

Development on simultaneous reduction system of NOx and PM from a diesel engine

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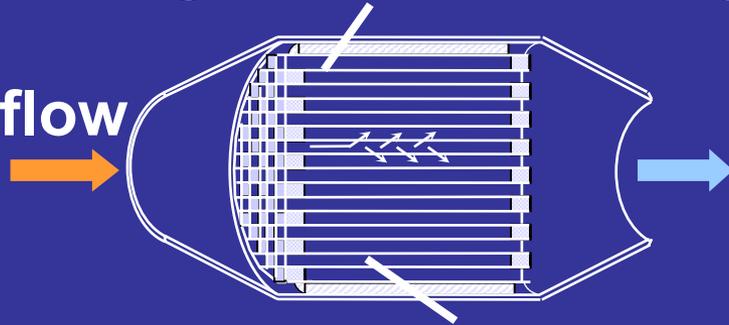
- 1. Concepts of Simultaneous PM and NOx Reduction System**
- 2. Emission Data of DPNR field trial in Europe**
- 3. Emission Potential in USA FTP 75 testing Mode**
- 4. Application of DPNR for Light-Duty Truck**

1. Concepts of Simultaneous PM and NOx Reduction System

DPNR Catalyst

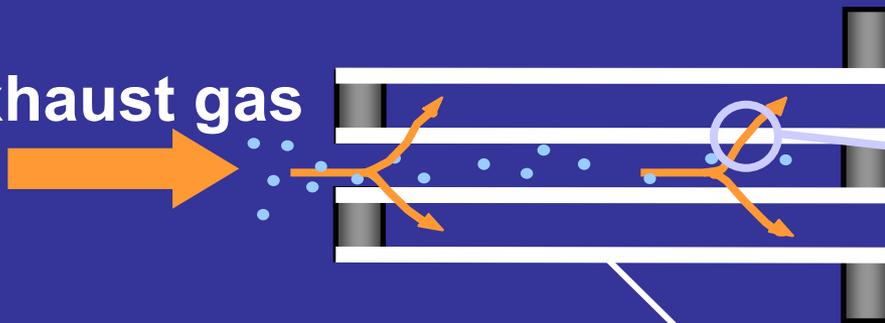
NOx storage reduction catalyst

Exhaust gas flow



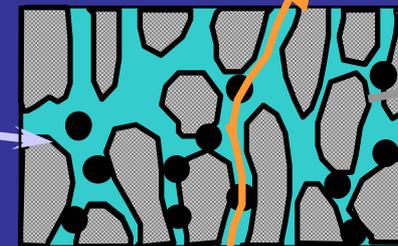
Fine porous ceramic structure

Exhaust gas



Fine porous ceramic structure

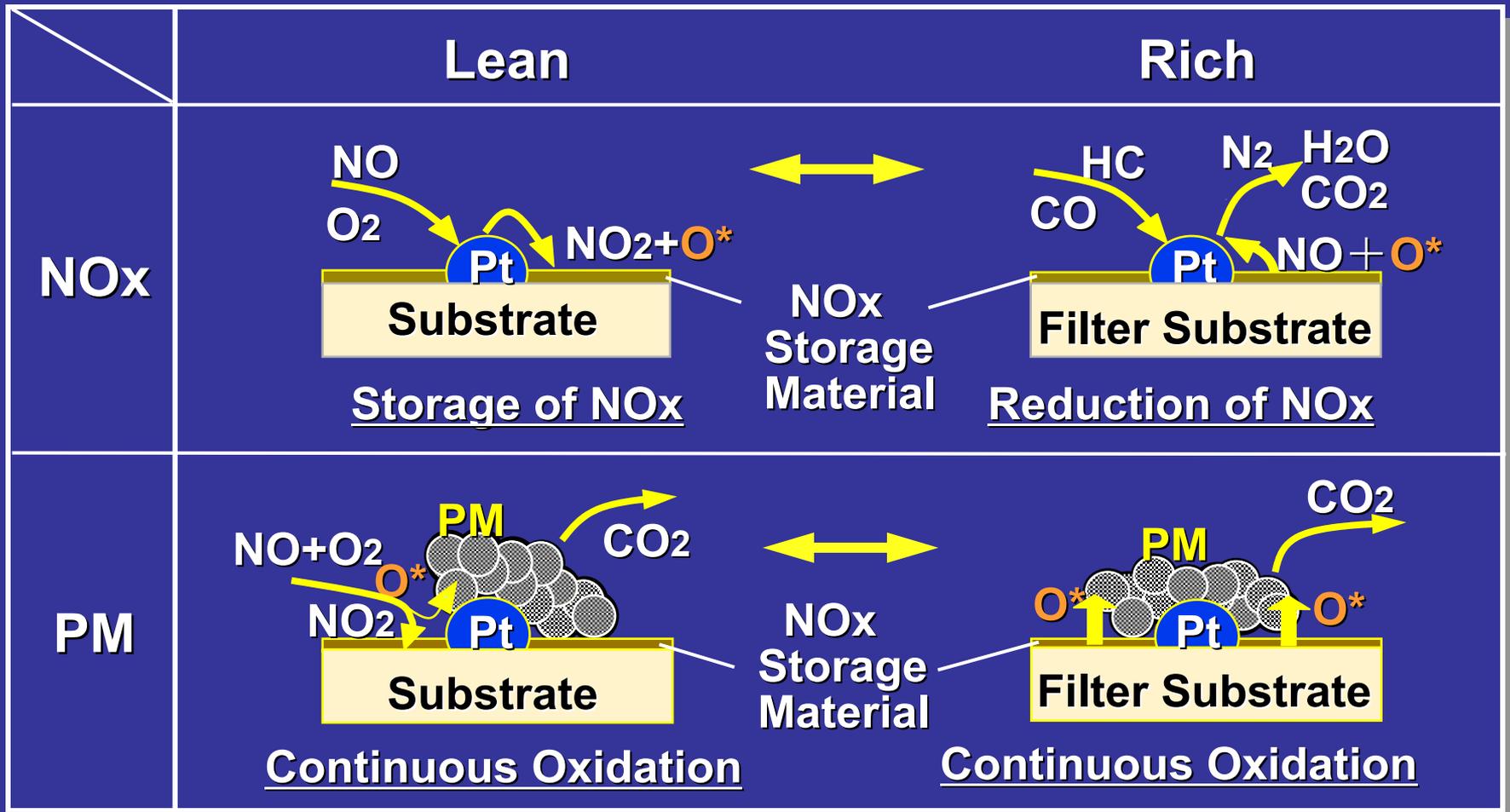
Enlarged view of exhaust gas flowing substrate wall



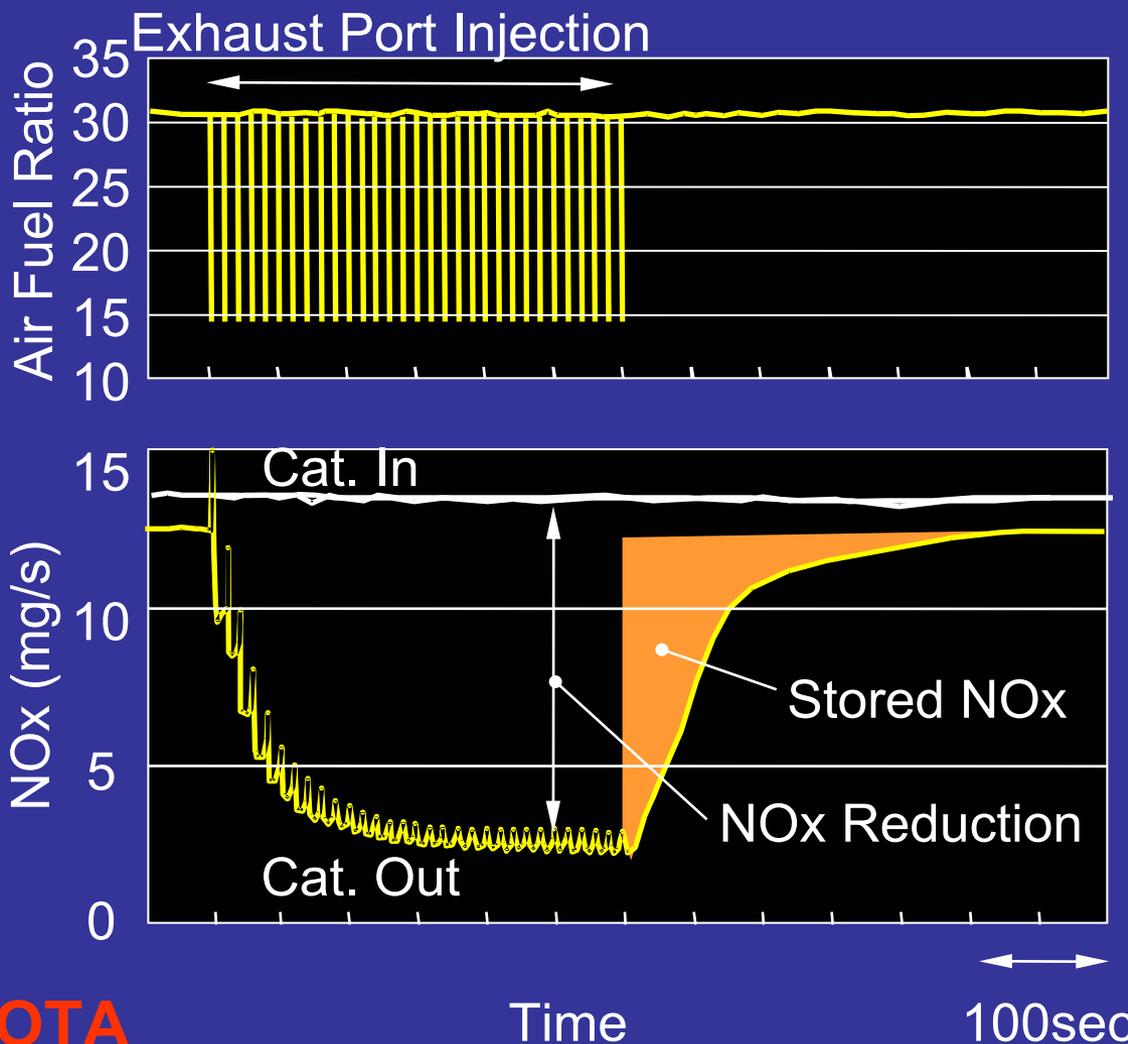
NOx,
storage
reduction
catalyst

Exhaust gas

NOx and PM Reaction Mechanism of DPNR Catalyst

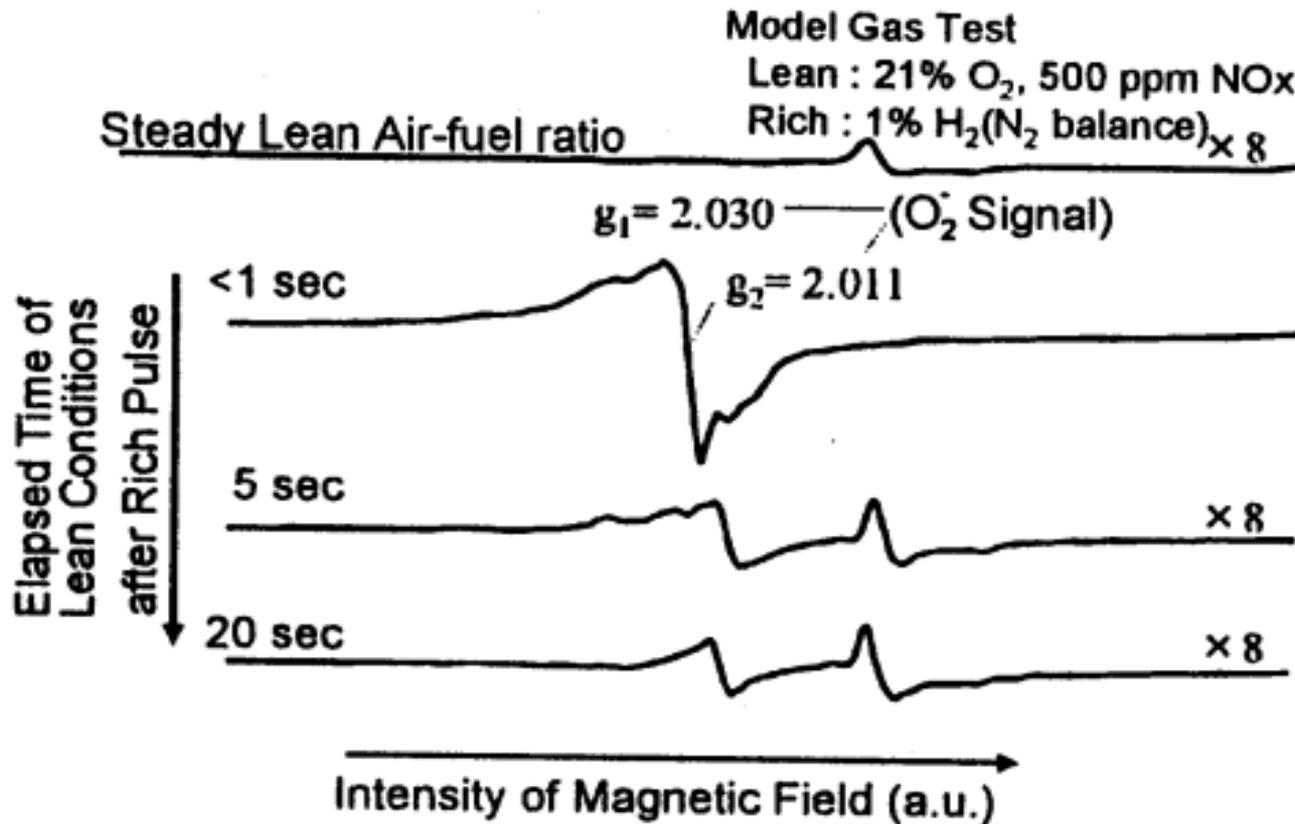


Characteristics of NOx Storage Reduction

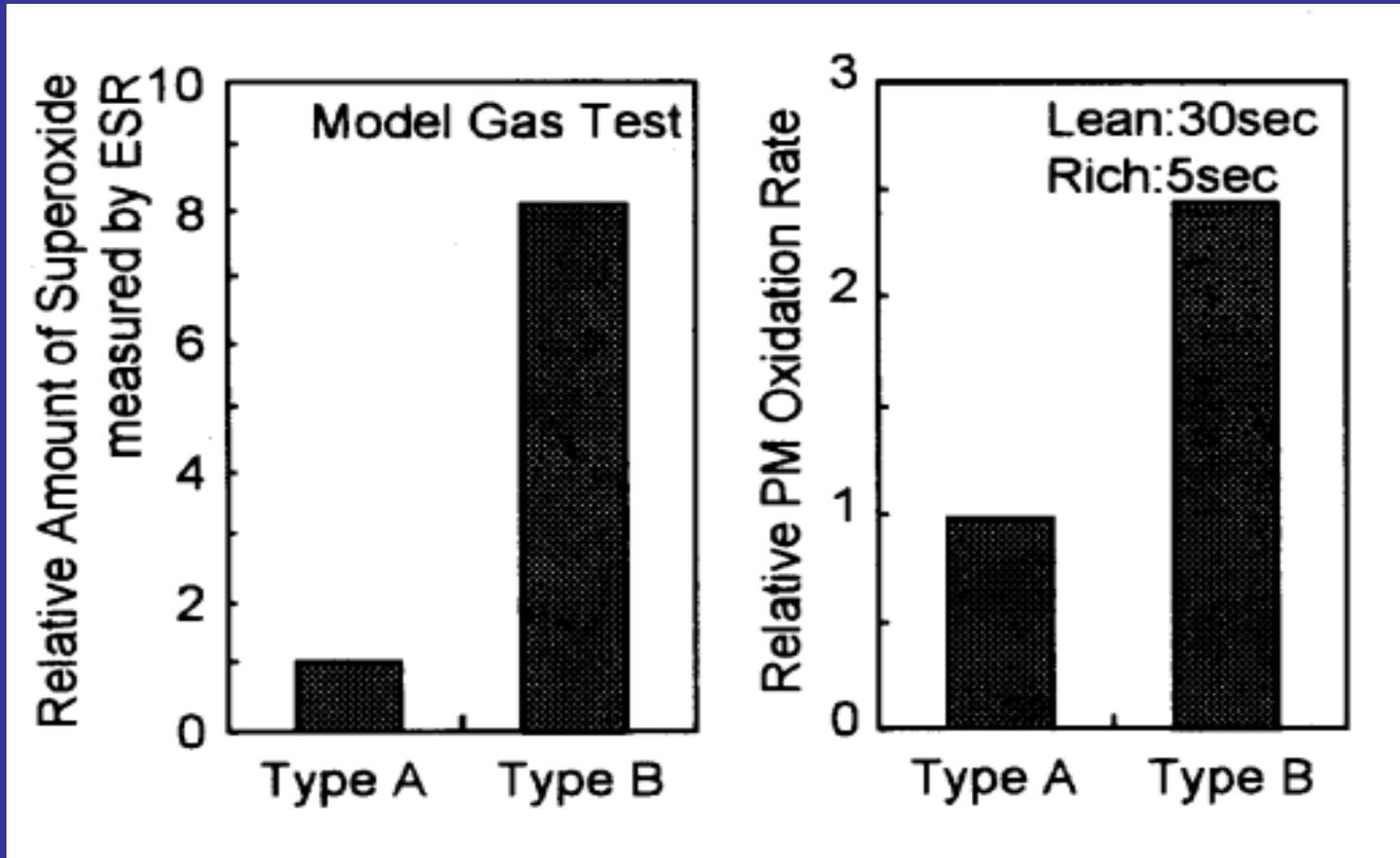


2L TDI
2900 rpm
 $P_{me}=0.50\text{MPa}$
Injection Interval
= 10sec

Effect of air-fuel ratio modulation on ESR spectra in DPNR catalyst



Effect of the amount of active oxygen on PM oxidation rate

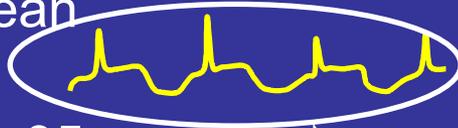


Characteristic of SOx Discharging

Passenger Vehicle
Engine : 2L TDI, DPNR : 2L

Rich and lean

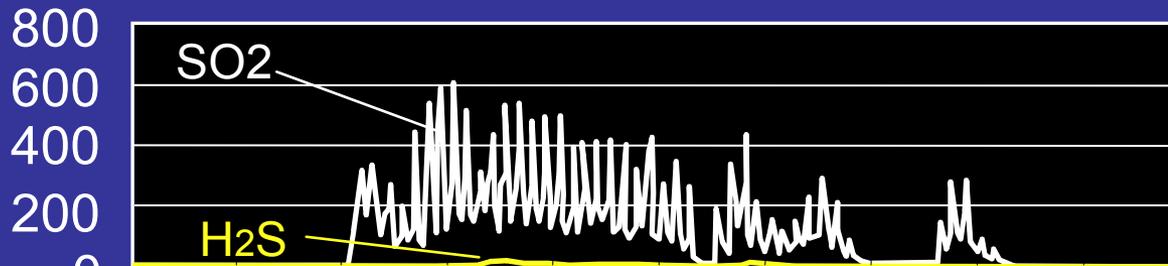
Air Fuel Ratio



Vehicle Speed 60km/h Const.



SOx, H2S (ppm)



Bed Temp. (deg.C)

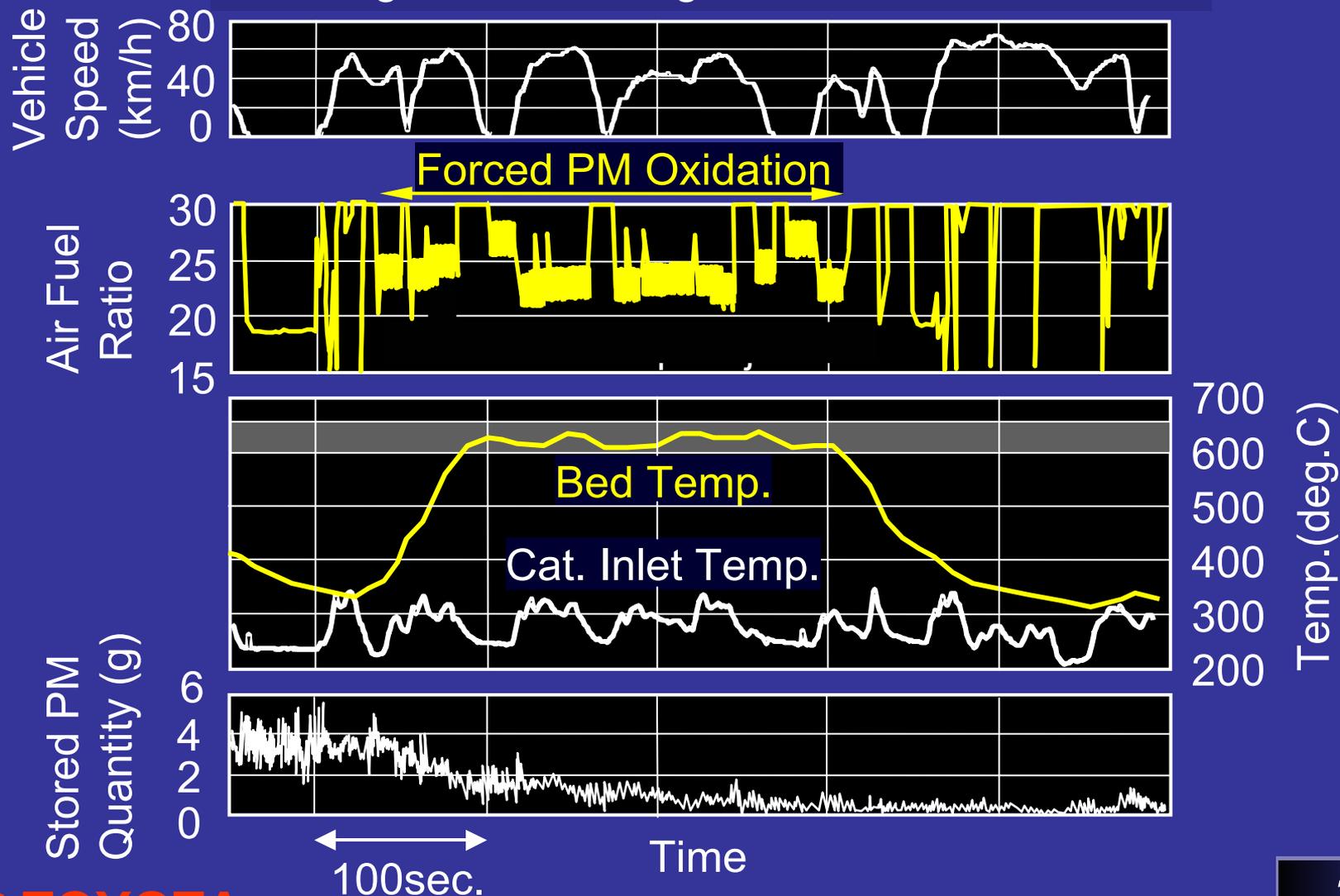


100sec.

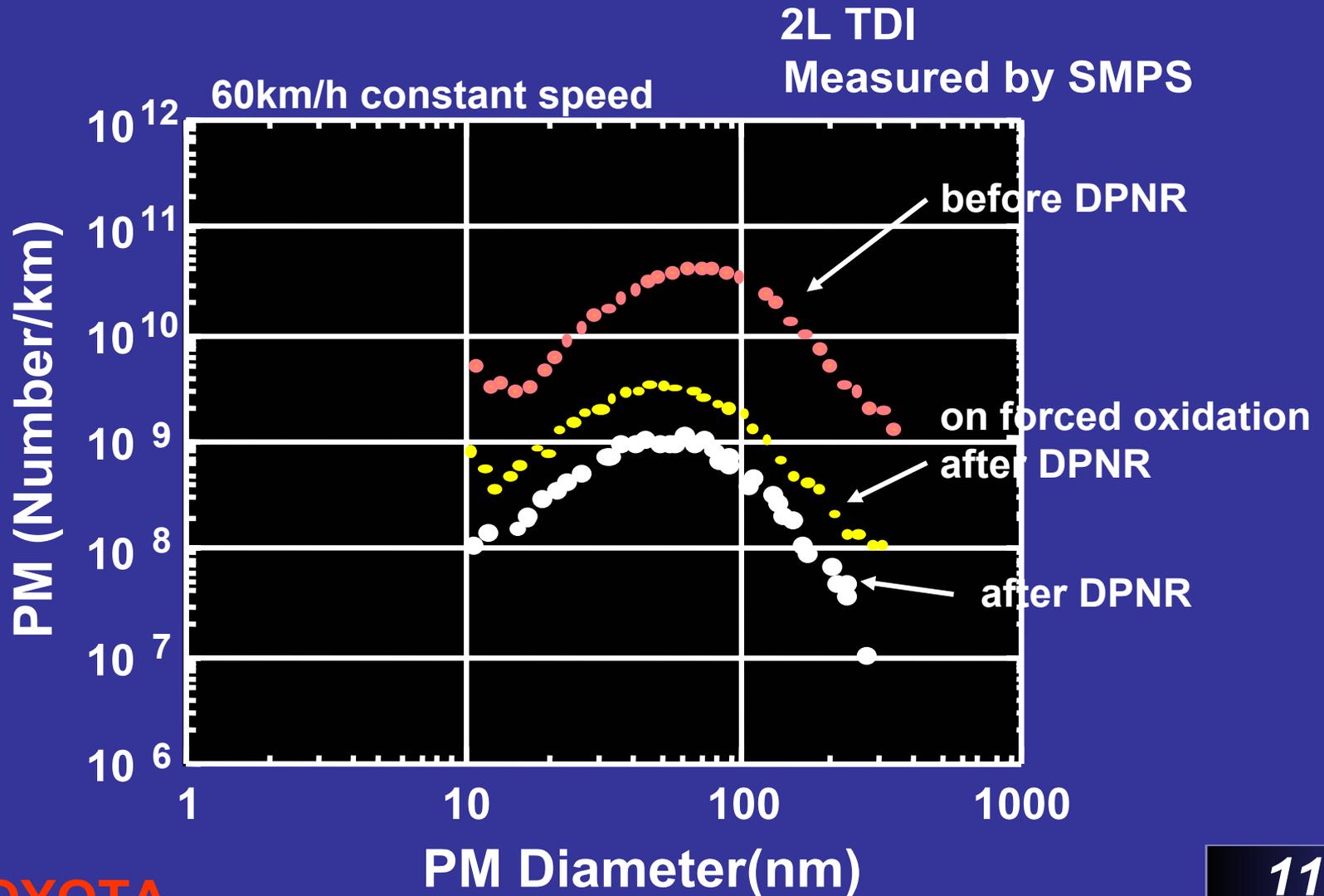
Time

Characteristic of Forced PM Oxidation

Passenger Vehicle, Engine : 2L TDI, DPNR : 2L



Distribution of PM diameter



2. Emission Data from DPNR field trial in Europe

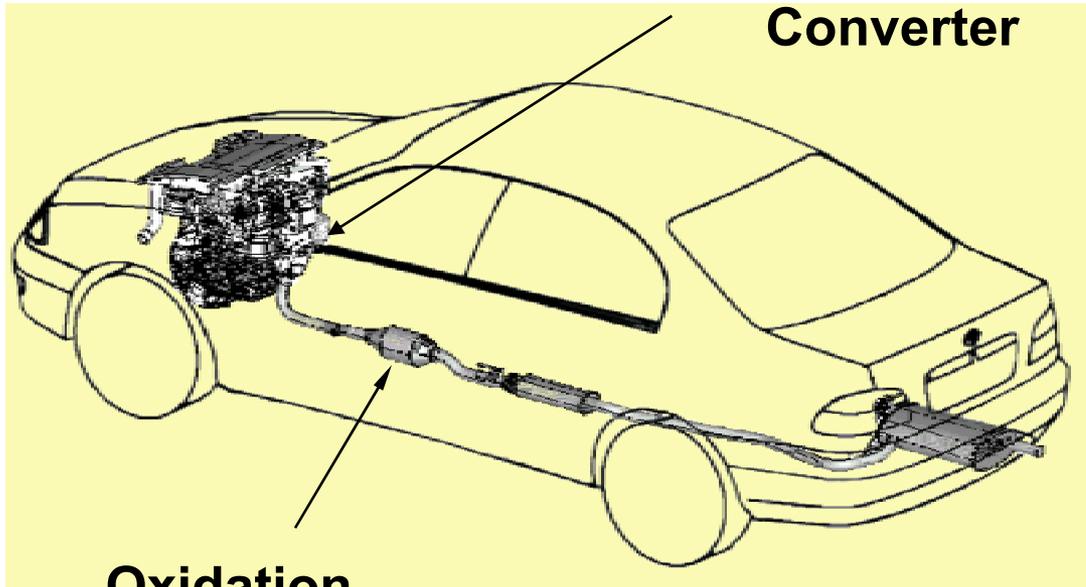
Field trial overview

Conditions	Country	Driving pattern	Nr. Of cars	Fuel S content
Normal	Germany	Highway	27	39ppm
		City		
		Standard		
Normal	UK	City	19	35 ppm
		Standard		
High altitude	Austria	Standard	7	277 ppm
Cold area	Norway	City - Standard	3	30 ppm
Normal	Italy	Highway	2	271 ppm
		City		
Cold area	Finland	Standard	1	32 ppm
Normal	Belgium	Standard	1	50 ppm

Engine Specification

	Field Monitoring Car	Current Model
Swept Volume	1995cc	←
Bore*Stroke	82.2mm*94mm	←
Compression ratio	18.2:1	18.6:1
Injection system	2nd Generation CR (Max.180MPa)	1st Generation CR (Max.135MPa)
Power	81(kW) at 4000 rpm	←
Max.Torque	250(Nm) at 2000-2400rpm	250(Nm) at 2000-2400rpm
Combustion Noise at 750 rpm Idle	68.0 (dB)	73.0 (dB)

Installation of DPNR



DPNR Catalytic Converter

Oxidation Catalytic Converter

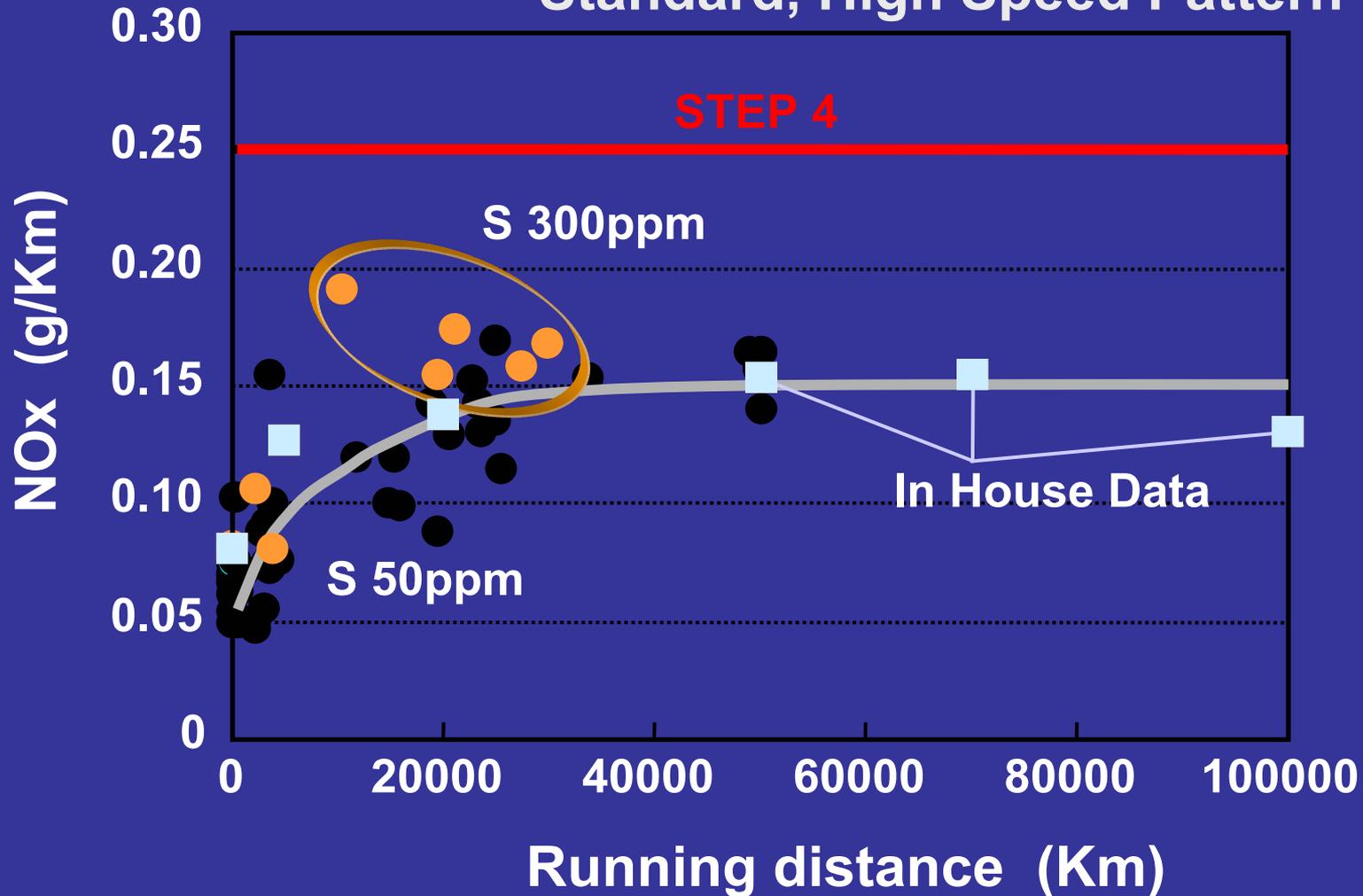
**Base Vehicle :Avensis
IW 1470kg**



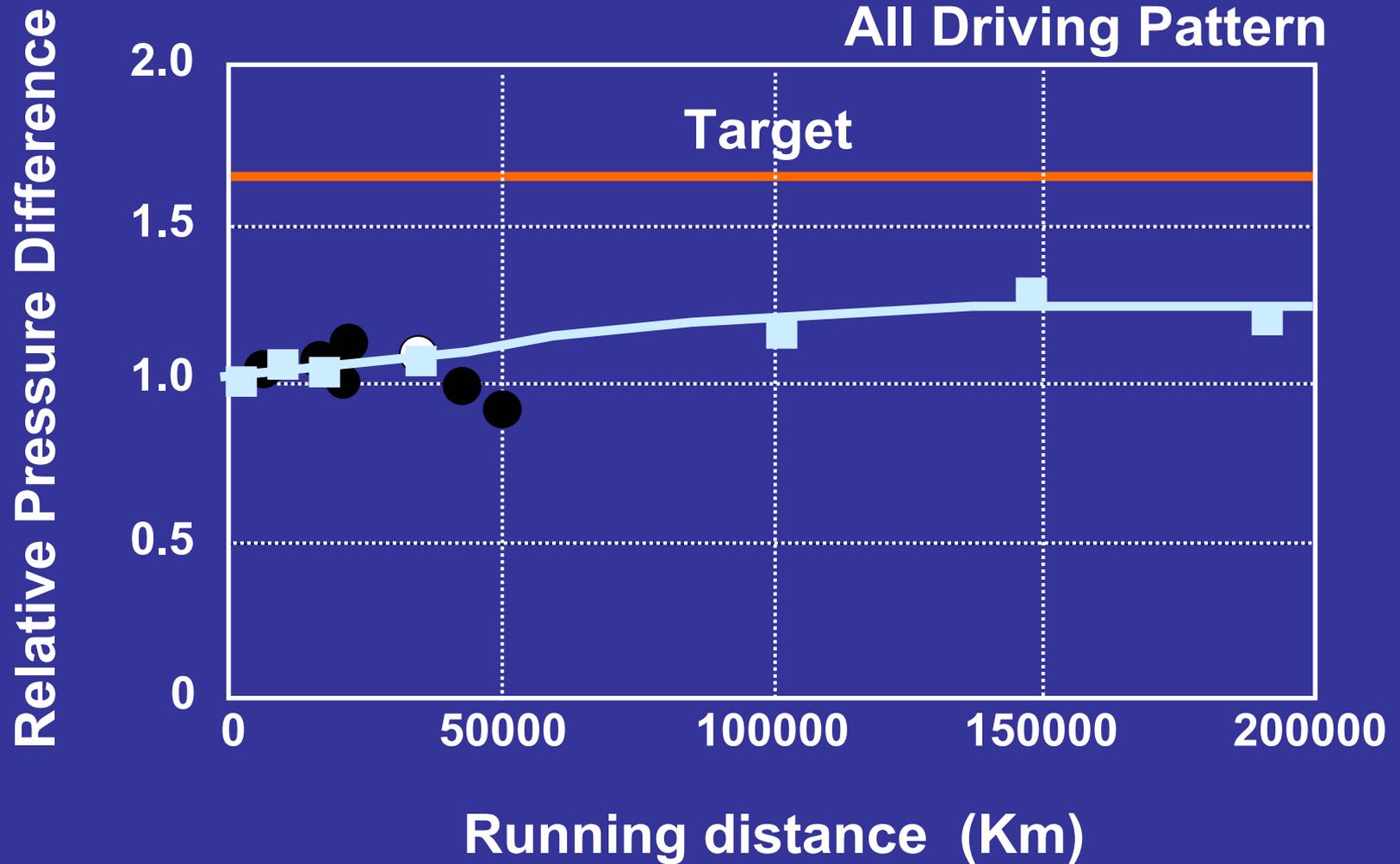
Base Engine:1CD-FTV z

Emission History

Standard, High Speed Pattern



Pressure Drop History



3. Emission Potential for US Regulation

Emission on US FTP75 mode

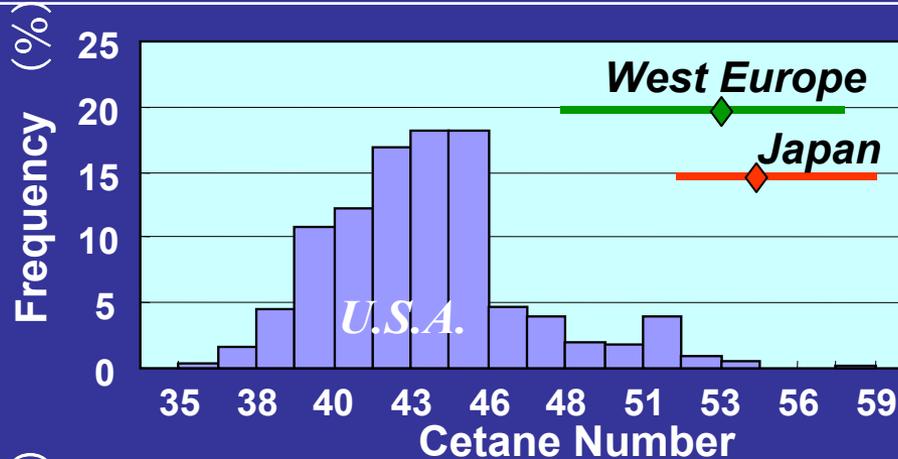
Fresh Cat.& Fuel:C.N.50.4 Aromatics26.0% Sulfur 6ppm

Test Cycle	PM (g/mile)	NO_x (g/mile)	NMHC (g/mile)	CO (g/mile)	CO₂ (g/mile)	FE (mile/gal)
FTP75	0.0057	0.05	0.07	0	273	37.2
US06	0.005	0.14	0.19	0	289	35.2
SC03	0.007	0	0.14	0	367	27.7
HWFET	0.002	0	0.12	0	192	52.9
NYCC	0.007	0	0.04	0	474	21.5

From SAE2002-01-2877 J.McDonald,B.Bunker

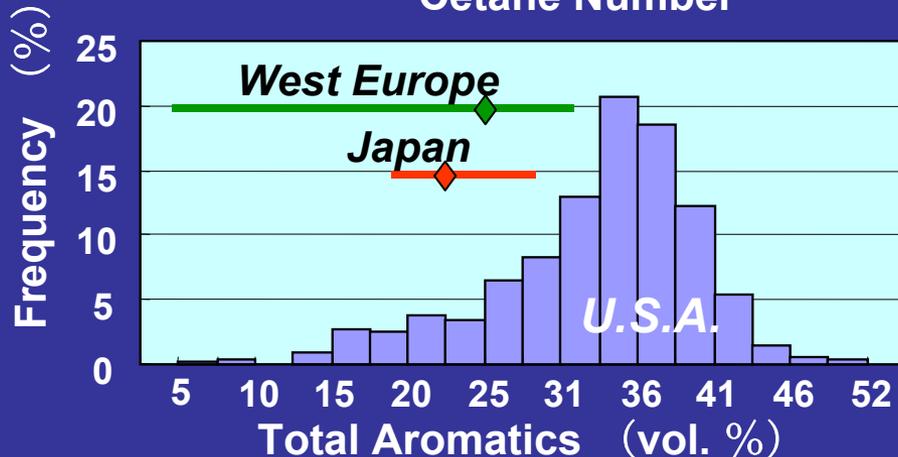
Cetane Number and Aromatics in US Market

Extreme low cetane and high Aromatics diesel fuels have existed in the US market.



Cetane Number

Ave. 44.8
Max. 60.1
Min. 37.8



Total Aromatics (%)

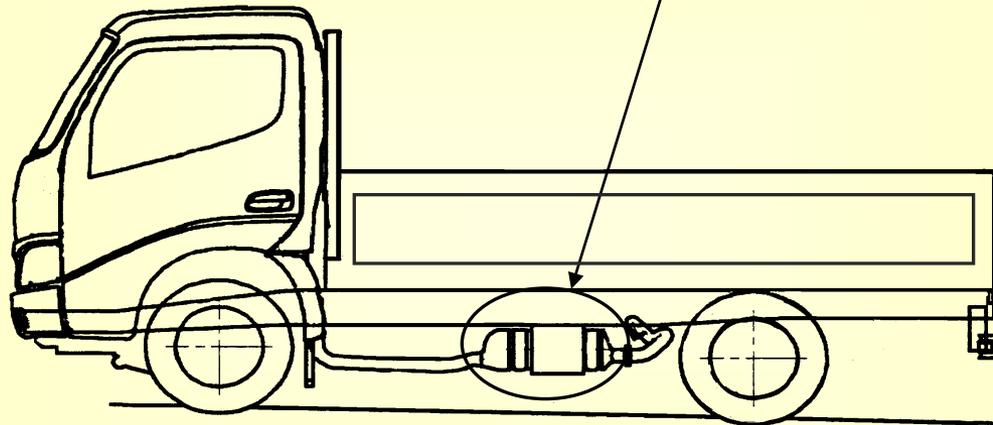
Ave. 35.8
Max. 54.2
Min. 9.8

557 samples of US fuel ('00 Winter - '02 Summer, surveyed by AAM)

4 . Application of DPNR for Light-Duty Truck

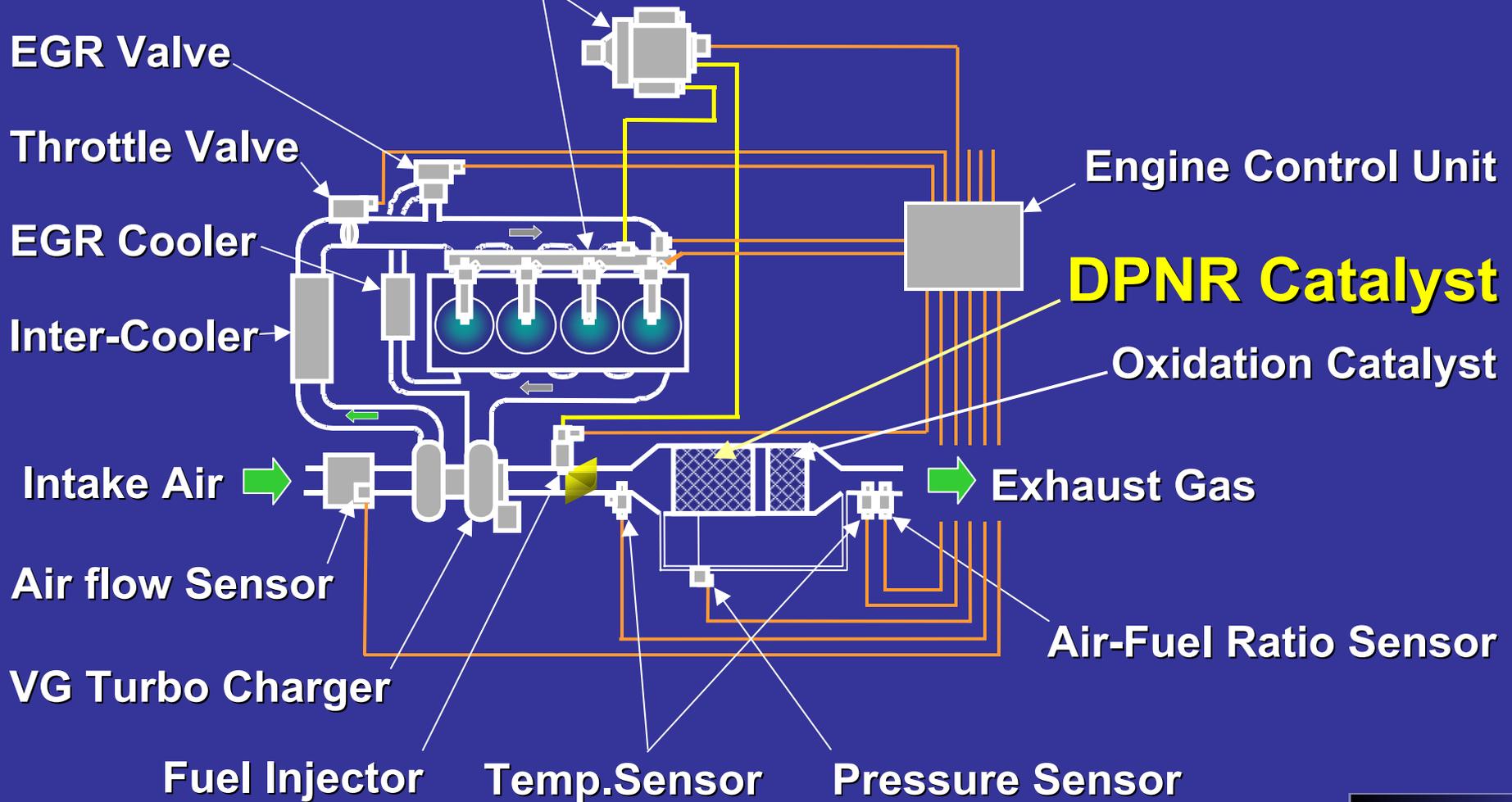
Installation of DPNR for Light-Duty Truck

**DPNR catalyst
and oxidation catalyst**

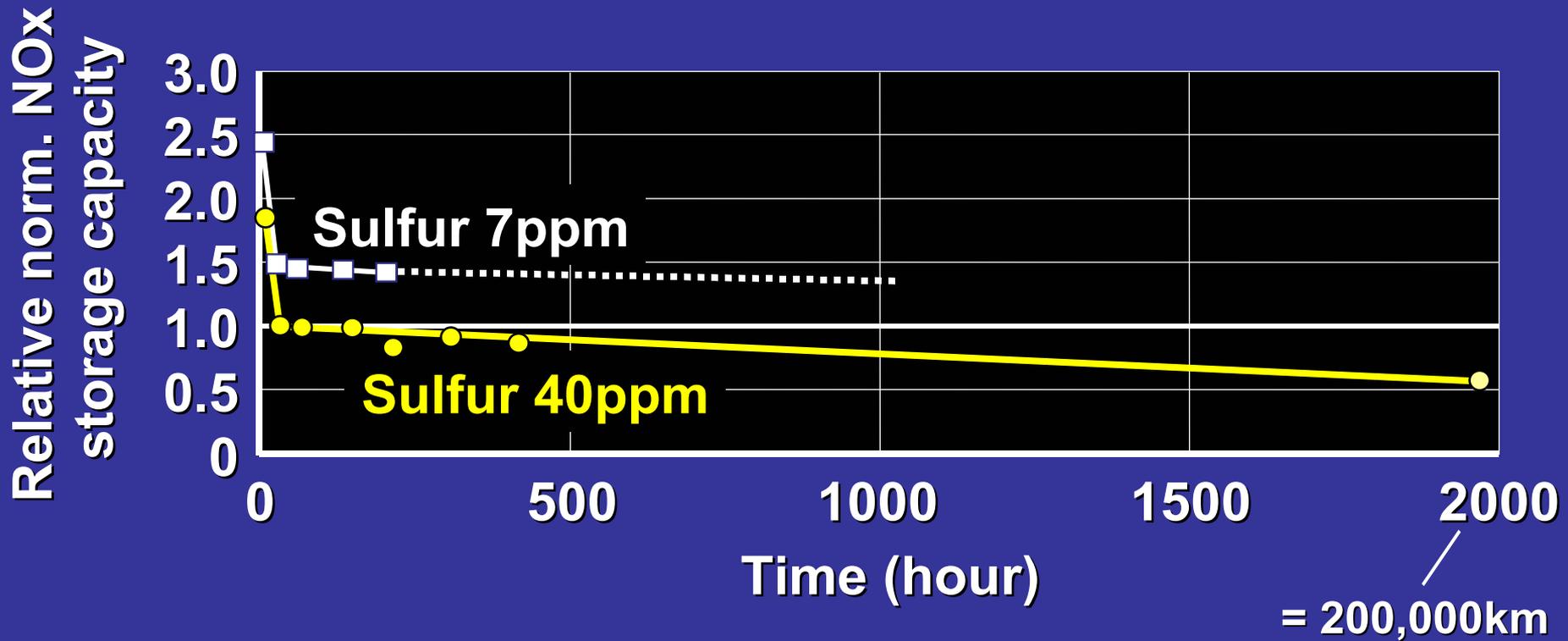


System Diagram of DPNR

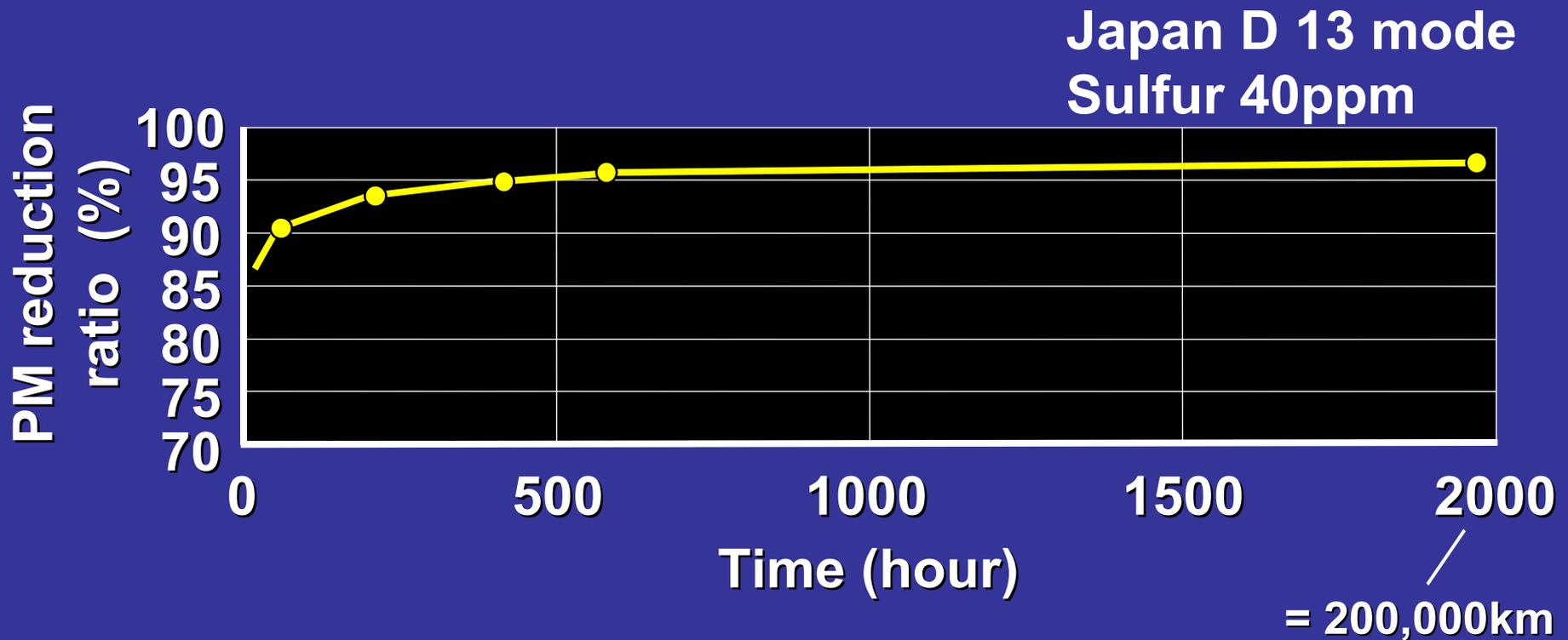
Common Rail Injection System



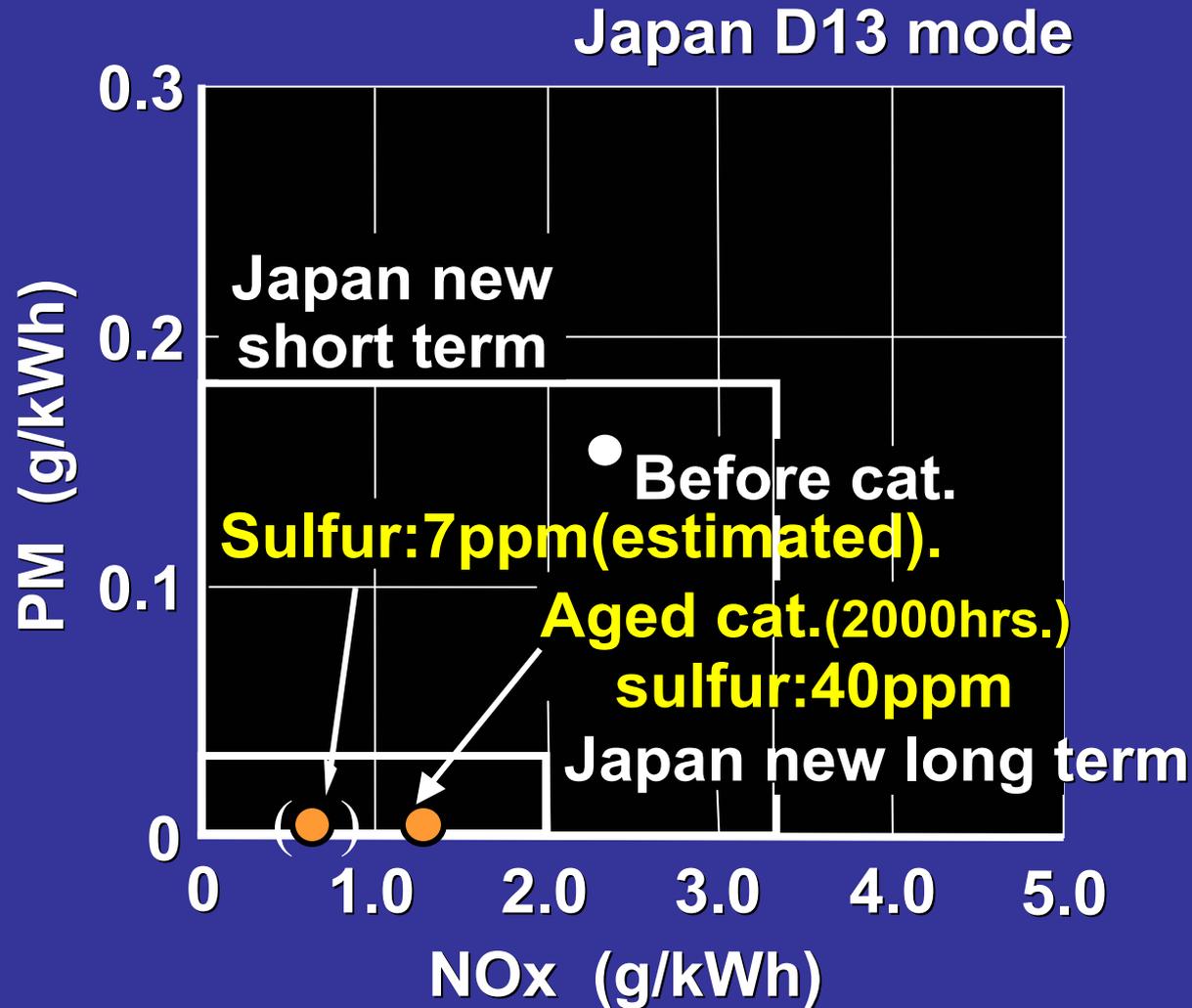
Decrease of NOx Storage Capacity according to continuous engine operation



PM Reduction Ratio Transition throughout the Durability Test



Emission Potential of Aged Cat.

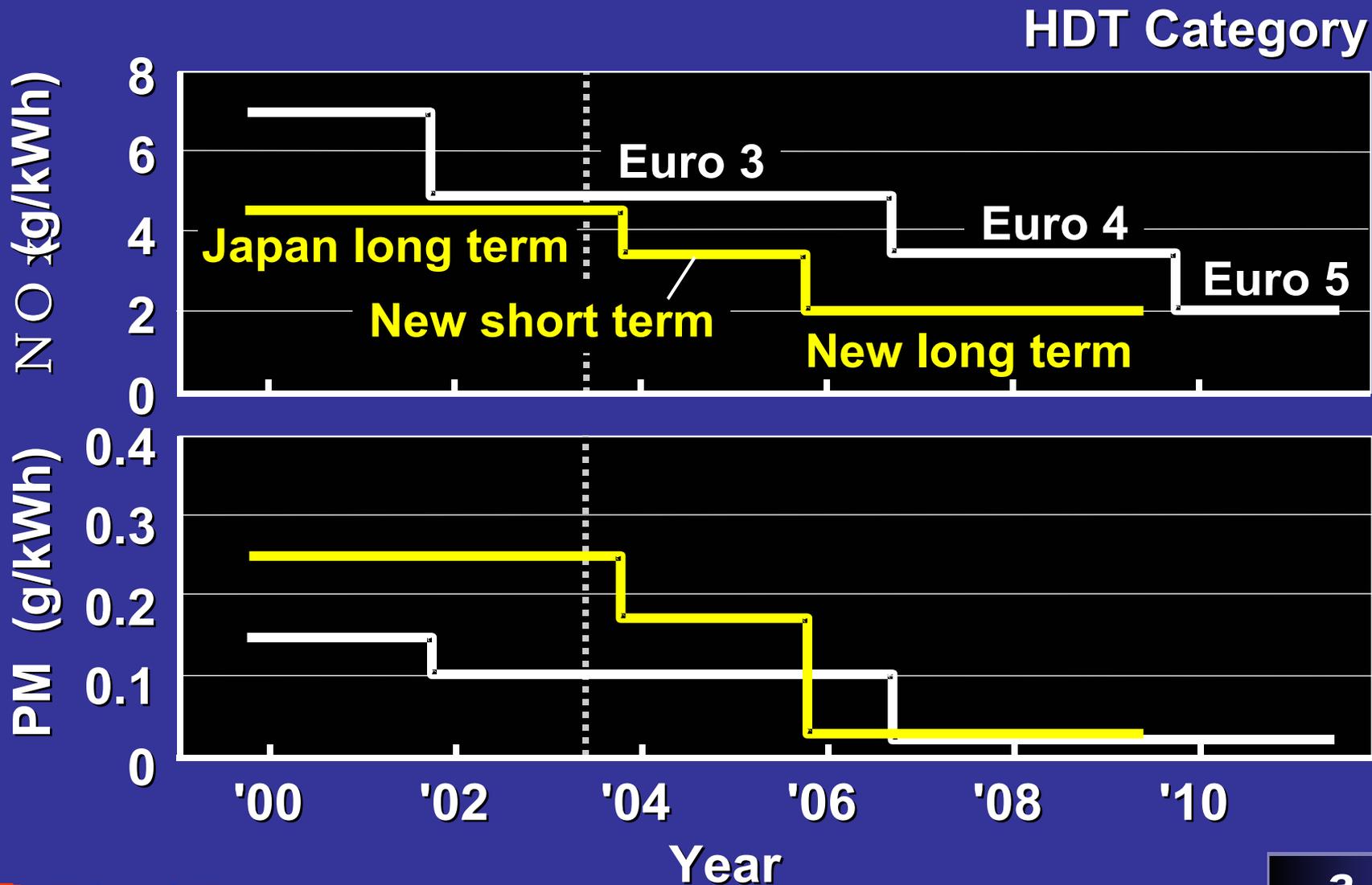


Summary

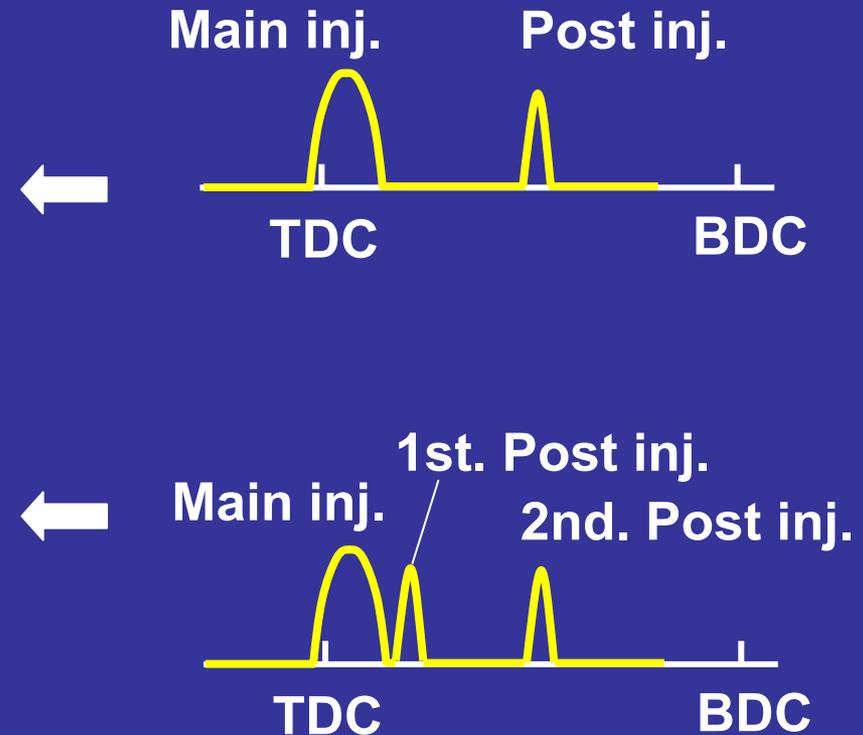
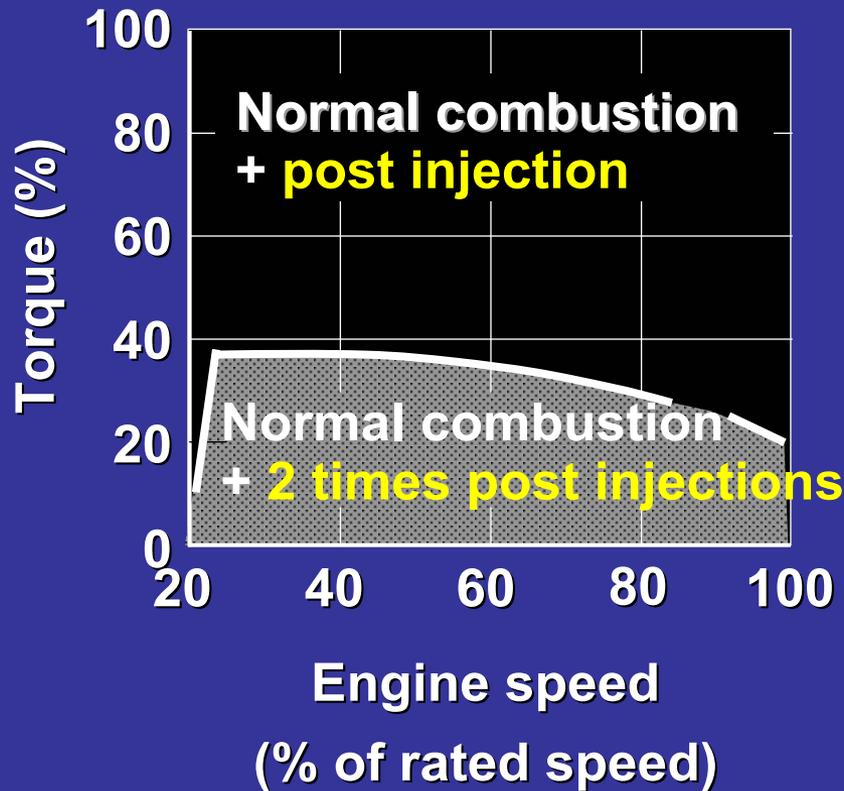
- The effects of aged DPNR has been verified by vehicle field testing in Europe and long hours durability testing on engine bench for Japanese market.
- On USA FTP75 testing, DPNR with fresh catalyst shown remarkable emission reduction efficiency although durability of catalyst is severe subject.
- Fuel specificatins, such as S contents, cetane number and aromatics, are very important for the realization of very low emission diesel engine.

**The end of presentation
Thank you for your attention**

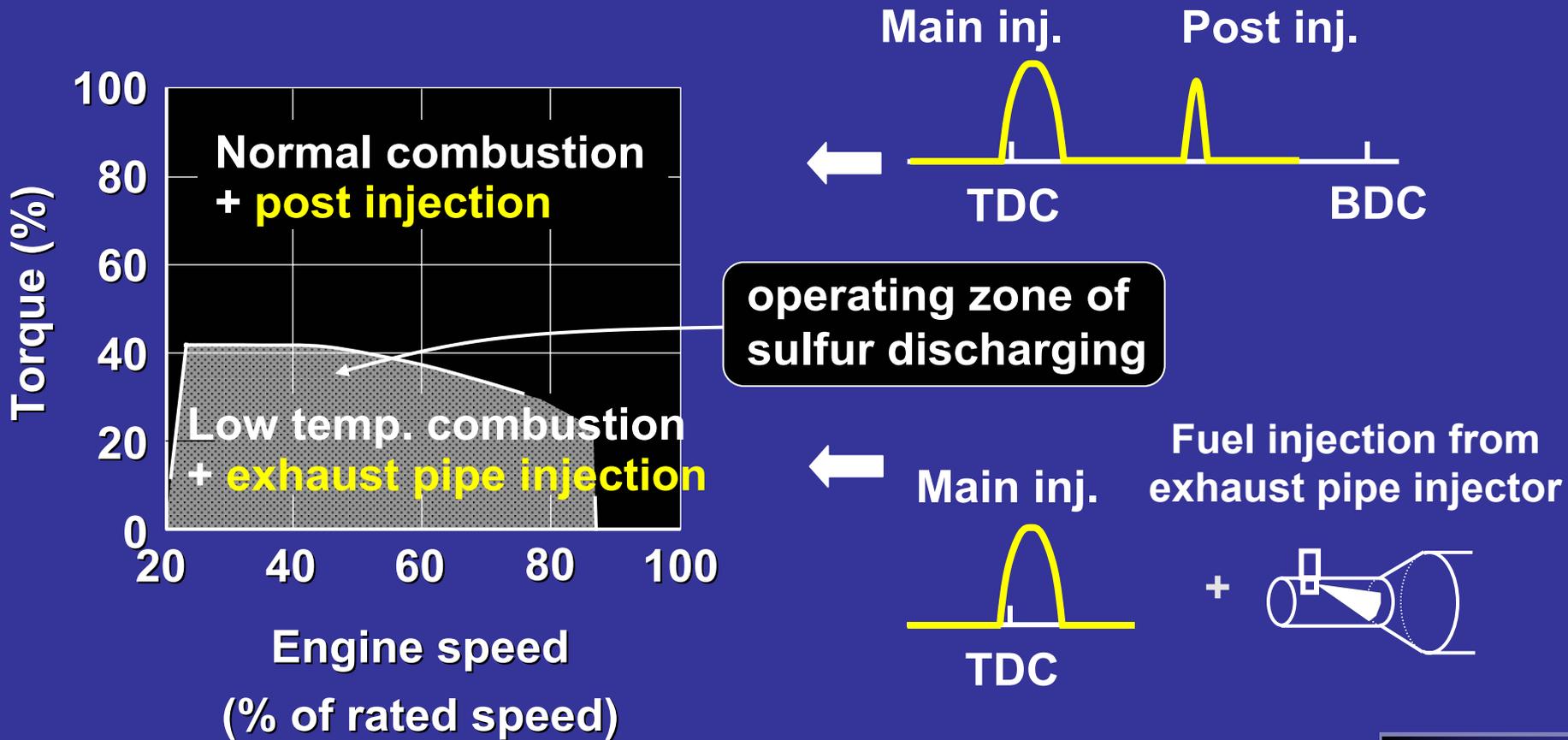
Emission Regulation Trend



System Control Strategies - Forced PM Oxidation-



System Control Strategies - Sulfur Discharging -



Technical Issues of DPNR

■ Improvement of Durability

- Heavy Duty Truck : Guarantee over 650,000 km
(in Japanese Case)

■ Improvement of Fuel Economy

- Rich pulse for NOx and PM reduction
- Regeneration of sulfur poisoning

■ Reduction of Cost

- Further simple control system

Relationship between PM Oxidation Rate and Bed Temperature in DPNR Catalyst

