Informal document **GRPE-77-14**
77th GRPE, 6–8 June 2018
Agenda item 7

77th UNECE GRPE session

PMP IWG Progress Report

Geneva, 7th -8th June 2018

UNITED NATIONS

PMP meetings in 2018

- 2018-01-09: PMP 46th (GRPE Geneva summary)
- 2018-05-16/17: PMP 47th

- NEXT F-2-F MEETING: **13th/14th (tbc) November 2018** (Location: tbc)

EXHAUST PARTICLE EMISSIONS

Main open points

- Round Robin Sub-23nm
- Raw exhaust sampling
- Calibration - Round Robin PNC (Particle Number Counter)
- Horizon 2020 projects

Sub23 nm particles

- Development of a sub23nm (cut-off size:~ 10 nm) particle number measurement procedure based on the existing PMP methodology conveniently adapted.

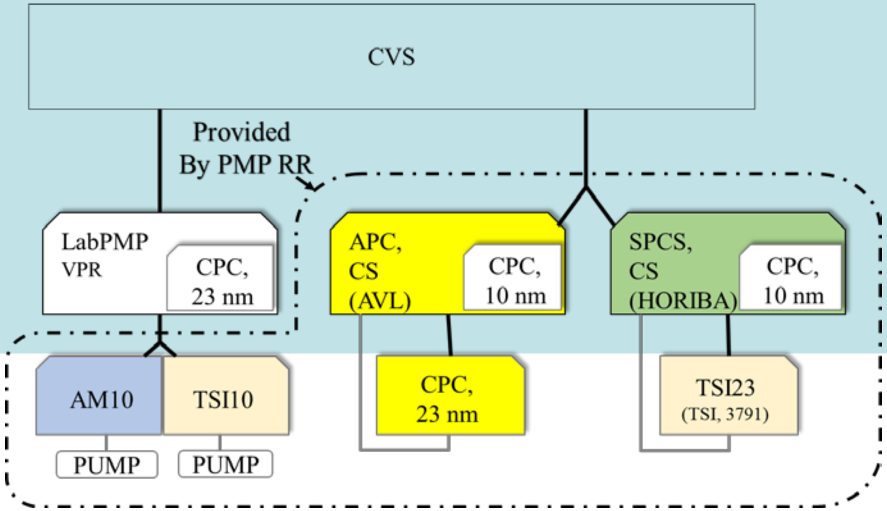
- Main purpose: Monitoring particle emissions of new engine/after-treatment technologies.

- Assessment of the repeatability/reproducibility of the proposed particle counting methodology by means of a “round robin”.

About the exercise

- Measurement of a LD GDI vehicle in 8 laboratories
- 3 cold WLTC, 5 hot WLTC, 1 steady speed test
- Objectives of the exercise is to
  - uncertainties PMP-23nm and PMP-10nm, the need of a catalytic stripper (CS) and data for sub23nm
- Two systems with CS and 10nm CPC to circulate

APC	10 and , 23 nm cut-off, CS
SPCS	10 nm cut-off, CS
AM10	10 nm cut-off LabPMP
TSI23	23 nm cut-off, SPCS
TSI10	10 nm cut-off LabPMP



About the exercise

- Measurements so far conducted in 6 different laboratories
- Switzerland and Japan to be done
- Some problems with instruments and transportation (always solved but caused some delay)

- PN10 and PN23 Data with Heated Evaporation Tube and Catalytic Stripper (CS) from all of the laboratories (CS1 or CS2)
- Until now only results from PMP vehicle (gasoline DI without GPF)

- The data shown is about variability between the laboratories

Summary

- The measurement data shows acceptable variability between the laboratories
  - CO_2 emission variability below 1 % between the laboratories (only one laboratory deviates from average)
  - The PN23 (particle diameter>23nm) data shows that the variability of current PMP-method (VPR) is at the same level as that of Catalytic Stripper-method
  - Similarly PN10 measurement variabilities are at the same level for both CS and for VPR
  - Next Steps - robustness : longer term durability of CS / efficiency checks and challenging the method also on HD engines Q4 2018

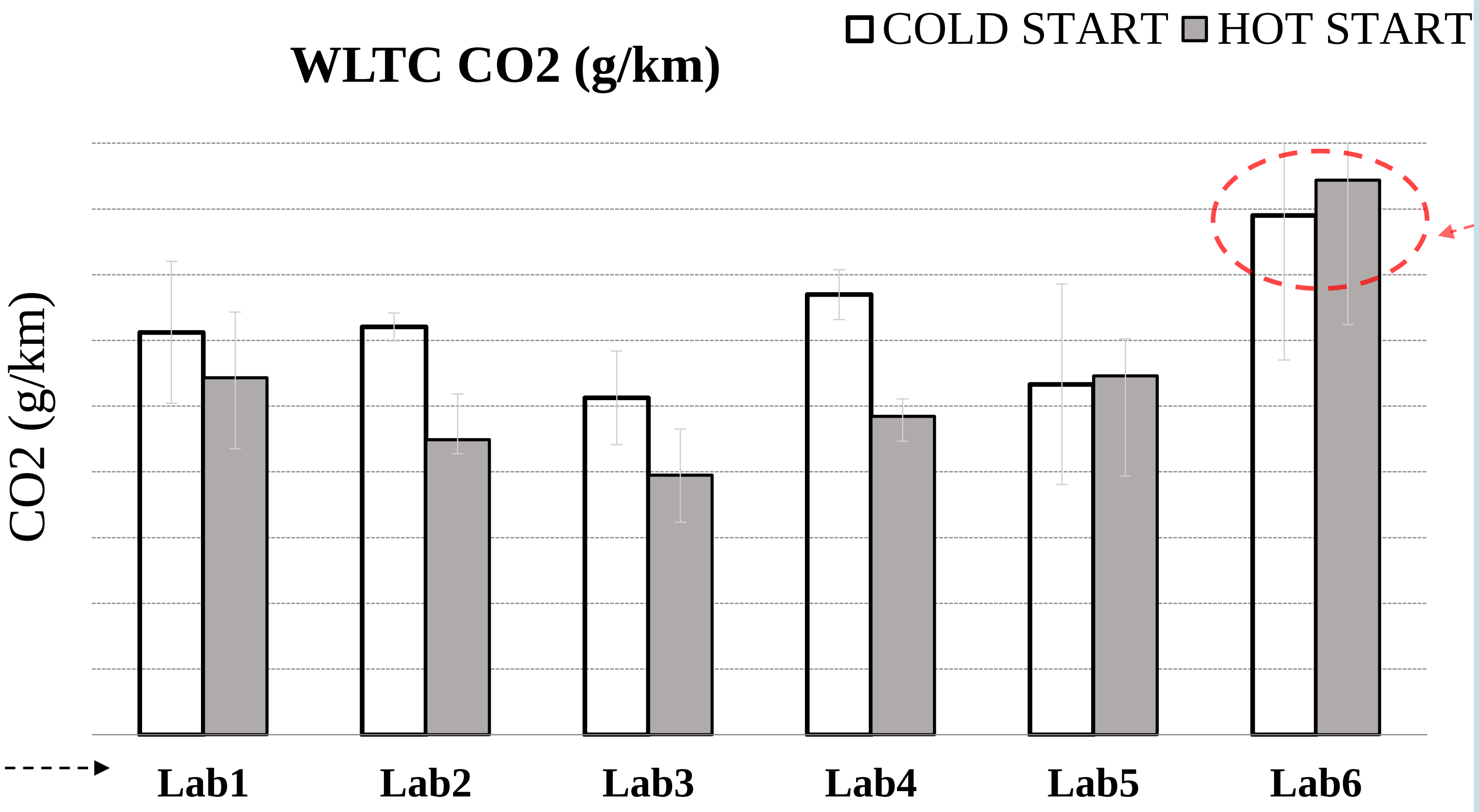
Summary

PN measurement variability between labs				
Speed/ gear	**PN23, VPR**	**PN23, CS**	**PN10, VPR**	**PN10, CS**
100/4	**11%**	**13%**	**27%**	**14%**
120/5	**6%**	**10%**	**27%**	**8%**
100/3	**4%**	**6%**	**19%**	**5%**
50/2	**5%**	**8%**	**22%**	**7%**

Measurement variability between laboratories over WLTC-cycle. The variablity between PN-emissions					
	CO2	**PN23, VPR**	**PN23, CS**	**PN10, VPR**	**PN10,CS**
HOT	**2%**	**19%**	**16%**	**19%**	**18%**
COLD	**1%**	**12%**	**12%**	**16%**	**8%**

Average CO2 emission in (WLTP)

Things to do:
recheck labs
normalization
temperature



Random order

CO2 variability, normalized to mean (100)							
	STD	**Lab1**	**Lab2**	**Lab3**	**Lab4**	**Lab5**	**Lab6**
HOT	**2%**	**100**	**99**	**98**	**99**	**100**	**104**
COLD	**1%**	**100**	**100**	**98**	**101**	**99**	**102**

Emissions normalized to mean
Reddish color |deviation| > std

PN Counting from Raw Exhaust via Fixed Dilution

- Interest in this approach confirmed by some engine manufacturers and some instrument manufacturers
- 01 Series of amendments to Reg. 132 already includes such possibility but the procedure is not defined
- Preliminary results generated by the JRC show 20% differences - Data presented by the industry during the 43rd meeting confirms good correlation

- ACEA and JRC have discussed and agreed to carry out a joint experimental programme to investigate all the open issues – Indicative timing: 4th quarter 2018

PNC Calibration Round Robin

- Draft final report finished – Uploaded on the PMP website for comments
  - Main message: soot can work well as material for calibration. Generation of soot particles critical

- Open issues:
  - o Emery oil or soot? "Academic calibration exercise" vs real world?
  - o Emery oil not suitable for the calibration of the whole system (RDE)
  - o Differences up to ±15% in the field among CPC calibrated according to the procedure (need to tighten tolerances?)

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PNC Calibration

- Options:
  1. Continue working for the improvement of the current calibration procedure to reduce the differences between PMP systems (up to ± 20% in the field)

     However impact on the existing systems and on limits should be considered

  2. Focusing the attention on the calibration procedure for systems able to measure below 23 nm

- The PMP group will prepare a roadmap in the November meeting for one or both options to be presented in the next GRPE plenary session

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HORIZON 2020 projects

- The group is monitoring the progress of the three projects funded by EU under the H2020 scheme
  - DownToTen
  - PEMS4nano
  - SUREAL-23

- These projects have the objective of investigating (nature, composition,...) sub23 nm emissions and to develop new test procedures to measure these particles
- Representative of the consortia provide regular updates to PMP group – Presentations available on the PMP website

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Gas engine testing

- Further investigations on light duty and heavy duty will be carried out during 2018

- Gas engine tested in the joint project ACEA/JRC?

Additional topics to be addressed?

In the informal meeting during the GRPE of January 2018 a few additional points were raised:

- Impact of fuel quality on PN emissions
- Effect of biofuels of different nature blended with conventional fuels on PN emissions

These topics are not included in the current mandate of PMP.

Additional topics to be addressed?

The PMP IWG has discussed in the last meeting the issue and has proposed the following approach

- First step: Literature survey and knowledge gap analysis
- Further steps to be decided on the basis of the result of the survey
- Scope of the literature survey to be defined (guidance from GRPE)
    - Engine out, tailpipe emissions or both?
    - Only light duty? (i.e. exclude motorcycles and HD ?)
    - PI, Diesel or both?
- Guidance from GRPE is welcome

NON-EXHAUST PARTICLE EMISSIONS

NON-EXHAUST PARTICLE EMISSIONS
DEVELOPMENT OF A NEW REAL-WORLD BRAKING CYCLE FOR STUDYING BRAKE PARTICLE EMISSIONS

- WLTP Database Analysis (Concluded)
- Comparison of WLTP data with Existing Industrial Cycles (Concluded)
- Development of a first version of the new (WLTP based) and backup (LACT based) braking schedule (Concluded)
- Validation of the cycles - Round robin (reproducibility assessment on different dynos) ~~(Deadline: March – April 2018)~~ (Deadline: December 2018)

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NON-EXHAUST PARTICLE EMISSIONS

DEVELOPMENT OF A NEW REAL-WORLD BRAKING CYCLE FOR STUDYING BRAKE PARTICLE EMISSIONS

- FORD has concluded the development of the schedule in collaboration with Heinz Steven
- Technical details regarding the cycle have been presented in EuroBrake 2018
- The cycle will become available to the public after its acceptance to the WEAR Journal (June 2018)

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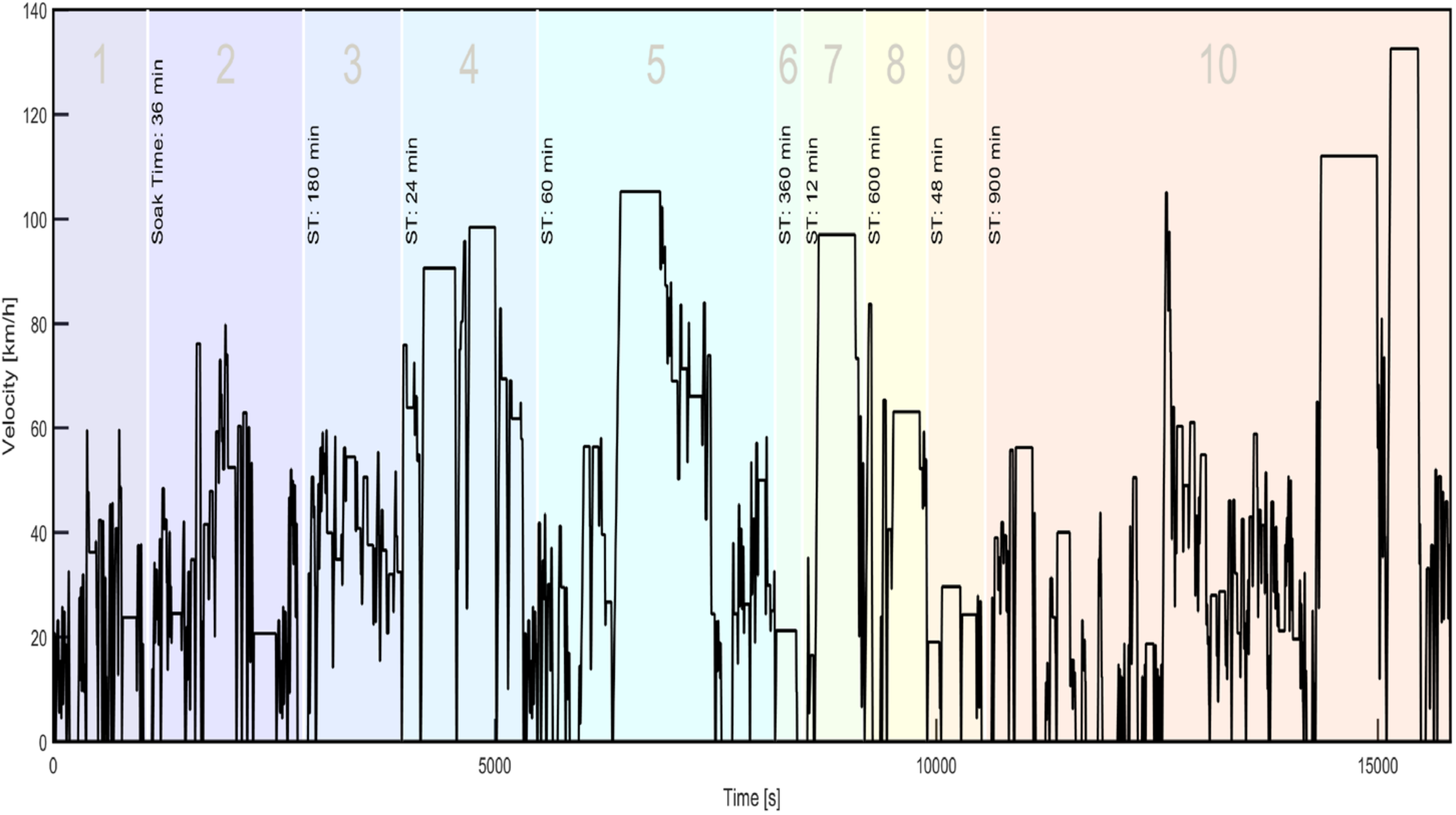
DEVELOPMENT OF A NEW REAL-WORLD BRAKING CYCLE FOR STUDYING BRAKE PARTICLE EMISSIONS

NOVEL CYCLE



- 303 stops at a distance of 192 km
- 4h 24min duration
- Average speed of 44 km/h and maximum speed of 133 km/h
- Deceleration 0.49 – 2.18 m/s^2 (mean of 0.97 m/s^2)

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BRAKING TEST CYCLE – OPEN ISSUES

- ✓ Low flow dynamometer testing will lead to higher maximum temperatures than observed in the field. How can we reproduce correct temperature levels?
- ✓ Which temperature will be achieved for other vehicles (vehicle classes)
- ✓ How to adapt cycle to other vehicle classes?
- ✓ Influence of breaks between the trips
- ✓ Temperature level and cooling influence on other test setups for emission testing

BRAKING TEST CYCLE – NEXT STEP

- ✓ A round robin has been scheduled for the next months with the purpose of validating both braking schedules in terms of temperature. All labs participating in TF1 will take part and the round robin is expected to be completed by the end of 2018

- ✓ A paper with the title ***“A novel real-world braking cycle for studying brake wear particle emissions”*** has been submitted to WEAR and is expected to be published soon

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BRAKE DUST SAMPLING AND MEASUREMENT
MAIN TASKS

- Selection of the testing methodology (Concluded)
- Comparison of existing systems/test rig configurations (Deadline: January 2018 – Concluded on-time)
- Selection/definition of testing parameters (Deadline: March 2018 – Still on-going)
- Validation of the selected configuration(s) & measurement methodologies (Deadline: To be defined depending on the progress)
- ~~Data processing method (Deadline: To be defined depending on the progress)~~

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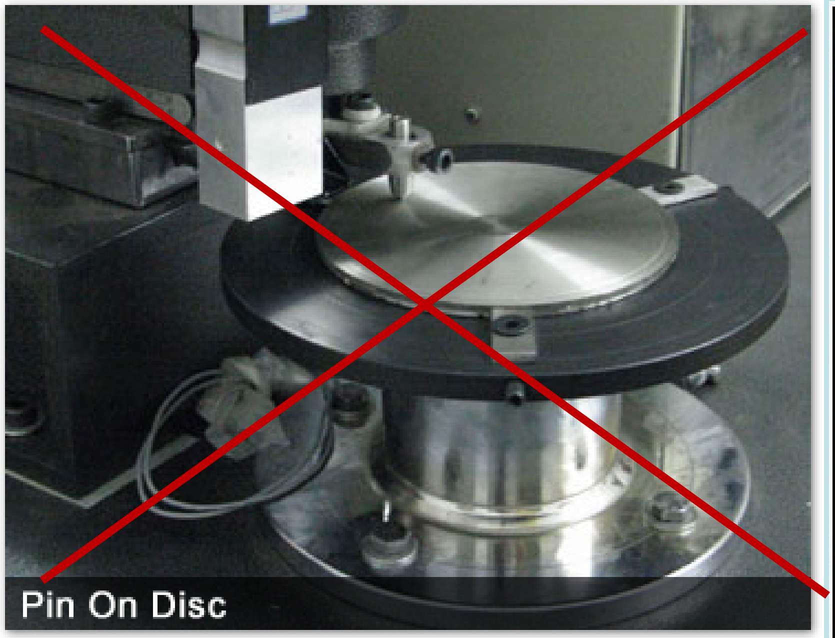
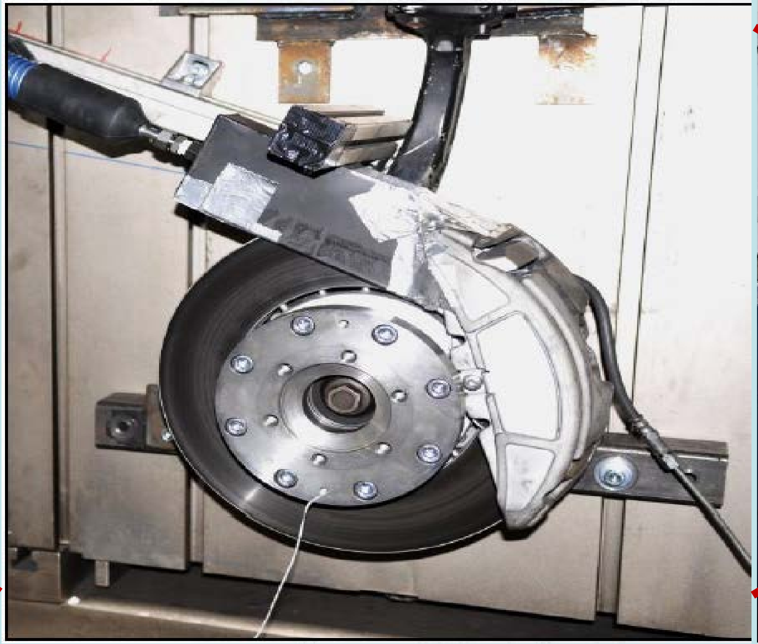
BRAKE DUST SAMPLING AND MEASUREMENT

SELECTION OF THE TESTING METHODOLOGY



Pin-on-disc



Brake dyno

Chassis dyno

✓ **Also, different on-road approaches have been employed by several researchers**

BRAKE DUST SAMPLING AND MEASUREMENT

COMPARISON OF EXISTING TEST RIG CONFIGURATIONS

Technical Specifications	JARI	TU Ilmenau	Ford	Horiba – Audi	Brembo	LINK	TU Ostrava	GM
Inlet air flowrate (Min – Max – Optimal)	Adjustable 30 – 300 m^3/h. Optimal 60 m^3/h	$PM_{2.5}$-setup: 850 m^3/h (Min: 100 m^3/h – Max: 1000m^3/h)	Optimal air flowrate value set at 250 m^3/h	Adjustable 430 – 3300 m^3/h Optimal value set at 3300 m^3/h	Adjustable 500 – 2500 m^3/h Optimal value set at 1175 m^3/h	Adjustable 250 – 2500 m^3/h	Max. 2500 m^3/h	Adjustable 630 to 4900 m^3/h. Not optimized for PM sampling
Duct diameter and geometry	Straight line. D = 84.9 mm (or 100 mm)	Horizontal π shaped duct. D = 160 mm	Vertical reverse U shaped duct . D =150 mm	90° bend CVS tunnel . D = 300 mm	Vertical reverse U shaped duct. D = 56 mm	Vertical reverse π shaped duct. D adjustable 100 – 250 mm	"C"-shaped duct. D =300 mm	Square. D =356mm

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BRAKE DUST SAMPLING AND MEASUREMENT

SELECTION/DEFINITION OF TESTING PARAMETERS

MAIN STEPS

- ✓ Define the scope based on the mandate and what is feasible to achieve with the current state of experience in the TF2 (Concluded)
- ✓ Structure the work in different thematic topics (Concluded)
- ✓ Define individual groups within the TF2 to deal with each thematic topic (On-going – to be concluded in June)
- ✓ Start collecting experimental data within the TF2 (June and onwards)

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BRAKE DUST SAMPLING AND MEASUREMENT

SELECTION/DEFINITION OF TESTING PARAMETERS

- ✓ Work structured in different thematic topics (Concluded)
- ✓ Define individual groups within the TF2 to deal with each thematic topic (On-going – to be concluded in June)

vi. What is the current status regarding these items?

- ✓ The work has been structured in 9 Chapters (document will be presented separately) based on the needs identified at the discussion for the definition of the scope
- ✓ Smaller groups have been nominated as “responsible” for drafting individual chapters (see document). Feedback from all TF2 partners will be added after the first draft of the chapters

BRAKE DUST SAMPLING AND MEASUREMENT

SELECTION/DEFINITION OF TESTING PARAMETERS

- ✓ Start collecting experimental data within the TF2 (June and onwards)
  - ➢ Data already exist from previous projects (already presented in 37th – 45th PMP Meetings)
  - ➢ TF2 members are involved in many on-going projects and more data will come from there in the near future
  - ➢ Based on this data the TF2 will define all necessary testing parameters and will come up with a minimum set of requirements for the sampling set-up and the necessary instrumentation

SAMPLING AND MEASUREMENT – Challenges

- There is a common understanding that both PM_{10} and $PM_{2.5}$ as well as PN emissions should be investigated

- Challenge: Optimal layout and sampling conditions might be different for mass and PN measurement!

- A compromise could be needed

How to take into consideration other technologies capable of reducing brake wear emissions?

- The test rig approach clearly focuses only on the brake system

- Other technologies (e.g. regenerative braking, v-2-v communication,…) may have the potential to reduce brake wear PN emissions

- How to assess these technologies?
  - The topic has been discussed in the last PMP meeting – Presentation from VDA
  - Different options have been identified (modified cycle, modified brake dynos, eco-innovation like approach, modelling…)
  - Further analysis will follow once the common methodology development is concluded

Particles from tyre and road wear

- In the 47th PMP meeting a session was dedicated to this subject

- No major developments in the field.

- JRC presented the results of a small study investigating the influence of the treadwear rating on PM/PN emissions

- The development of a standardized methodology to measure the abrasion rate is currently an option under discussion

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SCOPE OF THE EXERCISE

The aim is to explore the relevance of expected tyre durability expressed as the Treadwear Rating (TWR) for total tyre wear as well as for PM and PN emissions from the interaction between the tyre and the road surface.

iii. What is the Treadwear Rating (TWR)?

- ✓ The Treadwear Rating (TWR) provided by tyre manufacturers on the sidewall of summer tyres is a marking intended to inform the customer about the expected durability of the tyre (USA – "49 CFR 575.104 - Uniform tyre quality grading standards")
- ✓ TWR uses numbers from 100 to about 700. The higher the number, the higher the mileage that the customer can expect to drive before reaching the minimum allowed tread depth

WRAP-UP

- ✓ There is no general relation between TWR and measured tread mass loss or PM_{10}, $PM_{2.5}$ or PN concentration
- ✓ Tyres of different brands and same TWR display different wear as well as PM_{10} and $PM_{2.5}$ concentrations, thus not allowing a categorization based on the TWR
- ✓ Within the subset of two B tyres the one with lower TWR has higher tread mass loss and PM_{10} emissions. Further research with more tyres of same brand and different TWR is required to confirm the feasibility of categorization within the same brand

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WRAP-UP

- ✓ Approximately 50% (by mass) of emitted PM_{10} fall within the size range of fine particles
- ✓ Particle mass size distribution is bimodal with one peak falling to the coarse size range and another to the fine size range
- ✓ Particle number size distribution is unimodal and is dominated by ultrafine particles most often peaking at 20–30 nm
- ✓ The total tread mass loss was found to be 3-11 g/tyre resulting in a calculated wear rate of mass loss between 55–212 mg/km per vehicle*

*This does not refer to PM emissions factors BUT total mass loss of the 4 tyres

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Information Request on Tyre Activities in Contracting Parties:

- **EU 3rd Mobility Package**
- New Proposal from EC for a REGULATION on the labelling of tyres with respect to fuel efficiency and other essential parameters
- The mileage of tyres is related to their durability and life expectancy. Tyre abrasion is a major source of microplastics released into the environment.
- It is therefore proposed to consider using delegated powers to include these parameters in the future, once an appropriate test standard is finalised.
- Due to the lack of a reliable and reproducible testing method, this measure is not technically feasible at this stage. To facilitate this process, the Commission could give a mandate to CEN/CENELEC to develop such a methodology.

- Any similar activity in other contracting parties?

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Any questions?

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