

## Extended abstract for 17<sup>th</sup> ETH-Conference on Combustion Generated Nanoparticles June 23<sup>th</sup> – 26<sup>th</sup> 2013

Title: The future of Particle Measurement Programme (PMP).

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The UNECE Particle Measurement Programme (PMP) group activities since the inception of the group, focussed on development of a particle measurement system with increased sensitivity over the long existing particulate matter mass measurement system. A PMP measurement protocol was developed to complement the well-established particulate mass measurement; it consists of measuring the particle number after two dilution stages and a thermal treatment of the sample in order to remove the volatile particles and reproducibly counts only the non-volatile particles with a diameter larger than 23 nm. This protocol proved to be a robust and sensitive method to discriminate between high and low efficiency Diesel Particle Filters (DPFs) allowing to effectively regulate the emission of soot particles from DPF equipped diesel cars. However the absence of a filtration system could lead to the emissions of non-volatile particles with diameters smaller than 23 nm.

This first phase of the Particle Measurement Programme concluded with the developed and adoption into UNECE Regulations 83 (light duty emissions) and 49 (heavy duty emissions) of the particle number (PN) counting method, together with enhancements to the particulate mass (PM) measurement procedure.

The PMP particle counting methodology has been extended also to spark ignition vehicles for which now also emission standards based on particle number have been set. Among the different types of spark ignition vehicles the Gasoline Direct Injection (G-DI) cars have demonstrated the fastest market penetration in the last decade and the latest scenarios predict a share of G-DI in new registered gasoline vehicles in Europe that reaches 50% in 2015.

The European Union (EU) has then requested further investigation with a focus on particle number emissions from spark ignition engines relating to particle size (reduction of the d50 cut off specification) and to emissions under rich operation conditions.

A Terms of References (ToR) of the informal UNECE PMP group was presented during the June 2013 GRPE meeting in Geneva. As a general approach, the scope is

intentionally kept as wide as possible but the work programme will be limited to specific items.

It was also agreed that a prolongation and extension of the mandate of the group, in relation to the development and validation of new test procedures, should be considered in due time by GRPE (e.g. in relation to PN measurement systems compatible with PEMS or tyre / brake wear).

The existing scope of PM and PN measurements have to be adapted to technical progress as appropriate. At the moment it is not foreseen that further major technical adaptation is required for PM measurement. While for PN measurement the following issues will be addressed:

- (1) Existing PMP PN measurement equipment cut-off (d50) reduction.
- (2) Investigate the size distribution of particles emitted by positive ignition and compression ignition engines/vehicles.
- (3) Determine whether there is a clear need to revise the lower particle size d50 of the PMP of 23 nm.
- (4) If so, determine appropriate revised d50 and develop practical / appropriate measurement methodology and revise PN limits.
- (5) Determine whether light duty diesel regeneration measurements can be accurately, reliably and reproducibly performed using the new cut-off size.
- (6) Extension of the scope to particles emitted during regeneration (LD).
- (7) Extension of the scope to non-road mobile machinery.

The next PMP meeting will be held in October 2013 with the objectives of defining the details of the research work needed to address the identified issues and start organizing the experimental work.

JRC contribution to the PMP group will focus on the coordination of the working group making available the tests facilities and the activation of bilateral cooperation.



# The future of Particle Measurement Programme

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## Conclusions (PMP phases 1-3)

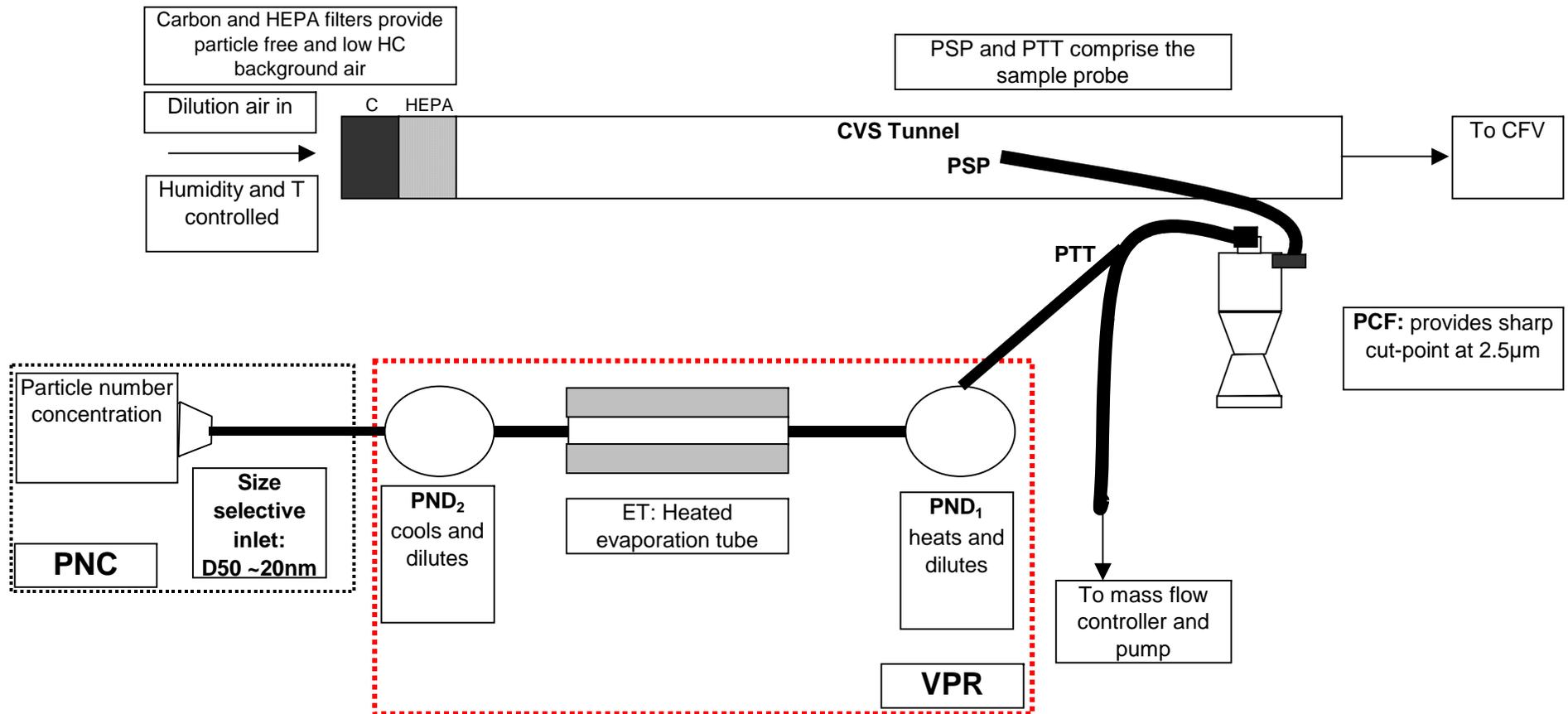
### 1. Improved Particulate Mass Measurement

- Dilute exhaust sampling with HEPA & HC filtered dilution air
- Cyclone pre-classifier
- Improved sample temperature control 47 +/-5 C
- Deletion of back-up filter

### 2. Introduced Solid Particle Number Count

- Dilute exhaust sampling with HEPA & HC filtered dilution air
- Cyclone Pre-classifier
- **Sample thermal conditioning:**  
heated dilution, evaporation tube, dilution
- Condensation Particle Counter **23nm** ( $d_{50}$ )

# The 'big picture'



## Scope

One of the main objectives of Euro 5/6 was to force the adoption of the best available technology to reduce particulate emissions

By means of:

- A simple and robust procedure
- With good repeatability and reproducibility
- And limited investments in terms of measuring equipment

## The New Terms of Reference (ToR)

- In the GRPE meeting of January 2013 it was agreed that a new mandate and a new ToR are needed
- A meeting has been held on the 16<sup>th</sup> May in Brussels to discuss the draft ToR version
- The “final” draft version was presented at the UNECE June GRPE meeting





## Terms of Reference (ToR)

- As a general approach, the scope is intentionally kept as wide as possible but the work programme will be limited to specific items
- All engine/vehicle categories should in principle be included
- A prolongation and extension of the mandate of the group, in relation to the development and validation of new test procedures, should be considered in due time by GRPE (e.g. in relation to PN measurement systems compatible with PEMS, tyre / brake wear,...)

## Terms of Reference (ToR) – Scope

- i) Particulate Matter Mass (PM) exhaust measurement
- ii) Particle Number (PN) exhaust measurement
- iii) Measurement Equipment
- iv) Calibration Guidelines
- v) Investigations



## Terms of Reference

i) Particulate Matter Mass (PM) exhaust measurement

Existing scope of PM mass measurements to be adapted to technical progress as appropriate - It is not foreseen that further major technical adaptation is required in the near term.

## Terms of Reference

### ii) Particle Number (PN) exhaust measurement

(1) Existing scope of PN measurements to be adapted to technical progress as appropriate.

(2) Extension of scope to

➤ Particles emitted during regeneration (LD)

➤ Non-road mobile machinery

*Issues to be addressed: Variability and emission levels of non-road engines over the range of size and for the different test cycles*



## Terms of Reference

### iii) Measurement Equipment

#### (1) Existing PMP PN measurement equipment d50 reduction

- (a) Investigate the size distribution of particles emitted by positive ignition and compression ignition engines/vehicles
- (b) Determine whether there is a clear need to revise the lower particle size d50 cut-off of the PMP of 23 nm
- (c) If so, determine appropriate revised d50 and develop practical / appropriate measurement methodology and revise PN limits
- (d) Determine whether light duty diesel regeneration measurements can be accurately, reliably, repeatably and reproducibly made using the new cut-off size.

*Issues to be addressed: Impact on measurement equipment, test procedures, calibrations,...*

## Terms of Reference

iv) Calibration Guidelines

(1) Update of existing calibration guidelines

v) Investigations

(1) Investigate the nature (solid or volatile) of exhaust particles emitted by positive ignition vehicles

(2) Compile and summarise the current knowledge regarding the physical nature and size distribution of particle emissions from brake and tyre wear.



# Work Programme

(1) NRMM – Investigation of the emission levels and variability for different engine size/power categories and over different cycles

- Priority: high
- Timing: Not possible to start before 2014 (availability of engines, definition of test protocol, availability of laboratories...)

(2) Emission of particles below 23 nm from light duty vehicles

- Priority: high
- Timing:
  - State of the art of knowledge and gap analysis (Sept 2013)
  - Definition of an experimental programme to address the identified issues (Oct 2013)



## Work Programme

(3) Monitoring of the progress of projects working on calibration procedure

- Priority: high
- Timing:
  - ISO 27891: Calibration of particle counters - a draft should be available early 2014
  - FP7 EMRP ENV02 project (2011-2014)

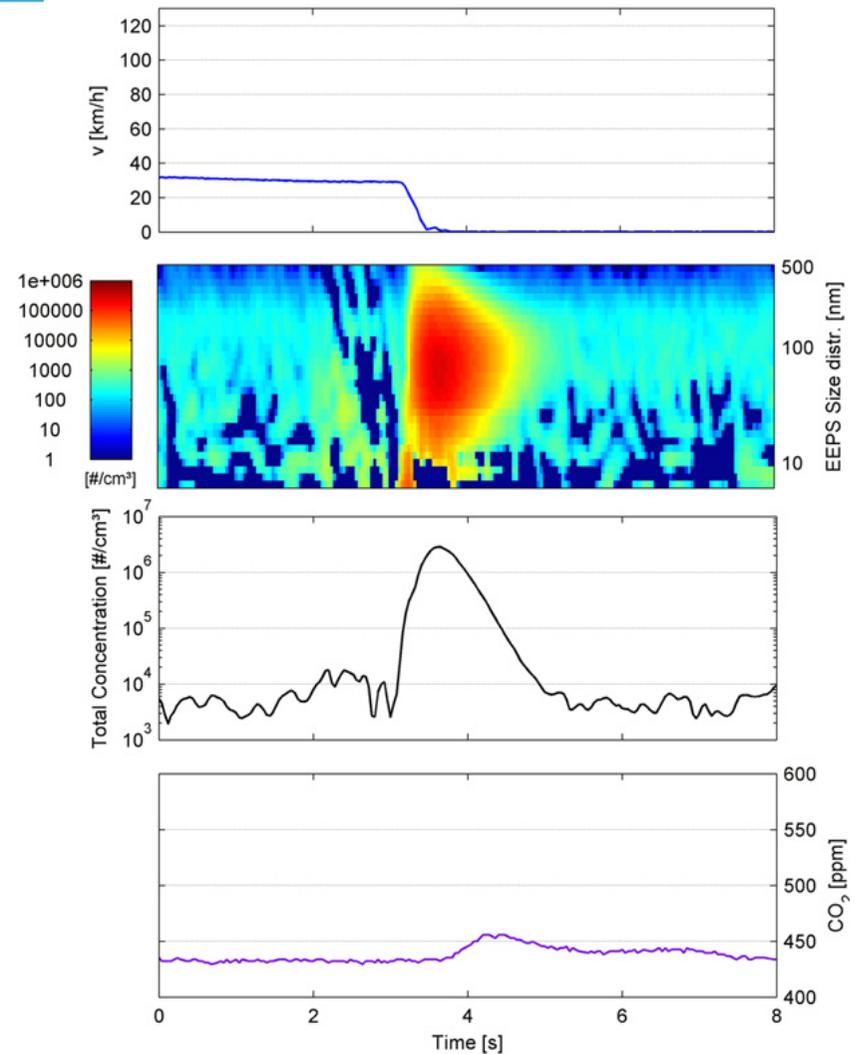
(4) Investigation of repeatability of PM mass / PN measurement from direct injection PI vehicles equipped with GPF especially during active regeneration

- Priority: Low
- Timing: When sufficient vehicles on the market

## Work Programme

(5) Literature survey to summarise the current knowledge regarding the physical nature and size distribution of particle emissions from brake and tyre wear.

- Priority: Medium
- Timing:
  - Literature survey to be completed within 2013





## Next Step

New PMP meeting to be held in October 2013 with the following objectives:

- Define the details of the research work needed to address the identified issues
- Start organizing the experimental work (**who does what**)

## JRC contribution

- Coordination of the working group
- Make available the tests facilities
- Activation of bilateral cooperation



**Thanks for yours attention!**