ABSTRACT
Due to the carried out results the different working groups of the PMP recommend for the upcoming EURO V and VI type approval for particle measurements a counting system based on a dilution system and a nucleous condensation particle counter CPC. Newer investigations showed that a thermo diluter instead of thermo absorber combinations should give the most reliable results. The next step will be a comparison of existing CPCs / SMPS systems and definitions for the most reliable system configurations. The portable Grimm CPC 5.403 and Grimm SMPS+C has proven its reliability in different measurement campaigns. Most of the specifications coming from the users are already integrated in the easy to handle measurement system.

- Validation to the existing measurement standard: CPC – Efficiency test to a reference
- Easy setup and low maintenance with different measurement modes (standard and expert)
- Autocontrolling system with integrated intelligence for monitoring and recording of the operation conditions
- Long term stability with automatic condensate drain off between saturator and condenser to avoid uncontrolled efficiency loss
- Range control system to avoid measurements below the detection limit
- Transportability for so called “real life” on road measurements

DEMANDS & EXPERIENCES
Several measurements at engine test rigs and dynamometers showed always the same requirements from the end user.

1) Reproducibility / repeatability and stability
   (more than absolute correctness and sensitivity)

2) Robust, easy „plug & play“ handling - low preparation time and reliable during all-day handling

3) Defined sampling / measurement method

4) Selfchecking / calibration

5) Others (mobile application, onboard diagnostic, etc.)

SUMMARY & OUTLOOK
The Grimm CPC and SMPS+C showed in field tests high quality measurements combined with easiest handling.

- Grimm CPC 5.403 is a reliable instrument with comparable results to equal instrument types
- Easiest handling and compact / robust system
- With rot. disk diluter MD19 fast plug and play setup for reproducible AND repeatable results

In future the CPC will be integrated in a complete “PMP” unit with sampling, measurement and a operating software for standard exhaust measurements.
Field Experience with portable SMPS+C system on Diesel Test Stands
(Fast Sequential Mobility Particle Sizer + Classifier)
Field Experience with portable SMPS+C system on Diesel Test Stands

Contents

1. Incentive
2. Demands & Experiences
3. Summary & Outlook
4. Further Demands
Field Experience with portable SMPS+C system on Diesel Test Stands

Contents

1. Incentive
2. Demands & Experiences
3. Summary & Outlook
4. Further Demands
1. Incentive

PMP (GRPE):

Phase II:  
Evaluation of particle measurement systems (potential candidates for use in a regulatory role).

Recommendation:

\textit{particle counting with (rotat./thermo) Diluter + CPC}

For detailed size information: CPC + DMA

Phase III:  
\textit{testing programm and validation of candidate systems}

Demands on a standard measurement technique / system
Field Experience with portable SMPS+C system on Diesel Test Stands

1. Incentive

Example for a PMP Nanoparticle Counting system

CPC 5.403 / SMPS+C / MD19
Nanosizer / rot. Disk Diluter

Raw Gas

Tailpipe
Field Experience with portable SMPS+C system on Diesel Test Stands

Contents

1. Incentive
2. Demands & Experiences
3. Summary & Outlook
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Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

Repro. & Stability

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Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences
Repro. & Stability

![Graph showing transient data with High resolution: 2. Gear, 3. Gear, 4. Gear]

Partikelanzahl ges. [P/ccm]
Zeit t [sec]

Reproduc. Cycles

Transient 1
Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

Repro. & Stability

CPC 5.403: Full Automatic Stand alone System
(with internal CPU & PCMCIA interface)

- Integrated Alcohol Tank with automatic supply
- Automatic DMA control for up to 255 channels
- Automatic system status control and recording
- Digital Board + Slot for Memory Cards
- Automatic Condensate Drain Off
- Temperature Automatic (for Saturator / Condenser)
- Air-Flow Pumps with automatic flow control
- fleece inside

External PC: only for start-parameter and receiving measured data (from internal counter memory)
Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

robust & reliable

1) Reproducibility / repeatability and stability
   (more than absolute correctness and sensitivity)

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   and reliable during all-day handling

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Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

robust & reliable

Setup takes in this version less than 10 minutes until the first measurement
2. Demands & Experiences

**Reliability: Water Condensation Problem:**
(condensation of humidity in the CPC condenser)

- Condensated water in the alcohol reduces count efficiency
- Long-term measurements without maintenance & efficiency loss

Diagram:
- Saturator 35°C
- Condenser 10°C
- Automatic Micropump
2. Demands & Experiences

defined conditions

1) Reproducibility / repeatability and stability
   (more than absolute correctness and sensitivity)

2) Rudged, easy „plug & play“ handling - low preparation time
   and reliable during all-day handling

3) Defined sampling / measurement method

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5) Others (mobile application, onboard diagnostic, etc.)
Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

defined conditions

work of the PMP group and the authorities ......
1) sampling and measurement devices
2) measurement procedure
3) sampling locations
4) test cycle
5) etc.
2. Demands & Experiences

measurement quality

1) Reproducibility / repeatability and stability
   (more than absolute correctness and sensitivity)

2) Rudged, easy „plug & play“ handling - low preparation
time
   and reliable during all-day handling

3) Defined sampling / measurement method

4) Selfchecking / calibration (measurement quality)

5) Others (mobile application, onboard diagnostic, etc.)
2. Demands & Experiences
measurement quality

Selfcheck:

- Zero count test (with clean air)
- Laser test (check of power output)
- Clean optic test (no backscattering of dirt in the optic)
- Recording of instrument conditions (for a later evaluation of data)
Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

System Efficiency:

- **TSI 3025 (Kesten 1991)**
  - \(d_{50} = 2.6\) nm
  - (0.1 lpm - Internal Dilution !)

- **Grimm 5.403**
  - \(d_{50} = 4.5\) nm

- **TSI 3022 (Ankilov 2002)**
  - \(d_{50} = 6.6\) nm

- **TSI 3010 (Ankilov 2002)**
  - \(d_{50} = 10.0\) nm

Nonhygroscopic Aerosols (Ag, WOx)

Carried out at Univ. Karlsruhe / Germany; Prof. G. Kasper
2. Demands & Experiences

Comparison: Step Response

- Grimm 5.403 (0.3 lpm)
- TSI 3022 (0.3 lpm)
- TSI 3010 (1.0 lpm)

- Nonideal response is also found for other instruments
- Comparable response of Grimm CPC and the TSI 3022 due to same principle technic
- Better performance of TSI 3010 due to higher flowrate and different designed saturator

Carried out at Univ. Karlsruhe / Germany; Prof. G. Kasper
Field Experience with portable SMPS+C system on Diesel Test Stands

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Field Experience with portable SMPS+C system on Diesel Test Stands

2. Demands & Experiences

Others...

Transportability:

- Compact System
  (Pumps + control integrated)
- Integrated alcohol tank
- Battery operated
- No computer required
  (memory cards for data storage)
- Alcohol only in saturated felt
2. Demands & Experiences

Transportability Problem:
(alcohol spill and odor)

- Due to mobility alcohol spill possible into the optic

- Integrated alcohol tank with automatic supply of saturator
- controlled by integrated sensor
- Tank level control (min. / max.)
- Optional: refill from external tank

Others...

<table>
<thead>
<tr>
<th>Saturator 35°C</th>
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<tbody>
<tr>
<td>Condenser 10°C</td>
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<tr>
<td>Active Carbon Filter</td>
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<tr>
<td>Laser Optic</td>
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<tr>
<td>Butanol kept in the felt (sponge)</td>
</tr>
</tbody>
</table>
Field Experience with portable SMPS+C system on Diesel Test Stands

Contents

1. Incentive
2. Demands & Experiences
3. Summary & Outlook
4. Further Demands
Field Experience with portable SMPS+C system on Diesel Test Stands

3. Summary & Outlook

+ Grimm CPC 5.403 is a reliable instrument with comparable results to equal instrument types
+ Easiest handling and compact / robust system
+ With rot. disk diluter MD19 fast plug and play setup for reproducible AND repeatable results
3. Summary & Outlook

- response time of a CPC is limited
- for Transient cycles: no size information (without DMA)
- sampling and dilution not integrated

A complete „PMP“ unit
(sampling + measurement) is requested!
Field Experience with portable SMPS+C system on Diesel Test Stands

Contents

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3. Summary & Outlook
4. Further Demands
4. Further Demands

Particle size measurements during TRANSIENT driving cycles!

- Enormous amount of data acquisition
- Analysis and Interpretation of data more complicated
- More technical effort
- Very high price >> EURO 50,000.-
Field Experience with portable SMPS+C system on Diesel Test Stands

4. Further Demands

Transient measurements

TR-DMPS - System (5.600)

10 channel ultra fast particle spectrometer for number size distributions in the size range of 3 - 600 nm with 5 Hz

Fast Acceleration: 0-120 km/h in 20 s.
Diesel engine 1.9 l, (EURO3)

Fast Acceleration: 0-120 km/h in 30 s.
Gasoline fueled engine, 3.5 l
Thank you for your attention!

END