HORIBA
Automotive Test Systems

European Automotive Congress
EAEC-ESFA 2015

University "Politehnica" of Bucharest

NEW TECHNOLOGIES FOR HIGH ACCURATE EXHAUST MEASUREMENT

Ernst Kargl

November 27th, 2015

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HORIBA Business Segments

HORIBA
Automotive Test Systems

ATS Automotive Test Systems

From Emission measurement, Driveline testing, virtual Battery simulation, Test Automation Systems, Wind Tunnel Balances and Brake Testing systems, we offer total solutions that are indispensable for overall Vehicle development.

Process & Environmental

Air, water, soil. HORIBA contributes to global environmental safety with measurement technology that complies with environmental regulations throughout the world.

Scientific

HORIBA's analytical and measurement equipment offers broad-ranging support for R&D and quality control in every kind of industry and is contributing to pioneering scientific research such as micro analysis at the nano level.

Medical

From the medical frontline (Point of Care Treatment) to testing centers. HORIBA's hematology analysers and clinical chemistry analysers help to construct the ideal diagnostic system.

Semiconductor

Providing advanced solutions for the control and monitoring of semiconductor manufacturing processes and for quality control inspections of semiconductors and LCD devices.

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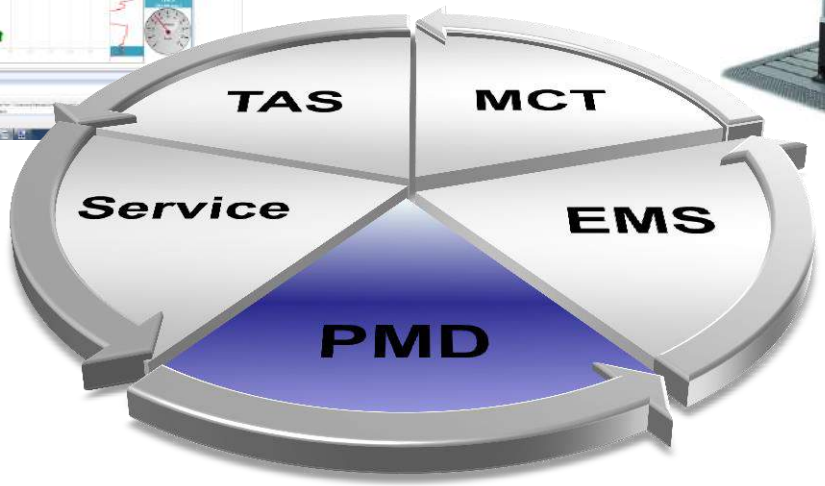
Automotive Test Systems Products and Services

HORIBA
Automotive Test Systems

TAS Test Automation Systems
Automation systems, STARS & VETS

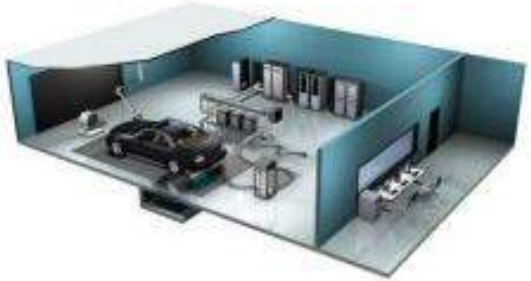
MCT Mechatronic Systems
Engine-, Vehicle-, Driveline Test Systems, Brake and Component Test Stand, Wind Tunnel Balances



Services
Installation, Comissioning, Training, Service & Maintenance

EMS Emission Measurement Systems
Exhaust Measurement Technology

PMD Project Management Department
Project Management & Coordination, Turnkey



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HORIBA In-House-Technologies

HORIBA
Automotive Test Systems

- **A long history of experience and partnership with industry, academia and regulatory bodies.**

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HORIBA In-House-Technologies

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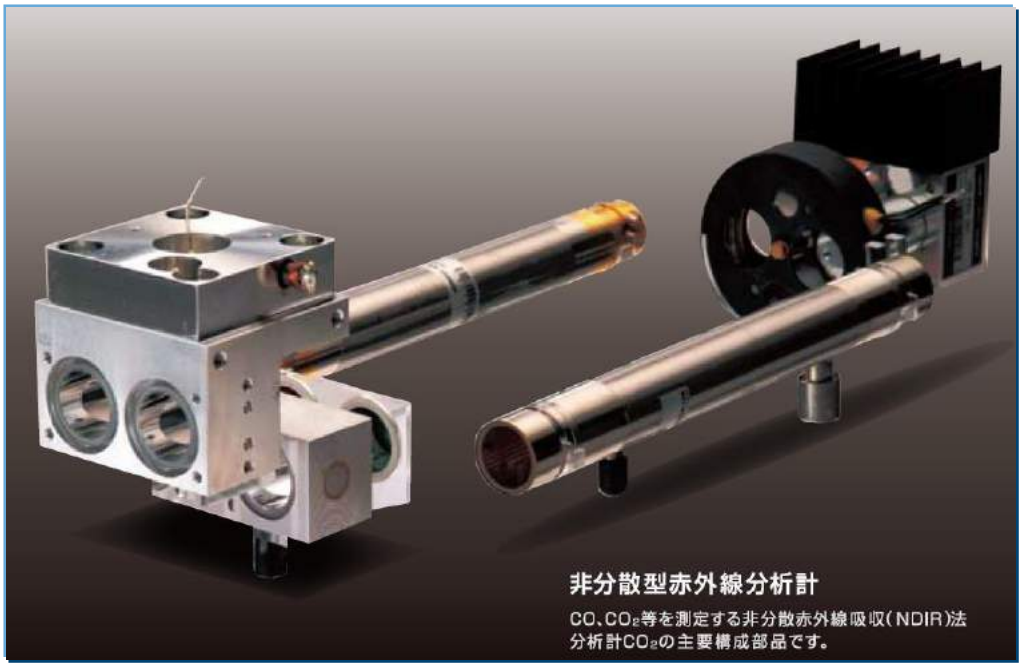
- **All core parts and analyzers are manufactured by HORIBA.**
  - Quality, Know-How, Availability, Service, Flexibility



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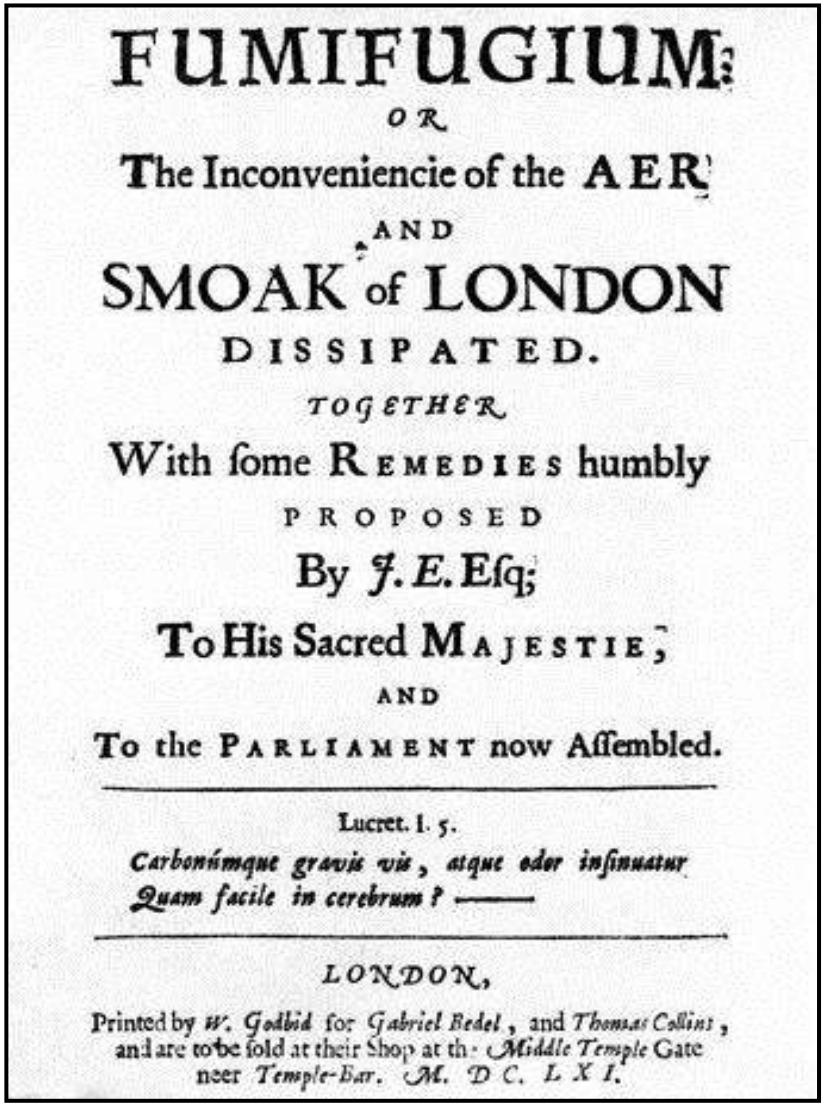
First Exhaust Regulation from 1661



FUMIFUGIUM:

OR

The Inconveniencie of the AER

AND

SMOAK of LONDON

DISSIPATED.

TOGETHER

With ſome REMEDIES humbly

PROPOSED

By J. E. Eſq;

To His Sacred MAJESTIE,

AND

To the PARLIAMENT now Aſſembled.

Lucret. l. 5.

Carbonúmque gravis vis, atque odor inſinuatur
Quam facile in cerebrum? ——

LONDON,

Printed by W. Godbid for Gabriel Bedel, and Thomas Collins, and are to be ſold at their Shop at th: Middle Temple Gate neer Temple-Bar. M. D C. L X I.

"Till more effectual methods can take place, it would be of great service to oblige all those Trades who make use of larger Fires to carry their Chimnies much higher into the air than they are at present; this expedient would frequently help to convey the Smoak away above the buildings, and in a great measure disperse it into distant parts without its falling on the houses below"

"Workmen should be consulted, and encouraged to make experiments, whether a particular construction of the Chimnies would not assist in conveying off the Smoak, and sending it higher into the air before it is dispersed….and Premiums should be given to those that were successful in it"

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Regulation Situation

- **European vehicle penalty for car makers**
  - When CO_2 fleet emission average of new cars will be exceeded.
- **EURO VI for HDV**
  - Limit value NH_3 = 10 ppm
- **U.S. EPA 40 CFR PART86 subpart B for LDV**
  - Limit value N_2O = 10 mg / mile
- **Real Driving Emissions Legislation**
  - Emission under normal life and conditions of use

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CO_2 Low Emission Measurement

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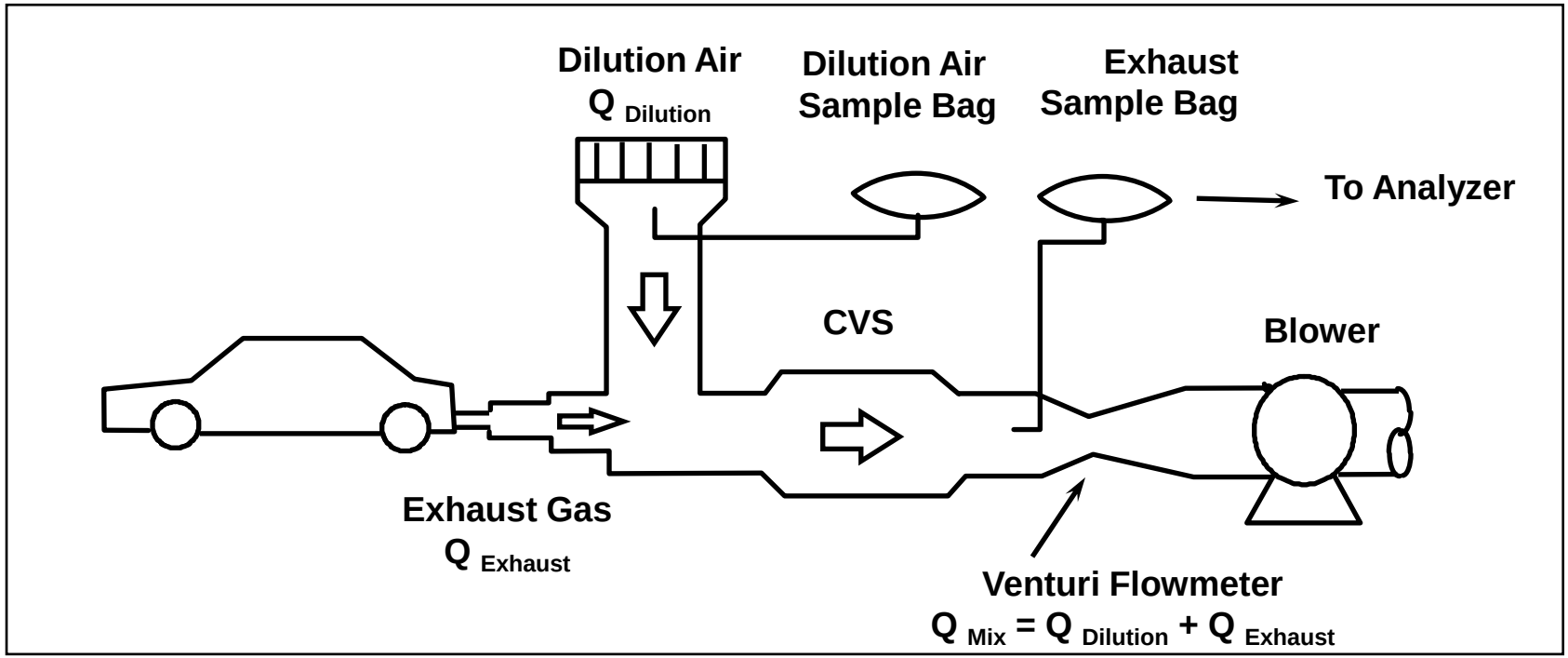
Mass Emission (g) = Gas Concentration (%, ppm) * Gas Density (g/m^3) * Exhaust Volume (m^3)

Gas Concentration = Gas Conc. Exhaust Sample Bag – Gas Conc. Dilution Air Sample Bag



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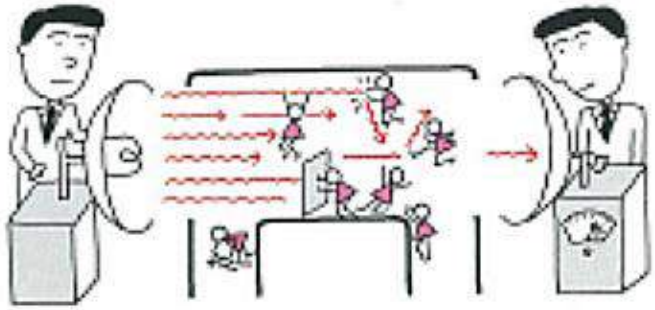
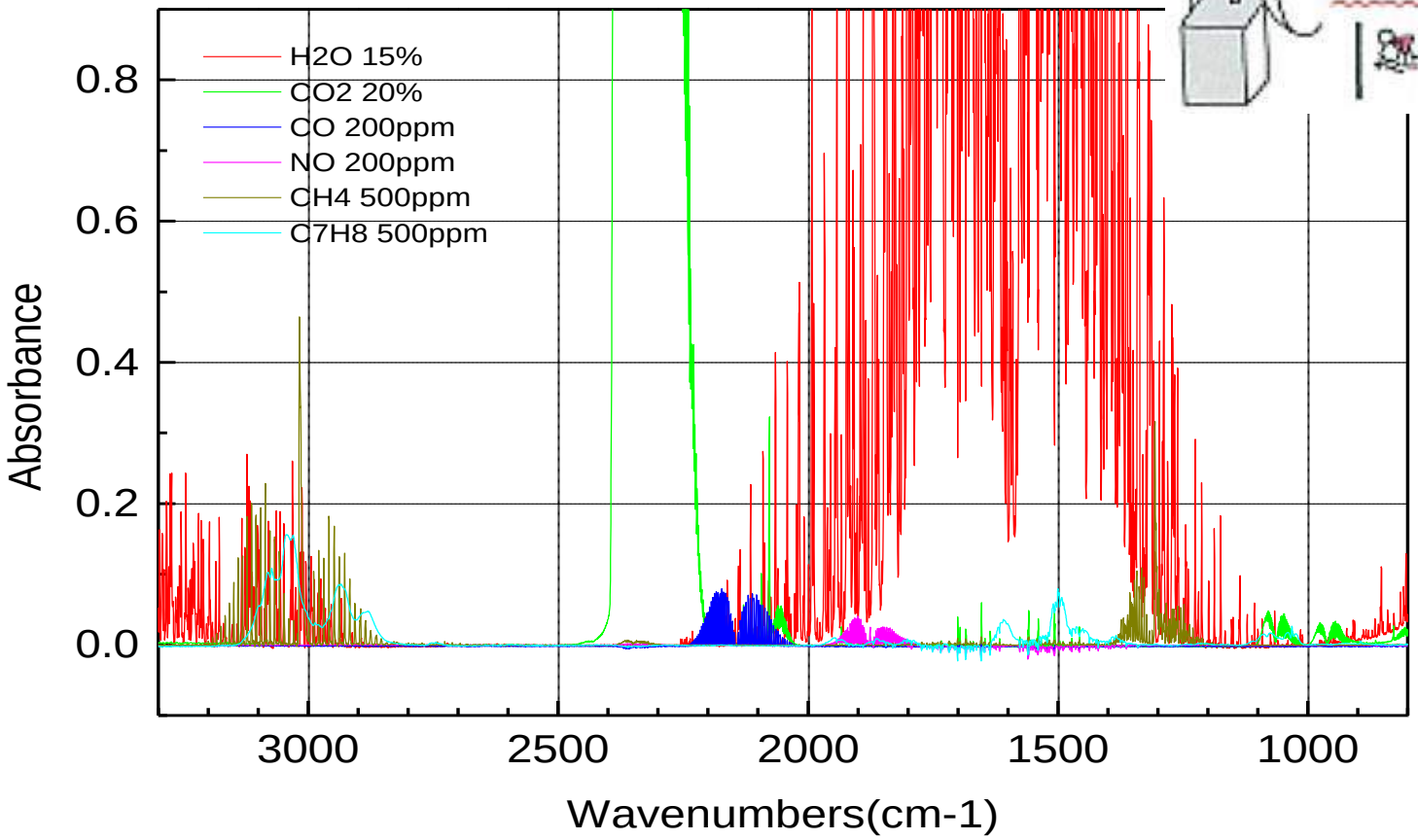
CO_2 Low Emission Measurement

- **NDIR Non-Dispersive Infrared Detector**





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CO_2 Low Emission Measurement

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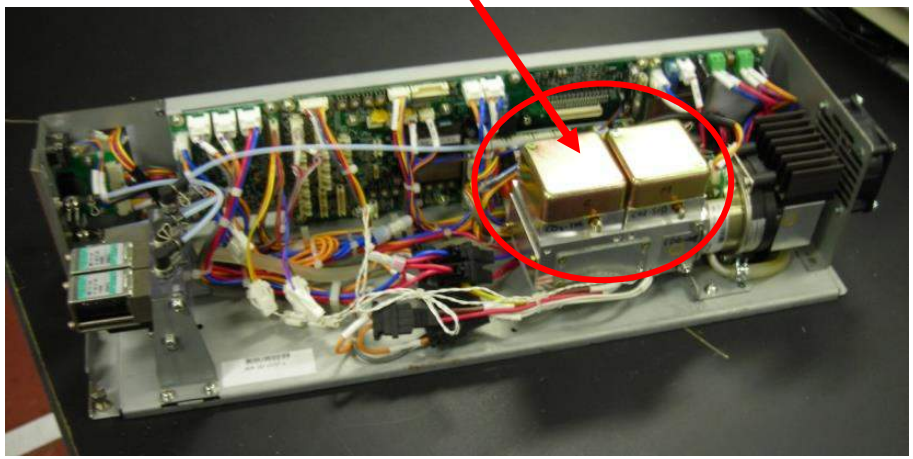
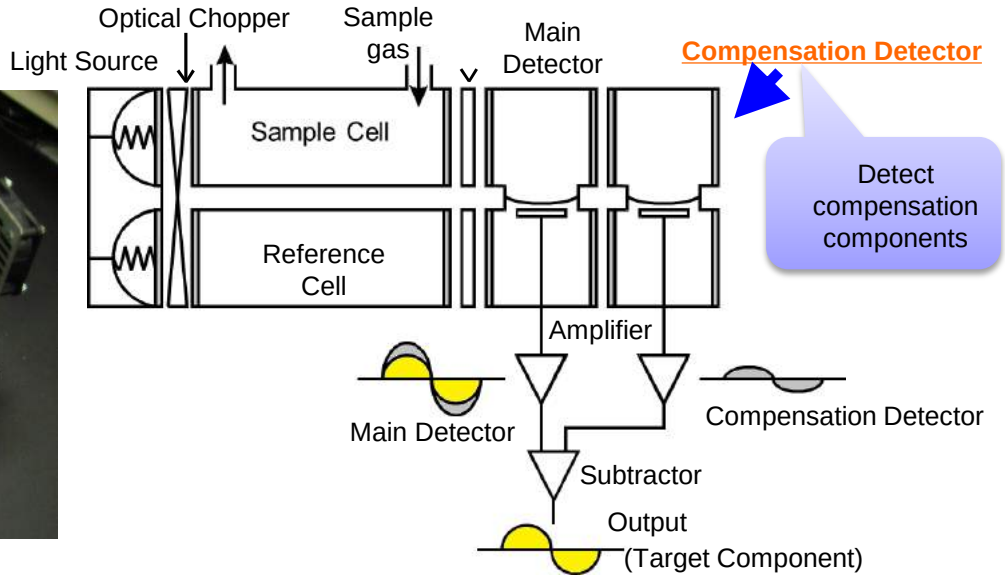
- **Higher accuracy – CO_2(L) Analyzer**
  - Water interference correction with compensation detector
  - No measurement error when different H_2O concentration is in sample- and ambient bag.
  - Measuring ranges: 0 - 1000 ppm to 6 vol%
  - FYI CO_2 ambient concentration: approx. 400 ppm
  - Noise: < 3 ppm

Main + Compensation Detector





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CO_2 Low Emission Measurement

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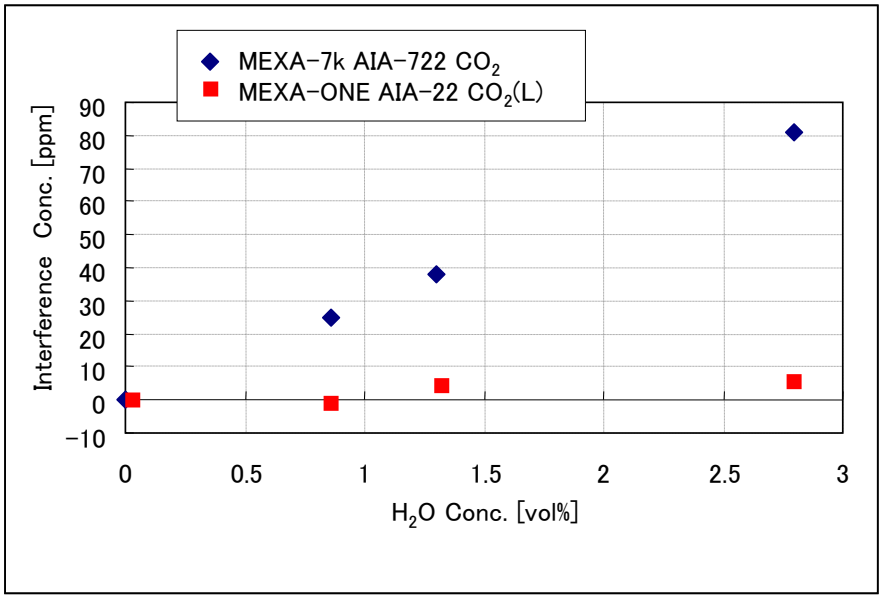
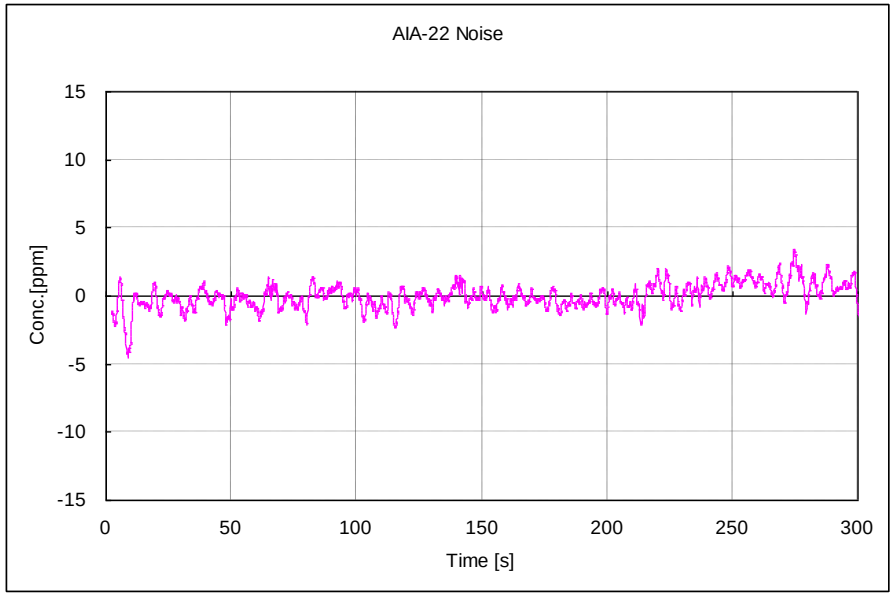
- **Water interference comparison and noise**





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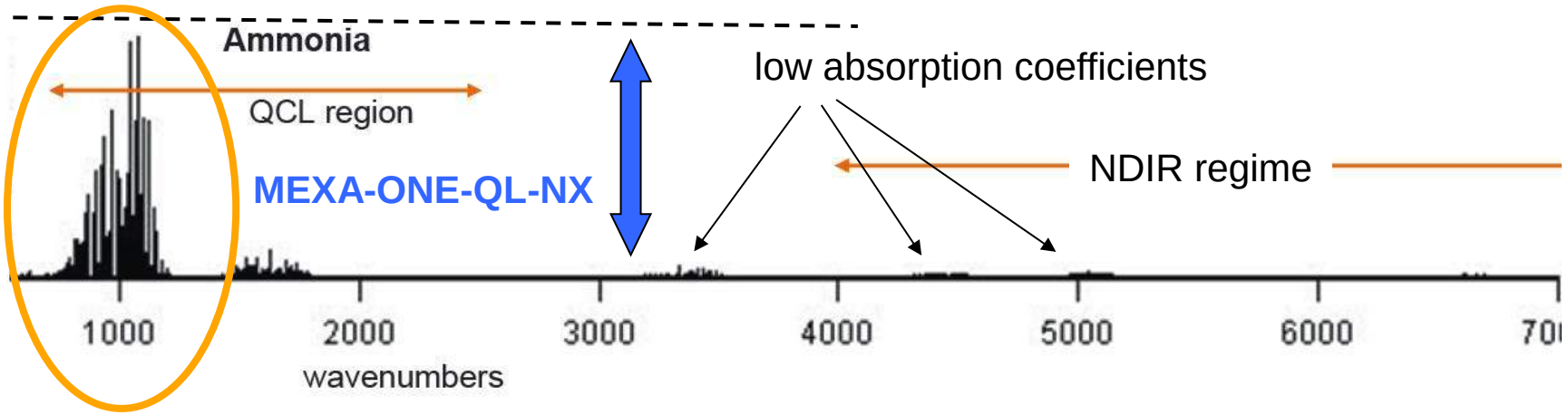
Quantum Cascade Laser Technology

- For NO, NO_2, NH_3, N_2O Measurement
- No operation gases
- Low concentration measurement with high power laser
- High resolution spectrum ⇨ minimum interference from other gases

Very high absorption coefficients



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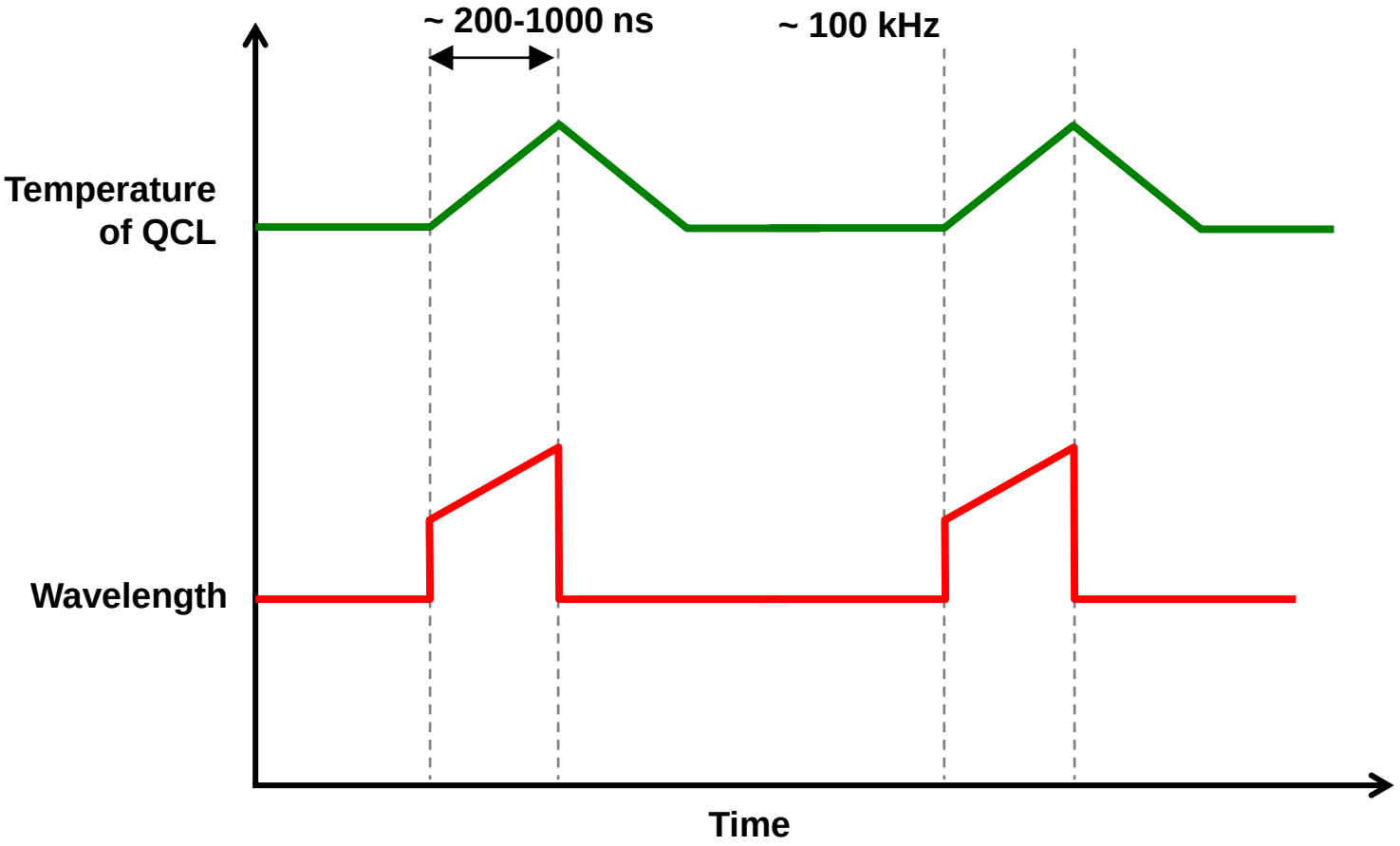
Quantum Cascade Laser Technology



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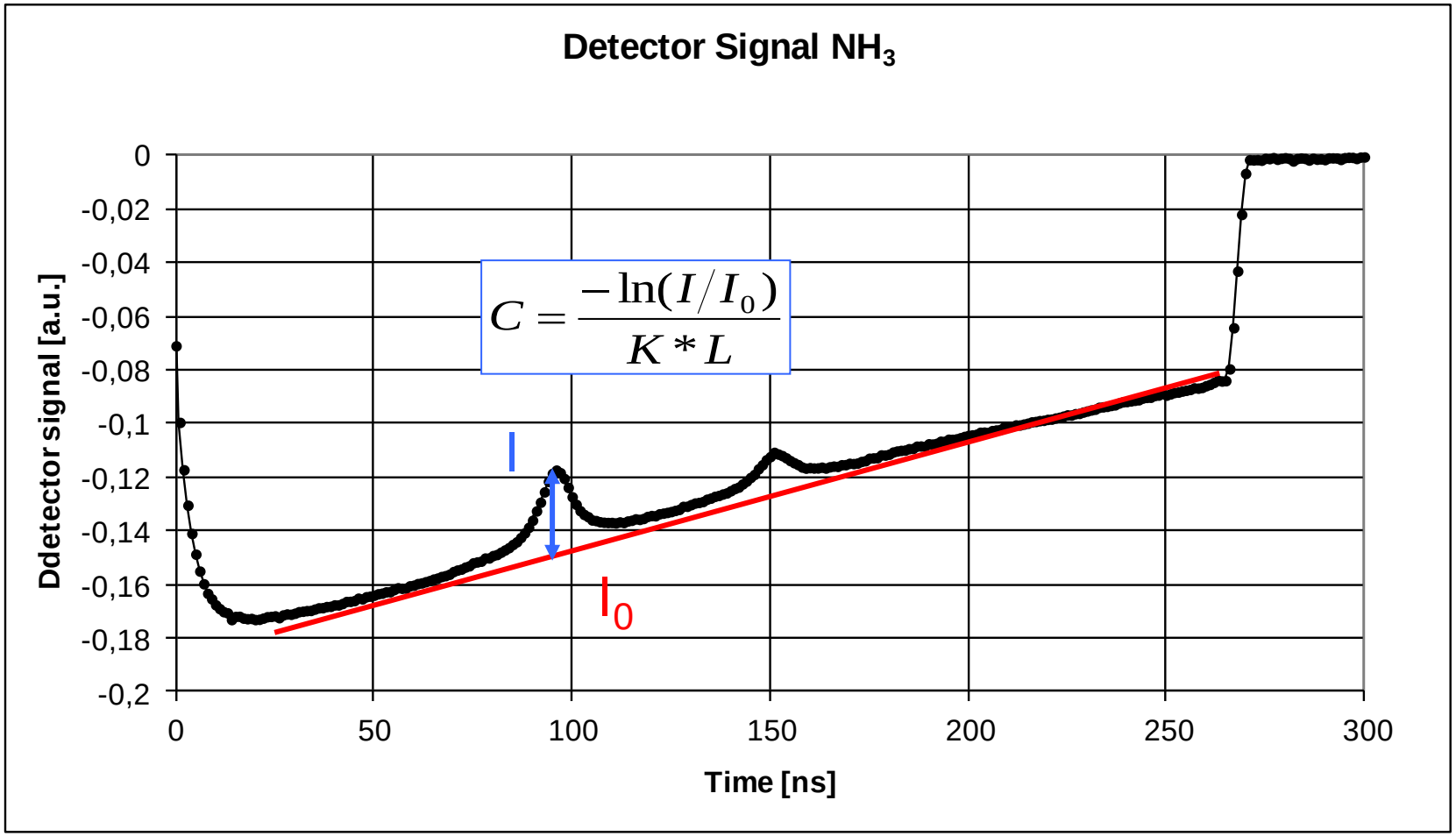
Quantum Cascade Laser Technology



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Quantum Cascade Laser Technology

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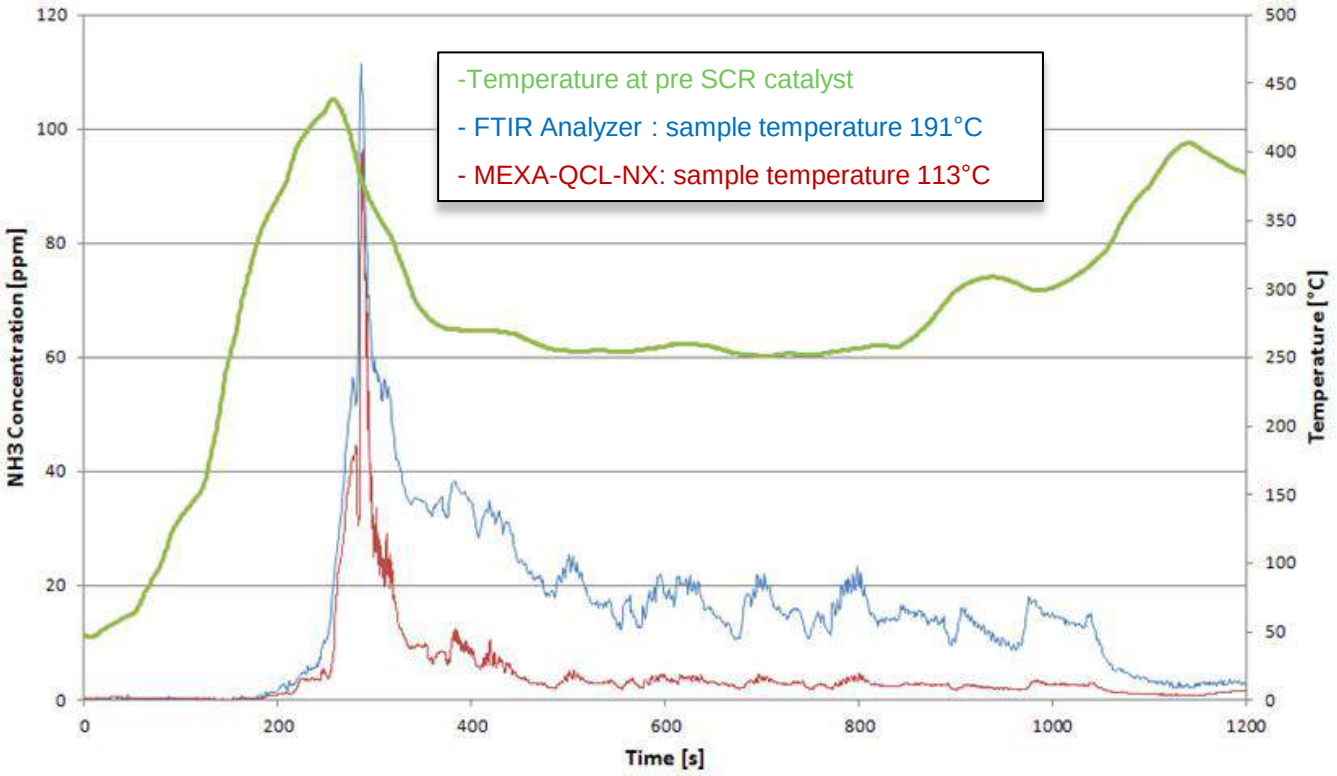
- **Incorrect NH_3 measurement when analyzer sample temp. is >133°C**
  - Comparison measurement with QCL and FTIR at pre SCR catalyst



Sample temperature >133°C: Thermolysis to isocyanic acid and ammonia $(NH_2)2CO \rightarrow NH_3 + HNCO$

Sample temperature >160°C: Hydrolysis of isocyanic acid to ammonia $HNCO + H_2O \rightarrow NH_3 + CO_2$

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Quantum Cascade Laser Technology

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Model	MEXA-ONE-QL-NX	
Sampling	Direct exhaust measurement	
Measuring ranges	NO: (Low) 0-10/100 ppm NO_2: (Low) 0-5/50 ppm N_2O: (Low) 0-10/100 ppm NH_3: (Low) 0-5/50 ppm	(High) 0-500/5000 ppm (High) 0-200/2000 ppm (High) 0-500/2000 ppm (High) 0-200/2000 ppm
Noise (2x STDEV)	NO: (Low) <0.4 ppm NO_2: (Low) <0.2 ppm N_2O: (Low) <0.4 ppm NH_3: (Low) 0.2 ppm	(High) <20 ppm (High) <8 ppm (High) <20 ppm (High) <8 ppm
Sample temperature	113 ± 6°C	
Response time T_{10-90}	NO, NO_2, N_2O: < 2 s; NH_3: < 2.5 s	
Dimensions	Main unit: W440 × D660 × H877 mm	

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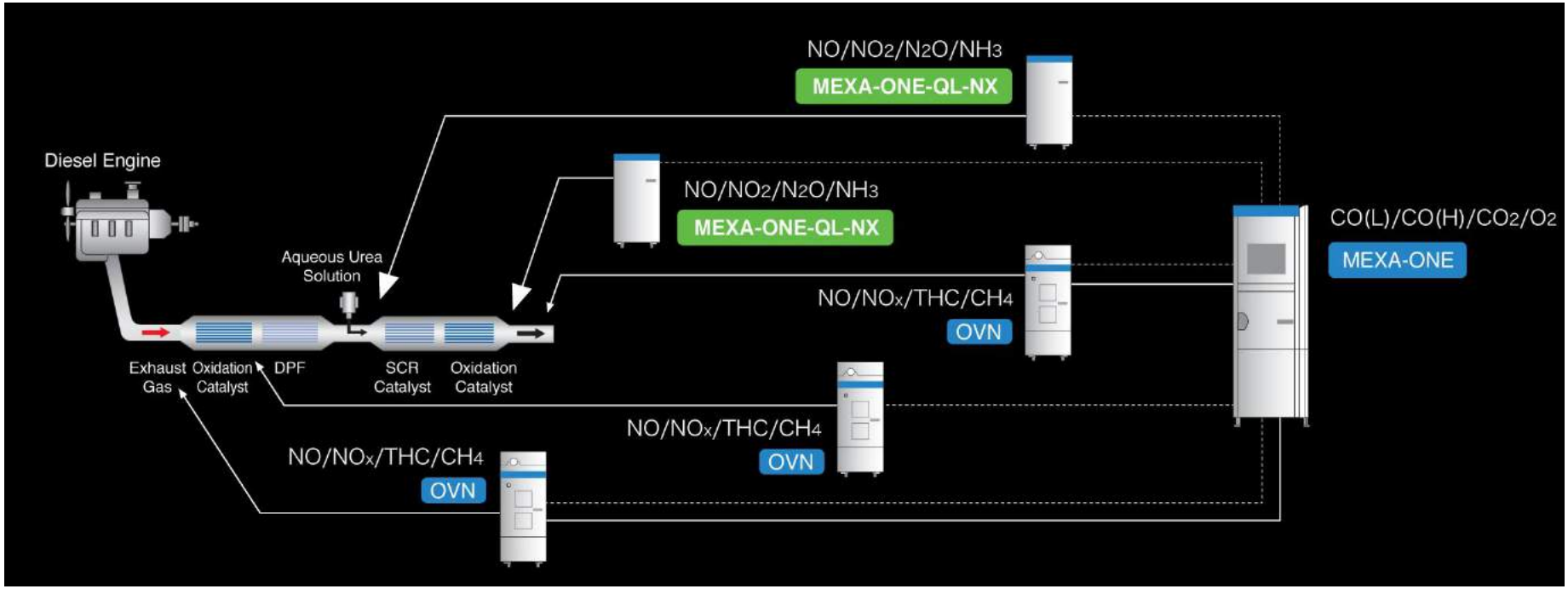
Quantum Cascade Laser Technology

- **Multi-Line CAT-Measurement**
  - With MEXA-ONE, OVN-25A & MEXA-ONE-QL-NX



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Quantum Cascade Laser Technology

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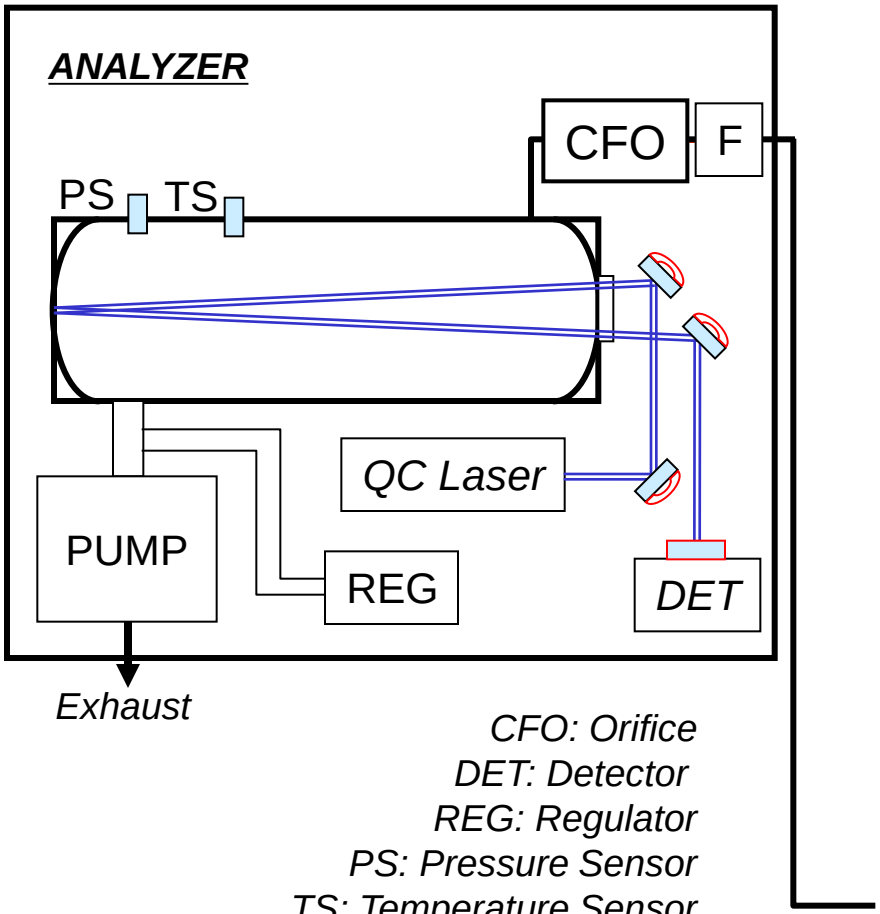
- Block Diagram MEXA-ONE-QL-N2O



Sample flow rate: 4 l/min

Cell volume: 300 ml

Optical path length: 80 m

Cell temp: 40 ℃

Cell pressure: 20 kPa

Range: 0 – 0.5/200 ppm

N_2O Ambient: approx. 0.32 ppm

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Model	MEXA-ONE-QL-N2O	
Sampling	CVS diluted exhaust gas measurement	
Measuring ranges	N_2O: (Low) 0-0.5/5 ppm	(High) 0-20/200 ppm
Noise (2x STDEV)	(Low) <0.01 ppm	(High) <0.4 ppm
Sample temperature	Room temperature: 15 to 35°C	
Response time T_{10-90}	< 4.5 s	
Dimensions	Main unit: W430 × D590 × H262 mm	

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Quantum Cascade Laser Technology

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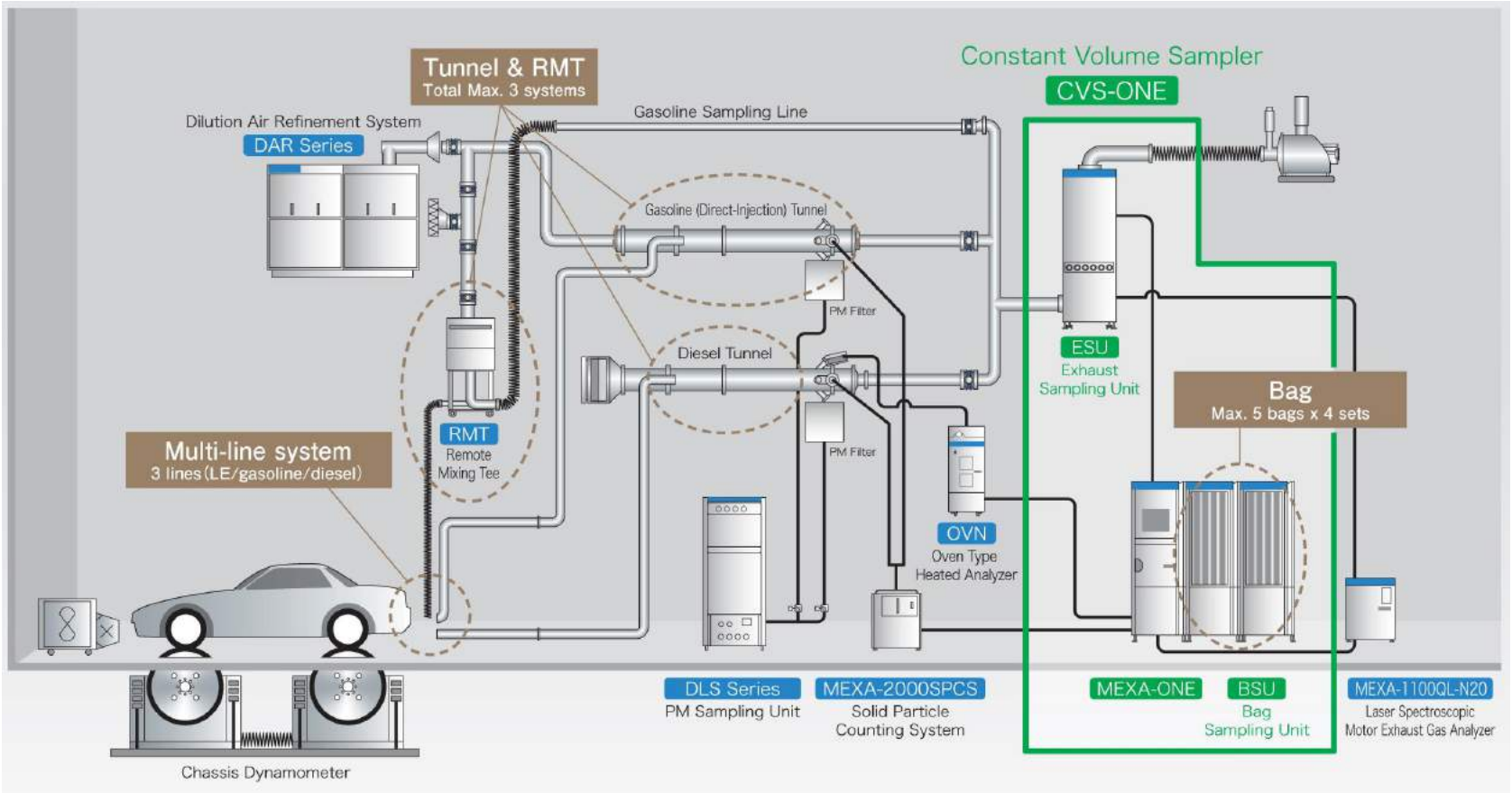
- **CVS diluted exhaust gas measurement**
  - With MEXA/CVS-ONE, DLS, MEXA-2000SPCS & MEXA-1100QL-N2O



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Fast Response EGR Measurement

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$$\text{EGR ratio} = \frac{CO_{2\ \text{Intake}} - CO_{2\ \text{Ambient}}}{CO_{2\ \text{Exhaust}} - CO_{2\ \text{Ambient}}}$$

- **General Specifications**
  - EGR ratio measurement by CO_2 trace method
  - Heated NDIR : **Intake CO_2, Exhaust CO_2**
- **Key Features**
  - **Accurate EGR measurement**
    - Heated NDIR method (HORIBA patented technology)
      - ✓ No water extraction with cooler
      - ✓ Dry-to-Wet compensation is not required
  - **Transient EGR Measurement**
    - Analysers and sample handling in one unit
      - ✓ Installation close to the sample point of test engine
    - Minimized influence of sample pressure on the transient error
    - Sample flow rate is only 2.5 l/min

HORIBA Patent

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Fast Response EGR Measurement

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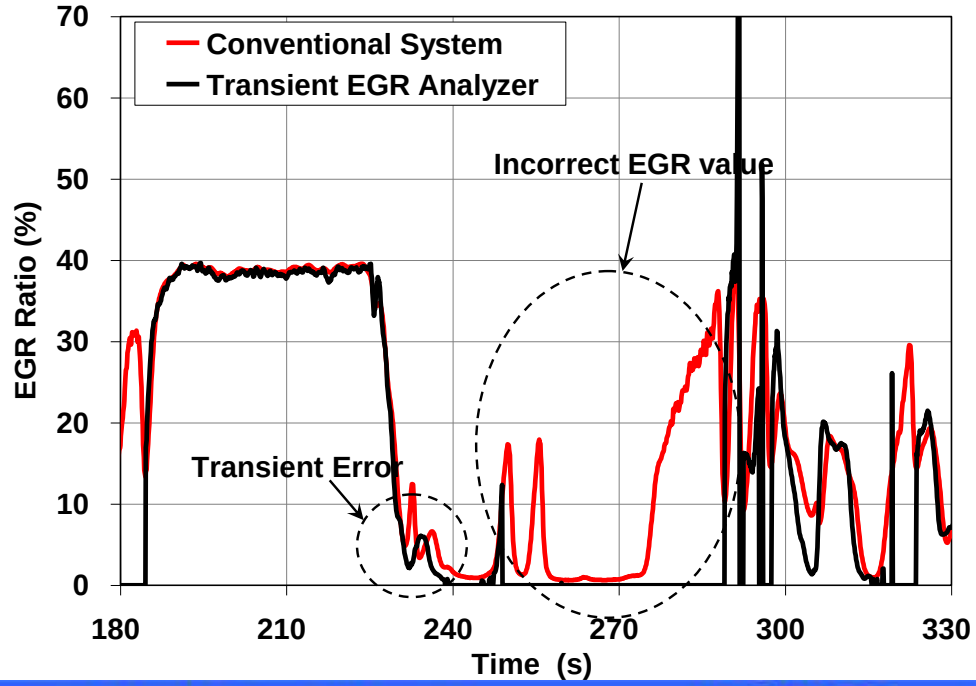
- **Comparison tests with conventional EGR-system (MEXA-7100DEGR):**
  - R-EGR analyzer follows EGR valve operation very well under transient condition.
  - Correct analysis at engine cold start because of the wet measurement capability.
  - R-EGR shows smaller transient errors under high pressure condition at sample inlet.
  - Good correlation with conventional system with dry/wet conversion under steady state

    (SAE paper 2012)



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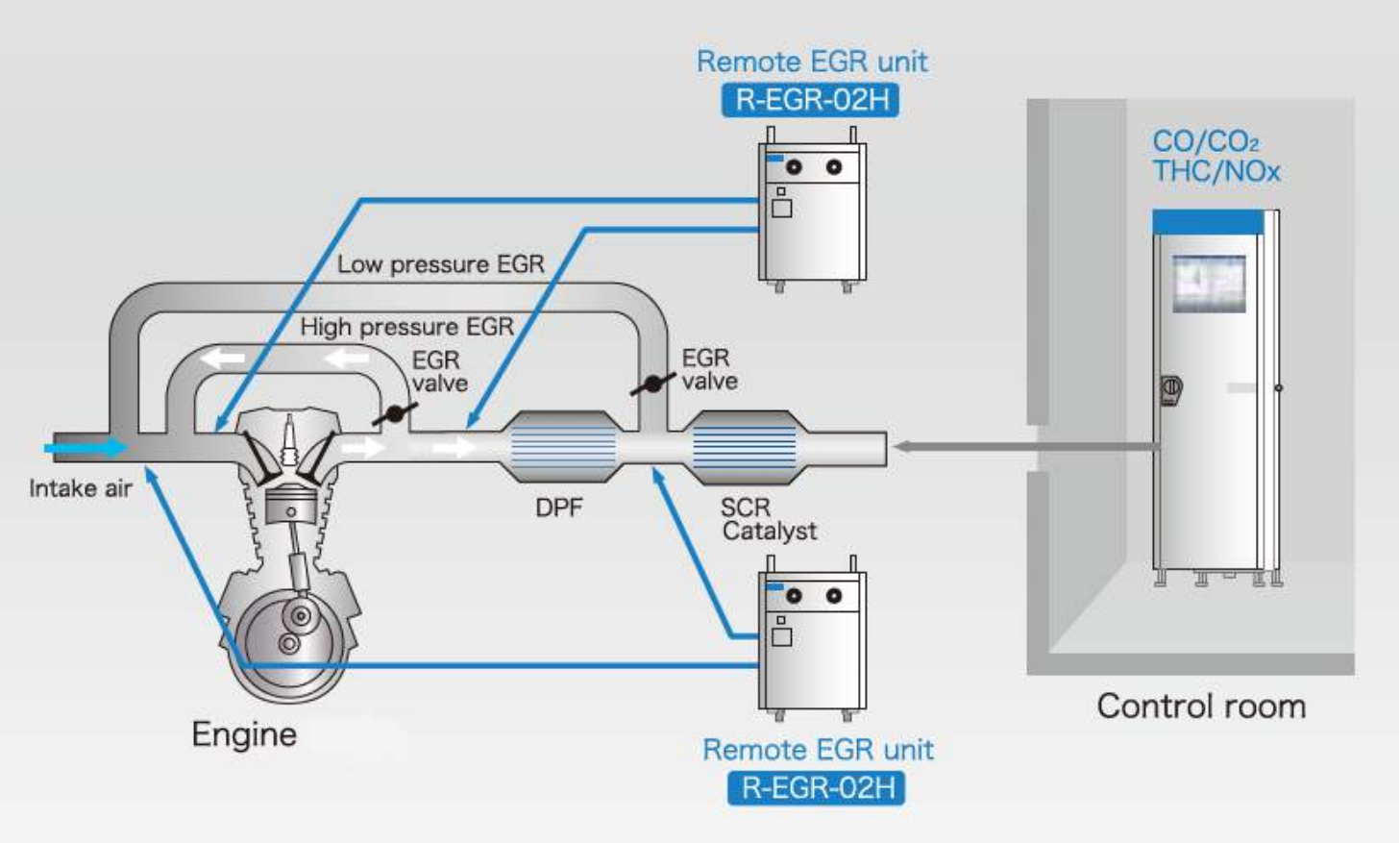
Fast Response EGR Measurement

- **Multi-point measurement: Easy addition of second unit for complicated measurement-setups**



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Portable Emission Measurement Systems

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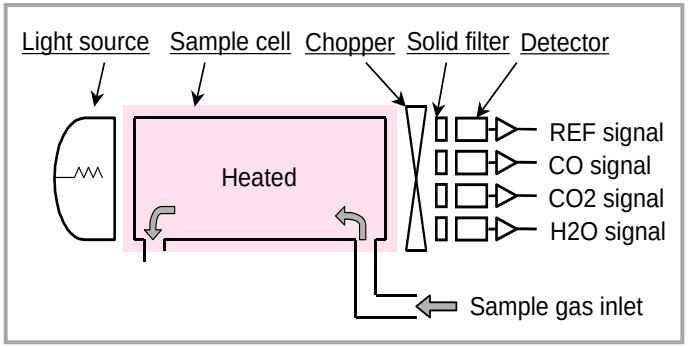
【HORIBA Patent No. JP 03771849】



"Wet" Based Heated Measurement

Direct emissions without dry to wet correction

- **Heated FID for THC**
  - Sample temp. 191˚C, no THC Hang-up
- **Heated Dual-CLD for NO, NO_2, NO_x**
  - No hydrolyses => no reduction of concentration
- **Heated NDIR for CO, CO_2**
  - No cooler/dehumidifier for sample gas
- **CPC Condensation Particle Counter for PN**
  - Real particle counting, no particle size dependency like DCS Diffusion Charging Sensor
- **Filter Batch Sampling for PM**
  - Partial flow gravimetric sampling method

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Portable Emission Measurement Systems

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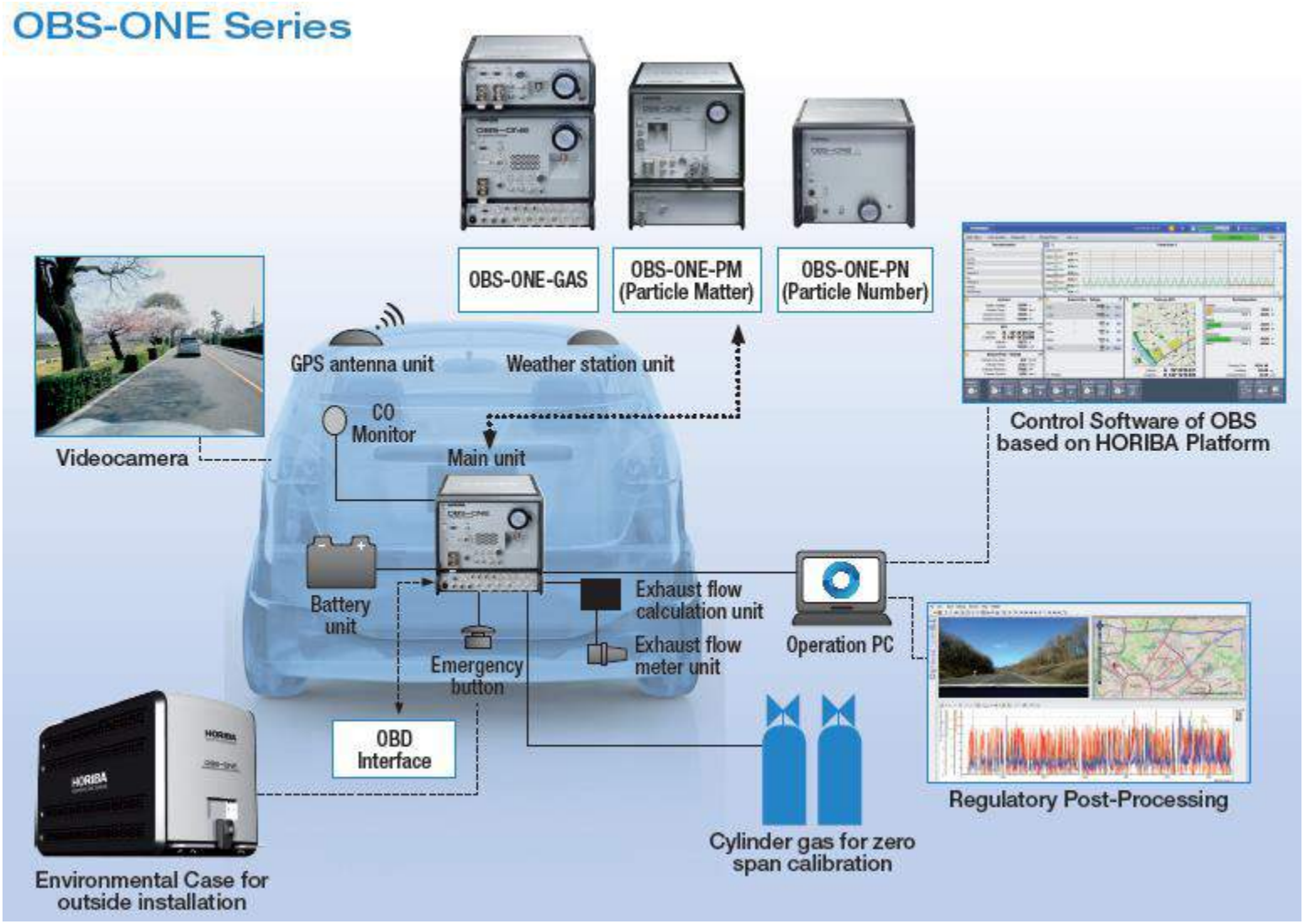

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Thank you

Omoshiro-okashiku
Joy and Fun

감사합니다

Cảm ơn

ありがとうございました

Dziękuję

धन्यवाद

Grazie

Merci

谢谢

நன்ற

ขอบคุณครับ

Obrigado

Děkuji

Σας ευχαριστούμε

شُكْرًا

Tack ska ni ha

Большое спасибо

Danke

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