


CANMET Mining and Mineral Sciences Laboratories

Engine Certification Testing and Ventilation Rates for Tier 4 Update


Mining Diesel Emissions Conference
October 2013

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Report CMIN-2013 (037)




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Diesel Issues / Topics


- Diesel in the news
- 2012/13 Additions to Certified Engine List
- Tier 4 technology developments
- Coal/Gassy Mine Certification



DEUTSCHE BUNDESPOST 12F SAARLAND
RUDOLF DIESEL * 18.3.1858



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Diesel in the News

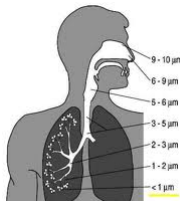


Figure 2 Particle deposition in respiratory system

- Quebec superior court decision (Fortin) provides case law linking occupational exposure to diesel exhaust with lung cancer. Implications for mining health and safety:
 - Accelerated development of diesel exposure controls
 - Economic incentive for cleaner engines and emission control technologies.

World Health Organization / IARC

- Reclassified diesel exhaust as “*carcinogenic to humans*” Group 1; similar to silica and asbestos.
- No more use of modifiers like “suspected” or “probable”.

- ACGIH NO₂
 - ACGIH (2012) lowered the TLV to 0.2 ppm for NO₂.
 - May significantly impact mining operations in Canada.


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Diesel Engine Certification Testing at CanmetMINING

- CSA M424.1 Coal and Gassy Mines
- CSA M424.2 Non-gassy Mines
- MSHA 30 CFR 7





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Recent List Additions (not yet online)

- CanmetMINING List of Certified Engines
 - [Kubota T4i](#)
 - V3800 (88/90/98hp)
 - [Caterpillar T3](#)
 - C4.4 (100hp)
 - [Cummins T4i](#)
 - QSL9 – C300/C265
 - [Perkins T4i \(Cat C7.1\)](#)
 - 1206E (192hp)

Perkins 1206E

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Tier 4 Engine Technology Path

- EPA has a single standard for Tier 4 engines >75 hp.
- Not technology-forcing so manufacturers can use any emission control strategy to achieve it.
- Two leading paths to EPA Tier 4:
 - Selective catalytic reduction (SCR)
 - Catalyst + particulate filter (DOC/DPF)

EMISSIONS REGULATIONS BY YEAR

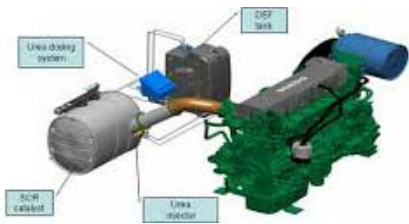
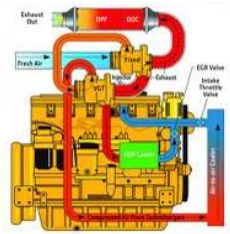
| Year | HORSEPOWER GROUP | | | | |
|------|------------------|--------------|--------------|----------------|----------------|
| | < 25.5 HP | 25.5 - 50 HP | 50 - 75 HP | 75 - 101 HP | 101 - 175 HP |
| 11 | AR | AR | AR | AR | AR |
| 12 | AR | AR | AR | TIER 3 | TIER 3 |
| 13 | AR | AR | AR | INTERIM TIER 4 | INTERIM TIER 4 |
| 14 | AR | FINAL TIER 4 | FINAL TIER 4 | FINAL TIER 4 | FINAL TIER 4 |
| 15 | AR | FINAL TIER 4 | FINAL TIER 4 | FINAL TIER 4 | FINAL TIER 4 |



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Tier 4 Engines

- This has implications for underground mining as each control strategy affects the NO/NO₂ ratio differently which is not generally considered in the EPA regs.
- Mining, however, considers NO and NO₂ separately and this affects the prescribed ventilation calculation.
- CanmetMINING has tested and certified several alternative Tier 4 engine configurations (SCR / DOCDPF).
- Two engines which comply with EPA Tier 4 standards may have significantly different CANMET/CSA ventilation rates.

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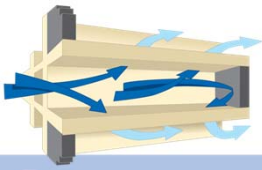
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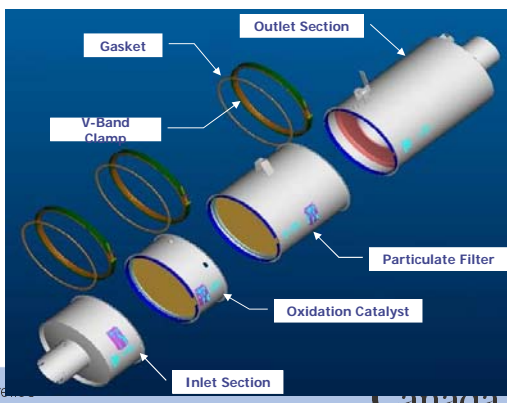
DOC+DPF



- Diesel particulate filter for PM control.
- Low NO_x achieved by engine calibration and exhaust gas recirculation (EGR).

Diesel Oxidation Catalyst

1. Oxidize NO to NO₂ – NO₂ is critical for **Passive Regeneration**
2. Oxidize dosed fuel to produce heat for **Active Regeneration**



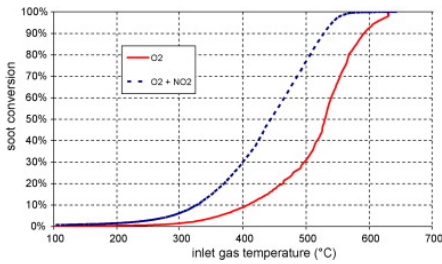
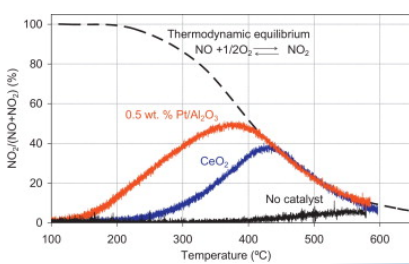




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DPF Regeneration using NO₂

- Must periodically burn off collected soot from DPF.
- Possible to do this with O₂, but need high exhaust temperatures. More favourable with NO₂.
- Use oxidation catalyst to generate NO₂






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DOC+DPF

- DOC oxidizes extra fuel in exhaust to raise temperature for active regen.
- Very active DOC can generate excess NO₂ at certain modes which passes into the mine.

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Selective Catalytic Reduction (SCR)

- SCR for NO and NO₂ emissions control
- Low PM achieved by engine calibration (advanced injection timing, high pressure).
- Additional reductant sprayed into exhaust
- $4\text{NO} + 4\text{NH}_3 + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O}$
- $6\text{NO}_2 + 8\text{NH}_3 \rightarrow 7\text{N}_2 + 12\text{H}_2\text{O}$

Natural Resources Canada Ressources naturelles Canada Urea Dosing Unit Urea Tank

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SCR Mining Applications



- Sandvik LH517
- Volvo TAD1361VE engine w/SCR

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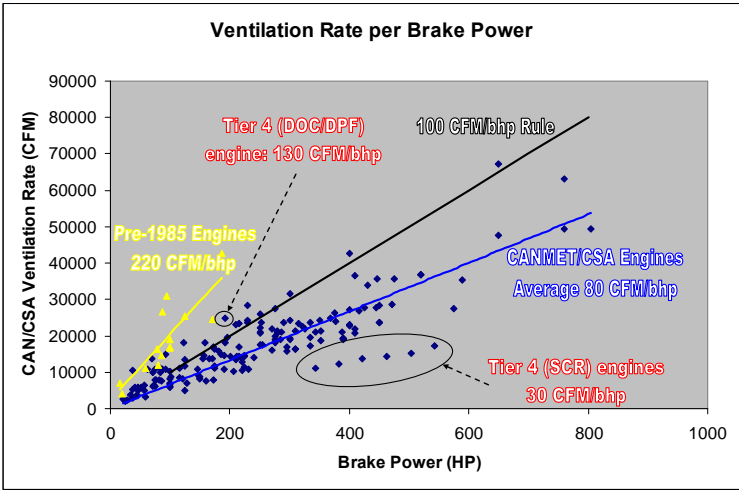
SCR System Design

- Oxidation catalyst used to fine tune NO/NO₂ ratio for most favourable reduction.
- Engine tuned for low PM emission.
- SCR then reduces both NO and NO₂.
- Slip catalyst for ammonia control.
- Lower temperature limit for operation.

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CAN/CSA Certified Engines





Ventilation Rate per Brake Power

CAN/CSA Ventilation Rate (CFM)

Brake Power (HP)


Tier 4 (DOC/DPF) engine: 130 CFM/bhp
Pre-1985 Engines 220 CFM/bhp
CANMET/CSA Engines Average 80 CFM/bhp
Tier 4 (SCR) engines 30 CFM/bhp
100 CFM/bhp Rule



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Coal mining engines

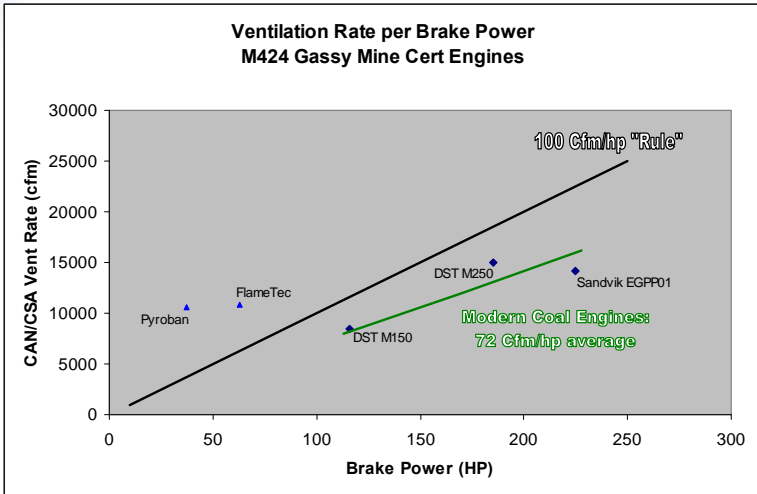
- Significant increase in M424.1 gassy mine engine certification tests in the past few years.
- There are now 5 packages certified under M424.1.
 - Sandvik EGPP01 / Cat 3126B (225hp / 63 cfm/hp)
 - DST M150 / Isuzu 6BG1 (116hp / 73 cfm/hp)
 - DST M250 / Cummins CTAA8.3C (185hp / 81 cfm/hp)
 - Pyroban 802507/5 Lister Petter LPWS4 (37hp / 286 cfm/hp)
 - FlameTec 7200085 Lister Petter DWS4 (63hp / 171 cfm/hp)





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Modern Coal Engine Ventilation Rate



| Engine Package | Brake Power (HP) | CAN/CSA Vent Rate (cfm) |
|----------------|------------------|-------------------------|
| Pyroban | 37 | 286 |
| FlameTec | 63 | 171 |
| DST M150 | 116 | 73 |
| DST M250 | 185 | 81 |
| Sandvik EGPP01 | 225 | 63 |


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Summary (1)

- WHO / IARC classifications provide impetus for deployment of clean diesel technologies underground.
- ACGIH NO₂ may force mines to review all sources of NO₂ including oxidation catalyts.
- Retrofit NO_x control with SCR may become critical for ambient air quality.
- Economic pressures may drive fuel economy research.
- Diesel engine technology is progressing rapidly and average power increasing.




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Summary (2)

- Emissions control technology is reducing emissions significantly which will improve underground air quality at pace.
- Underground coal engine certification is increasing and these engines are now low-emission and on par with regular diesel.
- CANMET/CSA certification still relevant in EPA Tier 4 environment as it can identify high NO₂ from differing control system strategies.
- CanmetMINING continues to provide diesel research in support of regulation and technology development.



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Questions

- Thank you for your consideration.

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