
UPDATE ON MSHA'S TECHNICAL SUPPORT WORK

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Updates

- MSHA's Engine Fuel Deration Guidelines for Altitude
- Kindling Temperatures of High Temperature Disposable DPM Filters

MSHA's ENGINE APPROVAL

- MSHA Part 7 engine approval specifies maximum fuel rate for maximum altitude
- For higher altitudes fuel rates must decrease
- Excessive CO and smoke will result if engine is overfueled
- November 1999 - only approved engines in underground coal mines
- January 2001 – approved engines or EPA compliant in M/NM mines

Altitude Issue

- MSHA, NIOSH, and the Mining Industry worked to resolve the fuel deration issues for approved engines
- Conducted field and laboratory test
- Establish guidelines for part 7 approved engines operating at altitude
- Guidelines can be used for non-approved engines in order to reduce engine emissions at altitude

Test Verification

- Two engines were tested at actual altitude and simulated altitude
 - DaimlerChrysler OM 904 LA
 - Reno, NV (4000ft) & Santa Fe, NM (6300ft)
 - Deutz BF4M1013FC
 - Santa Fe, NM (6300ft)
- Both engines are electronically controlled for altitude adjustments

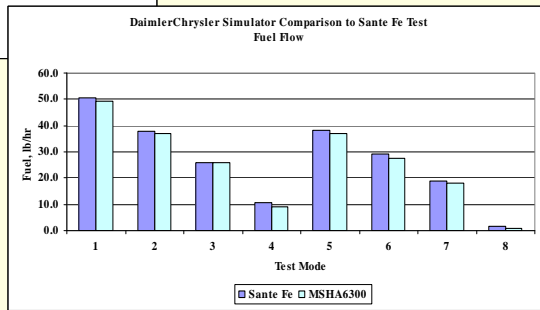
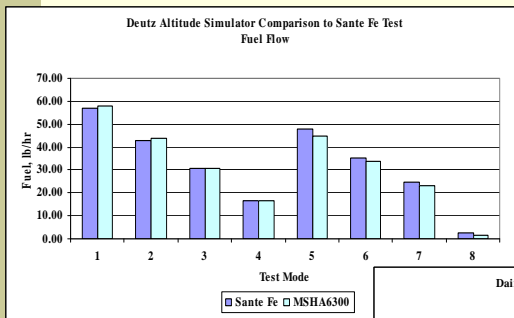
Simulator Test Verification

- Altitude Simulator
 - Uses a Roots Blower to lower pressure
 - Intake air
 - Exhaust
 - Electronic Control Box
 - Air is restricted to simulate various altitudes
 - Intake and Exhaust are at the same pressure
 - Emissions Measured
 - Horiba Bench for Gaseous Emissions
 - Sierra BG partial flow system for Particulate

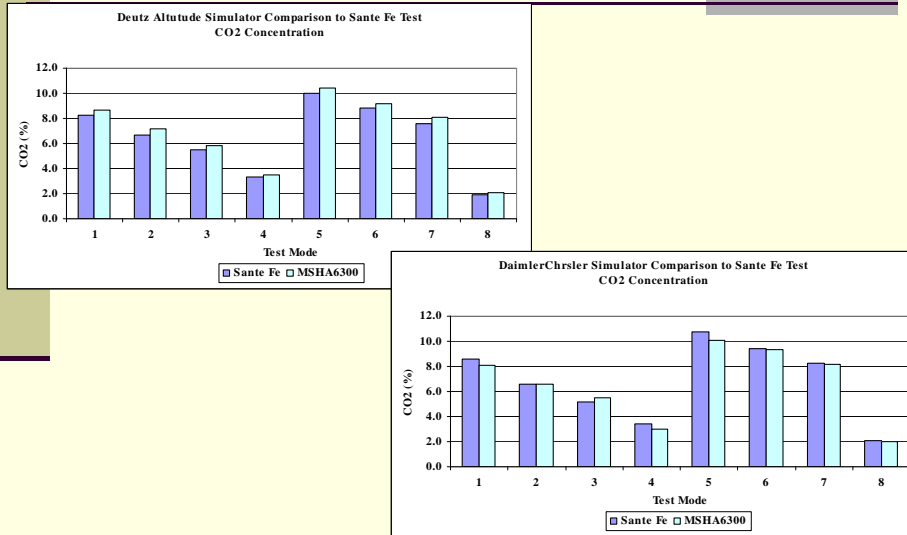
Altitude Simulator



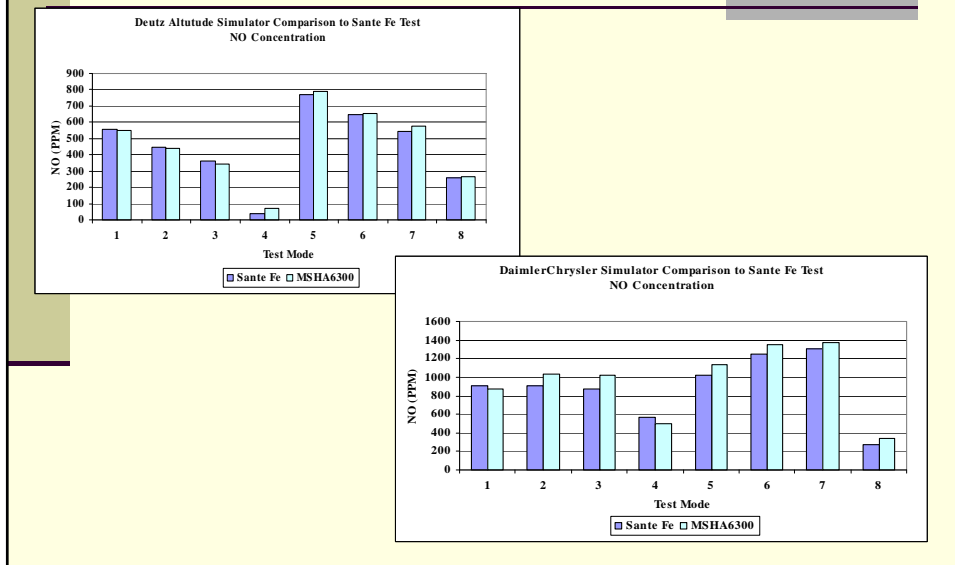
Simulator Test Data (Fuel)



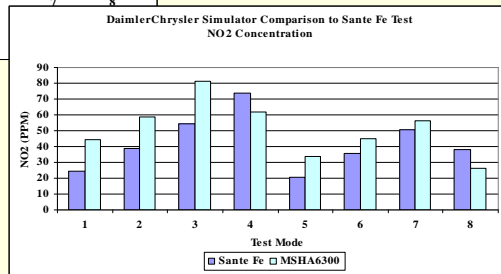
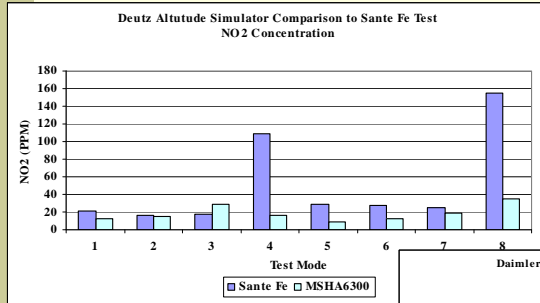
Simulator Test Data (CO2)



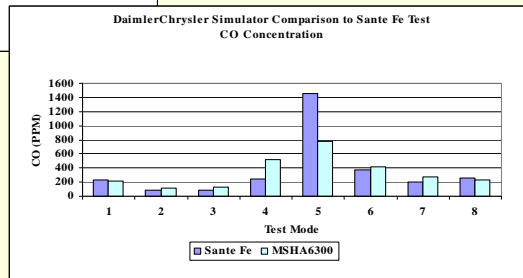
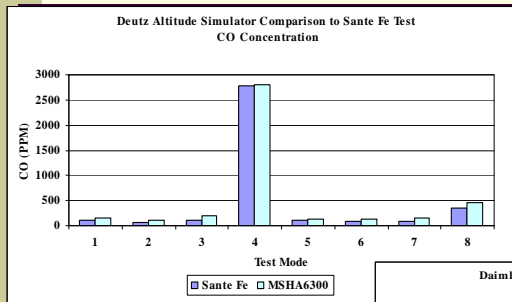
Simulator Test Data (NO)



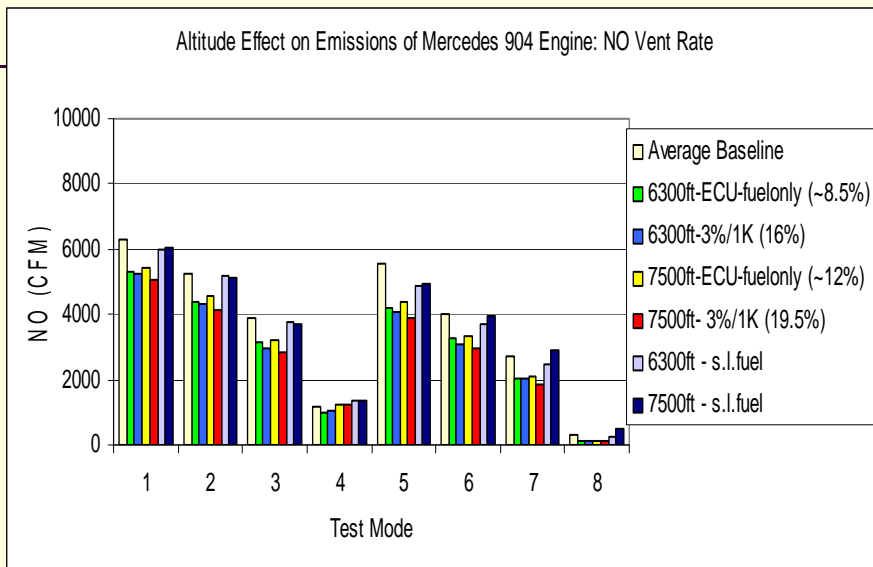
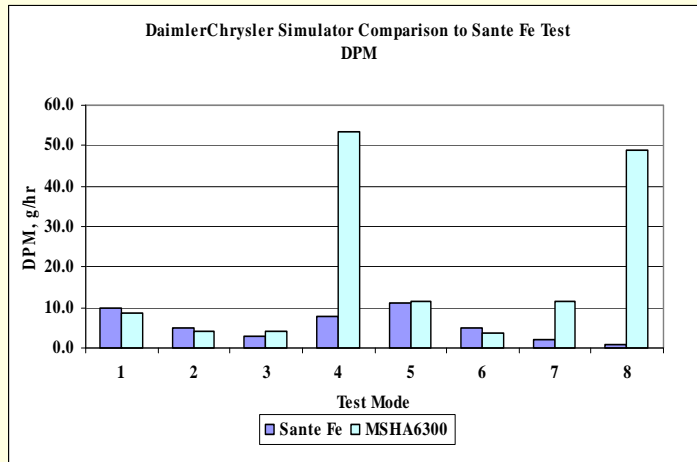
Simulator Test Data (NO2)

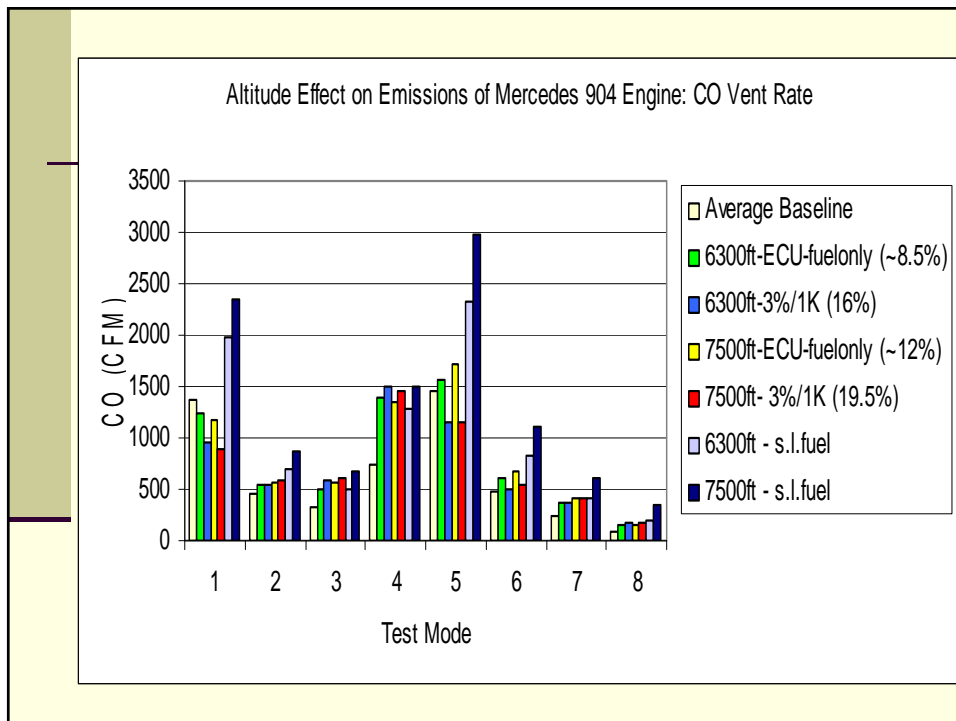
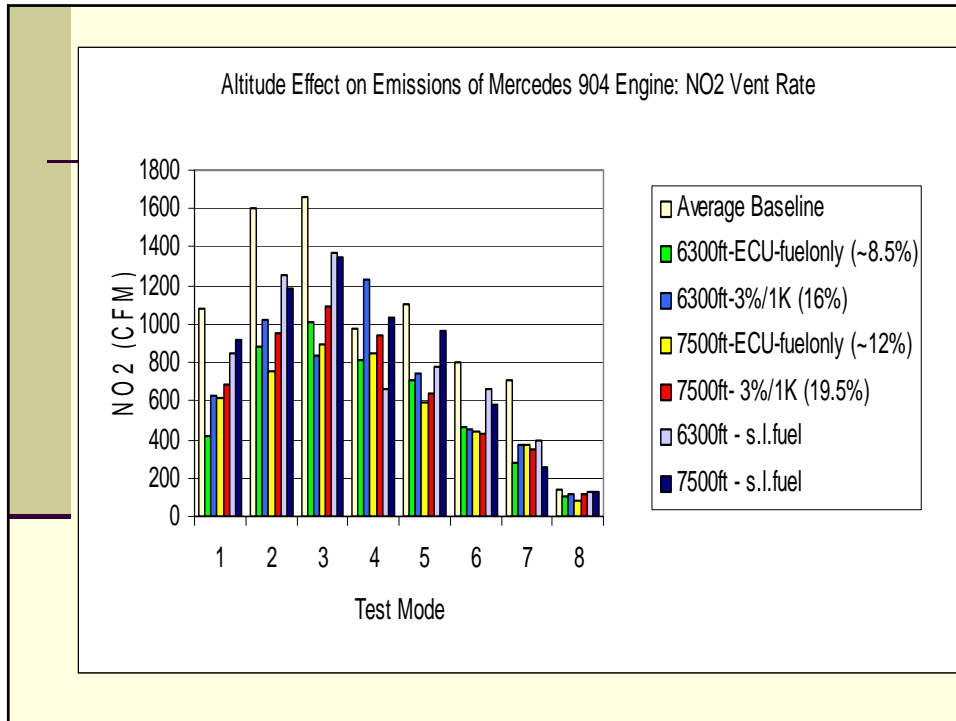


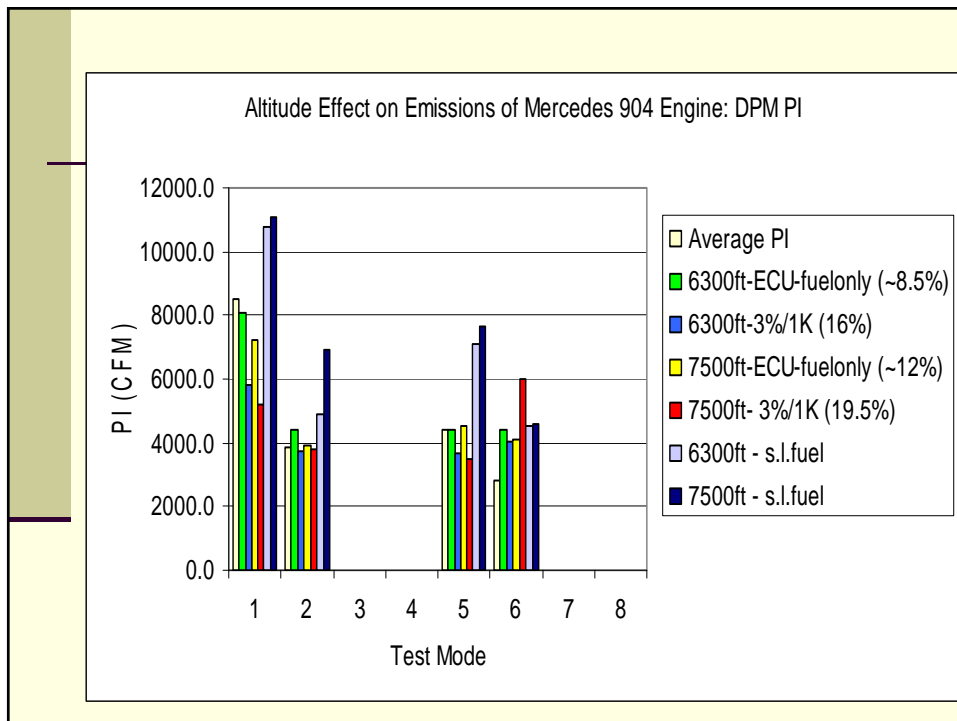
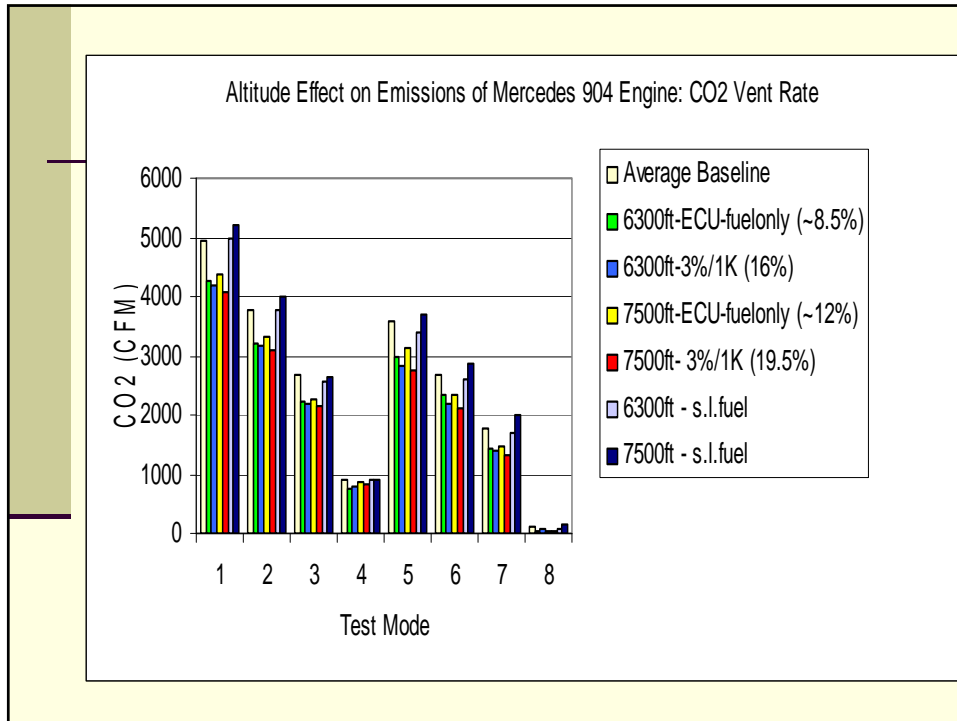
Simulator Test Data (CO)

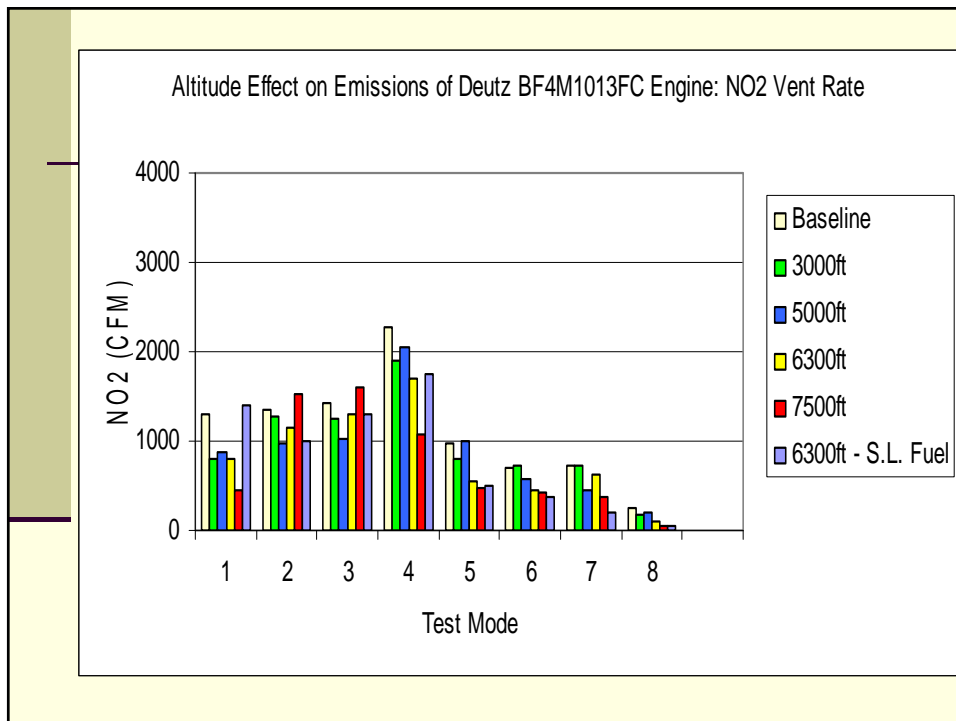
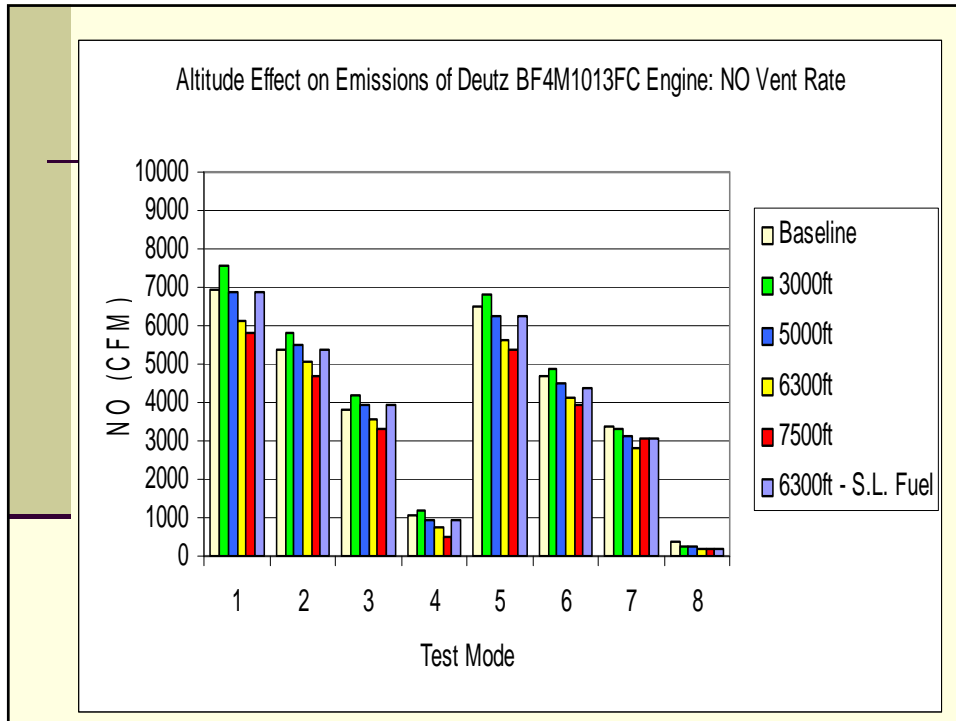


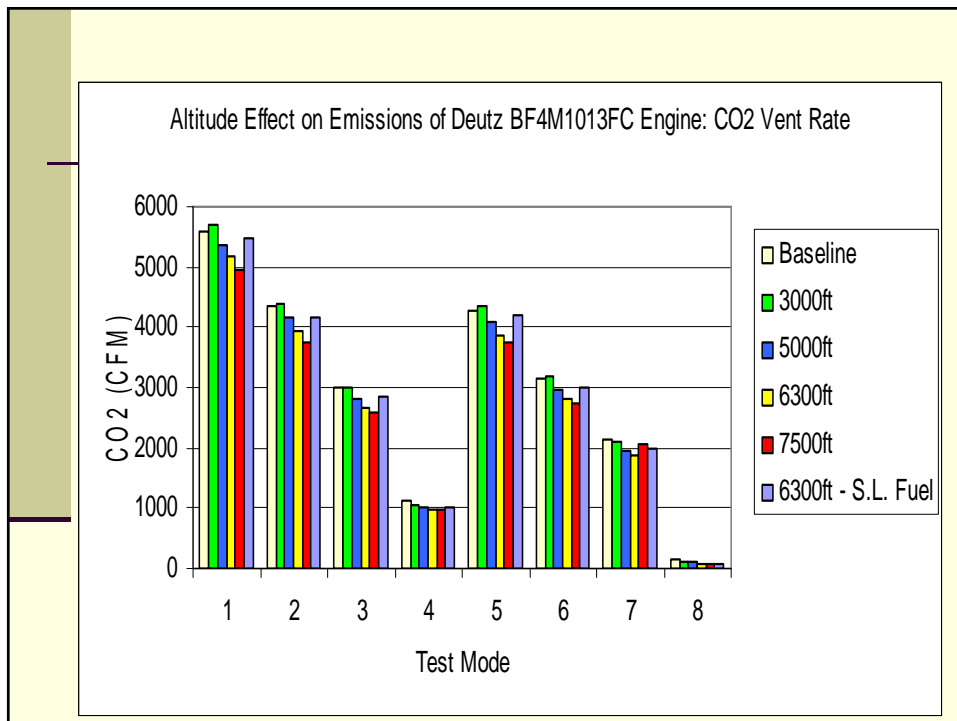
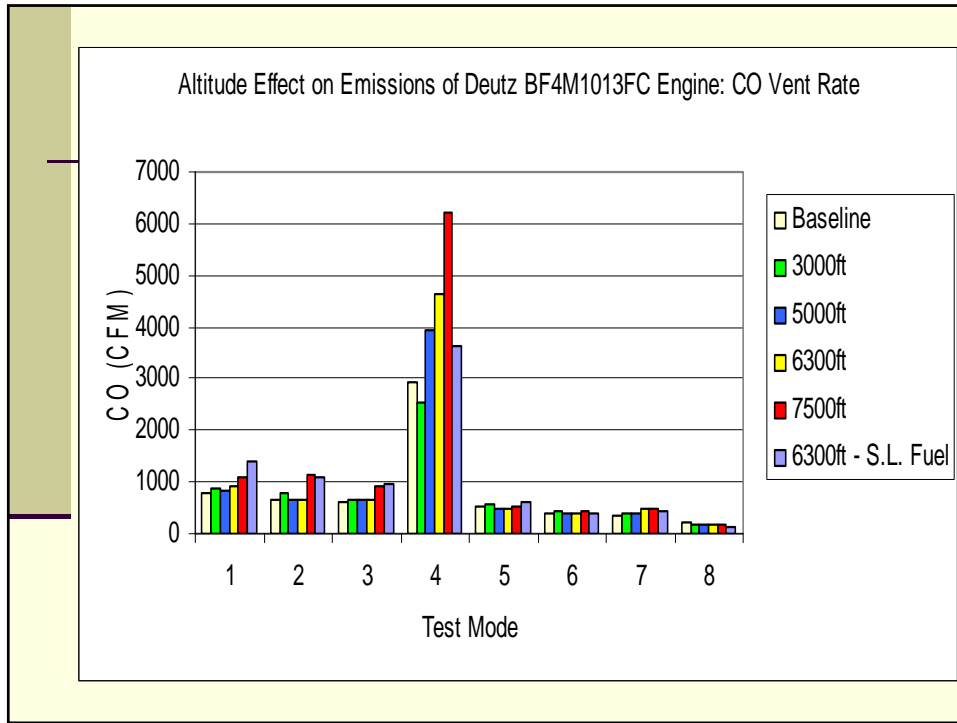
Simulator Test Data (DPM)











Engine Fuel Deration Guidelines

- Naturally Aspirated Engines: 3% per 1000 feet over 1000 feet
- Turbocharged Engines: f/a ratio greater than 0.047 at mode 5 of 8 mode test: 3% per 1000 feet over 1000 feet
- Turbocharged Engines: f/a ratio less than 0.047 at mode 5 of 8 mode test: 3% per 1000 feet over 3000 feet

- Engine can be tested for alternative deration schedule. Baseline (1000 feet) Gaseous Ventilation rate and Particulate Index cannot be exceeded at altitudes.
- No adverse effects on NOX emissions allowed for altitude compensation for electronic fuel controlled engines.
- Emission reduction components are permitted in order to keep the Gaseous Ventilation Rate and Particulate Index at base line values when operating at altitudes

Issue With High Temperature Disposable DPM Filters

- Reported Fires on Machines that were using these filters without exhaust gas cooling
- Material will not burn, it's a synthetic media
- Ignition caused by DPM, oils, un-burnt fuels collecting on the filter

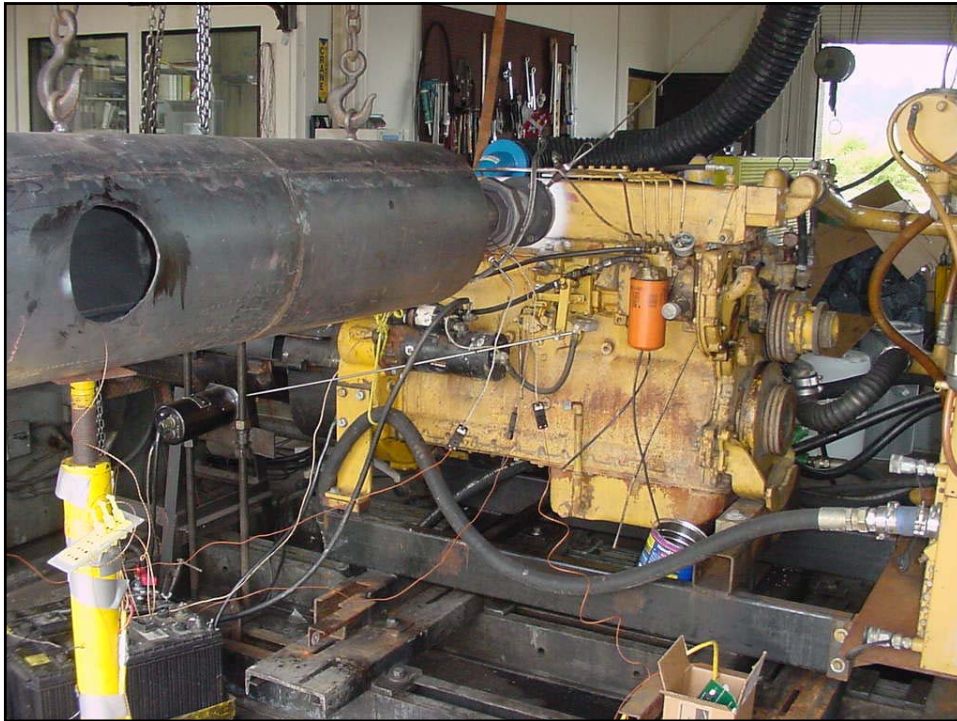


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- MSHA Issued a Program Information Bulletin (PIB) –July 20, 2004:
 - gave warning concerning ignitions (above 650°F)
 - described testing that MSHA would do
 - 83% DPM efficiency established at a maximum exhaust gas temperature of 650°F based on the 8 mode test.

Tests Conducted:

- Small Scale Tests:
 - heat gun testing
 - ASTM Setchkin Furnace testing
- Large Scale Tests:
 - diesel engine
 - actual filters from field





Results

- Small Scale Testing:
 - Heat Gun: 875F to 1100 F
 - w/ hydrocarbons added: 550F to 800F
 - Setchkin Furnace: 982F & above
 - w/ hydrocarbons added: 561F

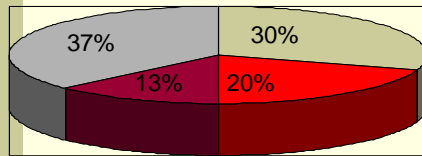
- Full Scale Testing:
 - 21 Different Tests: 645F to 1075F

EXHAUST GAS TEMPERATURE	POTENTIAL FOR FILTER KINDLING ¹
302	NONE
500	Filter kindling: improbable- unlikely to occur but possible under <i>unexpected engine operating conditions</i> .
550	Filter kindling: remote- unlikely but can reasonably be expected to occur under <i>expected engine operating conditions</i> . Filter Kindling was observed during small scale tests.
650	Filter kindling: occasional- will occur several times per year with widespread use of filters under <i>expected engine operating conditions</i> .
750	Filter kindling: probable- will occur frequently with widespread use of filters under normal engine operating conditions.
Above 750	Filter kindling: frequent- will be continuously experienced with widespread use of filters under normal engine operating conditions.

Recommended Options for Mines:

- Cool Exhaust for Disposable Hi-Temp. Filters
 - 650F Max (for compliance with 72.501)
 - to err on conservative side: 500F (safety factor)
- Hi-Temp. Shut Down
- Engine Maintenance
- Ceramic Filters / DST / Water Scrubbers

~600 Heavy Duty Machines, Generators, and Air Compressors Need a Filter in Underground Coal Mines



- Ceramic
- Hi-Temp Disp.
- DST or Scrubber
- Without DPM Filters



Hi-Temp. Disp. Filter



Conclusions

- Altitude Deration
 - Fuel Deration is necessary to maintain exhaust emission qualities at altitudes
- High Temperature Disposable DPM Filters
 - Option for mines to use for DPM reduction, however, need to reduce exhaust gas temperatures to prevent ignitions and to maintain maximum efficiency.