Informal document **GRPE-85-37-Rev.2**
85th GRPE, 10-14 Jan 2022
Agenda item 7.

European Commission

85th UNECE GRPE session

PMP IWG Progress Report

B. Giechaskiel, T. Grigoratos

Webconf, 10th -14th Jan 2022

UNITED NATIONS

Joint Research Centre

PMP meetings in 2021

2021-01-12: GRPE 82 (progress report)

2021-01-13: PMP Workshop on Brake wear emission regulation

2021-03-24: PMP Webconference (new ToR)

2021-06-03: GRPE 83 (progress report)

2021-07-15: PMP Webconference (non-exhaust dedicated)

2021-12-01: PMP Webconference (exhaust dedicated)

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

NEXT F-2-F MEETING: tbd

Summary of activities

New ToR

Chair changed in June 2021 (G. Martini → B. Giechaskiel)

Exhaust emissions

- Resolution for heavy-duty engines (laboratory sub-23 and direct tailpipe sampling) and experimental campaigns
- Light-duty sub-23 nm PN-PEMS technical specifications
- Heavy-duty sub-23 nm PN-PEMS experimental campaign
- Instrumentation calibration procedures

Summary of activities

Non-exhaust emissions

- TF1: Laboratory test cycle (completed Q2 2020)
- TF2: Technical specifications of setup (draft delivered Q3 2021)
- TF3: Inter-laboratory study (started Q3 2021)
- TF4: Regenerative braking (started Q4 2021)

GTR on brake PM & PN

- Informal document: GRPE-83-11 - (Japan, UK, EU) Request for authorization to develop a new UN GTR on brake PM and PN emissions
- ECE/TRANS/WP.29/2021/150: Authorization to develop a UN GTR on brake particulate emissions.

New ToR

The update **ToR** were adopted

Informal document: *GRPE-83-20 - (PMP) Updated terms of reference and rules of procedure for the IWG on PMP*

Points of attention for exhaust emissions (deadline June 2022)

- Monitoring of new sub23nm, tailpipe protocols, PEMS-10nm etc
- Common calibration procedures (PMP and PEMS)
- Robust method for VPR volatile removal efficiency

New ToR

Brake-wear PM and PN (Deadline for the GTR: draft June 2022)

- Interlaboratory Study: Task Force (TF3)
- Regenerative braking and future technologies: Task Force (TF4)
- Preparation – finalization of the PMP Brake protocol (TF2)

Tyre/Road Wear (monitoring of ongoing projects)

- A common task force between GRBP and GRPE will address the issue of tyre abrasion and particles from tyre/road wear (2nd phase, beyond 2023).

EXHAUST PARTICLE EMISSIONS

Update on GRPE Jan 2022

Proposal for a new Consolidated Resolution concerning Exhaust Ultra-Fine Particle Number Measurement For Heavy Duty Engines

Working document: *ECE/TRANS/WP.29/GRPE/2021/17 - (IWG on PMP)*

Informal document GRPE-82-29 (and the accompanying explanatory note GRPE-82-30)

Informal document ***GRPE-85-04***

Postponed for GRPE Jan 2022.

Sub-23 nm protocol: Agreed June 2021

Tailpipe sampling (Pre-diluter permitted losses): Agreed Dec 2021

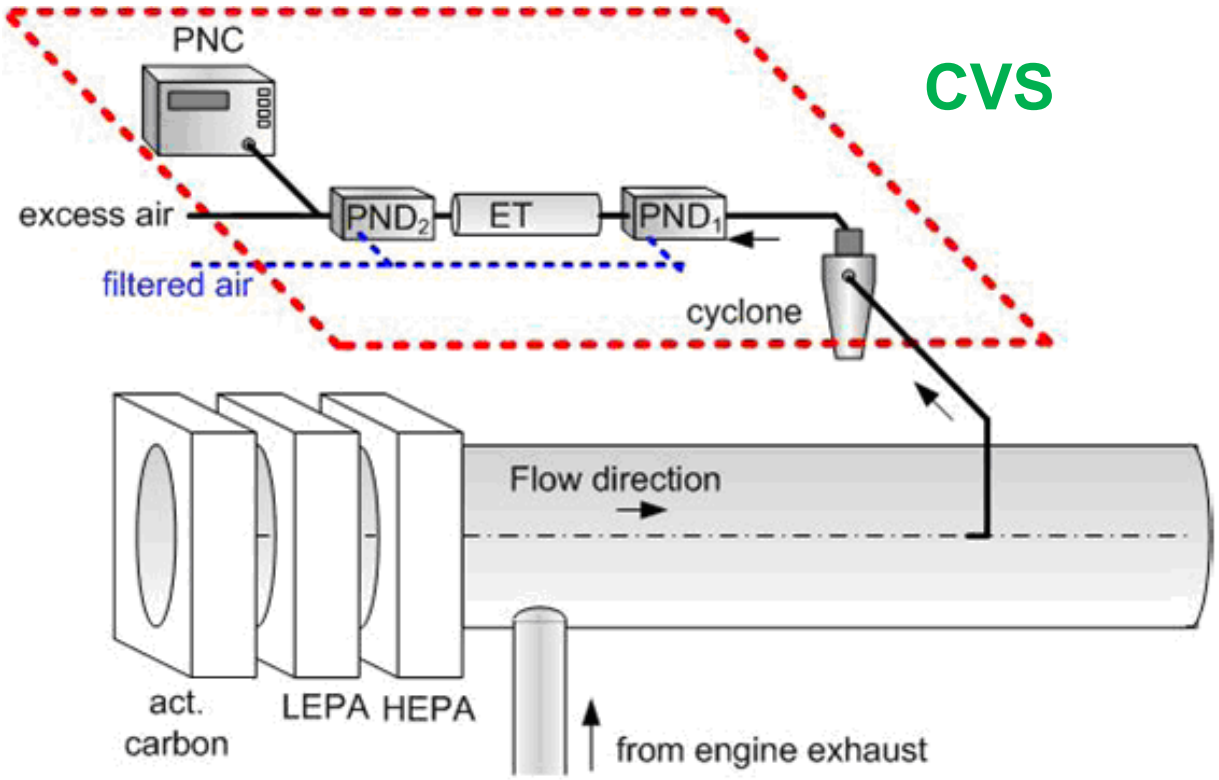
Table 1. Comparison of original LABS$_{23}$, improved LABS$_{23}$ and new (improved) LABS$_{10}$ technical specifications and calibration requirements. Dashed line separate the calibration requirements. In green improvements compared to the original regulation. In blue and italics specifications for the LABS$_{10}$ system.

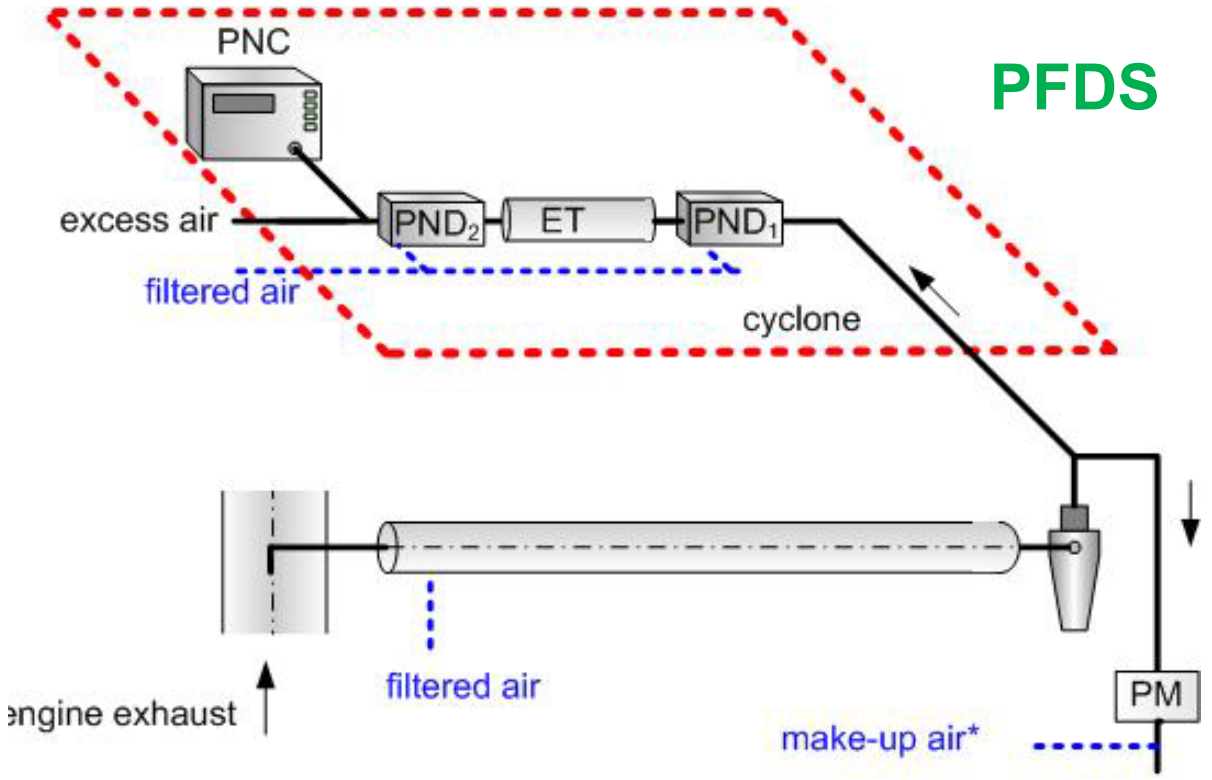
Part	SPN_{23} LABS$_{23}$ original	SPN_{23} LABS$_{23}$ improved	SPN_{10} LABS$_{10}$ (improved)
Sampling line	optional RT ≤ 3 s Re ≤ 1700	optional RT ≤ 3 s Re ≤ 1700	optional RT ≤ 3 s Re ≤ 1700
Volatile Particle Remover (VPR)	PND1 (DF ≥ 10:1) 150 ≤ T ≤ 400 (±10) °C 300 – 400 °C (recommended) No CS $T_{in,PNC}$ < 35°C	PND1 (DF ≥ 10:1) 150 ≤ T ≤ 400 (±10) °C 350 °C (recommended) May be CS $T_{in,PNC}$ < PNC specs	PND1 (DF ≥ 10:1) 150 ≤ T ≤ 400 (±10) °C 350 °C (recommended) With CS (recommended) $T_{in,PNC}$ < PNC specs
	P_{100} ≥ 70% (each instrument) $PCRF_{50}$ / $PCRF_{100}$ ≤ 1.2 $PCRF_{30}$ / $PCRF_{100}$ ≤ 1.3 - $VRE_{C40,30nm,≥10^4\ \#/cm^3}$ > 99.0% VRE yearly Thermally stable material Calibration 12 months PCRF validation 30, 50, 100 nm or polydisperse (50 nm): ±10%	P_{100} ≥ 70% (once for family) $PCRF_{50}$ / $PCRF_{100}$ ≤ 1.2 $PCRF_{30}$ / $PCRF_{100}$ ≤ 1.3 - $VRE_{C40,30nm,10^4\ \#/cm^3}$ > 99.0% VRE according to manuf. Thermally stable material Calibration 13 months PCRF validation 30, 50, 100 nm or polydisperse (50 nm): ±10%	P_{100} ≥ 70% (once for family) $PCRF_{50}$ / $PCRF_{100}$ ≤ 1.2 $PCRF_{30}$ / $PCRF_{100}$ ≤ 1.3 $PCRF_{15}$ / $PCRF_{100}$ ≤ 2.0 $VRE_{C40,≥50nm,1\ mg/m^3}$ > 99.9% VRE according to manuf. Thermally stable material Calibration 13 months PCRF validation 30, 50, 100 nm: ±10%

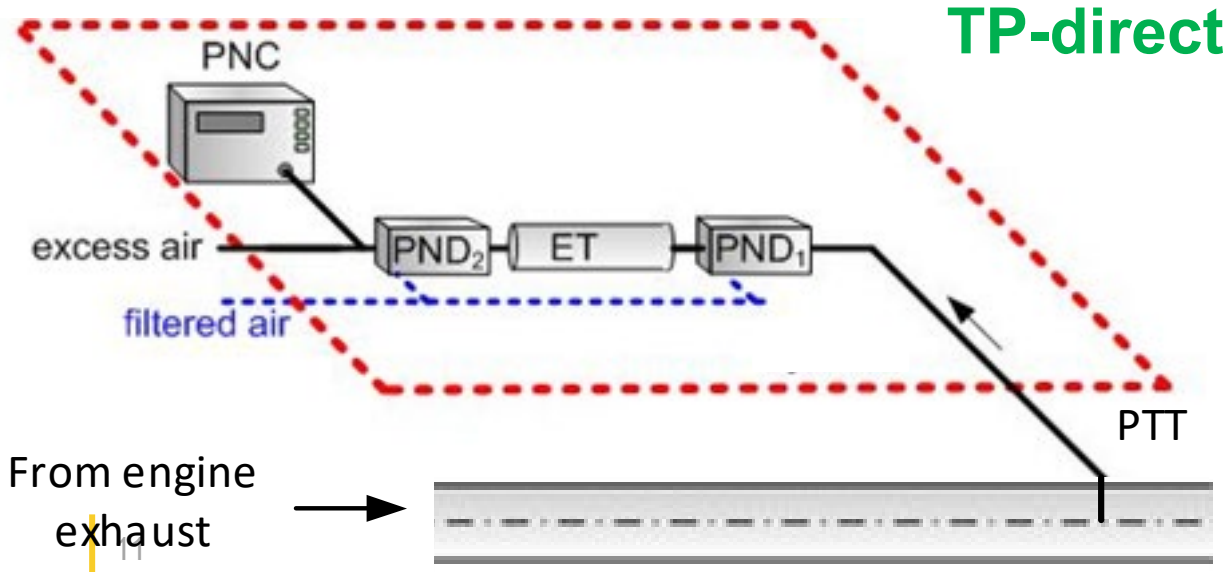
Table 1. Comparison of original $LABS_{23}$, improved $LABS_{23}$ and new (improved) $LABS_{10}$ technical specifications and calibration requirements. Dashed line separate the calibration requirements. In green improvements compared to the original regulation. In blue and italics specifications for the $LABS_{10}$ system.

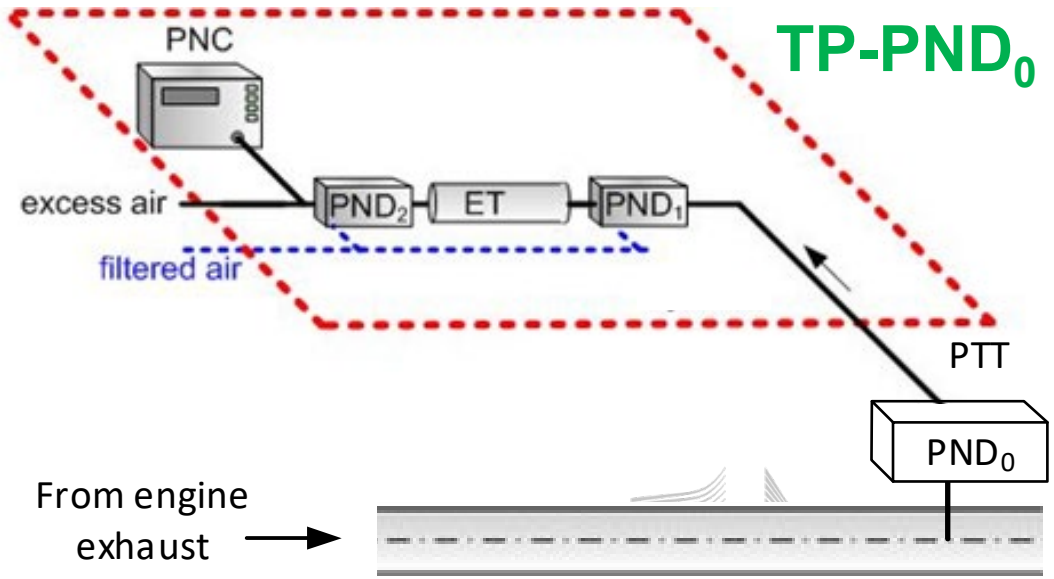
Part	$LABS_{23}$ original	$LABS_{23}$ improved	$LABS_{10}$ (improved)
Particle Number Counter (PNC)	$t_{90} < 5$ s Single counting mode Flow ±5% nominal Any material $0.9 < k_{slope} < 1.1$, $R^2 > 0.97$ Linearity ±10% $CE_{23} = 50\%$ (±12%) $CE_{41} > 90\%$ k_{slope} may be included in CE Coincidence correction <10% 6 mo monitor or wick exchange or ±10% of PNC_{Ref} or ≥ 2 PNCs Certificate 12 months	$t_{90} < 5$ s Single counting mode Flow ±5% last certificate Soot or PAO $0.9 < slope < 1.1$, $R^2 > 0.97$ Linearity ±5% from slope $CE_{23} = 50\%$ (±12%) $CE_{41} > 90\%$ k_{slope} included in CE Any internal correction 6 mo monitor or wick exchange or ±10% of PNC_{Ref} or ≥ 2 PNCs Certificate 13 months	$t_{90} < 5$ s Single counting mode Flow ±5% last certificate Soot or PAO $0.9 < slope < 1.1$, $R^2 > 0.97$ Linearity ±5% from slope $CE_{10} = 65\%$ (±15%) $CE_{15} > 90\%$ k_{slope} included in CE Any internal correction 6 mo monitor or wick exchange or ±10% of PNC_{Ref} or ≥ 2 PNCs Certificate 13 months
Combined	$PCRF_{ave}$ of 30, 50, 100 nm Total RT ≤ 20 s Ambient air: > 100 #/cm³	$PCRF_{ave}$ of 30, 50, 100 nm Total RT ≤ 20 s No error	$PCRF_{ave}$ of 30, 50, 100 nm Total RT ≤ 20 s No error

CE = counting efficiency; CS = catalytic stripper; DF = dilution factor; ET = evaporation tube; P = penetration; PCRF = particle number concentration reduction factor; PNC = particle number counter; RT = residence time; T = temperature; VRE = volatile removal efficiency; VPR = volatile particle remover.


CVS
PNC
excess air
PND2
ET
PND1
filtered air
cyclone
Flow direction
act.
carbon
LEPA
HEPA
from engine exhaust


PFDS
PNC
excess air
PND2
ET
PND1
filtered air
cyclone
engine exhaust
filtered air
PM
make-up air*


TP-direct
PNC
excess air
PND2
ET
PND1
filtered air
PTT
From engine
exhaust


TP-PND0
PNC
excess air
PND2
ET
PND1
filtered air
PTT
PND0
From engine
exhaust

Pre-diluter (PND_0)

Proposal for heavy-duty engines type approval: Sampling directly from the tailpipe with fixed dilution, optionally adding a pre-diluter.

Table 2. Technical specifications of the pre-diluter.

Specification	Description
Location	A cold or hot pre-diluter may be located at the end of the particle sampling probe and in front of the particle transfer tube (PTT). [1]
Dilution	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 ≥20 °C
Penetration	The complete system (pre-diluter, PTT, and VPR) penetration shall not decrease more than 10% the penetration requirements specified for the VPR.
PCRF	The complete system (pre-diluter, PTT, and VPR) PCRFs shall not exceed 0% of the PCRF requirements specified for the VPR for 50 nm, 10% for 30 nm, and 25% for 15 nm (if applicable).

[1] The residence time until the pre-diluter shall be ≤1 s. The tubing shall be heated at ≥150 °C if ≥10 cm

Decisions based on experimental data

- Literature review 2017 (PMP 42) [1]
- ACEA/JRC study 2019 [2]
- VETC/JRC (China) study 2020 [3]
- ACEA/JRC study 2021 [4]

The results (compared to PFDS or CVS) show a variability of ±40% (typically ±25%). In most cases positive values with the pre-diluter and negative values with the heated line concept. Better understanding is needed for temperatures at the >500°C range

[1] Combustion Engines. 2018, 174(3), 3-16. DOI: 10.19206/CE-2018-301
[2] Appl. Sci. 2019, 9, 4418; doi:10.3390/app9204418
[3] JAS 2021, 156 , 105799; doi:10.1016/j.jaerosci.2021.105799
[4] PMP meeting 1 Dec 2021 (presentation ACEA/JRC)

Procedural issue

Submissions of an informal proposal for HD raw exhaust PN sampling and extension of sub-23 nm procedure to HD engines

The PN measurement method for HD is described in UNECE Reg. 49 and not in GTR 4.

For this reason the proposal is defined as a technical document and not as an amendment to GTR 4.

Any decision on when and how this procedure will be introduced in a regulatory act will be taken later

Update on GRPE Jan 2022

PN-PEMS sub23 nm sent to RDE group (7 June 2021)

Document (uploaded: https://wiki.unece.org/display/trans/PMP+Web+Conference+15.07.2021)

PMP_Technical working document_RDE_PN measurement_03_01_2021

PN-PEMS testing for heavy duty also finalized. Results to be presented at next PMP meeting

Calibration procedures

Document: *20210430_JRC_questions_02* (uploaded: https://wiki.unece.org/display/trans/PMP+Web+Conference+15.07.2021)

Questions were sent end of March 2021, 12 replies received (OEMs and associations, instrument suppliers, institutes).

Preference for definition SPN (over PN)

Text on sub-23 nm was finalized with minor changes

Various topics to be discussed in the next PMP meeting

NON-EXHAUST PARTICLE EMISSIONS

Update on GRPE Jan 2022

GTR on brake PM & PN

Informal document: *GRPE-83-11 - (Japan, UK, EU) Request for authorization to develop a new UN GTR on brake PM and PN emissions*

ECE/TRANS/WP.29/2021/150: Authorization to develop a UN GTR on brake particulate emissions

First phase: Similar to current ToR (informal doc June 2022)

Second phase (2023-2025): Real world cycles, future technologies, Heavy-Duty Vehicles

InterLaboratory Study - Objectives

✓ Verify the feasibility and applicability of the defined minimum specifications for sampling and measuring brake emission particles (TF2 Output);

✓ Provide recommendations to the TF2 on further improving and/or extending the set of the defined specifications;

✓ Examine the repeatability and reproducibility of PM and PN emission measurements with the application of the defined specifications;

✓ Examine the repeatability and reproducibility of test conditions (i.e. speed, torque, temperature) with the application of the defined specifications;

✓ Propose alternatives that can improve the efficiency of some of the methods and specifications proposed (i.e. bedding procedure)

Hardware – Tested Brakes

	Mandatory Optional	OEM - Model	Axle	Vehicle Test Mass	Brake Force Distrib.	Nominal Test Inertia	Applied Test Inertia	Disc or Drum	Calliper Type	Pad Type	DM	WL/DM
Brake 1a	M	Ford Focus	Front	1600	71.6	56.7	49.3	Disc	Fixed	ECE	6.5	88.1
Brake 1b	M	Ford Focus	Front	1600	71.6	56.7	49.3	Disc	Fixed	NAO	6.5	88.1
Brake 2	M	Audi S4	Front	1668	68.0	58.4	50.8	Disc	Fixed	ECE	12.7	44.6
Brake 3	O	BMW X7	Front	2623	67.0	128.9	112.1	Disc	Fixed	ECE	17.3	50.7
Brake 4a	N/A	Opel Corsa	Front	1253	70.0	43.8	38.1	Disc	Slide	ECE	5.0	81.5
Brake 4b	O	Opel Corsa	Rear	1253	30.0	18.5	16.1	Drum	N/A	N/A	4.2	44.7
Brake 5a	O	VW Crafter	Front	2500	67.0	99.7	86.7	Disc	Floating	ECE	9.3	90.1
Brake 5b	O	VW Crafter	Front 90%	3390	67.0	135.2	117.6	Disc	Floating	ECE	9.3	122.1

Mandatory	Optional

Interlaboratory Study – Status on 15.12.2021

Tested Brake	Ford Focus ECE	Ford Focus NAO	Audi S4	BMW X7	Stellantis Drum	VW Crafter	VW Crafter	Repeatability	10 Trips #10 Bedding
Testing Payload	Nominal as per TF2	Nominal as per TF2	Nominal as per TF2	Nominal as per TF2	Nominal as per TF2	Nominal as per TF2	90% of Max	Nominal as per TF2	Nominal as per TF2
Lab #1	√	√	√			√	√		
Lab #2	√	√	√	√					
Lab #3	√	√	√	√				√	√
Lab #4	√	√	√					√	
Lab #5	√	√	√	√				√	√
Lab #6	√	√	√	√	√	√	√	√	
Lab #7	√	√	√	√					
Lab #8	√	√	√	√					
Lab #9	√	√	√		√				
Lab #10	√	√	√	√	√	√	√	√	
Lab #11	√	√	√	√		√	√	√	√
Lab #12	√	√		√	√	√	√	√	√
Lab #13	√	√	√						√
Lab #14	√	√	√						
Lab #15	√	√	√					√	
Lab #16	√	√	√		√				
Lab #17	√	√	√					√	√

Completed tests 65%

On-going tests 6%

Test Completed | **Test On-going** | **Not decided** | **Lab Withdrawn**

Task Force 4 – Overview

✓ TF4 aims in proposing a simplified approach for generalizing the PMP brake emissions testing procedure to electrified vehicles featuring regenerative braking (Mild-Hybrids, Full Hybrids, PHEVs, and BEVs)

✓ The TF4 group is moderated by FORD (J. GROCHOWICZ) and JRC (T. GRIGORATOS). TF4 includes 125 participants from 59 entities, worldwide – So far, an average number of 57 participants attended the meetings

✓ Nine TF4 meetings have already taken place – the group meets on a weekly basis since the beginning of November. The aim is to submit the final proposal to the PMP IWG by the end of March 2022

✓ The minutes of the meetings, technical presentations, and other material related to the testing specifications are available on TEAMS and will become available on the PMP website

Task Force 4 – Roadmap (Completed and Ongoing Items)

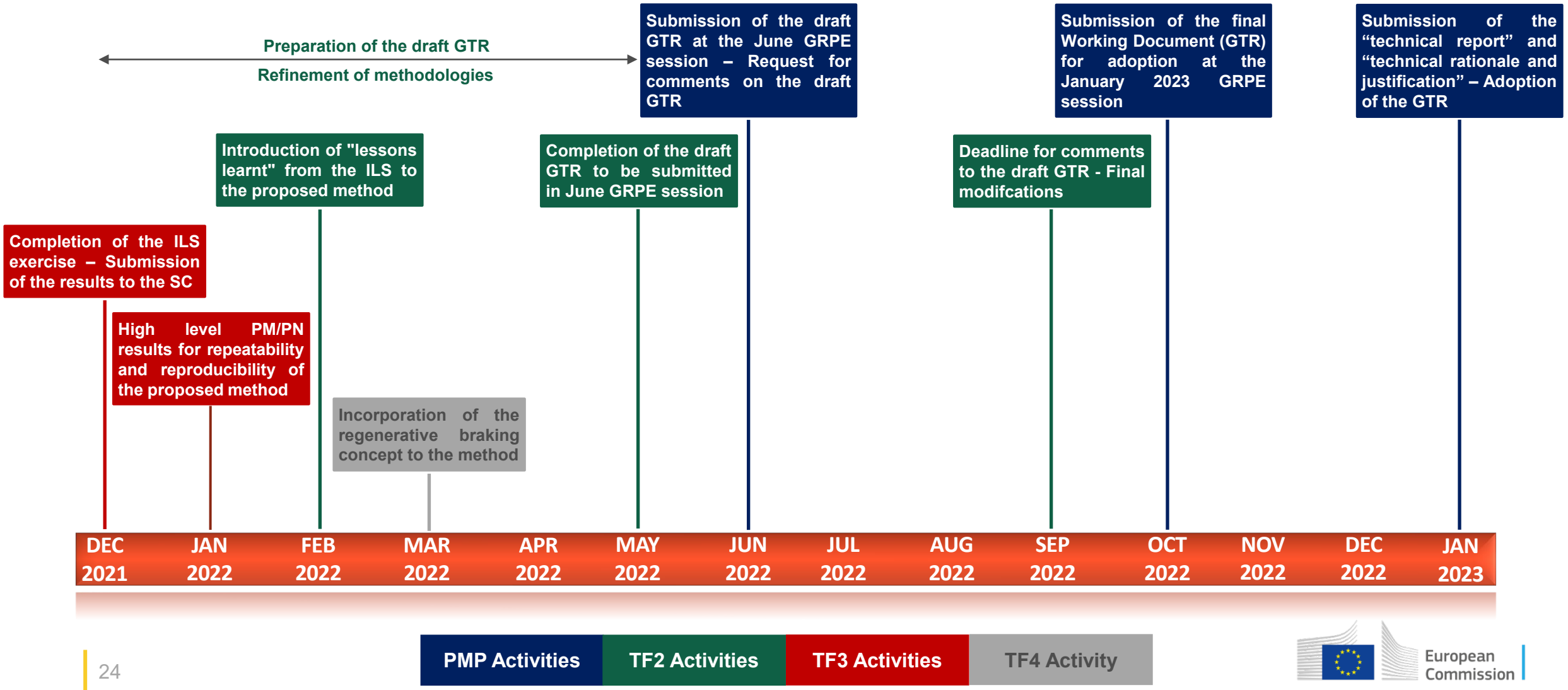
✓ High Level Approach: Brake Community in agreement with Powertrain Departments proposes a simplified methodology for testing of electrified vehicles (mild and full hybrids), relying on literature/norms for the method definition whenever possible:

- Agreement on powertrain types to be reflected in the procedure (Completed)
- Agreement on the test setup: Identical setup as for the Internal Combustion Engine (ICE) vehicles (Completed)
- Agreement on test cycle: Same test cycle as for ICE vehicles – Bedding procedure similar to that of ICE vehicles (Completed)
- Recuperation strategies must be replicated on brake dynamometer (Updated recuperation simulation algorithms designed and implemented on one dyno type). Proposal of TF4: Other dyno manufacturers follow this or a similar/equivalent dyno functionality approach (Ongoing)

✓ Team decision (UNECE PMP Group) if this is a feasible/reasonable approach

✓ Conduct a small scale measurement campaign to test robustness of the procedure

Roadmap to the GTR – Timeline



European Commission

Abrasion Rate – GRBP

✓ The GRBP (Groupe Rapporteur Bruit et Pneumatiques – Working Party on Noise and Tyres) has prioritised the development of a Tyre Abrasion Test method.

1) Method for rating tyres based on their abrasion performance

2) Quantification of microplastic emissions from tyres

3) Correlation between abrasion rate and durability of tyres

✓ A common Task Force between GRBP and GRPE will address the issue of tyre abrasion and particle emissions from tyre wear following the development of the method and in collaboration with the LEON-Project (2nd Phase – Beyond 2023).

✓ Proposal: A small group from the PMP to actively participate at the relative GRBP Working Group meetings – Expression of interest to Theo Grigoratos (Note At the PMP ToR: Only monitoring)

Keep in touch

EU Science Hub: ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub – Joint Research Centre

EU Science, Research and Innovation

Eu Science Hub

Thank you

European Commission