Evaluation of PMP Number Counting Method Applying for HD Diesel Engine

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ABSTRACT

The repeatabilities of PM measurements using the filter weighing method and the PMP-recommended number counting method with a full flow dilution system and a partial flow dilution system were evaluated. A DPF-equipped heavy duty diesel engine was used as the test engine, and the test modes were WHTC cold, WHTC hot, WHSC, ETC, ESC, and JE05.

The filter weighing method with a partial flow exhibited the best repeatability compared with that of full flow because of the lower dilution ratio. The other 3 measurements exhibited almost the same repeatability. However, using the number counting method, the results with full and partial flows were well correlated, suggesting that the fluctuation observed in the number counting method is due to a fluctuation in the exhaust PM emission, and not due to the measurement error. A better preconditioning procedure is required for the number counting method to improve the repeatability because its sensitivity is higher than that of the filter weighing method.

In the optimization tests, in which the WHTC cold mode was followed by 3 repetitions of the WHTC hot mode, a gradual reduction in the PM emission was observed with each repetition of the WHTC hot mode. This was caused not only by a change in the DPF filtering efficiency as soot loaded into the DPF, but also by fluctuations in the engine and/or the dilutor conditions. This was observed only with the number counting method, and not with the filter weighing method. For preconditioning, in the case of the number counting method, the WHTC cycle should be repeated at least 3 times to avoid fluctuations.

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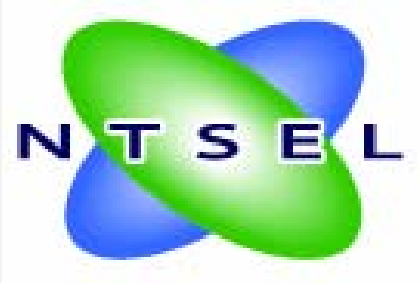

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Outline and Objective

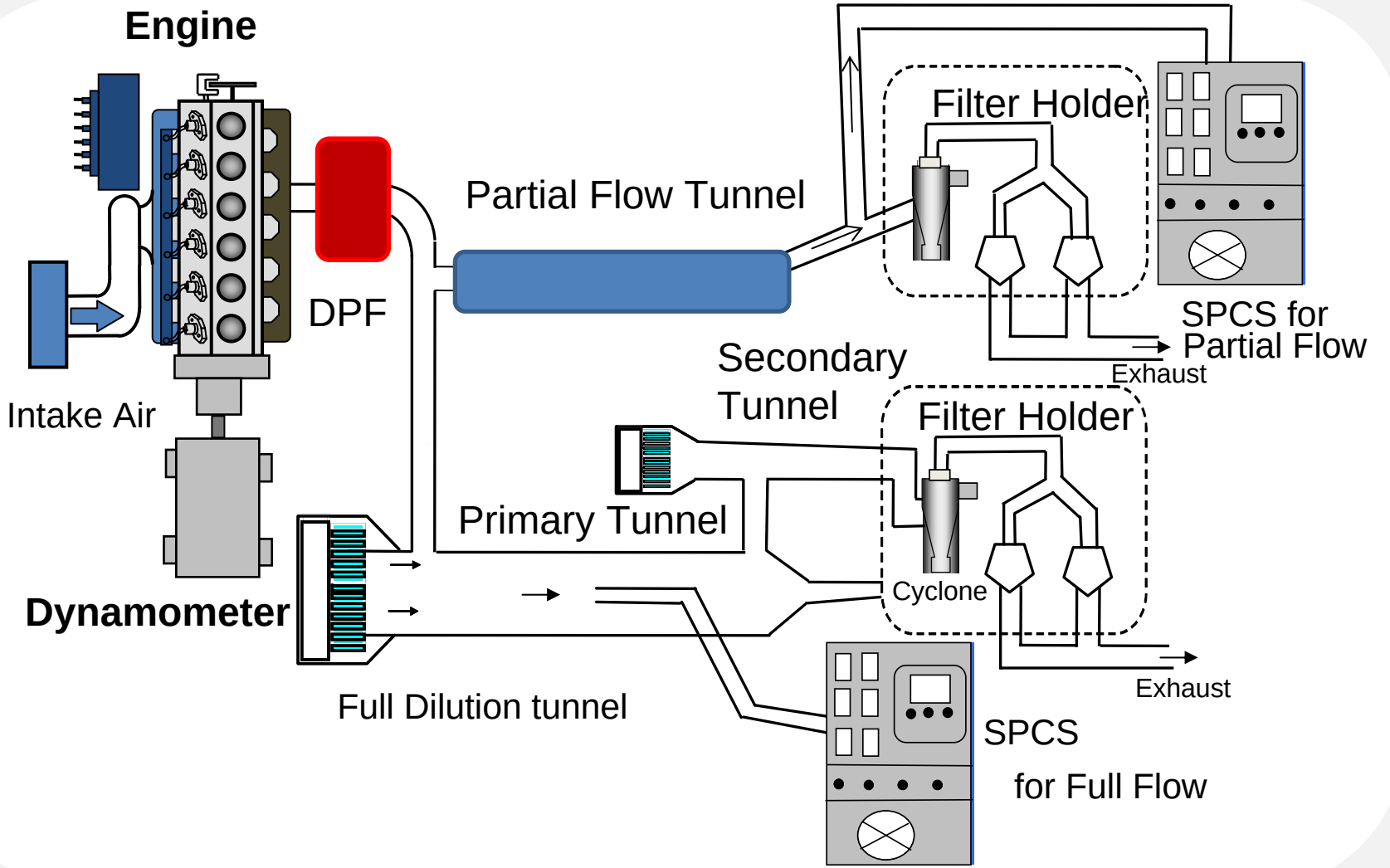
- Japanese round robin tests were held in 2Labs (NTSEL, JARI) to get information about number counting method application to HD engine.
- These tests can be regarded as second engine test in PMP validation exercise.
- This presentation introduces the results in NTSEL
  - Repeatabilities of number(PN) and weight(PM) with WHTC cold, WHTC hot, WHSC, ETC, ESC and JE05.
  - A correlation between full flow and partial flow

Test Engine

Engine Model	HINO J08E-TP
Configuration	Inline 6cyl, w/ I.C, T. C
Bore X Stroke	112 X 130
Inj. System	Common Rail (Max 1600bar)
Emission Reduction Device	**DPF** w/ CAT, Cooled EGR
Displacement	7.684
Compression Ratio	18
Performance	177/2700 kW/rpm
Emission	2005 JP, nearly **Euro V** (NOx:1.8g/kWh, PM:0.024g/kWh)

Number counting system : Horiba Mexa-SPCS

Experimental apparatus



4 measurements (PM full, PM partial, PN full and PN partial) were performed simultaneously.

Daily Schedule of the tests

- **Repeatability**
  - WHTC cold
  - WHTC hot(20min soak)
  - WHSC
  - JE05

  The total number of tests

  8 for each mode

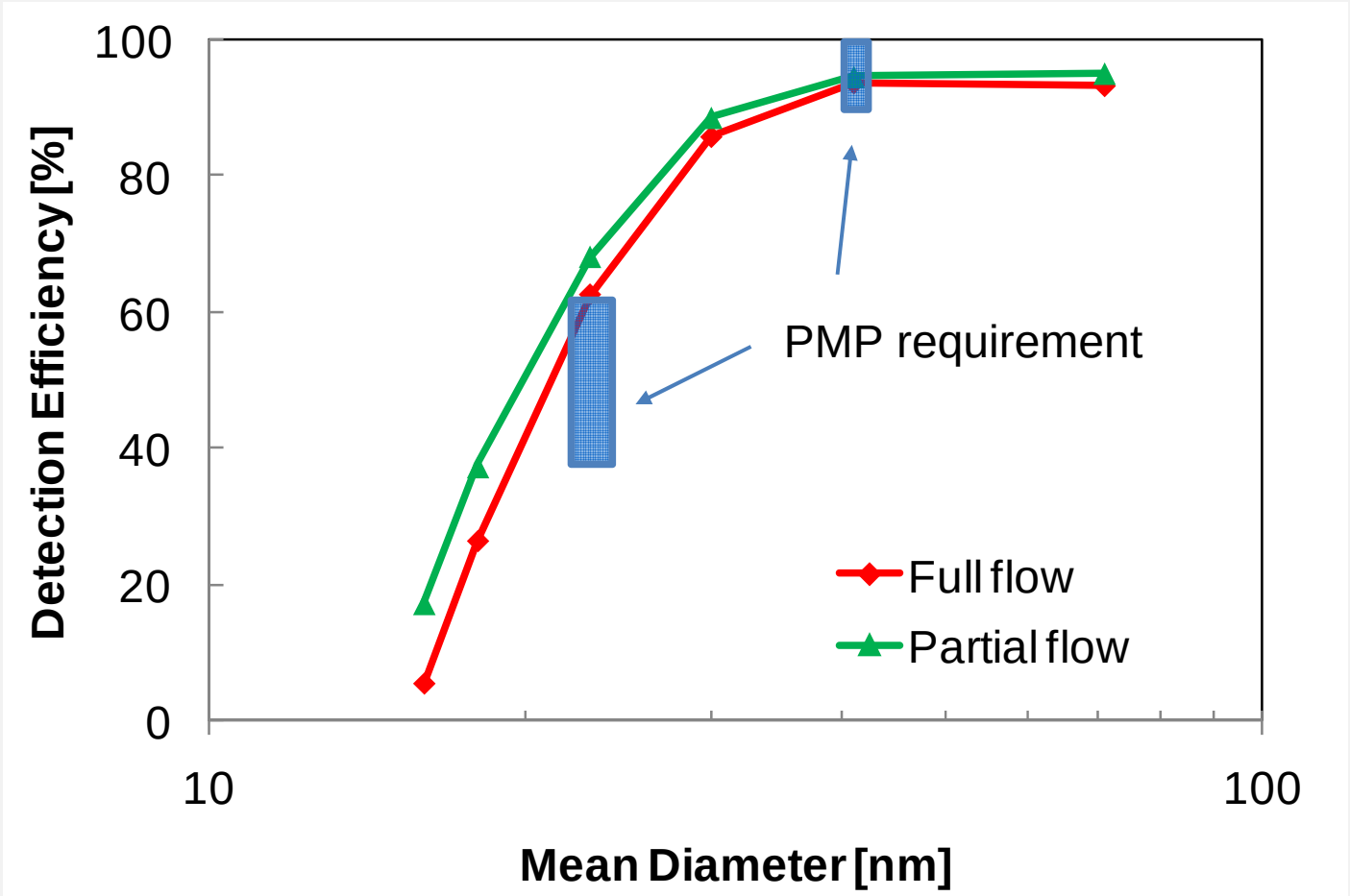
  Additional test

  -ETC, ESC

- **Sensitiveness**
  - WHTC cold
  - WHTC hot(20min soak)
  - WHTC hot(20min soak)
  - WHTC hot(20min soak)
  - DPF regeneration
  - Soot loading(If

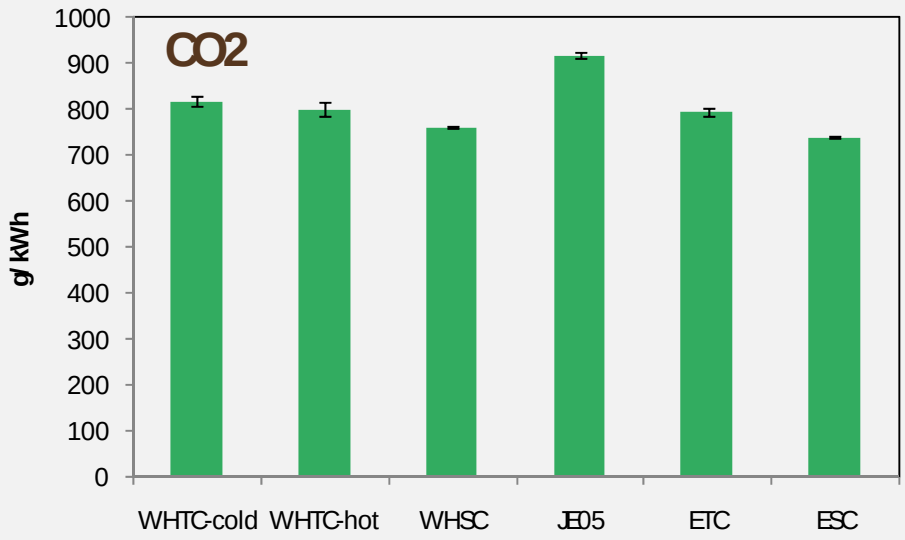
Tests were carried out under the same schedule to avoid an effect of wrong conditioning.

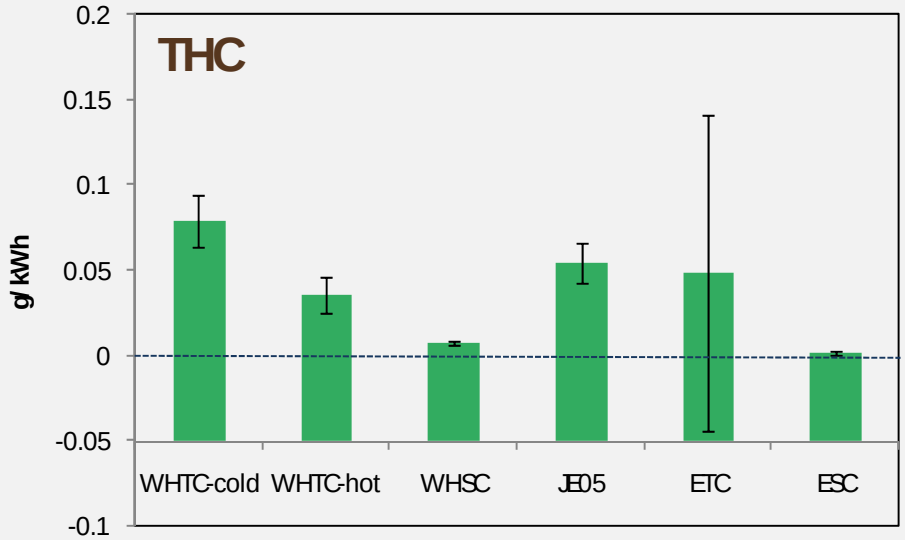
CPC Calibration results

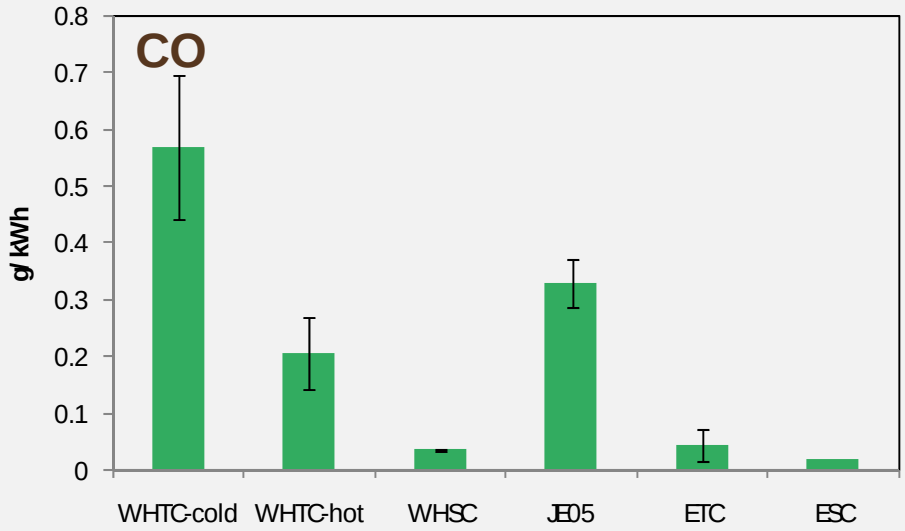


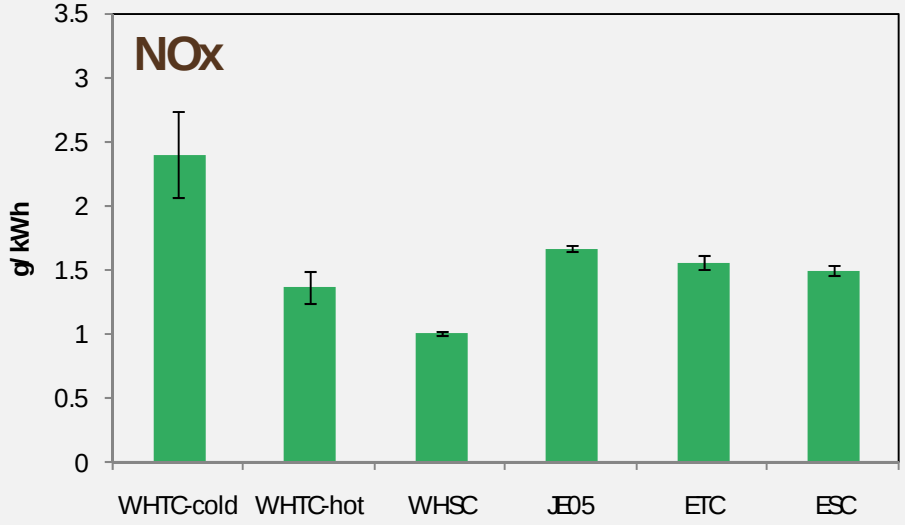
The CPC of partial flow exhibits slightly higher efficiency than PMP requirement, however the effect was not observed in this study (see latter data).

Regulated gas emission





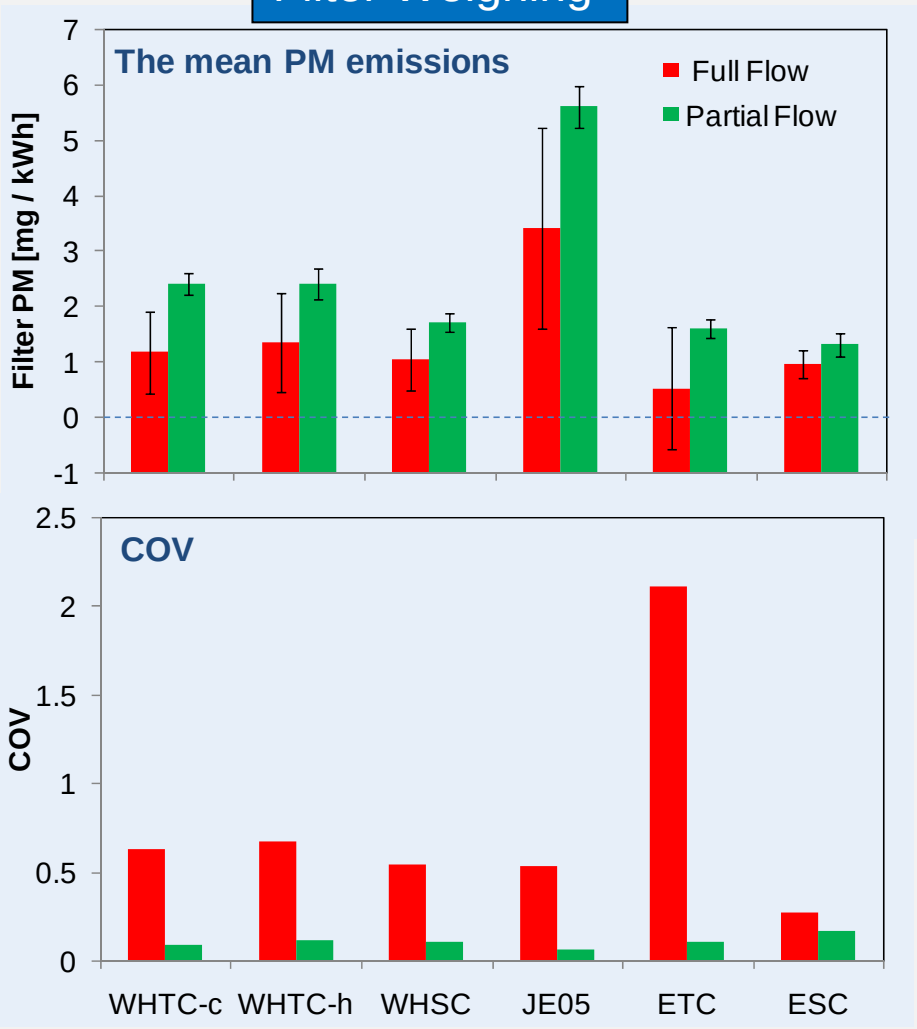




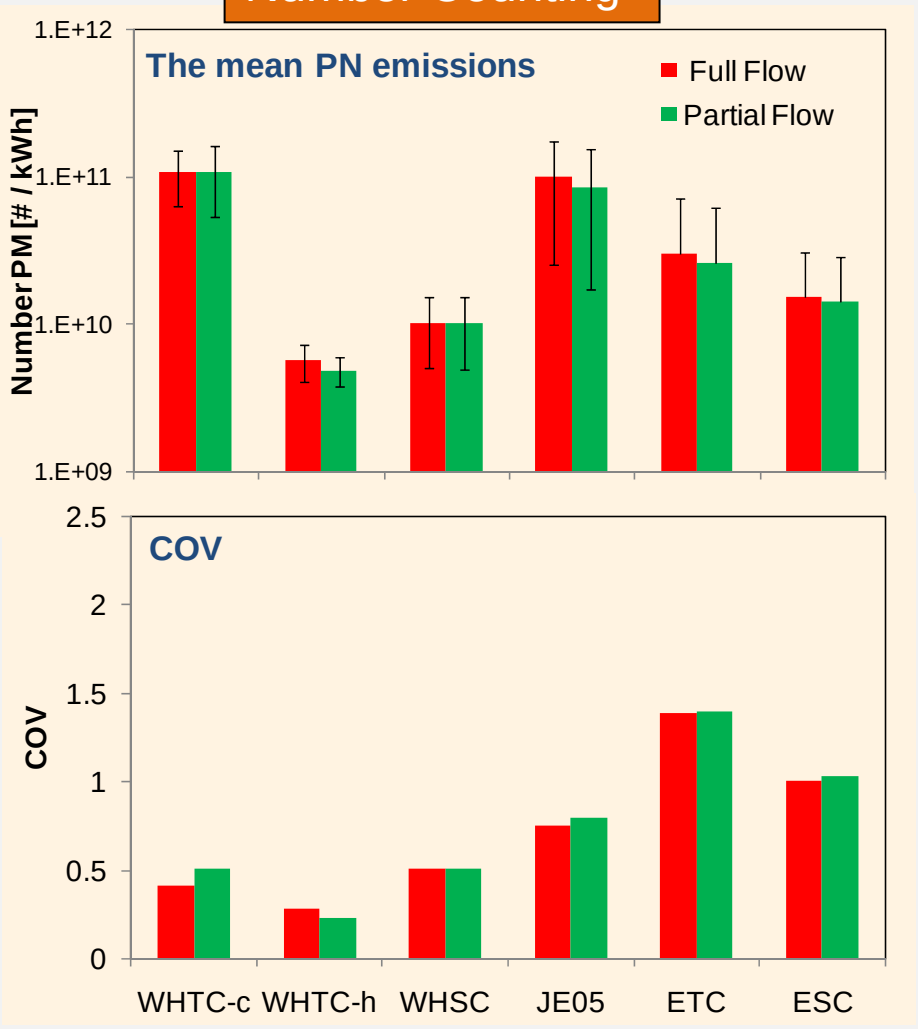
Regulated gas emissions were stable through out the tests.

PM and PN results

Filter Weighing



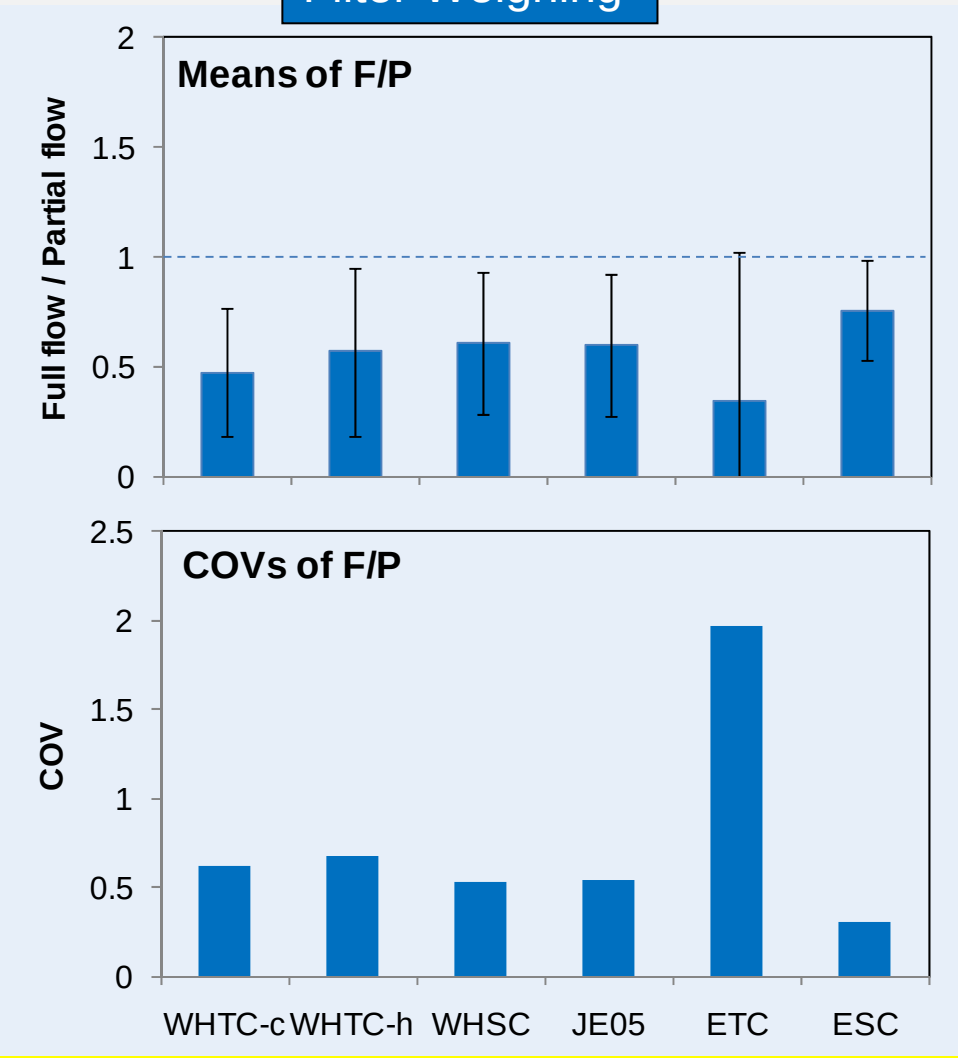
Number Counting



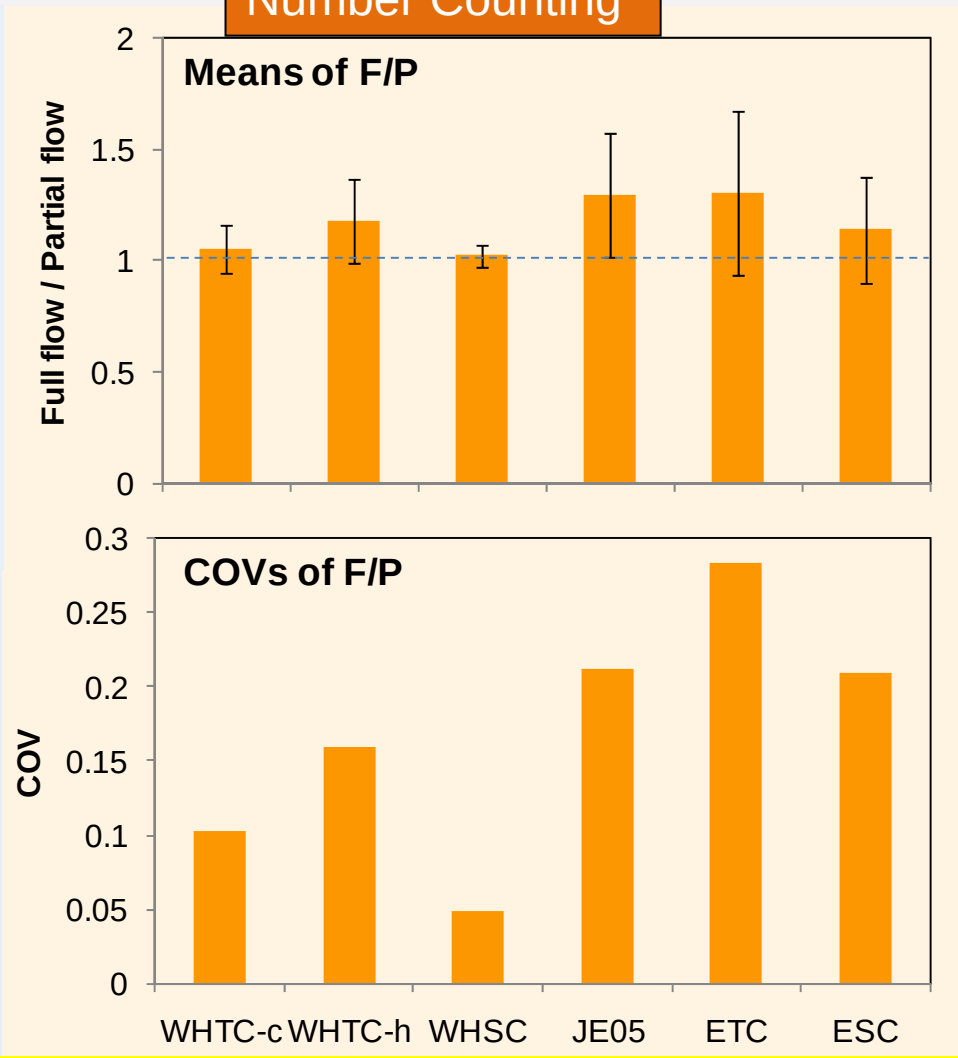
Relative emission differs between PM and PN(WHTC cold).
COVs of partial flow PM were quite good because of its low dilution factor.
Other three results were almost the same.

Correlation between full dilution and partial dilution

Filter Weighing



Number Counting



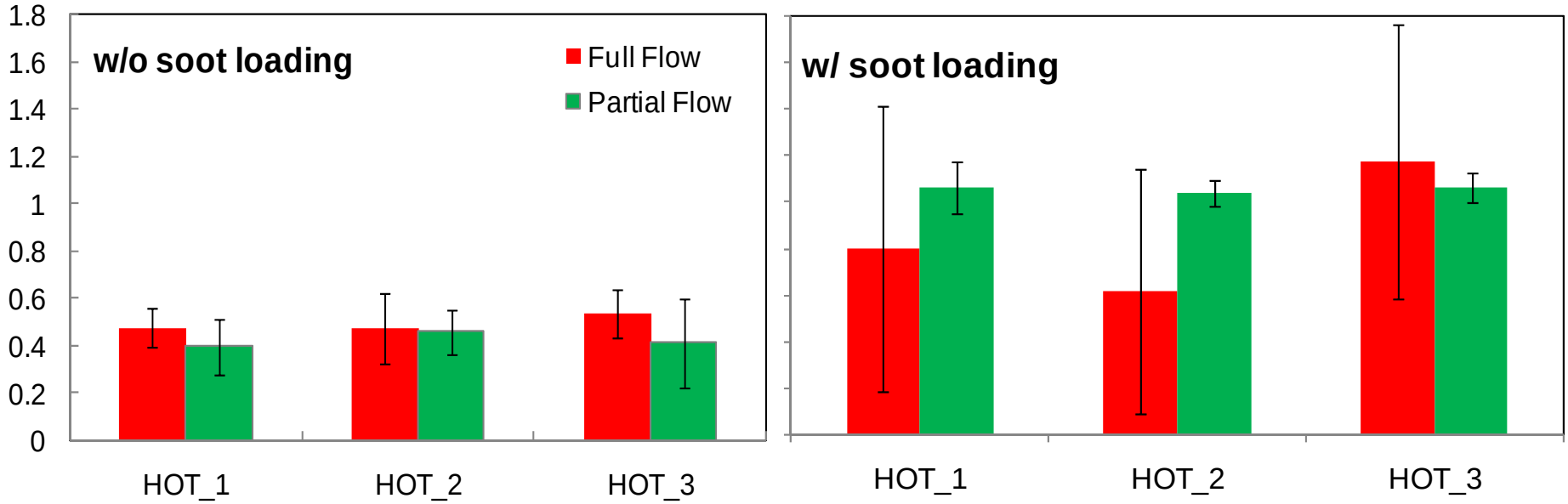
The correlations of PN was good.
Improvement of COV was observed in PN, indicating the fluctuations observed in PN may be arisen by difference of the engine exhaust.

Sensitiveness of the methods(PM)

Daily Schedule

WHTC cold	WHTC	WHTC
WHTC	Regeneration	ESC mode7 (w/ soot loading)

WHTC hot mode results of weighing method *Normalized by WHTC cold results of*



F_PM : PM by full tunnel, M_PM : PM by partial tunnel

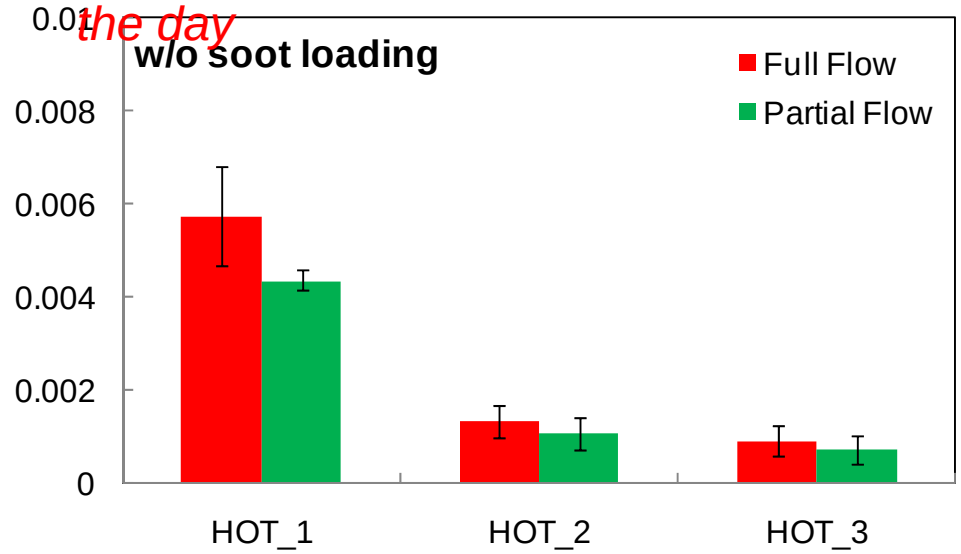
No effects of repeating WHTC hot mode were observed in both cases.

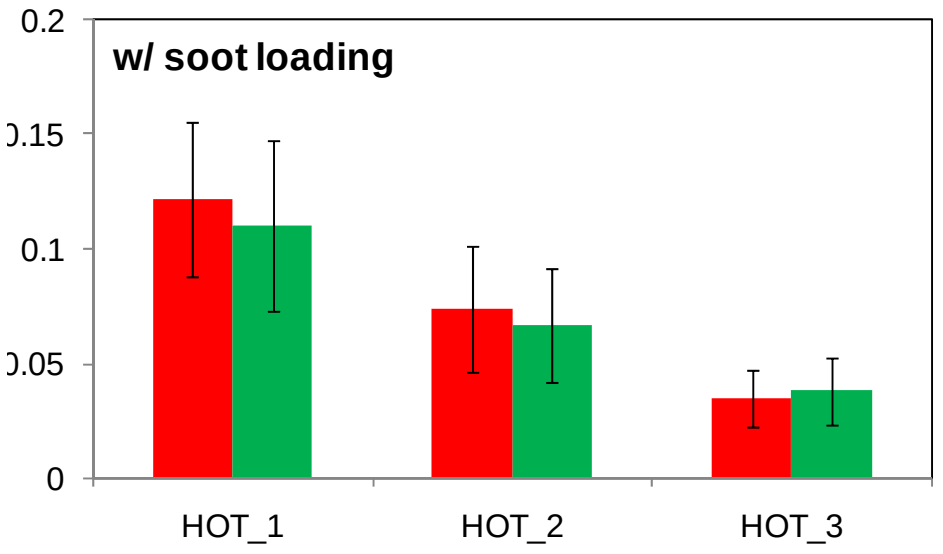
Sensitiveness of the methods(PN)

Daily Schedule

WHTC cold	WHTC	WHTC
WHTC	Regeneratio	ESC mode7 (w/ soot loading)

WHTC hot mode results of number counting *normalized by WHTC cold results of the day*





F_# : number by full tunnel, M_# : number by partial tunnel

- **Reductions of number emission were observed by repeating WHTC HOT mode .**
- **This feature was remarkable in case of w/o soot loading.**
- **Uncertainty of DPF and/or other condition has a possibility to cause an experimental error.**

Conclusions

- **The Partial flow PM exhibits the best repeatability.**
- **The Repeatabilities with the other 3 measurements were almost the same revel (0.5).**
- **In cold start mode, relatively high emission was observed in PN.**
- **One of the factors of the fluctuation observed with PN is unsteadiness of an engine exhaust.**
- **For the pre-conditioning of PN, at least 3 times WHTC modes are required to obtain certain results.**