Observations on the performance and control of 2008 Dodge Diesel Ram emissions system over 30,000 miles

Ken Price

Umicore Autocat USA

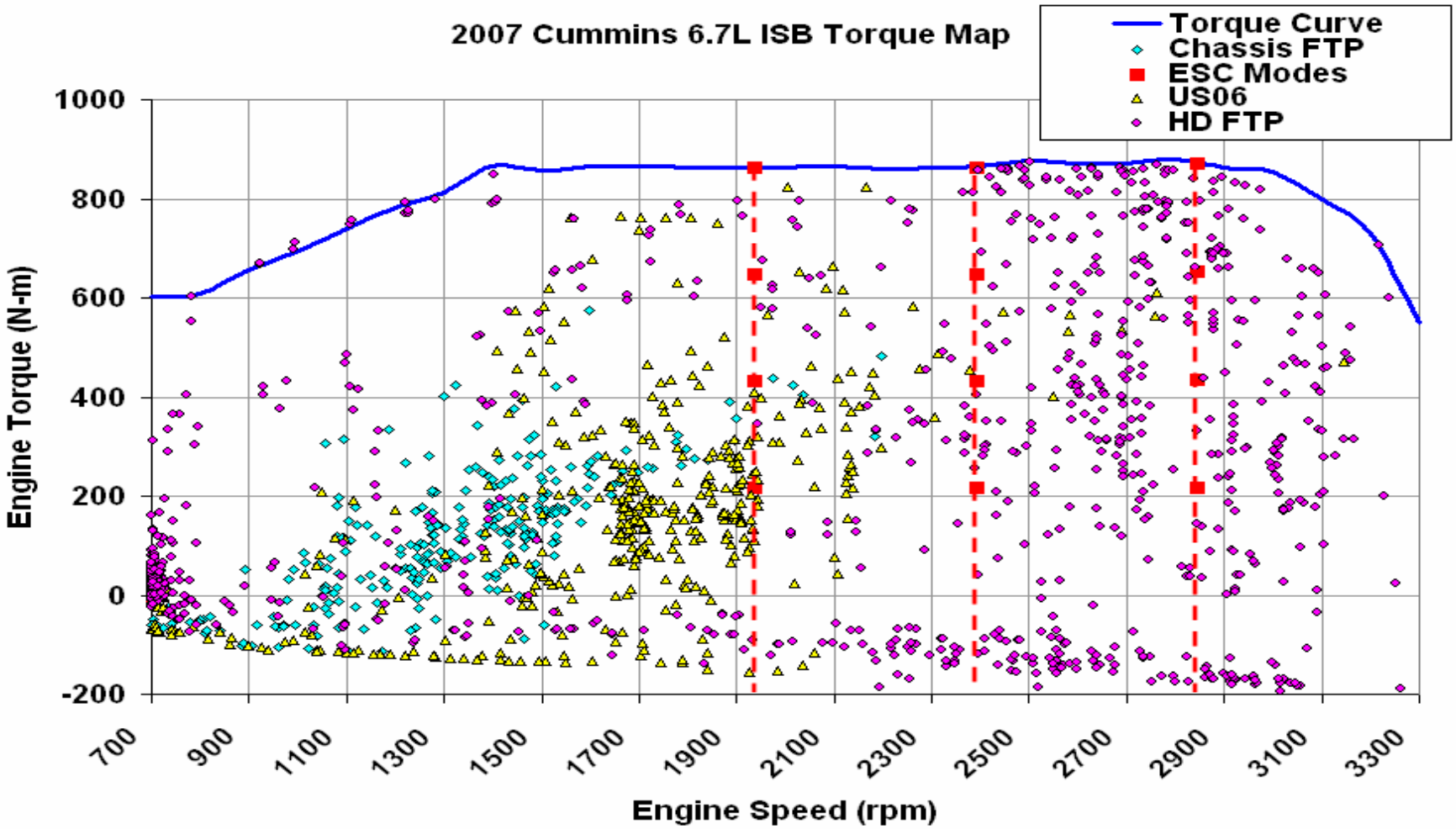
2008 Cummins - Dodge Ram2500HD
Exhaust System and Certification

EPA Certified to optional HD Chassis Cert for 8500-10,000 lb complete vehicles
(CARB MDV 8501-10,000 GVW similar except HCHO 1.0 vs STD 16 mg/mi)

Mfr Name	Division	Carline	Displ	ETW	Ax Ratio	U Life	Emission	Cert Level	Standard	Tier
CUMMINS	Dodge	RAM 2500 PICKUP 4WD	6.7	8500	3.73	120	CO	0.7	7.3	HDV
CUMMINS	Dodge	RAM 2500 PICKUP 4WD	6.7	8500	3.73	120	HC-NM	0.058	0.195	HDV
CUMMINS	Dodge	RAM 2500 PICKUP 4WD	6.7	8500	3.73	120	NOX	0.2	0.2	HDV
CUMMINS	Dodge	RAM 2500 PICKUP 4WD	6.7	8500	3.73	120	PM	0	0.02	HDV

Table Excerpt from www.epa.gov/otag/crttst.htm

HD FTP & SET vs FTP75 & US06 for Dodge 2008 ISB HD Chassis Cert <10,000 GVW

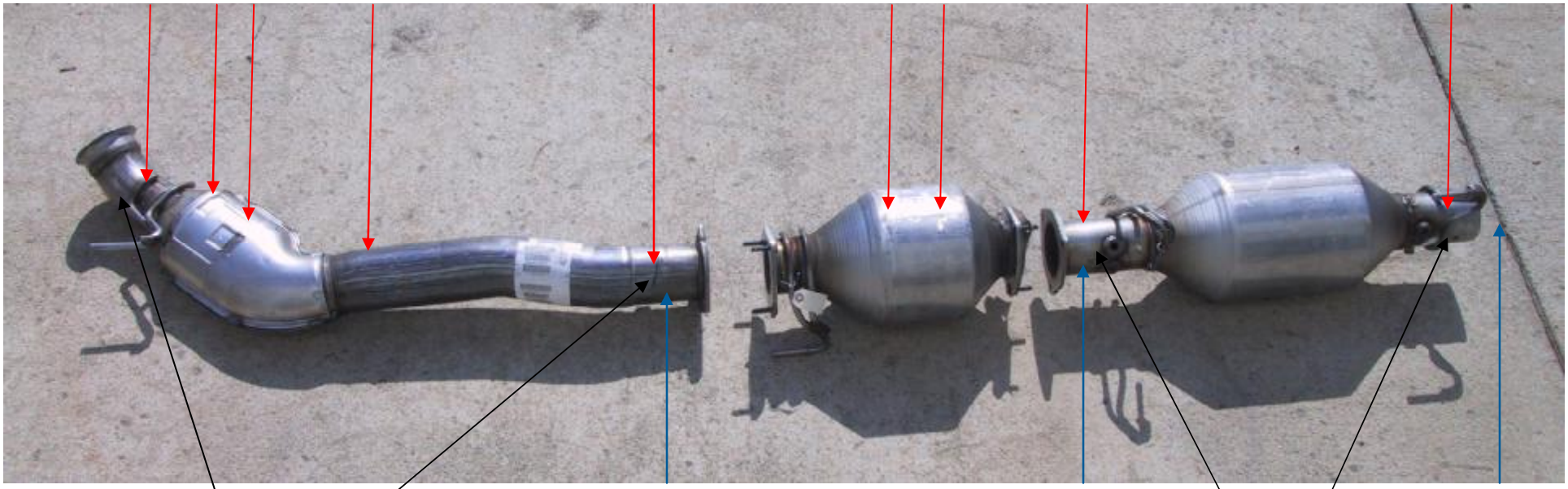


Data courtesy Southwest Research Institute® Heavy Duty Benchmarking Program

2008 Cummins ISB - Dodge Ram 2500HD Exhaust System Instrumentation Added

Temperatures (Thermocouples)

DOC In
DOC Beds @ 1” & 3”
DOC Out
LNT In
LNT Beds @1” & 4”
DPF In
DPF Out



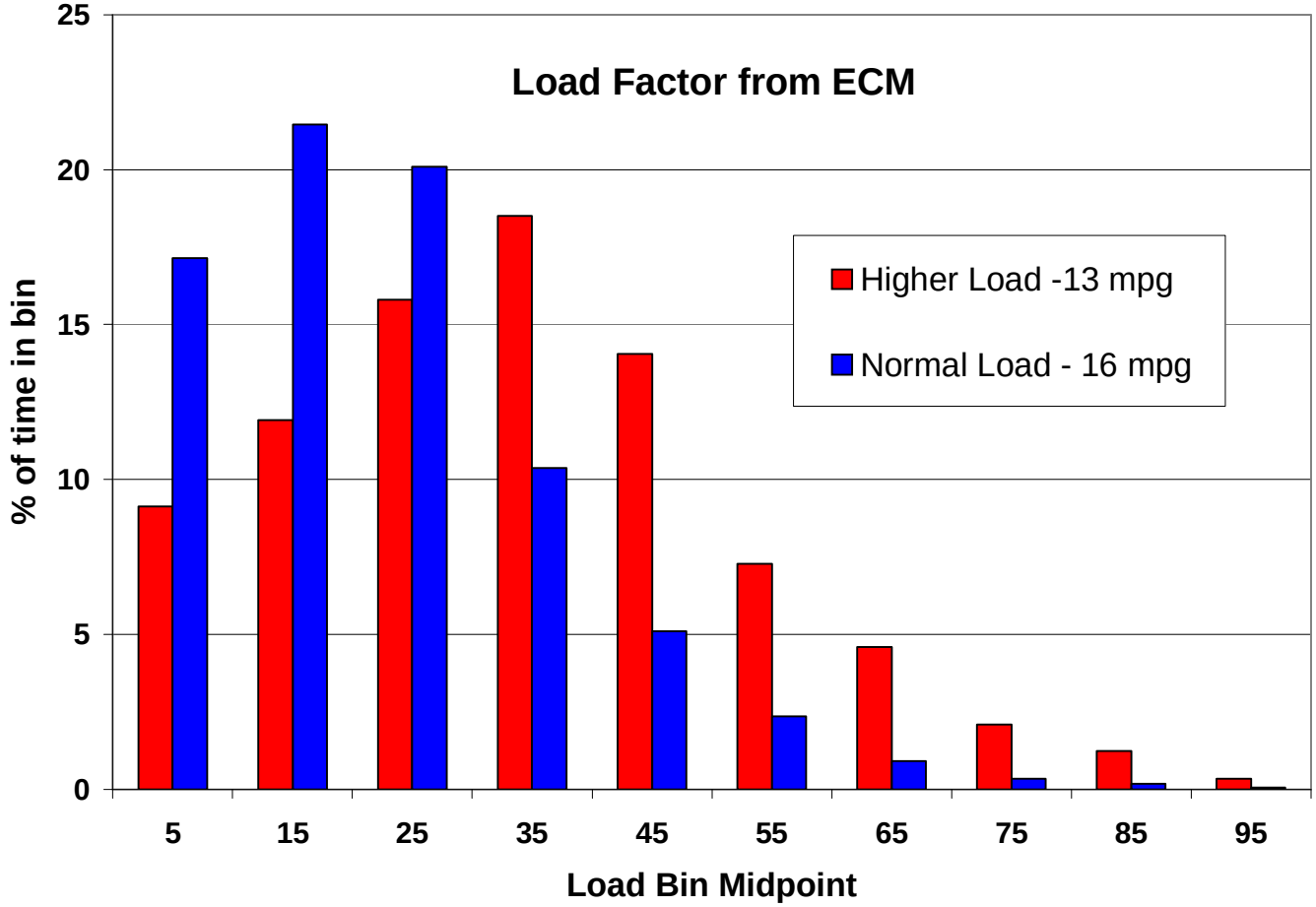
Lambda LNT In
Lambda LNT Out
Lambda DPF Out (Pipe)

Data Logger Pressure + “Engine Out” Modal Emissions Sample Location Options

Additional data was recorded from the ECM via CAN link, and observations were made using dealer type scan tool, “StarSCAN”

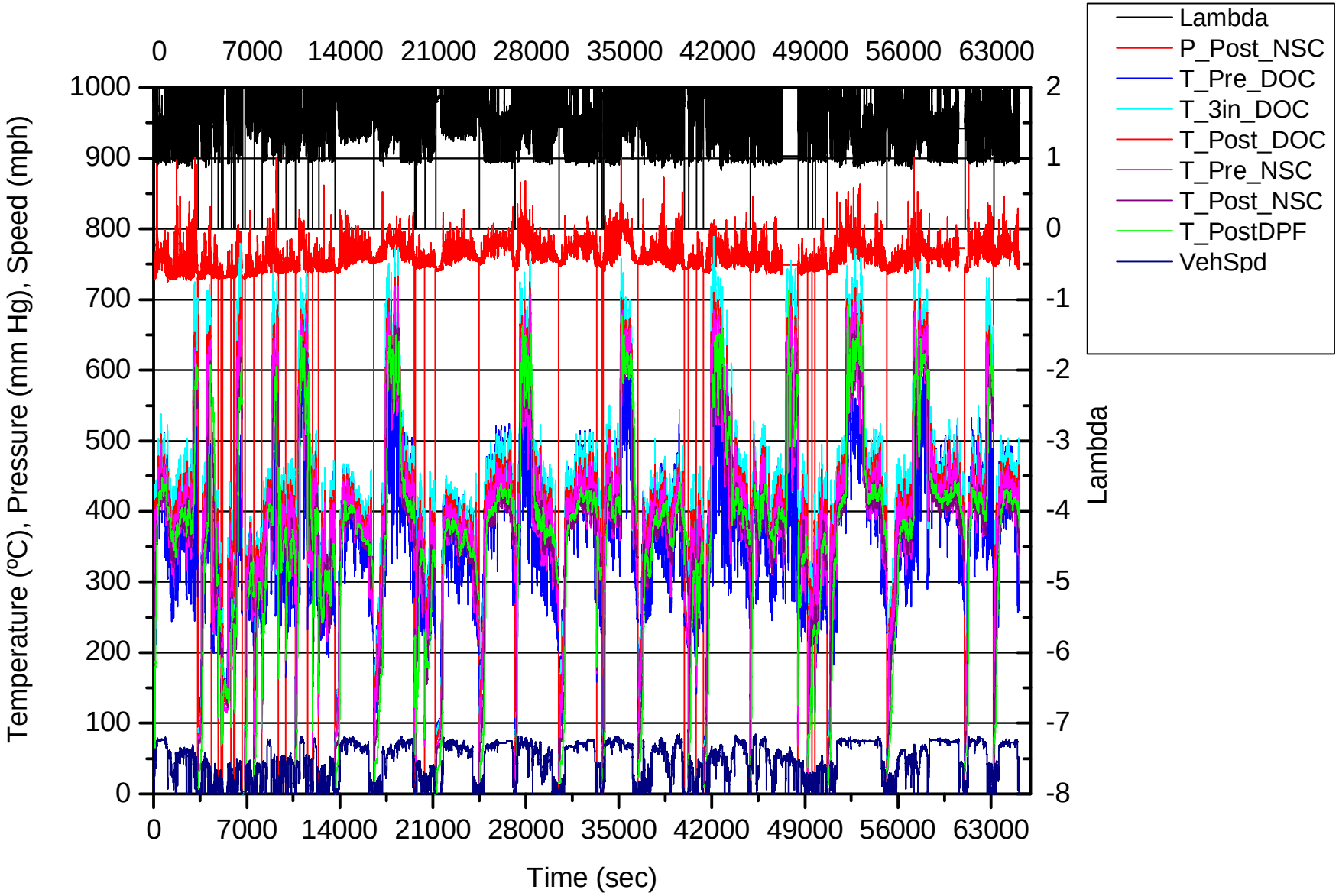
Data Logger Pressure+ “Tailpipe” Modal + Bag Emissions Sample Location Options

Load Factor from ECM and Fuel Economy – Normal and High Load (Towing & Grades)

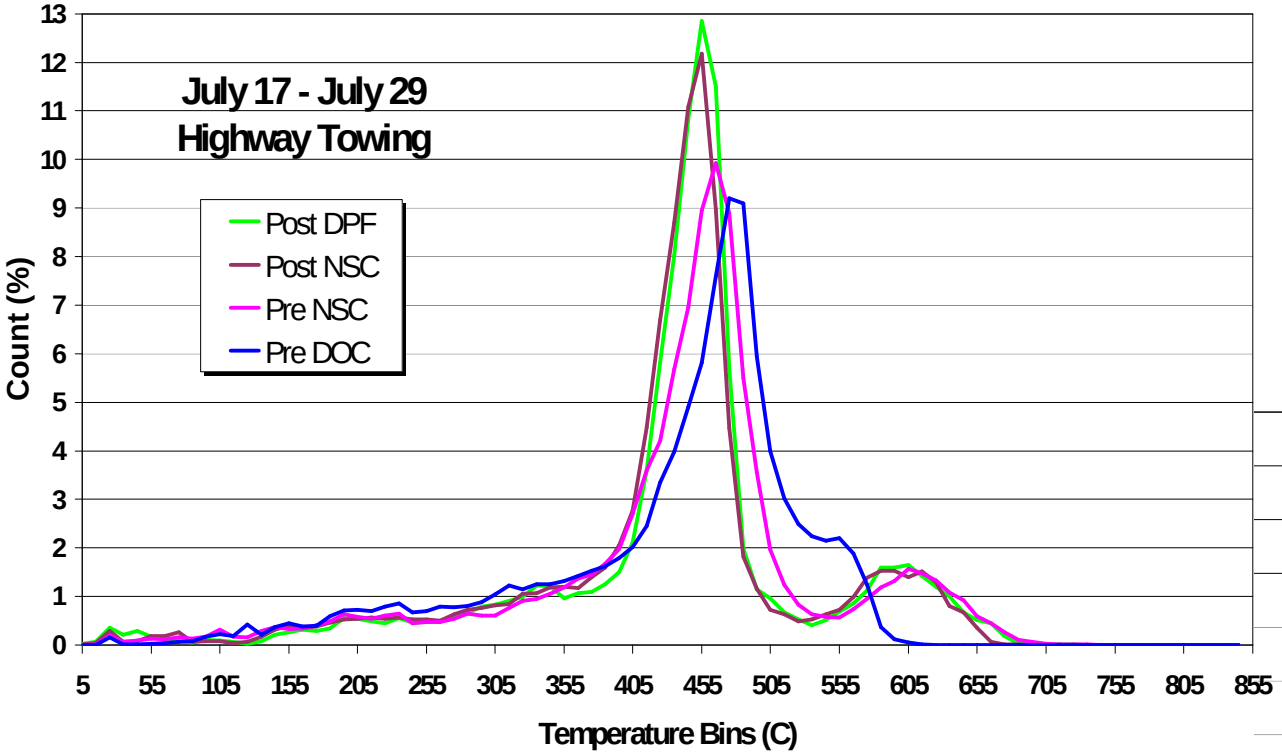


"Normal" driving: First 19,119 miles (Commuting, short trips, light towing)
Higher Load: 3619 mile round trip to Yellowstone with ~5000 lb trailer

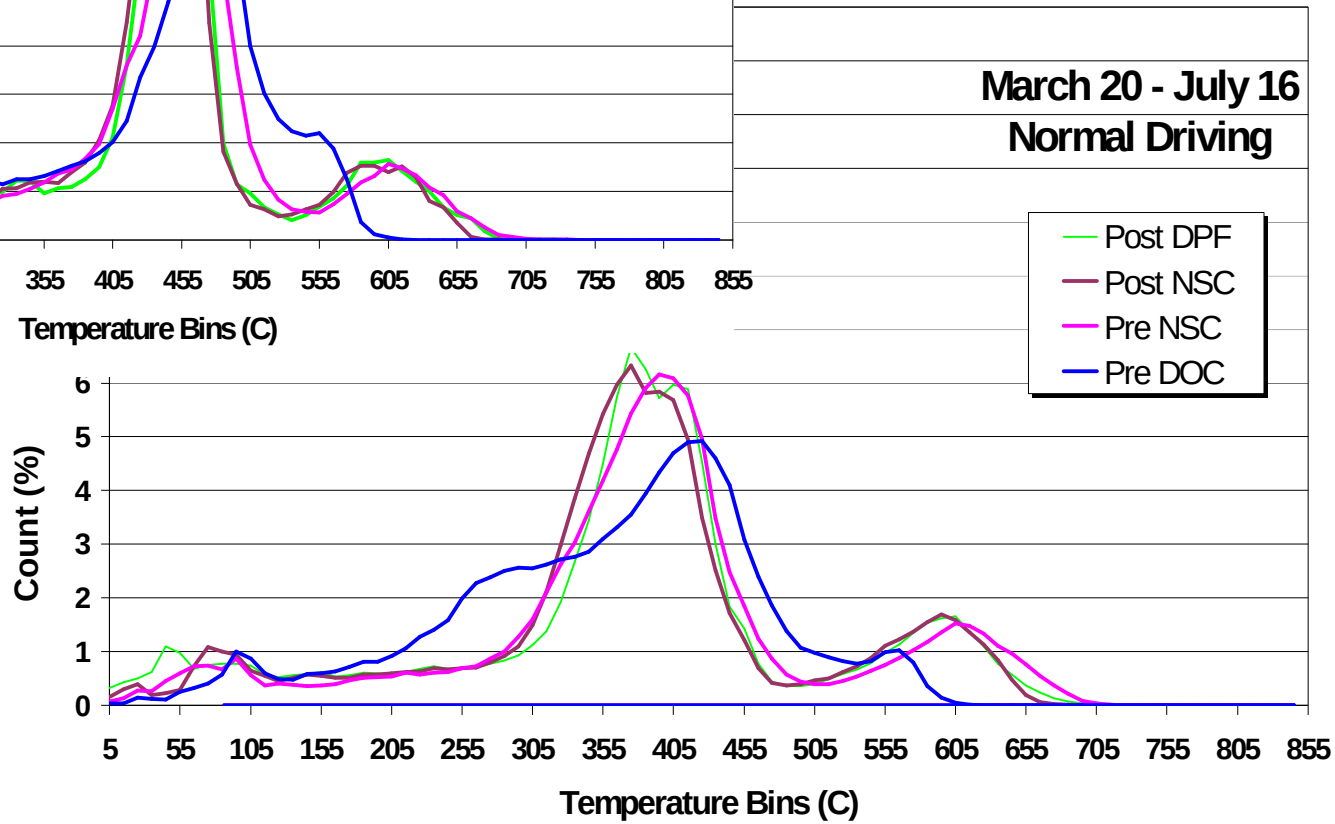
Road Data Example - Basic Operation



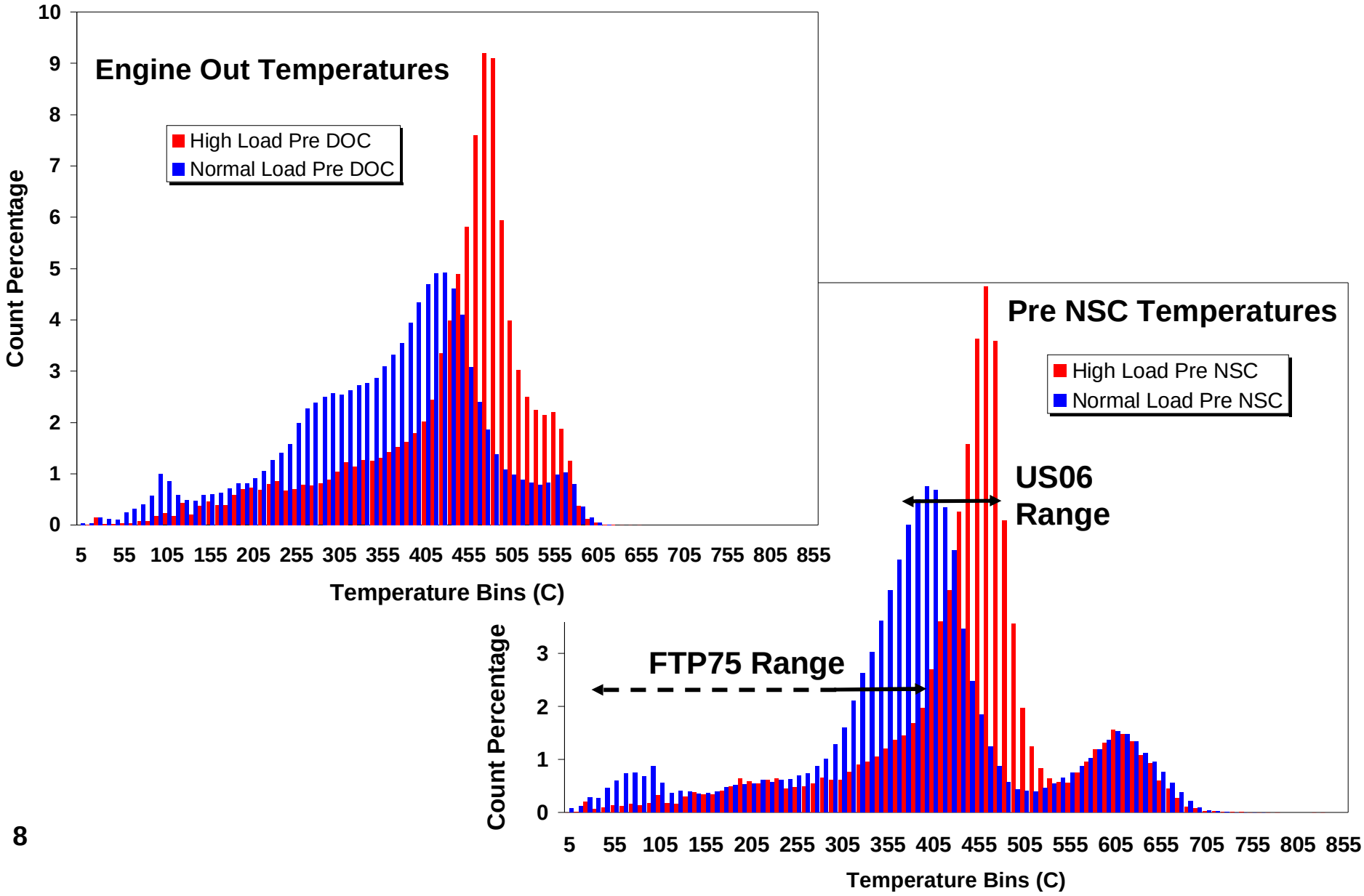
Road Aging Gas Temperatures



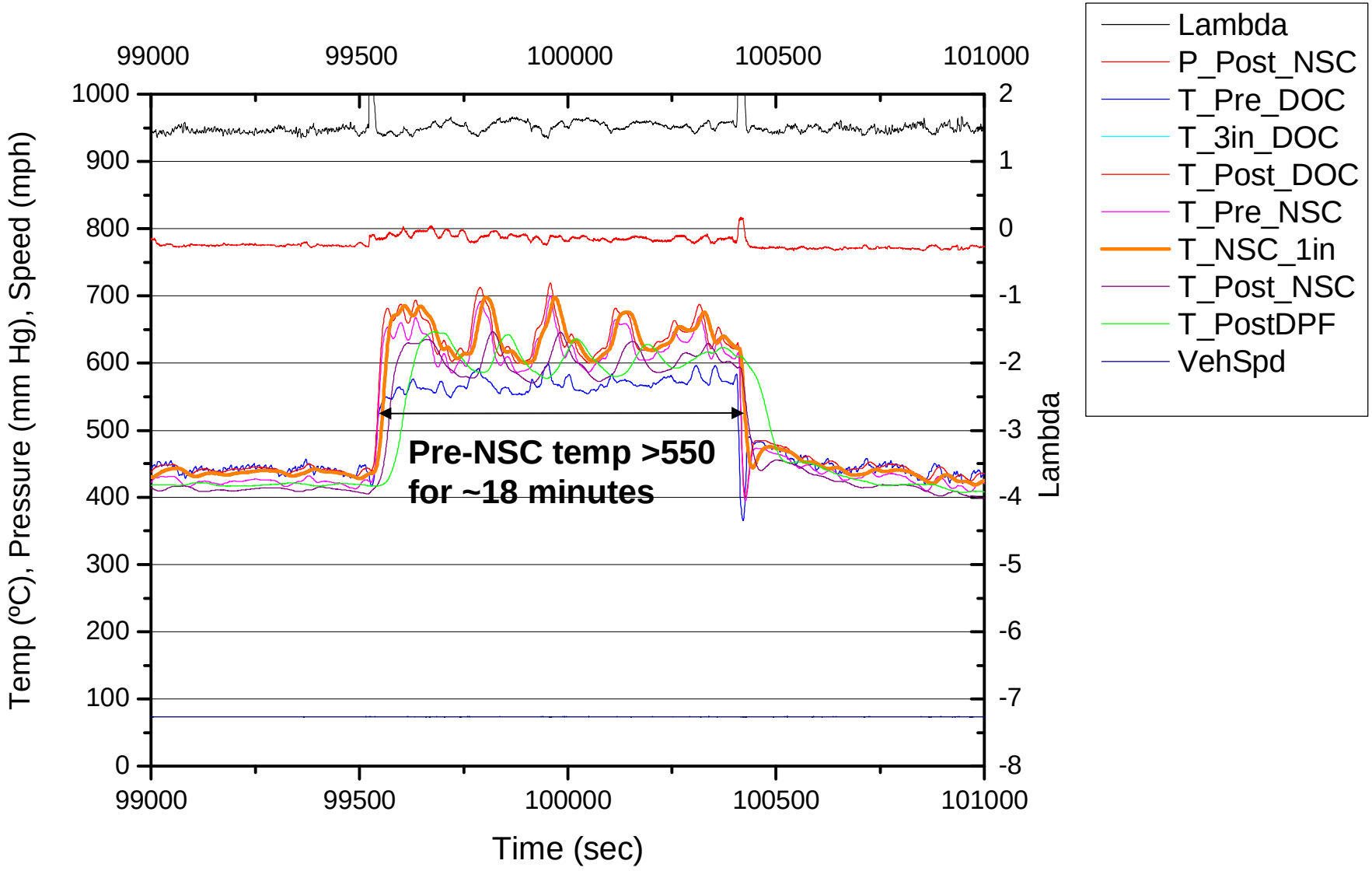
Plots: Histogram bin midpoints with 10° C bins



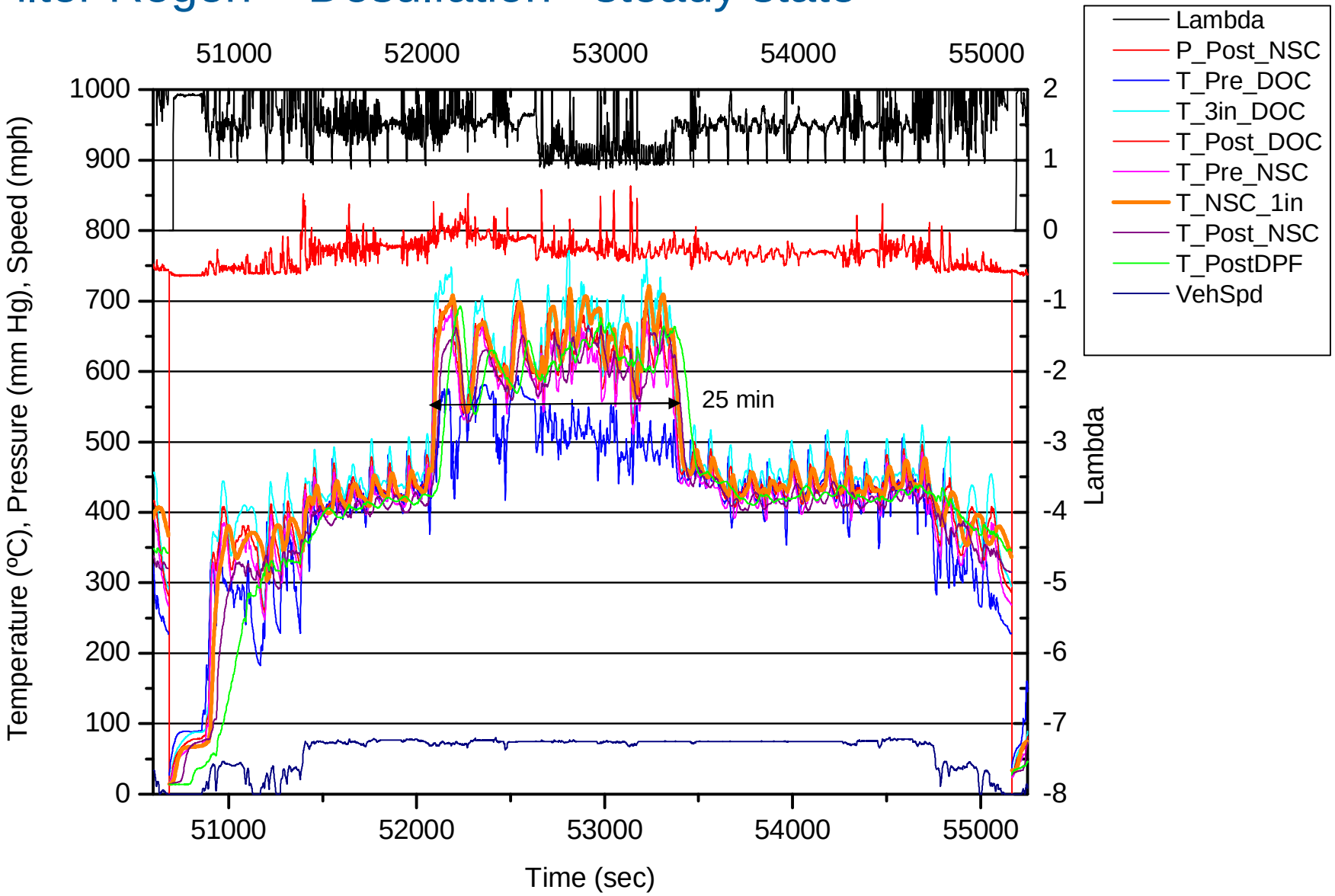
Road Aging Gas Temperatures – Comparison of normal and high load



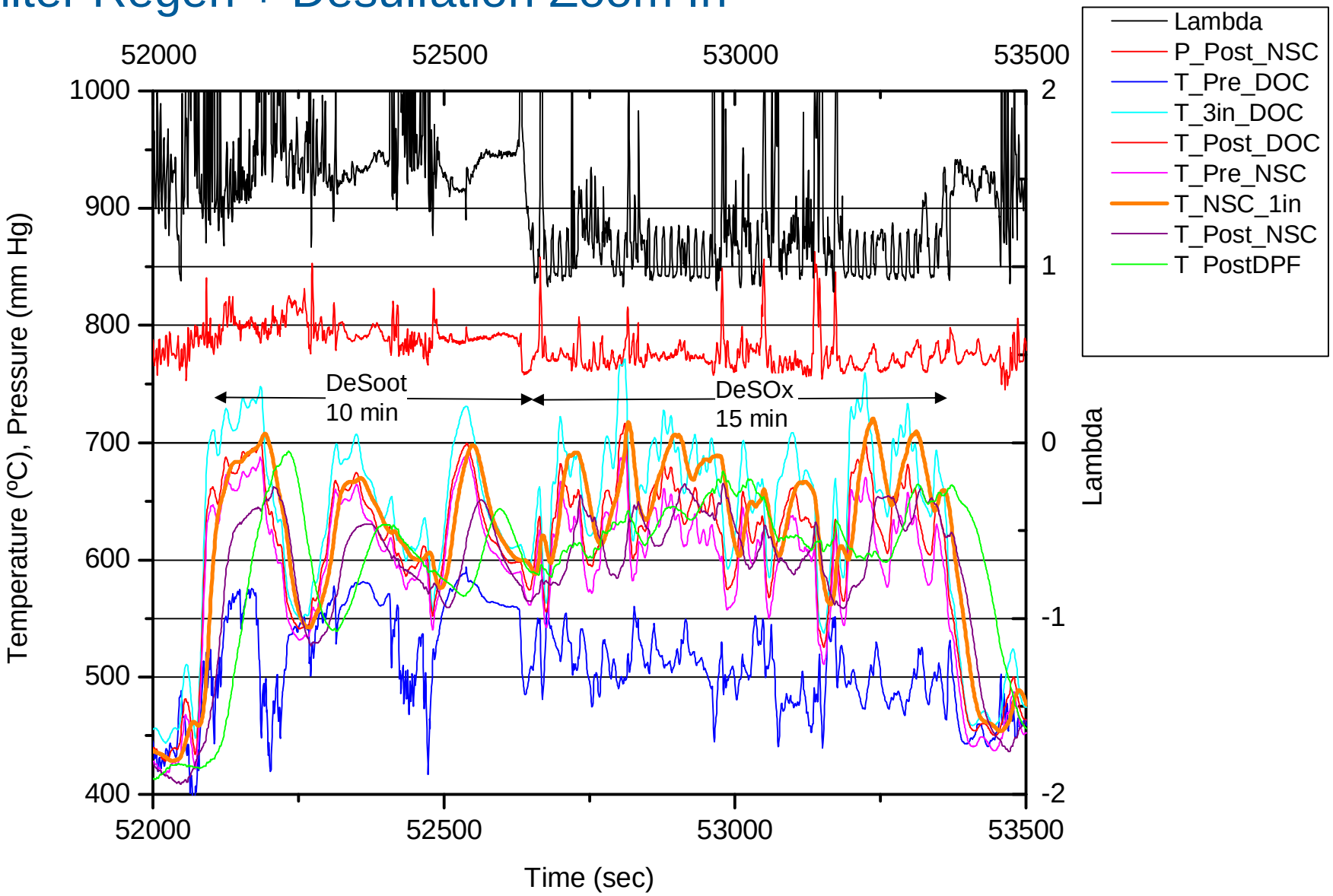
Road data example –
Normal Filter Regen ~steady state



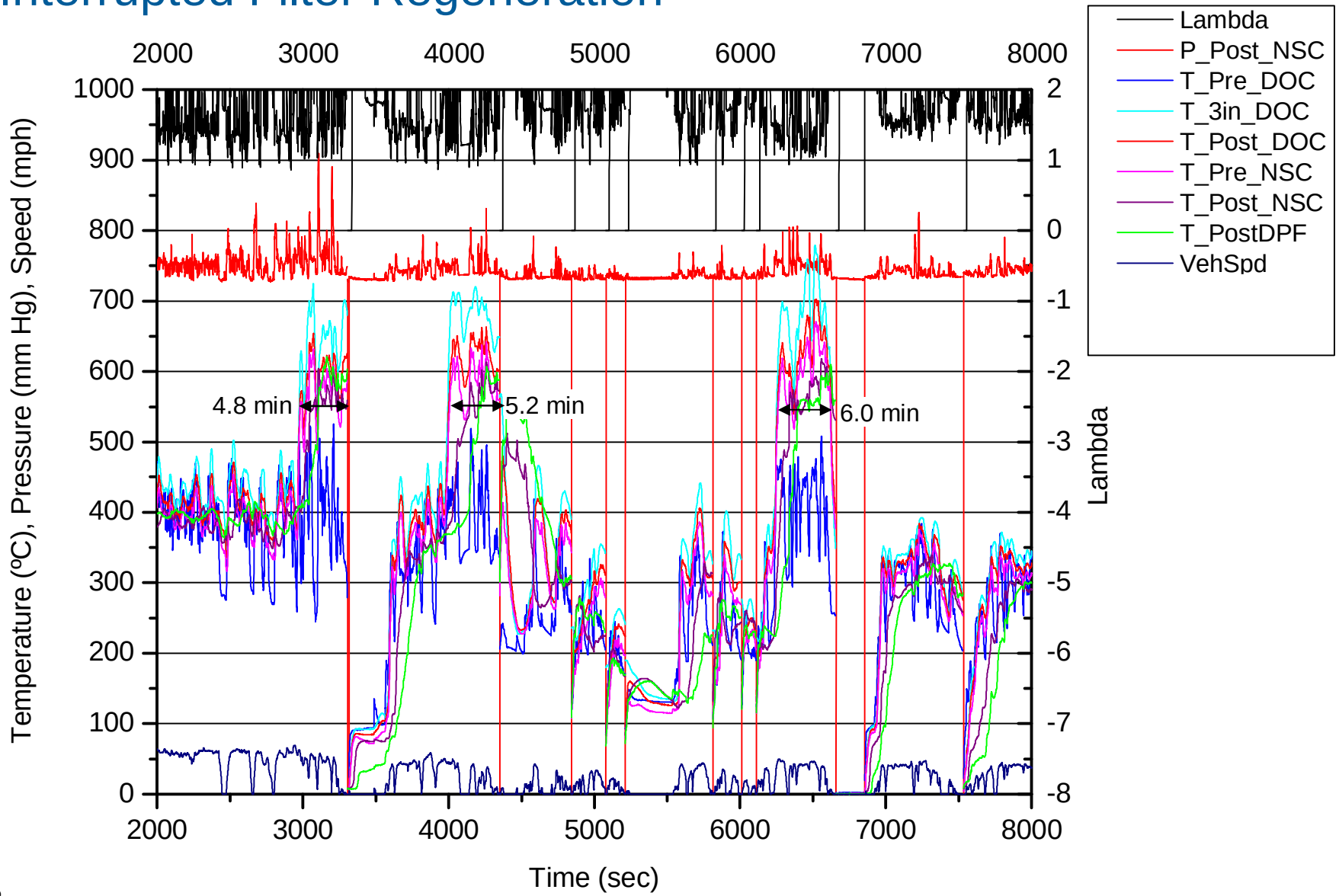
Road data example –
Filter Regen + Desulfation ~steady state



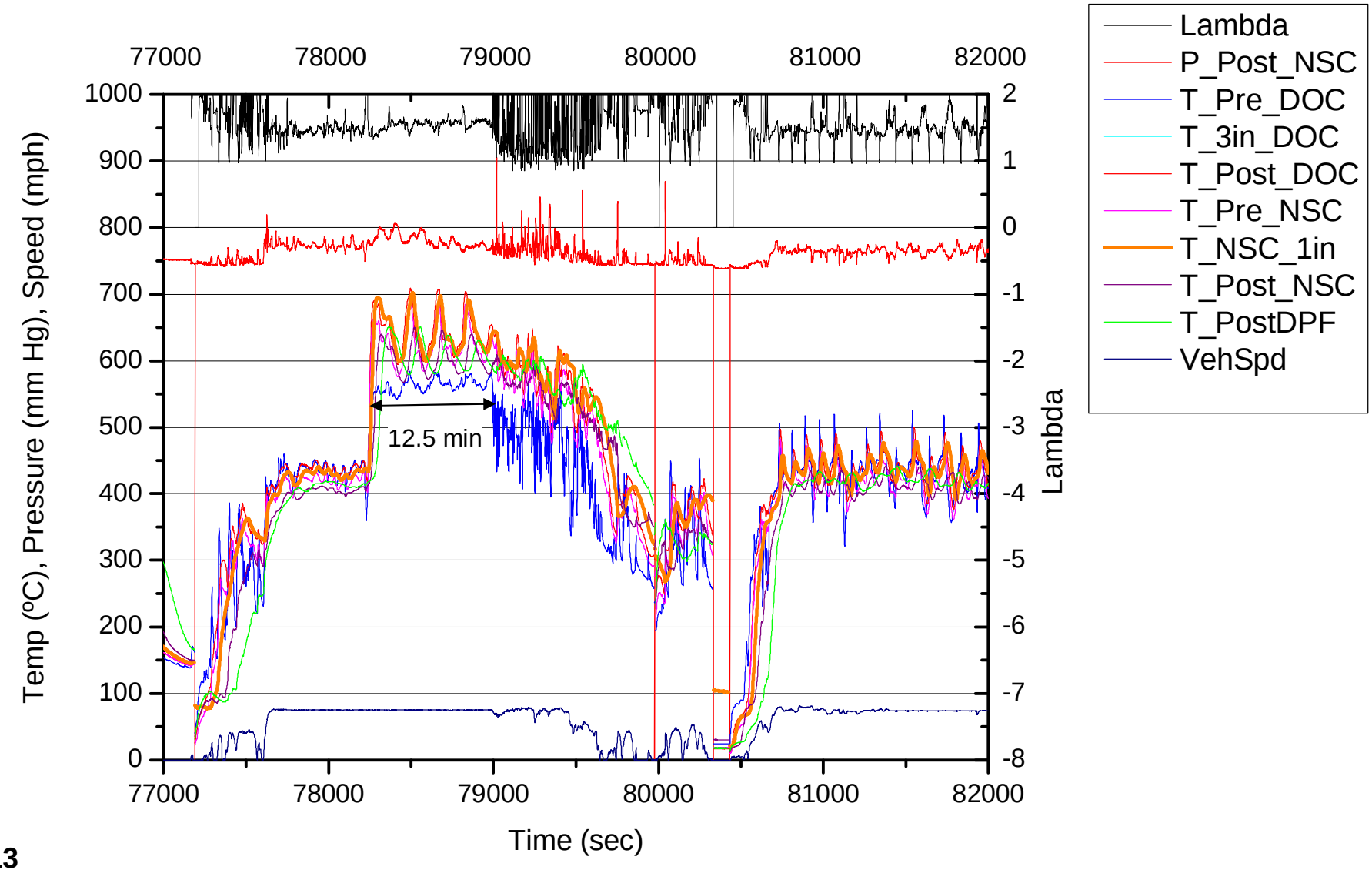
Road data example –
Filter Regen + Desulfation Zoom In



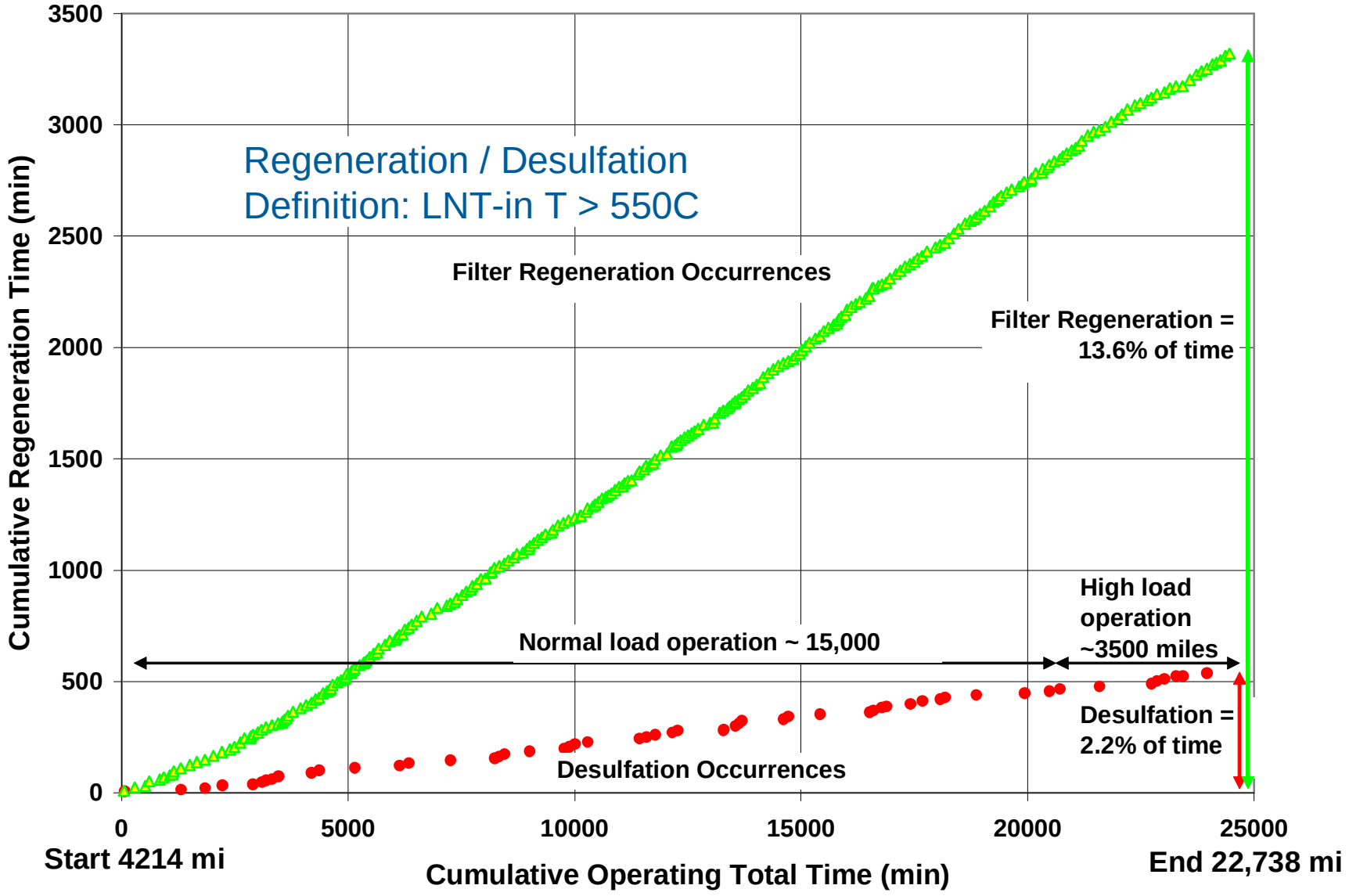
Road data example – Interrupted Filter Regeneration



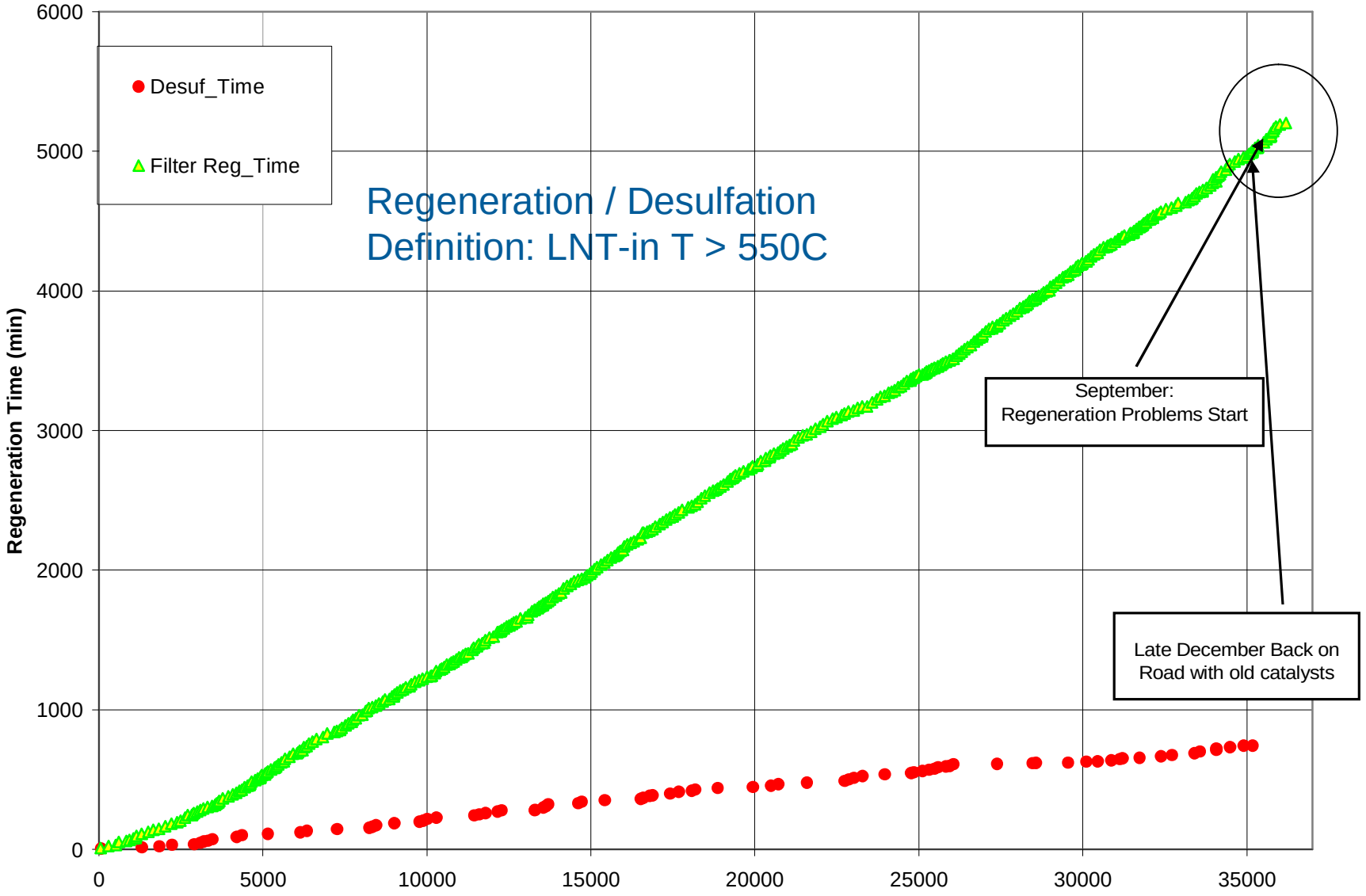
Road data example – Incomplete Desulfation



Road data summary – Filter regeneration and LNT desulfation occurrence



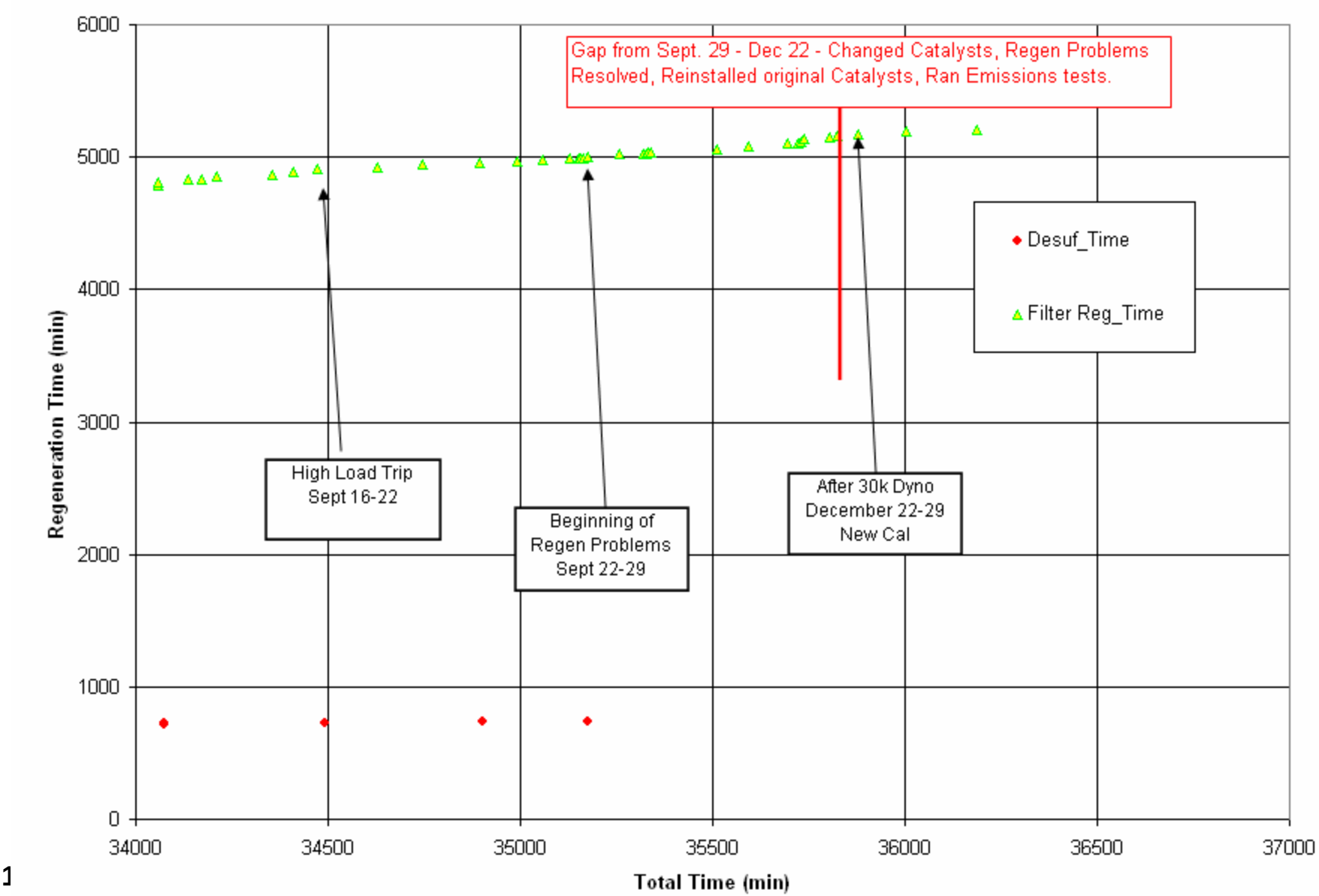
Road data summary – Filter regeneration and LNT desulfation occurrence thru ~30k



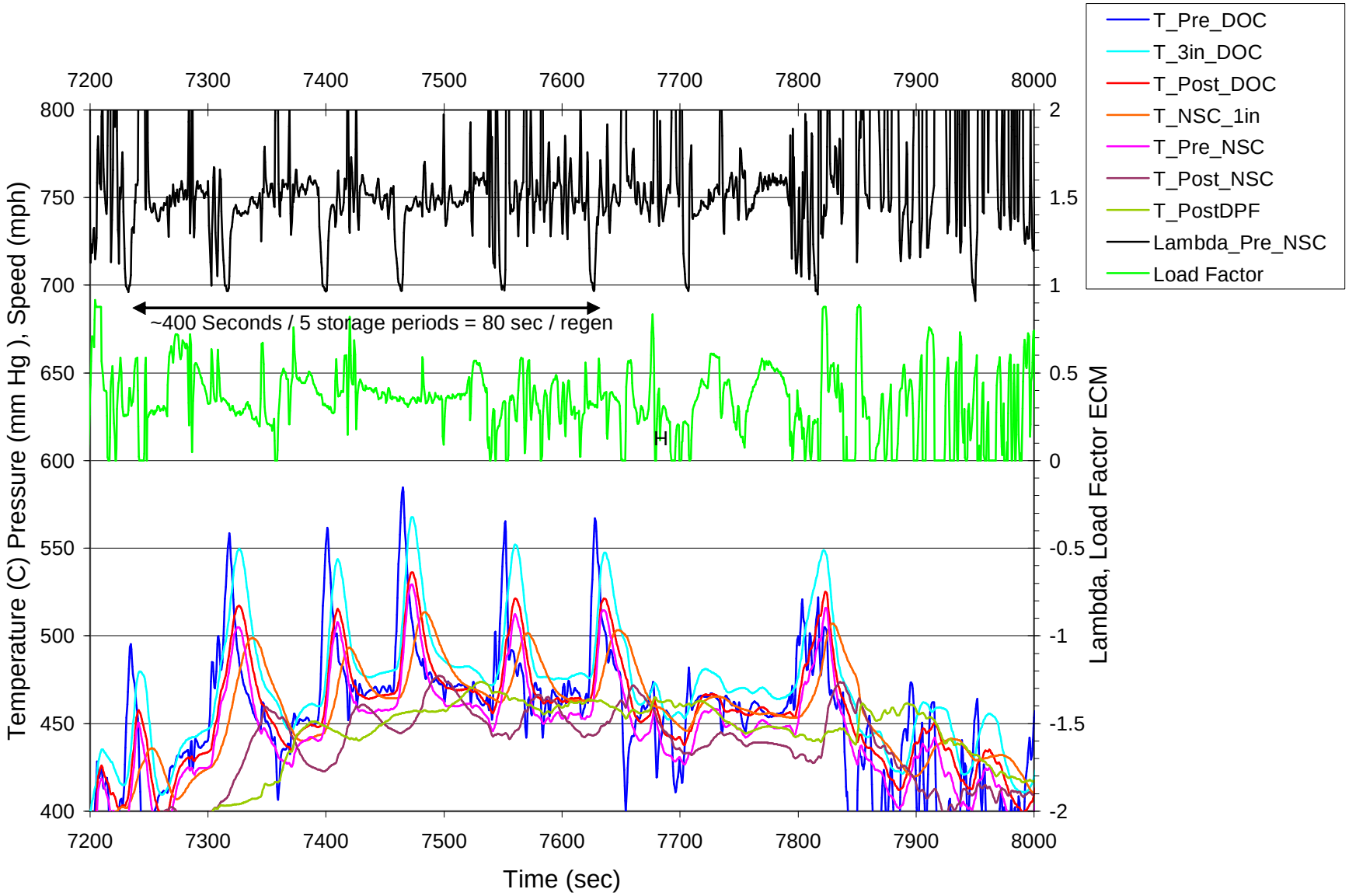
Start 4214 mi

End ~30,000 (catalyst)mi

Road data summary – Filter regeneration and LNT desulfation occurrence near 30k

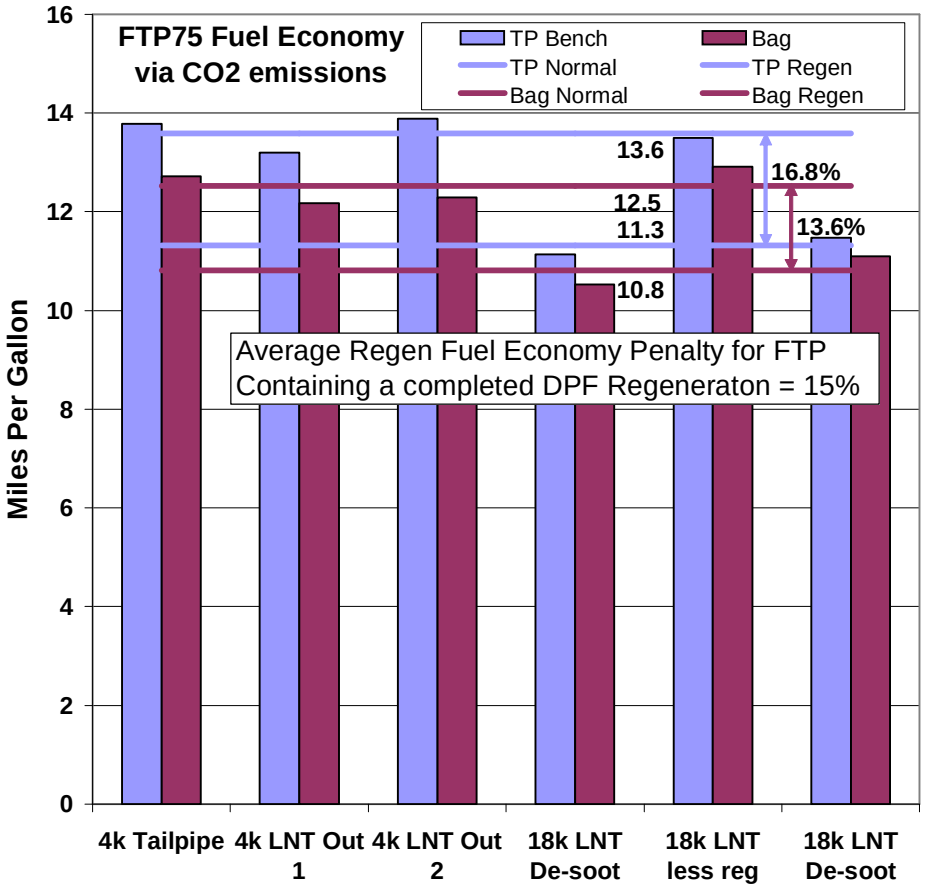


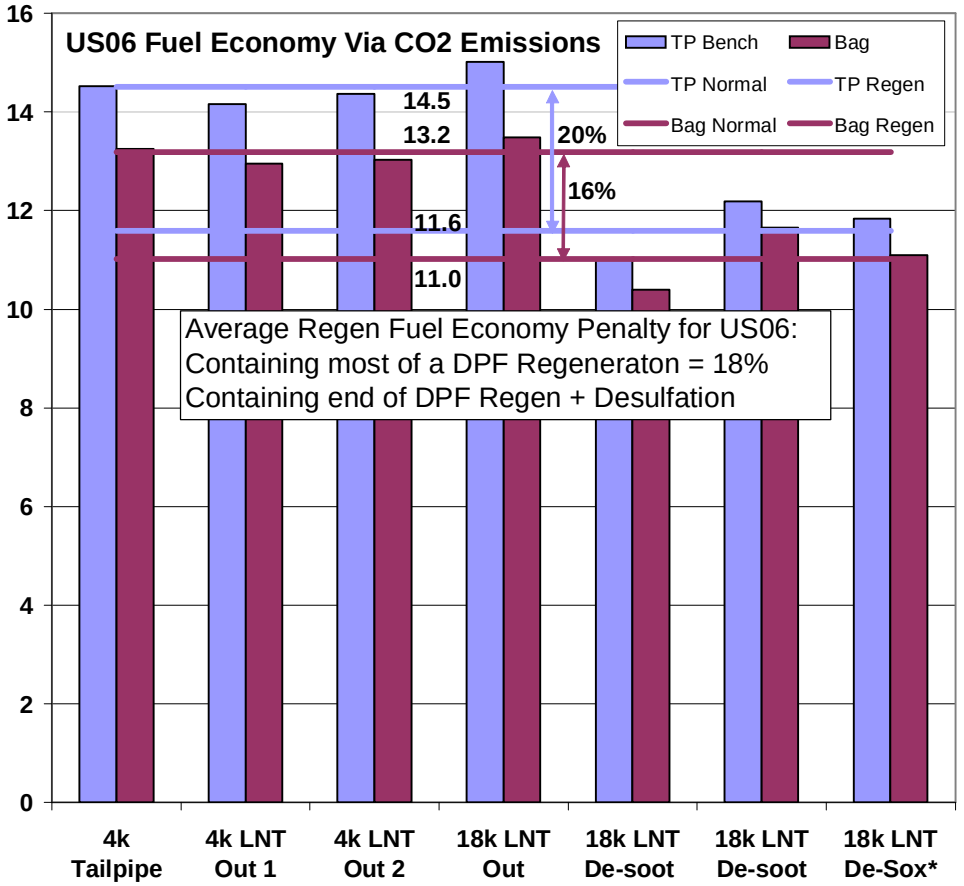
Road data example – Continuous high speed / load



Chassis emissions tests
at 4k,18k and ~30k (catalyst) miles

FTP75 and US06 Fuel Economy and Penalties





Cycle Fuel Economy Summary:

(Without DeSoot or DeSOx)

FTP (bag) = 12.5 mpg average

US06 (bag) = 13.2 mpg average

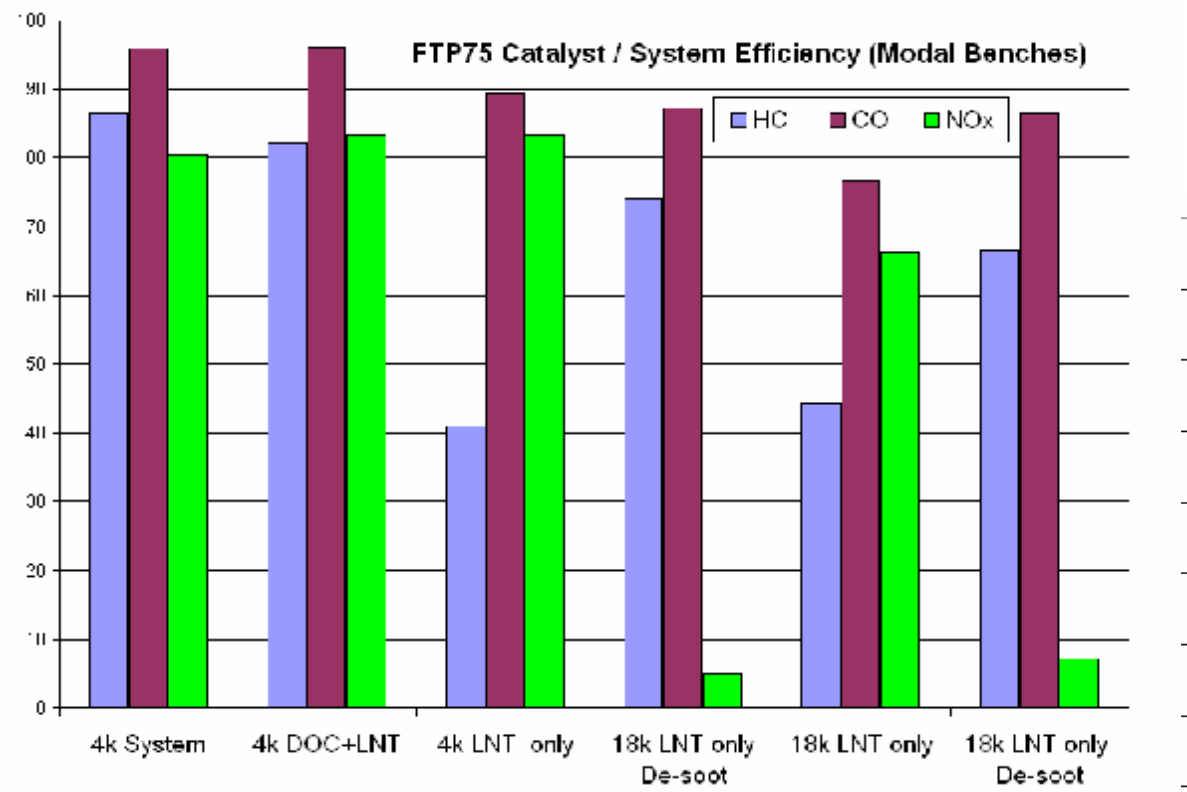
Cycle Event Fuel Economy Penalties:

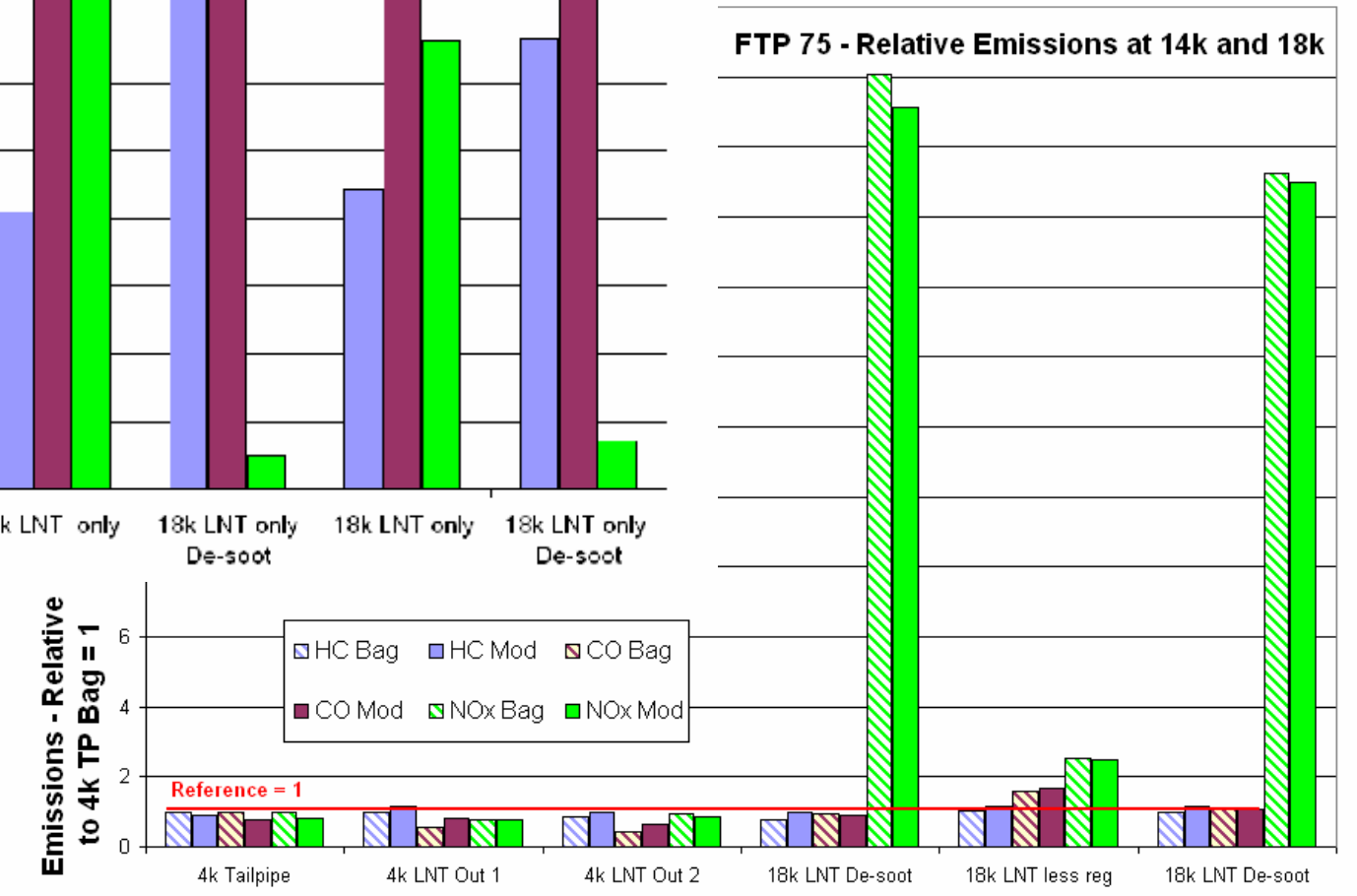
DeSoot within FTP = 15% (~27% in phase 2)

DeSoot (partial) within US06 = 18%

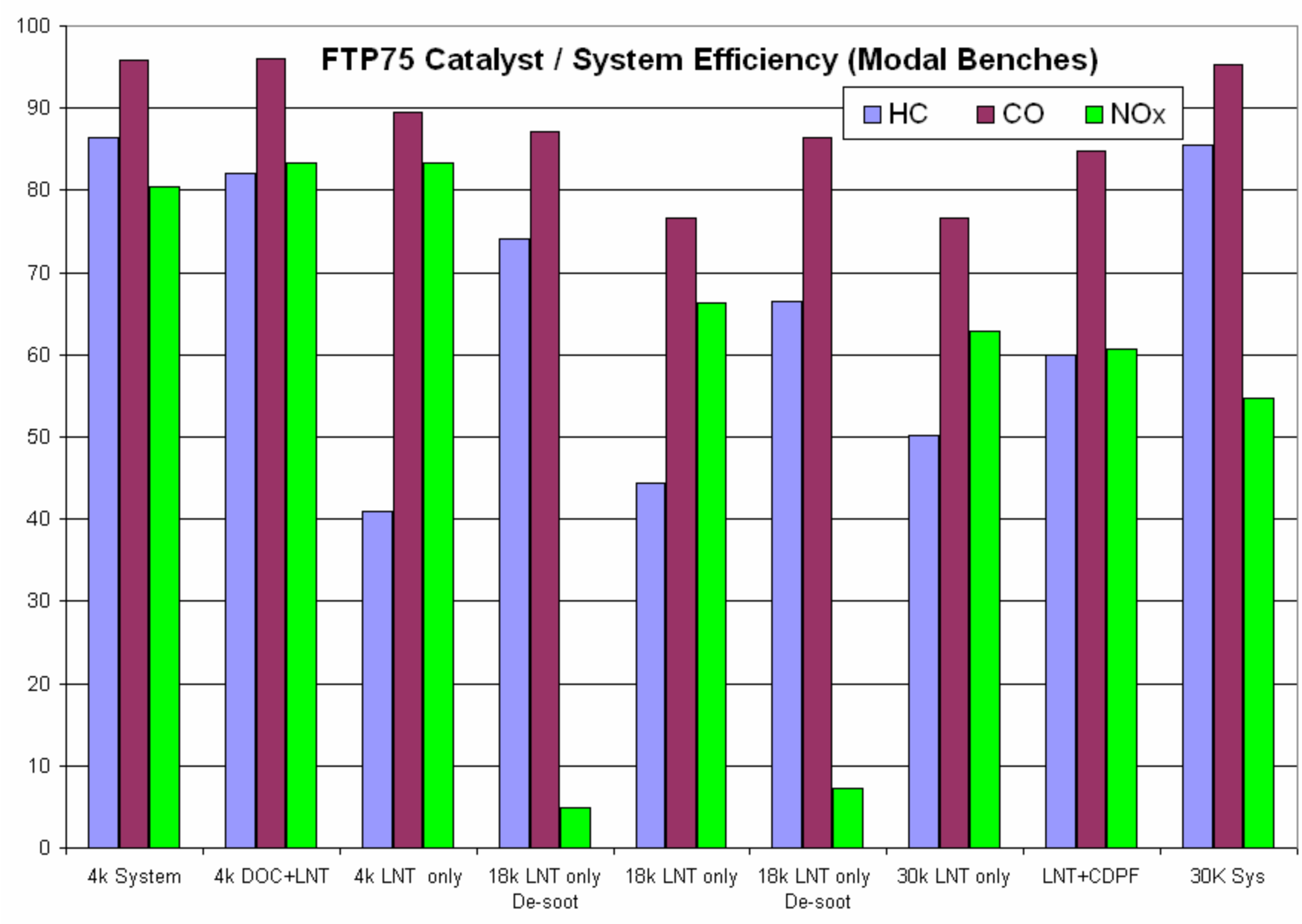
End DeSoot +DeSOx within US06 = 18%

FTP75 emissions at 4k and 18k miles

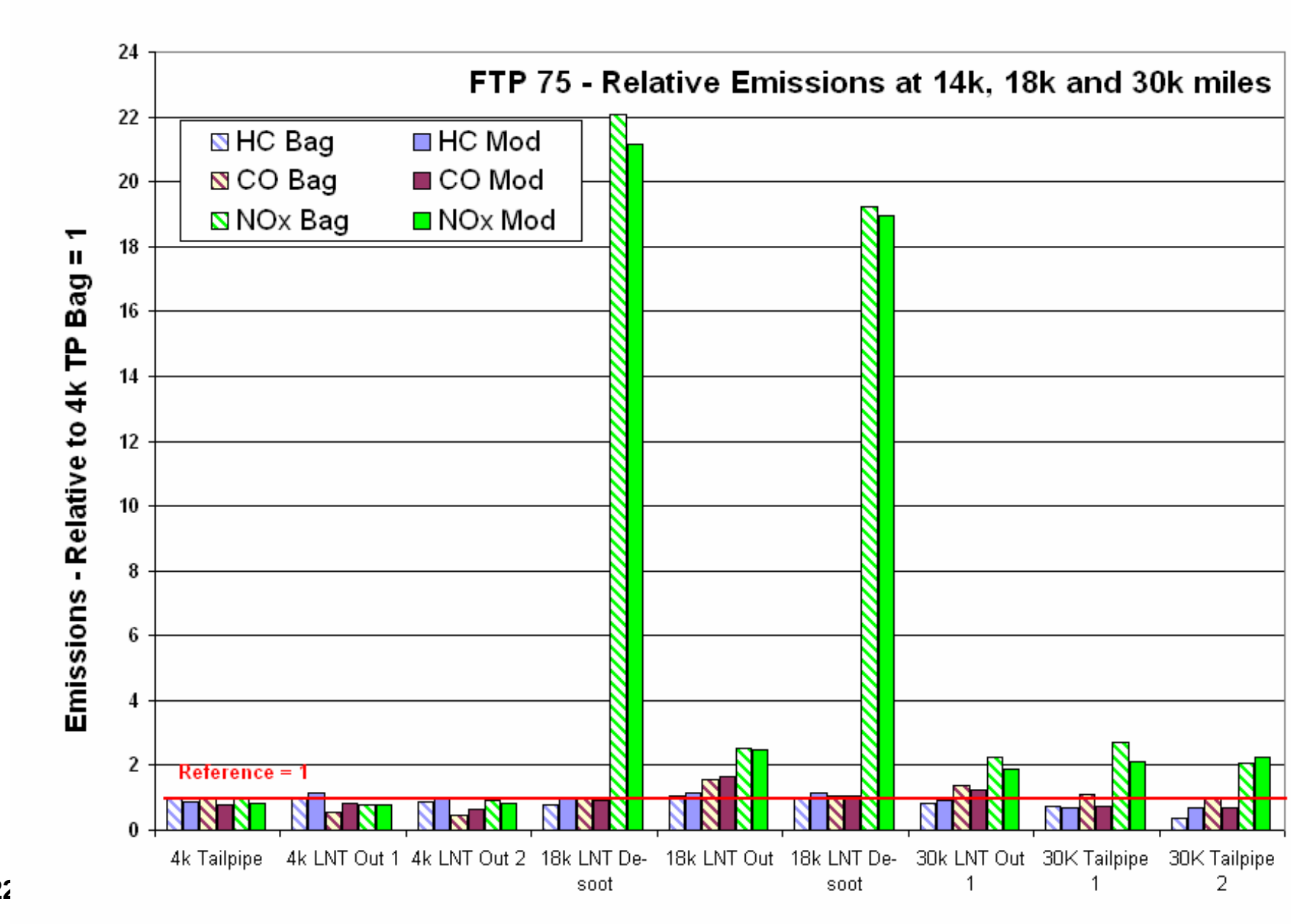




FTP75 Catalyst Efficiency

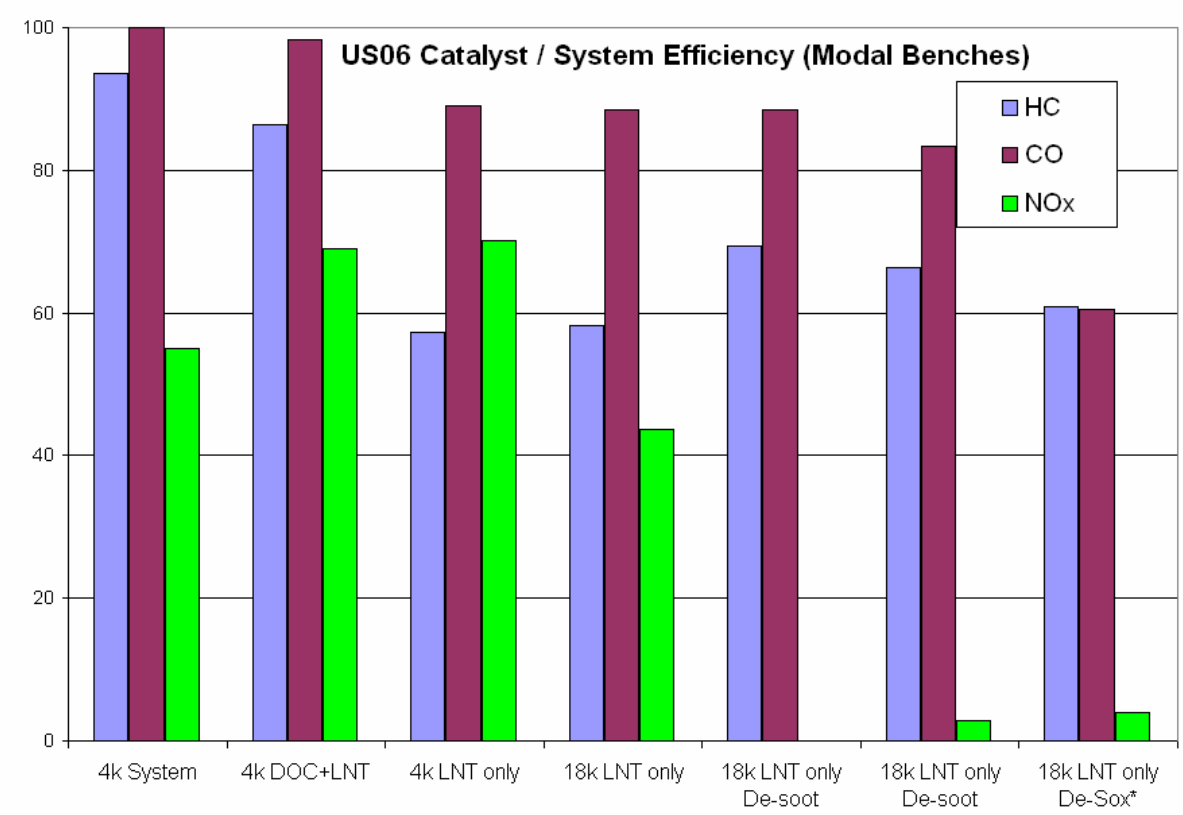


FTP75 System Relative Emissions

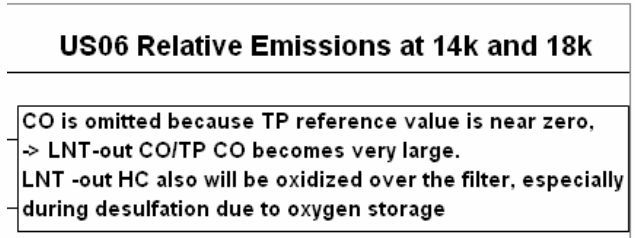


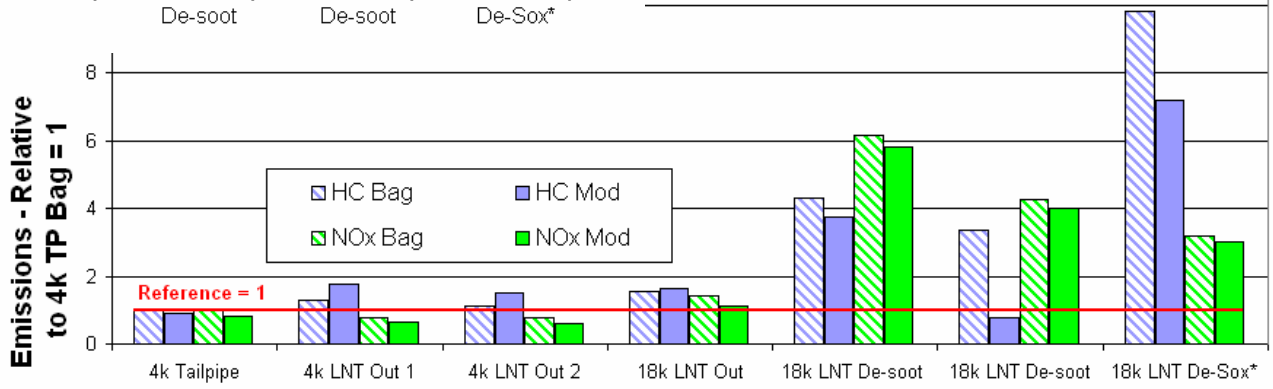
US06 emissions at 4000 and 18,500 miles

(Reference only – not required for HD Chassis Cert)



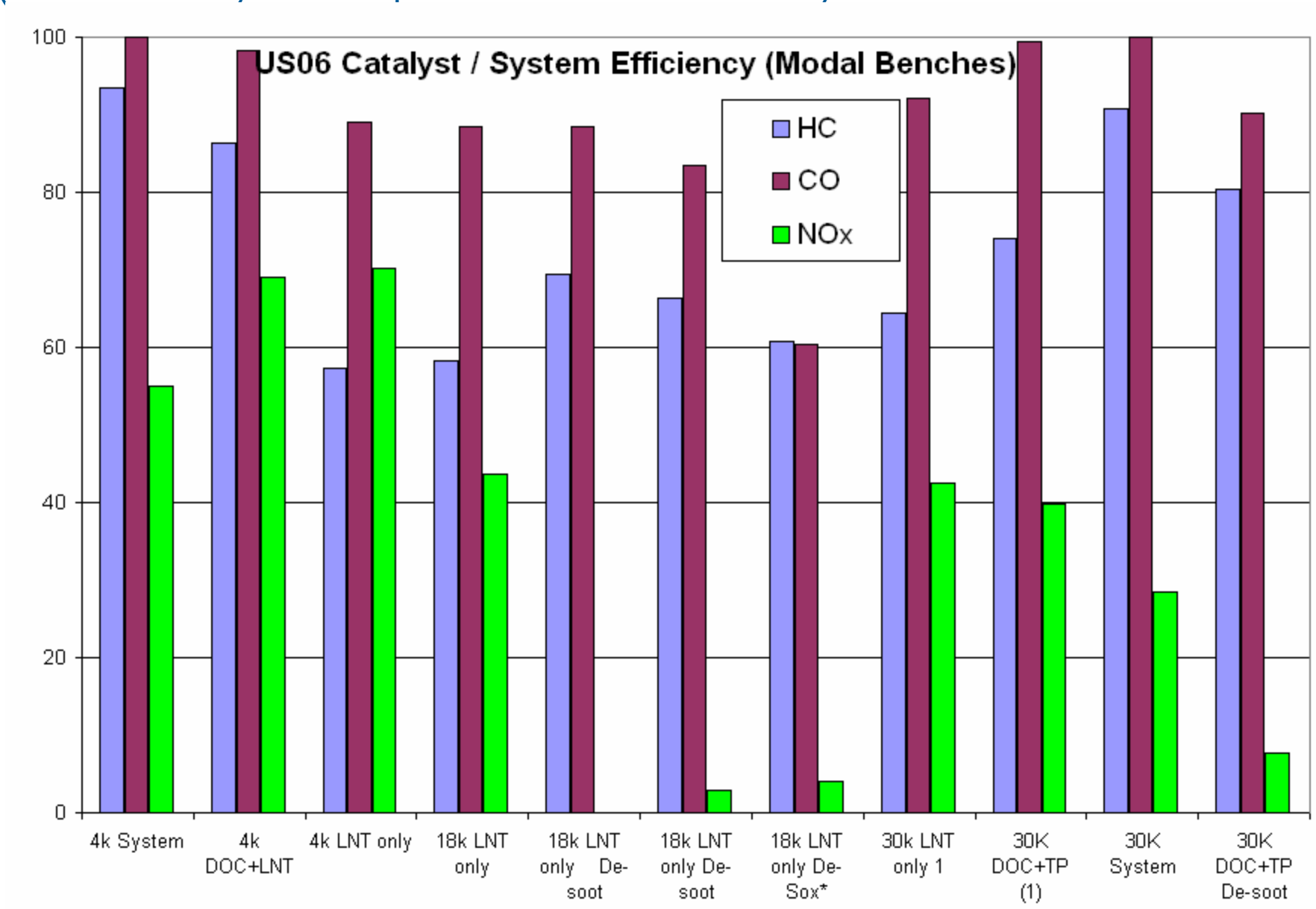
*Short De-Soot + Shortened De-SOx





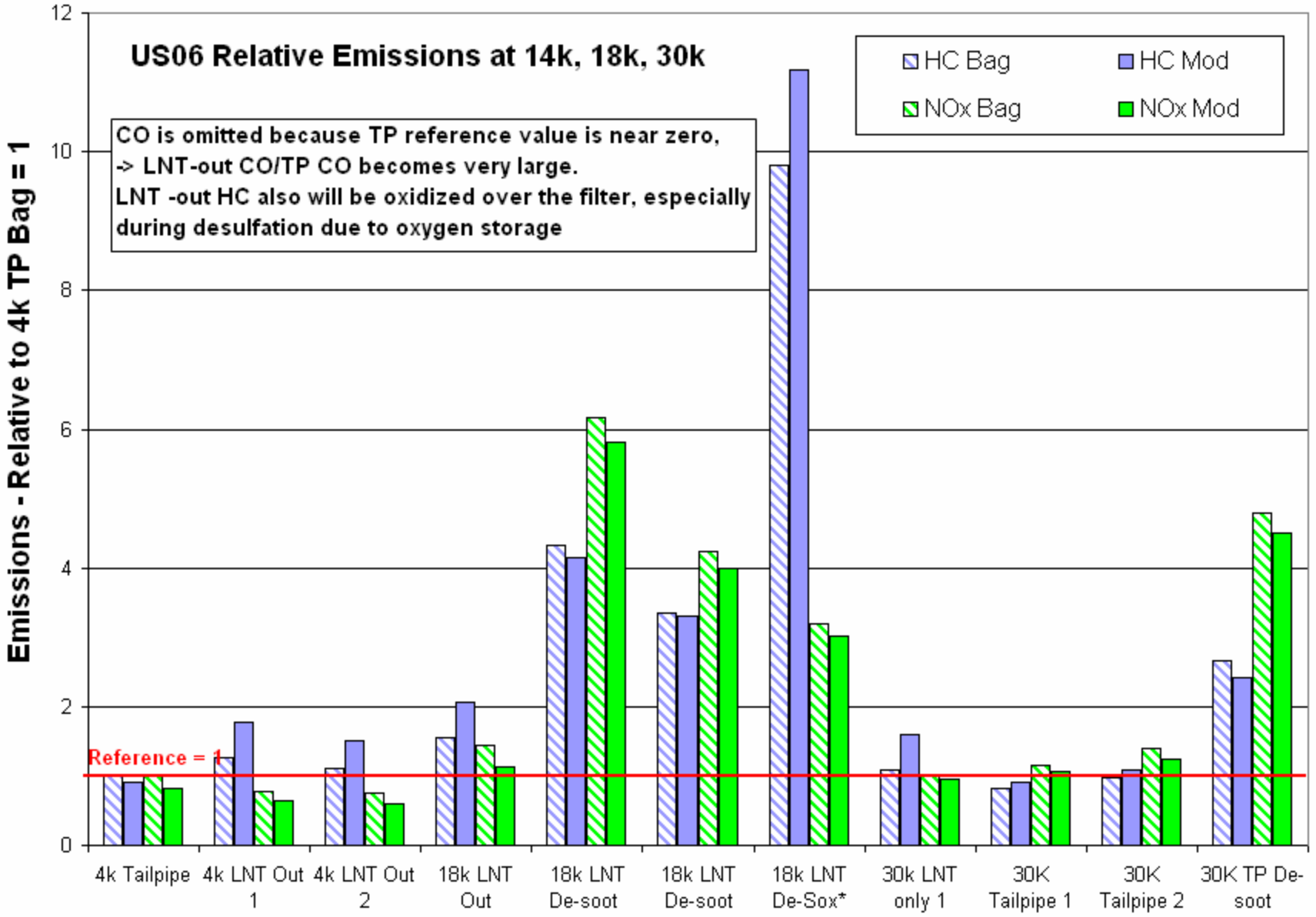
US06 Catalyst System Efficiencies

(Reference only – not required for HD Chassis Cert)



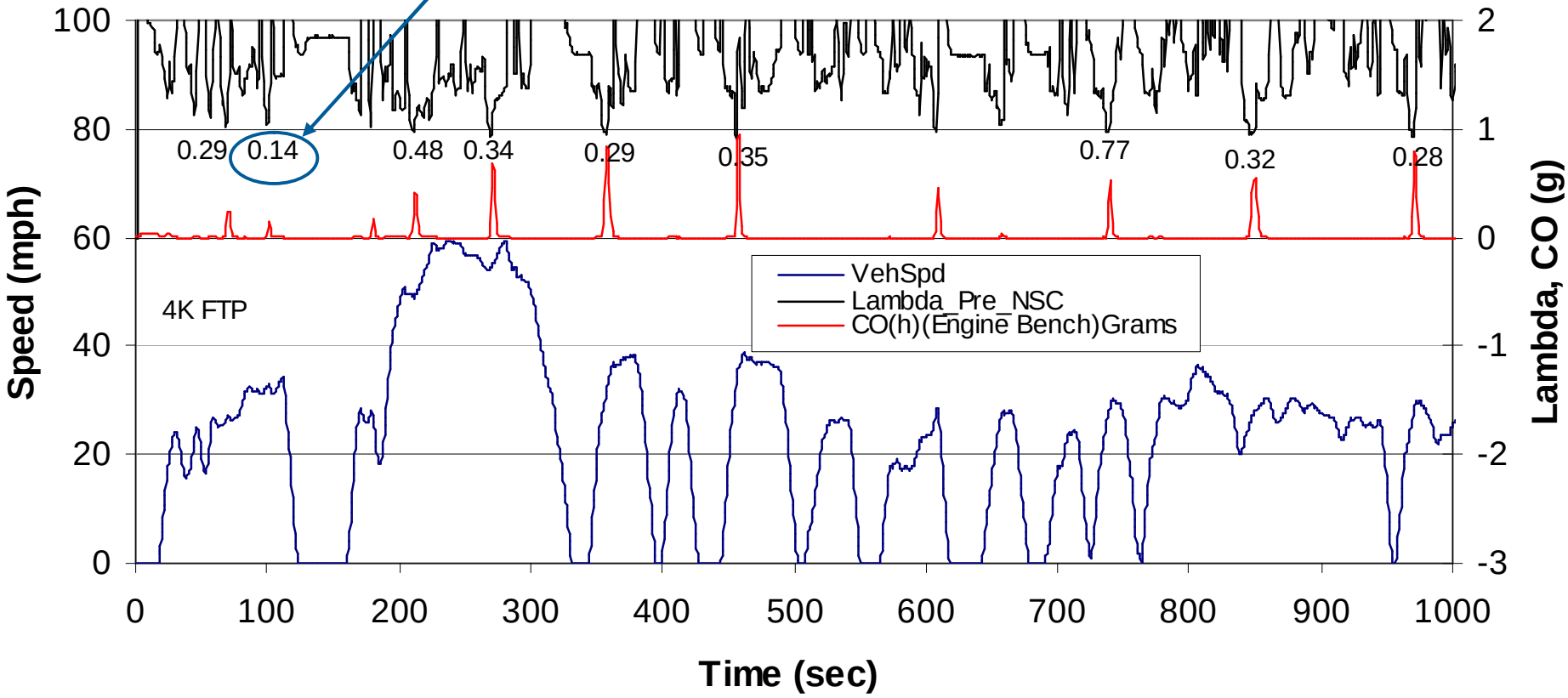
US06 System Relative Emissions

(Reference only – not required for HD Chassis Cert)

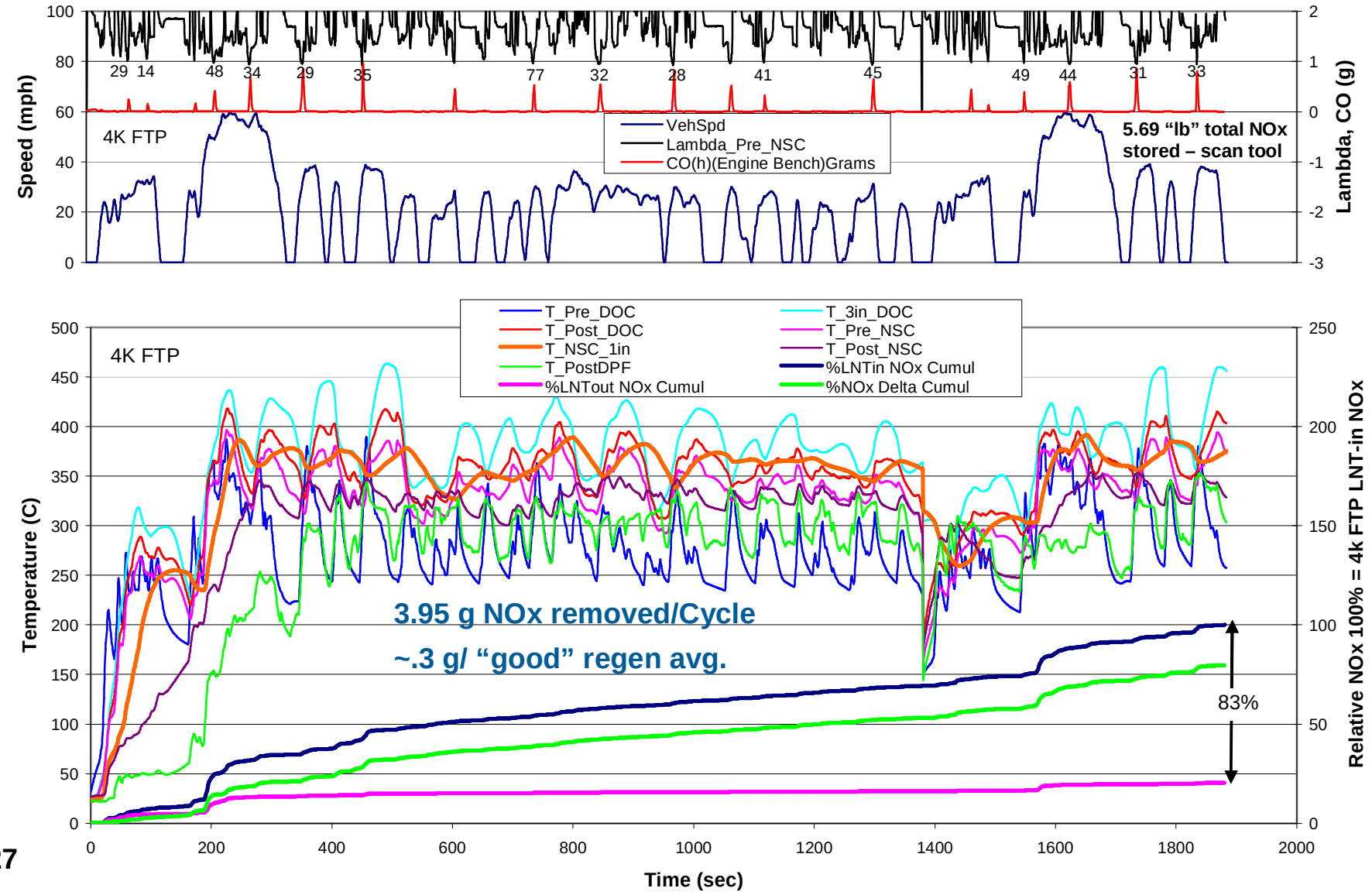


Indicators for NOx regeneration on FTP75 chassis test plots

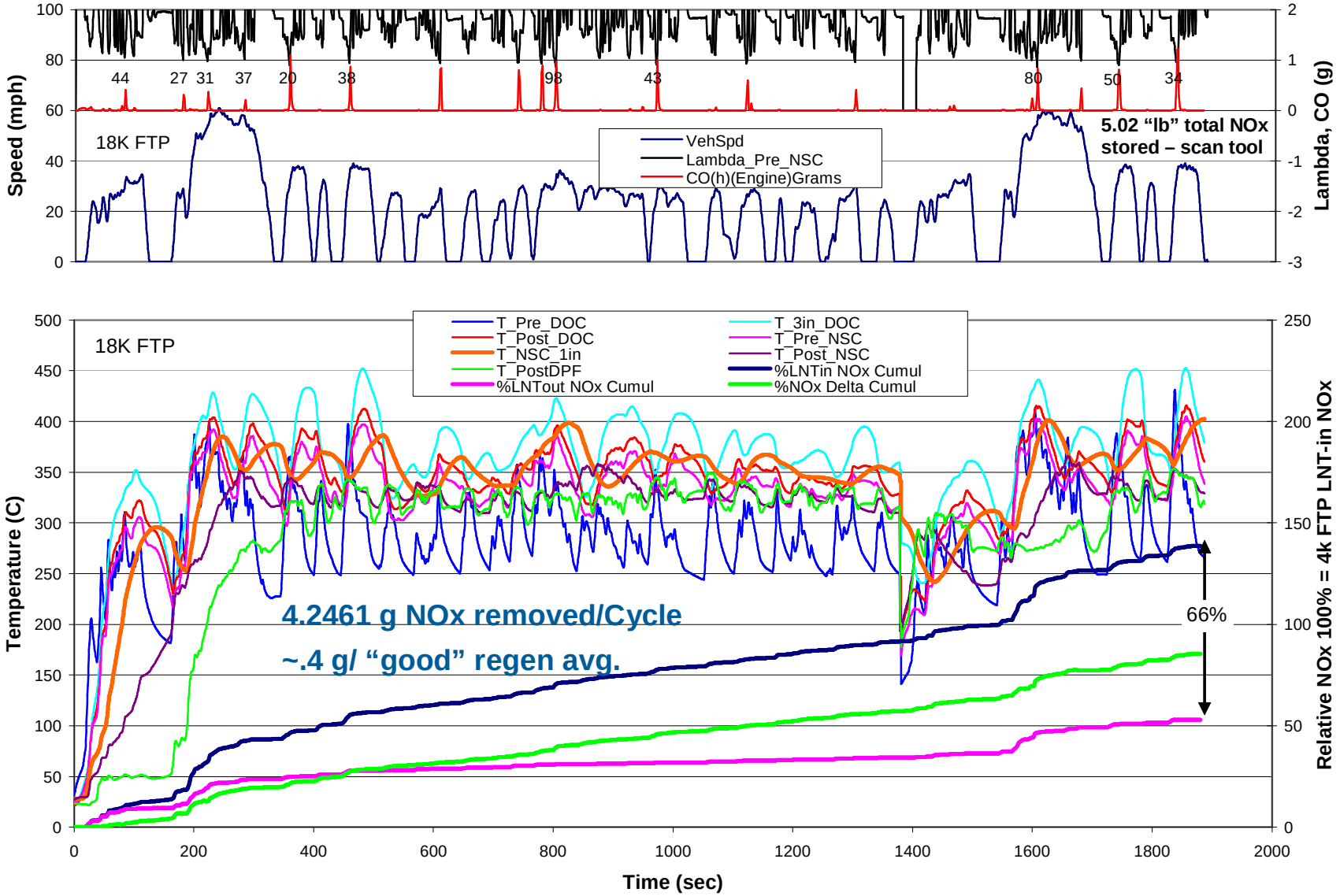
NOx mass "lb" reported by scan tool before reset to zero at DeNOx regeneration. Where no mass reported, scanner did not reset to zero even at apparent DeNOx



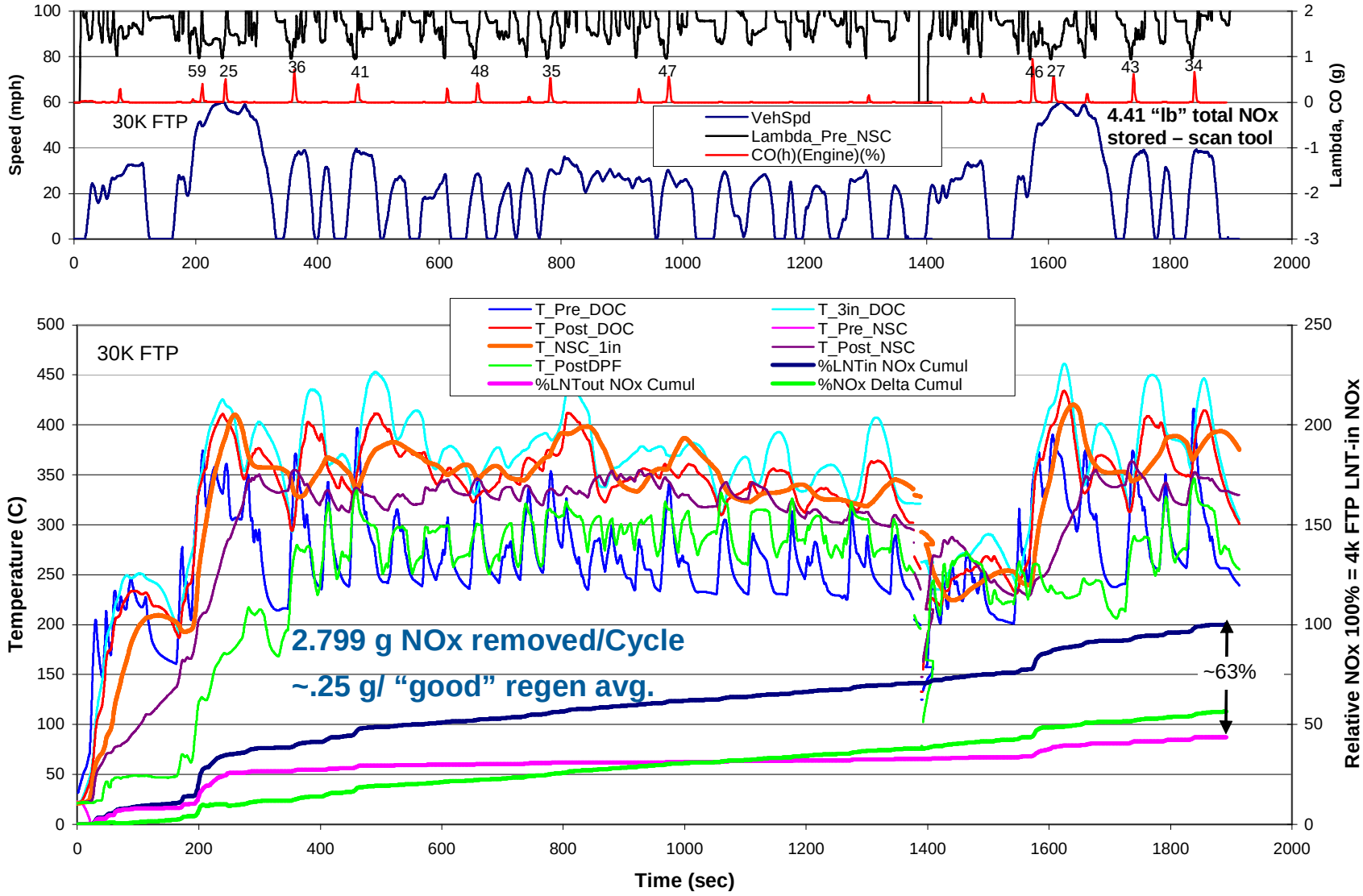
FTP75 Cycle at ~4000 miles
Bench locations across LNT only



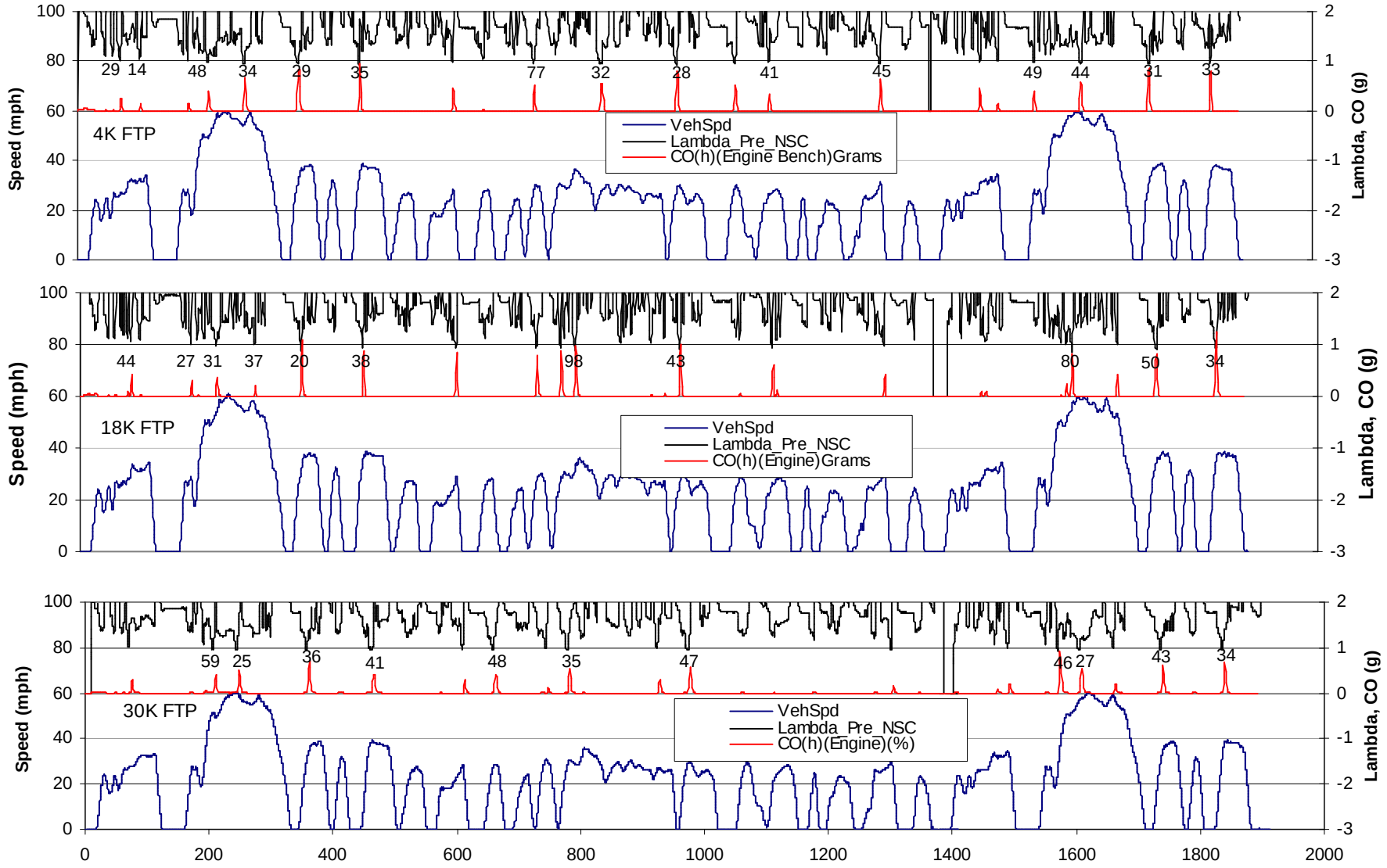
FTP75 Cycle at ~18,000 miles
Bench locations across LNT only



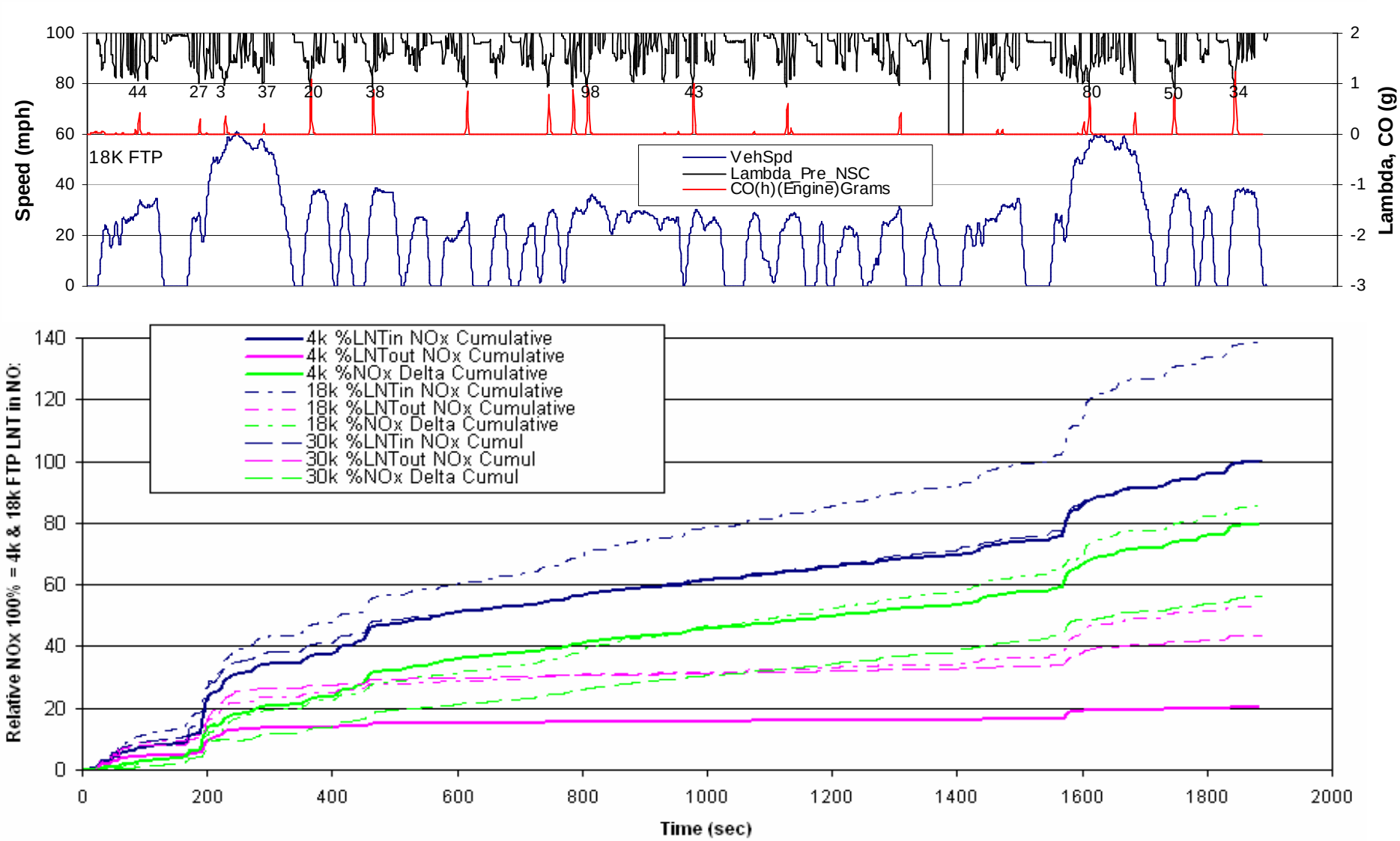
FTP75 Cycle at ~30,000 miles
Bench locations across LNT only



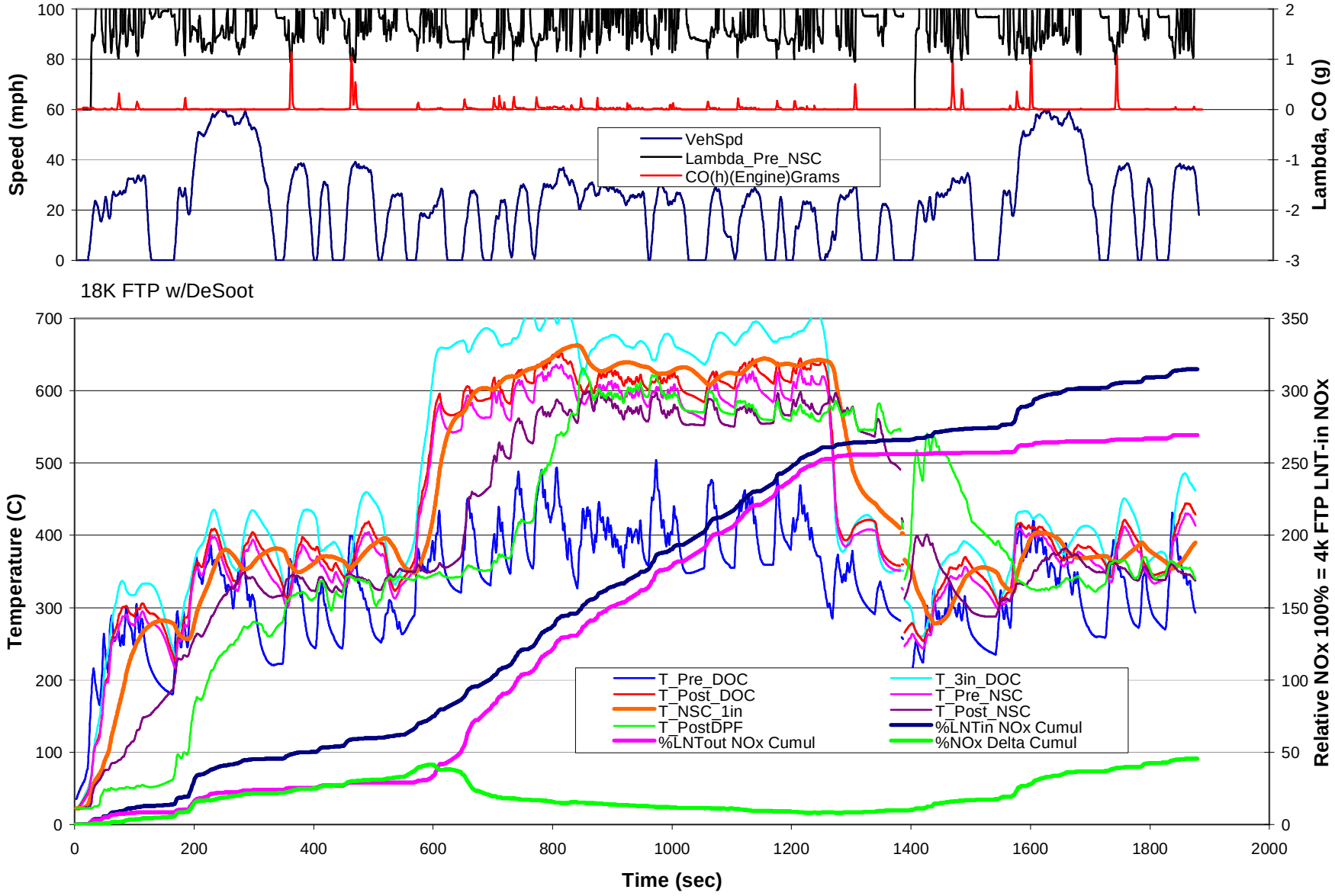
Comparison of 4k, 18k and 30k FTP75 Cycles / Regenerations



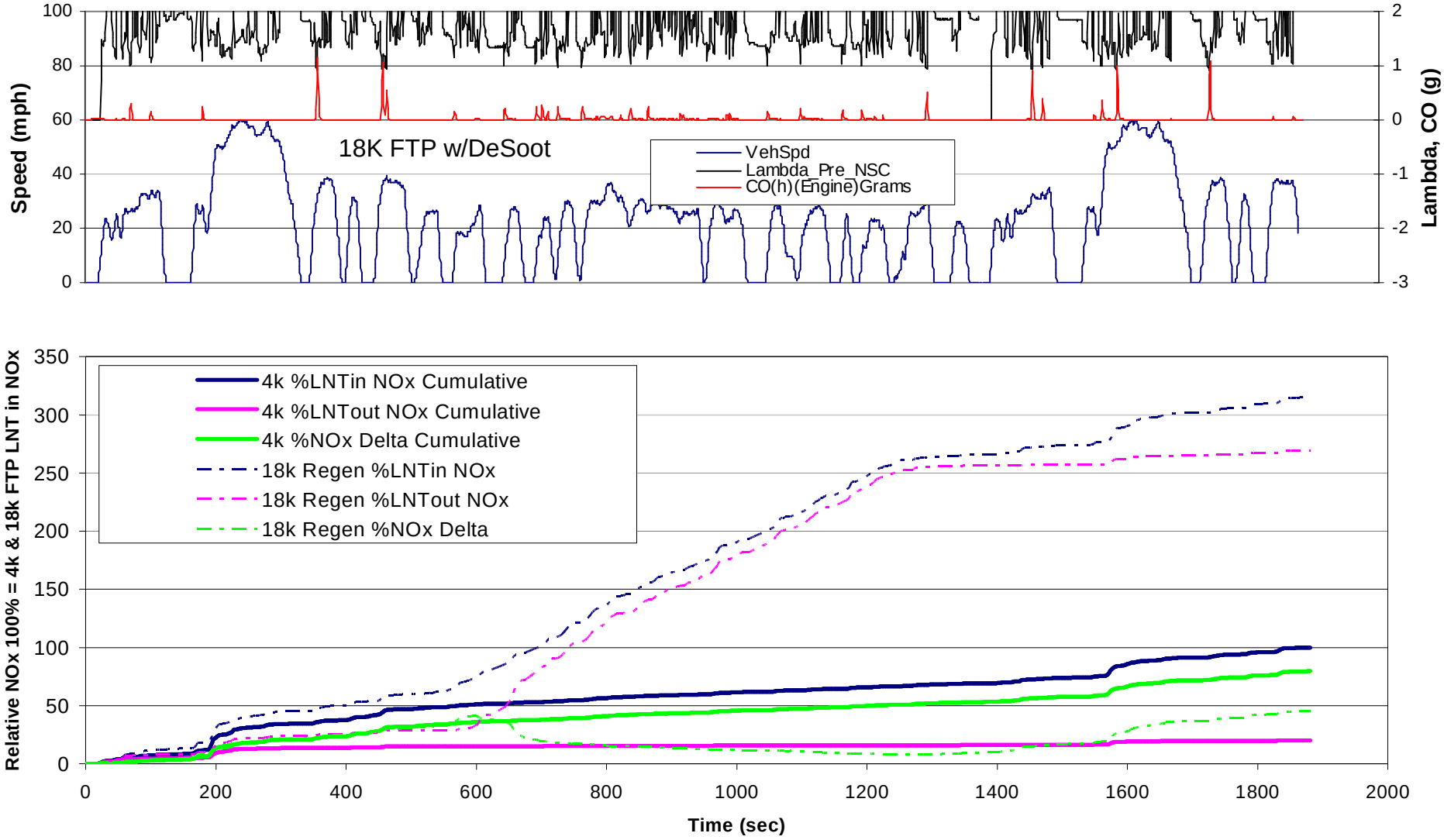
Comparison of FTP75 4k, 18k and ~30k Bench locations across LNT only



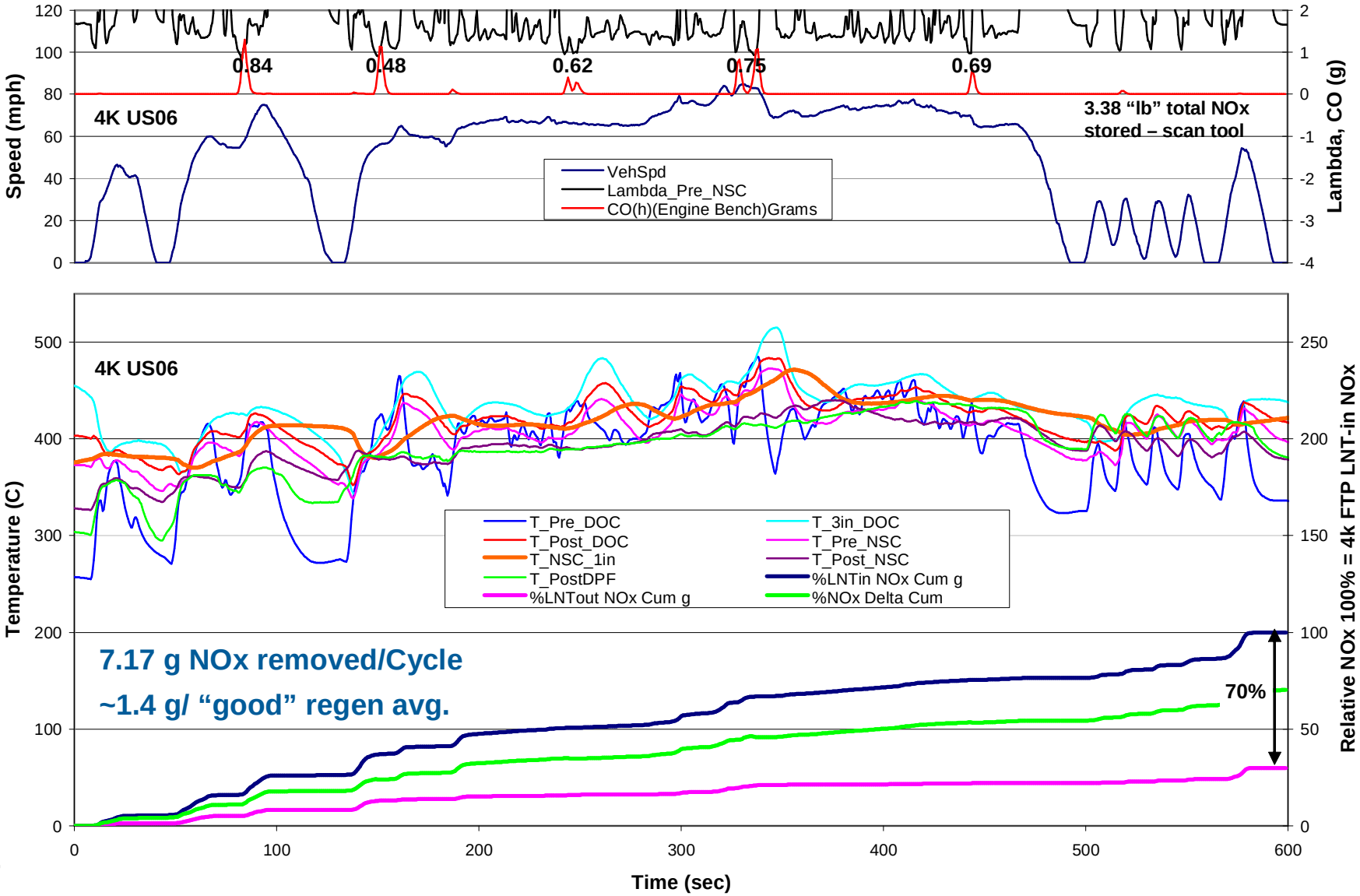
18k FTP75 with DeSoot Example
Bench locations across LNT only



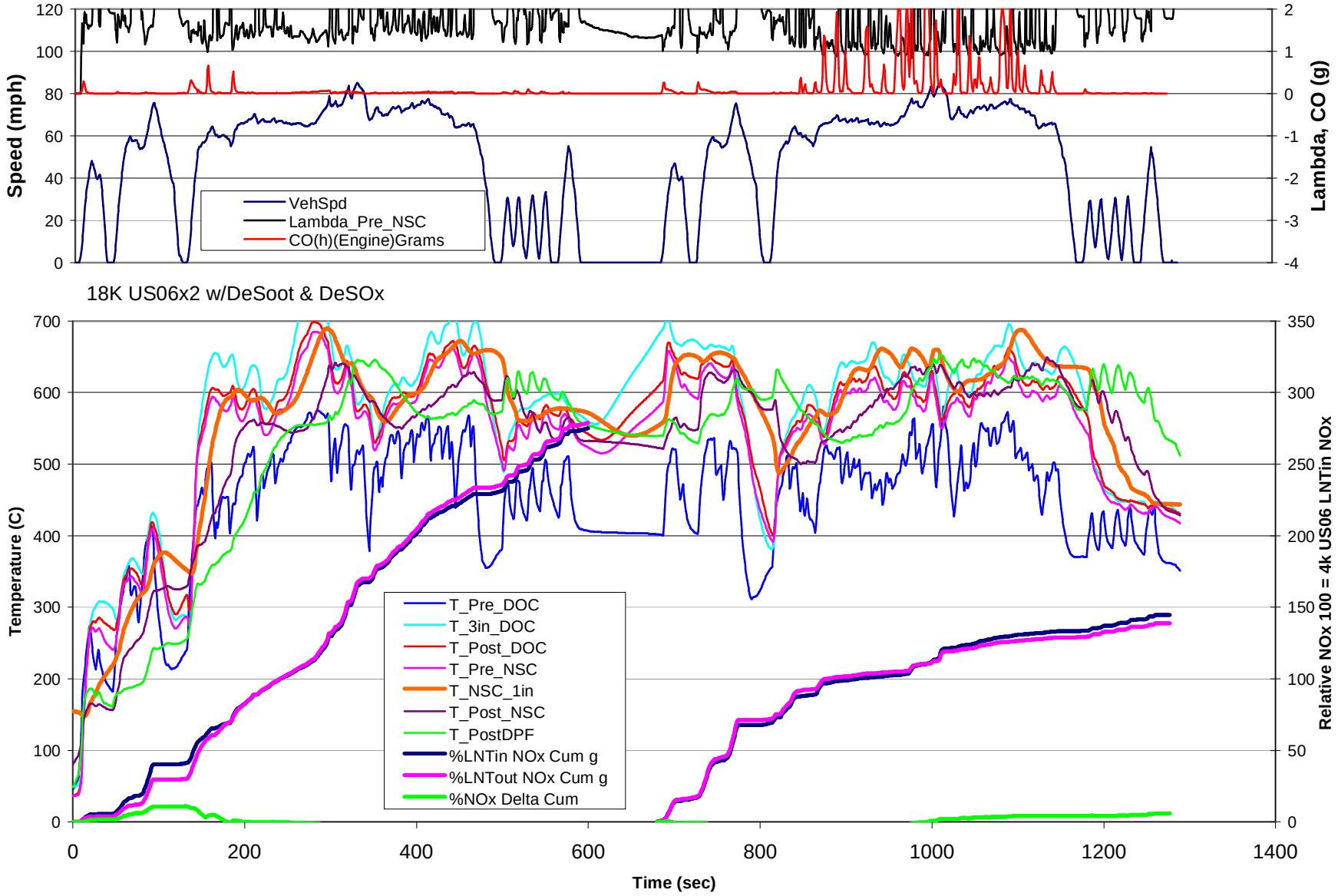
Comparison of FTP75 4k and 18k w/De-Soot Bench locations across LNT only



US06 Cycle at ~4000 miles
Bench locations across LNT only



US06 Cycles at 18k with DeSoot+DeSOx
Bench locations across LNT only



Conclusions from vehicle study

Chassis certification appropriate for this vehicle

- FTP75 covers lower exhaust temperature range of in-use vehicle operation
- US06 if applied would cover higher temperature range observed

LNT system regenerates under most operating conditions

- LNT system effective over FTP75 and US06
- LNT system not effective during high temperature system maintenance events

Fuel economy was 16mpg in “normal” driving, 13 mpg at higher loads

Filter regeneration observed ~13% of total time and desulfation ~2%

- Fuel economy penalties on FTP75 or US06 emissions cycle are 15-27%
- Overall resulting fuel economy penalty estimate < 4% (25% x 15%)

Note: Software updates and early maintenance of EGR system were made by dealer prior to 30,000 mile emissions testing

Acknowledgments

Data Analysis - Kettering Co-op students

- **Kayla Bachman**
- **Mychelle Flachsmann**
- **Max Botimer**

Derek Bidleman - vehicle instrumentation

Vehicle Emissions Lab Staff