Extended Abstract

PM and PN emission Histories from HD Vehicle with Periodical Regenerating DPF

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PN, PM and Regulated gas emission profiles were observed from the most recent diesel truck which is equipped with a periodically regenerating DPF. We continued JE08 mode without the preconditioning cycles for 5 days, and a total of 38 tests were performed. During whole tests, two times of regenerations were observed. This means the regenerations arose almost every 18 cycles.

For CO and NOx emissions, no changes were observed between the cycle with and without regeneration. Three times higher THC and NMHC were observed in the cycle with regeneration. These results are shown in Fig. 1.

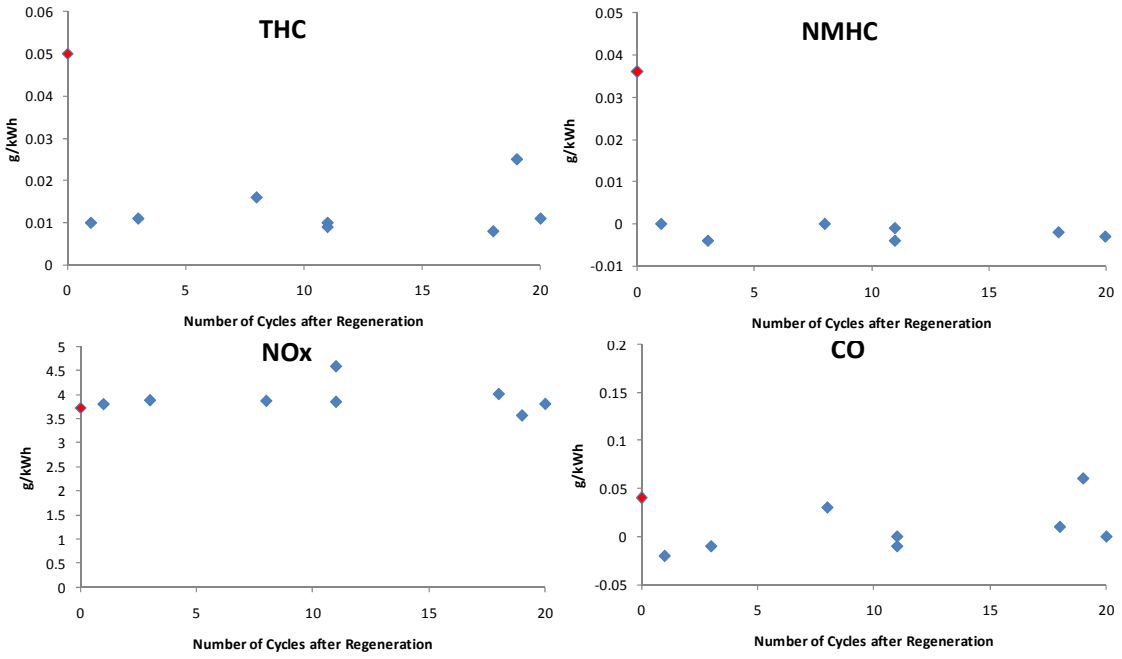

Fig. 1 Histories of regulated gas emissions as functions of the numbers of cycles after the regeneration.

Figure 2 shows the results of PM and PN. In the case of PM, the emission in the cycles with regeneration is almost three times high. The results without the regeneration were almost constant and not affected by the the number of the cycles after the regeneration.

On the other hand, PN emissions with the regeneration were almost thousand times higher than the results just before the cycle in which the regeneration appeared. In addition, an exponential decay along with the number of cycles after regeneration was observed.

A repeatability of PN emission during the regeneration by PMP system was good.

In case calculating the certification value of PN from the results in this study, almost 98 % of the average emissions was caused by the first three cycles from the regeneration.

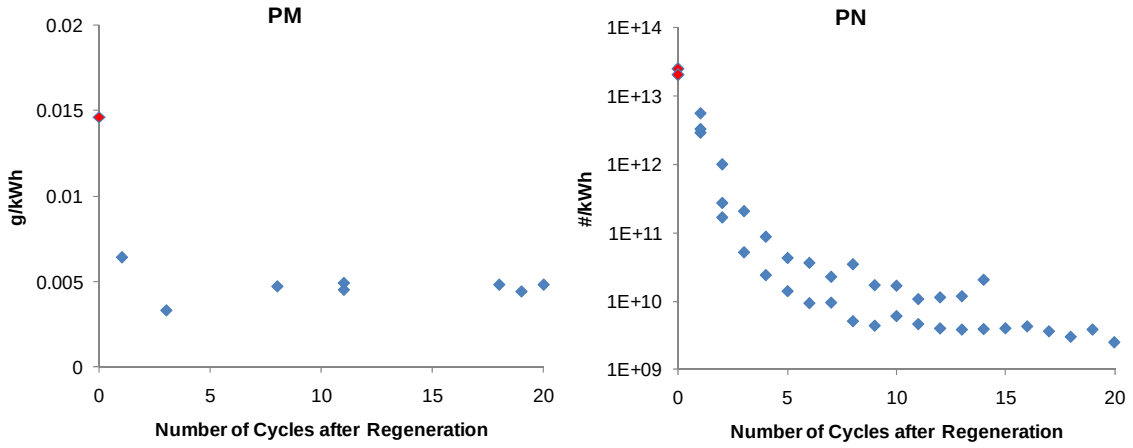

Fig. 2 Histories of PM and PN emissions as functions of the numbers of cycles after the regeneration.

PM and PN Emission Histories from HD Vehicle with Periodical Regenerating DPF

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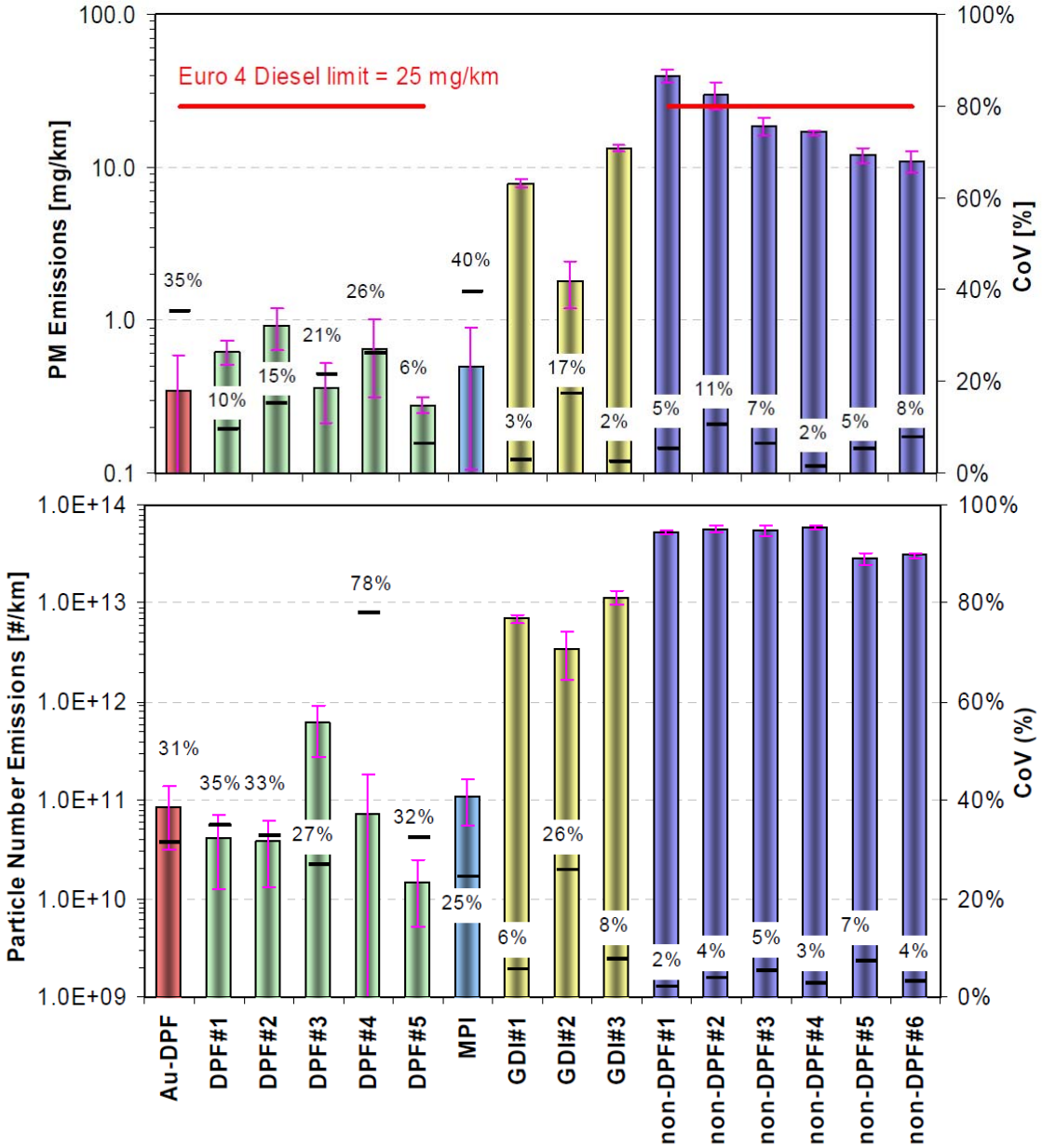
DPF Filtering Efficiency



PM
97% PM were trapped by DPF

PN
99.8 % decreased.

DPF is a powerful tool to reduce PM and PN

Reference
PMP ILCE_LD Final Report

Regeneration

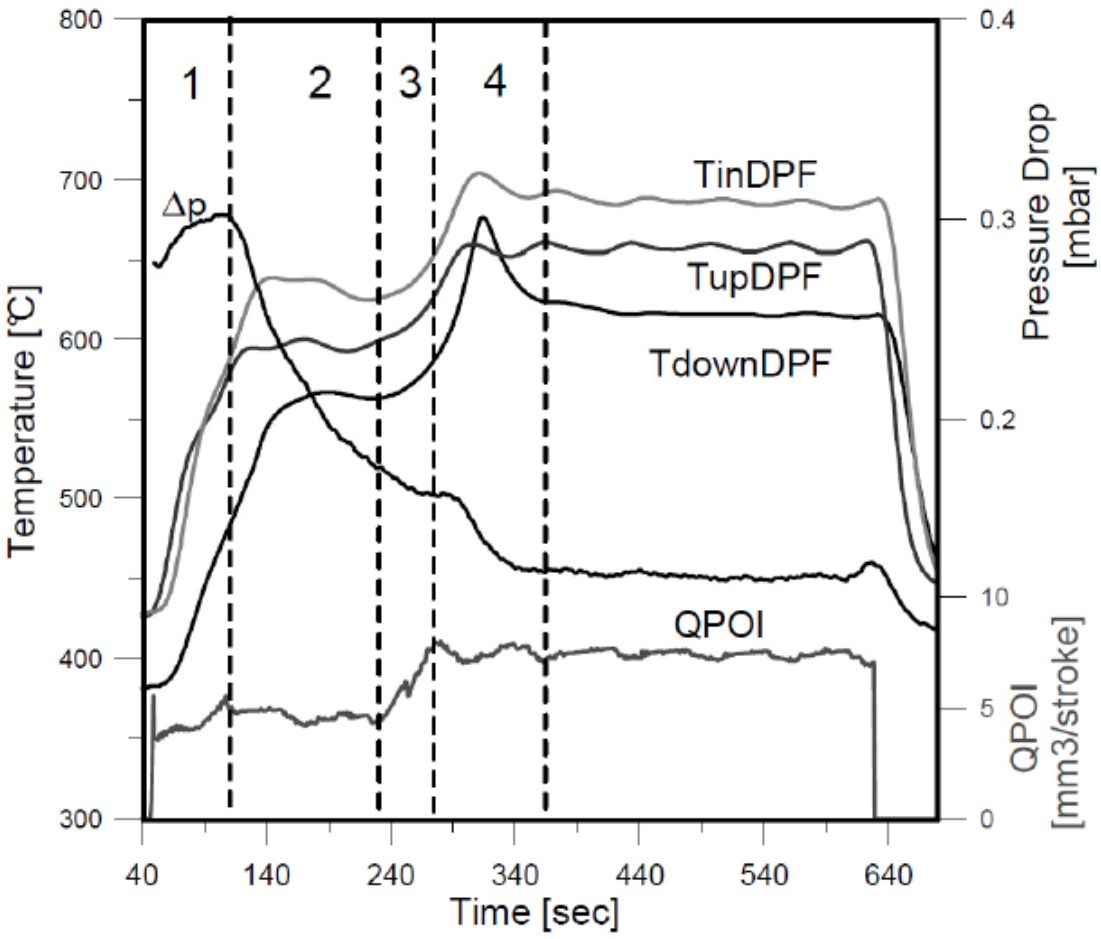


Figure 4. QPOI, Δp and temperature profiles measured upstream, inside and downstream the DPF during the regeneration of a loaded filter.

Particles trapped by DPF were oxidized during the regeneration period.

Are all particles completely oxidized?

Are there any effects on emissions during regeneration?

Reference
S. D. Iorio et al. SAE. Int. J. Engines, **4** 2510-2518

Treatments of the regeneration in the type approval tests

Equation to obtain a certification value in the case with periodic regeneration(R83, R49, WHTC)

$$M_{pi} = \left\{ \frac{M_{si} * D + M_{ri} * d}{D + d} \right\}$$

where,

M_{pi} = mass emissions of pollutant (i) in g/km,
M_{si} = mass emissions of pollutant (i) in g/km without regeneration,
M_{ri} = mass emissions of pollutant (i) in g/km during regeneration ,
d = number of operating cycles required for regeneration,
D = number of operating cycles between two cycles where regenerative phases occur

Certification value is obtained by the weighted average between Regeneration and non regeneration cycles.

Study about PN during the Regeneration

PN from LD during the Regeneration by PMP system

B. Giechaskiel et al. *SAE2007-01-1944*

PN from Golden Vehicle (LD) during the regeneration were measured by PMP system and EEPS. PN increased 2 orders of magnitude, but most of them are volatile particles. PN with PMP system was almost the same between the cycles w / and w/o the regeneration.

PN from HD during the Regeneration by non PMP system

S. D. Iorio et al. *Int. J. Engines* 4

PM and PN from HD engine(Euro 5) during the regeneration were measured by micro-soot sensor and DMS500. High emission of soot particles accompanying with volatile particles were observed. They pointed out the possibility of soot particles emission by fragment of soot cake.

Conclusions from these study differ from each other

Objectives

By obtaining the PM and PN histories over the DPF regeneration arising period,

- *Observe the emission features of PM and PN during the regeneration.*

- *Obtain the correlations between the emissions, and DPF condition.*

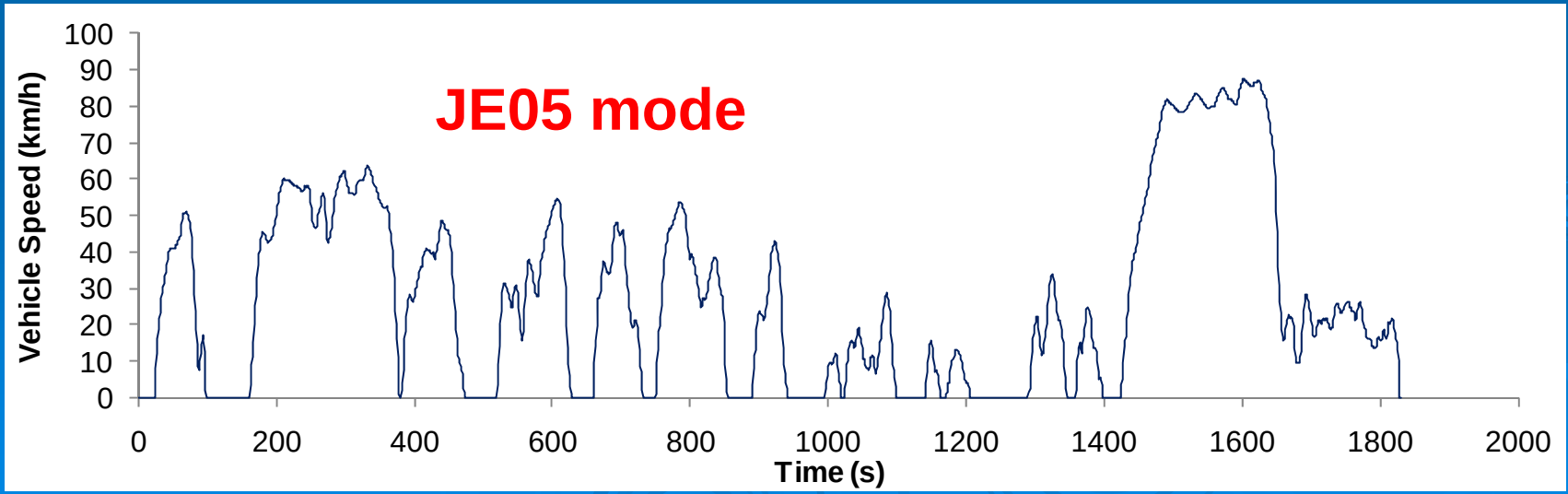
- *Confirm the reliability of the results measured with PMP system during the regeneration*

- *Discuss the effects of regeneration cycles on the certification values.*

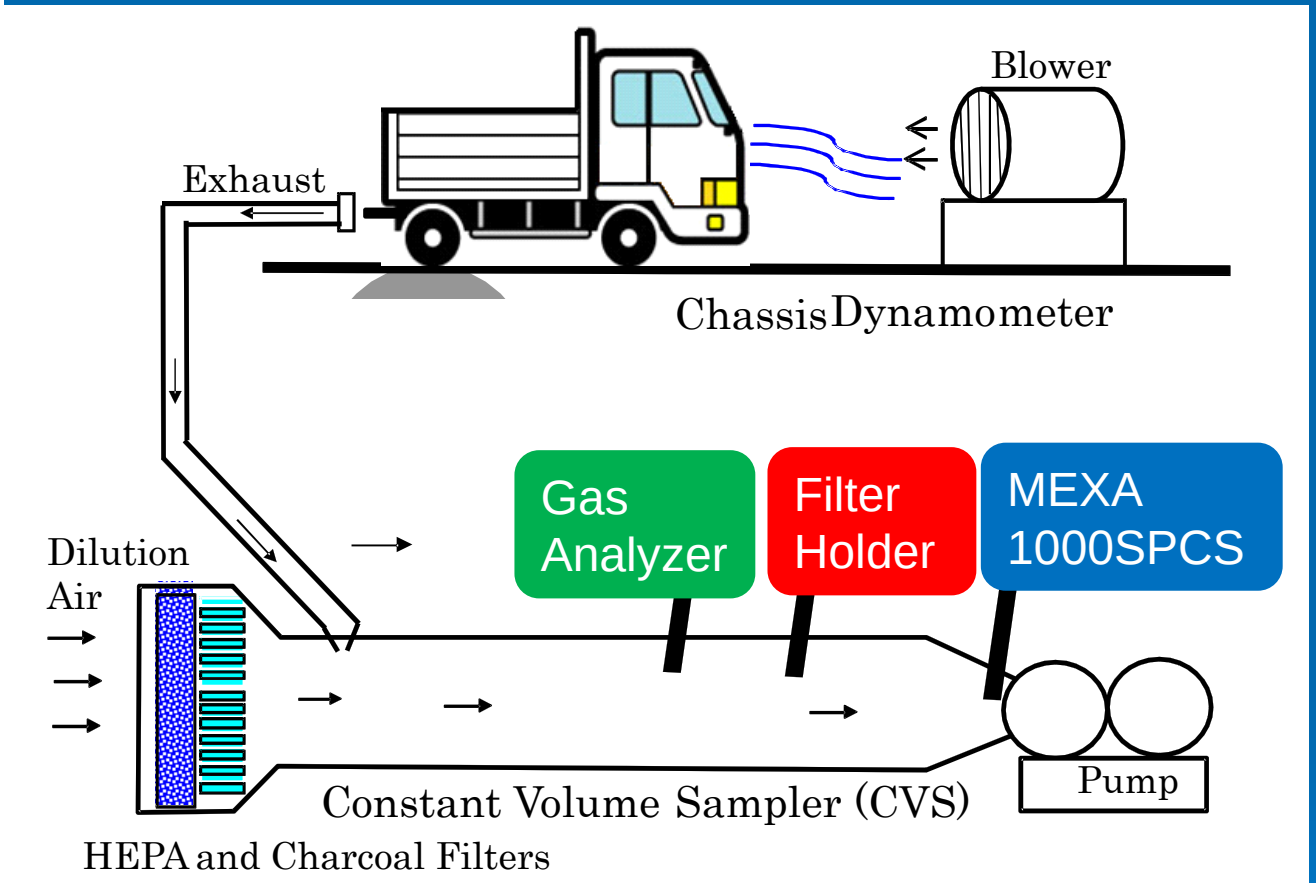
Test Vehicle

Manufacturer	Isuzu
Max. Power (kW / rpm)	177 / 2600
Max. Torque (Nm / rpm)	706 / 1600
Displacement (L)	5.193
Numbers of Cylinders	Inline 6
Emission Level	2010 JP
After Treatment	DOC, DPF
GVW(kg)	13,290

Test Mode

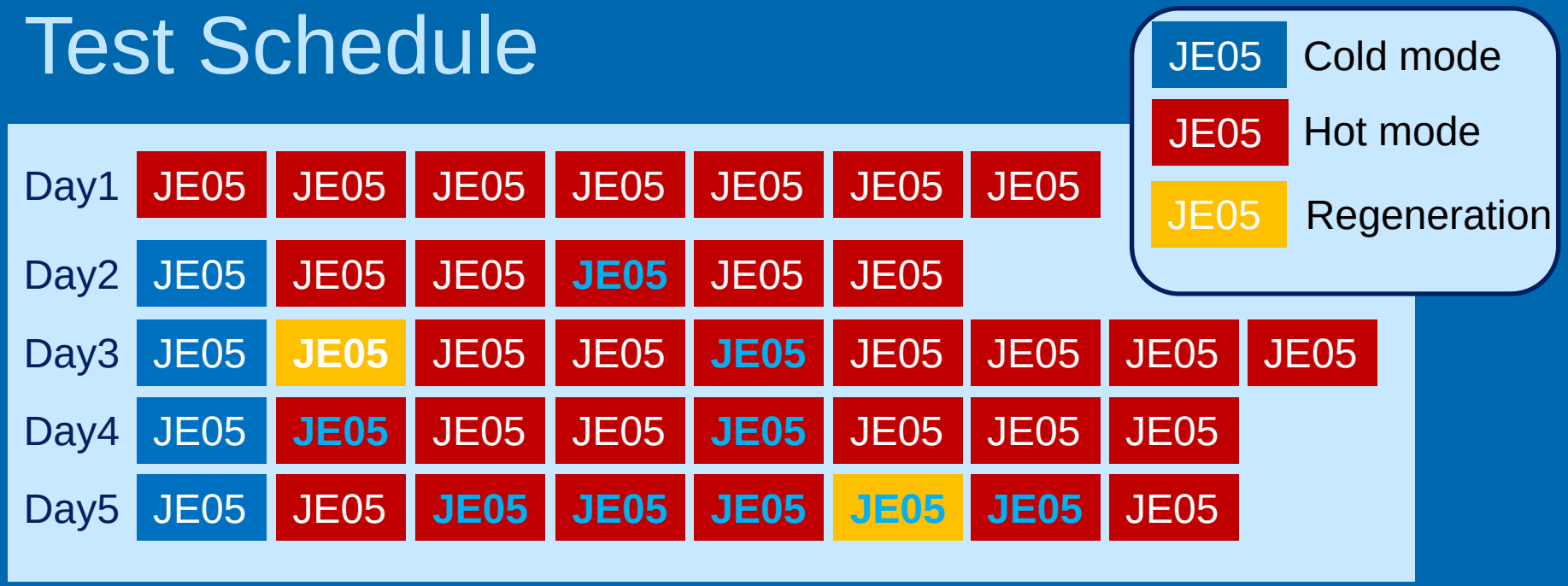


Exhaust Gas Measurement



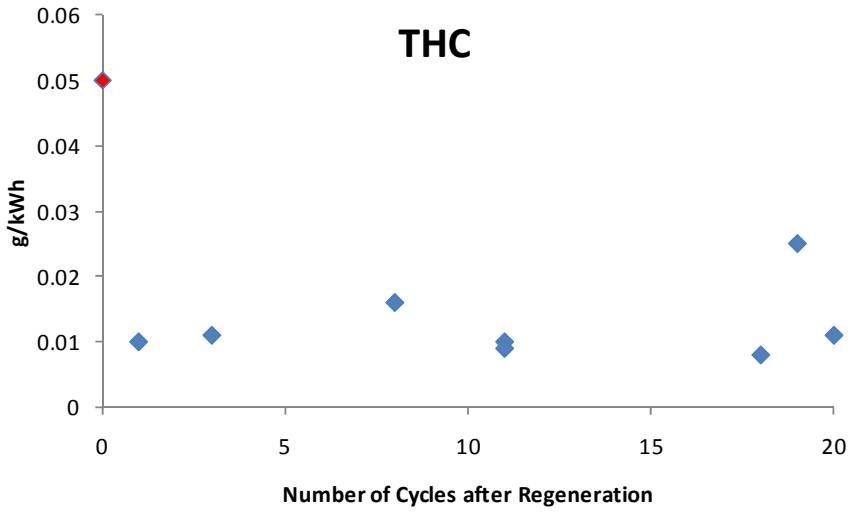
MEXA1000 SPCS

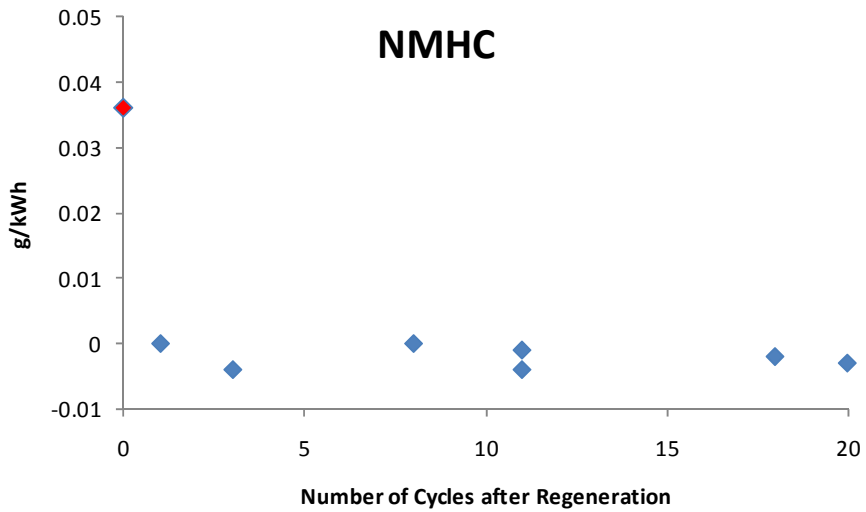
Test Schedule

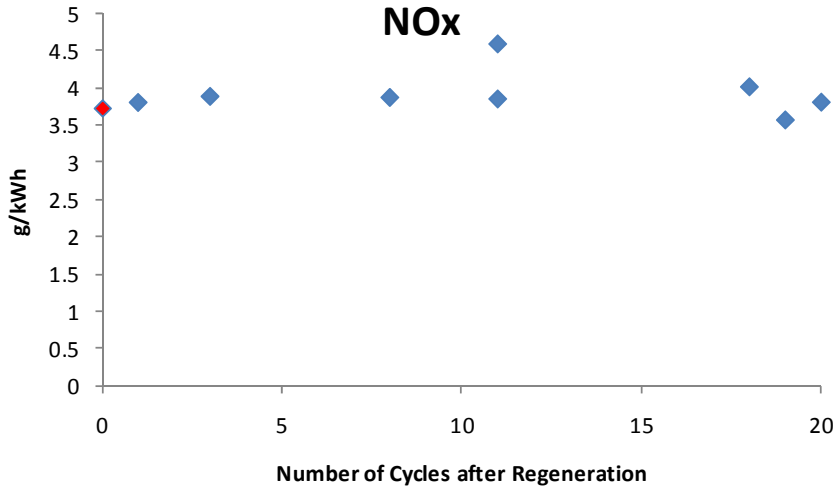


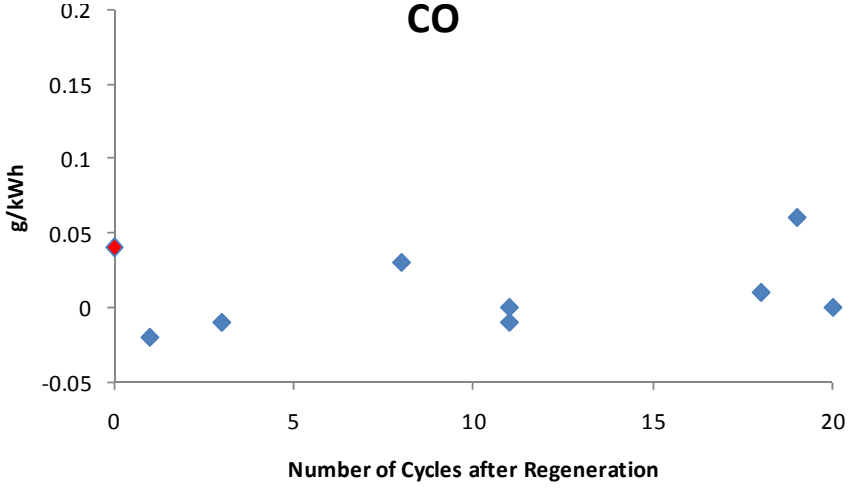
- We repeated JE05 mode for 5 days, total 38 tests.
- No preconditioning was performed during the tests.
- Active regeneration was performed before the test in Day 1.
- PN were measured in all tests.
- Regulated gases and PM were measured in selected tests (indicated with blue font).
- Regeneration appeared in 2 times(almost every 18 times)

Results (Regulated Emissions)



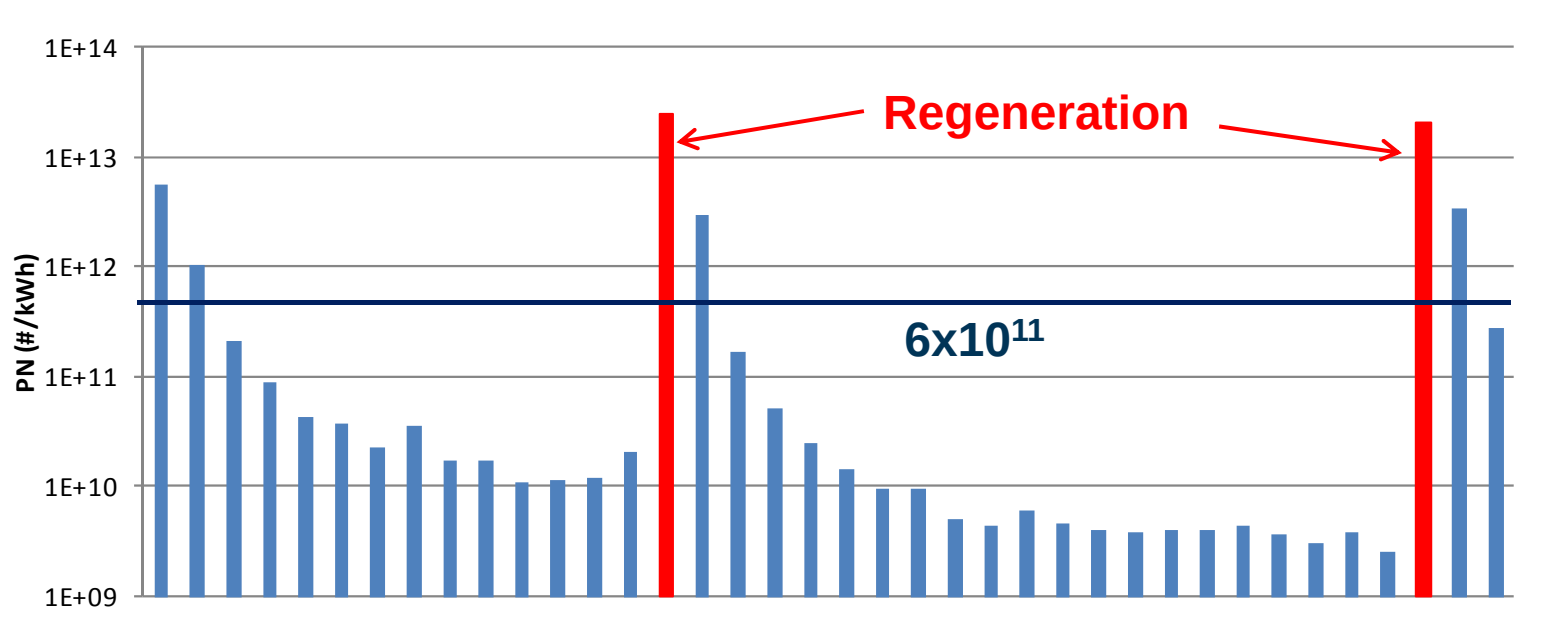


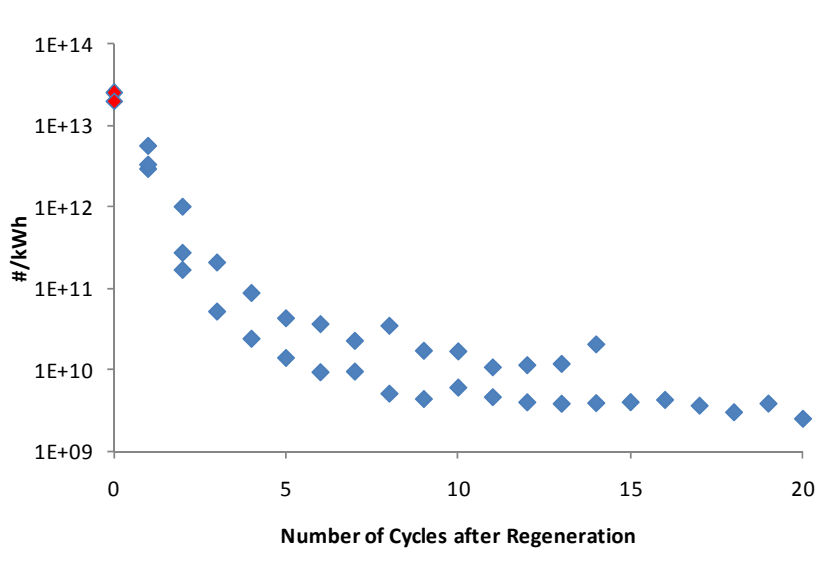




High emissions were observed in THC and NMHC the regeneration conditions. The results were constant in the conditions without the regeneration.

Results (PN)





Quite high PN were observed in the tests with the regenerations.
PN reduced exponentially as test number from the regeneration increased.

Results (PN, PM)

no regeneration term

regeneration term

$$M_{pi} = \left\{ \frac{M_{si} * D + M_{ri} * d}{D + d} \right\} = \frac{D}{D+d} M_{si} + \frac{d}{D+d} M_{ri}$$

Weight percentage of regeneration term

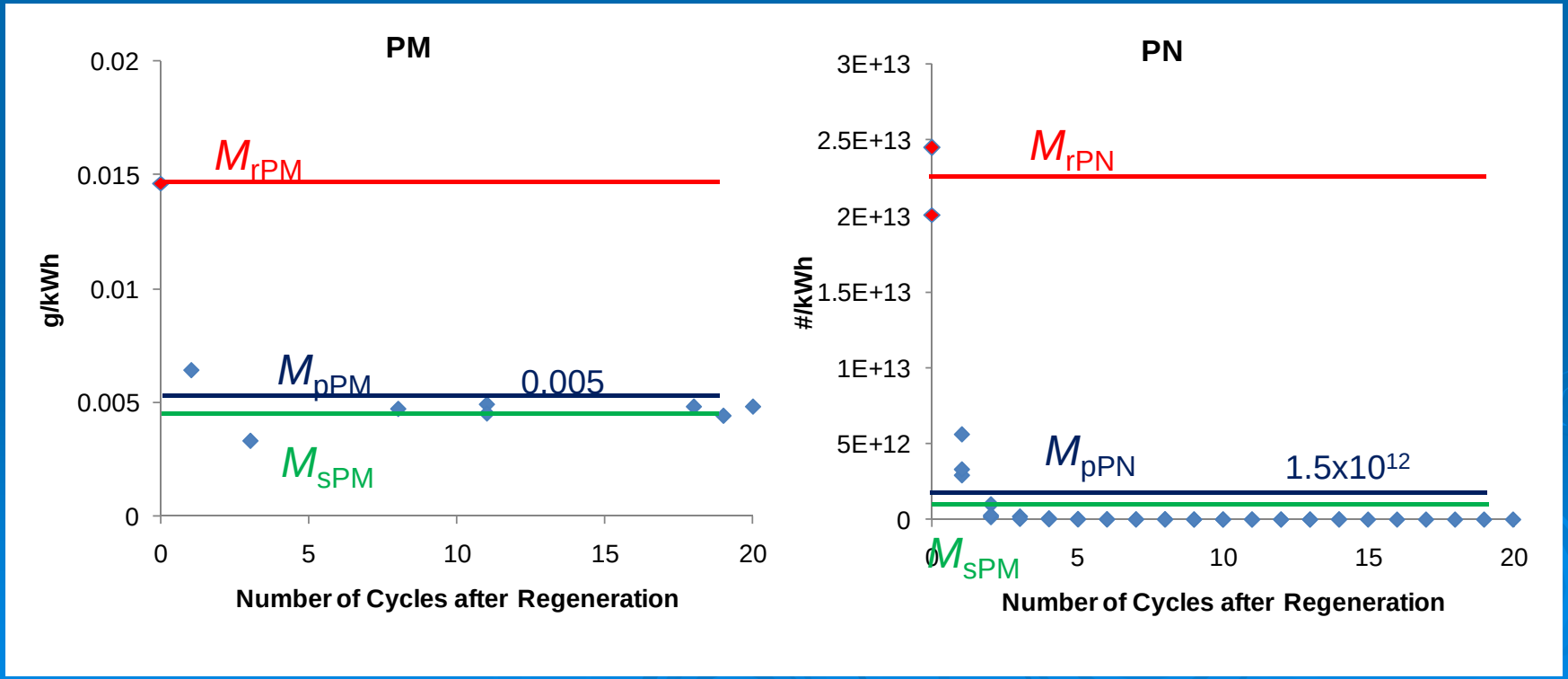
PM 16%

PN 81%

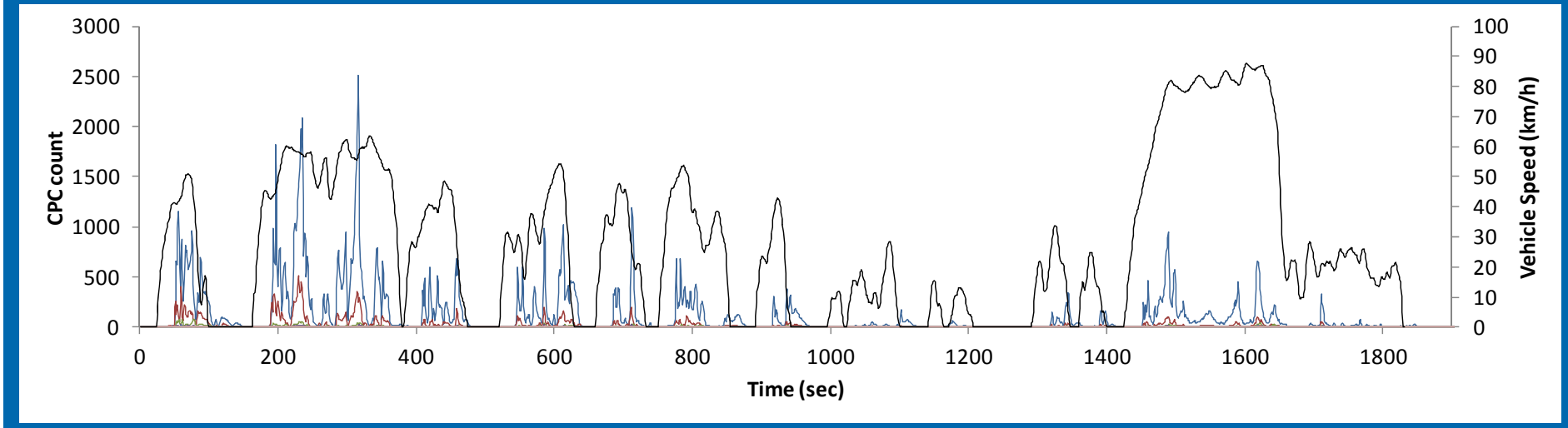
Next Cycle 16%

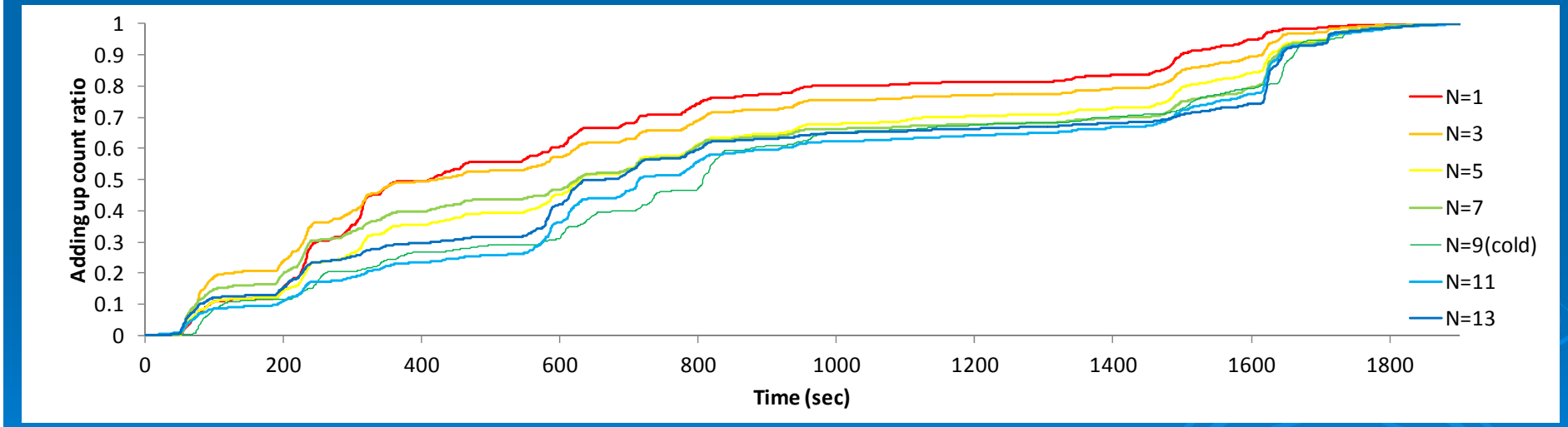
2 cycles after 2%

99% of M_{pPN} is derived from 3 cycles



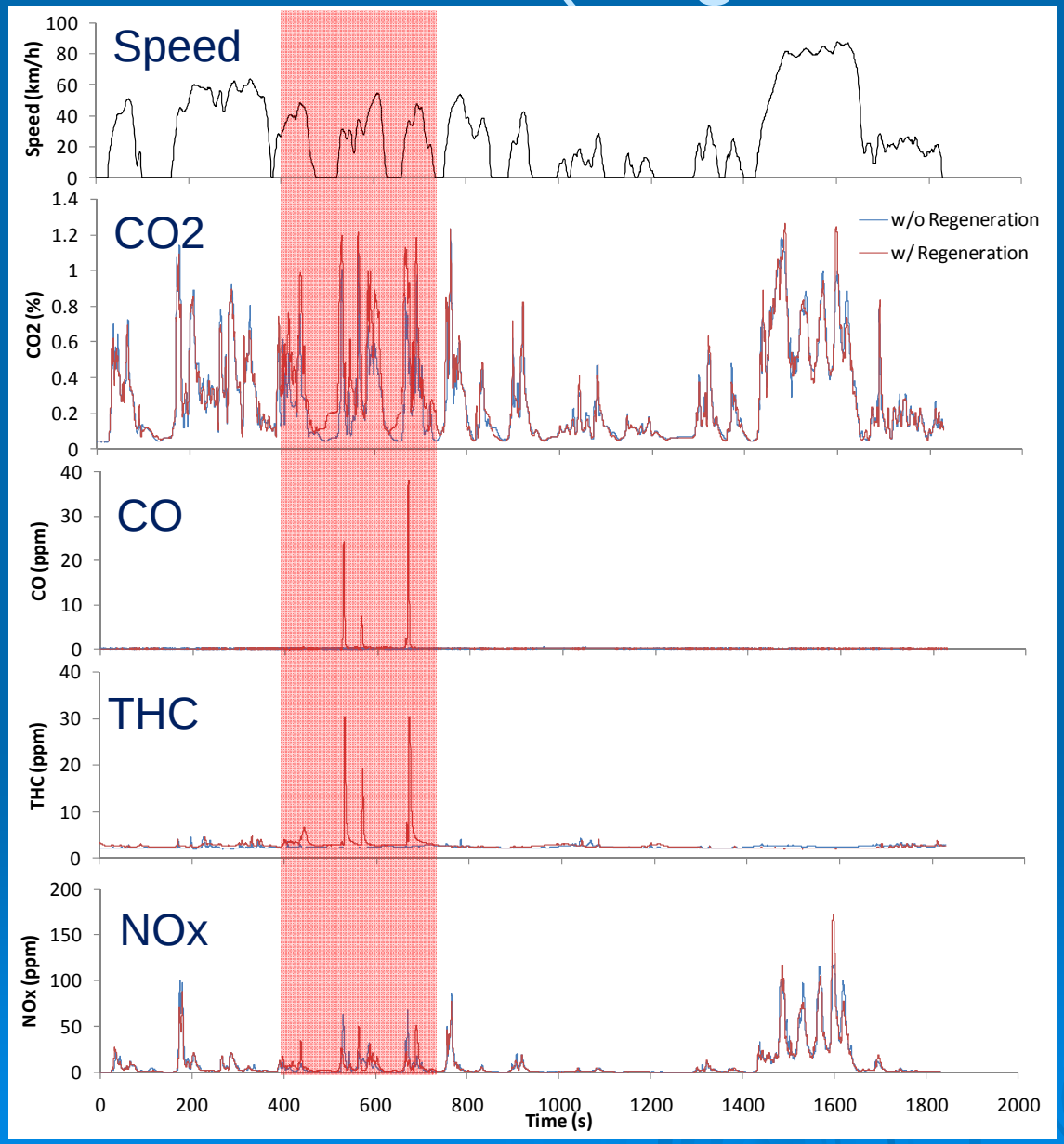
PN Profiles





Emissions with fresh DPF were quite high.
Emissions ratios in former part were higher with fresh DPF.

Gas Profiles (Regeneration)

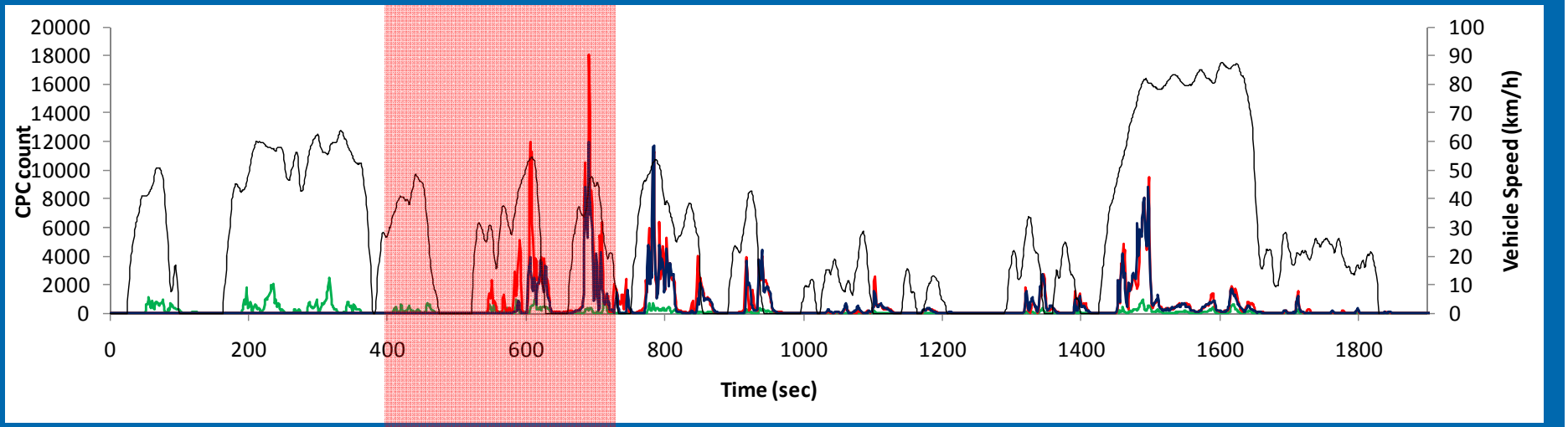


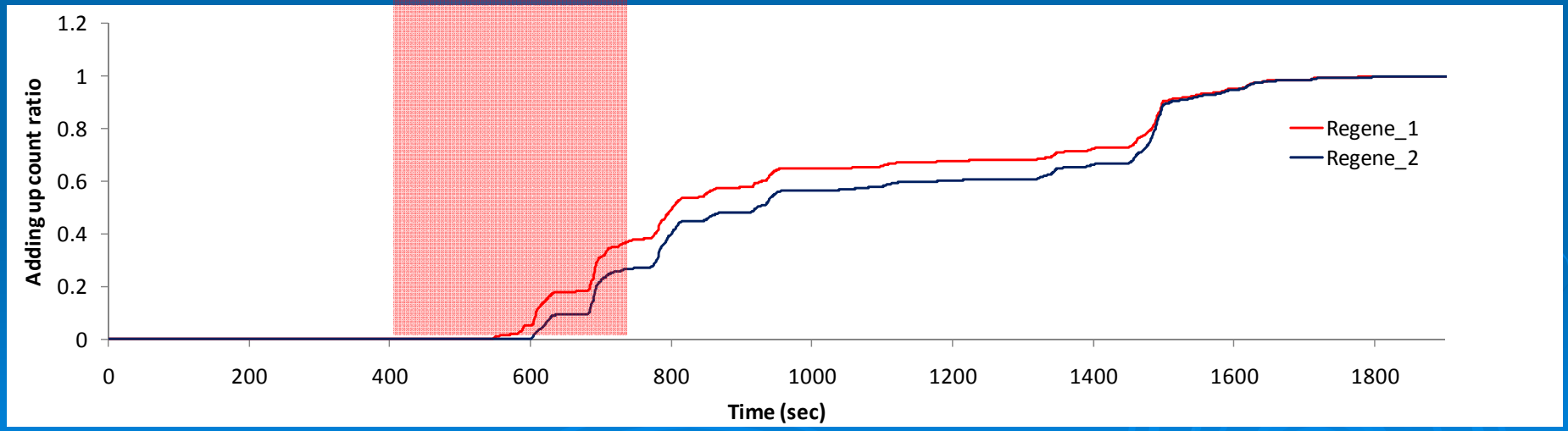
Regeneration started from 400s, lasted for 350 seconds.

Sharp peaks corresponding with acceleration were observed in CO and THC.

No change was observed in NOx profiles.

PN Profiles (Regeneration)





Emissions increased soon after the regeneration starts.
No special emission was observed in the regeneration.

Conclusion

- Histories of PN, PM and regulated emissions were observed from the recent HD truck which with periodically regenerating DPF.
- 3 times high emission of PM were observed with the regeneration.
- Almost thousand times high PN emission was observed, it decreases exponentially as test continues.
- In the certification value of PN, 81 % was due to the cycle with regeneration, 99 % to the three cycles from the regeneration.
- Repeatability of PN in the cycles with regeneration by PMP system was.
- Increase of PN during regeneration was due to DPF filtering efficiency drop by decreasing the trapped particles in DPF.