

NEW PTI PROCEDURES ARE NEEDED TO GUARANTEE EMISSION STABILITY

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Ministerie van Infrastructuur en Milieu

TNO innovation
for life

**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 ($k = 0,3 - 2,5 \text{ m}^{-1}$ 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

	Type approval, chassis dynamometer			Type Approval & PTI
	NEDC test 11 km			Free acceleration test
Emission class	PM limit value	PN limit value		Smoke (Opacity)
	[mg/km]	[/km]		k [m ⁻¹]
Euro 1 – 1993	140	-		3.0
Euro 2 – 1996	80	-		
Euro 3 – 2000	50	-		2.5
Euro 4 – 2005	25	-		
Euro 5a – 2009	5	-		
Euro 5b – 2011	4.5	6 * 10 ¹¹		1.5
Euro 6 – 2015	4.5	6 * 10 ¹¹		
2018				0.7



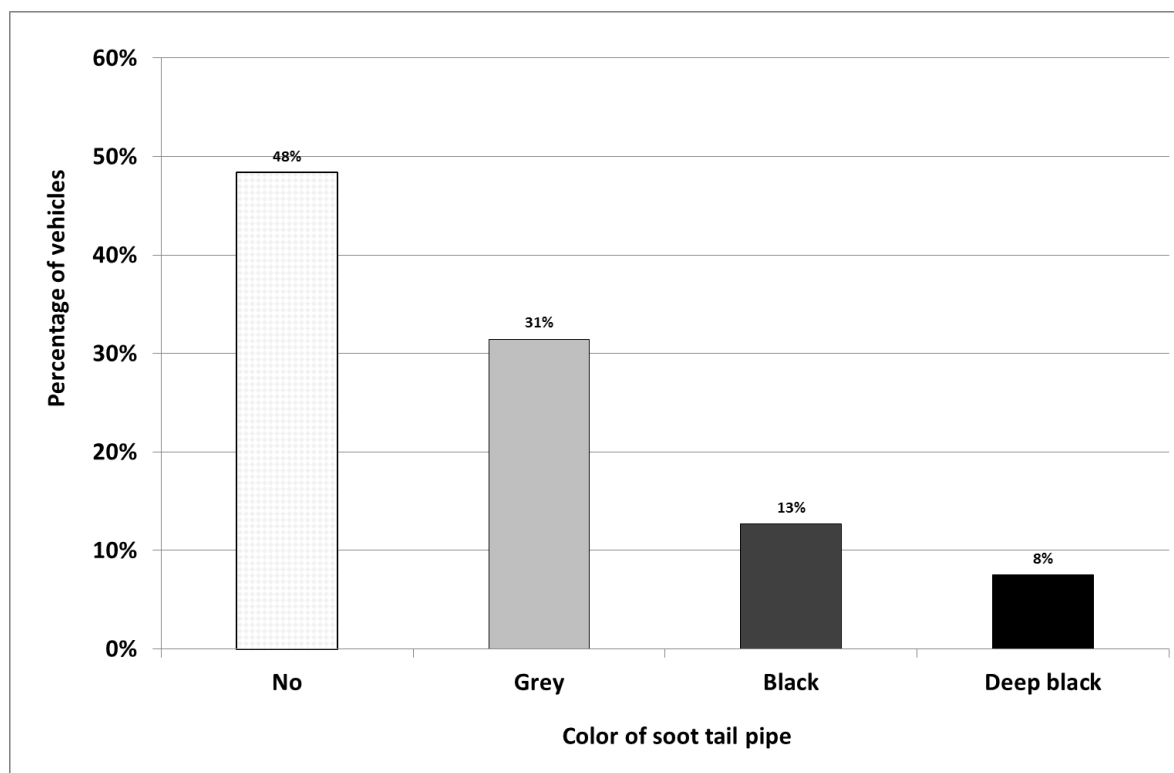
2015-2016: PTI VEHICLE SELECTION

- › 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.
- › Test period: December 2015 – February 2016.

PN tester CPC
Solid + volatile
> 10 nm

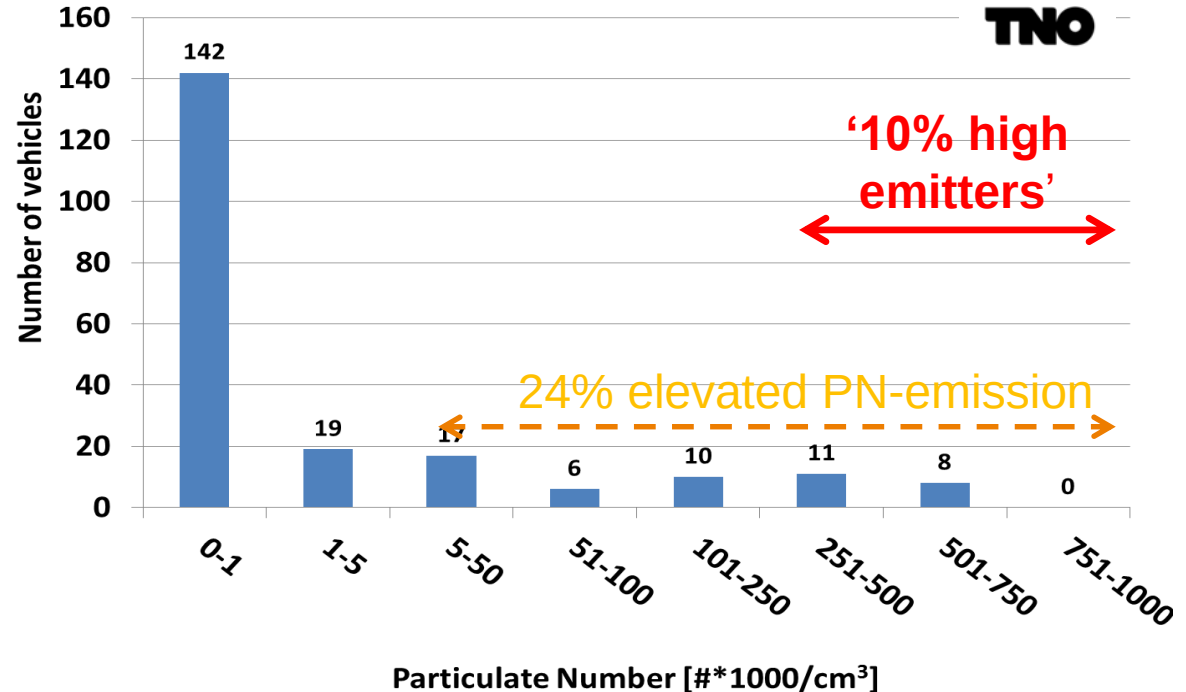


TEST RESULTS: FIRST IMPRESSION SWIPE TESTS



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!

PN EMISSIONS @ LOW IDLE SPEED



161 vehicles (76%) have a PN emission of $< 5000 \text{ \#/cm}^3$.

52 vehicles (24%) have an elevated PN emission of $> 5000 \text{ \#/cm}^3$.

10% of the vehicles have a PN emission of $> 250.000 \text{ \#/cm}^3$.

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



$K = 0 - 10 \text{ m}^{-1}$.



> 23 nm
solid

DF 100
Max. 5×10^7



> 23 nm
solid
10
 5×10^6



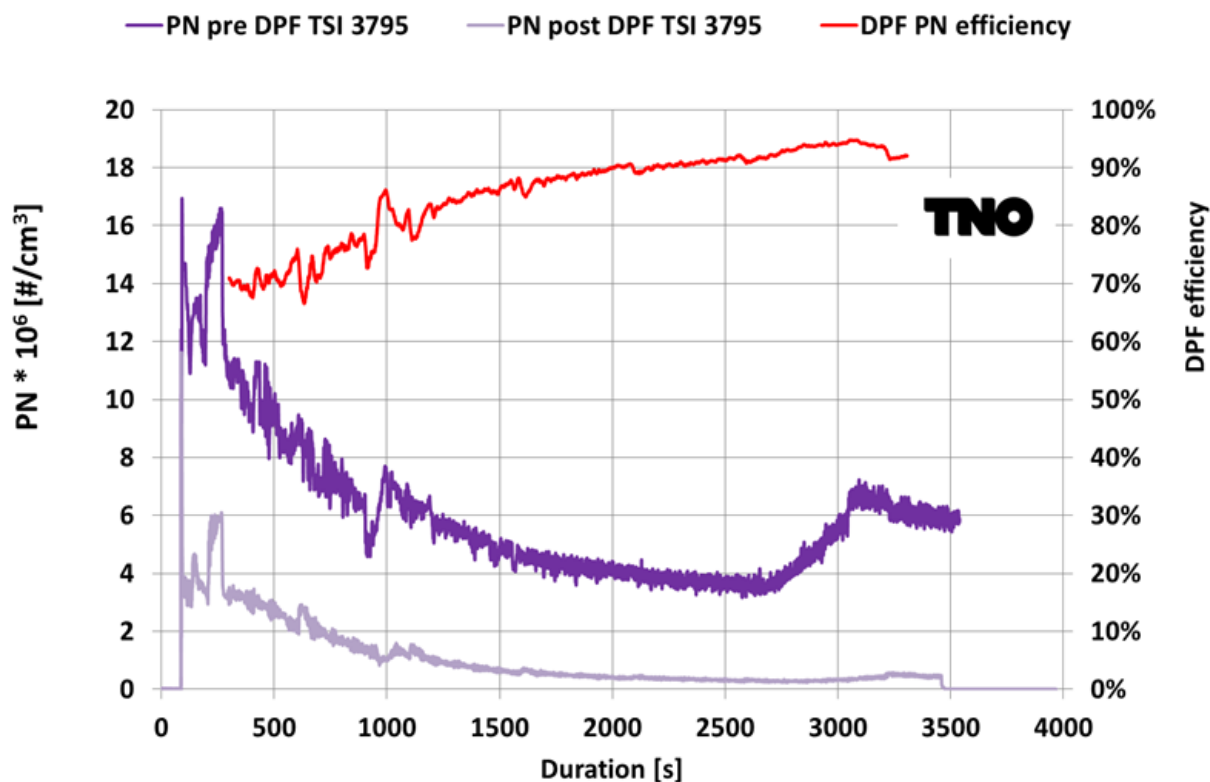
> 20 nm
solid+volatile
1
 5×10^5



> 10 nm
solid+volatile
1
 1×10^5

EXAMPLE PN EMISSIONS PRE & POST DPF

FORD FIESTA EURO 6: ENGINE START & WARMING UP @ 800 RPM



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: $k = 0.11 \text{ m}^{-1}$.

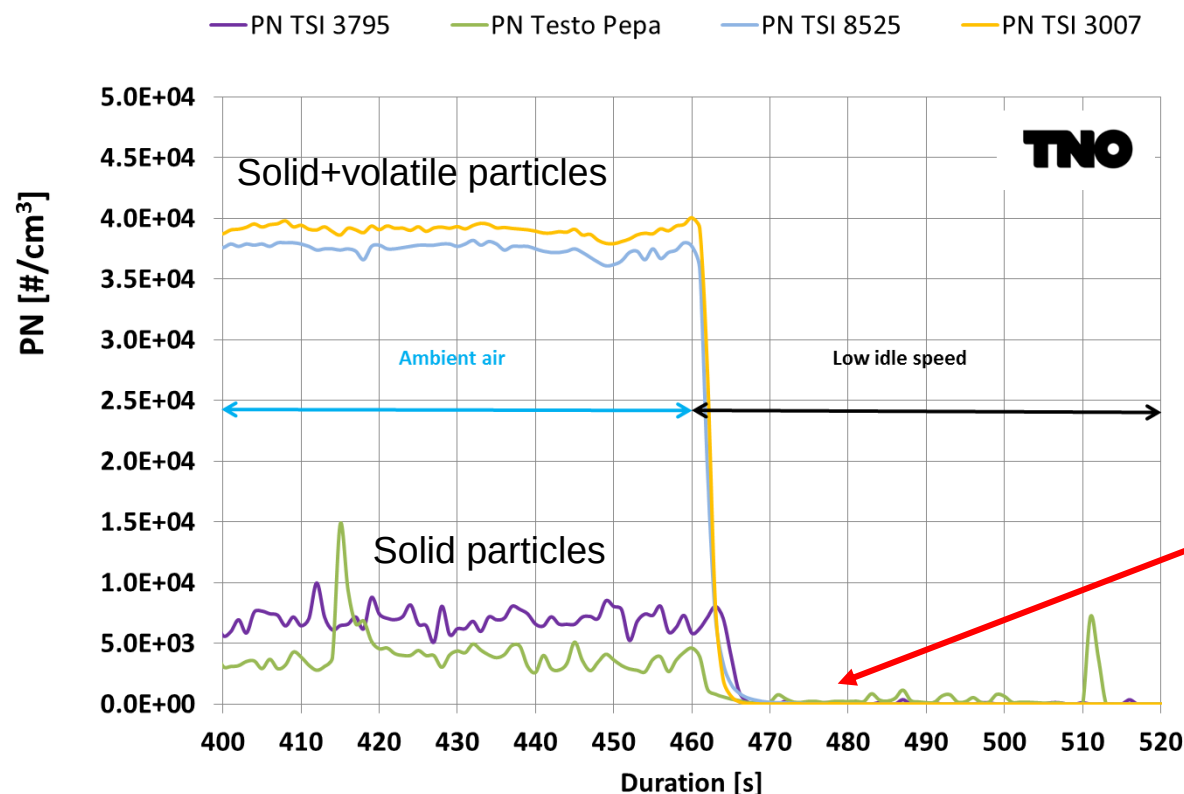
UNECE R83 Type I test
Chassis dyno NEDC*:
PM = 1.5 mg/km (CF = 0.3)
PN = $3.9 \times 10^{12} \text{ \#/km}$ (CF = 6.5)

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

* Limit values PM=4.5 mg/km, PN $6 \times 10^{11} \text{ \#/km}$.

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.

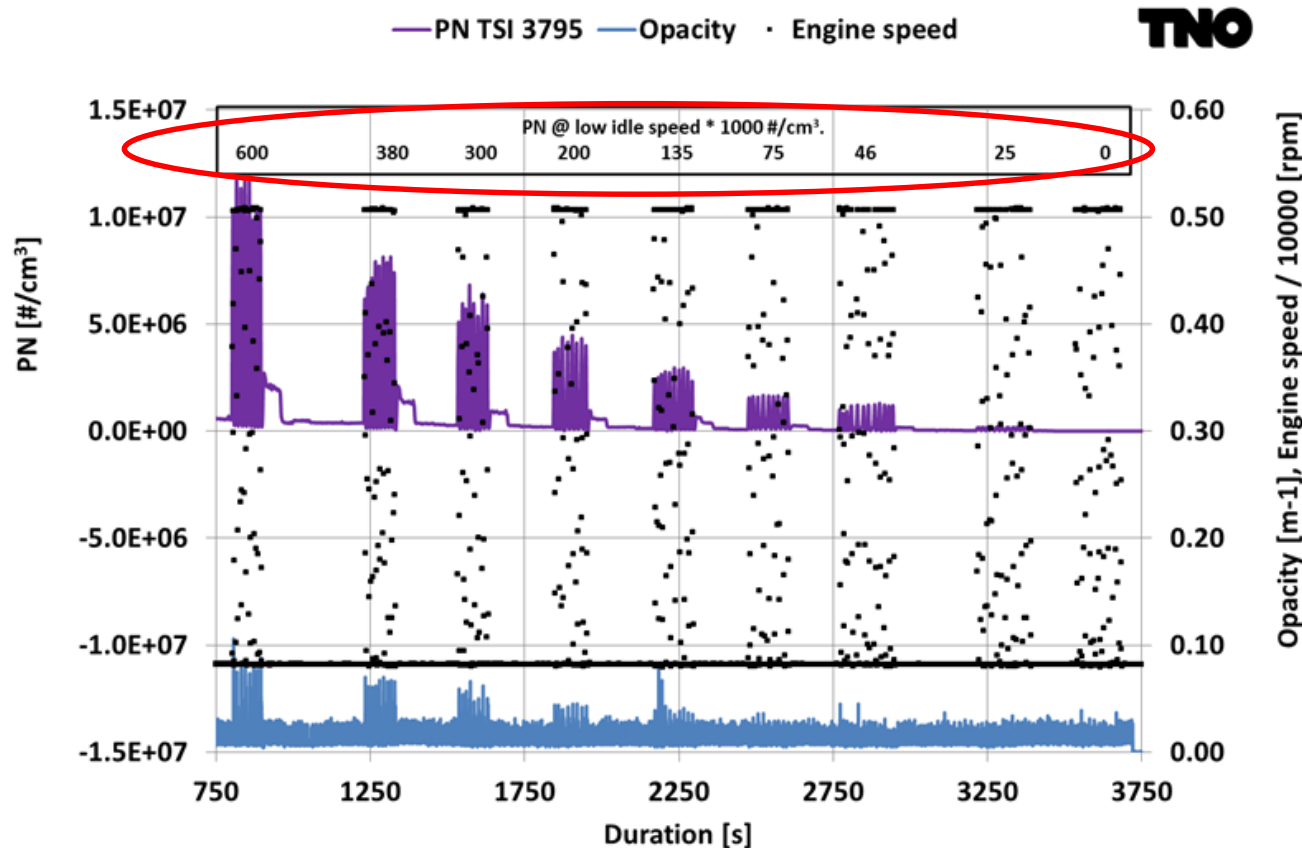
Candidate 10 second
PTI test @ low idle
speed

PEUGEOT PARTNER WITH DPF BYPASS



PN & SMOKE EMISSIONS IN FA TESTS

SIMULATED DPF FAILURES VIA DIFFERENT BYPASS FLOWS

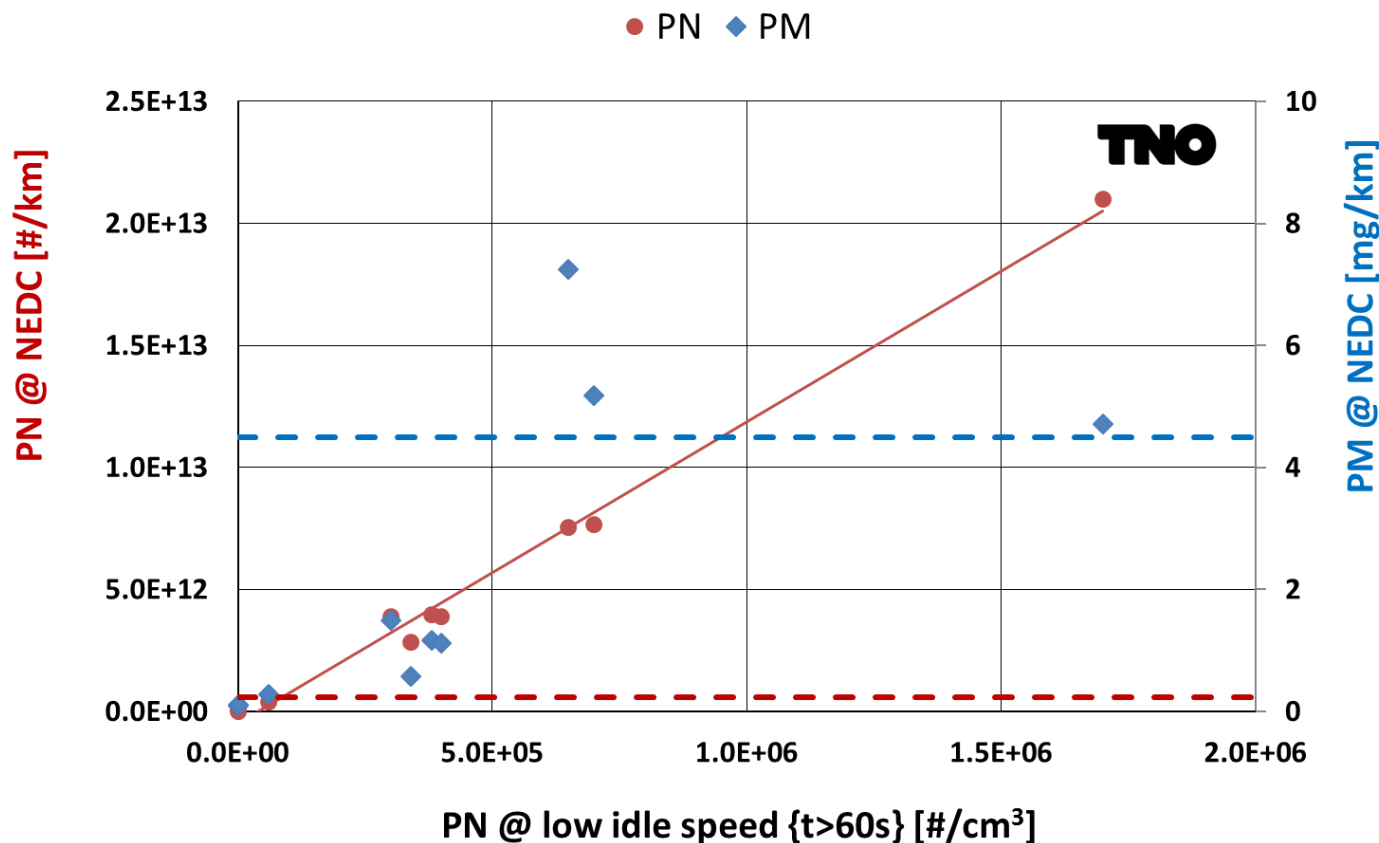


PN emission @ low idle speed is set with adjustable DPF bypass flow. Estimated maximum DPF leakage is 25%.

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

Ratio $\text{PN @ FA test} / \text{PN @ idle}$ is ~20.

PN & PM IN NEDC VERSUS PN @ LOW IDLE



PN @ low idle speed has a good correlation with PN in the NEDC

SPECIFICATION OF NEW PTI PN TESTER

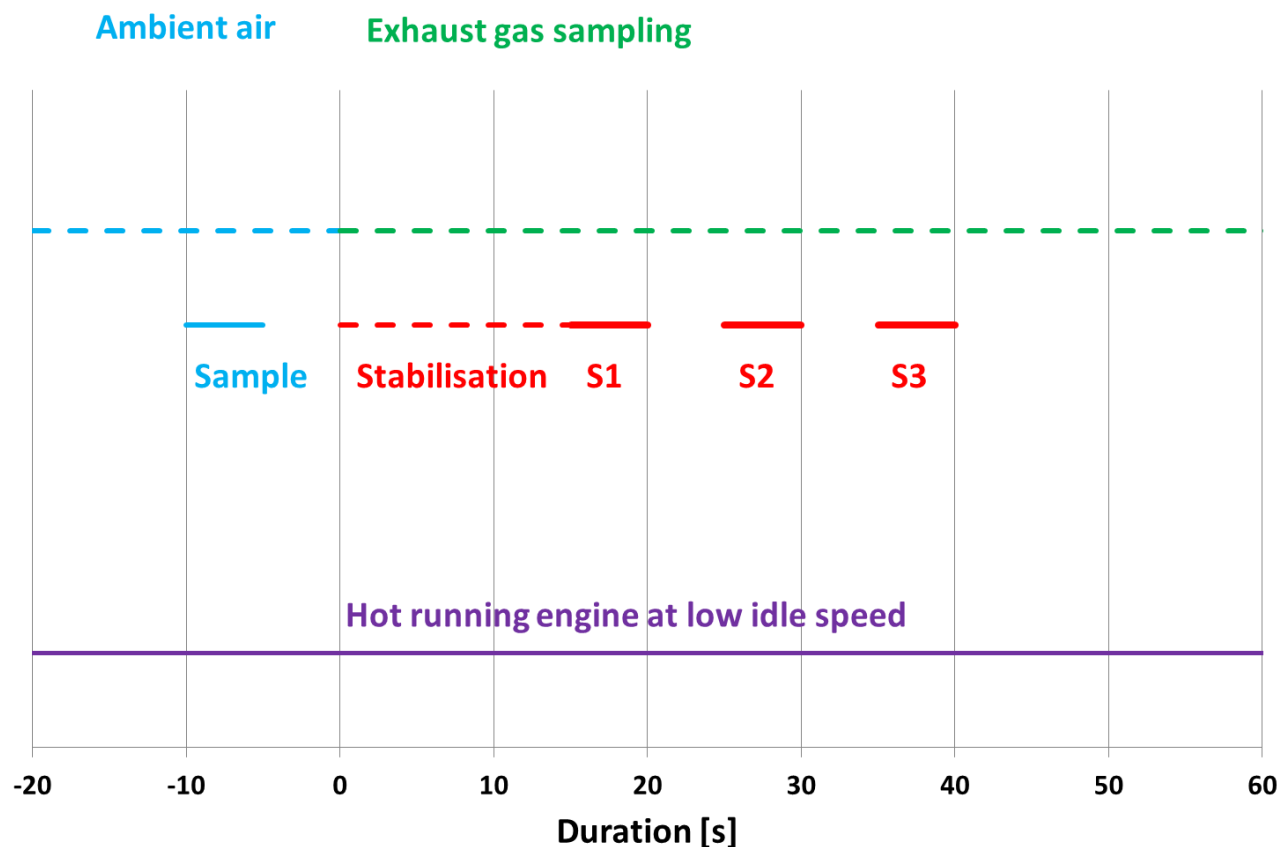
- › Psize: >50% @ 70 nm.
- › Dilution ratio: 10.
- › Measuring range: 0 – 5.000.000 #/cm³.
- › No catalytic stripper
- › Heated PN device @ 120 – 140 °C.



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 $\text{\#}/\text{cm}^3$

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 $< 2,500 \text{ \#/cm}^3$ @ $t = 15 \text{ s}$ $\rightarrow$ test passed (80% of vehicles).
- › Euro 5b/6: If average PN $< 250,000 \text{ \#/cm}^3$ $\rightarrow$ PTI pass.
- › Euro 5a: If average PN $< 1,500,000 \text{ \#/cm}^3$ $\rightarrow$ PTI pass.

NPTI TEST PROCEDURE



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- › www.tno.nl/vehicle-emissions or www.tno.nl/voertuigemissies

- › <https://www.tno.nl/en/focus-area/urbanisation/mobility-logistics/clean-mobility/emissions-of-particulate-matter-from-diesel-cars/>



**THANK YOU VERY MUCH FOR
YOUR ATTENTION**

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