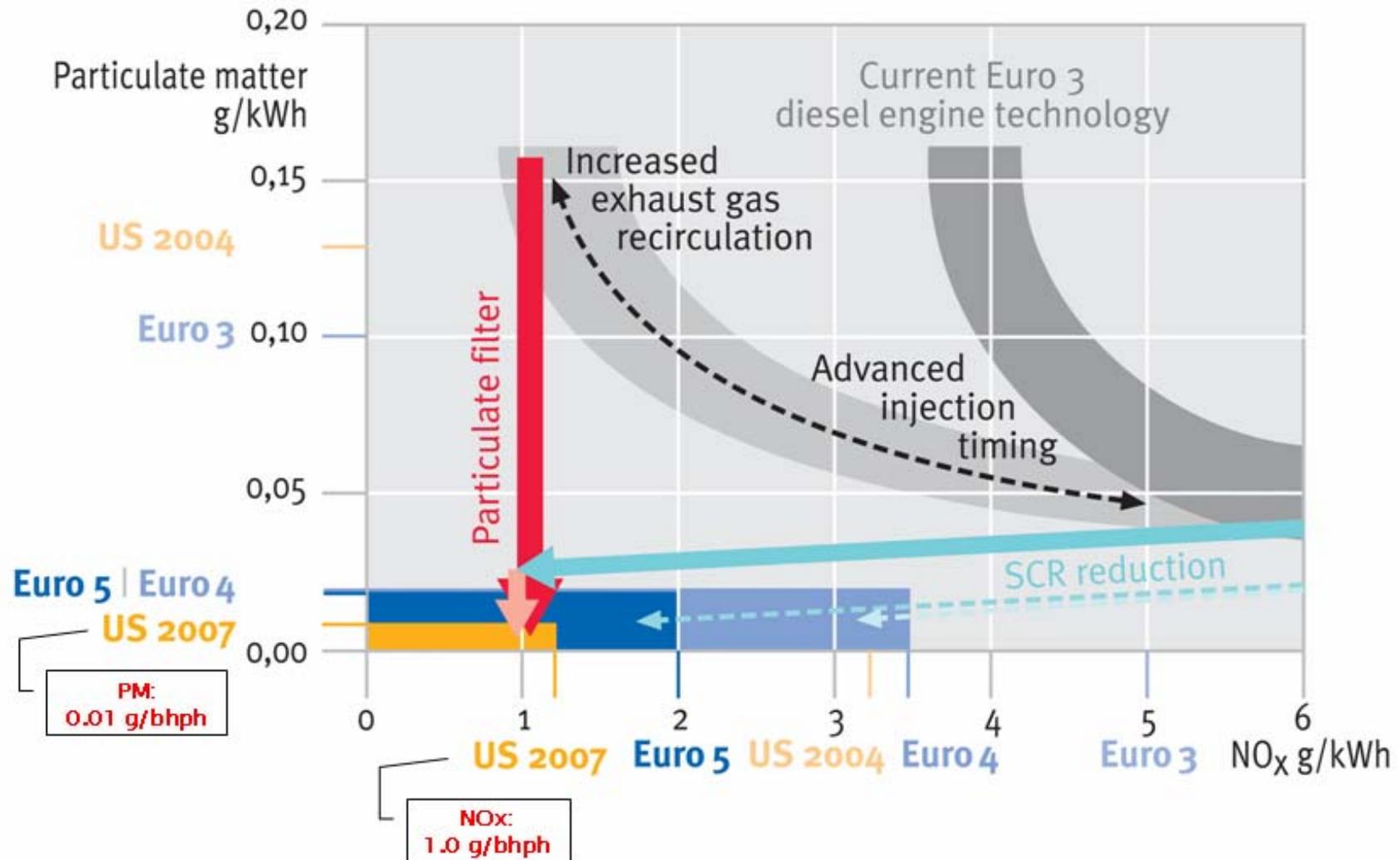




Requirements From Particulate Filter Technology For Commercial Vehicles: Sintered Metal Particulate Filter Opens A New Dimension Of Performance

Jim Biddinger
Program Manager
PUREM North America, LLC

Strategies For Emission Reduction For Future Legal Limits



Generic Requirements From An OEM View

- **OEM:**

- » **Durability:**

- 620,000 mi (1,000,000 km)

- » **Temperature Range:**

- Components frame mounted: - 40°C (-40° F) ... 80 °C (176° F)

- Components engine mounted: - 40°C (-40° F) ... 140 °C (285° F)

- **Legal Requirements USA, Basis EPA 07:**

- » **Useful life, emissions:**

- Medium Duty: 435,000 mi (700.000 km) /22.000 h/ 10 years

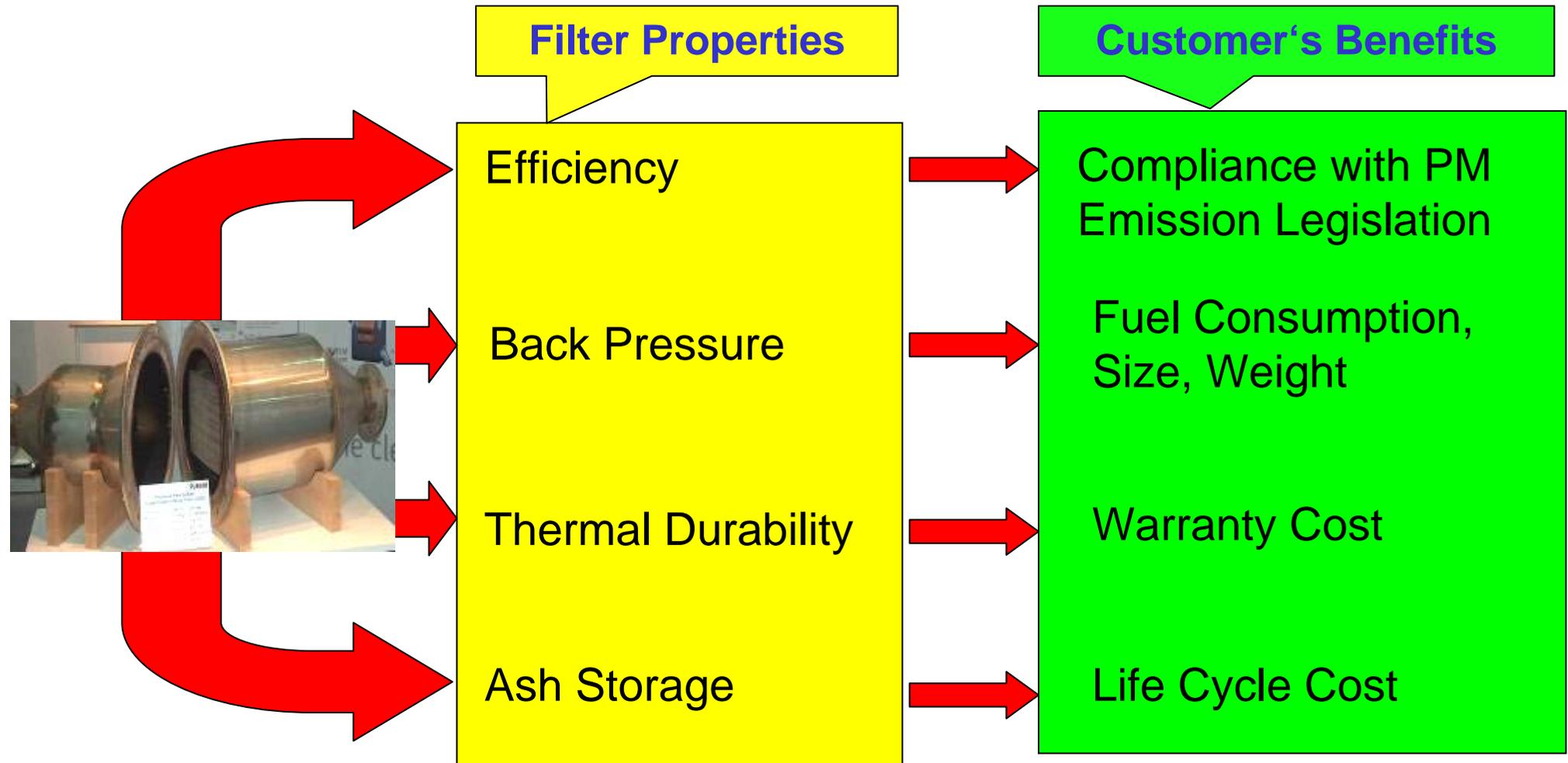
- Heavy Duty: 435,000 mi (700.000 km)/ 22.000 h/ 10 years

- » **Emission warranty until 1st Filter Cleaning**

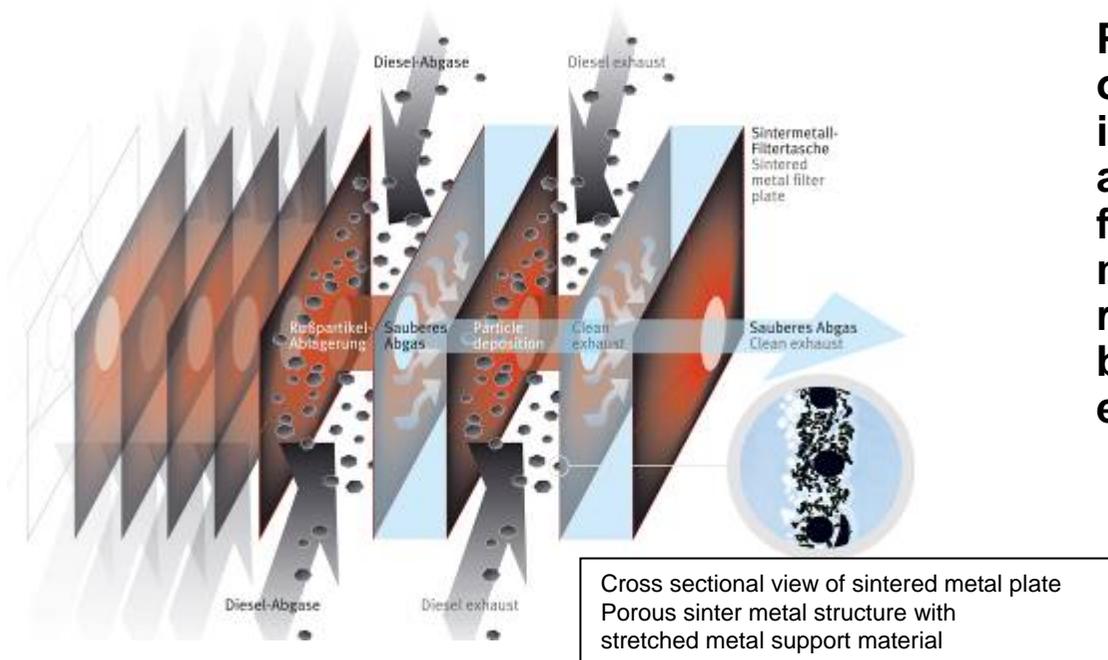
- 150,000 mi (240.000 km) / 4.500 h/ 2 years

- » **B 10 Life: 10% of trucks reach 1,000,000 mi (1.600.000 km)**

Particulate Filter Functions And Performance Implications For Customers



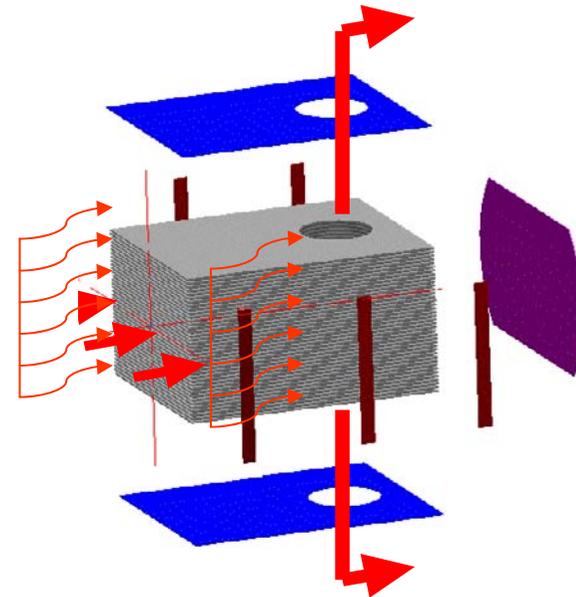
PMF™ Flow Principle Differs From Wall Flow Filtration Technology



Assembled like a kind of folded bellows the exhaust gas can flow from the outside inwards.

The soot particles are deposited on the filtration surface.

PMF™ defined with a number of sintered metal filter plates in a stacked configuration allow for the exhaust gas to flow in an unrestricted and more efficient manner resulting in a constant backpressure over an extended period of time.



Ash Accumulation On The Sintered Metal Filter Surface

Ash storage principle:

Ash is deposited across the filtration area

Ash will move even without active regeneration

Ash will concentrate around the outlet.



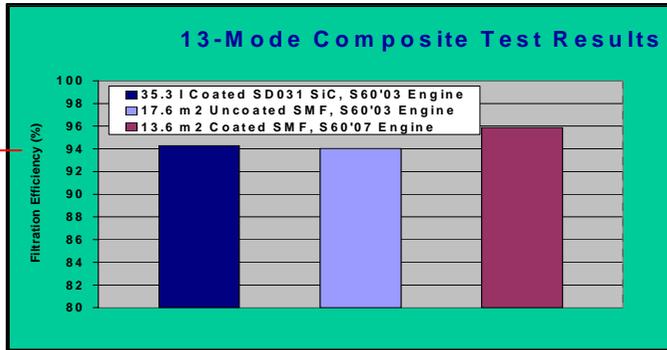
Example:

Truck filter with ash storage
after 193 k km

PMF™ Filtration Efficiency

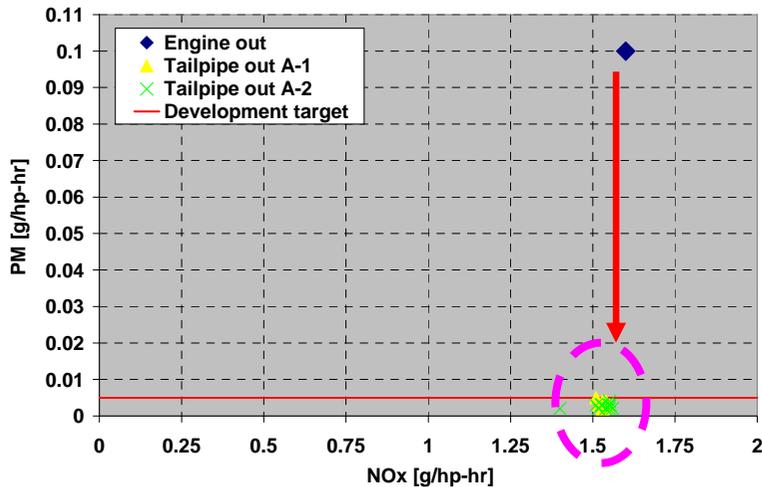
PMF™ Filtration Efficiency Is Greater Than 90%. Results Are Based On Testing With International OEMs And Accredited Test Laboratories.

US FTP and Steady State

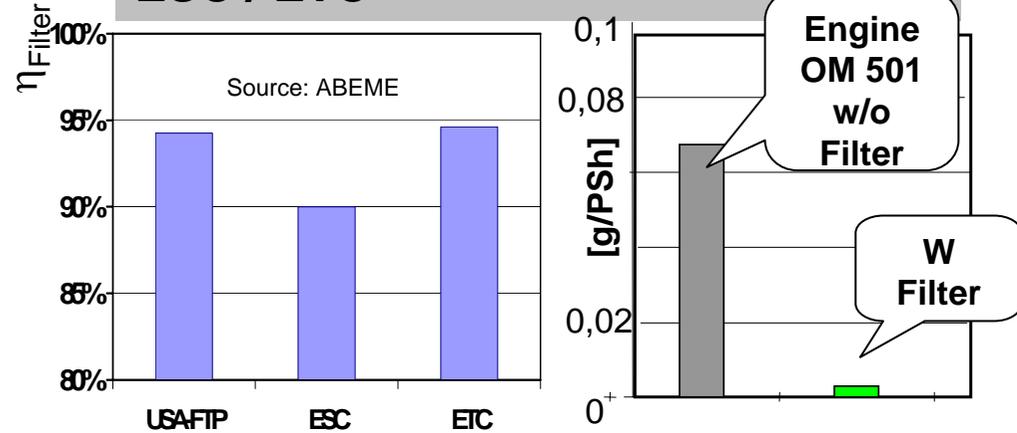


94%

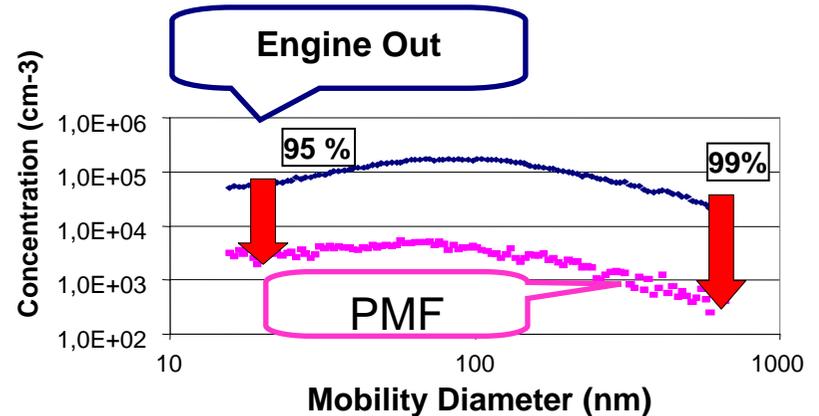
PMF™ Hot FTP Test Results



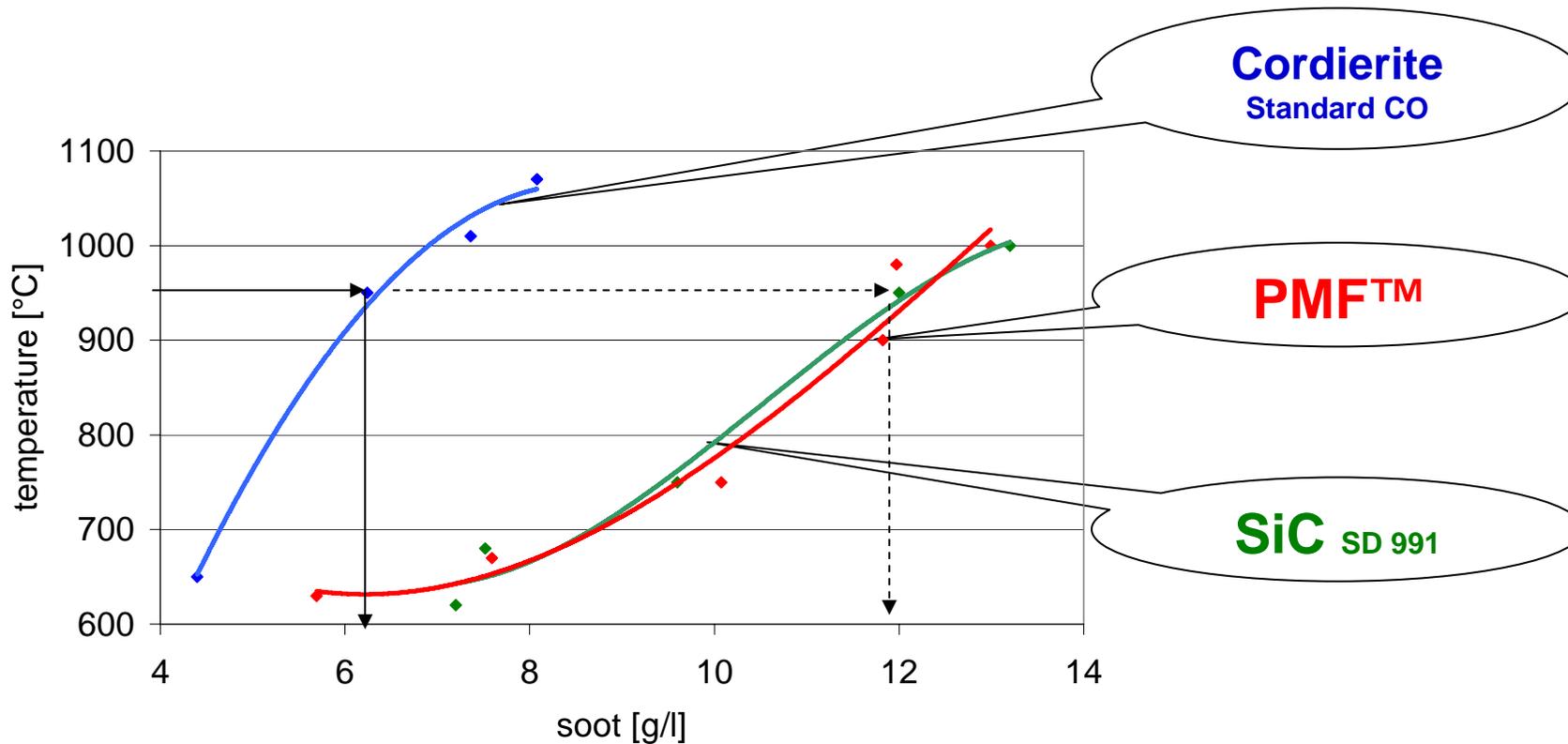
ESC / ETC



Particle Size Distribution Curve



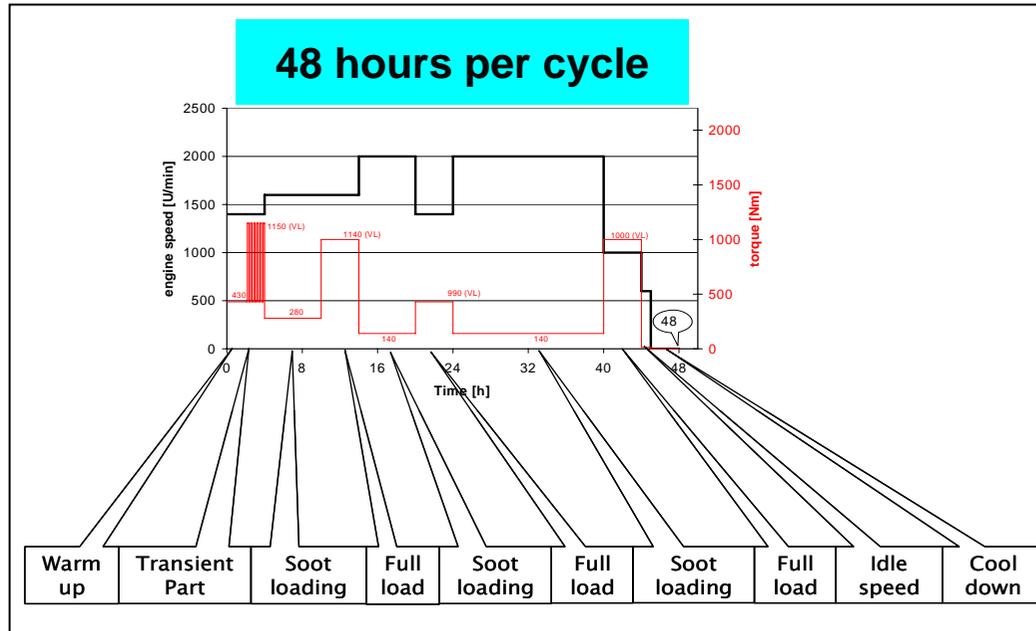
Thermal Characteristics With Soot Regeneration



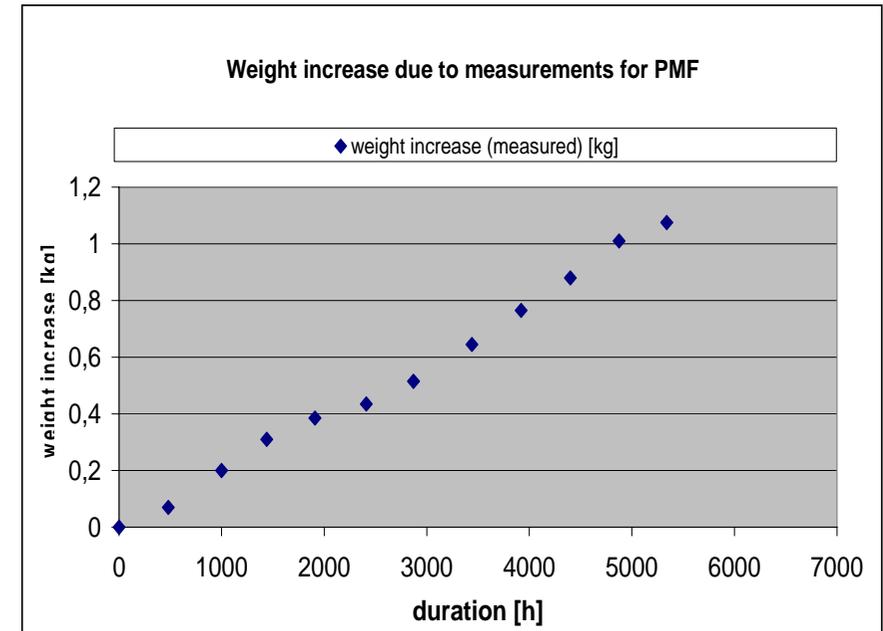
Note: All filters have approximately the same volume

PMF™ Follows The Same Approach Of SiC To Exhibit The Same Thermal Robustness.

Engine Cycle Shows Clear Design Direction For DPF To Achieve Fuel Efficient Lifetime Behavior



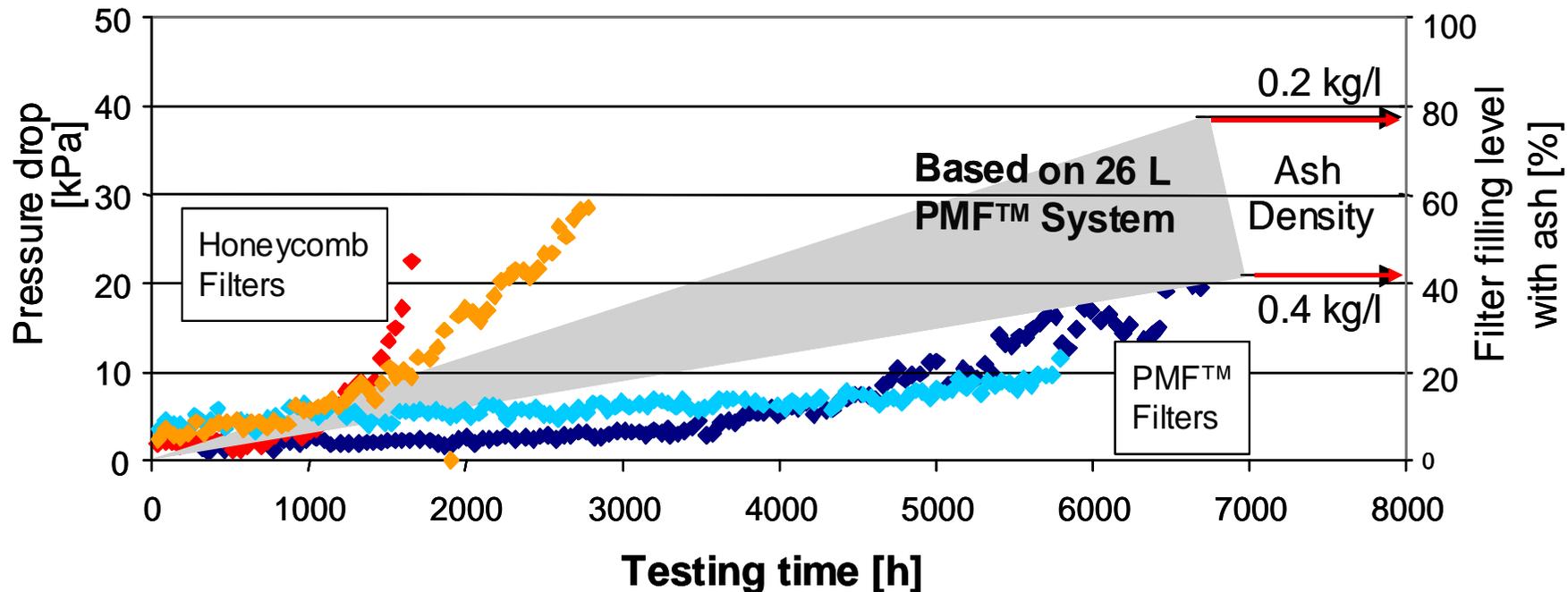
3 hours engine - off in 48 hours
1 hour idle in 48 hours
28 hours low engine load
12 hours higher engine load



Weight increase due to ash

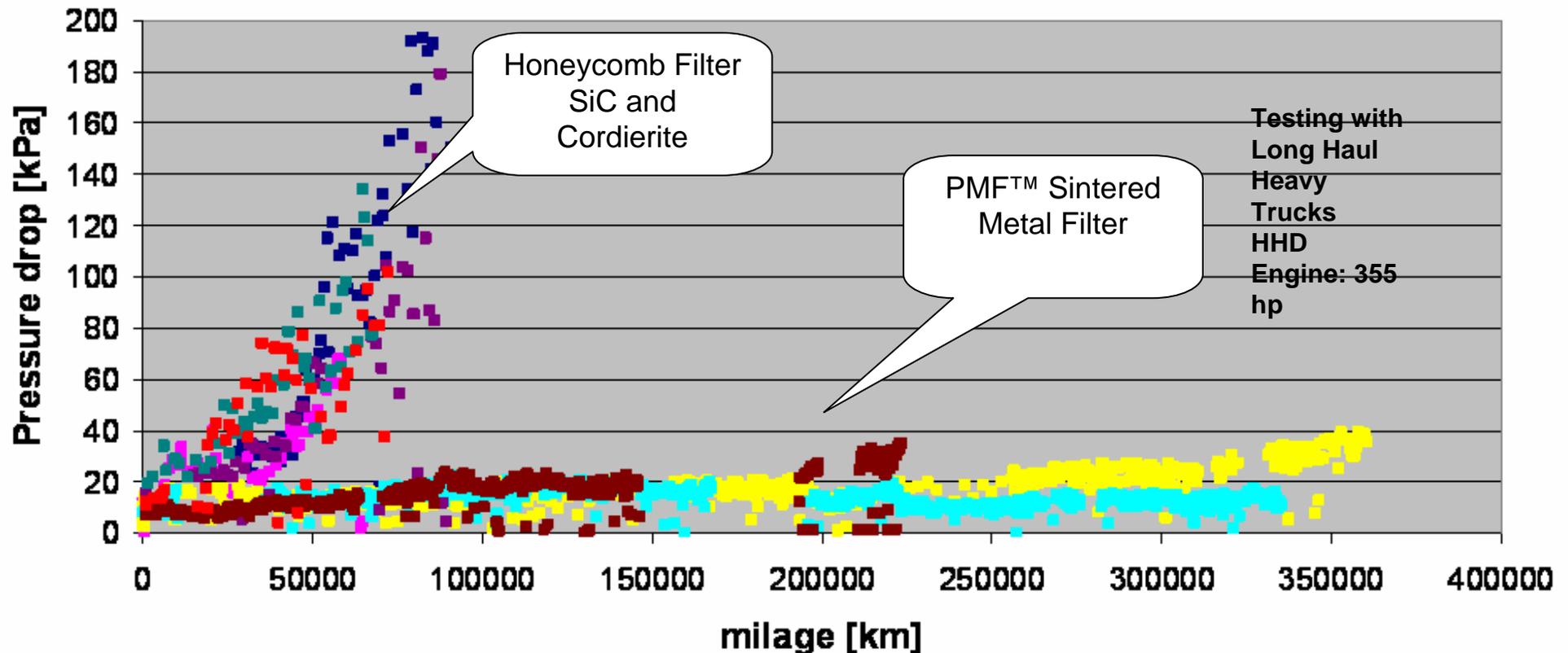
Influence Of Filter Filling With Ash Over Time/Mileage

Pressure drop versus time
 Engine OM 906, 205kW
 16h soot loading cycle at n=2000 rpm, M=135 Nm



PMF™ Test Results With On Road Testing

Demonstrate Superior Ash Storage Capacity and Effect On Backpressure Performance Of PMF™ Technology

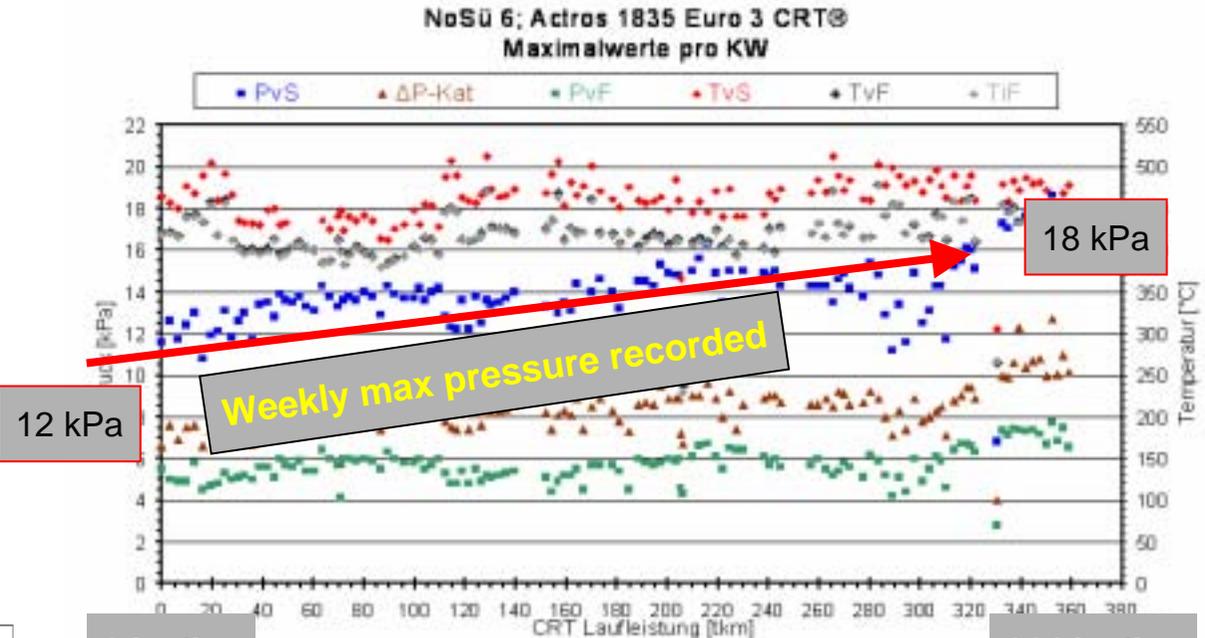


Data Source: Field Test Evaluation with PUREM & OCTEL

Durability Truck Testing For Design Validation: PMF™ With Long Service Interval In Original Muffler Housing



Muffler location



0 miles mileage 214 miles

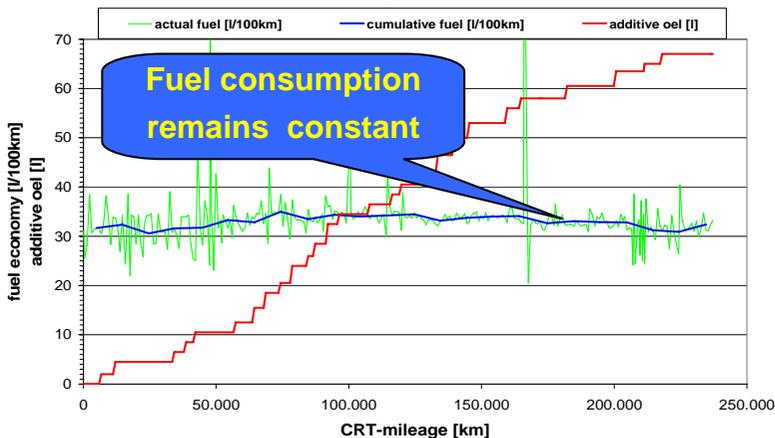
No active regeneration needed

Good fuel economy

Low backpressure increase

Long service intervall

fuel economy SO-UZ-482



Basic Properties Of Diesel Particulate Filter Types*

	Cordierite	Silicon Carbide SiC	Sintered Metal PMF™
Efficiency	++	++	++
Back Pressure	+	+	++
Durability	-	+	+
Ash Storage Capacity	-	0	++

* Based on PUREM research and testing

PMF™ Liquid Cleaning Tests

Summary of tests [2]



PMF™

With Ash And Soot



PMF™ With Ash

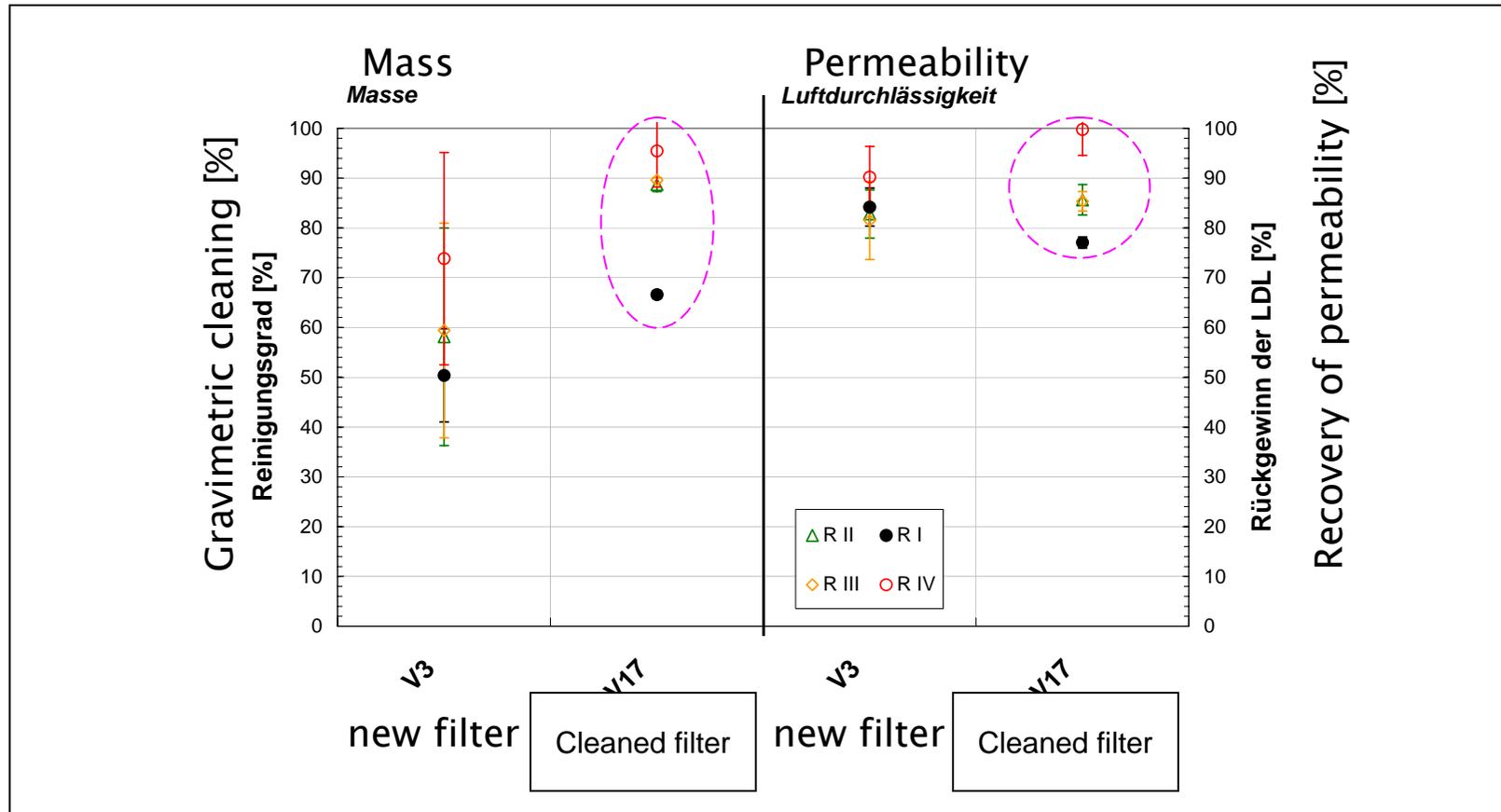
(After Thermal Treatment
At 600°C For 10 Hours)



PMF™ Cleaned

- ✓ **Successful Transfer From Lab Cleaning Tests With Coupons To Cleaning Of Full-size Units**
- ✓ **Based On Gravimetical Measurements; A Cleaning Efficiency Of Around 80% Was Reached**
- ✓ **Investigations Of Possible Effects On Catalytic Activity Were Conducted; No Effects Could Be Identified**

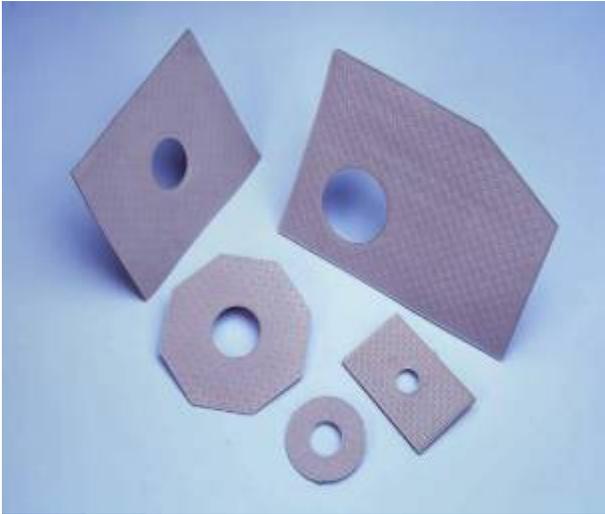
Effects of Cleaning on PMF™



PUREM Cleaning Procedure (under development) Does NOT Affect PMF™ Filtration Efficiency And Leads To Near New Performance.

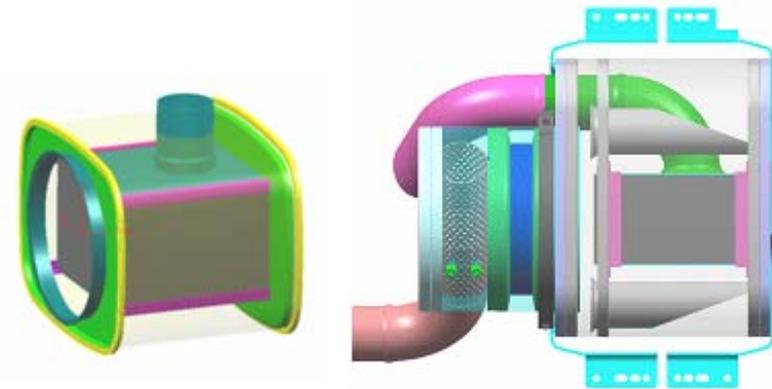
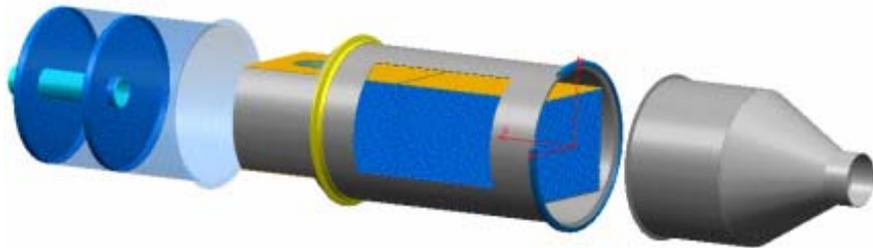
Design Flexibility With Sintered Metal Filterplates

Various designs can be accomplished by designing the appropriate cutting and stamping tools



Design Versions of PMF™ Filters

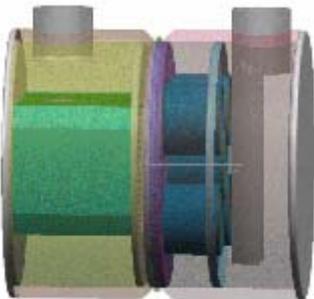
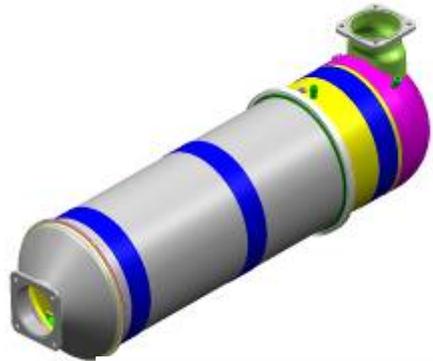
- After appropriate sizing of the PMF™ determining the filtration area, the customer can choose from standard filter sizes thus avoiding tooling cost. Filter dimensions are adjusted via length or Stack height.
- For special applications extra wide tooling can be offered to accommodate the most unusual request for packaging.



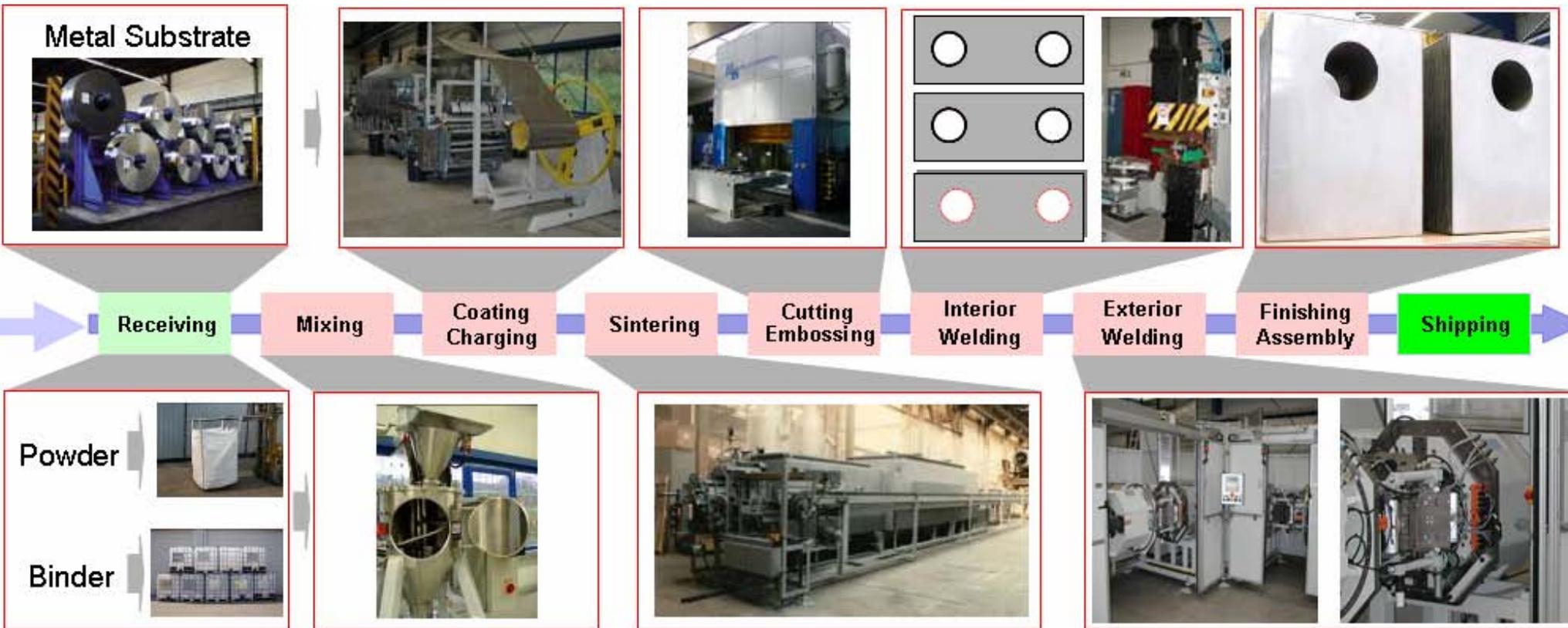
**Typical NAFTA Application
Canning Sample**

**Typical European Application
Canning Samples**

PMF™ Packaging Flexibility Enables OEM To House After Treatment Systems In A Wide Range Of Vehicles



Manufacturing Process of PMF™ Sintered Metal Filters



Conclusions Sintered Metal Filter PMF™

- ✓ PMF™ shows good ash accumulation performance and potential as a lifetime filter resulting in good backpressure performance from the large connected filtration surfaces, has high thermal durability, and can be easily adapted to different design configurations.
- ✓ Filtration efficiency of PMF™ is greater than 90% based on OEM testing and is suitable for all regeneration techniques.
- ✓ PMF™ has an advantage for cleaning either with liquid or air depending on the application with the potential for reduced maintenance frequency due to large ash storage capacity resulting in significantly reduced lifetime costs.
- ✓ PMF™ manufacturability is cost competitive and ready for the market.