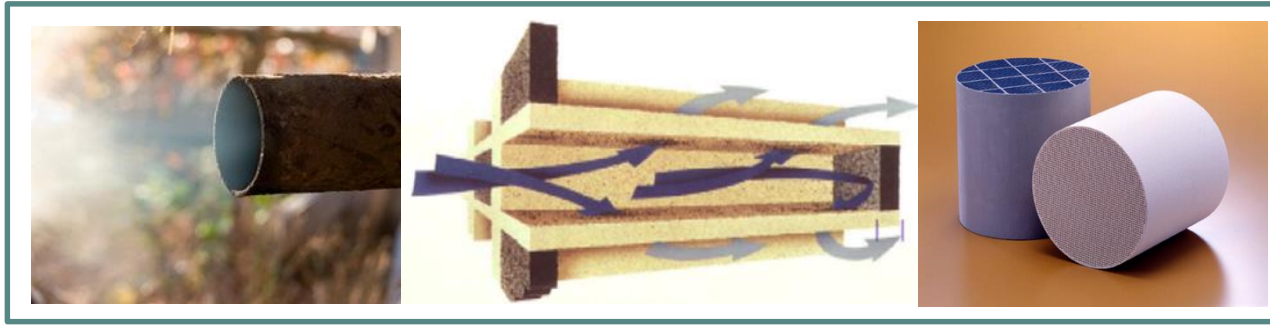




**GROEPING VAN ERKENDE ONDERNEMINGEN
VOOR AUTOKEURING EN RIJBEWIJS V.Z.W.**

**GROUPEMENT DES SOCIÉTÉS AGRÉÉES DE CONTRÔLE AUTOMOBILE
ET DU PERMIS DE CONDUIRE A.S.B.L.**

Rue de la Technologiestraat 21-25 | Bruxelles 1082 Brussel
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PN study

New fine particle emission measurement for the assessment of the quality of the particulate filter during the periodic inspection of diesel vehicles

23rd ETH-Conference on Combustion Generated Nanoparticles

20th of June 2019

Buekenhoudt, De Meyer & Chavatte

(2019)



Which vehicles have a DPF?

“Indien bij personenauto's met een verbrandingsmotor met compressie-ontsteking de deeltjesmassa is gemeten in g/km en de hiervoor in het kentekenregister vermelde waarde is kleiner dan of gelijk aan 0,005 g/km, moet het roetfilter aanwezig en niet duidelijk defect zijn.”

(Staatscourant, 2017).

Limit values type approval M1 diesel vehicles

Euro class	date	PM [mg/km]	PN [#/km]	Common used aftertreatment system
Euro 1	1993	140,0		none
Euro 2	1996	80,0		none
Euro 3	2000	50,0		DOC
Euro 4	2005	25,0		EGR + DOC
Euro 5a	2009	5,0		cooled EGR + DOC+ DPF
Euro 5b	2011	4,5	6,0 *E11	cooled EGR + DOC+ DPF
Euro 6a	2014	4,5	6,0 *E11	cooled EGR + DOC+ DPF
Euro 6b	2017	4,5	6,0 *E11	cooled EGR + DOC+ DPF + LNT/SCR

(Adopted from Kadijk et al.,2015)

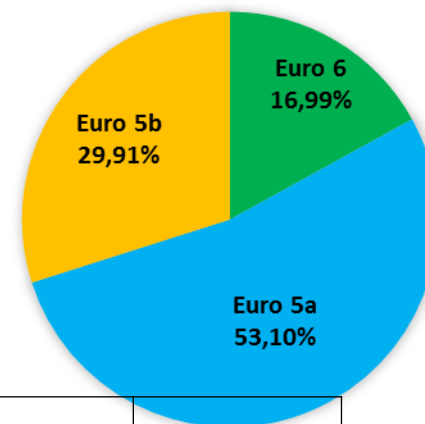
Tested PN equipment

Brand	AVL	NANEOS	PEGASOR	SENSORS	TESTO	TESTO	TSI	TSI	TSI
Type	DiTest Counter	Partector	Mi3	APA	DiscMini	Nanomet	NPET	PTI	PTI
Type number	-	-	-	-	-	3	3795	V1	V2
Handheld/ portable	portable	handheld	portable	portable	handheld	portable	portable	portable	portable
Production or prototype	Prototype	Prototype	Production	Prototype	Production	Production	Production	Prototype	Prototype
Working principle	DC	DC	DC	CPC	DC	DC	CPC	CPC	CPC
Unities	[#/cm ³]	[#/cm ³]	[#/cm ³]	[#/cm ³]	[#/cm ³]	[#/cm ³]	[#/cm ³]	[#/cm ³]	[#/cm ³]
Minimum readout	10.000	0	300		1000	10.000	10.000	1.000	1.000
Maximum readout	unlimited	5,00 E+06	1,30 E+09		1,00 E+06	3,00 E+08	5,00 E+07	5,00 E+06	5,00 E+06
Dilution	10:1	No dilution	10:1		/	10, 100 or 300	100:1	20:1	20:1
Removal volatile particles	Yes delution	no	yes	yes	no	yes	yes	no	Yes Catalytic Stripper
Range size particles [nm]	20 - 200	> 10 nm	10 - 90	10 - 200	10 - 700	10 - 700	23 - 1.000	23 – 1.000	23 – 1.000
Measurement frequency [Hz]	1	1	100		1	1	1	1	1
Response time T90 [s]	5 – 10	/	0,2	/	< 15	< 15	8	< 15	< 15

Equipment specifications (in collaboration with NPTI working group) are available;
Type approval, Initial verification, subsequent verification and routine testing for the PN equipment are possible;

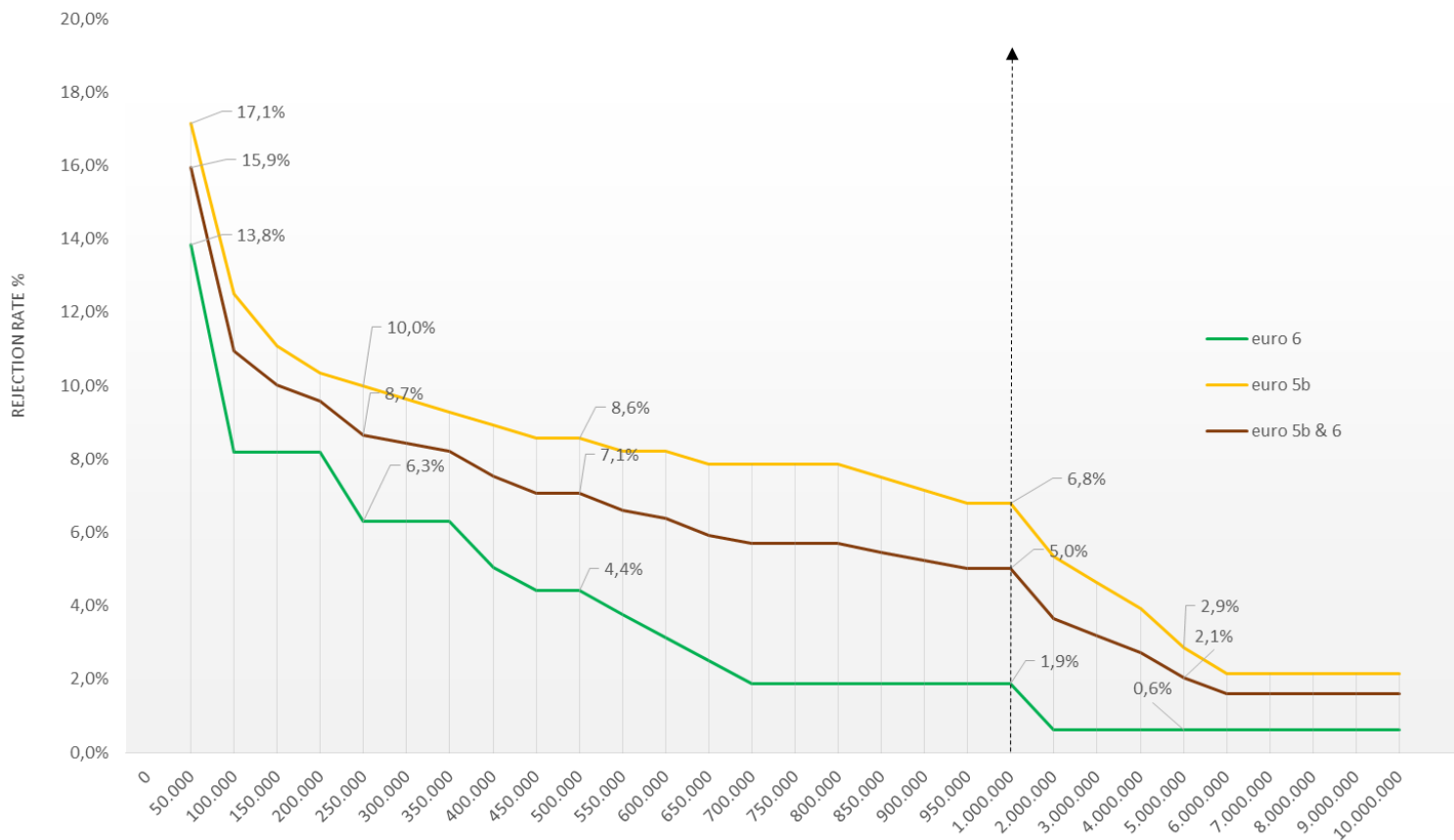
Test sample

REPARTITION OF THE 1006 VALIDATED TESTS IN
FUNCTION OF EURO CLASS OF THE VEHICLES



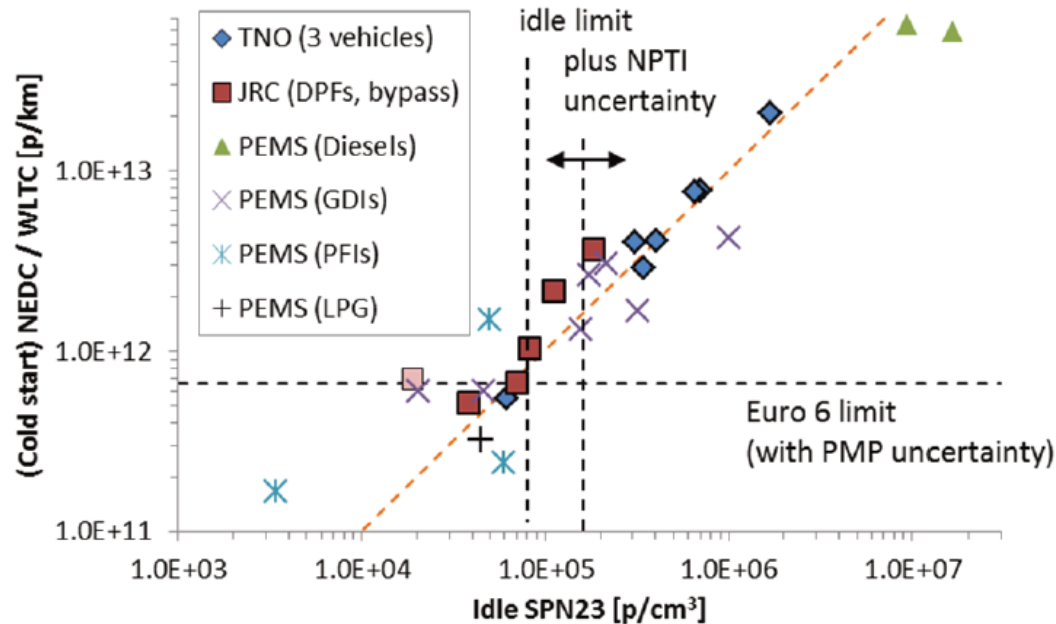
		Driven distance [1.000 km]					Total
		0 - 50	50 - 100	100 - 150	150 - 200	> 200	
Vehicle age	<4	8,22%	4,51%	1,39%	1,04%	0,69%	15,86%
	4-6	3,13%	16,20%	8,45%	4,40%	1,04%	33,22%
	6-8	1,39%	8,33%	9,14%	8,22%	3,70%	30,79%
	8-10	1,85%	4,86%	5,09%	4,86%	2,20%	18,87%
	>10	0,12%	0,00%	0,00%	0,23%	0,93%	1,27%
Total		14,70%	33,91%	24,07%	18,75%	8,56%	100,00%

Expected rejection rate in function of the limit value for Euro 5b and euro 6 vehicles [$\#/cm^3$]



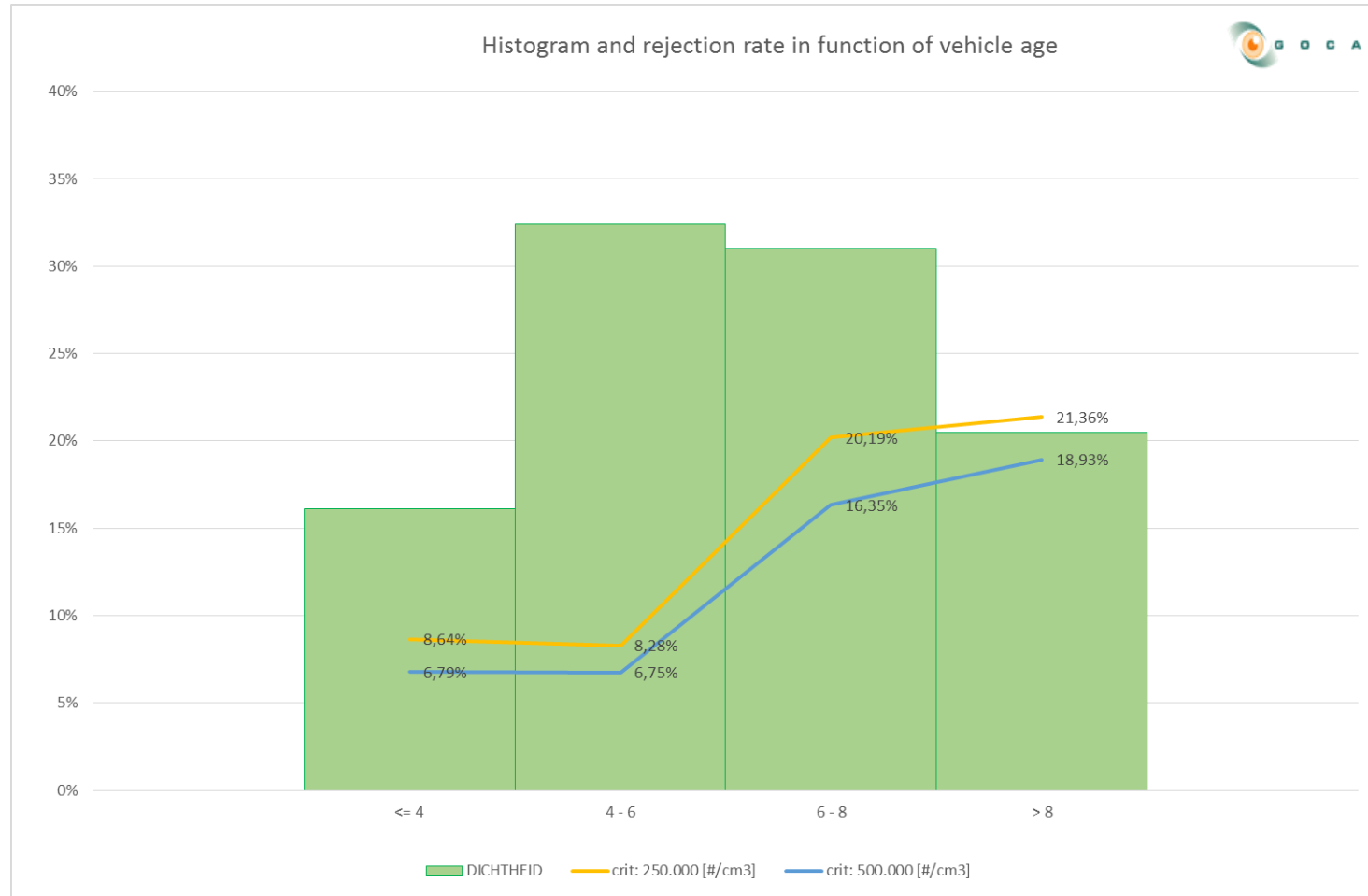
Limit value

NPTI 250.000 #/cm³ ??

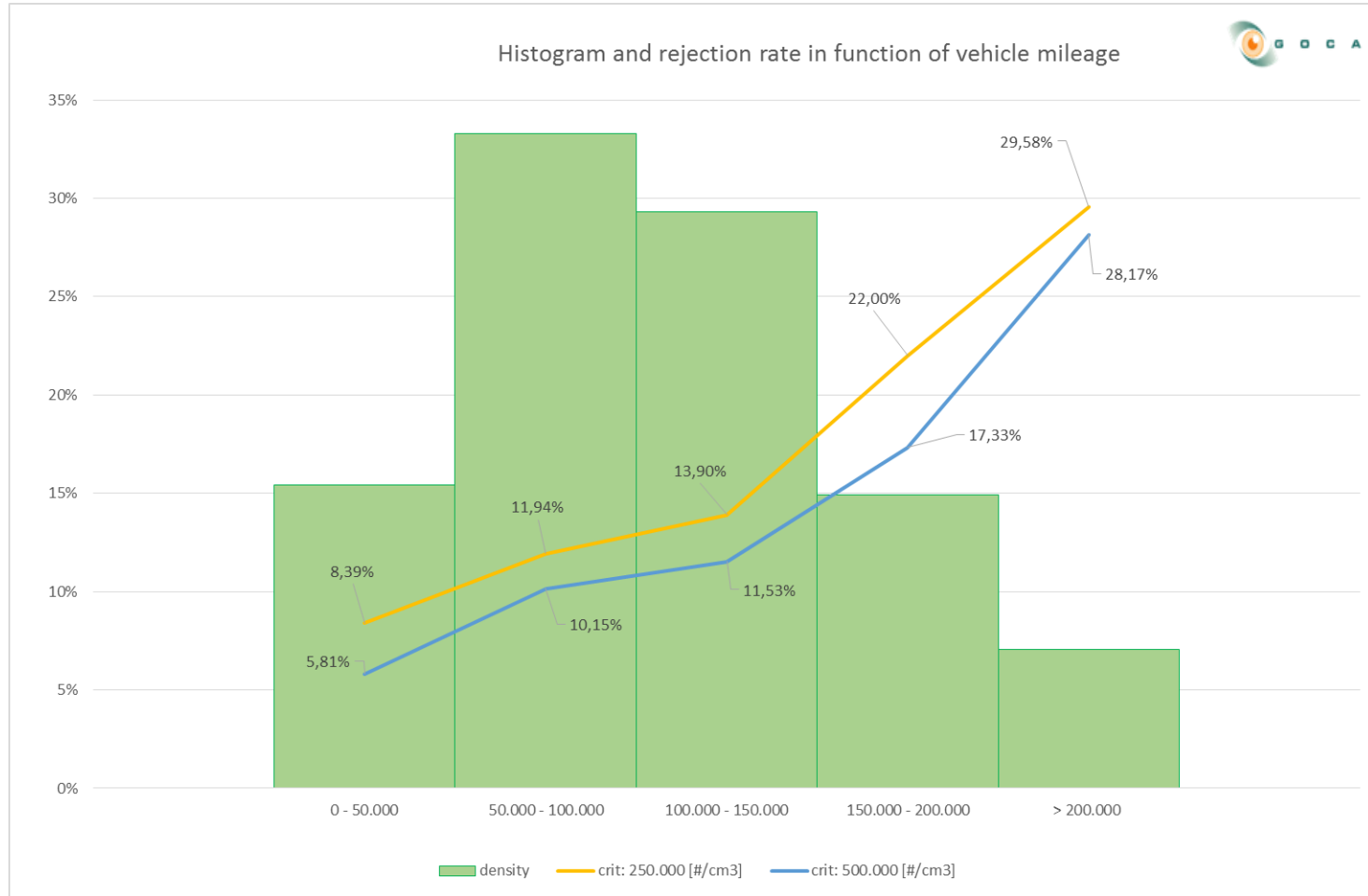


Emission factor [# / km] at NEDC or WLTC versus raw emission concentrations [# / cm³] measured at idle.
(Taken from Giechaskiel B., Lahde T., Suarez-Bertoa R. et al., 2018)

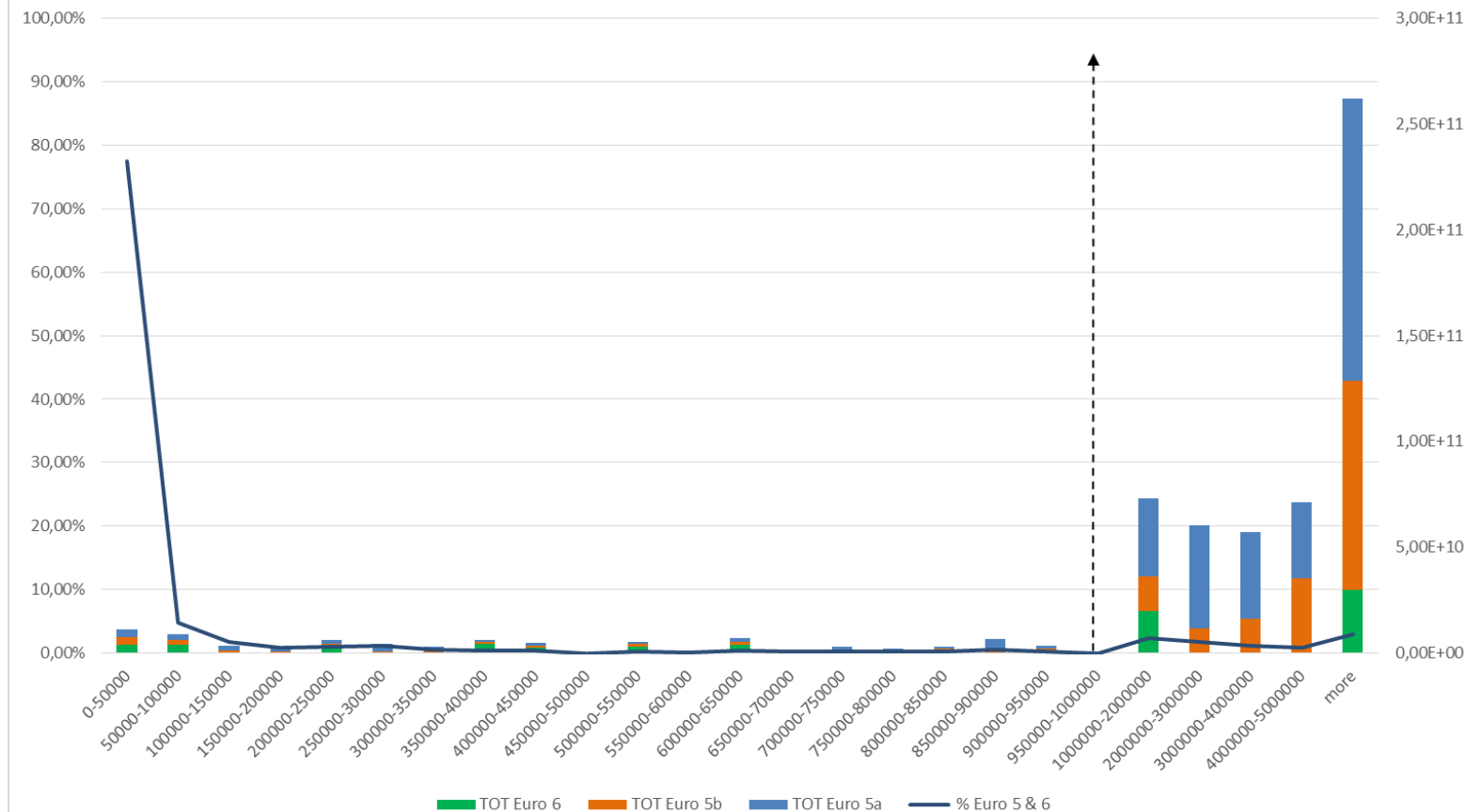
PN measurements – Sample of the study



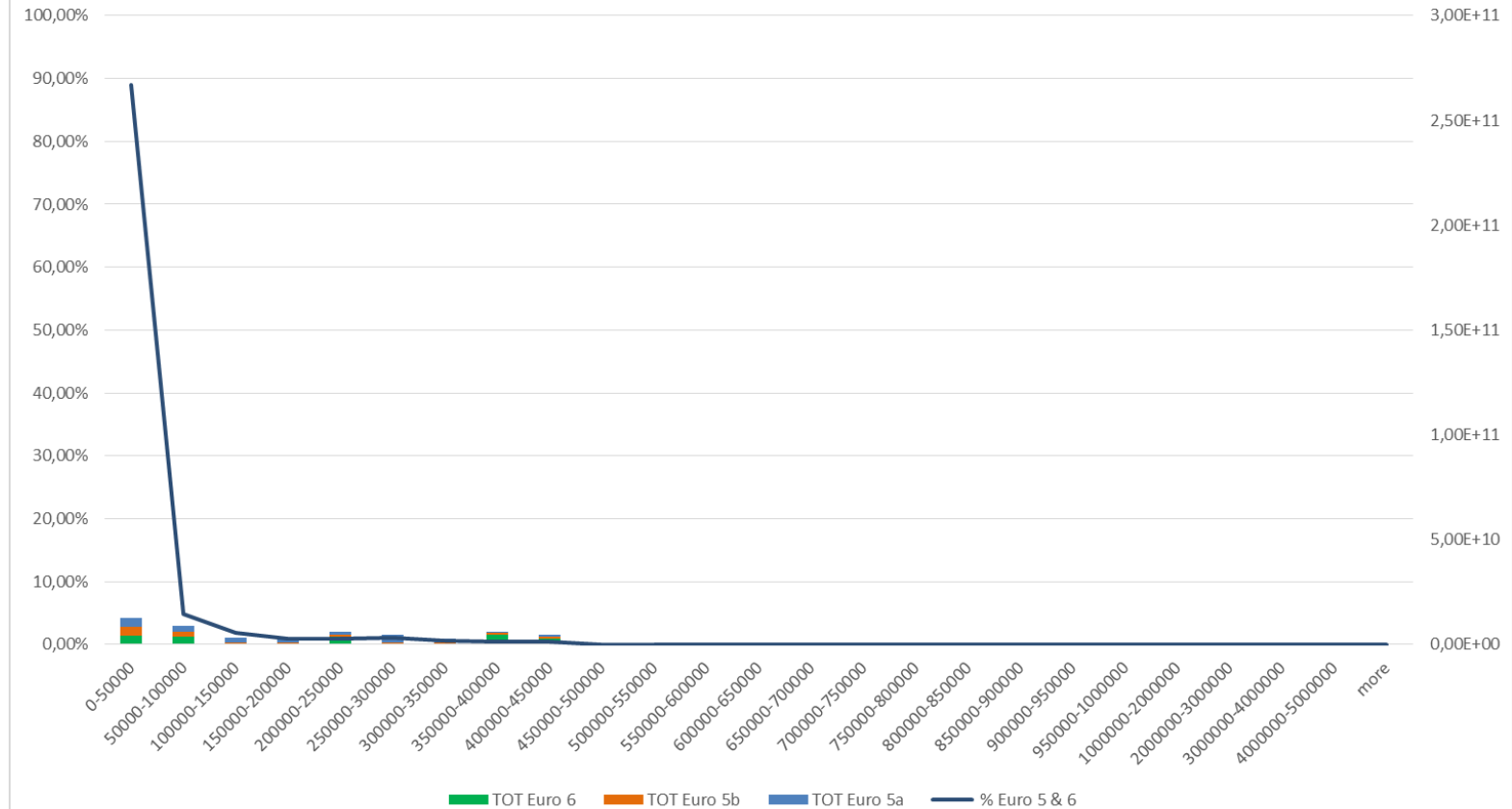
PN measurements – Sample of the study



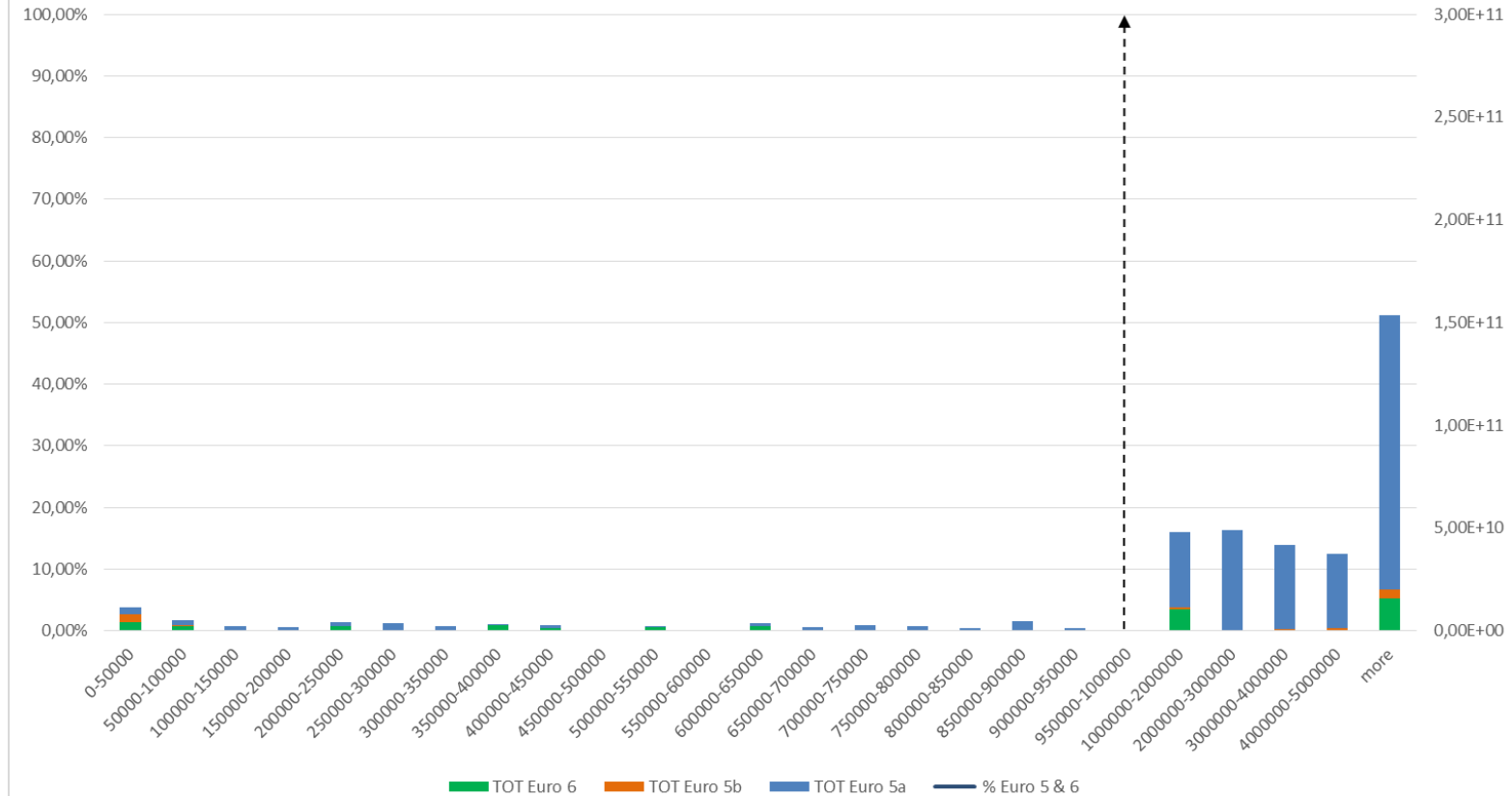
Simulation of the total particulate emissions [$\#/cm^3$] emitted
by the Euro 5 and 6 vehicles in Belgium
($6,07 \times 10^{11} \# / cm^3$)



Simulation of the total particulate emissions [$\#/cm^3$] emitted by the Euro 5 and 6 vehicles in Belgium, after tested and remedied all vehicles ($5,14 \times 10^{10} \#/cm^3$, reduction by 91%)



Simulation of the total particulate emissions [$\#/cm^3$] emitted
by the Euro 5 and 6 vehicles in Belgium,
after 1 year tested and remedied of Euro 5b and 6 vehicles more than 4 years old
($3,87 \times 10^{11} \#/cm^3$, reduction by 36%)



Introduction : Different measurement procedure !

Germany

Recommended because of particles, of behaviour

Min. Oil Ter

Recommended to have an EGR

Snap Accel

Recommended because of from average
Measure time

„Snap Acceleration“

Recommended

The Netherlands

Which measurement procedure/schedule to use ?

So many difference :

- Snap acceleration or not;
- Fast Pass and/or Fast Fail;
- Waiting time or not;
- Measurement time, etc ...

And still they are subject to change ...

Or will there a specific one for each country ?



PN(n1)
average
over 15 s

Pass

Pass

Perform a new

Fail

Average <= criteria ?

YES

Pass

NO

Fail

If PNave after one or more rounds of
optimizing the test conditions > limit value

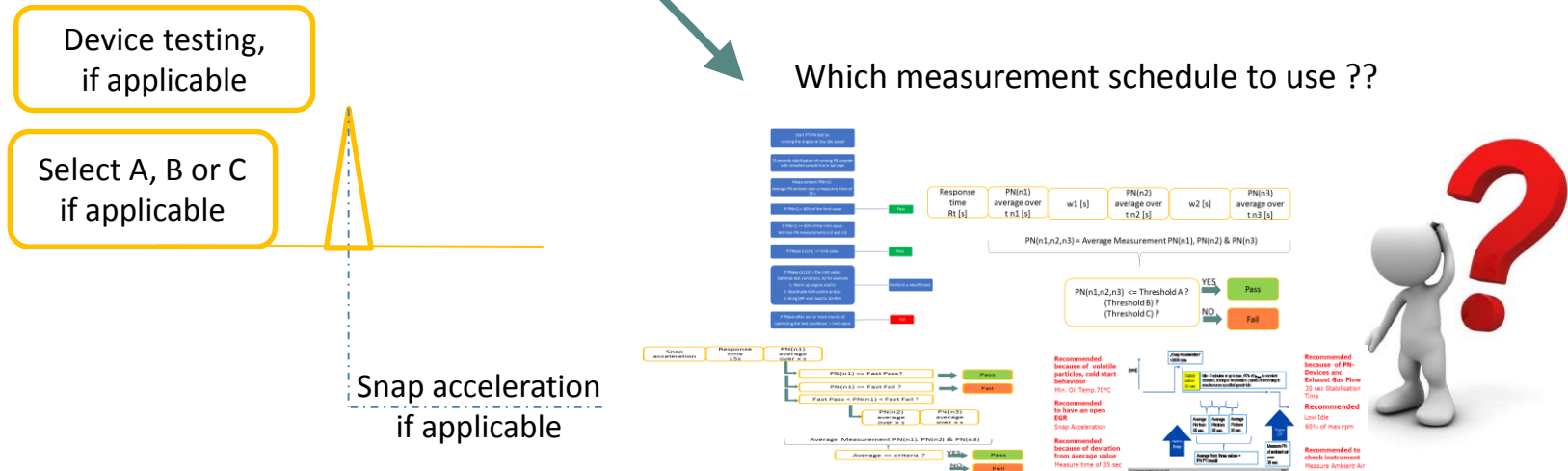
23/06/2019



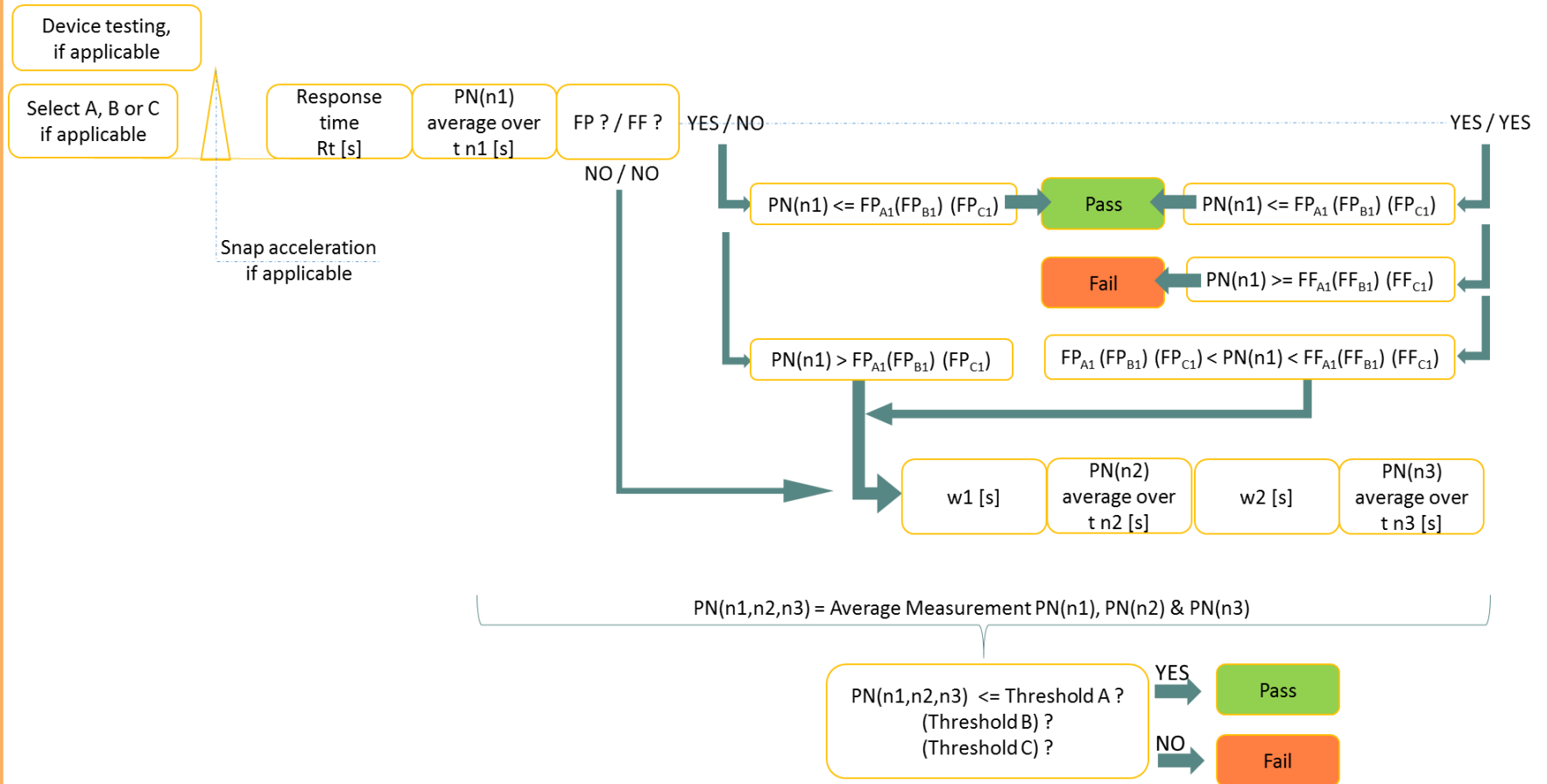
PN Measurement procedure

Measurement procedure

1. do some device testing before starting measuring procedure, if necessary;
2. Select vehicle category, if necessary (not needed if there is only one category);
3. Apply a snap acceleration if necessary;
4. Start the measurement, the vehicle will be running at low idle.



PN Measurement procedure – use of parameters



PN Measurement procedure – use of parameters

Symbol	Designation	Range	Unit	Value (Still subject to change)			
				GOCA	RDW	BASt	Switzerland
A	Def. for a certain vehicle category or class (A)	Text	/	+ euro 5b	< 1.1.2015	euro 6 ?	+ euro 5b
B	Def. for a certain vehicle category or class (B)	Text	/	/	> 1.1.2015	/	/
C	Def. for a certain vehicle category or class (C)	Text	/	/	/	/	/
Threshold A	Def. for a certain vehicle category or class (A), default	0 – 5x10 ⁶	#/cm ³	2,5x10 ⁵	1x10 ⁶	2,5x10 ⁵ ?	2,5x10 ⁵
Threshold B	Def. for a certain vehicle category or class (B)	0 – 5x10 ⁶	#/cm ³	/	2,5x10 ⁵	/	/
Threshold C	Def. for a certain vehicle category or class (C)	0 – 5x10 ⁶	#/cm ³	/	/	/	/
FP?	Instaling a Fast Pass procedure ?	Y or N	/	N	N	?	N
FF?	Installing a Fast Fail Procedure ?	Y or N	/	N	N	N	N
FP_{A1}	Fast Pass value for vehicle cat A after sample n1	0 – 5x10 ⁶	#/cm ³	/	/	?	/
FF_{A1}	Fast Fail value for vehicle cat A after sample n1	0 – 5x10 ⁶	#/cm ³	/	/	/	/
FP_{B1}	Fast Pass value for vehicle cat B after sample n1	0 – 5x10 ⁶	#/cm ³	/	/	/	/
FF_{B1}	Fast Fail value for vehicle cat B after sample n1	0 – 5x10 ⁶	#/cm ³	/	/	/	/
FP_{C1}	Fast Pass value for vehicle cat C after sample n1	0 – 5x10 ⁶	#/cm ³	/	/	/	/
FF_{C1}	Fast Fail value for vehicle cat C after sample n1	0 – 5x10 ⁶	#/cm ³	/	/	/	/
Rt	Response time	0 - 120	s	15	15	30?	0
n1	First measurement sample	/	/	/	/	/	/
n2	Second measurement sample	/	/	/	/	/	/
n3	Third measurement sample	/	/	/	/	/	/
t n1	Time first measurement sample	0 - 120	s	5	15	60?	5
t n2	Time second measurement sample	0 - 120	s	5	0	60?	5
t n3	Time third measurement sample	0 - 120	s	5	0	60?	5
PN (n1)	Average of first measurement sample	0 – 5x10 ⁶	#/cm ³	calculated	calculated	calculated	calculated
PN (n2)	Average of second measurement sample	0 – 5x10 ⁶	#/cm ³	calculated	calculated	calculated	calculated
PN (n3)	Average of tird measurement sample	0 – 5x10 ⁶	#/cm ³	calculated	calculated	calculated	calculated
PN (n1,n2)	Average of first and second measurement sample	0 – 5x10 ⁶	#/cm ³	calculated	calculated	calculated	calculated
PN (n1,n2,n3)	Average of first, second and tird measurement sample	0 – 5x10 ⁶	#/cm ³	calculated	calculated	calculated	calculated
w1	Waiting time 1	0 - 120	s	0	0	0	5
w2	Waiting time 2	0 - 120	s	0	0	0	5

Conclusions - What have we seen ?

- The Pareto principle also applies to our sample, namely that 20% of the diesel vehicles fitted with a particulate filter are responsible for 80% of the PN emissions and, conversely, 80% of the vehicles emit only 20% of the PN emissions;
- A new PN emission measurement can check the quality of the particulate filter during the periodic inspection of diesel vehicles;
- Especially older vehicles (+ 6years old) and/or vehicles with high mileages (+150000 km) have a high rejection rate;
- Implementing the PN measurement will due to the fact that the gross emitters can be detected and remedied, give a huge reduction on emitted particulate matter emissions.

Conclusions – Implementation is possible

- Equipment
 - Equipment specifications (in collaboration with NPTI working group) are available;
 - Type approval, Initial verification, subsequent verification and routine testing for the PN equipment are possible;
- proposal rejection limit: $250.000 \text{ \#/cm}^3$;
- One uniform test schedule of an idle test; if all steps are parametrized.

Conclusions

Belgium introduced a very ambitious implementation process: starts in 2020.

GOCA recommend

- for the future emission test of Euro 5b (or higher) diesel vehicle :
 - PN measurement instead of opacity test;
 - proposal rejection limit: 250.000 #/cm³;
- Further studies on:
 - Behavior and impact EGR on PN measurement;
 - Impact of regeneration of DPF;
 - Implementation for heavy duty and petrol vehicles,

Thank you for your attention

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Groepering van erkende ondernemingen voor autokeuring en rijbewijs v.z.w
Groupement des sociétés agréées de contrôle automobile et du permis de conduire a.s.b.l

