



HYDROGEN **SOURCE**

Fueling the Future™

Diesel Reformers for On-board Hydrogen Applications

2003 DEER Conference
2003-08-28

HydrogenSource Background

Created in 2001



UTC Fuel Cells

A United Technologies Company

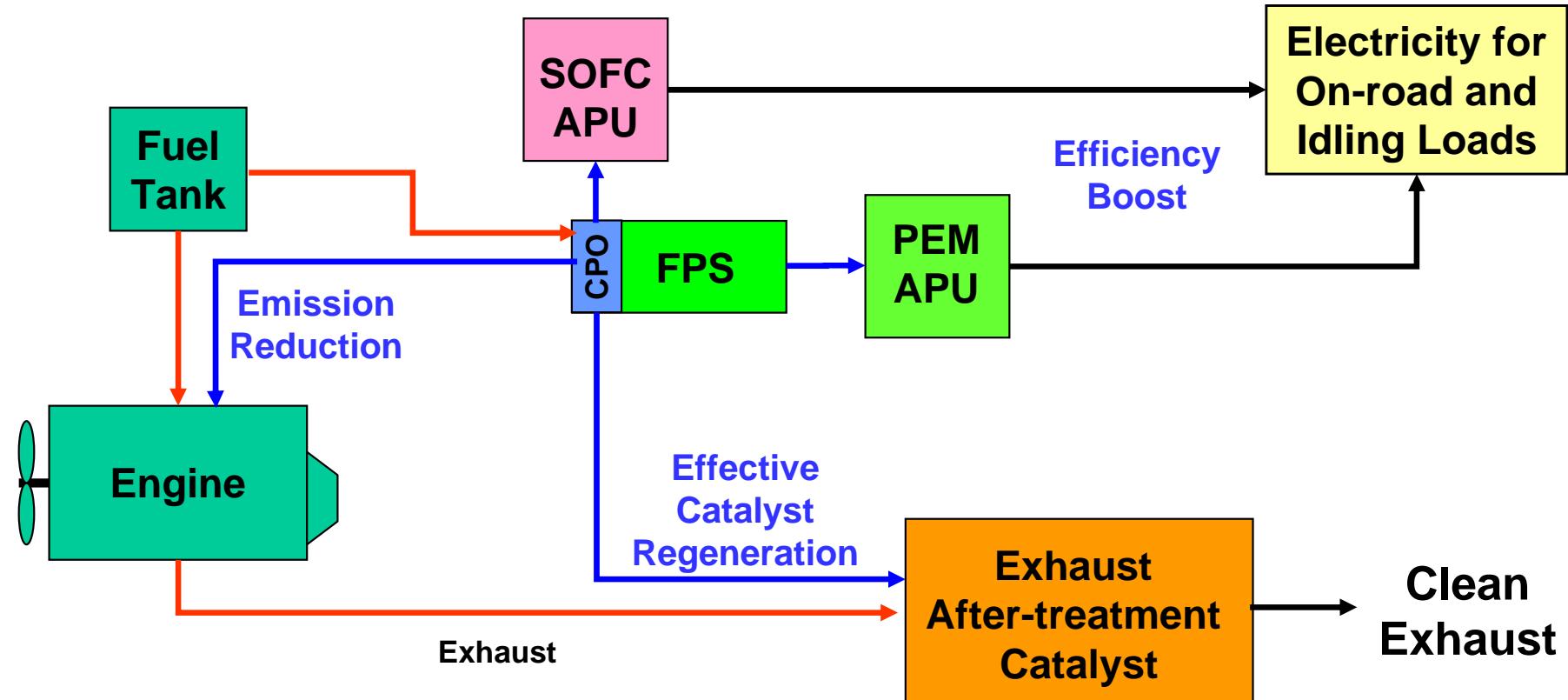


Develop, manufacture and sell Fuel
Processors



Reformers for On-board H₂ Applications

CPO improves emissions and vehicle efficiency



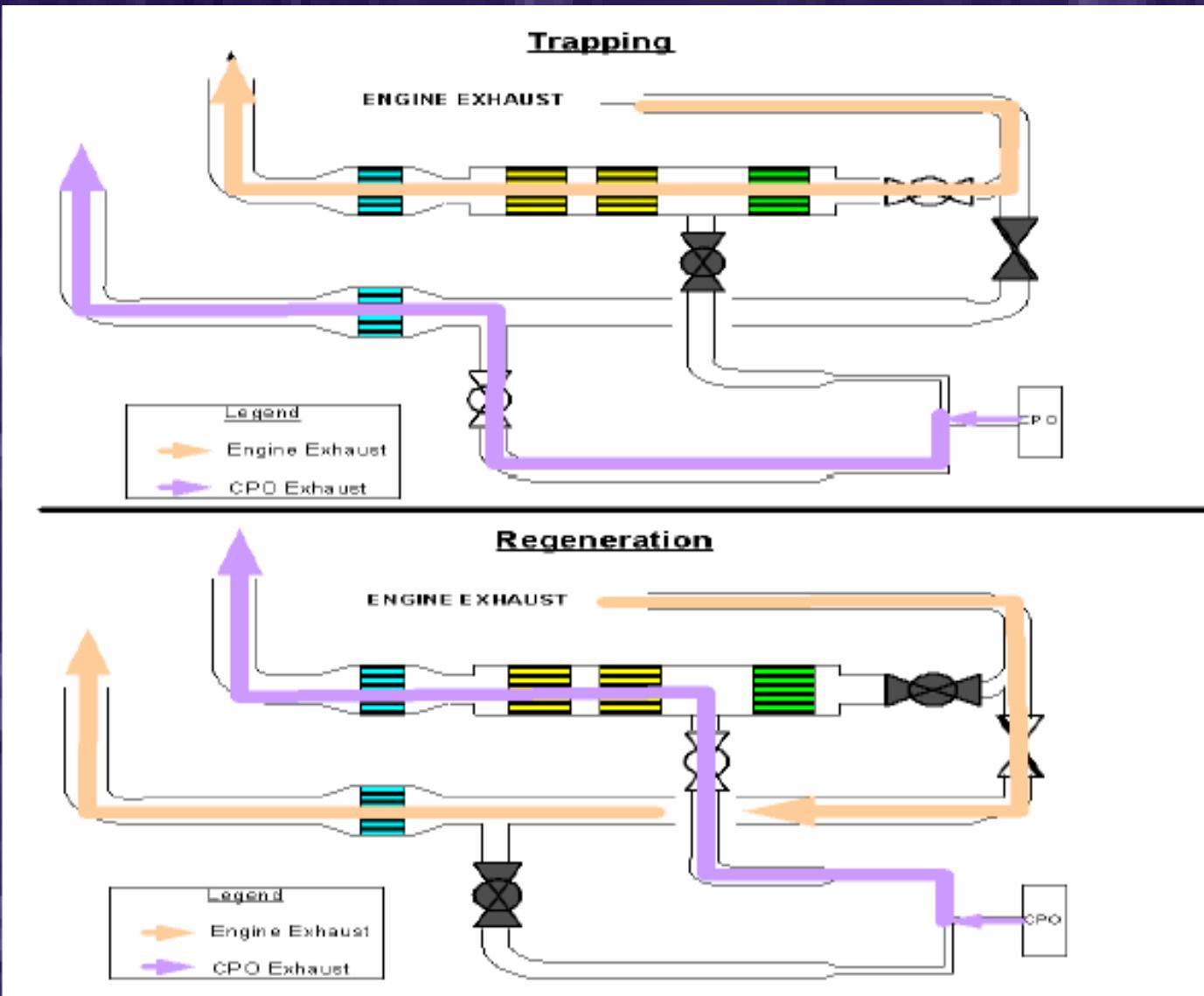
Initial Syngas LNT Regeneration Test

- **Test Objective**
 - Determine feasibility of using CPOx syngas for LNT regeneration
- **Demonstration Test Configuration**
 - Naphtha used for reformer fuel rather than diesel
 - Air used as oxidant rather than engine exhaust
 - Steady state engine & reformer operation
 - One leg of dual leg system
 - Fixed NOx trapping & regeneration cycles



Initial Syngas LNT Regeneration Test

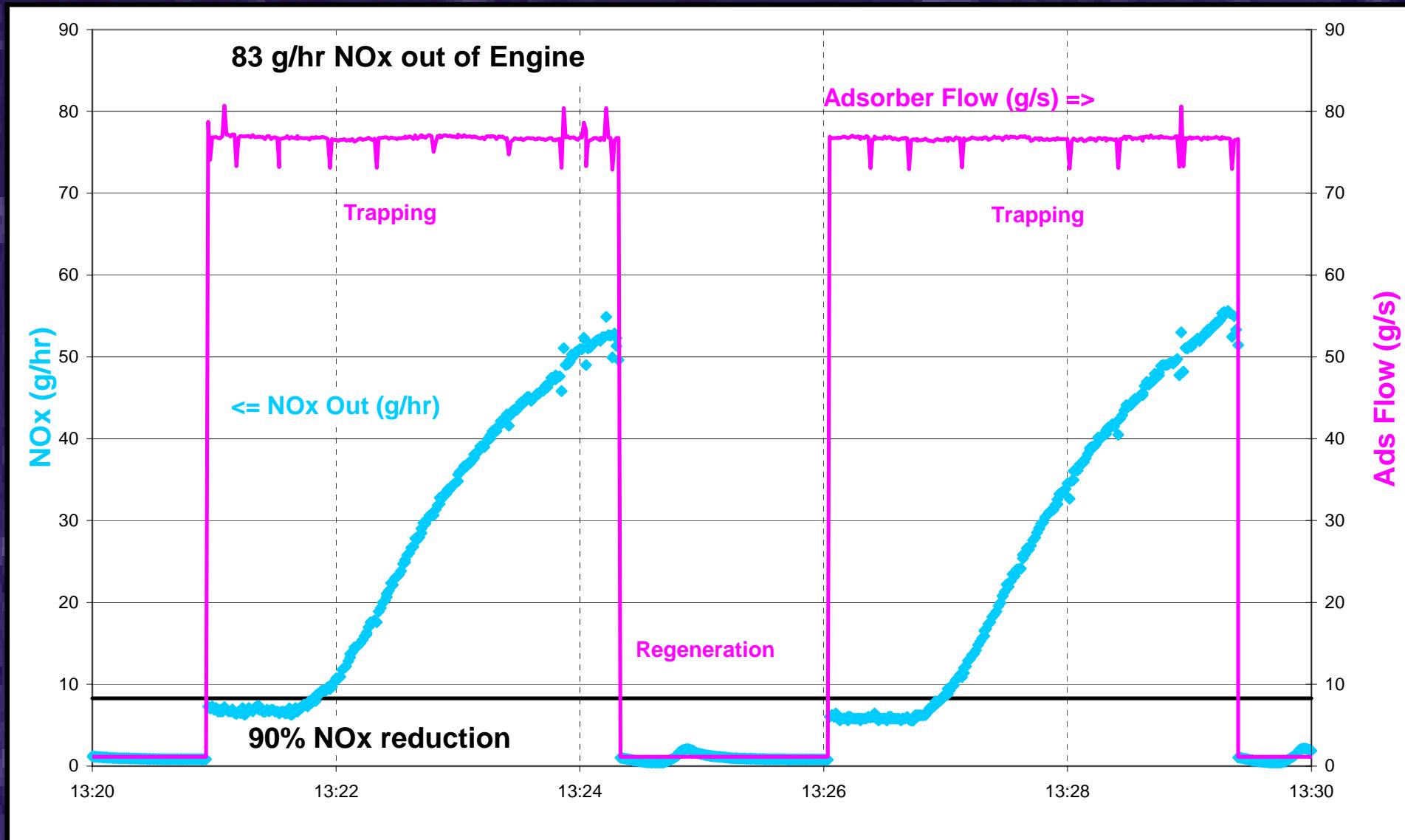
Test Configuration



- 5.9L engine
- 14L LNT
- Naphtha
- Syngas:
 - 33% H₂
 - 18% CO
 - 6% CO₂
 - 42% N₂
 - <1% THC

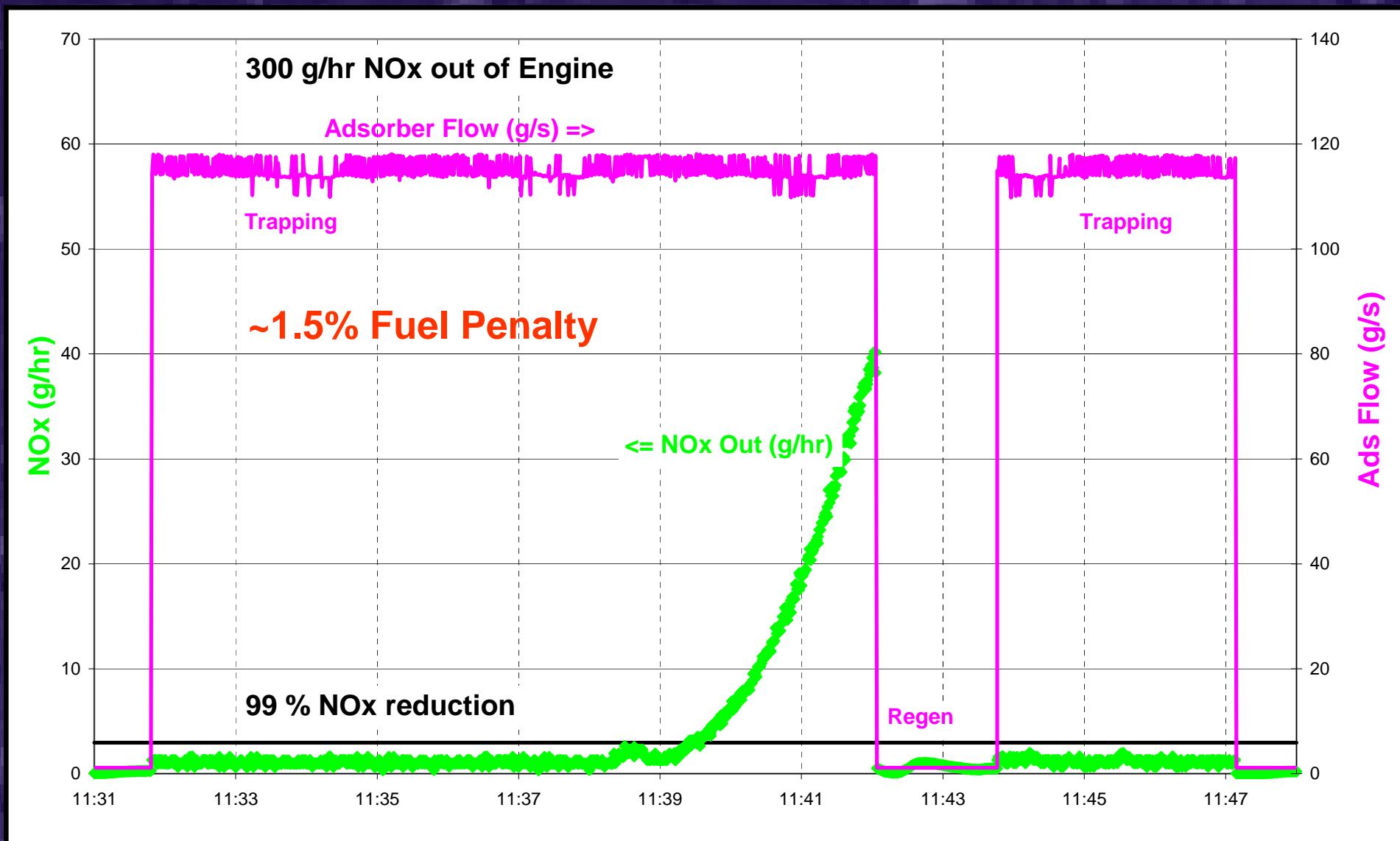
Syngas LNT Regeneration Test

90% NOx Reduction at 150°C LNT Temperature



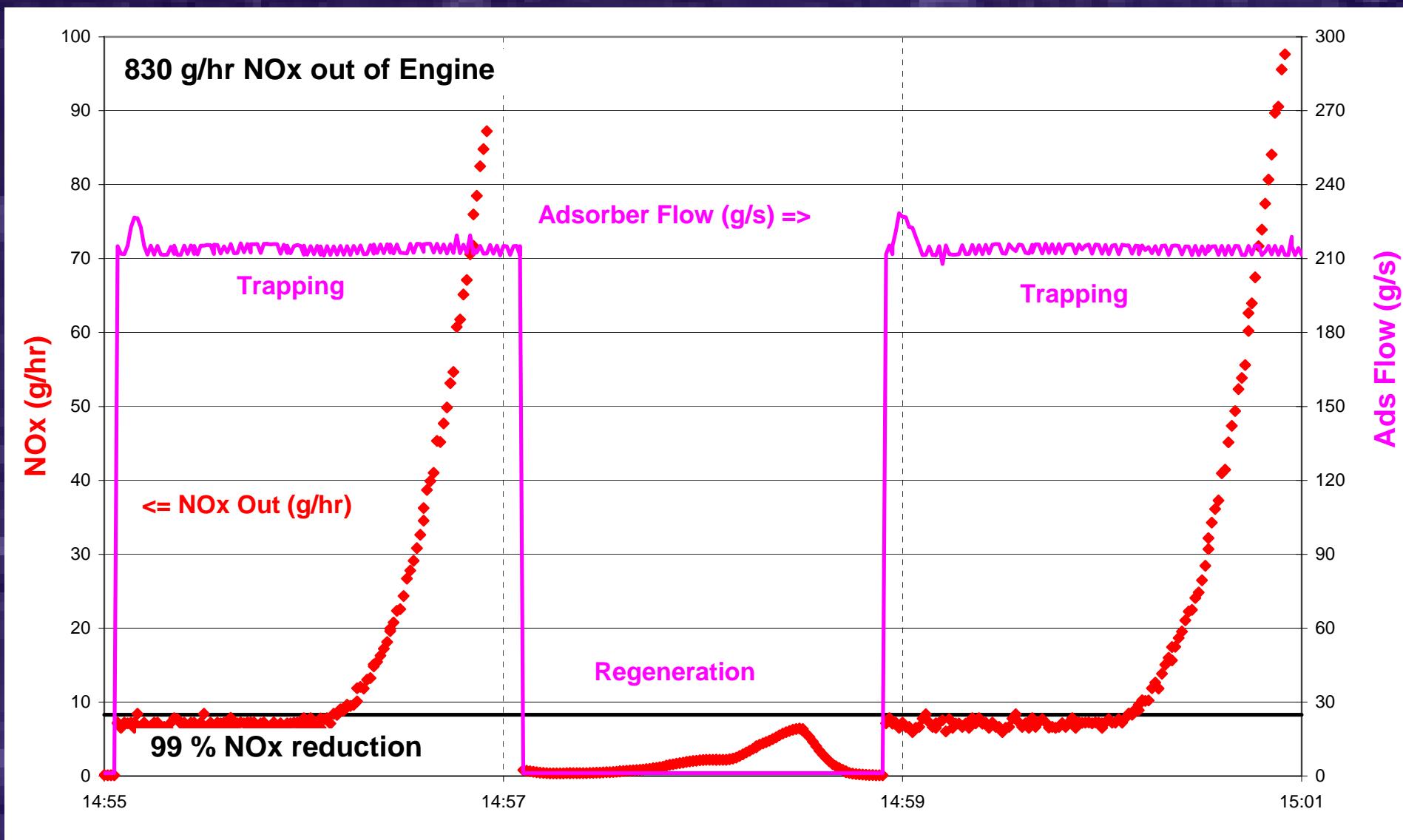
Syngas LNT Regeneration Test

99% NOx Reduction at 300°C LNT Temperature



Syngas LNT Regeneration Test

99% NOx Reduction at 450°C LNT Temperature



Challenges for CPOx Reformer

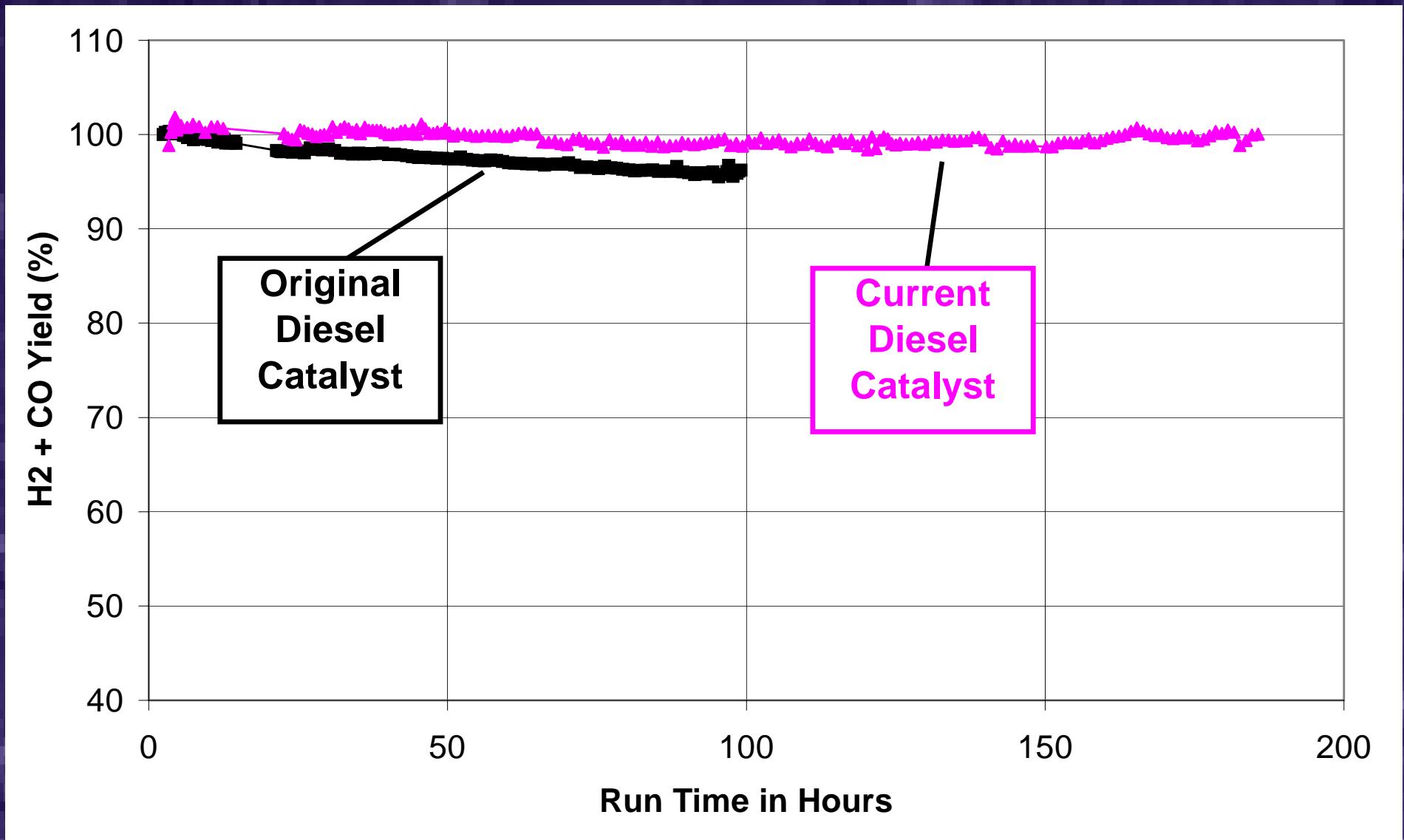
- **Durability**
 - Operation on engine exhaust
 - Thermal cycling for operating temperatures >800°C
 - Long-term durability

- **Total System Cost**
 - CPOx catalyst cost not expected to be an issue
 - Exhaust system configuration needs better definition to estimate CPOx cost (e.g. regeneration time & frequency, control implementation)



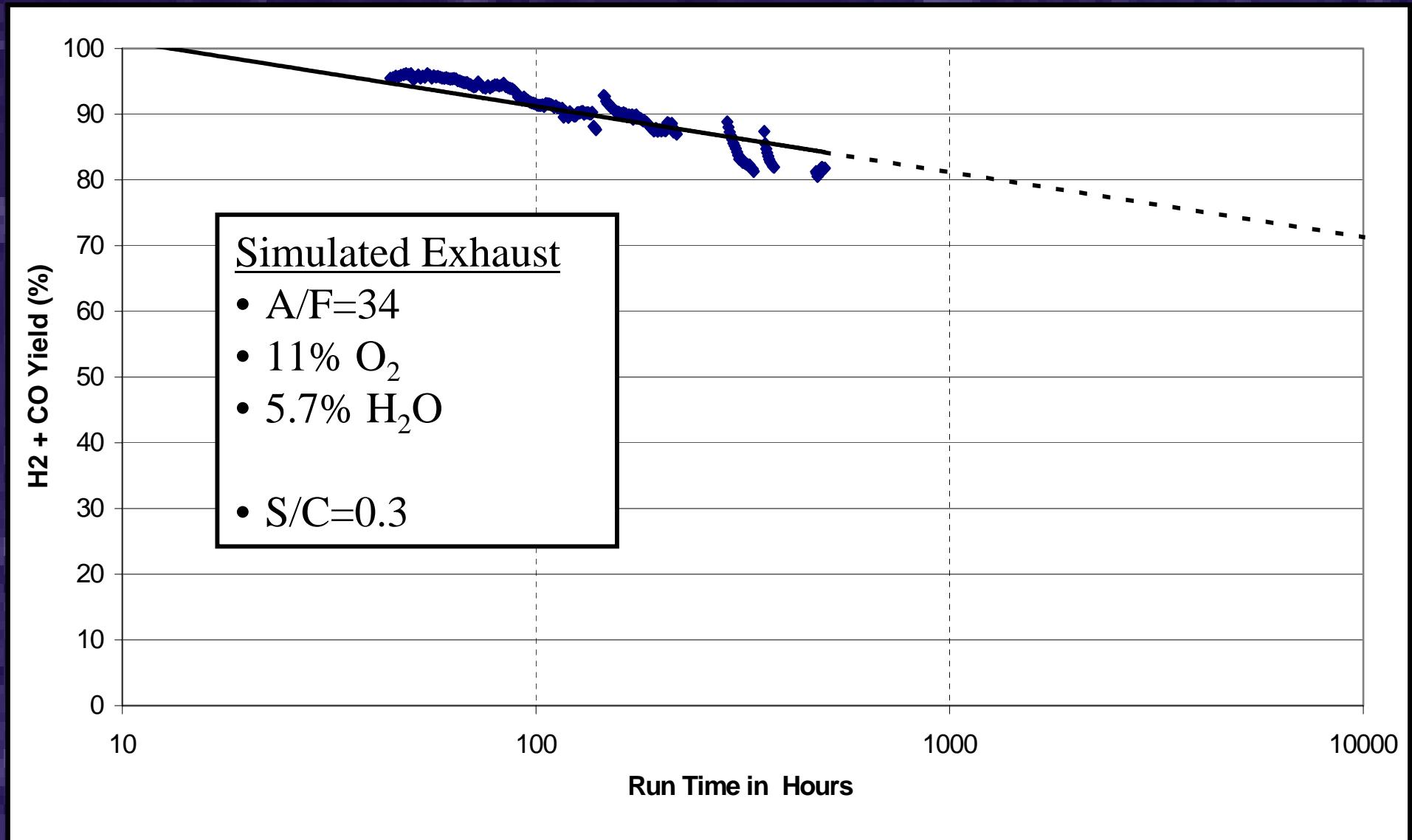
Stable Diesel CPOx Reforming

15ppm Sulfur Diesel Reformed using Air as Oxidant



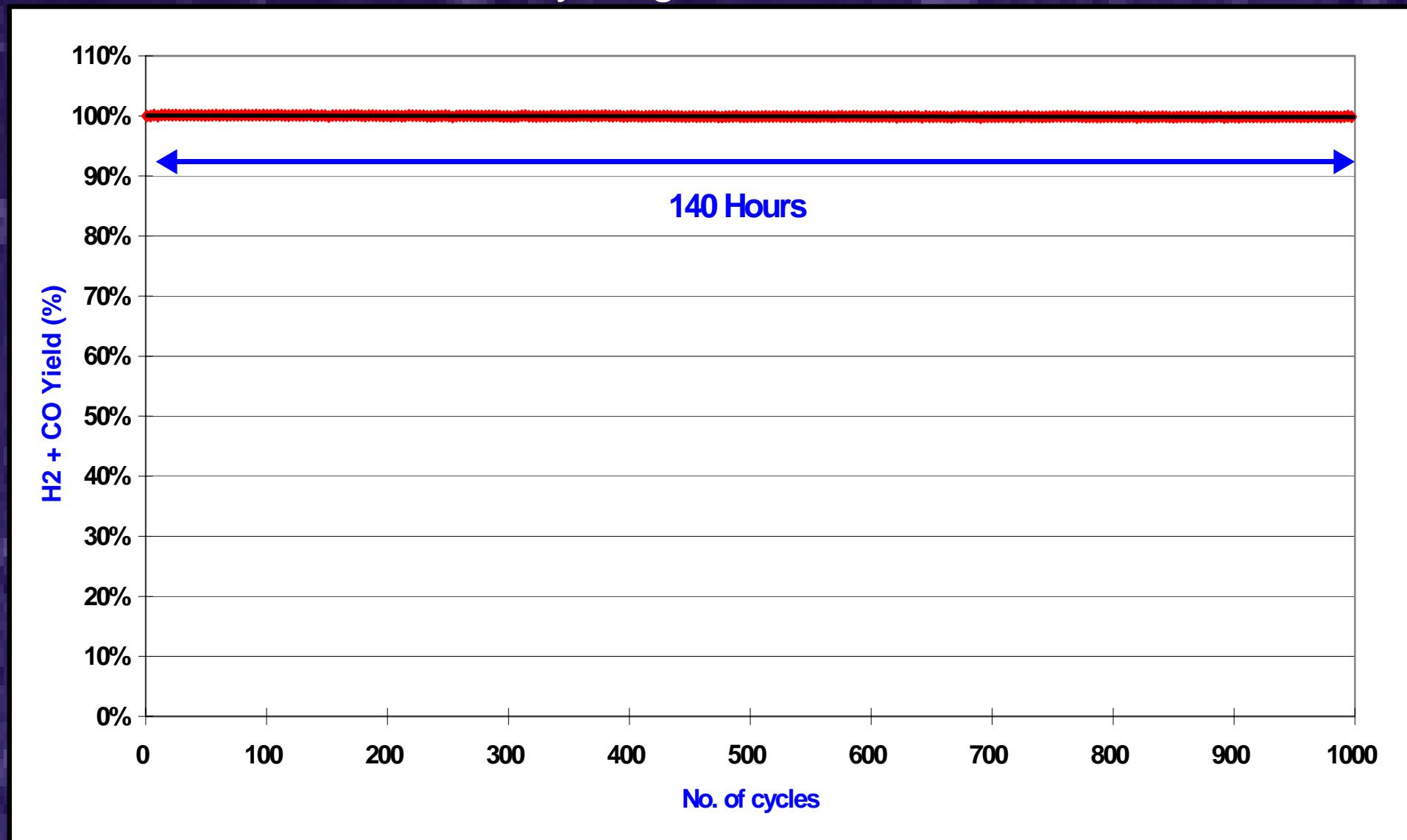
Stable Diesel CPOx Reforming

15ppm S Diesel Reformed using Simulated Exhaust as Oxidant



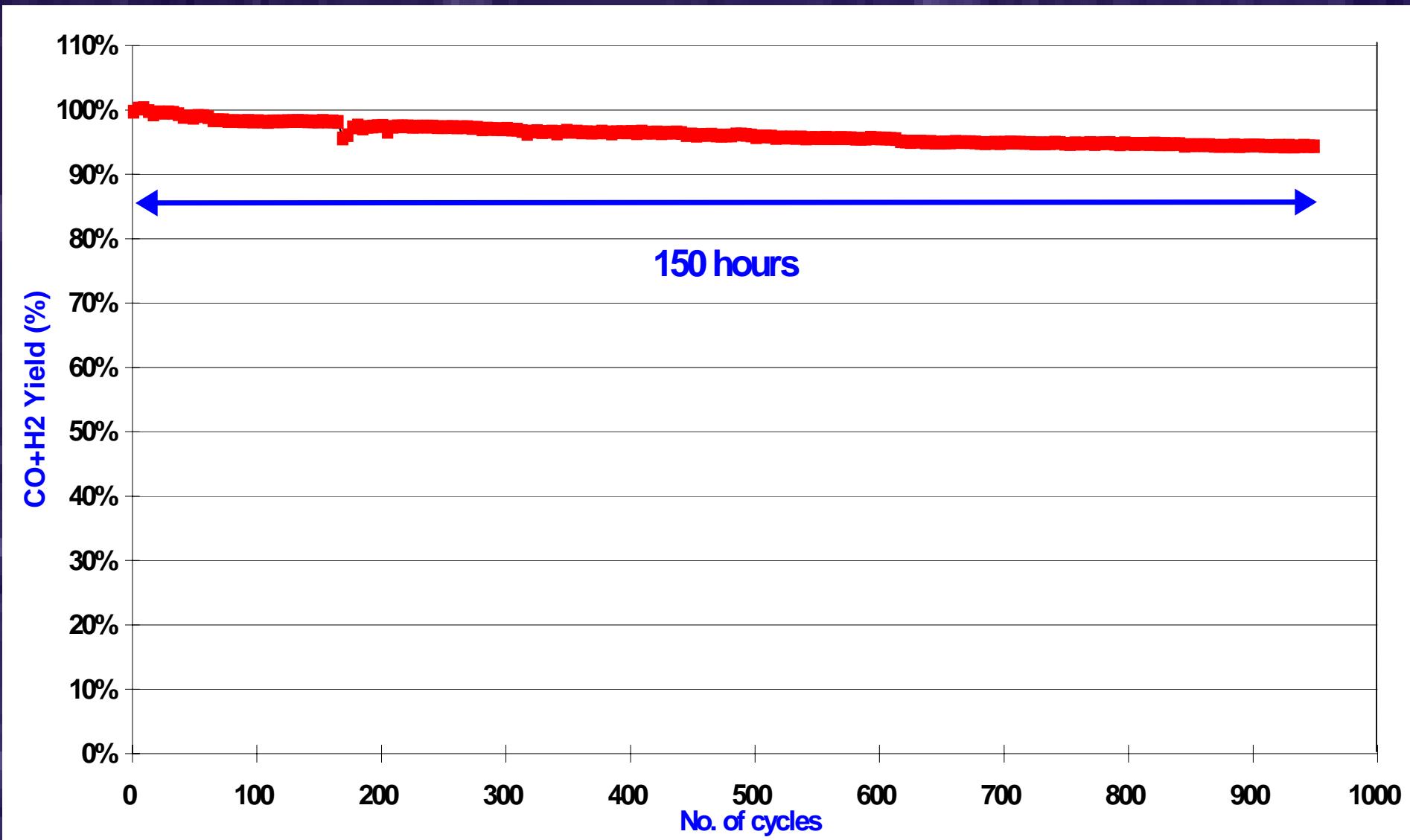
CPOx Thermal Cycling Data on Methane

800°C Thermal Shock Cycling



CPOx Thermal Cycling Data on Naphtha

800°C Thermal Shock Cycling



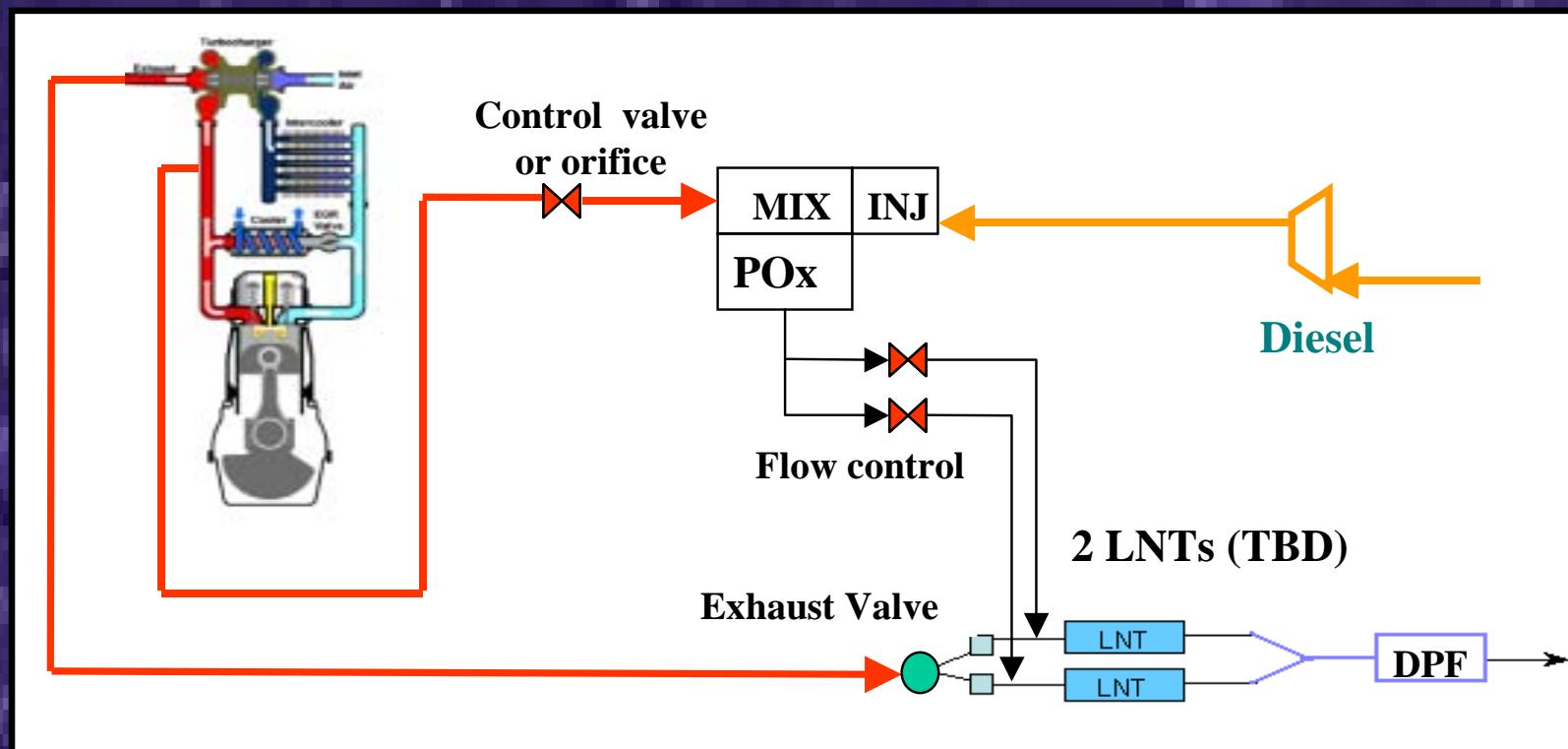
Benefits of Syngas Regeneration of LNT

- **Demonstrated Benefits**
 - Low Temperature Regeneration
 - >90% NOx Conversion from 150°C to 450°C
- **Expected Benefits**
 - Rapid exhaust catalyst light-off & thermal control
 - CPOx exotherm provides hot syngas flow (~800°C)
 - H₂ combustion on low temp noble metal catalysts
 - Faster or lower temperature desulfation
 - Lower fuel penalty
 - Smaller, more durable LNT system



Next Steps

- Demonstration LD truck
 - Complete vehicle integration December 2003
 - Drive cycle testing Q1 2004



Next Steps

- **Exhaust System with CPOx Reformer**
 - Demonstrate benefit for desulfation
 - Demonstrate rapid exhaust light-off
 - Cyclic & steady state durability testing
 - Optimize configuration for cost and performance

- **CPOx Reformer**
 - Longer term cyclic & steady state durability testing





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