Diesel Particulate Matter
Control Strategies

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Outline

• Control Strategies

• Effectiveness of DPM Exposure Controls
  • Ventilation
  • Environmental Cabs
  • Administrative Controls

• Emission Reductions

• Conclusions
DPM reduction depends on:

- Exposure controls
  - Ventilation
  - Environmental cabs
  - Administrative controls

- Emission reduction
  - Diesel engines
  - Engine maintenance
  - Biodiesel fuel
  - Aftertreatments

Almost all mines will require a combination of the controls to attain compliance.
Ventilation

• DPM reduction depends on nature of upgrade
• Improvement roughly proportional to airflow increase

Environmental cabs up to 80% reduction

• 800 $\mu$g/m$^3$ reduced to 160 $\mu$g/m$^3$ in cab
• Some workers cannot work inside a cab

Administrative Controls

• Specified changes in the way work tasks are performed that reduce or eliminate the hazard.
• Restricting the amount of diesel-powered equipment and total engine horsepower operating in a given area, ensuring that the capacity of the ventilation system is not exceeded.
Ventilation

• DPM reduction proportional to airflow
  (Doubling airflow ≈ 50% DPM reduction)

• Increasing ventilation can be difficult and costly
  • Major upgrades
  • Power
    • $1.25 \times \text{airflow} = 2 \times \text{hp} = 2 \times \text{electricity cost}$
    • $2 \times \text{airflow} = 8 \times \text{hp} = 8 \times \text{electricity cost}$
How Much Air is Enough?

• Particulate Index (PI) = airflow quantity needed to dilute DPM emissions to $1,000_{DPM}$ $\mu g/m^3$
  
  • $PI \rightarrow 1,000_{DPM} \mu g/m^3 = 800_{TC} \mu g/m^3$
  • $2 \times PI \rightarrow 500_{DPM} \mu g/m^3 = 400_{TC} \mu g/m^3$
  • $5 \times PI \rightarrow 200_{DPM} \mu g/m^3 = 160_{TC} \mu g/m^3$

• PI’s for MSHA Approved engines listed on MSHA’s Internet website

How Much Air is Enough?

• Examples of engine PI’s
  • Engine #1 150 hp (Tier 1)
    • PI = 23,000 cfm
    • 5 x PI = 115,000 cfm
  • Engine #2 150 hp (Tier 3)
    • PI = 4,000 cfm
    • 5 x PI = 20,000 cfm

• Boosting airflow is a good start, but also need to direct air where needed (walls, stoppings, doors)
  • Eliminate short circuits and recirculation paths
  • Ensure air reaches all working areas and faces
• Avoid
  • Adjacent intake and exhaust openings
  • Small diameter shafts/slopes < 10-foot diameter
    • Very high resistance (high power costs)
• Distributing air underground
  • Auxiliary fan and duct (rigid and flexible) for development ends
    • Inlet needs to be in fresh air
    • Maintain duct
• Properly placed free standing fans
• Brattice lines
Dead Ends – Free-Standing Fans

Critical parameters:
- Fan placement
- Angle off the rib
Dead Ends – Auxiliary Fan

Critical parameters:
- Fan placement
- Fan horsepower
- Duct length & diameter
- Duct bends & corners
- Duct leakage
Natural Ventilation

- Natural ventilation impacted by differences in:
  - Air density
  - Elevation

- Most significant in mines with limited mechanical ventilation pressure and large differences in elevation

- Air reversals may be possible
Environmental Cabs

• Environmental cabs can reduce:
  • DPM, silica and other dust exposure
  • Noise exposure

• Cabs should be:
  • Tightly-sealed with no openings
  • Repaired when windows are broken
  • Pressurized with filtered breathing air
    (follow regular filter change-out schedule of 250 hours)
  • Designed for 1 air change per minute
    (100 ft$^3$ cab requires 100 cfm fan)
  • Operated with doors & windows closed
    (may need air conditioning)
  • Maintained in good condition
Testing Cab for Positive Pressurization

- Close doors and windows
- Turn on AC fan or blower to high setting with “outside air”
- Attach Magnehelic gage to flexible tubing
- Place flexible tubing into cab and close door (make sure tube is not “pinched off”)
- Magnehelic gage should register +0.10-inch wg or more

Magnehelic Gage
Control DPM exposures through operating procedures, work practices, etc.

Examples:

- Minimize engine idling and lugging
- Keep fuel and lube oil clean
- Utilize traffic control and production scheduling
  - Keep heavy traffic downstream from miners who work outside of cabs (e.g. powder crew)
  - Route haul trucks in return air
- Schedule blasters on non-load/haul shifts
- Limit horsepower based on available cfm’s
- Keep cab doors and windows closed
Emission Reductions

Methods to reduce diesel particulate matter emissions:

• New engines produce lower DPM emissions
• Diesel particulate filters remove DPM
• Alternative fuels reduce DPM emissions
• Maintenance program ensures methods working properly
Newer Engines

• Newer tier engines produce lower DPM emissions

• Example of nonroad diesel engine with 175 to 300 horsepower:
  
  • Tier 1 (1996)  0.54 g/kWh
  • Tier 2 (2003)  0.20 g/kWh
  • Tier 3 (2006)  0.20 g/kWh
  • Tier 4 (2011)  0.02 g/kWh
Diesel Particulate Filters

- Passive regenerated ceramic filters
  - Self regenerate based on duty cycle

- Active regenerated ceramic filters
  - Need regeneration station

- Fuel burner with ceramic filter
  - Creates temperature as in passive type system

- Sintered metal fiber filters
  - Electrical heating for onboard regeneration

- Paper filters
  - Cooled exhaust

- High temperature disposable filter
  - Filter life based on duty cycle and operating time

- MSHA Filter Listing
  
Biodiesel Fuel Blends

• Biodiesel
  • Registered fuel & fuel additive with EPA
  • Ultra-low sulfur diesel fuel
  • Derived from vegetable oils or animal fats
  • Blended with standard petroleum-based diesel fuel
  • Significantly lowers EC emissions

• Transition from standard petroleum diesel to high biodiesel content fuel blend
  (cost, fuel quality & availability, low temperature properties, solvent effects, microbial growth, long term storage stability, energy content, oil change intervals)
Conclusions

Most mines should work to attain compliance with a combination of control strategies:

• 3 Exposure Controls
  • Ventilation
  • Environmental Cabs
  • Administrative Controls

• 4 Emission Reduction
  • Diesel Engines
  • Engine Maintenance
  • Biodiesel Fuel
  • Aftertreatments
Diesel Particulate Single Source Page

Metal/Nonmetal Mines

www.msha.gov/01-995/Dieselpartmnm.htm
Feel free to contact me with any questions.

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