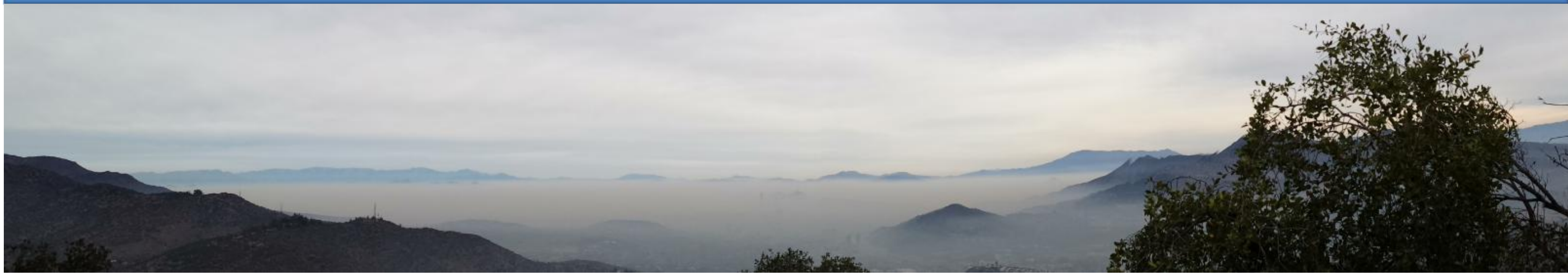
Buses Fleet Tested following the new concept in Santiago de Chile (2015).

1st Latin American Conference on the emission of nanoparticles in internal combustion engines



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Geasur
TECNOLOGIA Y MEDIOAMBIENTE

OVERVIEW

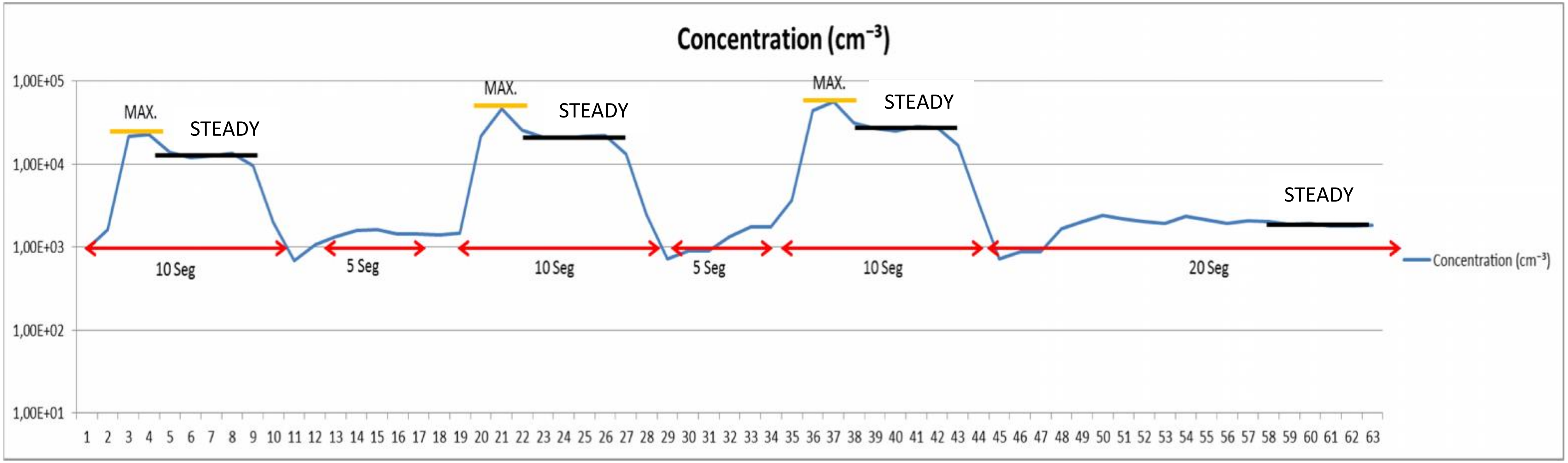
- Partnership between
  - Chilean Ministry of the Environment (MMA).
  - Climate and Clean Air in Latin American Cities (CALAC).
  - Swiss Agency for Development and Cooperation (SDA/COSUDE).
- 3,200 buses with CRT-DPF systems (1,000 retrofitted + 2,200 OEM).
- Follow up of DPF implementation program 2005-2013.
- DPF aged between 150,000 to 750,000 km (325,000 average).

OVERVIEW

- 400 roadside emissions measurements (200 with PN instrument), at end of pipe, to check DPF-quality.
- DPF-Efficiency, in-depot PN measurement, for 22 buses, at exhaust upstream and downstream of DPF, to compare with roadside results.
- Using NPET-TSI, new CH-METAS certified portable, low cost, highly sensitive PN number counting instrument (SR 941.242).
- Goal: To check aged DPF and develop a solid PN measurement for inspection in Santiago.

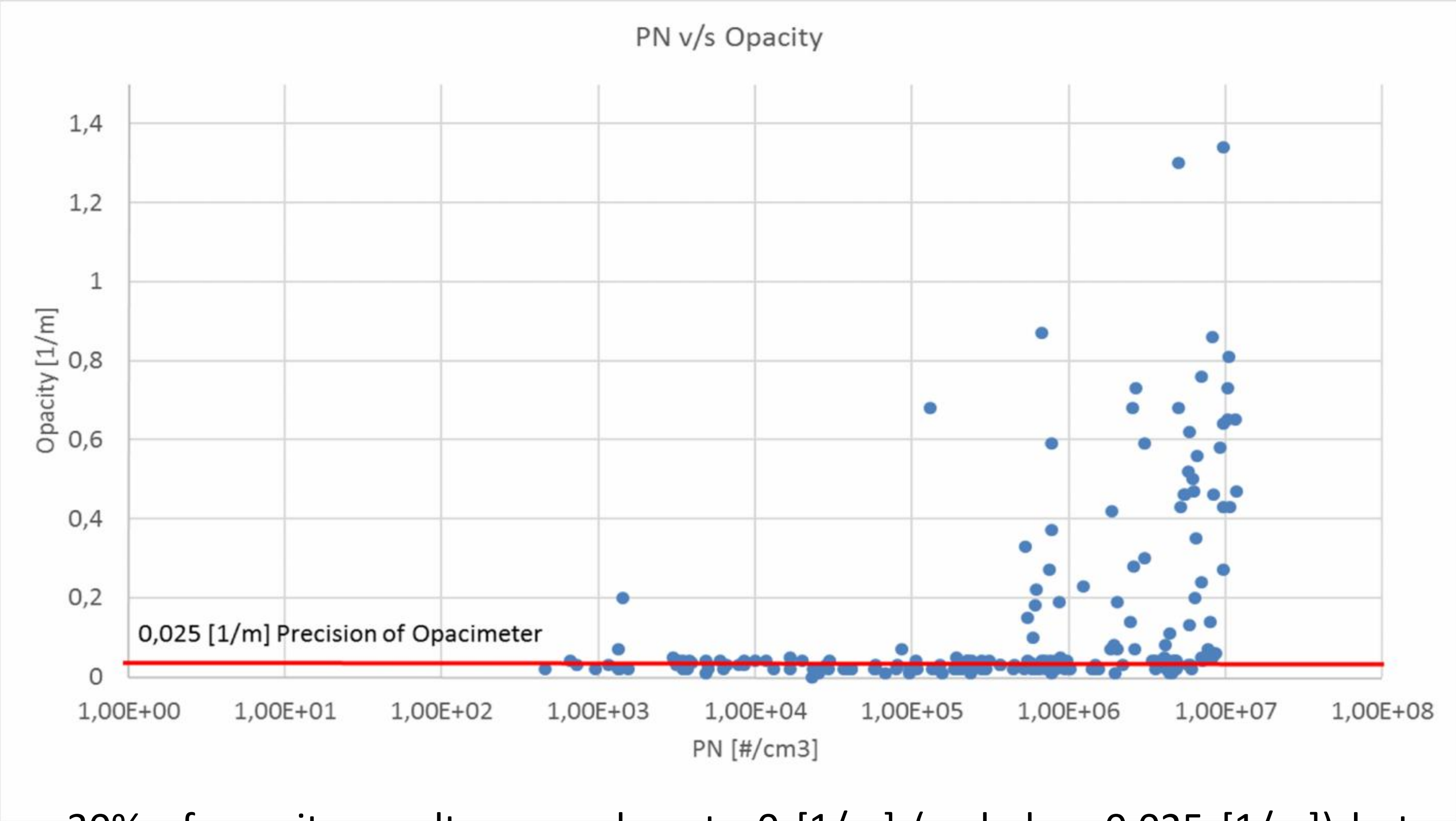
Measurement Protocol

- Roadside: Opacity and PN at exhaust exit during free acceleration, high idle and low idle.
- In-Depot: At low idle speed engine because low idle permit to measure PN of gross engine emissions inside of equipment range (< 5x10E+6)



Places of measurement campaign

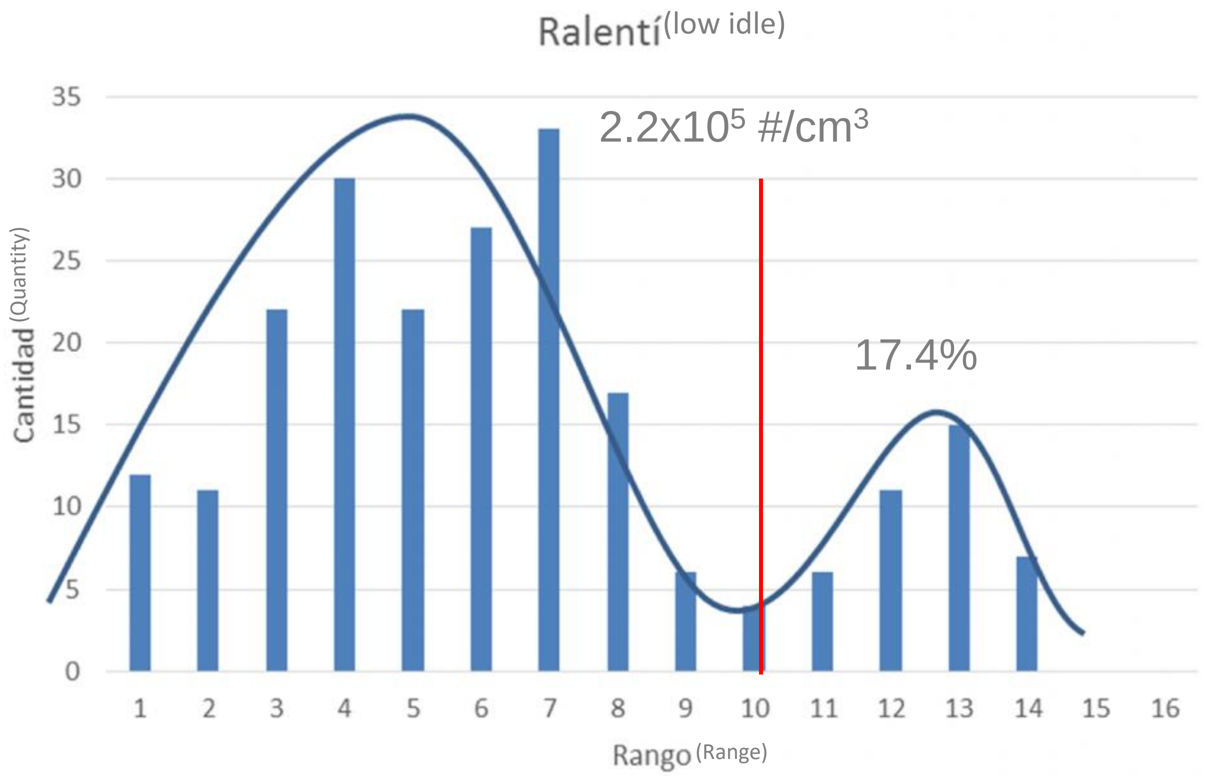
Comparison PN v/s Opacity at Free Acceleration



- 30% of opacity results were close to 0 [1/m] (or below 0.025 [1/m]) but with results between 10E+2 to 10E+9 [#/cm3] in PN.

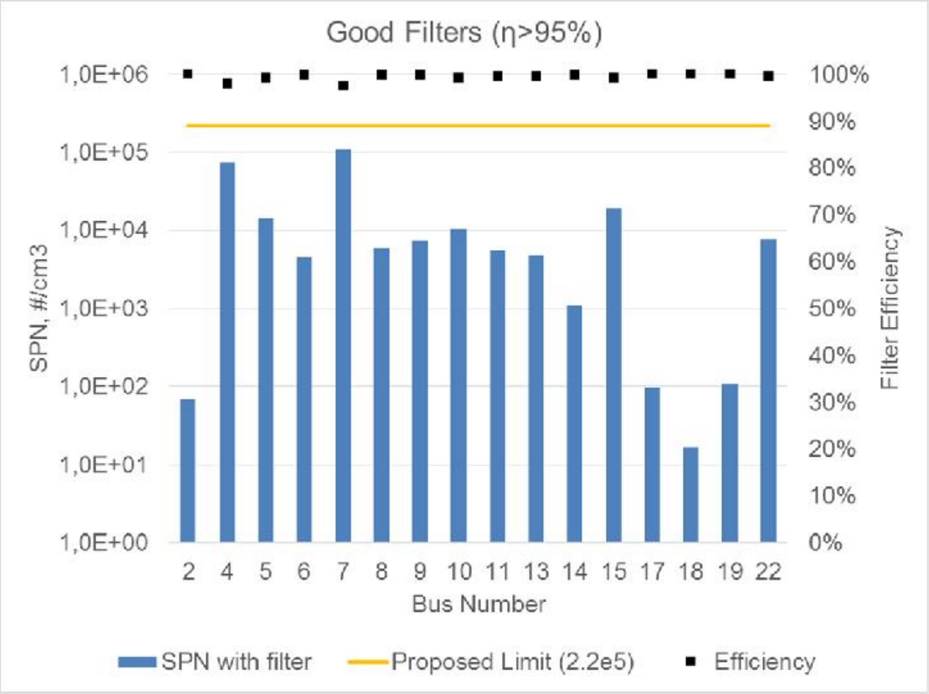
End of pipe PN Limit to detect Abnormal Emissions

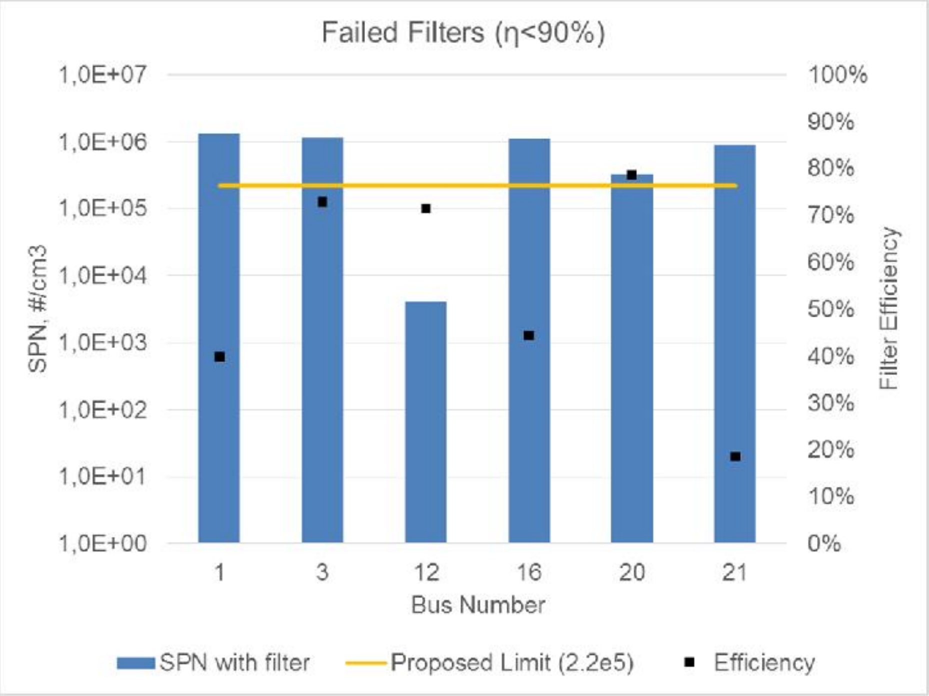
- Low Idle speed is enough sensitive and easier to implement in roadside control (no driver or RPM electronic control interferences)
- Binned bus measurements into 14 log-spaced concentration ranges.
- Separation in bimodal structure (normal and abnormal), clearest for low idle.
- Bimodal structure determines limit of 2.2x10E+5 [#/cm^3] as threshold.



DPF Efficiency results v/s end of pipe threshold

- 22 buses, PN measured at low idle downstream/upstream of DPF.
- All buses with η>95% passed limit ($\eta_{Average}$ = 99.5%)
- All but one bus with η<90% failed limit ($\eta_{Average}$ = 50%)
- Reference proposed limit of 2.2×10^5 #/cm^3 could be a good indicator of low efficient DPF.





Fleet summary considering proposed threshold

Model With DPF	Number of Abnormal Emissions	Buses Tested	Rate of Abnormal Emissions	Average DPF Age [km]
A	0	26	0,0%	224.651
B	9	127	7,1%	329.673
C	6	32	18,8%	225.000
D	10	14	71,4%	374.865
E	11	11	100,0%	714.583
F	3	13	23,1%	301.023
Total	39	223	17,5%	325.920

- Failure average rate of 17,5% for all fleet.
- Abnormal emissions are concentrated in two model types (older DPF > 5 years).

Conclusions

- Solid particle number concentration is a more sensitive metric than opacity for determining DPF condition.
- PN limit of $2.2x10^5$ #/cm^3 , at Low Idle speed, is a good indicator for detecting filters with low efficiency.
- In Santiago, buses with DPF above limit concentrated in two specific models
  - Which were implemented in early stage of project.
  - Where best maintenance practices had not been implemented.
  - Other implementation (for instance Model D) showed 0% of abnormal emissions.

Conclusions

- Good maintenance of Engine is equal or more important than DPF maintenance.
- Best practices to maintenance DPF and engine are both necessarily and must be implemented:
  - Backpressure alarm monitoring.
  - Low SAPs lubricant for engines.
  - Professional workshop for cleaning DPF.
  - Opacity measurement before DPF.
  - Preventive engine maintenance (diesel injectors replacement conform to recommended kilometers).
  - Etc.

Conclusions

- Cultural change from corrective to predictive maintenance had to be done in Santiago for DPF technology (retrofitting, new EuroIII+DPF and Euro VI).

- The new decontamination plan for Santiago require that a new PN periodical inspection be implemented in Santiago.

Artículo 15: Dentro de un plazo de 24 meses, contados desde la entrada en vigencia del presente Decreto, el Ministerio de Medio Ambiente en conjunto con el Ministerio de Transportes y Telecomunicaciones, evaluarán implementar métodos de control de emisiones del número de partículas en la vía pública de vehículos diésel, con el objetivo de establecer un control eficaz en detectar vehículos cuyo motor o sistema de control de emisiones se encuentran deteriorados o con falta de mantenimiento. Para este efecto se considerará el desarrollo de instrumentos, protocolos y límites máximos permitidos, usando como referencia la normativa internacional.

Conclusions

- New PN counting instruments (NPET-TSI), portable, low cost, highly sensitive permits verify DPF and introduce PN measurement as a part of best practices.

Acknowledgements

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- + Gobierno de Chile, Ministerio de Transportes.
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- + VERT.
- + TSI.

Particularly to:

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