Diesel Particulate Matter Control Strategies

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Overview

Control Strategies

DPM reduction depends on:

- Ventilation
- Environmental Cabs
- Administrative Controls
- Diesel Engines
- Engine Maintenance
- Biodiesel Fuel
- Aftertreatments
Control Strategies

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

Exposure Controls
- Ventilation
- Environmental Cabs
- Administrative Controls

Emission Reduction
- Diesel Engines
- Engine Maintenance
- Biodiesel Fuel
- Aftertreatments
Effectiveness of DPM Controls

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 or work practice controls
- DPM reduction depends
  - Mine conditions
  - Practices used
Ventilation

- Widely used method for DPM control
- DPM reduction proportional to airflow
  - Doubling airflow ≈ 50% DPM reduction
- Increasing ventilation can be difficult and costly
  - Major upgrades
    - Example:
      16-foot diameter shaft = $1,000/foot
  - Power
    - Example:
      250,000 cfm at 1-inch wg = 40 hp
      40 hp x 100 hours/week @ 10¢/kw-hour = $15,000/year
      1.25x airflow = 2x hp = 2x electricity cost
      2x airflow = 8x hp = 8x electricity cost
How Much Air is Enough?

Particulate Index (PI) = airflow quantity needed to dilute DPM emissions to $1,000_{\text{DPM}} \, \mu g/m^3$

- $\text{PI} \rightarrow 1,000_{\text{DPM}} \, \mu g/m^3 = 800_{\text{TC}} \, \mu g/m^3$
- $2 \times \text{PI} \rightarrow 500_{\text{DPM}} \, \mu g/m^3 = 400_{\text{TC}} \, \mu g/m^3$
- $5 \times \text{PI} \rightarrow 200_{\text{DPM}} \, \mu g/m^3 = 160_{\text{TC}} \, \mu g/m^3$

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

How Much Air is Enough?

- Examples of engine PI’s
  - Cat 3306 PCNA (150 hp)
    - PI = 27,000 cfm
    - 5 x PI = 135,000 cfm
  - Deutz BF4M2012 (150 hp)
    - PI = 3,000 cfm
    - 5 x PI = 15,000 cfm

*Remember:* \(2 \times cfm = 8 \times hp = 8 \times \$\)

- 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
Ventilation System Layouts

- Avoid
  - Adjacent intake and exhaust openings
  - Small diameter shafts/slopes < 10-foot diameter
    - Very high resistance (high power costs)

- Distributing air underground
  - Long unmined blocks
  - Brattice lines
  - Auxiliary fan and duct (rigid and flexible) for developments ends
    - Inlet needs to be in fresh air
    - Maintain duct
Adjacent Intake and Exhaust
Separated Intake and Exhaust
Recirculation

Free-standing booster fans with no ventilation control structures (stopplings, air walls, doors, etc.) cause recirculation.

recirculation path
Dead Ends – Free-Standing Fans

Main Airflow

Free Standing Fan

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

- Temperature difference causes pressure difference.
- Example:
  
  NVP = 0.03-inch wg per 100 feet per 10°F
  
  100-foot shaft and 40°F change (15°F to 95°F)
  
  NVP = 0.03 x 100/100 x 40/10 = 0.12-inch wg

  - 0.12-inch wg → 20,000 to 50,000 cfm is typical
  - 0.12-inch wg is maximum value & usually less
  - Not sufficient for DPM dilution

- Reverses from summer to winter

- Very low in spring and fall (sometimes zero)
Environmental Cabs

- Environmental cabs can reduce:
  - TC exposure
  - Noise exposure
  - Silica and other dust 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
Administrative Controls

- Control DPM exposures through operating procedures, work practices, etc.
- Job rotation prohibited as DPM administrative control  
  [§57.5060(e)]
  - Job rotation
    - Means assigning a job to more than one worker so that each worker does the assigned job for only part of a shift
    - Spreads exposure to more workers
    - Not acceptable for control of exposure to carcinogens in accordance with good industrial hygiene practice
Work Practices

- Work practices can reduce DPM emissions, concentrations, and exposures

- 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, especially when ascending ramps loaded
    - Limit horsepower based on available cfm’s
  - Schedule blasters on non-load/haul shifts
  - Keep cab doors and windows closed
Conclusions

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

- 3 exposure controls
- 4 emission reduction
Contact Information

Feel free to contact me with any questions.

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