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

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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

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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

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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

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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

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DOC Test System in Test Cell

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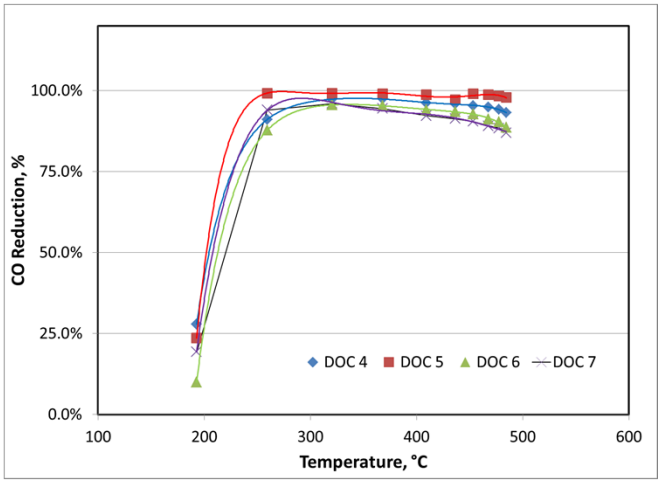
Percent Reduction in CO VS exhaust temperature



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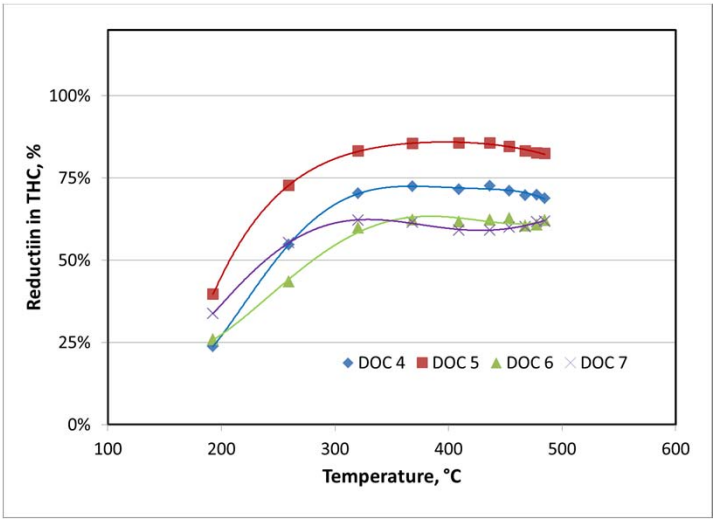
Percent Reduction in HC VS Exhaust Temperature



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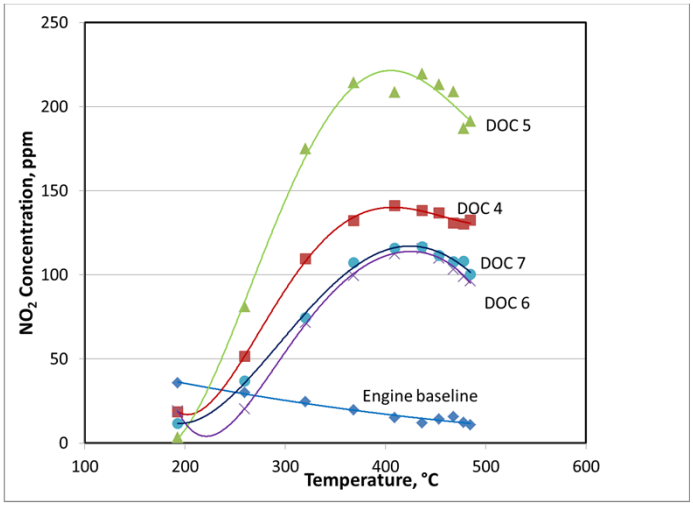
NO_2 emission before and after the DOCs



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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

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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 .

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Questions?