Development of a New Solid Particle Counting System for Engine Exhaust Emission Measurement

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The Particle Measurement Programme (PMP) under the auspices of UN ECE GRPE, proposed a measurement protocol for particle number emission from light duty vehicles together with particulate mass emission. An “Inter-Laboratory Correlation Exercises” has been arranged thereafter to verify the validity of the protocol. Many laboratories worldwide have participated to this inter-laboratory correlation exercises, and examined the measurement protocol

HORIBA has developed a Solid Particle Counting System (SPCS) according to the PMP proposal. During the inter-laboratory correlation exercises, the first generation SPCS has demonstrated good repeatability and reproducibility following the proposed protocol accurately. The first generation SPCS has great potential to measure very low particle emission from DPF equipped vehicles or port injection gasoline vehicles. However the system includes all the features proposed by PMP in one rack which makes the system bit bulky.

To reduce the space occupancy and make the system user friendly, HORIBA has developed a second generation SPCS which is suitable for use in engine test cells. Engine test cells are generally smaller than chassis test cells where the emission form light duty vehicles are tested. Therefore the major design concept of the second generation SPCS is down sizing and make it user friendly without compensating the accuracy of measurement. The volume of the second generation SPCS has been reduced by one third as compared to the first generation SPCS.

Moreover, the second generation SPCS shows very high penetration efficiency. The particle concentration reduction factor (PCRF) is close to the set up dilution ratio. The PCRFs for 30 nm, 50 nm and 100 nm particles are close to each others. Consequently, the second generation instrument is able to give reliable result of the exhaust emission from different engine and after treatment technologies such as direct injection gasoline vehicles who have different particle size distributions.

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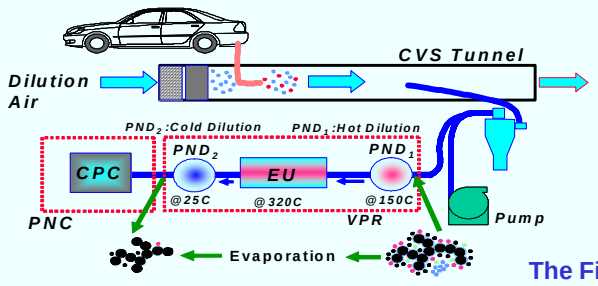
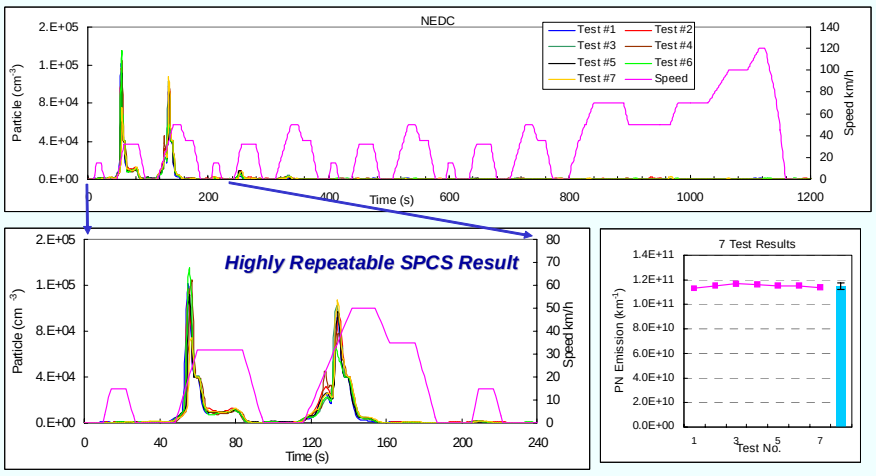
1. Solid Particle Counting System (SPCS)



- Horiba SPCS is designed based on the PMP recommendation.
- Two Wide Range Continuous Diluters (WRCD) are used as PND1 and PND2.
- The SPCS has been tested in many laboratories. Its performance achieves the PMP recommendation.
- The SPCS was validated in the Inter-Laboratory Correlation Exercise, and proved to be an effective, accurate measurement instrument for low emission vehicles, which could be required global future emissions regulation.

The First Generation SPCS (MEXA-1000 SPCS)

2. SPCS Light Duty Vehicle Application



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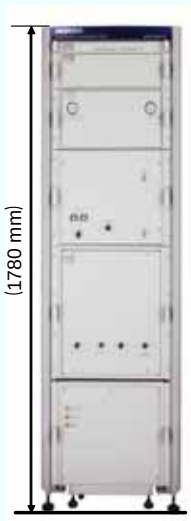
3. The New Target of SPCS

MEXA-1000SPCS

- Regulation Conformity . : UN/ECE R83
- High measurement accuracy.
- Two-stage dilution by Wide Range Continuous Diluter developed by HORIBA.
  PND1 : 10 – 700 PND2 : 10 - 50
- All-in-one system. : Various check function integrated



New generation SPCS (MEXA-2000SPCS)

The new system considered to be user friendly in the chassis test cell and the engine test cell.

- To reduce the space occupancy
- Practical dilution factor setting
  PND1: 10 - 200 PND2: 15
- Easy installation even in small engine test cells.
- To satisfy ECE R83 requirements and R49 in future.

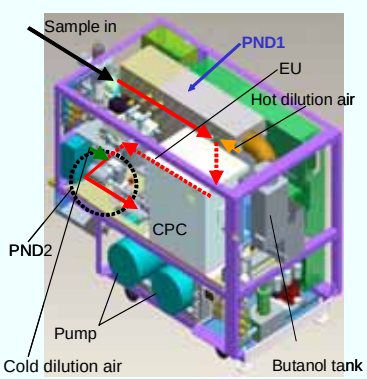
Size down to 1/3

MEXA-2000 SPCS

4. Key Features of MEXA-2000SPCS

The small system integrating the functions essential for daily measurement

- Includes basic functions and maintenance from MEXA-1000SPCS.
- Employ no rotating parts in dilution unit to assure durability accuracy.
- Optional check units and sample line selector.
  - ✓Sample line selector with pre-classifiers
  - ✓Dilution factor check
  - ✓ Particle concentration reduction factor check
  - ✓ Volatile particle removal efficiency check



Selector Cyclone Unit (SCU)

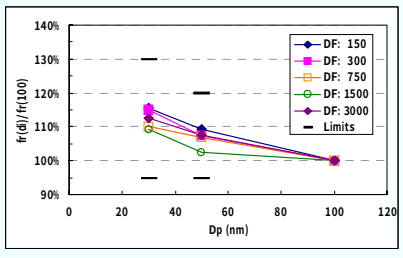
Dilution Factor Checker (DFC)

Volatile Particle Generation Unit (VGU)

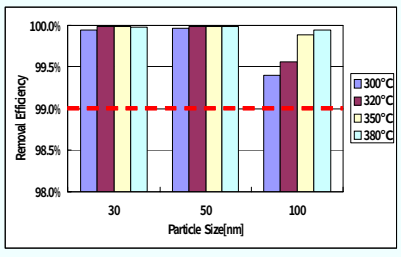
MEXA-2000SPCS Portable Main Unit

5. Basic Performance of The Second Generation SPCS

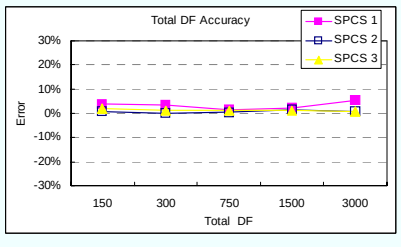
Particle Concentration Reduction Factor (*fr*)



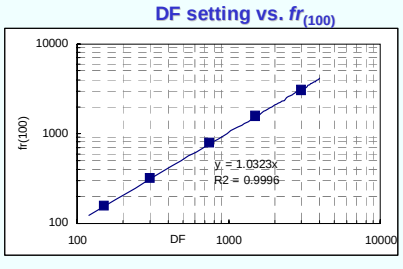
Volatile Particle Removal Efficiency



Total Dilution Factor Accuracy

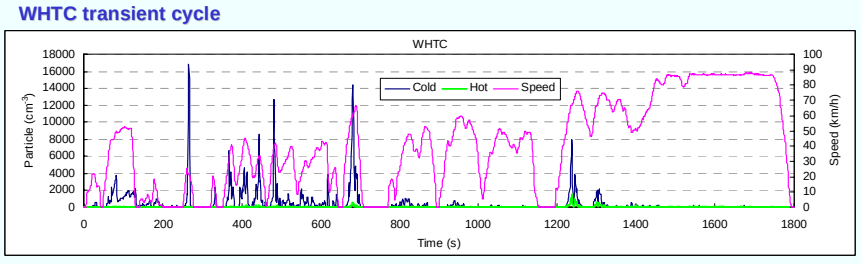


DF setting vs. $fr_{(100)}$

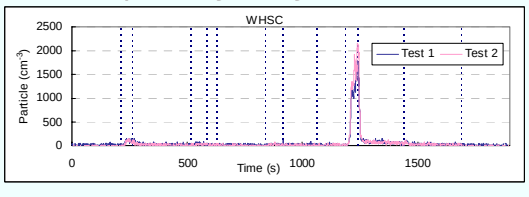


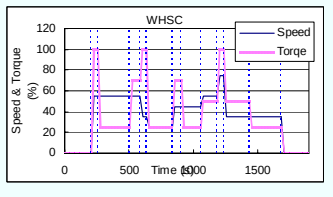
6. SPCS Heavy Duty Application

WHTC transient cycle



WHSC ramped steady state cycle





Two SPCSs were used in PMP Heavy Duty Validation Exercise as “Golden Instruments” and demonstrated their capability of measuring particle number emission from heavy duty engines.

Conclusions

- MEXA-2000SPCS became user-friendly by down sizing to one third at an engine test cell and chassis test cell.
- No noticeable degradation of basic performances from MEXA-1000SPCS, and satisfies ECE R83 requirements.
- Employ no rotating parts in dilution unit to assure durability and accuracy, and minimum particle loss.
- Ecologically sound as power consumption are material used have been reduced significantly.