CIMAC – June 10, 2004

Regeneration of Palladium Based Catalyst for Methane Abatement

Thierry Leprince

DCL International Inc.

Contents

- **Introduction**
- Deactivation mechanisms
- Regeneration strategies
- Conclusion

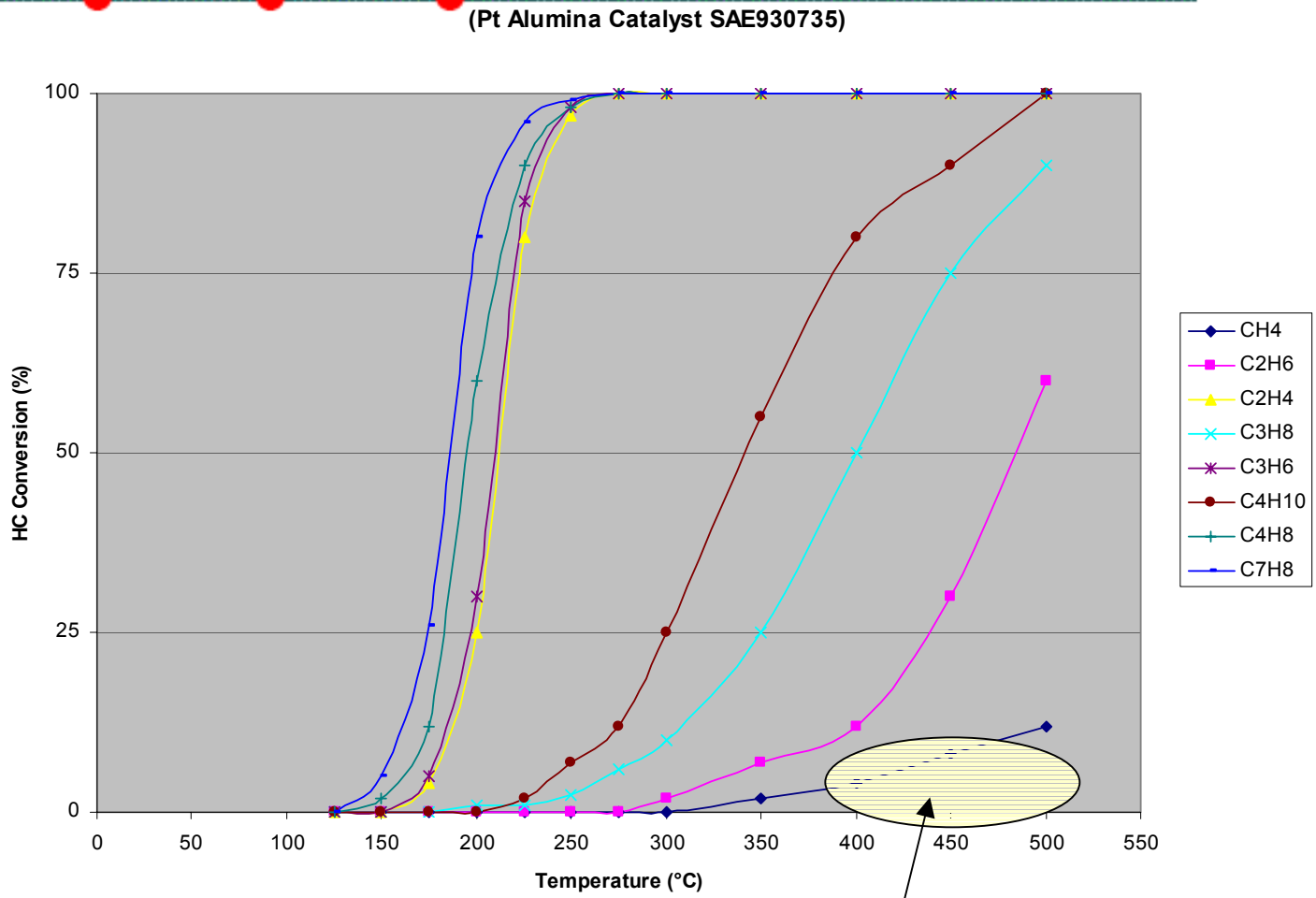
DCL International Inc.

Introduction

- Methane is a green house gas [1 t_{CH4} ~ 20 t_{CO2}]
- A 4 MW lean burn engine emits up to 300 tonnes of methane per year, or 6000 tonnes of CO2
- If we were able to oxidize this methane with a catalyst, we could generate a € 30,000 credit
- Furthermore, in case of co-generation application, heat resulting for methane slip oxidation will be recovered in the exhaust, thus improving overall system efficiency
- Problem: methane is most stable hydrocarbon, therefore most difficult to oxidize with a catalyst
- How can we get 90% CH4 conversion?

DCL International Inc.

CH4 Oxidation with Platinum catalyst



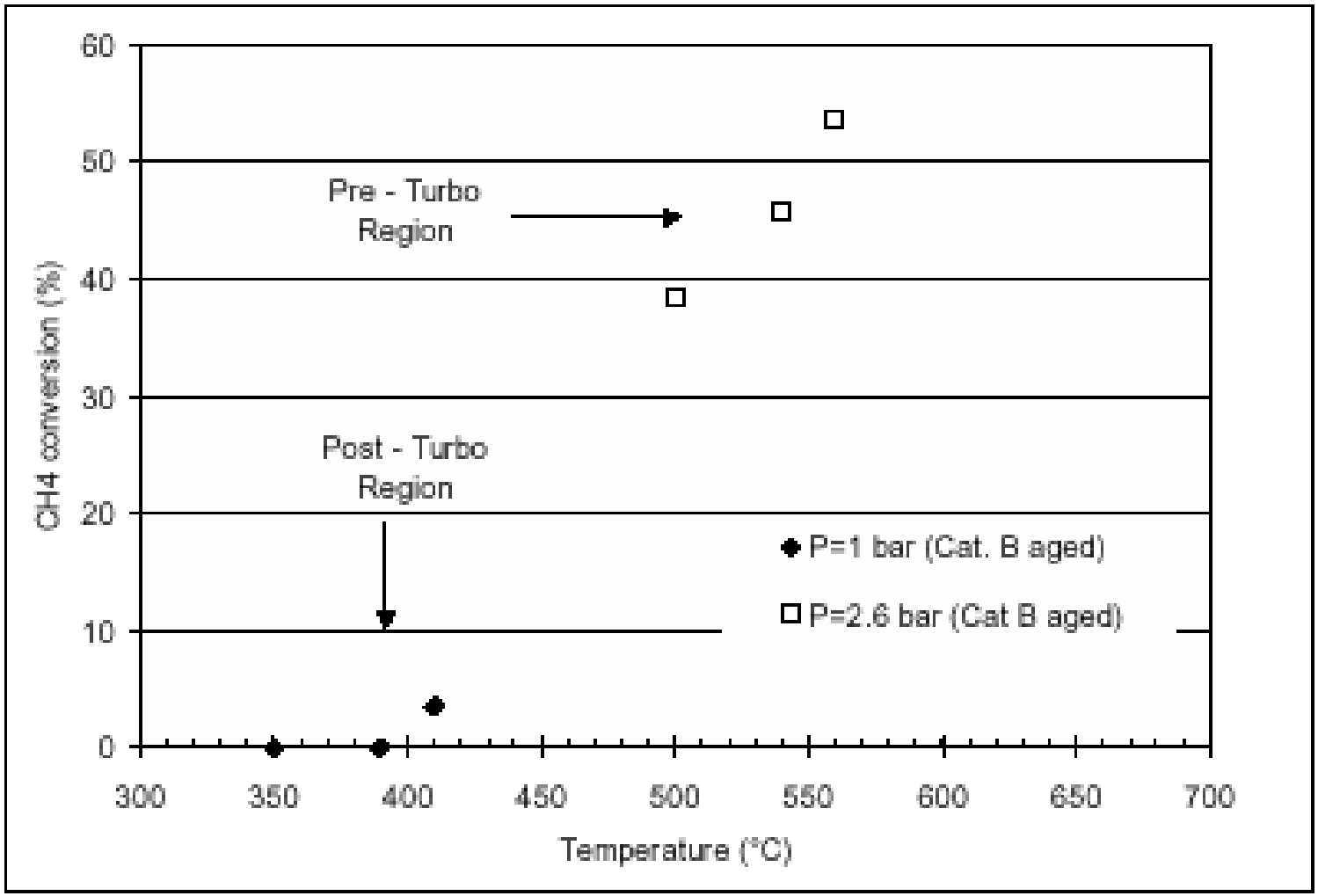
Operating window yields to little conversion

Need to install catalyst upstream of turbo

Need to use another type of catalyst

DCL International Inc.

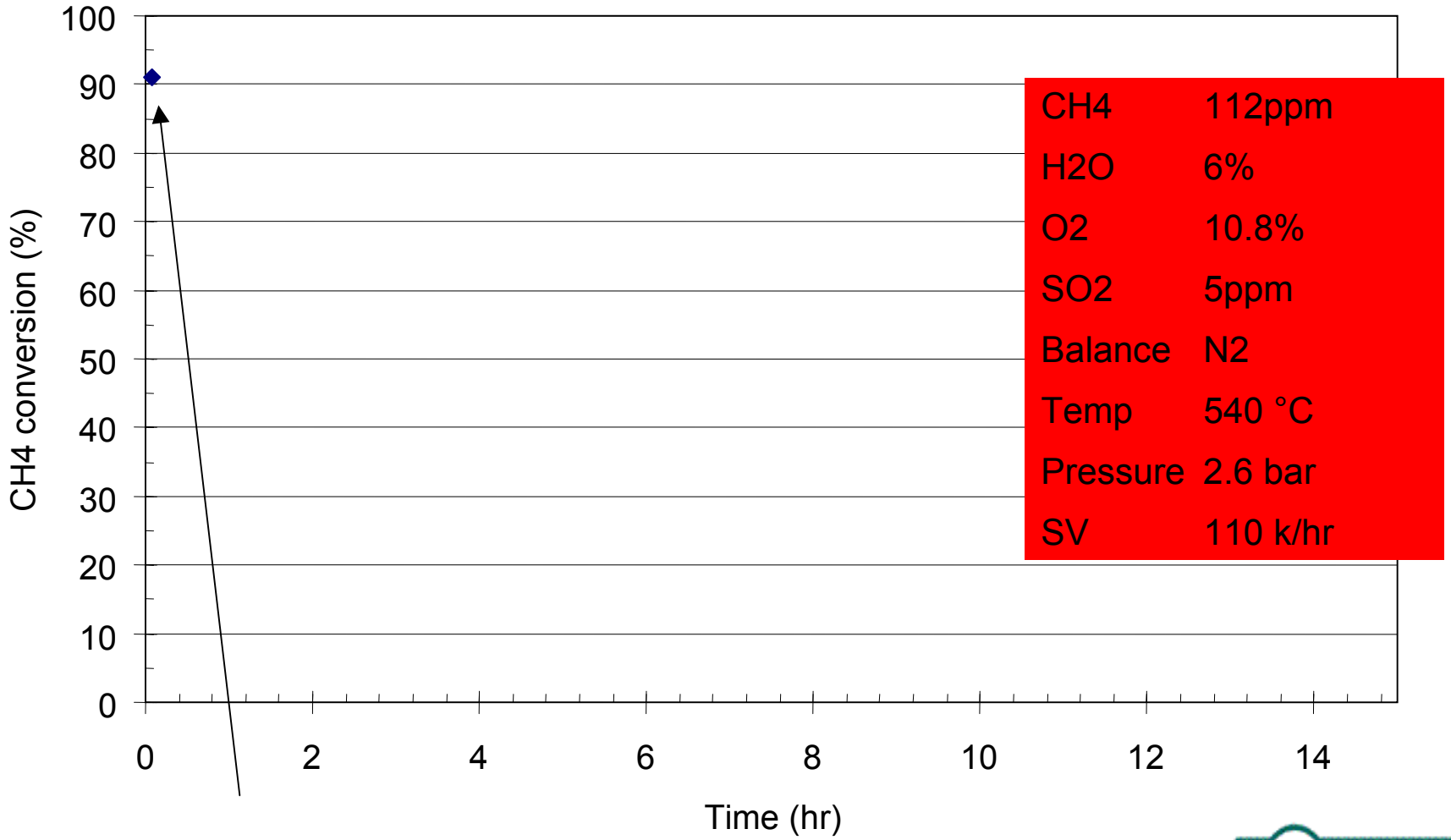
Pre-turbo catalyst



Higher conversions will require a different catalyst

DCL International Inc.

CH4 conversion and Pd catalyst



Pd catalyst can provide fairly high conversions of CH4

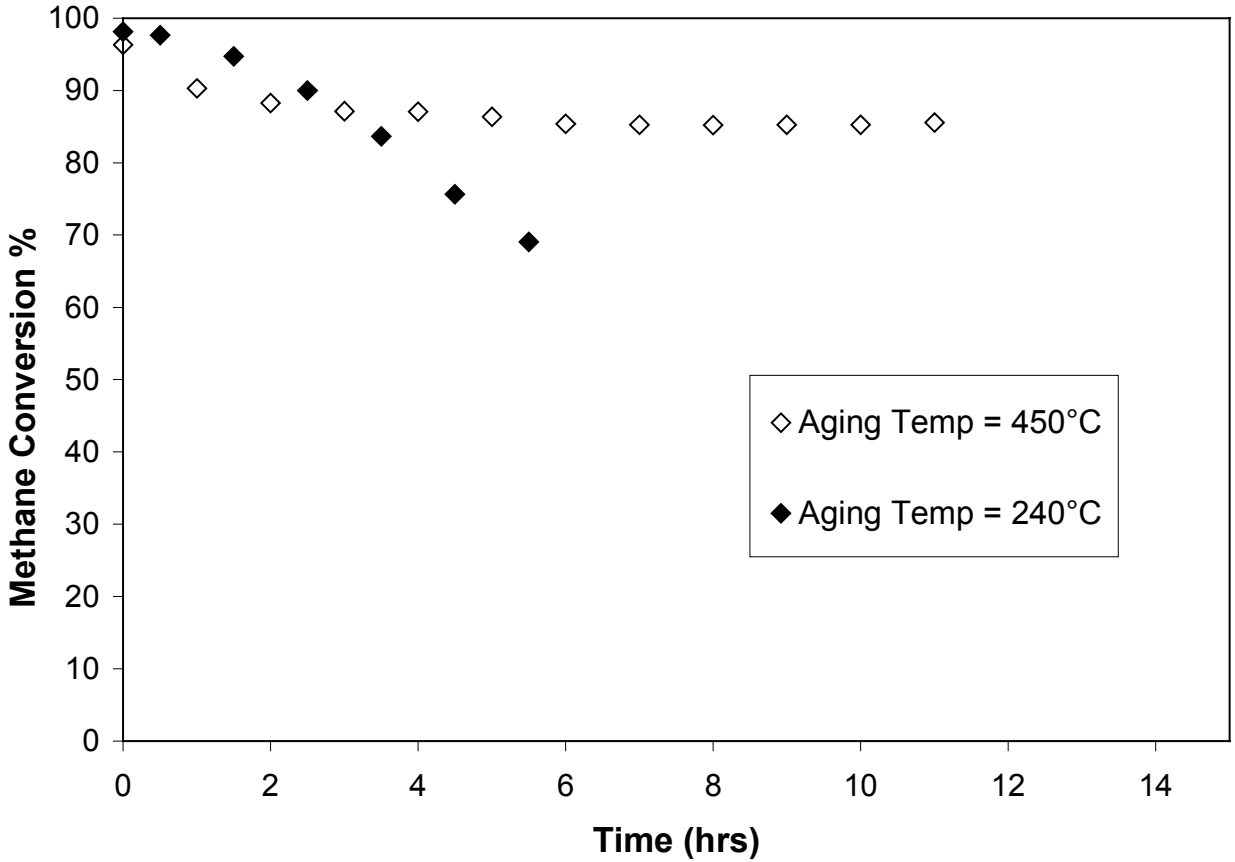
DCL International Inc.

Contents

- Introduction
- **Deactivation mechanisms**
- Regeneration strategies
- Conclusion

DCL International Inc.

Deactivation with time



Aging with 5 ppm SO2

DCL International Inc.

Role of sulfur in catalyst deactivation

- SO_2 adsorbs strongly on Pd
- The resulting PdO-SO_3 sites possess low activity for HC oxidation

- Methane is the most sensitive to SO2 poisoning

DCL International Inc.

What do we do next?

- Pd based catalyst is an interesting alternative but has serious durability issues

- Need to frequently replace catalyst
- Need to regenerate catalyst on a regular basis
  - Similar strategies have been developed for NOx storage catalysts in GDI engines
  - Use of Diesel NOx storage catalysts also require periodic catalyst regeneration
  - Will need system approach between engine OEM and catalyst supplier

- Can we actually regenerate methane catalyst?

DCL International Inc.

Contents

- Introduction
- Deactivation mechanisms
- **Regeneration strategies**
- Conclusion

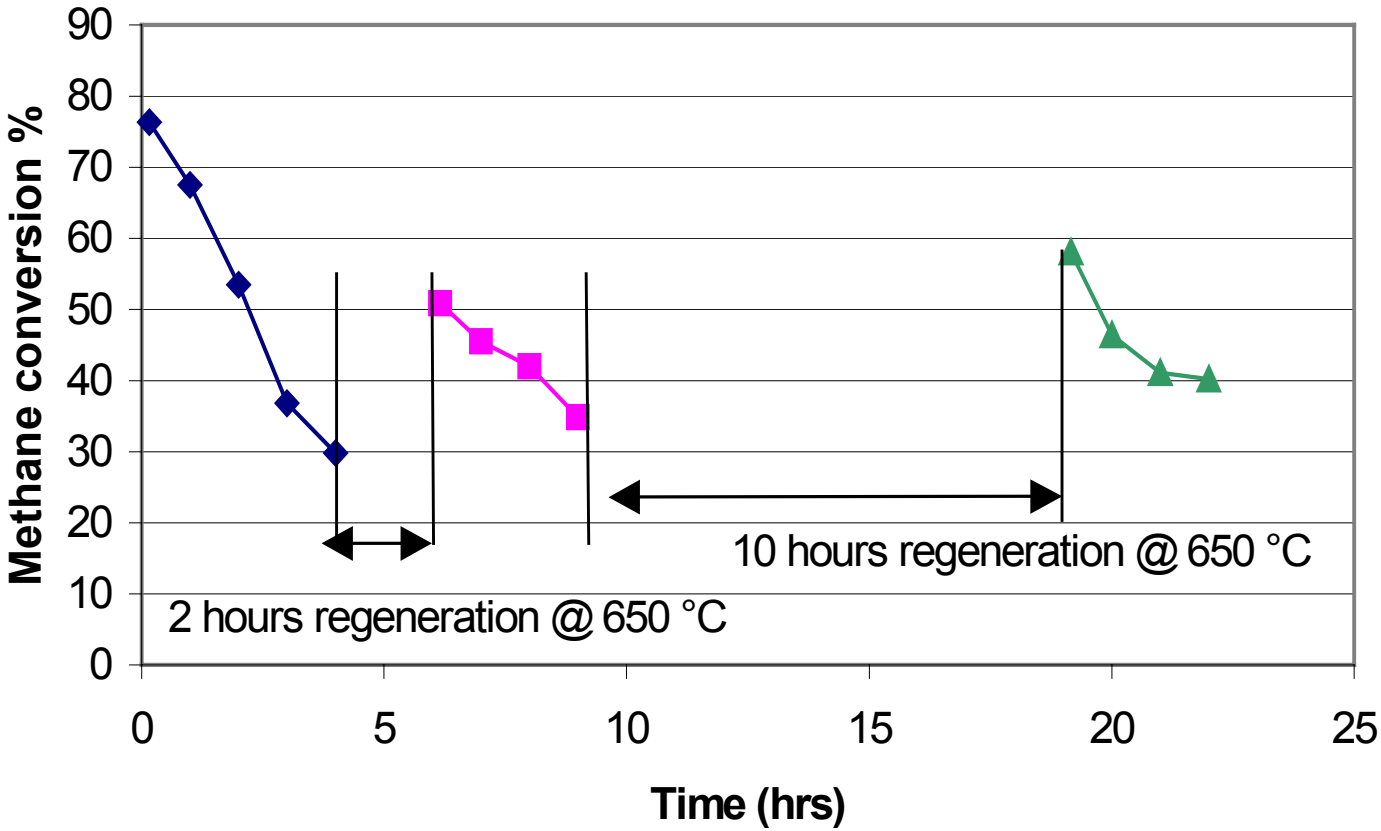
DCL International Inc.

Methane catalyst regeneration

- Thermal regenerations
- Rich regeneration strategies
  - With oxygen cuts
  - With H2
  - With H2 & CO
  - With gas mixtures

DCL International Inc.

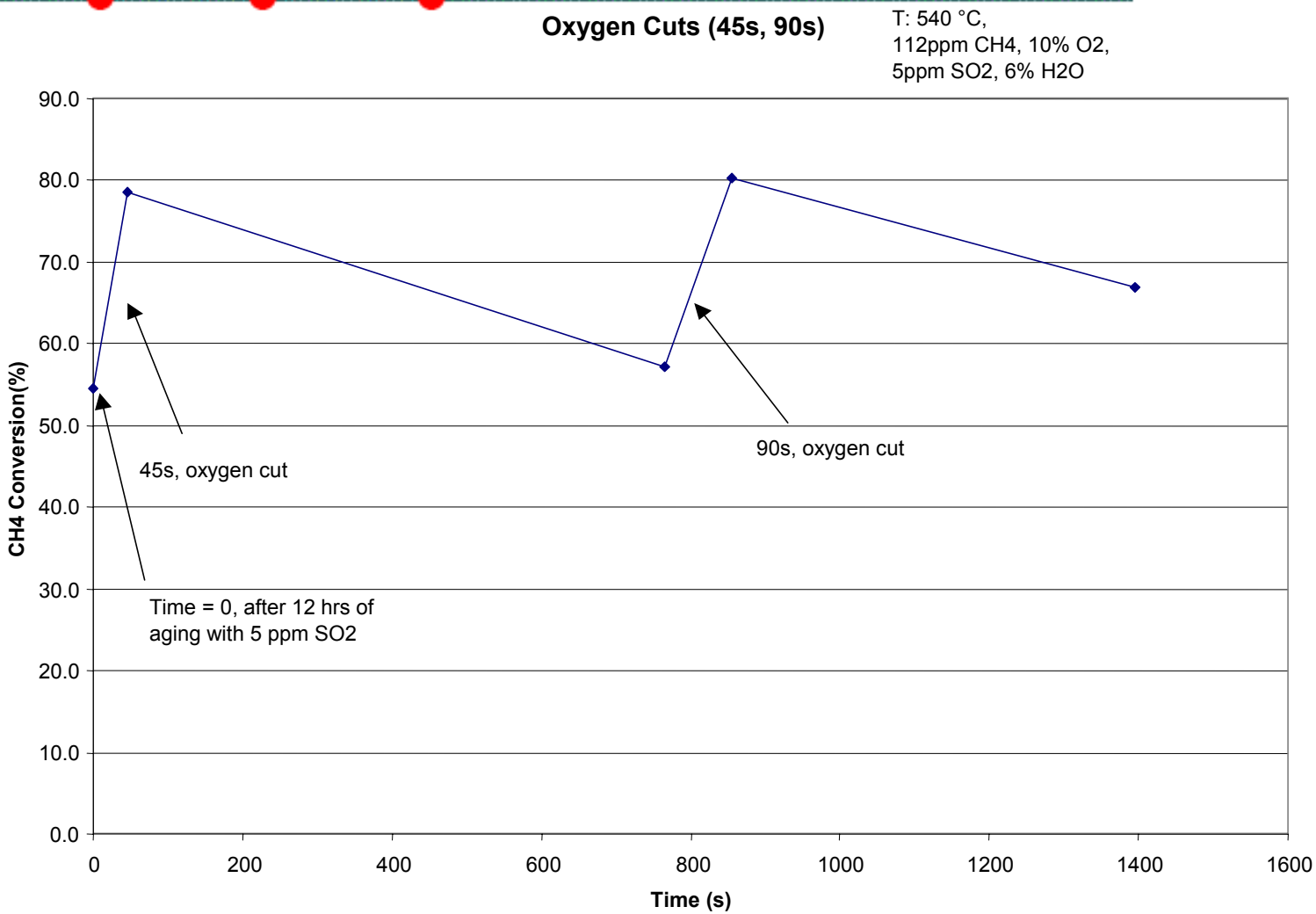
Thermal regeneration



Thermal regeneration is not an option

DCL International Inc.

Rich regeneration (oxygen cuts)



Oxygen cut is an option but is not practical

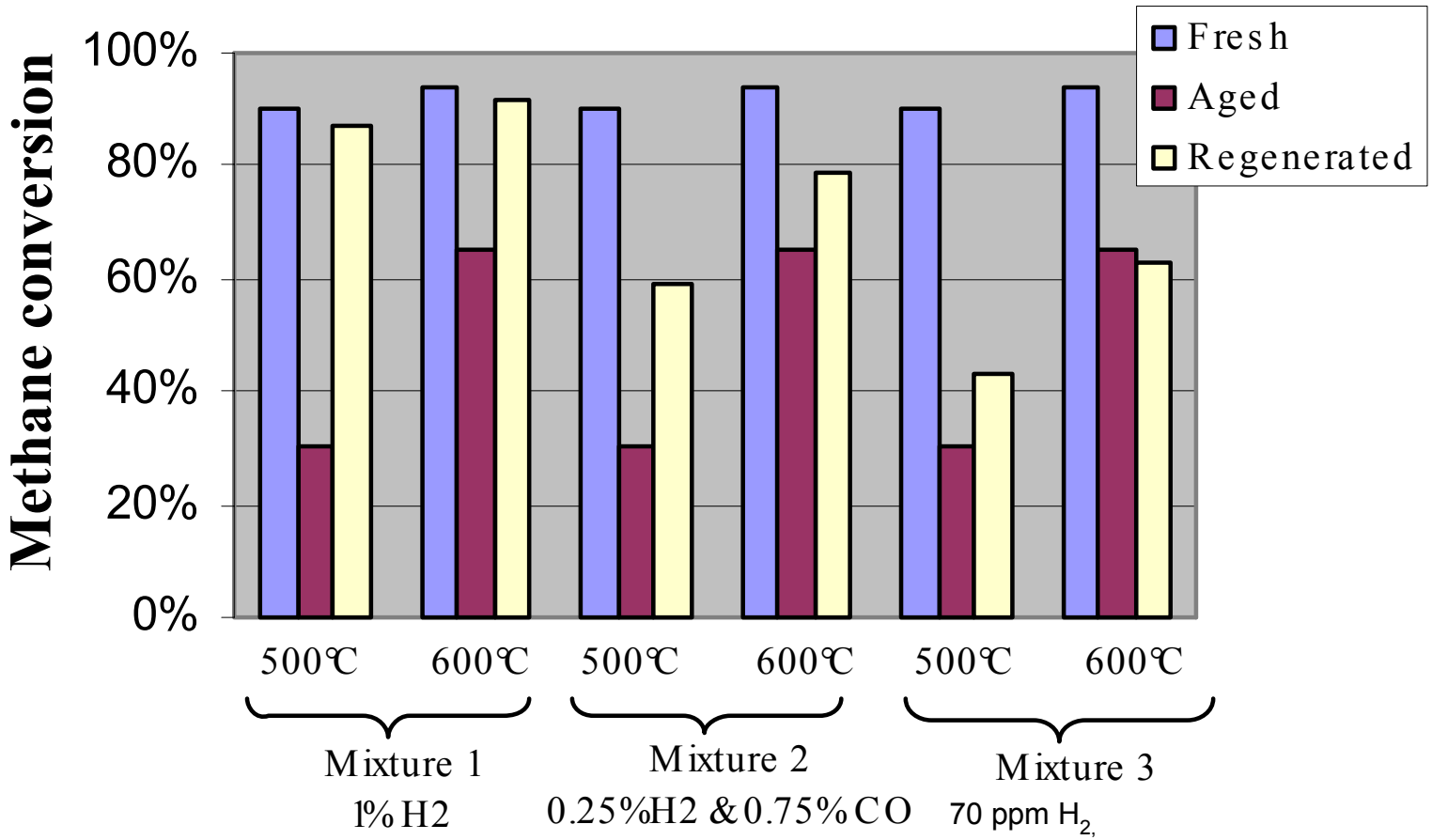
DCL International Inc.

Regeneration considerations

- From literature, H_2 is a good chemical for regenerating Pd catalysts
- H_2 could be produced by the engine when $\lambda < 1$
- CO can also be used as a reducing agent but is less efficient than H_2

DCL International Inc.

Regeneration results



DCL International Inc.

Results

- Mixture 1: complete regeneration
- Mixture 2: partial regeneration
- Mixture 3: partial/lower regeneration than mixture 2

- In actual engine conditions (mixture 3), catalyst will have to be exposed longer to regeneration conditions

DCL International Inc.

Questions?

DCL International Inc.