


NO₂ Management for Diesel Exhaust in Mines

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Outline

- Project Overview
- Project implementation
 - C.P. Ward
 - American Rock Salt
 - Equipment Characterization
 - Technology Deployment
 - In-Use Emissions Testing
- Challenges & Issues
- Technology Transfer to Mining

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Project Overview

<p>Project #1</p> <ul style="list-style-type: none">• Task – Reduce CO, HC & PM• Company owner concerned about new regulations• Device Configuration<ul style="list-style-type: none">- NO₂ Generation- CDPF	<p>Project #2</p> <ul style="list-style-type: none">• Task – Manage Engine-Out NO₂• EPA/CARB Standard for Off-Road NO₂ Emission• Device Configuration<ul style="list-style-type: none">- NO₂ Generation- CDPF- NO₂ Mitigation
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Engine Profile – C.P. Ward Project

- John Deere 4045 DF
150 hp, 4 cylinder diesel

Mounted as part of an Ingersoll Rand
Construction Compressor

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On-Engine Test Setup

John Deere 4045 DF150
on an Ingersol Rand Compressor


Catalyst:

Two 5.66 x 6 "substrates

- 1st Ceramic w/ FeMg
- 2nd Silicon Carbide w/ wc & 60 g Pt/cu ft

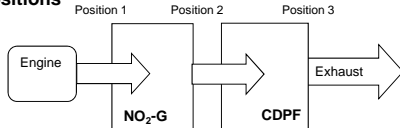


Equipment Type	Manufacturer	Model #	Date of Mfg.	Engine	Hp
Compressor	Ingersol Rand	IR xxx		John Deere 4045	150




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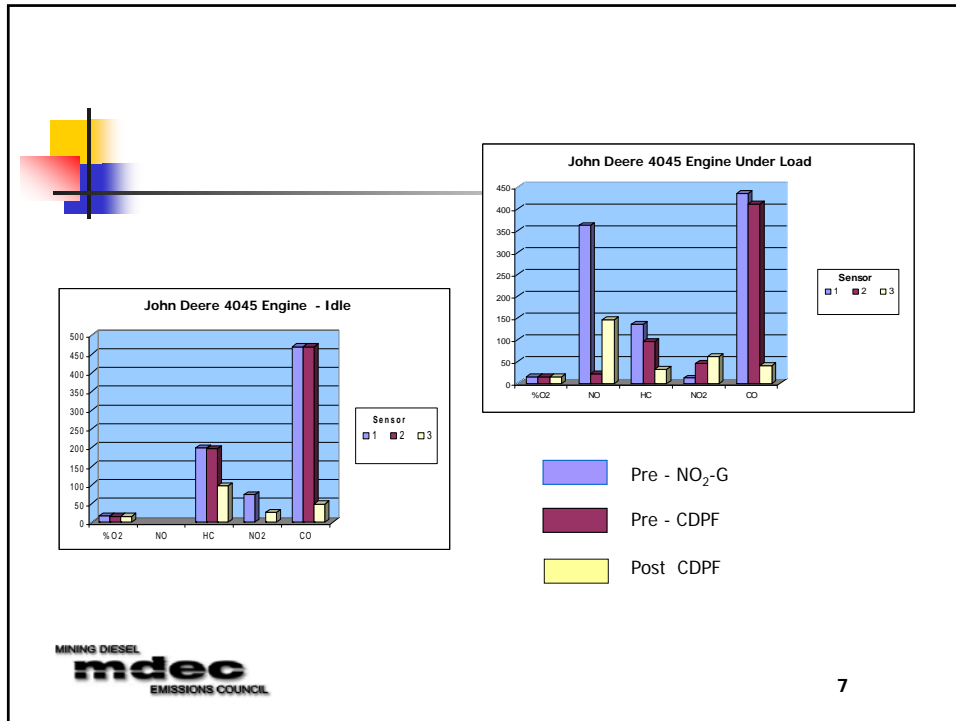
On-Engine Sensor Positions



	Sensor	Press. PSI	Temp °C	% O ₂	NO ppm	HC ppm	NO ₂ ppm	CO ppm
Start 3318	1	0.18	179	16.6	OS	199	74	470
	2	0.18	179	16.2	OS	197	OS	470
	3	0.02	167	16.0	OS	97	27	49
	1	0.22	186	15	OS	209	68	519
	2			15	OS	209	128	492
	3			15	OS	68	31	22
	1	0.15	152	16	OS	186	61	462
	2			16	OS	186	120	462
	3			16	OS	92	38	56
Hours 3607								
	1	0.87	270	14.2	362	135	61.7	436
	2			14.6	22	96	46.4	411
	3			15.2	146	32	12.2	40



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Site Activities

- 200 Acre Site
 - GenSet at 1280 feet underground
- Drilling
- Blasting
- Excavation
- Crushing
- Transport to Surface
- Surface Stockpiling
- Off-site Hauling

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Engine Profile – American Rock Salt Mine

- Caterpillar C15 Twin Turbo
550 hp, 60 Hz, 1800 rpm


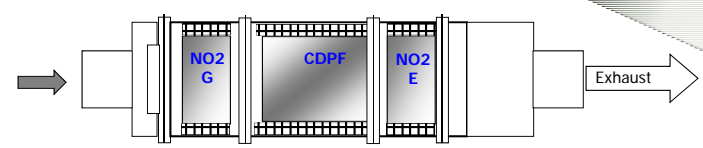
Equipment Type	Manufacturer	Model #	Date of Mfg.	Engine	Hp	Tier
Gen Set	Caterpillar	C15		Caterpillar C15	550	2

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Test Catalyst System


Unit was custom designed to monitor temperature, backpressure and CO, HC, O₂, NO, and NO₂.

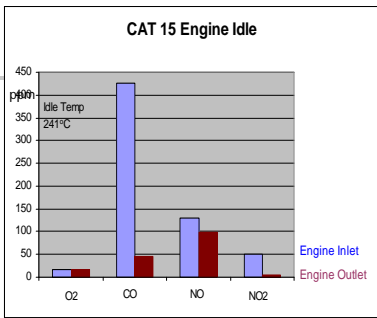
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In-Use Emissions Testing



CAT 15 Diesel Gen Set - Salt Mine Application

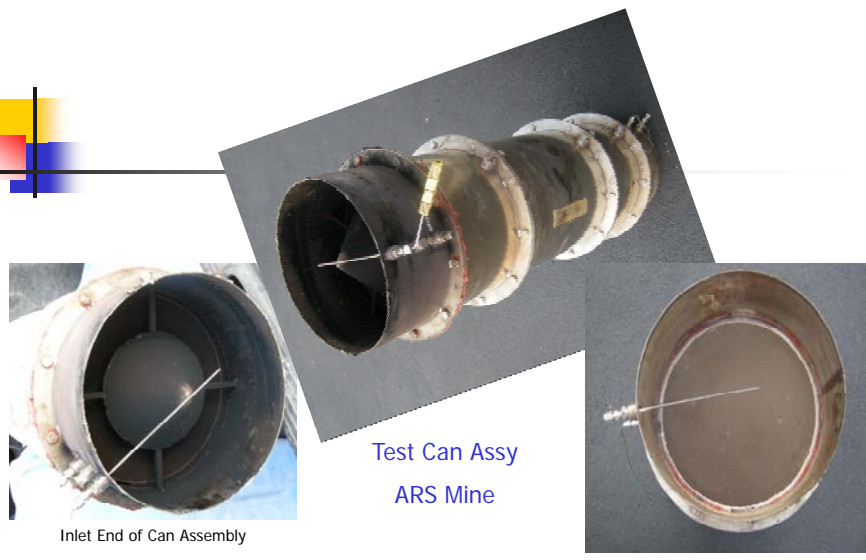



Gas	Engine Inlet	Engine Outlet
O ₂	~10	~10
CO	~400	~40
NO	~120	~100
NO ₂	~50	~10



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Test Can Assy
ARS Mine

Inlet End of Can Assembly


Exhaust End of Can Assembly

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Emission Monitoring Device

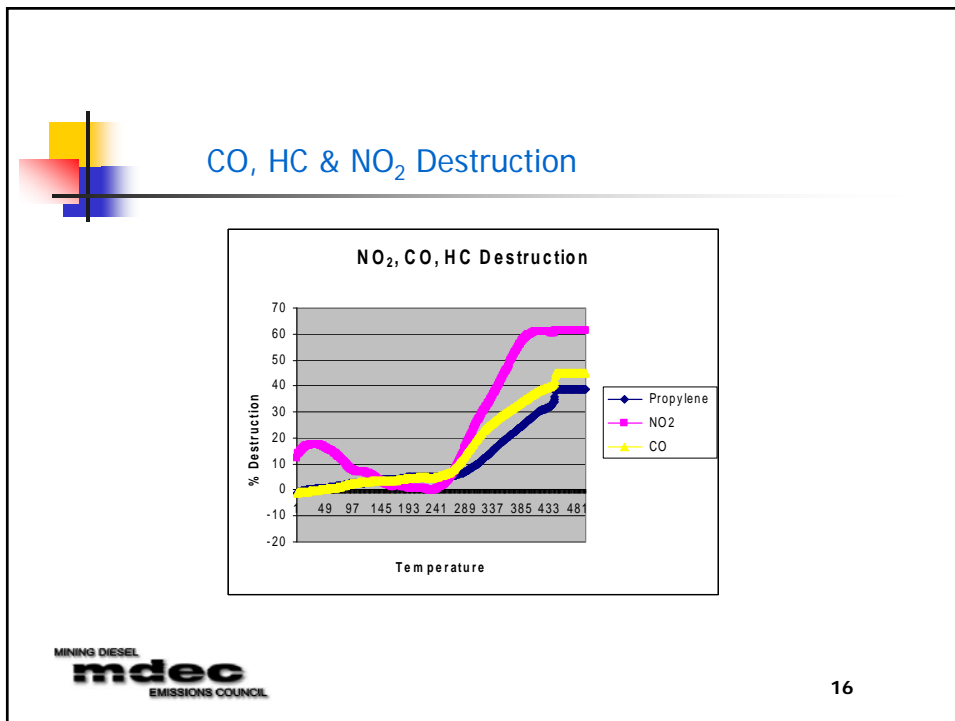
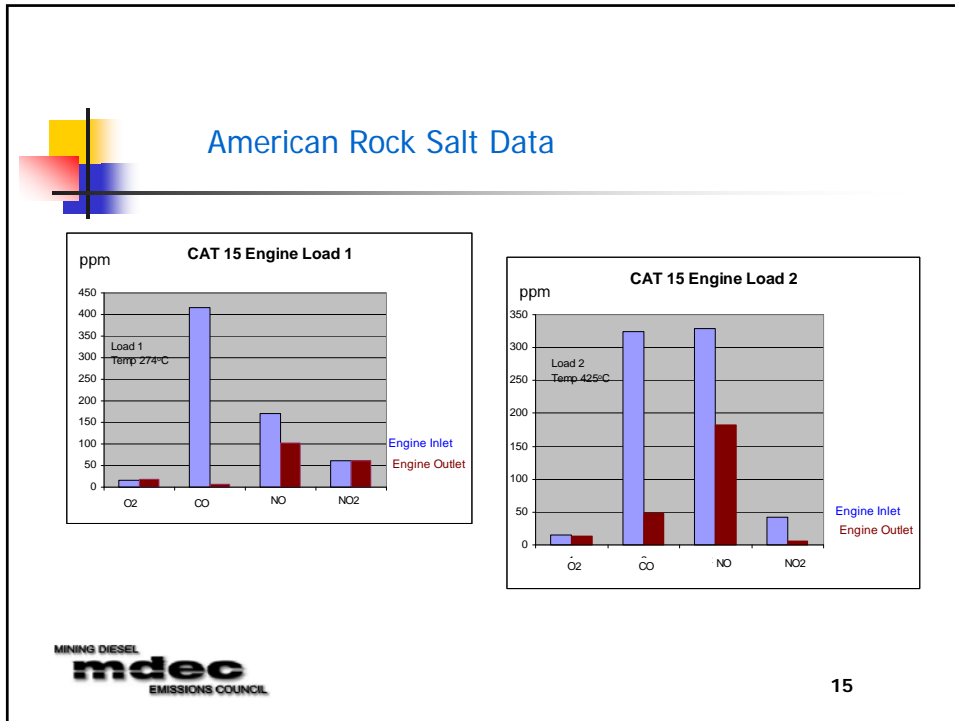



Industrial Scientific
Model # D143R21
MX6 iBrid 5 Gas Monitor

O₂, NO, NO₂, CO, HC

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Challenges and Issues

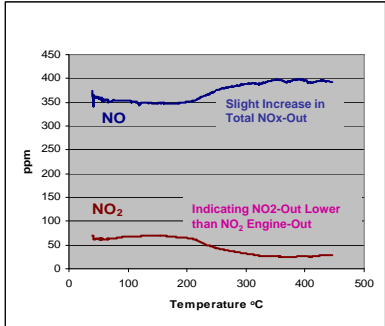
- Equipment in constant use on job sites
 - Sensitivity to site operations
 - Harsh conditions
 - Salt, Dampness, Dust
- Limited Access – Travel to sites has to be coordinated
 - personnel
 - equipment
- Communication with on-site personnel




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NO₂ Mitigator - Low NO₂ Output in ppm



Temperature (°C)	NO (ppm)	NO ₂ (ppm)
0	~350	~75
100	~350	~75
200	~360	~70
300	~380	~60
400	~390	~55
500	~400	~50



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Critical Steps in On-Site Testing

- Secure operations management buy-in
- Move to implement as quickly as possible
- Make it easy for maintenance personnel
- Document, document, document

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Summary

1. Two innovative and inexpensive catalysts were presented.
 - NO₂ Generator increases NO₂ to improve DPF performance
 - NO₂ Mitigator reduces NO₂ out
2. Patents applied for each NO₂ technology

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Next Steps

- Installations on additional equipment
A Cummins 6 liter engine at the National Center for Remanufacturing
- Productize designs for manufacture
Currently working with customers on product designs for their applications
- Start verification processes
Approval for use in PA mines