Advanced Portable Emissions Measurement System for New Measurement Components

~ NH_3, N_2O & SPN_{10} ~

18th March 2022

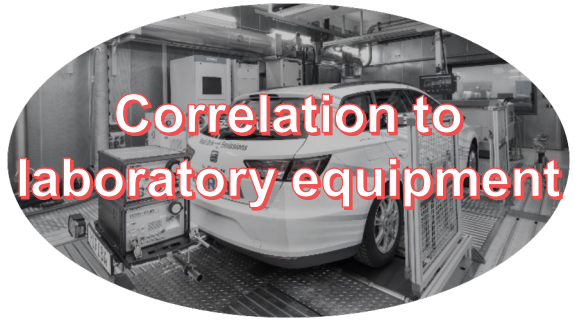
HORIBA, Ltd., Shun FUKAMI

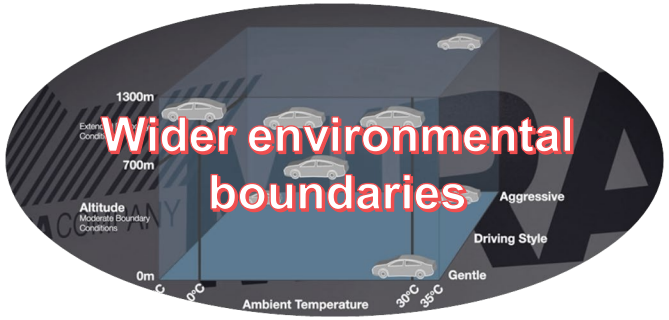
HORIBA Automotive

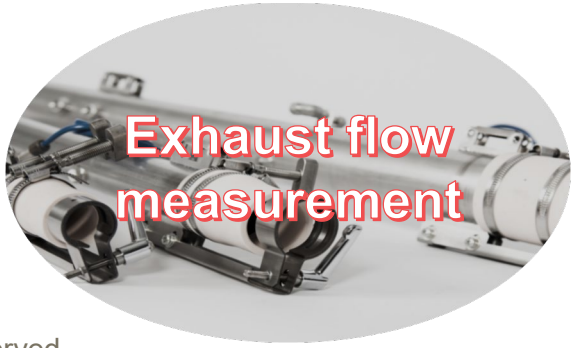
HORIBA Automotive

HORIBA Automotive

Challenges on RDE







HORIBA
Automotive

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

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”?

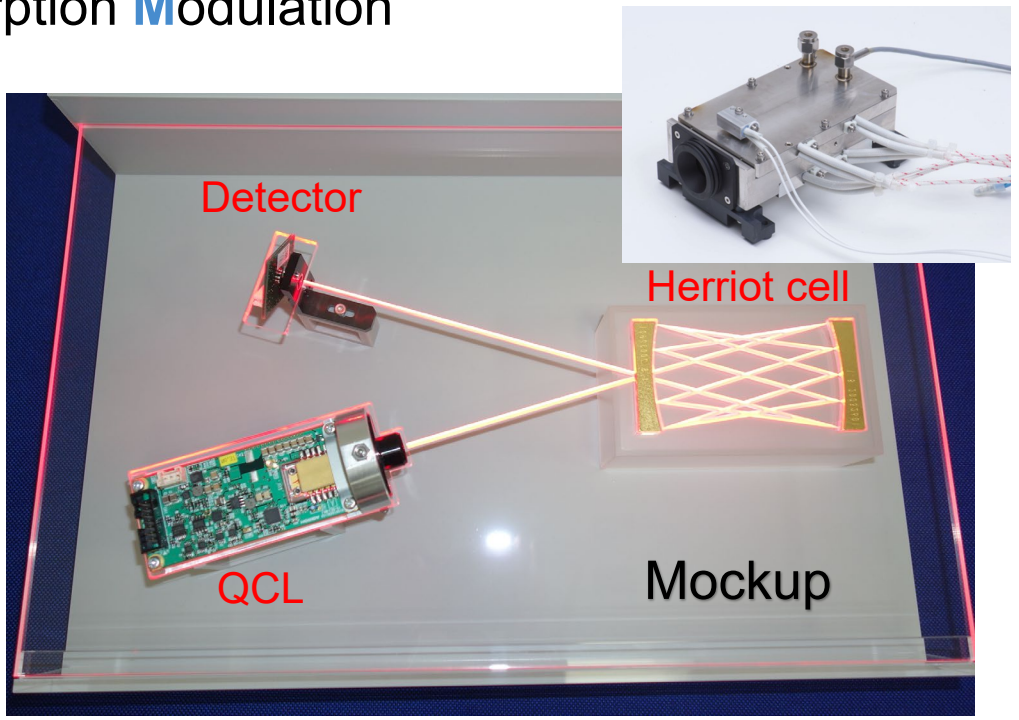
Newly developed gas analysis technology by HORIBA

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



HORIBA Automotive

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

HORIBA Automotive

Performance

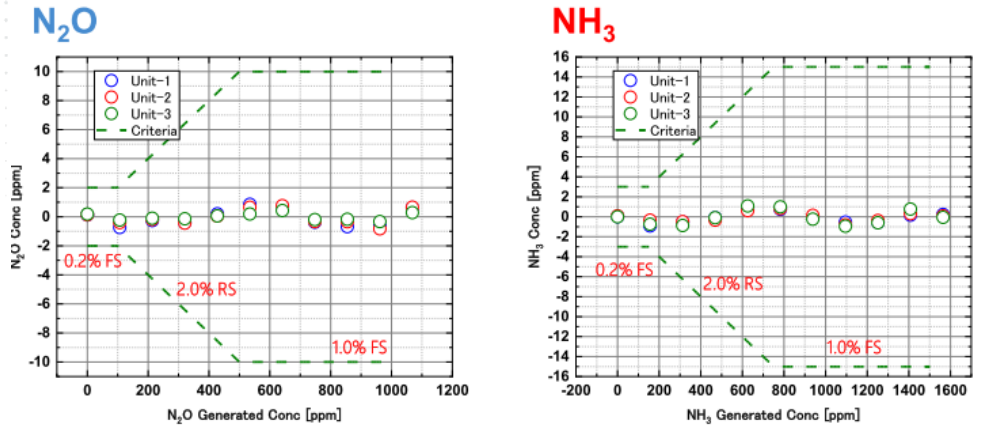
Accuracy & Response time

- 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

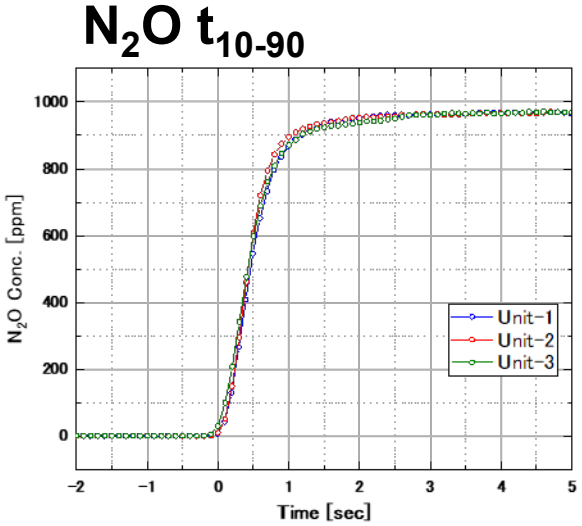


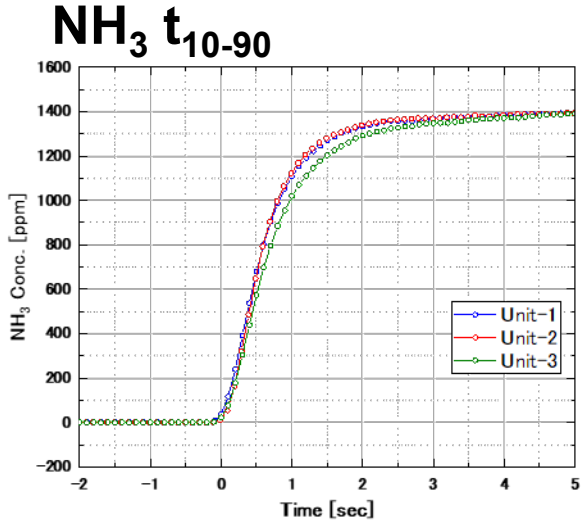
- Response time (Meas. line)

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

at 6m heated tube

Fast response





HORIBA Automotive

Performance

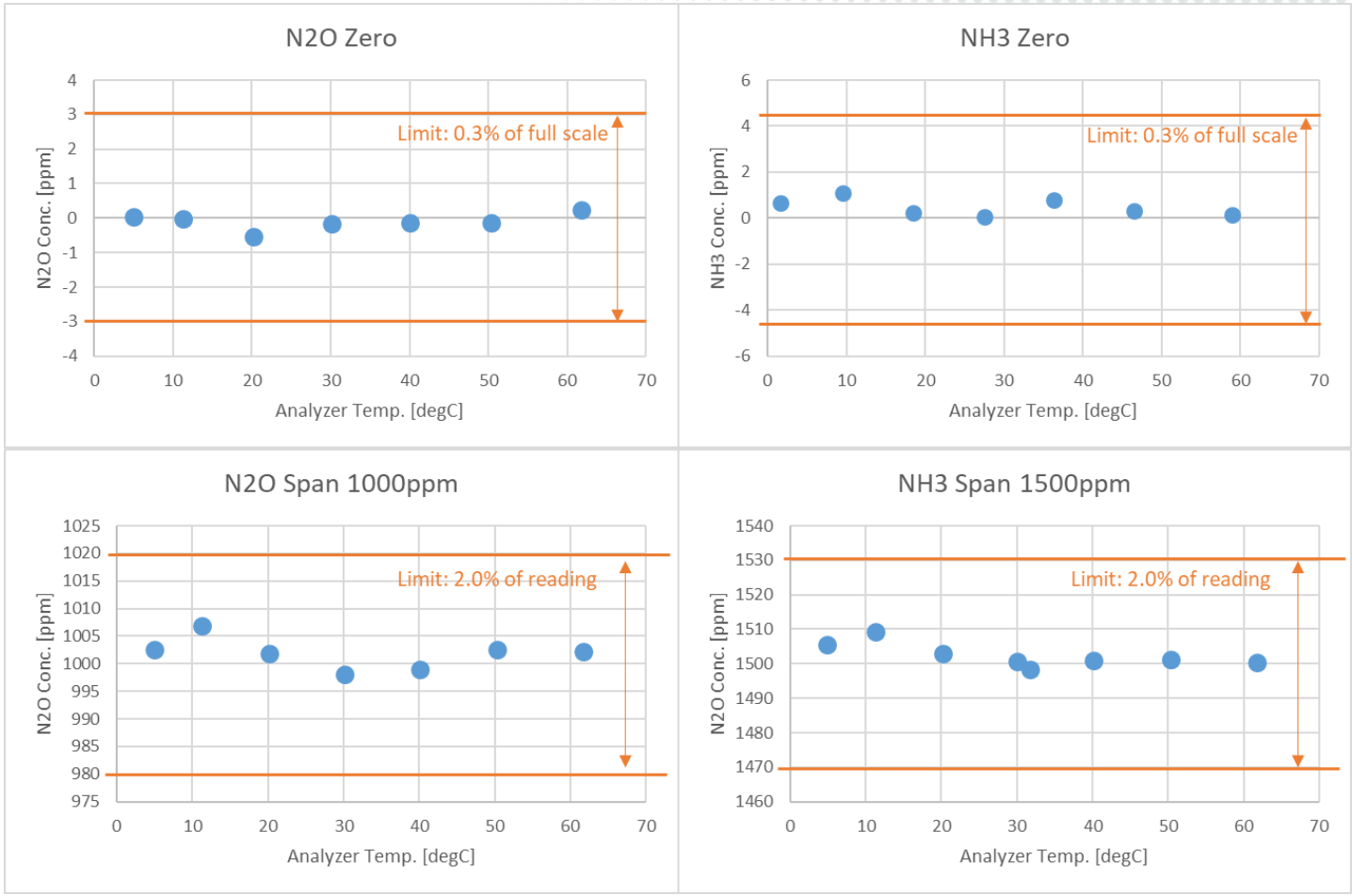
Temperature

- 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)

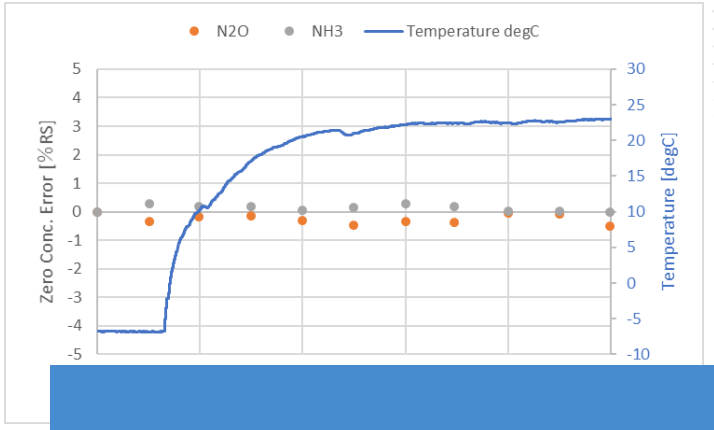
HORIBA Automotive

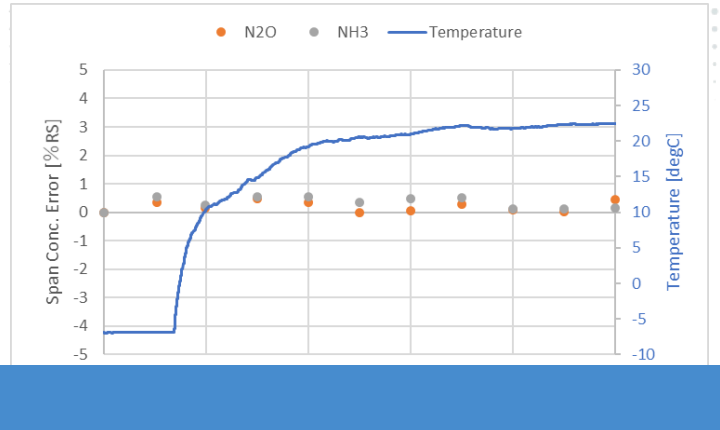
Performance

Transient temperature (Low⇒Ordinary & High⇒Ordinary)

- Temperature [-10 ⇒ 20 degC]

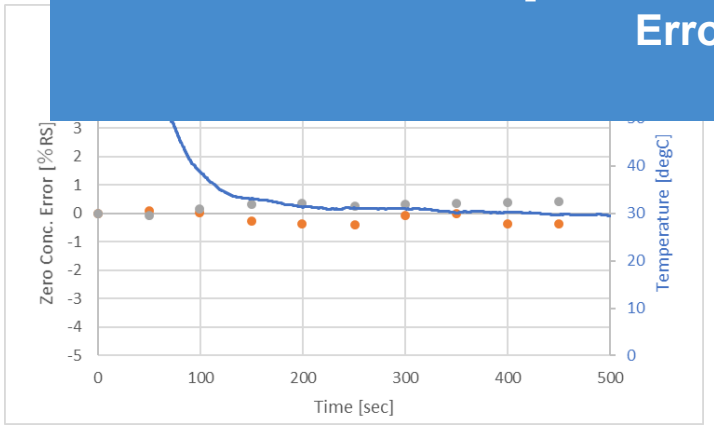
Span
N2O: 1000ppm
NH3: 1500ppm

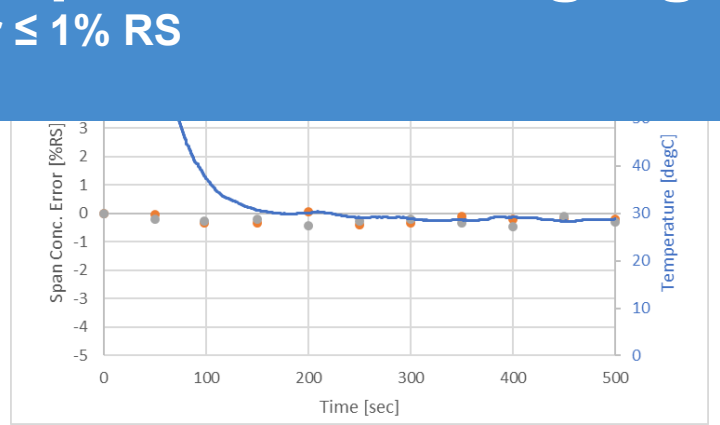




- Temperature [50 ⇒ 20 degC]

Span
N2O: 1000ppm
NH3: 1500ppm





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

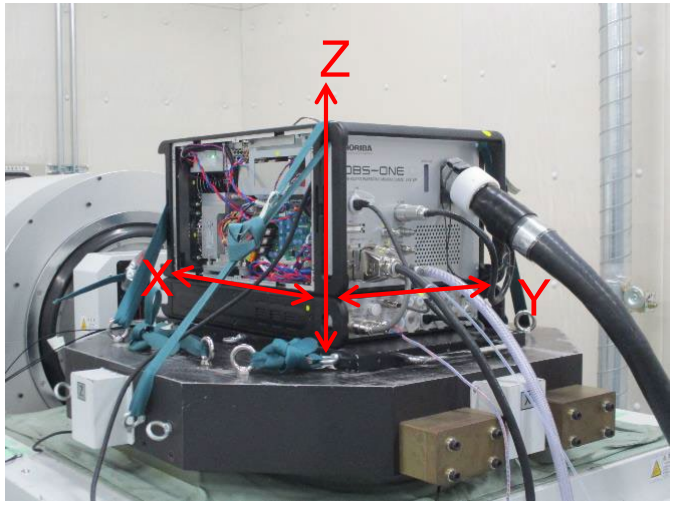
HORIBA Automotive

Performance

Vibration

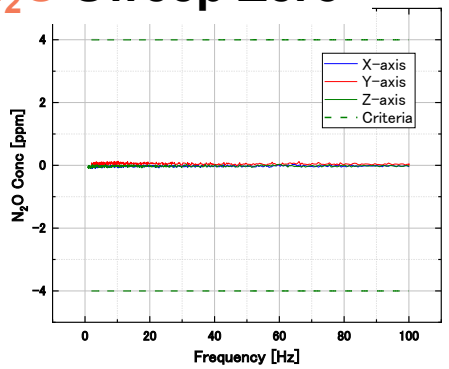
■ Profile

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

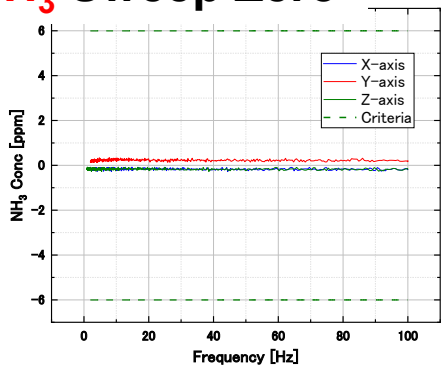


No issue by any vibration

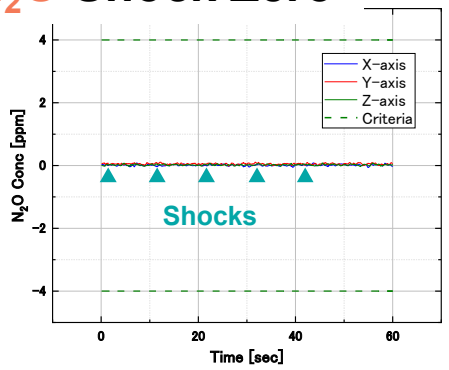
N_2O Sweep Zero



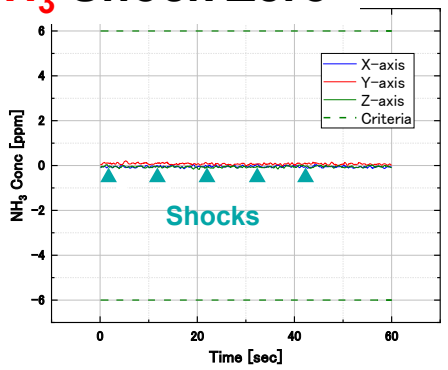
NH_3 Sweep Zero



N_2O Shock Zero



NH_3 Shock Zero

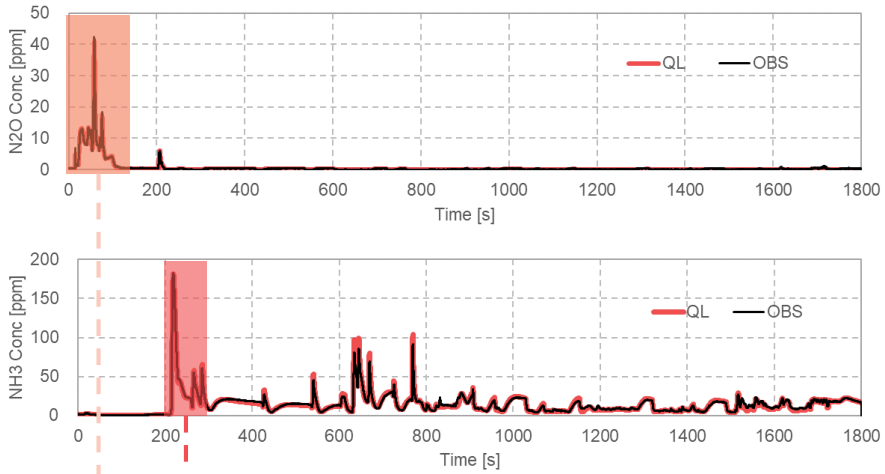


HORIBA Automotive

Performance

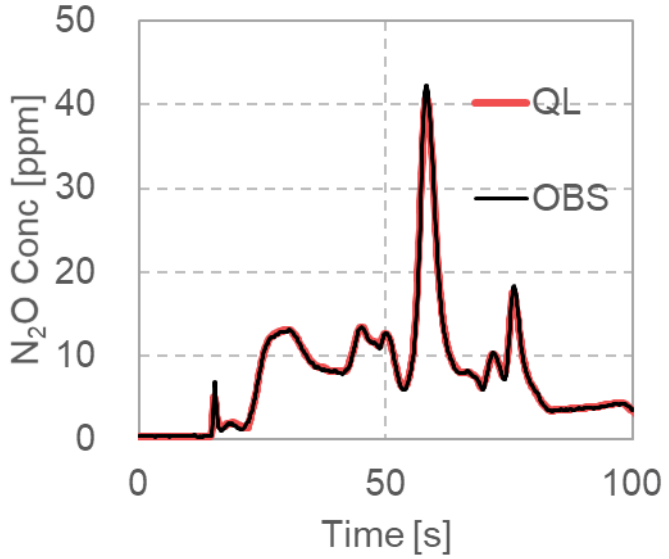
Comparison with MEXA

- 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

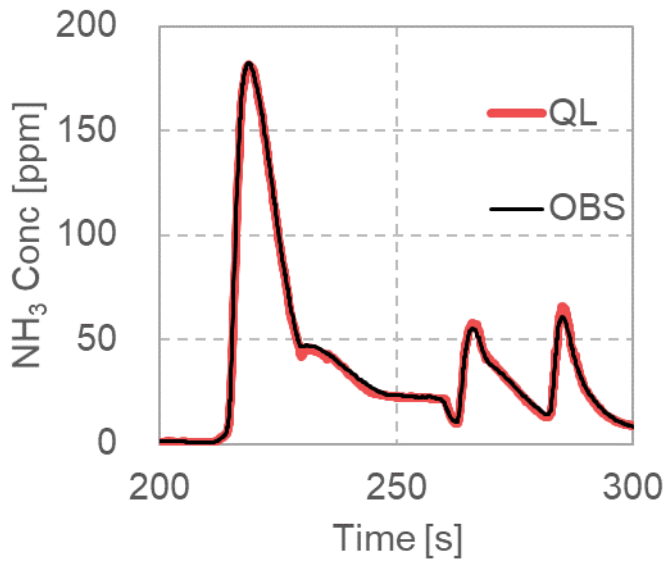


Enlarged peak

N_2O



NH_3



Very good Correlation with stationary type analyzer

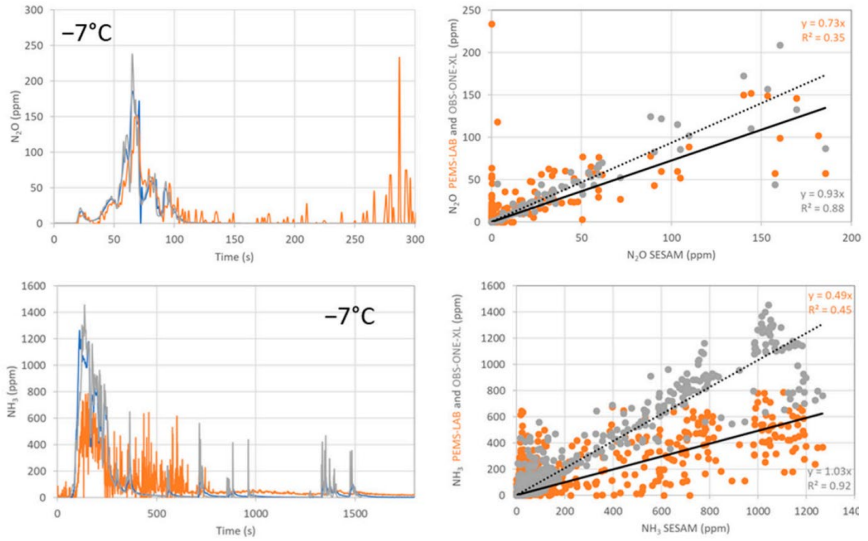
HORIBA Automotive

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

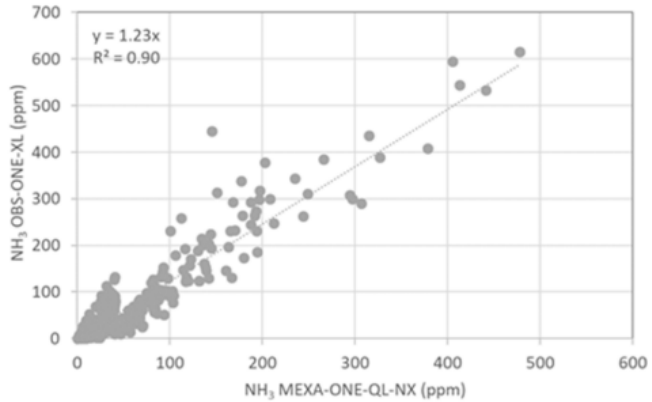


Gray: OBS

Orange: Other manufacture's FTIR-PEMS

Stable measurement even in a -7 ° C environment

Comparison of QL-NX and OBS-ONE-XL



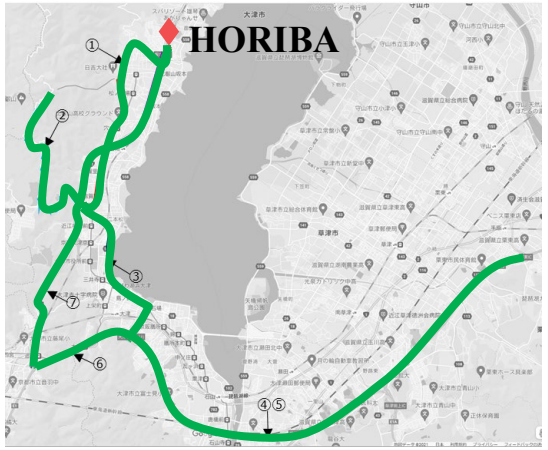
On the road, the correlation of the N_2O concentrations measured by the two on-board systems, OBS-ONE-XL and PEMS-LAB, was good, with an R^2 = 0.95 obtained. In the case of the NH_3 emissions, the OBS-ONE-XL showed a more accurate performance, with sharper, better defined peaks, and less tailing effects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

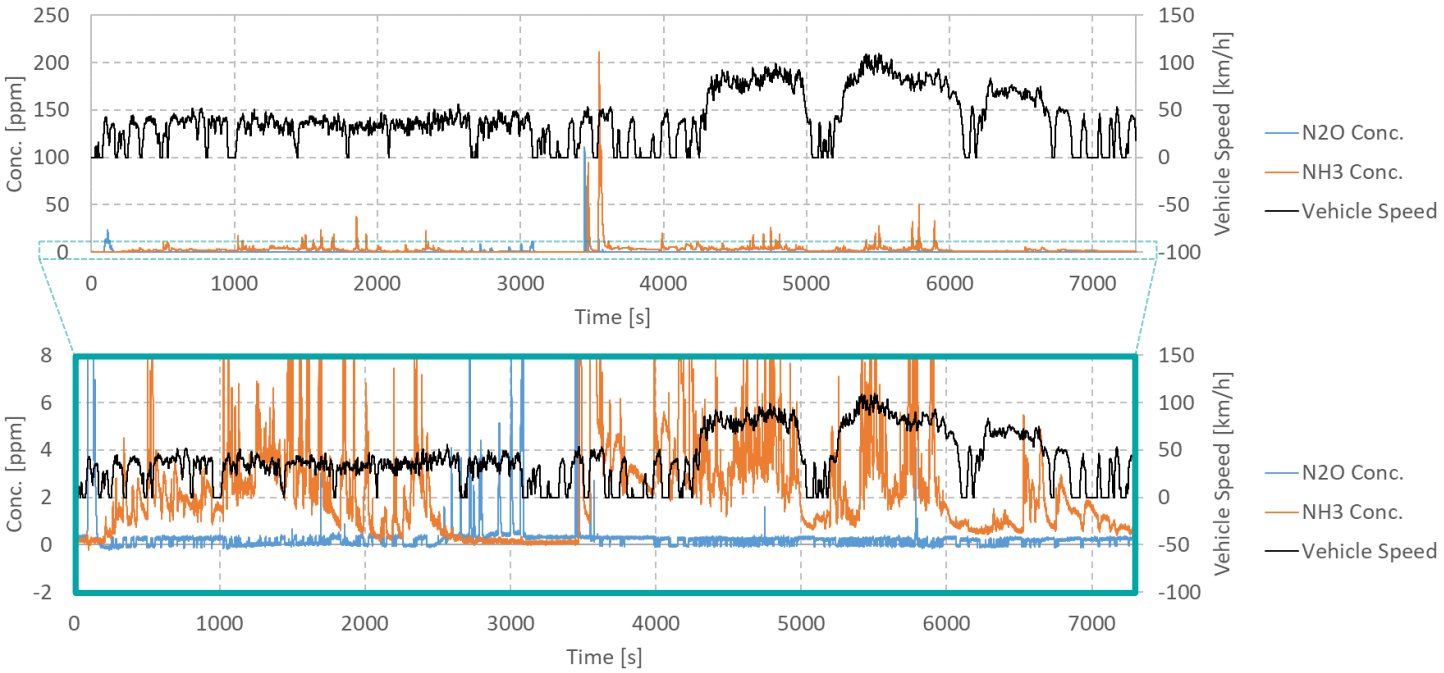
Performance

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%

HORIBA Automotive

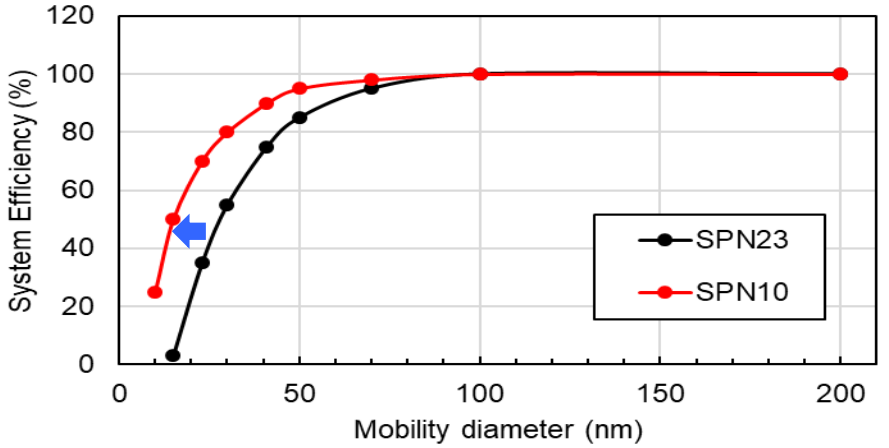
1	Background
2	N_2O & NH_3
3	SPN_{10}
4	Summary

HORIBA Automotive

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

HORIBA Automotive

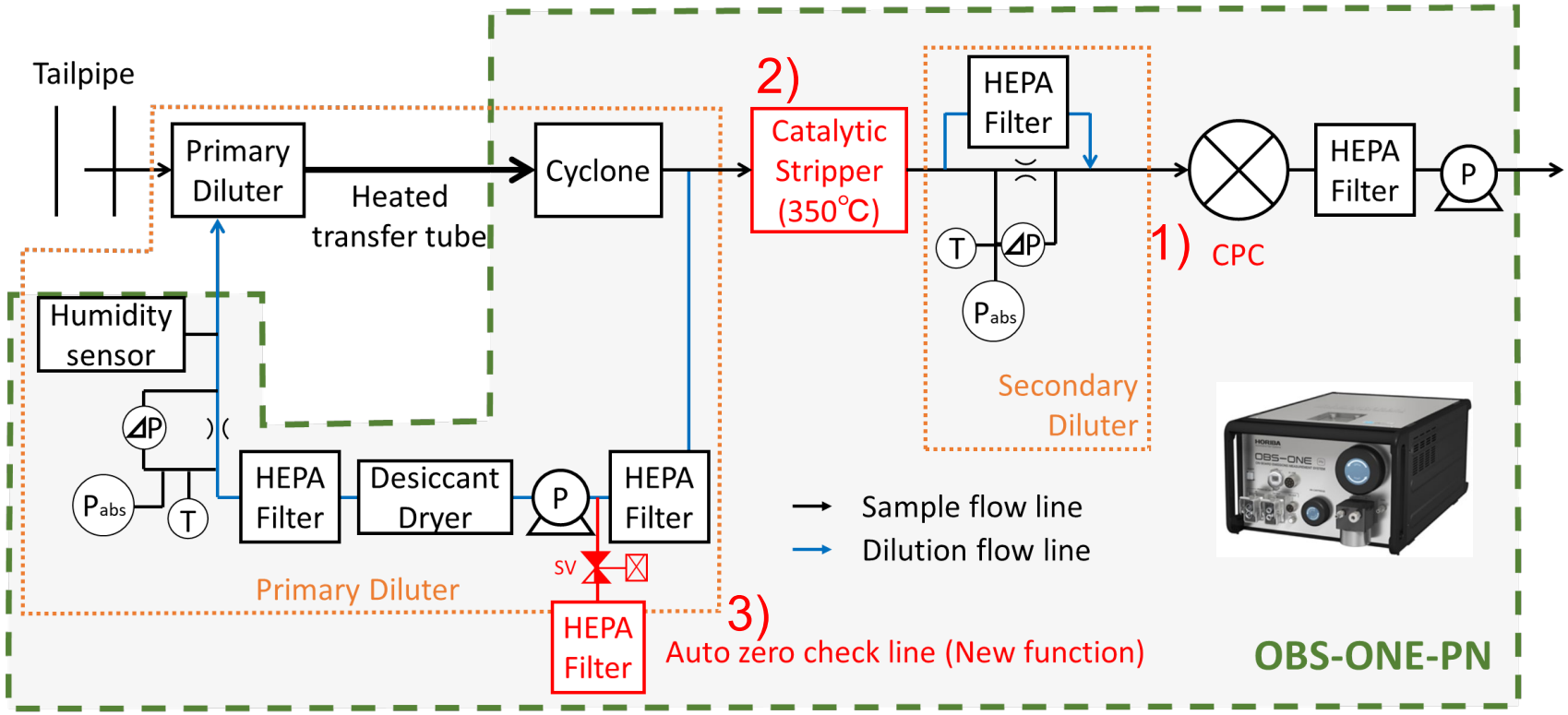
Improvements on OBS-ONE-PN10

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

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

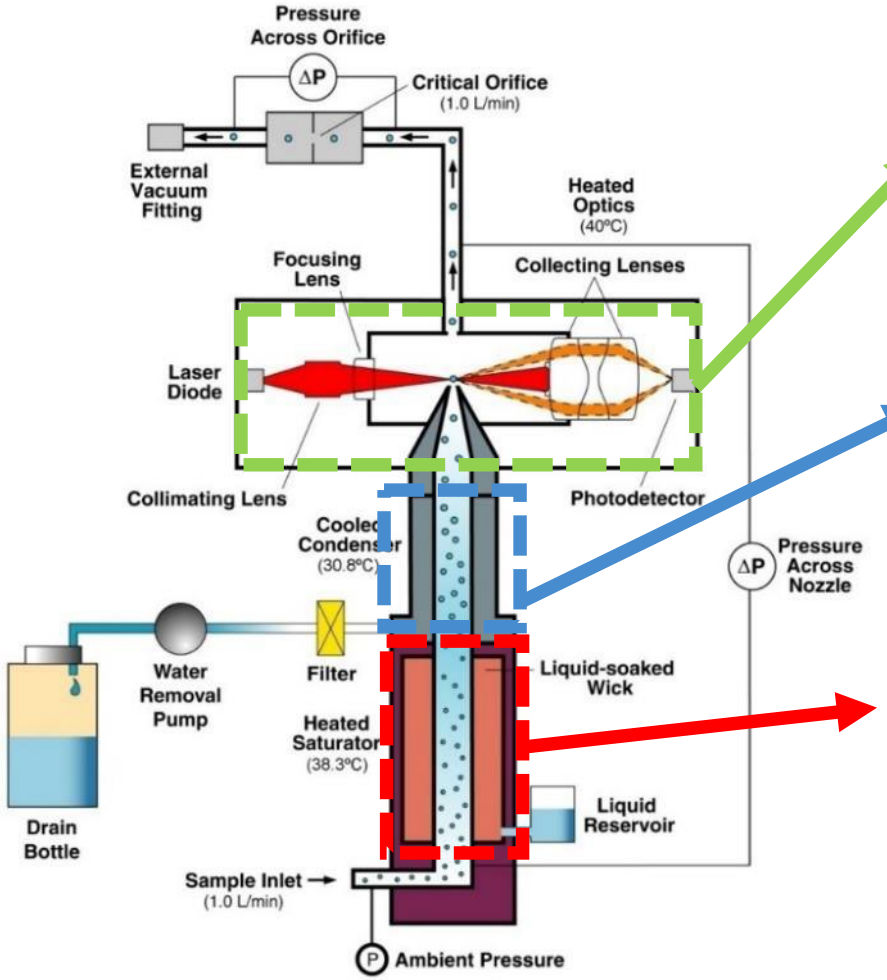
  2) Particle loss reduction and high volatile particle removal efficiency by optimizing the flow / oxidation catalyst (HCS)

  3) Add automated Zero check *Patent pending



PNC：Particle Number Counter

CPC：Condensation Particle Counter

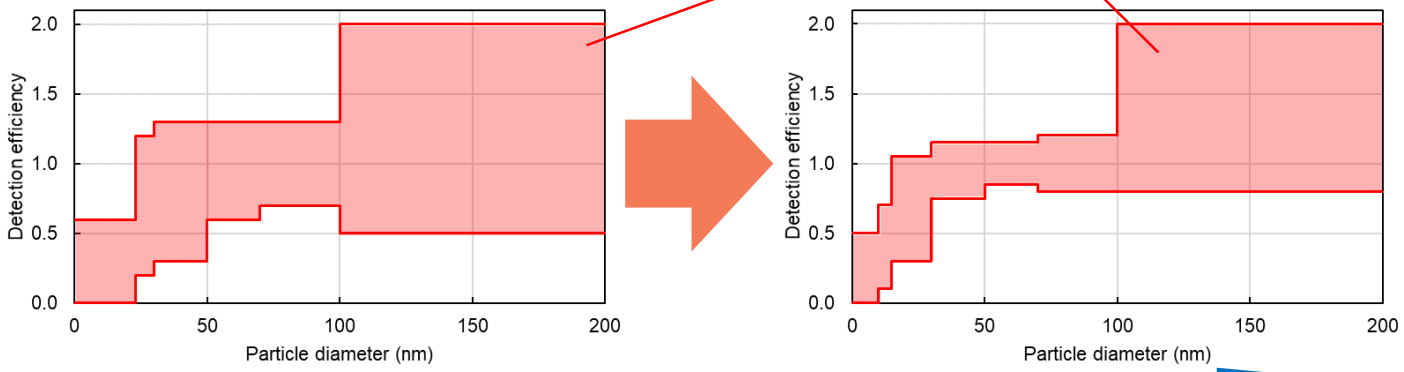


- **Optics**
  - ✓ Laser light is applied to solid particles to detect scattered light
  - ✓ Minimum detectable particle size depends on butanol saturation
- **Cooled Condenser**
  - ✓ Alcohol condenses into particles by cooling (30.5 to 31.5 degC) to supersaturate.
  - ✓ Particles become nuclei and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

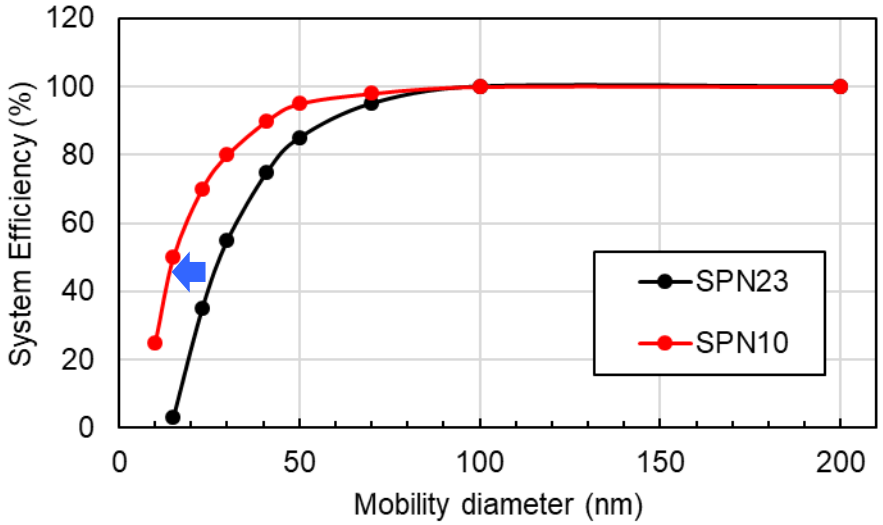
PMP SPN_{10} Draft requirements

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

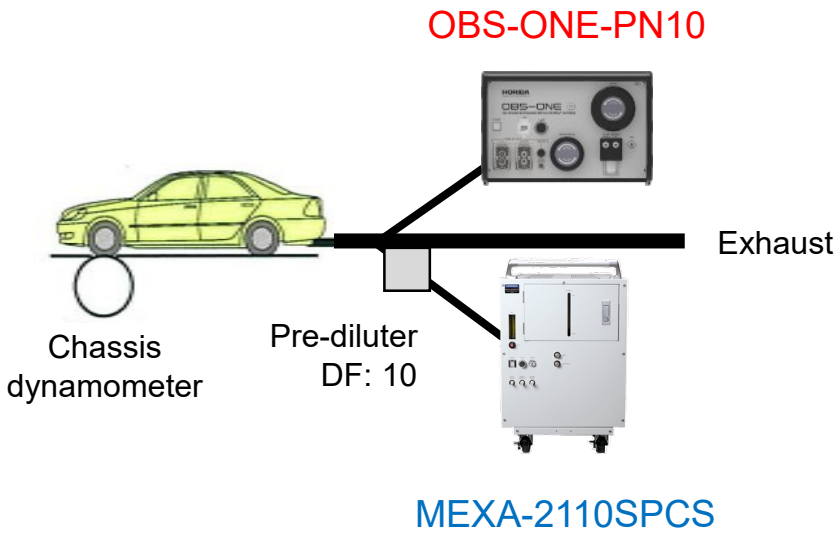
SPN_{10}: 99.9%

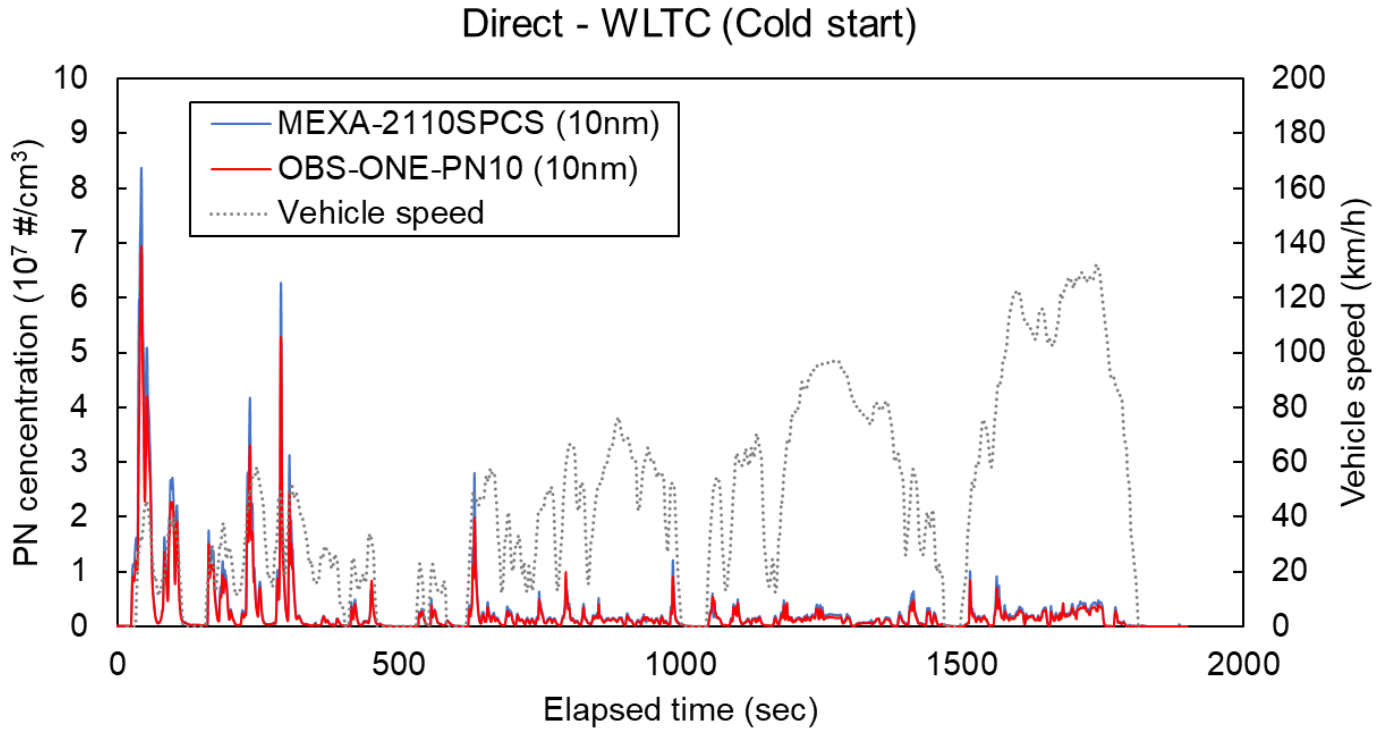
> 50 nm polydisperse tetracontane at > 1 mg/m³

HORIBA Automotive

Performance (Gasoline Direct injection turbo)

Comparison between MEXA-2110SPCS (10nm)





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

Patent pending

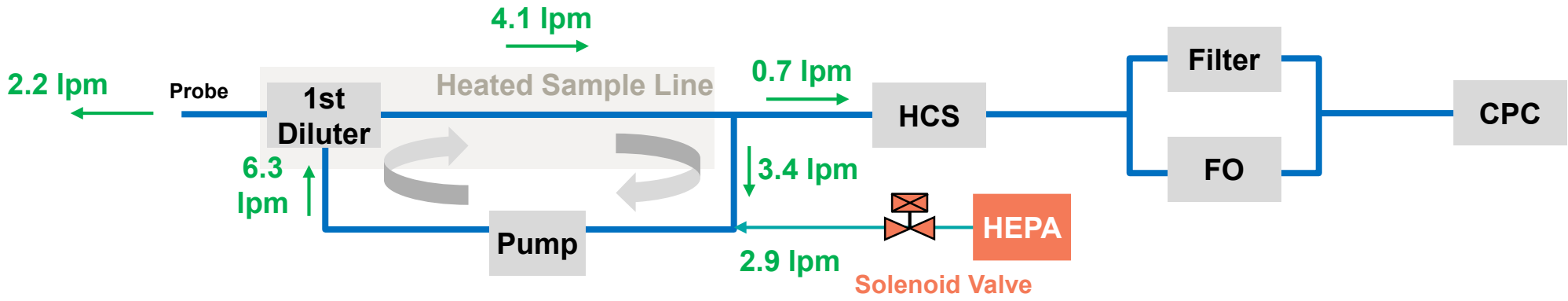
Auto Zero check function

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

HORIBA Automotive

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

HORIBA Automotive

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

HORIBA
Automotive