Meeting ACGIH Nitrogen Dioxide Limits in Mechanized Underground Mining

MDEC 2017

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Overview

- Understanding the Challenge
  - Reduction in ACGIH NO_2 TLV
  - NO_2 Sources in Underground Mining
- Recognize the Opportunity
  - Diesel Engines
- Experience in Implementation
  - Vendor Consultations
  - Operations Feedback
  - Opportunities & Challenges

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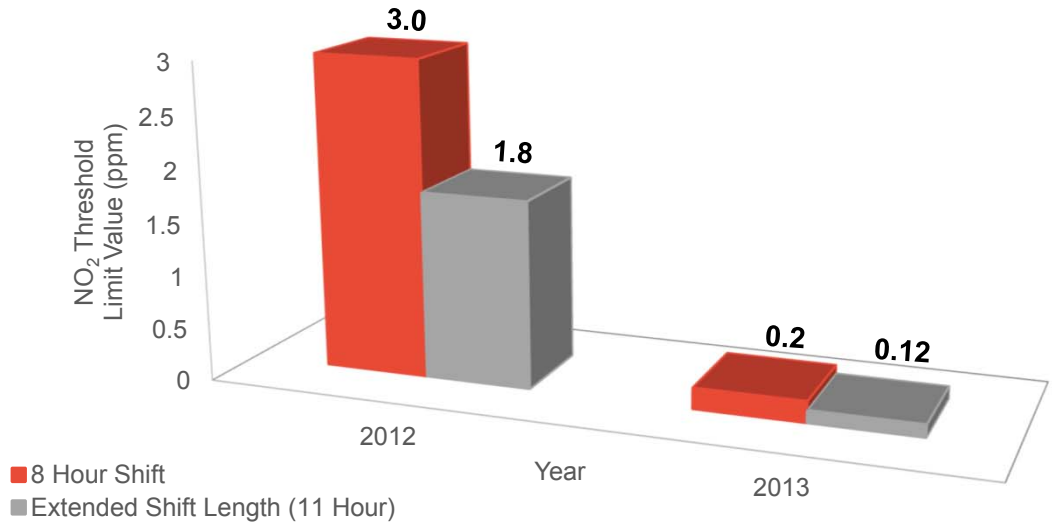
ACGIH NO_2 TLV Reduction



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NO_2 Sources in Mining

- Direct Fired Heaters
- Blasting Operations
- Diesel Equipment

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Mine Heating Contribution to Workplace NO_2

- Indirect heaters such as diesel units have no emission to the mine
- For direct firing heaters, high flame temperatures or “dwell” will cause NO_2 formation
- Burner emissions requirements were updated in 1999 by CSA Standard 3.7-1999 / ANSI Z83.4: less than 0.05 ppm as measured in the airstream
  - This is very low, but still >40% of an extended shift TLV
- Combustion performance is defined by burner design, not the overall heater system package.
  - Vendors report some improvements in burner product lines
  - NO_2 regularly measured/reported as zero in heated air
- For meeting ACGIH TLV, prefer indirect fired heating, but premium burner technology is improving and can likely beat CSA limit

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Blasting Gas Contribution to Workplace NO_2

- Blasting NO_2 is a concern both in smoke plume and in residual gasses in the muck that are released during mucking
- Plume can easily exceed 150 ppm (>1000 x TLV)
- Test work in 2016 at Glencore’s Nickel Rim South Mine – seeking to quantify blast clear times
  - Testing both ANFO and emulsion explosives (2 ea.)
  - ANFO blasts both >100 ppm NO_2
  - Discovered NO_2 below detection with emulsion
- Emulsion explosive very promising for compliance

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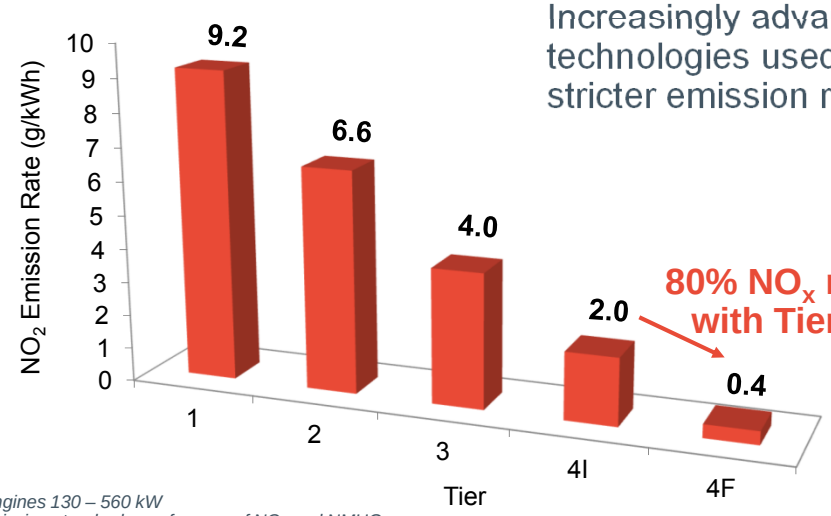
Diesel Engine Emission Control



Increasingly advanced engine technologies used to meet stricter emission regulations.

80% NO_x reduction with Tier 4 Final

**Applicable for engines 130 – 560 kW*
***Tier 2 and 3 emission standards are for sum of NO_x and NMHC*

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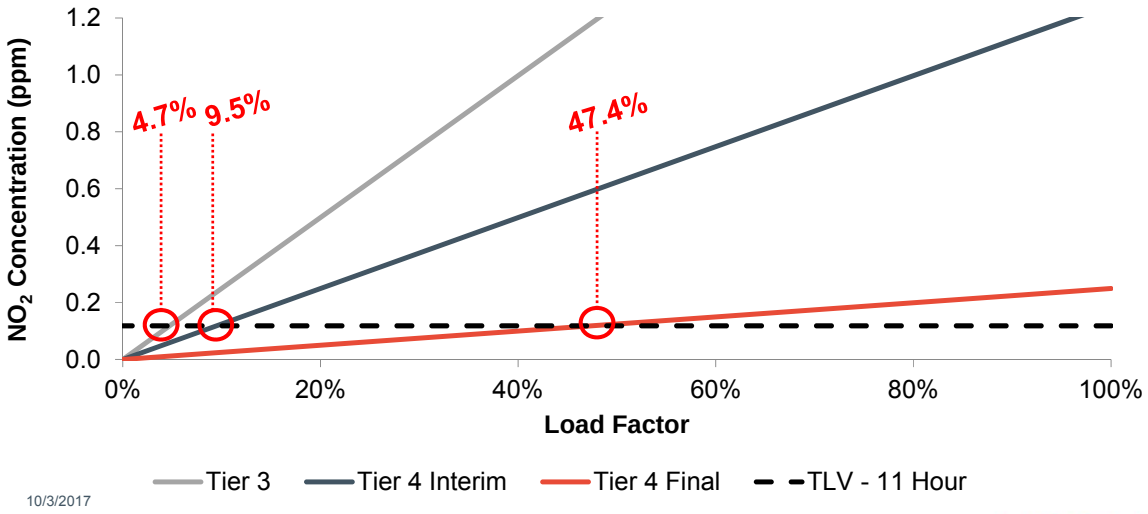
Airborne NO_2 Sensitivity

**Applicable for engines 130 – 560 kW*
***Assumptions:*
- *Ventilation air rate of 74 cfm/bhp*
- *Ambient conditions of 20°C and 1.2 kg/m³*
- *20% (wt%) NO_2/NO_x ratio*



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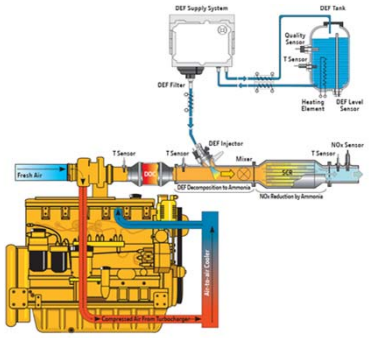
Vendor Consultation Experience

- Being Tier 4F certified does not guarantee an engine will meet workplace NO_2 limits
- Compliance requires low NO_2/NO_x ratio
- Ratio can vary greatly across different engine operating modes



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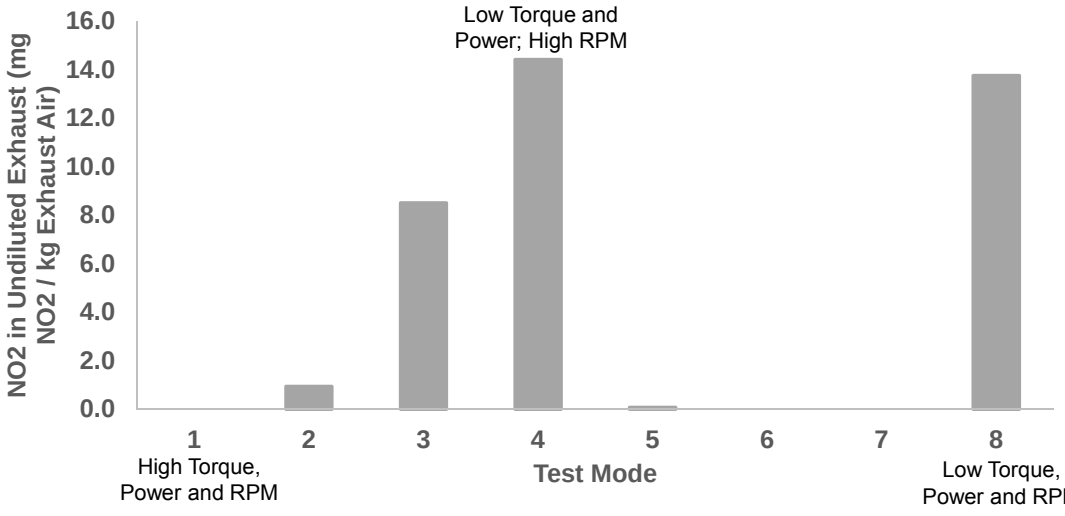
Vendor Consultation Experience



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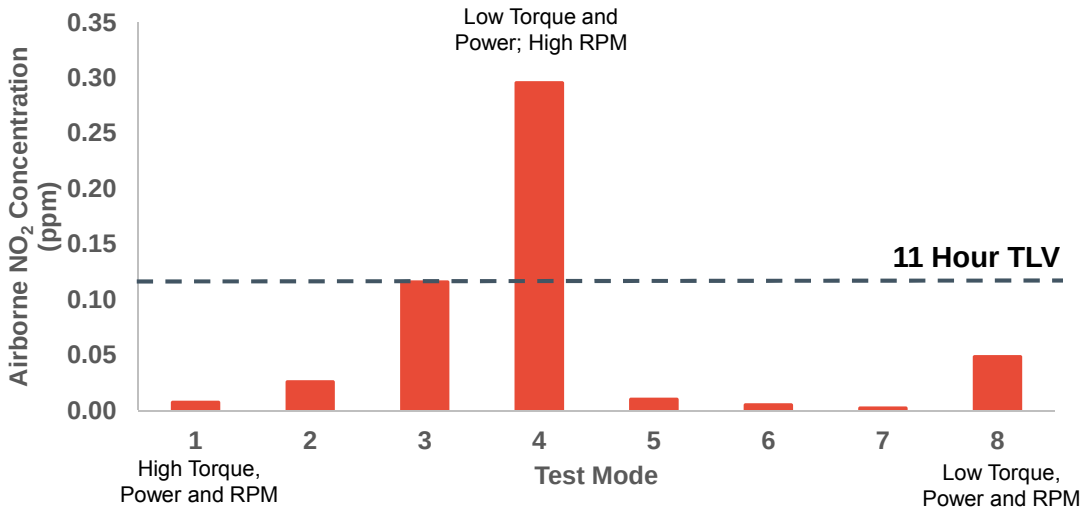
Vendor Consultation Experience

Assumptions:
- *10% (vol%) NO to NO_2 in ambient air*
- *Ventilation air rate of 74 cfm/bhp*
- *Ambient conditions of 20°C and 1.2 kg/m³*



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Operations Feedback

- Operator complaints about NO_x smell with Tier 2/3 engines
- Mine in Quebec repowered 50T truck with SCR technology
- Change highly appreciated by operators due to:
  - Improved environment odour due to lower NO_x content
  - Improved performance when trucks moving uphill
- Maintenance interval extended from 12,000 to 20,000 hours
  - Loss of diesel particulate filter helps reduce maintenance time
- Equipment found to be reliable and performs well in environment

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Benefits in addition to reduced NO_2 emissions

- Economic & achievable ventilation air quantities are maintained
- Reduced or eliminated need for engine exhaust gas recirculation, which improves performance and increases fuel efficiency
- Less particulate matter formed with more efficient combustion process, which reduces strain on engine's diesel particulate filter (DPF) or eliminates need for it
- Additional NO_x generated can help support DPF regeneration (if needed)

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Challenges

- Diesel exhaust fluid logistics and dispensing infrastructure
- Ammonia slip protection
- Readiness of engine vendors to bias SCR to NO_2 conversion
- NO_2 emissions during other engine operating modes
  - Start-up
  - Regeneration, etc.

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Discussion and Questions?

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