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Development of a Reduced PGM Catalyst for Meeting MC BS-6 Limits

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2 Wheeler Legislation Overview

Test Type	Parameter	BS IV		BS VI		% Decrease
-	Driving Cycle	WMTC	DF	WMTC	DF	-
Type I	CO (g/km)	1.4	Built within the norms	1.0	1.3	**28.6%**
	HC (g/km)	N/A		0.1	1.3	-
	NOx (g/km)	0.39		0.06	1.3	**84.6%**
	HC + NOx (g/km) NMHC for BS VI	0.79		0.068	1.3	**91.4%**
	PM (g/km)*	N/A		0.0045	1.0	-
Type II	Evaporation Test (g/test)	2	N/A	1.5	N/A	25.00%
Type V	Durability (km)	N/A		20,000 - 35,000		-
On Board Diagnostics (OBD) (g/km)		N/A		CO: 1.9, NMHC: 0.25 NOx: 0.3, PM: 0.05		-

* Applicable to gasoline direct injection (DI) engines only
** OBD Stage II will be implemented in April 2023

HC and NO_x are significant challenges.

Durability requirement is new for BSVI

Catalyst will need monitoring to meet OBD2 requirements in 2023

Catalyst BS6 Technical Challenges for 2 Wheelers

Overview

Operating Conditions

- Lower (<400°C) exhaust temperatures
- Non-stoic AFR events
- Higher space velocities

Engineering

- Packaging restraints
- Coating onto structured substrates

Legislation

- THC/NMHC and NO_x limits most challenging to meet
- New catalyst durability requirement

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Catalyst BS6 Technical Challenges for 2 Wheelers

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- **New catalyst durability requirement**

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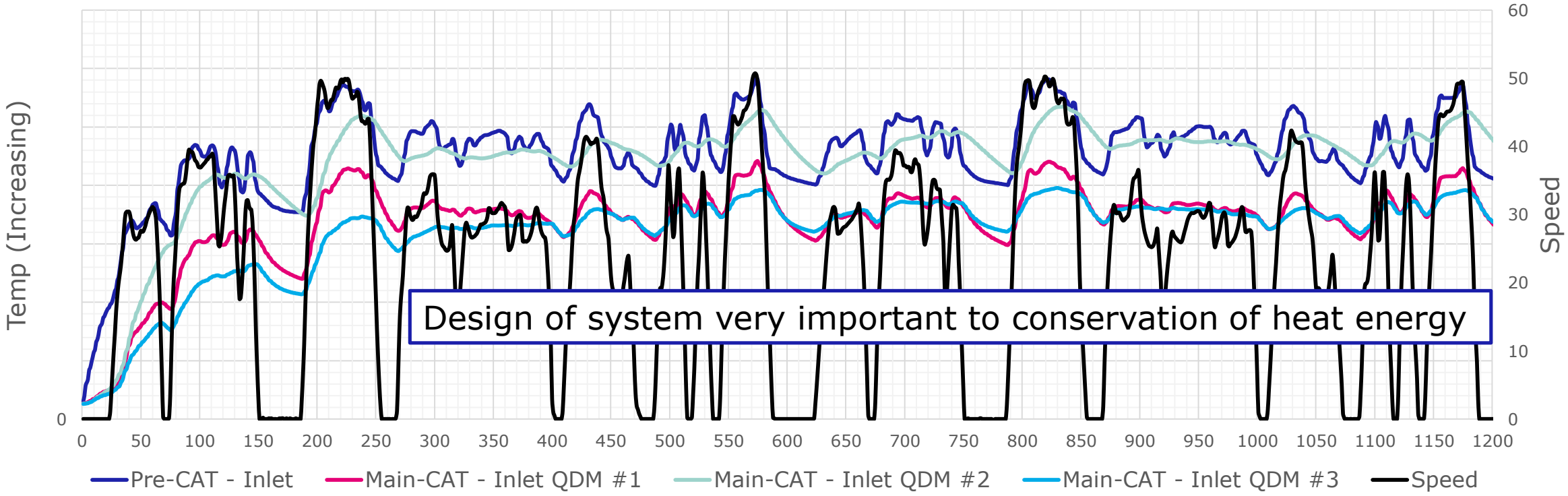
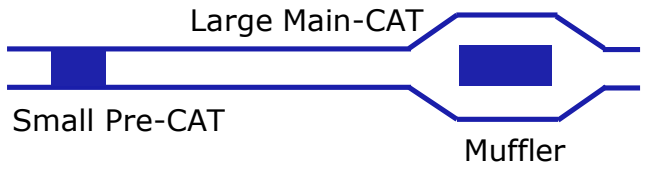
Catalyst BS6 Technical Challenges for 2 Wheelers

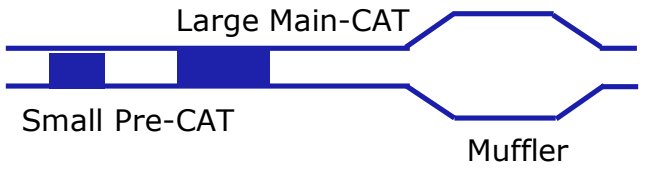
Lower (<400°C) exhaust temperatures

QDM = Quick De-Mountable

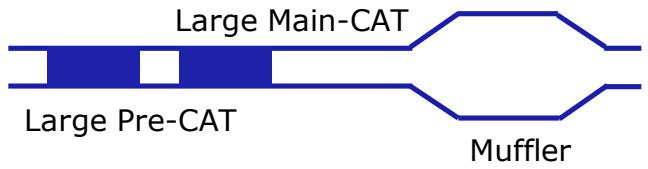




QDM #1



QDM #2



QDM #3

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Catalyst BS6 Technical Challenges for 2 Wheelers

Lower (<400°C) exhaust temperatures

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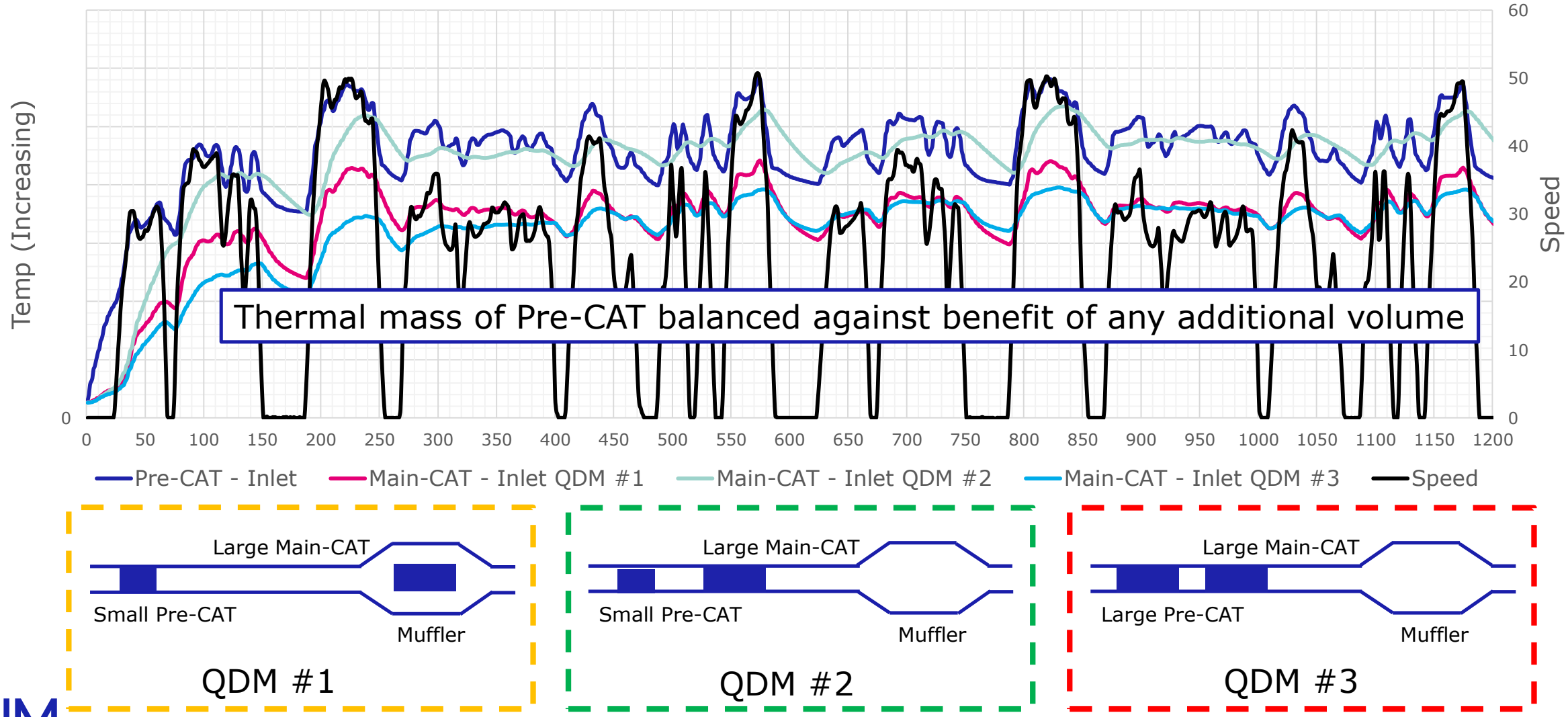
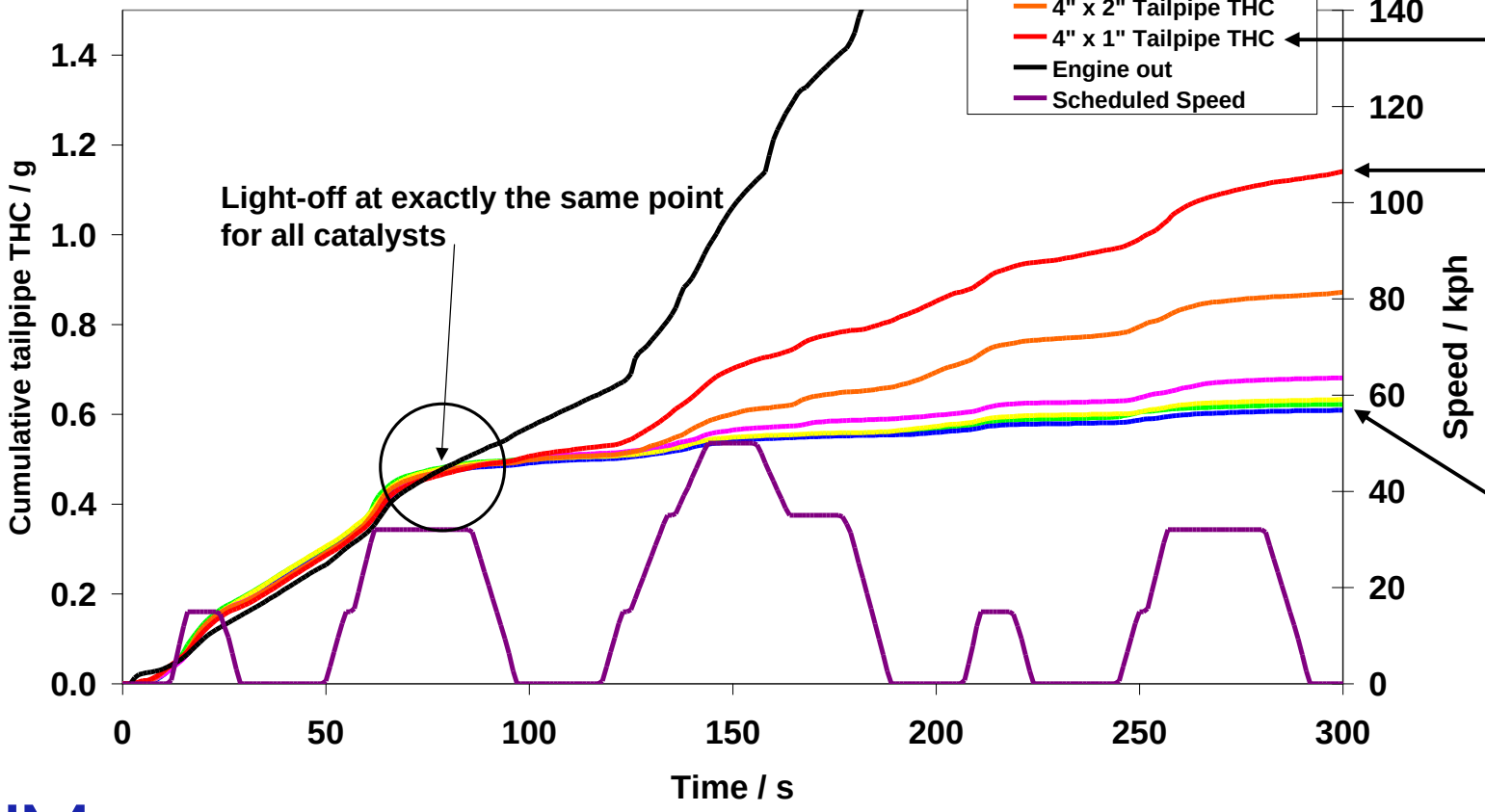


Catalyst BS6 Technical Challenges for 2 Wheelers

Higher space velocities

2 wheelers CATs have higher space velocities due to increased RPM needed for good drivability.



Large Catalyst Volume

Small Catalyst Volume

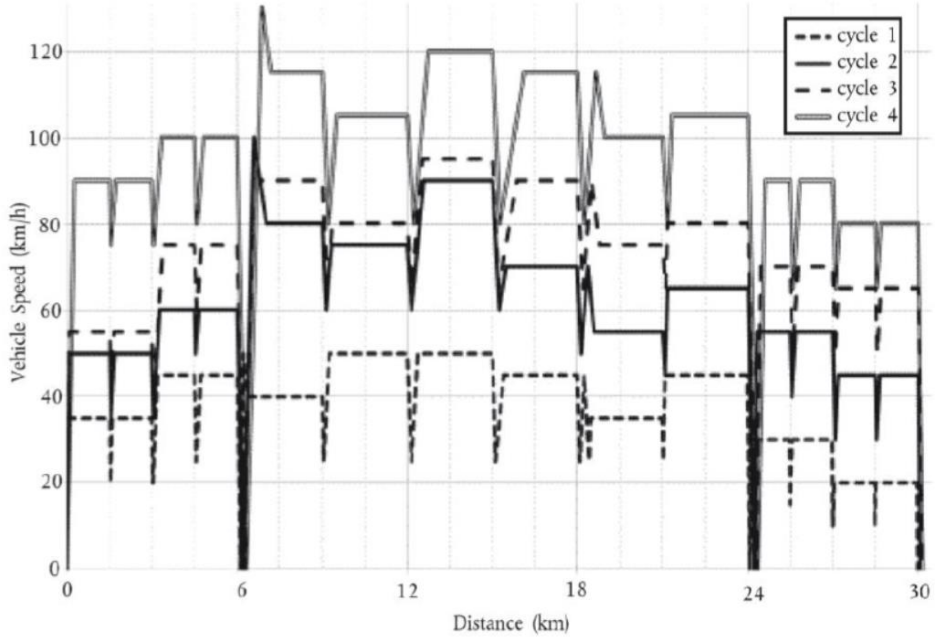
Insufficient volume leads to increased emissions during high speed driving.

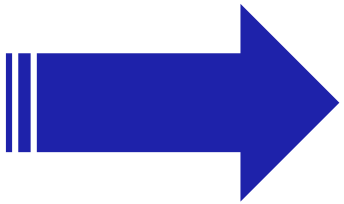
Systems with sufficient volume can control emissions under tough conditions.

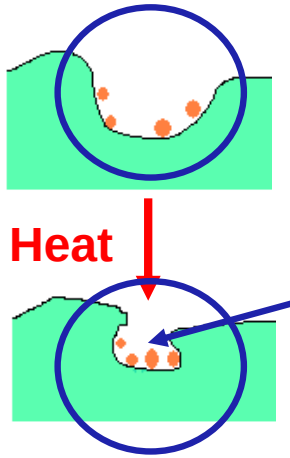
Catalyst BS6 Technical Challenges for 2 Wheelers

New catalyst durability requirement

Graphical overview of the SRC-LeCV







Fresh Washcoat

High surface area / high activity

PGM is difficult to access by exhaust gas

Aged Washcoat

Low surface area / low activity

- Higher temperatures expected for BS6, as catalysts are closer to the engine port.
- Washcoat degradation over 20-35,000km must be studied and design altered accordingly.

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Need for New BS6 Washcoat Technology

Reducing PGM Through Improved Catalyst Performance

- Substrate type, CAT position and engine calibration improvements were made during development; however PGM cost was still prohibitive and needed reducing further.

- New materials were required to have improved activity during cold start and at high speeds.
  - Also had to be resistant to higher temperatures, relative to BS4.

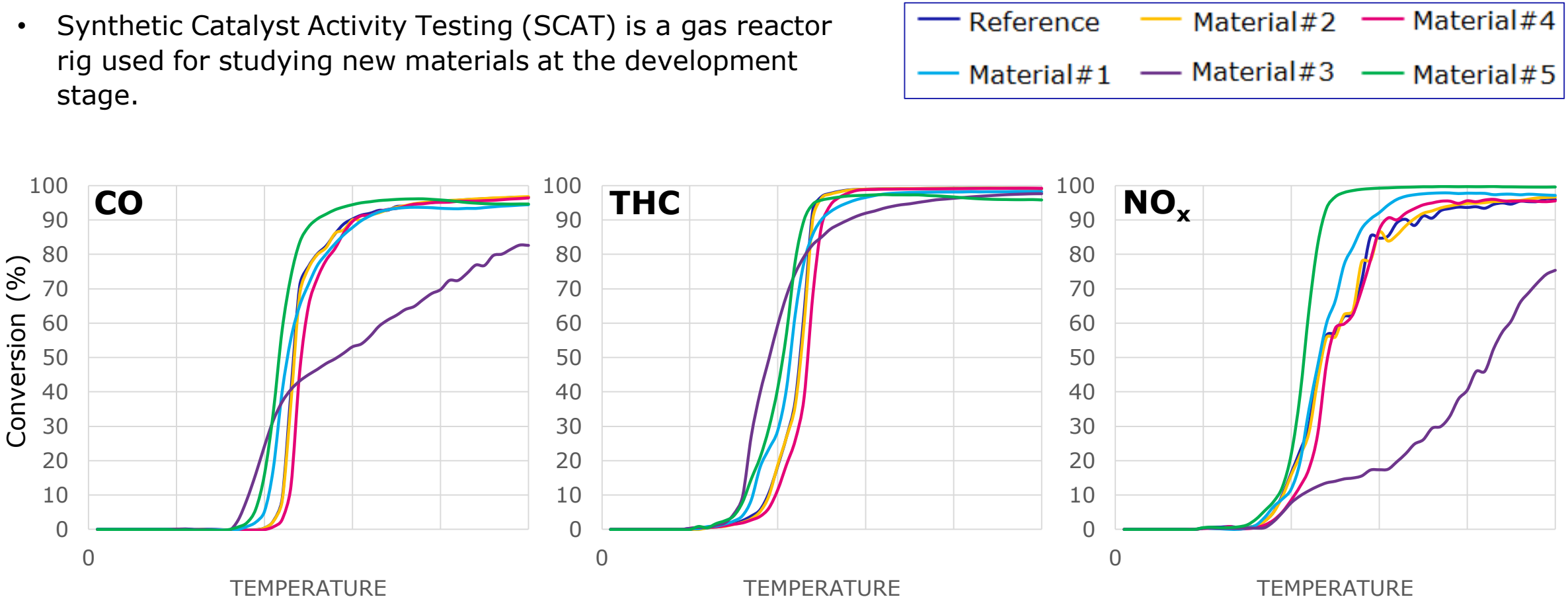
- A class of materials, which aimed to meet all the above requirements, were developed and tested specifically for 2 wheeler customers within the India market.

New BS6 Washcoat Technology Testing for India 2 Wheelers

Initial Screening of New Materials

SCAT Light Off Analysis – Aged to ≈1,000km

- Synthetic Catalyst Activity Testing (SCAT) is a gas reactor rig used for studying new materials at the development stage.



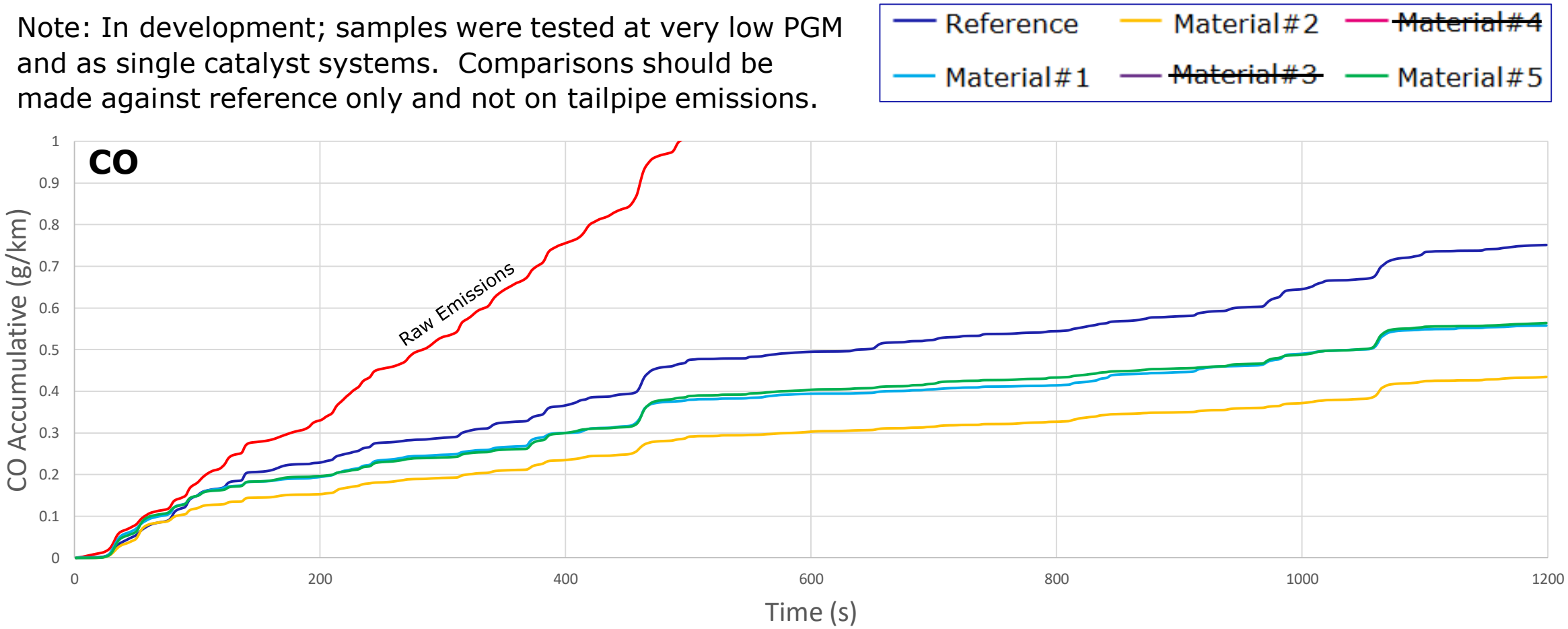
- Materials #1, #2 and #5 demonstrate best light off

New BS6 Washcoat Technology Testing for India 2 Wheelers

On Vehicle Evaluation of New Materials

CVS Testing Analysis – Aged to ≈1,000km

- Note: In development; samples were tested at very low PGM and as single catalyst systems. Comparisons should be made against reference only and not on tailpipe emissions.



- Material#2 shows both light off and hot conversion improvements

New BS6 Washcoat Technology Testing for India 2 Wheelers

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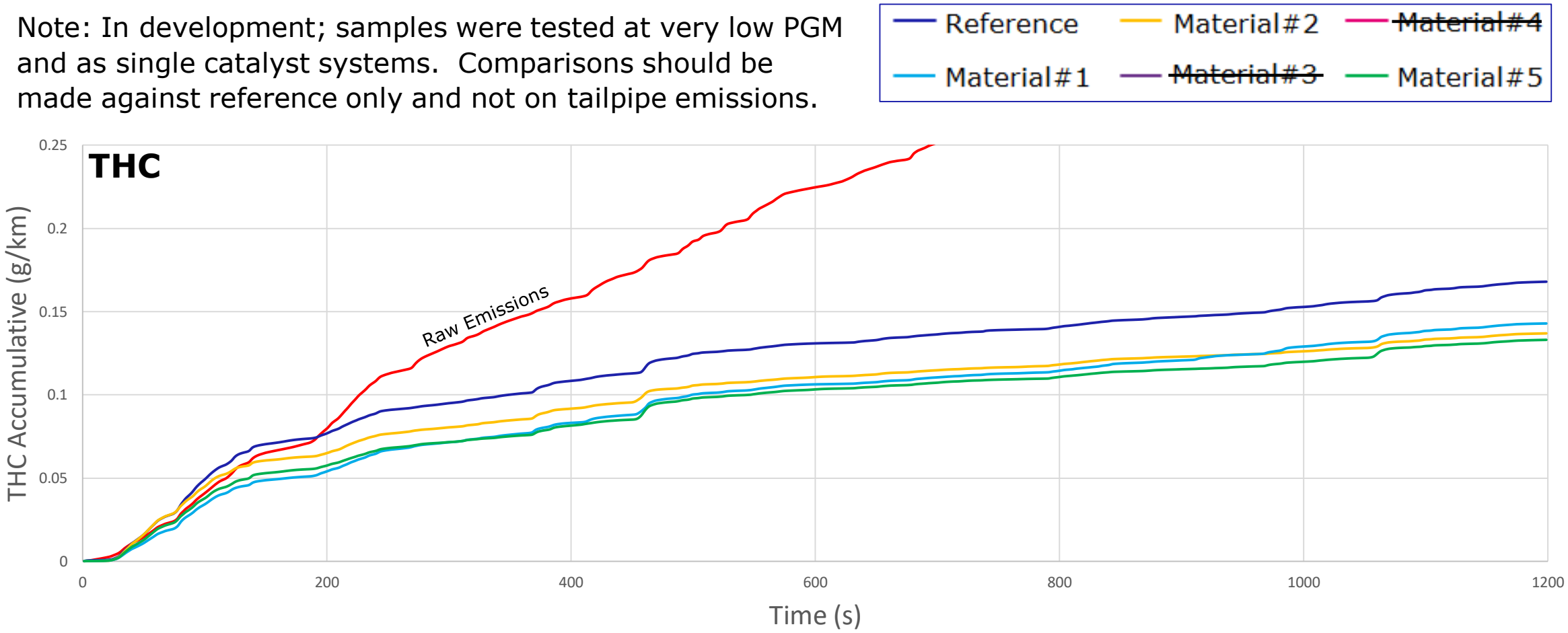

- Early light off improvement shown for THC

New BS6 Washcoat Technology Testing for India 2 Wheelers

On Vehicle Evaluation of New Materials

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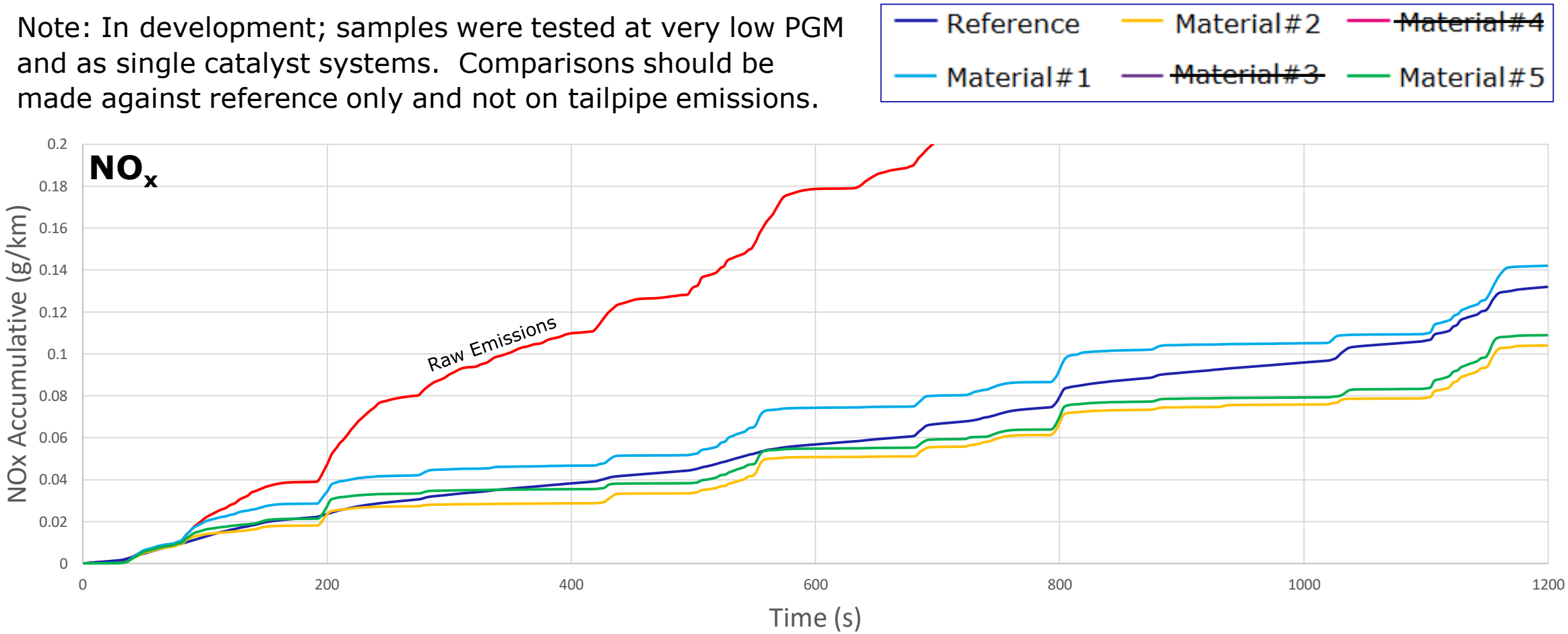
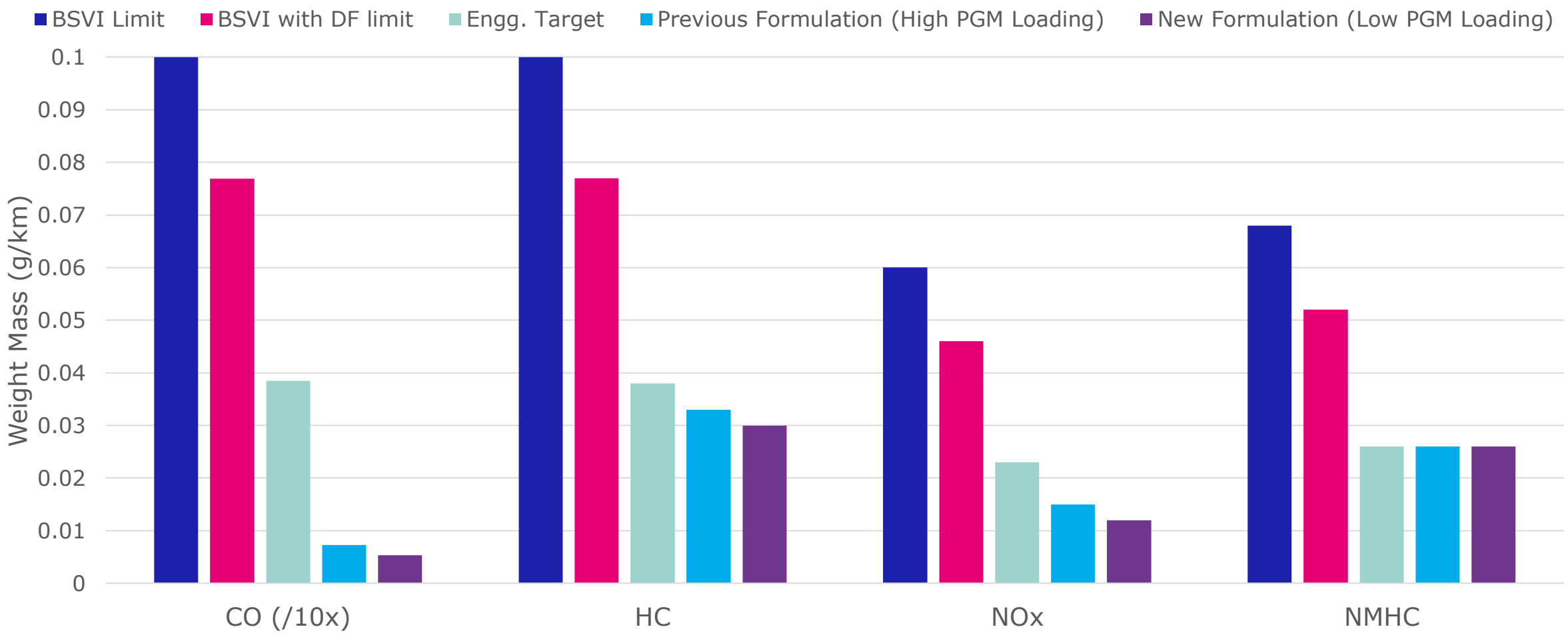


- Material #2 and #5 show improvement for NO_x light off and hot conversion

New BS6 Washcoat Technology Testing for India 2 Wheelers

Benchmark Results Against Previous Technology Formulation

CVS Testing Analysis – De-greened – 50:50 Weighting



Conclusions

- New formulations have improved low temperature activity, high speed conversion after 1,000km.
  - A comprehensive mileage accumulation study is currently in progress at JM.

- When supplied to OEMs for testing; new formulations able to meet customer engg. targets after on-vehicle mileage ageing.

- PGM reduction achieved was **40-50% across both Pre and Main-CATs**, when benchmarked against previous best class of materials able to meet BS6 emission limits.

- New products now fully scaled up and in mass production ready for BS6 launch.

- Further development is in progress to deliver next level of PGM reductions.

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JM Capabilities

- JM offers comprehensive 2 wheeler catalyst development support;
- Product Development - aims to deliver PGM saving technology via improved emission control.
- Application Engineering - for substrate evaluation, system design proposals, data analysis, prototype sampling requests, technical advice, PGM optimisation and after-market support.
- Testing for concept evaluation, durability and customer requests.
- Samples can be provided to fit any vehicle and at any PGM loading for OEM evaluation.


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