

Emission Characteristics and Evaluation Method of Solid Particle Number from Diesel Engines Equipped with a Periodically Regenerating DPF

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In certification testing for diesel engines equipped with a periodically regenerating DPF, a regeneration adjustment factor (k_r) is applied to account for the increase in emissions during regeneration. Although the k_r factor for solid particle number (SPN) is also evaluated using the same procedure as that for conventional emission components, there is a risk of underestimation because of the distinctive emission characteristics of SPN emissions. In this study, SPN emissions from heavy-duty diesel engines equipped with a periodically regenerating DPF were evaluated, and a simple method for improved evaluation of the k_r factor for SPN emissions was proposed.

Specifically, SPN23 and SPN10 emissions during repeated WHTC tests were measured using a direct sampling method for 5.2 L and 9.8 L diesel engines compliant with the 2016 Japanese emissions regulations. As shown in Figures 1 and 2, the filtration efficiency depended on soot accumulation, which also influenced SPN emissions. SPN emissions increased not only immediately after DPF regeneration but also, in some cases, immediately before regeneration.

The k_r factors for SPN emissions determined from the average of the emissions measured immediately before and after regeneration (Method (B) in Table 1) were lower than those obtained using Method (A), which uses the average of all WHTC tests. This indicates that Method (B) may underestimate the k_r factor for SPN emissions. Therefore, this study proposes Method (C), in which the k_r factor is determined from the average SPN emission during at least three consecutive WHTC hot tests after regeneration, where each SPN emission remains within $\pm 25\%$ of the average. As shown in Table 1, the proposed method can improve the evaluation of the k_r factor for SPN emissions while requiring relatively little effort.

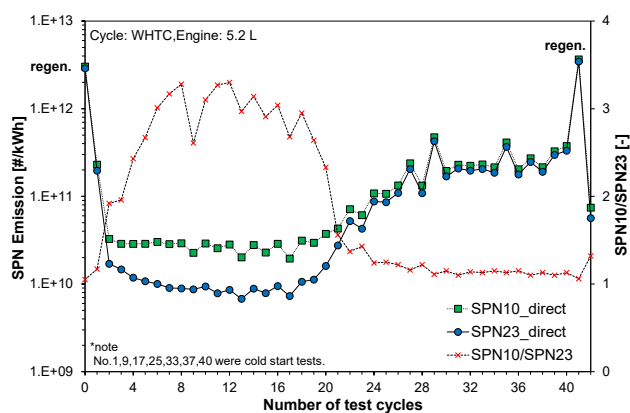


Fig. 1 SPN emissions of 5.2 L engine

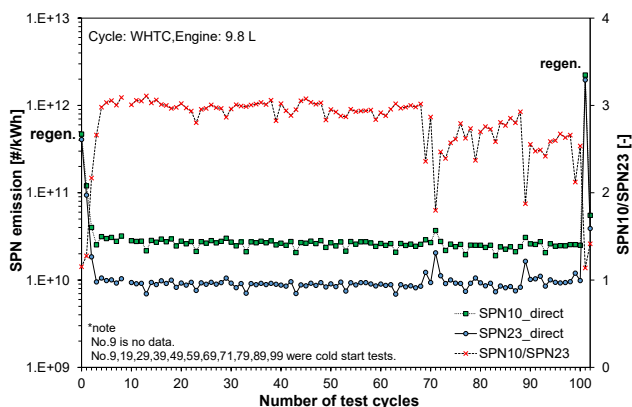


Fig.2 SPN emissions of 9.8 L engine

Table 1 Evaluation results of the k_r factor

*Proposed

Engine	SPN	Method	SPN emission [#kWh]			k_r factor	
			$\bar{e}$	$\bar{e}_r$	e_w	k_{r_mult}	k_{r_add}
5.2 L ($n=40, n_r=1$)	SPN23	(A)	1.03E+11	3.45E+12	1.85E+11	1.79	8.17E+10
		(B)	1.95E+11		2.74E+11	1.41	7.95E+10
		(C)*	9.32E+09		9.34E+10	10.01	8.40E+10
	SPN10	(A)	1.26E+11	3.66E+12	2.12E+11	1.69	8.62E+10
		(B)	2.25E+11		3.09E+11	1.37	8.38E+10
		(C)*	2.93E+10		1.18E+11	4.02	8.86E+10
9.8 L ($n=100, n_r=1$)	SPN23	(A)	1.02E+10	1.96E+12	2.95E+10	2.89	1.93E+10
		(B)	2.44E+10		4.35E+10	1.78	1.91E+10
		(C)*	1.00E+10		2.93E+10	2.93	1.93E+10
	SPN10	(A)	2.72E+10	2.23E+12	4.63E+10	1.80	2.18E+10
		(B)	4.01E+10		5.91E+10	1.54	2.17E+10
		(C)*	2.89E+10		4.80E+10	1.75	2.18E+10