DIESEL ENGINE EMISSIONS UNDER COLD & HOT START TRANSIENTS

Comments Made & Issues Raised

by

Naeim A. Henein

Wayne State University

DOE CLEERS MEETING

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NEED FOR VALIDATION OF THE MODELS FOR AFTER TREATMENT DEVICES

- Simulation models are necessary to expedite the design and cut the cost of developing the after treatment devices needed for the diesel engine to meet the future emission standards.
- Experimental validations under actual or near actual engine running conditions are equally necessary for the development of **useful** and **efficient predictive** models.
- Actual engine running conditions include both the steady and transient operating modes.
- Can the after treatment devices operate efficiently under the following transient engine conditions ?

DIESEL ENGINE EMISSIONS UNDER TRANSIENT OPERATING CONDITIONS

SAMPLES OF EXPERIMENTAL DATA OBTAINED AT WAYNE STATE UNIVERSITY ON DIFFERENT DIESEL ENGINES

Engines:

1. Single-Cylinder, Air Cooled, 4-Stroke-Cycle, Direct Injection Diesel Engine.
2. Four-Cylinder, Water-Cooled, 4-Stroke-Cycle, Direct-Injection, Heavy-Duty Diesel Engine.

Operating Conditions:

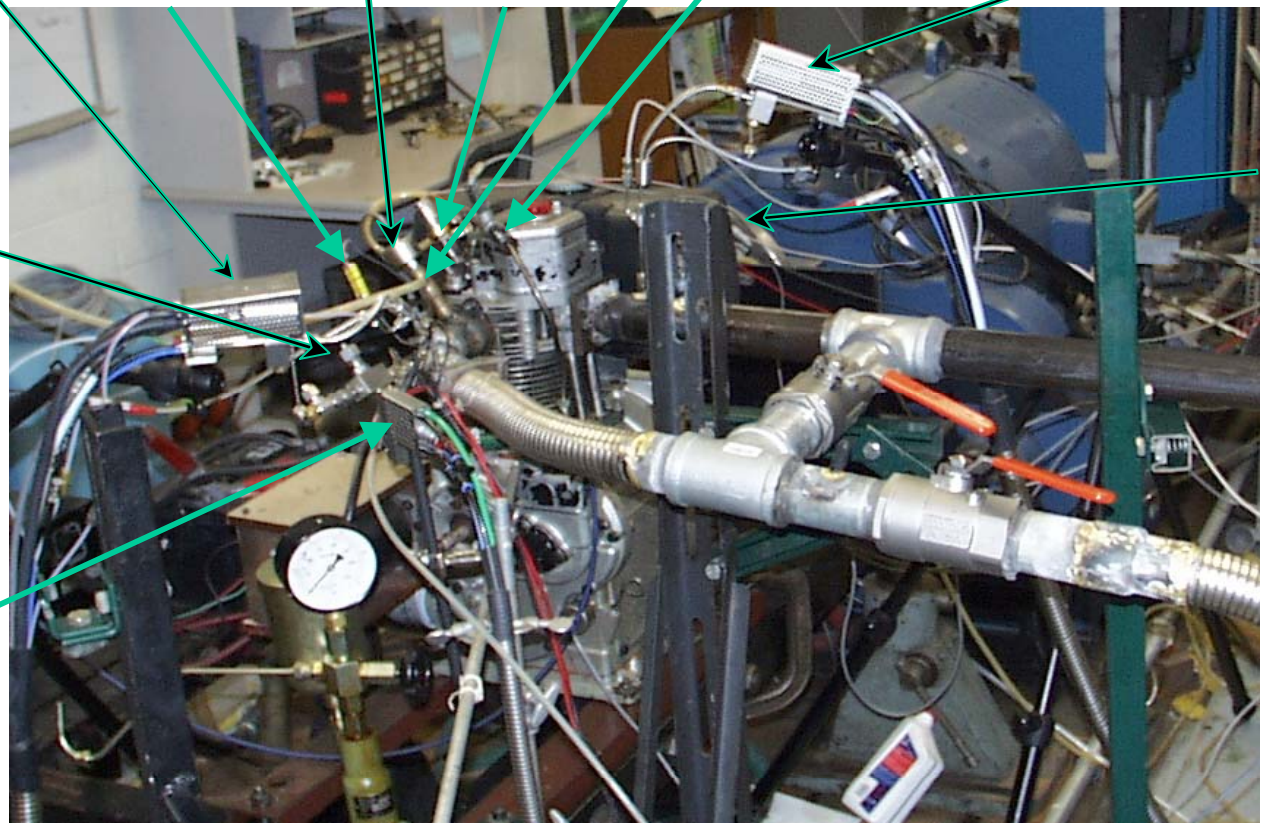
1. Cold Start, at different ambient room temperatures.
2. Hot Start, after shut off for different periods of time, to simulate the operation of hybrid diesel electric vehicles.

Single-Cylinder, Air-Cooled, Naturally Aspirated, DI Diesel engine.

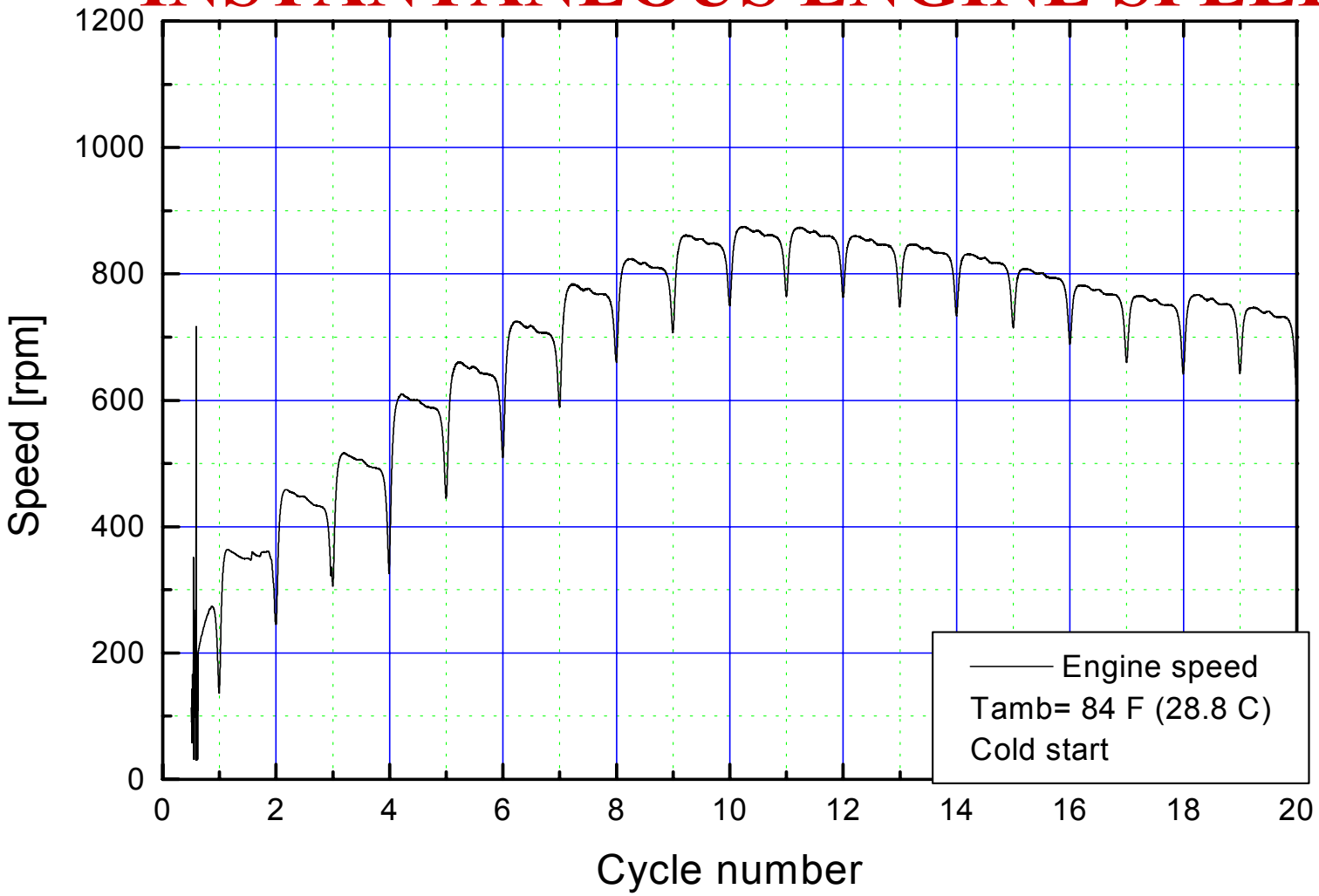
Funded by US Army TARDEC, NAC and ARC.

1. Advanced and Hybrid Diesel Power Trains Simulation Program. (Funded by U S NAC and ARC)
2. Cold Start Combustion Instability and White Smoke Reduction Program. (Funded by US TARDEC and ARO)

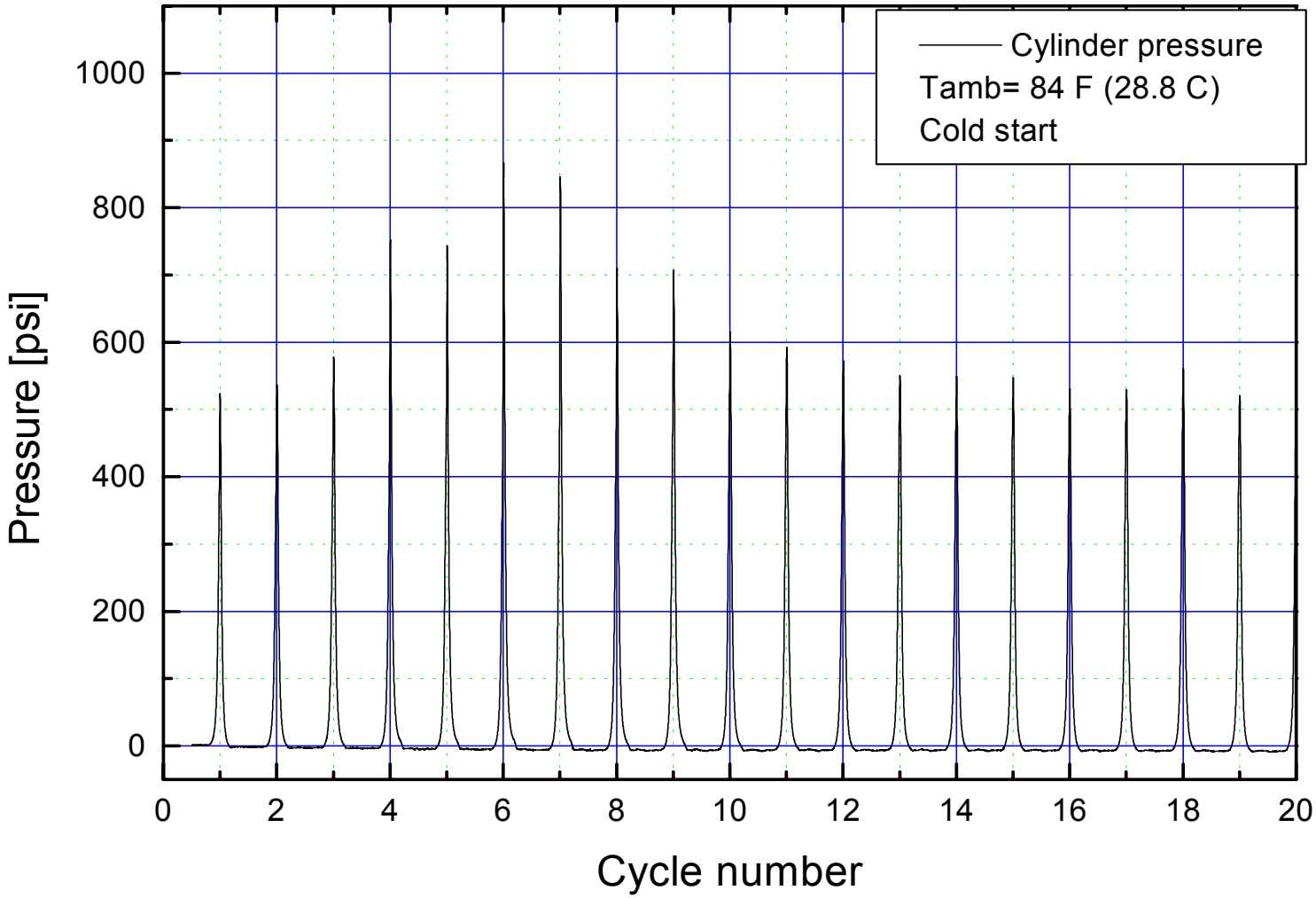
SINGLE-CYLINDER, DI, 4-S-C DIESEL ENGINE



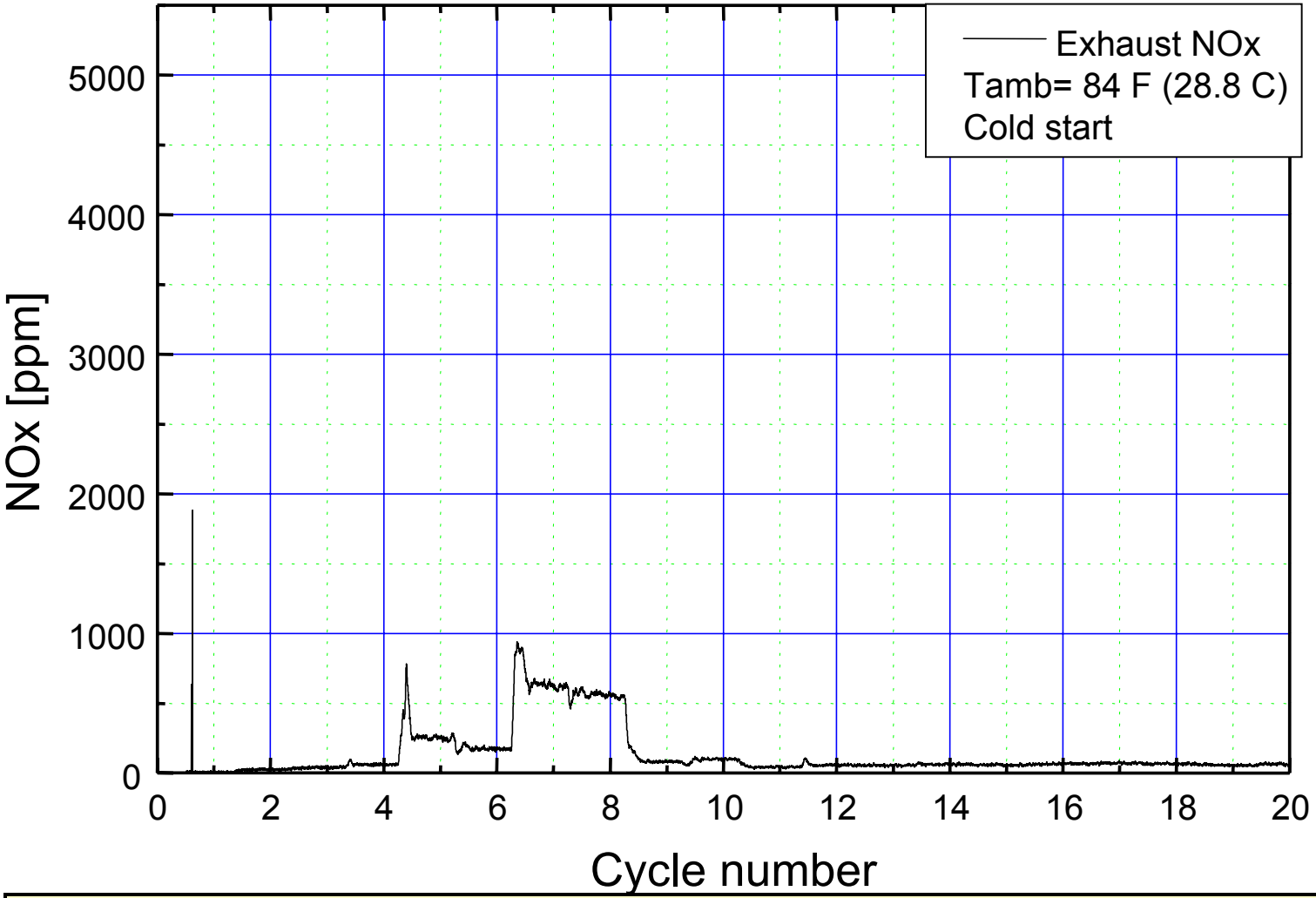
COLD START (29°C, DF2): INSTANTANEOUS ENGINE SPEED



COLD START (29 °C, DF2): CYLINDER GAS PRESSURE

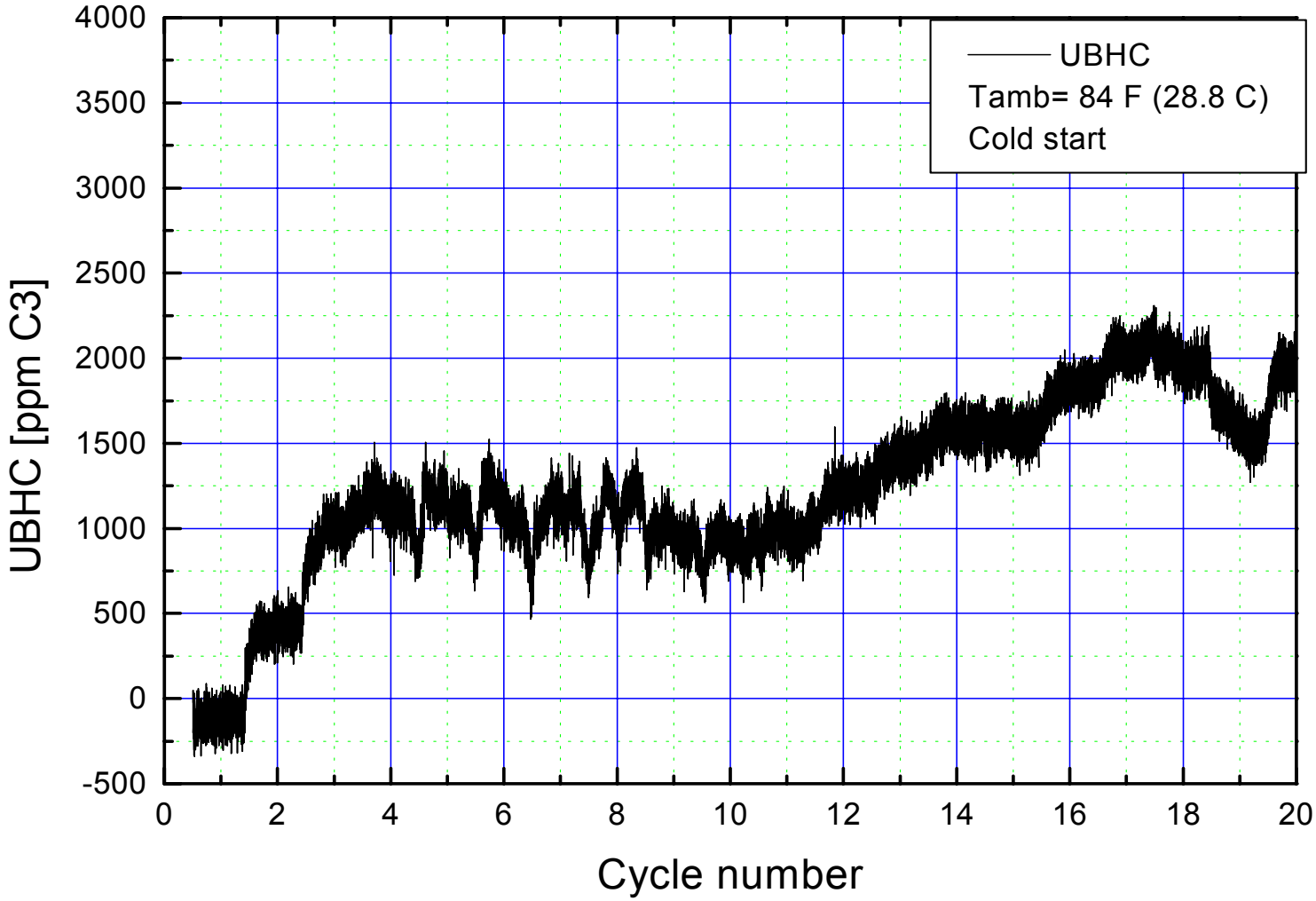


COLD START (29°C, DF2): CYCLE-RESOLVED NO_x

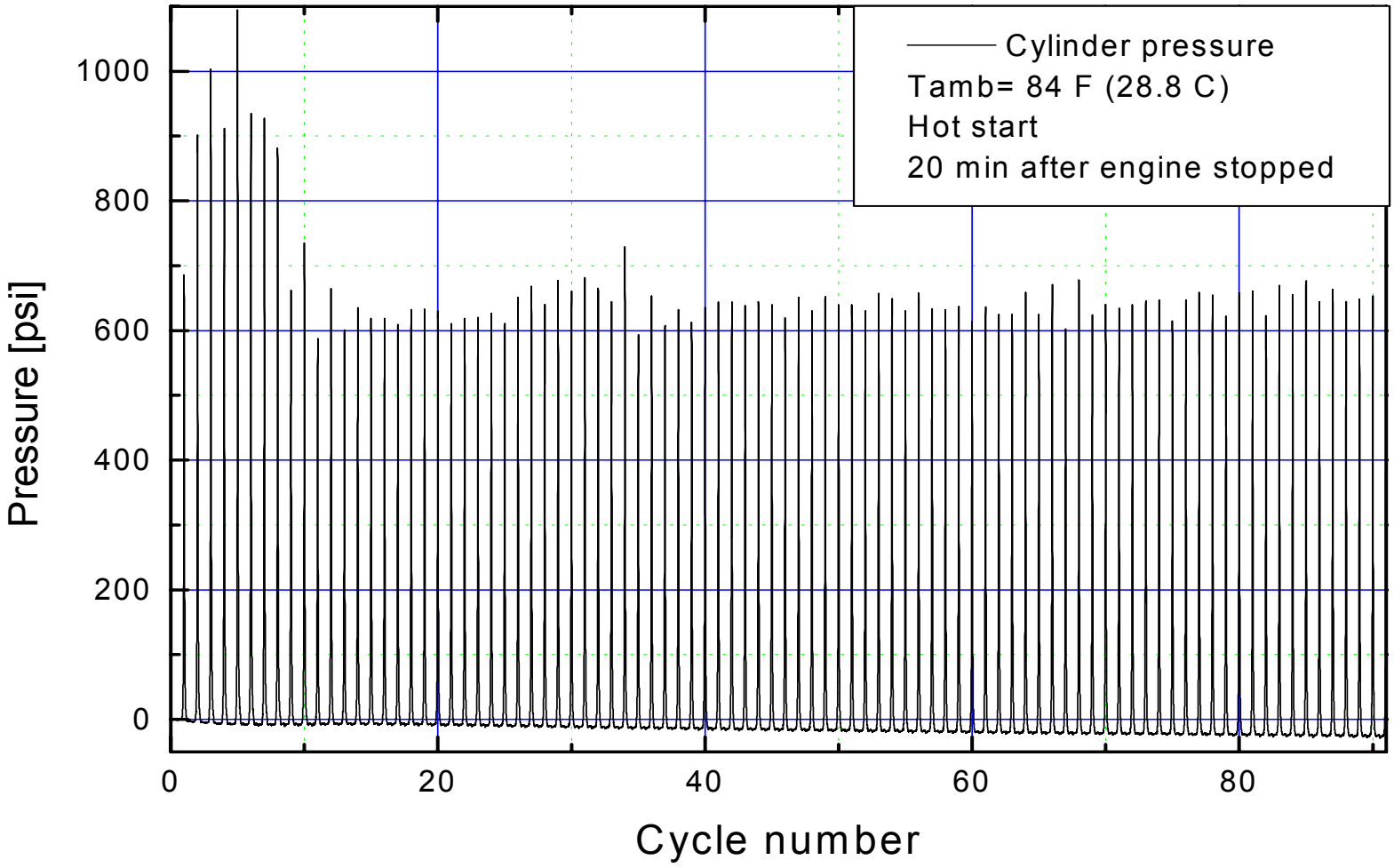


Exhaust gas temperature is close to 70°C……..

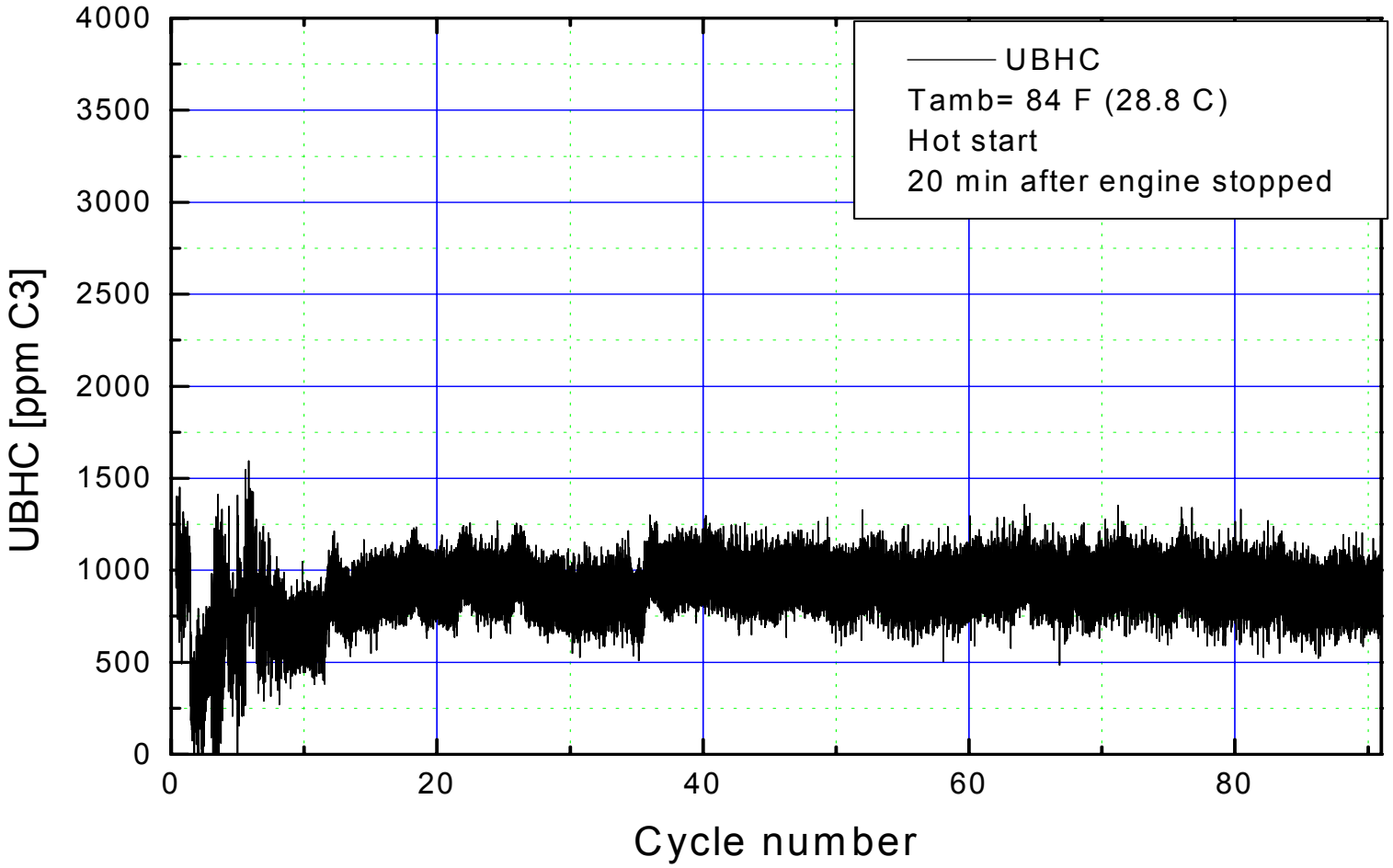
COLD START(29°C,DF2): CYCLE-RESOLVED HC



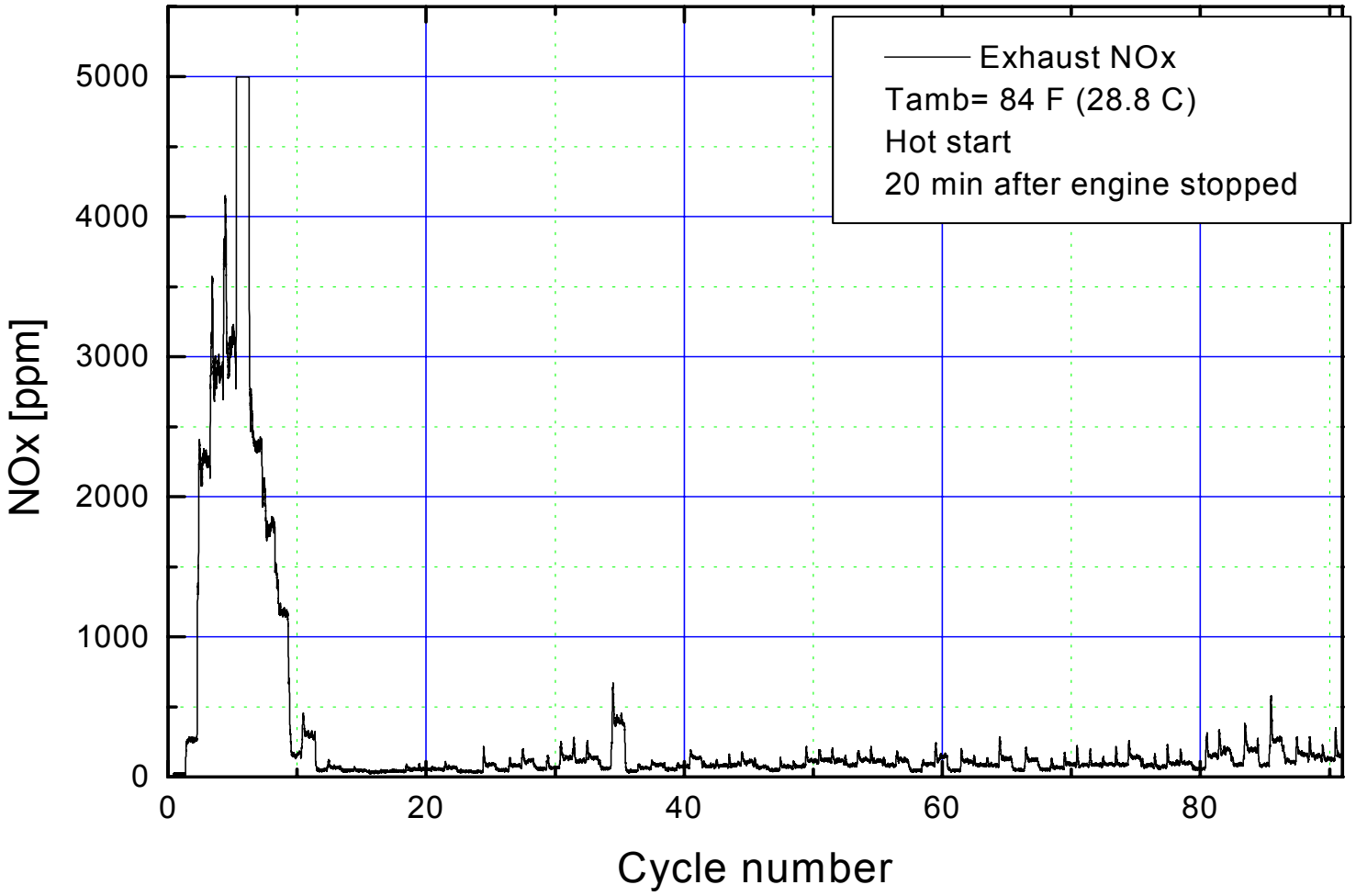
HOT START, AFTER 20 MINUTES: CYLINDER GAS PRESSURE(DF2)



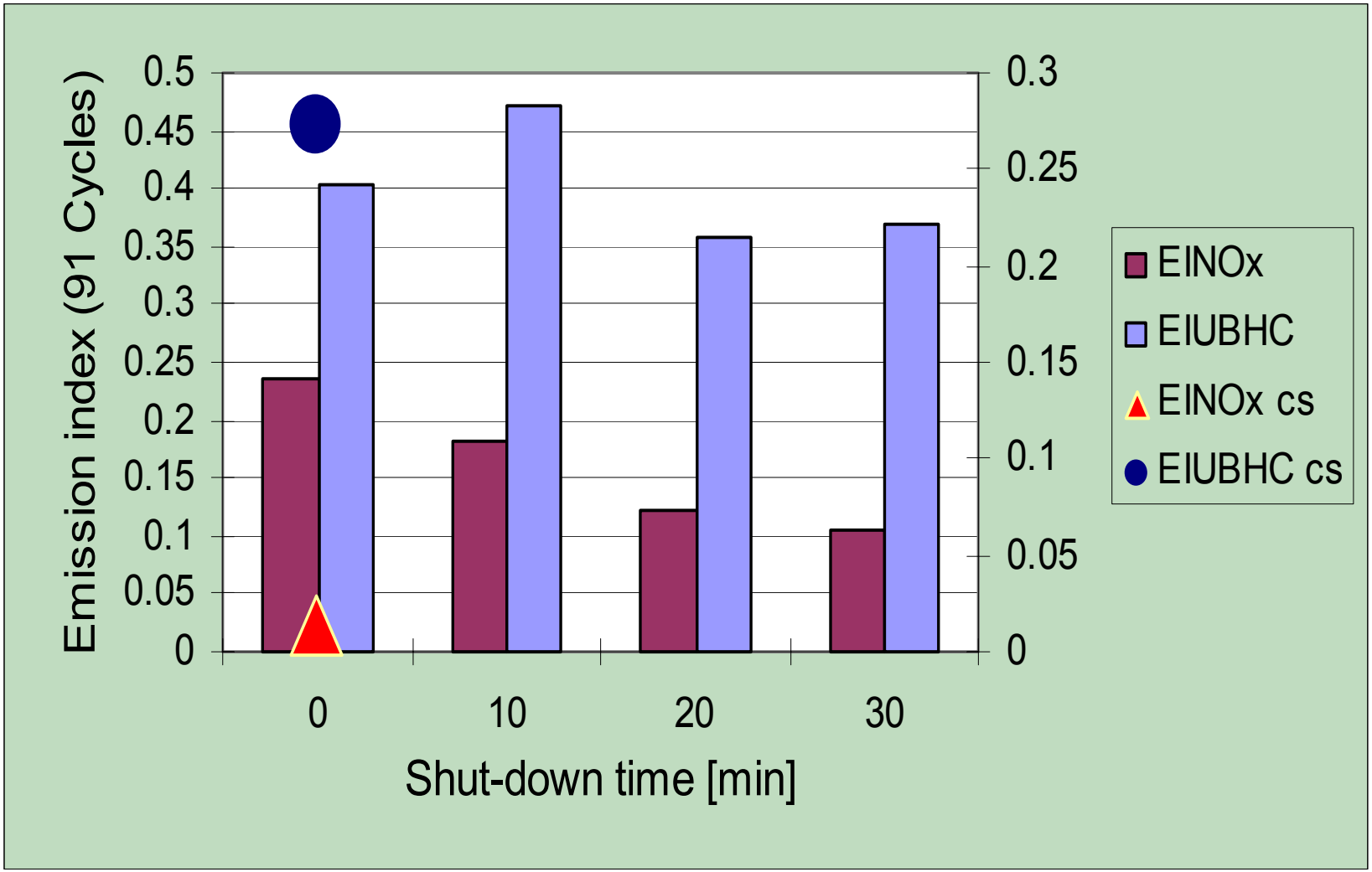
HOT START AFTER 20 MINUTES: CYCLE-RESOLVED HC (DF2)



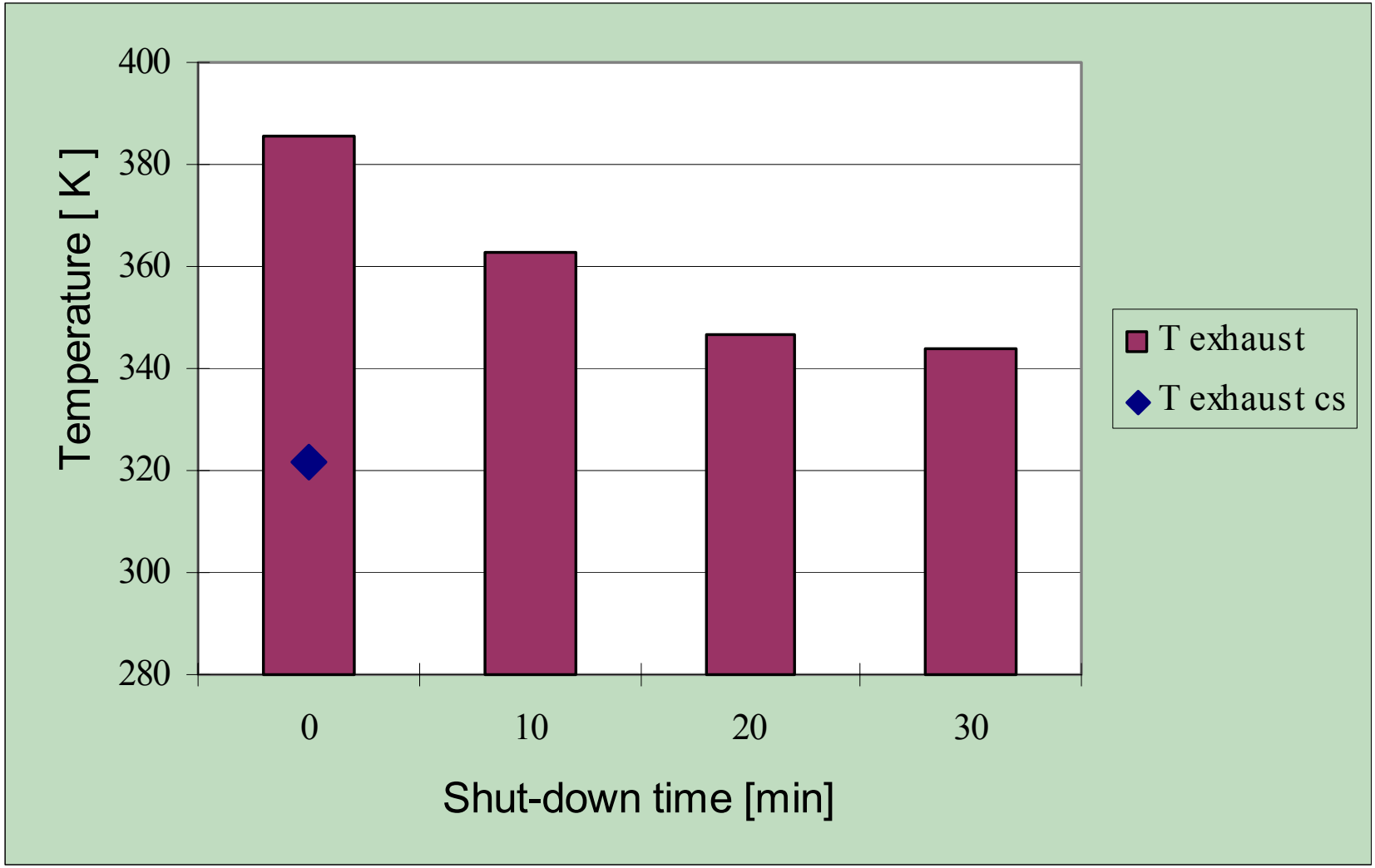
HOT START AFTER 20 MINUTES: CYCLE-RESOLVED NO_x



HOT AND COLD STARTS:
HC and NO EMMISION INDEX



COLD and HOT STARTS: MAXIMUM EXHAUST GAS TEMP.



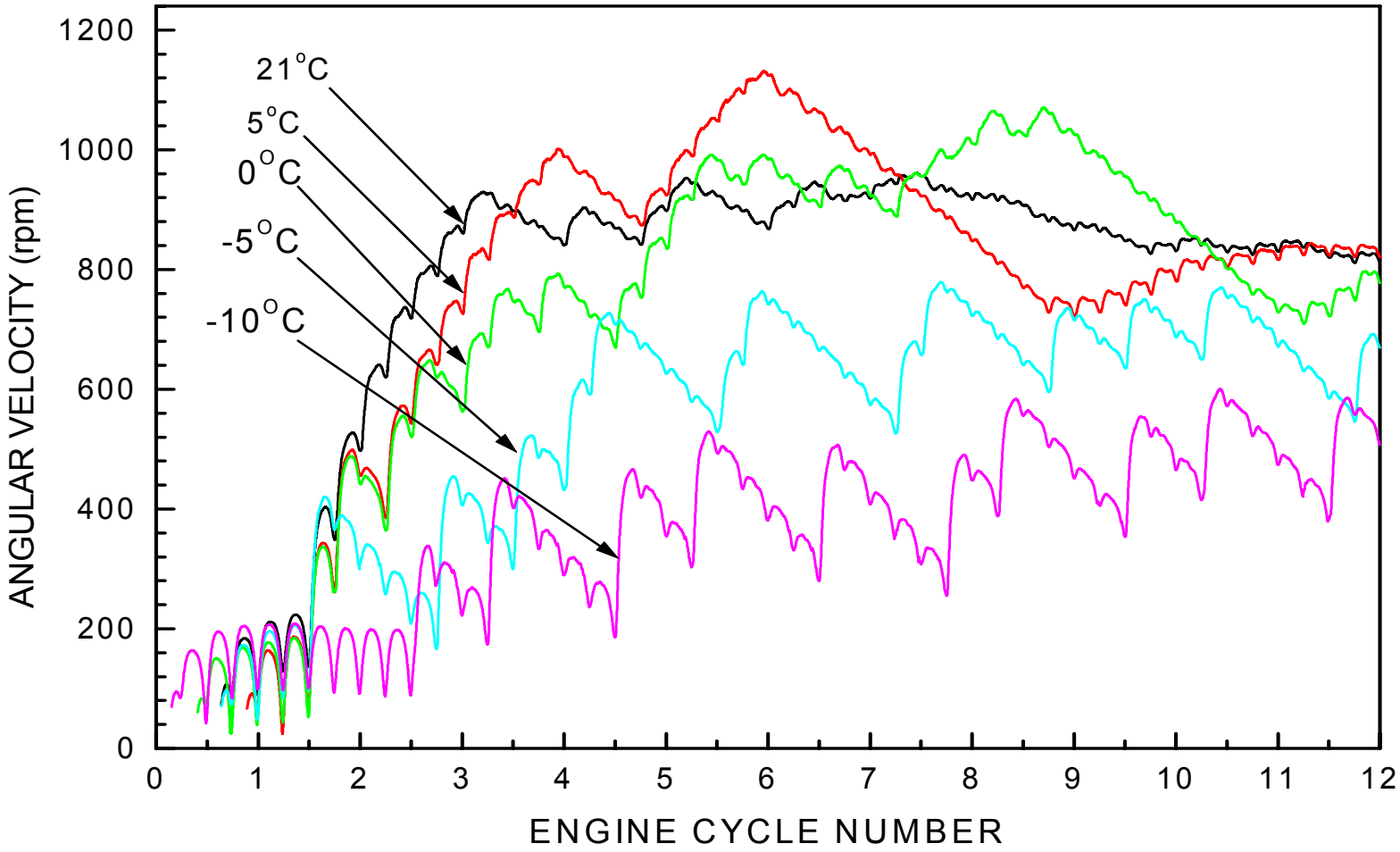
Heavy-duty, 4-Cylinder, Turbocharged, and Inter-cooled DI Diesel engine

Funded by US Army TARDEC and ARO

Cold Start Combustion Instability and White Smoke Reduction Program

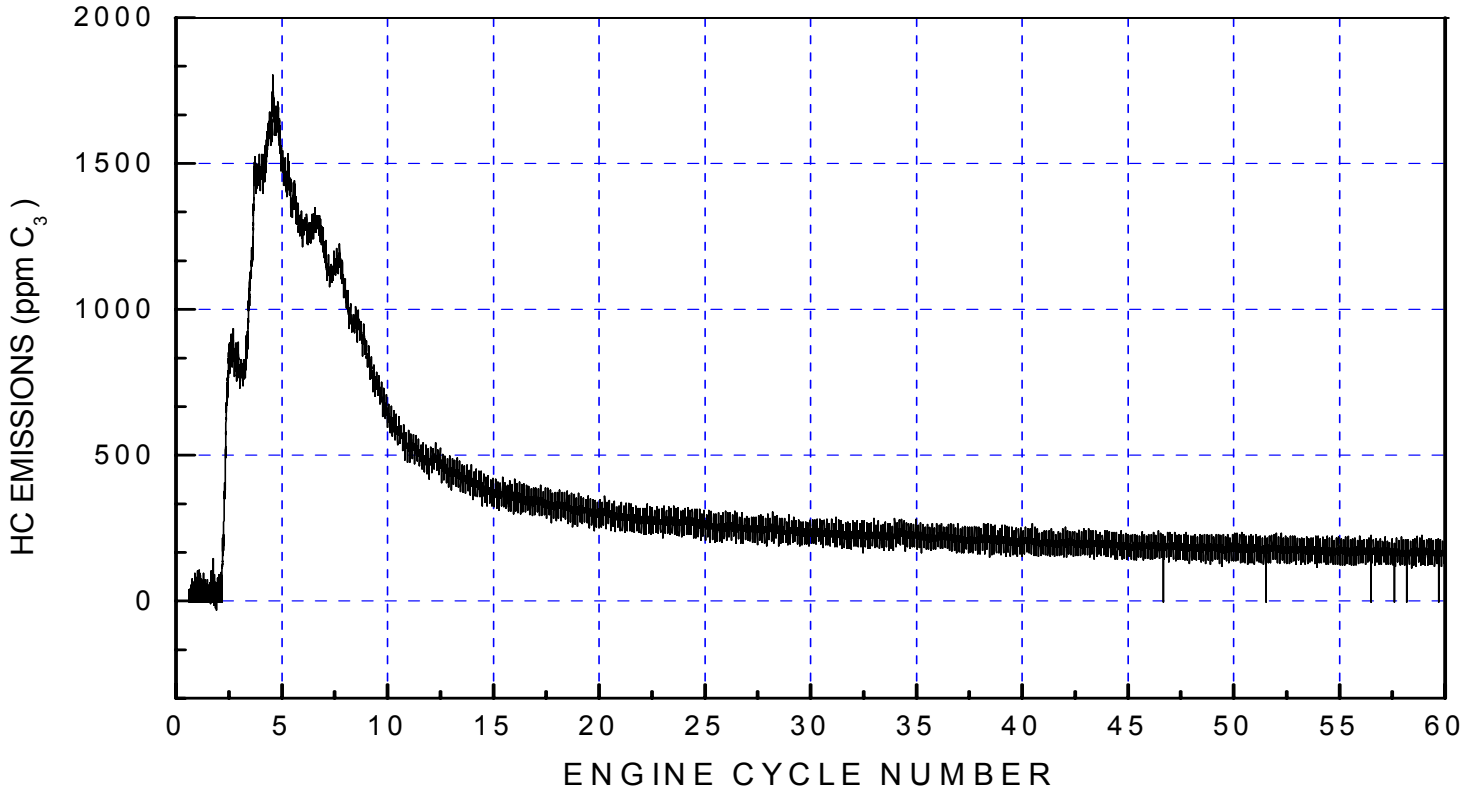
HEAVY DUTY 4-CYLINDER DIESEL

Instantaneous Engine Speed at Different Ambient Temperatures



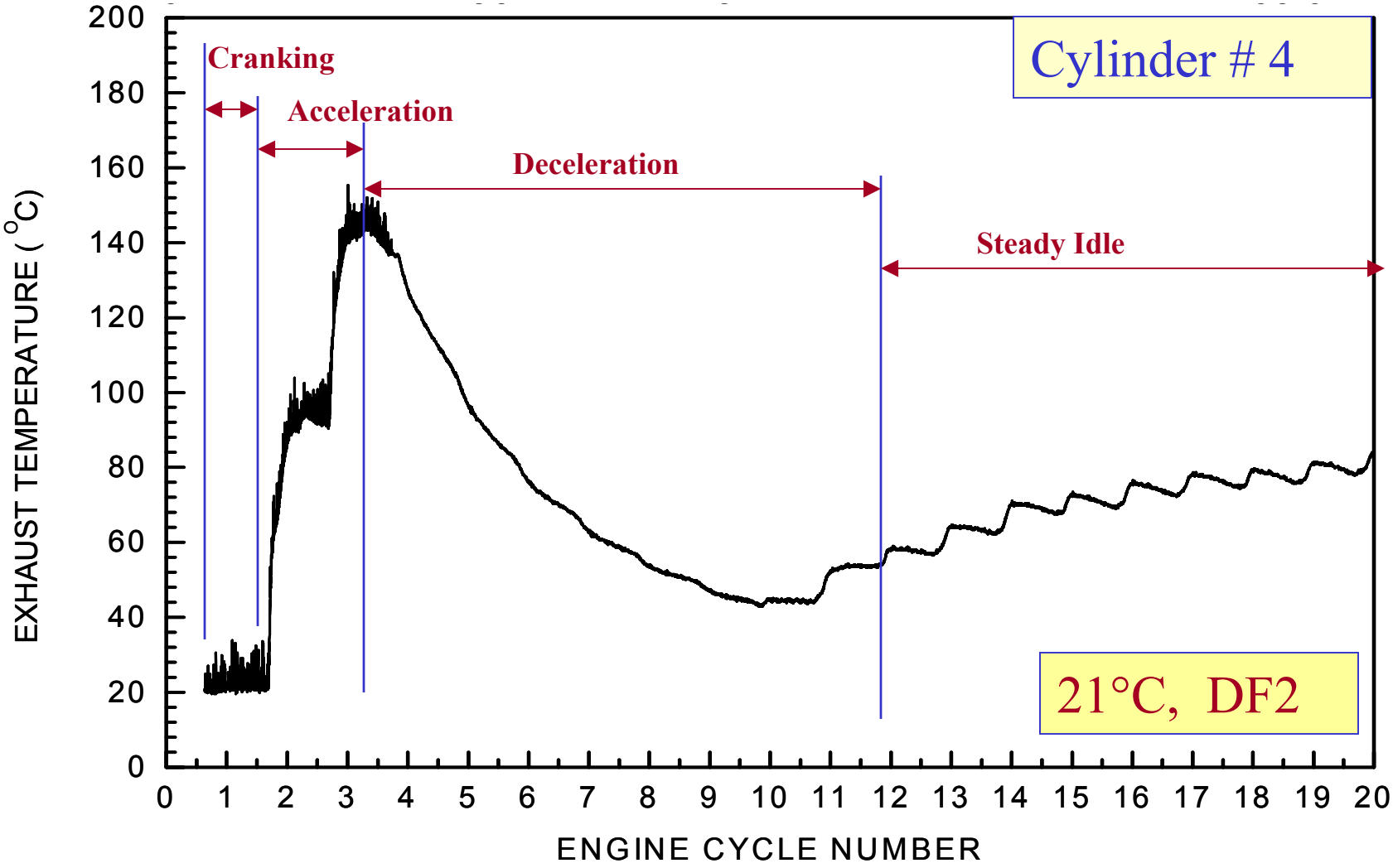
HEAVY DUTY 4-CYLINDER DIESEL

GASEOUS HYDROCARBON EMISSIONS AT 21 C



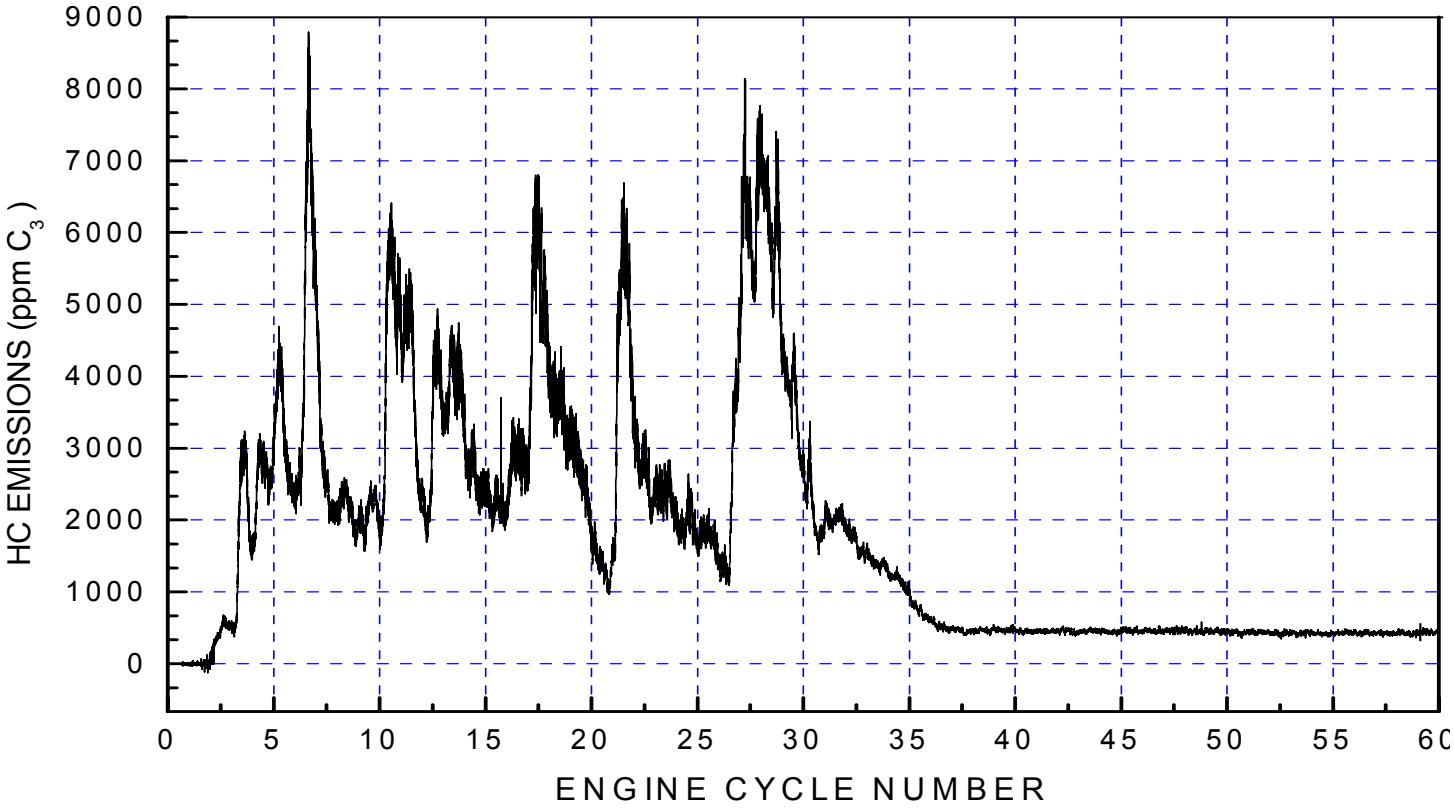
Can the after treatment devices burn this, with the exhaust temperature shown in the next figure?

HEAVY DUTY 4-CYLINDER DIESEL



HEAVY DUTY 4-CYLINDER DIESEL

GASEOUS HYDROCARBON EMISSIONS AT -5 C



White smoke includes gaseous HCs, and liquid particulates.
What is the effect of the liquid on the exhaust treatment devices?

CONCLUSIONS

VALIDATION OF SIMULATION MODELS UNDER ACTUAL ENGINE STEADY and TRANSIENT OPERATIUNG CONDITIONS IS A NECESSITY.

RECOMMENDATIONS

- Conduct tests on a typical production engine, equipped with the after-treatment devices, under actual transient running conditions and measure the real time gas temperature, pressure and composition, before and after the after treatment devices.

- Combine the diesel cycle simulation model with the after-treatment devices model and determine their effectiveness in reducing emissions.

- Improve the predictive capability of the model in order to reduce the effort, time and cost in optimizing the system for minimum tail pipe emissions.

REFERENCES

1. " White Smoke Emissions Under Cold Starting of Diesel Engines," N. A. Henein, M. Yassine, M. Tagomori and Walter Bryzik, SAE Paper No. 960249, SP 1161, pp. 89-109, 1996.

2 "Exploration of the Contribution of the Start/Stop Transients in HEV Operation and Emissions," Naeim A. Henein, Dinu Taraza, Nabil Chalhoub, Ming-Chia Lai and Walter Bryzik, SAE paper No. 2000-01-3086, Future Transportation Technology Conference, Costa Mesa, CA., August 21-23, 2000.

3. "Diesel Engine Cold Start Instability and Control Strategy," N. A. Henein, , Z. P. Han, B. Nitu, and W. Bryzik, SAE 2001-01-1237, 2001.