Integrated Diesel System Achieving Ultra-Low Urban and Motorway NOx Emissions on the Road

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RDE legislation has improved real-world NOx emissions

- RDE requirements ensure that emissions are controlled over wider range of conditions

![Diagram showing the impact of RDE legislation on NOx emissions](image-url)
RDE legislation has improved real-world NOx emissions

On-road emissions of Euro 6d-Temp cars are well within standards

Source: PEMS results from ACEA and JAMA RDE database
Objective: demonstrate consistent low NOx emissions

Challenging driving conditions

- Low speed/load  
  e.g. city driving

- High speed/load  
  e.g. motorway driving

- Transients  
  e.g. overtaking
Content

- Demonstrator concept: emission control technologies combined in integrated approach
- Tailpipe NOx and deNOx efficiency
  - RDE
  - City
  - Motorway
- Conclusions
Vehicle and powertrain characteristics

Vehicle
- C-segment
- 1700 kg

Drivetrain
- Manual gearbox, 6-speed
- 48 Volt mild-hybrid (belt-driven, P0)

Engine
- 1.5l, 4-cylinder, 2-valve
- EGR: uncooled HP and cooled LP

Euro 6b type approval (LNT + DPF)
Demonstrator concept: emissions control technologies

- LNT + dual-SCR to cover wide range of driving conditions

EGR: Exhaust Gas Recirculation
HP/LP: High/Low pressure
cc: close-coupled
LNT: Lean NOx trap
SCR: Selective Catalytic Reduction
DPF: Diesel Particulate Filter
SDPF: SCR on DPF
uf: underfloor
ASC: Ammonia Slip Catalyst
Demonstrator concept: hybrid support to emissions control

- Stabilisation of LNT regeneration during city driving
  - e.g. transient load compensation in case of unstable driver request

- Others
  - Reduction of engine-out NOx peaks during transients
  - Support to thermal management
Demonstrator concept: rapid prototype system control

- Stepwise active thermal management depending on LNT & ccSCR temperature
  - When LNT < 170°C & ccSCR < 150°C
    - throttle valve (used for EGR control): reduce exhaust mass flow rate
  - When LNT > 170°C & ccSCR < 220°C
    - late post-injection: create exothermic reaction on LNT
    - 48V mild-hybrid system: increase load on ICE

- Model-based control of SCR
  - For optimum NH₃ dosing control without slip
  - Separate dosing control for two urea injectors
  - 3 NOx sensors used
Combination of emissions tests on the road and in the lab

- **RDE**

- **City**

- **Motorway**

Typical SCR light-off temperature

[Graphs showing vehicle speed and temperature data for RDE, City, and Motorway tests]
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8-40 mg/km achieved on RDE

- 90-96% deNOx efficiency
- No impact of ambient temperature

* Results at end of programme with refined calibration
All aftertreatment components contribute to NOx control

- City driving: LNT and close coupled SCR+SDPF
- Motorway driving: underfloor SCR required to secure robust emissions control

![Diagram showing NOx emissions for Urban and Motorway RDE](image)
Robust NOx control in the city, including cold-start

- **LNT regeneration enabled at low load**
- **Active thermal management to ensure early heat-up**
  - Active throughout entire TfL test
  - Typical light-off temperature reached within 300s after cold-start (800s gained)

Thermal management:
- **Initial calibration**: not active
- **Refined calibration**: active
24-47 mg/km NOx in the city

- Including challenging Berlin and Transport for London (TfL) tests
- TfL NOx: 80% improvement due to LNT regeneration stabilisation and active thermal management
- Impact of calibration measures on CO₂ was below 3% on WLTC and RDE

**Urban NOx (mg/km)***

- Euro 6d-temp NTE
- Euro 6d NTE

**Transport for London cycle***

- Initial calibration: 216 mg/km
- Refined calibration: 47 mg/km
- 80% improvement
3-63 mg/km on the motorway

- 95-99% deNOx efficiency
- Main deNOx by dual-SCR
- Challenge is increase in engine-out emissions
Tailpipe NOx and deNOx efficiency summary

![Graph showing NOx emissions and deNOx efficiency across different average vehicle speeds.](image-url)
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Conclusions

- RDE requirements have ensured better control of NOx emissions under most EU driving conditions – these Euro 6d-temp cars are on the road today.

- This demo car shows that diesel NOx emissions can be kept at a very low level in a consistent way, over a wide range of driving conditions.

- Tailpipe NOx measured are 24-47 mg/km in the city and 3-63 mg/km on the motorway.

- This is achieved by combining existing catalyst technologies with improved emissions control functions supported by hybrid technology.
THANK YOU!

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