Extended Abstract

Sub 23 nm Particle Emissions from Vehicles with Diesel and Gasoline DI engines

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Emissions of particles from a light duty diesel vehicle with DPF, a heavy duty diesel truck with DPF and a heavy duty diesel truck without DPF were measured by a PMP methodology with a different particle counter which D50 = 2.5nm. We named the results with this method as “2.5PN”.
Figure1 show the real time 2.5PN from the light duty diesel vehicle with 100 km/h constant operation condition with varying PCRF. It is confirmed that 2.5PN increased with decreasing PCRF at the condition PCRF below 1000. This increase may come from a re-nucleation of volatile particles which are too small to be detected by the normal PMP methodology. In another words, the effect of the re-nucleation can be negligible by setting PCRF over 1000.

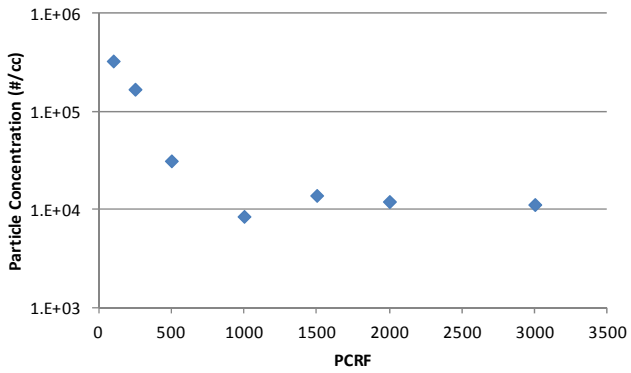

Fig. 1 2.5PN real time results from the diesel van with constant speed operation (100 km/h) as a function of PCRF.

Figure 2 shows the 2.5PN and PN results from the light duty diesel van with DPF. PN results were almost the same with hot and cold conditions. 2.5PN in cold mode was three orders of magnitude higher than PN in cold and 2.5PN in hot mode was two orders of magnitude higher than PN in that condition.

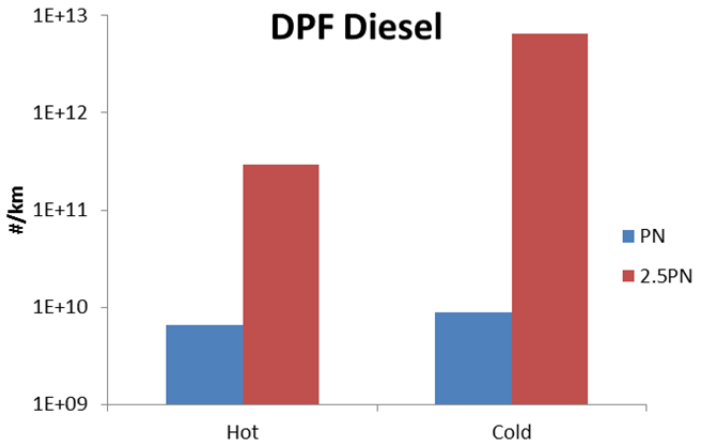

Fig. 2 PN and 2.5PN from light duty diesel van with DPF in JC08 cold and hot mode.

Figure 3 shows the PN and 2.5PN from the heavy duty truck with and without DPF. Tested mode was JE05 cold and hot mode. In both resutls of PN and 2.5PN, the truck with DPF emitted lower particles than that without DPF. In the results with the DPF truck, two orders of magnitude high 2.5PN was observed than PN. On the other hands, 2.5PN from the non-DPF truck was almost the same order conpared with that of PN.

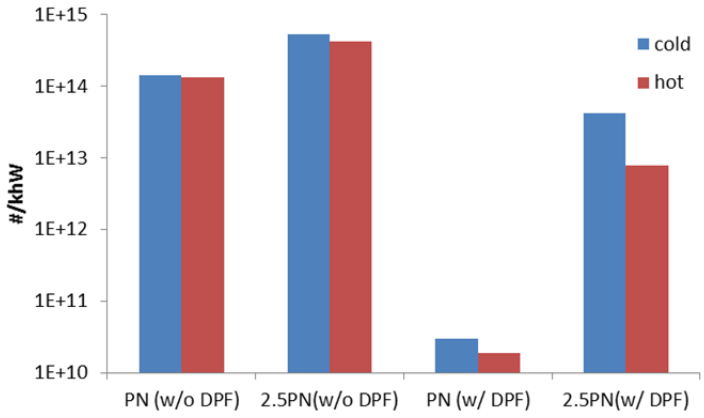

Fig. 3 PN and 2.5PN from heavy duty diesel truck with and without DPF in JE05 cold and hot mode.

Sub 23 nm particle emissions from vehicles with Diesel and ~~Gasoline DI engines~~

National Traffic Safety and Environment Laboratory, Japan

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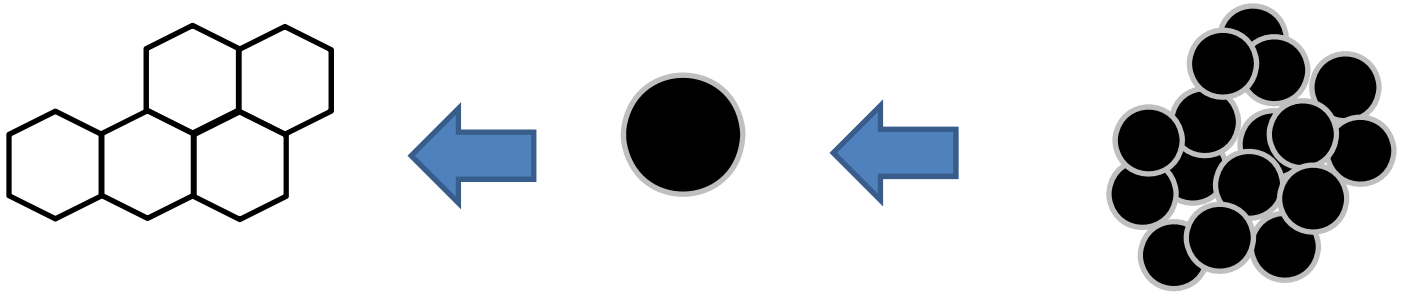
Background

- Particle number counting method was almost fixed by PMP working group of GRPE.
- Adopted method to European type approval tests was counting solid particles over 23nm.
- One of the next issue of PMP working group is **Sub-23 nm particles**.



Benzo a Pyrene(0.7nm)

Primary particle (10nm)

Agglomerated particles (70nm)

How small particles should we measure?

How small particles can we measure?

Source : TSI

TSI CPC3776

- The smallest detection limit (D50) of Commercial optical particle counter is (as long as I know) **2.5nm.**
- Particle number (PN) measurement from automobile exhaust was often performed with PMP methodology (D50 = 23nm) or PMP methodology with another counter (D50 = 10 nm)
- **No data was reported with the counter which D50 is 2.5 nm**.

We performed measurements of exhaust particles from diesel vehicle by PMP methodology with the counter which D50 is 2.5 nm. **We named "2.5PN"**

Measurement systems

HORIBA MEXA1000SPCS
PMP methodology (D50 =23nm)

Source : AVL

AVL APC
PMP methodology (D50 =23nm)

Source : TSI

TSI CPC3776
Counter (D50 = 2.5nm)

•Particle counter of AVL APC was changed into TSI CPC3775
•Normal PMP methodology was used simultaneously with MEXA1000 SPCS.

Tested Vehicles

Mazda Bongo

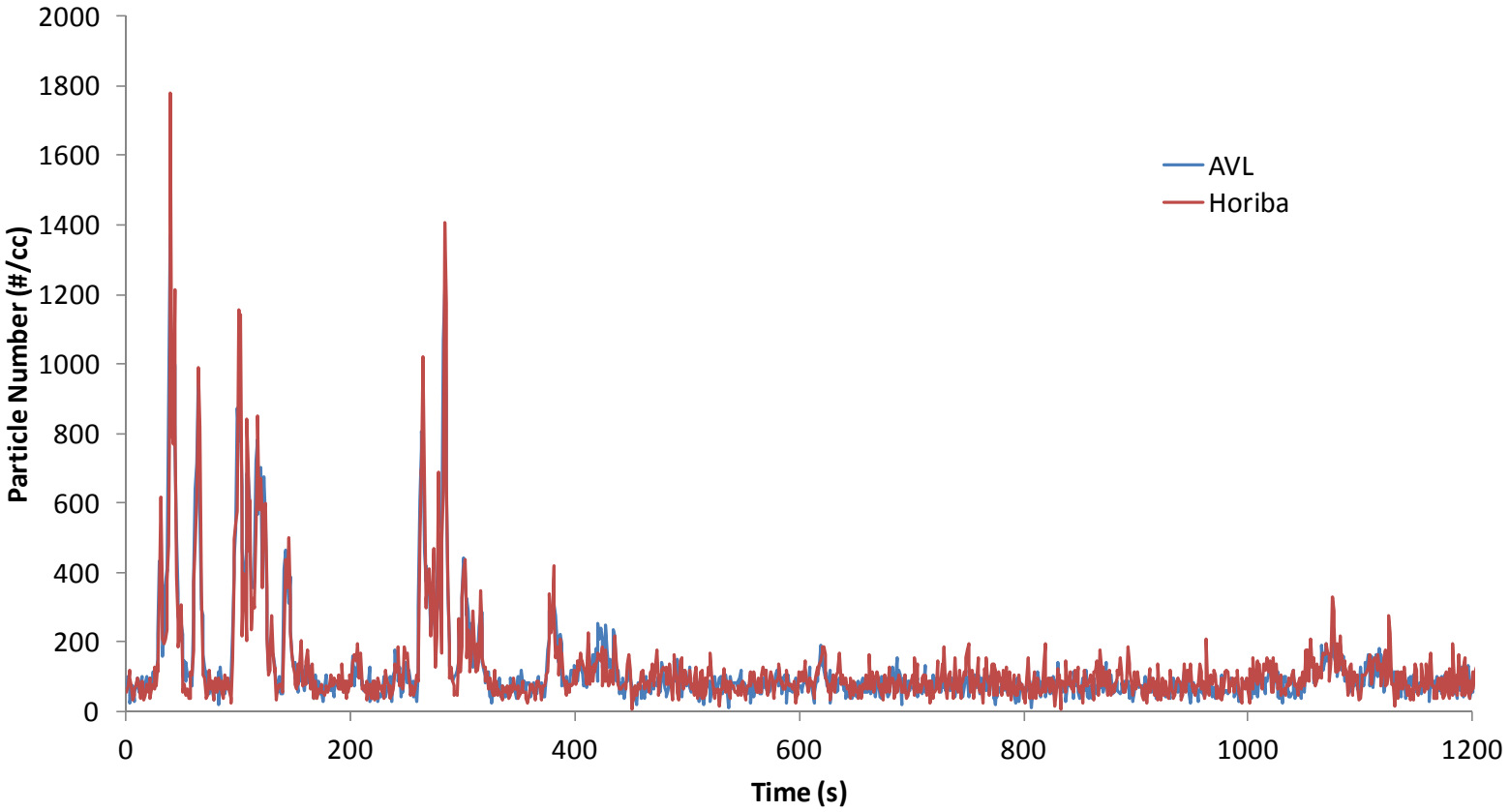
- **We tested 1 compact Van with DPF and 2 light duty trucks.**
- **2 trucks are same maker and same size, difference is that DPF is attached or not.**

Isuzu Elf (w/o DPF)

Isuzu Elf (w/ DPF)

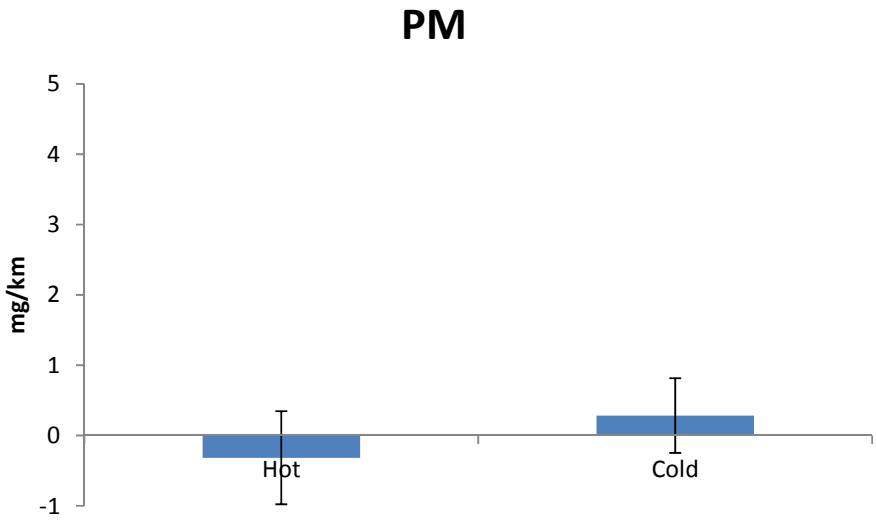
Horiba vs. AVL

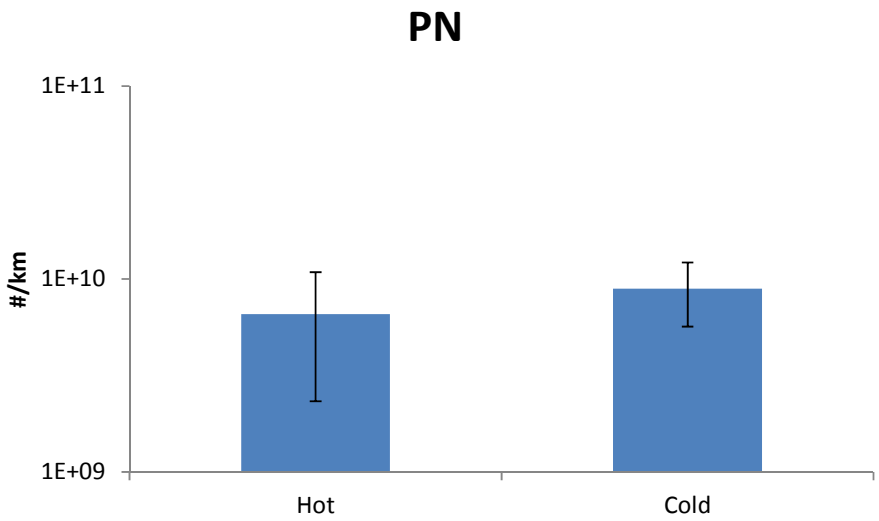
Bongo JC08 hot AVL: 1.18×10^{10} Horiba: 1.21×10^{10} (#/km)



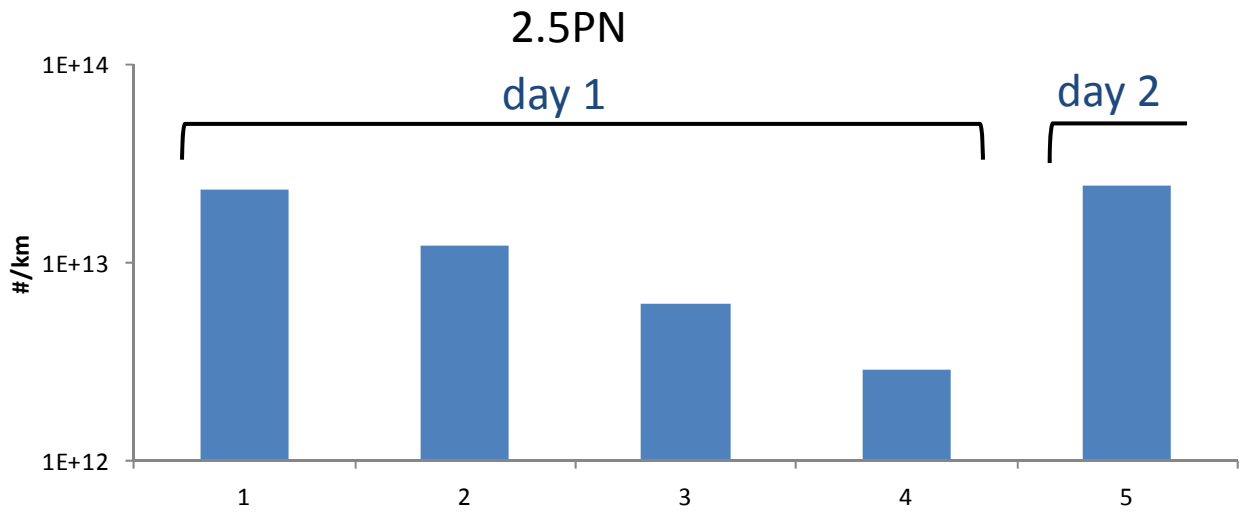
PN emissions with Horiba and AVL well agreed with each others

Results（Compact Van PM, PN）





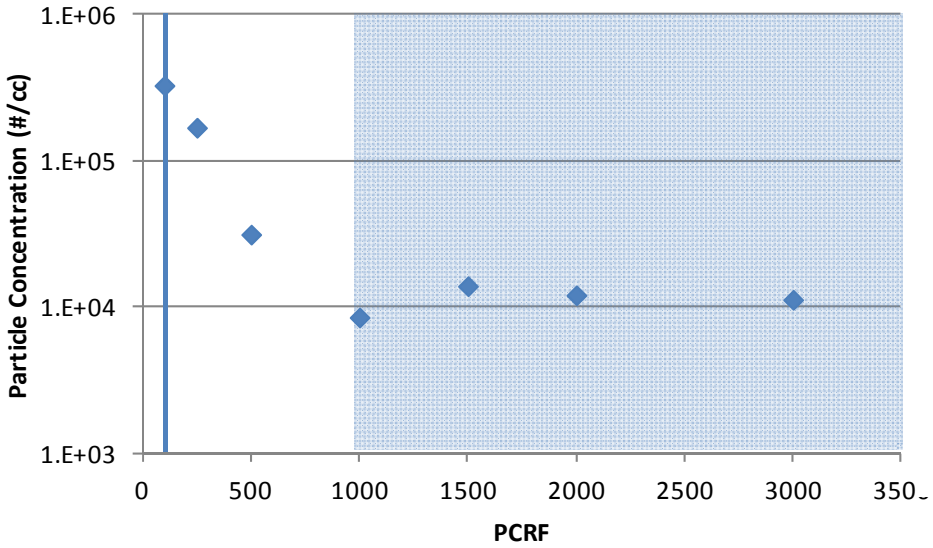
5 continuous hot results of Bongo JC08 hot



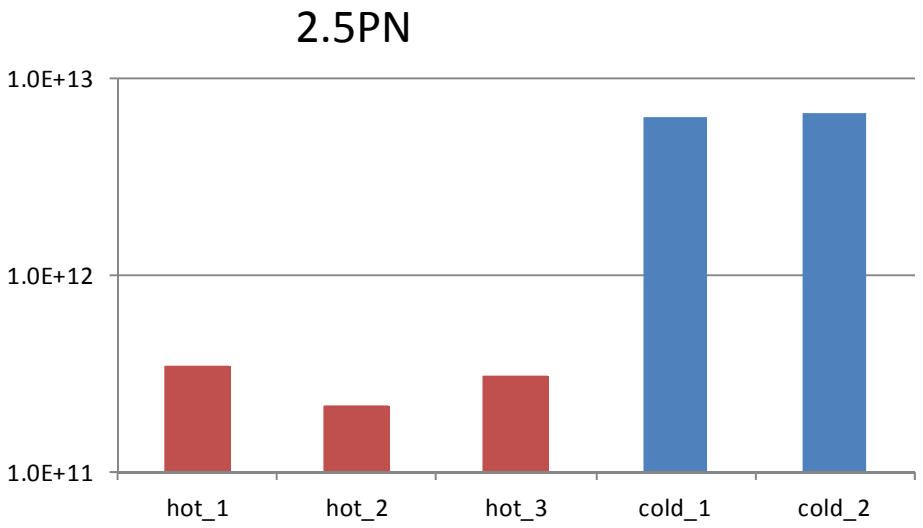
- **PM was undetectable level**
- **PN were well below European regulation limit.**
- **Periodic fluctuation was observed with 2.5PN.**

Particle concentrations against PCRF

Correlations between concentrations and PCRF
（Bongo 100km /h constant speed)



PCRF=1000, JC08 cold / hot



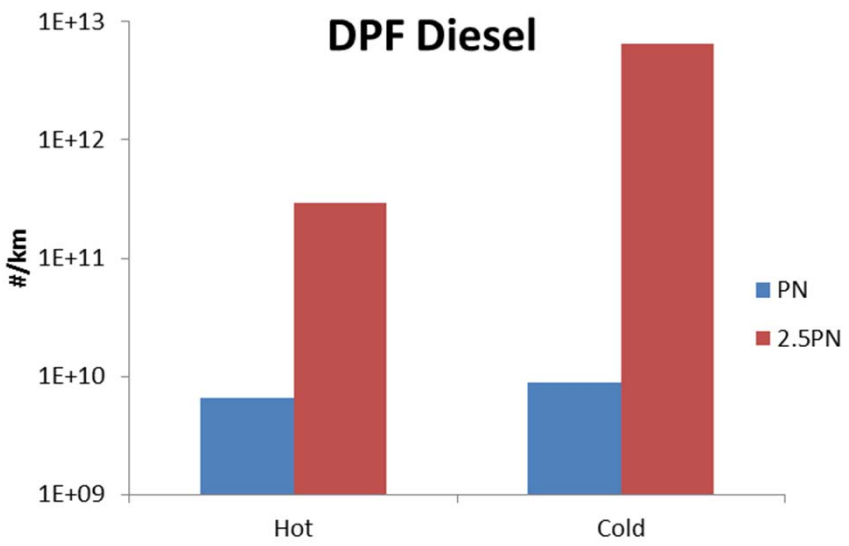
Tremendous increase of particle number was observed at lower PCRF

The results were almost constant with PCRF = 1000

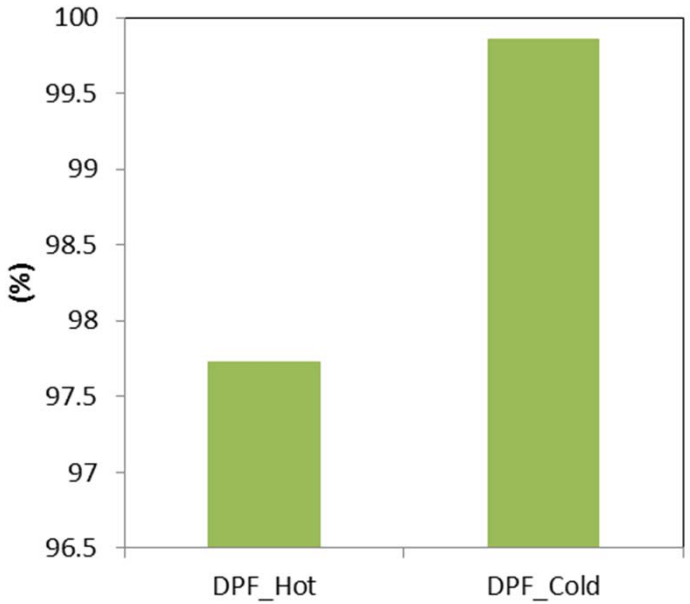
2.5PN is more sensitive about re-nucleation of volatile particles. Setting PCRF over 1000 is required to avoid the re-nucleation effect.

Comparisons between PN and 2.5 PN (DPF Van)

PN and 2.5 PN emissions in JC08



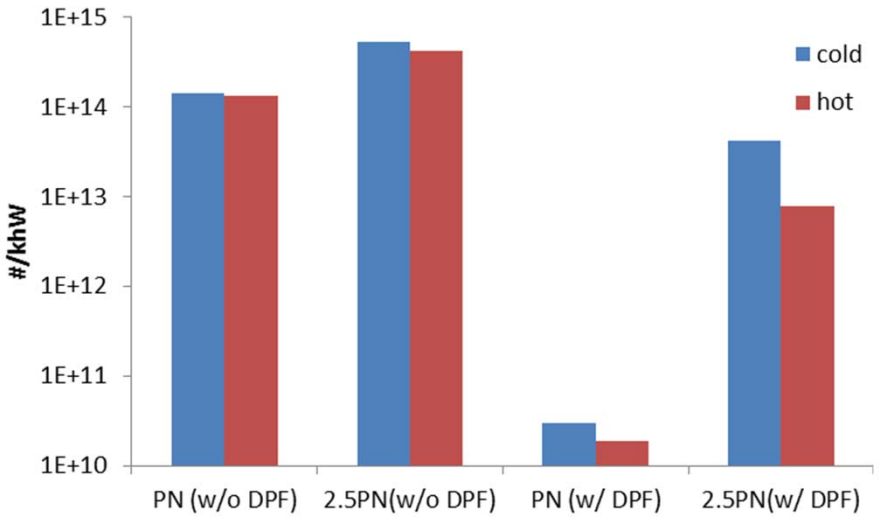
Percentage of particles 2.5~23nm



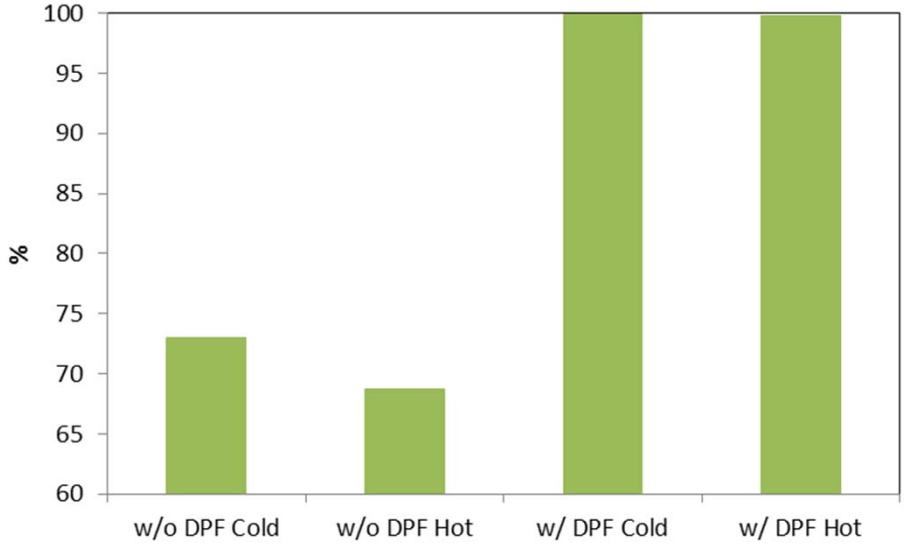
- **PN emissions were well below Euro 6 limit.**
- **PN in cold and hot mode were almost the same with each other.**
- **2.5 PN in cold mode were 20 times higher than those in hot mode**
- **Particles between 2.5 to 23 nm were dominant, 97.7% in hot mode, 99.9 % in cold mode.**

PN and 2.5PN from with and without DPF truck

PN and 2.5 PN emissions



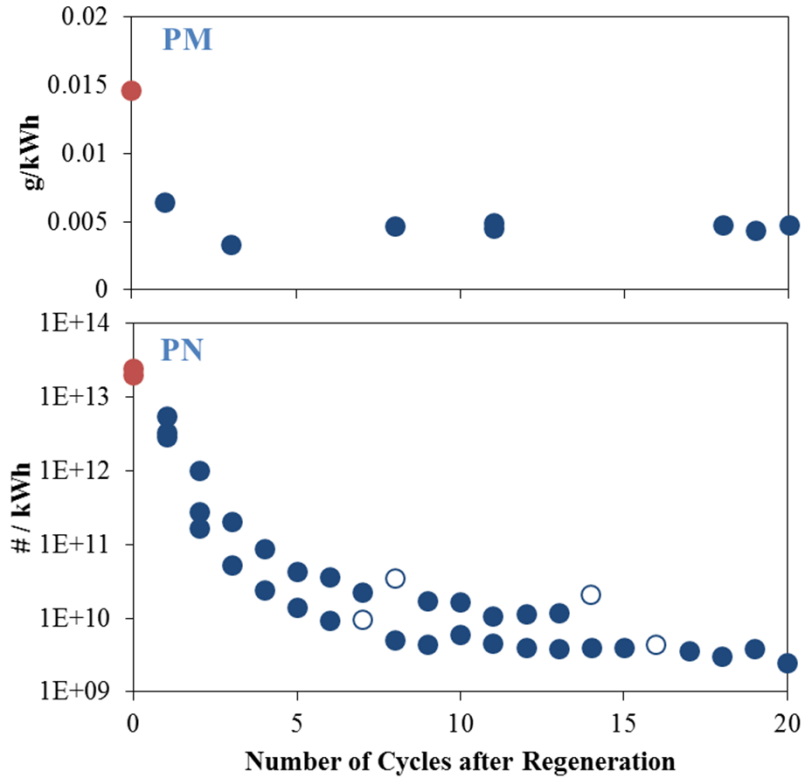
Percentage of 2.5~23 nm particles



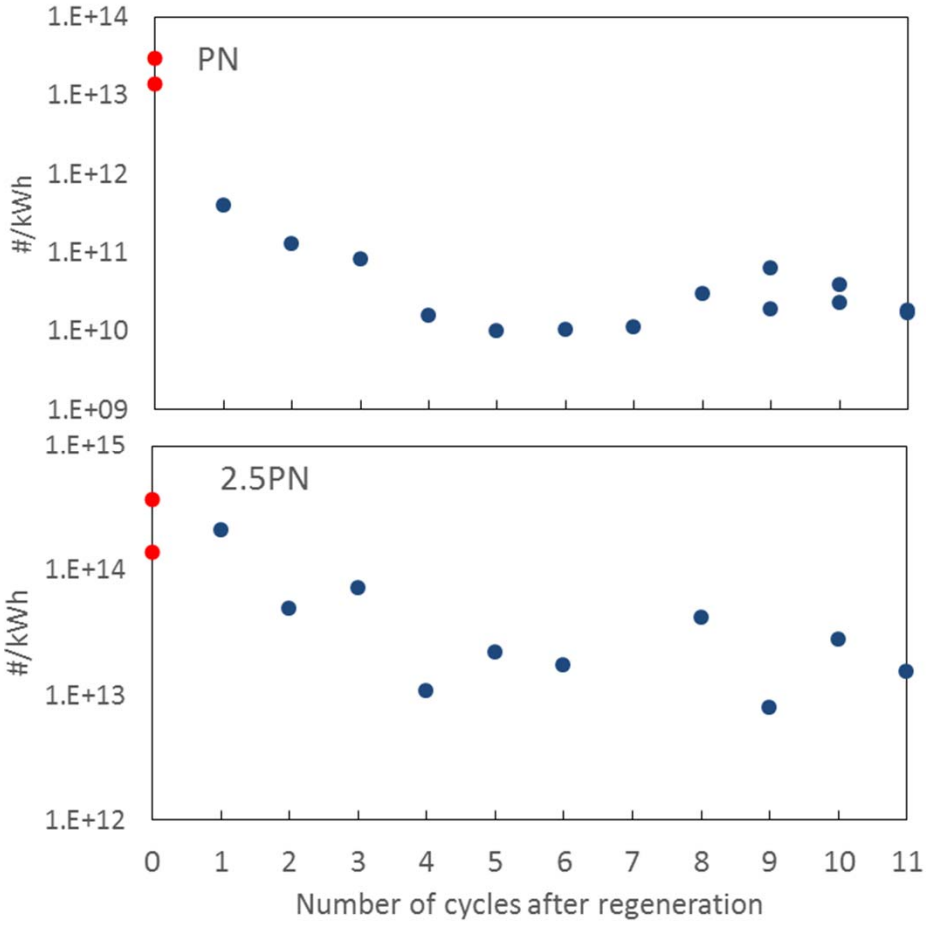
- **PN and 2.5 PN emissions from non DPF truck were in the same order.**
- **PN and 2.5 PN emissions from DPF truck were below those from non DPF truck.**
- **2.5PN from DPF truck were 3 orders of magnitude higher PN.**
- **Asurming particles concentrations from non DPF truck were the same with concentrations upstream of DPF, DPF filtering efficiencies are 99.99% for over 23 nm particles and 97.31 % for particles 2.5 to 23 nm.**

Periodic fluctuations of PN and 2.5 PN

Fluctuations presented last year conference



Fluctuations of PN and 2.5PN (new data)



- **Almost the same feature with last year data was observed in PN results**
- **Fluctuations were also observed in 2.5PN but deference is single order.**

Conclusion

- Exhaust gas of DPF Van and two trucks were monitored by PMP method and PMP method with different CPC which D50 is 2.5 nm (2.5PN).
- Data of 2.5PN was fluctuated in case PCRF=100, because of the effect of re-nucleation and this effect can be ignored by setting PCRF over 1000.
- 2.5PN with DPF van were quite high compared with PN(over 23nm) suggesting there were huge number of particles 2.5 to 23 nm.
- PN and 2.5 PN from DPF truck were lower than those from non-DPF truck.
- In case of non-DPF, 2.5PN were almost the same order with PN, but DPF truck case, 2.5 PN were three orders of magnitude higher than PN.
- Periodic fluctuation corresponding with DPF regeneration cycle were observed in both PN and 2.5PN. Changes in 2.5 PN were almost 10times and changes in PN were three orders of magnitude.

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