Testing a Low NO_2 CRT® DPF System

Presentation to the

Mining Diesel Emissions Conference

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Center for Diesel Research

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Outline

- Objectives
- Background
- Apparatus & Measurement Systems
- Methods
- Results
- Conclusions

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Objective

To evaluate the performance of a Johnson Matthey low NO_2 CRT® in a test cell under steady state and transient operation.

To determine the performance on particulate matter and gaseous emissions.

This presentation is "The rest of the story", most of it, anyway.

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Background

The continuously regenerating trap (CRT®) is a Johnson Matthey patented invention.

CRT's are very effective at removing DPM at relatively low exhaust temperature duty cycles, but they often produce elevated levels of NO_2 in the exhaust.

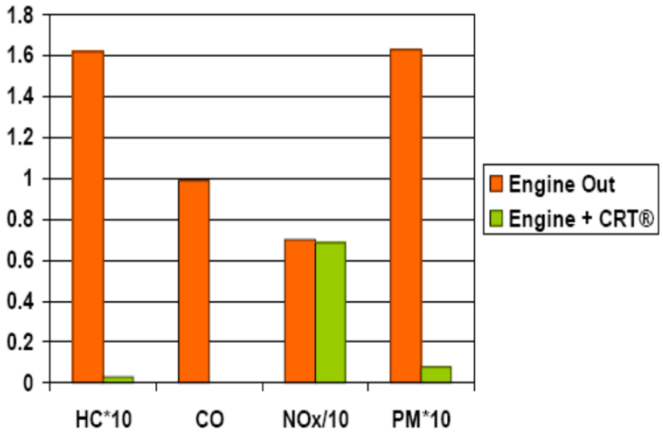
Inco sponsored literature surveys

- *Evaluation of CRT® NO_2 Production (2003)*
- *Influence of Fuel Sulfur Content and Diesel Oxidation Catalysts on Nitrogen Dioxide Concentrations in Diesel Exhaust (2004)*

This testing is a NIOSH sponsored project to evaluate emission control devices with potential for in-mine application.

CRT® System Performance

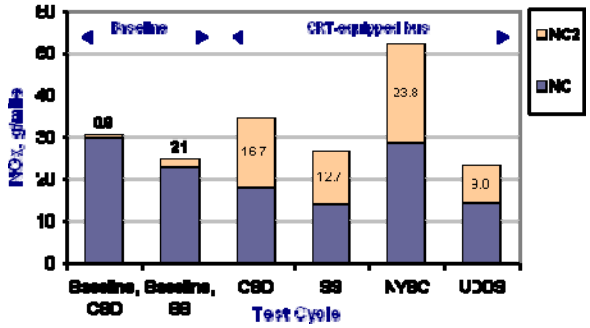
Euro 1 truck engine, ESC Cycle, units: g/kWh



Courtesy Johnson Matthey

CRT® Issues

Enhanced emissions of NO_2 or NO_2 slip.



Ayala, A., Kado, N., Okamoto, R., 2001. "ARB Study of Emissions from Late-model Diesel and CNG Heavy-duty Transit Buses", California Air Resources Board

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Experimental Apparatus

- 1999 Cummins ISM Engine
- 370 HP
- ULSD Fuel <15 ppm S
- Sierra BG-2 used for PM mass sampling, *90 mm filters*
- Quartz filters used for collection of EC samples
- TSI 3007 CPC, TSI 3070A EAD, DC and PAS for real-time particulate sampling.
- Pierburg emissions rack used for gaseous emissions sampling.
- ECOM KL used for direct NO and NO_2 measurements.

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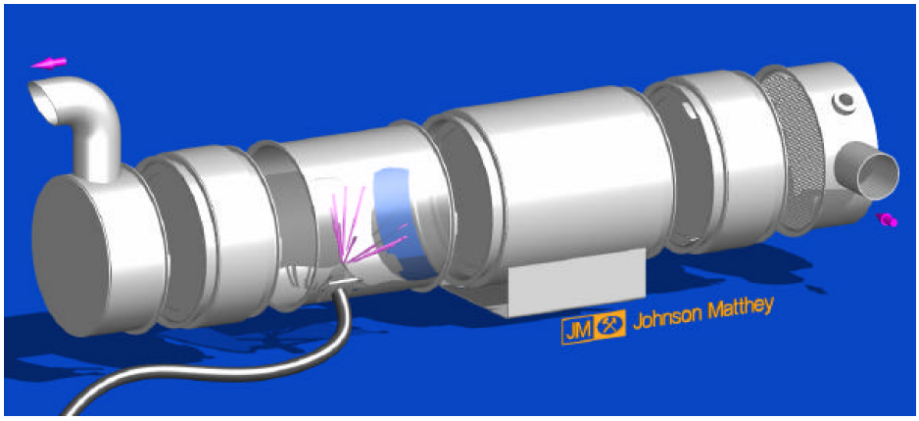
Low NO_2 CRT® System



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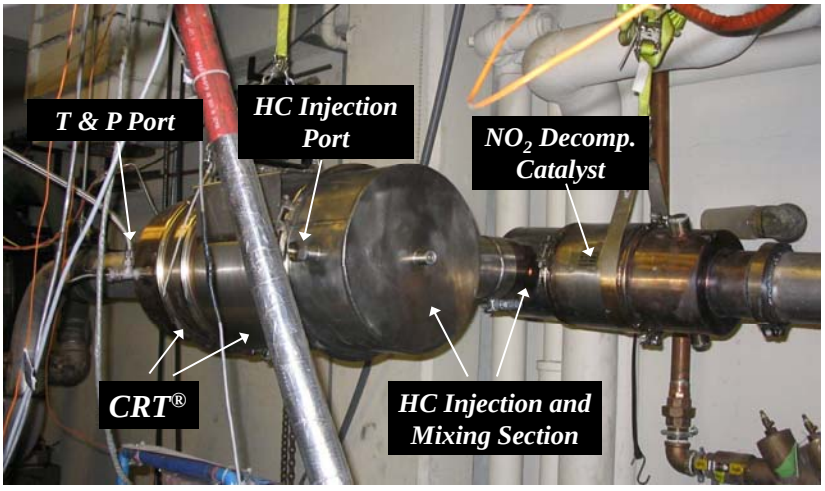
Low NO_2 CRT® System



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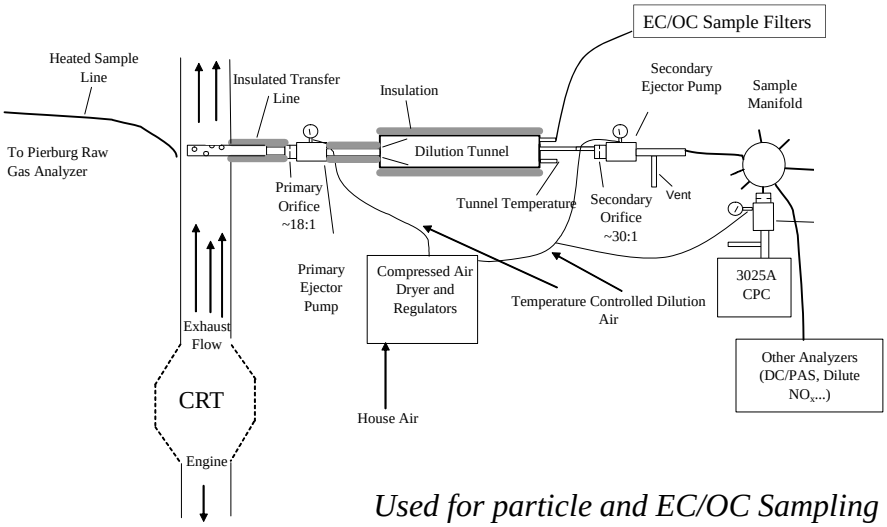
Particulate Sampling Setup



Used for particle and EC/OC Sampling

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Test Modes

ISO 8178 8-Mode Steady State Test

+ two light load modes

Mode	Speed (rpm)	Load (%)	Torque (N-m)	Power (kW)	T Exhaust (C)
1	1800	100	1451	273	480
2	1800	75	1118	211	439
3	1800	50	725	137	377
4	1800	10	149	28	195
a	*1800*	*25*	*268*	*51*	*308*
5	1200	100	1897	238	581
6	1200	75	1424	179	532
7	1200	50	948	119	462
b	*1200*	***28***	*400*	*50*	*347*
8	725	0	0	0	85

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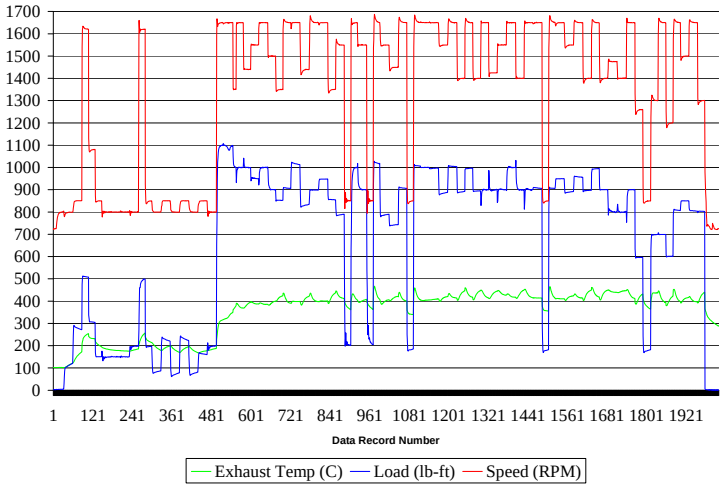
Test Cycle

"INCO" Transient Cycle

Based on logged exhaust temperature date

Similar Temperature Frequency Distribution



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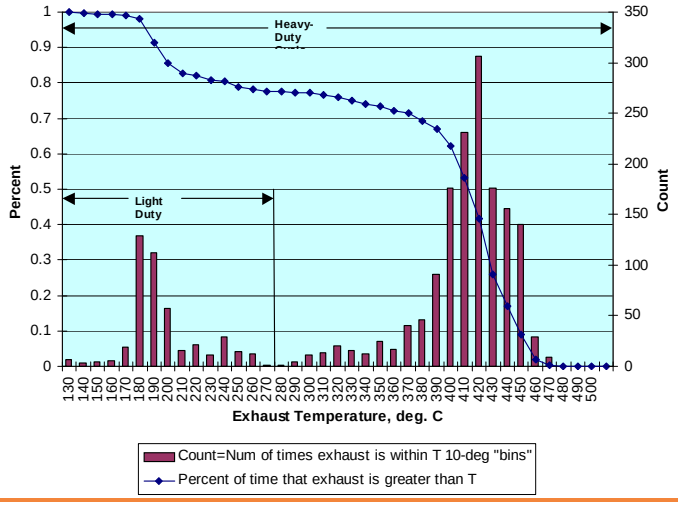
Test Cycle

"INCO" Transient Cycle – Exhaust Temperature Frequency Distribution



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Procedures

- System Installed and De-greened
- System run to collect "characterization" data for JM
  - CRT without HC injection
  - Gaseous emissions, flows, temperature data, etc
- Baseline Data Collected
  - No CRT installed
  - Steady State and Transient Testing
- Collect Data w/Low NO_2 CRT® System Installed
  - Steady State and Transient Testing
  - *Several Iterations Conducted prior to achieving acceptable performance*

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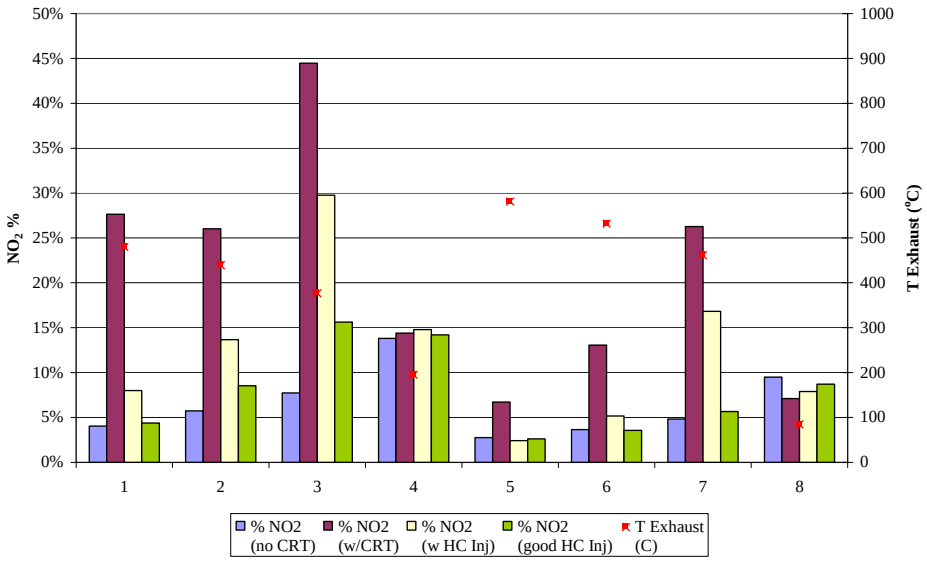
NO_2 Percent Vs Mode, w and w/o CRT



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NO_2 Catalyst Inlet

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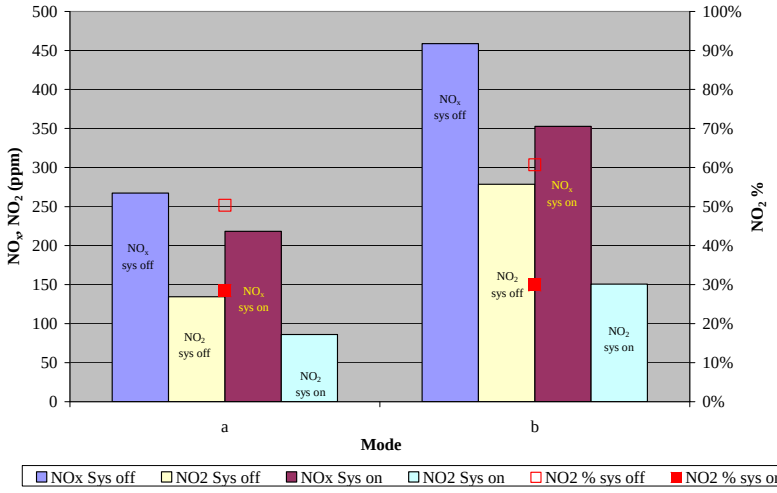
Mode A & B Emissions; w/CRT, HC Injection off & on



System	Mode	NO_x	NO_2	NO_2 %	T exh
off	1800/25%	267	134	50%	340
off	1200/28%	459	278	61%	310
on	1800/25%	218	86	28%	340
on	1200/28%	353	150	30%	310

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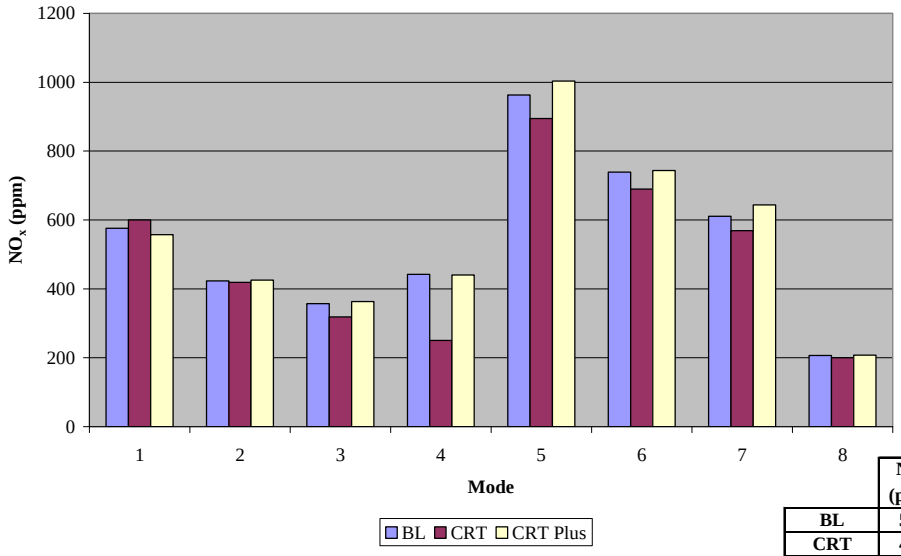
NO_x Emissions; Baseline, w/CRT, and w/Low NO_2 CRT



	NO_2 (ppm)
BL	510
CRT	471
CRT Plus	516

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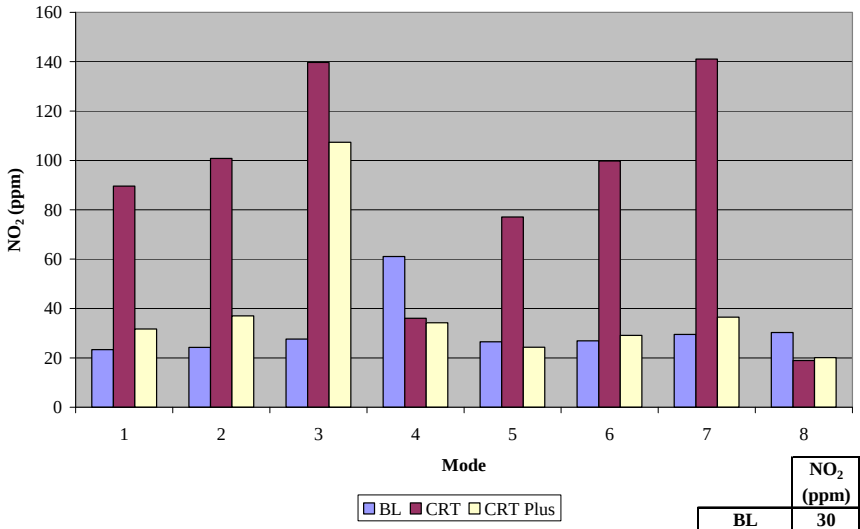
NO_2 Emissions; Baseline, w/CRT, and w/Low NO_2 CRT



	NO_2 (ppm)	%ch
BL	30	--
CRT	88	190%
CRT Plus	42	38%

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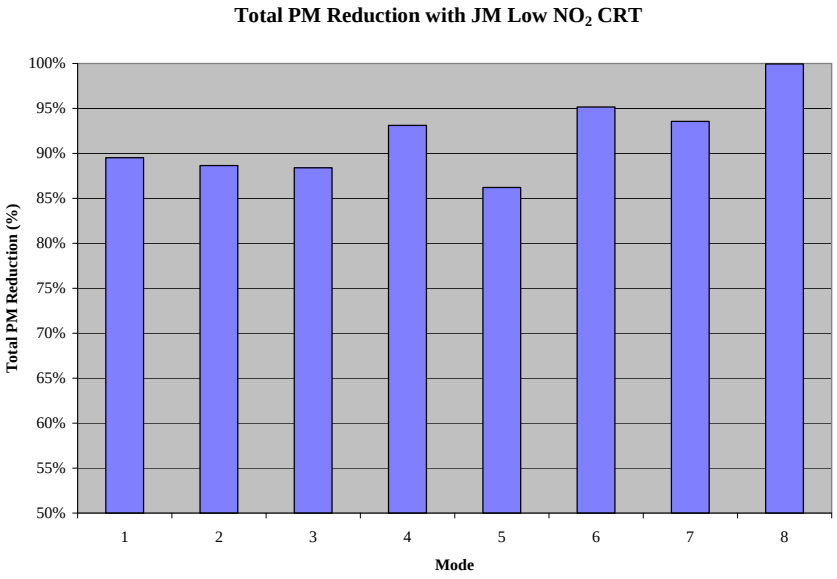

92% Cycle Weighted Average Reduction

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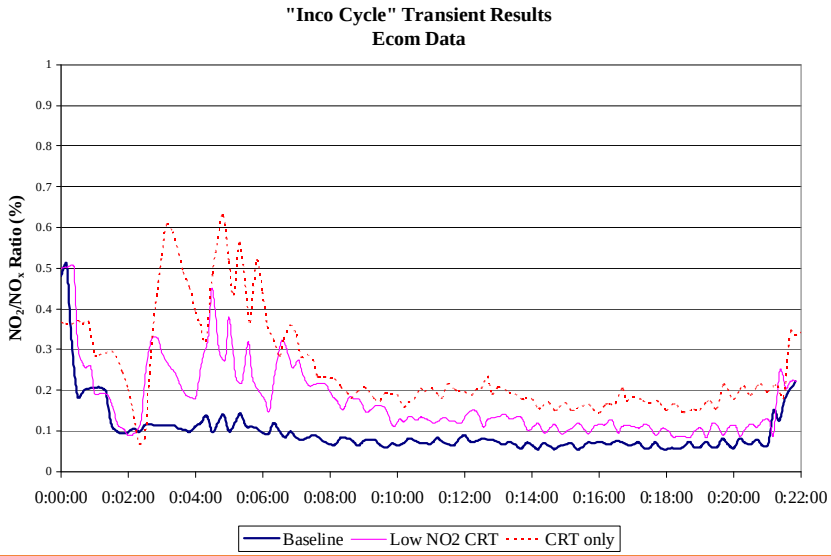
Inco Cycle Results



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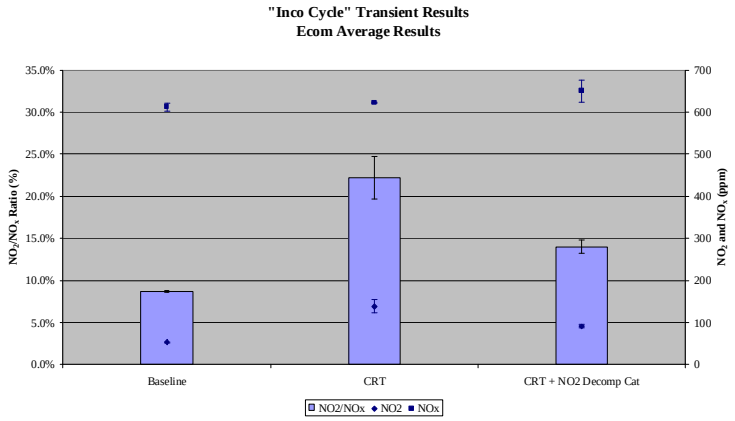
Inco Cycle Results



	NO	NO2	NOx	NO2/NOx
Baseline	559 ±8.7	53 ±1.2	612 ±9.8	8.7% ±0.1%
CRT	484 ±15.6	138 ±16	622 ±0.3	22.2% ±2.5%
CRT + NO_2 D C	559 ±26	91 ±4	650 ±26	14.0% ±0.8%

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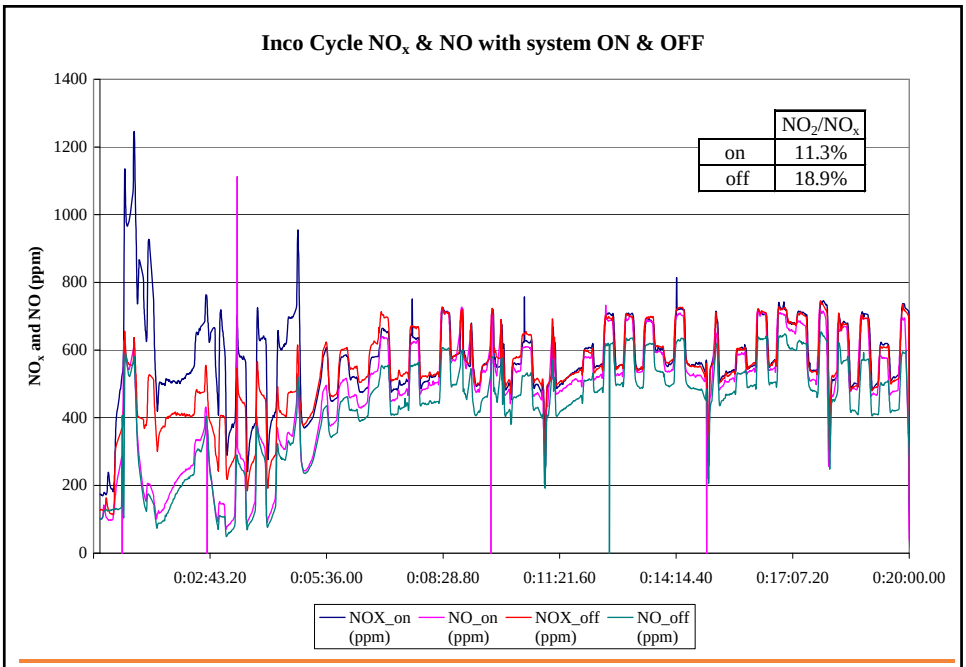

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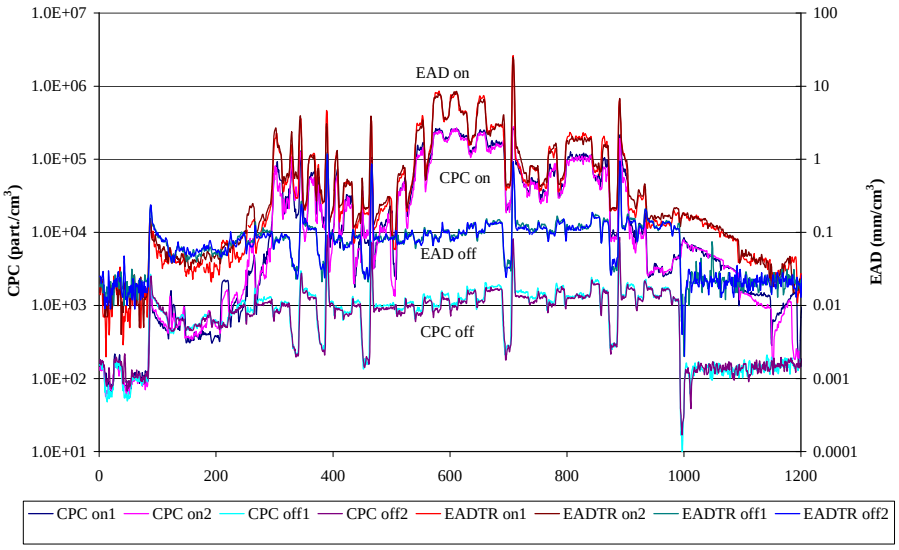
Inco Cycle CPC and EAD Data with system ON & OFF



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Status

- *Test the next generation device.*
- *Do a more detailed particle emissions study.*
- *Look towards getting the device field tested.*

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Conclusions

- *System performance has been primarily a function of HC mixing prior to the catalyst.*
- *NO_2 is still higher than the baseline, 38% over the 8 mode cycle and 71 % over the INCO cycle.*
- *PM reductions of 92% over the 8-mode cycle are reasonable, but the formation of ultrafine and nanoparticles may be an issue.*
- *JM has been working to improve the system.*

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We gratefully acknowledge our project sponsors and supporters:

NIOSH
INCO
Johnson Matthey

& Others

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- *Questions?*
- *Comments?*

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