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# The Effect of Diesel Oxidation Catalysts on $NO_2$ Emission from Mining Vehicles

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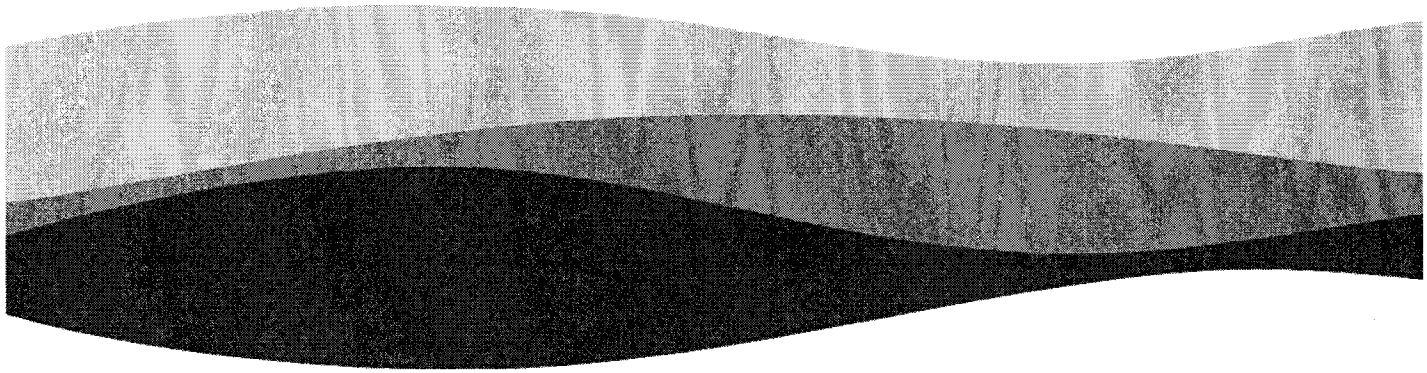


## Background

- Vale employs about 800 diesel-powered units with diesel oxidation catalysts in Sudbury mines
- In the past, DOCs were used in mines mainly to reduce CO and hydrocarbons, the main pollutants of concern at that time.
- Now, the pollutants of most concern are DPM and $NO_2$.
- From an occupational exposure point of view $NO_2$ (TLV 3 ppm) is more toxic than NO (TLV 25 ppm).
- In 2012 ACGIH reduced the TWA value of $NO_2$ from 3 ppm to 0.2 ppm, a reduction of over 90%.
- Many occupational exposure limits are derived from ACGIH TLVs.
- The recent studies indicate that most of the old DOCs increase $NO_2$ .

## Objectives

- **Objectives From Laboratory Studies:**
  - Determine the effect of DOCs on $NO_2$ emissions
  - Analyze representative DOCs selected from Vale mines
  - Test DOCs using progressive load cycle
  - Quantify any change in $NO_2$ emissions due to the DOC

Note: Ultra-low-sulphur fuel (<15 ppm sulphur) was used for all testing

## Selection of DOCs & Laboratory Test Details

- **4 Vale DOCs were selected based on:**
  - Engine type
  - Equipment type
  - DOCs type and model
  - Duration in mine service

- **Laboratory test details:**
  - All DOCs were tested on a DDEC 6063-WK32, series 60 engine, rated at 242 kW @ 2100 rpm
  - Mine diesel fuel conforming to CGSB 3.16 standard was used, ultra-low sulphur fuel (15 ppm)
  - Basic engine parameters (speed, torque, fuel rate etc.) and exhaust gas concentrations (CO, CO2, NO, NOx, THC) were measured before and after the DOC

## Progressive Load Test Cycle

- Is suitable to generate a performance curve for the DOC over its operating range
- Is useful in determining DOC conversion efficiency for exhaust emissions at a given temperature
- Was performed at intermediate engine speed of 1260 rpm, varying load from 10% to 100% at interval of 10% each
- Measured gaseous emissions at 10 modes, before and after the DOC

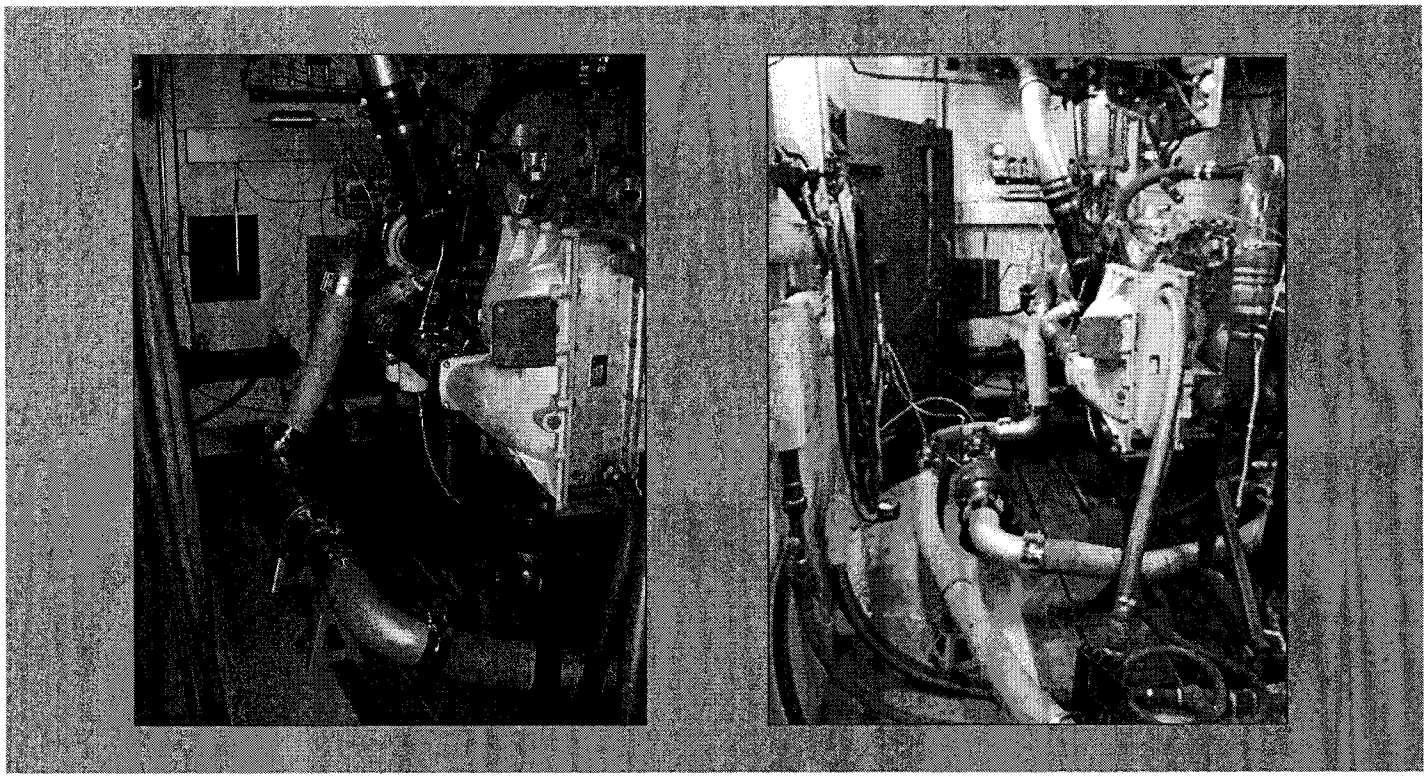
## Details of DOCs for Testing

| Lab ID | Equipment | Engine, kW | Hours in Service |
|---|---|---|---|
| DOC 4 | Boom truck | 151 | 730 |
| DOC 5 | Scissor truck | 112 | 2700 |
| DOC 6 | Jeep | 100 | 3400 |
| DOC7 | LHD | 100 | 254 |

## Test Engine

| | |
|---|---|
| Make | Detroit Diesel |
| Model | 6063-WK32, Series 60 |
| Rated power, kW | 242 |
| Displacement, L | 11.1 |
| Rated speed, rpm | 2100 |
| Intermediate speed, rpm | 1260 |
| Peak torque speed, rpm | 1200 |
| Peak torque, Nm | 1539 |
| Fuel rate, kg/h | 53.4 |
| Fuel system | Electronic fuel injection |

# DOC Test System in Test Cell



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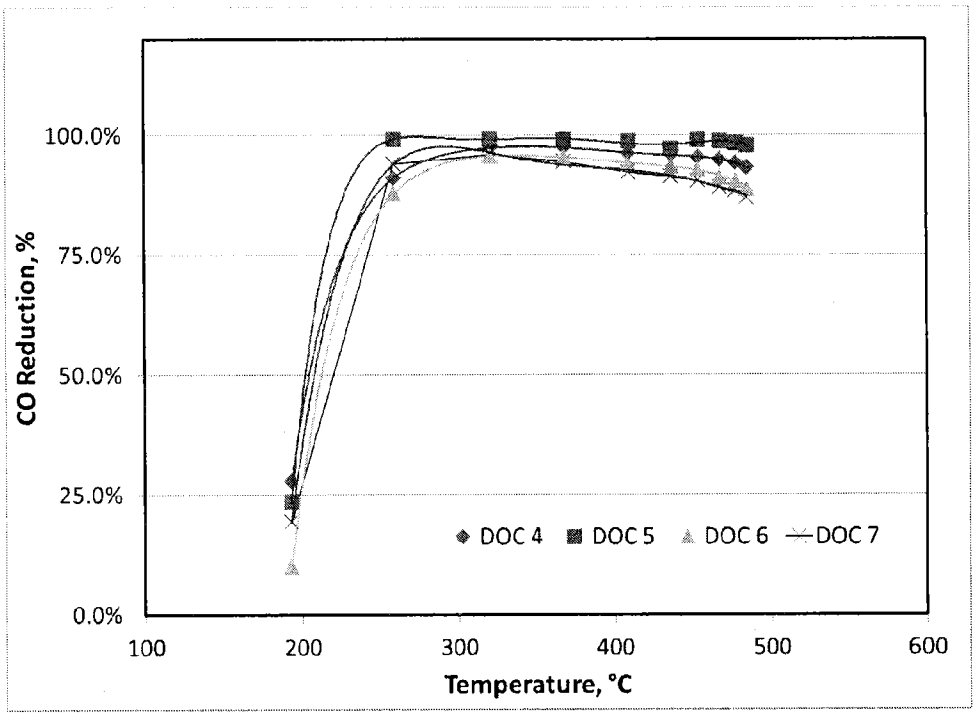
# Percent Reduction in CO VS exhaust temperature

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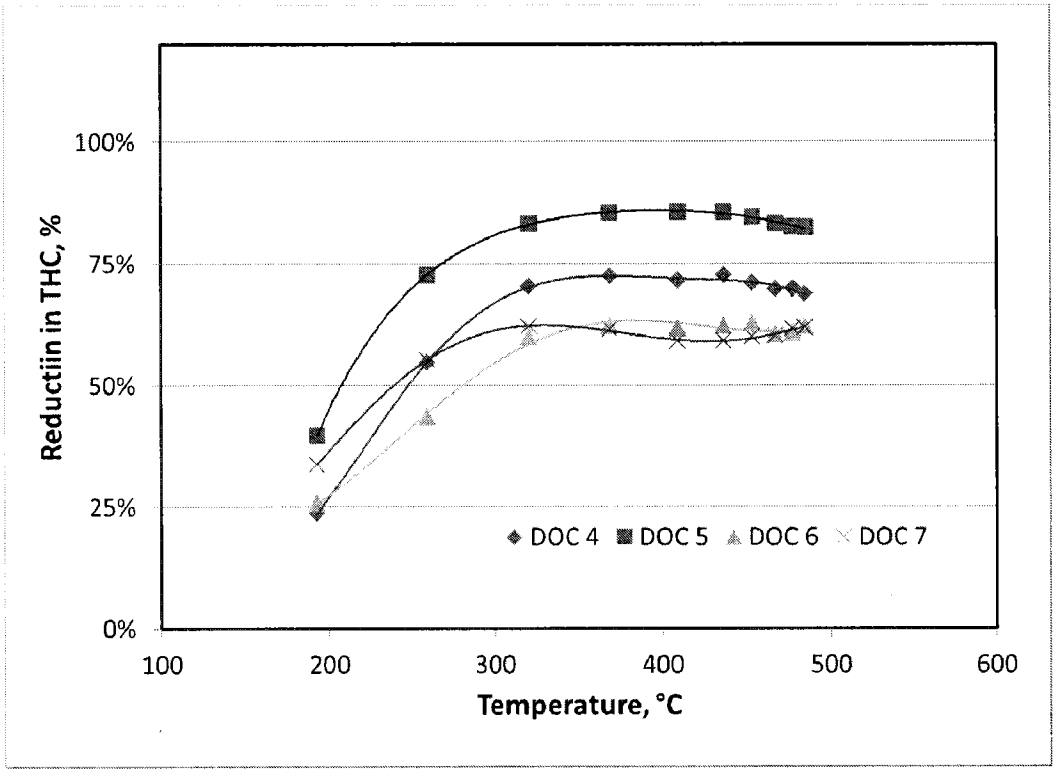
# Percent Reduction in HC VS Exhaust Temperature

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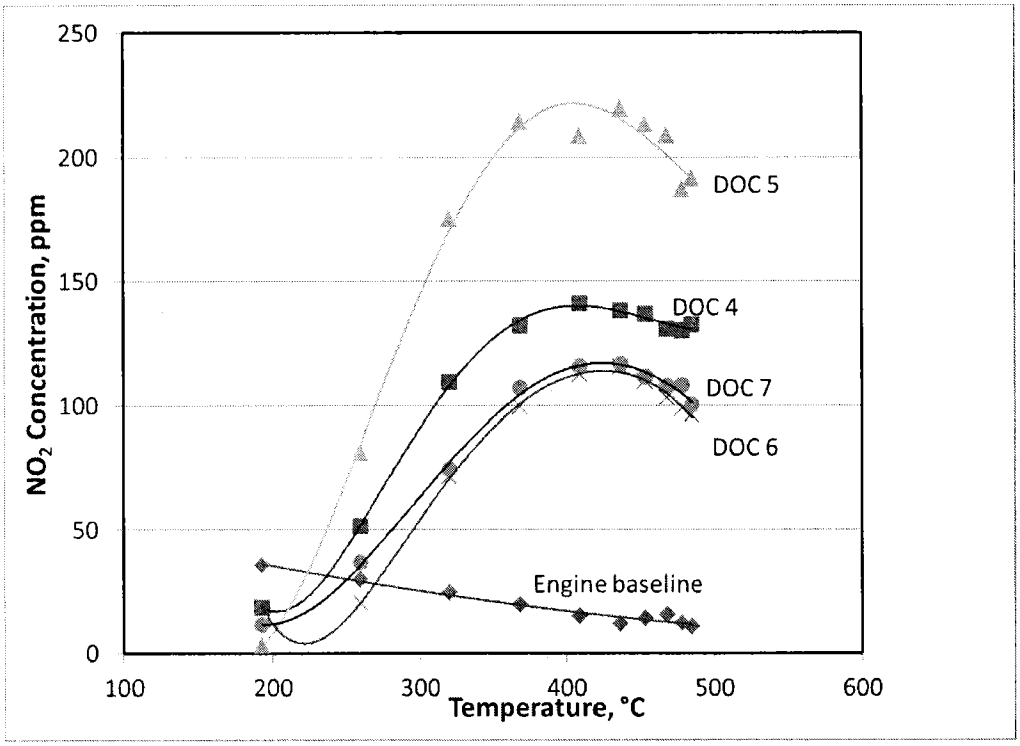
# $NO_2$ emission before and after the DOCs

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## DOC-Out $NO_2$ Values

| DOC | $NO_2$ decreases below °C | Maximum $NO_2$ ppm | Maximum $NO_2$ at °C |
|---|---|---|---|
| DOC 4 | 235 | 141 | 409 |
| DOC 5 | 225 | 225 | 410 |
| DOC 6 | 265 | 115 | 415 |
| DOC 7 | 250 | 116 | 416 |
| Average | 244 | 149 | 412 |

Engine-Out $NO_2$ = 13 ppm at 412 °C

## Concluding Remarks

- The impact of in-mine use of DOCs with regard to exhaust emissions were evaluated in the laboratory using a controlled engine dynamometer.
- The testing utilized progressive load test cycle.
- All DOCs reduced CO and HC emissions.
- At low temperatures all DOCs decreased $NO_2$, and then after reaching a certain temperature (~ 244 °C) started increasing $NO_2$.
- The maximum DOC-out $NO_2$ value varied from 115 ppm (DOC 6) to 225 ppm (DOC 5), compared to an engine-out value of 13 ppm.
- The maximum $NO_2$ increase was observed at a temperature of 412°C, where $NO_2$ significantly increased (up to 17 times) from its baseline value of 13 ppm.
- More extensive DOC evaluation is planned with additional units from other underground mines to confirm emission trends witnessed from the Vale DOCs .

## Acknowledgements


- Vale Ontario Operation for funding this project
- Al Laurich, Vale for selection and removal of DOCs for testing
- David Young, Brent Rubeli, Eric Leung, and Vince Feres, NRCan/CanmetMINING for laboratory testing of DOCs



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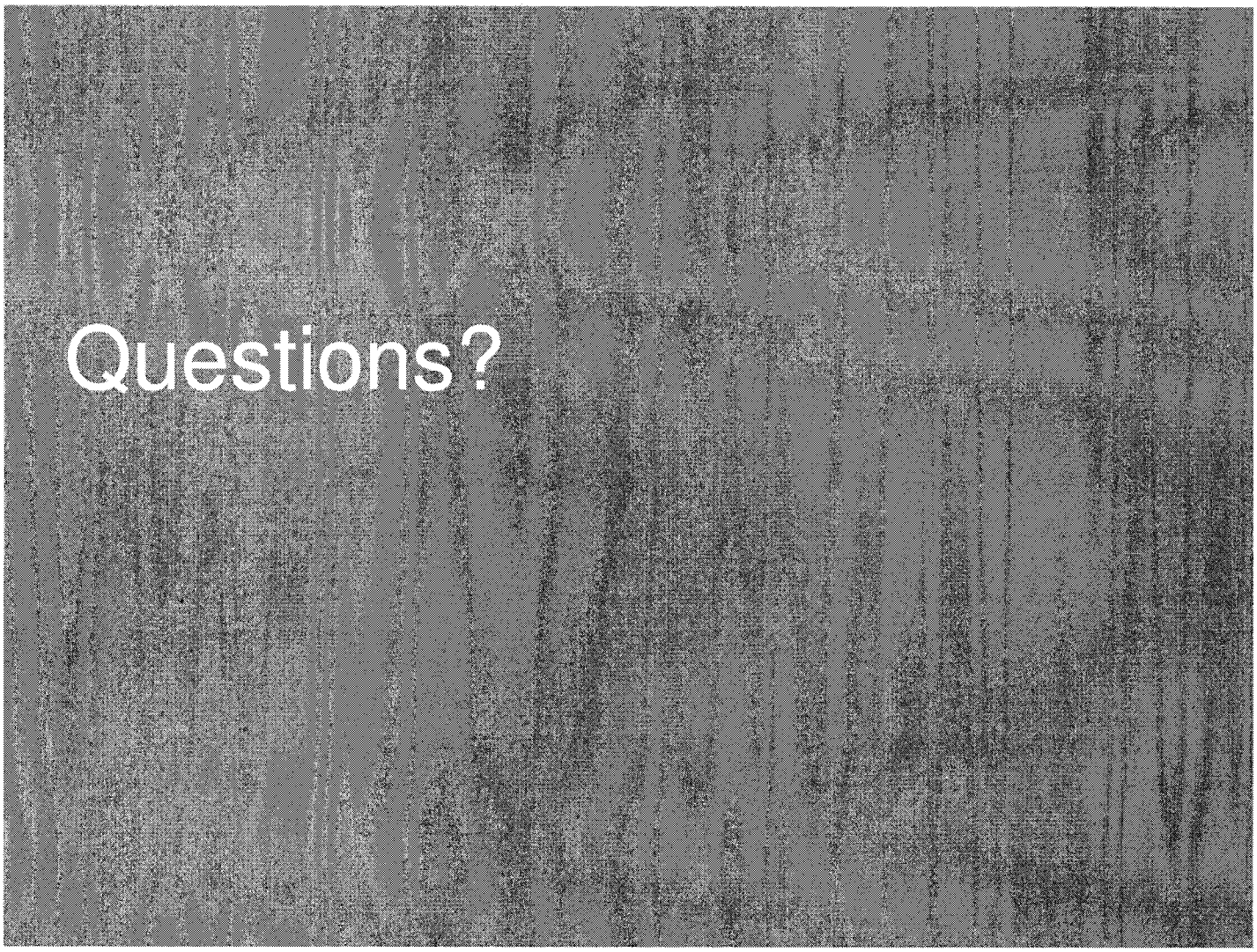
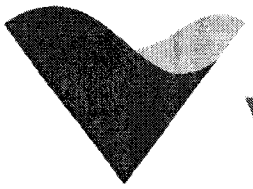

Questions?





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