Idaho National Laboratory

U.S. Department of Energy - FreedomCAR & Vehicle Technologies Program
(Advanced Vehicle Testing Activity)

Evaluation of Oil Bypass Filter Technology on Heavy-Duty Vehicles

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American Filtration and Separations Society
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Presentation Outline

- **Background & Objectives**
- **Oil bypass filters – features & reported benefits**
- **INL testing method**
- **puraDYN oil bypass filters**
- **Refined Global Solutions (RGS) oil bypass filters**
- **Testing results & trends**
- **Particulate and ferrography testing**
- **Initial INL Oil Bypass Filter Economics**
- **Potential fleet oil savings**
- **Testing Status**

Bypass Filter Evaluation - Background

- **Funded by the U.S. Department of Energy's FreedomCAR & Vehicle Technologies Program (Advanced Vehicle Testing Activity)**
- **Vehicles operated by Idaho National Laboratory's Fleet Operations group**
- **Idaho National Laboratory**
  - **Department of Energy (DOE) lab in eastern Idaho**
  - **900 square miles & 6,000 employees**
  - **99 motor coach buses operated 110 to 180 miles per round trip to move ~3,000 employees daily**
  - **11 Buses equipped with oil bypass filters**
  - **INL is managed by Battelle Energy Alliance**

Bypass Filter Evaluation - Objectives

- **Test the concept of using oil bypass filters to minimize engine oil changes & the generation of waste oils to support DOE's goal of increasing energy security**
- **Demonstration the economics of oil bypass filter systems**
- **Estimate potential engine oil saving from bypass filter technologies that can be achieved by INL, DOE complex, & Federal Fleets**

Typical Full Flow Filters

- **Standard to all OEM heavy-duty vehicles**
- **Filters the full flow of the oil pump (up to 50 gallons per minute)**
- **Generally filters out particles down to 40 to 60 micron-sized particles (varies with price)**

Oil Bypass Filters - Features

- **Aftermarket filter system**
- **Operates offline (bypass) of the main oil supply system**
- **Filters a partial flow of oil (6 to 8 gallons per hour)**
- **Cleans particles down to < 1 micron**
- **Some with additive packages**
- **Ability to capture & evaporate undesired fluids**
- **INL testing puraDYN and Refined Global Solutions (RGS) oil bypass filters**

Oil Bypass Filters - Reported Benefits

- **Extend oil drain intervals beyond standard 12,000 miles (diesel buses)**
- **~80% less oil used**
- **~80% less waste oil generated**
- **Longer engine life - particles in 5 to 20 micron range believed to cause 60% of engine wear**
- **Less maintenance time**
- **Return of investment: varies with vehicle**

INL Testing Method

- Change full flow filter(s), & install bypass filters & new engine oil (Shell Rotella-T oil - 15W-40)
- Change full flow & bypass filters only at service intervals (12,000 miles) - not oil
- Obtain 3 oil analysis samples - archive & 2 lab samples
  - CTC Laboratory
  - National Tribology Services Laboratory (NTS)
- Operate buses in routes to/from INL “site” & various locations, 110+ miles per round trip
- Validate extended oil drain use via oil analysis data
- Track & trend data

puraDYN Oil Bypass Filters

- Installed on
  - 3 four-cycle, Series 50 Detroit diesel engines
  - 4 four-cycle Series 60 Detroit diesel engines
  - 1 Model 310 Caterpillar engine
- Installed starting 10/2002 on buses 73425, 73432, 73433, 73446, 73447, 73448, 73449 & 73450
- Single unit system with additives package & fluid evaporator

Installed puraDYN System

puraDYN unit

Installed puraDYN System

puraDYN unit

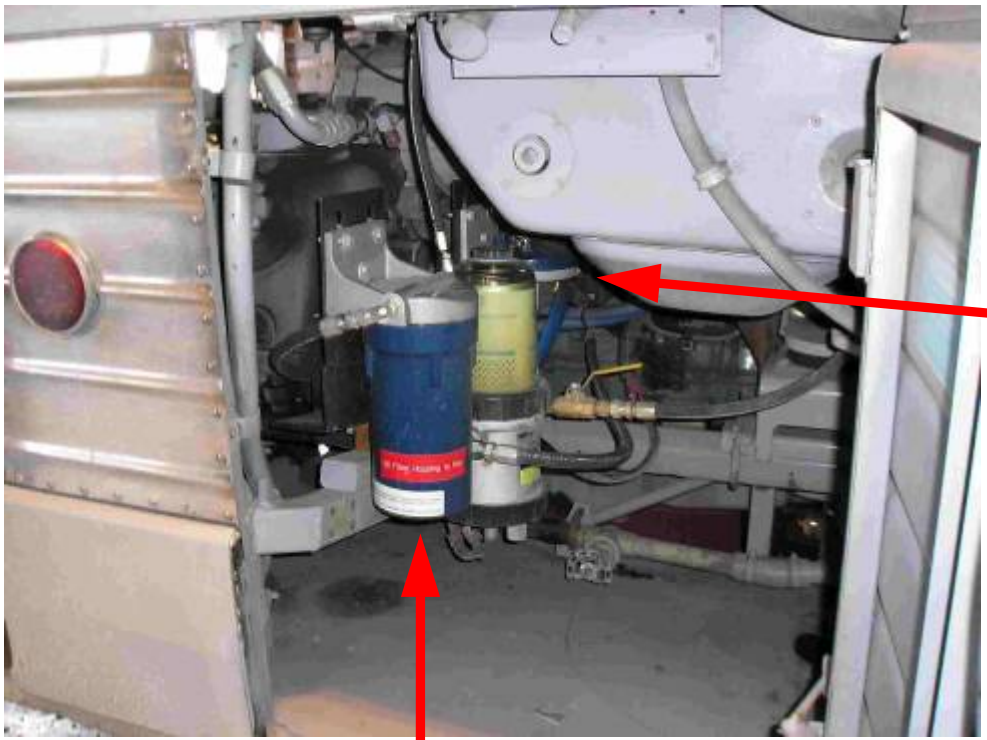
Refined Global Solutions Oil Bypass Filters

- **Installed on 3 four-cycle, Series 50 Detroit diesel engines**
- **Installed 12/2004 on buses 73413, 73416 & 73426**
- **2 unit system with fluid evaporator**

Processor (heater) unit

Filter housing

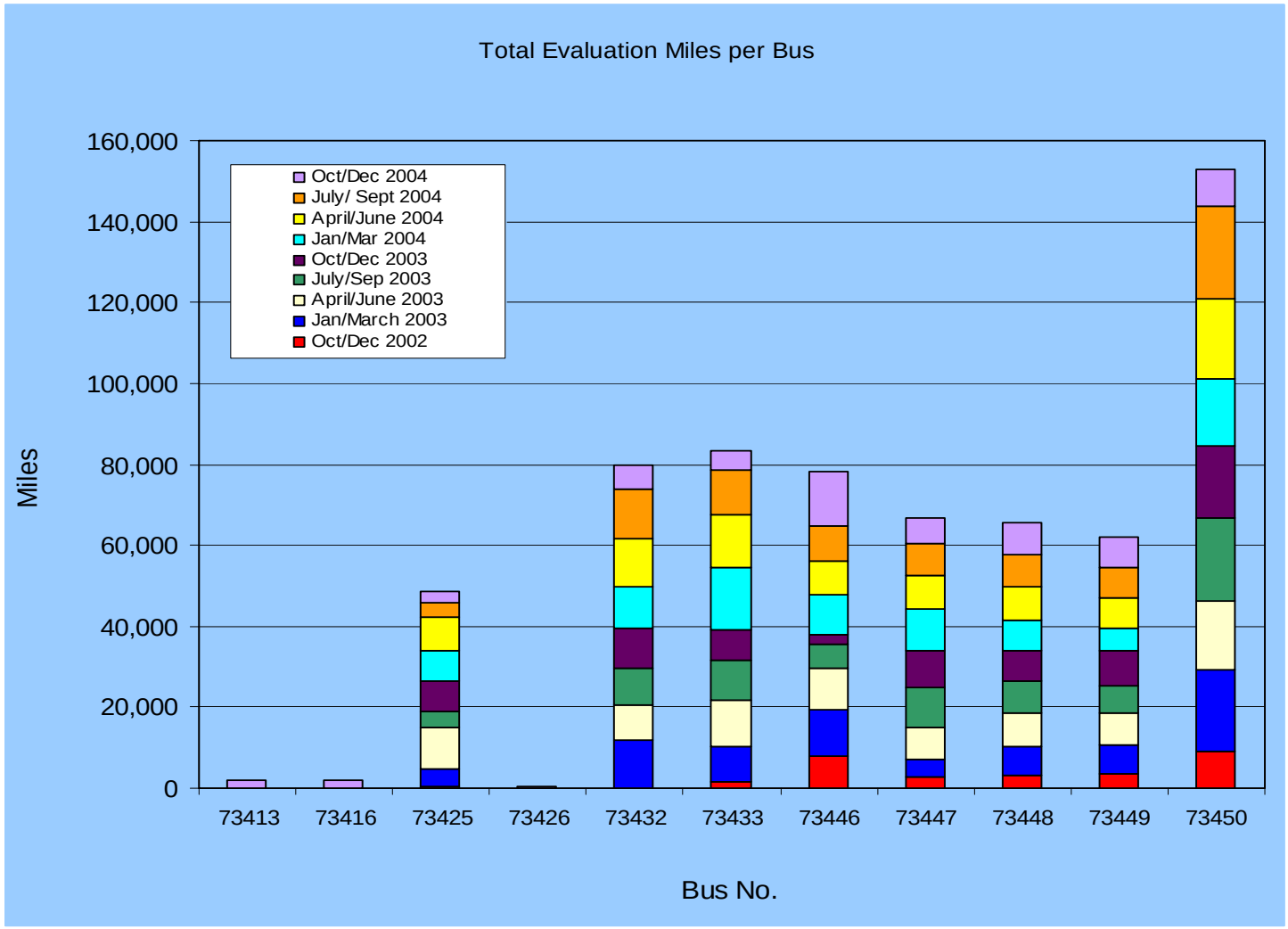
Installed Refined Global Solutions System



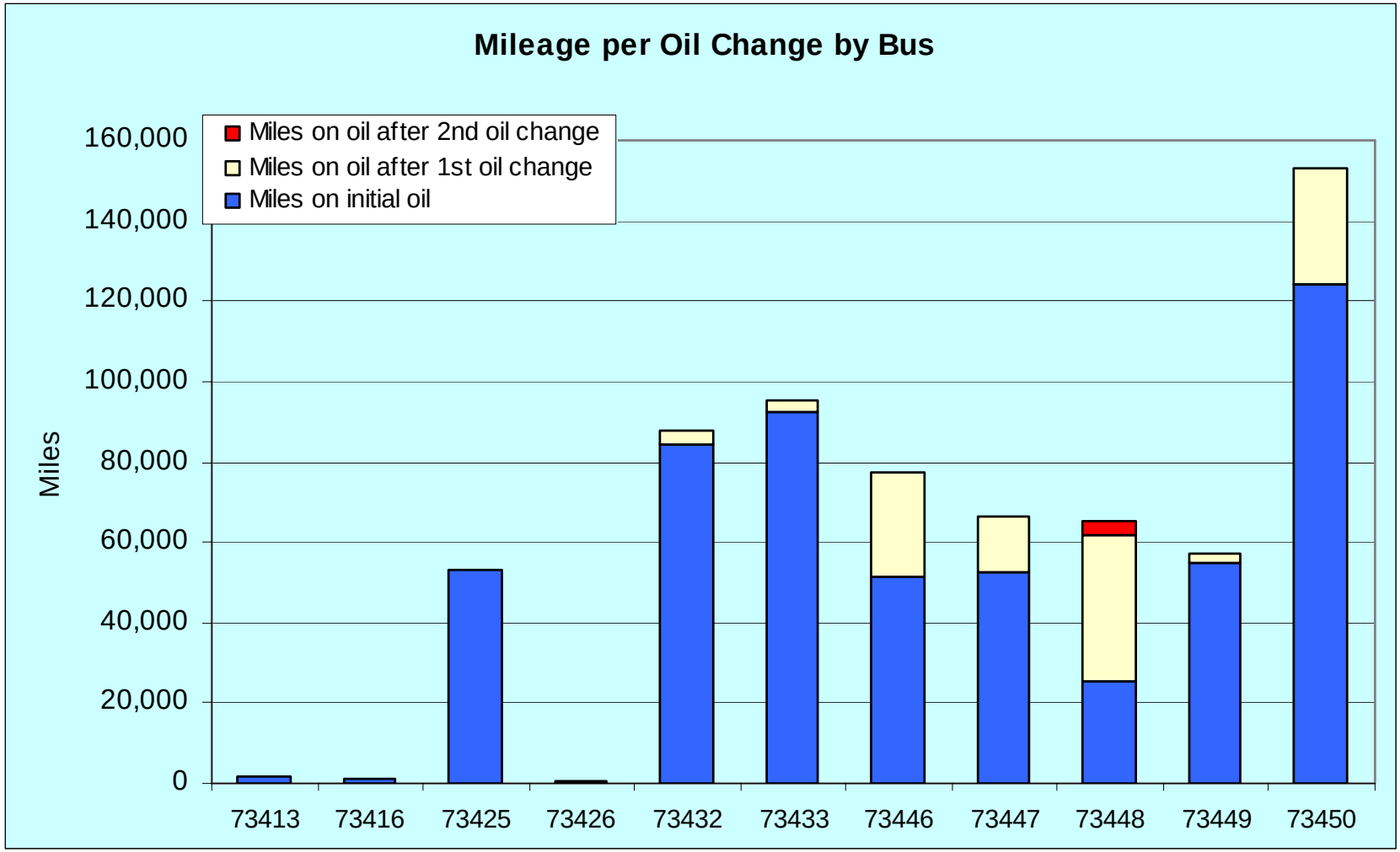
RGS filter unit

RGS processor unit

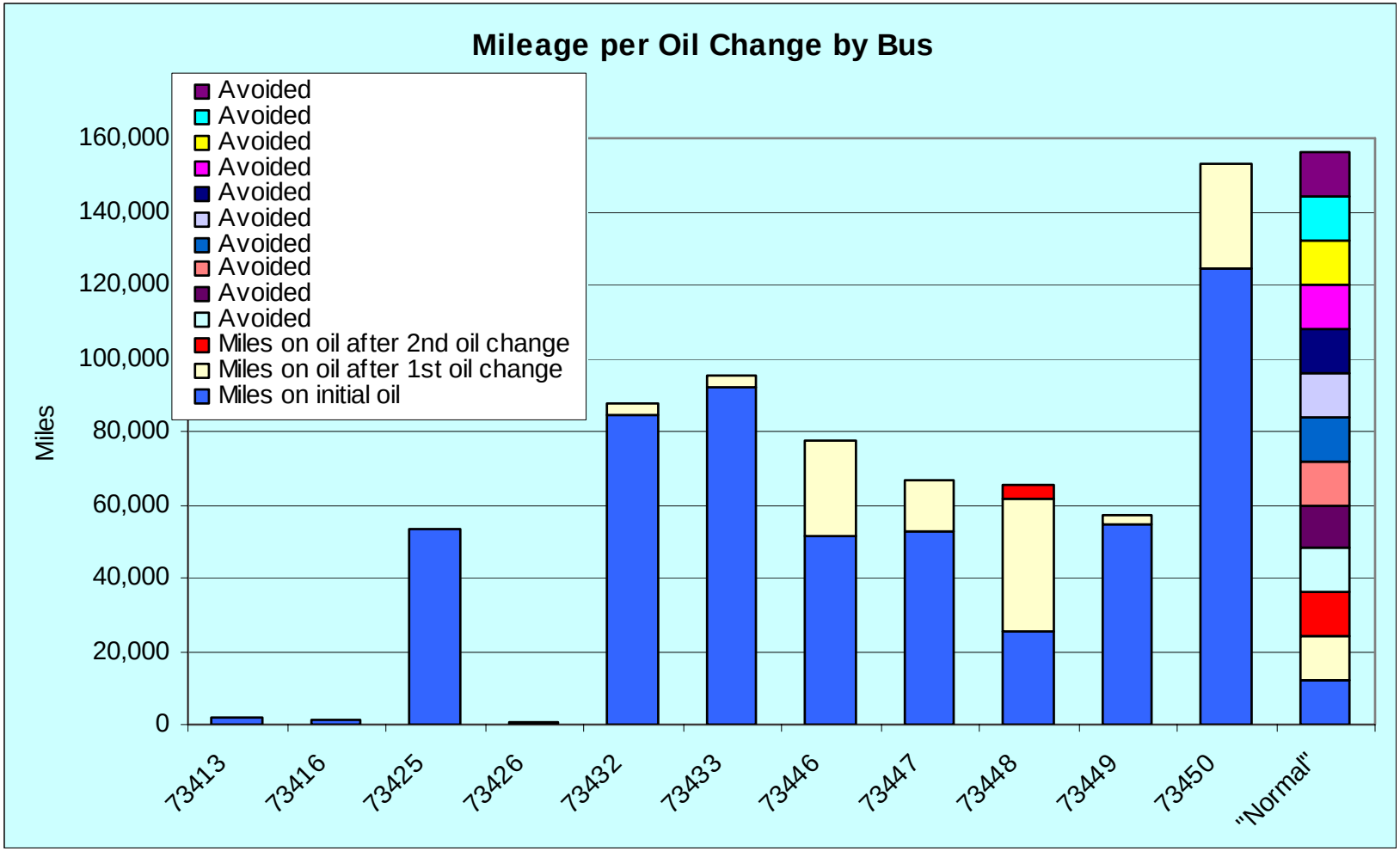
Bypass Filter Test Miles by Quarter



Bypass Filter Test Miles per Filter Change



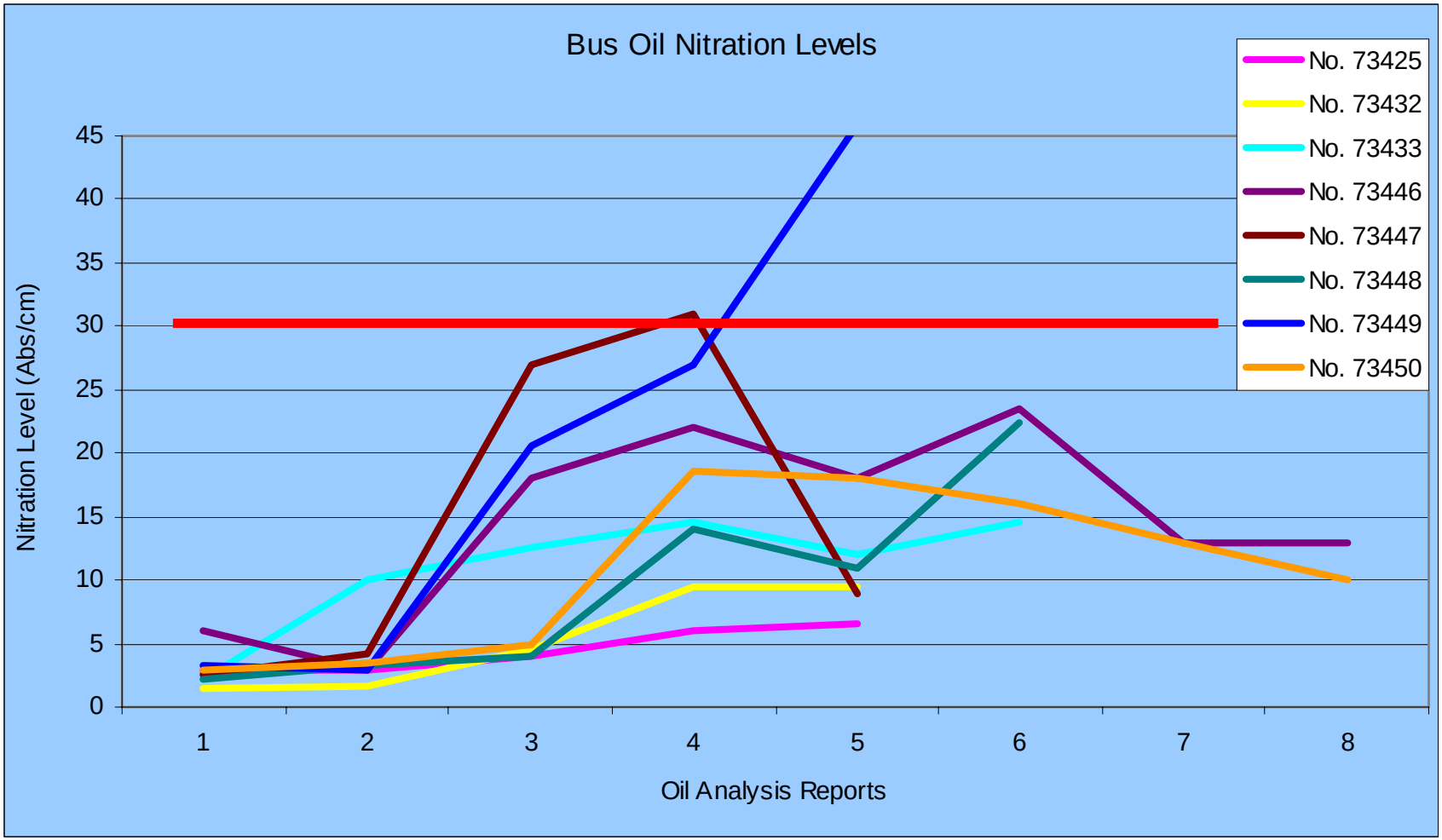
Bypass Filter Test Miles & Avoided Changes



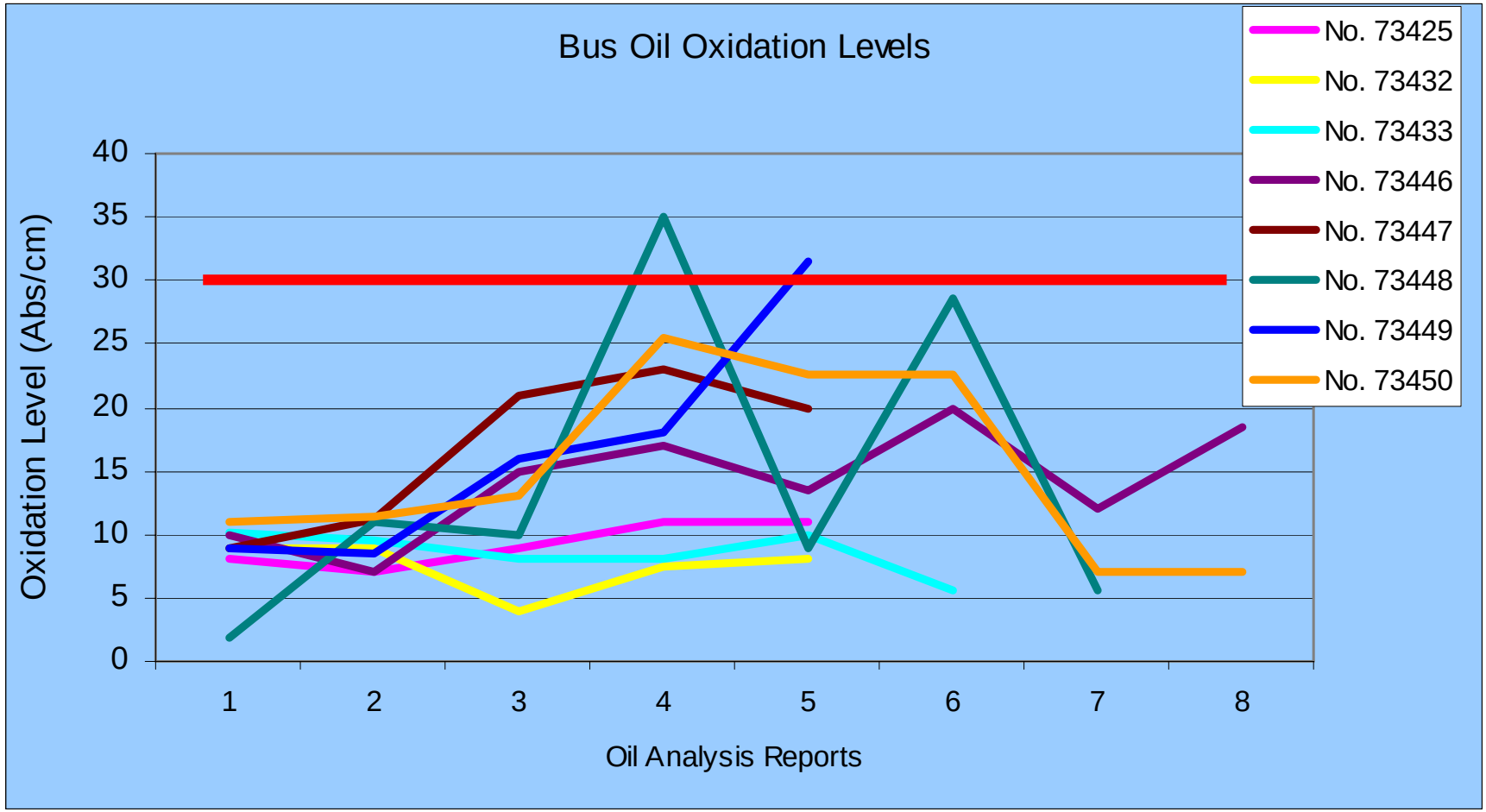
Oil Analysis Reports

- **Oil quality - contaminates/physical properties:**
  - **Presence of fuel (≤3%), water (<0.25%), and glycol (≤0.25%)**
  - **Soot content (≤3%)**
  - **Oxidation and nitration levels (≤30 Abs/cm)**
  - **Total base number (≥3.0 mgKOH/mL)**
  - **Viscosity (12.50 to 16.39 centistokes)**
- **Various additives**
- **Wear metals and other contaminates - (spectrochemical and particle count analyses)**
- **Trending analysis**

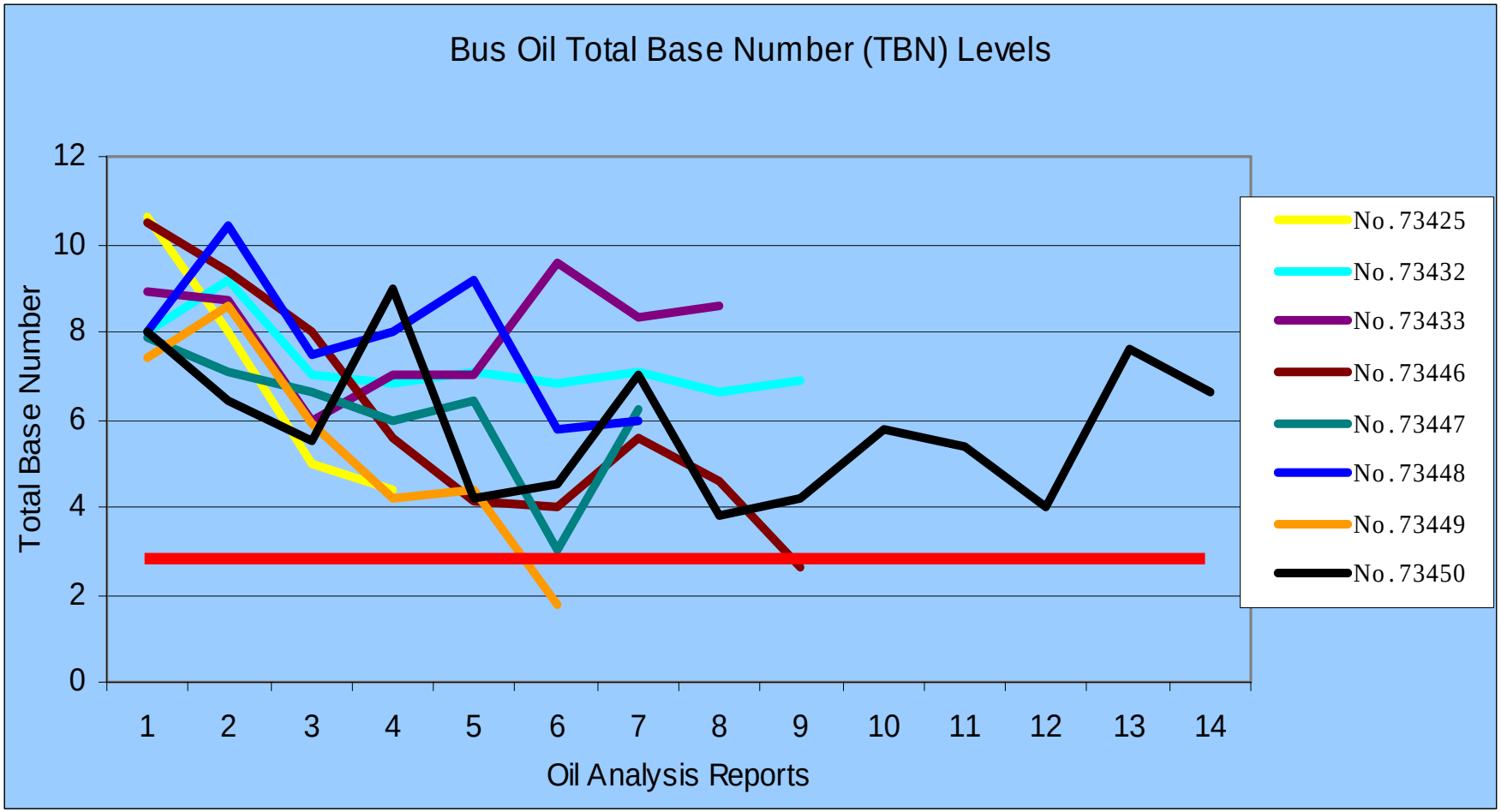
Nitration (desired ≤30 Abs/cm)



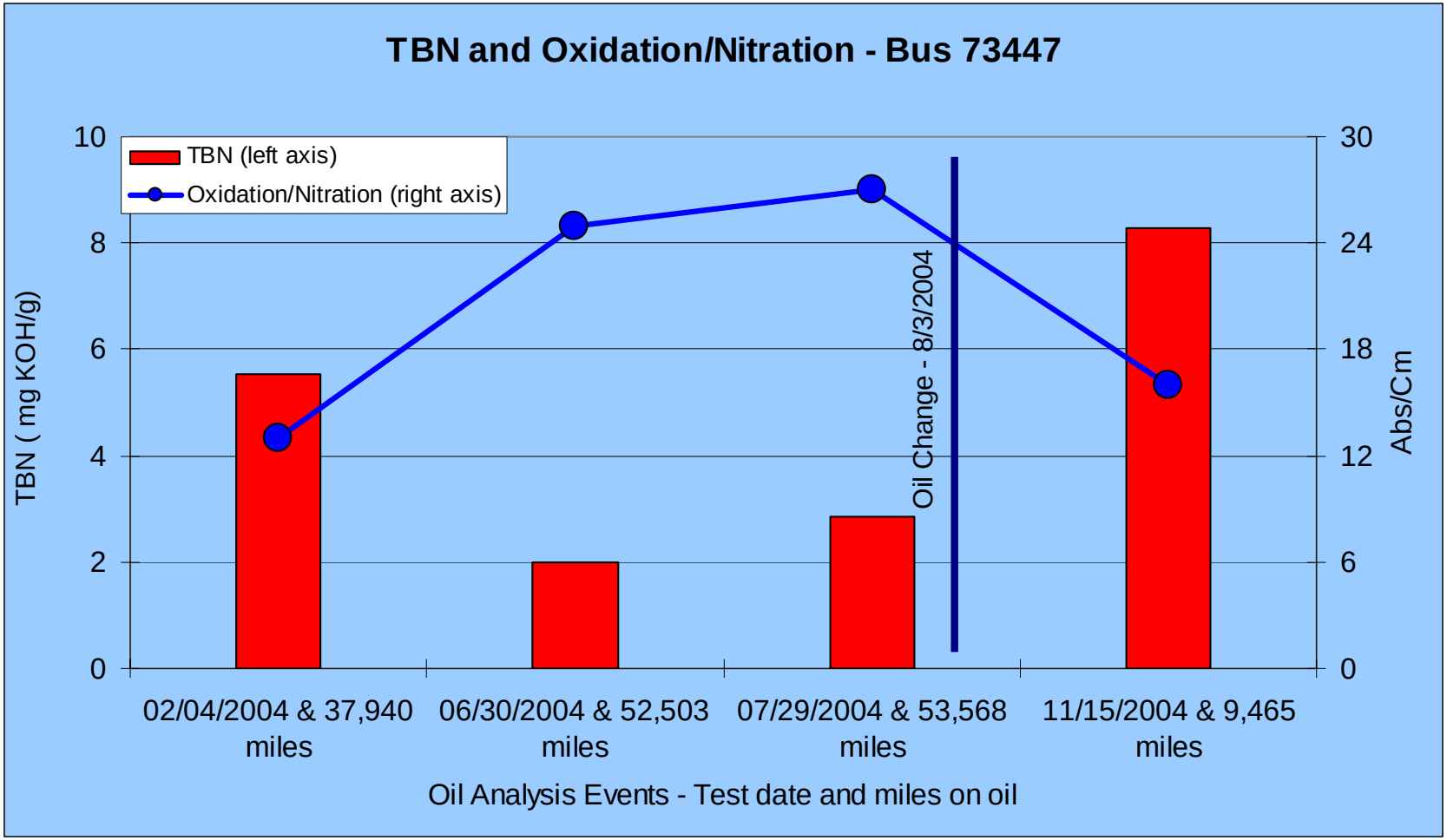
Oxidation (desired ≤30 Abs/cm)



Total Base Number (desired (≥3.0 mgKOH/mL)

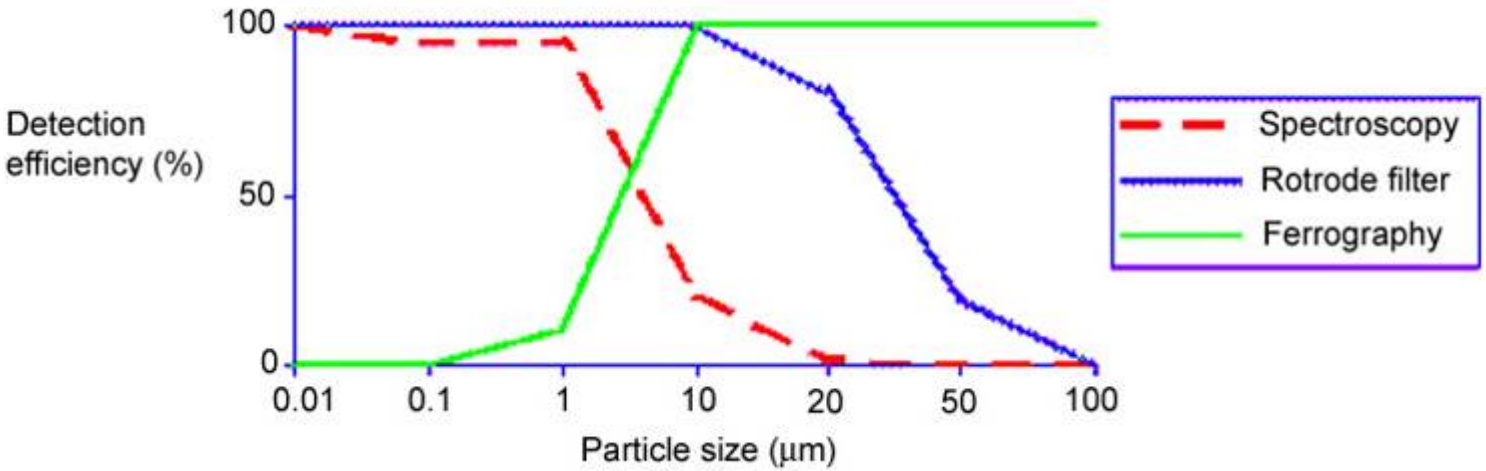


TBN and Oxidation/Nitration Trends



Particulate Tests

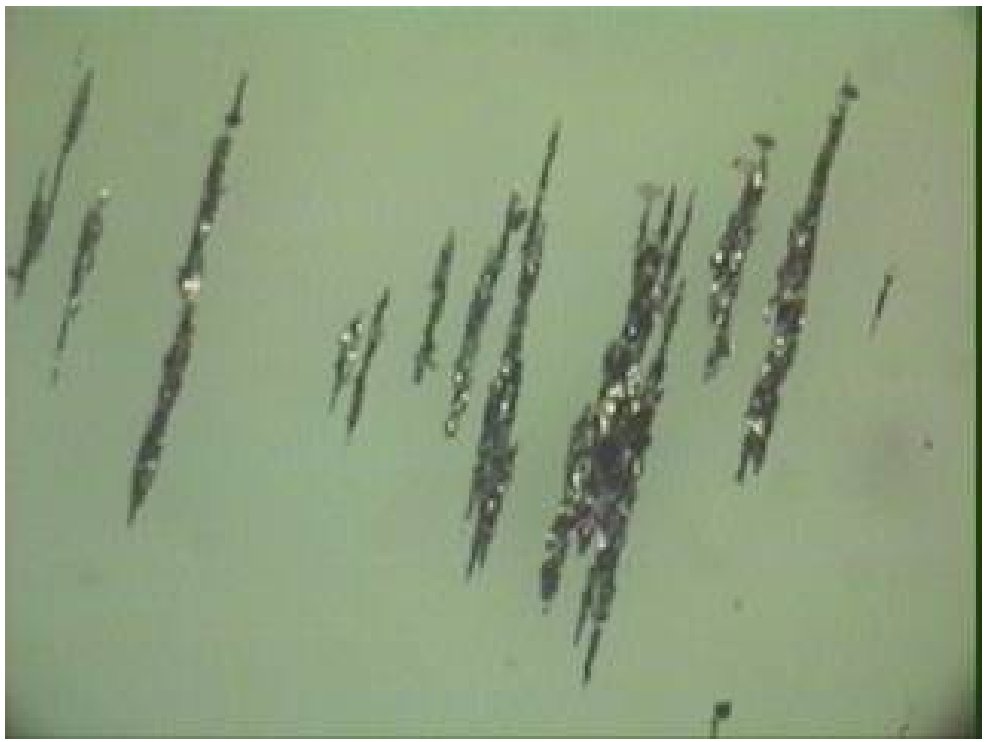
- **Evaluate filter effectiveness & engine wear metals**
- **Spectrometric/elemental analysis: < 4 micron**
- **Rotrode filter spectroscopy: 4 to 20 microns - wear trend**
- **Analytical ferrography - traps larger debris**
- **Particle count: 4 to 70 micron - particle binning**



Source - National Tribology Services Inc

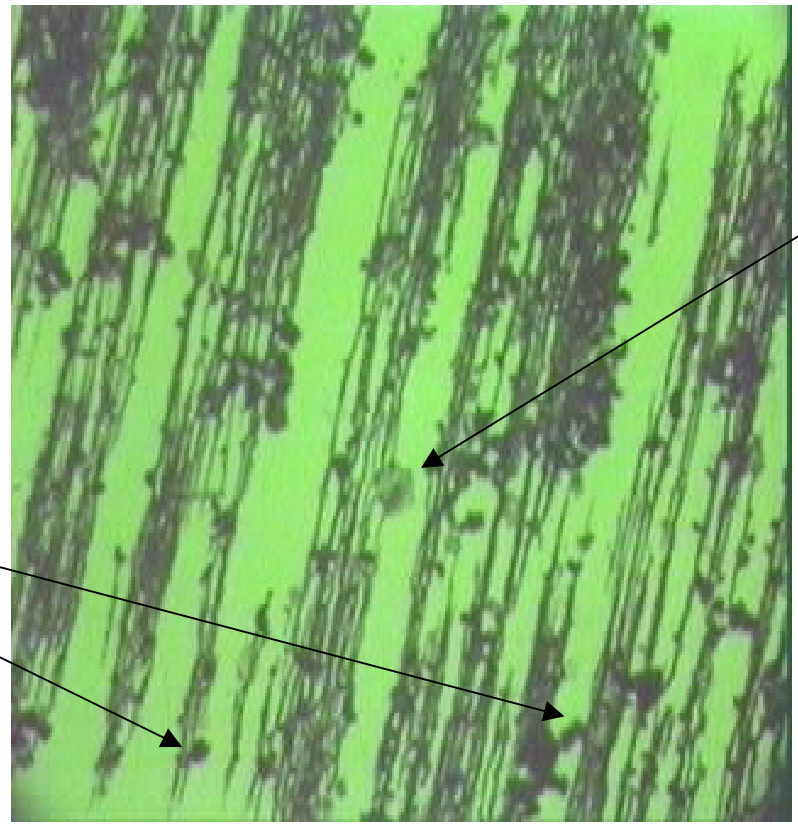
Analytical Ferrography (Bus 73450)

- **107,000 miles on bus 73450's engine oil**
- **Wear particle types - fine irons**
- **NTS's interpretive comments - trace amounts of rubbing wear particles**
- **Ferrogram - shows photo of rubbing wear particles, 100X magnification**



Bus 73432 Idling Study Ferrograms

- **Full flow filter media sonicated, 100X magnification**
- **Sampled at 79,000 miles**
- **Moderate amount of fine (<10 µm) ferrous particulate, typical of normal rubbing wear.**

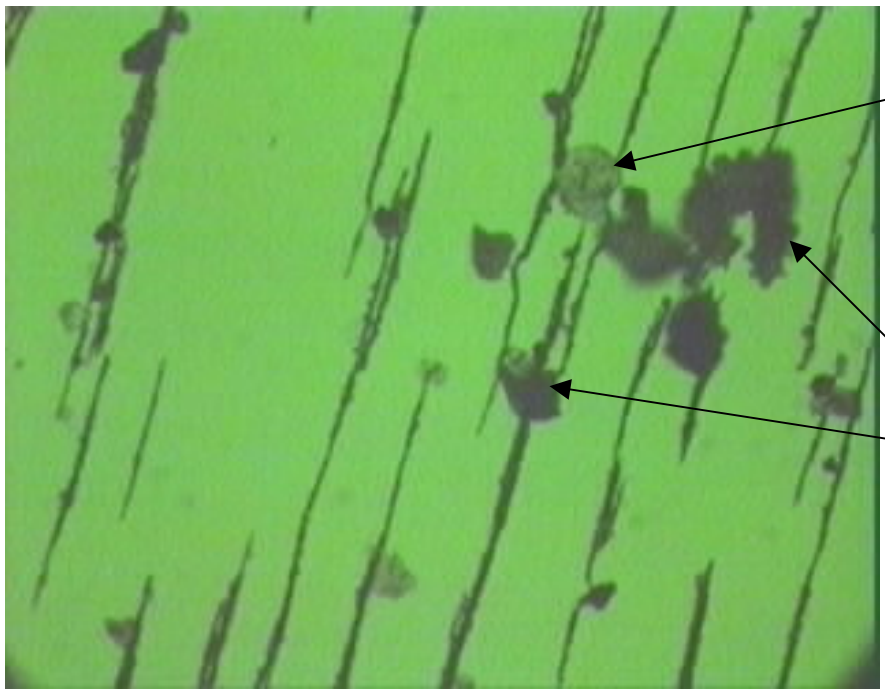


Non-ferrous spherical particle

Very fine spherical particles trapped by fine ferrous particulate

Bus 73432 Idling Study Ferrograms

- **Full flow filter residue, 250X magnification**
- **Sampled at 79,000 miles, 12/20/04**
- **Moderate amount of fine (<10-µm) ferrous particulate, typical of normal rubbing wear. A light amount of sand/dirt and filter media**



A spherical non-ferrous particle setting with the fine ferrous particulate

Other debris types - dirt and filter media

INL Bus Testing Results (January 2005)

- 650,000 bus test miles traveled
- Engine oil changed seven times intentionally
- 545,000 original test miles without intentional oil change
- 48 oil changes avoided
- 420 gallons engine oil not used & not disposed of
- 80+% of bus engine oil changes avoided

Initial INL Oil Bypass Filter Economics

- **Assumes zero waste oil disposal costs**
- **Includes higher INL labor costs & process costs**
- **Assumes $4.17 (recycled oil) & $7.20 / gallon oil costs**
- **Using INL costs - payback at 108,000 to 168,000 miles**
- **Increasing oil costs = faster payback**
- **Some fleets pay waste oil disposal costs = faster payback**
- **Additional analysis to be performed**

Potential Fleet Engine Oil Savings

- Assumed 80% oil changes avoided
- Used FAST[1] database for on-road fleet vehicles
- Assumed oil capacities and service intervals

Vehicle Type	Oil Capacity (Qts)	Service Interval (Miles)
Ambulance	5	3,000
Sedan/Station Wgn	5	3,000
LD truck 4 X 2	5	3,000
LD truck 4 X 4	5	3,000
MD truck 8.5k – 16k lb	6	4,000
HD truck >16k lb	15	6,000
Bus	35	12,000

[1] FAST – INL maintained Federal Acquisition Statistical Tool. Fiscal Year 2003 data

Potential Annual Engine Oil Savings

Fleet	Number Vehicles[1]	Total Miles (millions)[1]	Est. Oil Changes	Est. Oil Used (gals.)	Est. Oil Savings (gals.)
INL	871	8.3	2,077	4,286	3,428
DOE Complex[2]	15,464	91.7	26,433	39,635	31,707
All Federal Fleets[3]	607,630	4,838.1	1,492,895	2,073,456	1,658,764

[1] FAST on-road vehicle data for fiscal year 2003.

[2] 92 DOE fleets

[3] 61 administrations, agencies, authorities, boards, branches, corps, commissions, corporations, departments, institutions, offices and other Federal entities.

INL Bypass Oil Filter Evaluation Status

- **Third year of testing continues with puraDYN and RGS filters on 9 INL buses**
- **Idling 2 INL diesel buses for 1,000 hours each while evaluating oil quality & engine wear metals to identify engine wear rates during idling periods**
- **Also testing puraDYN oil bypass filters on 6 Chevrolet Tahoes**
- **1 million total test miles (including Tahoes)**

9 Oil Bypass Filter Technology Evaluation Quarterly reports and this presentation are available via:

http://avt.inel.gov

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