

Validity for Detecting DPF Failure by Measuring Particle Number in Tailpipe

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Background

An opacity measurement which is performed at the Periodic Technical Inspection (PTI) were known having not enough sensitivity to detect DPF failures. Recent studies have stated measuring tailpipe PN is useful tool to detect the DPF failures. Netherlands, Switzerland, Belgium and Germany have already adopted PN measurements at PTI. Currently, PN measurements at PTI have been operated different methodology in each countries with different limit values (1 million and 0.25 million /cc). In 2023, Joint Research Centre (JRC) of European Union published a guideline about the tailpipe PN measurement at PTI with the limit value of 0.25 million. Many countries in Europe, south America, East Asia are discussing to introduce PN measurements. Former introduced counties reported that 10 to 20 % of inspected cars were found to having failures in DPF and exceeding the limit value.

Objectives

We performed two experiments to evaluate a feasibility of monitoring PN concentration at tailpipe for detection of DPF troubles.

Correlation between chassis dyno test and tailpipe measurements

- PNs (SPN23 and SPN10) in WLTP from passenger diesel car with DPF which is intentionally damaged were measured using a chassis dynamometer.
- After chassis tests, tailpipe PNs were monitored with PN PTI device and evaluate the correlations between WLTP and tailpipe measurement.

PN measurement campaign for DPF diesel cars at PTI station in Japan

- PN measurements at PTI station in Japan were conducted to obtain the ratio of cars having troubled DPFs.

PN measurement campaign for DPF diesel cars at PTI station in Japan

Experimental



Tokyo



Osaka



Sapporo



	Tokyo-1	Osaka	Sapporo-1	Sapporo-2	Tokyo-2	Total
Date	Feb./1/2023	Feb./3/2023	Feb./17/2023	Aug./28, 29/2023/	Nov./22/2023/	
HD	9	23	10	30	14	86
LD	19	4	10	13	9	55

A test study for measuring tailpipe PN against Heavy Duty (HD) and Light Duty (LD) diesel cars with DPF were performed in 2023. The campaign was held at PTI stations in Tokyo, Osaka and Sapporo against cars came to be take actual PTI check. In total, the tailpipe PNs of 141 DPF diesel cars (HD: 86, LD:55) were measured based on the PTI test protocol in Netherlands.

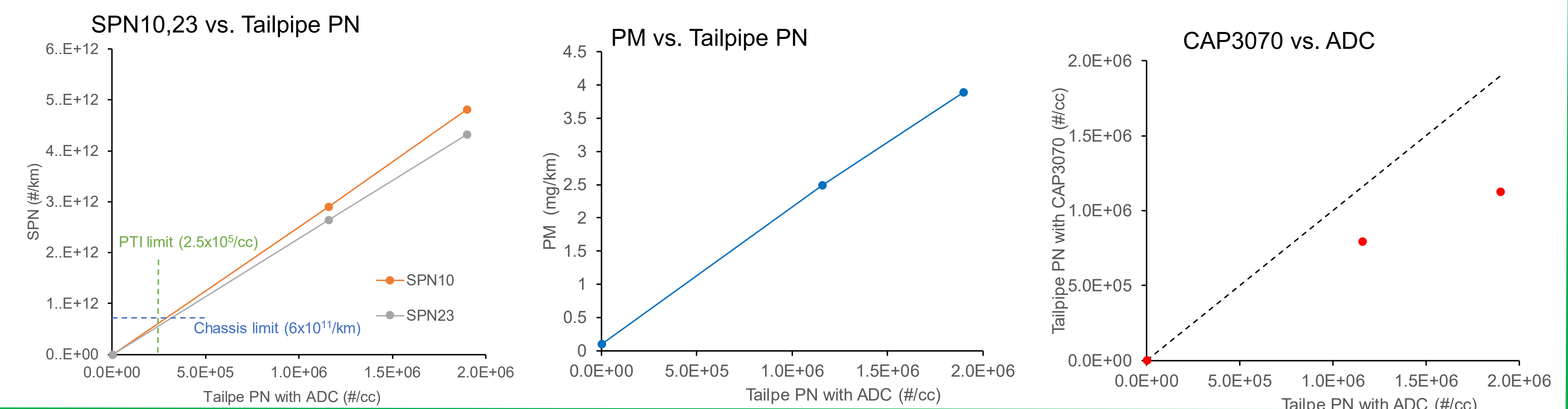
Results

- The opacities from all tested cars were below the PTI limit value (0.5).
- Cars which exhibited higher tailpipe PN than European guideline value (250,000/cc) were 34 out of 141 cars (24.1 %).
- The exceeding ratio of HD was higher than that of LD (26.7 % vs. 16.4 %).
- Variations from locations seem to be negligible.
- All the cars certificated with the most recent regulation (2018) exhibited lower emissions than European guideline value.

	Tokyo	Osaka	Sapporo	HD	LD	2018 reg.	2009 reg.	2005 reg.	Total
Test No.	51	27	63	86	55	23	100	68	141
Over 0.25 mil.	11	8	14	23	9	0	29	19	34
%	21.6%	29.6%	22.2%	26.7%	16.4%	0.0%	29.0%	27.9%	24.1%

Results

- Correlations between SPN10, 23 and tailpipe PN were well. $6 \times 10^{11}/\text{km}$ (Chassis limit) of SPN10 and 23 are almost equal to $2.5 \times 10^5 / \text{cc}$ (PTI guideline value).
- PM also exhibited good correlation against tailpipe PN.
- Two PTI devices showed some difference but linearity was good.



Conclusion

Tailpipe PNs exhibited good correlation against SPN10 and 23 with WLTP (type approval test). some difference among the devices (linearity was good)

In total 24.1 % of diesel cars at PTI station in Japan exhibited higher PNs than European guideline value. HD diesel cars exhibited higher ratio than LD cars in the point of exceeding guideline value.

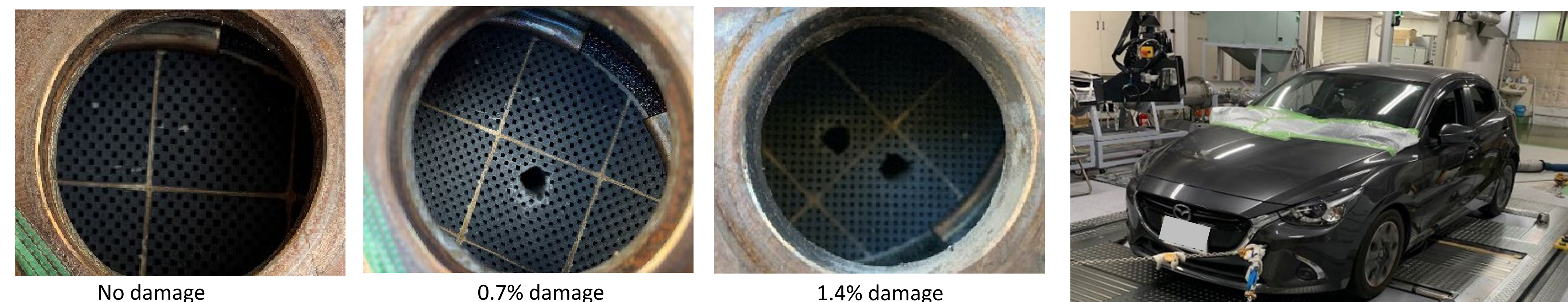
This study was supported by Ministry of the Environment Japan and the National Agency for Automobile and Land Transport Technology.

Correlation between chassis dyno test and tailpipe measurements

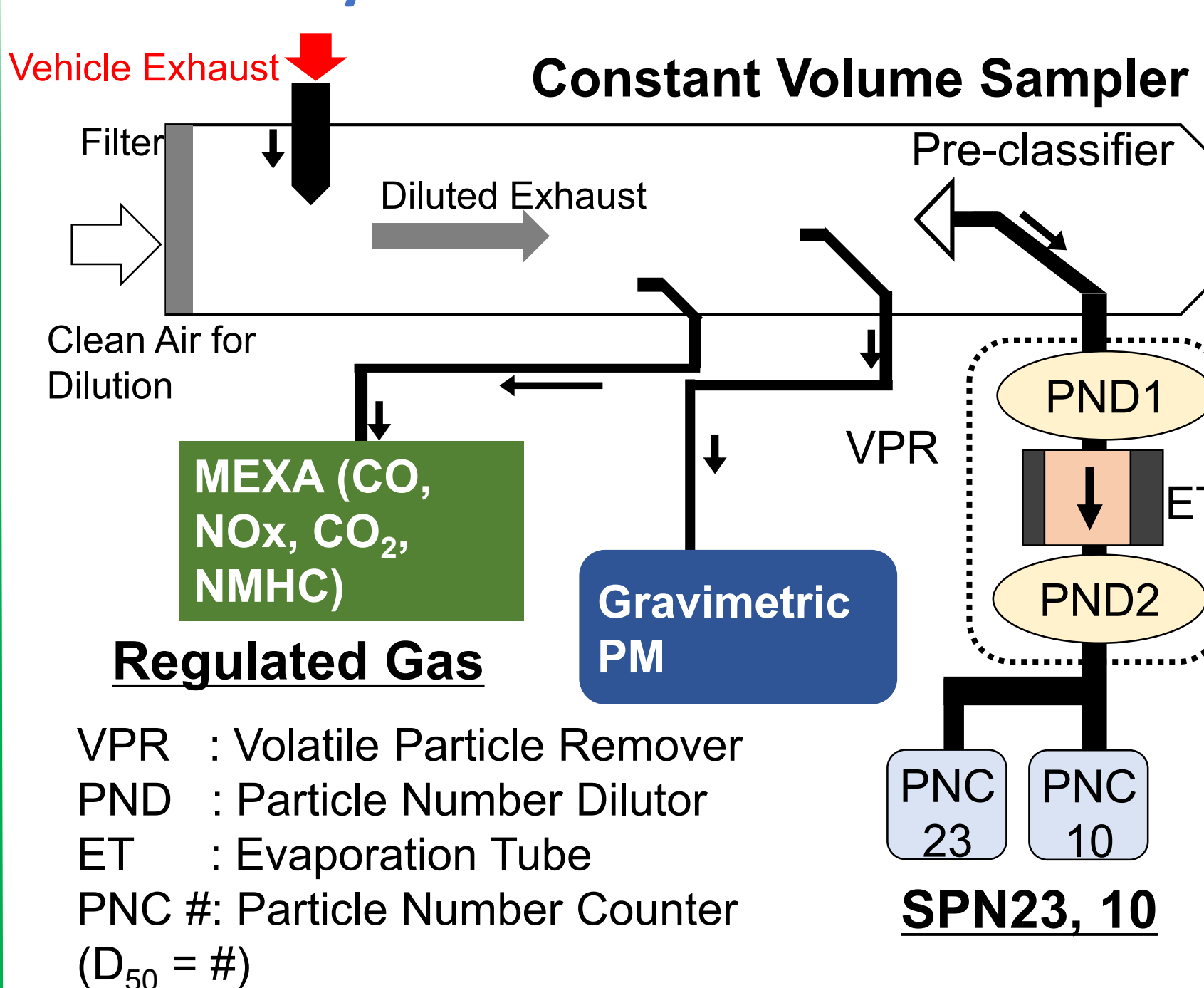
Experimental

WLTP (3phase) tests were performed for the passenger car with DPF which was intentionally damaged. Experiments were carried out with 3 conditions of DPF (no damage, 1 hole, 2 hole). Regulated gases, PM, SPN23 and SPN10 were measured. In the chassis experiments. AVL APC was used to measure SPN23 and SPN10.

Tailpipe PN measurements were conducted with three DPF conditions discussed above. Two PN counters (CAP3070;Capelec, ADC; AVL ditest) were used for the measurements



Chassis Dynamometer Test



	DPF Diesel
Vehicle name	Demio
Manufacturer	Mazda
Identification no.	LDA-DJ5FS
Vehicle Weight in kg	1130
Displacement in cm ³	1498
Engine family	DPF Diesel
After treatment	DPF
Intake management	Intercooler Turbo



Tailpipe Test

