

Mining DPF Challenge



MDEC Conference

Progress towards an Operational DPF for Heavy Duty Engines



Joe Stachulak, Vale, Canada

Evaluation of the Johnson-Matthey Diesel Particulate Filter Low NO₂ “Mining” CRT System

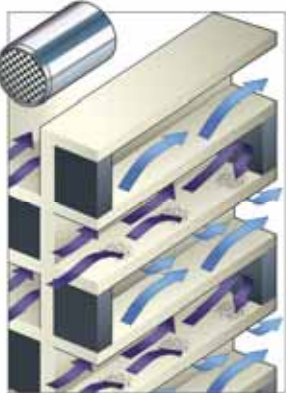
Project Sponsors

- KGHM
- XSTRATA - Nickel
- XSTRATA - Copper
- VALE – Thompson
- VALE – Sudbury, Project Lead
- CAMIRO Mining Division - Coordination



Project Approach – 3 Phases to success

- Phase 1 – Bench Test engine & DPF System at CANMET Facility in Ottawa, Canada. Completed
- Phase 2 – Surface Field Test, currently in progress at Vale's Totten Mine Project in Sudbury, Canada.
- Phase 3 – Underground deployment & testing at a Vale Sudbury mine site in 2013.



Principle of Wall Flow Filter

Si Carbide filters



Cordierite filters

The key to a usable system is filter regeneration.



Passive systems:

regenerate without external assistance:

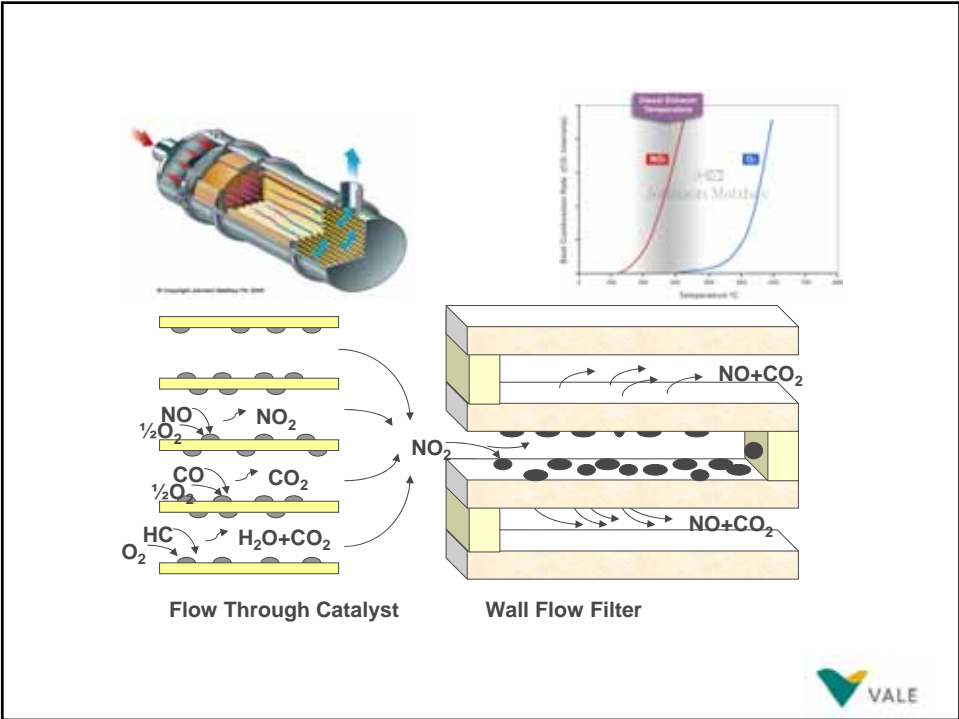
CRT® and CSF (catalysed soot filters)

Easy to install and operate

Active systems:

requires external input to enable regeneration:

Electrical heaters, Burner systems, Fuel Borne Catalyst



Limitations to the CRT® system

Fuel Sulphur (max 50ppm)

NOx: PM ratio in exhaust (>20:1)

Minimum exhaust temperatures (50% >250C)

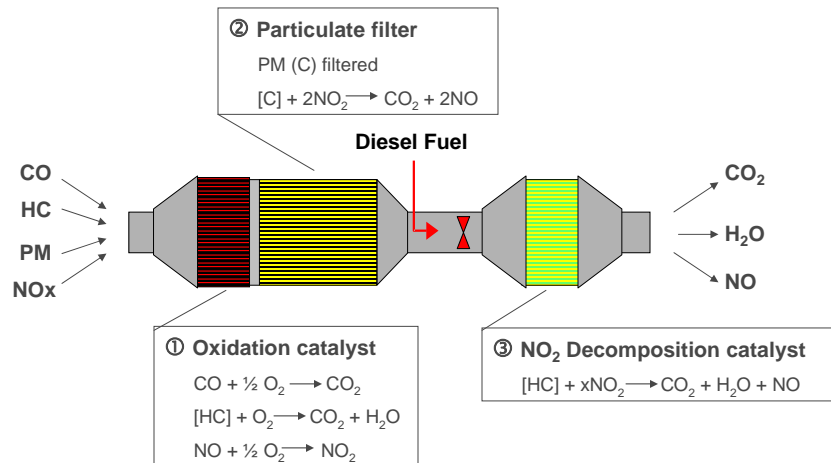
Because the CRT® system relies on NO₂ to remove PM it will produce an excess of NO₂ after the filter under some operating conditions

- Reliable regeneration dictates an excess of NO₂ after the filter over a given operating cycle
- Increased NO₂ levels are often not tolerated in underground mining environments

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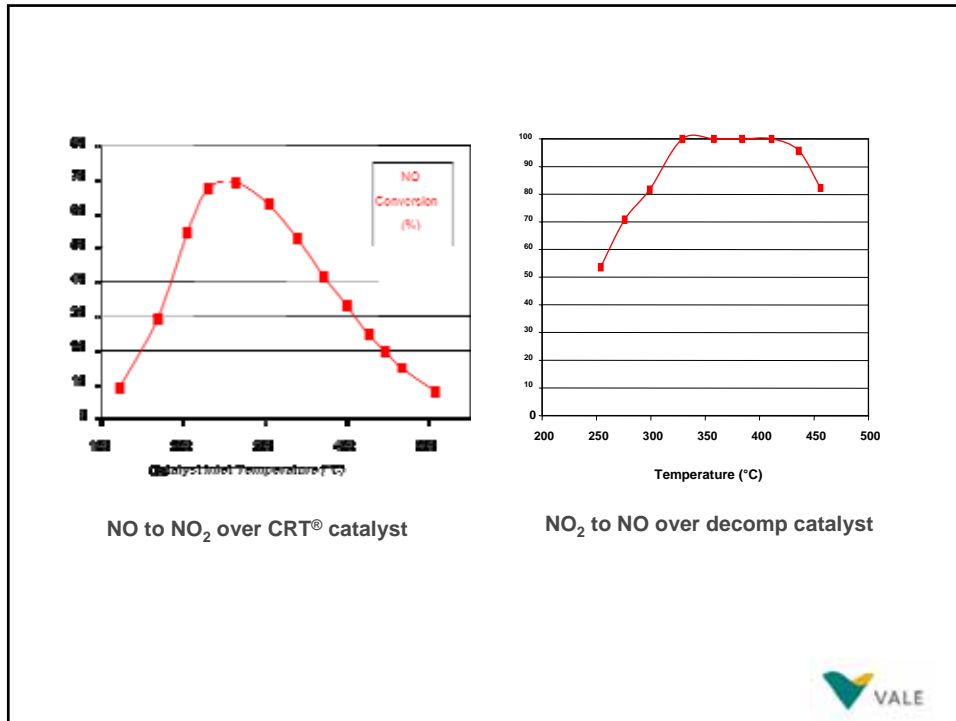


THE LOW NO₂ “MINING” CRT® SYSTEM



Similar system approved by CARB/EPA for bus/truck retrofit in US





VALE: Heavy Duty DPF Project - Phase 2

Phase 2: Surface Test on an Elphinstone Load Haul Dump (LHD) Machine

Location: Totten Mine Project, Surface Waste Rock Handling, Sudbury, Ontario, Canada

Manager: Robert Booth, P.ENG., Totten Mine Project Manager

Exercise: Demonstrate that the Mining-CRT® is robust enough to reliably operate in a mining load haul dump environment



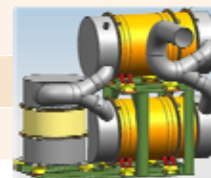
Engine type

Machine manufacturer	Caterpillar
Machine type	Scoop tram R1700G
Engine manufacturer	Caterpillar
Engine type	C11
Engine certification	EPA TIER 3
Engine power	263 kW
Engine speed	1800 RPM
Engine displacement	11,1 Litres
Number of cylinders	6, in line
Aspiration	Turbo charged and aftercooler
Exhaust gas volume	3.143 m3/hour / 1500 kg/h
Exhaust gas temperature	460-470°C
Fuel	Diesel fuel, max.15 ppm Sulphur



Filter type

Filter type:	Johnson Matthey Mining-CRT 2 x 2012SL
Regeneration:	Catalytic, continuously during operation
Requirements:	ULSD Fuel, S< 50ppm Exhaust gas temperature >250°C for >50% of the operational time
Particulate reduction:	> 99% by particulate number
NO2, CO and HC reduction:	Reduction
Filter body:	Stainless Steel



Phase 2 - Surface Testing at Totten Mine

Project Team Composition

➤VALE

- Project Manager – Jozef Stachulak
- Totten Mobile – Murray Tann
- Superintendent Capital Equipment – Fred Pelletier
- Communications – Jason David
- Technical Support – Douglas O'Connor

➤Coordination – C. Graham, J. White (Fin/Admin) CAMIRO

➤Toromont/CAT

- Management – Mike Pilon; Denys Bull
- Technical Support – Manuel Aguir

➤Johnson-Matthey – Peter Werth

➤T-Bell (Equipment Operations)

- Management – Herald Gauthier; Andre Pelletier



Project Training – Johnson-Matthey

- Materials were provided previous to installation
- Hands on demonstrations to the Toromont/CAT technicians were conducted by Johnson-Matthey personnel during the installations
- Awareness presentations were made by Peter Werth of Johnson-Matthey to all members of Totten Mine management, project team members and the equipment operators



Project Management and monitoring

- Weekly meetings are held at site to review progress and to address any issues arising during the previous period. Develop a path forward and assign work as required.

- ECOM exhaust gas readings are conducted weekly

- DPF system downloads are collected 3 times per week, results are sent to Johnson-Matthey in Germany for review and analysis

- Data is graphed and returned to the team members including comments prior to next meeting.



Totten Mine Test Cycles

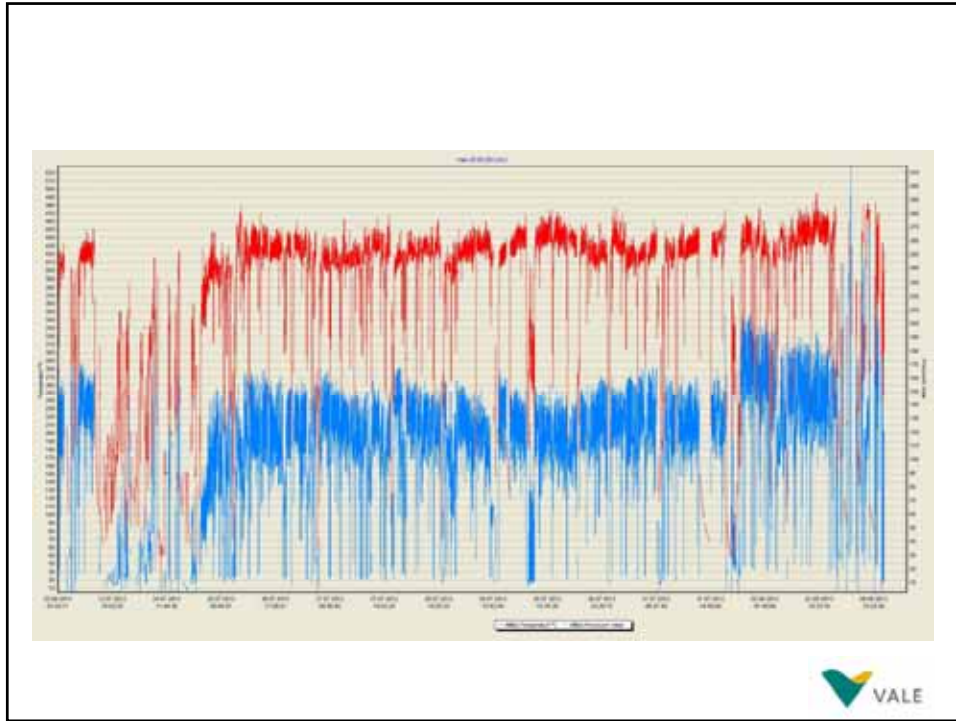
LHD Operation on Surface (Remote Control)

- Load from ground stock pile
(~ 175,000 tons to-date, 780 hrs of operation)

- Haul on remote control some 100 to 1000 feet

- Dump material into old cave area on surface





**ECOM Test using Heated Probe Line - No temperature sensors
Dual Torque Stall Test #1 @ 1700 rpm
1:56 PM**

	Contaminant	Intake	Conc %	Exhaust	Conc %	Reduction	Comments
Temp (°C)	Ambiant Air	15.0		16.1			
Temp (°C)	Gas	n/a		n/a			
Temp (°C)	Sensor	22.8		22.2			
O2	Oxygen	12.0%	12.00	12.0%	12	n/a	
CO	Carbon Monoxide	283		10		96%	
CO2	Carbon Dioxide	6.7%	6.70	6.7%	6.60	n/a	
NO	Nitrogen Oxide	292		293		0%	
NO2	Nitrogen Dioxide	22		17		23%	
NOx	Nitrous Oxide	314		310		1%	
DPM	Diesel Particulate Mater	9		1		n/a	
	Total % Volume of Gases	19%	18.70	19%	18.60		

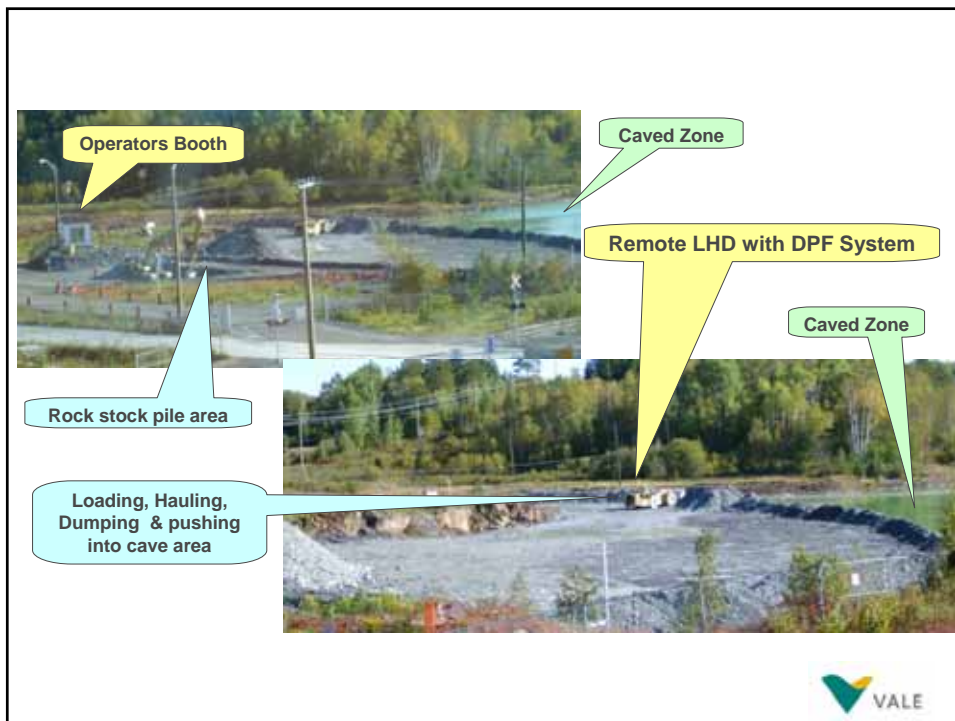


Phase 2 – Results to Date

RESULTS & COMMENTS

No operator involvement for DPF regeneration; normal operations

- Over-all the system operated very well with little maintenance & down time
- Operators need to minimize idle time to less than 20 minutes/hour due to < 250°C temperature which do not regenerate and cause accelerated plugging of filters
- DPF system malfunctioned at 630 hrs due to:
 - DPF quality control issue which was identified and corrected by Johnson-Matthey, Germany
 - Heat cured the rubber shock mounts resulting in excess vibration damage to DOC which moved inside of casing and blocked the filter (identified and heat shielding installed)



Totten Mine Test Site



Phase 2 – Surface Operations Summary

- Mining-CRT function successfully demonstrated
- Outstanding DPM reduction (smoke #9 reduced to 1)
- NO₂ tailpipe out is less than engine out emissions
- System is ready for Phase 3 (underground production testing)

