Feasibility report on the on-road measurement of particle number emissions from passenger cars and if applicable draft regulatory text

The European Regulation (EC) 715/2007 as amended by Regulation (EC) 459/2012 requires the application of a complementary test procedure assessing the real-driving Particulate Number (PN) emissions of vehicles at type approval as from 2017. PN emissions should be determined using portable equipment during on-road vehicle tests, according to the general rules for the Real Driving Emissions (RDE) test procedure.

In this respect, the DG-ENTR and JRC have published a call for "Participation in the development of a test protocol to measure PN emissions on-board of light-duty vehicles for type approval using Portable Emission Measurement Systems (PEMS)". Several major instrument manufacturers expressed their interest to participate and joined the exercise, aimed at evaluating the possibility to extend the RDE procedure to particle number.

JRC is coordinating the PN-PEMS programme whose aim is to assess whether the PN-PEMS equipment is suitable for measurements against a regulatory emission limit of $6 \cdot 10^{11}$ km^{-1}. In this case, the European Commission will proceed to the full integration of PN emission measurements into the general regulatory RDE test procedure.

The following slides have been presented by JRC at the PN-PEMS Expert Group audio-web meeting on the 28th October 2014. JRC reported the work performed on the vehicle emission test cell of VELA (Vehicle Emission LAboratory) to assess the performances of PN-PEMS candidate instruments and presented the roadmap for the second phase of the PN-PEMS project which is taking place at JRC in November –December 2014 and will be followed by a Round Robin (inter-laboratory comparison) exercise which involves several vehicle OEMs across Europe in early 2015. The aim of the second phase of the PN-PEMS project is to complete the assessment of the candidate instruments for the measurement of PN according to the RDE test procedure and to develop a PN-PEMS technical measurement procedure.

PN-PEMS Progress Update

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The regulatory framework /1

Regulation No 715/2007

The Commission should keep under **review** the need to **revise** the **New European Drive Cycle** as the test procedure that provides the basis of EC type approval emissions regulations. Updating or replacement of the test cycle may be required to reflect changes in vehicle specification and driver behaviour. **Revisions** may be necessary to **ensure** that **real world emissions correspond** to those **measured at type approval**. The use of **portable emission measurement systems** and the introduction of the 'not-to-exceed' regulatory concept **should also be considered**.

The regulatory framework /2

Regulation No 459/2012

Attention shall be given to the **particle emissions** of **positive ignition vehicles** under **real driving conditions** and the development of respective test procedures. The Commission should develop and introduce corresponding measurement procedures at the latest **three years after** the entry into force of **Euro 6**.

The impact

- *Euro 6 standard on particle number (PN) for gasoline direct injection vehicles (GDIs):*

  September 2014 $6x10^{12}$ p/km

  September 2017 $6x10^{11}$ p/km.

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- *Possibility of compliance through improvements in the combustion process without the need of Gasoline Particulate Filter (GPF).*

- *The introduction of a Real Drive Emission (RDE) test procedure for PN might require the installation of GPFs to comply with the new complementary test procedure.*

Real Drive Emission tests

1 - Emissions testing with random driving cycles in the laboratory

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2- On-road emissions testing with Portable Emissions Measurement Systems (PEMS)

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Call for expression of interests

Development of a test protocol to measure Particle Number (PN) on board of light-duty vehicles for type approval testing using Portable Emissions Measurement Systems (PEMS)

Phase I - feasibility study

Aim

Assess and **validate** the application and **performance** of portable PN instrumentation relative to each other and to a reference.

Evaluation criteria

- **Linearity** of the portable PN system with the reference system under controlled laboratory conditions (**chassis dyno tests**)

- Performance of long sampling on-board

Experimental setup

- **5 candidate PN-PEMS instruments**
- **5 vehicles** (3 GDI, 1 MPI and 1 Diesel w/DPF)
- **4 cycles** (NEDC, WLTP, RDE, ARTEMIS) + 3 Steady States at 8°C and 23°C
- **~ 120 chassis dyno tests**

Comparison of PN-PEMS (all in parallel) with PMP @CVS (reference)

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- **On-road tests** (1 GDI vehicle)

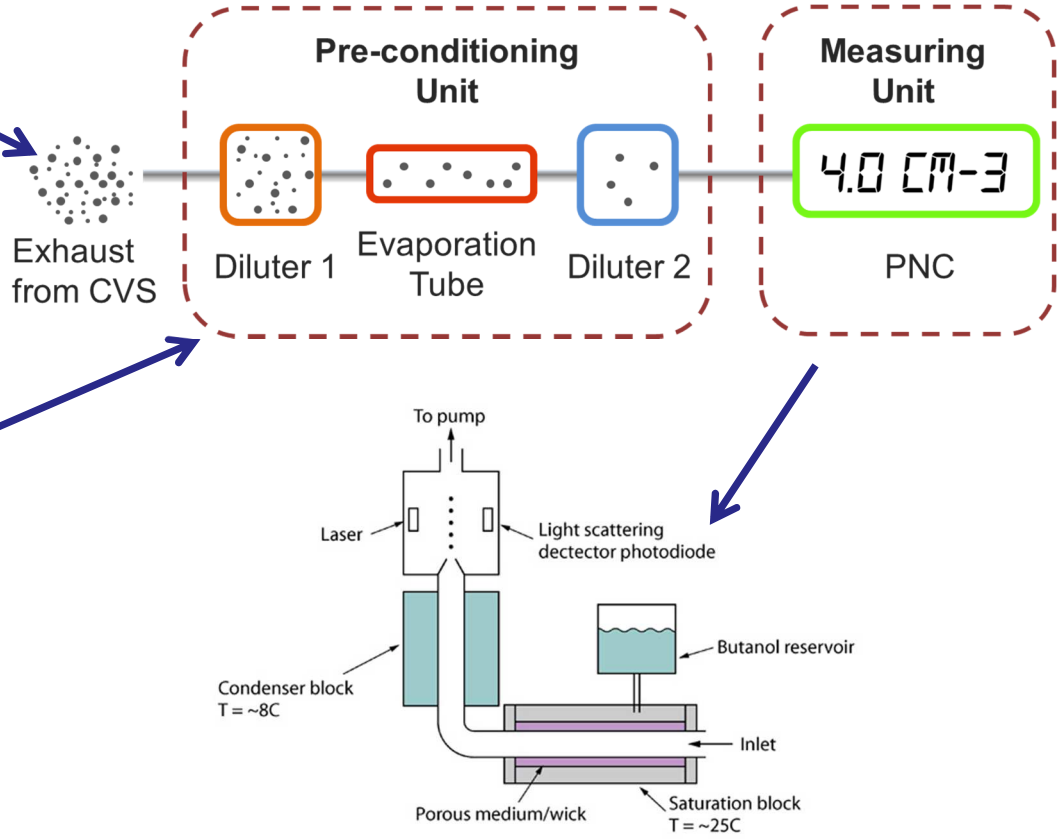
  4 PN-PEMS candidates (1 at a time) +

  1 Reference candidate instrument always on board +

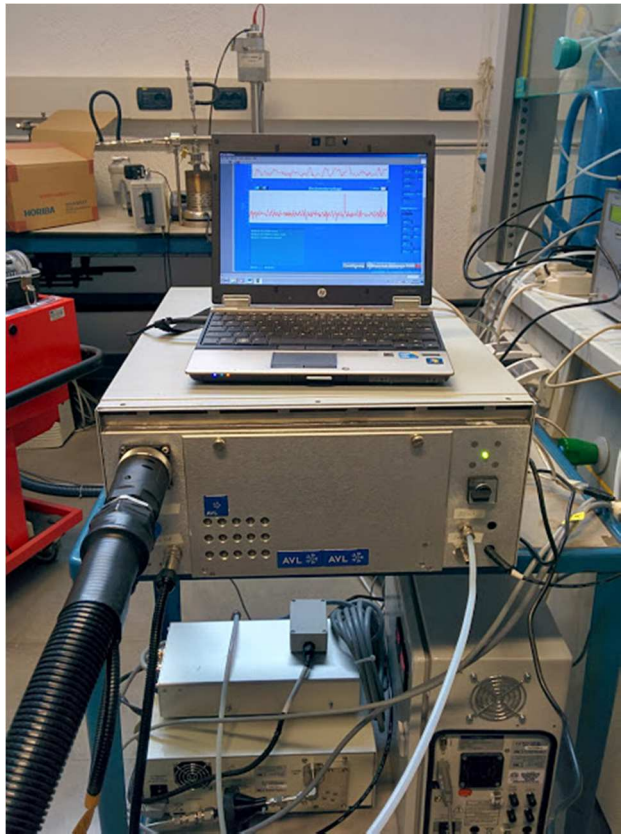
  1 Gas-PEMS

  Two types of tests: 1 and 2 hour long

The reference: PMP system

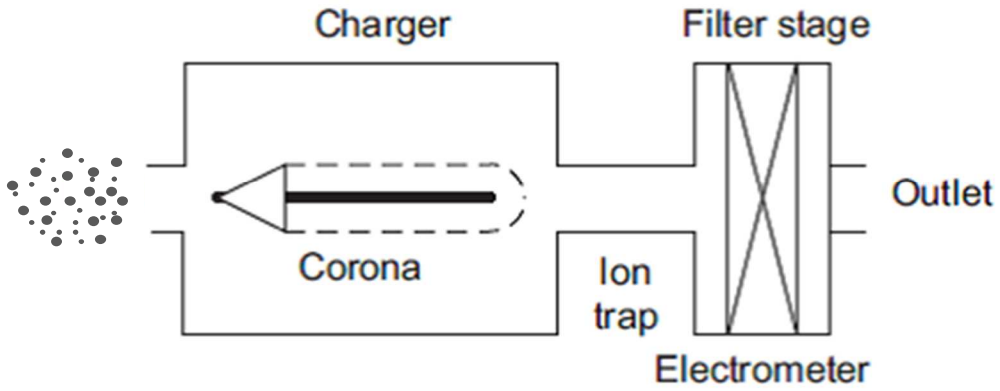


Candidate PN-PEMS systems

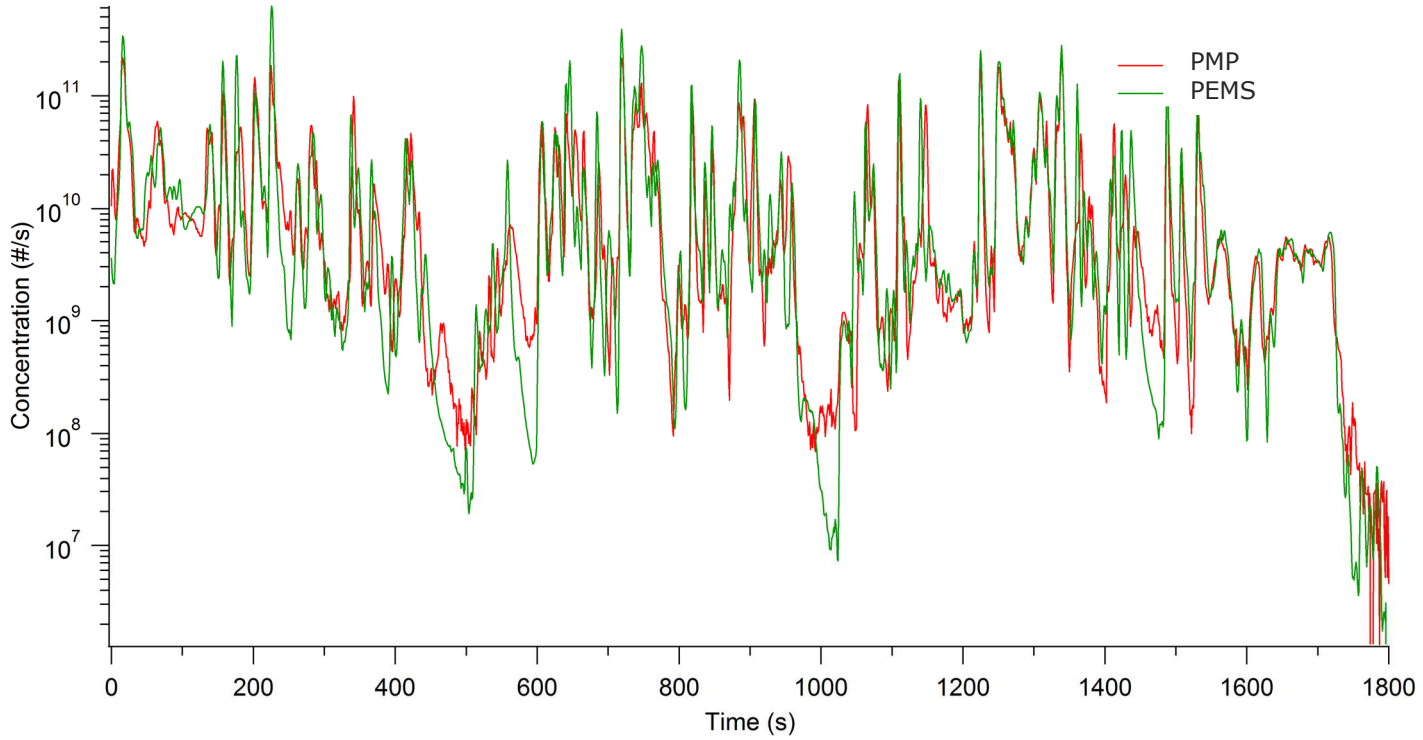


5 instruments (3 on market + 2 prototype)

All based on diffusion charging principle

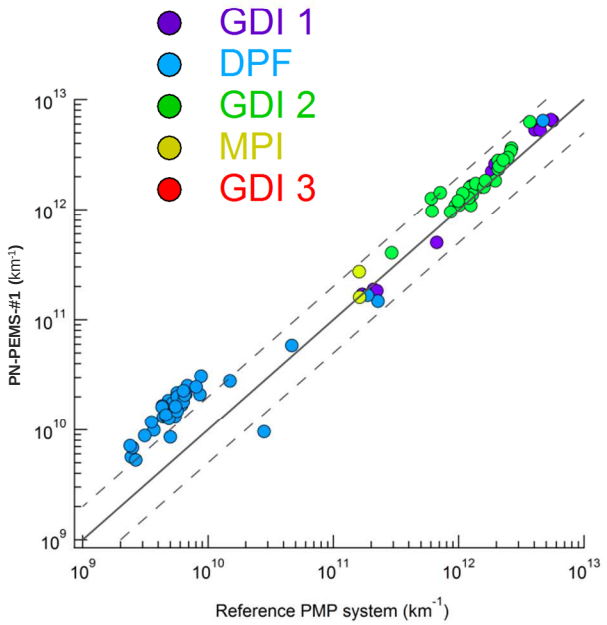


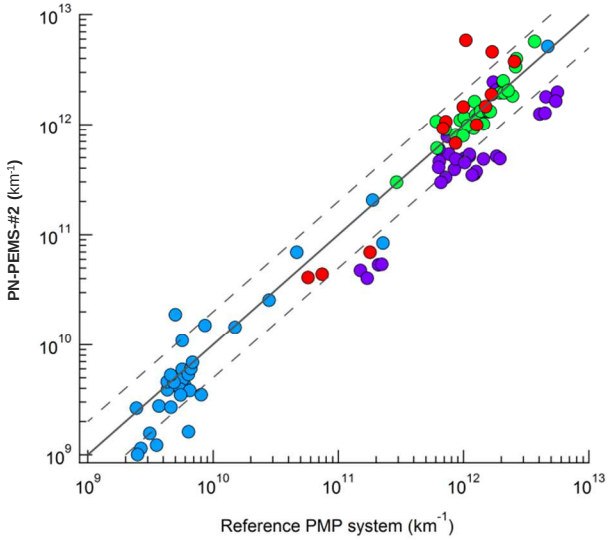
PMP vs PN-PEMS times series (log scale)

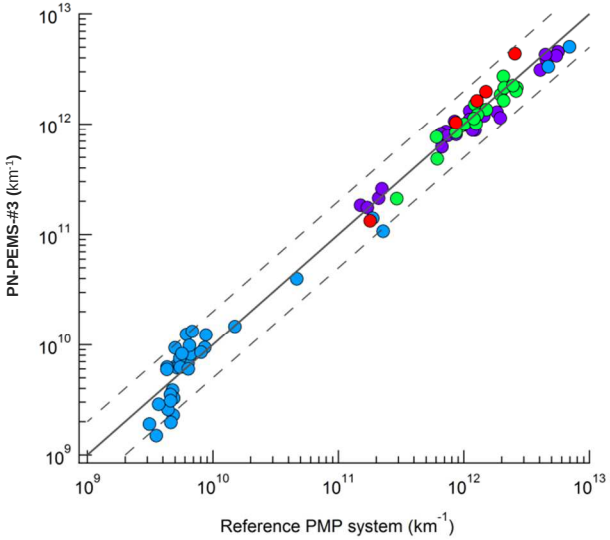


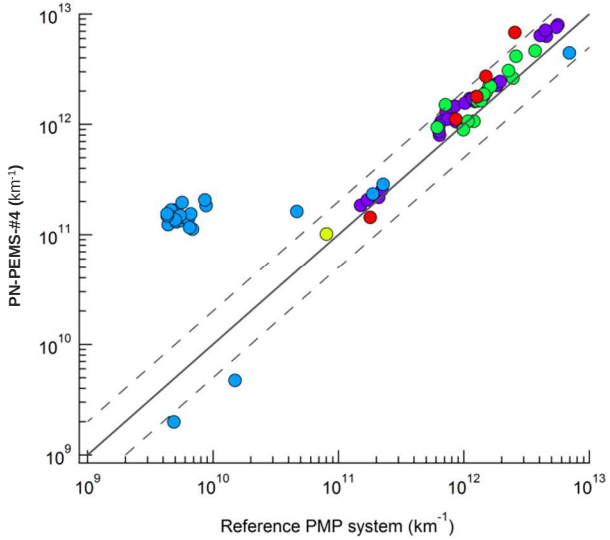
Unavoidable time misalignment due to **different response time** of the systems and **time delay** between tailpipe and CVS: Reported results are cycle average emission factor **#/km**

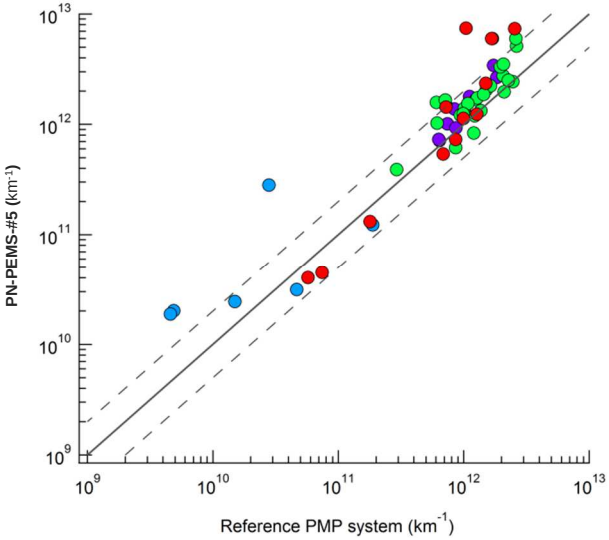
PN-PEMS vs PMP











Current best case:
PN-PEMS vs PMP @ CVS
95% data points
fall within
+100% -50%

Conclusions of Phase I

- *Diffusion charging resulted in a promising alternative to CPCs for PEMS measurements*

- *The estimated measurement variability is 2, due to different measurement principle and different sampling points*

- *Draft of the technical specifications for PN-PEMS*
  - *thermal treatment based on PMP*
  - *efficiency requirements still allow CPCs*

Phase II

Distributed documents:

- *Experimental plan for Phase II of the PN-PEMS project.*
- *The technical specification for the PN-PEMS.*
- *JRC Laboratory PN-PEMS Calibration Report: describing the calibrations of the prototypes PN-PEMS, the suggested calibration procedures and some results with the next generation PN-PEMS.*

Comments expected by 15th September.

Phase II

- ***Stage 1**: Calibration of the instruments in laboratory (CW 41-44).*

Instrument manufacturer's calibration will be checked at JRC applying the calibration procedure as defined in the laboratory calibration report

- ***Stage 2**: Validation of calibration on chassis dyno (CW 45-46).*

Proposal: comparison of PN-PEMS and PMP particle counter distance specific emission rate at CVS over a hot WLTC. Maximum allowed deviation to be defined. Maximum adjustment of instrument's manufacturer calibration is under discussion.

Phase II

- ***Stage 3**: Inter-laboratory comparison exercise (starting CW 47).*

Installation of at least one golden PN-PEMS on one golden vehicle. Al least the following tests will be performed at JRC and at the OEMs or technical services that want to participate to the exercise

- *1 x NEDC cold*
- *1 x NEDC hot*
- *2 x WLTC hot*
- *2 x on-road tests following the general RDE test procedure: minimum 90 min, distance divide as 1/3 urban (<60 km/h), 1/3 rural (60-90 km/h), 1/3 motorway (>90 km/h).*

The objective is to allow the OEMs to get familiar with the PN-EPMS instruments and with the installation/measurement procedure. If enough laboratories participate and data are collected consistently, repeatability, reproducibility and long term stability of PN-PEMS will be assessed

Thanks for your attention!