

Gasoline Cost Reduction Technologies for China


AVECC Conference 2004
China World Hotel
Beijing

Dr Neil Collins

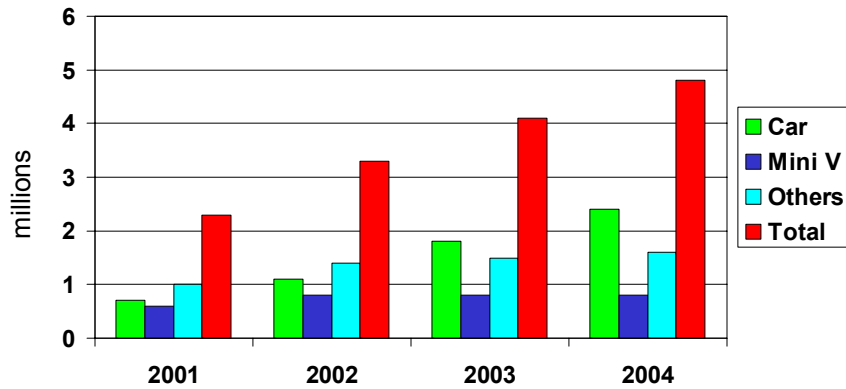
ENVIRONMENTAL CATALYSTS AND TECHNOLOGIES



Presentation Outline

- Chinese Market Analysis
 - Vehicle Production
 - Emissions legislation
 - Catalyst Requirements for Future legislation
 - Development of Advanced Three-way Catalyst Technology for Future legislation
 - Activity Testing
 - Thermal Durability Demonstration
 - Low PGM content Catalysts
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Chinese Vehicle Market (production)



Total Vehicle Emissions

Number of vehicles \times Vehicle km travelled \times Tailpipe emissions per vehicle (grams/km)

Legislation

Gasoline Passenger Car

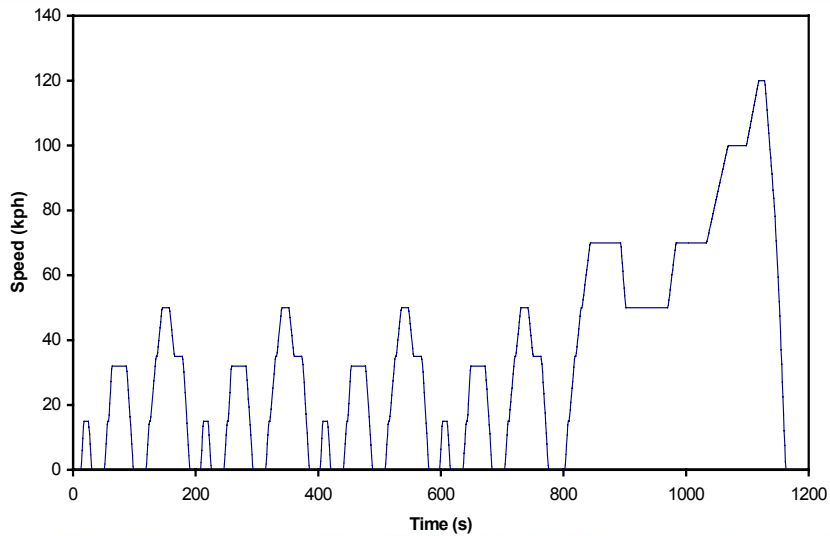
- Nationwide passenger cars require Euro I
- Nationwide passenger cars require Euro II from July 2004
- Tax incentive for Euro III will be implemented from July 2004
- Nationwide Euro III and Euro IV implementation in discussion, possible dates are 2008 and 2013 respectively



European Legislation



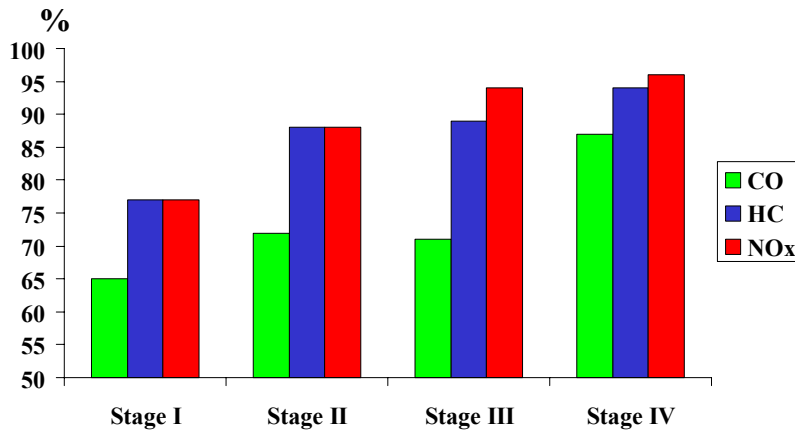
European Test Protocol: ECE/EUDC, MVEG-B



European Gasoline Legislation

Stage (year)	HC g/km	CO g/km	NOx g/km	HC+NOx g/km	Durability /k km
I (1993)		2.72		0.97	80
II (1996)		2.2		0.5	80
III (2000)	0.2	2.3	0.15		80
IV (2005)	0.1	1.0	0.08		100

Typical Percentage Reduction in Emissions Required To Meet European Legislation



Consequences of Tighter Legislation

Catalyst Development

Consequences of Tighter Legislation

- Higher conversions needed to meet legislation.
 - More active catalyst required
- Catalyst moved closer to the engine to start working more quickly. Catalyst sees higher temperatures.
 - Catalyst must be more thermally durable
- Catalyst must last longer.
 - Catalyst needs to be more resistant to poisons and thermal degradation
- Overall catalyst cost needs to be controlled.
 - Design catalysts that work at low PGM loadings

Targets for Catalyst Development: Stage III and IV Legislation

- Improved performance without increasing, and preferably decreasing, PGM content.
 - Enhanced activity
 - High temperature durability: $>1000^{\circ}\text{C}$
 - Close-coupled system
 - Real-world fuel economy
 - Platinum- and Palladium-based catalyst systems
 - PGM price fluctuations
 - Low PGM content

Catalyst Design

From the analysis using XRD, SEM, TPR and SCAT, of aged TWCs it was possible to identify three key design targets:

1. Improved thermal stability of non-OSC support material.
2. Optimised targeting of promoters of PGM.
3. Improved oxygen storage kinetics after high temperature ageing.

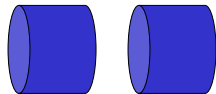


- 1) Improved support materials
- 2) Improved preparative methodologies



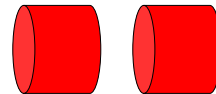
Catalyst Systems

Pd/Rh



Advanced vs. Current
35 g/ft³ (0:6:1)

Pt/Rh

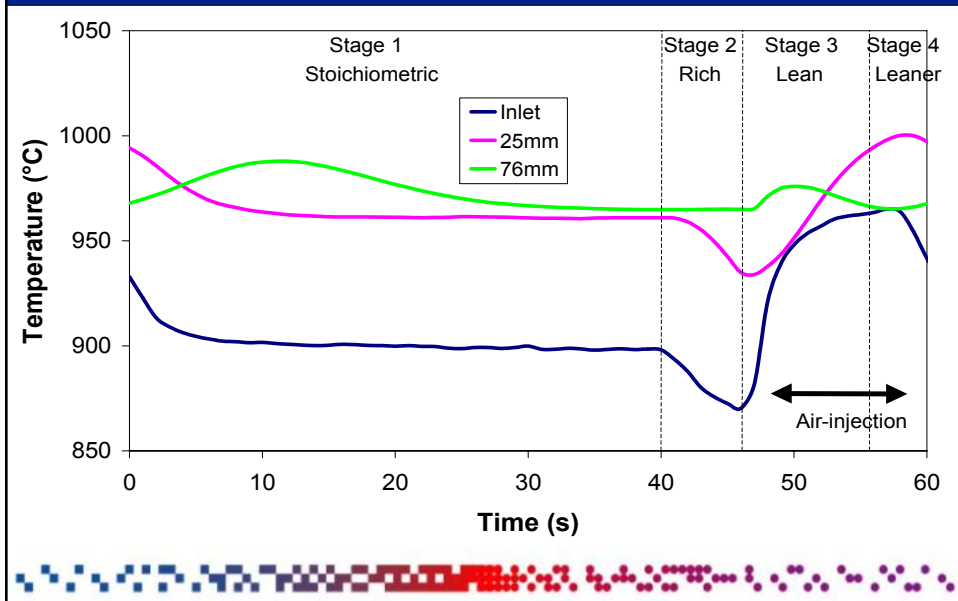


Advanced vs. Current
35 g/ft³ (6:0:1)

118 x 127 mm, 400/6 ceramic substrate
Total System Volume = 1.4 litre

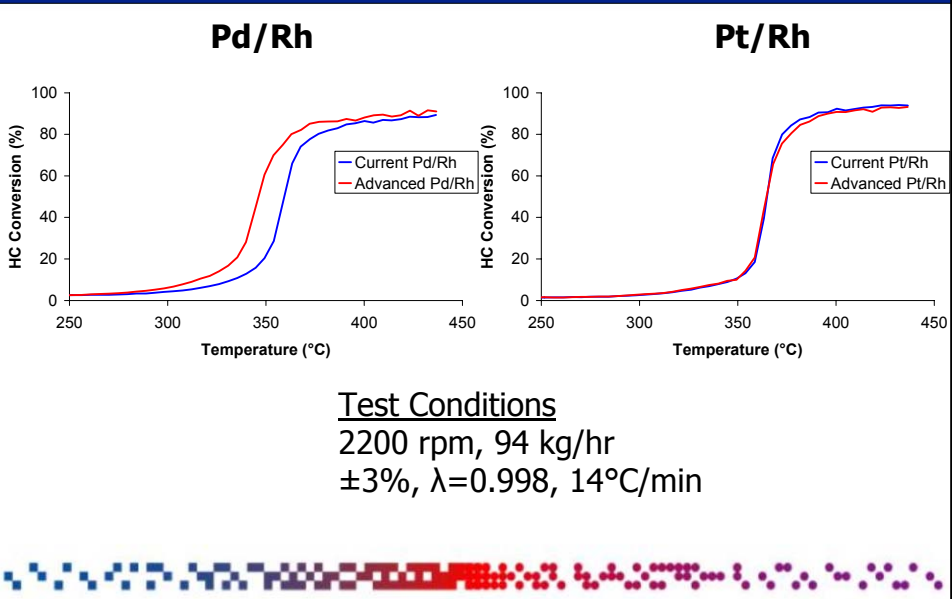


Ageing Cycle: Four lambda stages

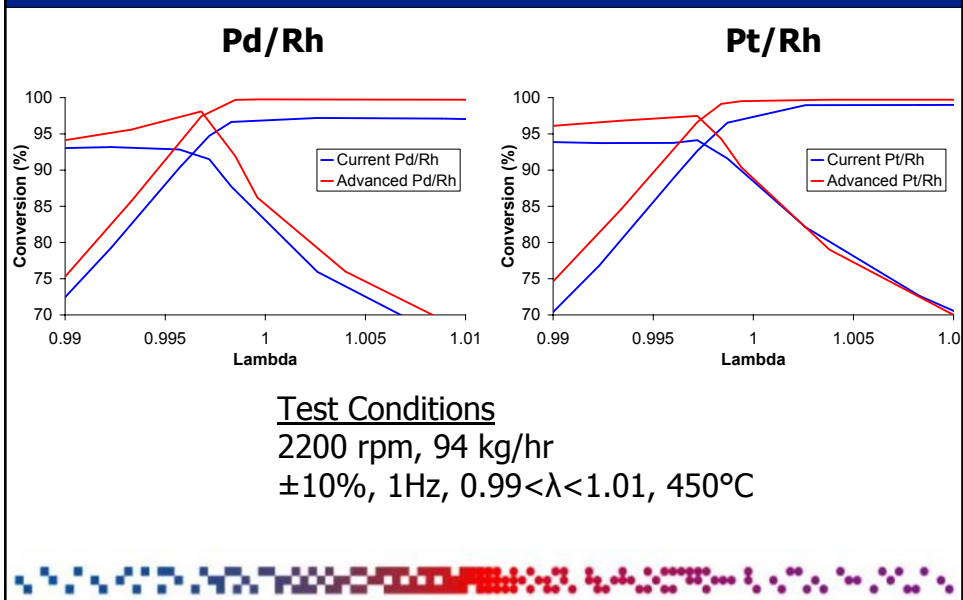


Testing of Advanced Formulations

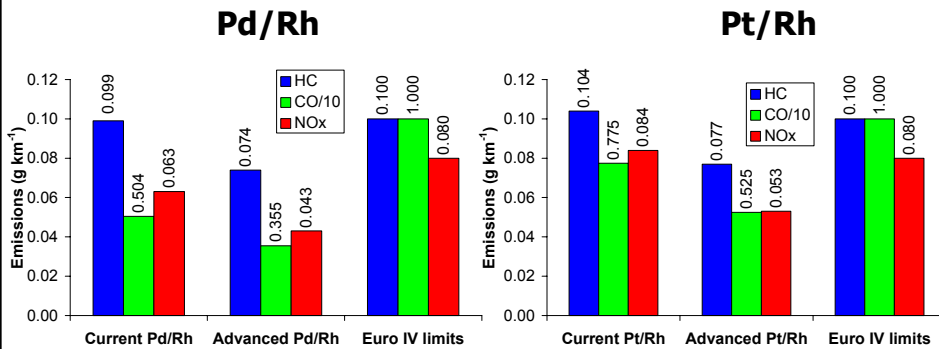
Engine Evaluation: Light-off test



Engine Evaluation: Lambda Scans



Vehicle Results



Test Conditions

1.25 l vehicle, European Stage II certified
European Stage III drive cycle

Conclusions

- By analysing the deactivation modes of current three-way catalysts, improved formulations have been designed.
- Testing of these advanced formulations after static dynamometer ageing at 1000°C have shown improvements in legislative emissions performance.

High Temperature Transient Ageing



High Temperature Transient Ageing

- To assess the on-road thermal durability of Advanced Pt/Rh and Pd/Rh a proprietary transient ageing cycle that represents real-world driving conditions was used.
- This ageing evaluated their capability to meet European Stage IV limits after ageing with maximum temperatures of 960 (standard), 1010 and 1050°C.



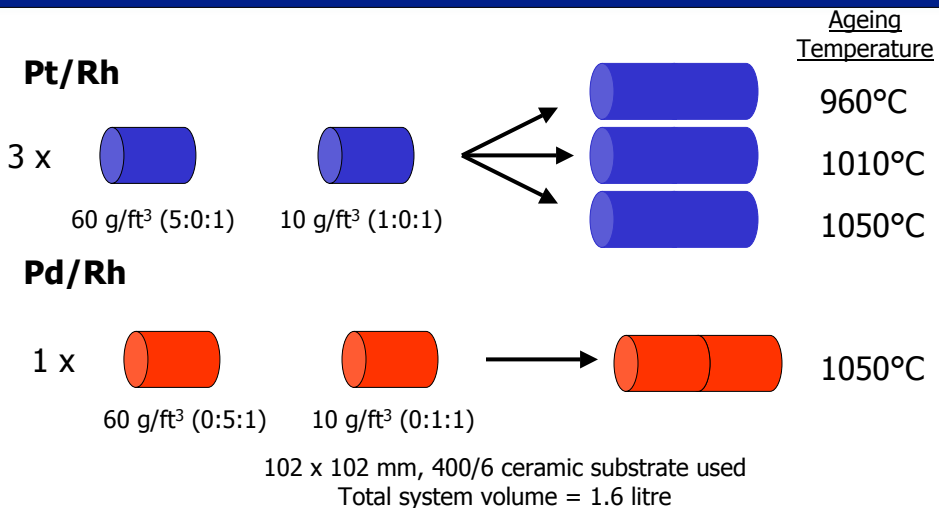
Ageing and Testing

- **Catalyst Ageing:**
 - Dynamic dynamometer using 1.6 litre engine
 - Proprietary high speed transient ageing cycle consisting of:
 - Wide-open throttle accelerations
 - Decelerations with fuel-cut
 - Maximum speed steady-state portions (960, 1010 or 1050°C)
 - Cycle just over one hour repeated for up to 120 cycles
 - Stage IV durability ca. 90 cycles

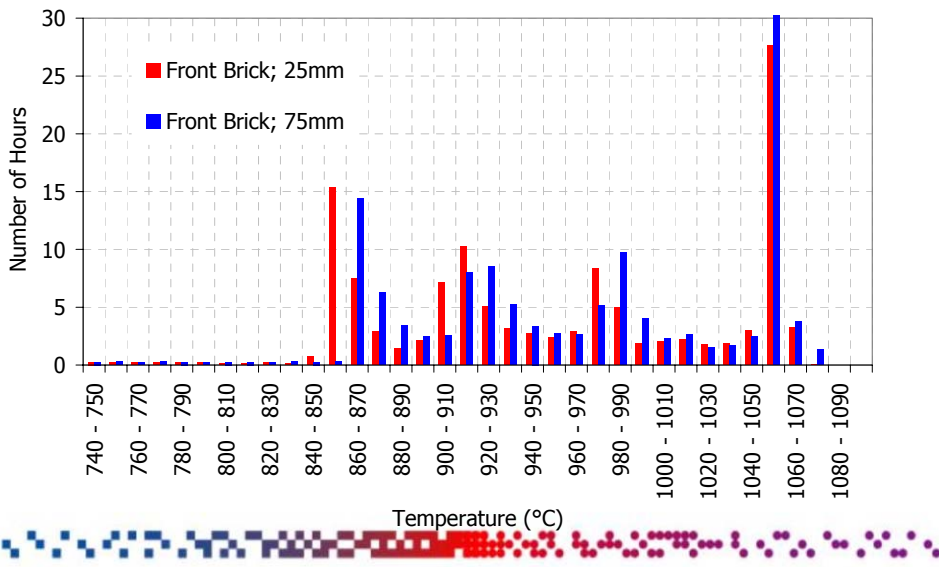
- **Catalyst evaluations every 30 cycles:**
 - Separate 1.6 litre engine with Stage IV calibration
 - ECE Stage III drive cycles



Advanced Catalyst Systems

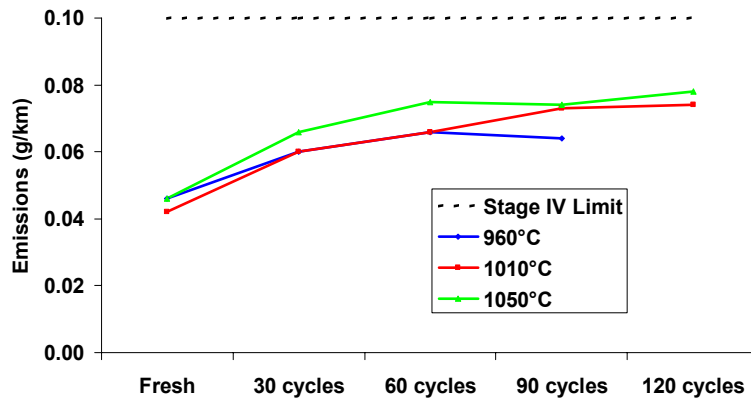


Ageing Cycle - 1050°C

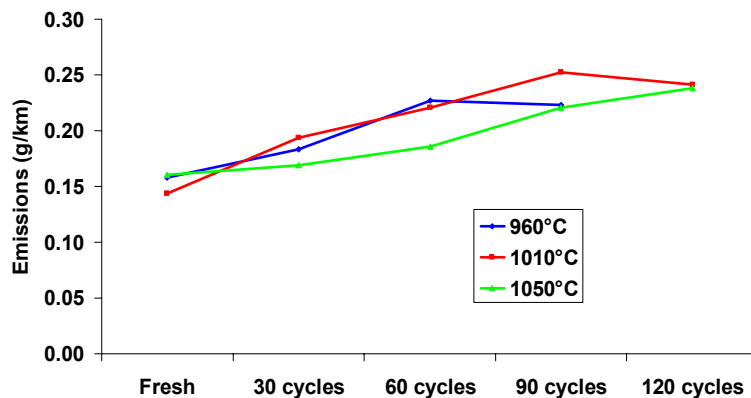


**Emissions testing on
European Drive Cycle**

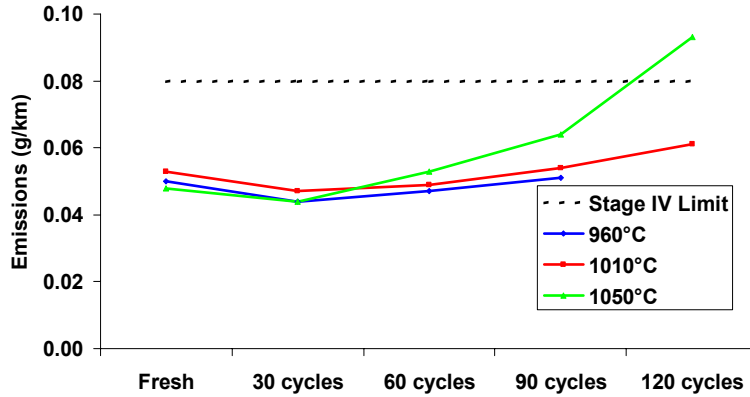
Emission Results for Advanced Pt/Rh Catalysts: HC



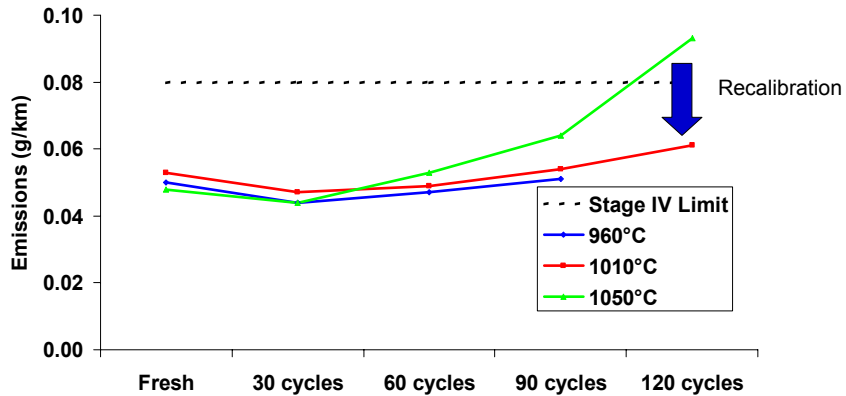
Emission Results for Advanced Pt/Rh Catalysts: CO



Emission Results for Advanced Pt/Rh Catalysts: NOx



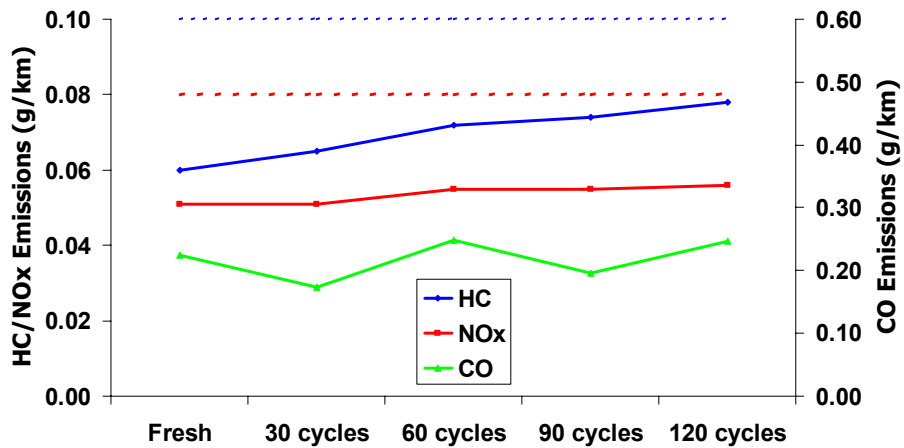
Emission Results for Advanced Pt/Rh Catalysts: NOx



Advanced Pd/Rh Catalysts

1050°C ageing

Emission Results for Advanced Palladium/Rhodium Catalyst: 1050°C Ageing



Conclusions

- The new Advanced Pt/Rh and Pd/Rh catalyst Technology is capable of meeting Stage IV emissions limits at low PGM loadings after transient ageing in excessive of 1050°C.
- This technology offers the opportunity to specify higher catalyst temperature limits using these coatings
 - Better Real-world fuel-economy



Low Loaded Case Studies

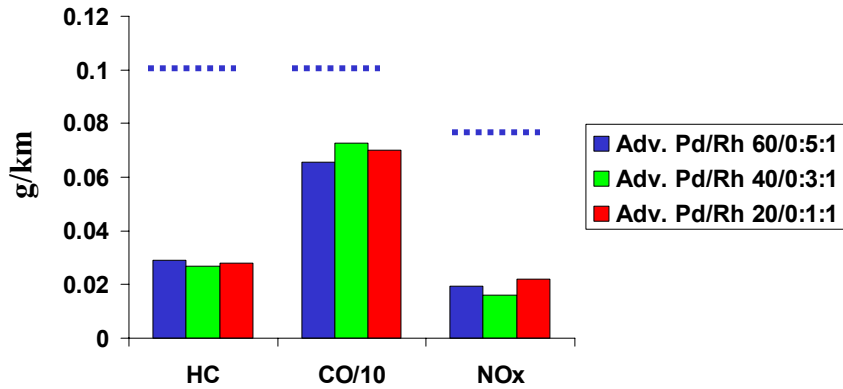


Low PGM Loadings: Case Study 1

1.8 litre vehicle. Aged 40 hours 1050°C bed temperature

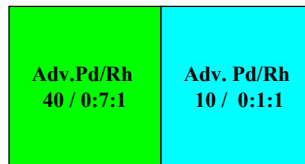
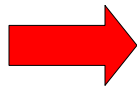
Catalyst: 1.68 litres, 600/4

..... Stage IV limit



Low PGM Loadings: Case Study 2

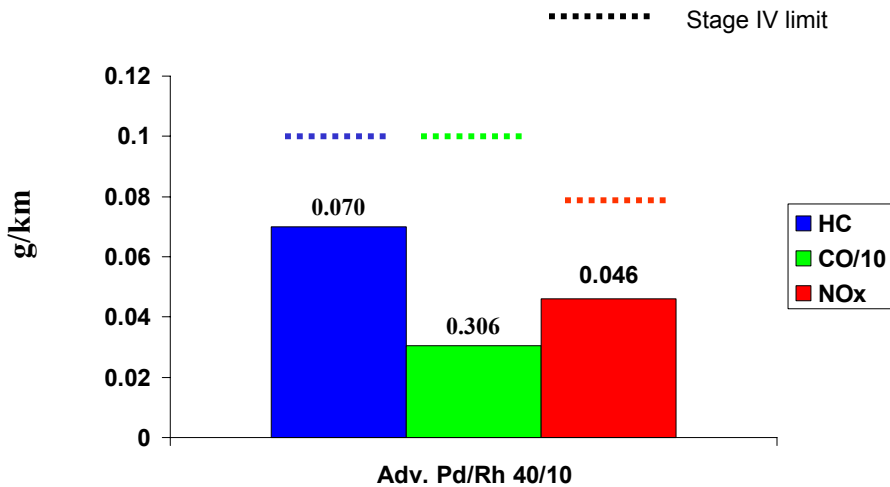
1.6 litre vehicle, 50 hours ageing, 1050°C bed temperature.



2 x 0.83 litres, 400/6

Low PGM Loadings: Case Study 2

1.6 litre vehicle, 50 hours ageing, 1050°C bed temperature.



Summary

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