A New Active DPF System for “Stop-&-Go” Duty Cycle Vehicles

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Presentation Outline

- Introduction
- Description of the Active DPF System
- Refuse Trucks Retrofit Applications
- Improvement in association with Fuel-Borne Catalyst
- Conclusions
Real Need of DPF System for “Stop-&-Go” Cycles

Passive Catalyzed-DPF Systems were tested on refuse trucks from May 2001 to March 2003:
- AIRMEEEX
- EMINOX (CRT®)
- ENGELHARD (DPX®)

a "Stop-&-Go" urban cycle:
- too low temperature for regeneration
- really dependant on the engine
- damage on the catalysts and filters

Rapid DPF damage with losing PM reduction efficiency

Source: Workshop on “Ecologic Refuse Trucks” 10/2003
To fit the “Stop-&-Go” Duty Cycle Requirements, a new Active DPF System was developed, to prevent risk of clogging and uncontrolled filter regenerations.

The Active DPF System is based on two main principles:
- a variable volume of filtration;
- a global thermal management:
  • a thermal insulation
  • a catalytic combustion of hydrocarbons

The DPF System is applicable to Smoke nbr. <2 m⁻¹: EURO 1-3 vehicles and some EURO 0

with high flexibility regarding the sulfur content in the fuels
Description of the Active DPF System
Management of Volume of Filtration

- Valves and actuators in order to isolate part of the volume of filtration (at idle or low load)
- 1/2 to 2/3 of filtration area is kept under higher temperature than 320°C
- slow but continuous soot combustion w/ Oxygen
Typical Thermal Profile with Simple Trap

Cycle Simulating Refuse Truck Driving and Collection Phases
Valve Effect on Filter Thermal Profile

Filter Temperatures

Exhaust Temperature

FULL LOAD

IDLE

T1

T2

T3

T4

T5
To demonstrate reliability, robustness, flexibility and durability, the Active DPF System was tested on different applications, such as urban buses and refuse trucks.

Exhaust emission measurements were performed at the official UTAC facilities on:

- Refuse Trucks (w/ Veolia) under the national ADEME evaluation program (Retrofit applications)
Refuse Truck Retrofit Applications

- Renault Trucks Premium 62045 MIDS
- 20-tons Refuse Truck with EURO II calibration,
- fitted with 6 SiC filters units (20m² filtration area)
- placed in the existing muffler volume

Evaluation with Standard fuel (350ppm Sulfur) over a 12 months program

Source: “The Ecologic Refuse Trucks: data and references” ADEME / 2003
Representative “Refuse Truck” Duty Cycle

All the data will be given in g/km

Measurements based on 3 successive cycles
Efficiency of the DPF System

Higher efficiency over the **Driving Part** vs. **Collection Part**
- CO: 60% vs. 17%
- HC: 65% vs. 32%
- PM: 93% vs. 82%
Average DPF System Efficiency over the Cycle

- 33% CO reduction
- 44% in HC reduction
- 89% in PM reduction
- Insignificant NOx effect
Reliability of the Active DPF System

Forced DPF Regeneration Situation

DPF Regeneration

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A backpressure kept lower than 150 mbar over 94% of the 12 months field test.
Urban buses Applications (smoke nbr. < 2 m⁻¹)
- fitting the standard muffler volume
- and the engine performance

*Example:*
For a 9 l / 250 hp Diesel engine, we need 4 SiC-DPF 5,66”x10” units
For the EURO III calibration, Premium DCI 11 320 engine:

- 11 l engine displacement
- max. power : 330 kW @ 1900rpm
- max. torque : 2130 Nm @ 1200rpm
- fitted with 6 SiC 5,66”x10” filters units
- placed in the standard muffler volume
Global Improvement of the Active DPF System

To improve performance, extend the market segments, reduce global cost and limited the maintenance, a Global System Approach is under development:

- Combination with Fuel-Borne Catalyst and Automatic On-Board Dosing System

- New Filter Design and Materials

- Downsizing of the DPF System to target the LDV, SUV and Sedan vehicles

- Combination with NOx reduction approaches
  - Water-based Fuel emulsion
  - SCR-based technologies
  - EGR technologies
Eolys™: Fast and Complete DPF Regeneration

Regeneration @ 1600 min⁻¹ / 750Nm
330°C inlet temperature
Post-injection time: 30 seconds
Data record stopped @ 240 mbar

Synergy effect observed with Eolys™, with reduction of the recommended dosing rate for complete and fast DPF regeneration
Eolys™: Extension of the DPF Operation

- Extend the DPF operation length, before maintenance
- Decrease the forced regeneration frequency:
  - extend the DPF loading time (synergy effect)
  - get a complete DPF regeneration
with global fuel economy
Synergy Effect w/ Eolys™

The dosing rate of Eolys™ is reduced from 20-30ppm to 7-5ppmn (for a EURO II engine)

With reduction of the soot loading time of filter (by factor 2)

With reduction of the filter maintenance:

<table>
<thead>
<tr>
<th>Maintenance frequency (Euro II)</th>
<th>w/o Eolys™</th>
<th>w/ Eolys™</th>
</tr>
</thead>
<tbody>
<tr>
<td>70–140,000 km</td>
<td>&gt; 150,000 km</td>
<td></td>
</tr>
<tr>
<td>12–18 months</td>
<td>&gt; 24 months</td>
<td></td>
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</tbody>
</table>

With flexibility with Sulfur fuel level: Standard (350ppm S), Xeol™ (40ppm S), GECAM ™ (water emulsion, 30ppm S)

Start of Retrofit field tests in Mexico (500ppm S) and China (350-2000ppm S)
A new Active DPF System has been developed for the “Stop-&-Go” Duty Cycle Applications (Urban buses, Refuse and Delivery Trucks), based on:

- Variation of Volume of Filtration (valves and actuators)
- Global Thermal Management, using Heat Injection in the Exhaust (Catalytic Combustion, Back-Pressure Management, Fuel-burner, etc...)

Efficiency, reliability, flexibility and durability of the DPF System have been demonstrated in retrofit program and OEM certifications:

- High efficiency on the Particulates
- Reliability of the Active DPF Regeneration Strategy
- Flexibility with the Sulfur content in the Fuels
Conclusions (cont.)

This Active DPF System has shown a cumulative mileage of 3,500,000+ km since its market introduction, with more than 3 years experience.

RENAULT Trucks proposes this Active DPF System as an option for the EURO 3 Premium DCI 11 320 Diesel engine (Refuse Trucks, Diesel-powered Cradles).

Synergy effects were found in the association with the Eolys™ Fuel-Borne Catalyst: limitation of the maintenance and flexibility; under the VERT Certification (till Nov. ’04).

Next step: association with NOx control strategies to offer a complete NOx/PM/CO₂ solution for Retrofit and OEM applications (EURO 4 w/ SCR NOx Reduction).
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