



Retrofit Program of a EURO 1 & EURO 2 Urban Bus Fleet in La Rochelle: Status after One Year Experience

Daniel Biancotto, Turkey Erol, Henri Georges –
AIRMEEX

Jacques Lavy, Brigitte Martin – **IFP**

Gilbert Blanchard, Pierre Macaudière, Laurent Rocher –
RHODIA Electronics & Catalysis

Jean-Marie Grellier – **CDA La Rochelle**





Highlights

- Introduction and presentation of the FBC-DPF system
- Preliminary evaluation (engine test bench – IFP study)
- Field results after 12 months of service on four EURO 1 and EURO 2 buses
- Extension of the retrofit program: feedback after 6 months
- Conclusion



Diesel emissions control is a major issue, particularly in urban areas

- Diesel Particulate Filter (DPF) regenerated thanks to engine management and ceria-based fuel borne catalyst (FBC) is a proven technology for passenger car applications

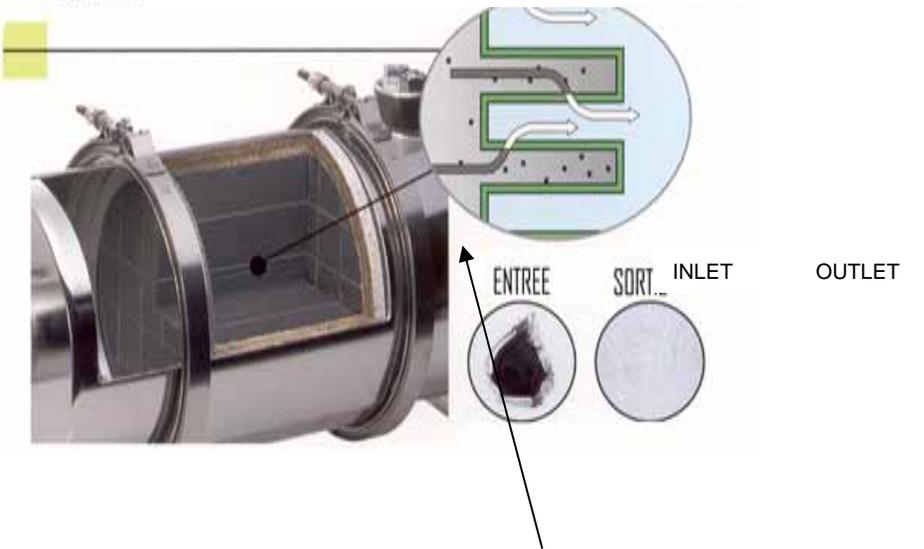
- Application to existing vehicles (RETROFIT) is even more challenging:
 - No possibility to adapt the engine management to facilitate the regeneration
 - The level of raw emissions is very high
 - ...

- A retrofit program was launched in 2003 by La Rochelle City to equip a fleet of 47 EURO 1 & EURO 2 buses



Description of the passive CARMEX DPF System

FILTRE C SILICIUM CARBIDE FILTER WALL FLOW MONOLITH



DPF (Ibiden, SiC, L=10" – D=9"
(10,4l), 200cpsi)

OXICAT (Rosi, metal,
2,8l, 200cpsi)

Technical choice: a DPF System (AIRMEEX)
regenerated thanks to EOLYS™ fuel borne catalyst
(RHODIA)



FBC dosing: centralized stationary strategy

- FBC addition is managed by an automatic off line equipment connected to the diesel refilling gun
- Bus equipped with DPF are identified by the refilling pump thanks to photoelectric devices
- After tank refilling the FBC pipe is electronically disconnected





The system was tested according to the European VERT protocol

Association of Ibiden's SiC DPF and Rhodia EOLYS™ ceria-based fuel-borne catalyst is validated and certified through the VERT protocol for Retrofit applications

- Overall filtration efficiency: > 99 % by number and 90 % by mass
- 99,94 % of Cerium FBC retention
- No increase of Polychlorinated Dibenzodioxins/Furans
- Reduction of PAH by 50-70 %
- No influence on CO, HC and NO_x (NO/NO₂ ratio stable)



Preliminary evaluations on EURO 2 engine test bench

Engine: Renault Trucks MIDR 62045

Type	MIDR 62045
Total capacity	9,84 litres
Cylinders	6
Volumetric ratio	17/1
Bore x course	120 mm x 145 mm
Max Power	190 kW (255 hp) at 2100 rpm
Max torque	1070 N.m at 1400 rpm
Fuel feeding	In line pump
Injection	direct
Air feeding	Cooled supercharging

- Diesel Fuel: EURO 2000 – **340 ppm** Sulfur
- Test with & without Ceria based fuel borne catalyst at **10 ppm** dosing rate



Preliminary evaluations on EURO 2 engine test bench

- Measurements of engine raw emissions, with or without FBC, on points A25, B50 and A100
- Filter loading : 40 hours on point A 25 (measurement of raw emissions, catalyst and filter efficiencies)
- Filter regeneration at point A 100 : regeneration temperature, downstream emissions, thermal stress, pressure drop etc..

Point	A25	B50	A100
Speed rpm	1260	1580	1260
Torque Nm	263	524	1073



Results on engine test bench: FBC advantages

- 33% lower back pressure increase at same mass load (12g/l): heterogeneous accumulation (crumbly soot structure) is observed with FBC, resulting in a higher permeability
- A lower back pressure level after regeneration due to a fast and more complete process (only 91g of soot are burnt against 97g with a FBC)
- No influence of the FBC on the particle filtering and smoke efficiencies (above 95%)
- Lower filter regeneration temperature with the FBC: 425°C against 455°C in these specific conditions
- No exotherm during regeneration – no thermal stress



Urban bus fleet evaluations

Phase 1 (July 2003): Retrofitting of 2 EURO 1 & 2 EURO 2 Buses

- 3 HEULIEZ GX Buses equipped with Renault Truck Diesel engines (317 & 107)
- 1 HEULIEZ GX articulated bus equipped with a Volvo trucks Diesel engine (187)

Phase 2 (2004): Extension of the DPF system to the whole urban bus fleet (47 buses)



HEULIEZ bus GX317



HEULIEZ bus GX107



Urban bus fleet evaluations

- Biodiesel fuel with 30% rapeseed oil (RME) in a standard EN 590 diesel fuel with a sulfur content of 105 to 250 ppm

- EOLYSTTM DPX 10 fuel-borne catalyst: 30 ppm dosing rate

- Data acquisition of different parameters:
 - Inlet temperature °C
 - Back-pressure : mbar
 - Ambient temperature °C
 - Time details



Urban bus fleet evaluations

- Small partial DPF regeneration daily occurs: slight back pressure decrease
- Constant increase of back pressure over 2 weeks before complete regeneration
- Complete DPF regeneration observed between 250°C to 350°C.



- Critical points to check:
 - Dosing system's photoelectric devices
 - Filter back pressure

- Filter cleaning operation: initially scheduled every 15000Km (3 to 6 months interval) on a mobile DPF washing machine

- Filter replacement is scheduled every 200 000 km



Extension of the retrofit program to the whole EURO 1 and 2 bus fleet

- 47 buses were equipped with the AIRMEEEX DPF passive system: no trouble or failure reported in more than six months of commercial use
- Filter regenerations operate perfectly well and don't depend on the driving conditions (bus line or driver profile)
- The stationary dosing system works well
- Filter maintenance operations are carried out, in average, every 18000 Km (twice a year) by AIRMEEEX



Conclusion

- A passive system (SiC DPF regenerated thanks to a ceria-based fuel-borne Catalyst) was certified according to the European VERT protocol for retrofit applications:
 - High particulate matter filtration efficiency
 - No secondary emissions like NO₂, Furan, Dioxins, PAH
- The system proved to work perfectly well in all driving conditions during real fleet conditions on Euro 1 and 2 urban buses
- Extension of these results : FBC can also greatly improve the operating conditions of buses equipped with Catalyzed Diesel particulate filters (CSF)

Thank you for your attention

The authors would like to thank all our colleagues for making available results, graphs...



Contact

Rhodia

pierre.macaudiere@eu.rhodia.com

chris.york@us.rhodia.com

laurent.rocher@eu.rhodia.com