Effectiveness of Desulfation Protocols on Dynamometer Aged LNT-SCR Systems

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Presentation Outline

- Dynamometer Aging
  - Experimental Set-up
  - 2- Desulfation Protocols (50,000 miles equivalent)
  - System Performance after Aging
- Effect of Protocol Sulfur Release
- Effect of Aging on Sulfur Release
- Accelerated Aging Conditions
  - Average/Peak Temperatures
  - Rich Time
  - HC and CO

LNT-SCR Concept for Lean NOx Reduction

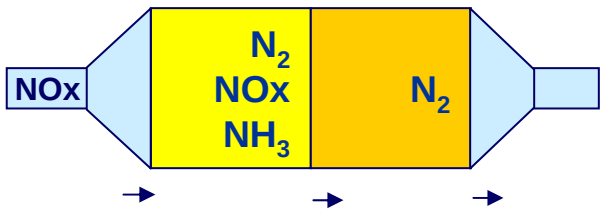
Typical System

NOx Adsorber

NOx Adsorber Vol = 2x PGM = 2y

New System

NOx Adsorber In-situ-SCR



NOx Adsorber Vol = 1x PGM = 1y
In-situ SCR Vol = 1x PGM = 0

- Products of LNTs NOx reduction include N2 and NH3.
- Replace ½ of lean NOx trap volume with ammonia SCR catalyst.
- Improves Net NOx conversion (to N2)

8NH3 + 6NO2 → 7N2 + 12H2O

4NH3 + 4NO + O2 → 4N2 + 6H2O

2NH3 + NO + NO2 → 2N2 +3H2O

50,000 mile Equivalent Aging Protocol for LNT-SCR System on Engine Dynamometer

Steady Engine Operation at 2000 rpm / 4 bar

MODE #1	MODE #2	MODE #3
Sulfur Exposure DeNOx = 345°C L(s)/R(s) = 120/5	DeSOx*= ~670°C L(s)/R(s)	DPF Regen – 600°C Lean Only

Desulfation Targets:

System A: 700°C ∓ 20°C

System B: 650°C ∓ 70°C

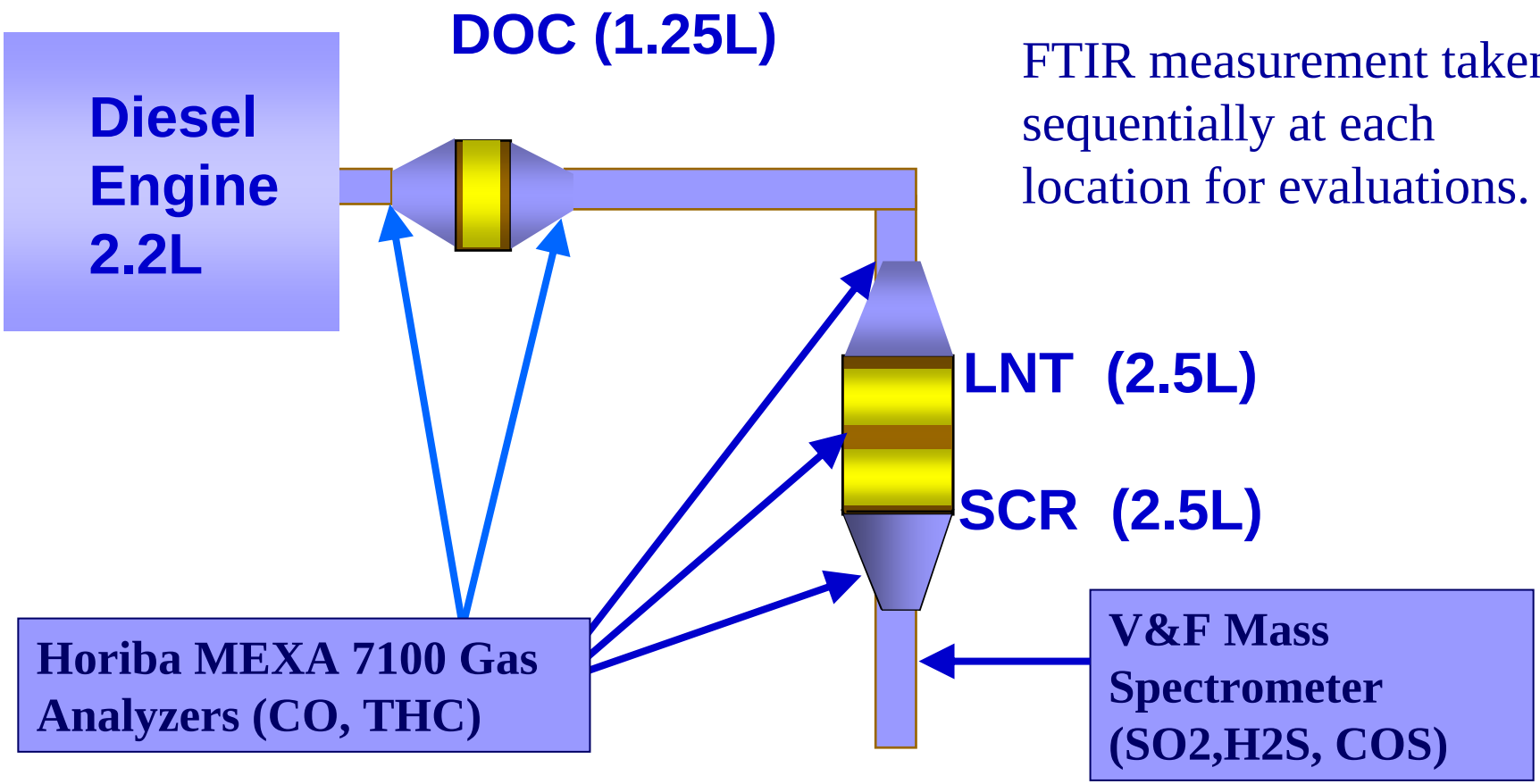
Average midbed temperature controlled by alternating between rich and lean post-injected engine operation.

Experimental Set-up and Measurement

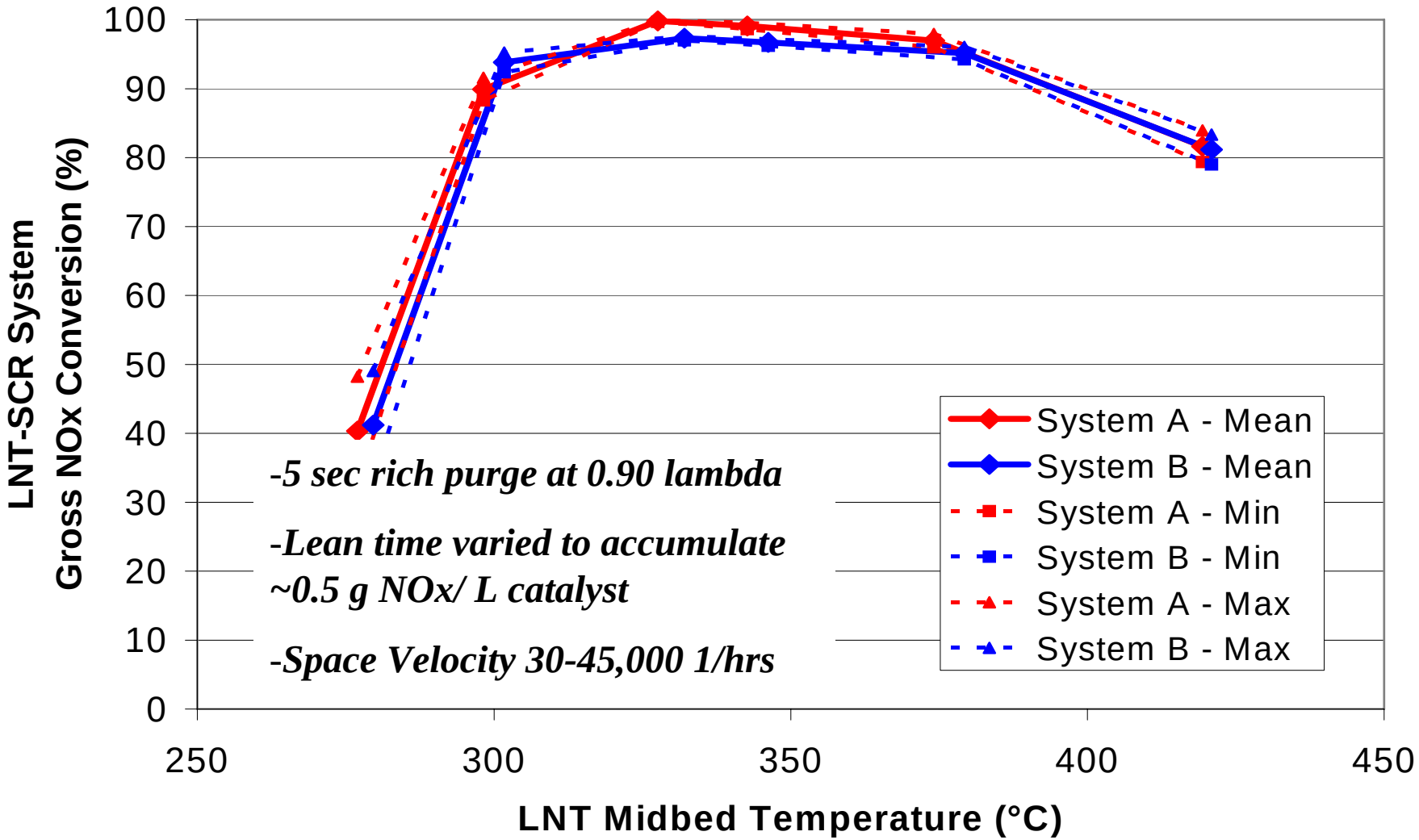
Temperature at LNT Midbed

Midac FTIR (NO,NO2, NH3)

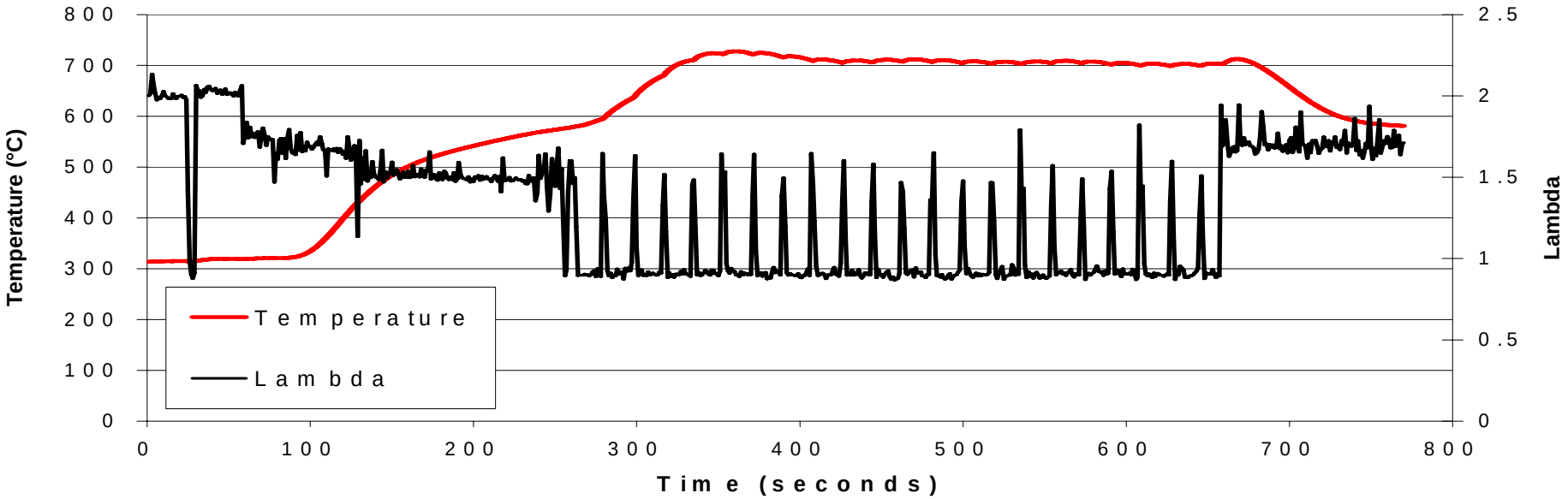
FTIR measurement taken sequentially at each location for evaluations.



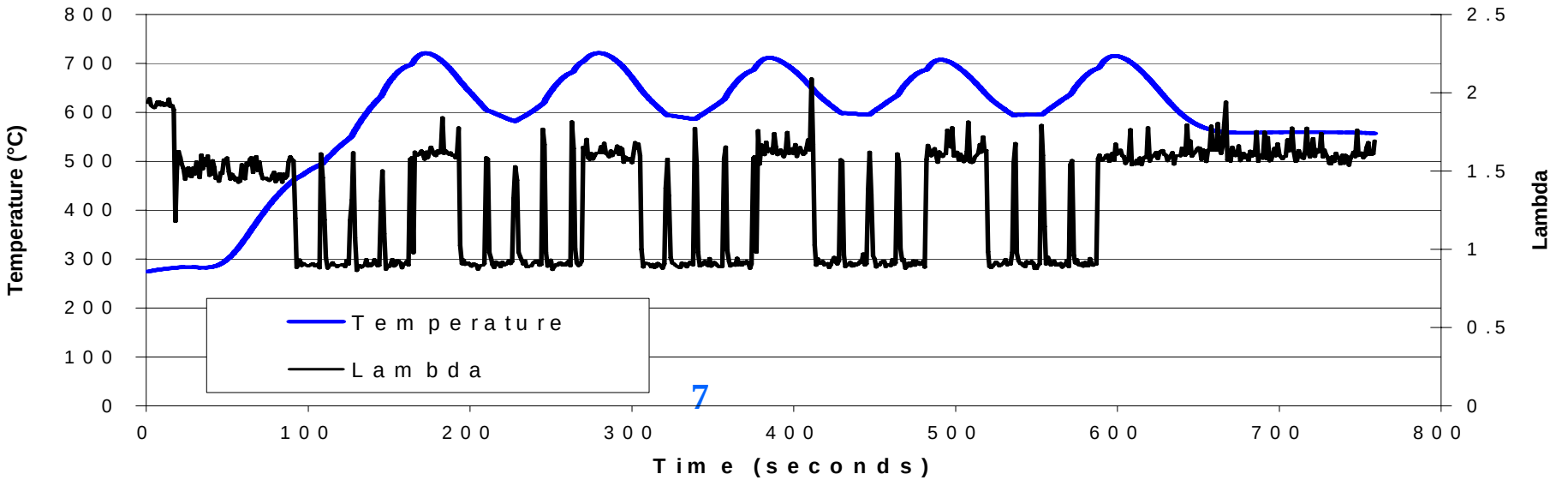
LNT-SCR Gross NOx Conversion After 50,000 mi Equivalent Aging on Engine Dynamometer



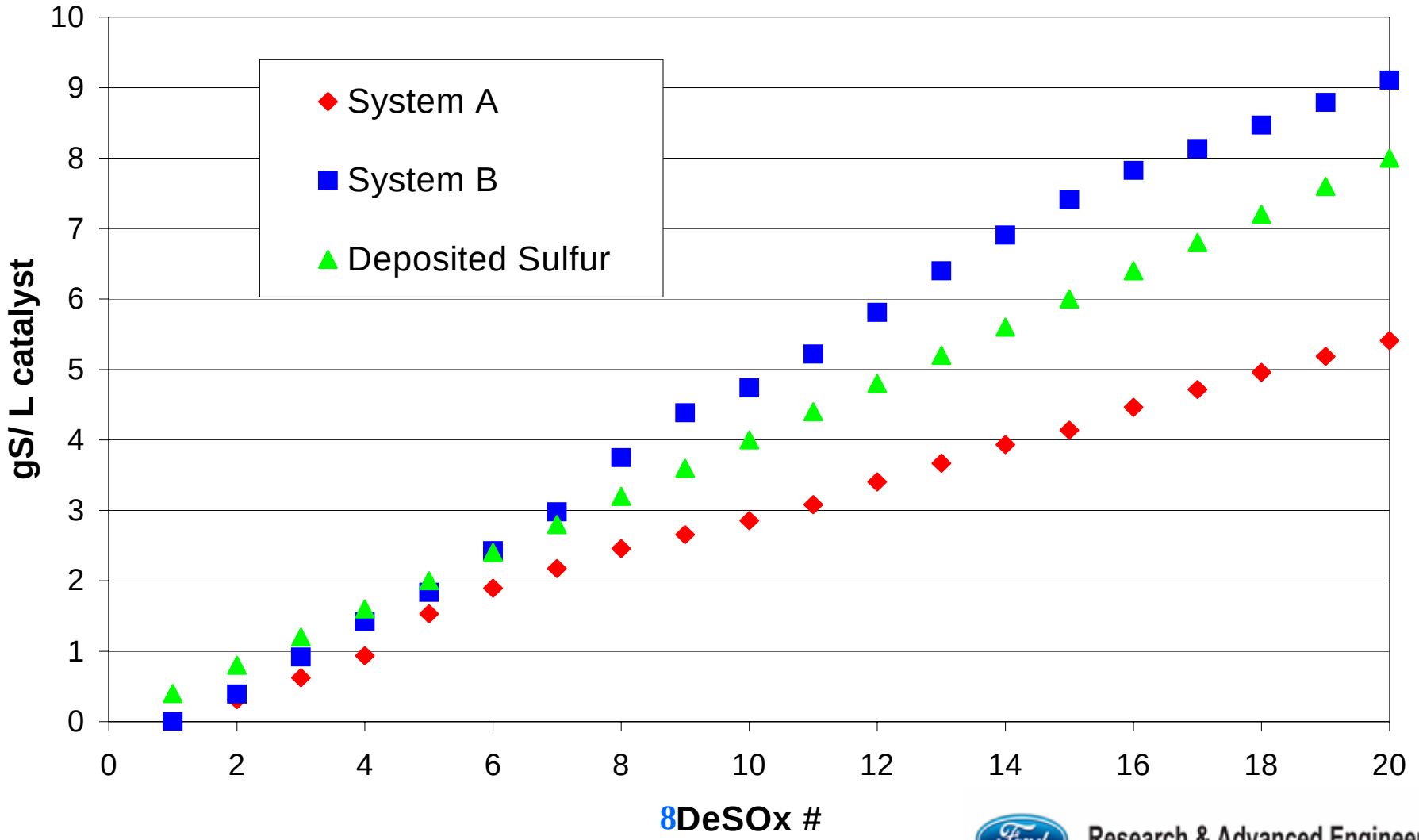
Desulfation Protocol: System A



Desulfation Protocol: System B



Sulfur Release at Outlet of SCR During DeSOx
(H2S, SO2, and COS Measured w/ a Mass Spectrometer)



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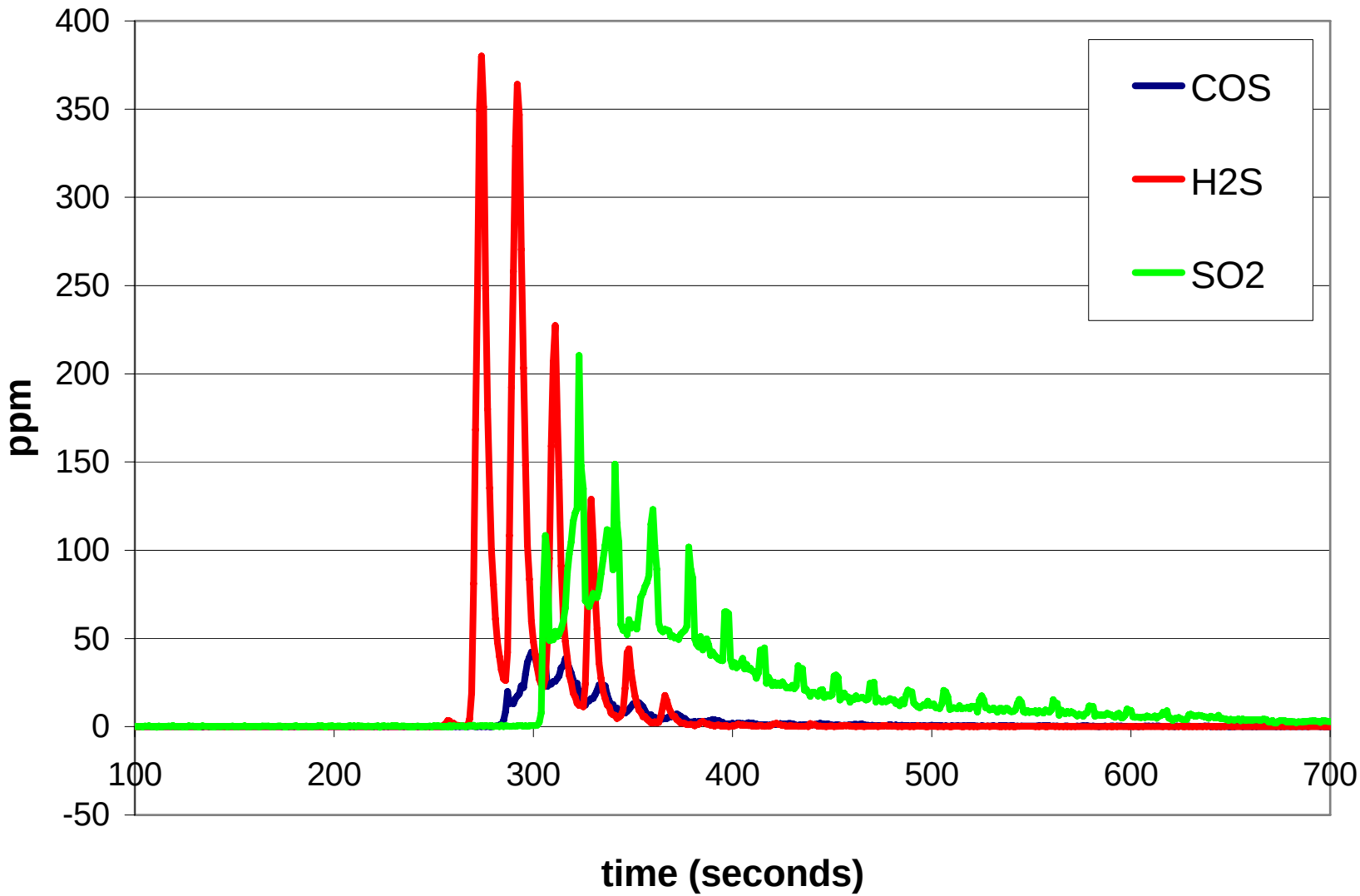
Desulfation Protocol

System A Desulfation: #12



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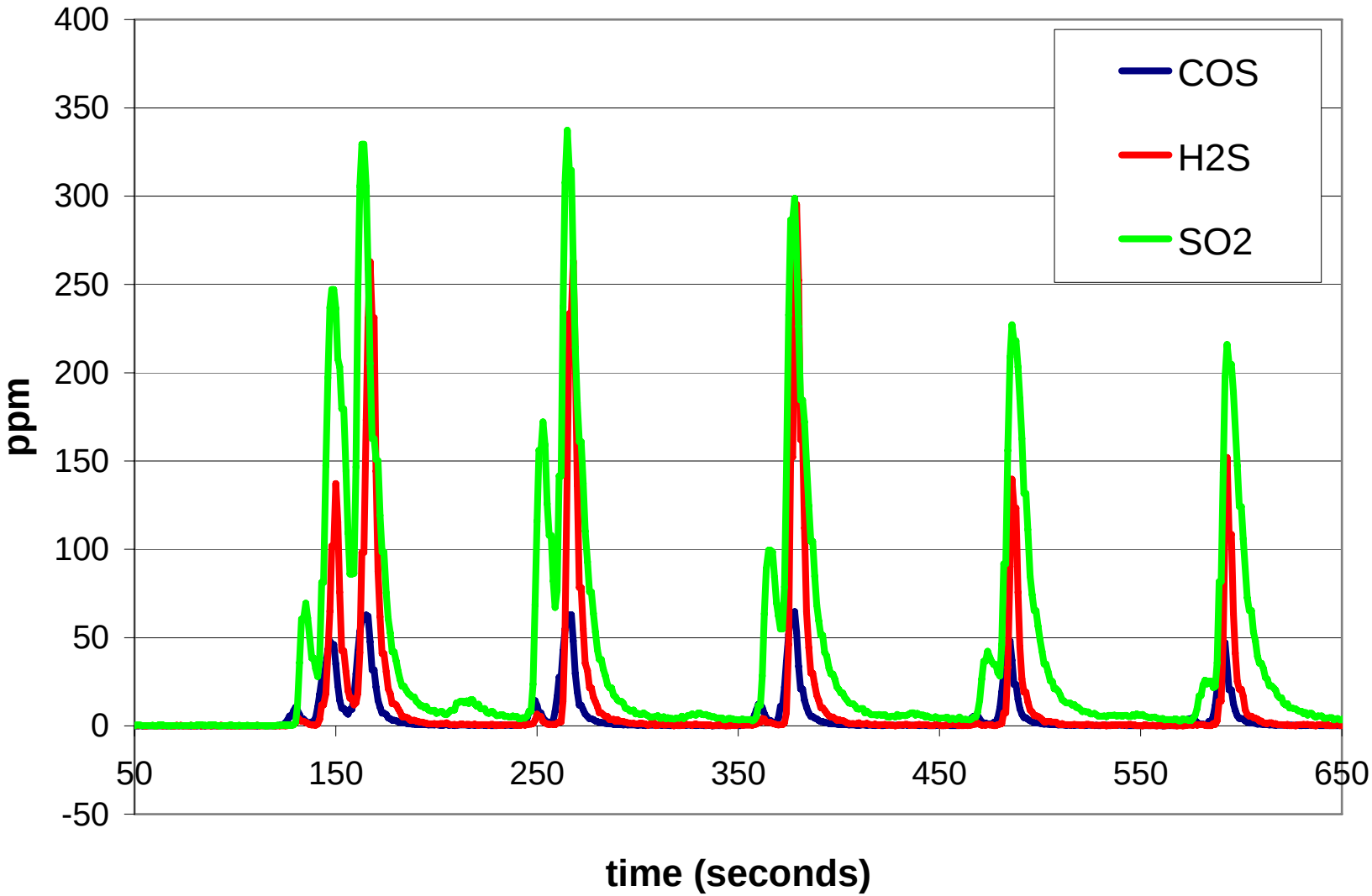
Desulfation Protocol

System B Desulfation: #12



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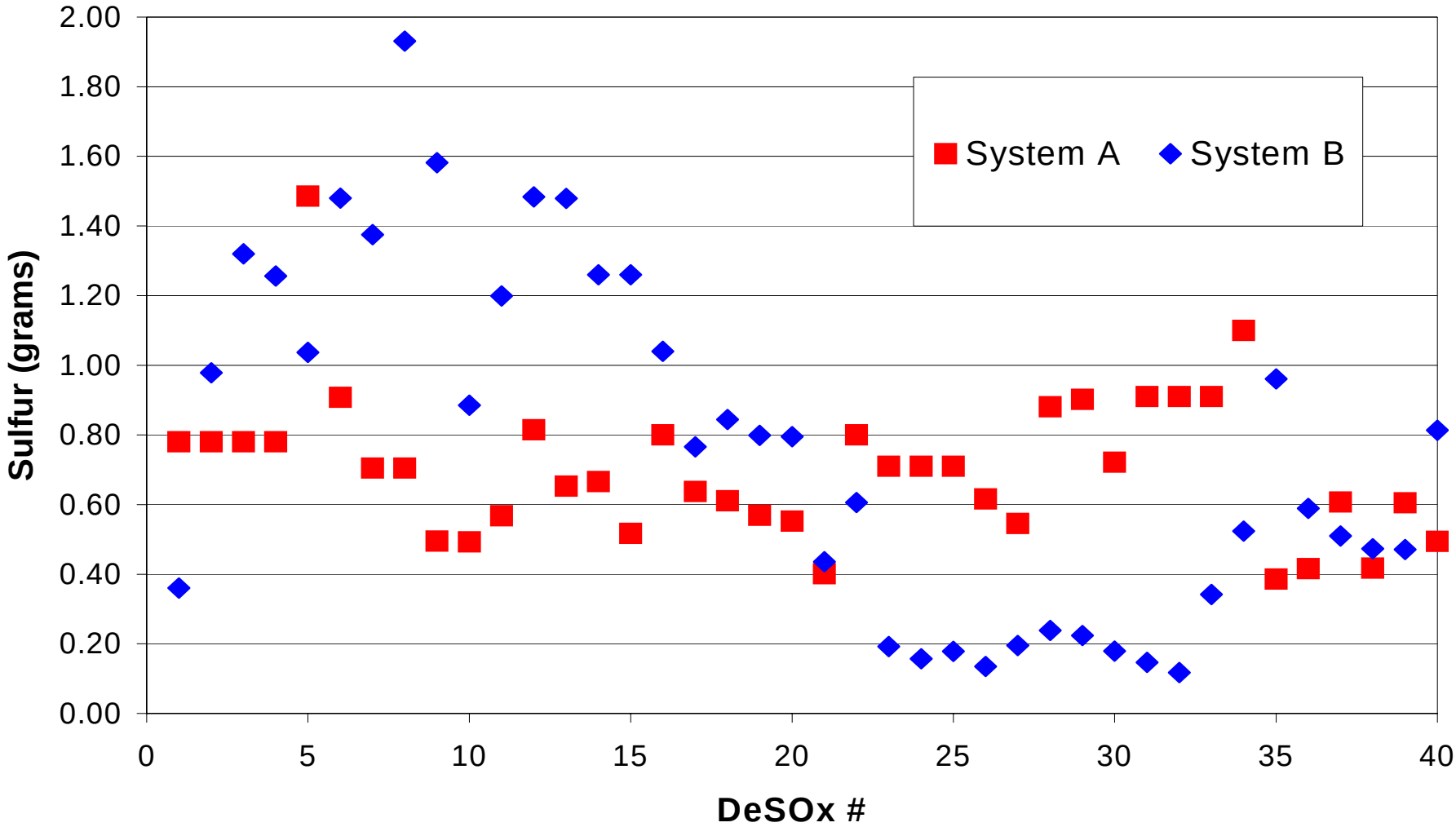
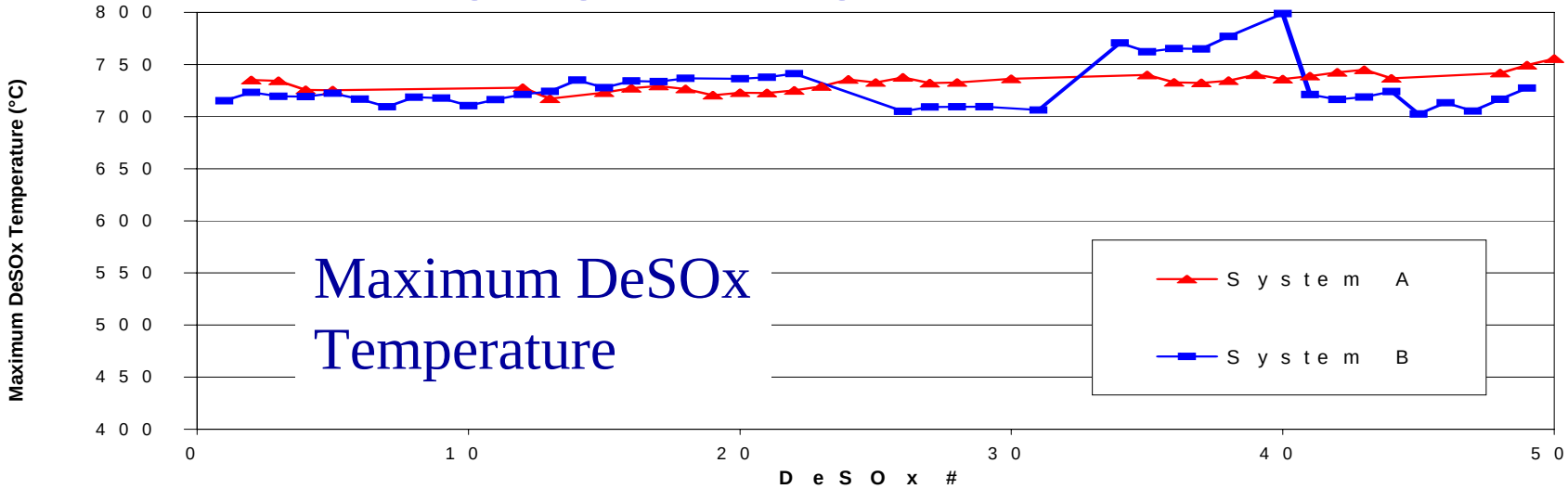
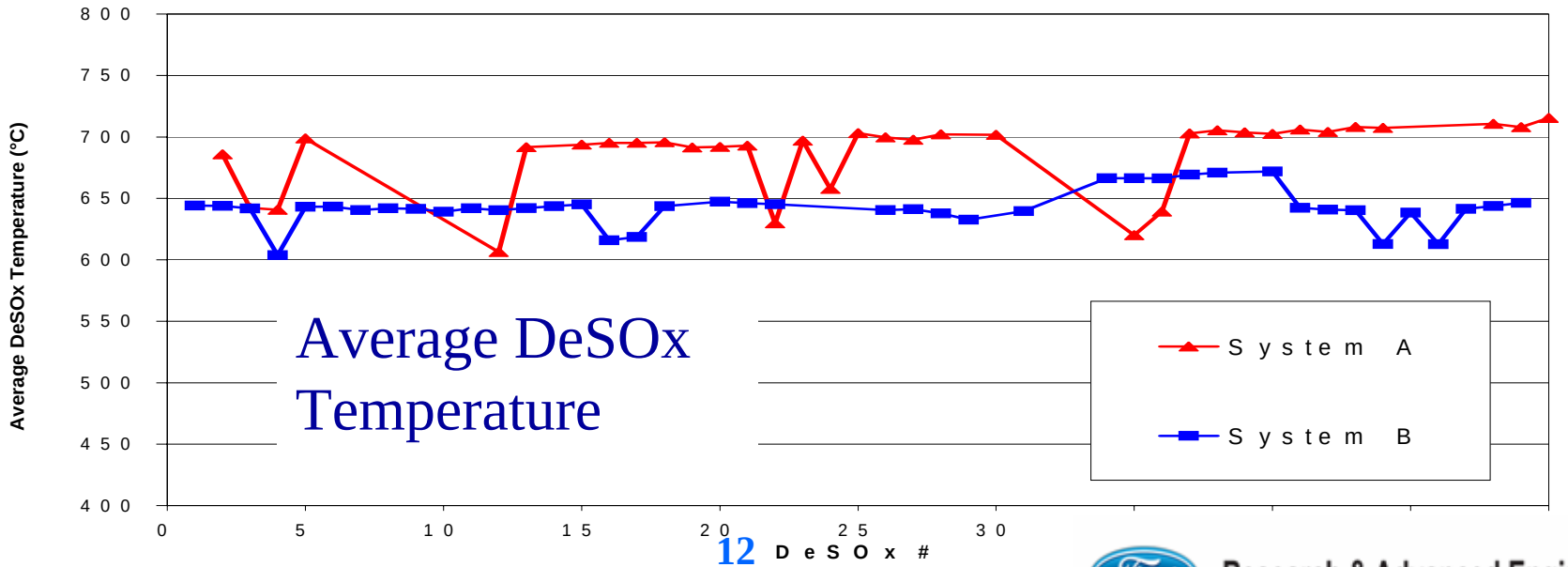
Desulfation Protocol

Total Sulfur Removal per Desulfation



LNT Desulfation Temperatures over 50,000 mi Equivalent Aging on Engine Dynamometer





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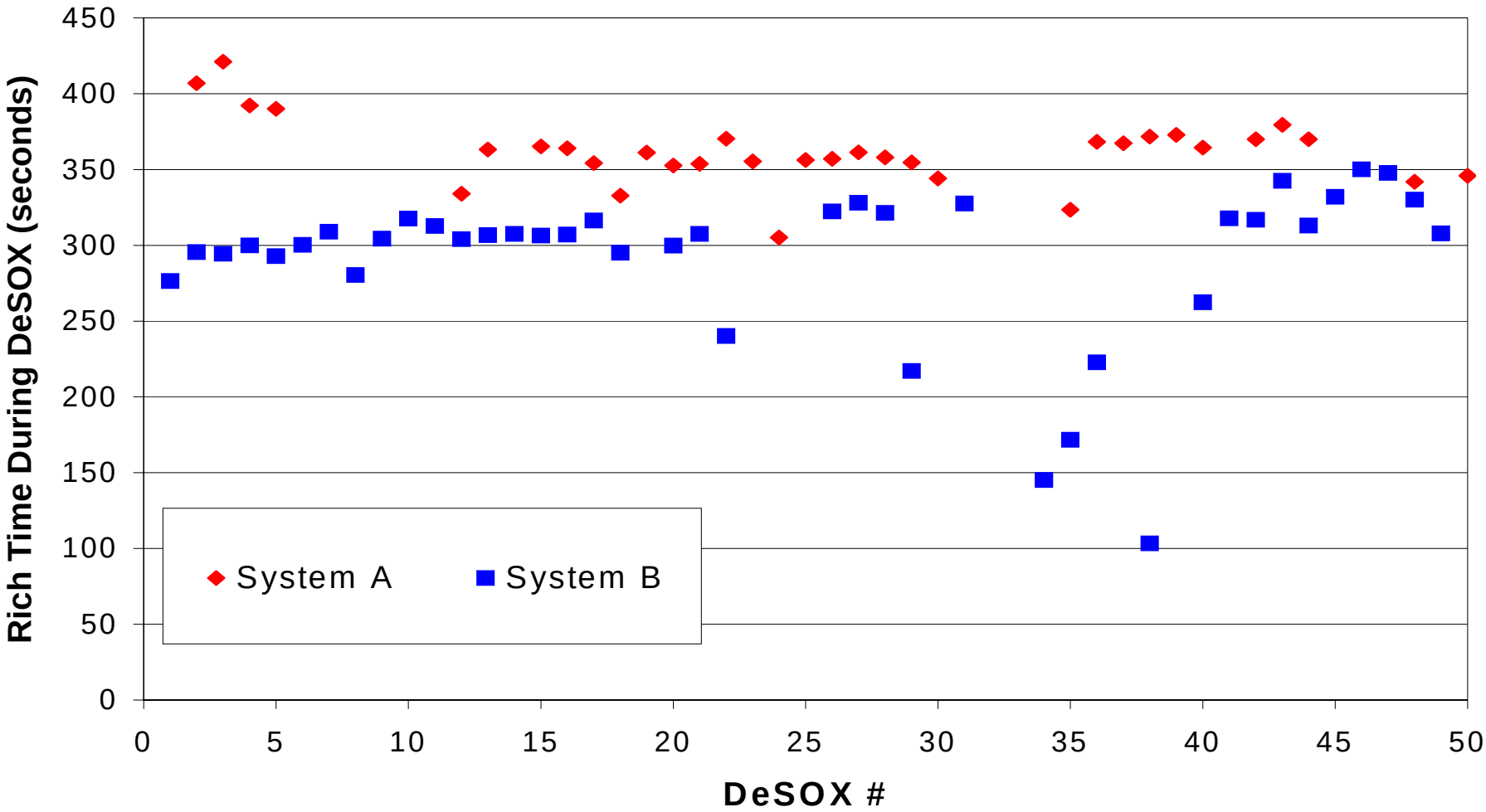
Accelerated Aging

Desulfation Rich Time During 50,000 mile Equivalent Aging on Engine Dynamometer



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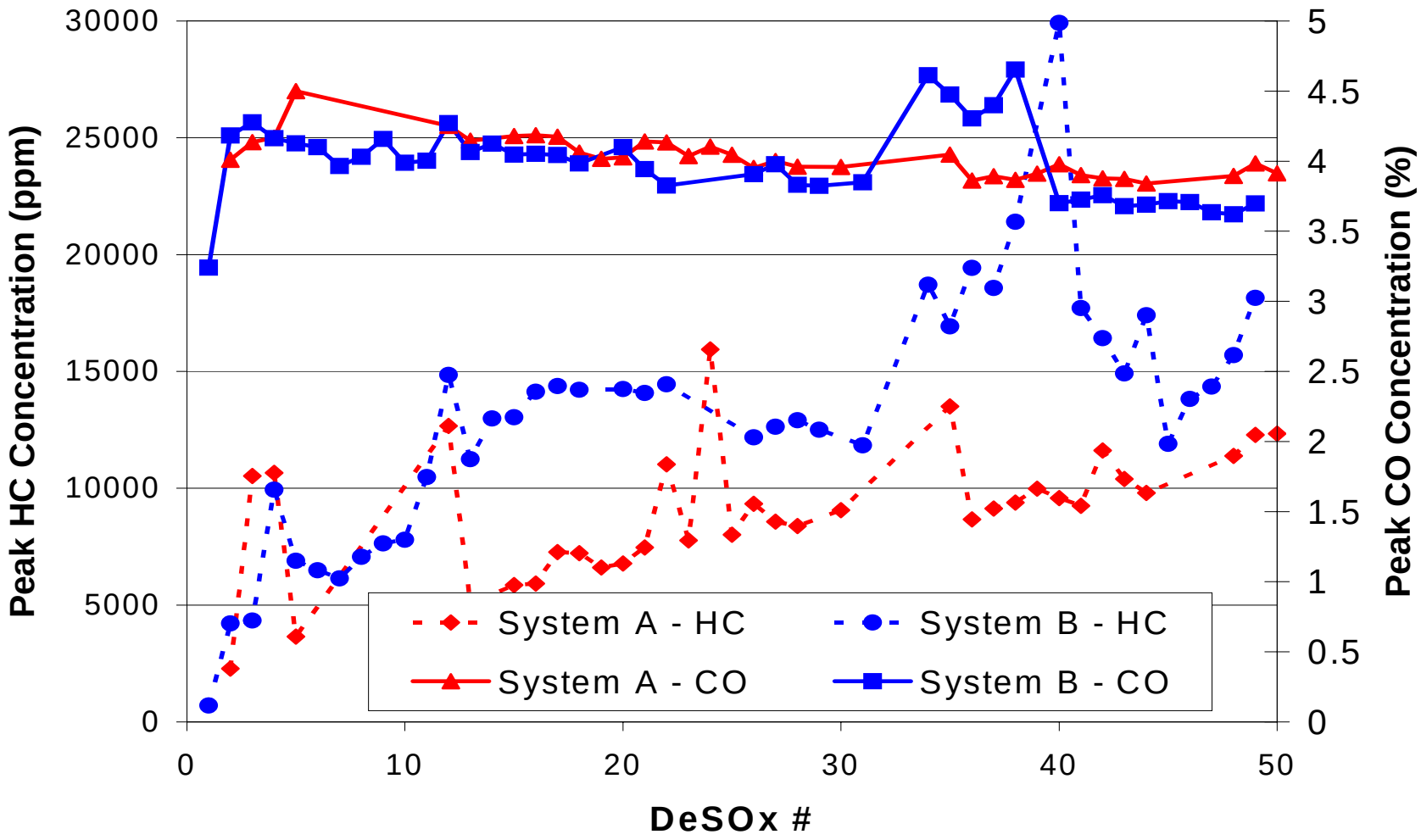
Accelerated Aging

CO and HC Emissions at the Inlet to the LNT during Desulfations over 50,000 mi Equivalent Aging



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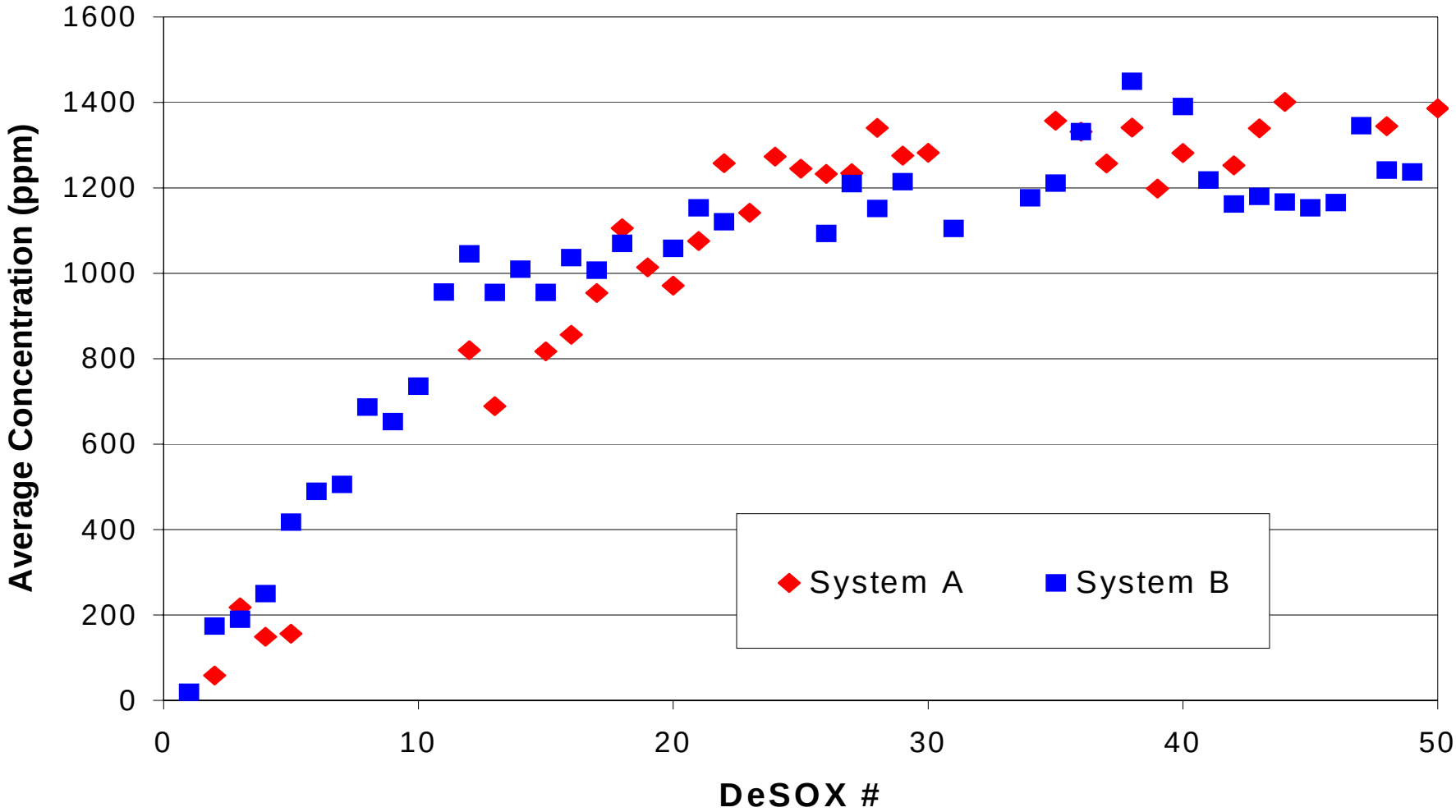
Accelerated Aging

Average HC Concentration at Inlet to LNT During Desulfations over 50,000 mile Equivalent Aging



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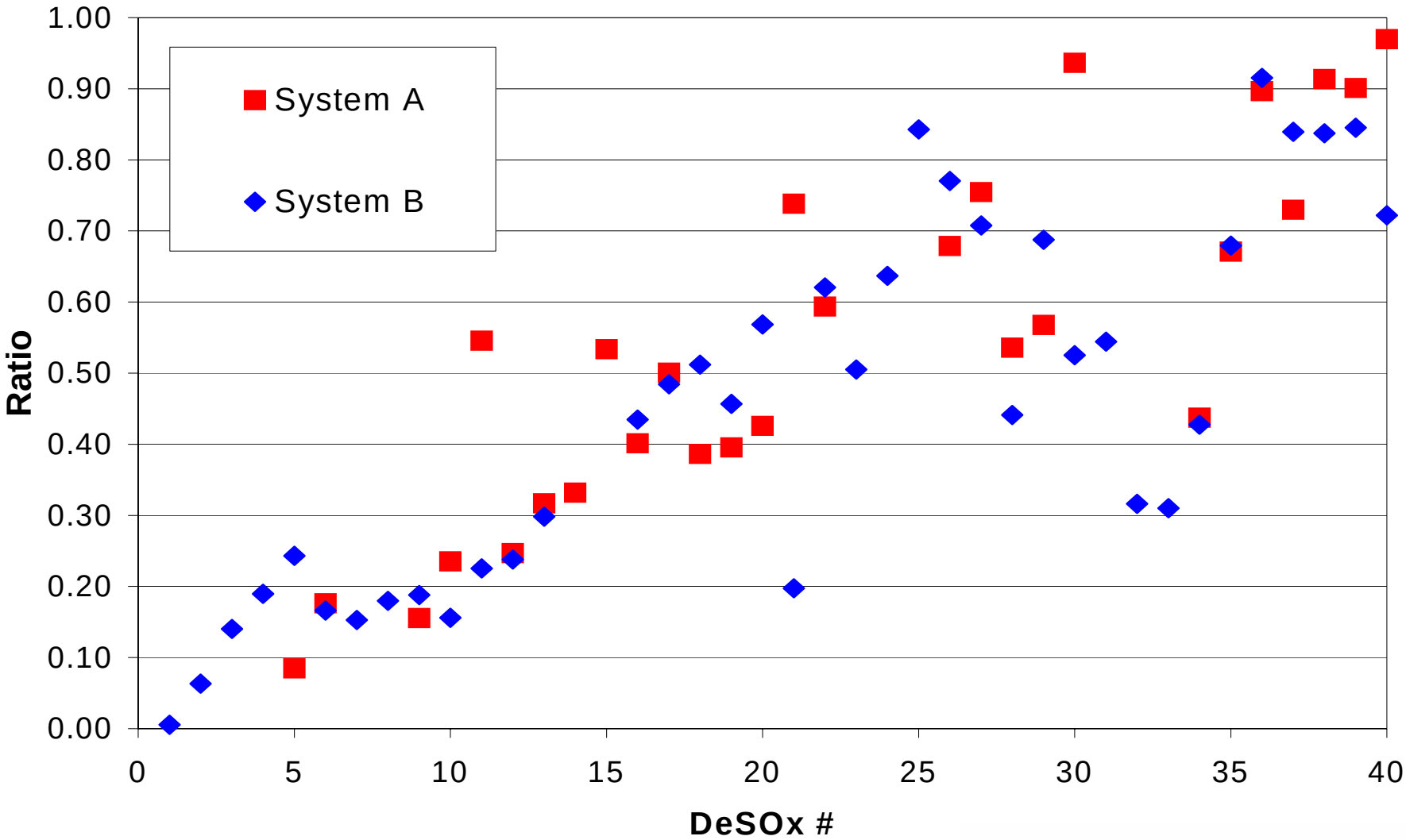
Accelerated Aging

Fraction of Sulfur Removed as H2S



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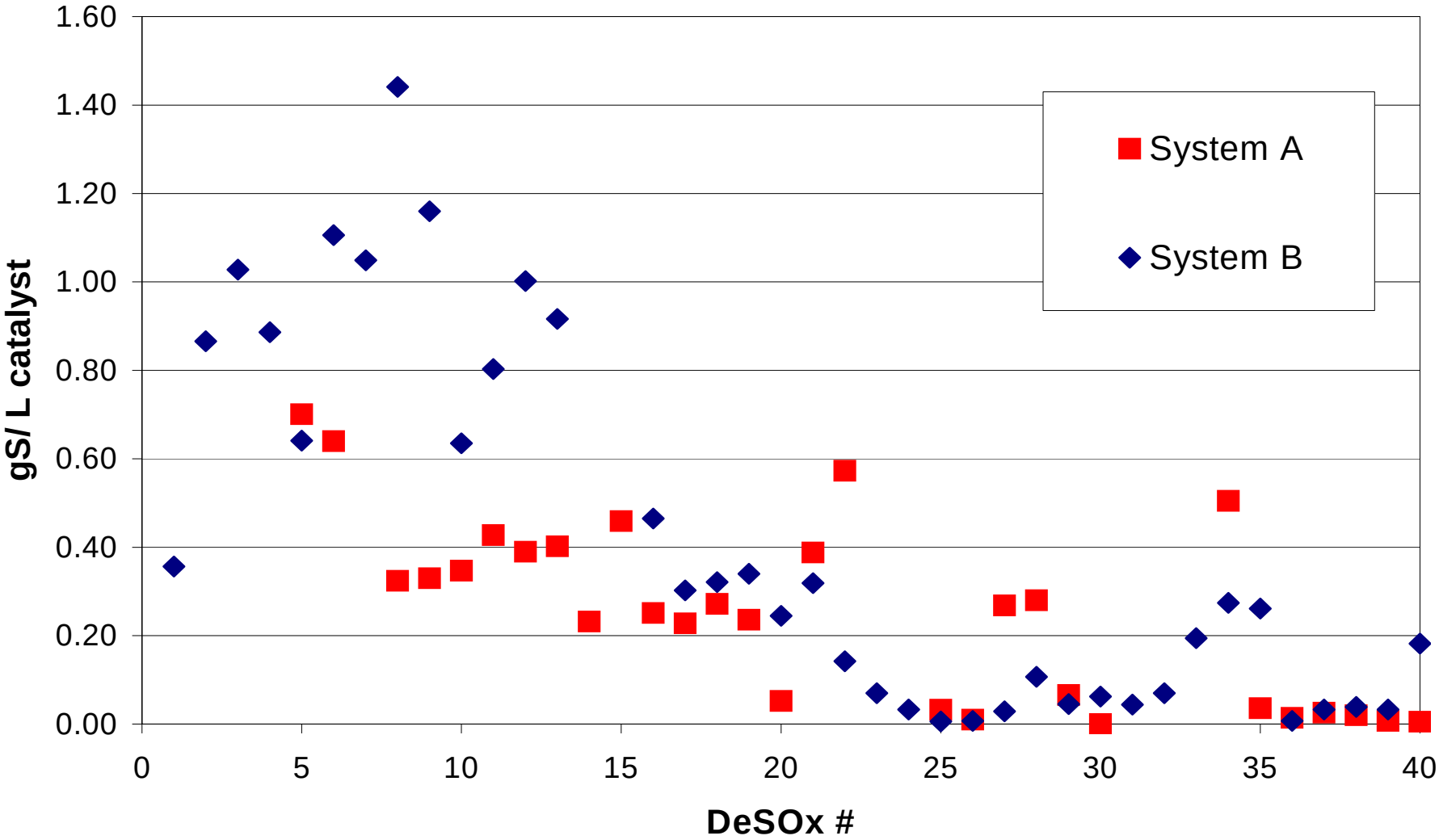
Sulfur Removed as SO2



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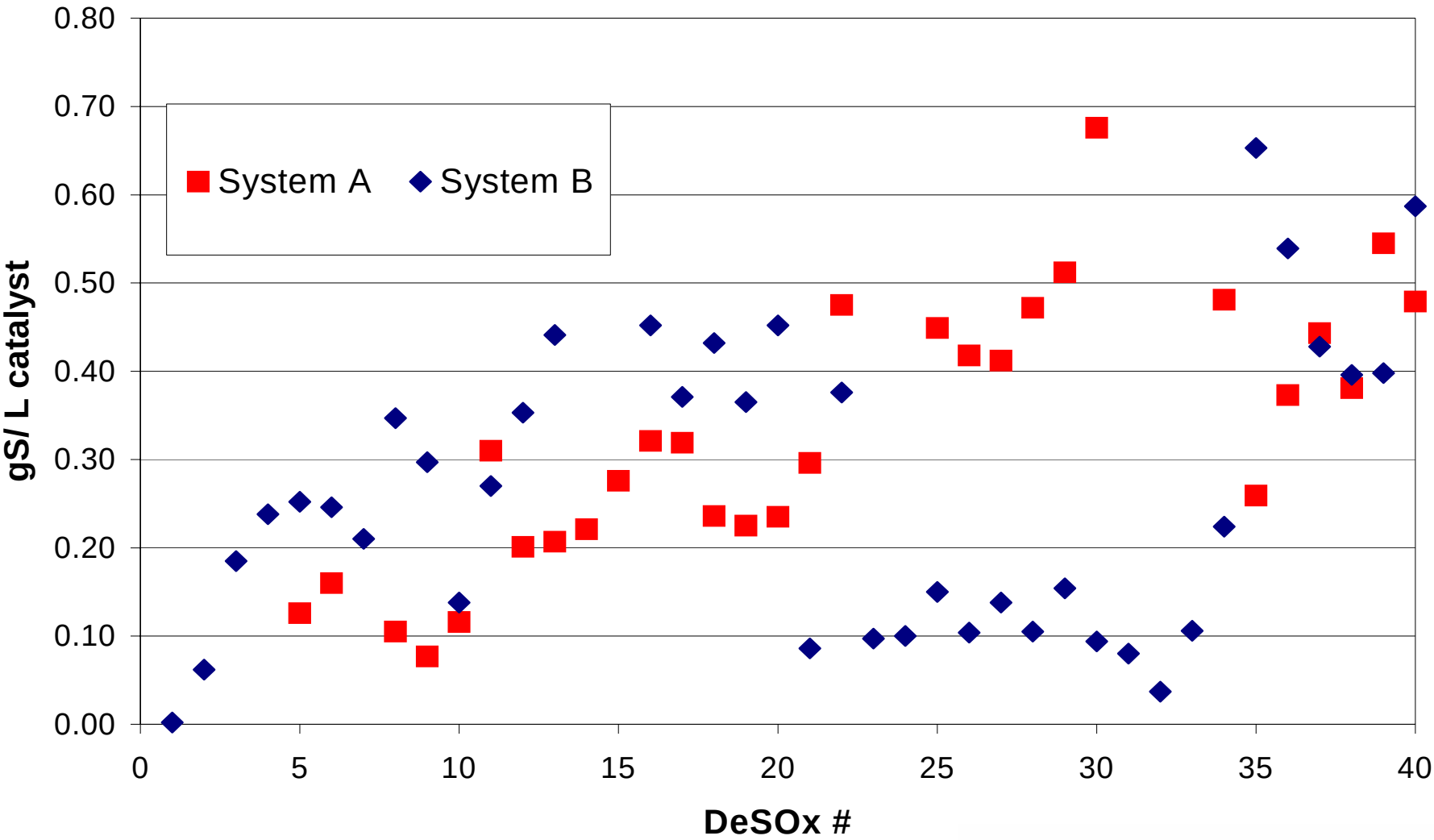
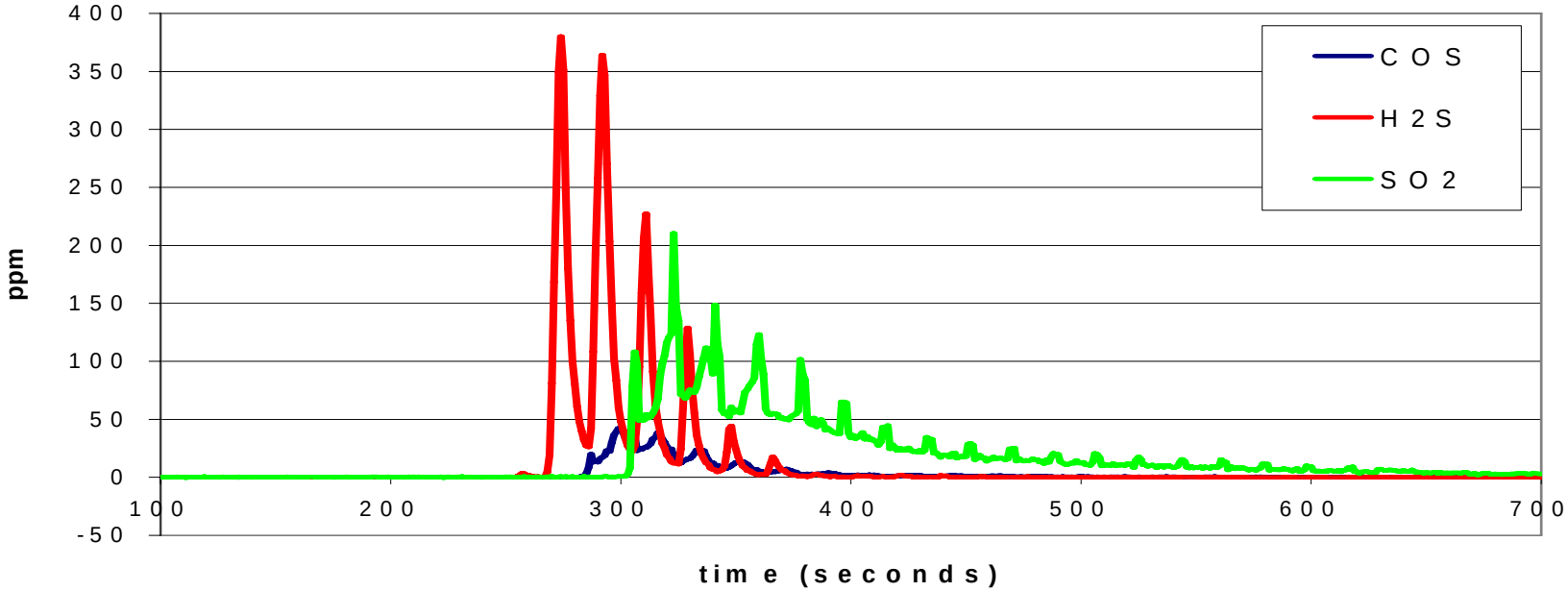
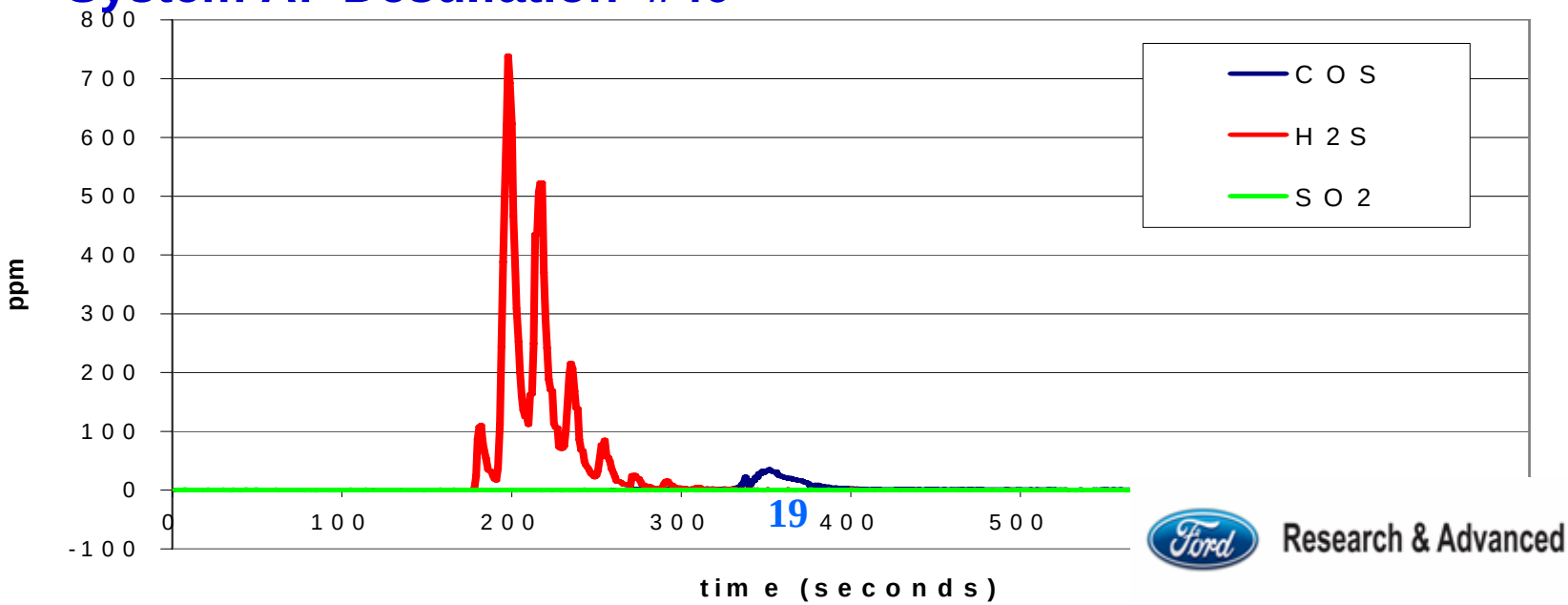
Sulfur Removed as H2S



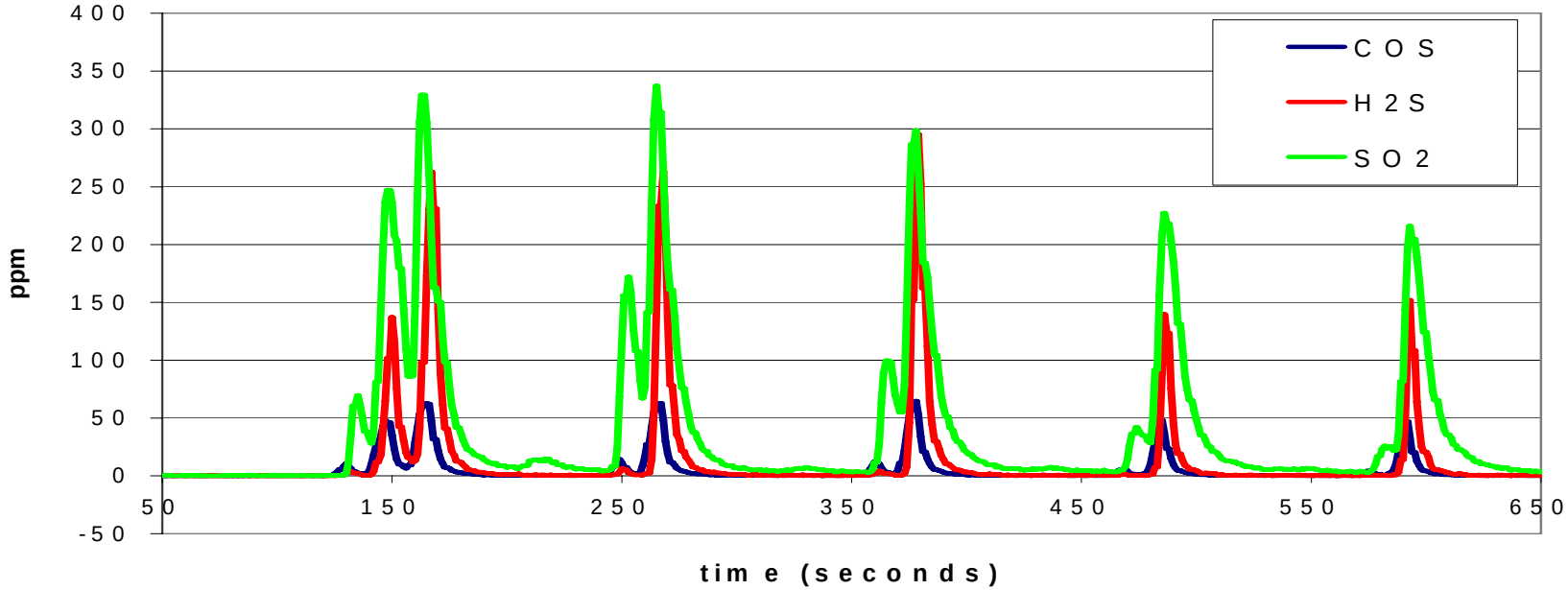
System A: Desulfation #12



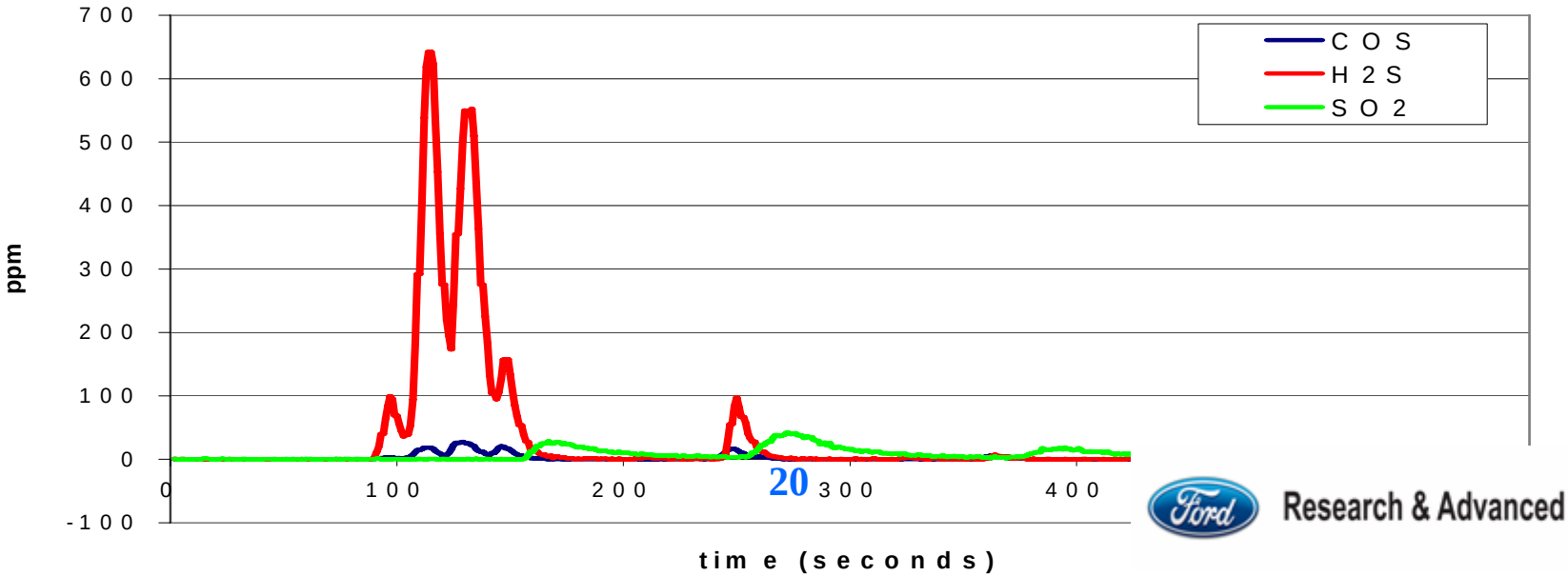
System A: Desulfation #40



System B: Desulfation #12



System B: Desulfation #40



Summary

- Rich conditions are necessary for the sulfur removal, however extending the rich time beyond a couple of minutes was not beneficial.
- Most of the sulfur release occurred at onset of switching to rich conditions after an extended lean period.
- The protocol used on System B better utilized the 10 minutes desulfation period due to lean/rich switching.

Summary

- For both protocols, SO2 production diminished over the course of the aging.
- The reduced amount of SO2 was offset by higher H2S emissions, although the total sulfur removed was still lower at the end of aging.
- The advantage of the lean/rich switching during desulfation diminished as the catalyst aged.