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Gasoline Particulate Filter for future Indian regulation

T. Shibata, A. Kawakami, K. Sugimoto, T. Matsumoto, T. Aoki
NGK Corporation

N. Hibi
NGK Technologies India Pvt. Ltd.

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➤ Market and regulatory background in India

BS7 introduces PN10 and covers MPI

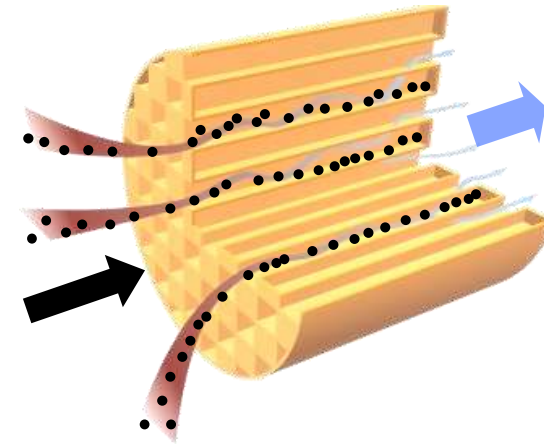
➤ Challenges for GPF in India

Filtration, pressure drop, packaging and cost

➤ NGK's solution to the challenges

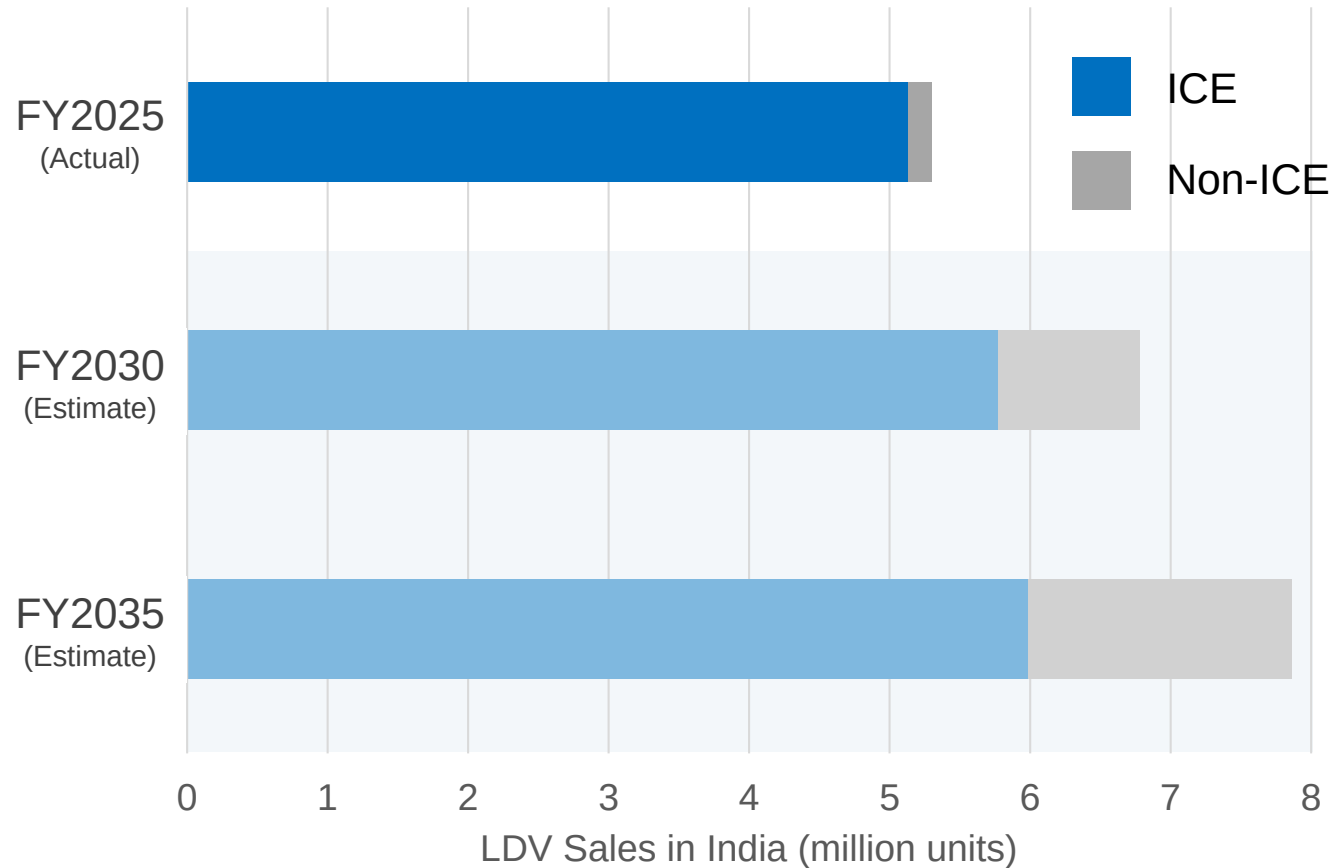
Cell structure optimization

➤ Summary



Gasoline Particulate Filter(GPF)

ICE-based powertrains stay dominant through India's powertrain transition.



Based on NGK understanding and estimation



Market Expands

- Vehicle demand keeps growing



ICE Stays The Core

- ICE remains the majority of sales in FY2035.
- ICE units keep rising in absolute terms



Non-ICE Ramps Gradually

- Non-ICE grows steadily but remains a minority.
- Adoption pace stays gradual, not disruptive

BS7 Expands the Need for GPF and Raises the Bar for TWC

Regulation timeline and limit comparison — BS (India) and EU

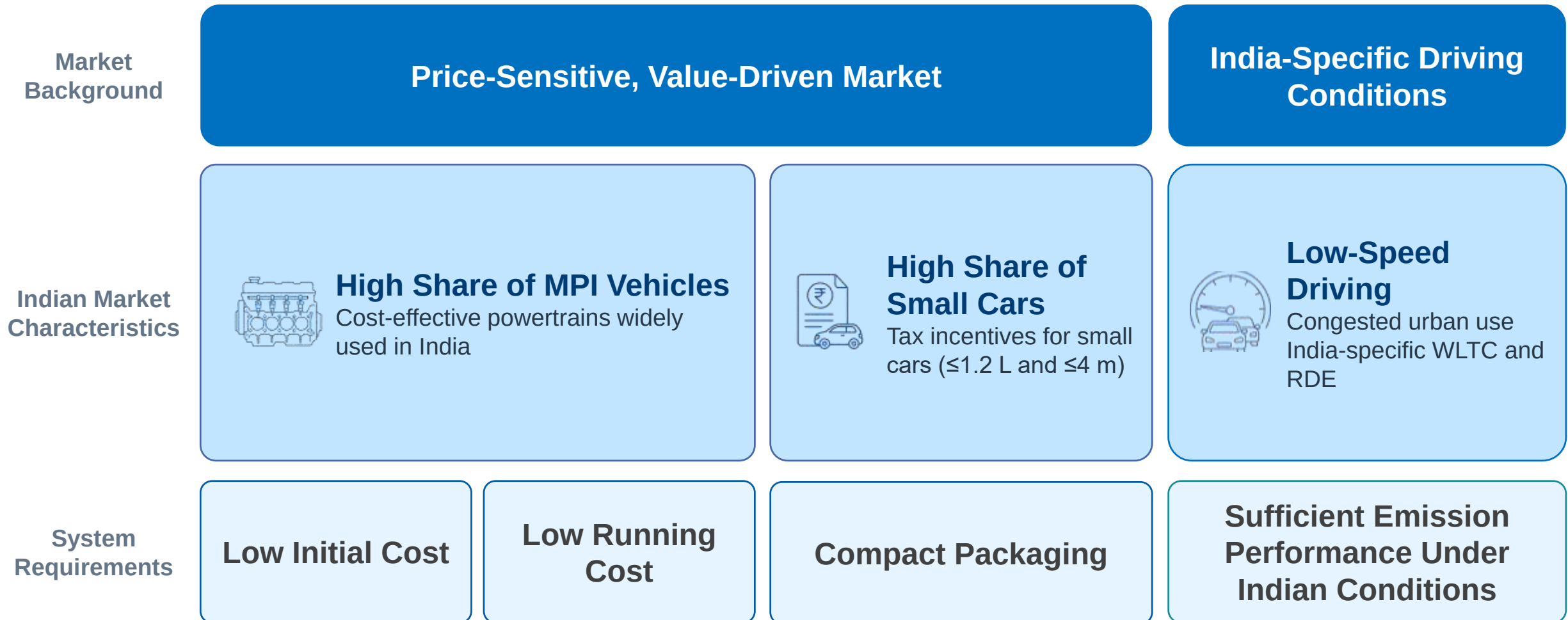
		2026	2027	2028	2029	2030	2031
BS		BS6 Stage2	BS6 Stage2 + WLTP			BS7 (Draft)* *RDE/CF from April 2030	
EU		Euro 6e	Euro 7				

	INDIA			EU	
Regulation	BS6 Stage2	BS6 Stage2 + WLTP	BS7 (Draft)* *RDE/CF from April 2030	Euro 6e	Euro 7
Test Cycle	MIDC + RDE	WLTC (to Ph.3) + RDE	WLTC (to Ph.3) + RDE	WLTC + RDE	WLTC + RDE
PN (#/km)	6.0×10 ¹¹ CF 1.5 PN23 · GDI only	6.0×10 ¹¹ CF 1.5 PN23 · GDI only	6.0×10 ¹¹ CF 1.0 PN10 · GDI + MPI	6.0×10 ¹¹ CF 1.34 PN23 · GDI only	6.0×10 ¹¹ CF 1.34 PN10 · GDI + MPI
NOx (mg/km)	60 CF 1.43	60 CF 1.43	60 CF 1.0	60 CF 1.1	60 CF 1.1
THC (mg/km)	100	100	100	100	100
NMHC (mg/km)	68	68	68	68	68
CO (mg/km)	1,000	1,000	1,000	1,000	1,000

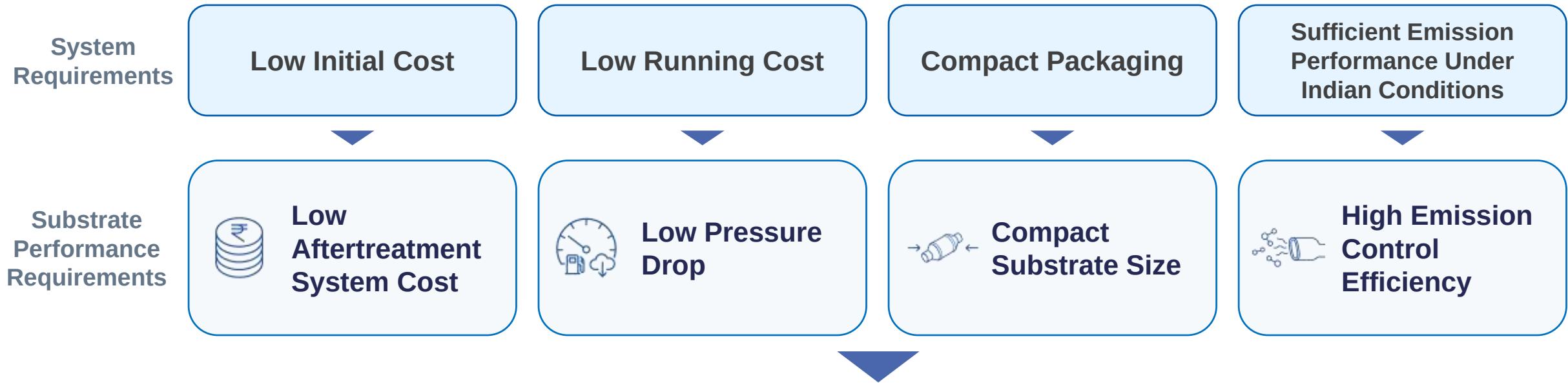
Along with the market growth, emission regulations are expected to become increasingly stringent.

BS7 requirements are based on NGK's current assumptions.

India-specific market and driving conditions make aftertreatment system optimization essential.



System Requirements Translated into Substrate Capabilities



Technology-Specific Substrate Requirements

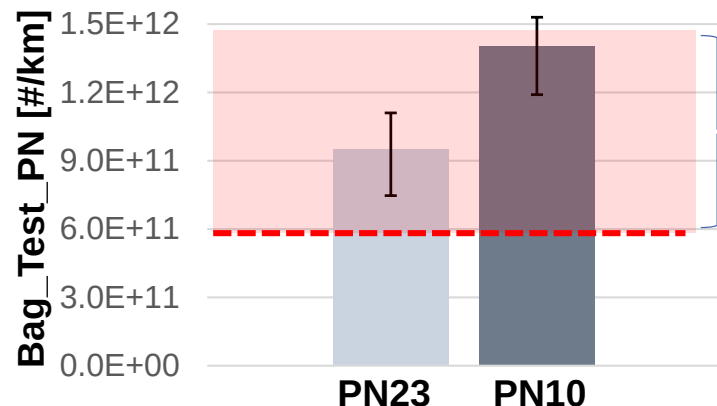


Expected changes in PN regulation under BS7

Particle size: PN23 $\Rightarrow$ PN10 (Particles down to 10 nm are counted)

Applicable engines: GDI $\Rightarrow$ GDI + MPI

PN emissions of an MPI vehicle



Exceeding PN limit
(6.0×10^{11} #/km)

Test condition

Test site: AVL India
Test vehicle: 1.2L BS6 Stage I
Test cycle: WLTC (up to Phase 3)

Challenges in installing a GPF in INDIA

Limited packaging space — on small MPI vehicles

Increase in pressure drop — caused by adding a GPF to the ATS

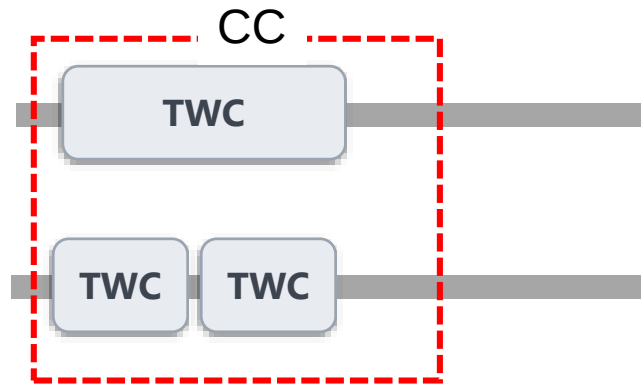
Ash accumulation — a filter-specific issue

Once BS7 covers PN10 and MPI, a GPF will become mandatory
- bringing packaging, pressure-drop and ash challenges.

Challenge 1: Limited packaging space

Representative aftertreatment system (ATS) Configuration for MPI vehicles

Current

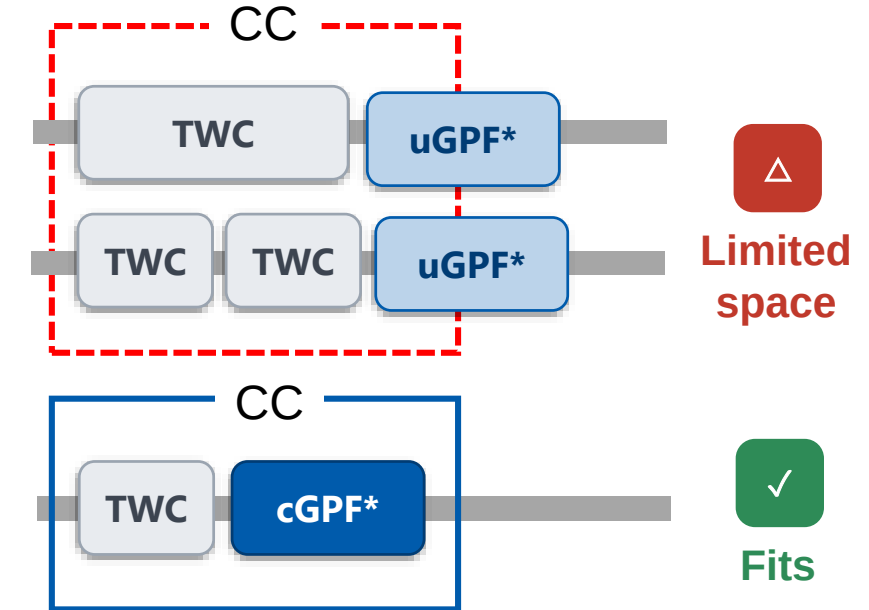


Add GPF?

or

Replace TWC with coated GPF?

(Estimated) BS7

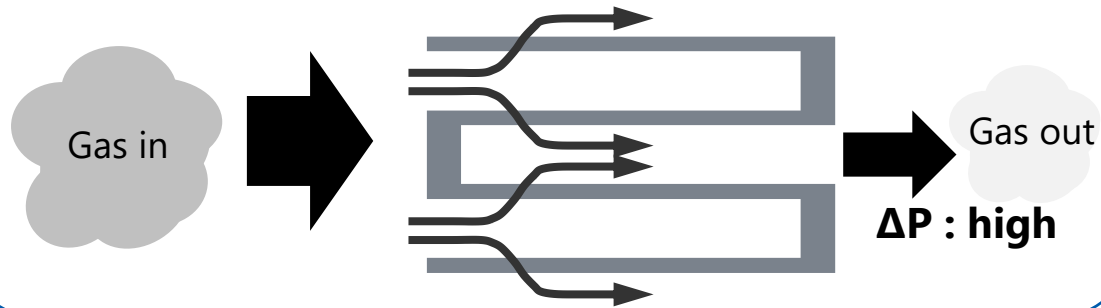


*uGPF : uncoated GPF
cGPF : coated GPF

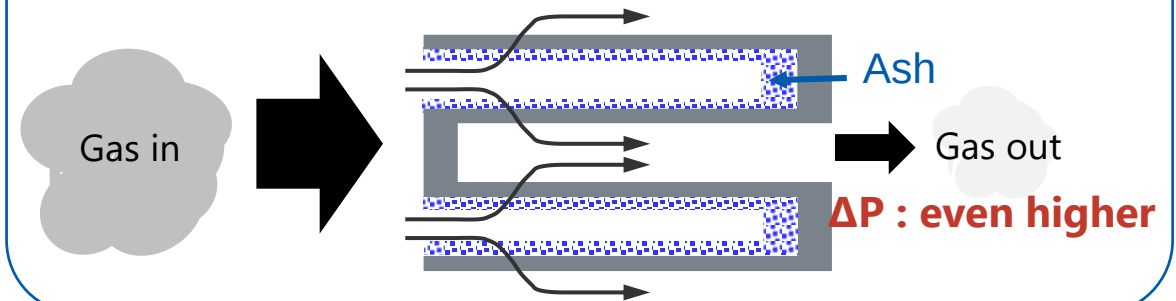
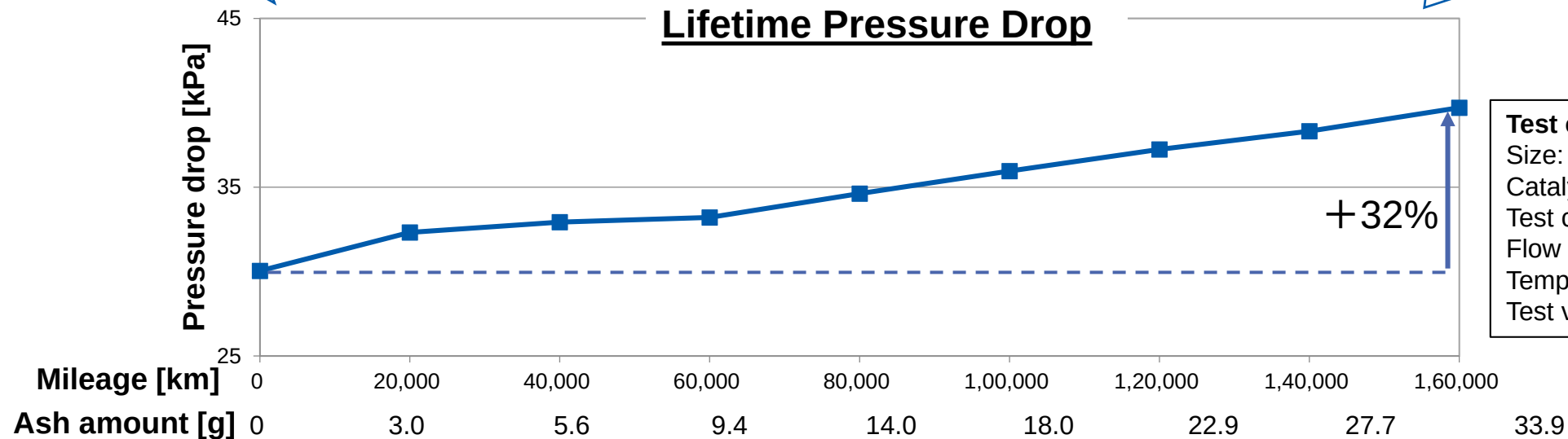
- ✓ MPI is used mainly on smaller vehicles — close-coupled catalyst space is limited.
- ✓ A coated GPF carries the TWC function, which would better fit limited space.

Challenge 2: Increase in pressure drop and ash accumulation

In a filter, gas must pass **through the walls**, which results in a **higher pressure drop** compared to TWC.



As ash accumulates, the pressure drop rises further due to thicker walls and shorter effective length.



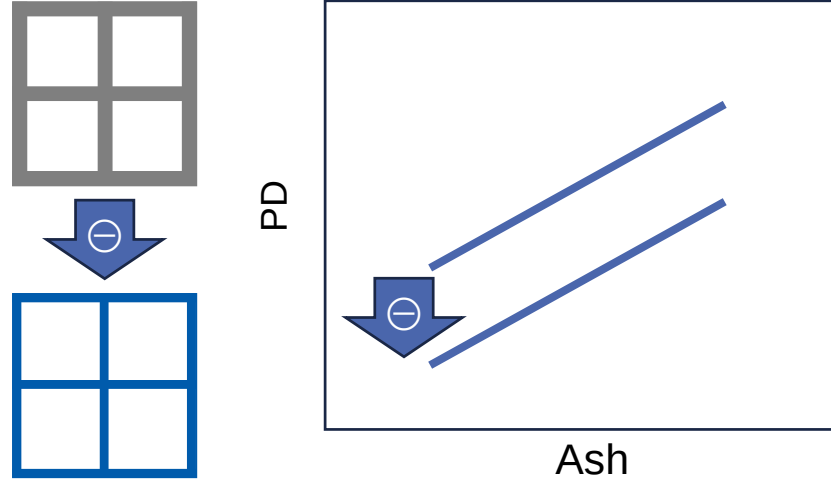
Test condition

Size: $\Phi 118.4 \times 127.0$ mm
Catalyst: Coated
Test cycle: Pseudo SRC
Flow rate: ca. 435 kg/h
Temp.: 200~500 °C
Test vehicle: 1.4L GDI China5

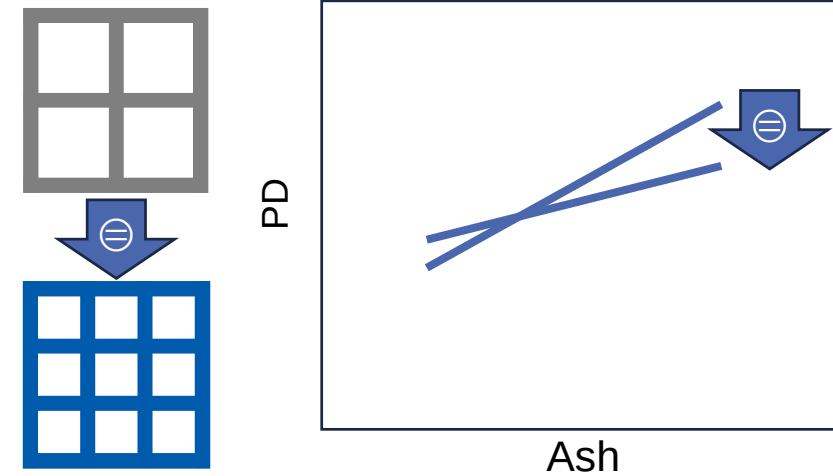
- ✓ GPF has a higher initial pressure drop than TWC
- ✓ GPF accumulates Ash during use, raising the pressure drop further

How to achieve low pressure drop

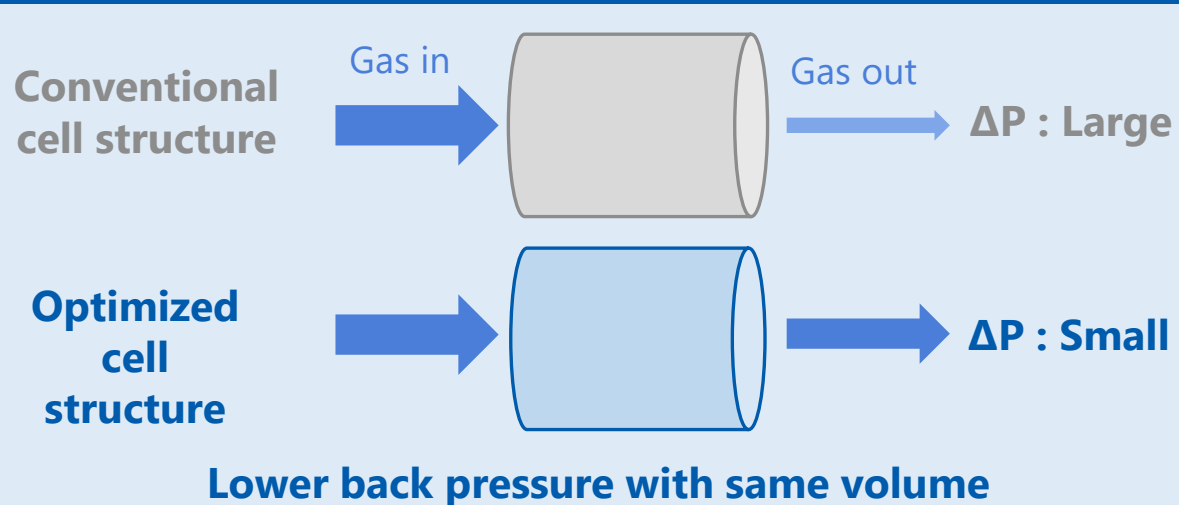
Thinner wall



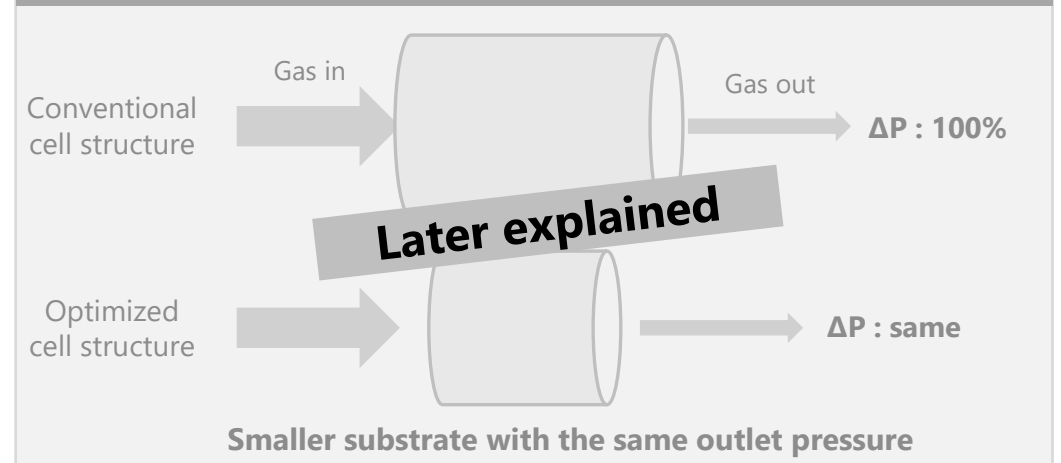
Higher cell density



Option 1: Reduce pressure drop



Option 2: Reduce GPF size



How to read this chart

Each plot = one **wall thickness** × **cell density** combination
Only **Min. 1.0 MPa isostatic strength** structures are plotted

Calculation condition

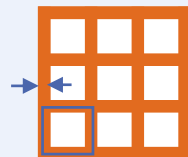
Size: $\Phi 132.1 \times 127.0$ mm
Wall thickness: 6–15 mil
Cell density: 200–400 cpsi
Catalyst: w/o
Flow rate: 10 m³/min
Temp.: 25 °C

Cell structure notation

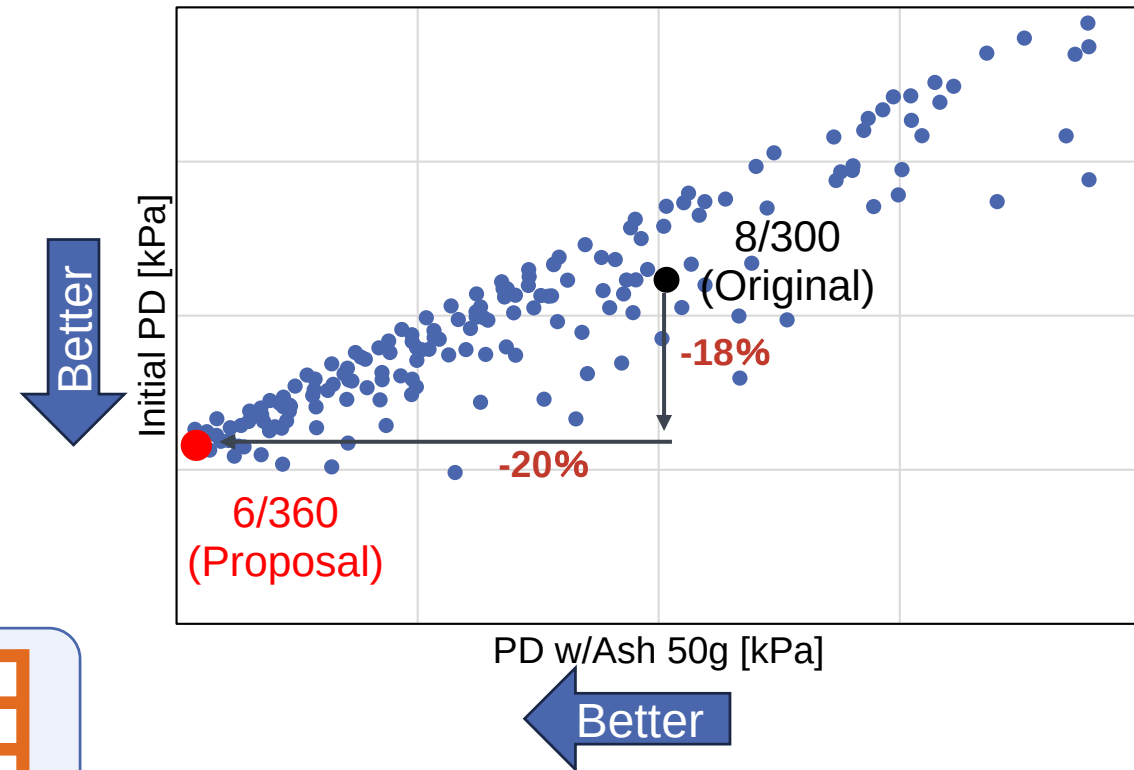
Ex. 8 / 300

8 = Wall thickness 8 mil

300 = Cell density 300 cpsi (cell per square inch)



Pressure drop calculation



Combination of “**Thin wall**” and “**High cell density**” lowers the pressure drop, initially and with ash.
→ **6/360** is the best candidate for the lower PD GPF.

6/360 reduces pressure drop, with and without ash

Test condition

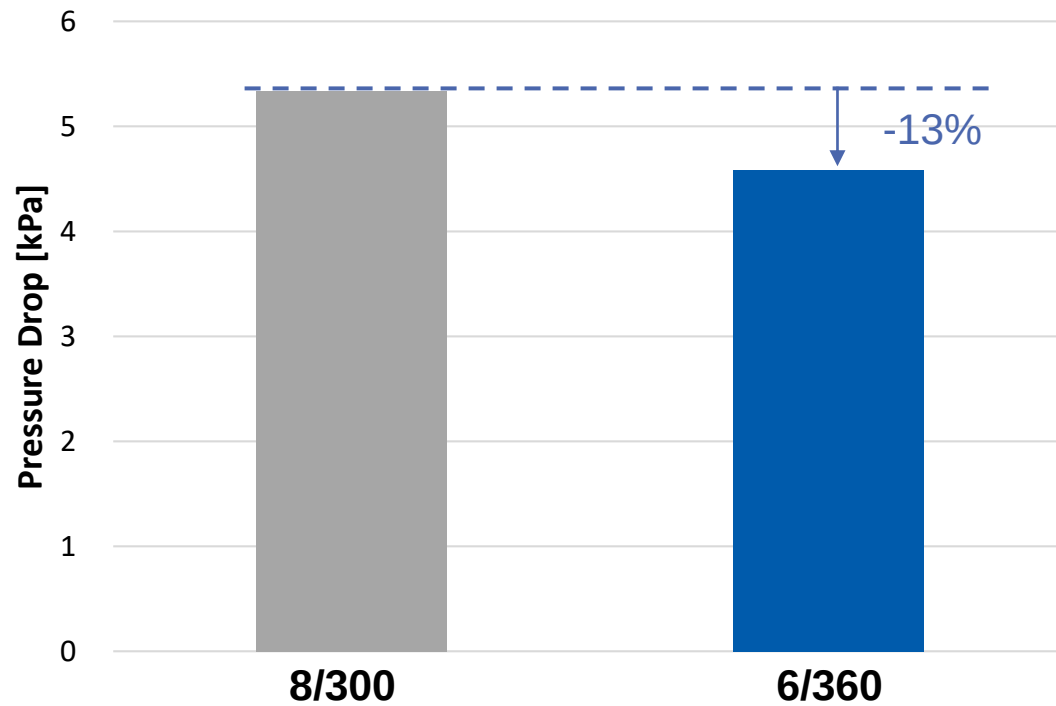
Flow rate: 600 kg/h

Temp.: RT

Size: $\Phi 132 \times 102$ mm

Catalyst: Coated (Type A)

Initial Pressure Drop



Test condition

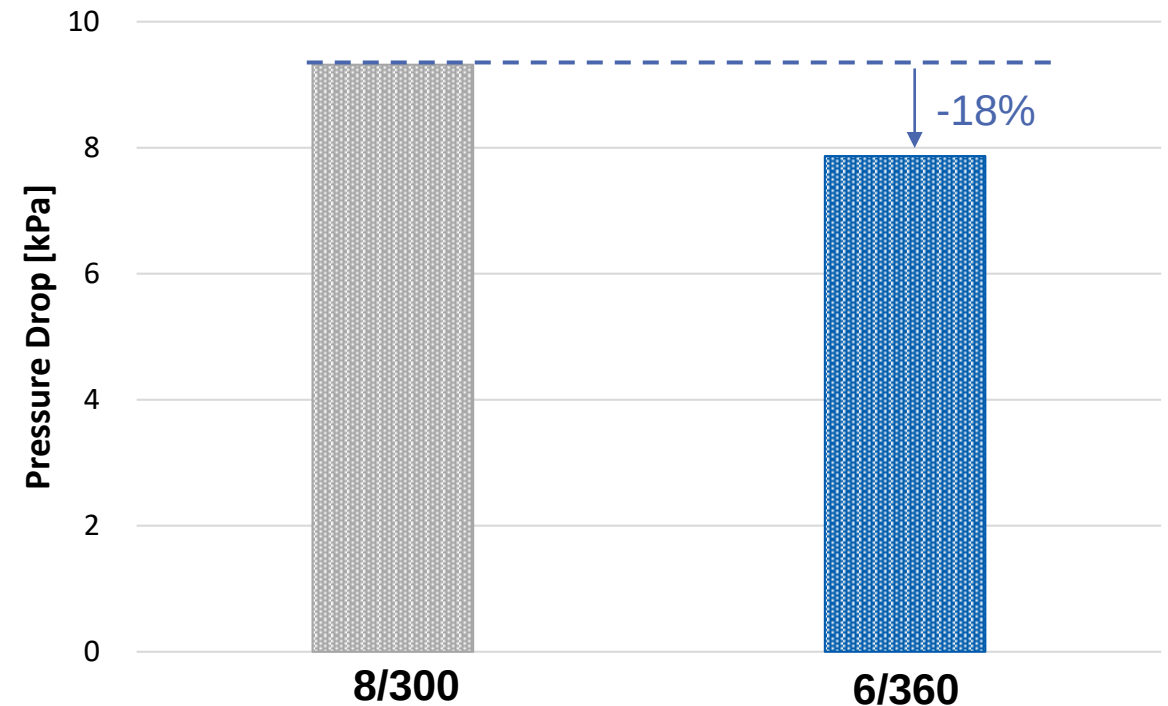
Flow rate: 600 kg/h

Temp.: RT

Size: $\Phi 132 \times 102$ mm

Catalyst: Coated (Type B)

Pressure drop with 30g Ash



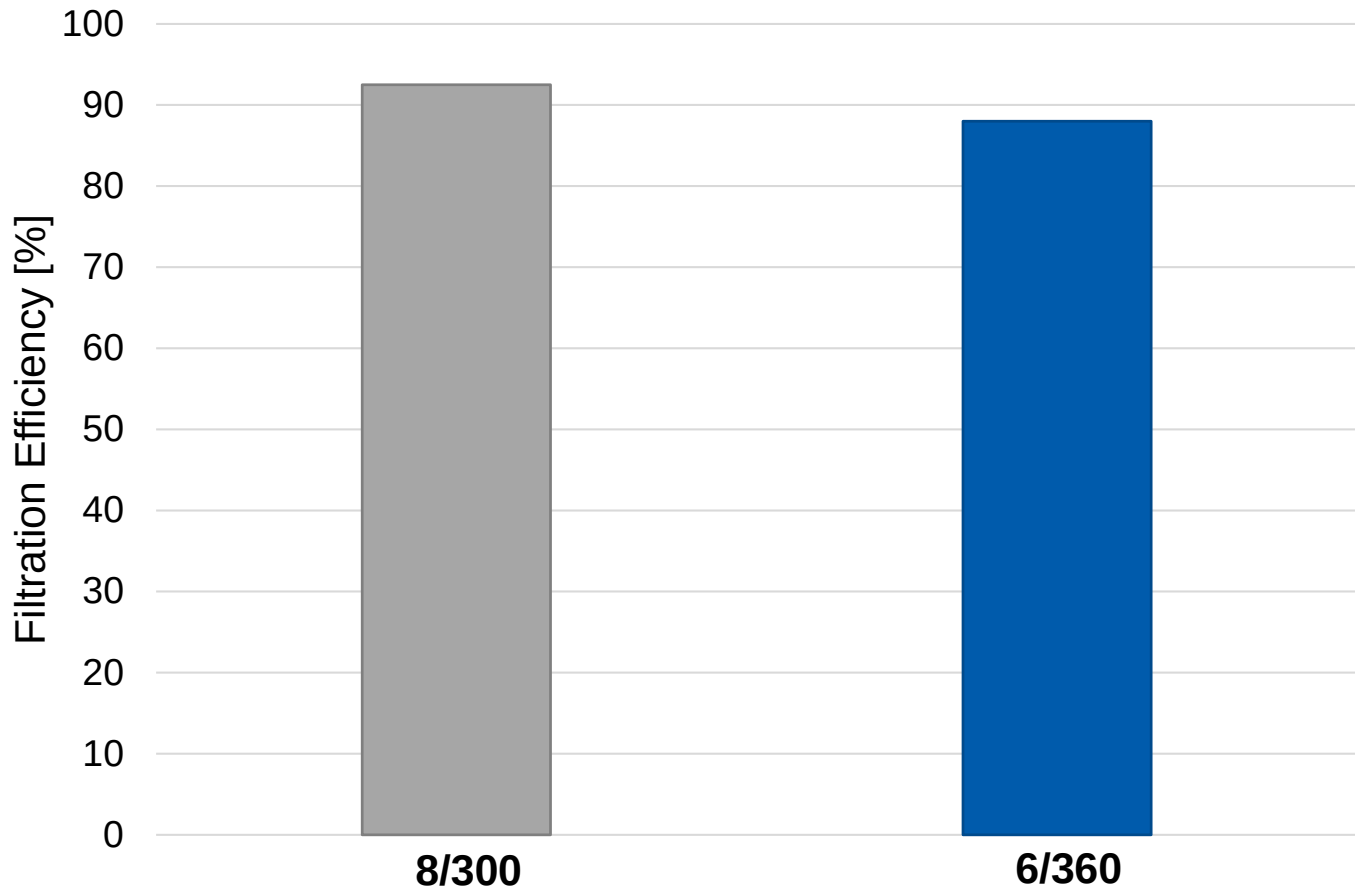
The 6/360 design minimizes the pressure drop increase caused by adding a GPF, both initially and after ash accumulation.

6/360 keeps PN emission well below the BS7 limit (1/2)

Test condition

Soot amount: 0.05 g
Flow rate: 250 kg/h
Temp.: 240 °C
Catalyst: Coated
Measured by: DPG*

*DPG (Diesel Particulate Generator) :
a burner-type soot generator widely used in
Europe for bench evaluation.

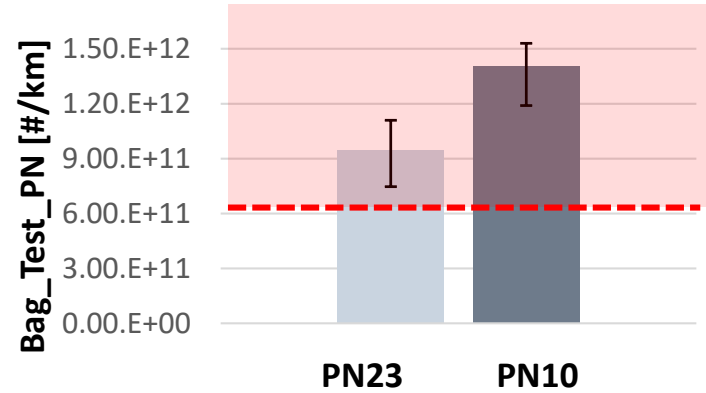


The 6/360 design has slightly lower filtration efficiency than original 8/300 due to its thinner wall.

6/360 keeps PN emission well below the BS7 limit (2/2)

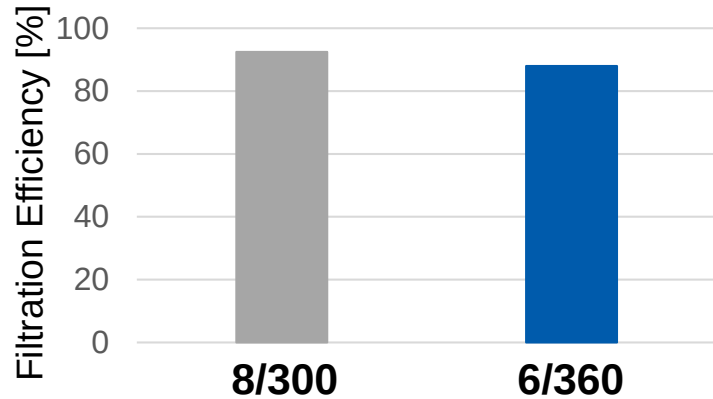
Slide 7

PN emission of MPI vehicle

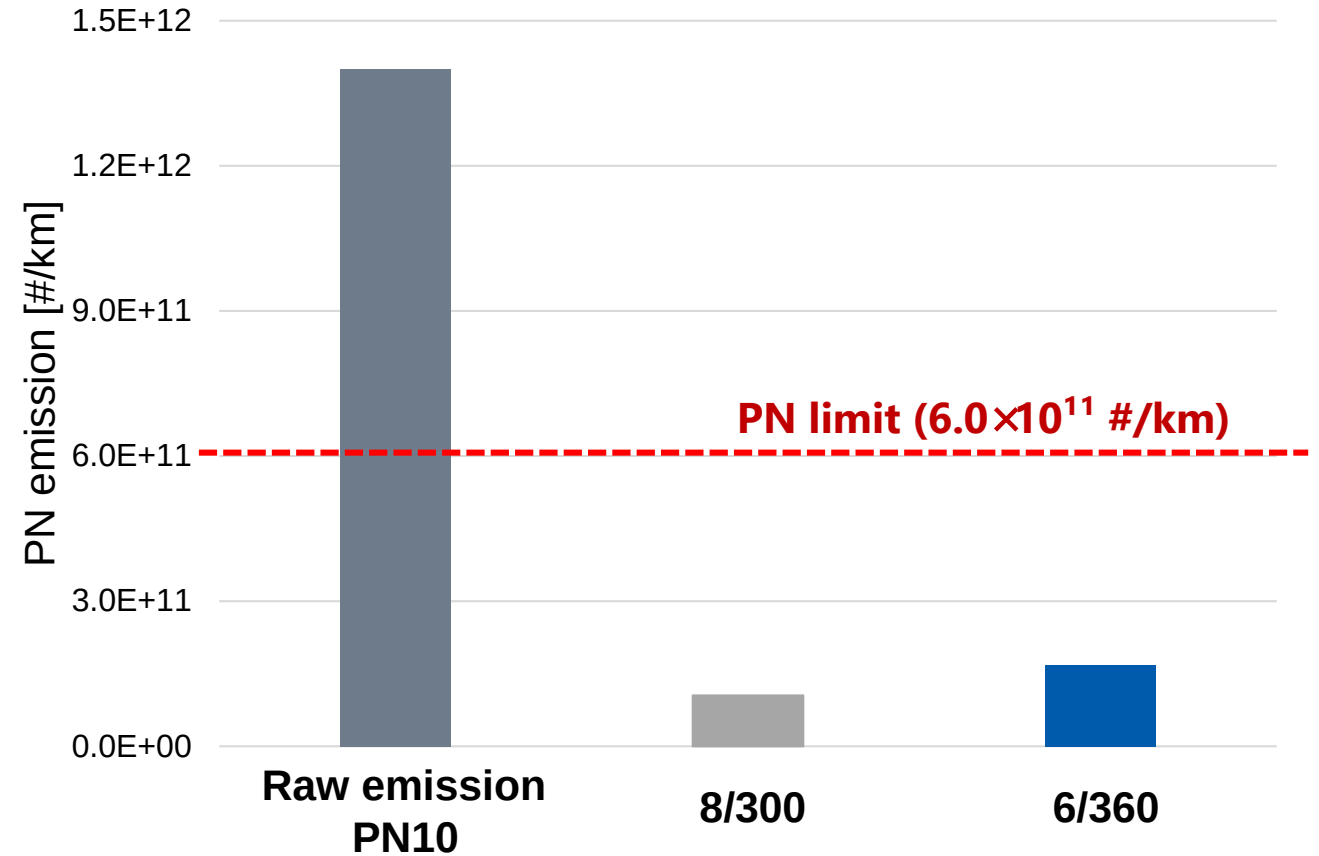


Slide 13

Filtration Efficiency



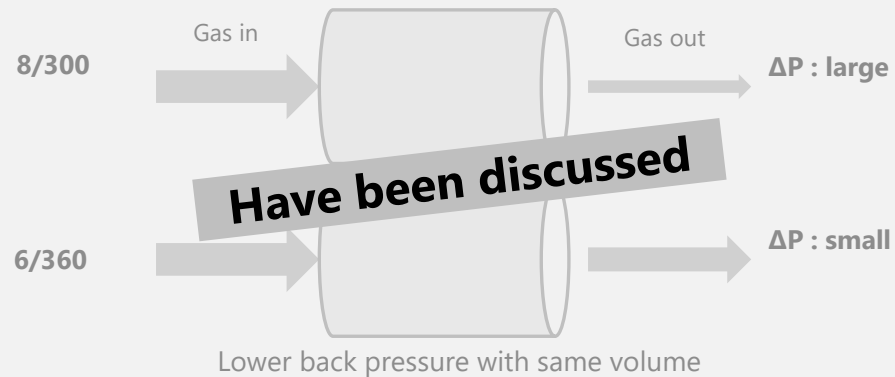
Estimated PN emission of MPI vehicle



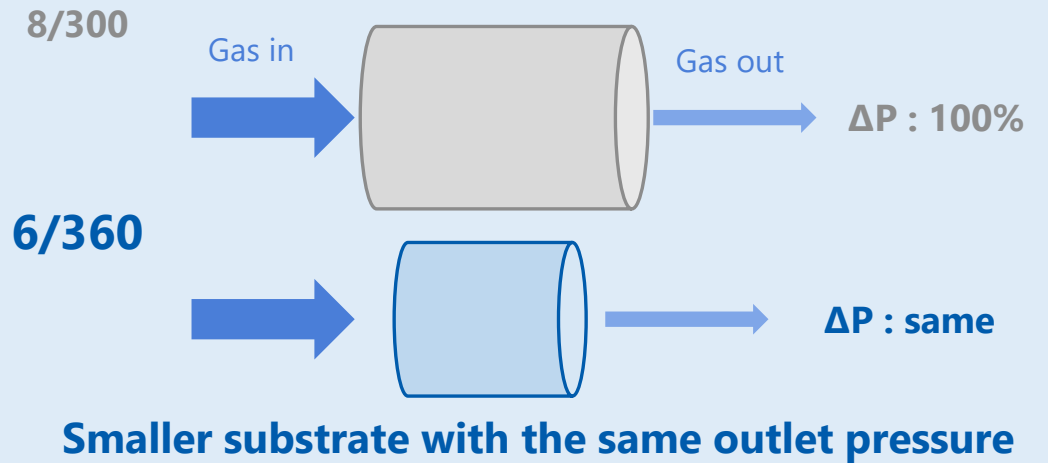
6/360 is expected to have sufficient filtration capability.

6/360 — Thinner wall & higher cell density, lower pressure drop

Option 1: Reduce pressure drop



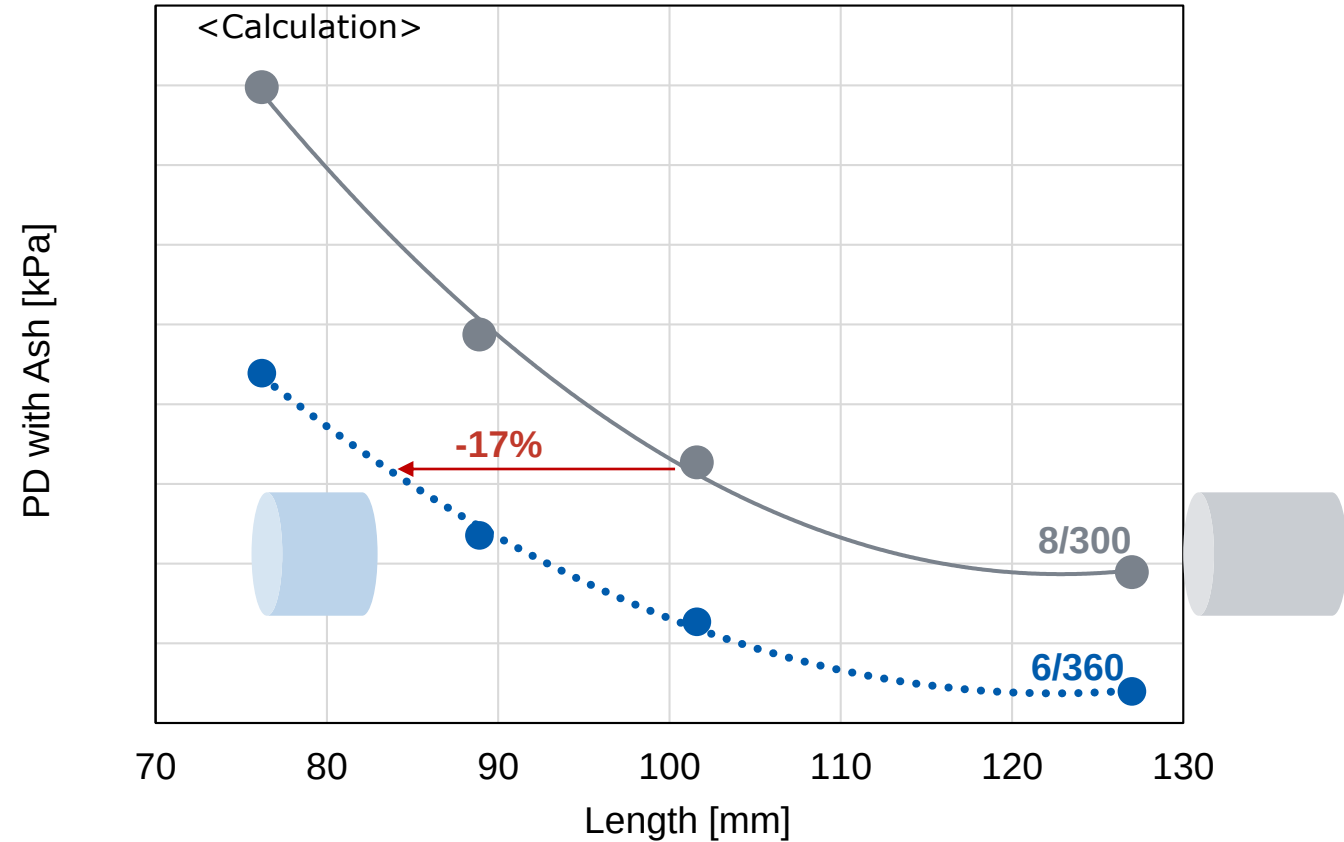
Option 2: Reduce GPF size



Calculation condition

Flow rate: 10 m³/min
Air temp.: 25 °C
Ash amount: 40 g*
Size: $\Phi 132.1 \times 76\text{--}127$ mm
Catalyst: w/o

* Based on vehicle evaluation with 200,000km durability



Shortening the GPF raises the pressure drop, but the lower pressure drop of 6/360 leaves margin for downsizing (approx. -17% in this case).

Downsizing potential with 6/360 – Emission

Test condition

Test cycle: WLTC

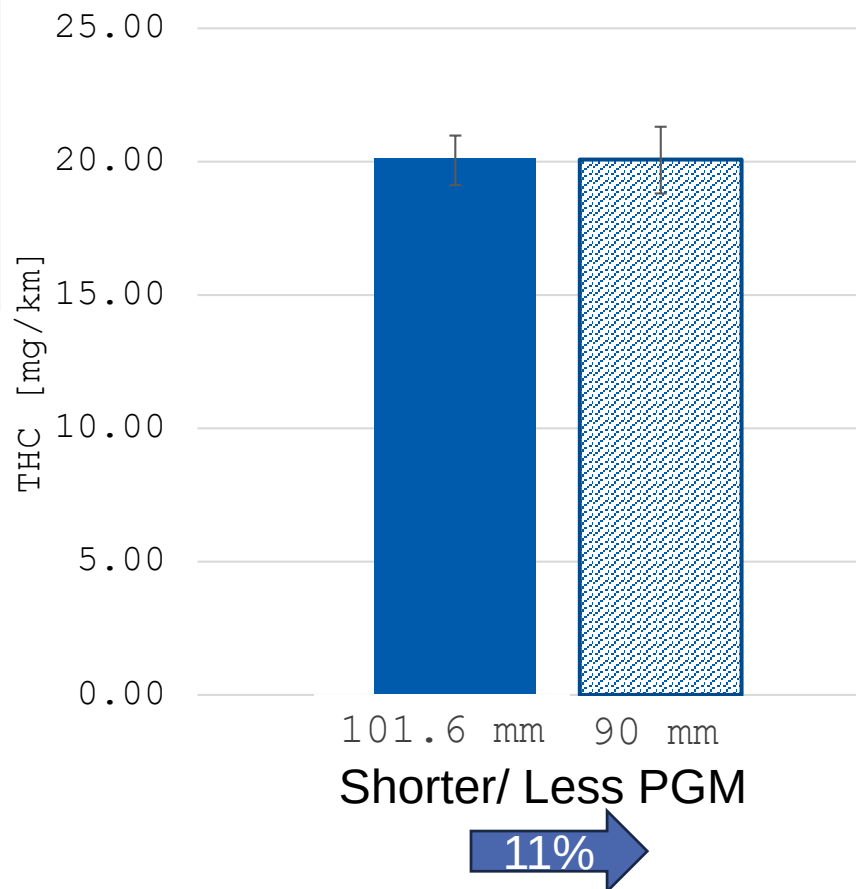
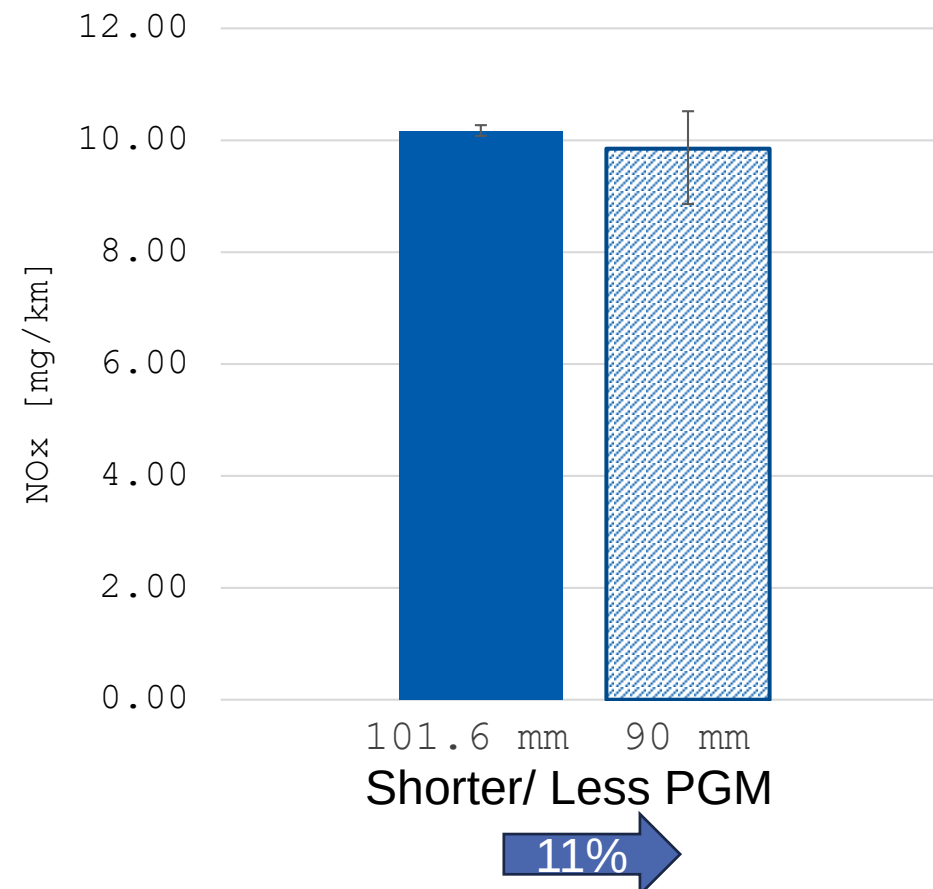
Test vehicle: 1.5L GDI, China6 B

Layout: GPF equipped behind TWC

Size: GPF $\Phi 132 \times 90$ -102 mm

Catalyst: TWC Coated

Tested: n=3



6/360 keeps NOx and THC bag emissions at the base level, even at 90 mm with the same catalyst amount per volume. This suggests 6/360 has potential for downsizing and reducing PGM.

Summary: 6/360-A promising GPF solution for BS7

Substrate
Performance
Requirements



**Low
Aftertreatment
System Cost**



**Low Pressure
Drop**



**Compact
Substrate Size**



**High Emission
Control
Efficiency**

System Optimization With NGK GPF : *Coated type 6/360*

Cost sensitivity	Pressure drop	Limited packaging space	PN10 + MPI coverage
Potential for Downsizing and PGM reduction	-13% initial -18% with 30 g ash vs. 8/300	Downsizing at the same pressure drop	Potential for Enough Margin for expected BS7 limit

➤ Next step: Planned vehicle evaluation in India

Verify 6/360 performance under actual driving conditions.



Contact us at;

NGK Corporation

Tomoko Shibata (to-shibata@ngk.co.jp)

NGK Technologies India Pvt. Ltd.

Noriyuki Hibi (n-hibi@ngkindia.co.in)

Appendix

Downsizing potential with 6/360-Emission

Test condition

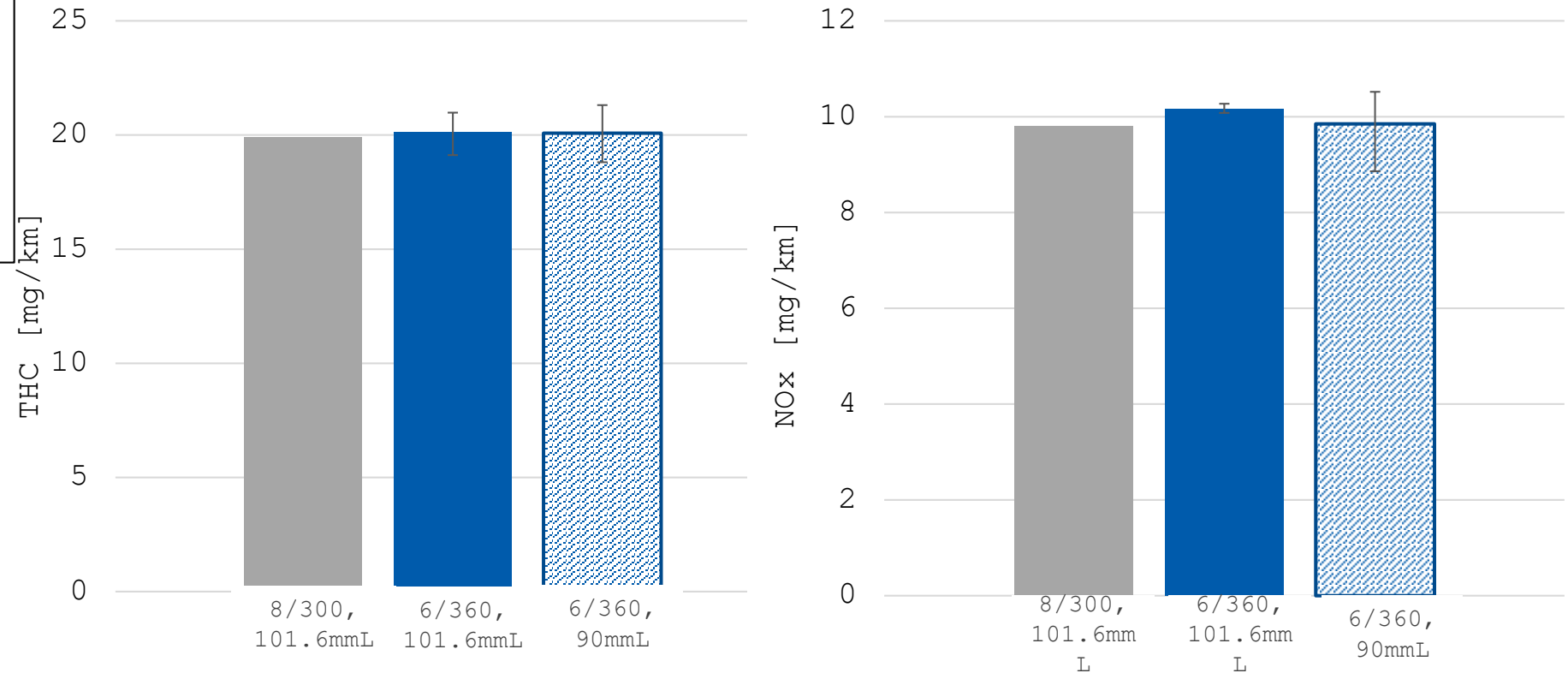
Test cycle: WLTC

Layout: GPF equipped behind TWC

Size: GPF $\Phi 132 \times 102$ mm

PGM amount: GPF 7 g/cft

Tested: n=1 for 8/300,
n=3 for 6/360



6/360 keeps NOx and THC bag emissions at the base level, even at 90mmL with the same catalyst amount per volume. This suggests 6/360 has potential for downsizing and reducing PGM due to increased surface area and weight reduction.