Worldwide Harmonized Heavy Duty Emissions Certification Procedure

58th GRPE, Geneva, 11 June 2009
General Overview

- WHDC approval of document ECE/TRANS/WP.29/GRPE/10 achieved with respect to the following major elements
  - Option 1: New structure of § 6.3 (engine power) and new Annex 7
  - Option 5: PM measurement
  - New structure of § 7 (test procedures)
  - Introduction of analyzer drift correction
  - Provisions on crankcase gases

- WHDC could not reach agreement on the following aspects of Document ECE/TRANS/WP.29/GRPE/10
  - Option 2: USA disagreement with Annex 2
  - Options 3 and 4: test results not fully available, further discussion after GRPE 58 will be needed
  - Dilution air temperature
Option 1 – Principles

- **General engine installation**
  Engine to be tested only with the auxiliaries or equipment listed in Annex 7. Other auxiliaries/equipment should be removed.

- **Auxiliaries/equipment required for the emissions test**
  If auxiliaries/equipment required for the test are not fitted, their power shall be subtracted from engine power.

- **Auxiliaries/equipment not required for the emissions test**
  If auxiliaries/equipment not required for the test are fitted, their power may be added to engine power.

- **Calculation of reference and actual cycle work must take into account auxiliaries/equipment power, if these are not fitted according to the list of Annex 7**
Option 2 - Reference Fuel

- Introduction of average reference fuel that covers national reference fuel specifications (Annex 2) is not supported by EPA
- Possible alternatives to be decided by GRPE
  - go back to original gtr with 3 reference fuels (USA, EU, Japan)
  - widen specs of Annex 4 and allow CP’s to apply tighter specs
- Test results on engine 2 (US07 engine) were presented by JRC
- Test results of SwRI program (US10 like engine) were presented by EMA
- Overall, influence of fuel on emissions was demonstrated to a more or lesser degree (depending on engine technology), which would not preclude acceptance of average reference fuel
Option 2 – EMA/SwRI NOx Results

<table>
<thead>
<tr>
<th></th>
<th>Morning</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Stdev</td>
<td>CVar</td>
<td>Average</td>
<td>Stdev</td>
</tr>
<tr>
<td>EU</td>
<td>0.119</td>
<td>0.0176</td>
<td>14.7%</td>
<td>0.151</td>
<td>0.0043</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.190</td>
<td>0.0129</td>
<td>6.8%</td>
<td>0.135</td>
<td>0.0145</td>
</tr>
<tr>
<td></td>
<td>0.095</td>
<td>0.0039</td>
<td>4.1%</td>
<td>0.148</td>
<td>0.0075</td>
</tr>
<tr>
<td>EU</td>
<td>0.117</td>
<td></td>
<td></td>
<td>U.S.</td>
<td>0.163</td>
</tr>
<tr>
<td>Day 1</td>
<td>0.119</td>
<td>0.151</td>
<td></td>
<td>Day 2</td>
<td>0.135</td>
</tr>
<tr>
<td>Day 3</td>
<td>0.095</td>
<td>0.148</td>
<td></td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Overall Stdev</td>
<td>0.0208</td>
<td>0.0218</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Cvar</td>
<td>18%</td>
<td>13%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Difference</td>
<td></td>
<td>0.047</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Emissions with US reference fuel are higher by about 30%
Option 2 – JRC Results/Engine 2

Emissions with US reference fuel slightly higher for NOx, very similar for PM
Option 3 – Hot Soak Period

- WP.29/AC.3 had agreed to exclude options 3 (hot soak period) and 4 (cold start weighting factor) from the current mandate.

- Automotive industry (EMA/ACEA/JAMA) offered to EPA a test program with 4 engines on soak period in order to find solutions to option 3.

- OICA indicated acceptance of the 14% cold start weighting factor in case of a compromise solution on option 3 (soak period).

- Test results of 2 engines were presented at 28th WHDC meeting.

- Test results of the remaining engines are not available for GRPE 58.

- WHDC is therefore asking GRPE to extend the timeline for further discussions.

- Final solution might only be taken at November 2009 WP.29.
## Option 3 – EMA/SwRI Results

<table>
<thead>
<tr>
<th>Soak Length</th>
<th>Cold</th>
<th>Hot 1</th>
<th>Hot 2</th>
<th>Hot 3</th>
<th>Hot 4</th>
<th>Hot 5</th>
<th>Hot 6</th>
<th>Hot 7</th>
<th>Hot 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>0.628</td>
<td>0.145</td>
<td>0.156</td>
<td>0.099</td>
<td>0.131</td>
<td>0.090</td>
<td>0.119</td>
<td>0.079</td>
<td>0.115</td>
</tr>
<tr>
<td>Day 2</td>
<td>0.735</td>
<td>0.141</td>
<td>0.103</td>
<td>0.107</td>
<td>0.094</td>
<td>0.112</td>
<td>0.083</td>
<td>0.091</td>
<td>0.042</td>
</tr>
</tbody>
</table>

- **Hot-start conversion (1.27 g/hp-hr NOx Engine-out)**
  - 10-min soak = 93 %
  - 20-min soak = 90 %
Option 3 – DDC Results

WHTC Soak Time Investigations - Cycle NO$_x$

- Cold: 10, 20, 10, 20, 10, 20, 10, 20

Soak Time (min): 0.00, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50

Cycle NO$_x$ (g/hp-hr): 20 minutes

- WHTC Alternating Soak Times - Day 1
- WHTC Alternating Soak Times - Day 2
Option 5 – PM Measurement

9.4.4.1. Filter specification

All filter types shall have a 0.3 \( \mu \text{m} \) DOP (di-octylphthalate) collection efficiency of at least 99 per cent. The filter material shall be either:
(a) fluorocarbon (PTFE) coated glass fiber, or
(b) fluorocarbon (PTFE) membrane.

9.4.4.2. Filter size

The filter shall be circular with a nominal diameter of 47 mm (tolerance of 46.50 ± 0.6 mm) and an exposed diameter (filter stain diameter) of at least 38 mm.
Comments and Corrigenda

- Corrigenda approved by WHDC
  - EMA: correction to table 4
  - OICA: correction of references

- Proposal from Poland approved by WHDC
  - more accurate formulae for CH4 and NMHC calculation
  - correction of NMHC u value in tables 5 and 6

- No further comments received
The following formulae, which take the methane response factor into account, are proposed by Poland.

Accurate formulae for calculation of the NMHC concentration:

\[
\frac{c_{HCW/O}^S \times (1 - E_M) - c_{HCW}^S}{E - E_M} \quad - \quad (b)
\]

\[
\frac{(c_{HCW/O}^S \times (1 - E_M) - c_{HCW}^S \times R_f \times (1 - E_M))}{E - E_M} \quad - \quad (c)
\]

\[
\frac{c_{HCW/O}^S \times (1 - E_M) - c_{HCW}^S \times R_f}{E - E_M} \quad - \quad (d)
\]

Formula for calculation of methane concentration:

\[
\frac{c_{HCW}^S - c_{HCW/O}^S \times (1 - E_E)}{R_f \times (E - E_M)} \quad - \quad \text{derived}
\]

\[
\frac{c_{HCW}^S - c_{HCW/O}^S \times (1 - E_E)}{E - E_M} \quad - \quad \text{GTR No. 4}
\]

\[
C_{HCW}^S \quad - \quad \text{R.83.06}
\]
Summary

- WHDC in conjunction with OCE is a major step forward for effectively controlling emissions from heavy duty vehicles
- Options 1 and 5 are solved
- Option 2 could not be solved by WHDC; two alternatives are presented to GRPE for discussion
- Option 3 (and 4) test results are not completely available; extension of timeline is requested for solving these 2 options
- GRPE approval is asked for
  - the proposed corrigenda
  - for introduction of more accurate NMHC/CH4 formulae proposed by Poland
- GRPE is asked to disband the informal group on WHDC, which has completed its mandate after 12 years of work and 28 meetings
- The WHDC group especially appreciates Dr. Cornelis Havenith, former chairman and mastermind of the WHDC process, for his contribution to global harmonization
- Chairman and secretary would like to thank all members of the group for their contributions to the success of this ambitious program