DPF Maintenance De-Mystified

Jeremy Anderson FSX Equipment, Inc.
Do you remember these days?
What is a DPF?

- Emission control device to trap particulate matter
- Designed to oxidize soot
- Required by EPA on 2007 engines
- High temperature ceramic material designed to operate at about 750° F or 400° C
- 5000 to 7000 dead end holes approximately 3/64” square x 12” deep
• The Particular Matter (PM) filter removes soot particles from the exhaust by passing the exhaust gases, primarily CO2, through a ceramic wall flow filter.
A Closer Look

- Soot particles (particulate matter – PM) are trapped on or in the ceramic filter wall

0.012 [in]
Diesel Exhaust

- **Soot** – unburned fuel & oil
- **Ash** – metals & minerals
Soot – Removed by Regeneration

- Overloading of fuels or oils
- Loads quickly due to unfavorable operating conditions

Causes:
- Low operating temperatures
- Engine malfunctions
- Worn-out engines
What Is Ash?

• Ash is material left after all carbon is oxidized

  ➢ Primary constituents
    ➢ Remains of oil & additives
    ➢ Engine wear metals
    ➢ Mineral compounds

Ash will remain permanently in the filter until cleaned
Ash – Must be cleaned out

- Loads Lineal Over Time
- Will not burn or regenerate
- Eventually destroys the DPF

Ash Accretion on Cell Wall
“A Sophisticated Garbage Can”
Two Current Thought Processes on Cleaning

• Reactive – Deal with problem when the DPF clogs up and truck is stranded on the side of the road

• Preventative – DPF needs regular service that prevents down time and increases engine efficiency
Manufacturer Recommendations

- Cummins
  Recommends Cleaning every 300K (4500 hrs)
- International
  Recommends Cleaning every 250K
- Paccar
  Recommends Cleaning every 200K (6000 hrs)
- Caterpillar
  Recommends Cleaning every 150-250K (4500 hrs)
- Detroit Diesel (DD15)
  Recommends Cleaning every 300K (9000 hrs)
Value of a Fleet’s DPF Investment

- Assumptions: 500 DPF-equipped trucks & average replacement cost of $3000 per DPF

\[ ($3000 \times 500 = $1,500,000) \]

At Risk = $1,500,000 million
Why Clean DPFs?

- Extend life of DPF
- High replacement cost between $3000 and $8000
- Higher chance of failure over 200K miles
- Increased Fuel Economy – 3-4%
- More power
- Resale Value Secondary Market
Diesel Particulate Filter Reuse Guidelines
**Visual Inspection**

- **Inspection based on established criteria**
  - Identify good and bad cores prior to cleaning process

- **Examples of acceptable filters:**
  1. Soot on inlet
  2. Clean on outlet
  3. Stain on outlet
  4. Bent flanges
  5. Scrapes on ceramic
Requires Replacement
Visual Inspection

- Examples of scrap filters:
  1. Soot on outlet
  2. Cracked ceramic
  3. Ceramic pushed out of the can
  4. Filter melted
  5. Round channels
  6. Swirl pattern on inlet or outlet sides
  7. Oil soaked
Ash & Cracking
Boroscope – DPF Internal Defects

- Crack
- Crack - Ledge
- Black Hole
- Melted Voids
“Journey to the Center of a DPF”
Hardened Ash Plugs & Accretions

Causes:
- High kilometers/hours
- Numerous active regenerations
- Excess oil burn
What Do Most Failures Have In Common?

Ash!
# Cleaning Method Comparison

<table>
<thead>
<tr>
<th>Cleaning Method</th>
<th>Recovery</th>
<th>Process Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulsing from one end</strong></td>
<td>74%</td>
<td>20 minutes</td>
</tr>
<tr>
<td><strong>Air scanning on both ends</strong></td>
<td>94%</td>
<td>22 minutes</td>
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</table>

**DPF PNEUMATIC CLEANING MACHINE COMPARISON**

- **Pulsing from one end**: Attempts to clean 5000 cells at once. Center cells clean first, while outside cells get little cleaning. Stops cleaning when a path of least resistance is established.

- **Air scanning on both ends**: Cleans using air knife scanning on both ends of the filter. Each individual cell is scanned hundreds of times from both directions.
DPF Cleaning & Testing System
STAGE 1 PNEUMATIC CLEANING

FSX TrapBlaster

- Air Knife Scanning cleans each cell individually
- Bi-Directional air wands clean both ends of the filter simultaneously
  Patented
- Diagnostic Capability identifies defective filters
  Patented
- Easy Set-up and Automated Operation
- Fits DPFs 36” High x 21” Dia.
- Durable & Proven
STAGE 1 PNEUMATIC CLEANING

Nozzle Diameter and High Air Volume are Important

Patented Bypass Detection

DPF Cleaning Technology
Air Nozzle Diagram

- Target Dirty Cell (Ceramic plug on outlet end)
- Adjacent Clean Cells (Open on outlet end)
- FSX Air Nozzle
  - Covers four adjacent clean cells.
  - Approximately 25% of the air blown down each clean cell enters the target dirty cell.
Diesel Particulate Filter

Progression of Ash Loading

Ash Aggregation on the Cell Walls

≥150,000 Miles
FSX Bi-Directional Air Scanning Technology
Dirty Side Nozzle Attacks Ash Plugs

Few End Plugs Remain, Flow Resistance Decreases

Clean Side Nozzle Removes Loosened Ash

FSX Bi-Directional Air Scanning Technology
Ash Ejection
Visible Ash Ejecta Indicates Bypass

Detection Of Bypass Phenomenon

Cell Wall Breach Is A Result of Thermal Damage
Visible Failure Mode Detection
Testing & Certification

FSX, Inc.
DPF Baseline Cleaning Range Mastersheet

Baselines are under constant development and are subject to change. Contact FSX to have your baseline data considered for inclusion.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Part No.</th>
<th>AR/MV / Other</th>
<th>Red Tag (if below)</th>
<th>Baseline</th>
<th>Green Tag Range</th>
<th>Orange Tag Range</th>
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<td>&gt; 3.50</td>
</tr>
</tbody>
</table>
Test - Clean Every Cell - Test again
STAGE 2 THERMAL CLEANING

**FSX TrapBurner**

- Thermal regeneration burns remaining soot and loosen ash
- Stair-step temperature gradient matches OEM specifications
- No air pumped through DPF; reduces risk of uncontrolled regenerations or cracking
Stage 2 DPF Cleaning: Thermal Processing

Thermal Expansion Coefficients of Ash and DPF Are Different

As Walls Heat Up, Ash Detaches from Wall
# Cleaning Data Worksheet

## Diesel Particulate Filter (DPF) - Cleaning History Worksheet

### Manufacturer/Distributor
- Caterpillar
- DCL
- Detroit Diesel
- Cummins
- ECS
- Isuzu
- Johnson Matthey
- Mack
- PACCAR
- Volvo

### Filter Dimensions
- OD
- ID
- Overall Height
- Ceramic Height

### Visual Inspection
- **Clean End Color** (Circle): White, Cream, Tan, Gray, Brown, Black, Other: _____
- **Dirty End Color** (Circle): White, Cream, Tan, Gray, Brown, Black, Other: _____
- Pin Gauge clean side to check for melting and note measurements (see grid at right)

### Step 1 - Visual Inspection
- Refer to Filter Cleaning Reference Data Posters
- Oil Soaked (circle): Yes / No
- If Yes, then Red Tag.
- FSX does not recommend cleaning oil, coolant, or fuel soaked DPF.
- Discoloration Rings: Yes or No (circle)

### TrapTester Airflow Test
- Airflow Test (Clean side down no gaskets)
- Initial Black Hole Count (on clean side) (rel. circle):
- 0 5 10 15 20 25 30 40 50 100+ 1000+

### Step 2 - Pneumatic Stage 1 Cleaning
- 2-minute Bypass Inspection: Important - Closely watch top surface of the DPF during first 2 minutes of air flow. Count defective cells allowing distinct spots of ash or soot, and indicate number below.
- Red Tag: stop process if over 20 cells have heavy spots of black, white, or gray particulate blowing out the clean end of the DPF during the first two minutes.
- Continue: if less than 20 defective cells (spots) noted.

### Step 3 - After Pneumatic Cleaning
- TrapBlaster Time (in minutes) (circle one)
- Pin Gauge dirty side for ash content and note measurement (see grid at right)
- TrapBlaster W.G.
- TrapTester Oil test (Clean side down no gaskets)
- Compare to FSX Baseline Chart
- Step 3 Status: Red Tag / Green Tag - Process Complete / Continue to Thermal

### Step 4 - After Thermal Cleaning
- TrapBlaster PI (circle):
- Pin Gauge dirty side for ash content and note measurement (see grid at right)
- TrapBlaster W.G.
- TrapTester Oil test (Clean side down no gaskets)
- Compare to FSX Baseline Chart
- Final Step 4 Status: Red Tag / Green Tag / Orange Tag
- Final Comments: Operator's Initials

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Dust Collection & Disposal

FSX SootSucker 2

- Captures released ash and soot
- Services TrapBlaster and TrapBurner
- Deposits ash in quick release bucket.
- Includes duct connections
- Dispose of ash and dust according to local code.
  - Most states and provinces allow dumping in normal waste dumpster
  - California – low level hazardous waste
Cleaning Coned Flange DPF
FSX Equipment Inc.
360-691-2999
fsxinc.com