Field Evaluations of Diesel Particulate Filter conditions using concentration of solid particle number in Bogotá.

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Overview

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1. Background

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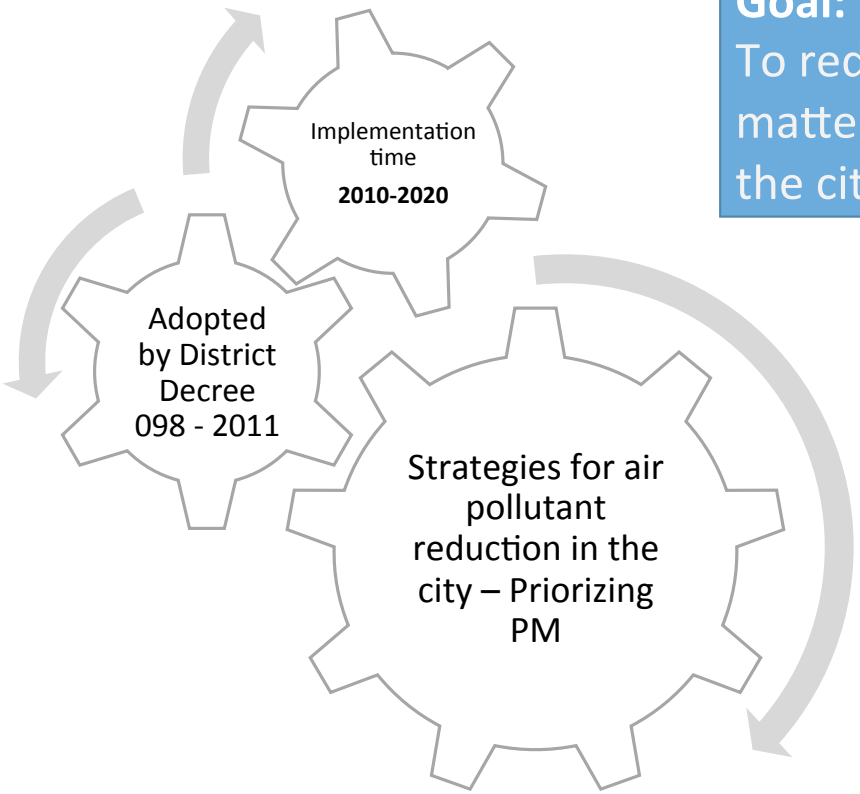
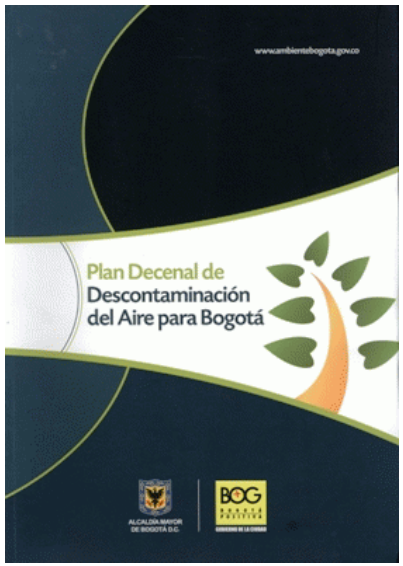
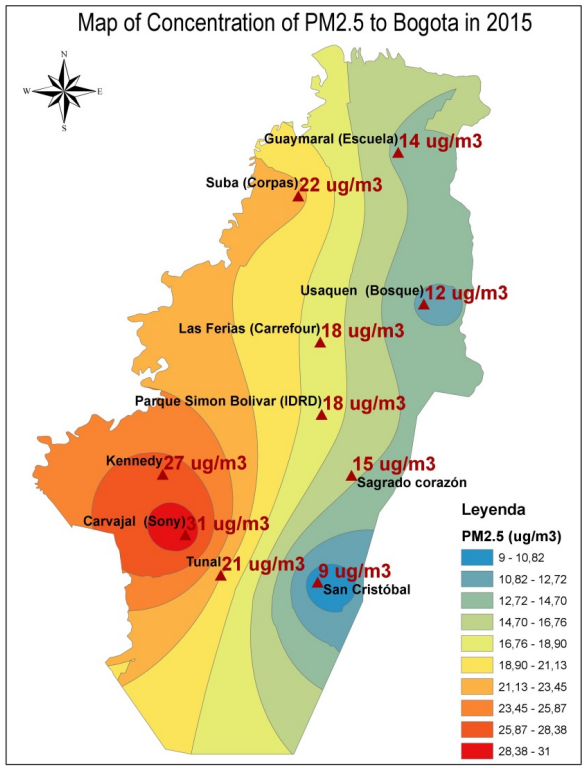
1. Background

Ten-year Air Decontamination Plan for Bogotá City



Goal:
To reduce 60% particulate matter (PM) emissions in the city





PM2.5 annual mean concentration Bogotá – 2015 – Air Quality Network SDA

1. Background

Reduction strategy for Public Transport buses

DPF-Retrofit Strategy

Pilot program
PM – PNC and other pollutants measured in buses under local conditions

Resolution 123 of 2015
Initial stage of DPF retrofit Program

Emissions threshold in buses + DPF

- *Opacity downstream DPF < 0.24 m^{-1} in K-Value*
- *Removal efficiency of Nano-particles > 97%*

Acevedo H., I.Molina, H. Saenz, J. Pulido, N. Rojas *Universidad national de Colombia*	2014	Bogota DPF Retrofitting Program for the Public Transport Buses Operating at High Altitude

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TRANSMILENIO

2. Objectives

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2. Objectives

1. To stablish a field measurement protocol for opacity and solid particle number concentration.

Considering different test conditions regarding the engine speed and load.

2. To compare PM2.5, the opacity and the solid particle number metrics.

All equipments designed to operate in field conditions

3. To compare results from several emission levels in buses.

Euro II, Euro III, Euro IV, Euro V

Euro II+DPF, Euro II+DPF

Visual indicator of PM emission in Transmilenio buses with and without DPF – 2015.

3. Methodology

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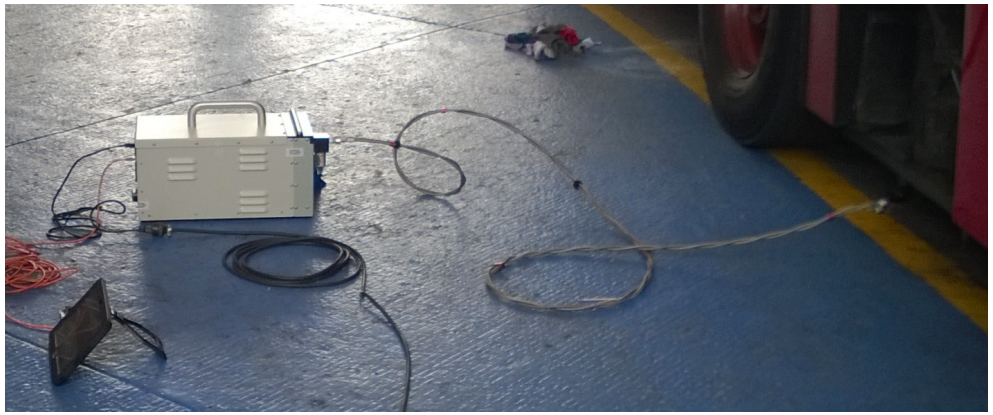
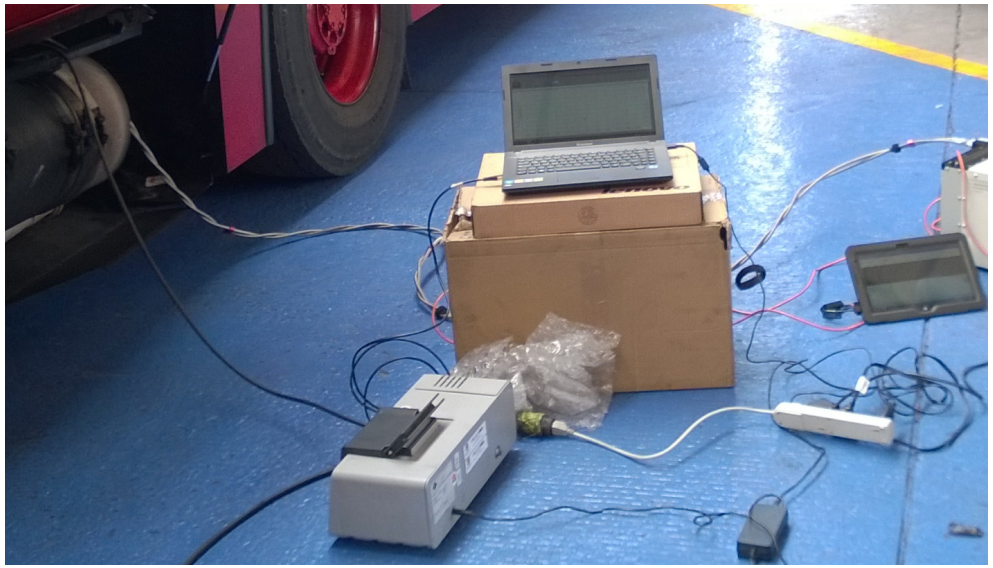
3. Methodology





Equipment principle	Brand
Condensation Particle Counter – CPC	TSI 3795
Laser Light Scattering Photometry – LLSP – PM2.5 - Opacimeter.	Maha 6.2.1
Optical opacimeter	Capelec

Test conditions.

M1: Low idle.
M2: 1200 RPM.
M3: 1500 RPM.

Mx-A: Upstream DPF.

Stoll test.
Opacity test.

3. Methodology

	CPC	LLSP Opacimeter	Optical Opacimeter
Test in Buses with DPF	146	71	16
Test in Buses without DPF	109	64	-

All performed test with equipment in parallel

Random selection in Buses without DPF

3 buses with DPF evaluated during different days

4. Results

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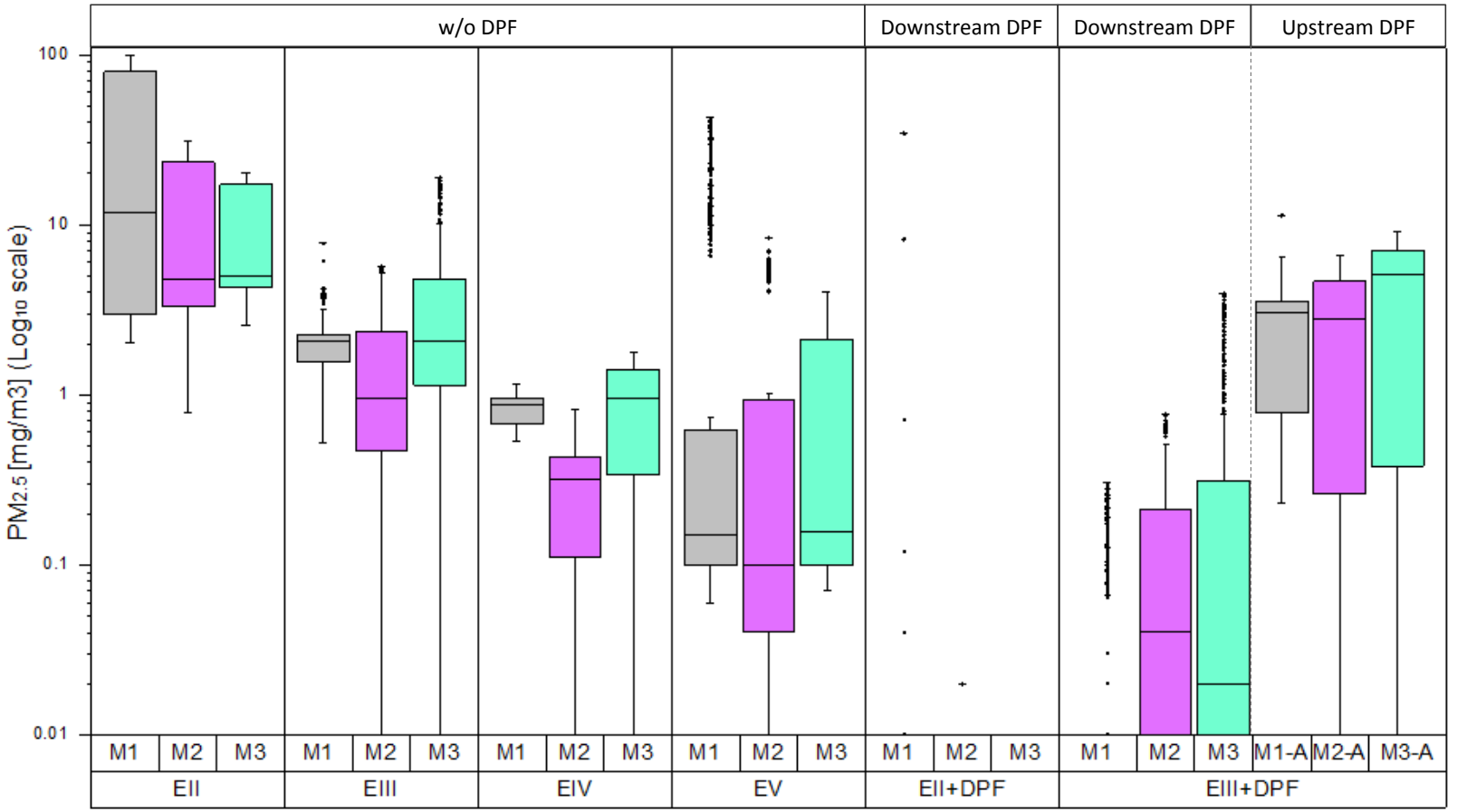
4. Results

PM2.5 concentration by emission standard



In some cases, the concentration in buses with DPF remain below the lower limit of detection.

Higher IQR and median concentrations in buses EII w/o DPF.

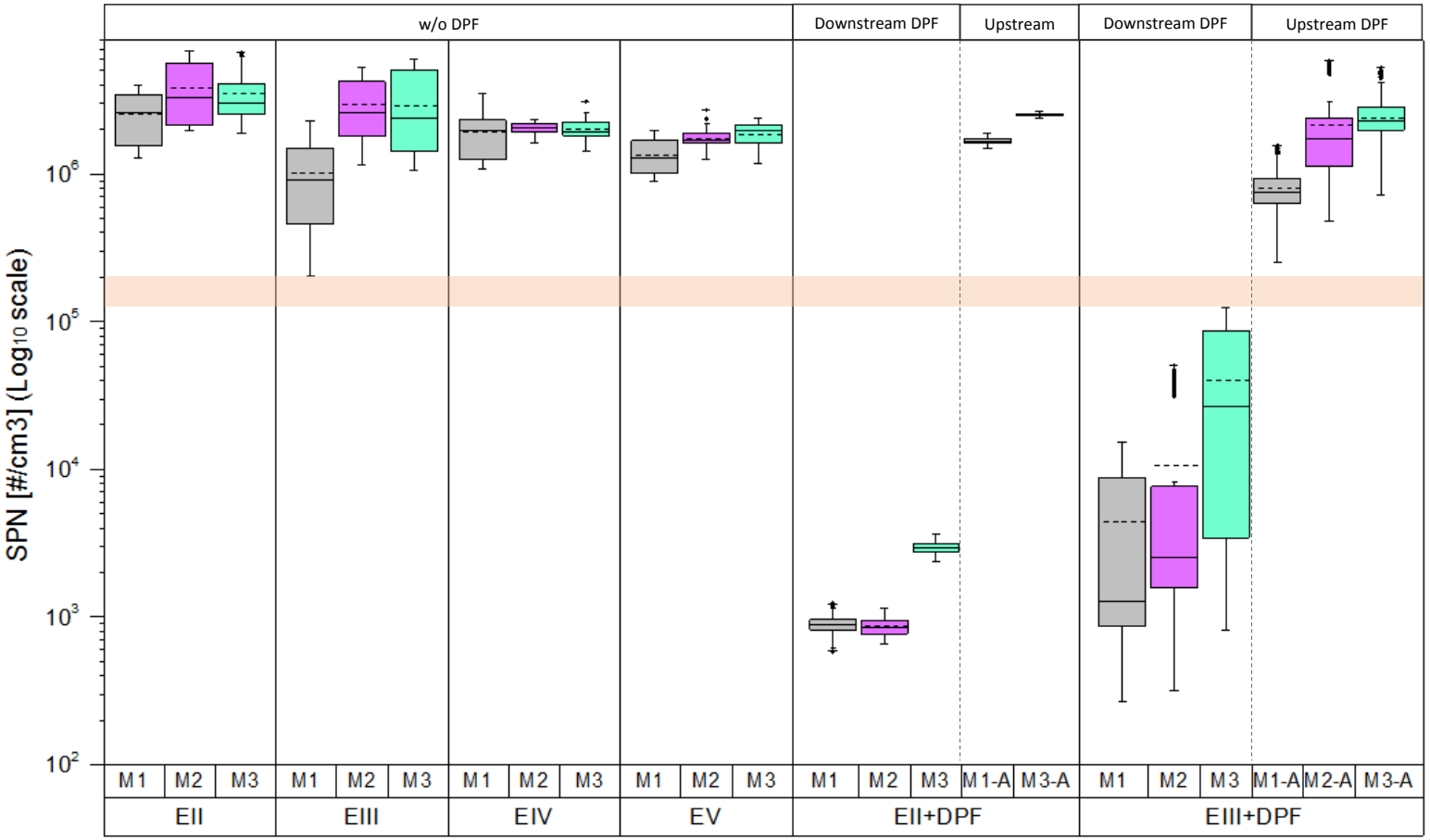
4. Results

Solid Particle Number measurements by emission standard

- *Idle speed (M1)*
- *1200 rpm (M2)*
- *1500 rpm (M3)*

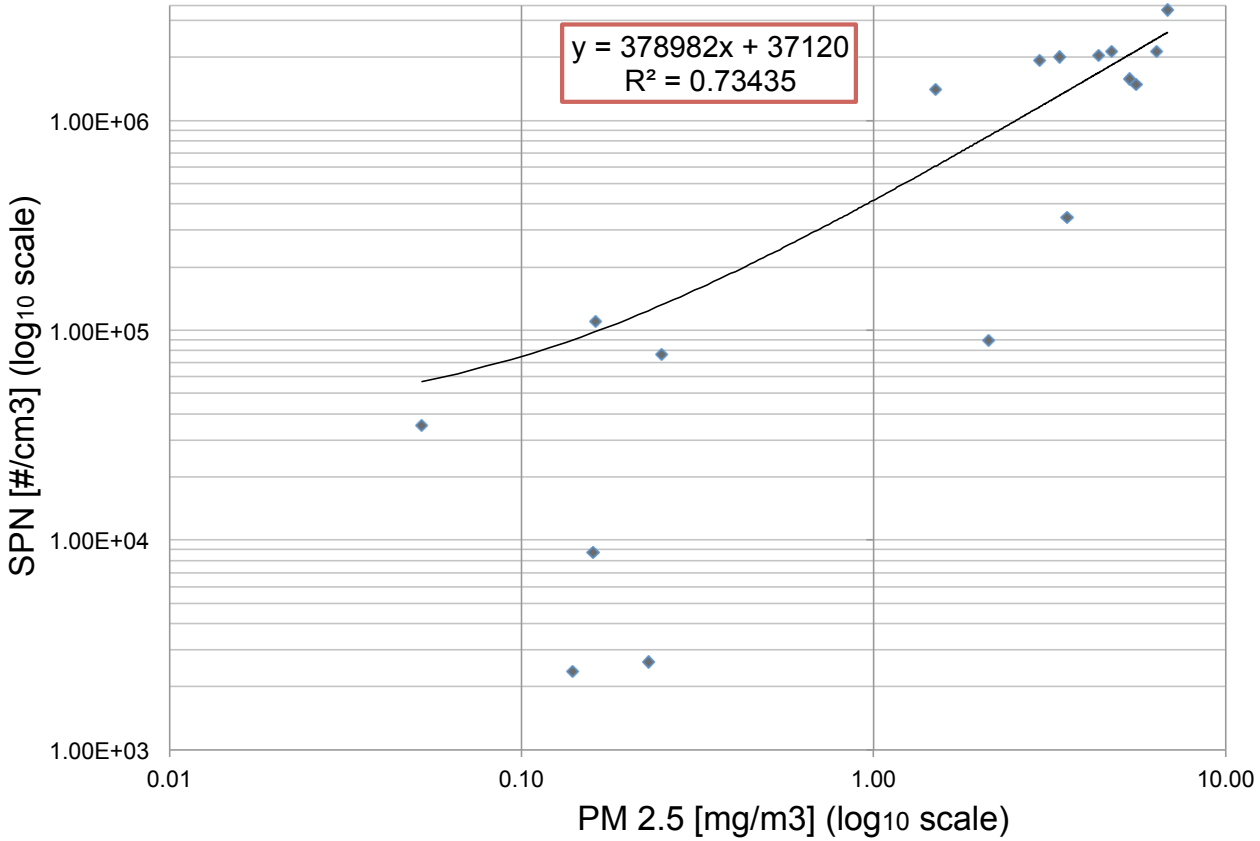
Clear distinction between DPF and non-DPF equipped buses

Proposed limit of 200.000 pt/cm3.



4. Results

Comparison between PM2.5 and SPN concentration



Good linear correlation between PM2.5 and SPN in high concentration levels.

SPN: best metric for DPF retrofit buses.

For non-filtered technologies, PM2.5 is a good metric

5. Conclusions

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5. Conclusions

1. Considering the results, the entity already have a protocol to measure removal efficiency of nano-particles in idle speed, we expect to modify it including a threshold downstream DPF near to 200.000 #/cm3 and another steady state test conditions.

2. Comparison between metrics:

- SPN concentration is superior metric to be used in buses with DPF installed. Have a good behavior under steady state tests and downstream DPF.
- PM2.5 is a good metric for non-filtered technologies.
- Opacity has high error levels in buses+DPF. Recommended for non-penalty tests.

3. Comparison between technologies of the fleet. Clear distinction of emission standards in SPN concentration results.

Acknowledgments

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- CALAC – Clean Air for Latin American Cities.

Thank you

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Plan Decenal de
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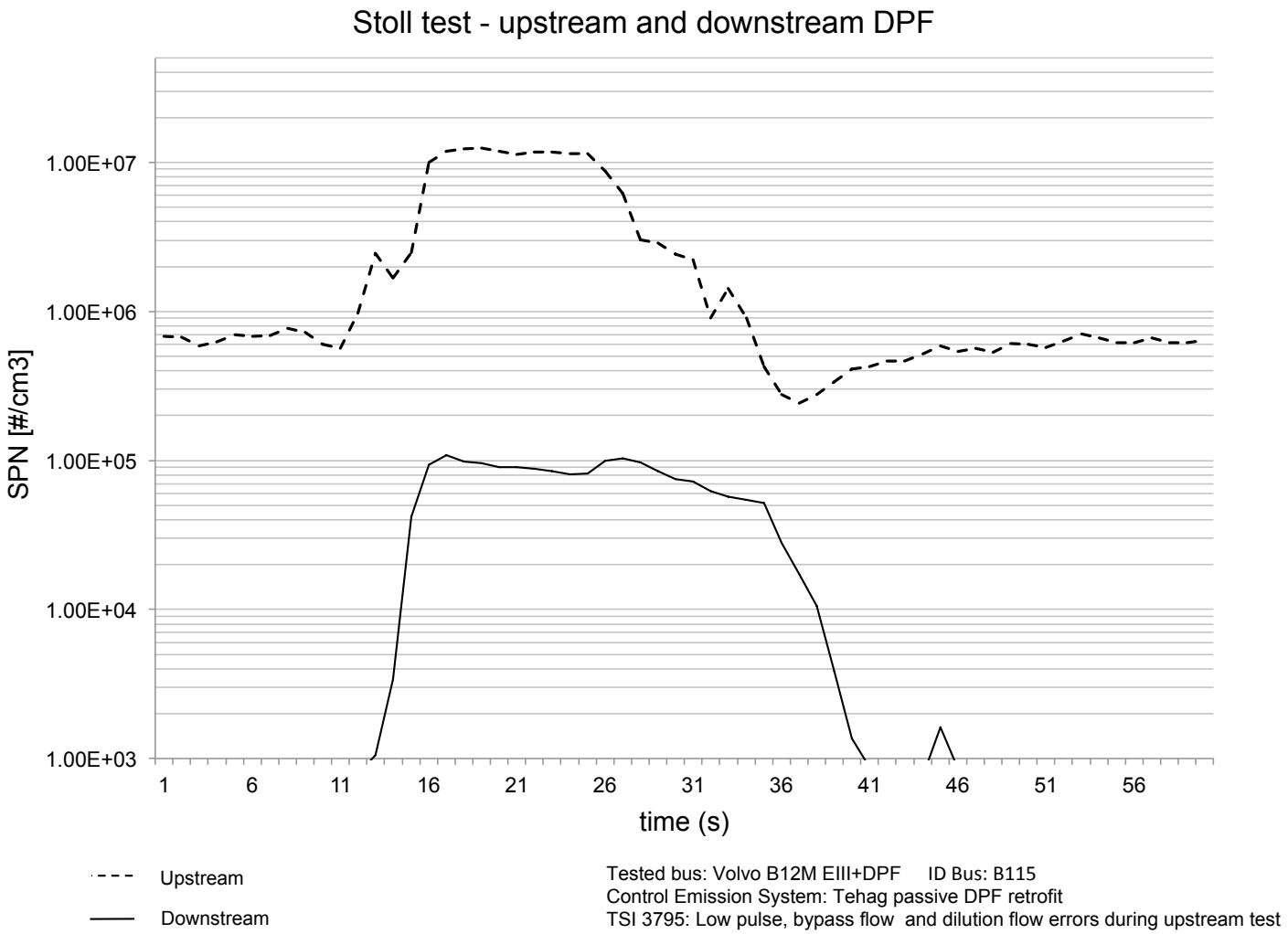
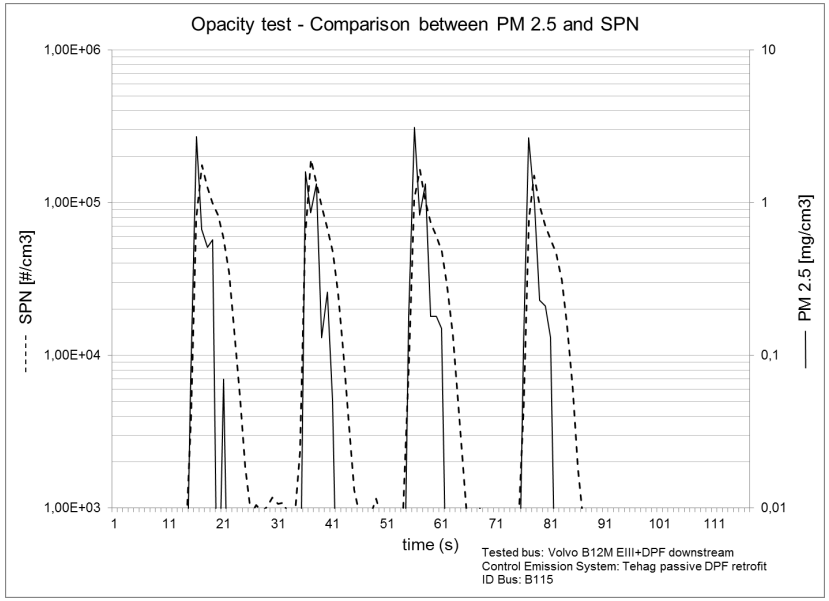
Stoll test


Stoll test - upstream and downstream DPF
SPN [#/cm3]
1.00E+07
1.00E+06
1.00E+05
1.00E+04
1.00E+03
1
6
11
16
21
26
31
36
41
46
51
56
time (s)
Upstream
Downstream
Tested bus: Volvo B12M EIII+DPF ID Bus: B115
Control Emission System: Tehag passive DPF retrofit
TSI 3795: Low pulse, bypass flow and dilution flow errors during upstream test

Opacity comparison



DISPLAYED ERRORS - MEASUREMENTS DOWNSTREAM IN BUSES WITH DPF

	BUS WITH DPF		
	Total	with error	% Valid Test
D1	9	3	66,7%
D-Stoll	9	5	44,4%
M1	12	3	75,0%
M2	13	3	76,9%
M3	12	3	75,0%
M-Chile	8	5	37,5%
M-Opa	13	6	53,8%
Total general	**76**	**28**	63,2%
% Valid Test	63,2%		

DISPLAYED ERRORS - MEASUREMENTS UPSTREAM IN BUSES WITH DPF, AND ALSO FOR BUSES WITHOUT DPF

DPF-upstream	Bus sin DPF	Total	with error	% Valid Test
D1-A		9	3	66,7%
D-Stoll-A	D-Stoll	4	4	0,0%
M1-A	M1	44	20	54,5%
M2-A	M2	42	15	64,3%
M3-A	M3	39	10	74,4%
M-Chile	M-Gobernada	12	7	41,7%
M-Opa-A	M-Opa	9	6	33,3%
Total general		**159**	**65**	59,1%
% Valid Test		59,1%		

#BUS	opa @ LTOE 430	Diferencia entre pruebas
K016+DPF	14,4521919	17,392
K016+DPF	9,00834069	14,265
K016+DPF	1,93583653	0,131
K016	94,2350005	0,911
S031	92,5764388	1,102
S031+DPF	1,62378463	0,255
K016	99,7853192	0,071
K016+DPF	69,0653824	1,756
K016+DPF	25,0641488	8,645
K016	67,3707536	0,383
K016	69,1841055	0,461
K016+DPF	23,7858318	0,294
K016	53,3456986	7,219
K016+DPF	31,4545197	6,703
B115	16,5183091	4,324
B115+DPF	0,14322732	0,129