

Alternative Fuels Effects on DPM

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Alternative Fuels – Topic Overview

- ✿ Types of available diesel fuels
- ✿ NIOSH results from in-mine test

- ✿ Overview of biodiesel characteristics
- ✿ Biodiesel fuel supplier experience
- ✿ Experience with synthetic petrodiesel
- ✿ Discussion of mining industry experiences, issues, and solutions

General Features of Alternative Fuels

- ✿ As a control alternative, fuel affects all vehicles
 - Mine- or section-wide deployment
 - Emissions reduced for ALL vehicles
 - No need to select target vehicles
- ✿ Engine brand-specific fuel system modifications might be necessary (doubtful)
- ✿ Storage and distribution system modifications may be needed
- ✿ High "business as usual" factor
- ✿ Issues with availability and cost



Available fuels

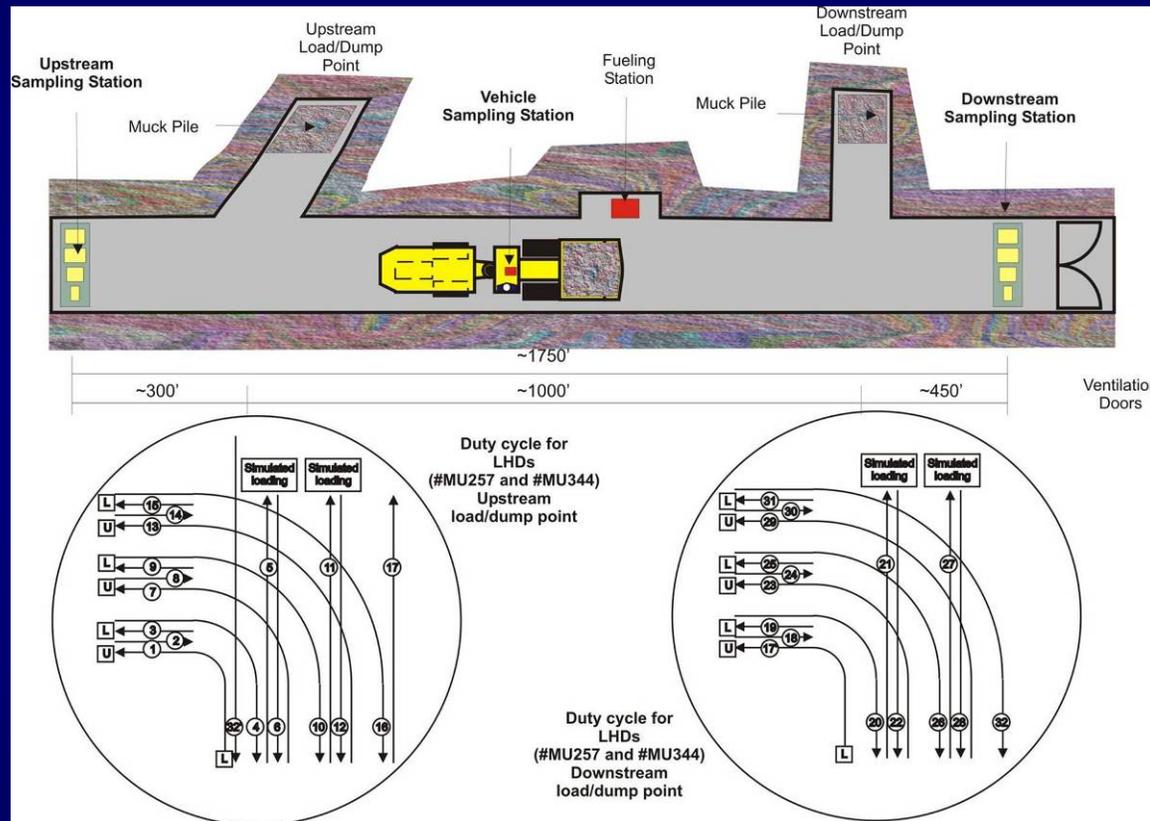
- ☀ Common diesel (petrodiesel) fuels
 - Dyed D2 or D1
 - Is usually an Ultra Low Sulfur Fuel (ULSF)
 - Low in aromatics?
 - Must use additive (1% biodiesel) for lubricity
 - Jet fuels
- ☀ Synthetic “petrodiesel” fuel
 - ULSF, low or no aromatics, i. e., “pure”
- ☀ Biodiesel (methyl esters)
 - B100
 - Blends with D2, B5 & B20
 - Variety of feedstock
 - “Green” fuel
- ☀ Fuel-water emulsions
 - Lubrizol’s PuriNox no longer available

Fuel Additives

- ✱ In general avoid unnecessary fuel additives - unless
 - ✱ They contain no metals (excepting fuel-borne catalysts to assist filter regeneration – a filter must always be used)
 - ✱ The claims are supported by rigorous experimental data – testimonials are not adequate
 - ✱ Have been “Okayed” by MSHA
 - ✱ Are EPA listed (but the listing does not guarantee health or effectiveness)

Fuel effects on DPM – In-mine test results

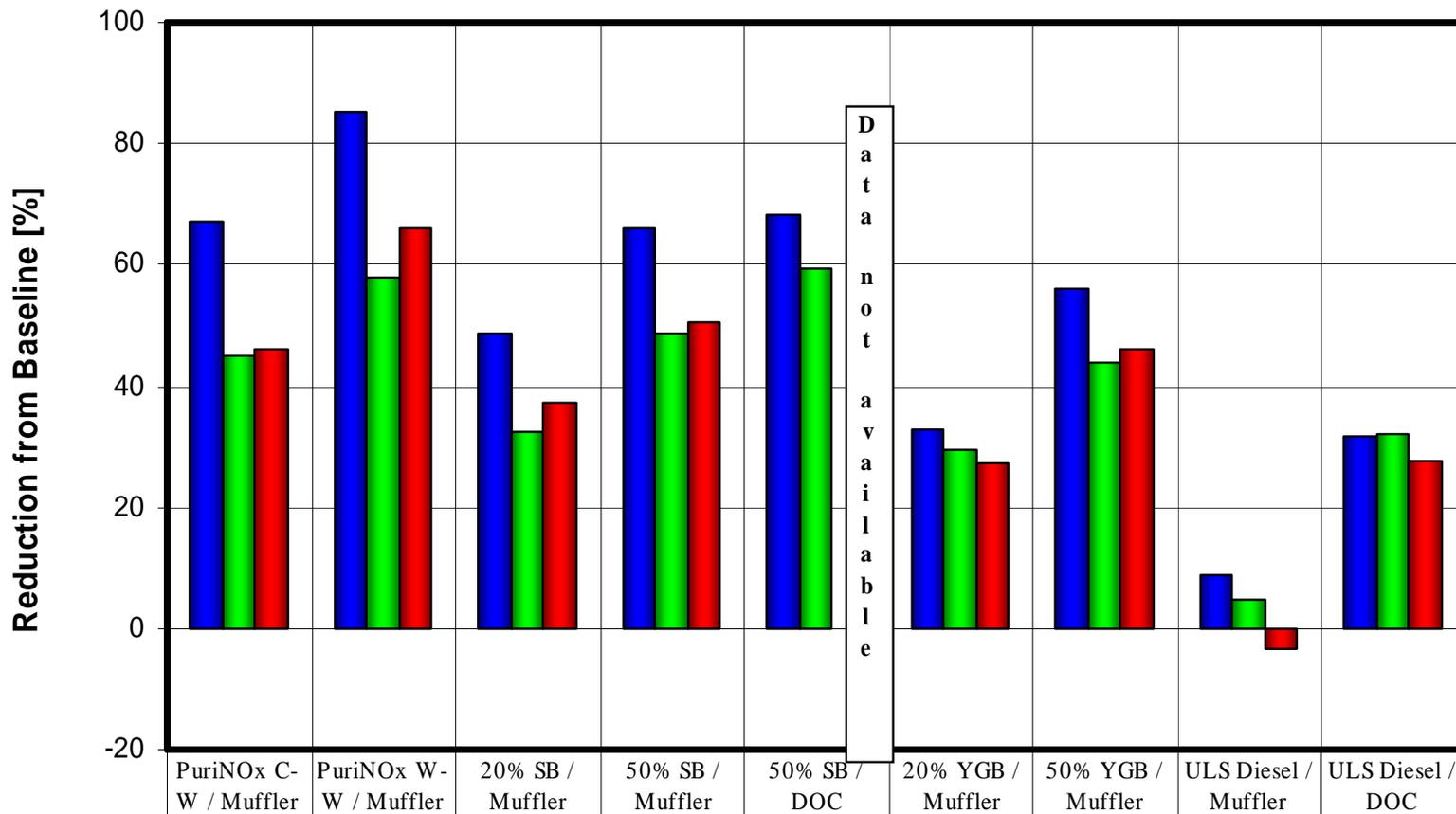
- NIOSH conducted isolated zone tests in 2004
- Realistic, repeatable operation of a single vehicle
- Fresh air contaminated only by test vehicle operation
- Simple & sophisticated measurements of DPM



Alternative Fuel Formulations Tested

- ✿ Biodiesel as B20 and B50:
 - ✿ Yellow grease;
 - ✿ Soy biodiesel.
- ✿ Water-in-diesel-fuel emulsions:
 - ✿ Hot-weather emulsion (77% #2 diesel, 20% water, 3% emulsifying agent).
 - ✿ Cold-weather emulsion (86% #2 diesel, 10% water, 2% methanol, 2% emulsifying agent).
- ✿ Synthetic ULSF diesel (GTL):
 - Extremely low sulfur content
 - Extremely low content of aromatics
 - High Cetane number

Effects of Alternative Fuels on Concentrations of EC and DPM – Stillwater August/September 2004 Study



| | | | | | | | | | |
|------------|----|----|----|----|----|----|----|----|----|
| ■ EC HV | 67 | 85 | 49 | 66 | 68 | 33 | 56 | 9 | 32 |
| ■ TPM GRAV | 45 | 58 | 32 | 48 | 60 | 30 | 44 | 5 | 32 |
| ■ TPM TEOM | 46 | 66 | 37 | 50 | | 27 | 46 | -3 | 27 |

Fuel Formulation Test Results – EC reductions

- ✱ Biodiesel as B20 and B50:
 - ✱ Yellow grease, 33%, 56%
 - ✱ Soy biodiesel, 49%, 66% (68% with DOC)

DPM loss results from the decrease in the number of larger, more massive particles with little or no increase small particle number.

- ✱ Water-in-diesel-fuel emulsions:
 - ✱ Hot-weather emulsion, 85%
 - ✱ Cold-weather emulsion, 67%
- ✱ Synthetic ULSF diesel
 - ✱ 9%
 - ✱ 32% with DOC

Summary

- ✿ Some alternative fuels can significantly reduce tailpipe emissions of DPM.
- ✿ Wednesday's presentations will address biodiesel and synthetic fuels.
- ✿ A discussion forum will follow the presentations.