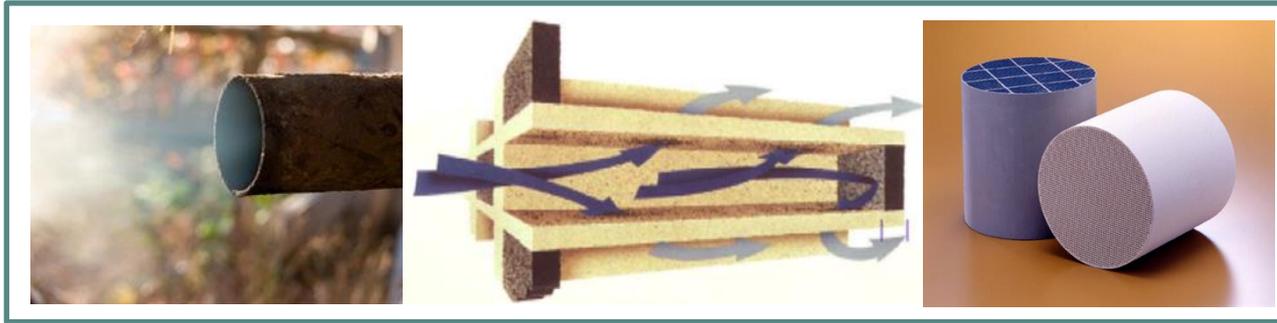




**GROEPING VAN ERKENDE ONDERNEMINGEN
VOOR AUTOKEURING EN RIJBEWIJS V.Z.W.**

**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
02/469 09 00 | 02/469 05 70 | goca@goca.be



PN study

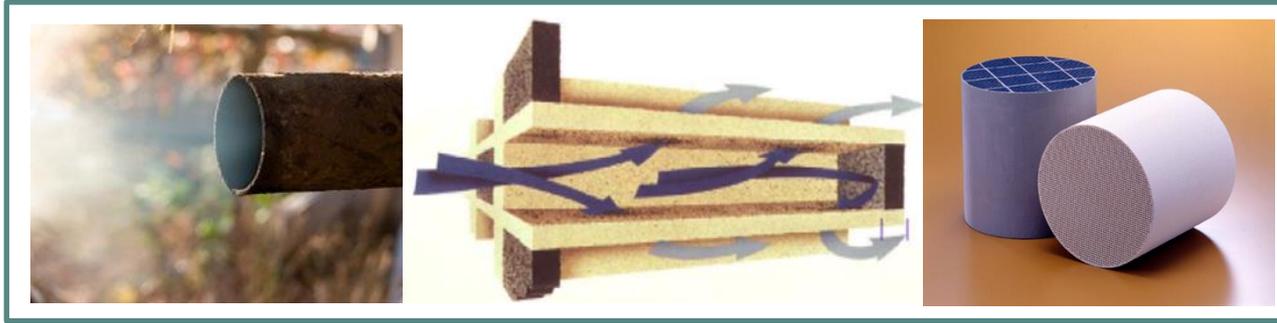
New fine particle emission measurement for the assessment of the quality of the particulate filter during the periodic inspection of diesel vehicles

Presentation for 10 years VERT Forum on 14th of March 2019, Dübendorf

Buekenhoudt, De Meyer & Chavatte

(2019)





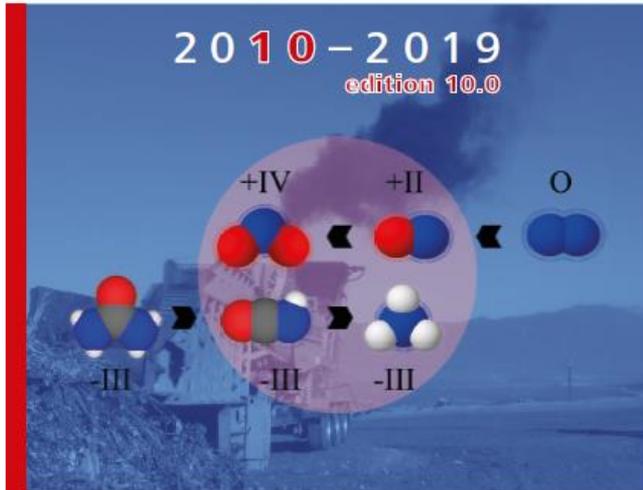
10th VERT FORUM

Best available emission control technology for in-use and OE-engines

10 years VERT Forum – A moment to celebrate

Too many DPF failures and manipulations in the Euro-5 and Euro-6 fleet

Pascal Buekenhoudt



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

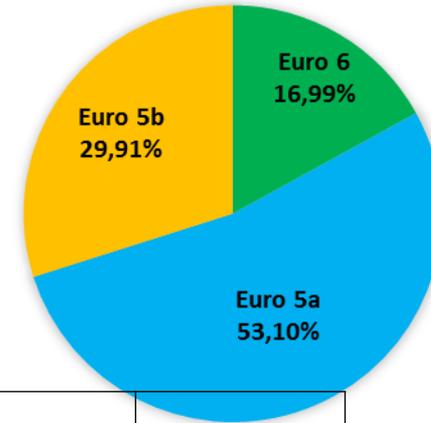
(Adopted from Kadijk et al.,2015)

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]								
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

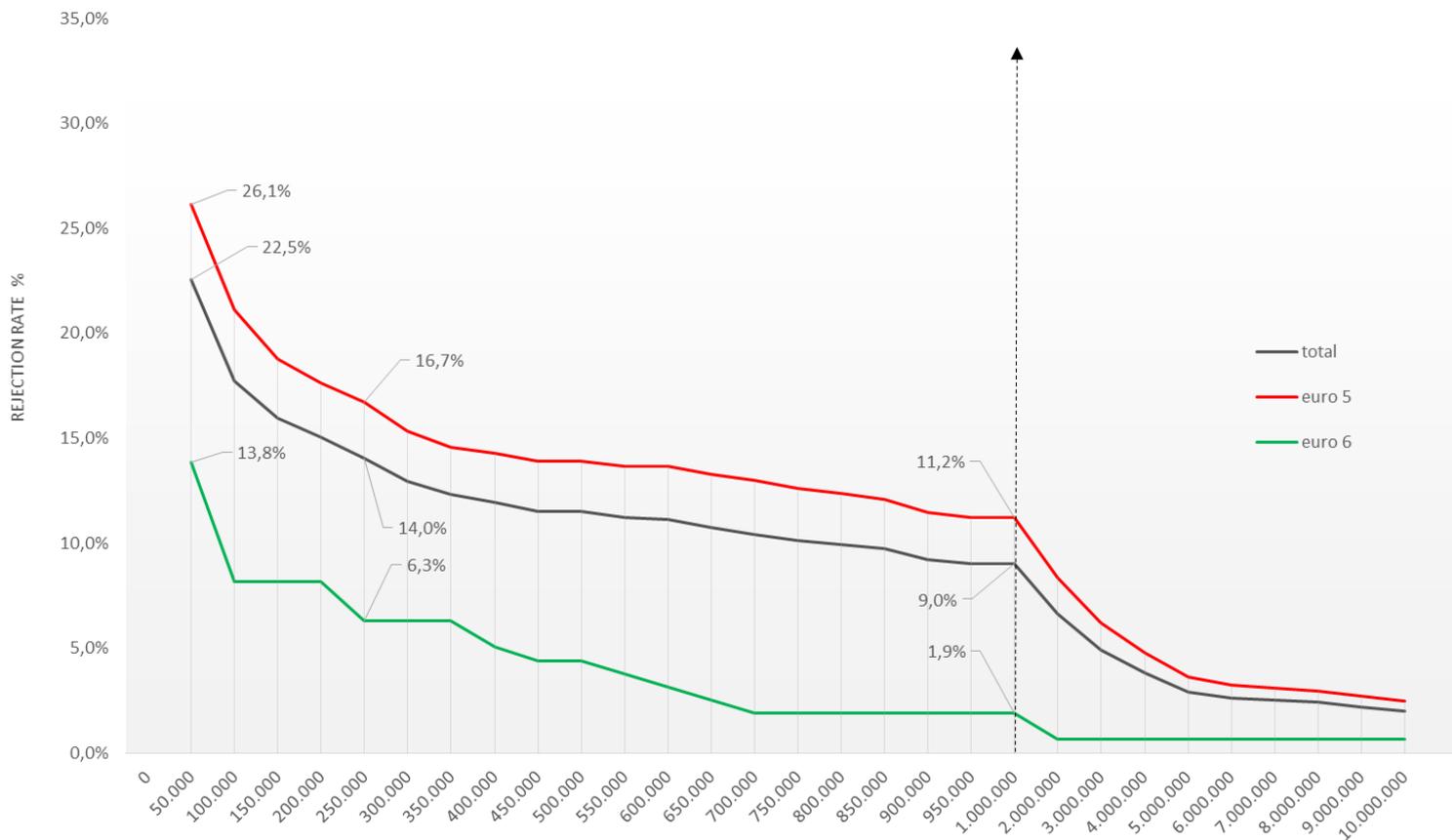
Test sample

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

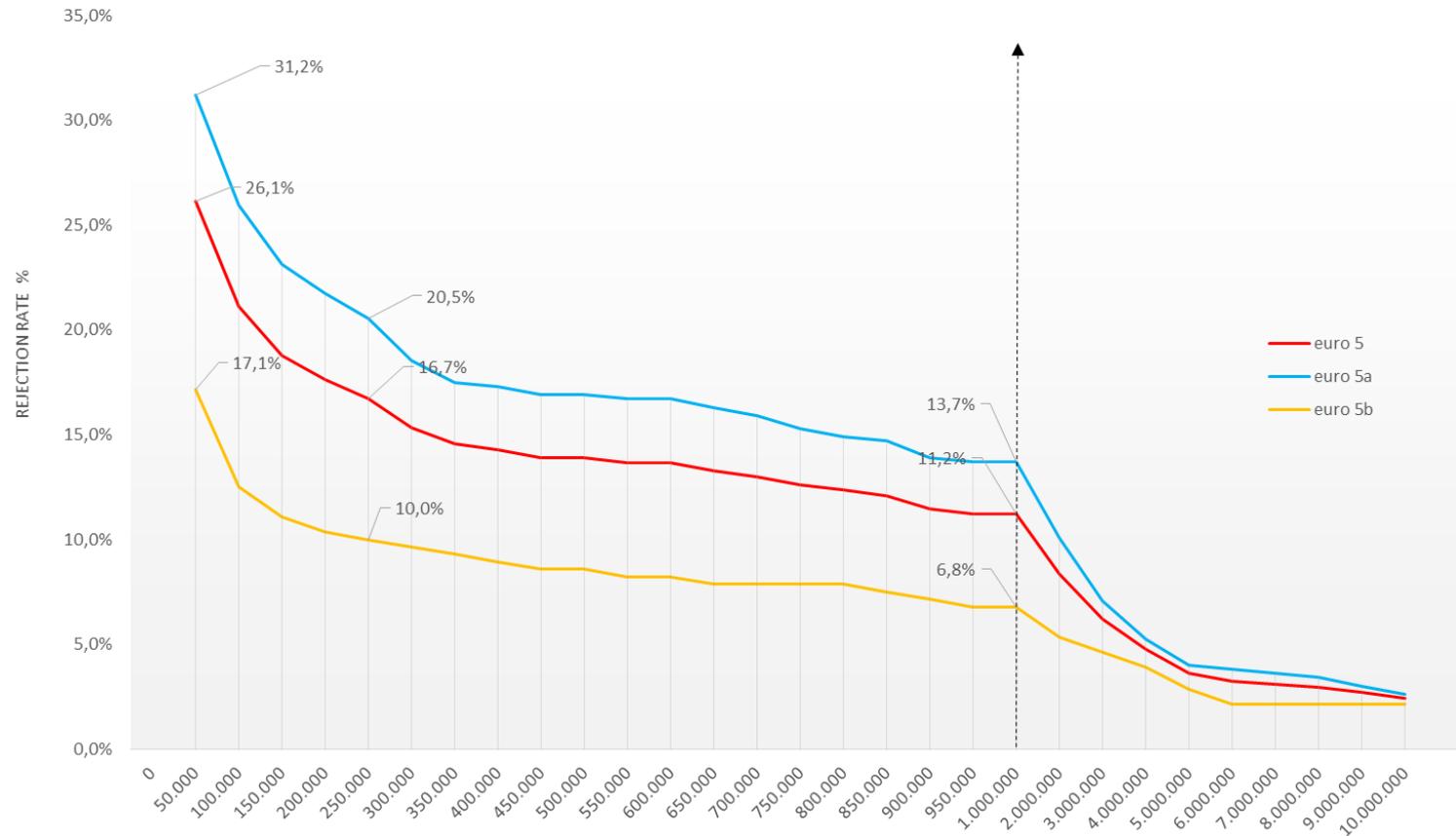


		Driven distance [1.000 km]					Total
		0 - 50	50 - 100	100 - 150	150 - 200	> 200	
Vehicle age	<4	8,22%	4,51%	1,39%	1,04%	0,69%	15,86%
	4-6	3,13%	16,20%	8,45%	4,40%	1,04%	33,22%
	6-8	1,39%	8,33%	9,14%	8,22%	3,70%	30,79%
	8-10	1,85%	4,86%	5,09%	4,86%	2,20%	18,87%
	>10	0,12%	0,00%	0,00%	0,23%	0,93%	1,27%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

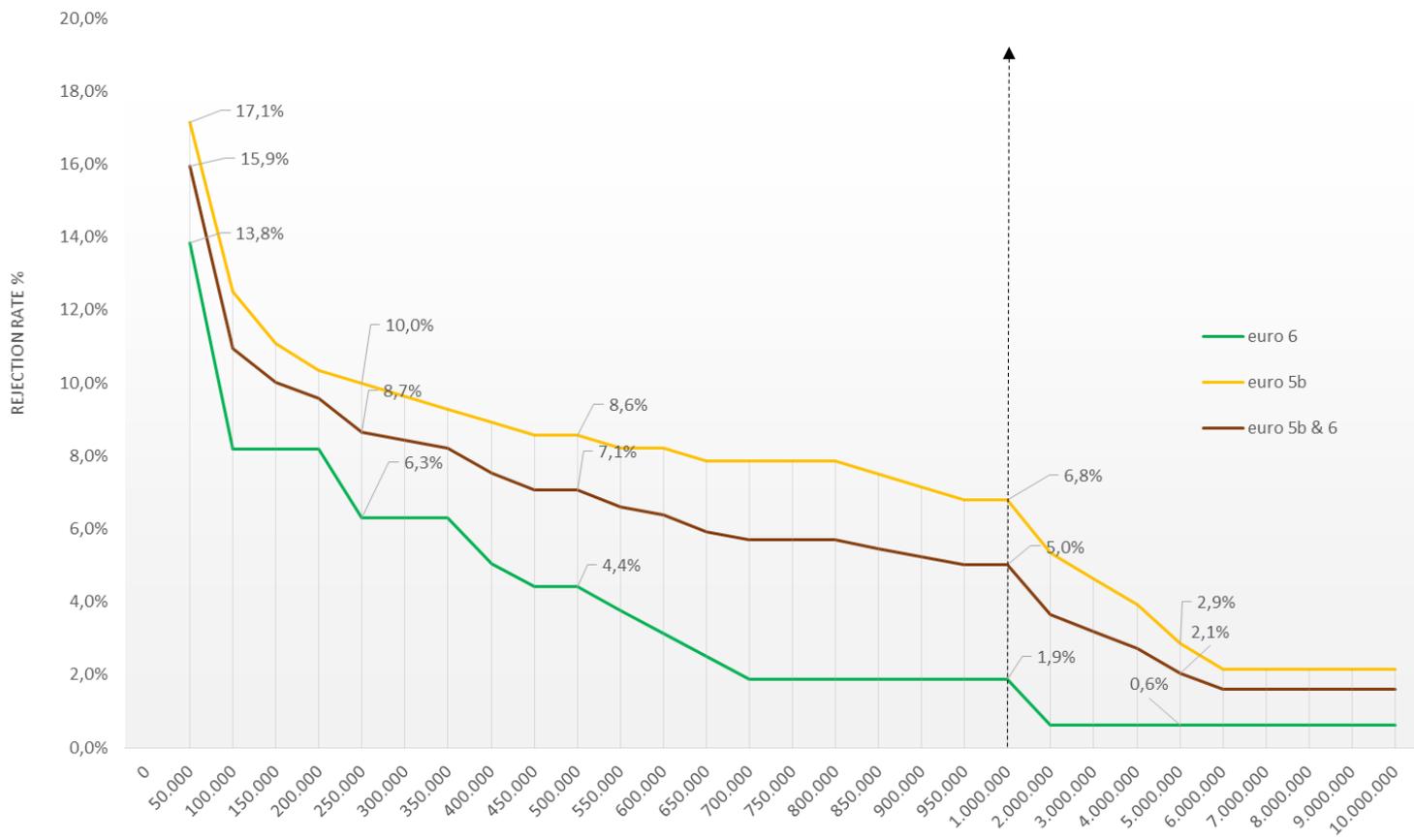
Expected rejection rate in function of the limit value for Euro 5 and euro 6 vehicles [# / cm³]



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

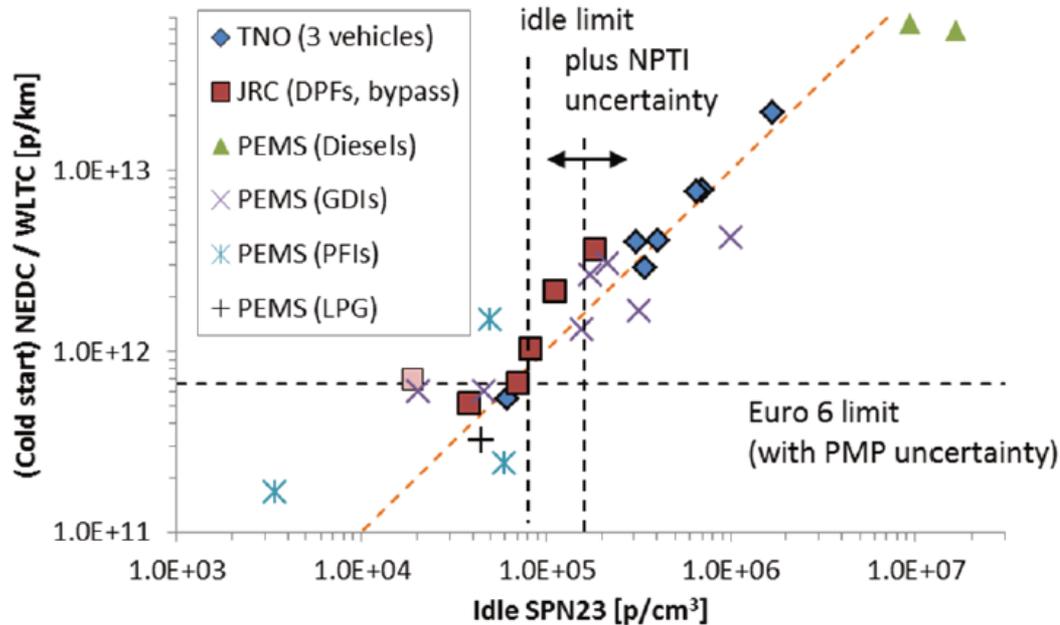


Expected rejection rate in function of the limit value for Euro 5b and euro 6 vehicles [$\#/cm^3$]



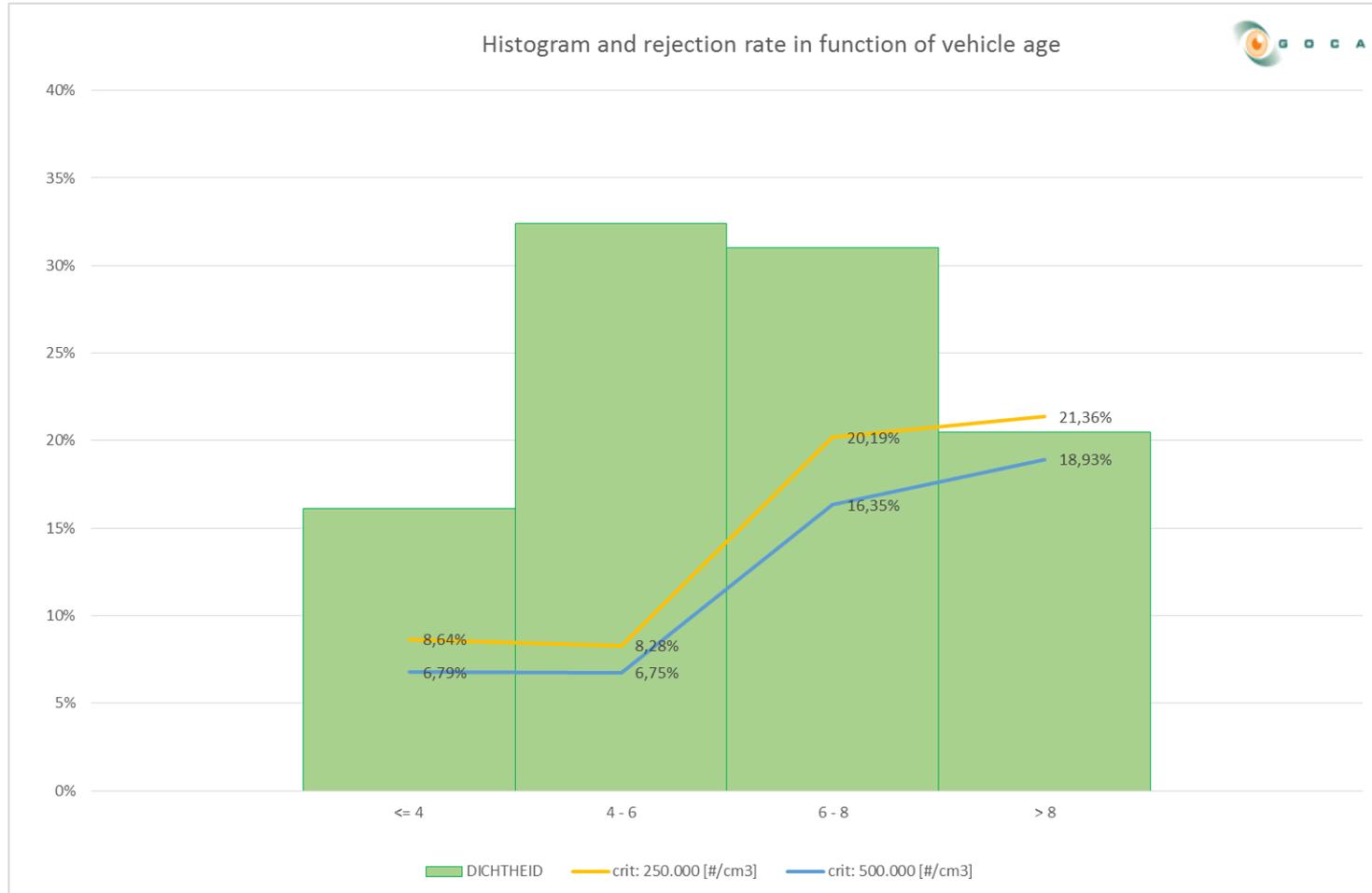
Limit value

NPTI 250.000 #/cm³ ??

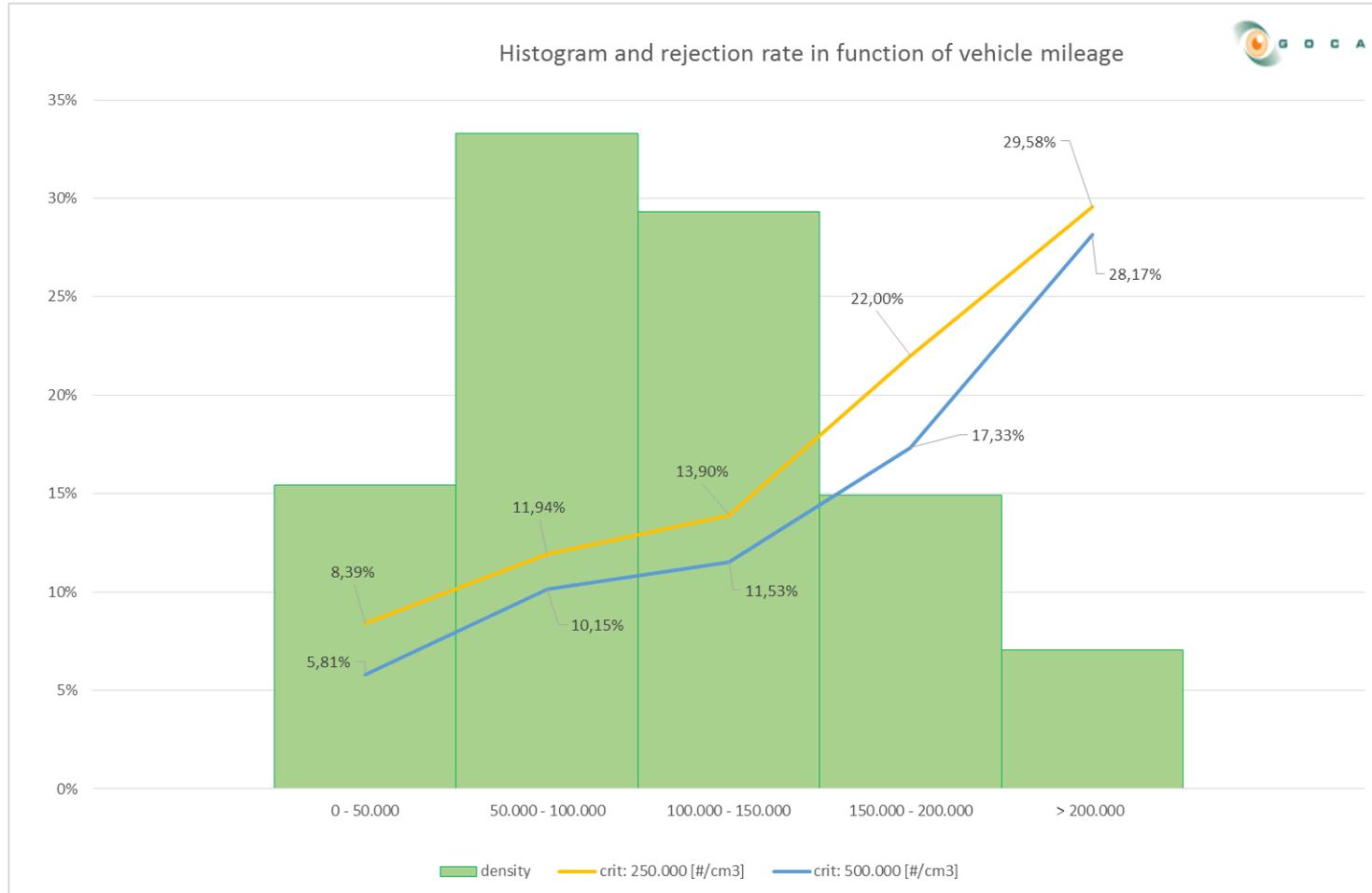


Emission factor [# / km] at NEDC or WLTC versus raw emission concentrations [# / cm³] measured at idle. (Taken from Giechaskiel B., Lahde T., Suarez-Bertoa R. et al., 2018)

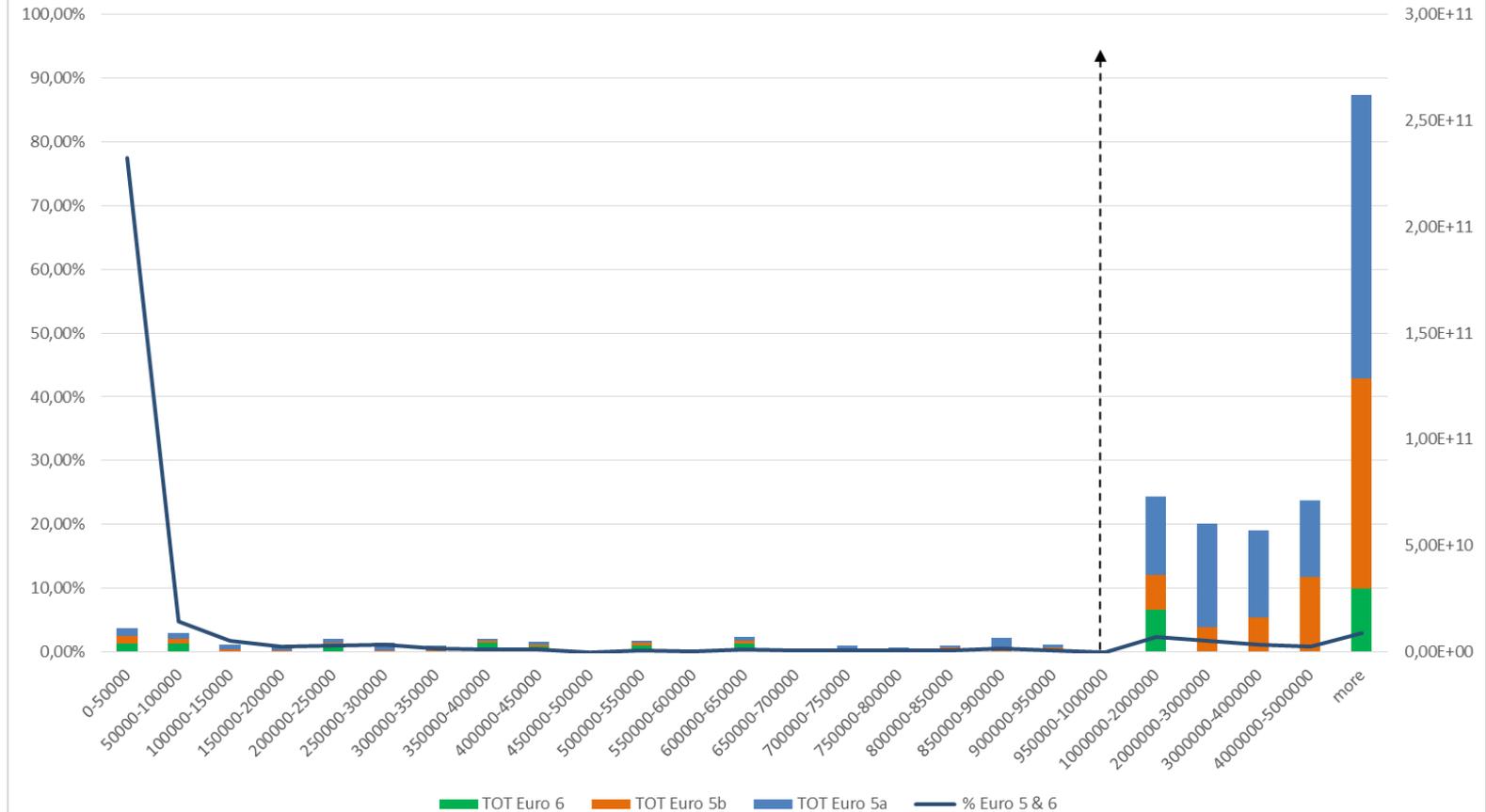
PN measurements – Sample of the study



PN measurements – Sample of the study

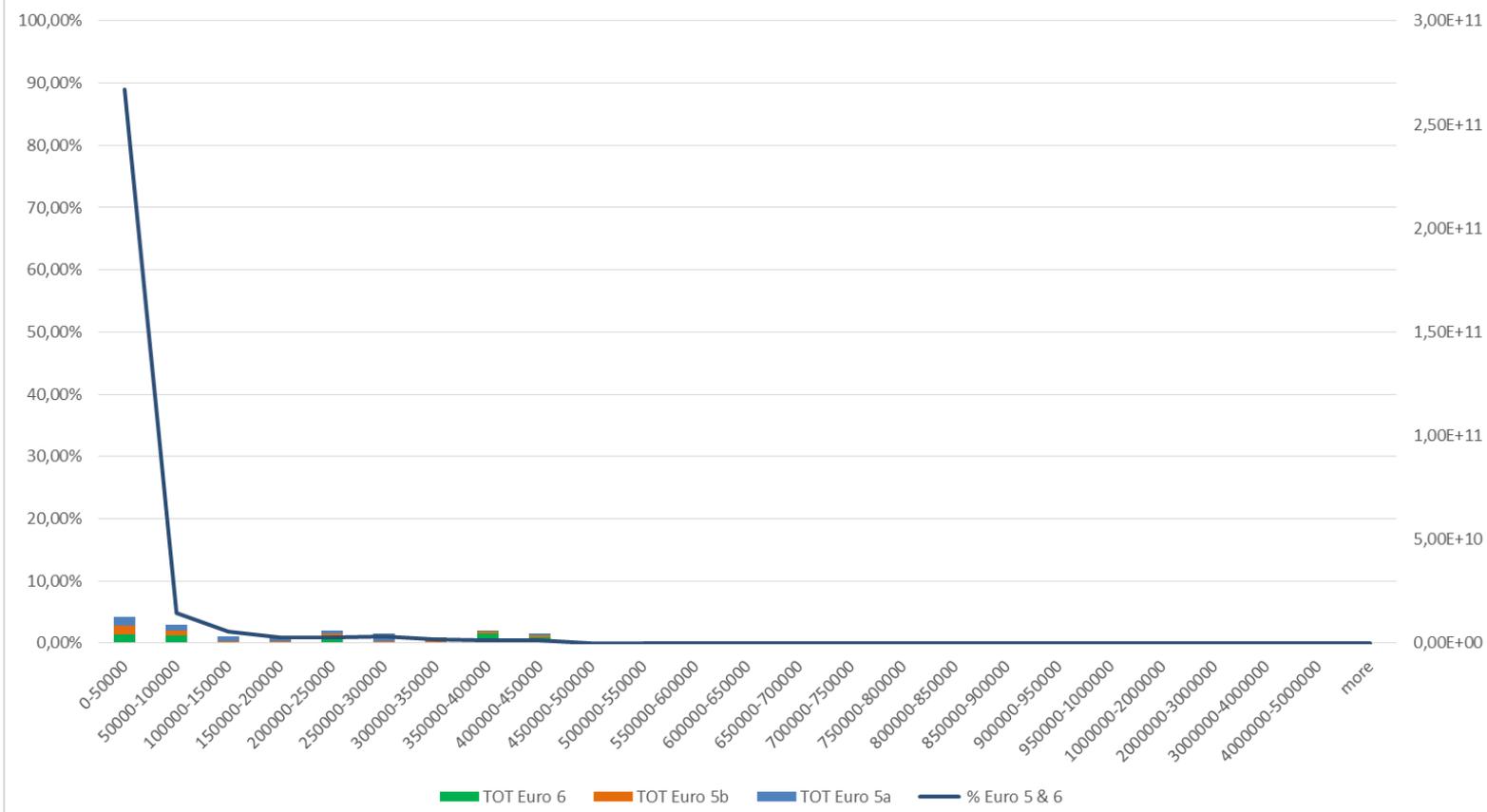


Simulation of the total particulate emissions [$\#/cm^3$] emitted
by the Euro 5 and 6 vehicles in Belgium
($6,07 \times 10^{11} \#/cm^3$)

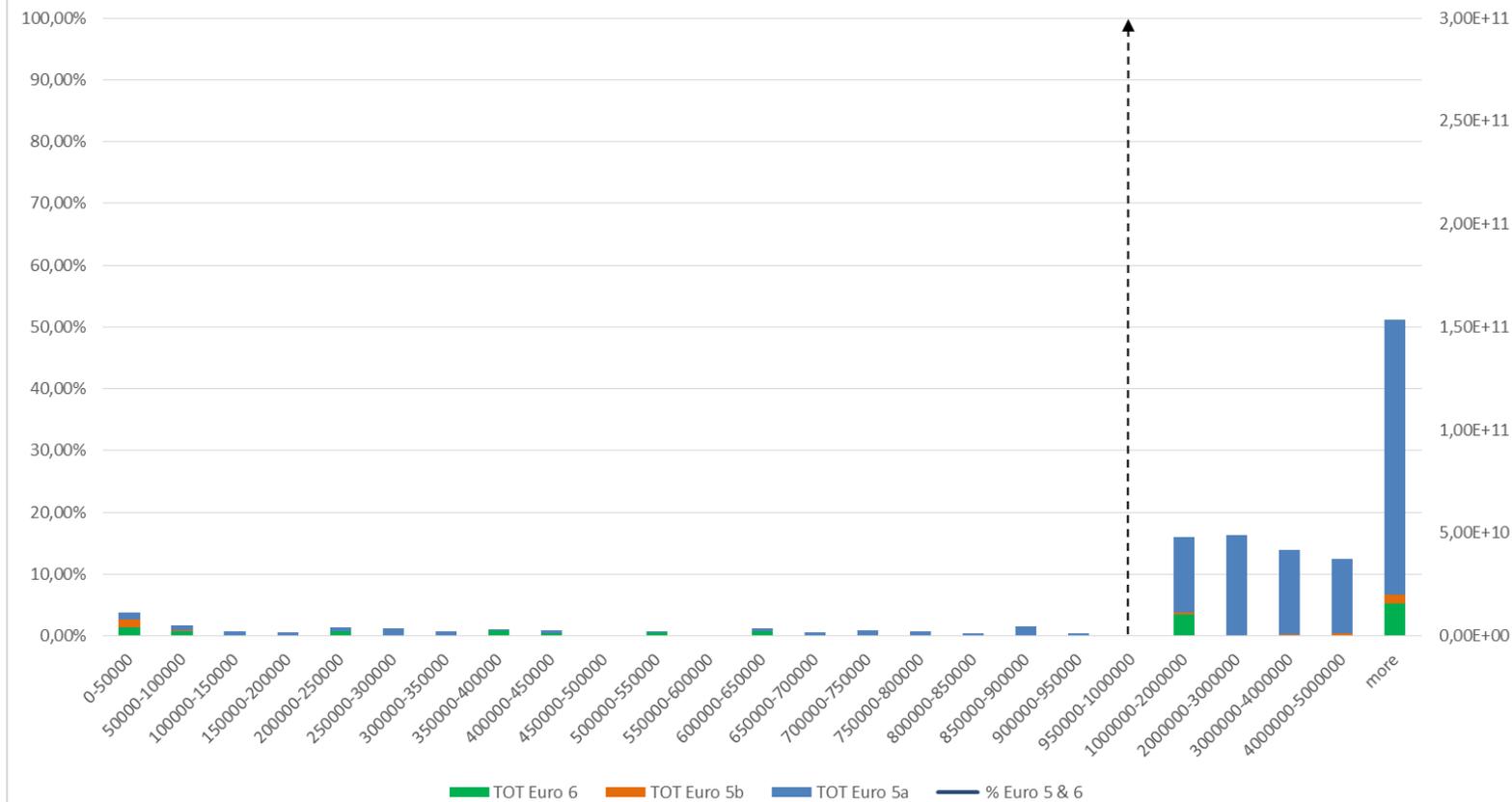


Simulation of the total particulate emissions [$\#/cm^3$] emitted by the Euro 5 and 6 vehicles in Belgium, after tested and remedied all vehicles

($5,14 \times 10^{10} \#/cm^3$, 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%)



Conclusions

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;

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

A new PN emission measurement can check the quality of the particulate filter during the periodic inspection of diesel vehicles;

Future emission test for Euro 5b diesel vehicle and higher:

- PN measurement instead of opacity test;
- proposal rejection limit: 250.000 #/cm³;

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;

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

Thank you for your attention

Pascal Buekenhoudt

Project & Innovation Manager

Rue de la Technologiestraat 21/25 | Bruxelles 1082 Brussel

T. 02/482.34.76 | M. 0476/82.34.76 | F. 02/469.32.55

buekenhoudt.p@goca.be | www.goca.be



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

Pascal Buekenhoudt

Member of Bureau Permanent

CITA asbl | Rue du Commerce 123| B-1000 BRUSSELS (Belgium)

TEL +32 (0)2 469 0670 | secretariat@citainsp.org

www.citainsp.org

