Workshop B1

Al Bustan Rotana Hotel, Harayer & Salsabeel


Chaired by Lothar Geilen

Member of CITA Bureau Permanent
Workshop B1

Presentation 1

**Sustainable Emission Test (SET)**

**Introduction of the Results of the Recent CITA Study**

— SET Project

Gerhard Müller

Policy Expert on Environmental Protection Systems, CITA
SET STUDY - AIMS

Field tests with diesel and petrol vehicles in different Member States as well as laboratory tests

Aims of the SET study:

1. Definition of suitable thresholds for PM-measurement and CO-measurement

2. Comparison of reading out OBD versus tailpipe emission test

3. Compiling a precise recommendation including a cost/benefit analysis for the European Commission to adjust the PTI directive
## 1. General Information

<table>
<thead>
<tr>
<th>Test centre</th>
<th>Diesel</th>
<th>Petrol</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With all necessary information</td>
<td>With all necessary information</td>
<td>Delivered data set</td>
</tr>
<tr>
<td>GOCA</td>
<td>412</td>
<td>350</td>
<td>763</td>
</tr>
<tr>
<td>DEKRA France</td>
<td>26</td>
<td>22</td>
<td>57</td>
</tr>
<tr>
<td>TUEV SUED</td>
<td>100</td>
<td>96</td>
<td>202</td>
</tr>
<tr>
<td>TUEV Nord</td>
<td>69</td>
<td>172</td>
<td>247</td>
</tr>
<tr>
<td>RDW</td>
<td>29</td>
<td>151</td>
<td>205</td>
</tr>
<tr>
<td>Applus</td>
<td>36</td>
<td>10</td>
<td>74</td>
</tr>
<tr>
<td>Certio</td>
<td>27</td>
<td>17</td>
<td>48</td>
</tr>
<tr>
<td>Itvasa</td>
<td>244</td>
<td>104</td>
<td>358</td>
</tr>
<tr>
<td>Syc</td>
<td>517</td>
<td>125</td>
<td>644</td>
</tr>
<tr>
<td>Itevelesa</td>
<td>109</td>
<td>99</td>
<td>210</td>
</tr>
<tr>
<td>Bilprovningen</td>
<td>44</td>
<td>21</td>
<td>65</td>
</tr>
<tr>
<td>Opus Bilprovning</td>
<td>85</td>
<td>228</td>
<td>316</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1698</strong></td>
<td><strong>1395</strong></td>
<td><strong>3189</strong></td>
</tr>
</tbody>
</table>
2. Thresholds

2.1 CO Thresholds

Petrol
All Euro classification vehicles: CO fast idle

<table>
<thead>
<tr>
<th>Category of CO values (%)</th>
<th>Number of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=0.05</td>
<td>1140</td>
</tr>
<tr>
<td>0.05&lt;CO&lt;=0.1</td>
<td>54</td>
</tr>
<tr>
<td>0.1&lt;CO&lt;=0.2</td>
<td>37</td>
</tr>
<tr>
<td>0.2&lt;CO&lt;=0.3</td>
<td>8</td>
</tr>
<tr>
<td>0.3&lt;CO&lt;=0.4</td>
<td>7</td>
</tr>
<tr>
<td>0.4&lt;CO&lt;=0.5</td>
<td>6</td>
</tr>
<tr>
<td>&gt;0.5</td>
<td>24</td>
</tr>
</tbody>
</table>

Possible limit: 0.05
Limit: 2010/48/EC

Conference and 17th General Assembly | 14-16th April | DUBAI U.A.E.
1.2 PM Thresholds

Diesel Euro 4 vehicles: $k$-values

<table>
<thead>
<tr>
<th>Category of $k$-values ($m^{-1}$)</th>
<th>Number of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 0.1$</td>
<td>359</td>
</tr>
<tr>
<td>$0.1 &lt; k \leq 0.2$</td>
<td>38</td>
</tr>
<tr>
<td>$0.2 &lt; k \leq 0.3$</td>
<td>55</td>
</tr>
<tr>
<td>$0.3 &lt; k \leq 0.5$</td>
<td>127</td>
</tr>
<tr>
<td>$0.5 &lt; k \leq 1.0$</td>
<td>200</td>
</tr>
<tr>
<td>$1.0 &lt; k \leq 1.5$</td>
<td>82</td>
</tr>
<tr>
<td>$&gt; 1.5$</td>
<td>142</td>
</tr>
</tbody>
</table>
1.3 PM THRESHOLDS

Diesel Euro 5 vehicles: k-values

Number of vehicles

Possible limit

Limit 2010/48/EC

Category of k-values (m⁻¹)

<=0.1 0.1<k<=0.2 0.2<k<=0.3 0.3<k<=0.5 0.5<k<=1.0 1.0<k<=1.5 >1.5

370 17 9 6 8 14 6

Conference and 17th General Assembly | 14-16th April | DUBAI U.A.E.
2. Comparison OBD – Tailpipe Test

2.1 CO measurement

Petrol - over all EURO classification

Number of vehicles

- Vehicles with DTCs
- Vehicles without DTCs

CO Fast idle (%) - category

<table>
<thead>
<tr>
<th>Category</th>
<th>Vehicles with DTCs</th>
<th>Vehicles without DTCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=0.01 CO</td>
<td>30</td>
<td>883</td>
</tr>
<tr>
<td>0.01&lt;CO&lt;=0.02</td>
<td>4</td>
<td>121</td>
</tr>
<tr>
<td>0.02&lt;CO&lt;=0.03</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>0.03&lt;CO&lt;=0.04</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>0.04&lt;CO&lt;=0.05</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>0.05&lt;CO&lt;=0.10</td>
<td>3</td>
<td>51</td>
</tr>
<tr>
<td>0.10&lt;CO&lt;=0.20</td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>0.20&lt;CO&lt;=0.30</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>0.30&lt;CO&lt;=0.40</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>0.40&lt;CO&lt;=0.50</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>&gt;0.50 CO</td>
<td>5</td>
<td>19</td>
</tr>
</tbody>
</table>
2.2 PM Measurement

Diesel - over all EURO classifications

Number of vehicles

- Vehicles with DTCs
- Vehicles without DTCs

<table>
<thead>
<tr>
<th>K-value category (m⁻¹)</th>
<th>Vehicles with DTCs</th>
<th>Vehicles without DTCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=0.1</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>0.1&lt;k&lt;=0.2</td>
<td>6</td>
<td>52</td>
</tr>
<tr>
<td>0.2&lt;k&lt;=0.3</td>
<td>10</td>
<td>58</td>
</tr>
<tr>
<td>0.3&lt;k&lt;=0.5</td>
<td>18</td>
<td>125</td>
</tr>
<tr>
<td>0.5&lt;k&lt;=1.0</td>
<td>40</td>
<td>185</td>
</tr>
<tr>
<td>1.0&lt;k&lt;=1.5</td>
<td>13</td>
<td>100</td>
</tr>
<tr>
<td>&gt;1.5</td>
<td>41</td>
<td>145</td>
</tr>
</tbody>
</table>
## 3. Implications of a New Emission Test

<table>
<thead>
<tr>
<th></th>
<th>Total tested vehicles</th>
<th>State of threshold</th>
<th>Threshold</th>
<th>Share of failed vehicles (%) only by exhaust emission testing</th>
<th>Share of failed vehicles (%) only by OBD testing</th>
<th>Share of failed vehicles (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All petrol – CO high idle (%)</td>
<td>1374</td>
<td>old</td>
<td>&gt;0.2</td>
<td>3.7</td>
<td>4.6</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td>1374</td>
<td>proposed</td>
<td>&gt;0.1</td>
<td>6.4</td>
<td>4.6</td>
<td>10.0</td>
</tr>
<tr>
<td>Diesel EURO 5 - k-value (m-1)</td>
<td>464</td>
<td>old</td>
<td>&gt;1.5</td>
<td>1.3</td>
<td>3.0</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>464</td>
<td>proposed</td>
<td>&gt;0.2</td>
<td>9.3</td>
<td>3.0</td>
<td>11.4</td>
</tr>
</tbody>
</table>
4. CONCLUSION

The SET study results clearly demonstrate, that emission controls for modern vehicles are maximally effective when:

- Both methods – **OBD and tailpipe testing** – are combined

- The **thresholds are adjusted** to the modern vehicle technology
  - PM: K-value for Diesel vehicle as of Euro 5: 0,2 m⁻¹
  - CO: Vol. % for Petrol vehicles as of Euro 4: 0,1 Vol. % high idle

- For customers **hardly any additional costs** arise

- The **benefit for the environment and health** is significantly.
Thank you for your attention.

Gerhard Müller
Policy Expert on Environmental Protection Systems
Phone:  +49 89 5791-2737
Fax:    +49 89 5791-2060
Mobile: +49 160 360 2840
Mail:   g.mueller@tuev-sued.de
NOx measurement for Diesel Euro 4/5/6 engine
NOx functional test: 1st field test campaign

- A functional test, based on NOx levels at IDLE and FAST IDLE, has been performed over 233 vehicles.
- Vehicles are flagged because of faulty behaviour of recycling system
- (EGR valves...)

EU directive position about NOx:

“Possibilities for improving test cycles to match on-road conditions should be closely examined in order to develop future solutions, including the establishment of test methods for the measurement of NOx levels and of limit values for NOx emissions.”

Because IDLE values are not reliable enough due to non homogenous vehicle’s manufacturer strategies
Valid test results cannot be considered in 4% of the use case.
NOx functional test: 2st Lab. Test campaign (Q1 2015)

Correlation between:

- Homologation test
- New PTI procedure functional test including Fast Idle & High RPM sequences based on tail pipe measurement (NOx) & EOBD dynamic values

Valid PTI procedure allows to flag faulty vehicle behavior of their anti NOx mechanism

Homologation cycle

- Euro 4
  - Zero default
  - EGR valve blocked open
- Euro 5
  - EGR valve blocked at 60 % closed
- Euro 6
  - EGR valve blocked at 80 % closed
- Euro 6 + SCR
  - EGR valve blocked at 100 % closed

Fast Idle + High RPM
Thank you for your attention.

Georges PETELET
Business Development CAPELEC
Phone: +33 (0)467 151 612
Fax: +33 (0)467 224 224
Mobile: +33 (0)672 994 120
Mail: georges.petelet@capelec.fr
Back up for discussion
Mean CO fast idle over Odometer

Mean CO fast idle over km-categories

<table>
<thead>
<tr>
<th>km-categories</th>
<th>Mean CO fast idle %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0&lt;x&lt;=50000</td>
<td>0.060</td>
</tr>
<tr>
<td>50000&lt;x&lt;=100000</td>
<td>0.040</td>
</tr>
<tr>
<td>100000&lt;x&lt;=150000</td>
<td>0.020</td>
</tr>
<tr>
<td>x&gt;150000</td>
<td>0.200</td>
</tr>
</tbody>
</table>
Mean k-value over Odometer

Mean Mean - k-values over km-categories

km-categories

Mean - k-values (m⁻¹)

0<\(x\)\leq50000

50000<\(x\)\leq100000

100000<\(x\)\leq150000

\(x\)\geq150000

Conference and 17th General Assembly | 14-16th April | DUBAI U.A.E.
Mean CO fast idle over vehicle age

The graph shows the mean CO fast idle values over different vehicle age categories. The categories are 0-3, 4-5, 6-7, and >7 years. The graph indicates a decrease in mean CO fast idle values as the vehicle age increases.
Mean k-values over vehicle age

<table>
<thead>
<tr>
<th>Vehicle age (year)</th>
<th>Mean k-values (m⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>0.00</td>
</tr>
<tr>
<td>4-5</td>
<td>0.20</td>
</tr>
<tr>
<td>6-7</td>
<td>0.60</td>
</tr>
<tr>
<td>&gt;7</td>
<td>1.40</td>
</tr>
</tbody>
</table>
Workshop B1

Presentation 2

**Performance of OBD Euro 6/VI**

Antonio Multari

Technical Expert Emissions at CITA and Vice Chairman of WG Diagnostics & Emissions at ASA and Sales Director Export, MAHA, Germany
Performance of OBD Euro 6VI

Workshop B1 - Priorities for new testing procedures – Testing Emission Systems

By Antonio Multari, Technical Expert Emissions at CITA and Vice Chairman of WG Diagnostic & Emissions at ASA and Sales Director Export at MAHA
Performance of Euro 6 / VI

Agenda

- Legal Background
- Types of Monitor
- Circuit Continuity Checks
- Rationality Checks
- System Checks
- OBD Tampering and DPF Removal
- Summary
Performance of Euro 6 / VI

Introduction

EURO 5-6 SPARK IGNITION EMISSION LIMITS

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Unit</th>
<th>PC M 1) LDT N1 CL 1</th>
<th>LDT N1 CL 2</th>
<th>LDT N1 CL 3, N2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Euro 5a</td>
<td>Euro 5b/b+</td>
<td>Euro 6b</td>
</tr>
<tr>
<td>THC</td>
<td>mg/km</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>NMHC</td>
<td></td>
<td>68</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>NOx</td>
<td></td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>CO</td>
<td></td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>PM 2)</td>
<td></td>
<td>5,0</td>
<td>4,5</td>
<td>4,5</td>
</tr>
<tr>
<td>PN # 3)</td>
<td>Nb/km</td>
<td>-</td>
<td>-</td>
<td>6,0 * E11 4)</td>
</tr>
</tbody>
</table>

1) No exemption for gasoline Passenger Car  2) Applicable to gasoline DI engines only  3) Test procedure defined in UN Reg 83 Suppl 7  4) Until 3 years after the dates for type approval / 1st registration particle emission limit of 6,0 x E12 may be applied to Euro 6 spark ignition DI vehicles upon request of manufacturer

EURO 5-6 COMPRESSION IGNITION EMISSION LIMITS

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Unit</th>
<th>PC M 1) LDT N1 CL 1</th>
<th>LDT N1 CL 2</th>
<th>LDT N1 CL 3, N2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Euro 5a</td>
<td>Euro 5b/b+</td>
<td>Euro 6b / 6c</td>
</tr>
<tr>
<td>NOx</td>
<td>mg/km</td>
<td>180</td>
<td>180</td>
<td>80</td>
</tr>
<tr>
<td>HC+NOx</td>
<td></td>
<td>230</td>
<td>230</td>
<td>195</td>
</tr>
<tr>
<td>CO</td>
<td></td>
<td>500</td>
<td>500</td>
<td>630</td>
</tr>
<tr>
<td>PM 2)</td>
<td></td>
<td>5,0</td>
<td>4,5</td>
<td>4,5</td>
</tr>
<tr>
<td>PN #</td>
<td>Nb/km</td>
<td>-</td>
<td>6,0 * E11 4)</td>
<td>6,0 * E11 4)</td>
</tr>
</tbody>
</table>

1) Exempted M1 vehicles have to comply with N1CI3 test I emissions limits - No more exemption for passenger cars from Euro 6  2) Test procedure defined in UN Reg 83 Suppl 7

Source: DELPHI
Performance of Euro 6 / VI Implementation Dates

EURO 5-6 IMPLEMENTATION ROADMAP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M, N1 CI I</td>
<td>TA</td>
<td>Euro 5b OR Euro 5b+ 01 Sep 2011</td>
<td>Euro 6b 01 Sep 2014</td>
<td>Euro 6c 01 Sep 2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FR</td>
<td>Euro 5a</td>
<td>Euro 5b</td>
<td>Euro 5b+</td>
<td>Euro 6b 01 Sep 2015</td>
<td>Euro 6c 01 Sep 2018</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N1 CI II, III, N2</td>
<td>TA</td>
<td>Euro 5b OR Euro 5b+ 01 Sep 2011</td>
<td>Euro 6b 01 Sep 2015</td>
<td>Euro 6c 01 Sep 2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FR</td>
<td>Euro 5a</td>
<td>Euro 5b</td>
<td>Euro 5b+</td>
<td>Euro 6b 01 Sep 2016</td>
<td>Euro 6c 01 Sep 2019</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Durability Requirements starting Euro 5: 160,000 km
Assigned Euro 5 DFs: PI: CO: 1,5; THC and NMHC: 1,3; NOx: 1,6; PM: 1,0
CI: CO: 1,5; NOx and THC+NOx: 1,1; PM/PN: 1,0
Alternatives: Calculated DFs based on Standard Road Cycle (SRC)
Test ageing bench: PI based on Standard Bench Cycle (SBC)
CI based on Standard Diesel Bench Cycle (SDBC)

Assigned Euro 6 DFs: PI: no change
CI: TBD
Or certification with aged (or rapid aged) exhaust system mandatory (t.b.c.)

In-Service Conformity
Up to 100,000 km or 5 years

Low Temperature Test (-7°C)
No change on positive igniton vehicles.
Compression ignition: Demonstration at TA of
- Performance of NOx aftertreatment device reaching sufficiently high temperature for efficient operation within 400 sec after a cold start (-7°C)
- Operation strategy of the EGR including its functioning at low temperature
- Potential introduction of NOx limitation (Gasoline & Diesel) with Euro 6c (t.b.c.)
- A reduction of HC and CO limits with Euro 6c (t.b.c.)

Evaporative emissions (see page 83)

Source: DELPHI
# Performance of Euro 6 / VI

## Euro 5 & 6 Regulation

**EURO 5 & 6 REGULATION**

### Main additional requirements - Compression Ignition Engines

<table>
<thead>
<tr>
<th>Used cycle</th>
<th>Euro 5a</th>
<th>Euro 5b</th>
<th>Euro 5b+</th>
<th>Euro 6-1</th>
<th>Euro 6-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEDC</td>
<td>M1 Vehicles with Ref. Mass &gt; 2000kg to carry at least 7 occupants</td>
<td>Special purpose M1 vehicles (ambulance, motor caravan, ..) with Ref.</td>
<td>M1 Vehicles with Ref. Mass &gt; 1750kg built specifically to accommodate wheelchair use inside the vehicle</td>
<td>No more exemption</td>
<td>NEDC &amp; RDE</td>
</tr>
</tbody>
</table>

| Emissions | | | | | |
|------------|-----------------|-----------------|-----------------|-----------------|
| HC+NOx=230mg/km; NOx=180mg/km; CO=500mg/km | PM=5mg/km | PM=4,5mg/km (Revised method) | CO=1750mg/km; NMHC=290mg/km; NOx=180mg/km | CO=1750mg/km; |
| PM=4,5mg/km | PN=6*10 E 11 Nb/km | PN=6*10 E 11 Nb/km | PM=25mg/km | |
| DFs: CO=1,5; NOx=1,1; NOx+THC=1,1; PM=1; PN=1 | Dfs: under discussion | |

<table>
<thead>
<tr>
<th>OBD thresholds</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PM=50mg/km except for vehicles with RM&gt;1760kg (80mg/km)</td>
<td>PM=50mg/km</td>
<td>NMHC=290mg/km; NOx=140mg/km; PM=12mg/km</td>
<td>IUPR ≥ 0,1 to be confirmed</td>
<td>IUPR ≥ 0,336 to be confirmed</td>
</tr>
</tbody>
</table>

- **CO**
- **HC**
- **NO**
- **NOx**
- **THC**
- **PM**
- **PN**
- **DFs**
- **NMHC**
- **IUPR**

For the moment, European Commission does not work on Euro 7 regulations. No official and validated information are available yet. Note that only main subjects are listed - some other differences exist between the different emissions targets.

*Source: DELPHI*
Performance of Euro 6 / VI
EOBD Thresholds

<table>
<thead>
<tr>
<th>Category</th>
<th>Class</th>
<th>PI</th>
<th>CI</th>
<th>PI</th>
<th>CI</th>
<th>PI</th>
<th>CI</th>
<th>PI</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>-</td>
<td>1900</td>
<td>1750</td>
<td>170</td>
<td>290</td>
<td>15</td>
<td>180</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>N₁</td>
<td>I</td>
<td>1900</td>
<td>1750</td>
<td>170</td>
<td>290</td>
<td>150</td>
<td>180</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>3400</td>
<td>2200</td>
<td>225</td>
<td>320</td>
<td>190</td>
<td>220</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>4300</td>
<td>2500</td>
<td>270</td>
<td>350</td>
<td>210</td>
<td>280</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>N₂</td>
<td>-</td>
<td>4300</td>
<td>2500</td>
<td>270</td>
<td>350</td>
<td>210</td>
<td>280</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Additional requirement starting Euro 5+:
In Use Performance Ratio Monitoring (IUPR)

IUPR indicates how often a specific monitor is operating relative to vehicle operation.

\[
\text{IUPR} = \frac{\text{Numerator}_m}{\text{Denominator}_m}
\]

Numerator\(_m\) measures number of times a monitoring function has run and a malfunction could have been detected.
Denominator\(_m\) measures the number of vehicle driving events taking into account special conditions.

Euro 5+:
- IUPR \(\geq 0.1\) for all monitors
- Euro 6- plus IUPR: IUPR \(\geq 0.1\) for all monitors
- Euro 6: IUPR \(\geq 0.260\) for secondary air system monitors and other cold starts related monitors
- IUPR \(\geq 0.1\) for DeNOx aftertreatment device using reagent and dosing systems (Euro 6-2 only)
- IUPR \(\geq 0.520\) for evaporative purge control monitor
- IUPR \(\geq 0.336\) for all other monitors
- Monitoring of total failure or removal for Diesel particulate filter and Doc

Separate IUPR reporting for:
- Catalysts
- Exhaust gas sensors
- Particulate filter
- VVT system
- Evap system
- EGR system
- Secondary air system
- NOx aftertreatment
- Boost pressure control system

<table>
<thead>
<tr>
<th>Category</th>
<th>Implementation Dates</th>
<th>CO</th>
<th>NMHC</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>M, LDT N1 CL1</td>
<td>01 Sep 2017, 01 Sep 2018</td>
<td>1.900</td>
<td>1.750</td>
<td>170</td>
<td>290</td>
</tr>
<tr>
<td>LDT N1 CL 2</td>
<td>01 Sep 2018, 01 Sep 2019</td>
<td>3.400</td>
<td>2.200</td>
<td>225</td>
<td>320</td>
</tr>
<tr>
<td>LDT N1 CL 3, N2</td>
<td>01 Sep 2018, 01 Sep 2019</td>
<td>4.300</td>
<td>2.500</td>
<td>270</td>
<td>350</td>
</tr>
</tbody>
</table>

Source: DELPHI
Performance of Euro 6 / VI
Euro VI OBD Legal Background

EURO VI Introduction Dates:
- Date for type approval of new types of vehicles or engines: 31.12.2012
- Date for registration of new vehicles: 31.12.2013

References:

Source: Daimler AG

WWH-OBD: World Wide Harmonized On-Board-Diagnostic
### Performance of Euro 6 / VI

**WWH-OBD Systems**

**EUROPEAN UNION**

**EURO IV** - Dir 88/77/EC as amended by Dir 1999/96/EC, Dir 2005/55/EC, Dir 2005/78/EC and Dir 2006/51/EC
- Diesel engines are tested on ESC, ELR and ETC cycles if required (see pages 14-15)
- Gas engine are tested on ETC cycle

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Euro IV</th>
<th>Euro IV - EEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESC/ELR</td>
<td>ETC</td>
</tr>
<tr>
<td></td>
<td>Diesel only</td>
<td>Diesel &amp; Gas</td>
</tr>
<tr>
<td>CO</td>
<td>1,5</td>
<td>4,0</td>
</tr>
<tr>
<td>HC</td>
<td>0,46</td>
<td>0,25</td>
</tr>
<tr>
<td>NMHC</td>
<td>-</td>
<td>0,55</td>
</tr>
<tr>
<td>CH₄¹⁾</td>
<td>-</td>
<td>1,1</td>
</tr>
<tr>
<td>NOx</td>
<td>3,5</td>
<td>3,5</td>
</tr>
<tr>
<td>PM</td>
<td>0,02</td>
<td>0,03²⁾</td>
</tr>
<tr>
<td>Smoke</td>
<td>0,5</td>
<td>0,15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Euro V</th>
<th>Euro V - EEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESC/ELR</td>
<td>ETC</td>
</tr>
<tr>
<td></td>
<td>Diesel Only</td>
<td>Diesel &amp; gas</td>
</tr>
<tr>
<td>CO</td>
<td>1,5</td>
<td>4,0</td>
</tr>
<tr>
<td>HC</td>
<td>0,46</td>
<td>0,25</td>
</tr>
<tr>
<td>NMHC</td>
<td>-</td>
<td>0,55</td>
</tr>
<tr>
<td>CH₄¹⁾</td>
<td>-</td>
<td>1,1</td>
</tr>
<tr>
<td>NOx</td>
<td>2,0</td>
<td>2,0</td>
</tr>
<tr>
<td>PM</td>
<td>0,02</td>
<td>0,03²⁾</td>
</tr>
<tr>
<td>Smoke</td>
<td>0,5</td>
<td>0,15</td>
</tr>
</tbody>
</table>

¹⁾ For natural gas engines only
²⁾ Not applicable for gas fuelled engines - Euro IV Stage

**EURO V** - Dir 2005/55/EC + Dir 2005/78/EC amended by Dir 2006/51/EC + Dir 2008/74/EC
For TA and for EEV’s, ETC and ESC/ELR tests are applicable (see pages 14-15)

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Euro V</th>
<th>Euro V - EEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESC/ELR</td>
<td>ETC</td>
</tr>
<tr>
<td></td>
<td>Diesel Only</td>
<td>Diesel &amp; gas</td>
</tr>
<tr>
<td>CO</td>
<td>1,5</td>
<td>4,0</td>
</tr>
<tr>
<td>HC</td>
<td>0,46</td>
<td>0,25</td>
</tr>
<tr>
<td>NMHC</td>
<td>-</td>
<td>0,55</td>
</tr>
<tr>
<td>CH₄¹⁾</td>
<td>-</td>
<td>1,1</td>
</tr>
<tr>
<td>NOx</td>
<td>2,0</td>
<td>2,0</td>
</tr>
<tr>
<td>PM</td>
<td>0,02</td>
<td>0,03²⁾</td>
</tr>
<tr>
<td>Smoke</td>
<td>0,5</td>
<td>0,15</td>
</tr>
</tbody>
</table>

Source: DELPHI
Performance of Euro 6 / VI
WWH-OBD Systems

EURO VI (Reg EC No: 595/2009 and implementing regulations (EU) No 582/2011 and 64/2012)
Scope: M1, M2, N1, N2 with RM > 2.610 kg
Application dates: TA 31DEC12 - FR 31DEC13

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>THC</th>
<th>NMHC</th>
<th>CH4</th>
<th>NOx</th>
<th>NH3</th>
<th>PM Mass</th>
<th>PM Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/kWh</td>
<td>ppm</td>
<td>mg/kWh</td>
<td>#/kWh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHSC (C.I.)</td>
<td>1.500</td>
<td>130</td>
<td></td>
<td></td>
<td>400</td>
<td>10</td>
<td>10</td>
<td>8.0 x 10^{11}</td>
</tr>
<tr>
<td>WHTC (C.I.)</td>
<td>4.000</td>
<td>160</td>
<td></td>
<td></td>
<td>460</td>
<td>10</td>
<td>10</td>
<td>6.0 x 10^{11}</td>
</tr>
<tr>
<td>WHTC (P.I.)</td>
<td>4.000</td>
<td>160</td>
<td>500</td>
<td></td>
<td>460</td>
<td>10</td>
<td>10</td>
<td>3)</td>
</tr>
</tbody>
</table>

Regulation covers:
- Only world harmonized driving cycles (WHTC, WHSC) are applicable as defined in ECE Regulation Annex 4B.
- Reference fuel specifications for Diesel (B7); Ethanol (ED95) (see pages 58)
- Access to vehicle OBD and vehicle repair and maintenance information.
- Off-cycle laboratory testing and vehicle testing of engines at type approval.

C.I. Compression Ignition
P.I. Positive Ignition
WHSC, WHTC (see pages 2-3)

1) Admissible level of NOx may be defined later
2) Measurement procedure to be introduced at a later date
3) Particle number limit and date of implementation not confirmed yet

Source: DELPHI
Performance of Euro 6 / VI
Types of Monitors

OBD Monitors can roughly be classified into three different groups

Circuit Continuity Checks
- Strictly component related
- Detection of electrical short cut and open load

Rationality Checks
- Component related
- Detection of sensor signal drifts and false actuator response

System Checks
- System related
- Monitoring of performance of (sub-)systems

Source: Daimler AG
Performance of Euro 6 / VI Circuit Continuity Checks

Scope of Circuit Continuity Checks is the detection of electrical failures (short cut to ground / to battery and broken wire).

- For most sensors and actuators signal range high / low checks are possible

Special Cases

- Smart sensors and actuators:
- Failure detection in sensor / actuator ECU → failure is communicated via CAN; ECU evaluates failure message

Source: Daimler AG
Performance of Euro 6 / VI
Rationality Checks

Scope of rationality checks

Sensors:
- Detection of sensor offsets or drifts. I.e. the measured signal is within the limits of the value/voltage look-up table. Detection of drifted high, drifted low, stuck in range is required

Actuators:
- Detection of in-correct response of the actuator. The check is a functional check and does not need to monitor the exact actuator behavior and is not linked with an emission threshold

Basic Principles:
- Usage of partial redundancies with other sensors
- Modelling of expected sensor values
- Modelling of expected actuator response

<table>
<thead>
<tr>
<th></th>
<th>Circuit Continuity</th>
<th>Rationality</th>
<th>System</th>
<th>Σ MUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>138</td>
<td>40</td>
<td>19</td>
<td>197</td>
</tr>
<tr>
<td>Aftertreatment System</td>
<td>77</td>
<td>27</td>
<td>15</td>
<td>119</td>
</tr>
</tbody>
</table>

Source: Daimler AG
Performance of Euro 6 / VI
System Checks

Scope of System Checks

The system checks shall monitor the overall performance of a (sub-) system.

Basic Principles:

- Several system checks are linked with OBD thresholds
- Monitoring is indirect, i.e. we do not directly monitor PM or NO\textsubscript{x} - emissions but monitor characteristic system values like temperatures, pressures etc. and correlate the deviation from the expected behavior with emissions on the test cycle.
Performance of Euro 6 / VI
OBD Tampering and DPF Removal

Websites for OBD/DPF Manipulation:

Cheat OBD Emissions Test

Cheat OBD Test

Cheat OBD Codes
http://www.cesenatico5stelle.it/wiki5st/index.php?title=Obd_2_code_cheats_download_fast_TKwS
http://www.deichcamp.de/index.php/Obsd_2_cheats_download_free_fast_KYqu

Diesel Particulate Filter Removal
http://www.ecuflash.co/dpf-removal/
http://www.tdperformance.co.uk/dpf-removal/
http://www.evolutionchips.co.uk/Diesel_Particulate_Filter_Removal_DPF.html
http://www.youtube.com/watch?v=7bXxXn3nL60

Source: Internet and DREW Technologies
Performance of Euro 6 / VI
Summary

For an Environmental effective Diesel and Petrol Emission Test it is necessary to have a modern Mechatronic System.

OBD + Tail Pipe = is the Ultimate Diesel and Petrol Emission Test System for an 100% PTI or garage test for Diesel and Petrol Emissions.

Especially for modern diesel-powered vehicles equipped with a emission after treatment system such as a diesel particulate filter, SRC, SRCT,…, only this combination of tests ensure the effectiveness of the emission test during PTI.

The above mentioned measuring instruments are available today.
Performance of Euro 6 / VI

Thank you for your attention!

MAHA Maschinenbau Haldenwang
GmbH & Co. KG
Hoyen 20
87490 Haldenwang
Germany

Telefon: +49 (0)8374-585-0 (-123)
Telefax: +49 (0)8374-585-497
Mobil: +49 (0)176 11585049
Internet: http://www.maha.de
E-Mail: antonio.multari@maha.de

Member of MAHA-Group

Antonio Multari
Director Project Management &
Sales Manager Export
Workshop B1

Presentation 3

PTI For EURO 5 AND 6 VEHICLES

Klaus Schulte

AVL DiTEST, Austria
PTI FOR EURO 5/V AND EURO 6/VI VEHICLES

Klaus Schulte
PTI FOR EURO 5/V AND EURO 6/VI VEHICLES

• New communication protocols
• Very low emission values
• Engines that do not reach the real cut of speed at free acceleration test.
• ...

These were only a few particularities of Euro 5/V and Euro 6/VI vehicles.

How to deal with these vehicles during PTI?
Europe: Since the European Direction 2010/48 the value of the manufacturers plate has to be taken as reference.

Plate values of 0,1 or 0,2 for modern Diesel engines are no rarity.

The max. calibration tolerance for approving / calibrating opacimeter is higher than the reference value.
Smoke meters are able to deal with EURO 5/V & EURO 6/VI vehicles

- Independent PTB study states that actual opacimeter are able to measure k-values of 0,05
- Tolerance for calibration error has to be reduced
- No expensive refurbishing of test equipment necessary
New OBD standard, called WWH-OBD, for EURO VI trucks
WWH-OBD includes ISO protocols as well as SAE J1939 Protocol.
New communication protocols and new kind of plug.
PTI FOR EURO 5/V AND EURO 6/VI VEHICLES

Professional OBD scan tools are able to deal with these new requirements.
Only a software update of existing tools is required.
Adapter (plug) already available

WWH-OBD is no problem for professional scan tools
EURO 5/V and EURO 6/VI engines do not reach the full cut off speed during free acceleration test.

“Low” cut off speed means less exhaust

Actual limits values were not sufficient for these kind of vehicles!
Vehicles with reduced cut off speed can be measured

- No change on the emission procedure required.
- No change in measurement technology required.
- Reducing the limit value for vehicles with cut off speed limitation to 0,2m$^{-1}$.

$k = 0,2$ m$^{-1}$
Particulate filters generally reduce the power of engines and may get blocked, especially in urban regions.
- Cost for changing the particulate filter > 1500 Euros
- Rising market for removing the particulate filter (cost < 300 Euros)
Detecting a removed particulate filters is possible using the emission test.
- Test procedure „Free Acceleration“
- Reduced Limit Value

\[ k = 0.2 \text{ m}^{-1} \]
NEW EURO 6 trucks have new types of exhaust pipes
No possibility to enter the exhaust probe!

Actually no solution for measuring exhaust on EURO 6 trucks
Summary:

- Actual available measuring instrument were able to deal with EURO 5/6 vehicles.
- Only small changes regarding limit values necessary
- Tailpipe test is the only possibility to detect DPF manipulation
Workshop B1

Presentation 4

THE MOVE FROM TAILPIPE TO OBD TESTING

Darrin Greene

CEO Applus+ Technologies, USA
OBDII Inspections in the U.S. & Advantages of OBDII

Presented by:

Darrin Greene
Applus Technologies, Inc.

April 2015
OBD was developed in 1989 by the California Air Resources Board as a way to inform motorists of problems with emissions control system components in their vehicles.

Problems are indicated visually when the vehicle’s “Check Engine” light is illuminated.

Education about the Check Engine light is the single best emissions control program:

- By servicing your vehicle immediately, you save on expensive repairs and fuel costs, AND prevent or reduce excessive emissions.

- The Check Engine light only illuminates when emissions are approximately 1.5 times higher than the certification level. It is not a maintenance indicator (for oil changes, etc.).

- If the light is on and the vehicle is within the warranty period, the manufacturer must perform any repairs necessary to make the light go out at no charge to the vehicle owner.
There are approximately 35 vehicle inspection programs in the U.S.

All U.S. inspection programs (except CA and CO) are exclusively performing OBDII inspections on 1996 and newer vehicles.

More than half are only performing OBDII inspections (and no other inspection types) due to the following:

- The cost of the testing equipment is low.
- Significantly less time is required to perform the OBDII inspection.
- The vast majority of vehicles on the road today that require an inspection are OBD compliant.
- The overall cost to perform the test is lower.
- The test can be performed anywhere, wirelessly.
In the U.S., OBD is present on:
- 1996 and newer light-duty gasoline-powered vehicles
- 1997 and newer light-duty diesel-powered vehicles
- 2008 and newer medium-duty diesel-powered vehicles
- 2014 and newer heavy-duty diesel-powered vehicles

Starting in 2014, all on-road vehicles introduced in the U.S. were required to be OBDII equipped.

OBDII is a standardized way to inspect vehicles:
- Standardized connector, usually under the dash
- Standardized “generic” communications

The OBDII testing system indicates when the OBD device has checked that the emissions control system of the vehicle is ready for inspection.

Failures reports provide “diagnostic trouble code(s)” which aid in determining the repairs needed by the motorist.
OBDII Background

- The OBDII inspection is “digital” so there is an electronic “fingerprint” which is used to detect fraud.
- The fingerprint of most U.S. vehicles is known.
- 2005 and newer vehicles even transmit their VIN.
- The OBDII test is NOT subjective; computers decide when the vehicle passes or fails, and when repairs are effective.
- OBDII not only measures hot running tailpipe emissions, but also start and evaporative emissions; therefore studies have shown that emissions reductions achieved by OBDII testing are greater than with tailpipe tests.
- New technology vehicles are so clean that tailpipe tests cannot measure the emissions the newer vehicles.
- OBDII lets motorists know if a component is about to fail.
“Analyzer” is now simple and cost effective:
- Tablet, with blue tooth, a camera and Wi-Fi
- OBD scan tool - wired or wireless
- Inspection report printer
- Bar code reader - if the tablet camera is not used
- Cart

OBDII is a great solution for testing diesels. Opacity measurements are only good for public perception (they reduce visible smoke); however studies show that smoke repairs cause increases in small (more lethal) particles. Repairs of diesels which fail the OBDII test do not have this problem.
Performing the OBDII test takes less than five minutes!

The test procedure includes determining that the Check Engine light on the dashboard works properly.

- **Key On Engine Off ("KOEO")**: The light does not illuminate when the engine is off/not running.
- **Key On Engine Running ("KOER")**: The light illuminates briefly when the engine is turned on, then goes off.

**Locate the Diagnostic Link Connector ("DLC").**

- There are photographs to assist with locating the DLC.

**Plug the OBD device into the DLC.**
OBDII Test Process

- The inspector initiates the test from the OBD testing system, causing the OBD device to communicate with the vehicle’s on-board computer.

- The OBD device inquires to determine whether the vehicle is ready to be tested.

- Then the OBD device checks the vehicle’s emissions control system to determine if all components are working properly.

- After the inquires, the OBD testing system prompts the inspector to disconnect the OBD device from the vehicle’s DLC.
Advantages to OBDII & Future Improvements

- OBDII inspection systems can be automated to detect and block fraudulent testing.
- Minimal skill is required of the inspector in order to perform the OBDII test.
- Future OBD technology may be even more motorist friendly:
  - Remote OBDII
    - Can be installed on in-use vehicles as an option. Many new vehicles are already equipped for monitoring by the manufacturer.
  - Self-service OBDII inspection kiosks
    - Can be accessible 24 hours a day, every day
  - Data logging OBDII
    - Plug in, drive for a week and return
    - Can be done in parallel with insurance monitoring
INTRODUCTION TO MONITORING AND ENFORCEMENT OF LIGHT-DUTY AND HEAVY-DUTY VEHICLE EXHAUST EMISSIONS WITH REMOTE SENSING DEVICES

Jim Sands
Opus Inspection, USA
Introduction to Monitoring and Enforcement of Light-Duty and Heavy-Duty Vehicle Exhaust Emissions with Remote Sensing Services

CITA General Assembly – Dubai 2015

Jim Sands, Opus Inspection
How does Remote Sensing Services (RSS) Operate?

**Primary Applications:**
- High-Emitter screening for penalty or re-inspection.
- Low-Emitter screening for exemption from periodic emissions inspection.
- Fleet emissions analysis and evaluation of the periodic emissions inspection programs.

**Other Applications:**
- Gross Liquid Leak Detection
- Fraudulent Emissions Inspection Detection
- Fleet Emissions Deterioration Studies
- On-board Diagnostic System Verification
- Vehicle Emissions Inventory and Model Development

1. **Lasers**
   - Tires cross to measure vehicle speed and acceleration

2. **Mirror**
   - Returns beams to detector
   - S/A Detector Lasers

3. **Camera**
   - Captures license plate image
   - Infrared light beams to mirror

4. **Wireless Computer**
   - Receives exhaust gaseous and particulate readings and vehicle evaporative emissions levels remotely.

**Less Pollution**
**Convenient**
**On-Road Data**

AccuScan®
ETEST Regional Cloud Servers

1. Select Sites
   - A high quality on-road site network is maintained.

2. Collect Data
   - Real-time validated data is uploaded to cloud-based servers.

3. Read Plates (CLOUD)
   - Optical Character Recognition software reads license plate images.

4. Merge Vehicle Info
   - Year, Make, Model, etc. is retrieved from govt. vehicle registry and merged with emissions.

5. Review Data (CLOUD)
   - Data is quality-reviewed by automated software algorithms.

6. Screen Candidates (CLOUD)
   - Automated algorithms continuously identify candidates according to program rules (i.e., Low Emitters (LE), High Emitters (HE), Gross Liquid Leakers (GLL), Smoky Vehicles (SV)).

7. Send Notices
   - Notices are sent via email, mail, or with registration to HEs, GLLs, SVs, and LEs.

8. Redeem Clean Screens
   - Low emitter recipients redeem their "Clean Screen" option with payment (~equivalent to station inspection fee).

9. Manage Cases
   - Oversight agencies are provided secure interface for Total Screen program oversight.

10. Analyze Data
    - Oversight agencies may request analyses and reports: Fleet Emissions Surveys, Inspection Program Evaluations, OBD Verification, Modeling/Inventories, Inspection Station Audits.

Quality Certified Emissions Data:
- Remote Sensing System
- Accuracy/Precision Audits
- Site Productivity & Performance Evaluations
- Screening and Analysis Dataset Validation

Cloud-Based Data Management:
- Quick Start-Up, Easily Scalable
- Secure, High-Speed Access from any Internet Location
- High Availability
How is RSS Deployed?
Mobile Attended
How is RSS Deployed?
Fixed Installed Unattended Deployment

Camera System
RSS Cabinet
Analyzer Module
Reflector Module
How is RSS Deployed?

Mobile Unattended
Seamless compliment to existing emissions testing programs.

- Secure, certified and accessible
  - Data stored in cloud
  - ETEST Certified data validity
  - Remote Sensing Services Process Certified ISO 17020 (in progress)
  - Accessible to Agencies

- Turnkey Solution
  - Complete services leased as turnkey solutions
  - Ongoing annual projects
RSS Applications

On-Road Enforcement

- Clean Screening
- High Emitter
- LEZ Access

On-Road Monitoring

- Fleet Characterization
- Program Evaluation
“Universal” I / M

Maintenance 20% → Inspection 100%

80% ← Inspection
I / M with Total Screen

- RSD
- Maintenance
- Inspection Station
- On Road RSS

20%
70%
30%
Use of remote sensing services as a control tool for Low Emission Zones (LEZ)

Rapid access control by on-road emission measurement in the LEZ

Eliminates the need for traditional stickers as the remote sensing measures on-road emissions real time when vehicles are in normal operating conditions.
Additional Value of On-Road Monitoring

Profile Vehicle Fleet Emissions
- Segment Classes & Highlight Principle Mobile Sources
- i.e. India, Chile (Days)

Evaluate Emissions Program Performance
- Compare Tested to Untested
- i.e. Virginia, Switzerland (Months)

Inventory Vehicle Fleet Emissions
- Compare Computer Model to Real-World
- i.e. Colorado (8M/yr.), China (Years)
How is HD RSS Deployed?

Mobile Attended (HDV)
Why the Interest in HDV Emissions?

- **Public**: “What are you doing about those trucks?
- **Modelers**: HDV contribution is growing.
- **Regulators**: Major new HDV vehicle regs adopted
Boston Bus Inspection Program (MBTA)

1. Efficient as an In-House Testing Protocol for Buses (1000/day):
   1. **Drivers** have learned to use RSD → Consistent & Reliable RSD data.
   2. **Mechanics** used Bus Emissions Summary Reports → Repairs.

2. Value of Public Reporting Recognized:

6 of 8 Depots

2 of 8 Depots
Effect of Maintenance

CNG Bus 6004 Repair Results

HC g/bhp-hr

NOx g/bhp-hr

Replaced O₂ Sensor

Friday Monday
Getting the Emissions Picture

N = 1,000 (Day)
Getting the Emissions Picture

N = 10,000 (Week)
Getting the Emissions Picture

N = 100,000 (2 Months)
Getting the Emissions Picture

N = 1,000,000 (1 Year)
Summary – Remote Sensing Services

- Total screen program is easy to implement, can be seamlessly added to existing programs;
- Certified results, fully controlled via cloud server, not by operator
- Pass/Fail results and additional values such as:
  - high emitter identification
  - liquid leakers
  - fleet characterization
- Easy access to data for authorized users via the internet.