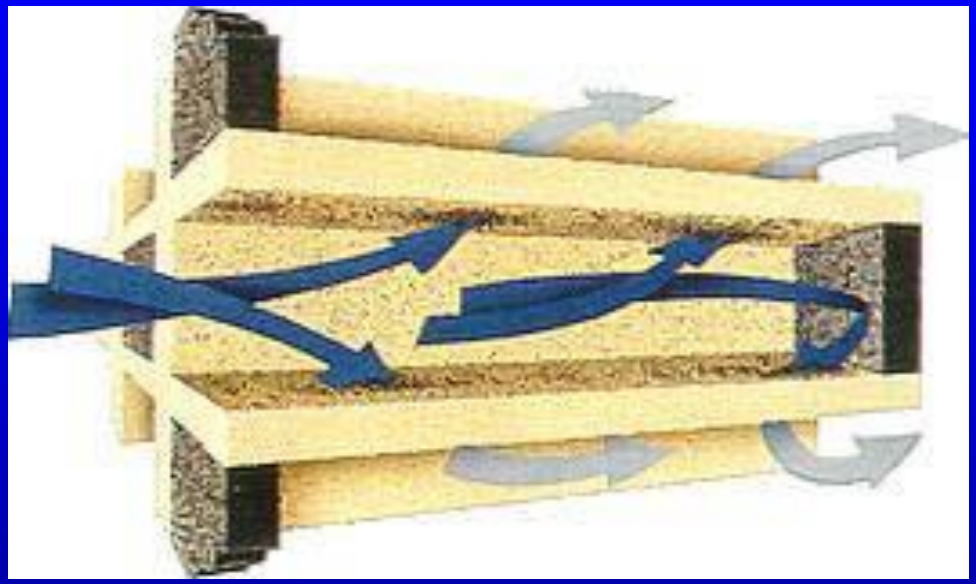
DPF Maintenance De-Mystified

Jeremy Anderson FSX Equipment, Inc.

Do you remember these days?

What is a DPF?

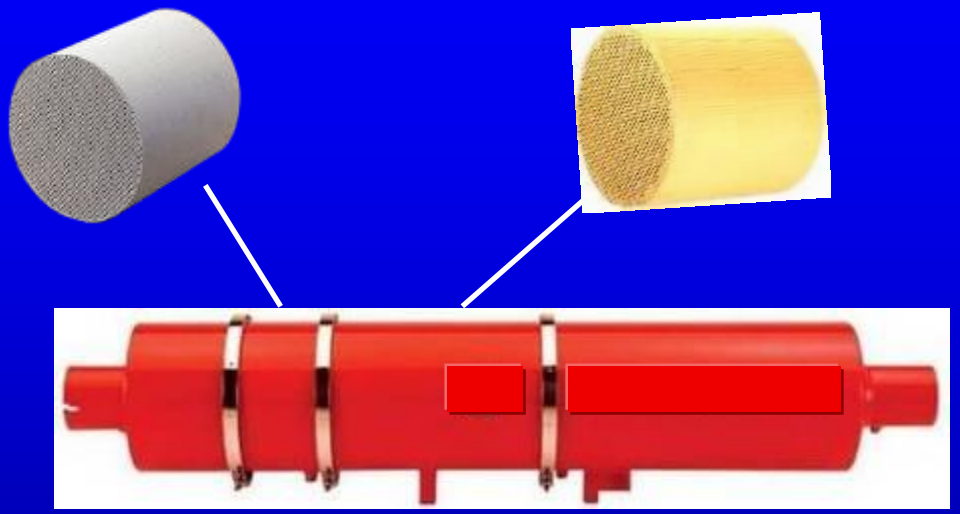
- Emission control device to trap particulate matter
- Designed to oxidize soot
- Required by EPA on 2007 engines
- High temperature ceramic material designed to operate at about 750° F or 400° C
- 5000 to 7000 dead end holes approximately 3/64” square x 12” deep

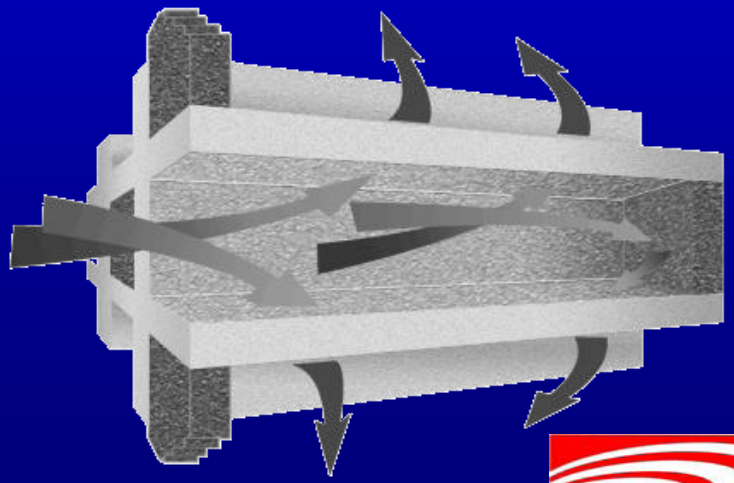


How Does It Work?

Diesel Oxidation Catalyst

Diesel Particulate Filter

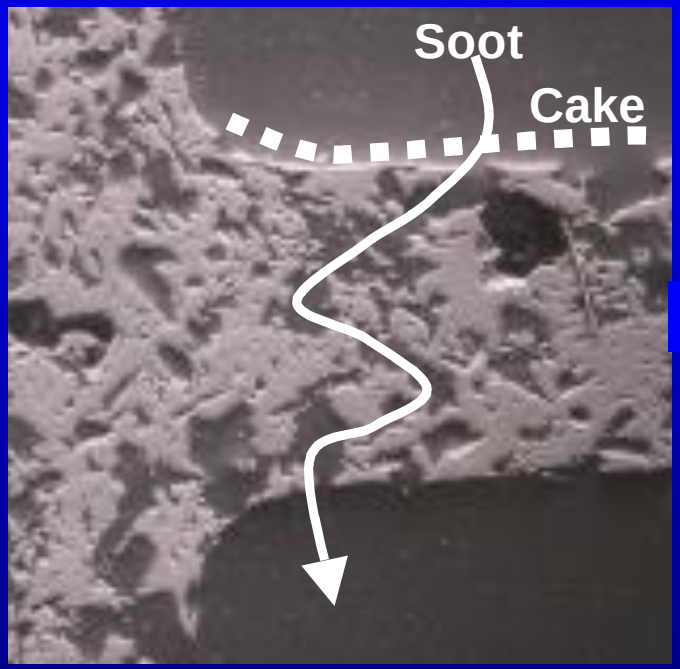




- The Particular Matter (PM) filter removes soot particles from the exhaust by passing the exhaust gases, primarily C02, through a ceramic wall flow filter

A Closer Look

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



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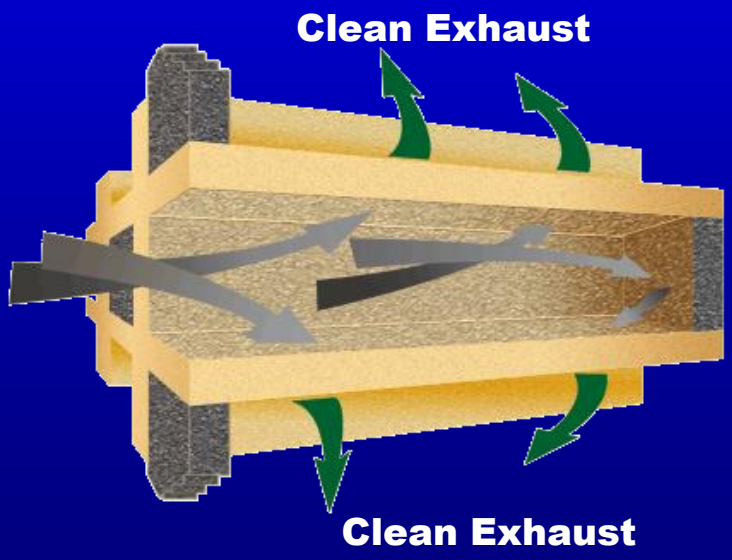


Diesel Exhaust

- **Soot** – unburned fuel & oil
- **Ash** – metals & minerals

Soot – Removed by Regeneration

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

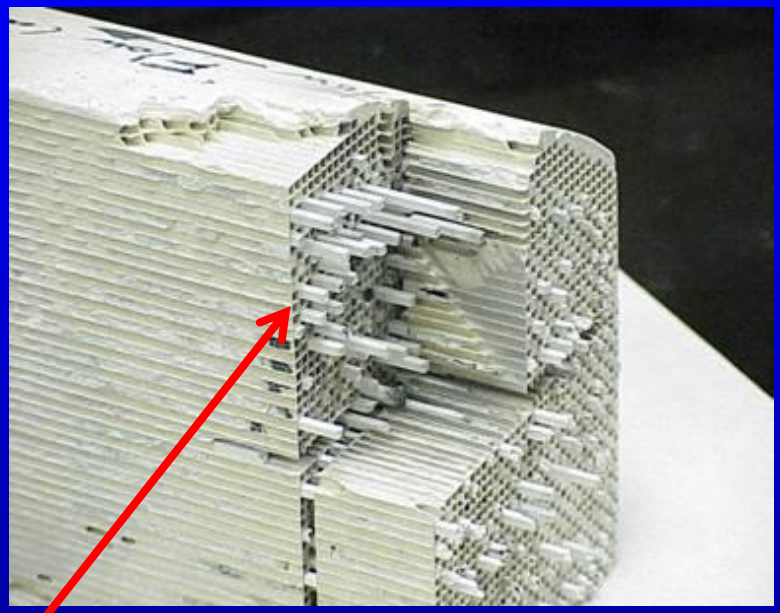
Causes:

- 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**



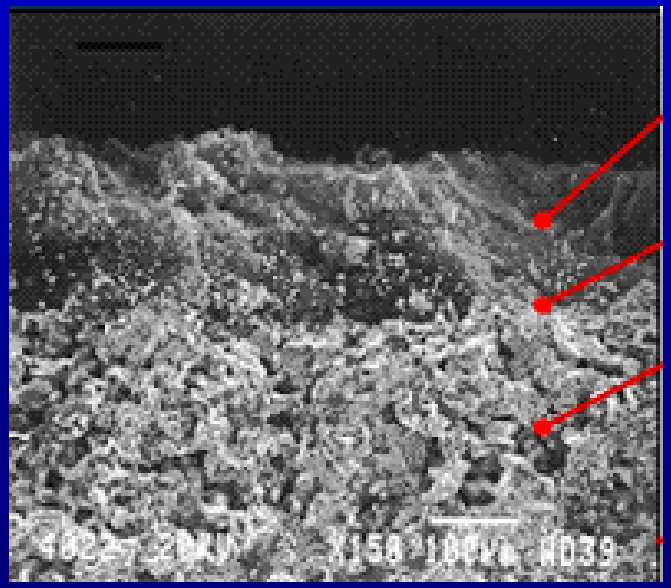
Hardened ash plugs

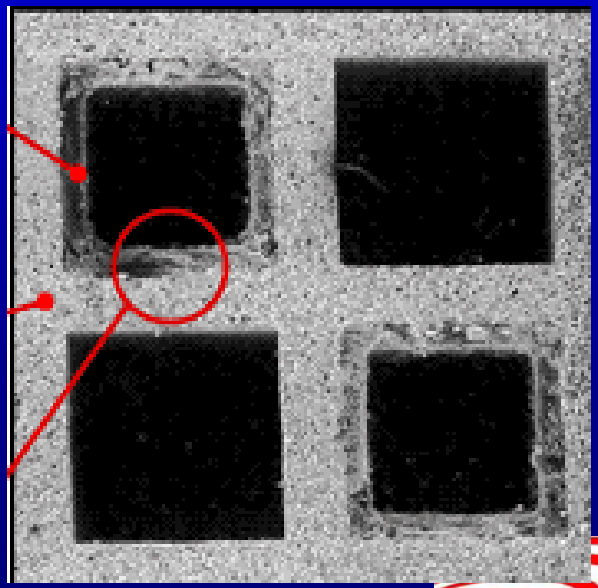
<u>Ash will remain permanently in the filter until cleaned</u>

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**

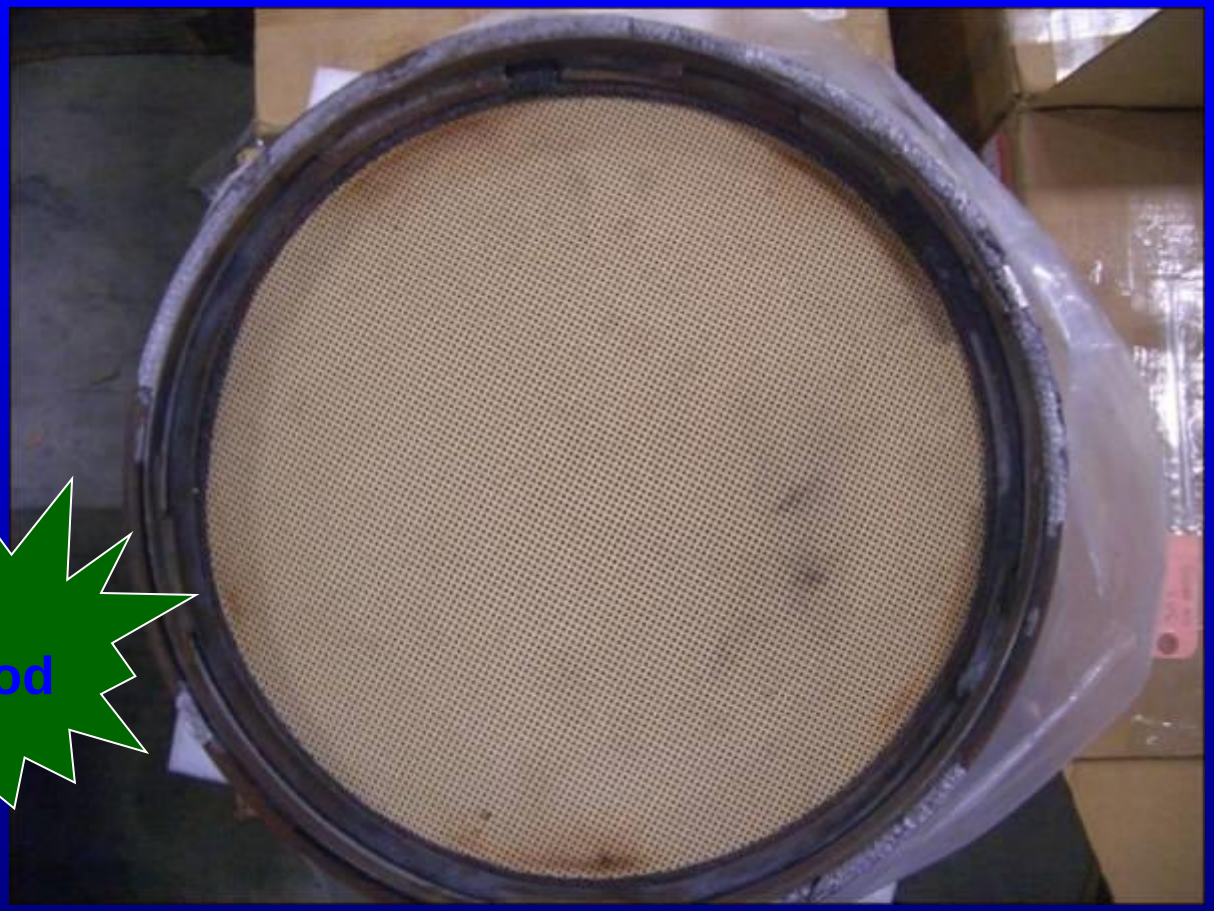
($3000 x 500 = $1,500,000)

At Risk = $1,500,000 million

Why Clean DPFs?

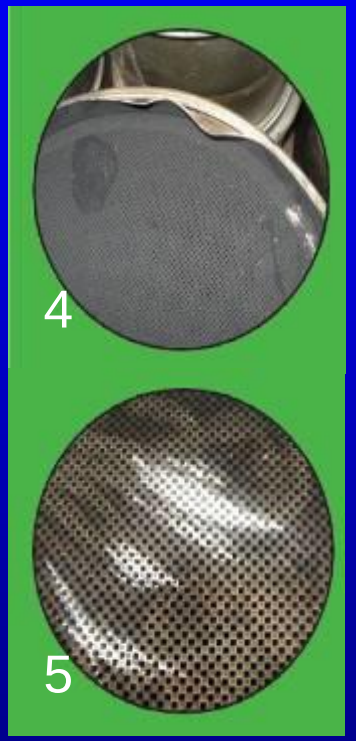
- Extend life of DPF
- High replacement cost between $3000 and $8000
- Higher chance of failure over 200K miles
- Increased Fuel Economy – 3-4%
- More power
- Resale Value Secondary Market

Diesel Particulate Filter Reuse Guidelines

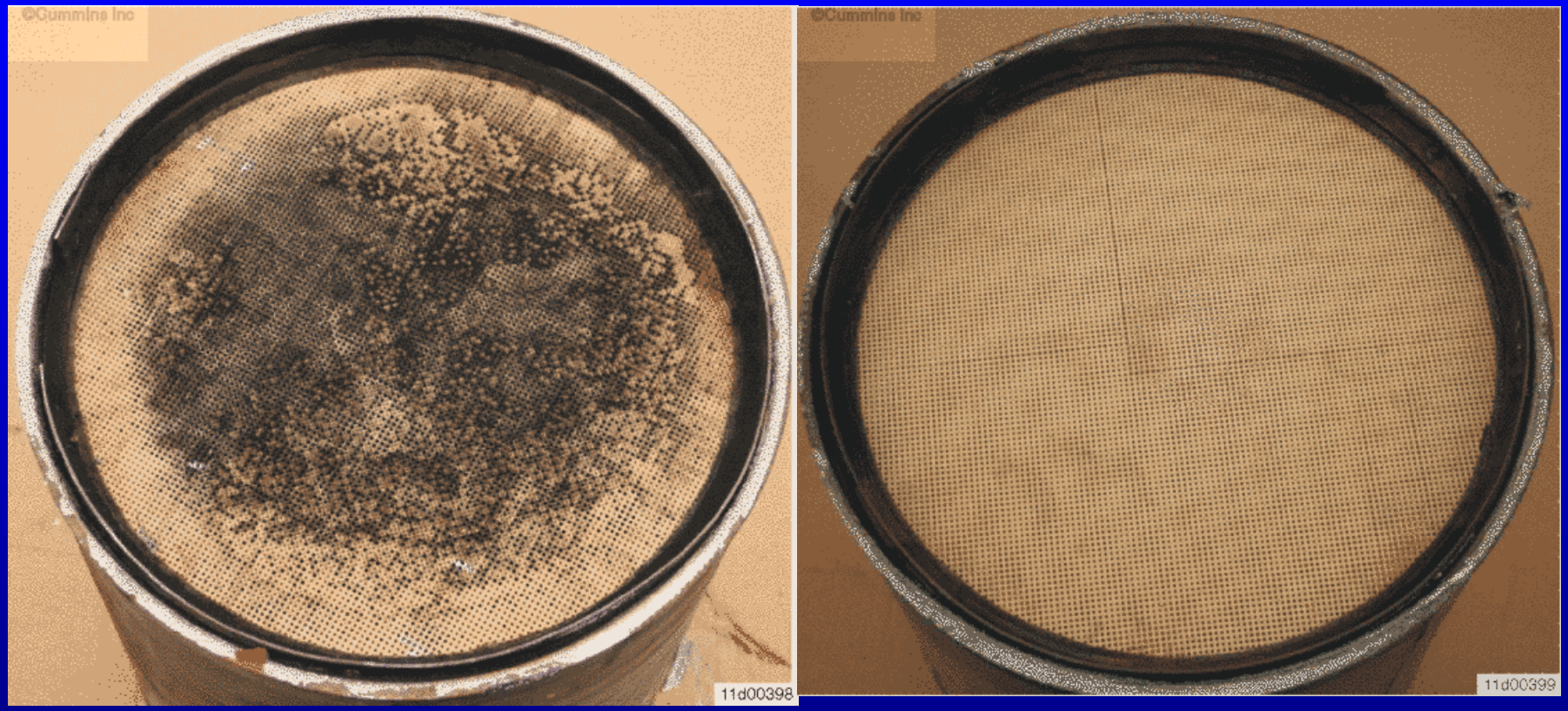


Visual Inspection

- **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**

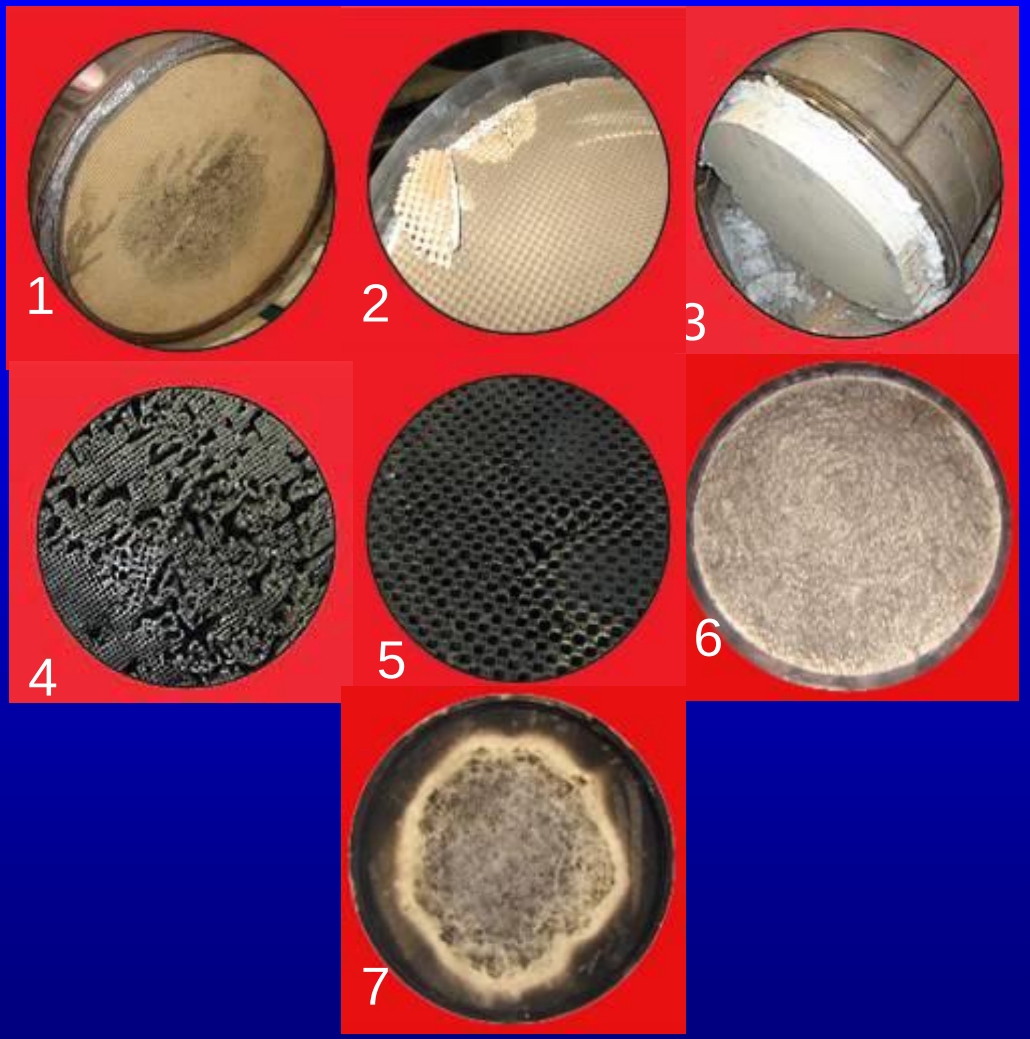


Requires Replacement



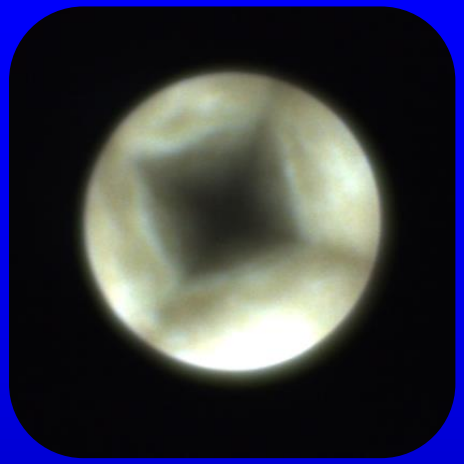
Visual Inspection

- **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

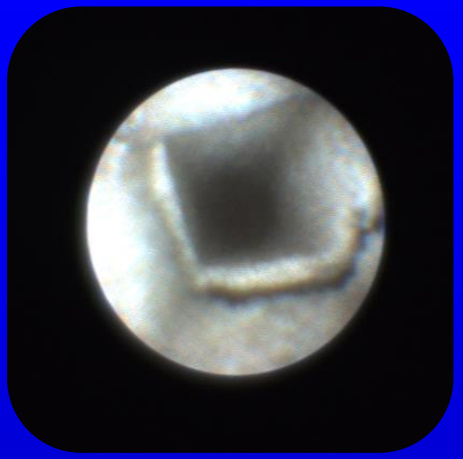


Ash & Cracking

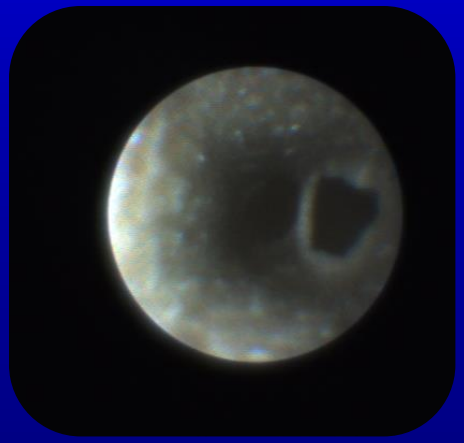
Boroscope – DPF Internal Defects



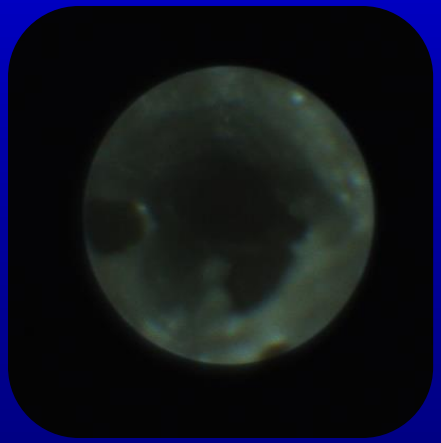
Crack



Crack - Ledge



Black Hole



Melted Voids

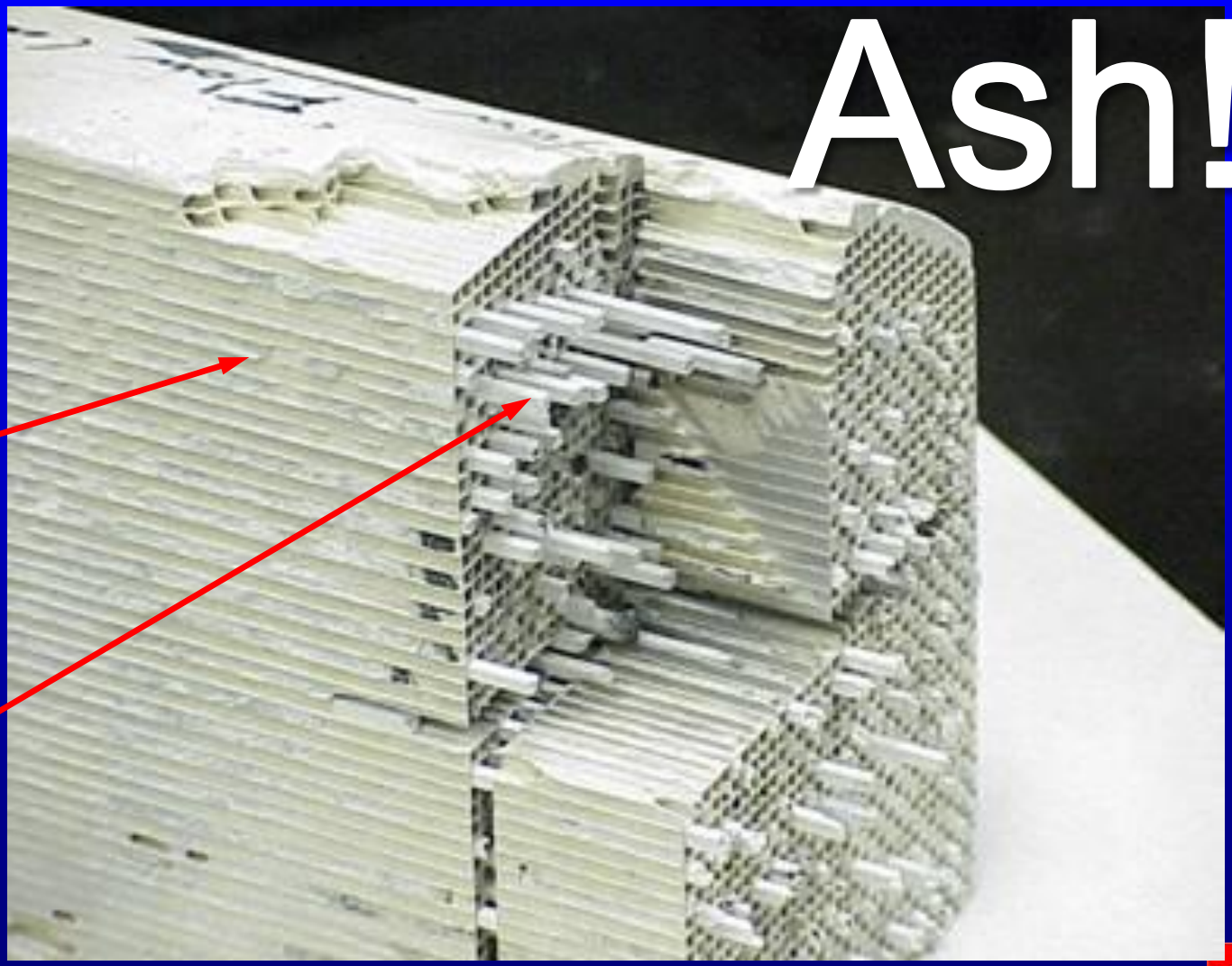
"Journey to the Center of a DPF"

Hardened Ash Plugs & Accretions

Causes:

- **High kilometers/hours**
- **Numerous active regenerations**
- **Excess oil burn**

What Do Most Failures Have In Common?



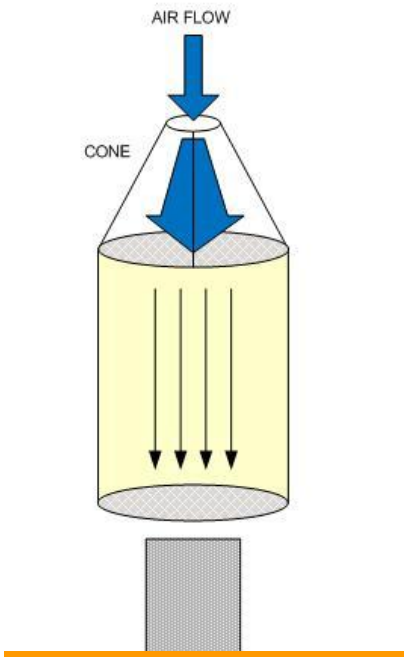
Cleaning Method Comparison

Air Scanning
vs
Pulsing

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.



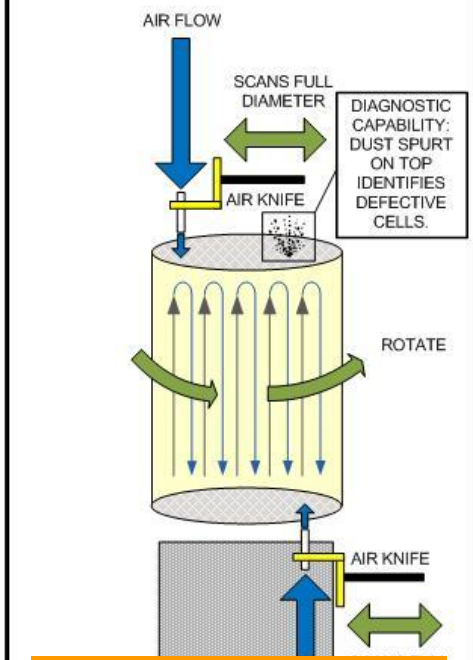
74% Recovery

PROCESS TIME: 20 MINUTES

CLEANING ACTION IS HIDDEN ON BOTH ENDS. OPERATOR CANNOT TELL WHEN CLEANING IS COMPLETE.

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.



94% Recovery

PROCESS TIME: 22 MINUTES

CLEANING ACTION 100% VISIBLE TO OPERATOR. CLEANING COMPLETE WHEN DUST STOPS EXITING FILTER.

DPF Cleaning & Testing System

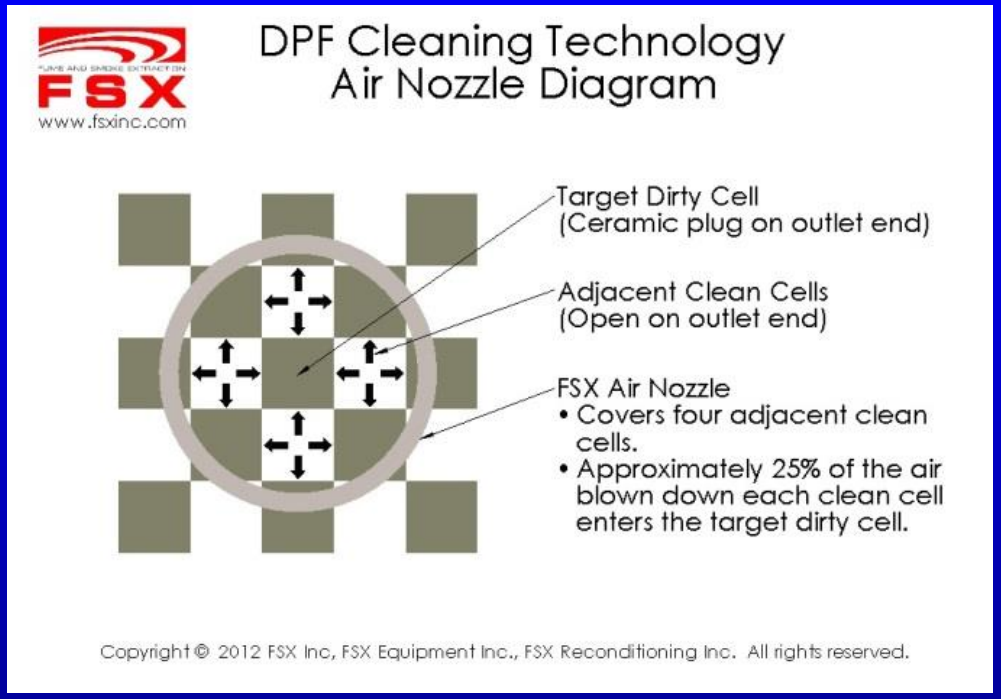
STAGE 1 PNEUMATIC CLEANING

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

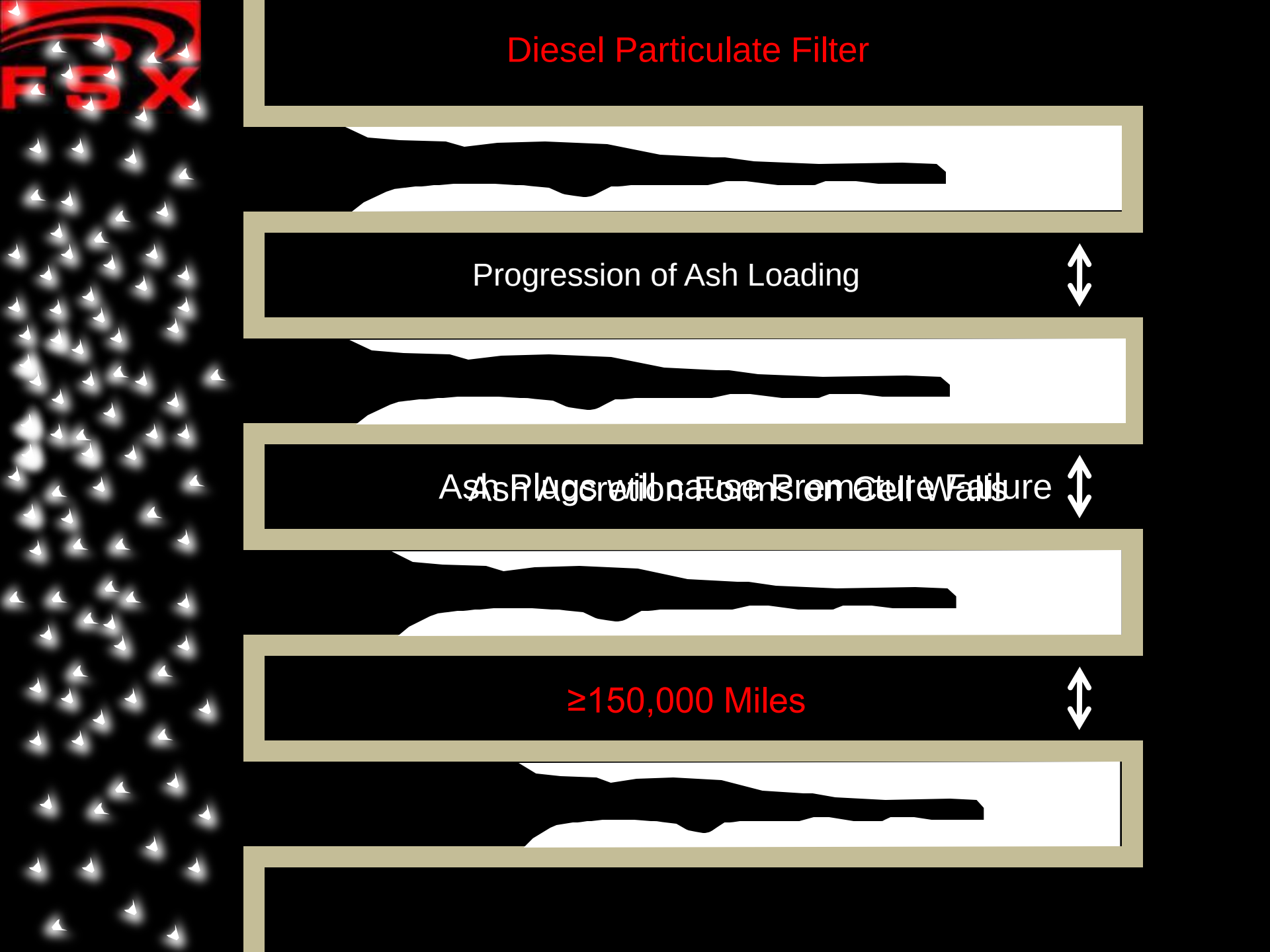
FSX TrapBlaster

STAGE 1 PNEUMATIC CLEANING

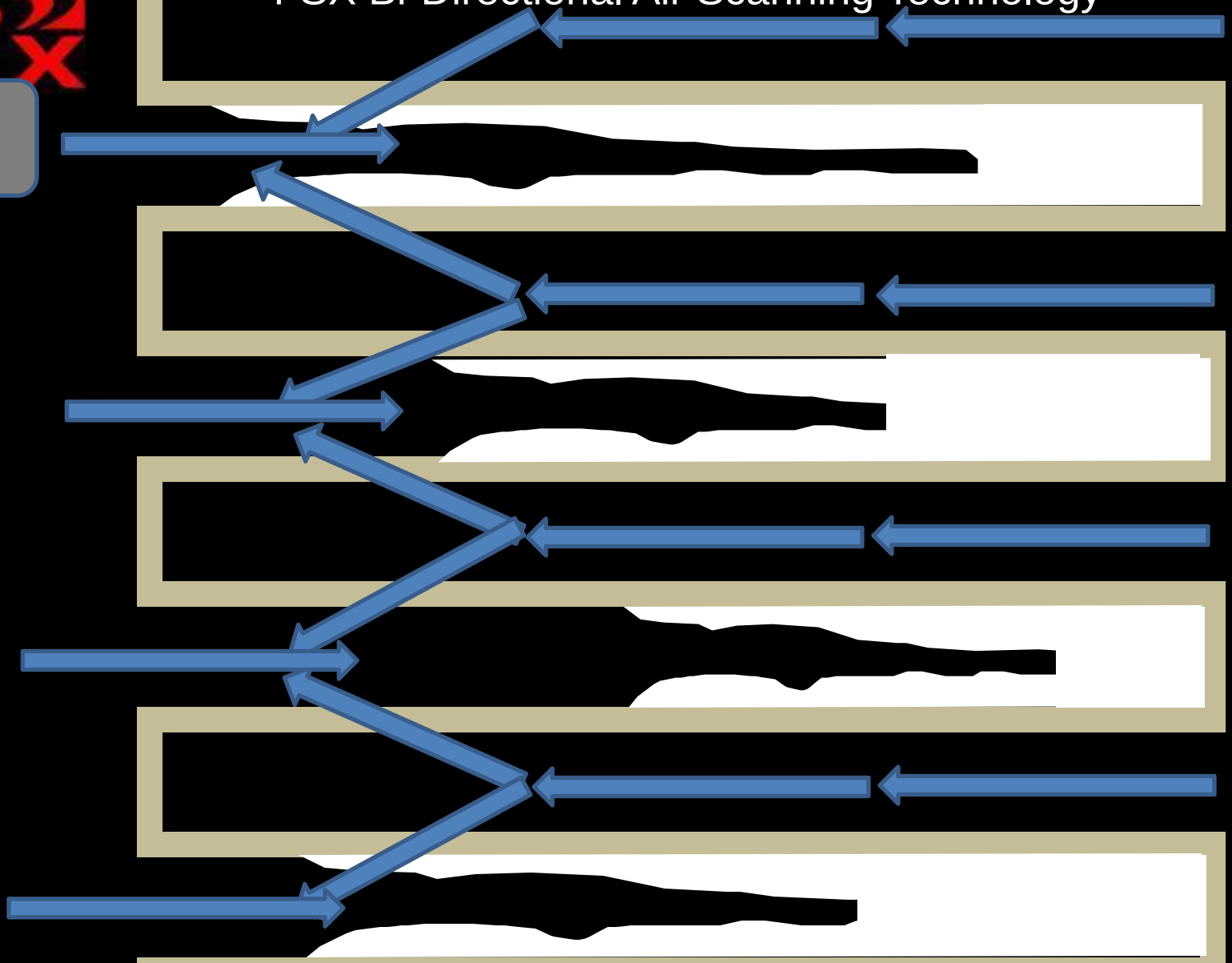


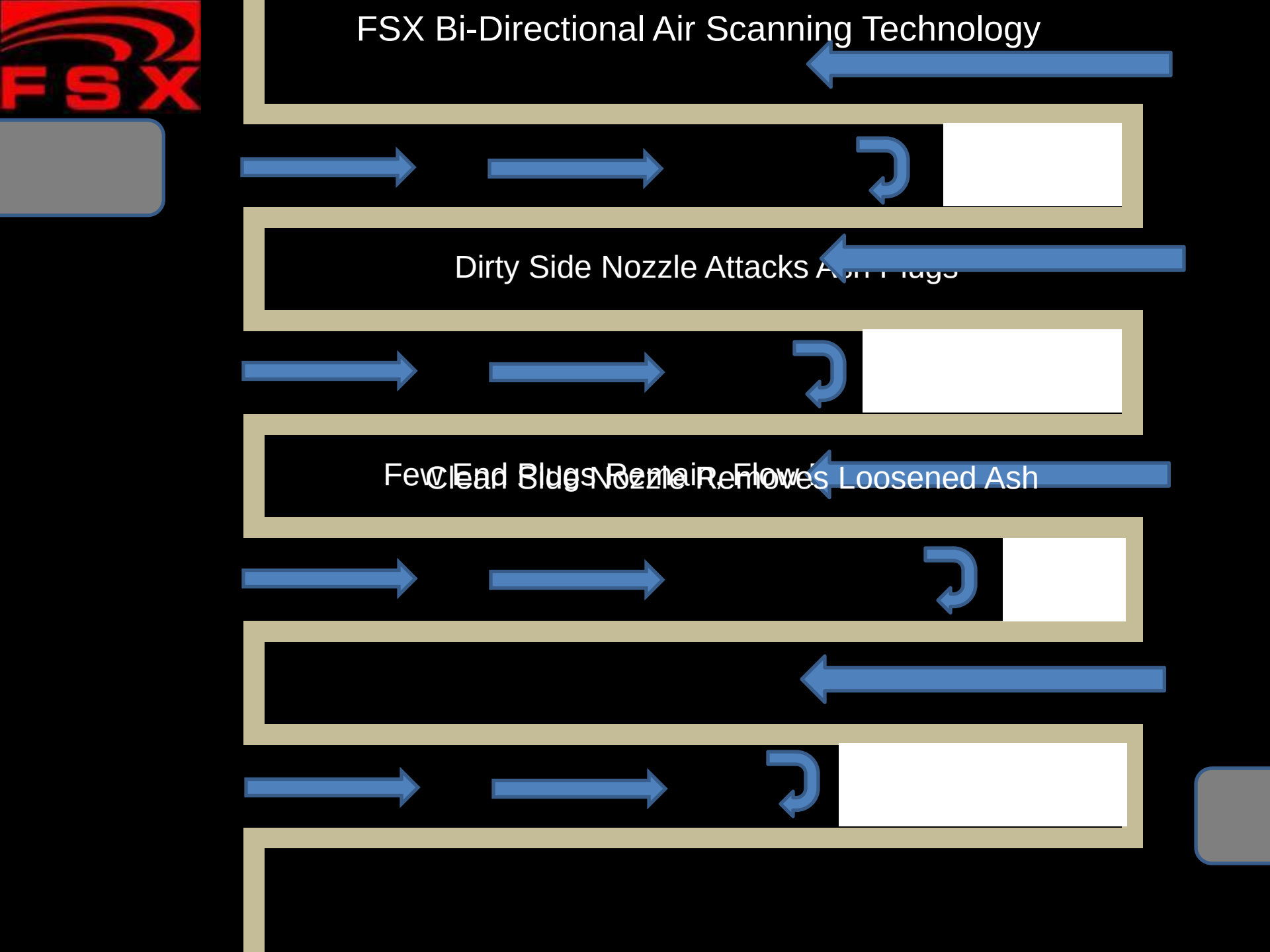
Nozzle Diameter and High Air Volume are Important

Patented Bypass Detection

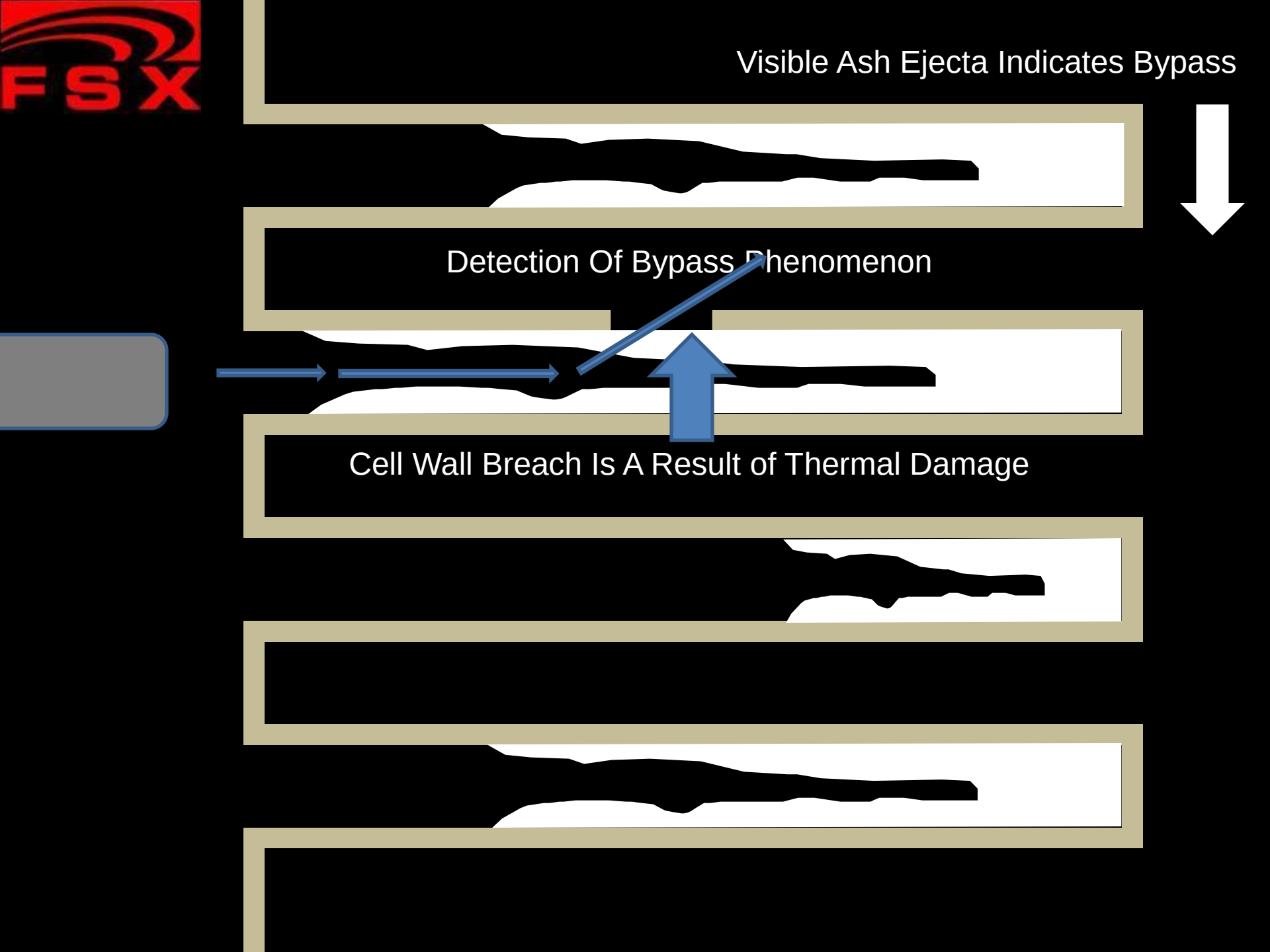

Diesel Particulate Filter
Progression of Ash Loading
Ash Plugs will cause Premature Failure
Ash Accumulation on Cell Walls
≥150,000 Miles

FSX Bi-Directional Air Scanning Technology




FSX Bi-Directional Air Scanning Technology
Dirty Side Nozzle Attacks Ash Plugs
Few Ash Plugs Remain, Flow Is
Clean Side Nozzle Removes Loosened Ash

Ash Ejection


FSX
Visible Ash Ejecta Indicates Bypass
Detection Of Bypass Phenomenon
Cell Wall Breach Is A Result of Thermal Damage

Visible Failure Mode Detection

Testing & Certification

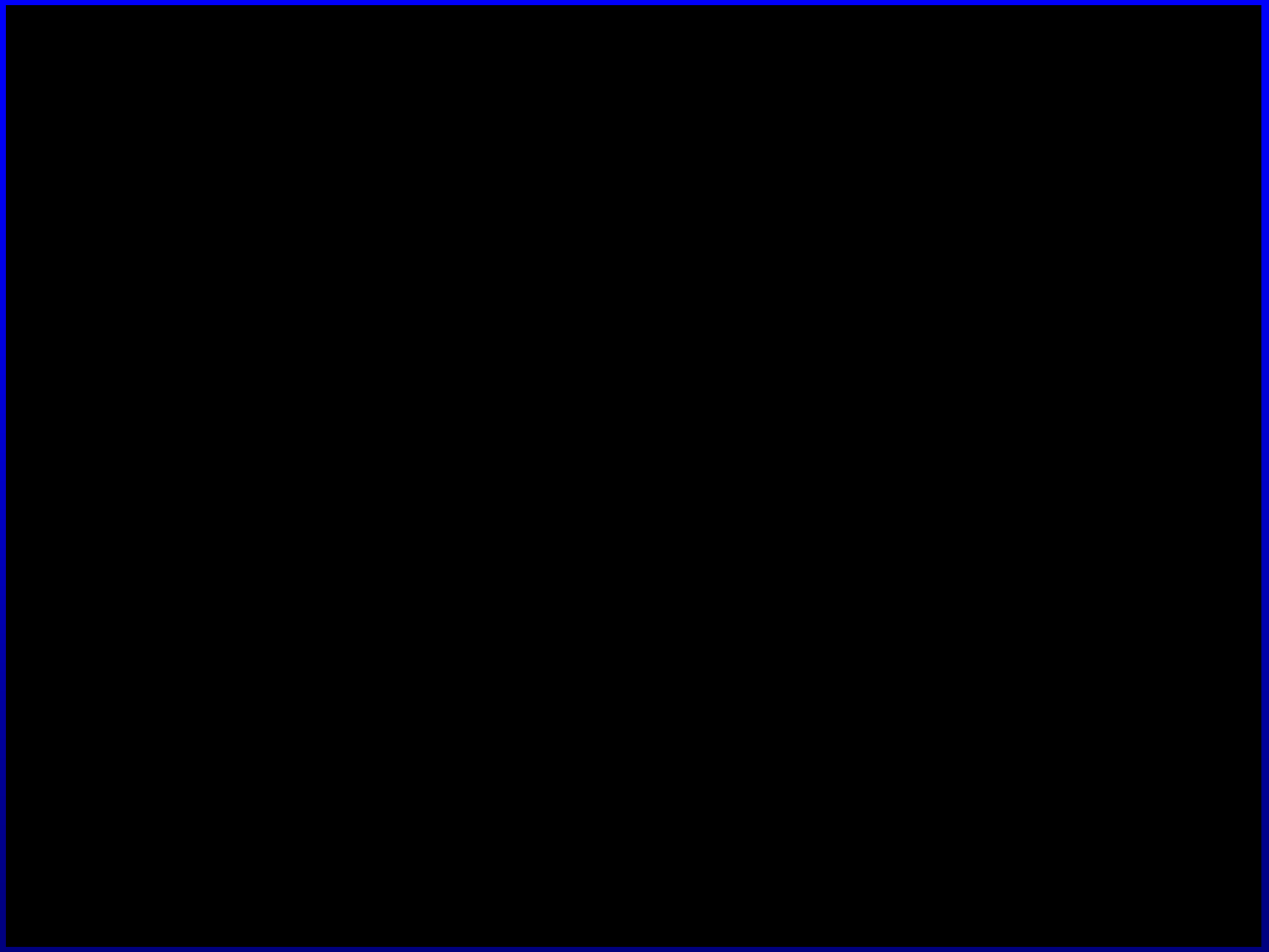
FSX, Inc.

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.

Manufacturer	Part No.	ARM# / Other	Target FSX Cleaning Ranges: Red Tag (if below)	Baseline	Green Tag Range	Orange Tag Range	Red Tag (if above)
Cummins	Q617785	(Catalyst)	< 1.25	1.25	1.25 - 1.75	1.80 - 2.25	> 2.25
Cummins	Q617787		< 3.00	3.00	3.00 - 3.50	3.55 - 4.00	> 4.00
Cummins	Q617788		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Cummins	Q617939	(Catalyst)	< 1.50	1.50	1.50 - 2.00	2.05 - 2.50	> 2.50
Cummins	Q617940		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Cummins	Q618458		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Cummins	Q618747		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Cummins	Q619495		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Cummins	Q619725		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Fleetguard/Nelson	29410A		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Fleetguard/Nelson	29411A		< 3.00	3.00	3.00 - 3.50	3.55 - 4.00	> 4.00
Fleetguard/Nelson	29412A		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Fleetguard/Nelson	29866A		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Fleetguard/Nelson	29972A		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Caterpiller	260-7807		< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Caterpiller	261-2318	2020917	< 2.35	2.35	2.35 - 2.85	2.90 - 3.35	> 3.35
Caterpiller	264-1556	2021619	< 2.35	2.35	2.35 - 2.85	2.90 - 3.35	> 3.35
Caterpiller	291-8514		< 2.25	2.25	2.25 - 2.75	2.80 - 3.25	> 3.25
Caterpiller	291-8519		< 2.25	2.25	2.25 - 2.75	2.80 - 3.25	> 3.25
Caterpiller	292-2944		< 2.25	2.25	2.25 - 2.75	2.80 - 3.25	> 3.25
Caterpiller	291-8520		< 2.25	2.25	2.25 - 2.75	2.80 - 3.25	> 3.25
Caterpiller	299-3513		< 2.25	2.25	2.25 - 2.75	2.80 - 3.25	> 3.25
Detroit Diesel	23535826	(Catalyst)	< 1.75	1.75	1.75 - 2.25	2.30 - 2.75	> 2.75
Detroit Diesel	23535827	(Trap)	< 2.50	2.50	2.50 - 3.00	3.05 - 3.50	> 3.50
Detroit Diesel	29278B		< 3.00	3.00	3.00 - 3.50	3.55 - 4.00	> 4.00
Detroit Diesel	29278N		< 3.00	3.00	3.00 - 3.50	3.55 - 4.00	> 4.00

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

TrapBurner

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

FSX www.fsxinc.com

Date: _____

Filter Style: DPF Catalyst

Serial Number: _____

Part Number: _____

Other Number: _____

Customer: _____

Manufacturer/Distributor (Circle)

Caterpillar	DCL	International	Mack
Cleaire	Detroit Diesel	Isuzu	PACCAR
Cummins	ECS	Johnson Matthey	Volvo

Other: _____

Mileage: _____ Vehicle #: _____

Engine: _____ Model: _____

Filter Dimensions

OD ____ ID ____

Overall Height _____

Ceramic Height _____

Pin Gauging

Depth of a totally clean cell

____ (Measure from Clean side)

Step 1 - Visual Inspection

Refer to Filter Cleaning Reference Data Posters

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)

Circle One

Chips, Gouges, Melting:	Pass	Fail
Surface Cracks:	Pass	Fail
Loose Ceramic (Ceramic moves) :	Pass	Fail

☐ Red Tag ☐ Continue

Oil Soaked (circle): Yes No

If Yes, then Red Tag.

FSX does not recommend cleaning oil, coolant, or fuel soaked DPF.

Discoloration Ring: **Yes** or **No** (circle)

TrapTester Airflow test _____ **w.g.** (Clean side down no gaskets)

Initial Black Hole Count (on clean side) **(est.) (circle):**

0 5 15 10 20 50 100 100+ 1000+ Other:_____

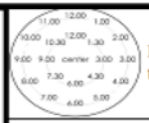
Step 2 - Pneumatic Stage 1 Cleaning

2-minute Bypass Inspection; Important - Closely watch top surface of the DPF during first 2-minutes of air blast. Count defective cells allowing distinct spurts of ash or soot, and indicate number below.

Circle: 0 1 2 3 4 5 10 15 20 50 100 100+ 1000+

☐ **Red Tag: stop process if over 20 cells have heavy spurts 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 (spurts) noted.**



Location of target cells to test

Pin Gauge Depth

(Measure available depth from dirty side of filter – tap lightly if necessary)

Step 3 - After Pneumatic Cleaning

TrapBlaster Time (in minutes) (circle one):

15 20 25 30

40 50 60 Other:_____

Pin Gauge dirty side for ash content and note measurement (see grid at right)

TrapTester Airflow test _____ **w.g.** (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

Important: Before putting the filter in the TrapBlaster make sure core temp is at or below 125°F

TrapBurner PI (circle): Yes or No

TrapBlaster Time (in minutes) (circle one):

15 20 25 30 40 50 60 Other:_____

TrapTester Airflow test _____ **w.g.** (Clean side down no gaskets)

Compare to FSX Baseline Chart

Pin Gauge dirty side for ash content and note measurement (see grid at right)

Final Step 4 status: ☐ Red Tag ☐ Green Tag ☐ Orange Tag

Final comments: _____

_____ Operator's Initials:_____

_____

Position	Clean Side Step 1	Dirty Side After Pneumatic Step 2	Dirty Side After Thermal Step 3
Outer 1:00			
Outer 2:00			
Outer 3:00			
Outer 4:00			
Outer 5:00			
Outer 6:00			
Outer 7:00			
Outer 8:00			
Outer 9:00			
Outer 10:00			
Outer 11:00			
Outer 12:00			
Inner 1:30			
Inner 3:00			
Inner 4:30			
Inner 6:00			
Inner 7:30			
Inner 9:00			
Inner 10:30			
Inner 12:00			
Center			
Average			

FSX

Dust Collection & Disposal

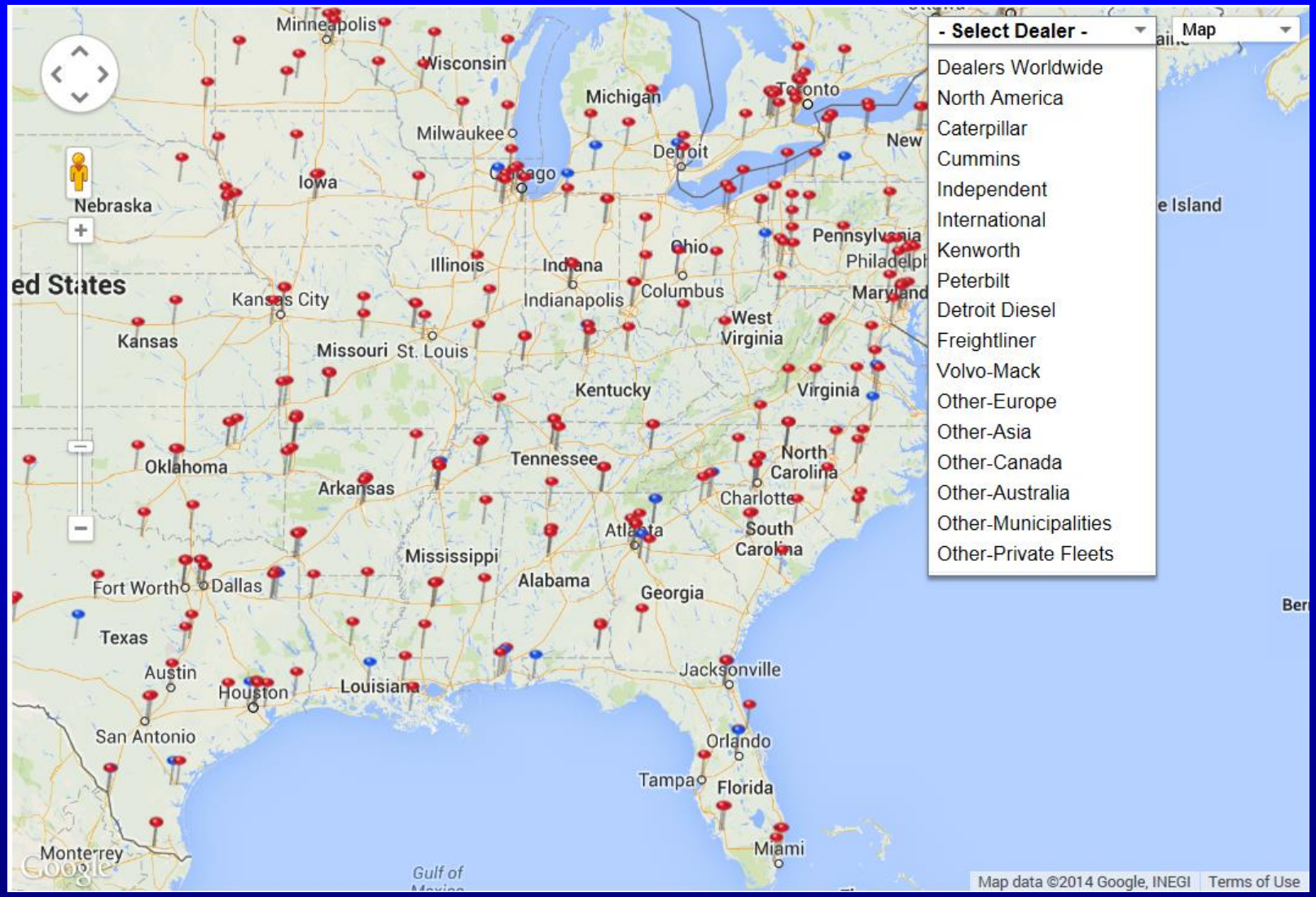
FSX SootSucker 2

- 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

SootSucker 2 Dust Collector

Cleaning Coned Flange DPF

FSX Service Locator Map



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