Informal document **GRPE-89-37**
89th GRPE, 30 - 2 June 2023
Agenda item 7.

European Commission

89th UNECE GRPE session

PMP IWG Progress Report

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Geneva, 1st June 2023

UNITED NATIONS

Joint Research Centre

PMP meetings in 2023

Before GRPE 89th session

2023-01-09: PMP Webconference (exhaust and non-exhaust)

2023-01-11: Presentation to GRPE

2023-04-27: PMP Webconference (exhaust and non-exhaust)

2023-05-24: PMP Webconference (non-exhaust)

Several ad-hoc webconferences (mainly TF4) to discuss specific issues related to exhaust and non-exhaust particle measurement procedures

PMP ToR (file GRPE_89_27)

ToR expiring June 2023: renew until June 2025

Non-exhaust emissions:

- Brakes LDV: (i) friction share coefficients (ii) round-robin
- Brakes HDV: (i) setup (ii) cycles (iii) non-friction braking
- Tyres/road: Continue monitoring on-going projects

Exhaust emissions:

- No new topics are expected. Continue monitoring current measurement and calibration* procedures

* Calibration procedures for brakes might be need assessment

Monitoring of projects

	UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE	European Commission	Horizon Europe	Department for Transport	UBA	VETC	Japan	EPA / CALIFORNIA AIR RESOURCES BOARD	HEI
Brakes	GTR Brakes emissions	GROW Project VERA	LowBrasys Aerosolfd					17RD016: Brake emissions 65A0703: CalTrans modeling	
Brakes & Tyres				Particles from Brakes & Tyres	Brakes & Tyres wear			22RD0002: Real-world Tyres & brakes	Real-world non-tailpipe
Tyres	UNR(?) Tyres abrasion	IDIADA Accelerated method	Leon-T						

Overview GTR on brake emissions

The Global Technical Regulation on brake emissions was adopted at the 87th GRPE session. The final vote will take place in June at WP.29 level. The file (GRPE 87-40) can be found at

https://unece.org/transport/documents/2023/01/informal-documents/clean-pmp-proposal-amend-ecetranswp29grpe20234

Submitted to June’s WP.29 session as WP.29/2023/79e:

https://unece.org/transport/documents/2023/04/working-documents/grpe-proposal-new-un-gtr-laboratory-measurement-brake

At the moment TF4 is preparing a methodology to determine case specific friction share coefficients.

GTR Amendment Submission Steps

Presentation of Annex C main parts at 89th GRPE Session – 01.06.2023

Submission of the Informal Document with Annex C – end June 2023 (indic.)

Deadline for comments on the Informal Document – mid Sept 2023 (indicative)

Submission of the Working Document (GTR Amendment) – Oct. 2023

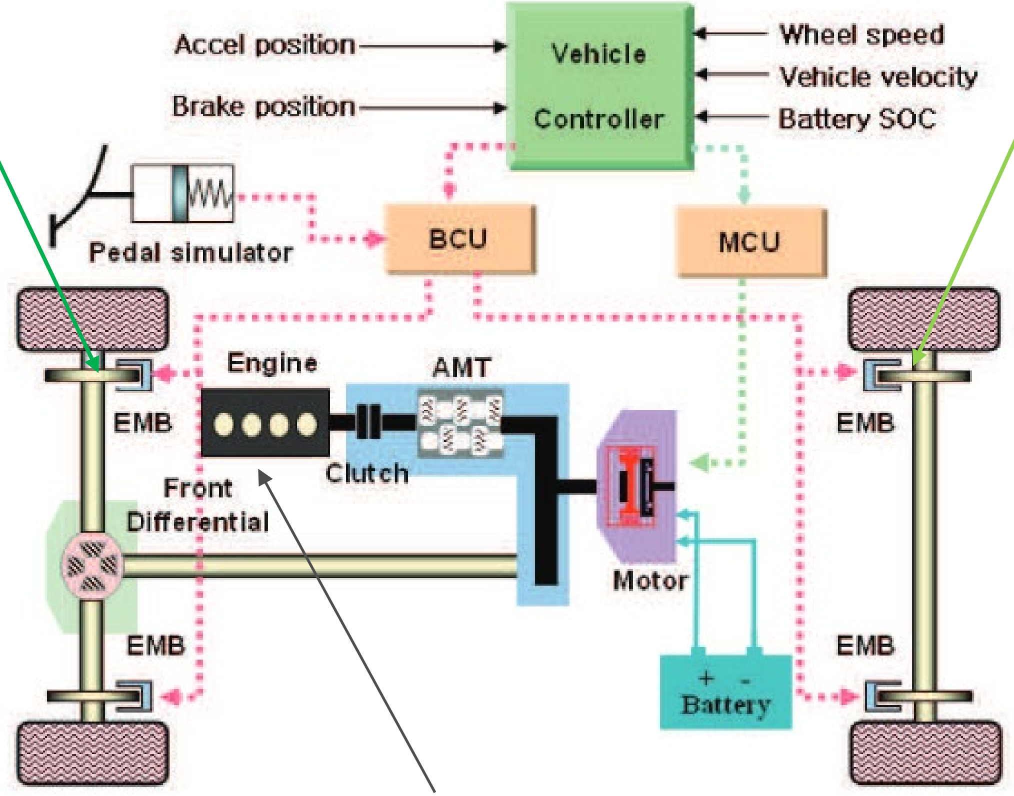
Submission of Informal Document amending the Working Document (Final GTR) – Jan. 2024 (if needed)

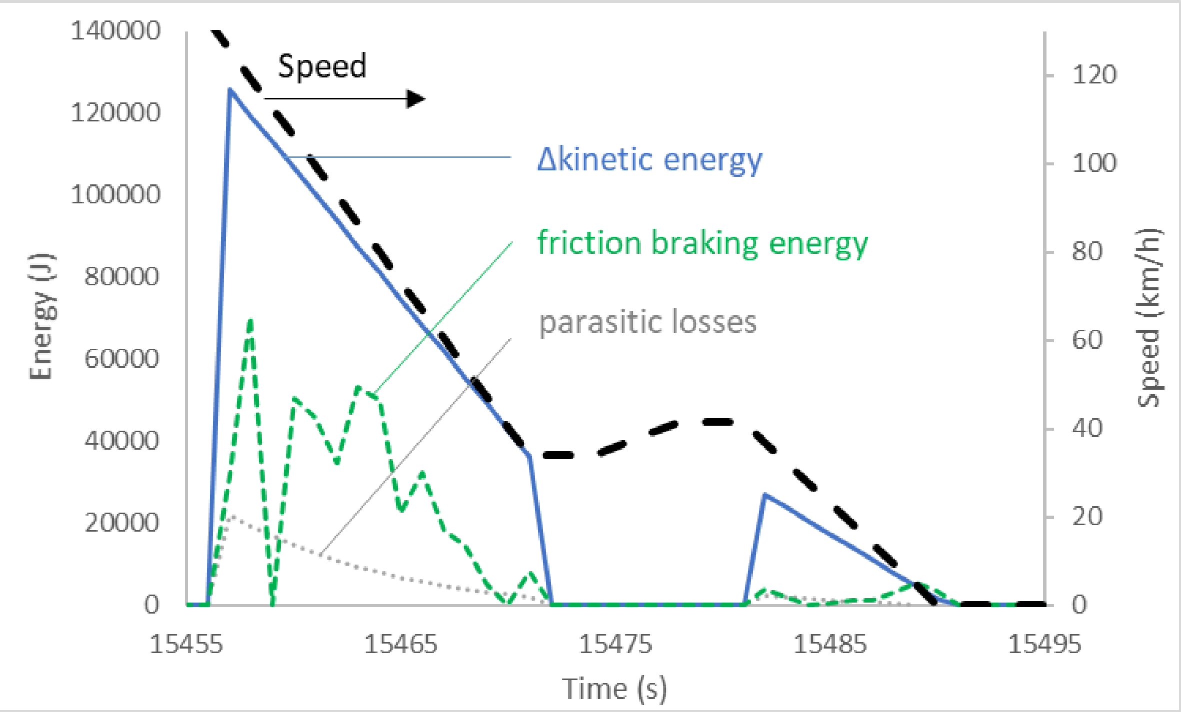
Voting of the GTR Amendment 90th GRPE Session – January 2024

Braking fundamentals

Friction (mechanical) braking

Non-friction (regenerative) braking





Engine motoring

Depending the measurement point
The ICE charging has to be subtracted

AMT: Automated Manual Transmission
ICE: Internal Combustion Engine
MCU: Motor Control Unit
BCU: Brake Control Unit

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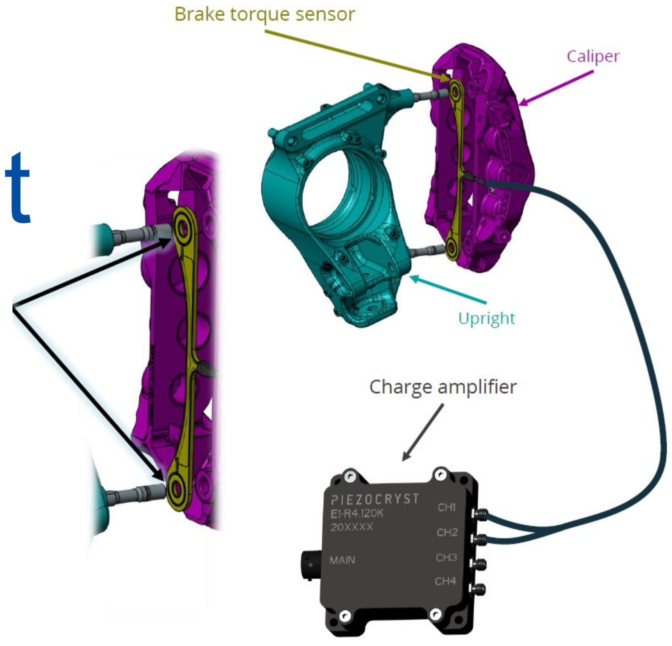
Friction braking: Direct measurement



__Ref. **Method A**__:
Brake torque sensor: Direct force measurement

$T_b = - F\, r_r$

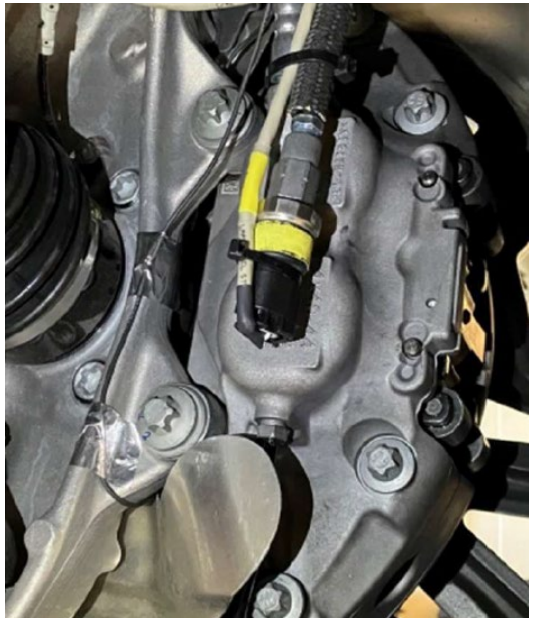
$W_b = T_b\ \omega$ (angular velocity)

__Ref. **Method B**__: Pressure measurement:

$T_b = - 2\, P_c\, A\, \mu\, r_r$ → $W_{\text{brake}} = Cp \sum_{i=1}^{N} \int_0^{t_{i-th}} p_{\text{brake}} \cdot 10^5 \cdot \frac{v}{r}\, dt$

T_b *braking torque*
A effective pad area
μ friction coefficient
r_r application radius
P_c caliper pressure.

c_p = torque to pressure ratio
(can be determined in the brake dyno)
c_e = torque to electric power ratio (for EMB)



__Method D__: With internal *Torq equiv.* sensors and the brake torque is CAN output

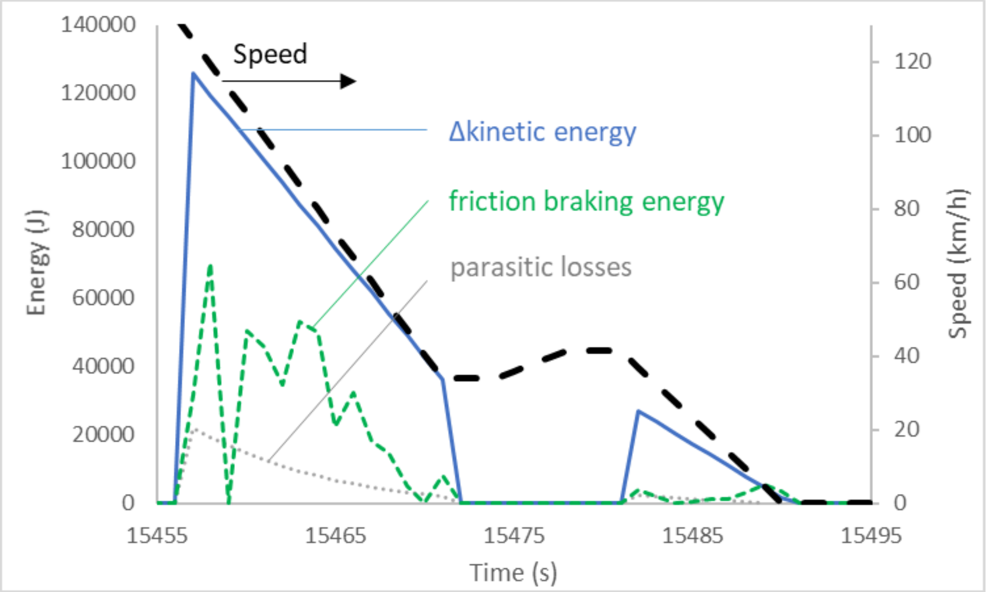
Friction braking: Indirect method (Energy balance)

$$E_{friction\ brk} = E^{neg}_{wheels} - E^{neg}_{ICE\ brk,wheels} - E^{neg}_{EMs\ brk,wheels}$$

power at wheels — power absorption for ICE motoring — EMs braking energy recuperation

EM: Electric Motor
ICE: Internal Combustion Engine

Method C: Due to lack of data and need for assumptions (ICE and EM efficiency etc.) discussion are still on-going if this method will be considered at this stage



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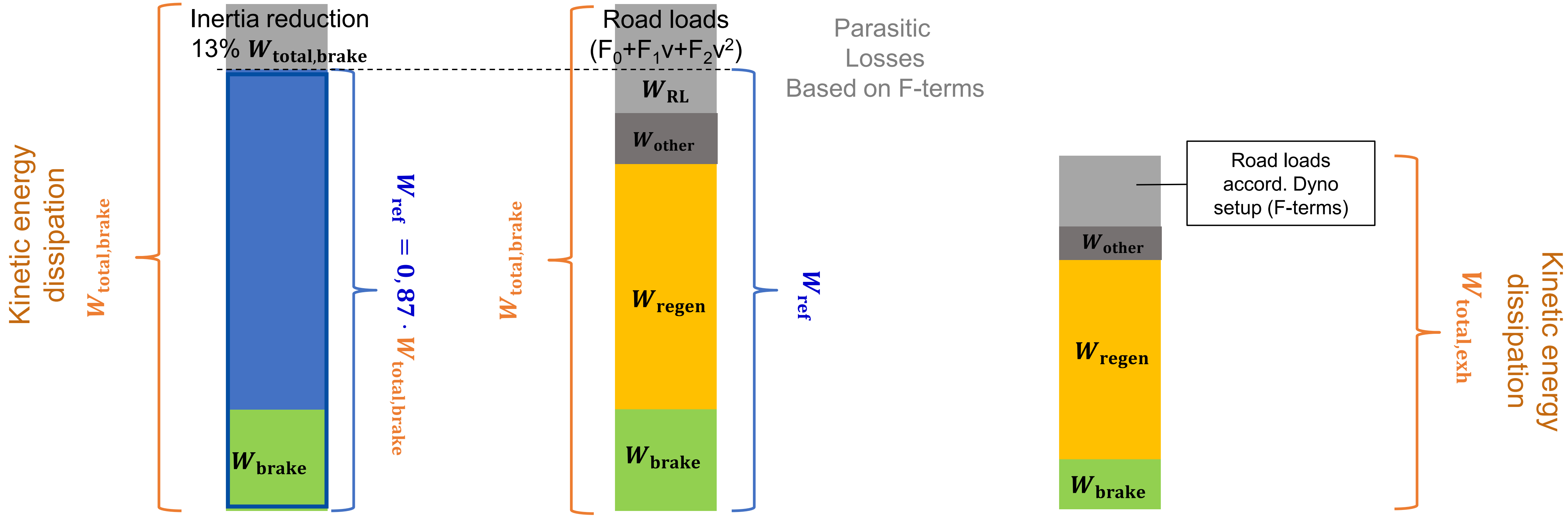
Friction braking share coeff. *c* determination

WLTP brake dyno test: WLTP brake chassis dyno: WLTP exhaust chassis dyno:



$$c = \frac{W_{brake}}{W_{ref}} = \frac{W_{brake}}{0.87 \cdot W_{total,brake}}$$

$$c_{exh} = \frac{W_{brake,exh}}{W_{total,exh}}$$

Overview of proposal

Instead of the values of Table 5.1, case specific friction braking share coefficients may be determined according to the methodology provided in Annex C [NEW].

The reference methods are based on: direct friction braking torque (method A) and/or braking pressure (method B).

Alternative [based on pressure/torque equivalent measurement] methods may be applied if they are demonstrated to be equivalent to [Method A] or [Method B].

The equivalency shall be demonstrated for at least one vehicle for each of the categories of Table 5.1 comparing the alternative method to [Method A or B], running the WLTP-Brake cycle or the WLTP-Brake cycle Trip #10.

The WLTP-Exhaust cycle may be used applying a correlation factor for NOVC-HEVs and/or friction share coefficients > [X]

Exhaust systems calibration

To assess current calibration procedures, JRC request calibration certificates

6 institutes sent data

JRC complemented a few topics

Topics covered (PCRF, counting efficiency, linearity)

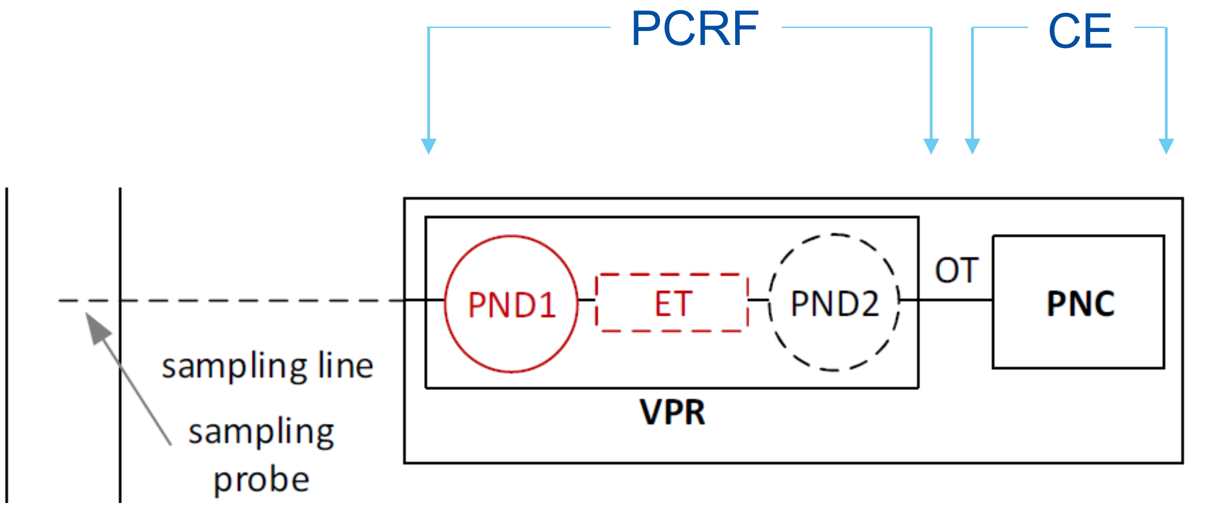
For some topics limited data are available (but not important for the main objective of this work)

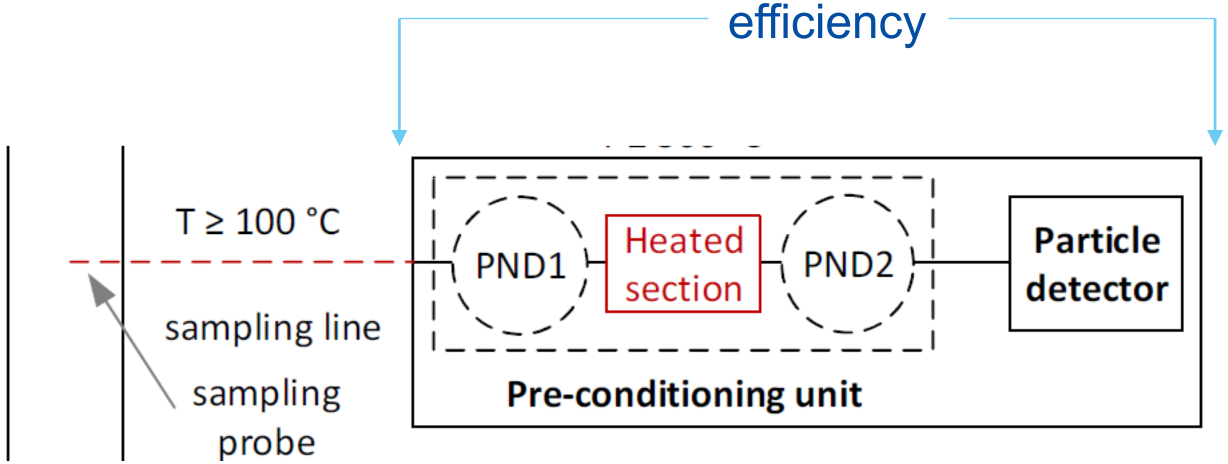
		received
VPR	PCRF ratios	Y
	uncertainty	Y
	uncertainty (volatiles removal)	1
	calibration material	Y
	Stability over time	1
	manufacturing variability	Y
CPC	counting efficiency	Y
	linearity	Y
	uncertainty	Y
	calibration material	Y
	Stability over time	1
	manufacturing variability	Y
PEMS	counting efficiency	Y
	linearity	1
	uncertainty (efficiency)	Y
	calibration material	0
	uncertainty (volatiles removal)	0
	Stability over time	0
	manufacturing variability	Y
PMP tailpipe vs PMP CVS		Y
PMP vs PEMS		1

Exhaust systems calibration conclusions

Uncertainty estimation were provided and were similar among labs

The measured “efficiencies” (PNCs, VPR, PEMS) at different institutes were in acceptable agreement. *A round robin is recommend to confirm the reported uncertainties*.





Exhaust systems calibration conclusions

For 10 nm PN systems the VPR is the main contributor of the final “efficiency” of the PMP system

- The material (Emery oil or soot) has negligible impact on 10 nm PNC’s counting efficiencies. *Thus, no change in the 10 nm regulatory text is needed, although soot is the preferred material. Silver was also suggested to be added, after confirmation with the round robin*.

For 23 nm PN systems the PNC is the main contributor of the final “efficiency” of the PMP system.

- For PNC calibration the material has impact mainly for the 23 nm PNCs. A preference for soot as calibration material was expressed (more comparable with other standards and representative of vehicle exhaust)

Exhaust systems calibration conclusions

Due to the impact of the material on the efficiencies of 23 nm PNCs, and in order not to have impact on the current market situation, which is mainly based on PAO calibrations, it is recommend to adjust soot-like (or other materials, e.g. silver) efficiencies to PAO or vice versa.

- There was no unique correlation of PAO and soot-like particles, but for simplification reasons a correlation factor could be used
- The correlations should be done independently at the respective calibration facility:
    - Calibrating a few CPCs with both emery oil and soot-like materials and determining a “correction” factor for 23 nm, and 41 nm.
    - Having a 23 nm “transfer” PNC calibrated with emery oil and adjusting (or comparing the rest) with the specific PNCs using soot-like particles

Preferred option is third bullet (already in 10 nm PNC procedures).
A round robin could investigate this topics; a calibration guidance could be prepared.

Thank you

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