ECT-2024
Session 03
Light Duty Applications
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Advanced Technologies for Future Spark Ignition Engine Emission Legislations

T. Aoki, K. Sugimoto, H. Mikami
NGK Insulators, Ltd.

N. Hibi, N. Gautam, S. Muraoka
NGK Technologies India Pvt. Ltd.

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- Introduction
  - ✓ Background
- Experimental Setup
  - ✓ Test Condition
  - ✓ Sample matrix
- Test Result and Discussion
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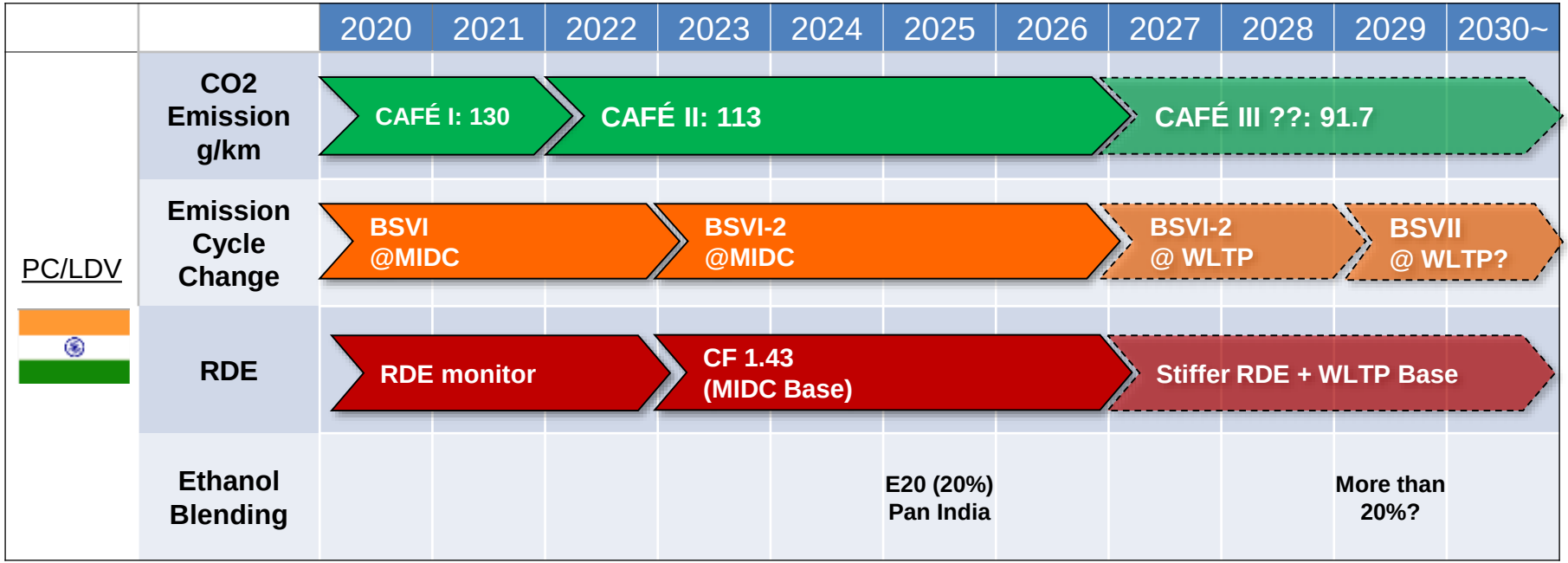
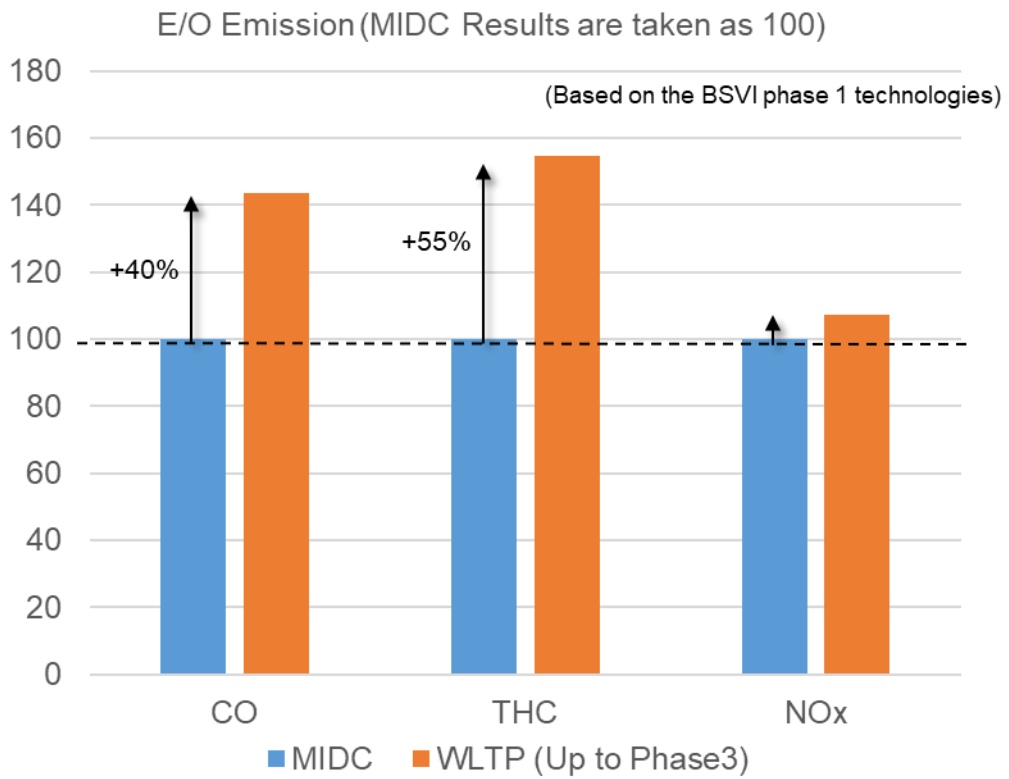
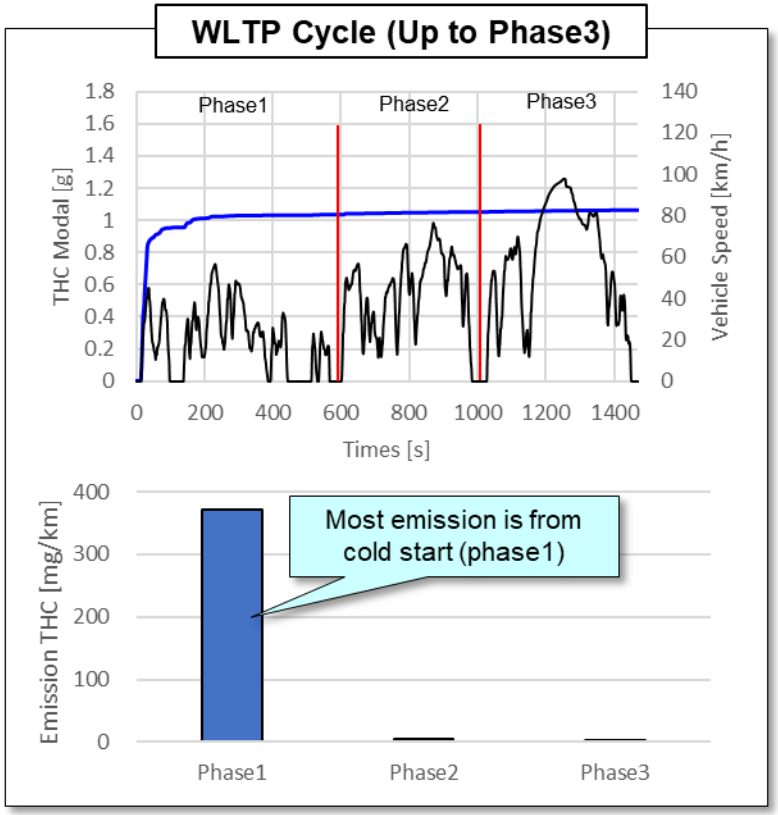
PC/ LDV Regulation



Next Challenges would be implementing WLTP Cycle and tighter CO2 regulations

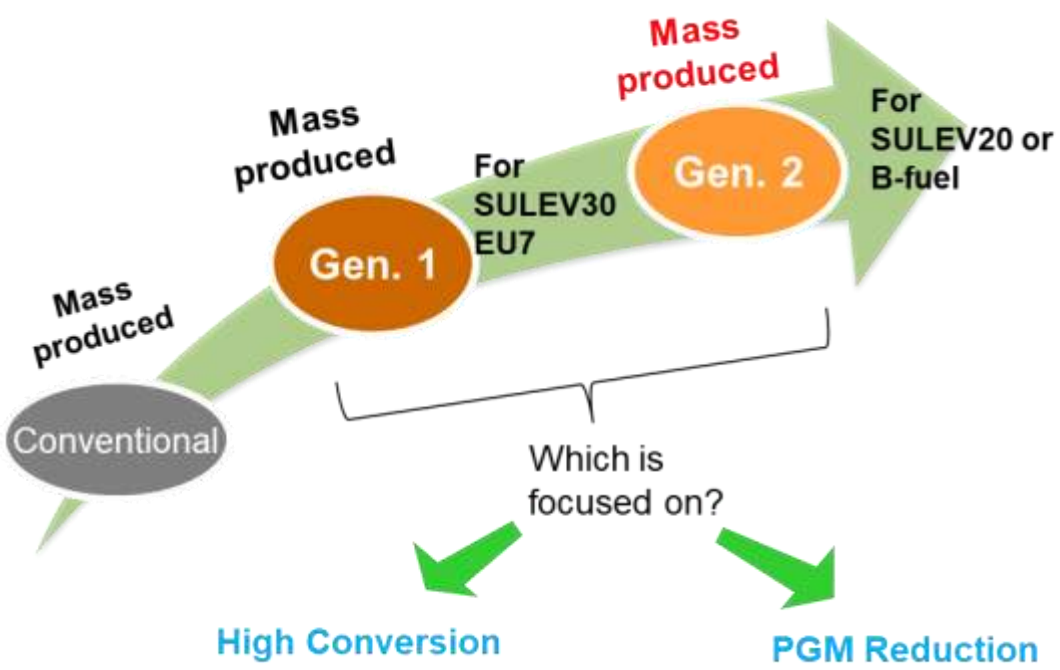
Next Challenges – Implementing WLTP Cycle

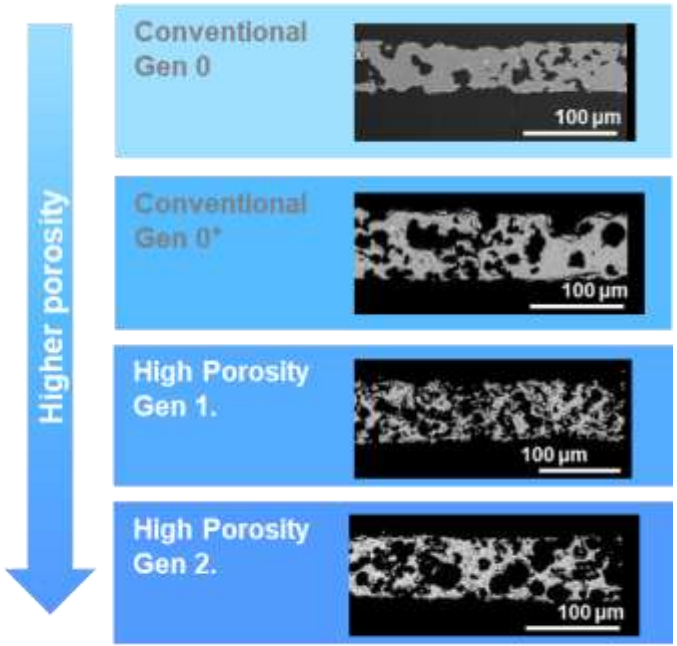




WLTP (Up to Phase3) is more severe than MIDC cycle. Especially THC is severe in WLTP

NGK Development Roadmap for Substrates





- ✓ To improve cold start emission, light off performance is the most important factor.
- ✓ New technologies has a potential for reducing PGM by improving catalyst conversion.

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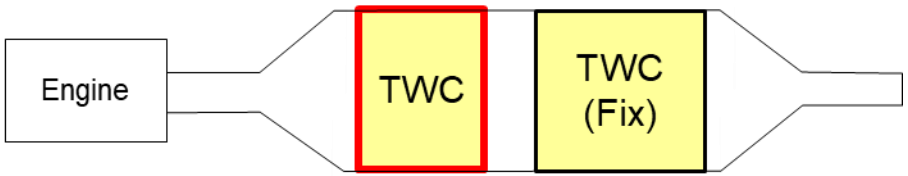
Experimental Setup

Tested conditions

Vehicle	1.2L MPI BSVI Stage I
Coating	BSVI Stage I basis
Aging	Method: Oven Max Temp.: 1050 deg.C Duration: 5hr
Tested cycle (3times each)	MIDC WLTP(up to phase3)



(1st Brick) Volume: 0.6L
(2nd Brick) Volume: 1.0L

Sample Matrix

TWC Sample Matrix:

1st Brick volume: 0.6L
2nd Brick volume: 1.0L

BD: Bulk Density
GSA: Geometrical Surface Area

Brick	Substrate Material	Cell Structure [mil/CPSI]	Bulk Density [g/cm3]	GSA [cm2/cm3]	PGM Loading*	Substrate Weight	
						Before Coating [g]	After Coating [g]
1st	Conv. (Gen.0)	2/600 SQ	0.264	35.1	100	157	336
	Gen. 0+	2/750 SQ	0.255	38.6	100	152	295**
	High Porosity (Gen. 1)	2/600 SQ	0.214	35.1	100	130	315
		2/750 SQ	0.215	38.6	100	128	307
		2/750 SQ	0.215	38.6	80	128	270
2nd	Conv. (Gen.0)	2/600 SQ	0.268	35.1	12	267	461

* Current part results are taken as 100
** Some coating variation are observed only this sample

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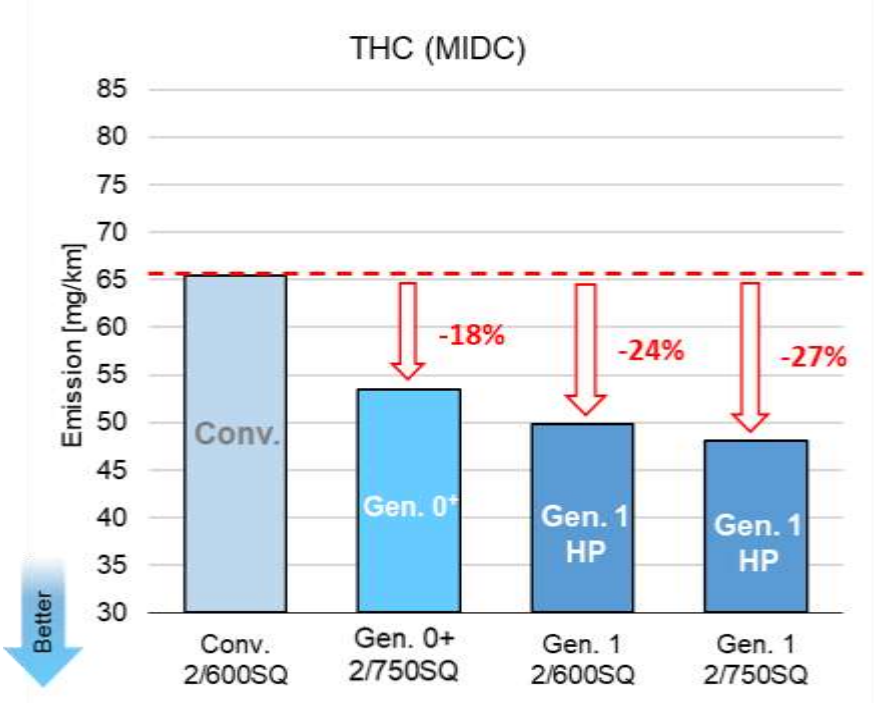
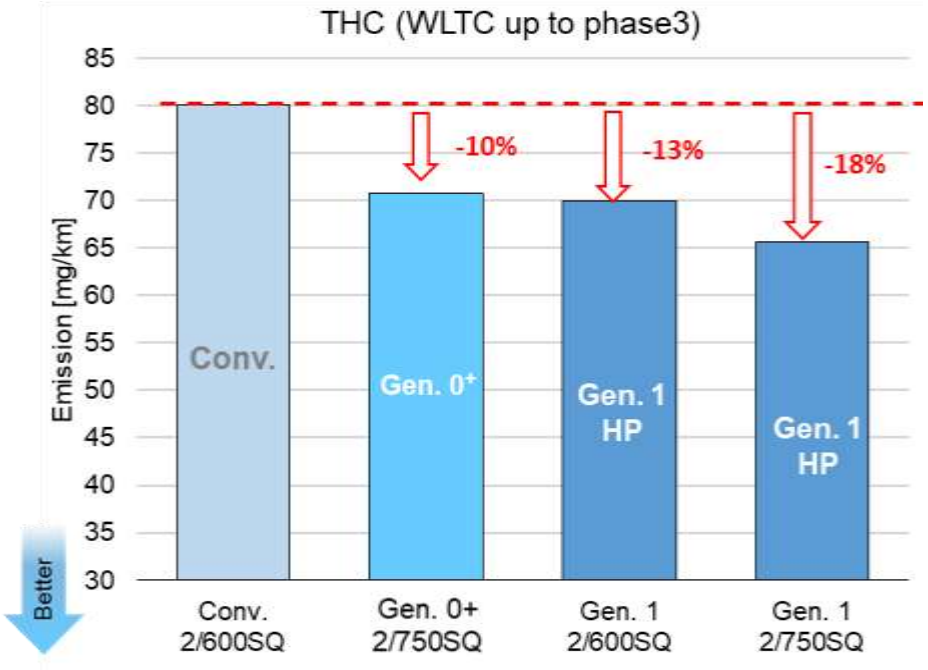
Total Bag Emission (THC)

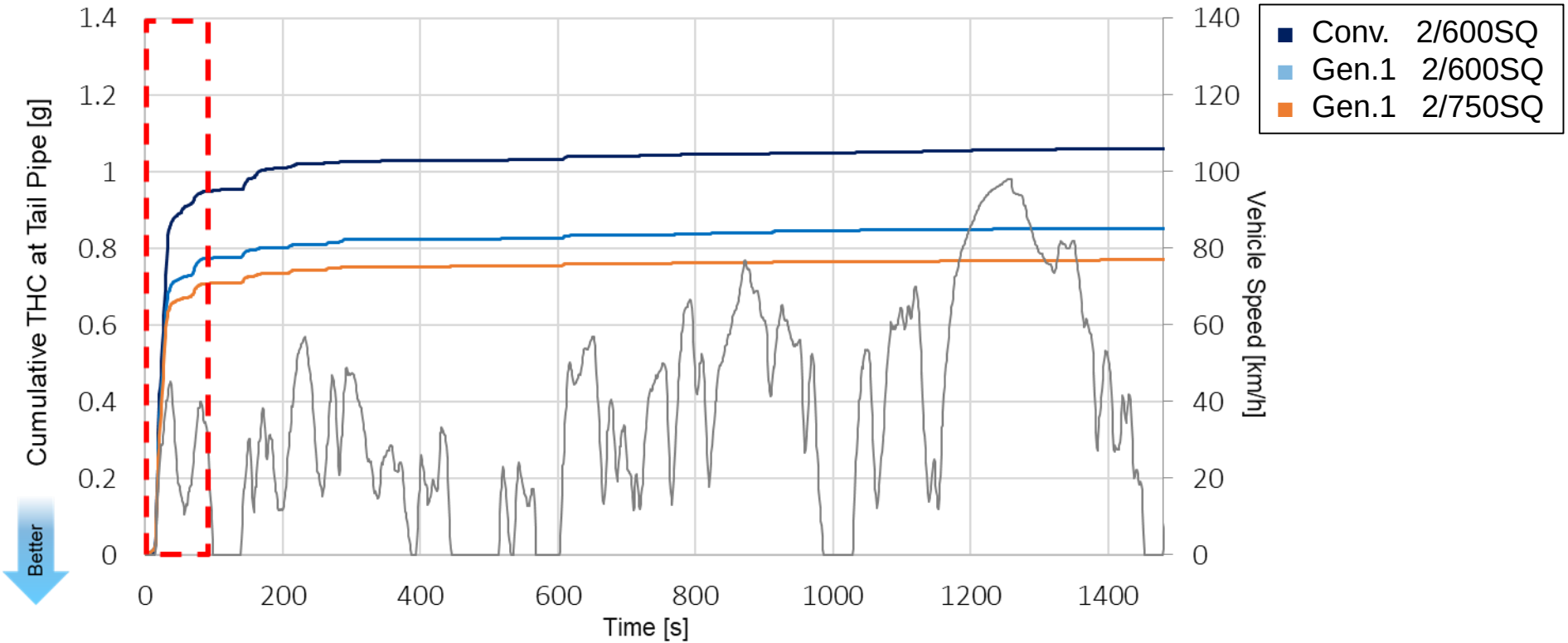




* HP: High Porosity

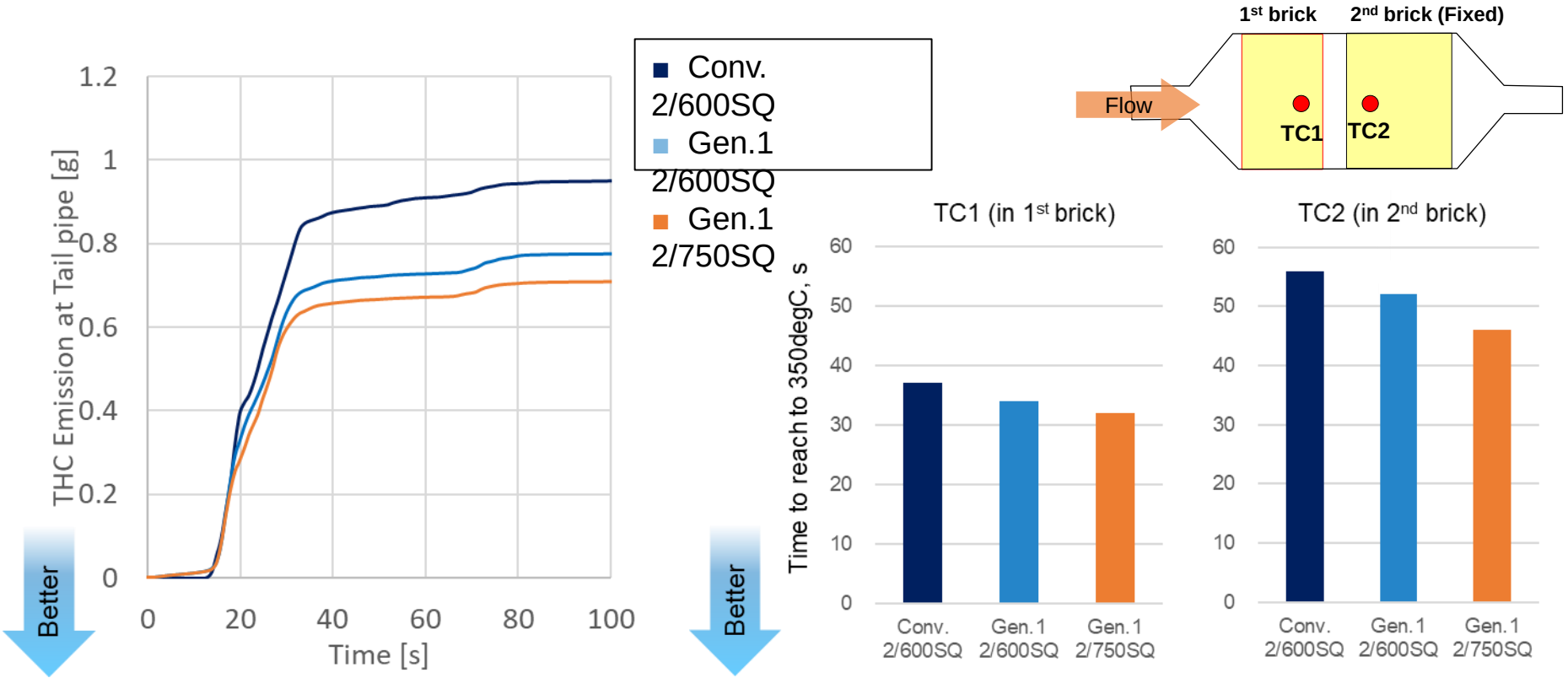
High Porosity & High Cell Density can reduce the THC emission. Same trend were observed in MIDC and WLTP.

Modal Emission THC in WLTP (Up to Phase3)



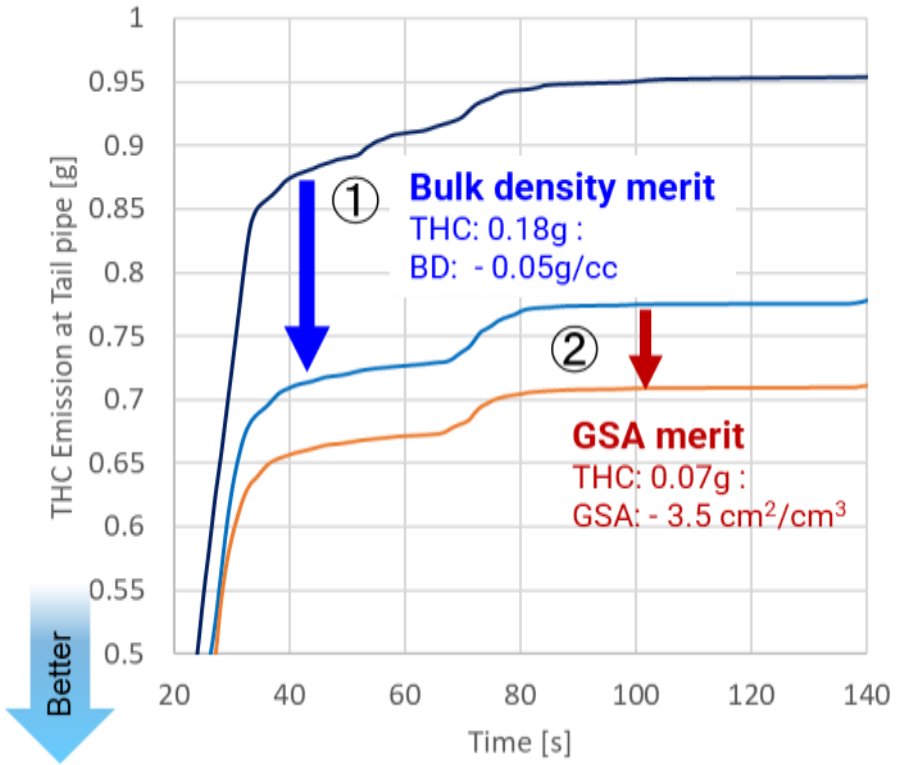
Focused on the first 100 seconds, since most emission in Phase1 is during engine start.

Phase1 modal Emission – Light Off Performance -



Faster light-off is confirmed for high porosity substrates (Gen.1).
The impact of light-off of HP substrate is observed even at the 2nd brick (fixed part).

Phase1 modal Emission – Effect of Bulk Density and GSA -



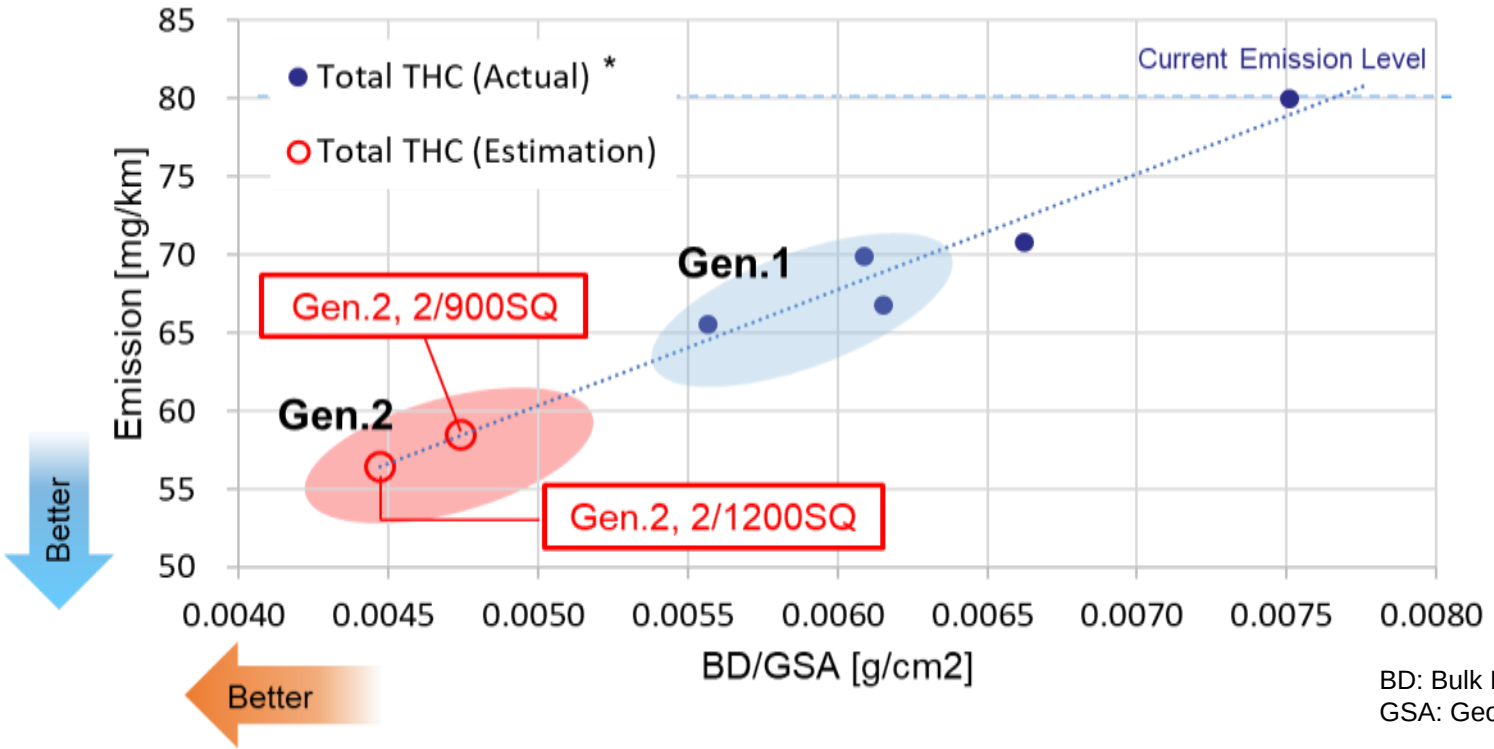
BD: Bulk Density
GSA: Geometrical Surface Area

Material	Cell Structure	BD*	GSA*	BD/GSA
		g/cm³	cm²/cm³	g/cm²
Conv.	2/600 SQ	0.264	35.1	0.0075
Gen.1	2/600 SQ	0.214	35.1	0.0061
Gen.1	2/750 SQ	0.215	38.6	0.0056

In initial phase, improved gaseous emissions conversion is confirmed not only from decreased BD with high porosity but also from increased GSA with high cell density (Gas contacting area).

Estimated THC Total Bag Emission (WLTP up to Phase3)

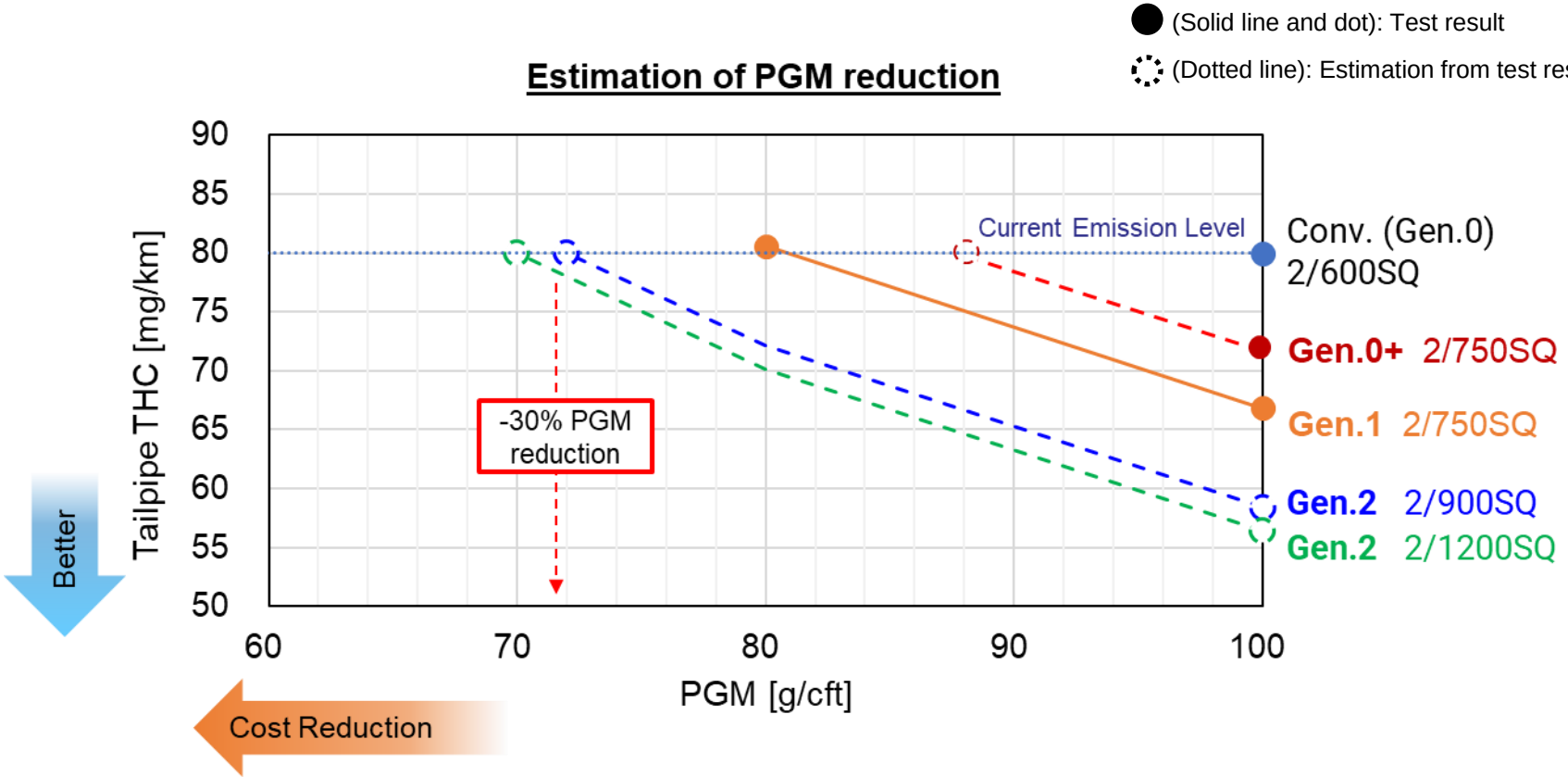
*Average value of three times test



BD: Bulk Density
GSA: Geometrical Surface Area

Gen.2 material with ultra thin wall & higher cell density has the potential for improving the THC Emission due to lower BD/GSA.

Estimation of potential for PGM reduction



Gen.2 material with ultra thin wall & higher cell density has the potential of PGM reduction.

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- When compared with MIDC vs. WLTP, WLTP has higher raw emission than MIDC, however, substrate with High Porosity and High Cell Density showed improvement effect on THC gas emission conversion under both cycles.
- High Porosity substrates shows advantages for initial emission of THC in terms of light-off performance.
- THC emission has high correlation with BD/GSA and lower BD/GSA is expected the reduction of THC emission.
- Lower BD/GSA substrates has potential benefit to alternative fuel vehicle which required more cold start emission.

Future Study

- Evaluation of Gen.2 substrate under WLTP condition in India etc.


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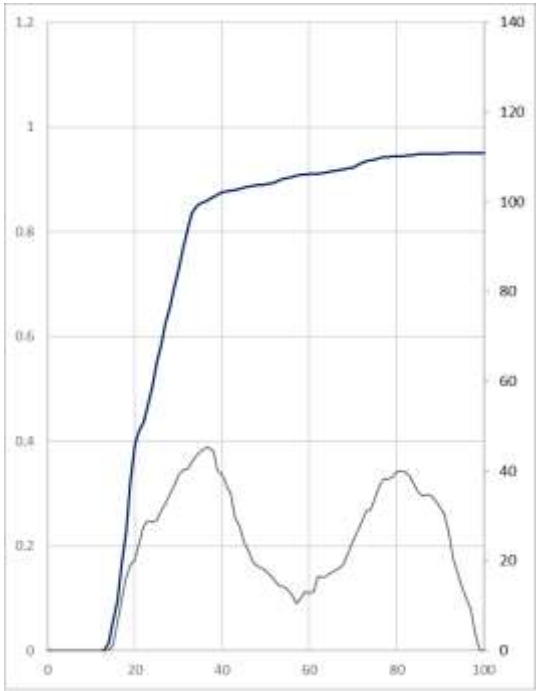
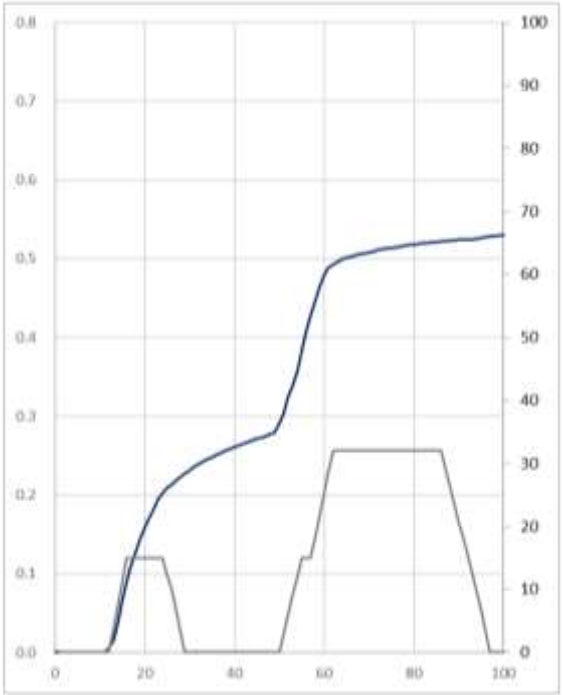
END

Comparison in first 100s for MIDC and WLTC

WLTC



MIDC



In the case of MIDC, there are two accelerations in the first 100 seconds.
For high porosity substrate, the catalytic warm-up is completed before the second acceleration, so that high purification performance were observed.