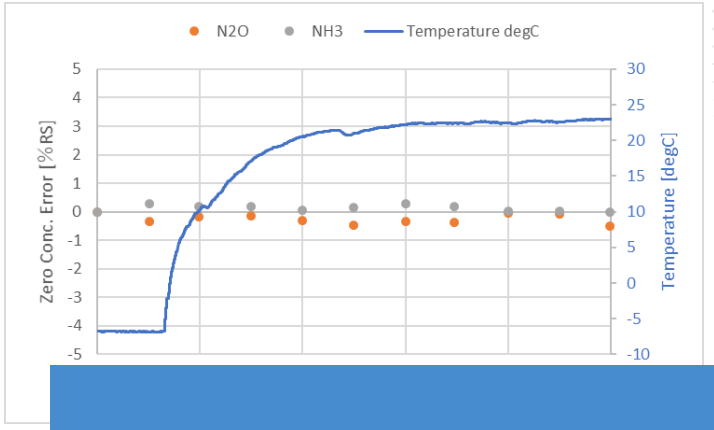
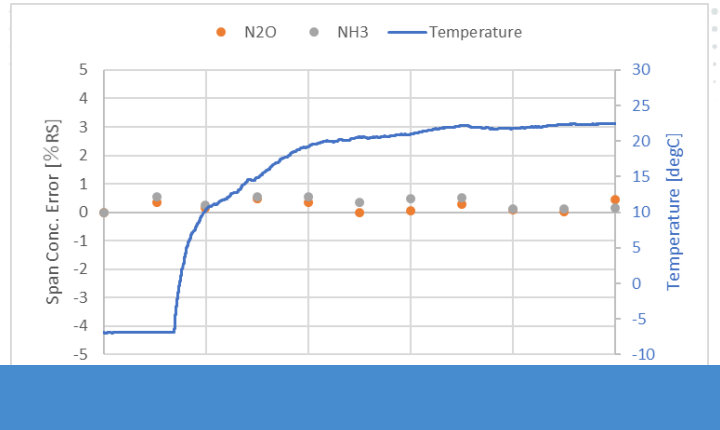
Performance

Transient temperature (Low⇒Ordinary & High⇒Ordinary)

- Temperature [-10 ⇒ 20 degC]

Span
N2O: 1000ppm
NH3: 1500ppm

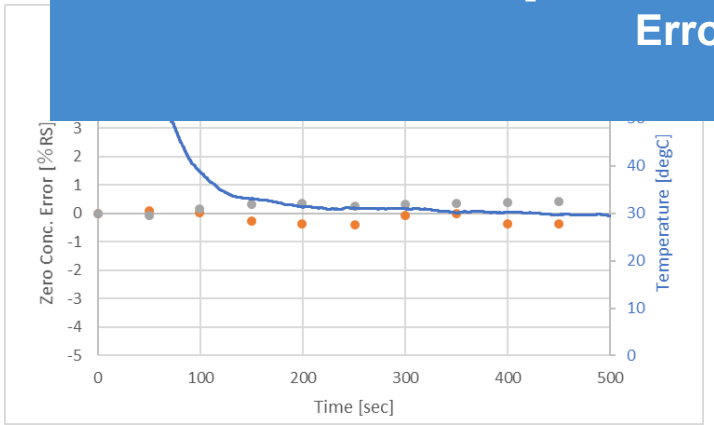


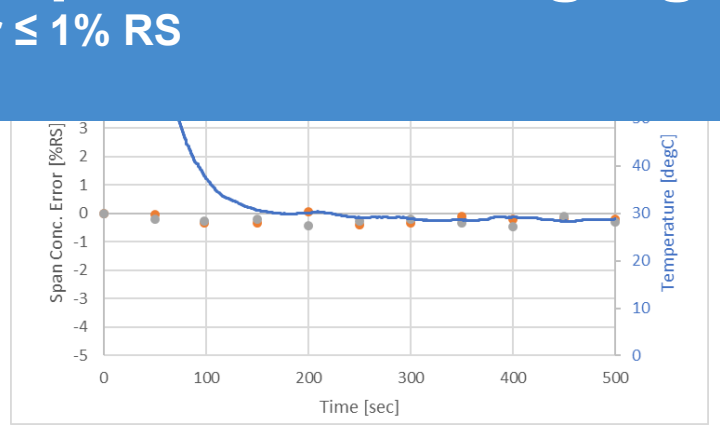


Stable in “rapid temperature changing”
Error ≤ 1% RS

- Temperature [50 ⇒ 20 degC]

Span
N2O: 1000ppm
NH3: 1500ppm





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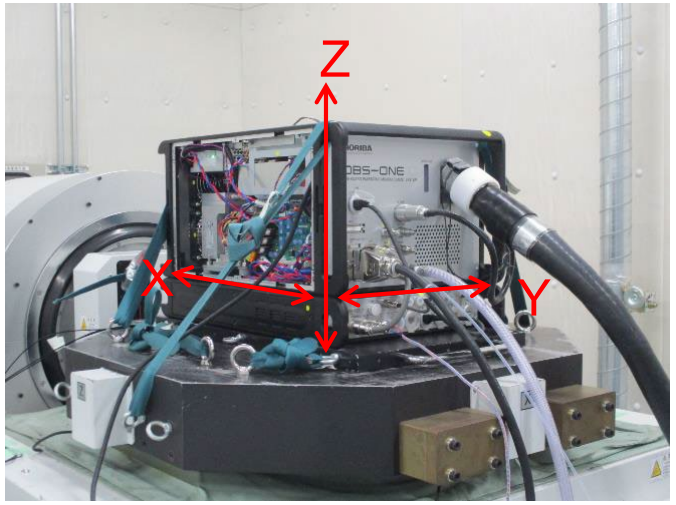
Performance

Vibration

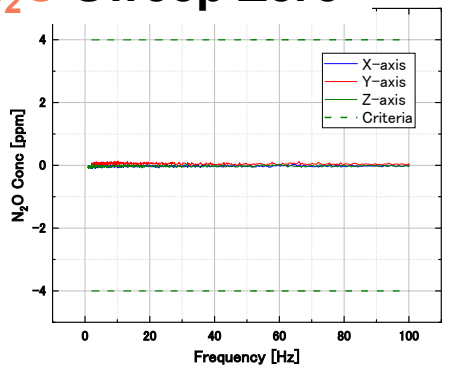
■ Profile

- ✓ Sweep : 1-100 [Hz], 9.8 [m/s^2]
- ✓ Shock test : 50 [m/s^2] (≒5G)

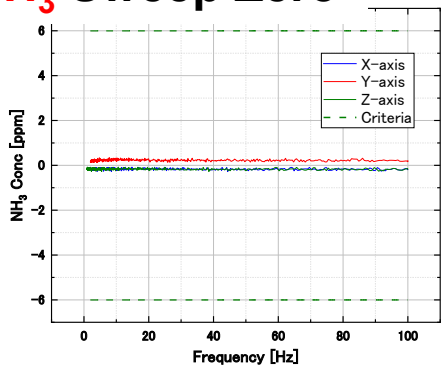


No issue by any vibration

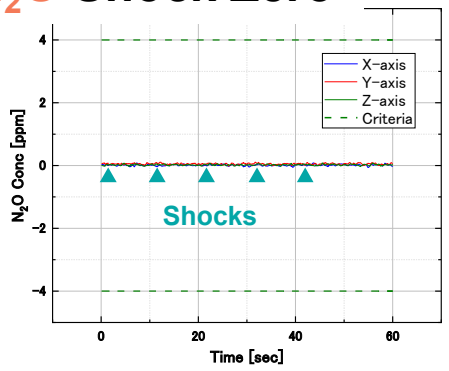
N_2O Sweep Zero



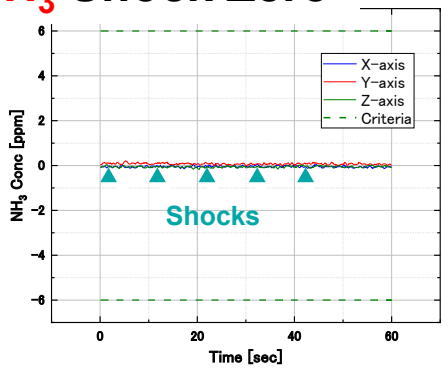
NH_3 Sweep Zero



N_2O Shock Zero



NH_3 Shock Zero



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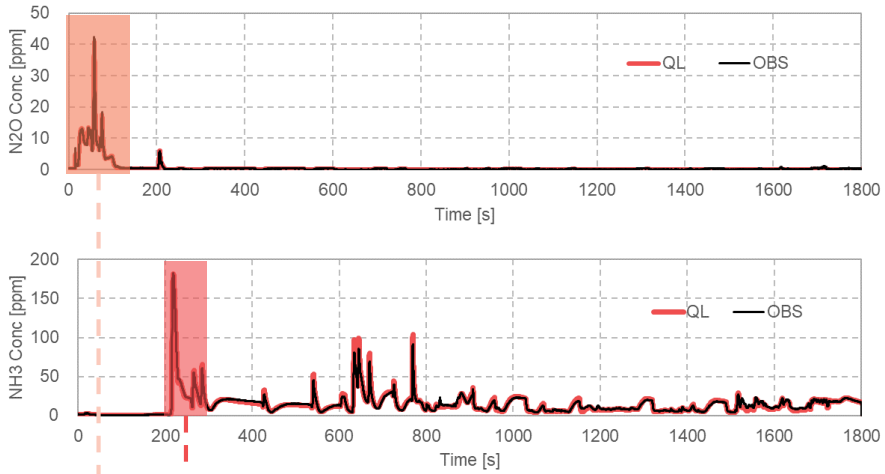
Performance

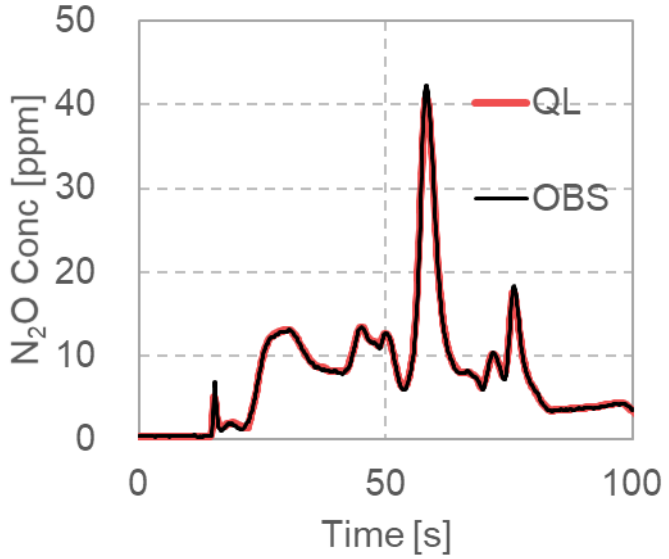
Comparison with MEXA

- Correlation test with MEXA(QL-NX) (Fuel: E10, Mode: WLTC)
- Good correlation
  - OBS shows similar behavior on both NH_3 and N_2O with QL
  - Same peak on both analyzer shows the good response on OBS

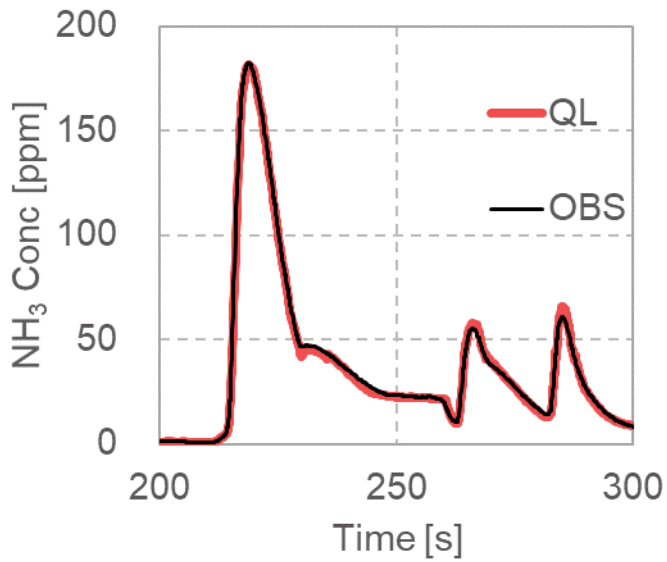


Enlarged peak

N_2O



NH_3



Very good Correlation with stationary type analyzer

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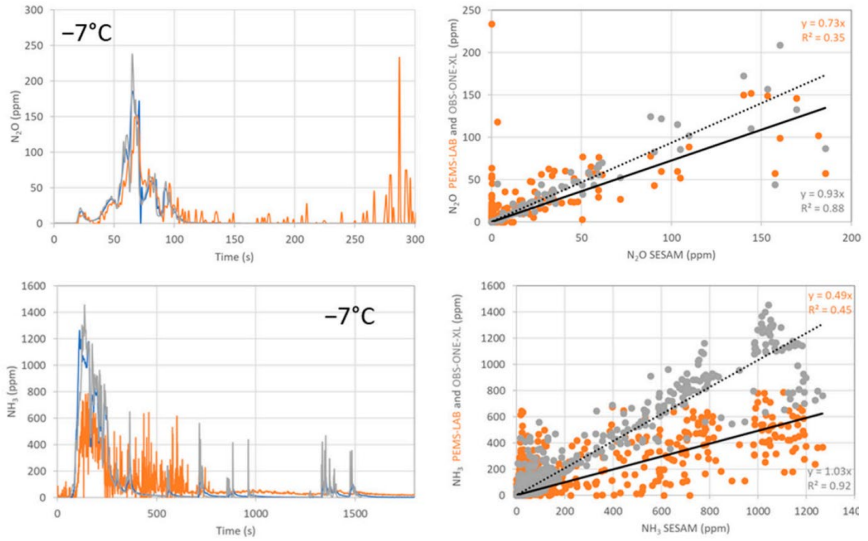
Performance

Correlation confirmation with MEXA-QL-NX (Fuel: CNG, Mode: WHTC)

- Comparison report* in several conditions with stationary analyzer by JRC
  - Comparing OBS-ONE-XL with a FTIR-PEMS (Notation: "PEMS-LAB") confirms superiority such as measurement stability and responsiveness in low temperature environment.

Comparative test in -7 ℃ with AVL SESAM

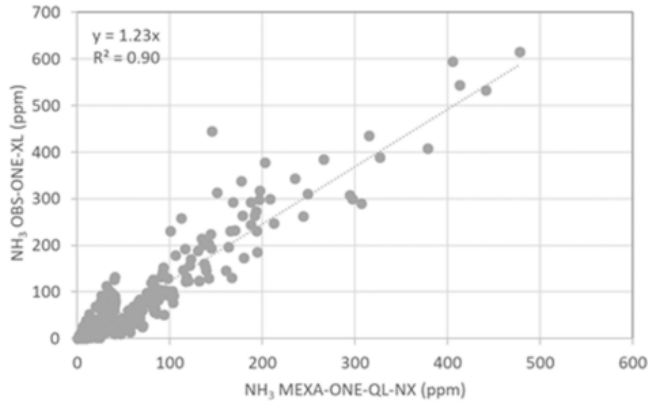


Gray: OBS

Orange: Other manufacture's FTIR-PEMS

Stable measurement even in a -7 ° C environment

Comparison of QL-NX and OBS-ONE-XL



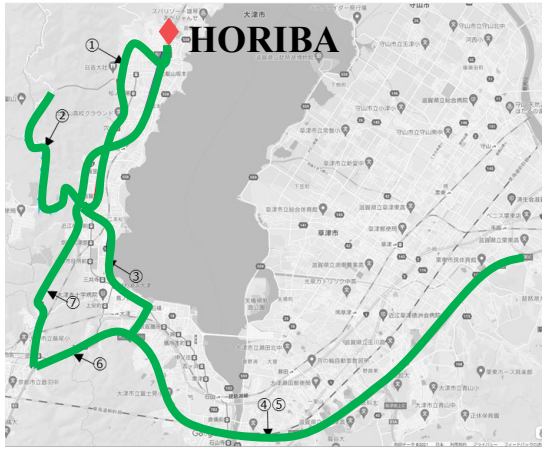
On the road, the correlation of the N_2O concentrations measured by the two on-board systems, OBS-ONE-XL and PEMS-LAB, was good, with an R^2 = 0.95 obtained. In the case of the NH_3 emissions, the OBS-ONE-XL showed a more accurate performance, with sharper, better defined peaks, and less tailing effects related to NH_3 adsorption on the setup obtained

*Appl. Sci. 2021, 11(21), 10055; Ricardo Suarez-Bertoam, et al.
Source: https://www.mdpi.com/2076-3417/11/21/10055

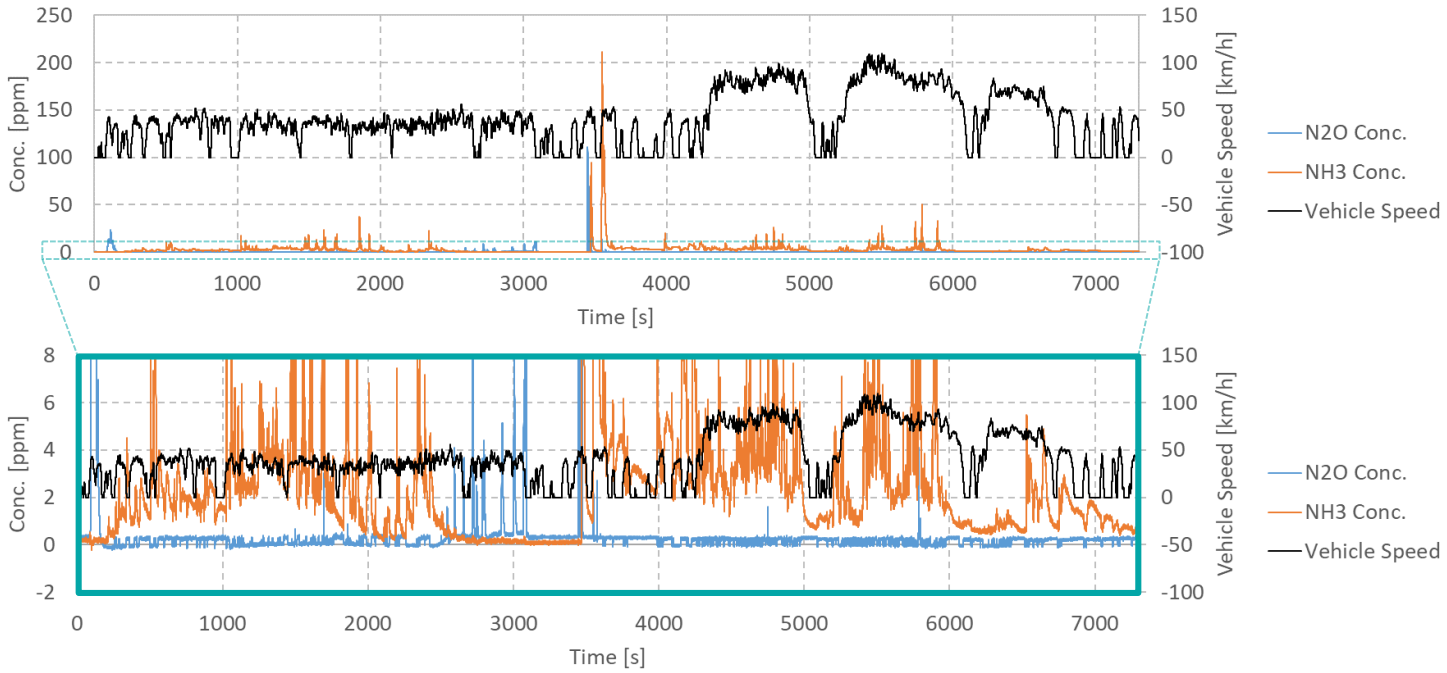
Performance

On-road test

- Petrol vehicle
- Displacement : 1.8L



Route
- 94km / 116 min
- Including climbing (Mt. Hiei)



Drift result

N2O

	Pre Test [ppm]	Post Test [ppm]	Drift [ppm]	Drift [%]
Zero	0.0	-0.1	-0.1	-
Span	978.8	977.2	-1.5	-0.2%

NH3

	Pre Test [ppm]	Post Test [ppm]	Drift [ppm]	Drift [%]
Zero	0.2	-0.3	-0.5	-
Span	1424.3	1420.8	-3.5	-0.2%

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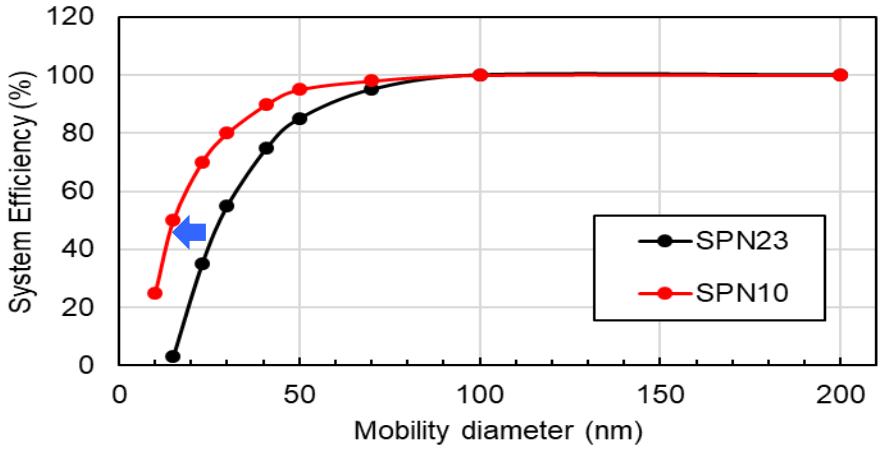
Overview of OBS-ONE-SPN$_{10}$

■Product Concept

- ✓Euro7 regulation compliant: SPN10 measurement
- ✓Adoption of CPC : Reliable SPN10 measurement
- ✓Auto Zero check function : Improved test efficiency



Expansion of system detection lower limit (23nm → 10nm)

■Basic performance, configuration, functions, etc.

- ✓Single specification for SPN10 measurement
- ✓Compatibility with conventional products (system configuration, design, operability)
- ✓Hot Hose length : 1.5m, 2.5m, 4.0m
- ✓Add auto Zero check function (New)
- ✓High reliability against vehicle body vibration

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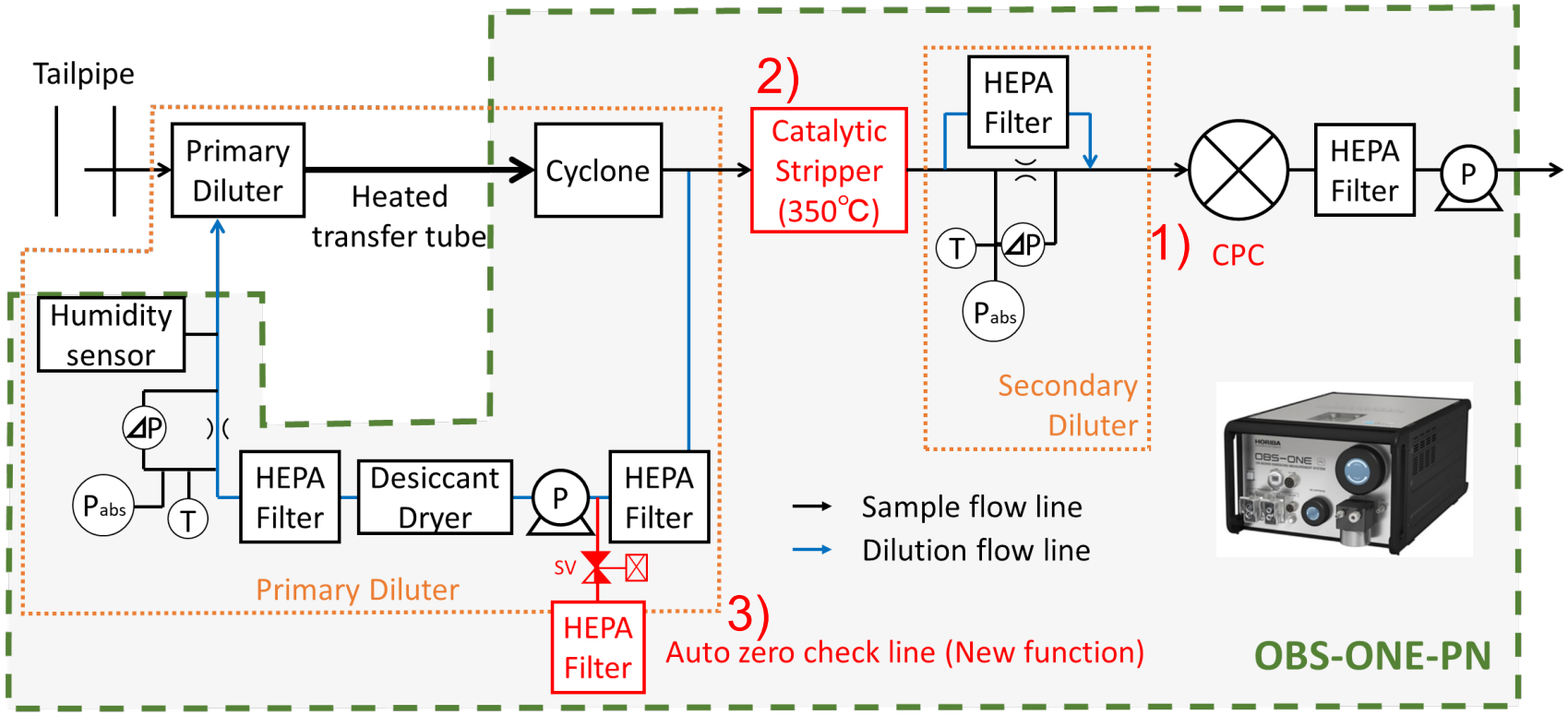
Improvements on OBS-ONE-PN10

- **Adjusted particle counter, re-design of piping & flow**

  1) Expansion to 10 nm by the temperature change inside the detector (CPC)

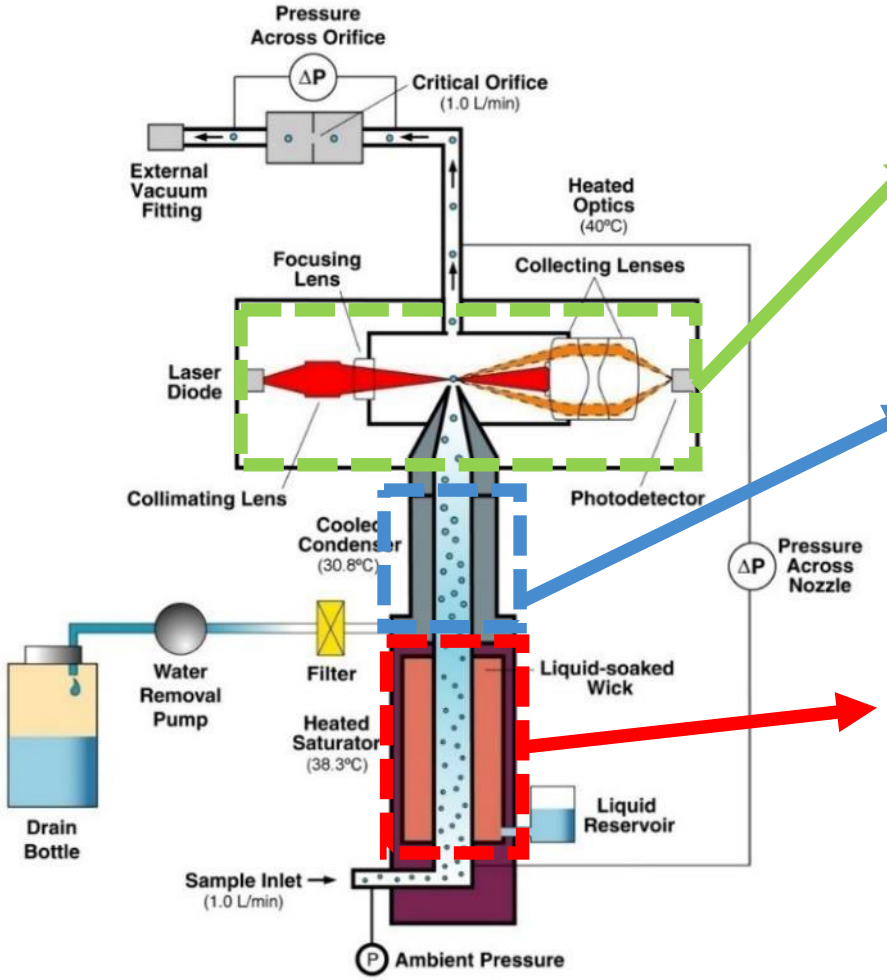
  2) Particle loss reduction and high volatile particle removal efficiency by optimizing the flow / oxidation catalyst (HCS)

  3) Add automated Zero check *Patent pending



PNC：Particle Number Counter

CPC：Condensation Particle Counter

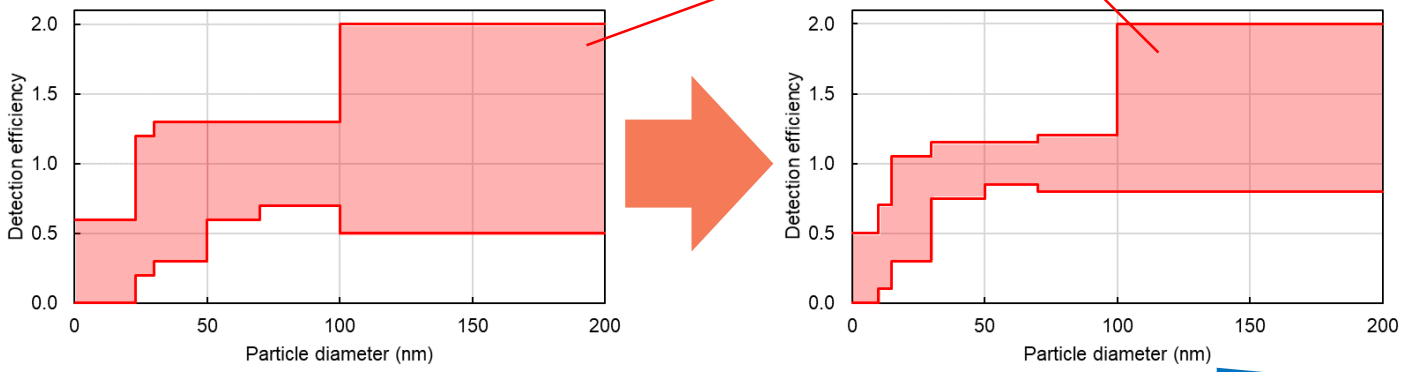


- **Optics**
  - ✓ Laser light is applied to solid particles to detect scattered light
  - ✓ Minimum detectable particle size depends on butanol saturation
- **Cooled Condenser**
  - ✓ Alcohol condenses into particles by cooling (30.5 to 31.5 degC) to supersaturate.
  - ✓ Particles become nuclei and grow to about 10um
- **Heated Saturator**
  - ✓ Heat butanol (38-39 degC) to saturate
  - ✓ Particles and alcohol vapor mixed

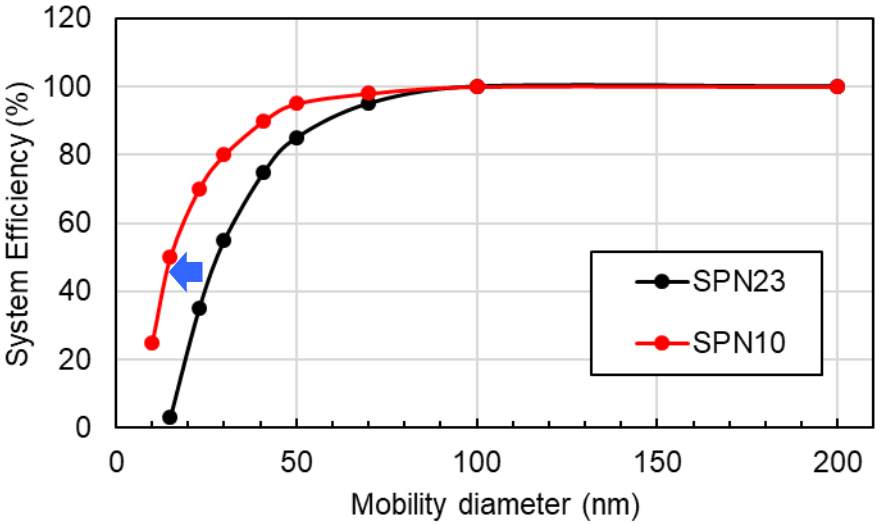
PMP SPN_{10} Draft requirements

Major changes from SPN_{23}

System detection efficiency



SPN_{23} SPN_{10}



Expansion of system detection lower limit (23nm → 10nm)

Trade-off

Volatile particle removal efficiency

SPN_{23}: > 99%

> 50 nm polydisperse alkane or emery oil at > 1 mg/m³

SPN_{10}: 99.9%

> 50 nm polydisperse tetracontane at > 1 mg/m³

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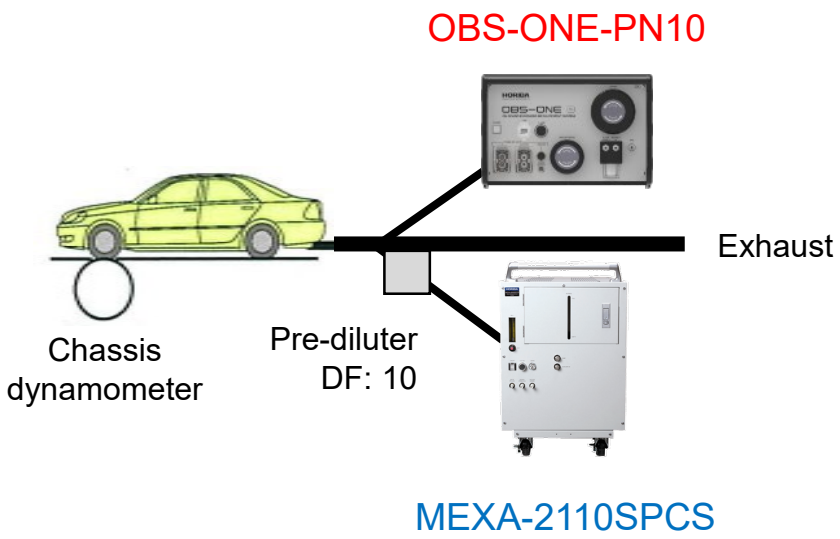
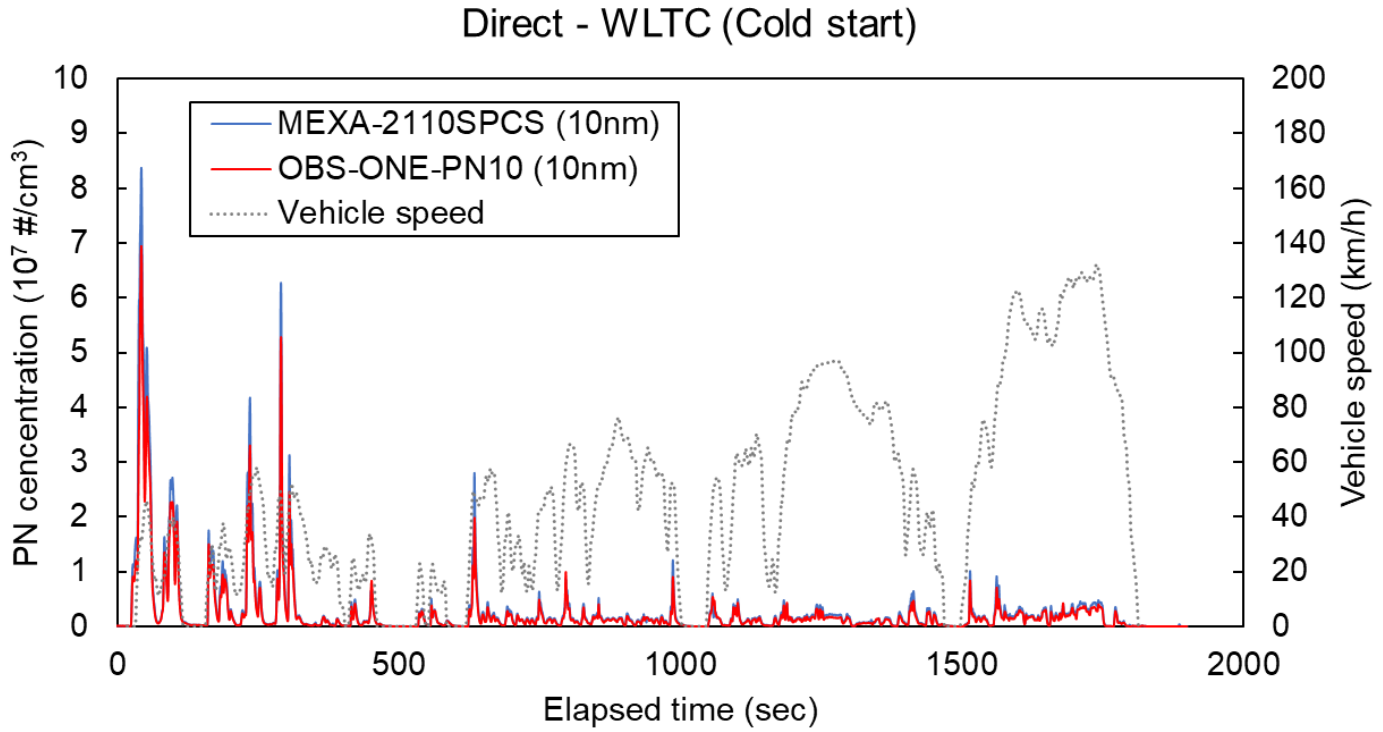
Performance (Gasoline Direct injection turbo)

Comparison between MEXA-2110SPCS (10nm)





OBS vs Reference (Lab. type SPCS): -18.2%

Patent pending

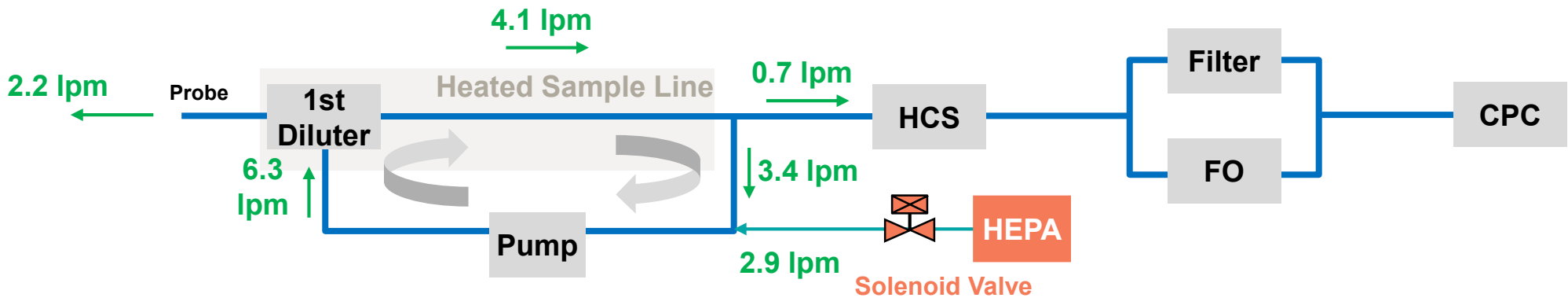
Auto Zero check function

Bult-in HEPA filter on primary diluter line

- Intake air from HEPA filter & exhaust from sampling prove
- Zero check after the primary diluter

Improved testing efficiency

- Easy installation & improved reliability and safety
- Time saving （No need to remove the sampling prove when checking）



1	Background
2	N_2O & NH_3
3	SPN_{10}
4	Summary

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Summary

NH_3, N_2O, SPN_{10}

- OBS-ONE-XL(NH_3, N_2O)
  - Supports NH_3, N_2O measurement on Real Driving Emission
  - High-precision and high-sensitivity measurement by adopting IRLAM technology
    - Responding to disturbances (environmental changes / vibration effects) on actual roads

- OBS-ONE-PN10(SPN_{10})
  - ✓ Support SPN10 measurement by expanding the existing system detection lower limit
  - ✓ Supporting Auto Zero check function(Patent pending)

More info:
https://www.horiba.com/en_en/irlam/

IRLAM by HORIBA

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Thank you

Cảm ơn

감사합니다

ありがとうございました

Dziękuję

धन्यवाद

Grazie

Merci

谢谢

நன்றி

ขอบคุณครับ

Gracias

Obrigado

Σας ευχαριστούμε

Děkuji

Teşekkürler

شكرا

Tack ska ni ha

Danke

Большое спасибо

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