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
Installed Refined Global Solutions System

RGS filter unit

RGS processor unit
Bypass Filter Test Miles & Avoided Changes

Mileage per Oil Change by Bus

- Avoided
- Avoided
- Avoided
- Avoided
- Avoided
- Avoided
- Avoided
- Avoided
- Avoided
- Avoided

Miles on oil after 2nd oil change
Miles on oil after 1st oil change
Miles on initial oil

“Normal”
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 $\leq 30$ Abs/cm)

Bus Oil Nitration Levels

Oil Analysis Reports

<table>
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<tr>
<th>No. 73425</th>
<th>No. 73432</th>
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Bus Oil Nitration Levels

Nitratan Level (Abs/cm)

Oil Analysis Reports

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</table>
Oxidation (desired $\leq 30$ Abs/cm)

Bus Oil Oxidation Levels

Oxidation Level (Abs/cm)

No. 73425
No. 73432
No. 73433
No. 73446
No. 73447
No. 73448
No. 73449
No. 73450

Oil Analysis Reports

Oxidation (Abs/cm)
Total Base Number (desired $\geq 3.0$ mgKOH/mL)

Bus Oil Total Base Number (TBN) Levels

Oil Analysis Reports

- No. 73425
- No. 73432
- No. 73433
- No. 73446
- No. 73447
- No. 73448
- No. 73449
- No. 73450

Graph showing the trend of total base number over Oil Analysis Reports.
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.
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 FAST¹ database for on-road fleet vehicles
- Assumed oil capacities and service intervals

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Oil Capacity (Qts)</th>
<th>Service Interval (Miles)</th>
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<tbody>
<tr>
<td>Ambulance</td>
<td>5</td>
<td>3,000</td>
</tr>
<tr>
<td>Sedan/Station Wgn</td>
<td>5</td>
<td>3,000</td>
</tr>
<tr>
<td>LD truck 4 X 2</td>
<td>5</td>
<td>3,000</td>
</tr>
<tr>
<td>LD truck 4 X 4</td>
<td>5</td>
<td>3,000</td>
</tr>
<tr>
<td>MD truck 8.5k – 16k lb</td>
<td>6</td>
<td>4,000</td>
</tr>
<tr>
<td>HD truck &gt;16k lb</td>
<td>15</td>
<td>6,000</td>
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<tr>
<td>Bus</td>
<td>35</td>
<td>12,000</td>
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¹ FAST – INL maintained Federal Acquisition Statistical Tool. Fiscal Year 2003 data
## Potential Annual Engine Oil Savings

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

\(^1\) 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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