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

Control Strategies

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.

Effectiveness of DPM Exposure 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 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 x airflow = 2 x hp = 2 x electricity cost
    - 2 x airflow = 8 x hp = 8 x 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 x PI $\rightarrow$ 500_{DPM} $\mu g/m^3$ = 400_{TC} $\mu g/m^3$
  - 5 x 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

  https://lakegovprod3.msha.gov/ReportView.aspx?ReportCategory=EngineAppNumbers#

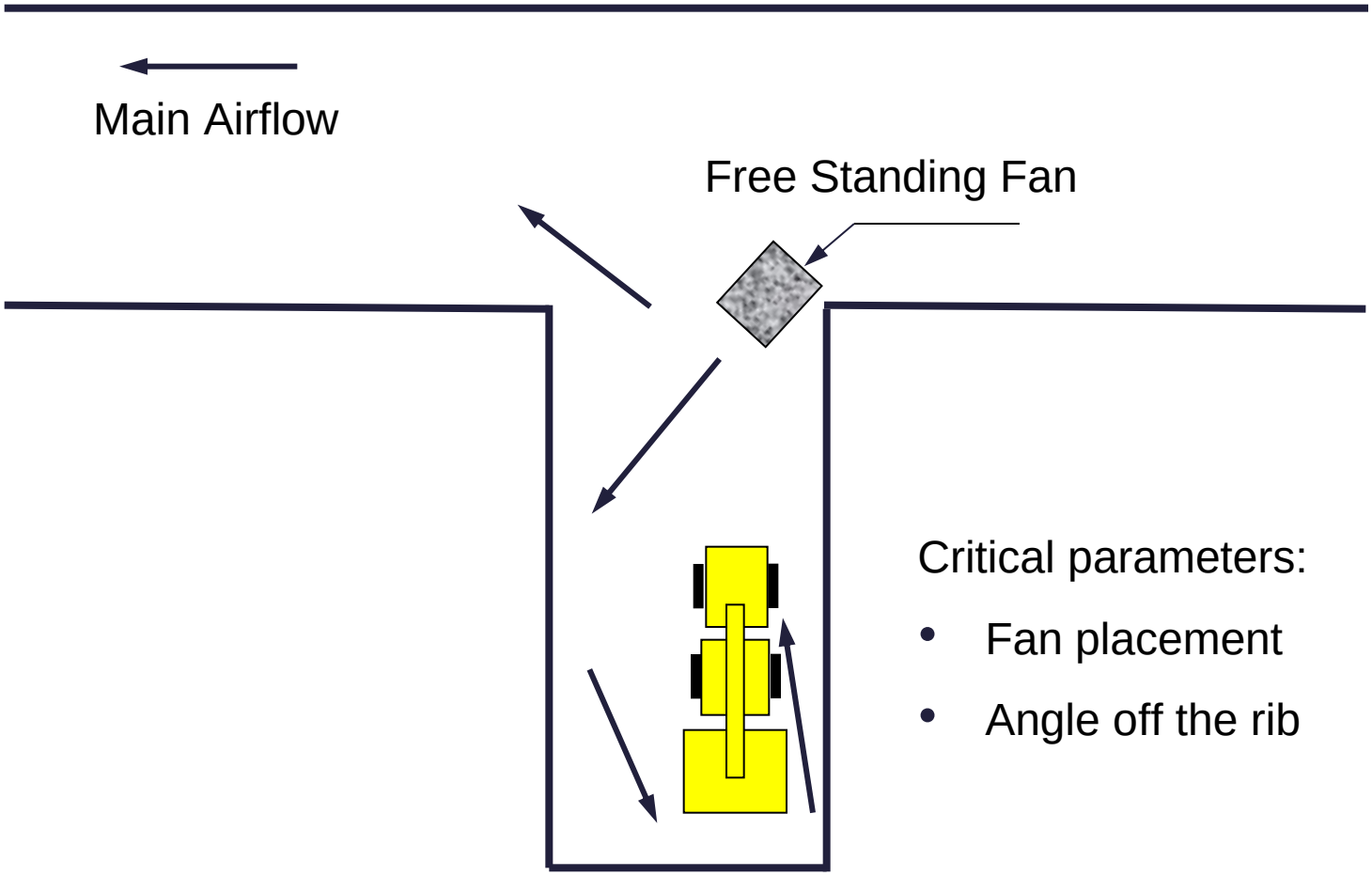
How Much Air is Enough?

- 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

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
  - 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

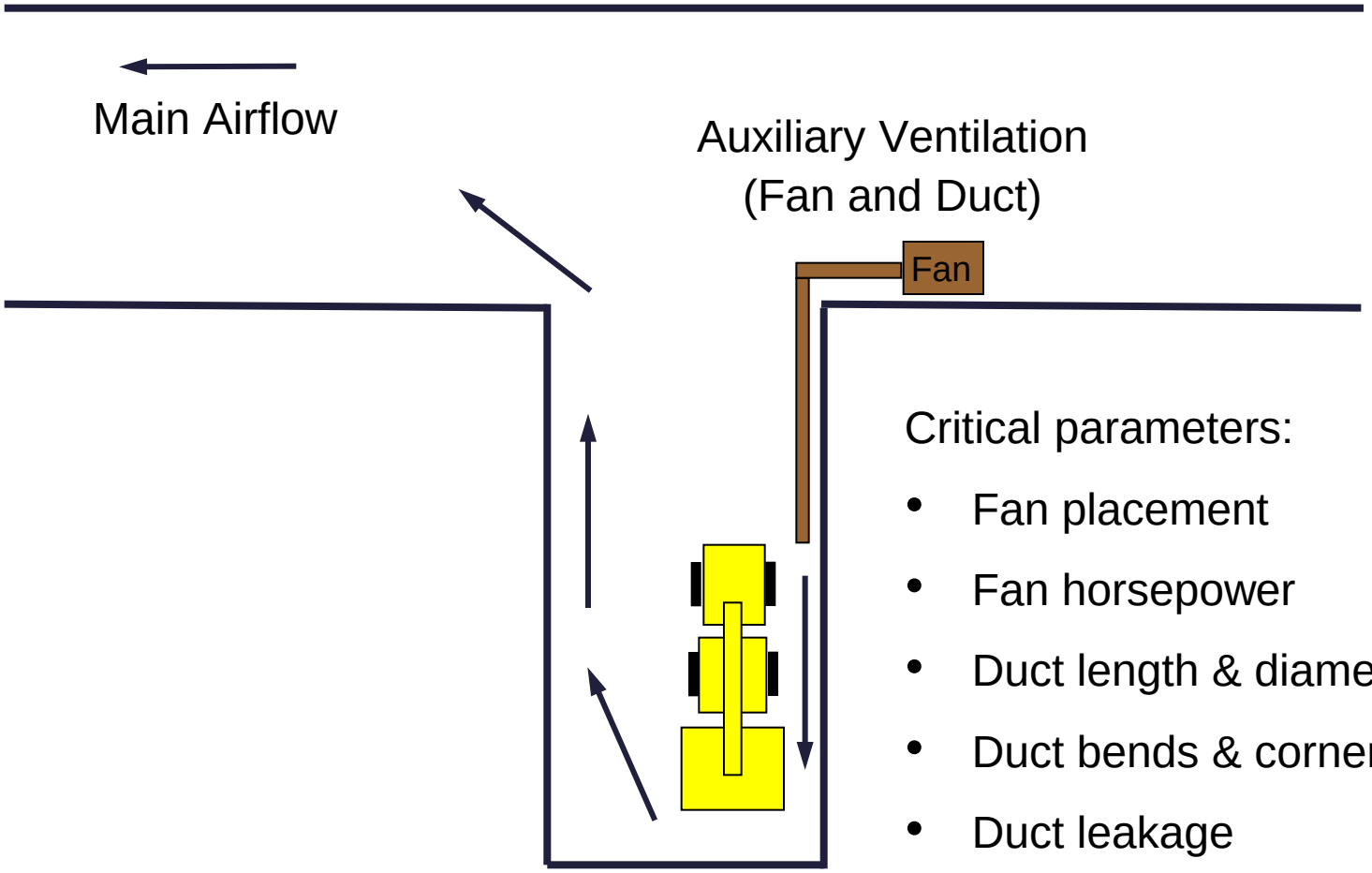
Dead Ends – Free-Standing Fans



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

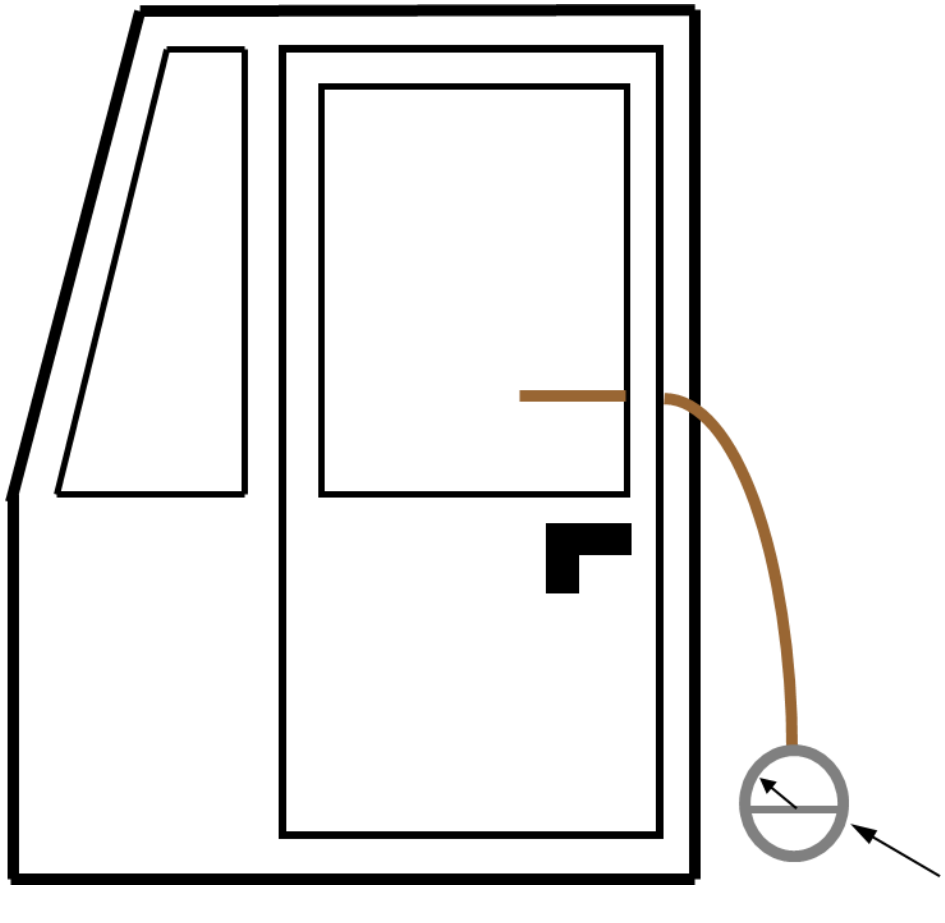
Natural Ventilation

- 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

Administrative Controls

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

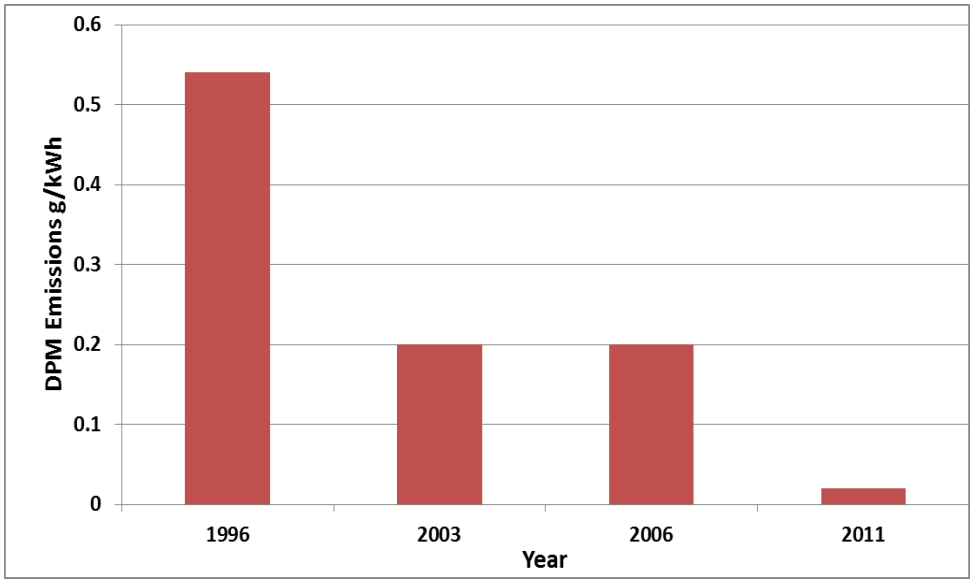
Emission Reductions

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
  http://arlweb.msha.gov/01-995/Coal/DPM-FilterEfflist.pdf

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

DPM Information

Diesel Particulate Single Source Page

Metal/Nonmetal Mines

www.msha.gov/01-995/Dieselpartmnm.htm

Contact Information

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