Evaluation of a NOx Adsorber System on a Light Duty Diesel Vehicle

APBF-DEC-JCAP-CAFE

Motor Fuels: Energy Efficiency & Emissions in Transportation

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Presentation Summary

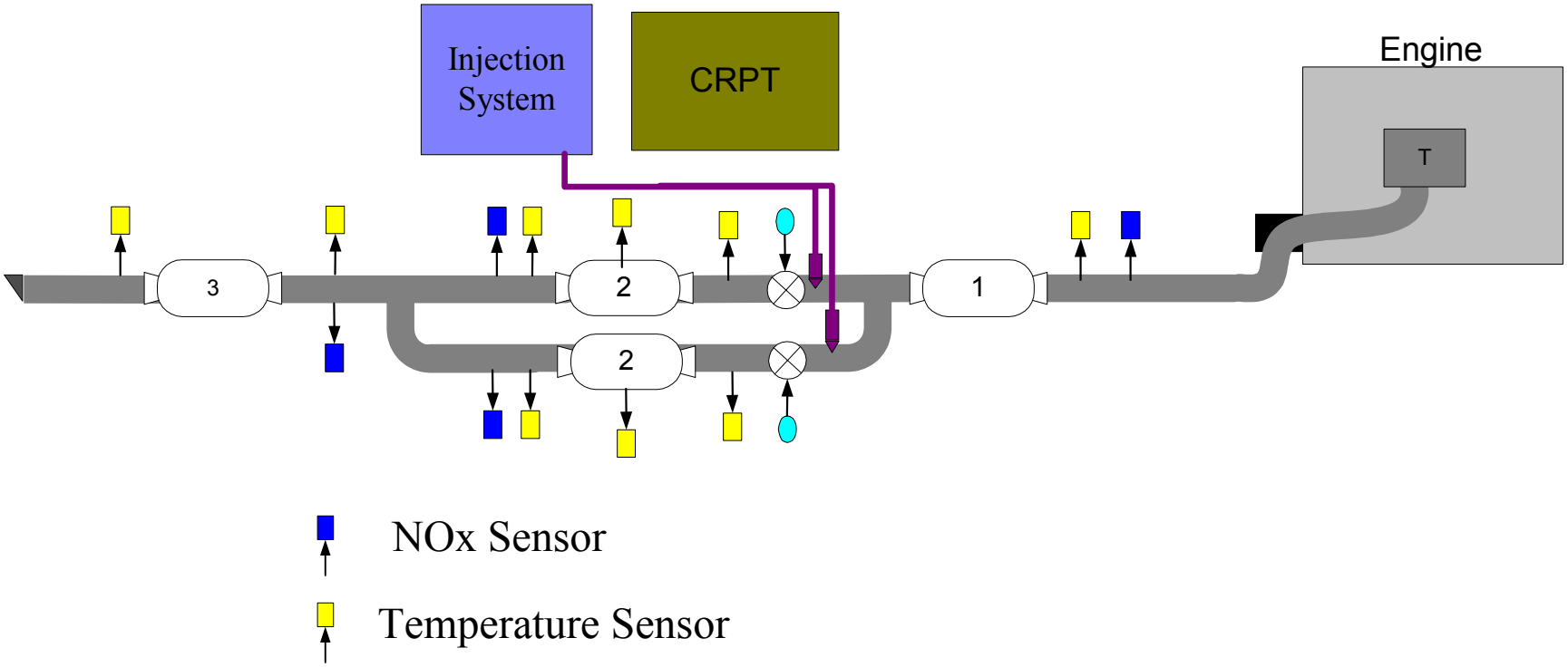
- Objectives
- System design
- Test results
- Conclusion
- Future work
- Acknowledgement

Objectives

- To develop the generic aftertreatment subsystem technologies applicable for LDV and LDT engines ranging from 55 kW to 200 kW.

- To develop an optimized aftertreatment subsystem for a LDT (Light Duty Truck) type vehicle, and to demonstrate the technology which will enable light duty diesel engines to meet Federal Tier II regulation with minimum impact on fuel economy.
    - •NOx conversion efficiency > 90%
    - •PM conversion efficiency > 90%
    - •Fuel injection penalty over FTP-75 < 5%
    - •Fuel injection penalty at cruise condition < 3%

System Description



System Description

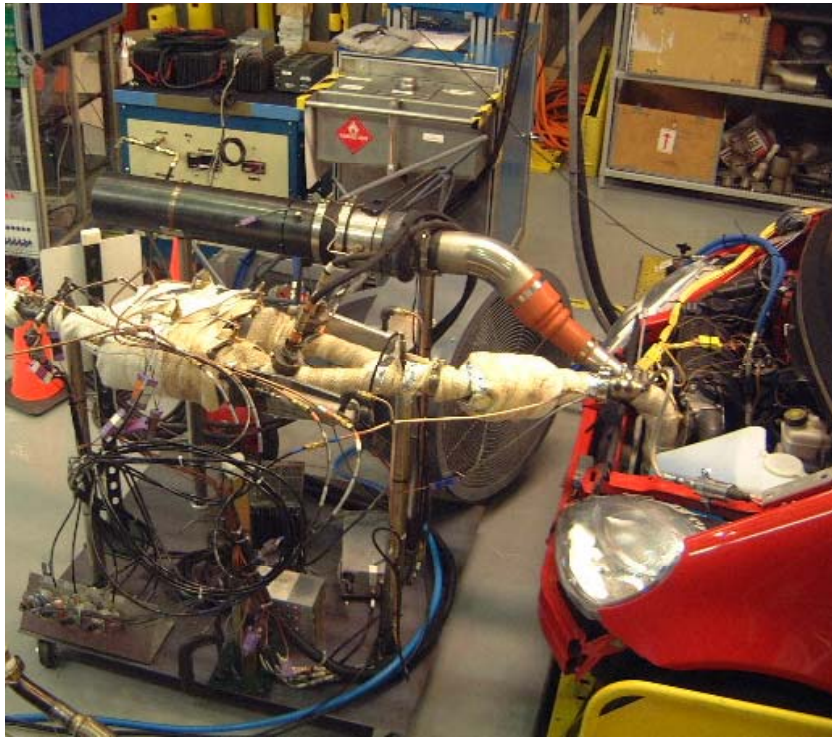
Mercedes A170 (1.7 L engine)

Sulfur trap

Adsorber

Catalyzed soot filter

System Description



Catalyst	Volume, L
Adsorber	3.1
SOx	1.25
CSF	2.5
Total	6.85

Mercedes A170 Baseline Results

With standard exhaust system

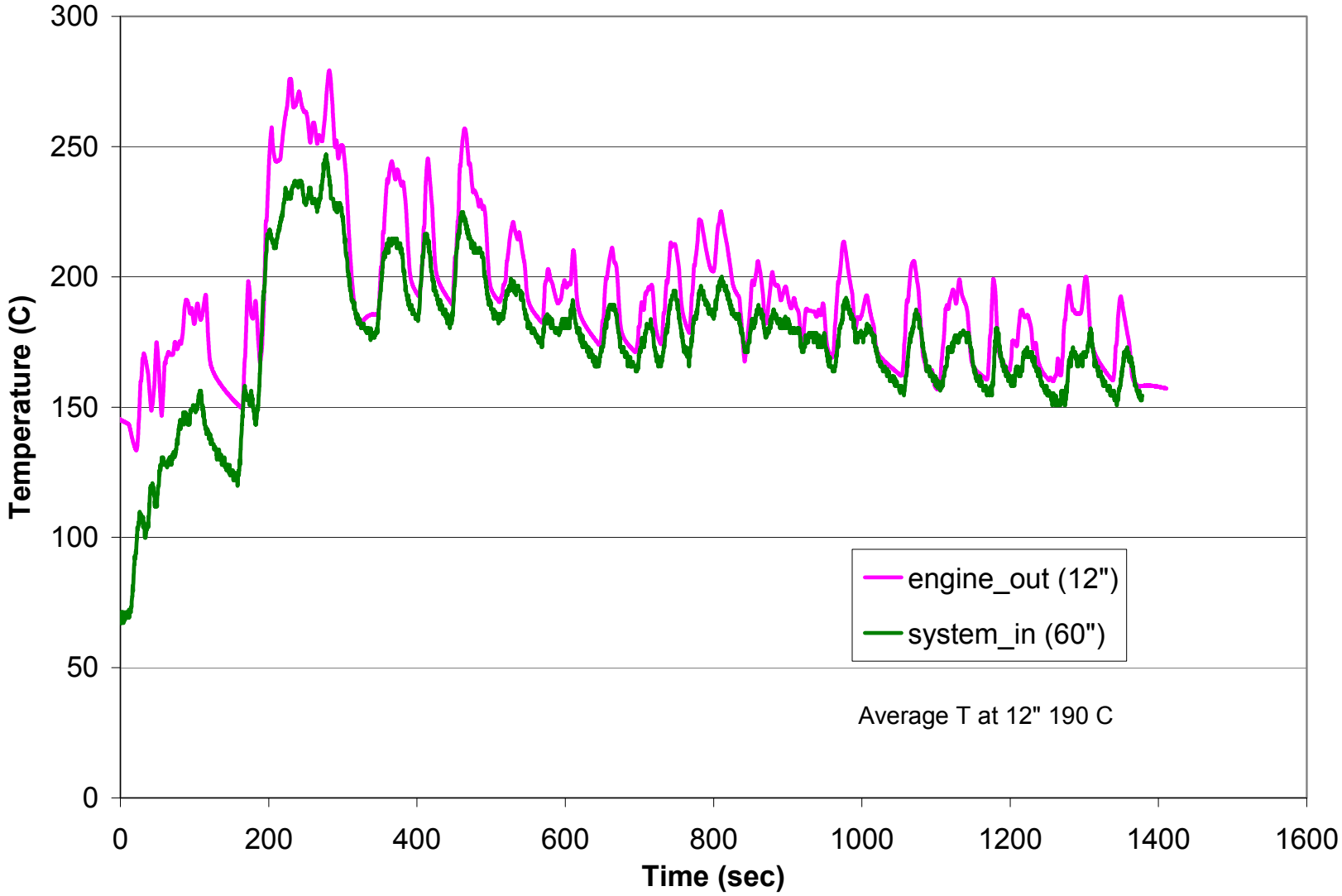
Cycle	CO	CO_2	THC	NOx	mpg
UDDS	1.266	223.2	0.073	0.807	45.1
HWFET	0.578	176.4	0.0288	0.686	57.4

With additional 2” Hg back pressure (to account for the EAS)

Cycle	CO	CO_2	THC	NOx	mpg
UDDS	1.289	223.3	0.0813	0.957	44.93
HWFET	0.626	176.5	0.0352	0.787	57.30

grams/mile

FTP Cycle Temperature History



Test Procedure

Strategy	Control Algorithm	Hardware	Cycle
1	Original	Original	FTP-72
2	Modified	Original	FTP-72
3	Original	Glow Plug	FTP-72
4	Original	Injector +GP	HWFET
5	Modified	Injector +GP	FTP-72

Test Results

For FTP-72 (UDDS) cycles the catalyst was preconditioned by running the vehicle at 65 mph for about 5 minutes.

For HWFET there was no preconditioning of the catalyst.

First Cycle Results: UDDS

Strategy	CO	CO_2	THC	NOx (% Conv.)	mpg
1	0.0238	251.8	0.021	0.085 (91)	40.2
2	0.0234	259.8	0.020	0.064 (93)	39.1
3	0.0235	253.9	0.012	0.039 (96)	40.1
5	0.0253	253.9	0.012	0.013 (99)	40.1
First Cycle Results: HWFET					
4	0.0107	193.0	0.026	0.029 (96)	52.7

grams/mile

Test Results

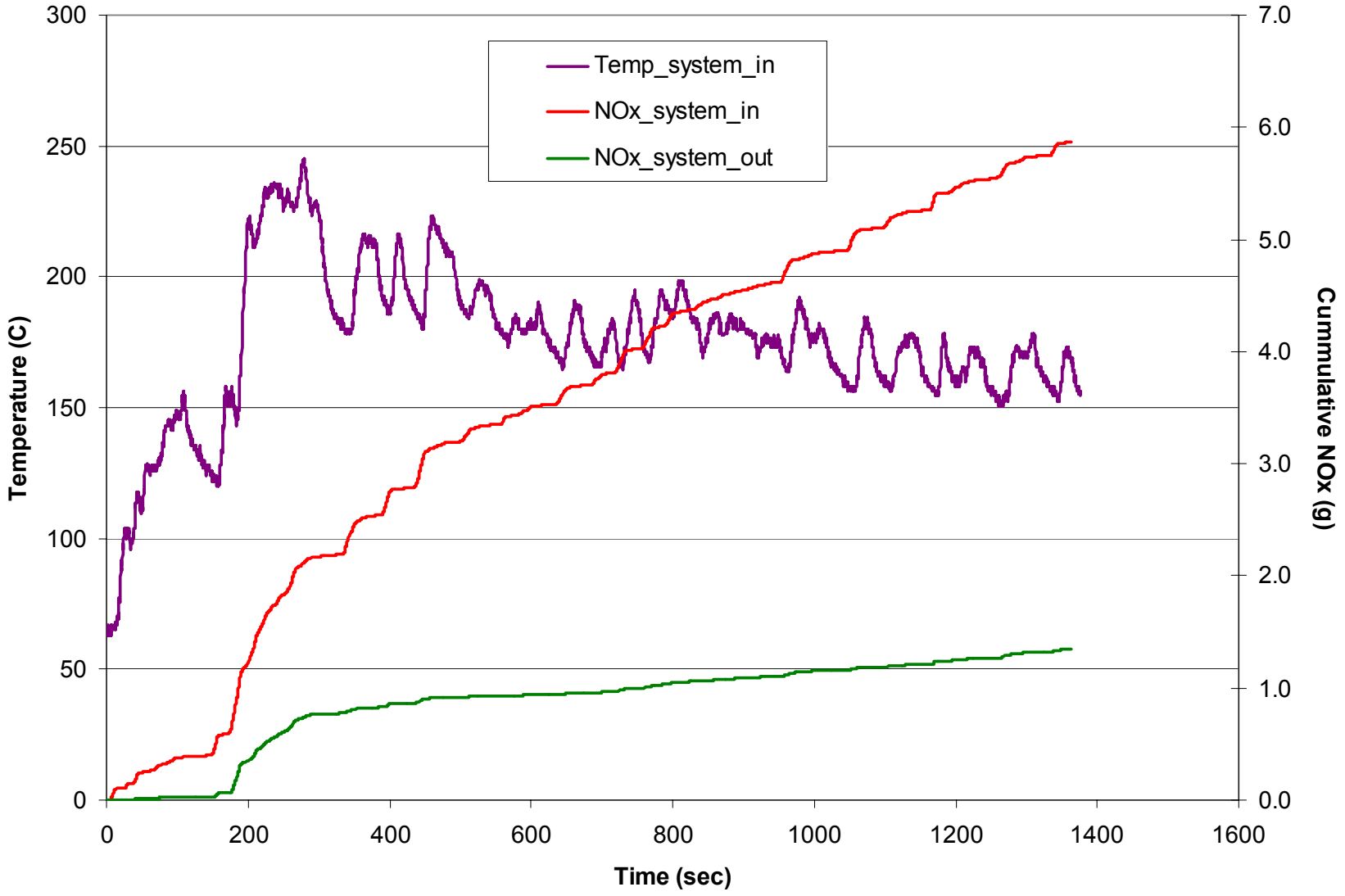
The second cycle was started 10 minutes after the first cycle ended. There was no preconditioning for the second cycle.

Second Cycle Results: UDDS

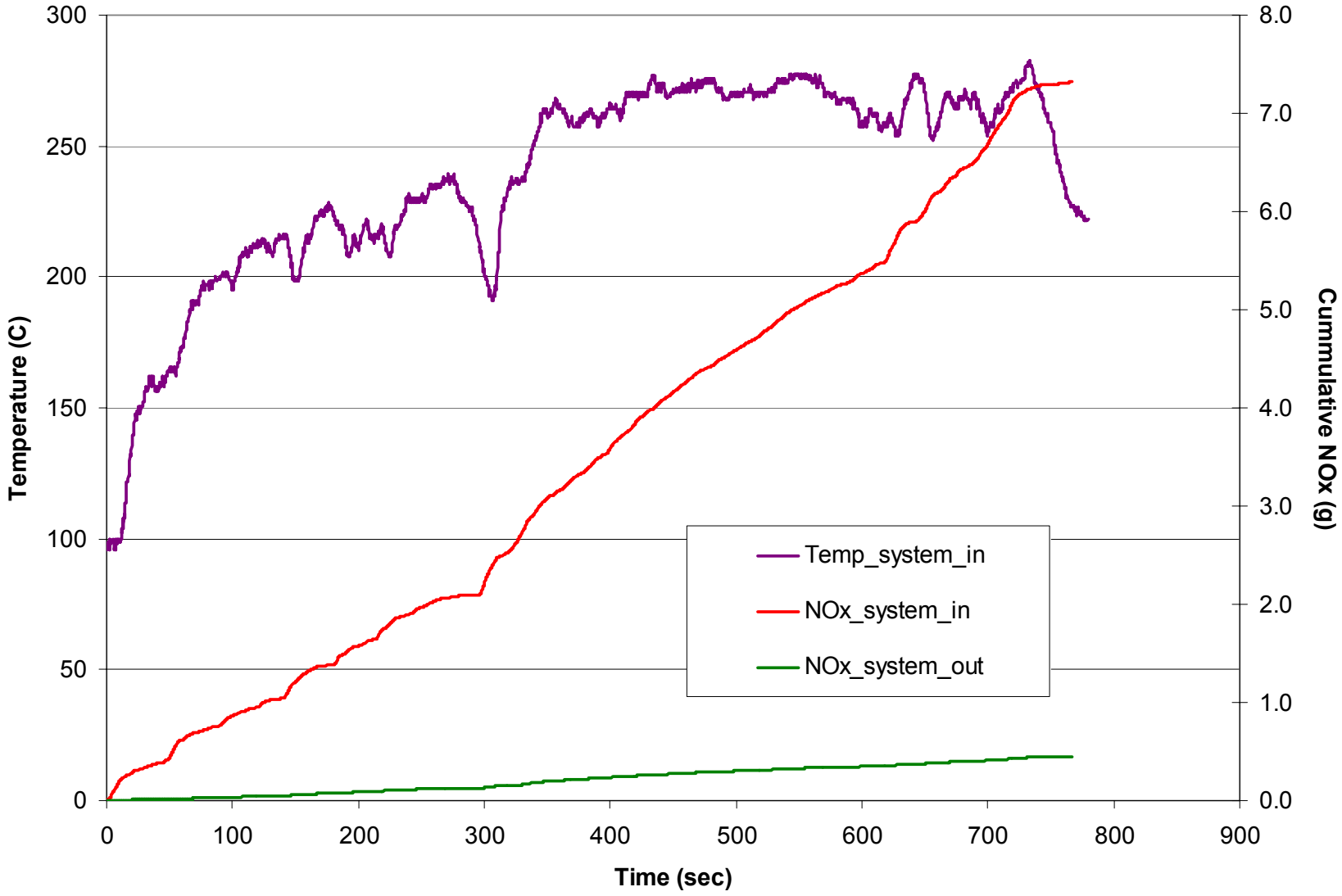
Strategy	CO	CO_2	THC	NOx (% Conv.)	mpg
1	0.0236	245.7	0.0282	0.198 (79)	41.4
2	0.0232	257.1	0.0245	0.192 (80)	39.5
3	0.0222	250.5	0.0649	0.218 (77)	40.6
5	0.0239	251.7	0.065	0.105 (89)	40.4
Second Cycle Results: HWFET					
4	0.0108	192.3	0.022	0.023 (97)	52.9

grams/mile

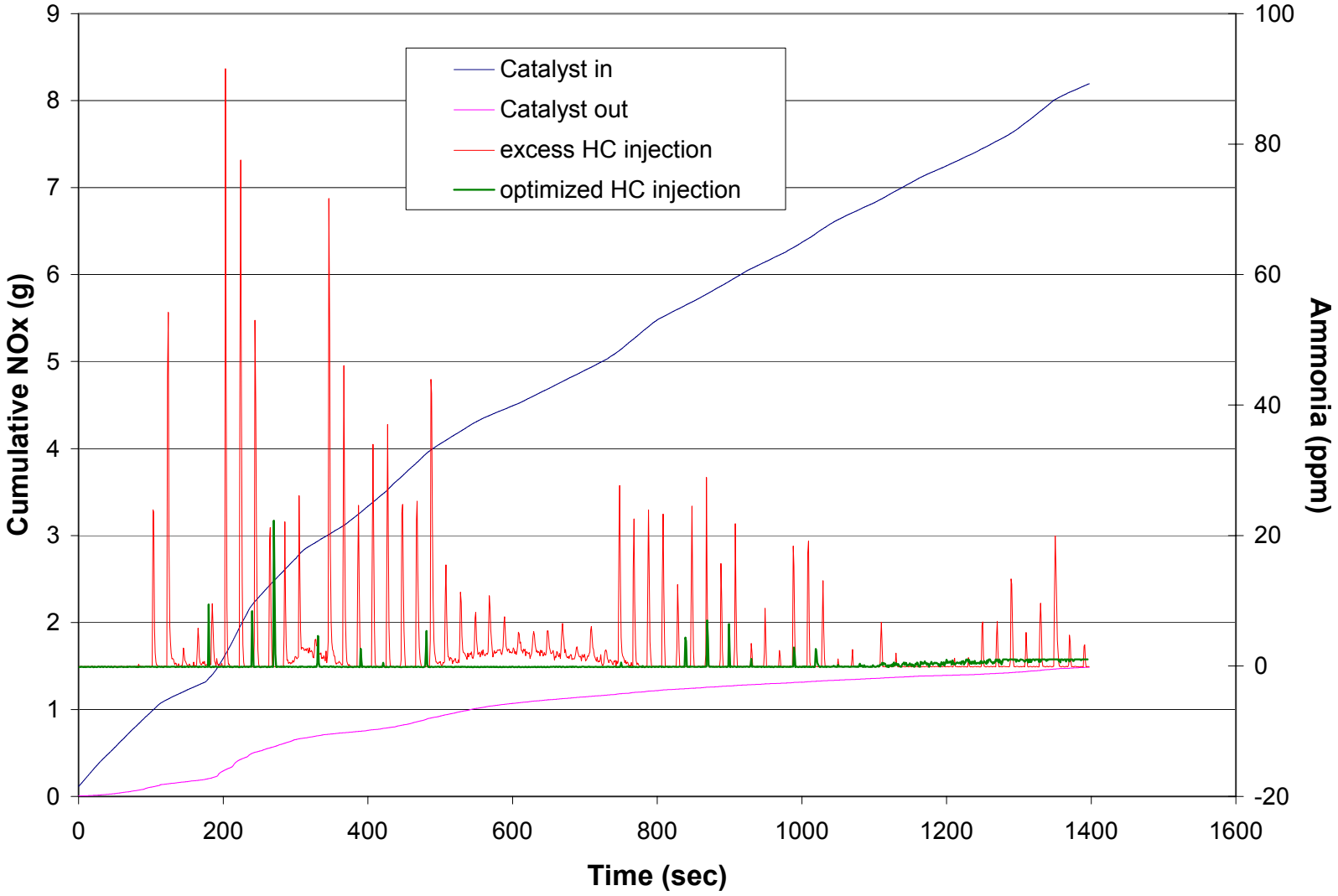
FTP Test Result



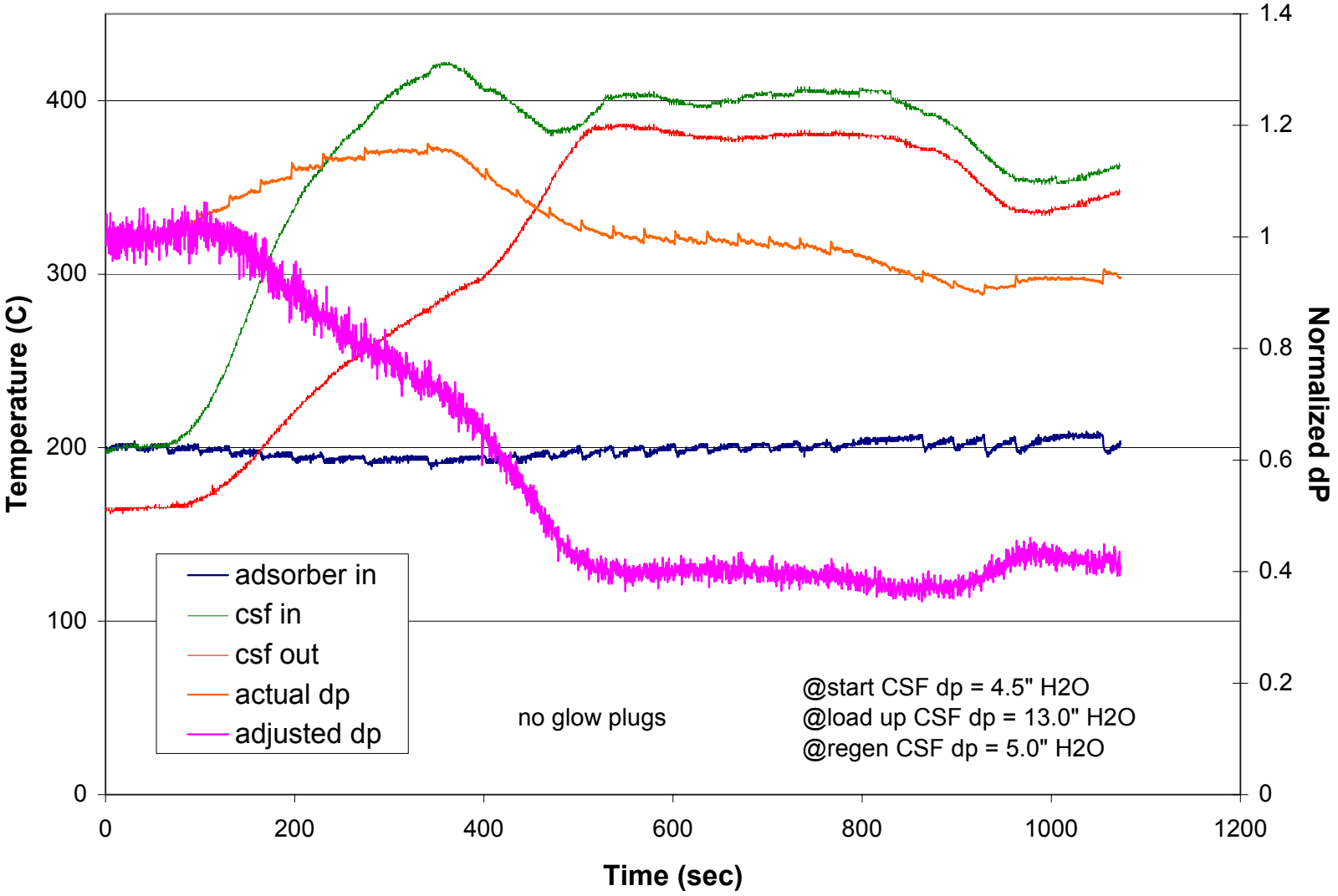
HWFET Results



NH_3 in Exhaust During FTP-72 Cycle



CSF Regeneration Using HC Injection



Conclusions

- Encouraging NOx conversion efficiency results were obtained at Argonne National Labs with the present EAS system. A NOx conversion efficiency of 99 % can be obtained with a preconditioned catalyst.
- Without preconditioning a NOx conversion efficiency of 89% could be achieved at about 11.6 % total fuel penalty for the FTP-72 cycle.
- The PM conversion was close to 100% and was beyond the detection capability of the measurement system at Argonne National Labs.
- There is some NH_3 production during adsorber regeneration but is not an issue if the HC injection is optimized.
- Heat release from HC injection for adsorber regeneration may be utilized to keep the CSF clean.
- With improved engine out NOx of ~0.5 g/mile instead of the present ~0.9 g/mile both the conversion efficiency and fuel penalty will improve.

Future Work

- Continue to develop and optimize catalyst formulations for best NOx and PM conversion efficiency under exhaust temperatures and space velocities consistent with anticipated light duty applications.
- Design and develop an integrated NOx and PM system for minimum package size/cost, maximum performance with minimum impact on fuel economy and provide high volume cost projections.
- Obtain and minimize the impact of the final optimized system on unregulated emissions.
- Obtain transient FTP-75 results on the LDT vehicle at Argonne National Laboratory.

Acknowledgement

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- We also wish to thank USCAR for their interest and participation.