PMP
Exhaust particles

Sub23nm-GTR Drafting - Status update to WLTP

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Telco on 16\textsuperscript{nd} of April 2020
Sub-23 nm exhaust particles

• Webconf held on 2\textsuperscript{nd} April - Objective: Address the still open points in the next weeks and freeze the proposal

• Amendment to GTR 15 or to Reg. 83/49?
  • This was discussed at the PMP meeting during the GRPE week in Geneva in Jan 2020
  • Clear preference for an amendment to GTR 15 (no immediate regulatory effect, transposition in national legislation needed)

• Request from some contracting parties: keep current methodology in GTR
  • Two different procedures in GTR 15: >23 and <23 nm
  • Advice asked to GRPE secretariat – Two annexes suggested

• Next steps
  • Discuss and agree the informal document to be submitted to GRPE in June 2020
  • Following months to acquire experience with the new procedure, collect and process data on emission levels of latest vehicle models
Question from PMP IWG

• Could the PN10 emission measurement cover also PN23 emission measurement in regulatory measurements?
  • If the vehicle passes the possible future PN10 limits could it be considered to pass also PN23-limit, although PN10 limits may not be valid in the region?
• The aim is to avoid double measurements
• Potential issue: vehicle failing the PN23 limit when using PN10 method but passing when using PN23 method
Technical aspects

• During the last meetings of the PMP IWG the following points were discussed:
  o The proposal for Sub23nm methodology
  o Possible improvements to the current methodology (cut-off size at 23 nm)
  o In the webconf of the 2nd these were not considered since these were already accepted with the exception of the issue of the Volatile Particle Removal (current text allows only the ET)

• The informal document will contain both (proposal for sub-23 nm and improvements for the current method)
VPR

- Current regulation allows only non-catalyzed Evaporation Tube (ET)
  - 4.3.1.2.3. All parts of the dilution system and the sampling system from the exhaust pipe up to the PNC, which are in contact with raw and diluted exhaust gas, shall be designed to minimize deposition of the particles. All parts shall be made of electrically conductive materials that do not react with exhaust gas components, and shall be electrically grounded to prevent electrostatic effects.

- Concerns about VPR efficiency in SPN10 if ET used
  - Risk of misuse/mistakes, for example too low DR for ET

- Catalyzed ET (CS) suggested

- Three options
  1. Allow parallel use of ET and CS for SPN10, ET kept for SPN23
  2. Force the use of catalyzed ET (CS) for SPN10, but no CS for SPN23
  3. Allow parallel use of ET and CS for SPN23, force CS usage for SPN10
     - Needs modification of the >23 nm regulation
Losses at 15 nm

- In some standardized (ISO 17025) calibrations of air craft PN-system with catalyzed ET,
  \[ \frac{fr(15 \text{ nm})}{fr(100 \text{ nm})} \approx 2.2 > 2 \]

- Request if the upper limit could be relieved to 2.2?

- Some current automotive applications
  \[ fr(15 \text{ nm})/fr(100 \text{ nm}) \approx 1.5 \]

- Assuming PCRF15/100 1.5 to 2 expected differences of 10% when GMD 15 nm
Diameter Uncertainties

- Answer from a NMI
- Size Uncertainty, ±1 nm is hard to justify
  - 1) the size of a soot particle can be defined in several different ways
  - 2) the selected electrical mobility diameter depends on theory-based extrapolation of DMA parameters that have been calibrated by larger PSL spheres.
- Term “Nominal” requires to specify how the size fraction is selected, with tolerances on how the DMA is calibrated and operated.
- Follow ISO Standards, rely on best practices

<table>
<thead>
<tr>
<th>Nominal, Particle size nm</th>
<th>PNC counting efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>65±15</td>
</tr>
<tr>
<td>15</td>
<td>&gt;90</td>
</tr>
</tbody>
</table>
4.3.1.3.3 Requirement of >70 % penetration for 100 nm in the sample preconditioning

<table>
<thead>
<tr>
<th>Need for &gt;70 % penetration requirement</th>
<th>NO need for &gt;70 % penetration requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Need to have a concrete penetration requirement</td>
<td>• Introduce additional calibration efforts and therefore costs</td>
</tr>
<tr>
<td>• This is &gt;35% penetration requirement for 15 nm particles</td>
<td>• PCRF concept account for this</td>
</tr>
</tbody>
</table>
CPC linearity

- GTR 5.7.1.3.3.
- draft: relative difference of the PNC within ± 5% from predicted values $\hat{N}$
  \[ \hat{N} = k \cdot N_{\text{ref},i} \]
- \[ D(N_{\text{PNC},i}) = \frac{N_{\text{PNC},i} - (k \cdot N_{\text{ref},i})}{(k \cdot N_{\text{ref},i})} \cdot 100\% \]

![Graph showing linearity and deviation](image)
Remove polydisperse testing possibility

- Will be removed for Sub23nm proposal
- 5.7.2.2 Where a polydisperse 50 nm aerosol is used for validation, the arithmetic average particle concentration reduction factor $f_v$ at the dilution setting used for validation shall be calculated using the following equation:
### Summary Sub-23-nm

<table>
<thead>
<tr>
<th>Subject</th>
<th>GTR 15, Annex 5</th>
<th>Proposal</th>
<th>Reasoning</th>
</tr>
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<tbody>
<tr>
<td>PNC- efficiency</td>
<td>50±12 % @ 23 nm, &gt;90% @ 41nm</td>
<td>65±15 % @ 10 nm, &gt;90% @ 15nm</td>
<td>Typical PNC-efficiency, well tested in the field.</td>
</tr>
<tr>
<td>Maximum VPR-loss requirement</td>
<td>@ 30nm 30% and @ 50 nm 20% higher than @ 100 nm</td>
<td>Addition @15 nm 100 % higher than at 100 nm</td>
<td>Generation of particles &lt; 15 nm challenging, uncertainties high</td>
</tr>
<tr>
<td>Polydisperse validation of VPR</td>
<td>a polydisperse 50 nm aerosol may be used for validation</td>
<td>Removed</td>
<td>Uncertainties @ 15 nm or below high → test serves no purpose</td>
</tr>
<tr>
<td>VPR validation</td>
<td>&gt; 99.0 % vaporization of 30 nm tetracosane particles, with an inlet concentration of ≥ 10,000 per cm³ (Monodisperse)</td>
<td>&gt; 99.x % removal efficiency of tetracosane particles with diameter &gt; 50 nm and mass &gt; 1 mg/m3. (Polydisperse)</td>
<td>Secure the functioning of VPR also for PNC with 65±15 % @ 10 nm, &gt;90% @ 15nm</td>
</tr>
</tbody>
</table>
## Summary Improvements SPN10 and SPN23

<table>
<thead>
<tr>
<th>SPN23</th>
<th>SPN10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evaporation device (ET) may be non-catalyzed or catalyzed</strong></td>
<td><strong>Evaporation device (ET) shall be catalyzed</strong></td>
</tr>
<tr>
<td>Catalyzed ET also allowed for SPN23 to achieve equivalence between SPN10 and SPN23</td>
<td>Catalyzed ET required to ensure evaporation efficiency. i.e. to avoid artefact solid particle counts.</td>
</tr>
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<td>Evaporation device @ VPR</td>
<td>All parts (of SPN-system) -- shall not react with exhaust gas components</td>
<td>--do not react with particles, in such way that solid particle number is changed.</td>
<td>Secure the functioning of VPR also for PNC10. Comparability of PNC10 and PNC23</td>
</tr>
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## Summary Improvements SPN10 and SPN23

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<td>PNC linearity</td>
<td>With no calibration factor applied to the PNC under calibration, measured concentrations shall be within ±10 per cent of the standard concentration for each concentration,</td>
<td>--PNC concentrations, shall be within ±5 per cent of the reference concentrations multiplied with the gradient K-factor between 0.9 and 1.1</td>
<td>Instead assuming the reference (standard) concentrations absolute true, we use residuals of regression</td>
</tr>
<tr>
<td>PNC linearity Minimum reference conc.</td>
<td>1,000 particles per cm³</td>
<td>2,000 particles per cm³</td>
<td>Faraday Cup Electrometer uncertainties increase steeply close to 1,000.</td>
</tr>
</tbody>
</table>

And some smaller improvements, all of them included in the draft texts