ECT-2023
Session 2
Light Duty Applications
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# Gasoline Particulate Filter (GPF) for Indian Market

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## Background

## GPF challenge to BS7

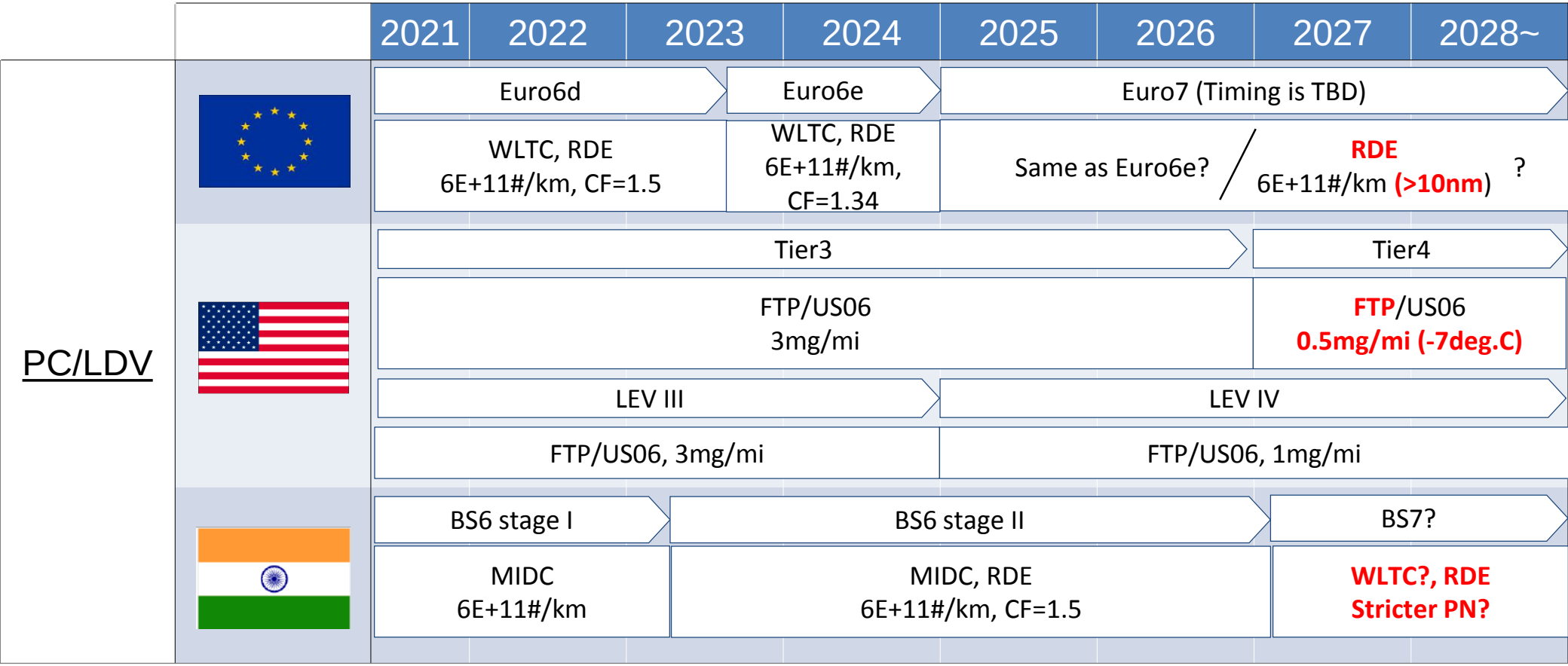
- GPF necessity with PFI engine?

- Any concern with ash and/or under real driving?

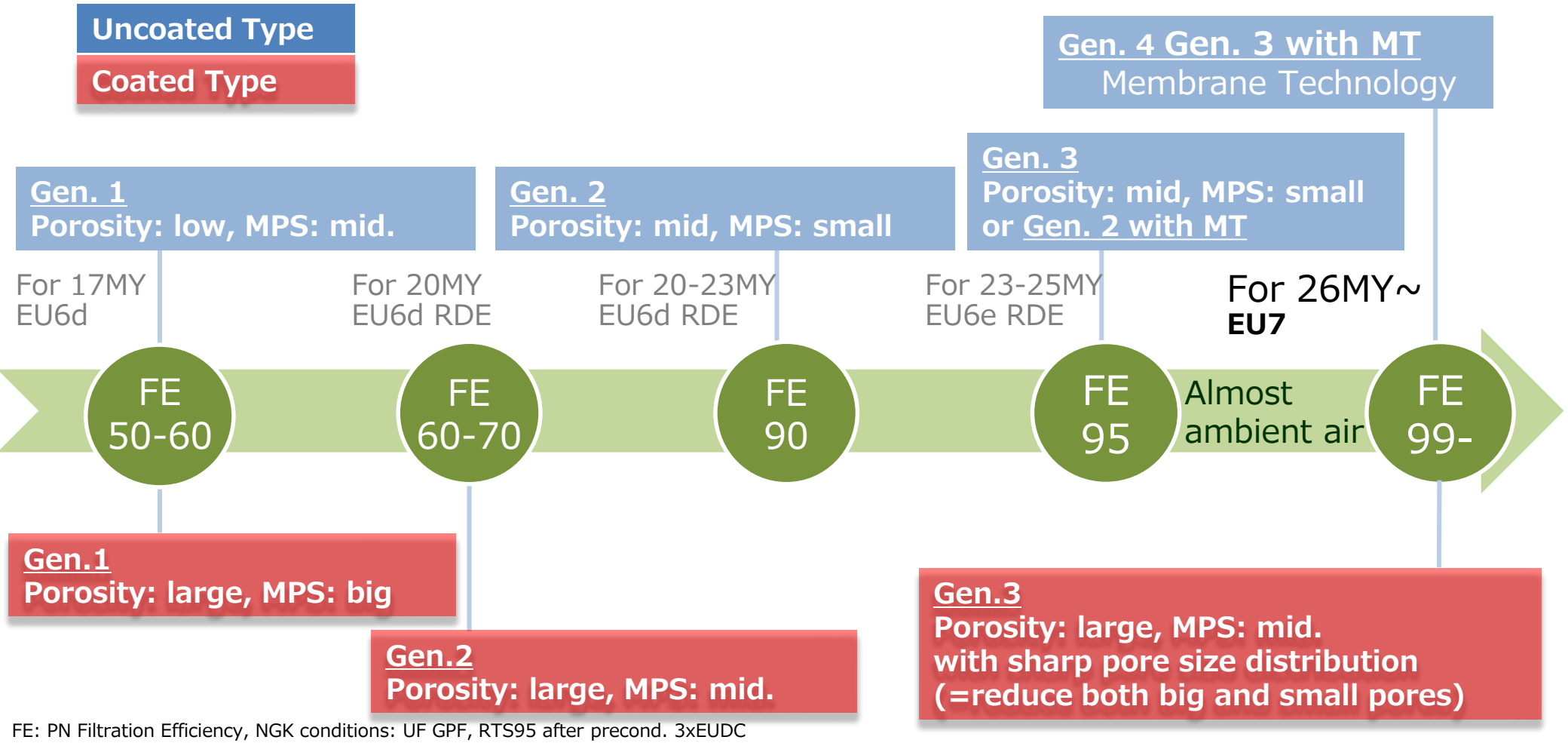
- Sub23nm PN?

## Summary

# PC/LDV PM/PN Regulation



# NGK GPF Development Roadmap

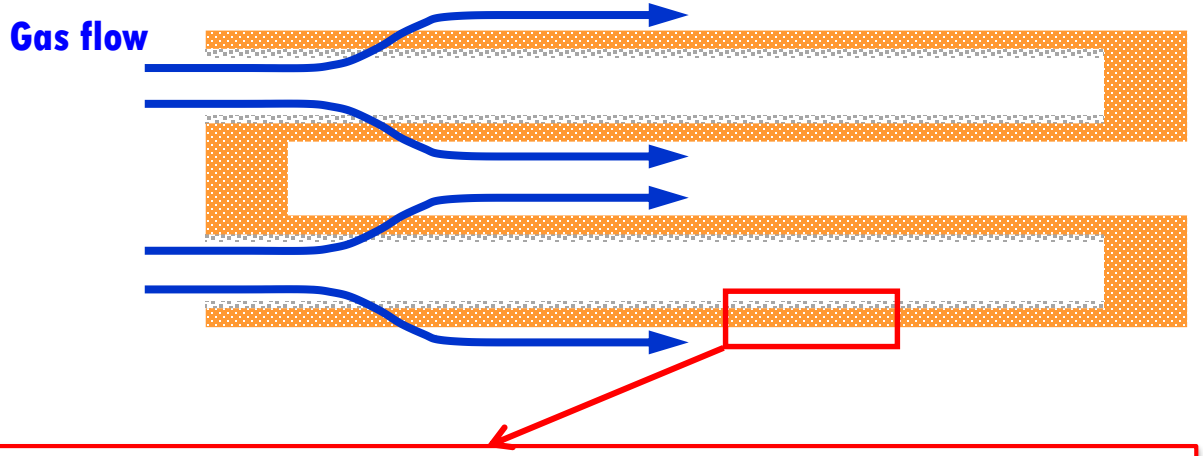


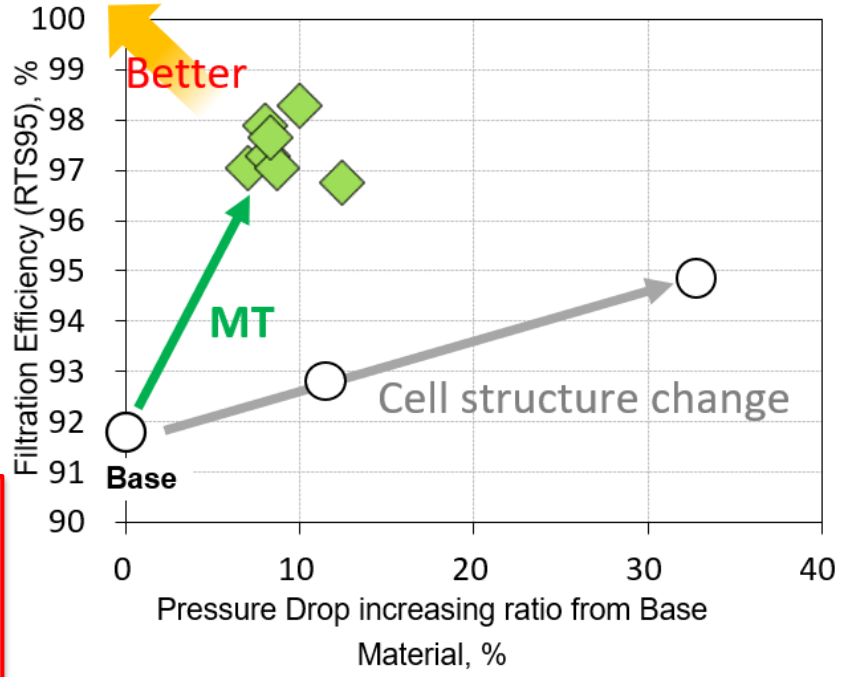

FE: PN Filtration Efficiency, NGK conditions: UF GPF, RTS95 after precond. 3xEUDC

MPS: Mean Pore Size

# NGK GPF Development for Euro7

## What is Membrane Technology (MT)

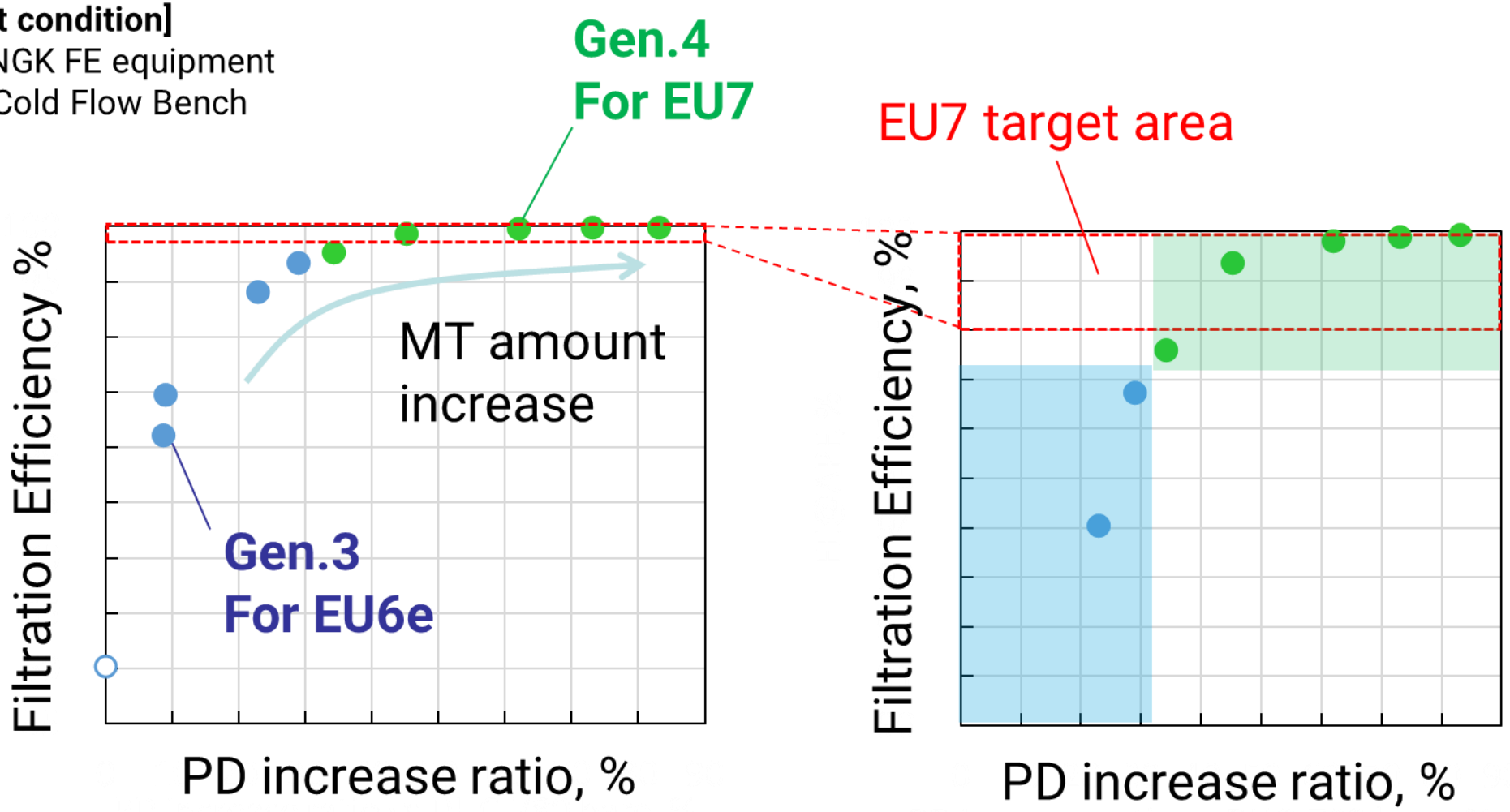



GPF base design change for high FE requirement causes pressure drop increase drastically.
MT improves FE with minimum pressure drop increase.

# NGK GPF Development for Euro7

**[Test condition]**
FE: NGK FE equipment
PD: Cold Flow Bench




Applying optimized MT condition, MT GPF can achieve EU7 FE target.

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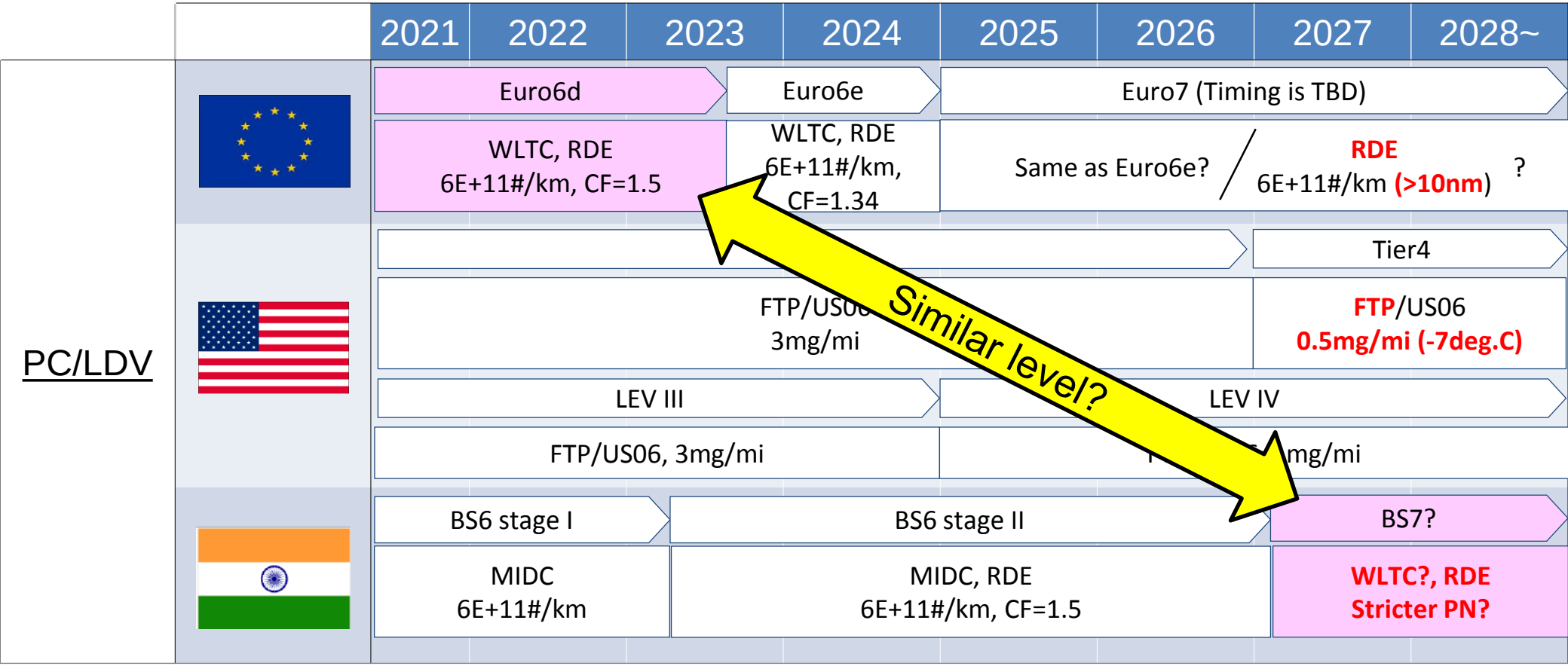


Potential BS7 PN regulation is assumed the similar level as Euro6d PN regulation? or somewhere in between Euro6d and Euro7?

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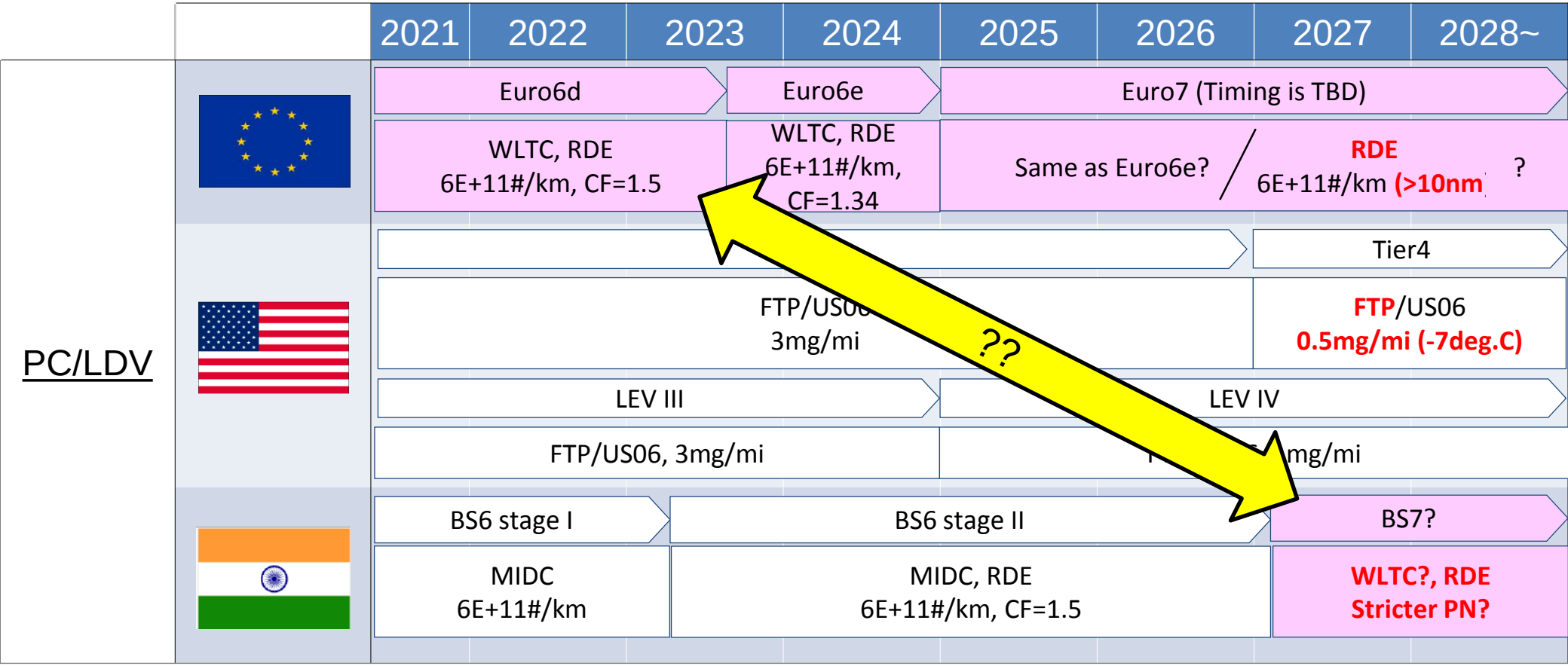


Potential BS7 PN regulation is assumed the similar level as Euro6d PN regulation? or somewhere in between Euro6d and Euro7?

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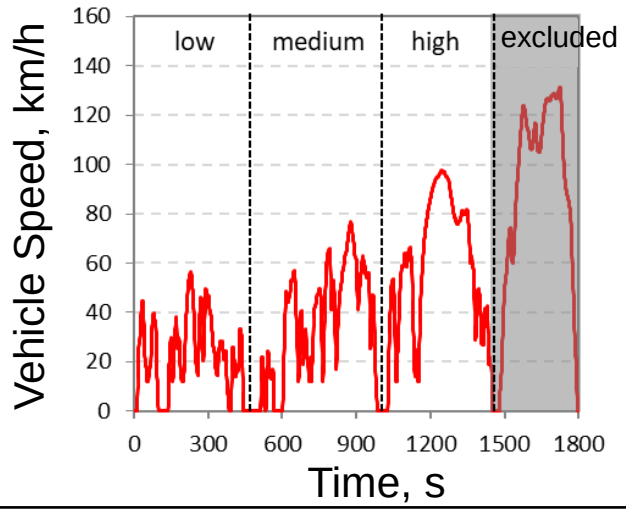
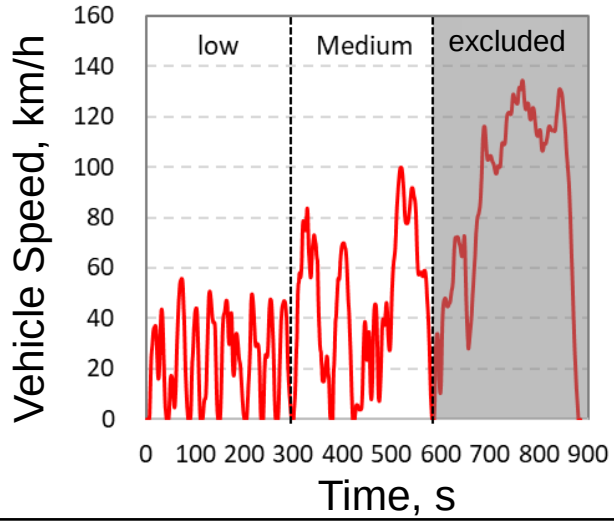
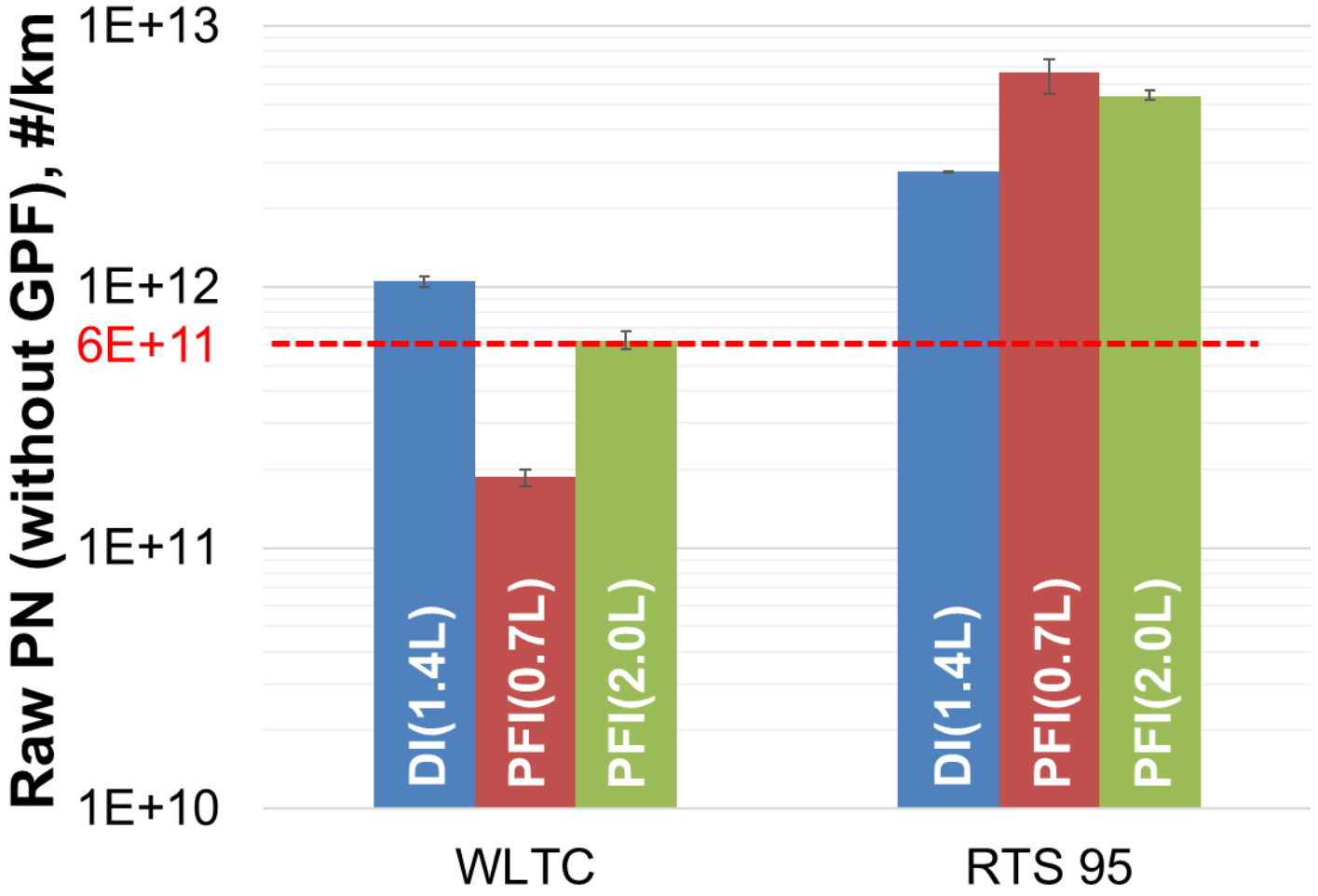
# PFI Vehicle PN Emission

| Cycle | WLTC | RTS95 |
|---|---|---|
| Time vs Vehicle speed |  |  |
| Max speed | 98 km/h | 100 km/h |
| Total time | 1477 s | 585 s |
| Distance | 15.0 km | 5.6 km |
| Concept | Legislation cycle (high speed phase is excluded) | Aggressive cycle / worst case? (high speed phase is excluded) |

# PFI Vehicle PN Emissions




**In some driving condition, PFI vehicle has higher engine out PN than DI and raw PN emission is above 6E+11 #/km.**

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# Vehicle Durability Test on Catalyzed GPF 160k km

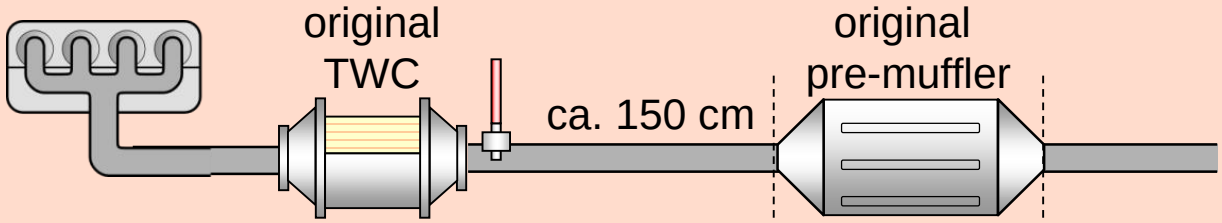
**Vehicle and GPF details:**

- Engine: 1.8L turbo DI, Euro 5
- Gen1 coated GPF, 10mil / 300cpsi, 1.3L with TWC

**Driving Mode:**

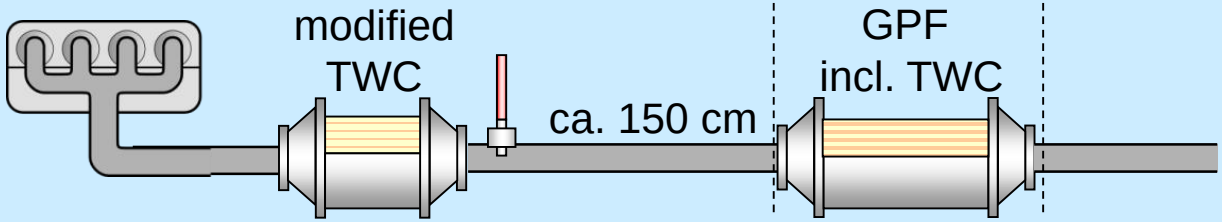
- Urban 6% (≤ 50 km/h)
- Extra-urban 11% (≤ 100 km/h)
- Motorway 81% (≤ 220 km/h)
- Transit 2%

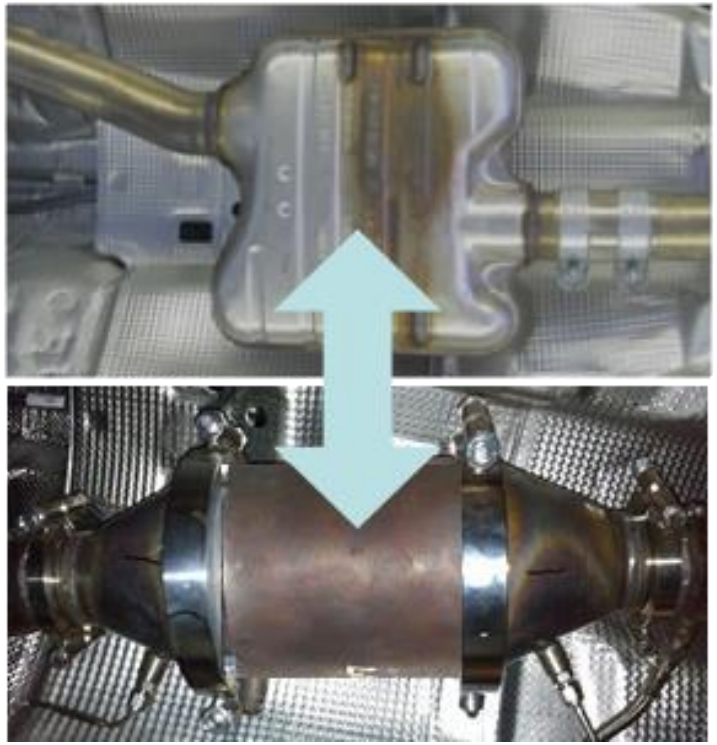
**Original System**



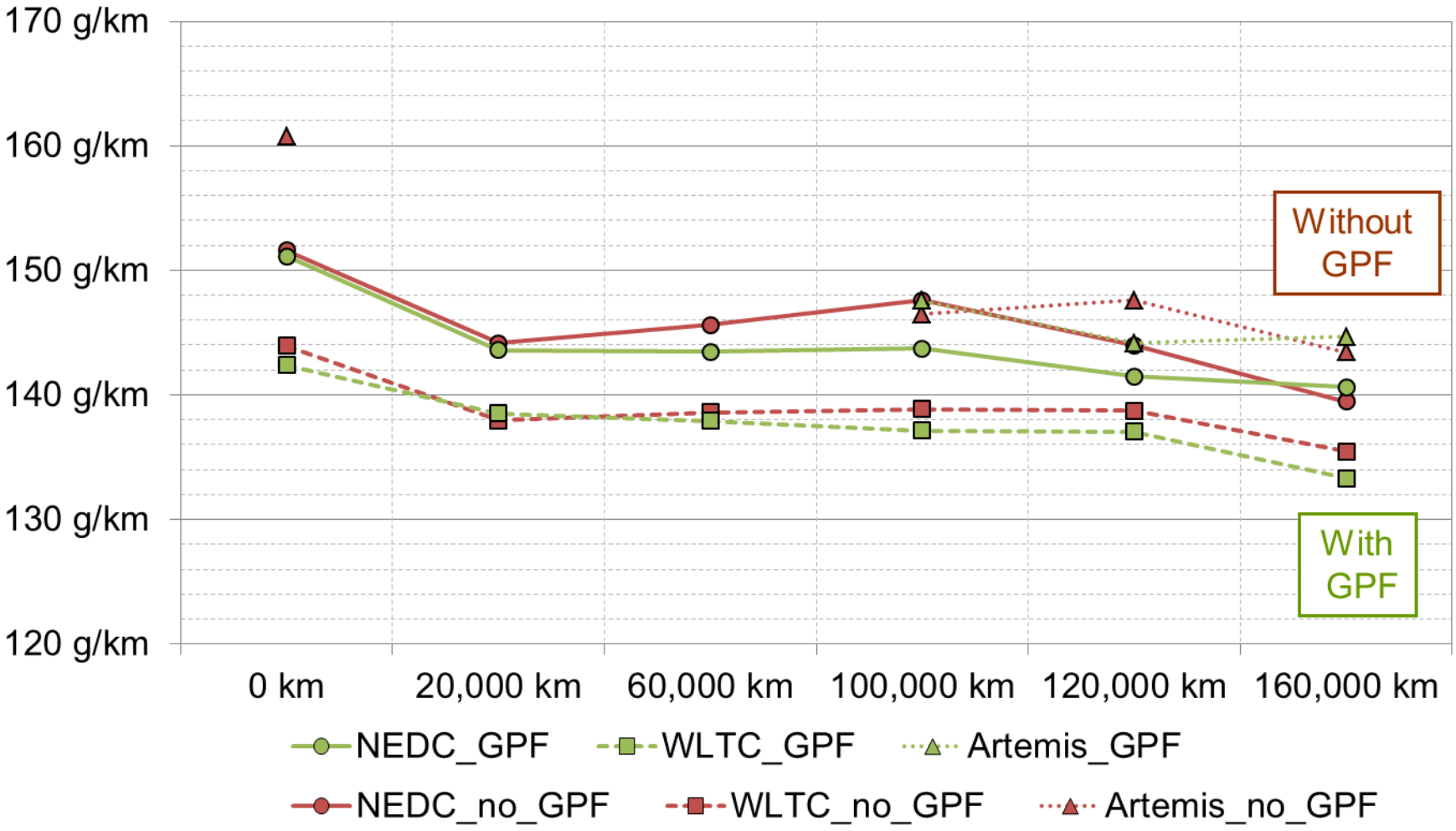

(Both systems same PGM)

**Modified System**



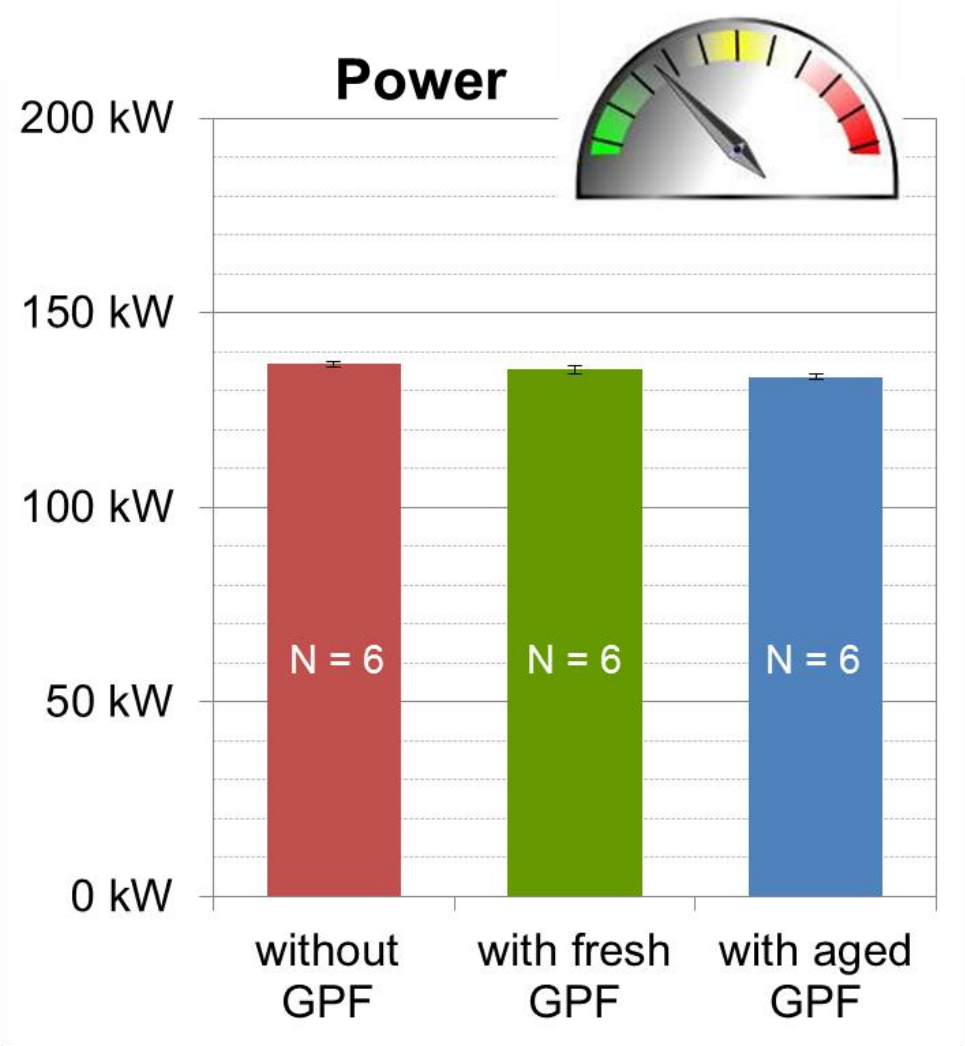



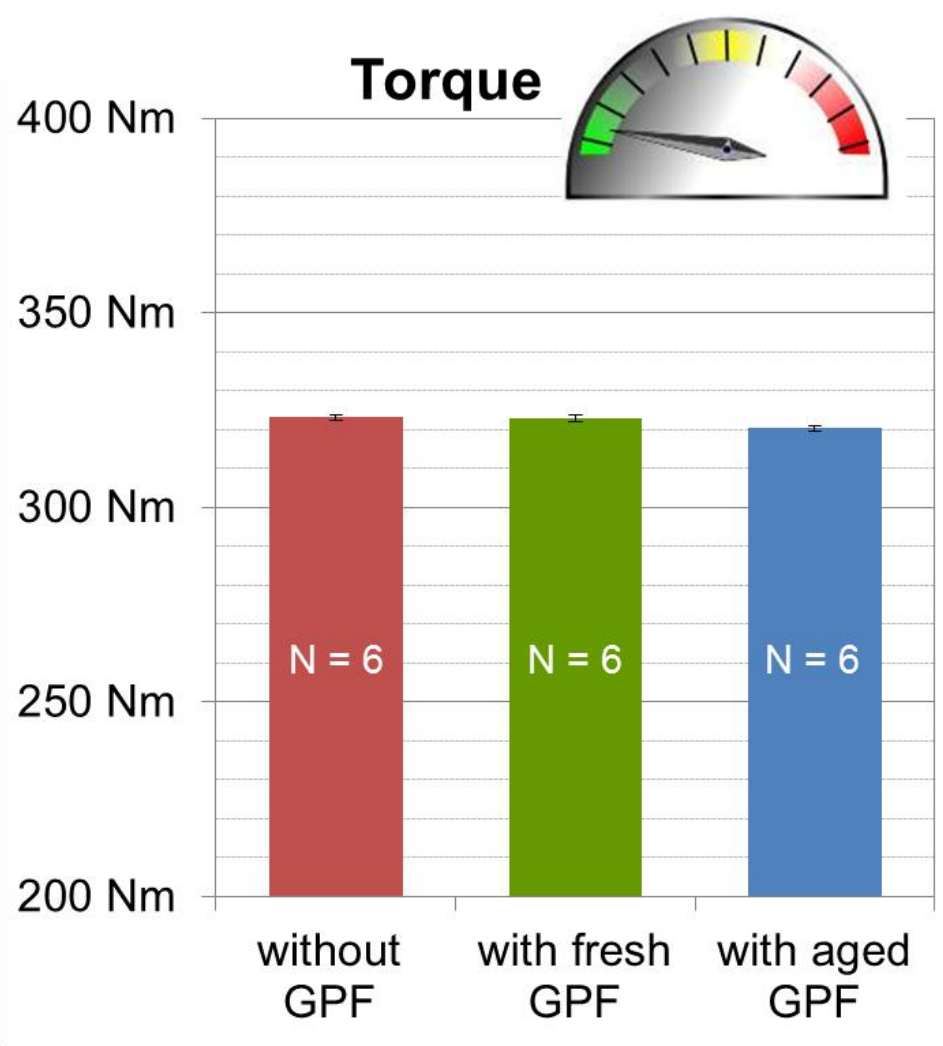
# CO2 Emissions




Impact on CO2 emission from a catalyzed GPF is negligible during most drive patterns.

# Wide Open Throttle Power Measurement



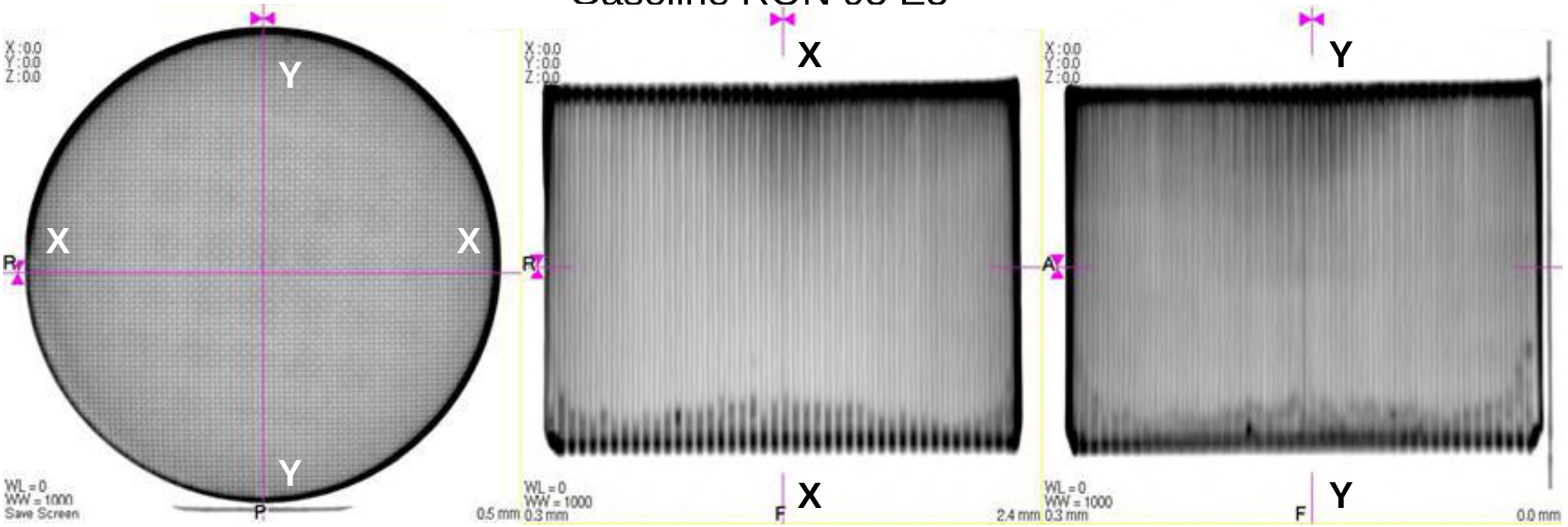

Less than 3% power loss and torque loss with aged GPF is observed during wide open throttle acceleration.

# CT Scan of GPF after 160,000 km

**Average Oil Consumption:**
**0.305 l/10,000 km**
5W-30

**Average Fuel Consumption:**
**8.46 l/100 km**
Gasoline RON 95 E5

**Average Speed:**
**80 km/h**

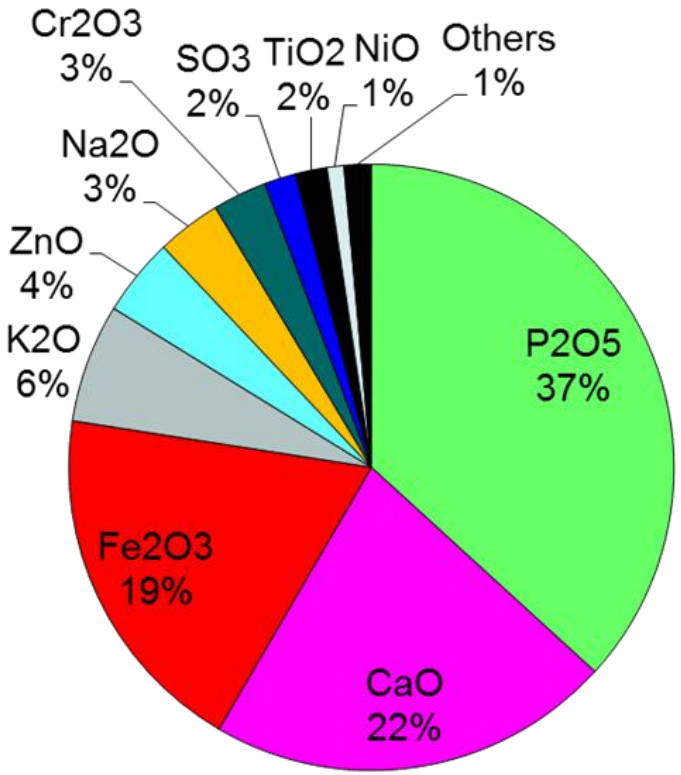



No cracks was observed in GPF.
Deposits of ash were detected mainly at the rear of GPF.
Ash amount determined after 160,000 km -> 22 g ash.

# Oil Ash Components Analysis

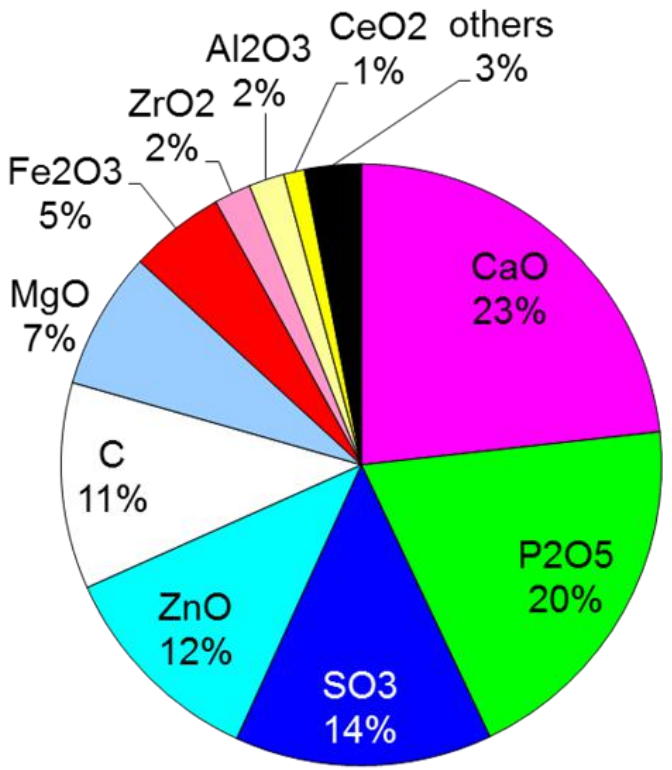
Engine oil : 5W-30
Measured by XRF(X-ray Fluorescence Analysis)
Unit: wt%

**Ash from 1.8L turbo GDI with catalyzed GPF**



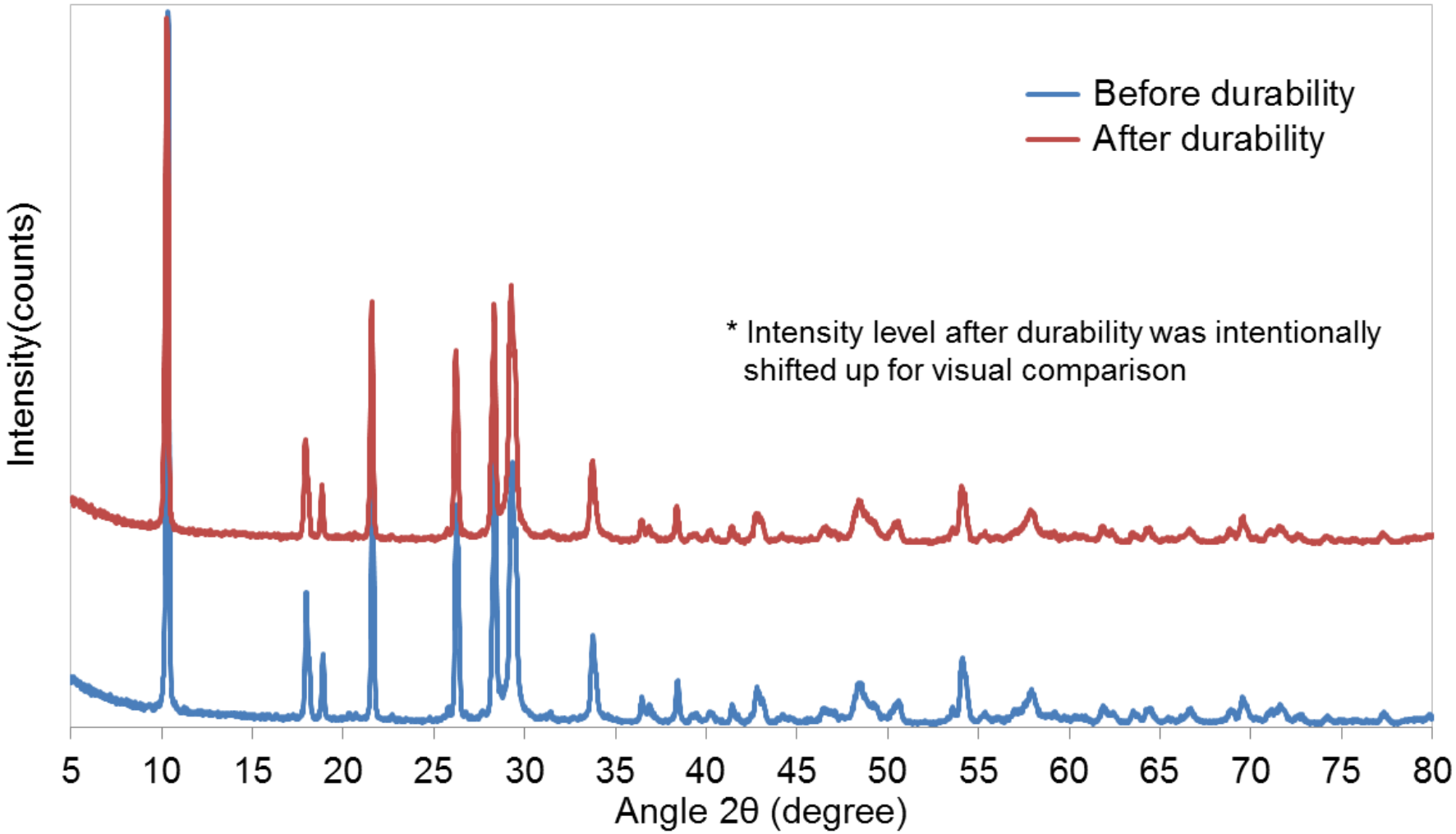

Engine oil : 5W-30
Measured by ICP-AES

**Ash from diesel with catalyzed DPF**




Gasoline engine oil ash components are similar to diesel reference oil ash. Ca and P are major components from oil.

# Chemical Reaction Analysis - XRD




No change for Cordierite crystalline structure after 160,000 km.
-> No reaction with ash occurred during this durability test.

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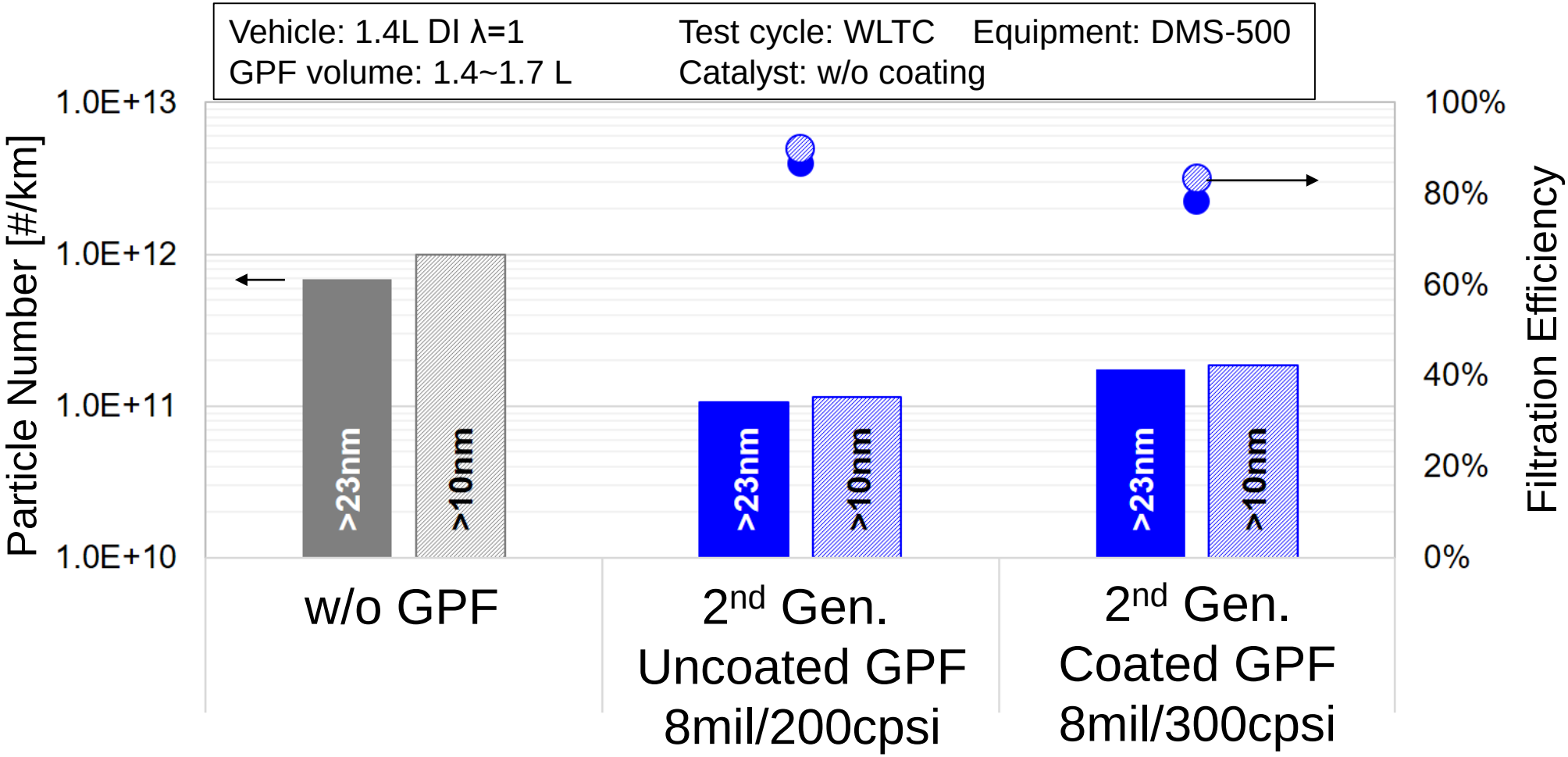
# Sub 23nm PN measurement results




PN emissions will increase by extending measurement range of PN size from >23 to >10nm. GPFs show higher filtration efficiency when counting >10nm particle size.

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PFI vehicle has higher engine out PN than DI in some driving condition and raw PN emission is above 6E+11 #/km.

No obvious concern of GPF implementation with ash and/or under real driving is confirmed.

Potential BS7 PN regulation is not clear. However, NGK has enough GPF experience and proper GPF can be proposed based on the customers' FE requirement.

# *Thank you*