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PN emissions from Japanese  
engines with catalyzed DPF system  
- Effect of Cycle Exhaust Temperature

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Prepared for  
2009/3/30 PMP-WG MEETING  
JASIC

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# Outline

- The Japanese Heavy-Duty inter-laboratory exercise has been conducted at the Japan Automobile Research Institute (JARI) and the National Traffic Safety and Environment Research Laboratory (NTSEL). The works were undertaken on a Hino J08E Heavy-Duty engine equipped with a Catalyzed Diesel Particulate Filter (C-DPF),
  - The evaluation of another Japanese engine is also conducted at JARI. The engine basically adopts same emission control technologies but showed different PN emission characteristics.
  - An analysis was conducted and the result showed that the exhaust temperature of the engine was higher than J08E, and by this self-regeneration of DPF occurred during the test cycles and which led to high PN emissions.
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# Engine Specifications

Engine	A (JAPAN)	B (J08E)	Cursor 8 for PMP Validation
Displacement	5193 cc	7684 cc	7.8 L
Max. Power / Rev.	154 kW / 2600 rpm	177 kW / 2700 rpm	260 kW / 1900~2400 rpm
Max. Torque / Rev.	637 Nm / 1600 rpm	716 Nm / 1600 rpm	1280 Nm / 1000~1900 rpm
DPF type	C-DPF (Cordierite)	C-DPF (Cordierite)	CRT (Cordierite)

Both Engine A and B are the newest 2005 model with cooled EGR & DPF, and B is used for Japanese round-robin test.

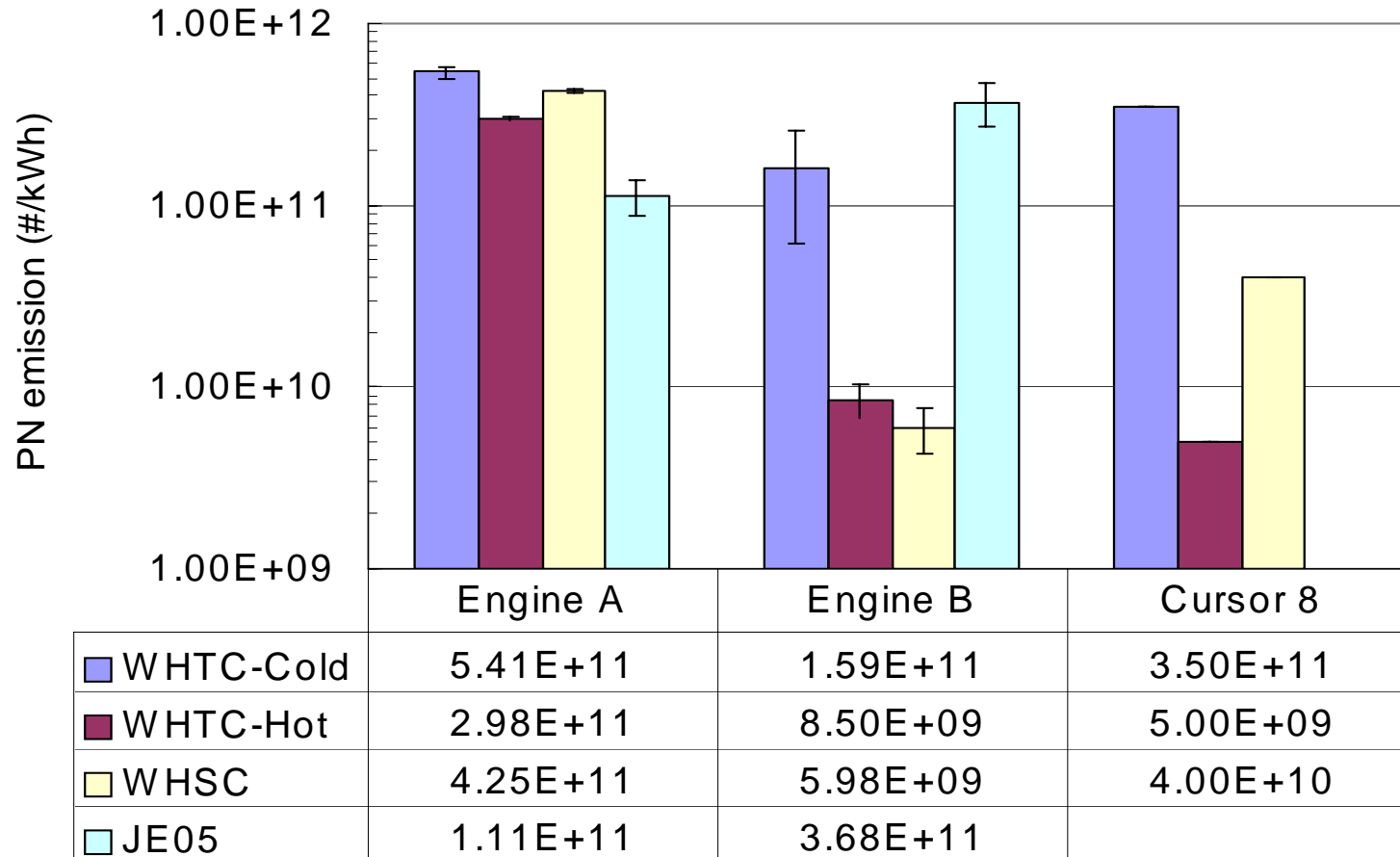
Engine A adopts higher boosting design which resulting higher exhaust temperature than B.

# Test Schedule

Engine A	Engine B	Cursor 8
TB measurement	TB measurement	IFV
<b>WHTC-Cold</b>	<b>WHTC-Cold</b>	<b>WHTC-Cold</b>
10 min soak	20 min soak	10 min soak
<b>WHTC-Hot</b>	<b>WHTC-Hot</b>	<b>WHTC-Hot</b>
10 min Mode9 (WHSC) 6 min Idle + 5min soak	10 min Mode9 (WHSC) 2 min Idle + 5min soak	10 min Mode9 (WHSC)
<b>WHSC</b>	<b>WHSC</b>	<b>WHSC</b>
20 min Full-Full	20 min Full-Full	5 min Mode7(ESC) 3 min idle
10 min soak	10 min soak	<b>ETC</b>
JE05 Precon	JE05 Precon	5 min Mode7(ESC) 3 min idle
10 min soak	10 min soak	<b>ESC</b>
<b>JE05</b>	<b>JE05</b>	Power Curve
DPF regeneration 20 min Full-Full WHTC-hot		15 min Mode10(ESC) 30 min Mode7(ESC)

 Pre-conditioning

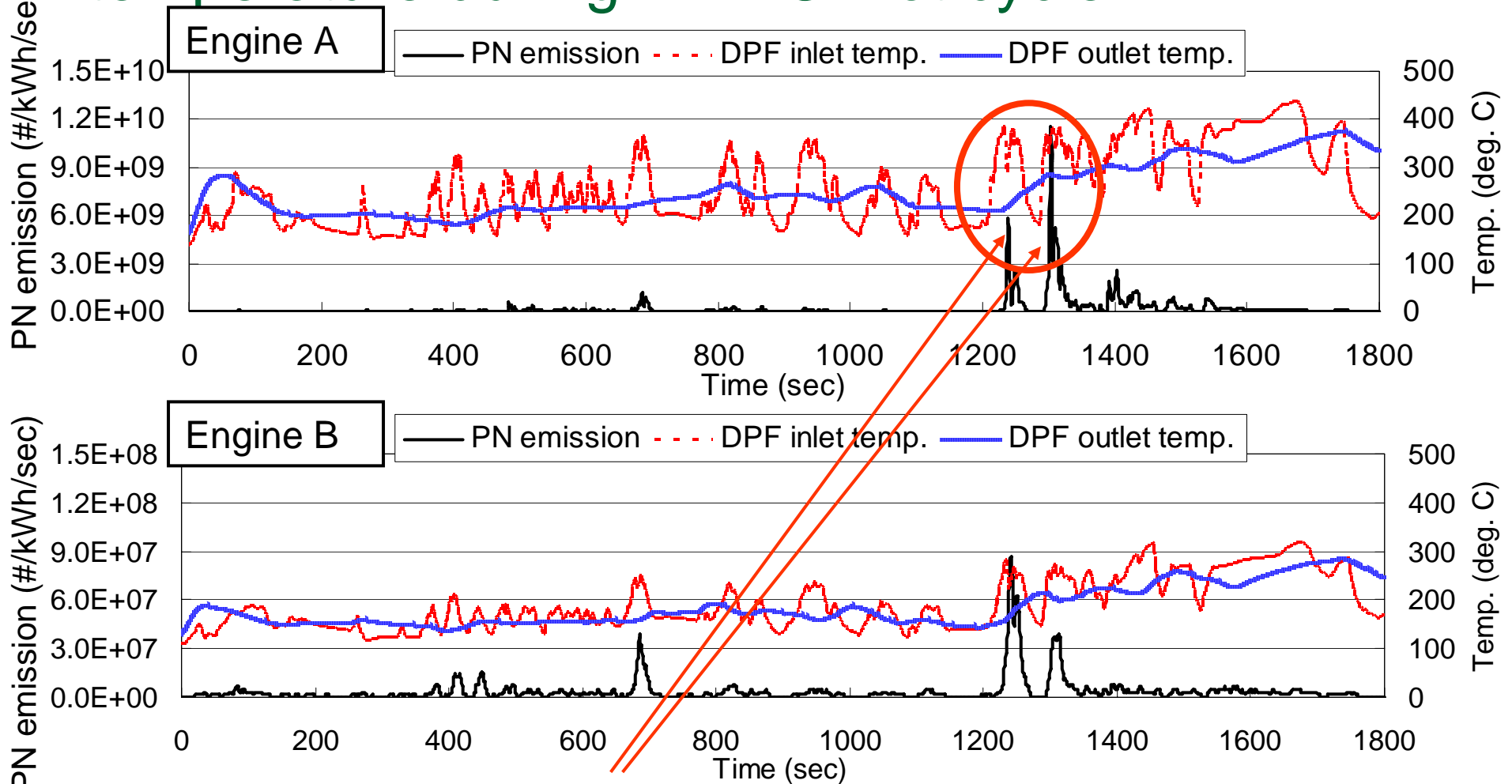
# PN emission (WHTC WHSC JE05)



Engine A showed lower PN emission in JE05

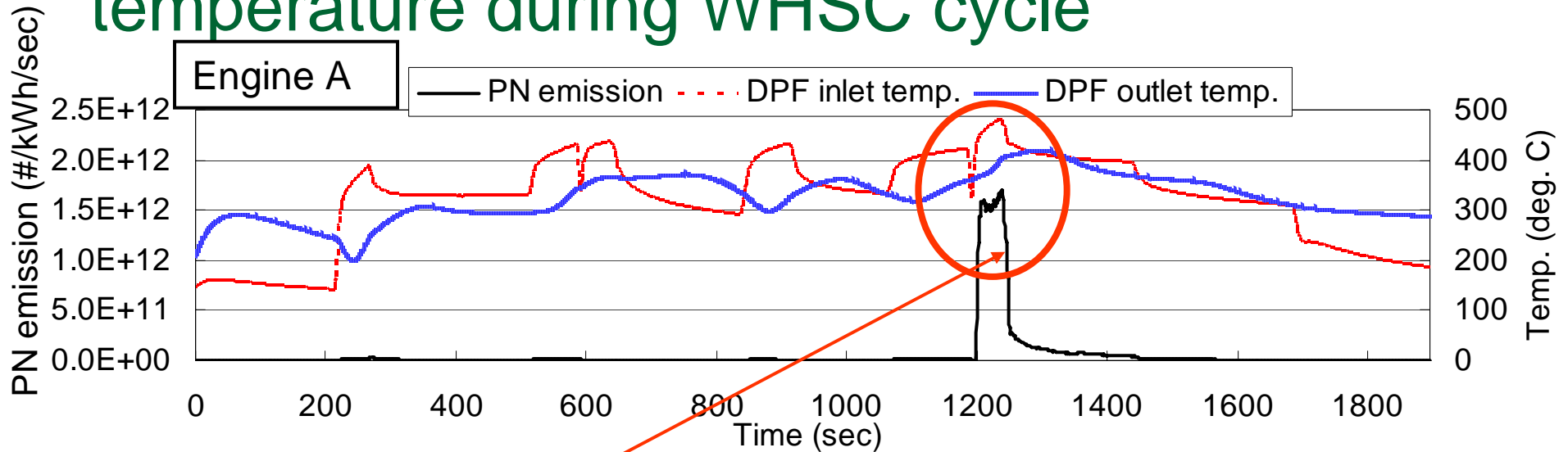
Engine A showed higher PN emission level than others, in WHTC and WHSC.

# Time History of PN emission and exhaust temperature during WHTC-Hot cycle

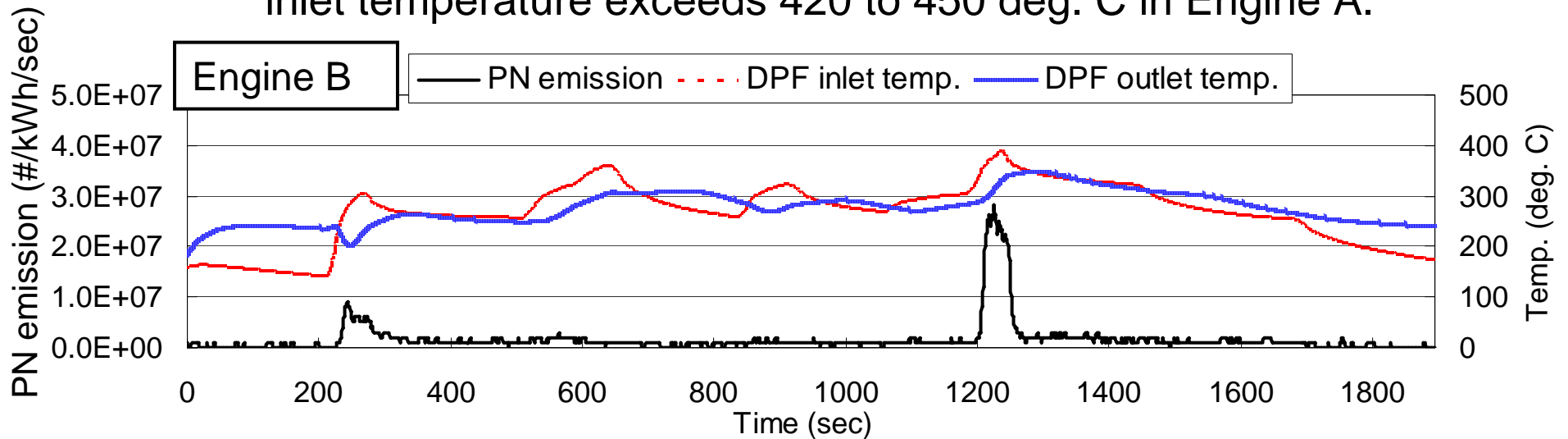


Remarkable increase in PN emission occur when the DPF inlet temperature exceeds 400 deg. C in Engine A.

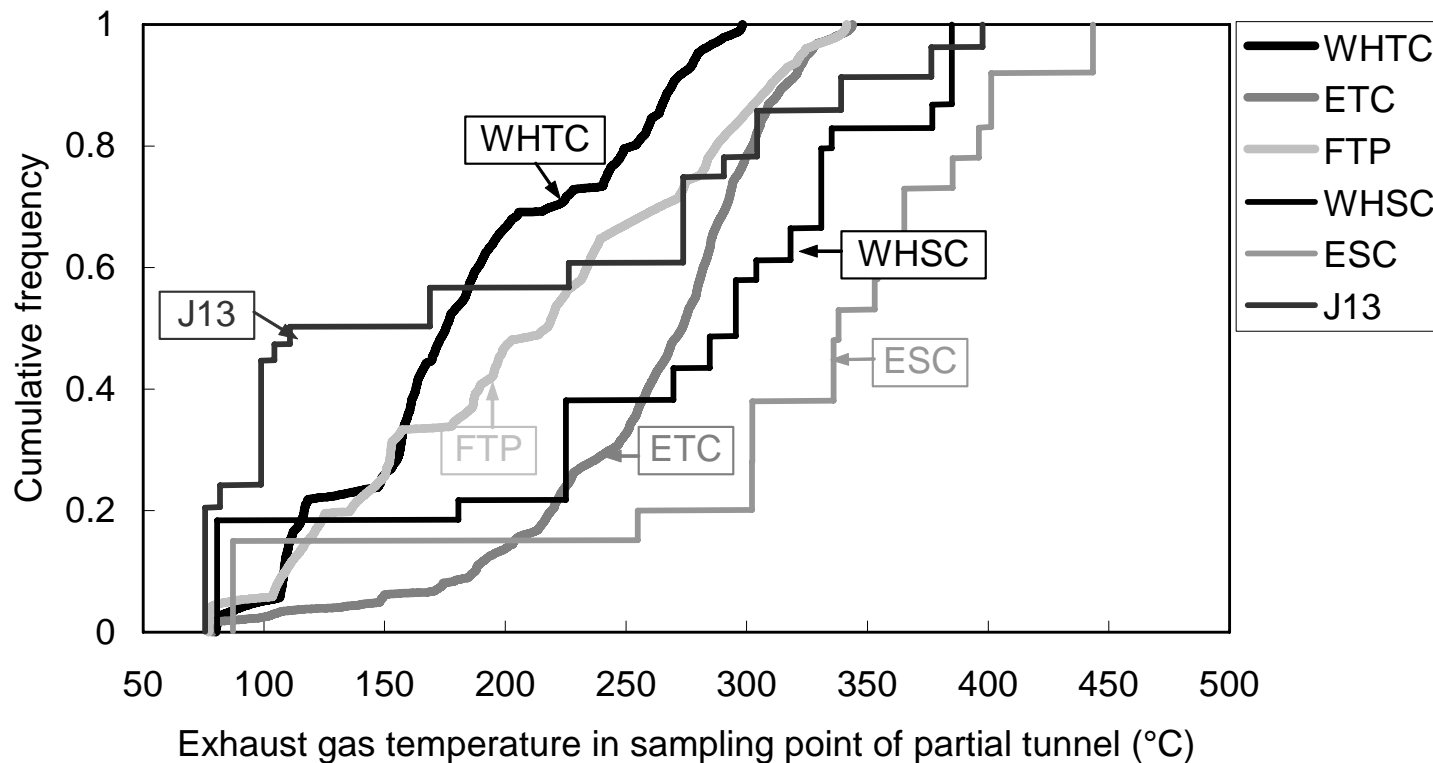
# Time History of PN emission and exhaust temperature during WHSC cycle



Remarkable increase in PN emission occur when the DPF inlet temperature exceeds 420 to 450 deg. C in Engine A.



# An Example of Exhaust Temperature Distributions During Emission Test Cycles ( Japan 2003 model engine case)



High ← → Low

ESC .> J13 > WHSC > ETC > FTP > WHTC



# European Validation Test Result (JRC report; Iveco Cursor 8)

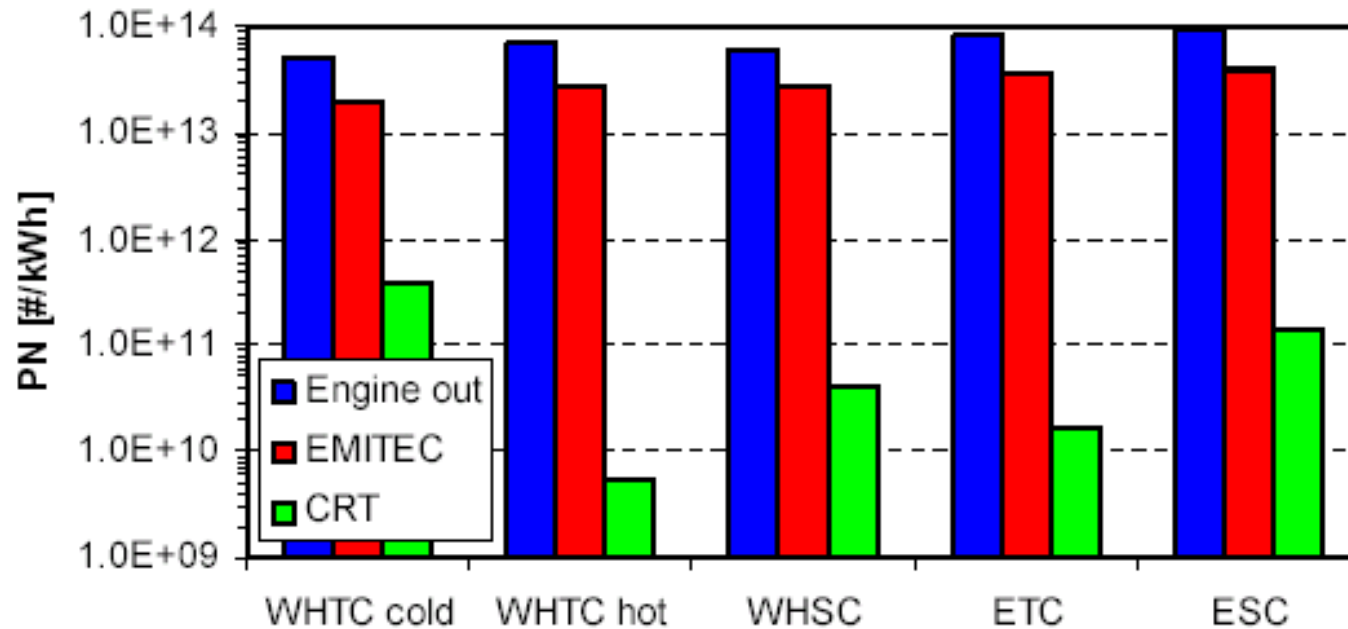


Figure 10: Number emissions of after-treatment devices.

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# Summary

- In our test there occurred regeneration phenomena of DPF during the test cycle operation of WHTC/WHSC, with engine A. Because of this, PN emission of engine A for both WHTC and WHSC is extremely higher than other engines.
  - The mechanism of the phenomena is considered that the exhaust temperature exceeded the self-ignition temperature (over 400 deg. C) of accumulated soot on C-DPF. This seems a special case for WHTC cycle to reach such a high temperature, but it is feasible for WHSC cycle, in which the maximum exhaust temperature is 50~100 deg. C higher than WHTC.
  - In the case of CRT the precious metal catalyst is not coated on DPF itself, so the self-ignition temperature for the accumulated soot will be higher than C-DPF, and regeneration during the test cycle will be less probable. But it will be noted that the PN emission of the European validation test engine with ESC cycle showed the highest value.
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