Low NOx emissions with modern diesel cars

Joachim Demuynck

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RDE legislation has improved real-world NOx emissions

- RDE entered into force on 1 September 2017 with Euro 6d-temp type-approval
- RDE requirements ensure that emissions are controlled over wider range of driving conditions
RDE legislation has improved real-world NOx emissions

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

Source: PEMS results from ACEA and JAMA RDE databases

Urban RDE tailpipe NOx in mg/km

pre-RDE vehicles

Euro 6d-temp vehicles available on the market

Total RDE tailpipe NOx in mg/km
RDE legislation has improved real-world NOx emissions

Reduction confirmed by independent testing
Light-duty diesel emissions control technology evolution
Towards combination of technologies in a compact design for RDE compliance

Source: Audi – Vienna Motor Symposium 2019

Source: Hyundai – Vienna Motor Symposium 2019
AECC-IPA-IAV ultra-low NOx emissions diesel demonstrator

Objective: demonstrate consistent low NOx emissions

- **Low speed/load**
  - e.g. city driving

- **High speed/load**
  - e.g. motorway driving

- **Transients**

Vehicle and powertrain characteristics

- Vehicle
  - C-segment
  - 1700 kg
- Drivetrain
  - Manual gearbox, 6-speed
  - 48 Volt mild-hybrid
- Engine
  - 1.5l, 4-cylinder, 2-valve
  - Exhaust Gas Recirculation (EGR)
- Euro 6b type-approval (LNT + DPF)
Emissions control technologies

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

EGR: Exhaust Gas Recirculation
HP/LP: High/Low pressure
cc: close-coupled
LNT: Lean NOx trap
ASC: Ammonia Slip Catalyst

Diagram:
- Engine-out components
- Close-coupled components for city driving
- Underfloor components for motorway driving

Graph:
- DeNOx performance
- Temperature downstream turbine
48V mild-hybrid support to emissions control

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

- To cut transient engine-out NOx peaks
- To support active thermal management
  - In addition to late post-injection in ICE when LNT>170°C & ccSCR<220°C
  - Throttle valve used when LNT<170°C
Consistent low NOx emissions were achieved
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

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**City driving**

<table>
<thead>
<tr>
<th>Component</th>
<th>NOx (mg/km)</th>
</tr>
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<tbody>
<tr>
<td>Engine-out</td>
<td>373</td>
</tr>
<tr>
<td>LNT</td>
<td>156</td>
</tr>
<tr>
<td>SCR + SDPF</td>
<td>187</td>
</tr>
<tr>
<td>SCR</td>
<td>0</td>
</tr>
<tr>
<td>Tailpipe</td>
<td>31</td>
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</table>

92% deNOx

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**Motorway driving**

<table>
<thead>
<tr>
<th>Component</th>
<th>NOx (mg/km)</th>
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</thead>
<tbody>
<tr>
<td>Engine-out</td>
<td>523</td>
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<tr>
<td>LNT</td>
<td>153</td>
</tr>
<tr>
<td>SCR + SDPF</td>
<td>305</td>
</tr>
<tr>
<td>SCR</td>
<td>45</td>
</tr>
<tr>
<td>Tailpipe</td>
<td>20</td>
</tr>
</tbody>
</table>

96% deNOx
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
3-63 mg/km on the motorway

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

![Graph showing NOx emissions at different vehicle speeds and stages of emission control systems](image)
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.
- Independent testing confirms low emissions of RDE compliant vehicles.
- AECC-IPA-IAV demonstrator 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.
- This is achieved by combining existing catalyst technologies with improved emissions control functions supported by hybrid technology.
Diesel Information Hub

https://dieselinformation.aecc.eu (now available in EN, FR, ES, IT; DE expected)
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