Parametric Study of NOx Adsorber Regeneration in Transient Cycles

Brian West

Scott Sluder

Oak Ridge National Laboratory

Sponsor: Kathi Epping

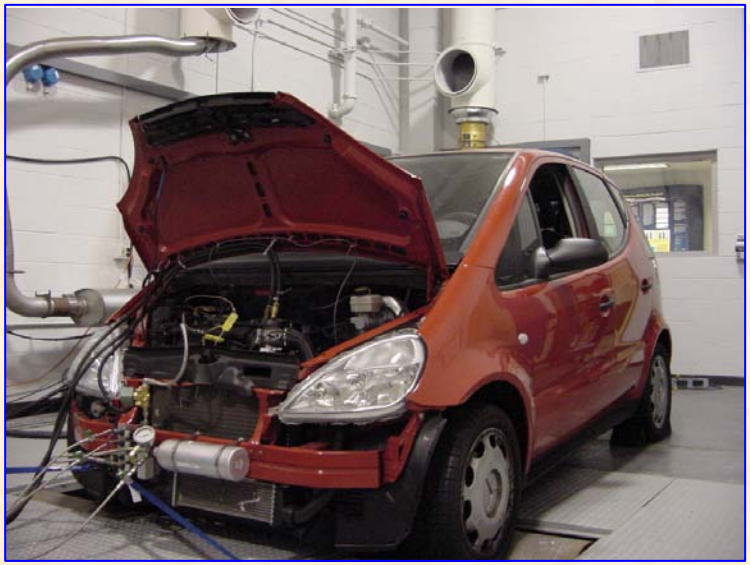
DOE FreedomCAR and Vehicle Technologies Office

8th DEER Workshop

August 25-29, 2002

Objective:

Determine effects of rich pulse air:fuel ratio and duration on NOx adsorber performance in transient operation

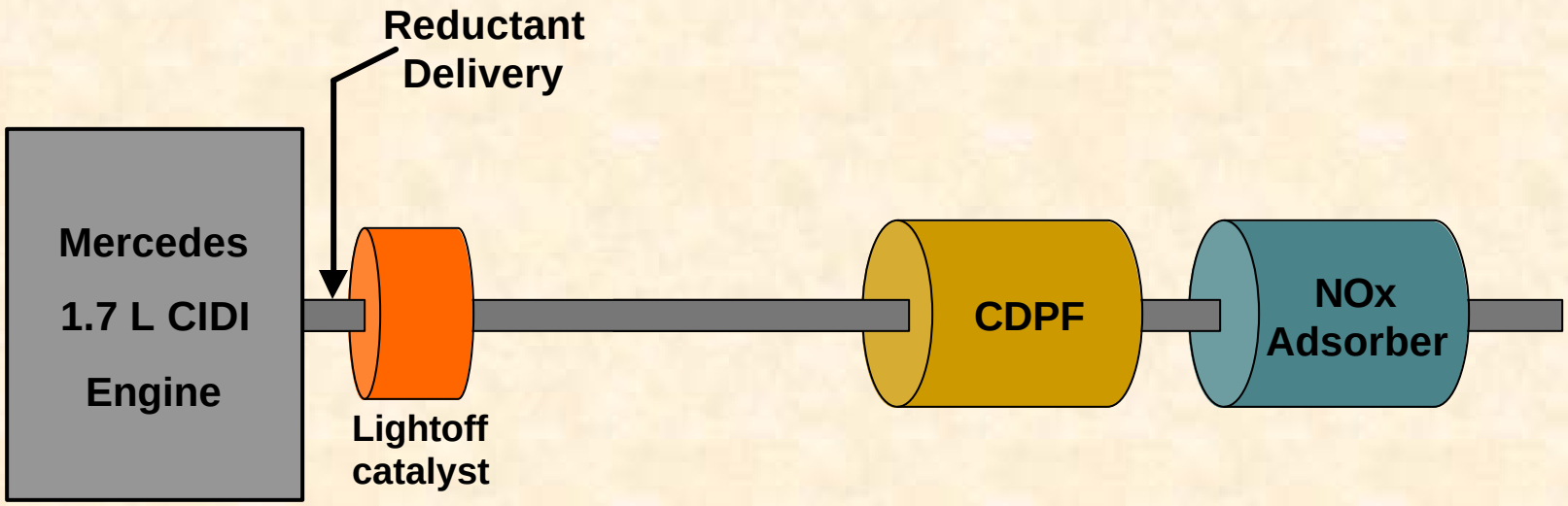


Motivation: Augment what can be learned from quasi-steady bench flow experiments with fixed flows and temperature

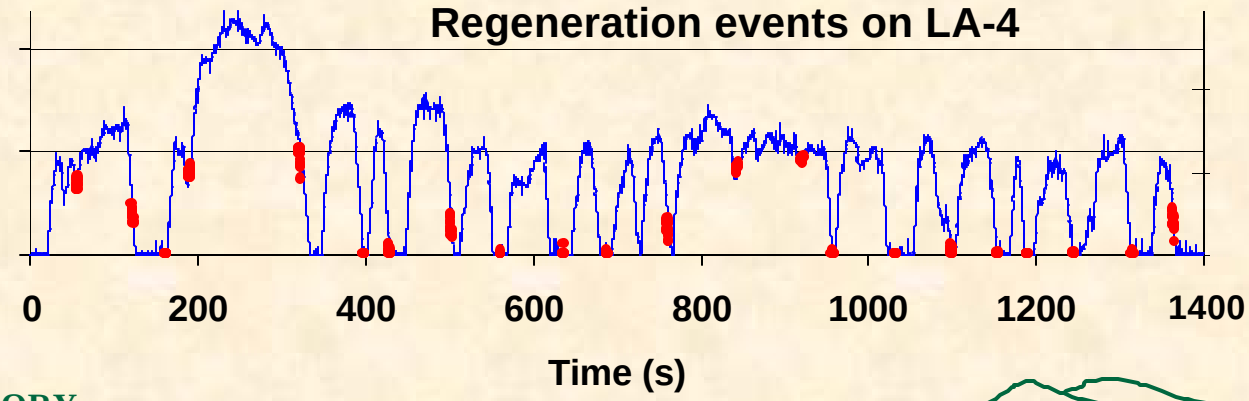
Experimental Approach

- Utilized Mercedes A170 CDI as “gas generator”
- ECU unmodified; regeneration controlled off-board
- Used synthesis gas as a reductant
  - Laboratory experiment, not intended for production
  - Syngas nominally 2/3 CO, 1/3 H_2, 3% C_2H_4
- Ran multiple hot LA-4 cycles to assess device performance on transient cycle
  - At least 3 replicate hot-starts at each condition
  - Test sequence: richest to leanest
- Measured indicated AFR (iAFR) at adsorber inlet during regeneration events with UEGO

Reductant delivered upstream of lightoff catalyst for regeneration



- Driver's aid controls:
  - Timing
  - Duration
- Auxiliary engine controller meters gas volume

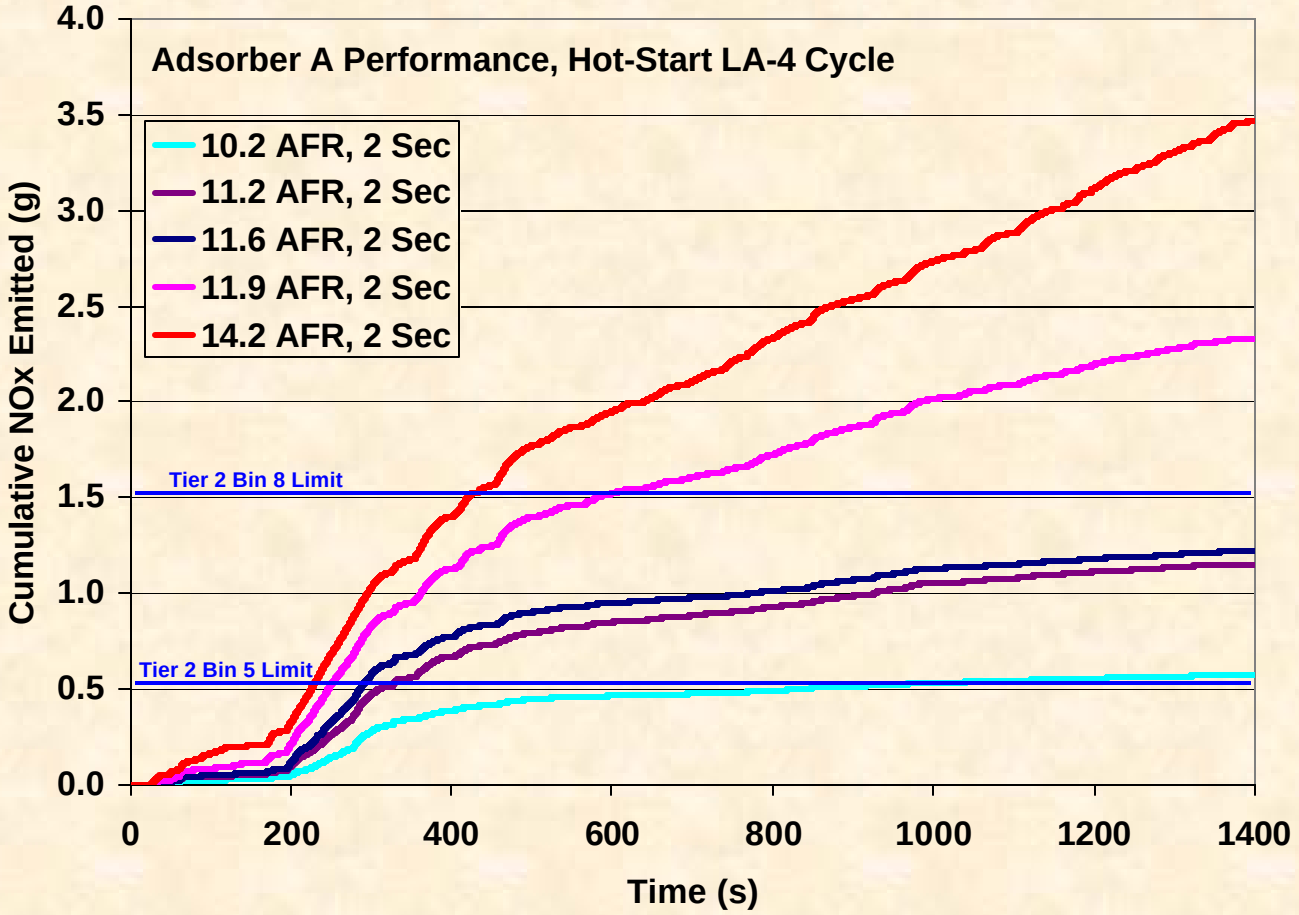


MECA members provided five prototype NOx adsorbers for evaluation.

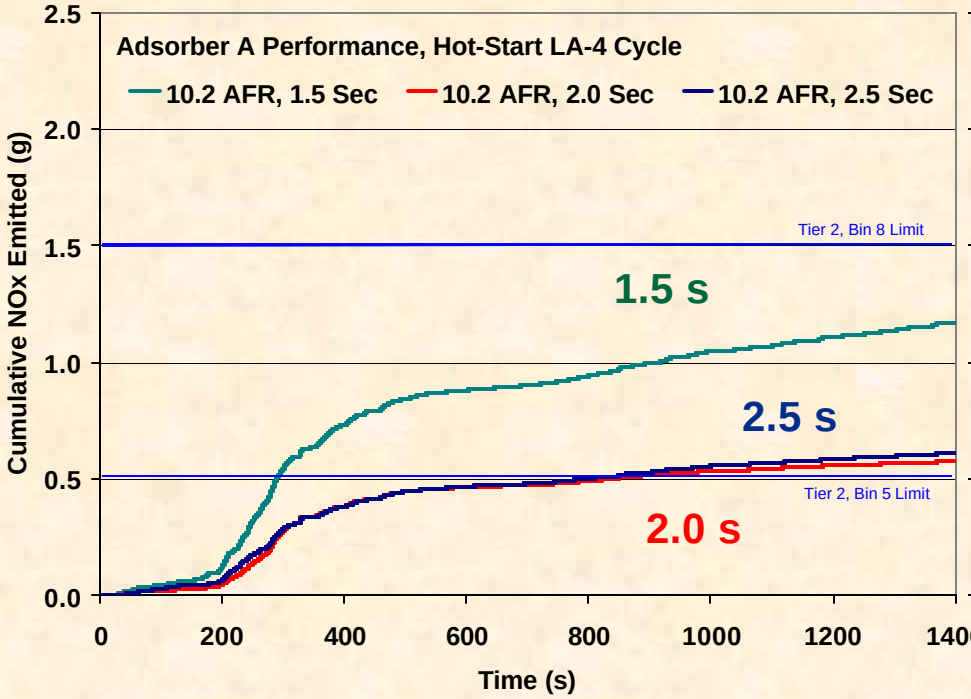
All units were 2.5 liter volume (5.66 in x 6 in round)

Adsorber	Cells/in^2	Precious Metal g/ft^3	Contains Barium/ Alkali metals
A	400	164	Yes/Yes
B	400	120	Yes/No
C	400	120	Yes/No
D	400	164	Yes/No
E	300	100	Unknown

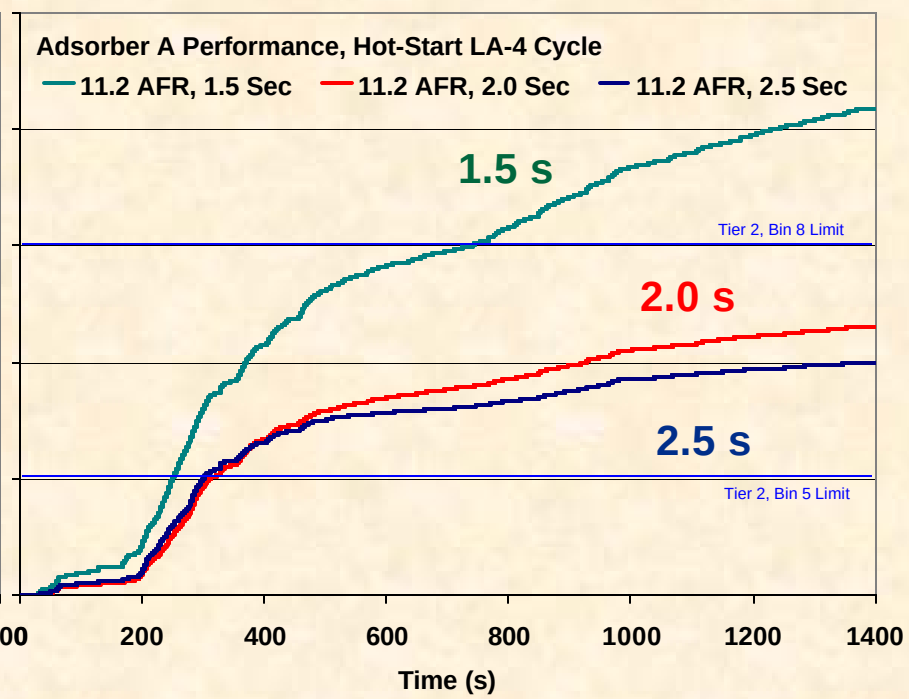
Decreasing air/fuel ratio during regeneration decreases tailpipe NO_x emissions



Shorter rich pulse duration significantly affects NOx performance of adsorber A

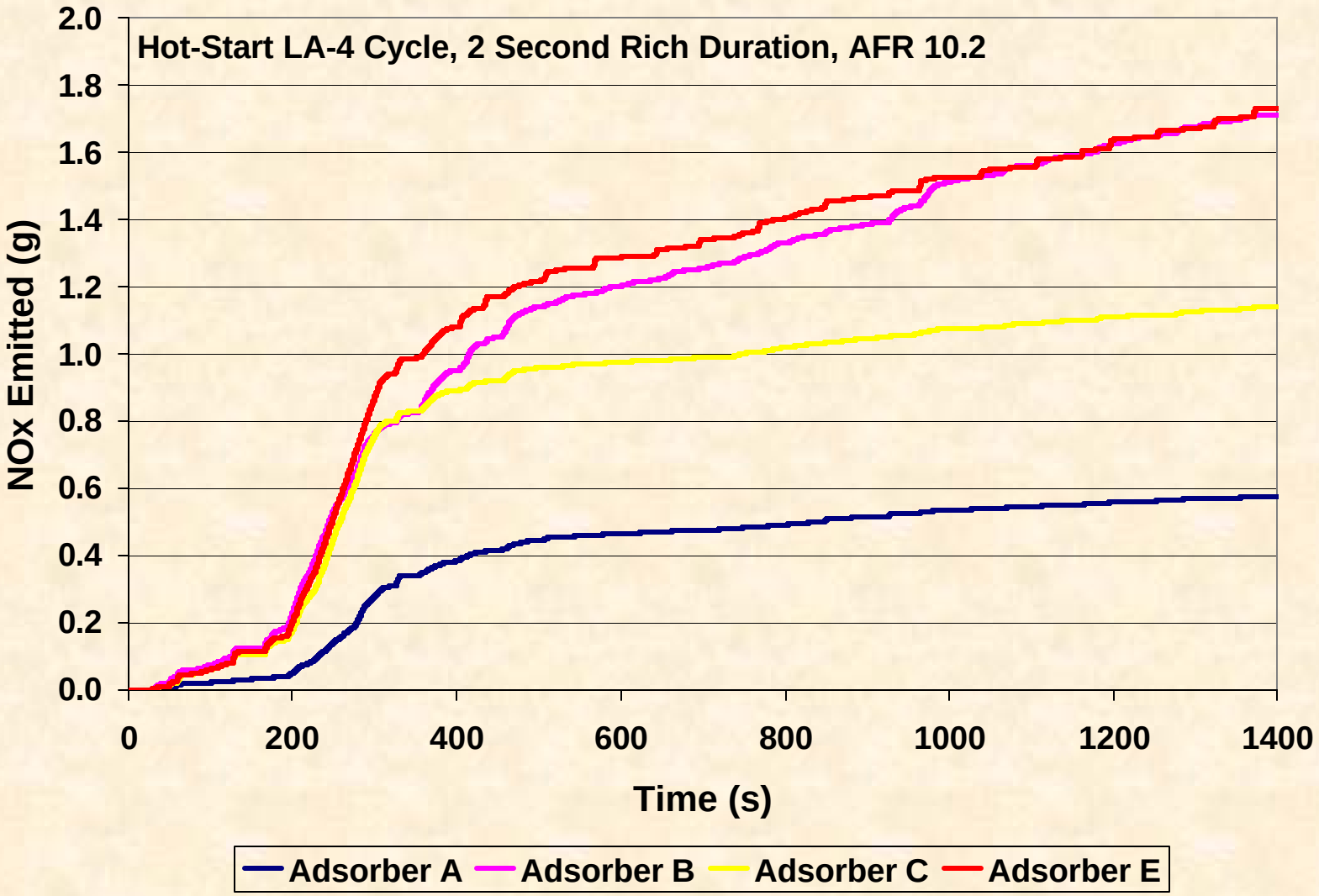


10.2 iAFR

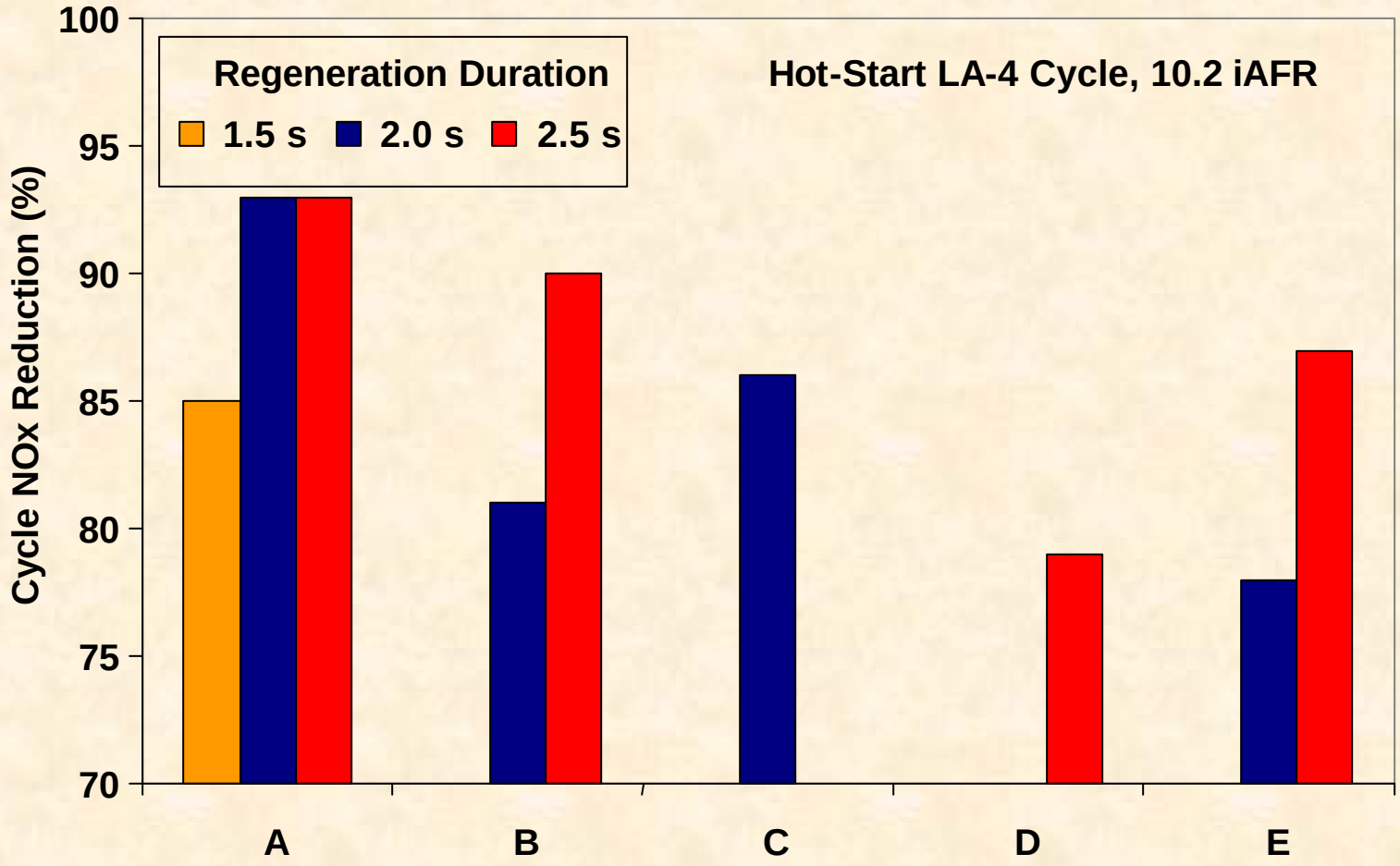


11.2 iAFR

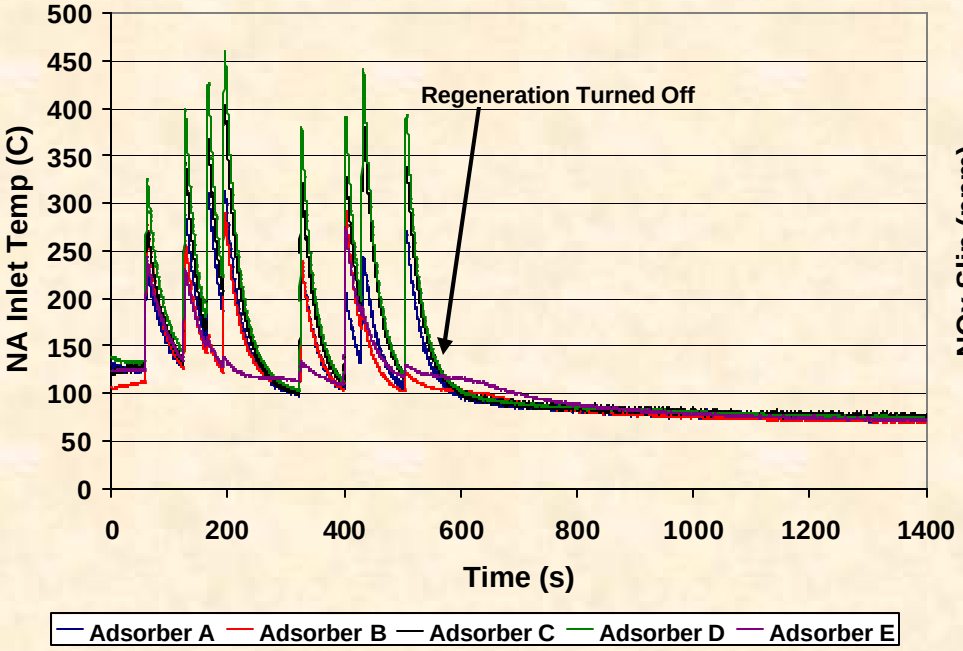
Adsorber A yields lowest NOx emissions

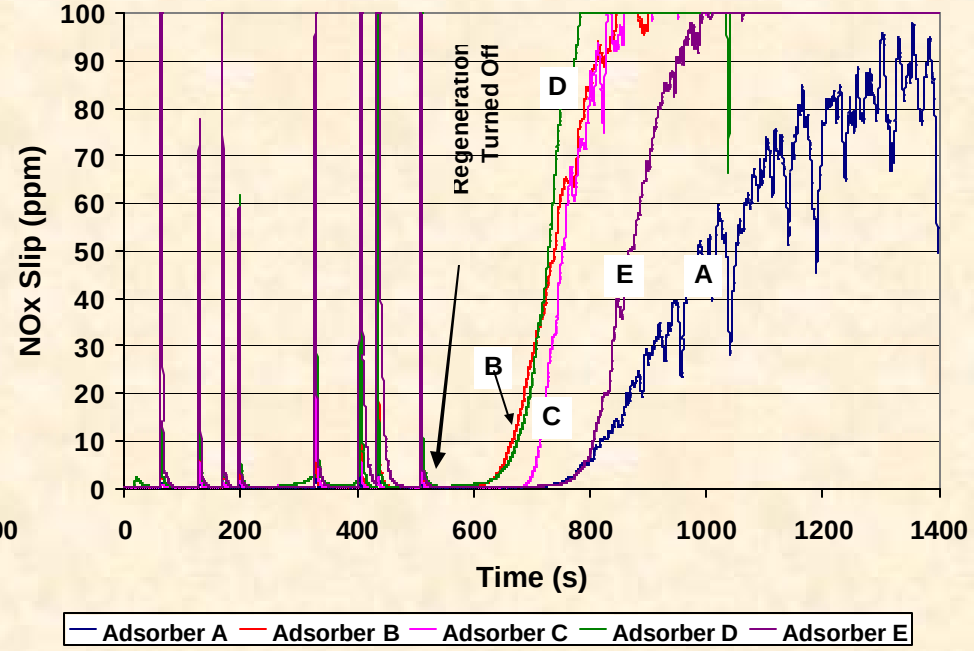


Adsorber A yielded the highest cycle-average NOx reduction. Longer duration regenerations generally improved performance



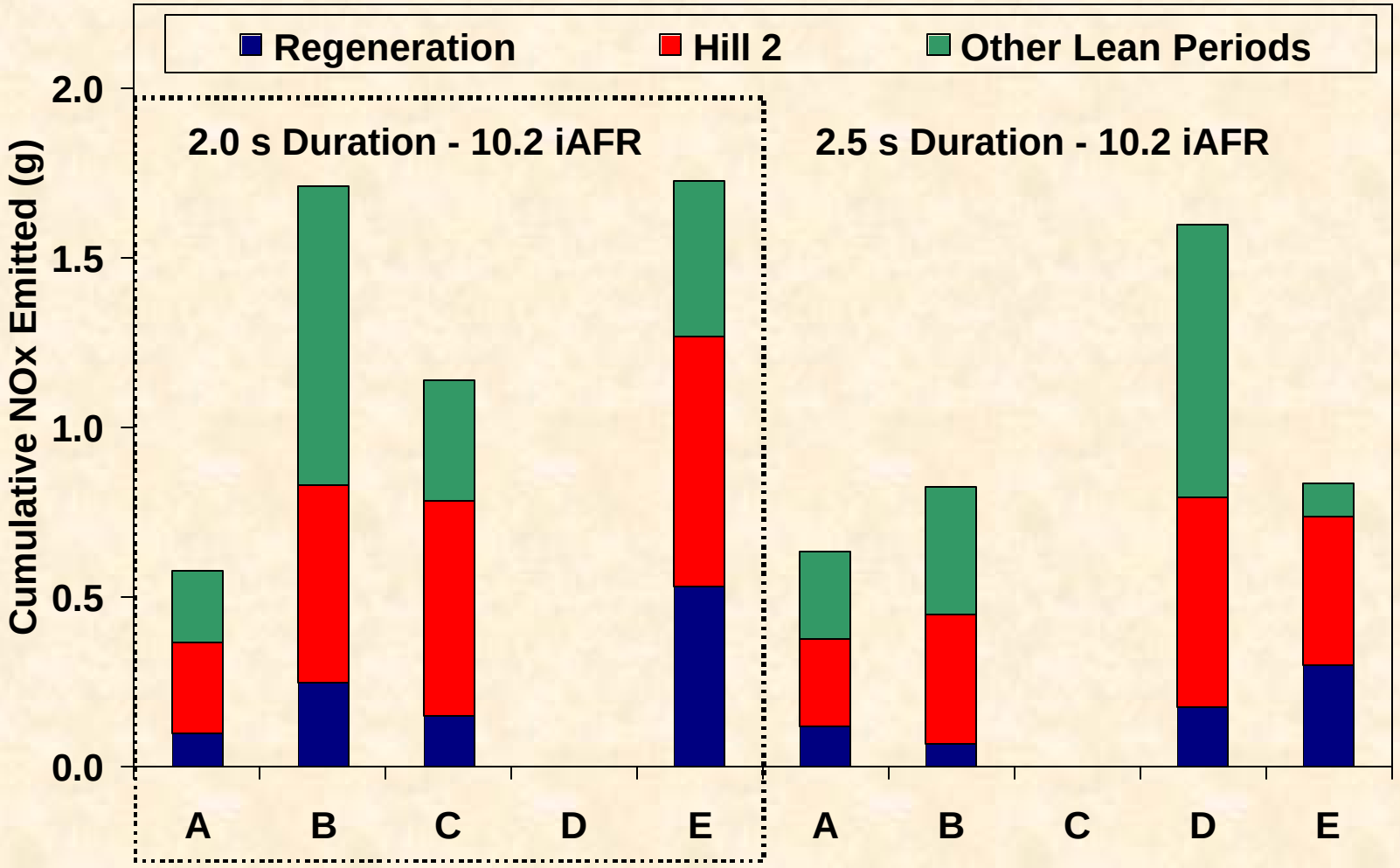
Idle-capacity experiment shows that adsorber A has highest capacity at low temperature



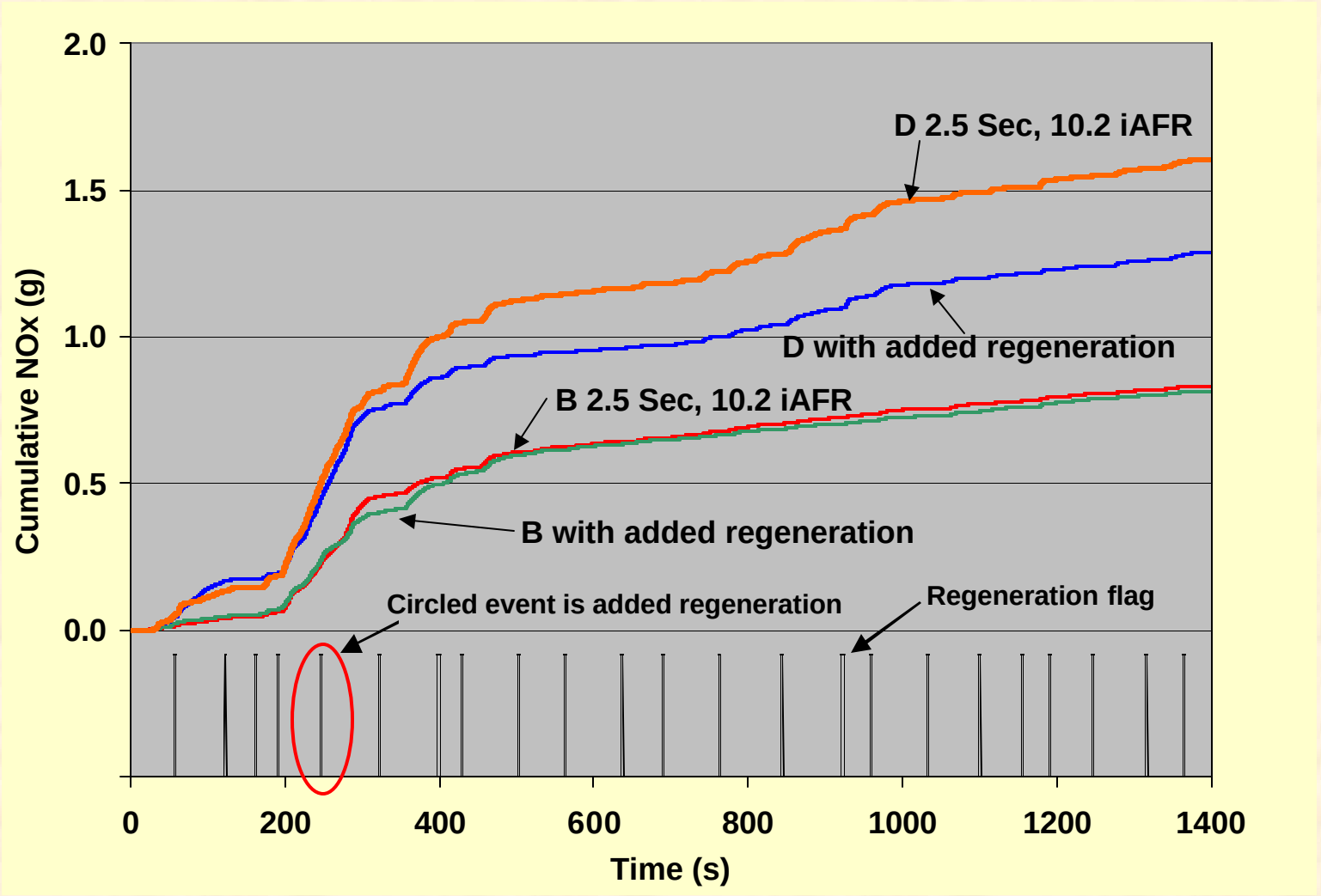


All adsorbers show near 100% capture of NO_X for a short period at less than 150 C exhaust temperature.

NOx slip during regeneration is not a significant source of NOx emissions. For the LA-4, hill 2 is a major source of NOx

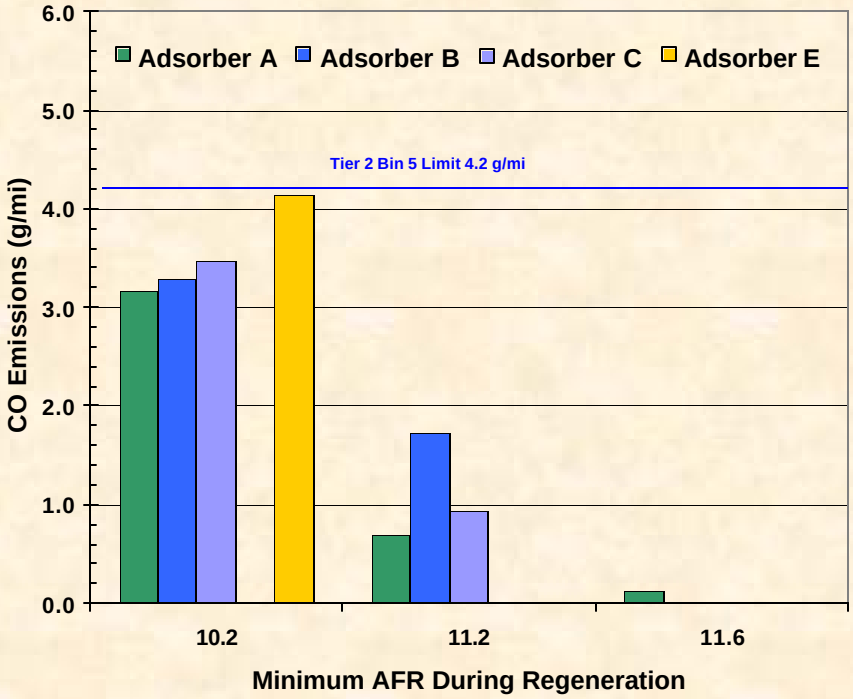


Added hill 2 regeneration improves adsorber D overall, but has only short term effect on adsorber B

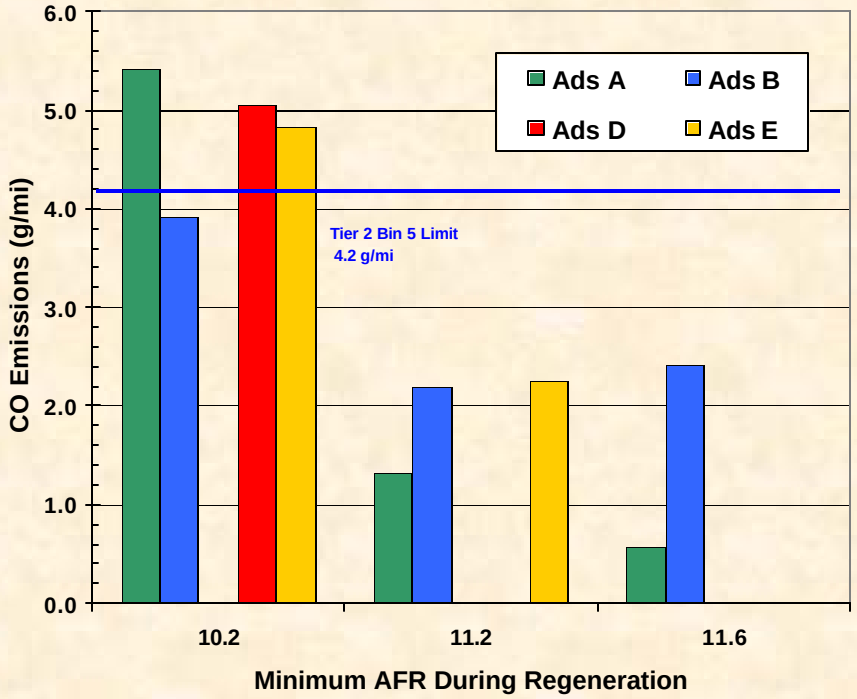


CO emissions were only problematic at the richest and longest duration regenerations

2.0 Second Rich Pulse

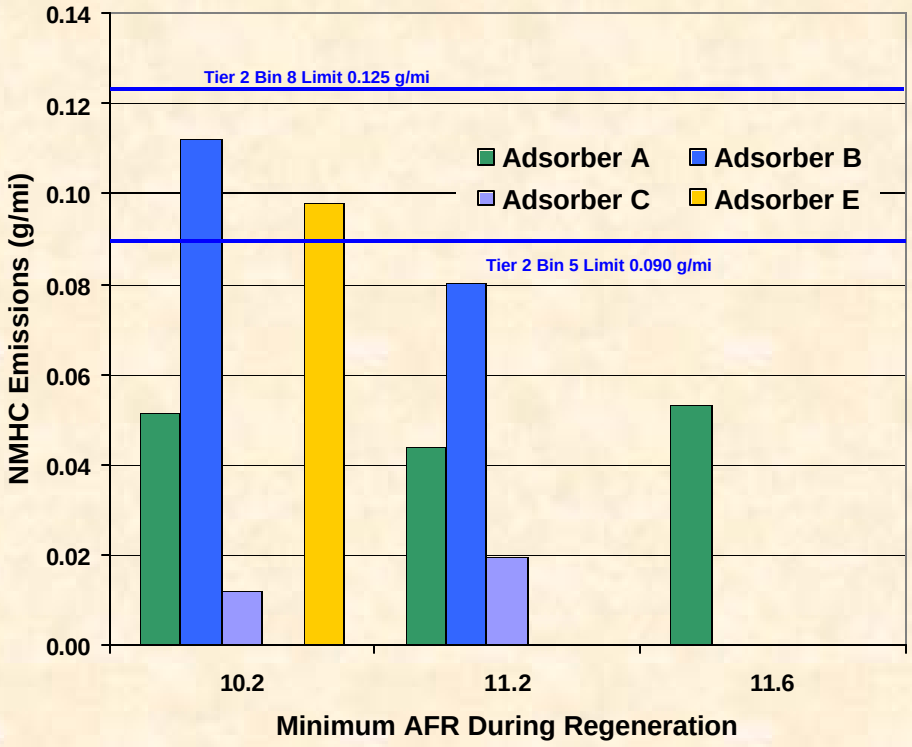


2.5 Second Rich Pulse

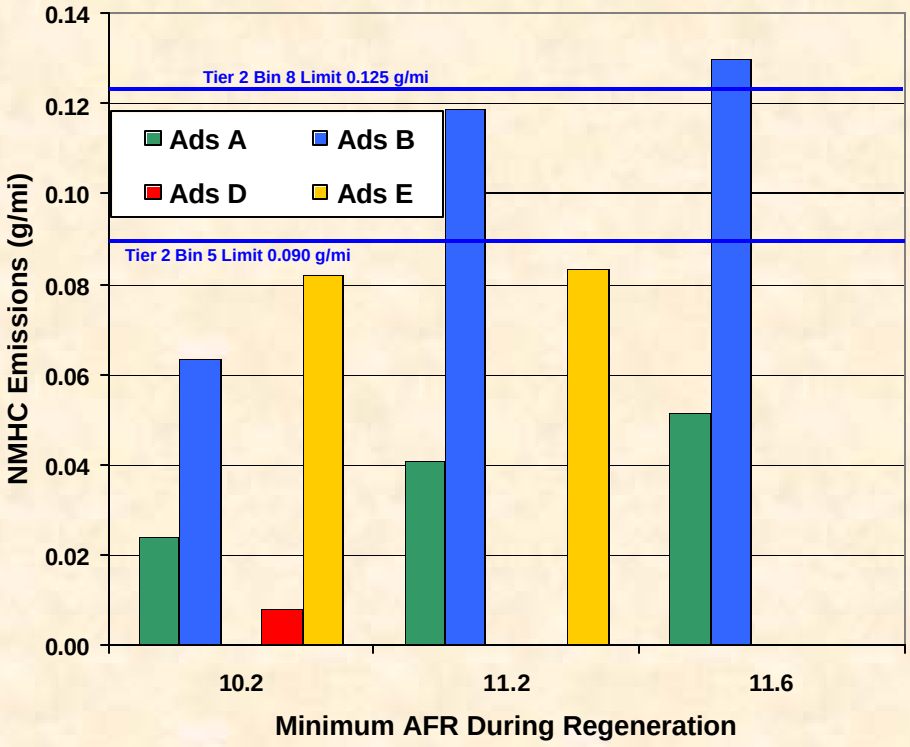


Adsorbers C and D are more effective at eliminating HC emissions

2.0 Second Rich Pulse



2.5 Second Rich Pulse



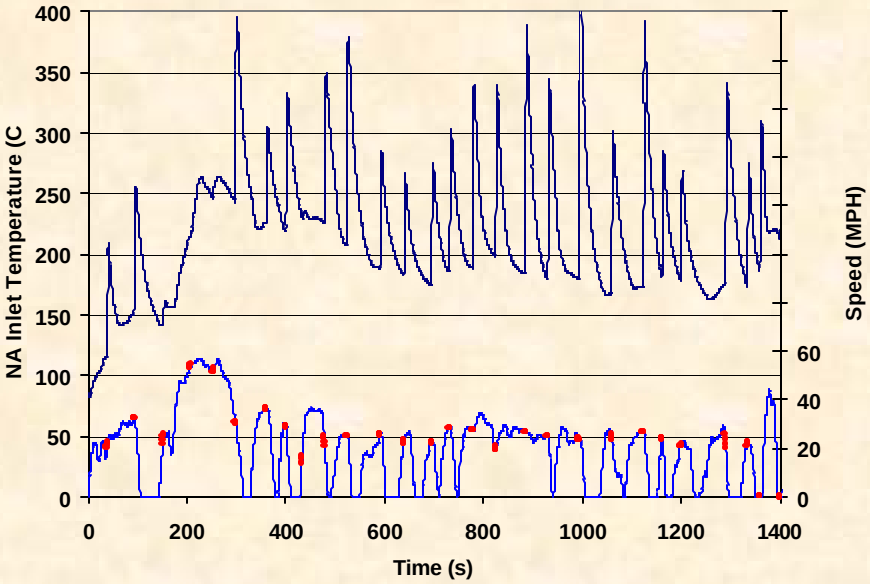
Summary and Conclusions

- **Adsorbers with highest apparent storage capacity yielded best NOx performance on “hill 2” and overall**
- **Reducing NOx slip during lean periods has more potential for improved cycle performance than slip during regeneration**
- **For a fixed regeneration schedule, reducing iAFR and and/or increasing duration of regeneration improves NOx performance**
  - **at expense of CO emissions**
  - **at expense of HC emissions for 2.0 second duration**
  - **with *improved* HC emissions for 2.5 second duration**

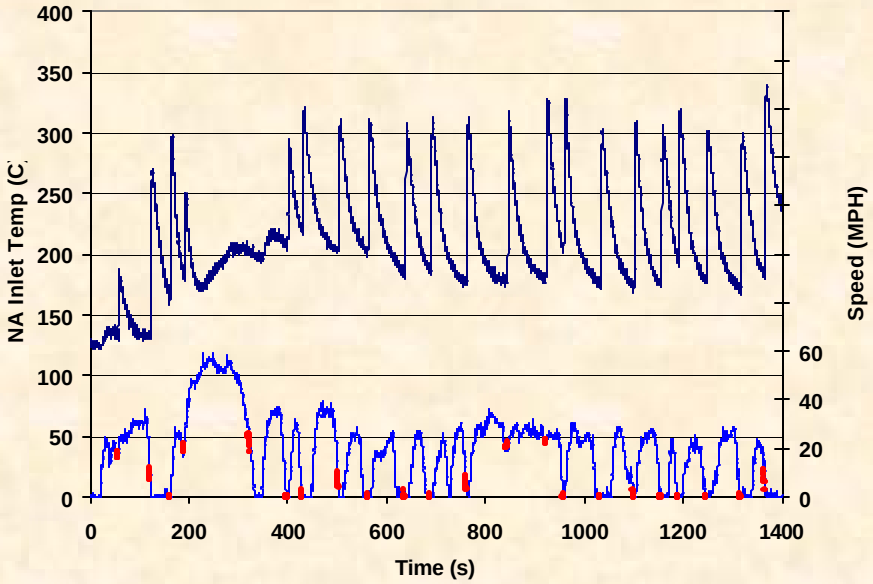
Questions?

- For further information, contact
  - Brian West, 865-946-1231
    westbh@ornl.gov
  - Scott Sluder, 865-946-1235
    sluders@ornl.gov
  - See SAE 2002-01-2876

Redesigning the regeneration schedule achieved lower exhaust temperatures than previous work



DVECSE Regeneration Schedule
SAE 2000-01-2912



New Regeneration Schedule

The new regeneration schedule was used for all experiments