NEW PTI PROCEDURES ARE NEEDED TO GUARANTEE EMISSION STABILITY

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DPF-PTI RESEARCH PROGRAM
RESULTS 2015-2017
OBJECTIVES DUTCH PTI DPF PROGRAM

- Development of a PTI test protocol (Periodic Technical Inspection) to judge the performance of Diesel Particulate Filters.

- What has been changed since the implementation of DPF’s?

  - Euro 1,2,3,4: determination of the **quality of the combustion**; smoke numbers are suitable \((k = 0,3 – 2,5 \text{ m}^{-1} \text{ on a measuring scale of } 0 – 10 \text{ m}^{-1})\).
  
  - Euro 5,6: Determination of the **filtration efficiency of the DPF**; smoke numbers are extremely low \((k = 0,00 – 0,05 \text{ m}^{-1})\).
## EMISSION LIMIT VALUES

<table>
<thead>
<tr>
<th>Emission class</th>
<th>Type approval, chassis dynamometer</th>
<th>Type Approval &amp; PTI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NEDC test 11 km</td>
<td>Free acceleration test</td>
</tr>
<tr>
<td></td>
<td>PM limit value</td>
<td>PN limit value</td>
</tr>
<tr>
<td></td>
<td>[mg/km]</td>
<td>[#/km]</td>
</tr>
<tr>
<td>Euro 1 – 1993</td>
<td>140</td>
<td>-</td>
</tr>
<tr>
<td>Euro 2 – 1996</td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>Euro 3 – 2000</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Euro 4 – 2005</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>Euro 5a – 2009</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Euro 5b – 2011</td>
<td>4.5</td>
<td>$6 \times 10^{11}$</td>
</tr>
<tr>
<td>Euro 6 – 2015</td>
<td>4.5</td>
<td>$6 \times 10^{11}$</td>
</tr>
</tbody>
</table>
2015-2016: PTI VEHICLE SELECTION

- Lease companies, service shops
- 220 vehicles were selected at random at the 7 test locations.
- Age 2 - 5 years old @ 50,000 – 250,000 km
- Selection is not representative for the Dutch fleet.

PN tester CPC
Solid + volatile
> 10 nm
TEST RESULTS: FIRST IMPRESSION SWIPE TESTS

21% of the tested vehicles have a (deep) black tail pipe. Swipe test results are a first impression but cannot be applied for PTI test purposes!
161 vehicles (76%) have a PN emission of < 5000#/cm³.
52 vehicles (24%) have an elevated PN emission of > 5000#/cm³.
10% of the vehicles have a PN emission of > 250,000#/cm³.
NEXT GOAL

Proposal of a development project for a new PTI DPF emission test procedure
1. Definition of a relevant emission test
2. Definition of a feasible PN limit value
3. Definition and specification of a low cost PN-tester

The PTI PN emission test, PN limit value and the new PN-tester are related and must be approached as a package.
2 OPACIMETERS & 4 PN TESTERS

K = 0 - 10 m⁻¹.
EXAMPLE PN EMISSIONS PRE & POST DPF
FORD FIESTA EURO 6: ENGINE START & WARMING UP @ 800 RPM

A potential PTI test must be executed with a hot engine.

DPF has a small failure
1 hour @ low idle speed.

At low idle speed the PN emission of the hot engine is
pre DPF 3,600,000 #/cm³
post DPF 300,000 #/cm³.

2014/45/EC
PTI smoke: $k = 0.11 \text{ m}^{-1}$.

UNECE R83 Type I test
Chassis dyno NEDC*:
PM = 1.5 mg/km (CF = 0.3)
PN = $3.9 \times 10^{12}$ #/km (CF = 6.5)

* Limit values PM=4.5 mg/km, PN $6 \times 10^{11}$ #/km.
**IDLE SPEED TEST WITH 4 PN-COUNTERS**

**PEUGEOT 308 EURO 6 @ 104,755 KM**

All PN-testers measure near zero #/cm$^3$ with a ‘normal’ (= well functioning) DPF.

Ambient air is cleaned!

No solid & volatile particle emission at low idle speed.

Candidate 10 second PTI test @ low idle speed
PEUGEOT PARTNER WITH DPF BYPASS

Research of a new PTI DPF PN emission test
PN & SMOKE EMISSIONS IN FA TESTS
SIMULATED DPF FAILURES VIA DIFFERENT BYPASS FLOWS

Researchers at ETH Zürich, June 22nd, 2017.

- Ratio PN @ FA test / PN @ idle is ~20.

- PN emissions in free acceleration test are probably too high for low cost PTI PN testers and smoke emissions are too low.

- PN emission @ low idle speed is set with adjustable DPF bypass flow. Estimated maximum DPF leakage is 25%.
PN @ low idle speed has a good correlation with PN in the NEDC.
SPECIFICATION OF NEW PTI PN TESTER

- Psize: >50% @ 70 nm.
- Dilution ratio: 10.
- Measuring range: $0 - 5,000,000 \text{#/cm}^3$.
- No catalytic stripper
- Heated PN device @ 120 – 140 °C.

In order to have a PTI PN counter with an acceptable price (< 5000 Euro) a simplified specification of the PN tester is needed.
PROPOSAL NEW PTI TEST PROCEDURE

New specification PTI PN-tester

Proposed PN limit value 250,000 #/cm³

Current UNECE R83 Type II test for petrol vehicles is very similar and this test can be added to R83.
NPTI TEST PROCEDURE

- Hot running engine (> 60 s.) at low idle speed.
- Start PN sampling of ambient air and exhaust gas at low idle speed.
- If PN is less < 2,500 #/cm$^3$ @ t = 15 s $\rightarrow$ test passed (80% of vehicles).
- Euro 5b/6: If average PN < 250,000 #/cm$^3$ $\rightarrow$ PTI pass.
- Euro 5a: If average PN < 1,500,000 #/cm$^3$ $\rightarrow$ PTI pass.
NPTI TEST PROCEDURE
CONTACT DETAILS

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Research of a new PTI DPF PN emission test

ETH Zürich, June 22nd, 2017.
Thank you very much for your attention.

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