



Particle Measurement Programme (PMP)

Update on the exhaust emissions

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Overview

Laboratory sub-23 nm protocol (HD=Heavy-Duty)

Tailpipe sampling with fixed dilution (HD=Heavy-Duty)

PEMS sub-23 nm (LD=Light-Duty)

Other issues

- Monitoring (new protocols): Regenerations, fuels etc.
- Common calibration procedures

Laboratory sub-23 nm protocol (HD)

Changes are based on LD proposal (GTR 15)

	23 nm (old in grey)	10 nm
PNC efficiency	23 nm: 50% ($\pm 12\%$) 41 nm: >90%	10 nm: 65% ($\pm 15\%$) 15 nm: >90%
PNC material	Not defined	Emery oil or soot-like
PNC linearity	$\pm 5\%$ from slope (from $\pm 10\%$)	$\pm 5\%$ from slope
PNC correction	Removed coincidence correction up to 10%	No specifications for internal corrections
PNC inlet temperature	Depending on the PNC specifications (removed 35°C)	Depending on the PNC specifications
PNC calibration interval	13 months (from 12 months)	13 months
PNC monitor	6 months (wick exchange or $\pm 10\%$ of reference PNC or two PNCs)	6 months (wick exchange or $\pm 10\%$ of reference PNC or two PNCs)

Laboratory sub-23 nm protocol (HD)

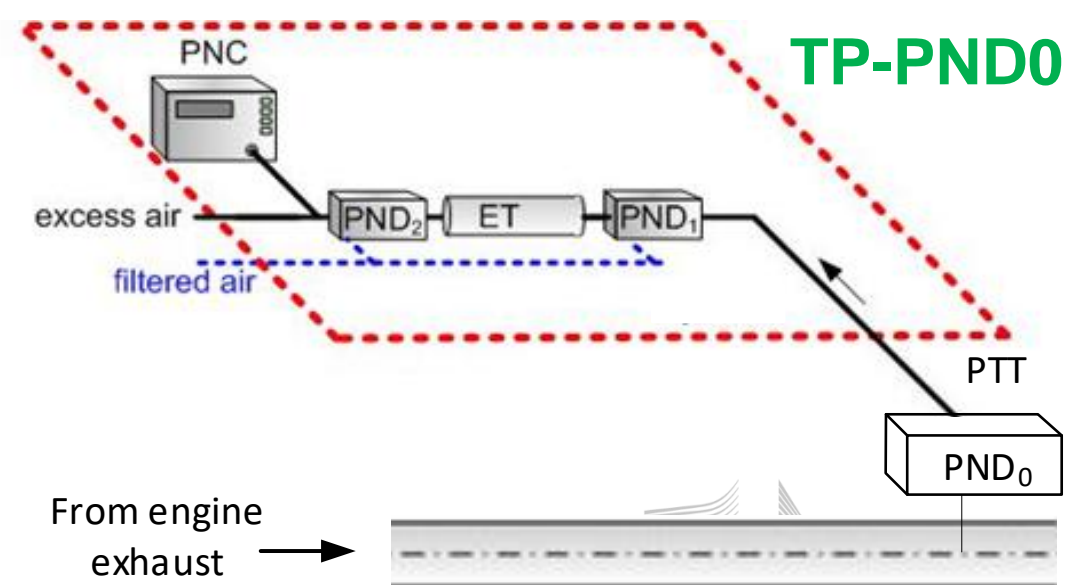
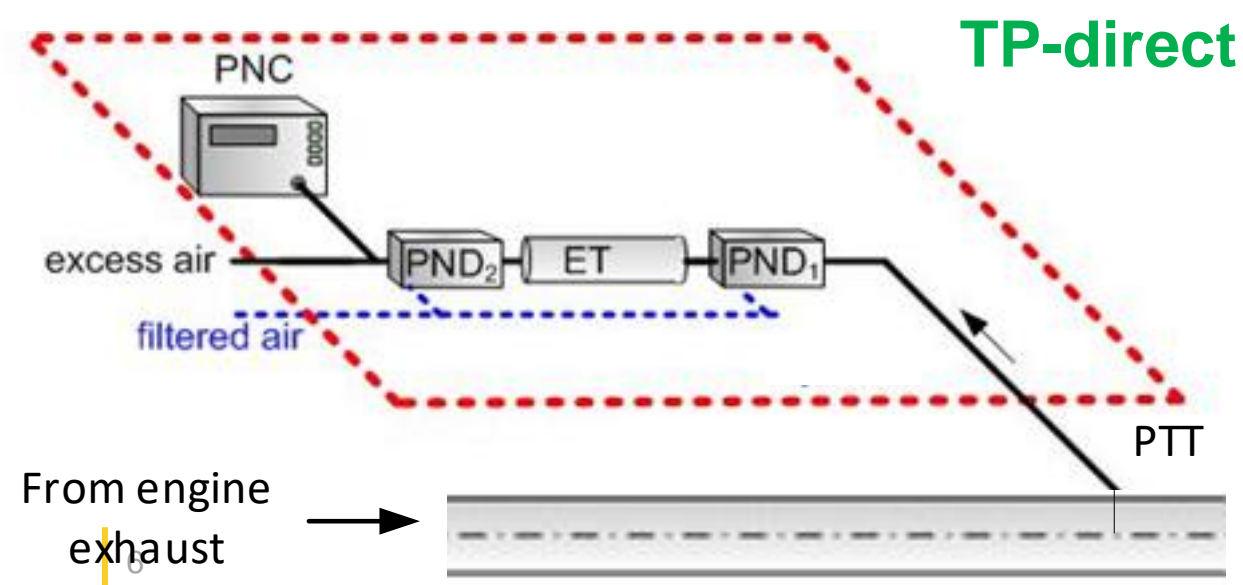
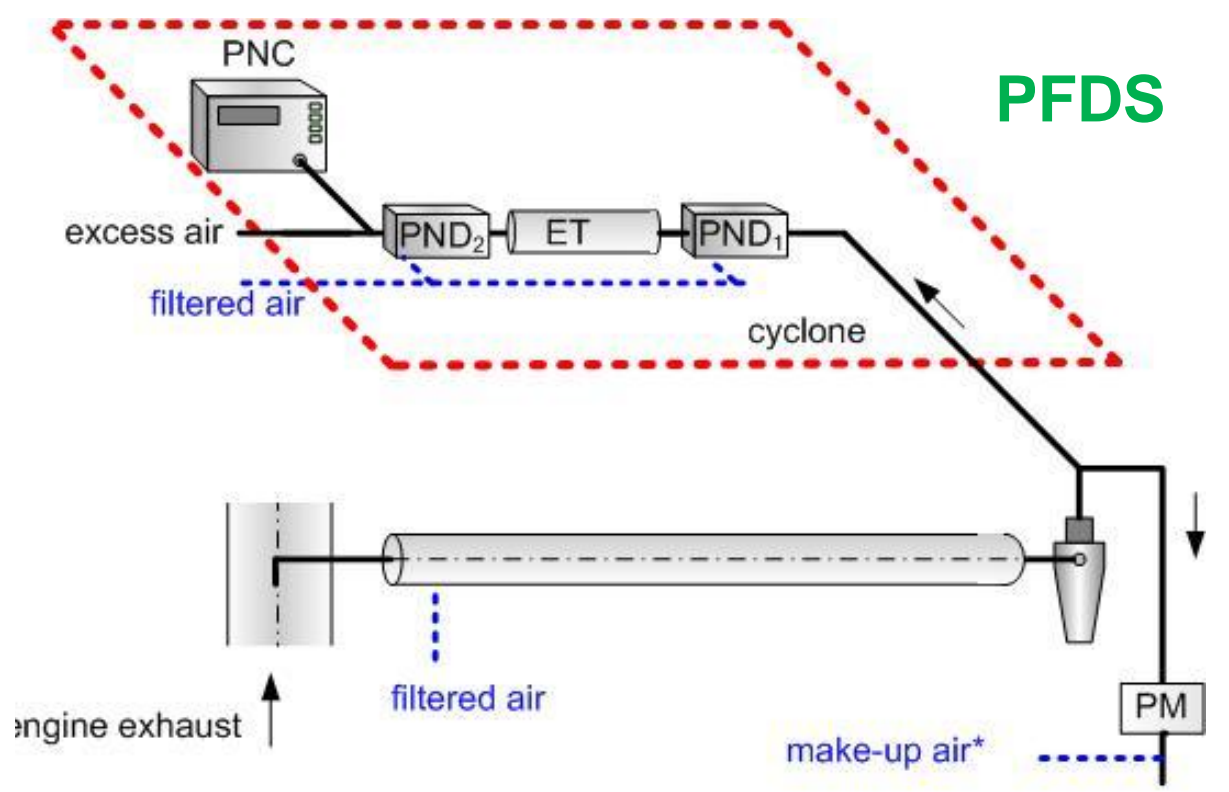
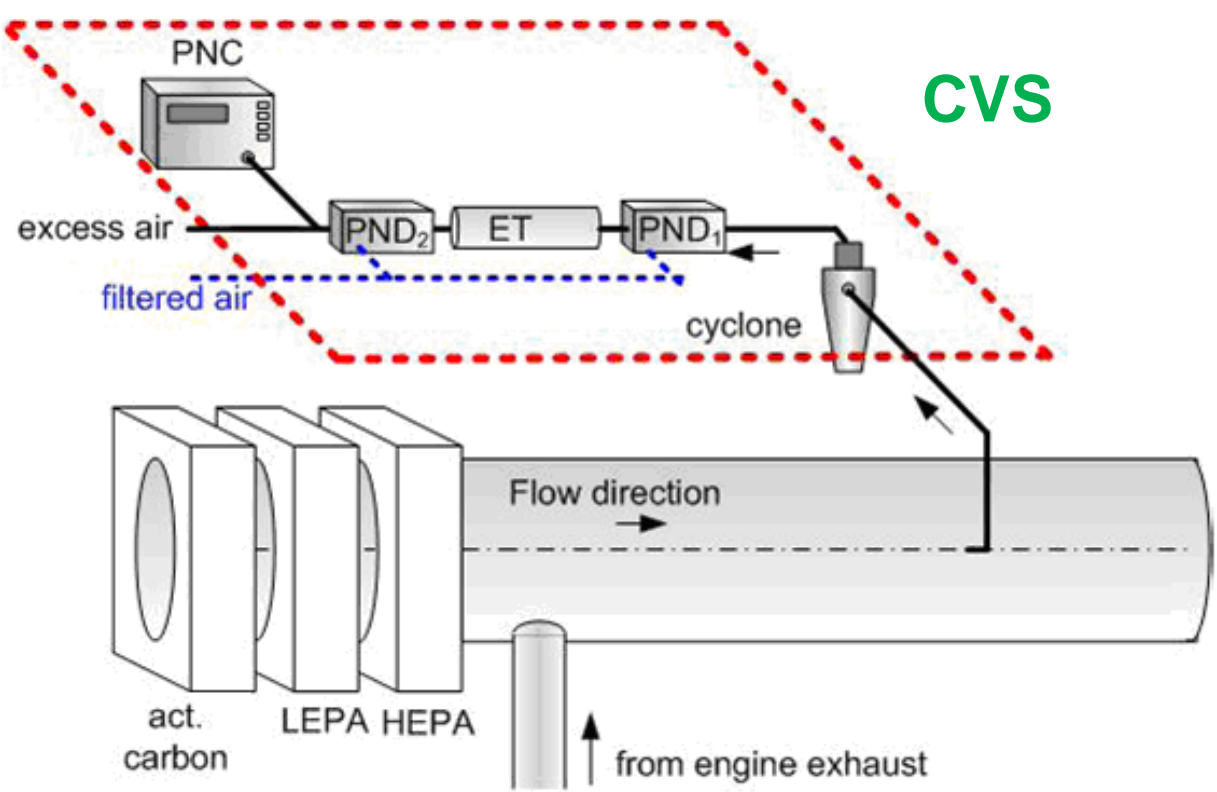
	23 nm (old in grey)	10 nm
VPR calibration	Same mean of PCRFB100, PCRFB50, PCRFB30	PCRFB15/100<2 (not taken into account in the calculations)
VPR calibration interval	13 months (from 12 months)	13 months
VPR validation	Monodisperse or polydisperse	Removed polydisperse
VPR penetration **	>70% at 100 nm (once for a family)	>70% at 100 nm (once for a family)
VPR volatile removal efficiency (VRE)	Same: >99.0% monodisperse 30 nm C40, 10 ⁴ p/cm ³	>99.9% polydisperse 50 nm C40, 1 mg/m ³
VPR VRE frequency	12 months for each instrument unless instr. manufacturer specifies otherwise for each instrument family	12 months for each instrument unless instrument manufacturer specifies otherwise for each instrument family
VPR evaporation tube	T=350°C (±10°C) from 300-400°C May be catalytically active	T=350°C (±10°C) Catalytically active * to be added T?
VPR ambient air check	No error (removed >100 p/cm ³)	No error

⁴** Missing from resolution, A.8.1.3.3.6

* Missing from GTR 15, **needs to be added**

Tailpipe sampling with fixed dilution (HD)

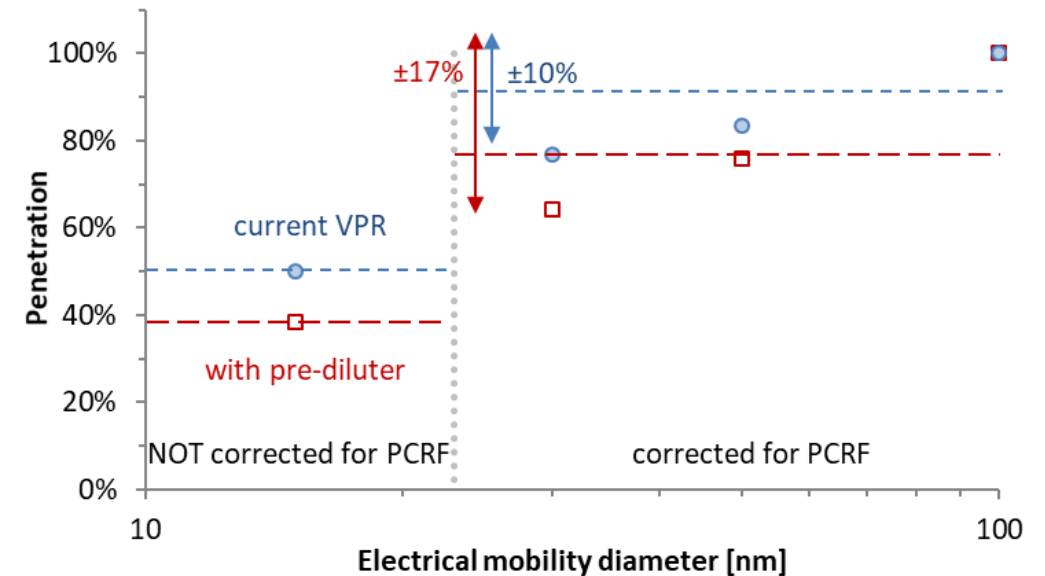
Pre-diluter	A cold or hot pre-diluter may be located at the end of the particle sampling probe and in front of the PTT. A fixed dilution ratio >5:1 shall be applied to the cold or hot dilution stage. Cold dilution is defined as a dilution with (unheated) dilution air and/or diluter temperature $\geq 20^{\circ}\text{C}$.
Losses	The penetration for each model of pre-diluter shall be determined as described in A.8.2.2.4 The final system penetration (pre-diluter, PTT and VPR) shall not decrease 20% the requirements of A.8.1.3.3.6. The particle concentration reduction factors of each pre-diluter shall be determined as described in A.8.2.2.2. The complete system (pre-diluter, PTT and VPR) shall not exceed 10% for 50 nm, 20% for 30 nm, and 30% for 15 nm (if applicable) the requirements of A.8.1.3.3.4.
Sampling line	When sampling directly from the tailpipe the residence time until the pre-diluter or the VPR shall be ≤ 1 seconds . The tubing shall be heated at $\geq 150^{\circ}\text{C}$ if >10 cm, otherwise only insulated. Any unheated parts shall be <10 cm



Comparison of systems

Case	Sampling line	RT	PND0	Dilution	Diff. losses	Therm. losses
CVS	Transfer tube	Variable	Dilution tunnel	Variable	Not included	Not included
PFDS	Connection tube	Variable	Micro tunnel	Variable	Not included	Not included
TP with PND0	<10 cm	Short	PND0	Constant >5:1	Characterised	Lower
TP direct	Sampling line	Constant <1s	None	None	Low	Not included

- Unknown losses of CVS & PFDS
- PND0 (vs direct) less thermophoretic but higher “calibration” losses
- Smaller effect at the >23 nm range



Tailpipe minor issues (HD)

Definition: PM number (R49) or SPN (current resolution)

Emission analyzers with automatic or manual range switching are permitted. During the test cycle, the range of the emission analyzers shall not be switched. (**refers to gas analyzers**)

Sampling rate 2Hz (tailpipe)

Q(extracted) <0.5% of cycle mean exhaust flow rate

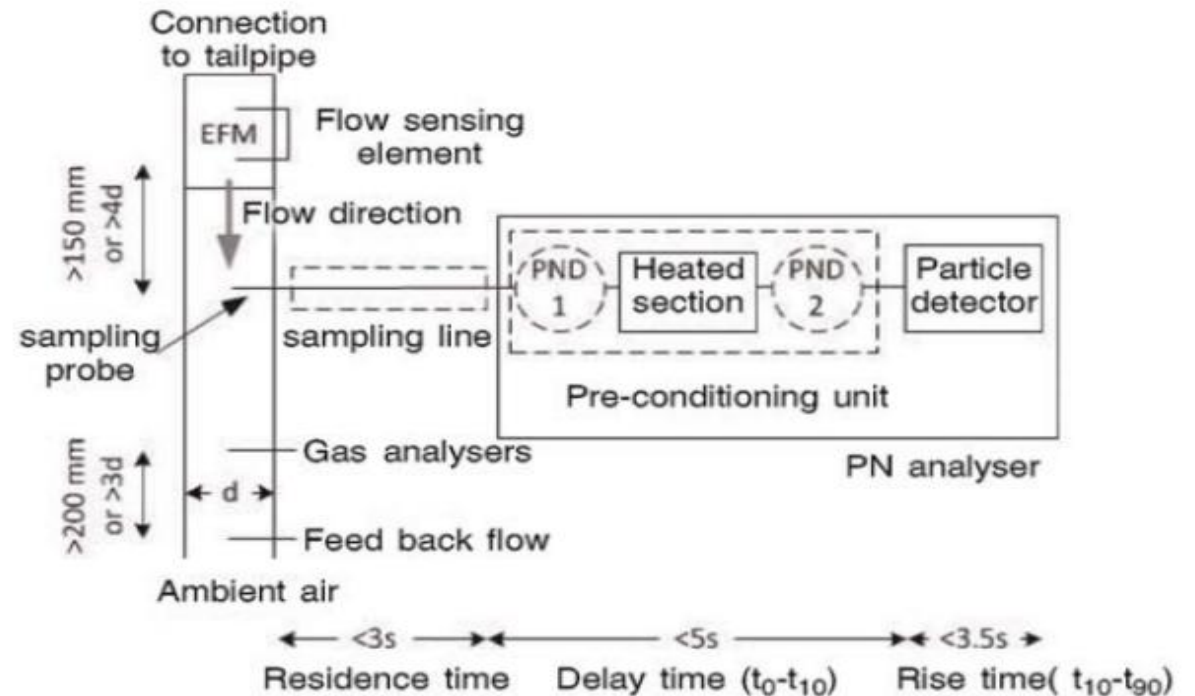
The exhaust shall be sampled from the center of the exhaust stream

Sampling close to the engine (**position representative to retention time in typical application**) as ~~to ensure an exhaust gas temperature of at least 343 K (70 °C) to avoid condensation at the probe.~~

PEMS sub-23 nm (LD)

Sampling line $\geq 100^\circ\text{C}$

Heated section $\geq 300^\circ\text{C}$



Annual calibration with thermally soot-like aerosol

Multiply charged particles corrections $\leq 10\%$ (and reported)

Zero: $\leq 5000 \text{ p/cm}^3$ over 4 h, (60 s during linearity)

Linearity: slope 0.85-1.15, offset $\leq 10\% x_{\text{max}}$, $R^2 \geq 0.95$, $\text{SEE} \leq 10\% x_{\text{max}}$,

Five points within 15% of the mean difference

PEMS sub-23 nm (LD)

Differences of 23 nm and 10 nm systems

VRE $\geq 99.9\%$ of C40 $\geq 1 \text{ mg/m}^3$, CMD $\geq 50 \text{ nm}$

Efficiency

	10	15	23	30	50	70	100	200
PEMS23	-	-	0.20-0.60	0.30-1.20	0.60-1.30	0.70-1.30	0.70-1.30	0.50-2.00
PEMS10	0.10-0.50	0.30-0.70	-	0.75-1.05	0.85-1.15	0.85-1.15	0.80-1.20	0.80-2.00

Other issues

Monitoring:

Input from stakeholders is needed regarding the application of the agreed protocols. Cases of high interest include regenerations, fuels, crankcase emissions etc.

Deadline: open

Inter-lab exercise with HD OEMs 10 nm PEMS (from mid April 2021)

Other issues

Common calibration procedures

JRC will prepare a proposal for common calibration procedures (Laboratory and PEMS). **Input is needed** on inconsistencies, traceability issues, etc.

Examples: sampling line is not included in the calibration of lab systems, but is included in PEMS, common calibration material, common calibration sizes

MetroPEMS project: <https://www.metropems.ptb.de/home/>

Deadline: June 2021 (tbc)

Keep in touch



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